STEEL STRUCTURES

IS - 800-2007 [Limit State Method]

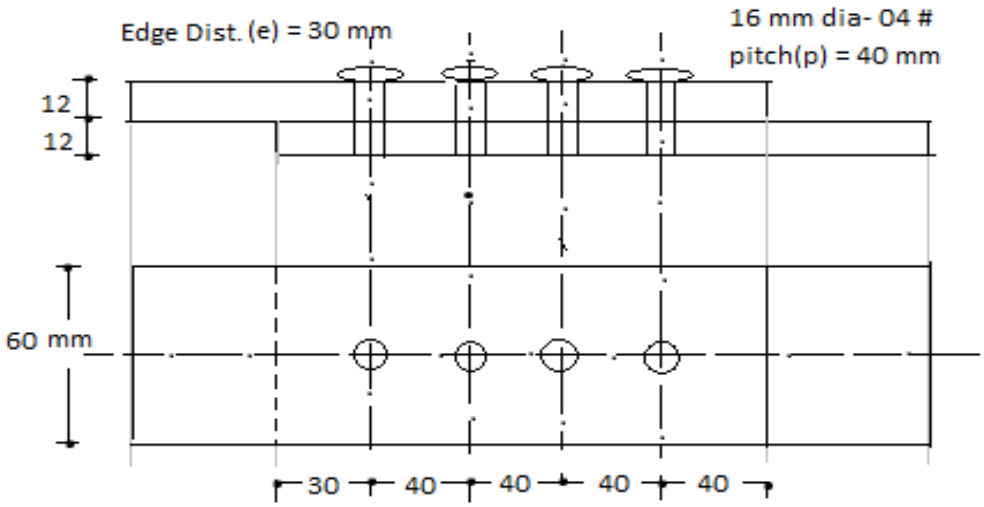
BOLTED CONNECTIONS

Problem 1) : Two plates 12 × 60 mm are connected in *Lap Joint* with 16 mm Ø – 04 No. Find Strength of Joint ?

Ultimate Strength of Bolt Material = 400 $^{N}/_{mm^2}$

Ultimate Strength of Plate Material = 410 $^{N}/_{mm^2}$

Figure is Given



Typical S/C Of Lap Joint (Single Shear)

Answer : Given data : a) F_{ub} = 400 $^{N}/_{mm^2}$

b) If Edge Distance (e) is not given then e = 1.5 × d_0

c) F_{uP} = 410 $^{N}/_{mm^2}$

d) If Pitch (P) is not given then P = 2.5 × d

e) Dia. Of Bolt = d = 16 mm

f) Dia. Of Bolt Hole = d_0 = 16 + 2 = 18 mm

Step 1) : Design Strength of one Bolt in Shear (V_{ds})

V_{ds} = 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ ($n_n A_{nb} + n_s A_{sb}$)].....IS 800-2007; cl. 10.3.3 ; pg. 75

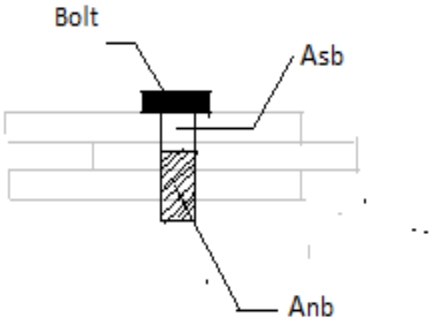
Where F_u = F_{ub} = 400 $^{N}/_{mm^2}$

n_n = No. of shear planes with threads intercepting shear planes. = 1 (Lap Joint – single Shear)

A_{Sb} = Nominal Plain Shank Area of the Bolt.

Anb = π/ 4 (d-0.9382 p)^2 = 363.997 *or*
= 0.78 to 0.80 (π d^2/4)
= 156.82

Taking Least Value



A_{nb} = Net shear area of bolts at threads. = 156.82 mm^2

n_s = No. of shear planes without threads intercepting shear planes. = 0

ɣ = Partial safety factor for Bolt Material = 1.25 …… IS 800-2007 ;Table 5 ; pg. 30

$$V_{ds} = 28975\ N$$

Step 2) : Design Strength of one Bolt in Bearing (V_{bs})

V_{bs} = 1/ ɣ $(2.5\ K_b\ d\ t\ F_u)$ ……IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub}$ = 400 $^N/_{mm^2}$

d = 16 mm ; t = Thickness of plate = 12 mm

Kb = I) e / 3 do = 30 / (3*18) = 0.556
II) P / 3 do - 0.25 = 0.49
III) Fub / Fup = 400 / 410 = 0.975
IV) 1.00

Least Value
Kb = 0.49

ɣ = Partial safety factor for Bolt Material = 1.25 …… IS 800-2007 ;Table 5 ; pg. 30

V_{ds} = 1/ ɣ $[\frac{F_u}{\sqrt{3}}\ (n_n\ A_{nb} + n_s\ A_{sb})\ ]$ = 1/ 1.25 $[\frac{400}{\sqrt{3}}\ (\ 156.82 + 0)\ ]$

$$V_{bs} = 75264\ N$$

Since, $V_{ds} < V_{bs}$

∴ **Strength Of bolt =** $V_{ds} = 28.975\ KN$

Step 3) : To Find Design Tensile Strength of Plate

I. Yielding Consideration : $T_{dg} = 1/\gamma \ (A_g \ F_y)$

.....IS 800-2007; cl. 6.2 ; pg. 32

Where, A_g = Gross Area Of plate S/c = (60 × 12) = 720 mm^2

F_y = Yield Strss Of the plate = Assume 250 N/mm^2

γ = Partial Safety Factor for failure by Yielding = 1.10

..... IS 800-2007 ; Table 5 ; pg. 30

$$\therefore T_{dg} = 16.3636 \quad KN$$

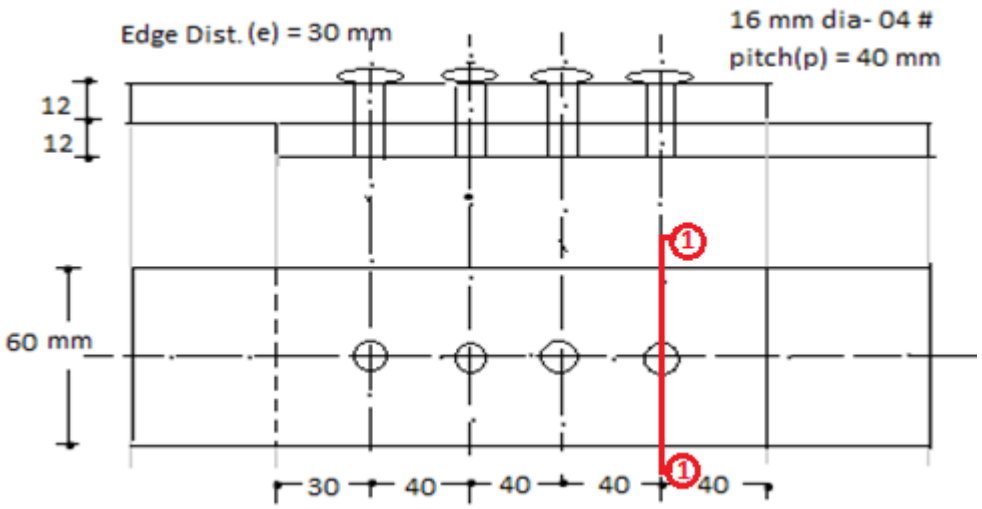
II Rupture Consideration : $T_{dn} = 1/\gamma \ (0.9 \ A_n \ F_u)$..... IS 800-2007; cl. 6.3.1 ; pg. 32

γ = Partial Safety Factor for failure by Rupture = 1.25

....IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = $((b) - (n \ d_o)) \times t$

Where , n = no. of Bolt Holes in weakest s/c (considering see s/c 1-1) = 1



A_n = (60-18) × 12 = 504 mm^2

$F_u = F_{up}$ = 410 N/mm^2

$$\therefore T_{dn} = 14.8780 \quad KN$$

Problem 2) : Determine Design Strength of 22 mm Ø Bolt for the case given below.

i) Lap Joint

ii) Single Cover Butt Joint With 12 mm cover plates.

iii) Double Cover Butt Joint With 10 mm cover plates.

The main plate is 16 mm thick.

Ultimate Strength of Bolt Material = 400 Mpa

Ultimate Strength of Plate Material = 410 Mpa

Answer : Given data : a) F_{ub} = 400 $^{N}/_{mm^2}$

b) F_{uP} = 410 $^{N}/_{mm^2}$

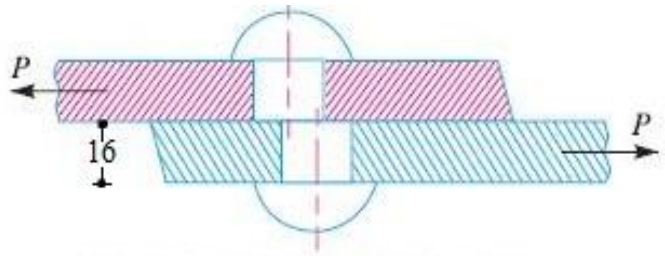
C) Dia. Of Bolt = d = 22 mm

d) Dia. Of Bolt Hole = d_0 = 22 + 2 = 24 mm

e) Edge Distance (e) e = 1.5 × d_0 = 1.5 × 24 = 36 mm say 40 mm

f) Pitch (P) P = 2.5 × d = 2.5 × 22 = 55 say 60 mm

a) *Lap Joint :*



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

i) Design Strength of one Bolt in Shear ($Single\ shear - Lap\ Joint$) (V_{ds})

V_{ds} = 1/ ɣ $[\frac{F_u}{\sqrt{3}}\ (n_n\ A_{nb})]$ .....IS 800-2007; cl. 10.3.3 ; pg. 75

$$A_{nb} = 1(Single\ shear)$$

$$A_{nb} = 0.78 \times \frac{\pi\ (22)^2}{4} =$$

V_{ds} = 1/ 1.25 $[\frac{400}{\sqrt{3}}\ (1 \times\ A_{nb})]$ = 54781 N = 54.781 KN

ii) Design Strength of one Bolt in Bearing (V_{bs})

V_{bs} = 1/ ɣ (2.5 $K_b\ d\ t\ F_u$) .....IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub} = 400\ {}^{N}/_{mm^2}$

d = 22 mm ; t = Thickness of plate = 16 mm

Kb = i) e / 3 do = 0.556
ii) (P / 3 do) -0.25 = 0.583
iii) (Fub / Fup) = 0.976
iv) 1.00

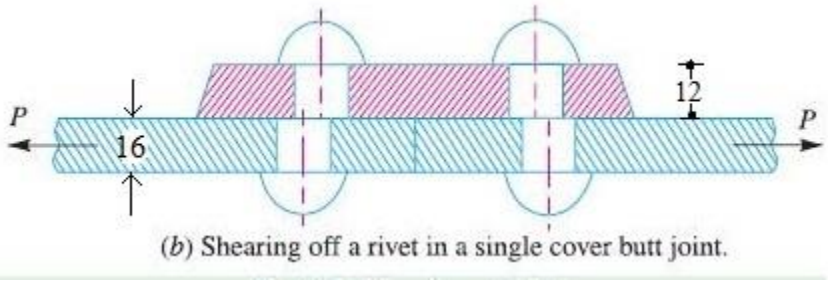
Take Least Value
Kb = 0.556

ɣ = Partial safety factor for Bolt Material = 1.25 …… IS 800-2007 ;Table 5 ; pg. 30

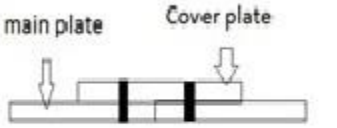
$$V_{bs} = 1565696\ N$$

Design Strength Of the bolt = Lesser of the above values = 54781 N = 54.781 KN

b) Single Cover Butt Joint With 12 mm cover plates. :



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



Single cover single bolted butt joint

i) Design Strength of Bolt in Shear $(Single\ shear)$ (V_{ds})

$$V_{ds} = 54781\ N$$

ii) Design Strength of Bolt in Bearing (V_{bs})

$V_{bs} = 1/\gamma\ (2.5\ K_b\ d\ t\ F_u)$ ……IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub} = 400\ {}^{N}/_{mm^2}$

d = 22 mm ; t = Lesser of the Thickness of plate from above = 12 mm

ɣ = Partial safety factor for Bolt Material = 1.25 …… IS 800-2007 ;Table 5 ; pg. 30

$$\therefore\ V_{bs} = 117427\ N$$

Design Strength Of the bolt = Lesser of the above values = 54781 N = 54.781 KN

c) Double Cover Butt Joint With 10 mm cover plates .

Bolts are in Double Shear ;

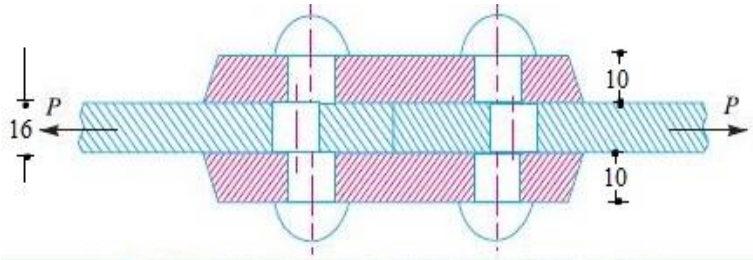
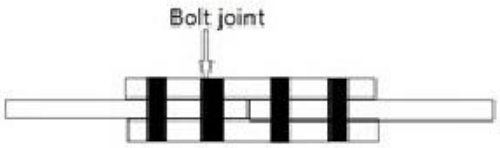


Fig. 9.16. Shearing off a rivet in double cover butt joint.



Double cover double bolted butt joint

i) Design Strength of Bolt in Shear $(Double\ shear)$ (V_{ds})

V_{ds} = { 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ $(n_n A_{nb})$] }

n_n = 2 $(Double\ shear)$

= 2{ 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ (A_{nb})] } = 2 × 54781 = 109562 N

ii) Design Strength of Bolt in Bearing (V_{bs})

V_{bs} = 1/ ɣ $(2.5\ K_b\ d\ t\ F_u)$ .....IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub}$ = 400 $^N/_{mm^2}$

d = 22 mm ;

t = a) Thickness of main Plate = 16 mm
b) Sum of thicknesses of cover plates = 10 + 10 = 20 mm

Taking Least Value
t = 16 mm

ɣ = Partial safety factor for Bolt Material = 1.25 ..... IS 800-2007 ;Table 5 ; pg. 30

∴ V_{bs} = 1565696 N

Design Strength Of the bolt = Lesser of the above all values = 54.781 KN

Problem 3) : Investigate (Design) the Safety of Lap Joint having plates 12 mm and 15 mm thick. Each plate is 75 mm wide. With bolts of Grade 4.6 ; 16 mm Ø

Grade of plate is 410 Mpa

Factored load = 75 KN

Answer :

As per IS 1367 ;

Grades of Bolt	Ultimate Strength of Bolt Material (F_{ub}) N/mm^2	Yiels Stress of Bolt Material (F_y) in Mpa = (0.6 × F_{ub})
4.6	*400*	*240*
4.8	*420*	*320*
5.6	*500*	*300*
5.8	*520*	*400*

Given data : a) From the table , Ultimate stress Of Bolt Material = F_{ub} = 400 $N/_{mm^2}$

b) Yield stress Of Bolt Material Fy = 240 $N/_{mm^2}$

b) Ultimate stress Of Plate Material F_{uP} = 410 $N/_{mm^2}$

b) Yield stress Of Plate Material Fy = 250 $N/_{mm^2}$ .....Assume

c) Dia. Of Bolt = d = 16 mm

d) Dia. Of Bolt Hole = d_0 = 16 + 2 = 18 mm

e) Edge Distance (e) = 1.5 × d_0 = 27 say 30 mm

f) Pitch (P) = 2.5 × d = 40 mm

g) Factored Load = 75 KN = 75000 N

Step 1) : Design Strength of one Bolt in Shear (V_{ds})

$$V_{ds} = 1/\gamma \left[\frac{F_u}{\sqrt{3}} (n_n A_{nb})\right]$$ .....IS 800-2007; cl. 10.3.3 ; pg. 75

Where F_u = F_{ub} = 400 $N/_{mm^2}$

n_n = No. of shear planes with threads intercepting shear planes. = 1 (Lap Joint)

A_{Sb} = Nominal Plain Shank Area of the Bolt.

A_{nb} = Net shear area of bolts at threads……. …….Refer 1st Problem

ɣ = Partial safety factor for Bolt Material = 1.25 ……. IS 800-2007 ;Table 5 ; pg. 30

$$V_{ds} = 1/\ 1.25\ \left[\frac{400}{\sqrt{3}}\left(1 \times 0.78\ \times \frac{\pi\,(16)^2}{4}\right)\right] = 28.975\ \text{KN}$$

Step 2) : Design Strength of one Bolt in Bearing (V_{bs})

$V_{bs} = 1/\ ɣ\ (2.5\ K_b\ d\ t\ F_u)$ ……IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub} = 400\ {}^{N}/_{mm^2}$

d = 16 mm ;

t = Lesser of the Thickness of plate from above = 12 mm

ɣ = Partial safety factor for Bolt Material = 1.25 ……. IS 800-2007 ;Table 5 ; pg. 30

Kb = i) e / 3 do = 0.556
ii) (P / 3 do) -0.25 = 0.490
iii) (Fub / Fup) = 0.976
iv) 1.00

Take Least Value
Kb = 0.490

$$V_{bs} = 1/\ 1.25\ (2.5\ \times 0.490\ \times 16\ \times 12 \times\ 400)$$

$$= 75.264\quad \text{KN}$$

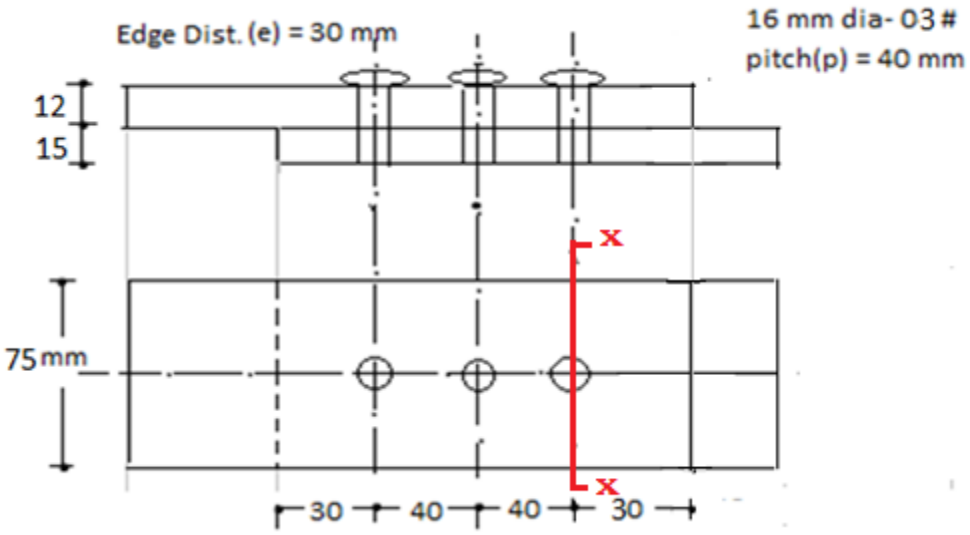
Design Strength of One Bolt = I) Vds = 28975 N
II) Vbs = 75264 N

Take Least Value = 28975 N

$$\text{Thus, no. of bolts required} = \frac{\text{Factored Load}}{\text{Bolt Value}}$$

$$= \frac{75000}{28975} = 2.6\ \textit{say}\ 3$$

Now, draw figure and show arrangement of bolts.



Step 3) : Check For the Strength of the Plate ;

I. Yielding Consideration : T_{dg} = 1/ ɣ $\left(A_g \ F_y \right)$

.....IS 800-2007; cl. 6.2 ; pg. 32

Where, A_g = Gross Area Of plate S/c = (75 × 12) = 900 mm^2

F_y = Yield Strss Of the plate = 250 $N/_{mm^2}$

ɣ = Partial Safety Factor for failure by Yielding = 1.10

..... IS 800-2007 ; Table 5 ; pg. 30

$\therefore$ $\boldsymbol{T_{dg}}$ **= 201917 N = 201.91 KN**

II Rupture Consideration : T_{dn} = 1/ ɣ (0.9 A_n F_u)..... IS 800-2007; cl. 6.3.1 ; pg. 32

ɣ = Partial Safety Factor for failure by Rupture = 1.25

..... IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = ((b) – (n d_o)) × t

= (75 - 18) × 12 = 684 mm^2

Where , n = no. of Bolt Holes in weakest s/c = 1 (See Fig. section x – x)

Where, F_u = F_{up} = 410 $N/_{mm^2}$

$\therefore$ $\boldsymbol{T_{dn}}$ **= 204545 N = 204.54 KN**

Problem 3) : The Lap Joint having two plates Of 120×8 mm which transmit factored load of 120 KN. Design the S/c ?

Use 12 mm diameter Bolt of Grade 4.6 and plates Of Grade 410.

Answer :

As per IS 1367 ;

Grades of Bolt	Ultimate Strength of Bolt Material (F_{ub}) N/mm^2	Yiels Stress of Bolt Material (F_y) in Mpa = ($0.6 \times F_{ub}$)
4.6	*400*	*240*
4.8	*420*	*320*
5.6	*500*	*300*
5.8	*520*	*400*

Given data : a) From the table , Ultimate stress Of Bolt Material = F_{ub} = 400 $N/_{mm^2}$

b) Yield stress Of Bolt Material Fy = 240 $N/_{mm^2}$

b) Ultimate stress Of Plate Material F_{uP} = 410 $N/_{mm^2}$

b) Yield stress Of Plate Material Fy = 250 $N/_{mm^2}$ .....Assume

c) Dia. Of Bolt = d = 12 mm

d) Dia. Of Bolt Hole = d_0 = 12 + 2 = 14 mm

e) Edge Distance (e) = 1.5 × d_0 = 21 say 20 mm

f) Pitch (P) = 2.5 × d = 30 mm

g) Factored Load = 120 KN = 120000 N

a) Design :

Step 1) : Design Strength of one Bolt in Shear (V_{ds})

$$V_{ds} = 1/\gamma \left[\frac{F_u}{\sqrt{3}} (n_n A_{nb}) \right]$$ .....IS 800-2007; cl. 10.3.3 ; pg. 75

Where $F_u = F_{ub}$ = 400 $N/_{mm^2}$

n_n = No. of shear planes with threads intercepting shear planes. = 1 (Lap Joint)

A_{Sb} = Nominal Plain Shank Area of the Bolt.

A_{nb} = Net shear area of bolts at threads……. …….Refer 1st Problem

ɣ = Partial safety factor for Bolt Material = 1.25 ……. IS 800-2007 ;Table 5 ; pg. 30

$$V_{ds} = 1/\ 1.25\ \left[\frac{400}{\sqrt{3}}\left(1 \times 0.78\ \times \frac{\pi\ (12)^2}{4}\right)\right] = 16.298\ \text{KN}$$

Step 2) : Design Strength of one Bolt in Bearing (V_{bs})

$V_{bs} = 1/\ ɣ\ (2.5\ K_b\ d\ t\ F_u)$ ……IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub} = 400\ ^N/_{mm^2}$

d = 12 mm ;

t = Lesser of the Thickness of plate from above = 8 mm

ɣ = Partial safety factor for Bolt Material = 1.25 …… IS 800-2007 ;Table 5 ; pg. 30

Kb = i) e / 3 do = **0.513**
ii) (P / 3 do) -0.25 = **0.519**
iii) (Fub / Fup) = 0.976
iv) 1.00

Take Least Value
Kb = **0.519**

$V_{bs} = 1/\ 1.25\ (2.5\ \times 0.519\ \times\ 12 \times 8\ \times\ 400)$

= 39.398 KN

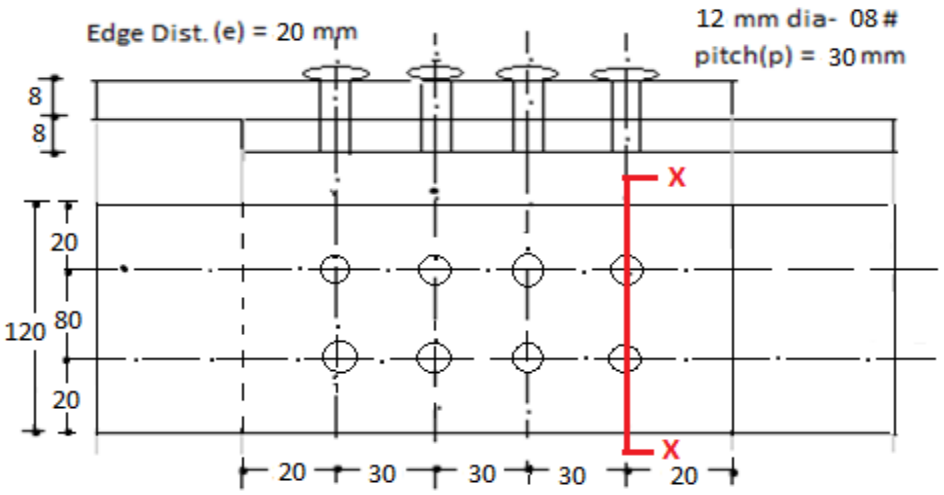
Since, $V_{ds}\ <\ V_{bs}$

$\therefore$ Bolt Value = V_{ds} = 16.298 KN

Thus, no. of bolts required = $\frac{\text{Factored Load}}{\text{Bolt Value}}$

$= \frac{120000}{16298}$ = *7.36 say 08*

Now, draw figure and show arragment of bolts.



Step 3) : Check For the Strength of the Plate ;

I. Yielding Consideration : $T_{dg} = 1/\gamma \ (A_g \ F_y)$

.....IS 800-2007; cl. 6.2 ; pg. 32

Where, A_g = Gross Area Of plate S/c = (120 × 8) = 960 mm^2

F_y = Yield Strss Of the plate = 250 N/mm^2

γ = Partial Safety Factor for failure by Yielding = 1.10

..... IS 800-2007 ; Table 5 ; pg. 30

$$\boldsymbol{T_{dg}} = \mathbf{218182\ N = 218.18\ KN}$$

II Rupture Consideration : $T_{dn} = 1/\gamma \ (0.9 \ A_n \ F_u)$..... IS 800-2007; cl. 6.3.1 ; pg. 32

γ = Partial Safety Factor for failure by Rupture = 1.25

..... IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = ((120) - (n × d_0)) × t

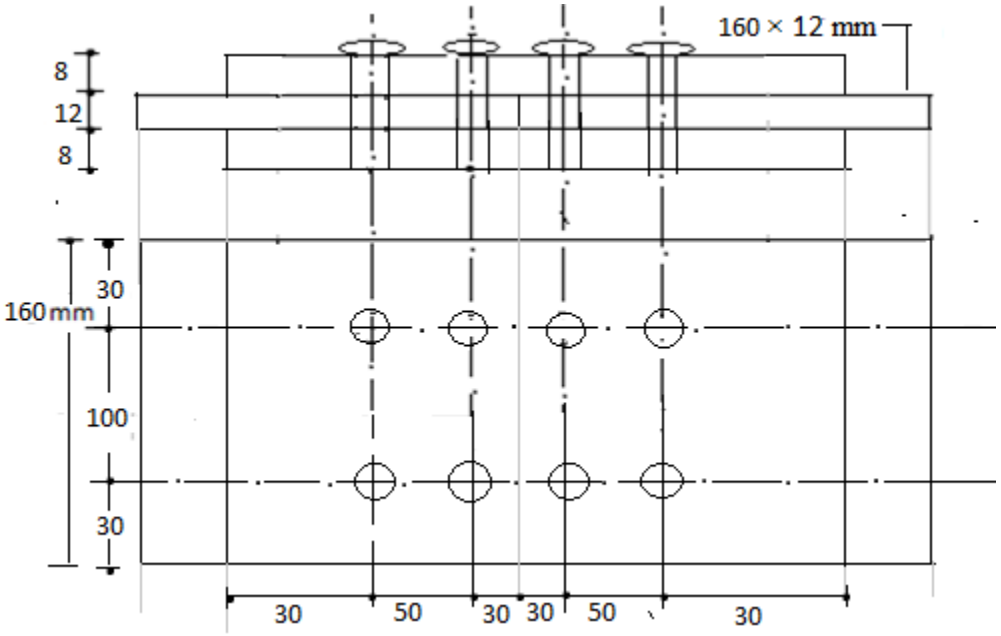
= ((120) - (2×14)) × 8 = 736 mm^2

Where , n = no. of Bolt Holes in weakest s/c = 2 (See section x-x in figure)

$$F_u = F_{up} = 410 \ N/mm^2$$

$$\therefore \ \boldsymbol{T_{dn}} = \mathbf{221990\ N = 221.99\ KN}$$

Problem 5) ***Imp***. : Find The efficiency of the Butt joint shown in fig. Bolts are 16 mm diameer of grade 4.6 . cover plates are 8 mm thick.



Answer : As per IS 1367 ;

Grades of Bolt	Ultimate Strength of Bolt Material (F_{ub}) N/mm^2	Yiels Stress of Bolt Material (F_y) in Mpa = (0.6 × F_{ub})
4.6	*400*	*240*
4.8	*420*	*320*
5.6	*500*	*300*
5.8	*520*	*400*

Given data : a) From the table , Ultimate stress Of Bolt Material = F_{ub} = 400 N/mm^2

b) Yield stress Of Bolt Material Fy = 240 N/mm^2

b) Ultimate stress Of Plate Material F_{uP} = 410 N/mm^2 ……..Assume

b) Yield stress Of Plate Material Fy = 250 N/mm^2 .....Assume

c) Dia. Of Bolt = d = 16 mm

d) Dia. Of Bolt Hole = d_0 = 16 + 2 = 18 mm

e) Edge Distance (e) = 30 mm (Given in Fig.)

f) Pitch (P) = 50 mm (Given in Fig.)

Step 1) i) Design Strength of one Bolt in Shear ($Double\ shear$) (V_{ds})

V_{ds} = { 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ ($n_n\ A_{nb}$)] }

Where $F_u = F_{ub}$ = 400 $^N/_{mm^2}$

n_n = No. of shear planes with threads intercepting shear planes. = 2 (Butt jt. With two Cover plates)

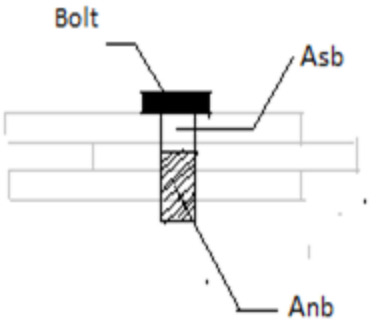
A_{nb} = Net shear area of bolts at threads = 156.82 mm^2

Anb = π/ 4 (d-0.9382 p)^2 = 750.40 *or*

= 0.78 to 0.80 (π d^2/4)

= 156.82

Taking Least Value



ɣ = Partial safety factor for Bolt Material = 1.25 ……. IS 800-2007 ;Table 5 ; pg. 30

V_{ds} = { 1/ 1.25 [$\frac{400}{\sqrt{3}}$ (2×156.82)] }

V_{ds} = 57.95 KN

ii) Design Strength of one Bolt in Bearing (V_{bs})

V_{bs} = 1/ ɣ ($2.5\ K_b\ d\ t\ F_u$) ……IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub}$ = 400 $^N/_{mm^2}$

d = 16 mm ;

t = a) Thickness of main Plate = 12 mm

b) Sum of thicknesses of cover plates = 8 + 8 = 16 mm

Taking Least Value

t = 12 mm

ɣ = Partial safety factor for Bolt Material = 1.25 …… IS 800-2007 ;Table 5 ; pg. 30

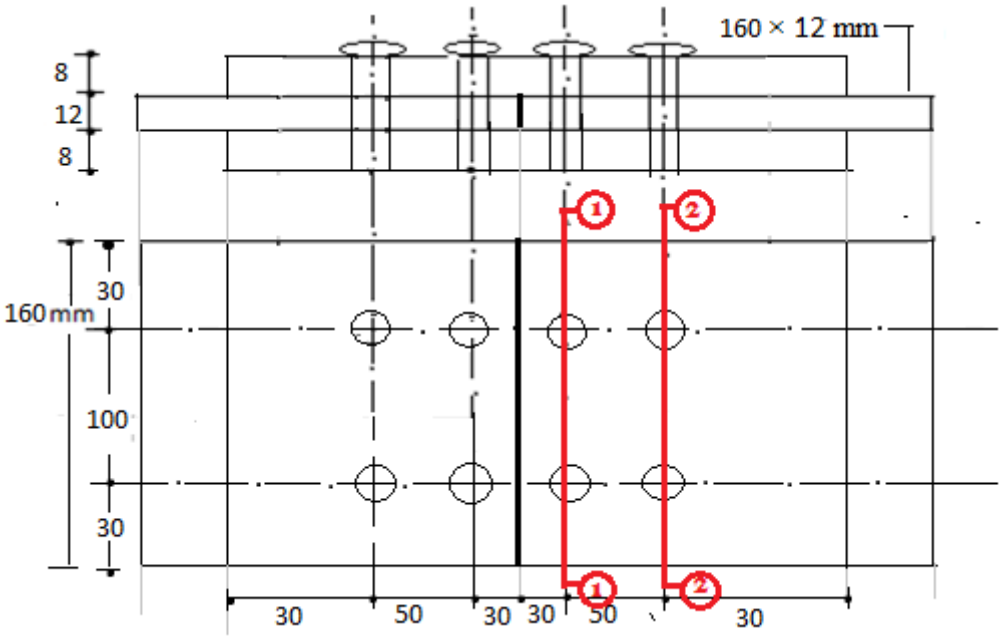
K_b = i) e / 3 d_o = 0.556
ii) (P / 3 d_o) -0.25 = 0.676
iii) (Fub / Fup) = 0.976
iv) 1.00

Take Least Value
K_b = 0.556

$\therefore$ V_{bs} = 85.25 KN

Design Strength of One Bolt = I) Vds = 57.95 KN
II) Vbs = 85.25 KN

Take Least Value 57.95 KN



$\therefore$ **Total Design Strength of four (considering S/c 1-1 & 2-2.) Bolts** (V_b) **= 4 × 57.95**

= 231.8 KN

Step 2) : Design Strength of the Plate in ;

I. Yielding Consideration : $T_{dg} = 1/\gamma \left(A_g \; F_y \right)$

.....IS 800-2007; cl. 6.2 ; pg. 32

Where, A_g = Gross Area Of plate S/c = (160 × 12) = 1920 mm^2

F_y = Yield Strss Of the plate = 250 N/mm^2

γ = Partial Safety Factor for failure by Yielding = 1.10

..... IS 800-2007 ; Table 5 ; pg. 30

$\therefore$ T_{dg} **= 436.36 KN**

II Rupture Consideration : T_{dn} = 1/ ɣ (0.9 A_n F_u)..... IS 800-2007; cl. 6.3.1 ; pg. 32

ɣ = Partial Safety Factor for failure by Rupture = 1.25

..... IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = ((160) - (2×d_0)) × t

= ((160) - (2×18)) × 12 = 1488 mm^2

Where , n = no. of Bolt Holes in weakest s/c = 2 (considering section 2-2)

Where, F_u = F_{up} = 410 $N/_{mm^2}$

$\therefore$ $\boldsymbol{T_{dn}}$ = **436.25 KN**

Since ; $\boldsymbol{T_{dn} < T_{dg}}$

Design strength of plate $(\boldsymbol{T_d})$ = **436.25 KN**

Design strength of bolts $(\boldsymbol{V_b})$ = **231.8 KN**

$$\therefore \quad efficiency = \left(\frac{V_b}{T_d} \right) \times 100$$

$$= 53.13 \ \%$$

Problem 6) : Find The *efficiency* of the Single bolted Butt joint with Double cover plates of 5 mm connecting main plate of 8mm thickne. Use 16 mm diameter bolts of grade 4.6 at pitch of 45 mm .

Answer : As per IS 1367 ;

Grades of Bolt	Ultimate Strength of Bolt Material (Fub) N/mm^2	Yiels Stress of Bolt Material (Fy) in Mpa = (0.6 × Fub)
4.6	400	240
4.8	420	320
5.6	500	300
5.8	520	400

Given data : a) From the table , Ultimate stress Of Bolt Material = F_{ub} = 400 $N/_{mm^2}$

b) Yield stress Of Bolt Material Fy = 240 $N/_{mm^2}$

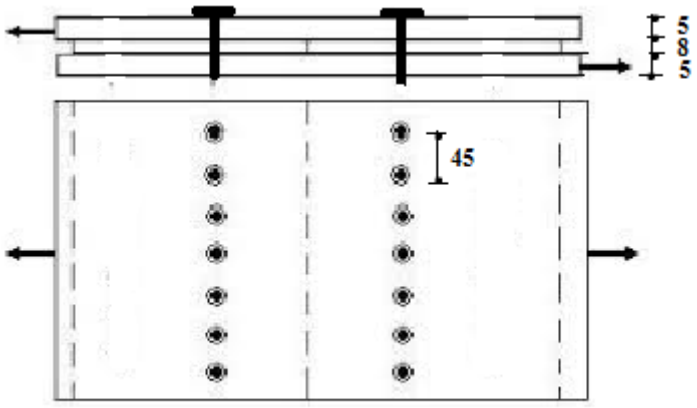
c) Ultimate stress Of Plate Material F_{uP} = 410 $N/_{mm^2}$ .....Assume

d) Yield stress Of Plate Material Fy = 250 $^{N}/_{mm^2}$ .....Assume

e) Dia. Of Bolt = d = 16 mm

f) Dia. Of Bolt Hole = d_0 = 16 + 2 = 18 mm

g) Pitch (P) = 45 mm



Single Bolted Butt Joint (Double Cover)

Since Butt joint is Butt type , ($Double\ shear$)
No.Of bolts covered per pitch length on each side of joint = 1
Consider per pitch length of joint ;

Step 1) i) Design Strength of one Bolt in Shear ($Double\ shear$) (V_{ds})

V_{ds} = { 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ ($n_n\ A_{nb}$)] }.....cl 10.3.3, pg 75

Where F_u = F_{ub} = 400 $^{N}/_{mm^2}$

n_n = No. of shear planes with threads intercepting shear planes. = 2 (Butt jt. – $Double\ shear$)

ɣ = Partial safety factor for Bolt Material = 1.25 ..... IS 800-2007 ;Table 5 ; pg. 30

$$\boldsymbol{V_{ds}} = 1/\ 1.25\ \left[\frac{400}{\sqrt{3}}\left(2 \times 0.78 \times \frac{\pi\ (16)^2}{4}\right)\right] = \textbf{57.950 KN}$$

ii) : Design Strength of one Bolt in Bearing (V_{bs})

V_{bs} = 1/ ɣ (2.5 $d\ t\ F_u$) .....IS 800-2007; cl. 10.3.4 ; pg. 75

Where, F_u = F_{ub} = 400 $^{N}/_{mm^2}$

d = 16 mm ;

t = Lesser of the Thickness of plate from. i) 5+5=10 mm : ii) 8 mm

t = 8 mm

ɣ = Partial safety factor for Bolt Material = 1.25 …….. IS 800-2007 ;Table 5 ; pg. 3

$$\boldsymbol{V_{bs}} = 1/\ 1.25\ (2.5\ \times\ 16 \times 8\ \times\ 400)$$

$$= \mathbf{102.400\ \ KN}$$

Step 2) : Design Strength of the Plate in ;

I. Yielding Consideration : $T_{dg} = 1/\ ɣ\ \left(A_g\ F_y\right)$ ……IS 800-2007; cl. 6.2 ; pg. 32

Where, A_g = Gross Area Of plate S/c = (45 × 8) =

F_y = Yield Strss Of the plate = 250 $N/_{mm^2}$

ɣ = Partial Safety Factor for failure by Yielding = 1.10

…… IS 800-2007 ; Table 5 ; pg. 30

$$\therefore\ \boldsymbol{T_{dg}} = \mathbf{81.818\ \ KN}$$

II Rupture Consideration : $T_{dn} = 1/\ ɣ\ (\ 0.9\ A_n\ F_u)$…… IS 800-2007; cl. 6.3.1 ; pg. 32

ɣ = Partial Safety Factor for failure by Rupture = 1.25

…… IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = ((45) - (1×d_0)) × t

= ((45) - (1×18)) × 8 = mm^2

Where , n = no. of Bolt Holes in weakest s/c = 1 (per pitch length)

Where, $F_u = F_{up}$ = 410 $N/_{mm^2}$

$$\therefore\ \boldsymbol{T_{dn}} = \mathbf{63.763\ KN}$$

$$Since\ ;\ \boldsymbol{V_{ds} < V_{bs} < T_{dn} < T_{dg}}$$

Least Design strength per pitch length ($\boldsymbol{V_b}$) = $\boldsymbol{V_{ds}}$ = **57.950 KN**

Step 3) : Design Strength of the Solid Plate per pitch lngth ;

$T_{dn} = 1/\ ɣ\ (\ 0.9\ A_n\ F_u)$…… IS 800-2007; cl. 6.3.1 ; pg. 32

ɣ = Partial Safety Factor for failure by Rupture = 1.25

…… IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = 45 × 8 = 360 mm^2

Where, $F_u = F_{up} = 410 \ {}^{N}/_{mm^2}$

$\therefore \ \boldsymbol{T_d = 106.272 \text{ KN}}$

Design strength of plate $(\boldsymbol{T_d})$ = **106.272 KN**

$\therefore \ efficiency = \left(\frac{V_b}{T_d}\right) \times 100 = 54.50 \ \%$

Problem 7) : Find The *efficiency* of the Double bolted Butt joint with Double cover plates of 6 mm connecting main plate of 8 mm thick. Use 16 mm diameter bolts of grade 4.6 at pitch of 50 mm .

Answer : As per IS 1367 ;

Grades of Bolt	Ultimate Strength of Bolt Material (F_{ub}) N/mm^2	Yiels Stress of Bolt Material (F_y) in Mpa = ($0.6 \times F_{ub}$)
4.6	*400*	*240*
4.8	*420*	*320*
5.6	*500*	*300*
5.8	*520*	*400*

Given data : a) From the table , Ultimate stress Of Bolt Material = $F_{ub} = 400 \ {}^{N}/_{mm^2}$

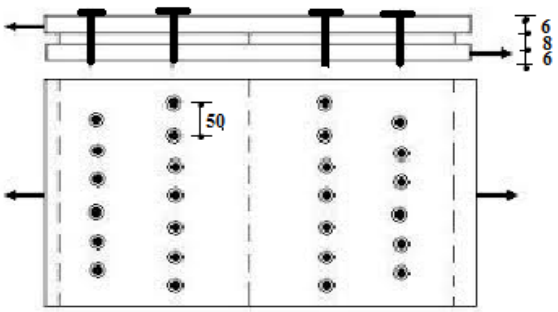
b) Yield stress Of Bolt Material $Fy = 240 \ {}^{N}/_{mm^2}$

c) Ultimate stress Of Plate Material $F_{uP} = 410 \ {}^{N}/_{mm^2}$ …….....Assume

d) Yield stress Of Plate Material $Fy = 250 \ {}^{N}/_{mm^2}$ .....Assume

e) Dia. Of Bolt = d = 16 mm

f) Dia. Of Bolt Hole = d_0 = 16 + 2 = 18 mm : g) Pitch (P) = 50 mm



Double Bolted Butt Joint (Double Cover)

Since Butt joint is Butt type , $(Double\ shear)$

No.Of bolts covered per pitch length on each side of joint = 2

Consider per pitch length of joint ;

Step 1) i) Design Strength of two Bolt in Shear $(Double\ shear)$ (V_{ds})

V_{ds} = { 1/ ɣ [$\frac{F_u}{\sqrt{3}}$ $(n_n A_{nb})$] }.....cl 10.3.3, pg 75

Where $F_u = F_{ub}$ = 400 N/mm^2

n_n = No. of shear planes with threads intercepting shear planes. = 2 (Butt jt. $- Double\ shear$)

ɣ = Partial safety factor for Bolt Material = 1.25 ..... IS 800-2007 ;Table 5 ; pg. 30

$$\boldsymbol{V_{ds}} = 2\ \left[\frac{1}{1.25} \times \frac{400}{\sqrt{3}} \left(2 \times 0.78 \times \frac{\pi\,(16)^2}{4}\right)\right] = \mathbf{115.90\ KN}$$

ii) **:** Design Strength of Two Bolt in Bearing (V_{bs})

V_{bs} = 2 { 1/ ɣ $(2.5\ d\ t\ F_u)$} .....IS 800-2007; cl. 10.3.4 ; pg. 75

Where, $F_u = F_{ub}$ = 400 N/mm^2

d = 16 mm ;

t = Lesser of the Thickness of plate from. i) 6+6=12 mm

ii) 8 mm

t = 8 mm

ɣ = Partial safety factor for Bolt Material = 1.25 ..... IS 800-2007 ;Table 5 ; pg. 3

$$\boldsymbol{V_{bs}} = 2\ \{\ 1/\ 1.25\ (2.5 \times 16 \times 8 \times 400)\}$$

$$= \mathbf{204.800\ KN}$$

Step 2) : Design tensile Strength of the Plate per pitch length in ;

I. Yielding Consideration : T_{dg} = 1/ ɣ $\left(A_g\ F_y\right)$ .....IS 800-2007; cl. 6.2 ; pg. 32

Where, A_g = Gross Area Of plate S/c = (50 × 8) = 400 mm^2

F_y = Yield Strss Of the plate = 250 N/mm^2

ɣ = Partial Safety Factor for failure by Yielding = 1.10

..... IS 800-2007 ; Table 5 ; pg. 30

$$\therefore\ \boldsymbol{T_{dg}} = \mathbf{90.909\ KN}$$

II Rupture Consideration : T_{dn} = 1/ ɣ (0.9 A_n F_u)..... IS 800-2007; cl. 6.3.1 ; pg. 32

ɣ = Partial Safety Factor for failure by Rupture = 1.25

..... IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = (50 - 18) × 8 = 256 mm^2

Where , n = no. of Bolt Holes in weakest s/c = 1 (per pitch length)

Where, $F_u = F_{up}$ = 410 $N/_{mm^2}$

∴ $\boldsymbol{T_{dn}}$ **= 75.571 KN**

Since ; $\boldsymbol{T_{dn} < T_{dg} < V_{ds} < V_{bs}}$

Least Design strength per pitch length ($\boldsymbol{V_b}$) = $\boldsymbol{T_{dn}}$ = **75.571 KN**

Step 3) : Design Strength of the Solid Plate per pitch lngth ;

T_{dn} = 1/ ɣ (0.9 A_n F_u)..... IS 800-2007; cl. 6.3.1 ; pg. 32

ɣ = Partial Safety Factor for failure by Rupture = 1.25

..... IS 800-2007 ; Table 5 ; pg. 30

A_n = Net effective area of the member = 50 × 8 = 400 mm^2

Where, $F_u = F_{up}$ = 410 $N/_{mm^2}$

∴ $\boldsymbol{T_d}$ **= 118.80 KN**

Design strength of plate ($\boldsymbol{T_d}$) = **118.80 KN**

∴ *efficiency* =

$$\left(\frac{V_b}{T_d}\right) \times 100 = 64\ \%$$