BHARAT INSTITUTE OF ENGGINEERING AND TECHNOLOGY

(APPROVED BY AICTE AFFILIATED TO SCTE & VT)

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PIN- 760002

LECTURE NOTES

ON

STRUCTURAL DESIGN-II

CIVIL, 5TH SEMESTER

PREPARED BY

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CHAPTER-II

LIMIT STATE METHOD

3.1 INTRODUCTION:

In the limit state design method the structure shall be designed to withstand safely all loads likely to act on it through out its life. It shall not suffer total collapse load such as from explosion or impact or due to consequences of human error to an extent beyond the total damage. The objective of design is to achieve a structure that will remain fit for use during its life with acceptable target reliability. In other word probability of limit state being reached during its life time should be very low. the acceptable limit for the safety & serviciability requirements before failure occures is called a limit state. In general a structure shall be design on the basis of the most critical limit state & shall be checked for other limit states.

3.2 Types of Limit State :-

3.2.1. Limit State of Collapse

IS Code Page-28
Clause 5.2.2.1

1. Loss of equilibrium
2. Loss of Stability
3. Failure by excessive deformation, rupture of the structure
4. Fracture due to fatigue (Reversal of stress)
5. Brittle Fracture

3.2.2 Limit State of Serviceability

1. Deflection
2. Cracking
3. Vibration
4. Corrosion/ durability
5. Fire

3.3 DESIGN STRENGTH:-

Strength of material which is considered for design of a structure

$$\text{Design Strength} = \frac{S_u}{\gamma_m}$$

Where γ_m = Partial safety factor

IS Code Page-30
Clause 5.4.1

NOTE:-

γ_m (Partial FOS of Material) Accounts For:-

1. Possibility of unfavourable deviation of material strength from Characteristic strength.

2. Possibility of variation of member size.

3. Possibility of unfavourable reaction in member strength due to fabrication & tolerance.

4. Uncertainity in the calculation of strength of members

3.4. Action (Load) :-

① Permanent Action - Dead Load

② Variable Action - Live load, Wind load, Earthquak Load

③ Accidental Action - Explosion, Impact of Vehicle

Characteristic Load:-

It is that value of load which has 95% of probability of not being exceed during life.

Design Load:-

Load for which structure is designed

$$\text{Design load} = \text{Characteristic Load} \times \text{Partial FOS}$$

(For Partial FOS, refer IS 800:2007 Page No 29. Table-4)

3.5. Deflection:-

Deflection Limits of structure are given in IS 800:2007, page 31, Table - 6.

CHAPTER-4
BOLTED CONNECTION

4.1. INTRODUCTION:-

Properly designed connections are very important to transfer load from one member to another member in steel structure.

4.2. Classification of Connection:-

4.2.1. Type-I Classification:-

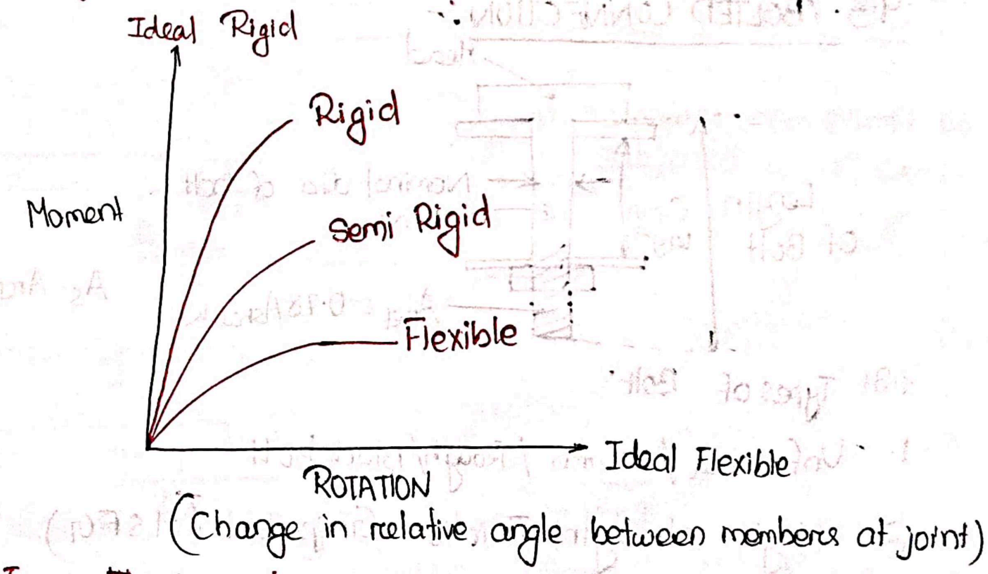
① Bolting
② Welding
③ Riveting
④ Pin

4.2.2. Type-II Classification:-

(I) ~~Rigid Joint~~:- It is used to transfer moment of one member to another member.

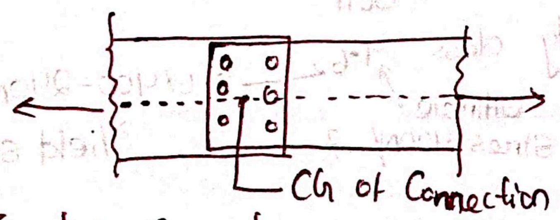
(II) Simple / Flexible Joint:- It doesn't transfer any moment.

(III) Semi Rigid - It transfer partial moment

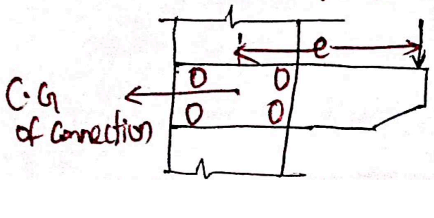


4.2.3 Type-III Connection:-

(1) Direct Connection:- Load is passing through CG of connection

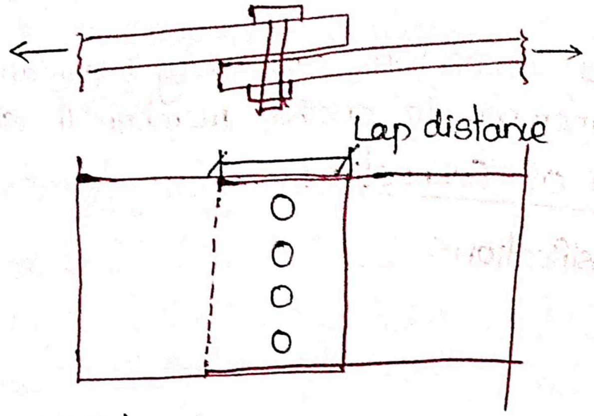


② Ecentric Connection:- Load is ecentric from CG of connection.

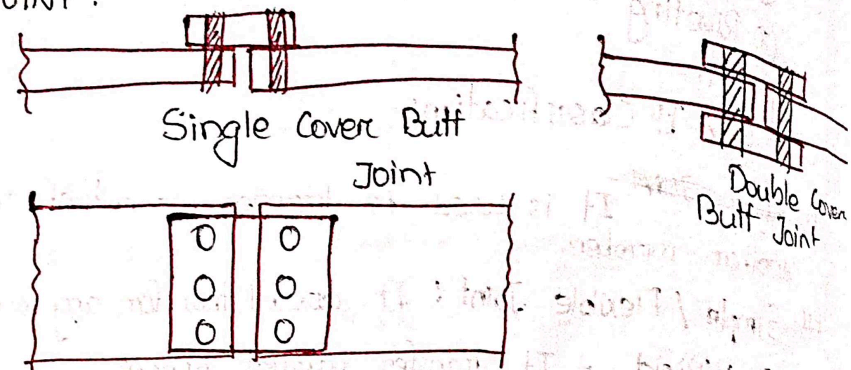


4.2.4 Type 'IV' Classification:-

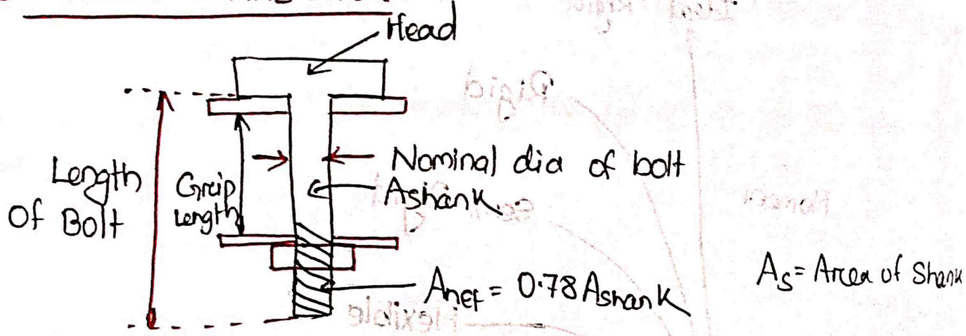
① Lap Joint



② BUTT JOINT:-



4.3. BOLTED CONNECTION:-



4.3.1 Types of Bolt:

1. Unfinished / Common / Rough / Block Bolt
2. High strength, Friction Grip bolt (HSFG)

1. Common Bolt - M12 ← Nominal dia of Bolt

Property class - 4.6

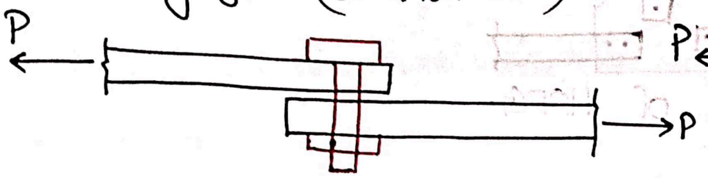
- 4 → Ultimate stress 400 N/mm²
- .6 → 0.6 × 400 = 240 N/mm² Yield stress

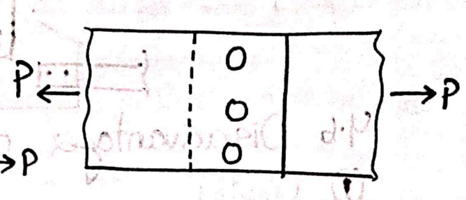
Tensile Properties of Bolt

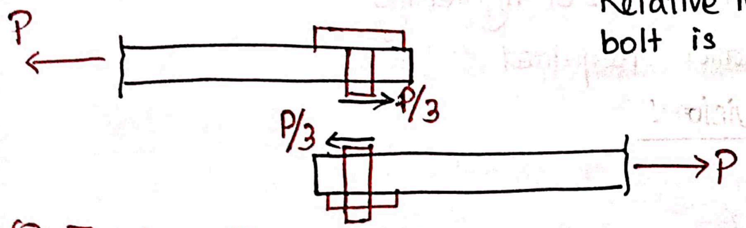
Property Class	Yield Stress	Ultimate Stress
3·6	180	330
4·6	240	400
4·8	320	420
5·6	300	500
5·8	480	520
6·8	980	600
8·8 (d<16mm)	640	800
8·8 (d>16mm)	660	830
9·8	720	900
10·9	940	1040
12·9	1100	1220

4·3·2· Types of Bolted Connection :-

① Bearing Type. (Common Bolt)

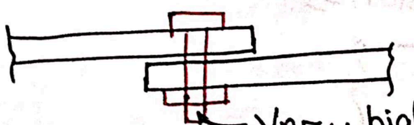




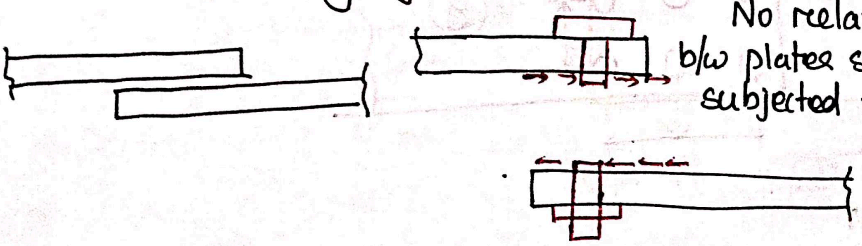


Relative movement b/w plates so bolt is subjected to shear.

② Friction Type (HSFG)



Very high tension in bolt



No relative movement b/w plates so bolt is subjected to no shear.

4.4. Advantages & Disadvantages of Bolted Connection:

(A) Advantages-

(1) Fast erection

(2) Less skilled manpower required

(B) Disadvantages :-

(1) Reduction in shank area due to threading.

(2) When subjected to vibration or shocks, bolt may loose (NF

4.5 Advantages of HSFG: -

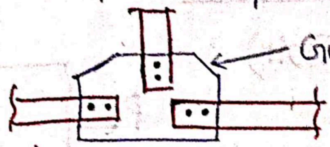
(1) Joints are rigid

(2) Bolts are subjected to tensile force

(3) High static strength of joint.

(4) High fatigue strength & stress concentration around hole avoided.

(5) Small gusset plate requirement because less no of b required.



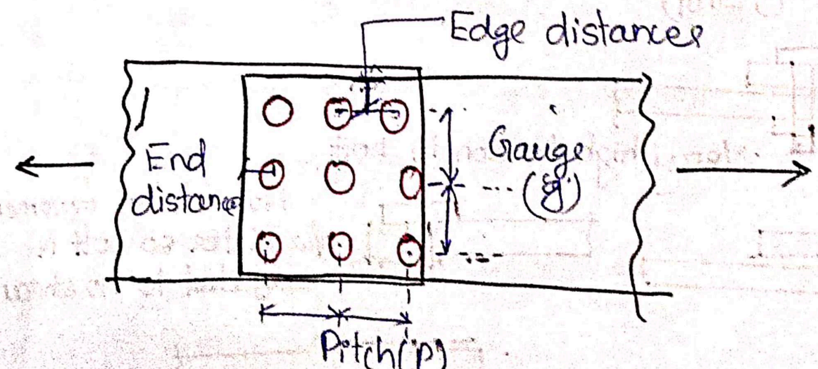
4.6 Disadvantages of HSFG.

① Costly

② Proper care at the time of tightening

③ Surface preparation required

4.7 Codal Provision :-



PITCH-

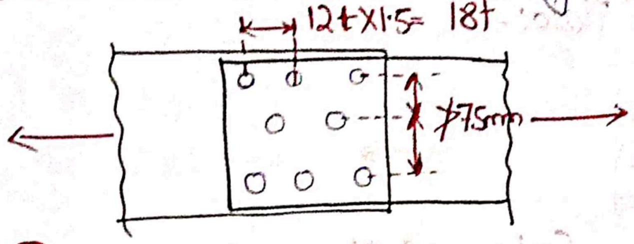
Minimum pitch is 2.5d

Maximum pitch.

- For tension member ≯ min^n { ·16t, ·200mm
- For Compression member ≯ min^n { ·12t, ·200mm

- For line near edge ~~should not be~~ ≯ min^m of { • (4t + 100) mm, • 200mm }

- For staggered bolts when gauge doesn't exceeds 75mm, the above values can be increased by 50%



②b Gauge (g):–

- Minimum Gauge is 2.5d
- Maximum Gauge ≯ min^m { • 32t, • 300mm }

③ End/Edge Distance:–

- Minimum should not be less than = 1.7 times dia of hole ($1.7d_0$) if hand flame cut is used
  - 1.5 times dia of hole ($1.5d_0$) if machine flame cut is used.
- Max^m should not be more than.
  - $12t\epsilon$ where $\epsilon = \sqrt{\frac{250}{f_y}}$ t = thickness of thinner plate
  - 40 + 4t, if exposed to corrosion environment

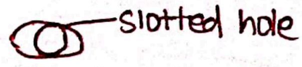
④ Tacking Bolts:–

These bolts are not subjected to any stress. They are used to combined two members & make them behave as a single member.

- For tension member, pitch ≯ 1000mm
- For compression member, pitch ≯ 600mm

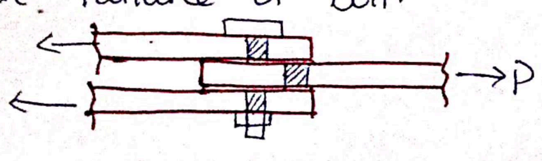
4.8 Dia of hole:–

Dia of Bolt	Dia of Hole
≤ 14mm	d + 1mm
14 ≤ d ≤ 24mm	d + 2
24mm < d	d + 3

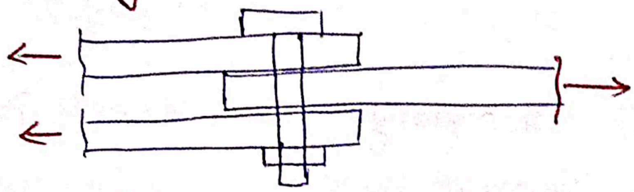


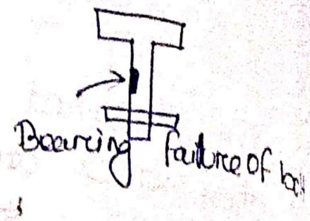
4.9 Modes of Failure of Bolted Connection:–

① Shear failure of Bolt.

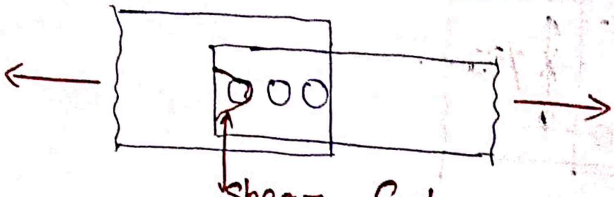


② Bearing Failure of Bolt:-

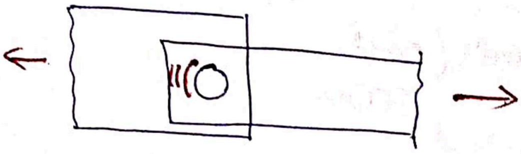




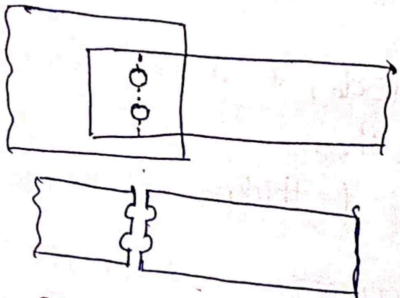
③ Shear failure of Plate:-



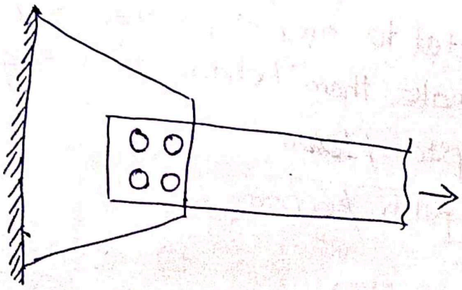
④ Bearing Failure of Plate:-



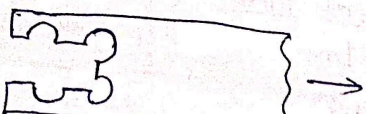
⑤ Tearing Failure of Plate/Rupture of Plate:-



⑥ Block Shear Failure:-



For more Clear diagram refer S.K. Duggal 3rd edition : Page No-197.



4.10 Bearing Type Bolted Connection :-

4.10.1. Shear Strength of Bolt

$$V_{nsb} = \frac{f_{ub}}{\sqrt{3}}(n_n A_{nb} + n_s A_{sb}) \beta_{lj} \beta_{lg} \beta_{pk}$$

V_{nsb} = Nominal Shear Capacity Bolt

f_{ub} = Ultimate tensile stress of Bolt.

n_n = No. of shear plane in threaded portion of Bolt.

A_{nb} = Net tensile Area of Bolt

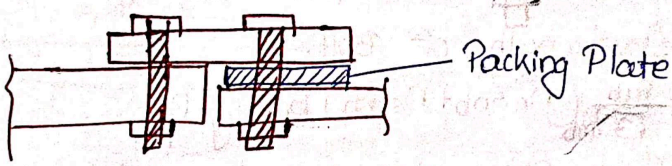
n_s = No. of shear plane in shank portion of Bolt

A_{sb} = Nominal shank Area

β_{lj} = Reduction factor to account for effect of long joint

β_{lg} = Reduction factor to account for long grip length

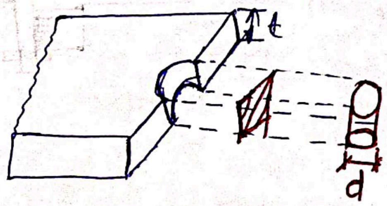
β_{pk} = Reduction factor to account for effect of packing plate



Design Shear Capacity of Bolt $(V_{dsb}) = \frac{V_{nsb}}{\gamma_{mb}}$

where $\gamma_{mb} = 1.25$

4.10.2. Bearing Capacity of Bolt :-



Nominal Bearing Strength of Bolt = $V_{npb} = 2.5 K_b (dt) f_u$

$K_b = \min^m$
- $\frac{e}{3d_0}$ ← End distance; d_0 ← dia of hole
- $\frac{p}{3d_0} - 0.25$ ← Pitch
- f_{ub}/f_u ← Ultimate Stress of Plate
- 1

Design Strength of Bolt in Bearing = $V_{dpb} = \frac{2.5 K_b (dt) f_u}{\gamma_{mb}}$

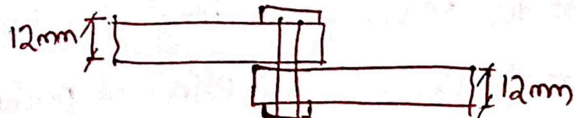
Where, $\gamma_{mb} = 1.25$

4.10.3 Tensile strength:

$$T_{ub} = \frac{0.9 f_{ub} A_{nb}}{\gamma_{mb}} < \frac{f_y A_{sb}}{\gamma_{m0}}$$

Q. Calculate the strength of M20 bolt grade 4.6 for following cases. The main plate to be joined are 12mm thick & grade Fe410. Holes are machine flame cut.
① Lap joint
② Single cover butt joint with cover plate 10mm thick
③ Double cover butt joint with thickness of each cover plate 8mm

Soln:- ① Lap Joint.



Shear strength of Bolt.

$$V_{dsb} = \frac{f_{ub}}{\sqrt{3}\gamma_{mb}}(n_n A_{nb} + n_s A_{sb})\beta_{lj}\cdot\beta_{lg}\cdot\beta_{pk}$$

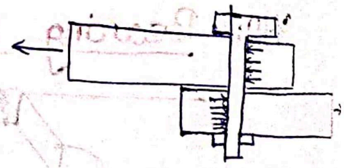
($\beta_{lj}, \beta_{lg}, \beta_{pk}$ = 1)

Assuming shear plane is in threaded portion

$$V_{dsb} = \frac{400}{\sqrt{3}\times1.25}\left(1\times0.78\times\frac{\pi}{4}\times20^2+0\right)\times1\times1\times1$$

$= 45.27kN$

Bearing strength of Bolt-



$$V_{dpb} = \frac{2.5 k_b (dt)\cdot f_u}{\gamma_{mb}}$$

$$k_b = \min\begin{cases} \cdot \frac{e}{3d_0} = \frac{1.5d_0}{3d_0} = 0.5 \\ \cdot \frac{p}{3d_0} - 1.25 = \frac{2.5\times d}{3d_0} - 1.25 \simeq 0.5 \\ \cdot \frac{f_{ub}}{f_u} = \frac{400}{410} = 0.9 \\ \cdot 1 \end{cases}$$

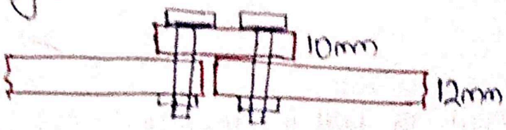
$k_b = 0.5$

$$V_{dpb} = \frac{2.5\times0.5\times20\times12\times410}{1.25}$$

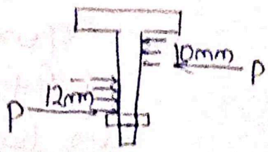
$= 98.4kN$

So strength of bolt is minimum of above 2 values = 45.27

(2) Single Cover Butt Joint



Shear capacity of bolts in single shear = 45.27 kN
(Same as above)



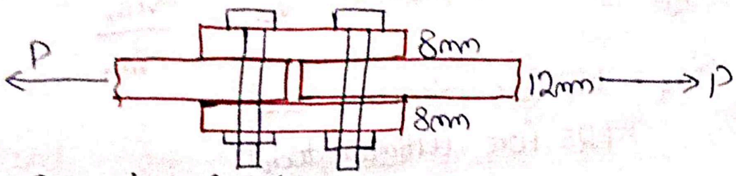
Capacity of Bolt in Bearing. $= \frac{2.5 K_b (dt) f_u}{\gamma_{mb}}$

$= \frac{2.5 \times 0.5 \times 20 \times 10 \times 410}{1.25}$

$= 82 kN$

∴ So capacity of bolt = 45.27 kN

(3) Double Cover Butt Joint :-



Assuming One shear plane is in shank & one is in threaded portion.

Capacity of Bolt in double shear $= \frac{f_{ub}}{\sqrt{3}\gamma_{mb}} (n_n A_{nb} + n_s A_{sb}) \beta_{lj} \beta_{lg} \beta_{pk}$

$= \frac{400}{\sqrt{3} \times 1.25} (1 \times 0.78 \times \frac{\pi}{4} \times 20^2 + 1 \times \frac{\pi}{4} \times 20^2) \times 1 \times 1 \times 1$

$= 103.27 kN$

Capacity of Bolt in bearing $= \frac{2.5 K_b (dt) f_u}{\gamma_{mb}}$

$K_b = 0.5$ (Same as above)

$= \frac{2.5 \times 0.5 \times 20 \times 12 \times 410}{1.25}$

$= 98.4 kN$

So capacity of bolt is minimum of above = 98.4 kN

NOTE:- In general capacity of bolt in single shear is governed by shear while capacity in double shear is governed by bearing.

4.11. Sheare strength of HSFG Bolt :

$V_{nsf} = \mu \cdot n_e K_h \cdot F_0$

V_{nsf} = Nominal sheare strength of bolt in friction

μ = Co-efficient of freiction

n_e = No of interface offering friction

K_h = depends on hole type

= 1 (for standred hole)

= 0.8 (for oversized & short slotted)

= 0.7 (for long slotted)

F_0 = Tension of bolt

$= A_n f_0$

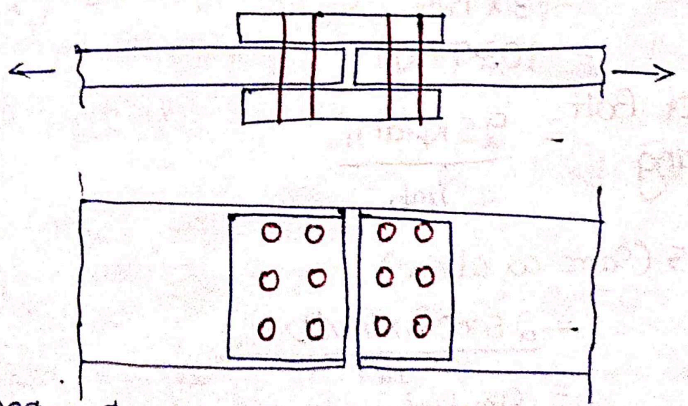
$f_0 = 0.7 f_{ub}$ (Proof stress)

Design sheare strength of bolt in fraction = $V_{dsf} = \dfrac{V_{nsf}}{\gamma_{mf}}$

γ_{mf} = 1.1 for service load

= 1.25 for ultimate load

Q. Calculate sheare resistance of freiction type bolted connection using M20 bolt grade 8.8, μ=0.3 Normal Cle At serevice load.



Soln:- Design sheare strength due to fraction $= \dfrac{\mu \cdot n_e \cdot K_h \cdot F_0}{\gamma_{mf}}$

$\mu = 0.3$

$n_e = 2$

$K_h = 1$

$F_0 = A_n f_0 \cdot n_b$

$= A_n \cdot 0.7 f_{ub} \times 6$

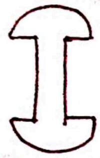
$= 6 \times 0.78 \times \frac{\pi}{4} \times 20^2 \times 0.7 \times 830$

$= 853.8$ KN

Now $V_{dsf} = \frac{0.3 \times 2 \times 1 \times 853.8}{1.1}$ $\gamma_{mf} = 1.1$ (For service)

$= 465 kN$

4.12 RIVET :-



Shear strength of Rivet = Shear stress × Area

$= \tau_s \times \frac{\pi}{4} \times d_0^2$ — (Hole dia)

Bearing strength of Rivet = Bearing stress × Area

$= \sigma_b \times d_0 t$

Permissible Stress of Rivet

	Tension	Shear	Bearing
Power driven	100	100	300
Hand driven	80	80	250

• For field rivets, above values are reduced by 10%.

Dia of Hole for Rivet

Dia of Rivet	Dia of Hole
$\phi \leq 25mm$	$\phi + 1.5mm$
$\phi > 25mm$	$\phi + 2mm$

4.13 Strength of Plate :-

Modes of failure.

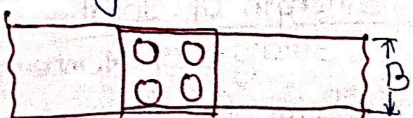
① Shear failure of Plate :-

Can be avoided by providing sufficient end distance

② Bearing Failure of Plate :-

It is taken care by calculating bearing strength of bolt.

③ Rupture / Tearing Failure of Plate :-

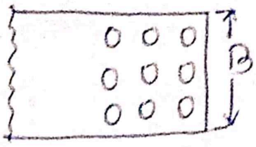


T_{dn} = Stress × Area

$= \frac{0.9 f_u}{\gamma_{m1}} \times A_n$

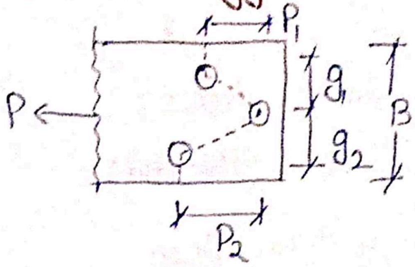
$A_n = (B - 2d_0) t$ $\gamma_{m1} = 1.25$, d_0 = dia of hole, t = Thickness of thinner Pl

Case I:- Chain Bolting



$A_n = (B - n d_0)\, t$

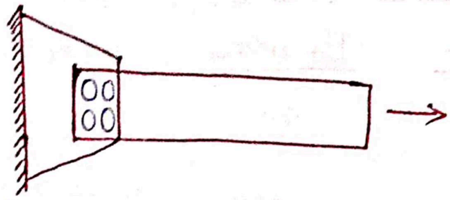
Case II: Staggered Bolting

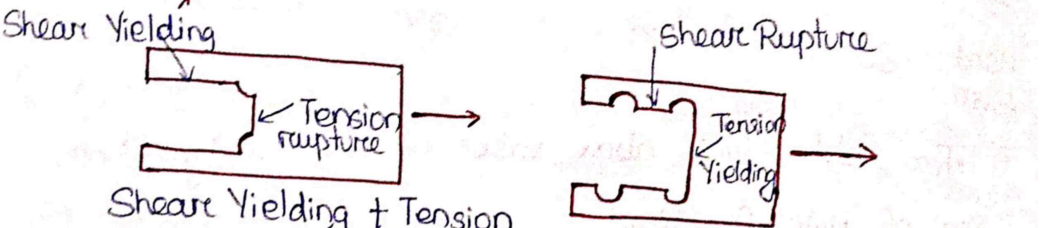


$$A_n = \left((B - 3d_0) + \frac{P_1^2}{4g_1} + \frac{P_2^2}{4g_2} \right) t$$

$$A_n = \left((B - n d_0) + \sum_{i=1}^{\infty} \frac{P_i^2}{4g_i} \right) t$$

~~Case~~ (4) Block Sheare Failure:-





Sheare Yielding + Tension Rupture

Sheare Rupture + Tension Yielding

Case-I:- Sheare Yielding + Tension Rupture

$$T_{db_1} = \frac{f_y}{\sqrt{3}\,\gamma_{m_0}} A_{vg} + \frac{0.9 f_u A_{tn}}{\gamma_{m_1}}$$

Case-II Sheare rupture + Tension Yielding

$$T_{db_2} = \frac{0.9 f_u}{\sqrt{3}\,\gamma_{m_1}} A_{vn} + \frac{f_y}{\gamma_{m_0}} A_{tg}$$

Block sheare strength is minimum of $(T_{db_1}, \& T_{db_2})$.

NOTE:-

Rupture is always on net area & Yielding is always in gross

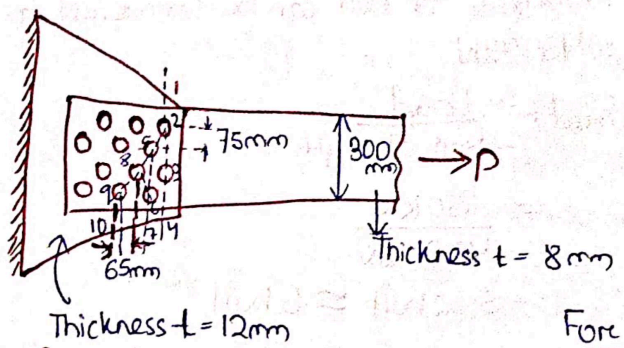
4.14. Efficiency of Joint:-

$$\text{Efficiency of Joint} = \frac{\text{Strength of Joint}}{\text{Strength of Member}}$$

Strength of Joint = min
- Sheare failure of bolt
- Beare failure of bolt
- Teare failure of plate
- Block shear failure

Strength of member = $\min^m \begin{cases} \bullet \ \frac{0.9 f_u}{\gamma_{m1}} \cdot A_g \\ \bullet \ \frac{f_y}{\gamma_{m0}} A_g \end{cases}$

Q.
Calculate the net area of plate for following case.
M18, 4.6



For M18 bolt bolt dia = 18+2 = 20mm

Soln:-

Case I: 1-2-3-4

$A_n = (B - 2d_0)t = (300 - 2 \times 20) \times 8 = 2080 \text{ mm}^2$

Case-II 1-2-5-6-7

$A_n = \left(B - 3d_0 + \frac{p^2}{4g}\right)t = \left(300 - 3\times 20 + \frac{65^2}{4\times 75}\right) \times 8 = 2032.67 \text{ mm}^2$

Case III 1-2-5-8-6-7

$A_n = \left(B - 4d_0 + 3\frac{p^2}{4g}\right)t = \left(300 - 4\times 20 + \frac{3\times 65^2}{4\times 75}\right) \times 8 = 2098 \text{ mm}^2$

Case IV 1-2-5-3-4

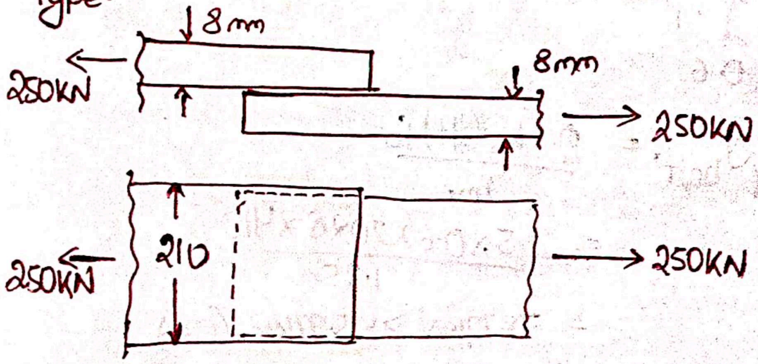
$A_n = \left(B - 3d_0 + \frac{2p^2}{4g}\right)t = \left(300 - 3\times 20 + \frac{2\times 65^2}{4\times 75}\right) \times 8 = 2145.33 \text{ mm}^2$

Case V = 1-2-5-8-9-10

$A_n = \left(B - 4d_0 + 3\frac{p^2}{4g}\right)t = \left(300 - 4\times 20 + \frac{3\times 65^2}{4\times 75}\right) \times 8 = 2098 \text{ mm}^2$

So critical section is Case-II.

Q. Two plates of Fe410 are joined using M20 bolts of grade 4.6 to make lap joint. Design the joint with suitable pitch for bolt & also calculate joint efficiency. Joint is bearing type.



Soln:

Design shear strength of bolt = Same as example after 4.10.2,

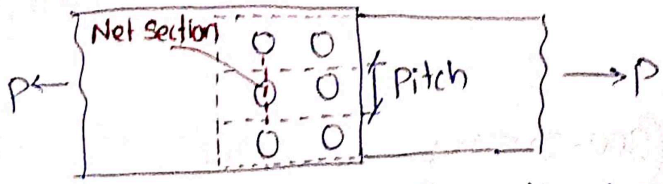
Design bearing strength of bolt = Can't be calculated here as data required for k_b is not

For preliminary design, strength of bolt can be considered as shear strength of bolt = 45.27 kN

$$\text{No. of bolts Required} = \frac{\text{Load}}{\text{Bolt strength}}$$

$$= \frac{250\,kN}{45.27\,kN}$$

$$= 5.52 \text{ bolt} \simeq 6 \text{ bolt}$$



Strength of bolt per pitch = Strength of Plate per pitch

$$\Rightarrow 2 \times 45.27 = (p - d_0)\, t \times \left(\frac{0.9 f_u}{\gamma_{m0}}\right)$$

$$2 \times 45.27 = (p - 22)\, 8 \times \left(\frac{0.9 \times 410}{1.25}\right)$$

$$p = 60.33\,mm$$

Providing pitch = 65mm

Min^m value of gauge = $2.5d = 2.5 \times 20 = 50mm < 65mm$ (ok)

$$\text{Edge distance} = \frac{B - 2\times65}{2} = \frac{210 - 2\times65}{2} = 40mm > 1.5d_0$$

$(1.5 \times 22) = 33mm$

Bearing strength of Bolt:-

k_b = min^m of

- $\frac{e}{3d_0} = \frac{40}{3\times22} = 0.6$
- $\frac{p}{3d_0} - 0.25 = \frac{65}{3\times22} - 0.25 = 0.73$
- $\frac{f_{ub}}{f_u} = \frac{400}{410} = 0.975$
- 1

= 0.6

$$\text{Design bearing Strength of bolt} = \frac{2.5 k_b (dt) f_u}{\gamma_{m1}}$$

$$= \frac{2.5 \times 0.6 \times 20 \times 8 \times 410}{1.25}$$

$$= 78.72\,kN > 45.27\,kN \text{ (OK)}$$

Joint Efficiency :-

Strength of Solid Plate = $\min^n \begin{cases} \frac{0.9 f_u}{\gamma_{m1}} \cdot A_g = \frac{0.9 \times 410}{1.25} \times 210 \times 8 = 495 kN \\ \frac{f_y}{\gamma_{m0}} \cdot A_g = \frac{250}{1.1} \times 210 \times 8 = 381.8 kN \end{cases}$

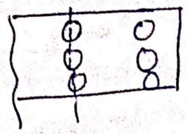
$= 381.81 kN$

Joint Strength = $\min^n$
- Bolt Strength in Shear
- Bolt Strength in Bearing
- Tear Strength of Plate
- Block Shear Strength

Bolt strength in Shear = $6 \times 45.27 = 271.62 kN$

Bolt strength in bearing = $6 \times 78.72 = 472.32 kN$

Tear strength of Plate = $(B - 3d_0)\, t \, \frac{0.9 f_u}{\gamma_{m1}}$



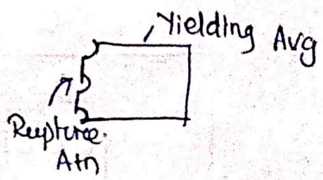
$= (210 - 3 \times 22) 8 \times \frac{0.9 \times 410}{1.25}$

$= 340.07 kN$

Block Shear strength =

Shear Yielding + Tension Rupture

$T_{db_1} = \frac{f_y}{\sqrt{3}\, \gamma_{m0}} A_{vg} + \frac{0.9 f_u}{\gamma_{m1}} A_{tn}$



$A_{tn} = \left(2P - \frac{d_0}{2} - d_0 - \frac{d_0}{2}\right) t$

$= \left(2 \times 65 - \frac{22}{2} - 22 - \frac{22}{2}\right) \times 8$

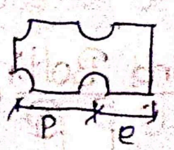
$= 688 mm^2$

$A_{vg} = (e + p) 2t = (40 + 65)\, 8 \times 2 = 1080 mm^2$

$T_{db_1} = \frac{250}{\sqrt{3} \times 1.1} \times 1080 + \frac{0.9 \times 410}{1.25} \times 688 = 423.54 kN$

Shear Rupture + Tension Yielding

$T_{db_2} = \frac{0.9 f_u}{\sqrt{3}\, \gamma_{m1}} A_{vn} + \frac{f_y}{\gamma_{m0}} A_{tg}$



$A_{vn} = \left\{(e + P) - \frac{d_0}{2} - d_0\right\} t \times 2$

$\left\{(40 + 65) - \frac{22}{2} - 22\right\} \times 8 \times 2 = 1152 mm^2$

$A_{tg} = 2pt = 2 \times 65 \times 8 = 1040 mm^2$

$T_{db_2} = \frac{0.9 f_u}{\sqrt{3}\, \gamma_{m1}} A_{vn} + \frac{f_y}{\gamma_{m0}} \times A_{tg}$

$= \frac{0.9 \times 410}{\sqrt{3} \times 1.25} 1152 + \frac{250}{1.1} \times 1040 = 432.7 kN$

So strength in block shear = 423.52 KN

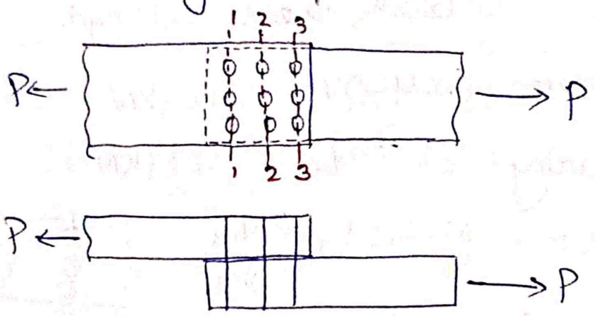
Now Joint Strength = min^n $\begin{cases} 271.62 \\ 472.32 \\ 340.07 \\ 423.54 \end{cases}$

= 271.62 kN

Joint efficiency = $\frac{271.62}{381.81} \times 100 = 71.14\%$

4.15 Arrangement of Bolts :-

① Chain Bolting

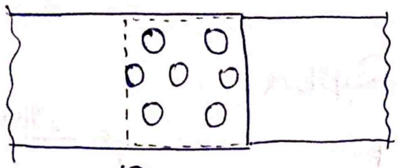


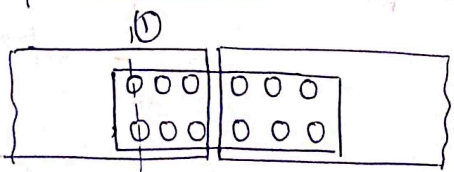
	Sections	
	1-1	2-2
Force in plate	P	$(P-3V_b)$
Section Area	A	A

$A = (B-3d_0)t$

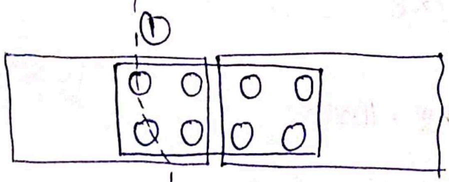
So Critical is 1-1 fo

② Staggered Bolting :-





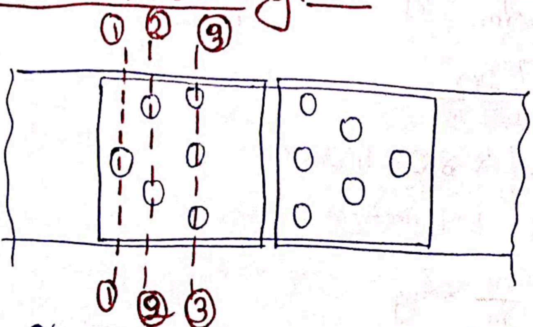
$A_{net} = (B-2d_0)t$



$A_{net} = \left(B-2d_0+\frac{p^2}{4g}\right)t$

In the case of staggered bolting. A_{net} is greater than c
bolting so staggered is better.

③ Diamond Bolting :-



Tearing Strength of plate at 1-1 = $(B-d_0)t \cdot \frac{0.9f_u}{\gamma_{m1}}$

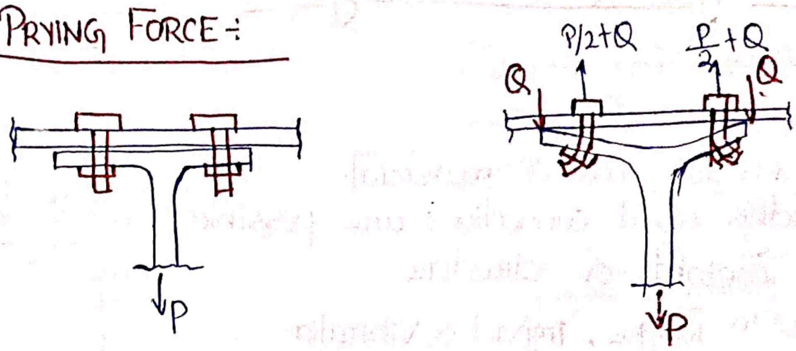
=

Tearing Strength of plate at 2-2 = $(B-2d_0)\,t\cdot\frac{0.9f_u}{\gamma_{m1}} + V_b$ (Strength of bolt)

Tearing strength of plate at 3-3 = $(B-3d_0)\,t\cdot\frac{0.9f_u}{\gamma_{m1}} + 3V_b$

In diamond bolting as we move from section 1-1 to Section 3-3, force in plate is reducing because some part of force goes in another by bolts & Anet is also reducing. That is why Diamond bolting is most efficient.

4.16 PRYING FORCE :-



- Due to Flexibility of connecting part, bolts are subjected to additional Force which is called as Prying Force (Q).
- It can be reduced by providing thick plate, or by reducing distance between bolts.
- For rigid connected part, prying forces is zero.

NOTE :-

When two members are connected by bolt & subjected to axial force in members then bolt are assumed to take equal forces. but practically outer bolts are subjected to more force than inner bolts.