Structural steel fastener & connections:

* The design of connection is very important because the failure of joint is sudden & it causes the whole structure collapse.

* The following three types of connection use in steel structure.

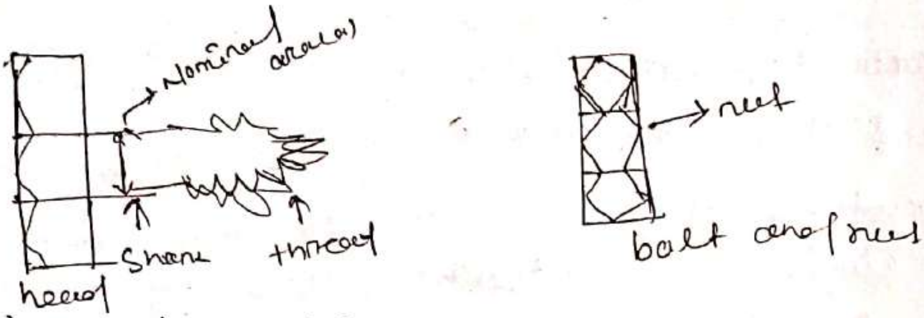
(i) Riveted connection
(ii) bolted connection
(iii) welded connection.

Bolted connection:

⇒ The bolt is a metal pin with head formed at one end and shank threaded at the other end in order to receive the nut.

⇒ Bolts are used for joining together pieces of · by inserting them through holes in the metal and titening the nut at the threaded end bolts are classified as.

(i) Unfinished or black bolts
(ii) Finished or turn bolts
(iii) High steam reaction brick bolts (HSFG)



Unfinished bolt :—

→ These bolts are made from mild steel rods with square & hexagonal heads. The shank is more unfinished as rough.

→ The yield strength of commonly used black bolts is 200 N/mm² & ultimate strength is 400 N/mm²

→ These bolts are as trusses & also temparature static loads such as trusses & also temperature connections required during construction.

Finished bolt :—

(i) These bolts are made form mild steel and their form hexagonal road which are finishes by clicking to a circular shape.

(ii) Actual diamentions of these volts are kept 1.2mm to 1.3 mm larger than the nominal diameter. Therefore the bolt hole is kept 1.5 mm larger then nominal diameter.

(iii) As the connection is more tight. it results in to much bearing constant. between the bolts & the holes.

(iv) These bolts are use in special places like connecting machine parts. Subjected to dynamic loading.

High strength friction grip bolts :-

(i) The HSFG bolts are made from high strength steel road. The surface of the shank is kept unfinished as in case of black bolts.

(ii) The shank of the bolt is not subject to any shearing these results in know slipage of joint.

(iii) commonly available nominal diameter of these bolts are 16mm, 20mm, 24mm, 30mm, 36mm.

Remember

6 = 28
10 = 78
12 = 113
16 = 201
20 = 314
25 = 491
30 = 707
36 = 1018

$\pi/4 \times d^2 = A$

Classification of bolts based on their load transfer

(i) bearing type
(ii) friction grip type.

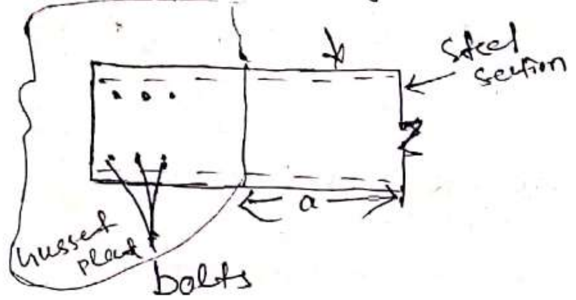
Bearing type :-

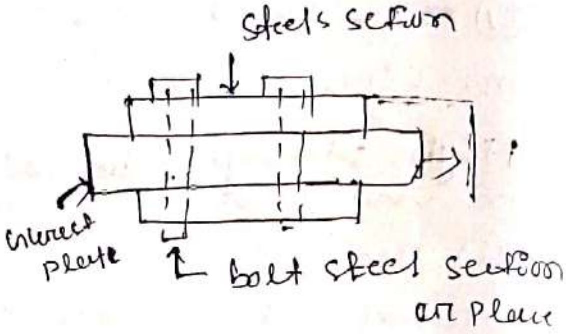
(i) These type of bolts transfer load by plate bearing.

(ii) Unfinished bolts & finished bolts belongs to bearing type since type transfer bears from one member to other member by bearing.

Friction grip type :-

HSFG bolts belongs to friction grip type since the transfer shear by friction .





Advantage of bolted connection :—

(i) Use of simple tools & less skilled labour & working area.

(ii) Speedy & noiseless connections.

(iii) Economical due to reduced labour equipment cost.

(iv) minm strength reduction at joint due to less number of holes or bolts.

(v) Easy alternation & dismantling of connection.

Disadvantage of bolted connections :—

(i) High cost of material.

(ii) Reduced tensile strength due to area of reduction at root of threads.

(iii) Normally loose fit reduces joint rigidity leading to excessive deflection.

(iv) Loosing of bolts under vibration & dynamic loads.

(v) Large joint space when heavy load are required

Terminology :—

The following terms are used in the bolted connection :-

(a) Pitch of the bolt (P)

It is the center to center spacing of the bolts in the row measure along the direction of the row.

(b) Gauge distance (g) :-

It is the distance between the consecutive bolts of adjacent rows & it measure at right angle to the row.

(C) Edge - distance :- (e)

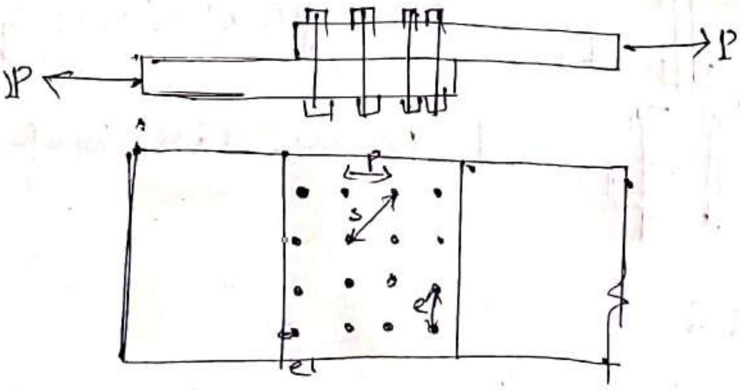
It is the distance of center of bolt hole from adjecent edge of plate.

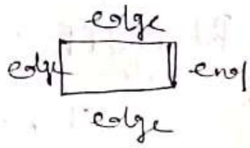
(d) End distance :- (e')

It is the distance of ~~center of bolt hole from~~ the nearest bolt form adjacent end of the plate.

(e) staggered distance :- (S)

It is the center to center distance of staggered bolts measured obliquely on the member.





Specification for spacing and edges distance of bolt hole:

(i) Pitch (p) shall not be less than 2.5 d where is the Nominals diameter of bolt., (page 73)

(2) pitch shall not be more then

(i) 16×t or 200mm which ever is less in case of tension member.

(ii) 12t or 200mm which ever is less in case of compression member. where t is the thickness of thinest member.

(3) In stagged pitch, pitch may be increased by 50%. for the value of gauge distance it is less than 75mm

(4) The gage line should not be more than 100 + 4t or 200mm which ever is less. ~~102~~

10·2·to 10·3

types of bolted connection :—

There are 2 types of bolted connections.

① Lap Joint

② Butt Joint

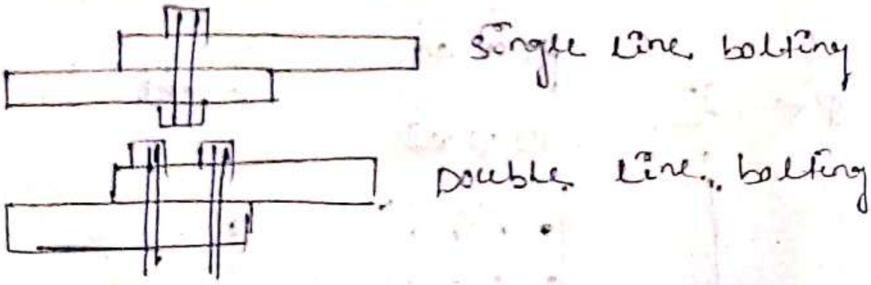
① LAP JOINT :—

It is the simplest type of joint. In this the pla to be connected over lap one another

Lap joints are up two types :—

(a) Single line bolting

(b) double line bolting



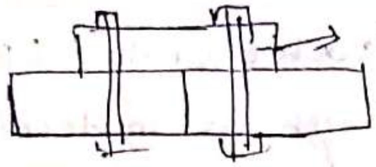
2) BUTT JOINT :—

In this type of connection two main plates are placed against each other in the same plane / the connection is made by providing a single cover plate connecting to the main plate or by double cover plate on or either side connected to main plate

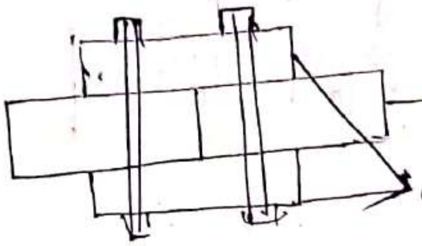
there are two types

(a) Single cover Butt joint

(b) Double cover " "



Single cover butt joint



Double cover butt joint

Assumption in design of bearing bolts :—

(i) Friction between plates is negligible.

(ii) The shear is uniform over the cross section of bolt.

(iii) The distribution of stress on the plates between the bolt hole is uniform.

(iv) Bolt is group subjected in direct load shear the load equally.

(v) Bearing stress develop in the ~~stem~~ bolt is neglected.

Connection Desing :—

A steel connection design consist of two designed parameters.

(a) Design strength of plate in a joint

(b) Design strength of bearing bolts.

(a) Design strength of plate in a joint :—

Plate in a joint may fail under following

(i) Shearing or bearing of plate

(ii) Crushing of plate

(iii) Rupture of plate.

The strength of the plate at a joint is given by

$T_{dn} = 0.9 A_n F_u / \gamma_{mL}$

where γ_{m1} = partial safety factor (page 30)

F_u = ultimate strength of material

A_n = Net effective area of plate at a critical section.

which is given by

$$A_n = \left[b - n d_0 + \Sigma \frac{P_{si}^2}{4g}\right] t$$

where,

b = width of the plate

t = thickness of thiness plate

d_0 = diameter of bolt hole

d_0 = Nominal dia of bolt + clearance (page 73)

g = Gauge length betn bolt hole

P_s = staggered pitch length between bold lines.

n = Number of bolt hole is critical section.

i = subscript for summation of all inclined legs.

Design strength of bearing bolts :-

The design strength of bearing bolts is least of following.

(i) Shear capacity

(ii) Bearing capacity

Shearing strength of bolt/shearing capacity :-

The design strength of the bolt in shear

$$V_{dsb} = \frac{V_{nsb}}{\gamma_{mb}}$$

where V_{nsb} = Nominal shear capacity of bolt

γ_{mb} = Partial safety factor of the material of the bolt.

$$V_{nsb} = \frac{f_{ub}}{\sqrt{3}} (A_n A_{nb} + n_s A_{sb})$$

where f_{ub} = ultimate strength of bolt.

n_n = no of shear planes with threads.

n_s = no. of shear planes with out threads.

A_{sb} = Nominal sank area of bolt

$$A_{sb} = \pi/4 \times d^2$$

d = dia of bolt

A_{nb} = Net shear area of bolt at threads = $0.78 A_{sb}$

when reduction factor are applied the bearing capacity of shear.

$$A_{nsb} = \frac{f_{ub}}{\sqrt{3}} (n_n A_{sb} + A_s A_{sb}) B_{lj} B_{lg} B_{pk}$$

where B_{lj} = reduction factor for long joint.

B_{lg} = reduction factor for large brick length.

B_{pk} = reduction factor ~~large~~ for packing plates

Bearing capacity of bolt :-

Design bearing strength of bolt

$$V_{dpb} = \frac{V_{npb}}{\gamma_{md}}$$

where V_{npb} = Nominal bearing strength

γ_{md} = partial safety factor of material

Nominal shear strength

$$V_{npb} = 2.5\, K_b d t f_u$$

p = thickness of plate

b = dia of bolt

K_b is the least of the following

(i) $\frac{e}{3d_0}$ (ii) $\frac{p}{3d_0} - 0.25$ (iii) $\frac{f_{ub}}{f_u}$ (iv) 1

k_b = reduction factor for bearing
e - edge distance
p - pitch

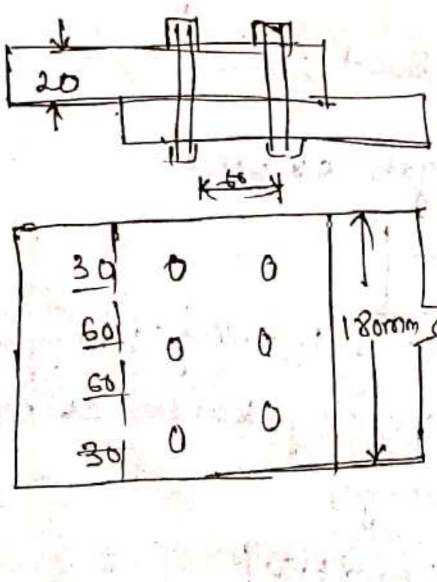
Efficiency of Joint:—

* It is defined as the ratio of strength of the joint and strength of the solid plate in tension.
* It is usually expressed in %.
* Efficiency (η) = $\frac{\text{strength of the joint}}{\text{strength of plate}} \times 100$

Strength of plate = $\frac{A_g \times f_y}{\gamma_{m0}}$.

PROBLEM :- 1

Find the efficiency of the lap joint as shown in fig. Given M20 bolt of grade 4.6 & Fe 410 (E 250) plates are used.



Given data

for bolts:—

For M20 bolts of grade 4.6

diameter of bolt (d) = 20mm

diameter of bolt hole (d_0) = d+2 = 20+2 = 22 mm

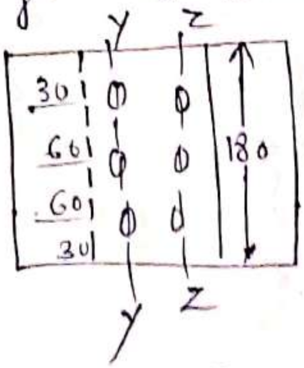
ultimate strength of bolt (fub) = 400
yield strength of bolt (fyb) = 240

Here plates:—

Given Fe410 (E250) plates are used
ultimate strength of plate (fu) = 410mpa
yield strength of plate (fy) = 250mpa
γ_{m0} = 1.10 (yield strength)
γ_{mb} = 1.25 (ultimate strength)
Pitch distance = 60
Gauge distance = 60
Edge distance = 30
thickness of plate = 20

grade of bolt	yield strength fy	ultimate strength fu
4.6	240 mpa	400mpa
4.8	320 mpa	420mpa
5.6	300 mpa	400 mpa
5.8	400 mpa	420 mpa

(a) strength of joint:—



Here Y-Y section is a critical section because the availability of resisting cross section area is minimum at that section.
So, no-of bolt hole along critical section (n) = 3
The net area of the section

$$A_n = \left(b - n d_0 + \frac{\Sigma p s^2}{4g}\right) t$$

$= (180 - 3\times 22)\times 20$
$= 2280\, mm^2$

(i) Design strength of bolt hole at joint:—
(A) strength of the bolt at shearing
Shank area (A_{sb}) = $\pi/4 \times d^2$ = $\pi/4 \times 20^2$ = 314 mm2

Thread area = $0.78 \times 314 = 244.92 \simeq 245\ mm^2$

Hence $n_n = 1$, $n_s = 0$ (Because lap Joint)

Nominal shear strength of bolt

$$= \frac{F_{ub}}{\sqrt{3}} (n_n A_{nb} + n_s A_{sb})$$

$$= \frac{400}{\sqrt{3}} (1 \times 245)$$

$\Rightarrow 56580.32 = 56.5\ KN$

Design shear strength

$$\frac{V_{nsb}}{\gamma_{mb}} = \frac{56.5}{1.25} = 45.2$$

(B) Strength of the bolt in bearing

$$V_{npb} = 2.5\ k_b\ d\ t\ F_u$$

dia of bolt = 20mm

t = thickness of plate = 20mm

k_b is the least of following

(i) $\frac{e}{3d_0} = \frac{30}{3 \times 22} = 0.45$

(ii) $\frac{p}{3d_0} - 0.25 = \frac{60}{3 \times 22} - 0.25 = 0.65$

(iii) $\frac{F_{ub}}{F_u} = \frac{400}{410} = 0.97$

(iv) 1

$k_b = 0.45$

Nominal bearing capacity

$= 2.5\ k_b\ d\ t\ F_u$

$= 2.5 \times 0.45 \times 20 \times 20 \times 410$

$= 184.5\ KN$

Design bearing capacity $(V_{dpb}) = \frac{V_{npb}}{\gamma_{mb}} = \frac{184}{1.25} = 147.2\ KN$

The design strength of bolt should be minimum of shearing and bearing which is equal to 45 KN

For 6 no of bolts the design strength of the