

## UNIT - 1

### Welding connections.

Design of Steel Structures - Dr. S.S. Bha-  
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Design of a building consists of two parts viz (i) functional and (ii) design and (iii) structural design. The first part is planning the building to serve the requirement taking into account the ventilation lighting aesthetics etc. The structural design is proposing the various elements of a building.

For transferring the loads to the ground various material like, asbestos sheets tiles bricks cement concrete reinforced concrete steel etc - minimum are used. However main body of the present day structure consist of R.C.C or steel.

### Common Steel Structures

Steel has high strength per unit mass. Hence it is used for constructing large column-free structure.

1) Roof trusses for factories cinema halls and auditoriums etc.

2) Trussed bent crane girders columns etc

3) Roof trusses and column to cover platform in railway stations and bus stands

The advantages of steel over other materials for construction are

- 1) It has high strength per unit mass. Hence even for large structure the size of steel structural is small space in construction and improving aesthetic view.
- 2) It has assured quality and high durability
- 3) speed of construction is another important advantages of steel structure. since standard section of steel are available which can be prefabricated

### Advantages And Disadvantages of Steel

It is susceptible to corrosion.

- 1) Maintenance cost is high since it needs painting to prevent corrosion.
- 2) Steel members are costly.

Steel is an alloy of iron and carbon. Apart from carbon by adding small percentage of manganese sulphur phosphorus chrome nickel and copper special properties can be imparted to iron and a variety of steel can be produced. The effect to different chemical.

③

\* Live load:-

\* This is the load to intended use of occupancy which may be stationary or moving

\* Is: 875 (part -2) 1987 gives the imposed load on building

ex: Tables, Chairs other moving stationary items

\* Wind load:-

\* since a structure obstructs the flow of air a load acts normally to the exposed surface of the structure which is known as wind load

\* It is prescribed by Is: 875 (part -3) - 1987  
ex: light weight structure high range building towers, etc.

\* Earthquake load:-

When an earthquake occurs inertia forces mainly in the horizontal directions act on the structures prescribed by Is: 1843 - 2002

\* Erection load:-

All loads required to be achieved by the position by structure.

## Accidental loads

load : due to blast impact or vehicles etc are said to be accidental loads.

## Secondary effects:-

It occurs due to differential settlement of foundation differential shortening of columns and eccentric connections

It is prescribed by IS : 875 & IS : 1893

IS : 1893 Railways bridge IS : 1991 are

preferred

## \* snow load:-

In India the load is to be considered in

Himalay Region where snow fall occurs

\* It is prescribed by IS : 875 (part 4)

- 1987

## \* Local Buckling behaviour of steel:-

A steel structures are more slender the

compression members in steel structures are

liable to buckling As a steel members

consist of a no. of thin plates the stability

of each part is to be considered to account

for buckling

## Mechanical properties:-

- \* yield stress ( $f_y$ )
- \* Tensile or ultimate stress ( $f_u$ ) = 410
- \* The maximum percentage elongation on a standard gauge length
- \* Notch toughness

The above four condition followed by IS:

800-2007 code book preferred (Table No. 1.1)

## Type of Loads:

- \* Dead load
- \* live load or imposed load
- \* wind load
- \* Earth quake load
- \* Erection load
- \* Accidental load
- \* Snow load
- \* Secondary effects

## \* Dead load:-

It include the weight of all permanent contractions [IS 11-875] - part - I - 1987

Ex:- Roof, floor, slab etc.

\* Type of Steel structures:

\* depends upon the connections

\* depends upon the strength

Depends upon the connections

\* Rivet steel

\* Bolt, nut washers

\* Steel castings

\* weldings

Depends upon the strength

Mild steel (Fe 250)

High yield deformation Brass steel of high

Tension steel (Fe 415, Fe 500)

Properties of structural steel

\* physical properties

\* unit mass of steel

$$\rho = 7850 \text{ kg/m}^3$$

\* modulus of elasticity

$$E = 2 \times 10^5 \text{ N/mm}^2$$

\* poisson's Ratio

$$\mu = 0.3$$

\* modulus of rigidity

$$G = 0.769 \times 10^5 \text{ N/mm}^2$$

\* Co-efficient of thermal Expansion

$$\alpha_G = 12 \times 10^{-6} / ^\circ\text{C}$$

\* The absence of gusset plates connecting angles etc.

\* Welding process is more adaptable than bolting

(b) Rewelding

Disadvantages:

\* Highly skilled person is required for welding

\* Welding joints are over rigid.

\* Proper welding in field condition is difficult

\* The inspection of welded joints and expensive

\* There is a greater possibility of brittle fracture in welding

(c) A welded joint fails earlier than bolted joints if the structure is under fatigue.

(d) Due to uneven heating & cooling members likely

distort is the process of welding.

Design requirement for fillet welding:

\* Size of the (fillet) weld  $\geq 3$  mm

\* When a fillet weld is applied to a square edge of a part or section  $\leq 1.5$  mm less than

the edge thickness of the section.

\* When a fillet weld is applied to a rounded thickness of the section.

The minimum size of fillet weld should be as given below to avoid cracking in a absence of pre-heating

thickness (t) of thicker

part in mm

$t \leq 10$	2 (mm)
$10 < t \leq 20$	3
$20 < t \leq 32$	5
$32 < t \leq 50$	6
	10 (min)

\* Effective throat thickness  $\geq 3\text{mm}$   $\leq 0.7 \times$  thickness of thinner part

\* effective length of a fillet weld equal to  $= (\text{actual length} - 25) \geq 45$

→ length of end returns  $< 25$

⇒ In lap connections the maximum length of the width should be less than 4 times the thickness of the thinner part joint (or) 40mm whichever is more

\* Throat thickness of the end fillet weld normal to direction of force should not be less than  $0.5 \times$  into thickness of part

\* Design shear strength of a fillet weld  $f_w = \frac{f_u}{\gamma_{mw}}$

where  $f_u$  = Normal shear strength

$f_u = \frac{f_u}{\sqrt{3}}$  to be using the ultimate strength of the weld or the parent metal

$\gamma_{mw}$  = partial safety factor for different condition

$\gamma_{mw} = 1.25$  for shop weld

$\gamma_{mw} = 1.5$  for site weld.

Problems

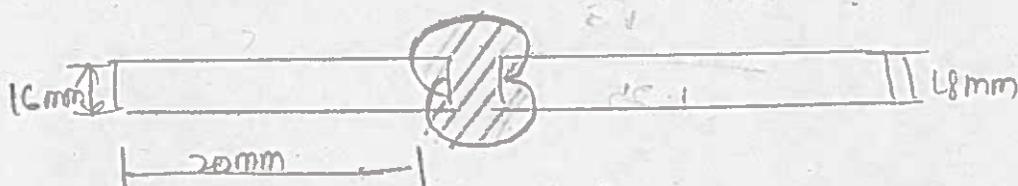
① A plate 18mm thick is joint to a 18mm plate by 200mm butt weld. determine the strength of the joint if

(i) a double v-butt weld is used

(ii) a single v-butt weld is used

Assume that  $f_u$  is 410 grade plate and shop weld used

(i) double v butt weld



Given data :  $t = 10 \text{ mm}$

eff length ( $l_w$ ) =  $200 \text{ mm}$

$f_y = 410 \text{ N/mm}^2$

$\gamma_{mw} = 1.25$

design strength of weld =  $\frac{l_w \times t \times f_y / \sqrt{3}}{\gamma_{mw}}$

$$= \frac{200 \times 10 \times \frac{410}{\sqrt{3}}}{1.25}$$

$1.25$

$$= 605.9 \text{ kN}$$

(ii) Single V-butt joint



Since penetration is not compute effective throat thickness ( $t$ ) =  $5/8 \times$  thickness of thick part

$$= 5/8 \times 10$$

$$t = 10 \text{ mm}$$

$$= \frac{l_w \times t \times f_y}{\sqrt{3}}$$

$\gamma_{mw}$

$$= \frac{200 \times 10 \times \frac{410}{\sqrt{3}}}{1.25}$$

$1.25$

$$= 378.74 \text{ kN}$$

Welded connections:

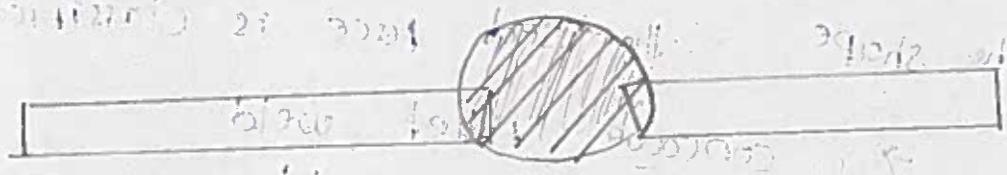
Welding is a joining two pieces of metals by establishment a metal logical bond b/w then the element to be connected through close and the metal is melted by means of electric arc using with rod which acts metal to the join after cooling the sand is establish b/w the two element oxyacetylene - flame

Type of welding connections

- Bolt weld
- Fillet weld
- Spot weld
- Plug weld
- \* Blot weld

Blot weld is also known as groove weld depending upon the shape of groove made for

welding Bolt weld are classified



square butt weld on one side



square butt weld

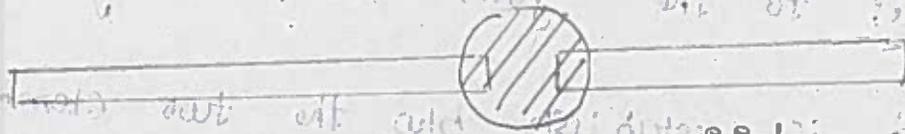
Both sides



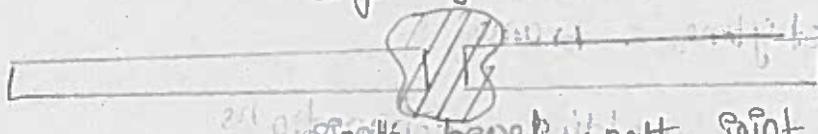
Single V-bolt weld Both sides



Single O-bolt joint



Single T-bolt joint



Single bevel bolt joint

\* Fillet weld is a weld of approximately triangular cross section joining two surfaces approximately two surfaces at right angles to lap each other in lap joint or T-section joint corner joint

\* True cross section of fillet weld with face then held  $45^\circ$  it is known as standard size of fillet weld is depends upon the shape the used face is classification

- \* concave fillet weld
- \* convex fillet weld
- \* mitre fillet weld

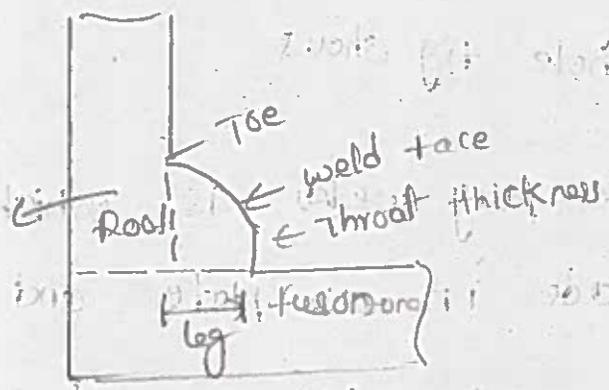
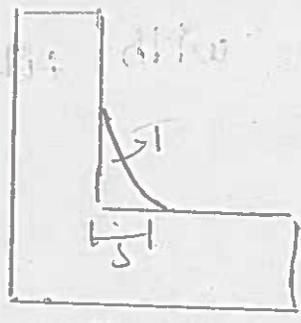
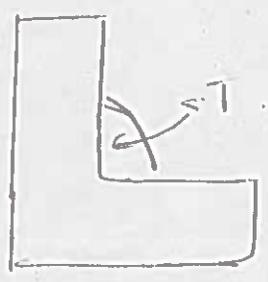


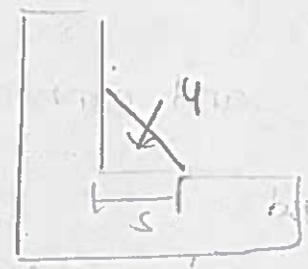
fig. fillet weld



wave (a) concave



(b) convex



(c) mitre

$\phi$  = size

t = thickness of throat

figs types of fillet welds

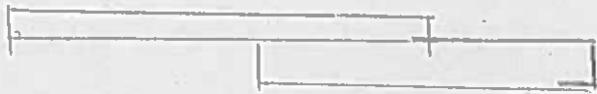
slot & plug welds

slot:-

fig shows a typical weld is which a plate with circular loads is with in another

Plate to be joint and then fillet welding is then along the hole fig shows

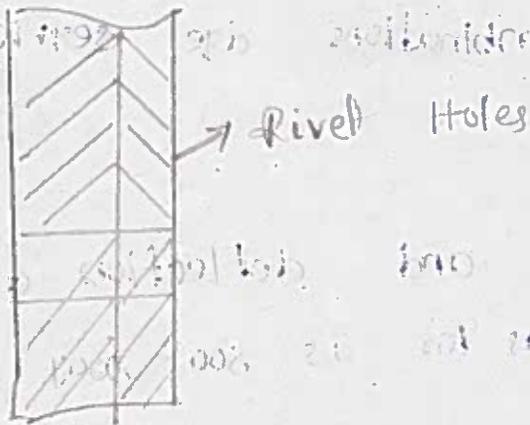
fig ② shows a plug welds is which small holes are made in one plate and is kept over another plate to connected and then entire hole is filled with fillet materials



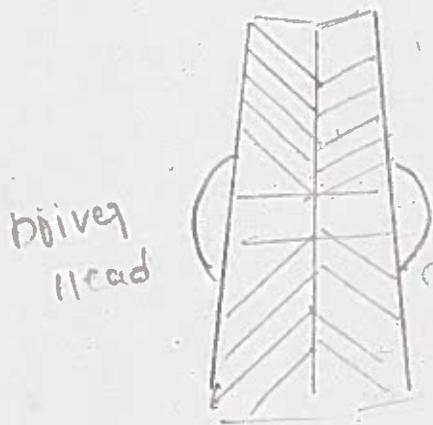
Advantages of welded and connection:

- \* welded joints are rigid
- \* welded connection have good appearance
- \* welded connection is air tight & water tight
- \* Alterations in connection can be easily made
- in design of welded connection
- \* Noise produced in welding process is relatively less
- \* due to the absence of gusset plates connection on angles

\* Rivets holes made in the structural members to be connected by punching or drilling. The size of rivet



Red. head rivet



Manufactured rivet head

\* Bolted connections:-

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

\* Bolt is used to joining pieces of metals by inserting the through holes is the nut

## Deflection limits:

Deflection limits are specified from the consideration that excess deformation do not cause damage

\* deflection are to be checked to advise best realistic combinations are service and their alligments

\* The limit and deflection are given in table-6 Page No-31 as for IS 800-2007 is met ered

## Design of connections:-

TO design of connections is important because of a failure of a joint sudden

\* Classification of connection

\* Rivets connection

\* Bolted connection

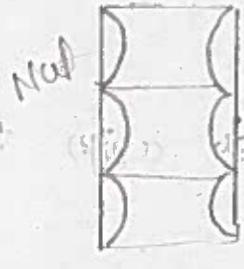
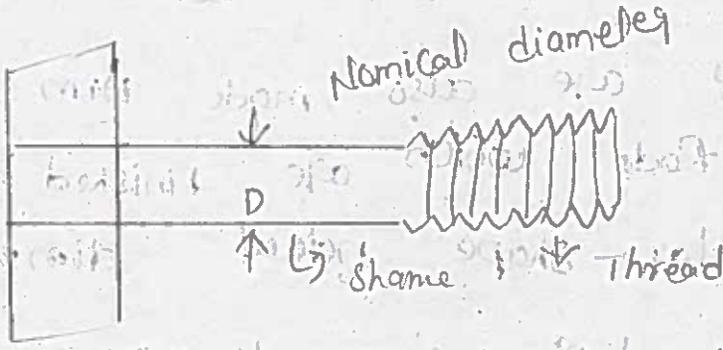
\* welded connection.

\* Rivet connection:-

\* Rivet is a method of joining to together pieces of metal by inserting ductile metal pieces called rivets into holes of pieces to

be connected and forming a head at the end of rivets to prevent which prevents pulled pieces coming out

⑥



\* Classification of bolts :-

- \* unfinished Bolt
- \* finished Bolt
- \* High strength friction grip (Edge grip)
- \* unfinished Bolt :-

These bolts are made from mild steel rods with square or hexagonal leads. The shank is left unfinished. Rough rolled. The diameter of bolt is 12, 16, 20, 22, 24, 27, 30 & 36 mm are available. The bolts used for light structures under statical loads such as trusses, Bracings and also temporary connections.

finishing bolts or Toned bolts:-

These bolts are also made from mild steel hexagonal rods which are finished by turnings to a circular shape. Actual dimensions of these bolts kept 1.2 mm to 1.3 mm larger than the normal diameter.

\* They need special methods to align to bolt holes before bolting.

\* As a connection is more tight it results to much better bearing contact between bolts and holes.

\* These bolts are used in special jobs like connecting machine parts subjected to dynamic loading.

High strength friction bolts:-

The edges of the bolts are made from the high strength steel. Rods surface of the shank is kept unfinished as in the case of black bolts.

The bolts are tightened in to a proof load using calibrated wrenches. Hence such as bolts can be used to connect.

\* Concept of limit state design

\* The limit state design method. The structures shall be designed to withstand safely all loads likely to act on throughout its lifetime

\* The objectives of the design is to achieve a structure that will remain fit use during its life with acceptable target reliability

\* The acceptable limit for the safety & serviceable requirement before failure occurs is (called as "limit state" method occurs is

\* generally the structures shall be designed limit state method preferable

Classification of limit states:

Limit state of collapse (S1) Strength

Limit state of serviceability

Limit state of collapse (S1) Strength

\* Limit state of strength are three associated with failures under the action of probable

and most unfavorable combination Loss of Equili-

brum of the strength and structures as a whole or any of its parts.

## Limit state of serviceability

\* Repairable damage of crack due to failure

\* corrosion durability

\* fire

Load combination

Dead load

Dead load + partially (or) full live load

Dead load + wind load

Dead load + live load + wind load (or)

seismic load

\* Design strength

A design strength  $\delta_d$  is obtained as given below form ultimate strength  $\delta_u$  and partial safety factors for materials  $\delta_m$

$$\delta_d = \frac{\delta_u}{\delta_m}$$

Design Strength ( $\delta_d$ ) =  $\frac{\text{ultimate strength } (\delta_u)}{\text{partial safety factor } (\delta_m)}$

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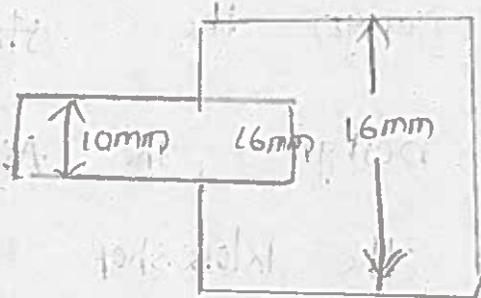
Q. 2

Design a suitable longitudinal fillet to be connected as shown in fig to transmit a pull equal to the full strength of strong plate. Given the plate size 12mm thick grade of plates Fe 410 & welding to be made in work shop.

Given data

minimum size to be used maximum

size - - - N



Max. size = 12-15 = 10.5mm

$f_y = 410 \text{ N/mm}^2$

thickness of plate = 12mm

breadth of plate = 10mm

full design strength of smaller plate =  $\frac{A_g f_y}{\gamma_{mw}}$

$\therefore A_g = 100 \times 12$

$f_y = 250 \text{ (Fe 410)}$

$\gamma_{mw} = 1.10$

$= \frac{100 \times 12 \times 250}{10}$

$= 272727 \text{ N}$

Assuming normal weld thickness (t) = 0.7x

Design strength of weld =  $k_w \times t \times \frac{f_y}{\sqrt{3}} \times \frac{1}{\gamma_{mw}}$

$272727 = k_w \times 7 \times \frac{410}{\sqrt{3}} \times \frac{1}{1.25}$

$$L_w = 205 - 7 \text{ mm}$$

- ③ A tie member of a roof truss consists of a pair of ISA 100 x 75 x 8 mm the angles are connected either side of a 10 mm gusset plate and the member is subjected to working load of 300 kN. Design the strength of welded connection. Design the Assume connection are made in the workshop.

$$\text{Load} = 300 \text{ kN}$$

$$2 \text{ ISA } 100 \times 75 \times 8 \text{ mm}$$

$$\text{thickness of plate} = 10 \text{ mm}$$

$$\text{thickness of weld} = 6 \text{ mm}$$

④ at the root to the angles section

$$= \frac{3}{4} \times \text{thickness} = 8 - 1.5 = 6.5 \text{ mm} \approx 6 \text{ mm}$$
$$s = 6 \text{ mm}$$

Each angle carries a factored load

$$= \frac{300}{2} = 150 \text{ kN}$$

Given

$$\text{working load} = 300 \text{ kN}$$

$$\therefore \text{factored load} = 300 \times 1.5 = 450 \text{ kN}$$

Each angles carried a factored

$L_w$  be the total length of the weld required

Assuming normal weld  $t = 0.7 \times 6 \text{ mm}$

$\therefore$  Design strength of the weld

$$= L_w t \frac{f_e}{\sqrt{15}} \times \frac{1}{1.25}$$

$$= L_w \times 0.7 \times 6 \times \frac{410}{\sqrt{3}} \times \frac{1}{1.25}$$

Equating it to the factored load we get

$$L_w \times 0.7 \times 6 \times \frac{410}{\sqrt{3}} \times \frac{1}{1.25} = 2.25 \times 10^3$$

$$\boxed{L_w = 283 \text{ mm}}$$

Center of the gravity of angles section is at a distance 31 mm from top let  $L$  be the

length of top weld &  $L_2$  be the length of the lower weld. To make center of gravity of weld to coincide with that of angles

$$L_1 \times 31 = L_2 (100 - 31)$$

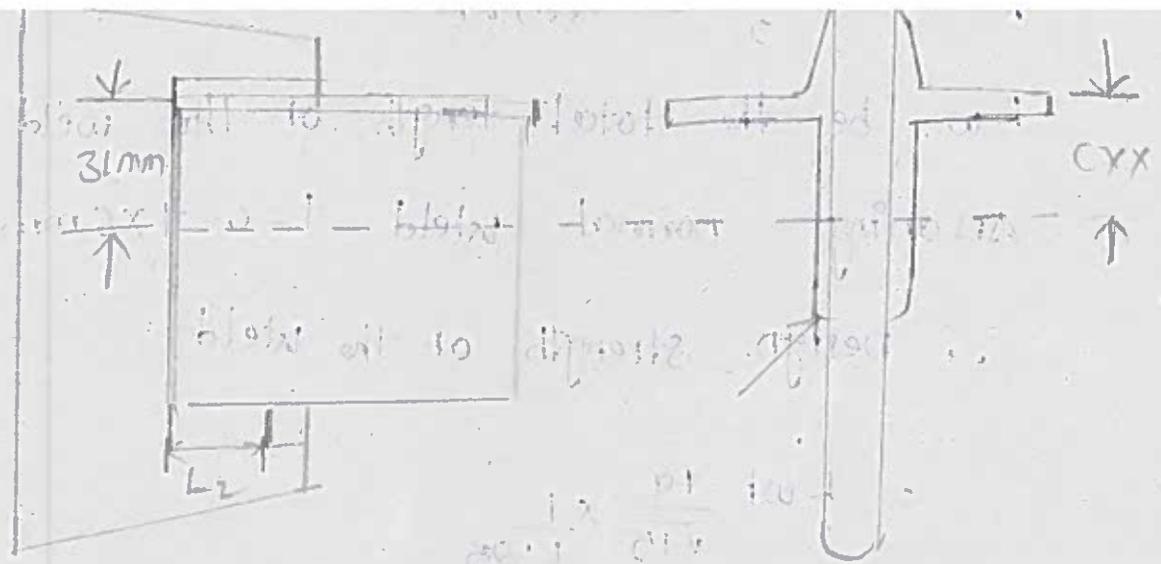
$$L_1 = \frac{69}{31} L_2$$

$$L_1 + L_2 = 283$$

$$\text{i.e. } L_2 \left( \frac{69}{31} + 1 \right) = 283$$

$$\text{or } L_2 = 87 \text{ mm}$$

$$\therefore L_1 = 195 \text{ mm}$$



\* combined axial and shear stress

If a weld is subjected to axial stress, compression or tension due to axial force bending moment simultaneously shear as a recommended for IS : 800 : 2007 preferred (19-80)

the equivalent stress for shall satisfied the following

$$f_e = \sqrt{f_a^2 + 3q^2} \leq \frac{f_y}{\sqrt{3} m_i}$$

where  $f_a$  = axial stress

$q$  = shear stress

Essential connection

due to moments at right angles to that

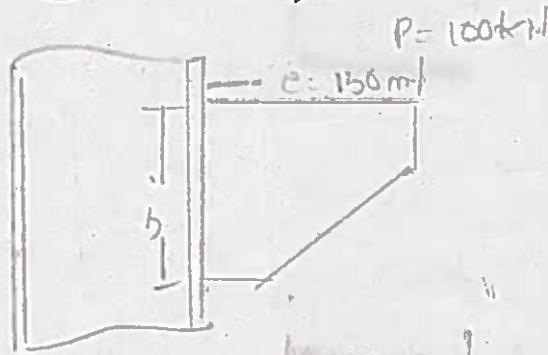
plane of weld

It shows as a typical case in which 'P' is the factored load at an eccentricity

Prob

①

Design a suitable fillet weld for the bracket as shown in fig with working load  $P = 100 \text{ kN}$  and eccentricity  $150 \text{ mm}$ . Thickness of bracket plate is  $12 \text{ mm}$  and the column used is ISB3 - 300 @ 618 N/m



Given that :-  $P = 100 \text{ kN}$

$$e = 150 \text{ mm}$$

Bracket plate =  $12 \text{ mm}$

Column section ISIB 300 @ 618 N/m is;  $10.6 \text{ mm}$

$\therefore$  minimum size of weld =  $5 \text{ mm}$

use  $8 \text{ mm}$  weld on each side of bracket plates

$$\text{throat thickness} = 0.7 \times 8 = 5.6 \text{ mm}$$

$$\text{fracted load} = 1.5 \times 100 = 150 \text{ kN}$$

$$\text{* Resistance of weld} = \frac{f_y}{\sqrt{3}} \times \frac{1}{\sigma_{\text{max}}}$$

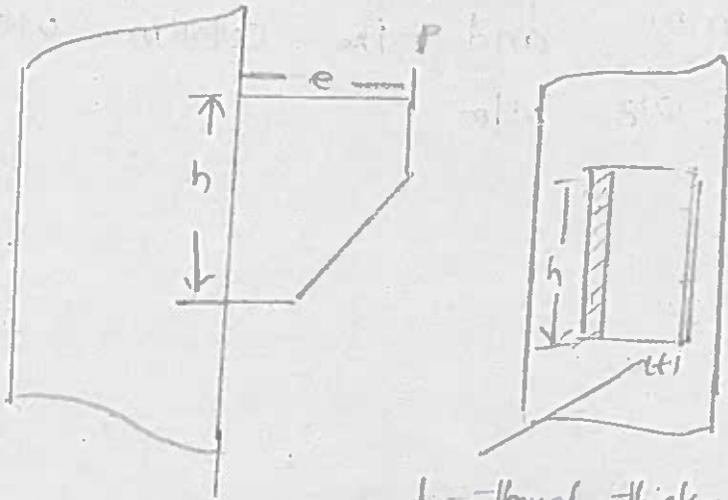
$$= \frac{410}{\sqrt{3}} \times \frac{1}{1.25} = 189.37 \text{ mm}$$

\* Depth of weld required to resistance of bending along

(13)

Let 'h' be the effective depth of weld

If the bolt sides of bracket plate hence if throat thickness 't' effective area  $(a) = 2ht$



t - throat thickness  
between 2 bolt covers

\* Direct Shear stress

$$q = \frac{P}{2ht}$$

\* Bending stress

$$f = \frac{m}{I} = \frac{Pe}{\frac{1}{6}(2ht^2)} = \frac{6Pe}{2ht^2} \quad (z = \frac{I}{y})$$

\* Equivalent stress

$$f_c = \sqrt{f^2 + 3q^2} \leq \frac{f_y}{\sqrt{3}}$$

for the purpose of finding the effective depth 'h' required first depth required for bending only may be found. TO case of shear also increase the value above 10%.

$$h = \sqrt{\frac{6m}{2t^2}}$$

$$h = 1.73 \sqrt{\frac{m}{t^2}}$$