Unit — IV

Design of Column Foundation :— Design of slab base and gusseted base, column bases subjected moment.

Design of Slab Base :—

Q. Design of SLABBASE for a column ISHB300 @ 577 N/m. Carrying an axial load of 1000 KN, M20 Concrete is used for the foundation yield stress of steel is 250 Mpa. Also design the Concrete pedestal if the safe bearing Capacity of soil is 190 KN/m³

Solution :—

1) Axial load (P) = 1000 KN.

Factored load (P_u) = 1.5 × 1000 = 1500 KN.

= 1500×10^3 N.

(2) Bearing strength of Concrete = 0.45 fck

= 0.45 × 20 = 9 N/mm²

(3) Area of base plate required = $\frac{P_u}{0.45 f_{ck}}$

$$A = \frac{1500 \times 10^3}{0.45 \times 20} = 166667 \text{ mm}^2$$

(4) Using a Square base plate, Side of square Base plate = $\sqrt{A}$ = $\sqrt{166667}$ = 408.25 mm

Side of Baseplate = 410 mm Say.

i.e 410 mm × 410 mm Base plate.

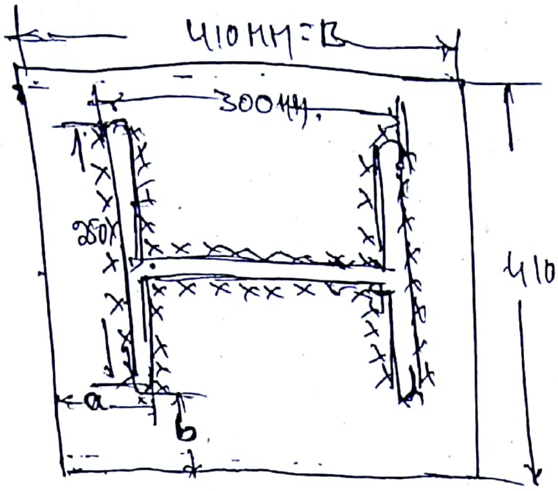
(6) Thickness of Base plate.

For ISHB 300 @ 577 N/m from steel tables.

Breath of I-Section = b = 250 mm

Height of I-Section = h = 300 mm

Thickness flange = T_f = 10.6 mm



B = Width of Baseplate = 410MM

b = width of I-section given

b = 250MM.

from fig

$a = \frac{1}{2}(B - b) = \frac{1}{2}(410 - 250) = 80MM$

$b = \frac{1}{2}(B - h) = \frac{1}{2}(410 - 300) = 55MM.$

w = pressure $= \frac{P_u}{A} = \frac{1500 \times 10^3}{410 \times 410} = \frac{Load}{Area} = 8.92 N/mm^2$

$\gamma_{mw} = 1.1$

$f_y = 250 N/mm^2$

Minimum thickness of slab base = t_s

$t_s = \sqrt{\frac{2.5 w (a^2 - 0.3b^2) \gamma_{mw}}{f_y}}$

$= \sqrt{\frac{2.5 \times 8.92 (80^2 - 0.3 \times 55^2) \times 1.1}{250}}$

$t_s = 23.21 mm \not> t_f = 10.6 MM,$

Say $t_s = 24mm < 10.6 (t_f)$

Hence it is O.K

∴ Provide 410 MM × 410 MM × 24MM size slab base

Fastenings :- Connect the column section with slab base by fillet welds and connect the slab base to concrete pedestal by Anchor bolts. Size 22MM ϕ

Size of Weld = 6mm size.

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Desisng Concrete pedestal.

Axial load = 1000 KN.

Assume 15% as self wt of foundation $= \frac{15}{100} \times 1000 = 150$ KN.

Total load $= 1000 + 150 = 1150$ KN

SBC of soil $= 190$ KN/M² (not given assume itself)

Area of required pedastal $= \frac{\text{load}}{\text{SBC of soil}} = \frac{1150}{190} = 6.05 M^2$

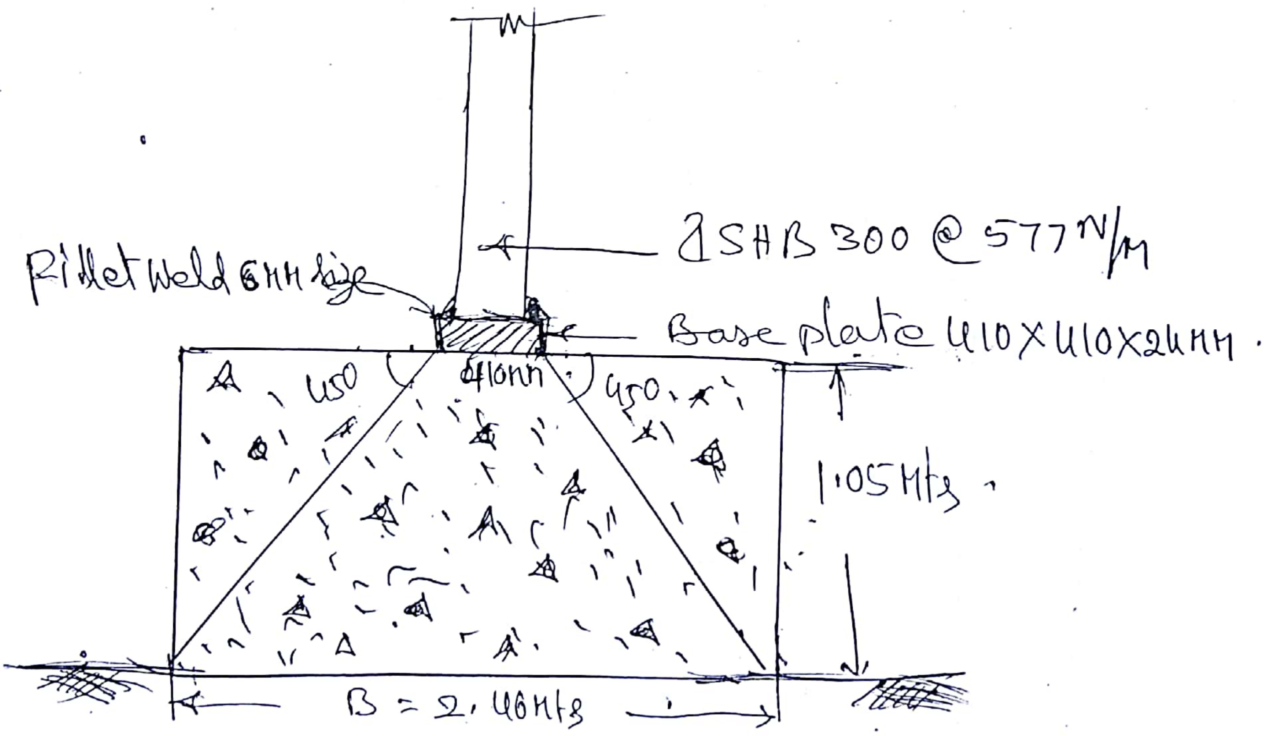
Size of Squre pedestal $= \sqrt{6.05} = 2.46$ mts.

Assuming an angle of dispersion of load as 45^0

Depth of Concrete pedastal $= \frac{1}{2}[\text{width of Concrete pedestal} - \text{width of slab base}]$

$= \frac{1}{2}[2.46 - 0.41] = 1.025$ Mts.

∴ Provide 2.46m × 2.46 × 1.05 mts size of Concrete pedastal



Q Design a slab base for a column section consisting of one ISHB 250 at 529 N/m with 2 cover plates 300×25 mm one on each flange carrying an axial load of 2500 KN. Use M20 grade concrete and Fe250 grade steel. Also design concrete pedestal if safe bearing capacity of soil is 250 kN/m²

Solution:-

$f_u = 409$

1) Design of slab base

Axial load = P = 2500 KN,

Factored load = 1.5×2500 = 3750 KN

$= 3750 \times 10^3$ N

Bearing strength of concrete = $0.45 f_{ck} = 0.45 \times 20 = 9 N/mm^2$

(2) Side of base plate required:

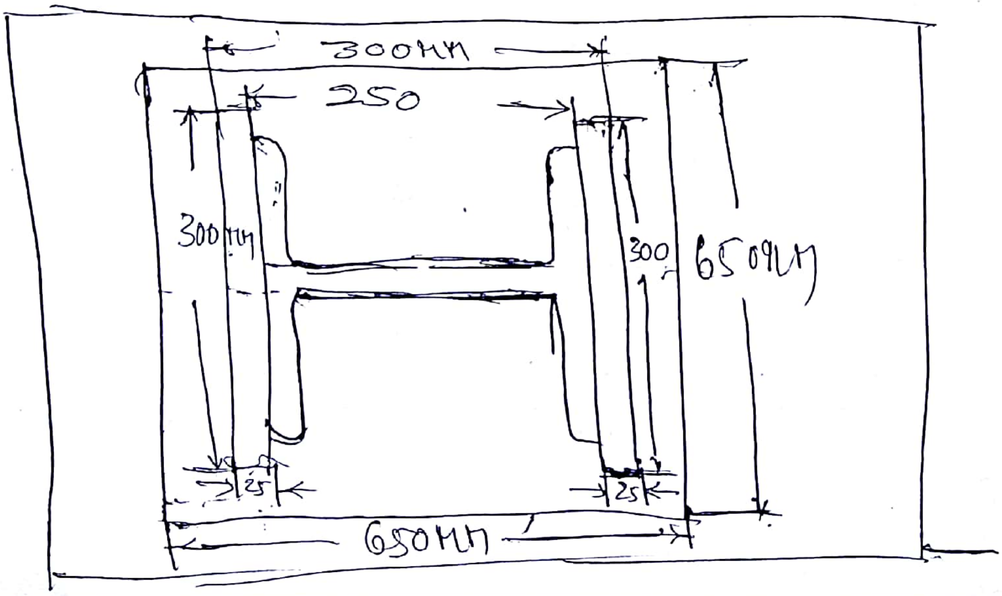
$$A = \frac{P_u}{0.45 f_{ck}} = \frac{load}{stress} = \frac{3750 \times 10^3}{9} = 416667 \ mm^2$$

Using a square base plate of

Side of the base plate = $a = \sqrt{A} = \sqrt{416667}$

a = 645.5 mm ≃ 650 mm

Size of the base plate = 650×650 mm



For ISHB 250 @ 537 N/m.

Width of section = 250 mm ; h = 250 mm.

$t_f = 9.7$ mm ; B = 650 mm ; b = 300 mm (including web & plates)

$a = \frac{1}{2}(B - b)$

$a = \frac{1}{2}(650 - 300) = 175$ mm.

$b = \frac{1}{2}(650 - 300) = 175$ mm

Pressure $w = \frac{3750 \times 10^3}{650 \times 650} = \frac{P_u}{B \times B} = 8.87$ N/mm²

Minimum thickness of slab base = t_s

$$t_s = \sqrt{\frac{2.5w(a^2 - 0.3b^2)\gamma_{mo}}{f_y}}$$

$$t_s = \sqrt{\frac{2.5 \times 8.87 [175^2 - 0.3 \times 175^2] \times 1.1}{250}}$$

$t_s = 45.73 < t_f$ (10.6 mm) ≈ 46 mm

Provide 650 × 650 × 46 mm size slab base.

Connect the column section with slab base by fillet welds and connect the slab base to concrete pedestal by anchor bolts., ~~Size of~~ Use weld = 6 mm size.

Design of Concrete pedestal :-

1) Axial load = 2500 kN

2) Assuming 15% as self-wt of foundation.

Load due at self wt = $2500 \times \frac{15}{100} = 375$ kN

3) Total load = 2500 + 375 = 2875 kN

4) SBC of soil = 250 kN/m²

5). Area of pedestal required = $\frac{2875}{250} = 11.5$ m²

6) Size of square pedestal = $\sqrt{11.5} = 3.39$ mts.

7) Assuming an angle description of load as 45°

Depth of concrete pedestal $= \frac{1}{2}(B - b) = \frac{1}{2}(3.39 - 0.65)$

= 1.37 mts

∴ provide a concrete pedestal of size = 3.39 × 3.39 × 1.37 m

Q. A steel column consists of 2 ISMC 400 at 489 N/m placed back to back at clear distance of 120 mm. It carries an axial load of 1200 kN. Use M20 grade concrete and E 250, Grade of steel. Design the slab base also design the concrete pedestal if the S.B.C of soil is 180 kN/m²

Solution :-

Design of slab base.

1) Axial load (P) = 1200 kN

2) Factored load = 1.5 × 1200 = 1800 kN

or = 1800×10^3 N

3) Bearing strength of Concrete = 0.45 × fck

= 0.45 × 20 = 9 N/mm²

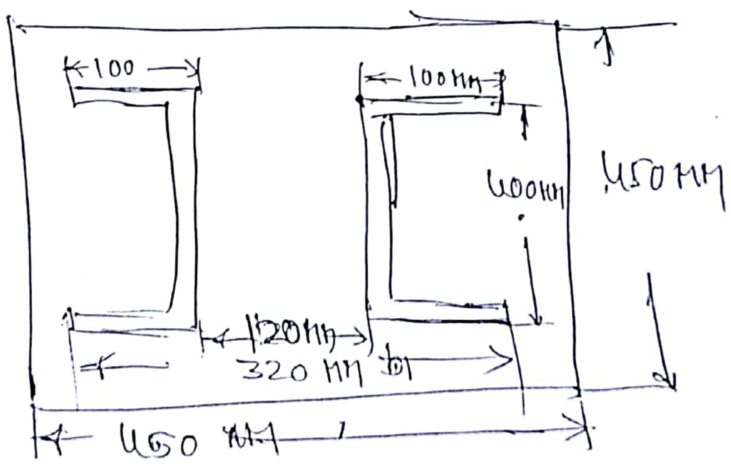
4) Area of Base plate required = $\frac{P_u}{0.45 f_{ck}} = \frac{1800 \times 10^3}{9}$

= 200000 mm²

5) Using a square base plate side of square base plate = $\sqrt{A}$

$\sqrt{A} = \sqrt{200000} = 447.213$ mm ≈ 450 mm.

6) Use 450 × 450 mm base plate.



For ISMC 400 @ 489 N/m,

b_f = 100 mm.

Depth of web = h = 400 mm

t_f = 15.3

$a = \frac{1}{2}(B - b_1) = \frac{1}{2}(450 - 320) = 65$ mm

$b = \frac{1}{2}(B - b_2) = \frac{1}{2}(450 - 400) = 25$ MM

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Pressure = $w = \frac{Pu}{\text{area of baseplate}} = \frac{1800 \times 10^3}{450 \times 450} = \frac{1800000}{2,02500} = 8.88 N/mm^2$

Pressure = $w = 8.88 N/mm^2$.

$\gamma_{mo} = 1.10$

Minimum thickness of slab base. = t_s

$$t_s = \sqrt{\frac{2.5 w (a^2 - 0.3 b^2) \gamma_{mo}}{f_y}}$$

$$= \sqrt{\frac{2.5 \times 8.88 (65^2 - 0.3 \times 25^2) 1.1}{250}}$$

$t_s = 19.85 > t_f = 15.3$ mm.

$t_s \approx 20$ MM.

provide 450 MM × 450 MM × 20 MM Size slab base plate.

Fastenings:

Connect the column section with slab base by fillet welds and connect the slab base to concrete pedestal by Anchor bolts.

<u>Design of Concrete pedestal</u>

1) Axial load = 1200 KN.

2) Assuming 15% as self wt of foundation load due to self wt = $\frac{15}{100} \times 1200 = 180$ KN

Total load = 180 + 1200 = 1380 KN

3) S.B.C of soil = 180 KN/m²

4) Area of the pedestal required = $\frac{\text{Total load}}{\text{SBC}} = \frac{1380}{180}$

= 7.667 m²

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Area of pedestal = $A = 7.667\ M^2$

5) Side of square pedestal $= \sqrt{A} = \sqrt{7.667} = 2.768\ M$

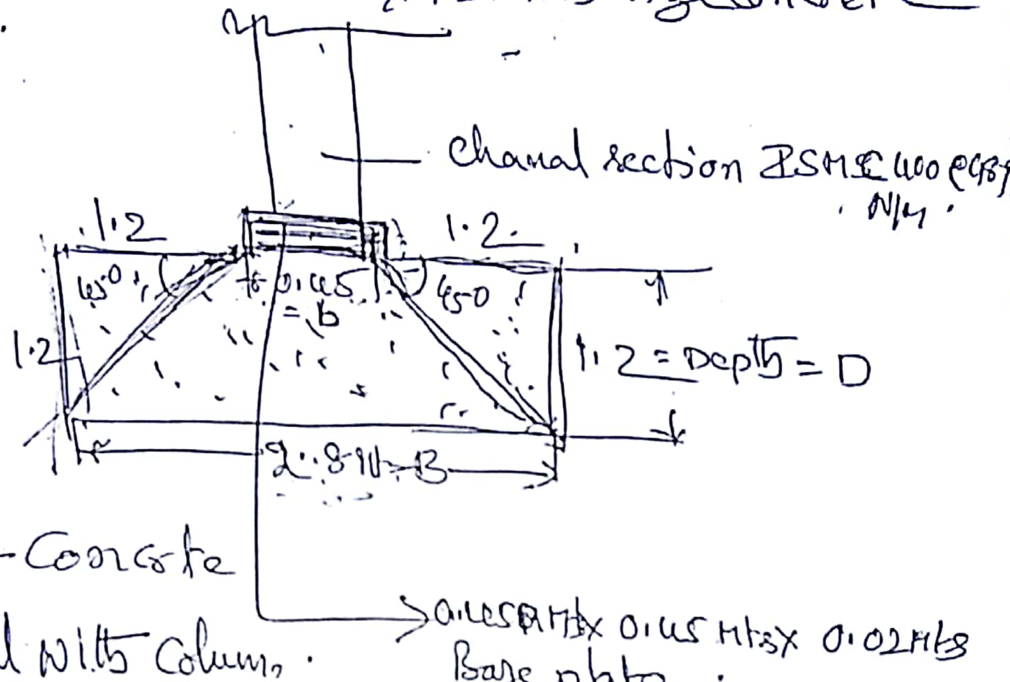
Assume an angle of despersion of load as 45°

Depth of concrete pedestal $= \frac{1}{2}(B - b)$

$= \frac{1}{2}(2.768 - 0.4)$

$= 1.159$ mts.

Provide 2.8 M X 2.8 X 1.2 mts size Concrete pedestal.



C/s of Concrete pedestal with column.

Section

H.W

Ø Design a slab base with rectangular base plate having equal projections for a column section consisting of ISHB 350 @ 661 KN/M carrying an axial load of 1200 KN including self wt. Use M20 grade Concrete & Fe250 grade steel. Also design the concrete pedestal if safe bearing capacity of soil 180 KN/M²

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1) Axial load = 1200 kN

2) Factored load = 1.5 × 1200 = 1800 kN.
or 1800×10^3 N

3) Bearing strength of concrete = $0.45 f_{ck}$ = 0.45 × 20 = 9 N/mm²

4) Area of Baseplate = $\frac{Load}{strength} = \frac{1800 \times 10^3}{9}$ = 200000 mm²

5) Using a rectangular base plate — Assume the width of the base plate = 400 mm.
Breadth
length of baseplate = $\frac{~~200000~~ 500}{~~400~~}$ = 500 mm.

The size of the Baseplate = 500 mm × 400 mm.

6) Thickness of Base plate:

pressure = w = $\frac{Load}{area\ of\ Baseplate} = \frac{1800 \times 10^3}{500 \times 400}$ = 9 N/mm²

Projection: $a = \frac{(500 - 350)}{2}$ = 75 mm.

$b = \frac{(400 - 250)}{2}$ = 75 mm

γ_{mo} = 1.10

f_y = 250 MPa

Minimum thickness of base plate.

$$t_s = \sqrt{\frac{2.5\,w\,(a^2 - 0.3\,b^2)\,\gamma_{mo}}{f_y}} = \sqrt{\frac{2.5 \times 9 (75^2 - 0.3 \times 75^2) 1.1}{250}}$$

~~t_s = 7.88 mm~~ < t_s (10.6 mm)

t_s = 19.74 mm > t_g < 12 mm.

t_s = 20 mm.

Provide Base plate = 500 × 400 × 20 mm

$$= \sqrt{\frac{22.5\,(5{,}625 - 1687.5)\,1.1}{250}}$$

$$= \sqrt{\frac{4331.25 \times 22.5}{250}}$$

$$t_s = \sqrt{389.8} = 19.74\ mm$$

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Design of Concrete pedestal:-

Axial load = 1200 KN

Factored load = 1.5×1200 = 1800 KN (or) 1800×10^3 N

Self wt of pedestal = $\frac{\text{load}}{\text{S.B.C}}$ = ~~$\frac{180 \times 10^3}{180}$ = 1000~~

$= \frac{1800}{180} = 10 m^2$

Rectangular pedestal,

Side of pedestal = 2.5 mts.

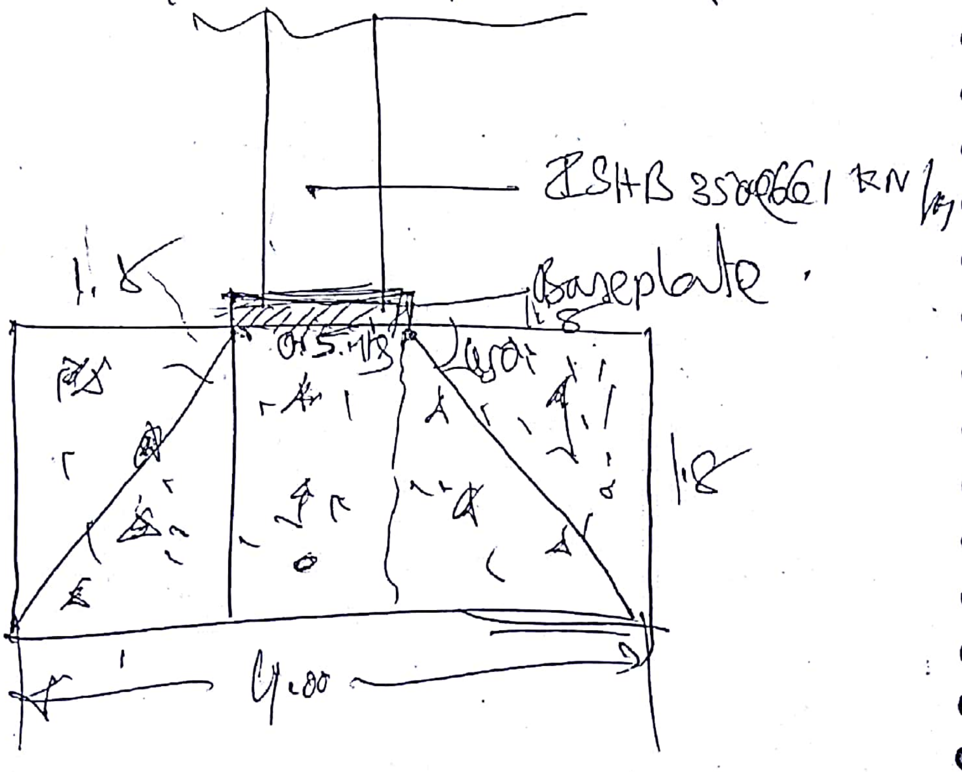
Length of pedestal = $\frac{10}{2.5}$ = 4 Mts.

Size of pedestal = 2.5 × 4 Mts.

depth of pedestal = $\frac{1}{2}(4 - 0.35)$

$= \frac{3.65}{2} = 1.825$ Mts

provide 4.00 × 2.5 Mts × 1.8 Mts depth



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Design of Gusseted Base

IS 800 -2007 Specifies that the gusset plate, angle cleats, Stiffeners and fastenings etc. In Combination With the bearing area, Shall be sufficient to take the loads Bending moments and reactions to the base plate Without exceeding specified Strength. All the bearing Surfaces shall be machined to ensure perfect Contact.

The Design procedure :—

1) Area of baseplate = $\frac{\text{Factored load}}{0.45 f_{ck}}$

2) Assume various members of gusset base.

a) Thickness of gusset plate is assumed as 16mm

b) Size of the gusset angle is assumed such that its vertical leg can accommodate two bolts on one vertical line Corresponding to this leg the other leg is assumed in which one bolt can be provided.

c) Width of gusset base is kept approximately equal to the thickness of gusset plate.

3) Width of gusset base is kept such that it will just project outside the gusset angle and hence

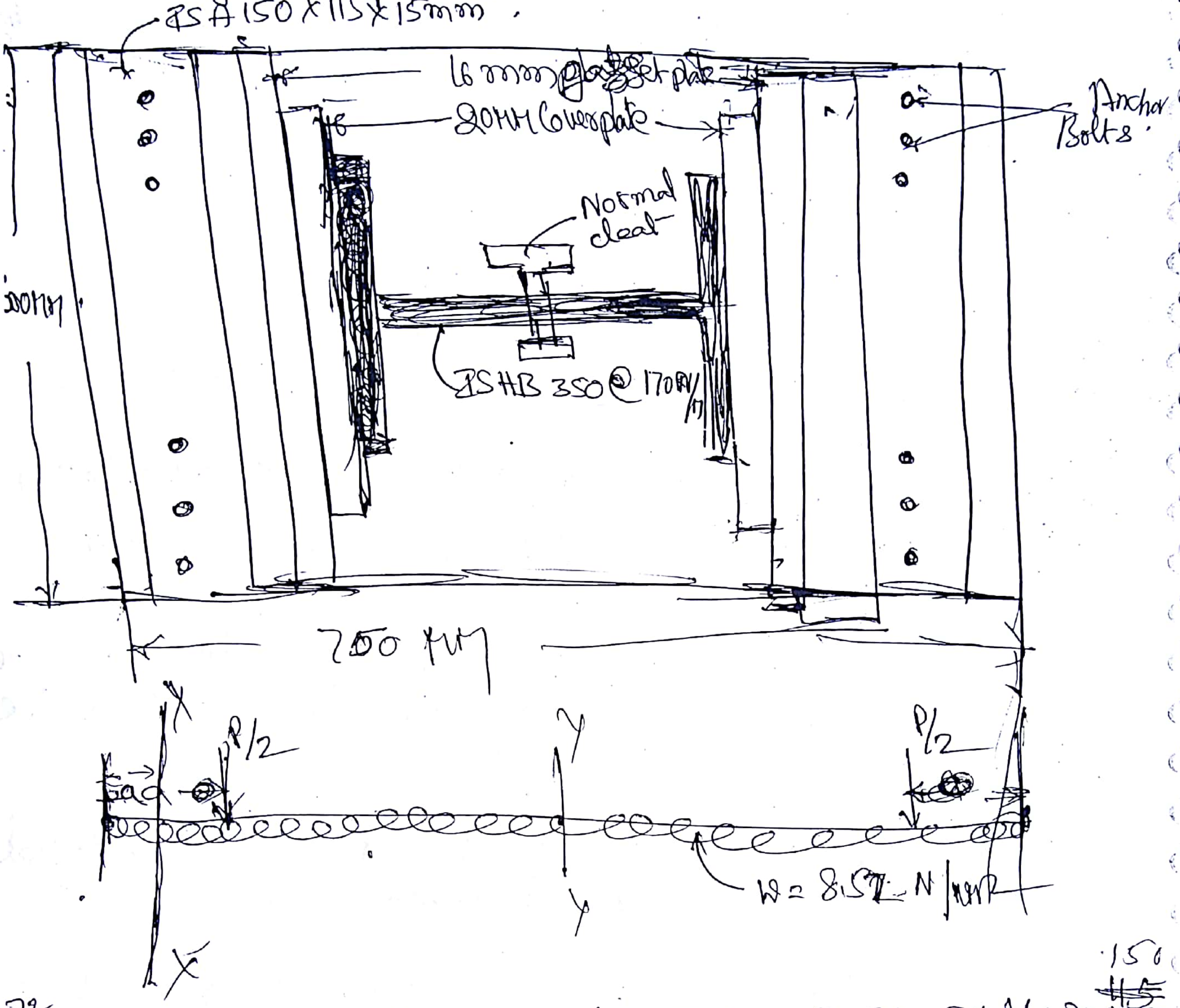
$$\text{Length} = \frac{\text{Area of the plate}}{\text{Width}}$$

Q. Design a gusseted base for a Column ISHB 350 @ 710 N/M With two plates 450 MM x 20 MM. Carrying a factored load of 3600 KN. The Column is to be Supported on Concrete pedestal to be built With M20 grade Concrete. Assume = f_y = 250 MPa

Solution :- $f_{ck} = 20 N/mm^2$; $P_u = 3600 kN$

$$A = \frac{P_u}{0.45 f_{ck}} = \frac{3600 \times 10^3}{0.45 \times 20} = 400000 \, mm^2$$

Selecting ISA 150x115x15mm Angle and 16 mm thick gusset plate.



72
115
115
350
652
20
722

Minimum width required : $350 + 2\times20 + 2\times16 + 2\times150$

$= 722 \, MM \approx 750 MM$.

Use 700 MM wide plate.

∴ Length of Baseplate $= \frac{A}{B} = \frac{400000}{750}$

$= 533 \, mm \approx 600 \, MM$

Provide 750 MM x 600 mm plate.

pressure under baseplate = $\frac{3600\times10^3}{700\times600}$ = 8.57 N/mm²

= 8.57 N/mm²

a) = $\frac{700 - (350 + 20\times2 + 16\times2)}{2}$

a = 164 mm

B.M at section X-X per mm width = 8.57 × $\frac{164^2}{2}$ = 115248.9 N-mm

At Section Y-Y B.M (Note = Per mm width = P = (8.57×350) N)

$M_{yy} = 8.57\times\frac{350^2}{2} - \frac{700}{2}\times8.57\times\left[\frac{350}{2}+20+\frac{16+16}{2}\right]$

= 106482 N-mm

∴ Design moment = 106482 N-mm

Bending strength = $\frac{f_y}{\gamma_{m0}} = \frac{250}{1.1}$ = 227.27 N/mm²

Equating moment of resistance to bending moment we gets

$1.2 * \frac{1}{6}\times1\times t^2\times227.27 = 106482$

∴ t = 48.4 mm

∴ Use 56 mm base plate of size = 700×600 mm

Assuming ends of columns are faced for complete bearing the connection between gusset plate and column will be designed for 50% of axial load

Design load = 0.5×3600 = 1800 kN

Load on each splice = $\frac{1800}{2}$ = 900 KN

Using 24 mm shop bolts.

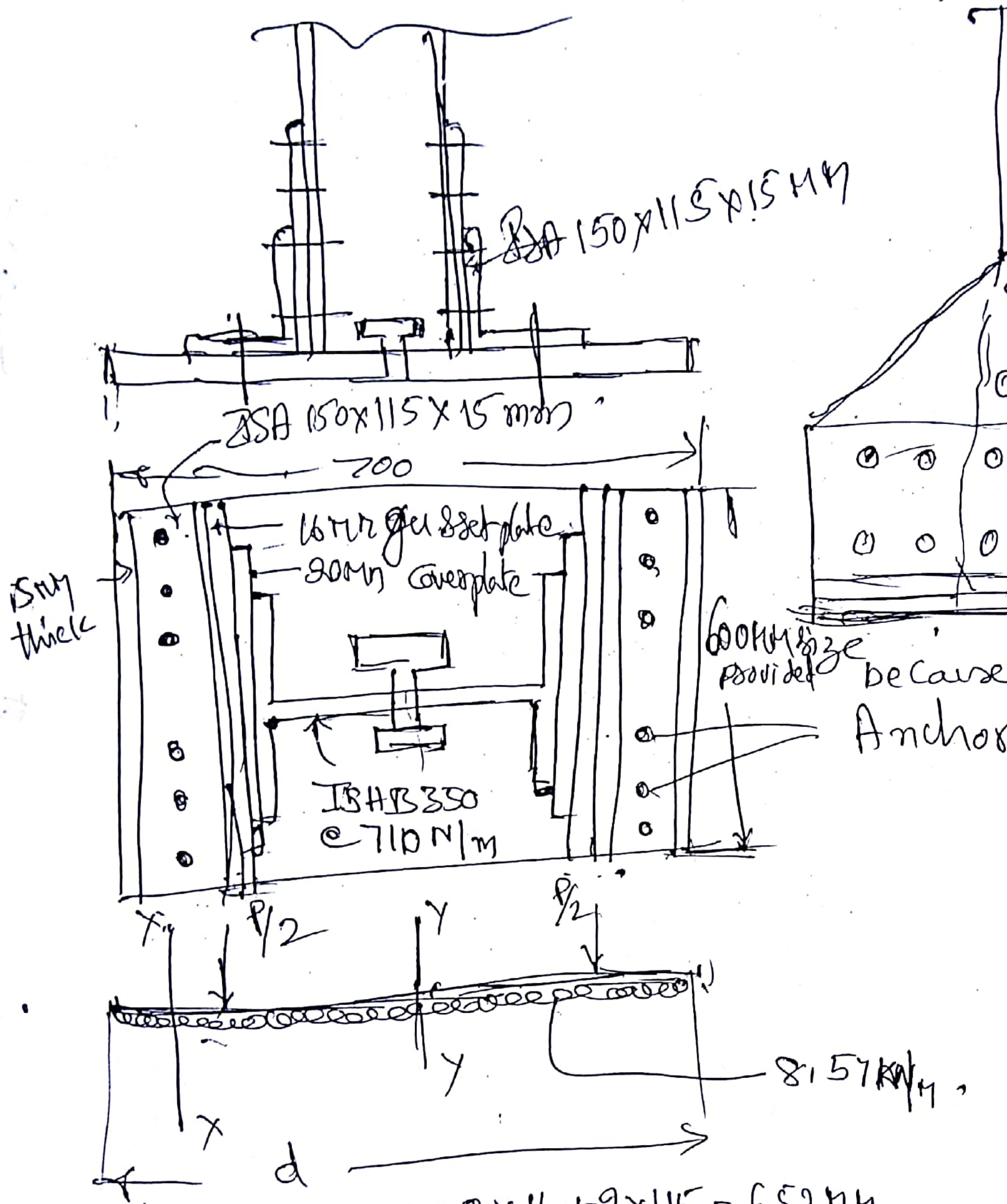
Strength of bolt in single shear = $0.7\times\frac{\pi}{4}\times24^2\times\frac{400\times1}{\sqrt{3}\times1.25}$

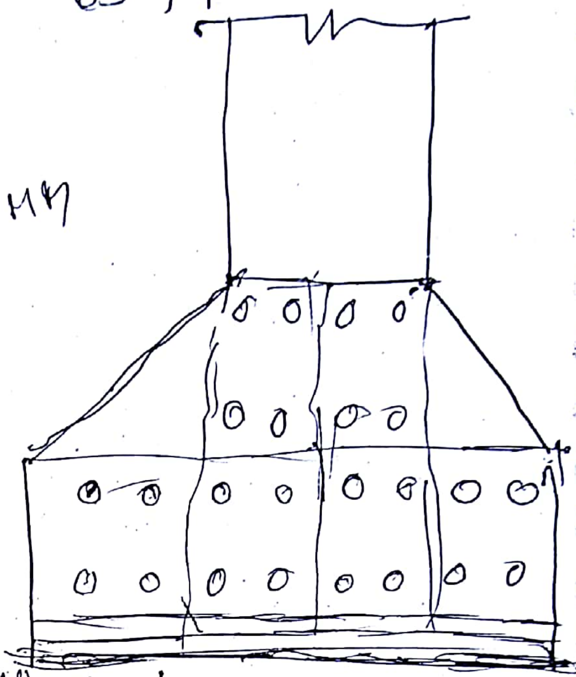
= 65192 N (formula = $0.7\times A_{ri}\times\frac{f_u}{\sqrt{3}\times\gamma_m}$)

Strength in Bearing is higher.

$\therefore$ Bolt Value = 65192 N

$\therefore$ No of bolts required = $\frac{900 \times 10^3}{65192}$ = 13.8 Nos





d = 350 + 2×20 + 2×16 + 2×115 = 652 MM

Beams:

A structural member which is subjected to bending moments and shear forces, due to the effect of transverse loads is called a beam.

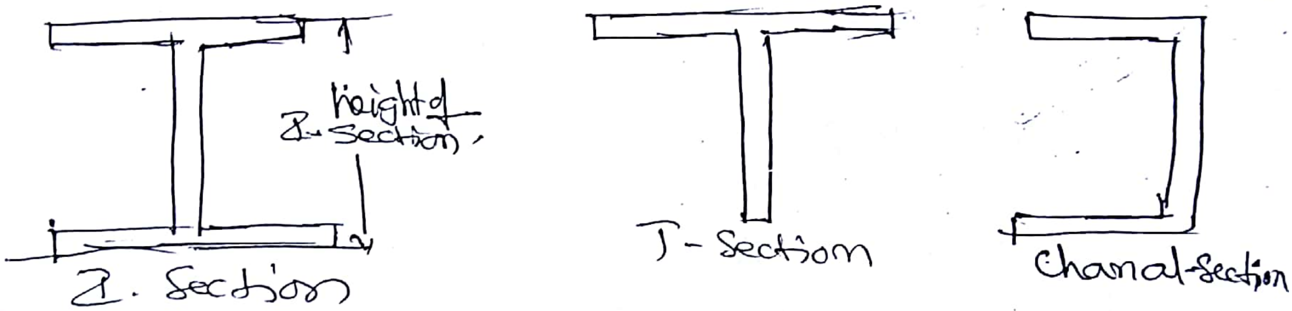
When the transverse load acts at an eccentricity to the longitudinal axis of the beam, it is subjected to torsional moment also.

A steel beam has to satisfy the strength and stiffness requirements as per IS 800 - 2007

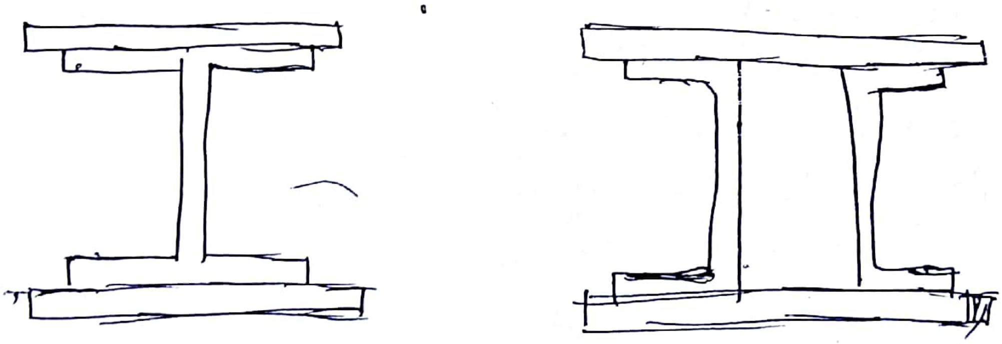
Classification of beams:

1. Simple beams.
2. Compound beams (or) plated beams (or) Builtup beam
3. plate girder

1) Simple beams :-



2) Compound Beam (or) Built up Beam :-



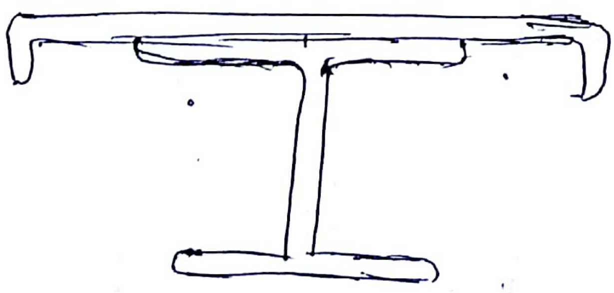
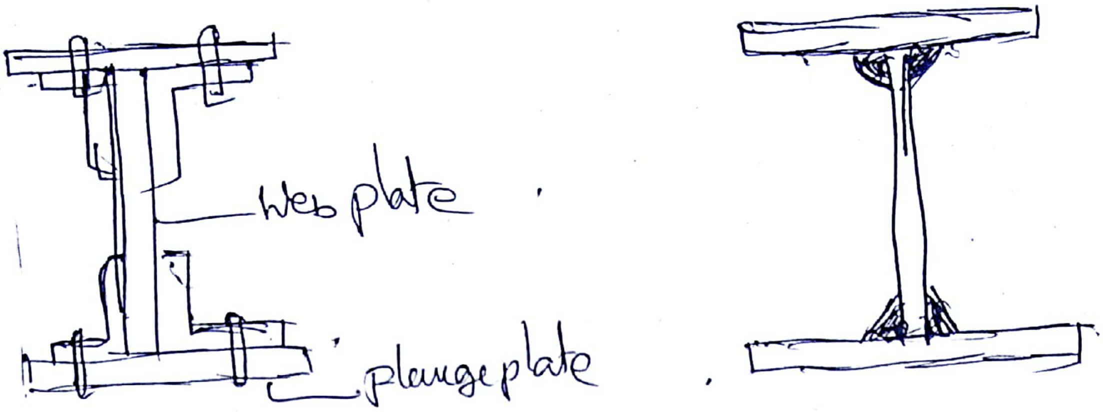


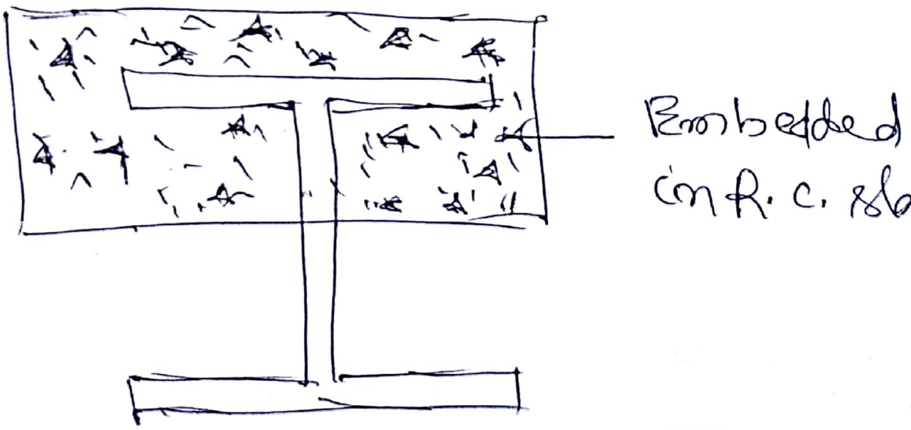
plate Girder:- A beam made up of flange plates and web plates along or together with angles riveted (or) welded to carry heavy loads on large spans is called plate girder.



Depending on the lateral restrained provided for the compression flange of the beam, to avoid lateral buckling of flanges, the beams are classified as: (1) Laterally supported beams.
(2) Laterally unsupported beams.

(1) Laterally supported Beams:-

The beams undergo lateral buckling in addition to bending when subjected to bending about the Major axis since the moment of inertia (M.I) about the minor axis is much less compared to that about the Major axis. The lateral Buckling of these sections may be prevented by providing continuous lateral support to the compression flange. Such beams are known as laterally supported beams.



② **Laterally unsupported Beams:-** When the Compression flange of the beam is not supported in the lateral direction there is always the possibility of lateral buckling. Such beams are called laterally ~~unsupp~~ unsupported beams.

Design strength in shear as per IS 800-2007.

The Factored design shear force, 'V' in a beam due to external action shall satisfy.

$$V \leq V_d$$

Where V_d = design strength

$$V_d = \frac{V_n}{\gamma_{m0}}$$

γ_{m0} = partial safety factor against shear failure

The nominal plastic shear resistance under pure shear is given by.

$$V_n = V_p = \frac{A_{vn} f_{yw}}{\sqrt{3}} = \frac{A_v f_{yw}}{\sqrt{3}}$$

A_v = Shear area and.

f_{yw} = yield strength of web.

For rolled section.

$$A_{vn} = h \times t_w$$

$$V_n = \frac{h \times t_w \times f_y}{\sqrt{3}}$$

The design shear strength of beam, = V_d

$$\boxed{V_d = \frac{h\, t_w\, f_y}{\sqrt{3}\, \gamma_{m0}}} \qquad \gamma_{m0} = 1.1$$