

31/01/2020

Design of Column Foundation

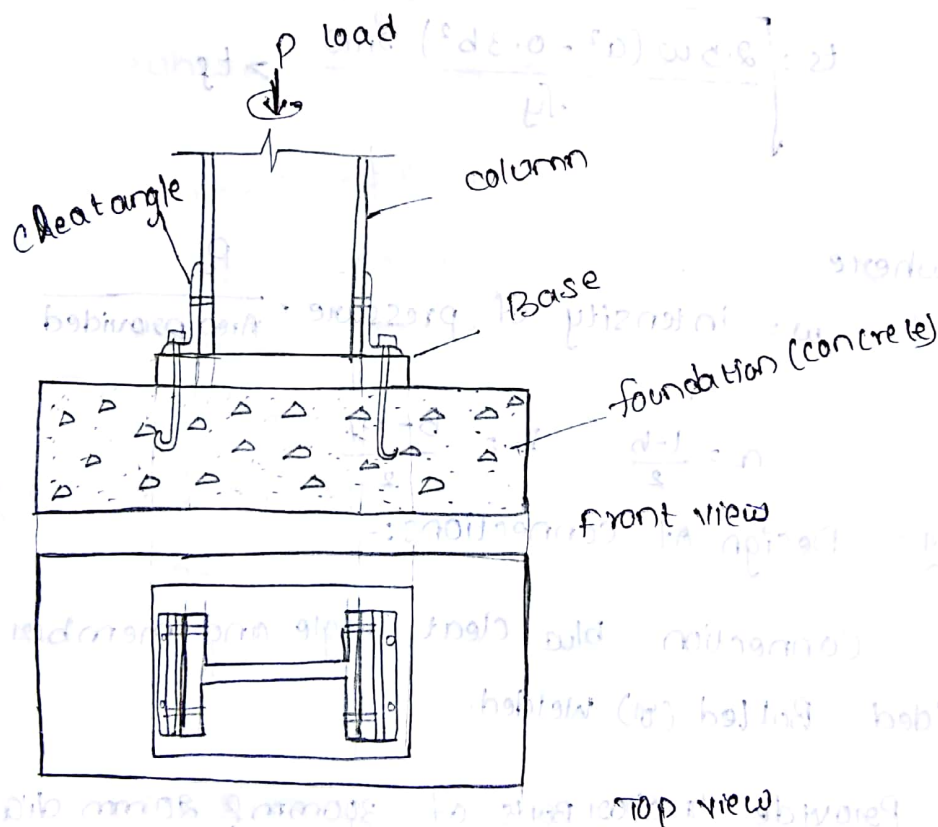
Column bases transmit column load to the concrete & masonry foundation blocks. The column bases spreads the load on a wider area, so that the intensity of bearing pressure on the foundation block is within the bearing strength.

They are two types of column bases commonly used

1) Slab Base.

2) Gusset Base.

1. Slab Base:-



These are used in columns carrying small loads. In this type the column is directly connected to the Base plate through cleat angle as shown in figure. The load is transmitted ^{to} through baseplate through Bearing.

Design procedure of slab base:-

Step-1: Required Area of the Base plate

$$A = \frac{P_u}{0.45 f_{ck}}$$

P_u = Bearing stress

where $0.45 f_{ck}$ is the Bearing strength of the concrete.

f_{ck} = Design characteristic strength of the concrete.

Step-2: Size of Base plate:

$$A = L \times B$$

$$\therefore L = h + 2(30)$$

Step-3:- Thickness of the Base plate:

from clause NO: 7.4.3.1 of IS 800:2007

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

where

w = intensity of pressure = $\frac{P_u}{\text{Area provided}}$

$$a = \frac{L-b}{2} \quad b = \frac{B-b_f}{2}$$

Step-4:- Design of connections:-

Connection b/w cleat angle and member is provided Bolted (or) welded.

Provide Anchor Bolts of 300mm ϕ 20mm dia.

Problem:-

1. Design a slab base of an ISMB column carrying a factored load of 150 kN. Assume Fe410 grade of steel plate & M25 concrete.

Sol Given that

① Assignment - 5
change value
factored load $W = 1500 \text{ kN}$

ISMB 500

$$h = 500 \text{ mm}, t_f = 17.2 \text{ mm}, I_{xx} = 45218.3 \times 10^3 \text{ mm}^4$$

$$b_f = 180 \text{ mm}, t_w = 10.2 \text{ mm}, I_{yy} = 1369.8 \times 10^3 \text{ mm}^4$$

$$r_{xx} = 202.1 \text{ mm}, r_{yy} = 55.2 \text{ mm}.$$

Step-1: Required Area of the Base plate:

$$A = \frac{P_u}{0.45 f_{ck}}$$

where $P_u = 1500 \times 10^3$

$$f_{ck} = 25 \text{ N/mm}^2$$

$$A = \frac{1500 \times 10^3}{0.45 \times 25}$$

$$A = 133.33 \times 10^3 \text{ mm}^2$$

Step-2: size of Base plate:

$$B \times L = A$$

$$L = h + 2(30)$$

$$L = 500 + 2(30)$$

$$L = 560 \text{ mm}$$

$$B \times 560 = 133.33 \times 10^3$$

$$B = 238.08 \text{ mm}$$

$$B = 240 \text{ mm}$$

$$\text{Provided area } A = 560 \times 240 = 134400 \text{ mm}^2$$

Step-3:- Thickness of the base plate:-

$$t_s = \sqrt{\frac{25w(a^2 - 0.3b^2)}{f_y}} \quad \text{mm}$$

$$w = \frac{P_u}{\text{area provided}}$$

$$= \frac{1500 \times 10^3}{134400}$$

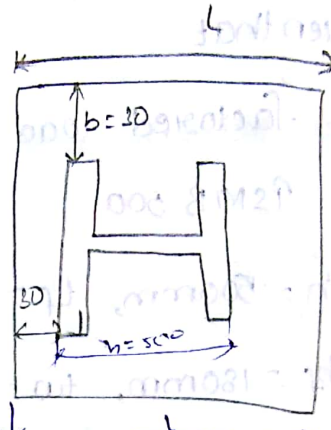
$$w = 11.160 \text{ N/mm}^2$$

$$a = \frac{L-h}{2} = \frac{560-500}{2} = 30 \text{ mm}$$

$$b = \frac{B-b_f}{2} = \frac{240-180}{2} = 30 \text{ mm}$$

$$t_s = \sqrt{\frac{25 \times 11.160 ((30)^2 - 0.3(30)^2)}{250}} \quad \text{mm}$$

$$t_s = 8.7 \text{ mm} \quad (17.2)$$



Assume thickness of base plate $t_s = 20 \text{ mm}$

Step-4: Design connection:-

$$\text{Strength of the weld } (P_w) = \frac{f_u w T}{\sqrt{3} \text{ mm}}$$

Min. Size of the weld = 8 mm

Max. size of the weld = Thickness of thinner plate = 15 mm

$$(0.5) \times 17.2 = 1.5$$

$$= 15.7 \text{ mm}$$

Provide size of the weld (S) = 12 mm

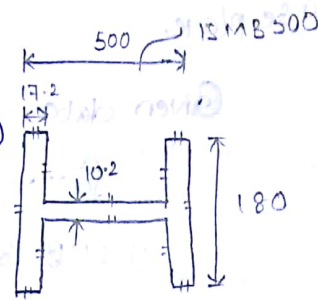
$$\text{Throat thickness } (T) = 0.7 \times 12 = 8.4 \text{ mm}$$

$$1500 \times 10^3 = \frac{410 \times L_w \times 8.4}{\sqrt{3} \times 1.25} \quad \text{mm}$$

$$L_w = 942.97 \text{ mm}$$

Effective length (l_{eff}) = Available length - 2(s) (no. of straight joining (8) NO. of rivets)

$$\begin{aligned} \text{Available length} &= 2(180) + 2(180 - 10.2) \\ &\quad + 2(500 - 17.2) \\ &= 1665.2 \text{ mm} \end{aligned}$$



$$l_{eff} = 1665.2 - 2(12)(12)$$

$$l_{eff} = 1377.2 \text{ mm}$$

$$L_w < l_{eff}$$

Result:

∴ provide length of the weld = 942.97 mm

Provide 4 NO. of anchor bolts of 300 mm length and 20 mm dia.

Result:- under the load 1500 kN

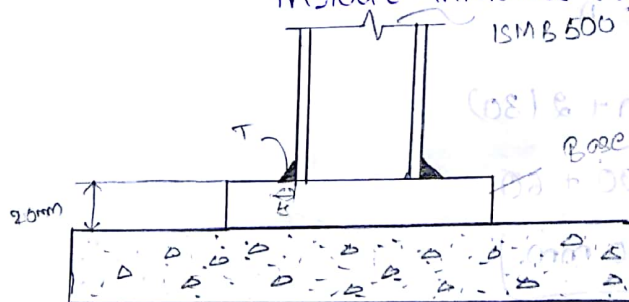
Provide Base plate 560 x 240 x 20

Provide Anchor Bolts of 300 mm long and 20 mm dia.

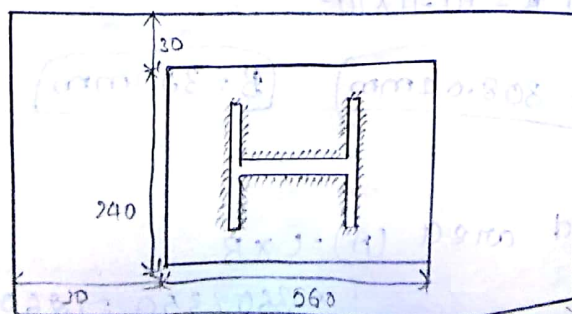
Provide length of the weld ($L_w = 942.97 \text{ mm}$)

Size of the weld (s) = 12 mm

Throat thickness (t) = 8.4 mm



front view



top view

Q. Design a slab base for an ISMB 300 column carrying an axial factored load of 1000 kN. M20 concrete is used for the foundation, provide welded connection between column and base plate.

Given data

Factored load = 1000 kN

ISMB 300

$h = 300 \text{ mm}$, $b_f = 250 \text{ mm}$, $t_f = 10.6 \text{ mm}$, $t_w = 7.6 \text{ mm}$

$I_{xx} = 12345.2 \times 10^4 \text{ mm}^4$; $I_{yy} = 246.7 \text{ mm}^4$

$r_{xx} = 129.5 \text{ mm}$, $r_{yy} = 541 \text{ mm}$

Step-1: Area required:

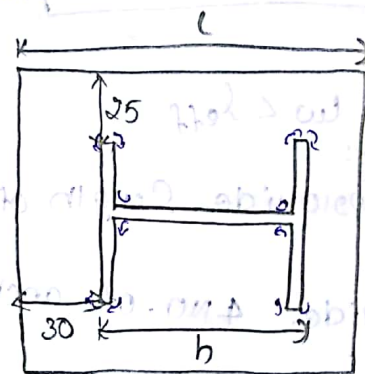
$$A = \frac{P_u}{0.45 f_{ck}}$$

$$P_u = 1000 \times 10^3$$

$$f_{ck} = 20 \text{ N/mm}^2$$

$$A = \frac{1000 \times 10^3}{0.45 \times 20}$$

$$A = 111.11 \times 10^3 \text{ mm}^2$$



Step-2: Size of base plate:

$$B \times L = A$$

$$L = h + 2(30)$$

$$= 300 + 60$$

$$L = 360 \text{ mm}$$

$$B \times 360 = 111.11 \times 10^3$$

$$B = 308.64 \text{ mm}$$

$$B = 350 \text{ mm}$$

Provided area (A) = $L \times B$

$$= 360 \times 350 = 126000 \text{ mm}^2$$

Step-3: Thickness of the base plate:

$$t_s = \sqrt{\frac{0.225 w (a^2 - 0.3b^2) \gamma_{m0}}{f_y}}$$

$$w = \frac{P_u}{\text{Provided area}} = \frac{1000 \times 10^3}{126000} = 7.936 \text{ N/mm}^2$$

$$\text{egf } a = \frac{L-b}{2} = \frac{360-300}{2} = 30 \text{ mm}$$

$$b = \frac{B-D}{2} = \frac{850-300}{2} = 275 \text{ mm}$$

$$t_s = \sqrt{\frac{0.225 \times 7.936 [(30)^2 - 0.3(275)^2] \times 1.1}{250}}$$

$$t_s = 24.939 \text{ mm} \quad t_s \neq t_f (10.6)$$

Assume thickness of base plate $t_s = 20 \text{ mm}$

Step-4: Design connection:

$$\text{Strength of the weld } (P_w) = \frac{f_u l_w T}{\sqrt{3} \gamma_{mw}}$$

min. size of the weld = 3 mm

max. size of the weld = Thickness of Thinner plate ~ 1.5

$$= 20 \times 1.5$$

$$= 30 \text{ mm}$$

provide size of the weld (s) = 12 mm

$$\text{Throat thickness } (t) = 0.7 \times 12 = 8.4 \text{ mm}$$

$$1000 \times 10^3 = \frac{410 \times l_w \times 8.4}{\sqrt{3} \times 1.25}$$

$$l_w = 628.64 \text{ mm}$$

Effective length (l_{eff}) = Available length $- 2(s)$ (No. of straight)

$$\begin{aligned}
 \text{Available length } (l_w) &= 2(b_f) + 2(b_f - t_w) + 2(b_f - t_f) \\
 &= 2(250) + 2(250 - 7.6) + 2(250 - 10.6) \\
 &= 1463.6 \text{ mm}
 \end{aligned}$$

$$l_{eff} = 1463.6 - 2(12)(12)$$

$$l_{eff} = 1175.3 \text{ mm}$$

$$l_w < l_{eff}$$

∴ provide length of the weld = 628.64 mm
 provide 4 no. of anchor bolts of 300mm with dia of 20mm.

- ③ Design a slab base for build up column consisting of 2 ISMC 250 placed back to back by distance of 160mm and factored axial load of column is 1200 kN

Sol Given data

factored load = 1200 kN

2 ISMC 250

= 1200 kN
2 ISMC 250
D = 250 mm, b = 80 mm

D = 250 mm, b = 80 mm, $t_f = 14.1$ mm, $t_w = 7.1$ mm

$I_{xx} = 3816.8 \times 10^4 \text{ mm}^4$, $I_{yy} = 219.1 \times 10^4 \text{ mm}^4$

$r_{xx} = 99.4$ mm, $r_{yy} = 23.8$ mm

Step-1: Area required:-

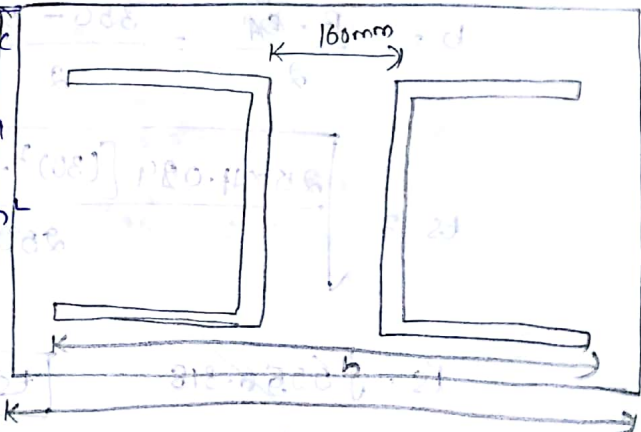
$$A = \frac{P_u}{0.45 f_{ck}}$$

$$P_u = 1200 \times 10^3 \text{ N}$$

$$f_{ck} = 25 \text{ N/mm}^2$$

$$A = \frac{1200 \times 10^3}{0.45 \times 25}$$

$$A = 106.667 \times 10^3 \text{ mm}^2$$



Step-2: Size of Base plate:-

$$B \times L = A$$

$$L = h + 2(30)$$

$$(2 \times 80 + 160)$$

$$= 320 + 60$$

$$L = 380 \text{ mm}$$

$$B \times 380 = 106.667 \times 10^3$$

$$B = \frac{106.667 \times 10^3}{380} = 280.702 \text{ mm}$$

$$B \geq 300 \text{ mm}$$

Provided area (A) = L x B

$$= 380 \times 300 \text{ mm}^2$$

$$A = 114000 \text{ mm}^2$$

Step-3:- Thickness of base plate:

$$t_s = \sqrt{\frac{25w(a^2 - 0.3b^2)}{f_y}} \quad \text{pg: 47}$$

$$w = \frac{P_u}{\text{provided area}}$$

$$= \frac{1200 \times 10^3}{18000}$$

$$w = 0.029 \text{ N/mm}^2$$

$$a = \frac{L-h}{2} = \frac{380 - 320}{2} = 30 \text{ mm}$$

$$b = \frac{B-D}{2} = \frac{350 - 80}{2} = 135 \text{ mm}$$

$$t_s = \sqrt{\frac{25 \times 0.029 [(30)^2 - 0.3(135)^2]}{250}} \times 1.10$$

$$t_s = \sqrt{5556.318}$$

$$t_s = 12.205$$

($\therefore t_s > t_f$)

$$t_s = 74.540 \text{ mm}$$

$$t_s < t_f (14.1)$$

$$t_s < t_f$$

Not satisfy

Assume thickness of base plate, $t_s = 15 \text{ mm}$

Size of the base plate are $380 \times 350 \times 15 \text{ mm}$

Step-4:- Design connections:

$$\text{Strength of the weld } (P_w) = \frac{f_u l_w t_w}{\sqrt{3} \gamma_w}$$

min. size of the weld: 3mm

max. size of the weld: Thickness of thinner plate - 1.5

$$= 14.1 - 1.5$$

$S = 12.6 \text{ mm}$
 Provide size of the weld (s) = 10mm
 Throat thickness $T = k \cdot s$

$$20.7 \times 10^{-6}$$

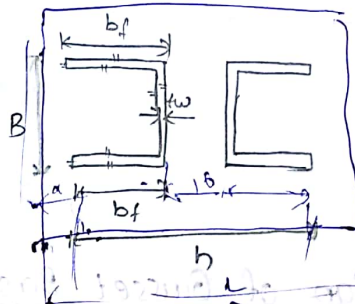
$$T = 8.82 \text{ mm}$$

$$1200 \times 10^3 = \frac{410 \times l_w \times 8.82}{\sqrt{3} \times 1.25}$$

$$l_w = 718.45 \text{ mm}$$

Effective length (l_{eff}) = Available length - $2(s)$ (No. of straight joints)

$$\text{Available length} = 2[2(b_f) + 2(b_f - t_w) + 2(B_f - t_f) + D + (D - 2t_f)]$$



$$= 2[2(80) + 2(80 - 7.1) + 250 + (250 - 2 \times 14.1)]$$

$$a = \frac{L - h}{2} = \frac{1555.2 - 250}{2} = 652.6$$

$$L = 1555.2 \text{ mm}$$

$$l_{eff} = 1555.2 - 2(10)(16)$$

$$l_{eff} = 1235.2 \text{ mm}$$

$$l_w < l_{eff}$$

$\therefore$ provide length of the weld $l_w = 905.25 \text{ mm}$

Provide 4 No. of anchor bolts of 300mm length and 20mm dia.

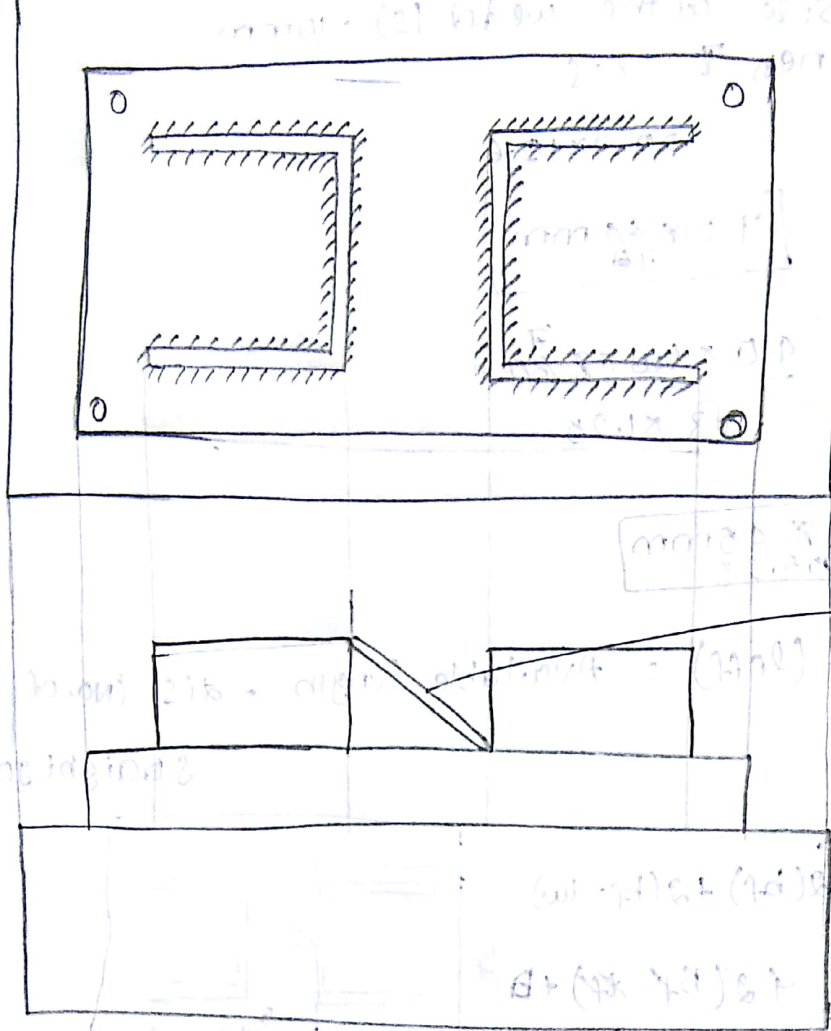
Result:- under the load 1200kN

Provide Base plate $380 \times 250 \times 15 \text{ mm}$

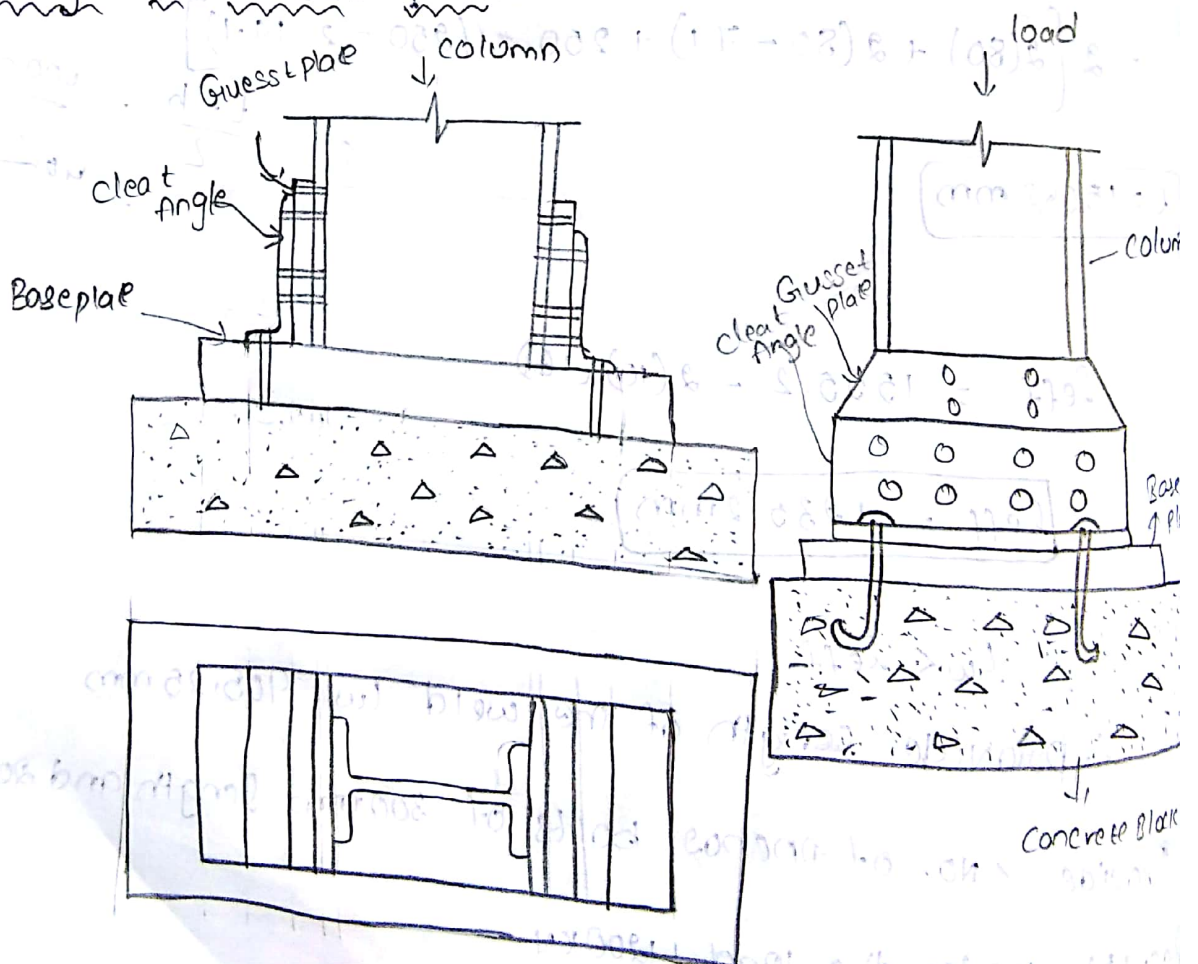
Provide anchor Bolts of 300 mm long and 20mm dia

Provide length of the weld $l_w = 905.25 \text{ mm}$

Size of the weld (s) = 10mm, Throat thickness = 7mm



Design of Gusset Base:-



Design Procedure:-

Step-1: Area required $A = \frac{P_u}{0.45 f_{ck}}$

Step-2: Size of the Base plate:

$$B \times L = A$$

$$L = D + 2(t_g) + 2(t_a) + 2(\text{Angle leg}) + 2(\text{clear length})$$

Provided area $A = B \times L$

Step-3: Moment developing @ critical section

Bearing strength of moment $M_d = 1.2 \times \frac{f_y}{f_{mo}} \times z_e \rightarrow \text{ISNO: 53}$

$$\frac{wL^2}{12} = 1.2 \times \frac{f_y}{f_{mo}} \times \frac{tL}{6}$$

$$t = \frac{6wL^2}{12 \times 1.2 \times f_y}$$

$$t^2 = c \sqrt{\frac{wL^2 \times 2.5}{1.5 f_y}}$$

Step-4: Design of connections:-

$$z_e = \frac{1 \times t^2}{6}$$

(i) welded connection

(ii) Bolted connection.

① Design a Gussset base plate for a column ISHB 350 @ 710 N/mm² carrying with two plates 450 x 20 mm carrying a factored load of 3600 kN. The column is to be supported and concrete pedestal to be built with M20 concrete.

sol) Given data

② Assignment - 5
③ values change

Factored load (P_u) = 3600 kN

ISHB 350 @ 710 N/mm²

$f_{ck} = 20 \text{ N/mm}^2$

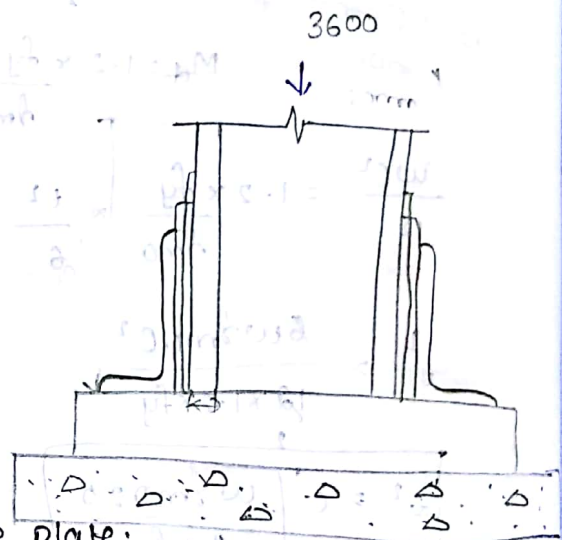
$D = h = 350$, $b_f = 250$, $t_f = 11.6$, $t_w = 10.1$

Step-1:- Area required:

$$A = \frac{P_u}{0.45 f_{ck}}$$

$$= \frac{3600 \times 10^3}{0.45 \times 20}$$

$$A = 400 \times 10^3 \text{ mm}^2$$



Step-2:- Size of the Base plate:

$$B \times L = A$$

$$B = \frac{A}{L}$$

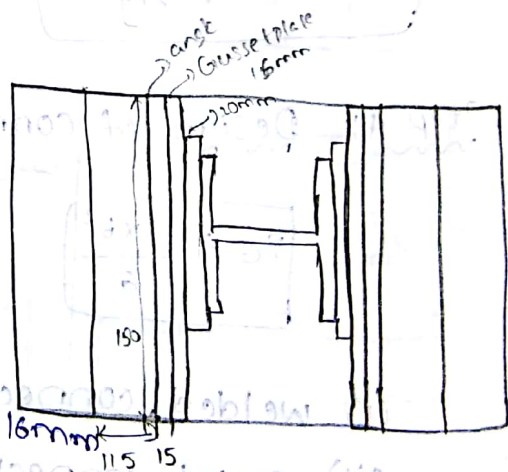
16 10 4 11

where $L = ?$

provide Gussset plate thickness = 16 mm

provide angle 150 x 115 x 5

provide clearance 30 mm on both sides



$$\text{Length of the base plate} = D + 2(t_g) + 2(t_a) + 2(\text{Angle length})$$

$$= 8$$

$$+ 2(\text{clearance})$$

$$= 350 + 2(20 + 16 + 15 + 115 + 30)$$

$$L = 742 \text{ mm}$$

$$L \approx 750 \text{ mm}$$

$$B = \frac{400 \times 10^3}{750}$$

$$B = 539.08$$

$$B \approx 540 \text{ mm}$$

Area provide $A = B \times L$

$$= 540 \times 750$$

$$A \approx 405 \times 10^3 \text{ mm}^2$$

Step-3: Thickness of Base plate

$$t = c \sqrt{\frac{2.5 \times W \times 1 \text{ mm}}{f_y}}$$

where

c = length of critical section

$$c = 115 + 30$$

$$c = 145 \text{ mm}$$

$$W = \frac{P_u}{\text{provided area}}$$

$$= \frac{3600 \times 10^3}{405 \times 10^3}$$

$$W = 8.8 \text{ kN}$$

$$t = 145 \sqrt{\frac{2.5 \times 8.8 \times 1.10}{250}}$$

$$t = 45.113 \text{ mm}$$

$$t \approx 50$$

Step-4: Design connections

$$(\times) \text{ Strength of the weld (Pw)} = \frac{f_u l_w T}{\sqrt{3} l_w}$$

min. size of the weld = 3mm

max. size of the weld = Thickness of the

$$\text{No. of bolts} = \frac{\text{Shear force}}{\text{strength of the single bolt.}}$$

Strength of the bolt:

(i) Shear capacity of the bolt:

from clause no: 10.3.3

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

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

$$A_{nb} = 0.78 \pi / 4 (d)^2$$

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

$$V_{nsb} = \frac{410}{\sqrt{3}} \left[0.78 \times \pi / 4 (20)^2 \right]$$

$$V_{nsb} = \frac{410}{\sqrt{3}} (245.04)$$

$$V_{nsb} = 58.00 \text{ kN}$$

$$V_{dsb} = \frac{58.00}{1.25}$$

$$V_{dsb} = 46.40 \text{ kN}$$

(ii) Bearing capacity of the bolt:

from clause no: 10.3.4

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

$$V_{npb} = 0.25 k_b \cdot d \cdot t \cdot f_u$$

k_b is smaller of following

$$\frac{e}{3d_0} = \frac{30}{3 \times 22} = 0.454$$

$$\frac{p}{3d_0} - 0.25 = \frac{361}{3 \times 22} - 0.25 = 0.265$$

$$\frac{f_{ub}}{f_u} = 1 = \frac{1.025}{0.975}$$

1

$$\therefore k_b = 0.265$$

$$V_{npb} = 2.5 \times 0.265 \times 20 \times 20 \times 410$$

$$V_{npb} = 106 \text{ kN}$$

$$V_{dpb} = \frac{106}{1.25}$$

$$V_{dpb} = 84 \text{ kN}$$

$$\therefore \text{NO. of bolts} = \frac{84 \times 10^3 \times 900}{84}$$

$$\text{NO. of bolts} = 10.$$

$$n = 10 \text{ bolts}$$

