

DESIGN OF COMPRESSION MEMBERS

Many Structural members are in compression, verticle compression members in buildings are called columns, Stanchions, posts. compression members in trusses are called as "struts". The ~~rib~~ of crane which carries compression is called a "Boom"

Buckling class of cross section:- Imperfections of fabrication resulting into ~~essentcity~~ largely depends Upon the cross section of the compression member, based on such imperfection buckling tendency where is. for IS 800-2007 (table-10) (pg-44) gives various cross sections into 4 buckling classes. A, B, C and D.

Slenderness Ratio:- It is defined as ^{the} ~~effem~~ ratio of effective length to it least radius of Gyration, of the section

$$\text{Slenderness Ratio} = \frac{L_e}{r} = \frac{K \cdot L}{r_{\min}}$$

Where K = Factor for effective length depends on end support conditions

(Given by table - 11, Pg-45)

Design compressive stress and strength:- (pg-34, cl-7.1.2)

Design compressive stress (f_{cd}) for axially loaded compression members

$$f_{cd} = \frac{f_y / \gamma_{m0}}{\phi + (\phi^2 - \lambda^2)^{0.5}} \leq \frac{f_y}{\gamma_{m0}}$$

where $\phi = 0.5 [1 + \alpha (\lambda - 0.2) + \lambda^2]$

and $\lambda =$ Non dimensional effective slenderness ratio

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}} = \sqrt{\frac{P_y \left(\frac{KL}{r}\right)^2}{\pi^2 E}}$$

where $f_{cc} = \frac{\phi^2 E}{\gamma_{m0}}$

$f_{cc} =$ Eulers buckling stress

$\alpha =$ Imperfection factor. (given by table-7 Pg-35)

$\gamma_{m0} = 1.1$

The design compressive strength

$$P_d = A_g * f_{cd}$$

Eg:- Determine the design axial load capacity of the column ISHB 300 @ 577 N/m, If the length of the column is 3m and its both ends are pinned.

Sol:-

Given that

ISHB 300 @ 577 N/m

L = 3m, both ends hinged

Step 1:- Data & Assumptions.

ISHB 300 @ 577 N/m, L = 3m

Assume $f_u = 410 \text{ N/mm}^2$, $f_y = 250 \text{ N/mm}^2$

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

Step 2:- Section properties

Sectional Area (A) = 7485 mm²

depth of the section (d) (or h) = 300 mm

breadth of the flange = 250 mm

Thickness of the flange = 250 mm

$r_{min} = 54.1 \text{ mm}$

Step 3:- Buckling class classification (Table-10, pg-44)

$$\frac{b}{b_f} = \frac{300}{250} = 1.2, \quad t_f = 10.6 \text{ mm}$$

buckling about z-z $\rightarrow b - 0.34$ (Pg-35, 1-7)

y-y $\rightarrow c - 0.49$

Step 4:- Design compressive strength (Table-11, pg-30)

$$P_d = A_c * f_{cd}$$

$$f_{cd} = \frac{f_y / \gamma_{m0}}{\phi [\phi^2 - \lambda^2]^{0.5}} \leq \frac{f_y}{\gamma_{m0}}$$

$$\phi = 0.5 [1 + \alpha (\lambda - 0.2) + \lambda^2]$$

" α " from table 47

$$\alpha = 0.34 \quad \text{Table 47}$$

$$\lambda = \sqrt{\frac{f_y}{f_{cc}}}$$

$$f_{cc} = \frac{\pi^2 E}{\left(\frac{KL}{r_{min}}\right)^2} = \frac{\pi^2 \times 2 \times 10^5}{\left(\frac{2000}{54.1}\right)^2} = 841.9 \text{ N/mm}^2$$

$$\lambda = \sqrt{\frac{fy}{f_{cc}}} = \sqrt{\frac{250}{841.9}} = 0.62$$

$$\text{and } \phi = 0.5 [1 + 0.49(0.62 - 0.2) + 0.62^2]$$

$$\phi = 0.79$$

$$f_{cd} = \frac{\frac{250}{1.1}}{0.79(0.79^2 - 0.62^2)^{0.5}} = 186.48 \text{ N/mm}^2$$

$$\text{design strength } P_d = 7485 \times 186.4 = 1418.15 \text{ kN}$$

$$\text{Applied load (or) working load} = \frac{1418.15}{1.5} = 945 \text{ kN}$$

(or)

Method (2):- Design compressive strength (P_d) (cl-3.1.2 pg-34)

$$P_d = A_c \times f_{cd}$$

$$\text{from table 9(b)}; f_{cd} = ? \rightarrow \frac{KL}{r_{min}} = \frac{1 \times 2000}{54.1}$$

$$\frac{KL}{r_{min}} = 55.45 \text{ refer}$$

$$fy = 250 \text{ N/mm}^2$$

table 9(b):-

$\frac{KL}{r}$	f_{cd}
50	194
55.45	?
60	181

$$f_{cd} = 186.9 \text{ N/mm}^2$$

$$\therefore P_d = 7485 \times 186.9 = 1398.9 \text{ kN}$$

$$\therefore \text{Working load} = \frac{1398.9}{1.5} = 932.2 \text{ kN}$$

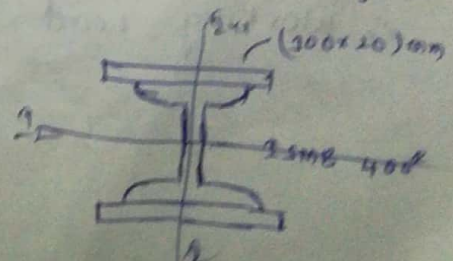
- * Determine the load carrying capacity of the column shown in figure if its actual length is 4.5 m. Its one end may be assumed to be fixed and other end hinged. assume necessary Data.

Given data is

Isma 400

actual length = 4.5 m.

fixed - hinged



Step 1:- Data & Assumptions

ISMB 400 section, $L = 4.5m$

Assume $f_u = 410 \text{ N/mm}^2$, $f_y = 250 \text{ N/mm}^2$

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

Step 2:- Sectional properties

ISMB 400 : $h = 400 \text{ mm}$, $b_f = 140 \text{ mm}$, $t_f = 16 \text{ mm}$

$t_w = 8.9 \text{ mm}$, $A = 7846 \text{ mm}^2$, $I_{zz} = 20458.4 \times 10^4 \text{ mm}^4$

$$I_{yy} = 422.1 \times 10^4 \text{ mm}^4$$

Step 3:- Buckling classification "c"

$$\lambda_{eff} = 20458.4$$

For Builtup section, I_{zz} , I_{yy}

$$I_{zz} = 20458.4 \times 10^4 + 2 \left[(300 \times 20) \times 210^2 \right]$$
$$= 733.78 \times 10^6 \text{ mm}^4$$

$$I_{yy} = 422.1 \times 10^4 + 2 \left[\frac{20 \times 300^3}{12} \right] = 94.22 \times 10^6 \text{ mm}^4$$

$$I_{yy} < I_{zz}$$

Step 4:-

$$r_{min} = \sqrt{\frac{I_{yy}}{A}} = \sqrt{\frac{94.22 \times 10^6}{(7846 + 2(300 \times 20))}}$$

$$\therefore r_{min} = 68.9 \text{ mm}$$

$$\frac{KL}{r} = \frac{0.8 \times 4500}{68.9} = 52.23$$

$$f_y = 250 \text{ N/mm}^2$$

$K = 0.8 \rightarrow$ for
given sup

$$P_d = A_c \times f_{cd}$$

$$P_d = 19846 \times 179.64$$

$$\therefore P_d = 3565.13 \text{ kN}$$

$$\therefore \text{Working Load} = 2376.75 \text{ kN}$$

$$50 \rightarrow 183$$

$$52.24 \rightarrow ? 179.64$$

$$60 \rightarrow 168$$

$$\textcircled{1} - 0 \rightarrow 10$$

$$\textcircled{2} - 0 \rightarrow 2.24 \times (2 - 11)$$

$$-33.6 = 10 \times -11$$

$$f_{cd} = 179.64 \text{ N/mm}^2$$

DESIGN OF COMPRESSION MEMBERS:-

* (i) Design stress in compression is to be assume.

(a) For rolled steel beam section the slenderness ratio where λ is 70 to 90. Hence corresponding design stress assumed to be 185 N/mm²

(b) Angle struts slenderness ratio varies 110 to 180 corresponding design stress assumed to be 90 N/mm²

(c) Large members are built up members due to consider 200 N/mm²

(ii) Effective sectional area required

$$P_d = A_c \cdot f_{cd} \Rightarrow A_c = \frac{P_d}{f_{cd}}$$

(iii) choose (or) select a section corresponding to required effective area depend on $\frac{KN}{R}$ an end condition check the section feasible (or) Not. for; with respect to the applied load (or) given load.

* A column 4m long has to support a factored load of 6000 KN. The column is effectively held at both ends and restrained in direction at one of the end. design the column using beam section and plate.

Sol:-

Steps:- Assume the design stress in compression.

assume $f_{cd} = \underline{200 \text{ N/mm}^2}$

$$A_c = \frac{P_d}{f_{cd}} = \frac{6000 \times 10^3}{200} = \underline{30,000 \text{ mm}^2}$$

Section properties of ISHB @ 450

$$\text{Sectional area (A)} = 117.89 \text{ cm}^2 = 11789 \text{ mm}^2$$

$$b_f = 250 \text{ mm}$$

$$t_w = 11.3 \text{ mm}$$

$$t_f = 13.7 \text{ mm}$$

$$\text{Total Area of section} = 30000 - 11789 = \underline{18211 \text{ mm}^2}$$

Select 20 mm plates

$$26 \times 20 = 18211$$

$$\therefore b = 455 \text{ mm}$$

choose (500x20) mm plates

breadth of the plate $b_p = 500$

thickness of the plate $t_p = 20$

$$= \frac{b_p - b_f}{t_p} = \frac{500 - 250}{20} = 12.5$$

$$\frac{KL}{r} = \frac{0.8 \times 4000}{r}$$

where $r = \sqrt{\frac{I_{yy}}{A}}$

for builtup section :-

$$I_{yy} = 3045.0 \times 10^4 \text{ mm}^4$$

$$I_{xx} = 40349.9 \times 10^4 \text{ mm}^4$$

$$I_{yy} = 3045.0 \times 10^4 + 2 \left[\frac{20(500)^3}{12} \right]$$

$$= 447.11 \times 10^6 \text{ mm}^4$$

$$Area = 11789 + (2(500 \times 20)) = 31789 \text{ mm}^2$$

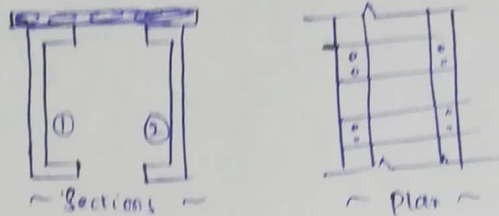
$$r = \sqrt{\frac{447.11 \times 10^6}{31789}} = 11.85$$

$$\Rightarrow \frac{KL}{r} = \frac{3200}{11.85} = 26.82$$

(pg-42)

- * The objective of providing lateral system is to keep the member of the column away from principle axis then the lacing are subjected to shear force due to horizontal force on column.

battens :- Instead of lacing we can use battens to keep member of column at required distances.



DESIGN OF LACED COLUMNS :- As per code IS 800-2007 (Pg-48, cl-7.6)

- * The thickness of flat lacing bars, shall not be less than $\frac{1}{40}$ times of its effective length for single lacing, and $\frac{1}{600}$ times of its effective length for double lacing. (7.6.3)
- * Lacing bars shall be placed ~~at~~ inclined at 40° to 70° to the axis of the built up member. (7.6.4)
- * The distance b/w the two main members should be kept, as to get " $r_{yy} > r_{zz}$ " (7.6.5)
- * Maximum spacing of lacing bars shall be such that the maximum slenderness of the main member b/w consecutive lacing connections is not greater than 50 (or) 0.7 times the most unfavorable slenderness ratio of member as a whole. (6.5.1 or 7.6.5.1)
- * The Lacing shall be designed to resist transverse shear (V_t) is equal to 2.5% axial force in the column, If there are two transverse parallel system then each system has to resist " $\frac{V_t}{2}$ " shear force. (7.6.5.2)
- * If the column is subjected to bending also (V_t) then the transverse shear = bending shear + 2.5% axial force.
- * Effective length of single laced system is equal to length b/w the inner end fastener. (7.6.6.1) for welded joints and double laced, effectively connected.

at intersection, effective length may be taken as 0.7 times of the actual length

* The slenderness ratio " $\frac{KL}{r}$ " for lacing bars should not exceeds 145 (7.6.6.3)

* The effective length or slenderness ratio ($\frac{KL}{r}$) of laced columns shall be taken as "1.05" times the actual maximum slenderness ratio, in order to account for shear deformations effects. (7.6.1.1)

DESIGN OF BATTENS:- (CI- 7.7, Pg-54)

* B

Problems on Laced columns - Design:-

- * Design a laced column with two channels back to back of length 10 m, to carry an axial factored load of 1400 kN. the column may be assumed to have restrained in position but not in direction at both ends

Sol:-

Step 1:- design of channel section

Assume $f_{cd} = 135 \text{ N/mm}^2$

$$\text{Area required (A}_c) = \frac{P_d}{f_{cd}} = \frac{1400 \times 1000}{135}$$

$$\therefore A_c = 10370 \text{ mm}^2$$

Take ISMC @ 350 ; 49.4 kN/m

Area provided = $2 \times 5366 = 10732 \text{ mm}^2$, $r_{zz} = 136.6$

distance will be maintained so as to get $r_{yy} \geq r_{zz}$

$$\text{actual } \frac{KL}{r} = \frac{1 \times 10000}{136.6} = 73.206 \quad (\text{for built up section})$$

$$\text{Since it is laced column } \frac{KL}{r} = 1.05 \times 73.206 = 76.87$$

from table. (9cc) pg-42 - from buckling class 'C'

by interpolation $f_{cd} = 141 \text{ N/mm}^2$ (pg-42)

(a) load carrying capacity of laced column

$$P_d = f_{cd} \times \text{Area}$$

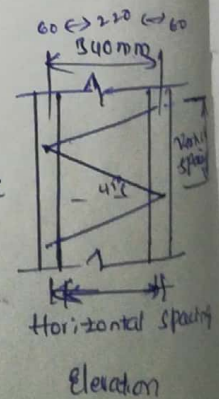
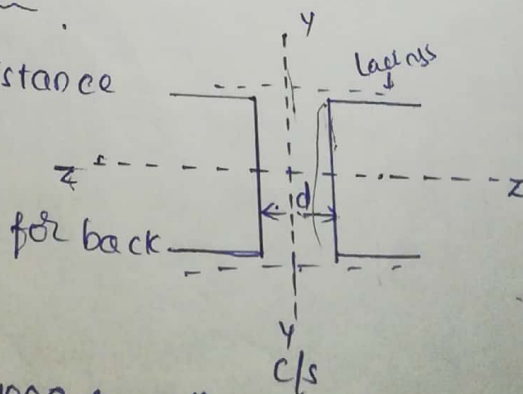
$$P_d = 141 \times 10732 = 1513.2 > 1400 \text{ kN}$$

Hence the design load carrying capacity is good

(b) Spacing b/w the channels:-

Let 'd' be 'clear distance b/w channels.

For built up section to back channels,



$$I_{xx} = I_{zz} = 2 \times 10008 \times 10^4$$

$$= 20016 \times 10^4 \text{ mm}^4$$

$$I_{yy} = 2 \left[430.6 \times 10^4 + 5366 \left(\frac{d}{2} + 24.4 \right)^2 \right]$$

$$1 \times 1 = 344$$

$$2 \left(430.6 \times 10^4 + 5266 \left(\frac{d}{2} + 244 \right)^2 \right) = 20016 \times 10^4$$

$$\left(\frac{d}{2} + 244 \right)^2 = 17848.3$$

$$\therefore \boxed{d = 218.4 \text{ mm}}$$

take distance as b/w two channel sections back to back
 $\boxed{d = 200 \text{ mm}}$

design of Lacing:-

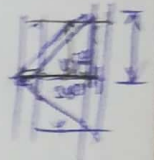
Let Lacing can provided 45° horizontal and that horizontal distance of the lacing = $220 + 60 + 60 = 340 \text{ mm}$

$$\text{Vertical spacing} = 340 \tan 45^\circ \times 2 = 680 \text{ mm}$$

$$\text{ryy of minimum of channel} = 28.3 \text{ mm}$$

$$\text{from that } \frac{KL}{r} \text{ channel } = 25.53$$

$$\frac{KL}{r} = \frac{680}{28.3} = 24.02$$



Transverse shear resisted by Lacing systems

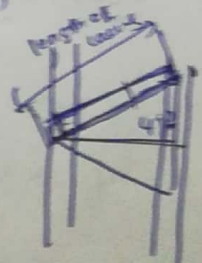
$$= 2.5\% \text{ Actual force}$$

$$\text{Shear to be resisted by each Lacing system} = \frac{35000}{2} = 17500 \text{ N}$$

$$\text{Length of Lacing} = 340 \times \frac{1}{\cos 45^\circ} = 480.83 \text{ mm}$$

$$(\text{or}) \boxed{(AP)^2 = (OP)^2 + (A)^2}$$

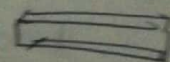
$$\therefore \text{thickness of lacing} = \frac{1}{40} \times 480.83 = 12.02 \text{ mm}$$



$$\therefore \text{Width of Lacing} = 3 \text{ times (*) Nominal dia of bolting (or) riveting} \\ = 3 \times 20 = 60 \text{ mm}$$

Lacing^{asth} choose indian standard (IS) flats - "60mm" ISF

1/4 L



- * Design a Battend column with two channels back to back of length 10m, to carry an axial factored load of 1000 kN. the column may be assumed to have restrained in position ~~and~~ also in direction at both ends.

Sol:-

Step 1:- design of channel section

Assume $f_{cd} = 135 \text{ N/mm}^2$

$$\text{Required Area } (A_c) = \frac{P_d}{f_{cd}} = \frac{1000 \times 1000}{135} = 7407.4$$

$$\therefore A_c = 7407.4 \text{ mm}^2$$

take ISMC @ 400 ; 494 N/m

$$\text{provided Area} = 2 \times 6293 = 12586 \text{ mm}^2$$

$$r_{zz} = 136.6 \text{ mm}$$

distance will be maintained so as to get $r_{yy} > r_{zz}$

$$\text{actual } \frac{KL}{r} = \frac{0.65 \times 10000}{136.6} = 47.58 \text{ (for battup case)}$$

$$\text{for battens } 1.1 \times \frac{KL}{r} = 1.1 \times 47.58 = 52.33$$

Properties of ISMC @ 400 @ 494 N/m is

depth of the section (h) = 400 mm

width of the flange (b) = 100 mm

thickness of the flange (t_f) = 15.2 mm

thickness of the web (t_w) = 8.8 mm

Table 9(c) - Pg-42

$$\therefore f_{cd} = 191 \text{ N/mm}^2$$

Load Carrying Capacity :-

$$P_d = f_{cd} \times \text{Area}$$

$$P_d = 191 \times 7407.4$$

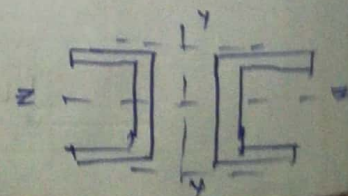
$$P_d = 1414.8 \text{ kN} > 1000 \text{ kN}$$

Hence the design load carrying capacity is high hence section can be safe against load carrying.

Spacing b/w the two channels :-

Let "d" be the clear distance b/w two channels.

$$I_{xx} = I_{zz} = 15082.8 \times 10^4 \text{ mm}^4$$



$$I_{yy} = 2 \left[430.6 \times 10^4 + 6293 \left(\frac{d}{2} + \frac{24.2}{2} \right)^2 \right]$$

We know that $I_{xx} = I_{yy}$

$$\frac{(15082.8 \times 10^4) - (430.6 \times 10^4)}{2 \times 6293} = \frac{d}{2} + 24.2$$

$$11641.66 = \frac{d + 48.4}{2}$$

$$d = 236.7 \approx 240 \text{ mm}$$

Design of battens :-

Let "c" be spacing of battens longitudinally, for that

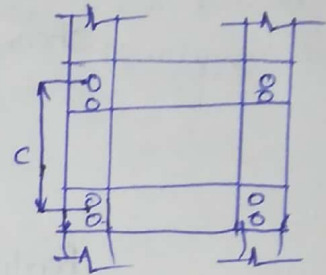
Radius of Gyration of channel section = 23.8 mm

2 back to back I_{smc}^{250} @ 297.2 N/m

$$\frac{KL}{r} = 1.1 \times \frac{0.65 \times 10000}{23.8} = 71.9$$

$$(i) \frac{c}{23.8} \leq 50 \Rightarrow c \leq 1190 \text{ mm}$$

$$(ii) \frac{c}{23.8} < 0.7 \times 71.9 < 1197.8 \text{ mm}$$



Let us consider 1100 mm as distance b/w batten to batten

$$\therefore c = 1100 \text{ mm}$$

$$\text{transverse shear } V_t = \frac{2.5}{100} \times 1000 \times 10^3 = 25000 \text{ N}$$

$$V_b = \frac{V_t c}{N s} = \frac{25000 \times 1100}{2 \times 230} = 59782.60$$

Where

V_t = transverse shear force

c = distance b/w c/c of battens longitudinally,

N = Number of parallel planes of battens.

s = Minimum transverse distance b/w centroid of rivet/bolt connecting of battens to the main member.

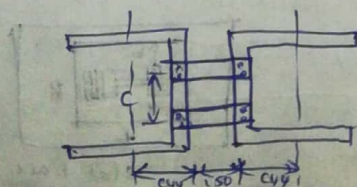
$$\text{Bend-Moment } (M) = \frac{V_b \cdot c}{2N} = \frac{25000 \times 1100}{2 \times 2}$$

$$M = 6875000 \text{ N-m}$$

Size of the batten :-

effective depth of end batten

$$< (150 + 2(23)) = 196$$



∴ Let us take effective depth = 210 mm

for intermittent battens

$$\text{effective depth} \leq \frac{3}{4} \times 196 = 147 \text{ mm}$$

∴ provide effective depth of ~~and~~ ^{intermittent} battens = 160 mm

give edge distance = 40 mm

∴ overall depth of battens = 240 mm

∴ Thickness of the batten shall not be less than $\frac{1}{50}$ th of c/c dist.

$$T \leq \frac{1}{50} \times 230 \leq 4.6$$

take 8 mm thickness of batten plates

check for stresses in batten plates:-

$$\text{shear stress} = \frac{59782}{8 \times 210} = 35.5 \text{ N/mm}^2$$

$$< \frac{f_y}{\sqrt{3}} \times \frac{1}{1.1} = 131.21 \text{ N/mm}^2 \quad \text{①}$$

$$\text{Bending stress} = \frac{6 \times M}{t \times d^2} = \frac{6 \times 6875000}{8 \times 210^2}$$

$$= 116.92 \text{ N/mm}^2 < \frac{f_y}{1.1} \times 1.2 = 272.72 \text{ N/mm}^2$$

∴ The designed battens are safe against bending and shear.

Column Bases :-

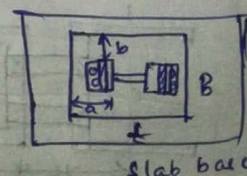
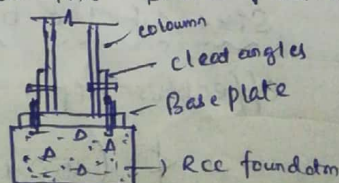
Column bases transmit the column load to the concrete or masonry foundation work. The column base spreads the load on wider area, so that the intensity of bearing pressure on the foundation block is within the bearing strength. ②

There are 2 types of column bases

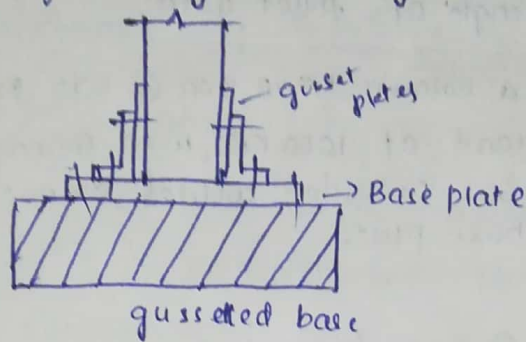
① Slab base

② Gusseted base.

Slab base:- These are used in columns to carrying small loads. The column is directly connected to the base plate through cleat angles. As shown in figure the load is transferred to the base plate through bearing



Gusseted Base :- For column carries heavy loads gusseted bases are used. In this the column is connected to base plate through gussets. The load is transferred to the base partly through bearing and partly through gussets.



DESIGN OF SLAB BASE :-

The design of slab base consist in finding the size and thickness of slab base. In the procedure given below it is assumed that the pressure is distributed uniformly under the slab base.

① Step 1 :- Size of base plate

find the bearing strength of concrete by $0.45 f_{ck}$

Step 2 :- Area of base plate required

$$A_{\text{base plate}} = \frac{P_u}{0.45 f_{ck}} \quad (P_u = \text{factored load})$$

Step 3 :- Select the size of the base plate

for economy as far as possible the projections a and b are equal.

② Thickness of the base plate

Step 1 :- find the intensity of pressure

$$w = \frac{P_u}{\text{Area of base plate}}$$

Step 2 :- minimum thickness of base plate

$$t_s = \sqrt{\frac{2.5 w (a^2 - 0.36 r^2) \gamma_{mo}}{f_y}} > t_f$$

t_s = thick of base plate

t_f = thickness of flange of ^{column} section of column

③ connections

Step 1 :- connect base plate to foundation concrete using $\#4$, $\phi 20$ mm and 300 mm long anchor Bolts.

Step 2:- If bolted connection is to be used for connecting column to base plate Use #2, ISA 65x65x6 mm

Step 3:- If weld is to be used for connecting column to base plate, check the weld length of fillet weld.

- ① Design a slab base for a column ISHB 300 @ 577 N/m carrying an axial factored load of 1000 kN, M20 concrete can be used for the foundation, provided welded connection b/w the column and base plate.

Sol:- Given data is

ISHB 300 @ 577 N/m

Factored Load (P_u) = 1000 kN.

Grade of Concrete (f_{ck}) = 20 N/mm²

Assume (F_e) = 410 N/mm²

Step 1:- ~~Bearing Strength~~ Size of the base plate.

(i) Bearing Strength of concrete = $0.45 f_{ck}$
 $= 0.45 \times 20 = 9 \text{ N/mm}^2$

(ii) Area of base plate required.

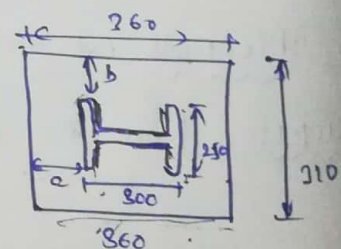
$$A_{\text{base plate}} = \frac{P_u}{0.45 \times f_{ck}}$$

$$A_b = \frac{1000 \times 10^3}{0.45 \times 20} = 11111 \text{ mm}^2$$

(iii) Select the size of the plate

choose 360 mm x 310 mm base plate

provided
 $\therefore$ Area = 111600 mm²



$$a = \frac{360 - 300}{2} = 30$$

$$b = \frac{310 - 250}{2}$$

Step 2:- Thickness of base plate

(i) Intensity of pressure

$$w = \frac{P_u}{\text{Area of base plate}} = \frac{1000 \times 10^3}{360 \times 310}$$

$$w = 80.96 \text{ N/mm}^2$$

(ii) minimum thickness of base plate

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

$$t_s = \left[\frac{2.5 \times 8.96 \times (30^2 - 0.3 \times 30^2) \times 101}{250} \right]^{0.5} > 10.6$$

$$t_s = 7.88 \text{ mm} > 10.6$$

choose t_f as 12 mm thickness

Base plate (360 x 310 x 12)

step 3:- connections.

(i) connect base to foundation concrete using

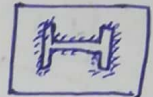
#4, 20 mm ϕ and 300 mm long anchor bolts.

(ii) connection of column to base plate using fillet welds

total length available for welding

$$= 2 \cdot (250 + 250 - 7.6 + 300 - 2 \times 10.6)$$

$$= 1542.4 \text{ mm}$$



$$(iii) \text{ Strength of weld} = \frac{f_u}{\sqrt{3} \times \gamma_{mw}} = \frac{410}{\sqrt{3} \times 1.25} = 189.37 \text{ N/mm}^2$$

Let 'S' be the size of the weld, the effective area of weld

Area (C) of steel

$$\text{eff Area} \geq 0.7 \times S \times L_e \times \text{eff stress} = \text{load}$$

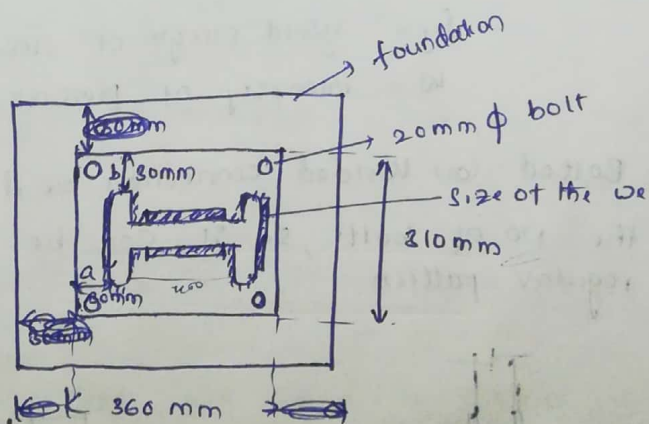
where L_e = eff length

provide $S = 6 \text{ mm}$

$$0.7 \times 6 \times L_e \times 189.37 = \text{Load}$$

$$\therefore L_e = \frac{1000 \times 10^3}{0.7 \times 6 \times 189.37} = 1257.3 \text{ mm}$$

Diagram:-



Gusset base design :-

Step 1:- Assume suitable grade of concrete, if not given.

(i) The bearing strength of concrete = $0.45 \times f_{ck}$

(ii) The area required of base plate is $(A) = \frac{P U}{0.45 \times f_{ck}}$

Step 2:- The size of the base plate is calculated from the following

(a) The gusset plate should not be less than 16 mm

(b) Dimension of base plate parallel to the web can be calculated as

$$L = \text{depth of section (d)} + 2 * (\text{thickness of gusset plate} + \text{leg length of angle} + \text{over hang})$$

(for bolted connection)

(for welded connection) $L = \text{depth of section (d)} + 2 (\text{thickness of gusset plate} + \text{over hang})$
and other dimension of plate $B = \frac{\text{Area (A)}}{\text{length (L)}}$

Step 3:- The intensity of bearing pressure (W) from the base concrete is calculated as

$$W = \frac{P}{\text{Area of base plate}}$$

The thickness of base plate is computed by equating the moment at the critical section to the moment of resistance of the gusset at the section.

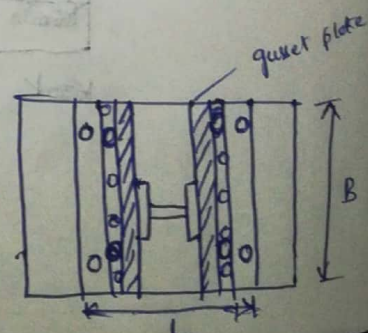
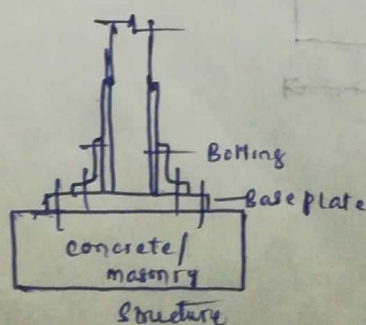
$$t = c_1 \sqrt{\frac{2.7 W}{f_y}}$$

where c_1 = the portion of base plate acting as cantilever in (mm)

f_y = yield strength of steel.

W = intensity of pressure.

Step 4:- Bolted (or) welded connections or designs are made with the no of bolts, so it can be provided by in regular pattern.



- * Design a gusseted base for a column ISHB 350 @ 710 N/m with 2 plates of size 450 mm * 20 mm carrying a factored load of 2500 kN. The column is to be supported on a concrete pedestal with M20 grade of concrete?

Soln-

Given data is:

Column ISHB 350 @ 710 N/m

2 Gusset plates = 450 mm x 20 mm

Factored load = 2500 kN = (P_u)

f_{ck} = 20 N/mm²

Properties of ISHB 350 @ 710 N/m

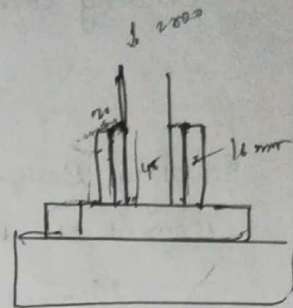
A = 9221 mm²

h = 350 mm

b_f = 250 mm

t_f = 11.6 mm

t_w = 10.1 mm



Step 1:-

$$\text{Area of base plate} = \frac{P_u}{0.45 f_{ck}} = \frac{2500 \times 10^3}{0.45 \times 20} = 277777 \text{ mm}^2$$

$$\text{Total sectional area (A)} = 9221 + 2(450 \times 20)$$

$$(A) = 27221 \text{ mm}^2$$

Assume 16 mm Gusset plates on both sides of the column

$$\text{Length of base plate} = 350 + 2(20 + t_f) = 422$$

∴ Let us take "50 mm" cover on both sides

∴ Take the base plate "550 x 550 mm"

$$\therefore \text{provided area} = 302500 \text{ mm}^2$$

Step 2:- Thickness of base plate

Bearing strength of concrete

$$w = \frac{2500 \times 10^3}{550 \times 550} = 8.26 \text{ N/mm}^2$$

$$\text{Moment @ } x-x = \frac{8.26 \times 642}{2} = 16916.48 \text{ N-mm}$$

$$\text{Reaction at } P/2 = \frac{wL}{2} = \frac{8.26 \times 550}{2}$$

$$= 2271.25 \text{ N}$$

$$\text{moment about } y-y = \frac{8.26 \times 275^2}{2} = (2271.25 \text{ N})$$

$$= -85181.25 \text{ N-mm}$$

Designed Bending moment

$$= 85181.25 \text{ N-mm}$$

$$\text{Bending strength} = \frac{f_y}{\gamma_{m0}}$$

$$= \frac{250}{1.1} = 227.27 \text{ N/mm}^2$$

Equating Design bending moment to the moment of Resistance

$$\text{Moment of Resistance} = \frac{1.2 f_y Z_e}{\gamma_{m0}}$$

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

$$\text{Moment of Resistance} = \frac{1.2 \times 250}{1.1} \times \frac{t^2}{6}$$

$$45.45 t^2 = 85181.25$$

$$\therefore \text{required } t = 43.28 \text{ mm}$$

$$\therefore \text{Base plate} = 550 \times 550 \times 50 \text{ mm}$$

Step 3 - Connections

① connection b/w base plate & foundation

#4, 20mm ϕ , 300mm long anchor bolts

② connecting gusset plate with section

$$\text{Strength of the weld} = \frac{f_u}{\sqrt{3} \gamma_{m0}} = \frac{410}{\sqrt{3} \times 1.1} = 189.37 \text{ N/mm}^2$$

Min size of the weld = 5mm (20mm thick)

Take size of the weld = 6mm

Connecting Gusset plate of column

$$\text{Strength of the weld} = \frac{f_u}{\sqrt{3} \gamma_{m0}} = \frac{410}{\sqrt{3} \times 1.1} = 189.37 \text{ N/mm}^2$$

Size of the weld = 6mm

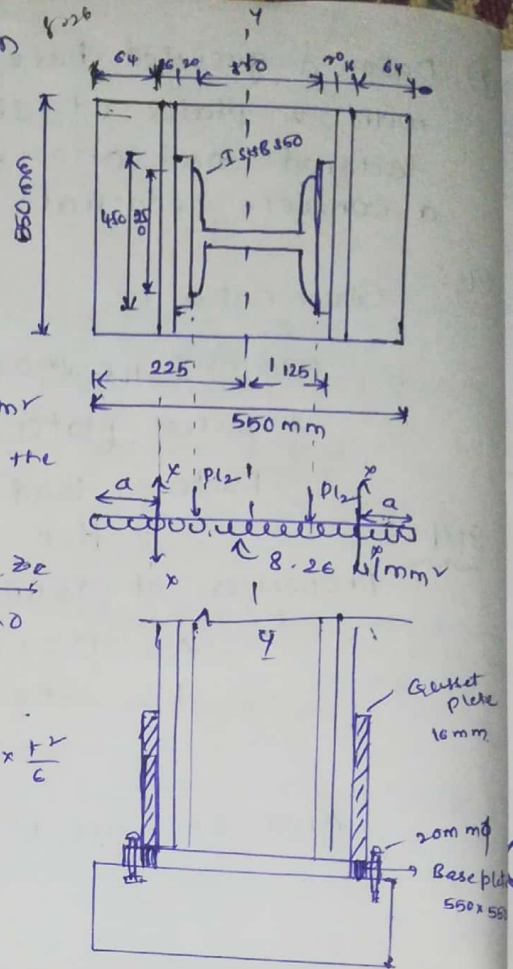
$$\text{Available length of the weld} = 550 + 2(300) = 1150 \text{ mm}$$

Height of the gusset plate 300mm

$\therefore$ Load on gusset plates = 50% of axial load

$$= \frac{2500}{2} = 1250 \text{ kN}$$

$$\text{Load on each gusset plate} = \frac{1250}{2} = 625 \text{ kN}$$



Strength of the weld = $0.7 \times 8 \times L_e \times 189.37 = 625 \text{ kN}$

$L_e = 785.1 \text{ mm}$

connecting column with base plate

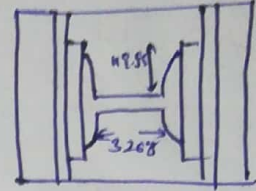
available length of weld = $2 [3268 + 250 - 10.1] + 200$

= 1533.4 mm

Required length of weld, $(L_e) = \frac{P}{A}$

$189.37 = \frac{1260 \times 10^3}{0.7 \times 8 \times L_e}$

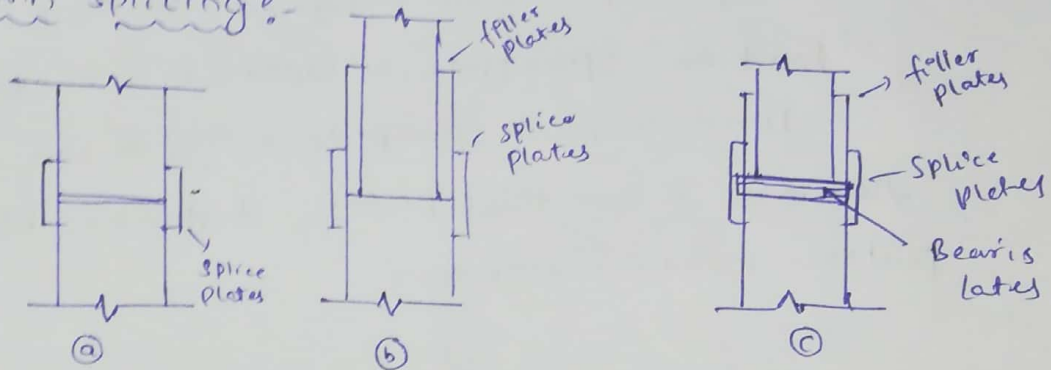
$L_e = 1571.62 \text{ mm}$



We can use extra welding length from the gusset plate connection (350 mm)

Hence we can provide 6 mm size of weld through out the circumference of the gusset base column section

* column splicing:-



* An upper storey column ISHB 300 @ 577 N/m carries a factored load of 1200 kN and factored moment of 12 kNm. It is to be spliced with lower storey column, ISHB 400 @ 806 N/m. Design a suitable splice.

Sol:-

Steps:- design of bearing plate

Assuming that the column load is transferred by flanges only

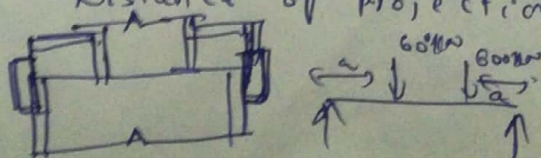
Load on each flange = $\frac{1200}{2} = 600 \text{ kN}$

e/c Distance b/w two flanges = $300 - 10.6 = 289.4 \text{ mm}$ of column 1

e/c distance b/w two flanges = $400 - 12.7 = 387.3 \text{ mm}$ of column 2.

Distance of Projection $(e) = \frac{387.3 - 289.4}{2}$

= 48.95 mm



$$\text{Design bending stress} = \frac{f_y}{\gamma_{mo}} = \frac{250}{1.1} = 227.27 \text{ N/mm}^2$$

equating moe with Bending moment

MOR = Section modulus * stress

$$= \frac{bt^2}{6} * f_{br} = M$$

$$= \frac{250 \times t^2 \times 227.27}{6} = 600 \times 48.95 \times 10^3$$

$$t = 55.69 \approx 56 \text{ mm}$$

Take the bearing plate of $250 \times 400 \times 56 \text{ mm}$

(ii) Design of splice plate :-

column ends are milled for complete bearing
Hence on splice plates are designed for 50% of axial load

$$\text{Load on splice plate} = 1200 \times 0.5 = 600 \text{ kN}$$

$$\text{Load on each splice plate} = \frac{600}{2} = 300 \text{ kN}$$

Assume 6 mm thick plates, distance b/w splice plates = $400 + 6 = 406 \text{ mm}$