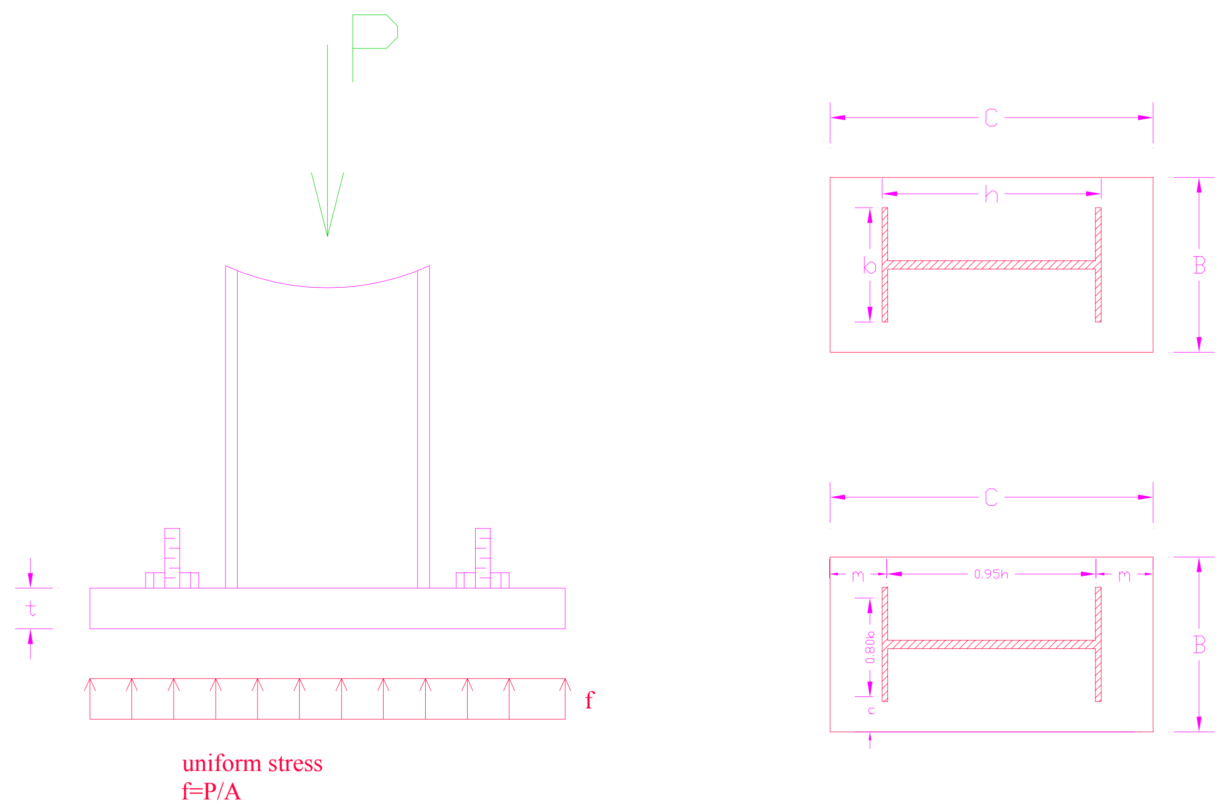
Analysis and Design of Basis

Base Plate

I - Axially Loaded Column :

Length (C) & Width(B) of base plate



In columns subjected to axially compression force (P) , the stress under the base plate of dimensions (C x B) is uniformly distributed and equal to

f = P/A where

f is the actual bearing stress under base plate
P is the design compression load
A is the area of base plate in contact with concrete = C x B

Since the allowable bearing stress for concrete (Fp) must be $\geq$ actual bearing stress (f)
Then $Fp \geq f = P/A$

Knowing that $Fp = 0.35\ Fc = (40 - 70)\ kg/cm^2$ where Fc is design compression strength of a concrete foundation .

Then $0.35\ Fc \geq P/A$ or $A \geq P/0.35\ Fc \rightarrow B \times C \geq P/0.35Fc$

Referring to above fig $C = 0.95h + 2n$
$B = 0.80b + 2m$

Then $(0.95h+2n)*(0.80b+2m) \geq P/0.35\ Fc$

For simplicity assume that m = n
And solve the equation to get m and n

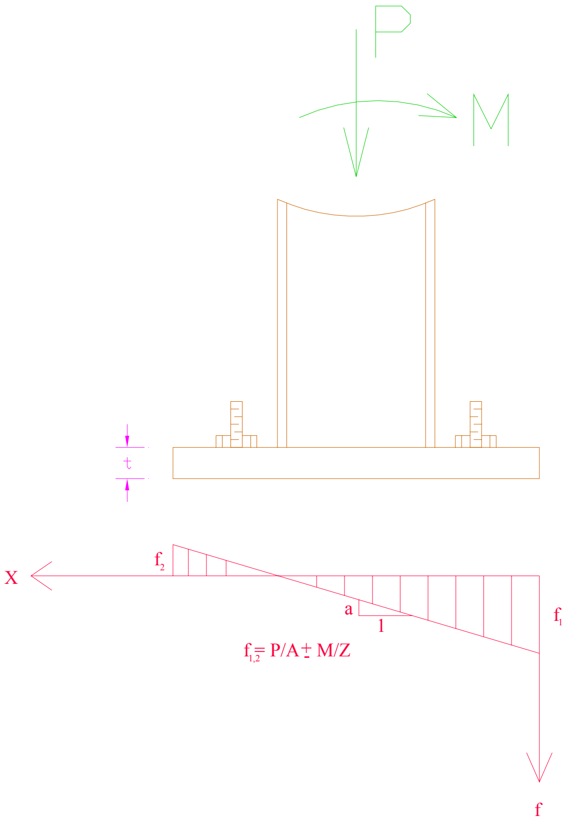
Then substitute in the following equations to get B & C
$C = 0.95h + 2n$
$B = 0.80b + 2m$

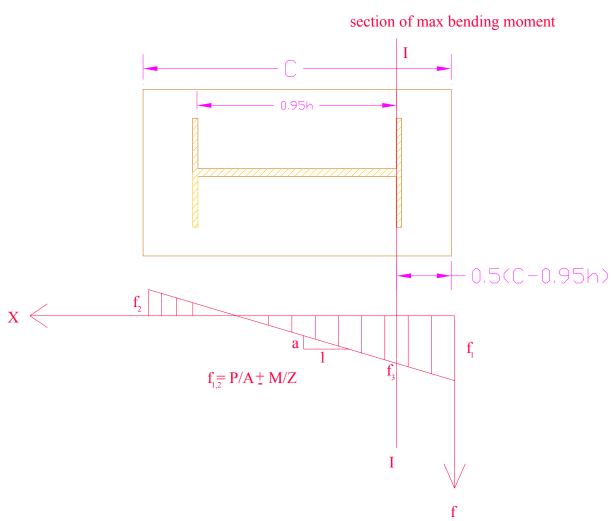
Thickness (t) of base plate

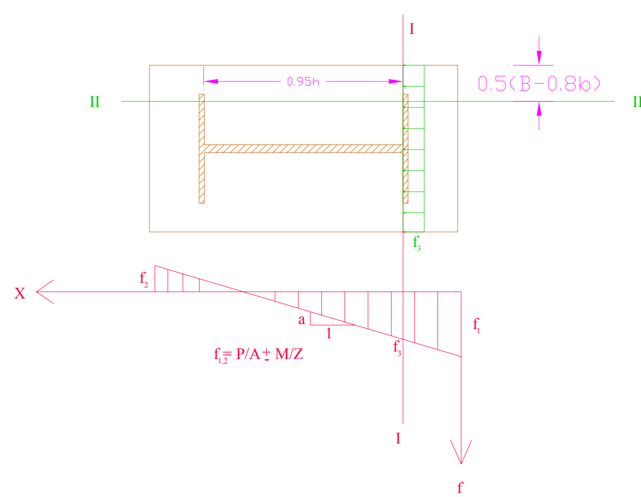
$t \geq$ (the greater between m or n) $*\sqrt{5f/fy}$
where f actual bearing stress and fy of steel used

II – Eccentrically Loaded Columns (M & P)

Length (C) & Width(B) of base plate







In columns subjected to axially compression force (P) and bending moment (M) , the stress under the base plate of dimensions (C x B) is triangular and equal to

$f1 = P/A + M/Z$
$f2 = P/A - M/Z$

where
f is the actual bearing stress under base plate
P is the design compression load
M is the design moment
A is the area of base plate in contact with concrete = C x B
$Z = BC^2 /6$

Assume C = 2 h and use $f1 = P/A + M/Z \leq 0.35\ Fc$ to find B

Thickness (t) of base plate

$t \geq \sqrt{6M/Fy}$

where
Fy = 0.6 fy of steel used
and M is the moment at sec I-I & II-II
the example illustrates how to find M

Welding between column and base plate

The weld between column and base plate is designed to transfer 60% of the axial load P in addition to the shear force, so :

$S \geq (0.6*P + shear) / (0.707*Lw*0.5*Fy)$

Anchor Bolts

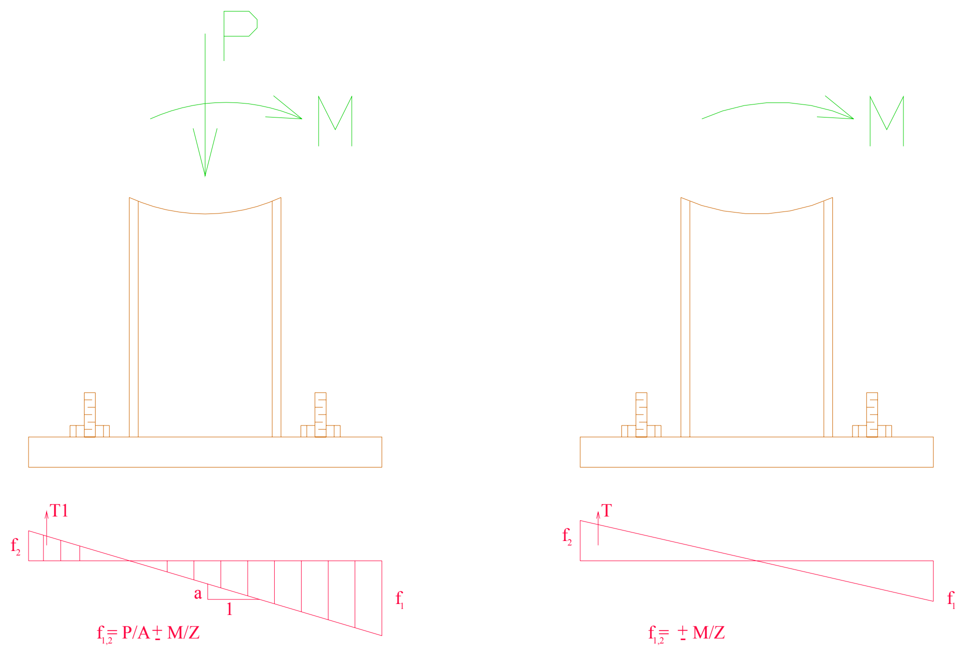
I – for axially loaded columns

The anchors are designed to resist shear force only

$fv = Vmax/A$
$Fv = 0.4\ Fy \geq fv = Vmax/A$
$A \geq Vmax/0.4Fy$
$a\ .n \geq Vmax\ /\ 0.4Fy$

where
V is shear force
a is area of each anchor bolt cross section = $3.14\ D^2/4$
D is anchor diameter
n is number of bolts used
A is total area of bolts cross sections

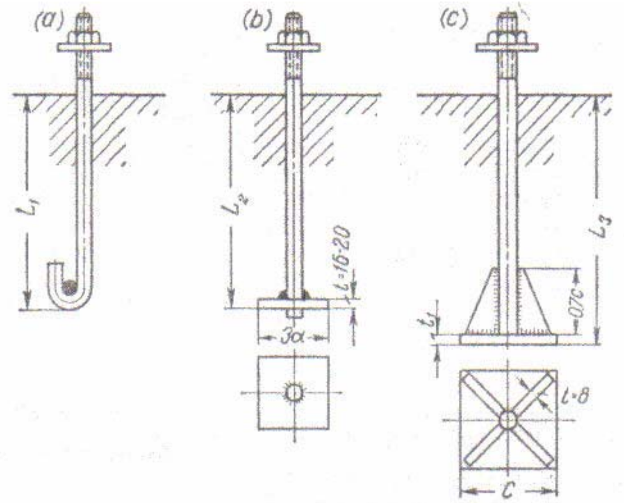
II – for eccentrically loaded columns



Actually only the anchor bolts in the tension zone will resist all the tensile force (T1) determined from the tension zone of the stress diagram , but to provide some reserve capacity to the anchorage system to resist considerable lateral force (shifting of column laterally) we will assume that the bolts in the tension zone will resist only the tensile force (T) provided by the bending moment only (note the axial force reduce the area of tension zone)

So A = T/0.6Fy   a x n = T/0.6Fy

Use the table to find the embedded length (L) of the anchors



Types of anchorages

Normal Dimensions of Anchor Bolts

External diameter of bolt, d mm	Net area (within root of thread), cm²	Length of anchor embedment, mm: without bearing washer (Fig. 8-36a and b) L_1	Length of anchor embedment, mm: without bearing washer (Fig. 8-36a and b) L_2	Length of anchor embedment, mm: with bearing washer (Fig. 8-36c) L_3	Dimension of washer c	Maximum design force allowed per bolt, kg (with R_t=1,400 kg/cm²)
20	2.25	700	—	—	—	3,150
22	2.81	750	—	—	—	3,940
24	3.24	850	—	—	—	4,540
27	4.27	950	—	—	—	5,980
30	5.18	1,050	—	—	—	7,250
36	7.58	1,250	—	700	160×16	10,600
42	10.0	1,450	—	800	200×20	14,000
48	13.4	—	1,450	850	240×25	18,700
56	18.75	—	1,650	1,000	240×25	26,200
64	24.65	—	1,850	1,100	280×30	34,500
72	31.6	—	2,000	1,250	280×30	44,200
76	35.8	—	2,100	1,350	320×30	50,100

Example

Design the base plate , column base plate welding and the anchors number and diameter for an HEB320 column carrying :

1 – axial load only P = 80 tons
2 – axial load P = 80 tons and bending moment M = 13 t.m

given that Fc = 180 kg/cm2 & St. 37 is used

solution

1 –

Base plate design

$A \geq P/Fp = 80000/0.35*180 = 80000/63 = 1270\ cm^2$
$C \times B \geq 1270\ cm^2$
$(0.95h+2n)*(0.80b+2m) \geq 1270$ cm2

Assume m=n and given for HEB320 h = 320 mm b = 300 mm
$4m2 + 108.8\ m + 729.6 \geq 1270$ cm2
Then m = n = 4.3 cm

$t \geq 4.3\sqrt{5f/fy} = 4.3\sqrt{5*62.16/2400} = 1.547$ cm

then use base plate 400*330*20 mm

welding design

the welding will transfer 60%P
welding length = Lw = 4*30+2*27.9 = 175.8 cm
$S \geq (0.6P)/(0.707*Lw*0.5*Fy) = 0.6*80/0.707*175.8*0.5*1.4 = 5.5$ cm

Use welding 6 mm

Anchors design

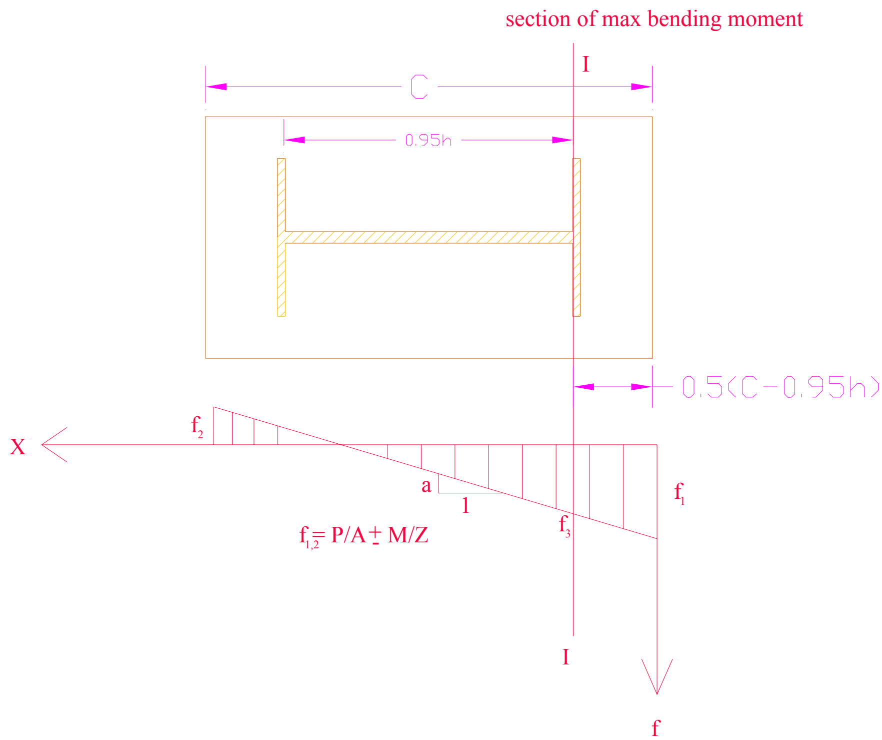
Since there is no shearing force use 2 bolts 25 mm diameter

2 –
Base plate dimensions design

Fp ≥ P/A+ M/Z
0.35*180 = 63 ≥ 80000/B*C + 6(1300000)/B x C^2
By trial and error let C = 60 cm then B = 56 cm

Base plate thickness design

Consider sec I – I



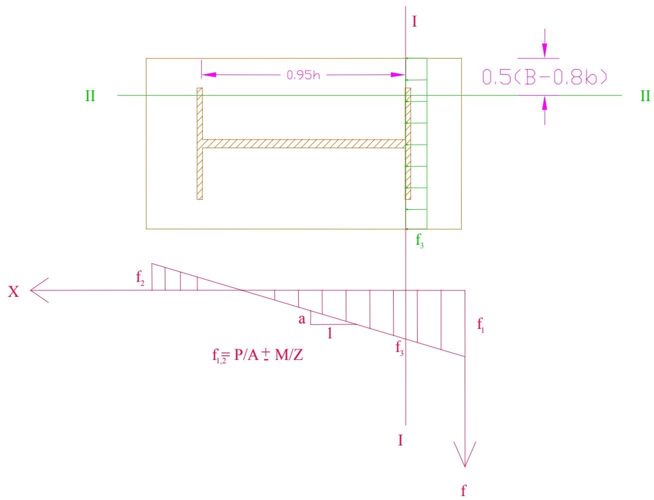
f1 = 80000/60*56 + 6*1300000/56*60^2 = 62.5 kg/cm2
f2 = 80000/60*56 - 6*1300000/56*60^2 = - 14.8 kg/cm2

stress equation is the equation of straight line from the stress diagram goemetry
f = 62.5 – 1.28X
integrate to find the shear equation
V = 62.5X – 1.28X^2/2
Integrate to find the moment equation
M = 62.5X^2/2 – 1.28X^3/6

The max moment is at sec I-I at X = 0.5*(C -0.95h) = 0.5(60 – 0.95*32) = 14.8 cm

Substitute in $M = 62.5X^2/2 – 1.28X^3/6$ for $X = 14.8$ then
$M = 62.5(14.8)^2/2 - 1.28(14.8)^3/6 = 6153$ kg.cm
Then $t = \sqrt{6*6153/0.6*2400} = 5$ cm = 50 mm

Consider sec II-II



f at x=14.8 cm is f=62.5-1.28(14.8) = 43.55 kg/cm2 uniformly distributed along the width of plate at the edge of column
the max moment is at sec II-II $M = 43.55(B-0.8b)^2/2 = 5575.168$ kg.cm
then $t = \sqrt{6*5575.168/0.6*2400} = 4.8$ cm = 48 mm

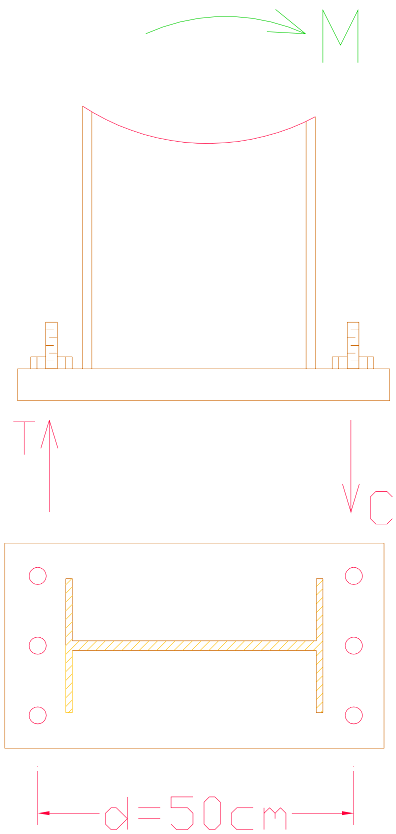
take the largest t = 50 mm

then the dimensions of the base plate is 600*560*50

welding design

the welding will transfer 60%P
welding length = Lw = 4*30+2*27.9 = 175.8 cm
$S \geq (0.6P)/(0.707*Lw*0.5*Fy) = 0.6*80/0.707*175.8*0.5*1.4 = 5.5$ cm
Use welding 6 mm

Anchors design



T = M/d = 1300000/50cm = 26 ton
A = 26000/0.6*3400 = 12.75cm2

Use 3 anchors each side 3a = 12.75 then a = 4.25 cm2 area of each bolt

D=√4*a/3.14 = 2.32 cm = 25 mm

Then use 6 bolts 3 each side of diameter 25 mm

Use the above table to find the embedded length

L = 850 mm