Transvese Reinforcement
Pitch

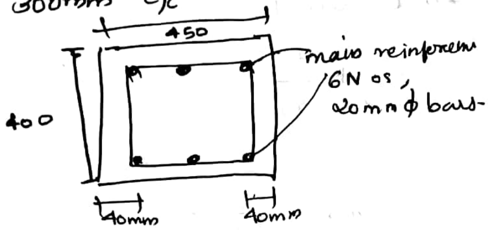
cl. 26.5.3.2

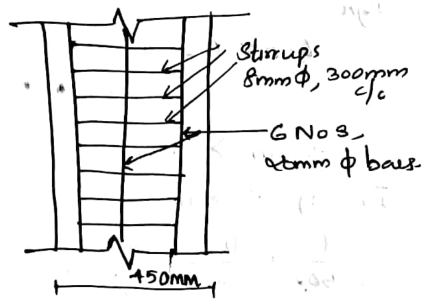
(i) least lateral dimension = 400

(ii) 16 ϕ = 16×20 = 320

(iii) 300mm

provide 8mm ϕ bars @ 300mm c/c





MODULE 4

ISOLATED FOOTING

ISOLATED FOOTING FOR AXIALLY LOADED COLUMNS

ISOLATED FOOTING FOR UNIFORM DEPTH FOR RCC COLUMN

Design a isolated footing of uniform thickness for a RCC column having a vertical load of 600kN and having a base of size foot 300mm The safe bearing capacity of soil is 120 kN/m². Use M_{20} concrete & Fe 415 steel.

$W = 600kN \quad q_0 = 120 \; kN/m^2$

$b = 500mm$
$d = 500mm$ } column.

$f_{ck} = 20 N/mm^2 \quad f_y = 415 N/mm^2$

Step 1: Dimension of the section

Let w' be the selfweight of the column 10% of Super imposed load.

$W' = 10\% \, W$
$= 600 \times \frac{10}{100} = 60kN$

Total load = 600 + 60 = 660kN

Area = $\frac{Load}{Pressure}$
$= \frac{660}{120}$
$= 5.5 m^2$

So provide a square column of size $B^2 = 5.5$
$B = 2.34 \approx$
$B = 2.4m$

Provide a square footing of 2.4 × 2.4m

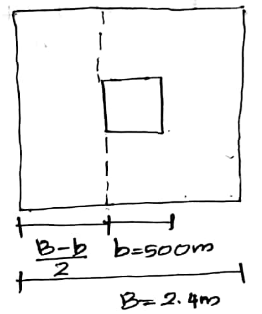
Net upward pressure = $\frac{Actual\ load}{Area} = \frac{600}{2.4 \times 2.4}$

$= 104.17 \; kN/m^2$

Design of the section

1. Depth on the basis bending compression.

The max bending mo act at the face o column



Moment

$M = \underbrace{P_0 B}_{load} \frac{(B-b)}{2} \times$

$\boxed{M = \frac{P_0 B}{8} (B}$

$M = \frac{104.17 \times 2.4}{8}$
$= 112.8016$ k

$M_u = M \times 1.5$
$= 169.20$
$= 169.2 \times$

Calculate 'd'

$M_{u\,limit} = 0.36 \frac{x_{umax}}{d} [1-$

$169.2 \times 10^6 = 0.36 \times 0.48 [1-$
2400

$d = 159.85$ mm $\approx$

$_o = 120$ KN/m²

umn.

$f_y = 415$ N/mm

ion of

selfweight 10% of load.

= 60kN

+60 = 660kN

square column

2.34

m

e footing

essure =

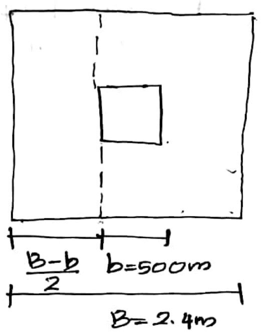
$\frac{600}{2.4 \times 2.4}$

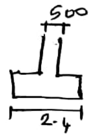
N/m²

Design of the section

1. Depth on the basis of bending compression. ⇒ Momentum load×distance

The max bending moment act at the face of the column





Moment

$$M = \underbrace{P_oB\frac{(B-b)}{2}}_{load} \times \frac{\frac{B-b}{2}}{2}$$

$$\boxed{M = \frac{P_oB}{8}(B-b)^2}$$

$$M = \frac{104.17 \times 2.4}{8}(2.4-0.5)^2$$

$= 112.8016$ kNm

$M_u = M \times 1.5$

$= 169.20$ KNm

$= 169.2 \times 10^6$ Nmm

Calculate 'd'

$$M_{u_{limit}} = 0.36\frac{x_{umax}}{d}\left[1 - 0.42\frac{x_{umax}}{d}\right] bd^2 f_{ck}$$

$$169.2 \times 10^6 = 0.36 \times 0.48\left[1 - 0.42 \times 0.48\right] 2400 \times d^2 \times 20$$

$d = 159.85$ mm ≈ 160mm

$\frac{B-b}{2} \times \frac{\frac{B-b}{2}}{2}$

$w \times l \times \frac{l}{2}$

$P_oB \quad \frac{B-b}{2} \quad \frac{\frac{B-b}{2}}{2}$

$1 \times \frac{1}{2}$

Assume clear cover of 50mm & 20mm ϕ bars.

$$D = 160 + 50 + \frac{20}{2}$$

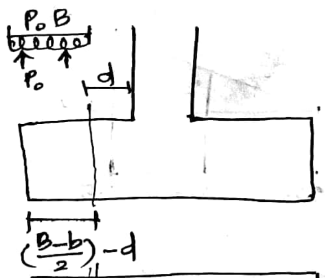
$= 220$mm

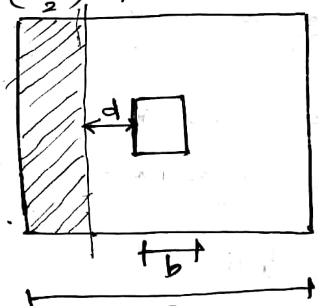
2. Depth on the basis of one way shear. ⇒ force load

For one way shear the critical section is located at a distance d from the face of the column.

$P = \frac{Load}{Area}$

$120 = \frac{}{Area}$





Shear force, $V = P_oB\left[\left(\frac{B-b}{2}\right)-d\right]$

$$= 104.17 \times 2.4 \times \left[\left(\frac{2.4-0.5}{2}\right) - d \times 10^{-3}\right]$$

$= 237.5076 - 0.25008\,d$

$V_u = (237.5076 - 0.25008\,d) \times 1.5$

$= 356.2614 - 0.375012\,d$

Nominal shear stress is equated to the permissible shear stress.

$\tau_v = k\tau_c$

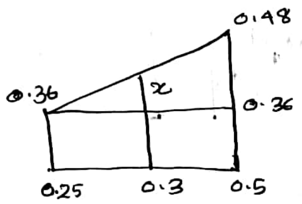
$\frac{V_u}{Bd} = k\tau_c \rightarrow$

Pgs 73

Assume 0.3% of %tensile reinforcement.

0.25

$\frac{100 A_s}{bd} = P_t = 0.3\%$



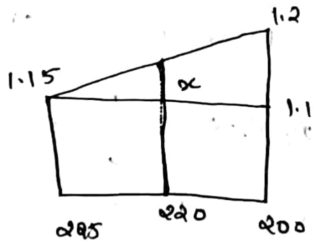
$\frac{0.48-0.36}{x} = \frac{0.5-0.25}{0.3-0.25}$

$x = 0.024$

$\tau_c = 0.36 + x = \underline{\underline{0.384}}$

value of k

D = 220 mm



$\frac{1.2-1.15}{x} = \frac{225-200}{225-220}$

$x = 0.01$

$k = 1.15 + x = 1.16$ mm

$\frac{(356.2614 - 0.375012\,d)10^3}{2400 \times d} = 1.16 \times 0.[...]$

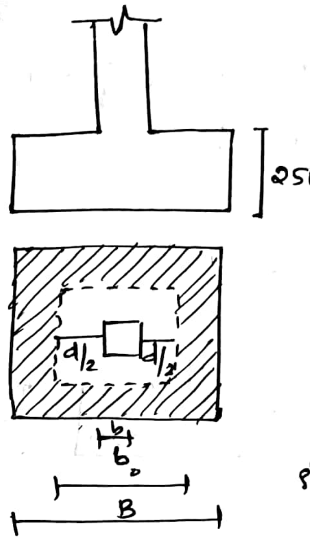
$\cancel{=1.069d}$
$= 1063.48d$

$356.2614 \times 10^3 = \cancel{376.08d}$
$= 1438.5d$

$\cancel{d = 947.29}$

$d = \cancel{246.4}\ 247.6$
$\approx \underline{250mm}$

CHECK FOR TWO-[...]



Shear forc[...]

V[...]

Shear stress[...]

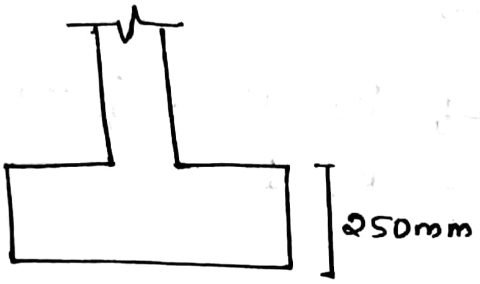
from cl. 31.6.3.1 of [...]
Permissible shea[...]
where k_s = 0.5 + [...]
β_c = rati[...]
sho[...]

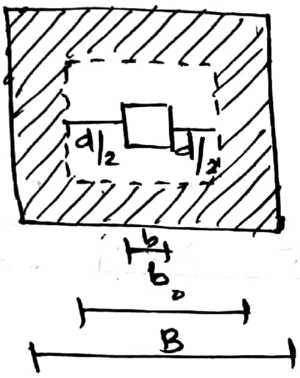
M = [...] / 8

= 103.8×3.4(3.4−[...] / 8

= 371.007 kN[...]

CHECK FOR TWO-WAY SHEAR / PUNCHING SHEAR





S/n lies @ d/2 distance from the column face all around

$b_0 = b + \frac{d}{2} + \frac{d}{2}$

$= 500 + \frac{250}{2} + \frac{250}{2}$

$= 750$ mm

Stress = load / Area

Area $= B^2 - b_0^2$

$= 2.4^2 - 0.75^2$

$= 5.1975 \text{ m}^2$

Shear force around the s/n

= Pressure x Area

$V = 104.17 \times (2.4^2 - 0.75^2)$.

$= 541.424$ kN

$V_u = 812.136$ kN

Shear stress $= \frac{V_u}{4 b_0 d} = \frac{812.136 \times 10^3}{4 \times 750 \times 250}$

4 side

$= 1.08$

from cl. 31.6.3.1 of IS 456:2000

Permissible shear stress $= k_s \tau_c$

where $k_s = 0.5 + \beta_c$

β_c = ratio of longer side to shorter side.

$$= \frac{500}{500} = 1$$

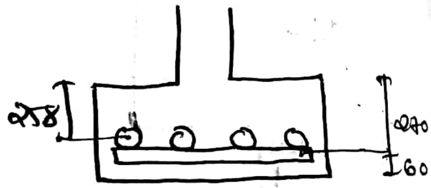
$\therefore \; k_s = 0.5 + 1 = 1.5$

Since the value of k_s is subjected to a max of 1. Take $k_s = 1$

$$\tau_c = 0.25 \sqrt{f_{ck}}$$

$$= 0.25 \sqrt{20} = 1.118$$

$$k_s \tau_c = 1.118$$



$\tau_v < k_s \tau_c$

$\therefore$ footing is safe

$\therefore$ Provide a footing of size 2.4m × 2.4m with effective depth = 250mm

Assume effective cover of 60mm

Overall depth = 250 + 60 = 310 mm

≈ 330 mm

d = 330 − 60 = 270

Design of steel reinforcement

effective depth in other di 270-1 = 258

Since the actual depth provided is greater than depth required for bending compression it is an under reinforced section

Annex G.

$$M_u = 0.87 f_y A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$$

$$169.224\times10^6 = 0.87\times 415\times Ast\times 258\left[1-\frac{Ast\times415}{2400\times258\times20}\right]$$

$$1816.665 = Ast - 3.35\times10^{-5}\,Ast^2$$

$$Ast = 1943.156$$

$$\text{No. of bars} = \frac{Ast}{\text{Area of 1bar}}$$

$$= \frac{1943.156}{\pi/4\times 20^2} = 17.19 \approx 18\,\text{Nos}$$

Check for development length

Min development length, $L_d = 47\times\phi$
$= 47\times12$
$= 564$ mm

$$\text{length of the bar} = \frac{B-b}{2} - 60$$

$$= \frac{2400-500}{2} - 60$$

$= 890 > L_d$

footing is Safe

Transfer of load at the column base

cl. 34.4 pg: 65

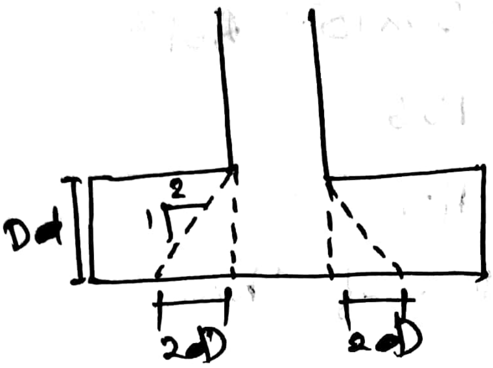
permissible bearing stress =

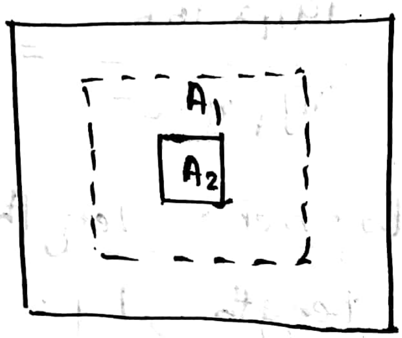
$$0.45\,f_{ck}\sqrt{\frac{A_1}{A_2}}$$

Load area of the column $= A_2$

$= 500 \times 500$

$= 250000$





$A_1 = (2D + 500 + 2D)^2$

$= (2 \times 330 + 500 + 2 \times 330)^2$

$= 3312400 \ mm^2$

$$\sqrt{\frac{A_1}{A_2}} = 3.64$$

∴ It is greater than 2

adopt max value 2

∴ permissible bearing stress

$= 0.45 \ f_{ck} \sqrt{\frac{A_1}{A_2}}$

$= 0.45 \times 20 \times 2$

$= 18 \ N/mm^2$

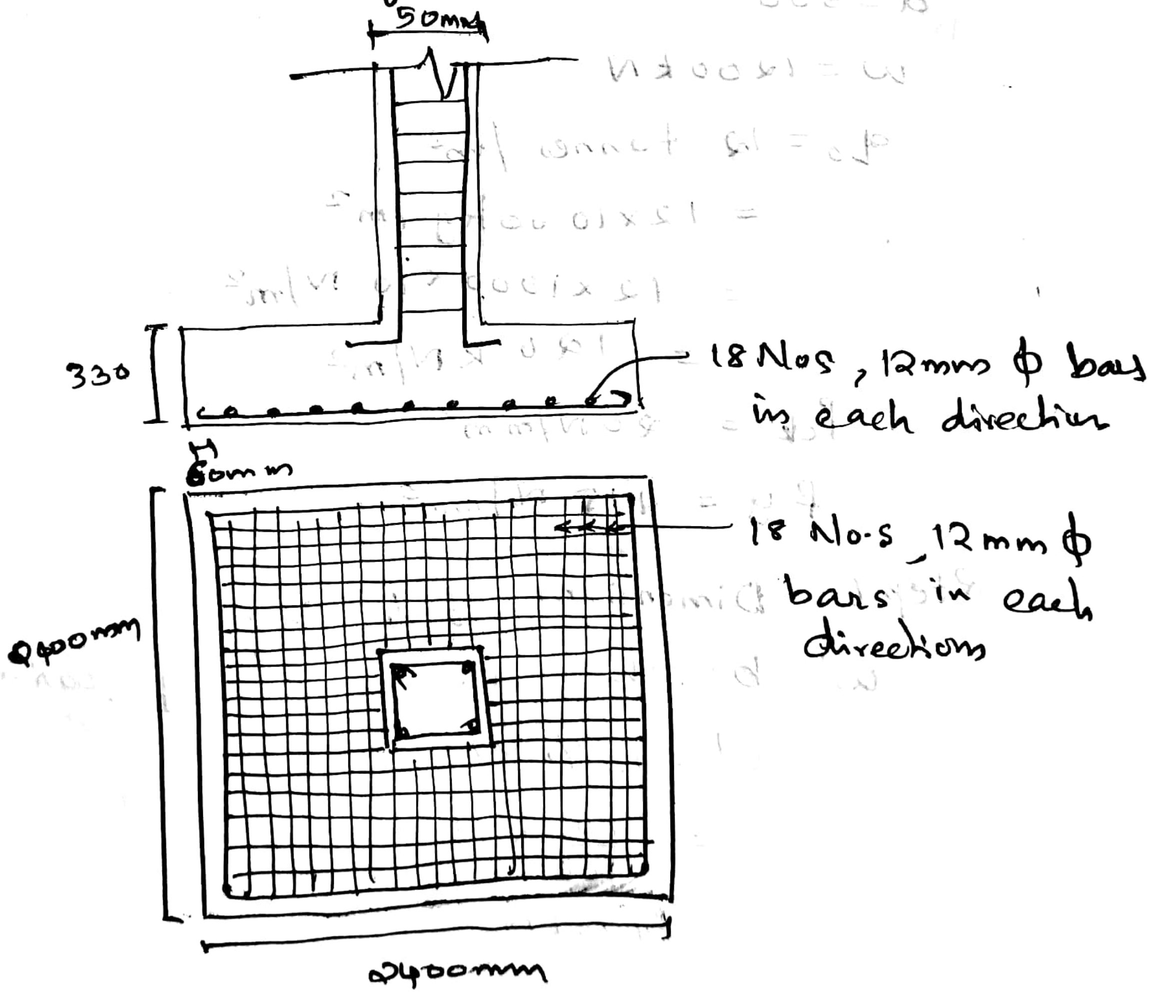
Actual bearing pressure $= \dfrac{F.O.S \times load}{Area}$

$$= \frac{1.5 \times 600 \times 10^3}{500 \times 500} = 3.6\, N/mm$$

Actual ~~value~~ bearing Stress < Permissible bearing Stress

$\therefore$ It is safe

No seperate bars are required to transfer the load.



ISOLATED SQUARE SLOPED FOOTING

Design an isolated square sloped footing for a column 500mm x 500mm transmitting an axial load of 1200kN. The column reinforced with 8 bars of 20mm diameter the safe bearing capacity of soil is 12 tons per meter^2 use M20 concrete & Fe415 steel

Given

$b = 500$

$d = 500$

$w = 1200\, kN$

$q_0 = 12\ tonnes/m^2$

$= 12 \times 1000\, kg/m^2$

$= 12 \times 1000 \times 10\ N/m^2$

$= 120\ kN/m^2$

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

$f_y = 415\ N/mm^2$

Step 1 : Dimensions of footing.

w' be the self wyt of footing

$w' = 10\%\ w$

$= \frac{10}{100} \times 1200$

$= 120\, kN$

Total load = $w + w'$

$= 1200 + 120 = 1320\,kN$

$$\text{Area} = \frac{\text{Load}}{\text{pressure}} = \frac{1320}{120} = 11\,m^2$$

$B^2 = 11$

$B = \sqrt{11} = 3.31 \approx 3.4\,m$

So provide a footing of $3.4\,m \times 3.4\,m$

$$\text{Net upward pressure} = \frac{1200}{3.4 \times 3.4}$$

$= 103.8\,kN/m^2$

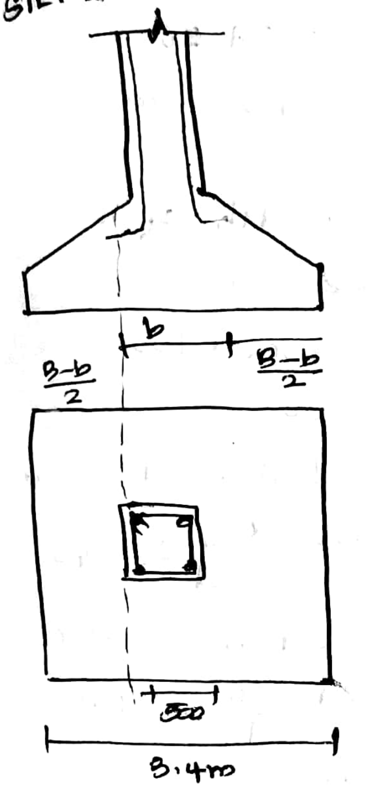
Scanned by CamScanner

$B = 3.4m$

Size $3.4m \times 3.4m$

Net pressure $103.8 kN/m^2$

STEP 2 DESIGN OF SECTION



1. Depth on the basis of bending compression.

The max bending moment occurs at the phase of the column & the magnitude is given by

$$M = \underbrace{P_o B \left(\frac{B-b}{2}\right)}_{\text{load}} \times \frac{B-b}{4}$$

$$M = \frac{P_o B (B-b)^2}{8}$$

$$= \frac{103.8 \times 3.4 (3.4 - 0.5)^2}{8}$$

$= 371.007$ kNm

$M_u = M \times 1.5$

$= 556.510$ kNm

Depth Annex G

$$M_{u\,limit} = 0.36 \frac{x_{umax}}{d} \left[1 - 0.42 \frac{x_{umax}}{d}\right] bd^2 f_{ck}$$

$$556.51 \times 10^6 = 0.36 \times 0.48 \left[1 - \frac{0.42 \times}{0.48}\right) \times 500 \times d^2 \times 20$$

$d = 635.117$ mm

fix overall depth $D = 760$mm,

assuming effective cover 60mm

effective depth 'd' $= 760 - 60 = 700$

effective depth in other direction $= 700 - 12 = 688$

Provide overall depth at end $= 200$ mm

Effective depth in one direction $200 - 60 = 140$mm

Effective depth in other direct? $140 - 12 = 128$ mm

CHECK FOR SHEAR

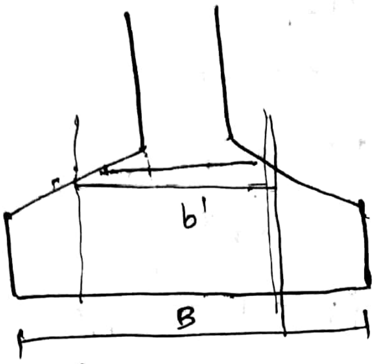
Check for one way shear | Beam shear :

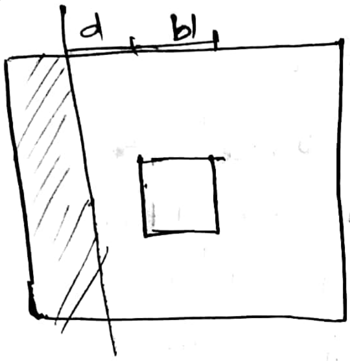
Assume critical section at 'd' distance from the phase of the column

shear force at section

$$V = P_o B \left[\frac{B-b}{2} - d\right]$$

$\tau_v = \frac{V_u}{b d_n}$



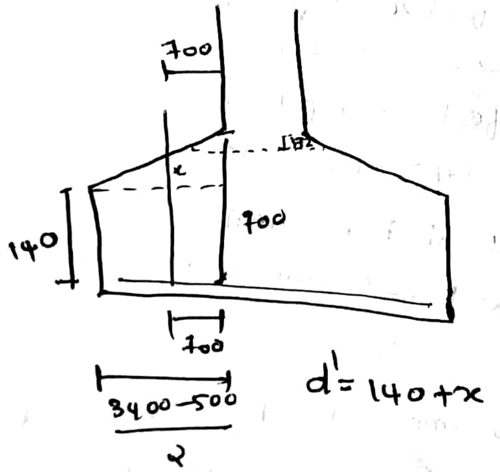


$V = 1038 \times 3.4 \left[\frac{3.4-0.5}{2} - 0.7\right]$

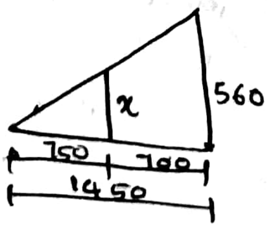
$= 264.69$

$V_u = 264.69 \times 1.5 = 397.035$

Effective Depth at critical section $d' = 140+x$



$d' = 140+x$



$\frac{560}{x} = \frac{1450}{750}$

$x = 289.6\,mm$

$d' = 289.6+140$

$d' = 429.06$

$= 430\,mm$

Top width of the @ the section =

$700+500+700$

$=1900$

For a balanced section we have $\frac{x_{umax}}{d} = 0.48$

If the section is under reinforced $\frac{x_u}{d}$ must be less than $\frac{x_{umax}}{d}$

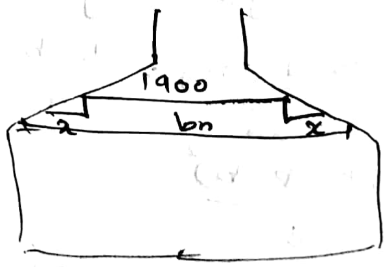
Adopt a value $\frac{x_u}{d} = 0.4$

$x_u = 0.4d' = 0.4 \times 430 = 172\,mm$

width of the section @ neutral axis

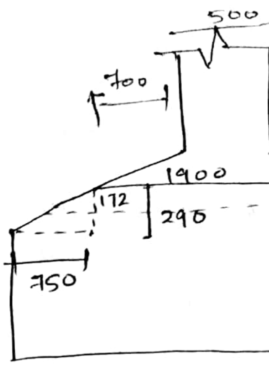
$1900 + x + x = b_n$

width b_n



19 NBDAP

$\frac{x}{750} = \frac{172}{290}$



$\frac{x}{750} = \frac{172}{290}$

$x = 445$

width b_n @ th

$x + 1900 +$

$= 445 + 19$

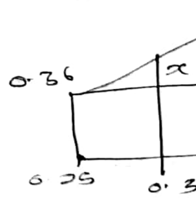
$\tau_v = \frac{V_u}{b_n d'} =$

$= 0.$

Assume 0.

reinforcement

Table 19.



$x =$

$\tau_c = 0.36 +$

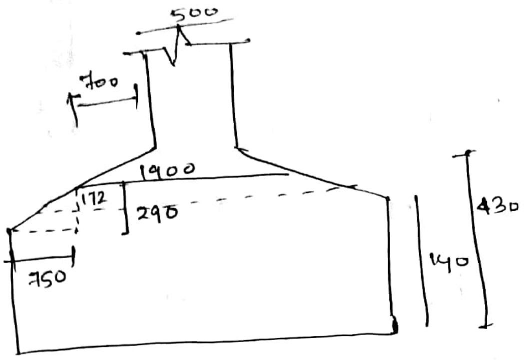
$\tau_v < k\tau_c$

$D = 760\,mm$

cl. 40.2.1.

1.12.19
VED NESDAY

$$\frac{x}{750} = \frac{172}{290}$$



$$\frac{x}{750} = \frac{172}{290}$$

$x = 445m$

width b_n @ the NA =

$x + 1900 + x$

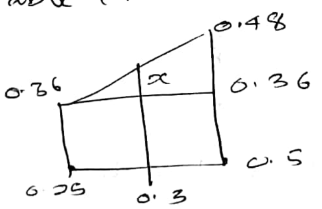
$= 445 + 1900 + 445 = 2790$

$$\tau_v = \frac{V_u}{b_n d'} = \frac{397.035 \times 10^3}{2790 \times 430}$$

$= 0.33$

Assume 0.3% tensile reinforcement

Table 19.



$x = 0.024$

$\tau_c = 0.36 + x = 0.384 \ N/mm^2$

$\tau_v < K\tau_c$

D = 760mm

cl. 40.2.1.1

D - 300 or more K = 1

K = 1 (760 = D)

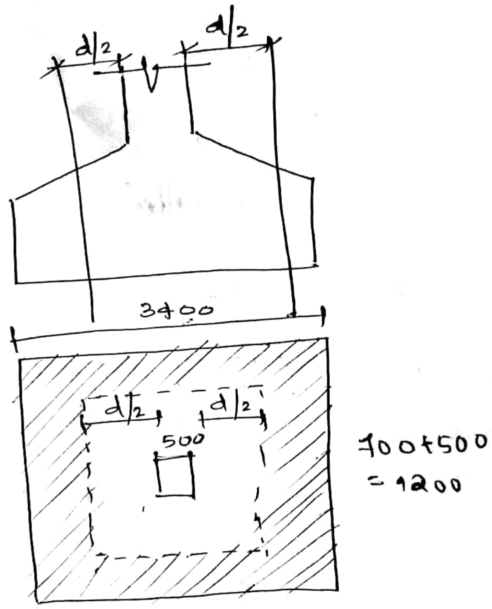
$K\tau_c = 0.384$

$\tau_v < K\tau_c$

Hence safe

CHECK FOR 2 WAY SHEAR /

PUNCHING SHEAR



Section lies @ d/2 distance from the column face

Punching shear force = stress × Area

$= 103.8 \left[B^2 - B_o^2 \right]$

$V = 103.8 \left[3.4^2 - 1.2^2 \right]$

$= 103.8 \left[10.12 \right]$

$= 1050.456 \ KN$

$V_u = 1050.456 \times 1.5$

$= 1575.684 \ KN$

$$\tau_v = \frac{V_u}{4 \times bd}$$

Scanned by CamScanner

$\tau_v = \frac{V_u}{4 B_o d}$

$= \frac{1575.684 \times 10^3}{4 \times 1200 \times 700}$

$= 0.468 \ N/mm^2$

ALLOWABLE SHEAR STRESS cl 31.6.3.3 $= K_s \tau_c$

$\tau_c = 0.25 \sqrt{F_{ck}}$

$= 0.25 \sqrt{20}$

$= 1.118 \ N/mm^2$

$K_s = 0.5 + \beta_c$

β_c = Ratio of longer side to shorter side of column.

$\therefore \beta_c = \frac{500}{500} = 1$

$K_s = 0.5 + 1 = 1.5$

K_s subjected to a max of 1

Take $K_s = 1$

$K_s \tau_c = 1.118 \ N/mm^2$

$\tau_v < K_s \tau_c$

Hence safe

DESIGN OF STEEL REINFORCEMENT

Annexe G

$M_u = 0.87 \ f_y A_{st} d \left[1 - \frac{A_{st} f_y}{b d f_{ck}}\right]$

$556.5 \times 10^6 = 0.87 \times 415 \times A_{st} \times 700 \left[1 - \frac{A_{st} \times 416}{500 \times 100 \times 415}\right]$

$2201.9 = A_{st} - A_{st}^2 \ 2.857 \times 10$

$A_{st} = 2215.8, \ 348661.2$

$A_{st} = 2215.8 \ mm^2$

No. of bars:-

$\frac{A_{st}}{\text{Area of 1 bar}} =$

$\frac{2215.8}{\frac{\pi}{4} \times 12^2} = 19.5 \approx$ 20 Nos.

Hence provide ~~12mm dia~~ 20 nos 12mm ϕ bars uniformly spaced in each direction

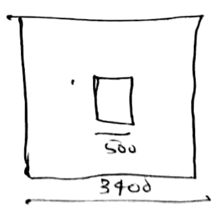
CHECK FOR DEVELOPMENT LENGTH

Min development length

$= 47 \times \phi$

$= 47 \times 12 = 564 \ mm$

Available length



~~3400~~ $- \frac{3400 - 500}{2} - 60 = 1390$

$1390 > L_d$

Hence safe.

TRANSFER OF LO

BASE

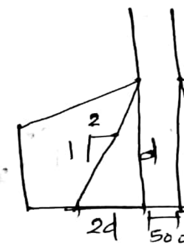
Cl 34.4

permissible bea

$= 0.45 \ f$

A_2 = loaded a

$= 500 \times 500$



$A_1 = (2d + 50$

$= (2 \times 100 +$

$= 10890$

$= 1089 \times$

$\sqrt{\frac{A_1}{A_2}} = 6.6$

$\therefore$ It is grea

adopt ma

Permissible

$= 0.45 \times f_{ck}$

$= 0.45 \times 2$

$= 18 \ N/$

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415 x Ast ... 700
x 416
...00 x 415

^{2} ... 2.857 $\times 10^{6}$

, 348661.24

mm^2

=

1.5 ≈

No.s.

~~12mm dia~~

m ϕ bars

spaced in

...tion

...EVELOPMENT

...ment length

2 = 564 mm

...ngth

...00 − 60 = 1390

1390 > Ld

Hence safe.

TRANSFER OF LOAD AT COLUMN BASE

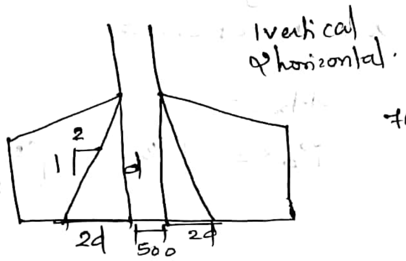
Cl-34.4 Pg: 65

permissible bearing stress

$= 0.45\, f_{ck} \sqrt{\dfrac{A_1}{A_2}}$

A_2 = loaded area of column

$= 500 \times 500 = 250000$



$A_1 = (2d + 500 + 2d)^2$

$= (2\times 700 + 500 + 2\times 700)^2$

$= 10890000$

$= 1089 \times 10^4\ mm^2$

$\sqrt{\dfrac{A_1}{A_2}} = 6.6$

∴ It is greater than 2

adopt max value 2

Permissible bearing stress

$= 0.45 \times f_{ck} \sqrt{\dfrac{A_1}{A_2}}$

$= 0.45 \times 20 \times 2$

$= 18\ N/mm^2$

Actual bearing pressure =

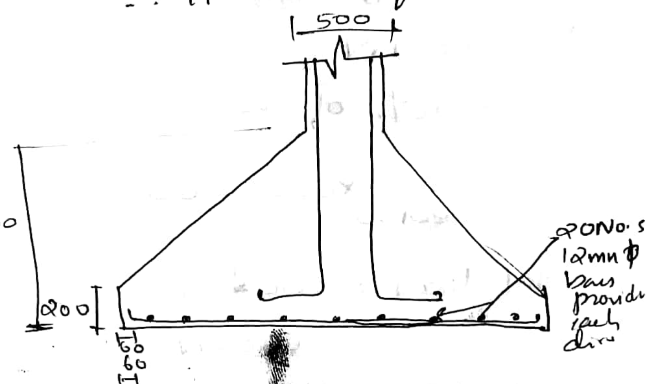
$\dfrac{F.O.S \times load}{Area}$

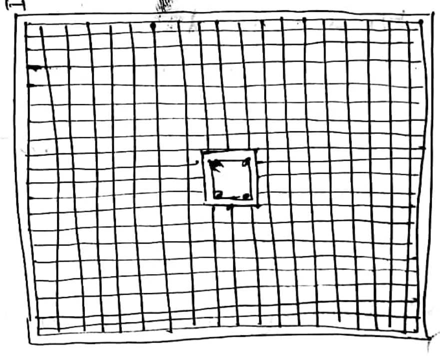
$= \dfrac{1.5 \times 1200 \times 10^3}{500 \times 500}$

$= 7.2\ N/mm$

Actual bearing pressure/stress < Permissible bearing pressure

∴ It is safe.





Q: Isolated rectangular footing of uniform thickness for RC column bearing a vertical load of 600 KN and having a base size 400x600mm with a safe bearing capacity is taken as 120 KN/m². Use M20 concrete and Fe 415 steel

16.12.19
MONDAY

$W = 600\,kN$

Size of column =

$400 \times 600\,mm$

$q_0 = 120\ kN/m^2$

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

$f_y = 415\ N/mm^2$

Step 1: Dimensions of the footing

$W = 600\,kN$

self wt $W' = 10\%$ of W

$= \frac{10}{100} \times 600 = 60$

Total load $= 600 + 60$

$= 660\,kN$

Area = $\frac{\text{load}}{\text{pressure}}$

$= \frac{660}{120} = 5.5\,m^2$

column moslam, same ratio

Ratio of breadth to length of footing $= \frac{400}{600} = \frac{2}{3}$

$\frac{B}{L} = \frac{2}{3}$

$B = \frac{2}{3}L$

Area $= 5.5\,m^2$

$L \times B = 5.5$

$L \times \frac{2}{3}L = 5.5$

$L = 2.87$

$L = 2.9\ mm \approx 3\ mm$

$B = 1.9\ mm \approx 2\ mm$

Provide a footing of length $2m \times 3m$.

Net upward pressure

$= \frac{600}{2 \times 3} = 100\ kN/m^2$

Step 2: Design of sections

D Depth on the basis of bending compression

Max bending moment occurs @ the face of the column bending moment about xx direction =

$BM_{xx} =$

$P_0 \times 2 \times \left(\frac{3-0.6}{2}\right)\left(\frac{3-0.6}{4}\right)$

$= 100 \times 2 \left(\frac{3-0.6}{2}\right)\left(\frac{3-0.6}{4}\right)$

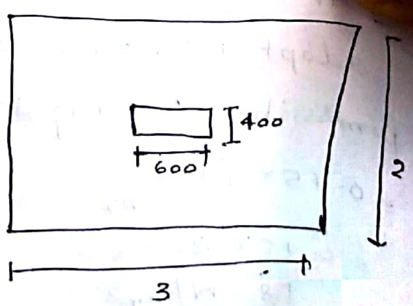
$= 144\ kNm$

$M_{uxx} = 216\ kNm$

$BM_{yy} = 100 \times 3 \times \left(\frac{2-0.4}{2}\right)\left(\frac{2-0.4}{4}\right)$

$M_{yy} = 96\ kNm$

$M_{uyy} = 144\ kNm$



(highest valu... is considered ... the depth of ...

Annexure G

$Mu_{limit} = 0.36 \frac{x_{um}}{d}$ ...

$96 \times 10^6 = 0.36 \times 0.4$...

$\times 200$...

$d = 197.8$

Take effective ...

$D = 197$...

$= 25$...

≈ 26...

$d = 260 - 60$...

18.12.19
Wednesday.

(2) Depth on ...

of beam s...

For beam sh...

is considered ...

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(highest value of moment is considered for finding the depth of footing)

Annexure G

$$Mu_{limit} = 0.36 \frac{x_{umax}}{d}\left[1 - 0.42\frac{x_{umax}}{d}\right] bd^2 f_{ck}$$

$$216 \times 10^6 = 0.36 \times 0.48[1 - 0.42 \times 0.48] \times 2000 \times d^2 \times 20$$

$d = 197.8$

Take effective cover = 60mm

$D = 197.8 + 60$

$= 257.8$ mm

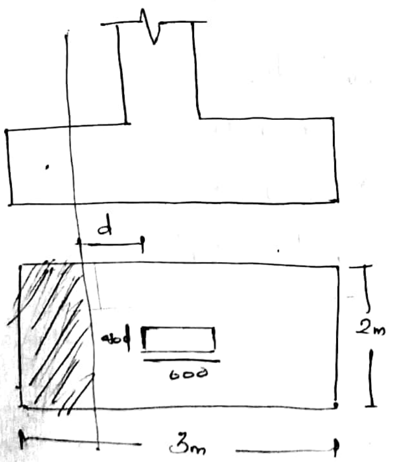
≈ 260

18.12.19 Wednesday.

$d = 260 - 60 = 200$ mm

(2) Depth on the basis of beam shear / one way

For beam shear, the sectn is considered at d distance from face of column.



Shear force

$$V = P_0 B\left[\frac{3-0.6}{2} - d \times 10^{-3}\right]$$

$$= 100 \times 2\left[\frac{3-0.6}{2} - d \times 10^{-3}\right]$$

$$V_u = 100 \times 2 \times 1.5\left[\frac{3-0.6}{2} - d \times 10^{-3}\right]$$

$V_u = 360 - 0.3d$

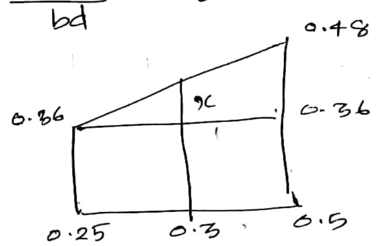
$$\tau_v = \frac{V_u}{bd}$$

$$= \frac{(360 - 0.3d)10^3}{2000 \times d}$$

$\tau_v = k\tau_c$

Assume $P_t = 0.3\%$ for M_{20} concrete.

$$\frac{100 A_s}{bd} = P_t = 0.3\%$$



$$\frac{0.48 - 0.36}{x} = \frac{0.5 - 0.25}{0.3 - 0.25}$$

$x = 0.024$

$\tau_c = 0.384$ N/mm²

Value of k

$D = 200$mm $k = 1.2$ mm

$\tau_v = k\tau_c$

$$\frac{(360 - 0.3d)10^3}{2000d} = 1.2 \times 0.384$$

$d = 294.69$

≈ 300mm

Effective depth in other direction $= 300 - 12 = \underline{288\,mm}$

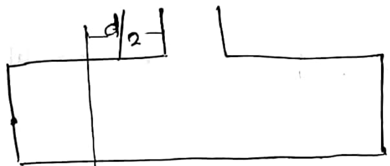
will take 300 (greater than 200)

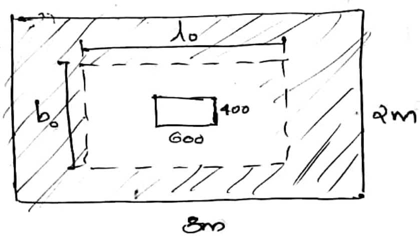
$\therefore d = 300$

3) Check for 2 way shear

For 2 way shear section lies at $d/2$ distance from phase of the column.

Adopt $d = 300mm$





$l_o = 0.6 + 0.3 = 0.9m$

$b_o = 0.4 + 0.3 = 0.7m$

Area $= l \times b - l_o b_o$

$= \underline{5.37\ m^2}$

Shear force

$V =$ Stress × area

$= 100 \times 5.37$

$= 537\ kN$

$V_u = 537 \times 1.5 = 805.5\ kN$

$\tau_v = \dfrac{V_u}{b_o d}$ perimeter.

$\tau_v = \dfrac{V_u}{\text{Perimeter} \times d}$

$= \dfrac{V_u}{2(l_o + b_o) \times d}$

$= \dfrac{805.5 \times 10^3\ N/mm^2}{2(900 + 700)\,300}$

$= \cancel{839062.5}$

$= 0.839\ N/mm^2$

Allowable stress $= k_s \tau_c$

Cl ~~31.6.3.1~~ 31.6.3.1

pg: 59

$\tau_c = 0.25 \sqrt{f_{ck}} = 1.11\ kN/m^2$

$k_s = 0.5 + \beta_c$

$= 0.5 + \dfrac{400}{600}$

$= 1.16$

Adopt $k_s = 1$

$k_s \tau_c = 1.11 \times 1$

$= 1.11\ N/mm^2$

$\tau_v < k_s \tau_c$

$\therefore$ Section is safe in 2 way shear.

Effective depth ~~200~~ 300 is safe.

Step 3: Design

$M_u = 0.87\ f_y$

$\times 10^6 = 0.87 \times 4$

$(1 -$

$A_{st} = 2154$

no. of bars $= \dfrac{2154}{\pi/4 \times}$

A_{st} in other

$M_u = 0.87\ f_y$

$\times 10^6 = 0.87 \times$

$[\ 1 -$

$A_{st} = 1433$

No. of bars

Step 5. C

min dev

$L_d =$

$=$

Length of

$=$

Step 3: Design for Reinforcement

$$M_u = 0.87\, f_y\, A_{st}\, d\left(1-\frac{A_{st} f_y}{b d f_{ck}}\right)$$

$$216\times10^6 = 0.87\times415\, A_{st}\times300\left(1-\frac{A_{st}\,415}{2000\times300\times20}\right)$$

$A_{st} = 2154$

No. of bars $= \frac{2154}{\pi/4\times12^2} = 19.04 \approx 20$ Nos

A_{st} in other direction

$$M_u = 0.87\, f_y\, A_{st}\, d\left[1-\frac{A_{st} f_y}{b d f_{ck}}\right]$$

$$144\times10^6 = 0.87\times415\times A_{st}\times288\left[1-\frac{A_{st}\,415}{3000\times288\times20}\right]$$

$A_{st} = 1433.3\ mm^2$

No. of bars $= \frac{1433.3}{\pi/4\times12^2}$

$= 12.6 \approx 13$ Nos.

Step 5: check for development lengths

min development length

$L_d = 47\times\phi$

$= 47\times12$

$= 564$ mm

Length of bars $= \left[\frac{3000-600}{2}\right]-60$

$= 1140$mm $> L_d$

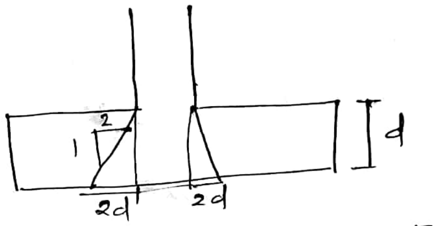
length of bars in other direction

$\left\{\frac{2000-400}{2}\right\}-60$

$= 740$mm $> L_d$

$\therefore$ safe.

Step 6: Transfer of load @ column base.



Permissible stress $= 0.45\, f_{ck}\sqrt{\frac{A_1}{A_2}}$

A_2 = loaded area of column

$A_2 = 400\times600 = 240000$

$A_1 = (2d + 600 + 2d)^2$

$= (600 + 600 + 600)^2$

$= 3240000$

$\sqrt{\frac{A_1}{A_2}} = 3.67$

Adopt $\sqrt{\frac{A_1}{A_2}} = 2$

Permissible stress $= 0.45\times20\times2$

$= 18\ N/mm^2$

Actual bearing stress $= \frac{1.5\times600}{Area} = \frac{1.5\times600}{400\times600}$

$= 3.75\ N/mm^2$

$\therefore$ Actual bearing pressure $<$ Permissible stress

$\therefore$ Footing is safe.

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Design a footing for circular column 560mm dia transmitting an axial load of 1200KN the column is reinforced with 8 bars with 10mm dia. Safe bearing capacity of soil is 120 KN/m^2 Use M20 concrete & Fe415 steel.

Given: $W = 1200$ KN

$\phi_{column} = 560$ mm

$q_0 = 120$ KN/m^2

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

$f_y = 415$

Step:1 Size of footing

$W = 1200$ KN

$w' = 10\%$ of W

$= \frac{10}{100} \times 1200 = 120$ KN

Total load $= 1200 + 120 = 1320$

Area of footing $= \frac{1320 \text{ load}}{120 \text{ sbc}}$

$= 11$ m^2

$\pi R^2 = 11$ m^2

$R = \sqrt{\frac{11}{\pi}} = 1.87$

$R = 1.9$ m

$\phi = 3.8$ m

length of one side of equivalent square,

$2\pi R = 4a$

$\frac{2\pi R}{4} = a$

$\frac{2 \times \pi \times 1.9}{4} = a$

$a = 2.98$ m

Rest same as b4

Q: Isolated footing subjected to eccentric load

Q: Design a isolated unsymmetric square footing for a column 500x500 transmitting a load of 600KN and a moment of 30KNm. The safe bearing capacity of soil is 120KN Use M20 Concrete Fe415 Steel.

Given = $W = 600$ KN

$M = 30$ KNm

Size of column = 500 x 500 mm

$q_0 = 120$ KN/m^2

$f_{ck} = 20$

$f_y = 415$

$W = 600$ KN

$w' = \frac{10 \times 600}{100}$

$w' = 60$ KN

total $W + W' = 660$ KN

Area of footing

$a^2 = 5.5$

$a = 2.345$

$a = 2.4$

Provide a footing

net upward press

$= \frac{600}{2.4 \times 2.}$

$= 104.1$

Moment = load x

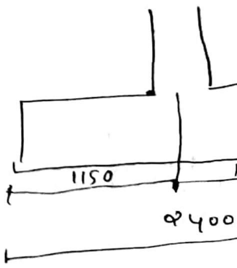
$M = P \times$

$e = \frac{M}{P}$

eccentricity $= \frac{M}{P}$

$= 0.0$

$= 50$



$W = 600\ kN$

$$W' = \frac{10 \times 600}{100}$$

$W' = 60\ kN$

Total $W + W' = 660\ kN$

$$\text{Area of footing} = \frac{660}{120}$$

$a^2 = 5.5\ m^2$

$a = 2.345$

$a = 2.4\ m$

Provide a footing of size 2.4×2.4

net upward pressure

$$= \frac{600}{2.4 \times 2.4}$$

$= 104.16\ kN/m^2$

Moment = load x distance

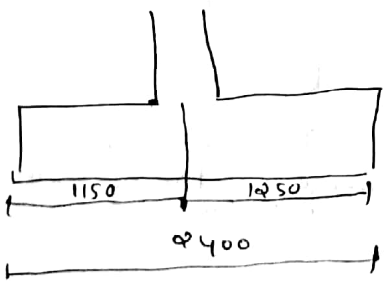
$M = P \times e$

$$e = \frac{M}{P}$$

$$\text{eccentricity} = \frac{M}{P} = \frac{30}{600}$$

$= 0.05\ m$

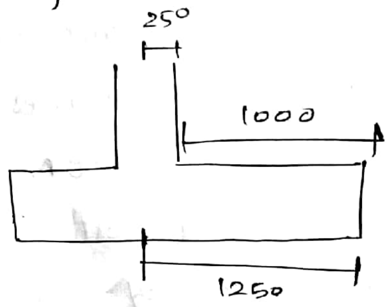
$= 50\ mm$



Step 2: Design of section

I) Depth on the basis of bending compression

(highest ഒന്നു എടുക്കാം)



Cantilever length / length from face of column =

$1250 - 250 = 1000\ mm$

$= 1\ m$

$$M = P_o B \left(\frac{B-b}{2}\right) \left(\frac{\frac{B-b}{2}}{2}\right)$$

$\Downarrow$ 1000 → 1000

$= P_o B \times 1 \times 1/2$

$= 104.16 \times 2.4 \times 1/2$

$M = \cancel{\ }\ 124.99\ kN$

$M_u = 124.9 \times 1.5$

$= 187.48\ kNm$

(Steps Same as b4)

Take larger distance for one way shear.

e side of
uare,
= a
18 m
b4
footing
eccentric
ted
nisymmetrical
g for a
500 transmi
of 600 kN
ent of
safe bearing
oil is 120 kN/
rete Fe 415
600 kN
kNm
olumn =
00 x 500 mm
kN/m²