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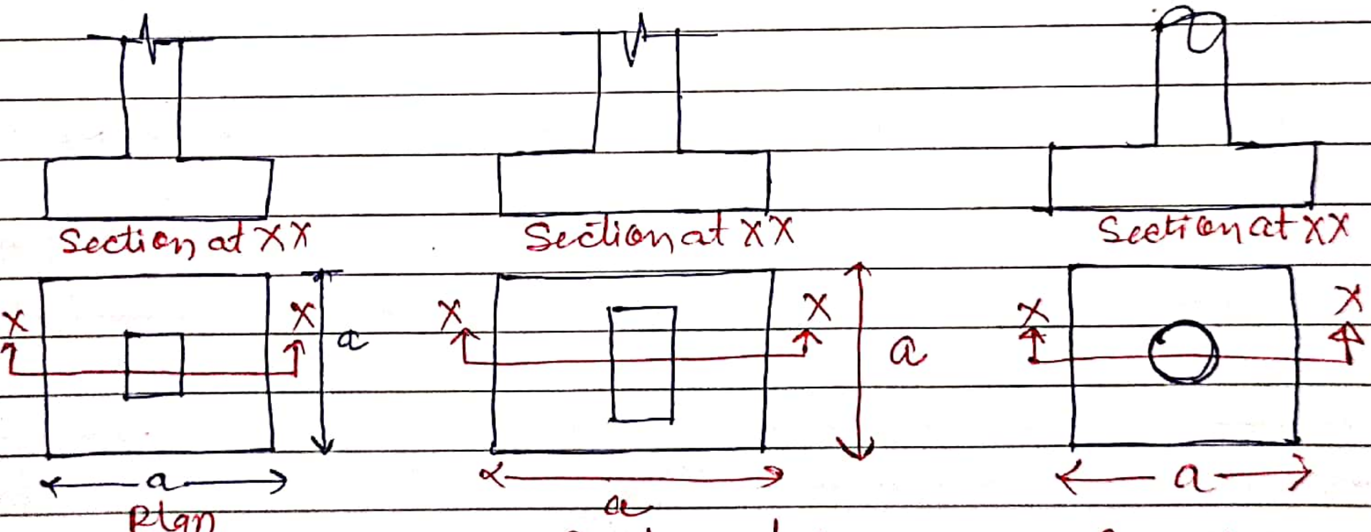
Footings

① Isolated footing
(a) square footing
(b) Rectangular footing
(c) Circular footing
(d)

② Combined footing
(a) Rectangular
(b) oval
(c) Trapezoidal

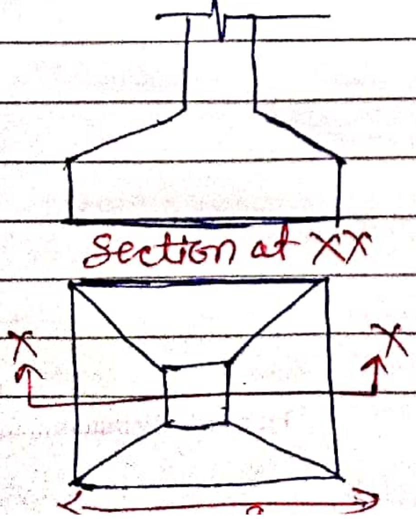
③ Continous or wall footings or strip footings
④ Strap footings
⑤ Raft or mat footing
⑥ Pile footings
⑦ well foundation



Square footings

Rectangular footing

Square footing



Square column with sloping footing

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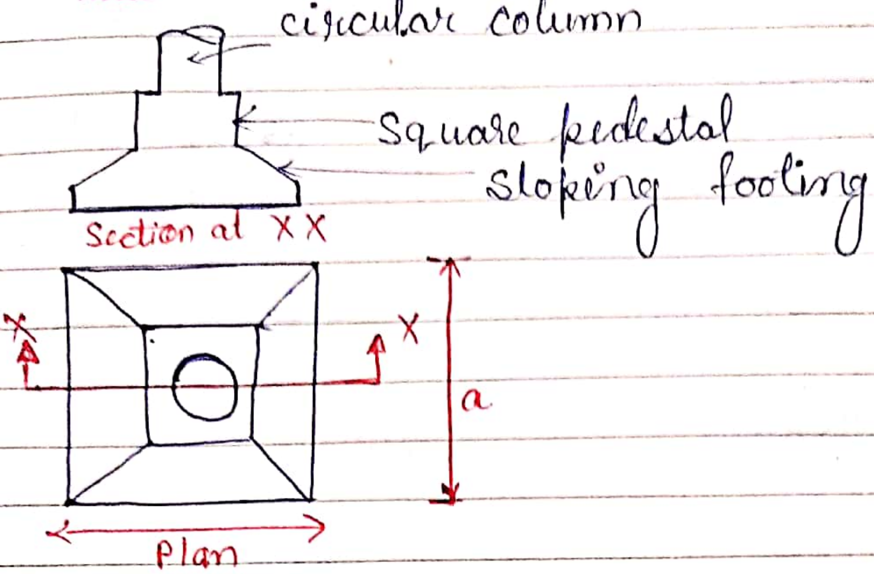
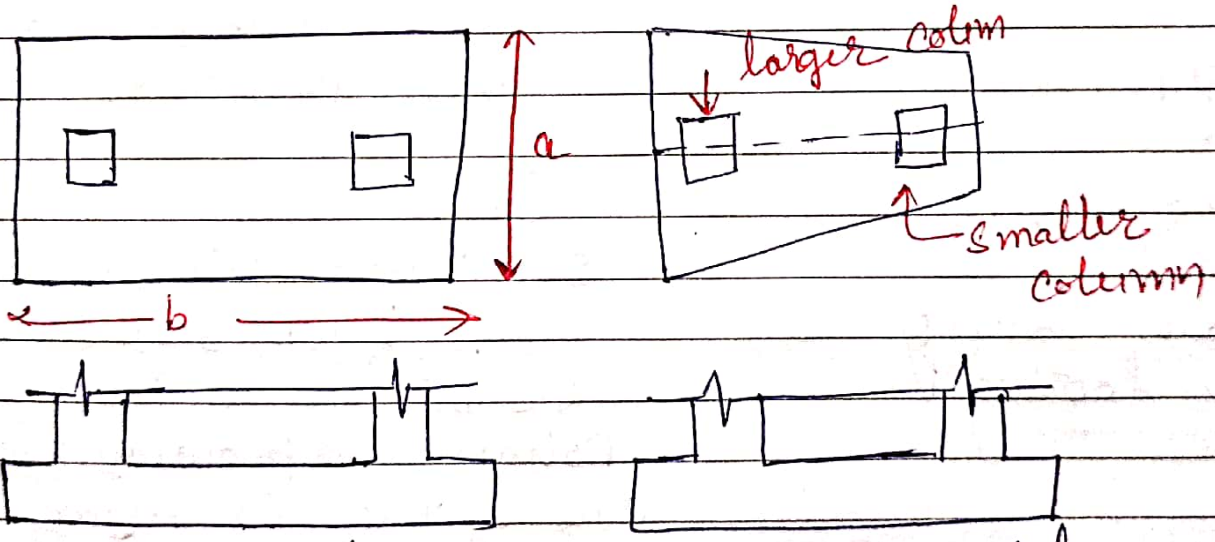
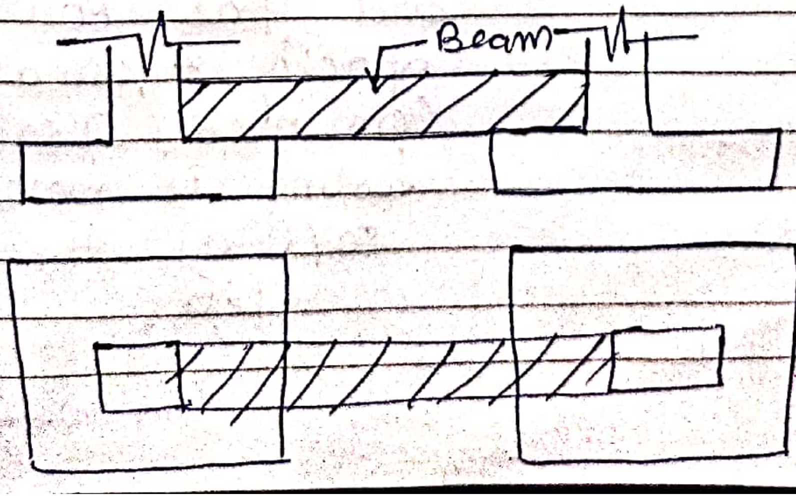


circular column
with square pedestal
and footing

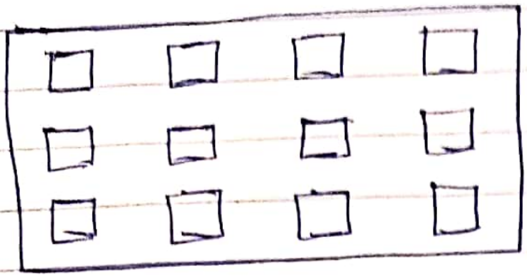


Rectangular

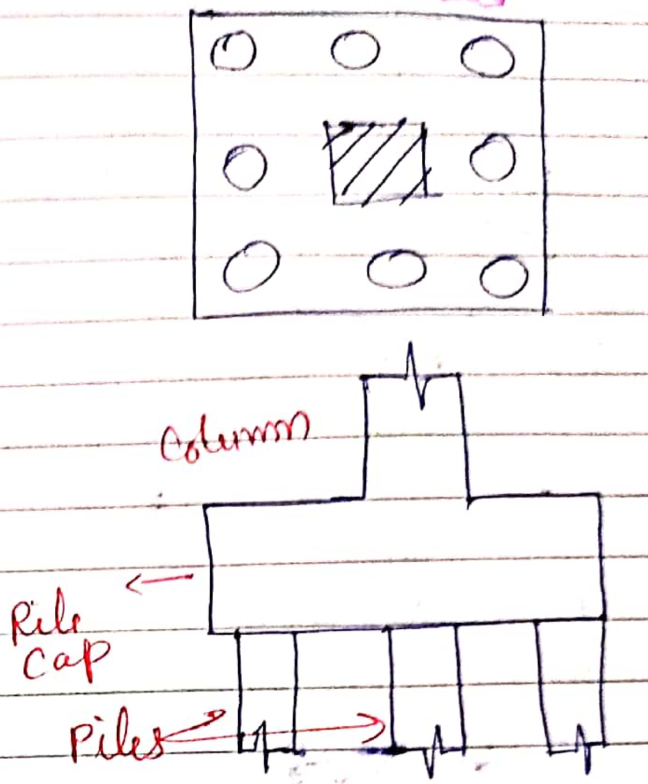
Trapezoidal



Strap footing



Raft /Mat foundation



Pile foundn

Type of foundn	when provided.
Isolated footing	Single column
Combined footing	2 or more column
Continous footing	Walls (bricks or RCC)
strap footing	Distant (far away) Column especially when one of them is near the edge of the property
Raft foundn.	soil has low bearing capacity & area of Combined / Isolated footing is more than 50% of the building Plan.

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Pile foundn — When loads are heavy
Soil has poor bearing capacity.

Well foundn — For bridges, rivers etc.

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Design of footing

Notes

load coming from the column → P
Self wt. of the footing → 0.1P (10% of column load)
Total working load on footing → 1.1P

Area of footing = $\frac{\text{total load}}{\text{Safe Bearing Capacity of soil}}$

$$A_{req.} = \frac{1.1P}{SBC}$$

ex - $5.8 m^2$

while calculating SBC there is already FOS is considered hence we do not use any FOS in calculation of working load.

ex = Aprovided = 2×3 m^2

$$A_{provided} = B \times L$$

upward soil pressure = $\frac{\text{load}}{\text{Area of Footing}}$

$$q = \frac{P}{B \times L}$$

kN/m^2

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Depth → factored load | Cl 304 (?)

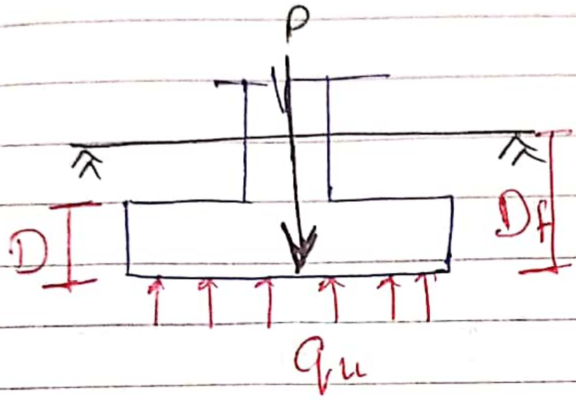
B2.4

Area → working load

Notes

Factored upward soil pressure

$$q_u = 1.5 \times q$$



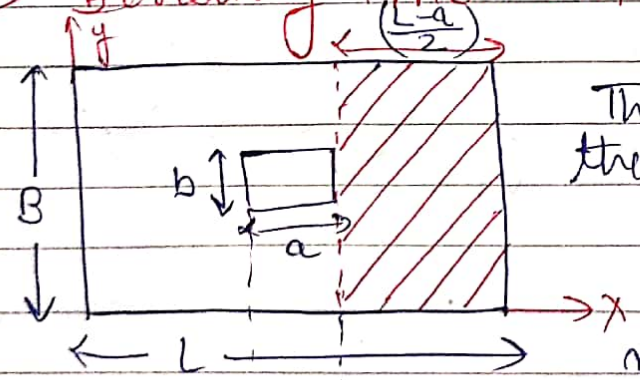
Depth can be calculated by

1) Bending moment criteria (d_1)
2) One way shear criteria (d_2)
3) Two way shear criteria (d_3)

Df = Depth of footing (Depth of excavation) → used in geotech

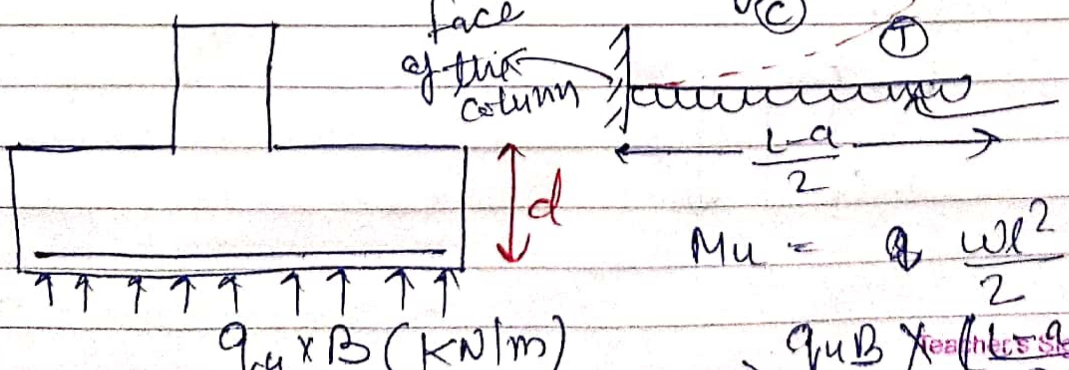
D = Depth of footing (thickness of concrete) → used in RCC

① Bending moment criteria



The critical section occurs at the face of the column.

To convert pressure q_u into UDL multiply it with width



$$M_u = \frac{wl^2}{2}$$

$$\Rightarrow \frac{q_u B \times \left(\frac{L-a}{2}\right)^2}{2}$$

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$$M_{uy} = \frac{q_u B (L-a)^2}{8}$$

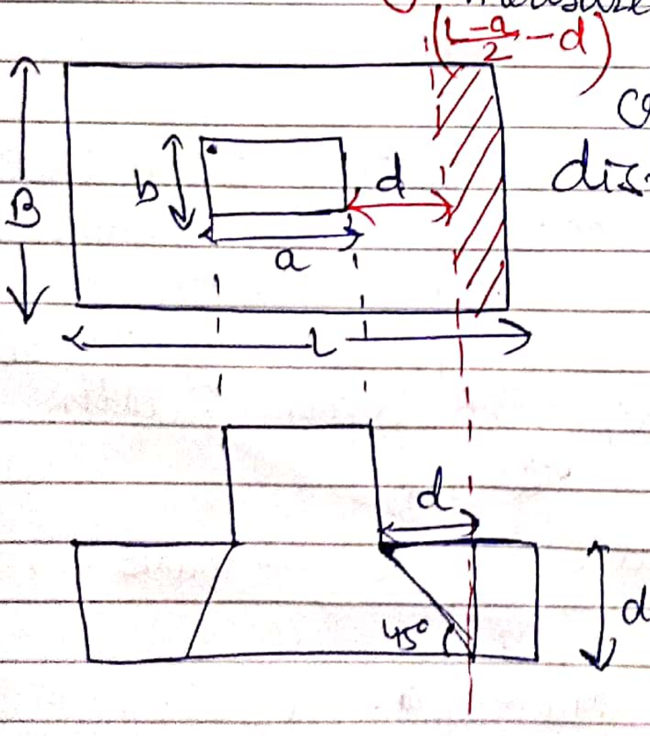
$$M_{ux} = \frac{q_u L (B-b)^2}{8}$$

$$M_{max} = \begin{cases} M_{ux} \\ M_{uy} \end{cases}$$ whichever is maximum

$$d_1 \Rightarrow Depth = \sqrt{\frac{M_{max}}{Q\, f_{ck}\, B}}$$

$Q = 0.148$ (fe250)
$Q = 0.138$ (fe415)
Q 0.133 (fe500)

② One way shear criteria (It is always measure in one direction (Larger))



Critical section occurs at a distance of effective depth (d)

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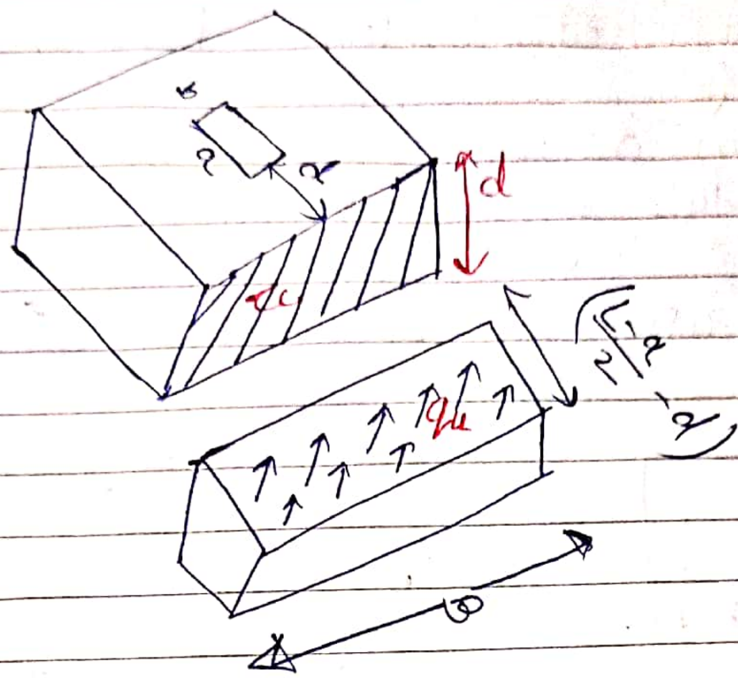

$$q_u B\left(\frac{L-a}{2} - d\right) \leq k\tau_c \cdot Bd$$

~~Stress x Area~~

τ_c – Table 19 IS456

from the above eqn eff. depth of footing d can be calculated as d2:

D Depth (mm)	K
≥ 300	1
275	1.05
250	1.1
225	1.15
200	1.20
175	1.25
≤ 150	1.30

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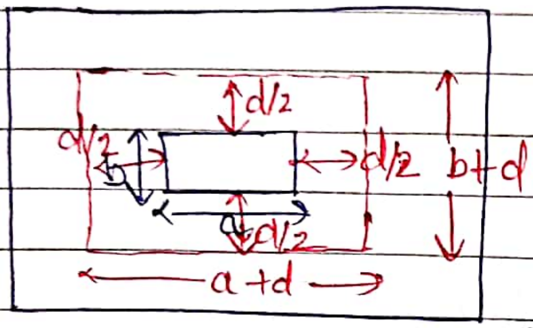
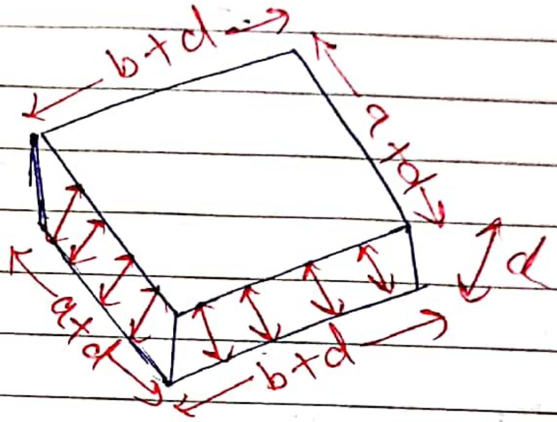
(3) Two way shear criteria (Punching shear)

→ critical section occurs at a distance of $\frac{d}{2}$ from face of the column.

→ It is measured in both the dirn.





$$q_u\left[B \times L - (a+d)(b+d)\right] \leq \tau_p \left\{2\left[(a+d)+(b+d)\right] \times d\right\}$$

from the above eqn d_3 can be calculated.

$$\tau_p = k_s \cdot \tau_{pc}$$

τ_{pc} $0.25\sqrt{f_{ck}}$ (LSM)

$0.16\sqrt{f_{ck}}$ (WSM)

Punching shear strength of concrete

$$k_s = 0.5 + \beta_c$$

$$\beta_c = \frac{b}{a} = \frac{\text{shorter side of column}}{\text{longer side of column}}$$

$$k_{s\,max} = 1$$

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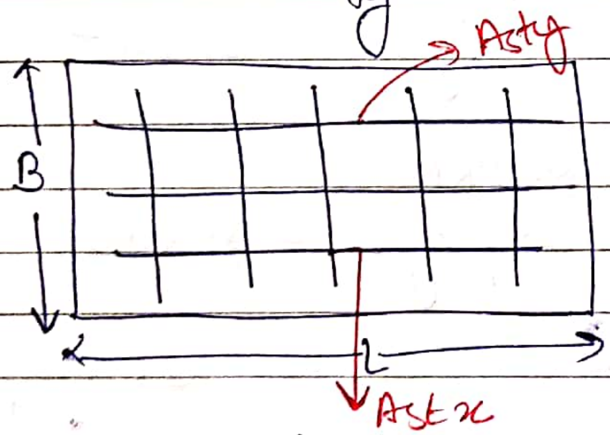
d provided = { d_1, d_2, d_3 } whichever is greater

Nominal clear cover
→ 50 mm (PCC is done) (M5, M10)
→ 75 mm (when no PCC) concrete is direct on ground.

Calculation of Ast

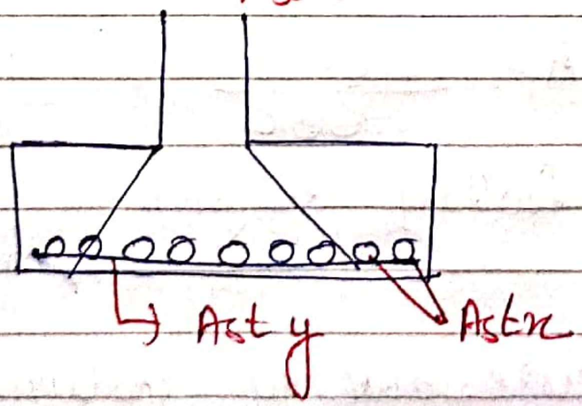
$$A_{sty} = \frac{0.5 f_{ck}}{f_y}\left[1-\sqrt{1-\frac{4.6 M_{uy}}{f_{ck} B d^2}}\right] Bd$$ longer R/F

$$A_{stx} = \frac{0.5 f_{ck}}{f_y}\left[1-\sqrt{1-\frac{4.6 M_{ux}}{f_{ck} B d^2}}\right] Bd$$ shorter R/F



Note → Asty & Astx both should be greater than min area.

(Mild steel)
Astmin = 0.15% of gross Area
→ 0.12% of gross Area (HYSD)



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Notes

Q. Design a Isolated footing of uniform thickness of a RC column Bearing a vertical load of 850 KN and having a size of 450 x 450 mm. The safe Bearing capacity of soil is 190 KN/m2 Use M20 & Fe415

Steps

1. Determine size of footing
2. Find out upward pressure (q_u)
3. Depth of footing max. out of one way shear, 2 way shear and Bending moment criteria
4. Area of R/F.

Given

$W_c = 850 KN$

$SBC = 190 \ KN/m^2$

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

load calculation $W_c = 850 KN$

Self wt. of footing $W_f = 10\%$ of $W_c = 85 KN$

Total load $= W_c + W_f = 935 KN$

Area of footing $A = \frac{W_c + W_f}{SBC} \Rightarrow \frac{935}{190} = 4.92 \ m^2$

Side of square footing $= \sqrt{4.92}$
$= 2.22 m$ Say $2.25 m$

Factored soil pressure due to column load

$q_u = \frac{1.5 \times 850}{2.25 \times 2.25} = 251.85 \ KN/m^2$

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Depth of footing by one way shear criteria

$q_u B\left(\frac{L-a}{2} - d\right) \leq k.\tau_c.B.d$

assume k = 1
% steel as 0.2%
so $\tau_c = 0.32 N/mm^2$

$257.85 \times 2.25\left(\frac{2.25-0.45}{2} - d\right) \leq \frac{0.32\times10^6}{10^3} \times 2.25 \times d$

on solving this eqn.

$d = \frac{509.99}{1286.66} = 0.396 m$

Depth of footing by 2 way shear criteria

$q_u[B\times L - (a+d)(b+d)] \leq \tau_p \{2((a+d)+(b+d))\times d\}$

$\Rightarrow 257.85\left[2.25\times2.25 - (0.45+d)^2\right] \leq 0.25\sqrt{20}\ \{2(a+d+b+d)\times d\}$

a = b = 0.45

$\Rightarrow$ 257.85[· $2(0.9+2d)\times d \Rightarrow (1.8+4d)d$

$1274.99 - 257.85(0.2025 + d^2 + 0.9d) = 2012.4d + 4472d^2$

$d = \frac{-0.423 \pm \sqrt{(-0.423)^2 - (4\times0.29)}}{2}$

$d = 0.367 m$

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Depth of footing by bending moment

$$M_{uy} = \frac{q_u B (L-a)^2}{8}$$

$$\Rightarrow \frac{251.05 \times 2.25 \times (2.25-0.45)^2}{8}$$

$$\Rightarrow 229.498 \times 10^6 \text{ N·mm}$$

$$d = \sqrt{\frac{M_u}{Q f_{ck} B}} \Rightarrow \sqrt{\frac{229.498 \times 10^6}{0.138 \times 20 \times 2.25}}$$

$$d = 0.192 \text{ m}$$

So the max. depth we got from one way shear criteria.

i.e. 0.396 m

let us adopt d = 400 mm

overall depth = 400 + 8 + 50

458 say 460 mm

(Taking clear cover as 50 mm & 16 mm dia bars)

$$A_{st} = \frac{0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6 M_y}{f_{ck} B d^2}}\right] Bd$$

$$\Rightarrow 1652.03 \text{ mm}^2$$

$$\text{min. } A_{st} = \frac{0.12 \times 2250 \times 460}{100} \quad 1242 \text{ mm}^2$$

Hence safe

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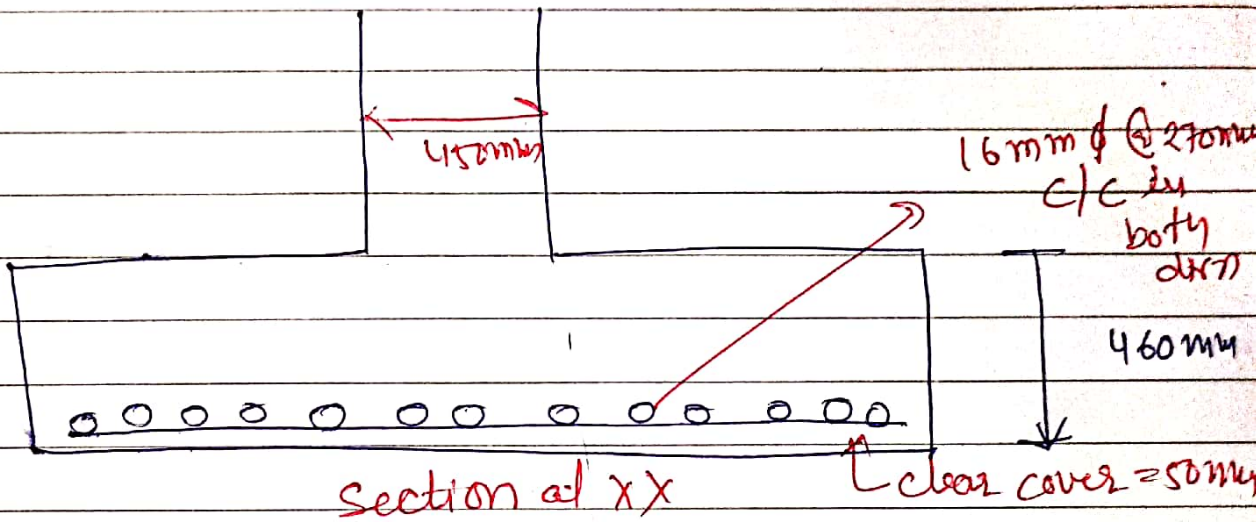
Notes

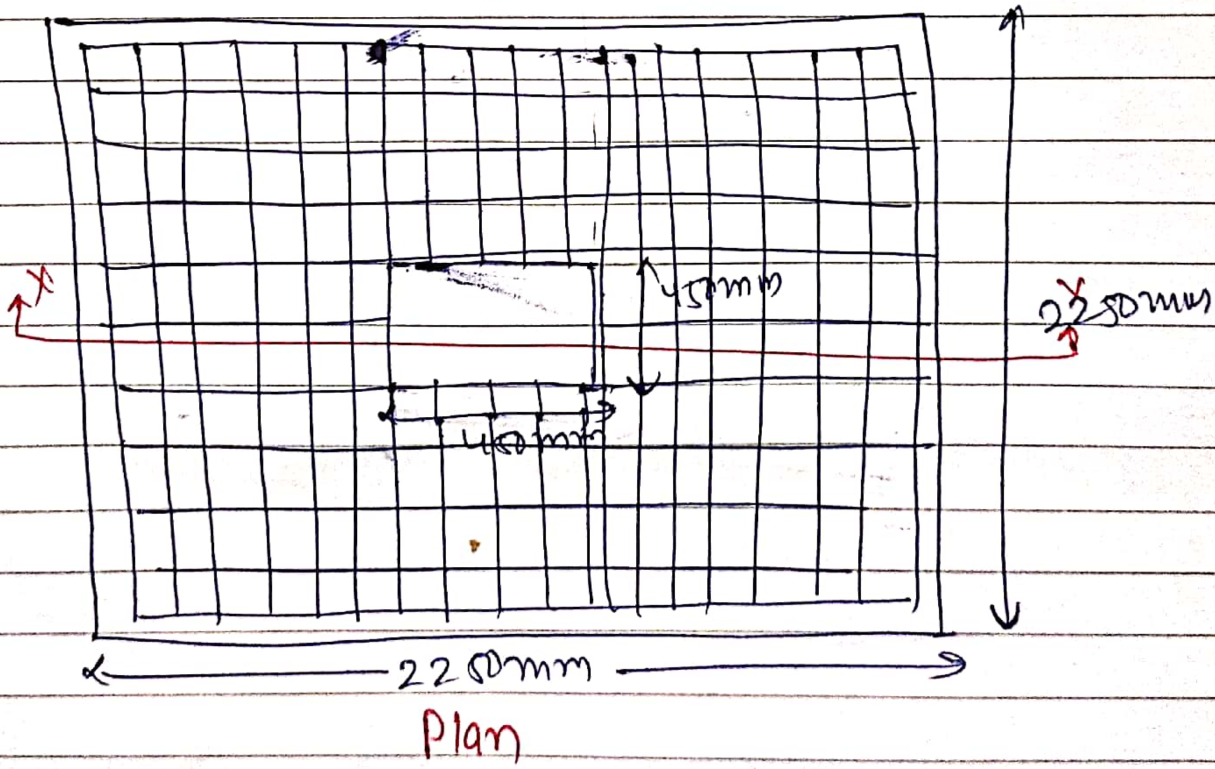
using 16 ϕ bars $A_\phi = \frac{\pi}{4} \times (16)^2 = 201 \, mm^2$

Spacing $\Rightarrow \frac{201 \times 2250}{165203} = 273 \, mm$

provide 16 ϕ bars @ 270 mm c/c in each dirn.



Section at XX



Plan

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