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INSTITUTE OF SCIENCE AND TECHNOLOGY
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SCHOOL OF BUILDING & ENVIRONMENT

DEPARTMENT OF ARCHITECTURE

UNIT – I - Building Structures III – SCI 1212

Limit State Method.

Types of staircase:

01. Bifurcated staircase
02. Half turn "
03. Quarter turn "
04. Straight Flight "
05. Dog legged "
06. Spiral "
07. Helicoidal "
08. Cantilever "
09. Circular "

09. Circular "

10. Foldid Type "

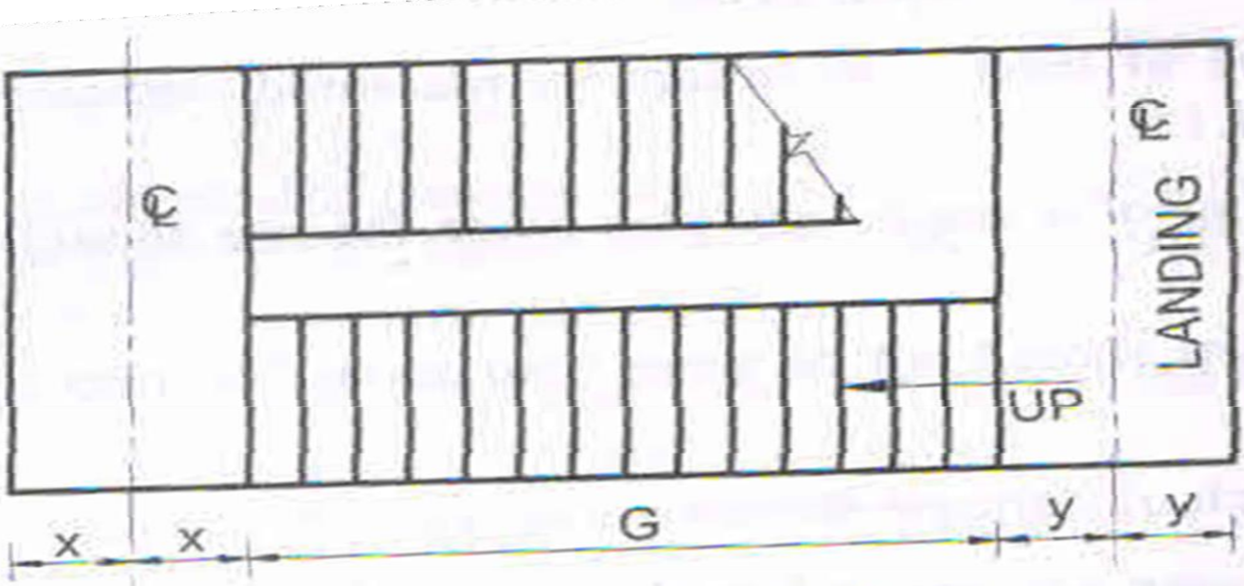
11. Open well "

12. Stinger-Beam Cantilever Staircase.

Design Of Dog-Legged Staircase

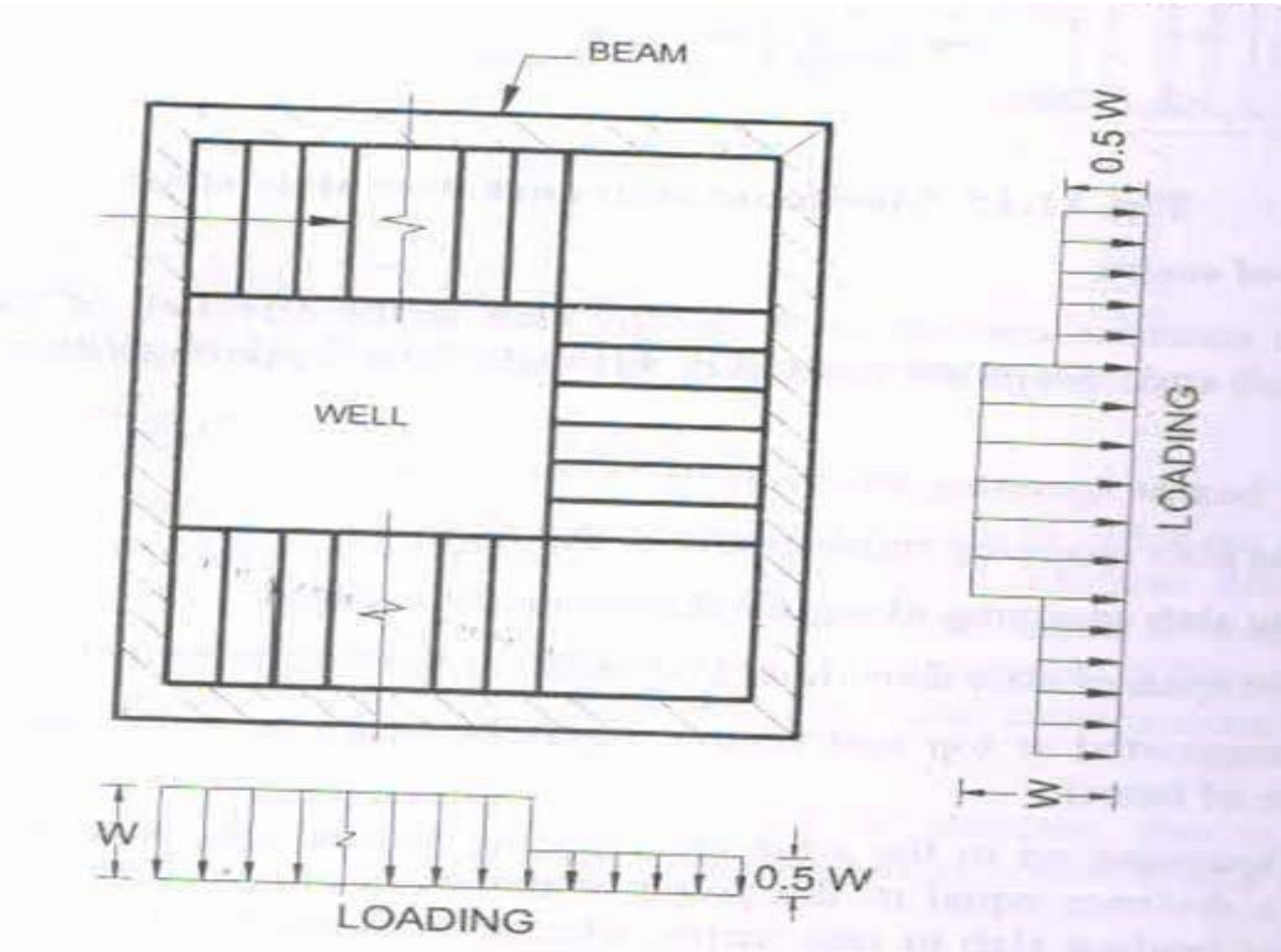
- Min. width of staircase = 1.2m
- Riser $\nless$ 150 mm $\ngtr$ 200 mm.
- Tread $\nless$ 250mm - 300mm.
- Clear head room Height - 2m
- Flight angle → 33° - 38°
- Landing width = width of staircase

- RISER
- TREAD WAIST/FLIGHT SLAB
- MIN AND MAX HEIGHT OF RISER
- MIN AND MAX SIZE OF TREAD HEAD ROOM
- MAX INCLINATION ANGLE
- LANDING MID/FLOOR



x m	y m	Span* M
< 1	< 1	G + x + y
< 1	≥ 1	G + x + 1
≥ 1	< 1	G + 1 + y
≥ 1	≥ 1	G + 1 + 1

*G = going measured horizontally


BEAM
WELL
W
0.5 W
LOADING
0.5 W
W
LOADING

09. Circular "

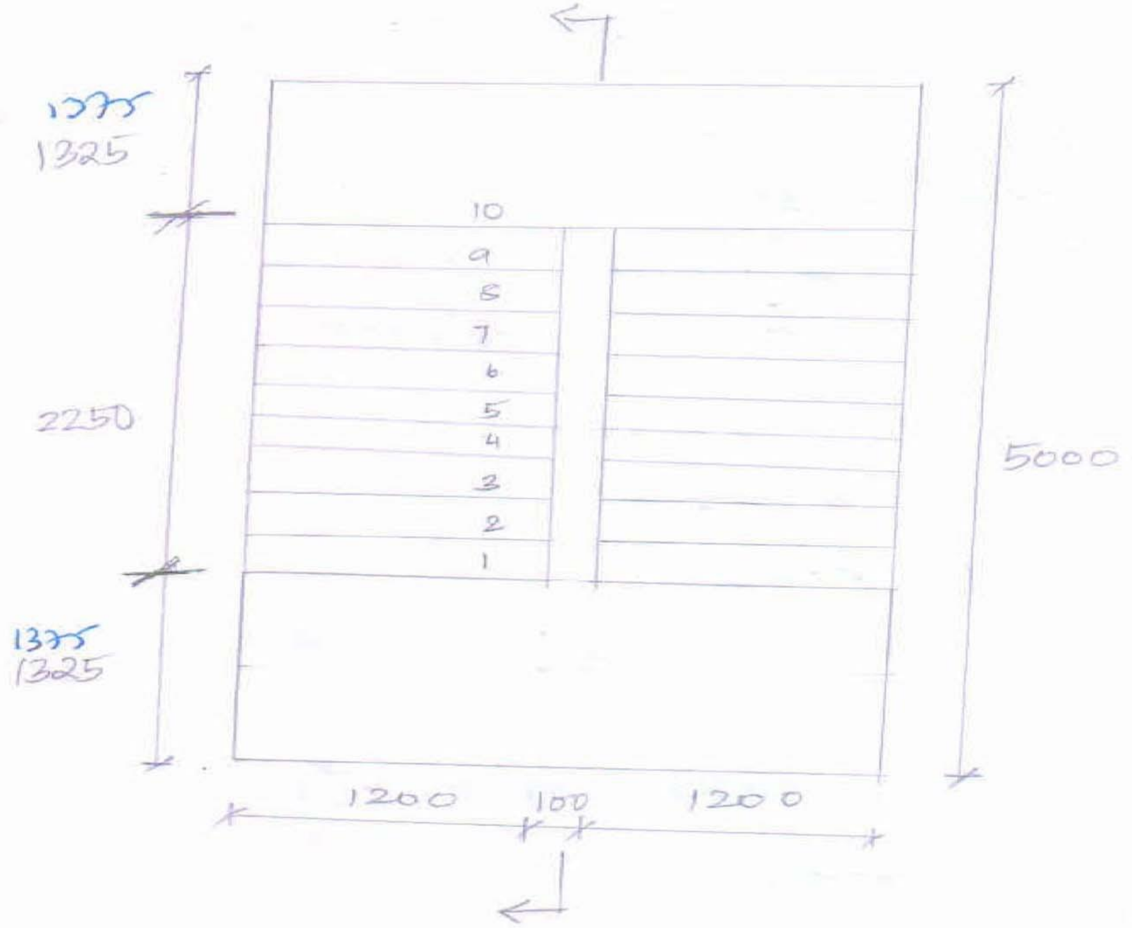
10. Foldid Type "

11. Open well "

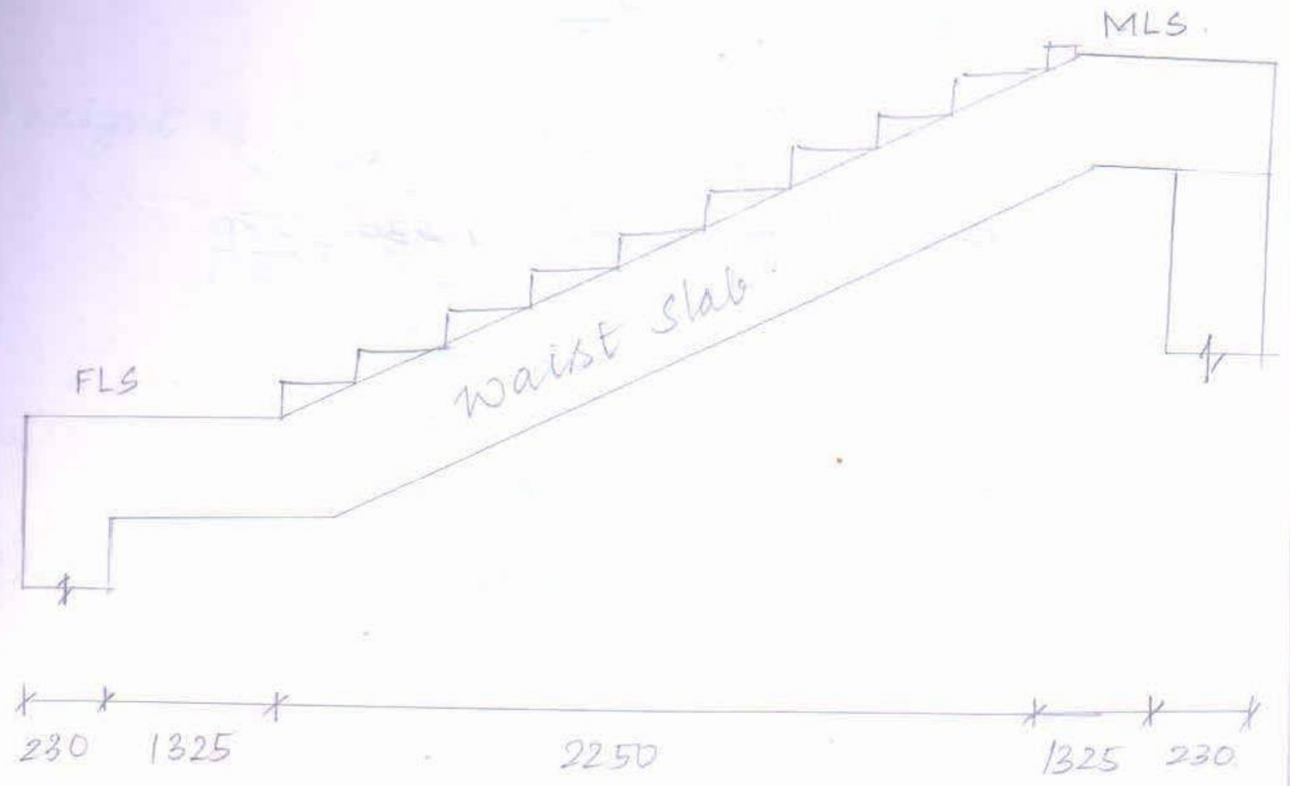
12. Stinger-Beam Cantilever Staircase.

Design Of Dog-Legged Staircase

- Min. width of staircase = 1.2m ✓
- Riser ≮ 150 mm ≯ 200 mm. ✓
- Tread ≮ 250 mm - 300 mm. ✓
- Clear head room Height - 2m ✓
- Flight angle → 33° - 38° ✓
- Landing width = width of staircase



1325
1325
2250
1325
1325
10
9
8
7
6
5
4
3
2
1
5000
1200
100
1200


MLS
FLS
waist slab
230
1325
2250
1325
230

<u>Problem</u> Design a ~~Logged~~ Dog legged Staircase for a room size of <u>5m x 2.5m</u> for a residential building. Assume Loads as per IS 875 part 1 and 2. Take fck 20 & fe 415 Steel.

<u>Step:1</u> <u>Data given:</u>

Size of room 5000 x 2500 mm.

Assume height of each floor = 3m = 3000 mm.

Live load for Residential stair] 4 kN/m²

Assume Riser 150 mm

Tread — 250 mm

Grade of Concrete: $f_{ck} = 20\ N/mm^2$ (or) 20 Mpa

Grade of Steel $f_y = 415\ N/mm^2$ (or) 415 Mpa

Type of stair: — Dog legged.

Step: 2 TO arrive dimensions of flight/ waist slab and landings

Height of 1 floor = 3000 mm

Type of stair: Dog legged

$\therefore$ No of flights / floor = 2

Height of 1 flight = $\frac{3000}{2}$ = 1500 mm.

Assume width of 1 flight = $\frac{2500 - 100}{2}$

= 1200 mm (100 mm gap between flights)

No. of risers / Flight = $\frac{1500}{150}$ = 10 Nos

No of Treads / Flight = 10-1 = 9 Nos

total length of waist slab = 9 X 250

= 2250 mm

Clear length available for 2 Landings and 1 waist

= 5000 mm

Length available for 2 landings

= 5000 - 2250 = 2750 mm

Assume width of Landing = width of Flight slab

Assume width of Landing = width of Flight slab

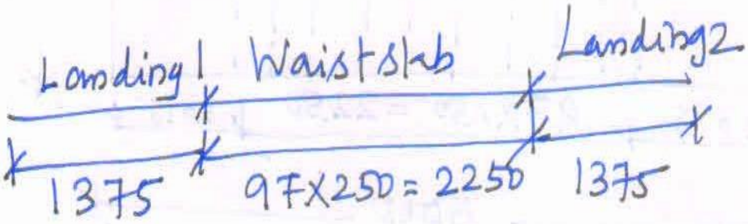
ie <u>1200 mm</u>

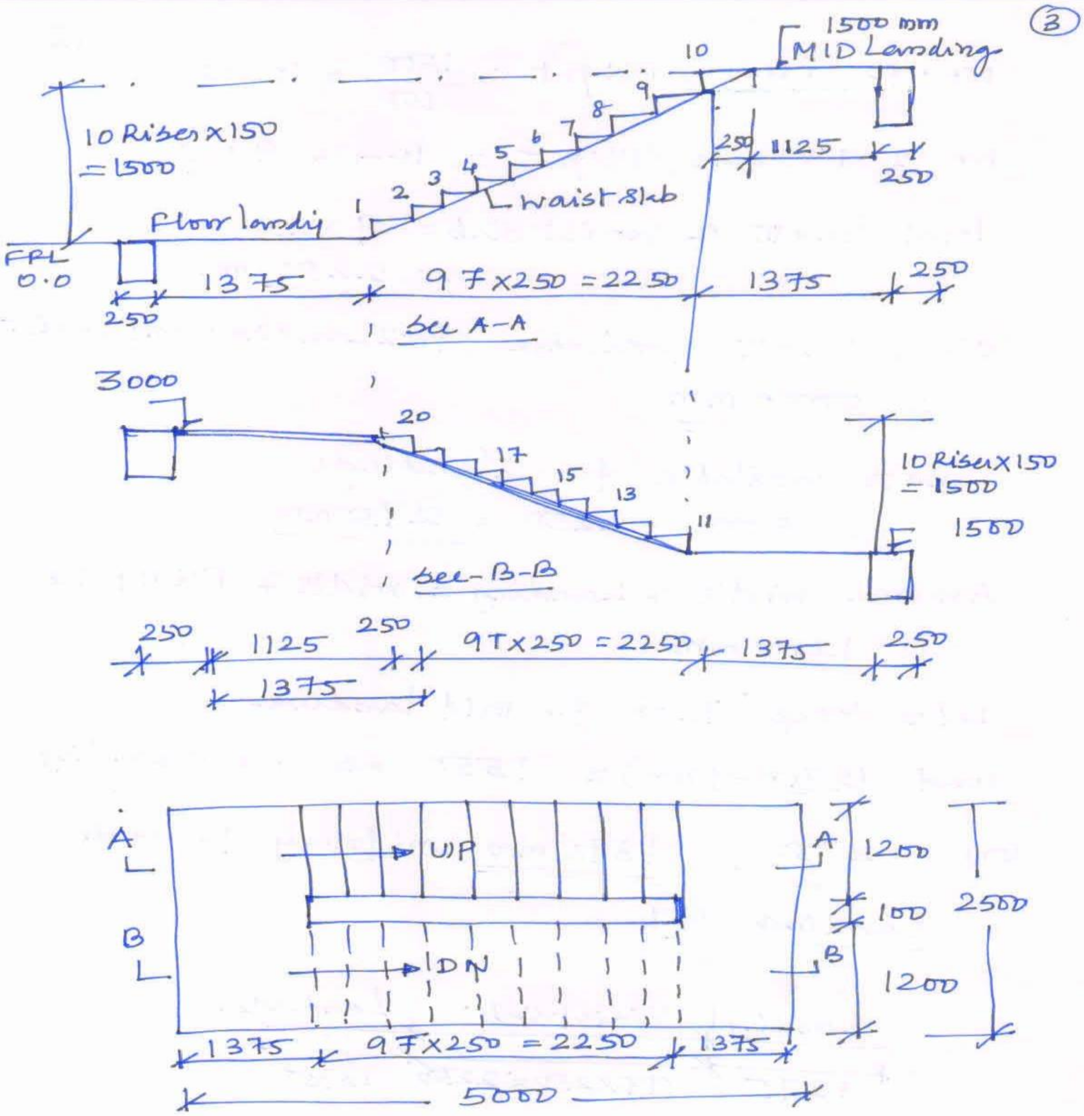
Let's keep 1200 for mid landing

and $(2750-1200) = 1550$ as Floor landing

(or) $\frac{2750}{2} = \underline{\underline{1375\text{ mm}}}$ Uniformly for each

<u>landing slab</u>





Plan of Stair Case

Step:3 Loadings

Detmn of d, D, l

eff. depth, overall Depth, effective length.

Assume $d = \frac{Span}{20} = \frac{5000}{20} = 250\,mm$

$D = d + cover + \frac{\phi}{2}$ (Assume 10 mm ϕ)

$= 250 + 20 + \frac{10}{2}$

(i) Effective Span $l = 5000 + \frac{250}{2} + \frac{250}{2} = \underline{\underline{5250}}$

(ii) effective Span $= L + d$

$= 5000 + 250 = \underline{\underline{5250}}$ ✓

Step: 4 Estimation of loads

(i) wt of Flight slab $= D \times \gamma$

$$= 0.275 \times 25 = 6.88 \text{ kN/m}^2$$

Equivalent Horizontal Weight

$$W_H = \frac{W_s \sqrt{R^2 + T^2}}{T}$$

$$= \frac{6.88 \times \sqrt{0.15^2 + 0.25^2}}{0.25}$$

$$= 8.02 \text{ kN/m}^2$$

(iii) Wt of Flight Per meter Run

= width of Flight × 8.02

= 1.2 × 8.02 = $\underline{\underline{9.62 \text{ kN/m}}}$ — (a)

(iv) Weight of 1 step = c/s area of 1 step × γ × width of Flight

$= \left(\frac{1}{2} \times 0.25 \times 0.15\right) \times 25 \times 1.2$

= 0.56 kN

weight of steps Per meter run (along the length of waist slab)

$= 0.56 \times \frac{1000}{250} = \underline{\underline{2.2 \text{ kN/m}}}$ (b)

(v) Wt of finishes (assume $\underline{1 \text{ kN/m}}$ (c)

Total Dead load = a+b+c

$= 9.62 + 2.2 + 1.0$

$= \underline{\underline{12.82 \text{ kN/m}}}$

Live load = $4 \text{ kN/m}^2 \times 1.2 = 4.8 \text{ kN/m}$

$\therefore$ Load on Waist slab = $9.62 + 2.2 + 4.8 + 1.0$

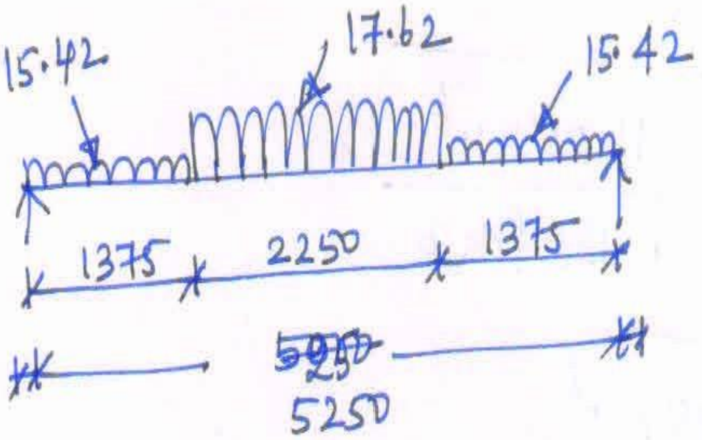
$= 12.82 + 4.8$

$= \underline{17.62} \text{ kN/m}$.

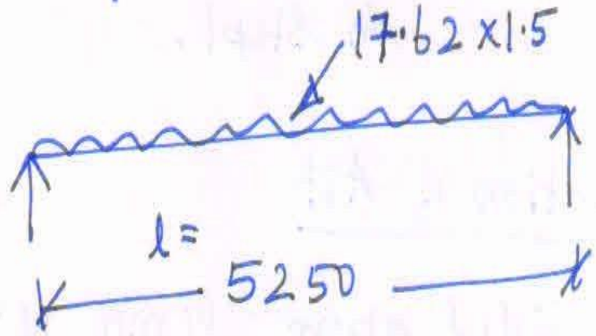
Load on Landings = $9.62 + 1.0 + 4.8$

$= \underline{\underline{15.42 \text{ kN/m}}}$

(6)



For simplycity, Consider maximum load Uniformly on flight as well as landings.



Step 4. Analysis to find B.M, d, Ast & Deflection

Bending moment $M_u = \frac{wl^2}{8}$

w = factored load = 1.5×17.62
$= 26.43$ kN/m.

$$m_u = \frac{26.43 \times 5.25^2}{8}$$

91.05 kN.m

Step: 5 Design as Balanced section.

for B.S Moment of Resistance $M.R = 0.138 f_{ck} b d^2$

Equate M.R = factored B.M.

$0.138 f_{ck} b d^2 = 91.05 \times 10^6$ N.mm

$$d = \sqrt{\frac{91.05 \times 10^6}{0.138\, f_{ck}\, b}}$$

$$= \sqrt{\frac{91.05 \times 10^6}{0.138 \times 20 \times 1000}}$$

$= 181.62 < 250$ mm assumed initially in Step 1.

Step 6 Determination of Ast

since d is provided above 181 mm which is the effective depth reqd for Balance section, as d = 250, the slab is designed as URS.

$A_{st} \Rightarrow M.R.$

$$91.05 \times 10^6 = 0.87 f_y A_{st} d \left(1 - \frac{f_y A_{st}}{f_{ck} b d}\right)$$

$$91.05 \times 10^6 = 0.87 \times 415\, A_{st} \times 250 \left(1 - \frac{415\, A_{st}}{20 \times 1000 \times 250}\right)$$

$A_{st} =$

(OR)

$$A_{st} = \frac{0.5 f_{ck}}{f_y}\left[1 - \sqrt{1 - \frac{4.6\, m_u}{f_{ck} b d^2}}\right] bd$$

$$= \frac{0.5 \times 20}{415}\left[1 - \sqrt{1 - \frac{4.6 \times 91.05 \times 10^6}{20 \times 1000 \times 250^2}}\right] \times 1000 \times 250$$

$6024.1 \times 0.18 = \underline{1084\ mm^2}$

Step: 7 minimum Ast

$$Ast\ min = 0.12\%\ bD$$

$$= \frac{0.12}{100} \times 1000 \times 275$$

$$= \underline{330\ mm^2} < 1084\ mm^2$$

If Ast min is greater than Ast Calculated, Provide the higher value as Ast.

Step: 8 Spacing of Reinforcement

$$S = \frac{ast}{Ast} \times 1000$$

Assume 12mm dia bar.

area of 1 bar = ast = $\frac{\pi}{4} \times 12^2 = \underline{113 \, mm^2}$

spacing = $\frac{113}{1084} \times 1000 = 104 \, mm$.

Provide 12mm ϕ @ 100 c/c as main Rod.

Step: 9 Spacing of Distribution Steel.

$A_{st} = 0.12\% \, bD = 330 \, mm^2$

Assume 8mm ϕ

area of 1 bar = $\frac{\pi}{4} \times 8^2 = \underline{\underline{50.25 \, mm^2}}$

$$\text{Spacing} = \frac{50.25}{330} \times 1000$$

$$= 150 \text{ mm}.$$

Provide <u>8mm ø @ 150 c/c</u>

<u>Step: 10</u> <u>Check for Shear:</u>

$W_u = 26.43$ kN/m.

$$V_u = \frac{W_u l}{2} = \frac{26.43 \times 5.25}{2}$$

$$= \underline{\underline{69.38 \text{ kN}}}$$

<u>Step: 11</u> Shear taken by Concrete shall be deducted from the total shear force:

$V_c = \tau_c bd \qquad \tau_c \Rightarrow p_t = \dfrac{100\, A_{st}}{bd}$

$$= \frac{100 \times 1084}{1000 \times 250} = \underline{\underline{0.43}}\,\%$$

<u>from table 19, Pg 73, IS 456</u>

for 0.43% and M_{20} $\tau_c \Rightarrow 0.47$

$$V_c = \tau_c bd = \frac{0.47 \times 1000 \times 250}{1000} = 117.5\ kN$$

$V_{us} = V_u - V_c \Rightarrow 69.38 - 117.5\,kN$

= −ve value means no shear reinforcement is required.

Check for Deflection:

$$d = \frac{span}{B \cdot V \times m \cdot f}$$

B·V = Basic Value

m·f = modification factor

$$= \frac{5250}{20 \times 1.3}$$

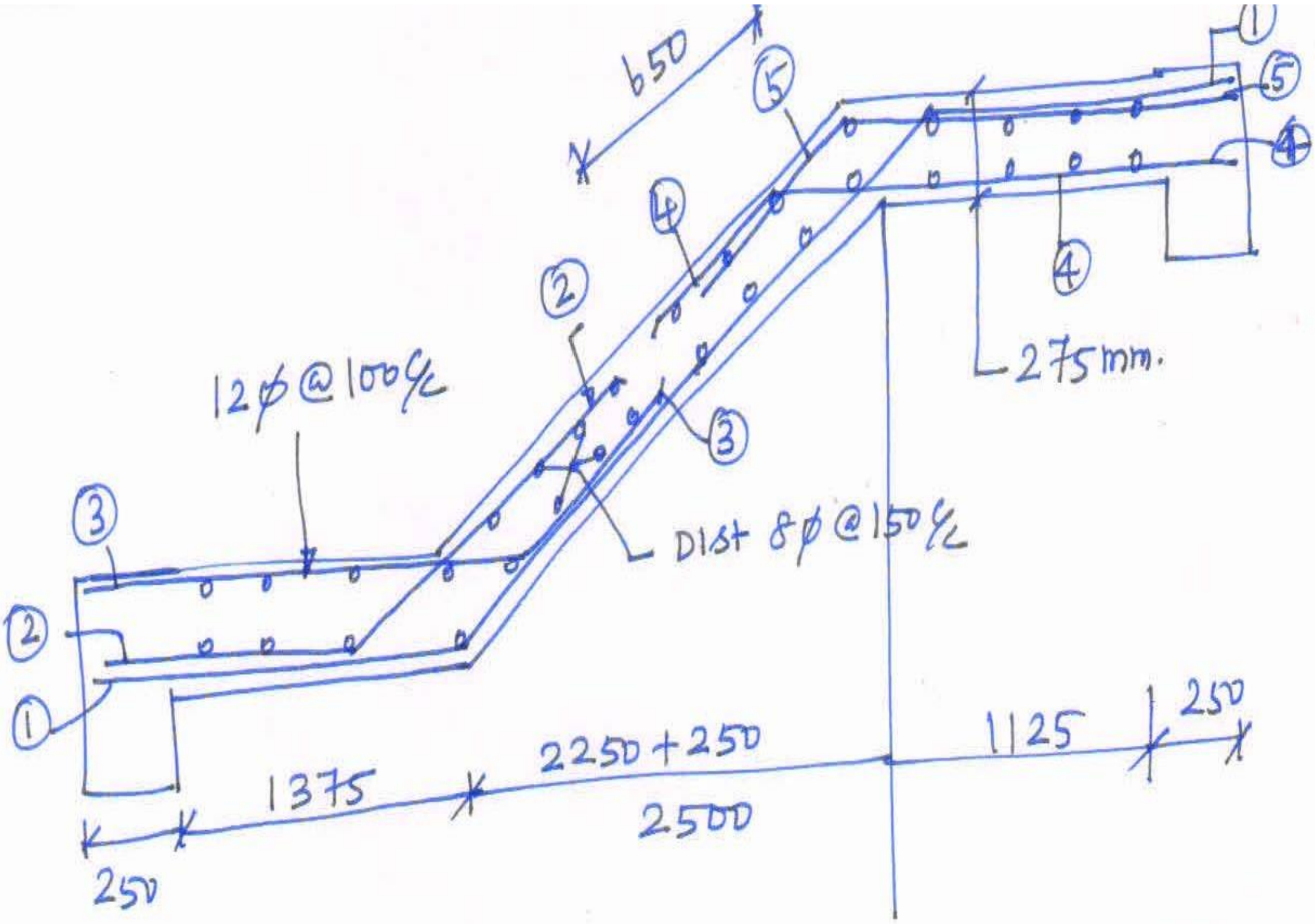
$m \cdot f \Rightarrow f_s = 0.58 \times f_y$

$= 0.58 \times 415$

$= 240.7$

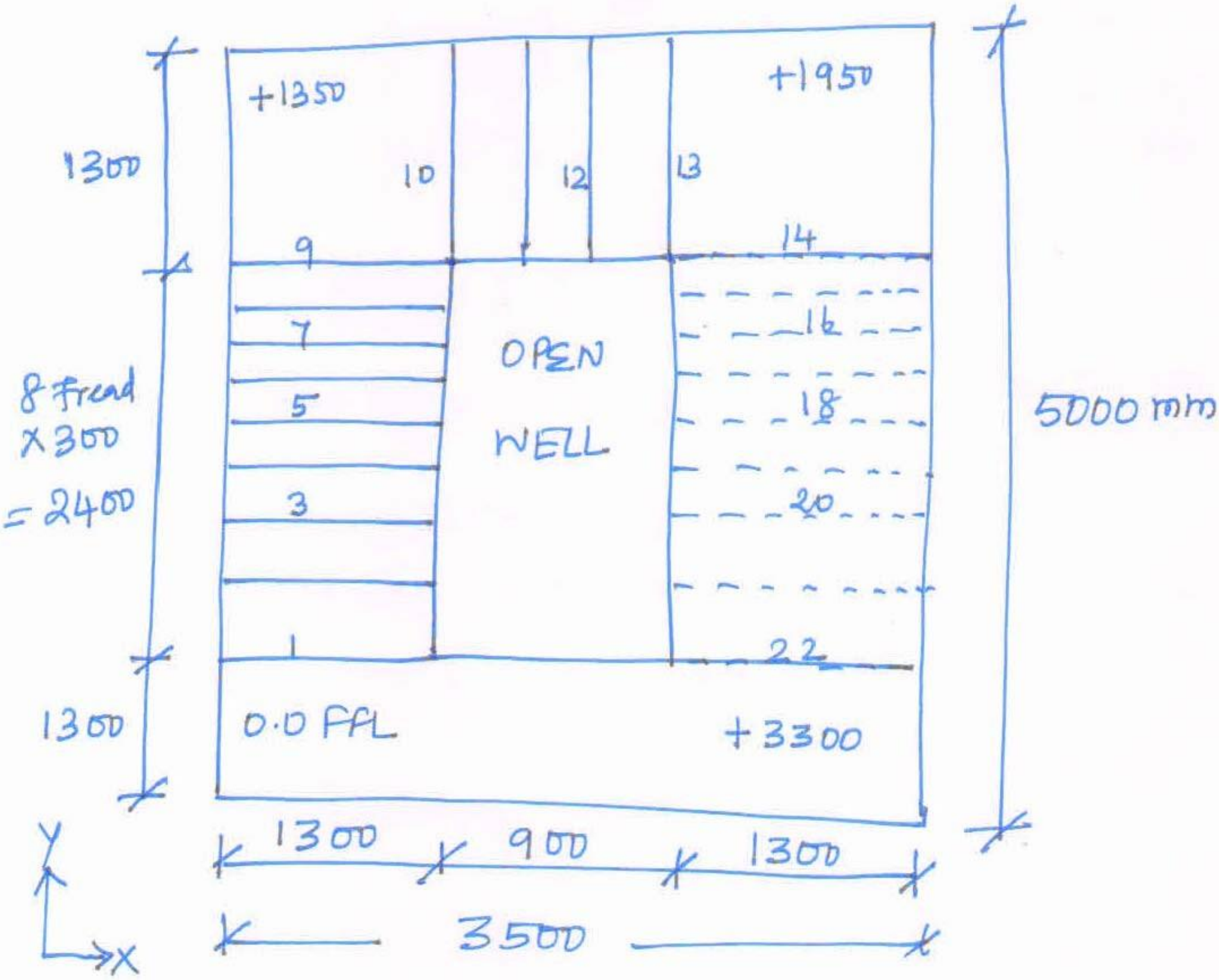
$= 202 < 250$

Reqd < Provided Safe!



Typical L.S of Waist slab Reinforcement.

DESIGN OF OPEN WELL STAIR CASE


+1350
+1950
1300
10
12
13
9
14
7
16
OPEN
8 tread
x300
=2400
5
18
5000 mm
WELL
3
20
1
22
1300
0.0 FFL
+3300
1300
900
1300
3500
Y
X

Design an open well Staircase for an office building whose room size is 3.5m X 5.0m. Take M25 grade of Concrete and Fe415 steel. Assume Suitable Tread and Riser. Ht of head room: 3.30 m.

Step:1 Data given:

Size of stair Room: 3.5m x 5.0 m

Grade of Concrete $f_{ck} = 25\ N/mm^2$ or Mpa

Grade of Steel Fe415; Head room: 3.30 m.

Step: 2 Assume: tread = 300 mm > 250 min for Residence

Riser: Head Room height 3.3m

$= 3300$ mm

Assume 150 mm Total no. of Riser

$$= \frac{3300}{150} = \underline{22 \text{ Nos}}$$

Assume width of stair case 1300 mm

Consider short dimn first = 3500

open well stair case consists of 2 landing on each Flight slab.

$\therefore$ $3500 - 2 \times 1300 = 900$ mm.

width of Tread = 300 mm

No of Tread $= \frac{900}{300} = 3$ nos.

$\therefore$ No of Riser $= 3+1 = \underline{\underline{4 \text{ nos}}}$ $\quad \begin{pmatrix} T = R-1 \\ R = T+1 \end{pmatrix}$

$\underline{4 \times 150 = 600 \text{ mm}}$

W.K.T. Total height of Head room = 3300 mm (3.3 m

$\therefore$ Height available for 2 flights =
(Totally 3 flight slab)

$= 3300 - 600 = 2700$ mm

Ht available for 1 flight $= \frac{2700}{2} = \underline{1350 \text{ mm}}$

Total Riser / Floor $= \frac{3300}{150} = 22$ nos.

Total Riser / Floor = $\frac{3300}{150}$ = 22 nos.

Risers Provided in shorter direction 22-4 = 18

∴ Risers to be accomodated in each flight in longer direction = $\frac{18}{2}$ = 9 Risers.

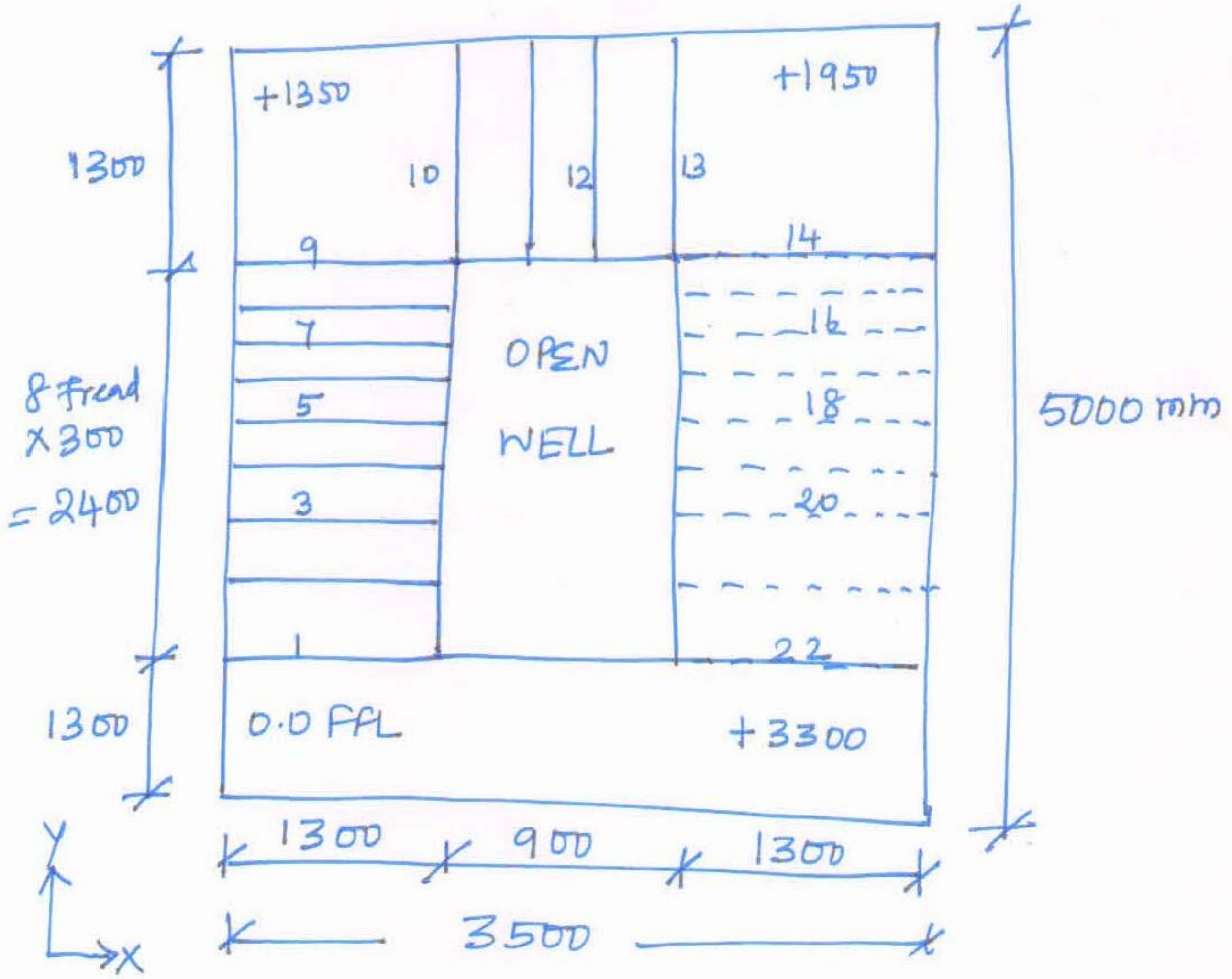
∴ No. of Treads in longer dim = 9 − 1 = 8

(R = T+1)
(T = R−1)

total Treads length
= 8×300 = 2400.

Total length of flight slab + Landing = 5.0m
= 5000mm

width of Landing = 5000 − 2400 = $\frac{2600}{2}$ = $\underline{\underline{1300}}$
(one

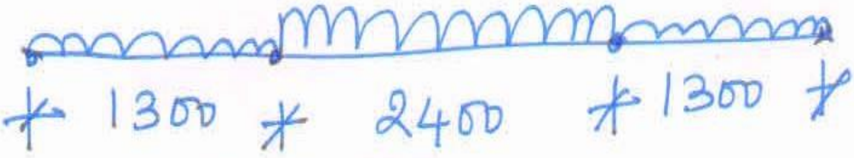


+1350
+1950
1300
10
12
13
9
14
7
16
OPEN
WELL
8 Tread
x300
=2400
5
18
5000 mm
3
20
1
22
1300
0.0 FFL
+3300
Y
1300
900
1300
X
3500

one flight in X dirn

2 flights in Y dirn.

Design of one longer flight as typical case and adopt the same detail for the other two flights.



Step. 3 Loadings

Detrmn of d, D, l

eff. depth, overall Depth, effective length.

Assume $d = \frac{Span}{20} = \frac{5000}{20} = 250\, mm$

$D = d + cover + \frac{\phi}{2}$ (Assume 10 mm ϕ)

$= 250 + 20 + \frac{10}{2}$

(i) Effective Span $l = 5000 + \frac{250}{2} + \frac{250}{2} = \underline{\underline{5250}}$

(ii) effective Span $= L + d$

$= 5000 + 250 = \underline{\underline{5250}}$ ✓

Step:4 Estimation of loads

(i) wt of Flight slab = $D \times \gamma$

$$= 0.275 \times 25 = 6.88 \ kN/m^2$$

Equivalent Horizontal Weight

$$W_H = \frac{W_s \sqrt{R^2 + T^2}}{T}$$

$$= \frac{6.88 \times \sqrt{0.15^2 + 0.25^2}}{0.25}$$

$$= 8.02 \ kN/m^2$$

(iii) wt of Flight Per meter Run

= width of flight × 8.02

= 1.3 × 8.02 = ~~9.62~~ 10.42 kN/m (a)

(iv) wt of 1 step: = c/s area × width of flight / length of step × γ

$=\left(\frac{1}{2}\times 0.3\times 0.15\right)\times 1.3\times 25$

= 0.73 kN/m (b)

wt of step /m = $0.73\times\frac{1000}{300}$ = 2.43 kN/m

(v) Assume finishes = 1 kN/m² ⇒ 1kN/m (c)

Total dead load = a + b + c

= 10.42 + 0.73 + 1

= 12.15 kN/m.

(v) Live load = 5 kN/m² (for office)

5 × 1.3 = 6.5 kN/m.

Step: Load on waist slab

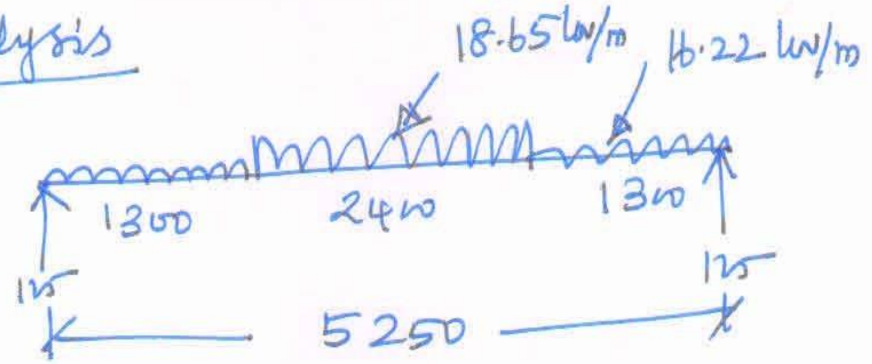
= 12.15 + 6.5 = 18.65 kN/m.

Load on landing 18.65 − (b) (wt of steps/m)

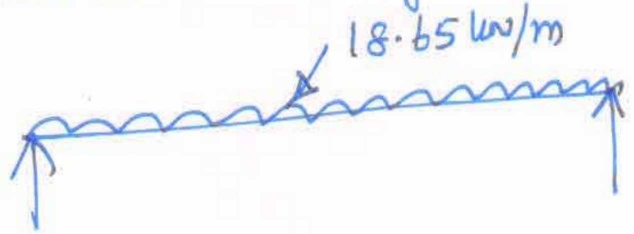
= 18.65 − 2.43

= 16.22 kN/m

Analysis



for simplicity, consider maximum loading which is loading on flight



Step: Analysis to find B.M, d, Ast, Deflection)

Bending moment = $m_u = \frac{Wl^2}{8}$

$W = 1.5 \times 18.65$

$= 27.98 \rightarrow$ Wu factored load

$l = 5.25\,m$

$$m_u = \frac{27.98 \times 5.25^2}{8}$$

96.38 kN.m.

Step: for Balanced Section:

$0.138\, f_{ck} b d^2 = 96.38 \times 10^6$

M.R = B.M.

$0.138 f_{ck} b d^2 = 96.38 \times 10^6$ (As Balanced section)

$$d = \sqrt{\frac{96.38 \times 10^6}{0.138 \times f_{ck}\, b}}$$

$$= \sqrt{\frac{96.38 \times 10^6}{0.138 \times 25 \times 1000}}$$ $f_{ck} = 25$ given

$= 167$ mm < 250 provided

$D = 250 + 20 + 10/2 = 275$ mm

Step: Detmn of Ast

Since we adopt 250 mm which is more depth than the depth required for Balanced Section the Section becomes Under Reinforced Section

$$A_{st} = 96.38 \times 10^6 = 0.87 f_y A_{st} d \left(1 - \frac{f_y A_{st}}{f_{ck} b d}\right)$$

$$= 96.38 \times 10^6 = 0.87 \times 415 \times A_{st} \times 250 \left(1 - \frac{415 \times A_{st}}{25 \times 250 \times 1000}\right)$$

(or)

$$A_{st} = \frac{0.5 \times f_{ck}}{f_y} \left[1 - \sqrt{1 - \frac{4.6 m_u}{f_{ck} b d^2}}\right] bd$$

$$= \frac{0.5 \times 25}{415} \left[1 - \sqrt{1 - \frac{4.6 \times 96.38 \times 10^6}{25 \times 1000 \times 250^2}}\right] 1000 \times 250$$

$$= \underline{1157.2 \text{ mm}^2}$$

Step: Check for minimum Ast

$A_{st}\,min = 0.12\%\ bD$

$= \frac{0.12}{100} \times 1000 \times 275$

$= 330\,mm^2 < 1157\,mm^2$

Since the Calculated Ast ($1157\,mm^2$) is greater than Ast min ($330\,mm^2$). Adopt the greater value.

Step: Spacing of reinforcement

Step: Spacing of main steel

$$S = \frac{ast}{Ast} \times 1000$$

Assume 12mm ϕ bar.

Area of 1 bar $= \frac{\pi}{4} \times 12^2 = \underline{113\,mm^2}$

Spacing $= \frac{ast}{Ast} \times 1000 = \frac{113}{1157} \times 1000 = 97.66\,mm$

Provide 12mm ϕ @ 90 mm c/c

Step: Spacing of Distribution Steel (Ast min)

$Ast = 0.12\%\ bD \Rightarrow 330\,mm^2$

Assume 8mm ϕ $ast = \frac{\pi}{4} \times 8^2 = 50.25\,mm^2$

Spacing of Dist $= \frac{50.25}{330} \times 1000 = 150\,mm.$

Provide 8ϕ @ 150 c/c

Step: Check for shear:

$$W_u = 1.5 \times 18.65 = 27.98 kN$$

$$V_u = \frac{W_u l}{2} = \frac{Wl}{2} = \frac{27.98 \times 5.25}{2} = 73.44 kN.$$

Step: Shear resisting by Concrete (V_c)

$$\Rightarrow V_c = \tau_c b d$$

$$\tau_c \Rightarrow p_t = \frac{100 A_{st}}{bd}$$

$$= \frac{100 \times 1157}{1000 \times 250} = 0.46$$

from table 19, Pg: 73

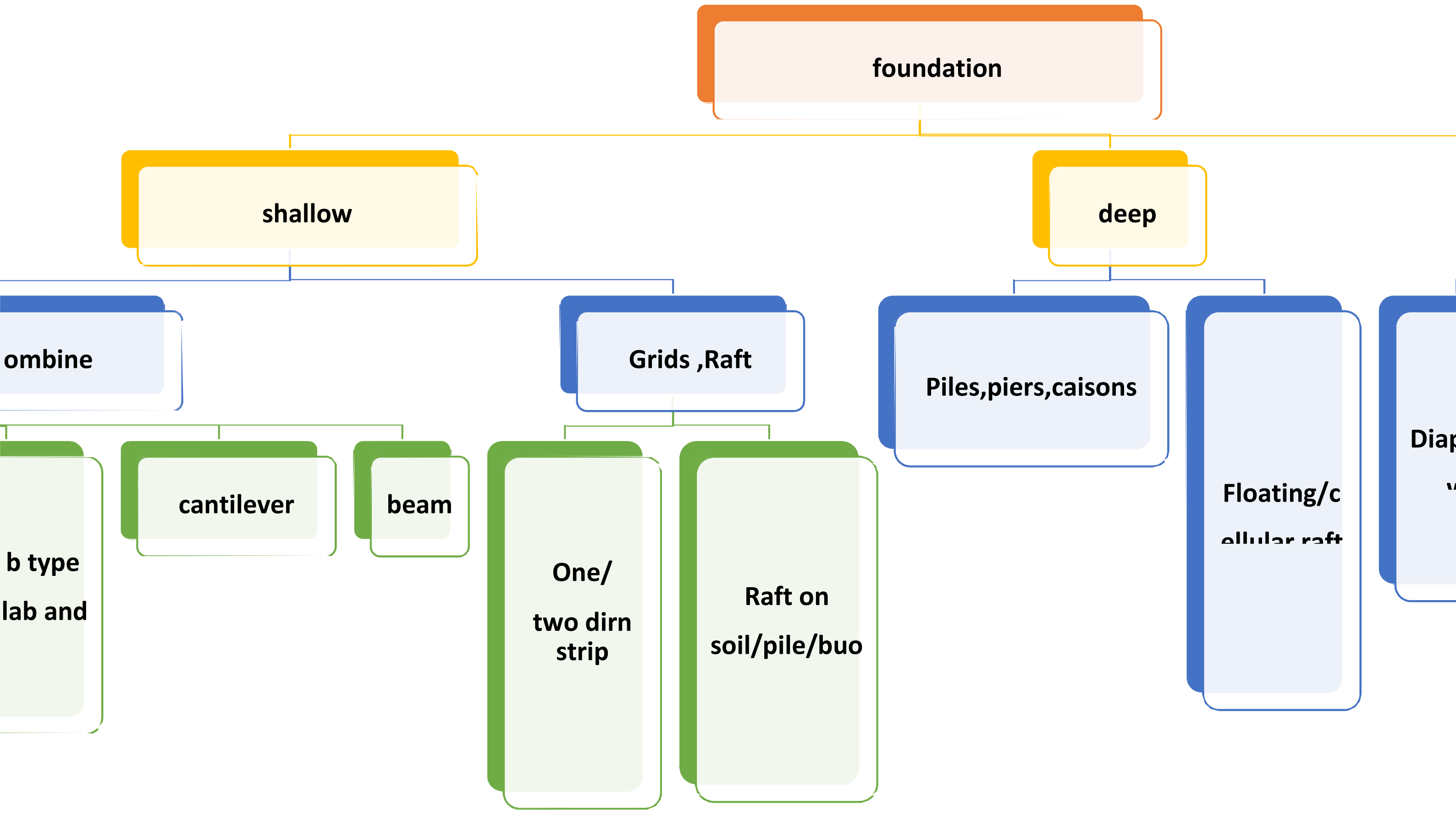
for 0.46% & M20 $\tau_c = 0.46$.

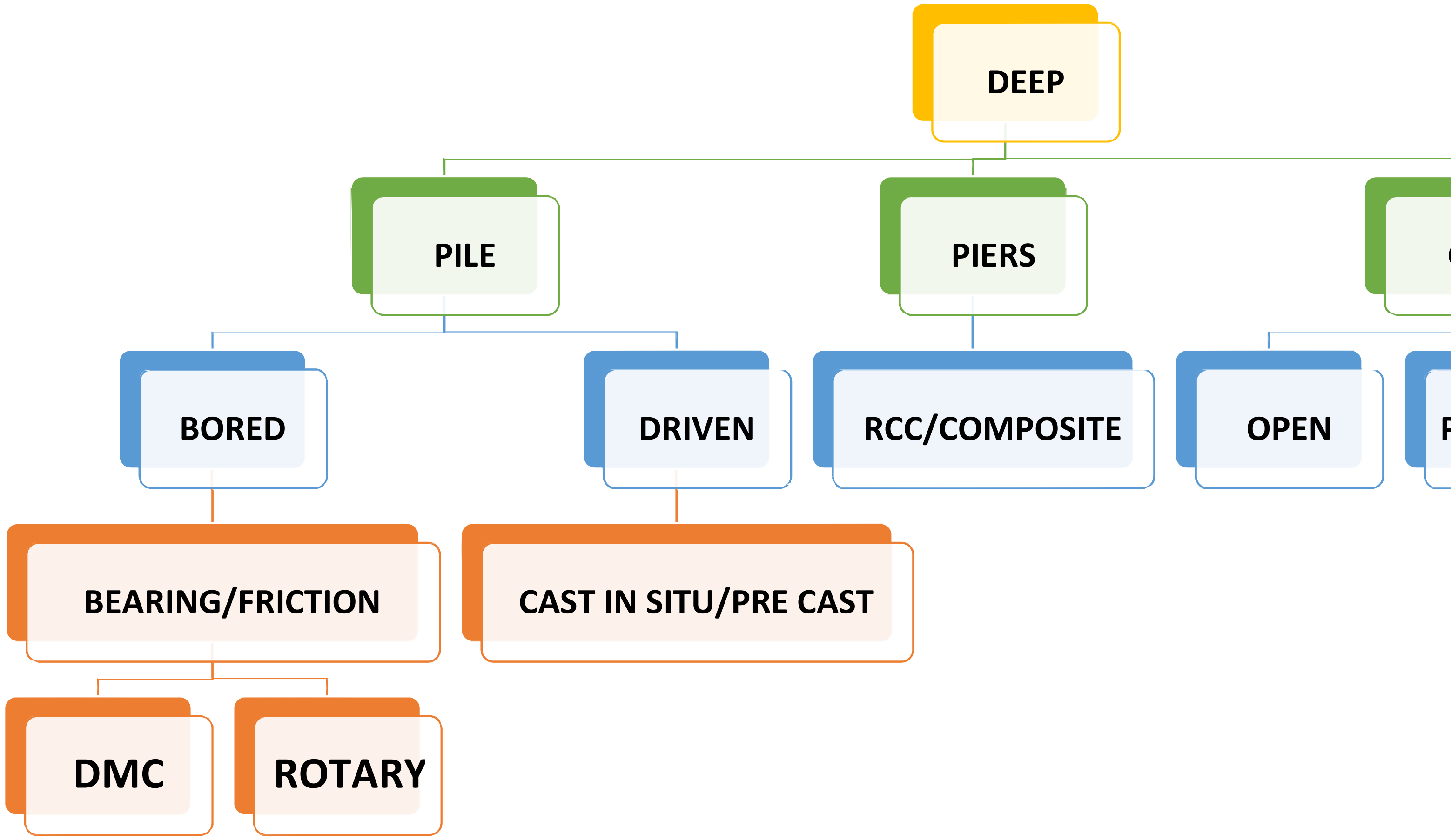
$$V_c = \tau_c bd = \frac{0.46 \times 1000 \times 250}{1000} = 115$$

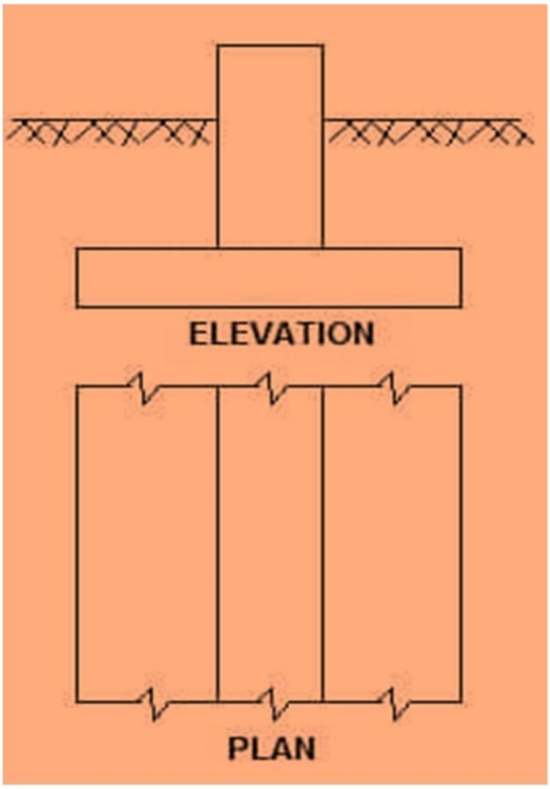
$V_{us} = V_u - V_c = 73.44 - 115 = -ve$ value

indicates no shear reinforcement is required.

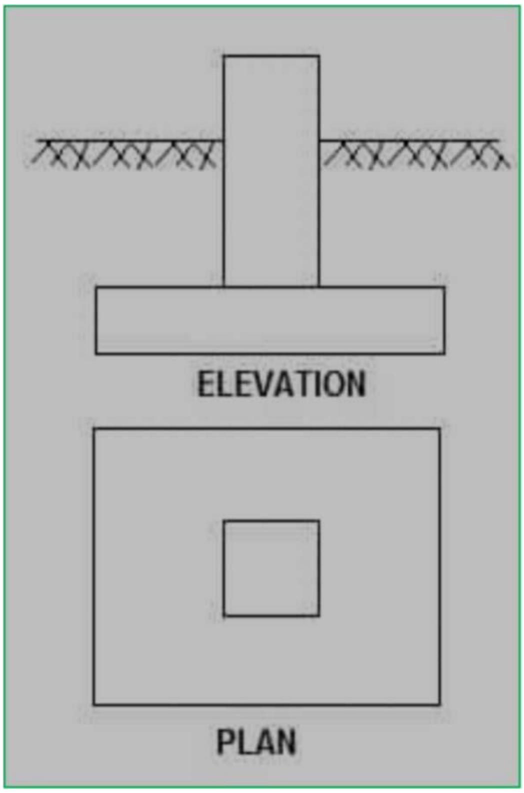
UNIT – II - Building Structures III – SCI 1212


foundation
shallow
deep
ombine
Grids ,Raft
Piles,piers,caisons
Floating/c
Diap
b type
lab and
cantilever
beam
One/
two dirn
strip
Raft on
soil/pile/buo

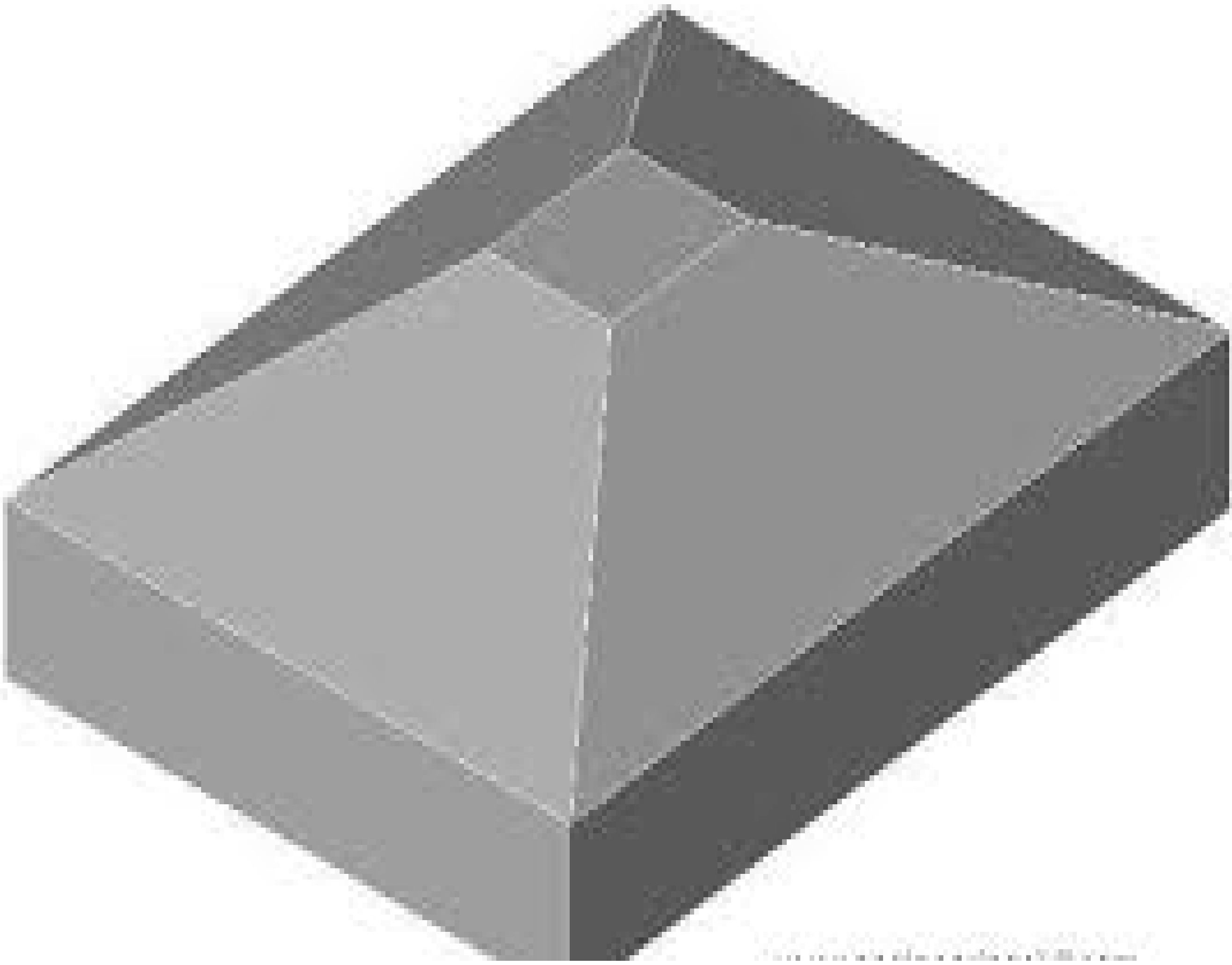

DEEP
PILE
PIERS
BORED
DRIVEN
RCC/COMPOSITE
OPEN
BEARING/FRICTION
CAST IN SITU/PRE CAST
DMC
ROTARY

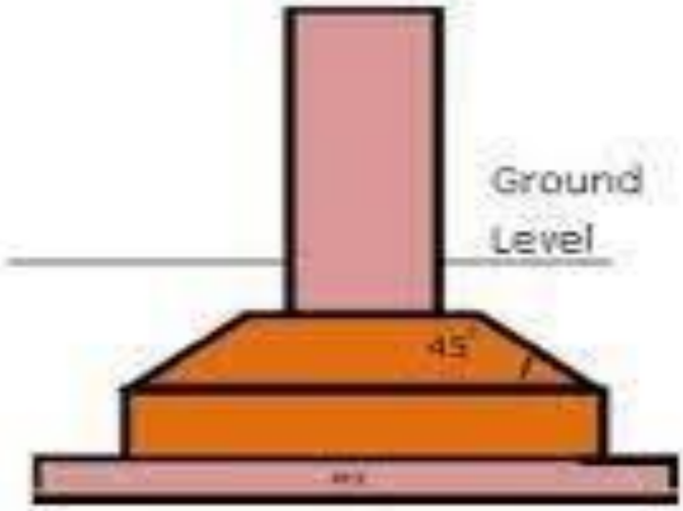


Strip footing



Spread or isolated footing

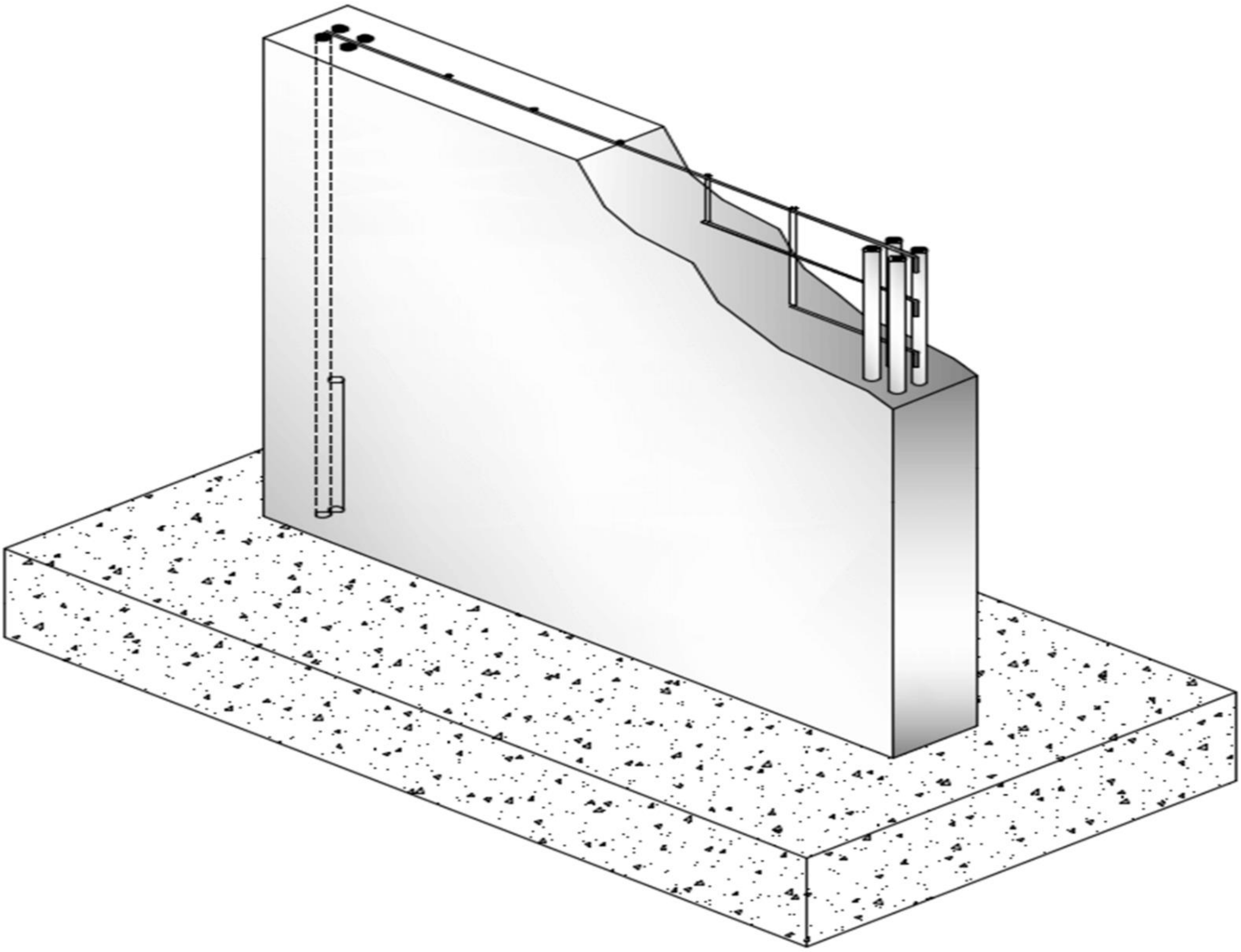




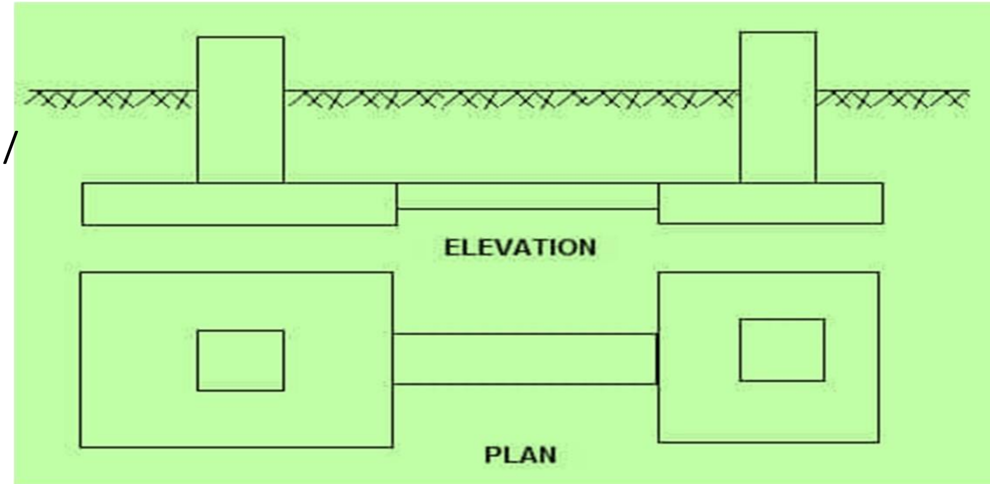
SLOPED FOOTING

WALL

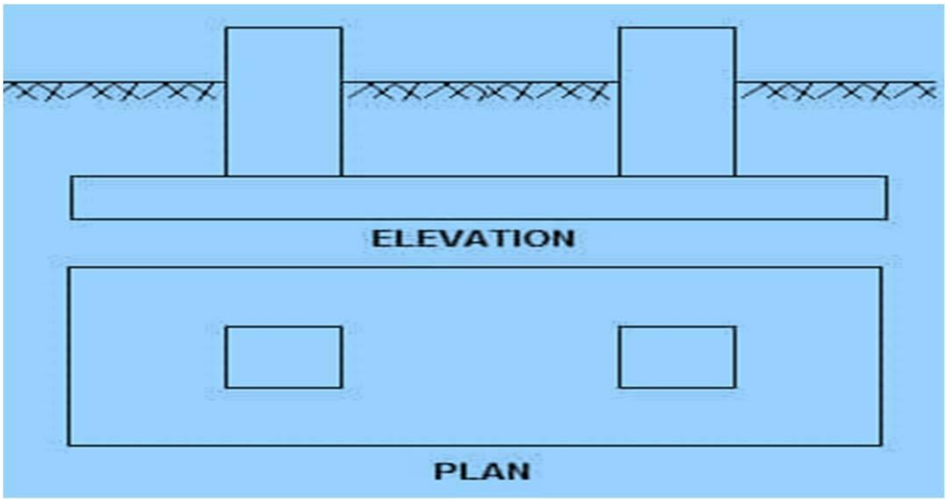
FOOTING

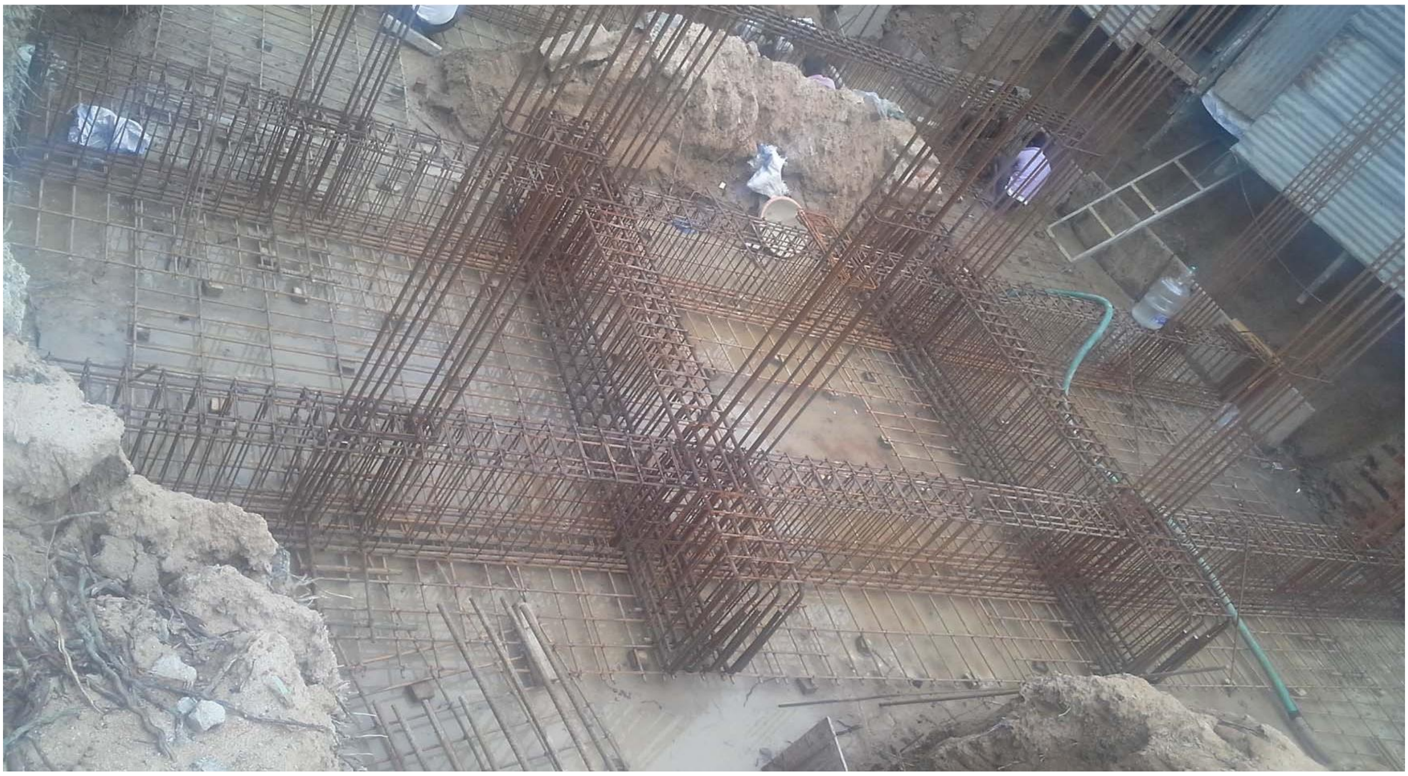


Cantilever / strap footing



Combined footing





- Depth of footing

- As per clause 34.1.2 of IS456: 2000

- *the thickness of footing at its edge* shall not be less than 150mm on soils.

- or less than 300mm for footings on piles.

- ***Step1 Depth of foundation below ground level***

  can be obtained by using Rankine’s formula:

$$h=\frac{p}{\gamma}\left(\frac{1-\sin\phi}{1+\sin\phi}\right)^2 \qquad \textit{Equation 1}$$

- h = minimum depth of foundation
- P = safe bearing capacity:
- γ= density of soil

- Step 2 Area of foundation : required for proper transfer of total load on the soil

- The total load (combination of dead load, live load and any other load without multiplying it with any load factor) are considered.

$$\text{Plan area of footing} = \frac{\text{Total load including self weight}}{\text{Allowable bearing capacity of soil}} \qquad \textit{Equation 3}$$

- **Step 3 Maximum Bending moment**
- According IS 456: 2000 clause 34.2.3.1 and 34.2.3.2, The bending moment will be considered at the face of
- column, pedestal or wall .
- **$mu=wl^2/2$**
- Mu = ultimate/ factored moment=1.5xw

Step4 Equate $mu = 0.138 f_{ck} b d^2$

Find 'd '

Step 5 Check ' d ' for one way shear

Calculate shear force at a distance of d from the face of column

Equate step 5 and 6, find the d reqd for satisfying one way shear IS 456

Step 7 check **'d'** for punching shear stress /two way

shear

= punching force/sliding area Punching

force = (A-a)x NBP Sliding/shearing

area=perimeter length x d A = area of

footing

a= punching area enclosed from d/2 distance from face of column on each side

NBP = net bearing pressure

Step8 max permitted shear stress = $0.25\sqrt{fck}$

- Step 9 : Determine Ast for under reinforced section /Ast = 0.25bd/100
- Step 10: check for min Ast= 0.12%bD
- Step 11: calculate spacing of reinforcement

s= (ast/Ast) x1000

note Check for bearing stress transfer, development length and pedestal are skipped

Design of Isolated Footing:

Design an Isolated footing to carry an axial load of 700kN from column. SBC of soil is 170 kpa. $\phi = 28^{\circ}$. $\gamma = 18\ kN/m^3$ size of column 300 x 300. M25 and Fe 415 grades are adopted for concrete and steel respectively

Data given: square footing.

Size of column: 300x300.

Axial load: 700 kN.

$\therefore$ factored load: $1.5 \times 700 = 1050$ kN. (should not be factored)

SBC 170 kpa = $170\ kN/m^2$

Angle of repose = $\phi = 28^{\circ}$; $\gamma = 18\ kN/m^3$.

Data given: square Footing.

Size of column: 300x300.

Axial load: 700 kN.

$\therefore$ factored load: $1.5 \times 700 = 1050$ kN. (should not be factored)

SBC 170 kpa = 170 kN/m^2

Angle of repose = $\phi = 28^\circ$; $\gamma = 18$ kN/m^3.

Step:1) Minimum depth of footing:

$$D_{min} = \frac{P_o}{\gamma}\left[\frac{1-\sin\phi}{1+\sin\phi}\right]^2$$

$$= \frac{170}{18}\left[\frac{1-\sin 28}{1+\sin 28}\right]^2 = \underline{1.23\ m}$$

Axial load from column = 700

for Self wt of footing
Add 10% of Axial load] = 70

770 kN

Area of footing = $\frac{770}{170}$ = $4.53\ m^2$

Size of footing $\sqrt{A} = \sqrt{4.53} = 2.13 \times 2.13$ m

Provide 2.2×2.20 m.

Step: 3 Net bearing pressure / capacity of soil.

$$NBP = \frac{\text{Axial load}}{\text{Area of Footing}} = \frac{700}{2.2 \times 2.2} = 144.63 < 170 \ kN/m^2$$

Factored NBP $= 1.5 \times 144.63$
$= 216.95\ kN/m^2$

Step: 4 Check for one way shear.

Shear force at a distance d from face of Column: $\left[\frac{2200-300}{2}\right] - d \times 2200 \times 0.217$ — (1)

Step:4 Check for one way shear.

Shear force at a distance d from face of Column: $\left[\frac{2200-300}{2}\right]-d \times 2200 \times 0.217$

— (1)

y.

Provide 0.25% of Reinforcement for footing.

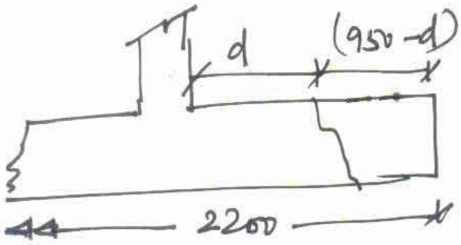
for M25 grade, for $p_t = 0.25 \Rightarrow \tau_c = 0.36\ N/mm^2$

Pg. 73, Tab 19

IS 456-2000

$\tau_c b d = 0.36 \times 2200 \times d$

$= \underline{792d}$ — (2)



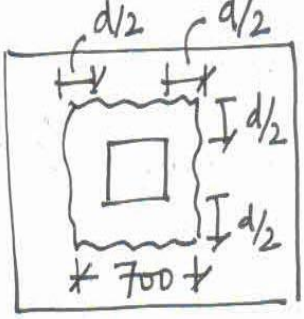
equate (1) & (2)

$(950-d) \times 2200 \times 0.217 = 792d$

$d = 365.98$ say $400\ mm$

$D = 400 + 50 + \frac{20}{2} = 460\ mm$

Step: 5 Check eff. depth 'd' for Punching shear:



A = total area

2200 x 2200

= 4840000 mm^2

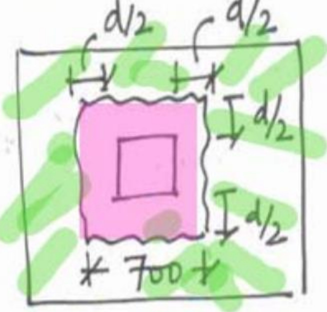
a = 700x700

= 490000 mm^2

Punching area = (A-a) = 4840000 - 490000

= 4350000 mm^2

Step: 5 Check eff. depth 'd' for Punching shear:



A = total area

2200 x 200

$= 4840000 \text{ mm}^2$

$a = 700 \times 700$

$= 490000 \text{ mm}^2$

Punching area $= (A-a) = 4840000 - 490000$

$= \underline{4350000 \text{ mm}^2}$

④

Net. Punching Shear Force $= (A - a) \times NBP$

$= \cancel{453}\ 4350000 \times 0.217$

$= \underline{943950}$

Sliding Area $= PL \times d$ PL = Perimeter Length

$= \underline{4 \times 700 =}\ 2800\ mm$

$= 2800 \times 400 = \underline{1120000}\ mm^2$

Punching Shear stress $= \dfrac{\text{Punching force}}{\text{Sliding Area}}$

$= \dfrac{943950}{1120000} = 0.84\ N/mm^2$ (Mpa)

Step: 6. Max. Permitted Punching Shear Stress (Pg-59 IS 456)

$= k_s \times \tau_c \qquad k_s = 1$

$\tau_c = 0.25\sqrt{f_{ck}} = 0.25\sqrt{25} = 1.25\ N/mm^2$

$0.84 < 1.25$ Mpa Safe.

Step: 7 Check d for Bending moment.

$$M_u = \frac{W_u l^2}{2} = \frac{216.95 \times 0.95^2}{2}$$

$= \underline{97.898 \text{ kN·m}}$.

d for Balanced Section of Fe 415 grade.

$0.138 f_{ck} \cdot bd^2 = 97.89 \times 10^6$

$d = 168.45 < 400$ mm Safe.

Step 18 Detmn of Ast.

$$A_{st} = \frac{Pbd}{100} = \frac{0.25 \times 1000 \times 400}{100}$$

$$= \underline{1000 \text{ mm}^2}$$

(or) $M_R = 0.87 f_y A_{st} d \left(1 - \frac{f_y A_{st}}{f_{ck} bd}\right)$ URS

Step: 9 Min. Ast $0.12\% \; bD$

$$= \frac{0.12}{100} \times 1000 \times 460 = \underline{552} < 1000\,mm^2$$

Step: 10 Max. Permitted spacing:

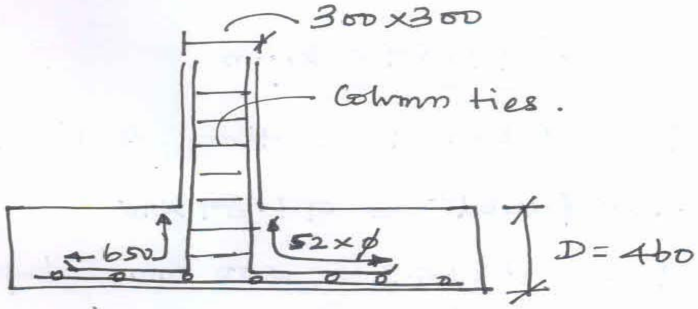
(i) – spacing $= \frac{ast}{Ast} \times 1000 = \frac{113}{1000} \times 1000$

$= 113\,mm$ Say $\underline{100}$ mm c/c

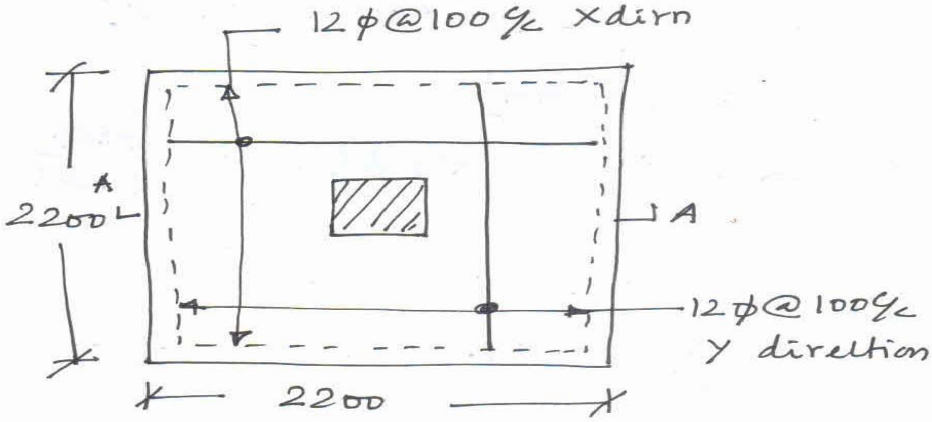
(ii) $3 \times d = 3 \times 400 = 1200$

(iii) ______ 300

Provide 12ϕ @ 100 c/c both direction (X & Y)



Section A-A



Plan of Isolated Footing.

Design of Combined footings.

1. Rectangular Footings.

Problems 1 square / Rectangular footings.

A rectangular reinforced Column 240 mm x 300 mm carries axial load of 400 kN. Design a Rectangular Footing of Uniform thickness (Flat Slab type), if the safe bearing capacity of the Soil is 80 kN/m^2

Use M20 grade of Concrete and Fe 415 Steel

Step 1 Data given:

Size of Column: 240 mm x 300 mm

Axial load : P = 400 kN

SBC ——— 80 kN/m^2

Grade of Concrete: M20

Grade of steel. Fe 415

Step 2 Size of Footing:

P = 400 kN

Add 10% for wt of footing + back fill of soil = 40 kN.

Total service load = 400 + 40 = 440 kN

SBC = 80 kN/m^2

Total service load = $400 + 40 = \underline{440 kN}$

$SBC = 80 \ kN/m^2$

$\therefore$ Size of footing / Area of footing $= \dfrac{440}{80} = \underline{5.5 \ m^2}$

Size of footing $= \sqrt{5.5} = \underline{2.35 \times 2.35} \ m$ for square

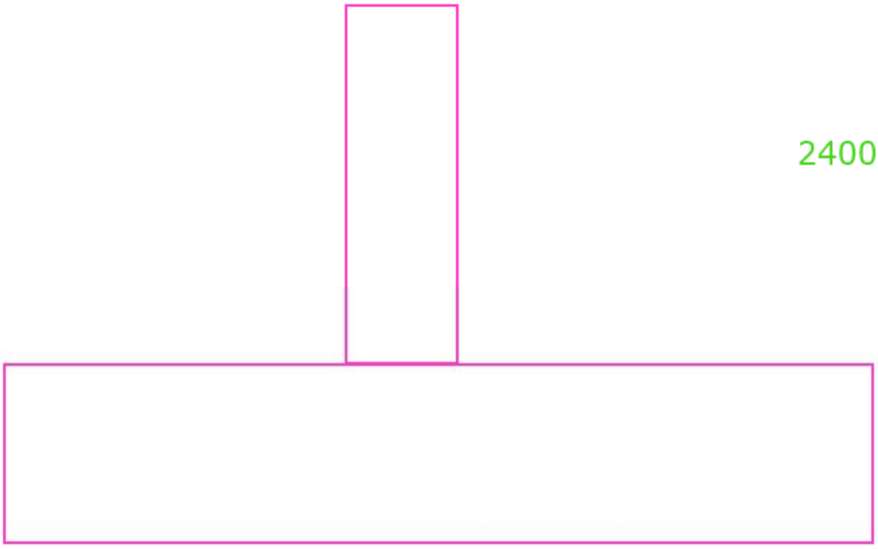
$\underline{\text{say } 2.4 m \times 2.4 m}$ – for square footing.

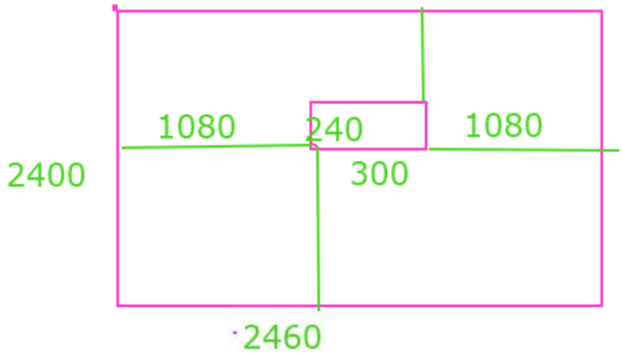
For Rectangular footing,

Col. $(300 - 240) = 60$ mm Add with one side of the footing

i.e. Size of Rectangular footing $= 2.4 m \times 2.46 m$

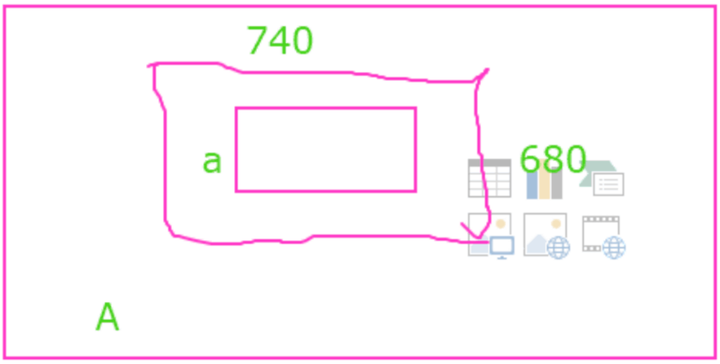
$\underline{\text{(or) } 2.4 \times 2\text{-}46 m}$ $\underline{2.4 \times 2.46 m}$





2460-300=2160/2=1080

2400-240=2160/2=1080



A-a=
2.4x2.46-0.74x.68=5.4m2

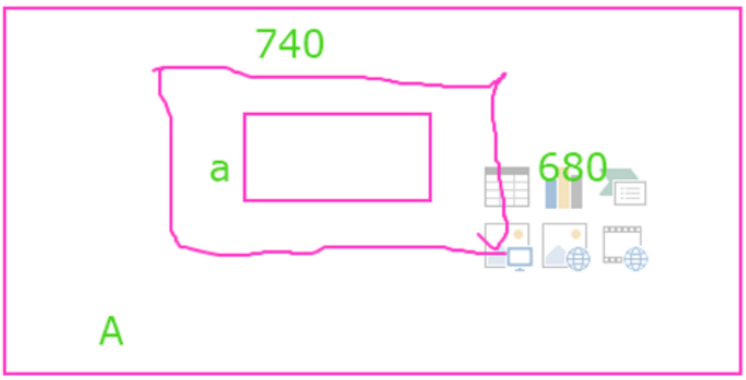
pun sh stress= A-ax NBP0.106/
pl2840 Xd 440

5.4x1000x100 x0.106/2840x440=.458 n/mm2

max permitted punching shear
stress= 0.25x$\sqrt{20}$

1.118 n/mm2

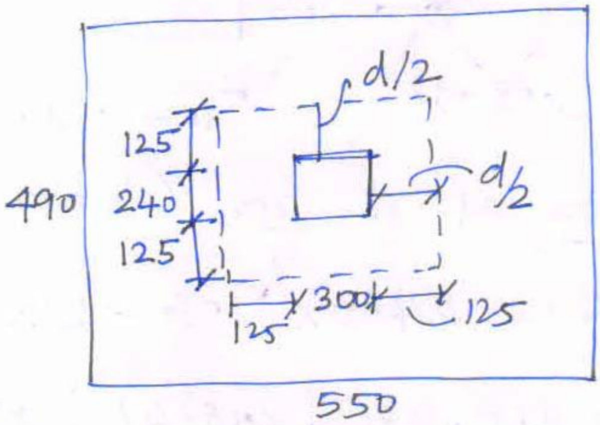
0.458<1.118 safe



A-a=
2.4x2.46-0.74x.68=5.4m2

pun sh stress= A-ax NBP0.
pl2840 Xd 440

5.4x1000x100 x0.106/2840x440=.458 n/mm2



Here $d = 250$

Factored Punching shear Force

$= N.BP\ (A - a)$

$= 0.106\ ((2460 \times 2400) - (550 \times 490))$

$= \underline{597257}\ N$

Punching shear stress $= \dfrac{597257}{PL \times d} = \dfrac{597257}{2080 \times 250}$

$PL = (550 + 490) \times 2 = 2080$

$= \underline{1.148}\ N/mm^2$

Step: Determ of Ast.

we have assumed $p_t = 0.25\%$.

$$\therefore A_{st} = \frac{Pbd}{100} = \frac{0.25 \times 1000 \times 290}{100}$$

$$= 725\,mm^2/m.$$

Spacing: Provide 12mm ϕ

$$s = \frac{a_{st}}{A_{st}} \times 1000$$

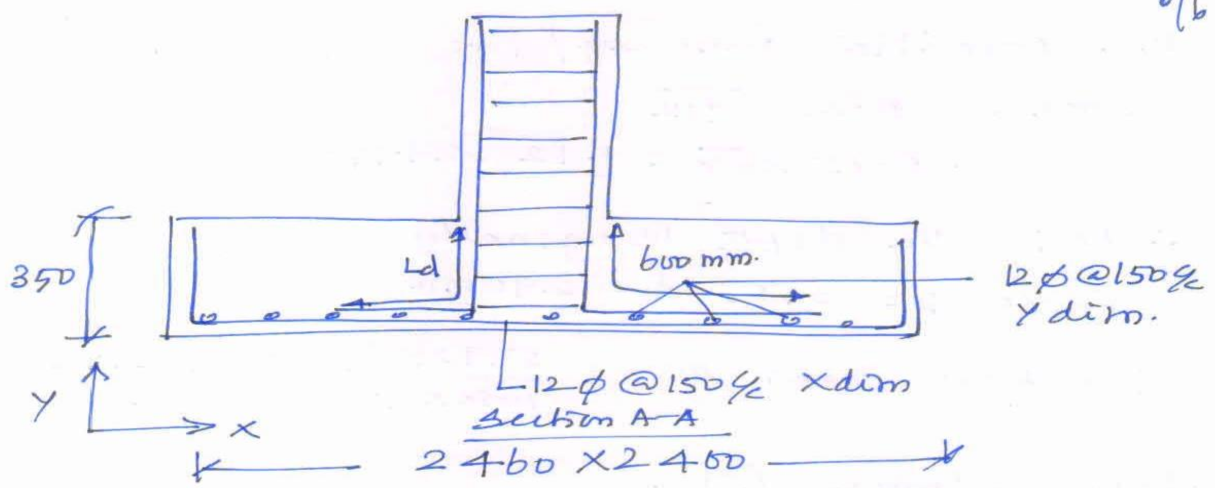
a_{st} = area of 1 bar $= \frac{\pi}{4} \times 12^2 = 113\,mm^2$

A_{st} = Total area of Steel $= 725\,mm^2$

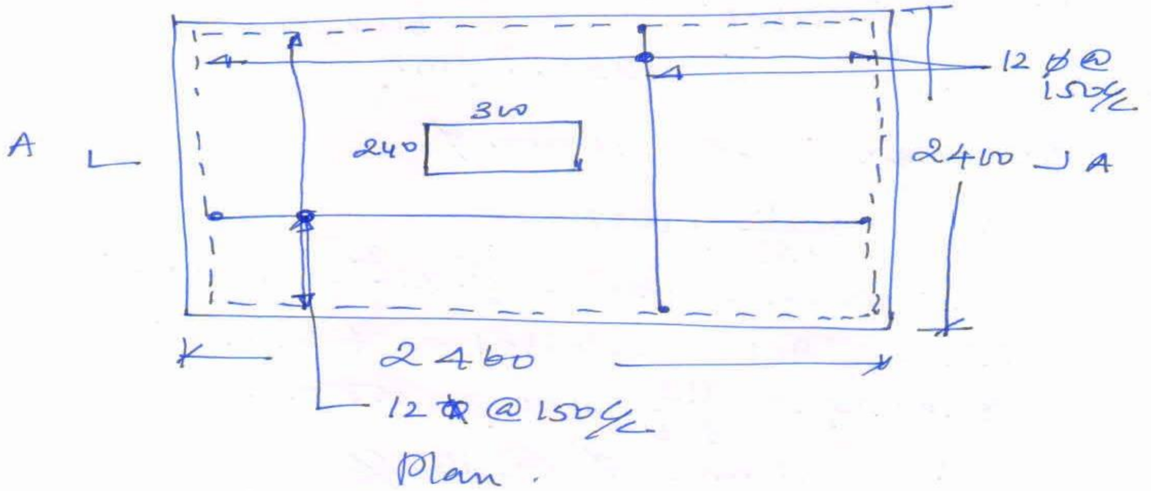
$$\text{Spacing} = \frac{113}{725} \times 1000 = 155\,mm$$

Provide 12mm ϕ @ 150 c/c

6/6



$$L_d = \frac{\phi \sigma_{st}}{4\tau_{bd}} = \frac{12\times 0.87\times 415}{4\times 1.2\times 1.6} = 564.\ \text{say } \underline{600\ mm}$$



UNIT – III - Building Structures III – SCI 1212

UNIT – IV - Building Structures III – SCI 1212