Unit-3.

Stair case:-

Stair case are generally provided to connect successive floor of a building

Flight:-

Flight consist of series of step provided b/w landing

Structural Component

Thread

Rise

Tread:-

It is usually 250 mm - 300 mm. wide depending upon the type of building

Flight of steps generally with 10 to 12 steps

Riser:-

It is the vertical distance b/w the adjacent treads. (or) vertical provision of the step

It range from 150 to 190 mm. and depend upon type of building

landing:-

This the horizontal platform provided at the head of series of steps.

Head Room.

It is the passage under the landing of step, The minimum clear head of the head room is 2.2 m.

The width of the landing is should not Smaller than width of the Stair

Width of stair.

The width of Stair varies from 1 m to 1.5 m.

The minimum value of width of stair is .8 m.

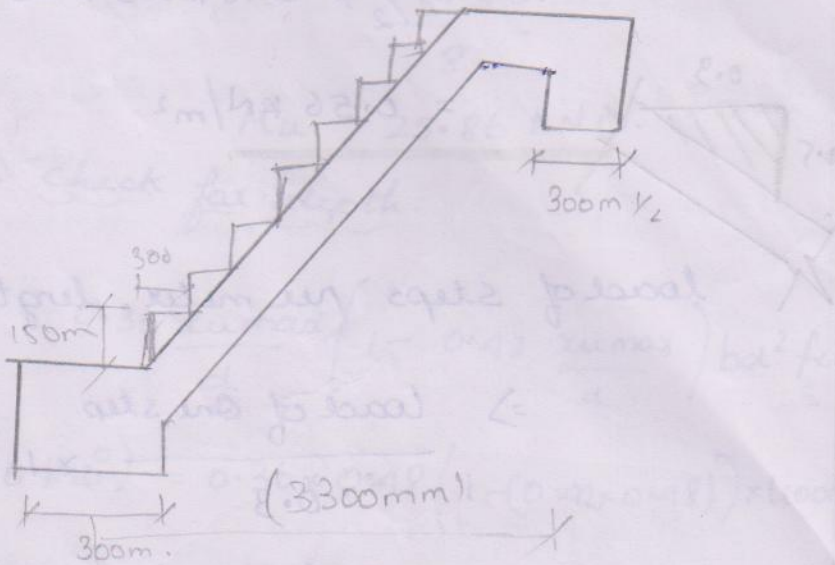
Types of Stair case:

(i) straight stair case. (with or without landing).
(2) dog leged Stair case.
(3) Quater turn
(4) Isolated cantilever type
(5) Spiral
(6) Circular stair case.
(7)

2 Design a flight of dog legged staircase Spaning b/w landing bean by using following data.

(i) No. of step = 10 #
(2) Tread = 300 mm.
(3) Rise = 150 mm
(4) width of land = 300 mm
use m 20 & Fe 415 grade material.

Step 2 :- Size of component of stair case :-



eff span ⇒ $(10 \times 300) + 2\left(\frac{300}{2}\right)$

$= 3300$ mm.

Thickness of waist slab :-

$l/d = 20$ (for dog leg)

$\Rightarrow \frac{3300}{20} = d$

$d = 165$ mm

Cover ⇒ 25 m.

$\Rightarrow D = d + d'$

$= 165 + 25 = 190$ mm.

Step 2 :- load calculation

dead load of slope (or) waist slab ⇒ $0.190 \times 1 \times 25$

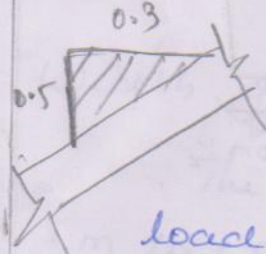
$= 4.75\ kN/m^2$

dead load (or) slab in horizontal direction $= \frac{ws\sqrt{R^2 + T^2}}{T}$

$= \frac{4.75\sqrt{0.15^2 + 0.3^2}}{0.3} = 5.31\ kN/m^2$.

Dead load of One step (for ⇒ brick 19)

$\Rightarrow \frac{1}{2} \times 0.15 \times 0.3 \times 25$



$= 0.56\ kN/m^2$

load of steps per meter length.

$\Rightarrow \frac{\text{load of One step}}{0.3} \times 1$

$= 0.56/0.3 = 1.86\ kN/m^2$

adopt floor finish $= 0.5\ kN/m^2$

→ Normal live load ⇒ for home $= 5\ kN/m^2$.

(Same) ⇒ Total dead load $= 1.86 + 0.5 + 5.31$

$= 7.67\ kN/m^2$

→ Total Service load.

$\Rightarrow 5\ kN/m^2$

∴ Total load $\Rightarrow 7.67 + 5$

$= 12.67\ kN/m^2$

∴ Factored load = 1.5 × Total load

$= 1.5 + 12.67$

$= 19.005\ kN/m^2$

$= 19\ kN/m^2$

Factored moment $M_U = \frac{W_U l^2}{8}$

$= \frac{19 \times 3.3^2}{8}$

$M_u = 25.86$ kNm.

Step 4 :- Check for depth.

$M_u = 0.36 \frac{x_{umax}}{d}\left(1 - 0.42 \frac{x_{umax}}{d}\right) bd^2 f_{ck}$.

$(25.86 \times 10^6) = 0.36 \times 0.48\left(1 - (0.42 \times 0.48)\right) \times (1000 \times d^2 \times 20)$.

$\Rightarrow \quad d = 96.8 < 165$ mm.

depth require is less than provide

Hence it is Safe

Step 5 :- Area of Steel :-

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

$(25.86 \times 10^6) = 0.87 \times 415 \times A_{st} \times (165)\left(1 - \frac{A_{st} \times 415}{20 \times 1000 \times 165}\right)$.

$\Rightarrow \quad A_{st} = 460.78 \text{ mm}^2$

Use 12mm ϕ

$\Rightarrow$ Spacing $\Rightarrow \frac{ast}{Ast} \times 1000$

$= \frac{\pi/4 \times 12^2}{46.78} \times 1000$.

$= 245.45$ mm

$\simeq 240$ mm c/c.

Provide 12 mm dia bar at 240 mm center to centre as main reinfor./

step 6 :- Area distribution steel

Area of distribution steel = 0.12 % b×D

$$\Rightarrow \frac{0.12}{100} \times (1000 \times 190)$$

$$= 228\ mm^2.$$

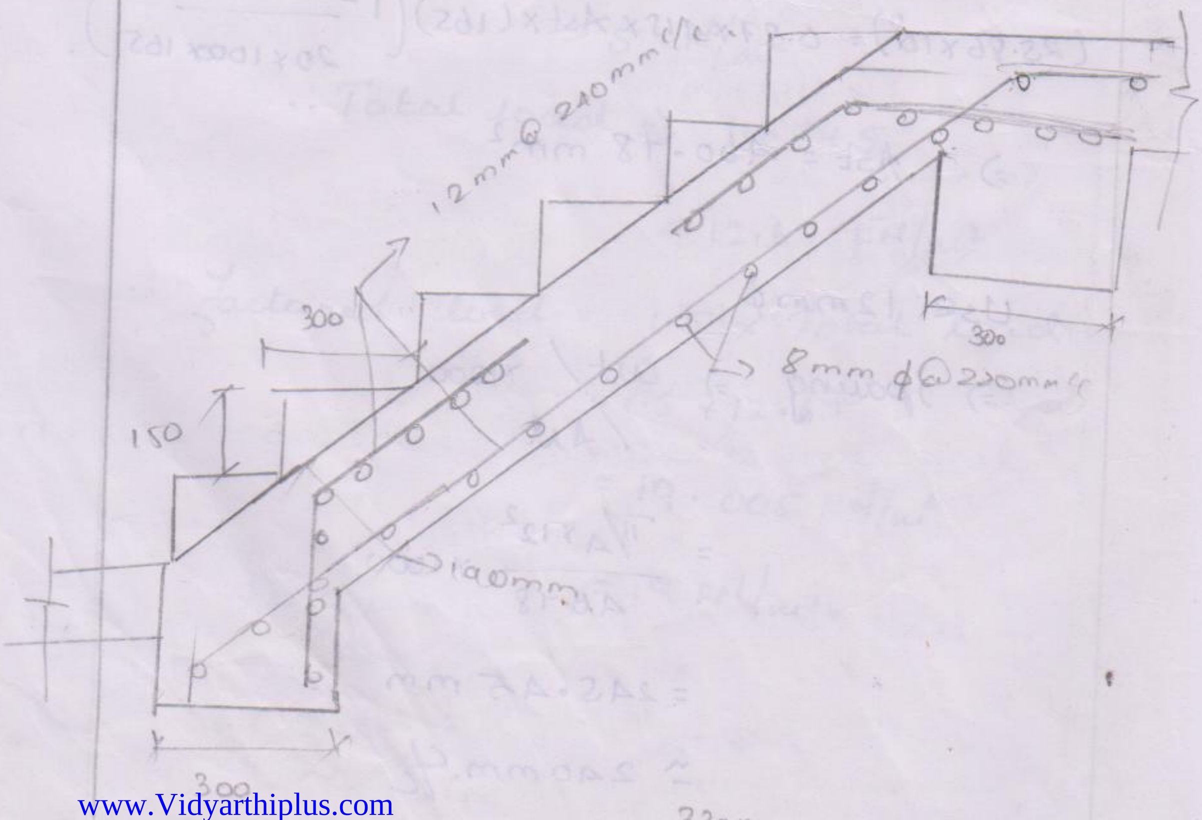
Use 8 mm dia bar.

$$S = \frac{ast}{Ast} \times 100$$

$$= 220.46\ mm$$

$$\simeq 220\ mm\ c/c$$

Provide 8 mm dia bar at 220 mm c/c as distribar.



(2)

3300.

Flat Slabs:-

Flat slab is the reinforced concrete slab supported directly by concrete coloumn with out use of beams.

Types of flat slabs:-

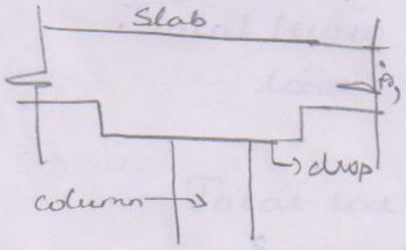
1, Slab resting directly on coloumns

2, flat slab with drop panel.

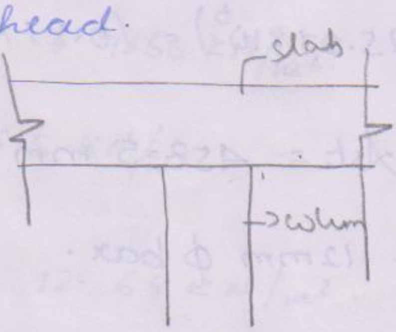
3, flat slab with column head

4, flat slab with drop panel + column head.

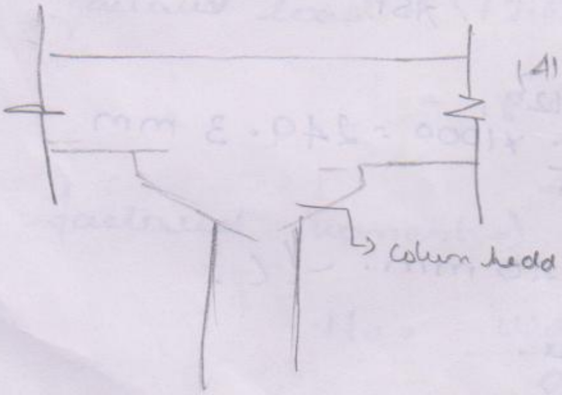
2,



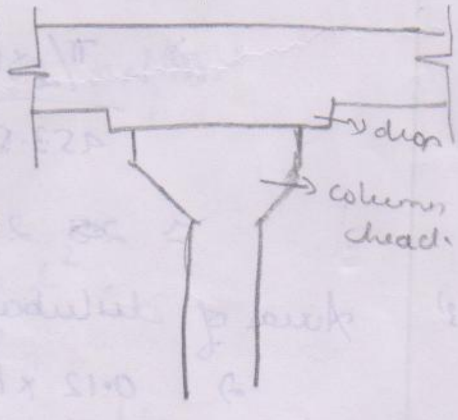
1,



3.



(4)



Uses of column head:

(1) Increase shear strength of slab

(2) Reduce moment in slab by reducing clear (or) effective span.

Uses of drop panel:

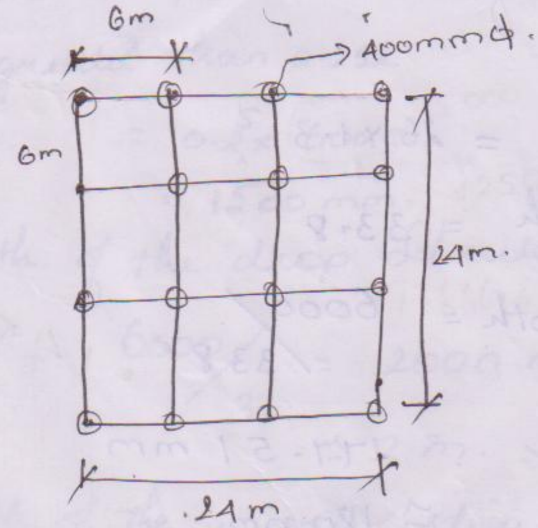
1) It also increase the shear strength of slab

2. It increase negative moment capacity of slab.

(3) It stiffen the slab and hence reduce the deflection.

—x—

i) Design the interior panel of the flat slab floor system for a warehouse. 24 x 24 m, divided into panel of 6m x 6m. loading class = 5 kN/m2 column size is 400 mm dia. use M20 & Fe415 grade material.



Size of ware house = 24 × 24

Size of One panel = 6 × 6 m.

Column Size = 400 mm φ

M20 & fe 415

Step 2: Dimension of flat slab:

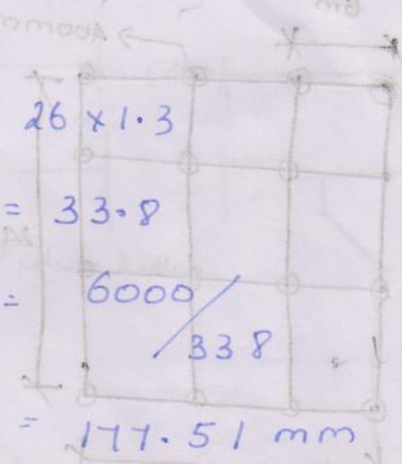
Over all Span by depth ratio = Basic value × M.F.

Span/depth

Basic value for two way continuous slab from IS456-2000 clauses 22.2.1 [page No: 37] is 26.

Minimum ast for the slab is 0.4 % of page No: 38, (fig: 4)

Modification factor = 1.3.



$$\text{Span}/\text{depth} = 26 \times 1.3$$

$$= 33.8$$

$$\text{depth} = 6000/33.8$$

$$= 177.51 \text{ mm}$$

$$\simeq 180 \text{mm} \rightarrow 180$$

150

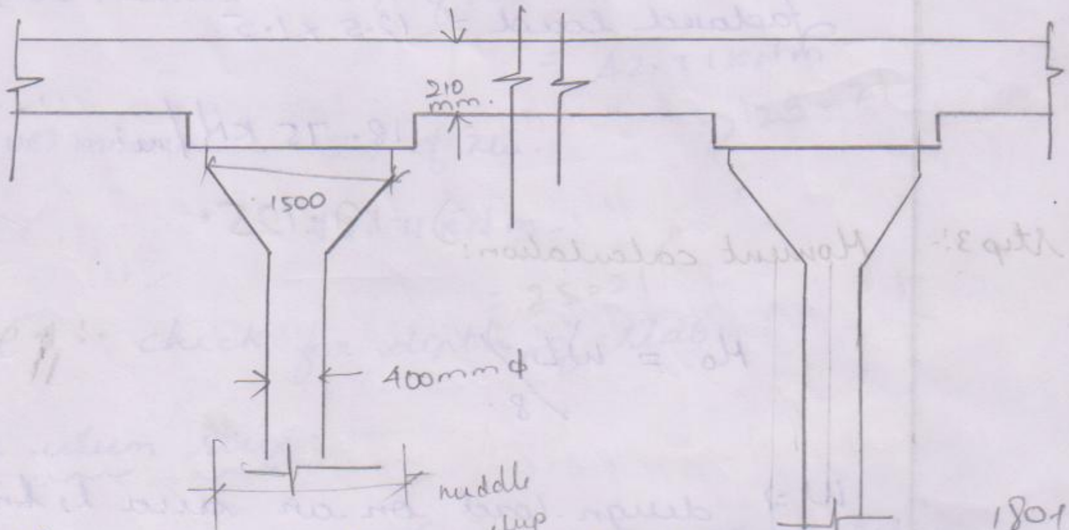
∴ Thickness of middle strip = 180mm. = d.

$D = d + d'$

$= 180 + 30.$ 150+30

Total depth => = 210mm.   => 180

Column strip is should not be less than 1/4 th of slab thickness and preferably should not be less than 100mm.



Hence the thickness of slab @ drop = 210+100 = 310mm.   180+10

(2) Column head diameter it should not be greater than 0.25l

$= 0.25 \times 6000$ 5000

= 1500 mm.   1250

280-30

310-30

(4) length of the drop should not be less than

16666.6 => 1700 mm.

$L/3 = 6000/3 = 2000$ mm.

≃ 2 m. => 1.7mm

width of the middle strip = 2× column head dia

= 2× 1.5

≃ 3 m. => 2.5

Step 2 :- Load calculation :-

Dead load = 5 KN/m².

live load = $\left(\frac{0.31 + 0.21}{2}\right) \times 1 \times 25$ (0.28 + 0.18)

= 6.5 KN/m² ⇒ 5.75

floor finish = 1 KN/m².

Total load = 12.5 KN/m².

Factored load = 12.5 × 1.5

= 18.75 KN/m²

Step 3 :- Moment calculation :- ⇒ 19.125

$M_0 = WL_n / 8$

W ⇒ design load on an area $l_2 l_n$.

L_n ⇒ clear span extending from face to face.

⇒ $W = w_u l_2 l_n$. $l_n = 6 - 1.5$

= 4.5 - 3.75

⇒ 18.75 × 6 × 4.5

⇒ 506.25 KN/m². ⇒ 358.59

$M_0 = \frac{506.25 \times 10^3 \times 4500^2}{8}$

M_0 = 284.765 KNm

168.08 × 10³

@ column strip:- (page No: 55)

Clauses: 31.4.3.2.

(-ve) moment = 49 % of $M_0 = 0.49 \times 284.77$ => 87.35 kNm

= 139.53 kNm.

=> ~~8.74~~ kN/m²

(+ve) moment - 21 % of $M_0 = 0.21 \times 284.77$

= 59.80 kNm.

=> 35.29.

b. Middle strip.

(-ve) moment = 15 % of $M_u = 0.15 \times 284.77$

= 42.71 kNm.

(+ve) moment = 15 % of M_u. => 25.21

= 42.71 kNm.

= 25.21

Step 4:- check for depth of slab:-

for colum strip:

$$M_{u\,lim} = 0.36 \frac{x_{umax}}{d}\left(1 - 0.42 \frac{x_{umax}}{d}\right) b d^2 f_{ck}.$$

$$(139.53 \times 10^6) = 0.36 \times 0.48(1 - (0.42 \times 0.48) \times 1000 \times 20 \times d.$$

$d = 224.87 - 280$ mm => $d = 172.7 - 250$

hence safe. hence saf.

for midle strip:-

$$(42.71 \times 10^6) = .36 \times 0.48(1 - 0.42 \times 0.48) \times 20 \times 1000 \times d^2.$$

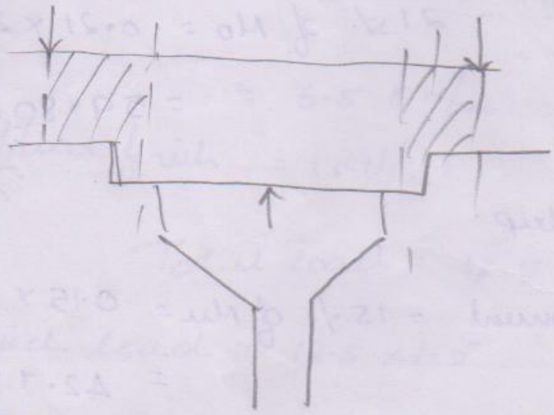
$d = 124$ mm < 180 mm => [210 - 30]

$d = 124 \not> 150$ mm here safe.

Hence safe.

Step 5 :- check for shear:

Shear stress is checked near the column head at section [D+d]



Total load on circular area (D+d)

$\Rightarrow w_1 = \pi/4 \, (D+d)^2 w_c$. $\pi/4 \times (1.25+0.25) \times 19.175$

$\Rightarrow \pi/4 \, (1.5 + 0.28)^2 \times 18.75 \Rightarrow$

$= 46.6 \text{ kN}$. $\Rightarrow 33.79 \text{ kN}$.

Shear force $= W - w_1$ $\Rightarrow (19.125 \times 5 \times 3.75) - 33.79$

$\Rightarrow (18.75 \times 6 \times 4.5) - 46.6$

$= 459.65 \text{ kN}$. $\Rightarrow \Rightarrow 336.52$ kN.

Shear force /m $= 459.6 / (D+d) =$

$= 258.23 \text{ kN}$

$= 224.34$.

shear stress (pg No: 42)

$\tau_v \Rightarrow V/bd$.

$= \frac{(258.2 \times 10^3)}{(1000 \times 280)}$

$\Rightarrow 0.9 N/mm^2 \Rightarrow 0.89 N/mm^2$.

permissible shear stress (pg No: 58)
(clause 31.6.3)

$\Rightarrow K_s \tau_c$

$K_s = (0.5 + \beta_c)$

$\beta_c = (L_1/L_2) = 6/6 = 1$

$\Rightarrow K_s = (0.5 + 1) \Rightarrow$ } same,
$= 1.5 > 1$ So adopt $K_s - 1$

$\tau_c = 0.25 \sqrt{fck}$.

$= 0.25 \sqrt{20}$

$= 1.11 \Rightarrow 1.11$.

$\Rightarrow K_s \times \tau_c = 1.1 \times 1$

$= 1.1 \Rightarrow 1.11$

actual shear stress < permissible shear

$\Rightarrow$ hence it is safe in shear.
shence saf in shear.

Step 6: Area of steel:-

Ast for negative bending moment $\Rightarrow$

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

82.35×10^6)

$(131.53 \times 10^6) = (0.87) \times 415 \times A_{st} \times 280 \left(1 - \frac{A_{st} \, 415}{1000 \times 280 \times 20}\right)$

250

$A_{st} = 1560.71 mm^2$.

for (+ve Bending moment).

$\Rightarrow 59.80 \times 10^6 = 0.87 \times 415 \times Ast \times 280 \left(1 - \frac{415\ Ast}{20 \times 100 \times 28}\right)$

Ast = 620 mm² ⇒ 404.5

Spacing for -ve B.M :-

Use 12 mm φ

$\Rightarrow S = \frac{(\pi/4 \times 12^2)}{(1560.7)}$ ⇒ 113.6 = 72.46 mm.

994.

adop S = 100 mm.

⇒ 110 mm.

Spacing for +ve B.M.

⇒ use 12 mm φ

$\Rightarrow$ Spacing $= \frac{\pi/4 \times 12^2}{620}$ ⇒ 279. 404.5

⇒ 270 mm

= 182.4 ≃ 180 mm

Provide 12 mm φ at 100 mm c/c as -ve reinforcement / 12 mm φ at 180 mm c/c as +ve reinforcement.

exterior panel

2. Design the ~~reinforcement~~ of flat slab floor system for a warehouse 24 × 24 m. divided in to panel of 6 × 6 m., load calss => 5 KN/m², colum size 400 mm dia height of story 3 m. Use M20 & Fe 415:.

Soln:

Step 1 dia of slab:-

(1) Thickness of slab.

(2) coloum head dia

(3) width of colum Strip

width of the middle strip are similar to those calculated in previous problem.

Step 2: Stiffness calculation :.

ratio of flextural stiffness of colum to flextural stifness of slab is given by.

$$\alpha_c = K_c / K_s.$$

Pg No: 56.

stiffness of colum.

$$K_c = \left[\frac{4 E I_c}{l}\right]$$

$$= \frac{4 \times E \times \pi \times 400^4}{64 \times 3000}$$

$$\boxed{K_c = 1.67 \times 10^6 \times E}$$

Stiffness of slab:

$K_S = 4EI_S / L$

$= \frac{4 \times E \times 6000 \times 280^3}{12 \times 6000}$

$= 7.31 \times 10^6 E$

$\alpha_c = K_c / K_S = \frac{(1.67 \times 10^6 E)}{(7.3 \times 10^6 E)}$

$\boxed{\alpha_c = 0.23}$

from IS 456 : 2000, Table 17 · 56 :

l_2/l_1 ratio $\alpha_c = 0.7$ min

permissible stiffness coeff.

Step 3 : Bending moment calculation :

$M_0 = W L_n / 8$

$W_n = W_n \times L_1 \times L_n = (18.75 \times 6 \times 4.5)$

$= 506.25$

$L_n = 6 - 1.5 = 4.5$

$= 4.5$

$M_0 = \frac{506.25 \times 10^{6} \times 4.5}{8}$

 =

$M_o \Rightarrow$ 284.76.76 KN·m.

page NO: 55.

Exterior negative design momen.

In the end Span total design moment shal be design according to IS 456 : 2000.

Interior negative design:

$$\left[0.75 - \frac{0.10}{1 + \frac{1}{\alpha c}}\right] M_o$$

$$= \left[0.75 - \frac{0.10}{1 + 1/0.7}\right] (284.76 \times 10^{6}).$$

$= 201.8$ KNm.

positive design moment:

$$\left(0.63 - \frac{0.28}{1 + 1/\alpha c}\right] M_o$$

$$= \left[0.63 - \frac{0.28}{1 + 1/0.7}\right] (284.76).$$

$= 146.57$ KNm.

Exterior negati

$$= M_o \left(\frac{0.65}{1 + 1/\alpha c}\right) = \left(\frac{0.65}{1 + 1/0.7}\right) (284.77.$$

$= 76.21$. KNm.

Moment in Colum & middle strip are Obtained by interior negative design moment.

(i) Interior (- ve) desig moment

for column strip :- = 75% of int (-ve) momen

$= 0.75 \times 201.8 = 151.35$ KNm.

for middle strip = 0.25 of int (-ve) design moment.

$= 0.25 \times 201.8$

$= 50.45$ KNm.

(ii) Exterior -ve design)

(1) for column strip = 76.21 KN-m

(2) Midle strip = 0

(iii) Interior (+ve) moment

colum Strip = 60% × 146.57

= 87.942 KNm.

Midle strip = 40% × 146.57

= 58.628 KNm.

Step 4 :- check for tk of slab :-

@ column :-

$$Mu\ lim = 0.36\left(\frac{x_{umax}}{d}\right)\left[\left(1 - 0.42\frac{x_{umax}}{d}\right) f_{ck}\, b d^2\right]$$

$$(151.35\times10^6) = (0.36\times0.48)\left[1-(0.42\times0.48)\right](20\times1000\times d^2)$$

$d = 234.2\ mm. < 280\ mm.$

~~hence depth provided is smaller than required depth adopt deat column strip~~

~~= 235 mm~~

~~D = 235 + 30~~

~~= 265 mm.~~

hence safe is depth.

@ middle strip :-

$$(58.62\times10^6) = (0.36\times0.48)\left[1-0.42\times d.48\right)\times20\times1000\times d^2).$$

$\Rightarrow\ d = 145.7\ mm < 180\ mm.$

required < provided.

Hence Safe.

Step 5 :- Area of steel :-

Area of colum strip (ist).

(i) for (+ve) moment.

$$Mu = 0.87\, f_y\, Ast\left[1 - \frac{f_y\, Ast}{bd\, f_{ck}}\right] d.$$

colum

$\Rightarrow (87.94 \times 10^6) = 0.87 \times 415 \times Ast \times 280 \left[1 - \frac{415 \times Ast}{20 \times 1000 \times 280}\right]$
(+ve)

$Ast = 934.6\ mm^2$

use 12 mm ϕ

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

$= 121.01$ mm c/c.

$= 120$ mm c/c.

Provide 12 mm ϕ at 120 mm c/c as +ve
(1) reinforcement for interior column strip.

(2) for (−ve) moment:

$\Rightarrow (151.35 \times 10^6) = 0.87 \times 415 \times Ast \times [$

$Ast = 1751.1\ mm^2$

use 16 mm dia

$S = \frac{ast}{Ast} \times 100$

$= 114.8 \simeq 115$ mm c/c

provide 16mm ϕ at 115 mm c/c as enlucar column strip

(3) Ast for middle strip :-

for (-ve) moment :-

$$(50.45\times10^6) = 0.87\times415\times Ast\times180\left[1-\frac{415\ Ast}{20\times1000\times180}\right]$$

$\Rightarrow$ $Ast = 861\ mm^2$

use 12 mm ϕ

$$S = \frac{ast}{Ast}\times1000$$

$= 131.3 \simeq 130$ mm c/c.

Provide 12 mm ϕ at 130 mm c/c.

for (+ve) Moment:

$$(58.52\times10^6) = 0.87\times415\times Ast\times180\left[1-\frac{415\ Ast}{20\times1000\times180}\right]$$

$Ast = 1022\ mm^2$

Spacing.

use : 16 mm ϕ

$$\Rightarrow\quad S = \frac{\pi/4\times16^2}{1022} = 196 \simeq 195\ mm\ c/c$$

Provide 16mm ϕ at 195 mm c/c as + reinfor for middle strip

Ast for colum strip (exterior).

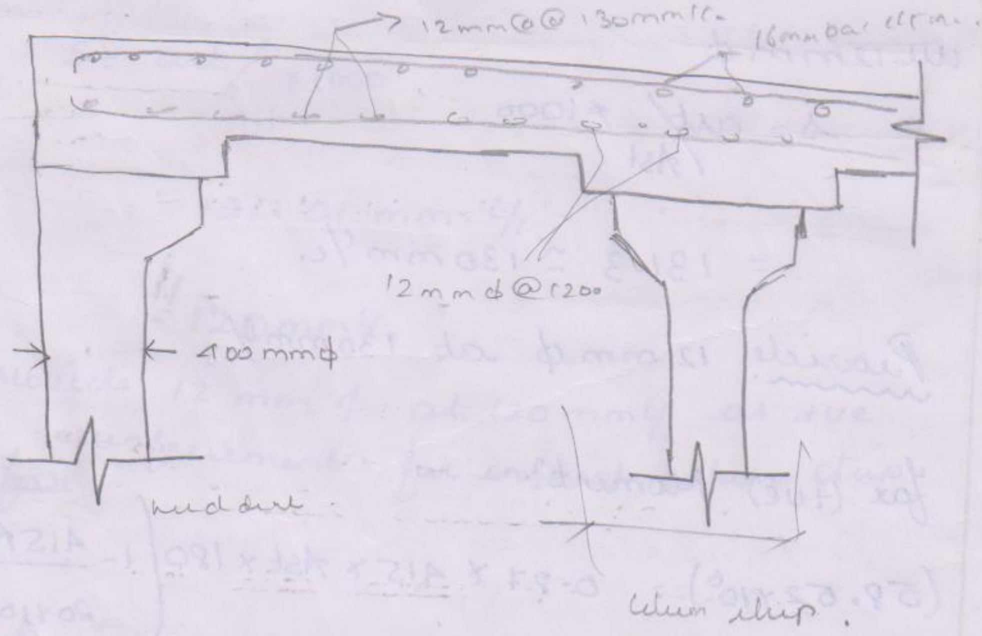
$$76.2\times10^6 = 0.87\times415\times Ast\times280\left[1-\frac{415\,Ast}{20\times1000\times280}\right]$$

$Ast = 801\ mm^2$

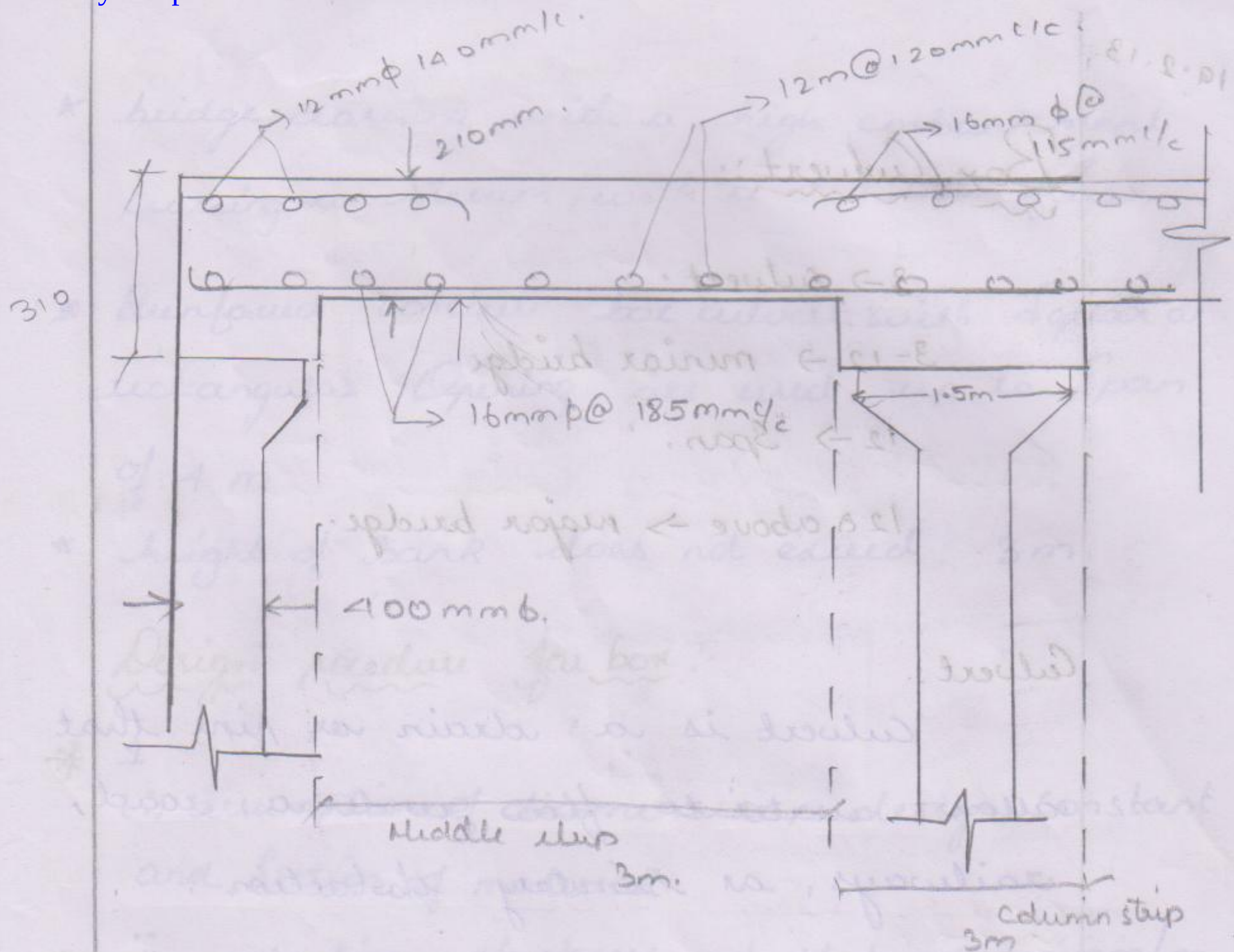
Provide 12 mm dia

$\Rightarrow$ Spacing $= \frac{\pi/4\times12^2}{Ast}\times1000$

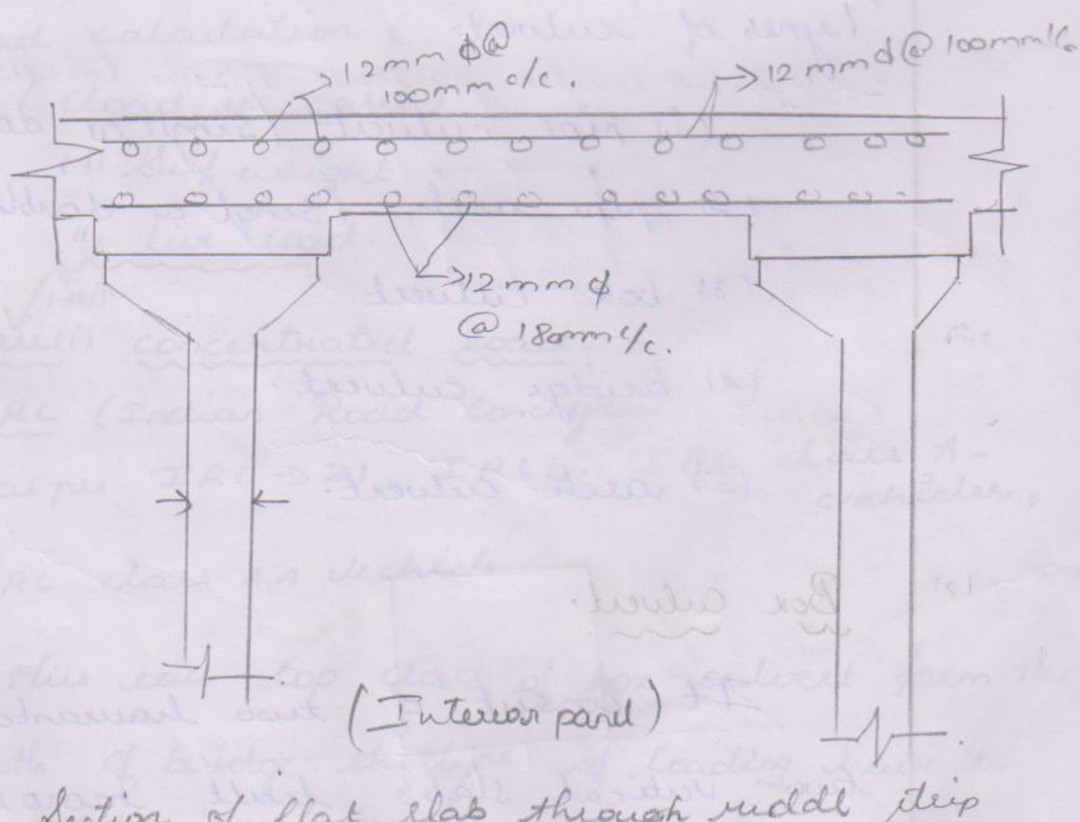
$= 141mm \simeq 140mm\ c/c.$



Section of flat slab throu
~~colum~~ strip
Middle



Section of flat slab through column strip



(Interior panel)

Section of flat slab through middle strip

19.2.13.

Box Culvert:

3 → culvert.

3-12 → miniar bridge

12 → Span.

12 & above → major bridge.

Culvert:

Culvert is a drain or pipe that allow water to flow under a road, railways, or similary obstaction.

Culvert is differ from bridges mainly in size and construction.

Types of culvert:

(1) pipe culvert. (single or double)

(2) pipe arch (single or double

(3) box culvert

(4) bridge culvert.

(5) arch culvert.

(2) Box Culvert.

It consist of two horizontal and two vertical slab's built monolythically (or) hyidrally. suitable for a road or railway bridge crossin

* bridge crossing with a high embankment crossing a stream, with a limited flow.

* Reinforced concrete box culvert with Square or rectangular Opening are used up to Span of 4 m

* height of bank does not exceed 3 m.

Design procedure for box :-

* 1

(i) assumption of diamension, design constant and section of material.

* (ii) adopting thickness of slab as 100 mm/m of Span.

* 2

load calculation (
 (load in cases)
 (i) Self weight
 (ii) live load.
 (iii)

case (i) concentrated load:

IRC (Indian Road Congress)
as per IRC → 21, IRC 6, IRC class A - vehicles,

IRC class AA vechicle

In this case top class of box culvert form the depth of bridge. the type of loading have to be determined by

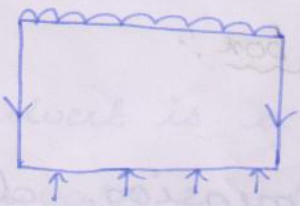
$$w = PI/2.$$

where, P → wheel load.

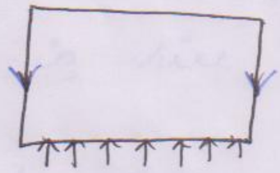
I = Impact load

w = Concentrated load.

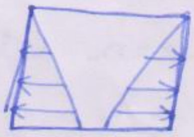
Case 2 :- Uniformly disturbuted load :-



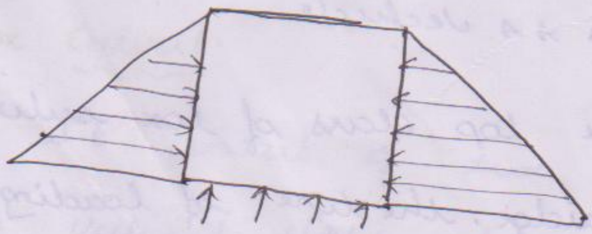
Case 3 :- Weight of Side wall.



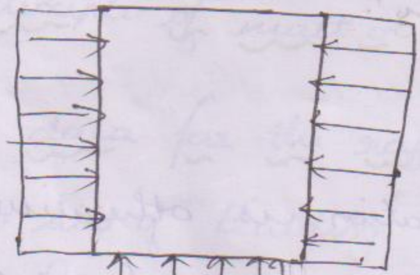
Case 4 :-> water pressure inside Culvert :-



Case 5 :- Earth pressure on Vertical side walls.



case 6: uniform lateral load on side wall.



(B) (2)
18-113

* 3 Analysis of moment, shear and thrust:

(i) Various loading pattern consider in last step are moment shear and thrust correspond to the different case of loading are evaluated, using co-efficient of different loading cases.

(ii) Design forces resulting from the combination of various cases yielding maximum moment and exposure at support of mid span. 5 -> (5) 8 -> (8) 13

* Design of reinforcement:-

(i) Reinforcement are designed by, moment for mid span of the bottom slab support section and vertical side wall and distributed reinforcement:

(ii) 0.3% of cross sectional area, is provided as the minimum reinfor.

(iii) for vertical side wall, minimum rein% => 0.8% of cross sectional area.

Raft foundation:-

Def:-

Raft foundation is otherwise known as matt foundation (or) raft foundation it support no. of heavily loaded coloumn situated on a soil of low bearing capacity

coloumn are inter connected with beam & beam are connected with RCC Slab

The slab is supported on soil. types of Raft.

(i) Raft (or) matt.

A thick slab like footing of reinfy concrete supporting a no. of column (or) entire building

ii. Ribbed matt:-

A matt foundation reinforced by a grid of ribbs abov or below the slab.

iii. Cellular matt.

a composite structure of reinforced concrete slab at basement walls serving as a mat foundation design principle of matt or Raft foundation :-

Required data for the raft foundation are

(i) Size of building

* Spacing of columns

* arrangement of Service load of each column,

* Size of column, Safe bearing capacity of Soil and characteristic of material.

* Step 1 : Design of Raft Slab :-

(i) → Total working load for all Columns. (↓)

⇒ No. of column × Service load per column

→ Self weight of Slab + beams.

= 10% of column load.

→ Total Service load = Total working load + Self weight of Slab

→ Area of Raft Slab = Total Service load / Safe bearing capacity

→ Total length of Slab = Spacing × No. of intervals

→ Width of slab = area / length

→ calculation of intensity of Soil pressure.

= total load / width × length.

total load/

→ Cantilever projection of slab

⇒ total width of slab − width of the beam.
―――――――――――――――
2.

→ Calculation of moment for cantilever portion & Shear force.

→ Effective depth Calculation

$$d = \sqrt{\frac{M_u}{0.138 f_{ck} b}}$$

→ = Design of reinforcement

Using Sp 16 calculate the % of ast

→ From % of ast, ast can be calculated.

→ Area of distribution reinforcement =

= 0.12 % cross sectional area.

→

* Step 2 :- Design of Continuous beam Over the Raft slab :-

→ Calculation service load on beam

= intensity of soil pressure × size of footing

→ Calculation of bending moment, factored moment, & Shear force.

→ breath of beams.

Normally breath of beam = width of column.

→ Effective depth of beam = d

$$d = \sqrt{\frac{Mu}{1.38 f_{ck} b}}$$

→ Calculation of percentage of reinforcement + reinforcement can be calculated by % of ast

* Step 3 :- shear reinforcement:-

from the Shear force we can calculate the nominal Shear ~~Shear~~ stress τ_v

If $\tau_v < \tau_c$ the minimum shear reinforcement is provide.

If $\tau_v > \tau_c$ then design a shear reinforcement

—x—.

Design the interior plane of flat slab for a auditorium building 25 m + 25 m is divided by panel of 5×5 m loading class = 6 kN/m² Size of column is 350 mm dia use M20 + Fe 415 grade material.