$\frac{ly}{lx} = \frac{5}{4} = 1.25$ ∴ two way slab

1)

Step 1: Fix the depth

39, d 4.1

$\frac{l}{d} = 40 \times 0.8$

$d = \frac{4000}{40 \times 0.8}$

$d = 125mm$

assuming 10mm ϕ bars, clear cover of 15mm

$D = 125 + 15 + \frac{10}{2}$

$D = 145mm$

Step 2: effective length

34, 22.2

$l_{eff} = l + d$ or $l_{eff} = l + \frac{300}{2} + \frac{300}{2}$

$= 4 + 0.125$ $= 4 + 0.3$

$= 4.125$ $= 4.03$

least

∴ $l_{eff} = 4.125m$

Step 3: load calculation

dead load = $25 \times 0.145 \times 1 = 3.625 kN/m$

live load = $3 kN/m^2 \times 1 = 3 kN/m$

floor finish = $1 kN/m^2 \times 1 = 1 kN/m$

Total Load = 3.625 + 3 + 1 = 7.625 kN/m

factored load = 11.44 kN/m

Step 4: Bending moment and S.F

IS 456, Annex-D

$M_x = \alpha_x . w . l_x^2$ $M_y = \alpha_y . w . l_x^2$

table 26, case 4

negative moments @ continuous edge

$M_x^{(-)} = \alpha_x^{(-)} . w . l_x^2$ $M_y^{(-)} = \alpha_y^{(-)} . w . l_x^2$

$= 0.0625 \times 11.44 \times 4.125^2$ $= 0.047 \times 11.44 \times 4.125^2$

$M_x^{(-)} = 12.17 kN\text{-}m$ $M_y^{(-)} = 9.15 kN\text{-}m$

positive moment at mid span

$M_x^{(+)} = \alpha_x^{(+)} . w . l_x^2$ $M_y^{(+)} = \alpha_y^{(+)} . w . l_x^2$

$= 0.047 \times 11.44 \times 4.125^2$ $= 0.035 \times 11.44 \times 4.1$

$M_x^{(+)} = 9.15 kN\text{-}m$ $M_y^{(+)} = 6.81 kN\text{-}m$

Step 5: check for depth

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

$12.17 \times 10^6 = 0.36 \times 0.48 (1 - 0.42 \times 0.48) \times 1000 \times d^2 \times 20$

$d = 66.41 mm$

$\because$ d req < d provided

$\therefore$ d is safe

step 6: Ast calculation

$$Mu = 0.87 \times fy \times Ast \times d \left(1 - \frac{fy \times Ast}{b.d.fck}\right)$$

$Asty^{(-)} = 210.07 mm^2$

$Ast_x^{(-)} = 282.95 mm^2$

spacing = 373.87mm

≈ 370mm

$$\text{spacing} = \frac{\text{area of 1 bar}}{Ast} \times 1000$$

$$= \frac{\pi/4 \times 10^2}{282.95} \times 1000$$

= 277.57mm

≈ 270mm

$Ast_x^{(+)} = 210.07 mm^2$

$Ast_y^{(+)} = 154.87 mm^2$

spacing = 373.87mm

≈ 370mm

spacing: 507.13mm

≈ 500mm

∴ provide spacing should be a min of

i) 300mm

ii) 3x deff = 3x125 = 375mm

iii) 270m

∴ provide 10mm ϕ @270mm c/c as main reinforcement along both directions i.e x and y directions

step 7: Check for shear

$$Tv = \frac{V_F}{b.d} = \frac{\frac{w \times Deff}{2}}{b \times d} = \frac{\frac{11.44 \times 4.125}{2} \times 10^3}{1000 \times 125} = 0.19 N/mm^2$$

$$P_t = \frac{100.Ast}{b.d}$$

$$Ast)_{new} = \frac{\pi/4 \times 10^2}{270} \times 1000 = 290.89 mm^2$$

$$P_t = \frac{100 \times 290.89}{1000 \times 125} = 0.23$$

#7.3, table 19,

$\tau_c = 0.34 N/mm^2$,,

∵ $\tau_v < \tau_c$

It is safe against shear

Step 8: Torsional Reinforcement

provided in 4 layers

#90, Annex D

Torsional reinforcement $= \frac{3}{4}(A_{st})$ D 1.8

$= \frac{3}{4} \times 290.89$

$= 218.17 mm^2$

spacing $= \frac{\pi/4 \times 6^2}{218.17} \times 1000 \approx 120mm$

∴ provide 6mm ϕ @ 120mm c/c as torsional reinforcement

side length of the torsional mesh

$= \frac{1}{5}(4.125)$

$= 825mm$

Step 9: check for deflection

$(\frac{l}{d})_{actual} : \frac{4.125}{0.125} = 33$

$(\frac{l}{d})_{max} = (\frac{l}{d})_{basic} \times k_t$

$k_t = 0.58 f_y \times \frac{(A_{st})_{req}}{(A_{st})_{provided}}$

At 38, fig 4 corresponding to $p_t \approx 0.23$, and $f_s \approx 240$

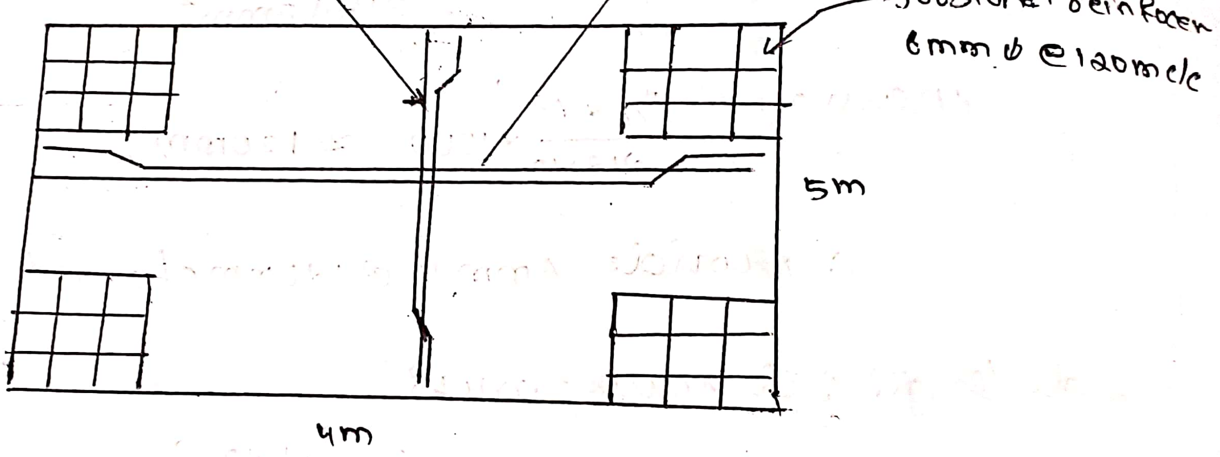
$k_t \approx 1.6$

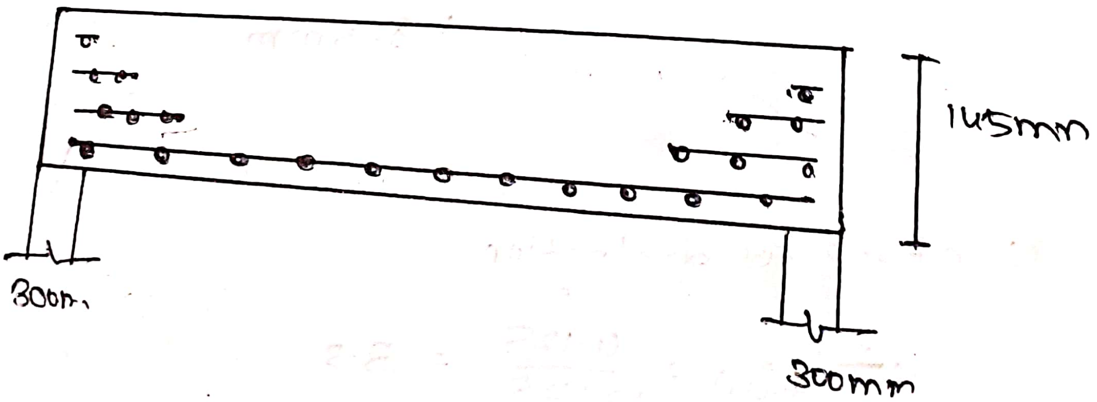
$\therefore \left(\frac{l}{d}\right)_{max} = 40 \times 0.8 \times 1.6 = 51.2$

$\because \left(\frac{l}{d}\right)_{max} > \left(\frac{l}{d}\right)_{actual}$

It is safe against deflection

Step 10:





8)

a) 450mm×450mm

$f_{ck} = 25 N/mm^2$

$f_y = 415 N/mm^2$

P = 1600kN

$P_u = 1600 \times 1.5 = 2400kN$

Step 1: Asc calculation

From 21, 39.3

$$P_u = 0.4 f_{ck} \cdot A_c + 0.67 \times f_y \times A_{sc}$$

$$2400 \times 10^3 = 0.4 \times 25 \times (450^2 - A_c) + 0.67 \times 415 \times A_{sc}$$

$$A_{sc} = 1398.99 mm^2$$

assuming 24mm ϕ bars,

no. of bars : $\frac{1398.99}{\frac{\pi}{4} \times 24^2} = 3.09$

≈ 4 bars

∴ provide, #4, 24mm ϕ as main bars

Step 2: ~~helical reinforcement~~ lateral ties

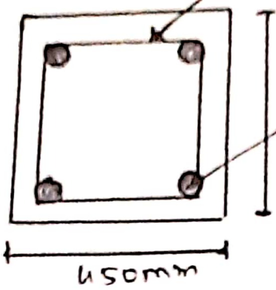
provide ~~helical reinf~~ lateral ties of 8mm ϕ

spacing, i) 16×d = 16×24 = 384mm

ii) b = 450mm } least

iii) 300mm

∴ provide 8mm ϕ ~~helix~~ lateral ties @ 300mm c/c



b) b = 300mm

D = 400mm

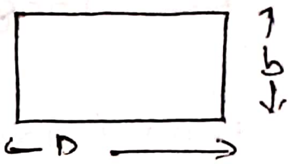
l_{eff} = 3.6m

P_u = 1200kN

M_u = 160kN-m

f_{ck} = 25N/mm²

f_y = 415N/mm²



Step 1: slenderness ratio

= ~~3.6/0.3 = 12~~ ② $\frac{l_{eff}}{D} = \frac{3.6}{0.4} = 9$ } # 41, 25.1.2

short column $\frac{l_{eff}}{b} = \frac{3.6}{0.3} = 12$

Step 2: min eccentricity

$e_{min} = \frac{l_{eff}}{500} + \frac{D}{30}$ / $\frac{l_{eff}}{500} + \frac{d}{30}$

$= \frac{3600}{500} + \frac{400}{30}$ $\frac{3600}{500} + \frac{300}{30}$

e_{min} = ~~17.2~~ 20.53mm or 20mm or 17.2

lead

e_{min} = ~~17.2 20.53mm~~ 17.2

min. eccentricity allowed, e_{min} = ~~0.005 × 400 = 20mm~~

= 0.05 × 300 = ~~20~~ 15

- 'valid scant

since min eccentricity is more than the eccentricity allowed, cannot design using 39.4, use SP-16

through the eccentricity is exceeding the allowable limits, design the as a short column as slenderness ratio = 12

moment due to eccentricity is less than the ultimate moment, hence design considering ultimate moment

step 3: Asc calculation

Let clear cover = 40mm

considering 25mm ϕ bar

$$d' = 40 + \frac{25}{2} = 52.5$$

Now, $\frac{d'}{D} = \frac{52.5}{400} = 0.131$

chart 33, # 118. SP-16 (reinforcement distributed on two sides i.e. rect. section)

$$\frac{P_u}{f_{ck} \cdot b D} = \frac{1200 \times 10^3}{25 \times 300 \times 400} = 0.4$$

$$\frac{M_u}{f_{ck} \cdot b \cdot D^2} = \frac{160 \times 10^6}{25 \times 300 \times 400^2} = 0.13$$

$$\therefore \quad \frac{p}{f_{ck}} \approx 0.11\%$$

$$p = 0.11 \times 25 = 2.75\%$$

$$A_s = \frac{p \cdot b \cdot D}{100} = \frac{2.75 \times 300 \times 400}{100} = 3300\,mm^2$$

$$\text{no. of bars} = \frac{A_s}{\text{area of one bar}} = \frac{3300}{\frac{\pi}{4} \times 24^2} = 7.29$$

$$\approx 8 \text{ bars}$$

∴ provide # 8, 20mm ϕ on two sides as main bars

Step v: lateral ties

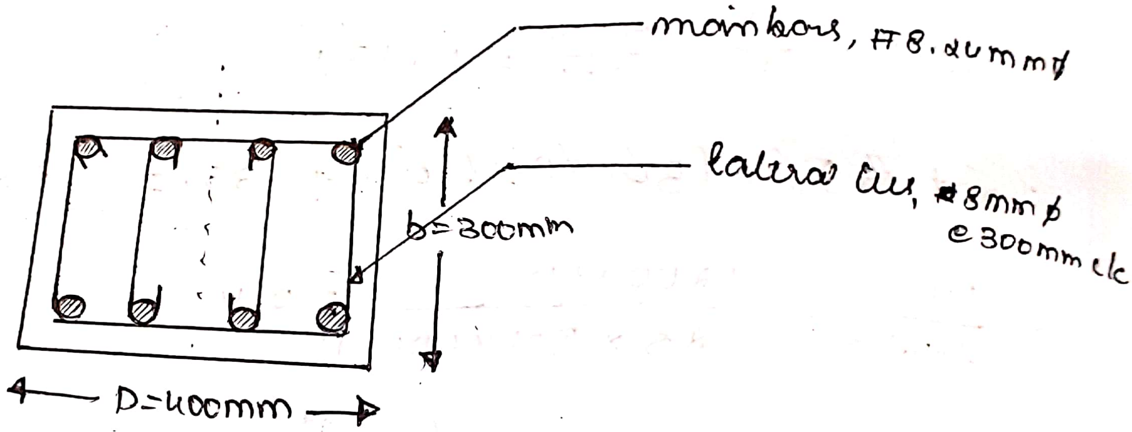
provide 8mm ϕ lateral ties

spacing i) 300mm

ii) b = 300mm } minimum

iii) 16 × bar ϕ = 16×24 = 384mm

∴ provide 8mm ϕ @ 300mm c/c as lateral ties



(8) a) Step :- 1

no of riser = $\frac{\text{floor height}}{\text{Riser}}$

$= \frac{3000}{150} = 20$

∴ dog legged staircase is 2 flight

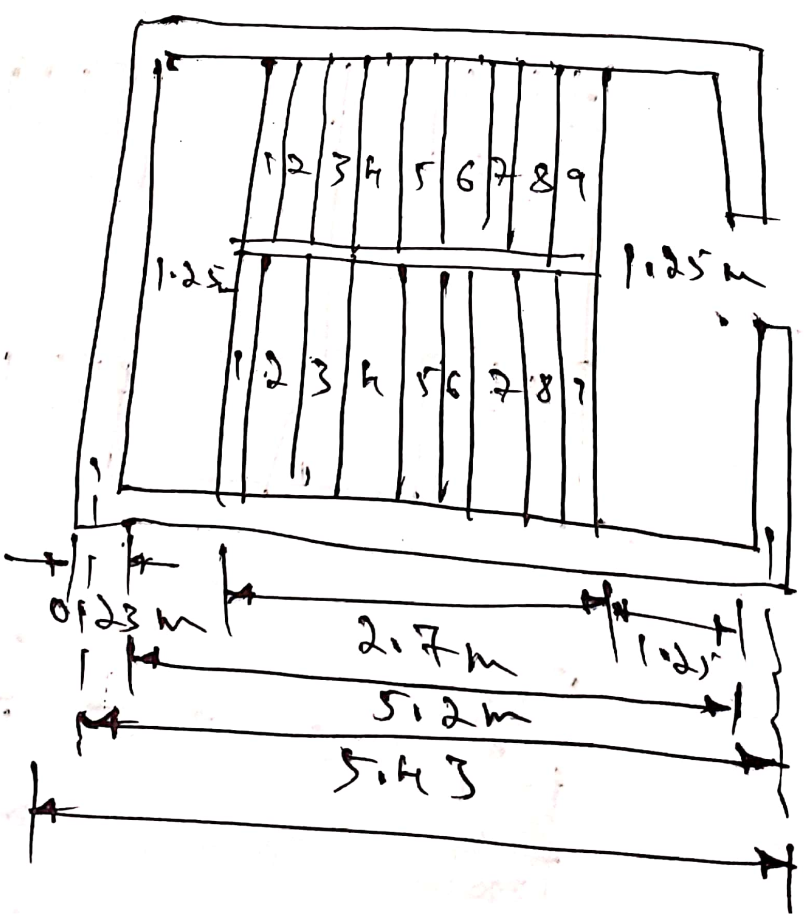
each one flight = 10 riser

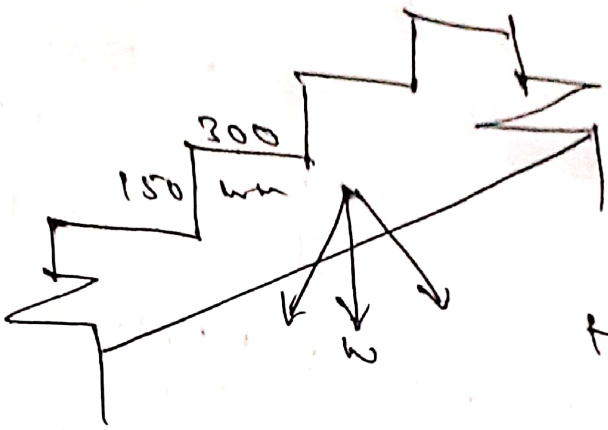
no of treads = 10 − 1

= 9 treads

Step :- 2

Effective length





$Hy = \sqrt{150^2 + 300^2}$
$= 335.41$ mm

Step :- 3

To find waist slab thickness

waist slab thickness $= d = \frac{l_{eff}}{20}$

$d = \frac{5430}{20} = 271.5$ mm

slab thickn 275 is more
hence $d = 250$ mm
take $= d = 250$ mm

$D = 250 + 15 + \frac{12}{2}$

$D = 271$ mm

Step :- 4

To find load calculations

1) To find waist slab loading

* self waist of slab $= \frac{0.335}{0.3} \times 25 \times 0.271$
$= 7.56$ kN/m

CMR

Self weight of steps = 1/2 × 0.15 × 25 × 1
= 1.875

L.L = 5 × 1 = 5 kN/m

F.F = 0.6 × 1 = 0.6 kN/m

Total load = 15.035 kN/m

factored load = 1.5 × 15.035
= 22.55 kN/m

Load of landing

Assume thickness of waist slab landi..
200 mm
= 0.20 × 25 × 1
= 5 kN/m

L.L = 5 × 1 = 5 kN/m

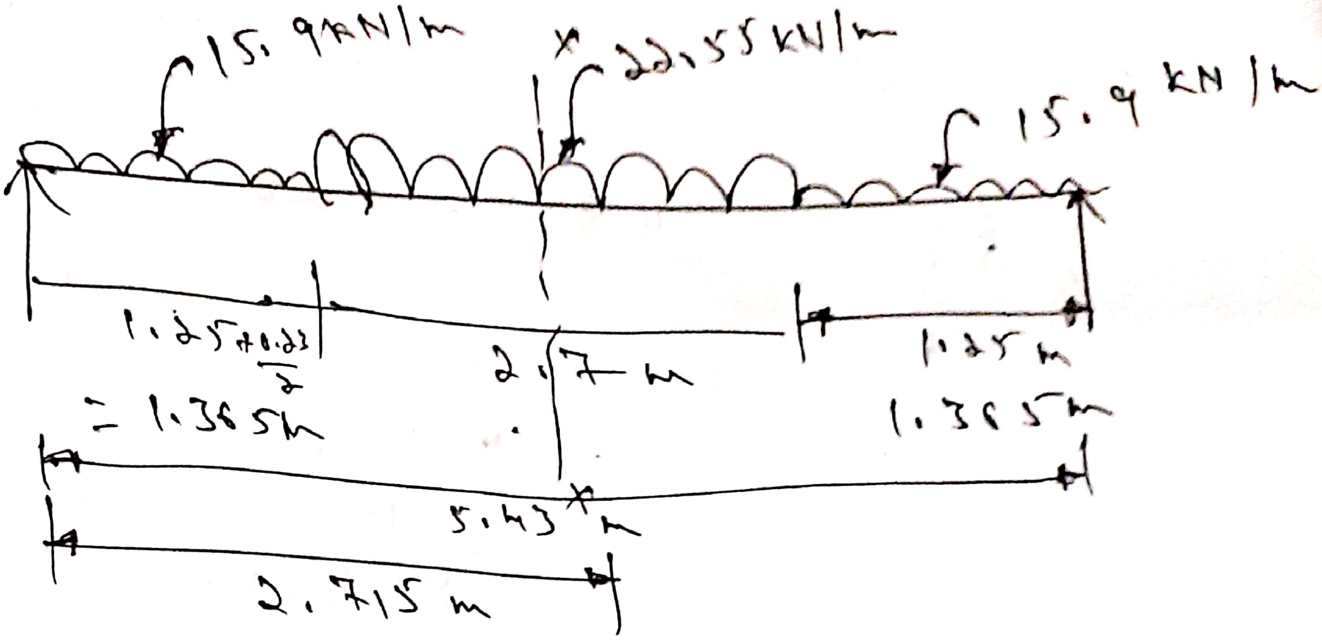
F.F = 0.6 × 1 = 0.6 kN/m

Total load = 10.6 kN/m

Factored load = 10.6 × 1.5
= 15.9 kN/m

Step :- 5

To find ~~loads~~ forces RA + RB and
moment



$RA + RB = 15.9 \times 1.365 + 22.55 \times 2.7 + 15.9 \times 1.365$

$RA + RB = \dfrac{104.292}{2}$

$RA + RB = 52.14 \text{ kN}$

Bm @ mid span $x = 2.715$ m

$M = RA \times 2.715 - 15.9 \times 1.365 \times \left(2.715 - \dfrac{2.715}{2}\right) - 22.55 \times \left(\dfrac{2.7}{2}\right) - (2.715 - 1.365) \times \left(2.715 - \dfrac{1.365}{2}\right)$

$M = 52.14 \times 2.715 - (21.7035 \times 1.3575) - 30.44 - 2.74$

$M = 78.91 \text{ kN-m}$

Step :- 6

To find Ast

$78.91 \times 10^6 = 0.87 \times 415 \times Ast \times 250 \left[1 - \frac{Ast \times 415}{20 \times 1000 \times 250}\right]$

$Ast \doteq 948.97 \ mm^2$

Spacing = use 12 mm ϕ bars

$= \frac{\frac{\pi \times 12^2}{4}}{948.97} \times 1000$

$= 119.17 \approx 120 \ mm$

∴ provide 12 mm ϕ bar @ 120 mm c/c as main reinforcement.

Step:- 7

To find distribution bars

use 10 mm ϕ bars $= \frac{\frac{\pi \times 10^2}{4}}{948.97} \times 100 = 82.7$

Spacing a) $3 \times d = 3 \times 250 = 750 \ mm$

b) 300 mm

c) 398.2 mm

use 10 mm dia bar (or)

$\frac{0.12}{100} \times 1000 \times 271$

$= 325.2 \approx$

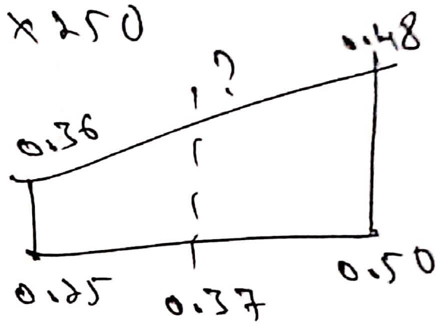
∴ provide 10 mm ϕ bars @ 300 mm c/c

Step :- 8

To find shear

$$\tau_v = \frac{V_f}{bd} = \frac{52.14 \times 10^3}{1000 \times 250} = 0.20 \text{ N/mm}^2$$

$$P_t = \frac{100 A_{st}}{bd} = \frac{100 \times 948.97}{1000 \times 250} = 0.37$$



$$\tau_c = \frac{0.48 - 0.36}{0.50 - 0.25} = \frac{x}{0.37 - 0.25}$$

$$\tau_c = 0.0576 + 0.36$$

$$\tau_c = 0.41 \text{ N/mm}^2$$

$$\tau_v < \tau_c$$

Hence safe against shear

Step :- 9