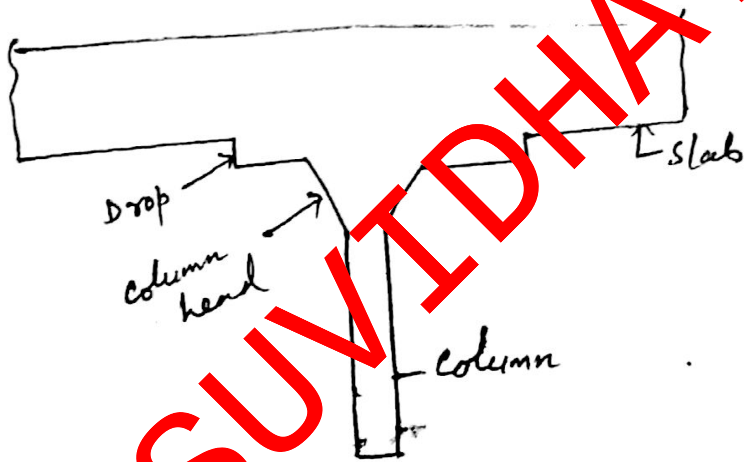
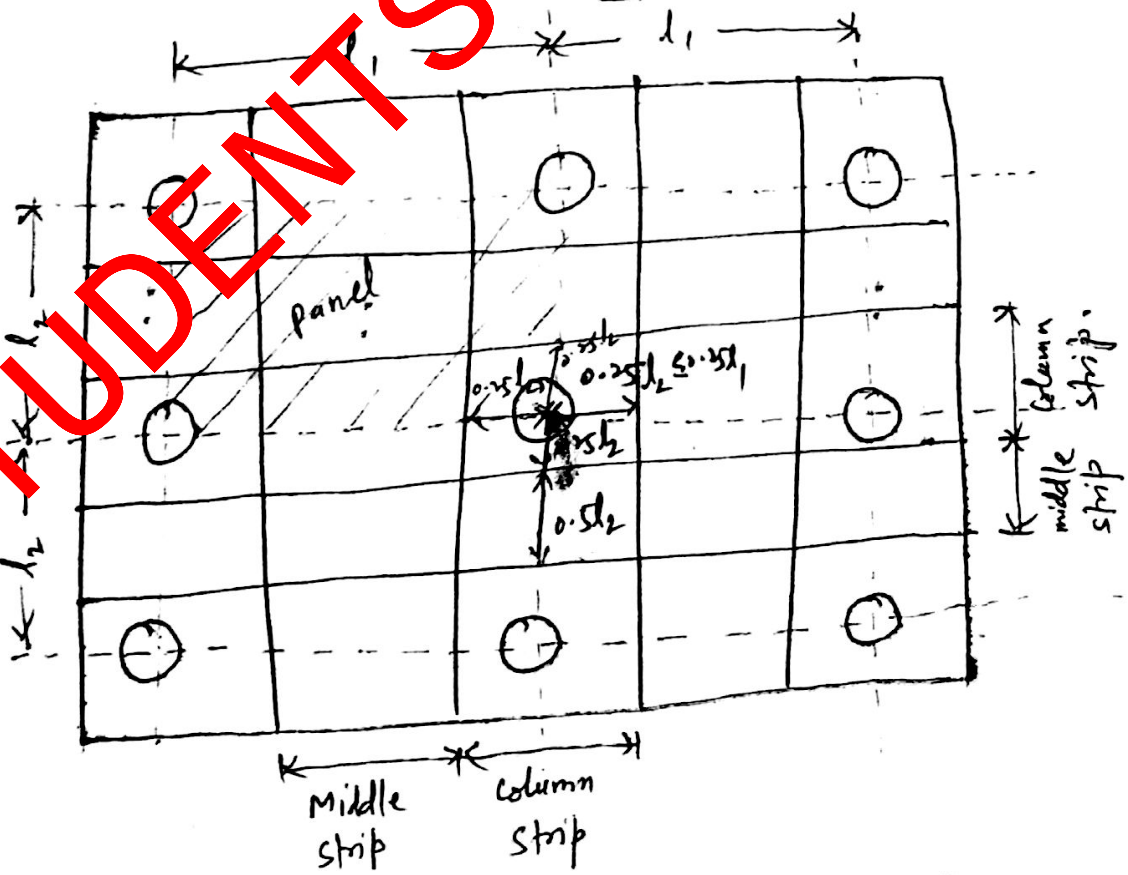
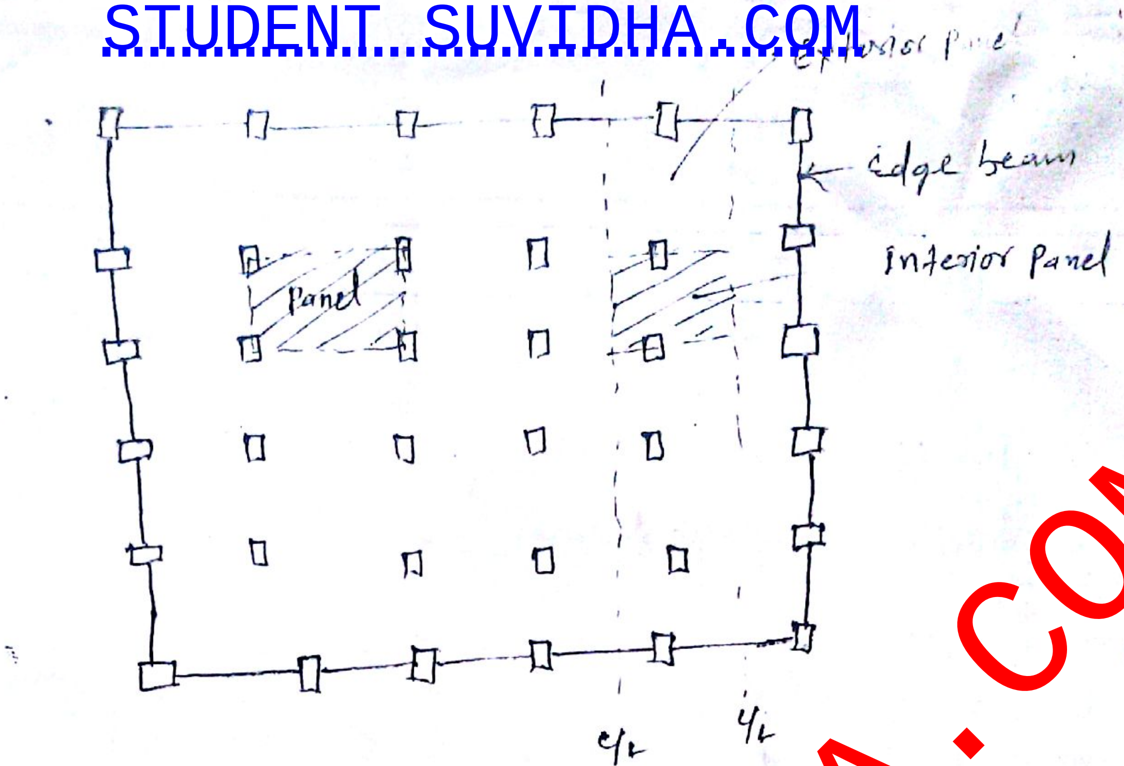
Civil - 6 Sem

Flat Slab

A reinforced concrete slab supported directly on column without any beams is called flat slab. The flat slab is easier to construct and requires cheaper form work. In the case of large spans and heavy load with a multistorey buildings, the total cost is considerably l







Design Methods :-

1. Direct Design method
2. Equivalent frame method

Direct Design method

Limitations :

1. There should be minimum of three continuous spans in each direction.
2. The panel should be rectangular, and the ratio of the longer span to the shorter span within a panel should not be greater than 2.
3. It should be permissible to offset columns to a maximum of 10% of the span in the direction of the offset

④ The successive span lengths in each direction should differ by more than one-third of the longer span. The end spans may be shorter but not longer than the interior spans.

⑤ The design live load should not exceed three times the design dead load..

Prob :-

Design of the interior panel of a flat slab 5.6m x 6.6m in size, for a super-imposed load of 7.75 KN/m². provide two-way reinforcement. Use M20 concrete and Fe-415 steel.

Design constant :-

$\sigma_{cbc} = 7\ N/mm^2$

$\sigma_{st} = 230\ N/mm^2$

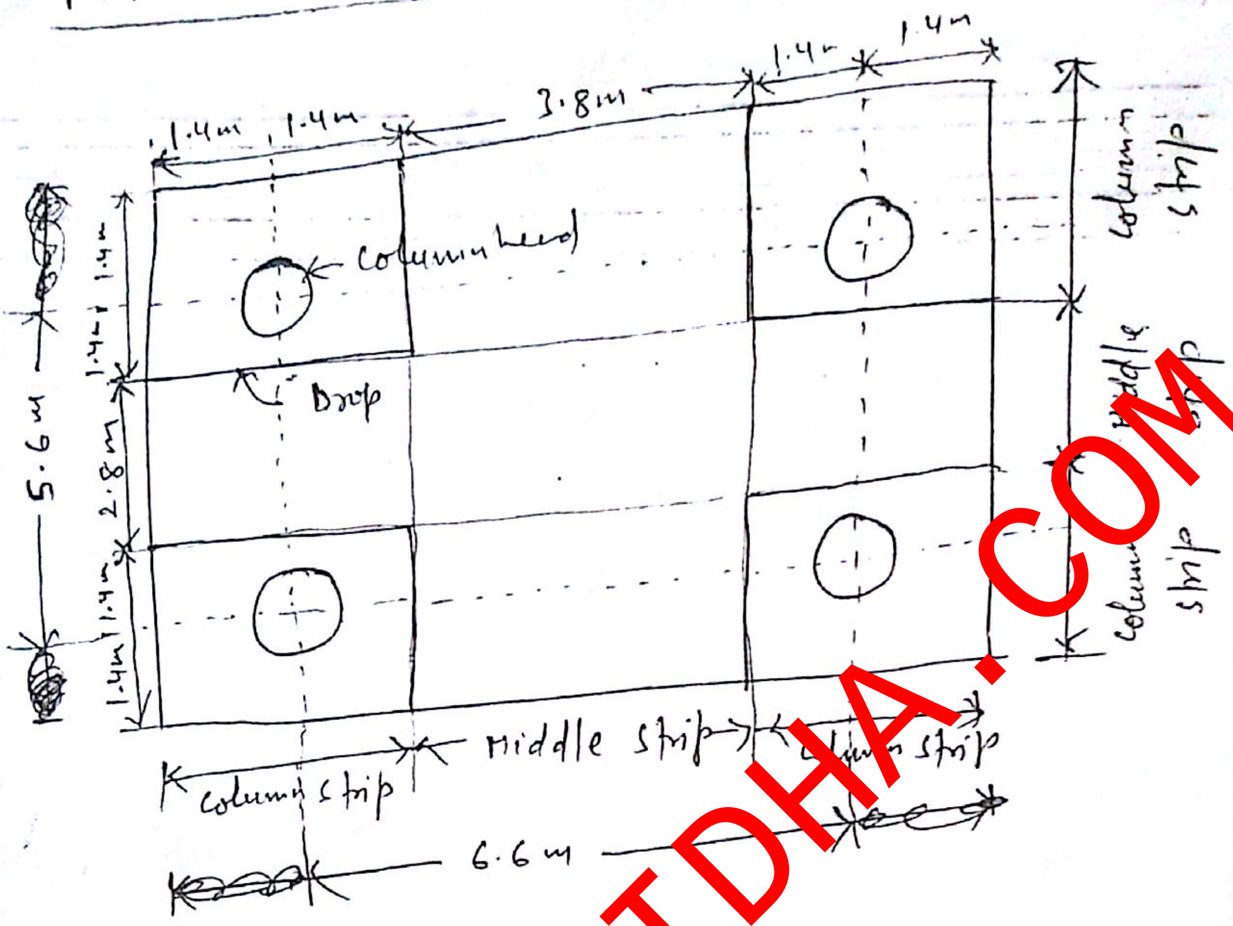
$m = \frac{280}{3\sigma_{cbc}} = \frac{280}{3\times7} = 13.33$

$K = \frac{m\sigma_{cbc}}{m\sigma_{cbc}+\sigma_{st}} = \frac{13.33\times7}{13.33\times7+230} = 0.289$

$J = 1-\frac{K}{3} = 1-\frac{0.289}{3} = 0.904$

$Q = \frac{1}{2}\sigma_{cbc}K\cdot J = \frac{1}{2}\times7\times0.289\times0.904 = 0.91$

Panel dimensions



width of column strip = 0.25 × 5.6 = 1.4 m

width of middle strip along longer span = 6.6 − 2×1.4
= 3.8 m

width of middle strip along shorter span = 5.6 − 2×1.4
= 2.8 m

Let us provide a rectangular drops also.

Minimum length of drop = $\frac{1}{3} l_1$ = $\frac{1}{3}$ × 6.6 = 2.2 m

Minimum width of drop = $\frac{1}{3} \times l_2$ = $\frac{1}{3}$ × 5.6 = 1.87 m

provide 2.8 × 2.8 size drop

Let the column have a column head of diameter one fifth of average span.

$\frac{1}{2}(6.6+5.6) = 6.1$ ∴ D = $\frac{6.1}{5}$ = 1.2 m

Depth and load calculation

$$\frac{\text{span}}{\text{effective depth}} = 26 \times 1.6$$

$$d = \frac{\text{Span}}{26 \times 1.6} = \frac{6.6 \times 1000}{26 \times 1.6} = 160 \text{ mm}$$

provide cover = 20 mm

$\therefore$ D = 160 + 20 = 180 mm

provide total thickness D = 200 mm

Thickness of drops is normally keep 25% to 50% more than the thickness of the slab. Let us assume an average thickness of 250 mm for slab load.

Dead load = $25 \times \frac{250}{1000} = 6.25$ KN/m

Super imposed load = 7.75 = 7.75 KN/m²

Total load, w = 14.00 KN/m

Moment along longer span

Total Moment, $M_1 = \frac{W_1 l_n}{8}$

$l_n \rightarrow$ clear span from face to face of columns $\nless 0.65 l_1$

$W \rightarrow$ design load on area l_2

Three columns ... of diameter 1.2 m

size of equivalent square support $= \sqrt{\frac{\pi}{4}(1.2)^2} = 1.06$ m

$l_{n_1} = l_1 - 1.06 = 6.6 - 1.06 = 5.54$ m

$W_1 = 14 \times (5.54 \times 5.6) = 434.34$ KN

$$M_L = \frac{W_1 l_{n_1}}{8} = \frac{434.34 \times 5.54}{8} = 300.8 \text{ KN-m}$$

Let height of the floor = 4 m

clear height of the column = ht of floor − depth of drop − thickness of slab − thickness of head

$= 4 - .250 - .200 - 0.300$

$= 3.25$ m

effective height of column $= 0.8 \times 3.25$

$= 2.600$ m

Stiffness of column. $K_c = \frac{I}{L_{eff}} = \frac{\pi d^4}{64 \times l_{eff}}$

$$= \frac{3.14 \times (1.2)^4}{64 \times 2.6} =$$

Stiffness of slab $K_s = \frac{I}{L_{eff}} = \frac{bD^3}{12 \times l} = \frac{5.6 \times (0.250)^2}{12 \times 6.6}$

$\frac{\sum K_c}{K_s}$ =

Total negative moment $= 0.65M = 0.65 \times 300.8 = 195.52$ KN

Total positive Moment $= 0.35M = 0.35 \times 300.8 = 105.28$ K

For column strips :-

$-ve$ moment $= 0.75 M_N = 0.75 \times 195.52 = 146.64$

$+ve$ moment $= 0.60 M_p = 0.60 \times 105.28 = 63.168$ KN

For Middle strip :-

$-ve$ moment $= 195.52 - 146.64 = 48.88$ KN-m

$+ve$ moment = Total +ve moment − positive column s mom

$= 105.28 - 63.168$ KN-m $= 42.112$ KN

Moment along shorter span :-

$l_{n2} = 5.6 - 1.06 = 4.54$ m

W_2 = Total design load on area $l_1 \cdot l_{n2}$

$= (6.6 \times 4.54) \times 14 = 419.50$ KN

Total Moment, $M_2 = \frac{W_2 l_{n2}}{8} = \frac{419.50 \times 4.54}{8} = 238.1$ KN-m.

Total $-ve$ moment $= 0.65 M_2 = 0.65 \times 238.1 = 154.765$ K

Total $+ve$ moment $= 0.35 M_2 = 0.35 \times 238.1 = 83.335$ K

For column strips

−ve Moment = 0.75 × 154.765 = 116.07 KN-m

+ve Moment = 0.60 × 83.335 = 50 KN-m

Middle strips

−ve moment = 154.765 − 116.07 = 38.7[illegible] KN-m

+ve moment = 83.335 − 50 = 33.3[illegible] KN-m

Thickness of slab and drops

The thickness of slab will be designed on the basis of maximum positive moment in the column strip of longer span.
width of column strip = 2.8 m

$$d = \sqrt{\frac{M_{max+ve}}{Q b}} = \sqrt{\frac{63.168 \times 10^6}{0.914 \times 2.8 \times 1000}} = 157 \text{ mm} < 160 \text{ mm}$$

∴ Hence our assume depth is correct. provide d = 160 mm, D = 180 mm

The thickness of drops d_d will be designed on the basis of maximum negative bending moment

$$d_d = \sqrt{\frac{M_{max-ve}}{Q b}} = \sqrt{\frac{146.64 \times 10^6}{0.914 \times 2.8 \times 1000}} = 240 \text{ mm}$$

provide d_d = 250 mm

D = [illegible] 270 mm.

Reinforcement along longer span :-

(a) for middle strip :-

$$A_{st} = \frac{M}{\sigma_{st} jd} \quad \leftarrow \text{+ve moment for middle strip}$$

$$= \frac{42.112 \times 10^6}{230 \times 0.904 \times 160} = 1266\ mm^2 \text{ (+ve Rein.}$$

provide 10mm φ bar

$$\text{spacing} = \frac{(2.8 \times 1000) \times \frac{\pi}{4} \times 10^2}{1266}$$

$$= 173\ mm$$

provide 10mm φ bar @ 170mm c/c for middle strip along longer span direction as +ve Rein.

-ve Reinforcement for middle strip

$$A_{st} = \frac{M}{\sigma_{st} jd} = \frac{48.88 \times 10^6}{230 \times 0.904 \times 160} = 1470\ mm^2$$

use 10mm φ bar

$$\text{spacing} = 2.8 \times 1000 \times \frac{\frac{\pi}{4} \times 10^2}{} = \frac{219800}{1470}$$

provide 10mm φ bar @ 160mm c/c along longer span as -reinforcement for middle strip.

Positive Reinforcement for Column Strip :

$$A_{st} = \frac{63.168 \times 10^6}{230 \times 0.904 \times 160} = 1899 \text{ mm}^2$$

$$\text{Spacing} = \frac{2.8 \times 1000 \times \frac{\pi}{4} \times 10^2}{1899} = 116 \text{ mm}$$

provide 10 mm ϕ bar @ 110 mm c/c along longer span for column strip as positive moment.

−ve Reinforcement for column strip along longer span

$$A_{st} = \frac{146.64 \times 10^6}{230 \times 0.904 \times 160} = 4408 \text{ mm}^2$$

$$\text{spacing} = \frac{2.8 \times 1000 \times \frac{\pi}{4} \times 10^2}{4408} = 49.9 \text{ mm}$$

provide 10 mm ϕ bar @ 45 mm c/c along longer span for column strip as −ve reinforcement.

Reinforcement along shorter span :-

Reinforcement along middle strip :-

+ve reinforcement along

$$A_{st} = \frac{M}{\sigma_{st} \, j d} = \frac{33.33 \times 10^6}{230 \times 0.904 \times 160} = 1002 \text{ mm}^2$$

$$\text{Spacing} = 3.8 \times 1000 \times \frac{\frac{\pi}{4} \times 10^2}{} = 297.7 \text{ mm}$$

Provide 10mm ϕ bar @ 250 mm c/c along shorter sp for middle strip as positive reinforcement.

−ve reinforcement along middle strip :-

$$A_{st} = \frac{38.7 \times 10^6}{230 \times 9.04 \times 160} = 1163.3 \text{ mm}^2$$

$$\text{spacing} = \frac{3.8 \times 1000 \times \frac{\pi}{4} \times 10^2}{1163.3} = 256.4 \text{ mm}$$

Provide 10mm ϕ bar @ 250 mm c/c as a −ve reinf along middle strip.

+ve Reinforcement along column strip :-

$$A_{st} = \frac{5? \times 10^6}{230 \times 0.904 \times 160} = 1503 \text{ mm}^2$$

$$\therefore \text{spacing} = \frac{2.8 \times 1000 \times \frac{\pi}{4} \times 10^2}{\therefore} = 46.5 \text{mm}$$

= ~~219800~~

Provide 10 mm ϕ bar @ 45 mm c/c as +ve reinforce along ~~cot~~ shorter span for column strip.

−ve reinforcement for column strip :-

$$A_{st} = \frac{116.07 \times 10^6}{230 \times 0.904 \times 160} = 3489 \text{ mm}^2$$

$$\text{Spacing} = 2.8 \times 1000 \times \frac{\pi}{4} \times 10^2 = 63 \text{ mm}$$

provide 10 mm ϕ bar @ 60 mm c/c for column strip as -ve reinforcement along shorter span direction.