DESIGN OF TWO - WAY SLAB

—* Design a RC slab for a room of size 5.5 m × 4 m clear dimensions & carrying a super imposed load of intensity 4 KN/m². Use M_{20} grade concrete HYSD steel; all the four edges are simply supported with corners held down?

Sol: Given data

* Intensity of live load on slab = 4 KN/m²
* Grade of concrete = M_{20}.
* Grade of steel = fe 415
* Length of the slab l_y = 5.5 m.
* Width of the slab l_x = 4 m.

$$\rightarrow \quad l_y/l_x = \frac{5.5}{4} = 1.375 \; [<2]$$

* Since $l_y/l_x < 2$, the slab is to be designed as the TWO - WAY SLAB.

→ STEP: ① Calculation of design loads on slab.

* Assume intensity of dead load due to slab and imposed floor finish as 5 KN/m². *[ANNEX-D]

* Considering a strip of unit width, along ~~the~~ [parallel to] the width of the slab in accordance with Appendex 'D' of IS: 456-2000 for the calculation of design loads.

* Assuming an effective depth of slab 120 mm with an effective cover of 20 mm [overall depth = 140 mm], the effective length of the slab

in both directions are as follows.

0.0835

* The Effective length along 'x' direction

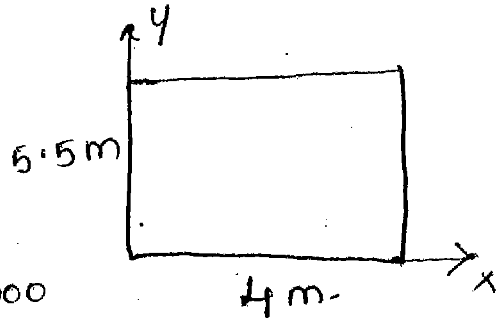
$l_x = 4 + 0.12 = 4.12\ m.$

* The Effective length along 'y' direction

$l_y = 5.5 + 0.12 = 5.62\ m.$

→ Design Bending Moments:

[Table 26]



According to D-1.1 of IS: 456-2000 the design bending moment expressions for slabs spanning in two directions are

$$M_x = \alpha_x W L_x^2$$

$$M_y = \alpha_y W L_x^2$$

Where W = Total factored intensity of UDL along short span direction per meter.

$= 1.5 [W_D + W_L] \times 1$

$= 1.5 [5 + 4] 1 = 13.5\ KN/m$

$L_x = 4.12\ m.$

$\alpha_x = 0.0835$

$\alpha_y = 0.056.$

} Refer Table 26 of ANNEX D Case: No (9). IS: 456-2000.

$\therefore M_x = 0.0835 [13.5] [4.12]^2$

$= 19.13\ KN\text{-}m/m.$

$M_y = 0.056\,[13.5]\,[4.12]^2$

$= 12.83$ KN-m/m

→ Design Shear force:

$\frac{WL}{2} = \frac{13.5 \times 4.4}{2} = 29.7$ KN

→ STEP: ② Determination of Required depth of slab: [ANNEX: G]

* $M_u = M_{ulim} = 0.138\, f_{ck}\, b d^2$

$\therefore d_{req} = \sqrt{\frac{M_u}{0.138 f_{ck} b}}$

$\Rightarrow d_{req} = \sqrt{\frac{19.13 \times 10^6}{0.138 \times 20 \times 1000}}$

$\Rightarrow d_{req} = 83.25$ mm. [< 120 mm] Hence OK

* from clause 24.1 of IS: 456-2000 pg-39

$L_x/d \leq 35 \times 0.8 = 28$

$\therefore d_{req} \geq \frac{4000}{28} = 142.85$ [> 120 mm]

∴ Revise the effective depth of the slab as 145 mm with an effective cover 20 mm [overall depth 165 mm]

→ STEP : ③ Design for flexure : [ANNEX : G & D]

→ Positive moment reinforcement along short span:

$$M_{ux} = 0.87 f_y A_{st} d \left[1 - \frac{f_y A_{st}}{f_{ck} b d}\right]$$

$$\Rightarrow 19.13 = 0.87 \times 415 \times A_{st} \times 145 \left[1 - \frac{415 A_{st}}{20 \times 1000 \times 145}\right]$$

⇒ ~~19.13 = 52.35 × 10^3 Ast [1 − 143 × 10^-6 Ast]~~

⇒ ~~19.13 = 52.35 × 10^3 Ast − 7.49 Ast^2~~

$$\Rightarrow A_{st} = 386.82 \text{ mm}^2.$$

* Spacing required $= S_{req} = \frac{1000 A_\phi}{A_{st}}$ [Assume 10 mm bars]

$$\Rightarrow S_{req} = \frac{1000 \times 78.5}{386.82}$$

$$\Rightarrow S_{req} = 202.93 \text{ mm}.$$

* provide 10 mm bars @ 150 mm c/c parallel to short span with a clear cover of 20 mm.

* provided $A_{st} = \frac{1000 A_\phi}{S_{prov}} = \frac{1000 \times 78.5}{150} = 523.33 \text{ mm}^2$ [> 386 mm²] OK

→ Positive moment reinforcement along long span:

$$M_{uy} = 0.87 f_y A_{st} d \left[1 - \frac{f_y A_{st}}{f_{ck} b d}\right]$$

⇒ ~~12.83 = 0.87 × 415 ×~~

Effective depth of slab along long span direction

$$d_y = 145 - 10 = 135 \text{ mm}.$$

$\therefore \quad 12.83 = 0.87 \times 415 \times A_{st} \times 135 \left[1 - \frac{415 \times A_{st}}{20 \times 1000 \times 135} \right]$

$\Rightarrow \quad A_{st} = 274.83 \text{ mm}^2$

* Spacing required $= S_{req} = \frac{1000\, A_\phi}{A_{st}}$ [Assume 8mm bars]

$\Rightarrow S_{req} = \frac{1000 \times 50.5}{274.83} = 183.74 \text{ mm}.$

$\therefore$ provide 8 mm dia bars @ 150 mm c/c parallel to long span with a clear cover of 30 mm.

* provide $A_{st} = \frac{1000\, A_\phi}{S_{prov}} = \frac{1000 \times 50.5}{150} = 336.6 \text{ mm}^2$

[> 274.83]

OK//.

→ Minimum Reinforcement:

[clause 26.5.2]

* Minimum reinforcement area $= \frac{0.12}{100} \times b \times D = 198 \text{ mm}^2$.

Hence OK $\begin{cases} x < 523.33 \text{ mm}^2 \\ y < 336.6 \text{ mm}^2. \end{cases}$

* Corner reinforcement [ANNEX D – D-1.8]

* Area of corner reinforcement required

$= \frac{3}{4} A_{st_{req}}$ along short span direction.

$= \frac{3}{4} \times 386.82 = 290.11 \text{ mm}^2.$

* Assume 8 mm bars, spacing req $= \frac{\frac{l_x}{5} \times A_\phi}{A_{st}}$

$= 143.43$ mm

$\therefore$ provide 8mm dia bars @ 100 mm c/c in 4 layers at each corner of the slab with in a distance equal to $l_x/5 = 825$ mm.

→ STEP : ④ Check for Shear [clause : 40]

* Design shear force $V_u = 29.7$ KN.

* Nominal shear stress $\tau_v = \frac{V_u}{bd} = \frac{29.7 \times 10^3}{1000 \times 145}$

$= 0.20$ mpa

* Maximum shear capacity $\tau_{c,max} = 2.8$ mpa. [T-20]

$\tau_v < \tau_c$ [Hence ok].

$P_t = 100 A_{st}/bd = \frac{100 \times 523 \times 0.5}{1000 \times 145} = 0.18\%$.

* Design shear strength [T-19, IS:456-2000]

$\tau_c = 0.304$

from Table-18, the value of k for a depth of 165 mm slab is 1.27.

$\therefore \tau_c' = k \times \tau_c = 1.27 \times 0.304 = 0.38$ mpa.

$\therefore \tau_v < \tau_c'$. [Hence ok]

∴ The slab is safe in shear

→ STEP : ⑤ Check for Development length : [cl : 26.2]

$L_d \leq 1.3 \frac{M}{V} + l_0$ where * L_d = Development length

$= \phi \times \sigma_s / 4 \times \tau_{bd}$

$= \frac{\phi \times 0.87 \times 415}{4 \times 1.2 \times 1.6} = 47\phi$

* $M = 0.87 f_y A_{st} d \times \left[1 - \frac{f_y A_{st}}{f_{ck} bd}\right]$

$= 0.87 \times 415 \times \frac{523}{2} \times 145 \times \left[1 - \frac{415 \times \frac{523}{2}}{20 \times 1000 \times 145}\right]$

$\Rightarrow M = 13.17$ N-mm

* $V = 29.7 \times 10^3$ N

* Initially $l_o = 0$

$\therefore \quad 47 \phi \leq 1.3 \frac{(13.17)}{29.7 \times 10^3} + 0$

$\Rightarrow \phi \leq 12.26$ mm [> 10 mm] Hence ok.

$\therefore$ The slab is safe in Development length.

→ STEP: ⑥ Check for deflection: [Cl: 23.2]

$l/d \leq K_1 \times K_2 \times K_3 \times K_4 \times K_5$

Where $l = l_x = 4000$ mm.

$d = 145$ mm

$K_1 = 35 \times 0.8 = 28$, $K_2 = 1$, $K_4 = 1$, $K_5 = 1$

$P_t = 100 A_{st}/bd = \frac{100 \times 523}{1000 \times 145} = 0.36\%$.

from fig-4 of pg: 38

$f_s = 0.58 f_y \times \frac{A_{st\ req}}{A_{st\ pro}} = 177.64$ mpa.

$\therefore \quad K_3 = 1.7$

$\therefore \dfrac{4000}{145} \leq 28 \times 1 \times 1.7 \times 1 \times 1.$

$\Rightarrow 27.58 \leq 47.6.$ [Hence Ok]

$\therefore$ The slab is safe in deflection

TRAFFIC VOLUME ANALYSIS

DAY: MONDAY
DATE; 16/09/2019

NAME OF THE NH-16
SURVEY LOCAT NEAR KALLAM SPPING MILLS

DIRECTION; TOWARDS GUNTUR

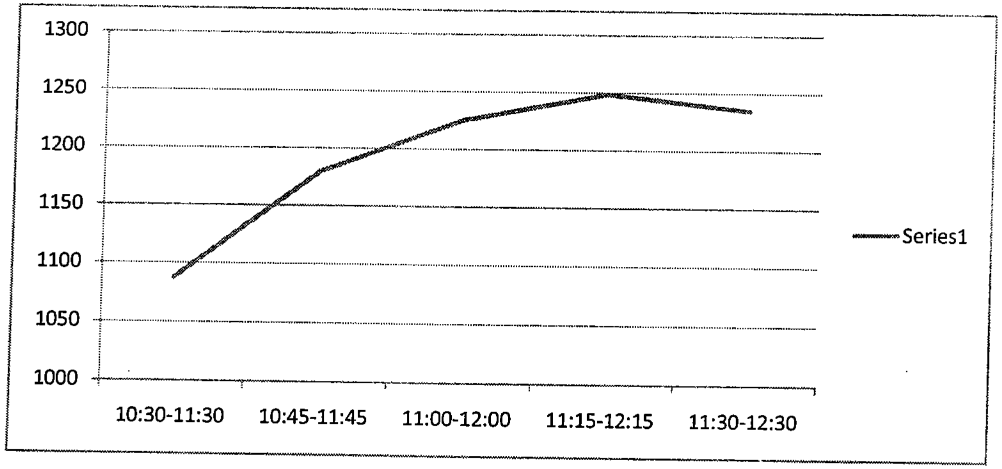
TIME	APSRTC		PRIVATE BUSES	LCV	AUTO RICKSHA W	LORRY	CAR	2 WHEELERS (BIKES)	BICYLES	TOTAL VEHICLES	PCU VALUES FOR EACH HOUR
	EXPRESS	ORDINARY									
10:30-10:45	12	5	5	4	22	30	79	99	2	258	249
10:45-11:00	10	9	4	11	18	34	66	125	5	282	265
11:00-11:15	18	14	9	18	10	20	85	113	8	295	293
11:15-11:30	22	11	7	4	29	29	58	123	4	287	280
11:30-11:45	26	12	11	19	24	34	72	134	3	335	341
11:45-12:00	10	5	5	25	20	44	68	155	7	339	311
12:00-12:15	13	19	6	14	18	33	72	162	1	338	317
12:15-12:30	18	11	8	10	10	19	77	119	5	277	266

PCU VALUES	2.2	2.2	2.2	1	0.5	2.2	1	0.4	0.7		

CALCULATIONS:

249 = (12X2.2)+(5X2.2)+(5X2.2)+(4X1)+(22X0.5)+(30X2.2)+(79X1)+(99X0.4)+(2X0.7)
265 =
293 =
280 =
341 =
311 =
317 =
266 =

TIME	TOTAL PCU PER HOUR
10:30-11:30	1088
10:45-11:45	1180
11:00-12:00	1225
11:15-12:15	1249
11:30-12:30	1235



time intreval	peak volume in PCU
11:15-11:30	280
11:30-11:45	341
11:45-12:00	311
12:00-12:15	317

PEAK HOUR FACTOR = $\frac{\textbf{Peak hour volume}}{\textbf{(60/15)*Max volume at 15 min at peak hour}}$

Peak hour volume = **1249**

Max volume at 15 min at peak hour = **341** **(from 11:30-11;45)**

$= \frac{1249}{4*341}$

= 0.92

Result:- peak hour volume is found for a time **11:15-12:15 and peak hour factor is 0.92**