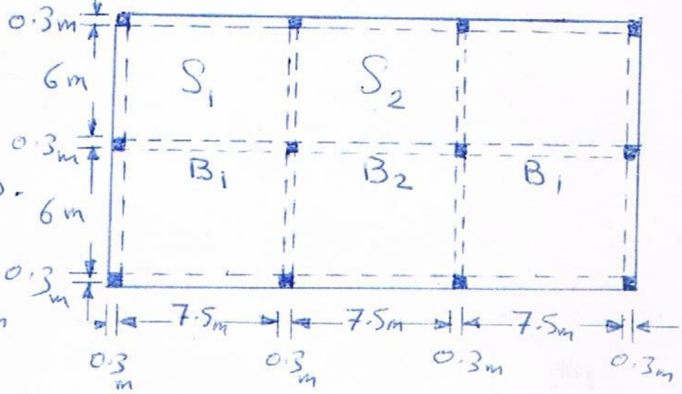
رابع ول ١٠

Ex.:- Design the slabs of the building showing below, L.L = 3 kN/m^2, The additive dead load (finshing & Tiling) equal to 2 kN/m^2, $f'_c = 30$ MPa, $f_y = 400$ MPa. Find the magnitude of loads which applied from the slabs on the beam B_1.



Solution:-

1- Thickness of the slab.

$$h \geq \begin{cases} \dfrac{P}{180} = \dfrac{2(6000+7500)}{180} = 150 \text{ mm} \\ 90 \text{ mm} \end{cases}$$

$\therefore$ Use $h = 150$ mm

2- Calculate the design loads:-

$$D.L. = 0.15 \times 1 \times 1 \times 24 + 2 = 5.6 \text{ kN/m}^2$$

$$W_u = 1.2(5.6) + 1.6(3) = 11.52 \text{ kN/m}^2$$

3- Cheack the thickness of slab according to shear requirements.

$$d = 150 - \underset{\text{cover}}{20} - \underset{d_b/2}{6} = 124 \text{ mm}$$

$$V_{ud} = 11.52\left(\frac{6}{2} - 0.124\right) = 33.13 \text{ kN}$$

$$\phi V_c = \frac{0.75}{6}\sqrt{30} * 1000 * 124 * 10^{-3} = 84.9 \text{ kN}$$

$\because V_{ud} < \phi V_c \Longrightarrow \therefore$ the thickness is adiqute for shear

4- Max. & Min. ratios of Steel Reinforcement:

$$\rho_{max} = (0.85)^2 * \frac{30}{400} * \frac{0.003}{0.003+0.004}, \ \varepsilon_t = 0.004 = 0.02322$$

$$A_{s\,min} = 0.0018bh = 0.0018 * 1000 * 150 = 270 \ mm^2/m$$

5- Calculating of BMs.

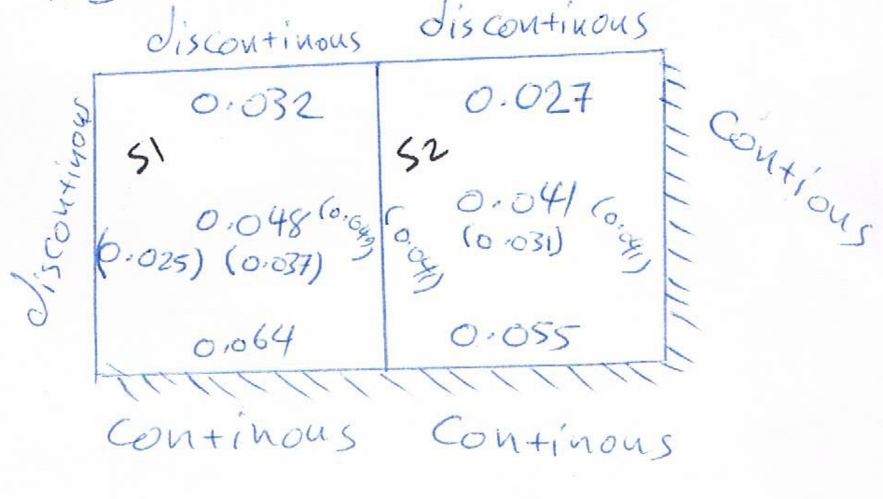
$$S \leq \begin{cases} c/c \text{ of short span length} = 6 + 0.3 = 6.3m \\ \text{clear length of short span} + 2h = 6 + 2*0.15 = 6.3m \end{cases}$$

take the smallest value $\therefore S = 6.3m$

$$L \leq \begin{cases} 7.5 + 0.3 = 7.8 \ m \\ 7.5 + 2 \times 0.15 = 7.8 \ m \end{cases}$$

$\therefore L = 7.8m$

$$m = \frac{6.3}{7.8} = 0.808$$



* Bending Moments in short direction

- Slab S1

$M_{\bar{u}\,disc.} = 0.032 * 11.52 * 6.3^2 = 0.032 * 457.23 = 14.63$ kN.m/m

$M_u^+ = 0.048 * 457.23 = 21.95$ kN.m/m

$M_{\bar{u}\,cont.} = 0.064 * 457.23 = 29.26$ kN.m/m

- Slab S2

$M_{\bar{u}\,disc} = 0.027 * 457.23 = 12.35$ kN.m/m

$M_u^+ = 0.041 * 457.23 = 18.75$ kN.m/m

$M_{\bar{u}\,con} = 0.055 * 457.23 = 25.15$ kN.m/m

* Bending Moments in long direction.

- Slab S1

$M_{\bar{u}\,disc} = 0.025 * 457.23 = 11.43$ kN.m/m

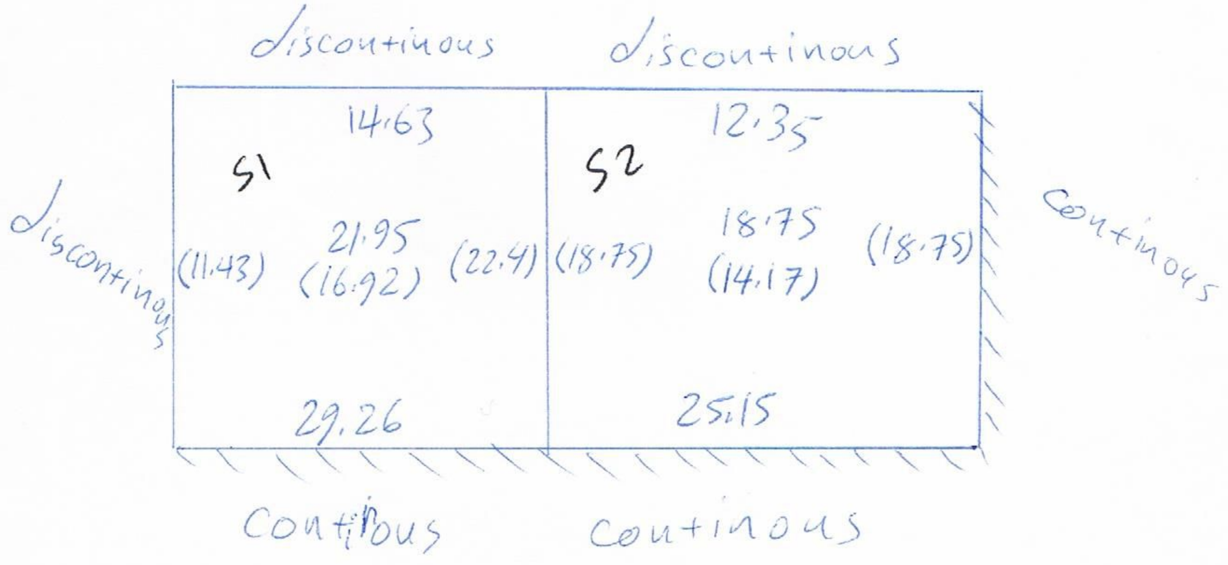
$M_u^+ = 0.037 * 457.23 = 16.92$ kN.m/m

$M_{\bar{u}\,cont.} = 0.049 * 457.23 = 22.4$ kN.m/m

- Slab S2

$M_{\bar{u}\,cont.} = 0.041 * 457.23 = 18.75$ kN.m/m

$M_u^+ = 0.031 * 457.23 = 14.17$ kN.m/m



Steel Reinforcement

a- Short Direction:-

$$K = \frac{M_u}{f'_c b d^2}, \quad \omega = \rho \frac{f_y}{f'_c}, \quad \rho = \boxed{\text{from Table (p4)}}$$

$$K = \frac{M_u}{\phi f'_c b d^2}$$

Reinforcement for middle Strip in short direction (S1)

Moment	K	ω	ρ	$A_s = \rho b d$	A_s Provided	A_s added
$M_u^+ = 21.95$	0.053	0.055	0.00413	512	$\phi 10/150$ (526)	—
$M_{u\,disc.}^- = 14.63$	0.035	0.036	0.0027	335	$\phi 10/300$ (263)	$\phi 8/300$ (167)
$M_{u\,con.}^- = 29.26$	0.070	0.074	0.0056	695	$\phi 10/150$ (526)	$\phi 10/300$ (263)

$\rho_{max} = 0.0232$, $\rho_t = 0.0203$, $A_{s\,min} = 0.002bh$

$A_{s\,min} = 0.00180 * 1000 * 150 = 270.0\ mm^2/m$

* All ρ value < $\rho_{max} = 0.0232$ ∴ o.k.
* All ρ value < $\rho_t = 0.0203$ ⟹ $\phi = 0.9$
* All A_s > $A_{s\,min}$ =

$$S = \frac{1000}{A_s/A_b} = \frac{1000 * 79}{512} = 154\ mm$$

Use $S = 150\ mm$ c/c

50% of bars will be bend & then (A_s provided) is found

$A_s = \frac{1000}{S} A_b$

Reinforcement for middle strip ~~in~~ short direction (S_2)

Moment	K	ω	ρ	$A_s = \rho b d$ (mm^2)	A_s provided (mm^2)	A_s add. (mm^2)
$M_u^+ = 18.75$	0.045	0.047	0.0035	434	ϕ10/180 (438)	—
$M_u^-{}_{disc.} = 12.35$	0.030	0.031	0.0023	286	ϕ10/360 (219)	ϕ8/360 (139)
$M_u^-{}_{con.} = 25.15$	0.060	0.063	0.0047	583	ϕ10/180 (438)	ϕ10/360 (219)

All value of ρ & A_s is ok for $\rho_{max.}$, ρ_t & $A_{s\,min}$.

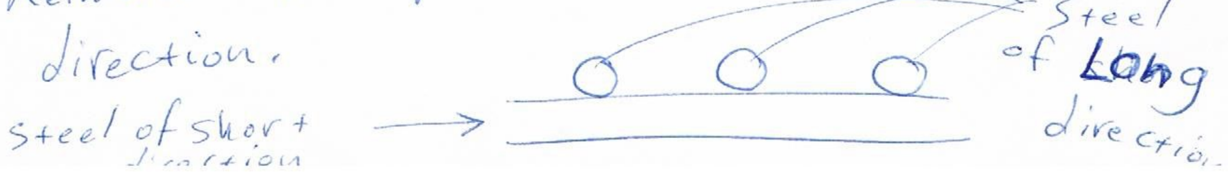
- for vertical strip the steel reinforcement $= \frac{2}{3}$ of steel reinforcement for middle strip.

* Spacing of vertical strip $= 1.5 * S$ of middle strip.
* S must not be more than $(2h)$.
* A_s for vertical strip $\geq A_{s\,min}$.
* In practical case A_s vertical strip $= A_s$ middle strip but in that case there are lost in steel reinforcement.

- Steel Reinforcement in Long Direction:-

$d = h - (1.5 d_b + 20) = 150 - (1.5 * 12 + 20) = 112\ mm$

This Reinforcement is putted on the steel of short direction.



Reinforcement of Long Direction.

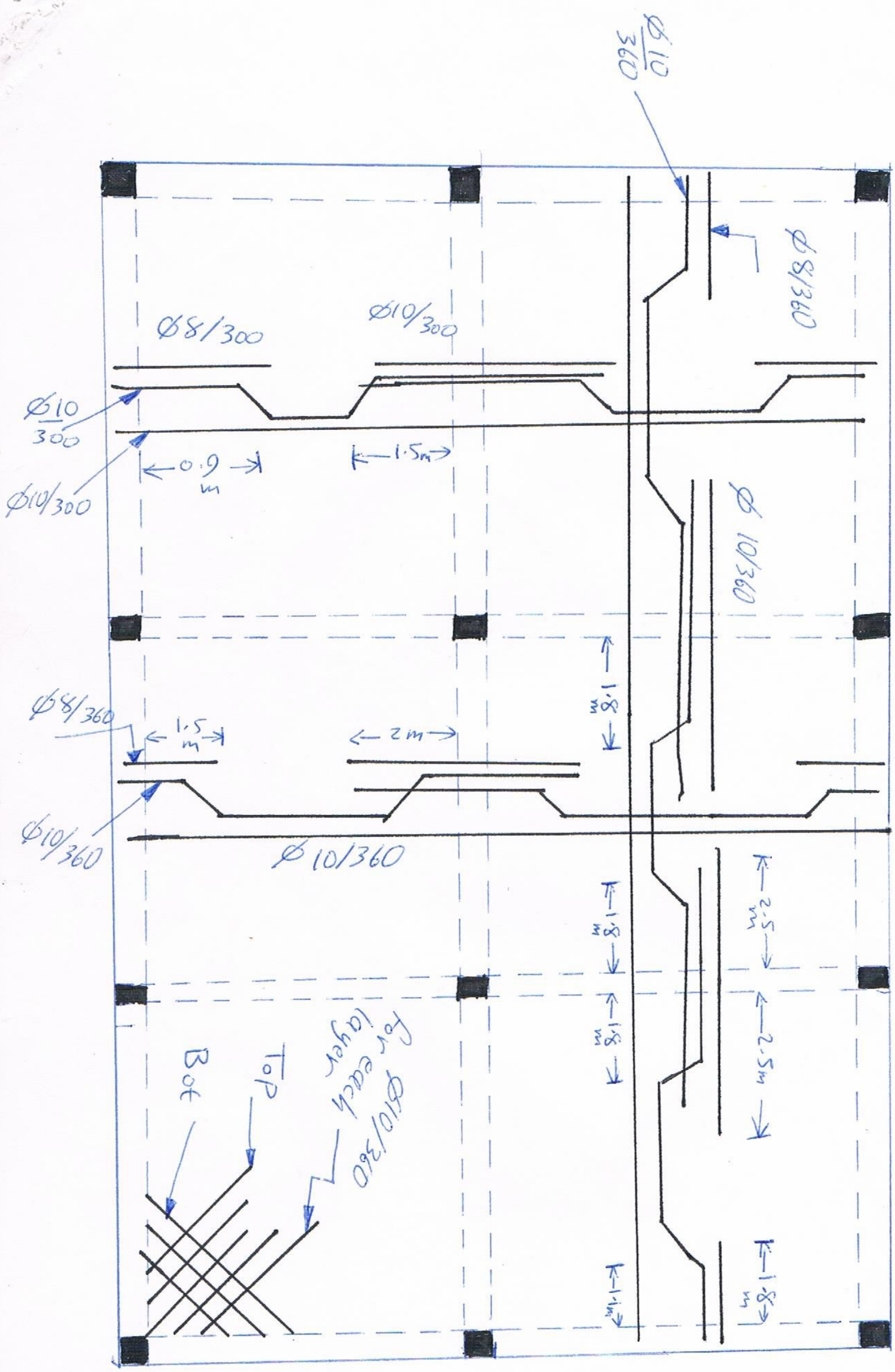
Moment kN·m	k	ω	ρ	$A_s = \rho b d$	A_s provided	A_s add.
$M_u^+ = 16.92$	0.05	0.052	0.0039	437	∅10/180 (438)	—
$M_{u\,disc.}^- = 11.43$	0.034	0.035	0.0026	292	∅10/360 (219)	∅8/360 (139)
$M_{u\,cai.}^- = 22.4$	0.066	0.069	0.0052	583	∅10/180 (438)	∅10/360 (219)

* For Torsion Reinforcemen the same diameters & Spacing of Posotive Reinforcement in short direction can be used.

- The Load which applied on beam (B_1) equal to:-

$$W_e = \frac{Ws}{3}\frac{(3-m^2)}{2} = \frac{11.52 * 6.3}{3}\frac{(3-0.8^2)}{2} * 2 = 57\ kN/m$$

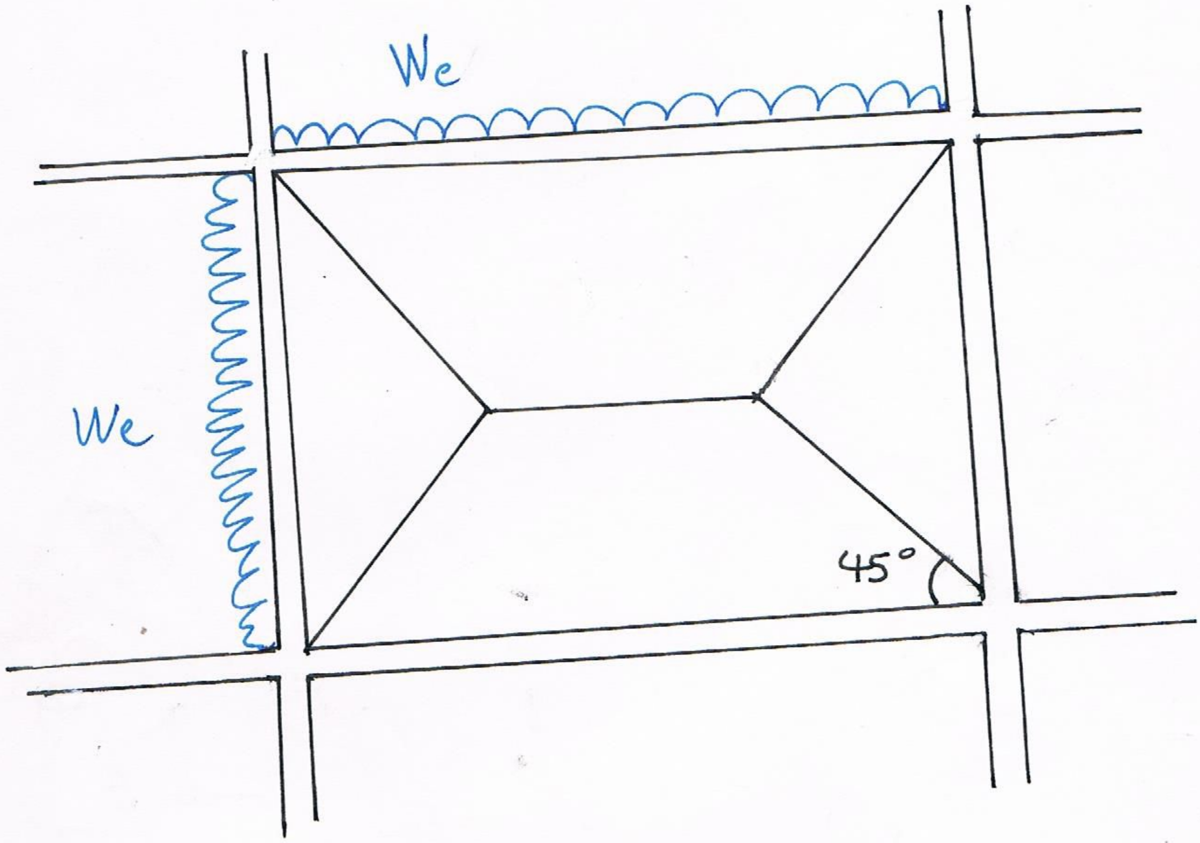
* Torsion Reinforcement Must put for every Corner.

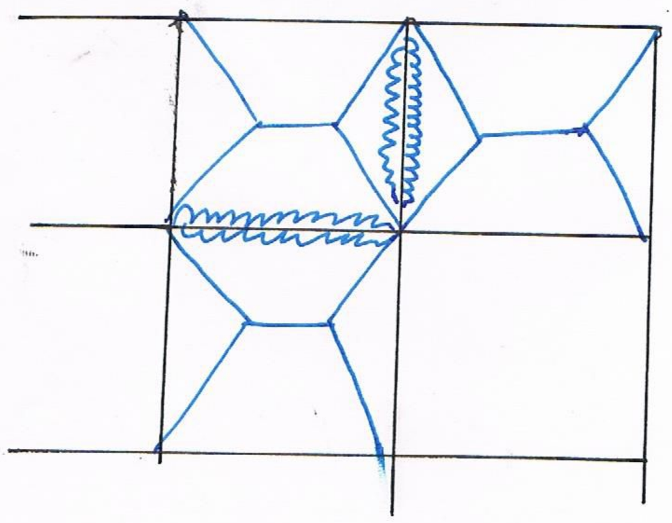

Ø10/360
Ø8/360
Ø8/300
Ø10/300
Ø10/300
Ø10/300
0.9 m
1.5m
Ø 10/360
1.8 m
Ø8/360
1.5 m
2m
Ø10/360
Ø 10/360
1.8 m
2.5 m
1.8 m
2.5 m
Bot
Top
for each layer
Ø10/360
1.1m
1.8 m

W equivelant

$$W_e(\text{for short beams}) = \frac{W_u S}{3}$$

$$W_e(\text{for Long beams}) = \frac{W_u S}{3}\left(\frac{3-m^2}{2}\right)$$





Torsion Reinforcement:-

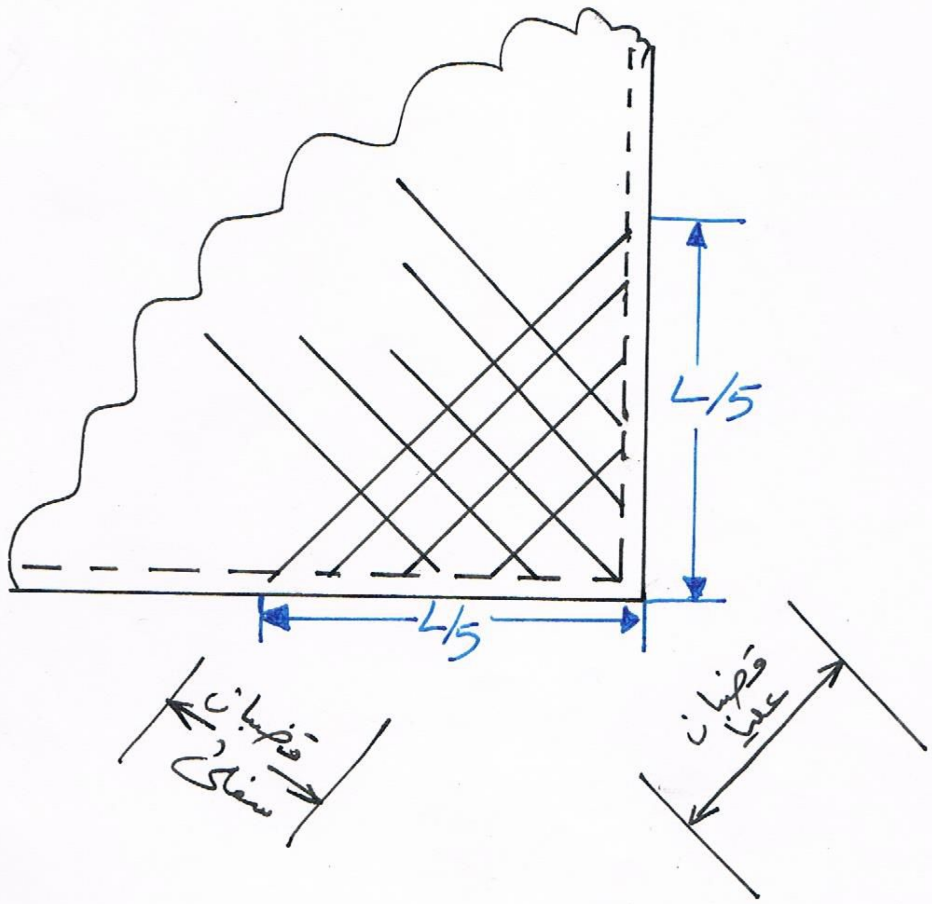
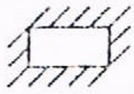
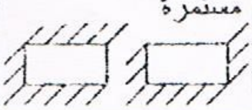
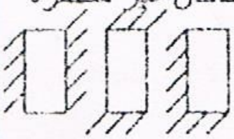
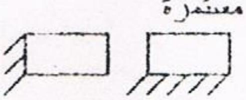
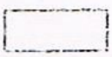


Table (1) ١٥

نوع البلاطة	العزوم	الاتجاه القصير: نسبة العرض الى الطول (m) 1.0	0.9	0.8	0.7	0.6	0.5	الاتجاه الطويل لجميع قيم (m)
بلاطة داخلية 	$M_{\bar{u}cont}$	0.033	0.040	0.048	0.055	0.063	0.083	0.033
	$M_{\bar{u}disc}$	-----	-----	-----	-----	-----	-----	-----
	M_u^+	0.025	0.030	0.036	0.041	0.047	0.062	0.025
أحد الحافات غير مستمرة 	$M_{\bar{u}cont}$	0.041	0.048	0.055	0.062	0.069	0.085	0.041
	$M_{\bar{u}disc}$	0.021	0.024	0.027	0.031	0.035	0.042	0.021
	M_u^+	0.031	0.036	0.041	0.047	0.052	0.064	0.031
حافتان غير مستمرة 	$M_{\bar{u}cont}$	0.049	0.057	0.064	0.071	0.078	0.09	0.049
	$M_{\bar{u}disc}$	0.025	0.028	0.032	0.036	0.039	0.045	0.025
	M_u^+	0.037	0.043	0.048	0.054	0.059	0.068	0.037
ثلاث حافات غير مستمرة 	$M_{\bar{u}cont}$	0.058	0.066	0.074	0.082	0.090	0.098	0.058
	$M_{\bar{u}disc}$	0.029	0.033	0.037	0.041	0.045	0.049	0.029
	M_u^+	0.044	0.050	0.056	0.062	0.068	0.074	0.044
جميع الحافات غير مستمرة 	$M_{\bar{u}cont}$	-----	-----	-----	-----	-----	-----	-----
	$M_{\bar{u}disc}$	0.033	0.038	0.043	0.047	0.053	0.055	0.033
	M_u^+	0.050	0.057	0.064	0.072	0.080	0.083	0.050

ملاحظات:

1- النهاية الوشرة يقصد بها مستمرة

2- الرموز $M_{\bar{u}cont}$ = العزم السالب للنهاية المستمرة .

$M_{\bar{u}disc}$ = العزم السالب للنهاية غير المستمرة

M_u^+ = العزم الموجب .

Design of Two-Way Slabs :-

* If $\frac{L}{S} < 2.0$, The slab should be desinged as two-way slab.
* There are many kinds of two-way slab like:-

1- Slabs supported by shallow beams.
2- Flat plate slabs.
3- Flat Slabs :-
   a.- Flat slabs with drop panels.
   b.- Flat slab with column capital.
   c.- Slab with drop panel & capital.
4- Tow way ribbed slabs.

Design of Edge Supported Slabs :-

* There are three method for design this type of slab
* We will use the second method for the design.