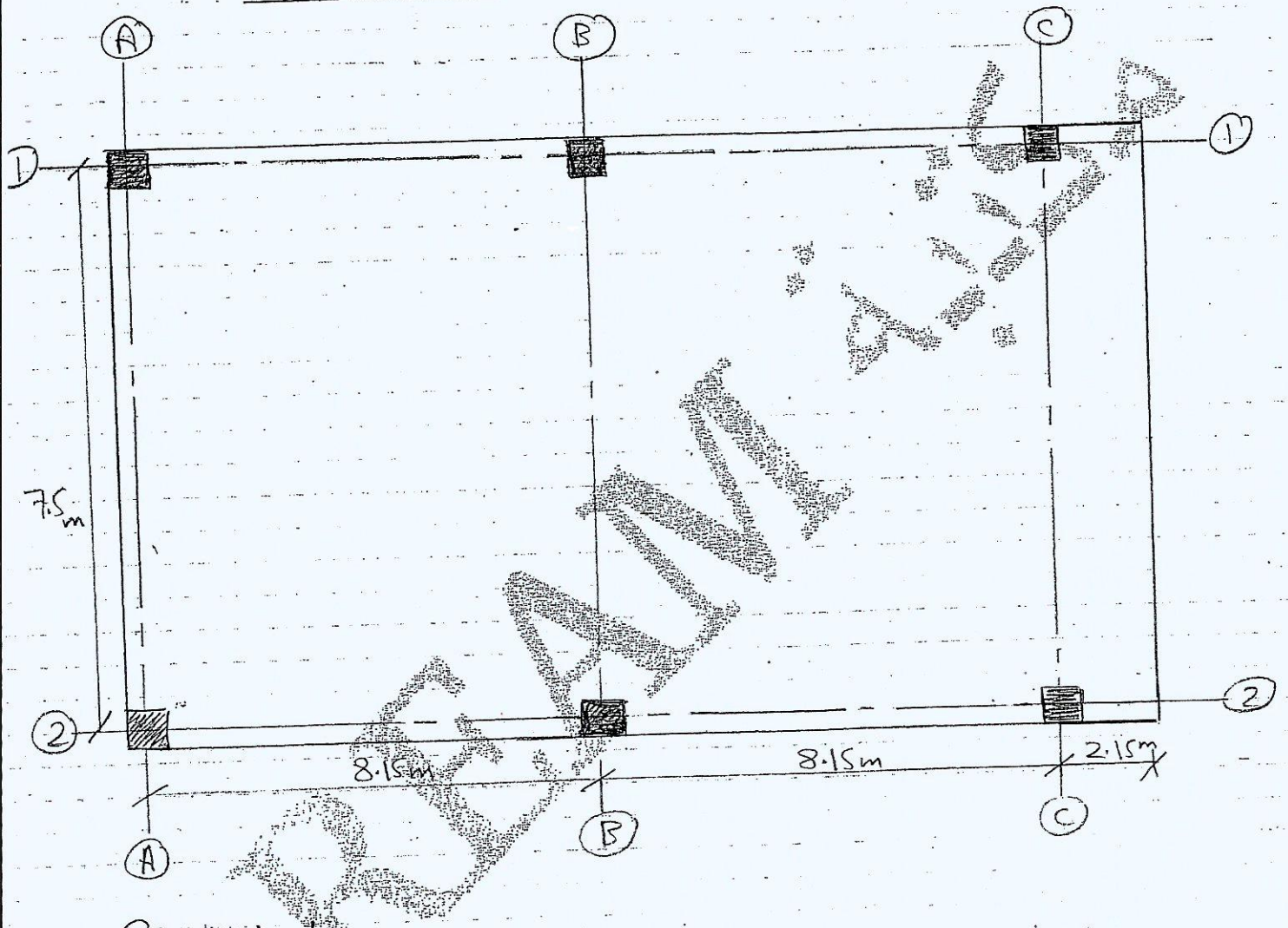
2

Hollow Blocks Slabs + sheet

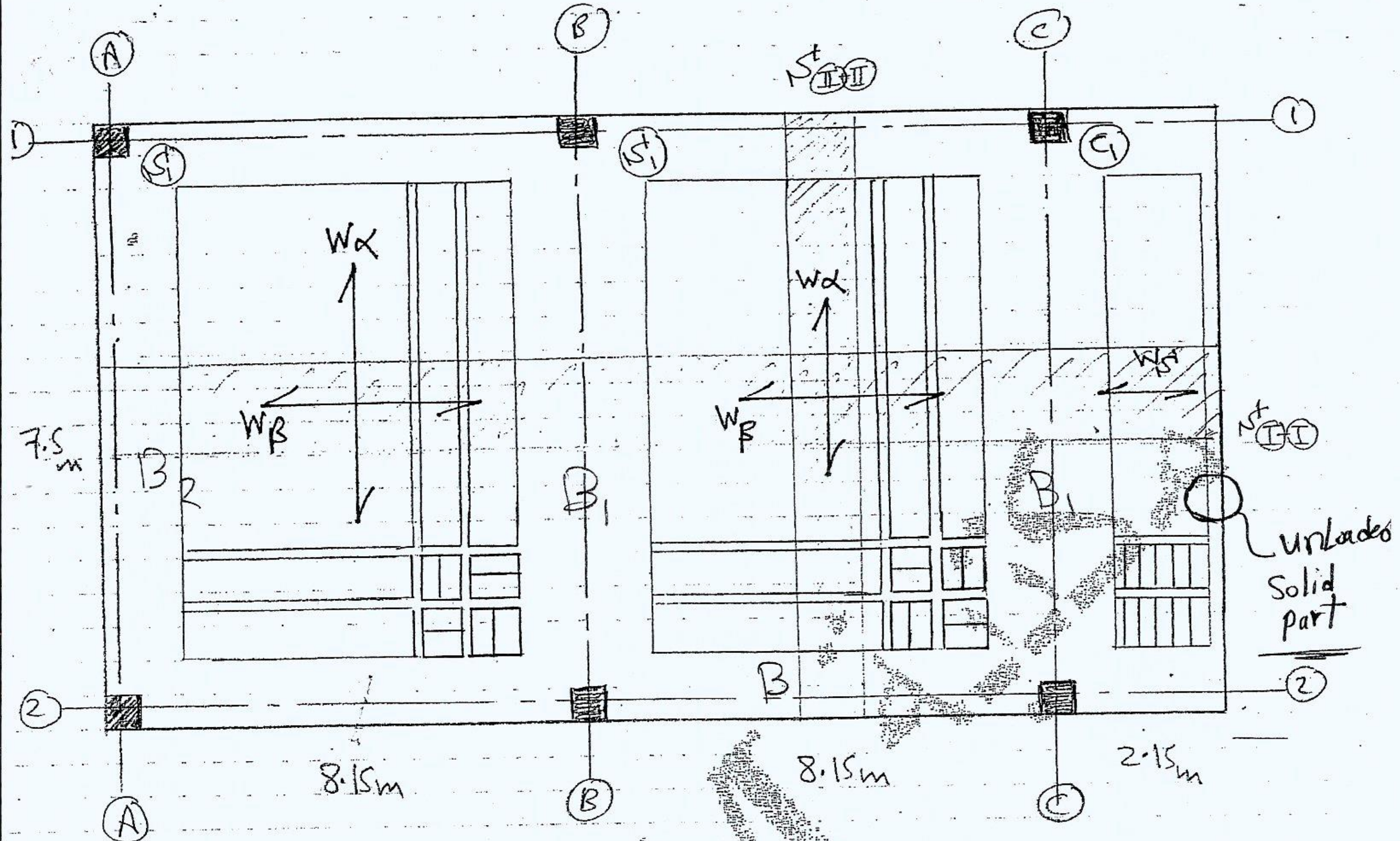
Example :-

Design the slabs of the roof using a Hollow-Block slab :-
[Using Hidden Beams]
& Design the Hidden Beam on axis (B)-(B)



Given Data :-

- Block 20X20X40 cm
- Live load = 600 kg/m²
- f_{cu} = 250 kg/cm²
- Flooring Cover = 150 kg/m²
- f_y = 3600 kg/cm²
- f_{yst} = 2400 kg/cm²



Arrangement of Blocks:-

S_1 (7.5m X 8.15m) [middle span]

+ Short Dir. (750 cm)

$$750 + 25 = 2B + 10n + 40(n+1)$$ • assume $B = 80$ cm

→ get $n = 11.5$ → $n = 11$ rib

→ get $B_{act} = 92.5$ cm

+ Long Dir. (815 cm)

$$815 = \frac{B_1}{2} + \frac{B_1}{2} + 10n + 40(n+1)$$ • assume $B_1 = 160$ cm

→ get $n = 12.3$ → $n = 12$ rib

→ get $B_{1act} = 175$ cm

S_1 (7.5m X 8.15m) [Edge span]

+ Short Dir. (750 cm) ok

+ Long Dir. (815 cm)

$$815 + \frac{25}{2} = B_2 + \frac{175}{2} + 10n + 40(n+1)$$ • assume $B_2 = 8$… cm

→ get $n = 12.4 \Rightarrow$ **n = 12 rib**

→ get $B_{2\,act} =$ 100 cm

C1 (215 cm)

$$215 = \frac{175}{2} + s_2 + 20\,m$$

• assume $s_2 = 15$ cm

→ get $m = 5.625 \Rightarrow$ **m = 5 block**

→ get $s_{2\,act} =$ 27.5 cm

Loads :-

→ $W_{s\,one\,way} = [W_{table} + \gamma_c (t_s - 0.05) + Covering] + L.L$

$W_{s\,one\,way} = [0.33 + 2.5(0.07 - 0.05) + 0.15] + 0.6 =$ **1.13 t/m²**

$W_{rib\,one\,way} = W_{s\,one\,way} * 0.5 = 1.13 * 0.5 =$ **0.565 t/m'**

→ $W_{s\,two\,way} = [0.38 + 2.5(0.07 - 0.05) + 0.15] + 0.6 =$ **1.18 t/m²**

$r\,(s_1) = \frac{L_{long}}{L_{short}} = \frac{8.25}{7.5} \cong 1.1$

(take the min)

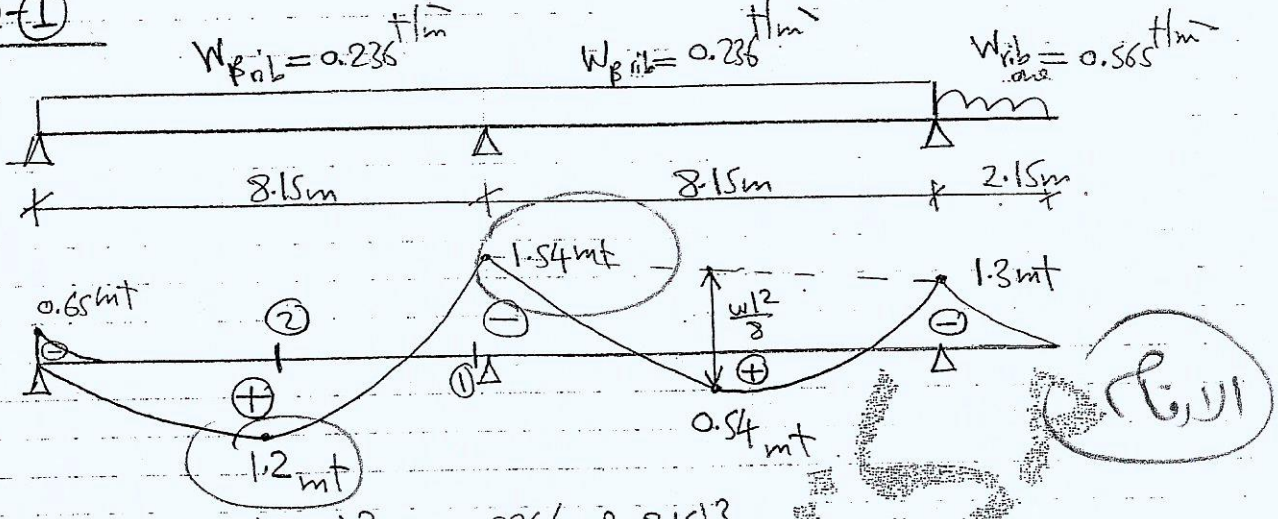
From Grassoff → L.L > 500 → $\alpha = 0.6$, $\beta = 0.4$

$W_{rib\,\alpha} = W_{s\,two\,way} * \alpha * 0.5 = 1.18 * 0.6 * 0.5 =$ **0.354 t/m'**

$W_{rib\,\beta} = W_{s\,two\,way} * \beta * 0.5 = 1.18 * 0.4 * 0.5 =$ **0.236 t/m'**

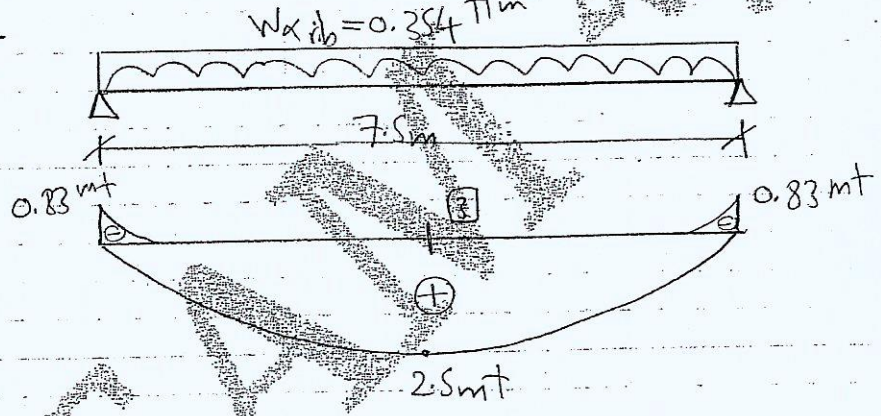
Strips :-

Strip (I)-(I)



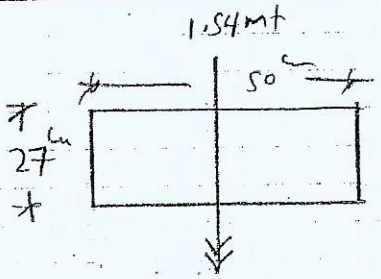
الكود الفرنسي $M_{-ve} = \dfrac{0.236\,(8.15)^3 + 0.236\,(0.8*8.15)^3}{8.5\,(8.15+0.8*8.15)} = 1.54\,mt$

Strip (II)-(II)



Design of sections :-

Sec (1) $M_{-ve} = 1.54\,mt$ [rect. sec.]



$$d = K_1\sqrt{\frac{M}{\beta}}$$

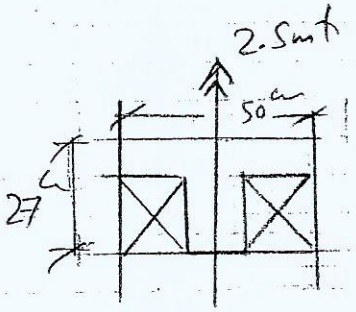
$$27-3 = K_1\sqrt{\frac{1.54*10^5}{50}}$$

$K_1 = 0.432 \xrightarrow{\alpha=0} K_2 = 1832$ $\qquad f_c = 45 < f_{call}$

$$A_s = \frac{M}{K_2 d} = \frac{1.54*10^5}{1832*24} = 3.5\,cm^2$$

Use 2 #16 / rib

Sec (3) $M_{+ve} = 2.5\,mt$ [T-sec.]



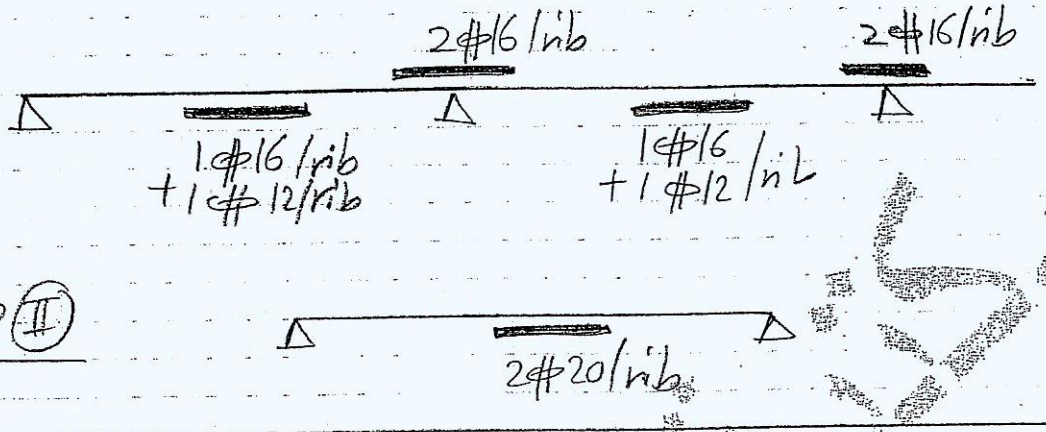
$$24 = K_1\sqrt{\frac{2.5*10^5}{50}}$$

$K = 0.229 \xrightarrow{\alpha=0} K_2 = 1818$ $\qquad f_c = 50 < 2/3 f_{call}$

$$A_s = \frac{M}{K_2 d} = \frac{2.5 * 10^5}{1818 * 24} = \boxed{5.73\ cm^2}$$

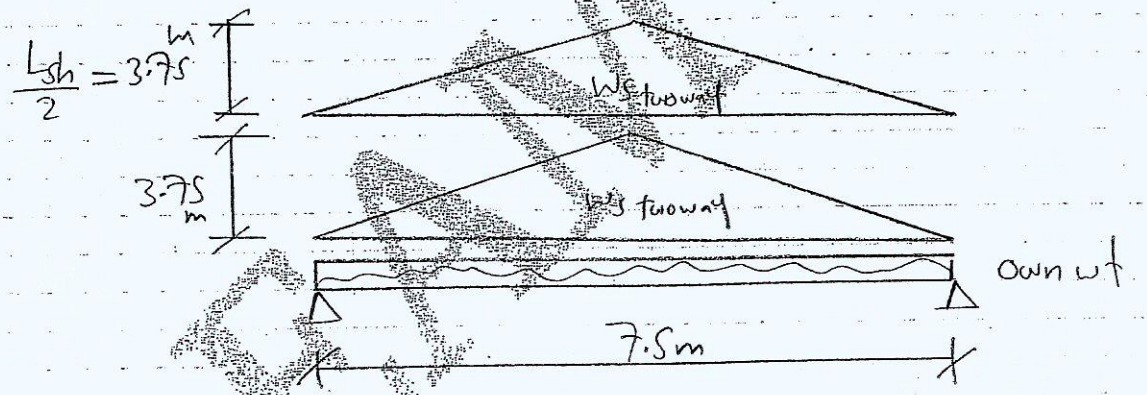
$$\boxed{\text{Use } 2\#20 / rib}$$

Strip (I)



Strip (II)

⊛ Design of Hidden Beam on axis (B)-(B) (175X27cm)



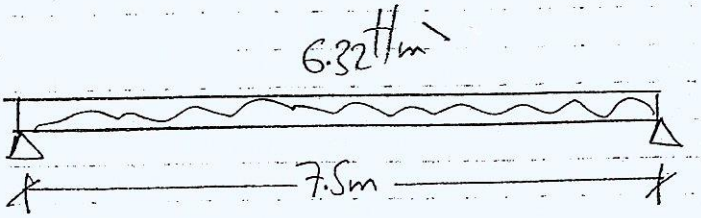
$$\text{own wt} = \gamma_c \cdot B \cdot t = 2.5 * 1.75 * 0.27 = \boxed{1.18\ t/m'}$$

$$W_{Beam} = \text{own wt} + \text{load from slab} - B\,(\text{own wt of slab})$$

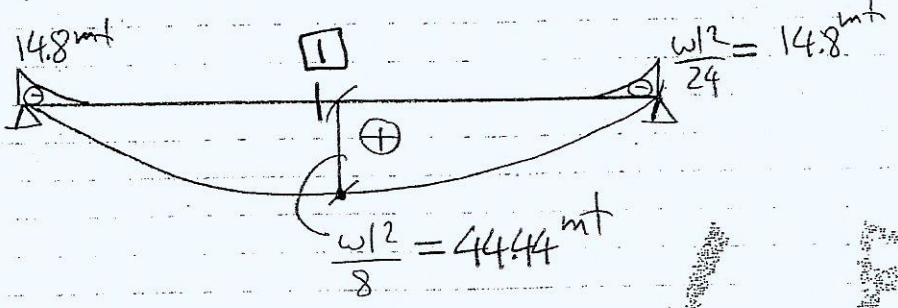
$$W_{(Moment)} = \gamma_c \cdot B \cdot t + 2\,[W_s \cdot X \cdot \alpha] - B\,(W_{table} + \gamma_c(0.02))$$

$$W_{(Moment)} = 1.18 + 2[1.18 * 3.75 * 0.666] - 1.75 * (0.38 + 2.5 * 0.02)$$

$$W_{(Moment)} = \boxed{6.32\ t/m'}$$



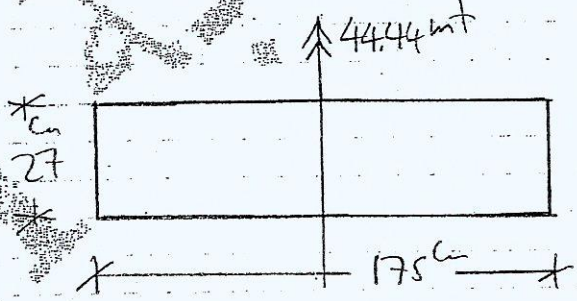
B.M.D



Design of sections :-

Sec 1 $M_{+ve} = 44.44$ mt

Red. sec.



$$d = K_1 \sqrt{\frac{M}{B}}$$

$$24 = K_1 \sqrt{\frac{44.44 * 10^5}{175}}$$

get $K_1 = 0.151$ ⟶ Unsafe

Increase B ⟶ $B = 275$ cm

$$24 = K_1 \sqrt{\frac{44.44 * 10^5}{275}}$$

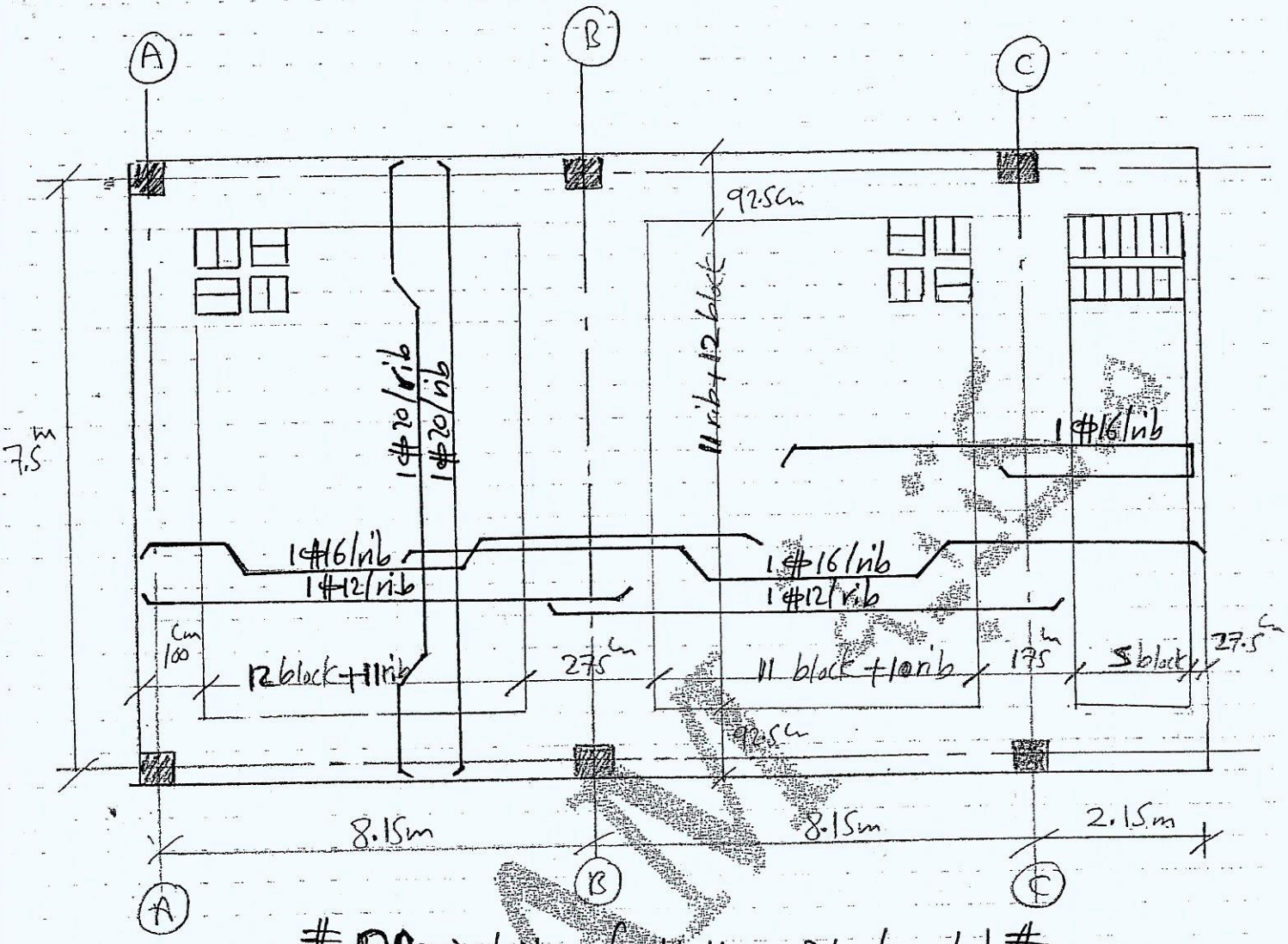
get $K_1 = 0.188$ ⟶ ($\alpha = 0.6$) ⟶ $K_2 = 1744$

$$A_s = \frac{M}{K_2 d} = \frac{44.44 * 10^5}{1744 * 24} = 106.173 \text{ cm}^2$$

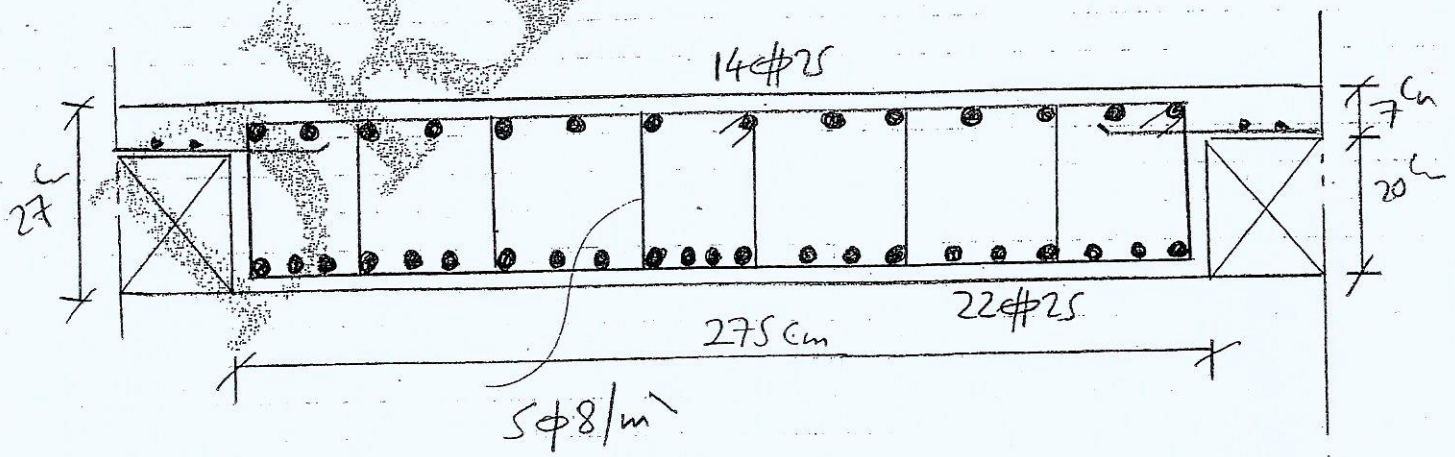
Use 22 ⌀25

$$A_s' = \alpha \cdot A_s = 0.6 * 106.173 = 63.7 \text{ cm}^2$$

Use 14 ⌀25



Rft Details of Hollow Block slab



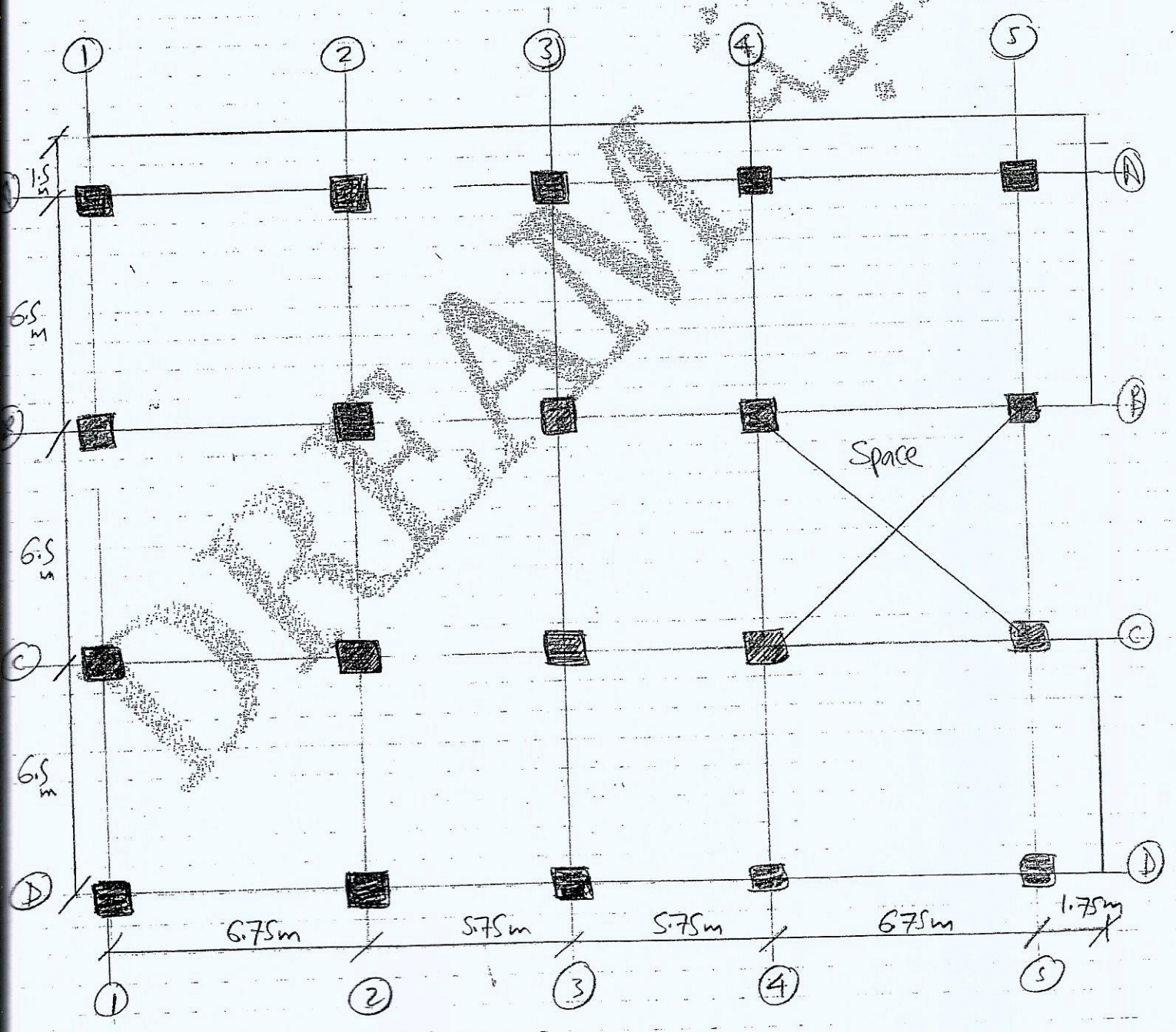
Cross_sec. of Hidden Beam on Axis (B)-(B)

Sheet (2)

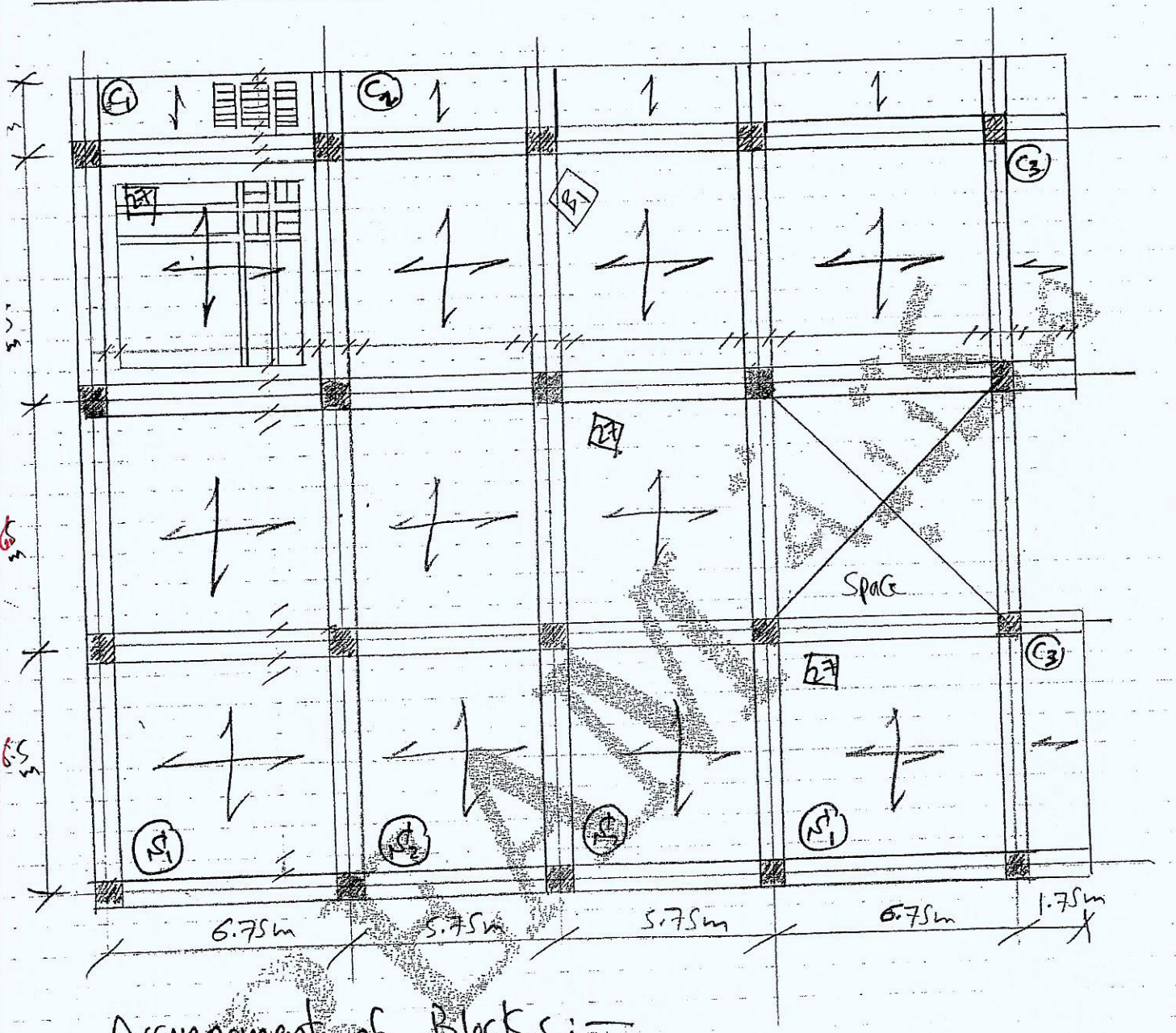
Design the slabs of the roof using a Hollow Block slab system.

a) Using dropped Beams
b) Using hidden Beams.

- L.L = 550 kg/m²
- f_{cu} = 300 kg/cm²
- Covering material = 150 kg/m²
- fy = 3600 kg/cm²



a) Using dropped Beams :—



Arrangement of Blocks :—

+ For S_1' (6.75 X 6.5 m) Two way slab.

Short Dir. (650 cm)

$$650 = 25 + 25 + 10n + 40(n+1)$$

get $n = 10.7$ rib → $n = 10$ rib

→ get $S_{1\,act}' = 42.5$ cm

Long Dir. (6.75 m)

$$675 = 25 + 25 + 10m + 40(m+1)$$

get $m = 11.2$ → $n = 11$ rib

→ get $S'_{1\,act} = 30$ cm

* For S'_2 (5.75 X 6.5m) Two way slab.

Short Dir. (5.75m)

$$575 = 25 + 2S'_1 + 10n + 40(n+1)$$

get $n \approx 9.2$ → n = 9 rib

→ get $S_{1\,act} = 30$ cm

Long Dir. (6.5m)

n = 10 rib

$S_{1\,act} = 42.5$ cm

* For C_1 (1.5m X 6.75m)

$$150 = 12.5 + \frac{S'_1}{25} + \frac{S'_2}{15} + 20m$$

get $n = 4.875$ → n = 4 blocks

→ get $S'_{1\,act} = 42.5$ cm

* For C_3 (1.75m X 6.5m)

$$175 = 12.5 + \frac{S'_1}{25} + \frac{S'_2}{15} + 20m$$

get $m = 6.125$ → m = 6 blocks

→ get $S'_{1\,act} = 27.5$ cm

Loads:- take $t_s = 7$cm → (L.L = 550 kg/m²)

$W_{slab\ (two\ way)} = W_{D.L} + W_{L.L}$

$= [0.38 + 2.5(0.02) + 0.15] + 0.55 = 1.13$ t/m²

$W_{slab\ (one\ way)} = [0.33 + 2.5(0.02) + 0.15] + 0.55 = 1.08$ t/m²

L.L = 550 kg/m² > 500 kg/m² → Use Grassouf values

(٢)

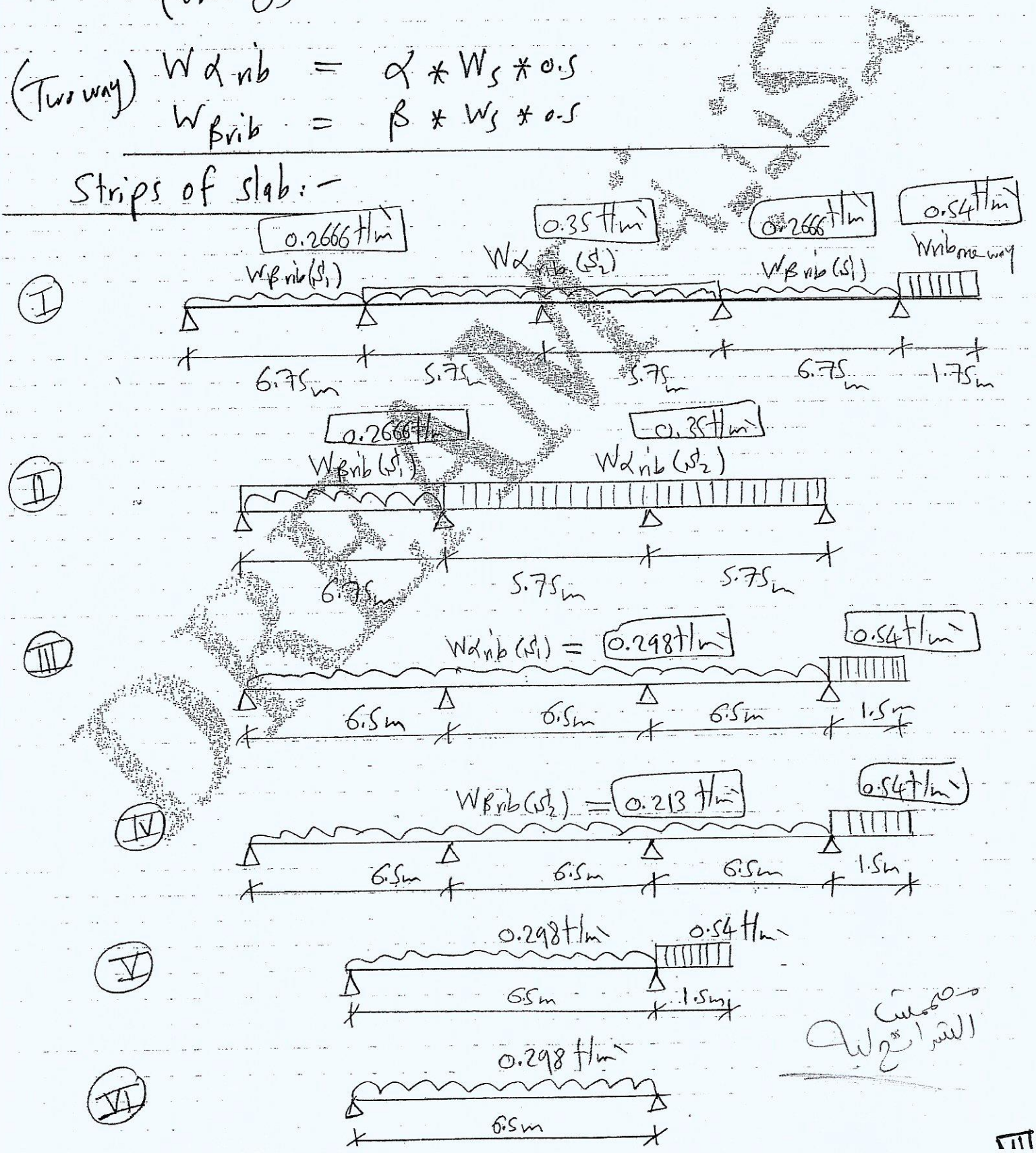
Slab	L_{lng}	L_{short}	L_{long}/L_{short}	α	β	$W_{\alpha rib}$	$W_{\beta rib}$
S_1	6.75	6.5	1.04	0.528	0.472	0.298	0.2666
S_2	6.5	5.75	1.13	0.623	0.377	0.35	0.213

- $W_{nb\ (one\ way)} = W_s * 0.5 = 1.08 * 0.5 = 0.54\ t/m'$

(Two way) $W_{\alpha nb} = \alpha * W_s * 0.5$

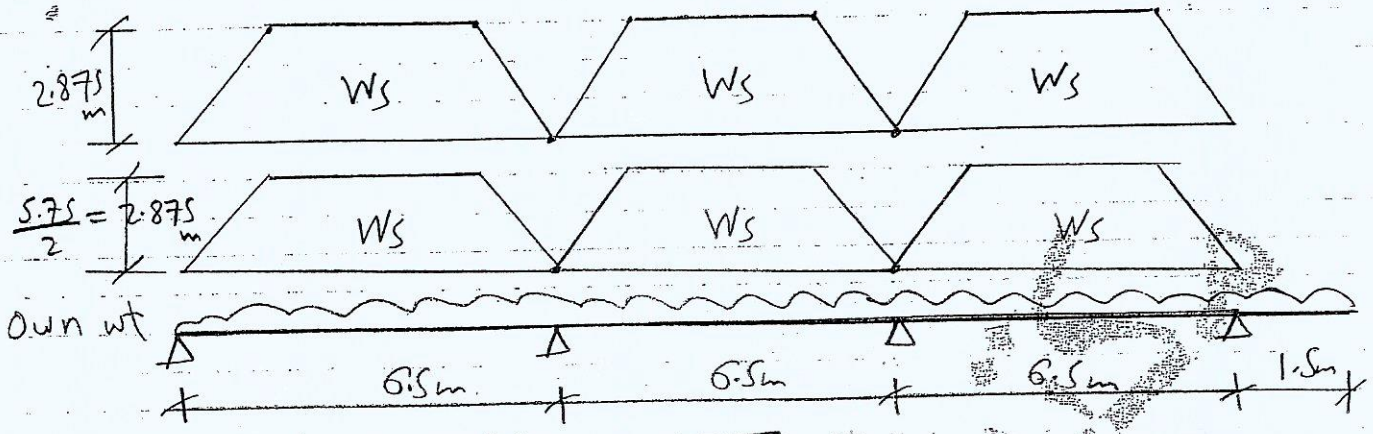
$W_{\beta rib} = \beta * W_s * 0.5$

Strips of slab :-



Design of Beams :-

B_1 (25 X 75 cm) [Dropped Beam]



$$r = \frac{L}{2x} = \frac{6.5}{5.75} = \boxed{1.13}$$

$\alpha = 0.7382$

$\beta = 0.5318$

- $W_{(Moment)}$ = own wt + wt from slab

$$W_{(M)} = 2.5 \times 0.25 \times 0.75 + 2\,[0.7382 \times 2.875 \times 1.13]$$

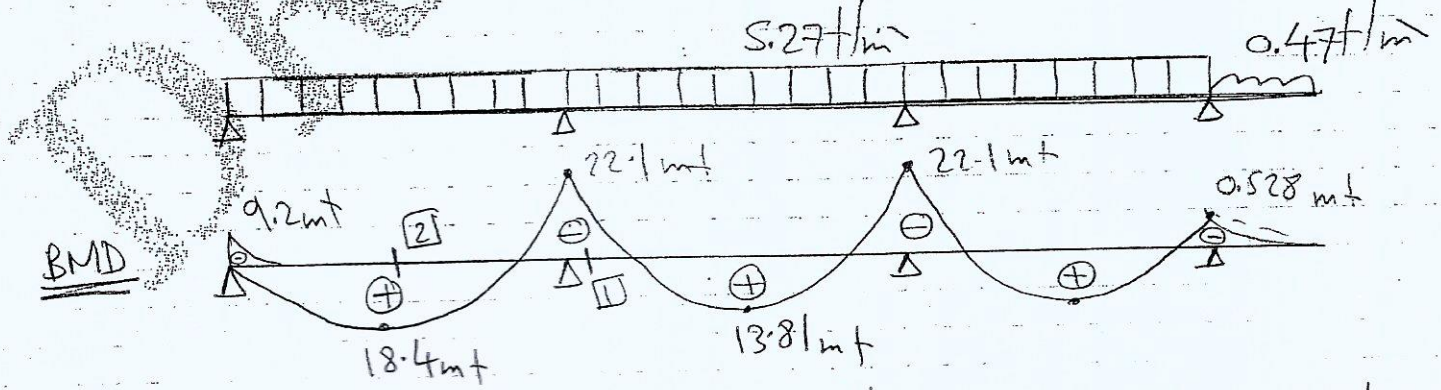
($\gamma_c \cdot b \cdot t$) ; ($\alpha \cdot X \cdot W_s$)

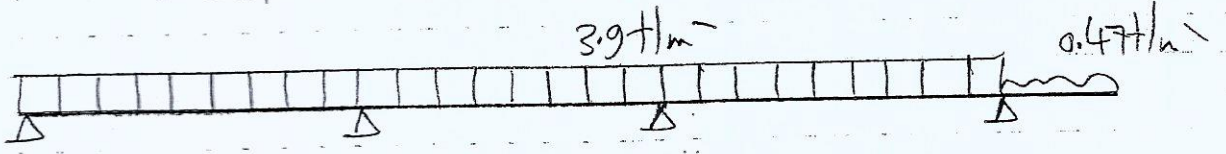
W_{Mom} = 5.27 t/m

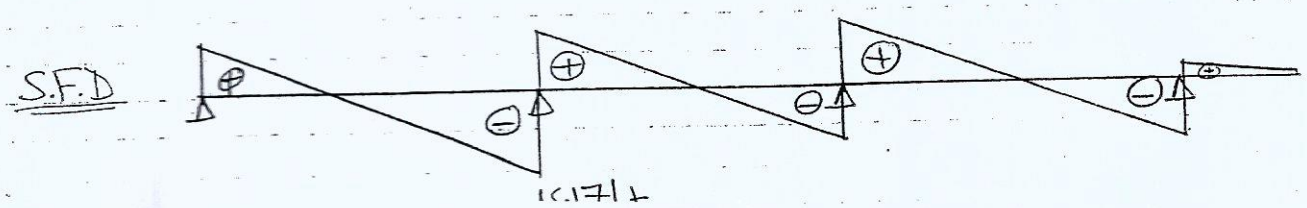
- $W_{(Shear)} = 2.5 \times 0.25 \times 0.75 + 2\,[0.5318 \times 2.875 \times 1.13]$

($\beta \cdot X \cdot W_s$)

W_{shear} = 3.9 t/m

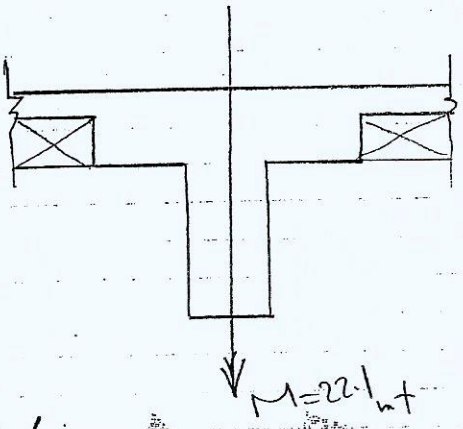






• Design For Moment :-

Sec (1) M-ve = 22.1 mt



$$d = K_1\sqrt{\frac{M}{b}} \qquad d = 75 - 5 = 70\,cm$$

$$70 = K_1\sqrt{\frac{22.1\times10^5}{25}}$$

$$K_1 = 0.235 \xrightarrow{\alpha=0.2} K_2 = 1735$$

$$f_c = 90\ kg/cm^2 < f_{call} = 105\ kg/cm^2 \ (ok)$$

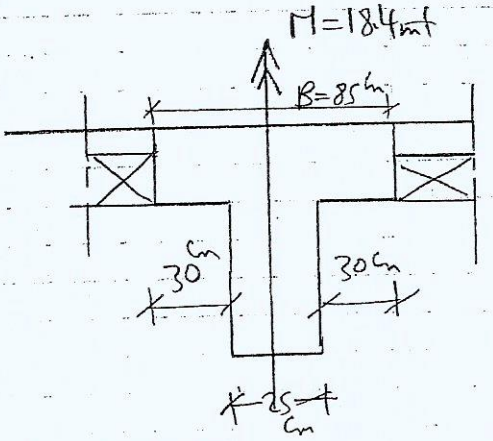
$$A_s = \frac{M}{K_2 d} = \frac{22.1\times10^5}{1735\times70} = \boxed{18.2\ cm^2}$$

Φ Use 6 Φ 20 mm

$$A_s' = 0.2\,A_s = \boxed{3.6\ cm^2}$$

Φ Use 2 Φ 16 mm

Sec (2) M+ve = 18.4 mt



$$d = K_1\sqrt{\frac{M}{B}}$$

$$70 = K_1\sqrt{\frac{18.4\times10^5}{85}}$$

$$K_1 = 0.475 \xrightarrow{\alpha=0} K_2 = 1832$$

$$A_s = \frac{M}{K_2 d} = \frac{18.4\times10^5}{1832\times70} = \boxed{14.34\ cm^2}$$

Φ Use 5 Φ 20 mm

• Design For Shear :- $\boxed{Q = 15.171\ t}$

$$q = \frac{Q}{bd} = \frac{15.171\times10^3}{25\times70} = 8.669\ kg/cm^2$$

$$q_2 = 24\ kg/cm^2 \longrightarrow f_{cu} = 300\ kg/cm^2$$

$$q_{st} = q - \frac{q_c}{2} = 8.669 - \frac{24}{2} = \boxed{7.62\ kg/cm^2}$$

$$q_{st} = \frac{A_{st} \cdot f_s}{S \cdot b}$$

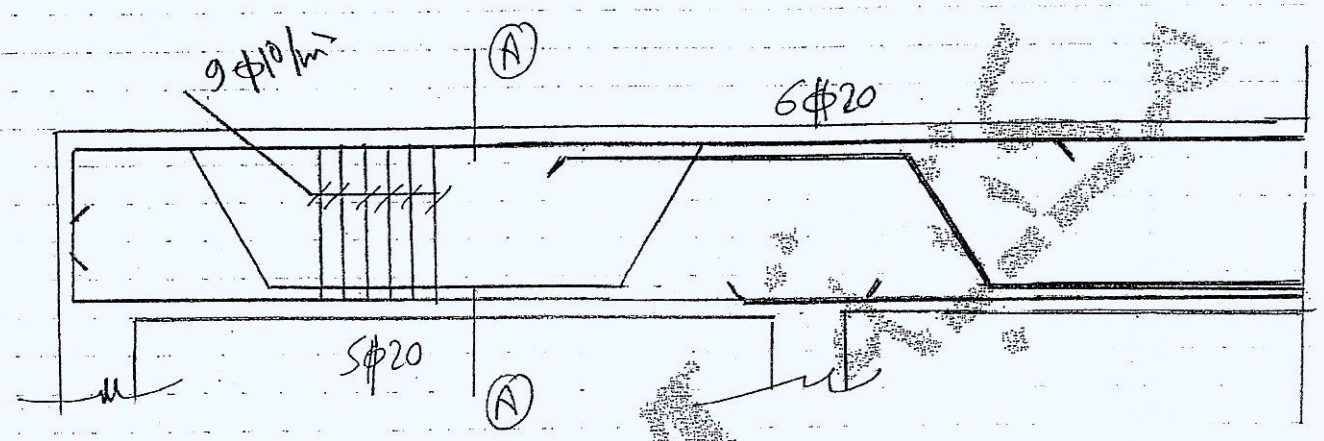
$f_{s\ stirrups} = 1400\ kg/cm^2$

assume using str ϕ10 2 branches

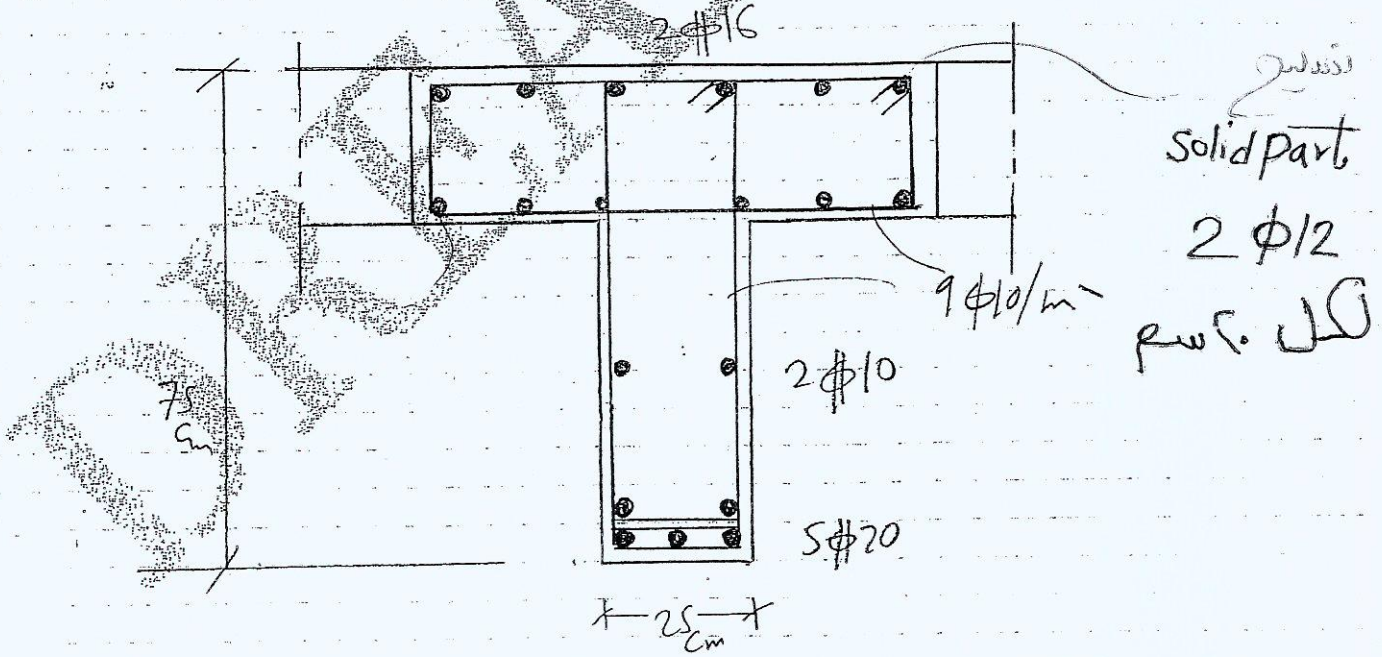
$$7.62 = \frac{1.57 \times 1400}{S \times 25}$$

get $S = 11.53$ Cm ok

Use 9 ϕ10/m'

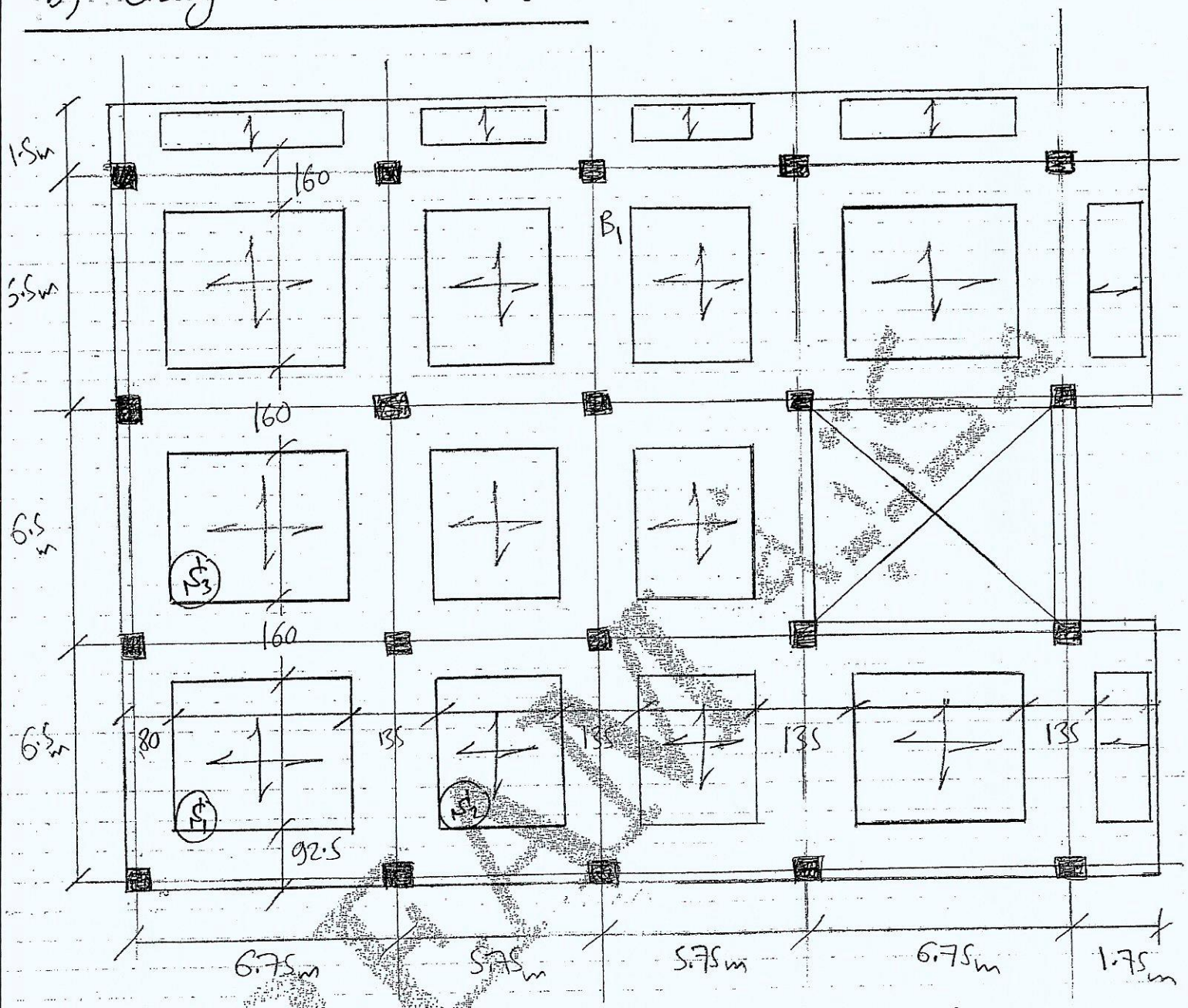


(Rft Details of B1)



(Cross section A-A)

b) Using Hidden Beams :-



Arrangement of Blocks & Hidden Beams :- ترتيب البلاكات والكمرات المخفية *

S_3 ↑ $650 = \cancel{B}^{120} + 10n + 40(n+1)$ ..

get $n = 9.8 \rightarrow$ **$n = 9$ rib**

→ get **$B_{act} = 160$ cm**

↑ $675 = (80 - 12.5) + \frac{B}{2}^{120} + 10n + 40(n+1)$

get $n = 10.15 \rightarrow$ **$n = 10$ rib**

→ get **$B_{act} = 135$ cm**

S_1 ↑ $650 = 80 + (B - 12.5) + 10n + 40(n+1)$

get $n = 9.25$ → $n = 9$ rib

→ get $B_{act} = 92.5$ cm

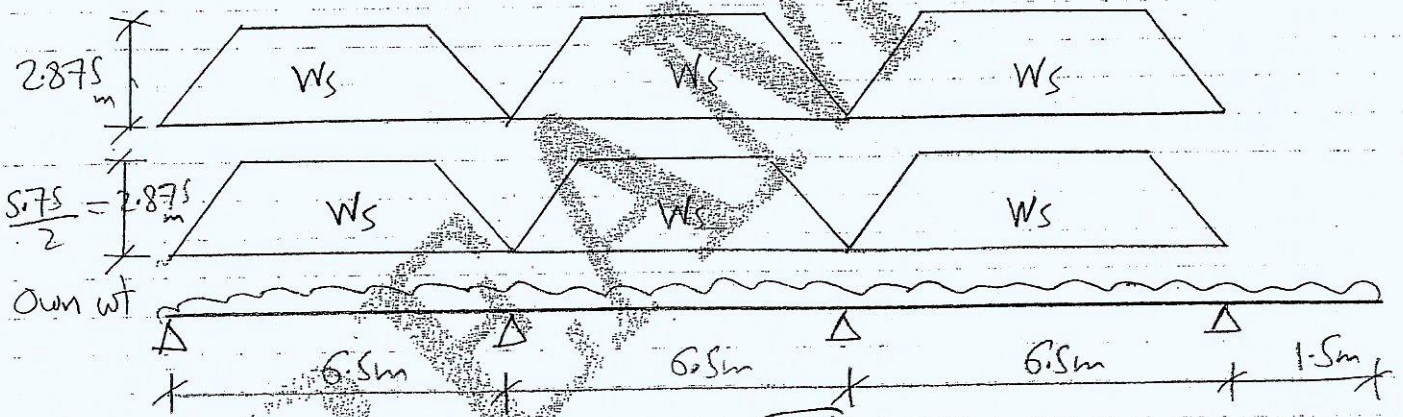
S_2 ↑ $575 = B + 10n + 40(n+1)$

get $n = 8$ rib

get $B_{act} = 135$ cm

Design of Beams:-

B_1 (27 X 135 cm) [Hidden Beam]



$r = \frac{L}{2x} = \frac{6.5}{5.75} = 1.13$

$\alpha = 0.7382$

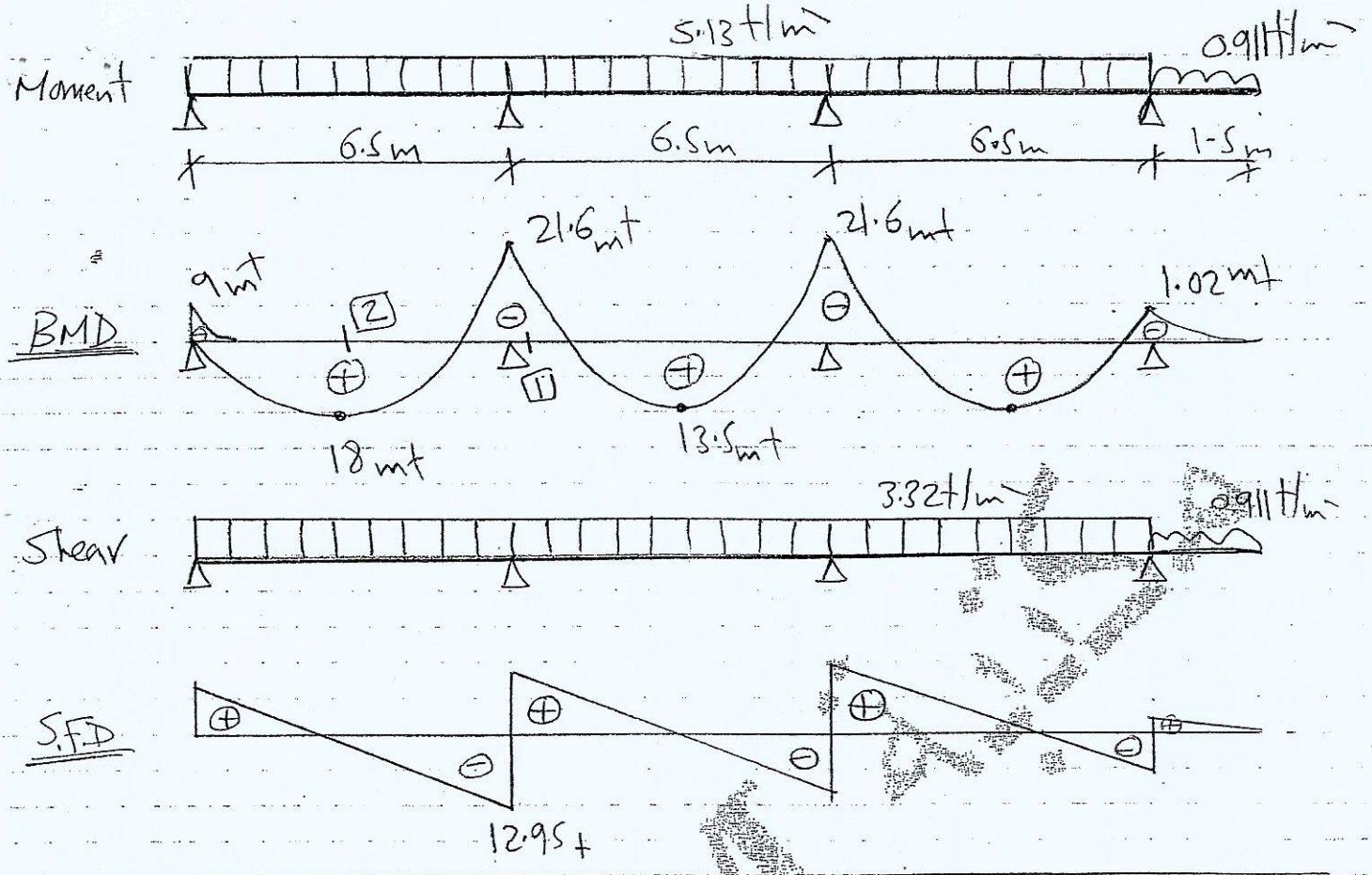
$\beta = 0.5318$

- W_{moment} = Own wt + wt from slab − wt on Beam width

$W_{(m)} = 2.5 \times 1.35 \times 0.27 + 2[0.7382 \times 2.875 \times 1.13] - 1.35 \times [0.38 + 2.5 \times 0.02] = 0.911 + 4.796 - 0.58 =$ **5.13 t/m**

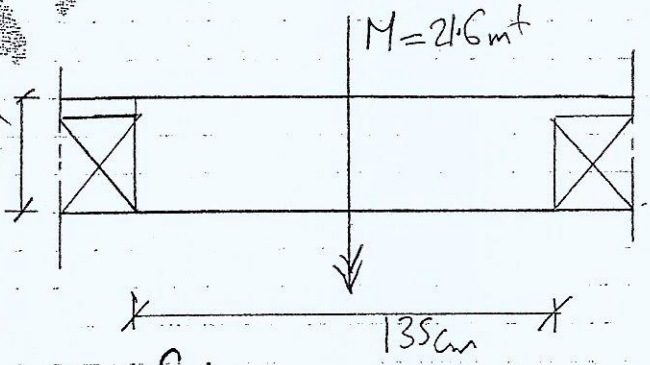
- W_{Shear} = own wt + wt from slab − wt on Beam width

$W_{(shear)} = 2.5 \times 1.35 \times 0.27 + 2[0.5318 \times 2.875 \times 1.13] - 1.35 \times [0.38 + 2.5 \times 0.02] =$ **3.32 t/m**



- Design for Moment :-

Sec [1] $M_{-ve} = 21.6$ mt



$$d = k_1\sqrt{\frac{M}{B}}$$

$$24 = k_1\sqrt{\frac{21.6\times10^5}{135}}$$

$k_1 = 0.189$ $\quad f_c > f_{call}$ (Unsafe)

Increase depth [Hidden Beam with enlarged depth]

Assume $t = 30$ Cm

$$27 = k_1\sqrt{\frac{21.6\times10^5}{135}}$$

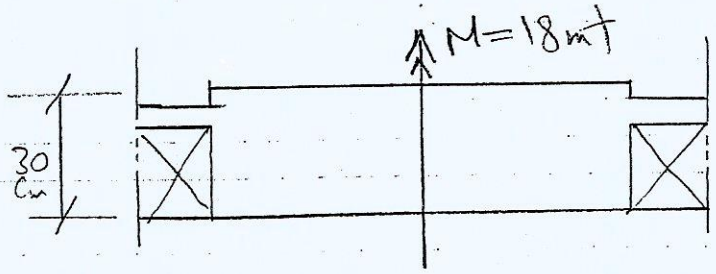
$k_1 = 0.213 \xrightarrow{\alpha=0.4} k_2 = 1739$ $\quad f_c = 95 < f_{call} = 105$

$$A_s = \frac{M}{k_2 d} = \frac{21.6\times10^5}{1739\times27} = 46\ Cm^2$$

Use 15 ϕ 20 mm

$A_s' = \alpha A_s = 0.4\times46 = 18.4\ Cm^2$ $\quad$ Use 10 ϕ 16 mm

Sec (2) $M = 18\ m.t$



$$d = k_1 \sqrt{\frac{M}{B}}$$

$$27 = k_1 \sqrt{\frac{18 \times 10^5}{135}}$$

$k_1 = 0.233 \xrightarrow{\alpha = 0.4} k_2 = 1748$ at $f_c = 90 < f_{call}$ (OK)

$$A_s = \frac{M}{k_2 d} = \frac{18 \times 10^5}{1748 \times 27} = \boxed{38.14\ Cm^2}$$

Use $13\ \phi\ 20\ mm$

$$A_s' = \alpha A_s = 0.4 \times 38.14 = \boxed{15.256\ Cm^2}$$

Use $8\ \phi\ 16\ mm$