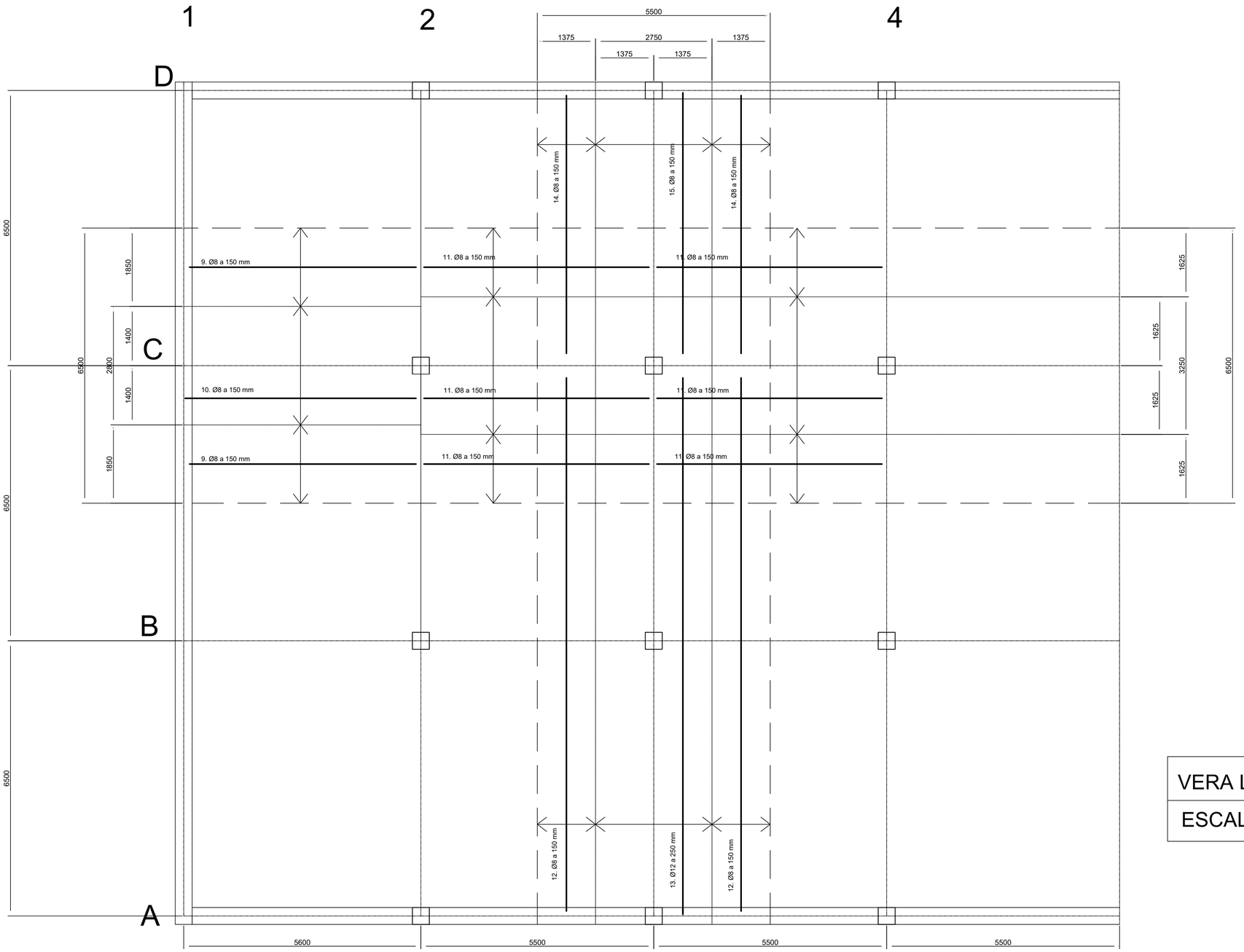
			DESIG						CHECK							
PANEL	**CROSS-SECTION**	**STRIP**	**Med**	**d**	**z**	**as,req**	**as,min**	**Desing**	**as,prov**	**x**	**ξ**	**z**	**Mrd**	**Mrd>Med**	**ξ<0,45**	**spacing**
			kNm/m	**mm**	**mm**	**mm^2**	**mm^2**		**mm^2**	**mm**		**mm**	**kNm/m**			
Cout	1 (left support)	no division	41,84	273	247	390	280	Φ12 a 250 mm	452	14,74	0,054	267	52,49	OK	OK	OK
	2 (midspan)	Column	27,03	273	247	252	280	Φ8 a 150 mm	335	10,92	0,040	269	39,13	OK	OK	OK
		Middle	13,64	273	247	127	280	Φ8 a 150 mm	335	10,92	0,040	269	39,13	OK	OK	OK
	3 (right support)	Column	62,76	273	247	584	280	Φ12 a 200 mm	566	18,45	0,068	266	65,36	OK	OK	OK
		Middle	15,83	273	247	147	280	Φ8 a 150 mm	335	10,92	0,040	269	39,13	OK	OK	OK
Cin	1 (left support)	Column	52,52	273	247	489	280	Φ12 a 200 mm	566	18,45	0,068	266	65,36	OK	OK	OK
		Middle	17,51	273	247	163	280	Φ8 a 150 mm	335	10,92	0,040	269	39,13	OK	OK	OK
	2 (midspan)	Column	22,63	273	247	211	280	Φ8 a 150 mm	335	10,92	0,040	269	39,13	OK	OK	OK
		Middle	15,09	273	247	140	280	Φ8 a 150 mm	335	10,92	0,040	269	39,13	OK	OK	OK
	3 (right support)	Column	52,52	273	247	489	280	Φ12 a 200 mm	566	18,45	0,068	266	65,36	OK	OK	OK
		Middle	17,51	273	247	163	280	Φ8 a 150 mm	335	10,92	0,040	269	39,13	OK	OK	OK
3out	1 (left support)	Column	44,58	266	236	435	272	Φ12 a 250 mm	452	14,74	0,055	260	51,12	OK	OK	OK
		Middle	1,38	266	236	13	272	Φ8 a 150 mm	335	10,92	0,041	262	38,11	OK	OK	OK
	2 (midspan)	Column	45,95	266	236	448	272	Φ12 a 250 mm	452	14,74	0,055	260	51,12	OK	OK	OK
		Middle	30,63	266	236	299	272	Φ8 a 150 mm	335	10,92	0,041	262	38,11	OK	OK	OK
	3 (right support)	Column	80,42	266	236	784	272	Φ12 a 100 mm	1131	36,87	0,139	251	123,55	OK	OK	OK
		Middle	32,76	266	236	319	272	Φ12 a 250 mm	452	14,74	0,055	260	51,12	OK	OK	OK

3in	1 (left support)	Column	74,67	266	236	728	272	Φ12 a 100 mm	1131	36,87	0,139	251	123,55	OK	OK	OK
		Middle	24,89	266	236	243	272	Φ8 a 150 mm	335	10,92	0,041	262	38,11	OK	OK	OK
	2 (midspan)	Column	32,16	266	236	313	272	Φ8 a 150 mm	335	10,92	0,041	262	38,11	OK	OK	OK
		Middle	21,44	266	236	209	272	Φ8 a 150 mm	335	10,92	0,041	262	38,11	OK	OK	OK
	3 (right support)	Column	74,67	266	236	728	272	Φ12 a 100 mm	1131	36,87	0,139	251	123,55	OK	OK	OK
		Middle	24,89	266	236	243	272	Φ8 a 150 mm	335	10,92	0,041	262	38,11	OK	OK	OK



9. Ø8 a 150 mm. L=5346mm

10. Ø8 a 150 mm, L=5454mm

11. Ø8 a 150 mm. L=5311

12. Ø8 a 150 mm. L=12594mm

13. Ø12 a 250 mm. L=12673mm

14. Ø8 a 150 mm. L=6090mm

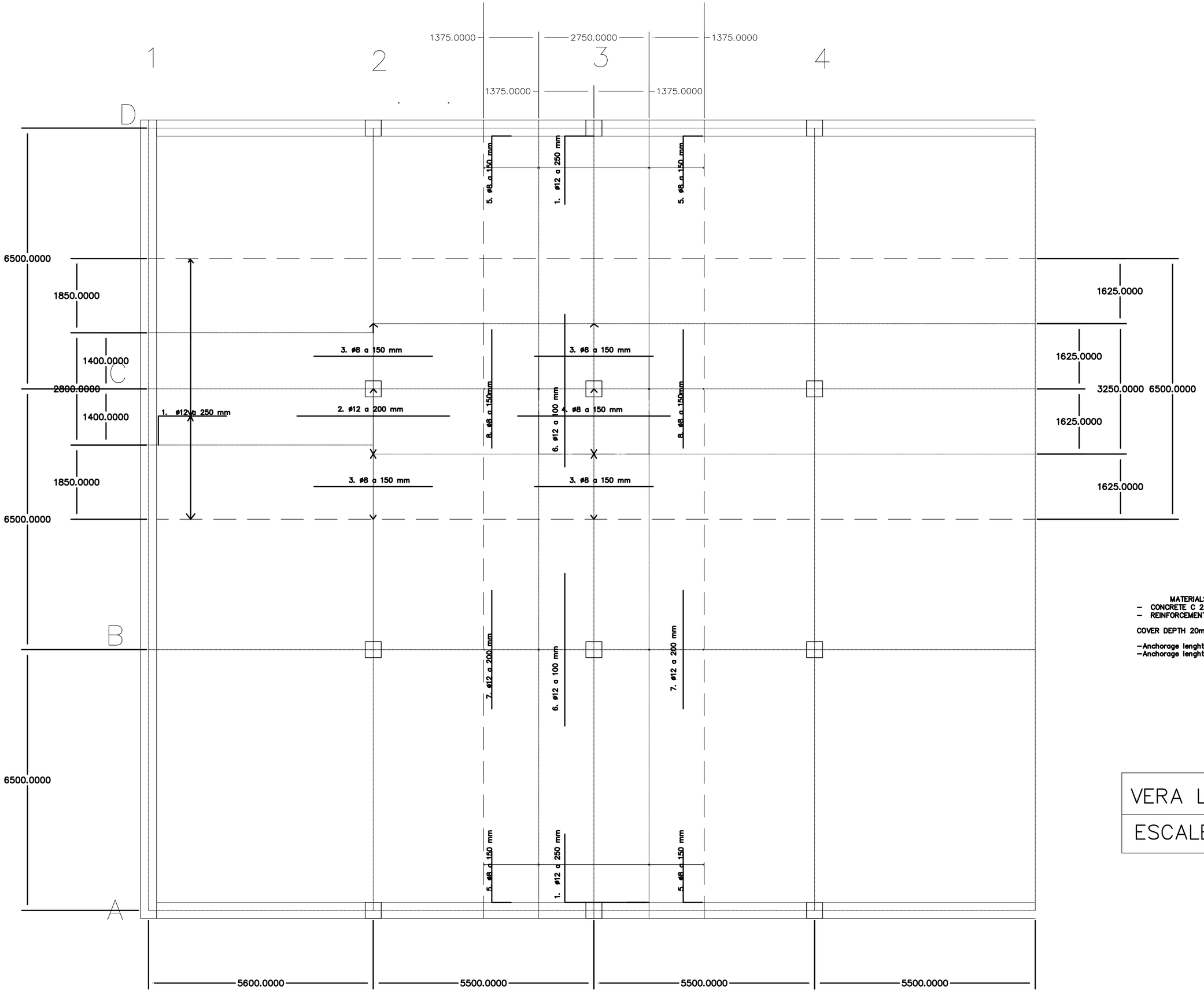
15. Ø8 a 150 mm. L=6153mm

MATERIALS
- CONCRETE C 25 / 30
- REINFORCEMENT B500

COVER DEPTH 20mm

-Anchorage lenght min 725 mm for Ø12
-Anchorage lenght min 483 mm for Ø8

VERA LÓPEZ GARCÍA	
ESCALE	1:1000



1. ø12 a 250 mm. L=2425mm

2. ø12 a 200 mm. L=3800mm

3. ø8 a 150 mm L=2950mm

4. ø8 a 150 mm. L=3800mm

5. ø8 a 150 mm. L=1758mm

6. ø12 a 100 mm L=3800 mm

7. ø12 a 200 mm. L=2950mm

8. ø8 a 150mm L=2950mm

MATERIALS
- CONCRETE C 25 / 30
- REINFORCEMENT B500

COVER DEPTH 20mm

-Anchorage lenght min 725 mm for ø12
-Anchorage lenght min 483 mm for ø8

VERA LÓPEZ GARCÍA	
ESCALE	1:1000

VERA LÓPEZ GARCÍA
79111720T

TASK 3. TWO-WAY SLAB SUPPORTED BY COLUMNS (FLAT SLAB). II PART.

PUNCHING IN COLUMN C3

1. Detailed checked of punching

RESISTANCE WITHOUT REINFORCEMENT

$$\rightarrow V_{Ed,1} = \frac{\beta \cdot V_{Ed}}{u_1 \cdot d} \leq V_{Rd,c} = \max\left[C_{Rd,c} \cdot K \cdot \sqrt[3]{(100 \rho_l) \cdot f_{ck}} \; ; \; 0'035 \sqrt{K^3 f_{ck}}\right]$$

- $d = \frac{d_c + d_3}{2} = \frac{273 + 266}{2} \simeq 270$ mm
- $u_1 = 4a + 2\pi \cdot d = 4 \cdot 350 + 2\pi \cdot 270 = 3096$ mm

$$V_{Ed,1} = \frac{1'15 \cdot 575}{3096 \cdot 270} \cdot e^3 = 0'79 \text{ MPa}$$

- $K = 1 + \sqrt{\frac{200}{d}} \leq 2$ $\quad K = 1 + \sqrt{\frac{200}{270}} = 1'86 < 2$
- $\rho_l = \sqrt{\rho_{lc} \cdot \rho_{l3}} \leq 0'02$

$$\rho_{lc} = \frac{a_{sc}}{1000 d_c} \; ; \; \rho_{l3} = \frac{a_{s3}}{1000 d_3}$$

$$\rho_{lc} = \frac{566}{1000 \, 273} = 0'00207 \; ; \; \rho_{l3} = \frac{1131}{1000 \, 236} = 0'00479$$

- $\rho_l = \sqrt{0'00207 \cdot 0'00479} = 0'00314 \leq 0'02$

$$\rho_l = 0'00314$$

$$V_{Rd,c} = \max\left[0'12 \cdot 1'86 \sqrt[3]{100 \cdot 0'00314 \cdot 25} \; ; \; 0'035 \sqrt{1'86^3 \cdot 25}\right]$$

$$= \max[0'44 \; ; \; 0'44] \text{ MPa}$$

$$V_{Rd,c} = 0'44 \text{ MPa}$$

$$V_{Ed,1} = 0'79 \text{ MPa} \not\leq V_{Rd,c} = 0'44 \text{ MPa}$$

Is needed it the desing of punching reinforcement.

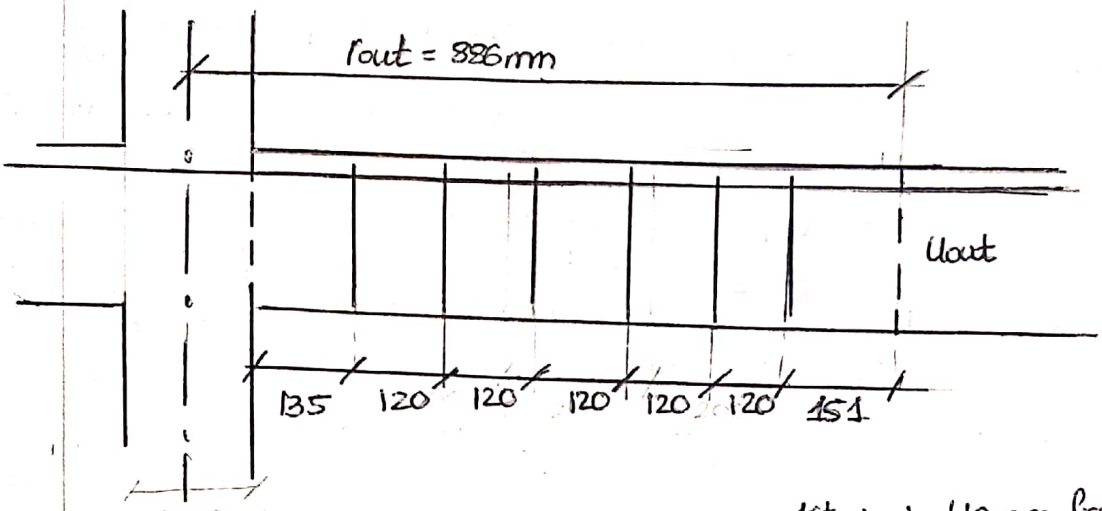
- $a = 350$ mm (From the first part of TASK 3)
- $V_{Ed} = 575$ KN
- $\beta = 1'15$ (coefft refff to position of column)
- $C_{Rd,c} = 0'12$ (Reduction factor)
- a_{sc} → Cin, right support in column. $a_{sc} = 566$ mm²
- a_{s3} → 3in, right support, in column $a_{s3} = 1131$ mm²

2. Desing of punching reinforcement

$$u_{out} = \frac{\beta \cdot V_{Ed}}{V_{Rd,c} \cdot d} \quad ; \quad r_{out} = \frac{u_{out}}{2\pi}$$

$$u_{out} = \frac{1'15 \cdot 575e^3}{0'44 \cdot 270} \simeq 5566 \text{ mm}$$

$$r_{out} = \frac{5566}{2\pi} \simeq 886 \text{ mm}$$



- 1st stud 40mm from column face
- Intermediate studs spacing 120 mm

. Calculation of number of rails

- In the distance of 1'5d from u_{out}, rails must be max 2d from each other and in u_1 rails must be max 1'5d:

$$n \geq \max\left(\frac{2\pi (r_{out} - 1'5d)}{2d} ; \frac{u_1}{1'5d} \right)$$

$$n \geq \max\left(\frac{2\pi (886 - 1'5 \cdot 270)}{2 \cdot 270} ; \frac{3096}{1'5 \cdot 270} \right)$$

$$n \geq \max(6 ; 8) \text{ rails} \rightarrow n = 8 \text{ rails}$$

The desing: 8 rails of 10mm diameter:

$$S_{t,max} = \frac{2\pi (r_{out} - 1'5d)}{n} \quad ; \quad S_{t,u_1} = \frac{u_1}{n}$$

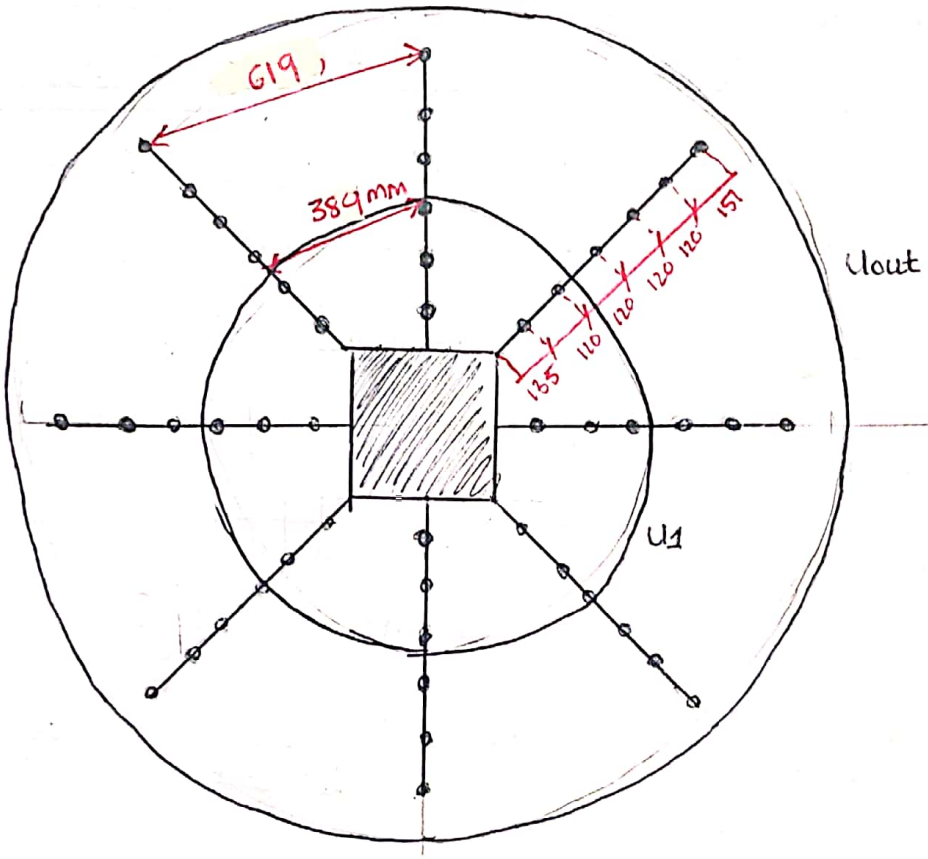
$$S_{t,max} = \frac{2\pi (886 - 1'5 \cdot 270)}{8} \simeq 377 \text{ mm}$$

$$S_{t,u_1} = \frac{3096}{8} = 387 \text{ mm}$$

In my case, up to the drawing:

$S_{t,max} = 619\ mm$

$S_{t,u1} = 389\ mm$



The cross-sectional area of studs in one perimeter:

$$A_{sw} = n \cdot A_{sw,1}$$

$$A_{sw,1} = \pi \cdot r^2 = \pi \cdot 5^2 = 79\ mm^2$$

$$A_{sw} = 8 \cdot 79 = 632\ mm^2$$

Check of punching reinforcement

$$V_{Ed,1} \leq V_{Rd,cs} = 0'75 \cdot V_{Rd,c} + 1'5 \cdot \frac{d}{s_r} A_{sw} f_{ywd,ef} \frac{1}{u_1 \cdot d} \operatorname{sen}\alpha$$

$$V_{Rd,cs} \leq K_{max} \cdot V_{Rd,c}$$

$$f_{ywd,ef} = 250 + 0'25 \cdot d \leq f_{ywd} = 435 \text{ MPa}$$

$\operatorname{sen}\alpha = 1$ because the angle between stud and slab is 90°

$K_{max} = 1'8$ for double-headed studs connected to a space bar.

$$f_{ywd,ef} = 250 + 0'25 \cdot 270 \simeq 318 \leq 435 \text{ MPa}$$

$$V_{Rd,c} = 0'75 \cdot 0'44 + 1'5 \cdot \frac{270}{120} \cdot 632 \cdot 318 \cdot \frac{1}{3096 \cdot 270}$$

$$V_{Rd,cs} = 1'14 \text{ MPa} \not\leq 1'8 \cdot 0'44 = 0'792 \text{ MPa}$$

Therefore, $V_{Rd,cs} = 0'792$ MPa

$$V_{Ed,1} = 0'79 \text{ MPa} \leq V_{Rd,cs} = 0'792 \text{ MPa} \checkmark$$

is checked!

Punching reinforcement ratio

$$\rho_{sw} = 1'5 \cdot \frac{A_{sw,1}}{s_r \cdot s_t} \geq \rho_{sw,min} = 0'08 \frac{\sqrt{f_{ck}}}{f_{yk}}$$

$$\rho_{sw,min} = 0'08 \cdot \frac{\sqrt{25}}{500} = 0'0008$$

$$\rho_{sw} = 1'5 \cdot \frac{79}{120 \cdot 151} = 0'0065$$

$$\rho_{sw} = 0'0065 \geq \rho_{sw,min} = 0'0008 \checkmark \text{ checked.}$$