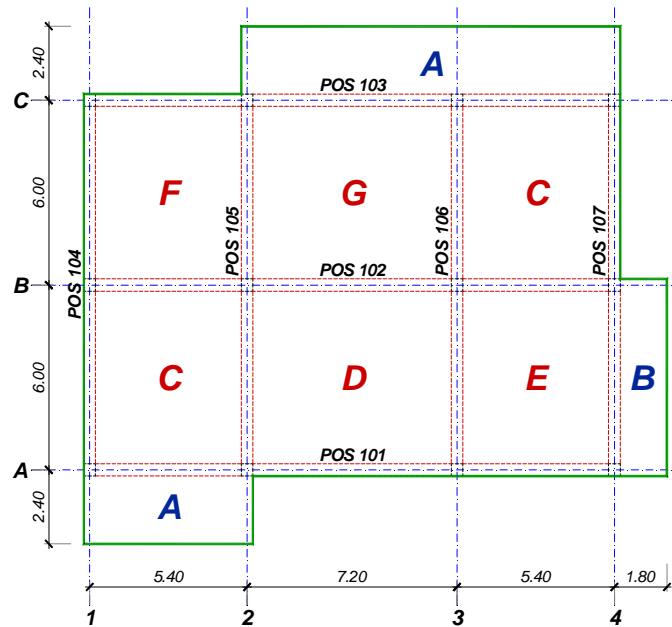


Krstasto armirane ploče

1



Procena debljine ploče

2

$$d_{p,min.} = \frac{L_0}{35} \approx \frac{0.8 \times 600}{35} = \frac{2 \times 240}{35} = 13.7 \text{ cm} \Rightarrow \text{usvojeno } d_p = 16 \text{ cm}$$

Analiza opterećenja

sopstvena težina ploče	0.16×25	= 4.0 kN/m ²
dodatno stalno opterećenje		= 2.0 kN/m ²
ukupno, stalno opterećenje	g	= 6.0 kN/m ²
povremeno opterećenje	p	= 10.0 kN/m ²
granično opterećenje	$1.6 \times 6.0 + 1.8 \times 10.0$	= 27.6 kN/m ²

Ploča "A" - konzolna ploča, raspona $L=2.4 \text{ m}$.

$$M_u = 27.6 \times 2.4^2 / 2 = 79.5 \text{ kNm/m}$$

Ploča "B" - konzolna ploča, raspona $L=1.8 \text{ m}$.

$$M_u = 27.6 \times 1.8^2 / 2 = 44.7 \text{ kNm/m}$$

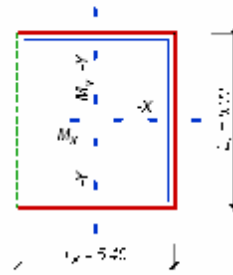
Ploča "C"

$$L_y / L_x = 6.0 / 5.4 = 1.11 \approx 1.1$$

$$G = g \times L_x \times L_y = 6.0 \times 5.4 \times 6.0 = 194.4 \text{ kN}$$

$$P = p \times L_x \times L_y = 10.0 \times 5.4 \times 6.0 = 324.0 \text{ kN}$$

	<i>k</i>		G	P	U
			kNm/m	kNm/m	kNm/m
kraći pravac, polje	0.024	M_x	4.7	7.8	21.5
duži pravac, polje	0.025	M_y	4.9	8.1	22.4
kraći pravac, oslonac	0.059	-X	11.5	19.1	52.8
duži pravac, oslonac	0.059	-Y	11.5	19.1	52.8



3

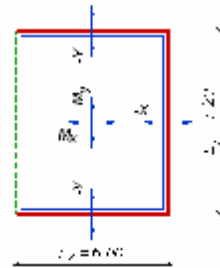
Ploča "D"

$$L_y / L_x = 7.2 / 6.0 = 1.20$$

$$G = g \times L_x \times L_y = 6.0 \times 6.0 \times 7.2 = 259.2 \text{ kN}$$

$$P = p \times L_x \times L_y = 10.0 \times 6.0 \times 7.2 = 432.0 \text{ kN}$$

	<i>k</i>		G	P	U
			kNm/m	kNm/m	kNm/m
kraći pravac, polje	0.026	M_x	6.7	11.2	31.0
duži pravac, polje	0.023	M_y	6.0	9.9	27.4
kraći pravac, oslonac	0.062	-X	16.1	26.8	73.9
duži pravac, oslonac	0.058	-Y	15.0	25.1	69.2



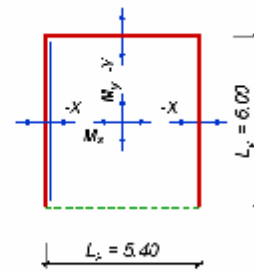
Ploča "E"

$$L_y / L_x = 6.0 / 5.4 = 1.11 \approx 1.1$$

$$G = g \times L_x \times L_y = 6.0 \times 5.4 \times 6.0 = 194.4 \text{ kN}$$

$$P = p \times L_x \times L_y = 10.0 \times 5.4 \times 6.0 = 324.0 \text{ kN}$$

	<i>k</i>		G	P	U
			kNm/m	kNm/m	kNm/m
kraći pravac, polje	0.026	M_x	5.1	8.4	23.3
duži pravac, polje	0.018	M_y	3.5	5.8	16.1
kraći pravac, oslonac	0.060	-X	11.7	19.4	53.7
duži pravac, oslonac	0.052	-Y	10.1	16.8	46.5



4

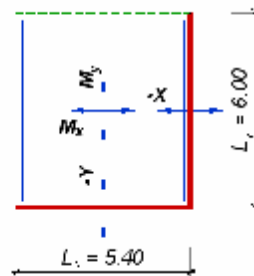
Ploča "F"

$$L_y / L_x = 6.0 / 5.4 = 1.11 \approx 1.1$$

$$G = g \times L_x \times L_y = 6.0 \times 5.4 \times 6.0 = 194.4 \text{ kN}$$

$$P = p \times L_x \times L_y = 10.0 \times 5.4 \times 6.0 = 324.0 \text{ kN}$$

	<i>k</i>		G	P	U
			kNm/m	kNm/m	kNm/m
kraći pravac, polje	0.030	M_x	5.8	9.7	26.8
duži pravac, polje	0.025	M_y	4.9	8.1	22.4
kraći pravac, oslonac	0.070	-X	13.6	22.7	62.6
duži pravac, oslonac	0.065	-Y	12.6	21.1	58.1



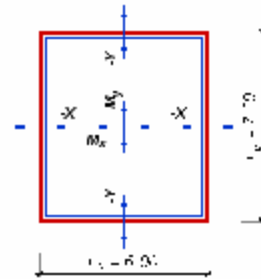
Ploča "G"

$$L_x/L_y = 7.2/6.0 = 1.20$$

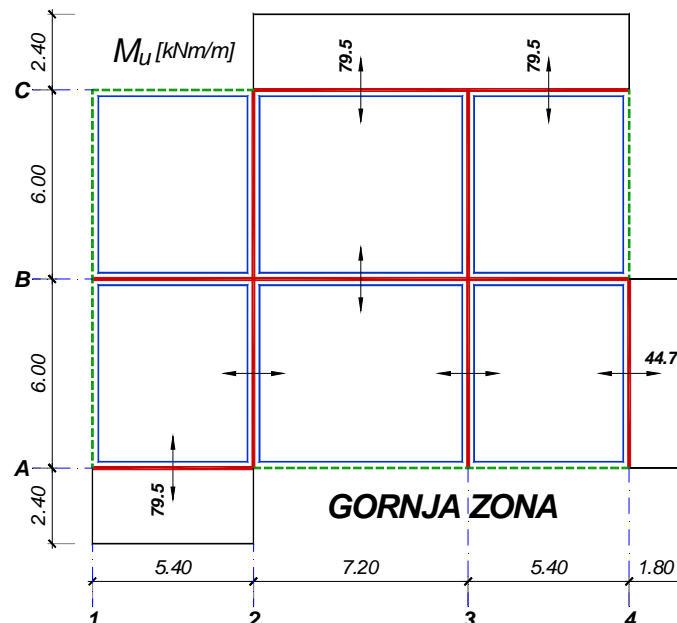
$$G = g \times L_x \times L_y = 6.0 \times 6.0 \times 7.2 = 259.2 \text{ kN}$$

$$P = p \times L_x \times L_y = 10.0 \times 6.0 \times 7.2 = 432.0 \text{ kN}$$

	<i>k</i>		G	P	U
			kNm/m	kNm/m	kNm/m
kraći pravac, polje	0.023	M_x	6.0	9.9	27.4
duži pravac, polje	0.017	M_y	4.4	7.3	20.3
kraći pravac, oslonac	0.053	-X	13.7	22.9	63.2
duži pravac, oslonac	0.047	-Y	12.2	20.3	56.0



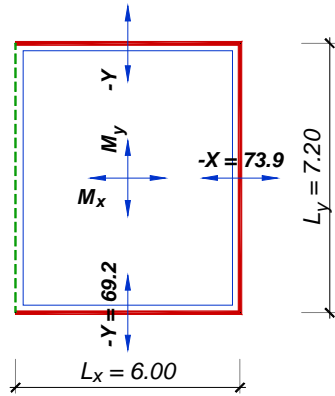
Granični momenti savijanja u ploči, posebno za donju, odnosno gornju zonu su prikazani na donjoj šemi. Vrednosti osloničkih momenata susednih ploča su osrednjeni na delovima gde se susičaju dve krstaste ploče različitih konturnih uslova i/ili dimenzija. Na delovima gde se krstasta ploča susiča sa konzolnim prepustom (ploče »A« i »B«), zadržane su vrednosti momenata savijanja sa konzola.

Momenti savijanja – gornja zona

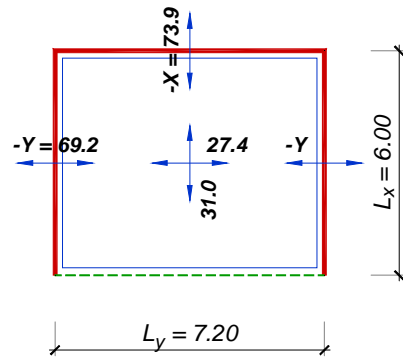
Ploča tipa "D"

7

LOKALNI SISTEM (TABLICA)

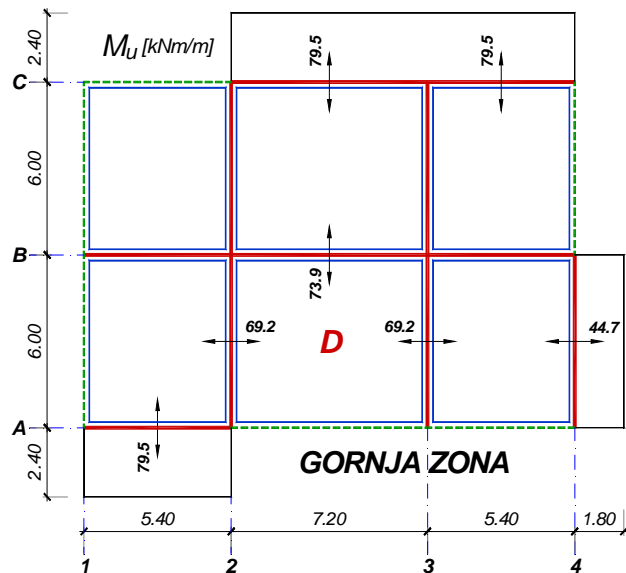
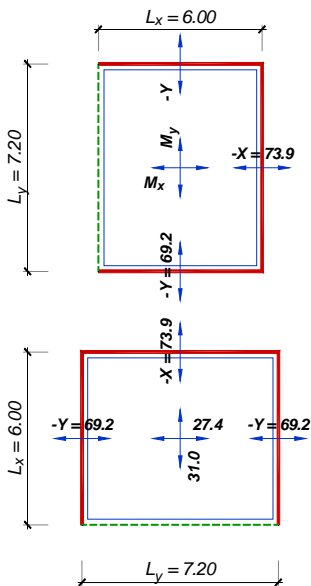


REALAN POLOŽAJ U KONSTRUKCIJI



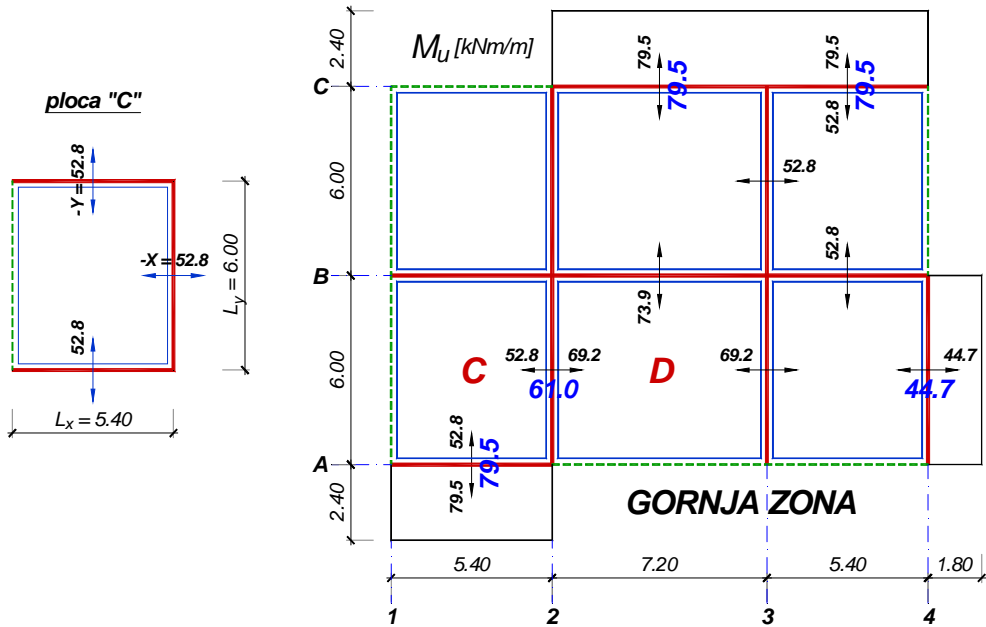
Momenti savijanja – gornja zona

8



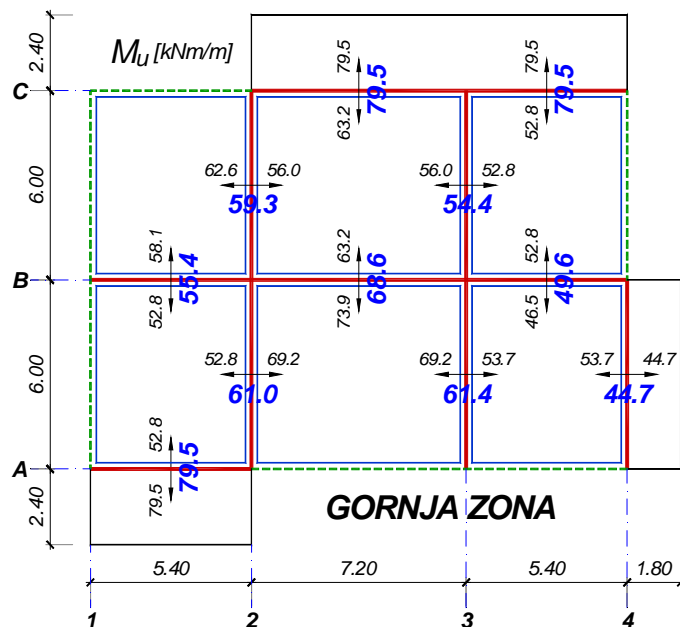
Momenti savijanja – gornja zona

9



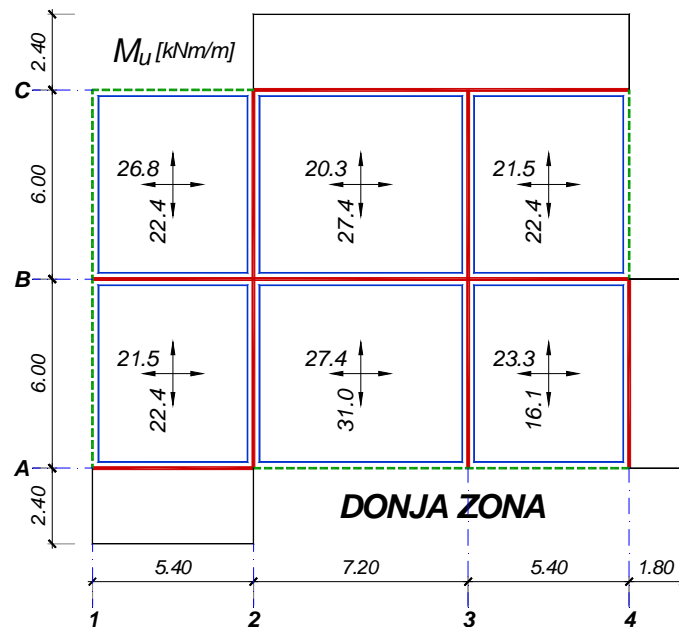
Momenti savijanja – gornja zona

10



Momenti savijanja – donja zona

11



Dimenzionisanje – gornja zona

12

a. globalni pravac Y

max. $M_u = M_{yu} = 79.5 \text{ kNm/m}$ (Y pravac, osa C: deo 2-4, osa A: deo 1-2)

pretp. $a_{1y} = 3.0 \text{ cm} \Rightarrow h_y = d - a_{1y} = 16 - 3.0 = 13.0 \text{ cm}$

$$k = \frac{13.0}{\sqrt{\frac{79.5}{2.05}}} = 2.088 \Rightarrow \varepsilon_y/\varepsilon_a = 3.5/7.163\% ; \bar{\mu} = 26.572\% ; \zeta = 0.863$$

$$A_{aY} = 26.572 \times 13.0 \times \frac{2.05}{40} = 17.70 \text{ cm}^2/\text{m}$$

$$\emptyset 16 \Rightarrow a_a^{(1)} = 2.01 \text{ cm}^2/\text{m} \Rightarrow e_a = \frac{100 \times a_a^{(1)}}{A_a} = \frac{100 \times 2.01}{17.70} = 11.4 \text{ cm}$$

usvojeno: **RØ16/10** ($20.10 \text{ cm}^2/\text{m}$)

$$A_{ap} = 0.2 \times 17.70 = 3.54 \text{ cm}^2/\text{m}$$

$$\text{pretp. } \emptyset 10 (a_{ap}^{(1)} = 0.785 \text{ cm}^2/\text{m}) \Rightarrow e_{ap} = \frac{100 \times a_{ap}^{(1)}}{A_{ap}} = \frac{100 \times 0.785}{3.54} = 22.2 \text{ cm}$$

usvojeno: **RØ10/20** ($3.93 \text{ cm}^2/\text{m}$)

Dimenzionisanje – gornja zona

13

b. globalni pravac X

max. $M_{xu} = 61.4 \text{ kNm/m}$ (X pravac, osa 3, deo A-B)

pretp. $\emptyset 14 \Rightarrow a_{1x} = 2.0 + 1.6 + 1.4/2 = 4.3 \text{ cm} \Rightarrow h_x = d - a_{1x} = 16 - 4.3 = 11.7 \text{ cm}$

$$k = \frac{11.7}{\sqrt{\frac{61.4}{2.05}}} = 2.138 \Rightarrow \varepsilon_p/\varepsilon_a = 3.5/7.777\% ; \bar{\mu} = 25.125\% ; \zeta = 0.871$$

$$A_{ax} = 25.125 \times 11.7 \times \frac{2.05}{40} = 15.07 \text{ cm}^2/\text{m}$$

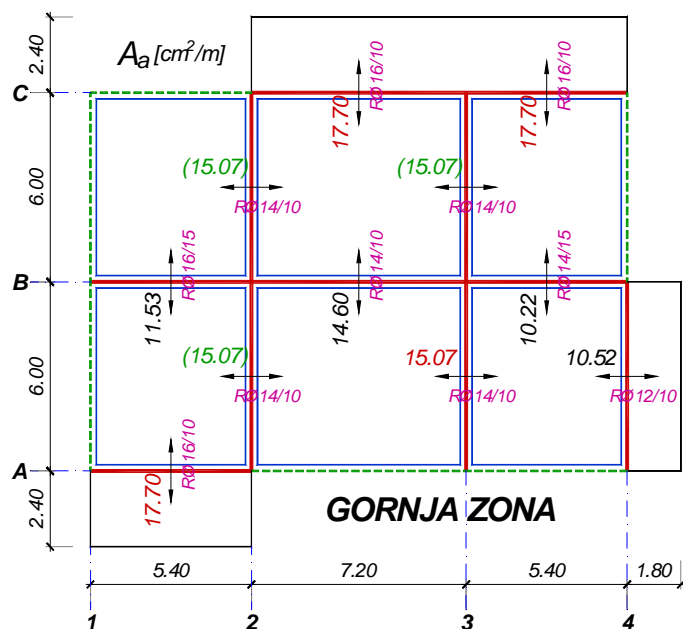
$$A_{ap} = 0.2 \times 15.07 = 3.01 \text{ cm}^2/\text{m}$$

usvojeno: **RØ14/10** (15.40 cm²/m)
RØ10/25 (3.14 cm²/m) - podeona armatura

Istom armaturom će biti armirani i preseći u osi 2 (delovi A-B i B-C) i u osi 3 (deo B-C) na kojima su momenti savijanja $M_{xu} = 61.0$, $M_{xu} = 59.3 \text{ kNm/m}$ odnosno $M_{xu} = 54.4 \text{ kNm/m}$.

Potrebna armatura – gornja zona

14



Dimenzionisanje – donja zona

15

a. globalni pravac Y

max. $M_u = M_{yu} = 31.0 \text{ kNm/m}$ (polje 2-3/A-B)

pretp. $\emptyset 12 \Rightarrow a_{1y} = 2.0 + 1.2/2 = 2.6 \text{ cm} \Rightarrow h_y = d - a_{1y} = 16 - 2.6 = 13.4 \text{ cm}$

$$k = \frac{13.4}{\sqrt{\frac{31.0}{2.05}}} = 3.446 \Rightarrow \varepsilon_p/\varepsilon_a = 1.706/10\text{‰} ; \bar{\mu} = 8.897\% ; \zeta = 0.947$$

$$A_{ay} = 8.897 \times 13.4 \times \frac{2.05}{40} = 6.11 \text{ cm}^2/\text{m}$$

usvojeno: **RØ12/15** (7.54 cm²/m)

Ostali preseći u donjoj zoni u Y pravcu će biti dimenzionisani pojednostavljeno, usvajajući da je krak unutrašnjih sila u svim razmatranim presećima konstantan i jednak kraku unutrašnjih sila $z_b = \zeta \times h = 0.947 \times 13.4 = 12.7 \text{ cm}$ koji odgovara najopterećenijem preseću:

polje 2-3/B-C: $M_{yu} = 27.4 \text{ kNm/m} \Rightarrow A_a \approx \frac{27.4}{31.0} \times 6.11 = 5.40 \text{ cm}^2/\text{m}$

usvojeno: **RØ12/20** (5.65 cm²/m)

Dimenzionisanje – donja zona

16

b. globalni pravac X

max. $M_{xu} = 27.4 \text{ kNm/m}$ (polje 2-3/A-B)

pretp. $\emptyset 12 \Rightarrow a_{1x} = 2.0 + 1.2 + 1.2/2 = 3.8 \text{ cm} \Rightarrow h_x = d - a_{1x} = 16 - 3.8 = 12.2 \text{ cm}$

$$k = \frac{12.2}{\sqrt{\frac{27.4}{2.05}}} = 3.336 \Rightarrow \varepsilon_p/\varepsilon_a = 1.788/10\text{‰} ; \bar{\mu} = 9.520\% ; \zeta = 0.944$$

$$A_{ax} = 9.520 \times 12.2 \times \frac{2.05}{40} = 5.95 \text{ cm}^2/\text{m}$$

usvojeno: **RØ12/15** (7.54 cm²/m)

Istom armaturom se armira polje 1-2/B-C ($M_{xu} = 26.8 \text{ kNm/m}$). Ostali preseći će biti dimenzionisani analogno Y pravcu, usvajajući $z_b = \zeta \times h = 0.944 \times 12.2 = 11.5 \text{ cm}$, koji odgovara najopterećenijem preseću:

polje 3-4/A-B: $M_{xu} = 23.3 \text{ kNm/m} \Rightarrow A_a \approx \frac{23.3}{27.4} \times 5.95 = 5.05 \text{ cm}^2/\text{m}$

usvojeno: **RØ10/15** (5.24 cm²/m)

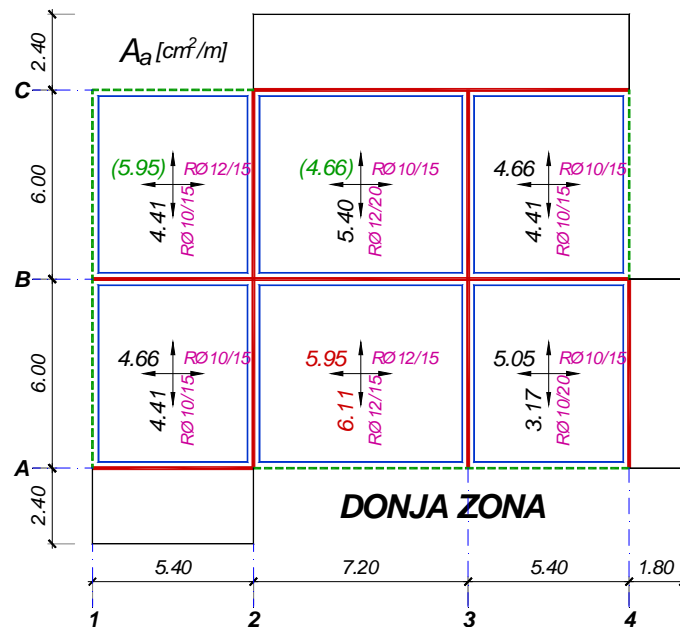
polje 1-2/A-B: $M_{xu} = 21.5 \text{ kNm/m} \Rightarrow A_a \approx \frac{21.5}{27.4} \times 5.95 = 4.66 \text{ cm}^2/\text{m}$

usvojeno: **RØ10/15** (5.24 cm²/m)

Na isti način se armiraju i polja 3-4/B-C i 2-3/B-C ($M_{xu} = 20.3 \text{ kNm/m}$).

Potrebna armatura – donja zona

17



Potrebna armatura – donja zona (MA 500/560)

18

