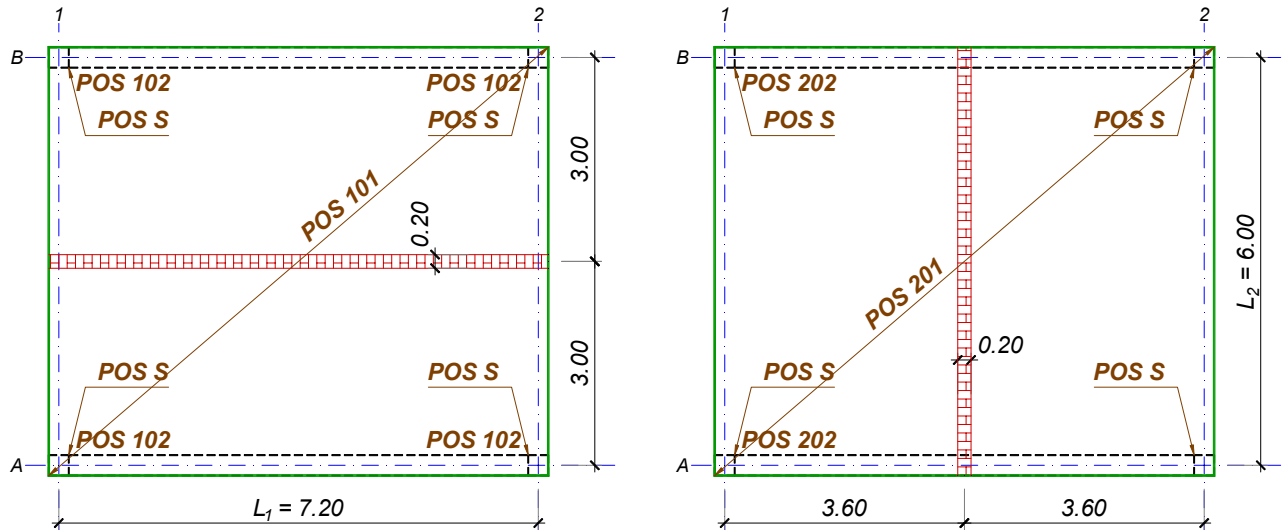


Ploče POS 101 i POS 201, debljine 20 cm, dimenzija 6.0×7.2m u osnovi su prikazane na donjoj skici. Oslonjene su na po dve paralelne grede (POS 102, POS 202) dimenzija 25/60 cm, a ove na kvadratne stubove POS S (b/d = 25/25 cm) u uglovima ploče. Pored sopstvene težine, ploče su opterećene jednako raspodeljenim dodatnim stalnim opterećenjem (slojevi poda) $\Delta g = 1.5 \text{ kN/m}^2$ i povremenim opterećenjem $p = 2.0 \text{ kN/m}^2$. Na pločama su izvedeni pregradni zidovi od giter bloka debljine 20 cm, visine 4 m, prema skici. Usvojiti da je jedinična težina omalterisanog zida 3.0 kN/m^2 . Potrebno je dimenzionisati ploče i grede, nacrtati planove armature i uraditi specifikacije i rekapitulacije. Kvalitet materijala: MB 30, RA 400/500.



1 PRORAČUN PLOČE POS 101

1.1 ANALIZA OPTEREĆENJA I PRORAČUN STATIČKIH UTICAJA

a. stalno opterećenje

- sopstvena težina ploče $d_p \times \gamma_b = 0.20 \times 25 = 5.0 \text{ kN/m}^2$
- dodatno stalno opterećenje $\Delta g = 1.5 \text{ kN/m}^2$
- ukupno, stalno opterećenje $g = 6.5 \text{ kN/m}^2$
- zid od giter bloka $G = g_{20} \times H_z = 3.0 \times 4.0 = 12.0 \text{ kN/m}^1$

b. povremeno opterećenje

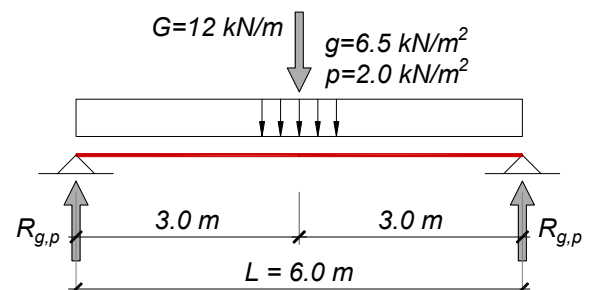
$$p = 2.0 \text{ kN/m}^2$$

$$M_g = \frac{6.5 \times 6.0^2}{8} + \frac{12.0 \times 6.0}{4} = 47.25 \frac{\text{kNm}}{\text{m}}$$

$$M_p = \frac{2.0 \times 6.0^2}{8} = 9.0 \frac{\text{kNm}}{\text{m}}$$

$$R_g = \frac{6.5 \times 6 + 12}{2} = 25.5 \frac{\text{kN}}{\text{m}}$$

$$R_p = \frac{2.0 \times 6}{2} = 6.0 \frac{\text{kN}}{\text{m}}$$



1.2 DIMENZIONISANJE PLOČE

$$M_u = 1.6 \times 47.25 + 1.8 \times 9.0 = 91.8 \text{ kNm/m}$$

$$\text{pretp. } a_1 = 3 \text{ cm} \Rightarrow h = 20 - 3 = 17 \text{ cm} ; b = 100 \text{ cm} = 1.0 \text{ m}$$

$$k = \frac{17}{\sqrt{\frac{91.8}{2.05}}} = 2.540 \Rightarrow \varepsilon_b/\varepsilon_a = 2.853/10\text{‰} ; \bar{\mu} = 17.009\%$$

$$A_{a,\text{potr.}} = 17.009 \times 17 \times \frac{2.05}{40} = 14.82 \frac{\text{cm}^2}{\text{m}}$$

usvojeno: **RØ14/10** (15.39 cm²/m)

$$A_{ap} = 0.20 \times 14.82 = 2.96 \text{ cm}^2/\text{m}$$

usvojeno: **RØ10/25** (3.14 cm²/m)

1.3 PRORAČUN GREDE POS 102

Grede su slobodno oslonjene, raspona 7.2 m, opterećene stalnim i povremenim opterećenjem sa ploče POS 101 i sopstvenom težinom.

1.3.1 Analiza opterećenja i statički uticaji

$$\text{sopstvena težina POS 102} \quad b \times d \times \gamma_b = 0.25 \times 0.6 \times 25 = 3.75 \text{ kN/m}$$

$$\text{od ploče POS 101} \quad R_g^{\text{POS 101}} = 25.50 \text{ kN/m}$$

$$\text{ukupno, stalno opterećenje} \quad g = 29.25 \text{ kN/m}$$

$$\text{povremeno opterećenje} \quad R_p^{\text{POS 101}} = p = 6.00 \text{ kN/m}$$

$$M_g = 29.25 \times 7.2^2 / 8 = 189.5 \text{ kNm} ; \quad M_p = 12.0 \times 7.2^2 / 8 = 38.9 \text{ kNm}$$

$$T_g = 29.25 \times 7.2 / 2 = 105.3 \text{ kN} ; \quad T_p = 12.0 \times 7.2 / 2 = 21.6 \text{ kN}$$

1.3.2 Dimenzionisanje

$$M_u = 1.6 \times 189.5 + 1.8 \times 38.9 = 373.3 \text{ kNm}$$

$$\text{pretp. } a_1 = 6 \text{ cm} \Rightarrow h = 60 - 6 = 54 \text{ cm}$$

$$B = \min \left\{ \begin{array}{l} b_1 + b + \frac{0.25}{3} \times l_0 \\ b_1 + b + 8 \times d_p \\ e / 2 \end{array} \right\} = \left\{ \begin{array}{l} 0 + 25 + \frac{0.25}{3} \times 720 = 85 \\ 0 + 25 + 8 \times 20 = 185 \\ 600 / 2 = 300 \end{array} \right\} = 85 \text{ cm}$$

Pretpostavlja se da je neutralna linija u ploči, pa se presek dimenzioniše kao pravougaoni, širine $B = 85 \text{ cm}$:

$$k = \frac{54}{\sqrt{\frac{373.3 \times 10^2}{85 \times 2.05}}} = 3.690 \Rightarrow \varepsilon_b/\varepsilon_a = 1.551/10\text{‰} ; \bar{\mu} = 7.721\% ; s = 0.134$$

$$x = s \times h = 0.134 \times 54 = 7.3 \text{ cm} < d_p = 20 \text{ cm}$$

Pretpostavka o položaju neutralne linije je dobra, pa sledi:

$$A_a = 7.721 \times \frac{85 \times 54}{100} \times \frac{2.05}{40} = 18.16 \text{ cm}^2$$

usvojeno: **5 RØ22** (19.01 cm²)

1.3.3 Kontrola glavnih napona zatezanja

$$T_u = 1.6 \times 105.3 + 1.8 \times 21.6 = 207.4 \text{ kN}$$

$$z \approx 0.9 \times h = 0.9 \times 54 = 48.6 \text{ cm} \Rightarrow \tau_n = \frac{207.4}{25 \times 48.6} = 0.171 \frac{\text{kN}}{\text{cm}^2} > \tau_r = 0.11 \frac{\text{kN}}{\text{cm}^2}$$

$$\lambda = \frac{720}{2} \times \left(1 - \frac{0.11}{0.171}\right) = 128.0 \text{ cm}$$

$$\tau_n < 3\tau_r = 0.33 \frac{\text{kN}}{\text{cm}^2} \Rightarrow \tau_{Ru} = \frac{3}{2} \times (0.171 - 0.11) = 0.091 \frac{\text{kN}}{\text{cm}^2}$$

usvojeno: $m = 2$, $\theta = 45^\circ$, $\alpha = 90^\circ$ (vertikalne uzengije), URØ8 ($a_u^{(1)} = 0.503 \text{ cm}^2$):

$$e_u = \frac{2 \times 0.503}{25 \times 0.091} \times 40 \times (\cos 90^\circ + \sin 90^\circ \times \cot 45^\circ) = 17.7 \text{ cm}$$

usvojeno: **URØ8/15** ($m=2$)

$$\Delta A_a = \frac{T_{mu}}{2\sigma_v} \times (\cot \theta - \cot \alpha) = \frac{207.4}{2 \times 40} \times (1 - 0) = 2.59 \text{ cm}^2$$

usvojeno: **2 RØ22** (7.60 cm^2)

2 PRORAČUN PLOČE POS 201

2.1 ANALIZA OPTEREĆENJA I PRORAČUN STATIČKIH UTICAJA

Jednako raspodeljeno opterećenje koje deluje po čitavoj površini ploče je isto kao za ploču POS 101 i sračunato je u tački 1.1. Težina pregradnog zida se raspodeljuje upravno na pravac glavne armature na širinu b_3 u skladu sa članom 213. PBAB 87:

$$b_3 = b_2 + \frac{A_{ap}}{A_a} \times L \leq b_2 + 0.65 \times L$$

gde je b_2 širina rasprostiranja koncentrisanog opterećenja u srednjoj ravni ploče upravno na pravac glavne armature, A_a i A_{ap} površine poprečnog preseka glavne i podeone armature, a L raspon ploče.

Za usvojeni minimalni odnos $A_{ap}/A_a = 0.20$, sledi:

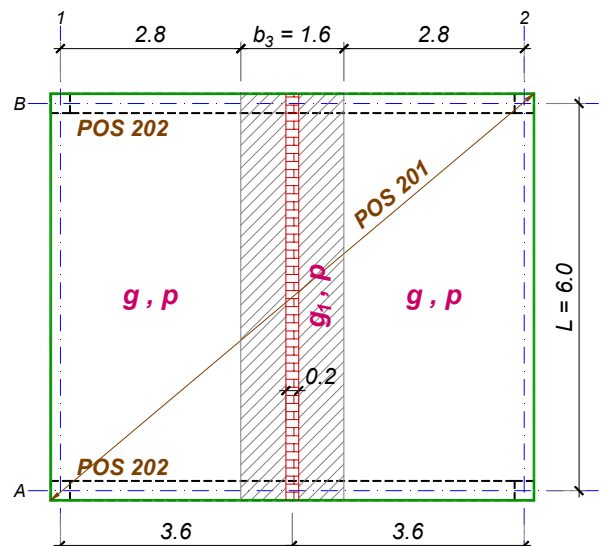
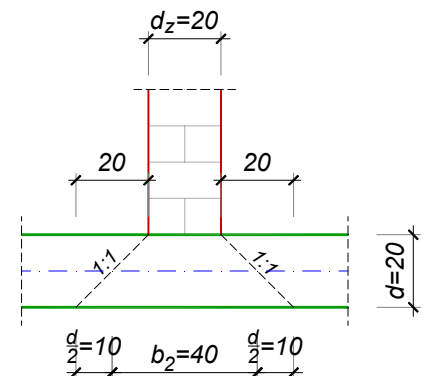
$$b_3 = 40 + 0.2 \times 600 = 160 \text{ cm}$$

Stalno opterećenje u zoni zida (osenci deo ploče na skici, širine $b_3 = 1.6 \text{ m}$), je:

$$g_1 = g + \frac{G_z}{b_3} = 6.5 + \frac{12.0}{1.6} = 6.5 + 7.5 = 14 \frac{\text{kN}}{\text{m}^2}$$

dok je na ostalom delu ploče, ukupne širine $2 \times 2.8 = 5.6 \text{ m}$, opterećenje $g = 6.5 \text{ kN/m}^2$.

Povremeno opterećenje je konstantno po čitavoj površini ploče ($p = 2 \text{ kN/m}^2$).



2.1.1 Deo ploče u zoni zida (na širini $b_3 = 1.6$ m)

$$q_{u1} = 1.6 \times g_1 + 1.8 \times p = 1.6 \times 14.0 + 1.8 \times 2.0 = 26.0 \text{ kN/m}^2$$

$$M_{u1} = 26.0 \times 6.0^2 / 8 = 117.0 \text{ kNm/m}$$

$$R_{g1} = 14.0 \times 6.0 / 2 = 42.0 \text{ kN/m} \quad ; \quad R_p = 2.0 \times 6.0 / 2 = 6.0 \text{ kN/m}$$

2.1.2 Deo ploče izvan zone zida

$$q_u = 1.6 \times g + 1.8 \times p = 1.6 \times 6.5 + 1.8 \times 2.0 = 14.0 \text{ kN/m}^2$$

$$M_u = 14.0 \times 6.0^2 / 8 = 63.0 \text{ kNm/m}$$

$$R_g = 6.5 \times 6.0 / 2 = 19.5 \text{ kN/m} \quad ; \quad R_p = 2.0 \times 6.0 / 2 = 6.0 \text{ kN/m}$$

2.2 DIMENZIONISANJE PLOČE**2.2.1 Deo ploče u zoni zida (na širini $b_3 = 1.6$ m)**

$$k = \frac{17}{\sqrt{\frac{117.0}{2.05}}} = 2.250 \Rightarrow \varepsilon_b/\varepsilon_a = 3.5/9.203\% \text{ ; } \bar{\mu} = 22.305\%$$

$$A_{a,\text{potr.}} = 22.305 \times 17 \times \frac{2.05}{40} = 19.43 \frac{\text{cm}^2}{\text{m}}$$

usvojeno: **RØ16/10** (20.10 cm²/m)

$$A_{ap} = 0.2 \times 19.43 = 3.89 \text{ cm}^2/\text{m}$$

usvojeno: **RØ8/12.5** (4.02 cm²/m)

2.2.2 Deo ploče van zone zida

$$k = \frac{17}{\sqrt{\frac{63.0}{2.05}}} = 3.067 \Rightarrow \varepsilon_b/\varepsilon_a = 2.033/10\% \text{ ; } \bar{\mu} = 11.355\%$$

$$A_{a,\text{potr.}} = 11.355 \times 17 \times \frac{2.05}{40} = 9.89 \frac{\text{cm}^2}{\text{m}}$$

usvojeno: **RØ16/20** (10.05 cm²/m)

$$A_{ap} = 0.2 \times 9.89 = 1.98 \text{ cm}^2/\text{m}$$

usvojeno: **RØ8/25** (2.01 cm²/m)

2.3 VARIJANTNO REŠENJE SA VEĆOM KOLIČINOM PODEONE ARMATURE

Povećanjem količine podeone armature povećava se širina b_3 i time smanjuje opterećenje od težine pregradnog zida.

$$b_3 = b_2 + \frac{A_{ap}}{A_a} \times L = 40 + 0.6 \times 600 = 400 \text{ cm}$$

Stalno opterećenje u zoni zida, na širini $b_3 = 4.0$ m, je:

$$g_1 = g + \frac{G_z}{b_3} = 6.5 + \frac{12.0}{4.0} = 6.5 + 3.0 = 9.5 \frac{\text{kN}}{\text{m}^2}$$

dok je na ostalom delu ploče, ukupne širine $2 \times 1.6 = 3.2$ m, opterećenje $g = 6.5$ kN/m². Povremeno opterećenje je konstantno po čitavoj površini ploče ($p = 2$ kN/m²).

2.3.1 Deo ploče u zoni zida (na širini $b_3 = 4.0 \text{ m}$)

$$q_{u1} = 1.6 \times g_1 + 1.8 \times p = 1.6 \times 9.5 + 1.8 \times 2.0 = 18.8 \text{ kN/m}^2$$

$$M_{u1} = 18.8 \times 6.0^2 / 8 = 84.6 \text{ kNm/m}$$

$$R_{g1} = 9.5 \times 6.0 / 2 = 28.5 \text{ kN/m} \quad ; \quad R_p = 2.0 \times 6.0 / 2 = 6.0 \text{ kN/m}$$

$$k = \frac{17}{\sqrt{\frac{84.6}{2.05}}} = 2.677 \Rightarrow \varepsilon_b / \varepsilon_a = 2.574 / 10\text{‰} \quad ; \quad \bar{\mu} = 15.171\%$$

$$A_{a,\text{potr.}} = 15.171 \times 17 \times \frac{2.05}{40} = 13.37 \frac{\text{cm}^2}{\text{m}}$$

usvojeno: **RØ16/15** (13.40 cm²/m)

$$A_{ap} = 0.6 \times 13.37 = 8.02 \text{ cm}^2/\text{m}$$

usvojeno: **RØ12/12.5** (9.05 cm²/m)

Ostali deo ploče se armira kao što je sračunato u tački 2.2.2.

2.4 PRORAČUN GREDE POS 202

2.4.1 Analiza opterećenja i statički uticaji

a. stalno opterećenje u zoni zida ($b_3 = 1.6 \text{ m}$)

sopstvena težina POS 202	$b \times d \times \gamma_b = 0.25 \times 0.6 \times 25 = 3.75 \text{ kN/m}$
od ploče POS 201	$R_g^{\text{POS 201}} = 42.00 \text{ kN/m}$

ukupno, stalno opterećenje $g_1 = 45.75 \text{ kN/m}$

b. stalno opterećenje van zone zida

sopstvena težina POS 202	$b \times d \times \gamma_b = 0.25 \times 0.6 \times 25 = 3.75 \text{ kN/m}$
od ploče POS 201	$R_g^{\text{POS 201}} = 19.50 \text{ kN/m}$

ukupno, stalno opterećenje $g = 23.25 \text{ kN/m}$

c. povremeno opterećenje van zone zida

od ploče POS 201 $R_p^{\text{POS 201}} = p = 6.00 \text{ kN/m}$

$$G = 23.25 \times 2.8 + \frac{45.75 \times 1.6}{2} = 101.7 \text{ kN}$$

$$P = 6.0 \times 7.2 / 2 = 21.6 \text{ kN}$$

$$A_u = 1.6 \times 101.7 + 1.8 \times 21.6 = 201.6 \text{ kN}$$

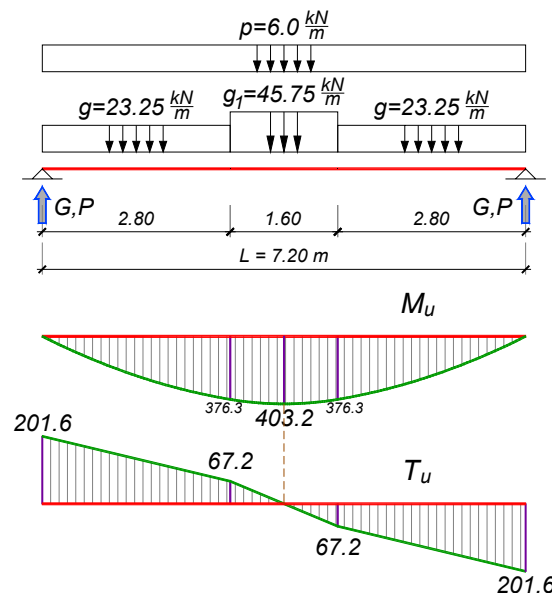
$$q_u = 1.6 \times 23.25 + 1.8 \times 6.0 = 48.0 \text{ kN/m}$$

$$q_{u1} = 1.6 \times 45.75 + 1.8 \times 6.0 = 84.0 \text{ kN/m}$$

$$T_{u1} = 201.6 - 84.0 \times 2.8 = 67.2 \text{ kN}$$

$$M_{u1} = 201.6 \times 2.8 - \frac{48.0 \times 2.8^2}{2} = 376.3 \text{ kNm}$$

$$M_u = 376.3 + 67.2 \times 0.8 - \frac{84.0 \times 0.8^2}{2} = 403.2 \text{ kNm}$$



2.4.2 Dimenzionisanje

$M_{u,max} = 403.2 \text{ kNm}$ (dijagram M_u , tačka 2.4.1)

$$B = \min \left\{ \begin{array}{l} 0 + 25 + \frac{0.25}{3} \times 720 = 85 \\ 0 + 25 + 8 \times 20 = 185 \\ 600 / 2 = 300 \end{array} \right\} = 85 \text{ cm}$$

Pretpostavlja se da je neutralna linija u ploči, pa se presek dimenzioniše kao pravougaoni, širine $B = 85 \text{ cm}$:

pretp. $a_1 = 7 \text{ cm} \Rightarrow h = 60 - 7 = 53 \text{ cm}$

$$k = \frac{53}{\sqrt{\frac{403.2 \times 10^2}{85 \times 2.05}}} = 3.484 \Rightarrow \varepsilon_b / \varepsilon_a = 1.679 / 10\text{‰} ; \bar{\mu} = 8.695\% ; s = 0.144$$

$x = s \times h = 0.144 \times 53 = 7.6 \text{ cm} < d_p = 20 \text{ cm}$

Pretpostavka o položaju neutralne linije je dobra, pa sledi:

$$A_a = 8.695 \times \frac{85 \times 53}{100} \times \frac{2.05}{40} = 20.07 \text{ cm}^2$$

usvojeno: **6 RØ22** (22.81 cm^2)

2.4.3 Kontrola glavnih napona zatezanja

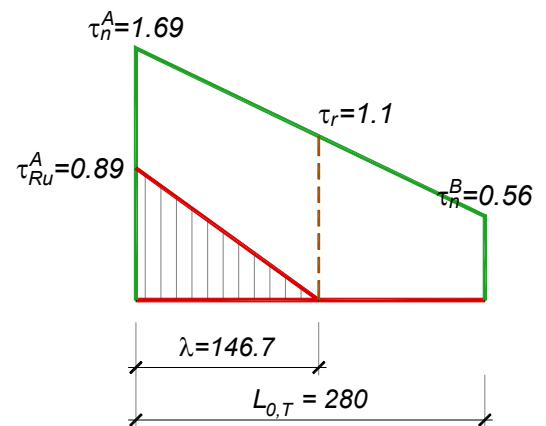
$T_{u,max} = 201.6 \text{ kN}$ (dijagram T_u , tačka 2.4.1)

$$\tau_n^A = \frac{201.6}{25 \times 0.9 \times 53} = 0.169 \frac{\text{kN}}{\text{cm}^2} > \tau_r$$

$$\tau_n^B = \frac{67.2}{25 \times 0.9 \times 53} = 0.056 \frac{\text{kN}}{\text{cm}^2} < \tau_r$$

$$\lambda = \frac{1.69 - 1.1}{1.69 - 0.56} \times 280 = 146.7 \text{ cm}$$

$$\tau_{Ru}^A = \frac{3}{2} \times (0.169 - 0.11) = 0.089 \frac{\text{kN}}{\text{cm}^2}$$



usvojeno: $m = 2$, $\theta = 45^\circ$, $\alpha = 90^\circ$:

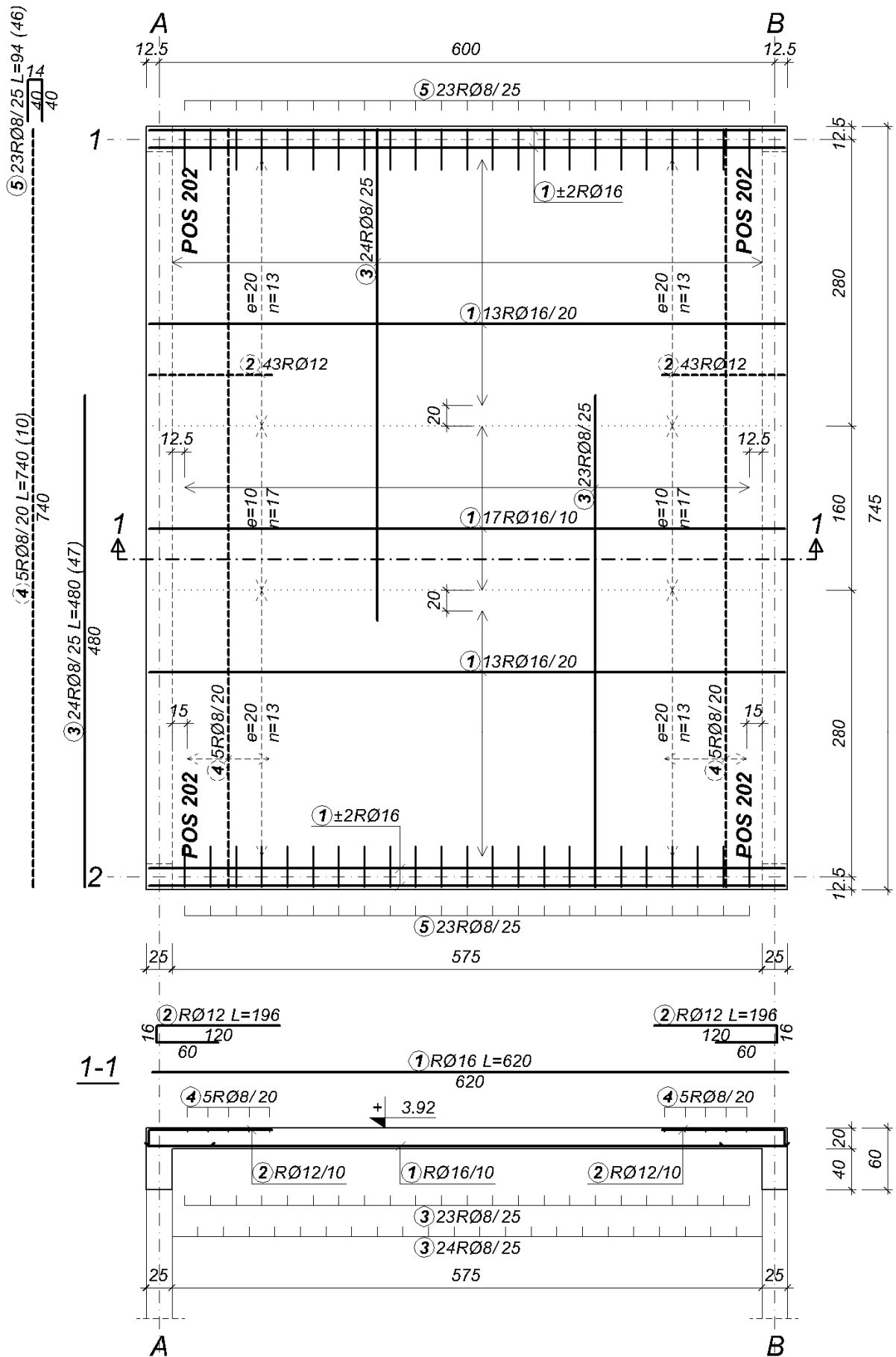
$$e_u = \frac{2 \times a_u^{(1)}}{25 \times 0.089} \times 40 \times (\cos 90^\circ + \sin 90^\circ \times \cot 45^\circ) = 36.1 \times a_u^{(1)}$$

pretp. URØ8 ($a_u^{(1)} = 0.503 \text{ cm}^2$) $\Rightarrow e_u = 36.1 \times 0.503 = 18.2 \text{ cm}$

usvojeno: **URØ8/15** ($m=2$)

$$\Delta A_a = \frac{T_{mu}}{2\sigma_v} \times (\cot \theta - \cot \alpha) = \frac{201.6}{2 \times 40} \times (1 - 0) = 2.52 \text{ cm}^2$$

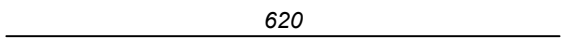
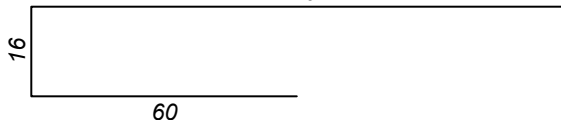
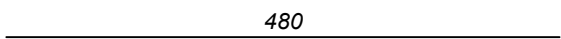
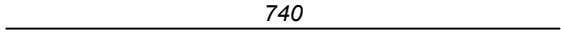
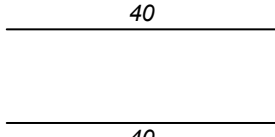
usvojeno: **2 RØ22** (7.60 cm^2)

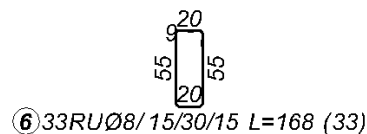
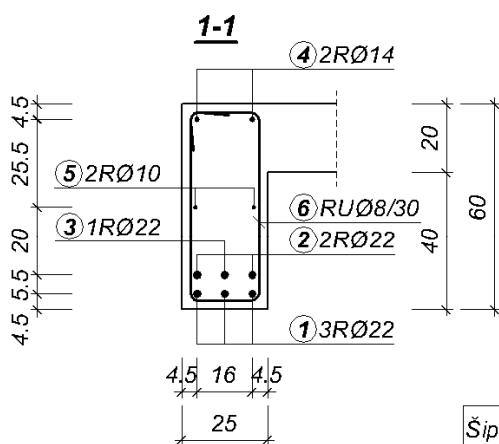
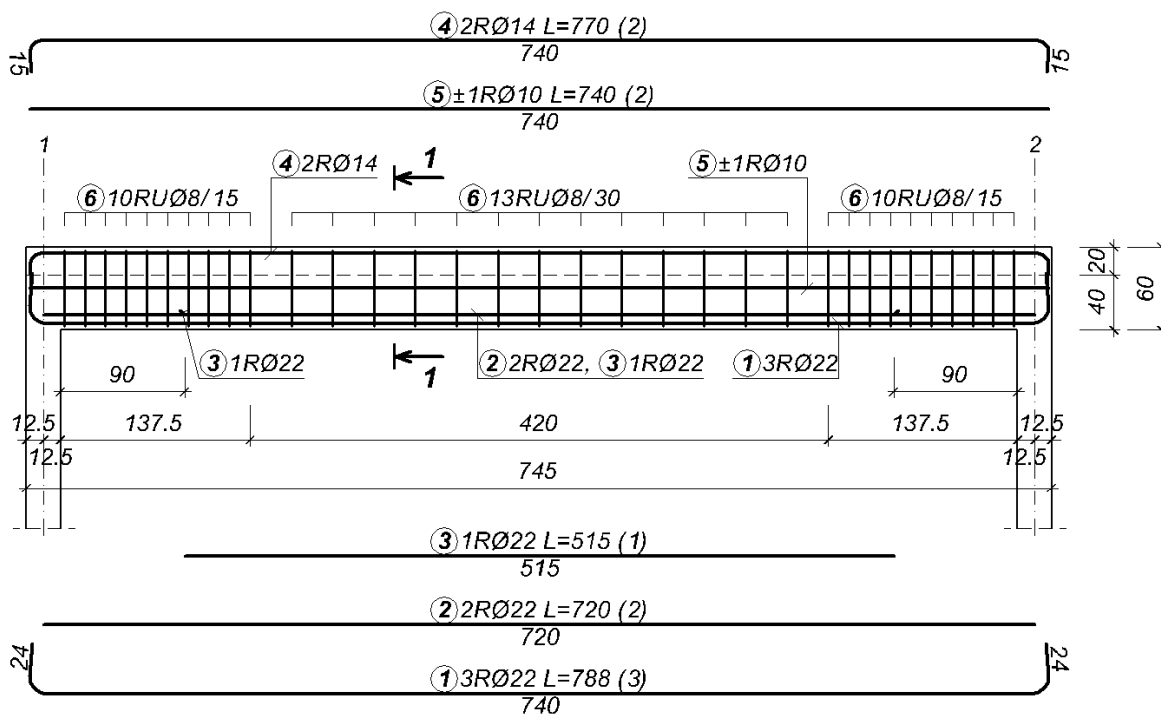


PLAN ARMATURE **POS 201**

MB 30 RA 400/500 R 1:50

Primer P3 - List br. 1

Šipke - specifikacija						
ozn.	oblik i mere [cm]	Č	Ø	lg [cm]	n [kom]	lgn [m]
POS 201 (1 kom)						
1	620 	RA2	16	620	51	316.20
2	120 16 60 	RA2	12	196	86	168.56
3	480 	RA2	8	480	47	225.60
4	740 	RA2	8	740	10	74.00
5	40 14 40 	RA2	8	94	46	43.24
Šipke - rekapitulacija						
Ø [mm]	lgn [m]	Jedinična težina [kg/m']		Težina [kg]		
RA2						
8	342.84	0.405		138.85		
12	168.56	0.911		153.56		
16	316.20	1.621		512.56		
Ukupno						804.97

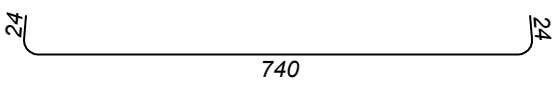
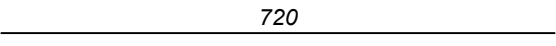
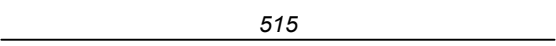
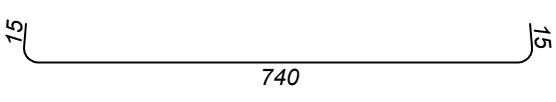
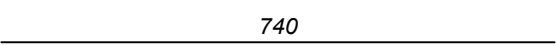
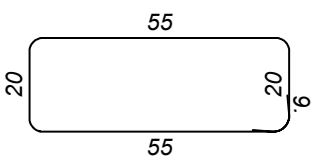


KOLIČINA BETONA: $V_b = 1.12 \text{ m}^3$

KOLIČINA ARMATURE: $\frac{183.02}{1.12} = 163.4 \text{ kg/m}^3$

Šipke - rekapitulacija			
Ø [mm]	lg [m]	Jedinična težina [kg/m]	Težina [kg]
RA2			
8	55.44	0.405	22.45
10	14.80	0.633	9.37
14	15.40	1.242	19.13
22	43.19	3.058	132.08
Ukupno			183.02

GRAĐEVINSKI FAKULTET UNIVERZITETA U BEOGRADU				
ODSEK ZA KONSTRUKCIJE		KATEDRE ZA MATERIJALE I KONSTRUKCIJE		
PROJEKTOVANJE I GRAĐENJE BETONSKIH KONSTRUKCIJA 1		PRIMER P3 - LIST br. 2		
PREDMETNI NASTAVNIK: DOC.DR B. MILOSAVLJEVIĆ	ASISTENT: M. STOJANOVIĆ		KANDIDAT:	
PLAN ARMATURE POS 202				
KVALITET MATERIJALA MB 30 RA 400/500	RAZMERA CRTEŽA R 1:50/20	FORMAT CRTEŽA 297×210	ŠKOLSKA 2015/2016	OVERA:

Šipke - specifikacija						
ozn.	oblik i mere [cm]	Č	Ø	lg [cm]	n [kom]	lgn [m]
POS 202 (1 kom)						
1		RA2	22	788	3	23.64
2		RA2	22	720	2	14.40
3		RA2	22	515	1	5.15
4		RA2	14	770	2	15.40
5		RA2	10	740	2	14.80
6		RA2	8	168	33	55.44
Šipke - rekapitulacija						
Ø [mm]	lgn [m]	Jedinična težina [kg/m']		Težina [kg]		
RA2						
8	55.44	0.405		22.45		
10	14.80	0.633		9.37		
14	15.40	1.242		19.13		
22	43.19	3.058		132.08		
Ukupno						183.02