

1. PRORAČUN PLOČE POS 1

1.1 ANALIZA OPTEREĆENJA I STATIČKI UTICAJI

Ploča je sistema kontinualnog nosača preko dva polja raspona $\lambda=6.0$ m. Pored sopstvene težine, opterećena je dodatnim stalnim opterećenjem Δg i povremenim opterećenjem p .

stalno opterećenje

- sopstvena težina ploče	0.16×25	$= 4.0 \text{ kN/m}^2$
- slojevi, izolacije	Δg	$= 2.0 \text{ kN/m}^2$
ukupno stalno opterećenje	g	$= 6.0 \text{ kN/m}^2$

povremeno opterećenje

ukupno, povremeno opterećenje	p	$= 4.0 \text{ kN/m}^2$
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stalno opterećenje

$$A_g = 0.375 \times 6.0 \times 6.0 = 13.5 \text{ kN/m} \quad ;$$

$$B_g = 1.25 \times 6.0 \times 6.0 = 45.0 \text{ kN/m} \quad ;$$

$$M_{g,osl} = 0.125 \times 6.0 \times 6.0^2 = 27.0 \text{ kNm/m} \quad ;$$

$$M_{g,polje} = 0.07 \times 6.0 \times 6.0^2 = 15.2 \text{ kNm/m} \quad ;$$

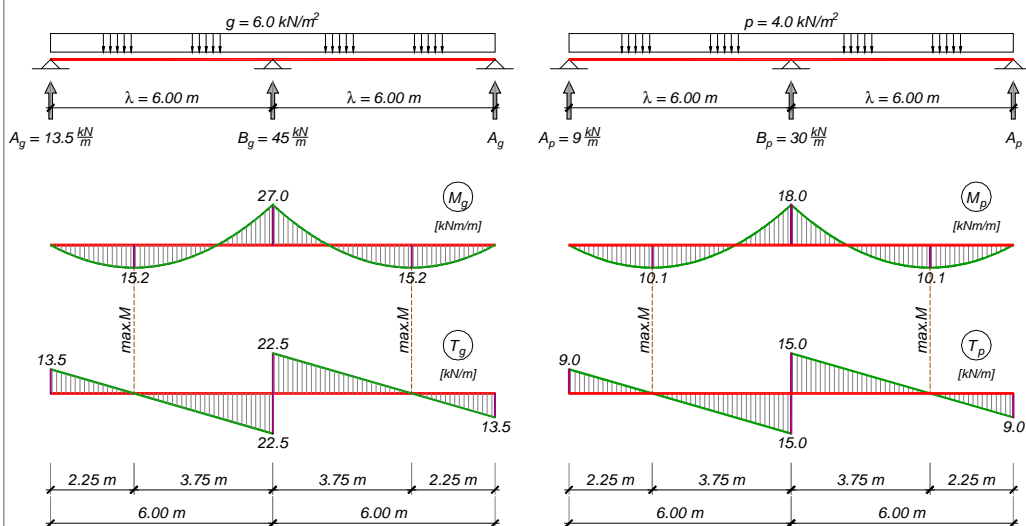
povremeno opterećenje

$$A_p = 0.375 \times 4.0 \times 6.0 = 9.0 \text{ kN/m}$$

$$B_p = 1.25 \times 4.0 \times 6.0 = 30.0 \text{ kN/m}$$

$$M_{p,osl} = 0.125 \times 4.0 \times 6.0^2 = 18.0 \text{ kNm/m}$$

$$M_{p,polje} = 0.07 \times 4.0 \times 6.0^2 = 10.1 \text{ kNm/m}$$



1.2 DIMENZIONISANJE

$$MB\ 30 \quad \Rightarrow \quad f_b = 20.5\ MPa = 2.05\ kN/cm^2$$

$$RA\ 400/500 \quad \Rightarrow \quad \sigma_v = 400\ MPa = 40.0\ kN/cm^2$$

1.2.1 GORNJA ZONA

$$M_u = 1.6 \times 27 + 1.8 \times 18 = 75.6\ kNm/m$$

$$\text{pretp. } a_1 = 3\ cm \Rightarrow b/d/h = 100/16/13\ cm$$

$$k = \frac{13}{\sqrt{\frac{75.6 \times 10^2}{100 \times 2.05}}} = 2.141 \Rightarrow \varepsilon_b/\varepsilon_a = 3.5/7.813\% ; \bar{\mu} = 25.044\%$$

$$A_a = 25.044 \times \frac{100 \times 13}{100} \times \frac{2.05}{40} = 16.69\ cm^2/m$$

$$\text{pretp. } \emptyset 16\ (a_a^{(1)} = 2.01\ cm^2/m) \quad \Rightarrow \quad e_a = \frac{100 \times a_a^{(1)}}{A_a} = \frac{100 \times 2.01}{16.69} = 12.1\ cm$$

usvojeno: **Ø16/10** (20.10 cm²/m)

$$A_{ap} = 0.2 \times 16.69 = 3.34\ cm^2/m$$

$$\text{pretp. } \emptyset 10\ (a_{ap}^{(1)} = 0.785\ cm^2/m) \quad \Rightarrow \quad e_{ap} = \frac{100 \times a_{ap}^{(1)}}{A_{ap}} = \frac{100 \times 0.785}{3.34} = 23.5\ cm$$

usvojeno: **Ø10/20** (3.93 cm²/m)

1.2.2 DONJA ZONA

$$M_u = 1.6 \times 15.2 + 1.8 \times 10.1 = 42.5\ kNm/m$$

$$\text{pretp. } \emptyset 12 \Rightarrow a_1 = a_0 + \frac{\emptyset}{2} = 2.0 + \frac{1.2}{2} = 2.6\ cm \Rightarrow b/d/h = 100/16/13.4\ cm$$

$$k = \frac{13.4}{\sqrt{\frac{42.5}{2.05}}} = 2.942 \Rightarrow \varepsilon_b/\varepsilon_a = 2.176/10\% ; \bar{\mu} = 12.396\%$$

$$A_a = 12.396 \times 13.4 \times \frac{2.05}{40} = 8.51\ cm^2/m > A_{a,min.} = 0.10 \times 16 = 1.6\ cm^2/m$$

$$\text{pretp. } \emptyset 12\ (a_a^{(1)} = 1.13\ cm^2/m) \quad \Rightarrow \quad e_a = \frac{100 \times a_a^{(1)}}{A_a} = \frac{100 \times 1.13}{8.51} = 13.3\ cm$$

usvojeno: **Ø12/12.5** (9.05 cm²/m)

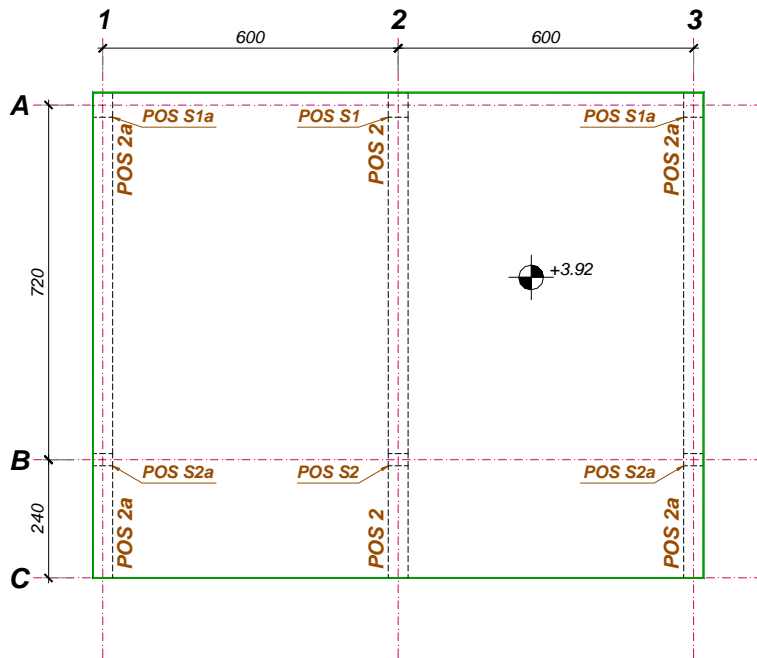
$$A_{ap} = 0.2 \times 8.51 = 1.70\ cm^2/m > A_{ap,min.} = 0.085 \times 16 = 1.36\ cm^2/m$$

$$\text{pretp. } \emptyset 8\ (a_{ap}^{(1)} = 0.503\ cm^2/m) \quad \Rightarrow \quad e_{ap} = \frac{100 \times a_{ap}^{(1)}}{A_{ap}} = \frac{100 \times 0.503}{1.70} = 29.5\ cm$$

usvojeno: **Ø8/25** (2.01 cm²/m)

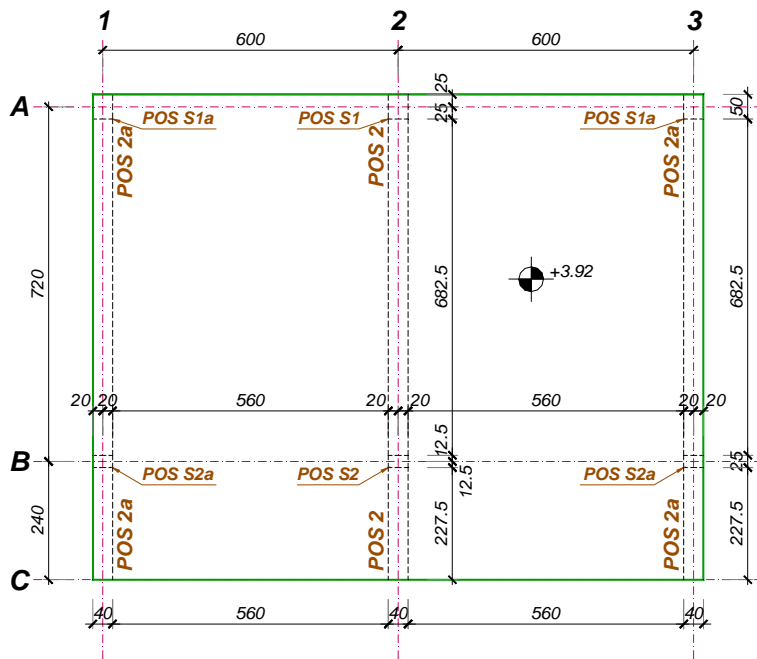
Plan optate

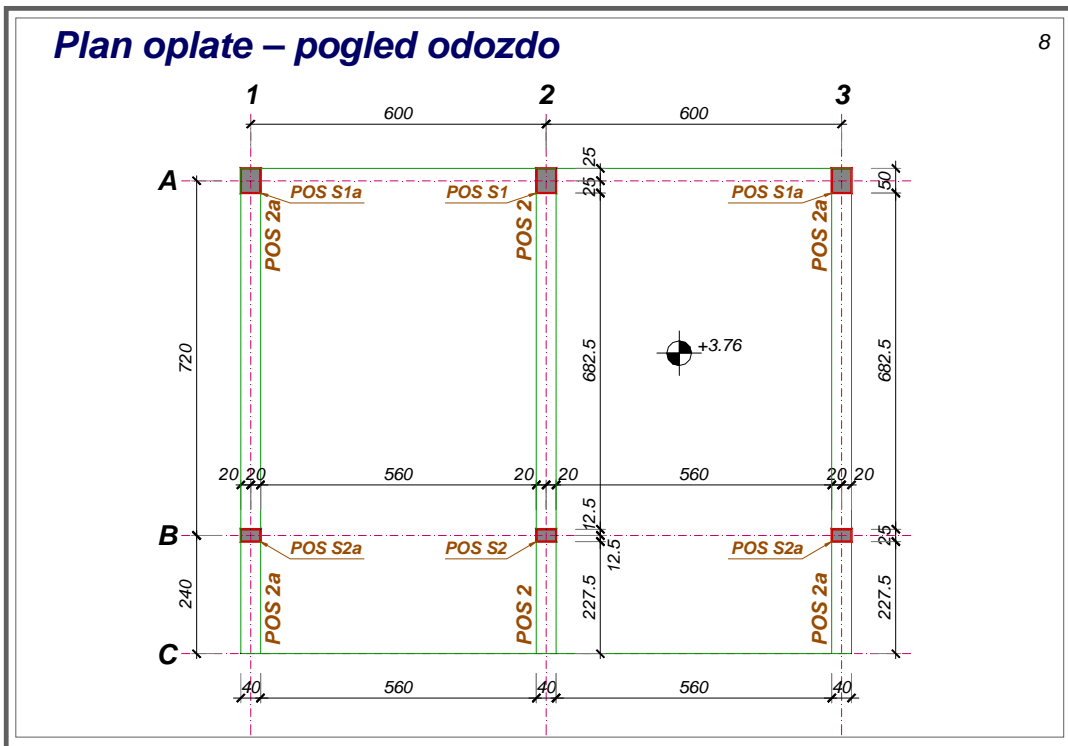
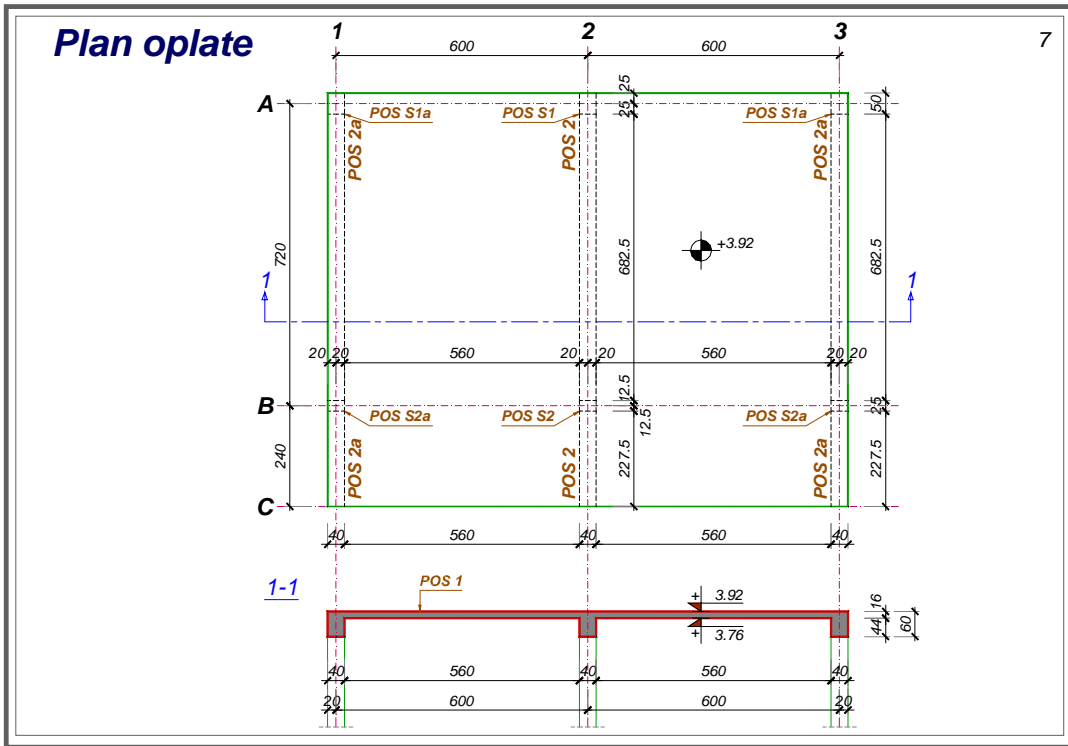
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Plan optate

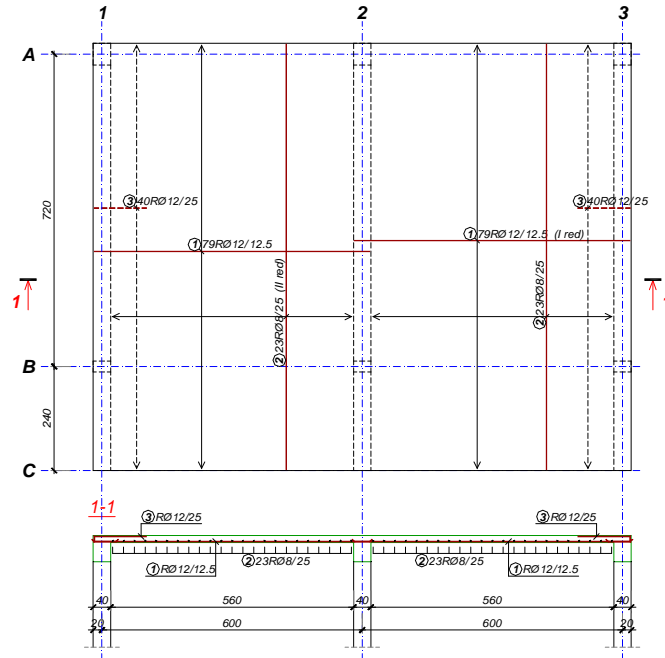
6





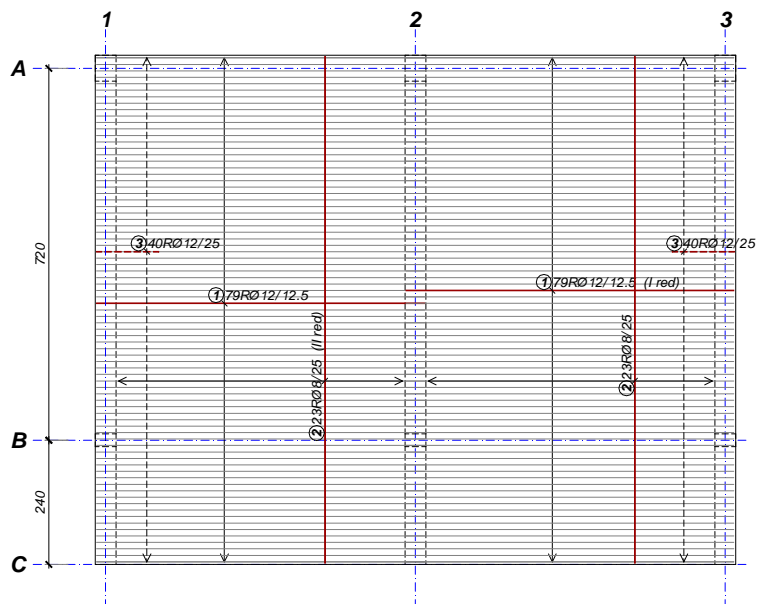
Plan armature - donja zona

9



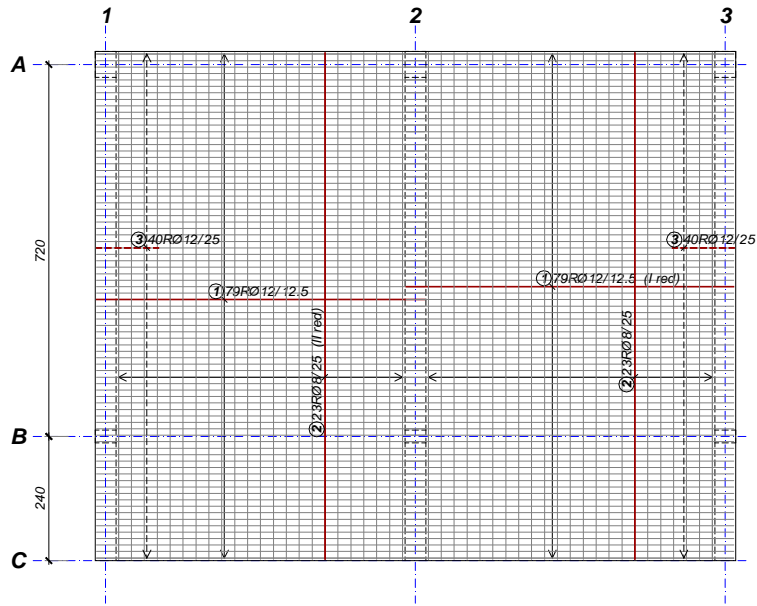
Donja zona – puni prikaz (1. sloj)

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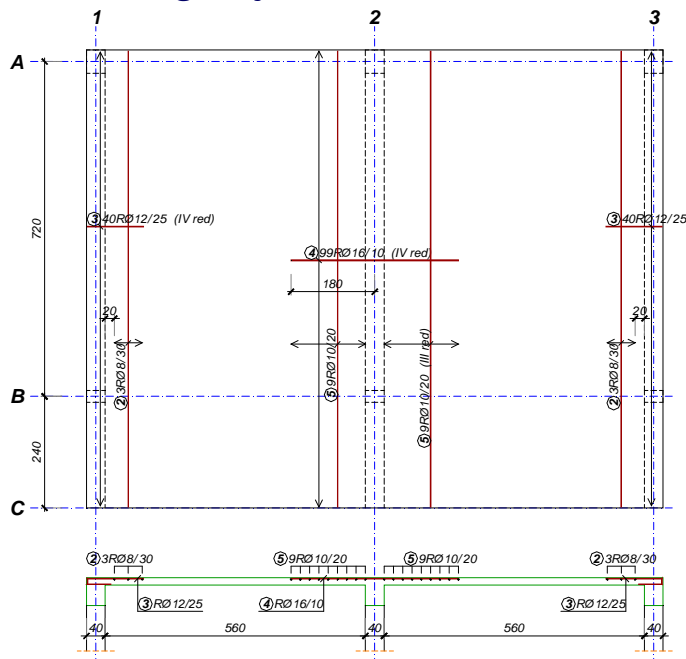
Donja zona – puni prikaz (1. i 2. sloj)

11



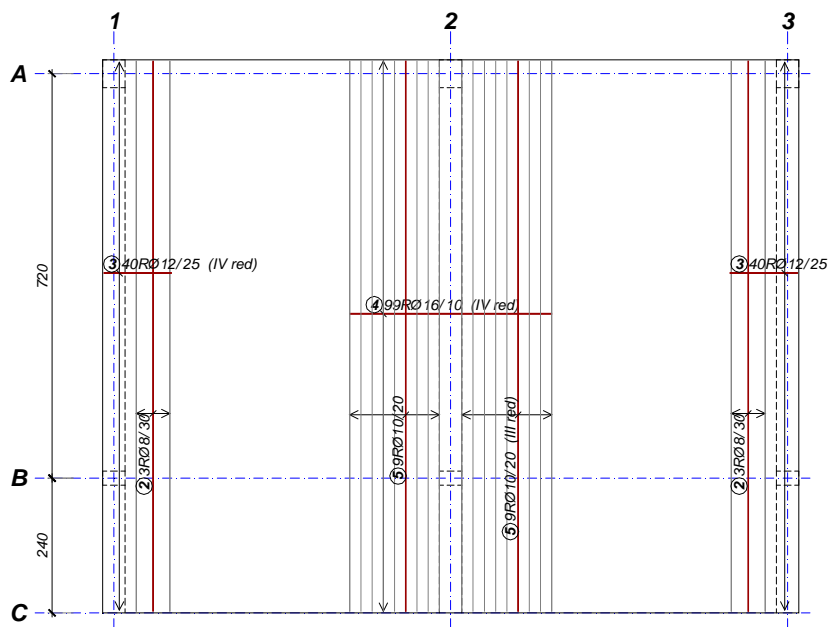
Plan armature - gornja zona

12



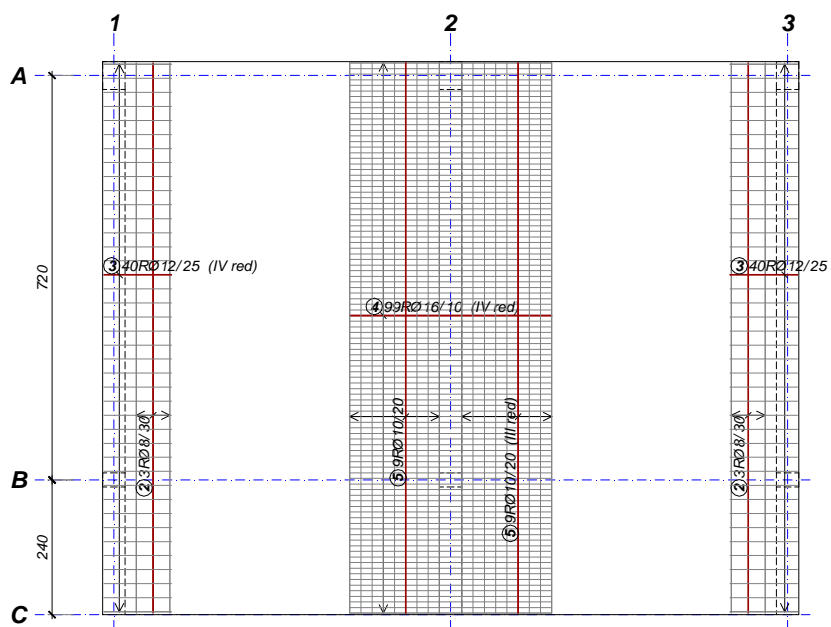
Gornja zona – puni prikaz (3. sloj)

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Gornja zona – puni prikaz (3. i 4. sloj)

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Specifikatori

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① 79RØ12/12.5 L=635 (158)
635

② 23RØ8/25 L=980 (52)
980

④ 99RØ16/10 L=360 (99)
360

⑥ 1RØ12 L=400 (8)
400

⑤ 9RØ10/20 L=980 (18)
980

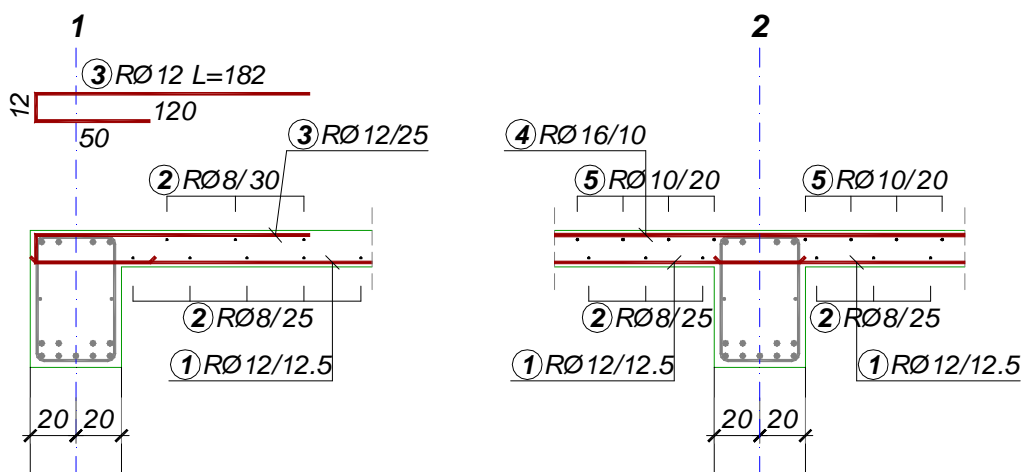
③ 40RØ12/25 L=182 (80)
 $\frac{12}{50} \frac{120}{50}$

⑦ 23RØ8/25 L=99 (92)
 $\frac{45}{45}$

⑧ RØ12 L=96 (192)
 $\frac{30}{25} \frac{96}{25}$

Detalji poprečnog preseka

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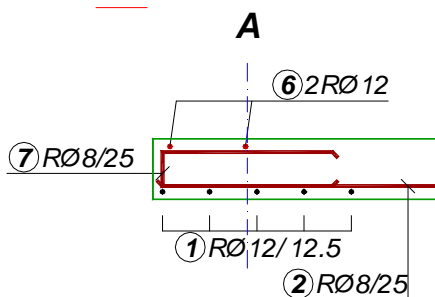
Detalj ojačanja slobodne ivice ploče

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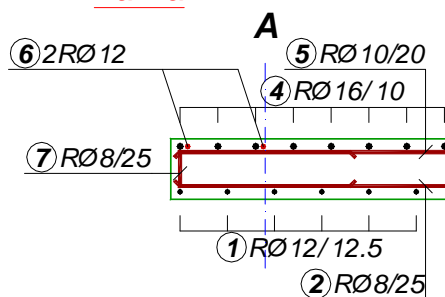
210

Duž slobodne ivice ploče bez oslonca, pored potrebne armature za momente savijanja, mora se dati podužna armatura iz konstruktivnih razloga, koja se sastoji od najmanje po jednog profila u gornjem i donjem uglu. Podužne šipke uz ivicu debljih polja, raspoređuju se i po visini ploče. Poprečna armatura duž slobodne ivice, koja obuhvata podužnu armaturu, sastoji se od uzengija "ukosnica", zatvorenih uzengija ili armature ploče upravne na slobodnu ivicu ploče (slika 52c).

2-2

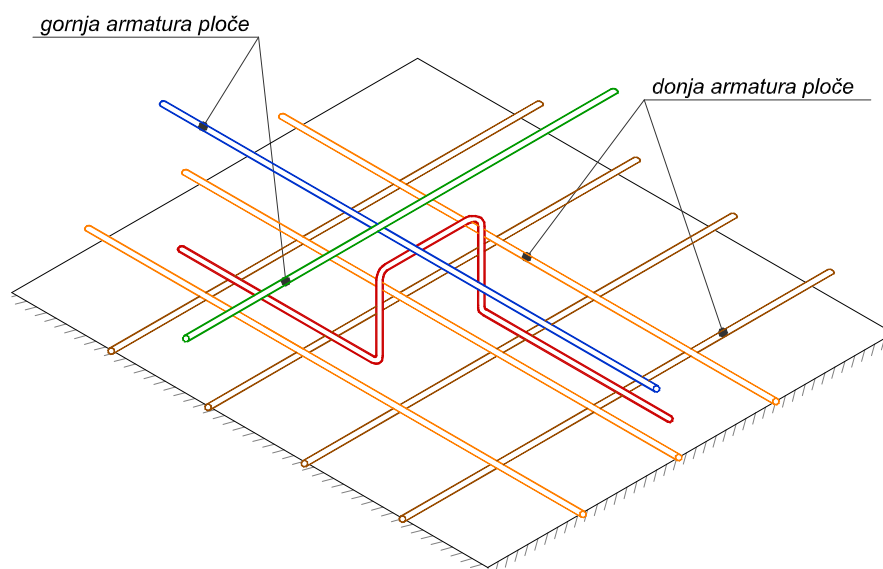


2a-2a



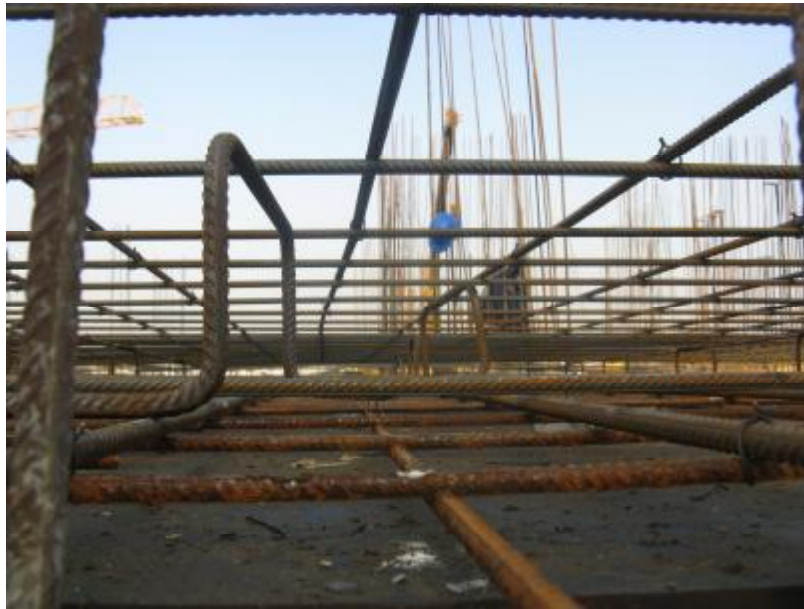
Detalj postavljanja distancera za gornju zonu

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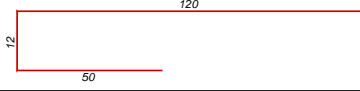



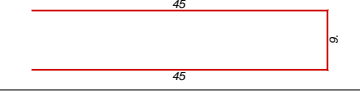
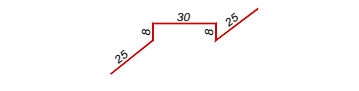
Distanceri za gornju zonu

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Specifikacija armature

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Šipke - specifikacija						
ozn.	oblik i mere [cm]	ozn.	Ø	lg [m]	n [kom]	lgn [m]
POS 1 - varijanta 1 (1 kom)						
1		RA2	12	6.35	158	1003.30
2		RA2	8	9.80	52	509.60
3		RA2	12	1.82	80	145.60
4		RA2	16	3.60	99	356.40
5		RA2	10	9.80	18	176.40
6		RA2	12	4.00	8	32.00
7		RA2	8	0.99	92	91.08
8		RA2	12	0.96	192	184.32

Rekapitulacija armature

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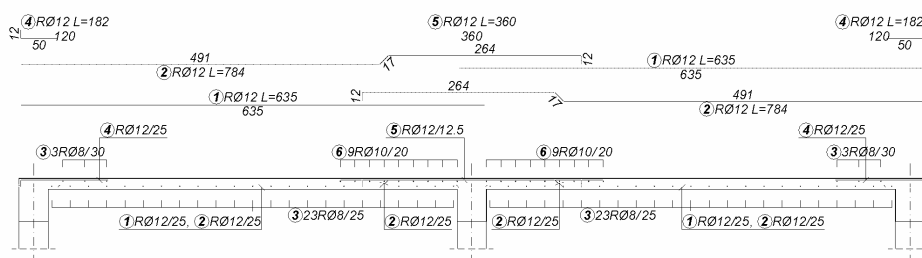
Šipke - rekapitulacija			
Ø [mm]	lgn [m]	Jedinicna težina [kg/m']	Težina [kg]
RA2			
8	600.68	0.405	243.28
10	176.40	0.633	111.66
12	1365.22	0.911	1243.72
16	356.40	1.621	577.72
Ukupno			2176.38

Usvajanje armature – varijanta 2

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1.3.1 Donja zona

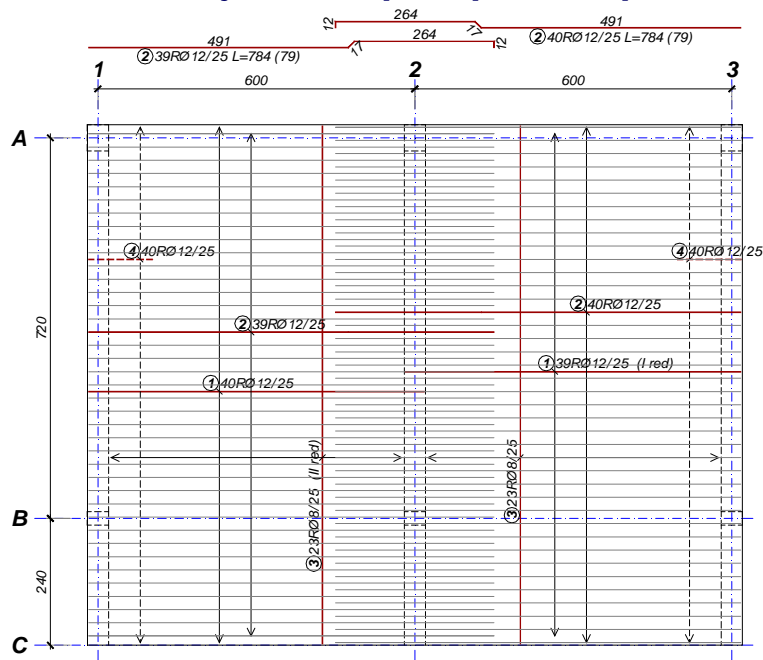
Usvojena armatura RØ12/12.5 u donjoj zoni će biti oblikovana iz dve grupe šipki, koje se naizmenično prepuštaju pravo (šipka broj 1) odnosno povijaju u gornju zonu kod srednjeg oslonca (šipka broj 2). Označeno rastojanje (RØ12/25) u poprečnom preseku na donjoj skici predstavlja osovinsko rastojanje istih pozicija armature. Njihovim naizmeničnim ređanjem u donjoj zoni, na mestu maksimalnih momenata savijanja, ostvareno je potrebno rastojanje profila od 12.5 cm.



Obezbeđivanje polovine armature iz polja u gornjoj zoni na krajnjim, slobodnim osloncima sa delimičnim elastičnim uklještenjem, je ostvareno postavljanjem ukosnica (šipke broj 4), mada je moguće spojiti ukosnicu sa šipkom 1 ili 2 (recimo, šipkom 2 koja je već savijena).

Donja zona – varijanta 2 – puni prikaz šipke 2

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Usvajanje armature – varijanta 2

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1.3.2 Gornja zona

Nakon postavljanja šipki broj 1 i 2, u gornjoj zoni se nalazi RØ12/25 iz levog, odnosno RØ12/25 iz desnog polja. Kako se šipke 1 i 2 naizmenično ređaju (na mestu gde je u levom polju šipka 1, u desnom je šipka 2), u gornjoj zoni se nalazi ukupno RØ12/12.5 cm. Međutim, potrebna površina armature u oslonačkom preseku je veća ($A_a = 16.69 \text{ cm}^2/\text{m}$, tačka 1.2.1) pa je neophodno dodati još armature (u ovom slučaju, prave šipke označene brojem 5). Smisleno rastojanje ove, dodatne armature, je 12.5 cm, s tim da će u ovom slučaju šipke 5 biti postavljene neposredno uz šipke 2. Naime, ukoliko bi se šipke 5 postavile između povijenih šipki 2, osovinsko rastojanje armature u gornjoj zoni bilo bi 6.25 cm, što nije dobro rešenje sa aspekta ugrađivanja betona.

Rastojanje dodatne armature (šipke 5) je usvojeno, pa je potrebno usvojiti njihov prečnik. Ukupna površina šipki 2 povijenih iz gornje u gornju zonu je

$$A_{a,1} = \frac{100 \times 1.13}{25} + \frac{100 \times 1.13}{25} = 4.52 + 4.52 = 9.05 \frac{\text{cm}^2}{\text{m}}$$

Nedostajuća površina armature u gornjoj zoni je:

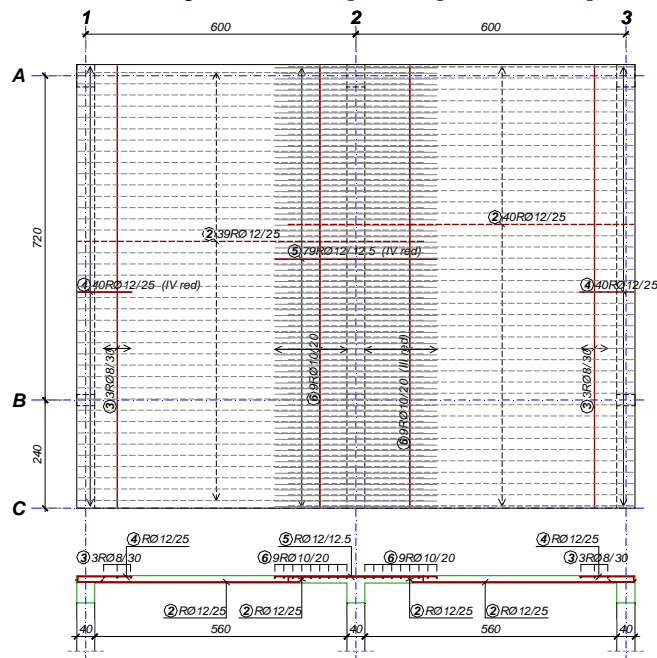
$$\Delta A_{a,1} = 16.69 - 9.05 = 7.64 \frac{\text{cm}^2}{\text{m}}$$

$$a_a^{(1)} = \frac{e_a}{100} \times \Delta A_{a,1} = \frac{12.5 \times 7.64}{100} = 0.96 \text{ cm}^2 \Rightarrow \text{usvojeno } RØ12 \text{ (} a_a^{(1)} = 1.13 \text{ cm}^2 \text{)}$$

usvojeno: **Ø12/12.5** (9.05 cm²/m) – dodatne šipke

Gornja zona – varijanta 2 – puni prikaz šipki 2 i 4

25



Donja zona – varijanta 3 (sa mrežama)

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1.2.2 DONJA ZONA

$$M_L = 1.6 \times 15.2 + 1.8 \times 10.1 = 42.5 \text{ kNm/m}$$

$$\text{pretp } \varnothing 12 \rightarrow a_s = a_c + \frac{\varnothing}{2} = 20 + \frac{1.2}{2} = 2.6 \text{ cm} \rightarrow b/d/h = 100/16/13.4 \text{ cm}$$

$$k = \frac{13.4}{\sqrt{42.5}} = 2.942 \rightarrow \epsilon_{bf}/\epsilon_{so} = 2.176/10\%_0 ; \bar{\mu} = 12.396\%$$

$$A_s = 12.396 \times 13.4 \times \frac{2.05}{40} = 8.51 \text{ cm}^2/\text{m} > A_{s,\text{min}} = 0.10 \times 16 = 1.6 \text{ cm}^2/\text{m}$$

Za usvojeno MA 500/560 ($s_v = 500 \text{ MPa} = 50 \text{ kN/cm}^2$):

$$A_s = 12.396 \times 13.4 \times \frac{2.05}{50} = 8.51 \times \frac{40}{50} = 6.81 \frac{\text{cm}^2}{\text{m}}$$

usvojeno: R-753
 glavna armatura: $\varnothing 12/15$ (7.53 cm²/m)
 poprečna armatura: $\varnothing 8/25$ (2.01 cm²/m)

Preklapanje mreža – član 163 PBAB 87

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Tabela 28. Dužina preklopa nosivih žica mrežaste armature

Podužne žice u nosivom pravcu	Prečnik ϕ (u mm)	Uslovi adhezije	Dužina preklopa (u cm)		Najmanji broj poprečnih žica (čvorova)	
			MAG	MAR	MAG	MAR
Jednostruke žice	$\phi < 12$	dobri	40	35	4	3
		lošiji	40	35	5	3
Dvostruke žice	$\phi \leq 8,5$	dobri	40	35	4	3
		lošiji	40	35	5	4
Dvostruke žice	$8,5 < \phi \leq 12$	dobri	50	45	5	4
		lošiji	50	45	6	5

Dužina preklopa glatke i orebrenе nenosive žice mrežaste armature data je u tabeli 29.

Tabela 29 Dužina preklopa nenosivih žica mrežaste armature

Poprečne žice	Prečnik žice	Uslovi adhezije	Dužina preklopa (u cm)	Broj podužnih žica (čvorova)
Jednostruke i dvostruke žice	$\phi \leq 6,5$	dobri	15	2
	$\phi > 6,5$	lošiji	20	3

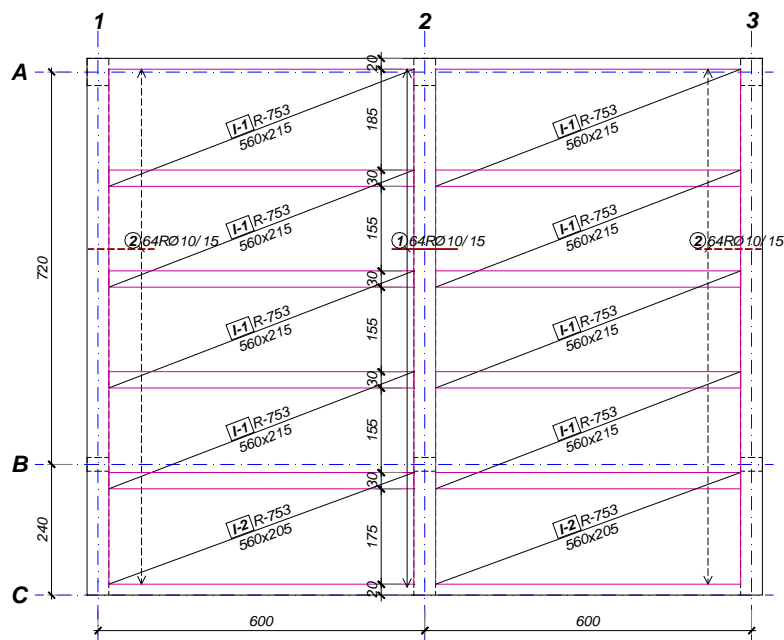
usvojeno: R-753

preklop glavne armature ($\phi 12$): $(4-1) \times 25 = 75 \text{ cm}$

preklop poprečne armature ($\phi 8$): $(3-1) \times 15 = 30 \text{ cm}$

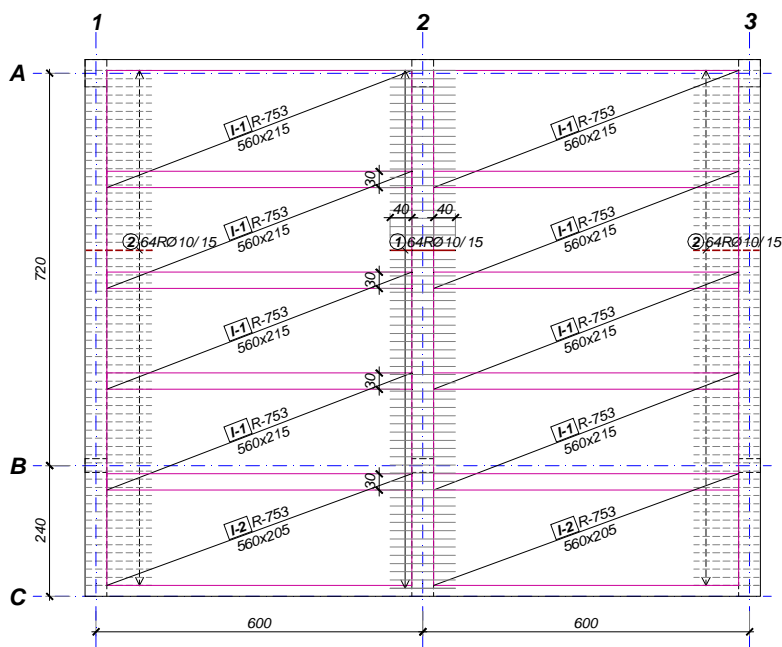
Donja zona – varijanta sa mrežama

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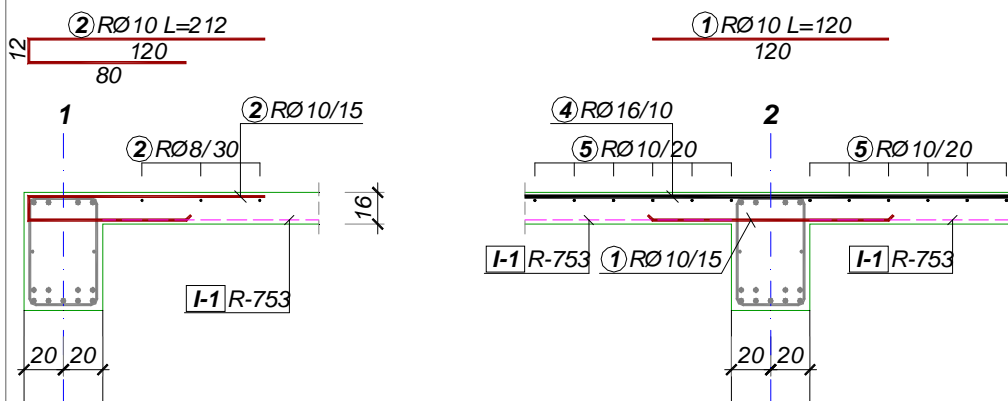
Donja zona – varijanta sa mrežama (puni prikaz)

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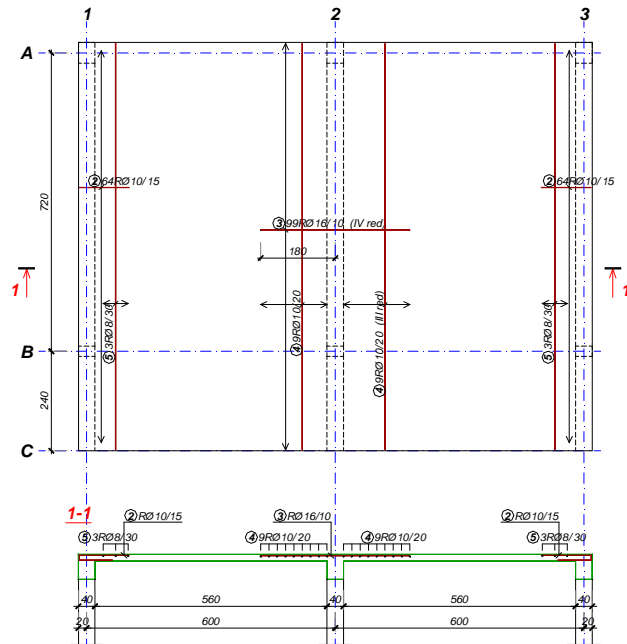
Detalji poprečnog preseka – varijanta MREŽE

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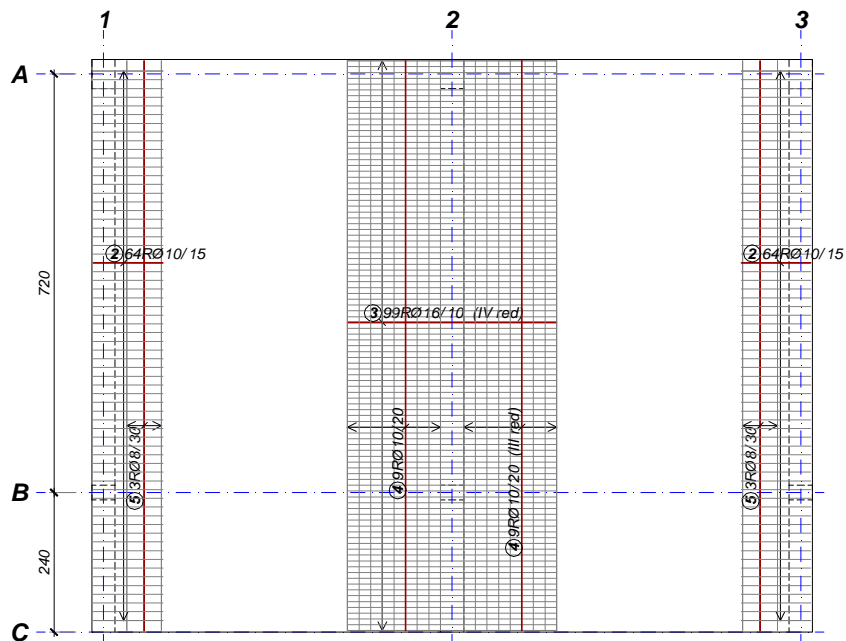
Gornja zona (u svemu kao varijanta 1)

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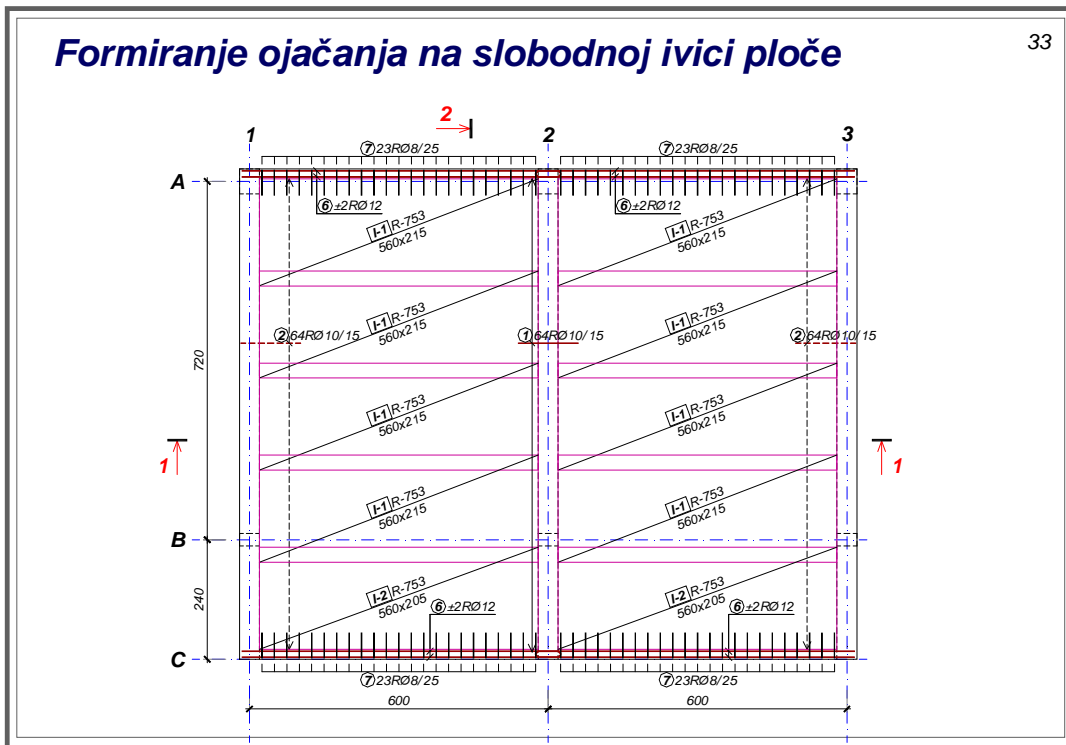
Gornja zona – puni prikaz

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Formiranje ojačanja na slobodnoj ivici ploče

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1.2 PRORAČUN DEFORMACIJA POS 1

Kao reprezentativan se usvaja presek u polju. Potrebne geometrijske karakteristike neisprskalog betonskog preseka i položaj težišta ukupne armature u preseku dati su izrazima:

$$A_b^I = b \times d = 100 \times 16 = 1600 \text{ cm}^2/\text{m}$$

$$y_{b1} = y_{b2} = d/2 = 16 / 2 = 8.0 \text{ cm}$$

$$J_b^I = \frac{b \times d^3}{12} = \frac{100 \times 16^3}{12} = 34133 \text{ cm}^4/\text{m}$$

$$A_{a1} = 9.05 \text{ cm}^2/\text{m} (\text{Ø}12/12.5) \quad ; \quad A_{a2} = 0 \quad \Rightarrow \quad A_a = A_{a1} + A_{a2} = 9.05 \text{ cm}^2/\text{m}$$

Položaj težišta ukupne armature u odnosu na gornju ivicu preseka, kao i položajni moment inercije armature u odnosu na težište ukupne armature, određeni su kao:

$$y_{a2} = h = 13.4 \text{ cm} \quad ; \quad J_a = 0$$

1.2.1 ELASTIČNO REŠENJE

Ugib u sredini raspona kontinualnog nosača preko tri oslonca, opterećenog jednako raspodeljenim opterećenjem $q=g+p$, uvodeći u proračun moment inercije BRUTO BETONSKOG PRESEKA, određen je izrazom:

$$v_b = \frac{2 \times q \times l^4}{384 \times E_b \times J_b} = \frac{2 \times (6.0 + 4.0) \times 6.0^4}{384 \times 31.5 \times 10^6 \times 34133 \times 10^{-8}} = 6.28 \times 10^{-3} \text{ m} = 6.28 \text{ mm}$$

1.2.2 PRORAČUN UGIBA U TRENUTKU NANOŠENJA OPTEREĆENJA

1.2.2.1 Početni ugib, ukupno opterećenje

Stanje I (bez prslina) - ukupno opterećenje

$$n = \frac{E_a}{E_b} = \frac{210}{31.5} = 6.67$$

$$A_i' = A_b' + n \times A_a = 1600 + 6.67 \times 9.05 = 1660.3 \text{ cm}^2/\text{m}$$

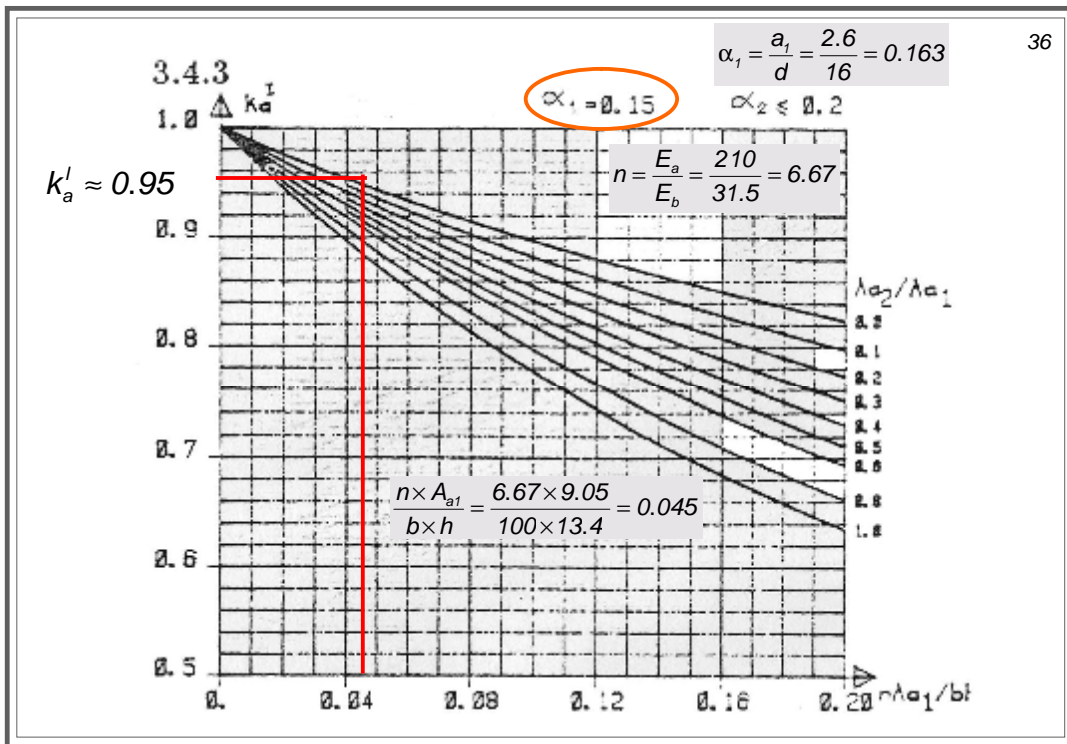
$$y_{i2}' = y_{b2}' + \frac{(y_{a2} - y_{b2}') \times n \times A_a}{A_i'} = 8.0 + \frac{(13.4 - 8.0) \times 6.67 \times 9.05}{1660.3} = 8.20 \text{ cm}$$

$$J_i' = J_b' + n \times J_a + A_b' \times (y_{a2} - y_{b2}') \times (y_{i2}' - y_{b2}')$$

$$J_i' = 34133 + 0 + 1600 \times (13.4 - 8.0) \times (8.20 - 8.0) = 35828 \text{ cm}^4/\text{m}$$

$$k_a' = \frac{J_b'}{J_i'} = \frac{34133}{35828} = 0.953$$

$$v_0' = k_a' \times v_b = 0.953 \times 6.28 = 6.0 \text{ mm}$$



1.1.1 ODREĐIVANJE NAPONA U ZATEGNUTOJ ARMATURI

$$n = \frac{E_a}{E_b} = \frac{210}{31.5} = 6.67 \quad ; \quad \alpha_2 = \frac{a_2}{h} = 0$$

$$\mu_1 = \frac{A_{a1}}{b \times h} = \frac{9.05}{100 \times 13.4} = 0.68\% \quad ; \quad \mu_2 = \frac{A_{a2}}{b \times h} = 0$$

$$s^2 + 2 \times 6.67 \times 0.68 \times 10^{-2} \times s - 2 \times 6.67 \times 0.68 \times 10^{-2} = 0$$

$$s^2 + 0.090 \times s - 0.090 = 0 \Rightarrow s = \mathbf{0.258}$$

Koeficijent kraka unutrašnjih sila određuje se iz izraza:

$$\zeta_b = 1 - \frac{s}{3} = 1 - \frac{0.258}{3} = 0.914 \Rightarrow z_b = \zeta_b \times h = 0.914 \times 13.4 = 12.25 \text{ cm}$$

$$\sigma_{a1} = \frac{M}{z_b \times A_{a1}} = \frac{(15.2 + 10.1) \times 10^2}{12.25 \times 9.05} = 22.85 \text{ kN/cm}^2 = 228.5 \text{ MPa}$$

$$\varepsilon_{a1} = \frac{\sigma_{a1}}{E_a} = \frac{228.5}{210 \times 10^3} = 1.088\%$$

Stanje II (sa prslinama) - ukupno opterećenje

Položaj neutralne linije određen je kod proračuna prslina ($s = 0.258$):

$$x'' = s \times h = 0.258 \times 13.4 = 3.46 \text{ cm}$$

$$A_b'' = b \times x'' = 100 \times 3.46 = 346 \text{ cm}^2/\text{m}$$

$$y_b'' = \frac{x''}{2} = \frac{3.46}{2} = 1.73 \text{ cm}$$

$$J_b'' = \frac{b \times (x'')^3}{12} = \frac{100 \times 3.46^3}{12} = 346 \text{ cm}^4/\text{m}$$

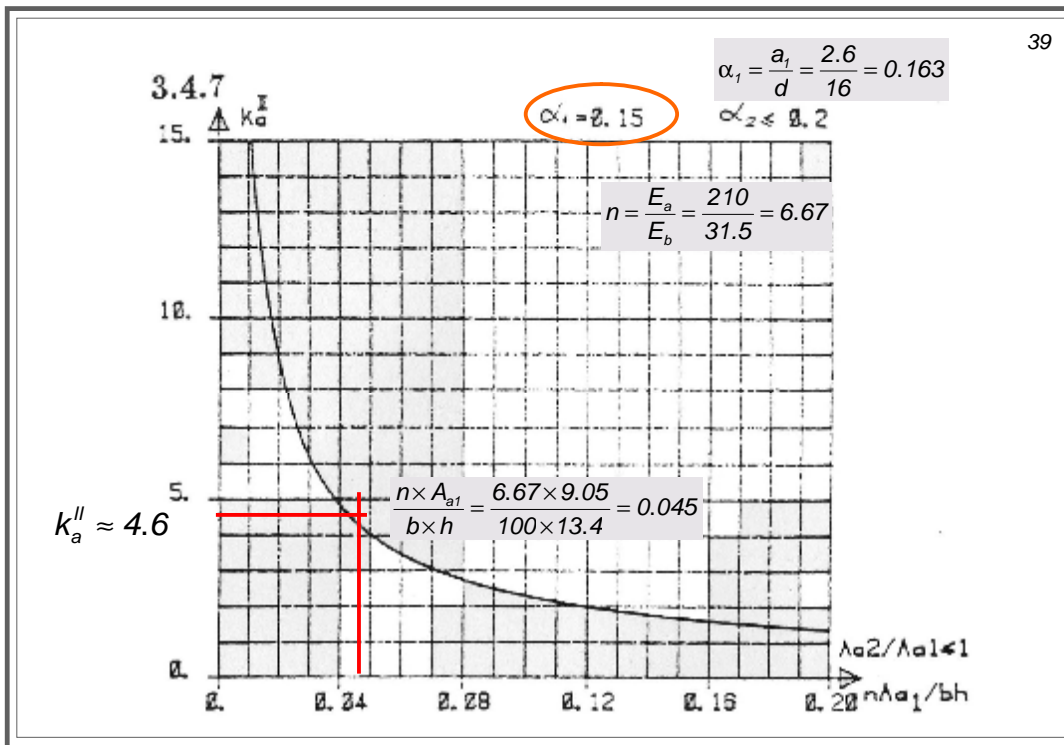
$$y_{i2}'' = x'' = 3.46 \text{ cm}$$

$$J_i'' = J_b'' + n \times J_a + A_b'' \times (y_{a2} - y_{b2}'') \times (y_{i2}'' - y_{b2}'')$$

$$J_i'' = 346 + 0 + 346 \times (13.4 - 1.73) \times (3.46 - 1.73) = 7340 \text{ cm}^4/\text{m}$$

$$k_a'' = \frac{J_b''}{J_i''} = \frac{34133}{7340} = 4.65$$

$$v_0'' = k_a'' \times v_b = 4.65 \times 6.28 = 29.2 \text{ mm}$$



Početni ugib u trenutku $t=0$ (ukupno opterećenje)

$$W_{i1}^I = \frac{J_i^I}{y_{i1}^I} = \frac{J_i^I}{d - y_{i2}^I} = \frac{35828}{16 - 8.20} = 4591 \text{ cm}^3/\text{m}$$

$$f_{bzs} = 2.40 \times \left(0.6 + \frac{0.4}{\sqrt[4]{0.16}} \right) = 2.96 \text{ MPa} = 0.296 \text{ kN/cm}^2$$

$$M_r = 0.296 \times 4591 \times 10^{-2} = 13.6 \text{ kNm/m} < M = M_g + M_p = 25.3 \text{ kNm/m}$$

$$\left. \begin{array}{l} \beta_1 = 1.0 \text{ (RA 400 / 500)} \\ \beta_2 = 1.0 \text{ (} t=0 \text{)} \end{array} \right\} \Rightarrow \zeta_{0,g+p} = 1 - 1.0 \times 1.0 \times \frac{13.6}{25.3} = 0.464$$

$$v_{g+p,0} = (1 - 0.464) \times 6.0 + 0.464 \times 29.2 = 16.7 \text{ mm}$$

Maksimalni ugib grede usled ukupnog, stalnog i povremenog opterećenja, u trenutku nanošenja opterećenja ($t=0$), je $v_{g+p,0} = 16.7 \text{ mm}$.

1.4.2.2 Početni ugib, stalno opterećenje

Stanje I (bez prslina) - stalno opterećenje

$$v_{g,0}^I = \frac{g}{g+p} \times v_{g+p,0}^I = \frac{6.0}{6.0+4.0} \times 6.0 = 3.6 \text{ mm}$$

Stanje II (sa prslinama) - stalno opterećenje

$$v_{g,0}^{II} = \frac{g}{g+p} \times v_{g+p,0}^{II} = \frac{6.0}{6.0+4.0} \times 29.2 = 17.5 \text{ mm}$$

Početni ugib u trenutku $t=0$ (stalno opterećenje)

$$\left. \begin{array}{l} \beta_1 = 1.0 \text{ (RA 400 / 500)} \\ \beta_2 = 1.0 \text{ (} t = 0 \text{)} \end{array} \right\} \Rightarrow \zeta_{0,g} = 1 - 1.0 \times 1.0 \times \frac{13.6}{15.2} = 0.106$$

$$v_{g,0} = (1 - 0.106) \times 3.6 + 0.106 \times 17.5 = 5.1 \text{ mm}$$

1.4.3 PRORAČUN UGIBA U TOKU VREMENA

$$\left. \begin{array}{l} \chi_{\infty} = 0.8 \\ \varphi_{\infty} = 2.5 \end{array} \right\} \Rightarrow \chi_{\infty} \times \varphi_{\infty} = 0.8 \times 2.5 = 2.0$$

$$E_b^* = \frac{E_b}{1 + \chi_{\infty} \varphi_{\infty}} = \frac{31.5}{1 + 2.0} = 10.5 \text{ GPa} \Rightarrow n^* = \frac{E_a}{E_b^*} = \frac{210}{10.5} = 20$$

1.4.3.1 Trajni ugib, stalno opterećenje

Stanje I (bez prslina) - stalno opterećenje

$$A_i^I = A_b^I + n^* \times A_a = 1600 + 20 \times 9.05 = 1781 \text{ cm}^2/\text{m}$$

$$y_{i2}^I = y_{b2}^I + \frac{(y_{a2} - y_{b2}^I) \times n^* \times A_a}{A_i^I} = 8.0 + \frac{(13.4 - 8.0) \times 20 \times 9.05}{1781} = 8.55 \text{ cm}$$

$$J_i^I = J_b^I + n^* \times J_a + A_b^I \times (y_{a2} - y_{b2}^I) \times (y_{i2}^I - y_{b2}^I)$$

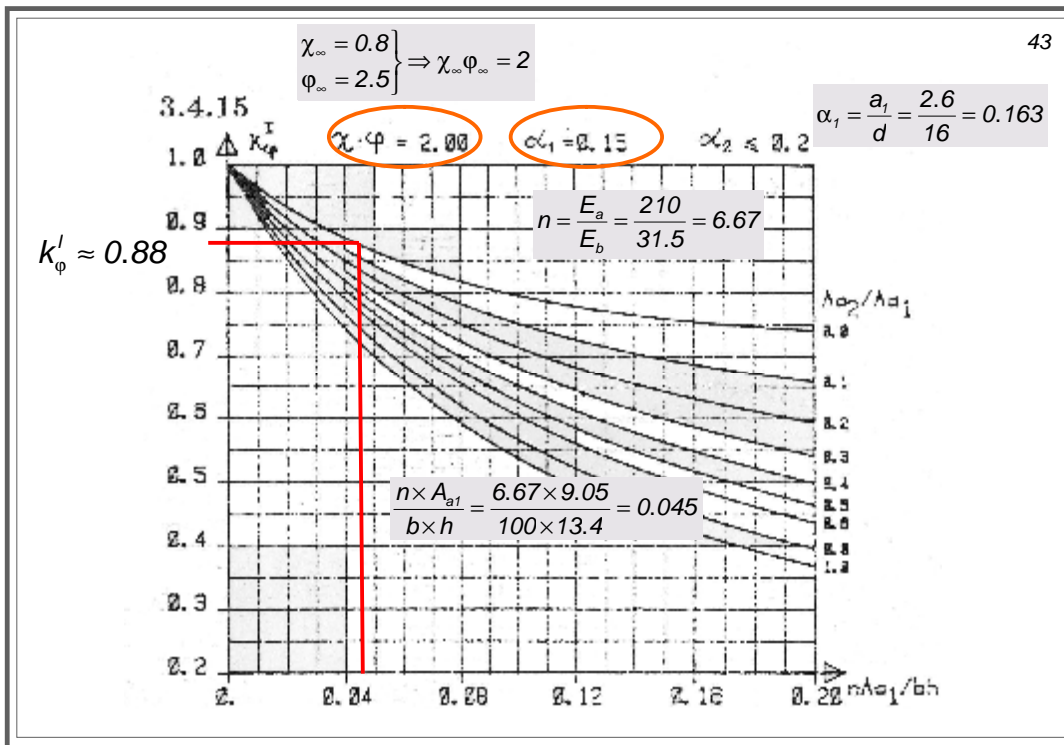
$$J_i^I = 34133 + 0 + 1600 \times (13.4 - 8.0) \times (8.55 - 8.0) = 38874 \text{ cm}^4/\text{m}$$

$$k_{\varphi}^I = 1 - \frac{n^*}{J_i^I} \times [J_a + A_a \times (y_{a2} - y_{i2}^I) \times (y_{a2} - y_{i2}^I)]$$

$$k_{\varphi}^I = 1 - \frac{20}{38874} \times [0 + 9.05 \times (13.4 - 8.20) \times (13.4 - 8.55)] = 0.882$$

$$v_{\infty,g}^I = k_{\varphi}^I \times (1 + k_{\varphi}^I \times \varphi_{\infty}) \times v_{b,g} = (1 + k_{\varphi}^I \times \varphi_{\infty}) \times v_{0,g}^I$$

$$v_{g,\infty}^I = (1 + 0.882 \times 2.5) \times 3.6 = 11.5 \text{ mm}$$



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Stanje II (sa prslinama) - stalno opterećenje

$$A_i^{II} = A_b^{II} + n^* \times A_a = 346 + 20 \times 9.05 = 527 \text{ cm}^2/\text{m}$$

$$y_{i2}^{II} = y_{b2}^{II} + \frac{(y_{a2} - y_{b2}^{II}) \times n^* \times A_a}{A_i^{II}} = 1.64 + \frac{(13.4 - 1.73) \times 20 \times 9.05}{527} = 5.74 \text{ cm}$$

$$J_i^{II} = J_b^{II} + n^* \times J_a + A_b^{II} \times (y_{a2} - y_{b2}^{II}) \times (y_{i2}^{II} - y_{b2}^{II})$$

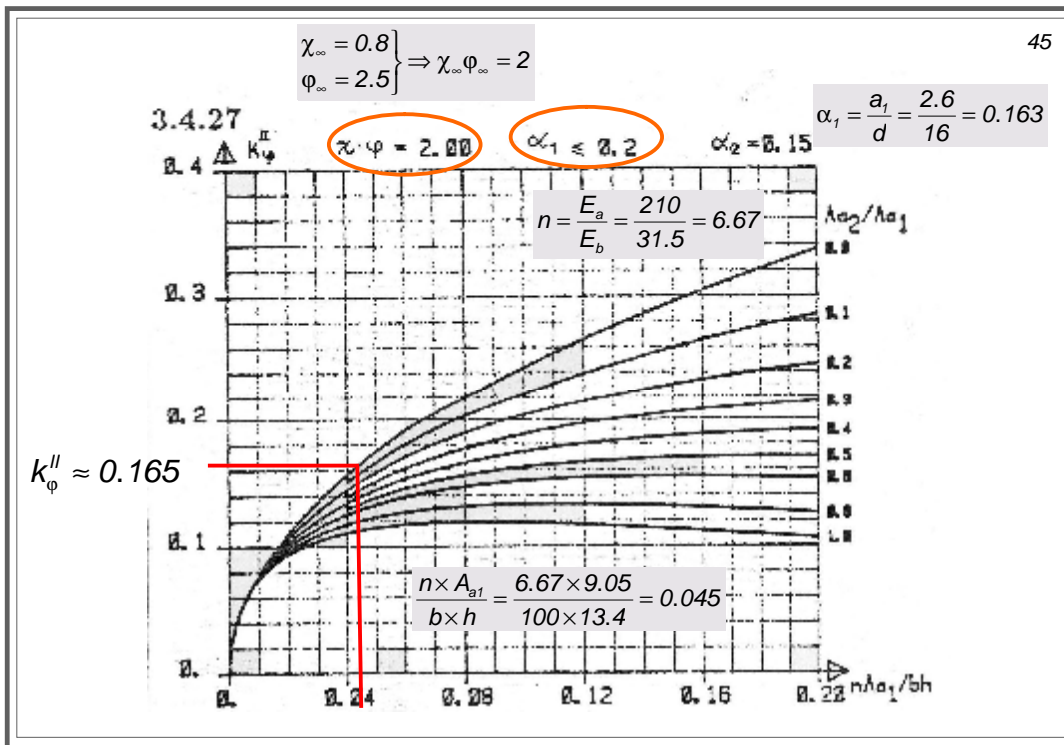
$$J_i^{II} = 346 + 0 + 346 \times (13.4 - 1.73) \times (5.74 - 1.73) = 16528 \text{ cm}^4/\text{m}$$

$$k_{\varphi}^{II} = 1 - \frac{n^*}{J_i^{II}} \times [J_a + A_a \times (y_{a2} - y_{i2}^{II}) \times (y_{a2} - y_{i2}^{II})]$$

$$k_{\varphi}^{II} = 1 - \frac{20}{16528} \times [0 + 9.05 \times (13.4 - 3.46) \times (13.4 - 5.74)] = 0.166$$

$$v_{\infty, g}^{II} = k_a^{II} \times (1 + k_{\varphi}^{II} \times \varphi_{\infty}) \times v_{b, g} = (1 + k_{\varphi}^{II} \times \varphi_{\infty}) \times v_{0, g}^{II}$$

$$v_{g, \infty}^{II} = (1 + 0.166 \times 2.5) \times 17.5 = 24.8 \text{ mm}$$



Trajni ugib u trenutku $t \rightarrow \infty$ (stalno opterećenje)

$$\left. \begin{array}{l} \beta_1 = 1.0 \text{ (RA 400/500)} \\ \beta_2 = 0.5 \text{ (} t \rightarrow \infty \text{)} \end{array} \right\} \Rightarrow \zeta_{\infty, g} = 1 - 1.0 \times 0.5 \times \frac{13.6}{15.2} = 0.553$$

$$v_{g, \infty} = (1 - 0.553) \times 11.5 + 0.553 \times 24.8 = 18.9 \text{ mm}$$

1.4.3.2 Trajni ugib, ukupno opterećenje

Konačna vrednost ugiba usled dejstva dugotrajnog i kratkotrajnog opterećenja:

$$v_{g+p, \infty} = v_{g+p, 0} + (v_{g, \infty} - v_{g, 0})$$

$$v_{g+p, \infty} = v_{max} = 16.7 + (18.9 - 5.1) = 30.5 \text{ mm}$$

$$v_{g+p, \infty} = v_{max.} \approx 3.0 \text{ cm} > v_{dop.} = \frac{L}{300} = \frac{600}{300} = 2 \text{ cm}$$