

Vođenje podužne armature

Za dati nosač i opterećenje:

- izvršiti analizu opterećenja,
- nacrtati dijagrame uticaja od stalnog i povremenog opterećenja,
- dimenzionisati nosač na momente savijanja u karakterističnim presecima,
- izvršiti kontrolu smičućih napona u karakterističnim presecima i po potrebi izvišiti osiguranje armaturom,
- nacrtati plan armiranja nosača,
- uraditi izvod i rekapitulaciju armaturnih profila.

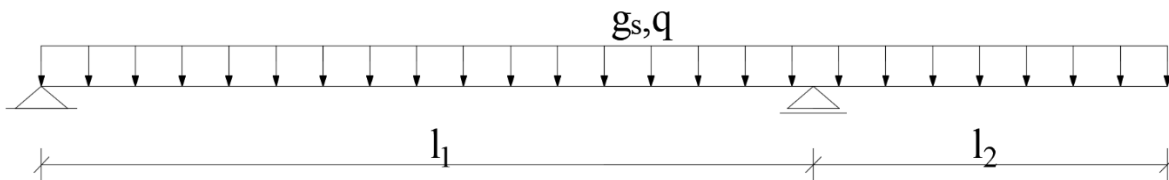
Podužni presek nacrtati u razmeri 1:25.

Poprečne preseke nacrtati u razmeri 1:10.

$$g=28\frac{\text{kN}}{\text{m}'} \quad q=11\frac{\text{kN}}{\text{m}'} \quad l_1=575\text{cm} \quad l_2=195\text{cm}$$

$$b=35\text{cm} \quad h=50\text{cm} \quad \text{C25/30} \quad \text{B500B}$$

$$b_{\text{sup}}=35\text{cm}-\text{širina oslonca}$$



Analiza opterećenja

1) Stalno opterećenje:

Sopstvena težina nosača:

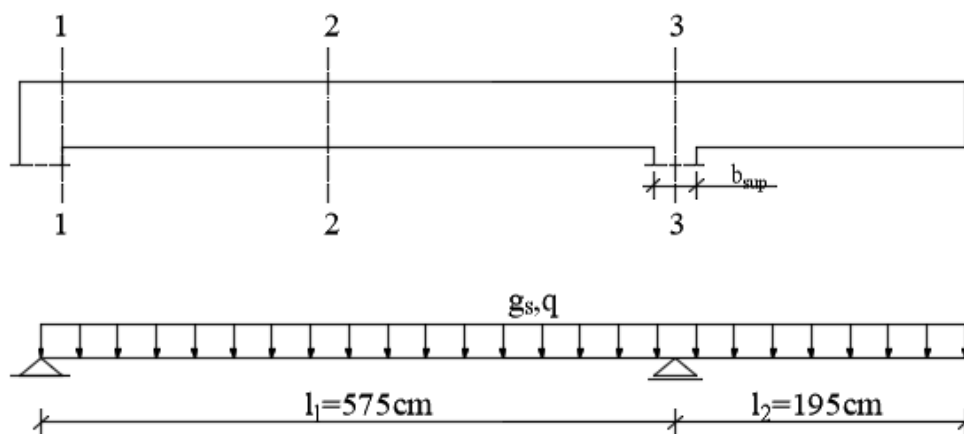
$$g_{\text{stn}}=b \cdot h \cdot 25\frac{\text{kN}}{\text{m}^3} \rightarrow g_{\text{stn}}=0,35 \cdot 0,50 \cdot 25 \rightarrow g_{\text{stn}}=4,37\frac{\text{kN}}{\text{m}'}$$

Ukupno stalno opterećenje:

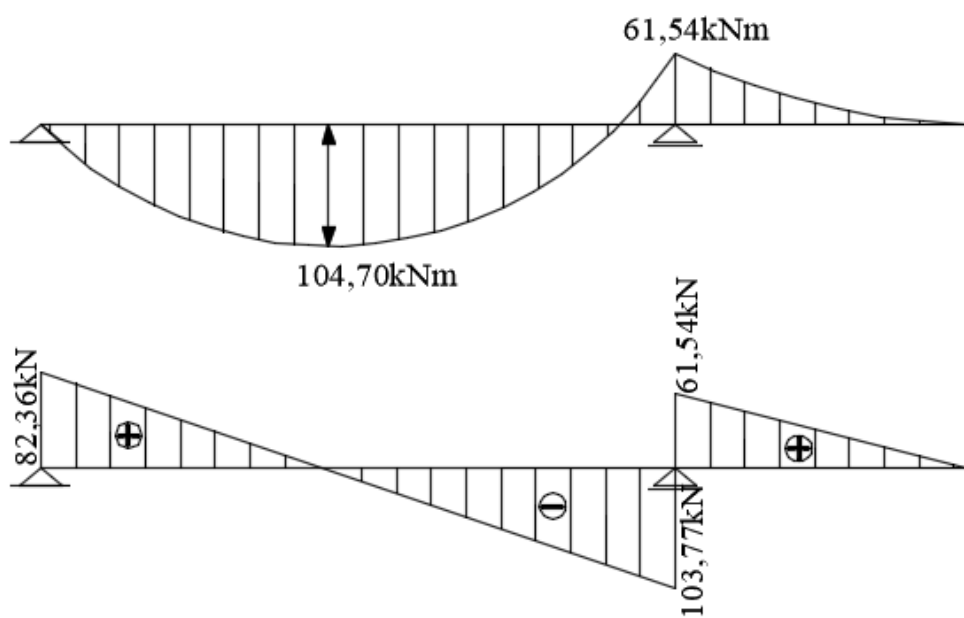
$$g_s=g_{\text{stn}}+g \rightarrow g_s=4,37+28 \rightarrow g_s=32,37\frac{\text{kN}}{\text{m}'}$$

2) Povremeno opterećenje:

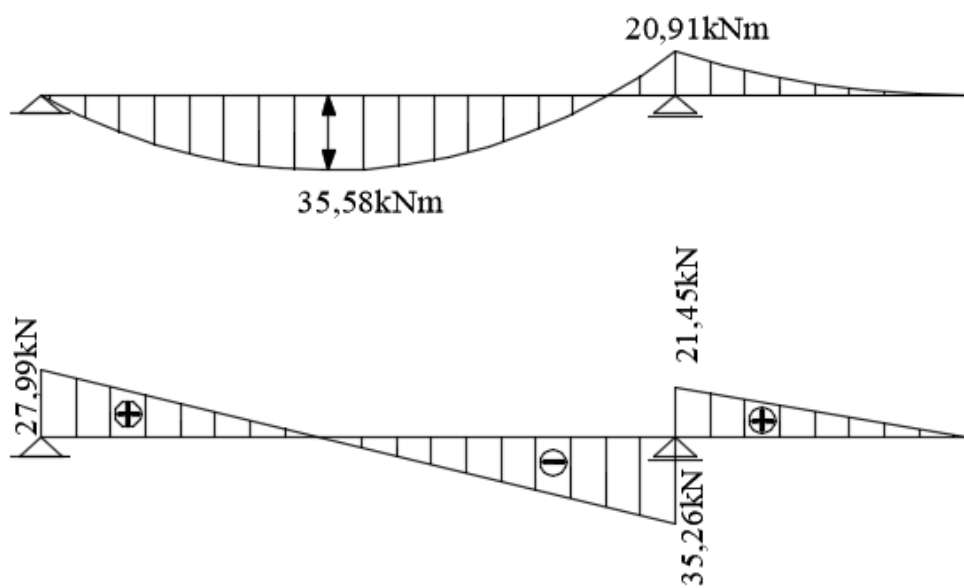
$$q=11\frac{\text{kN}}{\text{m}'}$$



Uticaji usled stalnog opterećenja [g_s]:



Uticaji usled povremenog opterećenja [q]:



Karakteristike materijala:

$$C25 / 30 \Rightarrow f_{cd} = \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_c} = 1,00 \cdot \frac{25}{1,5} = 16,67 \text{MPa} = 1,67 \frac{\text{kN}}{\text{cm}^2}$$

$$B500B \Rightarrow f_{yd} = \frac{f_{yk}}{\gamma_s} = \frac{500}{1,15} = 434,78 \text{MPa} = 43,48 \frac{\text{kN}}{\text{cm}^2}$$

$$d=0,9 \cdot h \rightarrow d=45 \text{cm}$$

Dimenzionisanje

Proračun armature za preuzimanje napona zatezanja

Napomena: dimenzionisanje armature za preuzimanje napona zatezanja se vrši za preseke nosača gde momentni dijagram (povremenog i stalnog opterećenja) dostiže ekstremnu vrednost, a to su preseki 2-2 i 3-3

Presek 2-2:

Statički uticaji:

$$M_{Ed} = 1,35 \cdot M_G + 1,5 \cdot M_Q$$

$$M_{Ed} = 1,35 \cdot 104,70 + 1,5 \cdot 35,58 = 194,72 \text{kNm} = M_{Eds}$$

$$\mu_{Ed} = \frac{M_{Eds}}{b \cdot d^2 \cdot f_{cd}} = \frac{194,72 \cdot 10^2}{35 \cdot 45^2 \cdot 16,67 \cdot 10^{-1}} = 0,164 < \mu_{lim} = 0,296$$

Očitano za $\mu=0,166$: $\omega = 0,183$; $\xi = 0,226$; $\zeta = 0,906$;

$$A_{s1}^{2-2} = \omega \cdot b \cdot d \cdot \frac{f_{cd}}{f_{yd}}$$

$$A_{s1}^{2-2} = 0,183 \cdot 35 \cdot 45 \cdot \frac{16,67}{434,78} = 11,05 \text{cm}^2 \rightarrow \text{Usvojeno } 4R\text{Ø}20(12,57 \text{cm}^2)$$

Presek 3-3:

Statički uticaji:

$$M_{Ed} = 1,35 \cdot M_G + 1,5 \cdot M_Q$$

$$M_{Ed} = 1,35 \cdot 61,54 + 1,5 \cdot 20,91 = 114,45 \text{kNm} = M_{Eds}$$

$$\mu_{Ed} = \frac{M_{Eds}}{b \cdot d^2 \cdot f_{cd}} = \frac{114,45 \cdot 10^2}{35 \cdot 45^2 \cdot 16,67 \cdot 10^{-1}} = 0,096 < \mu_{lim} = 0,296$$

Očitano za $\mu=0,096$: $\omega = 0,101$; $\xi = 0,130$; $\zeta = 0,947$;

$$A_{s1}^{3-3} = \omega \cdot b \cdot d \cdot \frac{f_{cd}}{f_{yd}}$$

$$A_{s1}^{3-3} = 0,101 \cdot 35 \cdot 45 \cdot \frac{16,67}{434,78} = 6,10 \text{cm}^2 \rightarrow \text{Usvojeno } 2R\text{Ø}20(6,28 \text{cm}^2)$$

-Minimalna potrebna površina armature za savijanje:

$$A_{s,min} \geq \max \left\{ \begin{array}{l} 0,26 \cdot \frac{f_{ctm}}{f_{yk}} \cdot b \cdot d \\ 0,0013 \cdot b \cdot d \end{array} \right.$$

C30/37 → $f_{ctm}=2,6\text{MPa}$ - srednja vrednost čvrstoće betona pri zatezanju (Tabela 3.1.- EC2)

$$A_{s,min} \geq \max \left\{ \begin{array}{l} 0,26 \cdot \frac{2,6}{500} \cdot 35 \cdot 45 = 2,13\text{cm}^2 \\ 0,0013 \cdot 35 \cdot 45 = 2,05\text{cm}^2 \end{array} \right. \rightarrow A_{s,min}=2,13\text{cm}^2$$

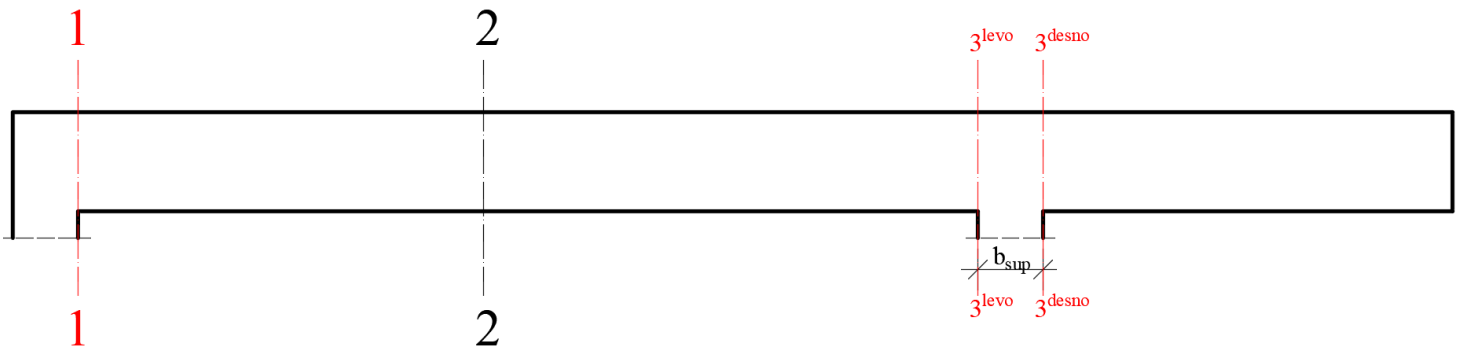
-Maksimalna površina armature za savijanje:

$$A_{s,max} = 0,04 \cdot b \cdot h$$

$$A_{s,max} = 0,04 \cdot 35 \cdot 50 = 70\text{cm}^2$$

Proračun armature za preuzimanje smičućih napona

Napomena: dimenzionisanje armature za preuzimanje smičućih napona se vrši za preseke nosača gde dijagram T-sila (povremenog i stalnog opterećenja) dostiže ekstremnu vrednost, a to su preseci 1-1, 3^{levo}-3^{levo} i 3^{desno}-3^{desno}



Presek 1-1:

Statički uticaji:

$$V_{Ed} = 1,35 \cdot V_G + 1,5 \cdot V_Q$$

$$V_{Ed} = 1,35 \cdot 82,36 + 1,5 \cdot 27,99 = 153,17\text{kN}$$

$$\Delta V_{Ed} = (1,35 \cdot g + 1,5 \cdot q) \cdot \left(\frac{b_{sup}}{2} + d \right)$$

$$\Delta V_{Ed} = (1,35 \cdot 32,37 + 1,5 \cdot 11) \cdot \left(\frac{0,35}{2} + 0,45 \right) = 37,62\text{kN}$$

$$V_{Ed}^* = V_{Ed} - \Delta V_{Ed} = 153,17 - 37,62 = 115,55\text{kN}$$

Maksimalna proračunska nosivost:

$$V_{Rd,c} = \max \left\{ \begin{array}{l} \left[C_{Rd,c} \cdot k \cdot (100 \cdot \rho_i \cdot f_{ck})^{\frac{1}{3}} + k_1 \cdot \sigma_{cp} \right] \cdot b_w \cdot d \\ (V_{min} + k_1 \cdot \sigma_{cp}) \cdot b_w \cdot d \end{array} \right.$$

$$C_{Rd,c} = \frac{0.18}{\gamma_c} = \frac{0.18}{1.5} = 0.12$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{450}} = 1,67 < 2.0 \rightarrow k = 1,67 \quad \text{d-statička visina [mm]}$$

$A_{s1} = 4R\emptyset 20 = 12,57 \text{ cm}^2$ (Površina armature (za preuzimanje napona zatezanja) u preseku 1-1)

$$\rho_i = \frac{A_{s1}}{b \cdot d} = \frac{12,57}{35 \cdot 45} = 0.007 \leq 0.02 \rightarrow \rho_i = 0,007$$

$k_1 = 0,15$ -preporučena vrednost

$$N_{Ed} = 0 \rightarrow \sigma_{cp} = \frac{N_{Ed}}{A_c} = 0$$

$$f_{ck} = 25 \text{ MPa}$$

$$V_{\min} = 0.035 \cdot k^{3/2} \cdot f_{ck}^{1/2} = 0.035 \cdot 1,67^{3/2} \cdot 25^{1/2} = 0,208$$

$$V_{Rd,c} = \max \left\{ \begin{array}{l} 0,12 \cdot 1,67 \cdot (100 \cdot 0,007 \cdot 25)^{\frac{1}{3}} + 0,15 \cdot 0 \\ (0,208 + 0,15 \cdot 0) \cdot 350 \cdot 450 \cdot 10^{-3} = 32,76 \text{ kN} \end{array} \right. = 81,94 \text{ kN}$$

Vrednosti b_w i d u [mm]

$$V_{Rd,c} = 81,94 \text{ kN} < V_{Ed}^* = 115,55 \text{ kN} \rightarrow \text{Potrebno je usvojiti armaturu (uzengije)}$$

Usvojene uzengije:

$\alpha = 90^\circ$ -ugao nagiba uzengija u odnosu na podužnu osu nosača

$m = 2$ -sečnost uzengija

$s = 10 \text{ cm}$ -razmak između uzengija

$A_{sw} = 1,01 \text{ cm}^2$ (2R $\emptyset 8$)

Nosivost vertikalne armature (uzengija):

$$V_{Rd,s} = \frac{A_{sw}}{s} \cdot 0,9 \cdot d \cdot f_{ywd} \cdot \text{ctg}\theta; \quad \theta = 45^\circ; \quad f_{ywd} = f_{yd}$$

$$V_{Rd,s} = \frac{1,01}{10} \cdot 0,9 \cdot 45 \cdot 43,47 \cdot 1$$

$$V_{Rd,s} = 177,81 \text{ kN} > V_{Ed}^* = 115,55 \text{ kN} \rightarrow \text{Usvojene uzengije UR}\emptyset 8/10$$

-minimalna površina armature za preuzimanje napona smicanja:

$$\rho_w = \frac{A_{sw}}{s \cdot b \cdot \sin\alpha}$$

$$\rho_w = \frac{1,01}{10 \cdot 35 \cdot \sin 90} = 0,003 \text{ cm}^2$$

-Maksimalna sila smicanja:

$$V_{Rd,max} = 0,5 \cdot b \cdot 0,9 \cdot d \cdot V_1 \cdot f_{cd}$$

$$V_1 = 0,6 \cdot \left[1 - \frac{f_{ck}}{250} \right] \rightarrow V_1 = 0,6 \cdot \left[1 - \frac{25}{250} \right] \rightarrow V_1 = 0,54$$

$$V_{Rd,max} = 0,5 \cdot 35 \cdot 0,9 \cdot 45 \cdot 0,54 \cdot 25 \cdot 10^{-1} \rightarrow V_{Rd,max} = 956,81 \text{ kN}$$

$$V_{Rd,max} > V_{Ed}^* \rightarrow \text{Uslov je ispunjen!}$$

Presek 3^{levo}-3^{levo}:

Statički uticaji:

$$V_{Ed} = 1,35 \cdot V_G + 1,5 \cdot V_Q$$

$$V_{Ed} = 1,35 \cdot 103,77 + 1,5 \cdot 35,26 = 192,98 \text{ kN}$$

$$\Delta V_{Ed} = (1,35 \cdot g + 1,5 \cdot q) \cdot \left(\frac{b_{sup}}{2} + d \right)$$

$$\Delta V_{Ed} = (1,35 \cdot 32,37 + 1,5 \cdot 11) \cdot \left(\frac{0,35}{2} + 0,45 \right) = 37,62 \text{ kN}$$

$$V_{Ed}^* = V_{Ed} - \Delta V_{Ed} = 192,98 - 37,62 = 155,36 \text{ kN}$$

Maksimalna proračunska nosivost:

$$V_{Rd,c} = \max \left\{ \left[C_{Rd,c} \cdot k \cdot (100 \cdot \rho_i \cdot f_{ck})^{\frac{1}{3}} + k_1 \cdot \sigma_{cp} \right] \cdot b_w \cdot d \right. \\ \left. (V_{min} + k_1 \cdot \sigma_{cp}) \cdot b_w \cdot d \right.$$

$$C_{Rd,c} = \frac{0,18}{\gamma_c} = \frac{0,18}{1,5} = 0,12$$

$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{450}} = 1,67 < 2,0 \rightarrow k = 1,67 \quad \text{d-statička visina [mm]}$$

$A_{s1} = 2R\emptyset 20 = 6,28 \text{ cm}^2$ (Površina armature (za preuzimanje napona zatezanja) u preseku 3-3)

$$\rho_i = \frac{A_{s1}}{b \cdot d} = \frac{6,28}{35 \cdot 45} = 0,004 \leq 0,02 \rightarrow \rho_i = 0,004$$

$k_1 = 0,15$ - preporučena vrednost

$$N_{Ed} = 0 \rightarrow \sigma_{cp} = \frac{N_{Ed}}{A_c} = 0$$

$$f_{ck} = 25 \text{ MPa}$$

$$V_{min} = 0,035 \cdot k^{3/2} \cdot f_{ck}^{1/2} = 0,035 \cdot 1,67^{3/2} \cdot 25^{1/2} = 0,208$$

$$V_{Rd,c} = \max \left\{ \left[0,12 \cdot 1,67 \cdot (100 \cdot 0,004 \cdot 25)^{\frac{1}{3}} + 0,15 \cdot 0 \right] \cdot 350 \cdot 450 \cdot 10^{-3} = 68,00 \text{ kN} \right. \\ \left. (0,208 + 0,15 \cdot 0) \cdot 350 \cdot 450 \cdot 10^{-3} = 32,76 \text{ kN} \right.$$

Vrednosti b_w i d u [mm]

$$V_{Rd,c} = 68,00 \text{ kN} < V_{Ed}^* = 155,36 \text{ kN} \rightarrow \text{Potrebno je usvojiti armaturu (uzengije)}$$

Usvojene uzengije:

$\alpha = 90^\circ$ - ugao nagiba uzengija u odnosu na podužnu osu nosača

$m = 2$ - sečnost uzengija

$s = 10 \text{ cm}$ - razmak između uzengija

$A_{sw} = 1,01 \text{ cm}^2$ (2R $\emptyset 8$)

Nosivost vertikalne armature (uzengija):

$$V_{Rd,s} = \frac{A_{sw}}{s} \cdot 0,9 \cdot d \cdot f_{ywd} \cdot \text{ctg}\theta; \quad \theta = 45^\circ; \quad f_{ywd} = f_{yd}$$

$$V_{Rd,s} = \frac{1,01}{10} \cdot 0,9 \cdot 45 \cdot 43,47 \cdot 1$$

$$V_{Rd,s}=177,81\text{kN} > V_{Ed}^* = 155,36\text{kN} \rightarrow \text{Usvojene uzengije UR}\varnothing 8/10$$

-minimalna površina armature za preuzimanje napona smicanja:

$$\rho_w = \frac{A_{sw}}{s \cdot b \cdot \sin\alpha}$$

$$\rho_w = \frac{1,01}{10 \cdot 35 \cdot \sin 90} = 0,003\text{cm}^2$$

-Maksimalna sila smicanja:

$$V_{Rd,max}=0,5 \cdot b \cdot 0,9 \cdot d \cdot V_1 \cdot f_{cd}$$

$$V_1=0,6 \cdot \left[1 - \frac{f_{ck}}{250}\right] \rightarrow V_1=0,6 \cdot \left[1 - \frac{25}{250}\right] \rightarrow V_1=0,54$$

$$V_{Rd,max}=0,5 \cdot 35 \cdot 0,9 \cdot 45 \cdot 0,54 \cdot 25 \cdot 10^{-1} \rightarrow V_{Rd,max}=956,81\text{kN}$$

$$V_{Rd,max} > V_{Ed}^* \rightarrow \text{Uslov je ispunjen!}$$

Presek 3^{desno}-3^{desno}:

Statički uticaji:

$$V_{Ed} = 1,35 \cdot V_G + 1,5 \cdot V_Q$$

$$V_{Ed} = 1,35 \cdot 63,12 + 1,5 \cdot 21,45 = 117,39\text{kN}$$

$$\Delta V_{Ed} = (1,35 \cdot g + 1,5 \cdot q) \cdot \left(\frac{b_{sup}}{2} + d\right)$$

$$\Delta V_{Ed} = (1,35 \cdot 32,37 + 1,5 \cdot 11) \cdot \left(\frac{0,35}{2} + 0,45\right) = 37,62\text{kN}$$

$$V_{Ed}^* = V_{Ed} - \Delta V_{Ed} = 117,39 - 37,62 = 79,77\text{kN}$$

Maksimalna proračunska nosivost:

$$V_{Rd,c} = \max \left\{ \left[C_{Rd,c} \cdot k \cdot (100 \cdot \rho_i \cdot f_{ck})^{\frac{1}{3}} + k_1 \cdot \sigma_{cp} \right] \cdot b_w \cdot d \right. \\ \left. (V_{min} + k_1 \cdot \sigma_{cp}) \cdot b_w \cdot d \right.$$

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$$k = 1 + \sqrt{\frac{200}{d}} = 1 + \sqrt{\frac{200}{450}} = 1,67 < 2,0 \rightarrow k = 1,67 \quad \text{d-statička visina [mm]}$$

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$$\rho_i = \frac{A_{s1}}{b \cdot d} = \frac{6,28}{35 \cdot 45} = 0,004 \leq 0,02 \rightarrow \rho_i=0,004$$

$k_1=0,15$ -preporučena vrednost

$$N_{Ed}=0 \rightarrow \sigma_{cp} = \frac{N_{Ed}}{A_c} = 0$$

$$f_{ck} = 25\text{MPa}$$

$$V_{min} = 0,035 \cdot k^{3/2} \cdot f_{ck}^{1/2} = 0,035 \cdot 1,67^{3/2} \cdot 25^{1/2} = 0,208$$

$$V_{Rd,c} = \max \left\{ \begin{aligned} & \left[0,12 \cdot 1,67 \cdot (100 \cdot 0,004 \cdot 25)^{\frac{1}{3}} + 0,15 \cdot 0 \right] \cdot 350 \cdot 450 \cdot 10^{-3} = 68,00 \text{ kN} \\ & (0,208 + 0,15 \cdot 0) \cdot 350 \cdot 450 \cdot 10^{-3} = 32,76 \text{ kN} \end{aligned} \right.$$

Vrednosti b_w i d u [mm]

$$V_{Rd,c} = 68,00 \text{ kN} < V_{Ed}^* = 79,77 \text{ kN} \rightarrow \text{Potrebno je usvojiti armaturu (uzengije)}$$

Usvojene uzengije:

$\alpha = 90^\circ$ -ugao nagiba uzengija u odnosu na podužnu osu nosača

$m=2$ -sečnost uzengija

$s=10$ cm-razmak između uzengija

$A_{sw}=1,01 \text{ cm}^2$ (2R Ø8)

Nosivost vertikalne armature (uzengija):

$$V_{Rd,s} = \frac{A_{sw}}{s} \cdot 0,9 \cdot d \cdot f_{ywd} \cdot \text{ctg}\theta; \quad \theta = 45^\circ; \quad f_{ywd} = f_{yd}$$

$$V_{Rd,s} = \frac{1,01}{10} \cdot 0,9 \cdot 45 \cdot 43,47 \cdot 1$$

$$V_{Rd,s} = 177,81 \text{ kN} > V_{Ed}^* = 79,77 \text{ kN} \rightarrow \text{Usvojene uzengije URØ8/10}$$

-minimalna površina armature za preuzimanje napona smicanja:

$$\rho_w = \frac{A_{sw}}{s \cdot b \cdot \sin\alpha}$$

$$\rho_w = \frac{1,01}{10 \cdot 35 \cdot \sin 90} = 0,003 \text{ cm}^2$$

-Maksimalna sila smicanja:

$$V_{Rd,max} = 0,5 \cdot b \cdot 0,9 \cdot d \cdot V_1 \cdot f_{cd}$$

$$V_1 = 0,6 \cdot \left[1 - \frac{f_{ck}}{250} \right] \rightarrow V_1 = 0,6 \cdot \left[1 - \frac{25}{250} \right] \rightarrow V_1 = 0,54$$

$$V_{Rd,max} = 0,5 \cdot 35 \cdot 0,9 \cdot 45 \cdot 0,54 \cdot 25 \cdot 10^{-1} \rightarrow V_{Rd,max} = 956,81 \text{ kN}$$

$$V_{Rd,max} > V_{Ed}^* \rightarrow \text{Uslov je ispunjen!}$$

Nosivost armature

$$\frac{M_{Ed}^{2-2}}{0,9 \cdot d} = \frac{194,72 \cdot 10^2}{0,9 \cdot 45} = 480,79 \text{ kN}$$

$$v = 0,5 \cdot d = 22,5 \text{ cm}$$

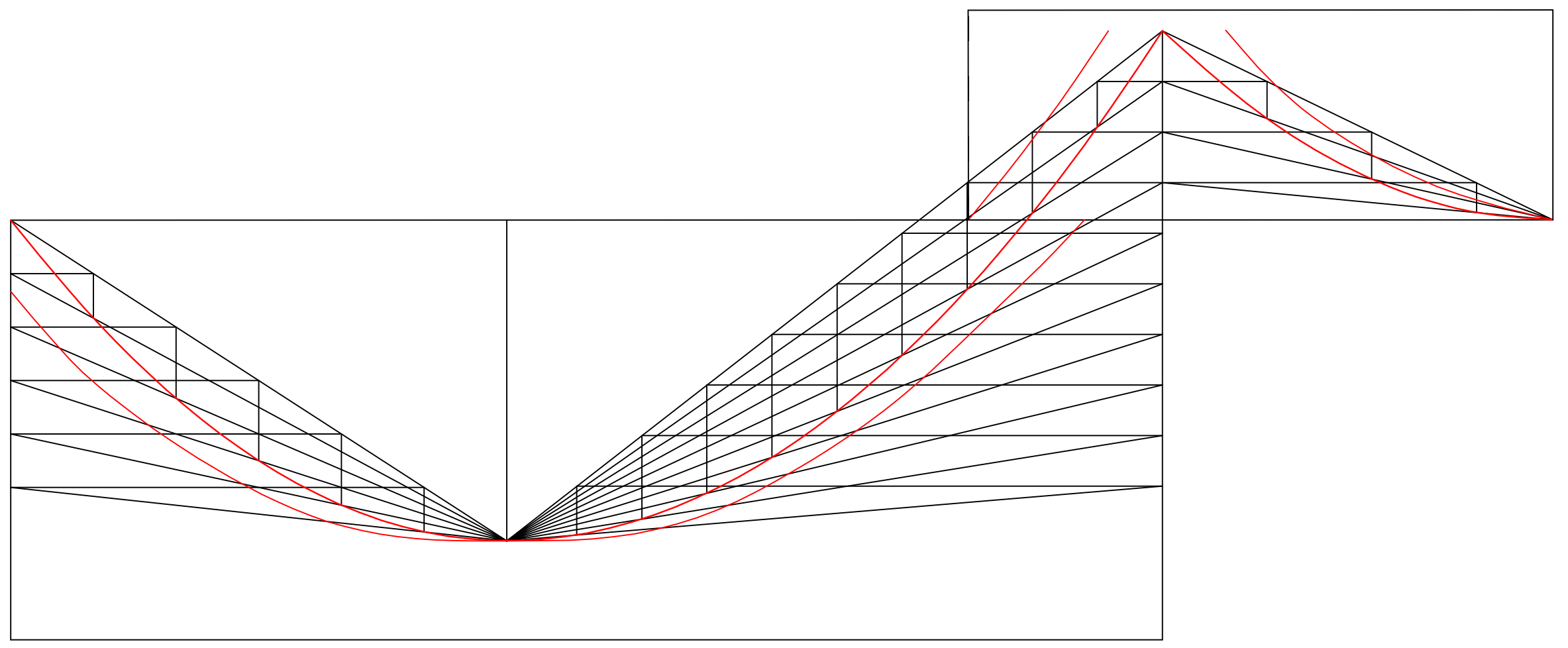
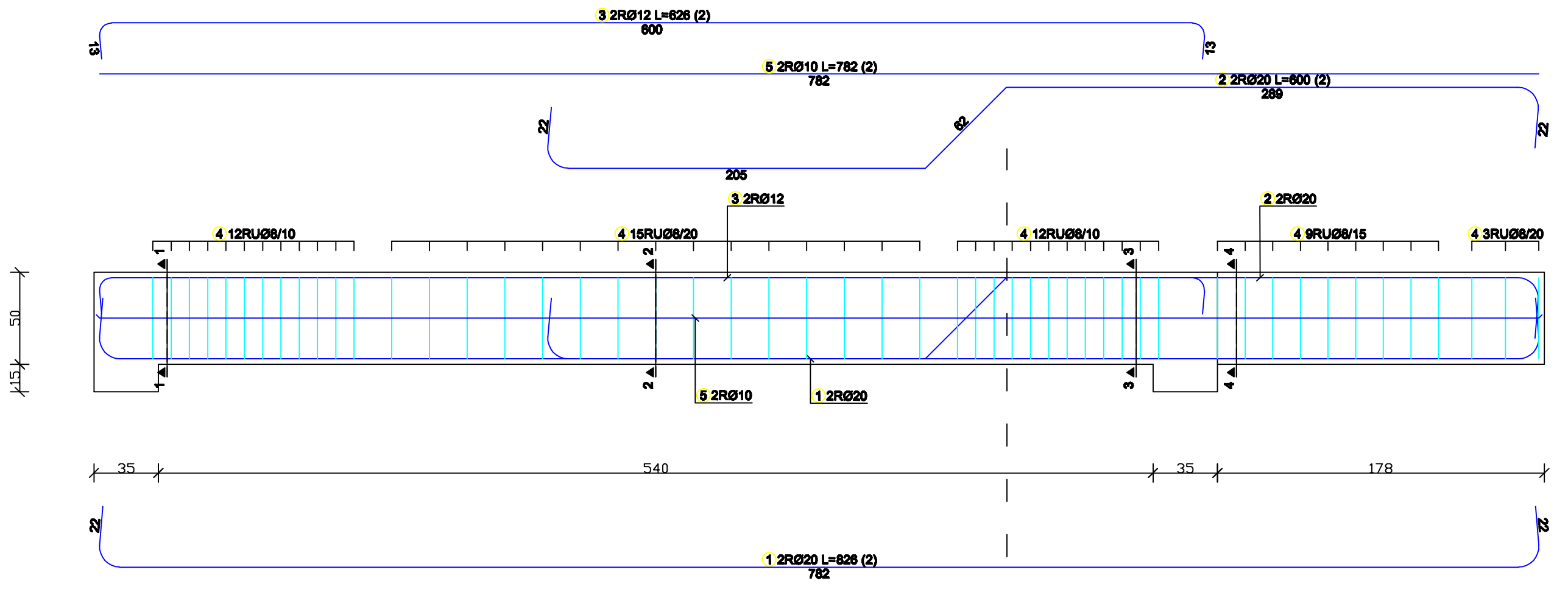
$$Z^{2-2} = A_{s1}^{2-2} \cdot f_{yk}$$

$$Z^{2-2} = 12,57 \text{ cm}^2 \cdot 50 \frac{\text{kN}}{\text{cm}^2} = 628,50 \text{ kN}$$

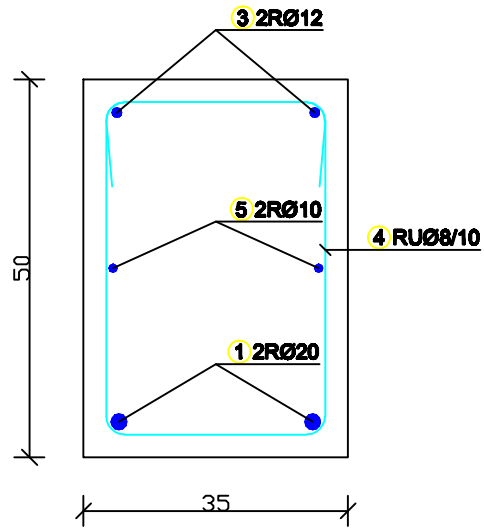
$$\frac{M_{Ed}^{3-3}}{0,9 \cdot d} = \frac{114,45 \cdot 10^2}{0,9 \cdot 45} = 282,59 \text{ kN}$$

$$Z^{3-3} = 6,28 \text{ cm}^2 \cdot 50 \frac{\text{kN}}{\text{cm}^2} = 314,00 \text{ kN}$$

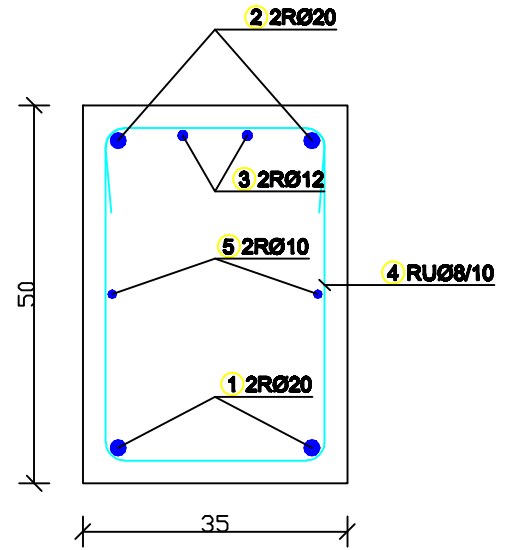
Usvojena razmera: 300kN=1m



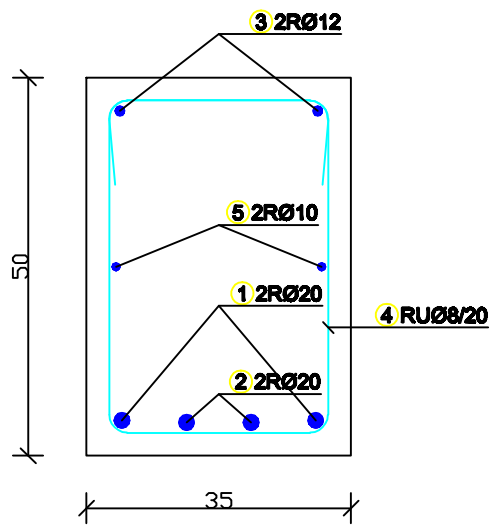
1-1
R=1:10



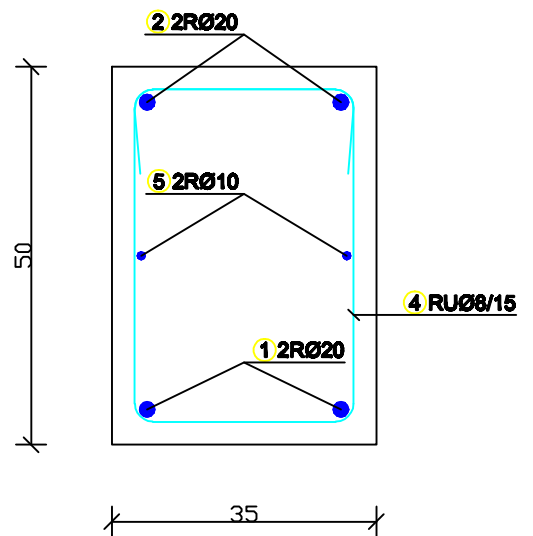
3-3
R=1:10


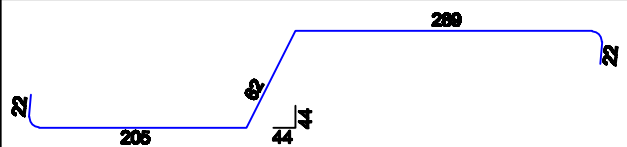
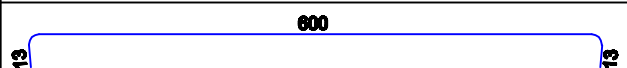
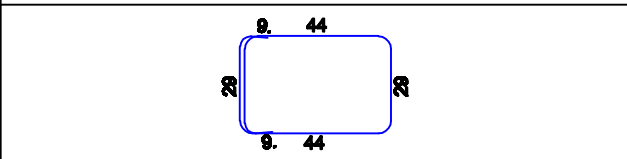



2-2
R=1:10



4-4
R=1:10



Шипке - спецификација					
оан.	облик и мере [cm]	Ø	lg [m]	n [ком.]	lgn [m]
попате (1 ком.)					
1		20	8.26	2	16.52
2		20	6.00	2	12.00
3		12	6.26	2	12.52
4		8	1.93	51	98.43
5		10	7.82	2	15.64
Шипке - рекалитулација					
Ø [mm]	lgn [m]	Јединична тежина [kg/m]	Тежина [kg]		
RA1					
8	98.43	0.41	40.26		
10	15.64	0.65	10.15		
12	12.52	0.92	11.52		
20	28.52	2.48	70.59		
Укупно					132.51