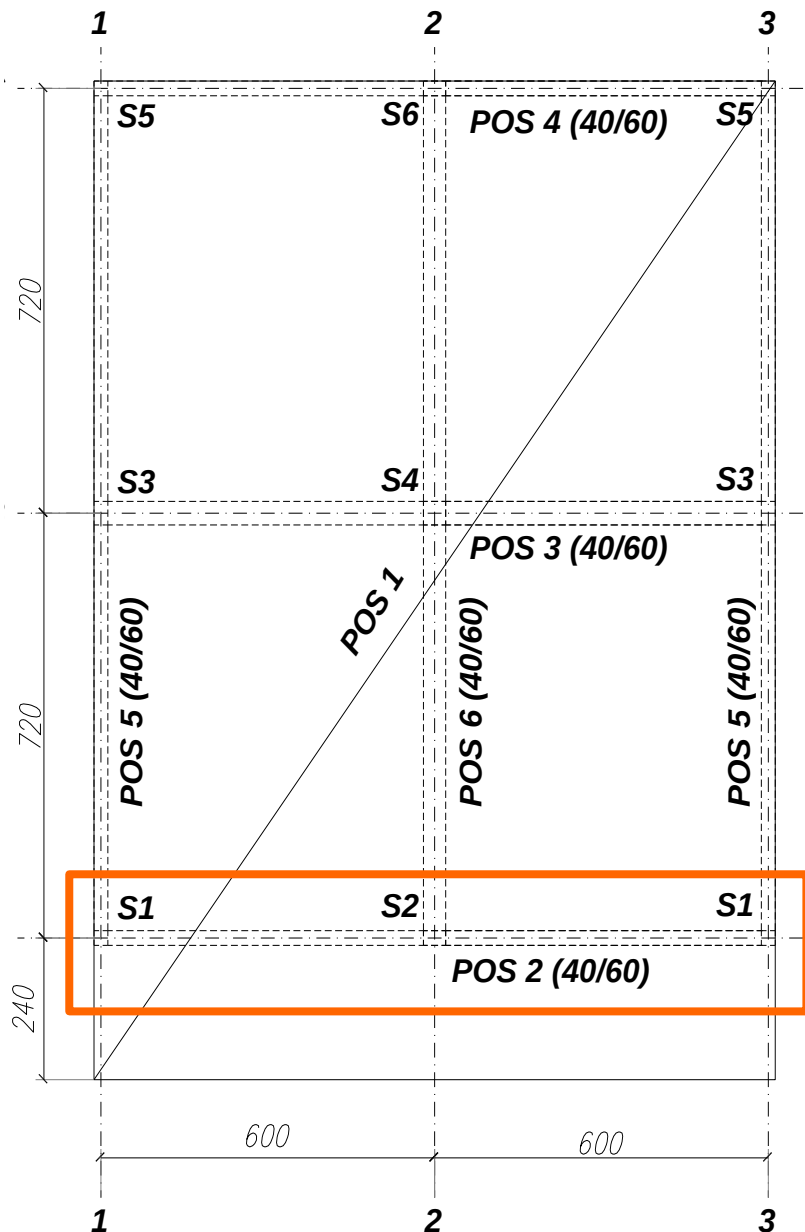
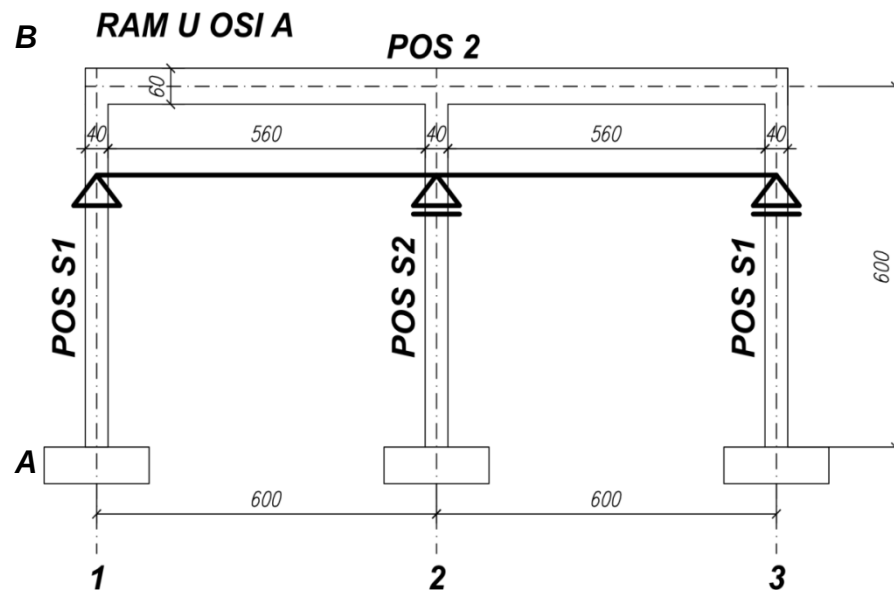
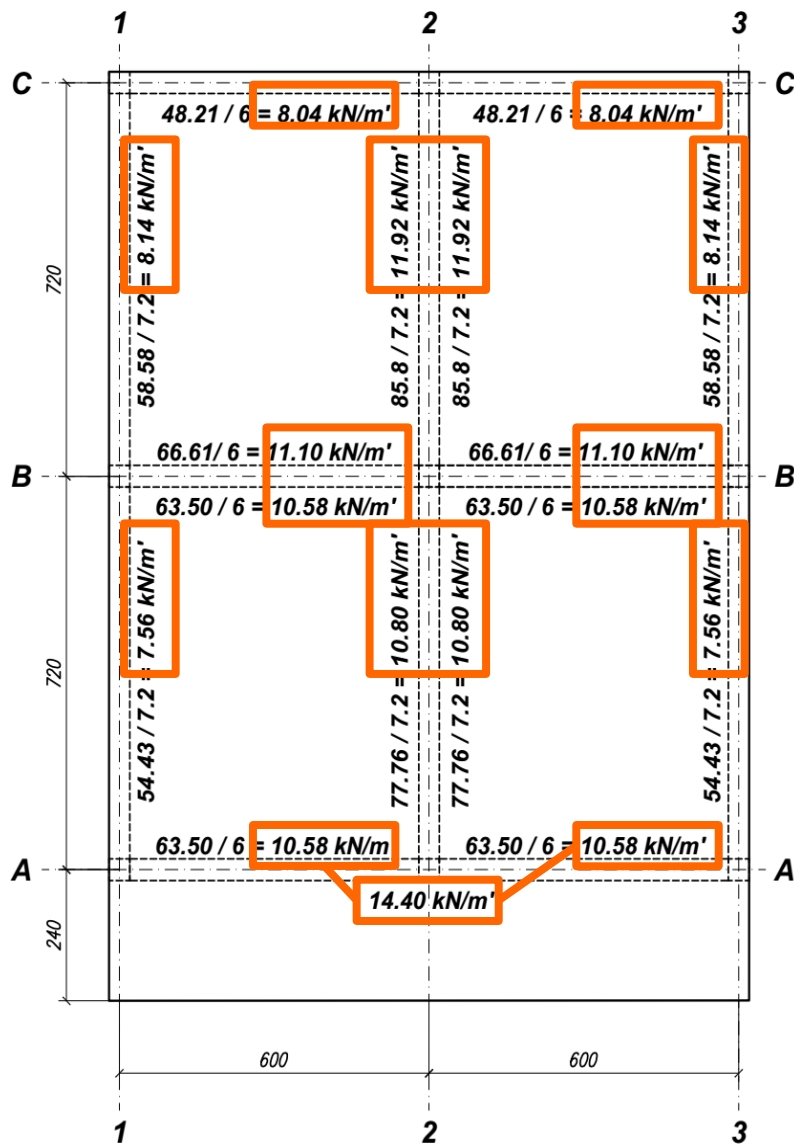




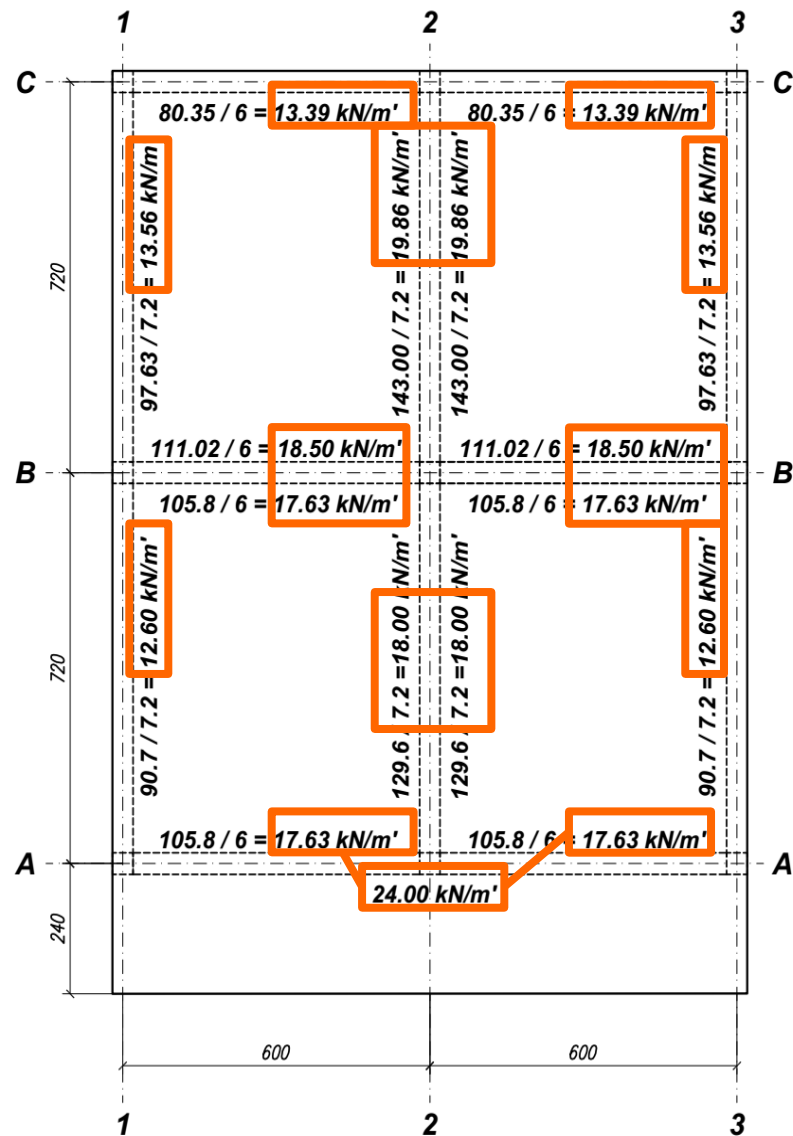
Statički sistem greda



Reakcije ploče - stalno opterećenje g (kN/m')



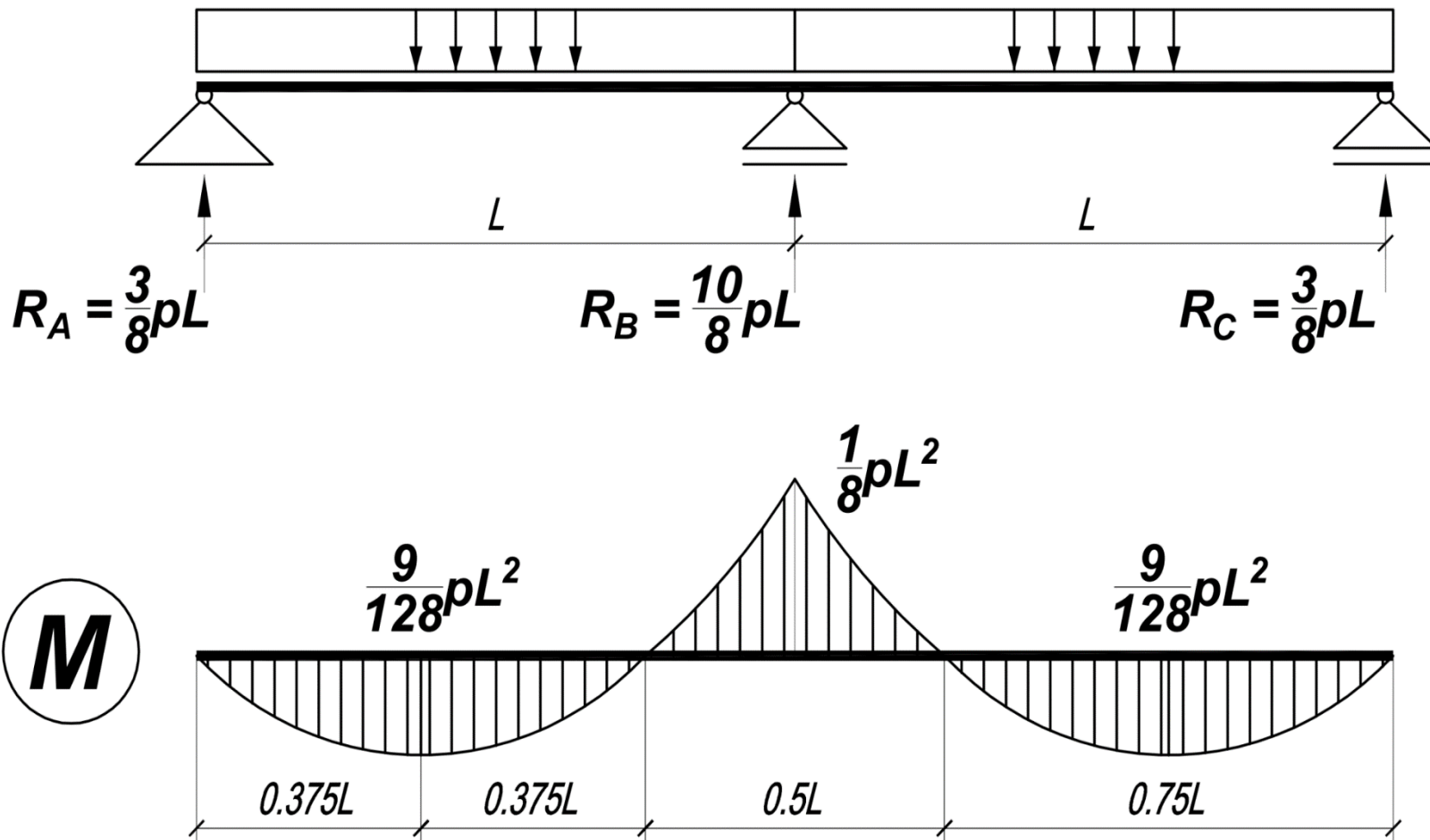
Reakcije ploče - promenljivo opterećenje q (kN/m')

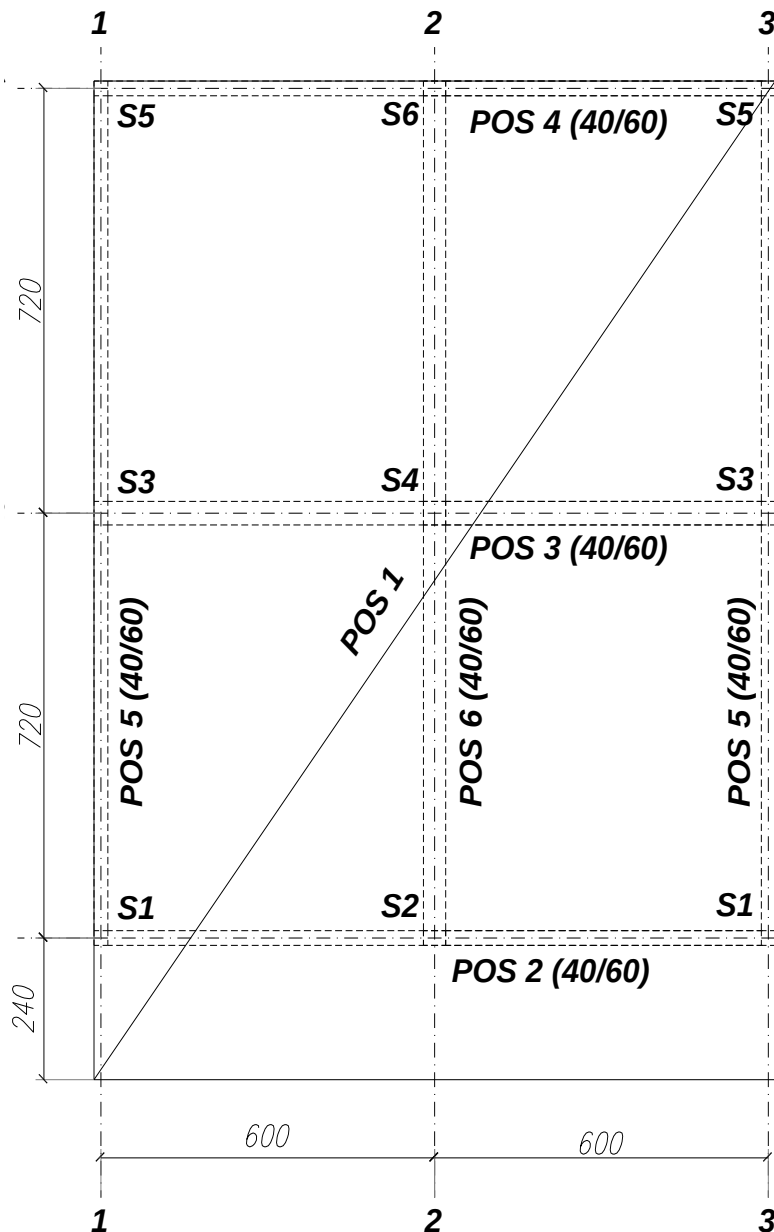


6. Analiza opterećenja greda

Grede u X -pravcu

$$p = 1.35g + 1.5q \text{ (kN/m')}$$

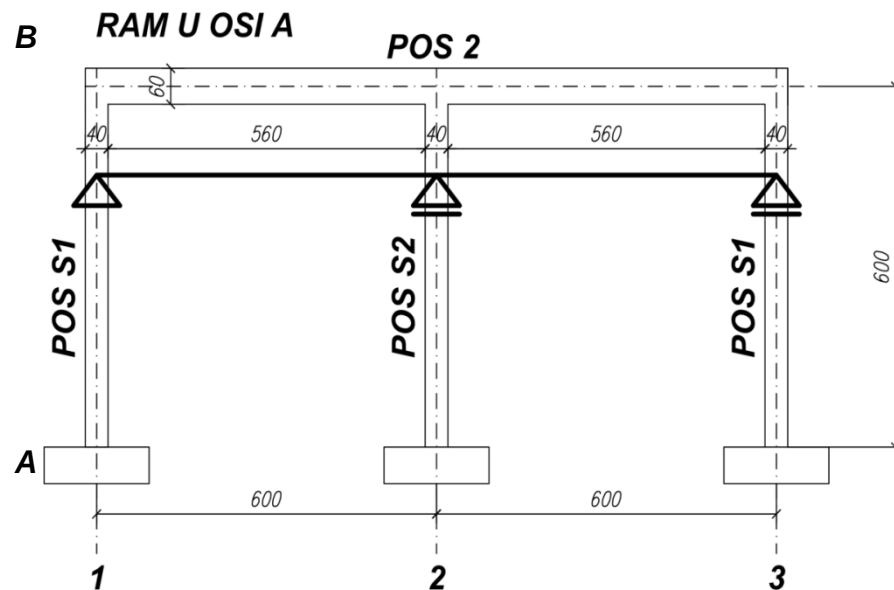




C

Statički sistem greda

B

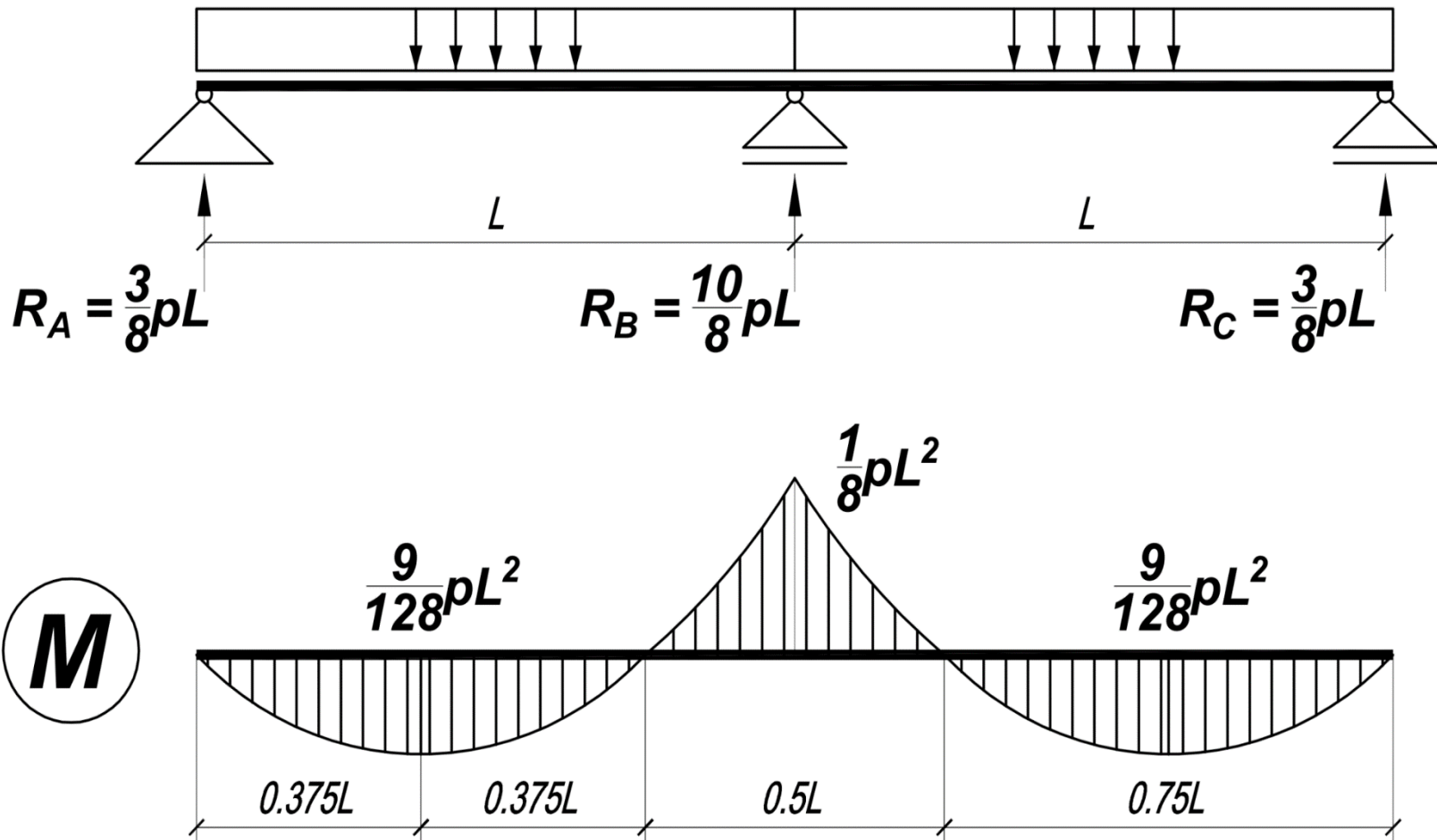


A

6. Analiza opterećenja greda

Grede u X -pravcu

$$p = 1.35g + 1.5q \text{ (kN/m')}$$



Dimenzionisanje greda

6.1. Greda POS 2

Stalno opterećenje

sopstvena težina grede

$$g_{st} = h \times b \times \gamma_c = 0.6 \times 0.4 \times 25.0 = 6.0 \text{ kN/m}$$

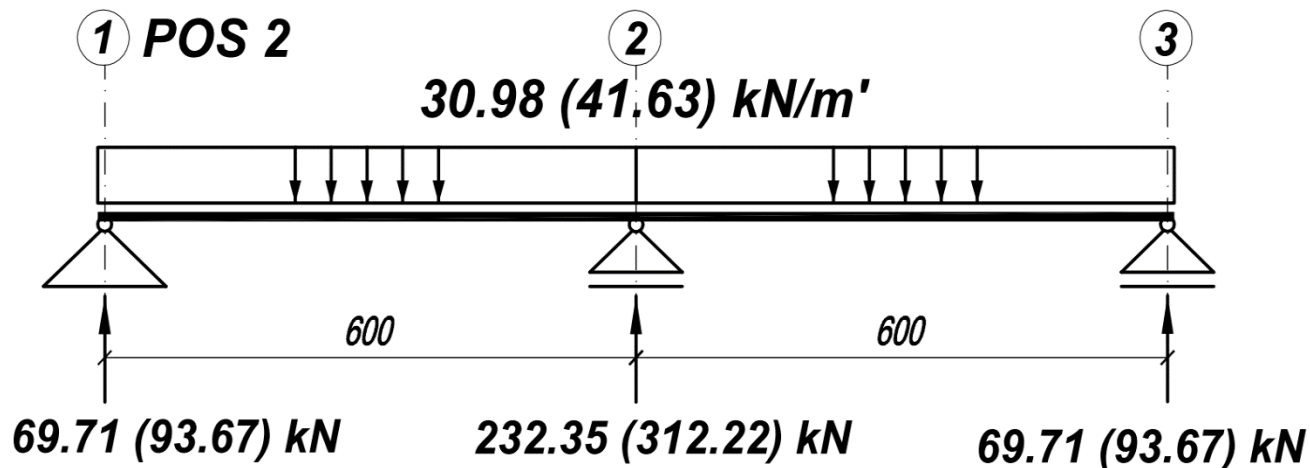
reakcija sa ploče

$$g_p = 10.58 + 14.40 = 24.98 \text{ kN/m}$$

$$g = 30.98 \text{ kN/m}$$

Promenljivo opterećenje

$$q = 17.63 + 24.00 = 41.63 \text{ kN/m}$$



6.2. Greda POS 3

Stalno opterećenje

sopstvena težina grede

$$g_{st} = h \times b \times \gamma_c = 0.6 \times 0.4 \times 25.0 = 6.0 \text{ kN/m}$$

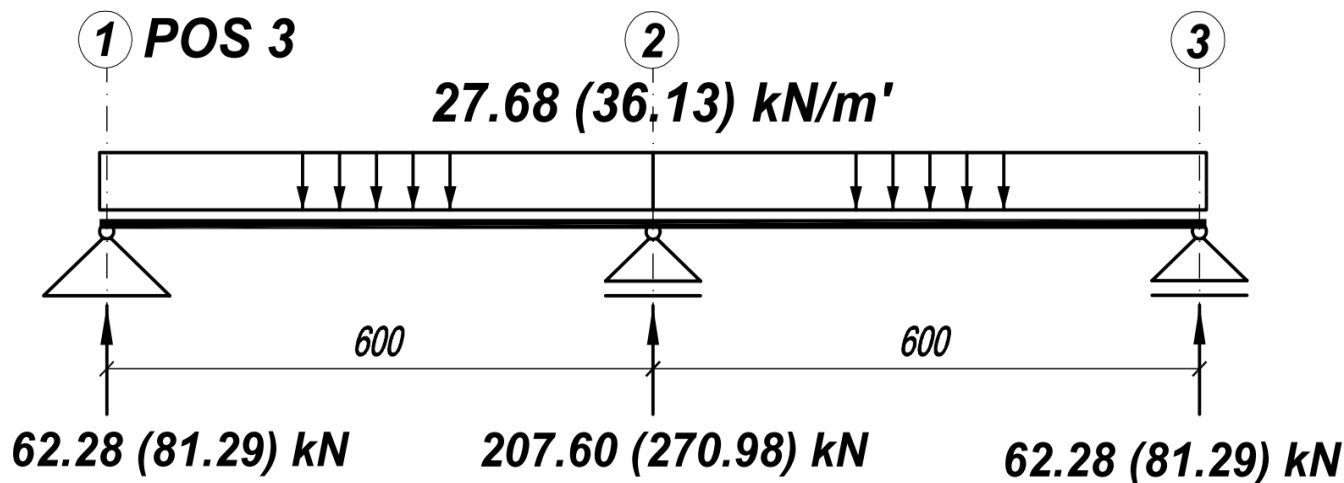
reakcija sa ploče

$$g_p = 10.58 + 11.10 = 21.68 \text{ kN/m}$$

$$g = 27.68 \text{ kN/m}$$

Promenljivo opterećenje

$$q = 17.63 + 18.50 = 36.13 \text{ kN/m}$$



6.3. Greda POS 4

Stalno opterećenje

sopstvena težina grede

$$g_{st} = h \times b \times \gamma_c = 0.6 \times 0.4 \times 25.0 = 6.0 \text{ kN/m}$$

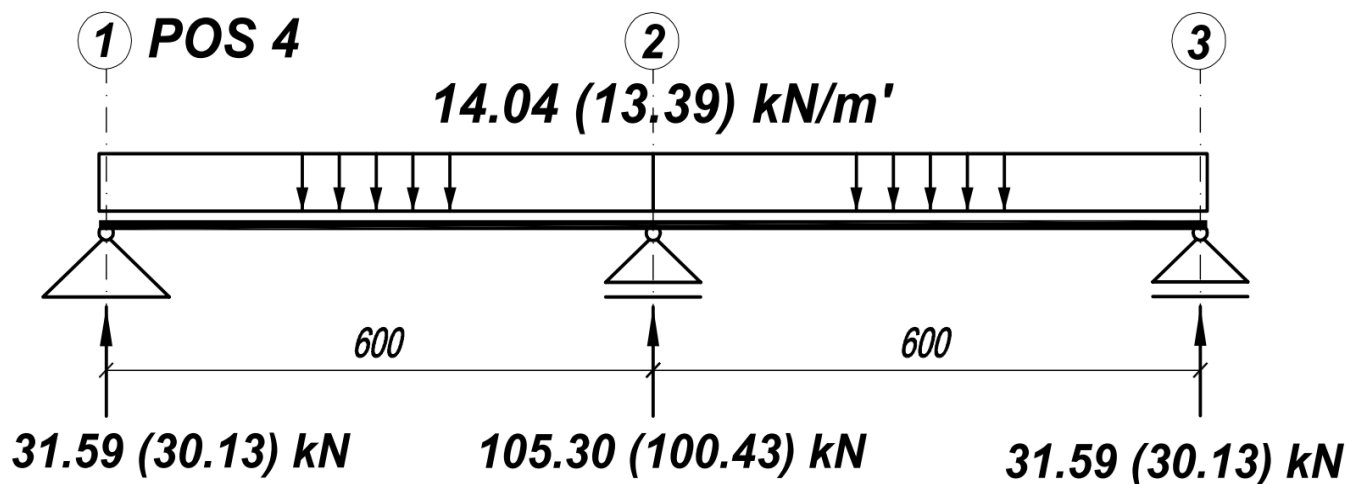
reakcija sa ploče

$$g_p = 8.04 \text{ kN/m}$$

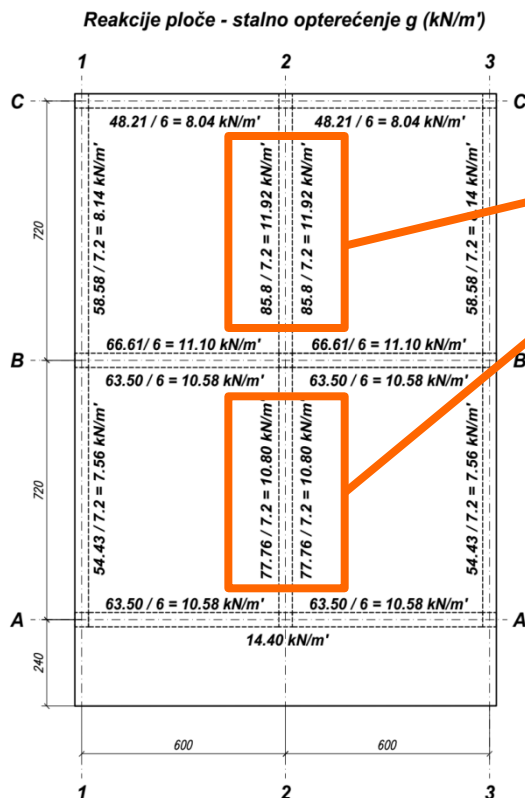
$$g = 14.04 \text{ kN/m}$$

Promenljivo opterećenje

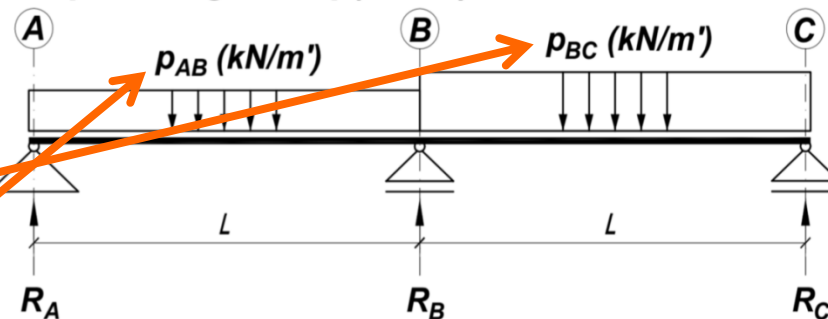
$$q = 13.39 \text{ kN/m}$$



Grede u Y - pravcu



$$p = 1.35g + 1.5q \text{ (kN/m')}$$



$$R_A = 0.438p_{AB}L - 0.063p_{BC}L$$

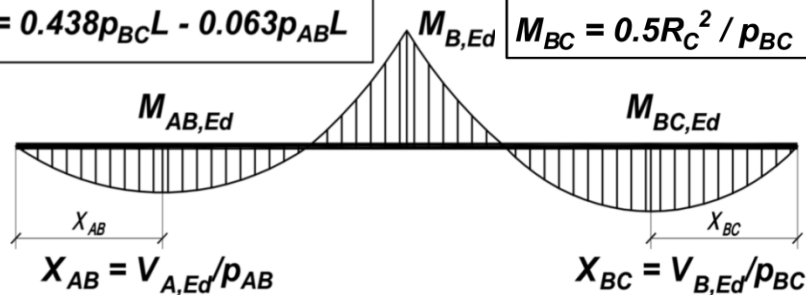
$$R_B = 0.625(p_{AB} + p_{BC})L$$

$$R_C = 0.438p_{BC}L - 0.063p_{AB}L$$

$$M_{AB} = 0.5R_A^2 / p_{AB}$$

$$M_B = -0.063(p_{AB} + p_{BC})L^2$$

$$M_{BC} = 0.5R_C^2 / p_{BC}$$



$M_{11(max)}$	$0.096 \quad pl^2$
$M_{12(max)}$	$-$
M_b	$-0.063 \quad pl^2$
$A = T_{1a(max)}$	$0.438 \quad pl$



$M_{11(max)}$	$-$
$M_{12(max)}$	$-$
$A = T_{1a(min)}$	$-0.063 \quad pl$

6.4. Greda POS 5

Stalno opterećenje

sopstvena težina grede

$$g_{st} = h \times b \times \gamma_c = 0.6 \times 0.4 \times 25.0 = 6.0 \text{ kN/m}$$

reakcija sa ploče u polju AB

$$g_{AB} = 7.56 \text{ kN/m}$$

reakcija sa ploče u polju BC

$$g_{BC} = 8.14 \text{ kN/m}$$

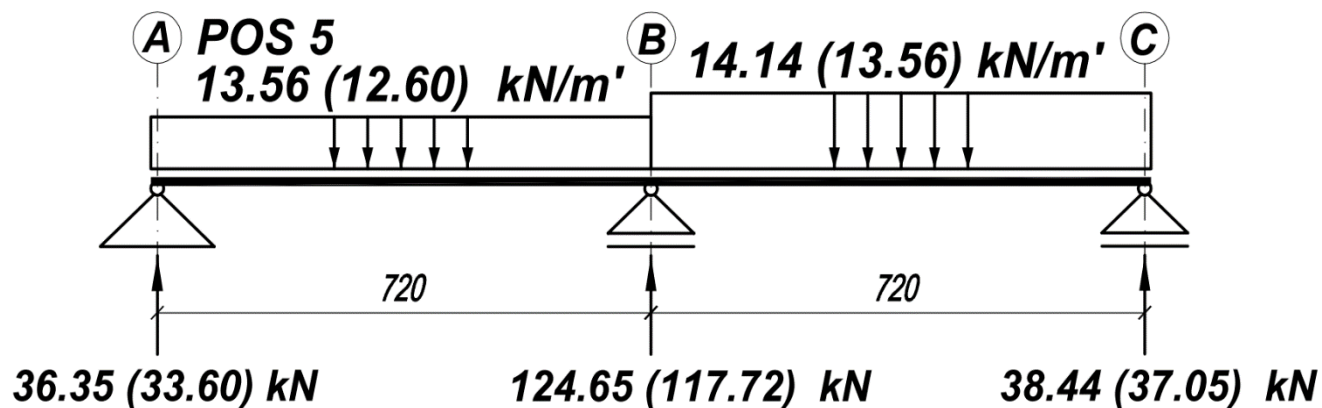
$$g_{AB} = 13.56 \text{ kN/m}$$

$$g_{BC} = 14.14 \text{ kN/m}$$

Promenljivo opterećenje

$$q_{AB} = 12.60 \text{ kN/m}$$

$$q_{BC} = 13.56 \text{ kN/m}$$



6.5. Greda POS 6

Stalno opterećenje

sopstvena težina grede

$$g_{st} = h \times b \times \gamma_c = 0.6 \times 0.4 \times 25.0 = 6.0 \text{ kN/m}$$

reakcija sa ploče u polju AB

$$g_{AB} = 2 \times 10.80 = 21.60 \text{ kN/m}$$

reakcija sa ploče u polju BC

$$g_{BC} = 2 \times 11.92 = 23.84 \text{ kN/m}$$

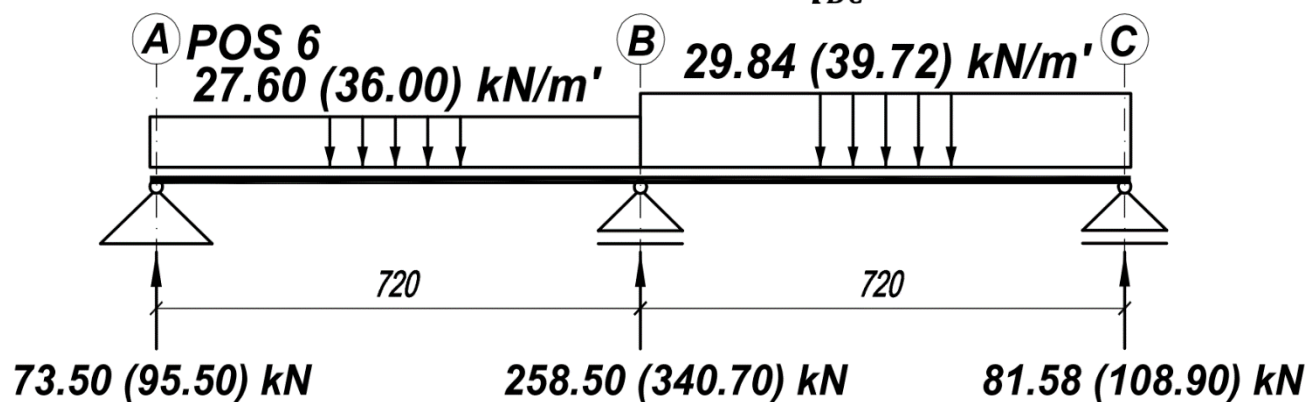
$$g_{AB} = 27.60 \text{ kN/m}$$

$$g_{BC} = 29.84 \text{ kN/m}$$

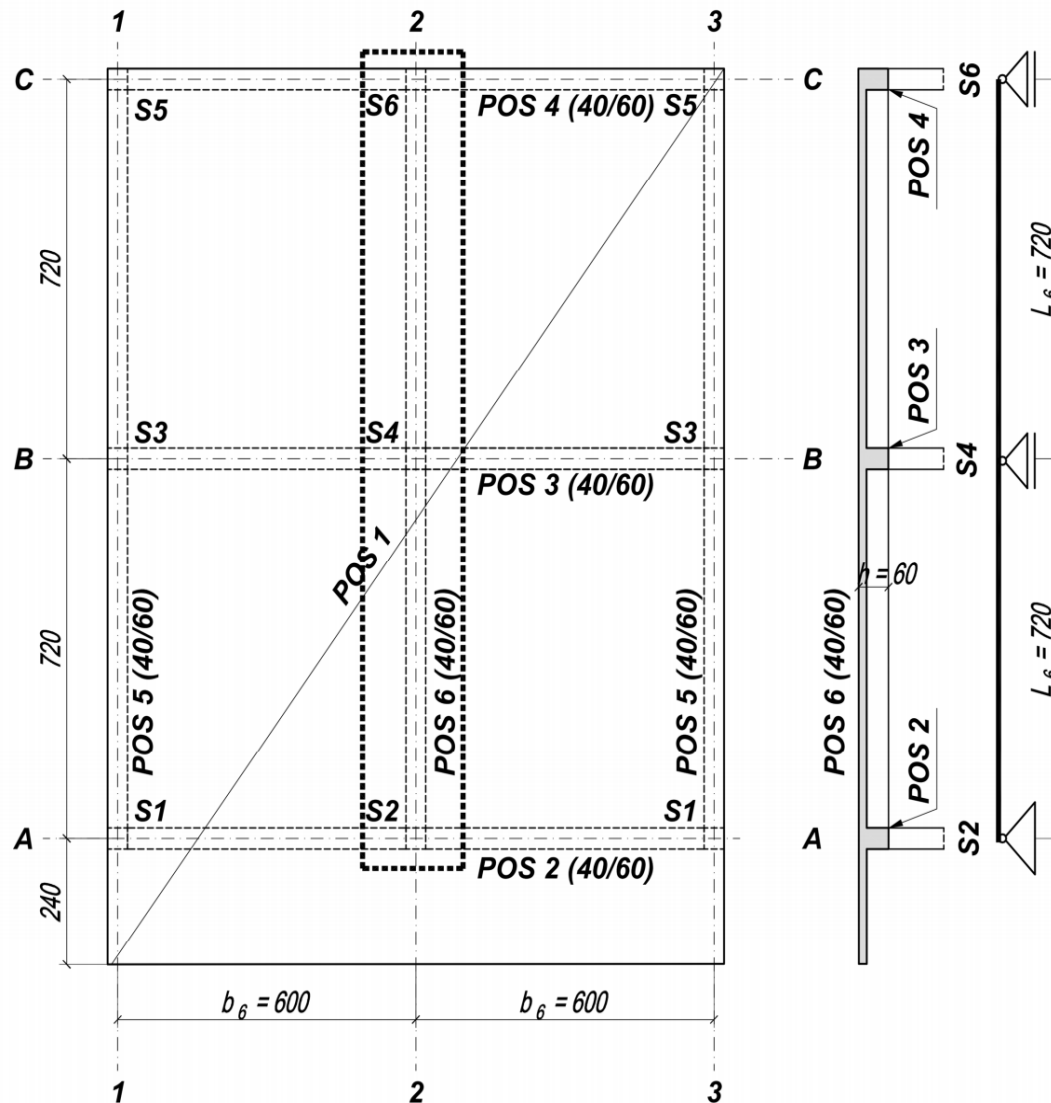
Promenljivo opterećenje

$$q_{AB} = 2 \times 18.00 = 36.00 \text{ kN/m}$$

$$q_{BC} = 2 \times 19.86 = 39.72 \text{ kN/m}$$



6.5.1. Greda POS 6 - Dimenzionisanje prema momentima savijanja



POS 6 $b/h = 40/60$ cm

C30/37 $f_{cd} = 1.7$ kN/cm²

B500B $f_{yd} = 43.48$ kN/cm²

XC3 $C_{nom} = 3.5$ cm

Maksimalni moment u polju AB:

$$M_{AB,g} = \frac{R_{A,g}^2}{2 \times g_{AB}} = \frac{73.5^2}{2 \times 27.6} = 97.9 \text{ kNm}$$

$$M_{AB,q} = \frac{R_{A,q}^2}{2 \times q_{AB}} = \frac{95.5^2}{2 \times 36.0} = 126.7 \text{ kNm}$$

Maksimalni moment u polju BC:

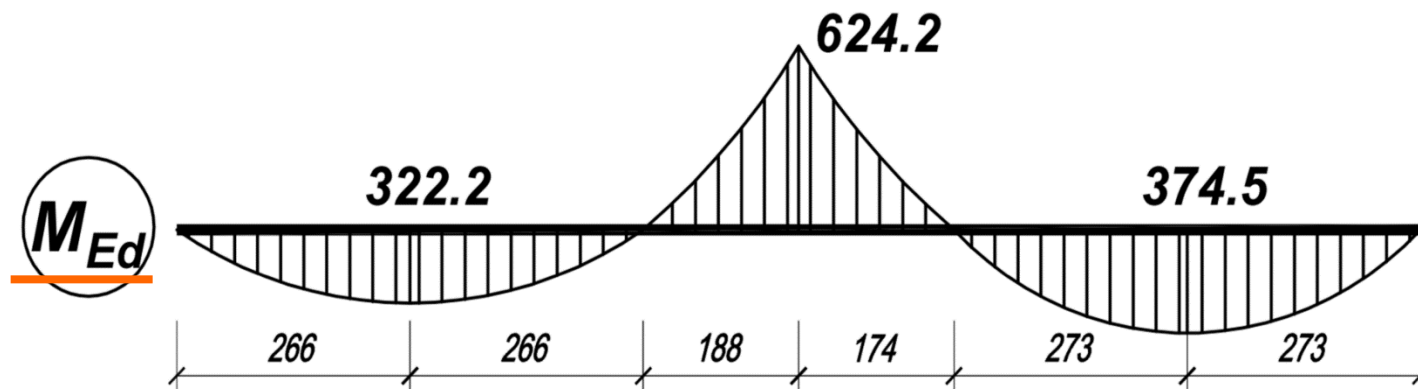
$$M_{BC,g} = \frac{R_{C,g}^2}{2 \times g_{BC}} = \frac{81.58^2}{2 \times 29.84} = 111.52 \text{ kNm}$$

$$M_{BC,q} = \frac{R_{B,q}^2}{2 \times q_{BC}} = \frac{108.9^2}{2 \times 39.72} = 149.29 \text{ kNm}$$

Maksimalni moment iznad oslonca B:

$$M_{B,g} = -0.063 \times (g_{AB} + g_{BC}) \times l^2 = -0.063 \times (27.6 + 29.84) \times 7.2^2 = 187.56 \text{ kNm}$$

$$M_{B,q} = -0.063 \times (q_{AB} + q_{BC}) \times l^2 = -0.063 \times (36.0 + 39.72) \times 7.2^2 = 247.30 \text{ kNm}$$



Dimenzionisanje prema maksimalnom momentu u polju AB

$$M_{AB,Ed} = 1.35 \times 97.9 + 1.5 \times 126.7 \\ = 322.2 \text{ kNm}$$

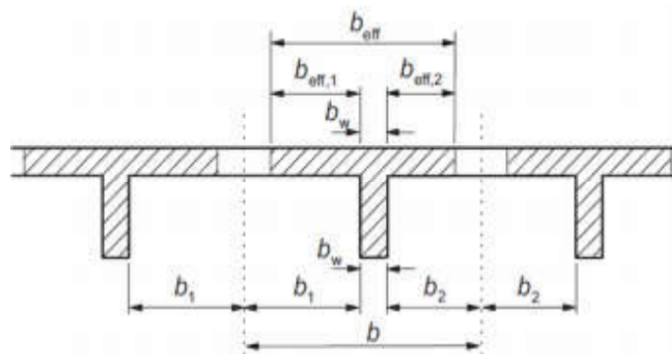
$$\text{pret. } d_1 = 6 \text{ cm} \rightarrow d = 60 - 6 = 54 \text{ cm}$$

$$k = \frac{54}{\sqrt{\frac{322.2 \times 100}{252.8 \times 1.7}}} = 6.237$$

$$\rightarrow \zeta = 0.987, \varepsilon_{s1} = 108.36\text{‰}$$

$$A_{s1} = \frac{322.2 \times 100}{0.987 \times 54 \times 43.48} = 13.90 \text{ cm}^2$$

Usvaja se: **5ø20 (15.7 cm²)**



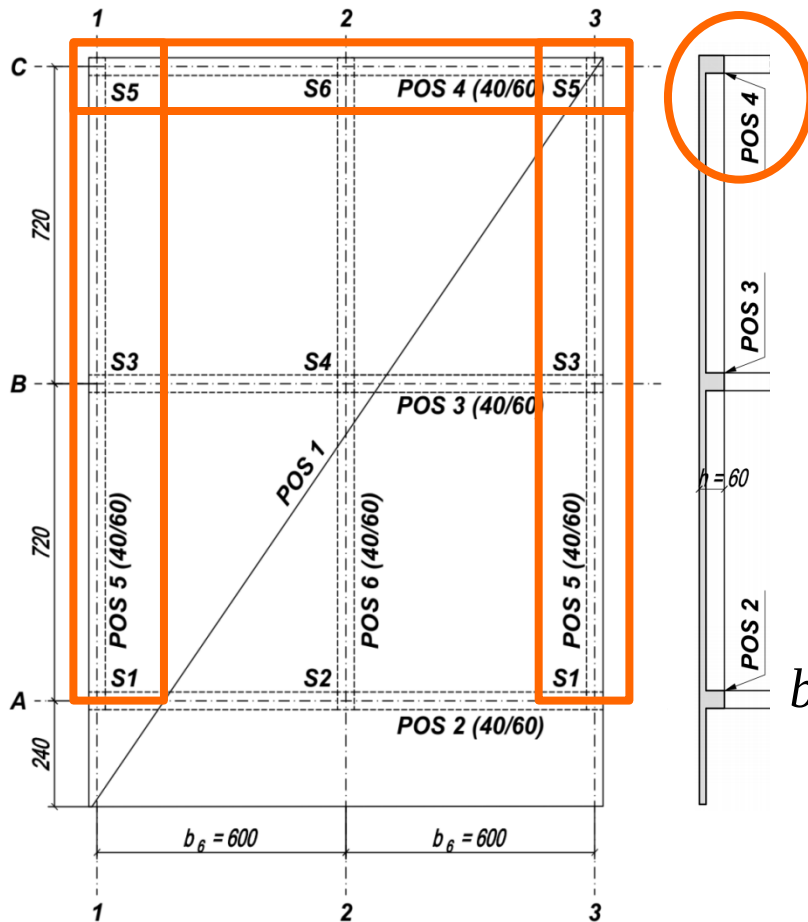
$$b_6 = 600 \text{ cm}$$

$$x_{AB} = \frac{73.5}{27.6} = 2.66 \text{ m}$$

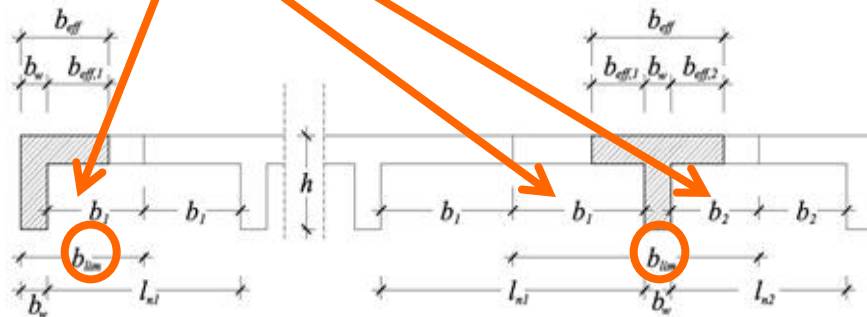
$$\rightarrow l_0 = 2 \times 266 = 532 \text{ cm}$$

$$b_{eff} = \begin{cases} 0.4 \times l_0 + b_w, & b \geq l_0 \\ 0.2 \times l_0 + 0.2 \times b, & b < l_0 \end{cases}$$

$$b_{eff,AB} = 0.4 \times 532 + 40 = 252.8 \text{ cm}, 600 \geq 532$$



$$b_{lim} = b = \begin{cases} b_1 + b_w, \text{"}\Gamma\text{" presek} \\ b_1 + b_2 + b_w, \text{"}T\text{" presek} \end{cases}$$



"T" presek - grede POS 2, 3, 6

$$b_{eff} = \begin{cases} 0.4 \times l_0 + b_w, b \geq l_0 \\ 0.2 \times l_0 + 0.2 \times b, b < l_0 \end{cases} \leq (b_1 + b_2 + b_w)$$

"T" presek - grede POS 4 i 5

$$b_{eff} = \begin{cases} 0.2 l_0 + b_w, b \geq l_0 \\ 0.1 \times l_0 + 0.2 \times b_1 + b_w, b < l_0 \end{cases} \leq (b_1 + b_w)$$

Dimenzionisanje prema maksimalnom momentu u polju BC

$$M_{BC,Ed} = 1.35 \times 111.52 + 1.5 \times 149.29 = 374.49 \text{ kNm}$$

$$\text{pret. } d_1 = 6 \text{ cm} \rightarrow d = 60 - 7 = 53 \text{ cm}$$

$$x_{BC} = \frac{81.58}{29.84} = 2.73 \text{ m} \rightarrow l_0 = 2 \times 273 = 546 \text{ cm}$$

$$b_{eff,BC} = 0.4 \times 546 + 40 = 258.4 \text{ cm}, \quad 600 \geq 532$$

$$k = \frac{53}{\sqrt{\frac{374.49 \times 100}{258.4 \times 1.7}}} = 5.740 \rightarrow \zeta = 0.984, \varepsilon_{s1} = 89.47\text{‰}$$

$$A_{s1} = \frac{374.49 \times 100}{0.984 \times 53 \times 43.48} = 16.51 \text{ cm}^2$$

Usvaja se: **6020 (18.84 cm²)**



Dimenzionisanje prema maksimalnom momentu iznad oslonca B

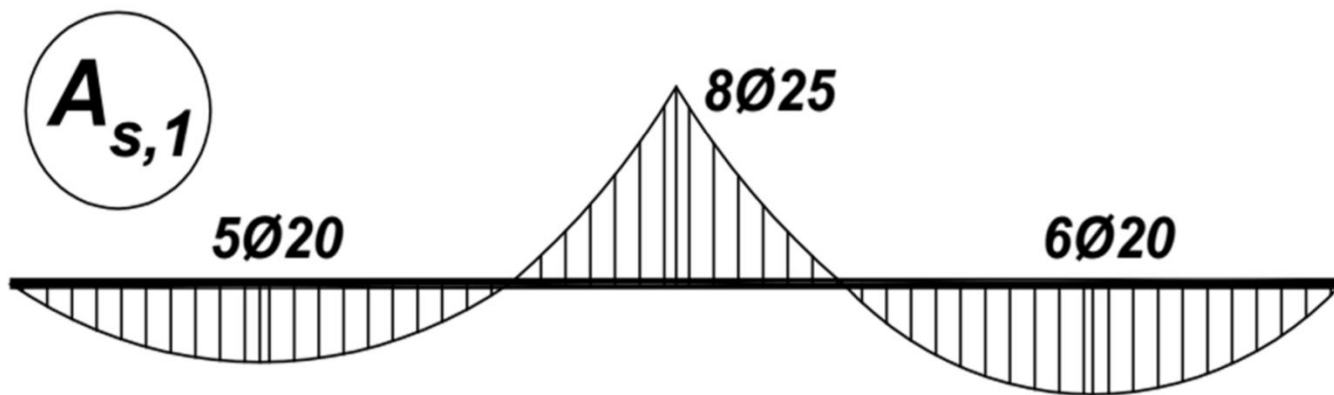
$$M_{B,Ed} = 1.35 \times 187.56 + 1.5 \times 247.30 = 624.16 \text{ kNm}$$

$$\text{pret. } d_1 = 8 \text{ cm} \rightarrow d = 60 - 8 = 52 \text{ cm}$$

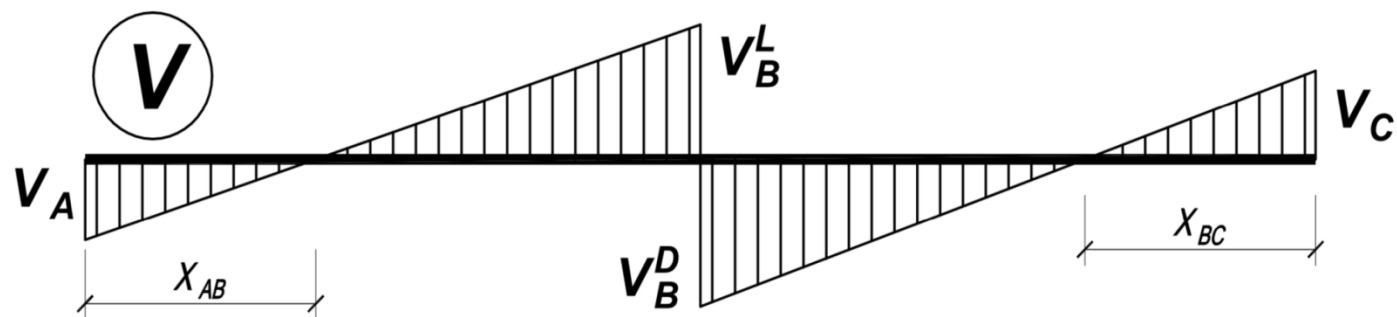
$$k = \frac{52}{\sqrt{\frac{624.16 \times 100}{40 \times 1.7}}} = 1.716 \rightarrow \zeta = 0.774, \varepsilon_{s1} = 2.953\text{‰}$$

$$A_{s1} = \frac{624.16 \times 100}{0.774 \times 52 \times 43.48} = 35.67 \text{ cm}^2 \quad \text{Usvaja se: } \boxed{8\text{Ø}25 \text{ (39.28 cm}^2\text{)}}$$

Usvojena armatura



6.5.2. Greda POS 6 - dimenzionisanje prema transverzalnim silama



$$V_{A,g} = 73.50 \text{ kN}$$

$$V_{A,q} = 95.50 \text{ kN}$$

$$V_{B,g}^L = 73.5 - 27.60 \times 7.2 = 125.22 \text{ kN}$$

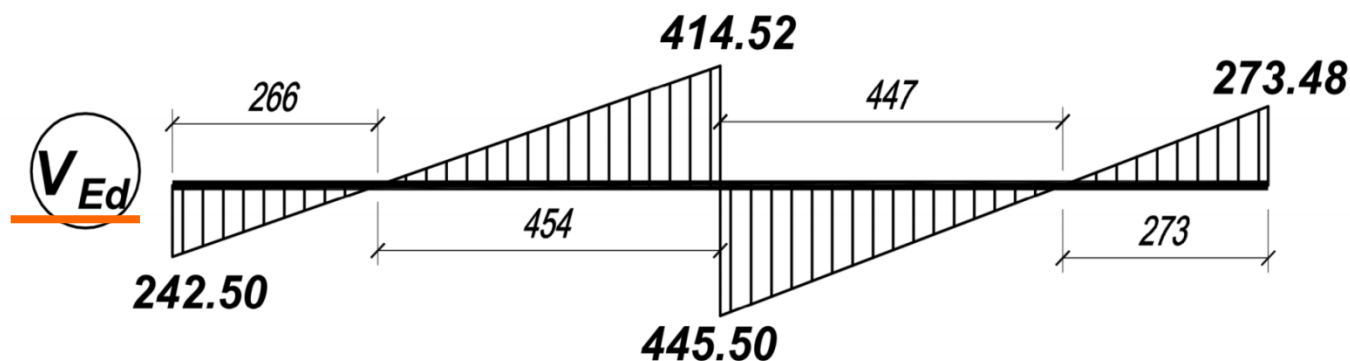
$$V_{B,q}^L = 95.50 - 36.00 \times 7.2 = 163.65 \text{ kN}$$

$$V_{B,g}^D = 125.22 - 258.50 = 133.28 \text{ kN}$$

$$V_{B,q}^D = 163.65 - 340.70 = 177.05 \text{ kN}$$

$$V_{C,g} = 81.58 \text{ kN}$$

$$V_{C,q} = 108.90 \text{ kN}$$



Oslonac A:

$$V_{A,Ed} = 1.35 \times 73.50 + 1.50 \times 95.50 = 242.50 \text{ kN}$$

**2Ø20 na mestu
krajnjeg oslonca A**

$$V_{Rd,c} = \left[\frac{0.18}{1.5} \times \left(1 + \sqrt{\frac{200}{540}} \right) \times \sqrt[3]{\left(100 \times \frac{6.28}{40 \times 54} \times 30 \right)} \right] \times \frac{40 \times 54}{10} = 85.82 \text{ kN}$$

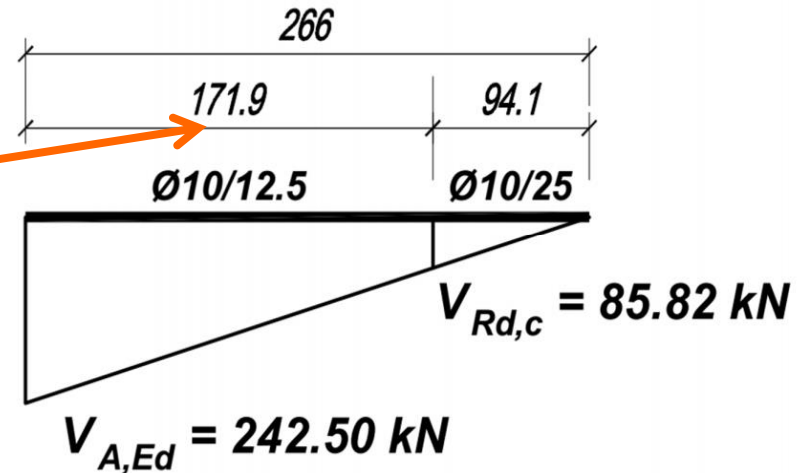
$$V_{Rd,c} < V_{A,Ed} \rightarrow \text{potrebno je osiguranje uzengijama}$$

Dužina osiguranja:

$$\lambda = 266 \times \left(1 - \frac{85.82}{242.5} \right) = 171.86 \text{ cm}$$

$$v_1 = 0.6 \left[1 - \frac{30}{250} \right] = 0.528$$

$$\text{Usvaja se: } \theta = 45^\circ, \alpha = 90^\circ, \text{ctg}\theta = 1$$



$$V_{Rd,max} = 40 \times 0.9 \times 54 \times 0.528 \times \frac{1.70}{(1 + 1)} = 872.47 \text{ kN} > 228.64 \text{ kN}$$

$$0.3V_{Rd,max} > V_{Ed} \rightarrow s_{max} = \min\{0.75d ; 30\text{cm}\} = 30\text{cm}$$

Pret. $\emptyset 10$, $m=2$

$$s \leq \frac{2 \times 0.785 \times 0.9 \times 54}{242.50} \times 43.5 \times 1 = 13.69 \text{ cm} < s_{max} = 30 \text{ cm}$$

Usvaja se: **$\emptyset 10/12.5$**

Dodatna zategnuta armature

$$\Delta F_{td} = 0.5 \times 242.50 \times 1 = 114.32 \text{ kN}$$

$$\Delta A_{s1} = \frac{\Delta F_{td}}{f_{yd}} = \frac{121.25}{43.5} = 2.79 \text{ cm}^2$$

Usvaja se: **$2\emptyset 20$** (6.28 cm^2)

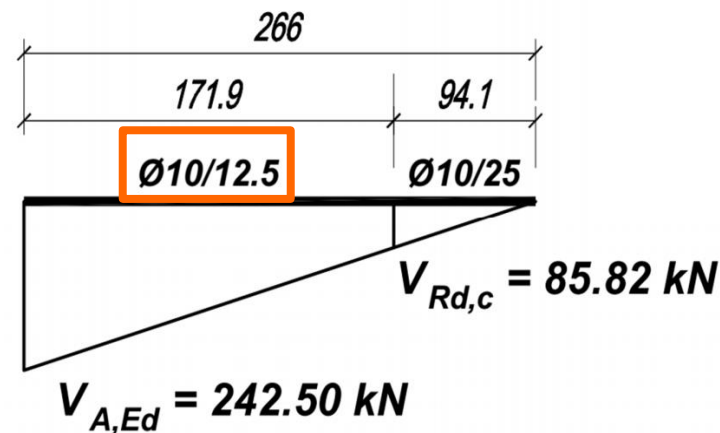
Izvan zone osiguranja usvaja se minimalni procenat armiranja

$$\rho_{w,min} = 0.08 \frac{\sqrt{f_{ck}}}{f_{yk}} = 0.08 \frac{\sqrt{30}}{500} = 0.00087 = 0.087\%$$

Pret. $\emptyset 10$, $m=2$

$$s \leq \frac{2 \times 0.785}{0.00087 \times 40} = 45.10 \text{ cm} > s_{max} = 30 \text{ cm}$$

Usvaja se: **$\emptyset 10/25$**



Oslonac B levo:

$$V_{B,Ed}^L = 1.35 \times 125.22 + 1.50 \times 163.65 = 414.52 \text{ kN}$$

**8Ø25 na mestu
srednjeg oslonca**

$$V_{Rd,c} = \left[\frac{0.18}{1.5} \times \left(1 + \sqrt{\frac{200}{520}} \right) \times \sqrt[3]{\left(100 \times \frac{39.28}{40 \times 52} \times 30 \right)} \right] \times \frac{40 \times 52}{10} = 155.30 \text{ kN}$$

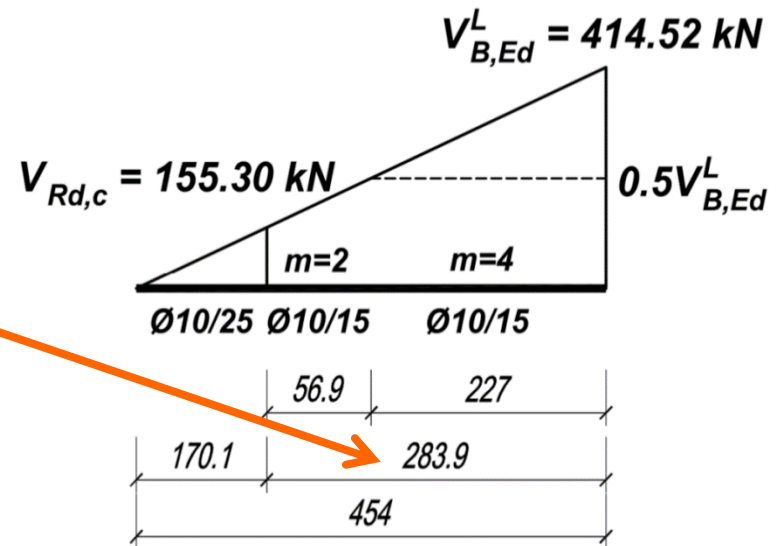
$$V_{Rd,c} < V_{B,Ed}^L \rightarrow \text{potrebno je osiguranje uzengijama}$$

Dužina osiguranja:

$$\lambda = 454 \times \left(1 - \frac{155.30}{414.52} \right) = 283.91 \text{ cm}$$

$$v_1 = 0.6 \left[1 - \frac{30}{250} \right] = 0.528$$

$$\text{Usvaja se: } \theta = 45^\circ, \alpha = 90^\circ, \text{ctg}\theta = 1$$



$$V_{Rd,max} = 40 \times 0.9 \times 52 \times 0.528 \times \frac{1.70}{(1+1)} = 840.15 \text{ kN} > 414.52 \text{ kN}$$

$$0.3V_{Rd,max} < V_{Ed} < 0.6V_{Rd,max} \rightarrow s_{max} = \min\{0.55d ; 30\text{cm}\} = 28.6\text{cm}$$

Pret. $\varnothing 10$, $m=4$

$$s \leq \frac{4 \times 0.785 \times 0.9 \times 52}{414.52} \times 43.5 \times 1 = 15.41 \text{ cm} < s_{max} = 28.6 \text{ cm}$$

Usvaja se: **$\varnothing 10/15$ $m=4$** na dužini od 227 cm

$\varnothing 10/15$ $m=2$ na dužini od 56.9 cm

!Dodatna zategnuta armature je jednaka nuli na mestu “špica” momenta (srednji oslonac)!

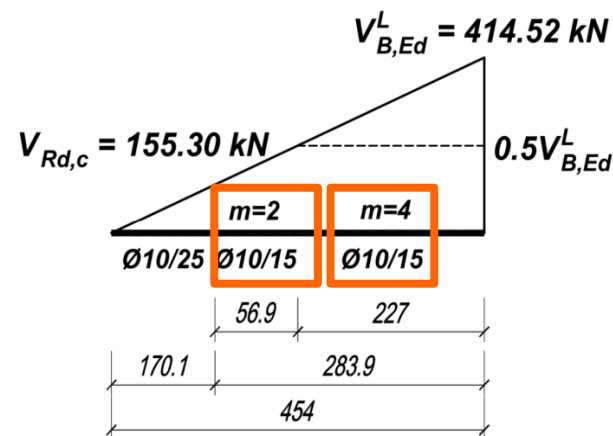
Izvan zone osiguranja usvaja se minimalni procenat armiranja

$$\rho_{w,min} = 0.08 \frac{\sqrt{f_{ck}}}{f_{yk}} = 0.08 \frac{\sqrt{30}}{500} = 0.00087 = 0.087\%$$

Pret. $\varnothing 10$, $m=2$

$$s \leq \frac{2 \times 0.785}{0.00087 \times 40} = 45.10 \text{ cm} > s_{max} = 28.6 \text{ cm}$$

Usvaja se: **$\varnothing 10/25$**



Oslonac B desno:

$$V_{B,Ed}^D = 1.35 \times 133.28 + 1.50 \times 177.05 = 445.50 \text{ kN}$$

**8Ø25 na mestu
srednjeg oslonca**

$$V_{Rd,c} = \left[\frac{0.18}{1.5} \times \left(1 + \sqrt{\frac{200}{520}} \right) \times \sqrt[3]{\left(100 \times \frac{39.28}{40 \times 52} \times 30 \right)} \right] \times \frac{40 \times 52}{10} = 155.30 \text{ kN}$$

$$V_{Rd,c} < V_{B,Ed}^D \rightarrow \text{potrebno je osiguranje uzengijama}$$

Dužina osiguranja:

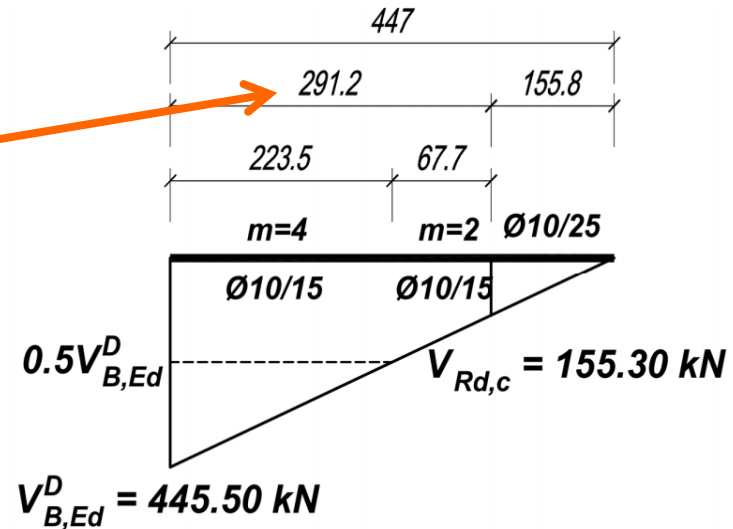
$$\lambda = 447 \times \left(1 - \frac{155.30}{445.50} \right) = 291.18 \text{ cm}$$

$$v_1 = 0.6 \left[1 - \frac{30}{250} \right] = 0.528$$

$$\text{Usvaja se: } \theta = 45^\circ, \alpha = 90^\circ, \text{ctg}\theta = 1$$

$$V_{Rd,max} = 40 \times 0.9 \times 52 \times 0.528 \times \frac{1.70}{(1 + 1)} = 840.15 \text{ kN} > 445.50 \text{ kN}$$

$$0.3V_{Rd,max} < V_{Ed} < 0.6V_{Rd,max} \rightarrow s_{max} = \min\{0.55d ; 30\text{cm}\} = 28.6 \text{ cm}$$



Pret. $\varnothing 10, m=4$

$$s \leq \frac{4 \times 0.785 \times 0.9 \times 52}{445.50} \times 43.5 \times 1 = 14.35 \text{ cm} < s_{max} = 28.6 \text{ cm}$$

Usvaja se: **$\varnothing 10/15 \text{ m}=4$** na dužini od 223.5 cm

$\varnothing 10/15 \text{ m}=2$ na dužini od 67.7 cm

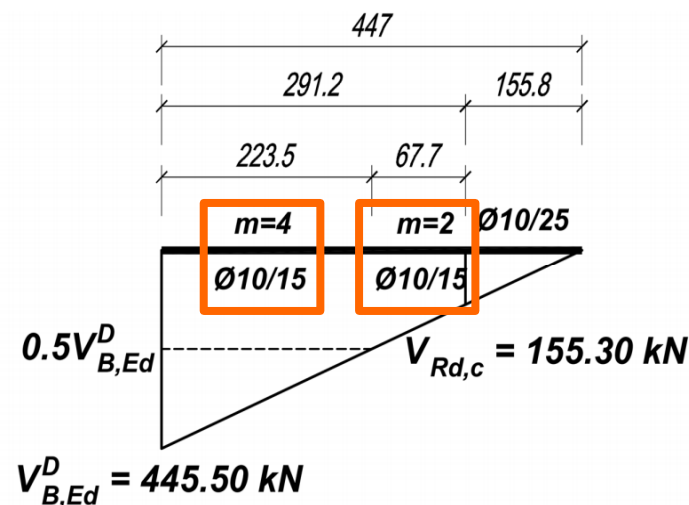
!Dodatna zategnuta armature je jednaka nuli na mestu “špica” momenta (srednji oslonac)!

Izvan zone osiguranja usvaja se minimalni procenat armiranja

Pret. $\varnothing 10, m=2$

$$s \leq \frac{2 \times 0.785}{0.00087 \times 40} = 45.10 \text{ cm} > s_{max} = 28.6 \text{ cm}$$

Usvaja se: **$\varnothing 10/25$**



Oslonac C:

$$V_{C,Ed} = 1.35 \times 81.58 + 1.50 \times 108.90 = 273.48 \text{ kN}$$

**2Ø20 na mestu
krajnjeg oslonca C**

$$V_{Rd,c} = \left[\frac{0.18}{1.5} \times \left(1 + \sqrt{\frac{200}{530}} \right) \times \sqrt[3]{\left(100 \times \frac{6.28}{40 \times 53} \times 30 \right)} \right] \times \frac{40 \times 53}{10} = 85.06 \text{ kN}$$

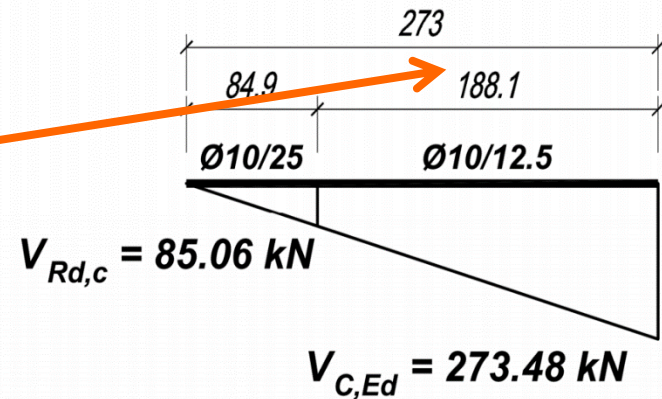
$$V_{Rd,c} < V_{B,Ed}^c \rightarrow \text{potrebno je osiguranje uzengijama}$$

Dužina osiguranja:

$$\lambda = 273 \times \left(1 - \frac{85.06}{273.48} \right) = 188.09 \text{ cm}$$

$$v_1 = 0.6 \left[1 - \frac{30}{250} \right] = 0.528$$

$$\text{Usvaja se: } \theta = 45^\circ, \alpha = 90^\circ, \text{ctg}\theta = 1$$



$$V_{Rd,max} = 40 \times 0.9 \times 53 \times 0.528 \times \frac{1.70}{(1 + 1)} = 856.31 \text{ kN} > 247.03 \text{ kN}$$

$$0.3V_{Rd,max} > V_{Ed} \rightarrow s_{max} = \min\{0.75d ; 30\text{cm}\} = 30\text{cm}$$

Pret. Ø10, m=2

$$s \leq \frac{2 \times 0.785 \times 0.9 \times 53}{273.48} \times 43.5 \times 1 = 11.91 \text{ cm} < s_{max} = 30 \text{ cm}$$

Usvaja se: **Ø10/10**

Dodatna zategnuta armatura

$$\Delta F_{td} = 0.5 \times 273.48 \times 1 = 136.74 \text{ kN}$$

$$\Delta A_{s1} = \frac{\Delta F_{td}}{f_{yd}} = \frac{136.74}{43.5} = 3.14 \text{ cm}^2$$

Usvaja se: **2Ø20** (6.28 cm²)

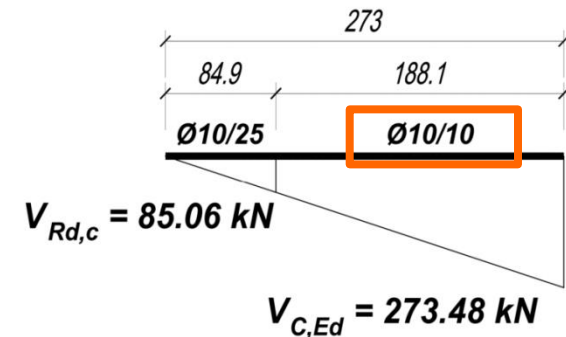
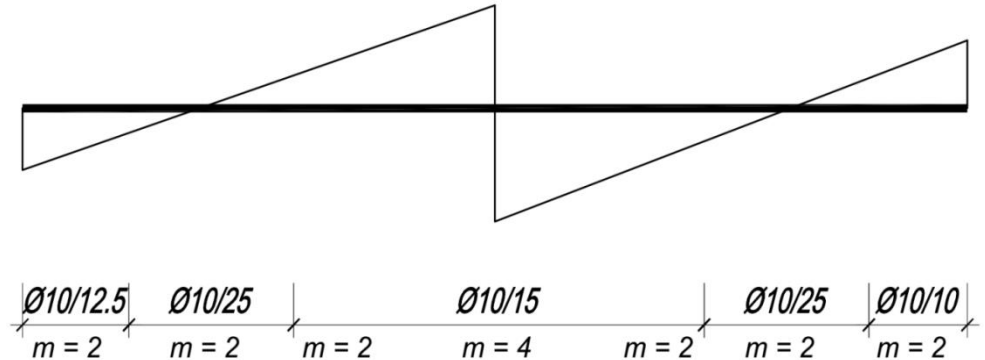
Izvan zone osiguranja usvaja se minimalni procenat armiranja

$$\rho_{w,min} = 0.08 \frac{\sqrt{f_{ck}}}{f_{yk}} = 0.08 \frac{\sqrt{30}}{500} = 0.00087 = 0.087\%$$

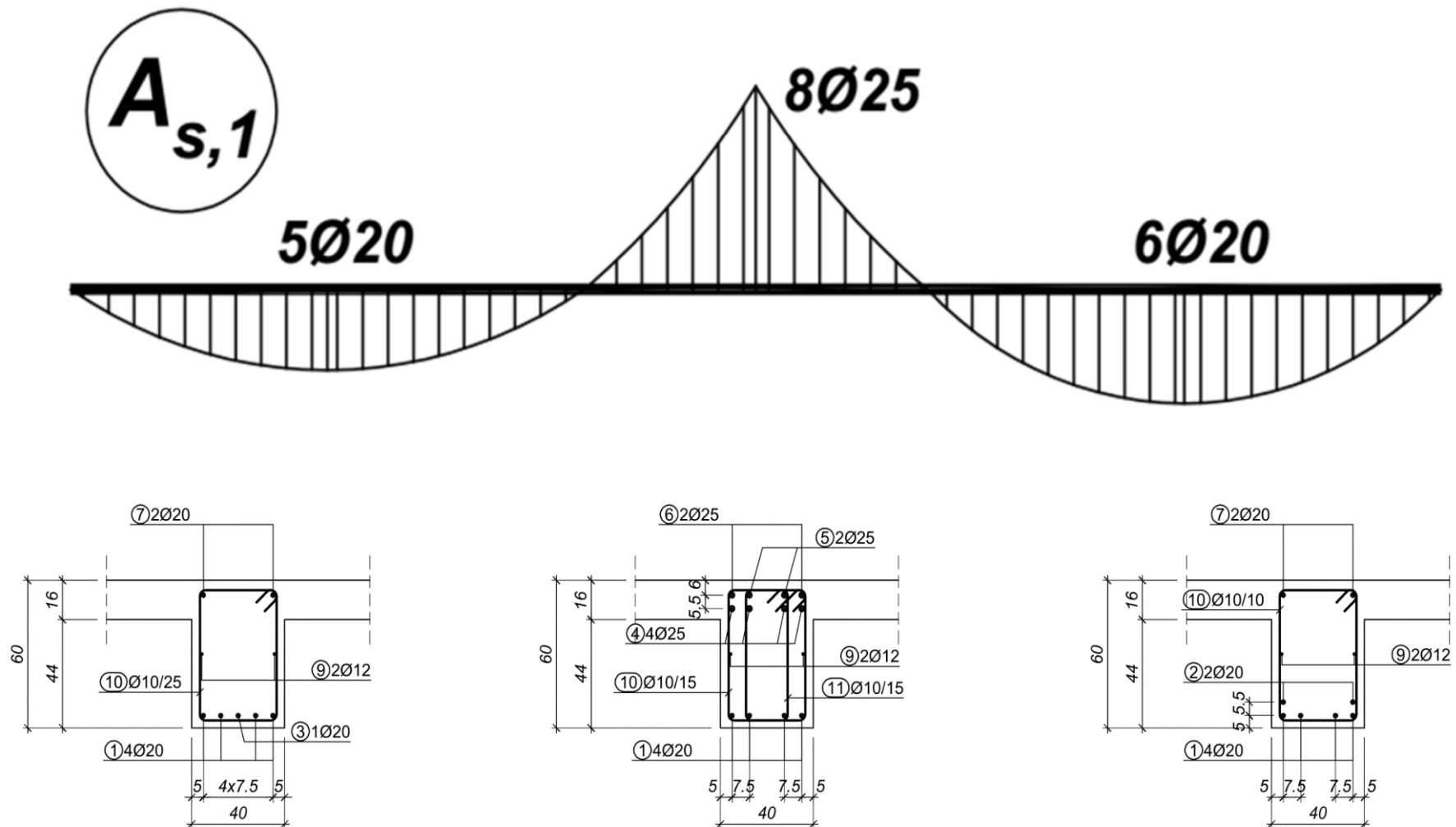
Pret. Ø10, m=2

$$s \leq \frac{2 \times 0.785}{0.00087 \times 40} = 45.10 \text{ cm} > s_{max} = 30 \text{ cm}$$

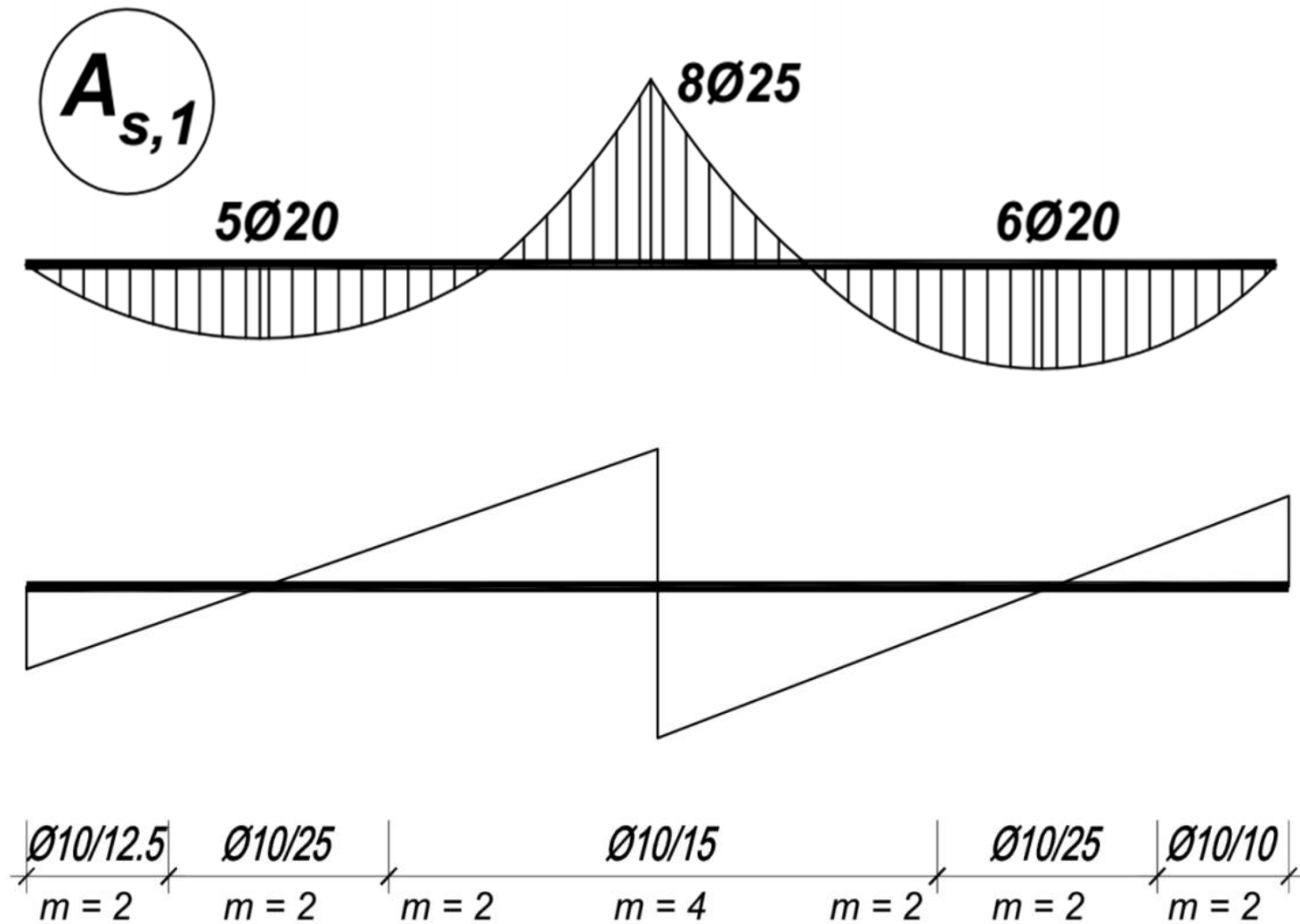
Usvaja se: **Ø10/25**

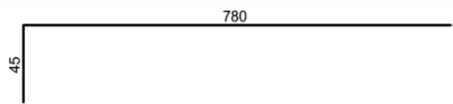
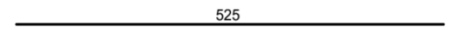
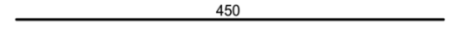
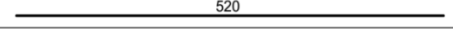
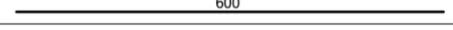
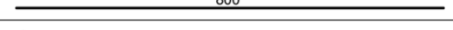
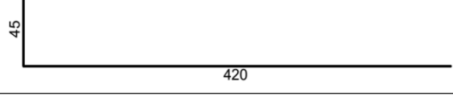
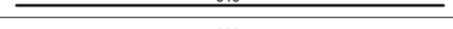
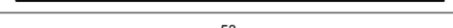
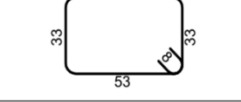
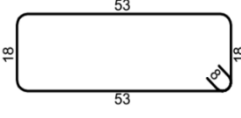


Usvojena armatura



Usvojena armatura



Šipke - specifikacija						
ozn.	oblik i mere [cm]	ozn.	Ø	lg [m]	n [kom]	lgn [m]
POS 6 (1 kom)						
1		B500B	20	8.25	8	66.00
2		B500B	20	5.25	2	10.50
3		B500B	20	4.50	1	4.50
4		B500B	25	5.20	4	20.80
5		B500B	25	6.00	2	12.00
6		B500B	25	8.00	2	16.00
7		B500B	20	4.65	2	9.30
8		B500B	20	6.40	2	12.80
9		B500B	12	6.80	4	27.20
10		B500B	10	1.88	89	167.32
11		B500B	10	1.58	30	47.40
Šipke - rekapitulacija						
Ø [mm]	lgn [m]	Jedinična težina [kg/m']		Težina [kg]		
B500B						
10	214.72	0.62		133.13		
12	27.20	0.89		24.15		
20	103.10	2.47		254.24		
25	48.80	3.85		188.03		
Ukupno						599.55

