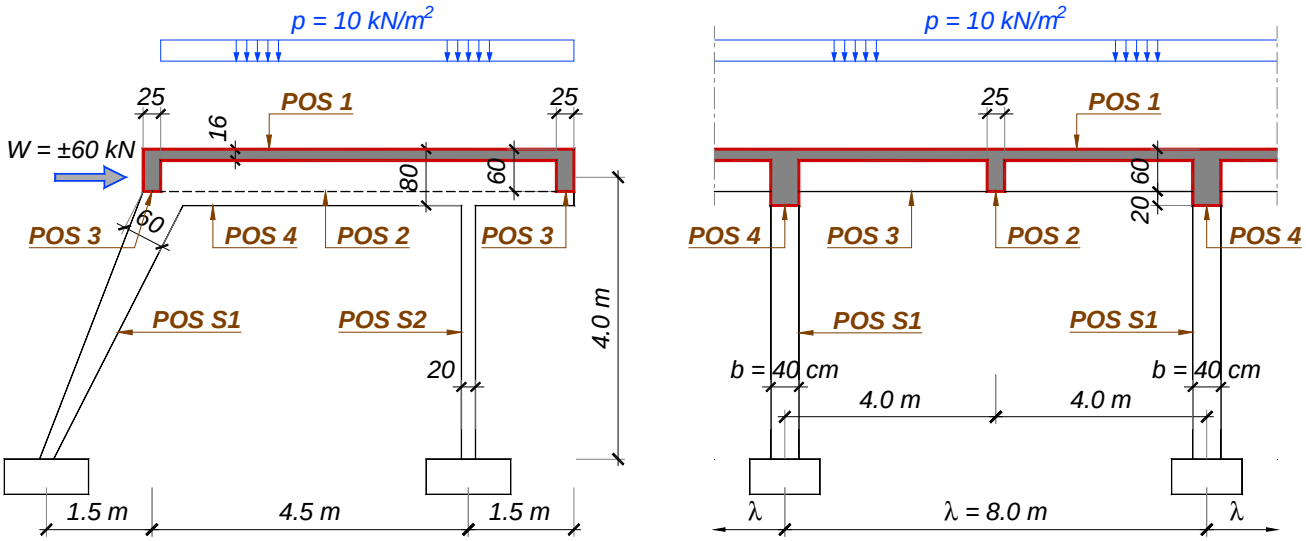
03

Za neko srednje polje konstrukcije prikazane na skici, potrebno je:

*1 Dimenzionisati u merodavnim presecima ploču **POS 1** (d_p = 16 cm). Usvojenu armaturu prikazati u osnovi (posebno gornja i donja zona).*

*2 Dimenzionisati gredu **POS 2** i **POS 3** (b/d = 25/60 cm) prema M i T.*



*3 Izvršiti analizu opterećenja za ram **POS 4, POS S1, POS S2** i nacrtati dijagrame M, N, T za stalno, povremeno i opterećenje vetrom (alternativni uticaj).*

*4 Dimenzionisati **POS 4, POS S1, POS S2** u karakterističnim presecima prema merodavnim uticajima sračunatim u prethodnoj tački. Za dužinu izvijanja stuba **POS S2** usvojiti sistemnu dužinu štapa.*

Podaci za proračun: MB 30, RA 400/500, W=±60 kN (sila svedena na jedan ram).

1. POS 1 – ploča d_p = 16 cm

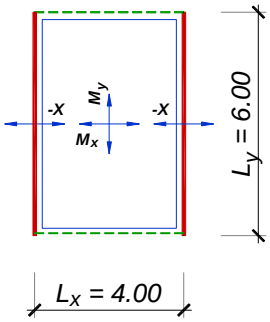
$L_y/L_x = 6.0/4.0 = 1.5$

$g = 0.16 \times 25 = 4.0$ kN/m^2 ; $p = 10.0$ kN/m^2

$G = 4.0 \times 4.0 \times 6.0 = 96$ kN ; $P = 10.0 \times 4.0 \times 6.0 = 240$ kN

$Q_u = 1.6 \times G + 1.8 \times P = 585.6$ kN

	k		G kNm/m	P kNm/m	**U kNm/m**
kraći pravac, polje	0.027	**M_X**	2.6	6.5	**15.8**
duži pravac, polje	0.009	**M_Y**	0.9	2.2	**5.3**
kraći pravac, oslonac	0.055	**-X**	5.3	13.2	**32.2**



<u>*Dimenzionisanje*</u>

MB 30 $\Rightarrow$ $f_B = 20.5$ MPa ; RA 400/500 $\Rightarrow$ $\sigma_v = 400$ MPa

max.M_{xu} = 32.2 kNm/m (gornja zona)

$a_1 = 3.0$ cm $\Rightarrow$ $h = d - a_1 = 16 - 3 = 13$ cm

$$k = \frac{13}{\sqrt{\frac{32.2}{2.05}}} = 3.280 \Rightarrow \varepsilon_b/\varepsilon_a = 1.833/10‰ \; ; \; \bar{\mu} = 9.862\% \; ; \; \zeta = 0.943$$

$$A_{aX} = 9.862 \times 13 \times \frac{2.05}{40} = 6.57\ cm^2/m$$

usvojeno: **RØ12/15** (7.54 cm^2/m)

$A_{ap} = 0.2 \times 6.57 = 1.31\ cm^2/m < A_{ap,\min} = 0.085 \times 16 = 1.36\ cm^2/m$

usvojeno: **RØ8/30** (1.67 cm^2/m) – podeona armatura

$M_{xu} = 15.8$ kNm/m (donja zona, kraći pravac)

$a_{1x} = 2.0 + 0.8/2 = 2.4\ cm \Rightarrow h_x = 16 - 2.4 = 13.6\ cm$

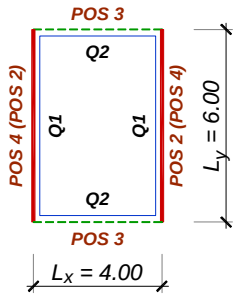
$$A_{aX} \approx \frac{15.8 \times 10^2}{0.9 \times 13.6 \times 40} = 3.22\ \frac{cm^2}{m} \Rightarrow$$ usvojeno: **RØ8/15** (3.35 cm^2/m)

$M_{yu} = 5.3$ kNm/m (donja zona, duži pravac)

$a_{1y} = 2.0 + 0.8 + 0.8/2 = 3.2\ cm \Rightarrow h_y = 16 - 3.2 = 12.8\ cm$

$$A_{aY} \approx \frac{5.3 \times 10^2}{0.9 \times 12.8 \times 40} = 1.14\ \frac{cm^2}{m} < A_{a,\min} = 1.6\ \frac{cm^2}{m} \Rightarrow$$ usvojeno: **RØ8/20** (2.51 cm^2/m)

Analiza opterećenja za grede POS 2 – POS 4

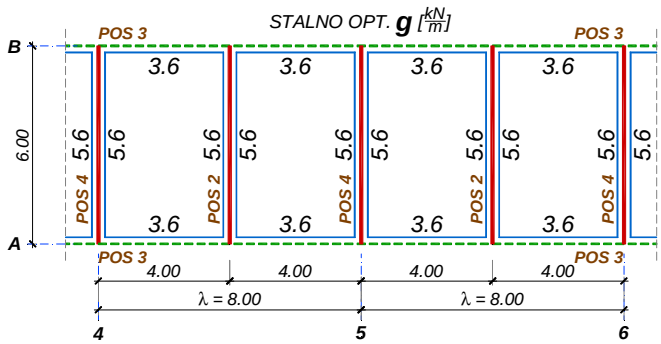


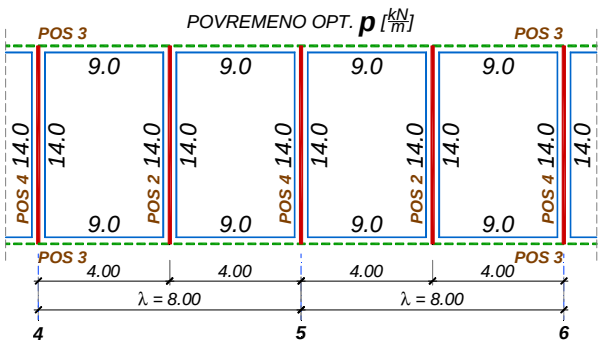
POS	k		G kN	P kN	L m	g kN/m	p kN/m
4 (2)	0.35	**Q_1**	33.6	84.0	6.0	**5.6**	**14.0**
3	0.15	**Q_2**	14.4	36.0	4.0	**3.6**	**9.0**

Stalnom opterećenju potrebno je dodati sopstvenu težinu greda:

$g_2 = 0.25 \times 0.6 \times 25 = 3.75\ kN/m = g_3$

$g_4 = 0.30 \times 0.8 \times 25 = 6.00\ kN/m$





2. Proračun greda POS 2, POS 3

POS 2 – greda b/d = 25/60 cm

Prosta greda, raspona 6.0 m, pored sopstvene težine opterećena opterećenjem sa POS 1.

$g = 2 \times 5.6 + 3.75 = 14.95\ kN/m$; $p = 2 \times 14.0 = 28.0\ kN/m$

$T_g = 14.95 \times 6.0/2 = 44.85\ kN$; $T_p = 28.0 \times 6.0/2 = 84.0\ kN$

$q_u = 1.6 \times 14.95 + 1.8 \times 28.0 = 74.32\ kN/m$

$M_u = 74.32 \times 6.0^2/8 = 334.4\ kNm$

$$B = \min.\begin{Bmatrix} 25 + 0.25 \times 600 = 175 \\ 25 + 20 \times 16 = 345 \end{Bmatrix} = 175\ cm$$

$a_1 = 7\ cm \quad \Rightarrow \quad B/b/d/h = 175/25/60/53\ cm$

$$k = \frac{53}{\sqrt{\frac{334.4\times10^2}{175\times2.05}}} = 5.489 \Rightarrow \begin{matrix}\varepsilon_b / \varepsilon_a = 0.943/10‰ \\ s = 0.086 \Rightarrow x = 0.086\times53 = 4.57\,cm < 16\,cm \\ \bar{\mu} = 3.422\%\end{matrix}$$

$$A_a = 3.422\times\frac{175\times53}{100}\times\frac{2.05}{40} = 16.26\,cm^2 \quad \Rightarrow \quad \text{usvojeno } \mathbf{5RØ22}\ (19.01\ cm^2)$$

$$T_u = 1.6\times44.85 + 1.8\times84 = 223\ kN \quad \Rightarrow \quad \tau_n = \frac{223}{25\times0.9\times53} = 0.187\,\frac{kN}{cm^2} \begin{cases} > \tau_r = 1.1\,MPa \\ < 3\tau_r \end{cases}$$

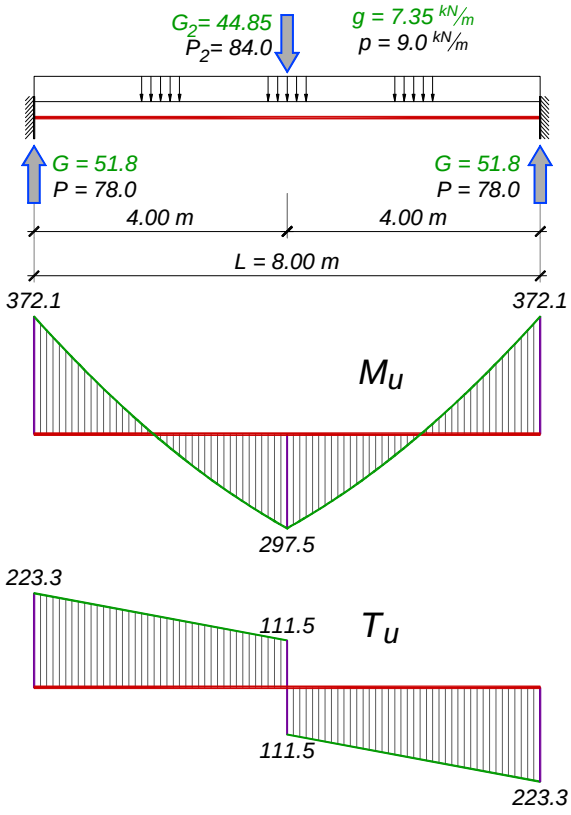
$$\lambda = \frac{6.0}{2}\times\left(1-\frac{0.11}{0.187}\right) = 1.23\,m \quad ; \quad \tau_{Ru}^A = \frac{3}{2}\times(0.187-0.11) = 0.115\,\frac{kN}{cm^2}$$

$$e_u = \frac{2\times0.503}{25\times0.115}\times40 = 13.9\ cm \quad \Rightarrow \quad \text{usvojeno } \mathbf{URØ8/12.5}\ (m=2)$$

$$\Delta A_a = \frac{223}{2\times40}\times(\cot45^\circ - \cot90^\circ) = 2.79\,cm^2 \quad \Rightarrow \quad \text{usvojeno } \mathbf{2RØ25}\ (9.82\ cm^2)$$

POS 3 *– greda b/d = 25/60 cm*

Kontinualna greda preko velikog broja oslonaca, raspona 8.0 m. Neko srednje polje se proračunava kao "K" štap, odnosno obostrano uklještena greda. Pored sopstvene težine, opterećena je raspodeljenim opterećenjem od ploče POS 1 (reakcija Q_2 na dužini L_x=4.0 m) i koncentrisanim silama od POS 2 u sredini raspona.



$g = 3.75 + 3.6 = 7.35\ kN/m$

$p = 9.0\ kN/m$

$G_2 = 44.85\ kN \quad ; \quad P_2 = 84\ kN$

$G = (7.35\times8.0 + 44.85)/2 = 51.8\ kN$

$P = (9.0\times8.0 + 84)/2 = 78\ kN$

$q_u = 1.6\times7.35 + 1.8\times9.0 = 28\ kN/m$

$Q_u = 1.6\times44.85 + 1.8\times84 = 223\ kN$

a. gornja zona

$$M_u^O = \frac{223\times8.0}{8} + \frac{28\times8.0^2}{12} = 372.1\,kNm$$

$a_1 = 7\ cm \quad \Rightarrow \quad b/d/h = 25/60/53\ cm$

$$k = \frac{53}{\sqrt{\frac{372.1\times10^2}{25\times2.05}}} = 1.967 \Rightarrow \varepsilon_b / \varepsilon_a = 3.5/5.734‰ \ ; \ \bar{\mu} = 30.684\%$$

$$A_a = 30.684\times\frac{25\times53}{100}\times\frac{2.05}{40} = 20.84\,cm^2 \quad \Rightarrow \quad \text{usvojeno } \mathbf{6RØ22}\ (22.81\ cm^2)$$

b. donja zona

$$M_u^P = \frac{Q_u \times L}{8} + \frac{q_u \times L^2}{24} = \frac{223 \times 8.0}{8} + \frac{28 \times 8.0^2}{24} = 297.5\,kNm$$

$$L_0 \approx 420\,cm \;\Rightarrow\; B = \min.\begin{Bmatrix} 25 + 420/12 = 60 \\ 25 + 8 \times 16 = 153 \end{Bmatrix} = 60\,cm$$

$a_1 = 7\ cm \quad \Rightarrow \quad B/b/d/h = 60/25/60/53\ cm$

$$k = \frac{53}{\sqrt{\frac{297.5 \times 10^2}{60 \times 2.05}}} = 3.408 \;\Rightarrow\; \begin{cases} \varepsilon_b / \varepsilon_a = 1.733 / 10‰ \\ s = 0.148 \;\Rightarrow\; x = 0.148 \times 53 = 7.8 < d_p = 16\,cm \\ \bar{\mu} = 9.105\% \end{cases}$$

$$A_a = 9.105 \times \frac{60 \times 53}{100} \times \frac{2.05}{40} = 14.84\,cm^2 \quad \Rightarrow \quad \text{usvojeno } \mathbf{4RØ22}\ (15.21\ cm^2)$$

c. kontrola glavnih napona zatezanja

T_u^A = 1.6×51.8 + 1.8×78 = 223.3 kN

$$\tau_n^A = \frac{223.3}{25 \times 0.9 \times 53} = 0.187\,\frac{kN}{cm^2} \begin{cases} > \tau_r = 1.1\,MPa \\ < 3\tau_r \end{cases}$$

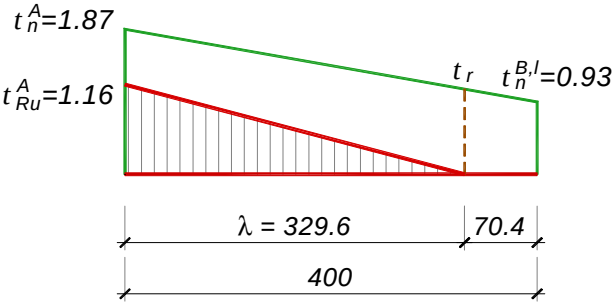
$T_u^{B,l}$ = (1.6×44.85 + 1.8×84)/2 = 111.5 kN

$$\tau_n^{B,l} = \frac{111.5}{25 \times 0.9 \times 53} = 0.093\,\frac{kN}{cm^2} < \tau_r = 1.1\,MPa$$

$$\lambda = 400 \times \frac{1.87 - 1.1}{1.87 - 0.93} = 329.6\,cm$$

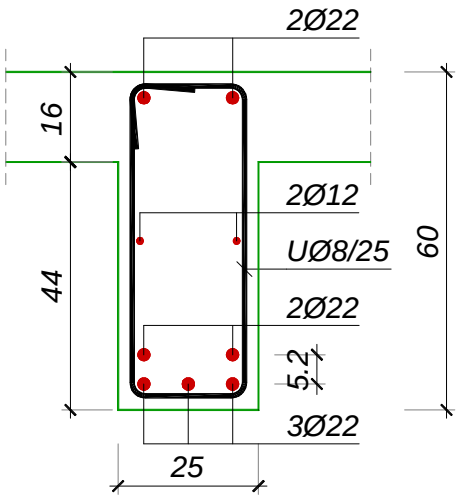
$$\tau_{Ru}^A = \frac{3}{2} \times (0.187 - 0.11) = 0.116\,\frac{kN}{cm^2} \quad \Rightarrow \quad e_u = \frac{2 \times 0.503}{25 \times 0.116} \times 40 = 13.9\ cm$$

usvojeno **URØ8/12.5** (m=2)

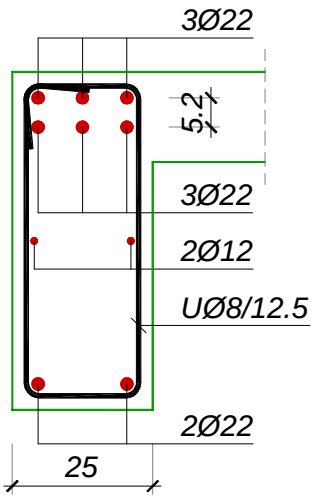


ΔA_a = 0 (»špic« momenta)

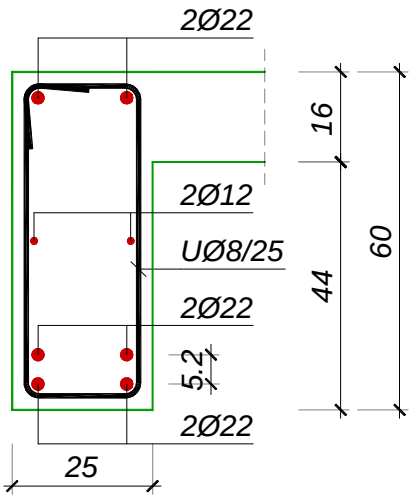
POS 2, polje



POS 3, oslonac



POS 3, polje



3. Proračun rama POS 4, POS S1, POS S2

Ram na tri zgloba[1]*, opterećen raspodeljenim stalnim i povremenim opterećenjem od ploče POS 1 i koncentrisanim silama od greda POS 3. Kao treći slučaj opterećenja razmatra se vetar (alternativno dejstvo), zadat kao koncentrisana horizontalna sila W = ±60 kN.*

a. stalno opterećenje

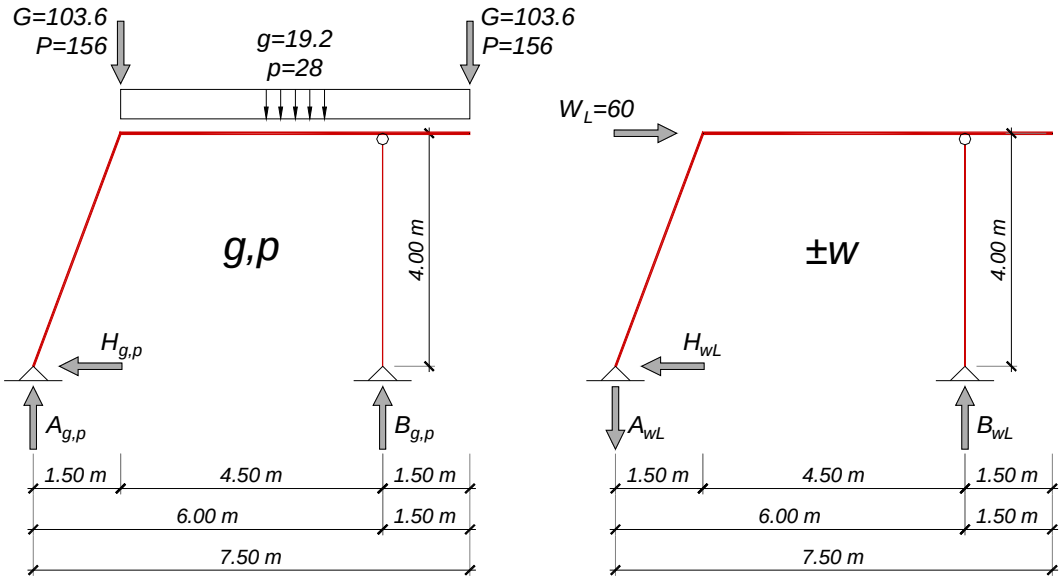
- *sopstvena težina POS 4:* $0.40\times0.80\times25 = 8.0$ kN/m
- *od POS 1* $2\times5.60 = 11.2$ kN/m

ukupno, stalno opterećenje $g = 19.2$ kN/m

- *od POS 3* $2\times51.8 = G = 103.6$ kN

b. povremeno opterećenje

- *od POS 1* $2\times14.00 = p = 28.0$ kN/m
- *od POS 3* $2\times78.0 = P = 156.0$ kN



$$B_g = \frac{19.2\times6.0\times\left(1.5+\frac{6.0}{2}\right)+103.6\times(7.5+1.5)}{6.0} = 241.9\,kN$$

$$A_g = 19.2\times6.0+2\times103.6-241.9 = 80.6\,kN \quad ; \quad H_g = 0$$

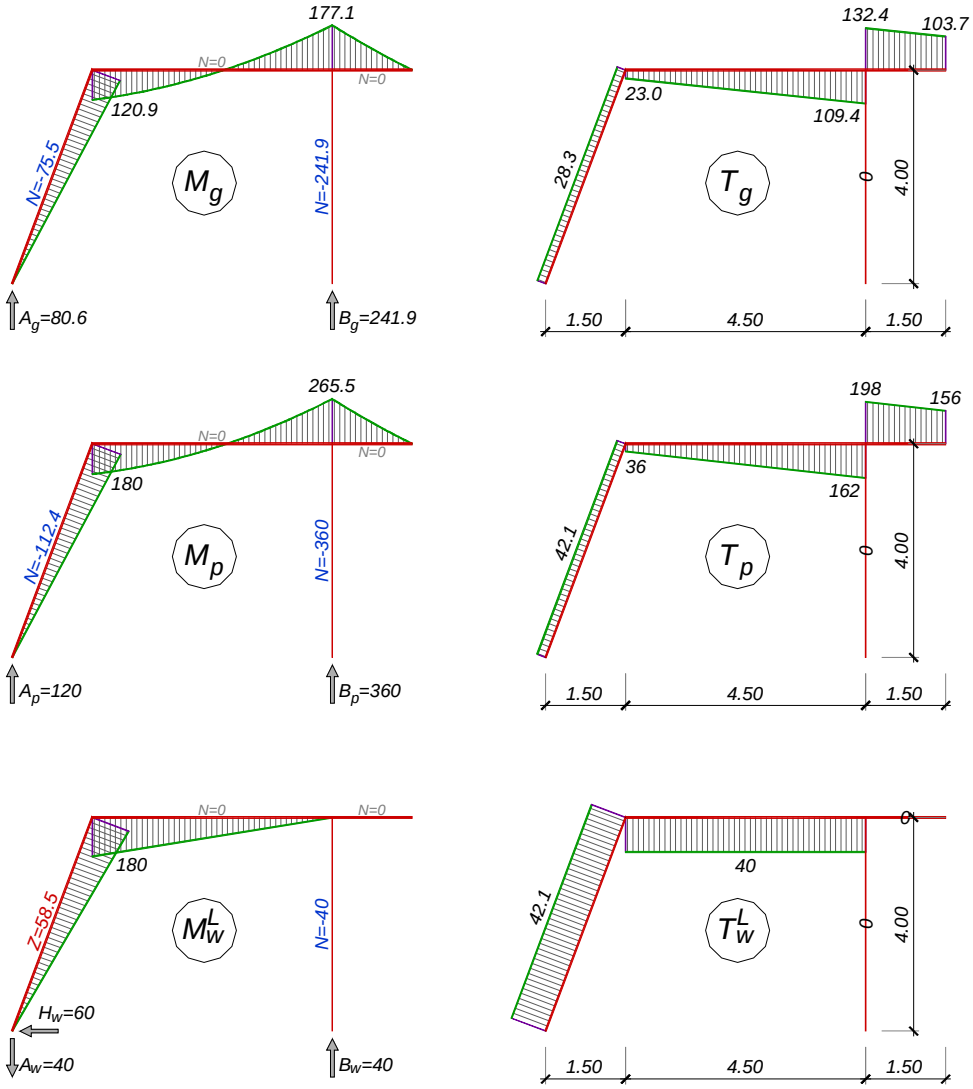
$$B_p = \frac{28\times6.0\times\left(1.5+\frac{6.0}{2}\right)+156\times(7.5+1.5)}{6.0} = 360\,kN$$

$$A_p = 28\times6.0+2\times156-360 = 120\,kN \quad ; \quad H_p = 0$$

$$B_{wL} = \frac{60\times4.0}{6.0} = 40\,kN = A_{wL} \quad ; \quad H_{wL} = W_L = 60\,kN$$

Dijagrami presečnih sila usled stalnog, povremenog i opterećenja vetrom (deluje sleva na-desno) su prikazani u nastavku. Dejstvo vetra je alternativno, što je uzeto u obzir pri pravljenju kombinacija uticaja u karakterističnim presecima.

[1] *Zglob na levom stubu POS S1, na spoju sa temeljom, je formiran postepenim smanjenjem krutosti stuba od gornjeg ka donjem kraju. Desni stub POS S2 je modeliran kao prost štap zbog znatno manje krutosti u odnosu na ostale elemente rama (dimenzije POS 4 i POS S1 su 80, odnosno 60 cm u odnosu na d = 20 cm stuba S2).*



4. Dimenzionisanje elemenata rama POS 4, POS S1, POS S2

Dimenzionisanje POS 4 (b/d = 40/80 cm)

<u>Presek uz stub S2</u>

$M_u = 1.6\times177.1 + 1.8\times265.5 = 761.2$ kNm

pretp. $a_1 = 6$ cm $\Rightarrow$ b/d/h = 40/80/74 cm

$$k = \frac{74}{\sqrt{\frac{761.2\times10^2}{40\times2.05}}} = 2.429 \quad \Rightarrow \quad \begin{matrix}\varepsilon_b / \varepsilon_a = 3.133/10‰ \\ \bar{\mu} = 18.780\%\end{matrix}$$

$$A_a = 18.780\times\frac{40\times74}{100}\times\frac{2.05}{40} = 28.49\,cm^2 \quad \Rightarrow \quad \text{usvojeno } \mathbf{6RØ25}\ (29.45\ cm^2)$$

<u>Presek uz stub S1 – donja zona</u>

Upoređivanjem dijagrama momenata savijanja od pojedinačnih opterećenja, lako je zaključiti da je merodavna kombinacija uticaja ***g+p+w$_L$****. Kako su transverzalne sile za ove uticaje istog znaka, presek sa maksimalnim momentom M_u je neposredno uz stub.*

Presek će biti dimenzionisan kao pravougaoni, dimenzija b/d = 40/80 cm, jer na oslonačkom delu grede nije realno ostvarivanje pune aktivne širine B.

$M_u = 1.6\times120.9 + 1.8\times(180 + 180) = 841.5\ kNm$

pretp. $a_1 = 6\ cm \quad \Rightarrow \quad b/d/h = 40/80/74\ cm$

$$k = \frac{74}{\sqrt{\frac{841.5\times10^2}{40\times2.05}}} = 2.310 \quad \Rightarrow \quad \begin{matrix}\varepsilon_b / \varepsilon_a = 3.5 / 9.987‰ \\ \mu = 21.008\%\end{matrix}$$

$$A_a = 21.008\times\frac{40\times74}{100}\times\frac{2.05}{40} = 31.87\ cm^2 \quad \Rightarrow \quad \text{usvojeno } \mathbf{7RØ25}\ (34.36\ cm^2)$$

<u>*Presek uz stub S1 – gornja zona*</u>

$M_u = 1.0\times(-120.9) + 1.8\times180 = 203.1\ kNm$ *(povoljno dejstvo G + vetar sdesna)*

pretp. $a_1 = 5\ cm \quad \Rightarrow \quad b/d/h = 40/80/75\ cm$

$$k = \frac{75}{\sqrt{\frac{203.1\times10^2}{40\times2.05}}} = 4.766 \quad \Rightarrow \quad \begin{matrix}\varepsilon_b / \varepsilon_a = 1.117 / 10‰ \\ \mu = 4.564\%\end{matrix}$$

$$A_a = 4.564\times\frac{40\times75}{100}\times\frac{2.05}{40} = 7.02\ cm^2 \quad \Rightarrow \quad \text{usvojeno } \mathbf{2RØ22}\ (7.60\ cm^2)$$

<u>*Kontrola glavnih napona zatezanja*</u>

$T_u^{B,d} = 1.6\times132.4 + 1.8\times198 = 568.3\ kN \quad ; \quad T_u^{C} = 1.6\times103.7 + 1.8\times156 = 446.6\ kN$

$T_u^{B,l} = 1.6\times109.4 + 1.8\times(162+40) = 538.7\ kN \ ; \quad T_u^{A} = 1.6\times23.0 + 1.8\times(36+40) = 173.6\ kN$

$$\tau_n^{B,d} = \frac{568.3}{40\times0.9\times74} = 0.213\frac{kN}{cm^2} \begin{cases} > \tau_r = 1.1\,MPa \\ < 3\tau_r \end{cases} \Rightarrow \tau_{Ru}^{B,d} = \frac{3}{2}\times(0.213 - 0.11) = 0.155\frac{kN}{cm^2}$$

$$\tau_n^{C} = \frac{446.6}{40\times0.9\times74} = 0.168\frac{kN}{cm^2} \begin{cases} > \tau_r \\ < 3\tau_r \end{cases} \Rightarrow \tau_{Ru}^{C} = \frac{3}{2}\times(0.168 - 0.11) = 0.086\frac{kN}{cm^2}$$

Kako je napon τ_r *prekoračen na čitavom prepustu (delu B-C), dužina osiguranja je* $\lambda = 1.5\ m$.

$$e_u = \frac{2\times a_u^{(1)}}{40\times0.155}\times40 = 12.9\times a_u^{(1)}$$

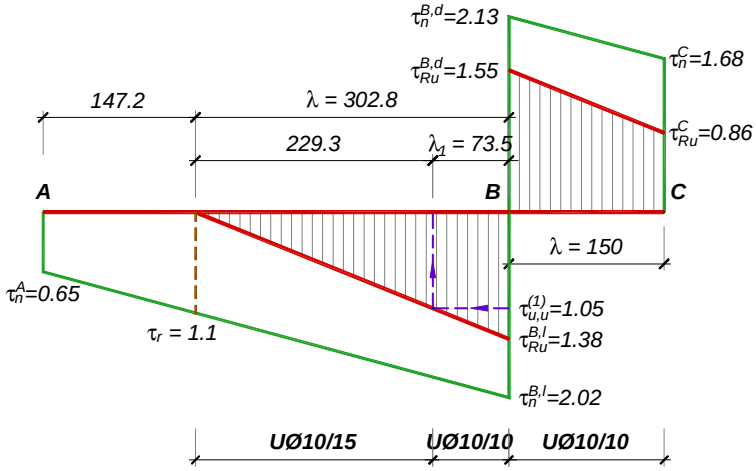
URØ10: $e_u \le 12.9\times0.785 = 10.1\ cm$

usvojeno: ***URØ10/10*** *(m=2)*

$$\tau_n^{B,l} = \frac{538.7}{40\times0.9\times74} = 0.202\frac{kN}{cm^2} \begin{cases} > \tau_r \\ < 3\tau_r \end{cases}$$

$$\tau_n^{A} = \frac{173.6}{40\times0.9\times74} = 0.065\frac{kN}{cm^2} < \tau_r$$

$$\lambda = 450\times\frac{2.02 - 1.1}{2.02 - 0.65} = 302.8\ cm$$



$$\tau_{Ru}^{B,l} = \frac{3}{2}\times(0.202 - 0.11) = 0.138\frac{kN}{cm^2} \quad \Rightarrow \quad e_u = \frac{2\times0.785}{40\times0.138}\times40 = 11.4\ cm$$

Minimalne uzengije na dužini osiguranja se proračunavaju iz minimalnog procenta armiranja:

$$e_u \le \frac{2\times0.785}{40\times\mu_{uz,\min}} = \frac{2\times0.785}{40\times0.2\times10^{-2}} = 19.6\ cm \quad \Rightarrow \quad \text{usvojeno: } \mathbf{URØ10/15}\ (m=2)$$

Ovako usvojene uzengije mogu prihvatiti napon:

$$\tau_{u,u}^{(1)} = \frac{m \times a_u^{(1)}}{b \times e_u} \times \sigma_v \times (\cos\alpha + \sin\alpha \cot\theta) = \frac{2 \times 0.785}{40 \times 15} \times 40 = 0.105 \frac{kN}{cm^2}$$

i njihova nosivost nije dovoljna na delu nosača dužine λ_1 (prethodna skica):

$$\lambda_1 = \lambda \times \left(1 - \frac{\tau_{u,u}^{(1)}}{\tau_{Ru}^{B,l}}\right) = 302.8 \times \left(1 - \frac{1.05}{1.38}\right) = 73.5\,cm$$

*Na ovoj dužini postavljaju se dvosečne uzengije **URØ10/10**.*

U presecima B^l i B^d nije potrebna dodatna zategnuta armatura (»špicevi« momenata). U ostalim presecima na dužini osiguranja ova armatura se uzima u obzir konstrukcijom linije zatežućih sila (pomeranjem linije M/z).

Dimenzionisanje POS S1 (b/d = 40/60 cm)

<u>Presek u vrhu stuba, donja zona</u>

M_u = 1.6×120.9 + 1.8×(180 + 180) = 841.5 kNm

N_u = 1.6×75.5 + 1.8×(112.4 – 58.5) = 217.7 kN (pritisak)

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

$$M_{au} = 841.5 + 217.7 \times \left(\frac{0.6}{2} - 0.07\right) = 891.6\ kNm$$

$$k = \frac{53}{\sqrt{\frac{891.6 \times 10^2}{40 \times 2.05}}} = 1.607 \quad \Rightarrow \quad \varepsilon_a < 3‰ \quad \Rightarrow \quad A_{a2} > 0$$

$$usv.\ \varepsilon_{a1}^* = 3‰ \ \Rightarrow \ \begin{cases} k^* = 1.719 \\ \bar{\mu}^* = 43.590\% \end{cases} \Rightarrow M_{abu} = \left(\frac{53}{1.719}\right)^2 \times 40 \times 2.05 \times 10^{-2} = 779.2\,kNm$$

$$\Delta M_{au} = 891.6 - 779.2 = 112.4\,kNm$$

$$pretp.\ a_2 = 5\ cm \quad \Rightarrow \quad A_{a2} = \frac{112.4 \times 10^2}{(53-5) \times 40} = 5.86\ cm^2$$

$$A_{a1} = 43.590 \times \frac{40 \times 53}{100} \times \frac{2.05}{40} - \frac{217.7}{40} + 5.86 = 47.77\ cm^2 \Rightarrow usv.\ \mathbf{10RØ25}\ (49.01\ cm^2)$$

<u>Presek u vrhu stuba, gornja zona</u>

M_u = 1.0×(-120.9) + 1.8×180 = 203.1 kNm

N_u = 1.0×75.5 + 1.8×58.5 = 180.8 kN (pritisak)

pretp. a = 5 cm $\Rightarrow$ h = 60 - 5 = 55 cm

$$M_{au} = 203.1 + 180.8 \times \left(\frac{0.6}{2} - 0.05\right) = 248.3\ kNm$$

$$k = \frac{55}{\sqrt{\frac{248.3 \times 10^2}{40 \times 2.05}}} = 3.161 \quad \Rightarrow \quad \begin{matrix} \varepsilon_b / \varepsilon_a = 1.939 / 10‰ \\ \bar{\mu} = 10.654\% \end{matrix}$$

$$A_a = 10.654 \times \frac{40 \times 55}{100} \times \frac{2.05}{40} - \frac{180.8}{40} = 7.49\,cm^2 > 5.86\,cm^2 \Rightarrow usv.\ \mathbf{2RØ22}\ (7.60\ cm^2)$$

Dimenzionisanje POS S2 (b/d = 40/20 cm)

G = 241.9 kN ; P = 360 + 40 = 400 kN

$$i = \sqrt{\frac{I_b}{A_b}} = \frac{d}{\sqrt{12}} = \frac{20}{\sqrt{12}} = 5.77\,cm \quad \Rightarrow \quad \lambda = \frac{L_i}{i} = \frac{400}{5.77} = 69.3 > 25$$

$e_0 = L_i/300 = 600/300 =$ ***2.0 cm***

$$I_b = \frac{b \times d^3}{12} = \frac{40 \times 20^3}{12} = 26667\,cm^4 \quad ; \quad E_b = 31.5\,GPa = 31.5 \times 10^6\,kN/m^2$$

$$N_E = 31.5 \times 10^6 \times 26667 \times 10^{-8} \times \frac{\pi^2}{4.0^2} = 5182\,kN$$

$$\alpha_E = \frac{N_g}{N_E} = \frac{241.9}{5182} = 0.047 \quad ; \quad e_g = \frac{M_g}{N} = 0 \quad ; \quad \varphi_\infty = 2.5$$

$$e_\varphi = (e_0 + e_g) \times \left(e^{\frac{\alpha_E}{1-\alpha_E} \times \varphi_\infty} - 1 \right) = (2+0) \times \left(e^{\frac{0.047}{1-0.047} \times 2.5} - 1 \right) = \mathbf{0.26\ cm}$$

$$\frac{e_1}{d} = 0 \Rightarrow e_d = 20 \times \frac{69.3 - 25}{100} \times \sqrt{0.1 + 0} = 2.8\,cm$$

e₂ *= $e_1 + e_0 + e_j + e_d$ = 0 + 2.0 + 0.26 + 2.8 =* ***5.06 cm***

N_u = 1.9×241.9 + 2.1×400 = 1299.6 kN $\Rightarrow$ $n_u = \dfrac{1299.6}{40 \times 20 \times 2.05} = 0.792$

$M_u = N_u \times e_2$ = 1299.6×5.06 = 6580 kNcm $\Rightarrow$ $m_u = \dfrac{6580}{40 \times 20^2 \times 2.05} = 0.201$

$$\frac{a}{d} = \frac{5}{20} = 0.25 \Rightarrow \bar{\mu}_1 \approx 0.28 \ , \ \varepsilon_{a1} \approx 0.3‰ \Rightarrow \gamma_{uG} = 1.87 \ , \ \gamma_{uP} = 2.07$$

Nakon korekcije koeficijenata sigurnosti, sledi:

N_u = 1.87×241.9 + 2.07×400 = 1279.1 kN $\Rightarrow$ $n_u = \dfrac{1279.1}{40 \times 20 \times 2.05} = 0.780$

$M_u = N_u \times e_2$ = 1279.1×5.06 = 6470 kNcm $\Rightarrow$ $m_u = \dfrac{6470}{40 \times 20^2 \times 2.05} = 0.197$

$$\frac{a}{d} = \frac{5}{20} = 0.25 \Rightarrow \bar{\mu}_1 \approx 0.268 \ , \ \varepsilon_{a1} \approx 0.32‰ \Rightarrow \gamma_{uG} = 1.868 \ , \ \gamma_{uP} = 2.068$$

Kako su dobijene vrednosti vrlo bliske pretpostavljenim, sledi:

$$A_{a1} = A_{a2} = 0.268 \times 40 \times 20 \times \frac{2.05}{40} = 11.00\,cm^2$$

usvojeno ***±3RØ22*** *(±11.41 cm²)*

$$\max.e_u = \min.\left\{ \begin{matrix} \min(b,d) = 20\,cm \\ 15Ø = 15 \times 2.2 = 33\,cm \\ 30\,cm \end{matrix} \right\} = 20\,cm$$

usvojeno ***URØ8/20*** *(m=2)*