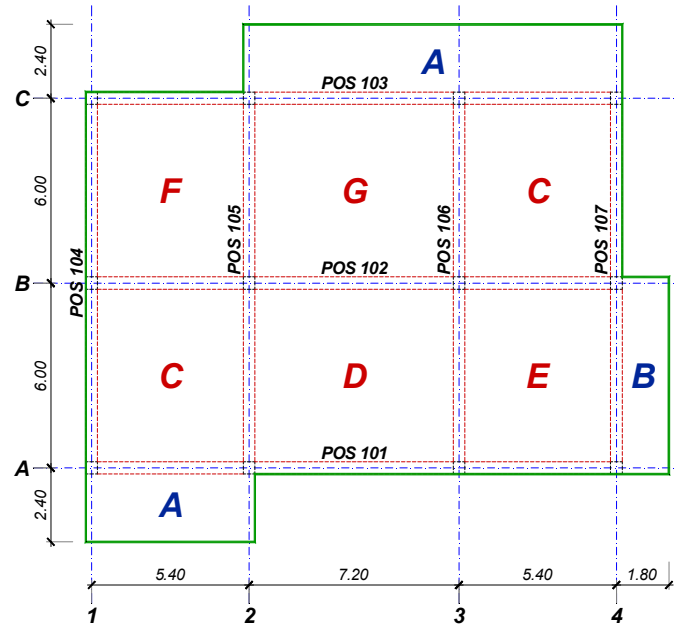


Svođenje opterećenja na grede

1



2

$l_y:l_x$	1,0	1,1	1,2	1,3	1,4	1,5	1,6	1,7	1,8	1,9	2,0
	Q_1 : 0,250	0,260	0,272	0,280	0,288	0,296	0,304	0,310	0,316	0,322	0,327
	Q_2 : 0,250	0,240	0,228	0,220	0,212	0,204	0,196	0,190	0,184	0,178	0,173
	Q_1 : 0,220	0,232	0,244	0,254	0,264	0,273	0,281	0,290	0,296	0,302	0,308
	Q_2 : 0,330	0,313	0,298	0,285	0,272	0,262	0,251	0,242	0,234	0,227	0,220
	Q_1 : 0,330	0,346	0,362	0,376	0,387	0,399	0,410	0,418	0,426	0,434	0,442
	Q_2 : 0,230	0,240	0,246	0,252	0,257	0,261	0,264	0,270	0,274	0,276	0,278
	Q_1 : 0,198	0,211	0,223	0,234	0,244	0,254	0,262	0,270	0,278	0,285	0,292
	Q_2 : 0,302	0,289	0,277	0,266	0,256	0,246	0,238	0,230	0,222	0,215	0,208
	Q_1 : 0,302	0,315	0,326	0,334	0,342	0,350	0,356	0,361	0,367	0,372	0,377
	Q_2 : 0,198	0,185	0,174	0,166	0,158	0,150	0,144	0,139	0,133	0,128	0,123
	Q_1 : 0,292	0,313	0,331	0,346	0,360	0,370	0,380	0,390	0,400	0,410	0,419
	Q_2 : 0,208	0,217	0,226	0,233	0,241	0,247	0,252	0,256	0,260	0,263	0,266
	Q_1 : 0,292	0,274	0,257	0,244	0,230	0,221	0,212	0,204	0,196	0,189	0,182
	Q_2 : 0,208	0,196	0,186	0,177	0,169	0,162	0,156	0,150	0,144	0,138	0,133
	Q_1 : 0,262	0,282	0,300	0,316	0,329	0,344	0,354	0,365	0,376	0,386	0,394
	Q_2 : 0,190	0,200	0,210	0,218	0,227	0,234	0,240	0,245	0,250	0,254	0,258
	Q_1 : 0,274	0,285	0,297	0,309	0,318	0,326	0,334	0,341	0,347	0,353	0,358
	Q_2 : 0,190	0,182	0,174	0,165	0,158	0,152	0,146	0,141	0,136	0,131	0,126
	Q_1 : 0,262	0,246	0,232	0,217	0,206	0,196	0,186	0,177	0,170	0,163	0,158
	Q_1 : 0,290	0,266	0,249	0,231	0,202	0,312	0,320	0,327	0,333	0,339	0,345
	Q_2 : 0,230	0,234	0,221	0,209	0,198	0,188	0,180	0,173	0,167	0,161	0,155

Približno opterećenje osloničke grede $q = \frac{Q}{l}$

Koeficijent γ za određivanje rezultirajuće reakcije oslonca krutino završeno simetrično ploče, odabirajući na svim četiri strana, opterećenih jednako podijeljenim opterećenjem q (kN/m²)

Određivanje opterećenja za grede

Jednako raspodeljeno opterećenje koje se sa pojedinačnih krstastih ploča prenosi na oslonačke grede, posebno za stalno i povremeno opterećenje, prikazano je tabelarno.

Ploča "A"

Konzolna ploča, raspona $L=2.4$ m.

$$R_G = 6.0 \times 2.4 = 14.4 \text{ kN/m}$$

$$R_P = 10.0 \times 2.4 = 24.0 \text{ kN/m}$$

Ploča "B"

Konzolna ploča, raspona $L=1.8$ m.

$$R_G = 6.0 \times 1.8 = 10.8 \text{ kN/m}$$

$$R_P = 10.0 \times 1.8 = 18.0 \text{ kN/m}$$

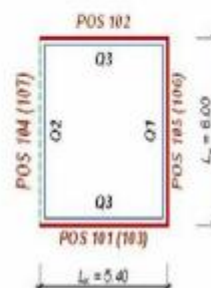
Ploča "C"

$$L_y/L_x = 6.0/5.4 = 1.11 = 1.1$$

$$G = 6.0 \times 5.4 \times 6.0 = 194.4 \text{ kN}$$

$$P = 10.0 \times 5.4 \times 6.0 = 324.0 \text{ kN}$$

		G	P	L	g	p
k		kN	kN	m	kN/m	kN/m
0.282	Q ₁	54.8	91.4	6	9.14	15.23
0.200	Q ₂	38.9	64.8	6	6.48	10.80
0.259	Q ₃	50.3	83.9	5.4	9.32	15.54

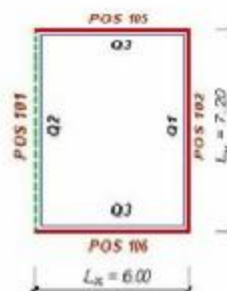
**Ploča "D"**

$$L_y/L_x = 7.2/6.0 = 1.20$$

$$G = 6.0 \times 6.0 \times 7.2 = 259.2 \text{ kN}$$

$$P = 10.0 \times 6.0 \times 7.2 = 432.0 \text{ kN}$$

		G	P	L	g	p
k		kN	kN	m	kN/m	kN/m
0.300	Q ₁	77.8	129.6	7.2	10.80	18.00
0.210	Q ₂	54.4	90.7	7.2	7.56	12.60
0.245	Q ₃	63.5	105.8	6	10.58	17.64

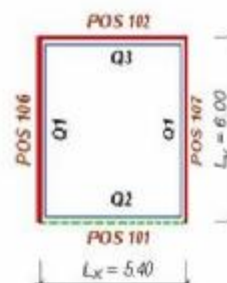
**Ploča "E"**

$$L_y/L_x = 6.0/5.4 = 1.11 = 1.1$$

$$G = 6.0 \times 5.4 \times 6.0 = 194.4 \text{ kN}$$

$$P = 10.0 \times 5.4 \times 6.0 = 324.0 \text{ kN}$$

		G	P	L	g	p
k		kN	kN	m	kN/m	kN/m
0.285	Q ₁	55.4	92.3	6	9.23	15.39
0.182	Q ₂	35.4	59.0	5.4	6.55	10.92
0.248	Q ₃	48.2	80.4	5.4	8.93	14.88



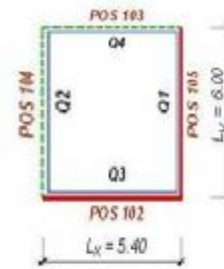
Ploča "F"

$$L_y/L_x = 6.0/5.4 = 1.11 \approx 1.1$$

$$G = 6.0 \times 5.4 \times 6.0 = 194.4 \text{ kN}$$

$$P = 10.0 \times 5.4 \times 6.0 = 324.0 \text{ kN}$$

k		G	P	L	g	p
		kN	kN	m	kN/m	kN/m
0.313	Q ₁	60.8	101.4	6	10.14	16.90
0.217	Q ₂	42.2	70.3	6	7.03	11.72
0.274	Q ₃	53.3	88.8	5.4	9.86	16.44
0.196	Q ₄	38.1	63.5	5.4	7.06	11.76

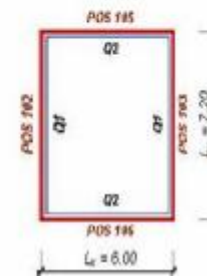
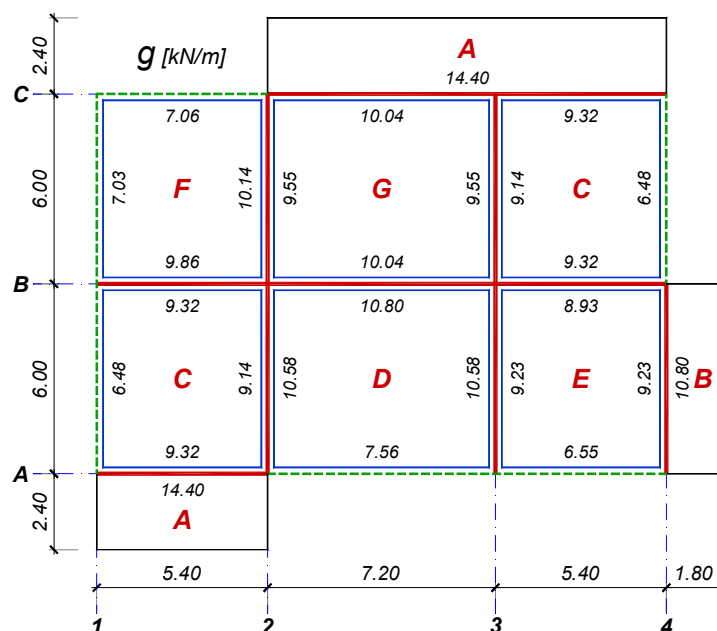
**Ploča "G"**

$$L_y/L_x = 7.2/6.0 = 1.20$$

$$G = 6.0 \times 6.0 \times 7.2 = 259.2 \text{ kN}$$

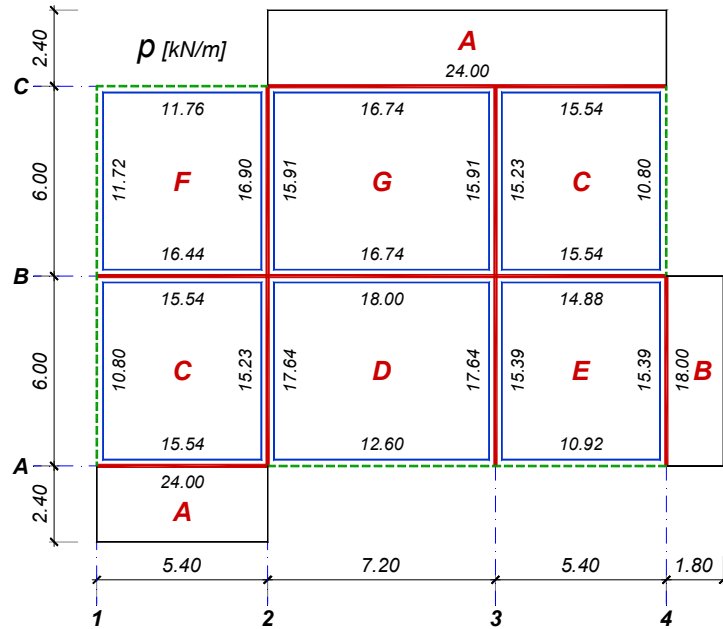
$$P = 10.0 \times 6.0 \times 7.2 = 432.0 \text{ kN}$$

k		G	P	L	g	p
		kN	kN	m	kN/m	kN/m
0.279	Q ₁	72.3	120.5	7.2	10.04	16.74
0.221	Q ₂	57.3	95.5	6	9.55	15.91

**Stalno opterećenje (bez s.t. gređa POS 101-POS 107)**

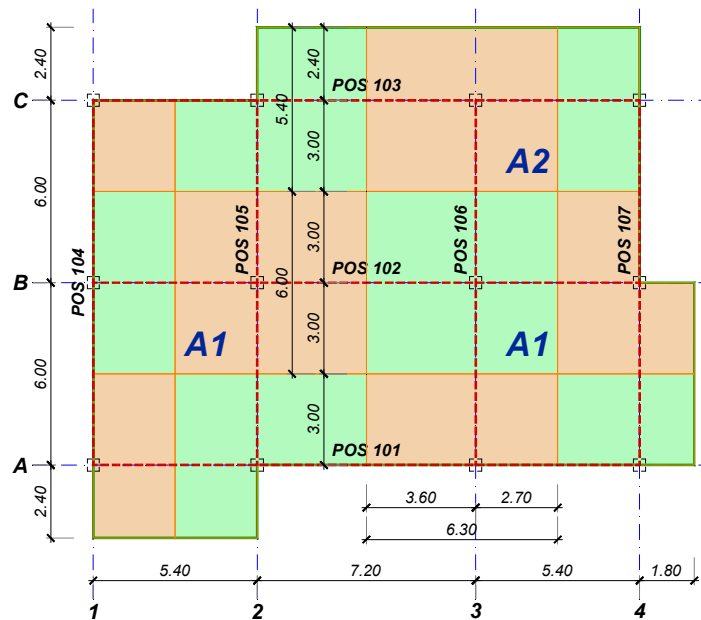
Povremeno opterećenje

7



Procena sila u stubovima

8



$$A_1 = 6.3 \times 6.0 = 37.8 \text{ m}^2$$

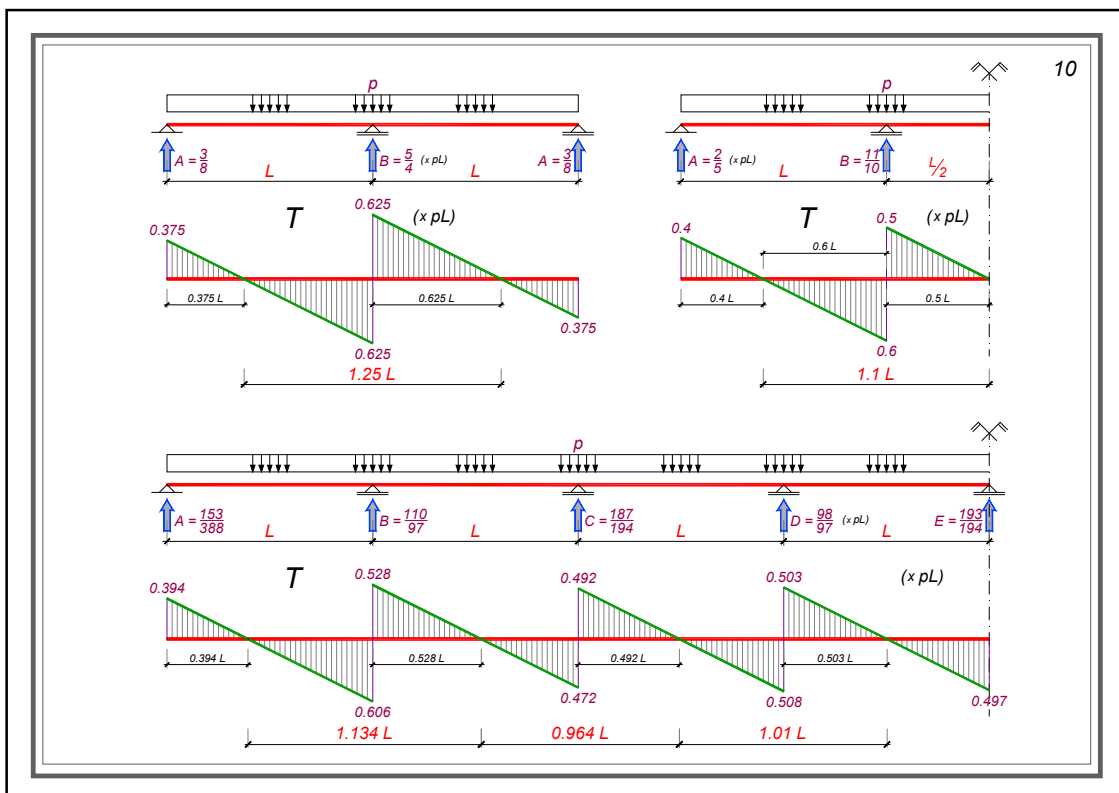
$$G+P \approx (g+p) \times A_1 = (6.0 + 10.0) \times 37.8 = 604.8 \text{ kN}$$

Ovu silu treba povećati barem 25% zbog povećanog naprezanja prve linije unutrašnjih stubova, kao i zbog zanemarenja sopstvene težine greda POS 102 i POS 106

$$(G+P)_{\max} \approx 1.25 \times 604.8 = 756 \text{ kN}$$

Za presek napregnut ovolikom **EKSPLOATACIONOM** silom potrebna površina poprečnog preseka je približno 756 cm^2 , pa se pretpostavlja dimenzija stubova $30 \times 30 \text{ cm}$.

Širina greda je jednaka širini stubova, dakle usvojeno **$b = 30 \text{ cm}$** .



POS 103 (osa C) – analiza opterećenja

11

pretp. $b=30\text{ cm}$; $d = L_2/12 = 720/12 = 60\text{ cm}$

sopstvena težina grede:

$$g_0 = 0.3 \times 0.6 \times 25 = 4.5\text{ kN/m}$$

stalno opterećenje

$$\text{polje 1-2: } g_1 = 4.5 + 7.06 = 11.56\text{ kN/m}$$

$$\text{polje 2-3: } g_2 = 4.5 + 10.04 + 14.4 = 28.94\text{ kN/m}$$

$$\text{polje 3-4: } g_3 = 4.5 + 9.32 + 14.4 = 28.22\text{ kN/m}$$

povremeno opterećenje

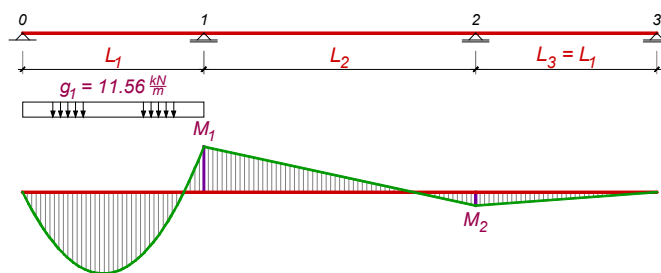
$$\text{polje 1-2: } p_1 = 11.76\text{ kN/m}$$

$$\text{polje 2-3: } p_2 = 16.74 + 24.0 = 40.74\text{ kN/m}$$

$$\text{polje 3-4: } p_3 = 15.54 + 24.0 = 39.54\text{ kN/m}$$

POS 103 – uticaji od stalnog opterećenja

12



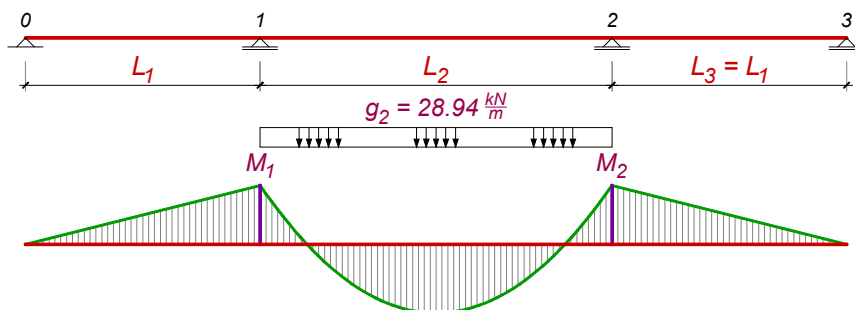
$$M_{1,g1} = -\frac{g_1 \times L_1^3}{2} \times \frac{L_1 + L_2}{4 \times L_1^2 + 8 \times L_1 \times L_2 + 3 \times L_2^2}$$

$$M_{1,g1} = -\frac{11.56 \times 5.4^3}{2} \times \frac{5.4 + 7.2}{4 \times 5.4^2 + 8 \times 5.4 \times 7.2 + 3 \times 7.2^2} = -19.7\text{ kNm}$$

$$M_{2,g1} = -M_{1,g1} \times \frac{L_2}{2 \times (L_1 + L_2)} = 19.7 \times \frac{7.2}{2 \times (5.4 + 7.2)} = 5.6\text{ kNm}$$

POS 103 – uticaji od stalnog opterećenja

13

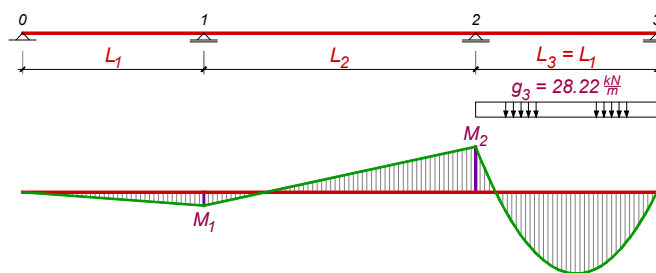


$$M_{1,g2} = -\frac{g_2 \times L_2^3}{2} \times \frac{1}{2 \times (2 \times L_1 + 3 \times L_2)} = M_{2,g2}$$

$$M_{1,g2} = -\frac{28.94 \times 7.2^3}{2} \times \frac{1}{2 \times (2 \times 5.4 + 3 \times 7.2)} = -83.4 \text{ kNm} = M_{2,g2}$$

POS 103 – uticaji od stalnog opterećenja

14



$$M_{2,g3} = -\frac{g_3 \times L_1^3}{2} \times \frac{L_1 + L_2}{4 \times L_1^2 + 8 \times L_1 \times L_2 + 3 \times L_2^2}$$

$$M_{2,g3} = -\frac{28.22 \times 5.4^3}{2} \times \frac{5.4 + 7.2}{4 \times 5.4^2 + 8 \times 5.4 \times 7.2 + 3 \times 7.2^2} = -48.0 \text{ kNm}$$

$$M_{1,g3} = -M_{2,g3} \times \frac{L_2}{2 \times (L_1 + L_2)} = 48.0 \times \frac{7.2}{2 \times (5.4 + 7.2)} = 13.7 \text{ kNm}$$

$$M_{1g} = -19.7 + (-83.4) + 13.7 = -89.3 \text{ kNm}$$

$$M_{2g} = 5.6 + (-83.4) + (-48.0) = -125.8 \text{ kNm}$$

$$A_g = \frac{11.56 \times 5.4}{2} - \frac{89.3}{5.4} = 14.7 \text{ kN}$$

$$B_g = \frac{11.56 \times 5.4 \times \left(\frac{5.4}{2} + 7.2\right) + 28.94 \times \frac{7.2^2}{2} - 125.8 - 14.7 \times (5.4 + 7.2)}{7.2}$$

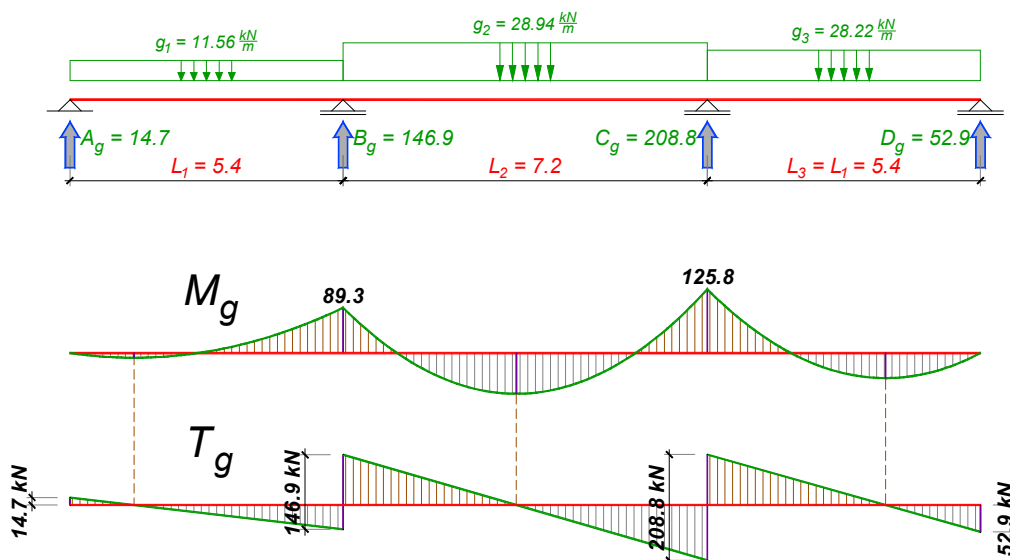
$$B_g = 146.9 \text{ kN}$$

$$D_g = \frac{28.22 \times 5.4}{2} - \frac{125.8}{5.4} = 52.9 \text{ kN}$$

$$C_g = (11.56 + 28.22) \times 5.4 + 28.94 \times 7.2 - (14.7 + 146.9 + 52.9)$$

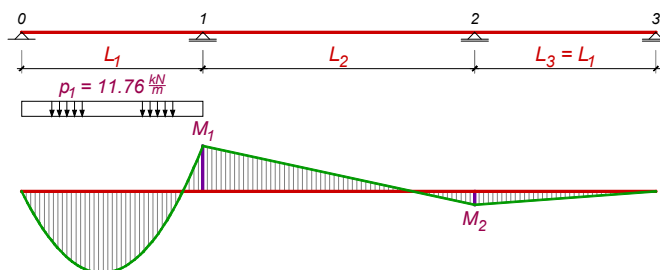
$$C_g = 208.8 \text{ kN}$$

POS 103 - stalno opterećenje (G)



POS 103 – uticaji od povremenog opterećenja

17



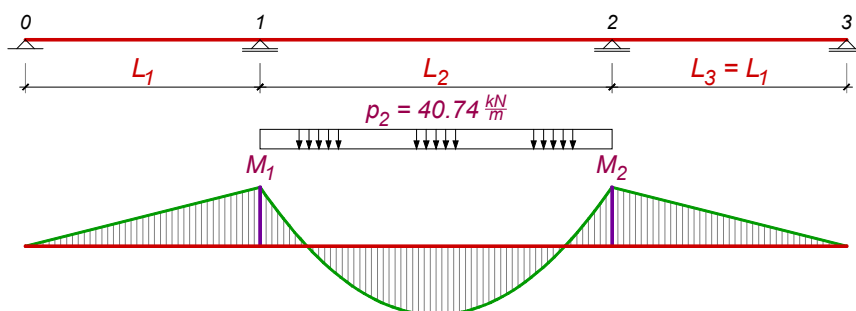
$$M_{1,p1} = -\frac{p_1 \times L_1^3}{2} \times \frac{L_1 + L_2}{4 \times L_1^2 + 8 \times L_1 \times L_2 + 3 \times L_2^2}$$

$$M_{1,p1} = -\frac{11.76 \times 5.4^3}{2} \times \frac{5.4 + 7.2}{4 \times 5.4^2 + 8 \times 5.4 \times 7.2 + 3 \times 7.2^2} = -20.0 \text{ kNm}$$

$$M_{2,p1} = -M_{1,p1} \times \frac{L_2}{2 \times (L_1 + L_2)} = 20.0 \times \frac{7.2}{2 \times (5.4 + 7.2)} = 5.7 \text{ kNm}$$

POS 103 – uticaji od povremenog opterećenja

18

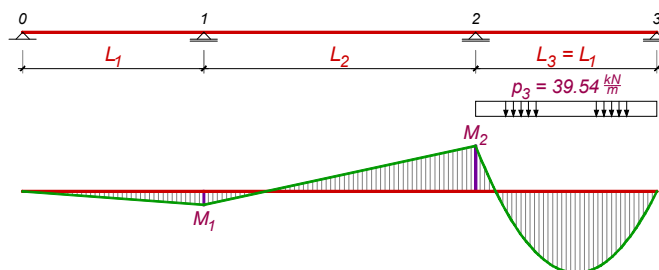


$$M_{1,p2} = -\frac{p_2 \times L_2^3}{2} \times \frac{1}{2 \times (2 \times L_1 + 3 \times L_2)} = M_{2,p2}$$

$$M_{1,g2} = -\frac{40.74 \times 7.2^3}{2} \times \frac{1}{2 \times (2 \times 5.4 + 3 \times 7.2)} = -117.3 \text{ kNm} = M_{2,p2}$$

POS 103 – uticaji od povremenog opterećenja

19



$$M_{2,p3} = -\frac{p_3 \times L_1^3}{2} \times \frac{L_1 + L_2}{4 \times L_1^2 + 8 \times L_1 \times L_2 + 3 \times L_2^2}$$

$$M_{2,p3} = -\frac{39.54 \times 5.4^3}{2} \times \frac{5.4 + 7.2}{4 \times 5.4^2 + 8 \times 5.4 \times 7.2 + 3 \times 7.2^2} = -67.3 \text{ kNm}$$

$$M_{1,p3} = -M_{2,p3} \times \frac{L_2}{2 \times (L_1 + L_2)} = 67.3 \times \frac{7.2}{2 \times (5.4 + 7.2)} = 19.2 \text{ kNm}$$

$$M_{1p} = -20.0 + (-117.3) + 19.2 = -118.1 \text{ kNm}$$

$$M_{2p} = 5.7 + (-117.3) + (-67.3) = -178.9 \text{ kNm}$$

$$A_p = \frac{11.76 \times 5.4}{2} - \frac{118.1}{5.4} = 9.9 \text{ kN}$$

$$B_p = \frac{11.76 \times 5.4 \times \left(\frac{5.4}{2} + 7.2\right) + 40.74 \times \frac{7.2^2}{2} - 178.9 - 9.9 \times (5.4 + 7.2)}{7.2}$$

$$B_p = 191.9 \text{ kN}$$

$$D_p = \frac{39.54 \times 5.4}{2} - \frac{178.9}{5.4} = 73.6 \text{ kN}$$

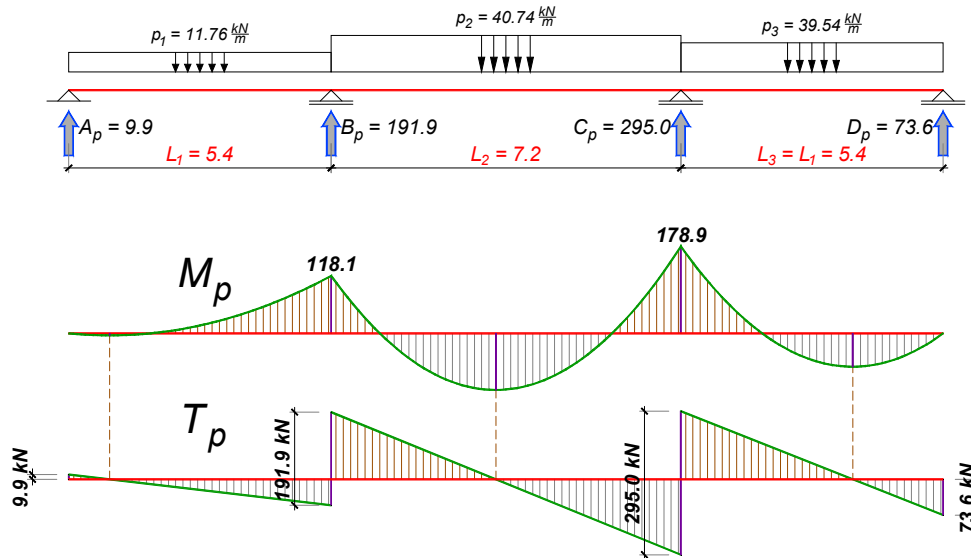
$$C_p = (11.76 + 39.54) \times 5.4 + 40.74 \times 7.2 - (9.9 + 191.9 + 73.6)$$

$$C_p = 295.0 \text{ kN}$$

20

POS 103 - povremeno opterećenje (P)

21



$$M_{1u} = 1.6 \times 89.3 + 1.8 \times 118.1 = 355.5 \text{ kNm (zateže gornju ivicu)}$$

$$M_{2u} = 1.6 \times 125.8 + 1.8 \times 178.9 = 523.2 \text{ kNm (zateže gornju ivicu)}$$

$$A_u = 1.6 \times 14.7 + 1.8 \times 9.9 = 41.2 \text{ kN}$$

$$q_{u1} = 1.6 \times 11.56 + 1.8 \times 11.76 = 39.66 \text{ kN/m}$$

22

$$x_{1,\max} = \frac{41.2}{39.66} = 1.04 \text{ m} \Rightarrow L_{0,1} = 2 \times 1.04 = 2.08 \text{ m}$$

$$M_{u01,\max} = 41.2 \times 1.04 - \frac{39.66 \times 1.04^2}{2} = 21.4 \text{ kNm}$$

$$D_u = 1.6 \times 52.9 + 1.8 \times 73.6 = 217.2 \text{ kN}$$

$$q_{u3} = 1.6 \times 28.22 + 1.8 \times 39.54 = 116.33 \text{ kN/m}$$

$$x_{3,\max} = \frac{217.2}{116.33} = 1.87 \text{ m} \Rightarrow L_{0,3} = 2 \times 1.87 = 3.73 \text{ m}$$

$$M_{u23,\max} = 217.2 \times 1.87 - \frac{116.33 \times 1.87^2}{2} = 202.8 \text{ kNm}$$

$$T_u^{B,l} = 41.2 - 39.66 \times 5.4 = -172.9 \text{ kN}$$

$$B_u = 1.6 \times 146.9 + 1.8 \times 191.9 = 580.3 \text{ kN}$$

$$T_u^{B,d} = -172.9 + 580.3 = 407.4 \text{ kN}$$

$$q_{u2} = 1.6 \times 28.94 + 1.8 \times 40.74 = 119.64 \frac{\text{kN}}{\text{m}}$$

$$x_{2,\max} = \frac{407.4}{119.64} = 3.41 \text{ m}$$

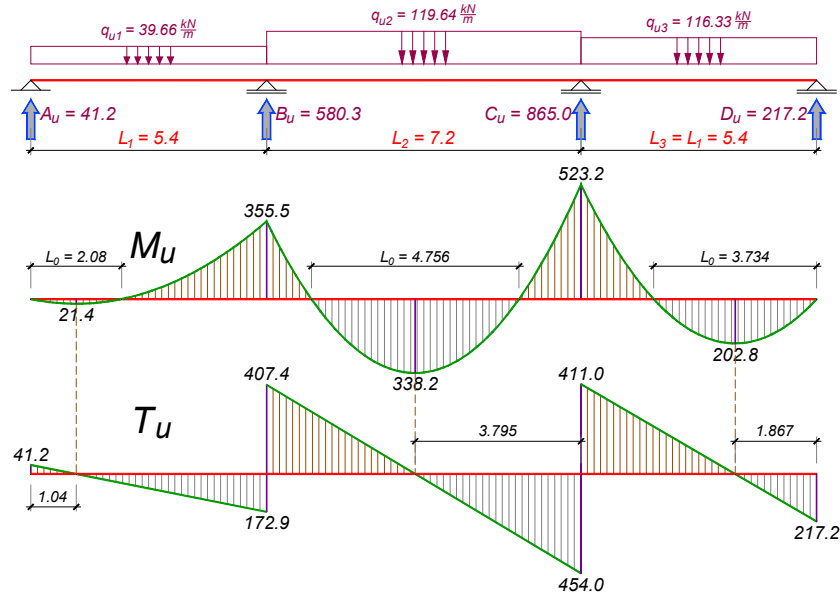
$$M_{u12,\max} = 407.4 \times 3.41 - \frac{119.64 \times 3.41^2}{2} - 355.5 = 338.2 \text{ kNm}$$

$$L_{0,2} = \sqrt{\frac{8 \times 338.2}{119.64}} = 4.76 \text{ m}$$

$$T_u^{C,l} = 407.4 - 119.64 \times 7.2 = -454.0 \text{ kN}$$

$$T_u^{C,d} = -217.2 + 116.33 \times 5.4 = 411.0 \text{ kN}$$

POS 103 - granično opterećenje (1.6×G+1.8×P)



POS 103 – dimenzionisanje

25

$M_{u,max} = 523.2 \text{ kNm}$ (osa 3, gornja zona)

MB 30 $\Rightarrow f_B = 20.5 \text{ MPa} = 2.05 \text{ kN/cm}^2$

RA 400/500 $\Rightarrow \sigma_v = 400 \text{ MPa} = 40 \text{ kN/cm}^2$

pretp. $a_1 = 7 \text{ cm} \Rightarrow b/d/h = 30/60/53 \text{ cm}$

$$k = \frac{53}{\sqrt{\frac{523.2 \times 10^2}{30 \times 2.05}}} = 1.817 \Rightarrow \frac{\varepsilon_b}{\varepsilon_a} = 3.5 / 4.052\% \\ \mu = 37.517\%$$

$$A_a = 37.517 \times \frac{30 \times 53}{100} \times \frac{2.05}{40} = 30.57 \text{ cm}^2$$

usvojeno: **2RØ16 + 6RØ25** (33.47 cm²)

POS 103 – kontrola glavnih napona zatezanja

26

$T_{u,max} = 454.0 \text{ kN}$ (preseki u osi 3 levo)

MB 30 $\Rightarrow \tau_r = 1.1 \text{ MPa} = 0.11 \text{ kN/cm}^2$

usv. $z = 0.9 \times h = 0.9 \times 53 = 47.7 \text{ cm}$

$$\tau_n^{C,I} = \frac{454.0}{30 \times 47.7} = 0.317 \text{ kN/cm}^2 \left\{ \begin{array}{l} > \tau_r = 0.11 \text{ kN/cm}^2 \\ < 3\tau_r = 0.33 \text{ kN/cm}^2 \end{array} \right.$$

$$\tau_{Ru} = 1.5 \times (0.317 - 0.11) = 0.311 \text{ kN/cm}^2$$

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

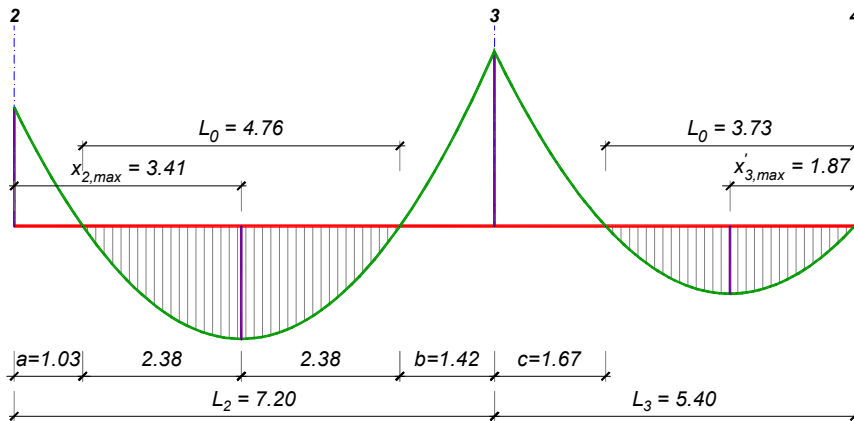
$$e_u = \frac{2 \times a_u^{(1)}}{30 \times 0.311} \times 40 = 8.58 \times a_u^{(1)}$$

URØ10 + URØ8 $\Rightarrow e_u = 8.58 \times (0.785 + 0.503) = 11.05 \text{ cm}$

usvojeno: **URØ10/10 + URØ8/10** (m=2)

Procena dužine šipki

27



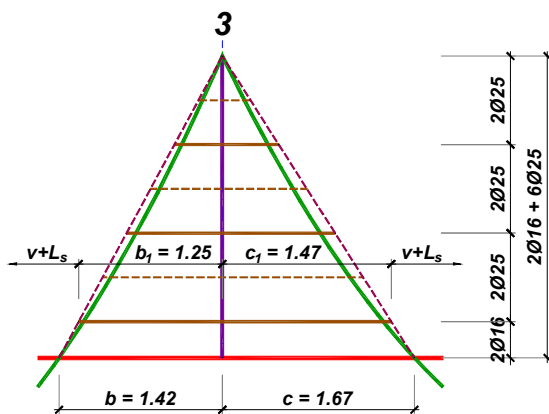
$$a = x_{2,\max} - \frac{L_{0,2}}{2} = 3.41 - \frac{4.76}{2} = 1.03 \text{ m}$$

$$b = L_2 - (L_{0,2} + a) = 7.2 - (4.76 + 1.03) = 1.42 \text{ m}$$

$$c = L_3 - L_{0,3} = 5.4 - 3.73 = 1.67 \text{ m}$$

Procena dužine šipki u gornjoj zoni

28



$$v = 0.75 \times 53 = 39.75 \text{ cm}$$

$$MB 30 \Rightarrow \tau_p = 1.75 \text{ MPa}$$

$$L_{s1} = \frac{400}{4 \times 1.8 \times 1.75} \varnothing = 31.75 \times \varnothing$$

$$L_{s2} = 1.5 \times L_{s1} = 47.6 \times \varnothing$$

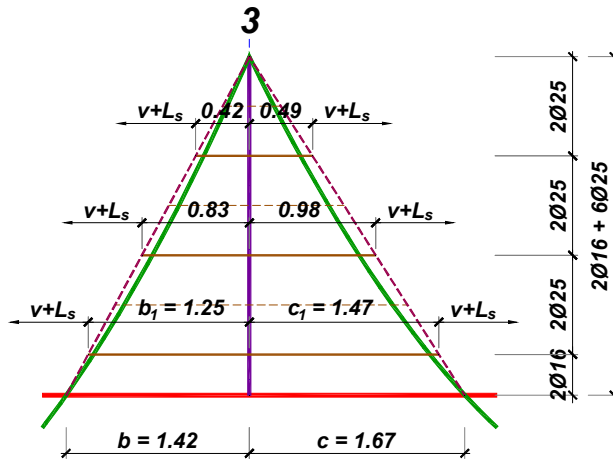
$$v + L_s = 39.75 + 47.6 \times 2.5$$

$$v + L_s = 158.8 \text{ cm}$$

$$A_a = 2 \times 2.01 + 6 \times 4.91 = 4.02 + 29.45 = 33.47 \text{ cm}^2$$

$$b_1 = b \times \frac{6\varnothing 25}{2\varnothing 16 + 6\varnothing 25} = 1.42 \times \frac{29.45}{33.47} = 1.25 \text{ m}$$

$$c_1 = c \times \frac{6\varnothing 25}{2\varnothing 16 + 6\varnothing 25} = 1.67 \times \frac{29.45}{33.47} = 1.47 \text{ m}$$



$$L_{s2} = 1.5 \times L_{s1} = 47.6 \times \emptyset$$

$$v + L_s = 39.75 + 47.6 \times 2.5$$

$$v + L_s = v + L_{s2} = 158.8 \text{ cm}$$

$$L_1 \approx v + L_s + b_1 + c_1 + v + L_s = 159 + 125 + 147 + 159 = 590 \text{ cm}$$

$$L_2 \approx v + L_s + \frac{2b_1}{3} + \frac{2c_1}{3} + v + L_s = 159 + \frac{2 \times 125}{3} + \frac{2 \times 147}{3} + 159 = 500 \text{ cm}$$

$$L_3 \approx v + L_s + \frac{b_1}{3} + \frac{c_1}{3} + v + L_s = 159 + \frac{125}{3} + \frac{147}{3} + 159 = 410 \text{ cm}$$

POS 103 – dimenzionisanje – ostali preseki

$M_u = 355.5 \text{ kNm}$ (osa 2, gornja zona)

MB 30 $\Rightarrow f_B = 20.5 \text{ MPa} = 2.05 \text{ kN/cm}^2$

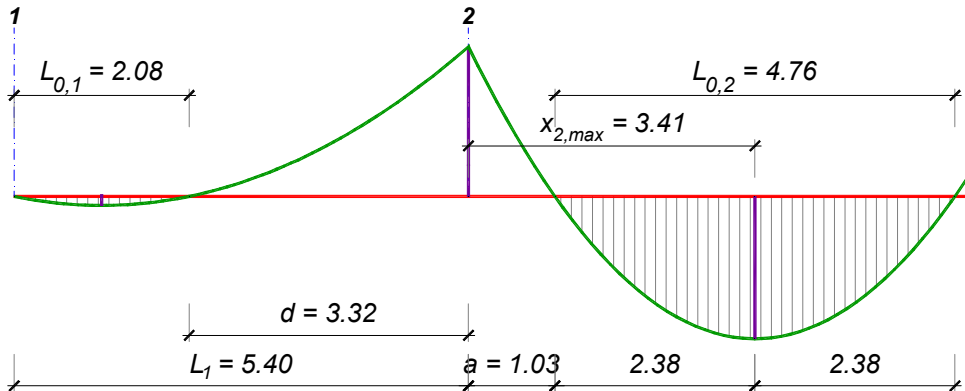
RA 400/500 $\Rightarrow \sigma_v = 400 \text{ MPa} = 40 \text{ kN/cm}^2$

pretp. $a_1 = 7 \text{ cm} \Rightarrow b/d/h = 30/60/53 \text{ cm}$

$$k = \frac{53}{\sqrt{\frac{355.5 \times 10^2}{30 \times 2.05}}} = 2.204 \Rightarrow \frac{\varepsilon_b}{\varepsilon_a} = 3.5 / 8.614\% \\ \mu = 23.389\%$$

$$A_a = 23.389 \times \frac{30 \times 53}{100} \times \frac{2.05}{40} = 19.06 \text{ cm}^2$$

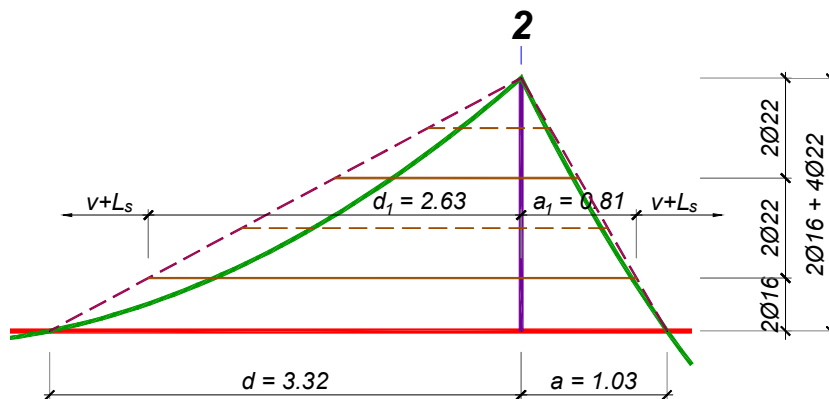
usvojeno: **2RØ16 + 4RØ22** (19.23 cm²)



$$a = x_{2,\max} - \frac{L_{0,2}}{2} = 3.41 - \frac{4.76}{2} = 1.03 \text{ m}$$

$$d = L_1 - L_{0,1} = 5.4 - 2.08 = 3.32 \text{ m}$$

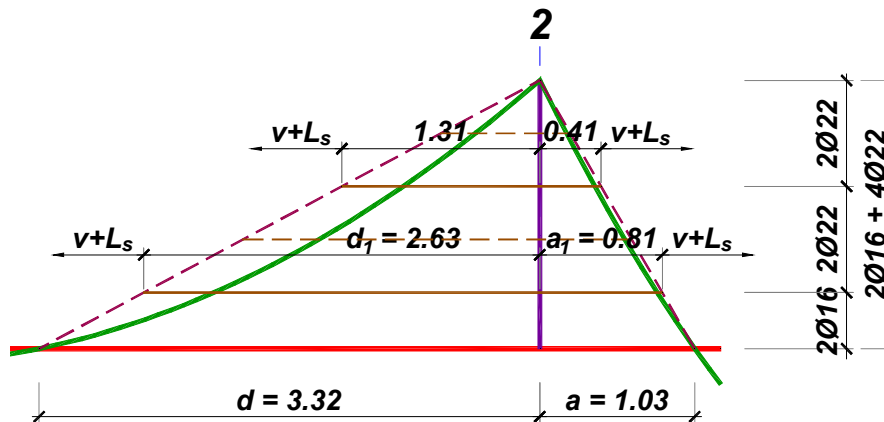
Procena dužine šipki u gornjoj zoni



$$A_a = 2 \times 2.01 + 4 \times 3.80 = 4.02 + 15.21 = 19.23 \text{ cm}^2$$

$$d_1 = d \times \frac{4\text{Ø}22}{2\text{Ø}16 + 4\text{Ø}22} = 3.32 \times \frac{15.21}{19.23} = 2.63 \text{ m}$$

$$a_1 = a \times \frac{4\text{Ø}22}{2\text{Ø}16 + 4\text{Ø}22} = 1.03 \times \frac{15.21}{19.23} = 0.81 \text{ m}$$



$$v + L_s = 39.75 + 47.6 \times 2.2 = 145 \text{ cm}$$

$$L_1 \approx v + L_s + d_1 + a_1 + v + L_s = 145 + 263 + 81 + 145 = 634 \approx 635 \text{ cm}$$

$$L_2 \approx v + L_s + \frac{d_1}{2} + \frac{a_1}{2} + v + L_s = 145 + \frac{263}{2} + \frac{81}{2} + 145 = 462 \approx 465 \text{ cm}$$

$M_u = 338.2 \text{ kNm}$ (polje 2-3, donja zona)

pretp. $a_1 = 7 \text{ cm} \Rightarrow b/d/h = 30/60/53 \text{ cm}$

$$L_0 = 4.76 \text{ m} \Rightarrow B = \min. \left\{ \begin{array}{l} 30 + 20 \times 16 = 350 \\ 600/2 + 240 = 540 \\ 30 + 0.25 \times 476 = 149 \end{array} \right\} = 149 \text{ cm}$$

$$k = \frac{53}{\sqrt{\frac{338.2 \times 10^2}{149 \times 2.05}}} = 5.035 \Rightarrow s = 0.095$$

$$\varepsilon_b / \varepsilon_a = 1.045 / 10\%$$

$$\bar{\mu} = 4.080\%$$

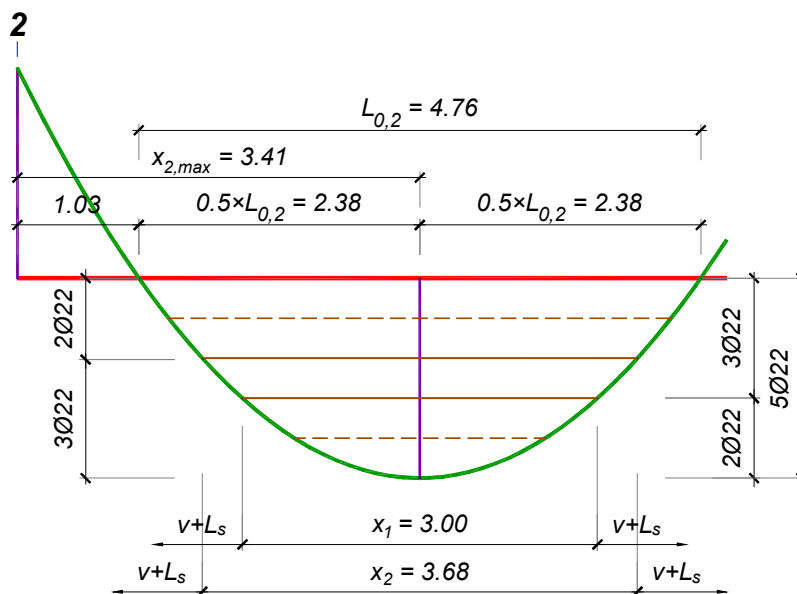
$$x = 0.095 \times 53 = 5.0 \text{ cm} < d_p = 16 \text{ cm}$$

$$A_a = 4.080 \times \frac{149 \times 53}{100} \times \frac{2.05}{40} = 16.50 \text{ cm}^2$$

usvojeno: **5RØ22** (19.01 cm²)

Procena dužine šipki u donjoj zoni

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Procena dužine šipki u donjoj zoni

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$$x_1 = L_0 \times \sqrt{\frac{M_1}{M}} = L_0 \times \sqrt{\frac{2\text{Ø}22}{5\text{Ø}22}} = 4.76 \times \sqrt{0.4} = 3.00 \text{ m}$$

$$v + L_s = v + L_{s1} = 39.75 + 31.75 \times 2.2 = 109.6 \text{ cm}$$

$$L_1 \approx v + L_s + x_1 + v + L_s = 110 + 300 + 110 = 520 \text{ cm}$$

$$x_2 = L_0 \times \sqrt{\frac{M_2}{M}} = L_0 \times \sqrt{\frac{3\text{Ø}22}{5\text{Ø}22}} = 4.76 \times \sqrt{0.6} = 3.68 \text{ m}$$

$$L_2 \approx v + L_s + x_2 + v + L_s = 110 + 368 + 110 = 588 \approx 590 \text{ cm}$$

Šipke su simetrično postavljene u odnosu na mesto maksimalnog momenta u polju ($x = 3.41 \approx 3.40 \text{ m}$ od ose 2 ka osi 3)

$M_u = 202.8 \text{ kNm}$ (polje 3-4, donja zona)

pretp. $a_1 = 5 \text{ cm} \Rightarrow b/d/h = 30/60/55 \text{ cm}$

$$L_0 = 3.73 \text{ m} \Rightarrow B = \min. \left\{ \begin{array}{l} 30 + 20 \times 16 = 350 \\ 600/2 + 240 = 540 \\ 30 + 0.25 \times 373 = 123 \end{array} \right\} = 123 \text{ cm}$$

$$k = \frac{55}{\sqrt{\frac{202.8 \times 10^2}{123 \times 2.05}}} = 6.142 \Rightarrow s = 0.076$$

$$\varepsilon_b / \varepsilon_a = 0.827 / 10\text{‰}$$

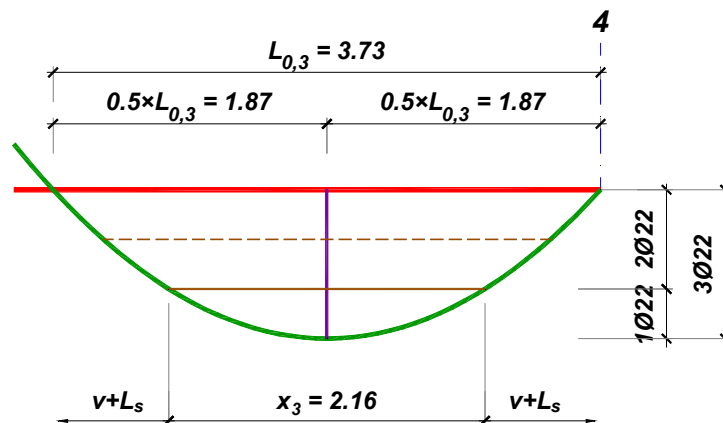
$$\bar{\mu} = 2.723\%$$

$$x = 0.076 \times 55 = 4.2 \text{ cm} < d_p = 16 \text{ cm}$$

$$A_a = 2.723 \times \frac{123 \times 55}{100} \times \frac{2.05}{40} = 9.47 \text{ cm}^2$$

usvojeno: **3RØ22** (11.41 cm²)

Procena dužine šipki u donjoj zoni



$$x_3 = L_0 \times \sqrt{\frac{M_3}{M}} = L_0 \times \sqrt{\frac{1Ø22}{3Ø22}} = 3.73 \times \sqrt{\frac{1}{3}} = 2.16 \text{ m}$$

$$L_3 \approx v + L_s + x_3 + v + L_s = 110 + 216 + 110 = 436 \approx 440 \text{ cm}$$