



Visoka građevinsko geodetska škola strukovnih studija

Beograd

Master studije

Betonske konstrukcije u visokogradnji

– vežbe –

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Karakteristike betona

Oznake – karakteristične čvrstoće pri pritisku

PBAB 87 MB f_{bk} [MPa]

EC2 C $f_{ck}/f_{ck,cube}$ [MPa/MPa] $f_{ck} < f_{ck,cube} \approx f_{bk}$

MB f_{bk}	15	20	25	30	35	40	45	50	55	60
C $f_{ck}/f_{ck,cube}$	12/15	16/20	20/25	25/30	30/37	30/37	35/45	40/50	45/55	50/60

Računske čvrstoće pri pritisku

PBAB 87 $f_B (= \frac{f_{bk}}{\gamma_B})$

MB f_{bk}	10	15	20	25	30	35	40	45	50	55	60
f_B [MPa]	7	10.5	14	17.5	20.5	23	25.5	27.75	30	31.5	33

EC2 $f_{cd} = \alpha_{cc} \cdot \frac{f_{ck}}{\gamma_c}$ $\alpha_{cc} = 0.85$ uticaj dugotrajnog dejstva

$\gamma_c = 1.5$ koef. sigurnosti za beton

C $f_{ck}/f_{ck,cube}$	12/15	16/20	20/25	25/30	30/37	35/45	40/50	45/55	50/60
f_{cd} [MPa]	6.8	9.07	11.33	14.17	17	20.97	22.67	25.5	28.33

Karakteristike armature

Oznake – granica razvlačenja

PBAB 87 GA/RA/MA σ_v/f_{ak} [MPa/MPa]

RA 400/500

EC2 B $f_{yk} Y$ [MPa] $\sigma_v \approx f_{yk}$

B 500 B

Računske čvrstoće i modul elastičnosti

PBAB 87 σ_v za RA 400/500 $\sigma_v = 400$ MPa

$E_a = 210$ GPa

EC2 $f_{yd} = \frac{f_{yk}}{\gamma_s}$ $\gamma_s = 1.15$ koef. sigurnosti za čelik

za B 500 B $f_{yd} = 434,78$ MPa

$E_s = 200$ GPa

Debljina zaštitnog sloja betona do armature

PBAB 87 $a_0 = \min a_0 + \Delta a_0$

$$\min a_0 = \begin{cases} 1.5\text{cm} & \text{za površinske elemente} \\ 2.0\text{cm} & \text{za linijske elemente} \end{cases} \quad \text{za slabo agresivnu sredinu, betoniranje na licu mesta}$$

$$\Delta a_0 = \begin{cases} +0.5\text{cm} & \text{za umereno agresivnu sredinu} \\ +1.0\text{cm} & \text{za jako agresivnu sredinu} \\ +0.5\text{cm} & \text{za } MB \leq 25 \\ +0.5\text{cm} & \text{površina betona nedostupna kontroli} \\ +1.0\text{cm} & \text{naknadna obrada površine betona} \\ +1.0\text{cm} & \text{za betoniranje u klizajućoj oplati} \\ -0.5\text{cm} & \text{za prefabrikovane elemente} \end{cases} \quad \text{kumulativno, simultano}$$

EC2 $c_{nom} = c_{min} + \Delta c$

klasa izloženosti	C			D	S
	C1	C2-C3	C4	D1-D3	S1-S3
c_{min} [mm]	10	20	25	40	40
Δc [mm]	10	15	15	15	15

Klasa izloženosti:	0 – nema rizika	0
	C – karbonatizacija	C1-C4
	D – hloridi	D1-D3
	S – morska voda	S1-S3
	F – zamrzavanje	F1-F4
	A – hemijski uticaji	A1-A3

Čist razmak šipki armature

PBAB 87 $\min e_{h,v} = \begin{cases} \max \emptyset \\ 0.8 \cdot D \\ 3.0\text{cm} \end{cases}$ D – nominalno najveće zrno agregata

EC2 $s_{min} = \begin{cases} \max \emptyset \\ d_g + 5\text{mm} \\ 20\text{mm} \end{cases}$ d_g – nominalno najveće zrno agregata

Granične dilatacije pri lomu

PBAB 87	lom po betonu	$\epsilon_b = 3.5\text{‰}$ (2‰)	pritisak (centrični pritisak)
	lom po armaturi	$\epsilon_a = 10\text{‰}$	zatezanje
EC2 7	lom po betonu	$\epsilon_c = 3.5\text{‰}$ (2‰)	pritisak (centrični pritisak)
	lom po armaturi	$\epsilon_s = 20\text{‰}$	zatezanje

Granične presečne sile

PBAB 87 $S_u = 1.6 \cdot S_g + 1.8 \cdot S_p$ za $\epsilon_a \geq 3\text{‰}$

$S_u = 1.9 \cdot S_g + 2.1 \cdot S_p$ za $\epsilon_a < 0\text{‰}$

$S_u = 1.3 \cdot S_g + 1.3 \cdot S_p + 1.3 \cdot S_{seizm}$

EC2 $S_{Sd} = 1.35 \cdot S_g + 1.5 \cdot S_q (+\psi_0 \cdot 1.5 \cdot S_{q2})$ $\psi_0 = \begin{cases} 0.7 & \text{za namenu prostora A, B, C, D} \\ 1.0 & \text{za namenu prostora E} \end{cases}$

$S_{Sd} = S_g + \psi_2 \cdot S_q + S_{seizm}$ $\psi_2 = \begin{cases} 0.3 & \text{za namenu prostora A, B} \\ 0.6 & \text{za namenu prostora C, D} \\ 0.8 & \text{za namenu prostora E} \end{cases}$

Namena prostora: A – stambene zgrade, hotelske sobe korisno opterećenje: $q_A = 2 \text{ kN/m}^2$
 B – poslovne zgrade (kancelarije) $q_B = 3 \text{ kN/m}^2$
 C – prostorije za okupljanje ljudi $q_C = 3\text{-}5 \text{ kN/m}^2$
 D – trgovačke zgrade $q_D = 5 \text{ kN/m}^2$
 E – skladišta $q_E = 6 \text{ kN/m}^2$

Ostale karakteristike betona

PBAB 87

MB f_{bk}	10	15	20	25	30	35	40	45	50	55	60
f_B [MPa]	7	10.5	14	17.5	20.5	23	25.5	27.75	30	31.5	33
E_b [GPa]		27	28.5	30	31.5	33	34	35	36	37	38
τ_r [MPa]		0.6	0.8	0.95	1.1	1.2	1.3	1.4	1.5	1.55	1.6
τ_p [MPa]		1.2	1.4	1.575	1.75	1.925	2.1	2.275	2.45	2.625	2.8

MB f_{bk} marka betona – karakteristična čvrstoća betona pri pritisku

f_B računska čvrstoća betona pri pritisku

E_b modul elastičnosti betona

τ_r računska čvrstoća betona pri smicanju

τ_p dopušteni napon prijanjanja, za RA 400/500

EC2

C $f_{ck}/f_{ck,cube}$	12/15	16/20	20/25	25/30	30/37	35/45	40/50	45/55	50/60
E_{cm} [GPa]	27	29	30	31	33	34	35	36	37
f_{ctm} [MPa]	1.6	1.9	2.2	2.6	2.9	3.2	3.5	3.8	4.1

E_{cm} modul elastičnosti betona

f_{ctm} srednja vrednost čvrstoće betona pri zatezanju

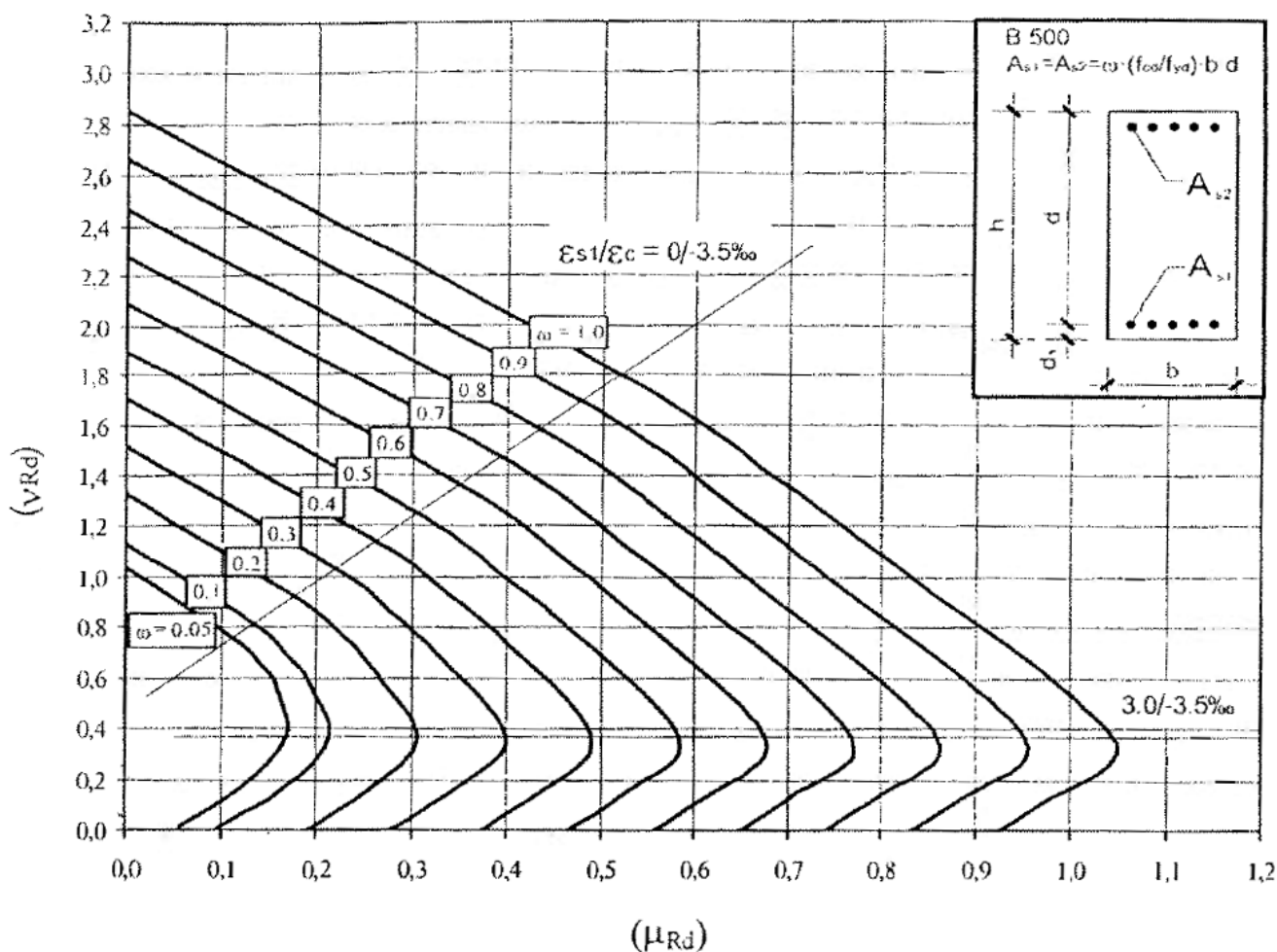
Tabela koeficijenta za proračun pravougaonih preseka opterećenih na savijanje prema EC2

ε_{c2} (‰)	ε_{s1} (‰)	$\xi=x/d$	$\zeta=z/d$	ω_1	μ_{Sd}	k_d
-0.1	20.0	0.005	0.998	0.000	0.000	∞
-0.2	20.0	0.010	0.997	0.001	0.001	31.623
-0.3	20.0	0.015	0.995	0.002	0.002	22.361
-0.4	20.0	0.020	0.993	0.003	0.003	18.257
-0.5	20.0	0.024	0.992	0.005	0.005	14.142
-0.6	20.0	0.029	0.990	0.007	0.007	11.952
-0.7	20.0	0.034	0.988	0.009	0.009	10.541
-0.8	20.0	0.038	0.987	0.011	0.011	9.535
-0.9	20.0	0.043	0.985	0.014	0.014	8.452
-1.0	20.0	0.048	0.983	0.017	0.017	7.670
-1.1	20.0	0.052	0.982	0.020	0.019	7.255
-1.2	20.0	0.057	0.980	0.023	0.023	6.594
-1.3	20.0	0.061	0.978	0.026	0.026	6.202
-1.4	20.0	0.065	0.977	0.030	0.029	5.872
-1.5	20.0	0.070	0.975	0.033	0.033	5.505
-1.6	20.0	0.074	0.973	0.037	0.036	5.270
-1.7	20.0	0.078	0.971	0.040	0.039	5.064
-1.8	20.0	0.083	0.969	0.044	0.043	4.822
-1.9	20.0	0.087	0.968	0.048	0.046	4.663
-2.0	20.0	0.091	0.966	0.052	0.050	4.472
-2.1	20.0	0.095	0.964	0.055	0.053	4.344
-2.2	20.0	0.099	0.962	0.059	0.056	4.226
-2.3	20.0	0.103	0.960	0.062	0.060	4.082
-2.4	20.0	0.107	0.959	0.066	0.063	3.984
-2.5	20.0	0.111	0.957	0.069	0.066	3.892
-2.6	20.0	0.115	0.955	0.073	0.069	3.807
-2.7	20.0	0.119	0.953	0.076	0.073	3.701
-2.8	20.0	0.123	0.951	0.080	0.076	3.627
-2.9	20.0	0.127	0.949	0.083	0.079	3.558
-3.0	20.0	0.130	0.947	0.086	0.081	3.514
-3.1	20.0	0.134	0.945	0.089	0.084	3.450
-3.2	20.0	0.138	0.943	0.093	0.088	3.371
-3.3	20.0	0.142	0.942	0.096	0.091	3.315
-3.4	20.0	0.145	0.940	0.099	0.093	3.279
-3.5	20.0	0.149	0.938	0.103	0.096	3.227
-3.5	19.5	0.152	0.937	0.105	0.098	3.194
-3.5	19.0	0.156	0.935	0.107	0.100	3.162
-3.5	18.5	0.159	0.934	0.109	0.102	3.131

Tabela koeficijenta za proračun pravougaonih preseka opterećenih na savijanje prema EC2 - nastavak

ε_{c2} (‰)	ε_{s1} (‰)	$\xi=x/d$	$\zeta=z/d$	ω_1	μ_{Sd}	k_d
-3.5	18.0	0.163	0.932	0.112	0.105	3.086
-3.5	17.5	0.167	0.931	0.115	0.107	3.057
-3.5	17.0	0.171	0.929	0.118	0.109	3.029
-3.5	16.5	0.175	0.927	0.120	0.112	2.988
-3.5	16.0	0.179	0.926	0.123	0.114	2.962
-3.5	15.5	0.184	0.923	0.127	0.117	2.924
-3.5	15.0	0.189	0.921	0.130	0.120	2.887
-3.5	14.5	0.194	0.919	0.133	0.123	2.851
-3.5	14.0	0.200	0.917	0.138	0.126	2.817
-3.5	13.5	0.206	0.914	0.142	0.130	2.774
-3.5	13.0	0.212	0.912	0.146	0.133	2.742
-3.5	12.5	0.219	0.909	0.151	0.137	2.702
-3.5	12.0	0.226	0.906	0.156	0.141	2.663
-3.5	11.5	0.233	0.903	0.160	0.145	2.626
-3.5	11.0	0.241	0.900	0.166	0.149	2.591
-3.5	10.5	0.250	0.896	0.172	0.154	2.548
-3.5	10.0	0.259	0.892	0.178	0.159	2.508
-3.5	9.5	0.269	0.888	0.185	0.164	2.469
-3.5	9.0	0.280	0.884	0.193	0.170	2.425
-3.5	8.5	0.292	0.879	0.201	0.177	2.377
-3.5	8.0	0.304	0.874	0.209	0.183	2.338
-3.5	7.5	0.318	0.868	0.219	0.190	2.294
-3.5	7.0	0.333	0.861	0.229	0.197	2.253
-3.5	6.5	0.350	0.854	0.241	0.206	2.203
-3.5	6.0	0.368	0.847	0.253	0.214	2.162
-3.5	5.5	0.389	0.838	0.268	0.224	2.113
-3.5	5.0	0.412	0.829	0.283	0.235	2.063
-3.5	4.5	0.438	0.818	0.301	0.247	2.012
-3.5	4.0	0.467	0.806	0.321	0.259	1.965
-3.5	3.5	0.500	0.792	0.344	0.272	1.917
-3.5	3.0	0.538	0.776	0.370	0.287	1.867
-3.5	2.5	0.583	0.757	0.401	0.304	1.814
-3.5	2.0	0.636	0.735	0.438	0.322	1.762
-3.5	1.5	0.700	0.709	0.482	0.342	1.710
-3.5	1.0	0.778	0.676	0.535	0.362	1.662
-3.5	0.5	0.875	0.636	0.602	0.383	1.616

Interakcioni dijagram za dimenzionisanje pravougaonih simetrično armiranih preseka prema EC2



Potrebni prilozi za dimenzionisanje preseka prema PBAB '87 (Tabela koeficijenata za proračun pravougaonih preseka opterećenih na savijanje i Interakcioni dijagram za dimenzionisanje pravougaonih simetrično armiranih preseka) izostavljaju se iz ovih priloga.

Tabele geometrijskih karakteristika armature

Ø	POVRŠINA POPREČNOG PRESEKA ZA KOMADA															Težina	Obim
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15		
mm	cm ²															kg/m	cm
5	0.20	0.39	0.59	0.79	0.98	1.18	1.37	1.57	1.77	1.96	2.16	2.36	2.55	2.75	2.95	0.154	1.57
6	0.28	0.57	0.85	1.13	1.41	1.70	1.98	2.26	2.55	2.83	3.11	3.39	3.68	3.96	4.24	0.222	1.89
8	0.50	1.01	1.51	2.01	2.51	3.02	3.52	4.02	4.52	5.03	5.53	6.03	6.54	7.04	7.54	0.395	2.51
10	0.79	1.57	2.36	3.14	3.93	4.71	5.50	6.28	7.07	7.85	8.64	9.43	10.21	11.00	11.78	0.617	3.14
12	1.13	2.26	3.39	4.52	5.66	6.79	7.92	9.05	10.18	11.31	12.44	13.57	14.70	15.83	16.97	0.888	3.77
14	1.54	3.08	4.62	6.16	7.70	9.24	10.78	12.32	13.86	15.39	16.93	18.47	20.01	21.55	23.09	1.208	4.40
16	2.01	4.02	6.03	8.04	10.05	12.06	14.07	16.09	18.10	20.11	22.12	24.13	26.14	28.15	30.16	1.578	5.03
18	2.54	5.09	7.63	10.18	12.72	15.27	17.81	20.36	22.90	25.45	27.99	30.54	33.08	35.63	38.17	1.998	5.65
20	3.14	6.28	9.43	12.57	15.71	18.85	21.99	25.13	28.27	31.42	34.56	37.70	40.84	43.98	47.12	2.466	6.28
22	3.80	7.60	11.40	15.21	19.01	22.81	26.64	30.41	34.21	38.01	41.81	45.62	49.42	53.22	57.02	2.984	6.91
25	4.91	9.82	14.73	19.64	24.54	29.45	34.36	39.27	44.18	49.09	54.00	58.90	63.81	68.72	73.63	3.853	7.85
28	6.16	12.32	18.47	24.63	30.79	36.95	43.10	49.26	55.42	61.58	67.73	73.89	80.05	86.21	92.36	4.834	8.80
32	8.04	16.09	24.13	32.17	40.21	48.26	56.30	64.34	72.38	80.42	88.47	96.51	104.55	112.60	120.64	6.313	10.05
36	10.18	20.36	30.54	40.72	50.89	61.07	71.25	81.43	91.61	101.79	111.97	122.15	132.32	142.50	152.68	7.990	11.31

REBRATA ARMATURA RA 400/500

RØ	POVRŠINA POPREČNOG PRESEKA ZA KOMADA															Težina	Obim
	1	2	3	1	5	6	7	8	9	10	11	12	13	14	15		
mm	cm ²															kg/m	cm
6	0.28	0.57	0.85	1.13	1.41	1.70	1.98	2.26	2.55	2.83	3.11	3.39	3.68	3.96	4.24	0.228	1.89
8	0.50	1.01	2.51	2.01	2.51	3.02	3.52	4.02	4.52	5.03	5.53	6.03	6.54	7.04	7.54	0.405	2.51
10	0.79	1.57	2.36	3.14	3.93	4.71	5.50	6.28	7.07	7.85	8.64	9.43	10.21	11.00	11.78	0.633	3.14
12	1.13	2.26	3.39	4.52	5.66	6.79	7.92	9.05	10.18	11.31	12.44	13.57	14.70	15.83	16.97	0.911	3.77
14	1.54	3.08	4.62	6.16	7.70	9.24	10.78	12.32	13.86	15.39	16.93	18.47	20.01	21.55	23.09	1.242	4.40
16	2.01	4.02	6.03	8.04	10.05	12.06	14.07	16.09	18.10	20.11	22.12	24.13	26.14	28.15	30.16	1.621	5.03
19	2.84	5.67	8.51	11.34	14.18	17.01	19.85	22.68	25.52	28.35	31.19	34.02	36.86	39.69	42.53	2.288	5.97
22	3.80	7.60	11.40	15.21	19.01	22.81	26.64	30.41	34.21	38.01	41.81	45.62	49.42	53.22	57.02	3.058	6.91
25	4.91	9.82	14.73	19.64	24.54	29.45	34.36	39.27	44.18	49.09	54.00	58.90	63.81	68.72	73.63	3.951	7.85
28	6.16	12.32	18.47	24.63	30.79	36.95	43.10	49.26	55.42	61.58	67.73	73.89	80.05	86.21	92.36	4.956	8.80
32	8.04	16.09	24.13	32.17	40.21	48.26	56.30	64.34	72.38	80.42	88.47	96.51	104.55	112.60	120.64	6.474	10.05
36	10.18	20.36	30.54	40.72	50.89	61.07	71.25	81.43	91.61	101.79	111.97	122.15	132.32	142.50	152.68	8.200	11.31

Tabele geometrijskih karakteristika armature

ZAVARENE ČELIČNE MREŽE MAG i MAR 500/560

Tip oznaka mreže	Prečnik		Rastojanje		Površina preseka		Prosečna dužina mreže
	Podužne šipke	Poprečne šipke	Podužne šipke	Poprečne šipke	Podužne šipke	Poprečne šipke	
	mm		mm		cm ² /m ²		
R 126	4.0	4.0	100	250	1.26	0.50	1.43
R 131	5.0	4.0	150	250	1.31	0.50	1.49
R 139	4.2	4.0	100	250	1.39	0.50	1.53
R 166	4.6	4.0	100	250	1.66	0.50	1.75
R 188	6.0	4.0	150	250	1.88	0.50	1.96
R 196	5.0	4.0	100	250	1.96	0.50	1.99
R 221	6.5	4.2	150	250	2.21	0.55	2.27
R 238	5.5	4.2	100	250	2.38	0.55	2.37
R 257	7.0	5.0	150	250	2.57	0.79	2.75
R 282	6.0	4.0	100	250	2.82	0.50	2.69
R 331	6.5	4.6	100	250	3.31	0.66	3.12
R 335	8.0	5.0	150	250	3.35	0.79	3.41
R 378	8.5	5.0	150	250	3.78	0.79	3.76
R 385	7.0	5.0	100	250	3.85	0.79	3.74
R 124	9.0	6.0	150	250	4.24	1.13	4.41
R 442	7.5	5.5	100	250	4.42	0.95	4.32
R 503	8.0	6.0	100	250	5.03	1.13	4.69
R 524	10.0	6.0	150	250	5.24	1.13	5.24
Q 111	4.6	4.6	150	150	1.11	1.11	1.80
Q 131	5.0	5.0	150	150	1.31	1.31	2.14
Q 188	6.0	6.0	150	150	1.88	1.88	3.09
Q 221	6.5	6.5	150	150	2.21	2.21	3.59
Q 257	7.0	7.0	150	150	2.57	2.57	4.20
Q 335	8.0	8.0	150	150	3.35	3.35	5.50
Q 378	8.5	8.5	150	150	3.78	3.78	6.14
Q 424	9.0	9.0	150	150	4.24	4.24	6.88
Q 524	10.0	10.0	150	150	5.24	5.24	8.50
T 257	5.0	7.0	250	150	0.79	2.57	2.68
T 378	5.0	8.5	250	150	0.79	3.78	3.64
T 524	6.0	10.0	250	150	1.13	5.24	5.09
Rd 168	4.0d	4.0	150	250	1.68	0.50	1.80
Rd 185	4.2d	4.0	150	250	1.85	0.50	1.94
Rd 222	4.6d	4.2	150	250	2.22	0.55	2.28
Rd 262	5.0d	4.2	150	250	2.62	0.55	2.61
Rd 317	5.5d	4.6	150	250	3.17	0.66	3.16
Rd 377	6.0d	5.0	150	250	3.77	0.79	3.74
Rd 443	6.5d	5.5	150	250	4.43	0.95	4.42
Rd 513	7.0d	6.0	150	250	5.13	1.13	5.15
Rd 566	6.0d	6.0	100	250	5.66	1.13	5.49
Rd 589	7.5d	6.5	150	250	5.89	1.33	5.93

Tip oznaka mreže	Prečnik		Rastojanje		Površina preseka		Prosečna dužina mreže
	Podužne šipke	Poprečne šipke	Podužne šipke	Poprečne šipke	Podužne šipke	Poprečne šipke	
	mm		mm		cm ² /m ²		
Qd 184	4.2d	6.0	150	150	1.84	1.88	3.03
Qd 222	4.6d	6.5	150	150	2.22	2.21	3.59
Qd 262	5.0d	7.0	150	150	2.62	2.57	4.20
Qd 376	6.0d	8.5	150	150	3.76	3.77	6.13
Qd 514	7.0d	10.0	150	150	5.14	5.24	8.41
SRd 168	4.0d	4.0	150	250	1.68	0.50	1.61
SRd 185	4.2d	4.0	150	250	1.85	0.50	1.73
SRd 222	4.6d	4.2	150	250	2.22	0.55	2.03
SRd 262	5.0d	4.2	150	250	2.62	0.55	2.32
SRd 317	5.5d	4.6	150	250	3.17	0.66	2.81
SRd 377	6.0d	5.0	150	250	3.77	0.79	3.33
SRd 443	6.5d	5.5	150	250	4.43	0.95	3.93
SRd 513	7.0d	6.0	150	250	5.13	1.13	4.54
SRd 589	7.5d	6.5	150	250	5.89	1.33	5.29
SQd 184	4.2d	6.0	150	150	1.84	1.88	2.62
SQd 222	4.6d	6.5	150	150	2.22	2.21	3.10
SQd 262	5.0d	7.0	150	150	2.62	2.57	3.63
SQd 376	6.0d	8.5	150	150	3.76	3.77	5.30
SQd 514	7.0d	10.0	150	150	5.14	5.24	7.29
SR 92	4.2/4.0	4.2	150	250	0.92	0.55	1.17
SR 111	4.6/4.0	4.2	150	250	1.11	0.55	1.29
SR 131	5.0/4.0	4.2	150	250	1.31	0.55	1.41
SR 92	4.2/4.0	4.2	150	150	0.92	0.92	1.46
SQ 131	5.0/4.0	5.0	150	150	1.31	1.31	1.92
SQ 158	5.5/4.0	5.5	150	150	1.58	1.58	2.25
R 753	12.0	7.5	150	250	7.53	1.77	7.66
R 1130	12.0	8.0	100	200	11.30	2.51	11.17
Q 753	12.0	12.0	150	150	7.53	7.53	12.18
Q 1130	12.0	12.0	100	100	11.30	11.30	17.97
Rd 664	6.5d	6.5	100	250	6.64	1.33	6.42
Rd 770	7.0d	7.0	100	250	7.70	1.54	7.25
Rd 884	7.5d	7.5	100	250	8.84	1.77	8.33
Rd 1005	8.0d	8.0	100	250	10.05	2.01	9.48
Rd 1135	8.5d	8.5	100	250	11.35	2.27	10.68
Qd 567	6.0d	8.5	100	100	5.65	5.67	8.89
Qd 636	6.5d	9.0	100	100	6.64	6.36	10.19
Qd 709	7.0d	9.5	100	100	7.70	7.09	11.60
Qd 866	7.5d	10.5	100	100	8.84	8.66	13.74

Statički uticaji krstasto armiranih pravougaonih ploča oslonjenih na sve četiri strane opterećenih jednako podjeljenim opterećenjem – momenti savijanja

Koeficijenti k_i za proračun momenata savijanja $M = k_i \cdot q \cdot l_x \cdot l_y$

$l_y:l_x$	1.0	1.1	1.2	1.3	1.4	1.5	1.6	1.7	1.8	1.9	2.0	
	M_x	0.044	0.047	0.049	0.051	0.052	0.052	0.053	0.052	0.052	0.051	0.050
	M_y	0.044	0.041	0.038	0.034	0.032	0.029	0.026	0.024	0.022	0.020	0.019
	M_x	0.037	0.037	0.038	0.037	0.037	0.035	0.034	0.033	0.032	0.031	0.030
	M_y	0.031	0.027	0.023	0.021	0.018	0.016	0.014	0.012	0.011	0.010	0.009
	M_0	0.084	0.084	0.082	0.079	0.077	0.074	0.071	0.069	0.066	0.063	0.061
	M_x	0.031	0.035	0.038	0.041	0.043	0.044	0.045	0.046	0.046	0.046	0.046
	M_y	0.037	0.036	0.034	0.032	0.030	0.028	0.026	0.024	0.022	0.021	0.019
	M_0	0.084	0.084	0.083	0.080	0.078	0.075	0.072	0.069	0.066	0.064	0.061
	M_x	0.028	0.030	0.032	0.032	0.032	0.032	0.032	0.031	0.031	0.030	0.029
	M_y	0.028	0.025	0.023	0.021	0.019	0.017	0.014	0.014	0.012	0.011	0.010
	M_0	0.068	0.070	0.071	0.071	0.070	0.069	0.067	0.065	0.063	0.061	0.059
	M_0	0.068	0.065	0.062	0.059	0.055	0.051	0.049	0.046	0.043	0.041	0.040
	M_x	0.032	0.031	0.030	0.029	0.028	0.027	0.026	0.024	0.023	0.022	0.021
	M_y	0.022	0.018	0.015	0.013	0.011	0.009	0.008	0.007	0.006	0.005	0.005
	M_0	0.070	0.067	0.064	0.061	0.058	0.055	0.052	0.050	0.047	0.044	0.042
	M_x	0.022	0.026	0.028	0.032	0.035	0.037	0.039	0.040	0.041	0.042	0.043
	M_y	0.032	0.032	0.031	0.030	0.029	0.027	0.026	0.024	0.023	0.021	0.020
	M_0	0.070	0.072	0.073	0.072	0.072	0.070	0.068	0.066	0.064	0.062	0.060
	M_x	0.026	0.026	0.027	0.027	0.026	0.025	0.024	0.024	0.022	0.022	0.021
	M_y	0.021	0.018	0.016	0.014	0.012	0.010	0.009	0.008	0.007	0.006	0.006
	M_0	0.060	0.060	0.059	0.057	0.055	0.053	0.050	0.048	0.046	0.044	0.042
	M_0	0.055	0.052	0.048	0.044	0.041	0.038	0.036	0.034	0.032	0.030	0.029
	M_x	0.021	0.024	0.026	0.028	0.029	0.029	0.029	0.029	0.028	0.028	0.028
	M_y	0.026	0.025	0.023	0.022	0.019	0.017	0.016	0.014	0.012	0.011	0.011
	M_0	0.055	0.059	0.062	0.036	0.064	0.063	0.062	0.061	0.059	0.058	0.057
	M_0	0.060	0.059	0.058	0.055	0.053	0.051	0.048	0.046	0.043	0.041	0.039
	M_x	0.021	0.023	0.023	0.024	0.020	0.020	0.023	0.022	0.022	0.021	0.021
	M_y	0.021	0.019	0.017	0.015	0.013	0.011	0.010	0.008	0.007	0.006	0.006
	M_0	0.052	0.054	0.053	0.053	0.052	0.051	0.049	0.048	0.046	0.044	0.042
	M_0	0.052	0.049	0.047	0.044	0.041	0.038	0.036	0.034	0.032	0.030	0.029

Statički uticaji krstasto armiranih pravougaonih ploča oslonjenih na sve četiri strane opterećenih jednako podeljenim opterećenjem – reakcije oslonaca

Koeficijenti r_i za proračun reakcija oslonaca $Q = r_i \cdot q \cdot l_x \cdot l_y$

$l_x:l_y$	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	0.330	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 ₃	0.220	0.207	0.196	0.186	0.178	0.170	0.163	0.156	0.150	0.145	0.140
	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 ₃	0.230	0.223	0.214	0.207	0.200	0.192	0.187	0.178	0.174	0.169	0.164
	Q ₄	0.292	0.313	0.331	0.346	0.360	0.370	0.380	0.390	0.400	0.410	0.419
	Q ₁	0.208	0.217	0.226	0.233	0.241	0.247	0.252	0.256	0.260	0.263	0.266
	Q ₂	0.292	0.274	0.257	0.244	0.230	0.221	0.212	0.204	0.196	0.189	0.182
	Q ₃	0.208	0.196	0.186	0.177	0.169	0.162	0.156	0.150	0.144	0.138	0.133
	Q ₄	0.302	0.315	0.326	0.334	0.342	0.350	0.356	0.361	0.367	0.372	0.377
	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	0.198	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	0.274	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 ₃	0.262	0.248	0.232	0.217	0.206	0.196	0.186	0.177	0.170	0.163	0.158
	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 ₃	0.274	0.259	0.245	0.233	0.222	0.211	0.203	0.195	0.187	0.180	0.174
	Q ₁	0.250	0.266	0.279	0.291	0.302	0.312	0.320	0.327	0.333	0.339	0.345
	Q ₂	0.250	0.234	0.221	0.209	0.198	0.188	0.180	0.173	0.167	0.161	0.155

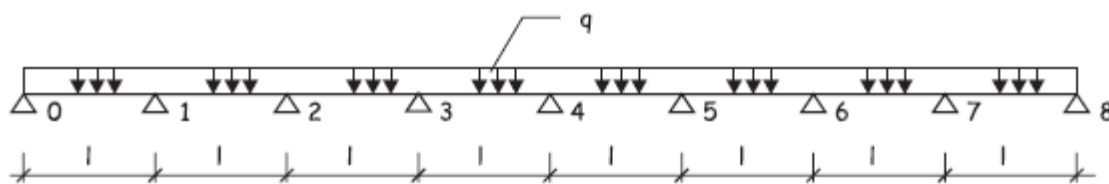
Statički uticaji greda jednog raspona

	Dispozicija nosača i opterećenja	Reakcije oslonaca R	Ekstremni momenti M_{max}
1.1		$A = B = \frac{q \cdot l}{2}$	$M_c = \frac{q \cdot l^2}{8} \quad x_c = \frac{l}{2}$
1.2		$A = Q \cdot \frac{b}{l} \quad B = Q \cdot \frac{a}{l}$	$M_b = Q \cdot \frac{a \cdot b}{l}$
1.3		$A = -B = -\frac{M}{l}$	$M_b^{levo} = -M \cdot \frac{a}{l}$ $M_b^{desno} = M \cdot \frac{b}{l}$
2.1		$A = q \cdot l$	$M_A = -\frac{q \cdot l^2}{2}$
2.2		$A = Q$	$M_A = Q \cdot a$
2.3		$A = 0$	$M_A = -M$
3.1		$A = \frac{5}{8} \cdot q \cdot l \quad B = \frac{3}{8} \cdot q \cdot l$	$M_A = -\frac{q \cdot l^2}{8}$ $M_b = \frac{9}{128} \cdot q \cdot l^2 \quad x_b = \frac{5}{8} \cdot l$
3.2		$A = \frac{Q}{2 \cdot l^3} \cdot b \cdot (3 \cdot l^2 - b^2)$ $B = \frac{Q}{2 \cdot l^3} \cdot a^2 \cdot (3 \cdot l - a)$	$M_A = -\frac{Q \cdot a \cdot b}{2 \cdot l^2} \cdot (l + b)$ $M_b = \frac{Q \cdot a \cdot b}{2 \cdot l^2} \cdot \frac{a}{l} \cdot (2 \cdot l + b)$

Statički uticaji greda jednog raspona - nastavak

	Dispozicija nosača i opterećenja	Reakcije oslonaca R	Ekstremni momenti M_{\max}
3.3		$A = -B = -\frac{3 \cdot M}{2 \cdot l} \cdot \left(1 - \frac{b^2}{l^2}\right)$	$M_A = \frac{M}{2} \cdot \left(3 \cdot \frac{b^2}{l^2} - 1\right)$ $M_b^{\text{levo}} = \frac{M}{2 \cdot l^3} \cdot [3 \cdot a \cdot b \cdot (l+b) - 2 \cdot l^3]$ $M_b^{\text{desno}} = \frac{3 \cdot M \cdot b}{2 \cdot l} \cdot \left(1 - \frac{b^2}{l^2}\right)$
4.1		$A = B = \frac{q \cdot l}{2}$	$M_A = M_B = -\frac{q \cdot l^2}{12} \quad M_C = \frac{q \cdot l^2}{24} \quad x_C = \frac{l}{2}$
4.2		$A = \frac{Q \cdot b^2}{l^3} \cdot (l + 2 \cdot a)$ $B = \frac{Q \cdot a^2}{l^3} \cdot (l + 2 \cdot b)$	$M_A = -Q \cdot \frac{a \cdot b^2}{l^2} \quad M_B = -Q \cdot \frac{a^2 \cdot b}{l^2}$ $M_D = 2 \cdot Q \cdot \frac{a^2 \cdot b^2}{l^3}$
4.3		$A = -B = -\frac{6 \cdot M \cdot a \cdot b}{l^3}$	$M_A = \frac{M \cdot b}{l^2} \cdot (2 \cdot a - b)$ $M_B = -\frac{M \cdot a}{l^2} \cdot (2 \cdot b - a)$ $M_b^{\text{desno}} = \frac{M \cdot a}{l^3} \cdot (6 \cdot a^2 - 9 \cdot a \cdot l + 4 \cdot l^2)$ $M_b^{\text{levo}} = M_b^{\text{desno}} - M$

Statički uticaji kontinualnih nosača jednakih raspona



Vrednost	Broj oslonaca						
	3	4	5	6	7	8	9
M_1	-0.125	-0.100	-0.107	-0.105	-0.106	-0.106	-0.106
M_2			-0.071	-0.079	-0.077	-0.078	-0.077
M_3					-0.087	-0.085	-0.085
							-0.083
max M_{01}	0.070	0.080	0.077	0.070	0.078	0.078	0.078
max M_{12}		0.025	0.036	0.033	0.034	0.034	0.034
max M_{23}				0.046	0.043	0.044	0.044
max M_{34}						0.041	0.041
Q_{1L}	-0.625	-0.600	-0.607	-0.605	-0.606	-0.606	-0.6061
Q_{1D}	0.625	0.500	0.536	0.526	0.529	0.528	0.528
Q_{2L}			-0.464	-0.474	-0.471	-0.472	-0.472
Q_{2D}			0.464	0.500	0.490	0.493	0.492
Q_{3L}					-0.510	-0.507	-0.508
Q_{3D}					0.510	0.500	0.503
Q_{4L}							-0.497
Q_{4D}							0.497
R_0	0.375	0.400	0.393	0.395	0.394	0.394	0.394
R_1	1.250	1.100	1.143	1.132	1.135	1.134	1.134
R_2			0.927	0.974	0.962	0.965	0.964
R_3					1.019	1.007	1.010
R_4							0.935
x_0	0.375	0.400	0.393	0.395	0.394	0.394	0.394
x_1		0.500	0.536	0.526	0.529	0.528	0.528
x_2					0.490	0.493	0.492
x_3						0.500	0.503

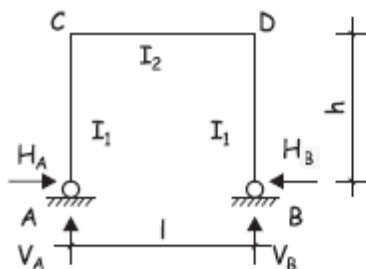
· ql^2

· ql

· l

Statički uticaji u jednobrodnim ramovima – dvozglobni ram

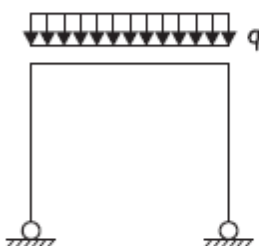
Dvozglobni ram



$$k = \frac{I_2 h}{I_1 l}$$

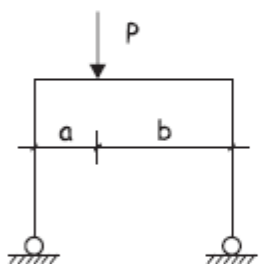
$$M_c = -H_A \cdot h$$

$$M_b = -H_B \cdot h$$



$$H_A = H_B = \frac{ql^2}{4h(2k+3)}$$

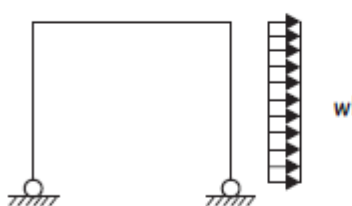
$$V_A = V_B = \frac{ql}{2}$$



$$H_A = H_B = \frac{3}{2} \cdot \frac{Pab}{hl(2k+3)}$$

$$V_A = P \frac{b}{l}$$

$$V_B = P \frac{a}{l}$$

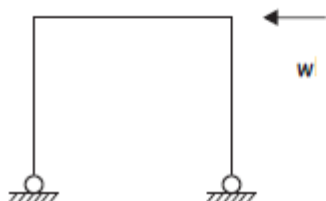


$$H_A = \frac{wh}{8} \cdot \frac{5k+6}{2k+3}$$

$$H_B = -\frac{wh}{8} \cdot \frac{11k+18}{2k+3}$$

$$V_A = V_B = P \frac{wh^2}{2l}$$

$$M_b = -H_B \cdot h - 0.5wh^2$$

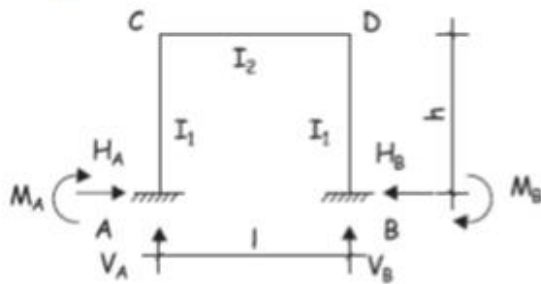


$$H_A = -H_B = \frac{W}{2}$$

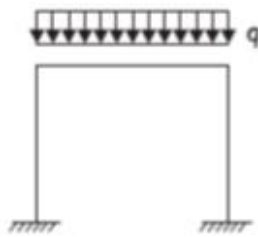
$$V_A = V_B = \frac{Wh}{l}$$

Statički uticaji u jednobrodnim ramovima – uklješteni ram

Uklješteni ram



$$k = \frac{I_2 \cdot h}{I_1 \cdot l}$$

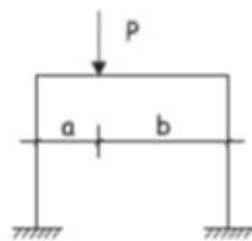


$$H_A = H_B = \frac{ql^2}{4h(k+2)}$$

$$V_A = V_B = \frac{ql}{2}$$

$$M_A = M_B = \frac{ql^2}{12(k+2)} = H \cdot \frac{h}{3}$$

$$M_C = M_D = \frac{ql^2}{6(k+2)} = 2H \cdot \frac{h}{3}$$



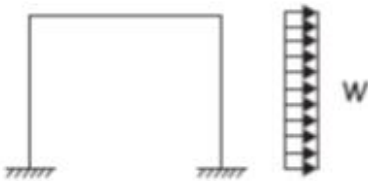
$$H_A = H_B = \frac{3}{2} \cdot \frac{Pab}{hl(k+2)}$$

$$V_A = P \frac{b}{l} \left[1 + \frac{a(b-a)}{l^2(6k+1)} \right] \quad V_B = P - V_A$$

$$M_A = \frac{Pab}{2l^2} \cdot \frac{5kl - l + 2a(k+2)}{(k+2)(6k+1)}$$

$$M_B = \frac{Pab}{2l^2} \cdot \frac{7kl + 3l - 2a(k+2)}{(k+2)(6k+1)}$$

$$M_C = M_A - Hh \quad M_D = M_B - Hh$$



$$H_A = \frac{wh}{8} \cdot \frac{2k+3}{k+2} \quad H_B = H_A - wh$$

$$V_A = -V_B = \frac{wh^2k}{l(6k+1)}$$

$$M_A = \frac{wh^2}{24} \left(\frac{5k+9}{k+2} - \frac{12k}{6k+1} \right)$$

$$M_C = M_A - H_A h \quad M_D = M_B - Hh + \frac{wh^2}{2}$$



$$H_A = -H_B = \frac{W}{2}$$

$$V_A = V_B = \frac{3Whk}{l(6k+1)}$$

$$M_A = -M_B = \frac{Wh}{2} \cdot \frac{3k+1}{6k+1}$$

$$M_C = -M_D = \frac{Wh}{2} \cdot \frac{3k}{6k+1}$$