

MIM232

BETONARME HESAPLARI İÇİN
YARDIMCI TABLOLAR VE DİYAGRAMLAR

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Donatı çubukları enkesit alanları

ϕ mm	g kg/m	Çubuk Sayısı									
		1	2	3	4	5	6	7	8	9	10
8	0.395	0.50	1.01	1.51	2.01	2.51	3.01	3.52	4.02	4.52	5.03
10	0.617	0.79	1.57	2.36	3.14	3.93	4.71	5.50	6.28	7.07	7.85
12	0.888	1.13	2.26	3.39	4.52	5.65	6.79	7.92	9.05	10.18	11.31
14	1.21	1.54	3.08	4.62	6.16	7.70	9.24	10.78	12.32	13.85	15.39
16	1.58	2.01	4.02	6.03	8.04	10.05	12.06	14.07	16.08	18.10	20.11
18	2.00	1.54	5.09	7.63	10.18	12.72	15.26	17.81	20.36	22.90	25.45
20	2.47	3.14	6.28	9.42	12.57	15.71	18.84	21.99	25.14	28.28	31.42
22	2.98	3.80	7.60	11.40	15.27	19.01	22.81	26.61	30.41	34.21	38.01
24	3.55	4.52	9.05	13.57	18.10	22.62	27.14	31.67	36.19	40.72	45.24
26	4.17	5.31	10.62	15.93	21.24	26.55	31.86	37.17	42.47	47.78	53.09
28	4.83	6.16	12.31	18.47	24.63	30.79	36.94	43.10	49.26	55.42	61.58
30	5.55	7.07	14.14	21.21	28.27	35.34	42.41	49.48	56.55	63.62	70.69
32	6.31	8.04	16.06	24.13	32.17	40.21	48.26	56.30	64.34	72.38	80.42
34	7.13	9.08	18.16	27.24	36.32	45.40	54.48	63.56	72.63	81.71	90.79
36	7.99	10.18	20.36	30.54	40.72	50.90	61.07	71.25	81.43	91.61	101.7
38	8.90	11.34	22.68	34.02	45.36	56.70	68.04	79.38	90.73	102.0	113.4
40	9.87	12.57	25.13	37.70	50.26	62.83	75.40	87.96	100.5	113.1	125.6
45	12.48	15.90	31.81	47.71	63.62	79.52	95.43	111.3	127.23	143.1	159.0
50	15.41	19.64	39.27	58.91	78.54	98.15	117.8	137.4	157.0	176.7	196.3

Kirişlerin b_w [cm] genişliği, ϕ_t minimum etriye çapı ve A_s donatısı [cm²]

ϕ mm	ϕ_t mm	3 Çubuk		4 Çubuk		5 Çubuk		6 Çubuk		7 Çubuk		8 Çubuk	
		b_w	A_s	b_w	A_s	b_w	A_s	b_w	A_s	b_w	A_s	b_w	A_s
12	8	11.8	3.4	15.0	4.5	18.2	5.7	21.4	6.8	24.6	7.9	27.8	9.1
14	8	12.4	4.6	15.8	6.2	19.2	7.7	22.6	9.2	26.0	10.8	29.4	12.3
16	8	13.0	6.0	16.6	8.0	20.0	10.0	23.8	12.1	27.4	14.1	31.0	16.1
18	8	13.6	7.6	17.4	10.2	21.2	12.7	25.0	15.3	28.8	17.8	32.6	20.4
20	8	14.6	9.4	18.6	12.6	22.6	15.7	26.6	18.8	30.6	22.0	34.6	25.1
22	8	15.6	11.4	20.0	15.2	24.4	19.0	28.8	22.8	33.2	26.6	37.6	30.4
24	8	16.6	13.6	21.4	18.1	26.2	22.6	31.0	27.1	35.8	31.7	40.6	36.2
26	10	18.0	15.9	23.2	21.2	28.4	26.5	33.6	31.9	38.8	37.2	44.0	42.5
28	10	19.0	18.5	24.6	24.6	30.2	30.8	35.8	36.9	41.4	43.1	47.0	49.3
30	10	20.0	21.2	26.0	28.3	32.0	35.3	38.0	42.4	44.0	49.5	50.0	56.5
32	12	21.4	24.1	28.0	32.2	34.2	40.2	40.6	48.3	47.0	56.3	53.4	64.3
34	12	22.4	27.2	29.2	36.3	36.0	45.4	42.8	54.5	49.6	63.6	56.4	72.6
36	12	23.4	30.5	30.6	40.7	37.6	50.9	45.0	61.1	52.2	71.3	59.4	81.4
38	14	24.8	34.0	32.4	45.4	40.0	56.7	47.6	68.0	55.2	79.4	62.8	90.7
40	14	25.8	37.7	33.8	50.3	41.8	62.8	49.8	75.4	57.8	88.0	65.8	100

Basit Eğilmede Dikdörtgen Kesitler İçin Boyutsuz Değerler

	ρ_m	m_u	k_c	k_z	$\% \epsilon_c$	$\% \epsilon_s$
1	0.002	0.002	0.020	0.993	0.2	10.0
2	0.006	0.006	0.038	0.987	0.4	10.0
3	0.013	0.013	0.057	0.981	0.6	10.0
4	0.022	0.021	0.074	0.974	0.8	10.0
5	0.032	0.031	0.091	0.968	1.0	10.0
6	0.044	0.042	0.107	0.962	1.2	10.0
7	0.056	0.054	0.123	0.956	1.4	10.0
8	0.069	0.065	0.138	0.950	1.6	10.0
9	0.082	0.077	0.153	0.944	1.8	10.0
10	0.094	0.089	0.167	0.938	2.0	10.0
11	0.107	0.099	0.180	0.931	2.2	10.0
12	0.119	0.110	0.194	0.925	2.4	10.0
13	0.130	0.120	0.206	0.919	2.6	10.0
14	0.142	0.129	0.219	0.913	2.8	10.0
15	0.153	0.138	0.231	0.907	3.0	10.0
16	0.165	0.149	0.250	0.899	3.0	9.0
17	0.180	0.160	0.273	0.890	3.0	8.0
18	0.198	0.174	0.300	0.879	3.0	7.0
19	0.220	0.191	0.333	0.865	3.0	6.0
20	0.248	0.210	0.375	0.848	3.0	5.0
21	0.283	0.234	0.429	0.827	3.0	4.0
22	0.331	0.264	0.500	0.798	3.0	3.0

f_{yd} / f_{cd} değerleri

	C14	C16	C18	C20	C25	C30	C35	C40	C45	C50
S220	20.5	17.9	15.9	14.3	11.5	9.6	8.2	7.2	6.4	5.7
S420	39.1	34.2	30.4	27.4	21.9	18.3	15.7	13.7	12.2	11.0
S500	46.6	40.8	36.2	32.6	26.1	21.7	18.6	16.3	14.5	13.0

Dönüştürülmüş Moment $m_u = \frac{M_u}{bd^2 f_{cd}}$

Mekanik Donatı Oranı $\rho_m = \rho \frac{f_{yd}}{f_{cd}}$

Donatı Oranı $\rho = \frac{A_s}{bd}$

DİKDÖRTGEN BASINÇ BÖLGEİ KESİTLER İÇİN KATSAYILAR

BAĞINTILAR

$$M_{su} = M_u - N_u y_s$$

$$M_{su} = b d^2 / K = b d^2 / k_d^2$$

$$K = k_d^2 = b d^2 / M_{su}$$

$$A_s = k_s M_{su} / d + N_u / f_{yd}$$

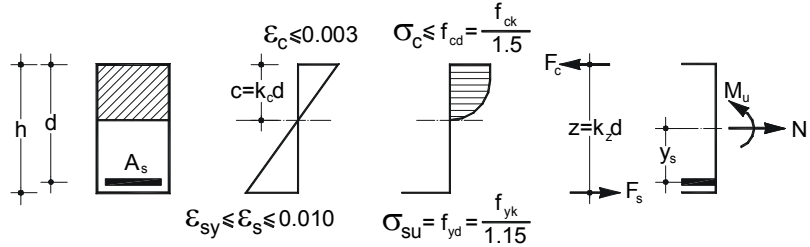
BİRİMLER

$$[b, d, y_s] : \text{cm}$$

$$[N_u] : \text{t} ; [M_u, M_{su}] : \text{tcm}$$

$$[f_{cd}, f_{yd}] : \text{t/cm}^2 ; [A_s] : \text{cm}^2$$

$$[K = k_d^2, k_s] : \text{cm}^2/\text{t}$$



	$K = k_d^2$					k_s			k_c	k_z	ϵ_c	ϵ_s
	C14	C16	C18	C20	C25	S220	S420	S500			%	%
1	6694.4	5857.6	5206.7	4686.1	3748.9	0.526	0.276	0.232	0.020	0.993	0.2	10
2	1778.9	1556.6	1383.6	1245.2	996.2	0.530	0.277	0.233	0.038	0.987	0.4	10
3	841.1	735.9	654.2	788.8	471.0	0.533	0.279	0.235	0.057	0.981	0.6	10
4	503.8	440.8	391.8	352.7	282.1	0.536	0.281	0.236	0.074	0.974	0.8	10
5	343.7	300.7	267.3	240.6	192.5	0.540	0.283	0.238	0.091	0.968	1.0	10
6	254.8	222.9	198.2	178.3	142.7	0.543	0.285	0.239	0.107	0.962	1.2	10
7	200.1	175.1	155.6	140.0	112.0	0.547	0.286	0.241	0.123	0.956	1.4	10
8	164.0	143.5	127.6	114.8	91.8	0.550	0.288	0.242	0.138	0.950	1.6	10
9	139.0	121.6	108.1	97.3	77.8	0.554	0.290	0.244	0.153	0.944	1.8	10
10	121.0	105.9	94.1	84.7	67.8	0.558	0.292	0.245	0.167	0.938	2.0	10
11	107.7	94.2	83.8	75.4	60.3	0.561	0.294	0.247	0.180	0.931	2.2	10
12	97.5	85.3	75.8	68.2	54.6	0.565	0.296	0.249	0.194	0.925	2.4	10
13	89.4	78.2	69.5	62.6	50.1	0.569	0.298	0.250	0.206	0.919	2.6	10
14	82.9	72.5	64.5	58.0	46.4	0.573	0.300	0.252	0.219	0.913	2.8	10
15	77.5	67.8	60.2	54.2	43.4	0.577	0.302	0.254	0.231	0.907	3.0	10
16	72.1	63.1	56.1	50.5	40.4	0.582	0.305	0.256	0.250	0.899	3.0	9
17	66.8	58.4	52.0	46.8	37.4	0.588	0.308	0.259	0.273	0.890	3.0	8
18	61.5	53.8	47.8	43.0	34.4	0.595	0.312	0.262	0.300	0.879	3.0	7
19	56.2	49.2	43.7	39.3	31.5	0.604	0.317	0.266	0.333	0.865	3.0	6
20	51.0	44.6	39.6	35.7	28.5	0.616	0.323	0.271	0.375	0.848	3.0	5
21	45.8	40.0	35.6	32.0	25.6	0.632	0.331	0.278	0.429	0.827	3.0	4
22	40.6	35.6	31.6	28.4	22.8	0.655	0.343	0.288	0.500	0.798	3.0	3
23	36.5	32.0	28.4	25.6	20.5	0.683	0.358	0.301	0.580	0.765	3.0	2.174
24	34.8	30.5	27.1	24.4	19.5	0.698	0.366	0.307	0.622	0.748	3.0	1.826
25	30.8	27.0	24.0	21.6	17.3	0.754	0.395	0.332	0.758	0.693	3.0	0.956

AÇIKLAMALAR

- N_u eksenel kuvvet; çekme (+), basınç (-) olarak alınacaktır.
- f_{yk} çelik akma sınırı; S220, S420, S500 çelik kalitelerine göre sırasıyla 2.2, 4.2 ve 5.0 t/cm² alınmıştır.
- 23, 24 ve 25. satırlar sıra ile S500, S420 ve S220 çelik kalitelerine göre dengeli kesit için $K^* = k_d^{*2}$ değerleridir.
- Altı çizgili k_s değerleri dengeli kesitin yaklaşık 0.85' i kadar donatı için sınırı belirtmektedir.
- Malzeme katsayıları $\gamma_{mc} = 1.50$, $\gamma_{ms} = 1.15$ ve çeliğin elastisite modülü $E_s = 2 \times 10^5$ N/mm² alınmıştır.
- Beton kalitesi C14 olan mevcut yapıların gerektiğinde kontrol edilebilmesi için, yönetmelikte bulunmamasına karşın, tabloya bu beton sınıfı ile ilgili değerler de eklenmiştir.

DİKDÖRTGEN BASINÇ BÖLGEİ KESİTLER İÇİN KATSAYILAR (devam)

BAĞINTILAR

$$M_{su} = M_u - N_u y_s$$

$$M_{su} = b d^2 / K = b d^2 / k_d^2$$

$$K = k_d^2 = b d^2 / M_{su}$$

$$A_s = k_s M_{su} / d + N_u / f_{yd}$$

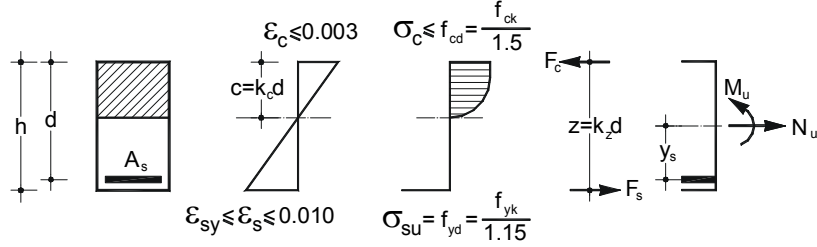
BİRİMLER

$$[b , d , y_s] : \text{cm}$$

$$[N_u] : \text{t} ; [M_u , M_{su}] : \text{tcm}$$

$$[f_{cd} , f_{yd}] : \text{t/cm}^2 ; [A_s] : \text{cm}^2$$

$$[K = k_d^2 , k_s] : \text{cm}^2/\text{t}$$



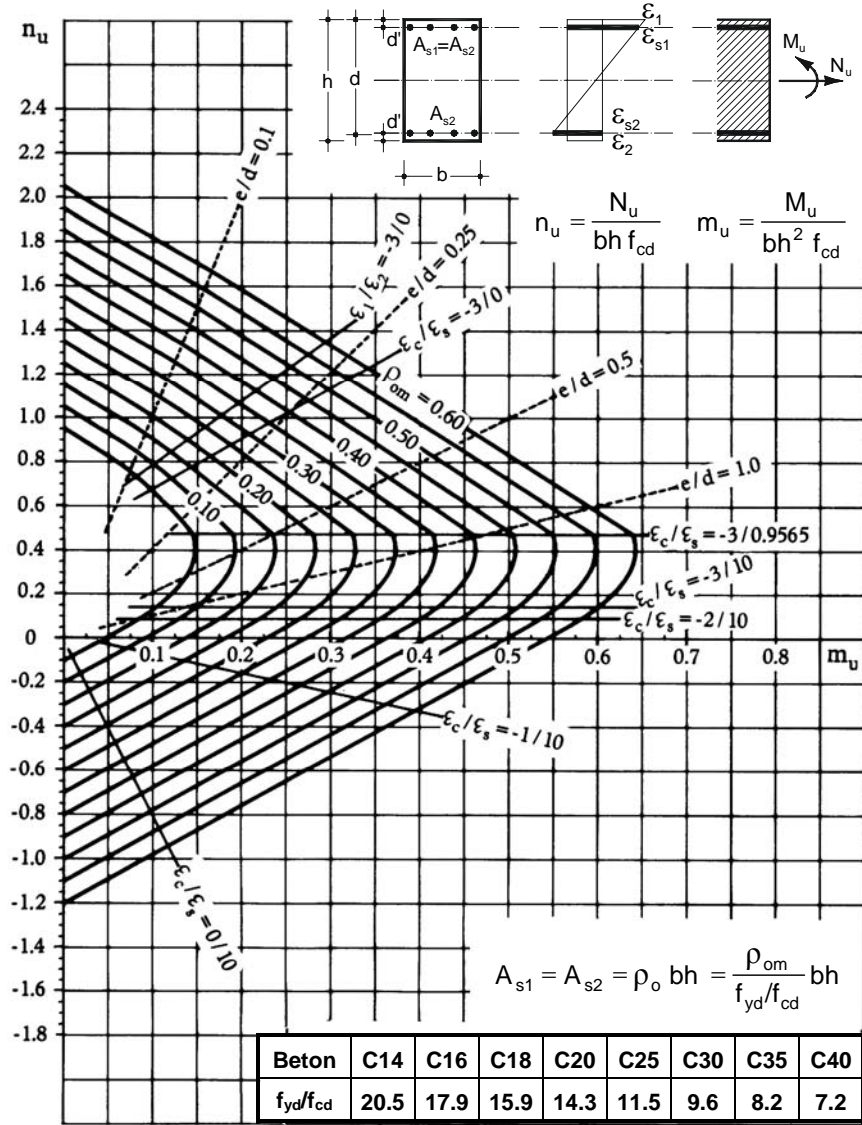
	$K=k_d^2$					k_s			k_x	k_z	ϵ_c	ϵ_s
	C30	C35	C40	C45	C50	S220	S420	S500				
1	3124.0	2677.8	2343.0	2082.7	1874.4	0.526	0.276	0.232	0.020	0.993	0.2	10
2	830.2	711.6	622.6	553.4	498.1	0.530	0.277	0.233	0.038	0.987	0.4	10
3	392.5	336.4	394.4	261.7	235.5	0.533	0.279	0.235	0.057	0.981	0.6	10
4	235.1	201.5	176.3	156.7	141.1	0.536	0.281	0.236	0.074	0.974	0.8	10
5	160.4	137.5	120.3	106.9	96.2	0.540	0.283	0.238	0.091	0.968	1.0	10
6	118.9	101.9	89.2	79.3	71.3	0.543	0.285	0.239	0.107	0.962	1.2	10
7	93.4	80.0	70.0	62.2	56.0	0.547	0.286	0.241	0.123	0.956	1.4	10
8	76.5	65.6	57.4	51.0	45.9	0.550	0.288	0.242	0.138	0.950	1.6	10
9	64.9	55.6	48.6	43.2	38.9	0.554	0.290	0.244	0.153	0.944	1.8	10
10	56.5	48.4	42.4	37.6	33.9	0.558	0.292	0.245	0.167	0.938	2.0	10
11	50.3	43.1	37.7	33.5	30.2	0.561	0.294	0.247	0.180	0.931	2.2	10
12	45.5	39.0	34.1	30.3	27.3	0.565	0.296	0.249	0.194	0.925	2.4	10
13	41.7	35.8	31.3	27.8	25.0	0.569	0.298	0.250	0.206	0.919	2.6	10
14	38.7	33.1	29.0	25.8	23.2	0.573	0.300	0.252	0.219	0.913	2.8	10
15	36.1	31.0	27.1	24.1	21.7	0.577	0.302	0.254	0.231	0.907	3.0	10
16	33.7	28.8	25.2	22.4	20.2	0.582	0.305	0.256	0.250	0.899	3.0	9
17	31.2	26.7	23.4	20.8	18.7	0.588	0.308	0.259	0.273	0.890	3.0	8
18	28.7	24.6	21.5	19.1	17.2	0.595	0.312	0.262	0.300	0.879	3.0	7
19	26.2	22.5	19.7	17.5	15.7	0.604	0.317	0.266	0.333	0.865	3.0	6
20	23.8	20.4	17.8	15.9	14.3	0.616	0.323	0.271	0.375	0.848	3.0	5
21	21.4	18.3	16.0	14.2	12.8	0.632	0.331	0.278	0.429	0.827	3.0	4
22	19.0	16.3	14.2	12.6	11.4	0.655	0.343	0.288	0.500	0.798	3.0	3
23	17.0	14.6	12.8	11.4	10.2	0.683	0.358	0.301	0.580	0.765	3.0	2.174
24	16.3	13.9	12.2	10.8	9.8	0.698	0.366	0.307	0.622	0.748	3.0	1.826
25	14.4	12.3	10.8	9.6	8.6	0.754	0.395	0.332	0.758	0.693	3.0	0.956

AÇIKLAMALAR

- N_u eksenel kuvvet; çekme (+), basınç (-) olarak alınacaktır.
- f_{yk} çelik akma sınırı; S220, S420, S500 çelik kalitelere göre sırasıyla 2.2, 4.2 ve 5.0 t/cm² alınmıştır.
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- Altı çizgili k_s değerleri dengeli kesitin yaklaşık 0.85' i kadar donatı için sınırı belirtmektedir.
- Malzeme katsayıları $\gamma_{mc}=1.50$, $\gamma_{ms}=1.15$ ve çeliğin elastisite modülü $E_s=2 \times 10^5$ N/mm² alınmıştır.
- Beton kalitesi C14 olan mevcut yapıların gerektiğinde kontrol edilebilmesi için, yönetmelikte bulunmamasına karşın, tabloya bu beton sınıfı ile ilgili değerler de eklenmiştir.

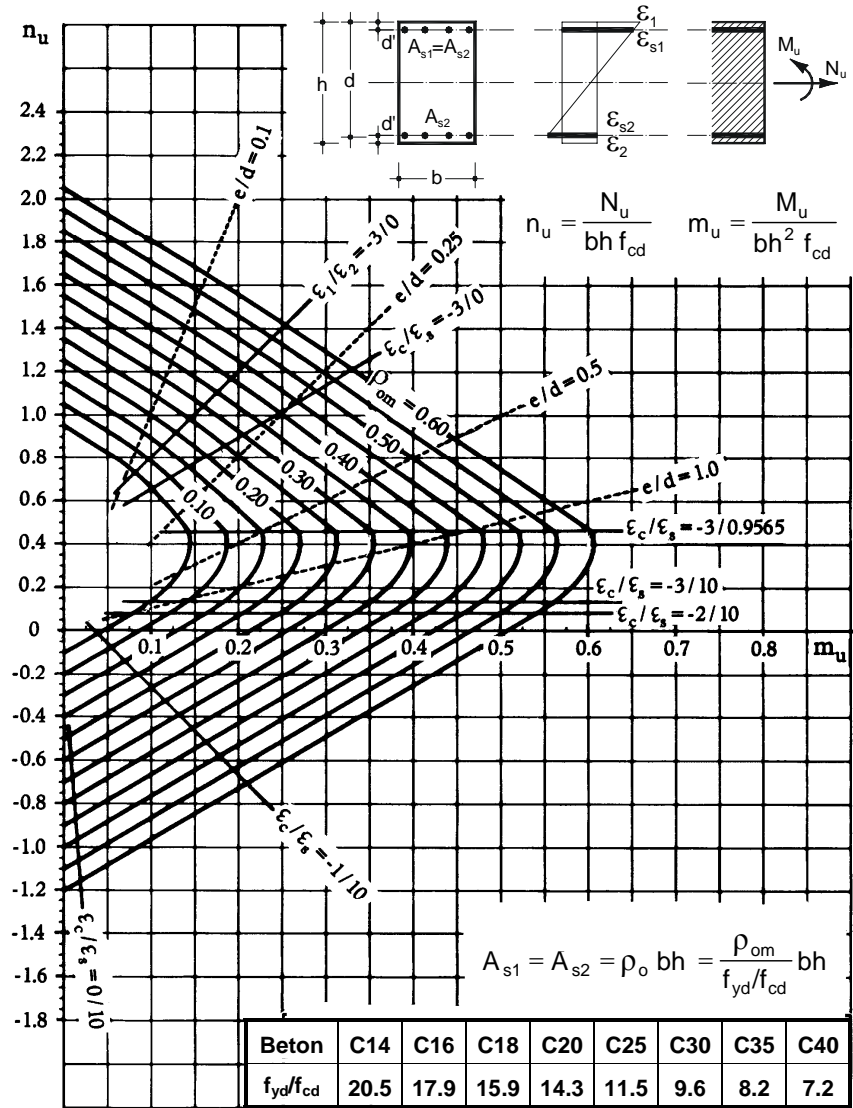
S220 [$f_{yk} = 2200 \text{ kgf/cm}^2$]

$\xi_1 = d' / h = 0.05$



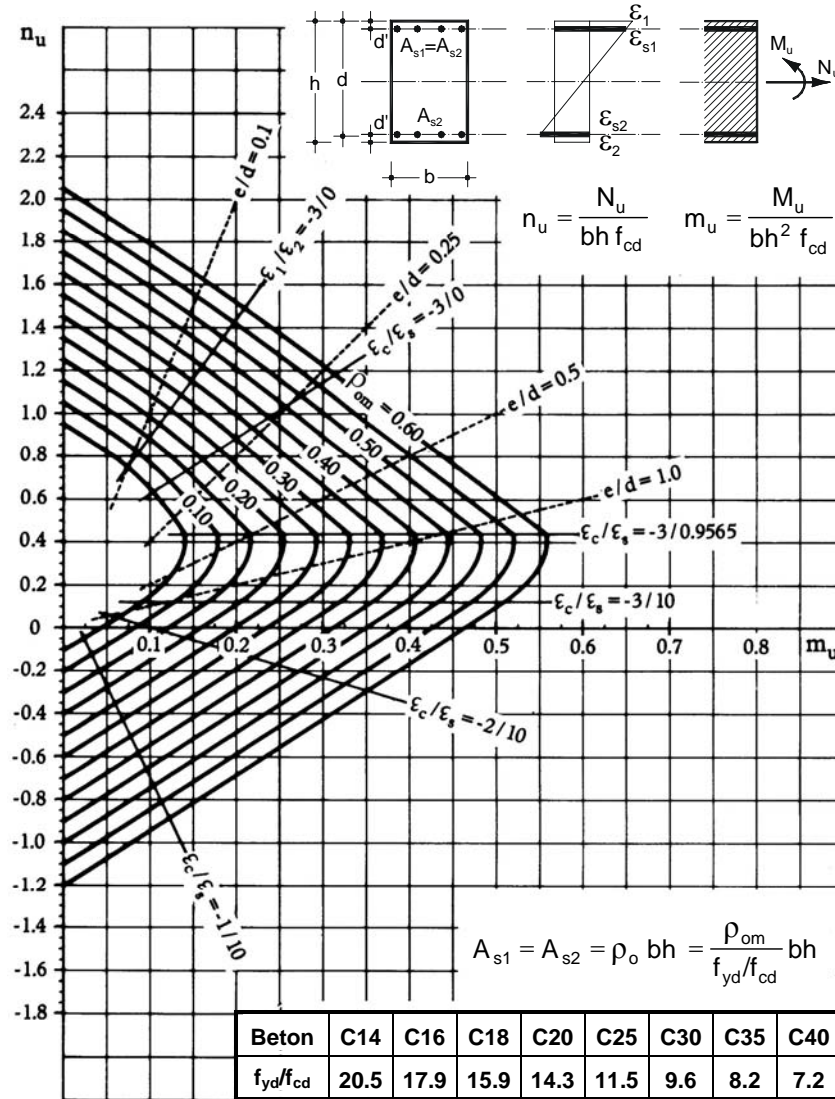
S220 [$f_{yk} = 2200 \text{ kgf/cm}^2$]

$\xi_1 = d' / h = 0.08$



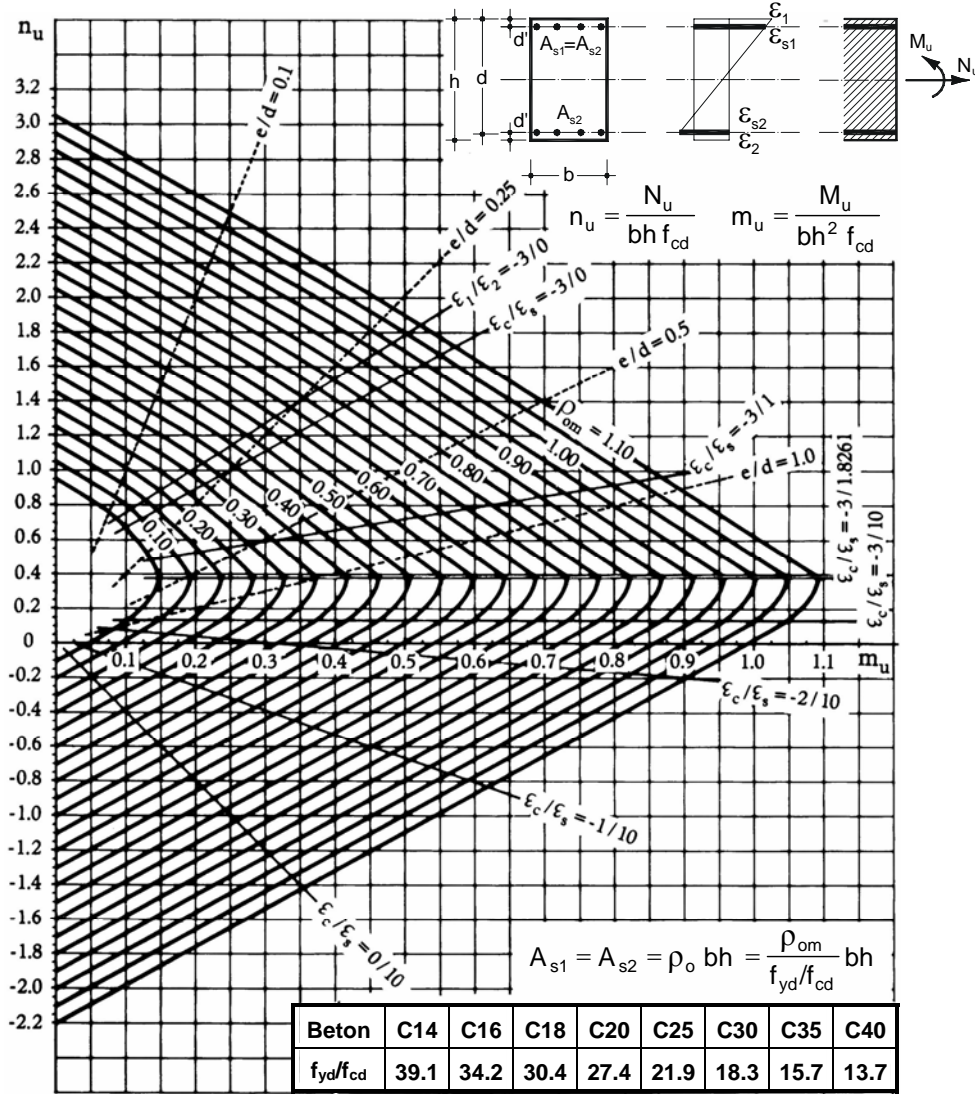
S220 [$f_{yk} = 2200 \text{ kgf/cm}^2$]

$\xi_1 = d' / h = 0.12$



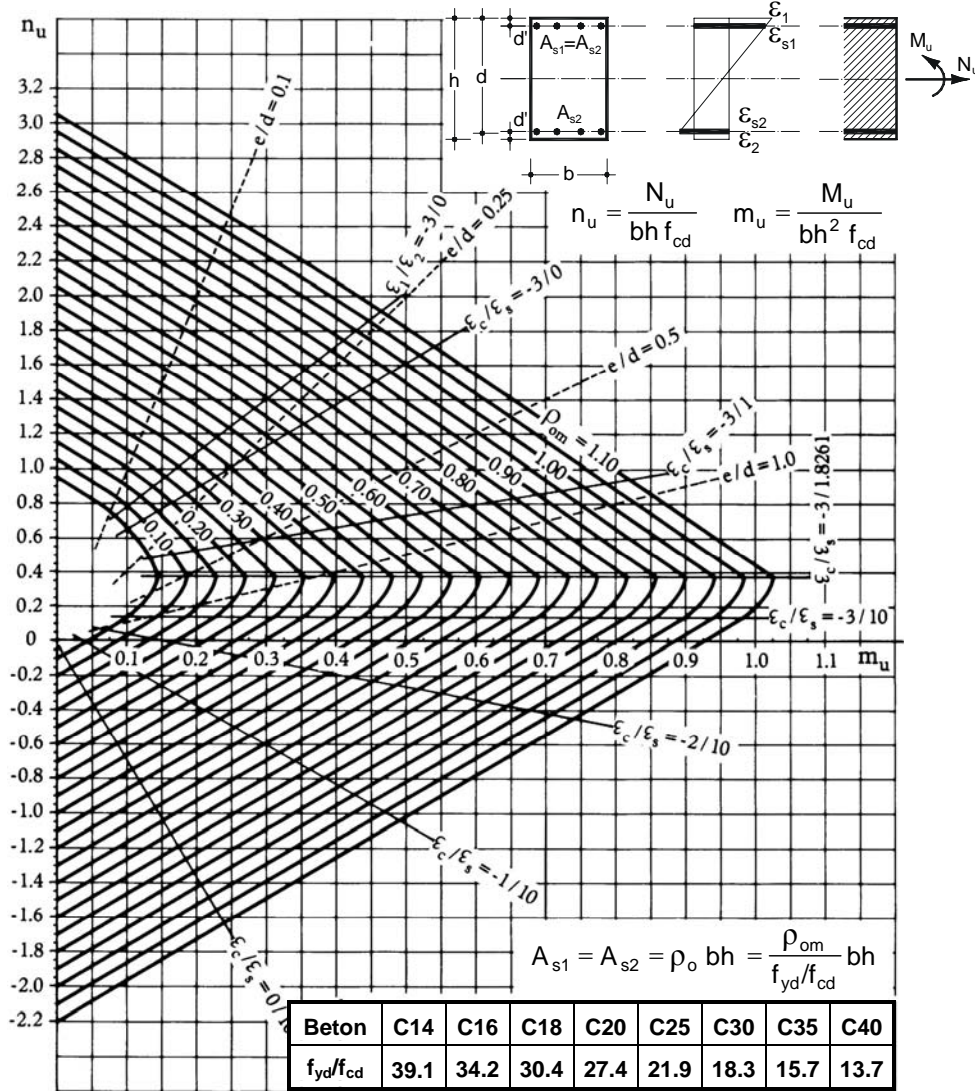
S420 [$f_{yk} = 4200 \text{ kgf/cm}^2$]

$\xi_1 = d' / h = 0.05$



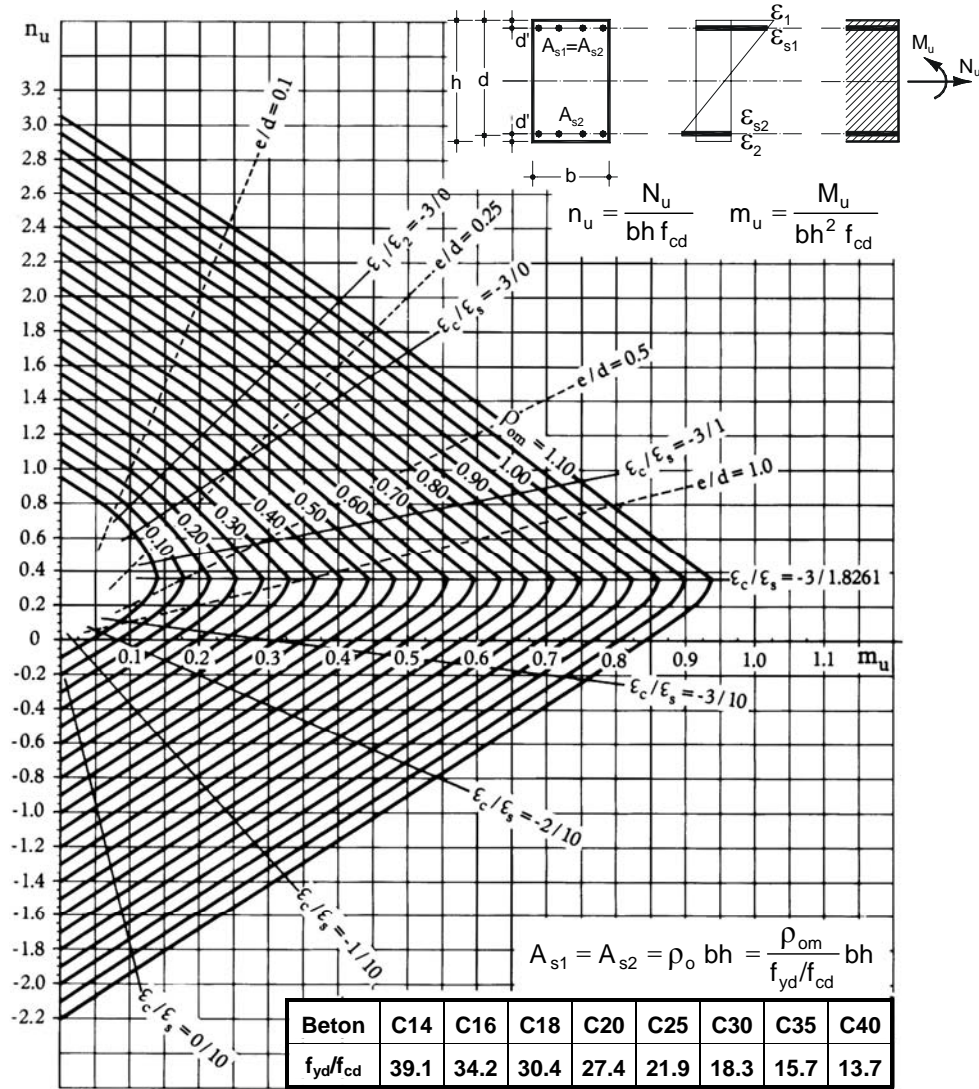
S420 [$f_{yk} = 4200 \text{ kgf/cm}^2$]

$\xi_1 = d' / h = 0.08$



S420 [$f_{yk} = 4200 \text{ kgf/cm}^2$]

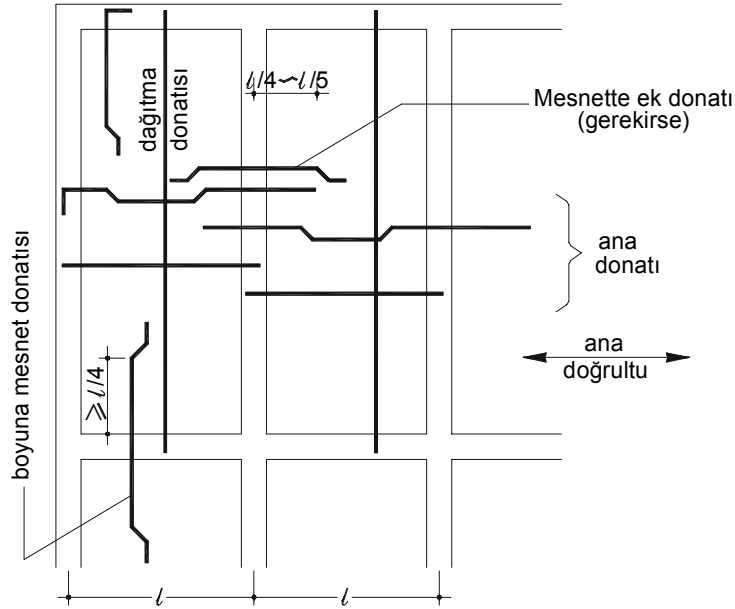
$\xi_1 = d' / h = 0.12$



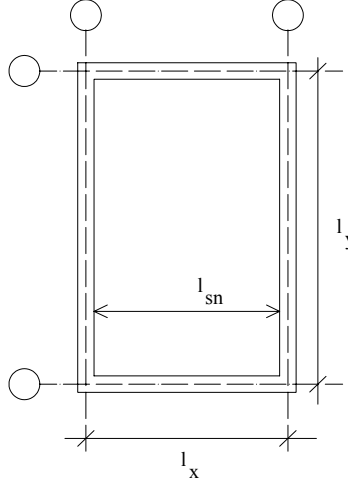
Döşemelerde 100 cm genişlik için donatı enkesit alanları [cm²]

t [cm]	Çap [mm]								
	8	10	12	14	16	18	20	22	24
7.0	7.18	11.22	16.16	21.99	28.73	36.36	44.87	54.30	64.63
7.5	6.70	10.47	15.08	20.52	26.81	33.93	41.88	50.81	60.32
8.0	6.28	9.82	14.14	19.24	25.14	31.81	39.26	47.51	56.55
8.5	5.91	9.24	13.31	18.11	23.66	29.94	36.95	44.72	53.22
9.0	5.59	8.73	12.57	17.10	22.34	28.28	34.90	42.23	50.27
9.5	5.29	8.27	11.90	16.20	21.17	26.79	33.06	40.01	47.62
10.0	5.03	7.85	11.31	15.39	20.11	25.45	31.41	38.01	45.24
10.5	4.79	8.48	10.77	14.66	19.15	24.24	29.91	36.20	43.09
11.0	4.57	7.14	10.28	13.99	18.28	23.14	28.55	34.55	41.13
11.5	4.37	6.83	9.84	13.39	17.49	22.13	27.31	33.05	39.34
12.0	4.19	6.54	9.42	12.83	16.76	21.21	26.17	31.67	37.70
12.5	4.02	6.28	9.05	12.32	16.09	20.36	25.13	30.41	36.19
13.0	3.87	6.04	8.70	11.84	15.47	19.58	24.16	29.24	34.80
13.5	3.72	5.82	8.38	11.40	14.90	18.85	23.27	28.16	33.51
14.0	3.59	5.61	8.08	11.00	14.38	18.18	22.44	27.15	32.31
14.5	3.47	5.42	7.80	10.62	13.87	17.55	21.66	26.21	31.20
15.0	3.35	5.24	7.54	10.26	13.41	16.97	20.94	25.34	30.16
15.5	3.24	5.07	7.30	9.93	12.97	16.42	20.27	24.52	29.19
16.0	3.14	4.91	7.07	9.62	12.57	15.90	19.64	23.76	28.28
16.5	3.05	4.76	6.85	9.33	12.19	15.42	19.04	23.04	27.41
17.0	2.96	4.62	6.65	9.05	11.83	14.97	18.48	22.36	26.61
17.5	2.87	4.49	6.46	8.79	11.49	14.54	17.95	21.72	25.85
18.0	2.79	4.36	6.28	8.55	11.17	14.14	17.46	21.12	25.13
18.5	2.72	4.25	6.11	8.32	10.87	13.76	16.94	20.55	24.45
19.0	2.65	4.13	5.95	8.10	10.58	13.39	16.54	20.01	23.81
19.5	2.58	4.03	5.80	7.89	10.31	13.05	16.11	19.49	23.20
20.0	2.51	3.93	5.65	7.69	10.05	12.72	15.72	19.01	22.62

TEK DOĞRULTUDA ÇALIŞAN PLAKLARDA DONATININ YERLEŞTİRİLMESİ



ÇİFT DOĞRULTUDA ÇALIŞAN DÖŞEMELER



Dört kenarından oturan çift doğrultuda donatılı dikdörtgen plakların α moment katsayıları

Plakın Mesnetlenme Biçimi ve Momentin Yeri	[Kısa açıklık] ε								Uzun Açıklık Her ε
	1.00	1.10	1.20	1.30	1.40	1.50	1.75	2.00	
Dört kenar sürekli									
Sürekli kenarda Negatif M	0.033	0.040	0.045	0.050	0.054	0.059	0.071	0.083	0.033
Açıklık ortasında Pozitif M	0.025	0.030	0.034	0.038	0.041	0.045	0.053	0.062	0.025
Bir kenar süreksiz									
Sürekli kenarda Negatif M	0.042	0.047	0.053	0.057	0.061	0.065	0.075	0.085	0.041
Açıklık ortasında Pozitif M	0.031	0.035	0.040	0.043	0.046	0.049	0.056	0.064	0.031
İki komşu kenar süreksiz									
Sürekli kenarda Negatif M	0.049	0.056	0.062	0.066	0.070	0.073	0.082	0.090	0.049
Açıklık ortasında Pozitif M	0.037	0.042	0.047	0.050	0.053	0.055	0.062	0.068	0.037
İki kısa kenar süreksiz									
Sürekli kenarda Negatif M	0.056	0.061	0.065	0.069	0.071	0.073	0.077	0.080	–
Açıklık ortasında Pozitif M	0.044	0.046	0.049	0.051	0.053	0.055	0.058	0.060	0.044
İki uzun kenar süreksiz									
Sürekli kenarda Negatif M	–	–	–	–	–	–	–	–	0.056
Açıklık ortasında Pozitif M	0.044	0.053	0.060	0.065	0.068	0.071	0.077	0.080	0.044
Üç kenar süreksiz									
Sürekli kenarda Negatif M	0.058	0.065	0.071	0.077	0.081	0.085	0.092	0.098	0.058
Açıklık ortasında Pozitif M	0.044	0.049	0.054	0.058	0.061	0.064	0.069	0.074	0.044
Dört kenar süreksiz									
Açıklık ortasında Pozitif M	0.050	0.057	0.062	0.067	0.071	0.075	0.081	0.083	0.050

$$M_d = \alpha p_d l_{sn}^2$$

$$\varepsilon = l_y/l_x$$

$$\text{Minimum plak kalınlığı kontrolü: } h_f \geq \frac{l_{sn}}{15 + \frac{20}{\varepsilon}} \left(1 - \frac{\alpha_s}{4} \right)$$