Pontifícia Universidade Católica do Rio Grande do Sul

FENGPUC RS

Faculdade de Engenharia

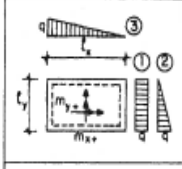
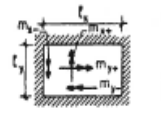
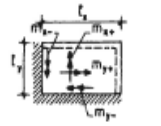
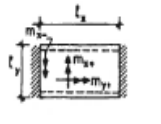
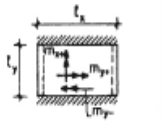
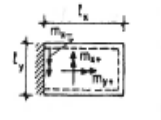
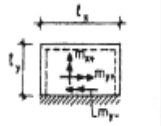
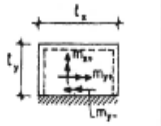
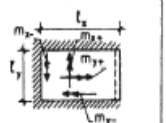
Engenharia Civil e Arquitetura

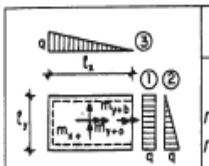
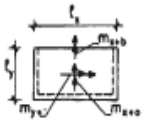
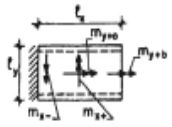
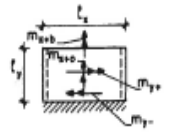
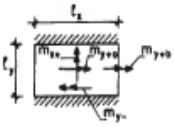
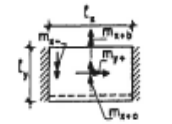
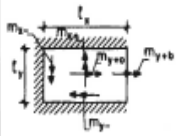
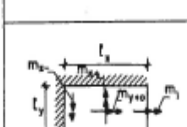
ESTRUTURAS DE CONCRETO ARMADO

TABELAS DE APOIO

Prof. Eduardo Giugliani

1) CÁLCULO DE SOLICITAÇÕES DE LAJES – 01
(MOMENTO FLETOR)

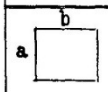
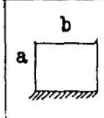
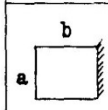
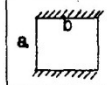
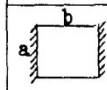
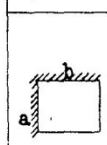
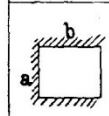
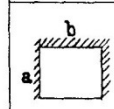
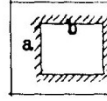
		CARGA UNIFORME ①						CARGA TRIANGULAR ②						CARGA TRIANGULAR ③					
	l_y/l_x	0,5	0,6	0,7	0,8	0,9	1	0,5	0,6	0,7	0,8	0,9	1	0,5	0,6	0,7	0,8	0,9	1
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	119	102	85	71	58	48	59	51	43	35	29	24	64	53	44	36	30	24
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	99	86	73	61	51	42	51	45	39	34	29	24	54	45	38	31	26	22
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	32	37	40	42	43	42	16	19	20	21	22	22	28	28	28	27	26	24
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	30	28	25	22	18	15	15	14	13	11	9	8	16	14	13	11	10	8
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	41	38	34	29	25	21	21	19	17	16	14	12	24	21	18	15	13	11
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	10	13	17	18	20	21	8	8	9	10	10	11	13	13	12	12	12	12
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	84	80	74	67	59	52	50	48	45	41	37	33	50	47	42	36	32	27
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	58	58	58	57	55	52	30	30	30	29	29	27	45	43	41	39	36	33
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	55	49	43	36	30	25	26	23	20	17	15	12	28	25	22	18	14	12
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	57	52	45	39	33	27	27	24	21	18	14	12	30	27	23	19	15	12
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	16	20	24	26	27	27	8	9	10	11	11	12	13	13	13	13	13	12
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	119	111	101	91	80	70	64	60	57	52	47	42	65	57	50	44	37	33
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	82	82	80	78	74	70	37	37	37	36	34	33	62	58	54	50	46	42
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	99	76	57	42	31	23	50	38	28	21	16	12	50	38	28	21	16	12
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	84	65	49	37	27	20	45	36	28	23	19	15	43	33	25	19	14	11
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	36	38	39	37	34	31	18	20	20	19	18	17	23	22	22	21	19	16
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	119	111	102	91	80	70	62	57	53	48	43	38	84	75	68	58	51	44
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	30	30	29	28	25	23	16	15	14	14	13	12	20	17	16	15	14	12
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	42	41	39	37	34	31	22	21	20	19	18	16	26	25	23	21	19	17
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	8	10	13	16	18	20	7	8	9	10	10	11	12	14	15	16	16	15
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	84	83	82	78	74	70	52	51	50	48	46	44	58	52	48	44	41	38
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	109	88	70	55	42	33							52	42	33	26	20	15
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	91	75	60	48	37	30							45	37	29	23	18	14
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	34	38	40	39	38	36							24	23	22	20	19	18
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	122	117	110	102	93	84							84	77	69	62	55	50
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	58	53	49	43	37	33	26	24	22	20	18	15						
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	60	56	51	46	40	36	28	27	25	22	20	18						
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	15	19	23	26	28	30	10	11	12	13	13	14						
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	122	116	109	101	93	84	66	63	60	56	53	50						
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	29	29	27	24	21	19							18	14	13	12	10	9
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	42	40	37	33	29	26							24	21	19	16	14	12
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	9	12	15	18	19	21							13	13	12	12	12	11
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	85	83	79	74	68	62							50	46	42	37	33	29
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	56	57	58	58	57	55							45	43	41	39	36	34
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	53	45	38	30	24	19	24	21	17	14	11	9						
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	55	48	40	33	26	21	26	23	20	16	14	11						
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	18	23	25	27	26	26	10	11	12	13	13	12						
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	114	102	91	88	66	55	62	57	51	45	39	34						
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	82	81	78	74	68	62	36	36	35	33	31	29						

	l_y/l_x	CARGA UNIFORME ①						CARGA TRIANGULAR ②						CARGA TRIANGULAR ③					
		0,5	0,6	0,7	0,8	0,9	1	0,5	0,6	0,7	0,8	0,9	1	0,5	0,6	0,7	0,8	0,9	1
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	160	157	153	148	143	136							64	56	50	46	42	40
	$m_{y+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	112	105	98	91	84	77							52	48	43	39	35	31
	$m_{x+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	132	129	126	122	117	111							28	30	32	34	34	33
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	26	28	30	31	31	31							15	16	17	18	18	18
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	1150	690	440	277	194	136	380	220	138	88	58	40						
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	83	69	56	46	38	31	44	37	31	26	22	18						
	$m_{x+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	137	123	109	96	87	77	51	49	43	39	35	31						
	$m_{x+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	230	202	173	144	128	111	76	65	56	47	39	33						
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	160	155	148	139	129	118							56	47	40	36	33	31
	$m_{y+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	103	92	82	72	63	54							47	40	33	28	24	20
	$m_{y+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	131	127	121	113	105	96							27	28	29	29	28	26
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	28	28	28	27	25	23							16	17	17	16	15	14
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	125	124	123	122	121	119							85	79	73	67	62	58
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	600	430	310	225	162	118	163	120	84	60	43	31						
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	−6	11	19	23	23	23	9	13	15	15	15	14						
	$m_{x+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	43	50	55	58	56	54	14	18	20	21	21	20						
	$m_{x+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	115	121	121	115	106	96	31	34	33	32	29	26						
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	310	250	207	170	142	119	116	100	87	75	66	58						
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	34	34	34	33	33	33							15	15	14	14	13	13
	$m_{y+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	42	42	41	39	38	37							21	21	20	19	18	17
	$m_{y+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	45	45	45	45	45	45							5	6	7	8	9	10
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	8	9	10	11	12	13							5	6	7	8	8	9
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	85	85	85	85	85	85							43	42	41	40	39	37
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	460	230	130	78	49	33	141	73	40	26	18	13						
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	52	40	30	23	17	13	36	26	20	15	12	9						
	$m_{x+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	93	75	61	50	43	37	36	31	26	23	20	17						
	$m_{x+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	144	112	87	69	55	45	46	33	25	18	14	10						
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	340	240	175	133	105	85	92	73	60	51	43	37						
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	34	34	34	33	33	33							15	15	14	13	11	10
	$m_{y+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	41	39	36	33	31	29							20	18	17	16	14	13
	$m_{y+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	45	45	45	45	44	44							5	6	7	8	9	10
	$m_{x+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	9	10	11	13	13	13							5	6	8	9	9	10
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	85	85	85	85	85	85							42	40	38	36	33	30
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	56	56	56	56	56	56							45	43	41	39	37	35
	$w = 0{,}001 \cdot q \cdot l_x^4 / Eh^3 \cdot$	340	200	121	76	49	33	83	52	30	20	14	10						
	$m_{y+} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	14	20	19	18	16	13	8	12	13	13	11	10						
	$m_{x+o} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	48	50	45	39	34	29	16	17	17	17	15	13						
	$m_{x+b} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	107	93	79	65	53	44	28	23	19	16	13	10						
	$m_{y-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	200	148	111	87	69	56	92	73	57	46	39	35						
	$m_{x-} = 0{,}001 \cdot q \cdot l_y^2 \cdot$	285	220	170	132	105	85	64	46	42	38	34	30						

3) CÁLCULO DE REAÇÃO EM LAJES

$K = q.a.b$ $\quad R_a = v_a.K/a$ $\quad R_b = v_b.K/b$

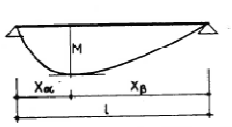
Valores de $1000v_a$ e $1000v_b$

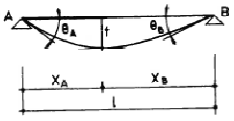
	b/a	1,00	1,05	1,10	1,15	1,20	1,25	1,30	1,35	1,40	1,45	1,50	1,55	1,60	1,80	2,00
	v_a	250	238	227	217	208	200	192	185	179	173	167	161	156	139	125
	v_b	250	262	273	283	292	300	308	315	321	327	333	339	344	361	375
	v_a	183	175	167	160	153	147	141	136	131	126	122	118	115	102	092
	v_{be}	402	412	422	431	440	447	455	461	468	474	479	484	488	504	517
	v_{br}	232	238	244	249	254	259	263	267	270	274	277	280	282	292	299
	v_{ae}	402	388	378	366	355	342	331	320	310	300	289	280	272	241	217
	v_{ar}	232	226	218	212	205	198	191	184	179	173	167	161	156	139	125
	v_b	183	193	202	211	220	230	239	248	256	264	272	280	286	310	329
	v_a	144	137	131	125	120	115	111	107	103	099	096	093	090	080	072
	v_b	356	363	369	375	380	385	389	393	397	401	404	407	410	420	428
	v_a	356	349	341	334	327	320	312	304	297	290	283	275	267	241	217
	v_b	144	151	159	165	173	180	188	196	203	210	217	225	233	259	283
	v_{ae}	317	302	288	276	264	254	244	235	227	219	211	204	198	176	159
	v_{ar}	183	175	167	160	153	147	141	136	131	126	122	118	115	102	091
	v_{be}	317	332	347	359	371	381	391	400	408	416	424	431	437	459	476
	v_{br}	183	191	198	205	212	218	224	229	234	239	243	247	250	263	274
	v_{ae}	250	237	227	217	208	200	192	185	179	173	165	161	156	138	125
	v_{ar}	144	137	131	125	120	114	110	107	103	099	096	093	090	080	071
	v_b	303	313	321	329	335	343	349	354	359	364	368	373	377	391	402
	v_a	304	294	284	274	264	254	244	235	227	219	211	204	198	176	159
	v_{be}	250	263	275	288	301	314	327	339	350	360	370	378	387	416	437
	v_{br}	142	149	157	164	171	178	185	191	196	202	208	214	217	232	245
	v_a	250	238	227	217	208	200	192	185	179	173	167	161	156	139	125
	v_b	250	262	273	283	292	300	308	315	321	327	333	339	344	351	375

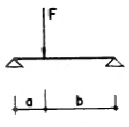
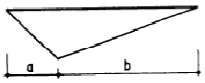
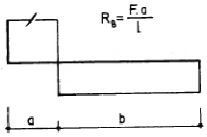
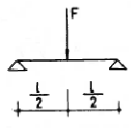
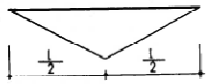
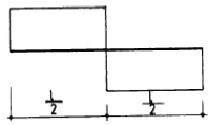
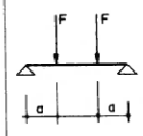
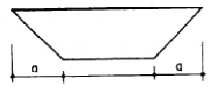
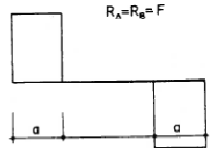
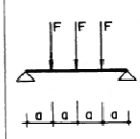
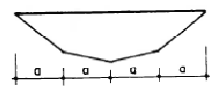
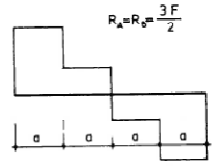
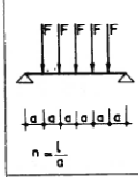
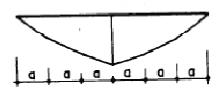
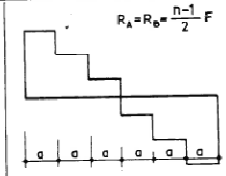
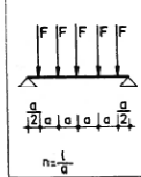
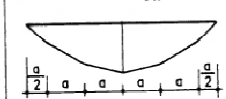
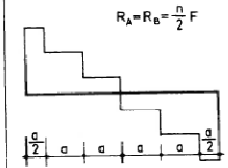
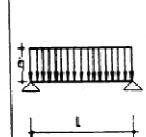
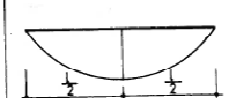
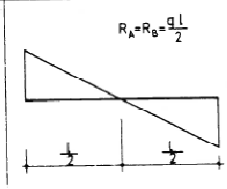
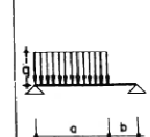
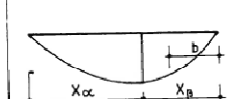
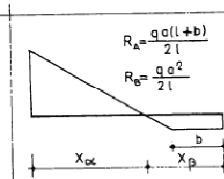
Valores tirados da obra: "Vigas Contínuas, Pórticos y Placas" - J. Hahn

4) CÁLCULO DE SOLICITAÇÃO DE VIGAS – 01
(MOMENTO FLETOR E REAÇÃO)

F, q y segmentos en valor absoluto.

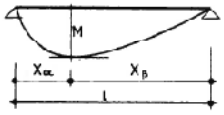


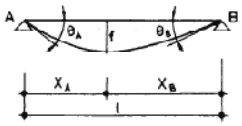


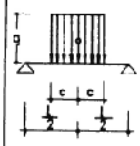
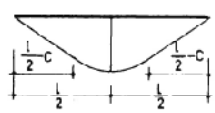
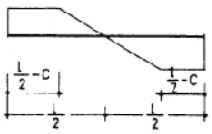
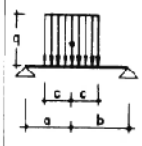
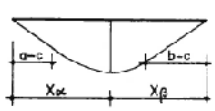
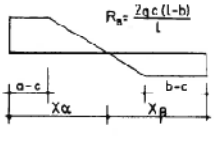
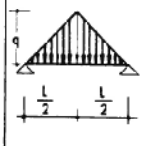
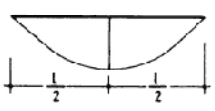
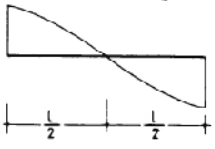
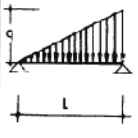
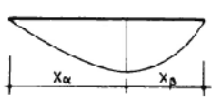
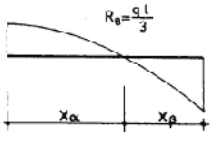
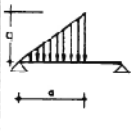
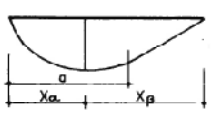
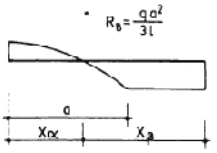
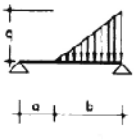
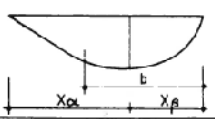
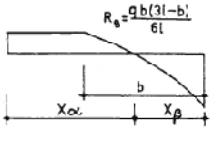
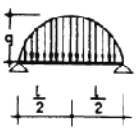
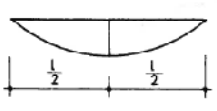
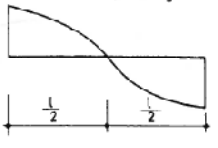
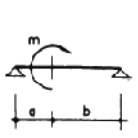
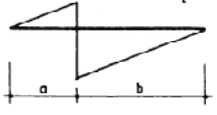
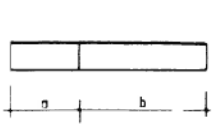
SOLICITACION	DIAGRAMA DE MOMENTOS FLECTORES MOMENTO MAXIMO	DIAGRAMA DE ESFUERZOS CORTANTES REACCIONES EN APOYOS	FLECHAS MAXIMAS ANGULOS DE GIRO EXTREMOS
	$M=\frac{Fab}{l}$ 	$R_A=\frac{F.b}{l}$ $R_B=\frac{F.a}{l}$ 	$a<b$ „ $x_B=\left[\frac{b(l+a)}{3}\right]^{\frac{1}{2}}$ „ $f=\frac{F.a}{3lEI}\left[\frac{b(l+a)}{3}\right]^{\frac{3}{2}}$ $a>b$ „ $x_A=\left[\frac{a(l+b)}{3}\right]^{\frac{1}{2}}$ „ $f=\frac{F.b}{3lEI}\left[\frac{a(l+b)}{3}\right]^{\frac{3}{2}}$ $\theta_A=\frac{Fab(l+b)}{6lEI}$ „ $\theta_B=\frac{Fab(l+a)}{6lEI}$
	$M=\frac{Fl}{4}$ 	$R_A=R_B=\frac{F}{2}$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{Fl^3}{48EI}$ „ $\theta_A=\theta_B=\frac{Fl^2}{16EI}$
	$M=Fa$ 	$R_A=R_B=F$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{Fa}{24EI}(3l^2-4a^2)$ $\theta_A=\theta_B=\frac{Fa(l-a)}{2EI}$
	$M=\frac{Fl}{2}$ 	$R_A=R_B=\frac{3F}{2}$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{19}{384}\cdot\frac{F}{EI}\cdot l^3$ $\theta_A=\theta_B=\frac{5Fl^2}{32EI}$
 $n=\frac{l}{a}$	$n=2k$ „ $M=\frac{n}{8}Fl$ $n=2k+1$ „ $M=\frac{n^2-1}{8n}Fl$ 	$R_A=R_B=\frac{n-1}{2}F$ 	$x_A=x_B=\frac{l}{2}\begin{cases} n=2k \text{ „ } f=\frac{5n^2-4}{384n}\cdot\frac{Fl^3}{EI} \\ n=2k+1 \text{ „ } f=\frac{(5n^2+1)(n^2-1)}{384n^3}\cdot\frac{Fl^3}{EI} \end{cases}$ $\theta_A=\theta_B=\frac{n^2-1}{24n}\cdot\frac{Fl^2}{EI}$
 $n=\frac{l}{a}$	$n=2k$ „ $M=\frac{n}{8}Fl$ $n=2k+1$ „ $M=\frac{n^2+1}{8n}Fl$ 	$R_A=R_B=\frac{n}{2}F$ 	$x_A=x_B=\frac{l}{2}\begin{cases} n=2k \text{ „ } f=\frac{-n^4+6n^2+2n^2+4n-4}{384n^2}\cdot\frac{Fl^3}{EI} \\ n=2k+1 \text{ „ } f=\frac{5n^4+2n^2+1}{384n^3}\cdot\frac{Fl^3}{EI} \end{cases}$ $\theta_A=\theta_B=\frac{2n^2+1}{48n}\cdot\frac{Fl^2}{EI}$
	$M=\frac{1}{8}ql^2$ 	$R_A=R_B=\frac{ql}{2}$ 	$x_A=x_B=\frac{l}{2}$ „ $f=\frac{5}{384}\frac{ql^4}{EI}$ $\theta_A=\theta_B=\frac{ql^3}{24EI}$
	$x_\alpha=\frac{a(l+b)}{2l}$ „ $M=\frac{qa^2(l+b)^2}{8l^2}$ 	$R_A=\frac{qa(l+b)}{2l}$ $R_B=\frac{qa^2}{2l}$ 	$a<0'4531.l$ „ $x_B=\left[\frac{2l^2-a^2}{6}\right]^{\frac{1}{2}}$ „ $f=\frac{qa^2}{6}\left[\frac{2l^2-a^2}{6}\right]^{\frac{3}{2}}$ $a>0'4531.l$ „ $x_B=\frac{58'575.l-8'575.a}{100}$ „ $f=\frac{ql^4}{10^3EI}(13'5734\frac{a}{l}-0'5526)$ $\theta_A=\frac{qal}{24EI}(2-\frac{a}{l})^2$ „ $\theta_B=\frac{qal}{24EI}(2-\frac{a^2}{l^2})$

5) CÁLCULO DE SOLICITAÇÃO DE VIGAS – 02
(MOMENTO FLETOR E REAÇÃO)

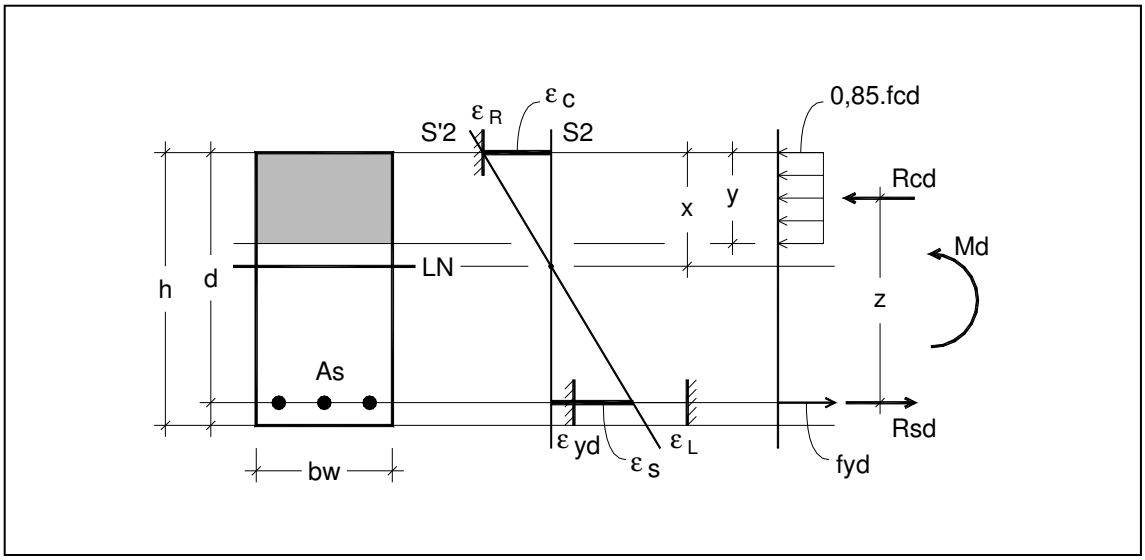
q y segmentos en valor absoluto





SOLICITACION	DIAGRAMA DE MOMENTOS FLECTORES MOMENTO MAXIMO	DIAGRAMA DE ESFUERZOS CORTANTES REACCIONES EN APOYOS	FLECHAS MAXIMAS ANGULOS DE GIRO EXTREMOS
	$M=\frac{qc(l-c)}{2}$ 	$R_A=R_B=qc$ 	$x_A=x_B=\frac{l}{2}$; $f=\frac{qcl^3}{24EI}\left[1-\frac{c^2}{l^2}\left(2-\frac{c}{l}\right)\right]$ $\theta_A=\theta_B=\frac{qcl^2}{24EI}\left(3-4\frac{c^2}{l^2}\right)$
	$X_\alpha=a+c-\frac{2ac}{l}$; $M=2qac\left(\frac{b-c}{l}+\frac{ac}{l^2}\right)$ 	$R_A=\frac{2qc(l-a)}{l}$ $R_B=\frac{2qc(l-b)}{l}$ 	$\theta_A=\frac{qbcl}{3EI}\left(1-\frac{b^2}{l^2}-\frac{c^2}{l^2}\right)$; $\theta_B=\frac{qacl}{3EI}\left(1-\frac{a^2}{l^2}-\frac{c^2}{l^2}\right)$
	$M=\frac{ql^2}{12}$ 	$R_A=R_B=\frac{ql}{4}$ 	$x_A=x_B=\frac{l}{2}$; $f=\frac{ql^4}{120EI}$ $\theta_A=\theta_B=\frac{5ql^3}{196EI}$
	$x_\alpha=\frac{l}{\sqrt{3}}$ $M=\frac{ql^2}{9\sqrt{3}}$ 	$R_A=\frac{ql}{6}$ $R_B=\frac{ql}{3}$ 	$x_A=0'5193\,l$; $f=\frac{6'522}{10^3}\frac{ql^4}{EI}$ $\theta_A=\frac{7ql^3}{360EI}$; $\theta_B=\frac{ql^3}{45EI}$
	$x_\alpha=a\left[\frac{3L-2a}{3L}\right]^{\frac{1}{2}}$; $M=\frac{qa^2}{3}\left[\frac{3L-2a}{3L}\right]^{\frac{3}{2}}$ 	$R_A=\frac{qc(3L-2a)}{5l}$ $R_B=\frac{qa^2}{3l}$ 	$a<0'4607\,l$; $x_B=\left[\frac{5l^2-3a^2}{15}\right]^{\frac{1}{2}}$; $f=\frac{3a^2}{9EIl}\left[\frac{5l^2-3a^2}{15}\right]^{\frac{3}{2}}$ $a>0'4607\,l$; $x_A=(1'593\frac{a}{l}-1'0737)\,l$; $f=\frac{ql^4}{10^3EI}(4'117+2'405\frac{a}{l})$ $\theta_A=\frac{(12a^2-45al+40l^2)qa^2}{360EIl}$; $\theta_B=\frac{(5l^2-3a^2)qa^2}{90EIl}$
	$x_\beta=b(1-\sqrt{\frac{b}{3l}})$; $M=\frac{qb^2}{6}\left[\frac{a}{l}+2\left(\frac{b}{3l}\right)^{\frac{3}{2}}\right]$ 	$R_A=\frac{qb^2}{6l}$ $R_B=\frac{qb(3l-b)}{6l}$ 	$b<0'4396\,l$; $x_A=\left[\frac{10l^2-3b^2}{30}\right]^{\frac{1}{2}}$; $f=\frac{qb^2}{18EIl}\left[\frac{10l^2-3b^2}{30}\right]^{\frac{3}{2}}$ $b>0'4396\,l$; $x_A=(1'2527-0'7334\frac{b}{l})\,l$; $f=\frac{ql^4}{10^3EI}(8'267\frac{b}{l}-1'745)$ $\theta_A=\frac{(10l^2-3b^2)qb^2}{360EIl}$; $\theta_B=\frac{(20l^2-15bl+3b^2)qb^2}{360EIl}$
c. parabólica 	$M=\frac{5}{48}ql^2$ 	$R_A=R_B=\frac{ql}{3}$ 	$x_A=x_B=\frac{l}{2}$; $f=\frac{61}{5760}\frac{ql^4}{EI}$ $\theta_A=\theta_B=\frac{ql^3}{30EI}$
	$a<b$, $M=\frac{mb}{l}$ $a>b$, $M=\frac{ma}{l}$ 	$R_A=-R_B=\frac{m}{l}$ 	$a<b$, $x_A=l-\left[\frac{l^2-3a^2}{3}\right]^{\frac{1}{2}}$; $f=\frac{m}{3EIl}\left[\frac{l^2-3a^2}{3}\right]^{\frac{3}{2}}$ $b<a$, $x_B=l-\left[\frac{l^2-3b^2}{3}\right]^{\frac{1}{2}}$; $f=\frac{m}{3EIl}\left[\frac{l^2-3b^2}{3}\right]^{\frac{3}{2}}$ $\theta_A=\frac{m(l^2-3b^2)}{6EIl}$; $\theta_B=\frac{m(l^2-3a^2)}{6EIl}$

6) TABELA PARA O CÁLCULO DE ARMADURAS FLEXÃO SIMPLES (PROF. ALMIR SCHÄFFER)



kx	ky	kz	km
0.26	0.208	0.896	0.158
0.28	0.224	0.888	0.169
0.30	0.240	0.880	0.180
0.32	0.256	0.872	0.190
0.34	0.272	0.864	0.200
0.36	0.288	0.856	0.210
0.38	0.304	0.848	0.219
0.40	0.320	0.840	0.228
0.42	0.336	0.832	0.238
0.44	0.352	0.824	0.247
0.46	0.368	0.816	0.255
0.48	0.384	0.808	0.264
0.50	0.400	0.800	0.272
0.52	0.416	0.792	0.280
0.54	0.432	0.784	0.288
0.56	0.448	0.776	0.296
0.58	0.464	0.768	0.303
Limite para o aco CA-60			
0.60	0.480	0.760	0.310
0.62	0.496	0.752	0.317
Limite para o aco CA-50			
0.64	0.512	0.744	0.324
0.66	0.528	0.736	0.330
0.68	0.544	0.728	0.337
0.70	0.560	0.720	0.343
0.72	0.576	0.712	0.349
0.74	0.592	0.704	0.354
0.76	0.608	0.696	0.360
Limite para o aco CA-25			
0.78	0.624	0.688	0.365

$$x = k_x.d$$

$$y = k_y.d$$

$$z = k_z.d$$

$$k_m = \frac{M_d}{b_w.d^2.f_{cd}}$$

$$A_s = \frac{M_d}{z.f_{yd}}$$

7) TABELA PARA DETALHAMENTO DE ARMADURAS (LAJES E ESTRIBOS)

LAJES

cm^2 / metro

e	1 RAMO - BITOLA Ø (mm)					
(cm)	5.0	6.0	6.3	8.0	10.0	12.5
4,5	4,44	6,22	7,00	11,11	17,78	27,78
5,0	4,00	5,60	6,30	10,00	16,00	25,00
5,5	3,64	5,09	5,73	9,09	14,55	22,73
6,0	3,33	4,67	5,25	8,33	13,33	20,83
6,5	3,08	4,31	4,85	7,69	12,31	19,23
7,0	2,86	4,00	4,50	7,14	11,43	17,86
7,5	2,67	3,73	4,20	6,67	10,67	16,67
8,0	2,50	3,50	3,94	6,25	10,00	15,63
8,5	2,35	3,29	3,71	5,88	9,41	14,71
9,0	2,22	3,11	3,50	5,56	8,89	13,89
9,5	2,11	2,95	3,32	5,26	8,42	13,16
10,0	2,00	2,80	3,15	5,00	8,00	12,50
11,0	1,82	2,55	2,86	4,55	7,27	11,36
12,0	1,67	2,33	2,63	4,17	6,67	10,42
12,5	1,60	2,24	2,52	4,00	6,40	10,00
13,0	1,54	2,15	2,42	3,85	6,15	9,62
14,0	1,43	2,00	2,25	3,57	5,71	8,93
15,0	1,33	1,87	2,10	3,33	5,33	8,33
16,0	1,25	1,75	1,97	3,13	5,00	7,81
17,0	1,18	1,65	1,85	2,94	4,71	7,35
17,5	1,14	1,60	1,80	2,86	4,57	7,14
18,0	1,11	1,56	1,75	2,78	4,44	6,94
19,0	1,05	1,47	1,66	2,63	4,21	6,58
20,0	1,00	1,40	1,58	2,50	4,00	6,25
21,0	0,95	1,33	1,50	2,38	3,81	5,95
22,0	0,91	1,27	1,43	2,27	3,64	5,68
23,0	0,87	1,22	1,37	2,17	3,48	5,43
24,0	0,83	1,17	1,31	2,08	3,33	5,21
25,0	0,80	1,12	1,26	2,00	3,20	5,00

ESTRIBOS

cm^2 / metro

e	2 RAMOS - BITOLA Ø (mm)					
(cm)	5.0	6.0	6.3	8.0	10.0	12.5
4,5	8,89	12,44	14,00	22,22	35,56	55,56
5,0	8,00	11,20	12,60	20,00	32,00	50,00
5,5	7,27	10,18	11,45	18,18	29,09	45,45
6,0	6,67	9,33	10,50	16,67	26,67	41,67
6,5	6,15	8,62	9,69	15,38	24,62	38,46
7,0	5,71	8,00	9,00	14,29	22,86	35,71
7,5	5,33	7,47	8,40	13,33	21,33	33,33
8,0	5,00	7,00	7,88	12,50	20,00	31,25
8,5	4,71	6,59	7,41	11,76	18,82	29,41
9,0	4,44	6,22	7,00	11,11	17,78	27,78
9,5	4,21	5,89	6,63	10,53	16,84	26,32
10,0	4,00	5,60	6,30	10,00	16,00	25,00
11,0	3,64	5,09	5,73	9,09	14,55	22,73
12,0	3,33	4,67	5,25	8,33	13,33	20,83
12,5	3,20	4,48	5,04	8,00	12,80	20,00
13,0	3,08	4,31	4,85	7,69	12,31	19,23
14,0	2,86	4,00	4,50	7,14	11,43	17,86
15,0	2,67	3,73	4,20	6,67	10,67	16,67
16,0	2,50	3,50	3,94	6,25	10,00	15,63
17,0	2,35	3,29	3,71	5,88	9,41	14,71
17,5	2,29	3,20	3,60	5,71	9,14	14,29
18,0	2,22	3,11	3,50	5,56	8,89	13,89
19,0	2,11	2,95	3,32	5,26	8,42	13,16
20,0	2,00	2,80	3,15	5,00	8,00	12,50
21,0	1,90	2,67	3,00	4,76	7,62	11,90
22,0	1,82	2,55	2,86	4,55	7,27	11,36
23,0	1,74	2,43	2,74	4,35	6,96	10,87
24,0	1,67	2,33	2,63	4,17	6,67	10,42
25,0	1,60	2,24	2,52	4,00	6,40	10,00

Ø	NÚMERO DE BARRAS													
(mm)	1	2	3	4	5	6	7	8	9	10	11	12	13	14
5,0	0,20	0,40	0,60	0,80	1,00	1,20	1,40	1,60	1,80	2,00	2,20	2,40	2,60	2,80
6,0	0,28	0,56	0,84	1,12	1,40	1,68	1,96	2,24	2,52	2,80	3,08	3,36	3,64	3,92
6,3	0,315	0,63	0,945	1,26	1,575	1,89	2,205	2,52	2,835	3,15	3,465	3,78	4,095	4,41
8,0	0,50	1,00	1,50	2,00	2,50	3,00	3,50	4,00	4,50	5,00	5,50	6,00	6,50	7,00
10,0	0,80	1,60	2,40	3,20	4,00	4,80	5,60	6,40	7,20	8,00	8,80	9,60	10,40	11,20
12,5	1,25	2,50	3,75	5,00	6,25	7,50	8,75	10,00	11,25	12,50	13,75	15,00	16,25	17,50
16,0	2,00	4,00	6,00	8,00	10,00	12,00	14,00	16,00	18,00	20,00	22,00	24,00	26,00	28,00
20,0	3,15	6,30	9,45	12,60	15,75	18,90	22,05	25,20	28,35	31,50	34,65	37,80	40,95	44,10
25,0	5,00	10,00	15,00	20,00	25,00	30,00	35,00	40,00	45,00	50,00	55,00	60,00	65,00	70,00

8) TABELA PARA DETALHAMENTO DE ARMADURAS (LAJES - AMPLIADA) – cm²/m

e	1 RAMO - BITOLA Ø (mm)								
(cm)	5.0	6.0	6.3	8.0	10.0	12.5	16.0	20.0	25.0
4,5	4,44	6,22	7,00	11,11	17,78	27,78	44,44	70,00	111,11
5,0	4,00	5,60	6,30	10,00	16,00	25,00	40,00	63,00	100,00
5,5	3,64	5,09	5,73	9,09	14,55	22,73	36,36	57,27	90,91
6,0	3,33	4,67	5,25	8,33	13,33	20,83	33,33	52,50	83,33
6,5	3,08	4,31	4,85	7,69	12,31	19,23	30,77	48,46	76,92
7,0	2,86	4,00	4,50	7,14	11,43	17,86	28,57	45,00	71,43
7,5	2,67	3,73	4,20	6,67	10,67	16,67	26,67	42,00	66,67
8,0	2,50	3,50	3,94	6,25	10,00	15,63	25,00	39,38	62,50
8,5	2,35	3,29	3,71	5,88	9,41	14,71	23,53	37,06	58,82
9,0	2,22	3,11	3,50	5,56	8,89	13,89	22,22	35,00	55,56
9,5	2,11	2,95	3,32	5,26	8,42	13,16	21,05	33,16	52,63
10,0	2,00	2,80	3,15	5,00	8,00	12,50	20,00	31,50	50,00
11,0	1,82	2,55	2,86	4,55	7,27	11,36	18,18	28,64	45,45
12,0	1,67	2,33	2,63	4,17	6,67	10,42	16,67	26,25	41,67
12,5	1,60	2,24	2,52	4,00	6,40	10,00	16,00	25,20	40,00
13,0	1,54	2,15	2,42	3,85	6,15	9,62	15,38	24,23	38,46
14,0	1,43	2,00	2,25	3,57	5,71	8,93	14,29	22,50	35,71
15,0	1,33	1,87	2,10	3,33	5,33	8,33	13,33	21,00	33,33
16,0	1,25	1,75	1,97	3,13	5,00	7,81	12,50	19,69	31,25
17,0	1,18	1,65	1,85	2,94	4,71	7,35	11,76	18,53	29,41
17,5	1,14	1,60	1,80	2,86	4,57	7,14	11,43	18,00	28,57
18,0	1,11	1,56	1,75	2,78	4,44	6,94	11,11	17,50	27,78
19,0	1,05	1,47	1,66	2,63	4,21	6,58	10,53	16,58	26,32
20,0	1,00	1,40	1,58	2,50	4,00	6,25	10,00	15,75	25,00
21,0	0,95	1,33	1,50	2,38	3,81	5,95	9,52	15,00	23,81
22,0	0,91	1,27	1,43	2,27	3,64	5,68	9,09	14,32	22,73
23,0	0,87	1,22	1,37	2,17	3,48	5,43	8,70	13,70	21,74
24,0	0,83	1,17	1,31	2,08	3,33	5,21	8,33	13,13	20,83
25,0	0,80	1,12	1,26	2,00	3,20	5,00	8,00	12,60	20,00
26,0	0,77	1,08	1,21	1,92	3,08	4,81	7,69	12,12	19,23
27,0	0,74	1,04	1,17	1,85	2,96	4,63	7,41	11,67	18,52
28,0	0,71	1,00	1,13	1,79	2,86	4,46	7,14	11,25	17,86
29,0	0,69	0,97	1,09	1,72	2,76	4,31	6,90	10,86	17,24
30,0	0,67	0,93	1,05	1,67	2,67	4,17	6,67	10,50	16,67
31,0	0,65	0,90	1,02	1,61	2,58	4,03	6,45	10,16	16,13
32,0	0,63	0,88	0,98	1,56	2,50	3,91	6,25	9,84	15,63
33,0	0,61	0,85	0,95	1,52	2,42	3,79	6,06	9,55	15,15
34,0	0,59	0,82	0,93	1,47	2,35	3,68	5,88	9,26	14,71
35,0	0,57	0,80	0,90	1,43	2,29	3,57	5,71	9,00	14,29

9) TABELA PARA POSICIONAMENTO DE ARMADURAS (VIGAS)

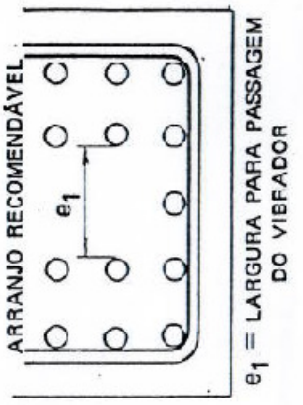
TABELA DC01.05

VALORES DE b_s (cm)

NÚMERO DE BARRAS	BITOLAS PADRONIZADAS (EB – 3/76)														
	DIÂMETRO MÁXIMO DO AGREGADO (d_{max})														
	12,5 mm					19,0 mm									
	BITOLA ϕ					BITOLA ϕ									
	10	12,5	16	20	22,2 (*)	25	10	12,5	16	20	22,2 (*)	25
2	5	6	7	8	9	10	6	6	7	8	9	10
3	8	9	11	12	14	15	9	10	11	13	14	15
4	11	12	14	16	18	20	12	13	15	17	18	20
5	14	16	18	20	22	25	15	17	19	21	23	25
6	17	19	21	24	27	30	19	20	23	25	27	30
7	20	22	25	28	31	35	22	24	27	30	32	35
8	23	25	29	32	36	40	25	27	30	34	36	40
9	26	29	32	36	40	45	29	31	34	38	41	45
10	29	32	36	40	44	50	32	34	38	43	45	50

(*) Bitola intermediária não especificada pela EB – 3/76

Observação: Para o cálculo desta tabela foram admitidos $\begin{cases} \phi_t \geq 6{,}3 \\ \phi_t \geq \phi/2 \end{cases}$



10) TABELA DE CONVERSÃO DE UNIDADES

TENDO	MULTIPLICAR POR →	OBTÉM
tf	10	**kN**
kgf	1/100	**kN**
kgf	10	**N**
kgf/cm²	1/10	**Mpa**
kgf/cm²	100	**kN/m²**
kgf/cm²	1/10	**MN/m²**
kgf/cm²	10	**N/cm²**
kgf/cm²	1/100	**kN/cm²**
tf/m²	10	**kN/m²**
tf/m²	1/100	**Mpa**
tf/m²	1/10	**kgf/cm²**
tf/m³	10	**kN/m³**
MPa	1000	**kN/m²**
MPa	1	**MN/m²**
MPa	1/10	**kN/cm²**
OBTÉM	**DIVIDIR POR** ←	**TENDO**

11) TABELA DE ANCORAGEM

COMPRIMENTO DE ANCORAGEM DE ACORDO COM A NBR 6118/2003

Lb básico — abril.2008

Prof. Eduardo Giugliani, PUCRS

Aço	Ø	Area	Peso	fck (Mpa)										
				20	21	22	23	24	25	28	30	35	40	50
Tipo	mm	cm2	kg/m	Lb em cm										
CA 60	3,4	0,090	0,072	29	28	27	26	25	25	23	22	20	18	16
	4,2	0,140	0,110	35	34	33	32	31	31	28	27	24	22	19
	4,6	0,170	0,132	39	38	36	35	34	33	31	30	27	24	21
	5,0	0,200	0,160	42	41	40	38	37	36	34	32	29	27	23
	6,0	0,280	0,230	51	49	47	46	45	44	40	39	35	32	27
	6,4	0,320	0,260	54	52	51	49	48	46	43	41	37	34	29
	7,0	0,385	0,300	59	57	55	54	52	51	47	45	41	37	32
eta1	8,0	0,500	0,400	67	65	63	61	60	58	54	51	46	42	37
1,40	Lb em Ø			**84**	**82**	**79**	**77**	**75**	**73**	**67**	**64**	**58**	**53**	**46**
Tipo	mm	cm2	kg/m	Lb em cm										
CA 50	6,3	0,315	0,250	28	27	26	25	24	24	22	21	19	17	15
	8,0	0,500	0,400	35	34	33	32	31	30	28	27	24	22	19
	10,0	0,800	0,630	44	42	41	40	39	38	35	33	30	28	24
	12,5	1,250	1,000	55	53	51	50	48	47	44	42	38	34	30
	16,0	2,000	1,600	70	68	66	64	62	60	56	53	48	44	38
	20,0	3,150	2,500	87	85	82	80	77	75	70	67	60	55	47
	22,5	4,000	3,150	98	95	92	90	87	85	79	75	68	62	53
	25,0	5,000	4,000	109	106	103	100	97	94	87	83	75	69	59
eta1	32,0	8,000	6,300	140	135	131	127	124	121	112	107	96	88	76
2,25	Lb em Ø			**44**	**42**	**41**	**40**	**39**	**38**	**35**	**33**	**30**	**28**	**24**

Lb básico — comprimento de ancoragem básido **= Ø / 4 x fyd / fbd** (para barras comprimidas/tracionadas)

- Ø = diâmetro da armadura
- fyd = resitência de cálculo do aço = fyk/1.15
- fbd = resistência de aderência de cálculo entre o concreto e a armadura = $\eta1.\eta2.\eta3.0,15.(fck)^{2/3}$
- η = coeficientes para cálculo da tensão fbd: η1=coef. de conformação do aço; η2 = 1.0; η3 = 1.0 (ver item 9.3.2.1)

Lb nec — comprimento de ancoragem necessário **= α x Lb x Ascal / Asef ≥ Lb min** ≥ 10 cm; ≥ 10 Ø; ≥ 0.33 Lb

- α = 1.0 ancoragem reta, sem gancho
- α = 0.7 ancoragem com gancho, com cobto no plano normal ao gancho ≥ 3Ø
- α = 0.5 ancoragem com gancho e barra transversal (ver itens 9.4.2.2 e 9.4.2.5)
- As cal = armadura calculada
- As ef = armadura efetiva

Lb min — comprimento de ancoragem mínimo

Obs: Para barras comprimidas (caso de pilares) não poderá ser utilizado gancho, somente ancoragem reta.