




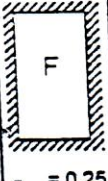




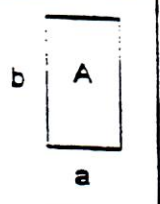
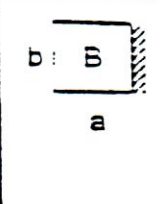
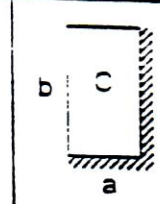
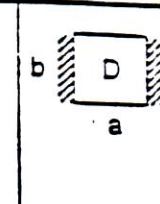
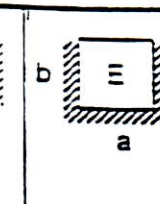
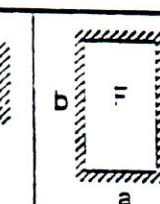
Tipo de Laje	A		B			C		D	E		
							$r_a = 0.183$ $r_a'' = 0.317$	$r_a = 0.144$			
$bia \downarrow$	$r_b$	$r_a$	$r_b$	$r_b''$	$r_b$	$r_b''$	$r_b$	$r_a$	$r_a''$	$r_b$	
0.50	-	0.165	0.125	0.217	-	-	0.217	0.125	0.217	0.158	
0.55	-	0.172	0.138	0.238	-	-	0.238	0.131	0.227	0.174	
0.60	-	0.177	0.150	0.260	-	-	0.259	0.136	0.236	0.190	
0.65	-	0.181	0.163	0.281	-	-	0.278	0.140	0.242	0.206	
0.70	-	0.183	0.175	0.302	-	-	0.294	0.143	0.247	0.222	
0.75	-	0.183	0.187	0.325	-	-	0.308	0.144	0.249	0.238	
0.80	-	0.183	0.199	0.344	-	-	0.320	0.144	0.250	0.254	
0.85	-	0.183	0.208	0.361	-	-	0.330	0.144	0.250	0.268	
0.90	-	0.183	0.217	0.376	-	-	0.340	0.144	0.250	0.281	
0.95	-	0.183	0.225	0.390	-	-	0.348	0.144	0.250	0.292	
1.00	0.250	0.183	0.232	0.402	0.183	0.317	0.356	0.144	0.250	0.303	
1.05	0.262	0.183	0.238	0.413	0.192	0.332	0.363	0.144	0.250	0.312	
1.10	0.273	0.183	0.244	0.423	0.200	0.346	0.369	0.144	0.250	0.321	
1.15	0.283	0.183	0.250	0.432	0.207	0.358	0.374	0.144	0.250	0.329	
1.20	0.292	0.183	0.254	0.441	0.214	0.370	0.380	0.144	0.250	0.336	
1.25	0.300	0.183	0.259	0.448	0.220	0.380	0.385	0.144	0.250	0.342	
1.30	0.308	0.183	0.263	0.455	0.225	0.390	0.389	0.144	0.250	0.348	
1.35	0.315	0.183	0.267	0.462	0.230	0.399	0.393	0.144	0.250	0.354	
1.40	0.321	0.183	0.270	0.468	0.235	0.408	0.397	0.144	0.250	0.359	
1.45	0.328	0.183	0.274	0.474	0.240	0.415	0.400	0.144	0.250	0.364	
1.50	0.333	0.183	0.277	0.479	0.244	0.423	0.404	0.144	0.250	0.369	
1.55	0.339	0.183	0.280	0.484	0.248	0.429	0.407	0.144	0.250	0.373	
1.60	0.344	0.183	0.282	0.489	0.252	0.436	0.410	0.144	0.250	0.377	
1.65	0.348	0.183	0.285	0.493	0.255	0.442	0.413	0.144	0.250	0.381	
1.70	0.353	0.183	0.287	0.497	0.258	0.448	0.415	0.144	0.250	0.384	
1.75	0.357	0.183	0.289	0.501	0.261	0.453	0.418	0.144	0.250	0.387	
1.80	0.361	0.183	0.292	0.505	0.264	0.458	0.420	0.144	0.250	0.390	
1.85	0.365	0.183	0.294	0.509	0.267	0.463	0.422	0.144	0.250	0.393	
1.90	0.368	0.183	0.296	0.512	0.270	0.467	0.424	0.144	0.250	0.396	
1.95	0.372	0.183	0.297	0.515	0.272	0.471	0.426	0.144	0.250	0.399	
2.00	0.375	0.183	0.299	0.518	0.275	0.475	0.428	0.144	0.250	0.401	

TABELA PARA CÁLCULO DE REAÇÕES DE LAJES

R = r . p . a

$g = e$  O VÃO NA DIREÇÃO DO MAIOR NÚMERO DE ENGASTES.

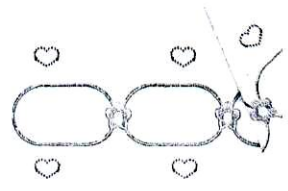
HAVENDO IGUALDADE DE NÚMERO DE ENGASTES NAS DUAS DIREÇÕES,  $g$  SERÁ O MENOR VÃO.

Tipo de Laje →							
$b/a \downarrow$	Flecha = $\frac{p^* \cdot \alpha^4}{E_c \cdot h^3}$ $p^* = (g - \varphi_2 q) \cdot x = n.^\circ$ obtido na tabela						$b/a$
0.50	-	0.0068	-	0.0062	0.0033	-	0.50
0.55	-	0.0090	-	0.0080	0.0045	-	0.55
0.60	-	0.011	-	0.0098	0.0058	-	0.60
0.65	-	0.014	-	0.012	0.0073	-	0.65
0.70	-	0.017	-	0.014	0.0090	-	0.70
0.75	-	0.020	-	0.015	0.011	-	0.75
0.80	-	0.022	-	0.017	0.012	-	0.80
0.85	-	0.025	-	0.019	0.014	-	0.85
0.90	-	0.031	-	0.020	0.015	-	0.90
0.95	-	0.030	-	0.021	0.017	-	0.95
1.00	0.048	0.033	0.025	0.023	0.018	0.015	1.00
1.05	0.053	0.035	0.027	0.024	0.020	0.016	1.05
1.10	0.057	0.037	0.029	0.024	0.021	0.018	1.10
1.15	0.062	0.039	0.032	0.025	0.022	0.019	1.15
1.20	0.066	0.041	0.034	0.026	0.023	0.020	1.20
1.25	0.071	0.043	0.036	0.027	0.024	0.021	1.25
1.30	0.075	0.044	0.038	0.027	0.025	0.022	1.30
1.35	0.079	0.046	0.040	0.028	0.026	0.023	1.35
1.40	0.083	0.047	0.041	0.028	0.026	0.024	1.40
1.45	0.087	0.049	0.043	0.029	0.027	0.025	1.45
1.50	0.090	0.050	0.045	0.029	0.027	0.026	1.50
1.55	0.094	0.051	0.046	0.029	0.028	0.027	1.55
1.60	0.097	0.052	0.047	0.029	0.028	0.027	1.60
1.65	0.100	0.053	0.048	0.030	0.028	0.027	1.65
1.70	0.103	0.053	0.049	0.030	0.028	0.028	1.70
1.75	0.106	0.054	0.050	0.030	0.028	0.028	1.75
1.80	0.109	0.055	0.050	0.030	0.028	0.028	1.80
1.85	0.112	0.056	0.051	0.030	0.029	0.029	1.85
1.90	0.114	0.056	0.052	0.030	0.029	0.029	1.90
1.95	0.116	0.057	0.054	0.030	0.029	0.029	1.95
2.00	0.119	0.058	0.055	0.030	0.029	0.029	2.00

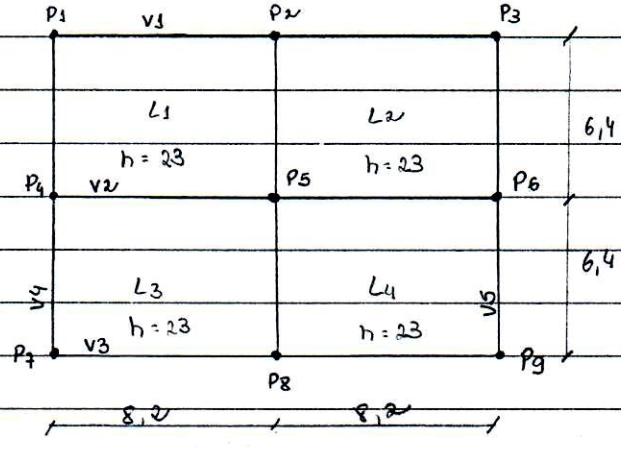
**TABELA PARA CÁLCULO DE FLECHAS EM LAJES — BASEADA EM BARRAS**

$g$  = É O VÃO NA DIREÇÃO DO MAIOR NÚMERO DE ENGASTES.

HAVENDO IGUALDADE DE NÚMERO DE ENGASTES NAS DUAS DIREÇÕES,  $g$  SERÁ O MENOR VÃO.



2) Laje nervurada



Dados:

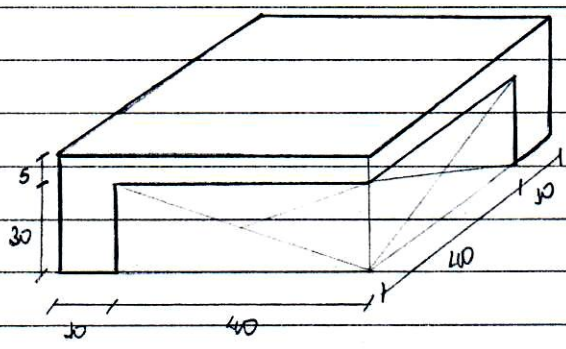
$f_{ck} = 25 \text{ MPa}$

Uço C4-50

$P1 \text{ a } P9 = 30 \times 30$

⇒ laje nervurada com preenchimento de tijolos com dimensões  $40 \times 40$ . Nervuras com 10 cm de espessura. Tijolo com peso específico de  $5 \text{ kN/m}^3$ .

\* detalhe da laje



⇒ Unidade da laje nervurada

⇒ cálculo do peso próprio:

Volume da unidade =  $0,50 \times 0,50 \times 0,35 = 0,0875 \text{ m}^3$

" do tijolo =  $0,40 \times 0,40 \times 0,30 = 0,048 \text{ m}^3$

" de concreto =  $0,0875 - 0,048 = 0,0395 \text{ m}^3$

Peso da unidade = 0,0395 \* 25 + 0,048 \* 5 = 1,223 KN

q/m² = 1,223 / (0,5 \* 0,5) = 4,91 KN/m²

q<sub>total</sub> = PP = 4,91

SC = 2,0

PEU = 1,0

ALU = 1,0

8,91 KN/m²

Calculo dos momentos factores

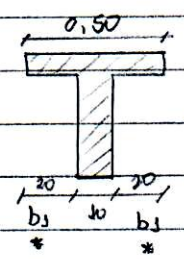
Caso 1 - A espessura das nervuras e o espaçamento entre elas são iguais a duas direções

Pela Tabela: Laje tipo C

a = 6,4	b = 8,2 ≈ 1,3	ma = 24,6	} Tabela
b = 8,2	a = 6,4	mb = 40,0	
		na = 30,7	
		nb = 12,8	

M = Pq² ⇒ 8,91 \* 6,4² ⇒ { Ma = 14,9 KN.m  
Mb = 9,1 KN.m

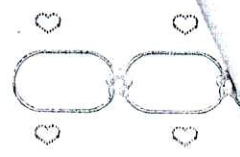
M/nerv ⇒ M/m \* bf(0,50) ⇒ { Ma = 7,45 KN.m  
Mb = 4,55 KN.m



x = Pa² ⇒ 8,91 \* 6,4² ⇒ { Na = 34,1 KN.m  
Nb = 22,5 KN.m

l/nerv ⇒ x/m \* bf(0,50) ⇒ { Ma = 17,05 KN.m  
Mb = 11,25 KN.m

16



$$b_1 \leq 0,5b_2 \Rightarrow \begin{cases} 0,5 \times 40 = 20 \text{ cm} \\ 0,1 a^* \\ 0,1 \times 630 = 63 \text{ cm} \\ 0,1 \times 480 = 48 \text{ cm} \end{cases}$$

\* Para Traços com momentos um uma só extremidade,

$$a = 0,75L \quad \circ \circ \quad L = 8,4 \text{ m} \Rightarrow 6,3 \text{ m}$$

$$L = 6,4 \text{ m} \Rightarrow 4,8 \text{ m}$$

\(\Rightarrow\) Dimensionamento p/  $M_a / m_{eu} = 7,45 \text{ kN.m}$

$$d = 35 - 3 = 32 \text{ cm}$$

$$f_c = 0,85 \times 25 / 1,4 = 1,52 \text{ kN/cm}^2$$

$$M_R = f_c \cdot b_f \cdot h_f (d - h_f / 2)$$

$$1,52 \cdot 50 \cdot 5 (32 - 5/2) \quad \circ \circ \quad M_R = 112,10 \text{ kN.cm} \text{ ou } 112,1 \text{ kN.m}$$

$$M_d = 1,4 \times 7,45 = 10,43 \text{ kN.m} \Rightarrow 1043 \text{ kN.cm}$$

$M_R (112,1) > M_d (10,43 \text{ kN.m}) \Rightarrow$  linha neutra na região da mesa.

(Flexão Simples)

$$k = \frac{M_d}{f_c \cdot b_f \cdot d^2} = \frac{1043}{1,52 \times 50 \times 32^2} = 0,013 < k_L = 0,32$$

$$A_{s1} = \frac{f_c \cdot b_f \cdot d (1 - \sqrt{1 - 2k'})}{f_y d} \Rightarrow \frac{1,52 \times 50 \times 32 (1 - \sqrt{1 - 2 \times 0,013})}{43,5}$$

$$A_{s1} = 0,75 \text{ cm}^2 / \text{m} \text{ VURA}$$

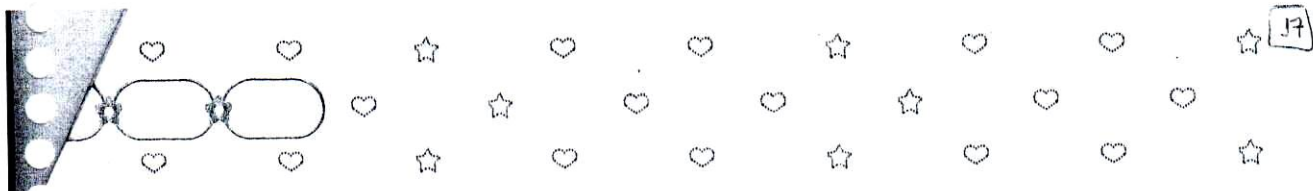
\(\Rightarrow\) Dimensionamento p/  $M_b / m_{eu} = 4,55 \text{ kN.m}$

$$M_d = 1,4 \times 4,55 = 6,37 \text{ kN.m} = 637 \text{ kN.cm}$$

$M_R (112,1) > M_d (6,37) \Rightarrow$  linha neutra na região

da mesa.

11/11/22



$$K = \frac{637}{1,52 \times 50 \times 32^2} = 0,008 < K_L = 0,32$$

$$A_s = \frac{1,52 \times 50 \times 32 (1 - \sqrt{1 - 2 \times 0,008})}{43,5}$$

$$A_s = 0,50 \text{ cm}^2 / \text{m} \text{ NURA}$$

Dimensionamento p/ Xa/nuv = 17,05 KN.m

$$M_d = 17,05 \times 1,4 = 23,87 \text{ KN.m} \Rightarrow 2387 \text{ KN.cm}$$

$$K = \frac{2387}{1,52 \times 50 \times 32^2} = 0,15 < K_L = 0,32$$

$$A_s = \frac{1,52 \times 50 \times 32 (1 - \sqrt{1 - 2 \times 0,15})}{43,5}$$

$$A_s = 1,87 \text{ cm}^2 / \text{m} \quad A_s = (1,87 / 50) \times 100 = 3,74 \text{ cm}^2 / \text{m}$$

Dimensionamento p/ Xb/nuv = 14,25 KN.m

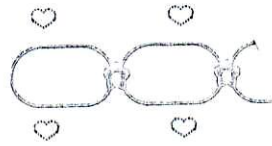
$$M_d = 14,25 \times 1,4 = 19,95 \text{ KN.m} = 1995 \text{ KN.cm}$$

$$K = \frac{1995}{1,52 \times 50 \times 32^2} = 0,128 < K_L = 0,32$$

$$A_s = \frac{1,52 \times 50 \times 32 (1 - \sqrt{1 - 2 \times 0,128})}{43,5}$$

$$A_s = 1,54 \text{ cm}^2 / \text{m} \quad A_s = (1,54 / 50) \times 100 = 3,08 \text{ cm}^2 / \text{m}$$

$$\Rightarrow A_{s \text{ MIN}} = 0,15 \% A_c = 0,15 \times (30 \times 30 + 5 \times 50) = 0,83 \text{ cm}^2$$



	Us calc	Us utiliz	Ø
M <sub>a</sub> -	0,75	0,83	2Ø8
M <sub>b</sub> -	0,50	0,83	2Ø8
X <sub>a</sub> -	3,74	3,74	Ø8c/12
X <sub>b</sub> -	3,08	3,08	Ø8c/15

⇒ Comparação Peso estimado

• laje coqueado

- Ø 30 → 3930 (m) → 2450 (kg)
- Ø 12.5 → 140 (m) → 135 (kg)
- Ø 16 → 130 (m) → 205 (kg)
- TOTAL 2790 (kg)

• laje nervurada

- Ø 8 → 2157 (m) → 852 (kg)

