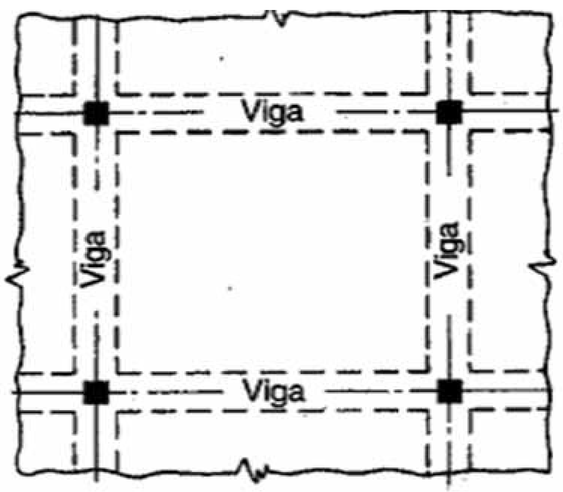
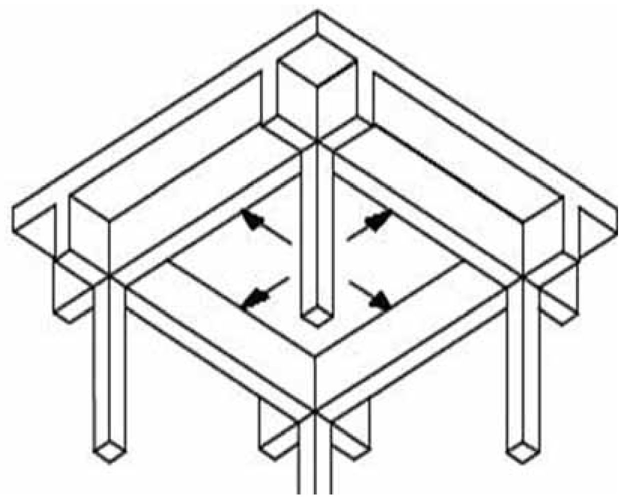
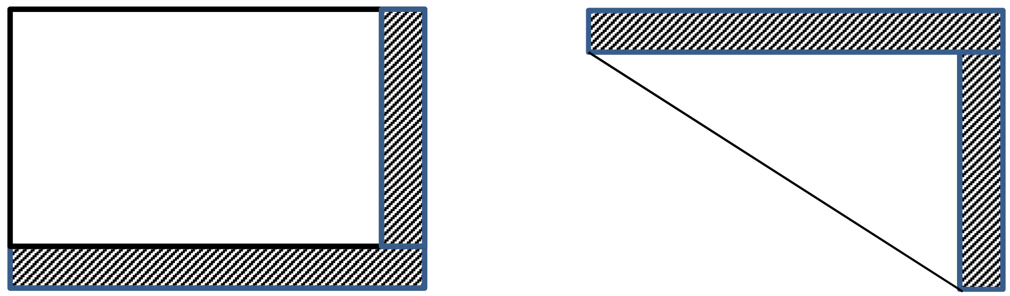
Losas en dos sentidos

Losas bidireccionales: también llamadas losas en dos sentido, se caracterizan porque trasladan las cargas en mas de una sola dirección ( ). (Losas cuadradas o casi cuadradas)





– Losas en dos sentidos:



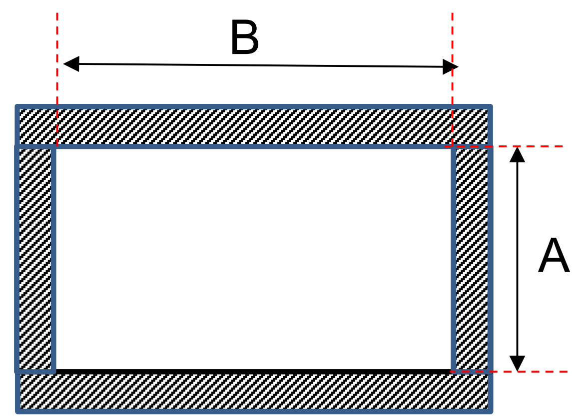
a) Losas con apoyos perpendiculares

b) Cuando la relación (R) es mayor o igual a 0.5

$$R = A/B \geq 0.5$$

Donde:
A = lado corto de la losa
B = lado largo de la losa

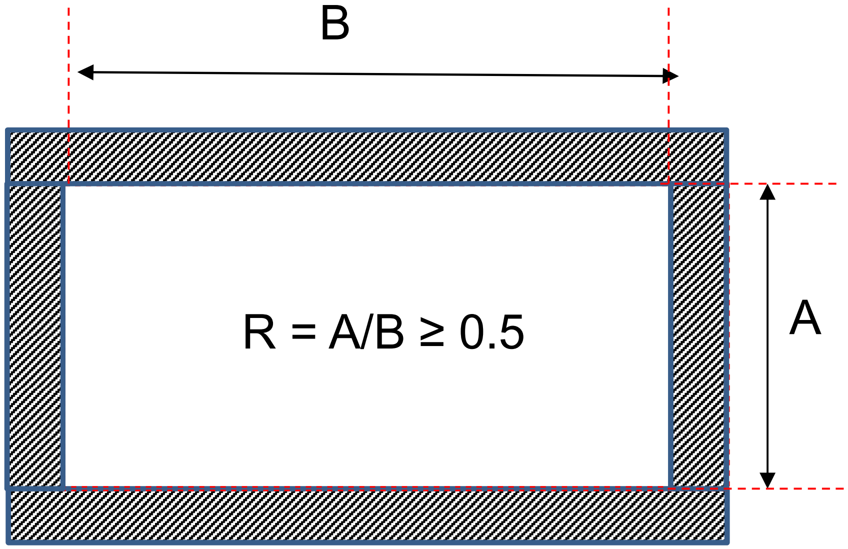
Luz libre de losas



Pre-dimensionamiento de losas en dos sentidos

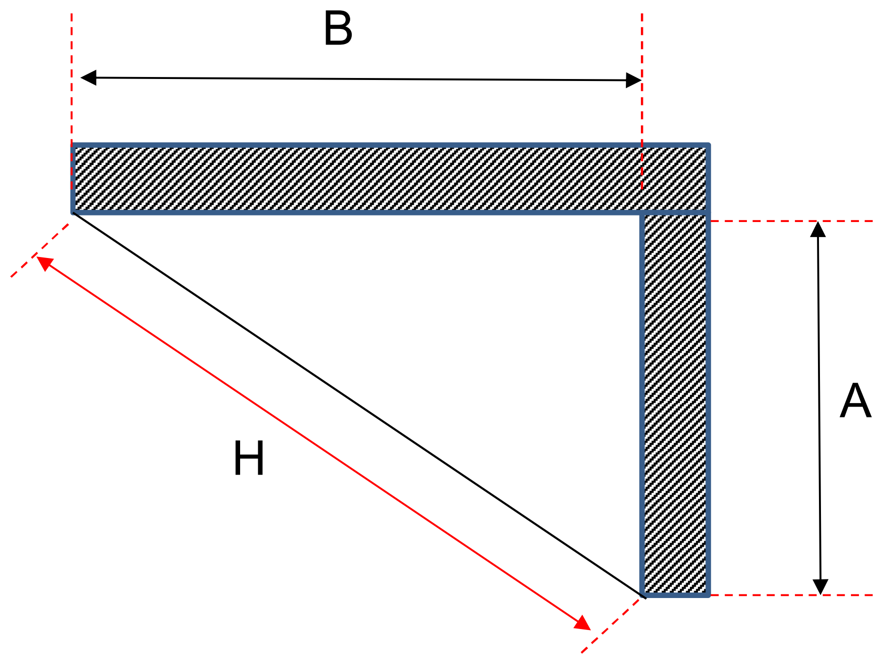
$$t = \frac{perimetro}{180}$$

$$t = \frac{A+A+B+B}{180} =$$



$$t = \frac{perimetro}{180}$$

$$t = \frac{A + B + H}{180}$$



$$t = \frac{perimetro}{180}$$

$$t = \frac{A + B + S}{180}$$

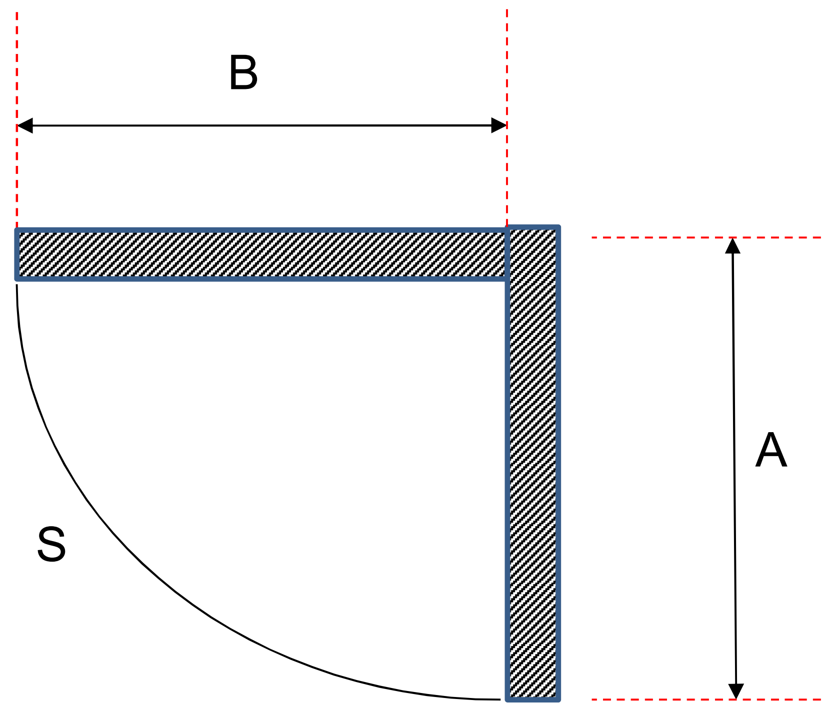
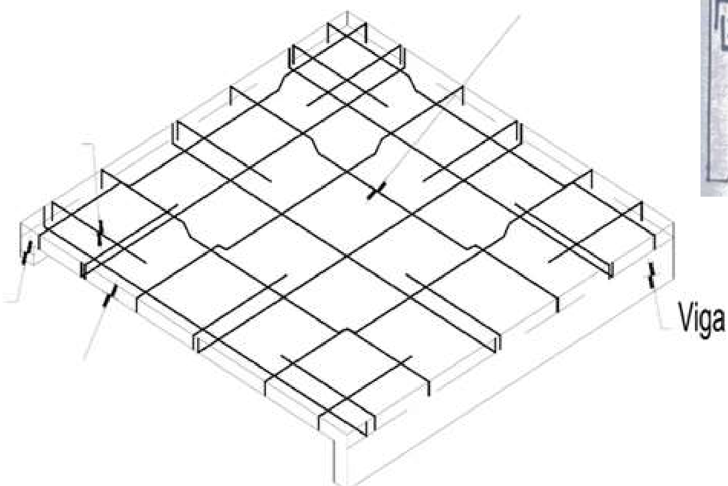


Table 8.3.1.2—Minimum thickness of nonprestressed two-way slabs with beams spanning between supports on all sides

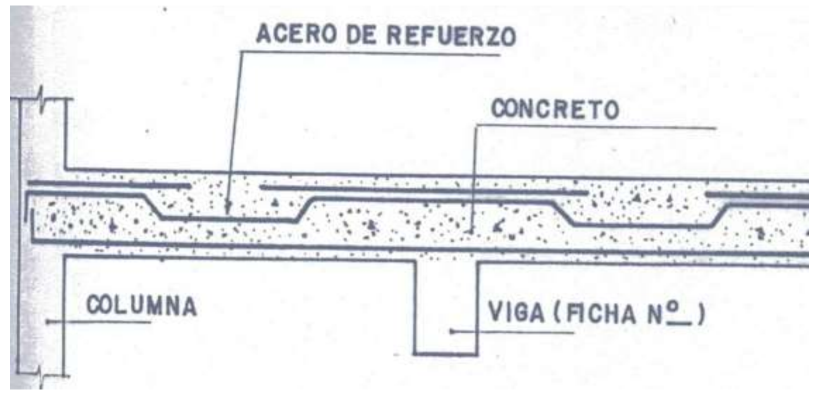
α_{fm}[1]	Minimum h, in.		
$\alpha_{fm} \le 0.2$	8.3.1.1 applies		(a)
$0.2 < \alpha_{fm} \le 2.0$	Greater of:	$\dfrac{\ell_n\left(0.8+\dfrac{f_y}{200{,}000}\right)}{36+5\beta(\alpha_{fm}-0.2)}$	(b)[1],[2]
		5.0	(c)
$\alpha_{fm} > 2.0$	Greater of:	$\dfrac{\ell_n\left(0.8+\dfrac{f_y}{200{,}000}\right)}{36+9\beta}$	(d)
		3.5	(e)

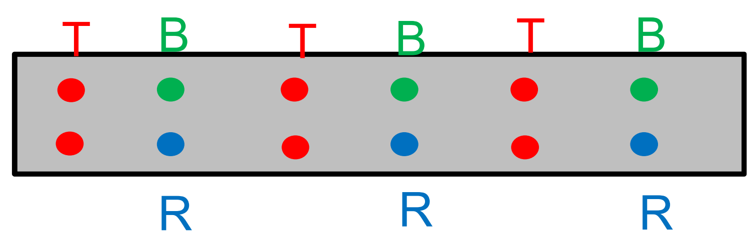
[1]α_{fm} is the average value of α_f for all beams on edges of a panel.
[2]ℓ_n is the clear span in the long direction, measured face-to-face of beams (in.).
[3]β is the ratio of clear spans in long to short directions of slab.

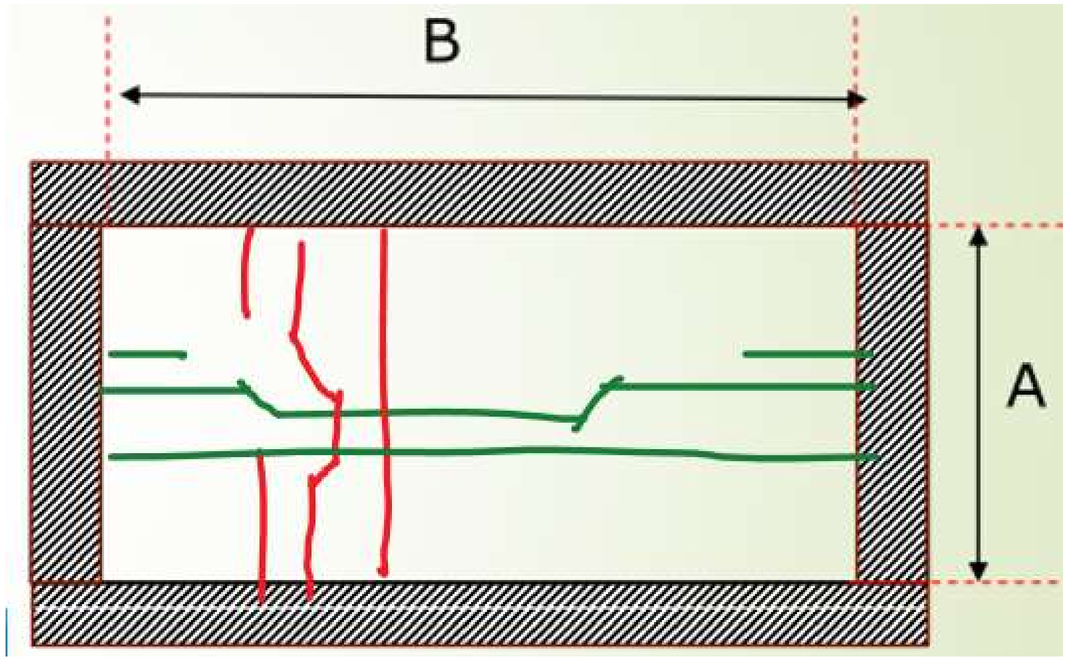
ARMADO DE LOSAS QUE TRABAJAN EN DOS SENTIDOS



DETALLE TÍPICO DE LOSA DE CONCRETO ARMADO







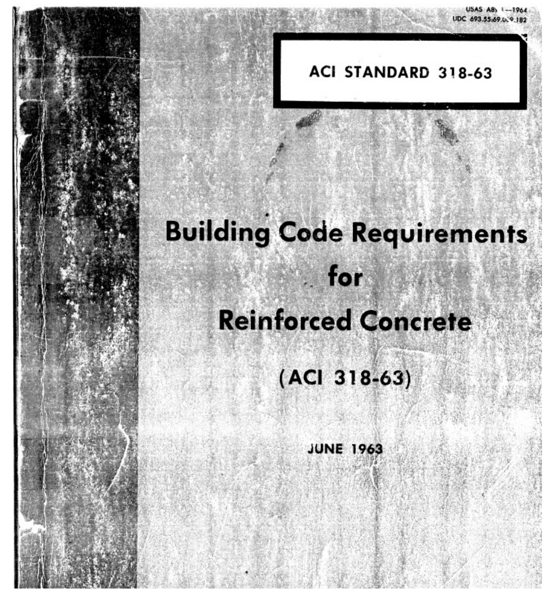
Refuerzo por flexión

Métodos de diseño de losas en dos sentidos

1. Método 3 del ACI (ACI 318-1963)
2. Método de diseño directo (ACI 318-14)
3. Método del pórtico equivalente (ACI 318-14)
4. Método por elementos finitos (ACI 318-19)

Método 3:

Surgió en la versión del ACI 318-1963, fue unos de los tres métodos propuestos por la normativa. En su apéndice.



APPENDIX

Utiliza tablas para su analisis estructural.

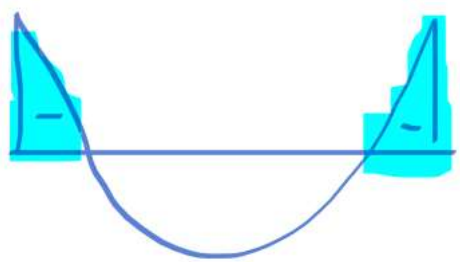
Debido a que a veces se subestimaban los momentos, fue eliminado en versiones posteriores

METHOD 3—TABLE I—COEFFICIENTS FOR NEGATIVE MOMENTS IN SLABS*

$$\left.\begin{array}{l} M_{A\,neg} = C_{A\,neg} \times w \times A^2 \\ M_{B\,neg} = C_{B\,neg} \times w \times B^2 \end{array}\right\} \text{ where } w = \text{total uniform dead plus live load}$$

Ratio $m = \frac{A}{B}$		Case 1	Case 2	Case 3	Case 4	Case 5	Case 6	Case 7	Case 8	Case 9
1.00	$C_{A\,neg}$		0.045		0.050	0.075	0.071		0.033	0.061
	$C_{B\,neg}$		0.045	0.076	0.050			0.071	0.061	0.033
0.95	$C_{A\,neg}$		0.050		0.055	0.079	0.075		0.038	0.065
	$C_{B\,neg}$		0.041	0.072	0.045			0.067	0.056	0.029
0.90	$C_{A\,neg}$		0.055		0.060	0.080	0.079		0.043	0.068
	$C_{B\,neg}$		0.037	0.070	0.040			0.062	0.052	0.025
0.85	$C_{A\,neg}$		0.060		0.066	0.082	0.083		0.049	0.072
	$C_{B\,neg}$		0.031	0.065	0.034			0.057	0.046	0.021
0.80	$C_{A\,neg}$		0.065		0.071	0.083	0.086		0.055	0.075
	$C_{B\,neg}$		0.027	0.061	0.029			0.051	0.041	0.017
0.75	$C_{A\,neg}$		0.069		0.076	0.085	0.088		0.061	0.078
	$C_{B\,neg}$		0.022	0.056	0.024			0.044	0.036	0.014
0.70	$C_{A\,neg}$		0.074		0.081	0.086	0.091		0.068	0.081
	$C_{B\,neg}$		0.017	0.050	0.019			0.038	0.029	0.011
0.65	$C_{A\,neg}$		0.077		0.085	0.087	0.093		0.074	0.083
	$C_{B\,neg}$		0.014	0.043	0.015			0.031	0.024	0.008
0.60	$C_{A\,neg}$		0.081		0.089	0.088	0.095		0.080	0.085
	$C_{B\,neg}$		0.010	0.035	0.011			0.024	0.018	0.006
0.55	$C_{A\,neg}$		0.084		0.092	0.089	0.096		0.085	0.086
	$C_{B\,neg}$		0.007	0.028	0.008			0.019	0.014	0.005
0.50	$C_{A\,neg}$		0.086		0.094	0.090	0.097		0.089	0.088
	$C_{B\,neg}$		0.006	0.022	0.006			0.014	0.010	0.003

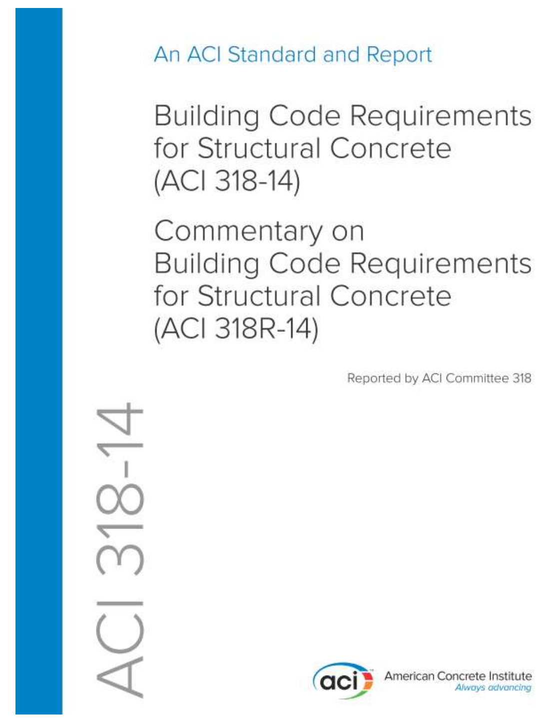
*A cross-hatched edge indicates that the slab continues across or is fixed at the support; an unmarked edge indicates a support at which torsional resistance is negligible.



Método de diseño directo:

Método visto por ultima vez en la versión del ACI 318-14, ya que por el avance de software para el analisis de placas y cascaras, ya no fue muy utilizado, al igual que por sus restricciones.

CHAPTER 8
TWO-WAY SLABS



8.10.2 *Limitations for use of direct design method*

8.10.2.1 There shall be at least three continuous spans in each direction.

8.10.2.2 Successive span lengths measured center-to-center of supports in each direction shall not differ by more than one-third the longer span.

8.10.2.3 Panels shall be rectangular, with the ratio of longer to shorter panel dimensions, measured center-to-center of supports, not to exceed 2.

8.10.2.4 Column offset shall not exceed 10 percent of the span in direction of offset from either axis between center-lines of successive columns.

8.10.2.5 All loads shall be due to gravity only and uniformly distributed over an entire panel.

8.10.2.6 Unfactored live load shall not exceed two times the unfactored dead load.

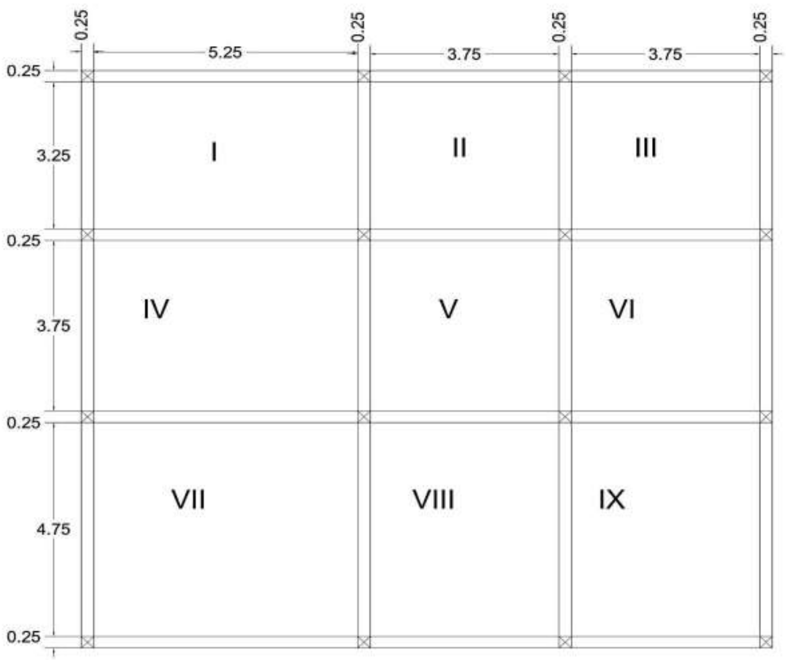
8.10.2.7 For a panel with beams between supports on all sides, Eq. (8.10.2.7a) shall be satisfied for beams in the two perpendicular directions.

$$0.2 \le \frac{\alpha_{f1}\ell_2^2}{\alpha_{f2}\ell_1^2} \le 5.0 \qquad (8.10.2.7a)$$

where $\boldsymbol{\alpha_{f1}}$ and $\boldsymbol{\alpha_{f2}}$ are calculated by:

$$\alpha_f = \frac{E_{cb}I_b}{E_{cs}I_s} \qquad (8.10.2.7b)$$

Se debía cumplir con 8.10.2



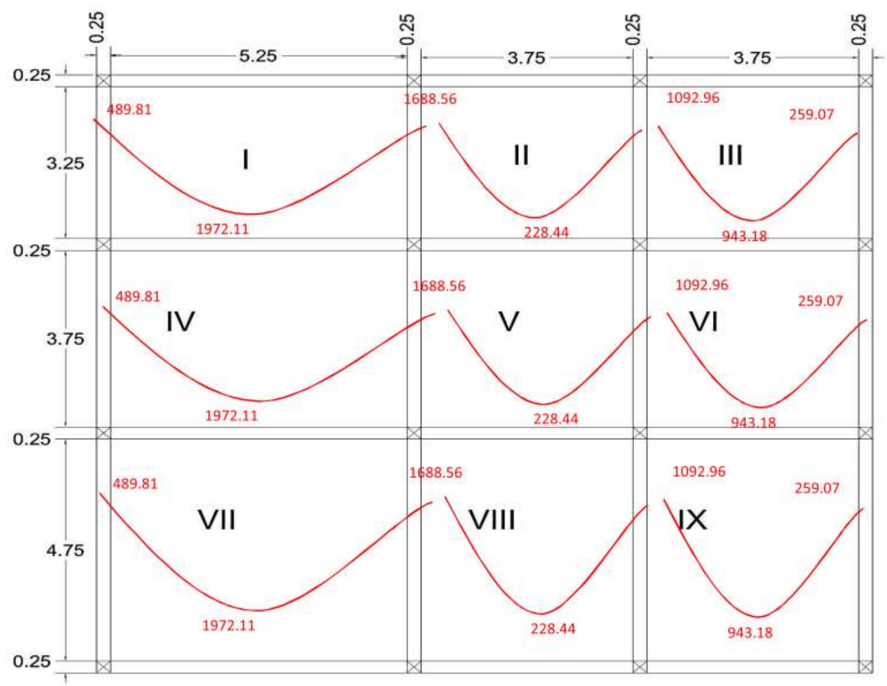
4 Verificacion de criterios para el uso del metodo

8.10.2.1	Hay mas de tres vanos	OK	
8.10.2.2	Tamaño de luz menor	3.666666667 < 4m	OK
8.10.2.3	Todas las losas son en dos sentidos	OK	
8.10.2.4	Columnas totalmente alineada	OK	
8.10.2.5	Todas las cargas son uniformemente distribuidas		OK
8.10.2.6	CV/CM=	0.490196078 < 2	OK

Table 8.10.4.2—Distribution coefficients for end spans

	Exterior edge unrestrained	Slab with beams between all supports	Slab without beams between interior supports: Without edge beam	Slab without beams between interior supports: With edge beam	Exterior edge fully restrained
Interior negative	0.75	0.70	0.70	0.70	0.65
Positive	0.63	0.57	0.52	0.50	0.35
Exterior negative	0	0.16	0.26	0.30	0.65

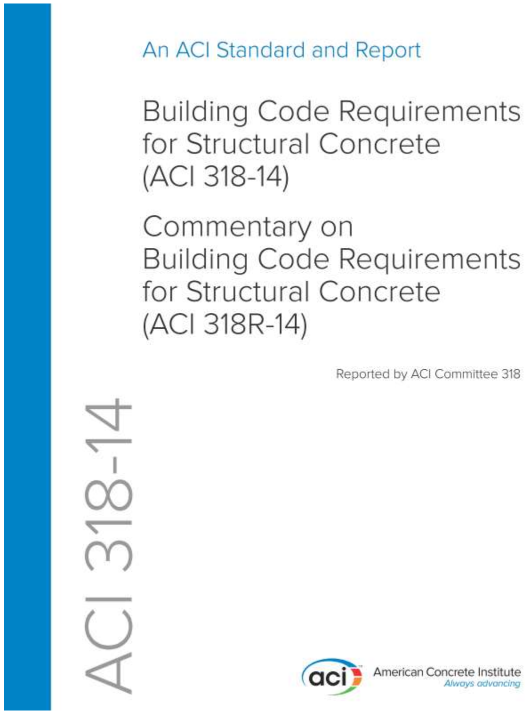
Tabla utilizada para obtener los momentos



Método de pórtico equivalente

Al igual que el método anterior, fui incluido por ultima vez en la versión del ACI 318-14.

CHAPTER 8
TWO-WAY SLABS



Un método que no tenia ninguna restricción, únicamente se debía analizar las losas como pórticos o marcos como los conocemos, agregando la rigidez por torsión a las columnas de las losas que llegan perpendicular.

En este método se trazan franjas centrales para formar los pórticos.

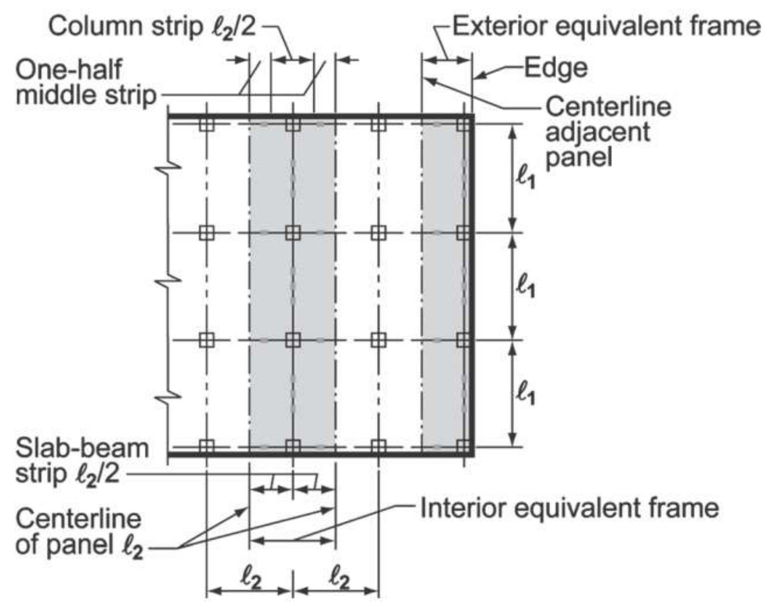
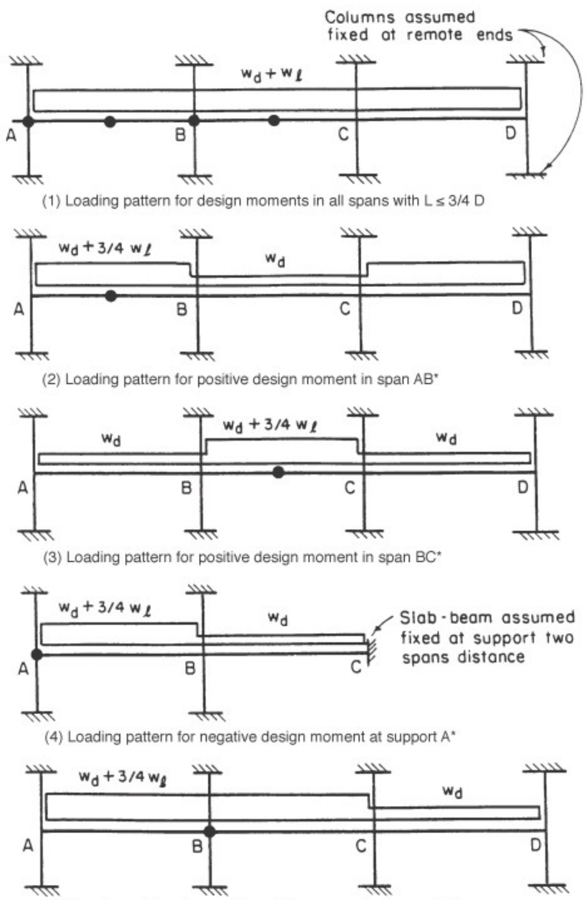


Fig. R8.11.2—Definitions of equivalent frame.

Ejemplo de la formación de un pórtico



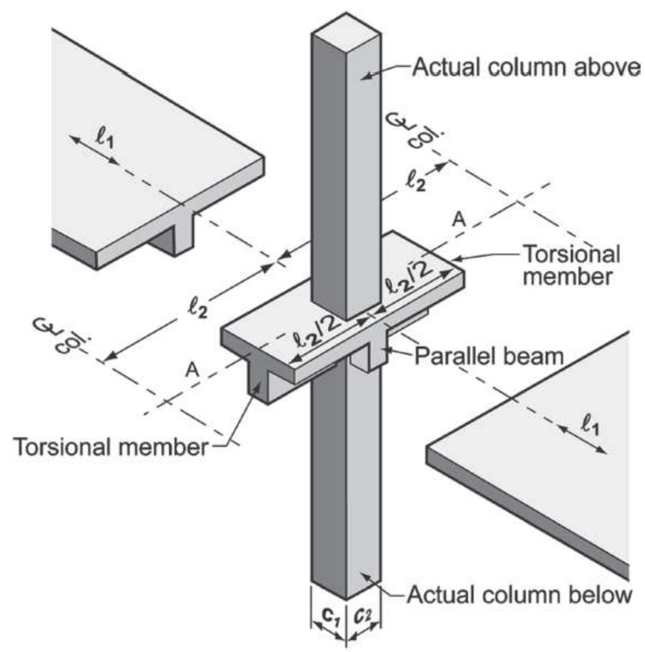


Fig. R8.11.4—Equivalent column (column plus torsional members).

Luego se utilizan tablas para la estimación de las rigideces equivalente y obtener los factores de distribución de momentos. También se estimaban los factores de transporte. Para esta parte es necesario realizar una distribución de momentos por el método de Cross

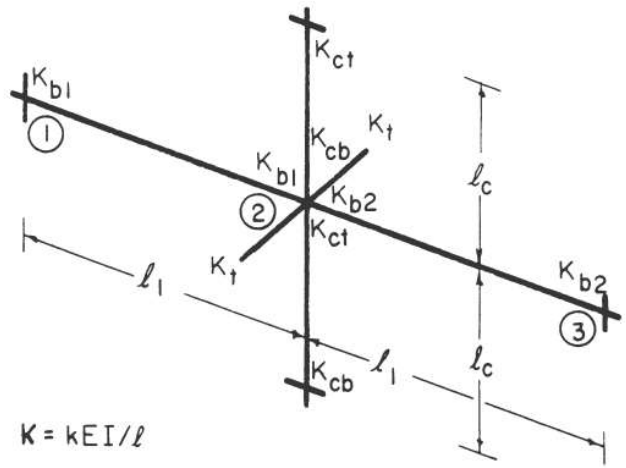
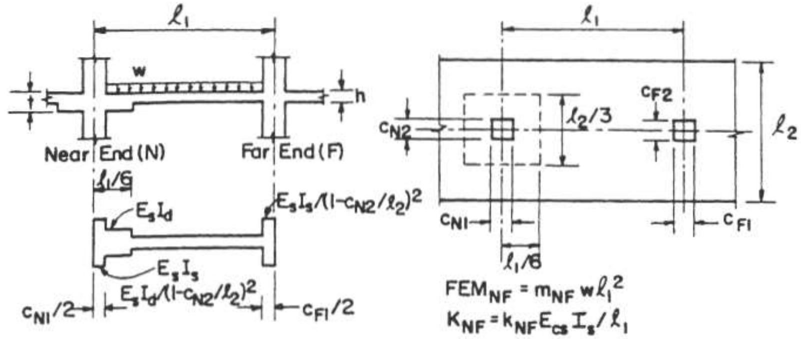


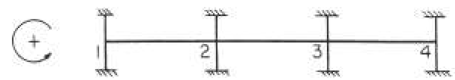
Figure 20-10 Moment Distribution Factors DF

Table A6 Moment Distribution Constants for Slab-Beam Members
(Column dimensions assumed equal at near end and far end —$c_{F1} = c_{N1}$, $c_{F2} = c_{N2}$)



C_1/ℓ_1	C_2/ℓ_2	t = 1.5h						t = 2h					
		k_{NF}	C_{NF}	m_{NF}	k_{FN}	C_{FN}	m_{FN}	k_{NF}	C_{NF}	m_{NF}	k_{FN}	C_{FN}	m_{FN}
0.00	—	5.39	0.49	0.1023	4.26	0.60	0.0749	6.63	0.49	0.1190	4.49	0.65	0.0676
0.10	0.00	5.39	0.49	0.1023	4.26	0.60	0.0749	6.63	0.49	0.1190	4.49	0.65	0.0676
	0.10	5.65	0.52	0.1012	4.65	0.60	0.0794	7.03	0.54	0.1145	5.19	0.66	0.0757
	0.20	5.86	0.54	0.1012	4.91	0.61	0.0818	7.22	0.56	0.1140	5.43	0.67	0.0778
	0.30	6.05	0.55	0.1025	5.10	0.62	0.0838	7.36	0.56	0.1142	5.57	0.67	0.0786
0.20	0.00	5.39	0.49	0.1023	4.26	0.60	0.0749	6.63	0.49	0.1190	4.49	0.65	0.0676
	0.10	5.88	0.54	0.1006	5.04	0.61	0.0826	7.41	0.58	0.1111	5.96	0.66	0.0823
	0.20	6.33	0.58	0.1003	5.63	0.62	0.0874	7.85	0.61	0.1094	6.57	0.67	0.0872
	0.30	6.75	0.60	0.1008	6.10	0.64	0.0903	8.18	0.63	0.1093	6.94	0.68	0.0892
0.30	0.00	5.39	0.49	0.1023	4.26	0.60	0.075	6.63	0.49	0.1190	4.49	0.65	0.0676
	0.10	6.08	0.56	0.1003	5.40	0.61	0.085	7.76	0.62	0.1087	6.77	0.67	0.0873
	0.20	6.78	0.61	0.0996	6.38	0.63	0.092	8.49	0.66	0.1055	7.91	0.68	0.0952
	0.30	7.48	0.64	0.0997	7.25	0.65	0.096	9.06	0.68	0.1047	8.66	0.69	0.0991

Table 20-1 Moment Distribution for Partial Frame

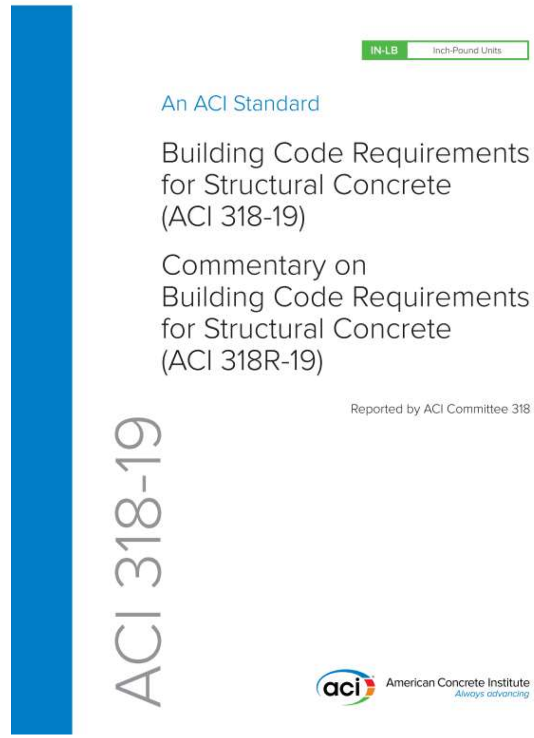


Joint	1	2		3		4
Member	1-2	2-1	2-3	3-2	3-4	4-3
DF	0.389	0.280	0.280	0.280	0.280	0.389
COF	0.509	0.509	0.509	0.509	0.509	0.509
FEM	+73.8	-73.8	+73.8	-73.8	+73.8	-73.8
Dist	-28.7	0.0	0.0	0.0	0.0	28.7
CO	0.0	-14.6	0.0	0.0	14.6	0.0
Dist	0.0	4.1	4.1	-4.1	-4.1	0.0
CO	2.1	0.0	-2.1	2.1	0.0	-2.1
Dist	-0.8	0.6	0.6	-0.6	-0.6	0.8
CO	0.3	-0.4	-0.3	0.3	0.4	-0.3
Dist	-0.1	0.2	0.2	-0.2	-0.2	0.1
CO	0.1	-0.1	-0.1	0.1	0.1	-0.1
Dist	0.0	0.0	0.0	0.0	0.0	0.0
Neg. M	46.6	-84.0	76.2	-76.2	84.0	-46.6
M @ midspan	44.1		33.2		44.1	

Método de elementos finitos

Por el avance tecnológico de hoy en día, existen software que puede analizar placas y cascaras con bastante precisión, utilizando método numéricos y teorías de elasticidad. Este método es el sugerido en la versión ACI 318-19

CHAPTER 6
STRUCTURAL ANALYSIS



6.9—Acceptability of finite element analysis

6.9.1 Finite element analysis to determine load effects shall be permitted.

6.9.2 The finite element model shall be appropriate for its intended purpose.

R6.9—Acceptability of finite element analysis

R6.9.1 This section was introduced in the 2014 Code to explicitly recognize a widely used analysis method.

R6.9.2 The licensed design professional should ensure that an appropriate analysis model is used for the particular problem of interest. This includes selection of computer software program, element type, model mesh, and other modeling assumptions.

A large variety of finite element analysis computer software programs are available, including those that perform static, dynamic, elastic, and inelastic analyses.

The element types used should be capable of determining the response required. Finite element models may have beam-column elements that model structural framing members, such as beams and columns, along with plane stress elements; plate elements; and shell elements, brick elements, or both, that are used to model the floor slabs, mat foundations, diaphragms, walls, and connections. The model mesh size selected should be capable of determining

Existen varios software para el analisis de losas por el método de elementos finitos

Ayudan a calcular análisis y diseño estructural bajo teorías y normas estructurales vigentes, por lo general, bajo métodos numéricos programables, como por ejemplo metodologías *FEM (finite element method)*

Tekla Structures

CSiBRIDGE CSiCOL ETABS SAFE SAP2000 PERFORM-3D

XTRACT

ANSYS

Bentley STAAD.Pro

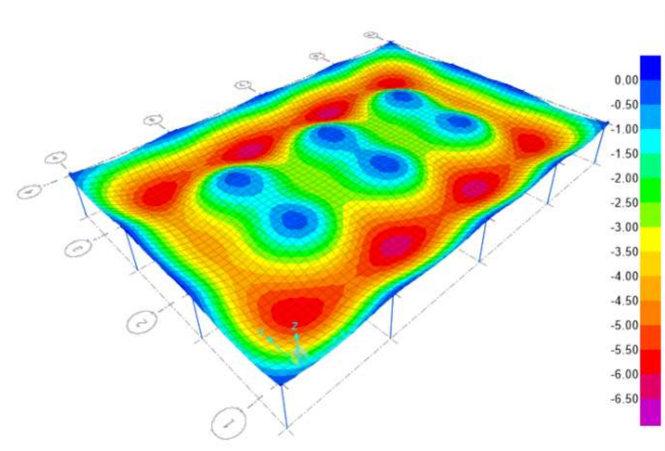
DIANA FEA

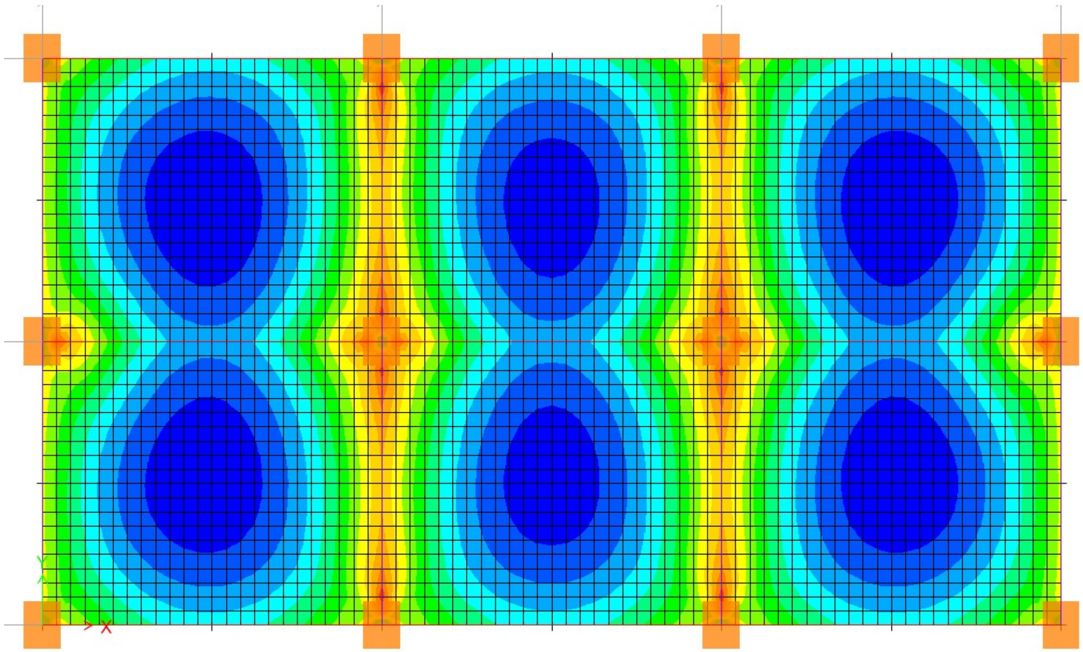
cype

AUTODESK ROBOT STRUCTURAL ANALYSIS

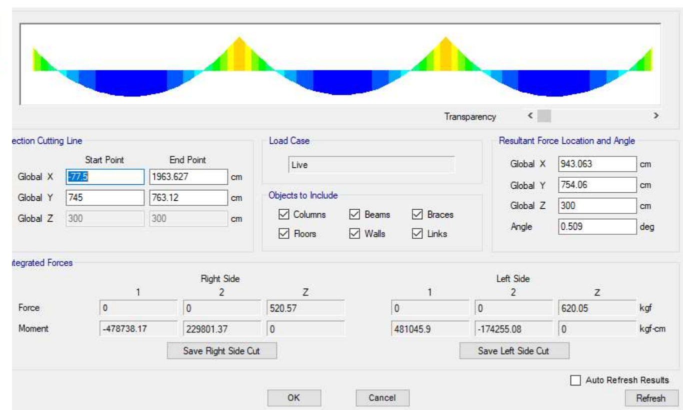
MIDAS

OpenSees

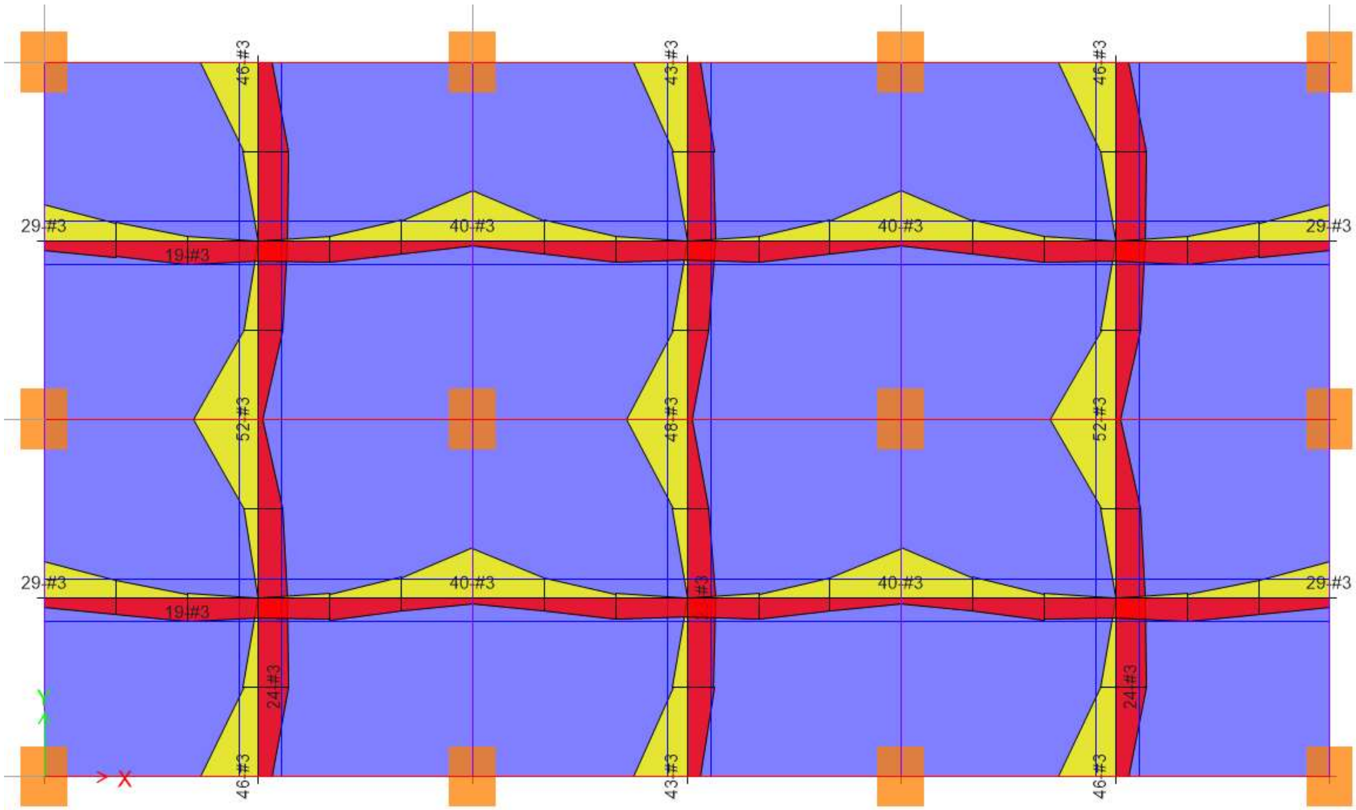




X



Transparency
ection Cutting Line
Start Point
End Point
Global X
-77.5
1963.627
cm
Global Y
745
763.12
cm
Global Z
300
300
cm
Load Case
Live
Objects to Include
Columns
Beams
Braces
Floors
Walls
Links
Resultant Force Location and Angle
Global X
943.063
cm
Global Y
754.06
cm
Global Z
300
cm
Angle
0.509
deg
tegrated Forces
Right Side
Left Side
1
2
Z
1
2
Z
Force
0
0
520.57
0
0
620.05
kgf
Moment
-478738.17
229801.37
0
481045.9
-174255.08
0
kgf-cm
Save Right Side Cut
Save Left Side Cut
Auto Refresh Results
OK
Cancel
Refresh



46 #3
43 #3
46 #3
29 #3
40 #3
40 #3
29 #3
19 #3
52 #3
48 #3
52 #3
29 #3
40 #3
40 #3
29 #3
19 #3
24 #3
24 #3
46 #3
43 #3
46 #3
Y
X

Requisitos de diseño

Acero mínimo de losas

8.6—Reinforcement limits

8.6.1 *Minimum flexural reinforcement in nonprestressed slabs*

8.6.1.1 A minimum area of flexural reinforcement, $A_{s,min}$ of $\mathbf{0.0018}A_g$, or as defined in 8.6.1.2, shall be provided near the tension face of the slab in the direction of the span under consideration.

Separación máxima de refuerzo

8.7.2 *Flexural reinforcement spacing*

8.7.2.1 Minimum spacing ***s*** shall be in accordance with 25.2.

8.7.2.2 For nonprestressed solid slabs, maximum spacing ***s*** of deformed longitudinal reinforcement shall be the lesser of **2*h*** and 18 in. at critical sections, and the lesser of **3*h*** and 18 in. at other sections.

8.7.2.3 For prestressed slabs with uniformly distributed loads, maximum spacing ***s*** of tendons or groups of tendons in at least one direction shall be the lesser of **8*h*** and 5 ft.

8.7.2.4 Concentrated loads and openings shall be considered in determining tendon spacing.