

Temporada de webinars

Diseño de acero

Diseño de sistemas de piso en acero

Ing. Daniel Silvério

CTS / Commercial Technical Support – ArcelorMittal International (Brasil)

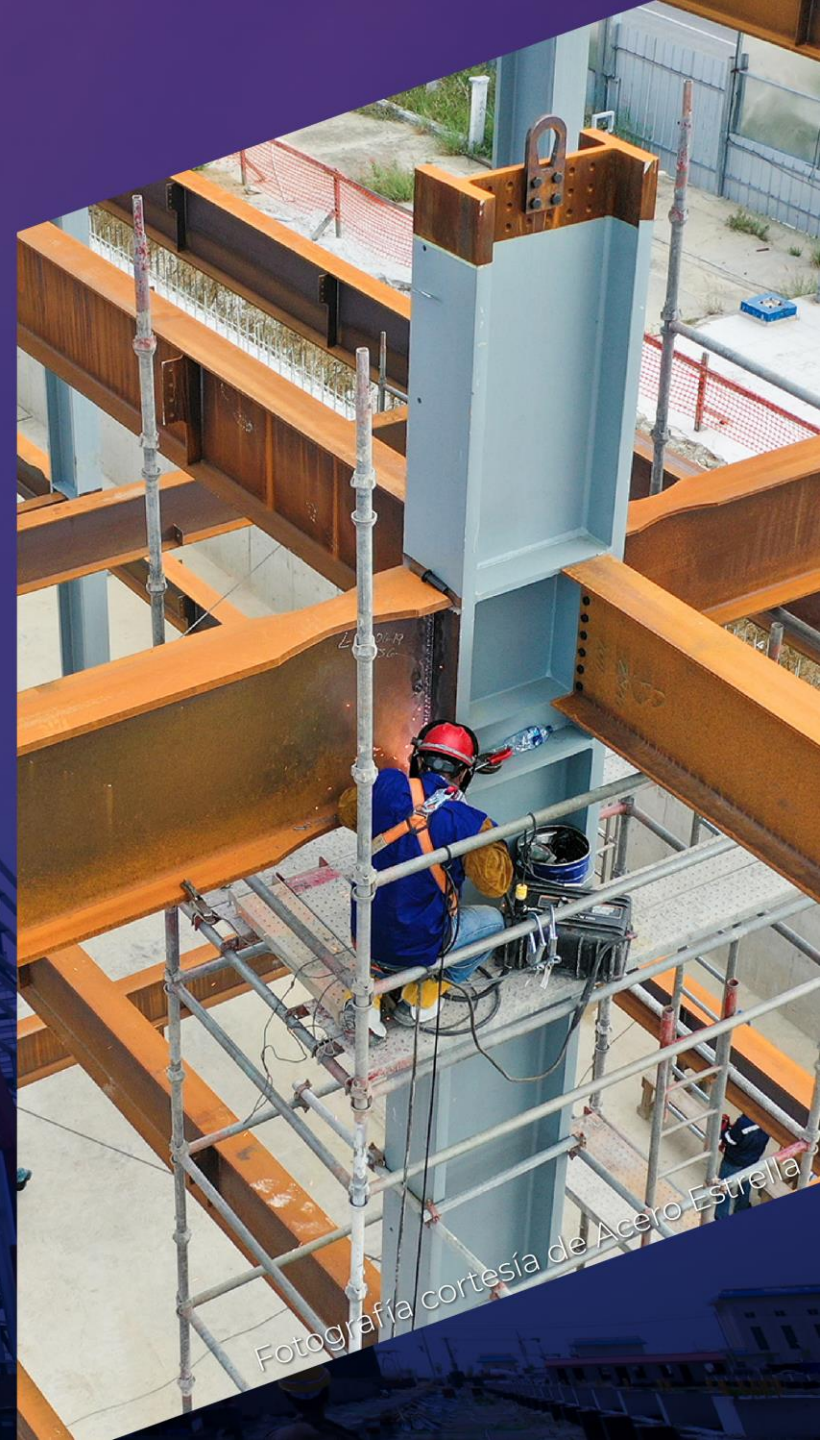
Ing. Daniel Ureña Muñoz M.Sc.

Sketch SRL- ACIES

Organiza



Patrocinan



Fotografía cortesía de Acero Estrella

Consideraciones iniciales

- Un placer poder darle seguimiento a esta serie de conversatorios enfocados en Acero Estructural
- Como objetivo principal, se pretende que los asistentes se familiaricen con las rutinas de diseño de sistemas de piso (vigas y columnas de acero)

Agenda de la conferencia

Parte 1 – Ing. Daniel Silvério

- Tipos de sistemas de piso
- Elementos estructurales
- Estructura Aislada x Mixta

Parte 2 – Ing. Daniel Ureña

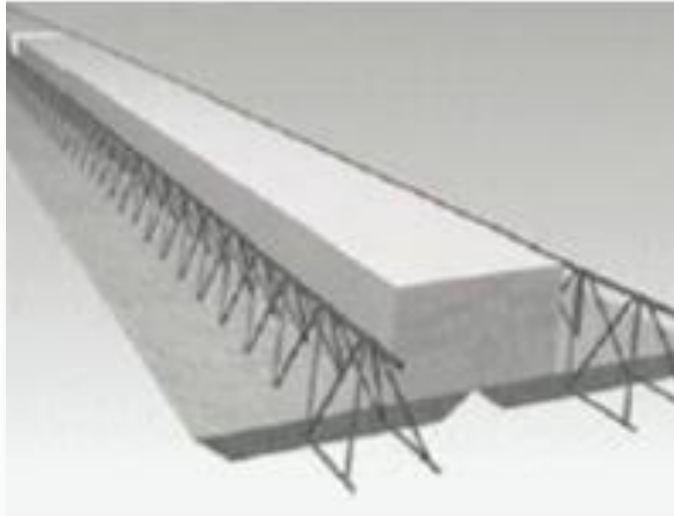
- Vigas – mecanismos de falla, esbeltez, estados límites

Parte 3 – Ing. Daniel Silvério

- Ejemplo práctico – diseño de viga y columna

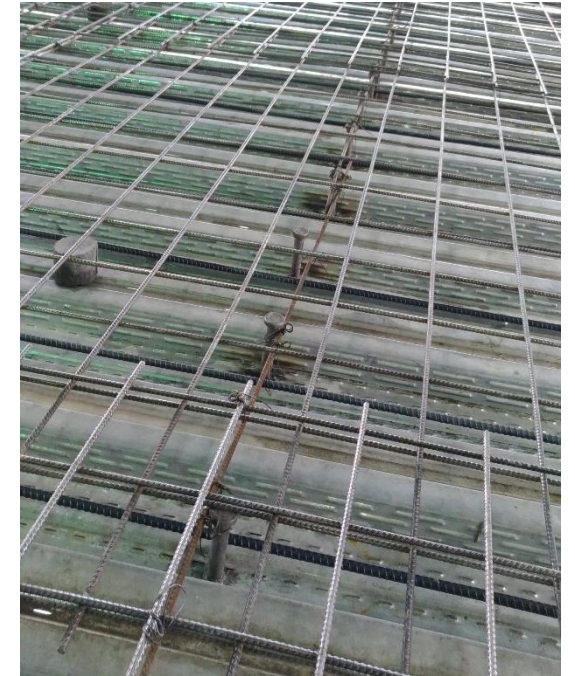
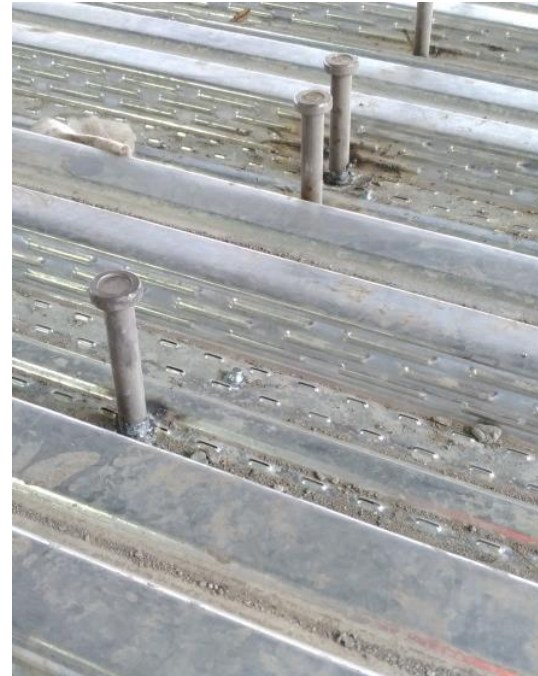
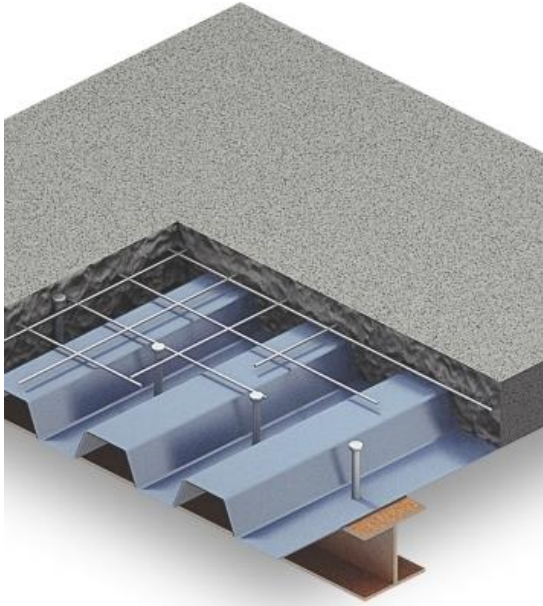
Sistemas de piso

Losas prefabricadas



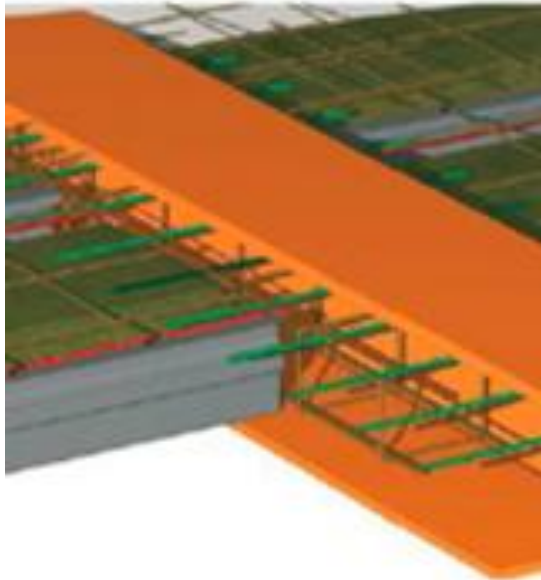
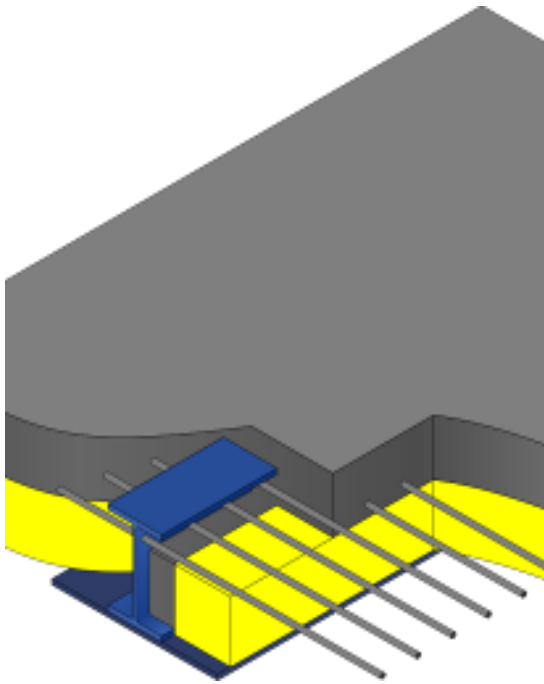
Sistemas de piso

Losas tipo enconfrado colaborante



Sistemas de piso

Slim-floor



Sistemas de piso

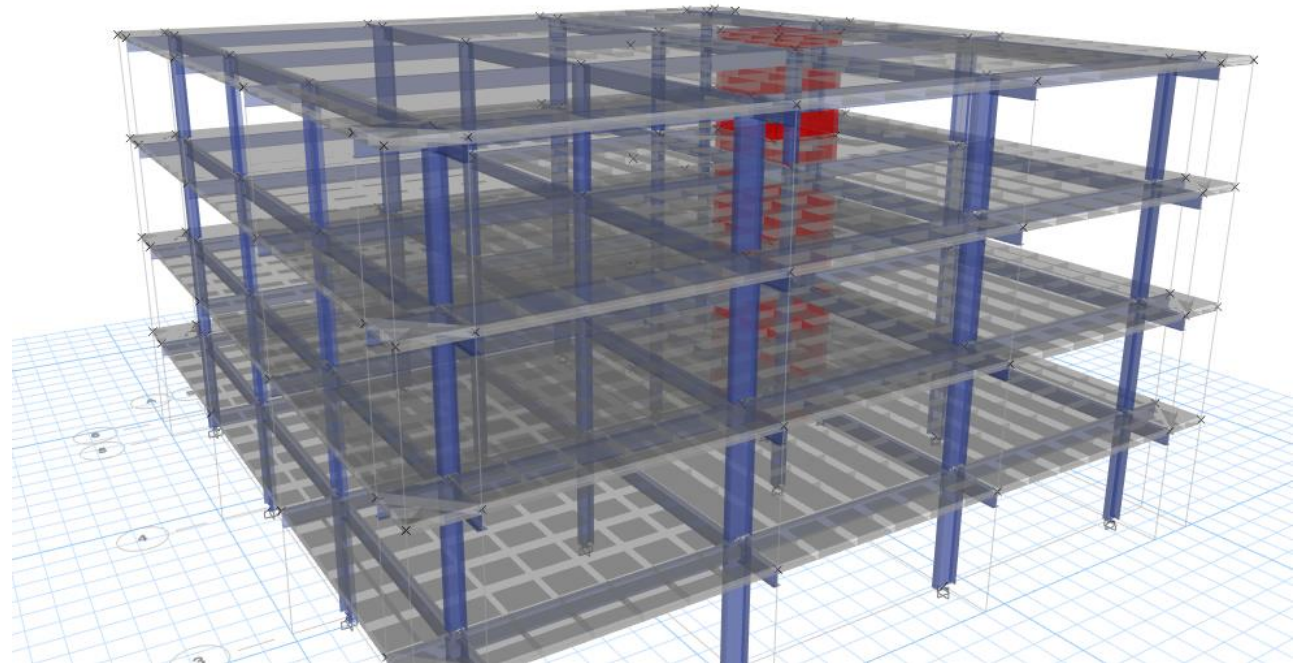
Otros tipos



Sistemas de piso

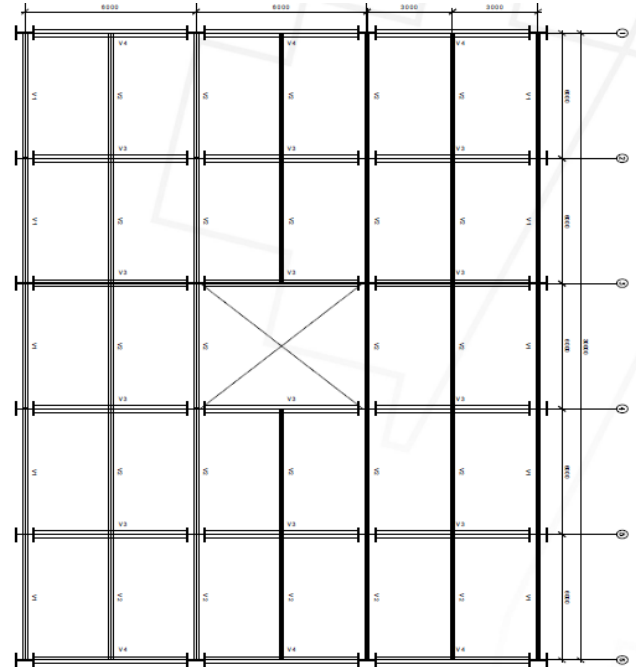
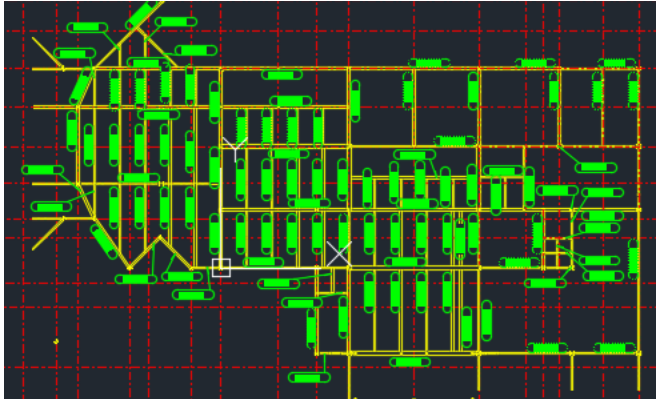
Otros tipos

- Disponibilidad
- Luces x cargas
- Transporte
- Montaje
- Mayor nivel de industrialización
- Costos



Estructura de soporte

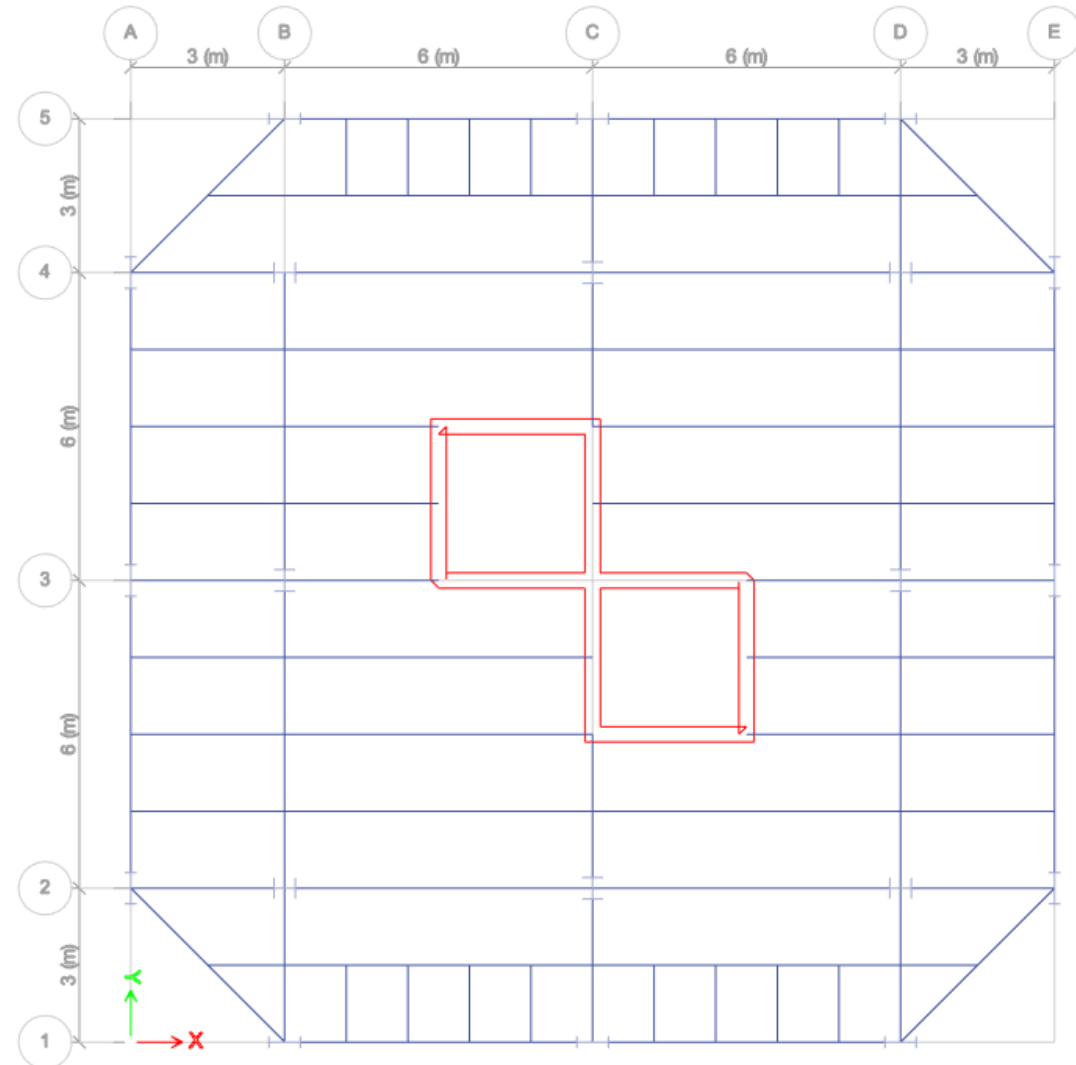
Malla de vigas



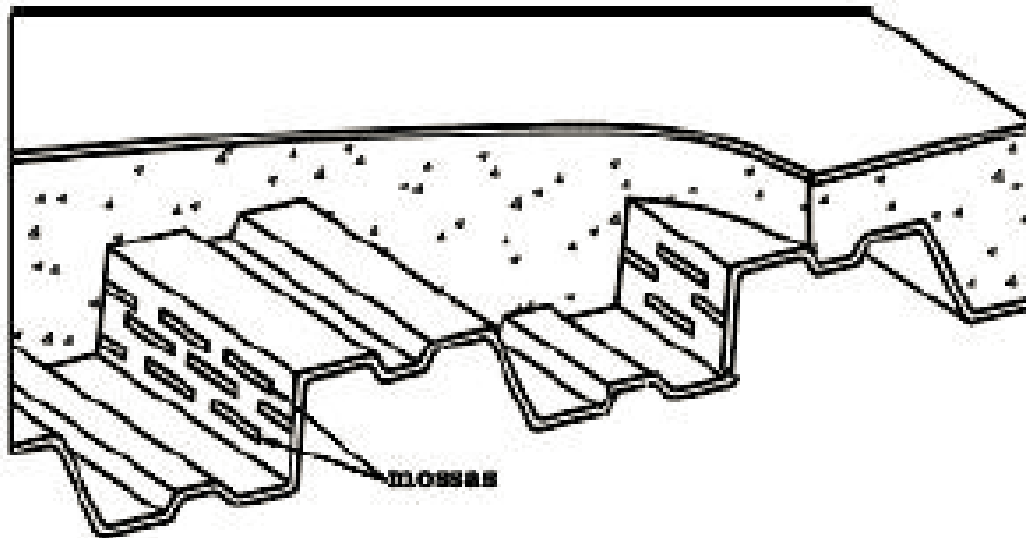
Estructura de soporte

Ubicando los elementos estructurales

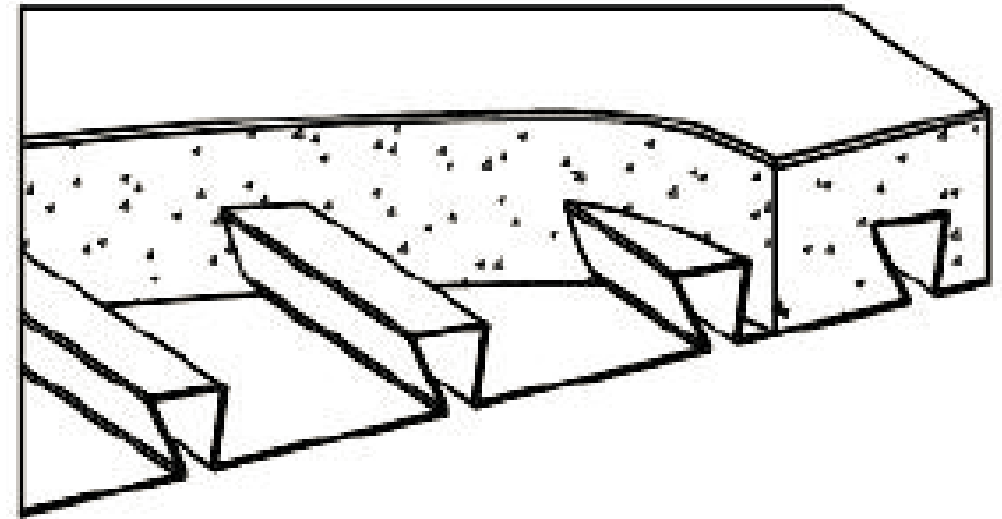
- Correas
- Vigas secundarias
- Vigas Principales
- Columnas



Losa mixta

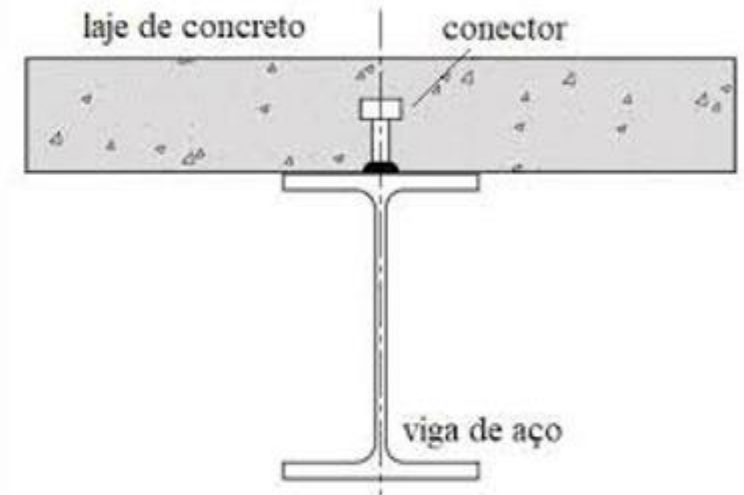
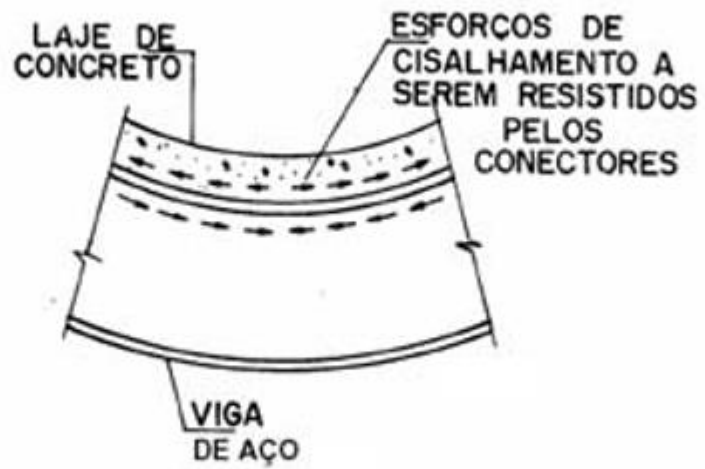
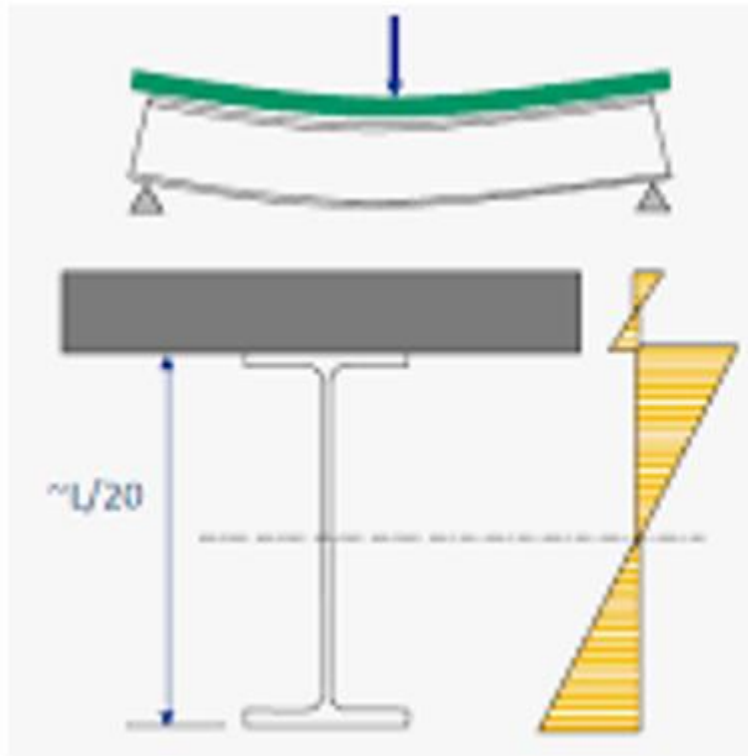


a) Forma trapezoidal

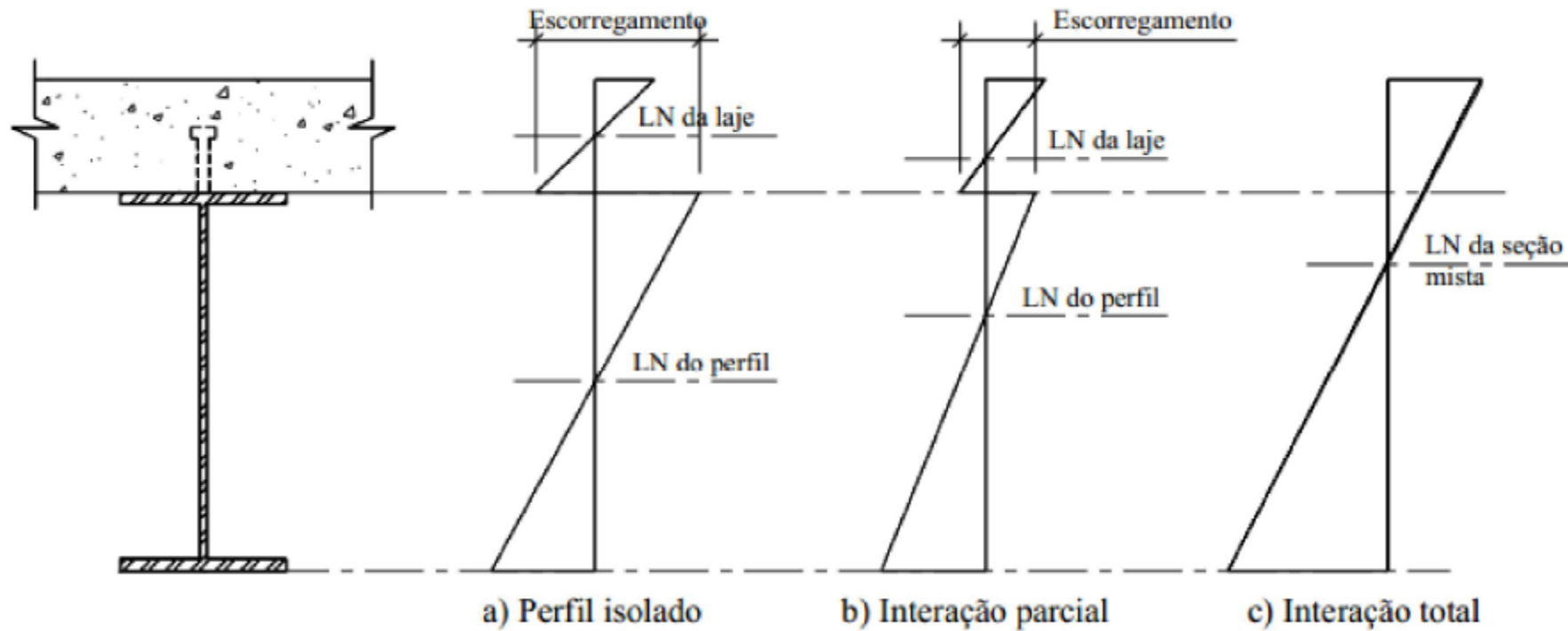


b) Forma reentrante

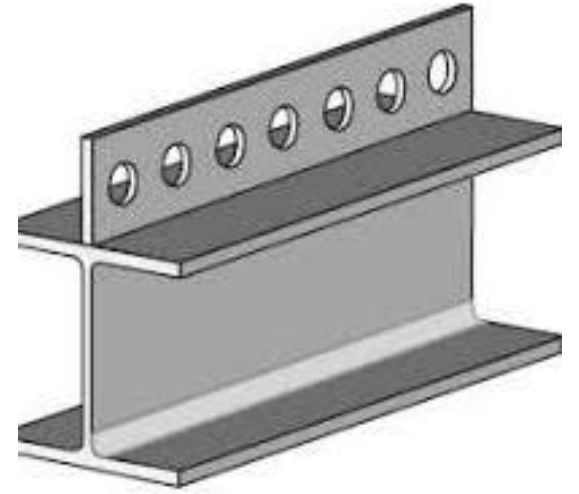
Viga mixta



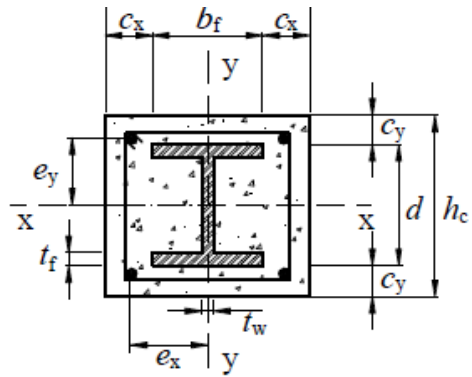
Viga mixta



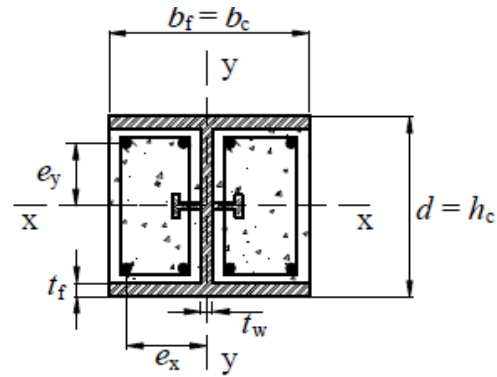
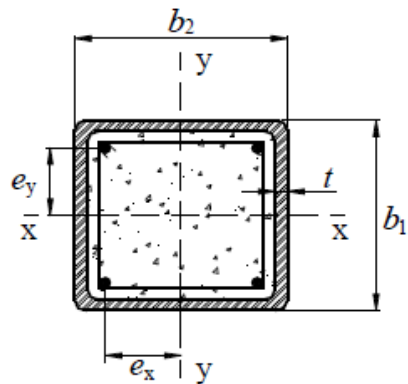
Conexión a corte



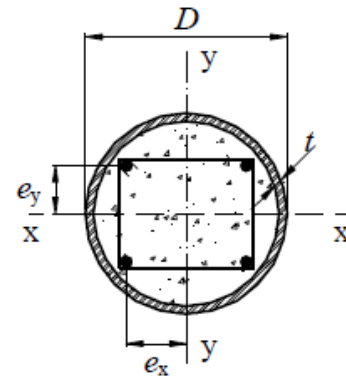
Pilares Mixtos



(a)



(b)

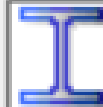


I Abrir Proyecto

Archivos recientes

Nueva Sección

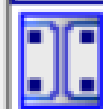
Abrir Archivo



Elemento de acero - I-Perfil



Columna mixta totalmente embebido - I-Perfil



Columna mixta parcialmente embebido - I-Perfil



Columna mixta - Sección circular - I-Perfil



Columna mixta - Tubo circular - I-Perfil

Parte II – Ing. Daniel Ureña

Ejemplo práctico

Entrepiso = 3.5m

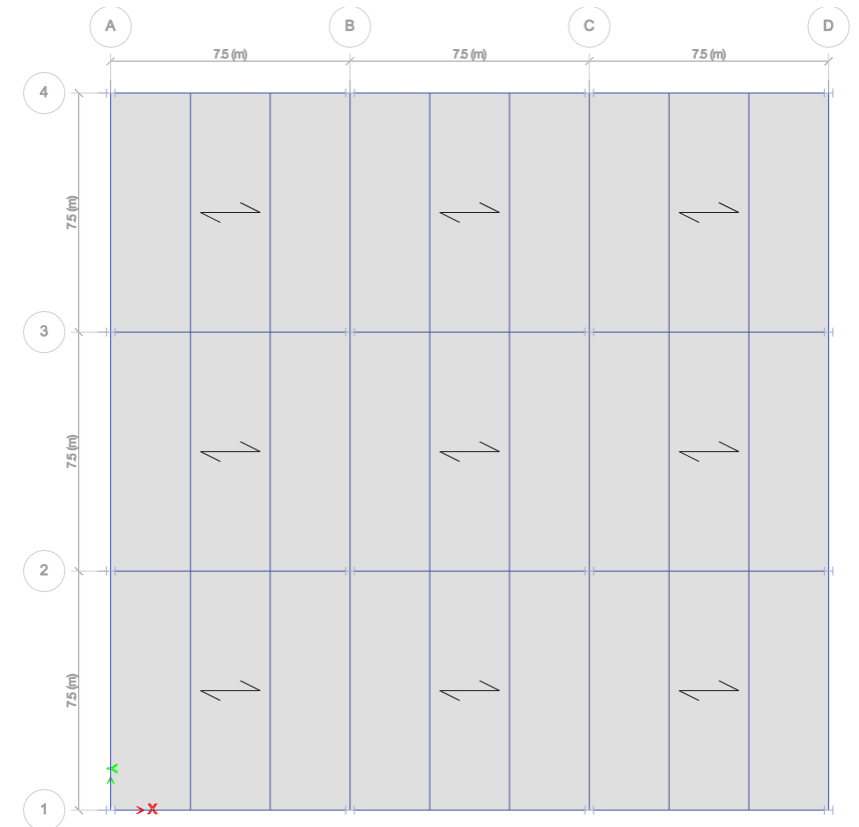
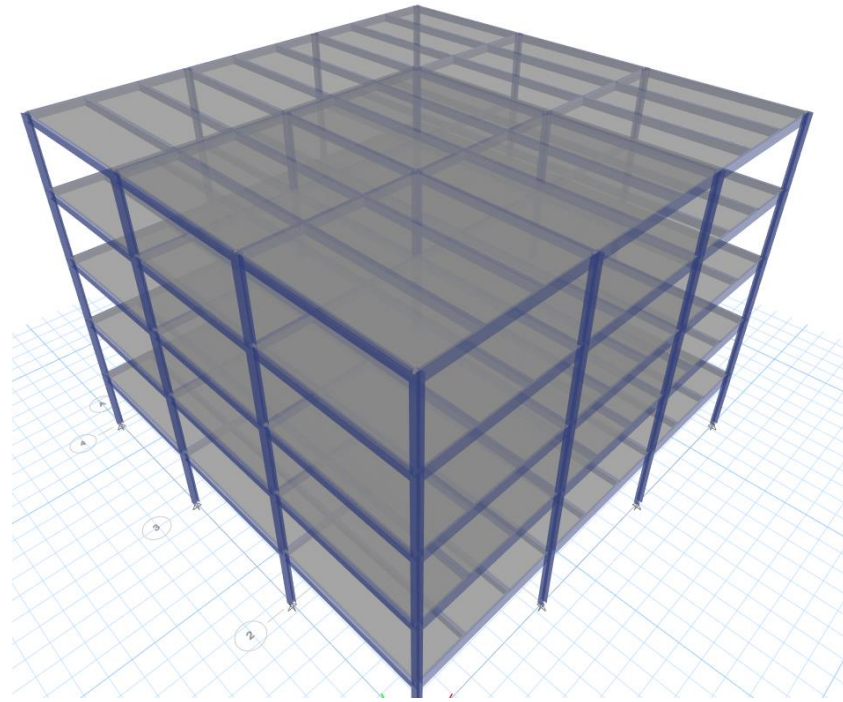
Acero ASTM A992 ($f_y=345$ MPa)

CP = 400 kgf/m²

CV = 300 Kgf/m²

Malla → 2,5mx7,5m x 7,5m

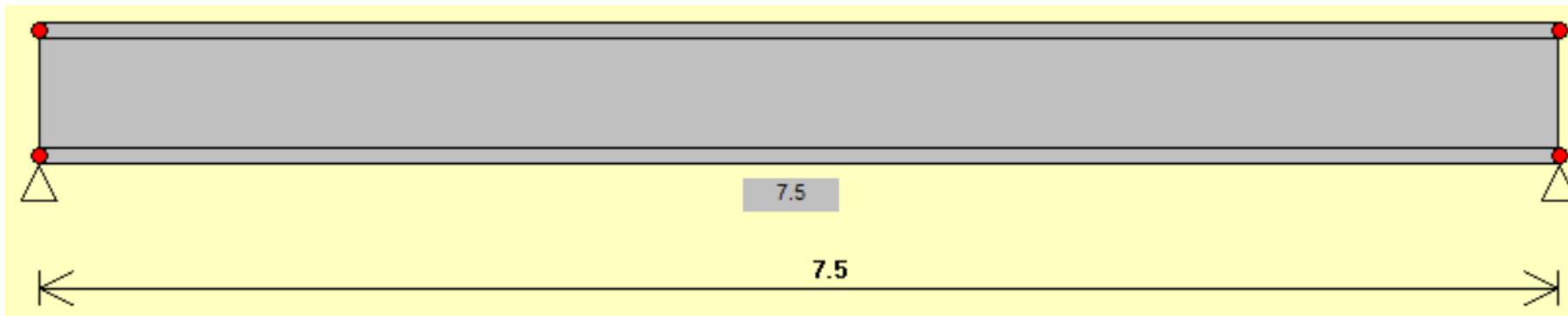
Numero de pisos = 5



Viga

Correa

- Viga de piso (oficina)
- Acero ASTM A992 ($f_y=345$ MPa)
- $CP = 400$ kgf/m²
- $CV = 300$ Kgf/m²
- $LUZ=7,5$ m
- Ancho tributário = 2,5m



Cargas/Esfuerzos

Obs.: Norma brasileña

•ELU

•ELS

Descripción	(kN/m ²)	γg
CP	4.00	1.4

CV (kN/m ²)	γq	ψ0	ψ1	ψ2
3.00	1.5	0.7	0.6	0.4

Combinaciones

$$F_d = \sum_{i=1}^m (\gamma_{gi} F_{Gi,k}) + \gamma_{q1} F_{Q1,k} + \sum_{j=2}^n (\gamma_{qj} \psi_{0j} F_{Qj,k})$$

Estado Límite Último

$$M_u = 17753,91 \text{ kN} \cdot \text{cm}$$
$$V_u = 94,69 \text{ kN}$$

$$F_{ser} = \sum_{i=1}^m F_{Gi,k} + F_{Q1,k} + \sum_{j=2}^n (\psi_{1j} F_{Qj,k})$$

**Estado Limite de Servicio
(deflexión excesiva)**

$$q_{ELS} = 0,145 \frac{\text{kN}}{\text{cm}}$$

Prediseño

$$h = \frac{L}{17,5} = \frac{7500}{17,5} \cong 430mm$$

$$flecha_{límite} = \frac{L}{350} = \frac{750}{350} \cong 2,14cm$$

$$I_{eje fuerte} = \frac{5 \times q \times L^4}{384 \times E \times flecha_{límite}}$$

$$I_{eje fuerte} = \frac{5 \times 0,145 \times 750^4}{384 \times 20000 \times 2,14} \cong 13960cm^4$$




Notations pages 166-168 / Bezeichnungen Seiten 166-168

Désignation Designation Bezeichnung	Valeurs statiques / Sectio				
	axe fort y-y strong axis y-y starke Achse y-y				
G	I_y	W_{ely}	W_{ply}	i_y	A_v
kg/m	cm ⁴	cm ³	cm ³	cm	cm ²



IPE 360	66,0	19040	1046	1186	15,0	40,20
IPE 360	57,1	16260	903,6	1019	14,9	35,13
IPE A 360	50,2	14510	811,8	906,7	15,0	29,76
IPE AA 360	47,0	13670	767,5	853,5	15,1	27,43

$$I_{eje fuerte} = 16260cm^4$$

Flexión

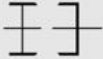
TABLE B4.1b Width-to-Thickness Ratios: Compression Elements Members Subject to Flexure					
Case	Description of Element	Width-to- Thickness Ratio	Limiting Width-to-Thickness Ratio		Examples
			λ_p (compact/ noncompact)	λ_r (noncompact/ slender)	
10	Flanges of rolled I-shaped sections, channels, and tees	b/t	$0.38 \sqrt{\frac{E}{F_y}}$	$1.0 \sqrt{\frac{E}{F_y}}$	  

$\lambda_{p limit}$ 6.69 λ_p 9.15

TABLE B4.1b (continued) Width-to-Thickness Ratios: Compression Elements Members Subject to Flexure					
Case	Description of Element	Width-to- Thickness Ratio	Limiting Width-to-Thickness Ratio		Examples
			λ_p (compact/ noncompact)	λ_r (noncompact/ slender)	
15	Webs of doubly symmetric I- shaped sections and channels	h/t_w	$3.76 \sqrt{\frac{E}{F_y}}$	$5.70 \sqrt{\frac{E}{F_y}}$	 

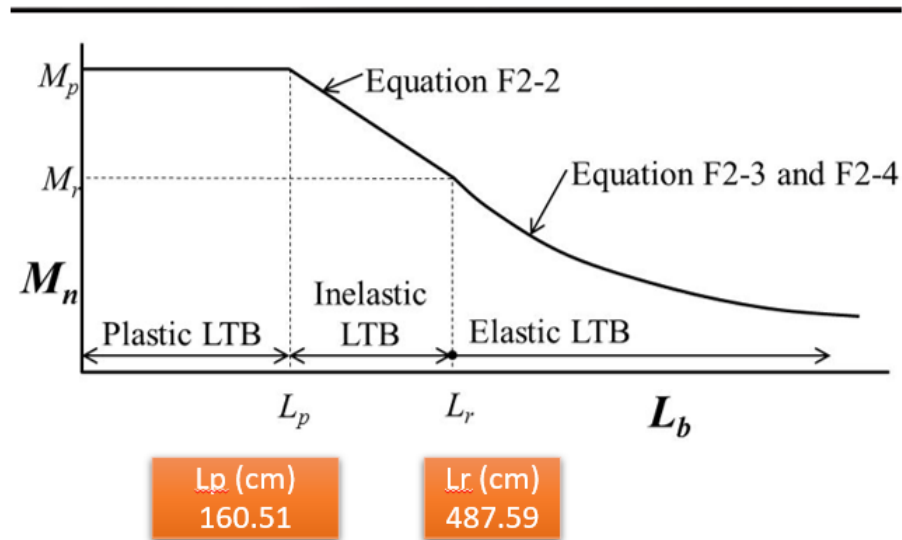
λ_{Alma} 37.33 λ_p 90.53

Sección Compacta

TABLE USER NOTE F1.1 Selection Table for the Application of Chapter F Sections				
Section in Chapter F	Cross Section	Flange Slenderness	Web Slenderness	Limit States
F2		C	C	Y, LTB

(TABLA extraída de AISC 360-16)

Flexión



$$L_p = 1.76 r_y \sqrt{\frac{E}{F_y}}$$

$$L_r = 1.95 r_{ts} \frac{E}{0.7 F_y} \sqrt{\frac{J_c}{S_x h_o} + \sqrt{\left(\frac{J_c}{S_x h_o}\right)^2 + 6.76 \left(\frac{0.7 F_y}{E}\right)^2}}$$

$$r_{ts}^2 = \frac{\sqrt{I_y C_w}}{S_x}$$

SUPOSICIÓN INICIAL → VIGA NO
ESTÁ SOPORTADA
LATERALMENTE

$$L_b = LUZ = 750cm$$

Flexión

(c) When $L_b > L_r$

$$M_n = F_{cr} S_x \leq M_p \quad (\text{F2-3})$$

where

L_b = length between points that are either braced against lateral displacement of the compression flange or braced against twist of the cross section, in. (mm)

$$F_{cr} = \frac{C_b \pi^2 E}{\left(\frac{L_b}{r_{ts}}\right)^2} \sqrt{1 + 0.078 \frac{Jc}{S_x h_o} \left(\frac{L_b}{r_{ts}}\right)^2} \quad (\text{F2-4})$$

Mn (kN.cm)

13713.47

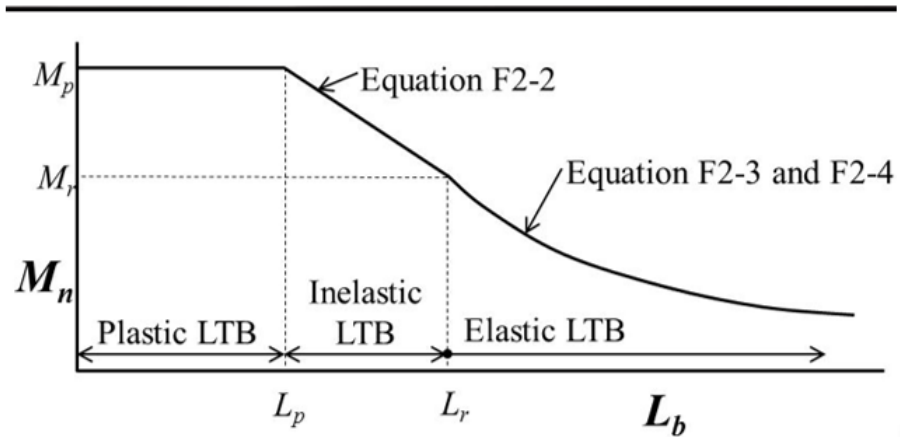
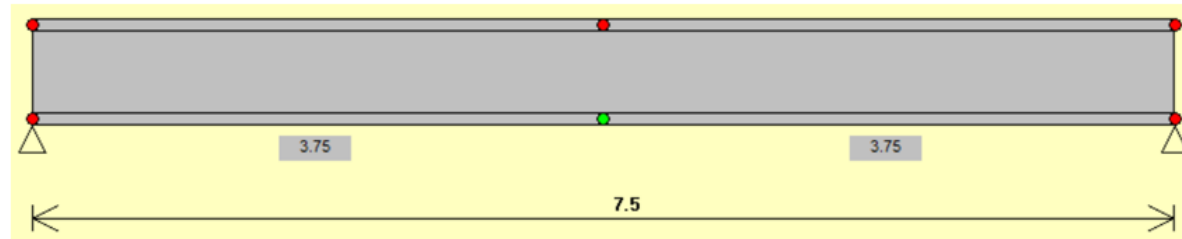
$\phi_b \cdot M_n$ (kN.cm)

12342.12

$$M_u = 17753,91 \text{ kN} \cdot \text{cm}$$

$$M_u / \phi_b \cdot M_n = \frac{17753,91}{12342,12} = 144\%$$

Flexión



L_p (cm)
160.51

L_r (cm)
487.59

$$L_b = \frac{LUZ}{2} = 375 \text{ cm}$$

(b) When $L_p < L_b \leq L_r$

$$M_n = C_b \left[M_p - (M_p - 0.7 F_y S_x) \left(\frac{L_b - L_p}{L_r - L_p} \right) \right] \leq M_p \quad (\text{F2-2})$$

$$M_u = 17753,91 \text{ kN} \cdot \text{cm}$$

$$M_u / \phi_b \cdot M_n = \frac{17753,91}{30819,72} = 58\%$$

M_n (kN.cm)
34244.13
 $\phi_b \cdot M_n$ (kN.cm)
30819.72

ELS (flecha)

$$f = \frac{5 \times q \times L^4}{384 \times E \times I}$$

$$f = \frac{5 \times 0,145 \times 750^4}{384 \times 20000 \times 16260} \cong 1,84cm$$

$$flecha_{límite} = \frac{L}{350} = \frac{750}{350} \cong 2,14cm$$

OK!

ELS (vibraciones)

Guía de ArcelorMittal

ArcelorMittal Europe - Long Products
Sections and Merchant Bars



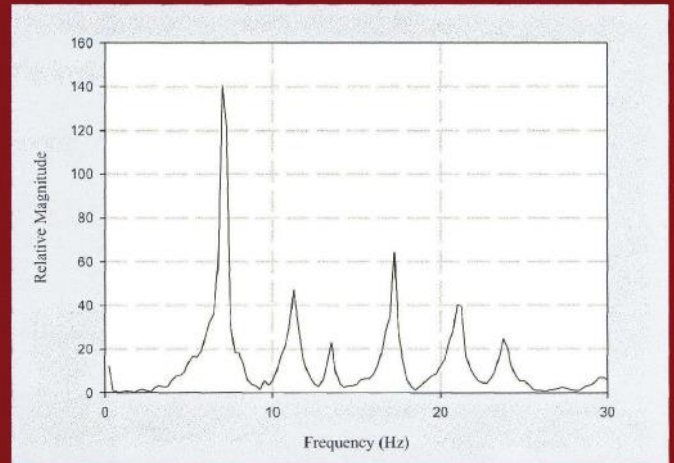
Guía de Diseño
para el análisis de las
vibraciones en forjados



11

Steel Design Guide Series

Floor Vibrations Due to Human Activity



ELS (vibraciones)

Guía de ArcelorMittal

OS-RMS₉₀ =

RMS – RMS valor de la velocidad de un paso representativo que incluya la intensidad del 90 % de los pasos de personas andando normalmente

OS: Un paso
v_{RMS}: Valor cuadrático medio = valor efectivo de la velocidad v:

$$v_{RMS} = \sqrt{\frac{1}{T} \int_0^T v(t)^2 dt} = \frac{v_{Peak}}{\sqrt{2}}$$

Siendo T el periodo de tiempo investigado.

Determinar las características dinámicas de los forjados

- Frecuencia Natural
- Masa Modal
- Amortiguación

(Capítulo 3; Anexo A)



Leer el Valor OS-RMS₉₀
(Capítulo 5)

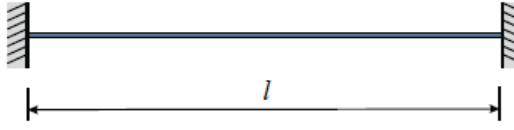
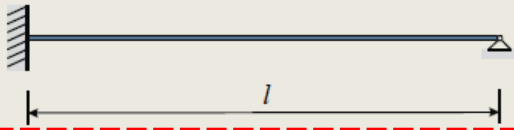
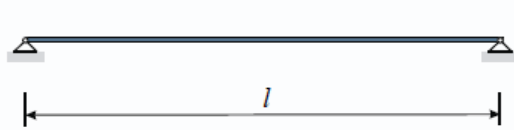
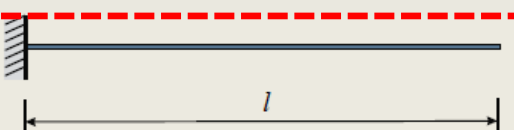


Determinar la Clase de Aceptación
(Capítulo 4)

ELS (vibraciones)

Frecuencia natural y masa modal

Tabla 3 Determinación de la primera frecuencia propia de vigas

Condiciones de apoyo	Frecuencia natural	Masa modal
	$f = \frac{4}{\pi} \sqrt{\frac{3 EI}{0.37 \mu l^4}}$	$M_{mod} = 0.41 \mu l$
	$f = \frac{2}{\pi} \sqrt{\frac{3 EI}{0.2 \mu l^4}}$	$M_{mod} = 0.45 \mu l$
	$f = \frac{2}{\pi} \sqrt{\frac{3 EI}{0.49 \mu l^4}}$	$M_{mod} = 0.5 \mu l$
	$f = \frac{1}{2\pi} \sqrt{\frac{3 EI}{0.24 \mu l^4}}$	$M_{mod} = 0.64 \mu l$

% CV	μ : Massa do piso (kg/m)	Massa Modal (kg)	Frecuencia Natural (Hz)
10.00%	1095.82	4109.33	4.83

ELS (vibraciones)

Amortiguamiento

Tabla 1 Determinación de la amortiguación

Tipo	Amortiguación (% de la amortiguación crítica)
Amortiguación estructural D_1	
Madera	6%
Hormigón	2%
Acero	1%
Mixta (Hormigón – Acero)	1%
Amortiguación debida al mobiliario D_2	
Oficina tradicional para 1 a 3 personas con tabiques de separación	2%
Oficina sin papeles	0%
Oficina en planta diáfana	1%
Biblioteca	1%
Casas	1%
Escuelas	0%
Gimnasios	0%
Amortiguación debida a terminaciones D_3	
Cielos rasos bajo el forjado	1%
Parquet flotante	0%
Capa de compresión	1%
Amortiguación total $D = D_1 + D_2 + D_3$	

$$D = 1\% + 2\% + 1\% = 4\%$$

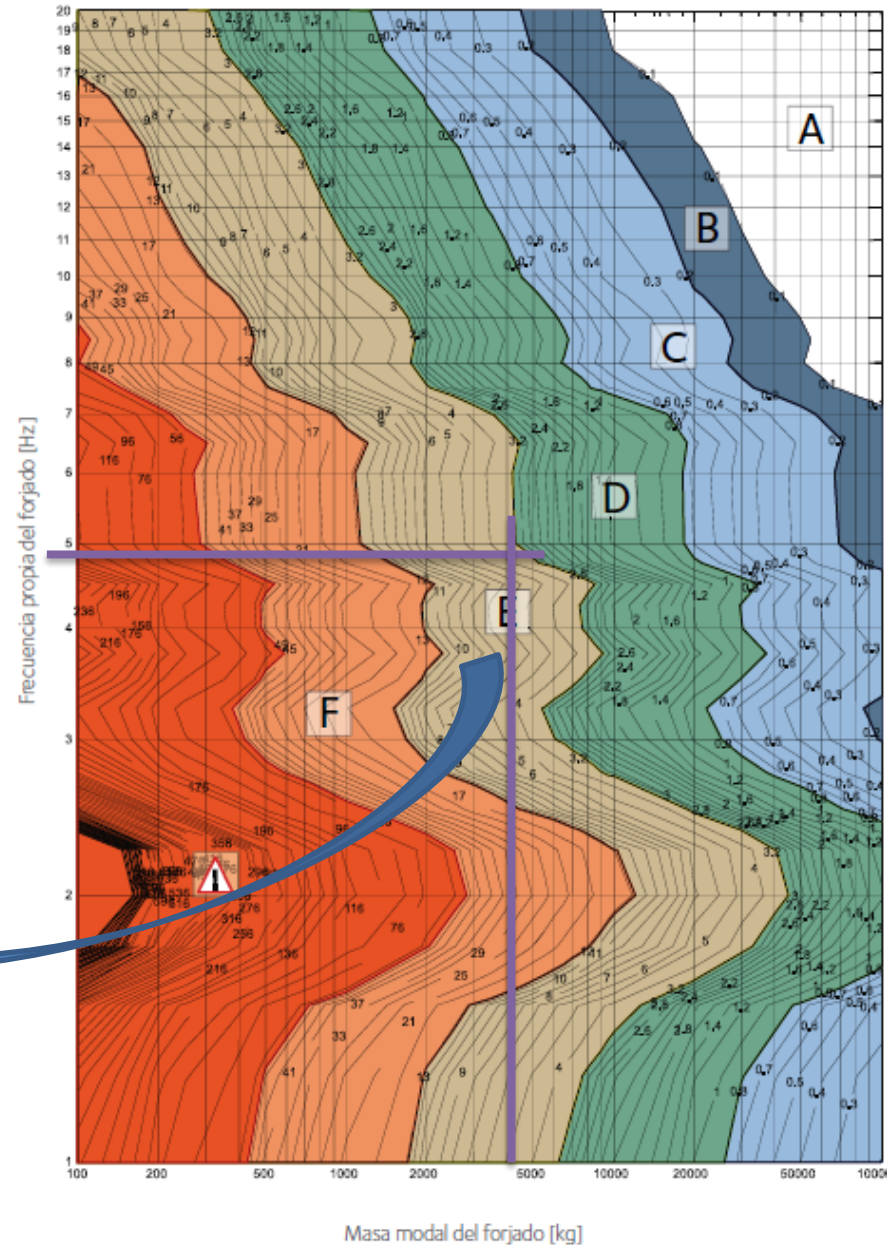
Clasificación basada en una amortiguación del 4%

ELS (vibraciones)

Ábaco

- D=4%
- F=4,83 Hz
- Massa Modal = 4109,33 kg

CLASE E

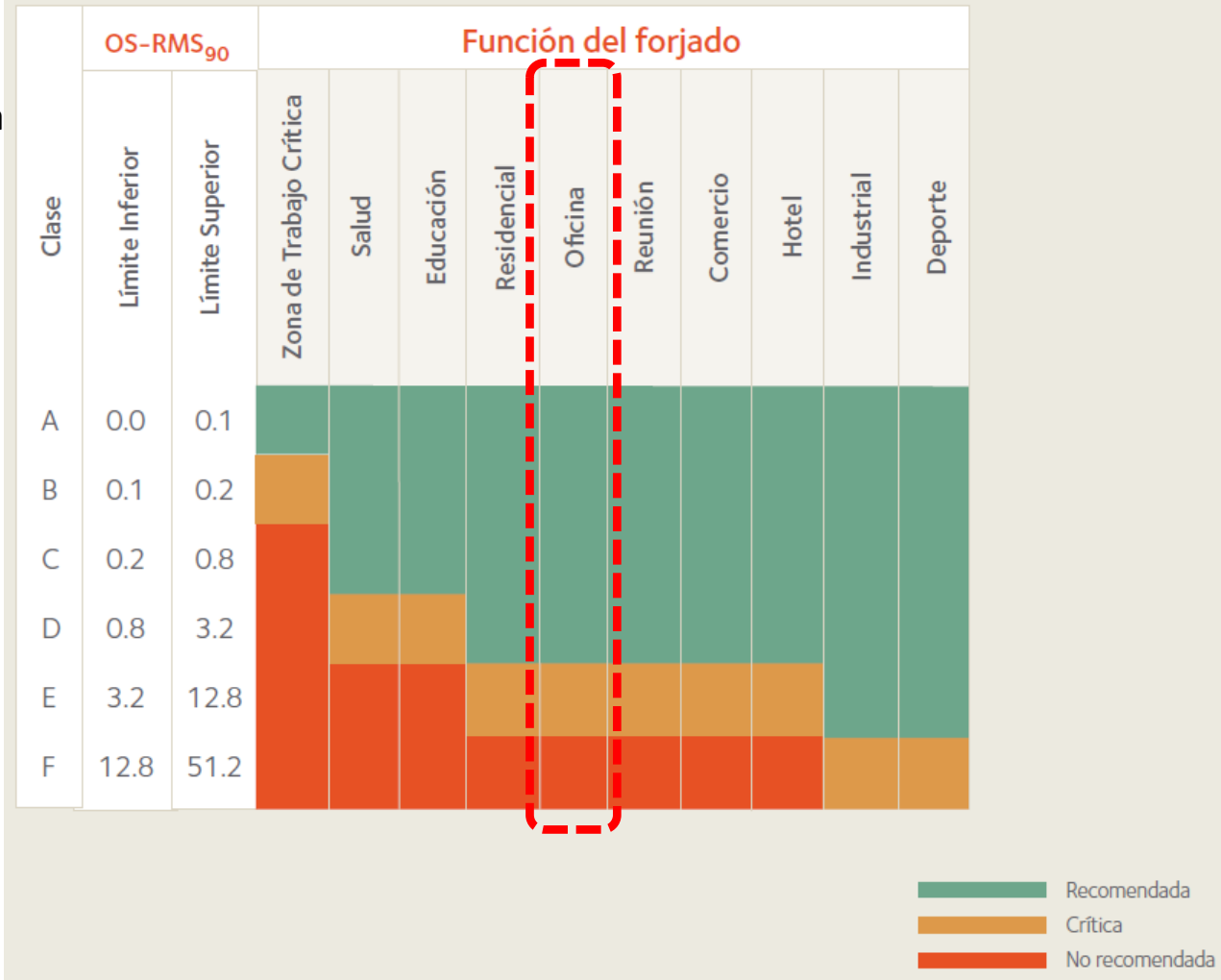


ELS (vibraciones)

Valores/rangos de aceptación

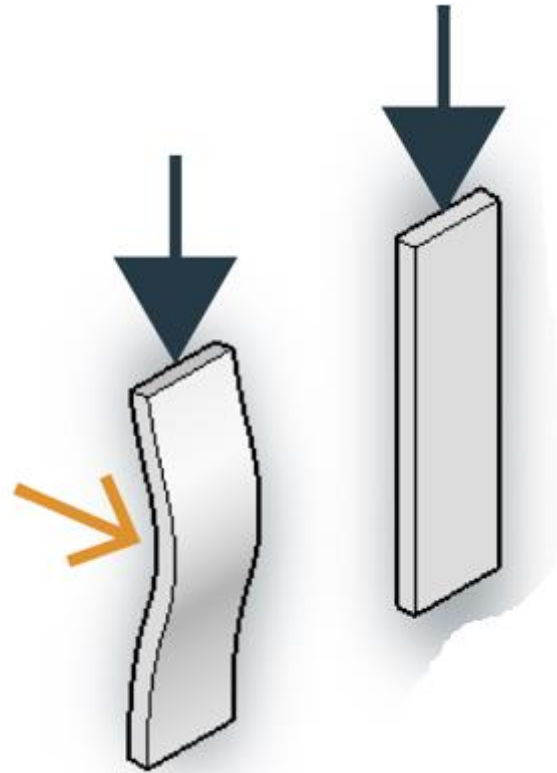
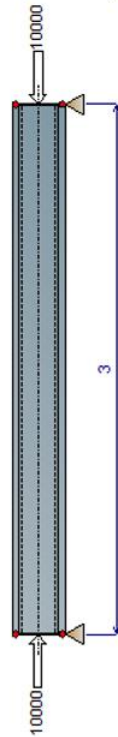
- Clase E + Oficinas → Condición crítica

Tabla 2 Clasificación de la respuesta del forjado y recomendaciones para la aplicación de clases



Column

ELEM. ACERO (I-PERFIL)



Cargas/Esfuerzos

Obs.: Norma brasileña

•ELU

Descripción	(kN/m ²)	γ _g
CP	4.00	1.4

CV (kN/m ²)	γ _q	ψ ₀	ψ ₁	ψ ₂
3.00	1.5	0.7	0.6	0.4

Combinaciones

$$F_d = \sum_{i=1}^m (\gamma_{gi} F_{Gi,k}) + \gamma_{q1} F_{Q1,k} + \sum_{j=2}^n (\gamma_{qj} \psi_{0j} F_{Qj,k})$$

Estado Límite Último

$$P_u = 5 \times 7,5 \times 7,5 \times (1,4 \times 4,0 + 1,5 \times 3,0) = 2840,625 \text{ kN}$$

Diseño a compresión

TABLE C-A-7.1 Approximate Values of Effective Length Factor, <i>K</i>						
Buckled shape of column is shown by dashed line	(a)	(b)	(c)	(d)	(e)	(f)
	Theoretical <i>K</i> value	0.5	0.7	1.0	1.0	2.0
	Recommended design value when ideal conditions are approximated	0.65	0.80	1.2	1.0	2.1
End condition code	 Rotation fixed and translation fixed Rotation free and translation fixed Rotation fixed and translation free Rotation free and translation free					

<u>P_u, S_d (kN)</u>	<u>K_x</u>	<u>L_x (m)</u>	<u>K_y</u>	<u>L_y (m)</u>	<u>K_z</u>	<u>L_z (m)</u>	<u>L_b, max (m)</u>	<u>Metric</u>	<u>Imperial</u>	<u>Steel Grade (MPa)</u>
2840.625	1	3.5	1	3.5	1	3.5	14.00	HE 280 A	0	345

<u>G (Kg/m)</u>	<u>h (mm)</u>	<u>bf (mm)</u>	<u>tw (mm)</u>	<u>tf (mm)</u>	<u>r (mm)</u>	<u>d (mm)</u>	<u>A_g (cm²)</u>	<u>I_x (cm⁴)</u>	<u>r_x (cm)</u>	<u>I_y (cm⁴)</u>	<u>r_y (cm)</u>	<u>J (cm⁴)</u>	<u>C_w (cm⁶)</u>	<u>λ_{FLANGE}</u>	<u>λ_{web}</u>
76.4	270	280	8	13	24	196	97.3	13670	11.86	4763	7	63.4561841	785400	10.77	24.50

Diseño a compresión

λ_{FLANGE}	λ_{web}
10.77	24.50

LOCAL BUCKLING ANALYSIS (TABLE B4.1a AISC 360-16)			
FLANGE		WEB	
λ_r	STATUS	λ_r	STATUS
13.48	OK	35.87	OK

The nominal compressive strength, P_n , shall be determined based on the limit state of flexural buckling:

$$P_n = F_{cr} A_g \tag{E3-1}$$

The critical stress, F_{cr} , is determined as follows:

(a) When $\frac{L_c}{r} \leq 4.71 \sqrt{\frac{E}{F_y}}$ (or $\frac{F_y}{F_e} \leq 2.25$)

$$F_{cr} = \left(0.658 \frac{F_y}{F_e} \right) F_y \tag{E3-2}$$

(b) When $\frac{L_c}{r} > 4.71 \sqrt{\frac{E}{F_y}}$ (or $\frac{F_y}{F_e} > 2.25$)

$$P_n = F_{cr} A_g \tag{E4-1}$$

The critical stress, F_{cr} , shall be determined according to Equation E3-2 or E3-3, using the torsional or flexural-torsional elastic buckling stress, F_e , determined as follows:

(a) For doubly symmetric members twisting about the shear center

$$F_e = \left(\frac{\pi^2 E C_w}{L_{cz}^2} + GJ \right) \frac{1}{I_x + I_y} \tag{E4-2}$$

FLEXURAL BUCKLING (AISC 360-16 / E3) X-X Axis			FLEXURAL BUCKLING (AISC 360-16 / E3) Y-Y Axis			TORSIONAL/FLEXURAL BUCKLING (AISC 360-16 / E4)			MEMBERS WITH SLENDER ELEMENTS (AISC 360-16 / E7)			
f_{e_x} (MPa)	F_{cr_x} (MPa)	$P_{n_{xx}}$ max (kN)	f_{e_y} (MPa)	F_{cr_y} (MPa)	$P_{n_{yy}}$ max (kN)	f_e (MPa)	F_{cr} (MPa)	P_n max (kN)	Flange Area Reduction (cm ²)	Web Area Reduction (cm ²)	A_e (cm ²)	P_n max (kN)
2266.54	323.71	3149.66	789.57	287.34	2795.80	951.39	296.42	2884.13	0.00	0.00	97.30	2795.80

P_u, R_d (kN)	P_u CHECK	$P_u, S_d / P_u, R_d$
2516.22	NÃO OK	112.89%

Diseño a compresión

<u>Pu, Sd (kN)</u>	<u>Kx</u>	<u>Lx (m)</u>	<u>Ky</u>	<u>Ly (m)</u>	<u>Kz</u>	<u>Lz (m)</u>	<u>Lb, max (m)</u>	<u>Metric</u>	<u>Imperial</u>	<u>Steel Grade (MPa)</u>
2840.625	1	3.5	1	3.5	1	3.5	15.14	HE 320 B	0	345

<u>G (Kg/m)</u>	<u>h (mm)</u>	<u>bf (mm)</u>	<u>tw (mm)</u>	<u>tf (mm)</u>	<u>r (mm)</u>	<u>d (mm)</u>	<u>Ag (cm²)</u>	<u>Ix (cm⁴)</u>	<u>rx (cm)</u>	<u>Iy (cm⁴)</u>	<u>ry (cm)</u>	<u>J (cm⁴)</u>	<u>Cw (cm⁶)</u>
127	320	300	11.5	20.5	27	225	161.3	30820	13.82	9239	7.57	230.452848	2069000

			LOCAL BUCKLING ANALYSIS (TABLE B4.1a AISC 360-16)			FLEXURAL BUCKLING (AISC 360-16 / E3) X-X Axis			FLEXURAL BUCKLING (AISC 360-16 / E3) Y-Y Axis			TORSIONAL/FLEXURAL BUCKLING (AISC 360-16 / E4)			MEMBERS WITH SLENDER ELEMENTS (AISC 360-16 / E7)								
			FLANGE		WEB																		
λ_{FLANGE}	λ_{web}	λ_r	STATUS		λ_r	STATUS		f_{e_x} (MPa)	F_{cr_x} (MPa)	P_{n_x} , max (kN)	f_{e_y} (MPa)	F_{cr_y} (MPa)	P_{n_y} , max (kN)	f_e (MPa)	F_{cr} (MPa)	P_n , max (kN)	Flange Area Reduction (cm ²)	Web Area Reduction (cm ²)	A_e (cm ²)	P_n , max (kN)	P_u , Rd (kN)	Pu CHECK	P_u , Sd / P_u , Rd
7.32	19.57	13.48	OK		35.87	OK		3077.58	329.19	5309.78	923.39	295.06	4759.25	1274.78	308.05	4968.88	0.00	0.00	161.30	4759.25	4283.32	OK	66.32%

Comparación → Software

VIGA SIN SOPORTE LATERAL

Stress Check forces and Moments

Location (m)	P_u (kN)	M_{u33} (kN-m)	M_{u22} (kN-m)	V_{u2} (kN)	V_{u3} (kN)	T_u (kN)
4	0.1791	176.75	0	6.3125	0	0

Axial Force & Biaxial Moment Design Factors (H1.2,H1-1b)

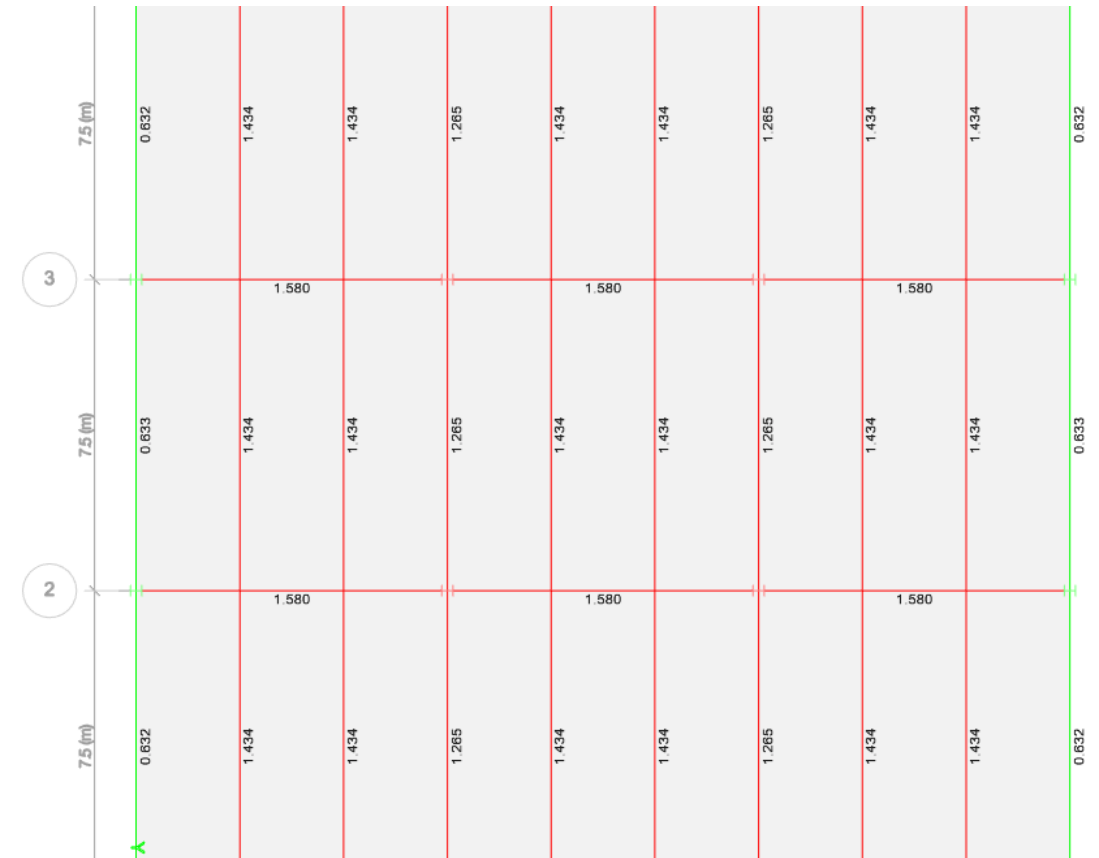
	L Factor	K_1	K_2	B_1	B_2	C_m
Major Bending	1	1	1	1	1	1
Minor Bending	1	1	1	1	1	1

Parameters for Lateral Torsion Buckling

L_{tb}	K_{tb}	C_b
1	1	1.137

Demand/Capacity (D/C) Ratio Eqn.(H1.2,H1-1b)

D/C Ratio =	$(P_u/2P_c) + (M_{u33}/M_{c33}) + (M_{u22}/M_{c22})$
1.434 =	$3.968E-05 + 1.434 + 0$



Comparación → Software

VIGA CON SOPORTE LATERAL

ET Steel Frame Design Overwrites for AISC 360-16

Item	Value
22 Total-Camber Deflection Limit, abs, m	0.03125
23 Specified Camber, m	0
24 Net Area to Total Area Ratio	1
25 Live Load Reduction Factor	0.996604
26 Unbraced Length Ratio (Major)	1
27 Unbraced Length Ratio (Minor)	1
28 Unbraced Length Ratio (LTB)	0.5
29 Effective Length Factor (K1 Major)	1
30 Effective Length Factor (K1 Minor)	1
31 Effective Length Factor (K2 Major)	1
32 Effective Length Factor (K2 Minor)	1
33 Effective Length Factor (K LTB)	1
34 Moment Coefficient (Cm Major)	1
35 Moment Coefficient (Cm Minor)	1
36 Bending Coefficient (Cb)	1.3
37 NonSway Moment Factor (B1 Major)	1
38 NonSway Moment Factor (B1 Minor)	1
39 Sway Moment Factor (B2 Major)	1

Item Description
The design section for the selected frame objects. When this overwrite is applied, any previous auto select section assigned to the frame object is removed. Program determined value means it is taken from the analysis section.

Explanation of Color Coding for Values
Blue: All selected items are program determined
Black: Some selected items are user defined
Red: Value that has changed during the current session

Set To Default Values: All Items, Selected Items
 Reset To Previous Values: All Items, Selected Items

OK Cancel

Stress Check forces and Moments

Location (m)	P _u (kN)	M _{u33} (kN-m)	M _{u22} (kN-m)	V _{u2} (kN)	V _{u3} (kN)	T _u (kN-m)
4	0.1831	176.75	0	6.3125	0	0

Axial Force & Biaxial Moment Design Factors (H1.2,H1-1b)

	L Factor	K ₁	K ₂	B ₁	B ₂	C _m
Major Bending	1	1	1	1	1	1
Minor Bending	1	1	1	1	1	1

Parameters for Lateral Torsion Buckling

L _{ltb}	K _{ltb}	C _b
0.5	1	1.3

Demand/Capacity (D/C) Ratio Eqn.(H1.2,H1-1b)

D/C Ratio =	$(P_r / 2P_c) + (M_{r33} / M_{c33}) + (M_{r22} / M_{c22})$
0.572 =	4.056E-05 + 0.572 + 0

Comparación → Software

COLUMNA

Stress Check forces and Moments

ation (m)	P _u (kN)	M _{u33} (kN-m)	M _{u22} (kN-m)	V _{u2} (kN)	V _{u3} (kN)	T _u (kN-m)
3.14	-2840.625	0.0085	-0.0003	-0.0027	0.0001	0

Axial Force & Biaxial Moment Design Factors (H1-1a)

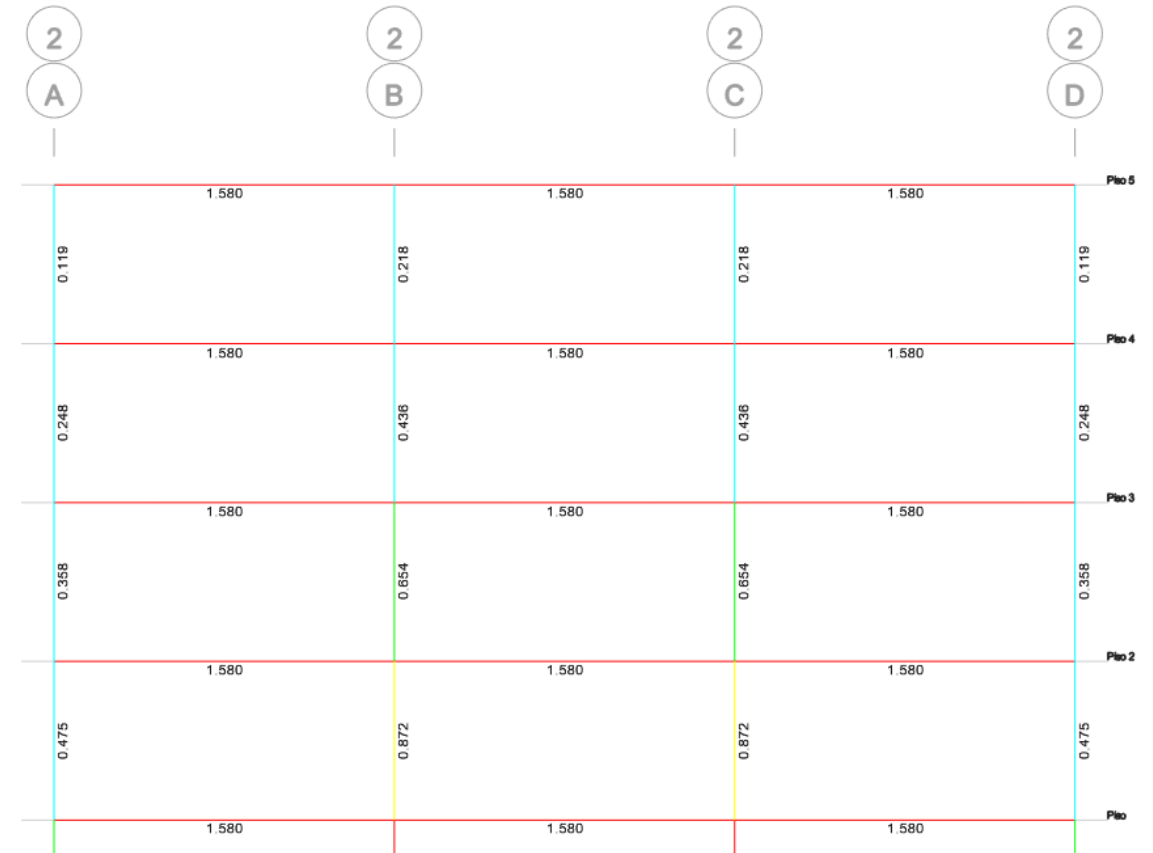
	L Factor	K ₁	K ₂	B ₁	B ₂	C _m
Major Bending	0.897	1	1	1	1	0.6
Minor Bending	0.897	1	1	1	1	0.6

Parameters for Lateral Torsion Buckling

L _{ltb}	K _{ltb}	C _b
0.897	1	1.667

Demand/Capacity (D/C) Ratio Eqn.(H1-1a)

D/C Ratio =	$(P_r/P_c) + (8/9)(M_{r33}/M_{c33}) + (8/9)(M_{r22}/M_{c22})$
1.09 =	1.09 + 2.27E-05 + 0



Comparación → Software

COLUMNA

Stress Check forces and Moments

Location (m)	P_u (kN)	M_{u33} (kN-m)	M_{u22} (kN-m)	V_{u2} (kN)	V_{u3} (kN)
3.1	-2840.625	-0.0214	-0.0006	0.0069	0.0002

Axial Force & Biaxial Moment Design Factors (H1-1a)

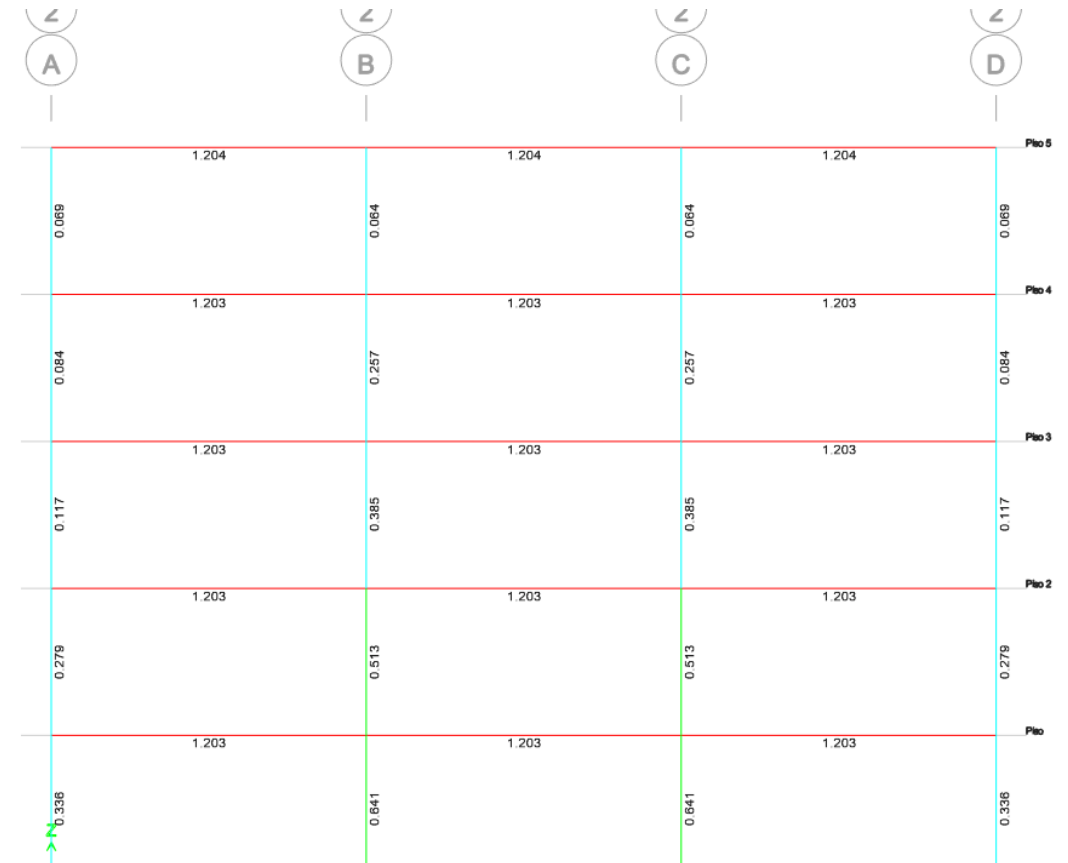
	L Factor	K_1	K_2	B_1	B_2	C_m
Major Bending	0.886	1	1	1	1	0.6
Minor Bending	0.886	1	1	1	1	0.6

Parameters for Lateral Torsion Buckling

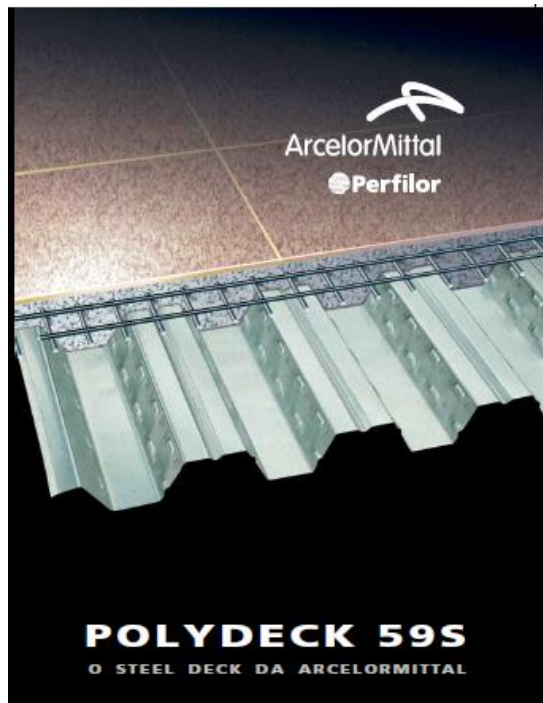
L_{ltb}	K_{ltb}	C_b
0.886	1	1.667

Demand/Capacity (D/C) Ratio Eqn.(H1-1a)

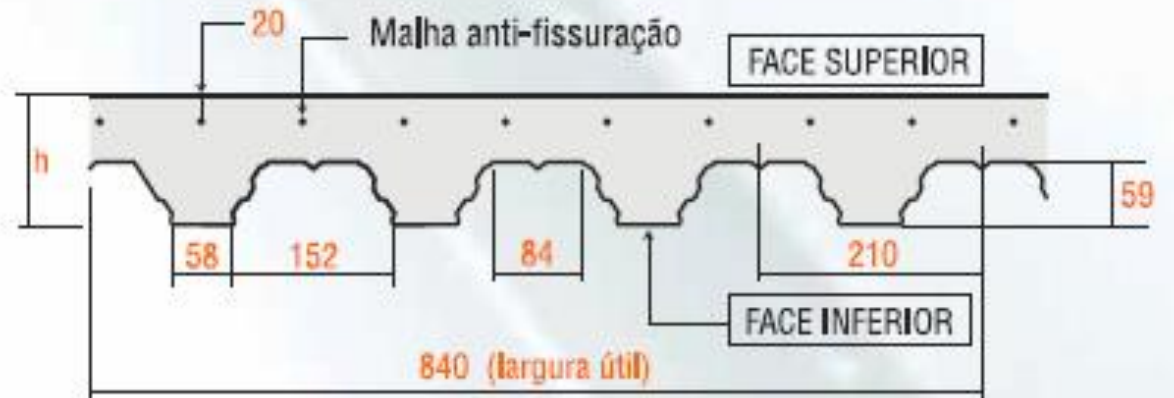
D/C Ratio =	$(P_r/P_c) + (8/9)(M_{r33}/M_{c33}) + (8/9)(M_{r22}/M_{c22})$
0.641 =	0.641 + 2.846E-05 + 0



¿Qué pasa si consideramos la viga en comportamiento mixto?



Características geométricas da laje



DESCRIÇÃO	TIPO	FASE	DURAÇÃO	VALOR (kN/m²)	$\chi_{g,q}$	ψ_0	ψ_1	ψ_2
P. proprio	Permanente	ISOLADA	N/A	0.00	1.4	N/A	N/A	N/A
Laje + piso	Permanente	ISOLADA	N/A	3.00	1.4	N/A	N/A	N/A
Rev., forro, partitioning+ utilities	Permanente	MISTA	LONGA	1.00	1.4	N/A	N/A	N/A
SC Hospital	Acidental	MISTA	CURTA	3.00	1.5	0.7	0.6	0.4

ANTES DA CURA (Ação Isolada)			
qELU (kN/m)	qELS (kN/m)	MSd (kN.cm)	VSd (kN)
10.50	7.50	12780.00	152.70

APÓS CURA (Ação Mista)				
qELU (kN/m)	qELSlong (kN/m)	qELScurt (kN/m)	MSd (kN.m)	VSd (kN)
25.25	2.50	4.5	17753.91	94.69

fck (MPa)	γc	TIPO DE LAJE	hc (tc) (cm)	hp (hf) (cm)	h laje (cm)	Lj (m)	bef Largura Efetiva (m)
25	1.4	STEEL-DECK	6.1	5.9	12.00	2.5	1.88

BITOLA	ø (mm)	L (mm)	Acs (cm²)	fucs (MPa)	γcs
M16x100	15.875	100	1.979	420	1.25

STEEL-DECK COM NERVURAS PERPENDICULARES À VIGA METÁLICA

COLOCAR CONECTORES A...	e,Nervura (mm)	el (mm)	TOT Conectores
cada 1 Nervura	N/A	210	35

RESUMO DA SOLUÇÃO INTRODUZIDA

LAJE	DIR. NERVURA	CONECTOR	ø (mm)	L (mm)	TOT Conectores	et (mm)	el (mm)
STEEL-DECK	Perpendicular	M16x100	15.875	100	35	N/A	210.00

GRAU DE INTERAÇÃO - 0.2.3.1.1.2.a (Vigas com mesas de mesma área)

Rtd ou Tad (kN)	Rcd ou Ccd (kN)	Fhd (kN)	ΣQRd (kN)	ηi	ηi, min	CHECK
2258.243122	1736.049107	1736.049107	847.9432971	0.488432783	0.473446668	INTERAÇÃO PARCIAL

	L Homo (cm)	Área Homo (cm²)	I homo (cm⁴)	YCG (cm)	y lage YCG (cm)	Y perfil YCG (cm)	Itot (Itr) (cm⁴)	Ief (cm⁴)
CURTA DUR.	22.31	136.11	422.04	35.56	9.39	-17.56	51114.77	40620.98307
LONGA DUR.	7.44	45.37	140.68	28.35	16.60	-10.35	36699.06	30546.13993

$$INERCIA_{aislada} = 16260 cm^4$$

Avaliação OS-RMS90

Considerado o Módulo Elástico do Concreto $E_{dyn} = 1,1 * E_{cm}$

EUROCODES

Ecm (kN/cm²)	Edyn (kN/cm²)	Alfa Homog.	Bef Seção Mista (cm)
3147.580621	3462.338683	5.7764424	32.45942515

Área Homo (cm²)	I homo (cm⁴)	YCG (cm)	y lage YCG (cm)	Y perfil YCG (cm)	Itot (Itr) (cm⁴)	Ief (cm⁴)
198.0024934	613.9727317	37.710165	7.239834759	-19.71016524	55512.5724	43694.5

<i>MRd,INT PARC</i> <i>(kN·cm)</i>
48008.63531

$$MRd_{aislada} = 30819.72 kN \cdot cm$$

FLIM (cm)	FLECHA ISOLADA (cm)	FLECHA MISTA(cm)		TOT (cm)
		Curta	Longa	
2.14	0.95	0.23	0.17	1.35

CF MÁX (cm)	CF APLIC. (cm)	FLECHA FIN (cm)	Rel. (L/?)	RESULTADO
0.95	0	1.35	557	OK

$$flecha_{aislada} = 1,84cm$$

% SC	μ: Massa do piso (kg/m)	Massa Modal (kg)	Frequencia Natural (Hz)	Freq. LIM (Hz)	RESULTADO
10.00%	1095.82	4109.33	7.91		OK

ELU FASE ISOLADA	MSd (kN.cm)	MRd (kN.cm)	TAXA
	12780.00	30828.60	41.46%
	VSd (kN)	VRd (kN)	TAXA
	152.70	536.54	28.46%

ELU FASE MISTA	MSd (kN.cm)	MRd (kN.cm)	TAXA
	17753.91	48008.64	36.98%
	VSd (kN)	VRd (kN)	TAXA
	94.69	536.54	17.65%

¡Muchas gracias por su atención!

DESCARGA DE MATERIAL DE APOYO

Catálogos

Folletos

Softwares de prediseño

sections.arcelormittal.com

INFORMACIÓN DE CONTACTO

Ing. Daniel Ureña Muñoz. M.Sc.

durenamunoz@gmail.com

(506) 8910-8072

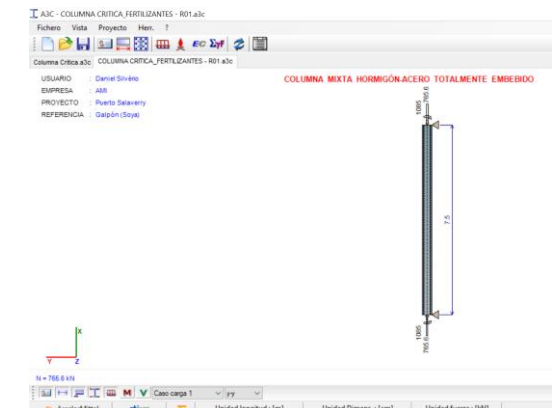
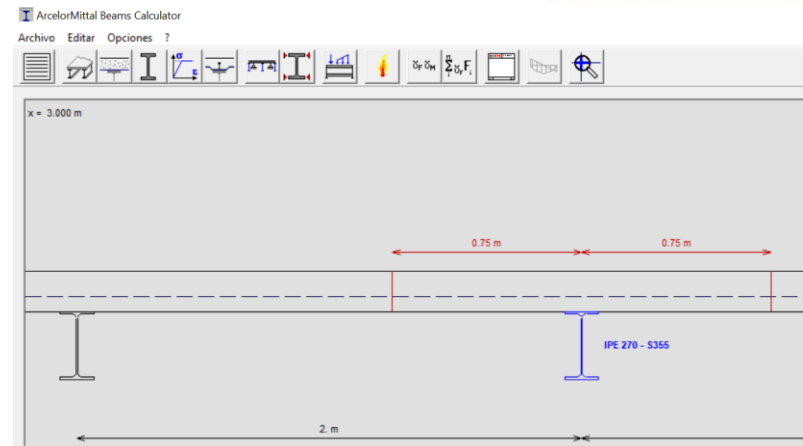
Cartago, Costa Rica

Ing. Daniel Silvério

daniel.Silverio@arcelormittal.com.br

+55 11 94511 6438

São Paulo, Brasil



Preguntas y Respuestas