


SISTEMA DINÁMICO FEMSA BOGOTÁ

MEMORIA DE CÁLCULO  
SISTEMA DINÁMICO FEMSA BOGOTÁ  
REFERENCIA: 220920-01-ES-MC-02 R1



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# SISTEMA DINÁMICO FEMSA BOGOTÁ

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## SISTEMA DINÁMICO FEMSA BOGOTÁ

### RESUMEN

Localización:	Bogotá
Niveles de almacenamiento sobre vigas:	Tres (3)
Sistema de piso:	N/A
Método de análisis:	Estático equivalente
Sistema estructural:	Anaqueles de acero para almacenamiento
Zona de amenaza sísmica:	Intermedia
Perfil del suelo:	Lacustre 500
Grupo de uso:	I (I= 1.00)

### CARGAS

#### MUERTAS

No hay cargas muertas adicionales al peso propio de los elementos estructurales

#### ALMACENAMIENTO

Estibas 1500 kgf

#### VIVAS

Plataforma 300 kgf/m<sup>2</sup>

### MATERIALES

#### ACERO ESTRUCTURAL

Fy= 235 MPa (Q235B)

Fy= 355 MPa (Q355B)

#### NORMAS Y REGLAMENTOS DE DISEÑO

Reglamento Colombiano de Construcción Sismo Resistente, NSR-10



# SISTEMA DINÁMICO FEMSA BOGOTÁ

## DESCRIPCIÓN GENERAL

Por solicitud de JUNGHEINRICH COLOMBIA S.A.S. se realizó el diseño de racks para sistema dinámico de tres (3) niveles a construirse en Bogotá, Colombia.

La Tabla 1 describe detalladamente la solución estructural, en función de su ubicación, para cada pórtico estructural.

Tabla 1 Descripción del sistema estructural

Sistema de resistencia sísmica (Fuerzas horizontales)	Sistema de resistencia para cargas verticales	$R_o$	$\Omega_o$
Anaqueles de acero para almacenamiento	El mismo	4.00	2.00

Tabla 2 Características generales

Zona de amenaza sísmica	Intermedia
Perfil del suelo	Lacustre 500
Grupo de uso	I (Ocupación normal)
Coefficiente de importancia	$I= 1.00$
Configuración estructural	
Irregularidad en planta	$\phi_p= 1.00$
Irregularidad en altura	$\phi_a= 1.00$
Irregularidad por ausencia de redundancia	$\phi_r= 1.00$
Coefficiente de disipación de energía básico	$R_o= 4.00$
Coefficiente de disipación de energía de diseño	$R= R_o \cdot \phi_p \cdot \phi_a \cdot \phi_r= 4.00$
Método de análisis	Estático equivalente

## SISTEMA DINÁMICO FEMSA BOGOTÁ

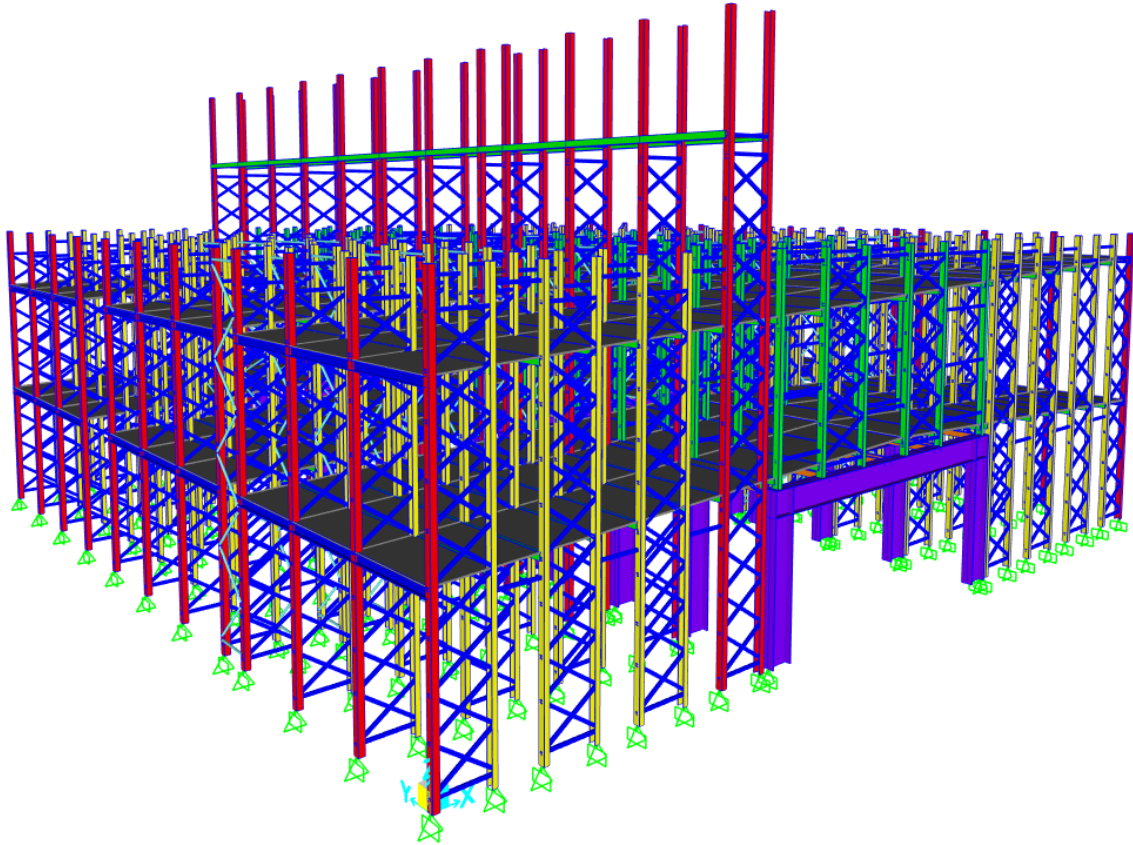


Fig. 1 Vista 3D del modelo estructural

### CÓDIGOS Y ESPECIFICACIONES

El presente diseño se ha realizado teniendo en cuenta las especificaciones y pautas del Reglamento Colombiano de Construcción Sismo Resistente, NSR-10, cumpliendo con los requisitos correspondiente con el sistema estructural utilizado.

### METODOLOGÍA

El diseño se hizo para la zona de amenaza sísmica intermedia de Bogotá, teniendo en cuenta los parámetros para el diseño sísmico del Reglamento Colombiano de Construcción Sismo Resistente, NSR-10.

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### 1 EVALUACIÓN DE LAS SOLICITACIONES DEFINITIVAS

#### 1.1 PESO PROPIO DE ELEMENTOS NO ESTRUCTURALES, D

El peso propio de la estructura (Parales, largueros y arriostramientos) es considerado automáticamente en el modelo estructural.

#### 1.2 PRODUCTO ALMACENADO, P

La carga por producto almacenado (Estibas) se concentra en los niveles 2 y 3 de la estructura.

El nivel 2 tiene dos zonas de almacenamiento (Dos pendientes) de 14.94 m<sup>2</sup> y 13.48 m<sup>2</sup> por bahía. Mientras el nivel 3 tiene una única zona (Una sola pendiente) de 28.41 m<sup>2</sup>.

La Tabla 3 muestra el peso por cada zona, considerando estibas de 1500 kgf (15 kN).

Tabla 3 Carga de diseño por zonas de almacenamiento

Nivel	Zona	Número de estibas	Peso (kPa)
3	Única	15	7.77
2	Izquierda	8	7.88
2	Derecha	7	7.64

#### 1.3 CARGAS VIVAS, L

En la plataforma de operación se considera una carga distribuida de 300 kgf/m<sup>2</sup> (3.00 kPa).

#### 1.4 IMPACTO, I

Las vigas de soporte serán diseñadas para una carga vertical adicional del 25%.

#### 1.5 FUERZAS DE VIENTO

Como los racks estarán instalados dentro de una nave industrial no se considera expuesto a las acciones eólicas.

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### 2 NIVEL DE AMENAZA SÍSMICA Y VALORES Aa Y Av

La estructura se construirá en el municipio de Bogotá. De acuerdo con el apéndice A-4 del Reglamento Colombiano de Construcción Sismo Resistente (NSR-10), se clasifica como se indica en la Tabla 4.

Tabla 4 Nivel de amenaza sísmica (Escenario sísmico de diseño)

Municipio	Código	Aa	Av	Zona de amenaza sísmica
Bogotá	11001	0.15	0.20	Intermedia

### 3 MOVIMIENTOS SÍSMICOS DE DISEÑO

Las características de la estratificación del suelo corresponden con un perfil de suelo Lacustre 500.

Adicionalmente, los valores de Aa y Av, obtenidos en la sección 2, los valores de Fa y Fv son:

Tabla 5 Factores de amplificación sísmica

Perfil de suelo	Fa	Fv
Lacustre 500	0.95	2.70

Considerando el uso de la estructura, se considera como una estructura de ocupación normal. De ese modo, la estructura se clasifica, de acuerdo con la sección A.2.5.1 de la NSR-10 y con la sección 2.6.2 de ANSI MH16.1:2012, como grupo de uso I. Obteniéndose un coeficiente de importancia  $I = 1.00$ .

Así, al aplicar las ecuaciones de la sección A.2.6 de la NSR-10, se obtiene el espectro elástico de diseño mostrado en la Fig. 2.

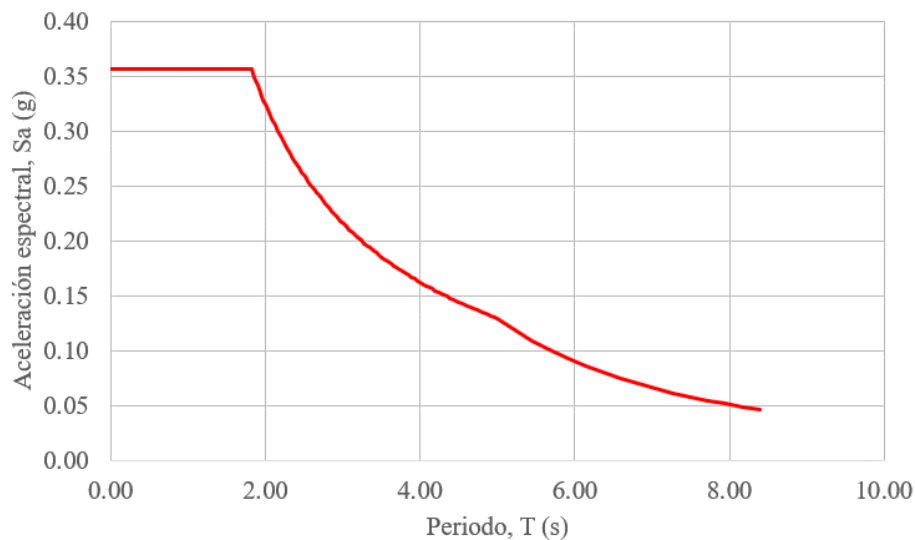


Fig. 2 Espectro elástico de diseño

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### 4 CARACTERÍSTICAS DE LA ESTRUCTURACIÓN Y DEL MATERIAL

Las Tabla 6 y Tabla 7 indican las especificaciones del material para los miembros metálicos.

Tabla 6 Características del material Q235B

Característica	Valor
Peso por unidad de volumen	77 kN/m <sup>3</sup>
Masa por unidad de volumen	7850 kg/m <sup>3</sup>
Módulo de elasticidad	200000 MPa
Relación de Poisson	0.30
Coefficiente de expansión térmica	1.17x10e-5
Módulo de corte	76923 MPa
Tensión cedente	235 MPa
Tensión de rotura	370 MPa

Tabla 7 Características del material Q335B

Característica	Valor
Peso por unidad de volumen	77 kN/m <sup>3</sup>
Masa por unidad de volumen	7850 kg/m <sup>3</sup>
Módulo de elasticidad	200000 MPa
Relación de Poisson	0.30
Coefficiente de expansión térmica	1.17x10e-5
Módulo de corte	76923 MPa
Tensión cedente	335 MPa
Tensión de rotura	470 MPa

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### 5 DETERMINACIÓN DE LAS FUERZAS SÍSMICAS

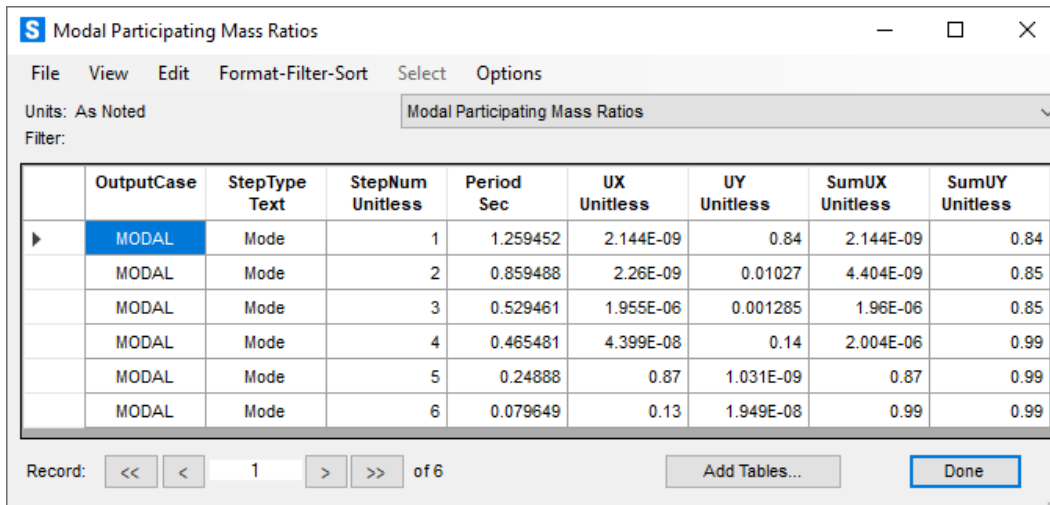
Considerando que en la sección anterior se indicó que se utilizará como procedimiento de análisis el método de fuerza horizontal equivalentes, las fuerzas sísmicas serán calculadas y aplicadas, –automáticamente por el programa– tomando en cuenta el espectro elástico de diseño, y el periodo de cada modo de vibración, producto del desacople modal de la ecuación de equilibrio dinámico del sistema estructural.

### 6 ANÁLISIS SÍSMICO DE LA ESTRUCTURA

#### 6.1 MODOS DE VIBRACIÓN

Para el análisis dinámico se ha considerado la masa total de la estructura más el 67% de la carga de almacenamiento y el 25% de la carga viva.

Se han utilizado 6 modos de vibración para incluir en la respuesta más del 90% de la masa participante de la estructura.



The screenshot shows a software window titled "Modal Participating Mass Ratios". It contains a table with the following data:

	OutputCase	StepType Text	StepNum Unitless	Period Sec	UX Unitless	UY Unitless	SumUX Unitless	SumUY Unitless
▶	MODAL	Mode	1	1.259452	2.144E-09	0.84	2.144E-09	0.84
	MODAL	Mode	2	0.859488	2.26E-09	0.01027	4.404E-09	0.85
	MODAL	Mode	3	0.529461	1.955E-06	0.001285	1.96E-06	0.85
	MODAL	Mode	4	0.465481	4.399E-08	0.14	2.004E-06	0.99
	MODAL	Mode	5	0.24888	0.87	1.031E-09	0.87	0.99
	MODAL	Mode	6	0.079649	0.13	1.949E-08	0.99	0.99

At the bottom of the window, there is a "Record:" section with navigation buttons (left arrow, right arrow) and a text box containing "1" followed by "of 6". There are also buttons for "Add Tables..." and "Done".

Fig. 3 Masa participativa

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### 6.2 CORTANTE SÍSMICO DE DISEÑO, VS

$$S_{DS} = 0.3563g$$

$$S_{D1} = 0.3563g$$

$$T = 1.2595s$$

$$\rho = \begin{cases} x \rightarrow 1.00 \\ y \rightarrow 1.00 \end{cases}$$

$$R = \begin{cases} x \rightarrow 4 \\ y \rightarrow 6 \end{cases}$$

$$C_s = \begin{cases} x \rightarrow 0.0707g \\ y \rightarrow 0.0472g \end{cases}$$

### 7 VERIFICACIÓN DE DISTANCIAS SÍSMICAS

Joint Text	OutputCase	CaseType Text	U1 mm	U2 mm
4779	EQX	LinStatic	1.798655	0.00809
4759	EQX	LinStatic	1.798299	0.009458
4777	EQX	LinStatic	1.798201	0.008401
4799	EQX	LinStatic	1.798138	-0.014797
4757	EQX	LinStatic	1.797871	0.008627
4797	EQX	LinStatic	1.797658	-0.018151
4739	EQX	LinStatic	1.796879	0.009599
4737	EQX	LinStatic	1.796456	0.009586
4719	EQX	LinStatic	1.795733	0.013399
4717	EQX	LinStatic	1.794886	0.013452

Joint Text	OutputCase	CaseType Text	U1 mm	U2 mm
4859	EQY	LinStatic	0.006264	33.533032
4860	EQY	LinStatic	0.016902	33.336091
4861	EQY	LinStatic	0.013706	33.181069
4858	EQY	LinStatic	0.01026	33.083733
4798	EQY	LinStatic	0.002526	33.082993
4862	EQY	LinStatic	0.021643	32.981999
4839	EQY	LinStatic	0.004875	32.351015
4819	EQY	LinStatic	-0.011218	32.34736
4820	EQY	LinStatic	-0.012688	32.194773
4840	EQY	LinStatic	0.002759	32.19196

Considerando los factores de amplificación de deflexión,  $C_d$ , para cada dirección de análisis, los desplazamientos esperados serían:

$$\delta = \begin{cases} x \rightarrow 3.5 \cdot 1.80\text{mm} = 6.30\text{mm} \\ y \rightarrow 5.5 \cdot 33.54\text{mm} = 184.50\text{mm} \end{cases}$$

Los desplazamientos máximos se limitan:

$$\delta_{\text{máx}} = \begin{cases} x \rightarrow 0.02 \cdot 6106\text{mm} = 122.12\text{mm} \\ y \rightarrow 0.05 \cdot 6106\text{mm} = 305.30\text{mm} \end{cases}$$

De este modo se verifica que los desplazamientos laterales son menores a los máximos definidos.

### 8 COMBINACIÓN DE LAS DIFERENTES SOLICITACIONES

La estructura, sus miembros, elementos y conexiones se verificarán para que, en los escenarios de diseño, tanto para estados límite de agotamiento y de servicio, su capacidad sea mayor a la demanda a la que estará sometida durante su vida útil, de acuerdo con sus condiciones de trabajo.

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### 8.1 COMBINACIONES DE CARGA MAYORADAS (RESISTENCIA)

Tabla 8 Combinaciones de carga mayoradas (Resistencia)

Identificación	Combinación de carga
DIS1	$1.4D+1.2P$
DIS2	$1.2D+1.4P+1.6L+0.5Lr$
DIS3	$1.2D+0.85P+0.5L+1.6Lr$
DIS4	$1.2D+0.85P+0.5L+0.5Lr$
DIS5	$(1.20+0.2SDS)D+(1.20+0.2SDS)P+0.5L+E$
DIS6	$0.9D+0.9P$
DIS7	$(0.9-0.2SDS)D+(0.9-0.2SDS)0.7PAPP+E$
DIS8	$1.2D+1.6L+1.4P+1.4I$

Las fuerzas sísmicas, E, utilizadas en las combinaciones de carga mayoradas, de la Tabla 8, hacen referencia a fuerzas sísmicas, calculadas de acuerdo con la sección 5, se reducirán por el coeficiente de disipación de energía de la estructura, R.

### 8.2 COMBINACIONES DE CARGA DE SERVICIO

Tabla 9 Combinaciones de carga de servicio

Identificación	Combinación de carga
SER1	$D+P$
SER2	$D+P+L$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### 9 VERIFICACIÓN DE LOS ELEMENTOS ESTRUCTURALES

Luego de haber realizado el modelo matemático y de establecer todos los datos de entrada indicados en las secciones anteriores, se obtienen relaciones de trabajo satisfactorias.

En los anexos se detallan los resultados para los elementos más importantes de la estructura.

### 10 CONCLUSIONES

Del diseño estructural se puede evidenciar que los miembros estructurales propuestos son satisfactorios, ya que presentan relaciones demanda/capacidad menores a 1.

Así mismo, la estructura posee una rigidez vertical y lateral adecuada, controlando los desplazamientos producidos por un evento sísmico.

En la dirección transversal se obtiene un desplazamiento de 6.30 mm, mientras que en la dirección longitudinal de 184.50 mm.

Estos valores son menores a los máximos sugeridos por AIS 180-13 y RMI.

# SISTEMA DINÁMICO FEMSA BOGOTÁ

## 11 ANEXOS

### 11.1 ANEXO 1: N100x95x2.5

#### CFS Version 13.0.2

Section: N100x95x2.5\_CFS.cfss

Humberto Marin

N100x95x2.5\_CFS

DSC

220920 - FEMSA

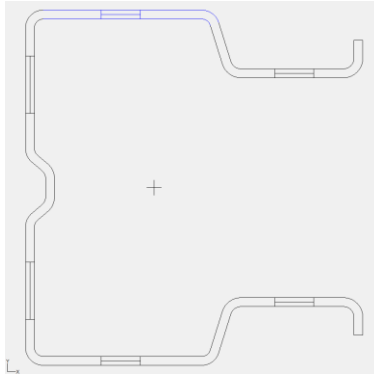
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Printed: 2023-07-11 10:30:23 PM

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### Section Inputs

---

Material: [Q355B]

Apply cold work of forming strength increase.

No inelastic reserve strength increase.

Modulus of Elasticity, E                      200000 MPa

Yield Strength, Fy                              355 MPa

Tensile Strength, Fu                            470 MPa

Torsion Constant Override, J                    0 mm<sup>4</sup>

Warping Constant Override, Cw                0 mm<sup>6</sup>

Hole Length                                      0.62992

Hole Spacing                                     4

Part 1, Thickness 2.5 mm

Placement of Part from Origin:

X to center of gravity                          0 mm

Y to center of gravity                          0 mm

Centerline dimensions, Open shape

Length	Angle	Radius	Web	k	Hole Size	Distance
--------	-------	--------	-----	---	-----------	----------

A handwritten signature in black ink, consisting of several loops and a long horizontal stroke.

## SISTEMA DINÁMICO FEMSA BOGOTÁ

	(mm)	(deg)	(mm)	Coef.	(mm)	(mm)
1	9.250	270.000	3.0000	None	0.000	4.625
2	36.206	180.000	3.0000	Single	0.000	18.103
3	17.282	107.455	3.0000	Single	0.000	8.641
4	51.155	180.000	2.5000	Single	0.000	25.577
5	39.274	270.000	2.5000	Single	0.000	19.637
6	7.436	-40.084	2.5000	None	0.000	3.718
7	8.962	270.000	3.0000	None	0.000	4.481
8	7.436	220.084	3.0000	None	0.000	3.718
9	39.274	270.000	2.5000	Single	0.000	19.637
10	51.155	0.000	2.5000	Single	0.000	25.577
11	17.282	72.545	2.5000	Single	0.000	8.641
12	36.206	0.000	3.0000	Single	0.000	18.103
13	9.250	270.000	3.0000	None	0.000	4.625

### Full Section Properties

---

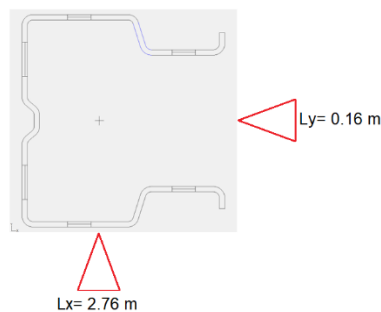
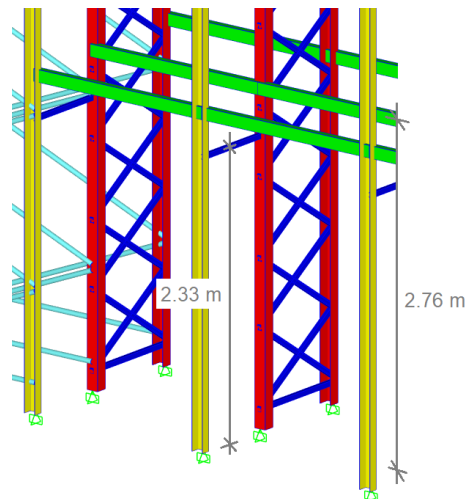
Area	797.81 mm <sup>2</sup>	Wt.	0.061359 kN/m	Flat	319.12 mm
Ix	1143444 mm <sup>4</sup>	rx	37.858 mm	Ixy	0 mm <sup>4</sup>
Sx(t)	22964 mm <sup>3</sup>	y(t)	49.794 mm	α	0.000 deg
Sx(b)	22964 mm <sup>3</sup>	y(b)	49.794 mm		
Zx	28363 mm <sup>3</sup>	Height	99.587 mm		
Iy	816134 mm <sup>4</sup>	ry	31.984 mm	x <sub>o</sub>	-80.985 mm
Sy(l)	22541 mm <sup>3</sup>	x(l)	36.207 mm	y <sub>o</sub>	0.000 mm
Sy(r)	13871 mm <sup>3</sup>	x(r)	58.837 mm	jx	87.523 mm
Zy	22728 mm <sup>3</sup>	Width	95.044 mm	jy	0.000 mm
I <sub>1</sub>	1143444 mm <sup>4</sup>	r <sub>1</sub>	37.858 mm	Cw	2.3905e09 mm <sup>6</sup>
I <sub>2</sub>	816134 mm <sup>4</sup>	r <sub>2</sub>	31.984 mm	J	1662.1 mm <sup>4</sup>
I <sub>c</sub>	1959578 mm <sup>4</sup>	r <sub>c</sub>	49.560 mm		
I <sub>o</sub>	7192044 mm <sup>4</sup>	r <sub>o</sub>	94.946 mm		

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Net Section Properties

$I_x$	888705 mm <sup>4</sup>	$r_x$	38.238 mm	Area	607.81 mm <sup>2</sup>
$S_x(t)$	17848 mm <sup>3</sup>	$y(t)$	49.794 mm	$I_{xy}$	0 mm <sup>4</sup>
$S_x(b)$	17848 mm <sup>3</sup>	$y(b)$	49.794 mm	$\alpha$	0.000 deg
$Z_x$	21618 mm <sup>3</sup>				
$I_y$	624498 mm <sup>4</sup>	$r_y$	32.054 mm	$x_o$	-84.693 mm
$S_y(l)$	16398 mm <sup>3</sup>	$x(l)$	38.084 mm	$y_o$	0.000 mm
$S_y(r)$	10964 mm <sup>3</sup>	$x(r)$	56.960 mm	$j_x$	90.213 mm
$Z_y$	17266 mm <sup>3</sup>			$j_y$	0.000 mm
$I_c$	1513203 mm <sup>4</sup>	$r_c$	49.896 mm	$C_w$	1.7878e09 mm <sup>6</sup>
$I_o$	5872956 mm <sup>4</sup>	$r_o$	98.298 mm	$J$	1266.3 mm <sup>4</sup>

### Member Check - AISI S100-07, US, LRFD (Mayor carga axial)



## SISTEMA DINÁMICO FEMSA BOGOTÁ

Material Type: [Q355B],  $F_y=355$  MPa

Design Parameters:

Lx	2.7600 m	Ly	0.1600 m	Lt	2.3300 m
Kx	0.9000	Ky	0.9000	Kt	0.9000
Cbx	1.0000	Cby	1.0000	ex	0.0000 mm
Cmx	1.0000	Cmy	1.0000	ey	0.0000 mm
Braced Flange:	None	$k\phi$	0 kN		
Red. Factor, R:	0	Lm	2.7600 m		

Loads:	P	Mx	Vy	My	Vx
	(kN)	(kN-m)	(kN)	(kN-m)	(kN)
Entered	34.510	0.5200	0.980	0.0000	0.210
Applied	34.510	0.5200	0.980	0.0000	0.210
Strength	45.642	5.7122	12.909	4.1224	77.816

Interaction Equations

Eq. C5.2.2-1 (P, Mx, My)  $0.756 + 0.103 + 0.000 = 0.859 \leq 1.0$

Eq. C5.2.2-2 (P, Mx, My)  $0.183 + 0.091 + 0.000 = 0.275 \leq 1.0$

Eq. C3.3.2-1 (Mx, Vy)  $\text{Sqrt}(0.008 + 0.006) = 0.119 \leq 1.0$

Eq. C3.3.2-1 (My, Vx)  $\text{Sqrt}(0.000 + 0.000) = 0.003 \leq 1.0$

Part 1 elements 5-9 number of stiffeners exceeds 0 (web).

Clear distance between holes less than 457.2 mm.

### Calculation Details - AISI S100-07, US, LRFD

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Axial Compression Strength

$(KL/r)_x=72.904, (KL/r)_y=5.0025$

$\sigma_{ex}=371.39$  MPa

Eq. C3.1.2.1-11

$\sigma_{ey}=78878$  MPa

Eq. C3.1.2.1-8

$\sigma_t=138.56$  MPa

Eq. C3.1.2.1-9

$F_e=107.03$  MPa

Eq. C4.1.2-1

$F_y=386.83$  MPa

$\lambda_c=1.9011$

Eq. C4.1-4

$F_n=93.867$  MPa

Eq. C4.1-3

$P_{ne}=74.887$  kN

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Local buckling (EWM)

Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=5$  mm

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.069502 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 2: Check for lip stiffener reduction

$$S=59.084 \quad \text{Eq. B4-7}$$

$$w/t < 0.328S \text{ (no lip reduction)}$$

Element 2: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.13183 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.11611 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 3: Stiffened,  $w=11.411$  mm

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.052008 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=11.411 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=5.7056 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=5.7056 \text{ mm} \quad \text{Eq. B2.3-10}$$

$$b_1+b_2 > \text{compression width (fully effective)}$$

Element 4: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.24083$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

$f_1=93.867$  MPa,  $f_2=93.867$  MPa

$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.22696$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

Elements 5 to 9:

Section B5 - Elements with Intermediate Stiffeners

$b_o=89.587$  mm,  $b_p=33.779$  mm

$k_{loc}=28.136$	Eq. B5.1.2-1
$\beta=2.0678$	Eq. B5.1.2-3
$k_d=6.6414$	Eq. B5.1.2-2
$R=1.7987$	Eq. B5.1-6
$k=11.946$	Eq. B5.1-5
$f=93.867$ MPa	
$F_{cr1}=1681.6$ MPa	Eq. B5.1-4
$\lambda=0.23626$	Eq. B5.1-3
$\rho=1$ (fully effective)	

Element 10: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$f_1=93.867$  MPa,  $f_2=93.867$  MPa

$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.22696$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

$f_1=93.867$  MPa,  $f_2=93.867$  MPa

$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.24083$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

Element 11: Stiffened,  $w=11.411$  mm

$f_1=93.867$  MPa,  $f_2=93.867$  MPa

$\psi=1$	Eq. B2.3-1
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## SISTEMA DINÁMICO FEMSA BOGOTÁ

k=4	Eq. B2.3-8
$\lambda=0.052008$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
be=11.411 mm	Eq. B2.1-2
$b_1=5.7056$ mm	Eq. B2.3-9
$b_2=5.7056$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 13: Unstiffened, w=5 mm	
$f_1=93.867$ MPa, $f_2=93.867$ MPa	
$\psi=1$	Eq. B3.2-1
k=0.43	Eq. B3.2-3
$\lambda=0.069502$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Element 12: Check for lip stiffener reduction	
S=59.084	Eq. B4-7
w/t < 0.328S (no lip reduction)	
Element 12: Treat as two unstiffened elements	
Hole spacing less than 609.6 mm, treat as rational analysis	
$f_1=93.867$ MPa, $f_2=93.867$ MPa	
$\psi=1$	Eq. B3.2-1
k=0.43	Eq. B3.2-3
$\lambda=0.13183$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
$f_1=93.867$ MPa, $f_2=93.867$ MPa	
$\psi=1$	Eq. B3.2-1
k=0.43	Eq. B3.2-3
$\lambda=0.11611$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Ae=607.81 mm <sup>2</sup>	
Pnl=57.053 kN	Eq. C4.1-1
$\Omega_c=2$ , $\phi_c=0.8$ (rational analysis)	

Distortional buckling for part 1 elements 10 to 13

$$A_f=276.14 \text{ mm}^2, I_{xf}=15499 \text{ mm}^4, I_{yf}=202220 \text{ mm}^4, I_{xyf}=46087 \text{ mm}^4$$

$$x_{of}=-8.6733 \text{ mm}, y_{of}=-1.7407 \text{ mm}, C_{wf}=5990900 \text{ mm}^6, J_f=575.29 \text{ mm}^4$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$h_{xf}=50.085$  mm,  $h_o=41.106$  mm,  $t_{web}=2.5$  mm

$L_{crd}=424.64$ mm	Eq. C4.2-13
$k\phi_{fe}=16.336$ kN	Eq. C3.1.4-13
$k\phi_{we}=13.924$ kN	Eq. C4.2-11
$k\phi=0$ kN	
$k\phi_{fg}=51.882$ mm <sup>2</sup>	Eq. C3.1.4-15
$k\phi_{wg}=0.1584$ mm <sup>2</sup>	Eq. C4.2-12
$F_{crd}=581.46$ MPa	Eq. C4.2-10
$P_{crd}=463.89$ kN	Eq. C4.2-5
$P_{nd}=268.29$ kN	Eq. C4.2-2
$\Omega_c=1.8$ , $\phi_c=0.85$	

### Flexural Strength about X-axis

$\sigma_{ey}=78878$ MPa	Eq. C3.1.2.1-8
$\sigma_t=138.56$ MPa	Eq. C3.1.2.1-9
$C_b=1$	Eq. C3.1.2.1-6
$F_e=10905$ MPa	Eq. C3.1.2.1-4
$M_{cre}=250.42$ kN-m	
$F_y=400.07$ MPa	
$F_c=400.07$ MPa	

Not subject to lateral-torsional buckling - same as fully braced strength

### Distortional buckling for part 1 elements 1 to 4

$A_f=276.14$  mm<sup>2</sup>,  $I_{xf}=15499$  mm<sup>4</sup>,  $I_{yf}=202220$  mm<sup>4</sup>,  $I_{xyf}=-46088$  mm<sup>4</sup>  
 $x_{of}=8.6733$  mm,  $y_{of}=-1.7407$  mm,  $C_{wf}=5990900$  mm<sup>6</sup>,  $J_f=575.29$  mm<sup>4</sup>

$h_{xf}=-50.085$  mm,  $h_o=41.106$  mm,  $t_{web}=2.5$  mm

$L_{crd}=383.71$ mm	Eq. C3.1.4-12
$k\phi_{fe}=23.839$ kN	Eq. C3.1.4-13
$k\phi_{we}=21.136$ kN	Eq. C3.1.4-14
$k\phi=0$ kN	
$k\phi_{fg}=63.542$ mm <sup>2</sup>	Eq. C3.1.4-15
$k\phi_{wg}=0.15015$ mm <sup>2</sup>	Eq. C3.1.4-16
$F_{crd}=706.13$ MPa	Eq. C3.1.4-10
$M_{crd}=16.633$ kN-m	Eq. C3.1.4-5
$M_{nd}=8.7023$ kN-m	Eq. C3.1.4-2
$\Omega_b=2$ , $\phi_b=0.8$ (rational analysis)	

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Flexural Strength about Y-axis

$$\sigma_x = 371.39 \text{ MPa} \quad \text{Eq. C3.1.2.1-11}$$

$$\sigma_t = 138.56 \text{ MPa} \quad \text{Eq. C3.1.2.1-9}$$

$$C_{tf} = 1 \quad \text{Eq. C3.1.2.1-12}$$

$$F_e = 373.17 \text{ MPa} \quad \text{Eq. C3.1.2.1-10}$$

$$M_{cre} = 5.1763 \text{ kN-m}$$

$$F_y = 470 \text{ MPa}$$

$$F_c = 339.52 \text{ MPa} \quad \text{Eq. C3.1.2.1-2}$$

$$M_{ne} = 4.7095 \text{ kN-m}$$

### Local buckling (EWM)

#### Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=5 \text{ mm}$

$$f_1 = 332.31 \text{ MPa}, f_2 = 332.31 \text{ MPa}$$

$$\psi = 1 \quad \text{Eq. B3.2-1}$$

$$k = 0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda = 0.13077 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 2: Check for lip stiffener reduction

$$S = 32.629 \quad \text{Eq. B4-7}$$

$$I_a = 0.25896 \text{ mm}^4 \quad \text{Eq. B4-8}$$

$$I_s = 26.042 \text{ mm}^4 > I_a \text{ (no lip reduction)}$$

$$k = 3.4294 \quad \text{Table B4-1}$$

Element 2: Partially stiffened,  $w=28.837 \text{ mm}$

$$f = 307.78 \text{ MPa}, k = 3.4294$$

$$\lambda = 0.25702 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 3: Stiffened,  $w=11.411 \text{ mm}$

$$f_1 = 117.98 \text{ MPa}, f_2 = 98.232 \text{ MPa}$$

$$\psi = 0.83259 \quad \text{Eq. B2.3-1}$$

$$k = 4.3442 \quad \text{Eq. B2.3-8}$$

$$\lambda = 0.05595 \quad \text{Eq. B2.1-4}$$

$$\rho = 1 \quad \text{Eq. B2.1-3}$$

$$b_e = 11.411 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1 = 5.2649 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2 = 6.1463 \text{ mm} \quad \text{Eq. B2.3-10}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$b_1+b_2 >$  compression width (fully effective)

Element 4: Stiffened,  $w=44.653$  mm

$f_1=77.589$  MPa,  $f_2=-180.08$  MPa

$\psi=2.321$  Eq. B2.3-1

$k=83.894$  Eq. B2.3-2

$\lambda=0.040401$  Eq. B2.1-4

$\rho=1$  Eq. B2.1-3

$b_e=44.653$  mm Eq. B2.1-2

$h_o=53.322$  mm,  $b_o=19.117$  mm,  $h_o/b_o=2.7893$

$b_1=8.3919$  mm Eq. B2.3-3

$b_2=22.326$  mm Eq. B2.3-4

Compression width= $13.446$  mm

$b_1+b_2 >$  compression width (fully effective)

Element 5: No compressive stress (fully effective)

Element 6: No compressive stress (fully effective)

Element 7: No compressive stress (fully effective)

Element 8: No compressive stress (fully effective)

Element 9: No compressive stress (fully effective)

Element 10: Stiffened,  $w=44.653$  mm

$f_1=77.589$  MPa,  $f_2=-180.08$  MPa

$\psi=2.3209$  Eq. B2.3-1

$k=83.893$  Eq. B2.3-2

$\lambda=0.040401$  Eq. B2.1-4

$\rho=1$  Eq. B2.1-3

$b_e=44.653$  mm Eq. B2.1-2

$h_o=53.322$  mm,  $b_o=19.117$  mm,  $h_o/b_o=2.7893$

$b_1=8.3919$  mm Eq. B2.3-3

$b_2=22.326$  mm Eq. B2.3-4

Compression width= $13.446$  mm

$b_1+b_2 >$  compression width (fully effective)

Element 11: Stiffened,  $w=11.411$  mm

$f_1=117.98$  MPa,  $f_2=98.232$  MPa

$\psi=0.83259$  Eq. B2.3-1

$k=4.3442$  Eq. B2.3-8

$\lambda=0.05595$  Eq. B2.1-4

$\rho=1$  Eq. B2.1-3

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$b_e=11.411$ mm	Eq. B2.1-2
$b_1=5.2649$ mm	Eq. B2.3-9
$b_2=6.1463$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 13: Unstiffened, $w=5$ mm	
$f_1=332.31$ MPa, $f_2=332.31$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.13077$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Element 12: Check for lip stiffener reduction	
$S=32.629$	Eq. B4-7
$I_a=0.25896$ mm <sup>4</sup>	Eq. B4-8
$I_s=26.042$ mm <sup>4</sup> $>$ $I_a$ (no lip reduction)	
$k=3.4294$	Table B4-1
Element 12: Partially stiffened, $w=28.837$ mm	
$f=307.78$ MPa, $k=3.4294$	
$\lambda=0.25702$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Center of gravity shift: $x=0$ mm	
$Sec=13871$ mm <sup>3</sup>	
$M_{nl}=4.7095$ kN-m	Eq. C3.1.2.1-1
$\Omega_b=1.67$ , $\phi_b=0.9$	
Distortional buckling for part 1 elements 10 to 13	
$A_f=276.14$ mm <sup>2</sup> , $I_{xf}=15499$ mm <sup>4</sup> , $I_{yf}=202220$ mm <sup>4</sup> , $I_{xyf}=46087$ mm <sup>4</sup>	
$x_{of}=-8.6733$ mm, $y_{of}=-1.7407$ mm, $C_{wf}=5990900$ mm <sup>6</sup> , $J_f=575.29$ mm <sup>4</sup>	
$h_{xf}=50.085$ mm, $h_o=41.106$ mm, $t_{web}=2.5$ mm	
$L_{crd}=631.35$ mm	Analytical
$k\phi_f=3.9407$ kN	Eq. C3.1.4-13
$k\phi_{we}=3.3663$ kN	Analytical
$k\phi=0$ kN	
$k\phi_{fg}=13.701$ mm <sup>2</sup>	Analytical
$k\phi_{wg}=0$ mm <sup>2</sup>	Analytical
$F_{crd}=533.3$ MPa	Eq. C3.1.4-10

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$M_{crd}=7.3974 \text{ kN-m}$

Eq. C3.1.4-5

$M_{nd}=5.3171 \text{ kN-m}$

Eq. C3.1.4-2

$\Omega_b=1.67, \phi_b=0.9$

### Compression and Bending Interaction

$\alpha_x=0.88353$

Eq. C5.2.2-4

$\alpha_y=0.99945$

Eq. C5.2.2-5

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Member Check - AISI S100-07, US, LRFD (Mayor momento flector)

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Material Type: [Q355B],  $F_y=355$  MPa

Design Parameters:

Lx	2.7600 m	Ly	0.6500 m	Lt	2.3300 m
Kx	0.9000	Ky	0.9000	Kt	0.9000
Cbx	1.0000	Cby	1.0000	ex	0.0000 mm
Cmx	1.0000	Cmy	1.0000	ey	0.0000 mm
Braced Flange:	None	$k\phi$	0 kN		
Red. Factor, R:	0	Lm	2.7600 m		

Loads:	P	Mx	Vy	My	Vx
	(kN)	(kN-m)	(kN)	(kN-m)	(kN)
Entered	2.800	0.8900	0.030	0.0400	0.530
Applied	2.800	0.8900	0.030	0.0400	0.530
Strength	45.642	5.7122	12.909	4.1224	77.816

Interaction Equations

Eq. C5.2.2-1 (P, Mx, My)  $0.061 + 0.157 + 0.010 = 0.228 \leq 1.0$

Eq. C5.2.2-2 (P, Mx, My)  $0.015 + 0.156 + 0.010 = 0.180 \leq 1.0$

Eq. C3.3.2-1 (Mx, Vy)  $\text{Sqrt}(0.024 + 0.000) = 0.156 \leq 1.0$

Eq. C3.3.2-1 (My, Vx)  $\text{Sqrt}(0.000 + 0.000) = 0.012 \leq 1.0$

Part 1 elements 5-9 number of stiffeners exceeds 0 (web).

Clear distance between holes less than 457.2 mm.

### Calculation Details - AISI S100-07, US, LRFD

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Axial Compression Strength

$(KL/r)_x=72.904, (KL/r)_y=20.323$

$\sigma_x=371.39$  MPa

Eq. C3.1.2.1-11

$\sigma_y=4779.3$  MPa

Eq. C3.1.2.1-8

$\sigma_t=138.56$  MPa

Eq. C3.1.2.1-9

$F_e=107.03$  MPa

Eq. C4.1.2-1

$F_y=386.83$  MPa

$\lambda_c=1.9011$

Eq. C4.1-4

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$F_n=93.867 \text{ MPa}$$

Eq. C4.1-3

$$P_{ne}=74.887 \text{ kN}$$

Local buckling (EWM)

Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=5 \text{ mm}$

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

$$k=0.43$$

Eq. B3.2-3

$$\lambda=0.069502$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$$S=59.084$$

Eq. B4-7

$$w/t < 0.328S \text{ (no lip reduction)}$$

Element 2: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

$$k=0.43$$

Eq. B3.2-3

$$\lambda=0.13183$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

$$k=0.43$$

Eq. B3.2-3

$$\lambda=0.11611$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

Element 3: Stiffened,  $w=11.411 \text{ mm}$

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1$$

Eq. B2.3-1

$$k=4$$

Eq. B2.3-8

$$\lambda=0.052008$$

Eq. B2.1-4

$$\rho=1$$

Eq. B2.1-3

$$b_e=11.411 \text{ mm}$$

Eq. B2.1-2

$$b_1=5.7056 \text{ mm}$$

Eq. B2.3-9

$$b_2=5.7056 \text{ mm}$$

Eq. B2.3-10

$$b_1+b_2 > \text{compression width (fully effective)}$$

Element 4: Treat as two unstiffened elements

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.24083 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.22696 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Elements 5 to 9:

Section B5 - Elements with Intermediate Stiffeners

$$b_o=89.587 \text{ mm}, b_p=33.779 \text{ mm}$$

$$k_{loc}=28.136 \quad \text{Eq. B5.1.2-1}$$

$$\beta=2.0678 \quad \text{Eq. B5.1.2-3}$$

$$k_d=6.6414 \quad \text{Eq. B5.1.2-2}$$

$$R=1.7987 \quad \text{Eq. B5.1-6}$$

$$k=11.946 \quad \text{Eq. B5.1-5}$$

$$f=93.867 \text{ MPa}$$

$$F_{cr1}=1681.6 \text{ MPa} \quad \text{Eq. B5.1-4}$$

$$\lambda=0.23626 \quad \text{Eq. B5.1-3}$$

$$\rho=1 \text{ (fully effective)}$$

Element 10: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.22696 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.24083 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 11: Stiffened,  $w=11.411 \text{ mm}$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.052008 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=11.411 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=5.7056 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=5.7056 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 13: Unstiffened,  $w=5 \text{ mm}$

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.069502 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 12: Check for lip stiffener reduction

$$S=59.084 \quad \text{Eq. B4-7}$$

$w/t < 0.328S$  (no lip reduction)

Element 12: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.13183 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=93.867 \text{ MPa}, f_2=93.867 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.11611 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$A_e=607.81 \text{ mm}^2$$

$$P_{nl}=57.053 \text{ kN} \quad \text{Eq. C4.1-1}$$

$$\Omega_c=2, \phi_c=0.8 \text{ (rational analysis)}$$

Distortional buckling for part 1 elements 10 to 13

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$A_f=276.14 \text{ mm}^2, I_{xf}=15499 \text{ mm}^4, I_{yf}=202220 \text{ mm}^4, I_{xyf}=46087 \text{ mm}^4$$

$$x_{of}=-8.6733 \text{ mm}, y_{of}=-1.7407 \text{ mm}, C_{wf}=5990900 \text{ mm}^6, J_f=575.29 \text{ mm}^4$$

$$h_{xf}=50.085 \text{ mm}, h_o=41.106 \text{ mm}, t_{web}=2.5 \text{ mm}$$

$$L_{crd}=424.64 \text{ mm}$$

Eq. C4.2-13

$$k\phi_{fe}=16.336 \text{ kN}$$

Eq. C3.1.4-13

$$k\phi_{we}=13.924 \text{ kN}$$

Eq. C4.2-11

$$k\phi=0 \text{ kN}$$

$$k\phi_{fg}=51.882 \text{ mm}^2$$

Eq. C3.1.4-15

$$k\phi_{wg}=0.1584 \text{ mm}^2$$

Eq. C4.2-12

$$F_{crd}=581.46 \text{ MPa}$$

Eq. C4.2-10

$$P_{crd}=463.89 \text{ kN}$$

Eq. C4.2-5

$$P_{nd}=268.29 \text{ kN}$$

Eq. C4.2-2

$$\Omega_c=1.8, \phi_c=0.85$$

### Flexural Strength about X-axis

$$\sigma_{ey}=4779.3 \text{ MPa}$$

Eq. C3.1.2.1-8

$$\sigma_t=138.56 \text{ MPa}$$

Eq. C3.1.2.1-9

$$C_b=1$$

Eq. C3.1.2.1-6

$$F_e=2684.3 \text{ MPa}$$

Eq. C3.1.2.1-4

$$M_{cre}=61.641 \text{ kN-m}$$

$$F_y=400.07 \text{ MPa}$$

$$F_c=400.07 \text{ MPa}$$

Not subject to lateral-torsional buckling - same as fully braced strength

### Distortional buckling for part 1 elements 1 to 4

$$A_f=276.14 \text{ mm}^2, I_{xf}=15499 \text{ mm}^4, I_{yf}=202220 \text{ mm}^4, I_{xyf}=-46088 \text{ mm}^4$$

$$x_{of}=8.6733 \text{ mm}, y_{of}=-1.7407 \text{ mm}, C_{wf}=5990900 \text{ mm}^6, J_f=575.29 \text{ mm}^4$$

$$h_{xf}=-50.085 \text{ mm}, h_o=41.106 \text{ mm}, t_{web}=2.5 \text{ mm}$$

$$L_{crd}=383.71 \text{ mm}$$

Eq. C3.1.4-12

$$k\phi_{fe}=23.839 \text{ kN}$$

Eq. C3.1.4-13

$$k\phi_{we}=21.136 \text{ kN}$$

Eq. C3.1.4-14

$$k\phi=0 \text{ kN}$$

$$k\phi_{fg}=63.542 \text{ mm}^2$$

Eq. C3.1.4-15

$$k\phi_{wg}=0.15015 \text{ mm}^2$$

Eq. C3.1.4-16

$$F_{crd}=706.13 \text{ MPa}$$

Eq. C3.1.4-10

$$M_{crd}=16.633 \text{ kN-m}$$

Eq. C3.1.4-5

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$M_{nd}=8.7023 \text{ kN-m}$$

Eq. C3.1.4-2

$$\Omega_b=2, \phi_b=0.8 \text{ (rational analysis)}$$

### Flexural Strength about Y-axis

$$\sigma_{ex}=371.39 \text{ MPa}$$

Eq. C3.1.2.1-11

$$\sigma_t=138.56 \text{ MPa}$$

Eq. C3.1.2.1-9

$$C_{tf}=1$$

Eq. C3.1.2.1-12

$$F_e=373.17 \text{ MPa}$$

Eq. C3.1.2.1-10

$$M_{cre}=5.1763 \text{ kN-m}$$

$$F_y=470 \text{ MPa}$$

$$F_c=339.52 \text{ MPa}$$

Eq. C3.1.2.1-2

$$M_{ne}=4.7095 \text{ kN-m}$$

### Local buckling (EWM)

#### Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=5 \text{ mm}$

$$f_1=332.31 \text{ MPa}, f_2=332.31 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

$$k=0.43$$

Eq. B3.2-3

$$\lambda=0.13077$$

Eq. B2.1-4

$\lambda < 0.673$  (fully effective)

Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$$S=32.629$$

Eq. B4-7

$$I_a=0.25896 \text{ mm}^4$$

Eq. B4-8

$$I_s=26.042 \text{ mm}^4 > I_a \text{ (no lip reduction)}$$

$$k=3.4294$$

Table B4-1

Element 2: Partially stiffened,  $w=28.837 \text{ mm}$

$$f=307.78 \text{ MPa}, k=3.4294$$

$$\lambda=0.25702$$

Eq. B2.1-4

$\lambda < 0.673$  (fully effective)

Eq. B2.1-1

Element 3: Stiffened,  $w=11.411 \text{ mm}$

$$f_1=117.98 \text{ MPa}, f_2=98.232 \text{ MPa}$$

$$\psi=0.83259$$

Eq. B2.3-1

$$k=4.3442$$

Eq. B2.3-8

$$\lambda=0.05595$$

Eq. B2.1-4

$$\rho=1$$

Eq. B2.1-3

$$b_e=11.411 \text{ mm}$$

Eq. B2.1-2

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$b_1=5.2649$ mm	Eq. B2.3-9
$b_2=6.1463$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 4: Stiffened, $w=44.653$ mm	
$f_1=77.589$ MPa, $f_2=-180.08$ MPa	
$\psi=2.321$	Eq. B2.3-1
$k=83.894$	Eq. B2.3-2
$\lambda=0.040401$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=44.653$ mm	Eq. B2.1-2
$h_o=53.322$ mm, $b_o=19.117$ mm, $h_o/b_o=2.7893$	
$b_1=8.3919$ mm	Eq. B2.3-3
$b_2=22.326$ mm	Eq. B2.3-4
Compression width= $13.446$ mm	
$b_1+b_2 >$ compression width (fully effective)	
Element 5: No compressive stress (fully effective)	
Element 6: No compressive stress (fully effective)	
Element 7: No compressive stress (fully effective)	
Element 8: No compressive stress (fully effective)	
Element 9: No compressive stress (fully effective)	
Element 10: Stiffened, $w=44.653$ mm	
$f_1=77.589$ MPa, $f_2=-180.08$ MPa	
$\psi=2.3209$	Eq. B2.3-1
$k=83.893$	Eq. B2.3-2
$\lambda=0.040401$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=44.653$ mm	Eq. B2.1-2
$h_o=53.322$ mm, $b_o=19.117$ mm, $h_o/b_o=2.7893$	
$b_1=8.3919$ mm	Eq. B2.3-3
$b_2=22.326$ mm	Eq. B2.3-4
Compression width= $13.446$ mm	
$b_1+b_2 >$ compression width (fully effective)	
Element 11: Stiffened, $w=11.411$ mm	
$f_1=117.98$ MPa, $f_2=98.232$ MPa	
$\psi=0.83259$	Eq. B2.3-1
$k=4.3442$	Eq. B2.3-8

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\lambda=0.05595$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=11.411$ mm	Eq. B2.1-2
$b_1=5.2649$ mm	Eq. B2.3-9
$b_2=6.1463$ mm	Eq. B2.3-10

$b_1+b_2 >$  compression width (fully effective)

Element 13: Unstiffened,  $w=5$  mm

$f_1=332.31$ MPa, $f_2=332.31$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.13077$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

Element 12: Check for lip stiffener reduction

$S=32.629$	Eq. B4-7
$I_a=0.25896$ mm <sup>4</sup>	Eq. B4-8
$I_s=26.042$ mm <sup>4</sup> $>$ $I_a$ (no lip reduction)	
$k=3.4294$	Table B4-1

Element 12: Partially stiffened,  $w=28.837$  mm

$f=307.78$ MPa, $k=3.4294$	
$\lambda=0.25702$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

Center of gravity shift:  $x=0$  mm

$Sec=13871$ mm <sup>3</sup>	
$M_{nl}=4.7095$ kN-m	Eq. C3.1.2.1-1
$\Omega_b=1.67$ , $\phi_b=0.9$	

Distortional buckling for part 1 elements 10 to 13

$A_f=276.14$ mm <sup>2</sup> , $I_{xf}=15499$ mm <sup>4</sup> , $I_{yf}=202220$ mm <sup>4</sup> , $I_{xyf}=46087$ mm <sup>4</sup>	
$x_{of}=-8.6733$ mm, $y_{of}=-1.7407$ mm, $C_{wf}=5990900$ mm <sup>6</sup> , $J_f=575.29$ mm <sup>4</sup>	
$h_{xf}=50.085$ mm, $h_o=41.106$ mm, $t_{web}=2.5$ mm	
$L_{crd}=631.35$ mm	Analytical
$k\phi_{fe}=3.9407$ kN	Eq. C3.1.4-13
$k\phi_{we}=3.3663$ kN	Analytical
$k\phi=0$ kN	
$k\phi_{fg}=13.701$ mm <sup>2</sup>	Analytical

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$k\phi_w g = 0 \text{ mm}^2$$

Analytical

$$F_{crd} = 533.3 \text{ MPa}$$

Eq. C3.1.4-10

$$M_{crd} = 7.3974 \text{ kN-m}$$

Eq. C3.1.4-5

$$M_{nd} = 5.3171 \text{ kN-m}$$

Eq. C3.1.4-2

$$\Omega_b = 1.67, \phi_b = 0.9$$

### Compression and Bending Interaction

$$\alpha_x = 0.99055$$

Eq. C5.2.2-4

$$\alpha_y = 0.99927$$

Eq. C5.2.2-5

# SISTEMA DINÁMICO FEMSA BOGOTÁ

## 11.2 ANEXO 2: N100x78x2.5

CFS Version 13.0.2

Section: N100x78x2.5\_CFS.cfss

Humberto Marin

N100x78x2.5\_CFS

DSC

220920 - FEMSA

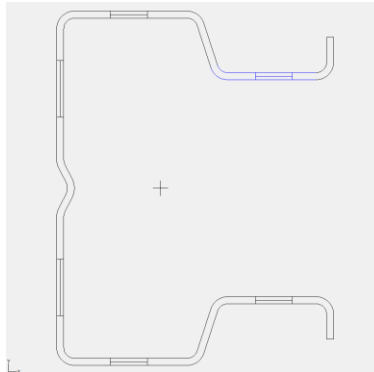
Rev. Date: 2023-07-11 7:28:50 PM

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Printed: 2023-07-11 11:59:44 PM

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### Section Inputs

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Material: [Q355B]

Apply cold work of forming strength increase.

No inelastic reserve strength increase.

Modulus of Elasticity, E                    200000 MPa

Yield Strength, Fy                            355 MPa

Tensile Strength, Fu                          470 MPa

Torsion Constant Override, J                0 mm<sup>4</sup>

Warping Constant Override, Cw              0 mm<sup>6</sup>

Hole Length                                    0.62992

Hole Spacing                                    4

Part 1, Thickness 2.5 mm

Placement of Part from Origin:

X to center of gravity                        0 mm

Y to center of gravity                        0 mm

Centerline dimensions, Open shape

Length	Angle	Radius	Web	k	Hole Size	Distance
(mm)	(deg)	(mm)		Coef.	(mm)	(mm)

## SISTEMA DINÁMICO FEMSA BOGOTÁ

1	11.250	270.000	3.0000	None	0.000	0.000	5.625
2	32.336	180.000	3.0000	Single	0.000	10.500	16.168
3	18.297	108.077	3.0000	Single	0.000	0.000	9.148
4	37.852	180.000	2.5000	Single	0.000	10.500	18.926
5	41.660	270.000	2.5000	Single	0.000	16.000	20.830
6	6.544	-62.712	2.5000	None	0.000	0.000	3.272
7	2.549	270.000	4.0000	None	0.000	0.000	1.274
8	6.544	242.712	4.0000	None	0.000	0.000	3.272
9	41.660	270.000	2.5000	Single	0.000	16.000	20.830
10	37.852	0.000	2.5000	Single	0.000	10.500	18.926
11	18.297	71.923	2.5000	Single	0.000	0.000	9.148
12	32.336	0.000	3.0000	Single	0.000	10.500	16.168
13	11.250	270.000	3.0000	None	0.000	0.000	5.625

### Full Section Properties

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Area	720.65 mm <sup>2</sup>	Wt.	0.055425 kN/m	Flat	288.26 mm
I <sub>x</sub>	987824 mm <sup>4</sup>	r <sub>x</sub>	37.023 mm	I <sub>xy</sub>	0 mm <sup>4</sup>
S <sub>x(t)</sub>	19756 mm <sup>3</sup>	y(t)	50.000 mm	α	0.000 deg
S <sub>x(b)</sub>	19756 mm <sup>3</sup>	y(b)	50.000 mm		
Z <sub>x</sub>	25010 mm <sup>3</sup>	Height	100.000 mm		
I <sub>y</sub>	519744 mm <sup>4</sup>	r <sub>y</sub>	26.855 mm	x <sub>o</sub>	-66.620 mm
S <sub>y(l)</sub>	17685 mm <sup>3</sup>	x(l)	29.389 mm	y <sub>o</sub>	0.000 mm
S <sub>y(r)</sub>	10612 mm <sup>3</sup>	x(r)	48.976 mm	j <sub>x</sub>	73.037 mm
Z <sub>y</sub>	17192 mm <sup>3</sup>	Width	78.365 mm	j <sub>y</sub>	0.000 mm
I <sub>1</sub>	987824 mm <sup>4</sup>	r <sub>1</sub>	37.023 mm	C <sub>w</sub>	1.4074e09 mm <sup>6</sup>
I <sub>2</sub>	519744 mm <sup>4</sup>	r <sub>2</sub>	26.855 mm	J	1501.4 mm <sup>4</sup>
I <sub>c</sub>	1507568 mm <sup>4</sup>	r <sub>c</sub>	45.738 mm		
I <sub>o</sub>	4706000 mm <sup>4</sup>	r <sub>o</sub>	80.810 mm		

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Net Section Properties

Ix	747312 mm <sup>4</sup>	rx	37.352 mm	Area	535.65 mm <sup>2</sup>
Sx(t)	14946 mm <sup>3</sup>	y(t)	50.000 mm	Ixy	0 mm <sup>4</sup>
Sx(b)	14946 mm <sup>3</sup>	y(b)	50.000 mm	α	0.000 deg
Zx	18571 mm <sup>3</sup>				
Iy	396482 mm <sup>4</sup>	ry	27.206 mm	x <sub>o</sub>	-70.861 mm
Sy(l)	12626 mm <sup>3</sup>	x(l)	31.401 mm	y <sub>o</sub>	0.000 mm
Sy(r)	8442 mm <sup>3</sup>	x(r)	46.964 mm	jx	76.202 mm
Zy	12789 mm <sup>3</sup>			jy	0.000 mm
Ic	1143794 mm <sup>4</sup>	rc	46.210 mm	Cw	1.0312e09 mm <sup>6</sup>
I <sub>o</sub>	3833467 mm <sup>4</sup>	r <sub>o</sub>	84.597 mm	J	1115.9 mm <sup>4</sup>

### Member Check - AISI S100-07, US, LRFD (Mayor carga axial)

Material Type: [Q355B], Fy=355 MPa

Design Parameters:

Lx	2.6400 m	Ly	0.1600 m	Lt	2.3300 m
Kx	0.9000	Ky	0.9000	Kt	0.9000
Cbx	1.0000	Cby	1.0000	ex	0.0000 mm
Cmx	1.0000	Cmy	1.0000	ey	0.0000 mm
Braced Flange:	None	kφ	0 kN		
Red. Factor, R:	0	Lm	2.6400 m		

Loads:	P (kN)	Mx (kN-m)	Vy (kN)	My (kN-m)	Vx (kN)
Entered	35.880	-0.5700	0.740	0.0000	0.280
Applied	35.880	-0.5700	0.740	0.0000	0.280
Strength	47.863	4.9518	14.467	3.1050	60.968

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Interaction Equations

$$\text{Eq. C5.2.2-1 (P, Mx, My)} \quad 0.750 + 0.128 + 0.000 = 0.878 \leq 1.0$$

$$\text{Eq. C5.2.2-2 (P, Mx, My)} \quad 0.215 + 0.115 + 0.000 = 0.330 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (Mx, Vy)} \quad \text{Sqrt}(0.013 + 0.003) = 0.126 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (My, Vx)} \quad \text{Sqrt}(0.000 + 0.000) = 0.005 \leq 1.0$$

Part 1 elements 5-9 number of stiffeners exceeds 0 (web).

Clear distance between holes less than 457.2 mm.

### Calculation Details - AISI S100-07, US, LRFD

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#### Axial Compression Strength

$$(KL/r)_x=64.175, (KL/r)_y=5.362$$

$$\sigma_{ex}=479.28 \text{ MPa}$$

Eq. C3.1.2.1-11

$$\sigma_{ey}=68655 \text{ MPa}$$

Eq. C3.1.2.1-8

$$\sigma_t=158.69 \text{ MPa}$$

Eq. C3.1.2.1-9

$$F_e=127.36 \text{ MPa}$$

Eq. C4.1.2-1

$$F_y=390.1 \text{ MPa}$$

$$\lambda_c=1.7501$$

Eq. C4.1-4

$$F_n=111.69 \text{ MPa}$$

Eq. C4.1-3

$$P_{ne}=80.493 \text{ kN}$$

#### Local buckling (EWM)

Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=7 \text{ mm}$

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

$$k=0.43$$

Eq. B3.2-3

$$\lambda=0.10614$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$$S=54.164$$

Eq. B4-7

$$w/t < 0.328S \text{ (no lip reduction)}$$

Element 2: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$k=0.43$	Eq. B3.2-3
$\lambda=0.11879$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.10111$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Element 3: Stiffened, $w=12.492$ mm	
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B2.3-1
$k=4$	Eq. B2.3-8
$\lambda=0.062107$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=12.492$ mm	Eq. B2.1-2
$b_1=6.2462$ mm	Eq. B2.3-9
$b_2=6.2462$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 4: Treat as two unstiffened elements	
Hole spacing less than 609.6 mm, treat as rational analysis	
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.16612$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.15051$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Elements 5 to 9:	
Section B5 - Elements with Intermediate Stiffeners	
$b_o=90$ mm, $b_p=37$ mm	
$k_{loc}=23.667$	Eq. B5.1.2-1
$\beta=1.3896$	Eq. B5.1.2-3
$k_d=4.2346$	Eq. B5.1.2-2

## SISTEMA DINÁMICO FEMSA BOGOTÁ

R=1.6264	Eq. B5.1-6
k=6.8873	Eq. B5.1-5
f=111.69 MPa	
Fcr1=960.61 MPa	Eq. B5.1-4
$\lambda=0.34099$	Eq. B5.1-3
$\rho=1$ (fully effective)	
Element 10: Treat as two unstiffened elements	
Hole spacing less than 609.6 mm, treat as rational analysis	
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B3.2-1
k=0.43	Eq. B3.2-3
$\lambda=0.15051$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B3.2-1
k=0.43	Eq. B3.2-3
$\lambda=0.16612$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Element 11: Stiffened, w=12.492 mm	
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B2.3-1
k=4	Eq. B2.3-8
$\lambda=0.062107$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
be=12.492 mm	Eq. B2.1-2
$b_1=6.2462$ mm	Eq. B2.3-9
$b_2=6.2462$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 13: Unstiffened, w=7 mm	
$f_1=111.69$ MPa, $f_2=111.69$ MPa	
$\psi=1$	Eq. B3.2-1
k=0.43	Eq. B3.2-3
$\lambda=0.10614$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Element 12: Check for lip stiffener reduction	
S=54.164	Eq. B4-7
w/t < 0.328S (no lip reduction)	

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Element 12: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.11879 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.10111 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$A_e=535.65 \text{ mm}^2$$

$$P_{nl}=59.829 \text{ kN} \quad \text{Eq. C4.1-1}$$

$$\Omega_c=2, \phi_c=0.8 \text{ (rational analysis)}$$

Distortional buckling for part 1 elements 1 to 4

$$A_f=240.86 \text{ mm}^2, I_{xf}=14350 \text{ mm}^4, I_{yf}=121150 \text{ mm}^4, I_{xyf}=-33219 \text{ mm}^4$$

$$x_{of}=11.211 \text{ mm}, y_{of}=-5.5027 \text{ mm}, C_{wf}=4313300 \text{ mm}^6, J_f=501.79 \text{ mm}^4$$

$$h_{xf}=-41.951 \text{ mm}, h_o=43.214 \text{ mm}, t_{web}=2.5 \text{ mm}$$

$$L_{crd}=409.54 \text{ mm} \quad \text{Eq. C4.2-13}$$

$$k\phi_{fe}=15.507 \text{ kN} \quad \text{Eq. C3.1.4-13}$$

$$k\phi_{we}=13.245 \text{ kN} \quad \text{Eq. C4.2-11}$$

$$k\phi=0 \text{ kN}$$

$$k\phi_{fg}=34.083 \text{ mm}^2 \quad \text{Eq. C3.1.4-15}$$

$$k\phi_{wg}=0.19786 \text{ mm}^2 \quad \text{Eq. C4.2-12}$$

$$F_{crd}=838.68 \text{ MPa} \quad \text{Eq. C4.2-10}$$

$$P_{crd}=604.4 \text{ kN} \quad \text{Eq. C4.2-5}$$

$$P_{nd}=268.9 \text{ kN} \quad \text{Eq. C4.2-2}$$

$$\Omega_c=1.8, \phi_c=0.85$$

Flexural Strength about X-axis

$$\sigma_{ey}=68655 \text{ MPa} \quad \text{Eq. C3.1.2.1-8}$$

$$\sigma_t=158.69 \text{ MPa} \quad \text{Eq. C3.1.2.1-9}$$

$$C_b=1 \quad \text{Eq. C3.1.2.1-6}$$

$$F_e=9729.3 \text{ MPa} \quad \text{Eq. C3.1.2.1-4}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$M_{cre}=192.22 \text{ kN-m}$$

$$F_y=414.13 \text{ MPa}$$

$$F_c=414.13 \text{ MPa}$$

Not subject to lateral-torsional buckling - same as fully braced strength

Distortional buckling for part 1 elements 10 to 13

$$A_f=240.86 \text{ mm}^2, I_{xf}=14350 \text{ mm}^4, I_{yf}=121150 \text{ mm}^4, I_{xyf}=33219 \text{ mm}^4$$

$$x_{of}=-11.211 \text{ mm}, y_{of}=-5.5027 \text{ mm}, C_{wf}=4313300 \text{ mm}^6, J_f=501.79 \text{ mm}^4$$

$$h_{xf}=41.951 \text{ mm}, h_o=43.214 \text{ mm}, t_{web}=2.5 \text{ mm}$$

$$L_{crd}=370.07 \text{ mm} \quad \text{Eq. C3.1.4-12}$$

$$k\phi_{fe}=22.637 \text{ kN} \quad \text{Eq. C3.1.4-13}$$

$$k\phi_{we}=20.149 \text{ kN} \quad \text{Eq. C3.1.4-14}$$

$$k\phi=0 \text{ kN}$$

$$k\phi_{fg}=41.743 \text{ mm}^2 \quad \text{Eq. C3.1.4-15}$$

$$k\phi_{wg}=0.17942 \text{ mm}^2 \quad \text{Eq. C3.1.4-16}$$

$$F_{crd}=1020.6 \text{ MPa} \quad \text{Eq. C3.1.4-10}$$

$$M_{crd}=20.681 \text{ kN-m} \quad \text{Eq. C3.1.4-5}$$

$$M_{nd}=8.1818 \text{ kN-m} \quad \text{Eq. C3.1.4-1}$$

$$\Omega_b=2, \phi_b=0.8 \text{ (rational analysis)}$$

Flexural Strength about Y-axis

$$\sigma_{ex}=479.28 \text{ MPa} \quad \text{Eq. C3.1.2.1-11}$$

$$\sigma_t=158.69 \text{ MPa} \quad \text{Eq. C3.1.2.1-9}$$

$$C_{tf}=1 \quad \text{Eq. C3.1.2.1-12}$$

$$F_e=440.86 \text{ MPa} \quad \text{Eq. C3.1.2.1-10}$$

$$M_{cre}=4.6785 \text{ kN-m}$$

$$F_y=459.74 \text{ MPa}$$

$$F_c=362.85 \text{ MPa} \quad \text{Eq. C3.1.2.1-2}$$

$$M_{ne}=3.8506 \text{ kN-m}$$

Local buckling (EWM)

Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=7 \text{ mm}$

$$f_1=353.59 \text{ MPa}, f_2=353.59 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.18885 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Element 2: Check for lip stiffener reduction

$$S=31.895 \quad \text{Eq. B4-7}$$

$w/t < 0.328S$  (no lip reduction)

Element 2: Stiffened,  $w=25.002$  mm

$$f_1=322.1 \text{ MPa}, f_2=136.87 \text{ MPa}$$

$$\psi=0.42492 \quad \text{Eq. B2.3-1}$$

$$k=5.5305 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.17951 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$be=25.002 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=9.7093 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=15.293 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 3: Stiffened,  $w=12.492$  mm

$$f_1=106.94 \text{ MPa}, f_2=78.217 \text{ MPa}$$

$$\psi=0.73144 \quad \text{Eq. B2.3-1}$$

$$k=4.5759 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.056817 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$be=12.492 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=5.5068 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=6.9856 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 4: Stiffened,  $w=31.381$  mm

$$f_1=51.806 \text{ MPa}, f_2=-180.69 \text{ MPa}$$

$$\psi=3.4878 \quad \text{Eq. B2.3-1}$$

$$k=193.75 \quad \text{Eq. B2.3-2}$$

$$\lambda=0.015267 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$be=31.381 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$h_0=40.009 \text{ mm}, b_0=20.11 \text{ mm}, h_0/b_0=1.9895$$

$$b_1=4.837 \text{ mm} \quad \text{Eq. B2.3-3}$$

$$b_2=15.691 \text{ mm} \quad \text{Eq. B2.3-4}$$

$$\text{Compression width}=6.9926 \text{ mm}$$

$b_1+b_2 >$  compression width (fully effective)

Element 5: No compressive stress (fully effective)

Element 6: No compressive stress (fully effective)

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Element 7: No compressive stress (fully effective)

Element 8: No compressive stress (fully effective)

Element 9: No compressive stress (fully effective)

Element 10: Stiffened,  $w=31.381$  mm

$$f_1=51.806 \text{ MPa}, f_2=-180.69 \text{ MPa}$$

$$\psi=3.4878 \quad \text{Eq. B2.3-1}$$

$$k=193.75 \quad \text{Eq. B2.3-2}$$

$$\lambda=0.015267 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$be=31.381 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$h_0=40.009 \text{ mm}, b_0=20.11 \text{ mm}, h_0/b_0=1.9895$$

$$b_1=4.837 \text{ mm} \quad \text{Eq. B2.3-3}$$

$$b_2=15.691 \text{ mm} \quad \text{Eq. B2.3-4}$$

$$\text{Compression width}=6.9926 \text{ mm}$$

$$b_1+b_2 > \text{compression width (fully effective)}$$

Element 11: Stiffened,  $w=12.492$  mm

$$f_1=106.94 \text{ MPa}, f_2=78.217 \text{ MPa}$$

$$\psi=0.73144 \quad \text{Eq. B2.3-1}$$

$$k=4.5759 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.056817 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$be=12.492 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=5.5068 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=6.9856 \text{ mm} \quad \text{Eq. B2.3-10}$$

$$b_1+b_2 > \text{compression width (fully effective)}$$

Element 13: Unstiffened,  $w=7$  mm

$$f_1=353.59 \text{ MPa}, f_2=353.59 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.18885 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 12: Check for lip stiffener reduction

$$S=31.895 \quad \text{Eq. B4-7}$$

$$w/t < 0.328S \text{ (no lip reduction)}$$

Element 12: Stiffened,  $w=25.002$  mm

$$f_1=322.1 \text{ MPa}, f_2=136.87 \text{ MPa}$$

$$\psi=0.42492 \quad \text{Eq. B2.3-1}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$k=5.5305$	Eq. B2.3-8
$\lambda=0.17951$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=25.002 \text{ mm}$	Eq. B2.1-2
$b_1=9.7093 \text{ mm}$	Eq. B2.3-9
$b_2=15.293 \text{ mm}$	Eq. B2.3-10
$b_1+b_2 > \text{compression width (fully effective)}$	

Center of gravity shift:  $x=0 \text{ mm}$

$S_{ec}=10612 \text{ mm}^3$

$M_{n1}=3.8506 \text{ kN-m}$

Eq. C3.1.2.1-1

$\Omega_b=1.67, \phi_b=0.9$

Distortional buckling for part 1 elements 1 to 4

$A_f=240.86 \text{ mm}^2, I_{xf}=14350 \text{ mm}^4, I_{yf}=121150 \text{ mm}^4, I_{xyf}=-33219 \text{ mm}^4$

$x_{of}=11.211 \text{ mm}, y_{of}=-5.5027 \text{ mm}, C_{wf}=4313300 \text{ mm}^6, J_f=501.79 \text{ mm}^4$

$h_{xf}=-41.951 \text{ mm}, h_o=43.214 \text{ mm}, t_{web}=2.5 \text{ mm}$

$L_{crd}=574.6 \text{ mm}$

Analytical

$k_{\phi fe}=4.5671 \text{ kN}$

Eq. C3.1.4-13

$k_{\phi we}=3.9321 \text{ kN}$

Analytical

$k_{\phi}=0 \text{ kN}$

$k_{\phi fg}=10.154 \text{ mm}^2$

Analytical

$k_{\phi wg}=0 \text{ mm}^2$

Analytical

$F_{crd}=837.06 \text{ MPa}$

Eq. C3.1.4-10

$M_{crd}=8.8831 \text{ kN-m}$

Eq. C3.1.4-5

$M_{nd}=4.6289 \text{ kN-m}$

Eq. C3.1.4-2

$\Omega_b=1.67, \phi_b=0.9$

Compression and Bending Interaction

$\alpha_x=0.89612$

Eq. C5.2.2-4

$\alpha_y=0.99927$

Eq. C5.2.2-5

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Member Check - AISI S100-07, US, LRFD (Mayor momento flector)

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Material Type: [Q355B],  $F_y=355$  MPa

Design Parameters:

Lx	2.6400 m	Ly	0.1600 m	Lt	2.3300 m
Kx	0.9000	Ky	0.9000	Kt	0.9000
Cbx	1.0000	Cby	1.0000	ex	0.0000 mm
Cmx	1.0000	Cmy	1.0000	ey	0.0000 mm
Braced Flange:	None	$k\phi$	0 kN		
Red. Factor, R:	0	Lm	2.6400 m		

Loads:	P	Mx	Vy	My	Vx
	(kN)	(kN-m)	(kN)	(kN-m)	(kN)
Entered	6.930	0.7000	0.440	0.0000	0.770
Applied	6.930	0.7000	0.440	0.0000	0.770
Strength	47.863	4.9518	14.467	3.1050	60.968

Interaction Equations

Eq. C5.2.2-1 (P, Mx, My)  $0.145 + 0.144 + 0.000 = 0.289 \leq 1.0$

Eq. C5.2.2-2 (P, Mx, My)  $0.041 + 0.141 + 0.000 = 0.183 \leq 1.0$

Eq. C3.3.2-1 (Mx, Vy)  $\text{Sqrt}(0.020 + 0.001) = 0.145 \leq 1.0$

Eq. C3.3.2-1 (My, Vx)  $\text{Sqrt}(0.000 + 0.000) = 0.013 \leq 1.0$

Part 1 elements 5-9 number of stiffeners exceeds 0 (web).

Clear distance between holes less than 457.2 mm.

### Calculation Details - AISI S100-07, US, LRFD

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Axial Compression Strength

$(KL/r)_x=64.175$ ,  $(KL/r)_y=5.362$

$\sigma_x=479.28$  MPa

Eq. C3.1.2.1-11

$\sigma_y=68655$  MPa

Eq. C3.1.2.1-8

$\sigma_t=158.69$  MPa

Eq. C3.1.2.1-9

$F_e=127.36$  MPa

Eq. C4.1.2-1

$F_y=390.1$  MPa

$\lambda_c=1.7501$

Eq. C4.1-4

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$F_n = 111.69 \text{ MPa}$$

Eq. C4.1-3

$$P_{ne} = 80.493 \text{ kN}$$

Local buckling (EWM)

Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w = 7 \text{ mm}$

$$f_1 = 111.69 \text{ MPa}, f_2 = 111.69 \text{ MPa}$$

$$\psi = 1$$

Eq. B3.2-1

$$k = 0.43$$

Eq. B3.2-3

$$\lambda = 0.10614$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$$S = 54.164$$

Eq. B4-7

$$w/t < 0.328S \text{ (no lip reduction)}$$

Element 2: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1 = 111.69 \text{ MPa}, f_2 = 111.69 \text{ MPa}$$

$$\psi = 1$$

Eq. B3.2-1

$$k = 0.43$$

Eq. B3.2-3

$$\lambda = 0.11879$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

$$f_1 = 111.69 \text{ MPa}, f_2 = 111.69 \text{ MPa}$$

$$\psi = 1$$

Eq. B3.2-1

$$k = 0.43$$

Eq. B3.2-3

$$\lambda = 0.10111$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

Element 3: Stiffened,  $w = 12.492 \text{ mm}$

$$f_1 = 111.69 \text{ MPa}, f_2 = 111.69 \text{ MPa}$$

$$\psi = 1$$

Eq. B2.3-1

$$k = 4$$

Eq. B2.3-8

$$\lambda = 0.062107$$

Eq. B2.1-4

$$\rho = 1$$

Eq. B2.1-3

$$b_e = 12.492 \text{ mm}$$

Eq. B2.1-2

$$b_1 = 6.2462 \text{ mm}$$

Eq. B2.3-9

$$b_2 = 6.2462 \text{ mm}$$

Eq. B2.3-10

$$b_1 + b_2 > \text{compression width (fully effective)}$$

Element 4: Treat as two unstiffened elements

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.16612 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.15051 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Elements 5 to 9:

Section B5 - Elements with Intermediate Stiffeners

$$b_o=90 \text{ mm}, b_p=37 \text{ mm}$$

$$k_{loc}=23.667 \quad \text{Eq. B5.1.2-1}$$

$$\beta=1.3896 \quad \text{Eq. B5.1.2-3}$$

$$k_d=4.2346 \quad \text{Eq. B5.1.2-2}$$

$$R=1.6264 \quad \text{Eq. B5.1-6}$$

$$k=6.8873 \quad \text{Eq. B5.1-5}$$

$$f=111.69 \text{ MPa}$$

$$F_{cr1}=960.61 \text{ MPa} \quad \text{Eq. B5.1-4}$$

$$\lambda=0.34099 \quad \text{Eq. B5.1-3}$$

$$\rho=1 \text{ (fully effective)}$$

Element 10: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.15051 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.16612 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 11: Stiffened,  $w=12.492 \text{ mm}$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.062107 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=12.492 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=6.2462 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=6.2462 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 13: Unstiffened,  $w=7 \text{ mm}$

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.10614 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 12: Check for lip stiffener reduction

$$S=54.164 \quad \text{Eq. B4-7}$$

$w/t < 0.328S$  (no lip reduction)

Element 12: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.11879 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=111.69 \text{ MPa}, f_2=111.69 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.10111 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$A_e=535.65 \text{ mm}^2$$

$$P_{nl}=59.829 \text{ kN} \quad \text{Eq. C4.1-1}$$

$\Omega_c=2, \phi_c=0.8$  (rational analysis)

Distortional buckling for part 1 elements 1 to 4

$$A_f=240.86 \text{ mm}^2, I_{xf}=14350 \text{ mm}^4, I_{yf}=121150 \text{ mm}^4, I_{xyf}=-33219 \text{ mm}^4$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$x_{of}=11.211$  mm,  $y_{of}=-5.5027$  mm,  $C_{wf}=4313300$  mm<sup>6</sup>,  $J_f=501.79$  mm<sup>4</sup>

$h_{xf}=-41.951$  mm,  $h_o=43.214$  mm,  $t_{web}=2.5$  mm

$L_{crd}=409.54$  mm Eq. C4.2-13

$k\phi_{fe}=15.507$  kN Eq. C3.1.4-13

$k\phi_{we}=13.245$  kN Eq. C4.2-11

$k\phi=0$  kN

$k\phi_{fg}=34.083$  mm<sup>2</sup> Eq. C3.1.4-15

$k\phi_{wg}=0.19786$  mm<sup>2</sup> Eq. C4.2-12

$F_{crd}=838.68$  MPa Eq. C4.2-10

$P_{crd}=604.4$  kN Eq. C4.2-5

$P_{nd}=268.9$  kN Eq. C4.2-2

$\Omega_c=1.8$ ,  $\phi_c=0.85$

### Flexural Strength about X-axis

$\sigma_{ey}=68655$  MPa Eq. C3.1.2.1-8

$\sigma_t=158.69$  MPa Eq. C3.1.2.1-9

$C_b=1$  Eq. C3.1.2.1-6

$F_e=9729.3$  MPa Eq. C3.1.2.1-4

$M_{cre}=192.22$  kN-m

$F_y=414.13$  MPa

$F_c=414.13$  MPa

Not subject to lateral-torsional buckling - same as fully braced strength

### Distortional buckling for part 1 elements 1 to 4

$A_f=240.86$  mm<sup>2</sup>,  $I_{xf}=14350$  mm<sup>4</sup>,  $I_{yf}=121150$  mm<sup>4</sup>,  $I_{xyf}=-33219$  mm<sup>4</sup>

$x_{of}=11.211$  mm,  $y_{of}=-5.5027$  mm,  $C_{wf}=4313300$  mm<sup>6</sup>,  $J_f=501.79$  mm<sup>4</sup>

$h_{xf}=-41.951$  mm,  $h_o=43.214$  mm,  $t_{web}=2.5$  mm

$L_{crd}=370.07$  mm Eq. C3.1.4-12

$k\phi_{fe}=22.637$  kN Eq. C3.1.4-13

$k\phi_{we}=20.149$  kN Eq. C3.1.4-14

$k\phi=0$  kN

$k\phi_{fg}=41.743$  mm<sup>2</sup> Eq. C3.1.4-15

$k\phi_{wg}=0.17942$  mm<sup>2</sup> Eq. C3.1.4-16

$F_{crd}=1020.6$  MPa Eq. C3.1.4-10

$M_{crd}=20.681$  kN-m Eq. C3.1.4-5

$M_{nd}=8.1818$  kN-m Eq. C3.1.4-1

$\Omega_b=2$ ,  $\phi_b=0.8$  (rational analysis)

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Flexural Strength about Y-axis

$$\sigma_{ex}=479.28 \text{ MPa} \quad \text{Eq. C3.1.2.1-11}$$

$$\sigma_t=158.69 \text{ MPa} \quad \text{Eq. C3.1.2.1-9}$$

$$C_{tf}=1 \quad \text{Eq. C3.1.2.1-12}$$

$$F_e=440.86 \text{ MPa} \quad \text{Eq. C3.1.2.1-10}$$

$$M_{cre}=4.6785 \text{ kN-m}$$

$$F_y=459.74 \text{ MPa}$$

$$F_c=362.85 \text{ MPa} \quad \text{Eq. C3.1.2.1-2}$$

$$M_{ne}=3.8506 \text{ kN-m}$$

### Local buckling (EWM)

#### Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=7 \text{ mm}$

$$f_1=353.59 \text{ MPa}, f_2=353.59 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.18885 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 2: Check for lip stiffener reduction

$$S=31.895 \quad \text{Eq. B4-7}$$

$$w/t < 0.328S \text{ (no lip reduction)}$$

Element 2: Stiffened,  $w=25.002 \text{ mm}$

$$f_1=322.1 \text{ MPa}, f_2=136.87 \text{ MPa}$$

$$\psi=0.42492 \quad \text{Eq. B2.3-1}$$

$$k=5.5305 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.17951 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=25.002 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=9.7093 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=15.293 \text{ mm} \quad \text{Eq. B2.3-10}$$

$$b_1+b_2 > \text{compression width (fully effective)}$$

Element 3: Stiffened,  $w=12.492 \text{ mm}$

$$f_1=106.94 \text{ MPa}, f_2=78.217 \text{ MPa}$$

$$\psi=0.73144 \quad \text{Eq. B2.3-1}$$

$$k=4.5759 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.056817 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$b_e=12.492$ mm	Eq. B2.1-2
$b_1=5.5068$ mm	Eq. B2.3-9
$b_2=6.9856$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 4: Stiffened, $w=31.381$ mm	
$f_1=51.806$ MPa, $f_2=-180.69$ MPa	
$\psi=3.4878$	Eq. B2.3-1
$k=193.75$	Eq. B2.3-2
$\lambda=0.015267$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=31.381$ mm	Eq. B2.1-2
$h_0=40.009$ mm, $b_0=20.11$ mm, $h_0/b_0=1.9895$	
$b_1=4.837$ mm	Eq. B2.3-3
$b_2=15.691$ mm	Eq. B2.3-4
Compression width= $6.9926$ mm	
$b_1+b_2 >$ compression width (fully effective)	
Element 5: No compressive stress (fully effective)	
Element 6: No compressive stress (fully effective)	
Element 7: No compressive stress (fully effective)	
Element 8: No compressive stress (fully effective)	
Element 9: No compressive stress (fully effective)	
Element 10: Stiffened, $w=31.381$ mm	
$f_1=51.806$ MPa, $f_2=-180.69$ MPa	
$\psi=3.4878$	Eq. B2.3-1
$k=193.75$	Eq. B2.3-2
$\lambda=0.015267$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=31.381$ mm	Eq. B2.1-2
$h_0=40.009$ mm, $b_0=20.11$ mm, $h_0/b_0=1.9895$	
$b_1=4.837$ mm	Eq. B2.3-3
$b_2=15.691$ mm	Eq. B2.3-4
Compression width= $6.9926$ mm	
$b_1+b_2 >$ compression width (fully effective)	
Element 11: Stiffened, $w=12.492$ mm	
$f_1=106.94$ MPa, $f_2=78.217$ MPa	
$\psi=0.73144$	Eq. B2.3-1
$k=4.5759$	Eq. B2.3-8

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\lambda=0.056817$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=12.492$ mm	Eq. B2.1-2
$b_1=5.5068$ mm	Eq. B2.3-9
$b_2=6.9856$ mm	Eq. B2.3-10

$b_1+b_2 >$  compression width (fully effective)

Element 13: Unstiffened,  $w=7$  mm

$f_1=353.59$ MPa, $f_2=353.59$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.18885$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

Element 12: Check for lip stiffener reduction

$S=31.895$	Eq. B4-7
$w/t < 0.328S$ (no lip reduction)	

Element 12: Stiffened,  $w=25.002$  mm

$f_1=322.1$ MPa, $f_2=136.87$ MPa	
$\psi=0.42492$	Eq. B2.3-1
$k=5.5305$	Eq. B2.3-8
$\lambda=0.17951$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=25.002$ mm	Eq. B2.1-2
$b_1=9.7093$ mm	Eq. B2.3-9
$b_2=15.293$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	

Center of gravity shift:  $x=0$  mm

$Sec=10612$ mm <sup>3</sup>	
$Mn1=3.8506$ kN-m	Eq. C3.1.2.1-1
$\Omega b=1.67$ , $\phi b=0.9$	

Distortional buckling for part 1 elements 1 to 4

$A_f=240.86$ mm <sup>2</sup> , $I_{xf}=14350$ mm <sup>4</sup> , $I_{yf}=121150$ mm <sup>4</sup> , $I_{xyf}=-33219$ mm <sup>4</sup>	
$x_{of}=11.211$ mm, $y_{of}=-5.5027$ mm, $C_{wf}=4313300$ mm <sup>6</sup> , $J_f=501.79$ mm <sup>4</sup>	
$h_{xf}=-41.951$ mm, $h_o=43.214$ mm, $t_{web}=2.5$ mm	
$L_{crd}=574.6$ mm	Analytical
$k\phi_{fe}=4.5671$ kN	Eq. C3.1.4-13

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$k\phi_{we}=3.9321$ kN	Analytical
$k\phi=0$ kN	
$k\phi_{fg}=10.154$ mm <sup>2</sup>	Analytical
$k\phi_{wg}=0$ mm <sup>2</sup>	Analytical
$F_{crd}=837.06$ MPa	Eq. C3.1.4-10
$M_{crd}=8.8831$ kN-m	Eq. C3.1.4-5
$M_{nd}=4.6289$ kN-m	Eq. C3.1.4-2
$\Omega_b=1.67$ , $\phi_b=0.9$	

### Compression and Bending Interaction

$\alpha_x=0.97994$	Eq. C5.2.2-4
$\alpha_y=0.99986$	Eq. C5.2.2-5

# SISTEMA DINÁMICO FEMSA BOGOTÁ

## 11.3 ANEXO 3: N100x78x2.0

CFS Version 13.0.2

Section: N100x78x2.0\_CFS.cfss

Humberto Marin

N100x78x2.0\_CFS

DSC

220920 - FEMSA

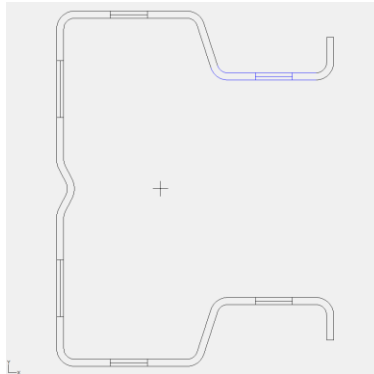
Rev. Date: 2023-07-11 7:32:10 PM

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Printed: 2023-07-12 12:23:45 AM

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### Section Inputs

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Material: [Q355B]

Apply cold work of forming strength increase.

No inelastic reserve strength increase.

Modulus of Elasticity, E                    200000 MPa

Yield Strength, Fy                            355 MPa

Tensile Strength, Fu                         470 MPa

Torsion Constant Override, J                0 mm<sup>4</sup>

Warping Constant Override, Cw             0 mm<sup>6</sup>

Hole Length                                    1.5

Hole Spacing                                    4

Part 1, Thickness 2 mm

Placement of Part from Origin:

X to center of gravity                        0 mm

Y to center of gravity                        0 mm

Centerline dimensions, Open shape

Length	Angle	Radius	Web	k	Hole Size	Distance
(mm)	(deg)	(mm)		Coef.	(mm)	(mm)

## SISTEMA DINÁMICO FEMSA BOGOTÁ

1	11.000	90.000	3.0000	None	0.000	0.000	5.500
2	31.899	180.000	3.0000	Single	0.000	10.500	15.950
3	18.296	251.923	3.0000	None	0.000	0.000	9.148
4	38.790	180.000	3.0000	Single	0.000	10.500	19.395
5	41.971	90.000	3.0000	Single	0.000	16.000	20.985
6	6.544	62.712	3.0000	None	0.000	0.000	3.272
7	2.427	90.000	4.0000	None	0.000	0.000	1.214
8	6.544	117.288	4.0000	None	0.000	0.000	3.272
9	41.971	90.000	3.0000	Single	0.000	16.000	20.985
10	38.790	0.000	3.0000	Single	0.000	10.500	19.395
11	18.296	-71.923	3.0000	None	0.000	0.000	9.148
12	31.899	0.000	3.0000	Single	0.000	10.500	15.950
13	11.000	90.000	3.0000	None	0.000	0.000	5.500

### Full Section Properties

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Area	578.53 mm <sup>2</sup>	Wt.	0.044494 kN/m	Flat	289.26 mm
I <sub>x</sub>	804600 mm <sup>4</sup>	r <sub>x</sub>	37.293 mm	I <sub>xy</sub>	0 mm <sup>4</sup>
S <sub>x(t)</sub>	16092 mm <sup>3</sup>	y(t)	50.000 mm	α	0.000 deg
S <sub>x(b)</sub>	16092 mm <sup>3</sup>	y(b)	50.000 mm		
Z <sub>x</sub>	20225 mm <sup>3</sup>	Height	100.000 mm		
I <sub>y</sub>	422314 mm <sup>4</sup>	r <sub>y</sub>	27.018 mm	x <sub>o</sub>	-67.197 mm
S <sub>y(l)</sub>	14396 mm <sup>3</sup>	x(l)	29.336 mm	y <sub>o</sub>	0.000 mm
S <sub>y(r)</sub>	8613 mm <sup>3</sup>	x(r)	49.031 mm	j <sub>x</sub>	73.671 mm
Z <sub>y</sub>	13901 mm <sup>3</sup>	Width	78.367 mm	j <sub>y</sub>	0.000 mm
I <sub>1</sub>	804600 mm <sup>4</sup>	r <sub>1</sub>	37.293 mm	C <sub>w</sub>	1.1682e09 mm <sup>6</sup>
I <sub>2</sub>	422314 mm <sup>4</sup>	r <sub>2</sub>	27.018 mm	J	771.4 mm <sup>4</sup>
I <sub>c</sub>	1226914 mm <sup>4</sup>	r <sub>c</sub>	46.052 mm		
I <sub>o</sub>	3839188 mm <sup>4</sup>	r <sub>o</sub>	81.463 mm		

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Net Section Properties

Ix	610178 mm <sup>4</sup>	rx	37.647 mm	Area	430.53 mm <sup>2</sup>
Sx(t)	12204 mm <sup>3</sup>	y(t)	50.000 mm	Ixy	0 mm <sup>4</sup>
Sx(b)	12204 mm <sup>3</sup>	y(b)	50.000 mm	α	0.000 deg
Zx	15046 mm <sup>3</sup>				
Iy	321905 mm <sup>4</sup>	ry	27.344 mm	x <sub>o</sub>	-71.269 mm
Sy(l)	10288 mm <sup>3</sup>	x(l)	31.291 mm	y <sub>o</sub>	0.000 mm
Sy(r)	6838 mm <sup>3</sup>	x(r)	47.076 mm	jx	76.669 mm
Zy	10362 mm <sup>3</sup>			jy	0.000 mm
Ic	932082 mm <sup>4</sup>	rc	46.529 mm	Cw	857135500 mm <sup>6</sup>
I <sub>o</sub>	3118863 mm <sup>4</sup>	r <sub>o</sub>	85.114 mm	J	574.0 mm <sup>4</sup>

### Member Check - AISI S100-07, US, LRFD (Mayor carga axial)

Material Type: [Q355B], Fy=355 MPa

Design Parameters:

Lx	0.20000 m	Ly	0.16000 m	Lt	0.20000 m
Kx	0.9000	Ky	0.9000	Kt	0.9000
Cbx	1.0000	Cby	1.0000	ex	0.0000 mm
Cmx	1.0000	Cmy	1.0000	ey	0.0000 mm
Braced Flange:	None	kφ	0 kN		
Red. Factor, R:	0	Lm	0.20000 m		

Loads:	P	Mx	Vy	My	Vx
	(kN)	(kN-m)	(kN)	(kN-m)	(kN)
Entered	79.28	1.2400	0.87	0.0000	7.51
Applied	79.28	1.2400	0.87	0.0000	7.51
Strength	121.14	3.9548	2.45	2.4372	46.04

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Interaction Equations

$$\text{Eq. C5.2.2-1 (P, Mx, My)} \quad 0.654 + 0.314 + 0.000 = 0.969 \leq 1.0$$

$$\text{Eq. C5.2.2-2 (P, Mx, My)} \quad 0.648 + 0.314 + 0.000 = 0.962 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (Mx, Vy)} \quad \text{Sqrt}(0.098 + 0.126) = 0.474 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (My, Vx)} \quad \text{Sqrt}(0.000 + 0.027) = 0.163 \leq 1.0$$

Part 1 elements 5-9 number of stiffeners exceeds 0 (web).

Clear distance between holes less than 457.2 mm.

### Calculation Details - AISI S100-07, US, LRFD

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#### Axial Compression Strength

$$(KL/r)_x=4.8266, (KL/r)_y=5.3297$$

$$\sigma_x=84731 \text{ MPa}$$

Eq. C3.1.2.1-11

$$\sigma_y=69489 \text{ MPa}$$

Eq. C3.1.2.1-8

$$\sigma_t=18553 \text{ MPa}$$

Eq. C3.1.2.1-9

$$F_e=16014 \text{ MPa}$$

Eq. C4.1.2-1

$$F_y=355 \text{ MPa}$$

$$\lambda_c=0.14889$$

Eq. C4.1-4

$$F_n=351.72 \text{ MPa}$$

Eq. C4.1-2

$$P_{ne}=203.48 \text{ kN}$$

#### Local buckling (EWM)

Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=7 \text{ mm}$

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

$$k=0.43$$

Eq. B3.2-3

$$\lambda=0.23544$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$$S=30.523$$

Eq. B4-7

$$I_a=3.4538 \text{ mm}^4$$

Eq. B4-8

$$I_s=57.167 \text{ mm}^4 > I_a \text{ (no lip reduction)}$$

$$k=2.8497$$

Table B4-1

Element 2: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$f_1=351.72 \text{ MPa}$ ,  $f_2=351.72 \text{ MPa}$

$\psi=1$  Eq. B3.2-1

$k=0.30635$  Eq. B3.2-3

$\lambda=0.31072$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

$f_1=351.72 \text{ MPa}$ ,  $f_2=351.72 \text{ MPa}$

$\psi=1$  Eq. B3.2-1

$k=0.30635$  Eq. B3.2-3

$\lambda=0.26697$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Element 3: Stiffened,  $w=12.492 \text{ mm}$

$f_1=351.72 \text{ MPa}$ ,  $f_2=351.72 \text{ MPa}$

$\psi=1$  Eq. B2.3-1

$k=4$  Eq. B2.3-8

$\lambda=0.13776$  Eq. B2.1-4

$\rho=1$  Eq. B2.1-3

$b_e=12.492 \text{ mm}$  Eq. B2.1-2

$b_1=6.2459 \text{ mm}$  Eq. B2.3-9

$b_2=6.2459 \text{ mm}$  Eq. B2.3-10

$b_1+b_2 >$  compression width (fully effective)

Element 4: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$f_1=351.72 \text{ MPa}$ ,  $f_2=351.72 \text{ MPa}$

$\psi=1$  Eq. B3.2-1

$k=0.43$  Eq. B3.2-3

$\lambda=0.37815$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

$f_1=351.72 \text{ MPa}$ ,  $f_2=351.72 \text{ MPa}$

$\psi=1$  Eq. B3.2-1

$k=0.43$  Eq. B3.2-3

$\lambda=0.34122$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Elements 5 to 9:

Section B5 - Elements with Intermediate Stiffeners

$b_o=90 \text{ mm}$ ,  $b_p=37 \text{ mm}$

$k_{loc}=23.667$  Eq. B5.1.2-1

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\beta=1.494$	Eq. B5.1.2-3
$k_d=4.6699$	Eq. B5.1.2-2
$R=1.6355$	Eq. B5.1-6
$k=7.6377$	Eq. B5.1-5
$f=351.72$ MPa	
$F_{cr1}=681.78$ MPa	Eq. B5.1-4
$\lambda=0.71825$	Eq. B5.1-3
$\rho=0.96582$	Eq. B5.1-2
$b_e=88.17$ mm	Eq. B5.1-1

Element 10: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$f_1=351.72$  MPa,  $f_2=351.72$  MPa

$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.34122$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

$f_1=351.72$  MPa,  $f_2=351.72$  MPa

$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.37815$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1

Element 11: Stiffened,  $w=12.492$  mm

$f_1=351.72$  MPa,  $f_2=351.72$  MPa

$\psi=1$	Eq. B2.3-1
$k=4$	Eq. B2.3-8
$\lambda=0.13776$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=12.492$ mm	Eq. B2.1-2
$b_1=6.2459$ mm	Eq. B2.3-9
$b_2=6.2459$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	

Element 13: Unstiffened,  $w=7$  mm

$f_1=351.72$  MPa,  $f_2=351.72$  MPa

$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.23544$	Eq. B2.1-4

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Element 12: Check for lip stiffener reduction

$S = 30.523$  Eq. B4-7

$I_a = 3.4538 \text{ mm}^4$  Eq. B4-8

$I_s = 57.167 \text{ mm}^4 > I_a$  (no lip reduction)

$k = 2.8497$  Table B4-1

Element 12: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$f_1 = 351.72 \text{ MPa}$ ,  $f_2 = 351.72 \text{ MPa}$

$\psi = 1$  Eq. B3.2-1

$k = 0.30635$  Eq. B3.2-3

$\lambda = 0.31072$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

$f_1 = 351.72 \text{ MPa}$ ,  $f_2 = 351.72 \text{ MPa}$

$\psi = 1$  Eq. B3.2-1

$k = 0.30635$  Eq. B3.2-3

$\lambda = 0.26697$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

$A_e = 430.53 \text{ mm}^2$

$P_{nl} = 151.42 \text{ kN}$  Eq. C4.1-1

$\Omega_c = 2$ ,  $\phi_c = 0.8$  (rational analysis)

Flexural Strength about X-axis

$\sigma_{ey} = 69489 \text{ MPa}$  Eq. C3.1.2.1-8

$\sigma_t = 18553 \text{ MPa}$  Eq. C3.1.2.1-9

$C_b = 1$  Eq. C3.1.2.1-6

$F_e = 105160 \text{ MPa}$  Eq. C3.1.2.1-4

$M_{cre} = 1692.2 \text{ kN-m}$

$F_y = 405.09 \text{ MPa}$

$F_c = 405.09 \text{ MPa}$

Not subject to lateral-torsional buckling - same as fully braced strength

Distortional buckling for part 1 elements 10 to 13

$A_f = 193.41 \text{ mm}^2$ ,  $I_{xf} = 11516 \text{ mm}^4$ ,  $I_{yf} = 98333 \text{ mm}^4$ ,  $I_{xyf} = -27041 \text{ mm}^4$

$x_{of} = 10.811 \text{ mm}$ ,  $y_{of} = -4.9865 \text{ mm}$ ,  $C_{wf} = 3507200 \text{ mm}^6$ ,  $J_f = 257.87 \text{ mm}^4$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$h_{xf}=-42.234$  mm,  $h_o=43.214$  mm,  $t_{web}=2$  mm

$L_{crd}=411.6$  mm Eq. C3.1.4-12

$L=200$  mm

$k\phi_{fe}=187.34$  kN Eq. C3.1.4-13

$k\phi_{we}=10.67$  kN Eq. C3.1.4-14

$k\phi=0$  kN

$k\phi_{fg}=116.62$  mm<sup>2</sup> Eq. C3.1.4-15

$k\phi_{wg}=0.48191$  mm<sup>2</sup> Eq. C3.1.4-16

$F_{crd}=1690.8$  MPa Eq. C3.1.4-10

$M_{crd}=27.764$  kN-m Eq. C3.1.4-5

$M_{nd}=6.5187$  kN-m Eq. C3.1.4-1

$\Omega_b=2$ ,  $\phi_b=0.8$  (rational analysis)

### Flexural Strength about Y-axis

$\sigma_{ex}=84731$  MPa Eq. C3.1.2.1-11

$\sigma_t=18553$  MPa Eq. C3.1.2.1-9

$C_{tf}=1$  Eq. C3.1.2.1-12

$F_e=52802$  MPa Eq. C3.1.2.1-10

$M_{cre}=454.79$  kN-m

$F_y=445.53$  MPa

$F_c=445.53$  MPa

Not subject to lateral-torsional buckling - same as fully braced strength

### Distortional buckling for part 1 elements 12 to 13

$A_f=82.365$  mm<sup>2</sup>,  $I_{xf}=637.03$  mm<sup>4</sup>,  $I_{yf}=9127.7$  mm<sup>4</sup>,  $I_{xyf}=-1232.7$  mm<sup>4</sup>

$x_{of}=-10.691$  mm,  $y_{of}=4.9841$  mm,  $C_{wf}=92.077$  mm<sup>6</sup>,  $J_f=109.82$  mm<sup>4</sup>

$h_{xf}=19.024$  mm,  $h_o=19.747$  mm,  $t_{web}=2$  mm

$L_{crd}=152.84$  mm Analytical

$k\phi_{fe}=18.391$  kN Eq. C3.1.4-13

$k\phi_{we}=15.251$  kN Analytical

$k\phi=0$  kN

$k\phi_{fg}=14.362$  mm<sup>2</sup> Analytical

$k\phi_{wg}=0.035678$  mm<sup>2</sup> Analytical

$F_{crd}=2336.5$  MPa Eq. C3.1.4-10

$M_{crd}=20.125$  kN-m Eq. C3.1.4-5

$M_{nd}=3.8374$  kN-m Eq. C3.1.4-1

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$\Omega_b=1.67, \phi_b=0.9$$

Compression and Bending Interaction

$$\alpha_x=0.99838$$

Eq. C5.2.2-4

$$\alpha_y=0.99803$$

Eq. C5.2.2-5

### Member Check - AISI S100-07, US, LRFD (Mayor momento flector)

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Material Type: [Q355B],  $F_y=355$  MPa

Design Parameters:

Lx	0.20000 m	Ly	0.16000 m	Lt	0.20000 m
Kx	0.9000	Ky	0.9000	Kt	0.9000
Cbx	1.0000	Cby	1.0000	ex	0.0000 mm
Cmx	1.0000	Cmy	1.0000	ey	0.0000 mm
Braced Flange:	None	$k\phi$	0 kN		
Red. Factor, R:	0	Lm	0.20000 m		

Loads:	P	Mx	Vy	My	Vx
	(kN)	(kN-m)	(kN)	(kN-m)	(kN)
Entered	31.40	2.5000	0.00	0.0000	16.60
Applied	31.40	2.5000	0.00	0.0000	16.60
Strength	121.14	3.9548	2.45	2.4372	46.04

Interaction Equations

$$\text{Eq. C5.2.2-1 (P, Mx, My)} \quad 0.259 + 0.633 + 0.000 = 0.892 \leq 1.0$$

$$\text{Eq. C5.2.2-2 (P, Mx, My)} \quad 0.257 + 0.632 + 0.000 = 0.889 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (Mx, Vy)} \quad \text{Sqrt}(0.400 + 0.000) = 0.632 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (My, Vx)} \quad \text{Sqrt}(0.000 + 0.130) = 0.361 \leq 1.0$$

Part 1 elements 5-9 number of stiffeners exceeds 0 (web).

Clear distance between holes less than 457.2 mm.

# SISTEMA DINÁMICO FEMSA BOGOTÁ

## Calculation Details - AISI S100-07, US, LRFD

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### Axial Compression Strength

$$(KL/r)_x=4.8266, (KL/r)_y=5.3297$$

$$\sigma_{ex}=84731 \text{ MPa} \quad \text{Eq. C3.1.2.1-11}$$

$$\sigma_{ey}=69489 \text{ MPa} \quad \text{Eq. C3.1.2.1-8}$$

$$\sigma_t=18553 \text{ MPa} \quad \text{Eq. C3.1.2.1-9}$$

$$F_e=16014 \text{ MPa} \quad \text{Eq. C4.1.2-1}$$

$$F_y=355 \text{ MPa}$$

$$\lambda_c=0.14889 \quad \text{Eq. C4.1-4}$$

$$F_n=351.72 \text{ MPa} \quad \text{Eq. C4.1-2}$$

$$P_{ne}=203.48 \text{ kN}$$

### Local buckling (EWM)

#### Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=7 \text{ mm}$

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.23544 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

#### Element 2: Check for lip stiffener reduction

$$S=30.523 \quad \text{Eq. B4-7}$$

$$I_a=3.4538 \text{ mm}^4 \quad \text{Eq. B4-8}$$

$$I_s=57.167 \text{ mm}^4 > I_a \text{ (no lip reduction)}$$

$$k=2.8497 \quad \text{Table B4-1}$$

#### Element 2: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.30635 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.31072 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.30635 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.26697 \quad \text{Eq. B2.1-4}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Element 3: Stiffened, $w=12.492$ mm	
$f_1=351.72$ MPa, $f_2=351.72$ MPa	
$\psi=1$	Eq. B2.3-1
$k=4$	Eq. B2.3-8
$\lambda=0.13776$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=12.492$ mm	Eq. B2.1-2
$b_1=6.2459$ mm	Eq. B2.3-9
$b_2=6.2459$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 4: Treat as two unstiffened elements	
Hole spacing less than 609.6 mm, treat as rational analysis	
$f_1=351.72$ MPa, $f_2=351.72$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.37815$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
$f_1=351.72$ MPa, $f_2=351.72$ MPa	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.34122$	Eq. B2.1-4
$\lambda < 0.673$ (fully effective)	Eq. B2.1-1
Elements 5 to 9:	
Section B5 - Elements with Intermediate Stiffeners	
$b_o=90$ mm, $b_p=37$ mm	
$k_{loc}=23.667$	Eq. B5.1.2-1
$\beta=1.494$	Eq. B5.1.2-3
$k_d=4.6699$	Eq. B5.1.2-2
$R=1.6355$	Eq. B5.1-6
$k=7.6377$	Eq. B5.1-5
$f=351.72$ MPa	
$F_{cr1}=681.78$ MPa	Eq. B5.1-4
$\lambda=0.71825$	Eq. B5.1-3
$\rho=0.96582$	Eq. B5.1-2
$b_e=88.17$ mm	Eq. B5.1-1

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Element 10: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.34122 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.37815 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 11: Stiffened,  $w=12.492 \text{ mm}$

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.13776 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=12.492 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=6.2459 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=6.2459 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 > \text{compression width}$  (fully effective)

Element 13: Unstiffened,  $w=7 \text{ mm}$

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.23544 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 12: Check for lip stiffener reduction

$$S=30.523 \quad \text{Eq. B4-7}$$

$$I_a=3.4538 \text{ mm}^4 \quad \text{Eq. B4-8}$$

$$I_s=57.167 \text{ mm}^4 > I_a \text{ (no lip reduction)}$$

$$k=2.8497 \quad \text{Table B4-1}$$

Element 12: Treat as two unstiffened elements

Hole spacing less than 609.6 mm, treat as rational analysis

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.30635 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.31072 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$f_1=351.72 \text{ MPa}, f_2=351.72 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.30635 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.26697 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$A_e=430.53 \text{ mm}^2$$

$$P_{nl}=151.42 \text{ kN} \quad \text{Eq. C4.1-1}$$

$$\Omega_c=2, \phi_c=0.8 \text{ (rational analysis)}$$

Flexural Strength about X-axis

$$\sigma_{ey}=69489 \text{ MPa} \quad \text{Eq. C3.1.2.1-8}$$

$$\sigma_t=18553 \text{ MPa} \quad \text{Eq. C3.1.2.1-9}$$

$$C_b=1 \quad \text{Eq. C3.1.2.1-6}$$

$$F_e=105160 \text{ MPa} \quad \text{Eq. C3.1.2.1-4}$$

$$M_{cre}=1692.2 \text{ kN-m}$$

$$F_y=405.09 \text{ MPa}$$

$$F_c=405.09 \text{ MPa}$$

Not subject to lateral-torsional buckling - same as fully braced strength

Distortional buckling for part 1 elements 10 to 13

$$A_f=193.41 \text{ mm}^2, I_{xf}=11516 \text{ mm}^4, I_{yf}=98333 \text{ mm}^4, I_{xyf}=-27041 \text{ mm}^4$$

$$x_{of}=10.811 \text{ mm}, y_{of}=-4.9865 \text{ mm}, C_{wf}=3507200 \text{ mm}^6, J_f=257.87 \text{ mm}^4$$

$$h_{xf}=-42.234 \text{ mm}, h_o=43.214 \text{ mm}, t_{web}=2 \text{ mm}$$

$$L_{crd}=411.6 \text{ mm} \quad \text{Eq. C3.1.4-12}$$

$$L=200 \text{ mm}$$

$$k\phi_{fe}=187.34 \text{ kN} \quad \text{Eq. C3.1.4-13}$$

$$k\phi_{we}=10.67 \text{ kN} \quad \text{Eq. C3.1.4-14}$$

$$k\phi=0 \text{ kN}$$

$$k\phi_{fg}=116.62 \text{ mm}^2 \quad \text{Eq. C3.1.4-15}$$

$$k\phi_{wg}=0.48191 \text{ mm}^2 \quad \text{Eq. C3.1.4-16}$$

$$F_{crd}=1690.8 \text{ MPa} \quad \text{Eq. C3.1.4-10}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$M_{crd}=27.764$  kN-m Eq. C3.1.4-5

$M_{nd}=6.5187$  kN-m Eq. C3.1.4-1

$\Omega_b=2$ ,  $\phi_b=0.8$  (rational analysis)

### Flexural Strength about Y-axis

$\sigma_{ex}=84731$  MPa Eq. C3.1.2.1-11

$\sigma_t=18553$  MPa Eq. C3.1.2.1-9

$C_{tf}=1$  Eq. C3.1.2.1-12

$F_e=52802$  MPa Eq. C3.1.2.1-10

$M_{cre}=454.79$  kN-m

$F_y=445.53$  MPa

$F_c=445.53$  MPa

Not subject to lateral-torsional buckling - same as fully braced strength

### Distortional buckling for part 1 elements 12 to 13

$A_f=82.365$  mm<sup>2</sup>,  $I_{xf}=637.03$  mm<sup>4</sup>,  $I_{yf}=9127.7$  mm<sup>4</sup>,  $I_{xyf}=-1232.7$  mm<sup>4</sup>

$x_{of}=-10.691$  mm,  $y_{of}=4.9841$  mm,  $C_{wf}=92.077$  mm<sup>6</sup>,  $J_f=109.82$  mm<sup>4</sup>

$h_{xf}=19.024$  mm,  $h_o=19.747$  mm,  $t_{web}=2$  mm

$L_{crd}=152.84$  mm Analytical

$k\phi_{fe}=18.391$  kN Eq. C3.1.4-13

$k\phi_{we}=15.251$  kN Analytical

$k\phi=0$  kN

$k\phi_{fg}=14.362$  mm<sup>2</sup> Analytical

$k\phi_{wg}=0.035678$  mm<sup>2</sup> Analytical

$F_{crd}=2336.5$  MPa Eq. C3.1.4-10

$M_{crd}=20.125$  kN-m Eq. C3.1.4-5

$M_{nd}=3.8374$  kN-m Eq. C3.1.4-1

$\Omega_b=1.67$ ,  $\phi_b=0.9$

### Compression and Bending Interaction

$\alpha_x=0.99936$  Eq. C5.2.2-4

$\alpha_y=0.99922$  Eq. C5.2.2-5

# SISTEMA DINÁMICO FEMSA BOGOTÁ

## 11.4 ANEXO 4: B100\_50

CFS Version 13.0.2

Section: B100\_50\_CFS.cfss

Humberto Marin

B100\_50

DSC

220920 - FEMSA

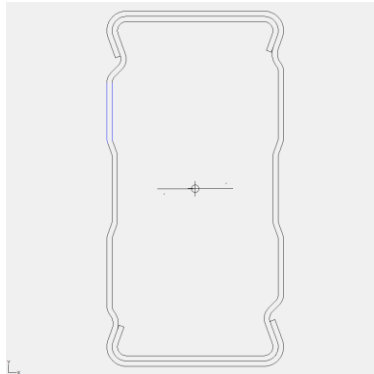
Rev. Date: 2023-07-12 12:47:49 AM

By: Humberto Marin

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Printed: 2023-07-12 12:49:14 AM

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### Section Inputs

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Material: [Q355B]

No cold work of forming strength increase.

Apply inelastic reserve strength increase.

Modulus of Elasticity, E                    200000 MPa

Yield Strength, Fy                            355 MPa

Tensile Strength, Fu                         470 MPa

Torsion Constant Override, J                0 mm<sup>4</sup>

Warping Constant Override, Cw              0 mm<sup>6</sup>

Connector Spacing                            0 mm

Part 1, Thickness 1.5 mm

Placement of Part from Origin:

X to center of gravity                        -8.7513 mm

Y to center of gravity                        -1.5227 mm

Centerline dimensions, Open shape

	Length	Angle	Radius	Web	k	Hole Size	Distance
	(mm)	(deg)	(mm)		Coef.	(mm)	(mm)
1	12.931	-70.000	4.0000	None	0.000	0.000	6.466

## SISTEMA DINÁMICO FEMSA BOGOTÁ

2	52.567	180.000	4.0000	Single	0.000	0.000	26.284
3	12.914	70.000	4.0000	None	0.000	0.000	6.457
4	3.812	128.695	4.0000	None	0.000	0.000	1.906
5	20.445	90.000	2.5000	Single	0.000	0.000	10.223
6	4.386	70.000	2.5000	None	0.000	0.000	2.193
7	19.146	90.000	2.5000	Single	0.000	0.000	9.573
8	4.386	110.000	2.5000	None	0.000	0.000	2.193
9	17.465	90.000	2.5000	Single	0.000	0.000	8.732
10	6.372	45.000	2.5000	None	0.000	0.000	3.186
11	12.863	110.000	2.5000	None	0.000	0.000	6.431
12	48.283	0.000	2.5000	Single	0.000	0.000	24.141
13	9.641	-110.000	2.5000	None	0.000	0.000	4.821

Part 2, Thickness 1.5 mm

Placement of Part from Origin:

X to center of gravity        8.7513 mm

Y to center of gravity        1.5227 mm

Centerline dimensions, Open shape

	Length (mm)	Angle (deg)	Radius (mm)	Web	k Coef.	Hole Size (mm)	Distance (mm)
1	12.931	110.000	4.0000	None	0.000	0.000	6.466
2	52.567	0.000	4.0000	Single	0.000	0.000	26.284
3	12.914	-110.000	4.0000	None	0.000	0.000	6.457
4	3.812	-51.305	4.0000	None	0.000	0.000	1.906
5	20.445	-90.000	2.5000	Single	0.000	0.000	10.223
6	4.386	-110.000	2.5000	None	0.000	0.000	2.193
7	19.146	-90.000	2.5000	Single	0.000	0.000	9.573
8	4.386	-70.000	2.5000	None	0.000	0.000	2.193
9	17.465	-90.000	2.5000	Single	0.000	0.000	8.732
10	6.372	-135.000	2.5000	None	0.000	0.000	3.186
11	12.863	-70.000	2.5000	None	0.000	0.000	6.431
12	48.283	180.000	2.5000	Single	0.000	0.000	24.141
13	9.641	70.000	2.5000	None	0.000	0.000	4.821

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Full Section Properties

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Area	627.08 mm <sup>2</sup>	Wt.	0.048228 kN/m	Flat	418.05 mm
Ix	975356 mm <sup>4</sup>	rx	39.439 mm	Ixy	-4951 mm <sup>4</sup>
Sx(t)	19507 mm <sup>3</sup>	y(t)	50.000 mm	α	0.385 deg
Sx(b)	19507 mm <sup>3</sup>	y(b)	50.000 mm		
Zx	22847 mm <sup>3</sup>	Height	100.000 mm		
Iy	238674 mm <sup>4</sup>	ry	19.509 mm	x <sub>o</sub>	0.000 mm
Sy(l)	9547 mm <sup>3</sup>	x(l)	25.000 mm	y <sub>o</sub>	0.000 mm
Sy(r)	9547 mm <sup>3</sup>	x(r)	25.000 mm	jx	0.000 mm
Zy	11332 mm <sup>3</sup>	Width	50.000 mm	jy	0.000 mm
I <sub>1</sub>	975389 mm <sup>4</sup>	r <sub>1</sub>	39.439 mm	Cw	362667500 mm <sup>6</sup>
I <sub>2</sub>	238640 mm <sup>4</sup>	r <sub>2</sub>	19.508 mm	J	470.3 mm <sup>4</sup>
I <sub>c</sub>	1214029 mm <sup>4</sup>	r <sub>c</sub>	44.000 mm		
I <sub>o</sub>	1214029 mm <sup>4</sup>	r <sub>o</sub>	44.000 mm		

### Member Check - AISI S100-07, US, LRFD

Material Type: [Q355B], Fy=355 MPa

Design Parameters:

Lx	1.6200 m	Ly	1.6200 m	Lt	1.6200 m
Kx	1.0000	Ky	1.0000	Kt	1.0000
Cbx	1.0000	Cby	1.0000	ex	0.0000 mm
Cmx	1.0000	Cmy	1.0000	ey	0.0000 mm
Braced Flange:	None	kφ	0 kN		
Red. Factor, R:	0	Lm	1.6200 m		

Loads:	P	Mx	Vy	My	Vx
	(kN)	(kN-m)	(kN)	(kN-m)	(kN)
Entered	0.000	4.0300	0.000	0.0000	0.000
Applied	0.000	4.0300	0.000	0.0000	0.000
Strength	95.663	4.2176	31.735	2.6657	47.350

## SISTEMA DINÁMICO FEMSA BOGOTÁ

### Interaction Equations

$$\text{Eq. C5.2.2-1 (P, Mx, My)} \quad 0.000 + 0.956 + 0.000 = 0.956 \leq 1.0$$

$$\text{Eq. C5.2.2-2 (P, Mx, My)} \quad 0.000 + 0.956 + 0.000 = 0.956 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (Mx, Vy)} \quad \text{Sqrt}(0.680 + 0.000) = 0.825 \leq 1.0$$

$$\text{Eq. C3.3.2-1 (My, Vx)} \quad \text{Sqrt}(0.000 + 0.000) = 0.000 \leq 1.0$$

Part 1 elements 5-9 number of stiffeners exceeds 0 (web).

Part 2 elements 5-9 number of stiffeners exceeds 0 (web).

### Calculation Details - AISI S100-07, US, LRFD

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#### Axial Compression Strength

$$(KL/r)_x=41.077, (KL/r)_y=83.037$$

$$\sigma_x=1169.9 \text{ MPa}$$

Eq. C3.1.2.1-11

$$\sigma_y=286.28 \text{ MPa}$$

Eq. C3.1.2.1-8

$$\sigma_t=254.37 \text{ MPa}$$

Eq. C3.1.2.1-9

$$F_e=254.37 \text{ MPa}$$

Eq. C3.1.2.1-9

$$F_y=355 \text{ MPa}$$

$$\lambda_c=1.1814$$

Eq. C4.1-4

$$F_n=197.94 \text{ MPa}$$

Eq. C4.1-2

$$P_{ne}=124.13 \text{ kN}$$

#### Local buckling (EWM)

Effective width calculations for part 1: Part 1

Element 1: Unstiffened,  $w=6.1476 \text{ mm}$

$$f_1=197.94 \text{ MPa}, f_2=197.94 \text{ MPa}$$

$$\psi=1$$

Eq. B3.2-1

$$k=0.43$$

Eq. B3.2-3

$$\lambda=0.20682$$

Eq. B2.1-4

$$\lambda < 0.673 \text{ (fully effective)}$$

Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$$S=40.687$$

Eq. B4-7

$$I_a=60.775 \text{ mm}^4$$

Eq. B4-8

$$I_s=25.847 \text{ mm}^4$$

$$d_s=2.6145 \text{ mm (lip ineffective width}=3.5331 \text{ mm)}$$

Eq. B4-6

$$k=2.5382$$

Table B4-1

## SISTEMA DINÁMICO FEMSA BOGOTÁ

Element 2: Partially stiffened,  $w=39$  mm

$$f=197.94 \text{ MPa}, k=2.5382$$

$$\lambda=0.54004 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 3: Stiffened,  $w=3.4594$  mm

$$f_1=197.94 \text{ MPa}, f_2=197.94 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.038159 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=3.4594 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=1.7297 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=1.7297 \text{ mm} \quad \text{Eq. B2.3-10}$$

$$b_1+b_2 > \text{compression width (fully effective)}$$

Element 4: Stiffened,  $w=3.9741e-6$  mm

$$f_1=197.94 \text{ MPa}, f_2=197.94 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=4.3837e-8 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=3.9741e-6 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=1.9871e-6 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=1.9871e-6 \text{ mm} \quad \text{Eq. B2.3-10}$$

$$b_1+b_2 > \text{compression width (fully effective)}$$

Elements 5 to 9:

Section B5 - Elements with Intermediate Stiffeners

$$b_o=62.812 \text{ mm}, b_p=18.731 \text{ mm}$$

$$k_{loc}=44.979 \quad \text{Eq. B5.1.2-1}$$

$$\beta=1.7539 \quad \text{Eq. B5.1.2-3}$$

$$k_d=4.2504 \quad \text{Eq. B5.1.2-2}$$

$$R=0.5 \quad \text{Eq. B5.1-6}$$

$$k=2.1252 \quad \text{Eq. B5.1-5}$$

$$f=197.94 \text{ MPa}$$

$$F_{cr1}=219.08 \text{ MPa} \quad \text{Eq. B5.1-4}$$

$$\lambda=0.95053 \quad \text{Eq. B5.1-3}$$

$$\rho=0.80855 \quad \text{Eq. B5.1-2}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$be=51.176 \text{ mm}$	Eq. B5.1-1
Element 10: Stiffened, $w=2.9555 \text{ mm}$	
$f_1=197.94 \text{ MPa}$ , $f_2=197.94 \text{ MPa}$	
$\psi=1$	Eq. B2.3-1
$k=4$	Eq. B2.3-8
$\lambda=0.032601$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$be=2.9555 \text{ mm}$	Eq. B2.1-2
$b_1=1.4778 \text{ mm}$	Eq. B2.3-9
$b_2=1.4778 \text{ mm}$	Eq. B2.3-10
$b_1+b_2 > \text{compression width (fully effective)}$	
Element 11: Stiffened, $w=6.1507 \text{ mm}$	
$f_1=197.94 \text{ MPa}$ , $f_2=197.94 \text{ MPa}$	
$\psi=1$	Eq. B2.3-1
$k=4$	Eq. B2.3-8
$\lambda=0.067845$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$be=6.1507 \text{ mm}$	Eq. B2.1-2
$b_1=3.0753 \text{ mm}$	Eq. B2.3-9
$b_2=3.0753 \text{ mm}$	Eq. B2.3-10
$b_1+b_2 > \text{compression width (fully effective)}$	
Element 13: Unstiffened, $w=5 \text{ mm}$	
$f_1=197.94 \text{ MPa}$ , $f_2=197.94 \text{ MPa}$	
$\psi=1$	Eq. B3.2-1
$k=0.43$	Eq. B3.2-3
$\lambda=0.16821$	Eq. B2.1-4
$\lambda < 0.673 \text{ (fully effective)}$	Eq. B2.1-1
Element 12: Check for lip stiffener reduction	
$S=40.687$	Eq. B4-7
$I_a=60.775 \text{ mm}^4$	Eq. B4-8
$I_s=13.962 \text{ mm}^4$	
$ds=1.1486 \text{ mm}$ (lip ineffective width= $3.8514 \text{ mm}$ )	Eq. B4-6
$k=2.2821$	Table B4-1
Element 12: Partially stiffened, $w=39 \text{ mm}$	
$f=197.94 \text{ MPa}$ , $k=2.2821$	
$\lambda=0.56954$	Eq. B2.1-4

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Effective width calculations for part 2: Part 2

Element 1: Unstiffened,  $w=6.1476$  mm

$f_1=197.94$  MPa,  $f_2=197.94$  MPa

$\psi=1$  Eq. B3.2-1

$k=0.43$  Eq. B3.2-3

$\lambda=0.20682$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$S=40.687$  Eq. B4-7

$I_a=60.775$  mm<sup>4</sup> Eq. B4-8

$I_s=25.847$  mm<sup>4</sup>

$ds=2.6145$  mm (lip ineffective width= $3.5331$  mm) Eq. B4-6

$k=2.5382$  Table B4-1

Element 2: Partially stiffened,  $w=39$  mm

$f=197.94$  MPa,  $k=2.5382$

$\lambda=0.54004$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Element 3: Stiffened,  $w=3.4594$  mm

$f_1=197.94$  MPa,  $f_2=197.94$  MPa

$\psi=1$  Eq. B2.3-1

$k=4$  Eq. B2.3-8

$\lambda=0.038159$  Eq. B2.1-4

$\rho=1$  Eq. B2.1-3

$b_e=3.4594$  mm Eq. B2.1-2

$b_1=1.7297$  mm Eq. B2.3-9

$b_2=1.7297$  mm Eq. B2.3-10

$b_1+b_2 >$  compression width (fully effective)

Element 4: Stiffened,  $w=3.9741e-6$  mm

$f_1=197.94$  MPa,  $f_2=197.94$  MPa

$\psi=1$  Eq. B2.3-1

$k=4$  Eq. B2.3-8

$\lambda=4.3837e-8$  Eq. B2.1-4

$\rho=1$  Eq. B2.1-3

$b_e=3.9741e-6$  mm Eq. B2.1-2

$b_1=1.9871e-6$  mm Eq. B2.3-9

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$b_2=1.9871e-6 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Elements 5 to 9:

Section B5 - Elements with Intermediate Stiffeners

$$b_o=62.812 \text{ mm}, b_p=18.731 \text{ mm}$$

$$k_{loc}=44.979 \quad \text{Eq. B5.1.2-1}$$

$$\beta=1.7539 \quad \text{Eq. B5.1.2-3}$$

$$k_d=4.2504 \quad \text{Eq. B5.1.2-2}$$

$$R=0.5 \quad \text{Eq. B5.1-6}$$

$$k=2.1252 \quad \text{Eq. B5.1-5}$$

$$f=197.94 \text{ MPa}$$

$$F_{cr1}=219.08 \text{ MPa} \quad \text{Eq. B5.1-4}$$

$$\lambda=0.95053 \quad \text{Eq. B5.1-3}$$

$$\rho=0.80855 \quad \text{Eq. B5.1-2}$$

$$b_e=51.176 \text{ mm} \quad \text{Eq. B5.1-1}$$

Element 10: Stiffened,  $w=2.9555 \text{ mm}$

$$f_1=197.94 \text{ MPa}, f_2=197.94 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.032601 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=2.9555 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=1.4778 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=1.4778 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 11: Stiffened,  $w=6.1507 \text{ mm}$

$$f_1=197.94 \text{ MPa}, f_2=197.94 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B2.3-1}$$

$$k=4 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.067845 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=6.1507 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=3.0753 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=3.0753 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 13: Unstiffened,  $w=5 \text{ mm}$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$f_1=197.94 \text{ MPa}, f_2=197.94 \text{ MPa}$$

$$\psi=1 \quad \text{Eq. B3.2-1}$$

$$k=0.43 \quad \text{Eq. B3.2-3}$$

$$\lambda=0.16821 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

Element 12: Check for lip stiffener reduction

$$S=40.687 \quad \text{Eq. B4-7}$$

$$I_a=60.775 \text{ mm}^4 \quad \text{Eq. B4-8}$$

$$I_s=13.962 \text{ mm}^4$$

$$d_s=1.1486 \text{ mm (lip ineffective width}=3.8514 \text{ mm)} \quad \text{Eq. B4-6}$$

$$k=2.2821 \quad \text{Table B4-1}$$

Element 12: Partially stiffened,  $w=39 \text{ mm}$

$$f=197.94 \text{ MPa}, k=2.2821$$

$$\lambda=0.56954 \quad \text{Eq. B2.1-4}$$

$$\lambda < 0.673 \text{ (fully effective)} \quad \text{Eq. B2.1-1}$$

$$A_e=568.57 \text{ mm}^2$$

$$P_n=112.54 \text{ kN} \quad \text{Eq. C4.1-1}$$

$$\Omega_c=1.8, \phi_c=0.85$$

Distortional buckling for part 1 elements 8 to 13

$$A_f=138.48 \text{ mm}^2, I_{xf}=18670 \text{ mm}^4, I_{yf}=40290 \text{ mm}^4, I_{xyf}=16059 \text{ mm}^4$$

$$x_{of}=-11.797 \text{ mm}, y_{of}=11.555 \text{ mm}, C_{wf}=514060 \text{ mm}^6, J_f=103.86 \text{ mm}^4$$

$$h_{xf}=-14.951 \text{ mm}, h_o=19.411 \text{ mm}, t_{web}=1.5 \text{ mm}$$

$$L_{crd}=210.03 \text{ mm} \quad \text{Eq. C4.2-13}$$

$$k\phi_f=8.1492 \text{ kN} \quad \text{Eq. C3.1.4-13}$$

$$k\phi_{we}=6.369 \text{ kN} \quad \text{Eq. C4.2-11}$$

$$k\phi=0 \text{ kN}$$

$$k\phi_{fg}=23.403 \text{ mm}^2 \quad \text{Eq. C3.1.4-15}$$

$$k\phi_{wg}=0.040908 \text{ mm}^2 \quad \text{Eq. C4.2-12}$$

$$F_{crd}=619.26 \text{ MPa} \quad \text{Eq. C4.2-10}$$

$$P_{crd}=388.33 \text{ kN} \quad \text{Eq. C4.2-5}$$

$$P_{nd}=202.33 \text{ kN} \quad \text{Eq. C4.2-2}$$

$$\Omega_c=1.8, \phi_c=0.85$$

Flexural Strength about X-axis

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\sigma_{ey}=286.28$ MPa	Eq. C3.1.2.1-8
$\sigma_t=254.37$ MPa	Eq. C3.1.2.1-9
$C_b=1$	Eq. C3.1.2.1-6
$F_e=381.66$ MPa	Eq. C3.1.2.1-4
$M_{cre}=7.4451$ kN-m	
$F_y=355$ MPa	
$F_c=292.53$ MPa	Eq. C3.1.2.1-2
$M_{ne}=5.7064$ kN-m	
Local buckling (EWM)	
Effective width calculations for part 1: Part 1	
Element 1: No compressive stress (fully effective)	
Element 2: No compressive stress (fully effective)	
Element 3: No compressive stress (fully effective)	
Element 4: No compressive stress (fully effective)	
Element 5: No compressive stress (fully effective)	
Element 6: No compressive stress (fully effective)	
Element 7: Stiffened, $w=18$ mm	
$f_1=60.247$ MPa, $f_2=-41.731$ MPa	
$\psi=0.69267$	Eq. B2.3-1
$k=17.085$	Eq. B2.3-2
$\lambda=0.053002$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=18$ mm	Eq. B2.1-2
$h_o=19.411$ mm, $b_o=4.6502$ mm, $h_o/b_o=4.1742$	
$b_1=4.8745$ mm	Eq. B2.3-6
$b_2=5.7596$ mm	Eq. B2.3-7
Compression width= $10.634$ mm	
$b_1+b_2 >$ compression width (fully effective)	
Element 8: Stiffened, $w=3.2396$ mm	
$f_1=83.791$ MPa, $f_2=66.545$ MPa	
$\psi=0.79417$	Eq. B2.3-1
$k=4.4291$	Eq. B2.3-8
$\lambda=0.022095$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=3.2396$ mm	Eq. B2.1-2
$b_1=1.4686$ mm	Eq. B2.3-9

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$$b_2=1.7709 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 9: Stiffened,  $w=15.546 \text{ mm}$

$$f_1=178.16 \text{ MPa}, f_2=90.089 \text{ MPa}$$

$$\psi=0.50566 \quad \text{Eq. B2.3-1}$$

$$k=5.2303 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.14227 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=15.546 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=6.2324 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=9.3133 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 10: Stiffened,  $w=2.9555 \text{ mm}$

$$f_1=203.02 \text{ MPa}, f_2=191.18 \text{ MPa}$$

$$\psi=0.94168 \quad \text{Eq. B2.3-1}$$

$$k=4.117 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.032544 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=2.9555 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=1.4359 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=1.5196 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 11: Stiffened,  $w=6.1507 \text{ mm}$

$$f_1=255.08 \text{ MPa}, f_2=222.34 \text{ MPa}$$

$$\psi=0.87163 \quad \text{Eq. B2.3-1}$$

$$k=4.261 \quad \text{Eq. B2.3-8}$$

$$\lambda=0.074622 \quad \text{Eq. B2.1-4}$$

$$\rho=1 \quad \text{Eq. B2.1-3}$$

$$b_e=6.1507 \text{ mm} \quad \text{Eq. B2.1-2}$$

$$b_1=2.8899 \text{ mm} \quad \text{Eq. B2.3-9}$$

$$b_2=3.2608 \text{ mm} \quad \text{Eq. B2.3-10}$$

$b_1+b_2 >$  compression width (fully effective)

Element 13: Unstiffened,  $w=5 \text{ mm}$

$$f_1=255.08 \text{ MPa}, f_2=228.47 \text{ MPa}$$

$$\psi=0.89565 \quad \text{Eq. B3.2-1}$$

$$k=0.46777 \quad \text{Eq. B3.2-2}$$

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$\lambda=0.18308$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Element 12: Check for lip stiffener reduction

$S=34.222$  Eq. B4-7

$I_a=162.56 \text{ mm}^4$  Eq. B4-8

$I_s=13.962 \text{ mm}^4$

$d_s=0.42943 \text{ mm}$  (lip ineffective width=4.5706 mm) Eq. B4-6

$k=1.7465$  Table B4-1

Element 12: Partially stiffened,  $w=39 \text{ mm}$

$f=279.79 \text{ MPa}$ ,  $k=1.7465$

$\lambda=0.77403$  Eq. B2.1-4

$\rho=0.92474$  Eq. B2.1-3

$b=36.065 \text{ mm}$  (ineffective width=2.9352 mm) Eq. B2.1-2

$b_1=1.5487 \text{ mm}$ ,  $b_2=34.516 \text{ mm}$

Effective width calculations for part 2: Part 2

Element 1: Unstiffened,  $w=6.1476 \text{ mm}$

$f_1=252.17 \text{ MPa}$ ,  $f_2=219.44 \text{ MPa}$

$\psi=0.87021$  Eq. B3.2-1

$k=0.4776$  Eq. B3.2-2

$\lambda=0.2215$  Eq. B2.1-4

$\lambda < 0.673$  (fully effective) Eq. B2.1-1

Element 2: Check for lip stiffener reduction

$S=33.714$  Eq. B4-7

$I_a=175.83 \text{ mm}^4$  Eq. B4-8

$I_s=25.847 \text{ mm}^4$

$d_s=0.90372 \text{ mm}$  (lip ineffective width=5.2439 mm) Eq. B4-6

$k=1.8642$  Table B4-1

Element 2: Partially stiffened,  $w=39 \text{ mm}$

$f=288.28 \text{ MPa}$ ,  $k=1.8642$

$\lambda=0.76046$  Eq. B2.1-4

$\rho=0.93457$  Eq. B2.1-3

$b=36.448 \text{ mm}$  (ineffective width=2.552 mm) Eq. B2.1-2

$b_1=2.679 \text{ mm}$ ,  $b_2=33.769 \text{ mm}$

Element 3: Stiffened,  $w=3.4594 \text{ mm}$

$f_1=252.17 \text{ MPa}$ ,  $f_2=233.75 \text{ MPa}$

$\psi=0.92696$  Eq. B2.3-1

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$k=4.1469$	Eq. B2.3-8
$\lambda=0.0423$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=3.4594$ mm	Eq. B2.1-2
$b_1=1.6688$ mm	Eq. B2.3-9
$b_2=1.7907$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 4: Stiffened, $w=3.9741e-6$ mm	
$f_1=207.72$ MPa, $f_2=207.72$ MPa	
$\psi=1$	Eq. B2.3-1
$k=4$	Eq. B2.3-8
$\lambda=4.4906e-8$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=3.9741e-6$ mm	Eq. B2.1-2
$b_1=1.9871e-6$ mm	Eq. B2.3-9
$b_2=1.9871e-6$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 5: Stiffened, $w=18.731$ mm	
$f_1=196.21$ MPa, $f_2=90.089$ MPa	
$\psi=0.45914$	Eq. B2.3-1
$k=5.3981$	Eq. B2.3-8
$\lambda=0.17708$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=18.731$ mm	Eq. B2.1-2
$b_1=7.372$ mm	Eq. B2.3-9
$b_2=11.359$ mm	Eq. B2.3-10
$b_1+b_2 >$ compression width (fully effective)	
Element 6: Stiffened, $w=3.2396$ mm	
$f_1=83.791$ MPa, $f_2=66.545$ MPa	
$\psi=0.79417$	Eq. B2.3-1
$k=4.4291$	Eq. B2.3-8
$\lambda=0.022095$	Eq. B2.1-4
$\rho=1$	Eq. B2.1-3
$b_e=3.2396$ mm	Eq. B2.1-2
$b_1=1.4686$ mm	Eq. B2.3-9
$b_2=1.7709$ mm	Eq. B2.3-10

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$b_1+b_2 >$  compression width (fully effective)

Element 7: Stiffened,  $w=18$  mm

$f_1=60.247$  MPa,  $f_2=-41.731$  MPa

$\psi=0.69267$

Eq. B2.3-1

$k=17.085$

Eq. B2.3-2

$\lambda=0.053002$

Eq. B2.1-4

$\rho=1$

Eq. B2.1-3

$b_e=18$  mm

Eq. B2.1-2

$h_o=19.411$  mm,  $b_o=4.6502$  mm,  $h_o/b_o=4.1742$

$b_1=4.8745$  mm

Eq. B2.3-6

$b_2=5.7596$  mm

Eq. B2.3-7

Compression width= $10.634$  mm

$b_1+b_2 >$  compression width (fully effective)

Element 8: No compressive stress (fully effective)

Element 9: No compressive stress (fully effective)

Element 10: No compressive stress (fully effective)

Element 11: No compressive stress (fully effective)

Element 13: No compressive stress (fully effective)

Element 12: No compressive stress (fully effective)

Center of gravity shift:  $y=-1.6387$  mm

$Sec=18022$  mm<sup>3</sup>

$M_{nl}=5.272$  kN-m

Eq. C3.1.2.1-1

$\Omega_b=2$ ,  $\phi_b=0.8$  (rational analysis)

Distortional buckling for part 1 elements 12 to 13

$A_f=82.322$  mm<sup>2</sup>,  $I_{xf}=3250.5$  mm<sup>4</sup>,  $I_{yf}=15284$  mm<sup>4</sup>,  $I_{xyf}=-6693.9$  mm<sup>4</sup>

$x_{of}=19.203$  mm,  $y_{of}=-6.1709$  mm,  $C_{wf}=91.613$  mm<sup>6</sup>,  $J_f=61.741$  mm<sup>4</sup>

$h_{xf}=-24.867$  mm,  $h_o=14.412$  mm,  $t_{web}=1.5$  mm

$L_{crd}=174.99$  mm

Eq. C3.1.4-12

$k\phi_f=14.392$  kN

Eq. C3.1.4-13

$k\phi_{we}=12.958$  kN

Eq. C3.1.4-14

$k\phi=0$  kN

$k\phi_{fg}=26.955$  mm<sup>2</sup>

Eq. C3.1.4-15

$k\phi_{wg}=0.025906$  mm<sup>2</sup>

Eq. C3.1.4-16

$F_{crd}=1013.7$  MPa

Eq. C3.1.4-10

## SISTEMA DINÁMICO FEMSA BOGOTÁ

$M_{crd}=20.705$  kN-m Eq. C3.1.4-5

$M_{nd}=6.925$  kN-m Eq. C3.1.4-1

$\Omega_b=2$ ,  $\phi_b=0.8$  (rational analysis)

### Flexural Strength about Y-axis

$\sigma_{ex}=1169.9$  MPa Eq. C3.1.2.1-11

$\sigma_t=254.37$  MPa Eq. C3.1.2.1-9

$C_b=1$  Eq. C3.1.2.1-6

$F_e=1576.5$  MPa Eq. C3.1.2.1-4

$M_{cre}=15.051$  kN-m

$F_y=355$  MPa

$F_c=355$  MPa

Not subject to lateral-torsional buckling - same as fully braced strength

### Distortional buckling for part 1 elements 12 to 13

$A_f=82.322$  mm<sup>2</sup>,  $I_{xf}=3250.5$  mm<sup>4</sup>,  $I_{yf}=15284$  mm<sup>4</sup>,  $I_{xyf}=-6693.9$  mm<sup>4</sup>

$x_{of}=19.203$  mm,  $y_{of}=-6.1709$  mm,  $C_{wf}=91.613$  mm<sup>6</sup>,  $J_f=61.741$  mm<sup>4</sup>

$h_{xf}=-24.867$  mm,  $h_o=14.412$  mm,  $t_{web}=1.5$  mm

$L_{crd}=314.35$  mm Analytical

$k\phi_{fe}=1.7081$  kN Eq. C3.1.4-13

$k\phi_{we}=1.46$  kN Analytical

$k\phi=0$  kN

$k\phi_{fg}=3.6824$  mm<sup>2</sup> Analytical

$k\phi_{wg}=0$  mm<sup>2</sup> Analytical

$F_{crd}=860.31$  MPa Eq. C3.1.4-10

$M_{crd}=8.7383$  kN-m Eq. C3.1.4-5

$M_{nd}=3.3892$  kN-m Eq. C3.1.4-1

$\Omega_b=1.67$ ,  $\phi_b=0.9$

### Compression and Bending Interaction

$\alpha_x=1$  Eq. C5.2.2-4

$\alpha_y=1$  Eq. C5.2.2-5

