

Nota de Lanzamiento

Fecha de Lanzamiento: Junio 2020

Versión del Producto : Civil 2020 (v3.1)



DESIGN OF CIVIL STRUCTURES

Integrated Solution System for Bridge and Civil Engineering

Mejoras

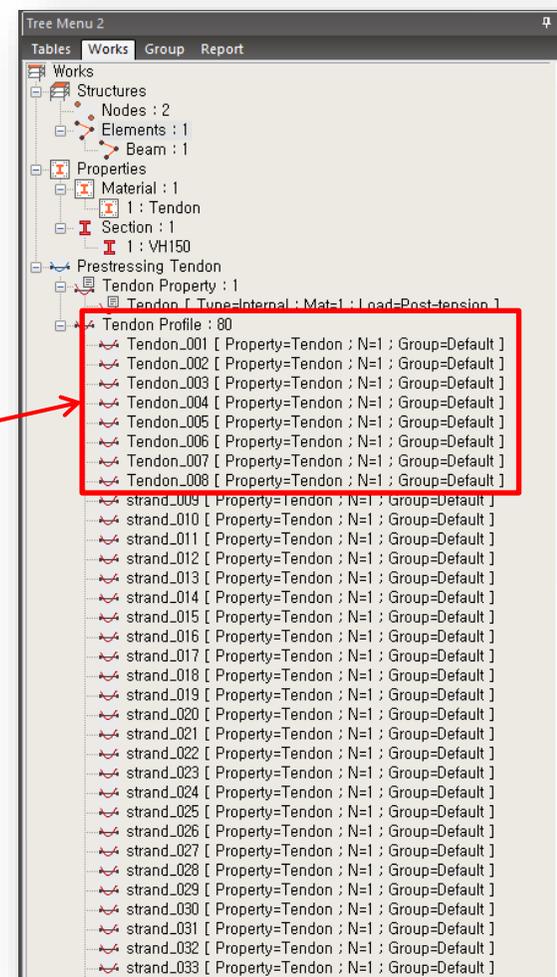
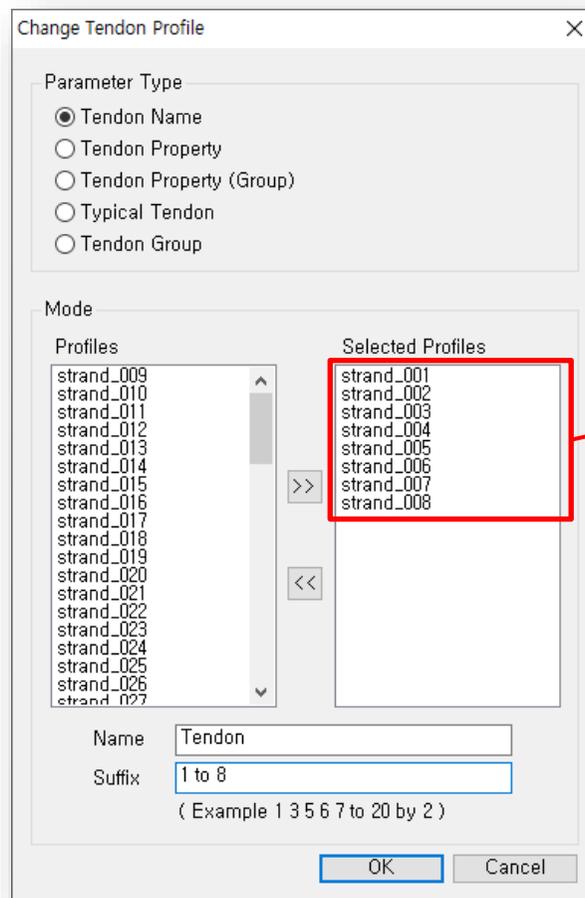
1. Edición por lotes del perfil del tendón
2. Datos de espesor del elemento Plane Strain
3. Generación automática de perfil de tendón - Tipos de secciones prefabricadas de Italia
4. Análisis de etapas de constructivas no lineal geométrica con elementos de plate
5. Set-back (Retroceso) para el saddle del puente colgante
6. Fuerzas concurrentes de elementos beam para el análisis tiempo historia
7. Diseño por AASHTO LRFD 8ª edición - Sección PSC / Compuesta, Sección RC
8. Diseño por AASHTO LRFD 8ª edición - Sección compuesta de acero
9. Combinación de carga por AASHTO LRFD 8ª edición - Generación automática
10. Efecto ortogonal de la carga sísmica: AASHTO LRFD
11. Cargas de tráfico ferroviario según AS 5100.2
12. Plataforma de carga pesada según AS 5100.2
13. Evaluación (Rating) de vehículos según AS 5100.2
14. Cargas de tráfico horizontales por AS 5100.2
15. Evaluación (Rating) de vehículos según CS 454
16. Diseño de viga presforzada según BS 5400
17. Mejora de la evaluación del puente según CS 454
18. Diseño de concreto reforzado según las especificaciones del IRS
19. Informe de diseño polaco



1. Edición por lotes del perfil del tendón

- La edición por lotes es posible para múltiples perfiles de tendones al mismo tiempo..
- Nombre del tendón, propiedad del tendón, número de tendones típicos, grupo de tendones

▪ *Load > Temp./Prestress > Tendon Profile > Change Tendon Profile*

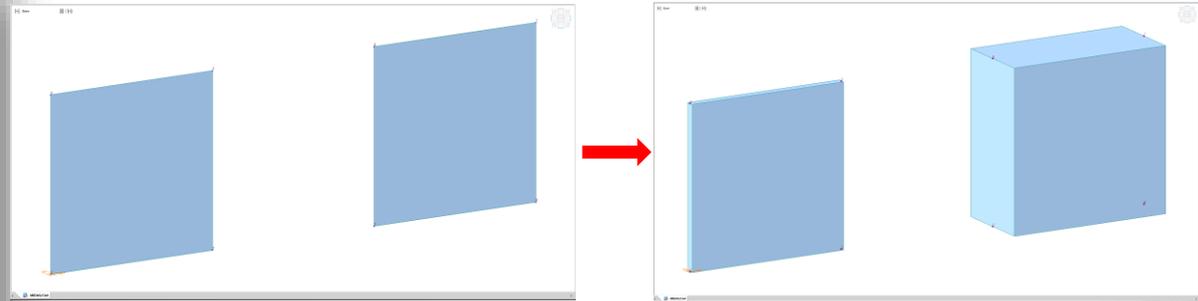


Cambio en perfil de tendón

2. Datos de espesor del elemento Plane Strain

- En versiones anteriores, el espesor del elemento plane strain se fija como 1 m.
- Ahora, el espesor se puede definir para el elemento de deformación plano, que se utilizará para calcular el peso propio..

Node/Element > Elements > Create Elements > Plane Strain



	No	Type	Material		Section		Thickness		L/AV		Unit Weight (kN/m ³)	Total Weight (kN)
			No	Name	No	Name	No	Name	Type	Value		
▶	1	PLANE ST	1	SS400	-	-	-	-	A	0.0000	76.9822	0.0003
	2	PLANE ST	1	SS400	-	-	-	-	A	0.0000	76.9822	0.0003

Previous Version

	No	Type	Material		Section		Thickness		L/AV		Unit Weight (kN/m ³)	Total Weight (kN)
			No	Name	No	Name	No	Name	Type	Value		
▶	1	PLANE ST	1	SS400	-	-	1	0.1	A	4.0000	76.9800	30.7920
	2	PLANE ST	1	SS400	-	-	2	1	A	4.0000	76.9800	307.9200

Civil 2020 (v3.1)

Previous Version

Civil 2020 (v3.1)

3. Generación automática de perfil de tendón - Tipos de secciones prefabricadas de Italia

- Se agregaron VH80N, VH100N, VH130N, VH140, VH150 de Italia para la auto-generación de perfiles de tendones.

▪ **Structure > Wizard > PSC Bridge > Tendon Template**

Tendon Template

Use Prefix Name : strand

Assigned Elements : 1 Add

No	Name	Property
1	strand_081	Tendon
2	strand_082	Tendon
3	strand_083	Tendon
4	strand_084	Tendon
5	strand_085	Tendon
6	strand_086	Tendon
7	strand_087	Tendon
8	strand_088	Tendon
9	strand_089	Tendon
10	strand_090	Tendon
11	strand_091	Tendon
12	strand_092	Tendon
13	strand_093	Tendon
14	strand_094	Tendon
15	strand_095	Tendon
16	strand_096	Tendon
17	strand_097	Tendon
18	strand_098	Tendon
19	strand_099	Tendon

Tendon

Plane View

Elevation View

Section

1

Pos. : i j

Auto Generation

Name prefix : strand

Tendon Property : Tendon

Tendon Group : Default

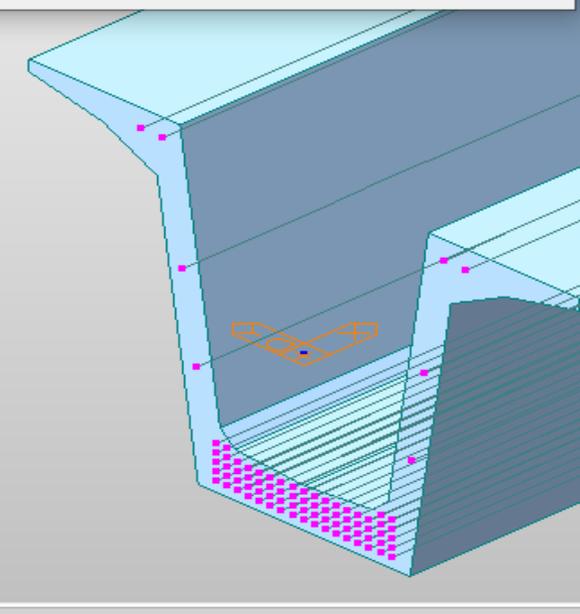
Code : Italy

Type : Italy-VH

Name : VH150

Origin Point : m

Initialize Tendon Tem



4. Análisis de etapas de constructivas no lineal geométrica con elementos de plate

- El análisis de la etapa de construcción se puede realizar considerando los efectos geométricos no lineales del elemento de plate.
- El desplazamiento tangente inicial puede aplicarse a elementos de plate así como a elementos de beam.

▪ Analysis > Analysis Control > Construction Stage > Initial Displacement for C.S

Construction Stage Analysis Control Data

Final Stage
 Last Stage Other Stage CS22

Restart Construction Stage Analysis Select Stages for Restart...

Analysis Option
 Analysis type Nonlinear Analysis Nonlinear Analysis Control
 Independent Stage Accumulative Stage
 Include Equilibrium Element Nodal Forces
 Include P-Delta Effect P-Delta Analysis Control
 Include Time Dependent Effect Time Dependent Effect Control

Load Cases to be Distinguished from Dead Load for C,S, Output

No	Load Case Name	Type	Case1	Case2	Add	Modify	Delete
<							

Cable-Pretension Force Control
 Internal Force External Force Add Replace

Initial Force Control
 Convert Final Stage Member Forces to Initial Forces for Post C.S.
 Truss Beam
 Change Cable Element to Equivalent Truss Element for Post C.S.
 Apply Initial Member Force to C.S.

Initial Displacement for C.S.
 Initial Tangent Displacement for Erected Structures
 All Group SG5
 Lack-of-Fit Force Control SG6
 Apply Camber Displacement to C.S. (if Defined)

Consider Stress Decrease at Lead Length Zone by Post-tension
 Linear Interpolation Constant : Stress +

Beam Section Property Changes
 Constant Change with Tendon

Frame Output
 Calculate Concurrent Forces of Frame
 Calculate Output of Each Part of Composite Section
 Self-Constrained Forces & Stresses

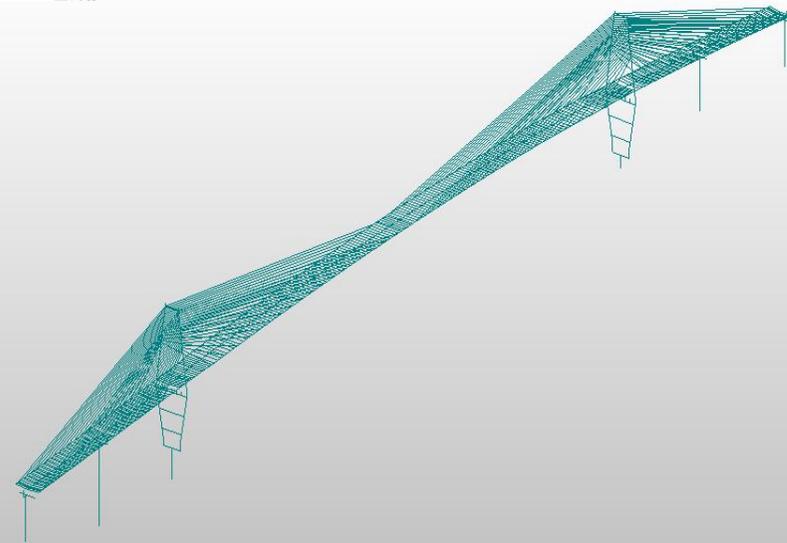
Save Output of Current Stage(Beam/Truss)

Remove Construction Stage Analysis Control Data

OK Cancel

Construction Stage Analysis Control

PostCS



Message Window

TANGENTIAL DISPLACEMENT RESULTS ARE SAVED.

CONSTRUCTION STEP NO. : 86 / 89 STAGE NO : 65 STEP NO : 1
 ENTRY PHASE FOR RENUMBERING
 ENTRY NUMBERING EQN
 ENTRY FORM_STIFF_MASS_LOAD
 THE INDIVIDUAL ELEMENT STIFFNESS AND LOAD MATRICES WILL NOW BE FORMED.
 ELEMENT NO. : 2414 OF 2466
 ENTRY SOLUTION PHASE
 INCREMENT NO. : 1 ITERATION NO. : 1 DISPL. NORM : 0.100E+01 TOTAL ITERATION : 244
 INCREMENT NO. : 1 ITERATION NO. : 2 DISPL. NORM : 0.118E-01 TOTAL ITERATION : 245
 INCREMENT NO. : 1 ITERATION NO. : 3 DISPL. NORM : 0.255E-03 TOTAL ITERATION : 246

Command Message Analysis Message

5. Set-back (Retroceso) para el saddle del puente colgante

- En un puente colgante de varios tramos, el sillín de la torre superior se puede mover con respecto a la torre antes de comenzar la construcción del cable..
- El Saddle (sillín) se puede simular con Elastic Link: tipo de silla de montar.

- **Boundary > Link > Elastic Link > Type: Saddle**
- **Load > Construction Stage > C.S Loads > Set-Back Loads for Nonlinear Construction Stage**

Set-Back Loads for Nonlinear

Load Case Name: SW

Load Group Name: Default

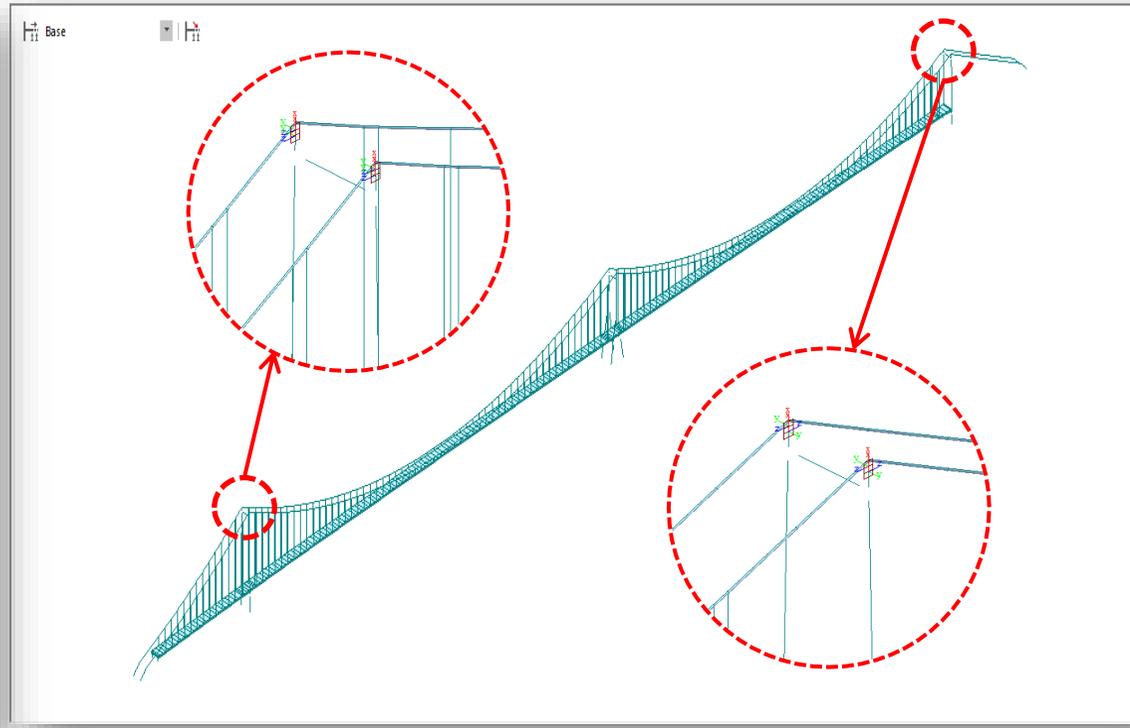
Options: Add Replace Delete

Saddle Type Elastic-Link Displacement (Local Direction)

Dx: 0 m
Dy: 0 m
Dz: 0 m

ID	Node1	Node2
15	4123	4901
16	4223	4902
17	8232	8902
18	8132	8901

Apply Close



Aplique set-back al Elastic Link que representa los saddles sobre las torres

Tree Menu 2

- Works
 - Analysis Control Data
 - Construction Stage Analysis [Stage>Last]
 - Structures
 - Nodes : 1465
 - Elements : 1025
 - Properties
 - Material : 11
 - Section : 244
 - Boundaries
 - Supports : 13
 - Elastic Link : 387
 - Rigid Link : 400
 - Static Loads
 - Static Load Case 1 [SW : Pylon, Main cable, Hanger
 - Static Load Case 2 [MC-wrapping ; Wrapping, Main
 - Static Load Case 3 [MC-clamp ; Cable clamps]
 - Static Load Case 4 [MC-socket ; Hanger socket on i
 - Static Load Case 5 [MC-handrail ; Hand rail, post, M
 - Static Load Case 6 [DECK-SW ; Deck, selfweight (in
 - Static Load Case 7 [DECK-DW ;]
 - Static Load Case 8 [MC-Setback ; Set-back]
 - Etc. Loads
 - Set-Back for Construction Stage : 4

Elastic Link

Boundary Group Name: Default

Options: Add Delete

Start Link Number : 1

Elastic Link Data

Type: Saddle

6. Fuerzas concurrentes de elementos beam para el análisis tiempo historia

- Fuerzas concurrentes para análisis tiempo-historia.
- Sólo elementos Beam.

Results > Results Tables > Beam > View by Max Value Item

Tree Menu 2

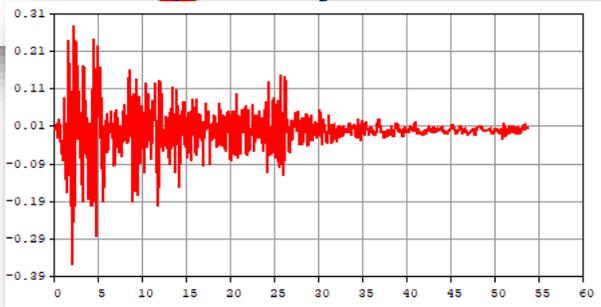
- Works
 - Analysis Control Data
 - Eigenvalue Analysis [Type=Eigen Vectors-Lanczo.
 - Structures
 - Nodes : 24
 - Elements : 20
 - Properties
 - Material : 1
 - Section : 2
 - Boundaries
 - Supports : 4
 - Elastic Link : 1
 - General Link Properties : 1
 - General Link : 1
 - Rigid Link : 1
 - Time History Analysis
 - Time History Load Cases : 1
 - Case 2 [Linear_Direct : Linear Direct Integration
 - Time Forcing Functions : 2
 - Function 1 [Sin : Sinusoidal Function ; Force]
 - Function 2 [Moment_Const ; Time Function ; Mo
 - Dynamic Nodal Loads : 3
 - Type 1 [LoadCase=Linear_Direct ; Function=Sin
 - Type 2 [LoadCase=Linear_Direct ; Function=Mo
 - Type 3 [LoadCase=Linear_Direct ; Function=Sin

Beam Forces Table

Elem	Load	Part	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Torsion (kN-m)	Moment-y (kN-m)	Moment-z (kN-m)
41	MSE(ma	J[23]	7.47	0.00	2.89	0.00	0.00	
41	MSE(ma	J[24]	7.47	0.00	2.89	0.00	9.92	
42	MSE(ma	J[24]	2173.37	0.00	310.20	0.00	9233.57	
42	MSE(ma	J[25]	2173.37	0.00	310.20	0.00	8599.10	
43	MSE(ma	J[25]	2223.34	0.00	278.02	0.00	8599.10	
43	MSE(ma	J[26]	2223.34	0.00	278.02	0.00	6128.84	
44	MSE(ma	J[26]	2140.57	0.00	253.99	0.00	6128.84	
44	MSE(ma	J[27]	2140.57	0.00	253.99	0.00	4418.04	
45	MSE(ma	J[27]	1996.63	0.00	210.71	0.00	4418.04	
45	MSE(ma	J[28]	1996.63	0.00	210.71	0.00	2750.17	
46	MSE(ma	J[28]	1841.19	0.00	170.51	0.00	2750.17	
46	MSE(ma	J[29]	1841.19	0.00	170.51	0.00	1411.97	
47	MSE(ma	J[29]	1703.47	0.00	127.41	0.00	1411.97	
47	MSE(ma	J[30]						
48	MSE(ma	J[30]						
48	MSE(ma	J[31]						
49	MSE(ma	J[31]						
49	MSE(ma	J[32]						
50	MSE(ma	J[32]						
50	MSE(ma	J[33]						
50	MSE(ma	J[33]						
51	MSE(ma	J[33]						
51	MSE(ma	J[34]						
51	MSE(ma	J[34]						
52	MSE(ma	J[34]						
52	MSE(ma	J[34]						
52	MSE(ma	J[36]						
53	MSE(ma	J[36]						
53	MSE(ma	J[36]						
53	MSE(ma	J[37]						
53	MSE(ma	J[37]						

Concurrent Forces Table

Elem	Load	Part	Component	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Torsion (kN-m)	Moment-y (kN-m)	Moment-z (kN-m)
41	MSE(max)	J[23]	Axial	7.47	0.00	2.79	-0.00	-0.00	0.00
41	MSE(max)	J[23]	Shear-y	2.92	0.00	0.17	-0.00	-0.00	0.00
41	MSE(max)	J[23]	Shear-z	7.28	0.00	2.89	-0.00	-0.00	0.00
41	MSE(max)	J[23]	Torsion	-5.74	-0.00	-1.75	0.00	-0.00	-0.00
41	MSE(max)	J[23]	Moment-y	-3.50	-0.00	-1.14	-0.00	0.00	-0.00
41	MSE(max)	J[23]	Moment-z	3.01	0.00	0.21	-0.00	-0.00	0.00
41	MSE(max)	J[24]	Axial	7.47	0.00	2.79	-0.00	-8.39	-0.00
41	MSE(max)	J[24]	Shear-y	2.92	0.00	0.17	-0.00	-0.52	-0.00
41	MSE(max)	J[24]	Shear-z	7.28	0.00	2.89	-0.00	-8.69	-0.00
41	MSE(max)	J[24]	Torsion	-5.74	-0.00	-1.75	0.00	5.25	0.00
41	MSE(max)	J[24]	Moment-y	-7.26	-0.00	-3.30	-0.00	9.92	-0.00
41	MSE(max)	J[24]	Moment-z	-5.82	-0.00	-1.82	0.00	5.48	0.00
42	MSE(max)	J[24]	Axial	2173.37	0.00	211.19	0.00	9233.39	-0.00
42	MSE(max)	J[24]	Shear-y	686.57	0.00	-125.55	0.00	2128.66	-0.00
42	MSE(max)	J[24]	Shear-z	1323.12	0.00	310.20	0.00	5925.36	-0.00
42	MSE(max)	J[24]	Torsion	613.28	0.00	-109.56	0.00	1846.23	-0.00
42	MSE(max)	J[24]	Moment-y	2173.33	0.00	211.41	0.00	9233.57	-0.00
42	MSE(max)	J[24]	Moment-z	-102.76	-0.00	-28.39	-0.00	-275.41	0.00
42	MSE(max)	J[25]	Axial	2173.37	0.00	211.19	0.00	8599.02	-0.00
42	MSE(max)	J[25]	Shear-y	686.57	0.00	-125.55	0.00	2505.79	-0.00
42	MSE(max)	J[25]	Shear-z	1323.12	0.00	310.20	0.00	4993.61	-0.00
42	MSE(max)	J[25]	Torsion	613.28	0.00	-109.56	0.00	2175.32	-0.00
42	MSE(max)	J[25]	Moment-y	2173.36	0.00	211.08	0.00	8599.10	-0.00
42	MSE(max)	J[25]	Moment-z	559.89	-0.00	227.68	-0.00	2386.86	0.00
43	MSE(max)	J[25]	Axial	2223.34	0.00	258.20	0.00	8599.10	-0.00
43	MSE(max)	J[25]	Shear-y	884.02	0.00	-18.70	0.00	2491.19	-0.00



Copy
Find...
Sorting Dialog...
Style Dialog...
Show Graph...
Activate Records...
Export to Excel...
View by Load Cases...
View by Max Value Item...
Dynamic Report Table...

Concurrent Forces Table

AASHTO LRFD 8th

Peer Review

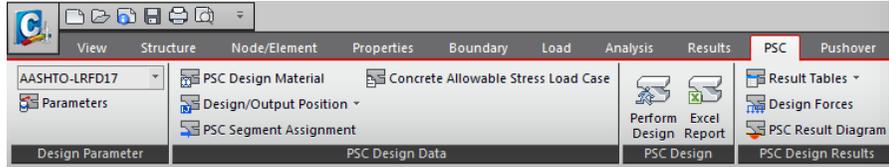
Nos gustaría expresar nuestro agradecimiento a algunos de nuestros expertos influyentes por la revisión de las actualizaciones en el código:

- ***Sungki Choi (Jacobs - Colorado, USA)***
- ***Vinceng Nganga (Jacobs - Missouri, USA)***
- ***Suthichai Saelim (HDR - Massachusetts, USA)***

7. Diseño por AASHTO LRFD 8ª edición - Sección PSC / Compuesta, Sección RC

- El nuevo estándar de AASHTO LRFD puede ser aplicado para las distintas funciones de diseño.
- Concreto Reforzado , Cajón presforzada, Compuesta presforzada.

■ PSC > Design > AASHTO LRFD 17



Torsional effects shall be investigated where:

$$T_u > 0.25\phi T_{cr} \quad (5.7.2.1-3)$$

- For solid shapes:

$$T_{cr} = 0.126K\lambda\sqrt{f'_c} \frac{A_{cp}^2}{P_c}$$

- For hollow shapes:

$$T_{cr} = 0.126K\lambda\sqrt{f'_c} 2A_o b_o$$

in which:

$$K = \sqrt{1 + \frac{f_{pc}}{0.126\lambda\sqrt{f'_c}}} \leq 2.0$$

5.7.2.6—Maximum Spacing of Transverse Reinforcement

The spacing of the transverse reinforcement shall not exceed the maximum permitted spacing, s_{max} , determined as:

- If $v_u < 0.125 f'_c$, then:

$$s_{max} = 0.8d_v \leq 24.0 \text{ in.} \quad (5.7.2.6-1)$$

- If $v_u \geq 0.125 f'_c$, then:

$$s_{max} = 0.4d_v \leq 12.0 \text{ in.} \quad (5.7.2.6-2)$$

where:

v_u = shear stress calculated in accordance with Article 5.7.2.8 (ksi)

d_v = effective shear depth as defined in Article 5.7.2.8 (in.)

1. Design Condition

Design Code	Element	Node(I/J)
AASHTO-LRFD2017	16	I

■ Section Properties

- Gross section	
H	117.992 (in)
B	492.126 (in)
C_{22}	42.858 (in)
C_{21}	75.134 (in)
- Transformed section	
H	117.992 (in)
B	492.126 (in)
C_{22}	43.709 (in)
C_{21}	74.283 (in)

■ Materials

- Concrete	
f'_c (ksi)	7.000

* β_1 : 0.85 if f'_c is lower t

- Prestressing steel information

No.	Tendon	B	T
1	S_L8_CS1	B	
2	S_L2_CS1	B	
3	S_L1_CS1	B	
4	S_R3_CS1	B	
5	S_L6_CS1	B	
6	S_R4_CS1	B	
7	S_L5_CS1	B	
8	S_R1_CS1	B	
9	S_R2_CS1	B	
10	S_L7_CS1	B	
11	S_R7_CS1	B	
12	S_L4_CS1	B	
13	S_L3_CS1	B	
14	S_R8_CS1	B	
15	S_R6_CS1	B	
16	S_R5_CS1	B	

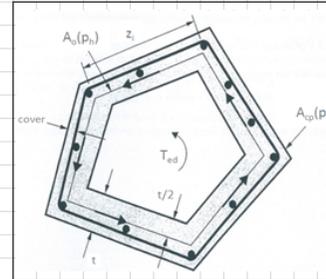
* d_p : Distance from extr

4. Torsional design for a section

■ Case of V_{max} .

- Section type	: Segmental-Box
- The Strength Limit Load Combination	: cLCB1
- Factored torsional moment	$T_u = -111236.26$ (kips-in)
- Factored shear force	$V_u = 1809.62$ (kips)
- Factored moment	$M_u = 1012397.15$ (kips-in)
- Factored axial force	$N_u = -12515.30$ (kips)
- Resistance factor for shear	$\Phi = 0.90$
- Component of prestressing force in direction of the shear force	$V_p = \Sigma A_{ps} f_{pe} \sin \alpha = 413.49$ (kips)

1) Notation



A_o = Area enclosed by the shear flow path, including any area of holes therein.	= 35799.879 (in ²)
P_h = Perimeter of the centerline of the closed transverse torsion reinforcement.	= 1113.426 (in)
A_{cp} = Total area enclosed by outside perimeter of the concrete section.	= 35799.879 (in ²)
P_o = The length of the outside perimeter of concrete section.	= 1113.426 (in)

2) Checking Torsional Effects

• Torsional cracking moment (T_{cr}).	
$b_e = 16.375$ (in) : The effective thickness of shear flow path of elements	
$T_{cr} = 0.126 K \sqrt{f'_c} 2A_o b_e = 781714.14$ (kips-in)	(Eq. 5.7.2.1-5)
$T_u = -111236.262 $ (kips-in) $\leq 0.25\Phi T_{cr} = 175885.68$ (kips-in)	(Eq. 5.7.2.1-3)
$\therefore T_u \leq 0.25\Phi T_{cr}$ Ignore Torsional Effects.	
• Check combined torsional and shear	(Eq. 5.12.5.3.8c-6)

$\frac{V_u}{b_v d_v} + \frac{T_u}{2A_o b_e} = 0.00$ (ksi) $\geq 0.474 \sqrt{f'_c} = 0.00$ (ksi)	OK
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8. Diseño por AASHTO LRFD 8ª edición - Sección compuesta de acero

- El nuevo estandar de AASHTO LRFD puede ser aplicada a las distintas funciones de diseño.
- Steel Composite (Viga de acero compuesta).

Design > Composite Design > AASHTO - LRFD 17

Parámetros de Diseño

Code	AASHTO-LRFD 2017
Element	3
Position	I
Moment Type	Beam

I. Design Condition (Positive Flexure)

1. Section Properties

1) Slab Properties

$B_s = 240.000$ in
 $t_s = 10.000$ in
 $t_b = 5.000$ in
 $f'_c = 3.000$ ksi
 $E_c = 3155.924$ ksi
 $A_s = 0.000$ in²
 $F_{yr} = 40.000$ ksi

2) Girder Properties
 [Section]

$b_{tc} = 130.000$ in $b_{tt} = 106.000$ in
 $t_{tc} = 3.000$ in $t_{tt} = 1.300$ in
 $D = 130.384$ in $t_w = 1.500$ in
 $H = 134.300$ in

Position	Material	Thick(in)	f_y (ksi)	f_u (ksi)	Note
Compression Flange	A36	3.000	36.000	58.000	
Tension Flange	A36	1.300	36.000	58.000	less than 2 in.
Web	A36	1.500	36.000	58.000	less than 2 in.

[Design Strength]

$F_{yc} = 36.000$ ksi (Compression Flange Yield Strength)
 $F_{yw} = 36.000$ ksi (Web Yield Strength)
 $F_{yt} = 36.000$ ksi (Tension Flange Yield Strength)
 $E_s = 29000.000$ ksi (Elastic Modulus of Steel)

3) Transverse Stiffener Properties

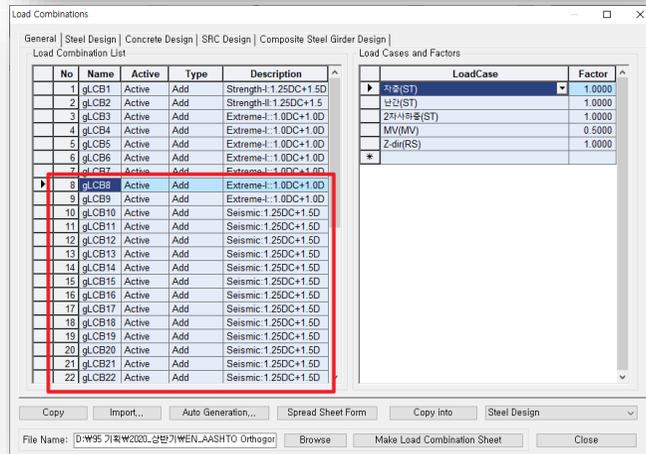
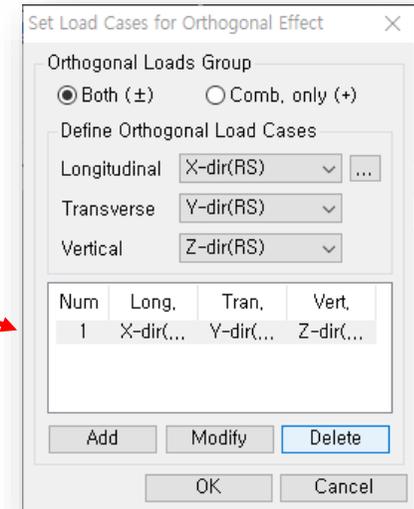
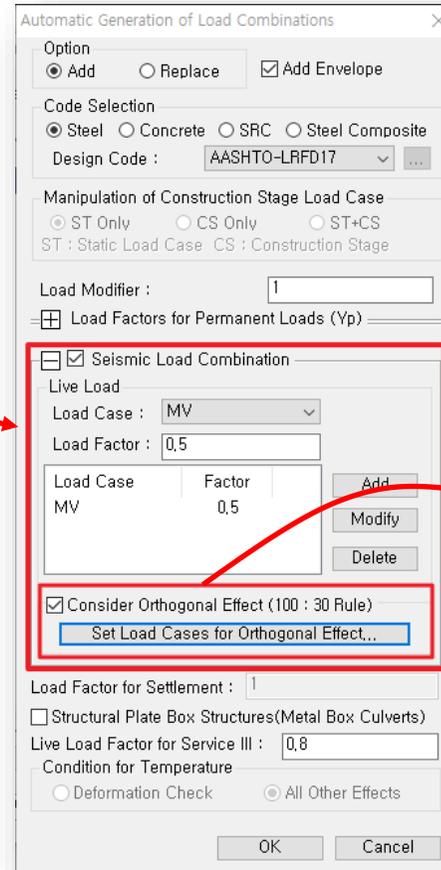
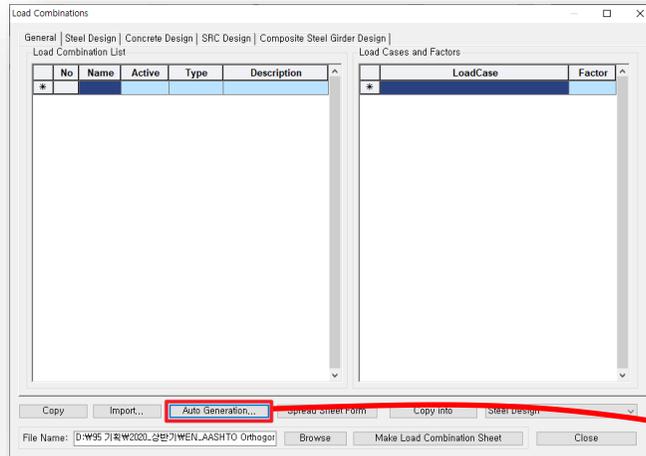
Position	Type	f_y (ksi)	H(in)	B(in)	t_w (in)	t_f (in)	d_o (in)
Web	1Side	35.000	10.000	10.000	2.000	2.000	100.000

Reporte de Diseño de Excel

10. Efecto ortogonal de la carga sísmica: AASHTO LRFD

- El efecto ortogonal de las cargas sísmicas se puede incluir en la autogeneración de combinaciones de carga para AASHTO-LRFD 16 y 17.

Results > Load Combination > Auto Generation...



Generación automática de combinaciones de carga

Definición de combinaciones de carga sísmicas

Definición de casos ortogonales de espectro

11. Cargas de tráfico ferroviario según AS 5100.2

- Cargas de tren definidas por el usuario, 300 LA, 150 LA
- Impacto distinto (dynamic allowance) para momento y todos los otros efectos

▪ **Load > Moving Load > Moving Load Code > Australia**

Define Standard Vehicular Load

Standard Name: AS 5100.2 - Rail Traffic Load

Vehicular Load Properties

Vehicular Load Name: 300LA

Vehicular Load Type: 300LA

Dynamic Load Allowance: 0 Bending Moment, 0 All Other Effects

No	Load(kN)	Spacing(m)
1	360	2
2	300	1.7
3	300	1.1
4	300	1.7
5	300	end

Distance Between Group

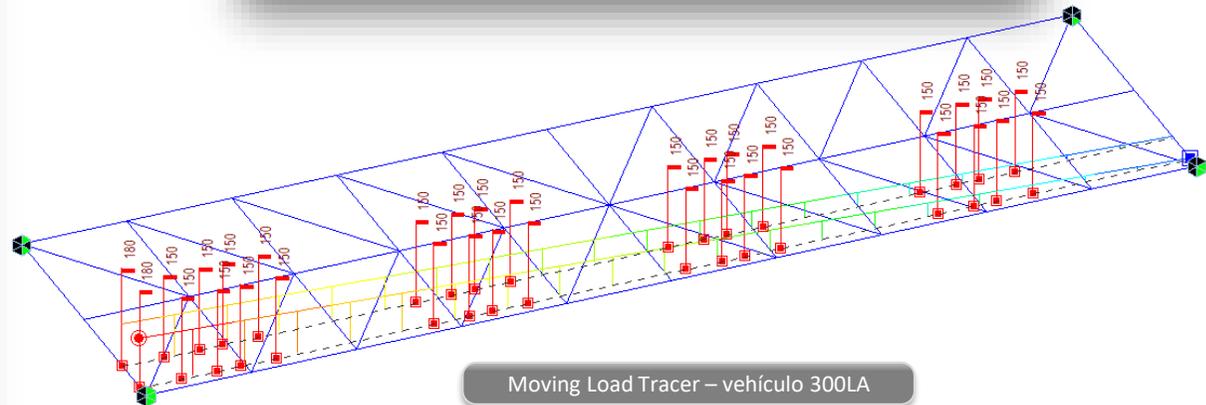
Dmin = 12m

Dmax = 20m

Increment of Dist(Dinc) = 1 m

D = Dmin+Dinc, Dmin+2Dinc, Dmin+3Dinc, ... Dmax

OK Cancel Apply



Tren 300LA

12. Plataforma de carga pesada según AS 5100.2

- Cargas de Plataforma definidas por el usuario HLP320, HLP400

▪ **Load > Moving Load > Moving Load Code > Australia**

Define Standard Vehicular Load ✕

Standard Name
AS 5100.2 - Heavy Load Platform

Vehicular Load Properties

Vehicular Load Name : HLP320

Vehicular Load Type : HLP320

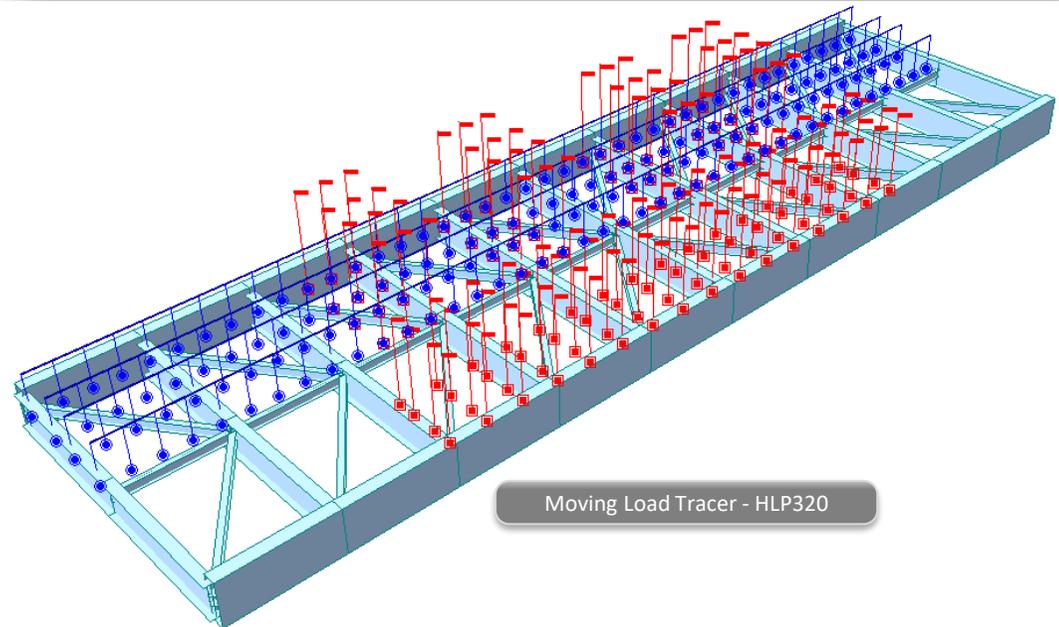
Dynamic Load Allowance : 0.1

P = kN

D = m

Number of Axles = 16

Plataforma de carga pesada HLP320



Moving Load Tracer - HLP320

13. Evaluación (Rating) de vehículos según AS 5100.2

- Vehículos de evaluación definidos por el usuario T44, L44

▪ **Load > Moving Load > Moving Load Code > Australia**

Define Standard Vehicular Load ✕

Standard Name
AS 5100.7 - Rating Vehicles

Vehicular Load Properties

Vehicular Load Name : T44

Vehicular Load Type : T44 Truck Load

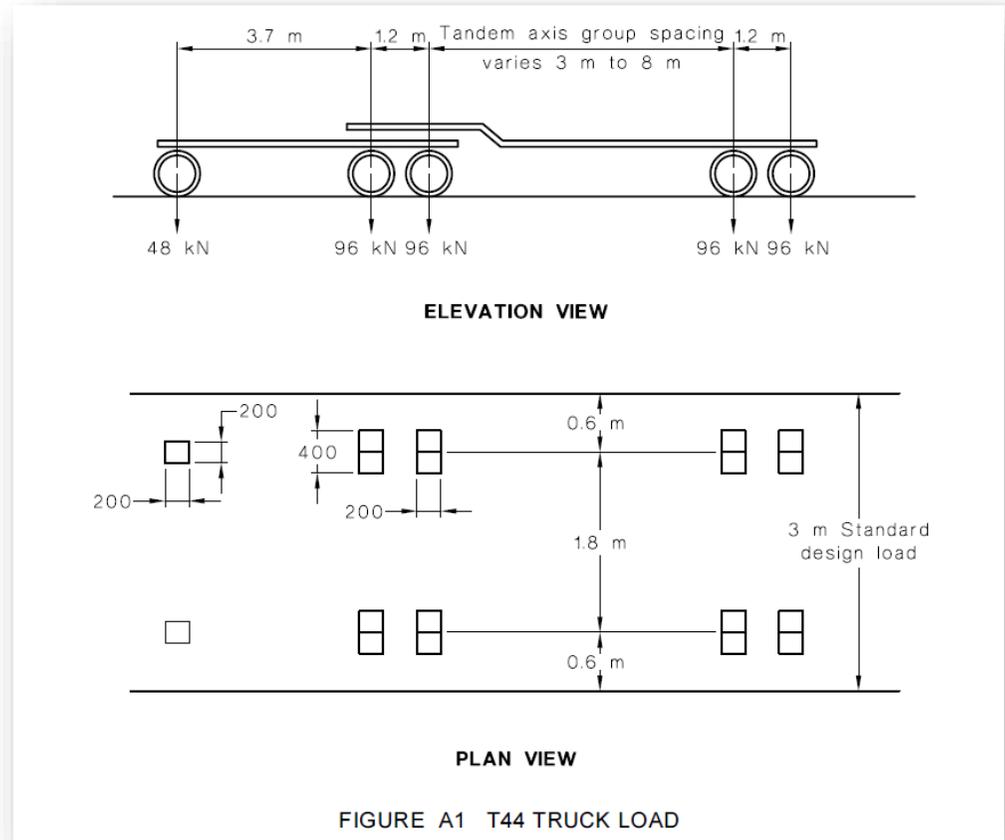
Dynamic Load Allowance : 0

P1 P2 P3 P4 P5

D1 D2 D3-D4 D5

No	Load(kN)	Spacing(m)
1	48	3.7
2	96	1.2
3	96	3
4	96	8
5	96	1.2

T44 Rating Vehicle



14. Cargas de tráfico horizontales por AS 5100.2

- Las fuerzas centrífugas, las fuerzas de tracción y frenado se pueden generar como casos de carga estática.

■ Moving Tracer > Moving Load Converted to Static Load

Moving Load Converted to Static Load ✕

Vertical Loads

Centrifugal Forces

Height of Forces from the top of the rail m

Design Speed m/sec

Radius of Curve m

Super Elevation (Road Traffic) %

Direction of Centrifugal Forces with reference to Vehicle Direction

Right-to-Left Direction Left-to-Right Direction

Longitudinal Force

Total Length of the Bridge (Rail Traffic) m

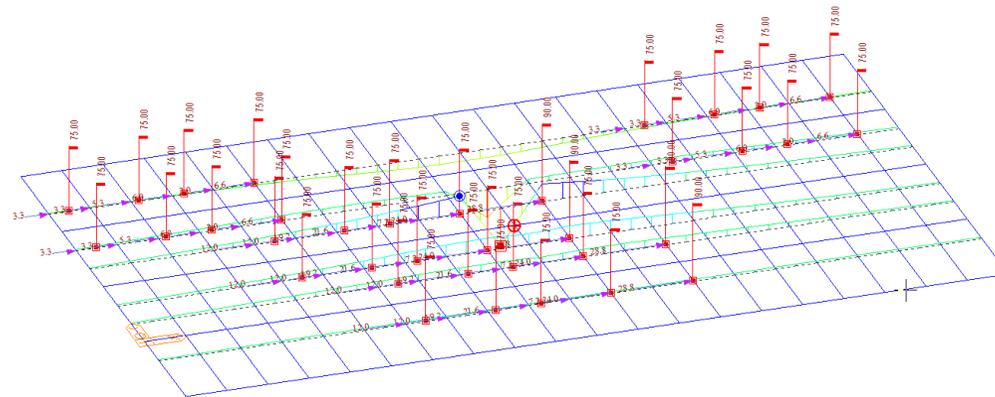
Traction Force

Braking Force

File Name

...

Conversion a cargas estáticas



9.7 Horizontal forces

9.7.1 Centrifugal forces

For rail bridges on horizontal curves, allowance shall be made for the centrifugal effects of rail traffic load by applying a centrifugal force (F_c) corresponding to each axle load horizontally through a point 2 m above the top of the rail.

The horizontal centrifugal force resulting from rail traffic loads shall be proportional to the design rail traffic load, and for each a (a) Braking forces:

$$F_c = \frac{V^2 A}{rg} \quad \text{BF} = 200 + 15L_{LF} \quad \dots 9.7.2.2(1)$$

where

BF = longitudinal braking force, in kilonewtons

L_{LF} = total length of the bridge, in metres

where

V = design speed, in metres per

A = axle load, in kilonewtons (b) Traction forces:

r = radius of curve, in metres

g = acceleration due to gravit;

The specified centrifugal force shall n

Centrifugal and nosing forces due to r

$$\text{TF} = 200 + 25L_{LF} \quad \text{for} \quad L_{LF} \leq 25 \text{ m} \quad \dots 9.7.2.2(2)$$

$$825 + 15(L_{LF} - 25) \quad \text{for} \quad 25 \text{ m} < L_{LF} \leq 50 \text{ m} \quad \dots 9.7.2.2(3)$$

$$1200 + 7.5(L_{LF} - 50) \quad \text{for} \quad 50 \text{ m} < L_{LF} \leq 250 \text{ m} \quad \dots 9.7.2.2(4)$$

$$2700 + 5.0(L_{LF} - 250) \quad \text{for} \quad 250 \text{ m} < L_{LF} \quad \dots 9.7.2.2(5)$$

where

TF = longitudinal traction force, in kilonewtons

L_{LF} = total length of the bridge, in metres

15. Evaluación (Rating) de vehículos según CS 454

- Todos los modelos 1 (normal traffic, 26 toneladas, 18 toneladas, 7.5 toneladas, 3 toneladas)
- Factor de impacto, factor de flujo de tráfico, factor de línea

▪ **Load > Moving Load > Moving Load Code > BS**

Define Standard Vehicular Load

Standard Name: CS 454 Assessment

Vehicular Load Properties

Vehicular Load Name: A-4AXLE

Vehicular Load Type: ALL MODEL 1

Sub Type: A-4AXLE

* A-4AXLE		
No	P (kN)	D (m)
1	64	1.2
2	64	3.9
3	113	1.3
4	74	end

O1 = 1 m, O2 = 1 m

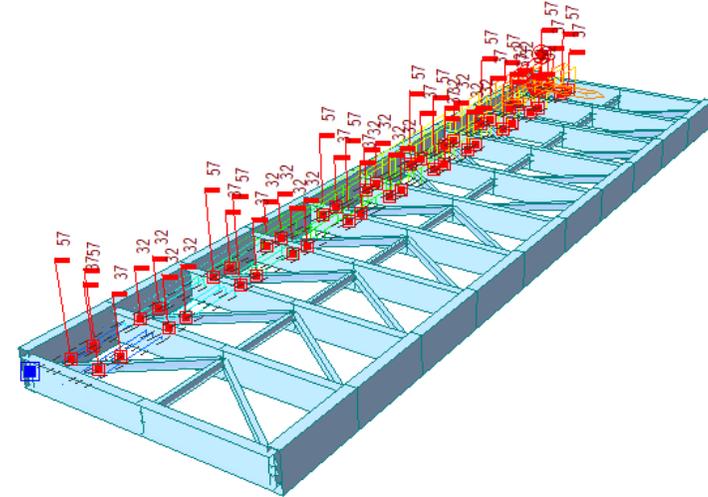
Loading Case: Single Convoy

Road Surface: Good Poor

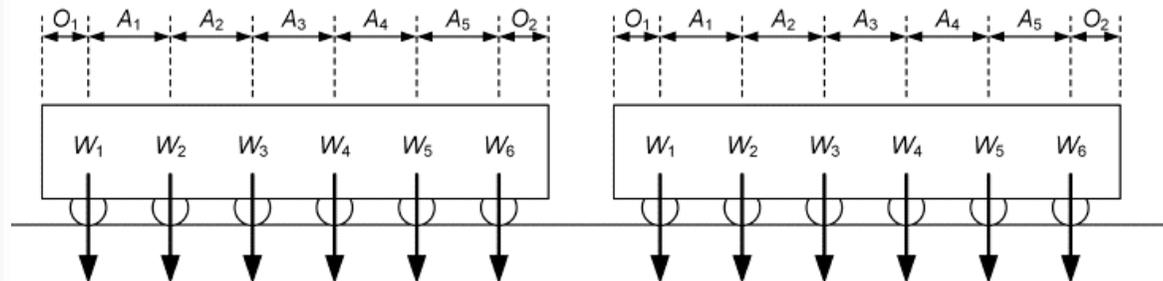
Traffic Flow Category: High Medium Low

OK Cancel Apply

- A-4AXLE
- B-4AXLE
- C-5AXLE
- D-5AXLE_1
- D-5AXLE_2
- E-5AXLE_1
- E-5AXLE_2
- F-6AXLE_1
- F-6AXLE_2
- G-6AXLE_1
- G-6AXLE_2
- H-5AXLE_1
- H-5AXLE_2
- I-3AXLE
- J-3AXLE
- K-3AXLE_1
- K-3AXLE_2
- L-3AXLE_1
- L-3AXLE_2
- M-2AXLE
- N-2AXLE
- O-2AXLE



Moving Load Tracer – ALL Model 1 A Convoy



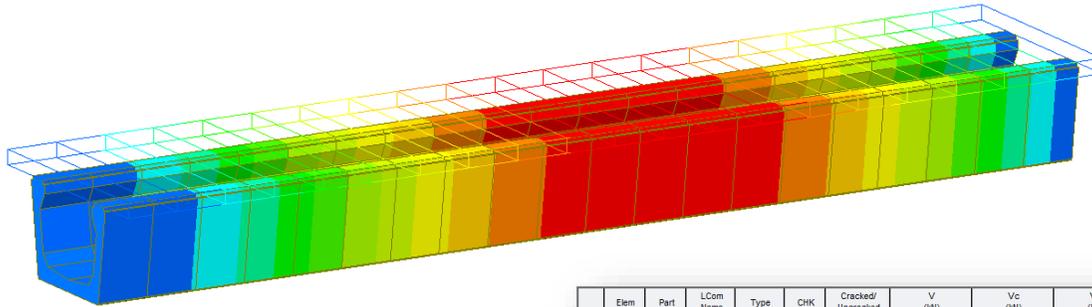
ALL Model 1 Convoy

Tren 300LA

16. Diseño de viga presforzada según BS 5400

- Estado límite ultimo: Flexión, Cortante, Torsión
- Estado límite de servicio: Esfuerzo, Fisura

■ PSC > Design Parameter > BS 5400



PSC Design Parameters

Design Code: BS 5400-4:1990

User Input Data

Principal Stress Limitation

Serviceability Limit States

Comp. 20 N/mm²

Tens. 1 N/mm²

Construction Stage

Comp. 20 N/mm²

Tens. 1 N/mm²

Output Parameters

Serviceability Limit States

Concrete stress limitation under service loads

Concrete stress limitation at Construction Stage

Principal stress under service loads

Principal stress at Construction Stage

Tensile stress for prestressing steel

Ultimate limit states

Bending resistance

Shear resistance

Torsional resistance

Select All Unselect All

OK Cancel

Parámetros de Diseño PSC

Elem	Part	LCom Name	Type	CHK	Cracked/UnCracked	V (kN)	Vc (kN)	Vp (kN)
31	[31]	clCB1	FX-MAX	OK	UnCracked	3697.7653	5600.6276	1069.4979
31	[32]	clCB1	FX-MAX	OK	UnCracked	4300.0696	6718.8185	2089.7983
32	[33]	clCB1	FX-MAX	OK	UnCracked	4367.9589	6718.6466	2089.7048
32	[33]	clCB1	FX-MAX	OK	UnCracked	4994.0855	7756.5974	3043.3164
33	[33]	clCB1	FX-MAX	OK	UnCracked	5096.0264	7756.3981	3043.1926
33	[34]	clCB1	FX-MAX	OK	UnCracked	5719.3801	8677.3702	3899.5326
34	[34]	clCB1	FX-MAX	OK	UnCracked	5783.4813	8676.4566	3898.9226
34	[35]	clCB8	FZ-MAX	OK	UnCracked	6490.1368	6486.1565	2029.9368
35	[35]	clCB8	FZ-MAX	OK	UnCracked	6489.9510	6485.9617	2029.8289
35	[36]	clCB8	FZ-MAX	OK	UnCracked	7429.1905	4429.1410	291.5115
36	[36]	clCB9	FZ-MIN	OK	UnCracked	-7790.3355	4428.9545	291.4776
36	[37]	clCB9	FZ-MIN	OK	UnCracked	-6962.3546	5153.2856	963.5172
37	[37]	clCB9	FZ-MIN	OK	UnCracked	-6962.4360	5152.5049	963.1935
37	[38]	clCB1	FX-MAX	OK	UnCracked	-5996.8881	6486.6041	2181.7369
38	[38]	clCB1	FX-MAX	OK	UnCracked	-6306.8902	8359.3716	3162.8951
38	[39]	clCB1	FX-MAX	OK	UnCracked	-5283.1850	8926.0487	3678.6665
39	[39]	clCB1	FX-MAX	OK	UnCracked	-5587.7388	8925.3904	3678.2591
39	[40]	clCB1	FX-MAX	OK	UnCracked	-4564.0558	8883.8478	3652.2015
40	[40]	clCB1	FX-MAX	OK	UnCracked	-4887.5397	7726.5373	2895.2502
40	[41]	clCB1	FX-MAX	OK	UnCracked	-3865.8775	7147.4793	2354.1593
41	[41]	clCB1	FX-MAX	OK	UnCracked	-4186.7548	7146.7462	2353.7085
41	[42]	clCB1	FX-MAX	OK	UnCracked	-3177.8515	5622.5204	968.4353
42	[42]	clCB1	FX-MAX	OK	UnCracked	-2272.7099	5622.1340	968.2604
42	[43]	clCB1	FX-MAX	OK	UnCracked	-1725.7445	4611.5058	59.1826
43	[43]	clCB1	FX-MAX	OK	UnCracked	-1725.7820	4611.4441	59.1790
43	[44]	clCB1	FX-MAX	OK	UnCracked	-1178.6167	4548.9947	11.5620
44	[44]	clCB1	FX-MAX	OK	UnCracked	-1178.8348	4548.8963	11.5620
44	[45]	clCB1	FX-MAX	OK	UnCracked	-831.8694	4521.4062	2.0371
45	[45]	clCB1	FX-MAX	OK	UnCracked	-631.8804	4521.3875	2.0371
45	[46]	clCB1	FX-MAX	OK	UnCracked	-84.9151	4502.6167	2.7656
46	[46]	clCB1	FX-MAX	OK	UnCracked	-84.9273	4502.5904	2.7656
46	[47]	clCB1	FX-MAX	OK	UnCracked	462.0381	4500.9674	21.8337
47	[47]	clCB1	FX-MAX	OK	UnCracked	462.0311	4500.7999	21.8327
47	[48]	clCB1	FX-MAX	OK	UnCracked	1008.9965	4652.9981	356.1016
48	[48]	clCB1	FX-MAX	OK	UnCracked	1009.0100	4652.8649	356.0749

Tabla de Resultado de PSC

1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34			
1. Design Condition			Design code	Element	Node(I/J)																															
			BS 5400-4:1990	16	J																															
■ Section Properties			Section Type																																	
			Non-Composite																																	
- Gross section			H	3000.000 (mm)	A _g	6.209E+06 (mm ²)	S _x	6.505E+09 (mm ³)																												
			B	8500.000 (mm)	I _y	7.867E+12 (mm ⁴)	S _y	4.399E+09 (mm ³)																												
			C _{cp}	1209.410 (mm)																																
			C _{cm}	1790.590 (mm)																																
- Transformed section			H	3000.000 (mm)	A _g	6.439E+06 (mm ²)	S _x	6.790E+09 (mm ³)																												
			B	8500.000 (mm)	I _y	8.116E+12 (mm ⁴)	S _y	4.497E+09 (mm ³)																												
			C _{cp}	1195.243 (mm)																																
			C _{cm}	1804.757 (mm)																																
■ Partial Safety Factors			- Partial Safety Factors for Ultimate Limit State																																	
			γ _{mc} for Concrete		Characteristic																															
					1.5																															
			γ _{ms} for Reinforce/Prestress		1.15																															
- Partial Safety Factors for Serviceability Limit State			Type of Stress		γ _{mc} for concrete																															
			Triangular Compressive		1.25																															
			Uniform Compressive		1.67																															
			Pre-tension		1.25																															
			Post-tension		1.55																															
■ Material			- Concrete																																	

Reporte Detallado de Diseño PSC

17. Mejora de la evaluación del puente según CS 454

- Revisión de estado límite de servicio para sección tipo clase 3
- Revisión de estado límite ultimo y servicio para tendones no adheridos.

Rating > Bridge Rating Design > CS 454/19

Section for Assessment Check ...

Option

Add/Replace Delete

Position

I J I & J

Class Category

Class 1

Class 2

Class 3

Tendon Type for Class 3

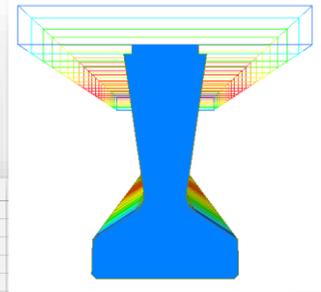
Type C : Pre-tensioned tendons distributed close to the tension faces

Apply Close

Categoría de Clase

Element	Part	Class	Rating Case	Load Effect	sig_c (N/mm ²)	sig_c_lim (N/mm ²)	sig_t (N/mm ²)	sig_t_lim (N/mm ²)	A	Check
12	J[14]	Class 3	SLS1_Fzz(Min)	Positive	15.2245	25.0000	-7.9229	-11.5705	1.4604	OK
12	J[14]	Class 3	SLS1_Mxx(Max)	Positive	15.2245	25.0000	-7.9229	-11.5705	1.4604	OK
12	J[14]	Class 3	SLS1_Mxx(Min)	Positive	15.2245	25.0000	-7.9229	-11.5705	1.4604	OK
12	J[14]	Class 3	SLS1_Myy(Max)	Positive	17.2856	8.1046				
12	J[14]	Class 3	SLS1_Myy(Min)	Positive	8.1046					
12	J[14]	Class 3	SLS1_Mzz(Max)	Positive	8.1046					
12	J[14]	Class 3	SLS1_Mzz(Min)	Positive	8.1046					
13	I[14]	Class 3	SLS1_Fxx(Max)	Positive	15.6500	8.1046				
13	I[14]	Class 3	SLS1_Fxx(Min)	Positive	8.1046					
13	I[14]	Class 3	SLS1_Fyy(Max)	Positive	8.1046					
13	I[14]	Class 3	SLS1_Fyy(Min)	Positive	8.1046					
13	I[14]	Class 3	SLS1_Fzz(Max)	Positive	16.5127					
13	I[14]	Class 3	SLS1_Fzz(Min)	Positive	15.2245					
13	I[14]	Class 3	SLS1_Mxx(Max)	Positive	15.2245					
13	I[14]	Class 3	SLS1_Mxx(Min)	Positive	15.2245					
13	I[14]	Class 3	SLS1_Myy(Max)	Positive	17.2856					
13	I[14]	Class 3	SLS1_Myy(Min)	Positive	8.1046					
13	I[14]	Class 3	SLS1_Mzz(Max)	Positive	8.1046					
13	I[14]	Class 3	SLS1_Mzz(Min)	Positive	8.1046					
13	J[15]	Class 3	SLS1_Fxx(Max)	Positive	14.2445					
13	J[15]	Class 3	SLS1_Fxx(Min)	Positive	7.6422					
13	J[15]	Class 3	SLS1_Fyy(Max)	Positive	7.6422					
13	J[15]	Class 3	SLS1_Fyy(Min)	Positive	7.6422					
13	J[15]	Class 3	SLS1_Fzz(Max)	Positive	15.8003					
13	J[15]	Class 3	SLS1_Fzz(Min)	Positive	13.8680					
13	J[15]	Class 3	SLS1_Mxx(Max)	Positive	12.8885					
13	J[15]	Class 3	SLS1_Mxx(Min)	Positive	12.8885					
13	J[15]	Class 3	SLS1_Myy(Max)	Positive	16.3155					
13	J[15]	Class 3	SLS1_Myy(Min)	Positive	7.6422					
13	J[15]	Class 3	SLS1_Mzz(Max)	Positive	7.6422					
13	J[15]	Class 3	SLS1_Mzz(Min)	Positive	7.6422					
14	I[15]	Class 3	SLS1_Fxx(Max)	Positive	15.1026					
14	I[15]	Class 3	SLS1_Fxx(Min)	Positive	7.6422					
14	I[15]	Class 3	SLS1_Fyy(Max)	Positive	7.6422					
14	I[15]	Class 3	SLS1_Fyy(Min)	Positive	7.6422					

Tabla de SLS Reserve Factor



5. Serviceability Limit State for a Section

Class 3 Limit Check

- Check If Stresses are Within Class 3 Limits
- * For Bonded Tendons
- Compression
- Service limit load combination : SLS1
- Service limit load combination type : MY-MAX

$$\sigma_{c,min} \leq 0.625 \frac{f_{cu}}{\gamma_{mc}} = \sigma_{c,limit} = 25.00 \text{ (MPa)}$$

- Tension
- Service limit load combination : SLS1
- Service limit load combination type : MY-MAX

$$\sigma_{c,max} \leq \sigma_{limit} * DF + \sigma_{rebar} = \sigma_{c,limit} = -11.31 \text{ (MPa)}$$

where,

- $\sigma_{c,max}$: Tensile stress on the prestressed concrete = -11.29 (MPa)
- $\sigma_{c,min}$: Compressive stress on the prestressed concrete = 18.12 (MPa)
- σ_{limit} : Flexural tensile stresses for class 3 members (Table 25) = -7.80 (MPa)
- DF : Depth factor for class 3 members based on the depth of member = 0.70
- $A_{conc,T}$: Area of concrete in tensile section = 251932.18 (mm²)
- $A_{rebar,T}$: Area of rebar in tensile section = 4909.00 (mm²)
- σ_{rebar} : Increase in the tensile stress limit due to the presence of additional reinforcement = -5.85 (MPa)
- $\sigma_{c,limit}$: Flexural tensile stress limit
- $\sigma_{c,limit}$: Flexural compressive stress limit

Since

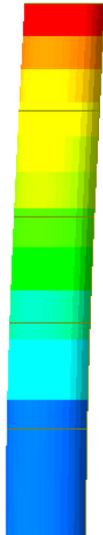
$\sigma_{c,max} \leq \sigma_{c,limit}$	∴	OK
$\sigma_{c,min} \leq \sigma_{c,limit}$	∴	OK

Reporte de chequeo de estado límite de servicio

18. Diseño de concreto reforzado según las especificaciones del IRS

- El diseño de hormigón armado según el IRS ya está disponible. Diseño de vigas, columnas y chequeo de vigas y columnas ahora se pueden realizar para IRS.
- Se pueden generar los reportes gráficos / detallados que incluyen las comprobaciones de estado límite último y estado límite de servicio según las especificaciones del IRS.

Design > RC Design > IRS



No: 160

1. Design Information

Member Number : 160
 Design Code : IRS
 Unit System : kN, m
 Material Data : fck = 30000, fy = 500000, fyw = 500000 KPa
 Beam Span : 0.472727 m
 Section Property : mid (No: 1)

2. Section Diagram

TOP: 0.00786 m²
 BOT: 0.00786 m²
 STIRRUPS: NO SECTION

No: 187

1. Design Condition

Design Code : IRS
 Unit System : kN, m
 Member Number : 187
 Material Data : fck = 30000, fy = 500000, fyw = 500000 KPa
 Column Height : 4.75 m
 Section Property : PIER (No: 12)
 Rebar Pattern : Total Rebar Area Ast = 0.0113097 m² (RhoSt = 0.0100)

2. Applied Loads

Load Combination 36+ AT (J) Point
 N_{Ed} = 2035.00 kN, M_{Edy} = 246.587, M_{Edz} = 1862.67, M_{Ed} = 1878.92 kN-m

3. Axial Forces and Moments Capacity Check

Concentric Max. Axial Load N_{Rdmax} = 39244.8 kN
 Axial Load Ratio N_{Ed}/N_{Rd} = 2035.00 / 4765.59 = 0.427 < 1.000OK
 M_{Edy}/M_{Rdy} = 246.587 / 578.278 = 0.426 < 1.000OK
 Moment Ratio M_{Edz}/M_{Rdz} = 1862.67 / 4361.91 = 0.427 < 1.000OK
 M_{Ed}/M_{Rd} = 1878.92 / 4400.07 = 0.427 < 1.000OK

4. P-M Interaction Diagram

N(kN)	M _{Rd} (kN-m)	N _{Rd} (kN)	M _{Rd} (kN-m)
39244.78	0.00	39244.78	0.00
35689.30	1608.83	35689.30	1608.83
30608.49	3591.27	30608.49	3591.27
25788.21	4874.66	25788.21	4874.66
21810.48	5579.97	21810.48	5579.97
18652.82	5931.38	18652.82	5931.38
16185.09	6013.27	16185.09	6013.27
13940.09	5952.35	13940.09	5952.35
11488.38	5744.15	11488.38	5744.15
8463.42	5280.91	8463.42	5280.91

MIDAS/Text Editor - [RCC T girder IRS RC design.rcs]

```

MIDAS/Civil - RC-BEAM Analysis/Design Program.
*.PROJECT :
*.DESIGN CODE : IRS, *.UNIT SYSTEM : kN, m
*.MEMBER : Member Type = BEAM, MEMB = 160

*.DESCRIPTION OF BEAM DATA (ISEC = 1) : mid
Section Type : Tee-Section (TEE)
Beam Length (Span) = 0.473 m.
Section Depth (Hc) = 1.450 m.
Section Width (Bc) = 0.300 m.
Width of Flange (bf) = 2.800 m.
Depth of Flange (hf) = 0.250 m.
    
```

MIDAS/Text Editor - [RCC T girder IRS RC design.rcs]

MIDAS/Civil - RC-Column Design [IRS]

```

*.MIDAS/Civil - RC-COLUMN Analysis/Design Program.
*.PROJECT :
*.DESIGN CODE : IRS, *.UNIT SYSTEM : kN, m
*.MEMBER : Member Type = COLUMN, MEMB = 187, LCB = 36+, POS = J

*.DESCRIPTION OF COLUMN DATA (ISEC = 12) : PIER
Column Height (L) = 4.750 m.

Section Type : SOLID ROUND (SR)
Section Diameter (D) = 1.200 m.
Concrete Strength (fck) = 30000.000 KPa.
Main Rebar Strength (fy) = 500000.000 KPa.
Ties/Spirals Strength (fyw) = 500000.000 KPa.
Modulus of Elasticity (Es) = 200000000.000 KPa.

*.REINFORCEMENT PATTERN :
Concrete Cover to C.O.R. (do) = 0.065 m.
Total Rebar Area = 0.01131 m^2.

*.Ties : Failure

[[[*]]] CALCULATE SLENDERNESS RATIOS, MAGNIFIED FORCES/MOMENTS.

( ) . Factored forces/moments caused by unit load case. Unit : kN, m.
*.Load combination ID = 36+

Load Case N_Ed_max Myi Myj Mzi Mzj
-----
DL 2070.96 -1.03 -5.29 0.00 0.00
LL -6.43 0.00 1120.50 1109.33
DL+LL 2064.53 -1.03 -5.29 1120.50 1109.33
Others -29.52 48.47 251.88 304.79 753.34
-----
DL+LL+Others 2035.00 47.44 246.59 1425.29 1862.67

( ) . Check slenderness ratios of BRACED/UNBRACED frame.
-. End Moments (My1) = 1.03 kN-m.
    
```

Concrete Design Code

Design Code : IRS

Apply Special Provisions for Seismic Design

Moment Redistribution Factor for Beam : 1

Torsion Design

OK Close

Opción de código de Diseño Por IRS

Reporte gráfico para diseño de vigas y columnas

Reporte detallado para diseño de vigas y columnas

19. Informe de diseño polaco

- Informe de diseño de Polonia aplicado en viga cajón y compuesta presforzada, acero compuesta por Eurocode

▪ PSC Box&Composite > Design > Report

Select Print Language

Select the language for print.

Language : English

English
Czech
Polish

OK

Numer elementu	1075
Position Information	I

1.Przypadek wymiarowania

1.1 Parametry wymiarowania

- Współczynniki częściowe dla SGU (EN 1992-1-1:2004, 2.4.2.4)

Przypadki wymiarowania	γ_c dla betonu	γ_s dla stali zbrojenowej	γ_s dla stali sprężającej
Staly i zmienny	1.500	1.150	1.150
Wyjątkowy	1.200	1.000	1.000

- Współczynnik α_{cc} , α_{ct} : współczynnik długoterminowych wpływów na wytrzymałość na ściskanie i zginanie.

α_{cc} = 0.850 (dla wytrzymałości na ściskanie)

α_{ct} = 1.000 (dla wytrzymałości na rozciąganie)

1.2 Informacje o przekroju

Informacje o przekroju	Przechr. zast.(ciąg., zbroj.) (Dźwigar)	Przechr. zas (Po ścisk.) (Dźwigar + Płyta)
A (mm ²)	515465.603	952336.200
I_y (mm ⁴)	137162101892.318	224570272776.134
y_{st} (mm)	-	512.636
y_{sp} (mm)	-	212.636
y_1 (mm)	543.286	212.636
y_2 (mm)	806.714	1137.364
Z_{st} (mm ³)	-	438069976.161
Z_{sp} (mm ³)	-	1056127262.797
Z_1 (mm ³)	46047196.375	1056127262.797
Z_2 (mm ³)	189305140.655	197447956.212

1.3 Dane materiałowe

▪ Dźwigar (EN 1992-1-1:2004, Table 3.1)

- Informacje o betonie

Reporte de Diseño Presforzado

▪ Steel Composite > Design > Report

Select Print Language

Select the language for print.

Language : English

English
Czech
Polish

OK

Numer elementu	2
Położenie elementu	I

1 Przypadek wymiarowania

1.1 Parametry do wymiarowania

▪ Współczynniki częściowe

γ_c dla betonu	0.60	γ_v dla sworzni z łbem	1.10
γ_s dla stali zbrojenowej	0.70	γ_{F1} dla równow. zakresu zmienności naprężeń o st	0.90
γ_{M2} dla stali konstrukcyjn	0.80	γ_{M1} dla wytrzymałości zmęczeniowej	0.80
γ_{M1} dla stali konstrukcyjn	0.90	$\gamma_{M1,s}$ dla wytrzymałości zmęczeniowej przy ścianii	0.70

1.2 Dane materiałowe

▪ Stal konstrukcyjna

f_{sk} = 440.000 MPa E_s = 210000.000 MPa

▪ Beton

f_{ck} = 40.000 MPa E_{cm} = 35000.000 MPa

▪ Zbrojenie

f_{yk} = 400.000 MPa E_r = 210000.000 MPa

1.3 Informacje o przekroju

Reporte de Diseño de acero compuesto