Release Note

Release Date : May 2020

Product Ver. : Civil 2020 (v3.1)

DESIGN OF CIVIL STRUCTURES

Integrated Solution System for Bridge and Civil Engineering

Enhancements

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2. Thickness Data of Plane Strain Element
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18. RC Design as per IRS specifications
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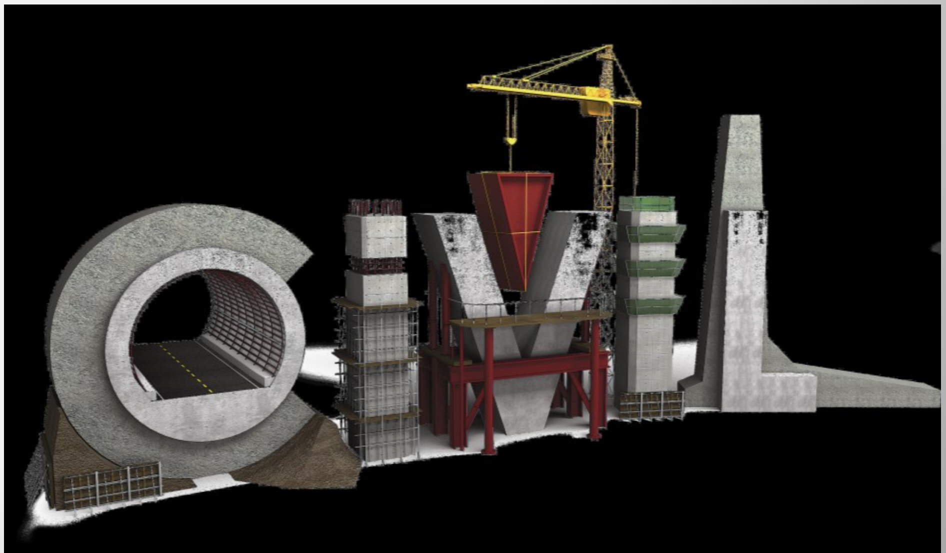
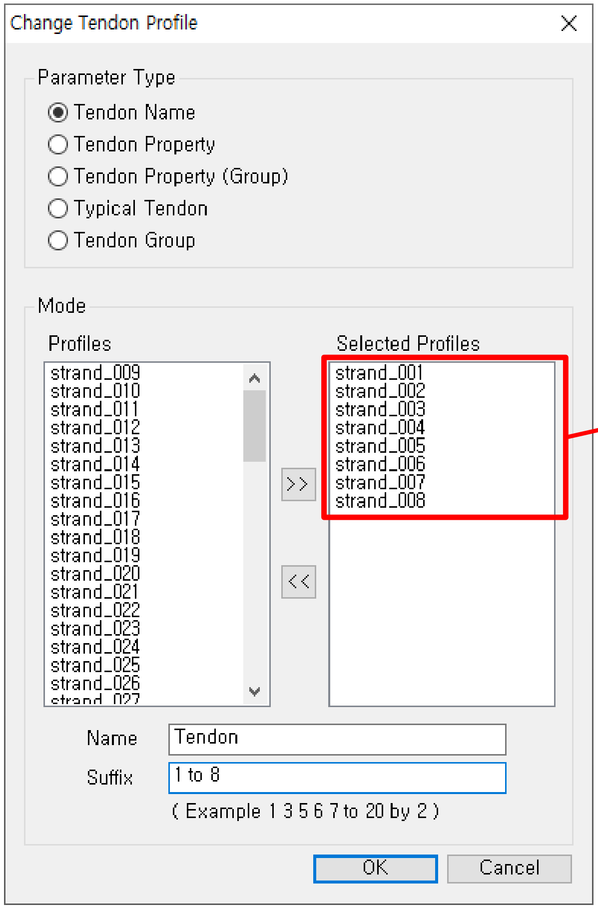


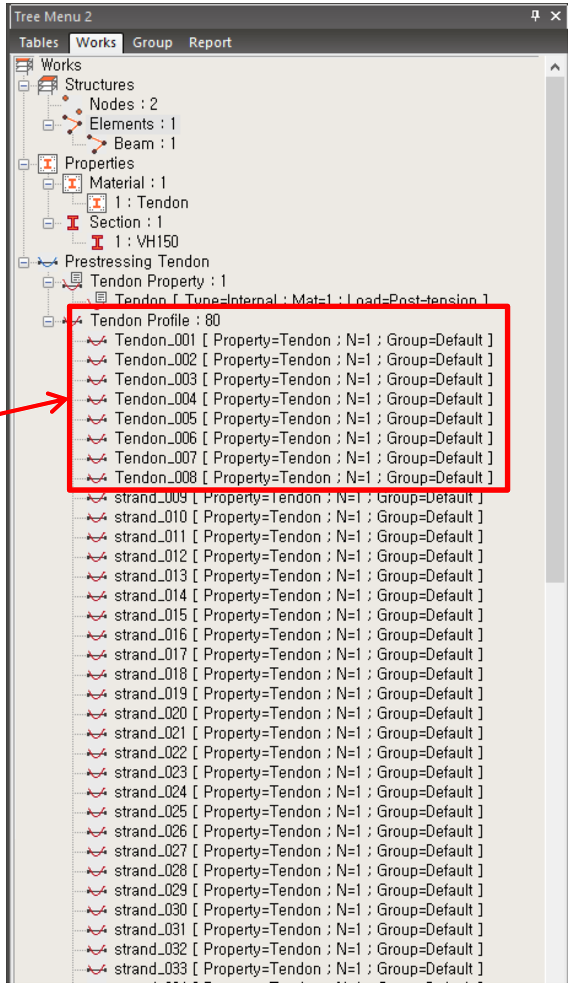
1. Batch Edit of Tendon Profile

- Batch editing is possible for the multiple tendon profiles at the same time.
- Tendon Name, Tendon Property, Number of Typical Tendons, Tendon Group

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



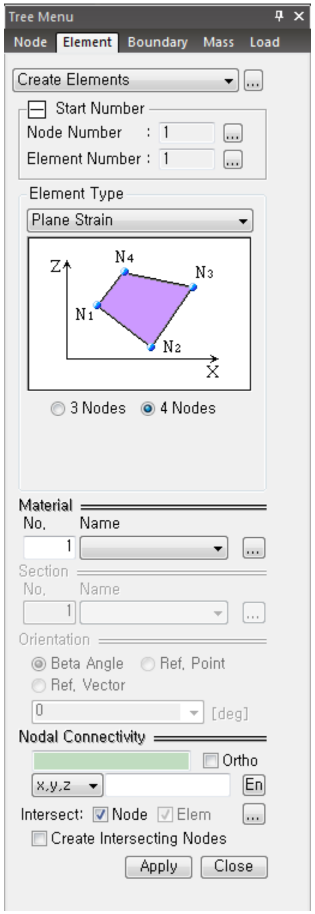
Change Tendon Profile



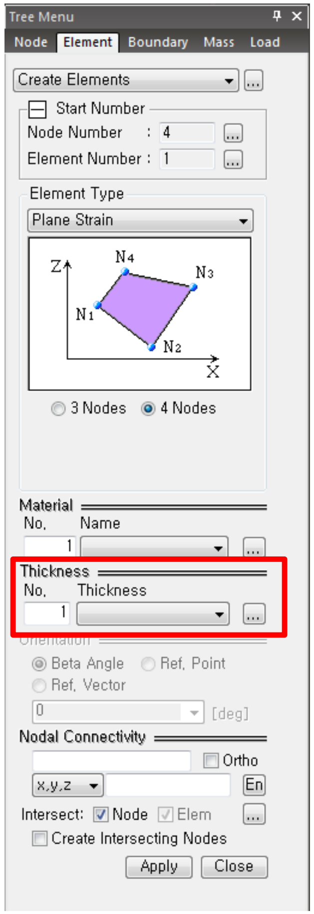
2. Thickness Data of Plane Strain Element

- In earlier versions, thickness of plane strain element is fixed as 1 m.
- Now, thickness can be defined for the plane strain element, which will be used to calculate self weight.

▪ *Node/Element > Elements > Create Elements > Plane Strain*



Previous Version



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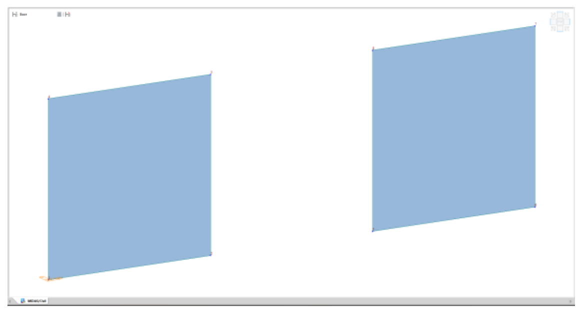

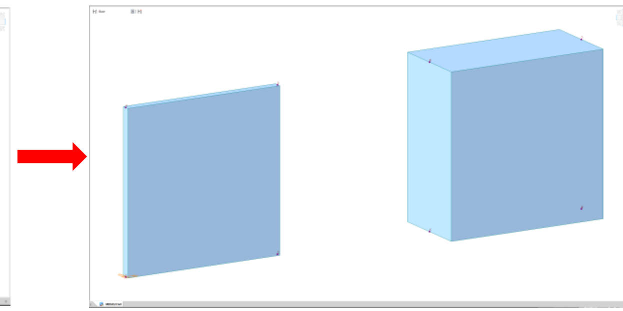

	No	Type	Material		Section		Thickness		L/A/V		Unit Weight (kN/m³)	Total Weight (kN)
			No	Name	No	Name	No	Name	Type	Value		
▸	1	PLANE ST	1	SS400	-	-	-	-	A	0.0000	76.9822	0.0003
	2	PLANE ST	1	SS400	-	-	-	-	A	0.0000	76.9822	0.0003

Previous Version

	No	Type	Material		Section		Thickness		L/A/V		Unit Weight (kN/m³)	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

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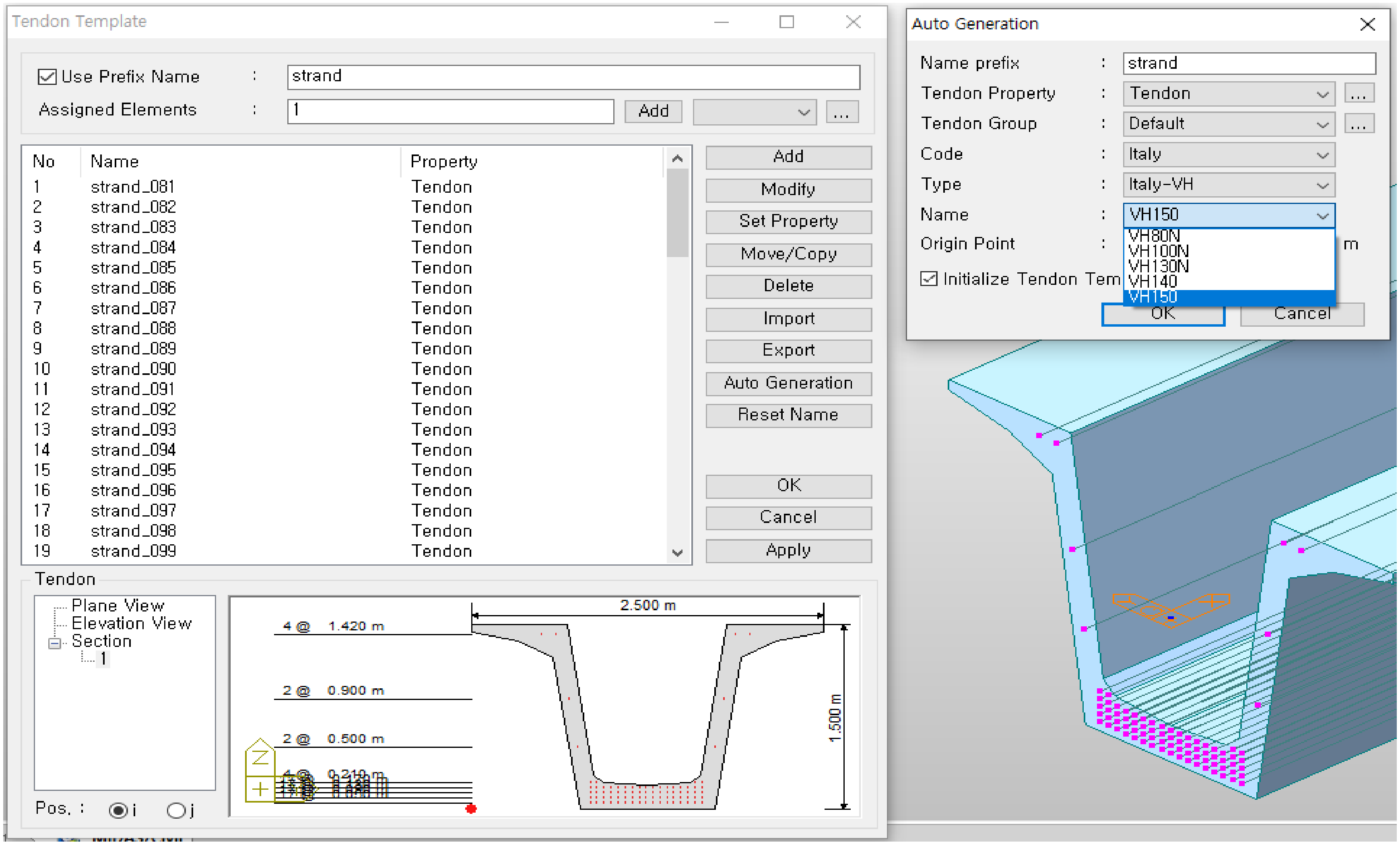
3. Auto-generation of Tendon Profile – Italy Precast Section Types

- Italy – VH80N, VH100N, VH130N, VH140, VH150 are newly added for the auto-generation of tendon profiles.

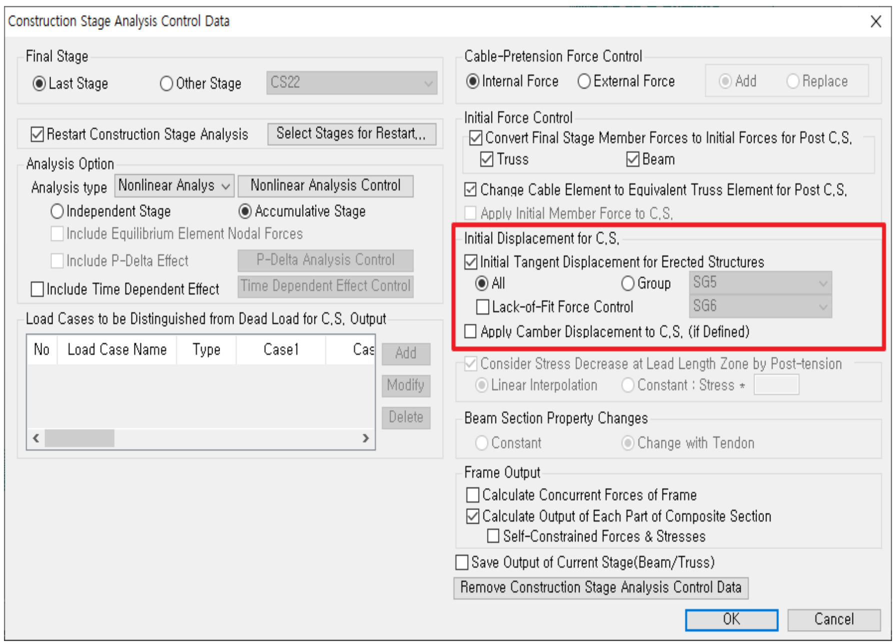
- ***Structure > Wizard > PSC Bridge > Tendon Template***



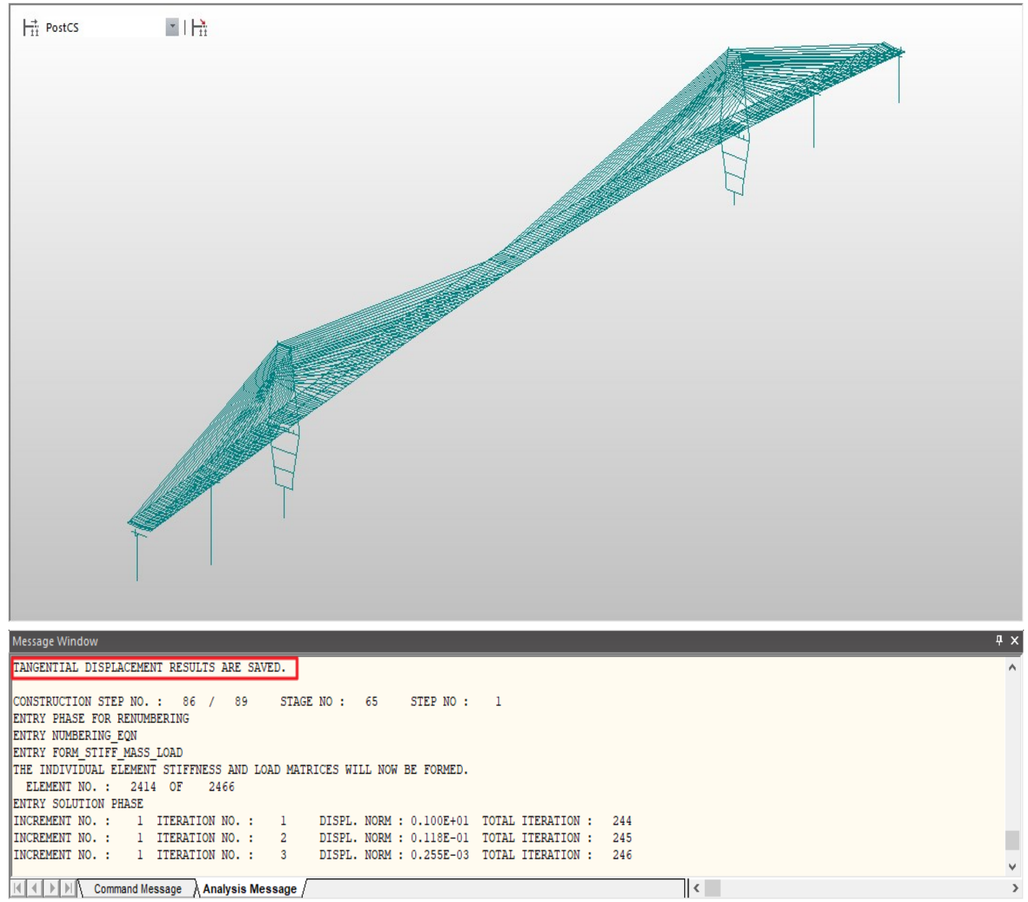
4. Geometric Nonlinear Construction Stage Analysis with Plate Elements

- Construction stage analysis can be performed considering geometric nonlinear effects of plate element.
- Initial tangent displacement can be applied to plate elements as well as beam elements.

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



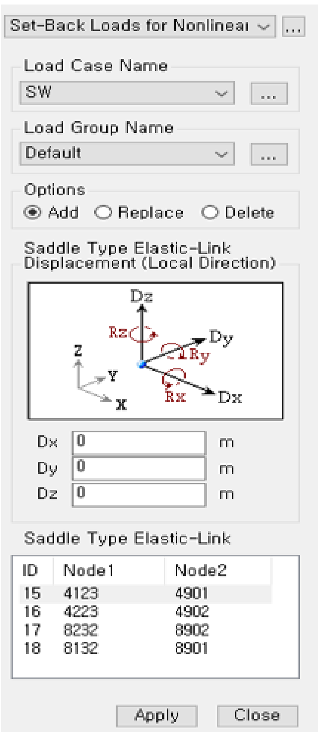
Construction Stage Analysis Control

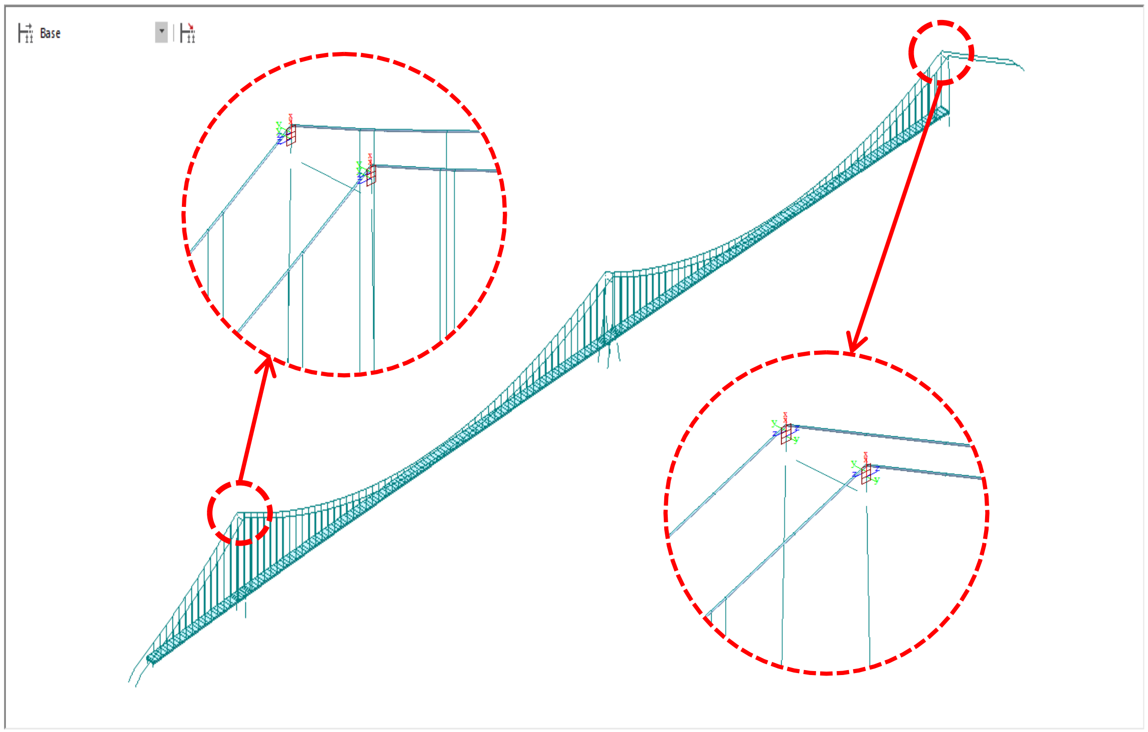


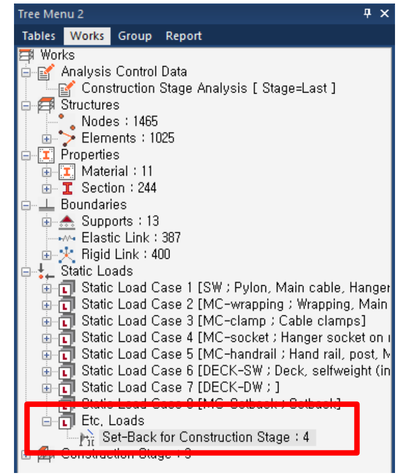
5. Set-Back for Saddle of Suspension Bridge

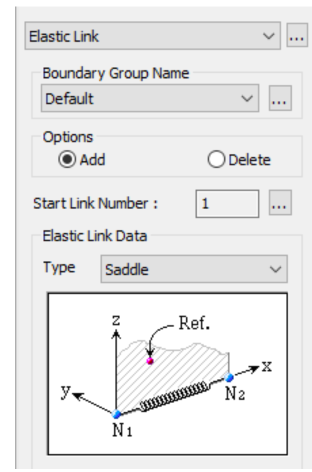
- In a multi-span suspension bridge, top tower saddle can be shifted relative to the tower before starting the cable erection.
- Saddle can simulated using Elastic Link: saddle type.

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







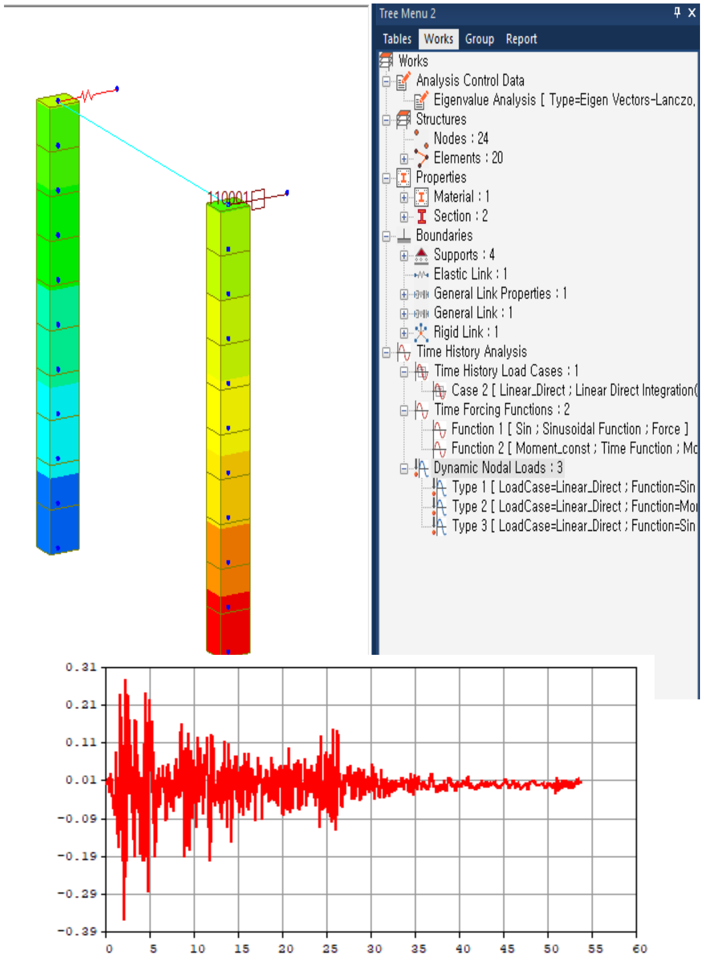


Apply set-back to Elastic Linsk representing top tower saddles

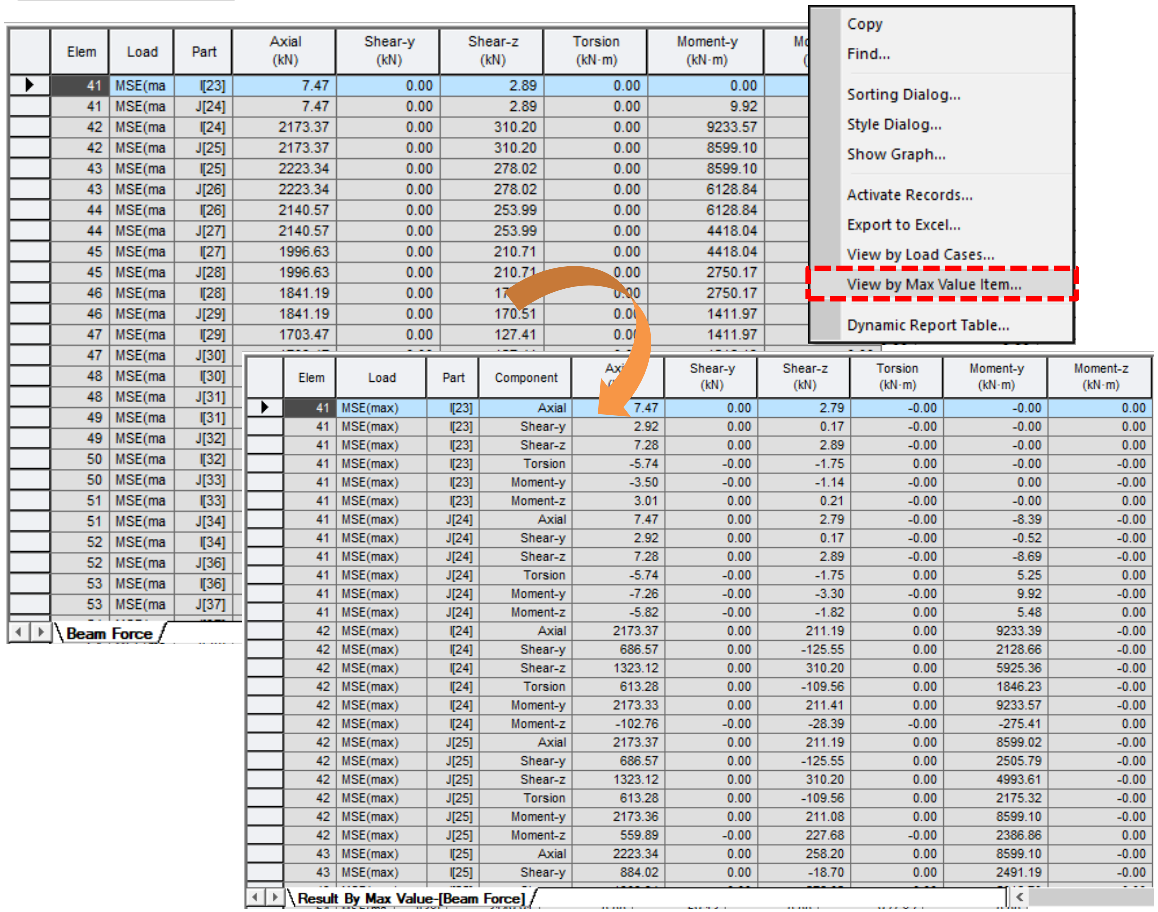
6. Concurrent Forces of Beam Elements for Time History Analysis

- Concurrent forces for time-history analysis.
- Beam elements only.

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



Beam Forces Table



Elem	Load	Part	Axial (kN)	Shear-y (kN)	Shear-z (kN)	Torsion (kN·m)	Moment-y (kN·m)
41	MSE(ma	I[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	I[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	I[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	I[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	I[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	I[28]	1841.19	0.00	17	[illegible]	2750.17
46	MSE(ma	J[29]	1841.19	0.00	170.51	0.0	1411.97
47	MSE(ma	I[29]	1703.47	0.00	127.41	0.0	1411.97
47	MSE(ma	J[30]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
48	MSE(ma	I[30]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
48	MSE(ma	J[31]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49	MSE(ma	I[31]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
49	MSE(ma	J[32]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	MSE(ma	I[32]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
50	MSE(ma	J[33]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
51	MSE(ma	I[33]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
51	MSE(ma	J[34]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52	MSE(ma	I[34]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
52	MSE(ma	J[36]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
53	MSE(ma	I[36]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]
53	MSE(ma	J[37]	[illegible]	[illegible]	[illegible]	[illegible]	[illegible]

Beam Force

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...

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)	I[23]	Axial	7.47	0.00	2.79	-0.00	-0.00	0.00
41	MSE(max)	I[23]	Shear-y	2.92	0.00	0.17	-0.00	-0.00	0.00
41	MSE(max)	I[23]	Shear-z	7.28	0.00	2.89	-0.00	-0.00	0.00
41	MSE(max)	I[23]	Torsion	-5.74	-0.00	-1.75	0.00	-0.00	-0.00
41	MSE(max)	I[23]	Moment-y	-3.50	-0.00	-1.14	-0.00	0.00	-0.00
41	MSE(max)	I[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)	I[24]	Axial	2173.37	0.00	211.19	0.00	9233.39	-0.00
42	MSE(max)	I[24]	Shear-y	686.57	0.00	-125.55	0.00	2128.66	-0.00
42	MSE(max)	I[24]	Shear-z	1323.12	0.00	310.20	0.00	5925.36	-0.00
42	MSE(max)	I[24]	Torsion	613.28	0.00	-109.56	0.00	1846.23	-0.00
42	MSE(max)	I[24]	Moment-y	2173.33	0.00	211.41	0.00	9233.57	-0.00
42	MSE(max)	I[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)	I[25]	Axial	2223.34	0.00	258.20	0.00	8599.10	-0.00
43	MSE(max)	I[25]	Shear-y	884.02	0.00	-18.70	0.00	2491.19	-0.00

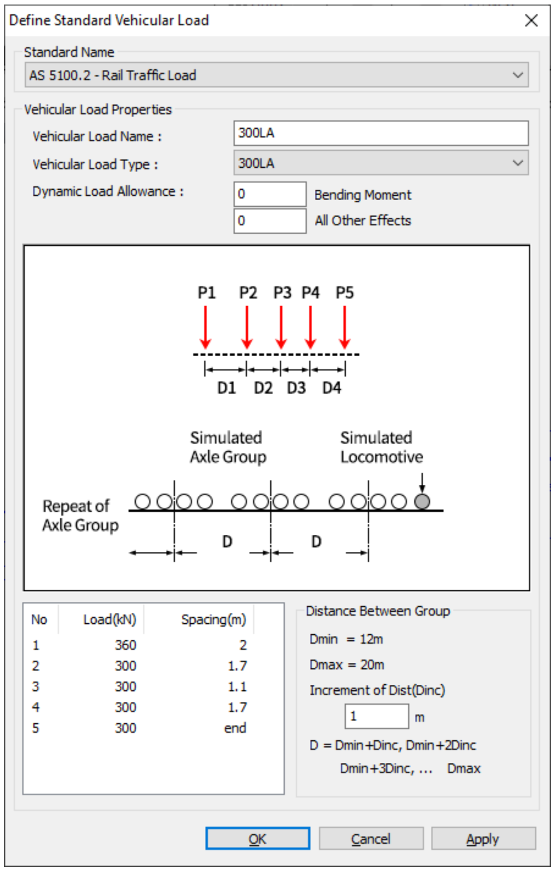
Result By Max Value-[Beam Force]

Concurrent Forces Table

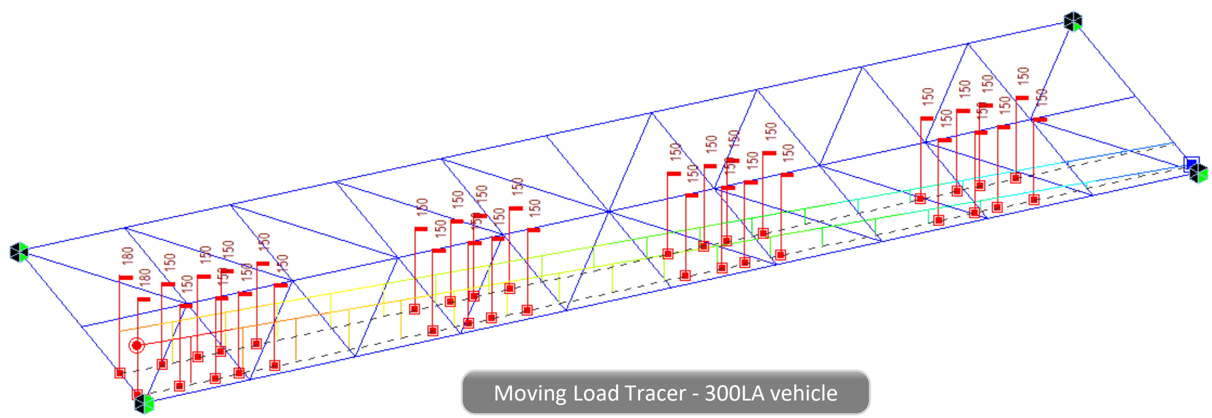
7. Rail traffic loads to AS 5100.2

- 300 LA, 150 LA, User-defined rail traffic loads
- Different dynamic load allowances for bending moment and all other effects

- ***Load > Moving Load > Moving Load Code> Australia***



300LA Train

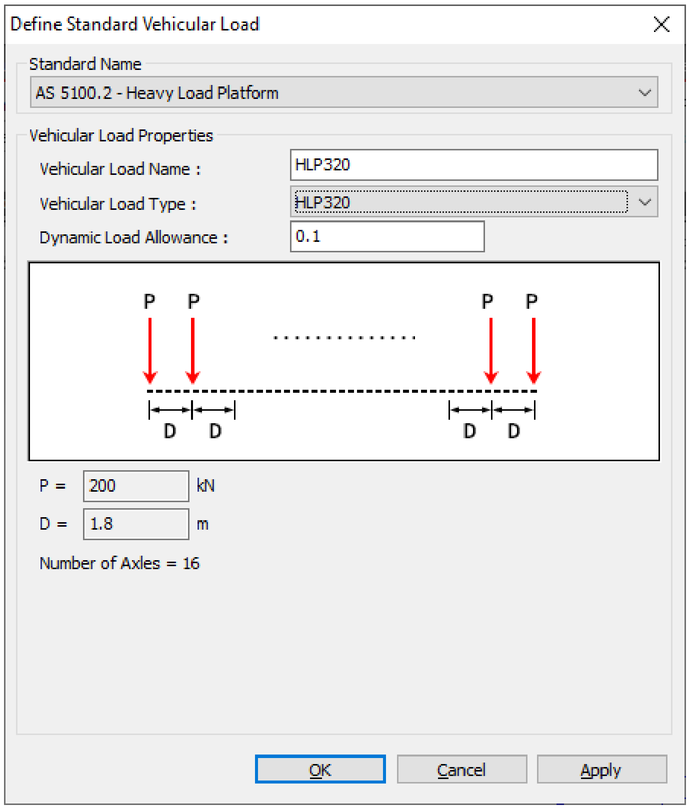


Moving Load Tracer - 300LA vehicle

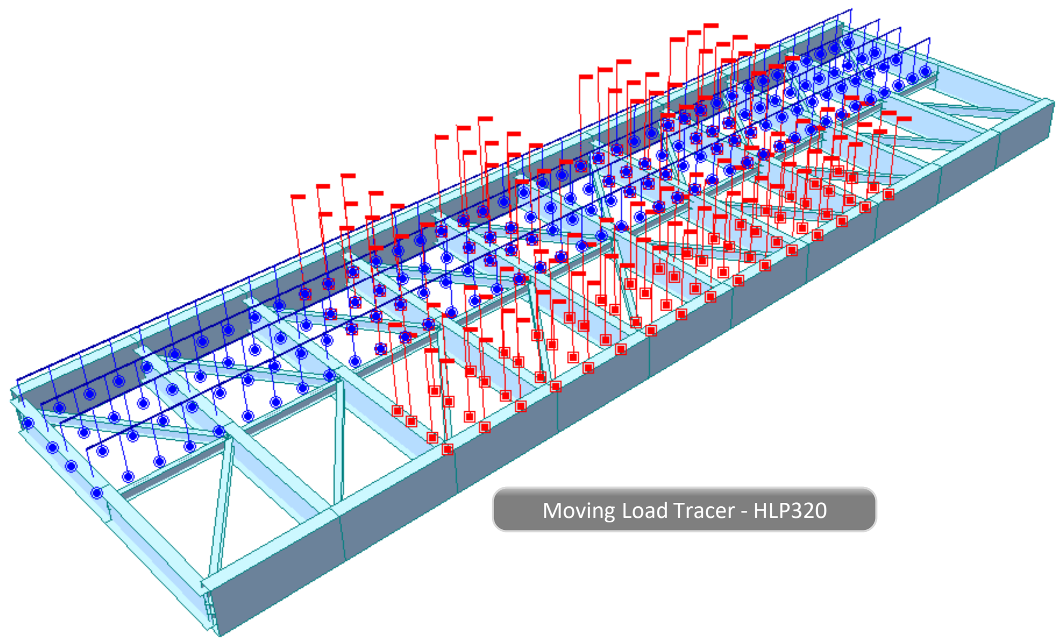
8. Heavy Load Platform to AS 5100.2

- HLP320, HLP400, User-defined heavy load platform loads

- ***Load > Moving Load > Moving Load Code> Australia***



HLP320 Heavy Load Platform

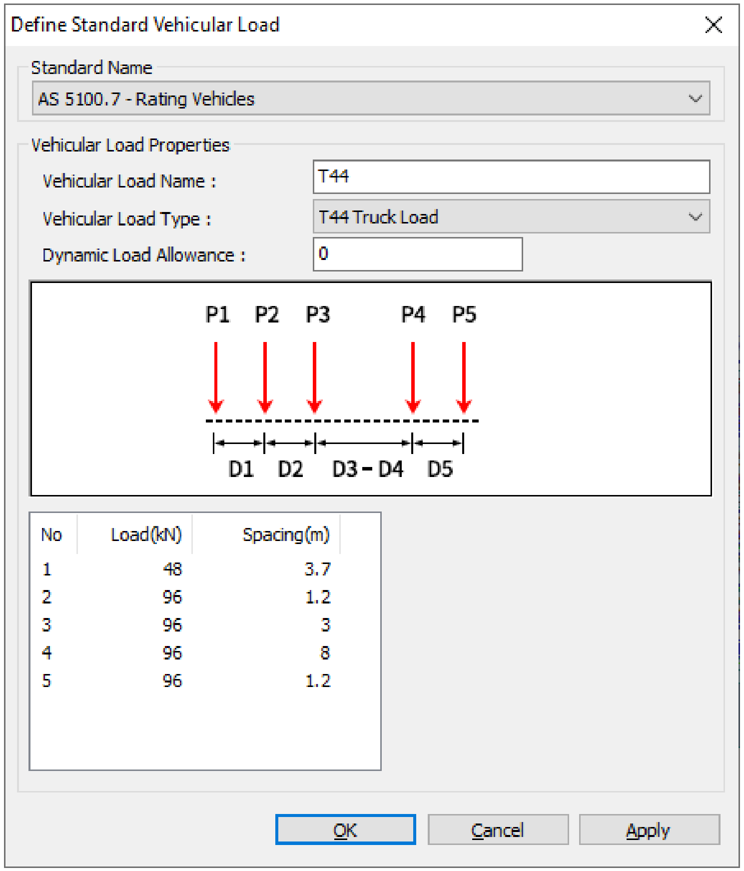


Moving Load Tracer - HLP320

9. Rating Vehicles to AS 5100.2

- T44, L44, User-defined rating vehicle loads

- ***Load > Moving Load > Moving Load Code> Australia***



T44 Rating Vehicle

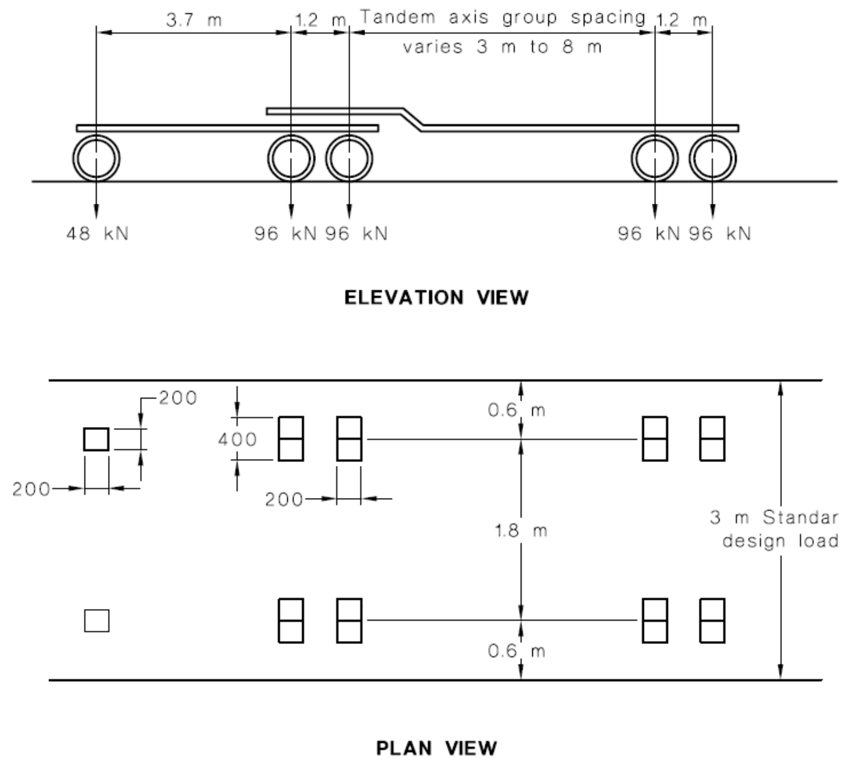
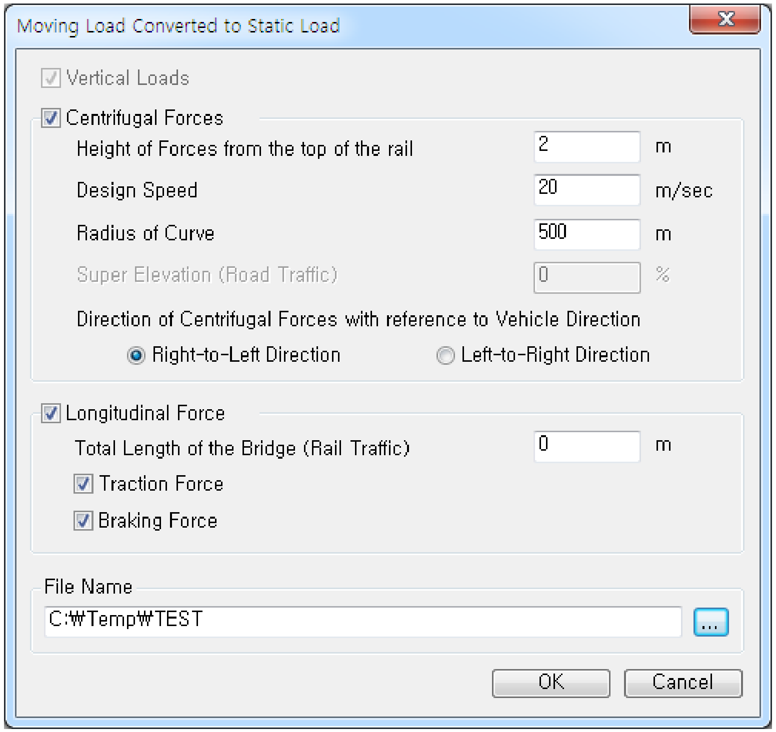


FIGURE A1 T44 TRUCK LOAD

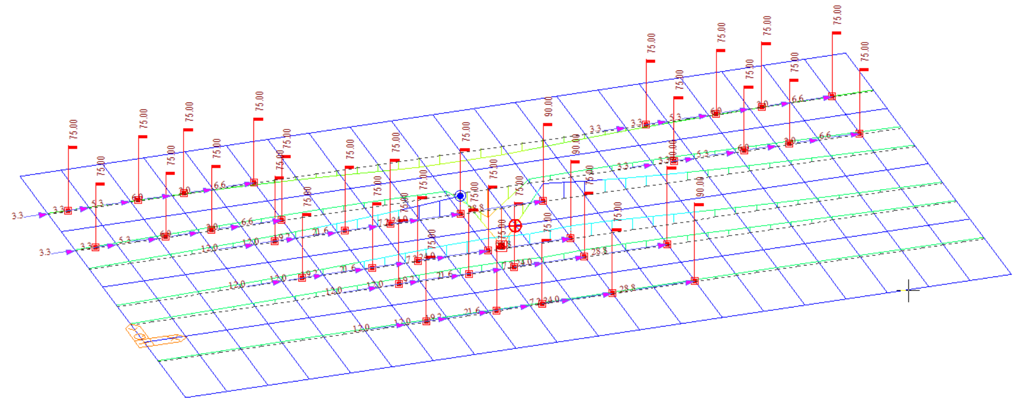
10. Horizontal Traffic Loads to AS 5100.2

- Centrifugal forces, traction and braking forces can be generated as static load cases .

▪ *Moving Tracer > Moving Load Converted to Static Load*



Conversion to Static Loads



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

$$F_c = \frac{V^2 A}{rg}$$

where

V = design speed, in metres pe

A = axle load, in kilonewtons

r = radius of curve, in metres

g = acceleration due to gravit

The specified centrifugal force shall n

Centrifugal and nosing forces due to r

(a) Braking forces:

$$BF = 200 + 15L_{LF} \quad \text{. . . 9.7.2.2(1)}$$

where

BF = longitudinal braking force, in kilonewtons

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

(b) Traction forces:

TF	$= 200 + 25L_{LF}$	for	$L_{LF} \le 25$ m	. . . 9.7.2.2(2)
	$825 + 15\,(L_{LF} - 25)$	for	$25 \text{ m} < L_{LF} \le 50$ m	. . . 9.7.2.2(3)
	$1200 + 7.5\,(L_{LF} - 50)$	for	$50 \text{ m} < L_{LF} \le 250$ m	. . . 9.7.2.2(4)
	$2700 + 5.0\,(L_{LF} - 250)$	for	$250 \text{ m} < L_{LF}$	. . . 9.7.2.2(5)

where

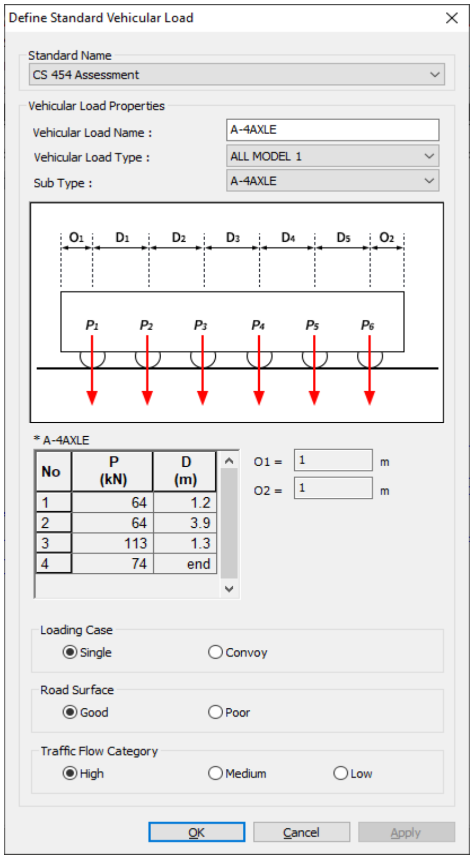
TF = longitudinal traction force, in kilonewtons

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

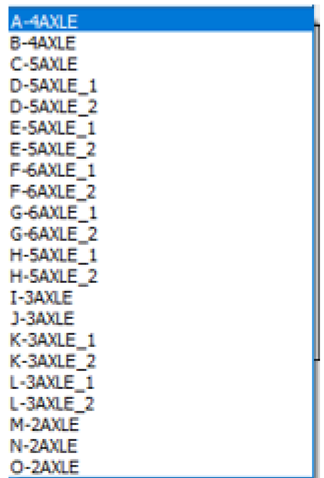
11. Rating Vehicles to CS 454

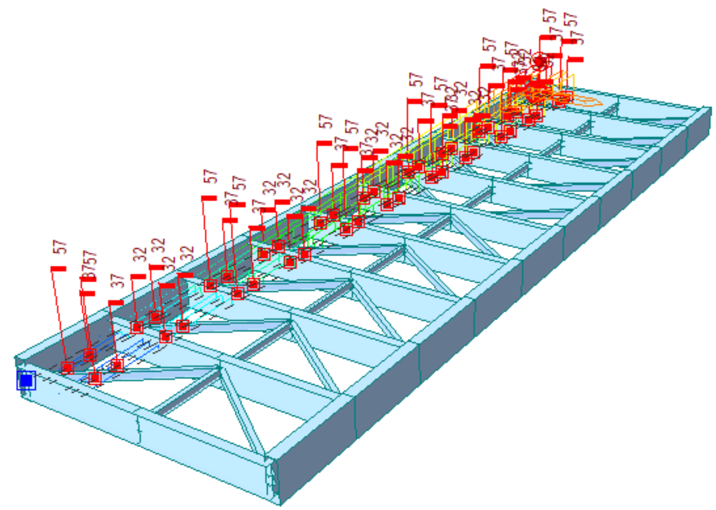
- ALL Model 1 (normal traffic, 26 tonnes, 18 tonnes, 7.5 tonnes, 3 tonnes)
- Impact factor, traffic flow factor, lane factor

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

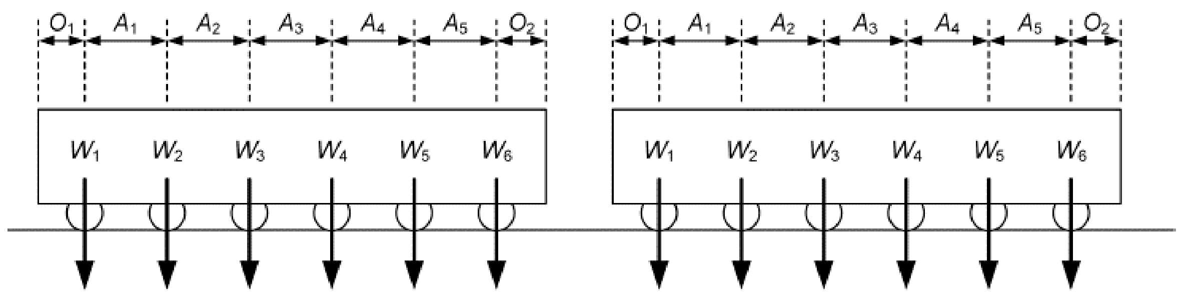


300LA Train





Moving Load Tracer – ALL Model 1 A Convoy

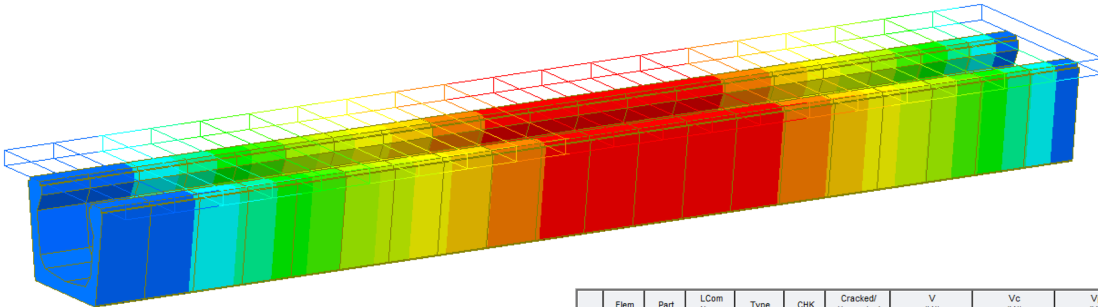


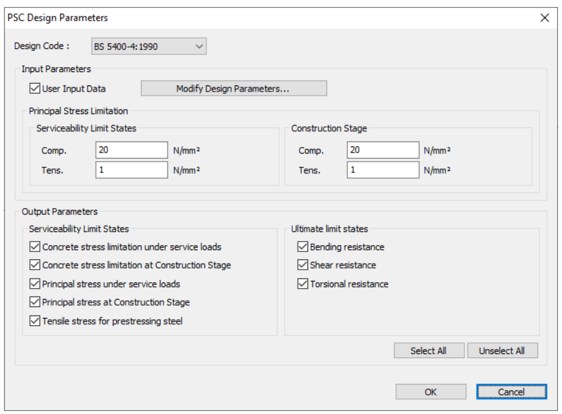
ALL Model 1 Convoy

12. Prestressed Girder Design to BS 5400

- Ultimate Limit State: Flexure, Shear, Torsion
- Serviceability Limit Stage: Stress, Crack

■ ***PSC > Design Parameter > BS 5400***





PSC Design Parameter

Elem	Part	LCom Name	Type	CHK	Cracked/ Uncracked	V (kN)	Vc (kN)	Vp (kN)
31	I[31]	cLCB1	FX-MAX	OK	Uncracked	3697.7653	5600.6276	1069.4979
31	J[32]	cLCB1	FX-MAX	OK	Uncracked	4300.0696	6718.8185	2089.7983
32	I[32]	cLCB1	FX-MAX	OK	Uncracked	4387.9569	6718.6466	2089.7048
32	J[33]	cLCB1	FX-MAX	OK	Uncracked	4994.0855	7756.5974	3043.3164
33	I[33]	cLCB1	FX-MAX	OK	Uncracked	5096.0264	7756.3981	3043.1926
33	J[34]	cLCB1	FX-MAX	OK	Uncracked	5719.3801	8677.3702	3899.5325
34	I[34]	cLCB1	FX-MAX	OK	Uncracked	5783.4813	8676.4566	3898.9226
34	J[35]	cLCB8	FZ-MAX	OK	Uncracked	6490.1368	6486.1565	2029.9368
35	I[35]	cLCB8	FZ-MAX	OK	Uncracked	6489.9510	6485.9617	2029.8289
35	J[36]	cLCB8	FZ-MAX	OK	Uncracked	7429.1805	4429.1410	291.5115
36	I[36]	cLCB9	FZ-MIN	OK	Uncracked	-7798.3355	4428.9545	291.4776
36	J[37]	cLCB9	FZ-MIN	OK	Uncracked	-6962.3546	5153.2856	963.5172
37	I[37]	cLCB9	FZ-MIN	OK	Uncracked	-6962.4360	5152.5049	963.1935
37	J[38]	cLCB1	FX-MAX	OK	Uncracked	-5996.8881	6486.6041	2181.7369
38	I[38]	cLCB1	FX-MAX	OK	Uncracked	-6306.8062	8359.5716	3162.6951
38	J[39]	cLCB1	FX-MAX	OK	Uncracked	-5283.1850	8926.0487	3678.6885
39	I[39]	cLCB1	FX-MAX	OK	Uncracked	-5587.7388	8925.3904	3678.2591
39	J[40]	cLCB1	FX-MAX	OK	Uncracked	-4564.0556	8883.8478	3652.2015
40	I[40]	cLCB1	FX-MAX	OK	Uncracked	-4887.5397	7726.5373	2895.2502
40	J[41]	cLCB1	FX-MAX	OK	Uncracked	-3865.8775	7147.4793	2354.1593
41	I[41]	cLCB1	FX-MAX	OK	Uncracked	-4166.7548	7146.7462	2353.7085
41	J[42]	cLCB1	FX-MAX	OK	Uncracked	-3177.8515	5622.5204	968.4353
42	I[42]	cLCB1	FX-MAX	OK	Uncracked	-2272.7099	5622.1340	968.2604
42	J[43]	cLCB1	FX-MAX	OK	Uncracked	-1725.7445	4611.5058	59.1826
43	I[43]	cLCB1	FX-MAX	OK	Uncracked	-1725.7820	4611.4441	59.1790
43	J[44]	cLCB1	FX-MAX	OK	Uncracked	-1178.8167	4548.8947	11.5920
44	I[44]	cLCB1	FX-MAX	OK	Uncracked	-1178.8348	4548.8863	11.5920
44	J[45]	cLCB1	FX-MAX	OK	Uncracked	-631.8694	4521.4062	2.0371
45	I[45]	cLCB1	FX-MAX	OK	Uncracked	-631.8804	4521.3875	2.0371
45	J[46]	cLCB1	FX-MAX	OK	Uncracked	-84.9151	4502.6167	2.7656
46	I[46]	cLCB1	FX-MAX	OK	Uncracked	-84.9273	4502.5904	2.7656
46	J[47]	cLCB1	FX-MAX	OK	Uncracked	462.0381	4500.8674	21.8337
47	I[47]	cLCB1	FX-MAX	OK	Uncracked	462.0311	4500.7999	21.8327
47	J[48]	cLCB1	FX-MAX	OK	Uncracked	1008.9965	4852.9981	356.1016
48	I[48]	cLCB1	FX-MAX	OK	Uncracked	1009.0100	4852.8649	356.0749

Shear Strength | MIDAS/Civil | Check Flexure Strength | Check Shear Strength

PSC Design Result Table

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_t	6.505E+09	(mm^3)
B	8500.000	(mm)	I_y	7.867E+12	(mm^4)	S_b	4.393E+09	(mm^3)
C_{zp}	1209.410	(mm)						
C_{zm}	1790.590	(mm)						

- Transformed section

H	3000.000	(mm)	A_g	6.439E+06	(mm^2)	S_t	6.790E+09	(mm^3)
B	8500.000	(mm)	I_y	8.116E+12	(mm^4)	S_b	4.497E+09	(mm^3)
C_{zp}	1195.243	(mm)						
C_{zm}	1804.757	(mm)						

■ **Partial Safety Factors**

- Partial Safety Factors for Ultimate Limit State

	Characteristic
γ_{mc} for Concrete	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**

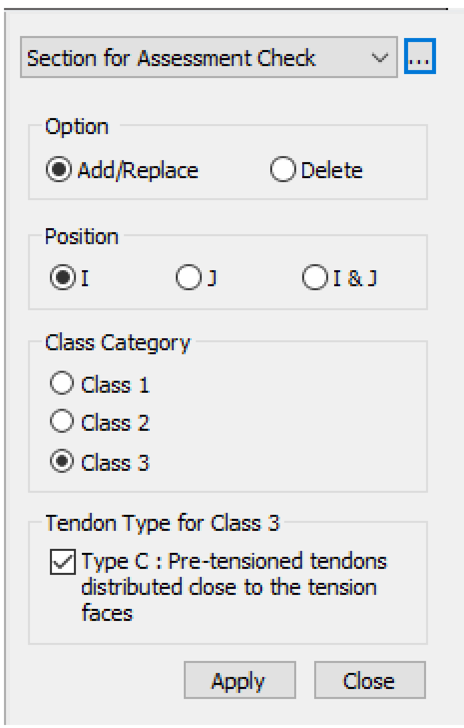
- Concrete

PSC Design Detail Report

13. Improvement of Bridge Assessment to CS 454

- Serviceability limit state check for Class 3 type section
- Ulltimate limit state check and serviceability limit state check for unbonded tendons

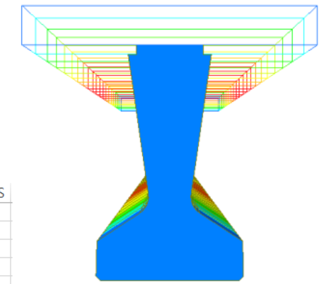
▪ ***Rating > Bridge Rating Design > CS 454/19***



Class Category

Element	Part	Class	Rating Case	Load Effect	sig_c (N/mm²)	sig_c_lim (N/mm²)	sig_t (N/mm²)	sig_t_lim (N/mm²)	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					
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					
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					

SLS Reserve Factor Table



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

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

■ Tension

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

$\sigma_{c,max} \le \sigma_{limit} * DF + \sigma_{rebar} = \sigma_{t,limit} = -11.31$ (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 (mm^2)

$A_{rebar,T}$: Area of rebar in tensile section
= 4909.00 (mm^2)

σ_{rebar} : Increase in the tensile stress limit due to the presence of additional reinforcement
= -5.85 (MPa)

$\sigma_{t,limit}$: Flexural tensile stress limit

$\sigma_{c,limit}$: Flexural compressive stress limit

Since

$\sigma_{c,max} \le \sigma_{t,limit}$ ∴ OK

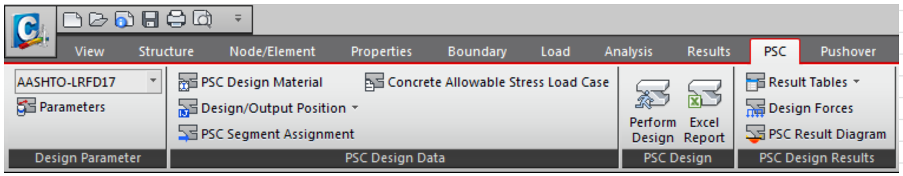
$\sigma_{c,min} \le \sigma_{c,limit}$ ∴ OK

Serviceablity Limit State Check Report

14. AASHTO LRFD 8th Design Standard – PSC/Composite Section, RC Section

- New AASHTO LRFD design standard can be applied to various design functions.
- RC , PSC Box, PSC Composite.

■ *PSC > Design > AASHTO LRFD 17*



Torsional effects shall be investigated where:

$T_u > 0.25\phi T_{cr}$ (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:

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

in which:

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

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:

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

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

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

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_{zp}	42.858	(in)
C_{zm}	75.134	(in)

- Transformed section

H	117.992	(in)
B	492.126	(in)
C_{zp}	43.709	(in)
C_{zm}	74.283	(in)

■ **Materials**

- Concrete

f_c (ksi)
7.000

* β_1 : 0.85 if fc is lower t

- Prestressing steel informatio

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

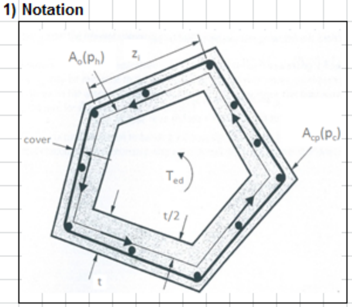
* d_p : Distance from extr

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 : Φ = 0.90
- Component of prestressing force in direction of the shear force $V_p = \Sigma A_{ps} \cdot f_{e(z\text{-}dir)}$ = 413.49 (kips)

1) Notation



A_o = Area enclosed by the shear flow path, including any area of holes therein.
= 35799.879 (in²)

p_h = Perimeter of the centerline of the closed tranverse torsion reinforcement.
= 1113.426 (in)

A_{cp} = Total area enclosed by outside perimeter of the concrete section.
= 35799.879 (in²)

p_c = 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) ≤ $0.25\Phi T_{cr}$ = 175885.68 (kips·in) (Eq. 5.7.2.1-3)

∴ $T_u \le 0.25\Phi T_{cr}$, Ignore Torsional Effects.

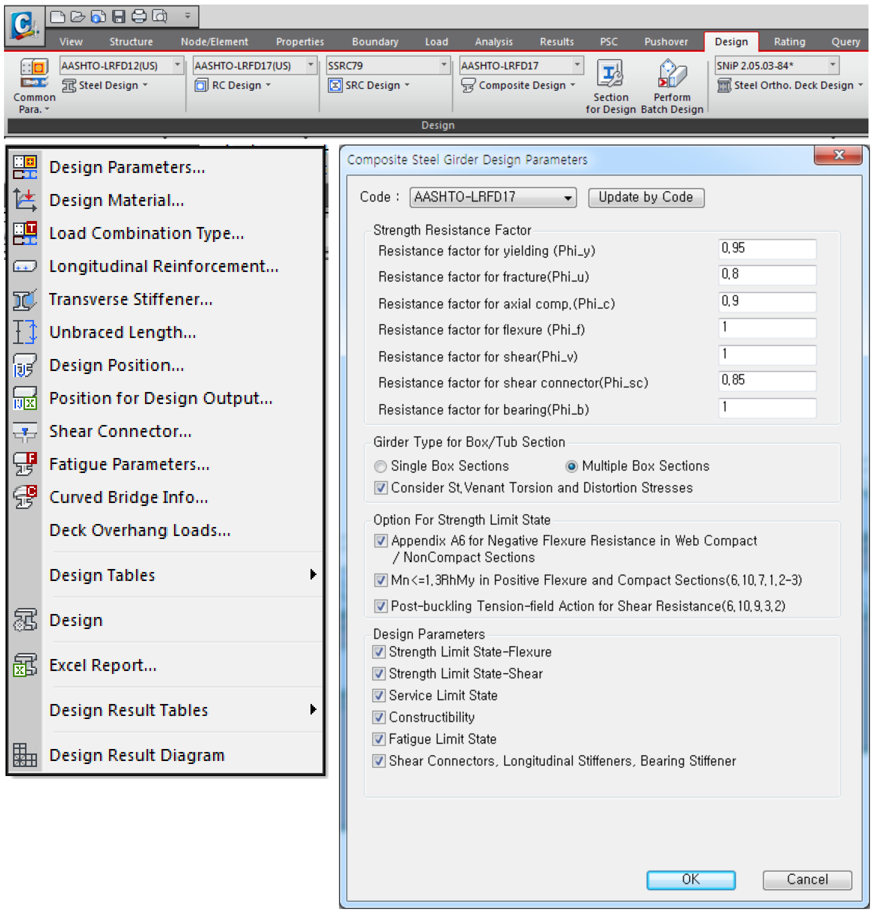
- Check combined torsional and shear (Eq. 5.12.5.3.8c-6)

$$\frac{V_u}{b_v d_v} + \frac{T_u}{2A_o b_e} = 0.00 \text{ (ksi)} \ge 0.474\sqrt{f'_c} = 0.00 \text{ (ksi)}$$ OK

15. AASHTO LRFD 8th Design Standard – Steel Composite Section

- New AASHTO LRFD design standard can be applied to various design functions.
- Steel Composite

▪ ***Design > Composite Design > AASHTO - LRFD 17***



Design Parameters

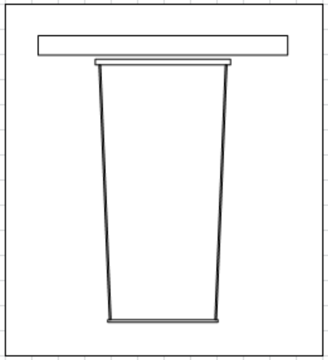
Code	AASHTO-LRFD 2017
Element	3
Position	I
Moment Type	Beam

I. Design Condition (Positive Flexure)

1. Section Properties

1) Slab Properties

B_s = 240.000 in
t_s = 10.000 in
t_h = 5.000 in
f_c' = 3.000 ksi
E_c = 3155.924 ksi
A_r = 0.000 in²
F_{yr} = 40.000 ksi



2) Girder Properties

[Section]

b_{fc} = 130.000 in b_{ft} = 106.000 in
t_{fc} = 3.000 in t_{ft} = 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_0(in)
Web	1Side	35.000	10.000	10.000	2.000	2.000	100.000

Excel Design Report

16. AASHTO LRFD 8th Load Combination – Auto Generation

- Load factors of extreme event.
- Load factors of fatigue .

- ***Result > Load Combinations > AASHTO LRFD 17***

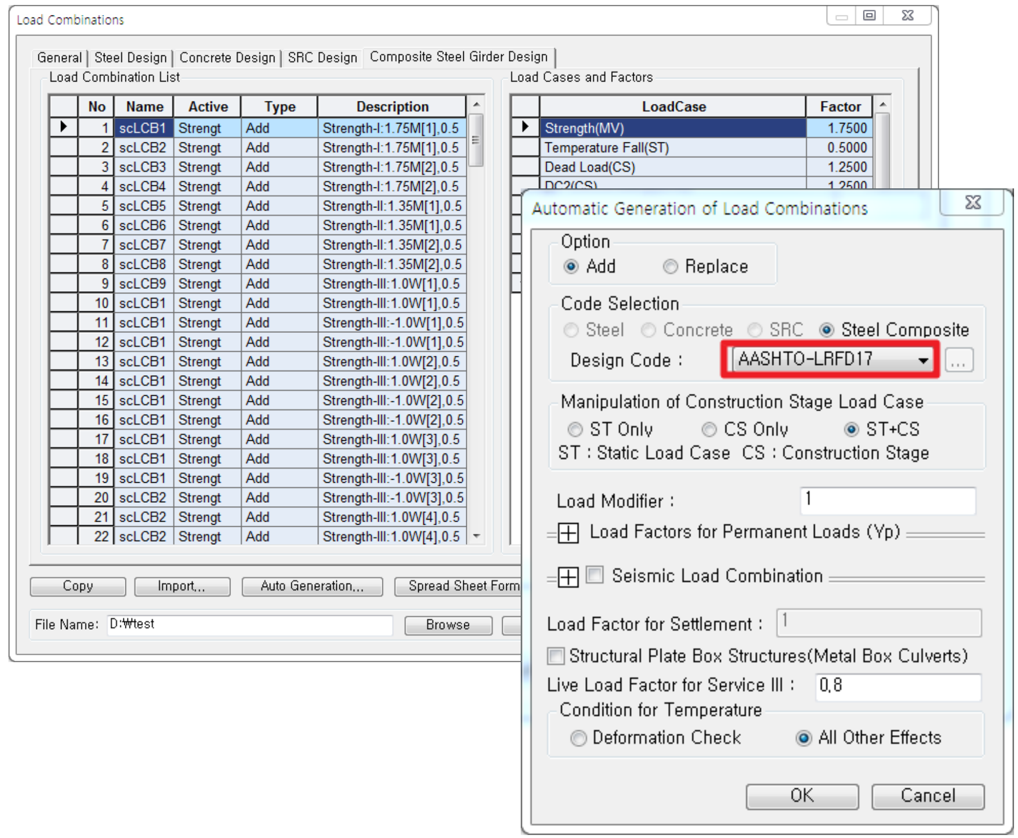
Table 3.4.1-1—Load Combinations and Load Factors

Load Combination Limit State	DC DD DW EH EV ES EL PS CR SH	LL IM CE BR PL LS	WA	WS	WL	FR	TU	TG	SE	Use One of These at a Time EQ	BL	IC	CT	CV
Strength I (unless noted)	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength III	γ_p	—	1.00	1.40	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—	—
Strength V	γ_p	1.35												
Extreme Event I	γ_p	γEQ												
Extreme Event II	γ_p	0.50												
Service I	1.00	1.00												
Service II	1.00	1.30												
Service III	1.00	0.80												
Service IV	1.00	—												
Fatigue I—*LL, IM & CE* only	—	1.50												
Fatigue II—*LL, IM & CE* only	—	0.75												

Table 3.4.1-1—Load Combinations and Load Factors

Load Combination Limit State	DC DD DW EH EV ES EL PS CR SH	LL IM CE BR PL LS	WA	WS	WL	FR	TU	TG	SE	Use One of These at a Time EQ	BL	IC	CT	CV
Strength I (unless noted)	γ_p	1.75	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength II	γ_p	1.35	1.00	—	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength III	γ_p	—	1.00	1.00	—	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Strength IV	γ_p	—	1.00	—	—	1.00	0.50/1.20	—	—	—	—	—	—	—
Strength V	γ_p	1.35	1.00	1.00	1.00	1.00	0.50/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Extreme Event I	1.00	γ_{EQ}	1.00	—	—	1.00	—	—	—	1.00	—	—	—	—
Extreme Event II	1.00	0.50	1.00	—	—	1.00	—	—	—	—	1.00	1.00	1.00	1.00
Service I	1.00	1.00	1.00	1.00	1.00	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service II	1.00	1.30	1.00	—	—	1.00	1.00/1.20	—	—	—	—	—	—	—
Service III	1.00	γ_{LL}	1.00	—	—	1.00	1.00/1.20	γ_{TG}	γ_{SE}	—	—	—	—	—
Service IV	1.00	—	1.00	1.00	—	1.00	1.00/1.20	—	1.00	—	—	—	—	—
Fatigue I—*LL, IM & CE* only	—	1.75	—	—	—	—	—	—	—	—	—	—	—	—
Fatigue II—*LL, IM & CE* only	—	0.80	—	—	—	—	—	—	—	—	—	—	—	—

Changes of Load Factors

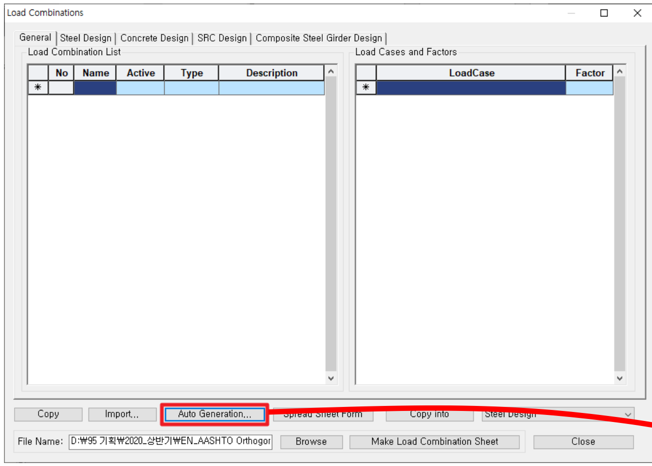


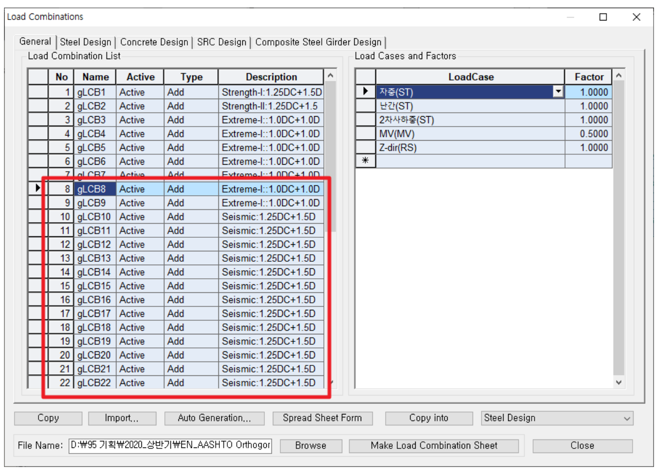
Automatic Generation of Load Combination

17. Orthogonal effect of Seismic Load: AASHTO LRFD

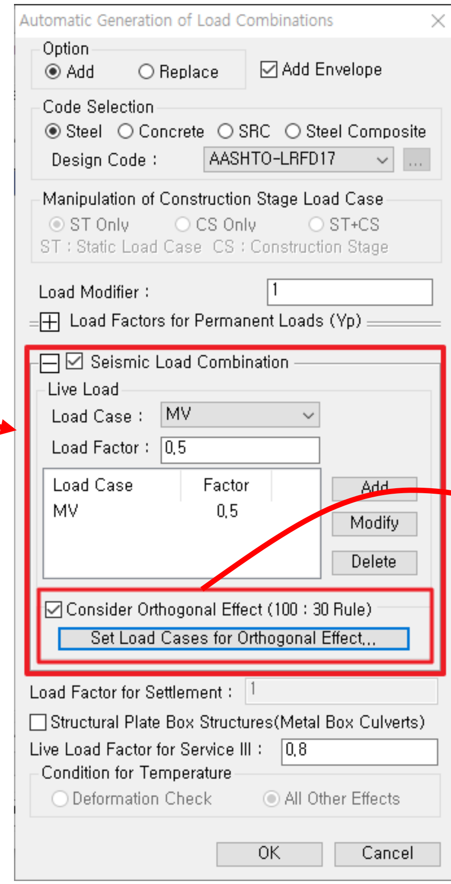
- Orthogonal effect of seismic loads can be included in the auto-generation of load combination to AASHTO-LRFD 16 & 17.

▪ *Results > Load Combination > Auto Generation…*

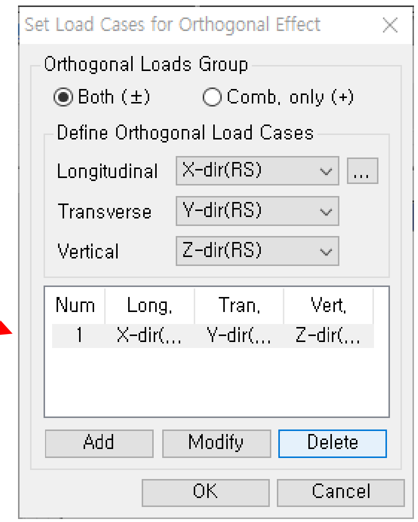




Automatic Generation of Load combination



Define Seismic Load Combination

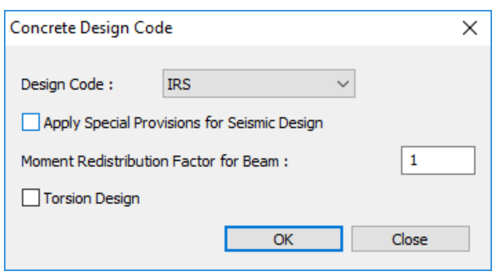


Define Orthogonal RS Loads

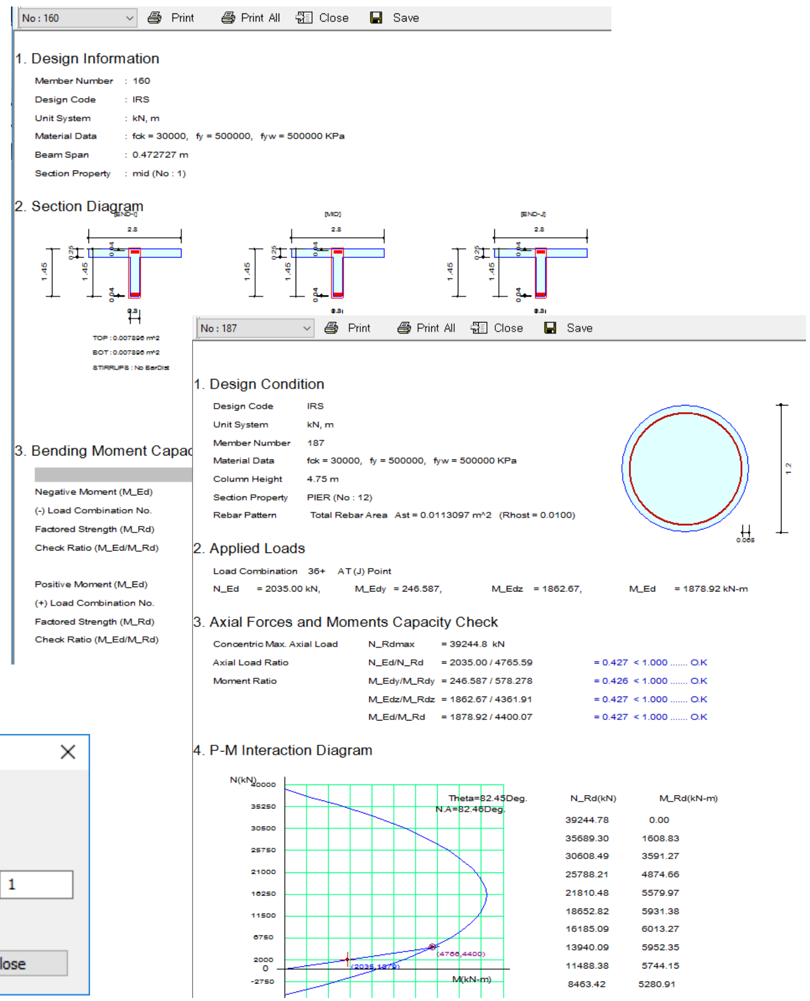
18. RC Design as per IRS specifications

- Reinforced Concrete Design as per IRS is now available. RC Beam Design, Beam Checking, Column Design and Column Checking can now be performed for IRS.
- The Graphic/Detailed reports which include both Ultimate Limit State and Serviceability Limit State checks as per IRS Specifications can be generated.

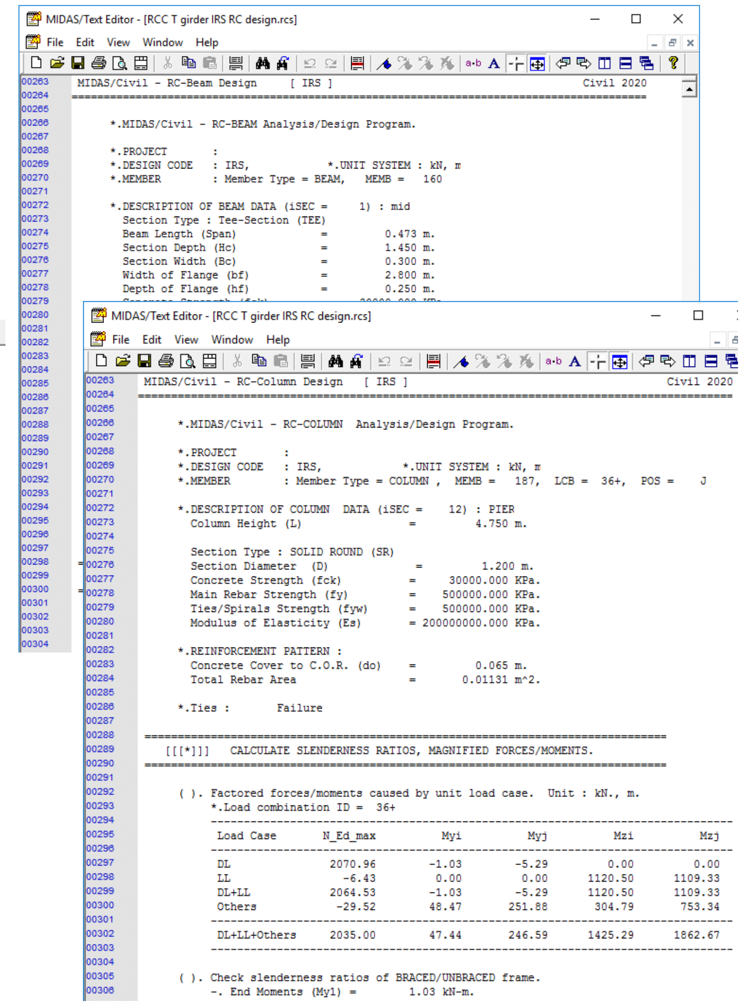
- ***Design > RC Design> IRS***



Code option for IRS RC Design



Graphic report for Beam and Column design



Detailed report for Beam and Column Design

19. Polish Design Report

- Poland Design Report applied in PSC Box&Composite, Steel Composite in 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 zbrojeniowej	γ_S dla stali sprężającej
Stały i zmienny	1.500	1.150	1.150
Wyjątkowy	1.200	1.000	1.000

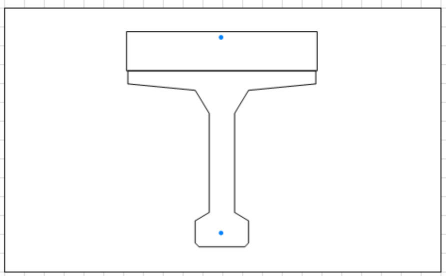
- Współczynnik α_{cc} , α_{ct} : współczynnik długoterminowych wpływów na wytrzymałość na ściskanie i zginanie.

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

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

1.2 Informacje o przekroju

Informacje o przekroju		Przekr. zast(cięg., zbroj.) (Dźwigar)	Przekr. 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_{sb}	(mm)	-	212.636
y_t	(mm)	543.286	212.636
y_b	(mm)	806.714	1137.364
Z_{st}	(mm^3)	-	438069976.161
Z_{sb}	(mm^3)	-	1056127262.797
Z_t	(mm^3)	46047196.375	1056127262.797
Z_b	(mm^3)	189305140.655	197447956.212



1.3 Dane materiałowe

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

- Informacje o betonie

PSC Design Report

▪ *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 zbrojeniowej	0.70	γ_{Ff} dla równow. zakresu zmienności naprężeń o st	0.90
γ_{M0} dla stali konstrukcyjn	0.80	γ_{Mf} dla wytrzymałości zmęczeniowej	0.80
γ_{M1} dla stali konstrukcyjn	0.90	$\gamma_{Mf,s}$ dla wytrzymałości zmęczeniowej przy ścianiu	0.70

1.2 Dane materiałowe

■ Stal konstrukcyjna

f_{sk} = 440.000 MPa E_s = 210000.000 MPa

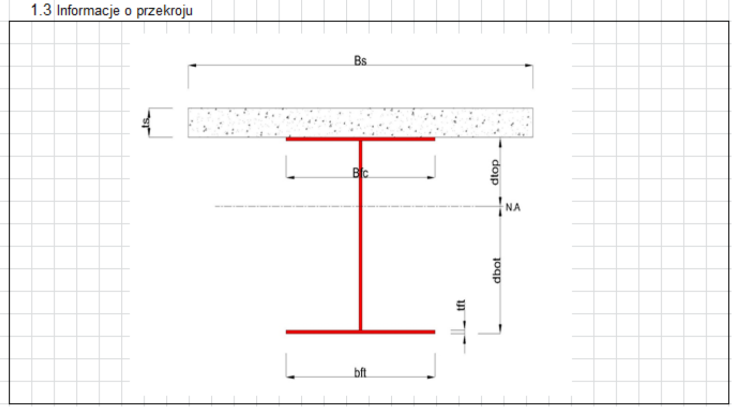
■ Beton

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



Steel Composite Design Report