Release Note

Release Date : Nov. 08, 2023

Product Ver. : Civil 2024 (v1.1)

DESIGN OF CIVIL STRUCTURES

Integrated Solution System for Bridge and Civil Engineering

Enhancements

Enhancements in Civil 2024 (v1.1)

- Pre & Post processing

1. Plate Thickness Temperatures
2. Equivalent Beam Stress Results for Construction Stage Analysis
3. HL-93TDM considering 100% combined effect of two tandems as per AASHTO LRFD Vehicle Load
4. Time Dependent Material as per IRC 112: 2020
5. Response Spectrum function as per SP 268.1325800.2016
6. Stress Calculation for Part2 of Composite Section with Cracked Section option

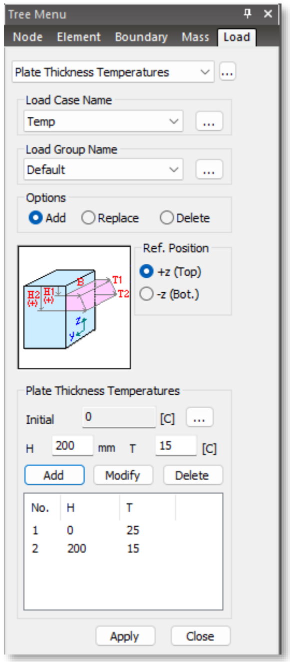
- Design

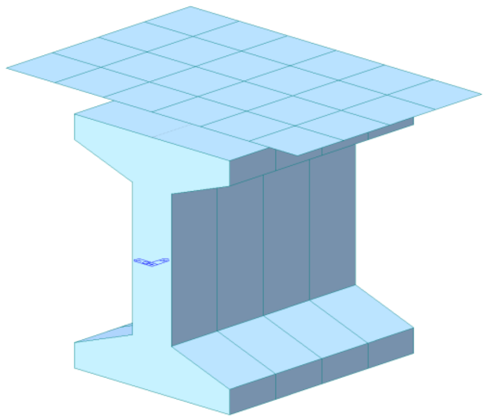
7. Design Calculation Speed
8. Steel Composite Design as per AS 5100.6:2017
9. RC, Steel, Steel Composite, and PSC Design as per AASHTO LRFD 2020
10. PSC Design as per CSA S6:19
11. Steel Composite Design as per CSA-S6-19
12. Design of Solid web girder as per IRS SBC:2017
13. Other Enhancements

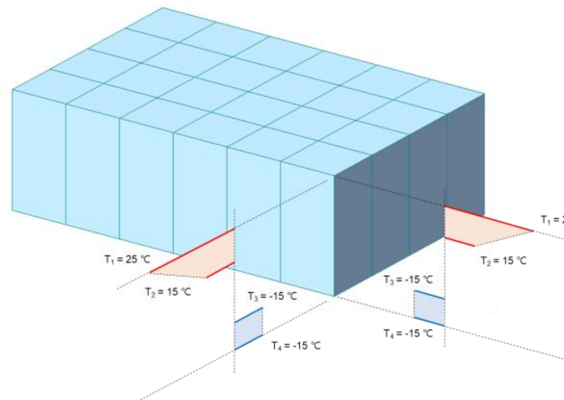
1. Plate Thickness Temperatures

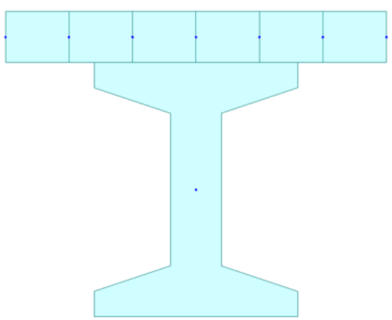
- The nonlinear temperatures in the thickness direction of plate elements can be applied for the thermal stress analysis.
- Plate Thickness Temperatures function is applicable to a composite girder which has plate elements as a slab and beam elements as a girder.

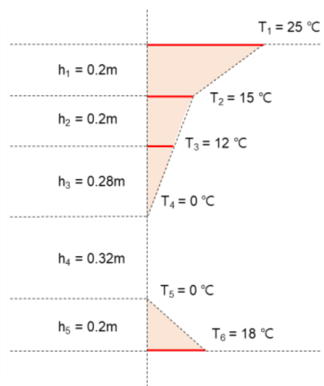
▪ ***Load > Temperature Loads > Plate Thickness Temperatures***











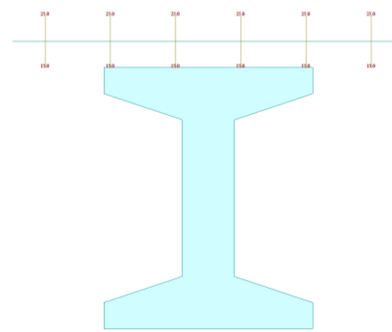
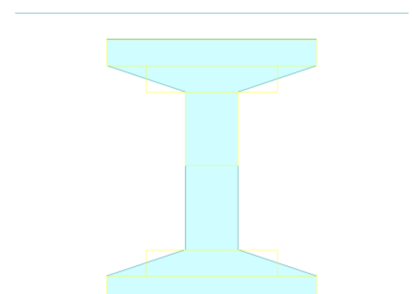


Plate Thickness Temperatures

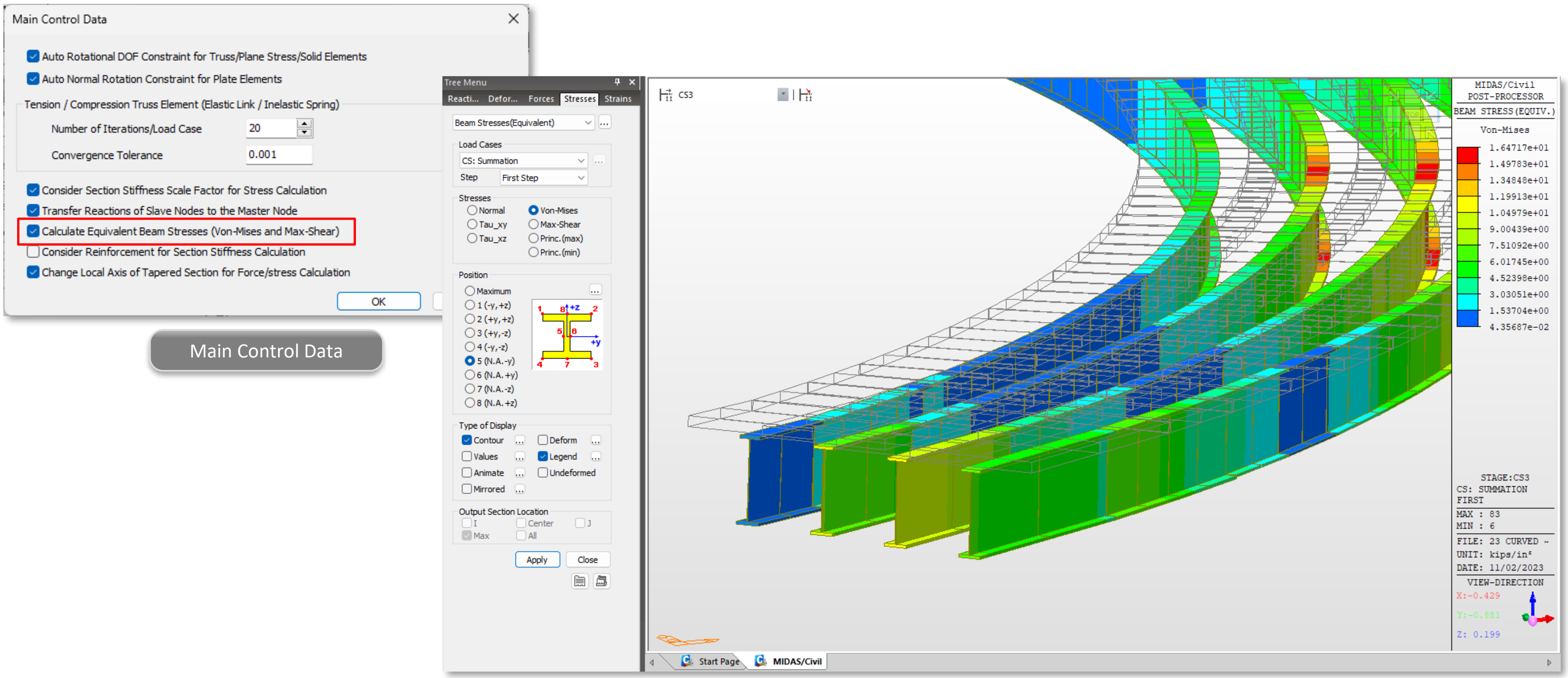


Beam Section Temperatures

2. Equivalent Beam Stress Results for Construction Stage Analysis

- Equivalent beam stresses including Von-Mises stresses of the steel composite sections are now provided for the construction stage analysis.
- Steel-I (Type 1), Steel-Tub (Type 1), and Steel-Box (Type 1) are available.

▪ ***Results > Stresses > Beam Stresses(Equivalent)***



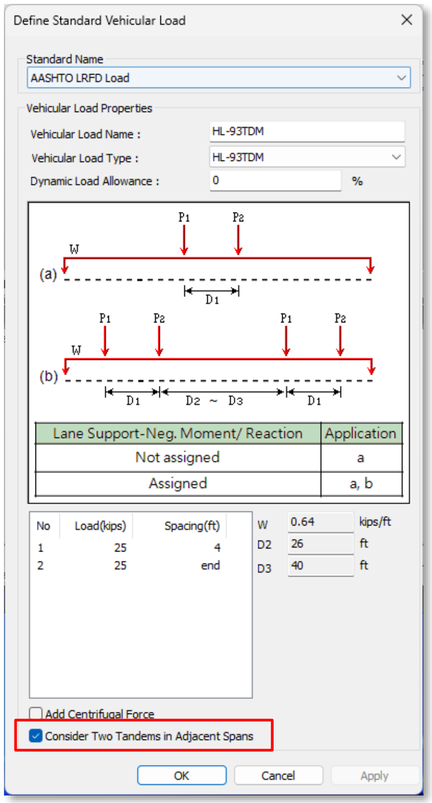
Main Control Data

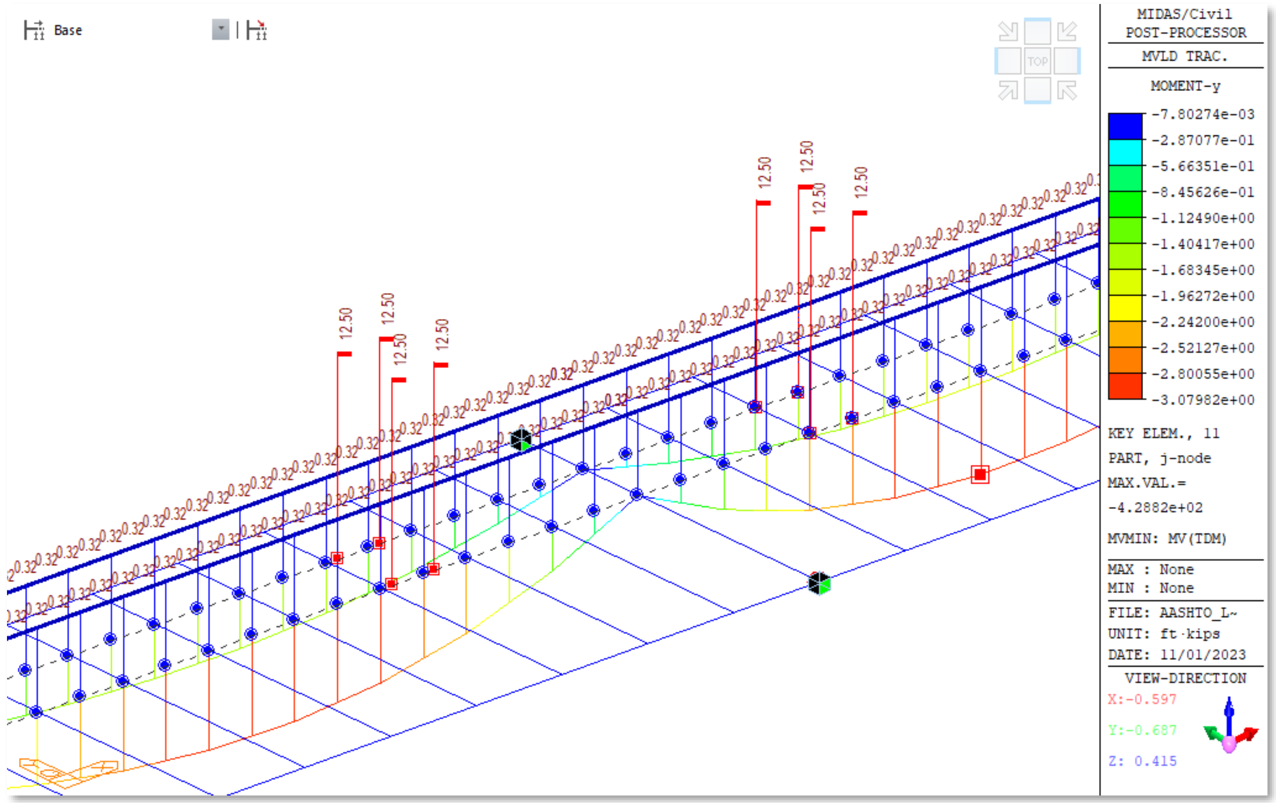
Von-Mises Stresses at Centroid of Steel Composite Section

3. HL-93TDM considering 100% combined effect of two tandems as per AASHTO LRFD Vehicle Load

- According to C3.6.1.3.1 AASHTO LRFD 2020, one hundred percent of the combined effect of the two design tandems and the design lane load should be used to investigate negative moment and reactions at interior supports.
- HL-93TDM vehicle load in AASHTO LRFD Load provides the option to consider the combined effect.

▪ ***Load > Load Type > Moving Load > Vehicle > AASHTO LRFD Load***



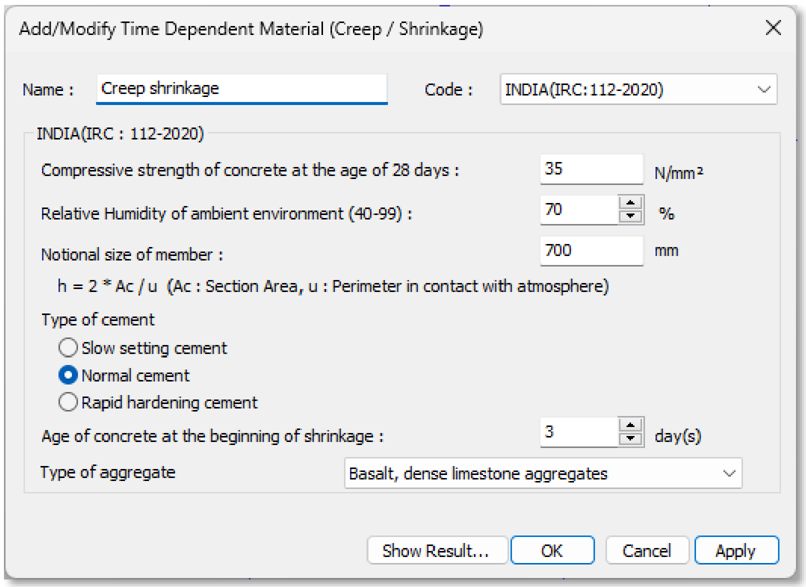


Vehicular Load

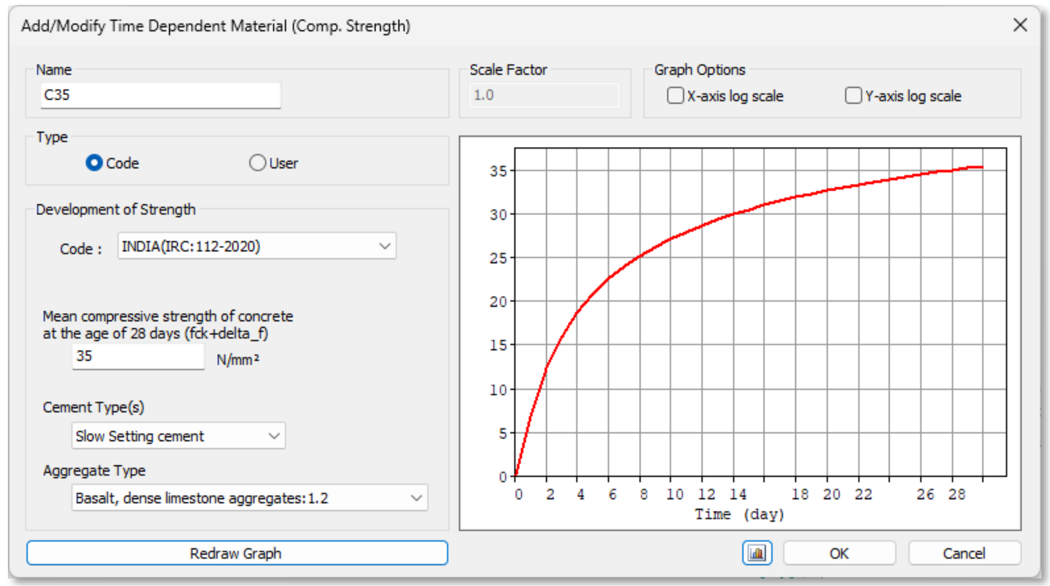
4. Time Dependent Material as per IRC 112: 2020

- The time dependent materials for creep/shrinkage and compressive strength as per IRC 112:2020 can be applied.

- ***Properties > Time Dependent Material > Creep/Shrinkage***
- ***Properties > Time Dependent Material > Compressive Strength***



Time Dependent Material(Creep/Shrinkage)

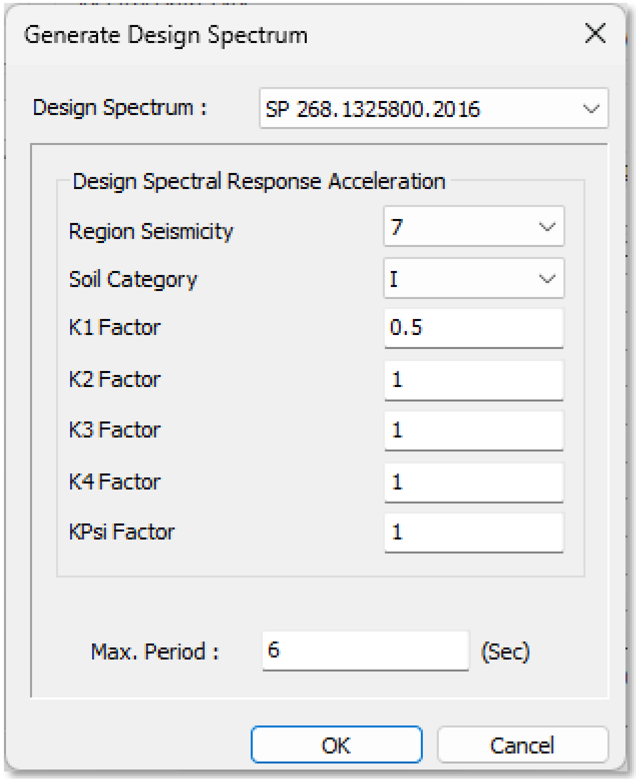


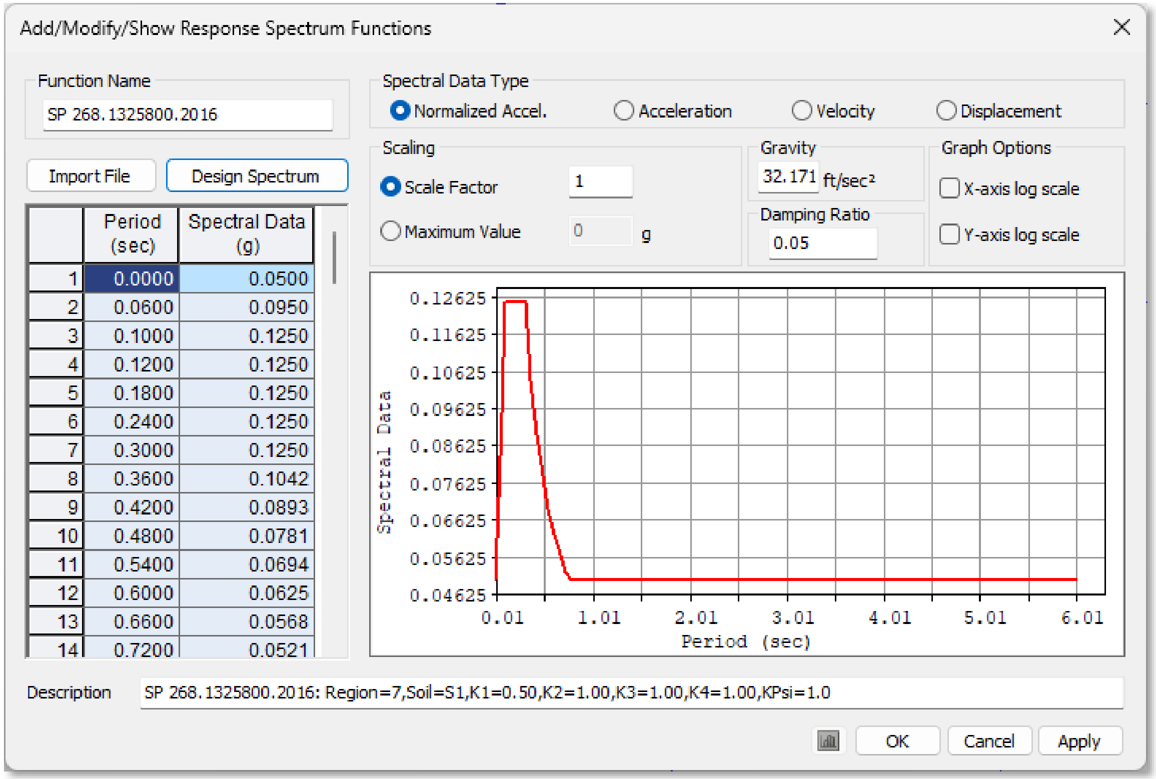
Time Dependent Material(Compressive Strength)

5. Response Spectrum function as per SP 268.1325800.2016

- The Response Spectrum function provides the design spectrum as per SP 268.1325800.2016.

▪ ***Load > Load Type > Dynamic Loads > Response Spectrum Functions***



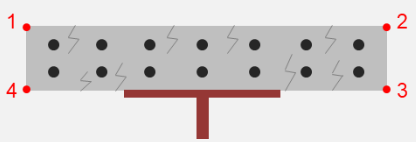
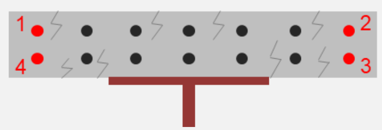


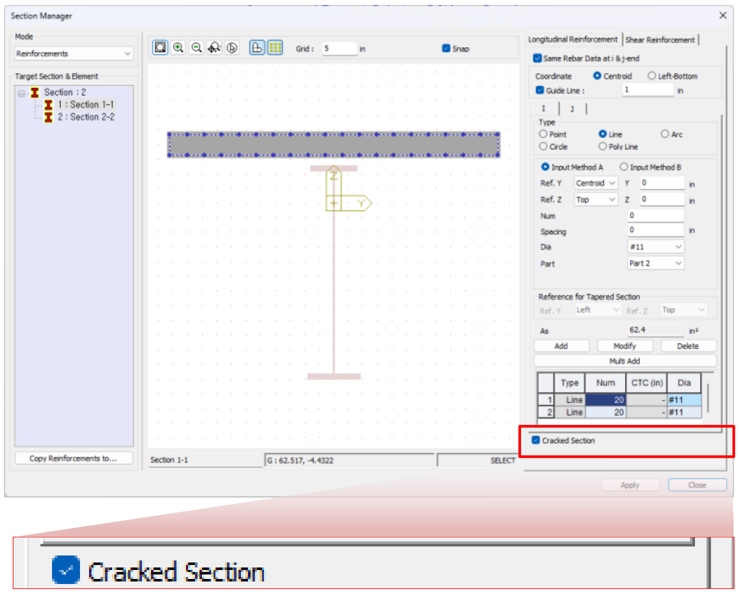
Response Spectrum Functions

6. Stress Calculation for Part2 of Composite Section with Cracked Section option

- The effect of the cracked section option has changed.

- ***Properties > Section Manager > Reinforcements > Cracked Section***
- ***Results > Stresses > Beam Stresses***
- ***Results > Stresses > Beam Stresses Diagram***

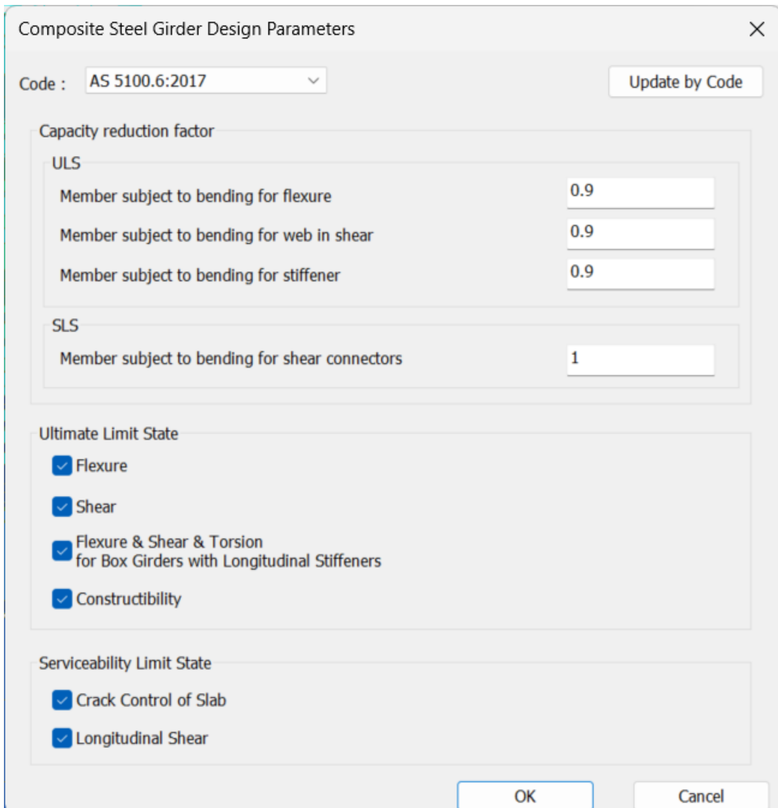
Cracked Section	**Previous versions**	**Civil 2024 (v1.1)**
Stress points of Part 2	The corners of a slab section. 	Rebars placed at corners of a slab. 
Stresses of Part 2	Calculate the stresses in the concrete, and hence zero stress value.	Calculate the stresses in the rebars.



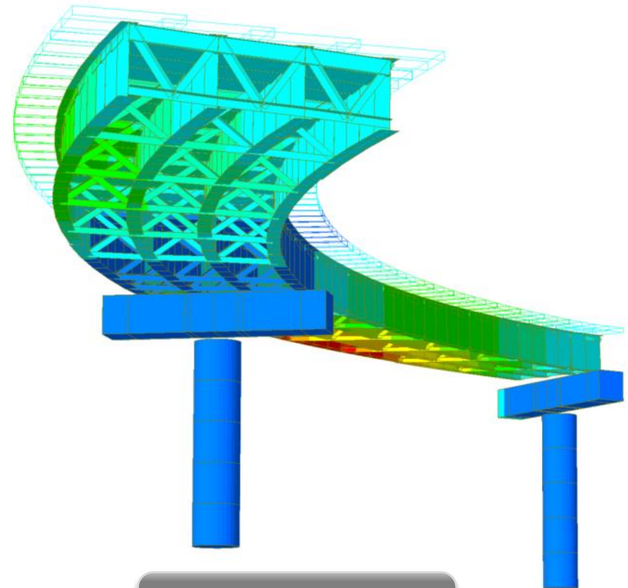
7. Steel Composite Girder Design as per AS 5100.6: 2017

- Steel plate girder and tub/box girder with composite slab can be designed for strength, service, and constructability based on AS 5100.6: 2017.
- The results of the code checks can be viewed graphically, in tables and in a detailed report.

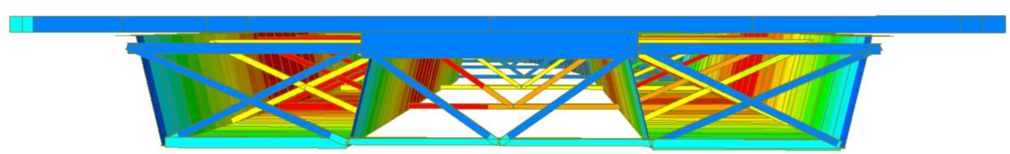
- ***Design > Steel Design > Design Code***



Design Parameter



Composite I-Section Girder

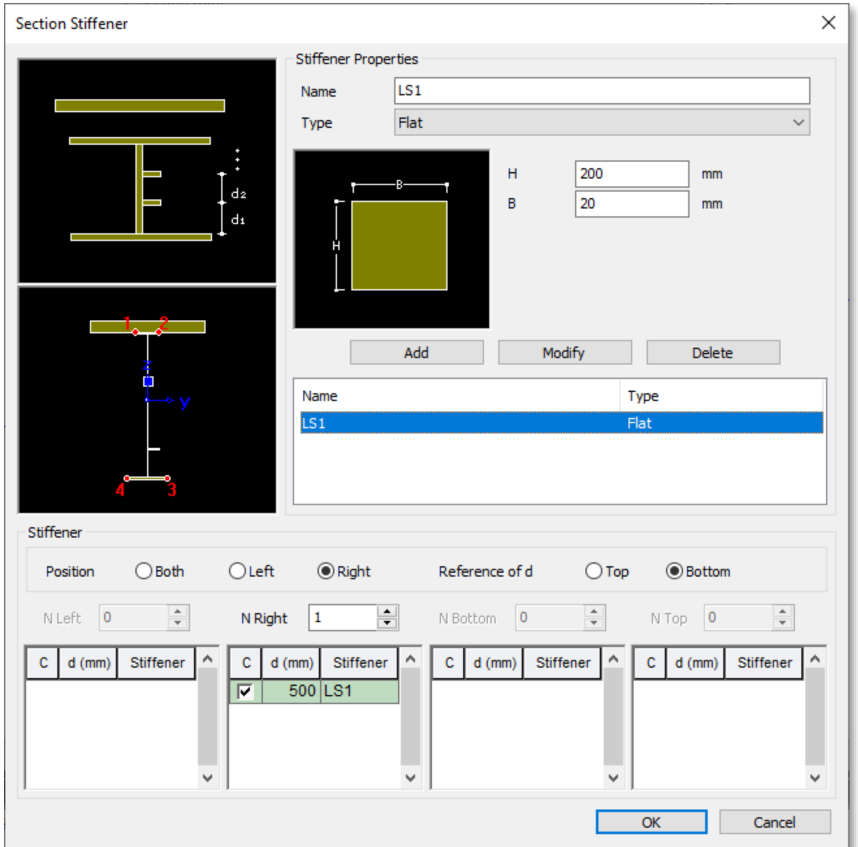


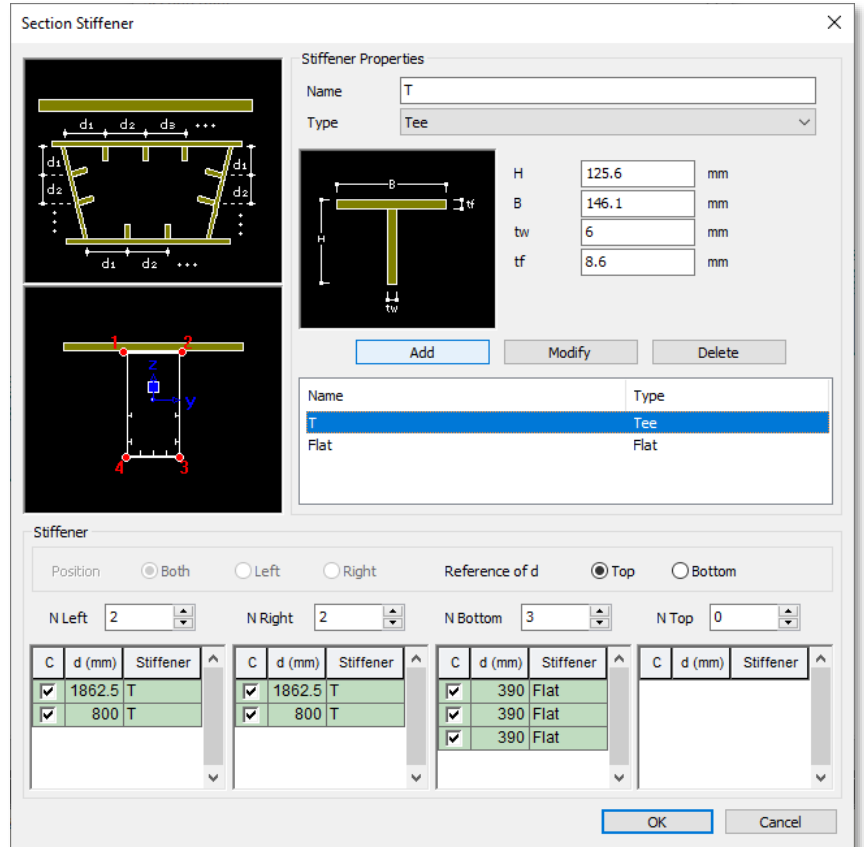
Composite Box Girder

7. Steel Composite Girder Design as per AS 5100.6: 2017

- To enhance local buckling resistance, longitudinal stiffeners can be positioned in both the web and the box flange.

- ***Design > Composite Design > Longitudinal Reinforcement***



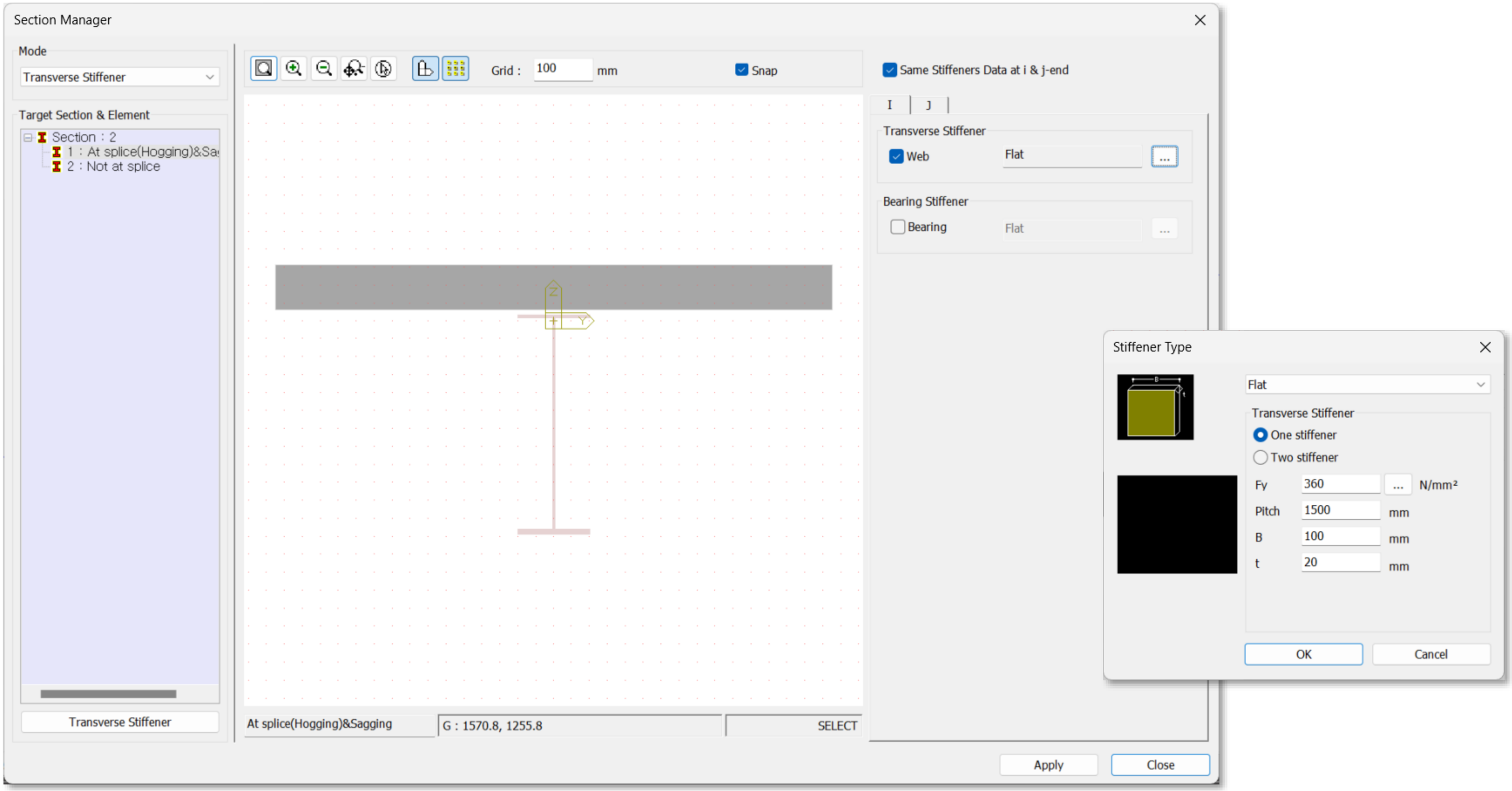


Longitudinal Stiffener

7. Steel Composite Girder Design as per AS 5100.6: 2017

- Transverse intermediate stiffeners can be defined to increase the shear resistance of the web.

▪ ***Design > Composite Design > Transverse Stiffener***

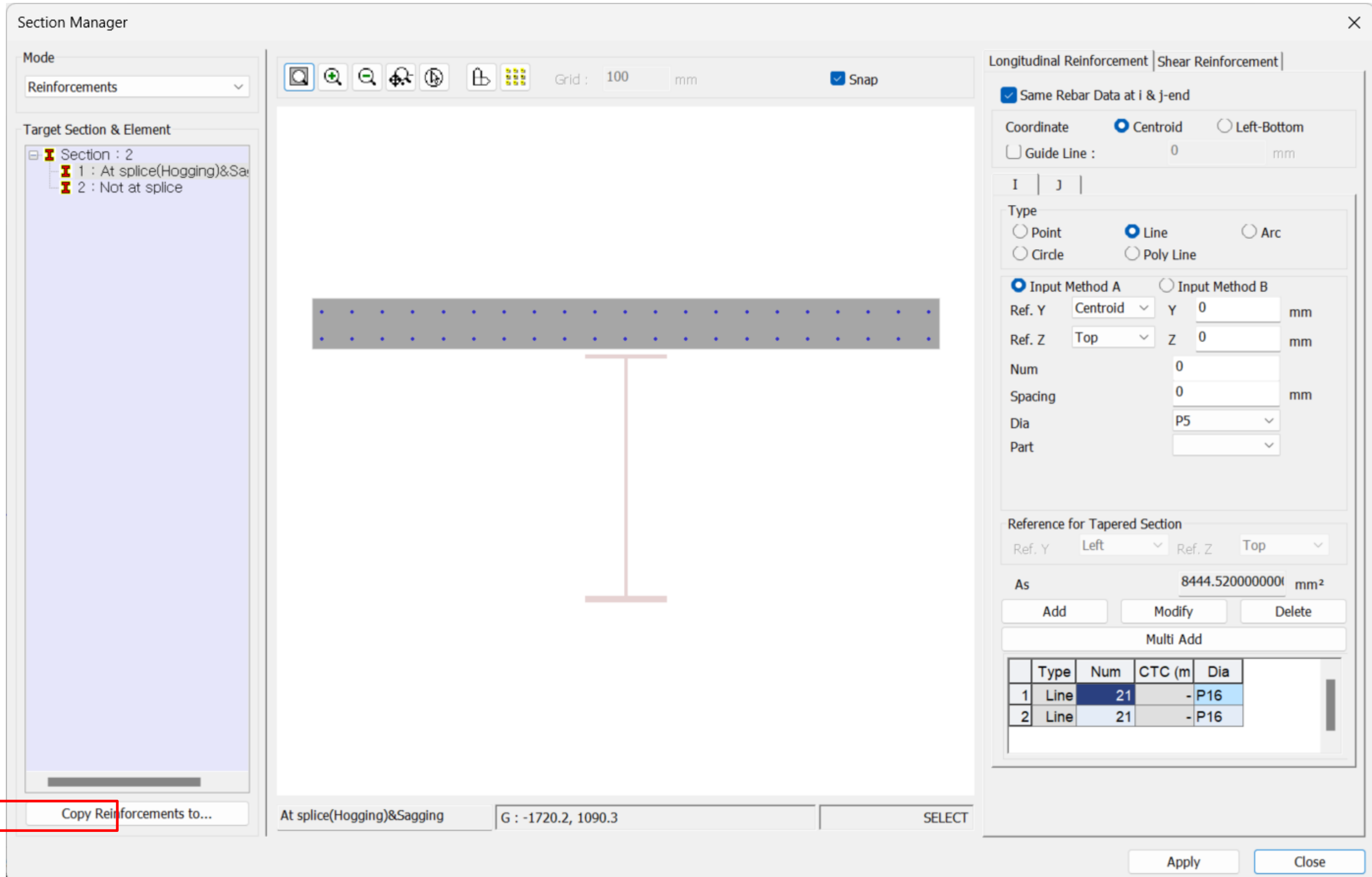


Graphical Report

7. Steel Composite Girder Design as per AS 5100.6: 2017

- Longitudinal reinforcement can be entered into the concrete slab. Cracked section will be applied to calculate stresses for the negative moments.

▪ ***Design > Composite Design > Longitudinal Reinforcement***

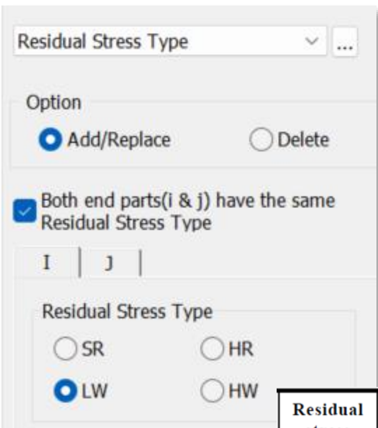


Longitudinal Reinforcement

7. Steel Composite Girder Design as per AS 5100.6: 2017

- Defining the plasticity and yield limits of the flange plates relies on categorizing the residual stress type.
- Headed studs can be checked for the serviceability limit state.

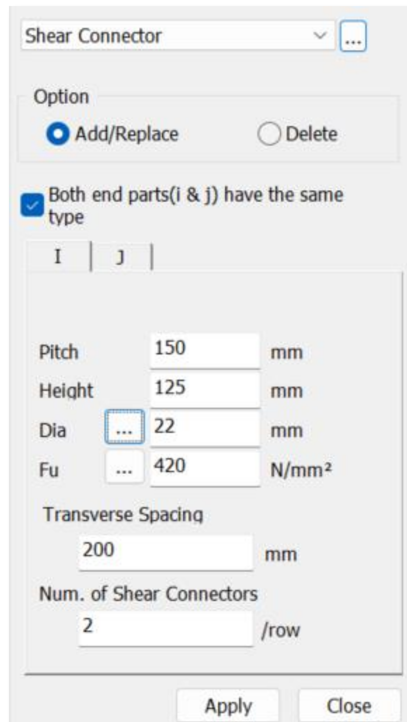
▪ *Design > Composite Design > Residual Stress Type*



Residual stress (see Notes)	Plasticity limit (λ_{ep})	Stress distribution	Yield limit (λ_{ey})	Stress distribution
SR	10	Compression	16	Compression
HR	9		16	
LW, CF	8		15	
HW	8		14	
SR	30	Compression	45	Compression
HR	30		45	
LW, CF	30		40	
HW	30		35	

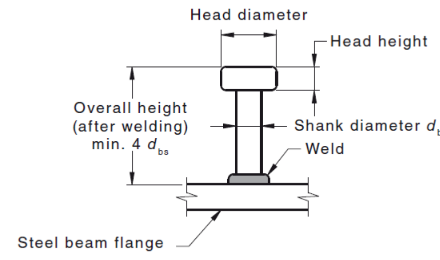
Residual Stress Type

▪ *Design > Composite Design > Shear Connector*



Longitudinal Shear

$$v_L^* = \frac{V^* A_t y_c}{I_t}$$



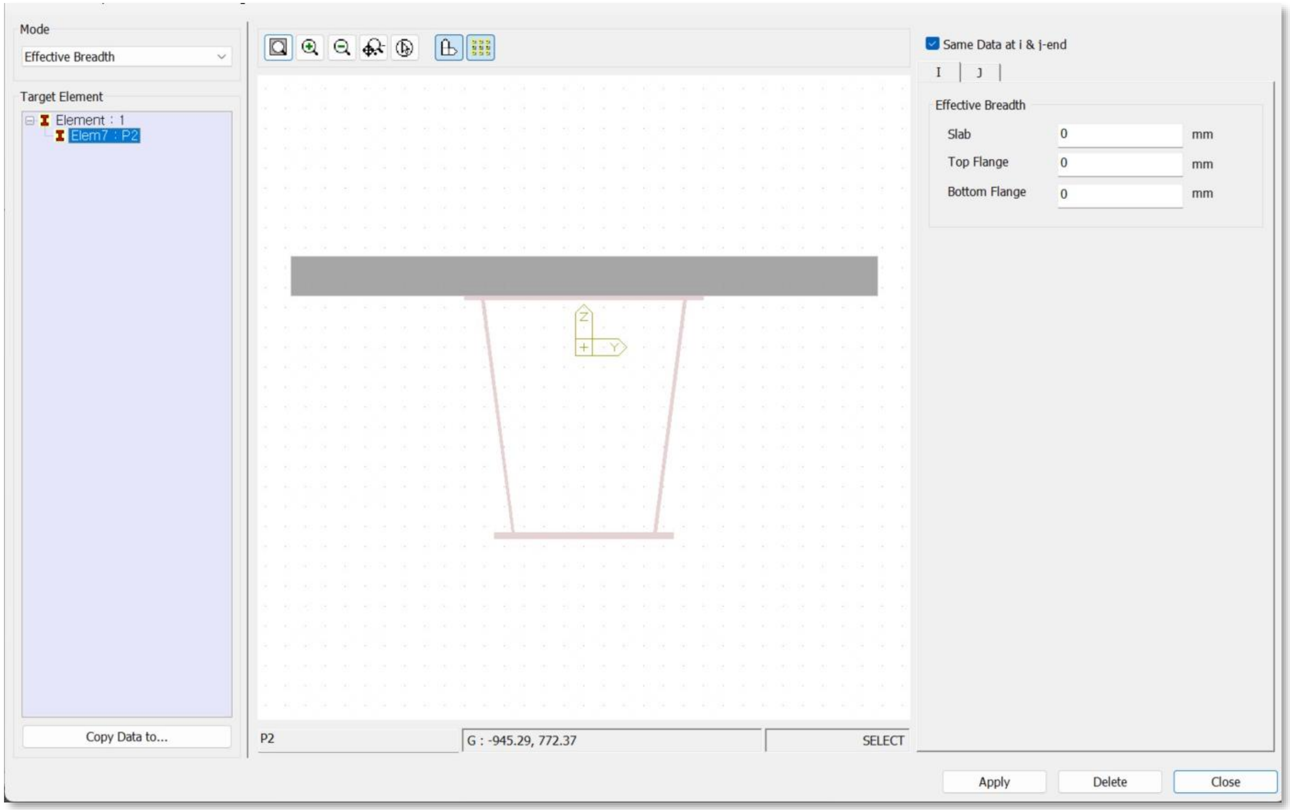
(a) Headed studs

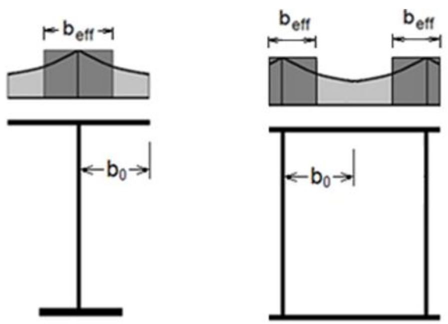
Shear Connector

7. Steel Composite Girder Design as per AS 5100.6: 2017

- The effective width of concrete slab, top flange, or bottom flange can be defined.
- The effective section properties to consider the local buckling of the flange plate are determined by the program.

▪ ***Design > Composite Design > Effective Width by Shear Lag***





Effective Width by Shear Lag

7. Steel Composite Girder Design as per AS 5100.6: 2017

- Design results and detailed calculation procedures are provided in a Word format.

▪ *Design > Composite Design > Print Result*

Longitudinal shearMemb1.doc [Read-Only] [Compatibility Mode] - Word

Navigation

- MEMBER NAME : Steel Com...
  - 1. Member Information
  - 2. Moment Capacity (y-D...
  - 3. Shear Capacity (z-Dir.)
  - 4. Interaction of shear & b...
  - 5. Longitudinal Shear for...
  - 6. Moment Capacity (Ne...
  - 7. Shear Capacity

■ MEMBER NAME : Steel Composite : 83 - i

1. Member Information

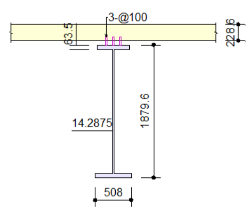
1) Design Code
AS 5100.6:2017

2) Section Property
Section 2-2

3) Material
Steel
f_y = 320.000MPa, E = 200,000.000MPa
Concrete
f_c' = 32.000MPa, E_c = 30,100.000MPa
Reinforcement
f_{sy} = 500.000MPa, E_r = 200,000.000MPa

4) Length
L = 1.441m

5) Section Properties



	Steel Section	Short-Term Composite Section	Long Term Composite Section
Area	86,330.473mm²	185,951.564mm²	114,055.580mm²
I_y	5.686783e+10mm⁴	1.186307e+11mm⁴	8.481588e+10mm⁴
I_z	1.199866e+9mm⁴	7.080595e+10mm⁴	2.057163e+10mm⁴
C_y	254.000mm	254.000mm	254.000mm
C_z	905.870mm	1,522.787mm	1,185.789mm

	Short-Term Composite Section(Reinforcement)	Long Term Composite Section(Reinforcement)
Area	96,014.324mm²	89,558.423mm²
I_y	6.848039e+10mm⁴	6.101762e+10mm⁴
I_z	7.947699e+9mm⁴	3.449057e+9mm⁴
C_y	254.000mm	254.000mm
C_z	1,022.345mm	947.494mm

Page 1 of 4 1051 words English (United States) 130%

Tub-Section not compactMemb1.doc [Read-Only] [Compatibility Mode] - Word

Navigator

- MEMBER NAME : Ste...
  - 1. Member Inform...
  - 2. Moment Capaci...
  - 3. Shear Capacity (...
  - 4. Interaction of sh...
  - 5. Strength of stiff...
  - 6. Strength of stiff...
  - 7. Strength of long...

■ MEMBER NAME : Steel Composite : 1 - i

1. Member Information

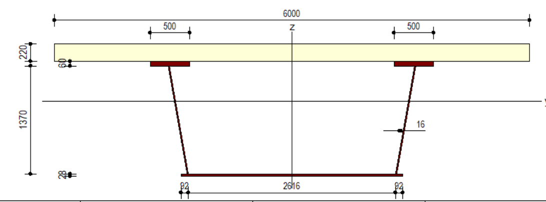
1) Design Code
AS 5100.6:2017

2) Section Property
G1-3

3) Material
Steel
f_y = 360.000MPa, E = 200,000.000MPa
Concrete
f_c' = 32.000MPa, E_c = 30,100.000MPa
Reinforcement
f_{sy} = 500.000MPa, E_r = 200,000.000MPa

4) Length
L = 1.000m

5) Section Properties



	Steel Section	Short-Term Composite Section	Long Term Composite Section
Area	188,163.617mm²	386,823.617mm²	236,046.609mm²
I_y	7.623030e+10mm⁴	1.610550e+11mm⁴	1.096118e+11mm⁴
I_z	2.857647e+11mm⁴	8.817447e+11mm⁴	4.294137e+11mm⁴
C_y	1,790.000mm	1,790.000mm	1,790.000mm
C_z	635.533mm	1,114.418mm	824.688mm

	Short-Term Composite Section(Reinforcement)	Long Term Composite Section(Reinforcement)
Area	200,227.217mm²	192,184.817mm²
I_y	8.611792e+10mm⁴	7.966363e+10mm⁴
I_z	3.219155e+11mm⁴	2.978149e+11mm⁴
C_y	1,790.000mm	1,790.000mm
C_z	691.714mm	655.043mm

2. Moment Capacity (y-Dir., Negative)

Neg. Moment LCB LCB

Page 1 of 3 790 words English (United States) 120%

Design Report

7. Steel Composite Girder Design as per AS 5100.6: 2017

- For all design checks, demand and capacity are represented in a table format.

■ ***Design > Composite Design > Design Result Tables***

Elem	part	Positive/ Negative	Lcom	Type	CHK	M_demand (N·mm)	ΦMb (N·mm)	fs (N/mm²)	Φfy (N/mm²)
35	I[50]	Pos	scLCB1	FX-MAX	OK	785552117.	3019476	-	-
35	J[287]	Neg	-	-	-	-			
35	J[287]	Pos	scLCB1	MY-MIN	OK	-450953350			
36	I[51]	Neg	scLCB1	MY-MIN	OK	-176618382			
36	I[51]	Pos	-	-	-	-			
36	J[288]	Neg	scLCB1	MY-MIN	OK	-325816309			
36	J[288]	Pos	-	-	-	-			
37	I[52]	Neg	scLCB1	MY-MIN	OK	-489278107			
37	I[52]	Pos	-	-	-	-			
37	J[289]	Neg	scLCB1	MY-MIN	OK	-660255514			
37	J[289]	Pos	-	-	-	-			
38	I[53]	Neg	scLCB1	MY-MIN	OK	-840656031			
38	I[53]	Pos	-	-	-	-			
38	J[290]	Neg	scLCB1	MY-MIN	OK	-107131001			
38	J[290]	Pos	-	-	-	-			
39	I[54]	Neg	scLCB1	MY-MIN	OK	-132240146			
39	I[54]	Pos	-	-	-	-			
39	J[291]	Neg	scLCB1	MY-MIN	OK	-159944309			
39	J[291]	Pos	-	-	-	-			
83	I[10]	Neg	scLCB1	MY-MIN	NG	-225504069			
83	I[10]	Pos	-	-	-	-			
83	J[332]	Neg	scLCB1	MY-MIN	NG	-190746000			
83	J[332]	Pos	-	-	-	-			
84	I[95]	Neg	scLCB1	MY-MIN	OK	-158914050			
84	I[95]	Pos	-	-	-	-			
84	J[333]	Neg	scLCB1	MY-MIN	OK	-129141403			
84	J[333]	Pos	-	-	-	-			
85	I[96]	Neg	scLCB1	MY-MIN	OK	-101631624			
85	I[96]	Pos	-	-	-	-			
85	J[334]	Neg	scLCB1	MY-MIN	OK	-765269486			
85	J[334]	Pos	-	-	-	-			
86	I[97]	Neg	scLCB1	MY-MIN	OK	-538011914			
86	I[97]	Pos	-	-	-	-			
86	J[335]	Neg	scLCB1	MY-MIN	OK	-324642625			

Moment capacity

Elem	part	Lcom	Type	CHK	V*/web (kN)	V* (kN)	ΦVv (kN)
27	I[6]	scLCB1	FZ-MIN	OK	-1373.7	-1373.7	4085.3
27	J[279]	scLCB1	FZ-MIN	OK	-1293.6	-1293.6	4085.3
28	I[43]	scLCB1	FZ-MIN	OK	-1098.1	-1098.1	4085.3
28	J[280]	scLCB1	FZ-MIN	OK	-1018.1	-1018.1	4085.3
29	I[44]	scLCB1	FZ-MIN	OK	-800.2	-800.2	4085.3
29	J[281]	scLCB1	FZ-MIN	OK	-720.2	-720.2	4085.3
30	I[45]	scLCB1	FZ-MIN	OK	-567.0	-567.0	4085.3
30	J[282]	scLCB1	FZ-MIN	OK	-487.0	-487.0	4085.3
31	I[46]	scLCB1	FZ-MIN	OK	-282.7	-282.7	3287.7
31	J[283]	scLCB1	FZ-MA	OK	245.8	245.8	3287.7
32	I[47]	scLCB1	FZ-MA	OK	339.1	339.1	3287.7
32	J[284]	scLCB1	FZ-MA	OK	416.7	416.7	3287.7
33	I[48]	scLCB1	FZ-MA	OK	656.3	656.3	3287.7
33	J[285]	scLCB1	FZ-MA	OK	733.9	733.9	3287.7
34	I[49]	scLCB1	FZ-MA	OK	863.2	863.2	3287.7
34	J[286]	scLCB1	FZ-MA	OK	940.8	940.8	3287.7
35	I[50]	scLCB1	FZ-MA	OK	1077.0	1077.0	3287.7
35	J[287]	scLCB1	FZ-MA	OK	1154.6	1154.6	3287.7
36	I[51]	scLCB1	FZ-MA	OK	1325.0	1325.0	4085.3
36	J[288]	scLCB1	FZ-MA	OK	1405.1	1405.1	4085.3
37	I[52]	scLCB1	FZ-MA	OK	1440.3	1440.3	4085.3
37	J[289]	scLCB1	FZ-MA	OK	1520.4	1520.4	4085.3
38	I[53]	scLCB1	FZ-MA	OK	1758.0	1758.0	4085.3
38	J[290]	scLCB1	FZ-MA	OK	1838.1	1838.1	4085.3
39	I[54]	scLCB1	FZ-MA	OK	2020.8	2020.8	4085.3
39	J[291]	scLCB1	FZ-MA	OK	2100.9	2100.9	4085.3
83	I[10]	scLCB1	FZ-MIN	OK	-2619.4	-2619.4	4085.3
83	J[332]	scLCB1	FZ-MIN	OK	-2539.1	-2539.1	4085.3
84	I[95]	scLCB1	FZ-MIN	OK	-2300.2	-2300.2	4085.3
84	J[333]	scLCB1	FZ-MIN	OK	-2219.9	-2219.9	4085.3
85	I[96]	scLCB1	FZ-MIN	OK	-1937.2	-1937.2	4085.3
85	J[334]	scLCB1	FZ-MIN	OK	-1857.0	-1857.0	4085.3
86	I[97]	scLCB1	FZ-MIN	OK	-1832.2	-1832.2	4085.3
86	J[335]	scLCB1	FZ-MIN	OK	-1751.9	-1751.9	4085.3
87	I[98]	scLCB1	FZ-MIN	OK	-1559.5	-1559.5	3287.7

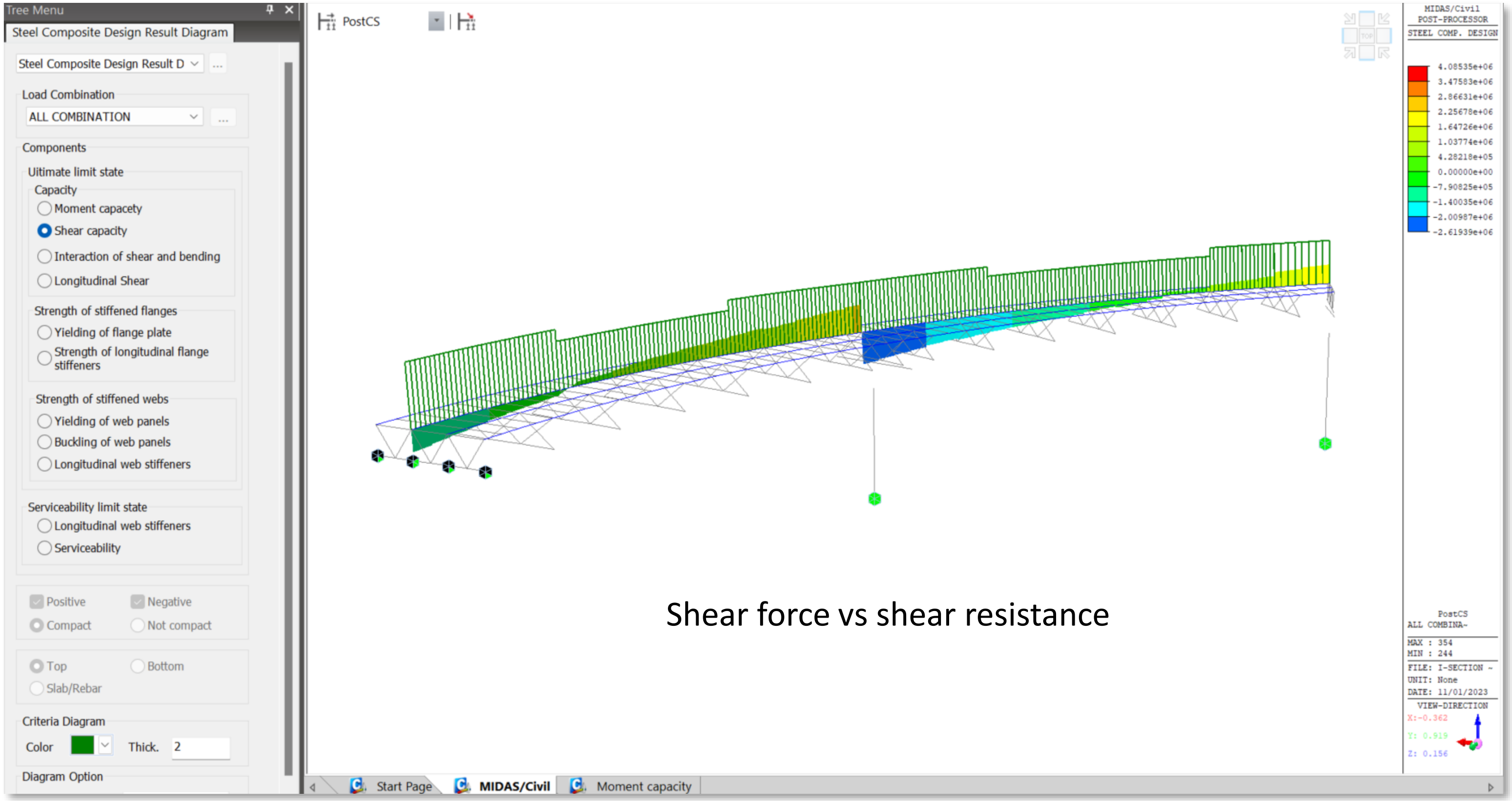
Shear capacity

Design Result Tables

7. Steel Composite Girder Design as per AS 5100.6: 2017

- For all design checks, demand and capacity can be represented in a diagram format.

- ***Design > Composite Design > Steel Composite Design Result Diagram***



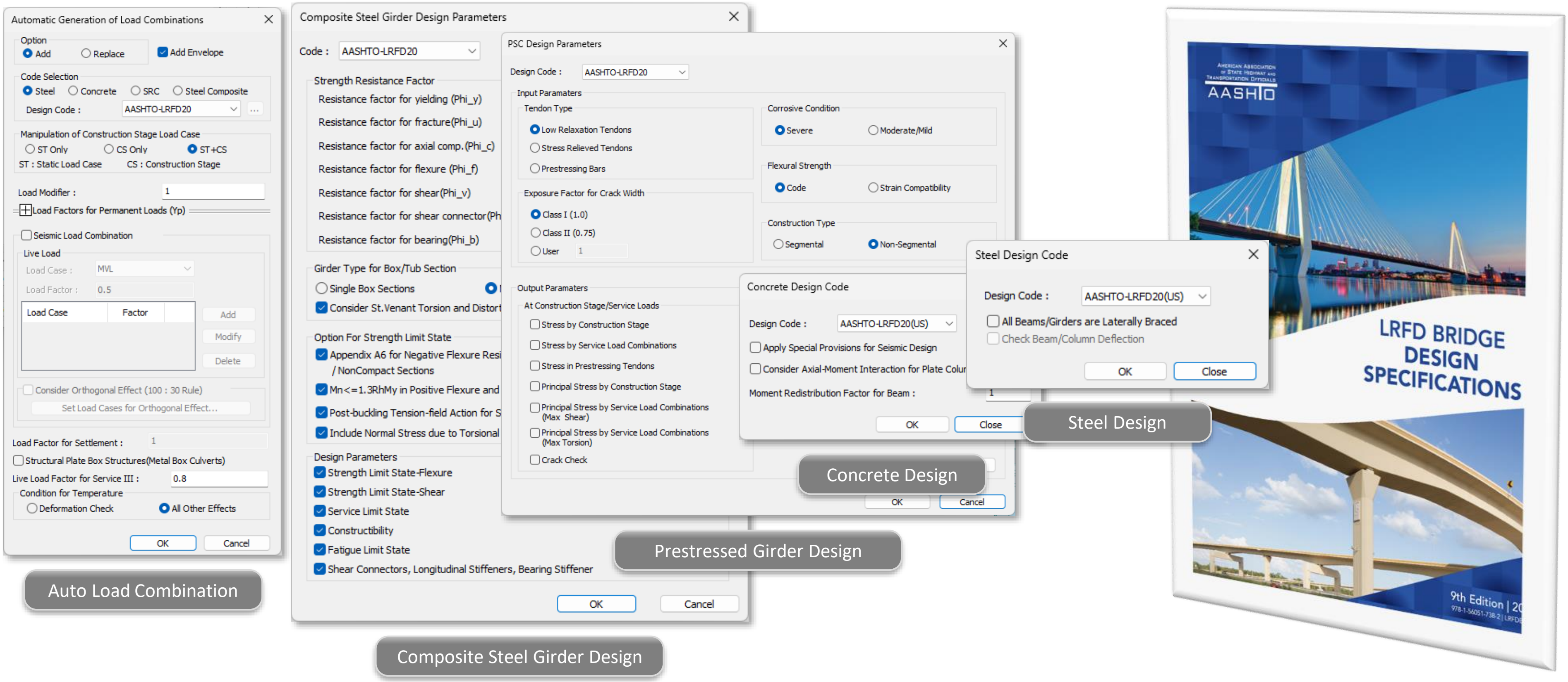
Shear force vs shear resistance

Design Result Diagram

8. RC, Steel, Steel Composite, and PSC Design as per AASHTO LRFD 2020

- RC, Steel, Steel Composite, and PSC Design function as per AASHTO LRFD 2020 has been updated.
- The design report provides SI and US unit options.
- The design report of RC is now generated in Word format, which is faster than text format and enables the user to change the report style with ease.

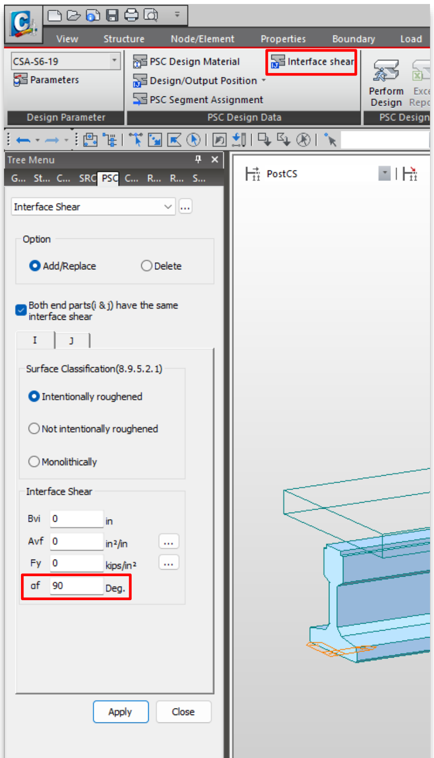
- ***Design > RC, Steel, and Composite Design***
- ***PSC > PSC Design***



9. PSC Design as per CSA S6:19

- The reinforcement angle α_f is considered in the Interface Shear Transfer function as per 8.9.5.1 and 8.9.5.4, CSA S6:19.

▪ *PSC > Design Parameter > CSA-S6-19*



Interface Shear

CSA S6:14

8.9.5 Interface shear transfer

8.9.5.1 General

A crack shall be assumed to occur along the shear plane and the relative displacement shall be considered to be resisted by cohesion and friction maintained by the shear-friction reinforcement crossing the crack. In lieu of more detailed calculations, the shear resistance of the plane, v_r may be calculated as $\phi_c(c+\mu\sigma)$, but v shall not exceed $0.25\phi_c f'_c$ or 6.5 MPa. c and μ shall be as specified in Clause 8.9.5.2 and σ shall be as specified in Clause 8.9.5.3.

8.9.5.3 Value of σ

The value of σ in Clause 8.9.5.1 shall be calculated as follows:

$$\sigma = \rho_v f_y + \frac{N}{A_{cv}}$$

where

$$\rho_v = \frac{A_{vf}}{A_{cv}}$$

9) Interface Shear

- Factored interface shear stress (V_{fi})
  - V_{fi} = $V_f / (b_{vi} \cdot d_{vi})$ = 3.323 (MPa)
  - where, V_f = 2039.154 (kN)
  - b_{vi} = 300.00 (mm)
  - d_{vi} = 2045.59 (mm)
- Interface shear resistance without shear-friction reinforcement ($v_{ri\_concrete}$)
  - V_{ri1} = $\Phi_c (c + \mu \cdot N/A_{cv})$ = 0.375 (MPa)
  - Interface shear resistance shall not exeed 0.25 $\Phi_c f'_c$ or 6.5Mpa.
  - V_{ri2} = $0.25\,\Phi_c f'_c$ = 3.878 (MPa)
  - V_{ri3} = 6.500 (MPa)
  - Therefore, $v_{ri\_concrete}$ = 0.375 (MPa)
  - $v_{ri\_concrete}$ = 0.375 (MPa) < v_{fi} = 3.323 (MPa) **NG**
  - ∴ Shear-frction reinforcement is required.
- Interface shear resistance with shear-friction reinforcement ($v_{ri\_reinforcement}$)
  - v_{ri1} = $\Phi_c (c + \mu(\rho_v \cdot f_y + N/A_{cv}))$ = 7.65 (MPa)
  - Interface shear resistance shall not exeed 0.25 $\Phi_c f'_c$ or 6.5Mpa.
  - v_{ri2} = $0.25\,\Phi_c f'_c$ = 3.878 (MPa)
  - v_{ri3} = 6.500 (MPa)
  - Therefore, $v_{ri\_reinforcement}$ = 3.878 (MPa)
  - $v_{ri\_reinforcement}$ = 3.878 (MPa) ≥ v_{fi} = 3.323 (MPa) **OK**

CSA S6:19

8.9.5 Interface shear transfer

8.9.5.1 General

A crack shall be assumed to occur along the shear plane and the relative displacement shall be considered to be resisted by cohesion and friction maintained by the shear-friction reinforcement crossing the crack. In lieu of more detailed calculations, the factored shear resistance of the plane shall be computed from

$$v_r = \lambda_1 \phi_c (c + \mu\sigma) + \phi_s \rho_v f_y \cos\alpha_f$$

where the expression $\lambda_1 \phi_c (c + \mu\sigma)$ shall not exceed $0.25\phi_c f'_c$ or 6.5 MPa.

8.9.5.4 Values of σ and ρ_v

The value of σ in Clause 8.9.5.1 shall be calculated as follows:

$$\sigma = \rho_v f_y \sin\alpha_f + \frac{N}{A_{cv}}$$

where

$$\rho_v = \frac{A_{vf}}{A_{cv}}$$

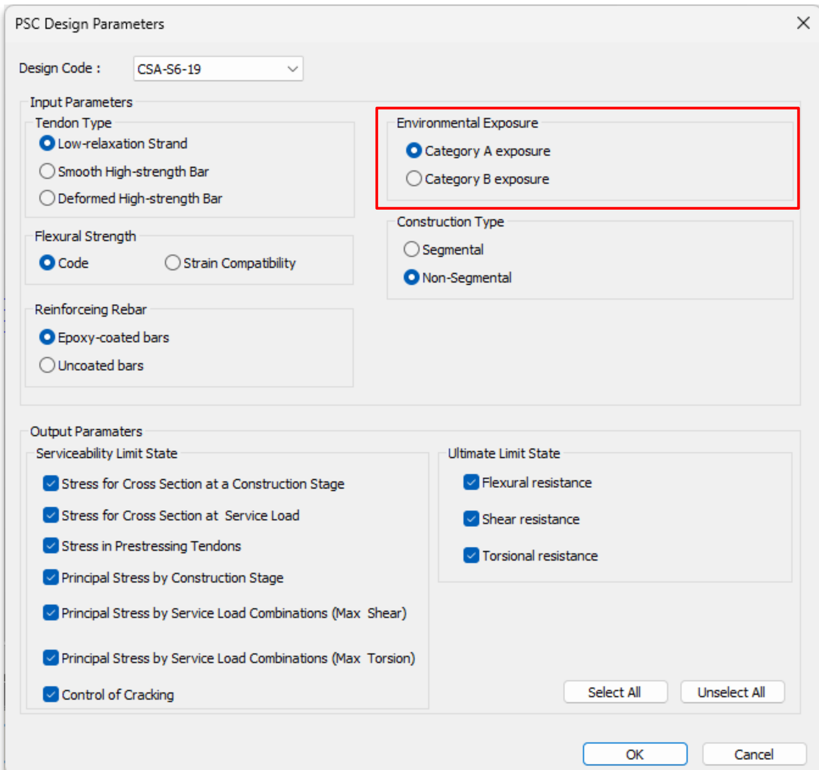
9) Interface Shear

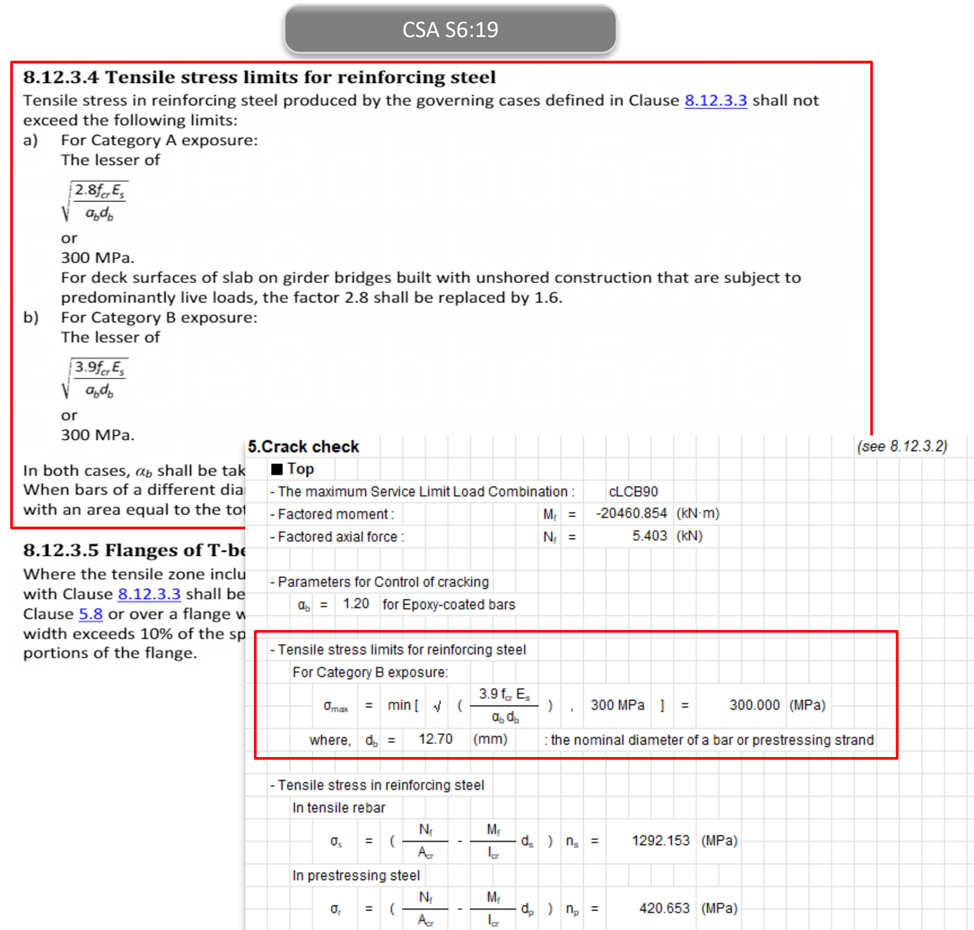
- Factored interface shear stress (v_{fi})
  - v_{fi} = $V_f / (b_{vi} \cdot d_{vi})$ = 3.323 (MPa)
  - where, b_{vi} = 300.000 (mm)
  - d_{vi} = 2045.592 (mm)
- Factored interface shear resistance without shear-friction reinforcement ($v_{ri,concrete}$)
  - v_{ri1} = $\lambda_1 \Phi_c (c + \mu \cdot N/A_{cv})$ = 0.375 (MPa)
  - Interface shear resistance shall not exeed 0.25 $\Phi_c f'_c$ or 6.5Mpa.
  - v_{ri2} = $0.25\,\Phi_c f'_c$ = 3.878 (MPa)
  - v_{ri3} = 6.500 (MPa)
  - Therefore, $v_{ri,concrete}$ = 0.375 (MPa)
  - $v_{ri,concrete}$ = 0.375 (MPa) < v_{fi} = 3.323 (MPa) **NG**
  - ∴ Shear-friction reinforcement is required.
- Factored interface shear resistance of the plane (v_{ri})
  - v_{ri1} = $\lambda_1 \Phi_c (c + \mu\sigma) + \Phi_s \rho_v f_y \cos\alpha_f$ = 7.653 (MPa)
  - $\lambda_1 \Phi_c (c + \mu\sigma)$ shall not exeed 0.25 $\Phi_c f'_c$ or 6.5Mpa.
  - v_{ri2} = $0.25\,\Phi_c f'_c + \Phi_s \rho_v f_y \cos\alpha_f$ = 3.878 (MPa)
  - v_{ri3} = $6.5 + \Phi_s \rho_v f_y \cos\alpha_f$ = 6.500 (MPa)
  - Therefore, v_{ri} = 3.878 (MPa)
  - v_{ri} = 3.878 (MPa) ≥ v_{fi} = 3.323 (MPa) **OK**

9. PSC Design as per CSA S6:19

- The Environmental Exposure option in PSC Design Parameters function has changed as per 8.12.3.4, CSA S6:19.
- The tensile stress of reinforcing steel is now checked along the environmental exposure class.

- ***PSC > Design Parameter > CSA-S6-19***




CSA S6:19

8.12.3.4 Tensile stress limits for reinforcing steel

Tensile stress in reinforcing steel produced by the governing cases defined in Clause 8.12.3.3 shall not exceed the following limits:

a) For Category A exposure:
The lesser of

$$\sqrt{\frac{2.8 f_{cr} E_s}{\alpha_b d_b}}$$

or
300 MPa.
For deck surfaces of slab on girder bridges built with unshored construction that are subject to predominantly live loads, the factor 2.8 shall be replaced by 1.6.

b) For Category B exposure:
The lesser of

$$\sqrt{\frac{3.9 f_{cr} E_s}{\alpha_b d_b}}$$

or
300 MPa.

In both cases, α_b shall be tak
When bars of a different dia
with an area equal to the tot

8.12.3.5 Flanges of T-be

Where the tensile zone inclu
with Clause 8.12.3.3 shall be
Clause 5.8 or over a flange w
width exceeds 10% of the sp
portions of the flange.

5.Crack check (see 8.12.3.2)

■ Top

- The maximum Service Limit Load Combination : cLCB90
- Factored moment : M_f = -20460.854 (kN·m)
- Factored axial force : N_f = 5.403 (kN)
- Parameters for Control of cracking
  α_b = 1.20 for Epoxy-coated bars
- Tensile stress limits for reinforcing steel
  For Category B exposure:
  σ_{max} = min [$\sqrt{\left(\frac{3.9 f_{cr} E_s}{\alpha_b d_b}\right)}$, 300 MPa] = 300.000 (MPa)
  where, d_b = 12.70 (mm) : the nominal diameter of a bar or prestressing strand
- Tensile stress in reinforcing steel
  In tensile rebar
  $\sigma_s = \left(\frac{N_f}{A_{cr}} - \frac{M_f}{I_{cr}} d_s\right) n_s$ = 1292.153 (MPa)
  In prestressing steel
  $\sigma_r = \left(\frac{N_f}{A_{cr}} - \frac{M_f}{I_{cr}} d_p\right) n_p$ = 420.653 (MPa)

9. PSC Design as per CSA S6:19

- The coefficient of allowable stress based on the tendon types has changed.

- ***PSC > Design Parameter > CSA-S6-19***

CSA S6:14

Table 8.2
Prestressing tendon stress limits
(See Clause 8.7.1.)

	Tendon type		
		High-strength bar	
	Low-relaxation strand	Smooth	Deformed
At jacking			
Pretensioning	$0.78f_{pu}$	—	—
Post-tensioning	$0.80f_{pu}$	$0.76f_{pu}$	$0.75f_{pu}$
At transfer			
Pretensioning	$0.74f_{pu}$	—	—
Post-tensioning			
At anchorage and couplers	$0.70f_{pu}$	$0.70f_{pu}$	$0.66f_{pu}$
Elsewhere	$0.74f_{pu}$	$0.70f_{pu}$	$0.66f_{pu}$

CSA S6:19

Table 8.2
Prestressing tendon stress limits
(See Clause 8.7.1.)

	Tendon type		
	Low-relaxation strand	High-strength bar	
		Smooth	Deformed
Pretensioning			
Immediately prior to transfer	$0.75f_{pu}$	—	—
Post-tensioning			
At jacking	$0.80f_{pu}$	$0.76f_{pu}$	$0.75f_{pu}$
Immediately after transfer			
At anchorage and couplers	$0.70f_{pu}$	$0.70f_{pu}$	$0.66f_{pu}$
Elsewhere	$0.74f_{pu}$	$0.70f_{pu}$	$0.66f_{pu}$

9. PSC Design as per CSA S6:19

- The formula for the review of shear resistance by transverse reinforcement has changed as per 8.9.1.2, CSA S6:19.

▪ ***PSC > Design Parameter > CSA-S6-19***

CSA S6:14

8.9.1.2 Regions requiring transverse reinforcement

Except for solid slabs, walls, and footings, transverse reinforcement shall be provided in all regions where V_f is greater than $(0.20\phi_c f_{cr} b_v d_v + 0.5\phi_p V_p)$ and T_f is greater than $0.25T_{cr}$.

6) Factored shear resistance by transverse reinforcement (V_s).

- Judgement (see 8.9.1.2)

$0.2\Phi_c f_{cr} b_v d_v + 0.5\Phi_p V_p$	=	2493.152 (kN)	$<$	V_f	=	5522.327 (kN)
				∴ Need shear reinforcing		

- shear resistance by transverse reinforcement (V_s). (see 8.9.3.5)

$$V_s = \frac{\Phi_s \cdot A_v \cdot f_y \cdot d_v(\cot\theta + \cot\alpha)\sin\alpha}{s} = 20425.169 \text{ (kN)}$$

where, s = 150.000 (mm)

α = 90.000 (deg.)

- Maximum spacing of reinforcement for shear. (see 8.14.6)

$0.1\Phi_c f'_c b_v d_v + V_p$	=	9703.873 (kN)	$>$	V_f	=	5522.327 (kN)
s_{max} =	Min[$0.75d_v$, 600(mm)]	=	600.000 (mm)			
∴ s	=	150.000 (mm)	$\leq$	s_{max}		**OK**

CSA S6:19

8.9.1.2 Regions requiring transverse reinforcement

Except for footings and walls, transverse reinforcement shall be provided in regions where T_f is greater than $0.25T_{cr}$ and in regions where V_f is greater than $k_v V_c + V_p$. The value of k_v shall be taken as 1.0 for d less than or equal to 300 mm, as 0.5 for d greater than or equal to 600 mm, and as $-0.00167d + 1.5$ for values of d between 300 mm and 600 mm. Quantity d shall be as defined in Clause 8.9.1.5.

6) Factored shear resistance by transverse reinforcement (V_s).

- Judgement (see 8.9.1.2)

$k_v V_c + V_p$	=	4091.979 (kN)	$\geq$	V_f	=	3009.777 (kN)
where, k_v	=	0.500	: effective depth , $d \geq 600$mm			
				∴ No-need shear reinforcing		

- shear resistance by transverse reinforcement (V_s). (see 8.9.3.5)

$$V_s = \frac{\Phi_s \cdot A_v \cdot f_y \cdot d_v(\cot\theta + \cot\alpha)\sin\alpha}{s} = 9872.751 \text{ (kN)}$$

where, s = 150.000 (mm)

α = 90.000 (deg.)

9. PSC Design as per CSA S6:19

- The formula for the angle of inclination(θ) has changed as per 8.9.3.7, CSA S6:19

▪ ***PSC > Design Parameter > CSA-S6-19***

CSA S6:14

8.9.3.7 Determination of β and θ (general method)

The value of β shall be calculated as follows:

$$\beta = \left[\frac{0.4}{(1+1500\varepsilon_x)}\right]\left[\frac{1300}{(1000+s_{ze})}\right]$$

For sections containing at least the minimum transverse reinforcement required by Clause 8.9.1.3, s_{ze} shall be taken as 300 mm; otherwise, s_{ze} shall be calculated in accordance with Clause 8.9.3.6. The value of a_g in Clause 8.9.3.6 shall be taken as zero if f'_c is greater than 70 MPa and shall be linearly equal to zero as f'_c goes from 60 to 70 MPa. The angle of inclination, θ, shall be calculated as $(29 + 7000\varepsilon_x)(0.88 + s_{ze}/2500)$.

4) Values of β and θ

- Parameter that account for influence of aggregate size (see 8.9.3.7)

S_{ze} = 300.000 (mm) ∵ $A_v \geq A_{v,min}$

- Values of β and θ

$\beta = \left[\frac{0.4}{(1 + 1500\,\varepsilon_x)}\right] \cdot \left[\frac{1300}{(1000 + S_{ze})}\right]$ = 0.400

$\theta = (29 + 7000\,\varepsilon_x) \cdot (0.88 + S_{ze} / 2500)$ = 29.000 (deg.)

CSA S6:19

8.9.3.7 Determination of β and θ (general method)

The value of β shall be calculated as follows:

$$\beta = \left[\frac{0.4}{(1+1500\varepsilon_x)}\right]\left[\frac{1300}{(1000+s_{ze})}\right]$$

For sections containing at least the minimum transverse reinforcement required by Clause 8.9.1.3, s_{ze} shall be taken as 300 mm; otherwise, s_{ze} shall be calculated in accordance with Clause 8.9.3.6. The value of a_g in Clause 8.9.3.6 shall be taken as zero if f'_c is greater than 70 MPa and shall be linearly reduced to zero as f'_c goes from 60 to 70 MPa. The angle of inclination, θ, shall be calculated as $(29 + 7000\varepsilon_x)$.

4) Values of β and θ

- Parameter that account for influence of aggregate size (see 8.9.3.7)

S_{ze} = 300.000 (mm) ∵ $A_v \geq A_{v,min}$

- Values of β and θ

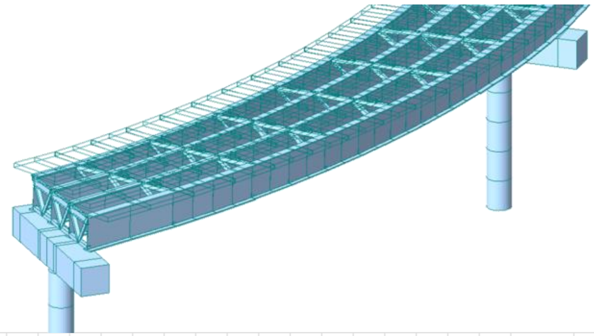
$\beta = \left[\frac{0.4}{(1 + 1500\,\varepsilon_x)}\right] \cdot \left[\frac{1300}{(1000 + S_{ze})}\right]$ = 0.076

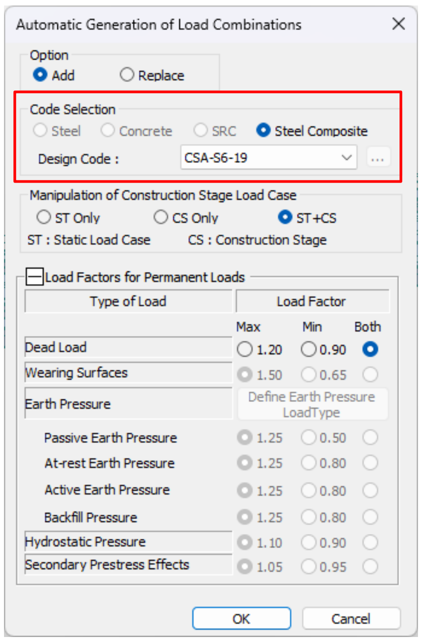
$\theta = (29 + 7000\,\varepsilon_x)$ = 48.911 (deg.)

10. Steel Composite Design as per CSA-S6-19

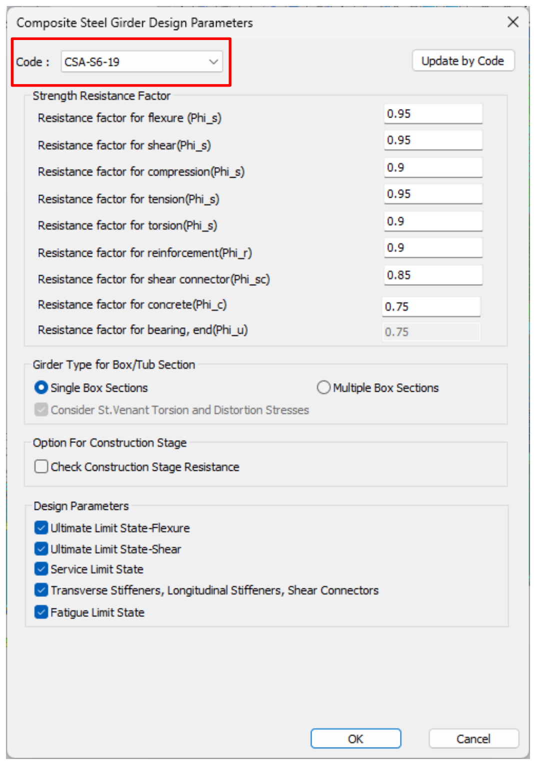
- Bearing stiffeners can now be designed based on the latest code provisions. Summary report as well as a detailed excel report can be obtained.
- Load combinations and fatigue category details for shear stud connectors have been updated to reflect the latest code provisions. Now shear studs are considered in Category S for fatigue.

- ***Results > Load Combination > Composite Steel Girder Design***
- ***Design > Composite Design > Composite Steel Girder Design Parameters***
- ***Design > Composite Design > Transverse Stiffener***

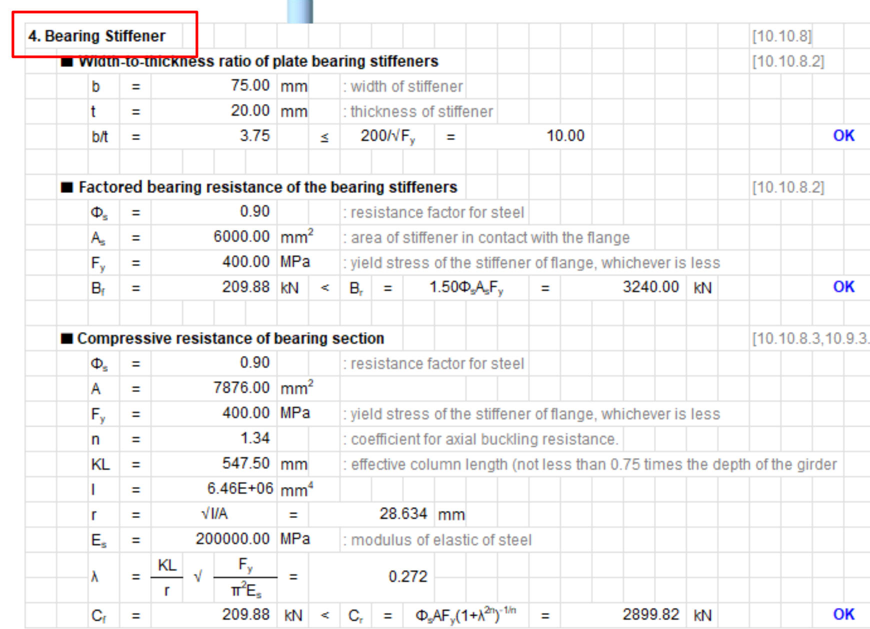




Auto-generation of Load Combinations



Design code & Parameter input



4. Bearing Stiffener [10.10.8]

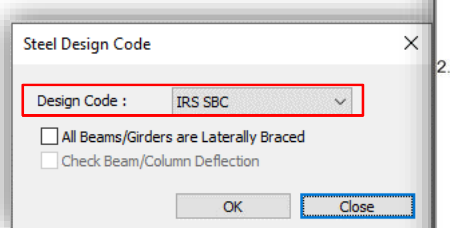
■ Width-to-thickness ratio of plate bearing stiffeners										[10.10.8.2]
b	=	75.00	mm	: width of stiffener						
t	=	20.00	mm	: thickness of stiffener						
b/t	=	3.75		≤	$200/\sqrt{F_y}$	=	10.00		OK	
■ Factored bearing resistance of the bearing stiffeners										[10.10.8.2]
Φ_s	=	0.90		: resistance factor for steel						
A_s	=	6000.00	mm^2	: area of stiffener in contact with the flange						
F_y	=	400.00	MPa	: yield stress of the stiffener of flange, whichever is less						
B_f	=	209.88	kN	<	B_r = $1.50\Phi_s A_s F_y$	=	3240.00	kN	OK	
■ Compressive resistance of bearing section										[10.10.8.3,10.9.3.1]
Φ_s	=	0.90		: resistance factor for steel						
A	=	7876.00	mm^2							
F_y	=	400.00	MPa	: yield stress of the stiffener of flange, whichever is less						
n	=	1.34		: coefficient for axial buckling resistance.						
KL	=	547.50	mm	: effective column length (not less than 0.75 times the depth of the girder						
I	=	6.46E+06	mm^4							
r	=	$\sqrt{I/A}$		=	28.634	mm				
E_s	=	200000.00	MPa	: modulus of elastic of steel						
λ	=	$\frac{KL}{r}\sqrt{\frac{F_y}{\pi^2 E_s}}$		=	0.272					
C_f	=	209.88	kN	<	C_r = $\Phi_s A F_y (1+\lambda^{2n})^{-1/n}$	=	2899.82	kN	OK	

Detailed excel report – Bearing Stiffener

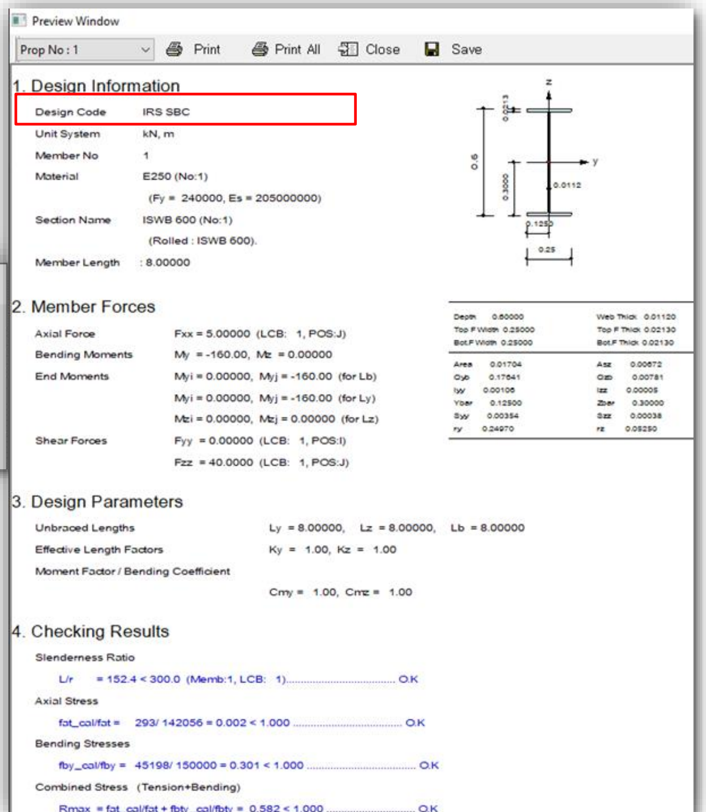
11. Design of Solid web girder as per IRS SBC:2017

- Detailed calculation report as well as a graphical report can now be generated for solid web steel beam sections based on IRS SBC:2017
- Design checks for I, C, L and T sections based on stress limits provided in IRS are supported.

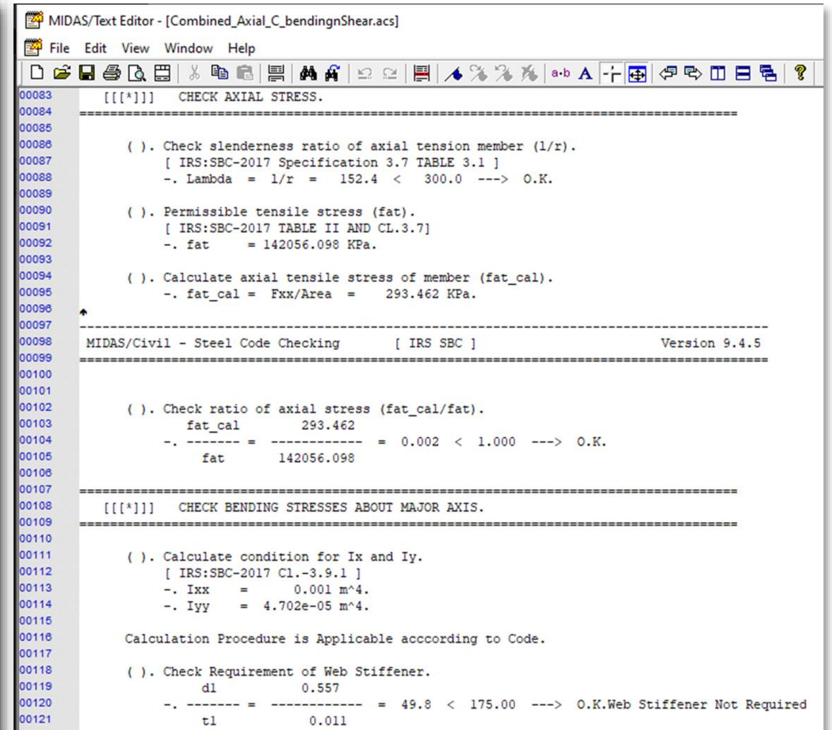
- ***Design > Steel Design > Design Code***



Steel Design Code



Graphical Report

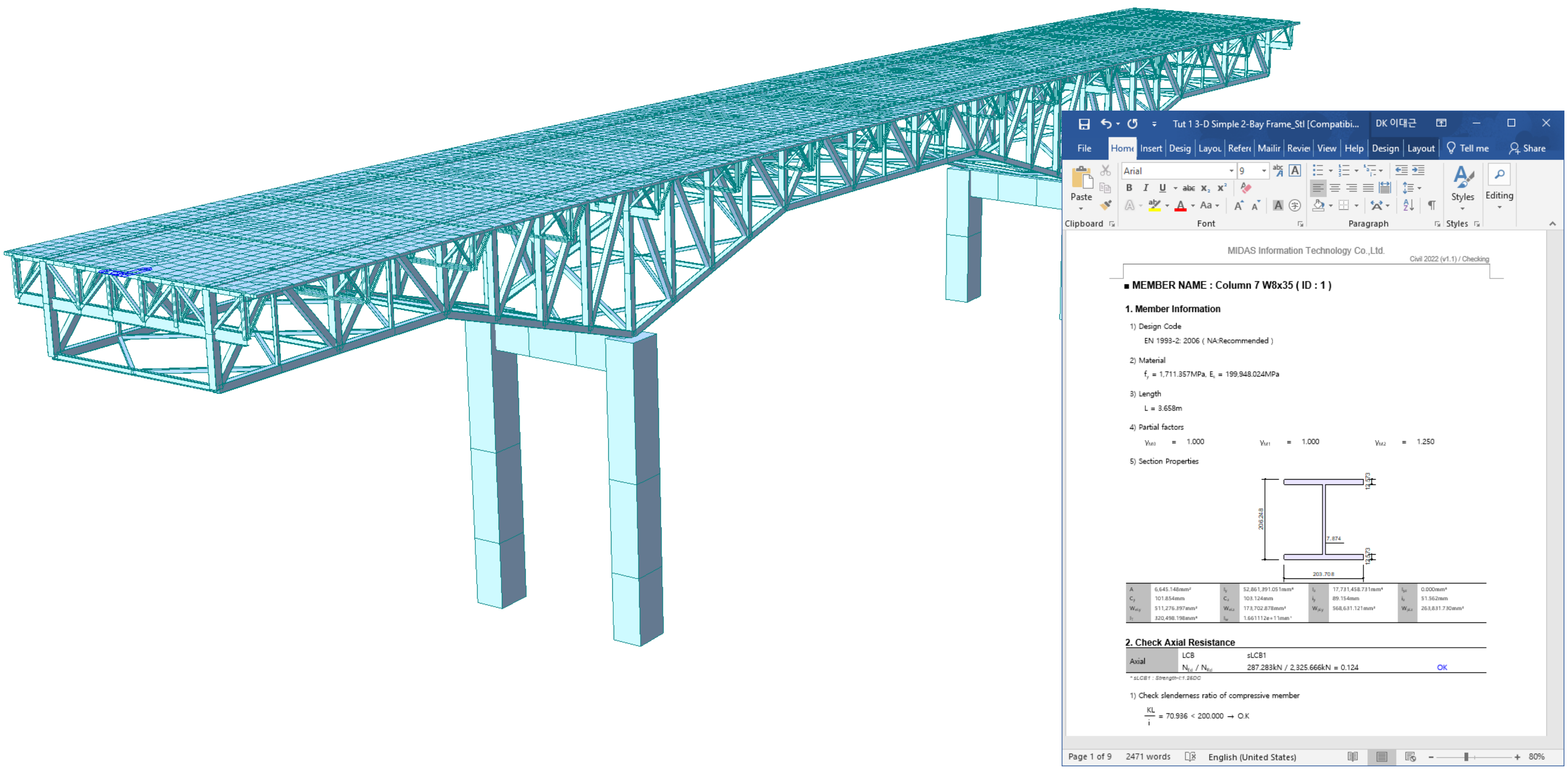


Text Report

12. Design Calculation Speed

- The multithreading is now applied to the design calculation.
- The calculation time has been reduced to around 40% (40 mins. -> 16 mins.) for a test model.
  - Test model condition: 2844 beam elements, steel code check as per AASHTO LRFD 2017

▪ ***Design***



13. Other Enhancements

- Update Interface with BIM software
  - Revit 2024 Interface
  - Tekla 2023 Interface