MIDAS WEBINAR ON

PEDESTRIAN STEEL COMPOSITE BRIDGE & DYNAMIC ANALYSIS PEDESTRIAN BRIDGES

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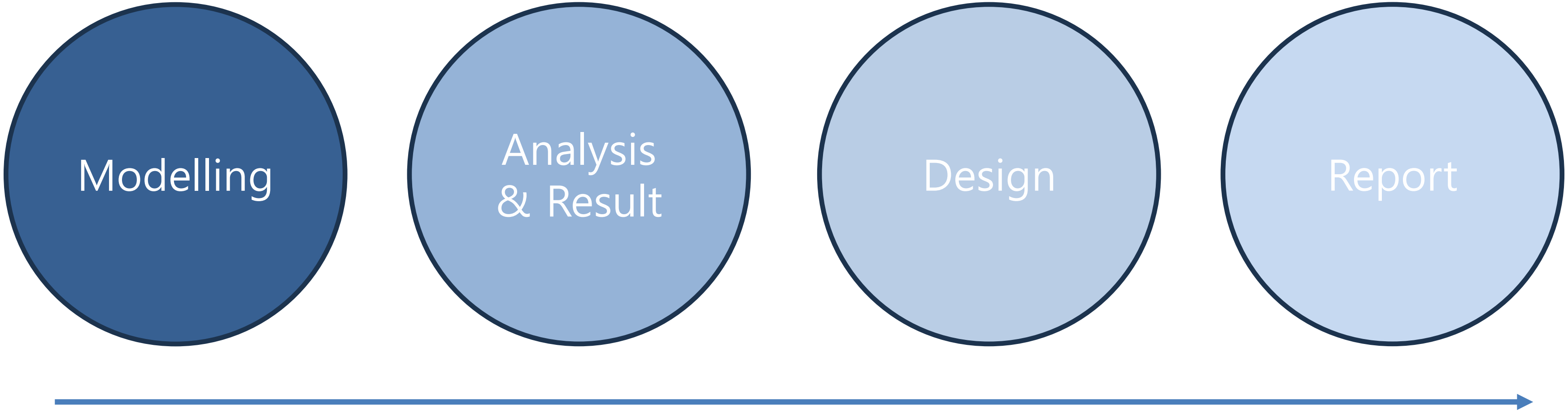
1.1 Introduction



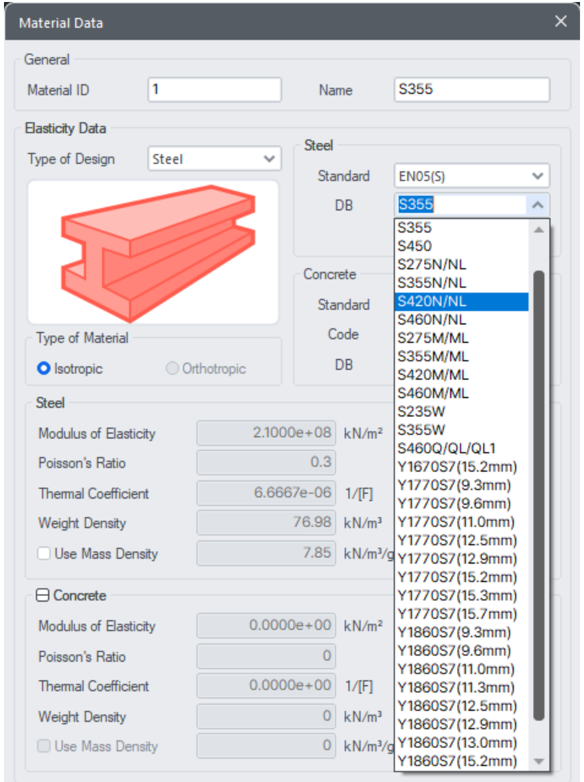
- Wizard
- Manual Modelling
- Drawing Import

- Static Load
- Moving Load
- Thermal Load
- Dynamic Load

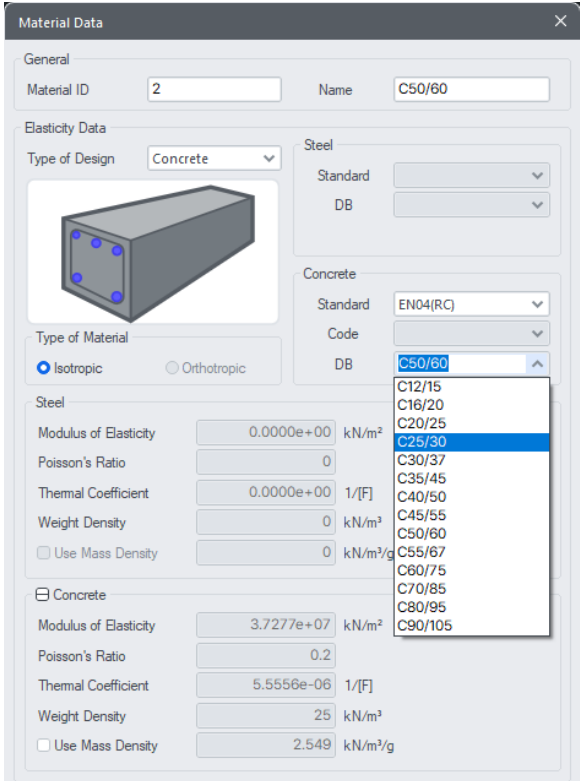
- ULS check
- SLS check

- Auto-generate design report

1.2 Material and Section Properties

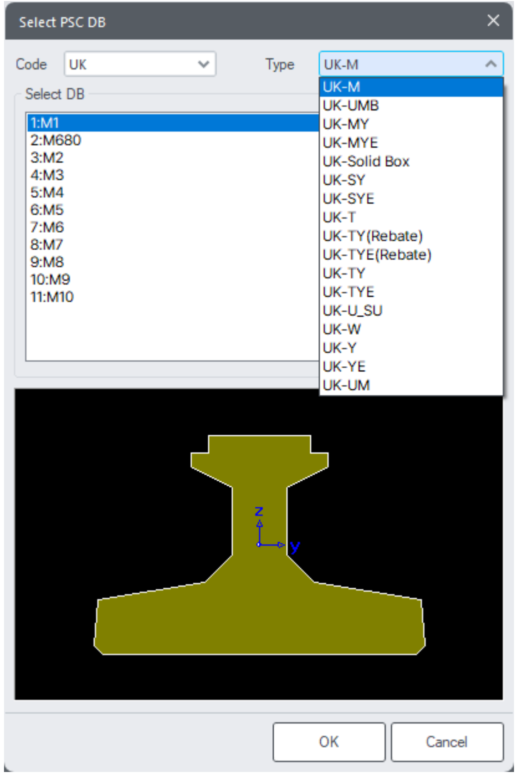


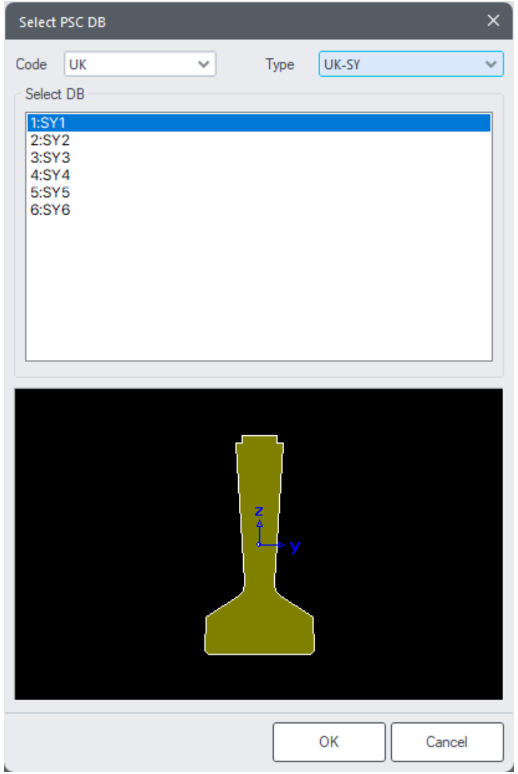
Steel material specific to EN Standard

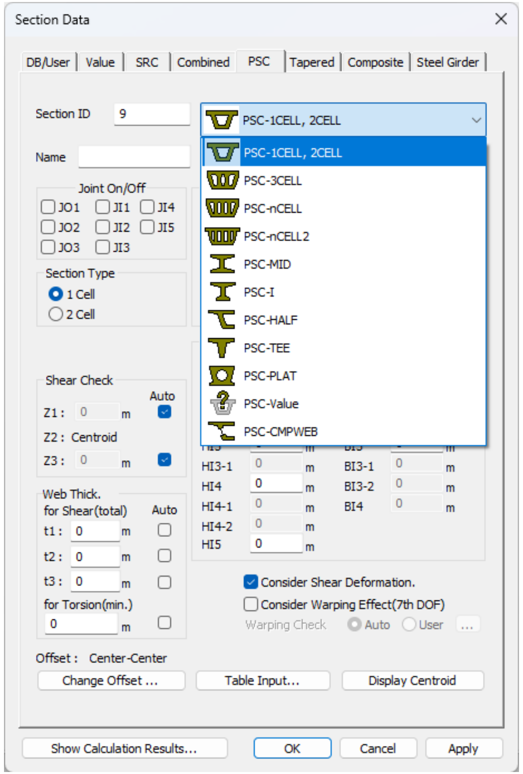


RC material for EN Standard

1.2 Material and Section Properties



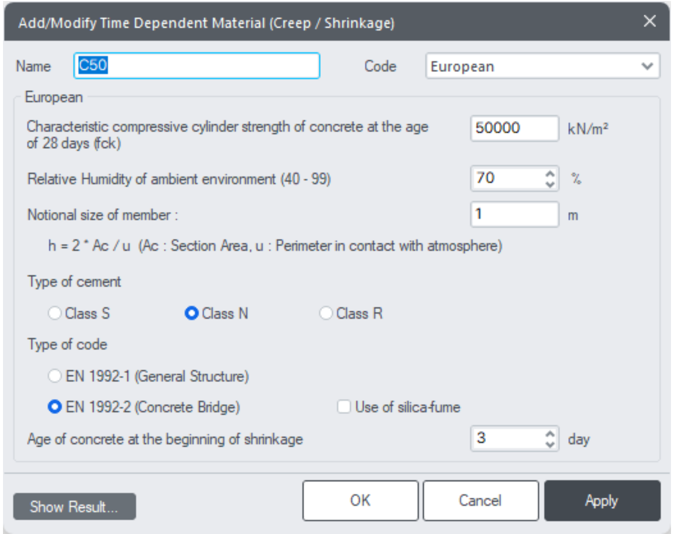




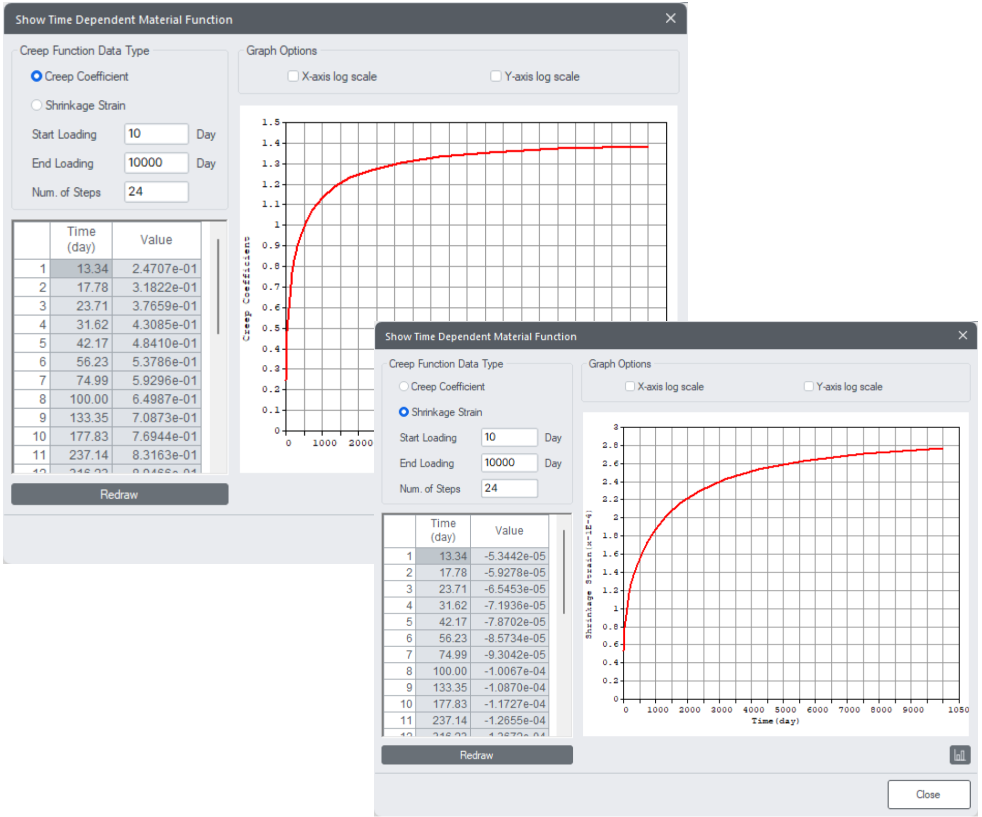
EN- Standard Section

And much more…

1.2 Material and Section Properties

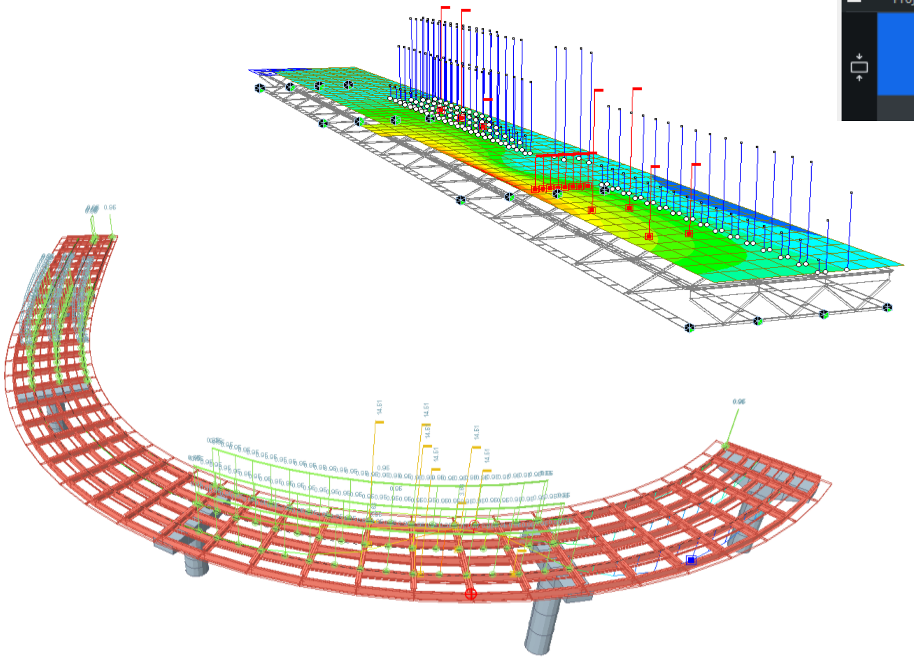


Creep & Shrinkage input based on EN Code

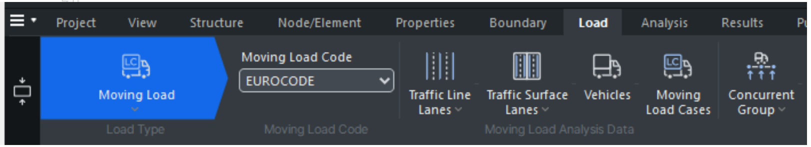


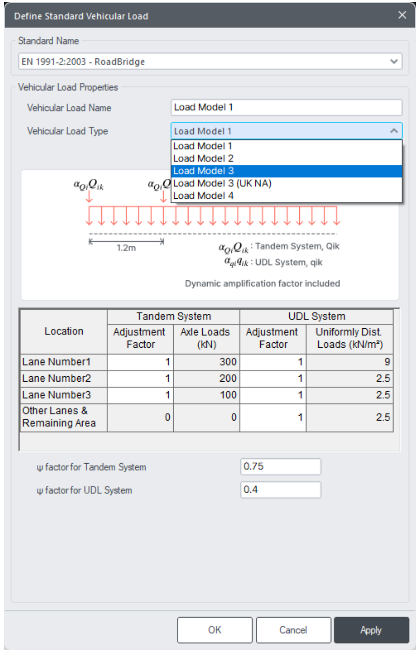
Autogenerated creep & shrinkage curves

1.3 Loading (Moving Load)



Influence line based moving load analysis





Define Standard Vehicular Load

Standard Name: EN 1991-2:2003 - RoadBridge

Vehicular Load Properties

Vehicular Load Name: Load Model 1

Vehicular Load Type: Load Model 1

- Load Model 1
- Load Model 2
- Load Model 3
- Load Model 3 (UK NA)
- Load Model 4

$\alpha_{Qi}Q_{ik}$: Tandem System, Qik

$\alpha_{qi}q_{ik}$: UDL System, qik

1.2m

Dynamic amplification factor included

Location	Tandem System		UDL System	
	Adjustment Factor	Axle Loads (kN)	Adjustment Factor	Uniformly Dist. Loads (kN/m²)
Lane Number1	1	300	1	9
Lane Number2	1	200	1	2.5
Lane Number3	1	100	1	2.5
Other Lanes & Remaining Area	0	0	1	2.5

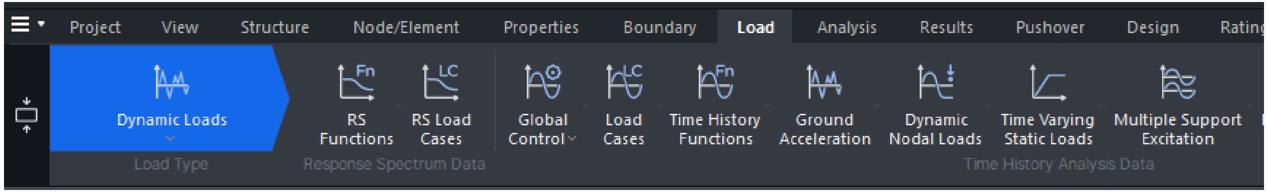
ψ factor for Tandem System: 0.75

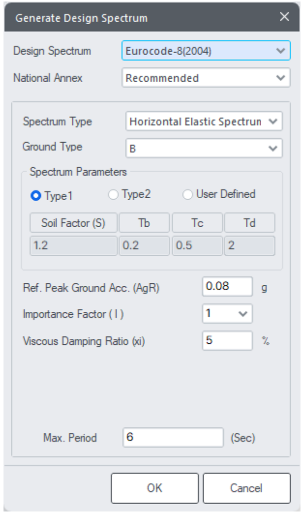
ψ factor for UDL System: 0.4

OK | Cancel | Apply

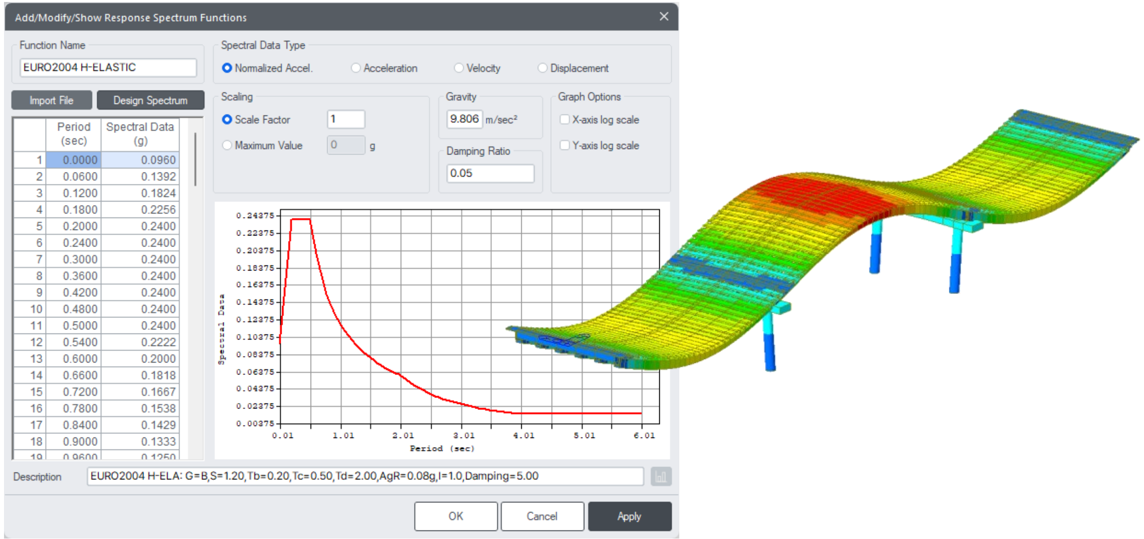
Standard vehicles for EN Code

1.4 Loading (Response Spectrum)



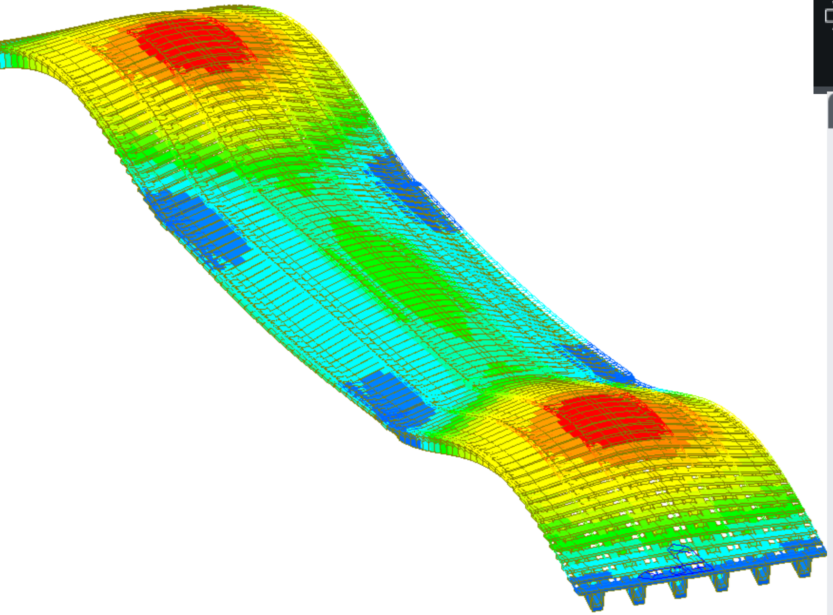


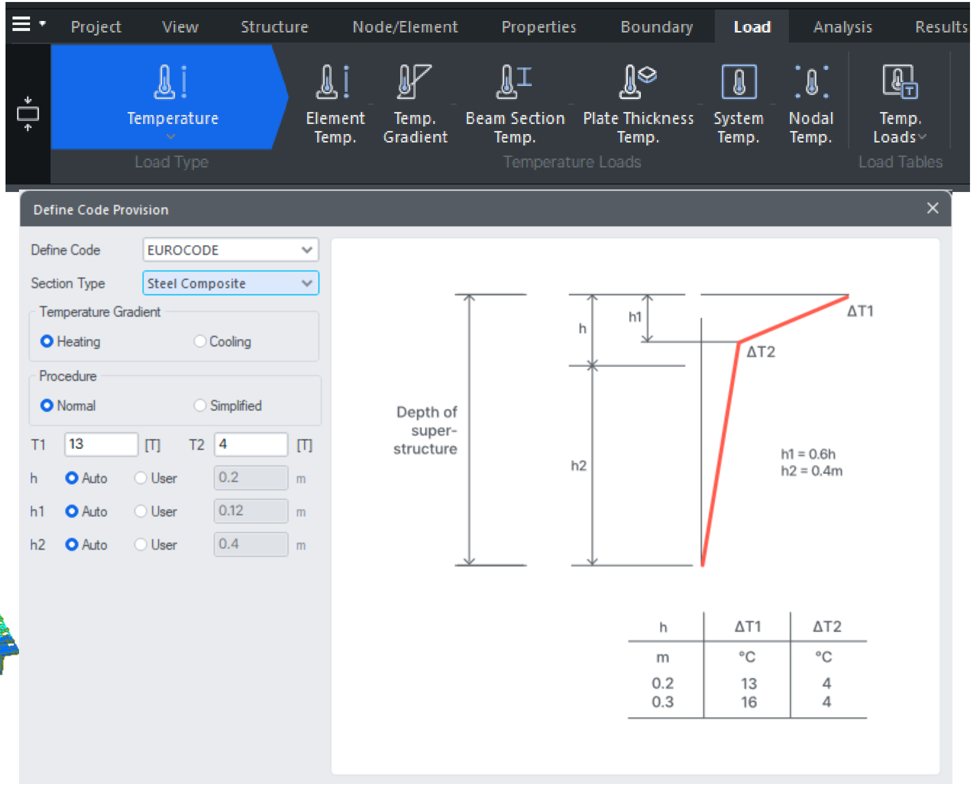
Response spectrum input based on Eurocode



Generated RS curve

1.5 Loading (Temperature Gradient)





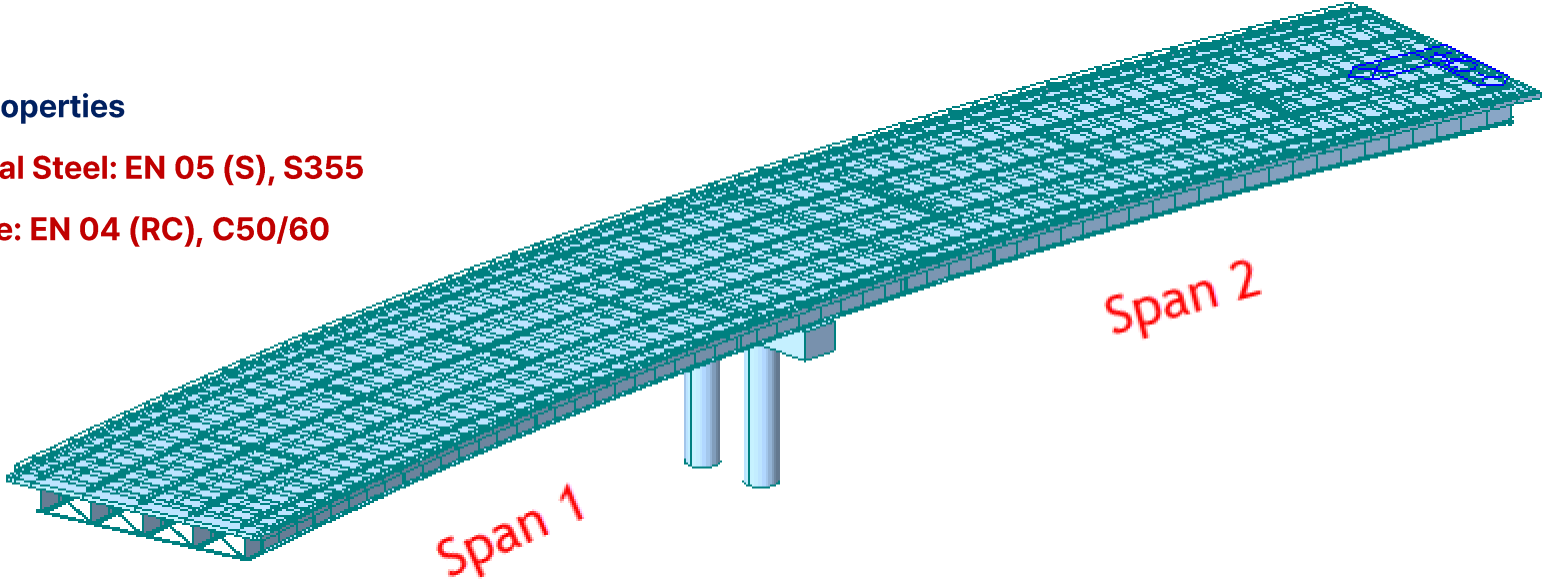
Temperature gradient input based on Eurocode

2. Specification of Bridge

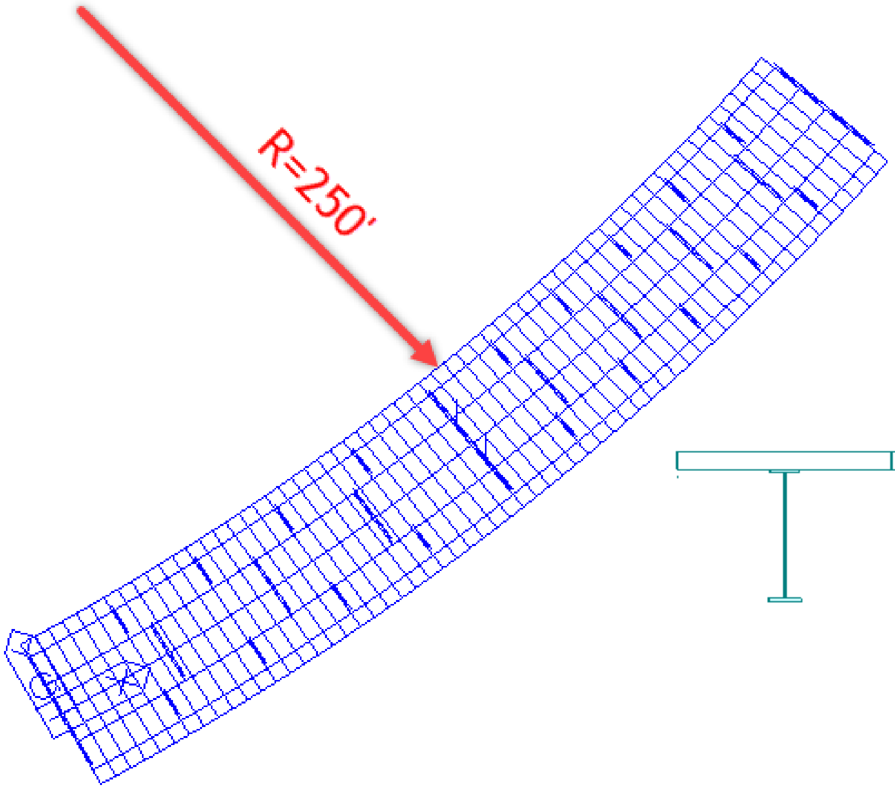
- Bridge Type: 2-Span steel composite I girder curved bridge
- Number of main girders: 5
- Curvature Radius: 250′

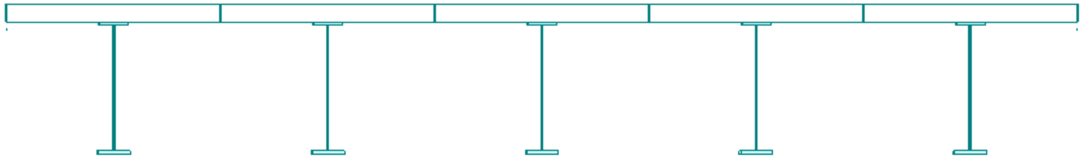
Material Properties

- Structural Steel: EN 05 (S), S355
- Concrete: EN 04 (RC), C50/60



2. Specification of Bridge





C/C distance between girder 3m

Jump into!!

CVL

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Introduction

- Steel Composite bridge
- Eurocode consideration in Midas Civil

Modelling

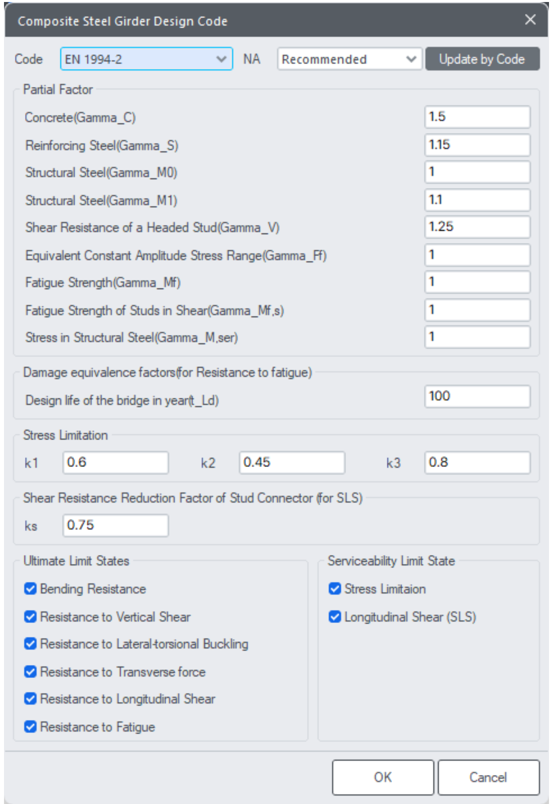
- Load Application (Static, Moving, Dynamic, Thermal)

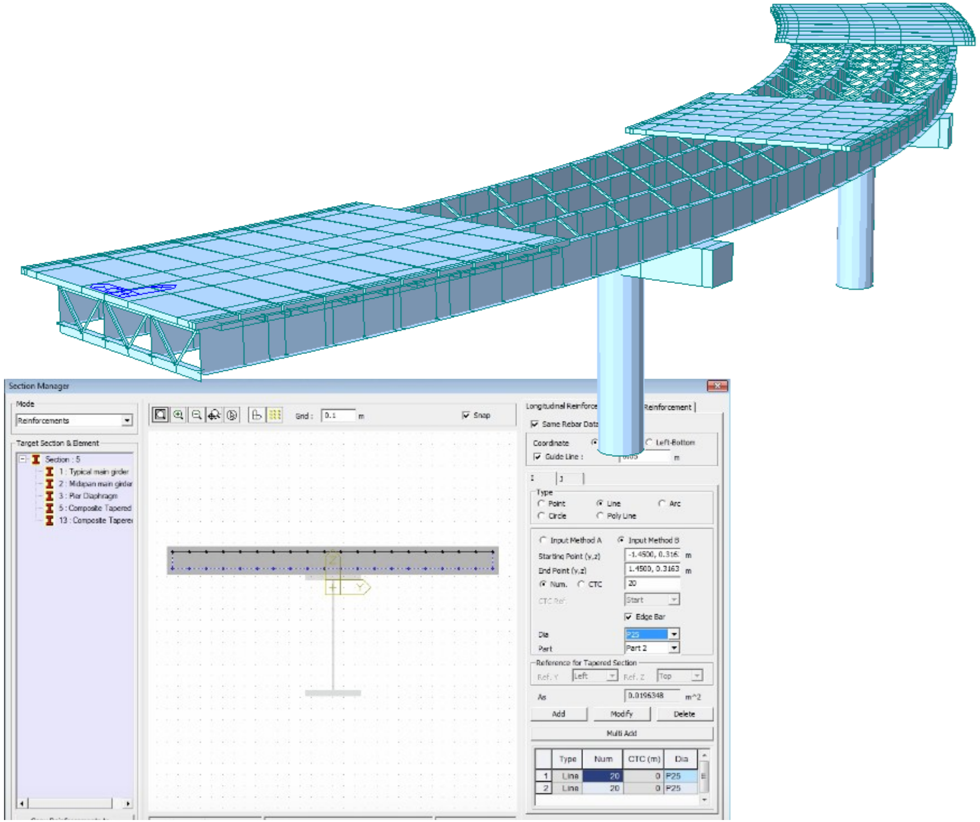
Analysis & Result

- Deformation
- Forces and Moment

Design & Dynamic Analysis of Pedestrian Bridge

3. Steel Composite Design as per EN 1994-2





Dynamic Analysis of Pedestrian Bridge

- Introduction

Introduction

→ Pedestrian Bridge are more sensitive to dynamic load generated by moving pedestrian.

→ Walking, running and jumping on footbridges produce dynamic forces which can activate appreciable vibration.

→ Vibration can cause discomfort to pedestrians.

→ Excess vibration can cause deterioration of the footbridge's structure integrity.

- Bridge Layout

Modelling Data

Geometric Details

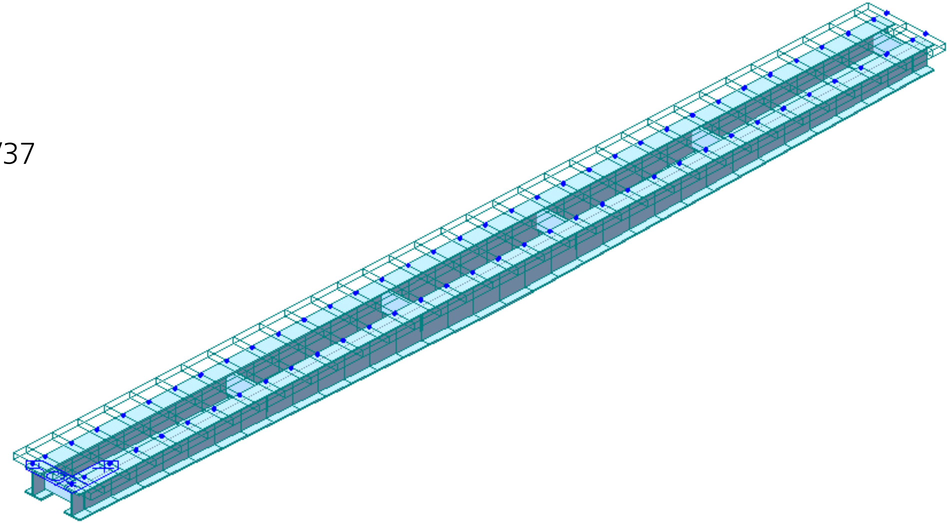
→ Bridge Type: Single Span Simply Supported Composite Steel I Girder Bridge

→ Span length 33m with 2 main girder

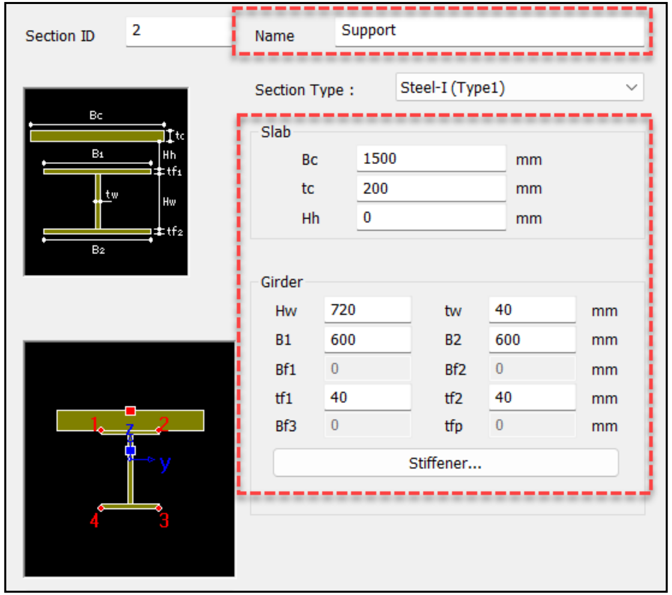
Material Details

→ Girder: S355

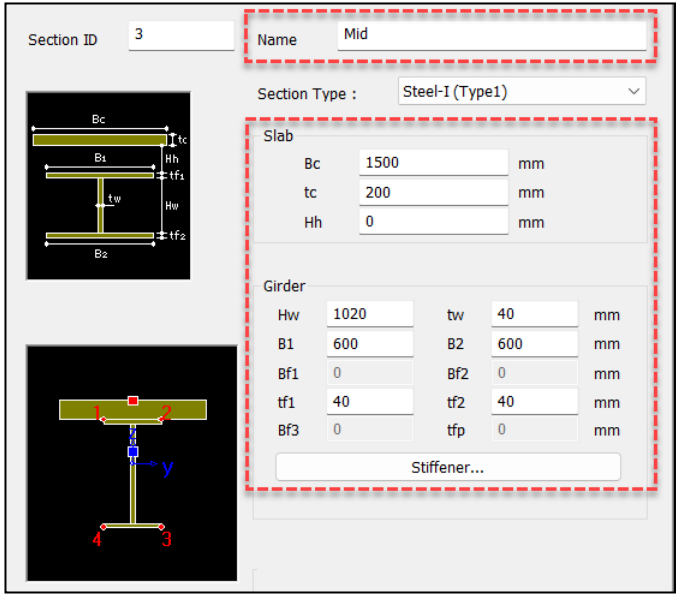
→ Substructure: C30/37



Bridge Cross Section



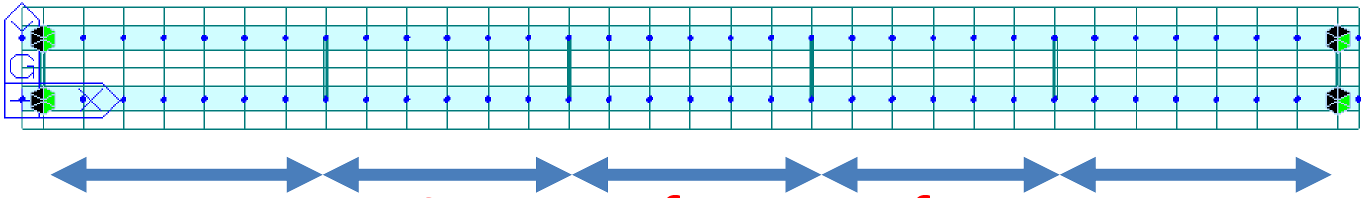
Near Support



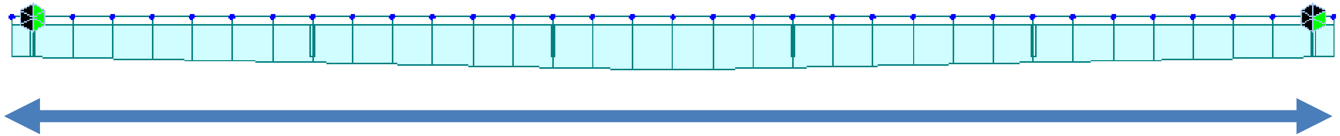
Near Mid Span

Note: All Dimensions are in mm unless mentioned otherwise

Bridge Geometry



C/C distance between girder = 1.5m



→ Height @ Support = 1000mm

→ Height @ Mid = 1300mm

- Loadings

Loading Details

Self Weight

Parapet

→ Load on Each Girder = Area * Density of Concrete

= (1* 0.4) * 25

= 10 kN/m

Services **(50mm thk, density 22 kN/m3)**

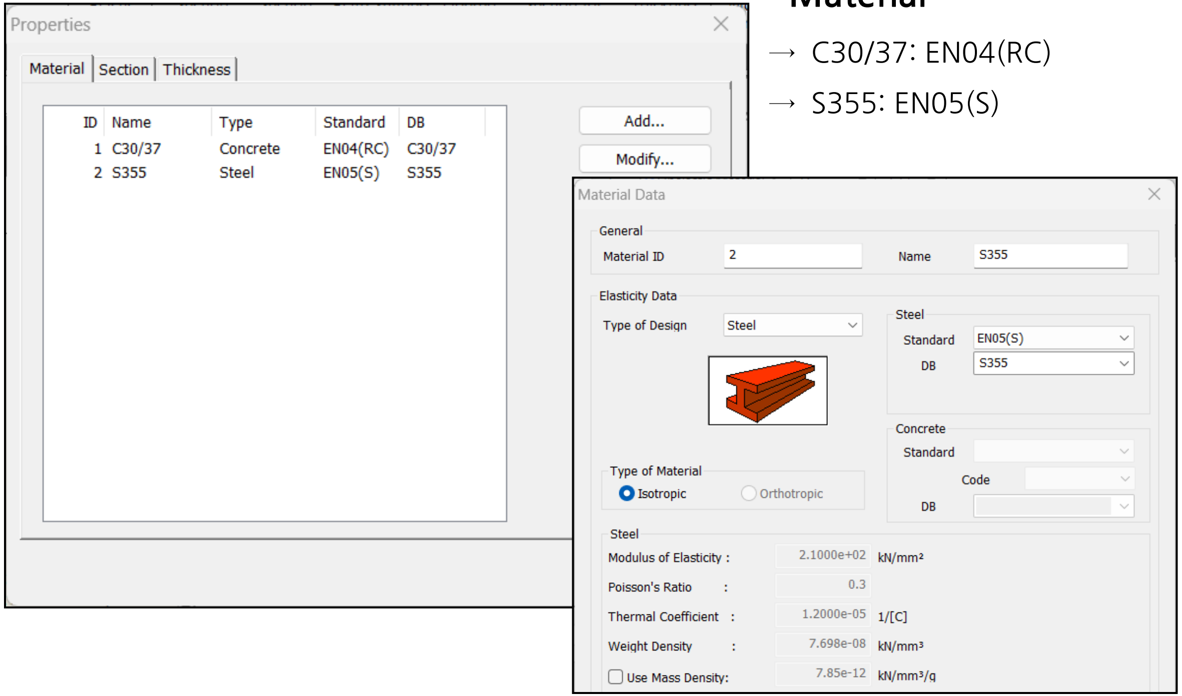
→ Load on Each Girder = Area * Density of Wearing Surface

= (0.05*1.5) * 22

= 1.65 kN/m

- Modelling Steps

Defining Material Properties

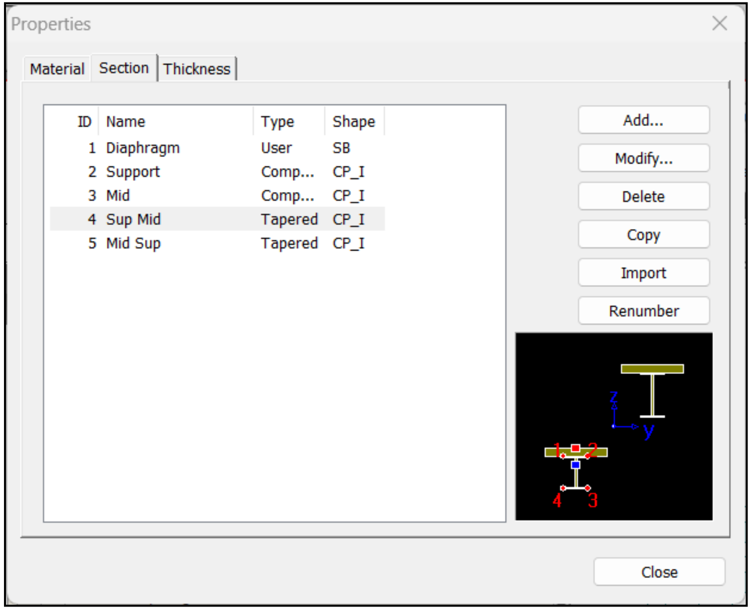


Material

→ C30/37: EN04(RC)

→ S355: EN05(S)

Defining Section Properties



→ **Diaphragm :** 800 x 100 mm

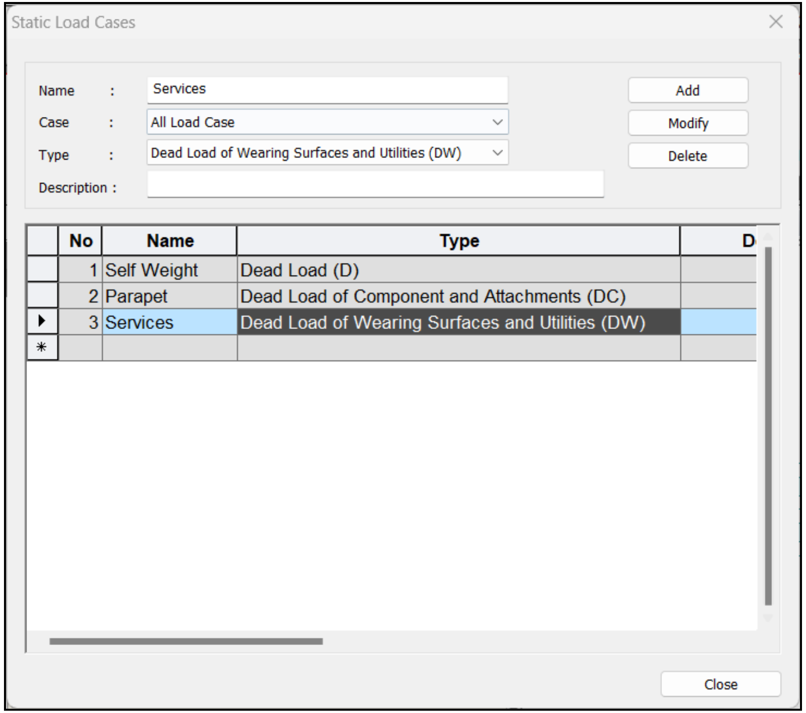
→ **Support Section**

→ **Mid Section**

→ **Tapered Section:** Sup-Mid

→ **Tapered Section:** Mid-Sup

Define Static Load Cases and Add Loads



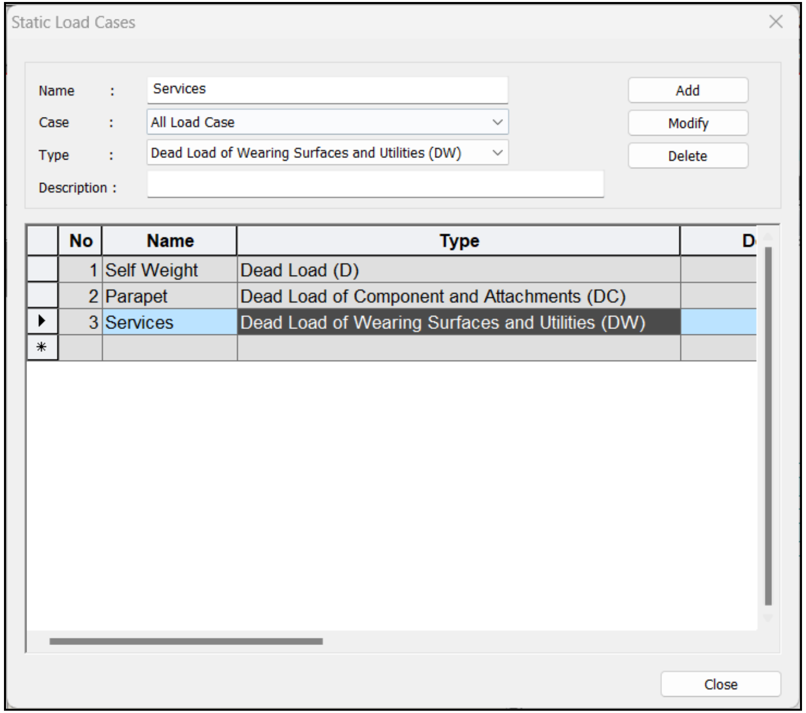
Add Static Load Case

→Self Weight

→ Parapet

→ Services

Define Static Load Cases and Add Loads



Add Static Load Case

→Self Weight

→ Parapet

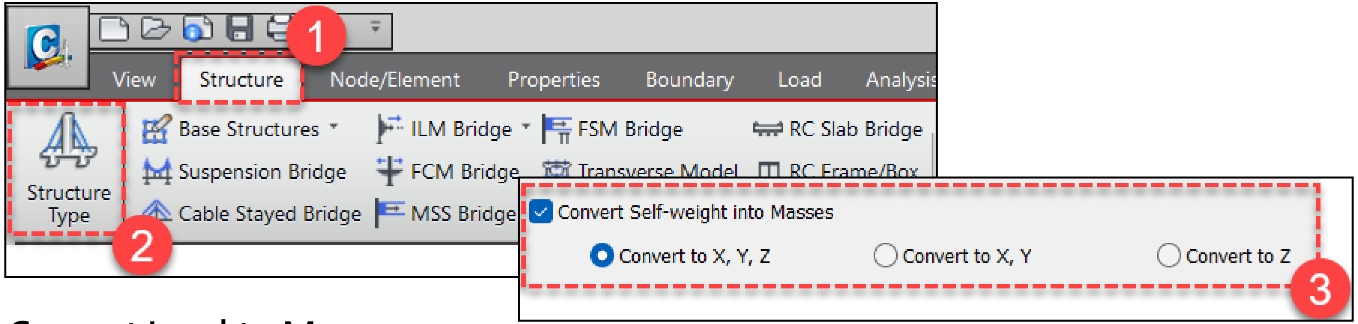
→ Services

Workflow for Vibration Analysis of Pedestrian Bridges

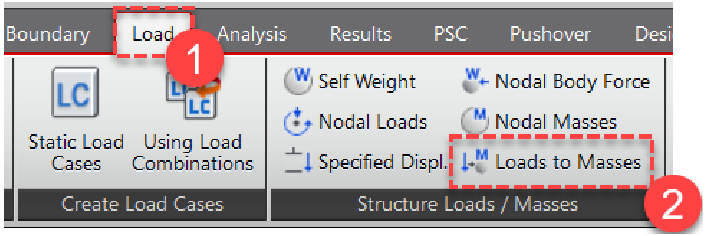
1. Perform Modal analysis to determine natural frequencies
2. Determine pedestrian time forcing functions
3. Apply time forcing function along the length of the bridge while maintaining constant pedestrian velocity
4. Check for acceleration time response and determine peak acceleration
5. Code checks for peak acceleration limit
6. Vibration Control if necessary (Stiffening of the bridge; Dampers etc.)

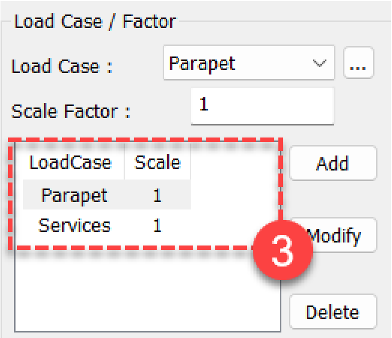
1. Perform Modal Analysis

Convert Self weight into Mass



Convert Load to Mass

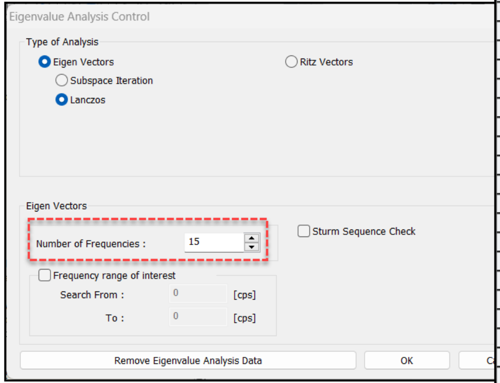




1. Perform Modal Analysis

Eigen Value Analysis

Analysis > Eigen Value Analysis



Result > Vibration Mode Shape

EIGENVALUE ANALYSIS

Mode No	Frequency (rad/sec)	Frequency (cycle/sec)	Period (sec)	Tolerance
1	10.221648	1.626826	0.614694	0.0000e+00
2	13.425429	2.136723	0.468006	0.0000e+00
3	29.150874	4.639506	0.215540	0.0000e+00
4	34.002950	5.411738	0.184784	0.0000e+00
5	49.059223	7.808018	0.128073	0.0000e+00
6	70.800871	11.268309	0.088744	0.0000e+00
7	71.885612	11.440951	0.087405	0.0000e+00
8	105.598438	16.806513	0.059501	6.5500e-117
9	113.449011	18.055971	0.055383	1.0776e-109
10	126.403133	20.117683	0.049708	2.4380e-101
11	139.969591	22.276852	0.044890	1.1440e-90
12	141.348723	22.496348	0.044452	2.2882e-89
13	144.081138	22.931225	0.043609	2.8125e-88
14	146.110175	23.254157	0.043003	5.7318e-87
15	157.344056	25.042084	0.039933	8.9576e-83

MODAL PARTICIPATION MASSES PRINTOUT

Mode No	TRAN-X MASS(%)	TRAN-X SUM(%)	TRAN-Y MASS(%)	TRAN-Y SUM(%)	TRAN-Z MASS(%)	TRAN-Z SUM(%)	ROTN-X MASS(%)	ROTN-X SUM(%)	ROTN-Y MASS(%)	ROTN-Y SUM(%)	ROTN-Z MASS(%)	ROTN-Z SUM(%)
1	0.00	0.00	81.55	81.55	0.00	0.00	0.68	0.68	0.00	0.00	0.19	0.19
2	0.51	0.51	0.00	81.55	82.74	82.74	0.00	0.68	0.20	0.20	0.00	0.19
3	0.00	0.51	0.73	82.28	0.00	82.74	81.69	82.37	0.00	0.20	0.00	0.20
4	0.00	0.51	0.00	82.28	0.00	82.74	0.00	82.37	0.00	0.20	59.36	59.56

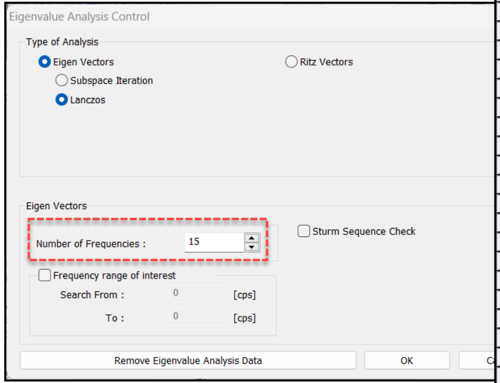
From A.2.4.3.2 of EN 1990, a verification of the comfort criteria should be performed if the fundamental frequency of the deck is less than:

→**5 Hz** for Vertical Vibration
→**2.5 Hz** for Horizontal (lateral) and torsional vibration

1. Perform Modal Analysis

Eigen Value Analysis

Analysis > Eigen Value Analysis



Result > Vibration Mode Shape

EIGENVALUE ANALYSIS

Mode No	Frequency (rad/sec)	Frequency (cycle/sec)	Period (sec)	Tolerance
1	10.221648	1.626826	0.614694	0.0000e+00
2	13.425429	2.136723	0.468006	0.0000e+00
3	29.150874	4.639506	0.215540	0.0000e+00
4	34.002950	5.411738	0.184784	0.0000e+00
5	49.059223	7.808018	0.128073	0.0000e+00
6	70.800871	11.268309	0.088744	0.0000e+00
7	71.885612	11.440951	0.087405	0.0000e+00
8	105.598438	16.806513	0.059501	6.5500e-117
9	113.449011	18.055971	0.055383	1.0776e-109
10	126.403133	20.117683	0.049708	2.4380e-101
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12	141.348723	22.496348	0.044452	2.2882e-89
13	144.081138	22.931225	0.043609	2.8125e-88
14	146.110175	23.254157	0.043003	5.7318e-87
15	157.344056	25.042084	0.039933	8.9576e-83

MODAL PARTICIPATION MASSES PRINTOUT

Mode No	TRAN-X		TRAN-Y		TRAN-Z		ROTN-X		ROTN-Y		ROTN-Z	
	MASS(%	SUM(%)	MASS(%	SUM(%)	MASS(%	SUM(%)	MASS(%	SUM(%)	MASS(%	SUM(%)	MASS(%	SUM(%)
1	0.00	0.00	81.55	81.55	0.00	0.00	0.68	0.68	0.00	0.00	0.19	0.19
2	0.51	0.51	0.00	81.55	82.74	82.74	0.00	0.68	0.20	0.20	0.00	0.19
3	0.00	0.51	0.73	82.28	0.00	82.74	81.69	82.37	0.00	0.20	0.00	0.20
4	0.00	0.51	0.00	82.28	0.00	82.74	0.00	82.37	0.00	0.20	59.36	59.56

From A.2.4.3.2 of EN 1990, a verification of the comfort criteria should be performed if the fundamental frequency of the deck is less than:

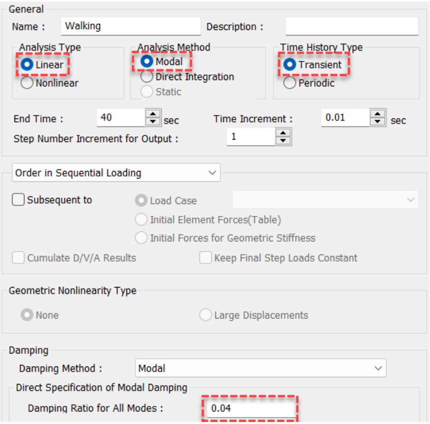
→**5 Hz** for Vertical Vibration (2.136 Hz < 5 Hz)
→**2.5 Hz** for Horizontal (lateral) and torsional vibration (1.626 Hz < 2.5 Hz)

1. Perform Modal Analysis

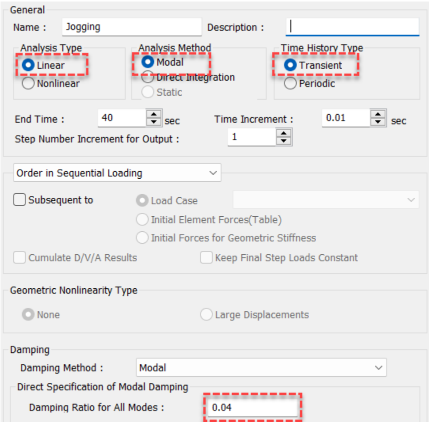
Time History Analysis

Load > Seismic > Time History Analysis Load Case

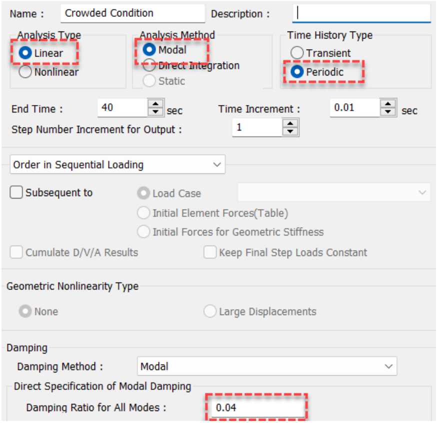
N.A 2.44 of BS EN1991-2, takes into account the following dynamic load cases for comfort criteria check



Walking Pedestrian



Jogging Pedestrian



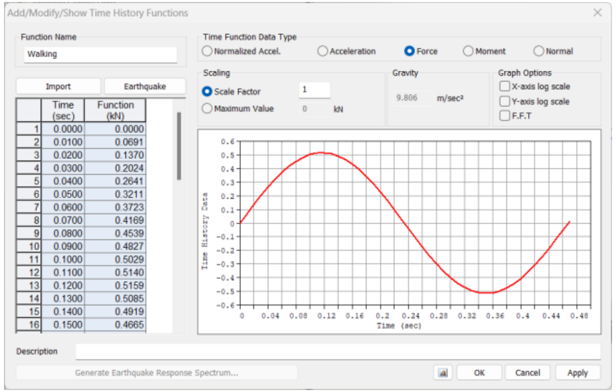
Crowded Steady State

→Damping ratio = **4%** as per BC EN 1991-1-4

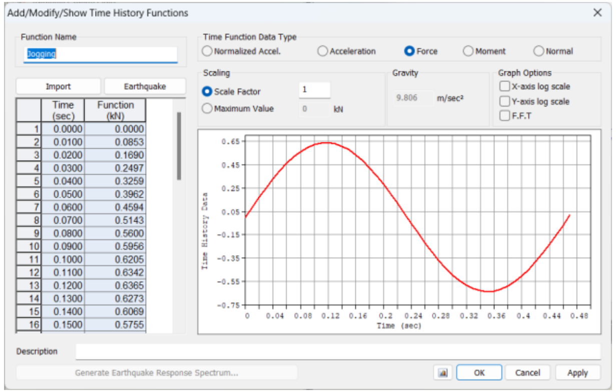
1. Perform Modal Analysis

2. Add Time History Function

Load > Seismic > Time History Function



Walking Pedestrian



Jogging Pedestrian

→Forcing function calculated as per NA 2.44.4 BS EN 1991-2

→fv = 2.136 Hz
→Gamma = 0.8
→Walking, N=4
→Jogging, N=1
→Walking, k(fv)=1
→ Jogging, k(fv)=0.7

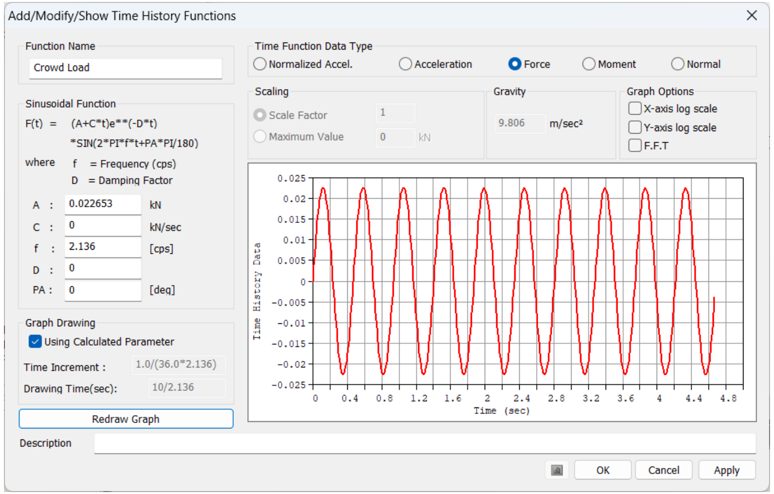
→Walking, Fo= 280 kN
→ Jogging, Fo= 910 kN

$$F = F_0 . k(f_v) . \sqrt{1 + \gamma . (N - 1)} . \sin(2\pi f_v . t)$$

1. Perform Modal Analysis

2. Add Time History Function

Load > Seismic > Time History Function



→fv = 2.136 Hz

→Area = 99 m2

→gamma=0.2

→k(fv)=1

→Fo= 280 kN

→Crowd density=0.4 per/m2

Crowded Steady State

→Forcing function calculated as per NA 2.44.5 BS EN 1991-2

$$w = 1.8\left(\frac{F_0}{A}\right).k(f_v).\sqrt{\gamma.N/\lambda}.\sin(2\pi.f_v.t)$$

1. Perform Modal Analysis

2. Add Time History Function

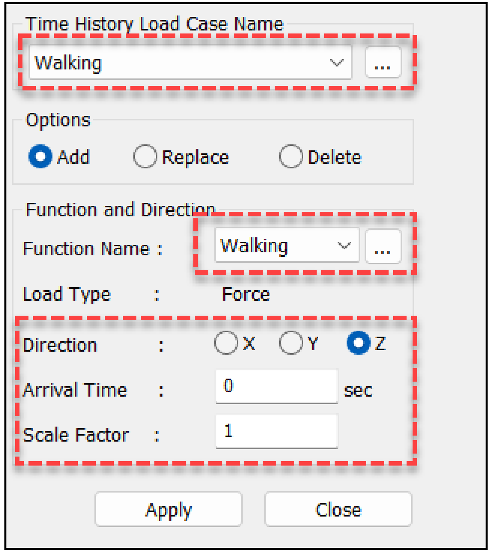
Load > Seismic > Dynamic Nodal loads

→Forcing function are applied along the length of bridge as dynamic load with a time gap = 0.615sec (fundamental period) to achieve worst case response due to resonance

→ Dynamic Nodal loads should simulate constant velocity

→ Velocity for walking and jogging are taken from Table NA.8

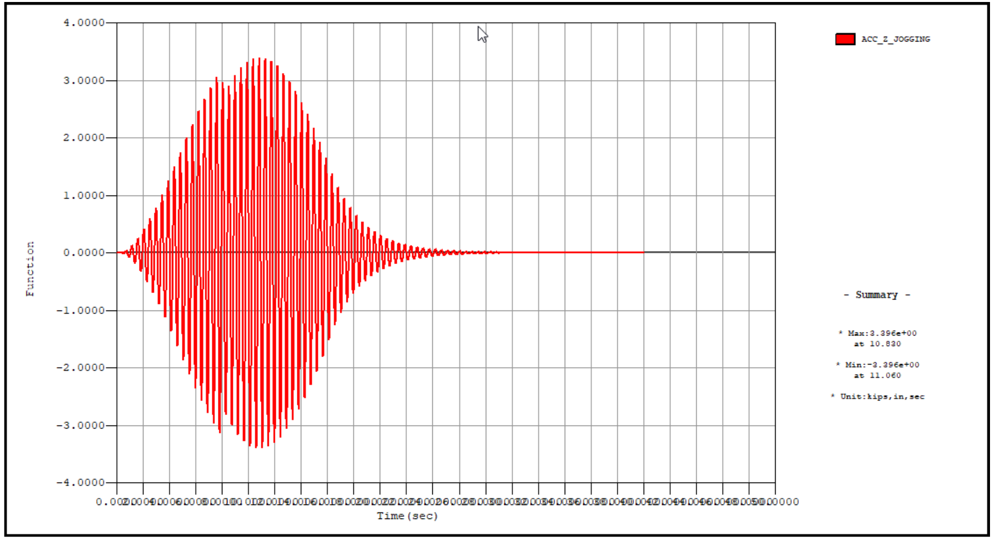
→ Crowd condition dynamic nodal loads should be applied with zero interval time.



1. Perform Modal Analysis

Check Results

Results > Time History Graph



→As per NA 2.44.6, Peak acceleration limit is given by

→From Table NA.9, K1=1.3

→From Table NA.10, K2=0.7

→From Table NA.11, K3=1

$$\alpha_{limit} = 1.0\ k_1 k_2 k_3 k_4\ m/s^2$$

and $0.5 m/s^2 \leq \alpha_{limit} \leq 2 m/s2$

Q & A

Thank you!

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Global Technical Support:

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