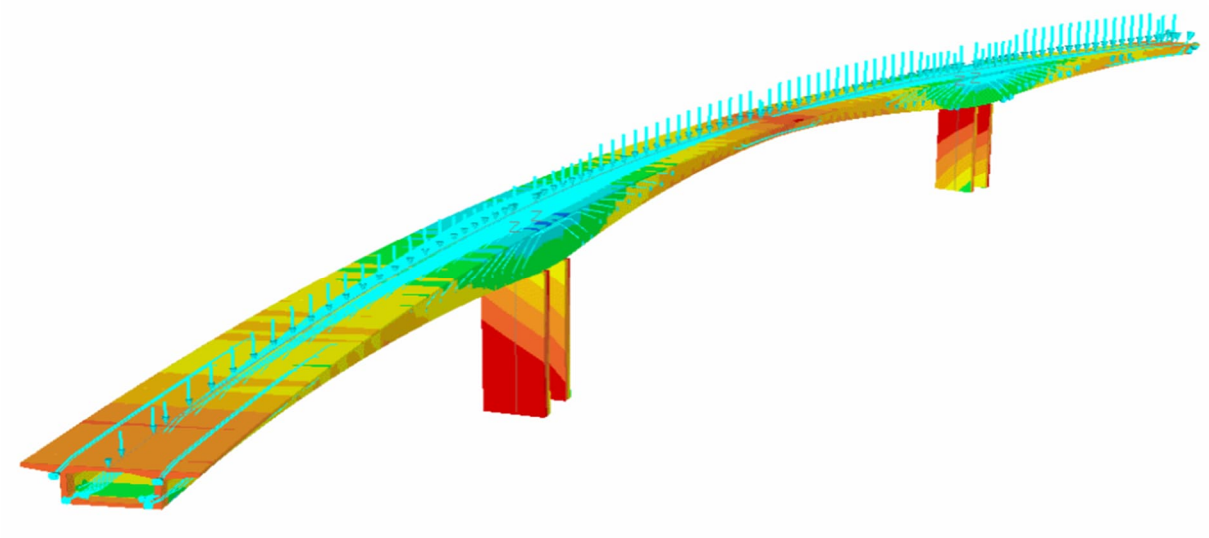
Pretensioned curved tapered box bridge (FCM)

Principle workflow:

1. **Analysis 1** is transient (day 0 → 120 years) considering prestress, dead weight, relaxation, creep and and shrinkage during alla stages of construction.
   This analysis is transient with regard to material and active parts of structure during construction. In total there are 7 differrent construction stages.

2. **Analysis 2** is none transient and only linear. This is analysis is used for all loads acting after completed construction.

3. Results from **Analysis 1 & 2** are combined to ULS & SLS.



CONTENTS

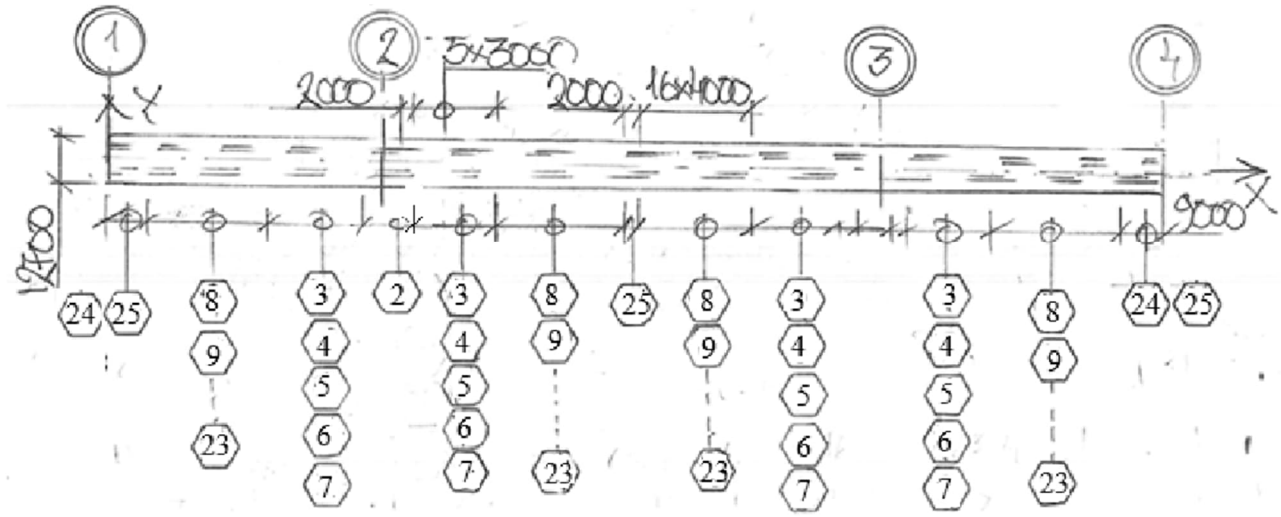
1. GENERAL / MEASUREMENT

1.1 CONSTRUCTION TYPE

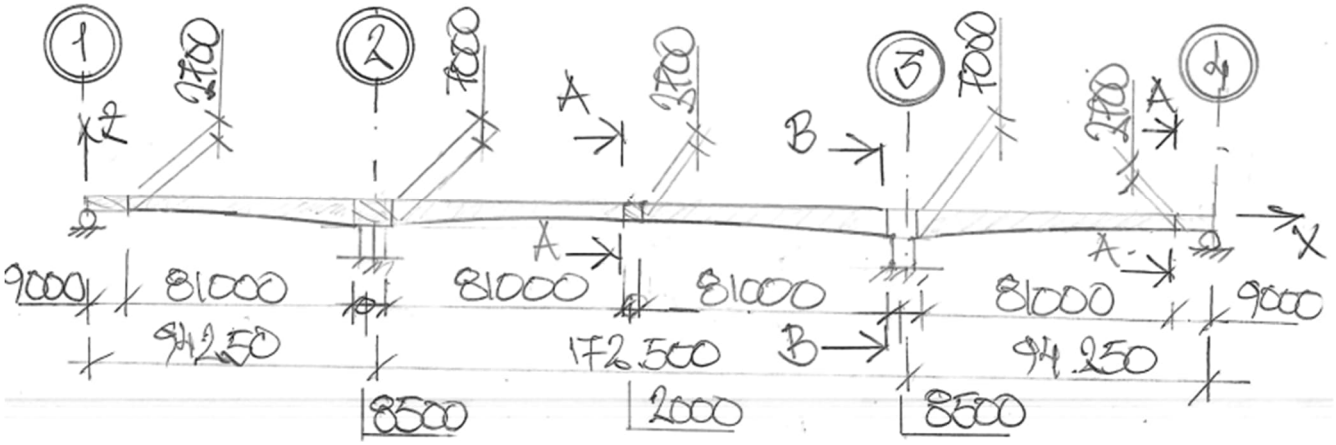
The bridge is a pretensioned single box bridge constructed using a free cantilever method (FCM).

In total 52 casting stages ($\therefore$ = 2 x CS: 1 $\rightarrow$ 26) is assumed.

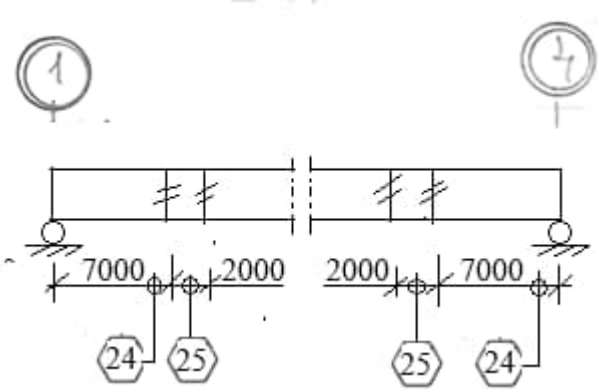
1.2 MEASURMENT



PLAN

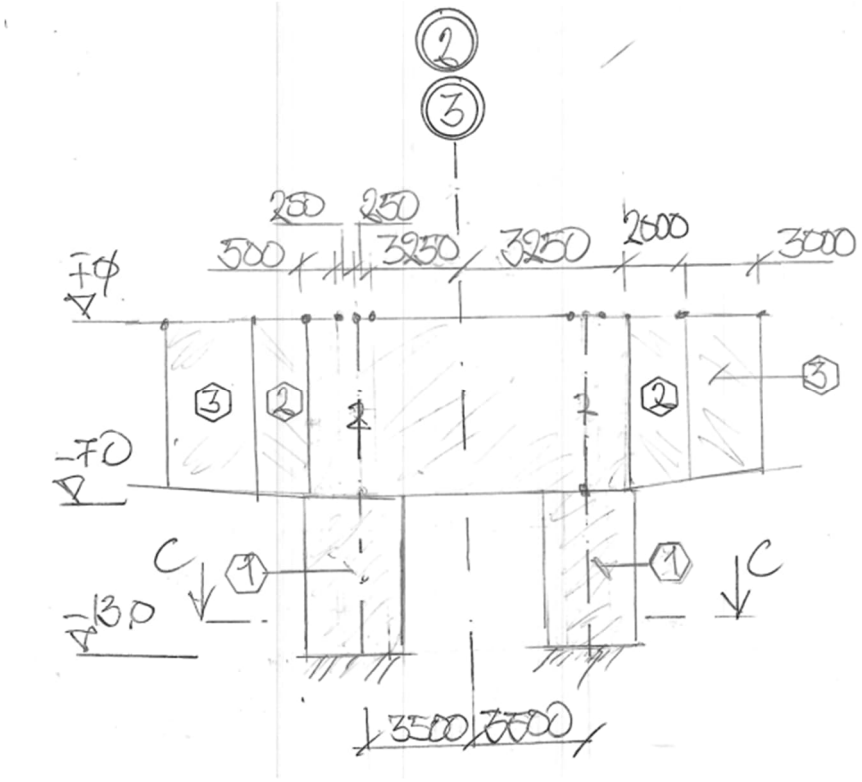


ELEVATION

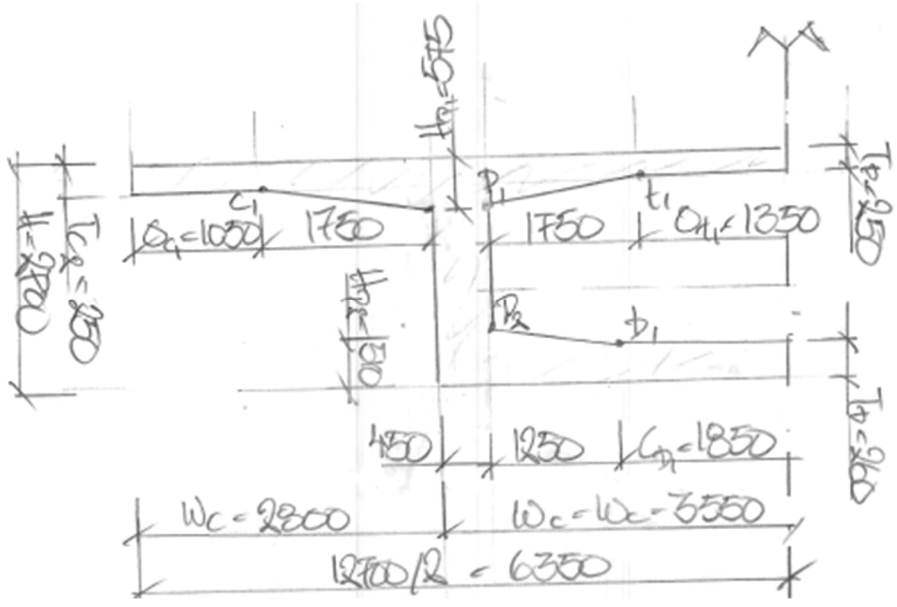


DETAIL 1

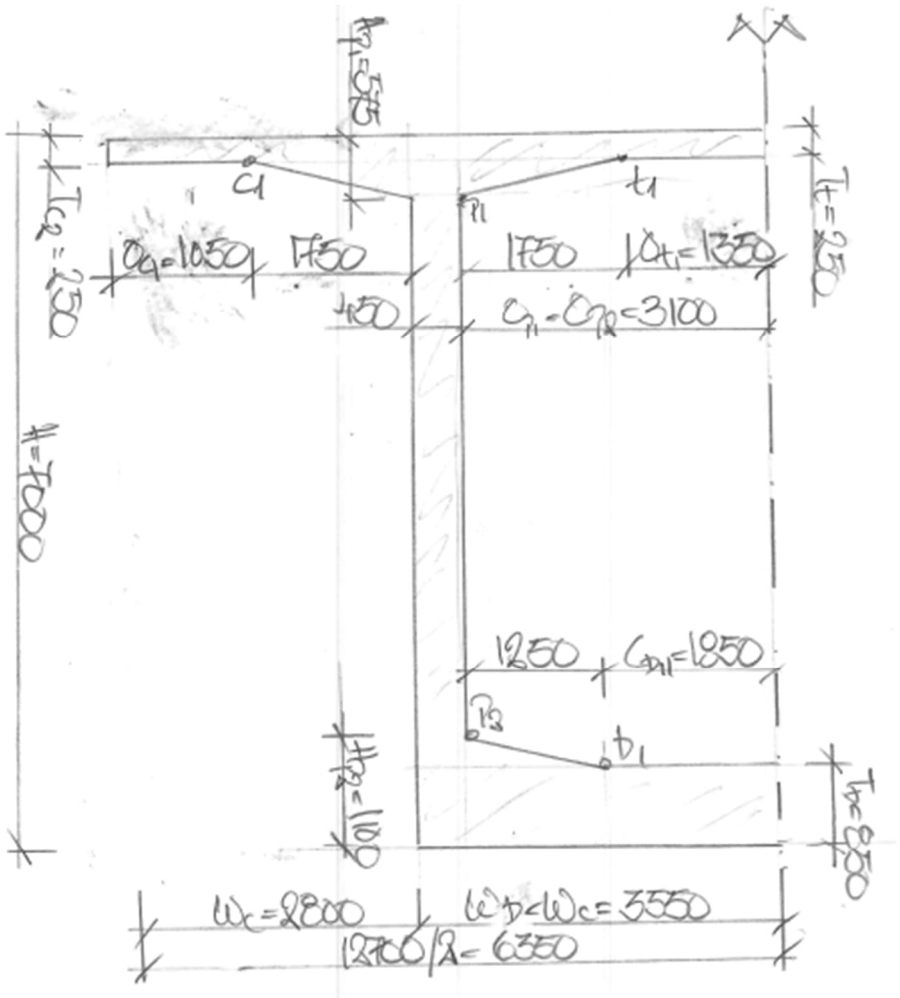
Longtidinal view at support 1 & 4.



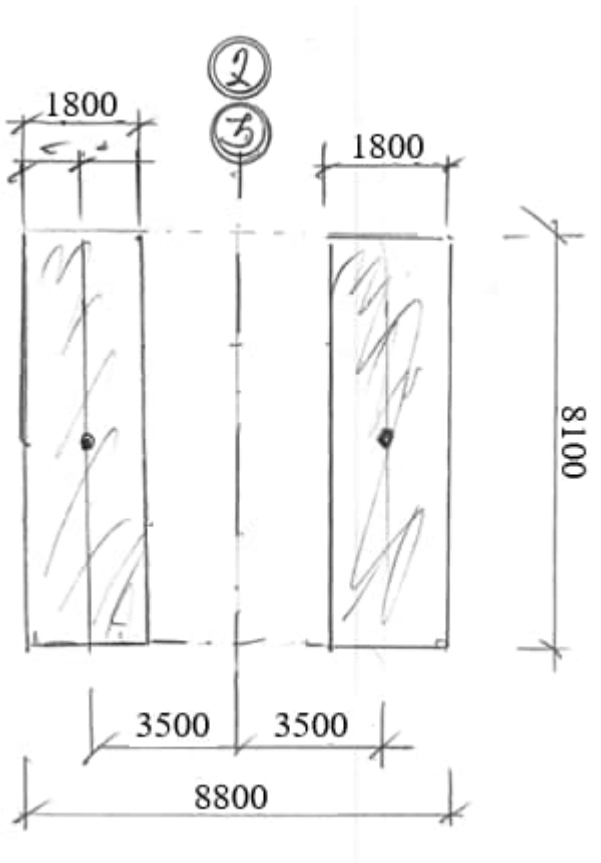
DETAIL 2
Longtidinal view at support 2 & 3.



SECTION A-A



SECTION B-B



SECTION C-C

1.3 FOUNDATION

Bottom slabs are assumed resting on rock.

1.4 CODE OCH TENDER DOCUMENTS

- ”Bro och broliknande konstruktion allmänna krav” (TRVINFRA-00226 v5)
- ”Bro och broliknande konstruktion byggande” (TRVINFRA-0027 v6)
- ”TSFS 2018:57 med ändringar tom TSFS 2022:50”
- ”AMA Anläggning 23”
- ”TRV ändringar och tillägg till AMA 23” (TDOK 2023:0125 v3)
- ”Geokonstruktion dimensionering och utformning” (TRVINFRA-00230 v2)
- Document SS-EN 1990 to SS-EN 1999, see TRVINFRA section A.1.2.3.2

1.5 TECHNICAL SERVICE LIFE

Technical life span 120 years (L100).

1.6 ENVIRONMENT

Road traffic enviroment (“vägmiljö”) is assumed for the overlying traffic road since salt is used at winter, see TB section B1.

1.7 MATERIAL

Concrete :	C35/45 (CEM I 42.5 N, Anläggningscement klass N)
Reinforcement :	B500B
Compacted fill :	”Förtärkningslagermaterial” according to AMA CEB.415
Backfill :	”Grovkrossad sprängsten” according to AMA CEB.524
Surfacing :	See document RKFM
Pretension:	VSL system or eqivalent

1.8 GEOTECHNICAL CLASS

Geotechnical class GK2

1.9 SAFETY CLASS

Geotechnical resistance: SK 2

Brigde structure : SK 3

1.10 CONCRETE COVER AND CRACK CRITERIA

Class identification bridge components :

Bridge components	Exposure class[1.)]	Life spann	max vct_{ekv}[2.)]	ζ [3.)]
Substructure incl. linkplate:				
▫ Wingwall towards filling	XD1/XF4	L100	0.45	1.5
▫ Wingwall from filling	XD1/XF4	L100	0.45	1.5
▫ Abutement below ground	XC2/XF3	L100	0.50	1.0
▫ Abutement in air	XC4/XF3	L100	0.50	1.2
▫ Bottom slab in general	XC2/XF3	L100	0.50	1.0
▫ Bottom slab underside	XC2/XF3	L100	0.50	1.0
▫ Link slab in general	XD3/XF2	L100	0.40	1.8
▫ Link slab underside	XD3/XF2	L100	0.40	1.8
Superstructure:				
▫ Edge beam	XD3/XF4	L100	0.40	1.8
▫ Bridge deck	XD1/XF4	L100	0.40	1.5
▫ End shield towards filling	XD1/XF4	L100	0.40	1.5
▫ End shield from filling	XC2/XF3	L100	0.50	1.0

Footnote:
1.) TRVINFRA-00227 section 5.3.2.3
2.) TSFS table 12.1
3.) TSFS table 12.3

Design parameters low corrosion sensitive reinforcement (rebars):

$c_{min.dur}$: minimum cover with regard to environmental impact

$c_{min.b}$: minimum cover with regard to adhesion requirements

Δc_{dev} : execution tolerance

$c_{min} = \max(c_{min.b}; c_{min.dur}; 10mm)$: SS-EN 1992-1-1 eq. 4.2

$c_{nom} = c_{min} + \Delta c_{dev}$: SS-EN 1992-1-1 eq. 4.1, noted as BM on the drawing

Construction part	$c_{min.dur}$ [1.)]	$c_{min.b}$ [2.)]	c_{min}	c_{dev} [3.)]	c_{nom}	$w_{k,till}$ [4.)]
Substructure incl. linkplate:						
▫ Wingwall towards filling	30	20	30	10	40	0.20
▫ Wingwall from filling	30	20	30	10	40	0.20
▫ Abutement below ground	20	20	20	10	30	0.40
▫ Abutement in air	25	20	25	10	35	0.30
▫ Bottom slab in general	20	20	20	10	30	0.40
▫ Bottom slab underside	20	20	20	10	30	0.40
▫ Link slab in general	45	20	45	10	55	0.15
▫ Link slab underside	45	20	45	10	60 [5.)]	0.15
Superstructure:						
▫ Edge beam	45	20	45	10	55	0.15
▫ Bridge deck	25	20	25	10	35	0.20
▫ End shield towards filling	25	20	25	10	35	0.20
▫ End shield from filling	25	20	25	10	35	0.40

Footnotes:

1.) TSFS table 12.1

2.) SS-EN 1992-1-1 section 4.4.1.2 table 4.2

3.) SS-EN 1992-1-1 section 4.4.1.3

4.) TSFS tabele 12.2

5.) TSFS chapter 12 paragraph 3§ $k_1 = c_{min} + 15$ mm vhen casting against building foil.

Design parameters high corrosion sensitive reinforcement (pretension):

$c_{min.dur}$: minimum cover with regard to environmental impact

$c_{min.b}$: minimum cover with regard to adhesion requirements

Δc_{dev} : execution tolerance

$c_{min} = \max(c_{min.b}; c_{min.dur}; 10mm)$: SS-EN 1992-1-1 eq. 4.2

$c_{nom} = c_{min} + \Delta c_{dev}$: SS-EN 1992-1-1 eq. 4.1, noted as BM on the drawing

Construction part	$c_{min.dur}$ 1.)	$c_{min.b}$ 2.)	c_{min}	c_{dev} 3.)	c_{nom}	$w_{k,till}$ 4.)
Superstructure:						
▫ Top bridge deck	25	90	90	10	100	*
▫ Other part of bridge deck	25	90	90	10	100	*
	mm	mm	mm	mm	mm	mm

Footnotes:

1.) TSFS table 12.1

2.) SS-EN 1992-1-1 section 4.4.1.2 (3) specifies pretension tube ϕ90

3.) SS-EN 1992-1-1 section 4.4.1.3

4.) TSFS table 12.2 states that crack width is not needed when ”tensile stress” for SLS-F is less than $f_{ctk.0.05}/\zeta$

1.11 CONSTRUCTION STAGES

The construction of bridge is performed using free cantilever method (FCM).

A total of 7 stages with construction time seen below.

It is assumed that concrete is activated structurally after 60 days for piers (∴ CS 1), 15 days after upper part of piers (∴ CS 2) and 5 days for remining construction stages (∴ CS 3 → CS 26).

Construction time is 60 days for piers (∴ CS 1), 10 days after upper part of piers (∴ CS 2) and 6 days for remining construction stages (∴ CS 3 → CS 26).

CS 1 (∴ Costruction Stage 1)
Time: 0 day → 60 day

C3_2
Time: 61 day → 66 day

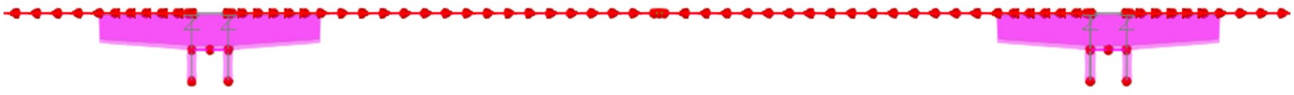
CS_3
Time: 67 day → 72 day

CS_4
Time: 73 day → 78 day

CS_5
Time: 79 day → 84 day

CS_6
Time: 85 day → 90 day

CS_7
Time: 91 day → 96 day



CS_8
Time: 97 day → 102 day

CS_9
Time: 103 day → 108 day

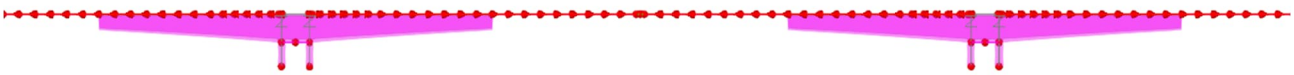
CS_10
Time: 109 day → 115 day

CS_11
Time: 116 day → 120 day

CS_12
Time: 121 day → 126 day

CS_13
Time: 127 day → 132 day

CS_14
Time: 133 day → 138 day



CS_15
Time: 139 day → 144 day

CS_16
Time: 145 day → 150 day

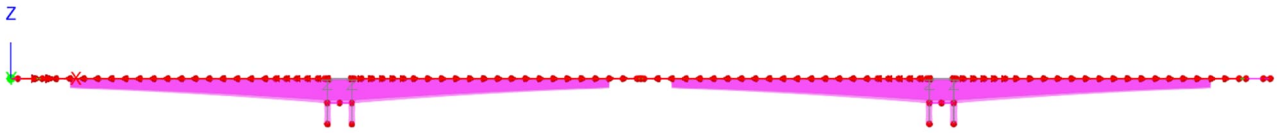
CS_17
Time: 151 day → 156 day

CS_18
Time: 157 day → 162 day

CS_19
Time: 163 day → 168 day

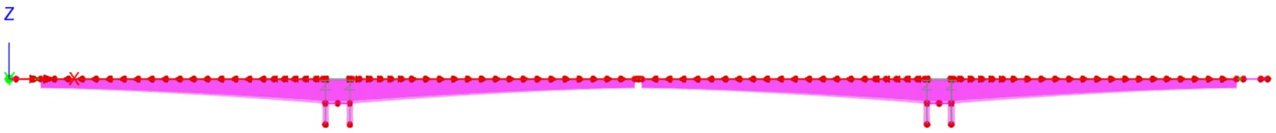
CS_20
Time: 169 day → 174 day

CS_21
Time: 175 day → 180 day

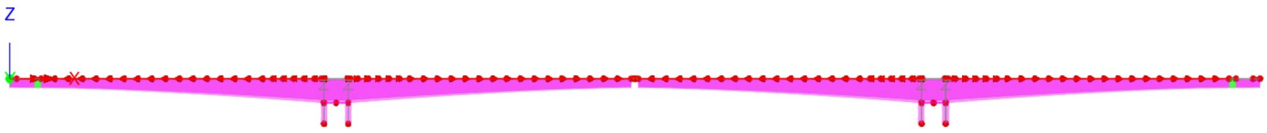


CS 22
Time: 181 day → 186 day

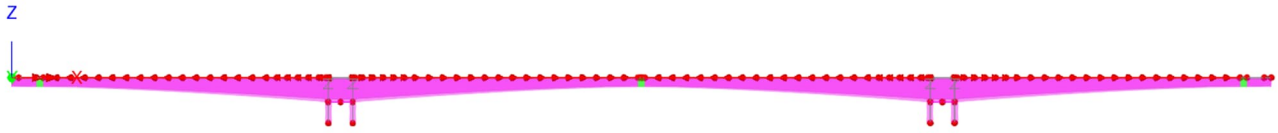
CS 23
Time: 187 day → 192 day



CS 24
Time: 193 day → 194 day



CS 25
Time: 195 day → 196 day



CS 26
Time: 197 day → 206 day

2. SYSTEM ANALYSIS

2.1 GENERAL

The pretensioned single box bridge constructed using a free cantilever method (FCM). The construction during 52 stages.

Entire structure is modelled with 3D-beam elements (BM21) a location of nodal lines.

Entire structure is modelled using isotropic material.

In system analysis gross cross section may be used for longitudinal beams in superstructure, see SS-EN 1992-1-1 section 5.3.2.1 (4).

The effect of creep and shrinkage is considered by applying times of construction stages.

During the 25 stages of construction a method of activation is applied.

In the model the static effect of edge beam is not considered according to technical practice since edge beams generally need replacement.

When determining the long-term effect of creep, shrinkage and relaxation 120 years is considered (∴ 43 800 days).

Superstructure has varying height from H = 2.70 m (∴ section 1) to H = 7.00 m (∴ section 2) long a distance of 81 m. This creates difficulty when interpolating torsional rigidity (J) since does not vary as H. To circumvent this issue no interpolation is made over a longer distance than 4 m. This results in several lines (21 lines) along the total distance of 81 m instead of only one.

When construction using free cantilever method (FCM) where end span (L = 94.25 m) is longer than 50 % of midspan length (L = 172.5 m) there is a need to introduce temporary supports at near end support at casting stage 24.

Connection between piers superstructure is rigid. Constraints are modelled using rigid link (joint element JSH4). Since nodal line of superstructure is located at top of deck a fictive “hinge” is added to rigid link at level of centroid.

Several different static models are applied depending on casting stage. The base analysis is the static linear model with entire structure active (= Analysis 2). During the casting stages part of superstructure are deactivated as seen in table below.

Stage	LC CS 1	LC CS 2	LC CS 3	LC CS 4	LC CS 5	LC CS 6	LC CS 7	Analysis
1	Active	Active	Active	Active	Active	Active	Active	1
2	Deactive	Active	Active	Active	Active	Active	Active	1
3	Deactive	Deactive	Active	Active	Active	Active	Active	1
4	Deactive	Deactive	Deactive	Active	Active	Active	Active	1
5	Deactive	Deactive	Deactive	Deactive	Active	Active	Active	1
6	Deactive	Deactive	Deactive	Deactive	Deactive	Active	Active	1
7	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
8	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
9	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
10	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
11	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
12	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
13	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
14	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
15	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
16	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
17	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
18	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
19	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
20	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
21	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
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24	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
25	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1

Table of construction stages
LC CS 1→ CS 7.

Stage	LC CS 8	LC CS 9	LC CS 10	LC CS 11	LC CS 12	LC CS 13	LC CS 14	Analysis
1	Active	Active	Active	Active	Active	Active	Active	1
2	Active	Active	Active	Active	Active	Active	Active	1
3	Active	Active	Active	Active	Active	Active	Active	1
4	Active	Active	Active	Active	Active	Active	Active	1
5	Active	Active	Active	Active	Active	Active	Active	1
6	Active	Active	Active	Active	Active	Active	Active	1
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11	Deactive	Deactive	Deactive	Active	Active	Active	Active	1
12	Deactive	Deactive	Deactive	Deactive	Active	Active	Active	1
13	Deactive	Deactive	Deactive	Deactive	Deactive	Active	Active	1
14	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Active	1
15	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
16	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
17	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
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23	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
24	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
25	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1

Table of construction stages
LC CS 8→ CS 14.

Stage	LC CS 16	LC CS 9	LC CS 17	LC CS 18	LC CS 19	LC CS 20	LC CS 21	Analysis
1	Active	Active	Active	Active	Active	Active	Active	1
2	Active	Active	Active	Active	Active	Active	Active	1
3	Active	Active	Active	Active	Active	Active	Active	1
4	Active	Active	Active	Active	Active	Active	Active	1
5	Active	Active	Active	Active	Active	Active	Active	1
6	Active	Active	Active	Active	Active	Active	Active	1
7	Active	Active	Active	Active	Active	Active	Active	1
8	Active	Active	Active	Active	Active	Active	Active	1
9	Active	Active	Active	Active	Active	Active	Active	1
10	Active	Active	Active	Active	Active	Active	Active	1
11	Active	Active	Active	Active	Active	Active	Active	1
12	Active	Active	Active	Active	Active	Active	Active	1
13	Active	Active	Active	Active	Active	Active	Active	1
14	Active	Active	Active	Active	Active	Active	Active	1
15	Active	Active	Active	Active	Active	Active	Active	1
16	Active	Active	Active	Active	Active	Active	Active	1
17	Deactive	Active	Active	Active	Active	Active	Active	1
18	Deactive	Deactive	Active	Active	Active	Active	Active	1
19	Deactive	Deactive	Deactive	Active	Active	Active	Active	1
20	Deactive	Deactive	Deactive	Deactive	Active	Active	Active	1
21	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Active	1
22	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
23	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
24	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1
25	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	Deactive	1

Table of construction stages

LC CS 15→ CS 21.

Stage	LC CS 22	LC CS 23	LC CS 24	LC CS 25	LC CS 26	LC Longterm	Analysis
1	Active	Active	Active	Active	Active	Active	1
2	Active	Active	Active	Active	Active	Active	1
3	Active	Active	Active	Active	Active	Active	1
4	Active	Active	Active	Active	Active	Active	1
5	Active	Active	Active	Active	Active	Active	1
6	Active	Active	Active	Active	Active	Active	1
7	Active	Active	Active	Active	Active	Active	1
8	Active	Active	Active	Active	Active	Active	1
9	Active	Active	Active	Active	Active	Active	1
10	Active	Active	Active	Active	Active	Active	1
11	Active	Active	Active	Active	Active	Active	1
12	Active	Active	Active	Active	Active	Active	1
13	Active	Active	Active	Active	Active	Active	1
14	Active	Active	Active	Active	Active	Active	1
15	Active	Active	Active	Active	Active	Active	1
16	Active	Active	Active	Active	Active	Active	1
17	Active	Active	Active	Active	Active	Active	1
18	Active	Active	Active	Active	Active	Active	1
19	Active	Active	Active	Active	Active	Active	1
20	Active	Active	Active	Active	Active	Active	1
21	Active	Active	Active	Active	Active	Active	1
22	Active	Active	Active	Active	Active	Active	1
23	Deactive	Active	Active	Active	Active	Active	1
24	Deactive	Deactive	Active	Active	Active	Active	1
25	Deactive	Deactive	Deactive	Active	Active	Active	1

Table of construction stages

LC CS 22→ CS 25 (& LC Longterm).

Stage	Surfacing	Variable loads	Analysis
1	Active	Active	2*
2	Active	Active	2*
3	Active	Active	2*
4	Active	Active	2*
5	Active	Active	2*
6	Active	Active	2*
7	Active	Active	2*
8	Active	Active	2*
9	Active	Active	2*
10	Active	Active	2*
11	Active	Active	2*
12	Active	Active	2*
13	Active	Active	2*
14	Active	Active	2*
15	Active	Active	2*
16	Active	Active	2*
17	Active	Active	2*
18	Active	Active	2*
19	Active	Active	2*
20	Active	Active	2*
21	Active	Active	2*
22	Active	Active	2*
23	Active	Active	2*
24	Active	Active	2*
25	Active	Active	2*

Table of operation stages
(* = Base analysis)

Appendices:

Appendix	Name
1	Input receipt
2	Results reactions
3	Results piers
4	Results superstructure

2.2 SKETCH SYSTEM ANALYSIS

2.2.1 Geometry

To describe geometry first POINTS are defined.

Beam elements are defined by applying attributes to LINES.

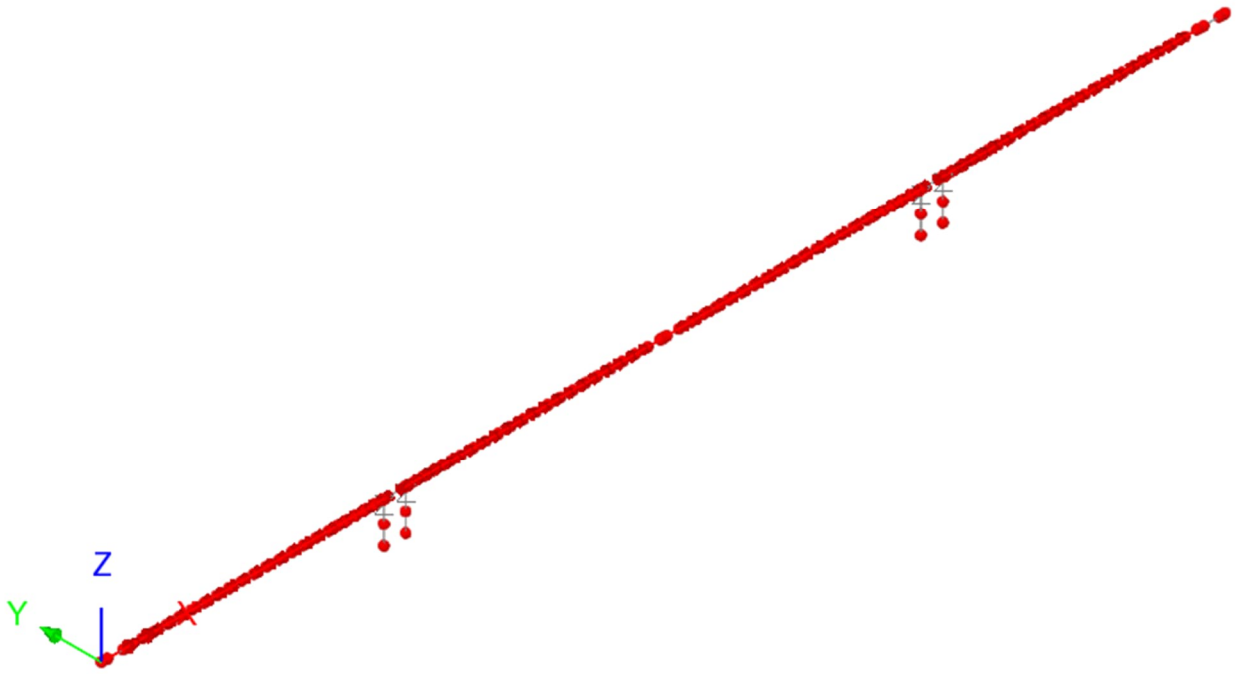
Attached pictures are retrieved from graphical sketches generated by FEM program of POINTS and LINES.

All coordinates needed to describe POINTS are found in Appendix 1.

All POINTS needed to describe LINES are found in Appendix 1.

Overview :

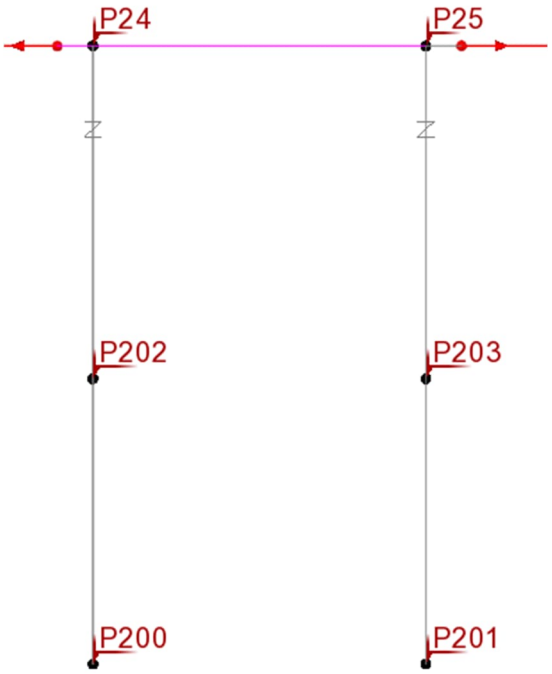
ELVEVATION



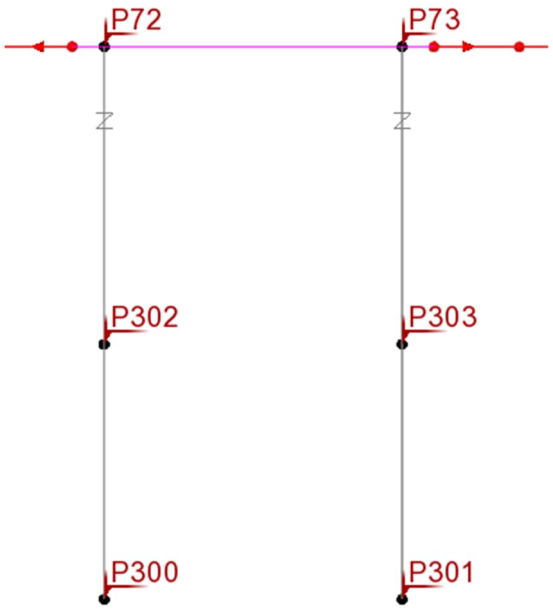
3D VIEW

2.2.1.1 Geometry : POINTS

Pier – support 2 :

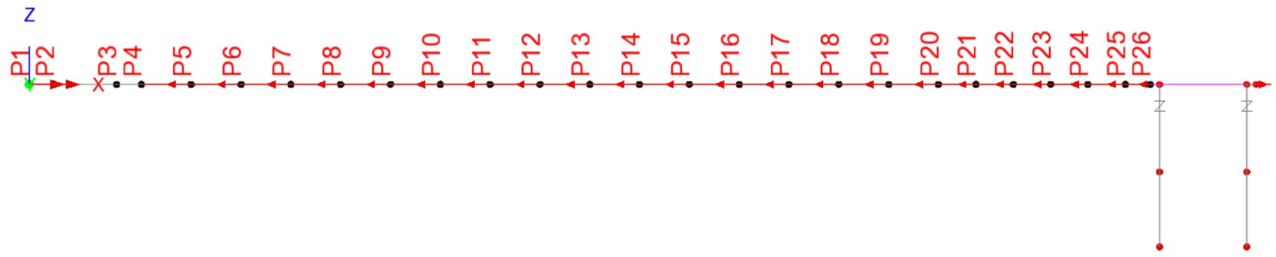


Pier – support 3 :

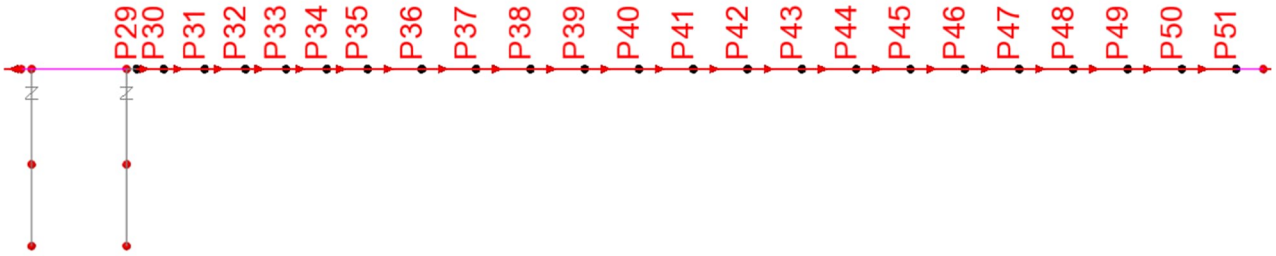


Remark
See direction local coordinate system.

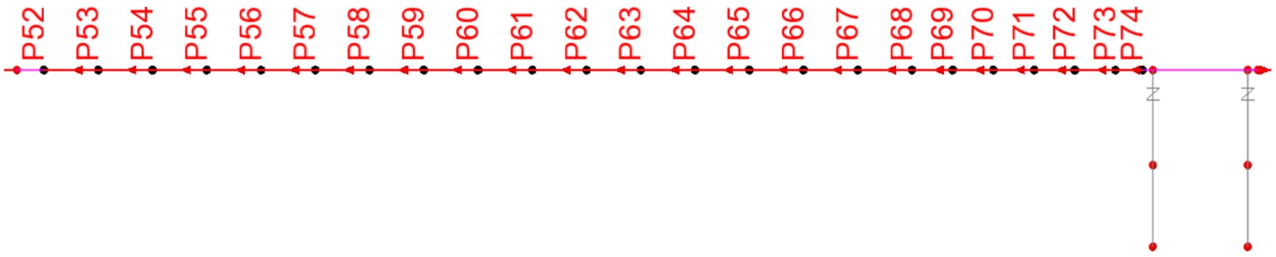
Superstructure :



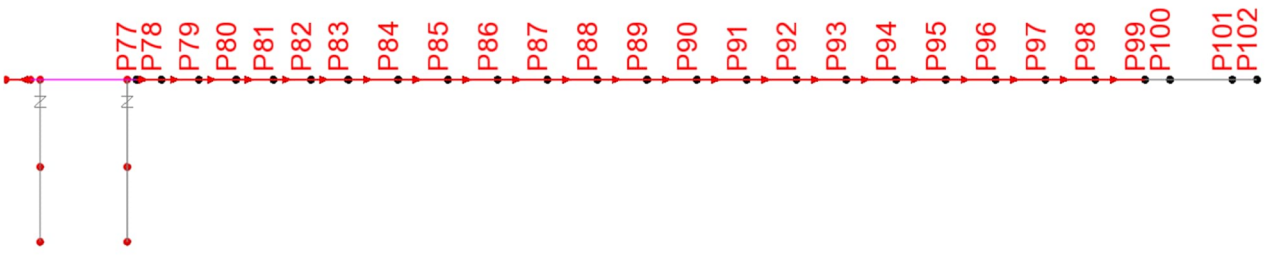
ELEVATION
Span 1-2



ELEVATION
Span 2-3: left



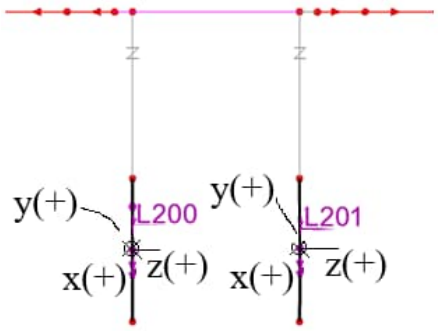
ELEVATION
Span 2-3: right



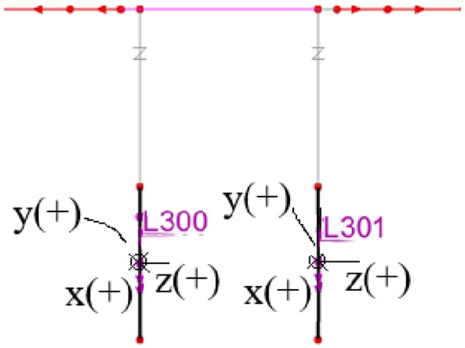
ELEVATION
Span 3-4

2.2.1.2 Geometry : LINES

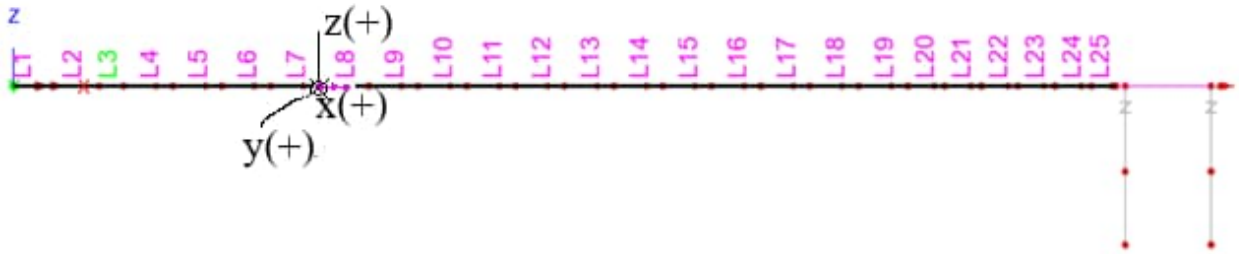
Pier – support 2 :



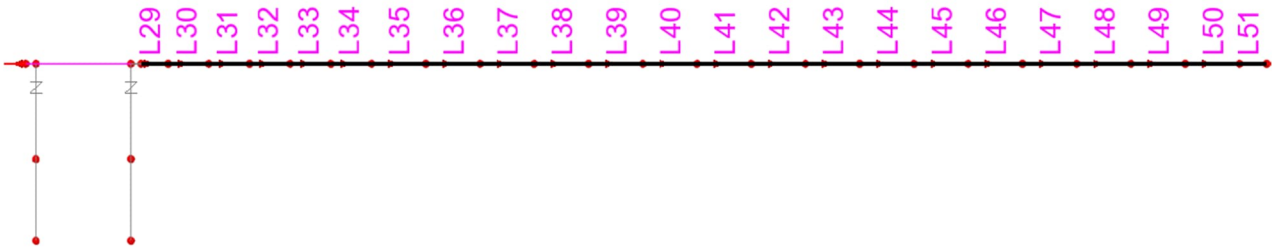
Pier – support 3 :



Superstructure :



ELEVATION
Span 1-2



ELEVATION
Span 2-3: left

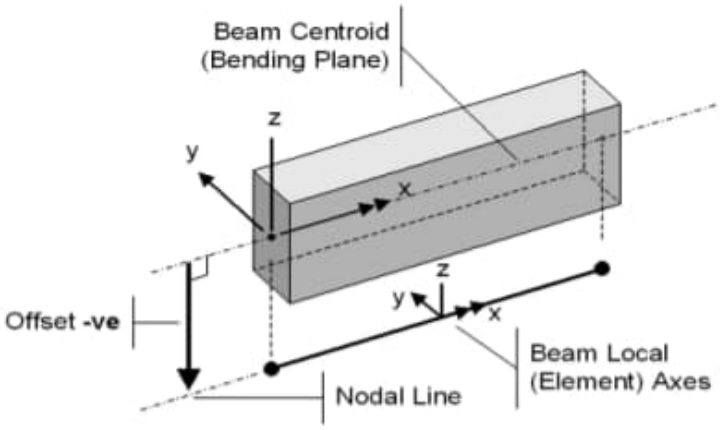
ELEVATION
Span 2-3: right

ELEVATION
Span 3-4

2.3 CROSS SECTION PROPERTIES

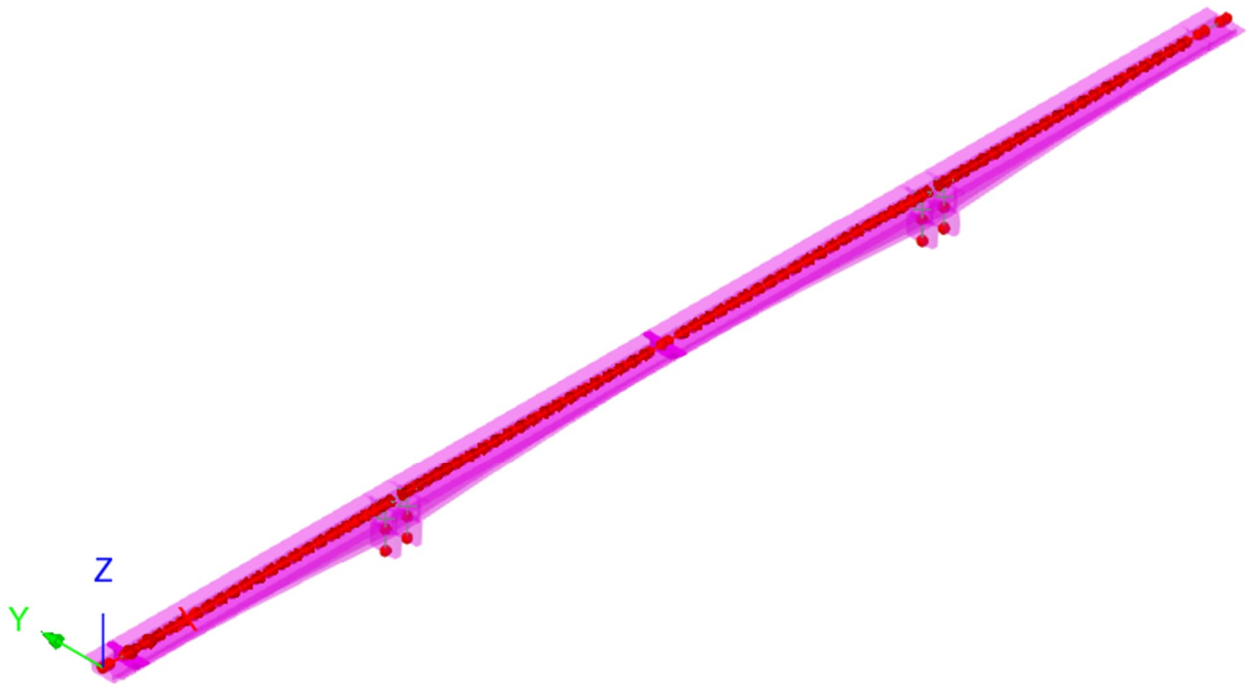
The structure only contain 3D-beams (”Thick beam” / BMS3).

Principal sketch of geometry associated to 3D beam elements are seen below.



Principal sketch
3D-element

Overview 2D
Graphic visualization



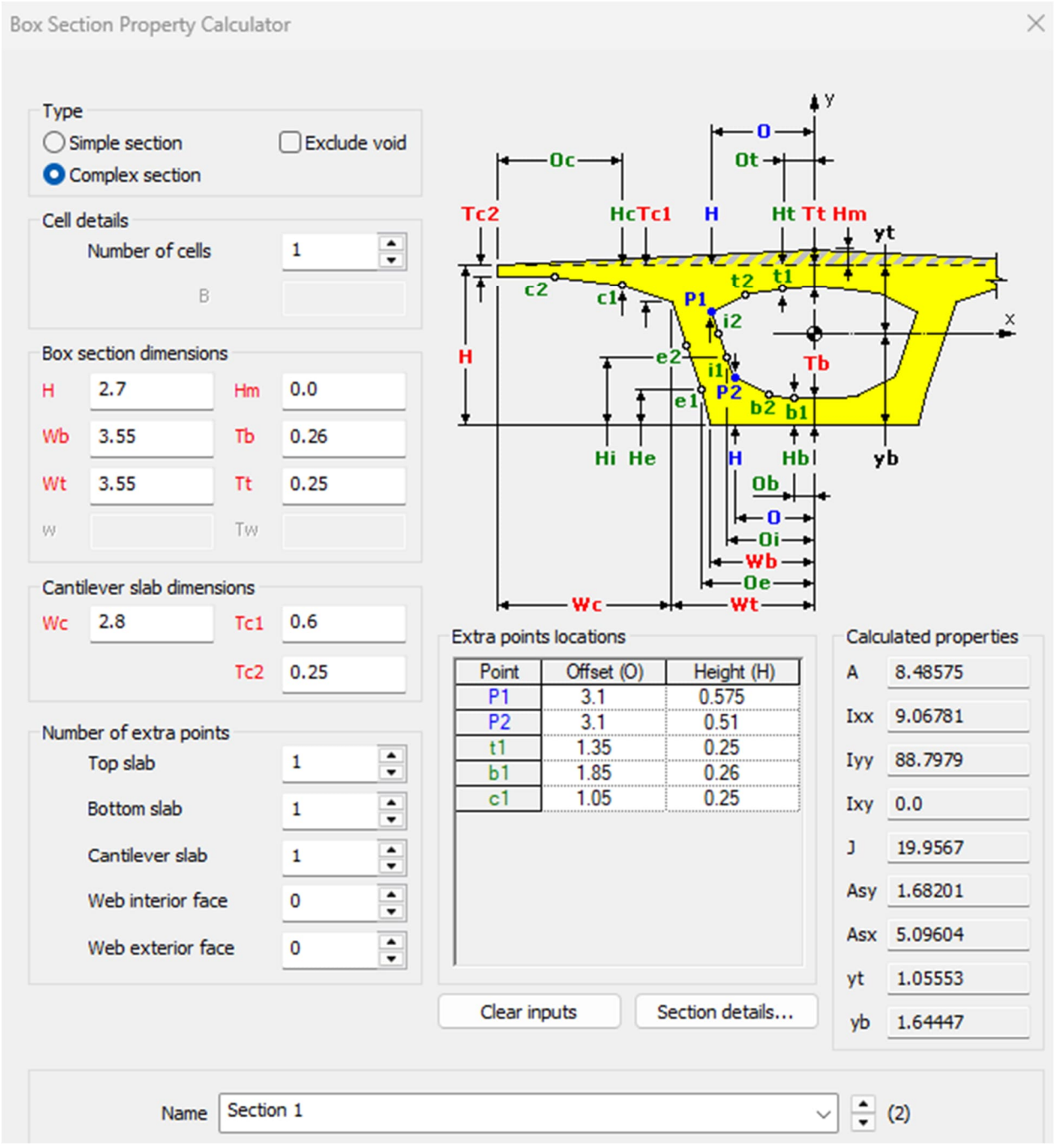
Overview 3D
Graphic visualization

2.3.1 Definition cross sections

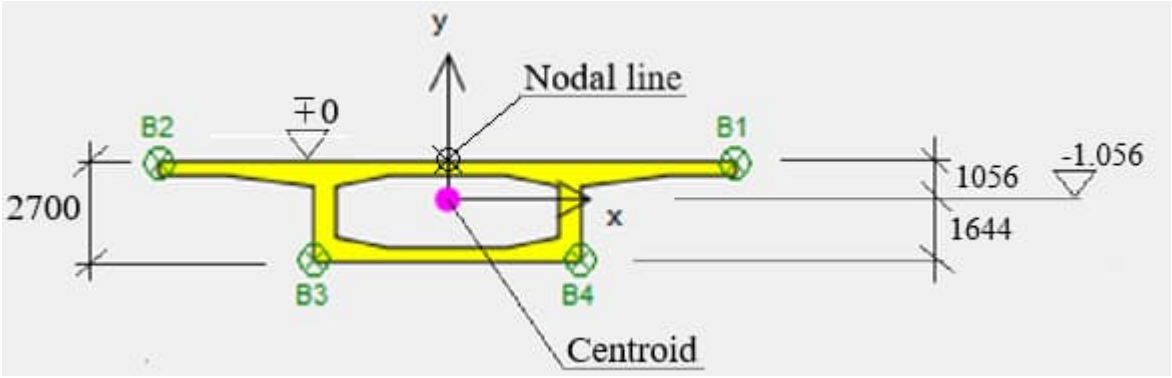
2.3.1.1 Section 1 (superstructure - H = 2.20 m)

The geometry seen below is used to calculate cross section properties.

Input measurements (see page A1:4):



Results section properties:



Cross section properties

Section Details

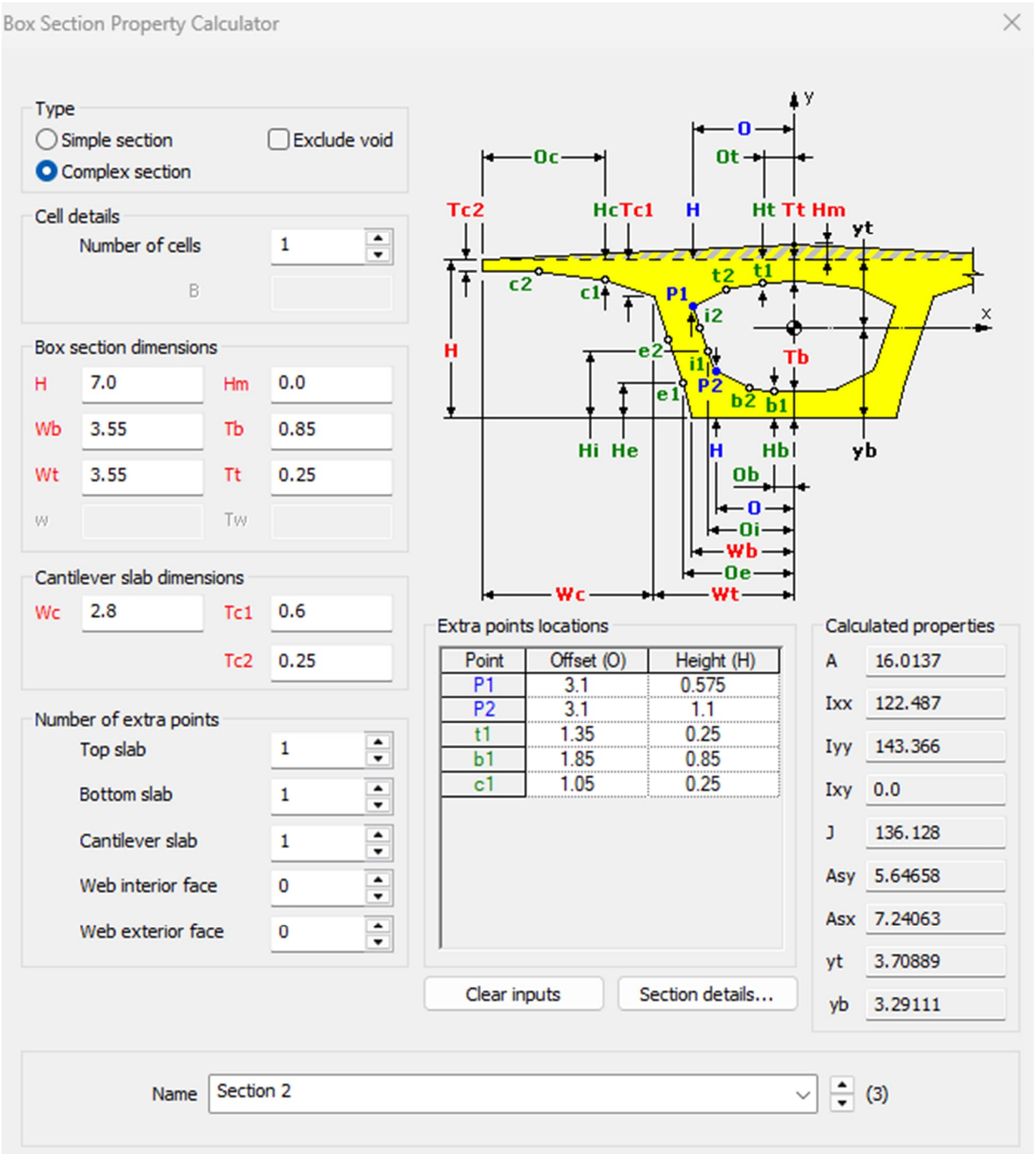
Calculated properties

		Value
Cross sectional area	A	8.48575
Second moment of area about x axis	Ixx	9.06781
Second moment of area about y axis	Iyy	88.7979
Product moment of area	Ixy	0.0
Torsional constant	J	19.9567
Effective shear area in x direction	Asx	5.09604
Effective shear area in y direction	Asy	1.68201
Radius of gyration about x axis	kx	1.03373
Radius of gyration about y axis	ky	3.23487
Warping torsional constant about shear centre	Cw	24.3584
Shear centre x distance from centroid	xo	0.0
Shear centre y distance from centroid	yo	-0.379164
Monosymmetry constant about x	betax	3.37534
Monosymmetry constant about y	betay	0.0
Wagner constant 1st moment of square radius about x	Ixr	23.7322
Wagner constant 1st moment of square radius about y	Iyr	29.6565E-12
Wagner constant 4th moment of area about origin	Irr	1.73493E3
Wagner constant 2nd moment of warping about origin	Iwr	-72.8571E-6
Plastic section modulus about x axis	Zpx	7.46032
Plastic section modulus about y axis	Zpy	24.7124
Plastic torsional section modulus	Zpt	15.7484
Plastic neutral axis, distance from centroid along x axis	xp	0.0
Plastic neutral axis, distance from centroid along y axis	yp	0.629717

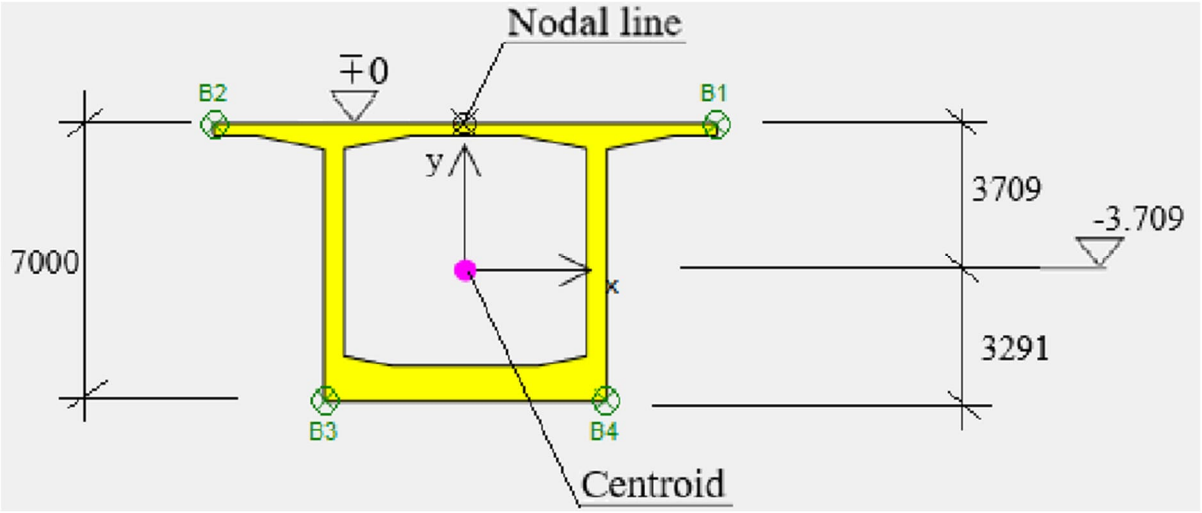
2.3.1.2 Section 2 (superstructure - H = 7.0 m)

The geometry seen below is used to calculate cross section properties.

Input measurements (see page A1:5):



Results section properties:



Cross section properties

Section Details

Calculated properties

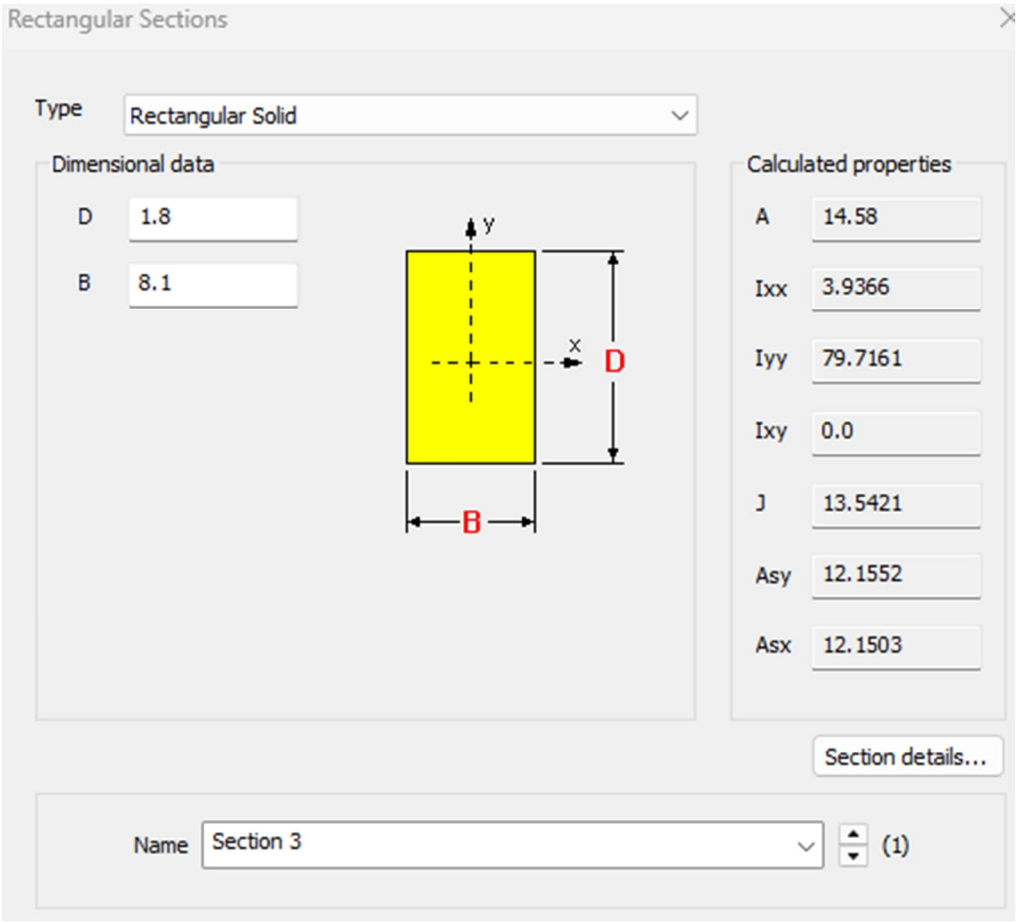
		Value
Cross sectional area	A	16.0137
Second moment of area about x axis	Ixx	122.487
Second moment of area about y axis	Iyy	143.366
Product moment of area	Ixy	0.0
Torsional constant	J	136.128
Effective shear area in x direction	Asx	7.24063
Effective shear area in y direction	Asy	5.64658
Radius of gyration about x axis	kx	2.76565
Radius of gyration about y axis	ky	2.99211
Warping torsional constant about shear centre	Cw	81.4629
Shear centre x distance from centroid	xo	0.0
Shear centre y distance from centroid	yo	-0.823051
Monosymmetry constant about x	betax	3.42725
Monosymmetry constant about y	betay	0.0
Wagner constant 1st moment of square radius about x	Ixr	218.172
Wagner constant 1st moment of square radius about y	Iyr	-0.112437E-9
Wagner constant 4th moment of area about origin	Irr	5.5589E3
Wagner constant 2nd moment of warping about origin	Iwr	-3.72957E-3
Plastic section modulus about x axis	Zpx	41.1095
Plastic section modulus about y axis	Zpy	43.2501
Plastic torsional section modulus	Zpt	50.2356
Plastic neutral axis, distance from centroid along x axis	xp	0.0
Plastic neutral axis, distance from centroid along y axis	yp	-0.597325

Location shear centre (SC) from top of deck → 3.71 m + yo = 2.89 m

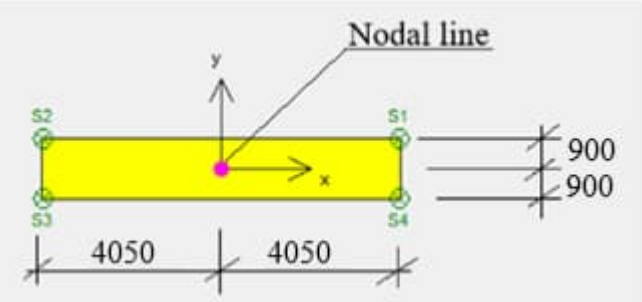
2.3.1.3 Section 3 (rectangular: B x H = 6000 x 1000)

The geometry seen below is used to calculate cross section properties.

Input measurements (see page A1:6):



Cross section properties



Cross section properties

Section Details

Calculated properties

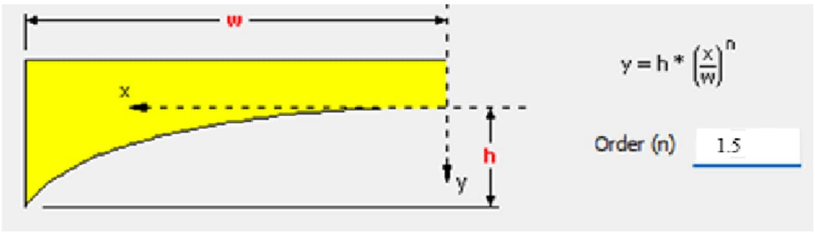
		Value
Cross sectional area	A	14.58
Second moment of area about x axis	Ixx	3.9366
Second moment of area about y axis	Iyy	79.7161
Product moment of area	Ixy	0.0
Torsional constant	J	13.5421
Effective shear area in x direction	Asx	12.1503
Effective shear area in y direction	Asy	12.1552
Radius of gyration about x axis	kx	0.519615
Radius of gyration about y axis	ky	2.33827
Warping torsional constant about shear centre	Cw	17.5045
Shear centre x distance from centroid	xo	0.0
Shear centre y distance from centroid	yo	0.0
Monosymmetry constant about x	betax	0.0
Monosymmetry constant about y	betay	0.0
Wagner constant 1st moment of square radius about x	Ixr	-4.16539E-15
Wagner constant 1st moment of square radius about y	Iyr	0.233966E-12
Wagner constant 4th moment of area about origin	Irr	829.486
Wagner constant 2nd moment of warping about origin	Iwr	-35.1142E-12
Plastic section modulus about x axis	Zpx	6.561
Plastic section modulus about y axis	Zpy	29.5245
Plastic torsional section modulus	Zpt	16.5698
Plastic neutral axis, distance from centroid along x axis	xp	0.0
Plastic neutral axis, distance from centroid along y axis	yp	0.0

2.3.2 Superstructure: span left side pier 2

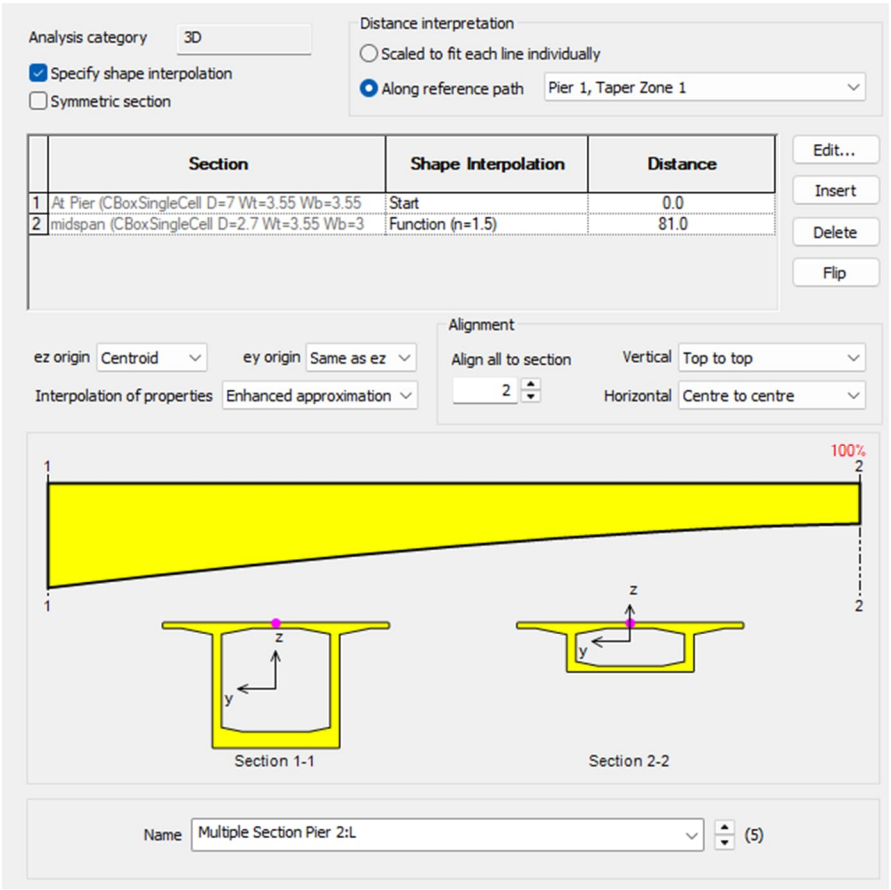
Beam is tapered with section varying with function seen below from section 1 → section 2.

ELEVATION

Function:

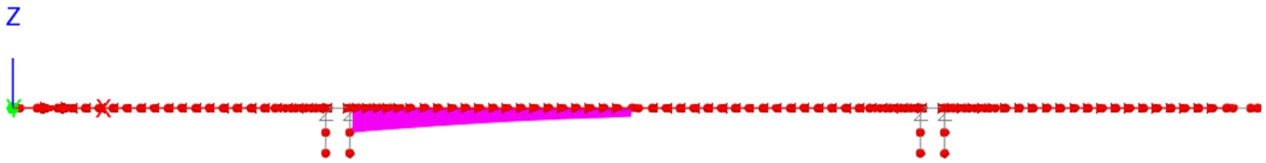


Multiple varying section:



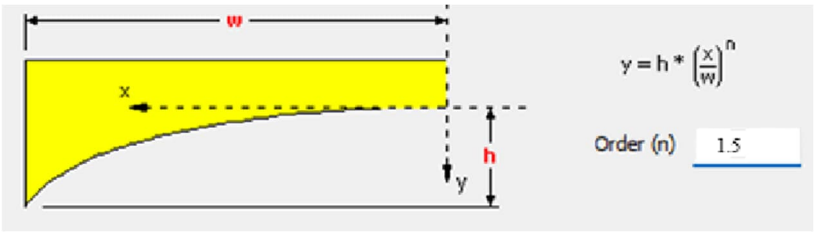
2.3.2 Superstructure: span right side pier 2

Beam is tapered with section varying with function seen below from section 1 → section 2.

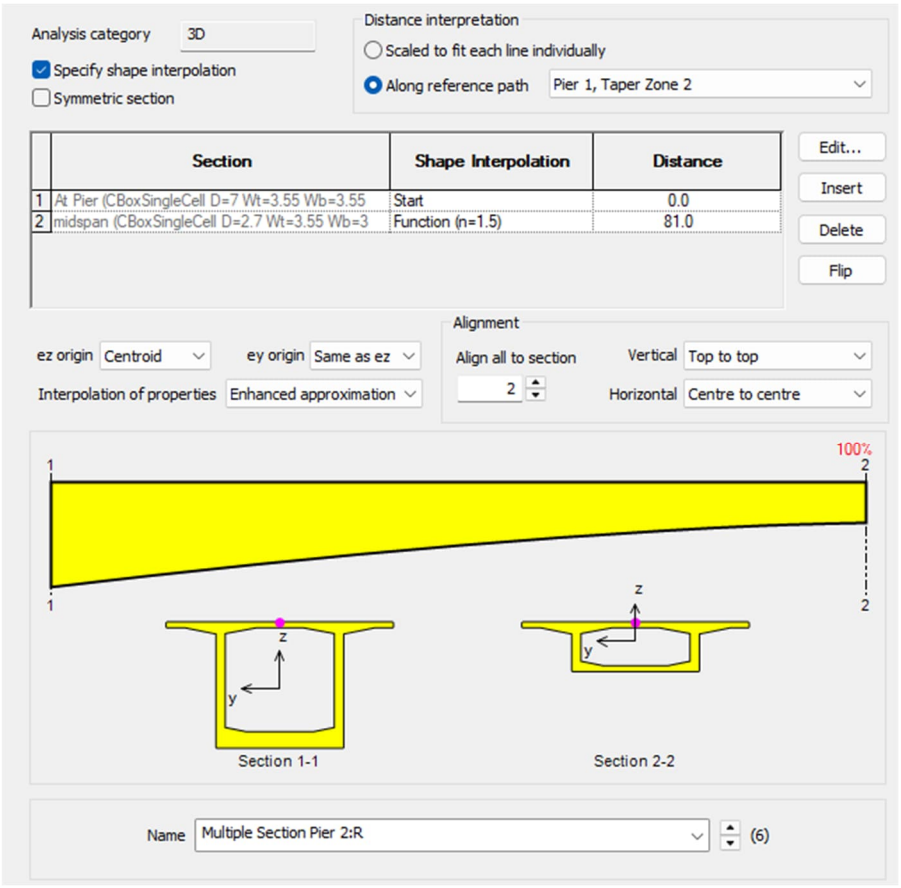


ELEVATION

Function:

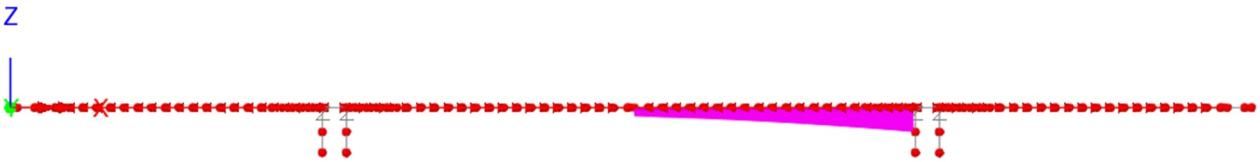


Multiple varying section:



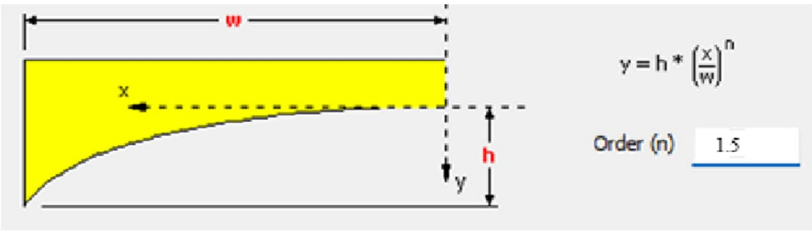
2.3.3 Superstructure: span left side pier 3

Beam is tapered with section varying with function seen below from section 1 → section 2.

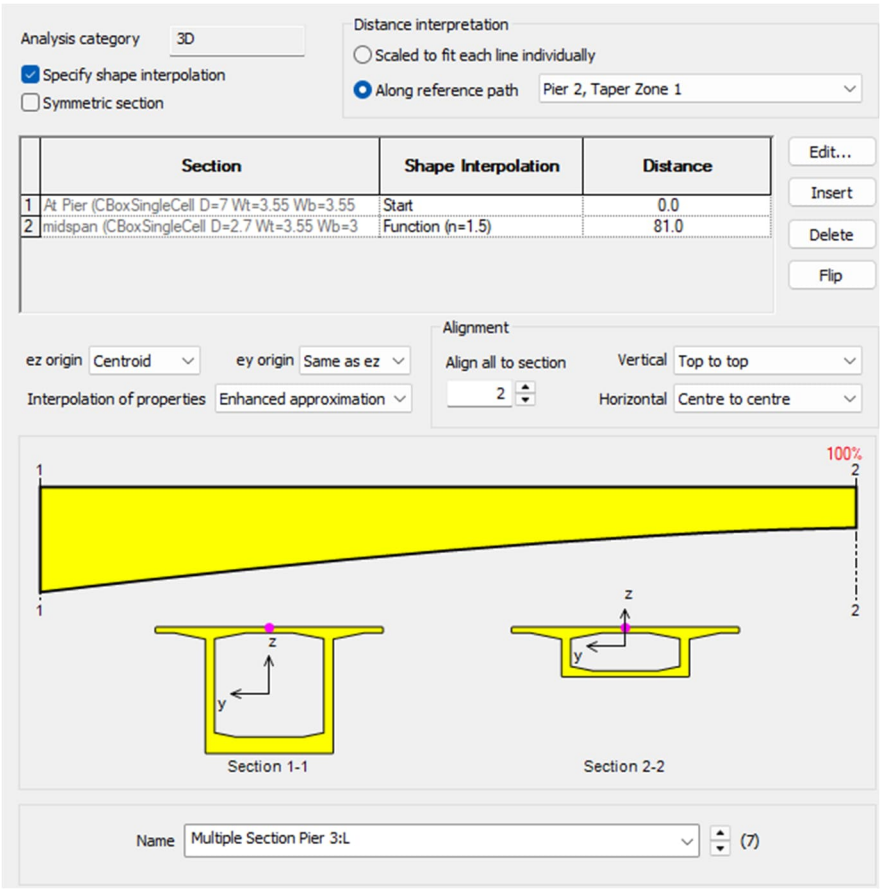


ELEVATION

Function:



Multiple varying section:

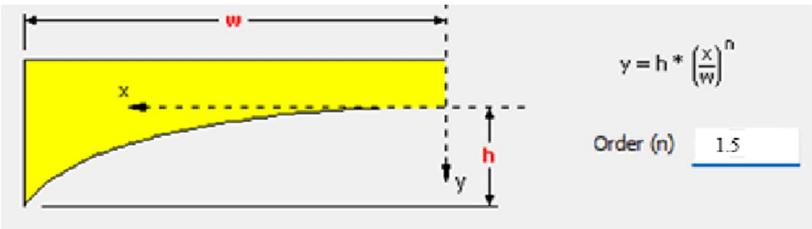


2.3.4 Superstructure: span right side pier 3

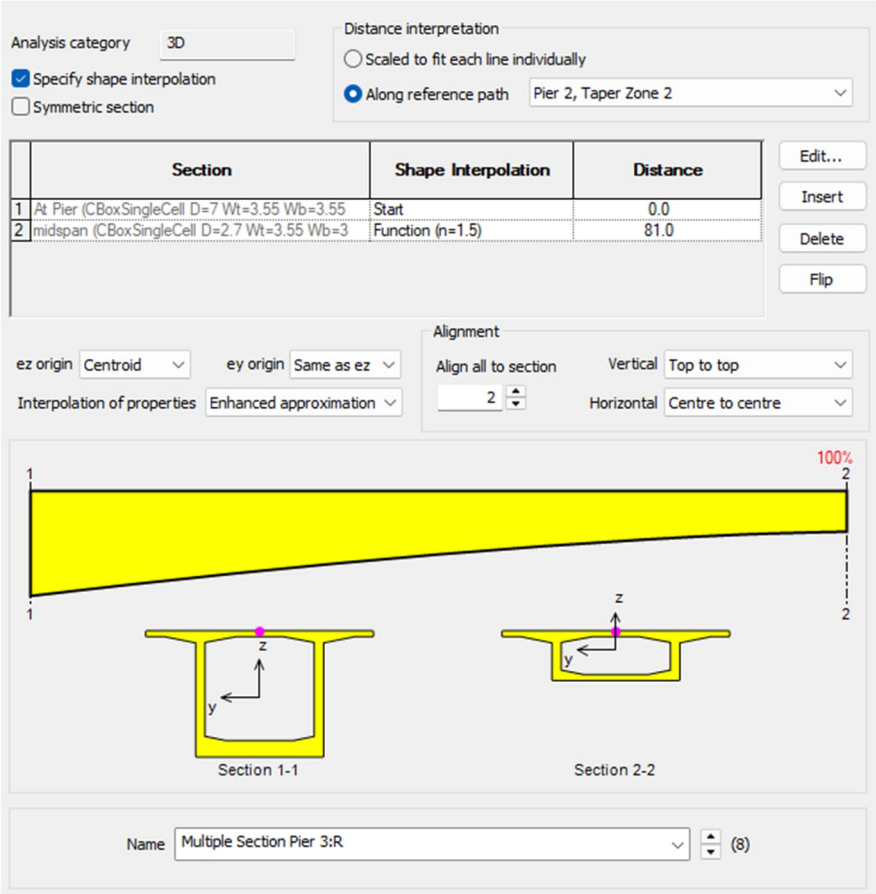
Beam is tapered with section varying with function seen below from section 1 → section 2.

ELEVATION

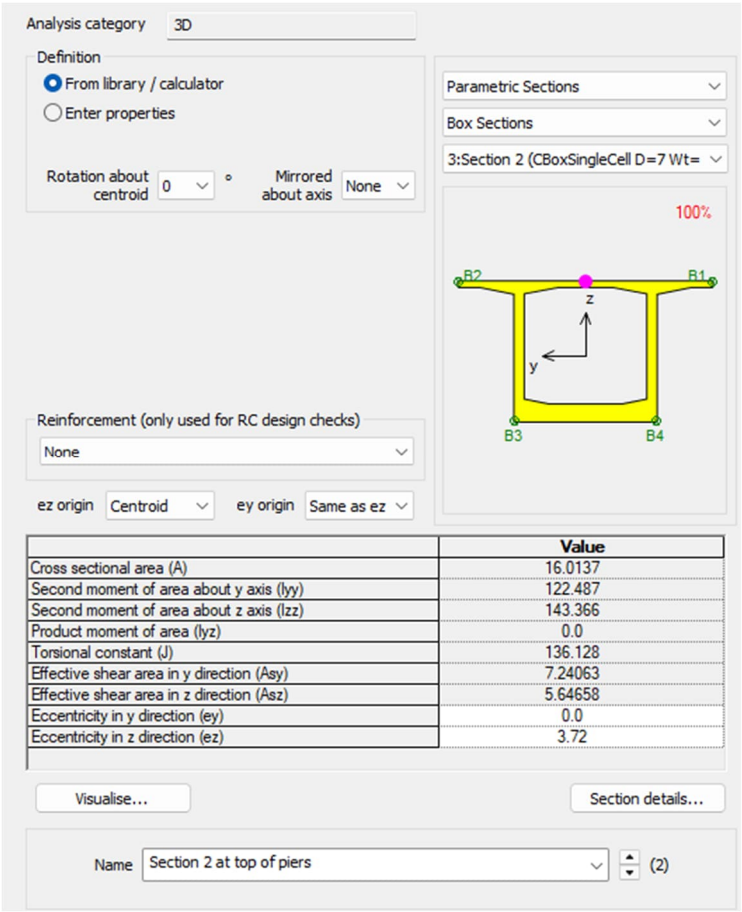
Function:



Multiple varying section:

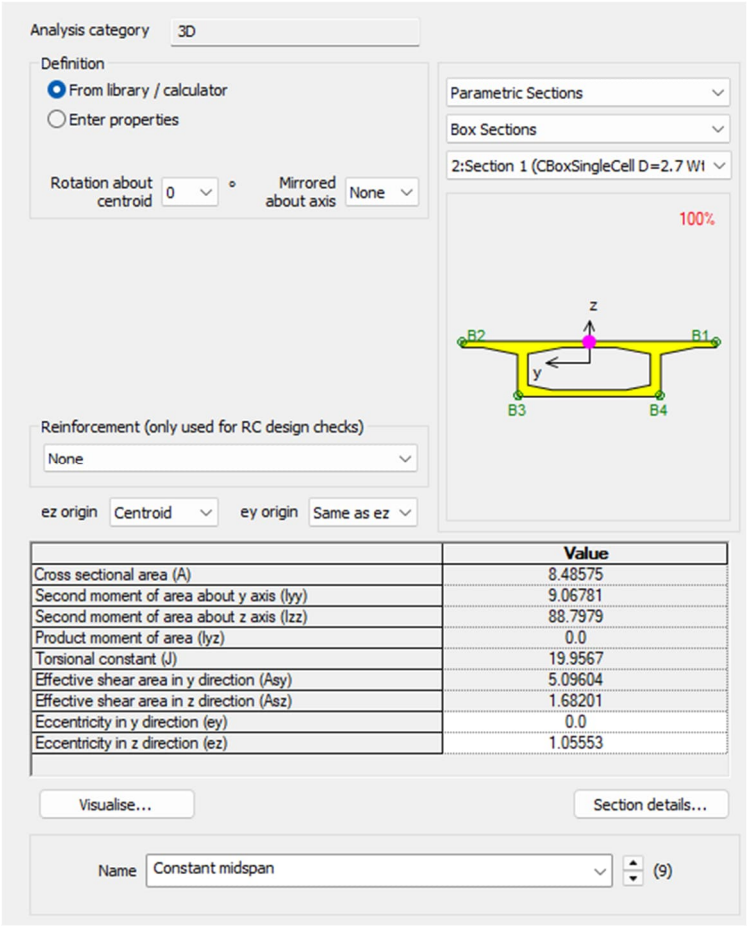


2.3.5 Superstructure: on top of pier

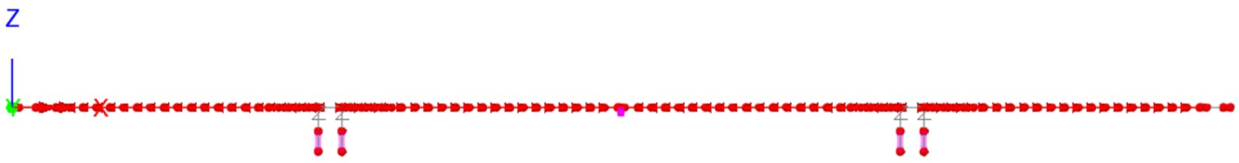


ELEVATION

2.3.6 Superstructure: constant height midspan

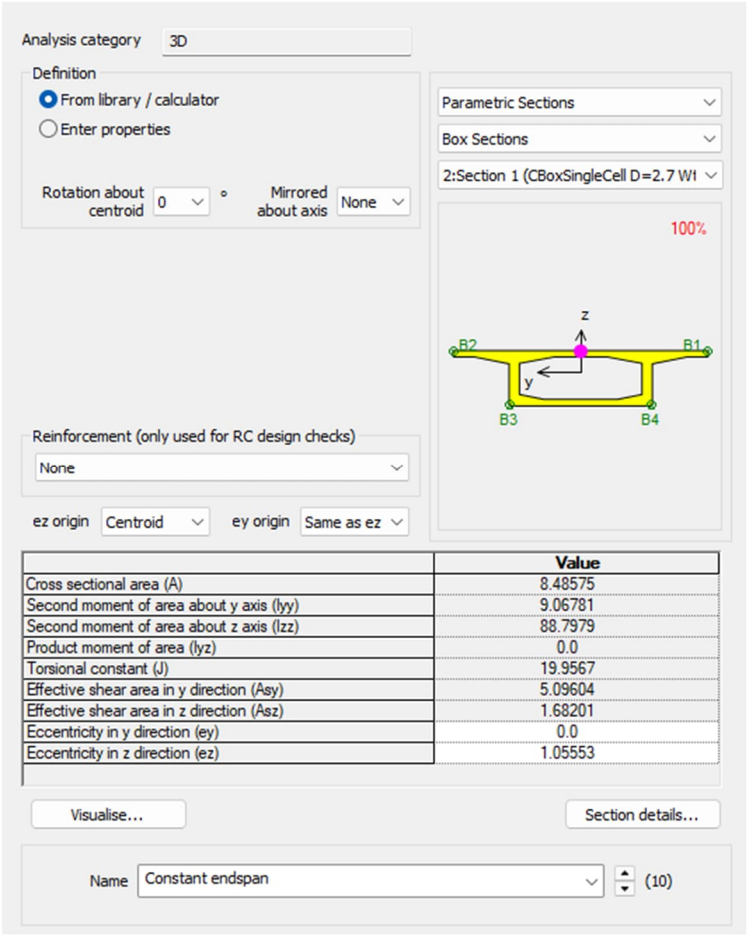


	Value
Cross sectional area (A)	8.48575
Second moment of area about y axis (Iyy)	9.06781
Second moment of area about z axis (Izz)	88.7979
Product moment of area (Iyz)	0.0
Torsional constant (J)	19.9567
Effective shear area in y direction (Asy)	5.09604
Effective shear area in z direction (Asz)	1.68201
Eccentricity in y direction (ey)	0.0
Eccentricity in z direction (ez)	1.05553



ELEVATION

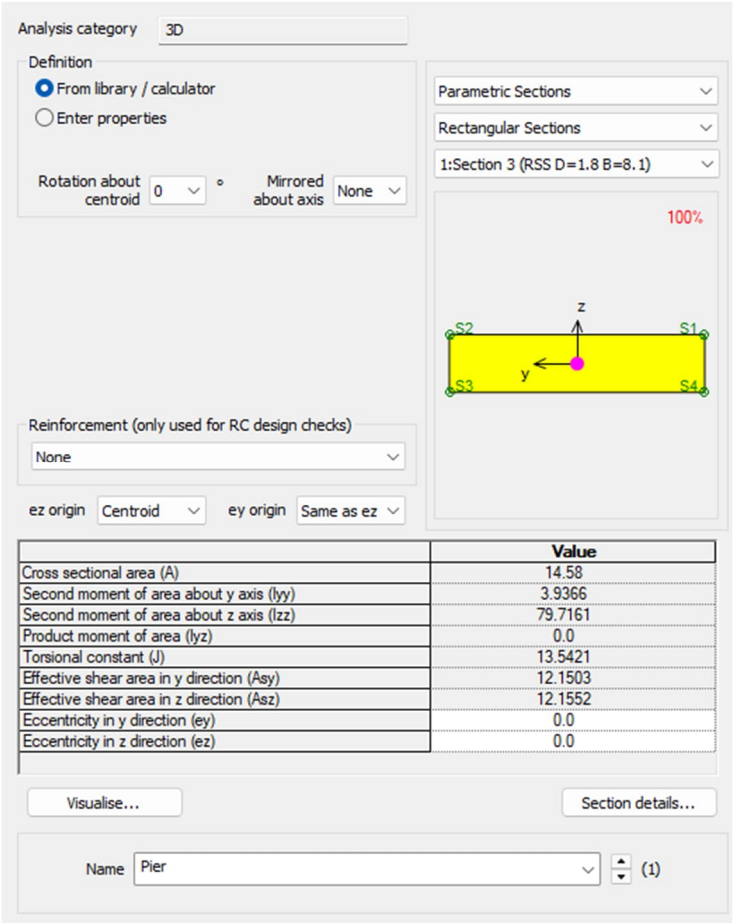
2.3.7 Superstructure: constant height endspan



	Value
Cross sectional area (A)	8.48575
Second moment of area about y axis (Iyy)	9.06781
Second moment of area about z axis (Izz)	88.7979
Product moment of area (Iyz)	0.0
Torsional constant (J)	19.9567
Effective shear area in y direction (Asy)	5.09604
Effective shear area in z direction (Asz)	1.68201
Eccentricity in y direction (ey)	0.0
Eccentricity in z direction (ez)	1.05553

ELEVATION

2.3.8 Pier

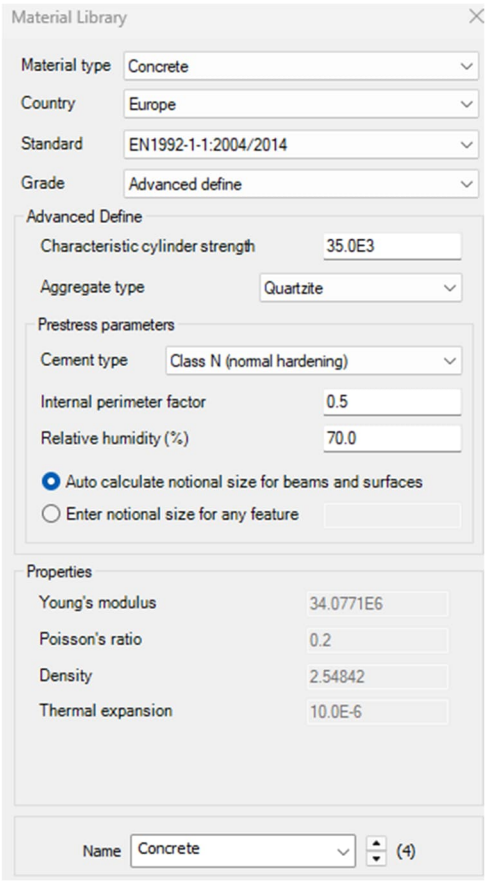


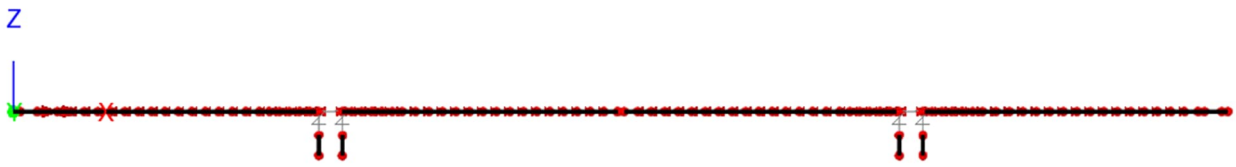
ELEVATION

2.4 MATERIAL

Material properties seen below are to be used. Relative humidity (RH) 80 % is used to determine creep and shrinkage. according to SS-EN 1992-1-1.

Concrete C35/45 : E_{cm} = 34 GPa



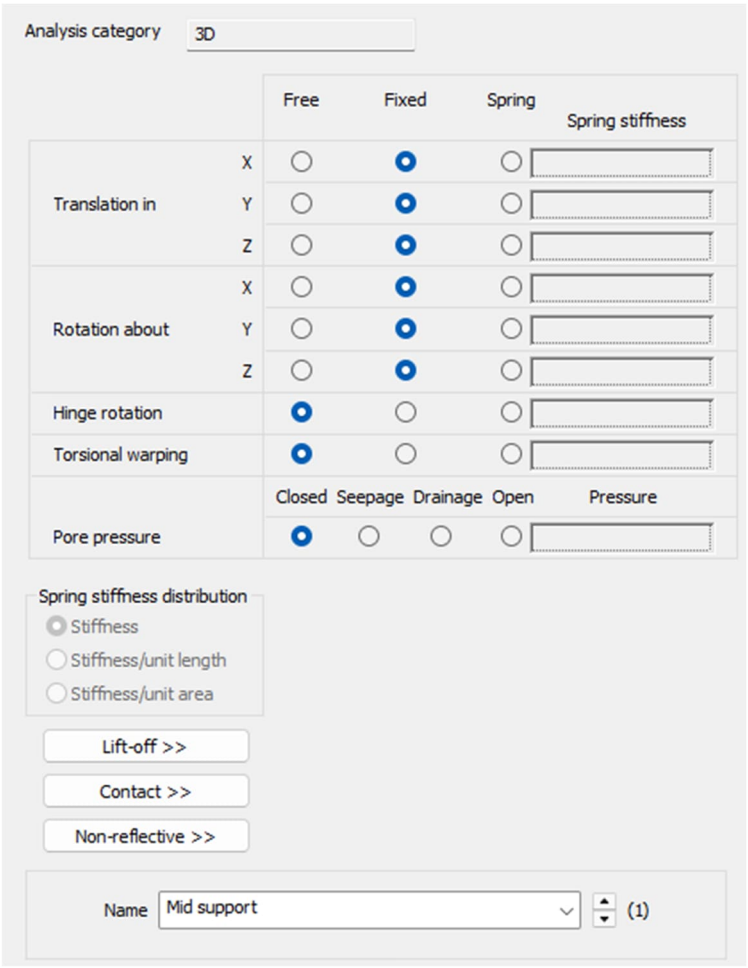


ELEVATION

2.5 BOUNDARY CONDITIONS

2.5.1 Mid supports

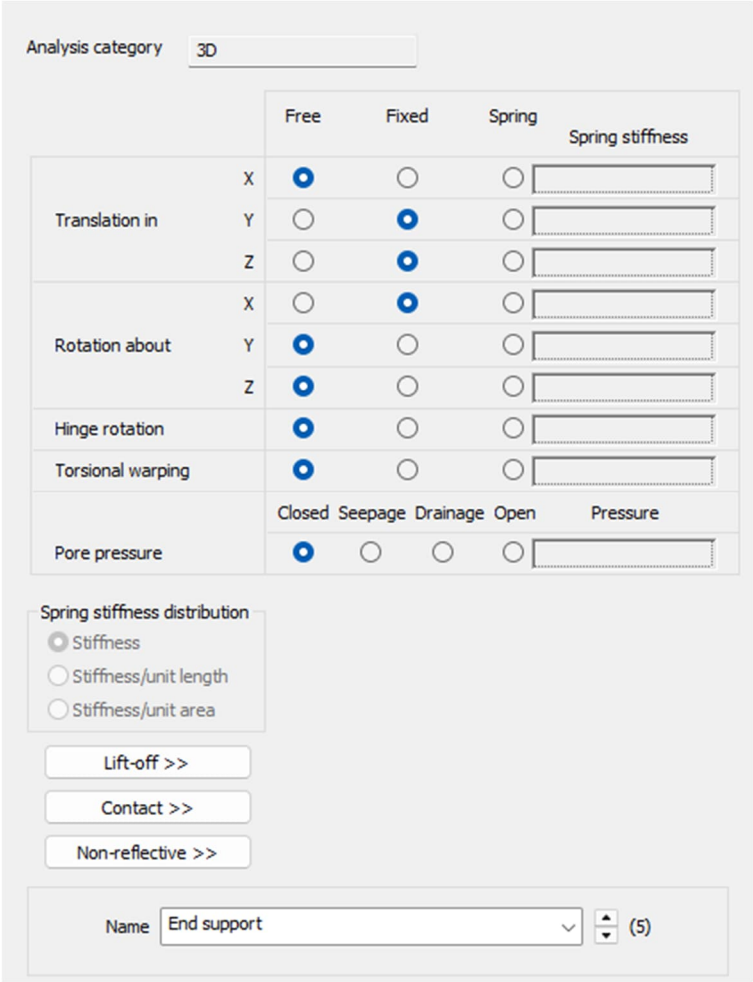
At points P200, P201, P300 & P301 boundary condition seen below is applied.



ELEVATION

2.5.2 End supports

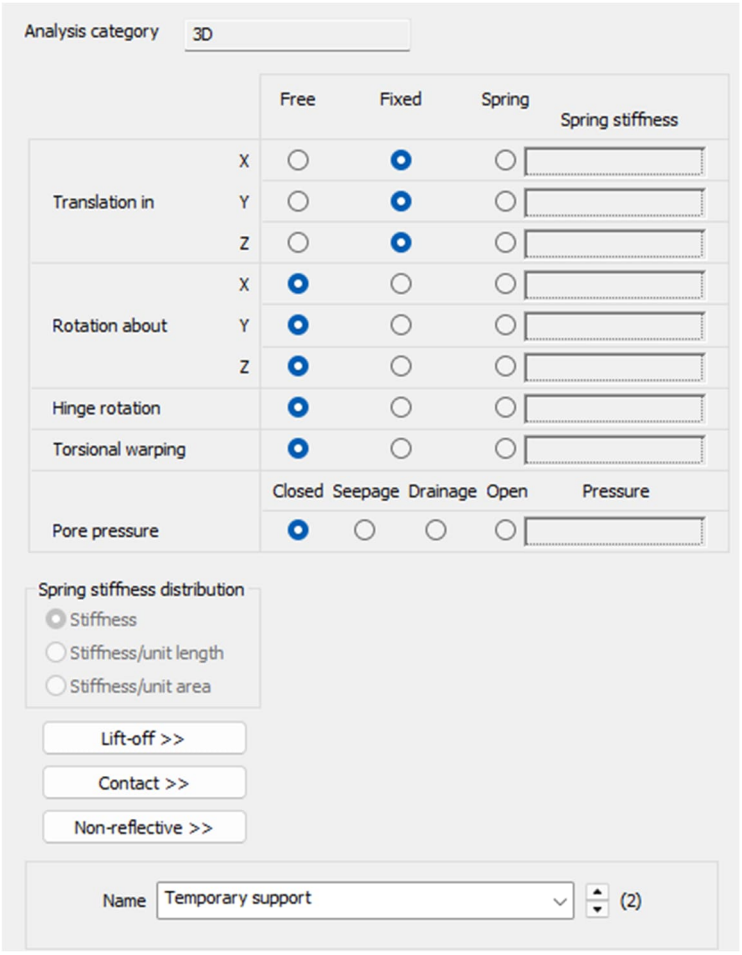
At points P1 & P102 boundary condition seen below is applied.

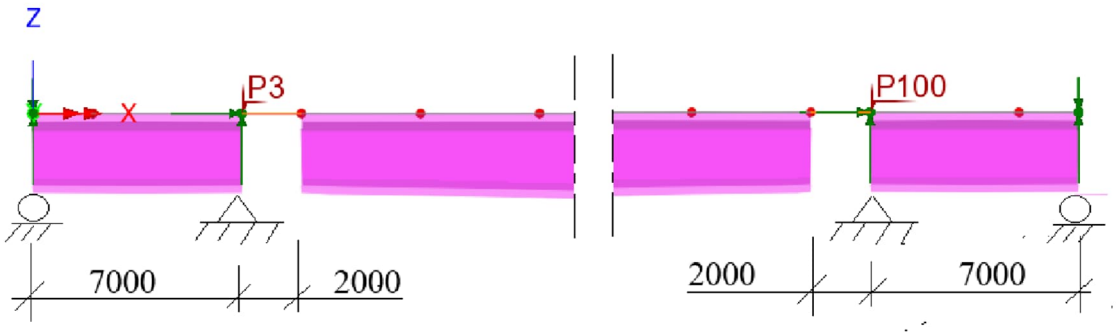


ELEVATION

2.5.
3 Temporary supports

During casting stage 24 there is a need of temporary supports at points 31 & P100.





Remark

This support is “removed” in casting stage 25 by adding fictive support using with free movement in all directions. The boundary condition is termed “Removal temporary support”.

2.6 MESH

2.6.1 Line elements

Linear beams elements (BM21) are with various subdivisions as seen below.

Typ	Divisions	End release: Start	End release: End
Element 1	1	None	None

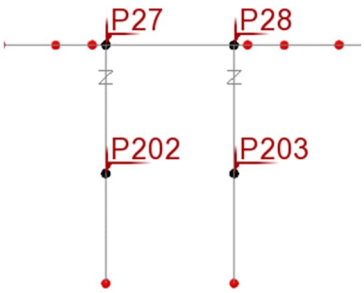
ELEVATION

2.6.2 Point elements

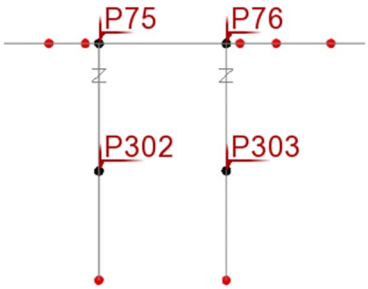
Point elements are used to tie superstructure with piers (∴ support 2 & 3) acting as “rigid links”.

FEM-elememts:

Rigid joint element (JSH4) are used to tie superstructure with piers. “Primary node” is located at top of superstructure, while “secondary node” is located at top of pier, se sketches below.



ELEVATION
Support 2



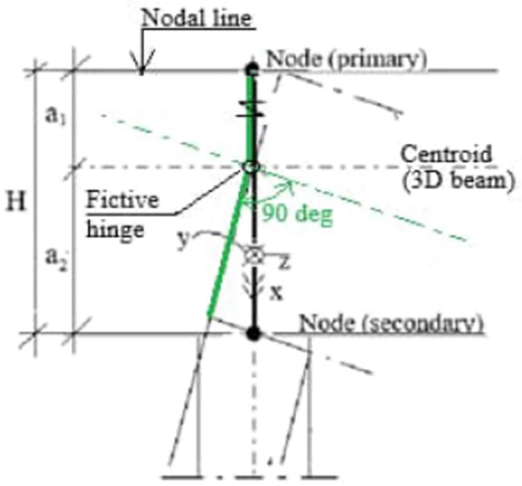
ELEVATION
Support 3

Material properties (JSH4):

“Rigid link” is modelled using rigid springs as seen in table below.

Geometric properties:

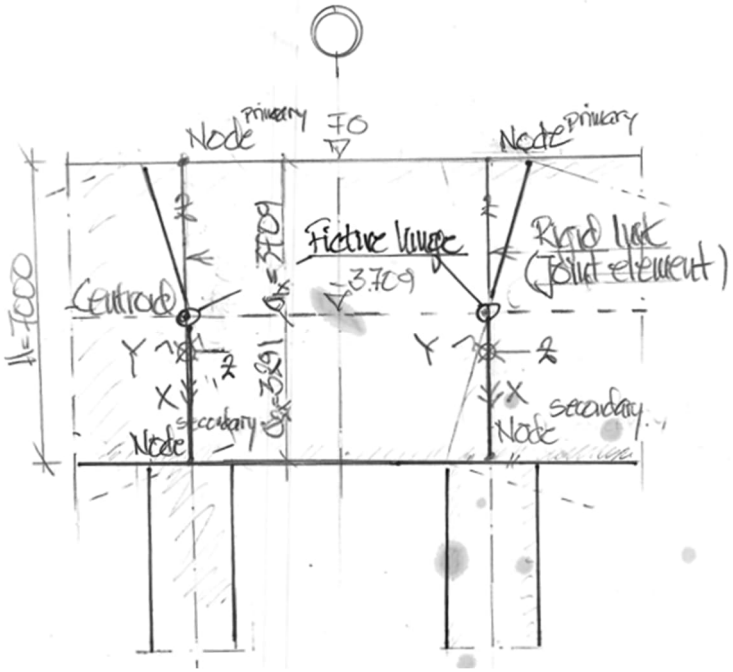
The superstructure has nodal line located at top of deck instead of a level centroid fictive “hinge” is added at level of centroid, see sketch belpw.



Prometric distance to fictive “hinge” from primary node:

$\eta_y = \frac{a_{1y}}{H} = \frac{2.89m}{7.0m} = 0.41$: transversal direction (shear centre)

$\eta_z = \frac{a_{1x}}{H} = \frac{3.71m}{7.0m} = 0.53$: longitudinal direction (centroid)

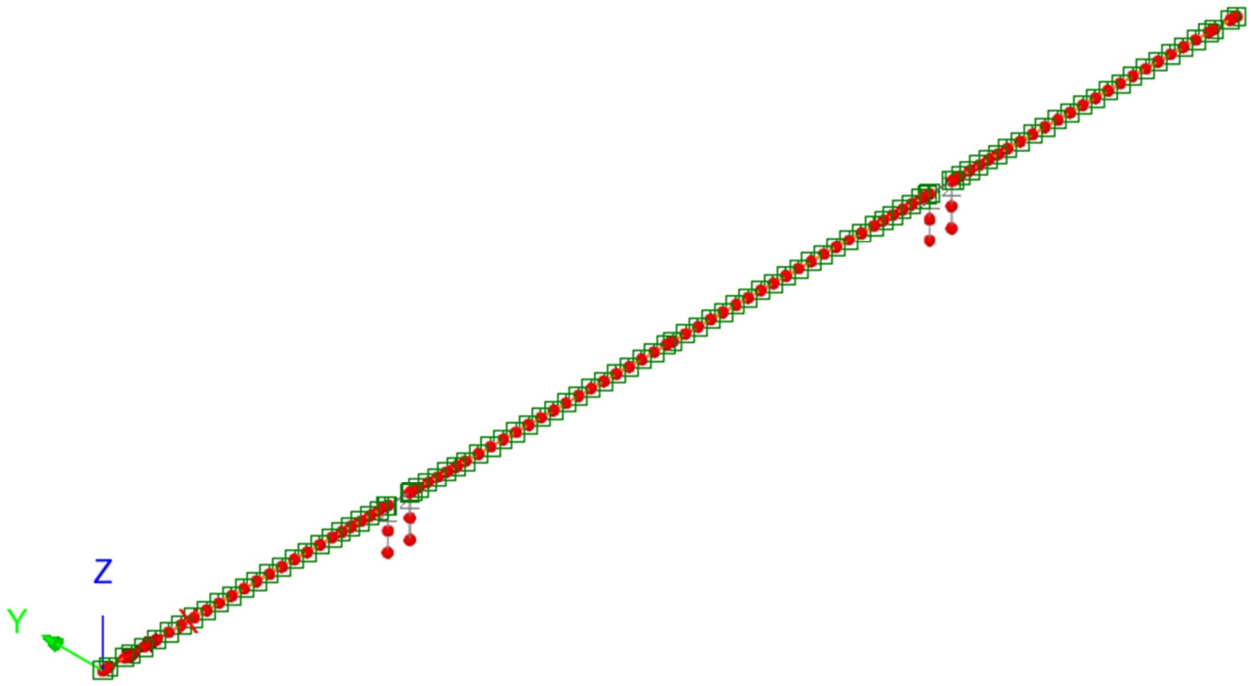


ELEVATION

2.7 SEARCH AREA

Discrete load can be applied to structure as geometrical load areas. In FEM program load areas are termed Search Area.

Search area : “Superstructure”



Overview

2.8 STUCTURE ACTIVATION

All part are active unless deactivated.

When it comes to decactivation there are several types. For FCM deactivated mesh is expected to follow movement of at connecting active mesh but (no stress will occur since stiffness zero). This deactivation is called "*follow active mesh"* and is used for all casting stages except castings stages 25 at end spans. At these locations deactivation "*closing part"* is used between two previously constructed parts that are active.

Stage 1: (Analysis 1)
Entire superstructure is assigned as "DEACTIVE" (stage 2-26).

Stage 2: (Analysis 1)
Marked stage 2 is assigned as "ACTIVE".

Stage 3: (Analysis 1)
Marked stage 3 is assigned as "ACTIVE".

Stage 4: (Analysis 1)
Marked stage 4 is assigned as "ACTIVE".

Stage 5: (Analysis 1)
Marked stage 5 is assigned as “ACTIVE”.

Stage 6: (Analysis 1)
Marked stage 6 is assigned as “ACTIVE”.

Stage 7: (Analysis 1)
Marked stage 7 is assigned as “ACTIVE”.

Stage 8: (Analysis 1)
Marked stage 8 is assigned as “ACTIVE”.

Stage 9: (Analysis 1)
Marked stage 9 is assigned as “ACTIVE

Stage 10: (Analysis 1)
Marked stage 10 is assigned as “ACTIVE

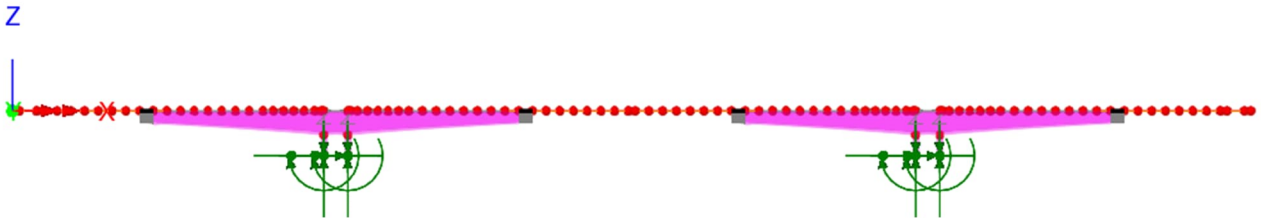
Stage 11: (Analysis 1)
Marked stage 11 is assigned as “ACTIVE

Stage 12: (Analysis 1)
Marked stage 12 is assigned as “ACTIVE

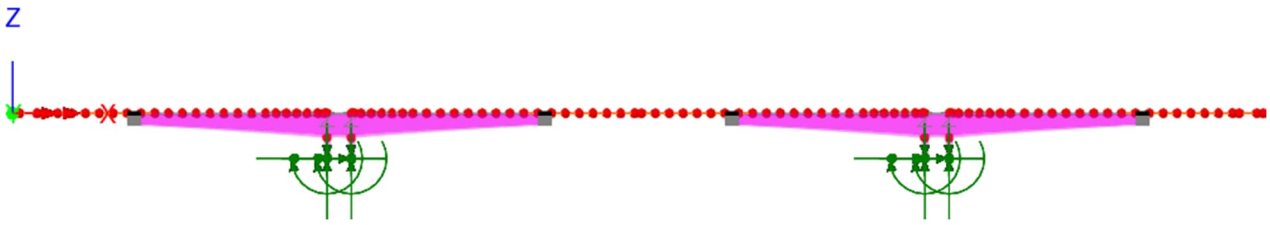
Stage 13: (Analysis 1)
Marked stage 13 is assigned as “ACTIVE

Stage 14: (Analysis 1)
Marked stage 14 is assigned as “ACTIVE

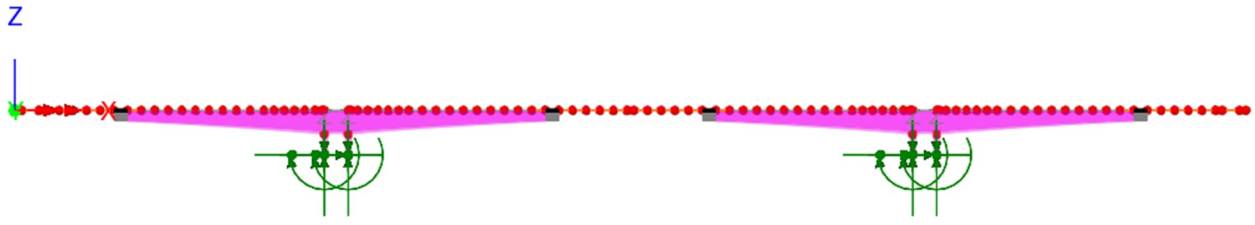
Stage 15: (Analysis 1)
Marked stage 15 is assigned as “ACTIVE



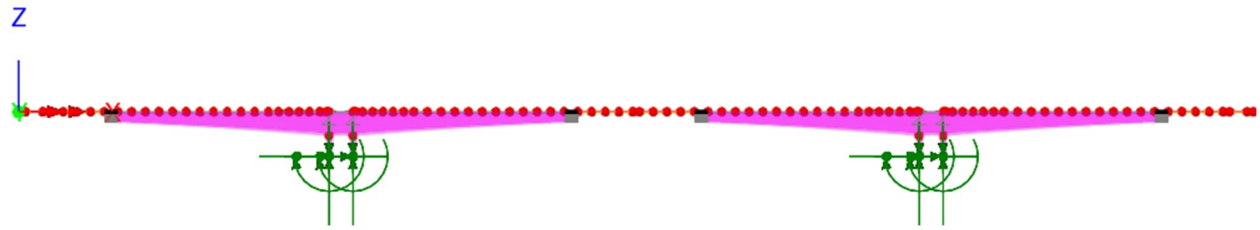
Stage 16: (Analysis 1)
Marked stage 16 is assigned as “ACTIVE



Stage 17: (Analysis 1)
Marked stage 17 is assigned as “ACTIVE



Stage 18: (Analysis 1)
Marked stage 18 is assigned as “ACTIVE



Stage 19: (Analysis 1)
Marked stage 19 is assigned as “ACTIVE

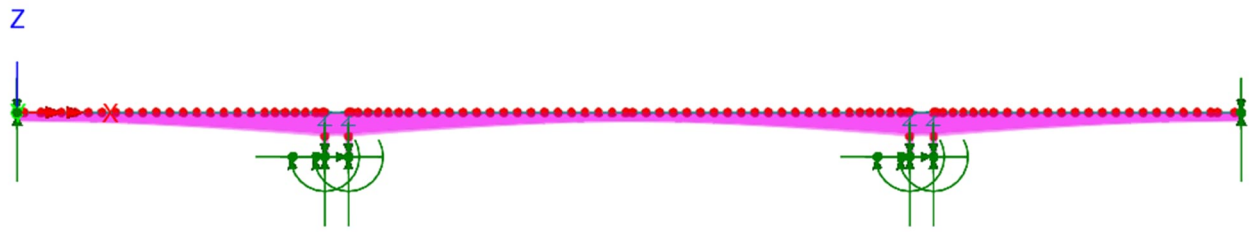
Stage 20: (Analysis 1)
Marked stage 20 is assigned as “ACTIVE

Stage 21: (Analysis 1)
Marked stage 21 is assigned as “ACTIVE

Stage 22: (Analysis 1)
Marked stage 22 is assigned as “ACTIVE

Stage 23: (Analysis 1)
Marked stage 23 is assigned as “ACTIVE

Stage 24: (Analysis 1)
Marked stage 24 is assigned as “ACTIVE. Also supports “End support” & “Temporary support” is added.



Stage 25 (Analysis 1)
Same as stage 25 but after removal “Temporary support”.

During operation (Analysis 2)
Entire superstructure is active including all permanent supports, same as stage 25.

3. LOADS

3.1 DEAD WEIGHT

$\gamma_c = 25 \cdot \frac{kN}{m^3}$: concrete

3.1.1 Body loads

Load: Dead weight 1

Linear acceleration in Z (a_z) : -10 $\frac{m}{s^2}$

Load case : Stage 1→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 2→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 3→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 4→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 5→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 6→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 7→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 7→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 8 → until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 9 → until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 10→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 8 → until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 9 → until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 10→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 11→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 12→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 13→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 14→ until end analysis 1

Load: Dead weight 1

ELEVATION

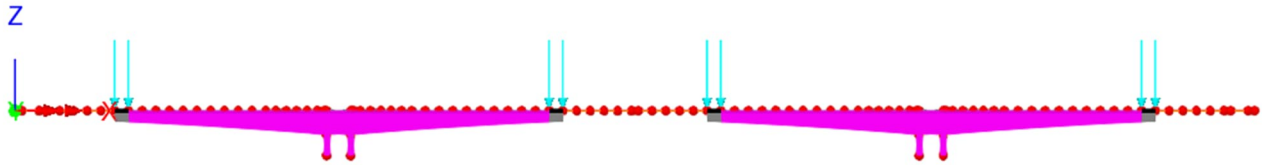
Load case : Stage 15→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 16→ until end analysis 1

Load: Dead weight 1

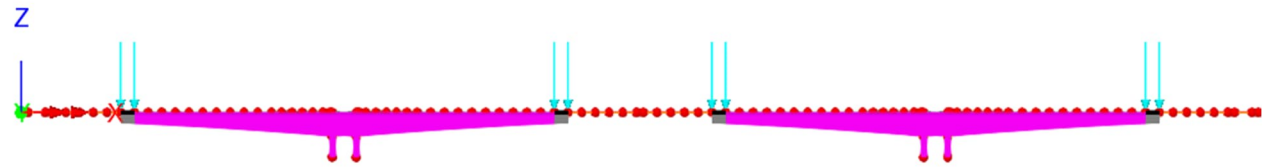


ELEVATION

Load case : Stage 17→ until end analysis 1

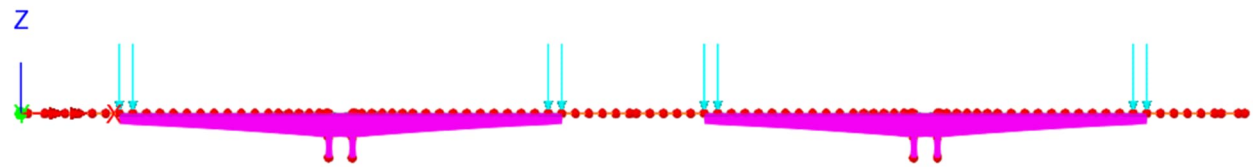
Load: Dead weight 1

ELEVATION



Load case : Stage 18→ until end analysis 1

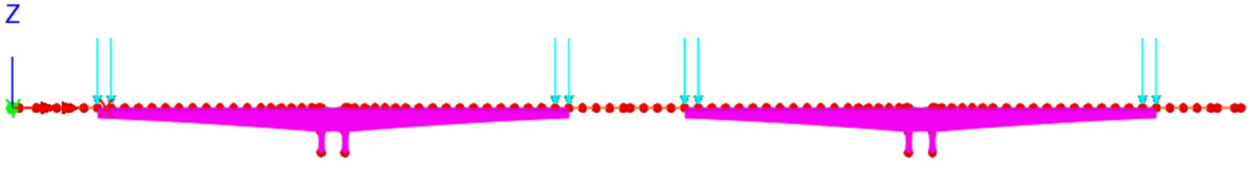
Load: Dead weight 1



ELEVATION

Load case : Stage 19→ until end analysis 1

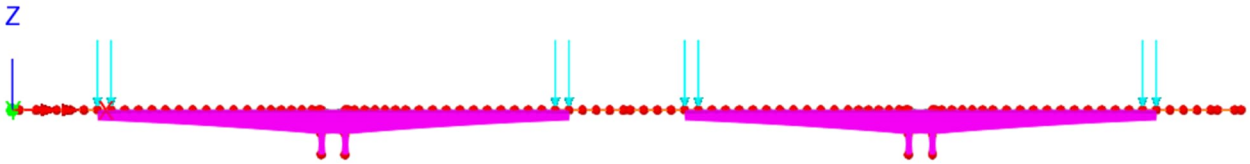
Load: Dead weight 1



ELEVATION

Load case : Stage 20→ until end analysis 1

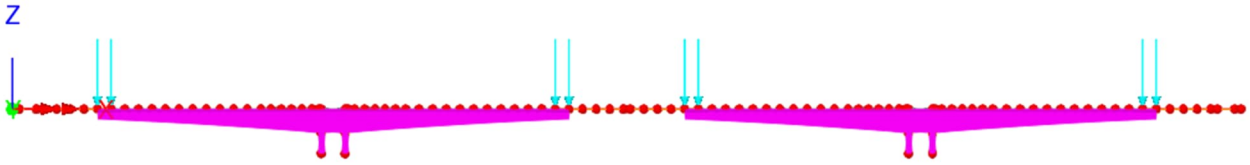
Load: Dead weight 1



ELEVATION

Load case : Stage 21→ until end analysis 1

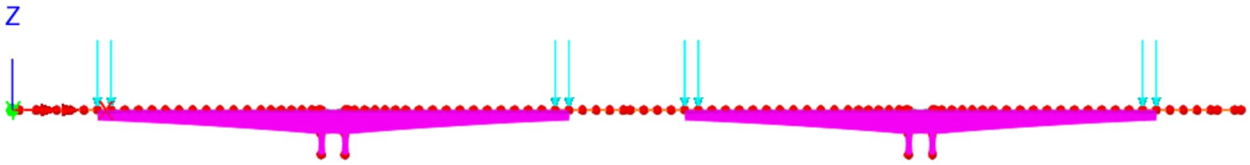
Load: Dead weight 1



ELEVATION

Load case : Stage 22→ until end analysis 1

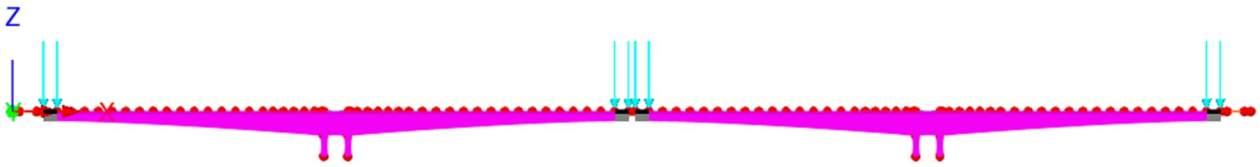
Load: Dead weight 1



ELEVATION

Load case : Stage 23→ until end analysis 1

Load: Dead weight 1



ELEVATION

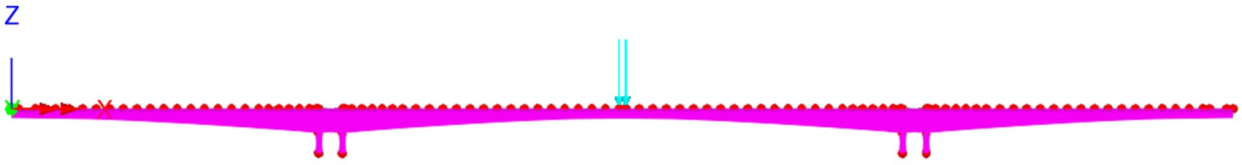
Load case : Stage 24→ until end analysis 1

Load: Dead weight 1

ELEVATION

Load case : Stage 25→ until end analysis 1

Load: Dead weight 1



ELEVATION

3.1.2 Edge beams including railing

Along each edge bream a line load is introduced. The load includes weight of both edge beams and railings.

$p_{räcke} = 0.7 \frac{kN}{m}$: weight railing

$$\rightarrow p_z = 2p_{räcke} + 2p_{KB} = 2 \cdot 0.7 \frac{kN}{m} + 2 \cdot 0.45m \cdot 0.45m \cdot 25 \frac{kN}{m^3} = -12 \frac{kN}{m}$$

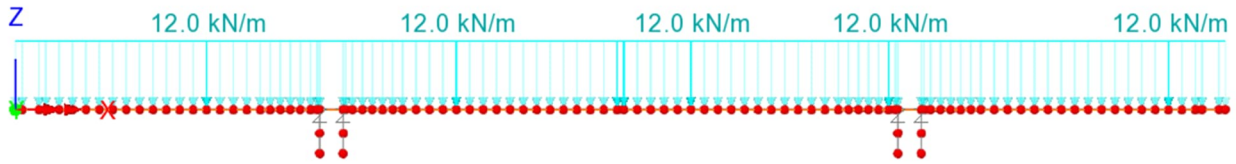
Load: Dead weight 2

Structural loading : Global distributed

Line load per unit length in Z direction: -12 $\frac{kN}{m}$

Load case : Stage 25→ until end analysis 1

Load: Dead weight 2



ELEVATION

3.2 SURFACING

Thickness pavement with a thickness of 95 mm built as follows:

- Wearing course ABS 11 40 mm
- Combined protective and binder course PGJA 50 mm
- Waterproofing layer 5 mm

$\gamma = 23\frac{kN}{m^3}$: course

$q_{matta} = 0.11kPa$: waterproofing

$$q_{beläg} = \gamma_{beläggning} \cdot t + q_{matta} = 23\frac{kN}{m^3} \cdot 0.09m + 0.11kPa = 2.2kPa$$

$$\rightarrow p_z = B \cdot q_{beläg} = 12.7m \cdot 2.2kPa = -29\frac{kN}{m}$$

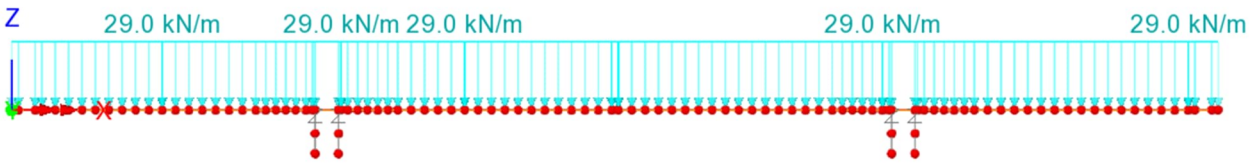
Load : Surfacing

Structural loading : Global distributed

Surface load per unit length in Z direction: -29 $\frac{kN}{m}$

Load case : Stage 25→ until end analysis 1

Load: Surfacing



ELEVATION

Remark
Load is also applied to Analysis 2 (LC Surfacing).

.3 TIME MANAGEMENT

The effect of creep, shrinkage and relaxation is determined by assuming construction times see below.

$t_0 = 5\ days$

$t_1 = 120\ years \therefore$ 43800 days

Only "Analysis 1 " use time dependent nonlinear analysis with regard to material. Below time table used for this analysis.

"Age at placement" : time after casting until concrete is assumed statically active

"Age at shrinkage" : time after casting until concrete is assumed statically active

"Stage duration" : length between casting stages

	Loadcase	Age at Placement	Age at shrinkage	Stage Duration	Response Time
	CS 1	5	5	10	10
	CS 2	5	5	10	20
	CS 3	5	5	10	30
	CS 4	5	5	10	40
	CS 5	5	5	10	50
	CS 6	5	5	10	60
	CS 7	5	5	10	70
	CS 8	5	5	10	80
	CS 9	5	5	10	90
	CS 10	5	5	10	100
	CS 11	5	5	10	110
	CS 12	5	5	10	120
	CS 13	5	5	10	130
	CS 14	5	5	10	140
	CS 15	5	5	10	150
	CS 16	5	5	10	160
	CS 17	5	5	10	170
	CS 18	5	5	10	180
	CS 19	5	5	10	190
	CS 20	5	5	10	200
	CS 21	5	5	10	210
	CS 22	5	5	10	220
	CS 23	5	5	10	230
	CS 24	5	5	0	230
	CS 25	5	5	0	230
	Prestress (CS 25)	-	-	0	230
	Longterm	-	-	43800	44030
	Prestress (longterm)	-	-	0	44030

3.4 CREEP

Creep is determined according to SS-EN 1992-1-1 §3.1.4.

Time for first loading (= time when formwork was removed) is termed t_0.

$t_0 = 5\ days$

$t_1 = 120\ years$

In this analysis only used to determine pretension loss over time.

3.5 SHRINKAGE

Shrinkage is determined according to SS-EN 1992-1-1 §3.1.4.

Time for first loading (= time when formwork was removed) is termed t_0.

$t_0 = 5\ days$

$t_1 = 120\ years$

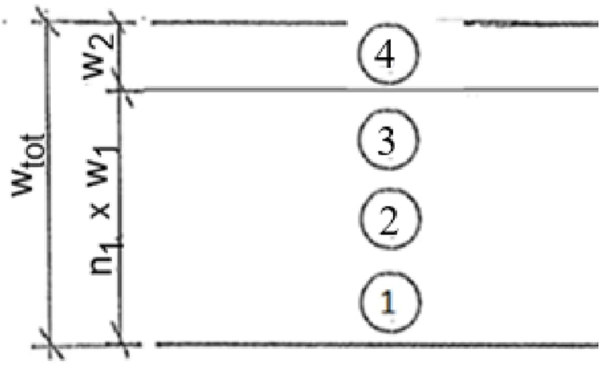
In this analysis only used to determine pretension loss over time.

3.6 TRAFFIC

Evaluation of vertical traffic is performed for LM 1 and LM 2 according to SS-EN 1991-2 section 4.3.

Evaluation will also be performed EG A/B = 180kN/300 kN according to TRVFS 2011:12 chapter 6 point 3§.

3.6.1 Traffic lane division



Total traffic width : $w_{tot} = 0.1\ m + 12.7\ m + 0.1\ m = 12.9\ m$

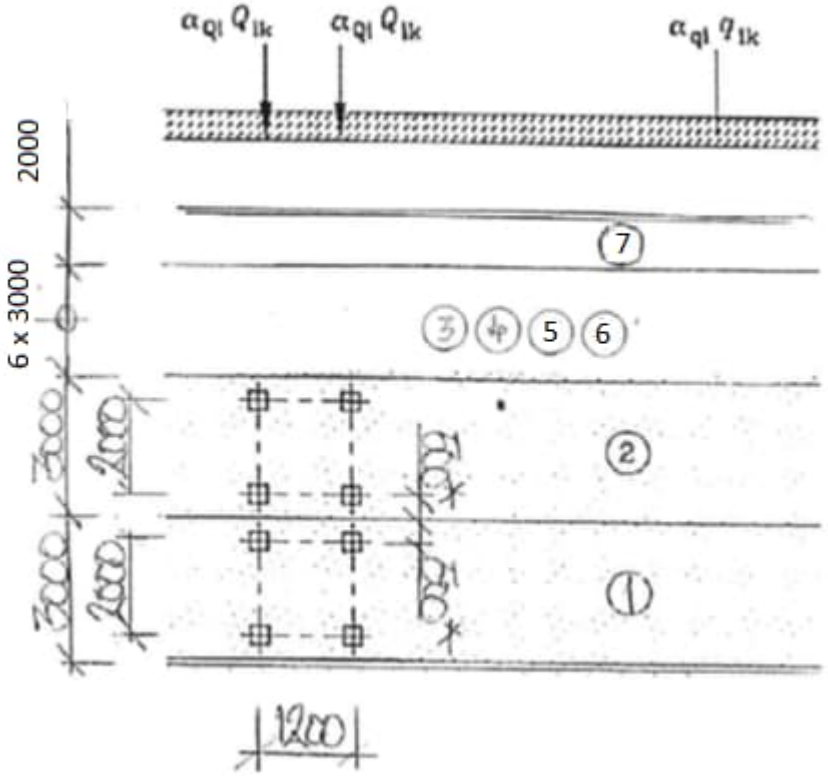
Number of traffic lanes : $n_1 = Integer\left[\frac{w_{tot}}{3.0m}\right] = 4\ lanes$

Full traffic width : $w_1 = 3.0m$

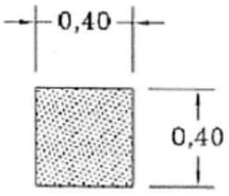
Remaining width : $w_2 = 0.9m$

3.6.2 Load model 1 (LM 1)

Characteristic values according to SS-EN 1991-2 §4.3.2.



* = When studying local effects 250 mm is to be assumed.



Axellaster :

α_Q : national adaptation factor according to TRVFS 2011:12 table 7.1

$Q'_k = \alpha_Q \cdot Q_k$: characteristic value including national adaptation factor

Traffic lane	Q_k	α_Q	Q'_k	Remark
1	300	0,9	270	LM1- 2 x 270 kN
2	200	0,9	180	LM1- 2 x 180 kN
3-4	100	0	0	No load
-	kN	-	kN	-

Utbredda laster :

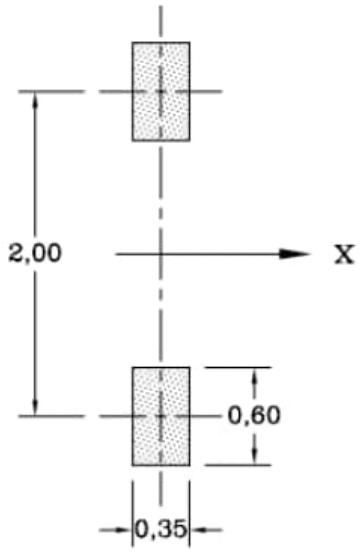
α_q : national adaptation factor according to TRVFS 2011:12 table 7.1

$q'_k = \alpha_q \cdot q_k$: characteristic value including national adaptation factor

Traffic lane	q_k	α_q	q'_k
1	9.0	0.8	7.2
2-4	2.5	1.0	2.5
-	kPa	-	kPa

3.6.3 Load model 2 (LM 2)

Characteristic vertical load according to SS-EN 1991-2 §4.3.3.



$\beta_Q = \alpha_Q = 0.90$: national adaptation factor

$Q_k = 400$ kN : characteristic value

$Q'_k = \beta_k \cdot Q_k = 360$ kN : characteristic value including national adaptation factor

Tire pressure

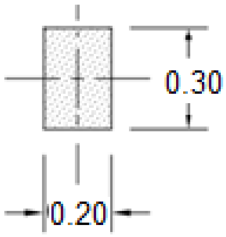
TSFS Chapter 11 Section 4 states that the same contact surface as LM 1 may be used.

3.6.4 Load model EG A/B

Calculation is performed using traffic load EG A/B = 180 kN/300 kN excluding dynamic factor.

Traffic load EG A/B are applied to two traffic lanes. Traffic on first lane is multiplied by 1.00 while second lane is multiplied 0.80.

The center distance between the wheel pressures is 2.0 meters according to TSFS chapter 11 §2.



Wheel pressure

ε_{dyn} = 25 % : dynamic factor [1.)]

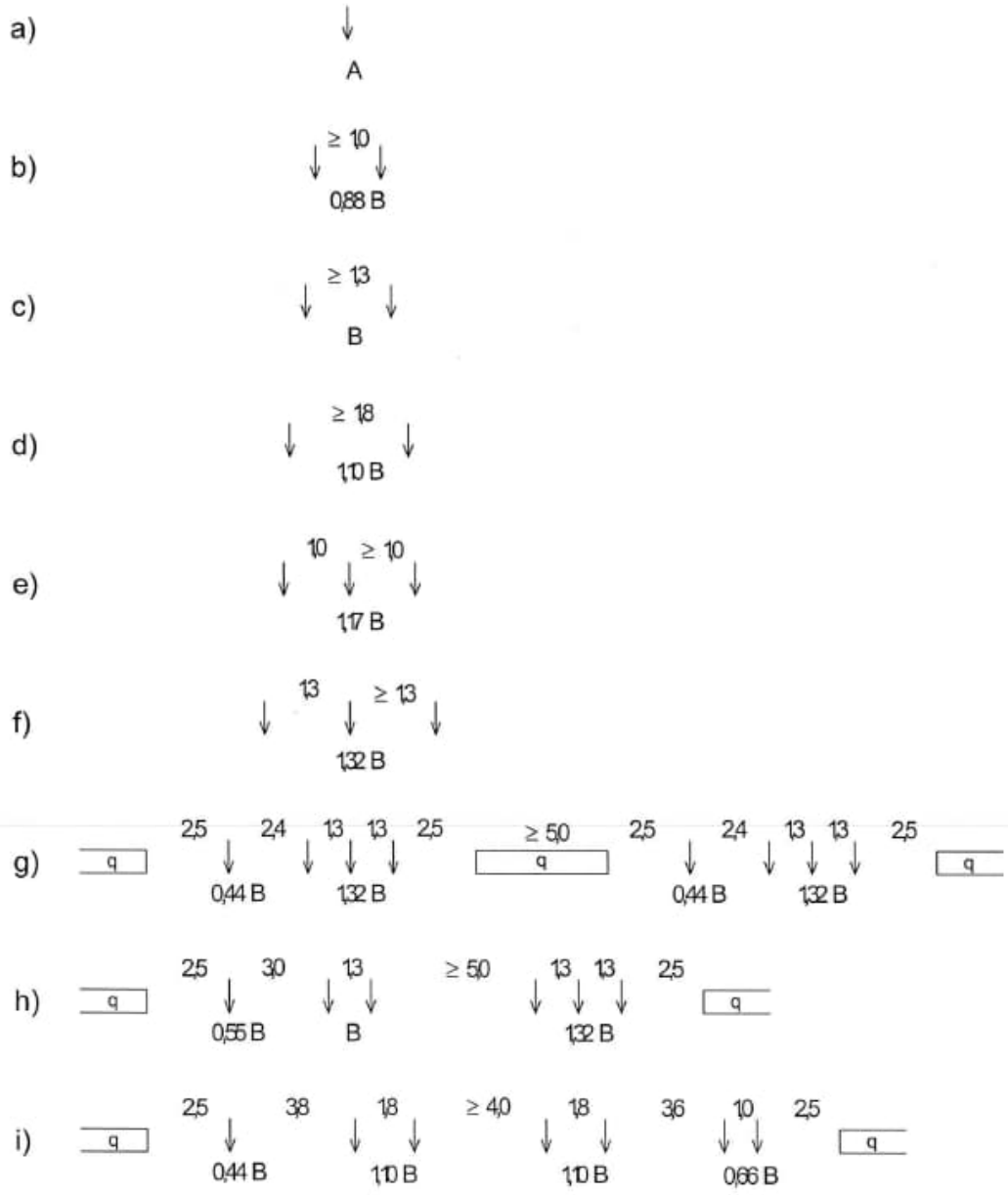
A´= A·(1 + ε_{dyn}) = 180 kN·(1+0.25) = 225 kN : single load including dynamic factor

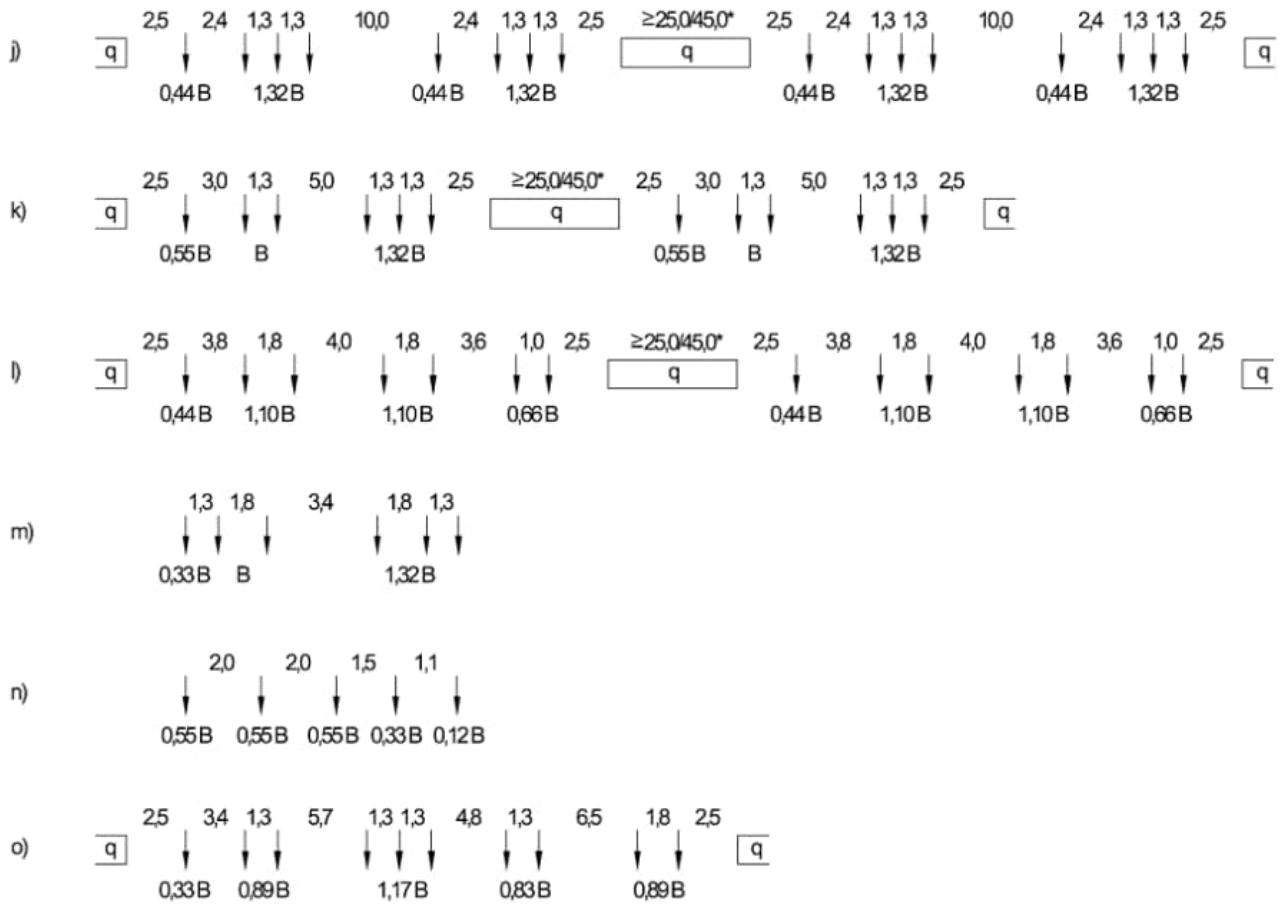
B´= B·(1 + ε_{dyn}) = 300 kN·(1+0.25) = 375 kN : tandem load including dynamic factor

$p = 5\frac{kN}{m}$: surface load

Footnote:
[1.)] TRVINFRA-00227 table 7.1-5 section 4.2.1(1) states apply 25 % ..

Graphic presentation of common vehicle types:
(Vehicle types according to TRVINFRA-00331 Appendix 1)





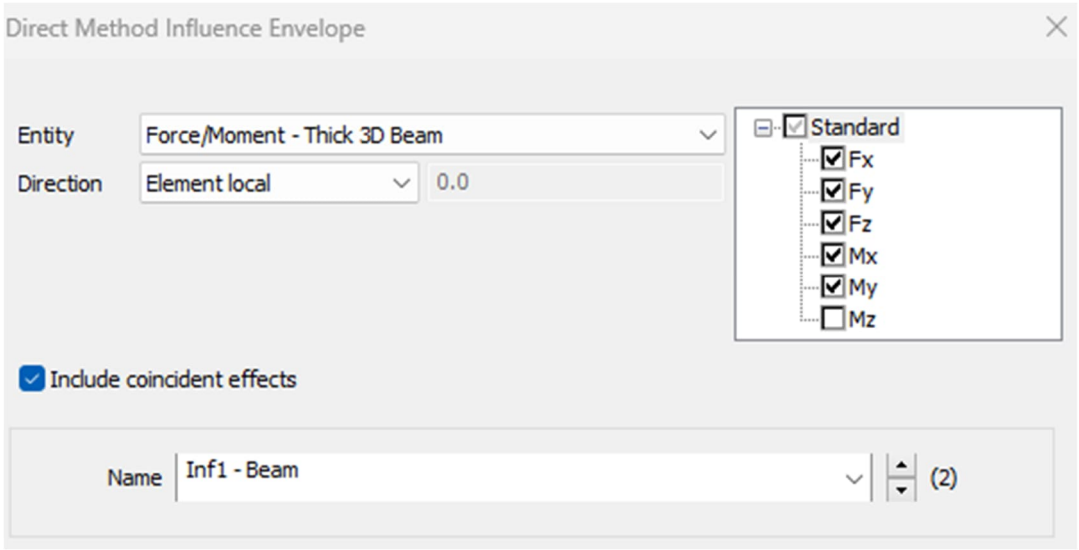
Note:
Evaluation is carried out with the script Vehicle Load Optimization (VLO), see sections 3.5.3 and 3.5.4.
Since there is no motorway, * = 45 m is applied according to TRVINFRA-00331 section 8.3.2.2.1 for vehicle types j, k, and l.

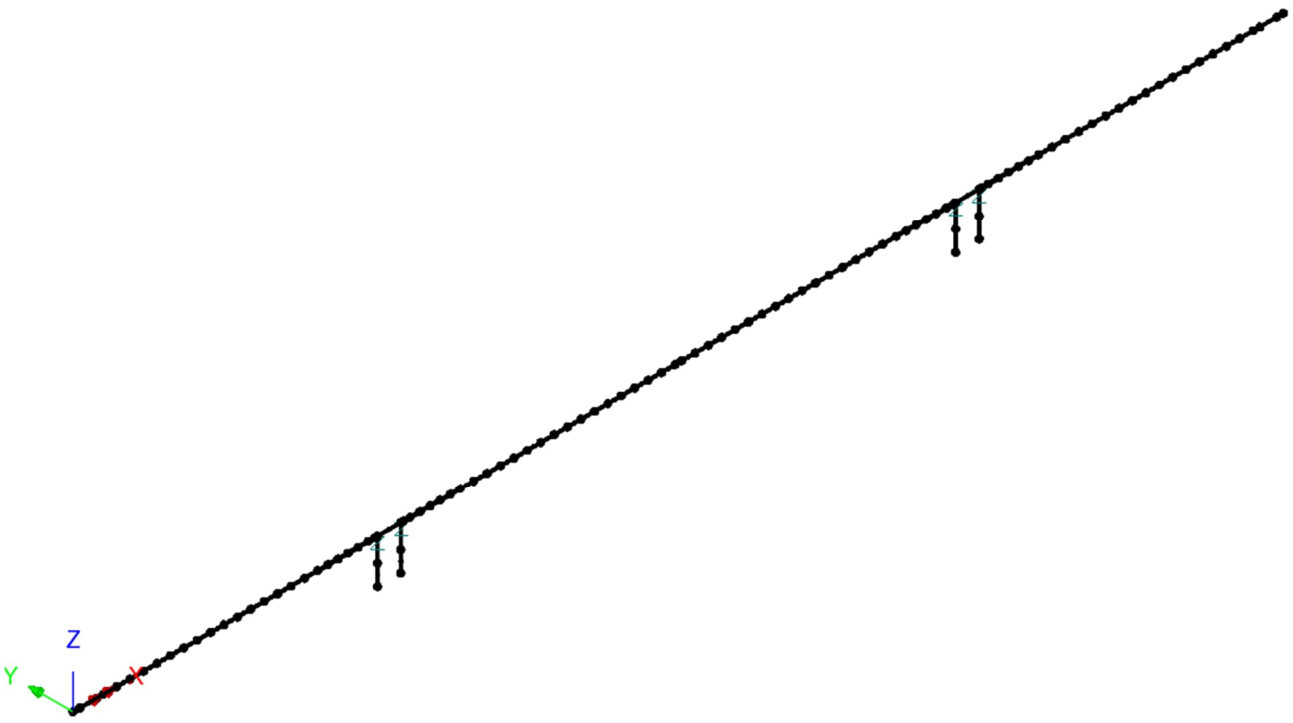
3.6.5 Vehicle Load Optimization (VLO)

Influence surfaces are created using *Method Influence Envelope* for indicated components.

Influence	Components	Entity	Method
Inf1 - Beam	Fx, Fy, Fz, Mx, My	Forces 3D-beam	*Influence Envelope*
Inf2 - Reaction	FX, FY, FZ, MX, MY	Reaction	*Influence Envelope*

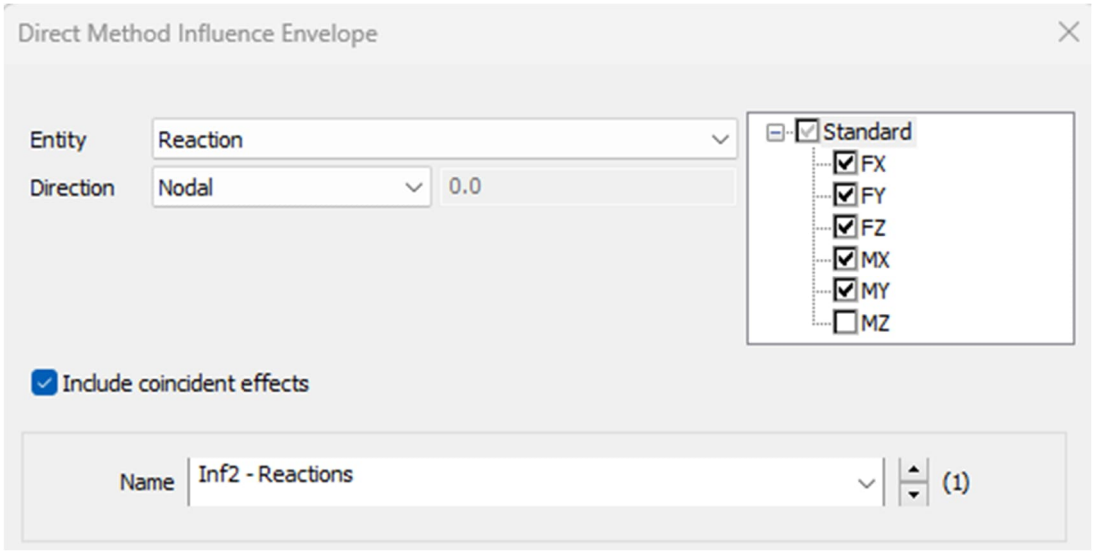
Inf1 – Beam :





Overview 3D

Inf2 – Reactions :



ELVEVATION

3.6.5.2 Influence surface analysis

Influence surfaces :

Search area: Superstructure

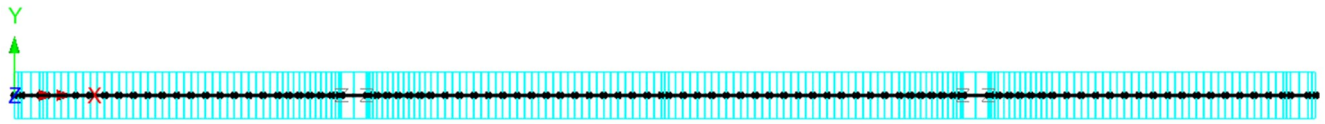
Definition type: Nodes in seach areas

Path: Centerline X

Transverse width: 12.9 m

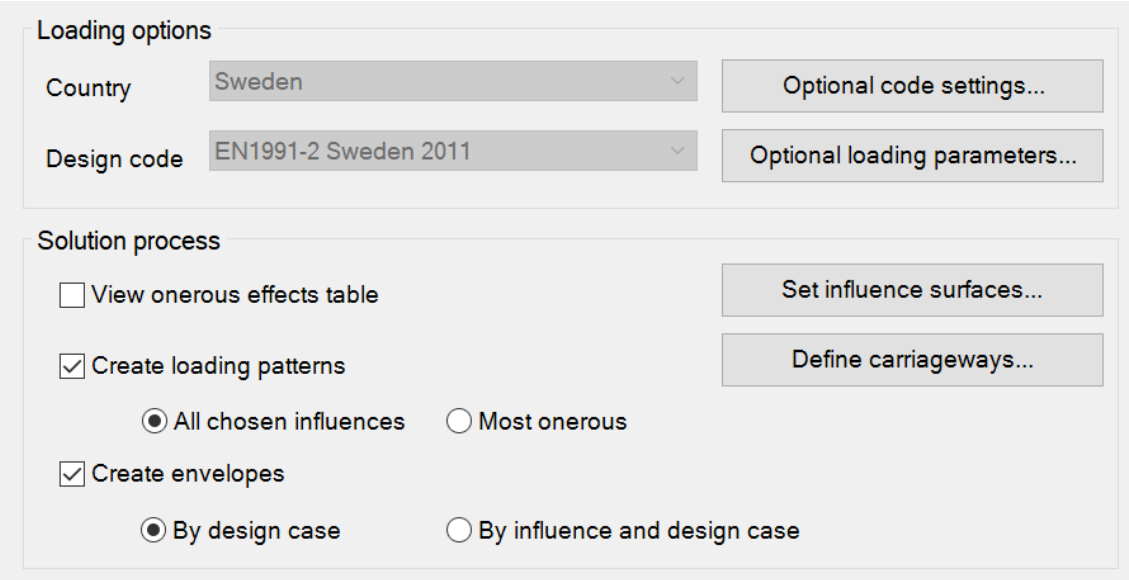
Longitudinal spacing: - (not used since type not grid)

Transversal spacing: - (not used since type not grid)

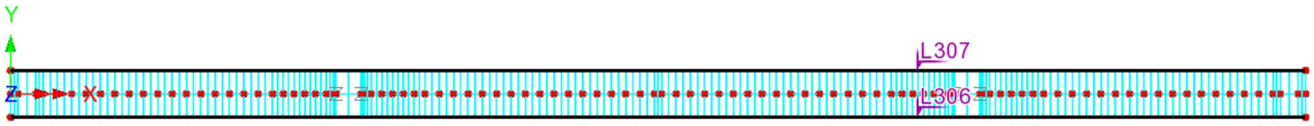


PLAN

3.6.5.3 Traffic load analysis (VLO)



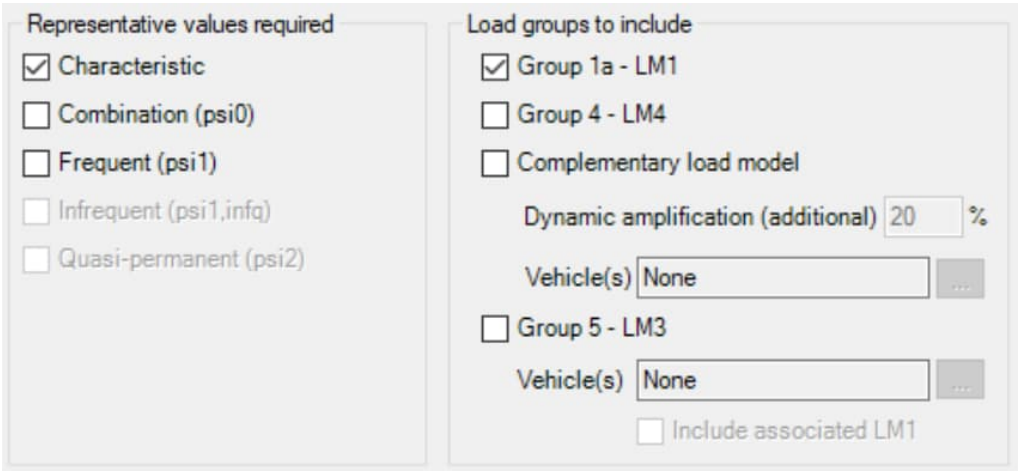
Vehicle longitudinal incremental movement:	0.25 m
Vehicle transverse incremental movement:	0.25 m
Vehicle direction:	both
Definition of carriageway (kerbs):	L306 & L307
Influence surfaces:	Include all (positive & negative)



PLAN

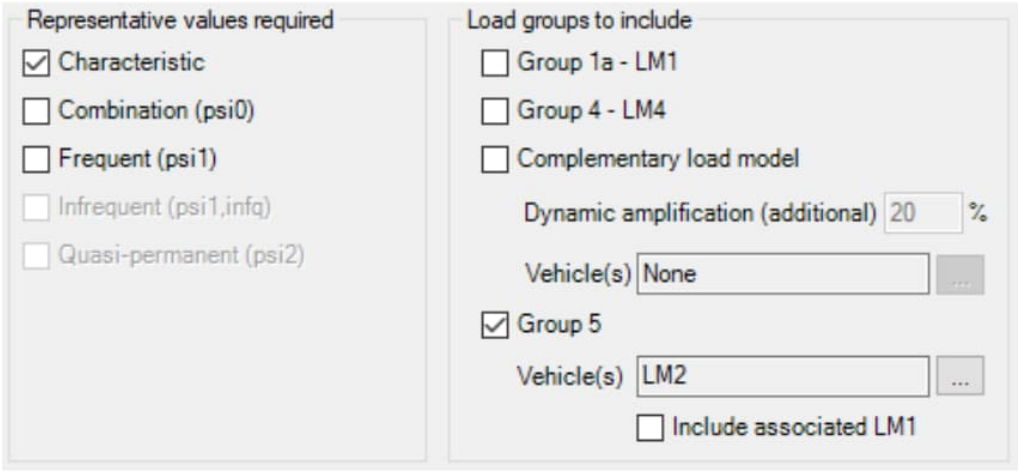
3.6.5.4 Envelope : LM 1

Load model 1 (LM1) defined in SS-EN 1991-2 section 4.3.2.



3.6.5.5 Envelope : LM 2

Load model 2 (LM2) defined in SS-EN 1991-2 section 4.3.3. The load is defined in Group 5 vehicle) since Group 1b is not defined in present version of software.



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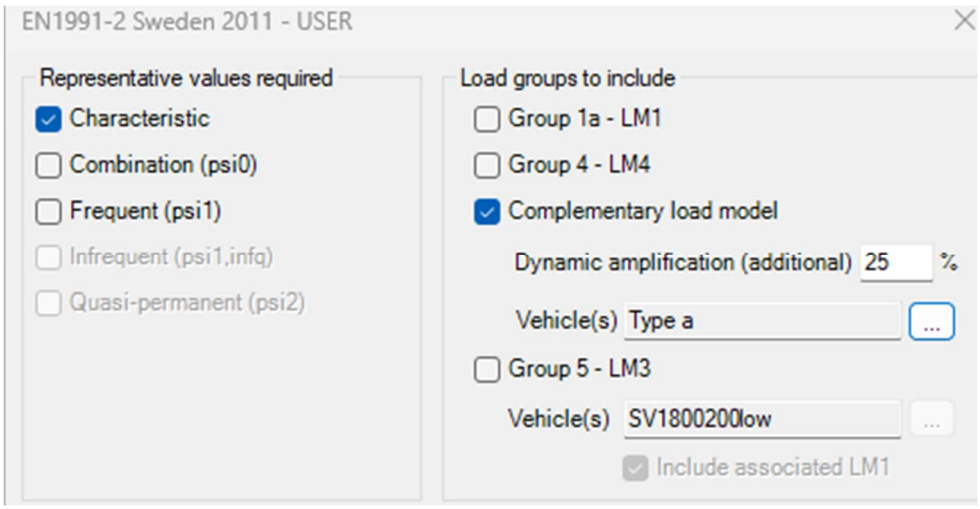
3.6.5.6 Envelope : EG A

EG A is defined as complementary load model with options seen below.

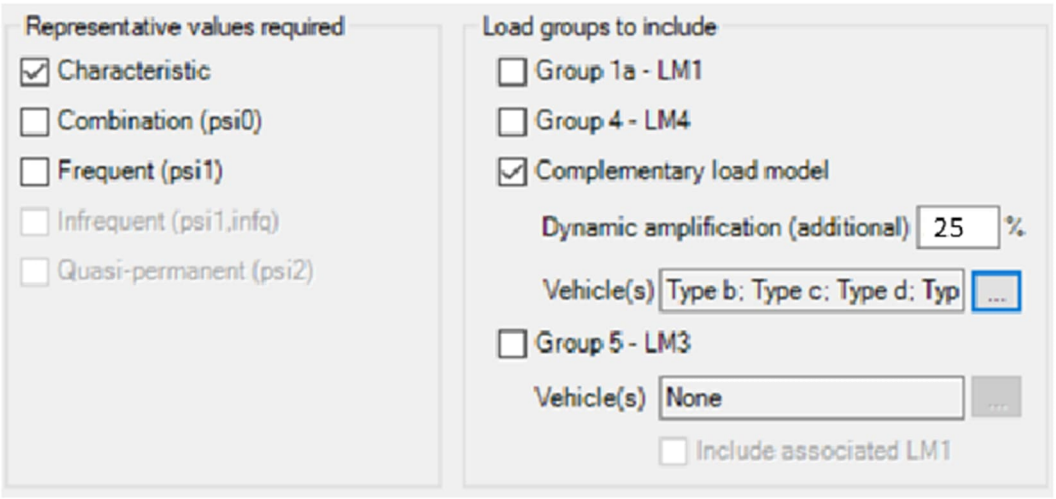


Dynamic amplification (additional): 25 %

Vehicle selection: Type a

3.6.5.7 Envelope : EG B

EG B is defined as complementary load model with options seen below.



Dynamic amplification (additional): 25 %

Vehicle selection: Type b → o

3.6.5.8 Combined traffic load (TRAFIK)

There are a total 4 different traffic loads termed LM 1, LM2, EG A and EG B.

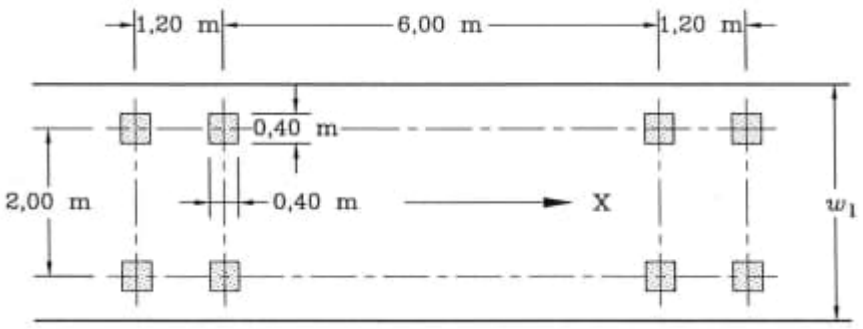
The envelope is used to identify the most onerous load effect.

Envelope TRAFIK :

Envelope
LM 1
LM 2
EG A
EG B

3.6.5.9 Fatigue model

Fatigue model 3 (UTM3) defined in SS-EN 1991-2 section 4.6.4. The load is defined in Group 5 (special vehicle) in present version of software.



Q_k = 120 kN : characteristic value including nation adaptation factors.

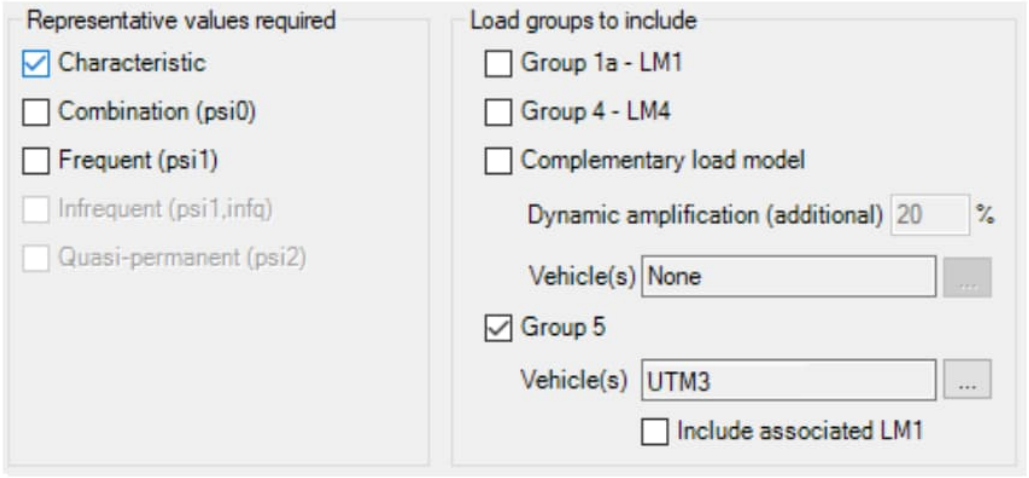
Traffic category:
TRVINFRA-0027 table 7.1-5(h) gives traffic category 3

Reference values for the number of heavy vehicles:
According to SS-EN 1991-2 section 4.6.1 table 4.5(n), Category 3 is obtained

→ N_{obs} = 125,000 vehicles/year

The load definition:

The load UTM3 is defined as a special vehicle in "load group 5."



3.7 PRESTESS

Analysis of pre tensioned cable is studied at times : t_0 (5 days) until t_2 (120 years).

3.7.1 General

Properties chosen system see below.

Material :
$f_{p0.1k} = 1675MPa$
$f_{pk} = 1860MPa$
$E_{sk} = 195GPa$
$\mu = 0.18$
$k = 0.005 \cdot \frac{1}{m}$

Casting tube :
80 mm / 86 mm

Slip during locking:
6 mm

Permissible curvature :
$R_{\min} = 5.7m$

Cabel area :
$A_p = 4106mm^2$

Anchor plate :
290 mm x 290 mm (same for both passiv and active anchorage)

Ultimate load :
$F_u = 4106mm^2 \cdot 1860MPa = 7637kN$

Permissible stress before locking :
See SS-EN 1992-1-1 section 5.10.2.1

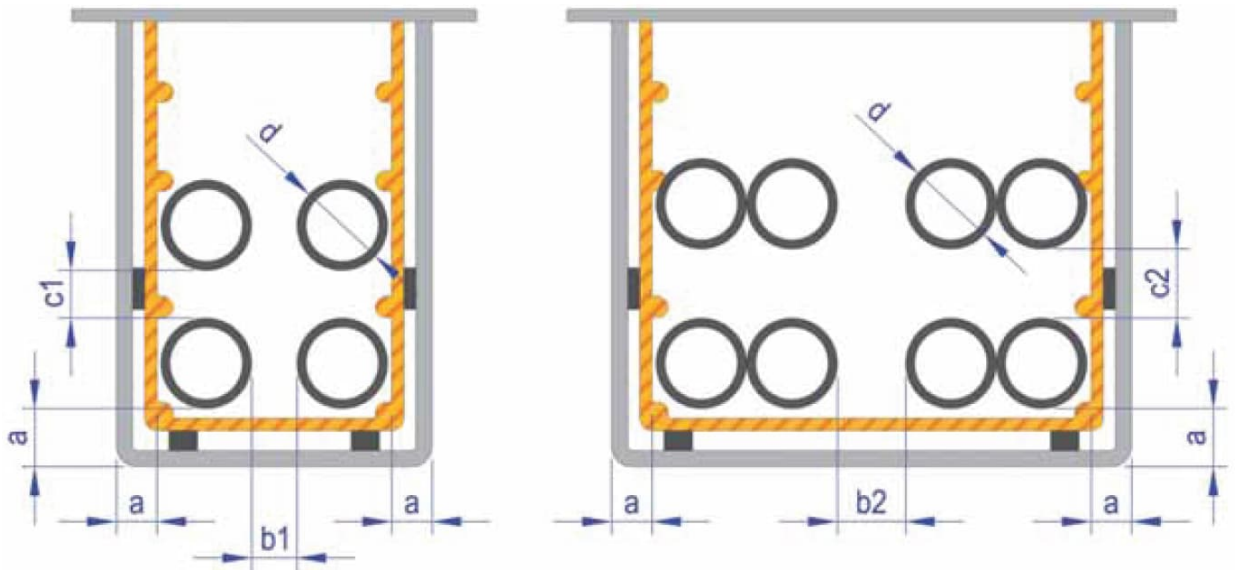
$$\sigma_{p,max}^{before} = min(0.8f_{pk}; 0.9f_{p0.1k}) = min(1488MPa; 1507MPa) = 1488MPa$$

Permissible stress after locking :
See SS-EN 1992-1-1 section 5.10.3

$$\sigma_{p,max}^{after} = min(0.75f_{pk}; 0.85f_{p0.1k}) = min(1395MPa; 1423MPa) = 1395MPa$$

3.7.2 Execution

Recommended measurements :



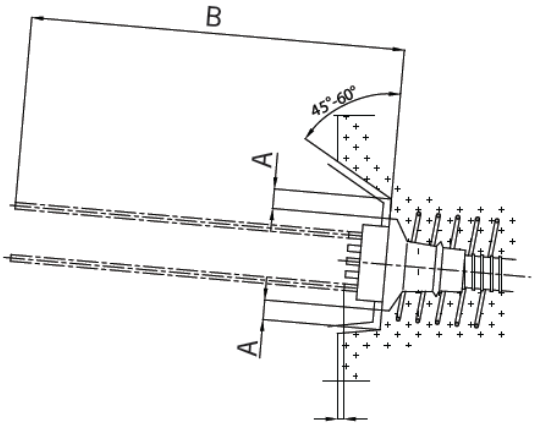
d = 90 mm

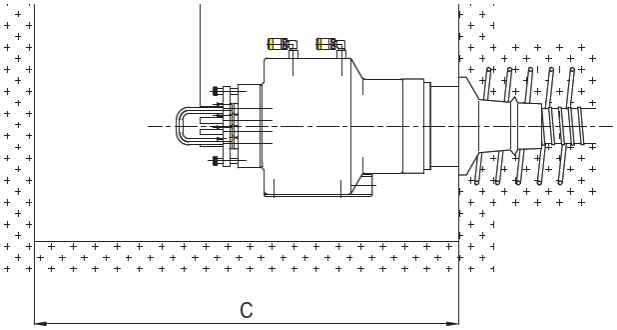
a > 50 mm

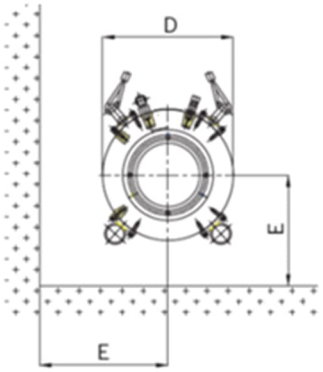
b1, c1 > 0.7d = 63 mm but 100 chosen !

b2, c2 > 1.0d = 90 mm but 100 mm chosen !

Demand for space during tensioning :





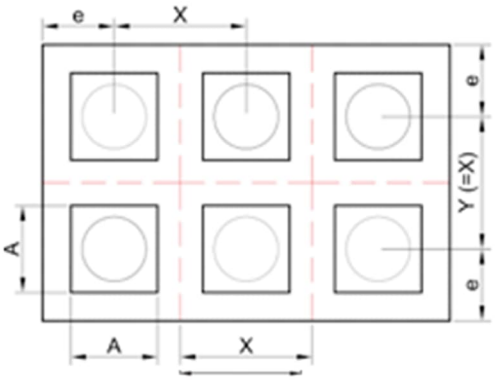


A = 70 mm

B = 1200 mm

C = 1700 mm

Measurements of cables 37ϕ15 :



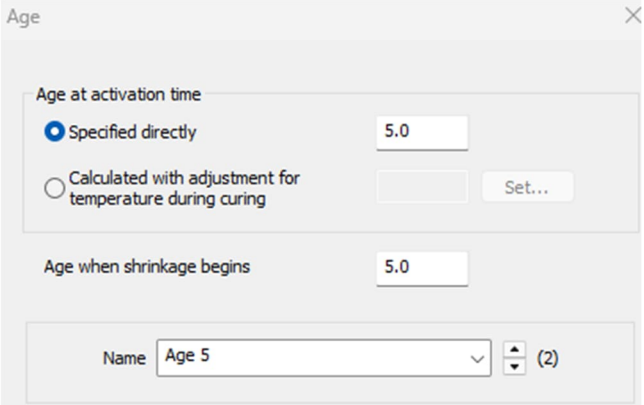
A = 290 mm

e ≥ 175 mm + TB

X ≥ 400 mm

3.7.3 Time concrete aging

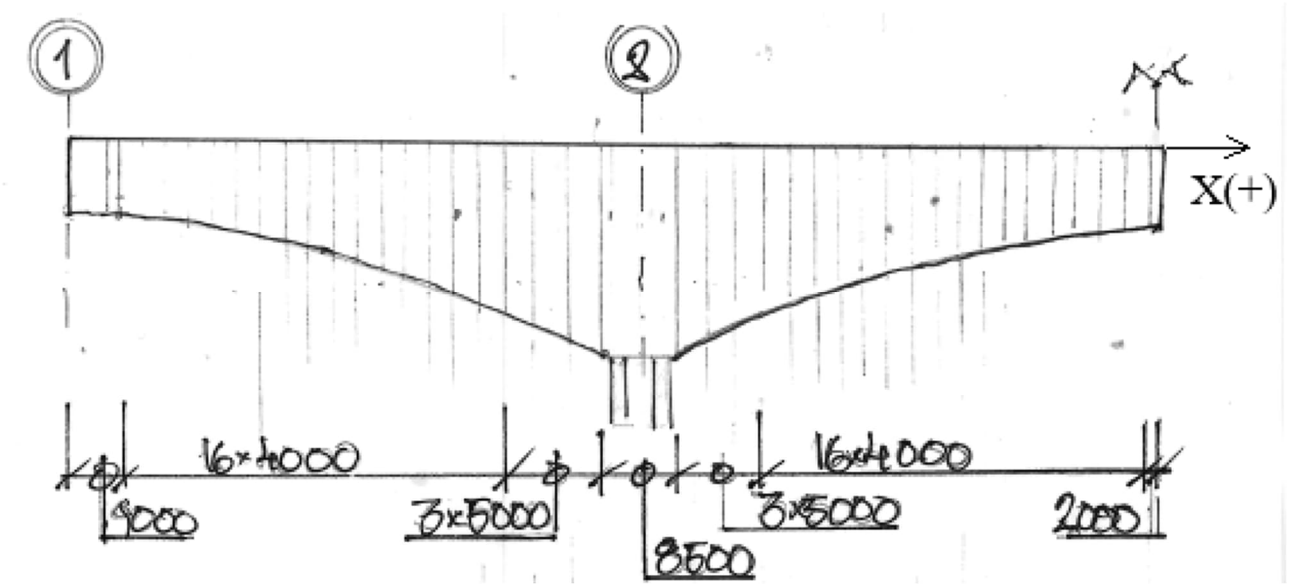
In order to determine time losses due to shrinkage and creep all parts of bridge is assumed to be statically active 7 days after casting, see page A3:15.



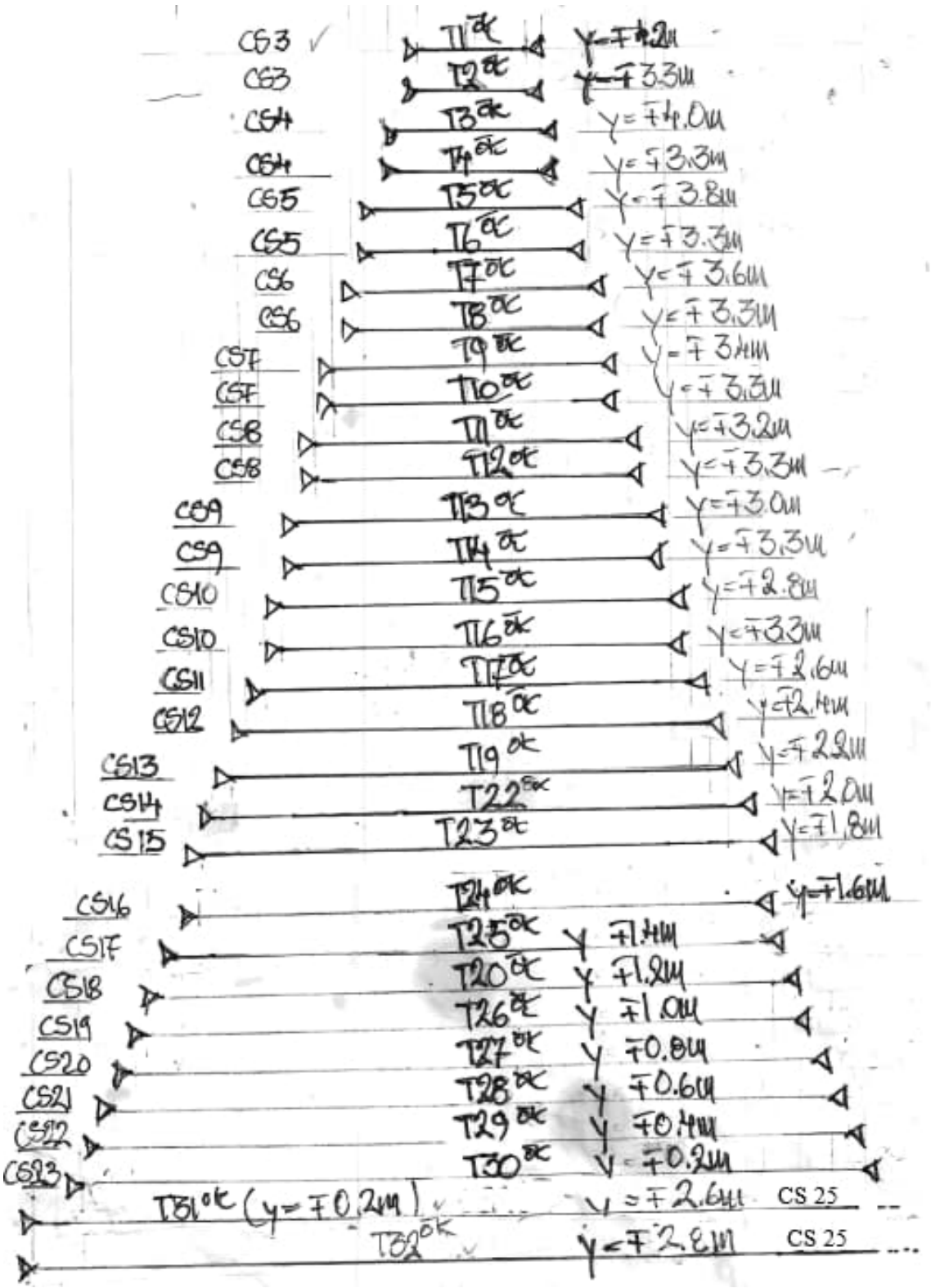
ELEVATION

3.7.4 Tendon location

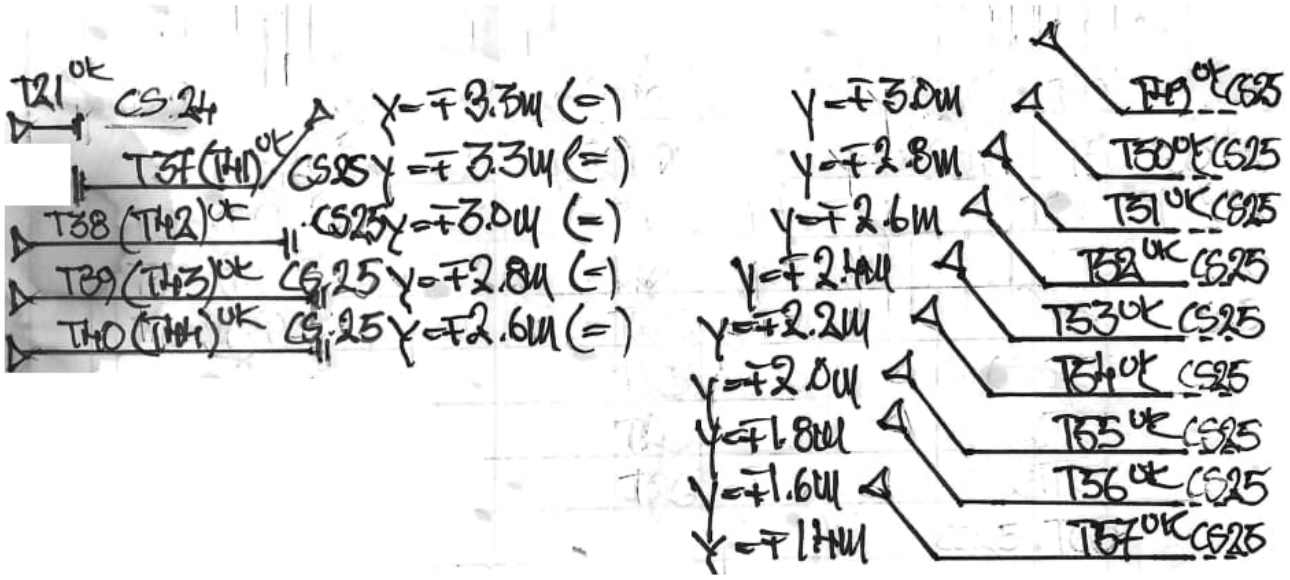
Cables are defined using “global coordinates”



ELEVATION



ELEVATION
Cables T1-T22, T31 and T32.



ELEVATION
Cables T21, T37-T44 and T49-T57.

Casting stage	Tendon	X:start	X:end	Y(+)	Nr.
CS 1:S2	-	90.75	97.75	-	-
CS 1:S3	-	263.25	270.25	-	-
CS 2:S2	-	88.00	100.50	-	-
CS 2:S3	-	260.50	273.00	-	-
CS 3:S2	T1 - S2:L	85.00	103.50	+4.2	1
"	T1 - S2:R	”	”	-4.2	2
"	T2 - S2:L	”	”	+3.3	3
"	T2 - S2:R	”	”	-3.3	4
CS 3:S3	T1 - S3:L	257.50	276.00	+4.2	5
"	T1 - S3:R	”	”	-4.2	6
"	T2 - S3:L	”	”	+3.3	7
"	T2 - S3:R	”	”	-3.3	8
CS 4:S2	T3 - S2:L	82.00	106.50	+4.0	9
"	T3 - S2:R	”	”	-4.0	10
"	T4 - S2:L	”	”	+3.3	11
"	T4 - S2:R	”	”	-3.3	12
CS 4:S3	T3 - S3:L	254.50	279.00	+4.0	13
"	T3 - S3:R	”	”	-4.0	14
"	T4 - S3:L	”	”	+3.3	15
"	T4 - S3:R	”	”	-3.3	16
CS 5:S2	T5 - S2:L	79.00	109.50	+3.8	17
"	T5 - S2:R	”	”	-3.8	18
"	T6 - S2:L	”	”	+3.3	19
"	T6 - S2:R	”	”	-3.3	20
CS 5:S3	T5 - S3:L	251.50	282.00	+3.8	21
"	T5 - S3:R	”	”	-3.8	22
"	T6 - S3:L	”	”	+3.3	23
"	T6 - S3:R	”	”	-3.3	24
CS 6:S2	T7 - S2:L	76.00	112.50	+3.6	25
"	T7 - S2:R	”	”	-3.6	26
"	T8 - S2:L	”	”	+3.3	27
"	T8 - S2:R	”	”	-3.3	28
CS 6:S3	T7 - S3:L	248.50	285.00	+3.6	29
"	T7 - S3:R	”	”	-3.6	30
"	T8 - S3:L	”	”	+3.3	31
"	T8 - S3:R	”	”	-3.3	32
-	-	m	m	m	-

Casting stage	Tendon	X:start	X:end	y(+).	Nr.
CS 7:S2	T9 - S2:L	73.0	112.5	+3.4	33
"	T9 - S2:R	”	”	-3.4	34
"	T10 - S2:L	”	”	+3.3	35
"	T10 - S2:R	”	”	-3.3	36
CS 7:S3	T9 - S3:L	245.5	288.0	+3.4	37
"	T9 - S3:R	”	”	-3.4	38
"	T10 - S3:L	”	”	+3.3	39
"	T10 - S3:R	”	”	-3.3	40
CS 8:S2	T11- S2:L	69.0	119.5	+3.2	41
"	T11 - S2:R	”	”	-3.2	42
"	T12- S2:L	”	”	+3.3	43
"	T12 - S2:R	”	”	-3.3	44
CS 8:S3	T11- S3:L	241.5	292.0	+3.2	45
"	T11 - S3:R	”	”	-3.2	46
"	T12 - S3:L	”	”	+3.3	47
"	T12 - S3:R	”	”	-3.3	48
CS 9:S2	T13 - S2:L	65.0	123.5	+3.0	49
"	T13 - S2:R	”	”	-3.0	50
"	T14 - S2:L	”	”	+3.3	51
"	T14- S2:R	”	”	-3.3	52
CS 9:S3	T13 - S3:L	237.5	296.0	+3.0	53
"	T13 - S3:R	”	”	-3.0	54
"	T14 - S3:L	”	”	+3.3	55
"	T14 - S3:R	”	”	-3.3	56
CS 10:S2	T15 - S2:L	61.0	127.5	+2.8	57
"	T15 - S2:R	”	”	-2.8	58
"	T16 - S2:L	”	”	+3.3	59
"	T16 - S2:R	”	”	-3.3	60
CS 10:S3	T15 - S3:L	233.5	300.0	+2.8	61
"	T15 - S3:R	”	”	-2.8	62
"	T16 - S3:L	”	”	+3.3	63
"	T16 - S3:R	”	”	-3.3	64
-	-	m	m	m	-

Casting stage	Tendon	X:start	X:end	y(+)	Nr.
CS 11:S2	T17 - S2:L	57.0	131.5	+2.6	65
"	T17 - S2:R	”	”	-2.6	66
CS 11:S3	T17 - S3:L	229.5	304.0	+2.6	67
"	T17 - S3:R	”	”	-2.6	68
CS 12:S2	T18 - S2:L	53.0	135.5	+2.4	69
"	T18 - S2:R	”	”	-2.4	70
CS 12:S3	T18 - S3:L	225.5	308.0	+2.4	71
"	T18 - S3:R	”	”	-2.4	72
CS 13:S2	T19 - S2:L	49.0	139.5	+2.2	73
"	T19 - S2:R	”	”	-2.2	74
CS 13:S3	T19 - S3:L	221.5	312.0	+2.2	75
"	T19 - S3:R	”	”	-2.2	76
CS 14:S2	T22 - S2:L	45.0	143.5	+2.0	77
"	T22 - S2:R	”	”	-2.0	78
CS 14:S3	T22 - S3:L	217.5	316.0	+2.0	79
"	T22 - S3:R	”	”	-2.0	80
CS 15:S2	T23 - S2:L	41.0	147.5	+1.8	81
"	T23 - S2:R	”	”	-1.8	82
CS 15:S3	T23 - S3:L	213.5	320.0	+1.8	83
"	T23 - S3:R	”	”	-1.8	84
CS 16:S2	T24 - S2:L	37.0	151.5	+1.6	85
"	T24 - S2:R	”	”	-1.6	86
CS 16:S3	T24 - S3:L	209.5	324.0	+1.6	87
"	T24 - S3:R	”	”	-1.6	88
CS 17:S2	T25 - S2:L	33.0	155.5	+1.4	89
"	T25 - S2:R	”	”	-1.4	90
CS 17:S3	T25 - S3:L	205.5	328.0	+1.2	91
"	T25 - S3:R	”	”	-1.2	92
CS 18:S2	T20 - S2:L	29.0	159.5	+1.2	93
"	T20 - S2:R	”	”	-1.2	94
CS 18:S3	T20 - S3:L	201.5	332.0	+1.0	95
"	T20 - S3:R	”	”	-1.0	96
CS 19:S2	T26 - S2:L	25.0	163.5	+1.0	97
"	T26 - S2:R	”	”	-1.0	98
CS 19:S3	T26 - S3:L	197.5	336.0	+1.0	99
"	T26 - S3:R	”	”	-1.0	100
-	-	m	m	m	-

Casting stage	Tendon	X:start	X:end	y(+)	Nr.
CS 20:S2	T27 - S2:L	21.0		+0.8	101
"	T27 - S2:R	”	”	-0.8	102
CS 20:S3	T27 - S3:L	193.5		+0.8	103
"	T27 - S3:R	”	”	-0.8	104
CS 21:S2	T28 - S2:L	17.0		+0.6	105
"	T28 - S2:R	”	”	-0.6	106
CS 21:S3	T28 - S3:L	189.5		+0.4	107
"	T28 - S3:R	”	”	-0.4	108
CS 22:S2	T29 - S2:L	13.0		+0.4	109
"	T29 - S2:R	”	”	-0.4	110
CS 22:S3	T29 - S3:L	185.5		+0.4	111
"	T29 - S3:R	”	”	-0.4	112
CS 23:S2	T30 - S2:L	9.0		+0.2	113
"	T30 - S2:R	”	”	-0.2	114
CS 23:S3	T30 - S3:L	181.5		+0.2	115
	T30 - S3:R	”	”	-0.2	116
CS 24:S1	T21 – S1:L	0	7.0	+3.3	117
"	T21 – S1:R	”	”	-3.3	118
CS 24:S4	T21 – S4:L	354.0	361.0	+3.3	119
"	T21 – S4:R	”	”	-3.3	120
CS 25	T31 :L	0		+2.6	121
"	T31:R	”	”	-2.6	122
"	T32 :L	7.0		+2.8	123
"	T32:R	”	”	-2.8	124
"	T37:L	0		+3.3	125
"	T37:R	”	”	-3.3	126
"	T38 :L	0		+3.0	127
"	T38:R	”	”	-3.0	128
"	T39:L	0		+2.8	129
"	T39:R	”	”	-2.8	130
"	T40:L	0		+2.6	131
"	T40:R	”	”	-2.6	132
"	T41 :L	332.0	354.0	+3.3	133
"	T41:R	”	”	-3.3	134
"	T42:L	332.0	361.0	+3.0	135
"	T42:R	”	”	-3.0	136
"	T43:L	328.0	361.0	+2.8	137
"	T43:R	”	”	-2.8	138
-	-	m	m	m	-

Casting stage	Tendon	X:start	X:end	y(+)	Nr.
CS 25	T44 :L	324.0	361.0	+2.6	139
"	T44:R	”	”	-2.6	140
"	T49 :L	163.5	197.5	+2.8	141
"	T49:R	”	”	-2.8	142
"	T50 :L	159.5	201.5	+2.8	143
"	T50:R	”	”	-2.8	144
"	T51 :L	155.5	205.5	+2.6	145
"	T51:R	”	”	-2.6	146
"	T52 :L	151.5	209.5	+2.4	147
"	T52:R	”	”	-2.4	148
"	T53 :L	147.5	213.5	+2.2	149
"	T53:R	”	”	-2.2	150
"	T54 :L	143.5	217.5	+2.0	151
"	T54:R	”	”	-2.0	152
"	T55 :L	139.5	221.5	+1.8	153
"	T55:R	”	”	-1.8	154
"	T56 :L	135.5	225.5	+1.6	155
"	T56:R	”	”	-1.6	156
"	T57 :L	131.5	229.5	+1.4	155
"	T57:R	”	”	-1.4	156
-	-	m	m	m	-

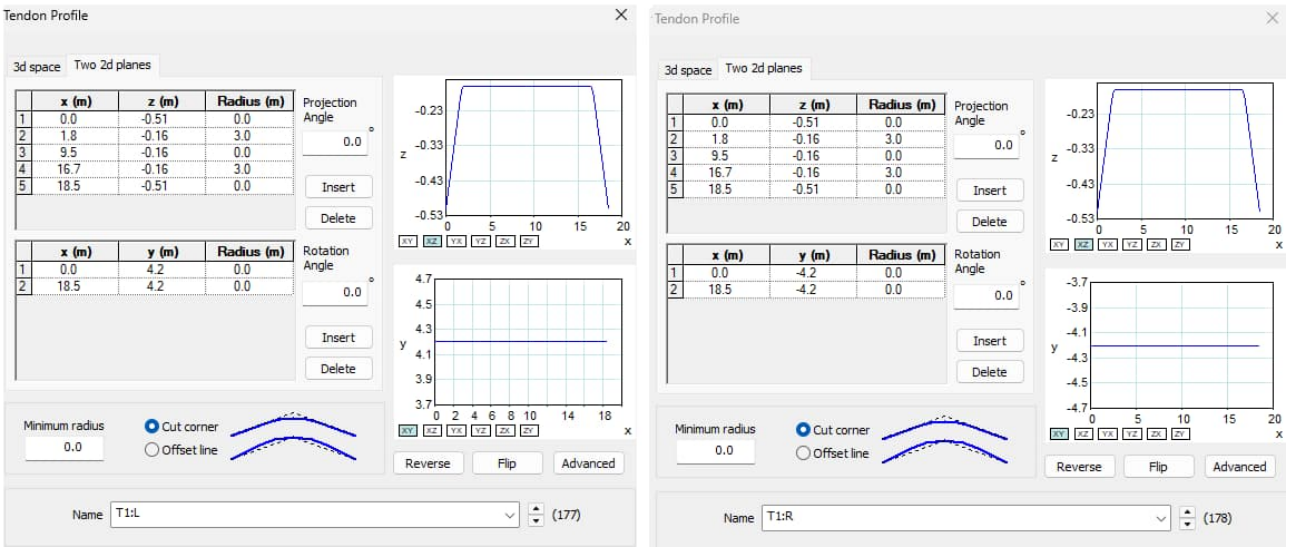
3.7.4.1 Casting stage 3: Tendon T1 & T2

Tendons are used as seen in sketches below.

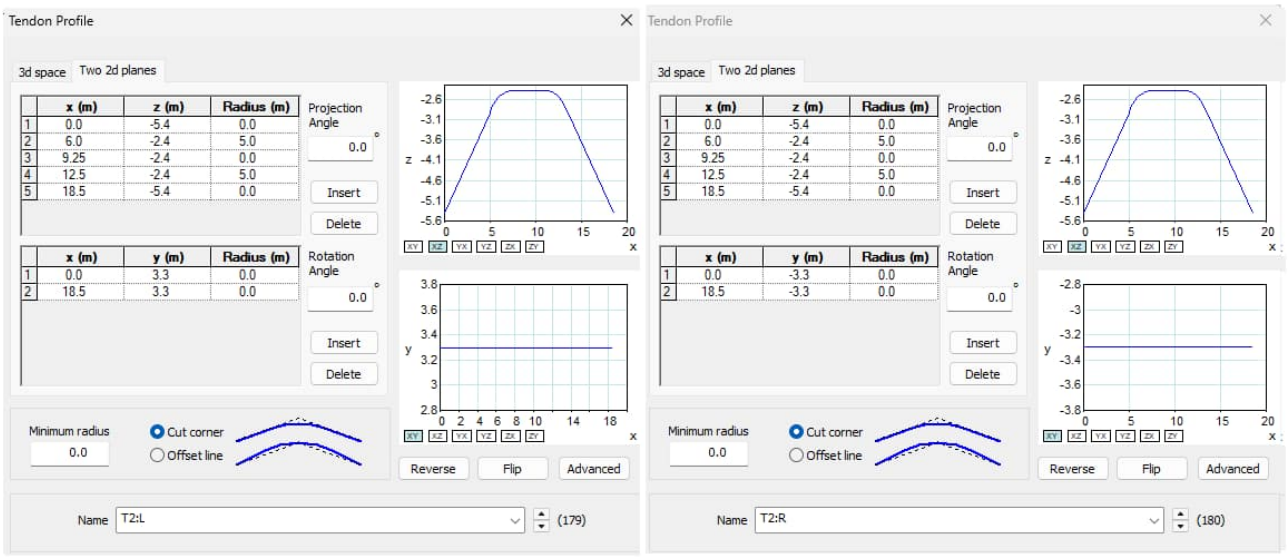
PLAN

ELEVATION

Table definition tendon - T1:
See also appendix 1.



Definition tendon – T2:
See also appendix 1.



3.7.4.2 Casting stage 4: Tendon T3 & T4

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.3 Casting stage 5: Tendon T5 & T6

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.4 Casting stage 6: Tendon T7 & T8

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.5 Casting stage 7: Tendon T9 & T10

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.6 Casting stage 8: Tendon T11 & T12

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.7 Casting stage 9: Tendon T13 & T14

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.8 Casting stage 10: Tendon T15 & T16

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.9 Casting stage 11: Tendon T17

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.10 Casting stage 12: Tendon T18

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.11 Casting stage 13: Tendon T19

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.12 Casting stage 14: Tendon T22

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.13 Casting stage 15: Tendon T23

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.14 Casting stage 16: Tendon T24

Tendons are used as seen in sketches below.

PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.15 Casting stage 17: Tendon T25

Tendons are used as seen in sketches below.

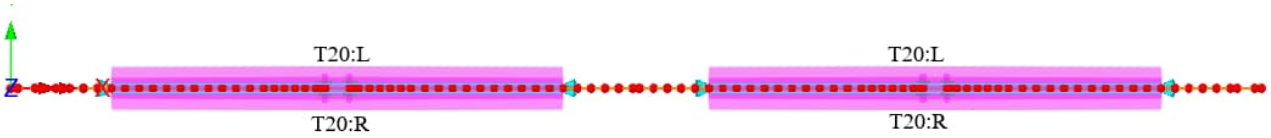
PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.16 Casting stage 18: Tendon T20

Tendons are used as seen in sketches below.



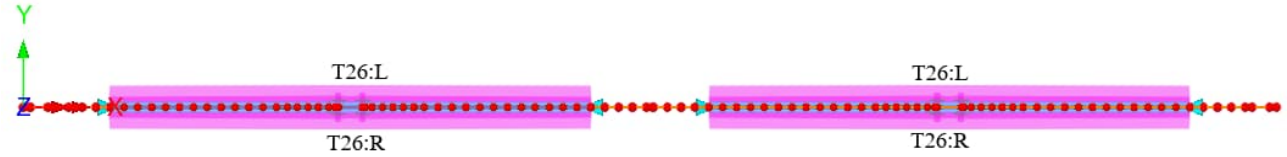
PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.17 Casting stage 19: Tendon T26

Tendons are used as seen in sketches below.



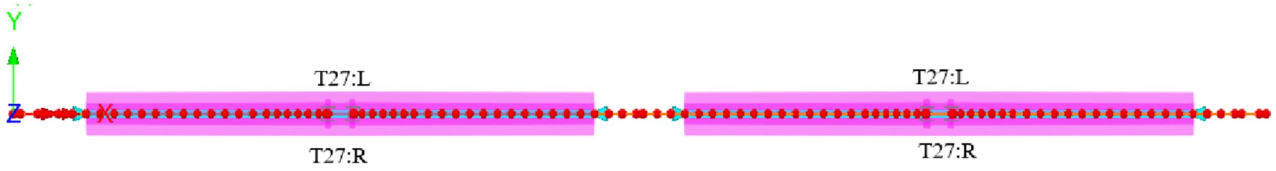
PLAN

ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.18 Casting stage 20: Tendon T27

Tendons are used as seen in sketches below.



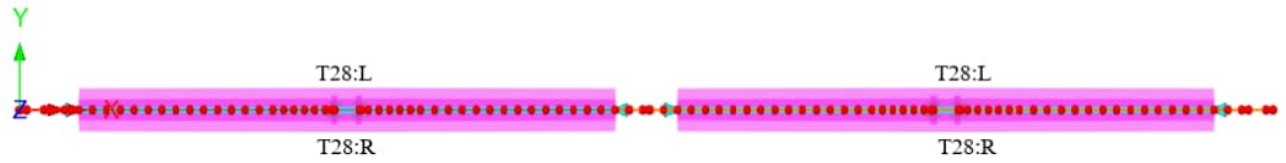
PLAN

ELEVATION

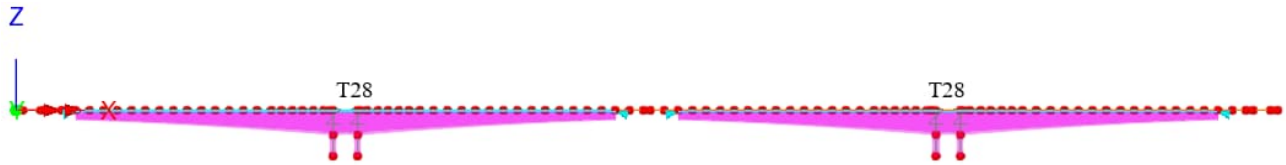
Table definition tendons:
See appendix 1.

3.7.4.19 Casting stage 21: Tendon T28

Tendons are used as seen in sketches below.



PLAN

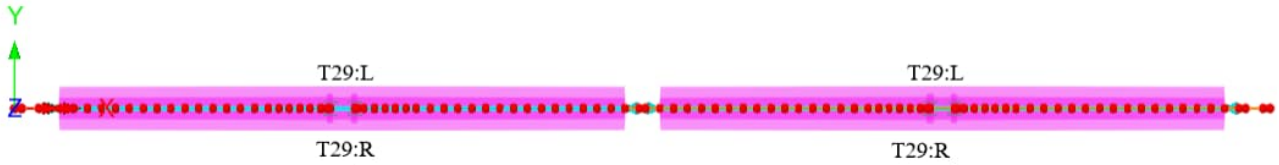


ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.20 Casting stage 22: Tendon T29

Tendons are used as seen in sketches below.



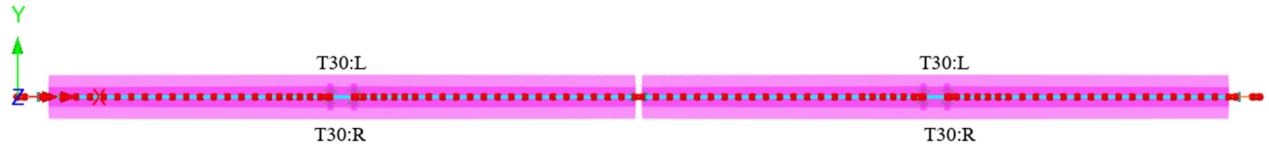
PLAN

ELEVATION

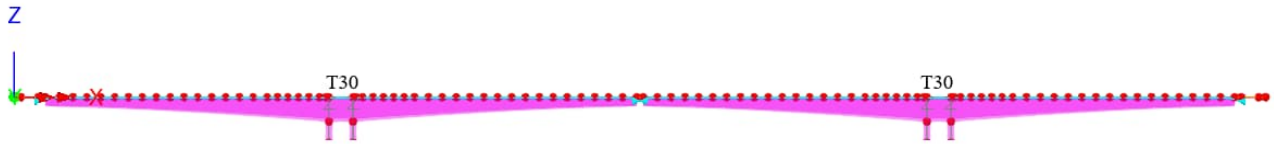
Table definition tendons:
See appendix 1.

3.7.4.21 Casting stage 23: Tendon T30

Tendons are used as seen in sketches below.



PLAN

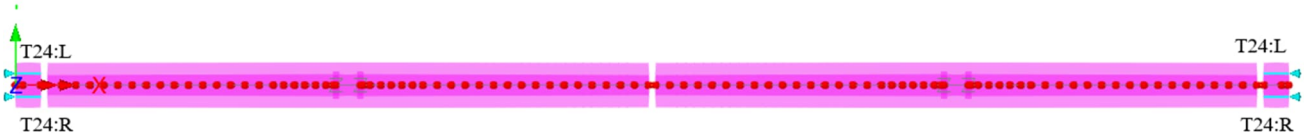


ELEVATION

Table definition tendons:
See appendix 1.

3.7.4.22 Casting stage 24: Tendon T21

Tendons are used as seen in sketches below.



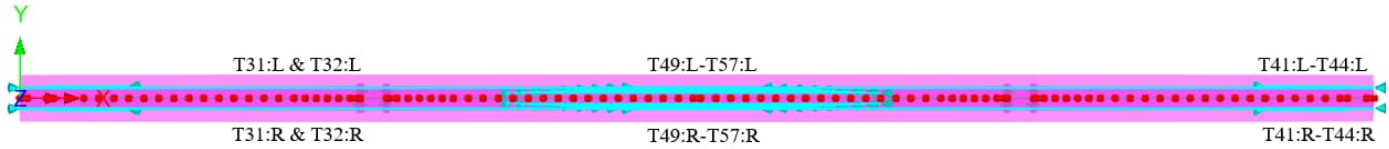
PLAN

ELEVATION

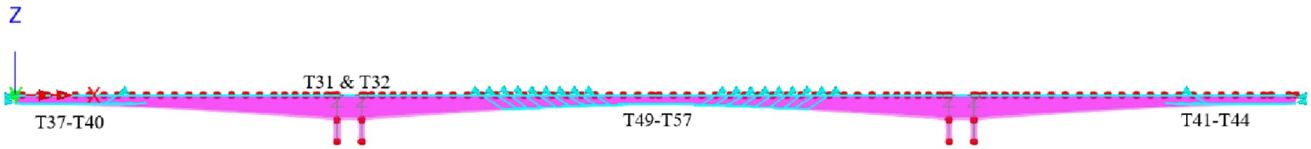
Table definition tendons:
See appendix 1.

3.7.4.23 Casting stage 25: Tendon T37-T44 & T49-T57

Tendons are used as seen in sketches below.



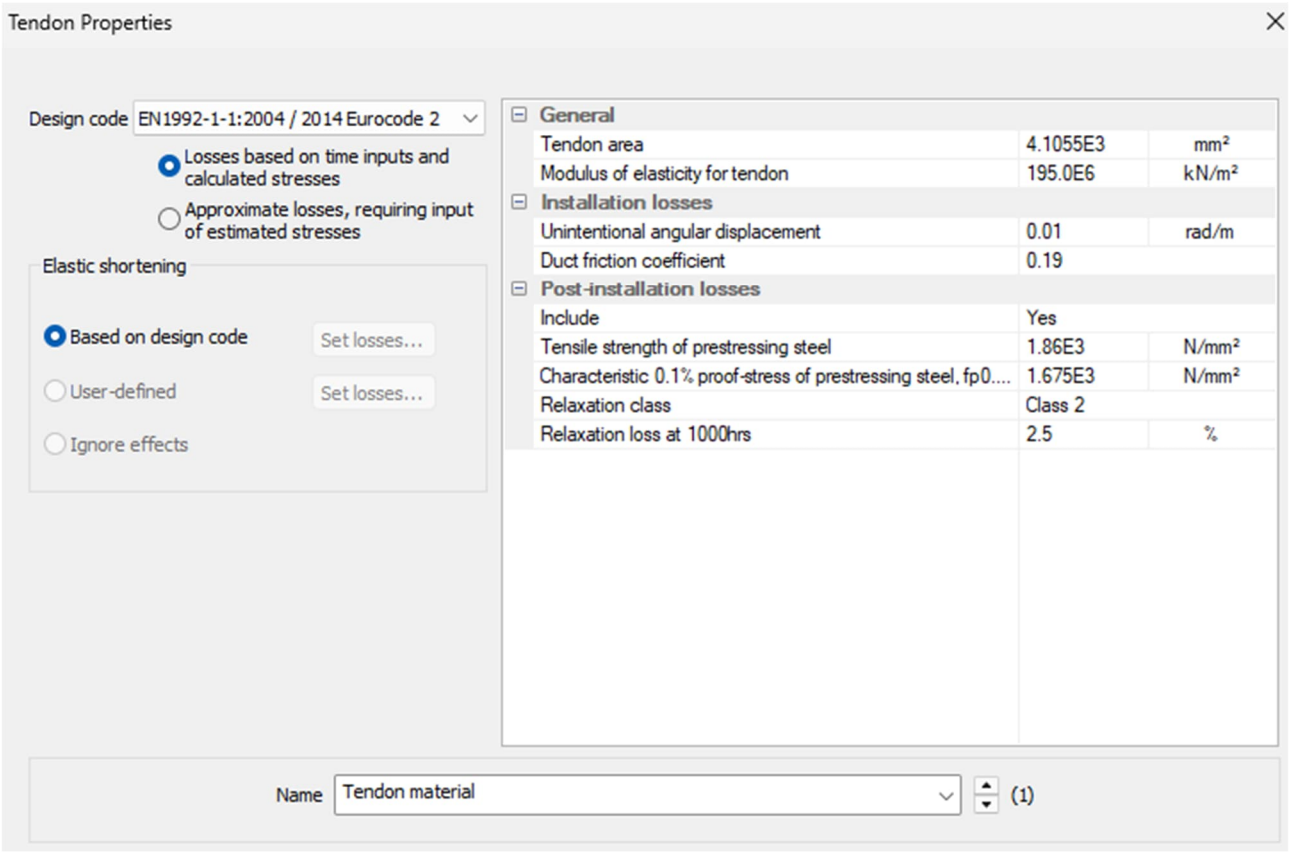
PLAN



ELEVATION

Table definition tendons:
See appendix 1.

3.7.5 Tendon material



Friction coefficient installation

$$P_{(x)} = P_o \cdot e^{-\mu(\alpha + k \cdot x)}$$

μ = 0.19

$$k = 0.010 \frac{rad}{m}$$

Chosen prestress before locking (see page A3:33)

$max\ F_p = 4106mm^2 \cdot 1488MPa = 6110kN$ but $F_p = 6100kN$ is chosen.

3.7.6 Load definition

Slip is 6 mm but dure to re-tensioning of tendons after locking slip 0 mm is applied.

Load	Angle	Slip	Left side	Right side	Prestress force
T1-T23	0	0	Active	Active	6100
T24:S1	0	0	Active	Passive	6100
T24:S4	0	0	Passive	Active	6100
T31-T32	0	0	Active	Active	6100
T37	0	0	Passive	Active	6100
T38-T40	0	0	Active	Passive	6100
T41	0	0	Active	Passive	6100
T42-T44	0	0	Passive	Active	6100
T49-T57	0	0	Active	Active	6100
-	deg	mm	-	-	kN

3.7.7 Envelope prestress

Envelope PT::

Load case	Permanent factor	Variable factor
Prestress (stage 25)	1.00	0
Prestress (longterm)	0.90	0.20

3.8 LOAD COMBINATIONS

Verification of load capacity shall be carried out for several limit states as detailed in this section.

Fatigue Limit State:
The risk of fatigue according to the partial factor method is checked using equation 6.69 provided in document SS-EN 1992-1-1.

Other Limit States:
For other limit states, section 6.4.3 of EN-1990 is applied.

Verification of load capacity shall be carried out for several limit states as detailed in this section.

Fatigue Limit State:
The risk of fatigue according to the partial factor method is checked using equation 6.69 provided in document SS-EN 1992-1-1.

Other Limit States:
For other limit states, section 6.4.3 of EN-1990 is applied.

3.8.1 Ultimate Limit States (ULS)

When checking the ultimate limit state, the load factors vary depending on the type of failure as detailed below:

STR: Verification of structural bearing capacity

GEO: Verification of geotechnical bearing capacity

For checking the ultimate limit state, TRVNFRA-00227 section 7.1.6.3 specifies requirements for load combinations as follows.

Design Method D2 (Set B):
Design Method D2 (Set B) according to TSFS 2018:57 Table 4.4 shall be applied for the structural bearing capacity of the construction (STR; SK 3).

Design Method is defined according to EN-1990 equations 6.10a and 6.10b as detailed below.

$$E_{Sd}^{10a} = \sum_{j\geq 1} \gamma_{G.j} \cdot G_{k,j} + \gamma_{Q.1} \cdot \psi_{0,1} \cdot Q_{k.1} + \sum_{i>1} \gamma_{Q.i} \cdot \psi_{0,i} \cdot Q_{k,i} = \psi\gamma_{ULS-A} \cdot (\sum_{j>1} G_{k,j} + \sum_{i>1} Q_{k,i})$$

$$E_{sd}^{10b} = \sum_{j\geq 1} \xi_j \cdot \gamma_{G.j} \cdot G_{k,j} + \gamma_{Q.1} \cdot Q_{k.1} + \sum_{i>1} \gamma_{Q.i} \cdot \psi_{0,i} \cdot Q_{k,i} = \psi\gamma_{ULS-B} \cdot (\sum_{j>1} G_{k,j} + \sum_{i>1} Q_{k,i})$$

Equation 6.10a refers to the (ULS-A) case where the permanent loads are dominant, usually during the construction phase.

Equation 6.10b refers to the (ULS-B) case where the variable loads are dominant.
Design method 2 (set B) according to TSFS 2018:57 table 4.4 shall be applied for the structural capacity (STR; SK3).

Design method D3 (set C):

Design method D3 (set C) according to TSFS 2018:57 table 4.5 shall be applied for determining geotechnical bearing capacity (GEO; SK 2).

The design method is defined according to EN-1990 equation 6.10a and 6.10b as presented below.

$$E_{Sd}^{10a} = \sum_{j\geq 1} \gamma_{G.j} \cdot G_{k,j} + \gamma_{Q.1} \cdot \psi_{0,1} \cdot Q_{k.1} + \sum_{i>1} \gamma_{Q.i} \cdot \psi_{0,i} \cdot Q_{k,i} = \psi\gamma_{ULS-GA} \cdot (\sum_{j>1} G_{k,j} + \sum_{i>1} Q_{k,i})$$

$$E_{sd}^{10b} = \sum_{j\geq 1} \xi_j \cdot \gamma_{G.j} \cdot G_{k,j} + \gamma_{Q.1} \cdot Q_{k.1} + \sum_{i>1} \gamma_{Q.i} \cdot \psi_{0,i} \cdot Q_{k,i} = \psi\gamma_{ULS-GB} \cdot (\sum_{j>1} G_{k,j} + \sum_{i>1} Q_{k,i})$$

Equation 6.10a refers to the (ULS-A) case where the permanent loads are dominant, usually during the construction phase.

Equation 6.10b (ULS-B) refers to the case where the variable loads are dominant.

Design method 3 (set C) according to TSFS 2018:57 table 4.5 shall be applied for determining geotechnical bearing capacity (GEO).

Simplified Design Method ULS

To limit the number of load combinations, design method D2 (STR) is also applied for checking geotechnical bearing capacity (GEO). This is done by adjusting load coefficients associated with the geotechnical loads.
When applying the geotechnical loads, the earth pressure coefficient corresponding to D2 is applied.

Permanent loads:

Nr	Load		$\psi\gamma_{ULS-A}$	$\psi\gamma_{ULS-B}$		$\psi\gamma_{ULS}$
1	Dead weight	max	1.35	1.20		1.20
		min	1.00	1.00		1.00
2	Surfacing	max	1.49	1.33		1.33
		min	0.90	0.90		0.90
3	Fillling	max	1.49	1.33		1.33
		min	0.90	0.90		0.90
4	Earth pressure	max	1.49	1.33	$\Rightarrow$	1.48[1.)]
		min	0.90	0.90		0.90
5	Water pressure	max	1.35	1.09		1.09
		min	1.00	1.00		1.00
6	Support settlement	max	1.35	1.20		1.20
		min	1.00	1.00		1.00
7	Shrinkage	max	1.35	1.20		1.20
		min	1.00	1.00		1.00
8	Prestress	max	1.35	1.35		1.35
		min	1.00	1.00		1.00

Variable loads:

Nr	Load	$\psi\gamma_{ULS-A}$	$\psi\gamma_{ULS-B}$		$\psi\gamma_{ULS}$
	Load model LM 1 :				
9	Tandem axel	1.13	1.03/1.50		1.03/1.50
10	Surface load	0.60	0.60/1.50		0.60/1.50
11	Braking force	0.84	0.84/1.13		0.84/1.13
12	Lateral force	0.84	0.84/1.13		0.84/1.13
13	Centrifugal force	0.84	0.84/1.13		0.84/1.13
	Load model LM 2 :				
14	Single axel	0	0/1.50		0/1.50
	Complementary load EG A/B :				
15	Vehicle EG A/B	1.13	1.13/1.50		1.13/1.50
16	Braking force	0.84	0.84/1.13		0.84/1.13
17	Lateral force	0.84	0.84/1.13		0.84/1.13
18	Centrifugal force	0.84	0.84/1.13	$\Rightarrow$	0.84/1.13
19	Temperature	0.90	0.90/1.50		0.90/1.50
	Wind load:				
20	Wind against bridge	0.45	0.45/1.50		0.45/1.50
21	Wind against vehicles	0.45	0.45/1.50		0.45/1.50
22	Surcharge	1.13	1.13/1.50		1.13/1.50

Load combination smart *ULS-PERM :*

Load case	Permanent factor	Variable factor
Dead weight (stage 7	1.00	0.20
Surfacing	0.90	0.43

Load combination smart *ULS-VAR :*

Load case	Permanent factor	Variable factor
TRAFIK	1.03	0.47

Load combination smart *ULS :*

Load case	Permanent factor	Variable factor
ULS-PERM	1	0
PT	1	0.35
ULS-VAR	0	1

Load combination smart *ULS-0 :*
(Is identical to ULS but does not contain prestress)

Load case	Permanent factor	Variable factor
ULS-PERM	1	0
ULS-VAR	0	1

3.14.2 Service limit state (SLS)

The service limit state is divided into 3 load combinations based on their duration. The load combinations are presented below.

Load combination	Duration
SLS:K	Characteristic
SLS:F	Frequent
SLS:Q	Quasi-permanent

Load Combination SLS:K according to EN 1990 equation 6.14b is presented below.

$$E_{Sd} = \sum_{j\geq 1} G_{k,j} + Q_{k.1} + \sum_{i>1} \psi_{0,i} \cdot Q_{k,i} = \psi\gamma_{SLS.K} \cdot (\sum_{j>1} G_{k,j} + \sum_{i>1} Q_{k,i})$$

Load Combination SLS:F according to EN 1990 equation 6.15b is presented below.

$$E_{Sd} = \sum_{j\geq 1} G_{k,j} + \psi_1 \cdot Q_{k.1} + \sum_{i>1} \psi_{2,i} \cdot Q_{k,i} = \psi\gamma_{SLS.2} \cdot (\sum_{j>1} G_{k,j} + \sum_{i>1} Q_{k,i})$$

Load Combination SLS:Q according to EN 1990 equation 6.16b is presented below.

$$E_{Sd} = \sum_{j\geq 1} G_{k,j} + \sum_{i>0} \psi_{2,i} \cdot Q_{k,i} = \psi\gamma_{SLS.Q} \cdot (\sum_{j>1} G_{k,j} + \sum_{i>1} Q_{k,i})$$

When designing, load coefficients according to equations 6.14a, 6.15b, and 6.16b are applied.

Permanent loads:

Nr	Load		$\psi\gamma_{SLS-K}$	$\psi\gamma_{SLS-F}$	$\psi\gamma_{SLS-Q}$
1	Dead weight	max	1.00	1.00	1.00
		min	1.00	1.00	1.00
2	Surfacing	max	1.10	1.10	1.00
		min	0.90	0.90	1.00
3	Fillling	max	1.10	1.10	1.00
		min	0.90	0.90	1.00
4	Earth pressure	max	1.48[3.)]	1.48[3.)]	1.34[3.)]
		min	0.90	0.90	1.00
5	Water pressure	max	1.00	1.00	1,00
		min	1.00	1.00	1.00
6	Support settlement	max	1.00	1.00	1.00
		min	1.00	1.00	1.00
7	Shrinkage	max	1.00	1.00	1.00
		min	1.00	1.00	1.00
8	Prestress	max	1.00	1.00	1.00
		min	1.00	1.00	1.00

Variable loads:

Nr	Load	$\psi\gamma_{SLS-K}$	$\psi\gamma_{SLS-F}$	$\psi\gamma_{SLS-Q}$
	Load model LM 1 :			
9	Tandem axel	0.75/1.00	0/0.75	0
10	Surface load	0.40/1.00	0/0.40	0
11	Braking force	0.56/0.75	0/0.56	0
12	Lateral force	0.56/0.75	0/0.56	0
13	Centrifugal force	0.56/0.75	0/0.56	0
	Load model LM 2 :			
14	Single axel	0.75/1.00	0/0.75	0
	Complementary load EG A/B :			
15	Vehicle EG A/B	0.75/1.00	0/0.75	0
16	Braking force	0.56/0.75	0/0.56	0
17	Lateral force	0.56/0.75	0/0.56	0
18	Centrifugal force	0.56/0.75	0/0.56	0
19	Temperature	0.60/1.00	0.50/0.60	0.50
	Wind load:			
20	Wind against bridge	0.30/1.00	0/0.30	0
21	Wind against vehicles	0.30/1.00	0/0.30	0
22	Surcharge	0.75/1.35	0/0.75	0

Load combination smart *SLS-PERM :*

Loadcase	Permanent factor	Variable factor
Dead weight (stage 7)	1.00	0
Surfacing	0.90	0.20

Load combination smart *SLS-K-VAR :*

Load case	Permanent factor	Variable factor
TRAFIK	0.75	0.25

Load combination smart *SLS-F-VAR :*

Load case	Permanent factor	Variable factor
TRAFIK	0	0.75

Load combination smart *SLS-K :*

Load case	Permanent factor	Variable factor
SLS-PERM	1	0
PT	1	0
SLS-K-VAR	0	1

Load combination smart *SLS-F :*

Load case	Permanent factor	Variable factor
SLS-PERM	1	0
PT	1	0
SLS-F-VAR	0	1

Load combination smart *SLS-Q :*

Load case	Permanent factor	Variable factor
Dead weight (stage 7)	1.00	0
Surfacing	1.00	0.20
Prestress (longterm)	1	0

3.14.4 Fatigue load combination

Fatigue is considered according to SS EN 1992-1-1, 6.8.4 and 6.8.6, and SS EN 1992-2, 6.8 and Appendix NN.

The risk of fatigue is checked using a simplified method, denoted as the λ-method.
Load combination according to equation SS-EN 1992-1-1 section 6.8.3 equation 6.69.

In this load combination, the traffic load is considered to consist of UTM, whereby other traffic loads are excluded.

$$E_{Sd} = \sum_{j\geq 1} G_{k,j} + P + \psi_{1,1} \cdot Q_{k,1} + \sum_{i>1} \psi_{2,i} \cdot Q_{k,i} + Q_{fat} = \psi\gamma_{UTM} \cdot (\sum_{j\geq 1} G_{k,j} + P + \sum_{i\geq 1} Q_{k,i} + Q_{fat})$$

Permanent loads:

Nr	Load		$\psi\gamma_{UTM}$
1	Egentyngd	max	1.00
		min	1.00
2	Beläggning	max	1.10
		min	0.90
3	Överfyllnad	max	1.10
		min	0.90
4	Jordtryck	max	1.48
		min	0.90
5	Vattentryck	max	1.00
		min	1.00
6	Stödförskjutning	max	1.00
		min	1.00
7	Krympning	max	1.00
		min	1.00
8	Prestress	max	1.00
		min	1.00

Variable loads:

Nr	Load	ψγUTM
	Lastmodell LM 1 :	
9	Boggiesystem	-
10	Utbredd last	-
11	Bromskraft	-
12	Sidokraft	-
13	Centrifugalkraft	-
	Lastmodell LM 2 :	
14	Enstaka axellast	-
	Typfordon EG A/B :	
15	Typfordon EG A/B	-
16	Bromskraft	-
17	Sidokraft	-
18	Centrifugalkraft	-
19	Temperatur	0.60
	Vindlaster:	
20	Vindlast mot bro	0.30
21	Vindlast mot trafik	0.30
22	Överlast	1.01
23	UTM3	1.00

Load combination smart FAT :

Load case	Permanent factor	Variable factor
Dead weight (stage 7)	1.00	0
Surfacing	1.00	0
Prestress (longterm)	1.0	0
UTM3	-	1.00