Pretensioned hollow deck bridge

CONTENT

1. GENERAL / MEASUREMENT

1.1 CONSTRUCTION TYPE

Bridge superstructure is performed as a pretensioned slab bridge with a total of 8 spans.

In the transverse direction, there are 8 void tubes Ø650 at a distance of 1.0 m from each other.

End supports are constructed as free standing abutments with expansion joints.

All foundations are constructed with slabs on compacted fill.

Spans according to the presentation below.

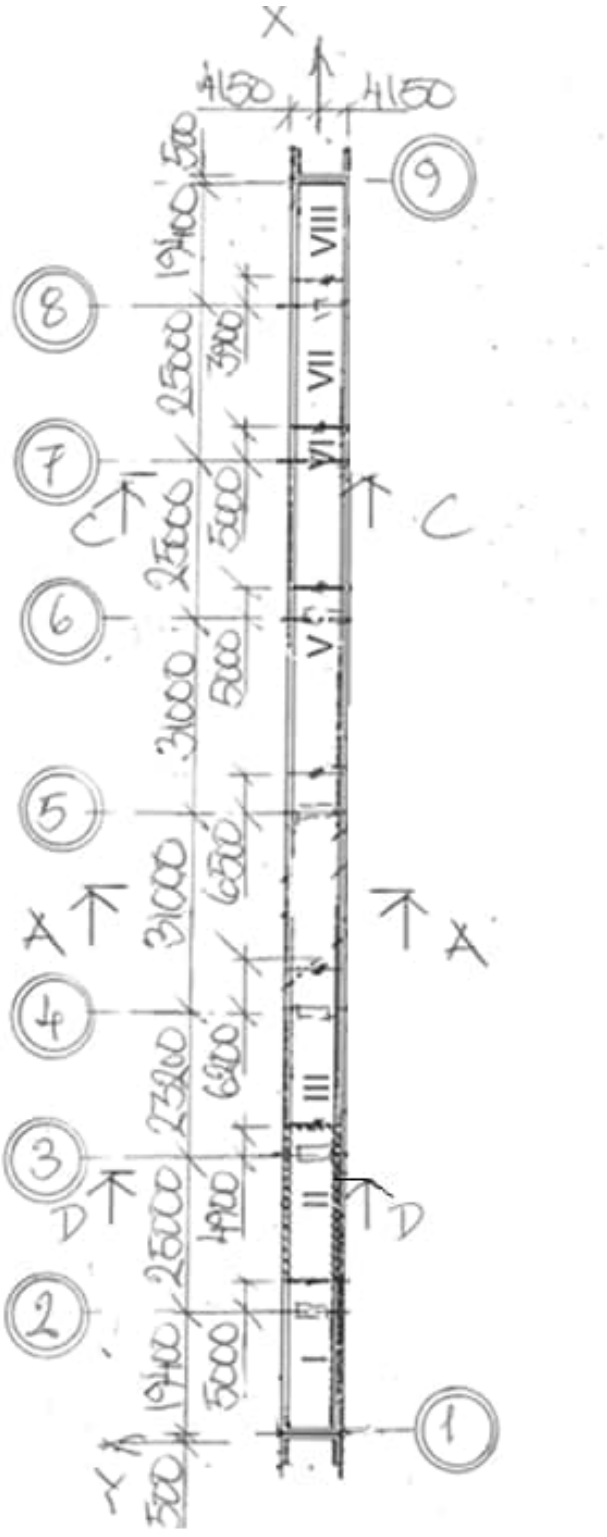
Span nr.	Length
1	19,1
2	25,0
3	23,2
4	31,0
5	31,0
6	25,0
7	25,0
8	19,1
-	m

The impact of phased construction is considered in the determination of load effects.

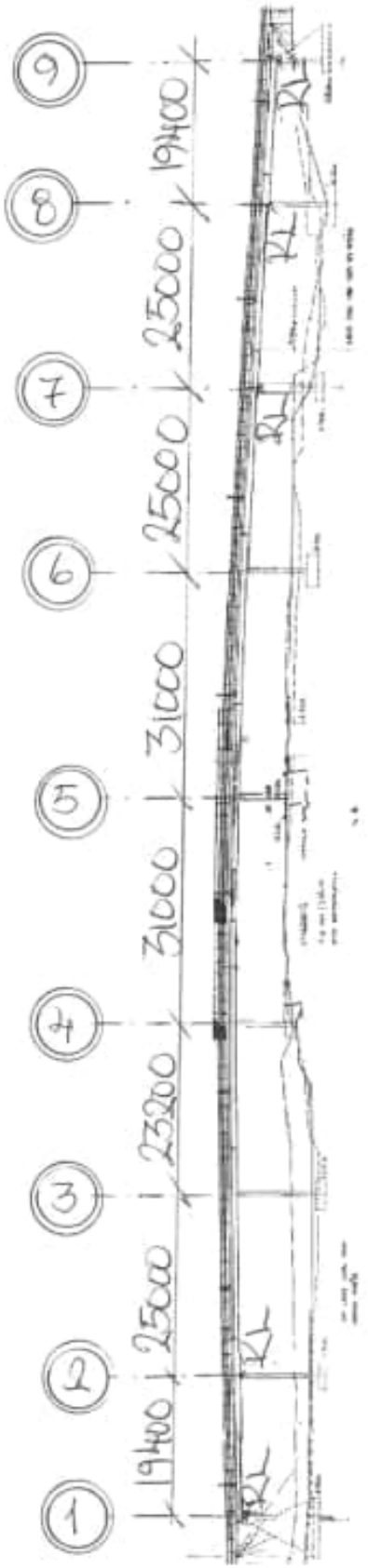
The bridge has a total of 8 cast joints (stages I-VIII).

PLAN

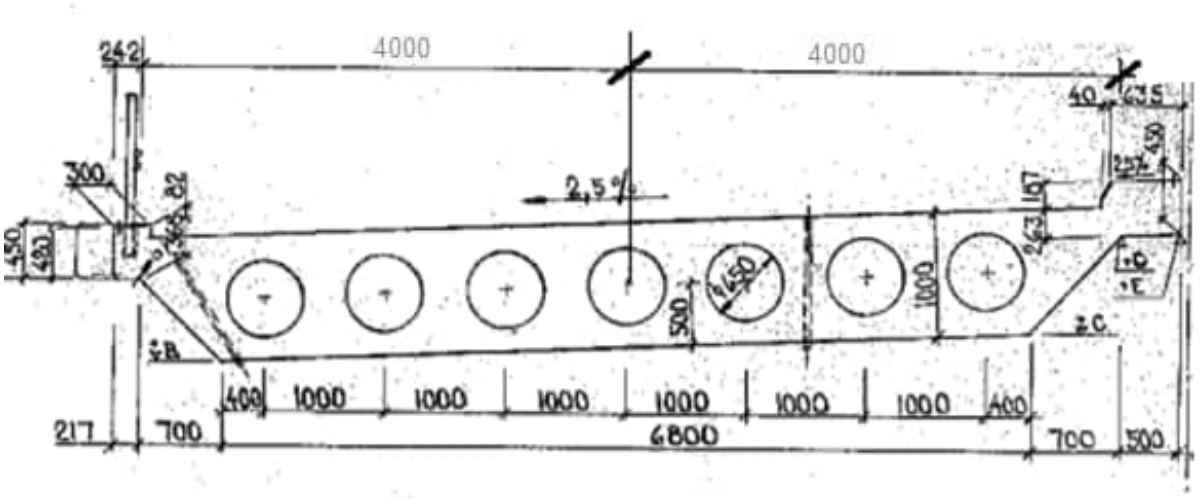
1.2 MÅTT



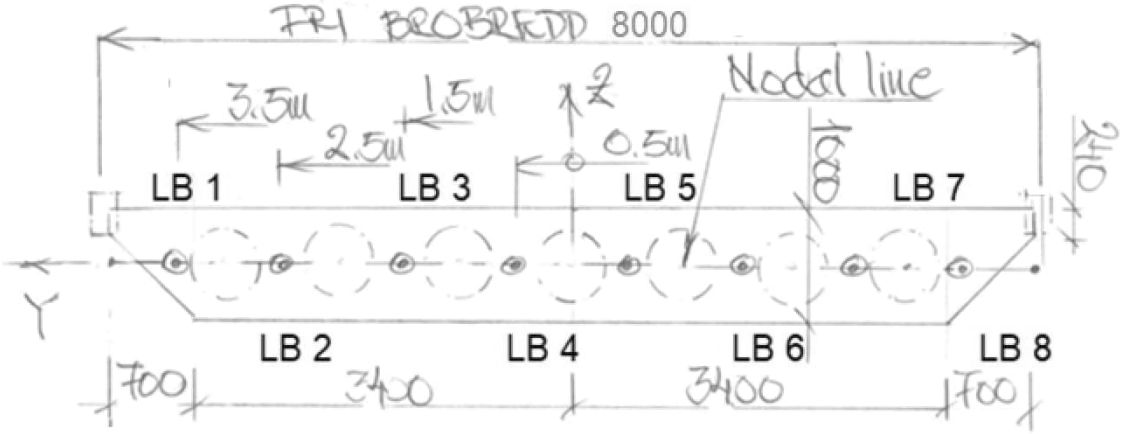
PLAN
Overview



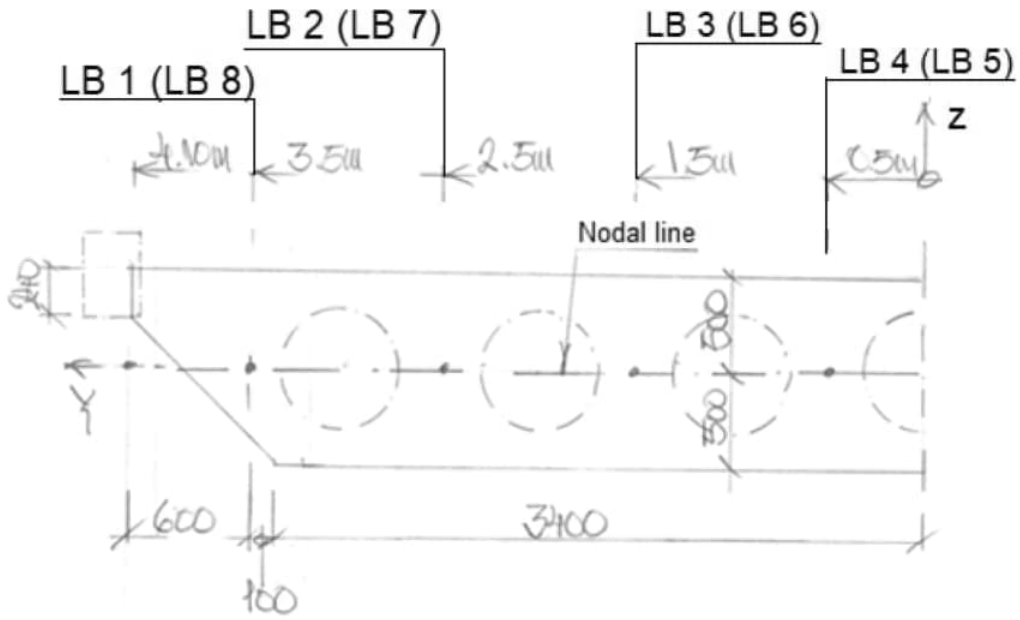
ELEVATION



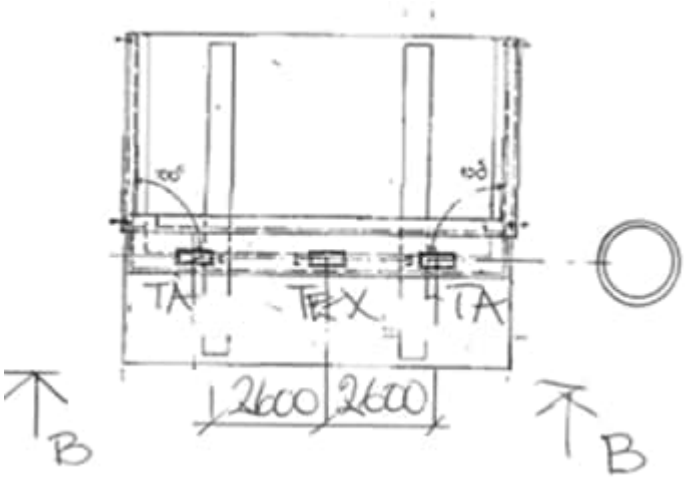
SECTION A-A
Drawing



SECTION A-A
Calculation

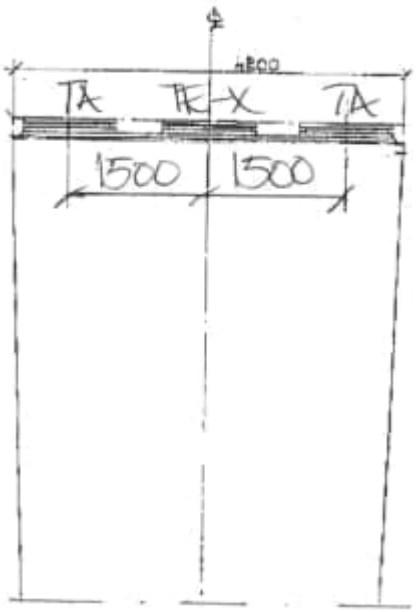


DETAIL 1
Calculations

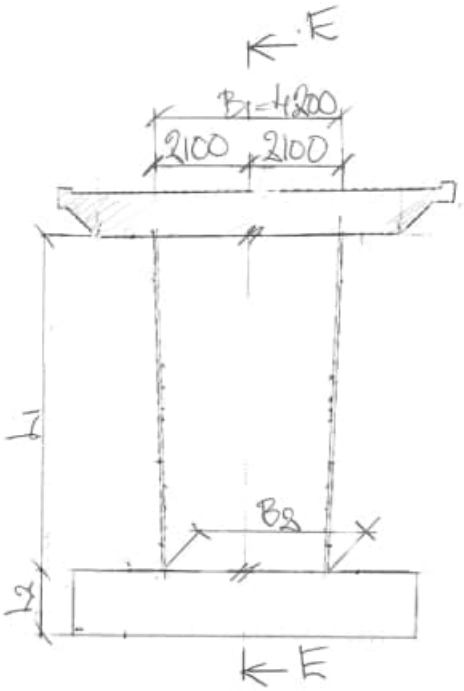


PLAN
Support 1 & 9

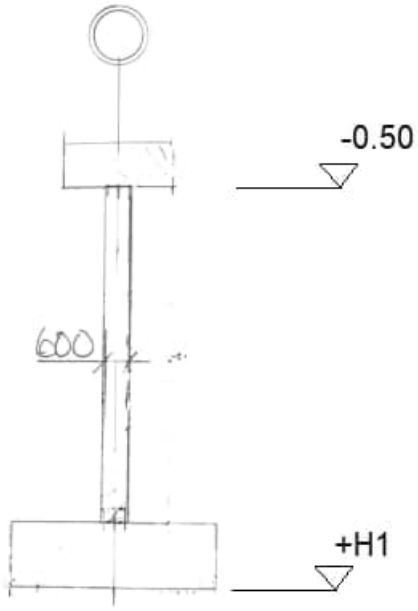
VIEW B-B
Support 1 & 9



SECTION C-C
Support 2, 7 & 8



SECTION D-D
Support 3-6



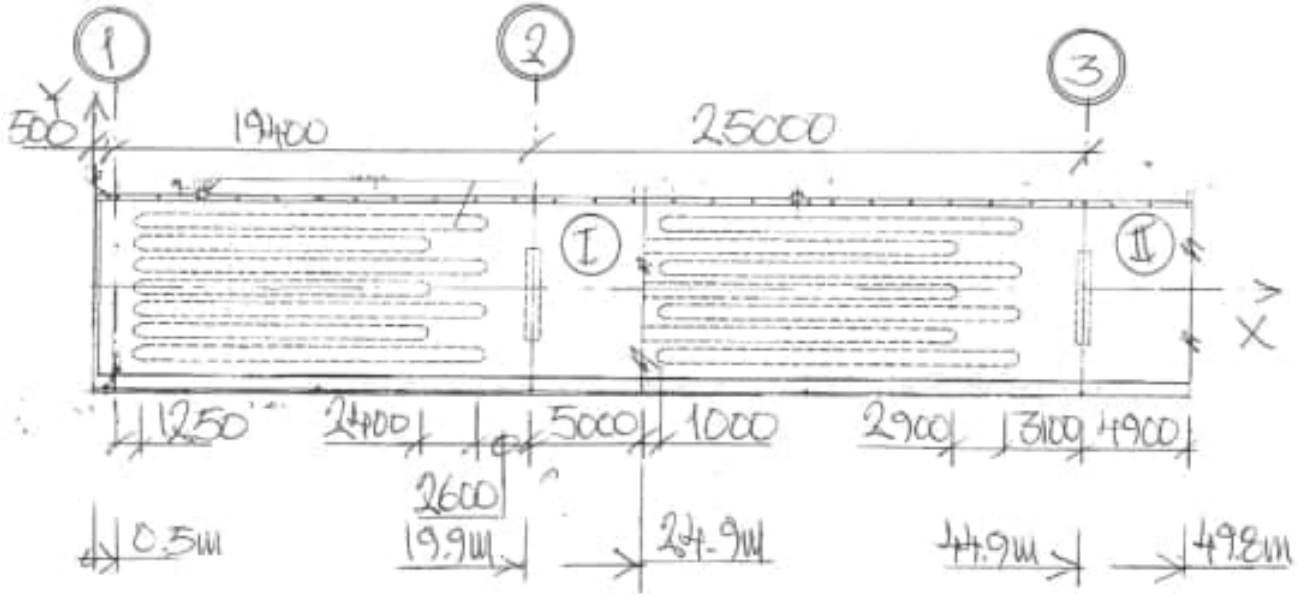
SEKTION E-E
Support 3-6

Support	B1	B2	L1	L2	+H1	Line
3	4200	3500	10970	1300	-11.77	P1300→P1301
4	4200	3500	9680	1400	-11.58	P1400→P1401
5	4200	3700	7470	1450	-9.37	P1500→P1501
6	4200	3600	8280	1400	-10.18	P1600→P1601
-	mm	mm	mm	mm	m	-

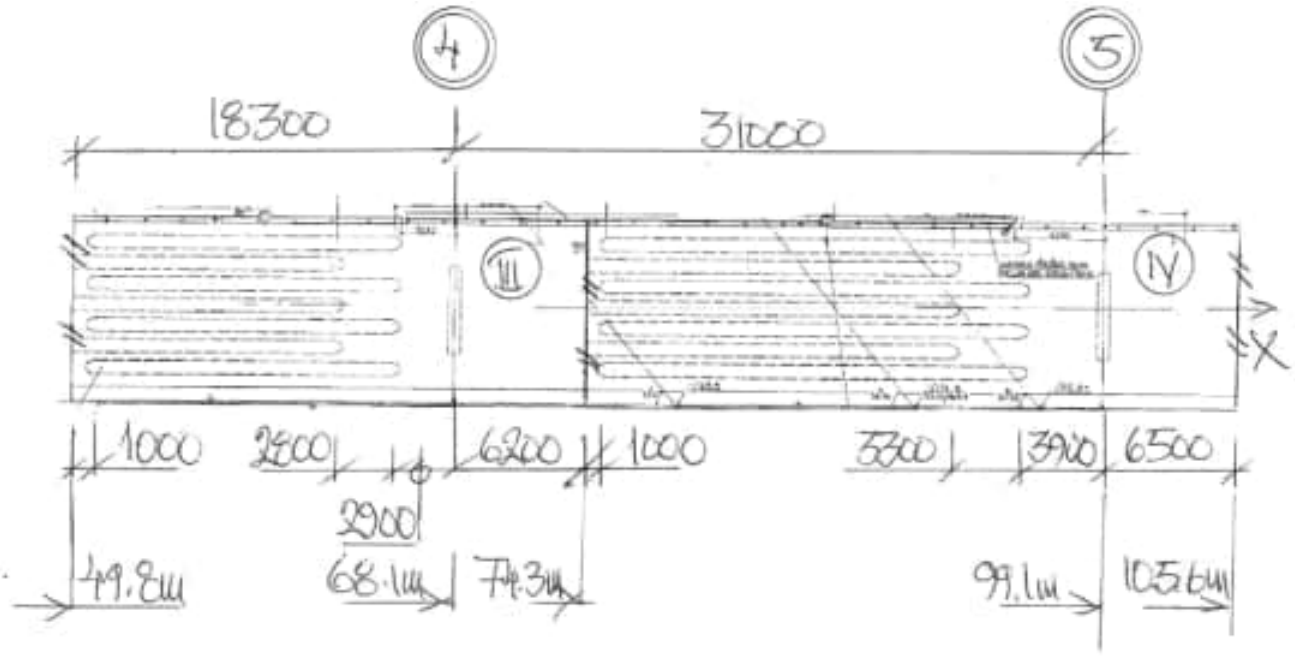
Tabell
Support 3-6

1.3 CASTING STAGES

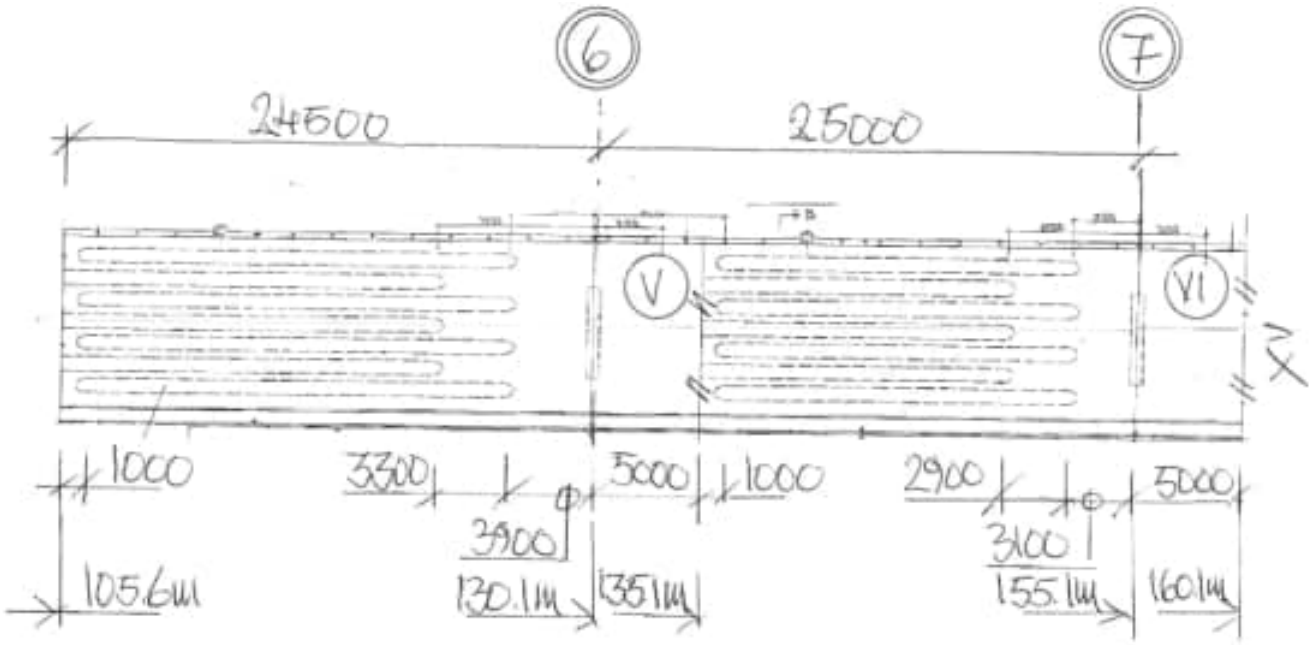
There is at total of 8 casting stages with as seen below.



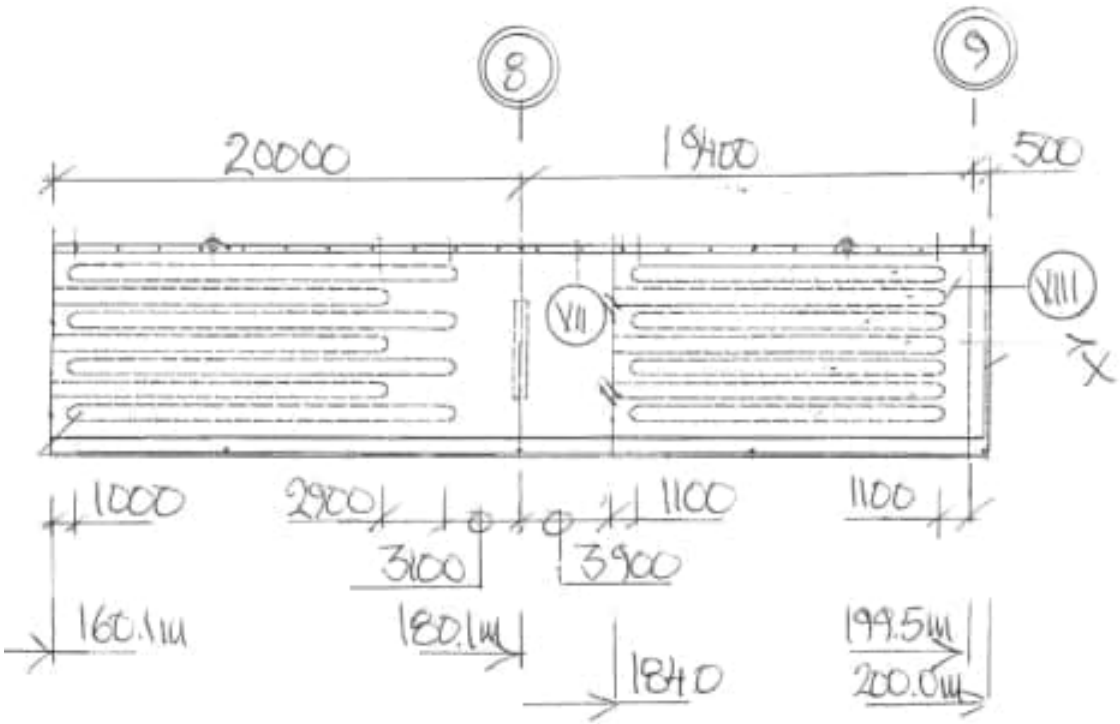
PLAN
Casting stage 1 & 2



PLAN
Casting stage 3 & 4



PLAN
Casting stage 5 & 6

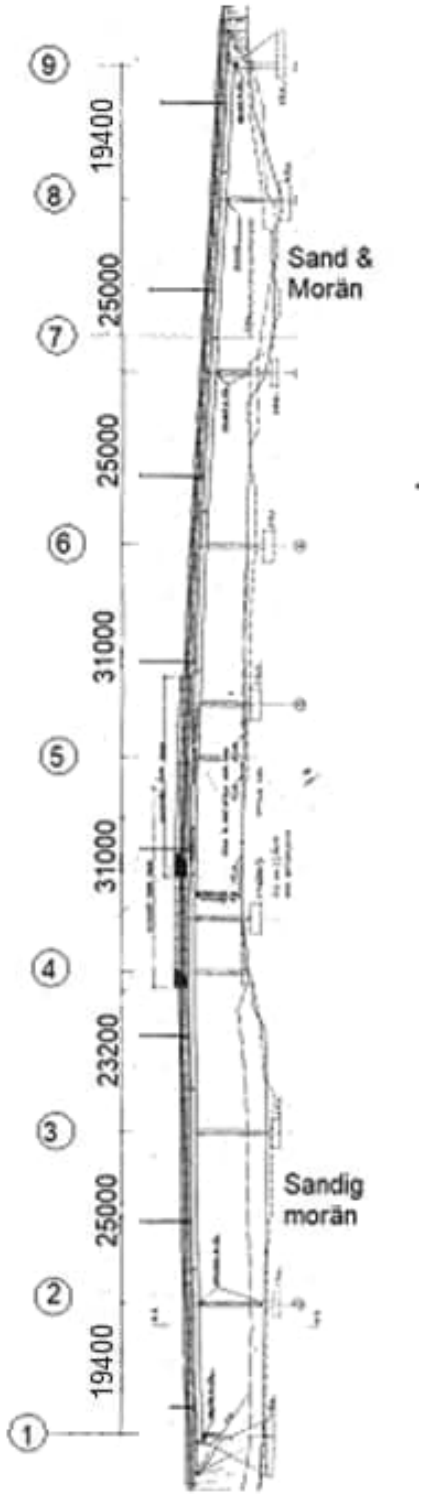


PLAN
Casting stage 7 & 8

1.4 FOUNDATION

Foundation at all support on compacted filling.

Benith filling sand, ”morän” and sandy ”morän” according interpretation seen below.



1.5 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

1.6 TECHNICAL SERVICE LIFE

Technical life span 120 years (L100).

1.7 ENVIRONMENT

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

1.8 MATERIAL

Concrete : C30/37 & 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

1.9 GEOTECHNICAL CLASS

Geotechnical class GK2

Geotechnical class GK2

1.10 SAFETY CLASS

Geotechnical resistance: SK 2

Brigde structure : SK 3

1.11 CONCRETE COVER AND CRACK CRITERIA

Class identification bridge components :

Bridge components	Exposure class[1.)]	Life spann	max vct_{ekv}[2.)]	ζ [3.)]
Substructure:				
▫ 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

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:						
▫ 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

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 $f_{ctk.0.05}/\zeta$

2. SYSTEM ANALYSIS

2.1 GENERAL

Regulations, SS-EN 1992-1-1 section 5.3.1 (3) specifies criteria for “slab” and “beam” as follows:

- Slab: $B > 5H$
- Beam: $B \leq 5H$

The studied bridge deck is therefore a slab structure, since $B > 7.5H$, and not a beam.

Edge beams are not considered to contribute any stiffness, only load.

The bridge deck is modeled as grillage using longitudinal and transverse beams.

There are a total of 8 longitudinal beams. These are modeled as 3D beam elements and defined along longitudinal nodal lines. Each beam has a width of 1 m.

Transverse beams are introduced at both the bottom and top of the bridge deck. These are assigned a maximum width of 3 m in accordance with technical code practice. The transverse beams are included to enable evaluation of bending moments and shear forces between the voids. These beams are also modeled as 3D beam elements defined along transverse nodal lines. A stiffness increase of 1:3 is applied when determining their thickness.

To avoid shear reinforcement (stirrups) to resist torsion and shear effects, the chosen analysis model must account for this. This is achieved by assigning negligible torsional stiffness to both longitudinal and transverse beams, thereby preventing torsional forces from developing in these elements. This assumption results in a somewhat reduced load distribution in the transverse direction.

The columns at supports 3–6 are modeled as 3D beam elements. At their top, these elements are rigidly connected to the lower transverse beams using beam joints (JSH4). At their base, the columns are modeled with pinned connections, consistent with the original analysis.

Traffic load evaluation is performed using the Vehicle Load Optimiser (VLO) for Swedish traffic loads.

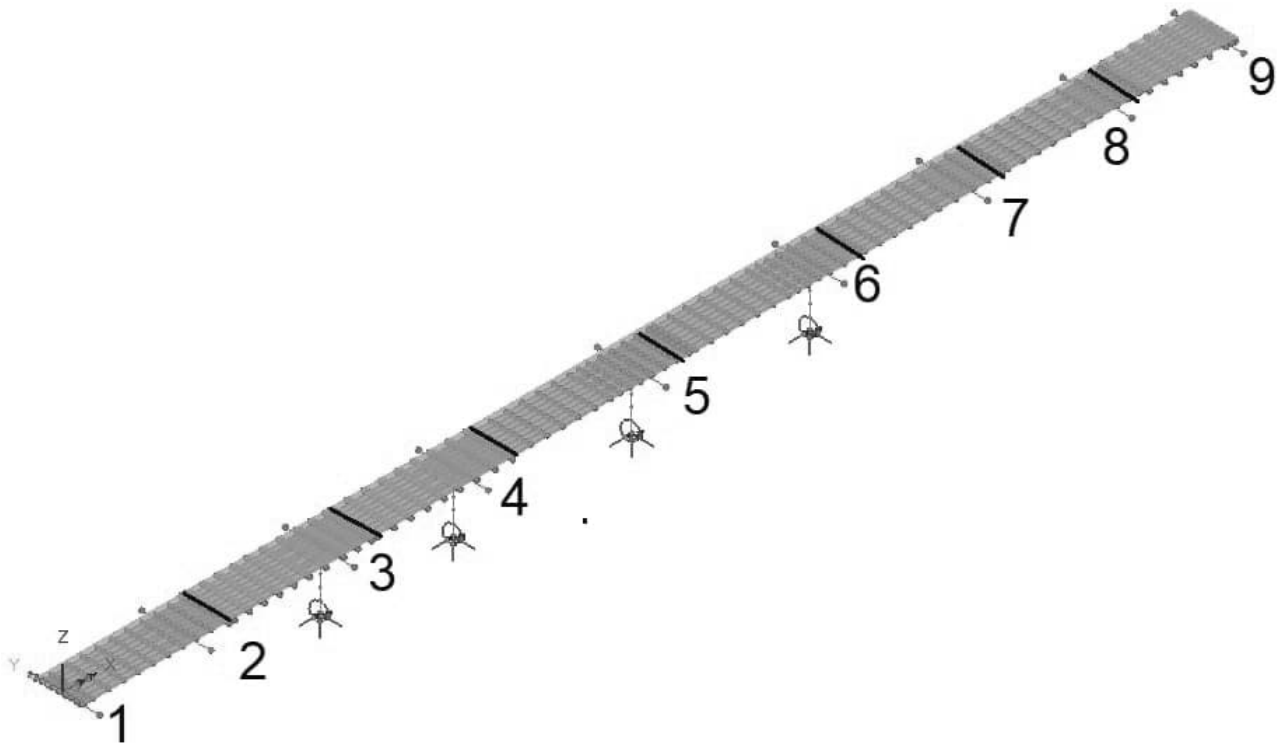
The bridge is constructed in a total of 8 casting stages (STAGE 1 through STAGE 8).

LUSAS allows multiple structural systems within a single model. For this bridge, 9 different structural systems are used. One for each construction stage and one for operational stage.

The reason for selecting a 3D analysis is that line supports are not present at each support location. Longitudinal beams LB1 and LB8 have no supports at all, while LB2 and LB7 lack supports at several locations.

Appendices:

Appendix	Name
1	Input recipt
2	Results reactions
3	Results bearings
4	Resuls longitudinal girders



3D Overview

2.2 SKETCH SYSTEM ANALYSIS

2.2.1 Geometry

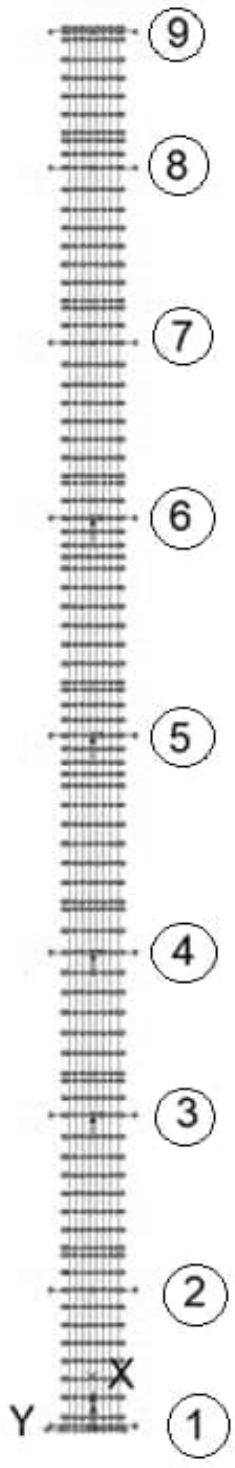
To describe geometry first POINTS are defined.

Beam elements are defined by applying attributes to LINES.

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

All coordinates needed to describe POINTS are found in Input Receipt.

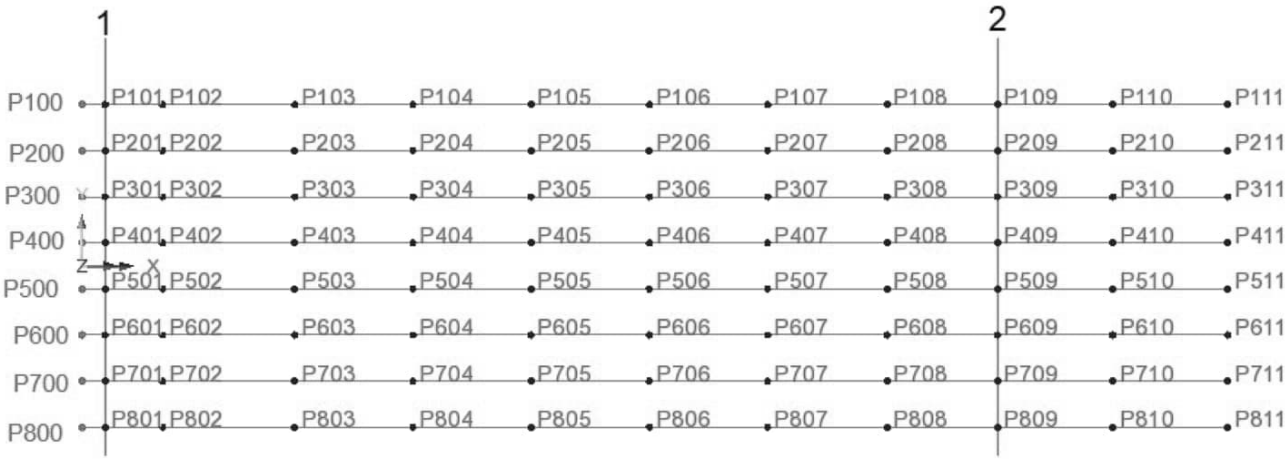
All POINTS needed to describe LINES are found in Input Receipt.



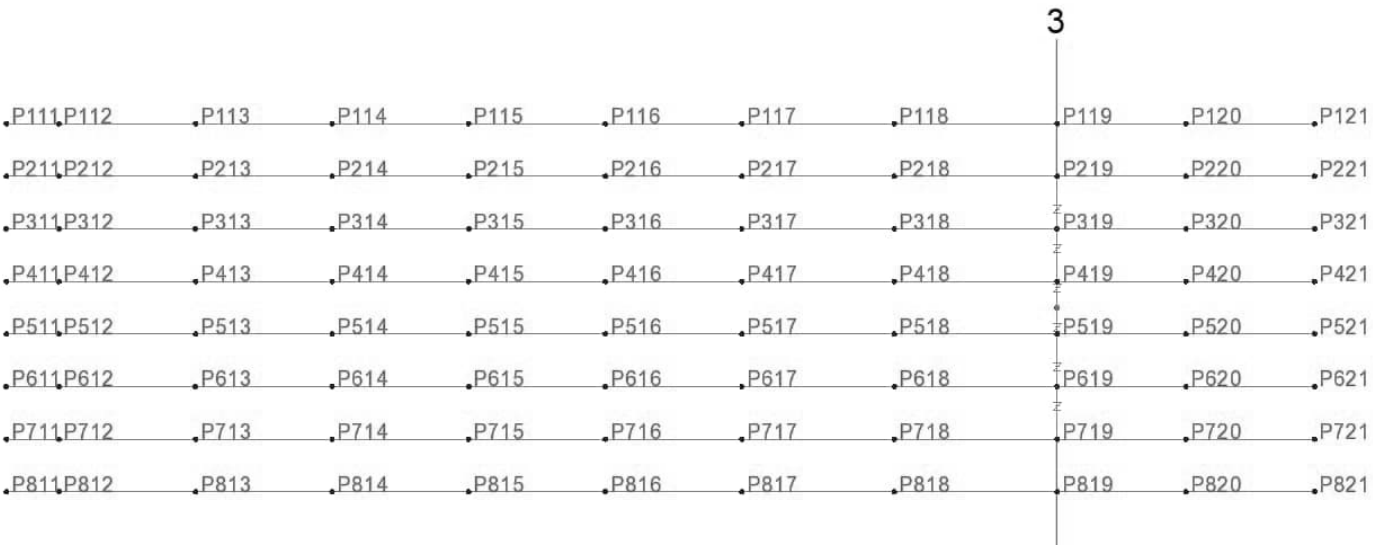
PLAN (nodal lines)
Overview

2.2.1.1 Geometry : POINTS

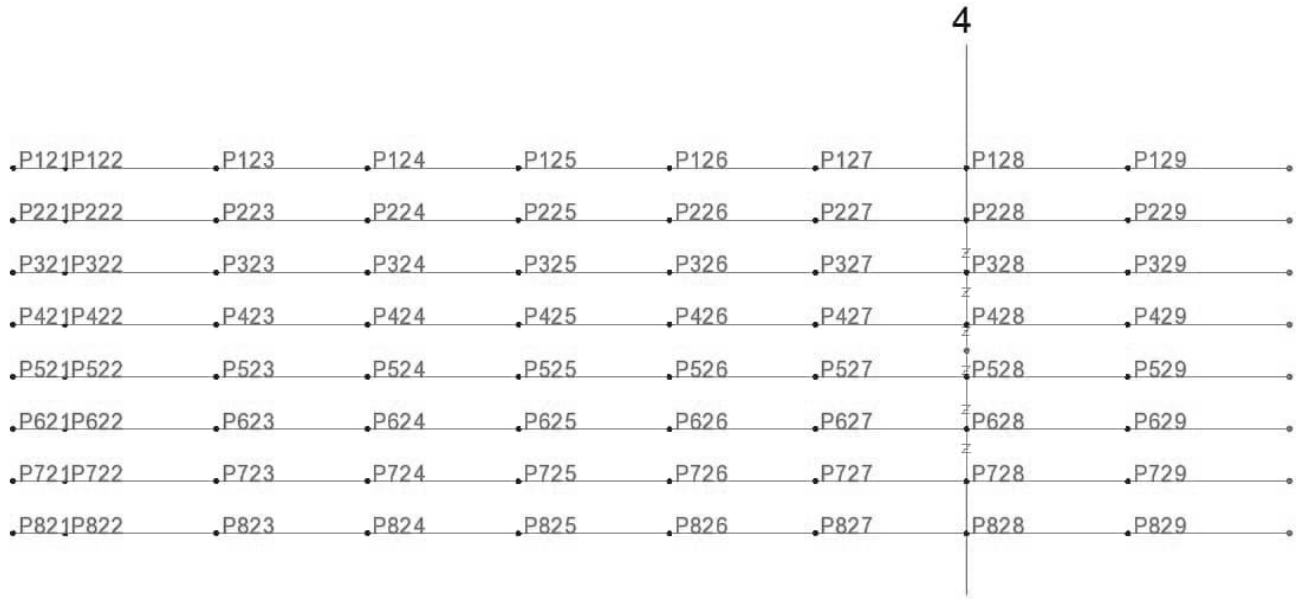
Casting stage 1 - Longitudinal beams (LB):



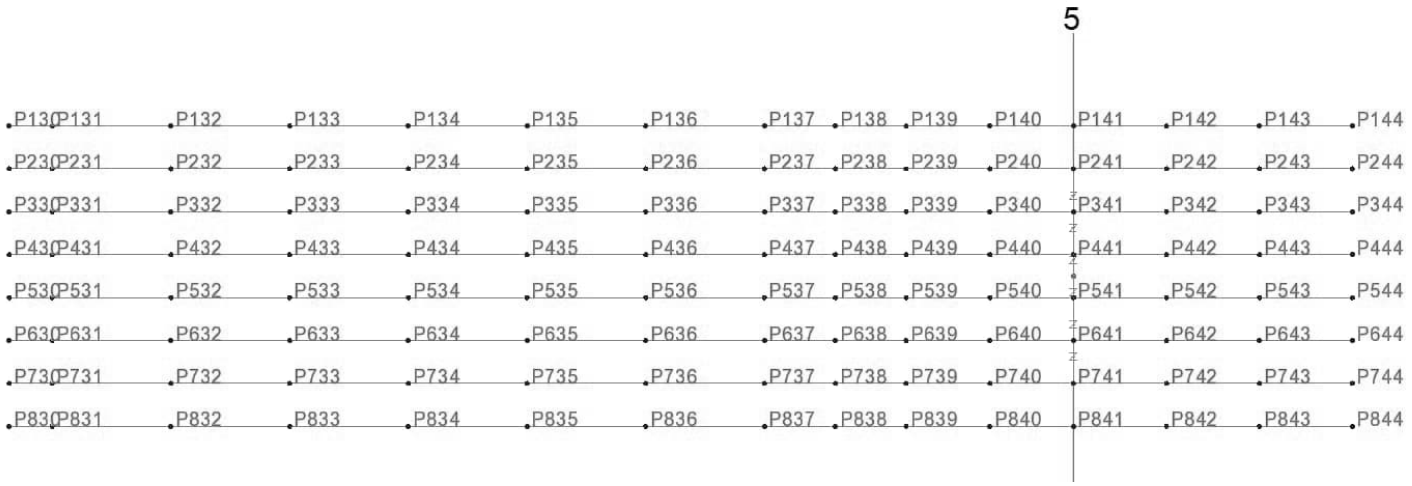
Casting stage 2 - Longitudinal beams (LB):



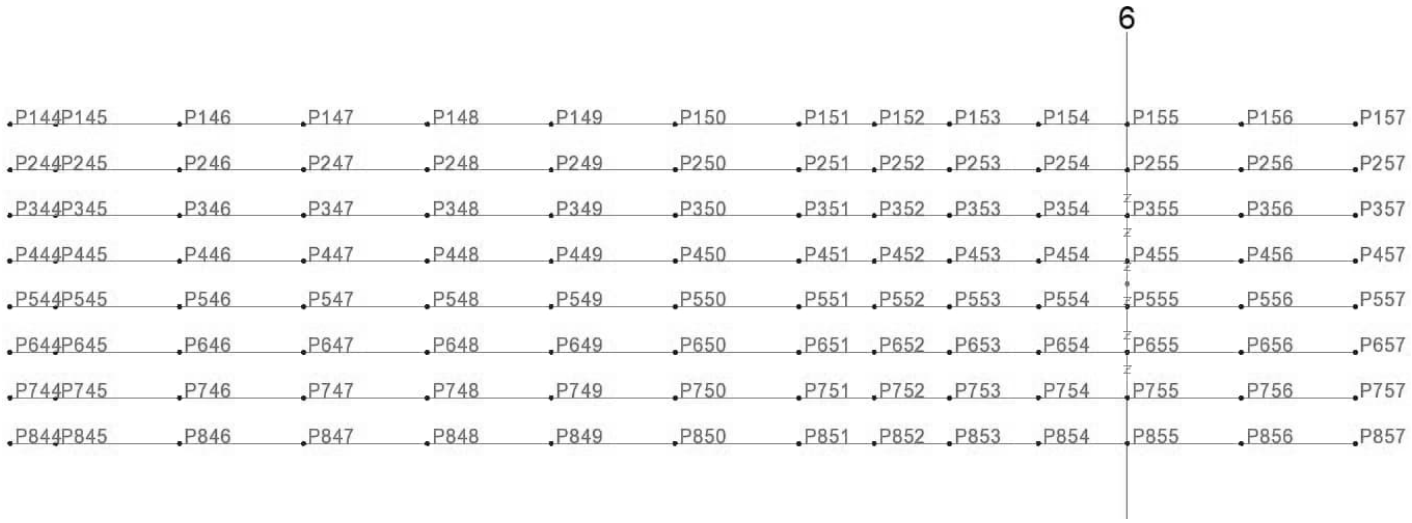
Casting stage 3 - Longitudinal beams (LB):



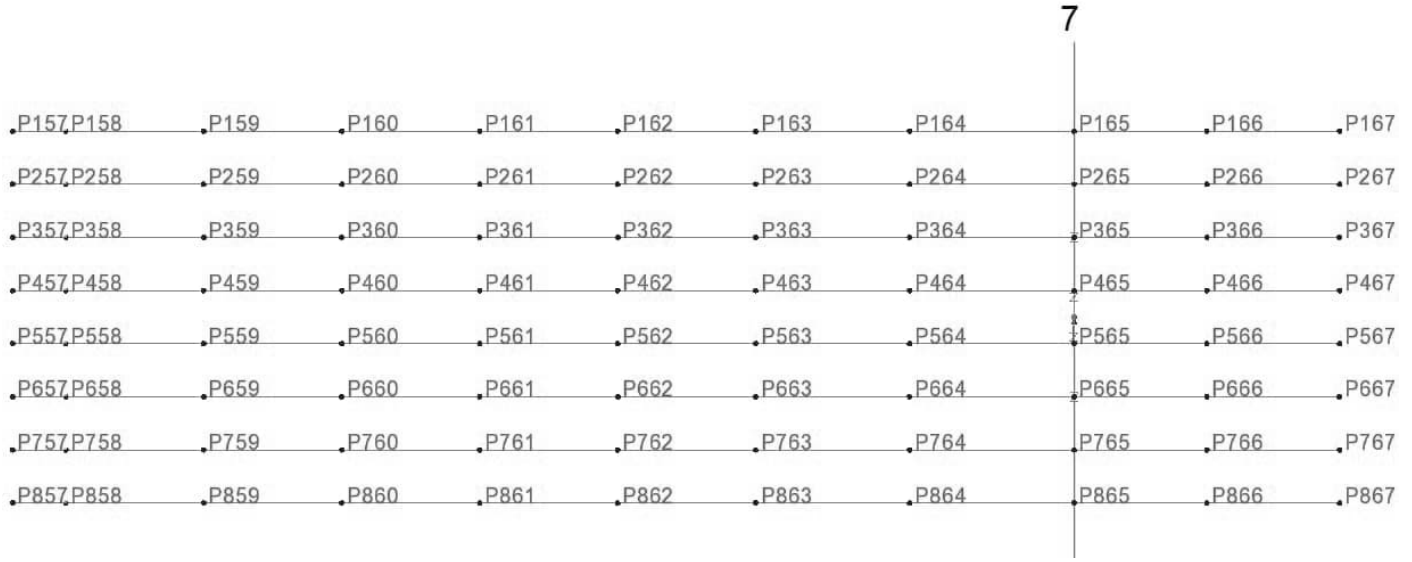
Casting stage 4 - Longitudinal beams (LB):



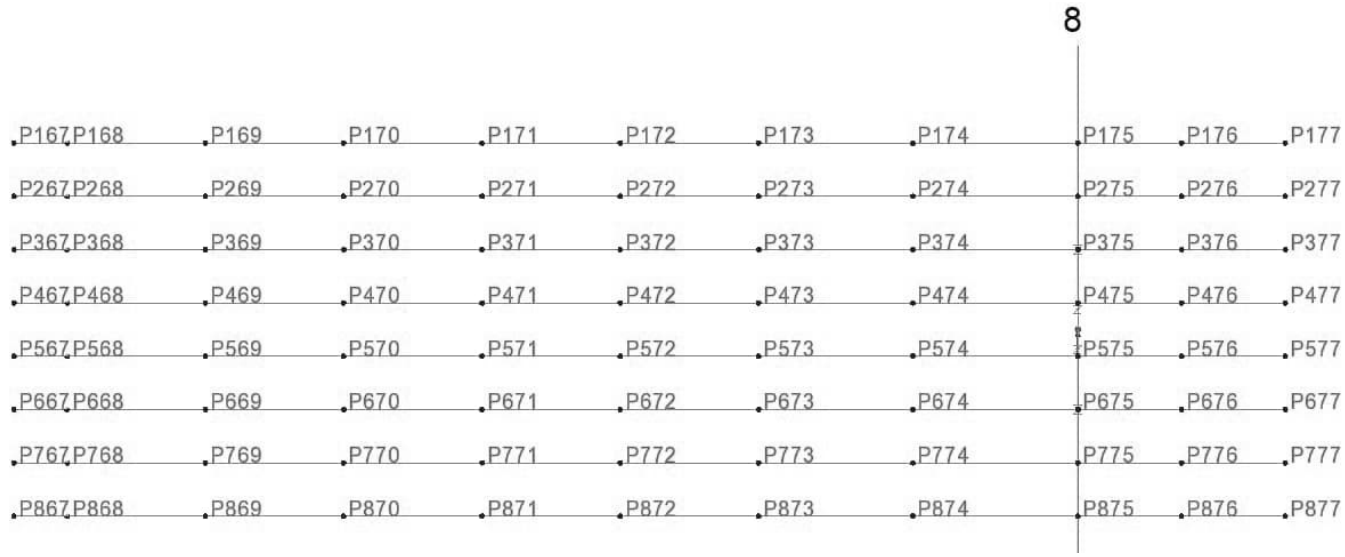
Casting stage 5 - Longitudinal beams (LB):



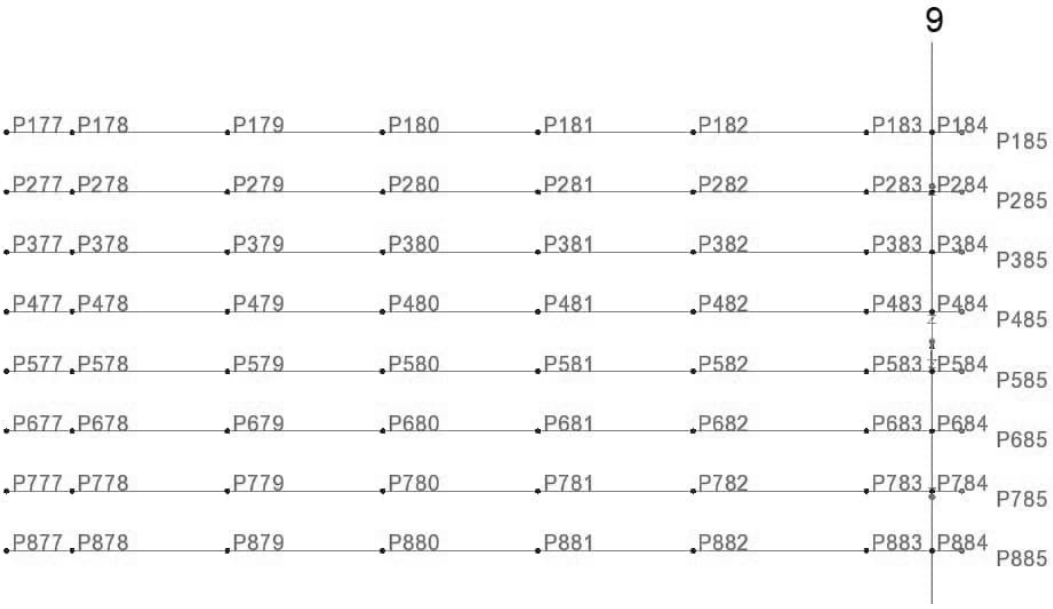
Casting stage 6 - Longitudinal beams (LB):



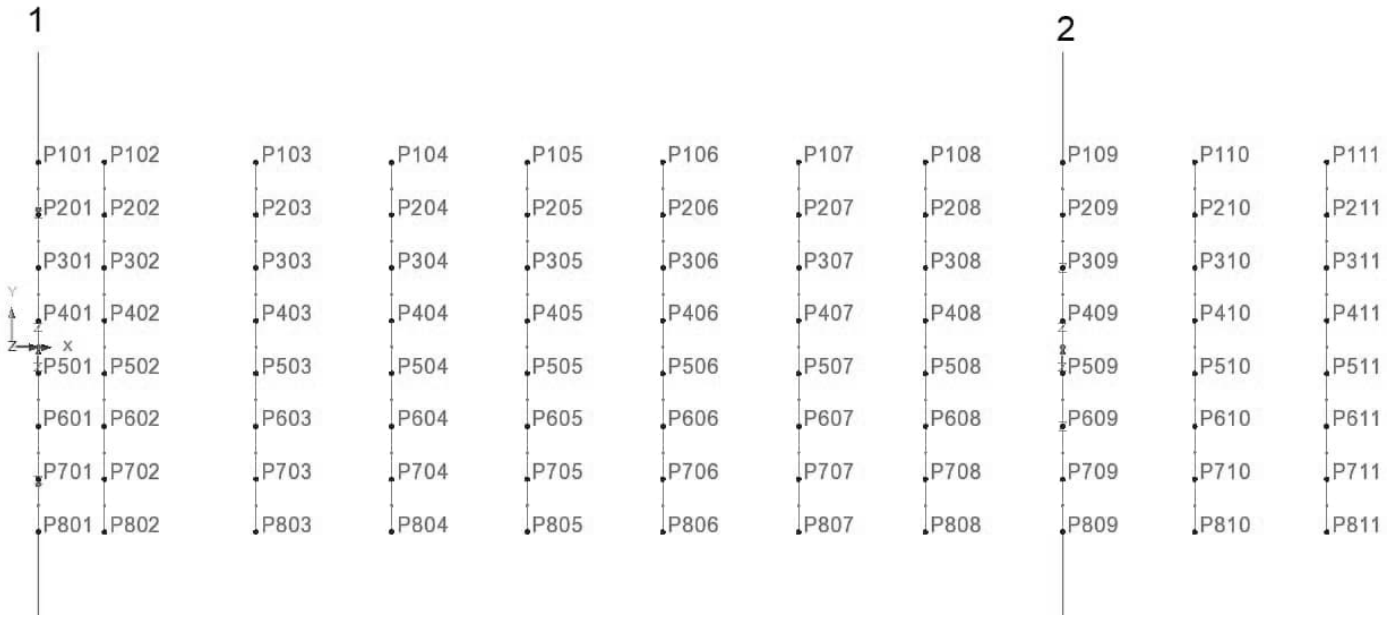
Casting stage 7 - Longitudinal beams (LB):



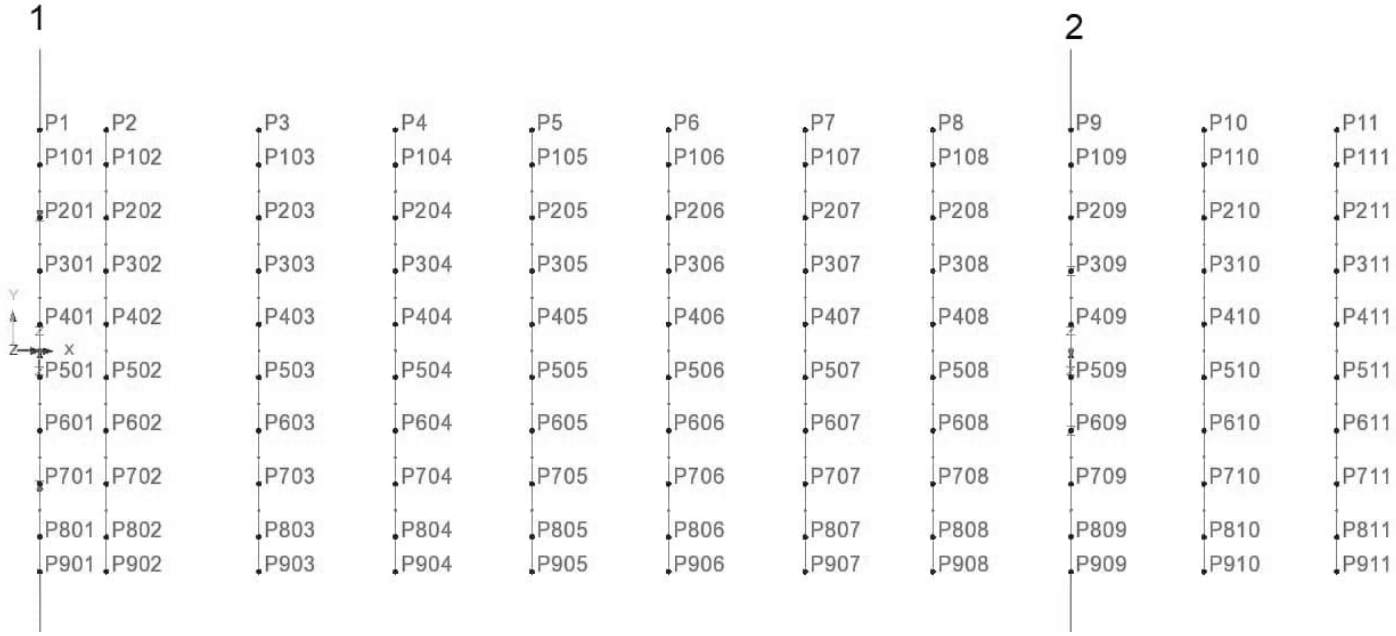
Casting stage 8 - Longitudinal beams (LB):



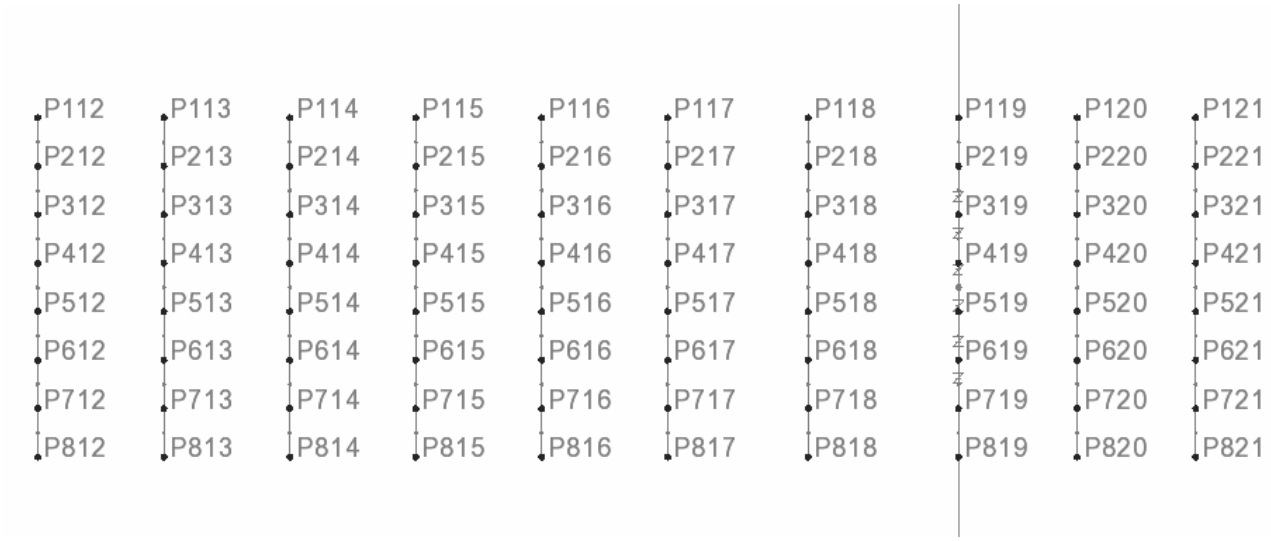
Casting stage 1 - Transversal beams UK (TB-UK):



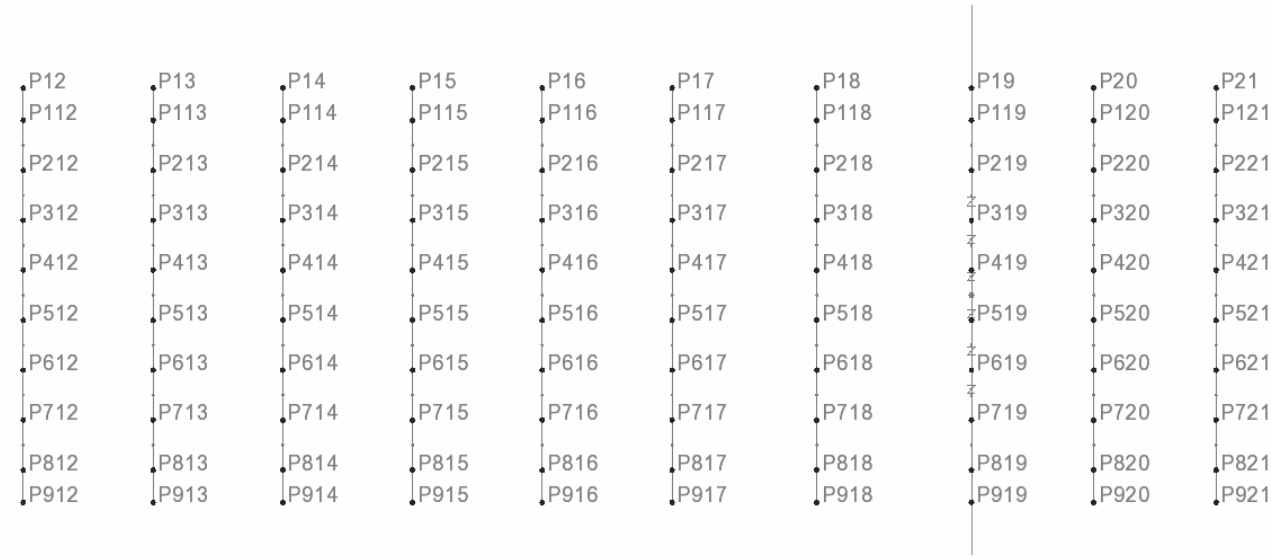
Casting stage 1 - Transversal beams OK (TB-OK) & Edge beams (EB):



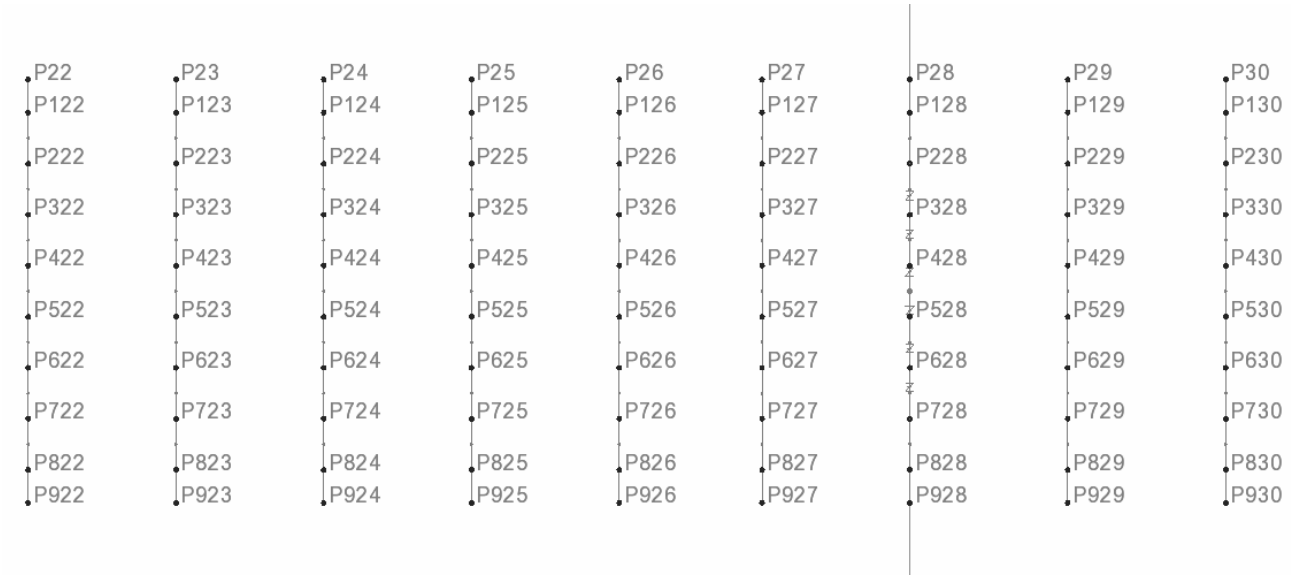
Casting stage 2 - Transversal beams UK (TB-UK):



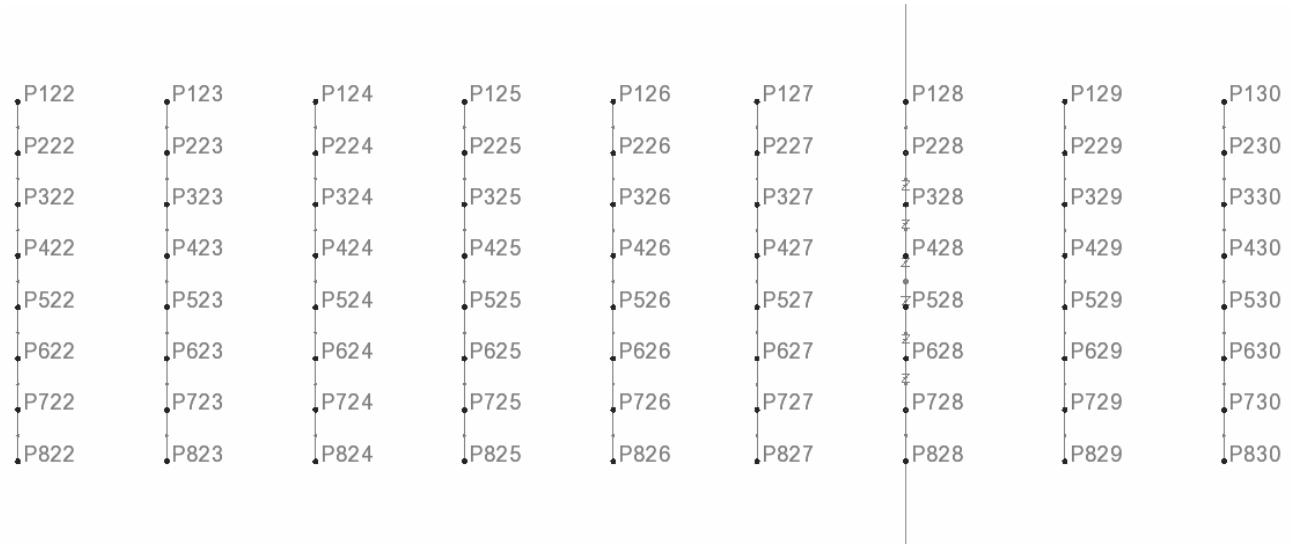
Casting stage 2 - Transversal beams OK (TB-OK) & Edge beams (EB):



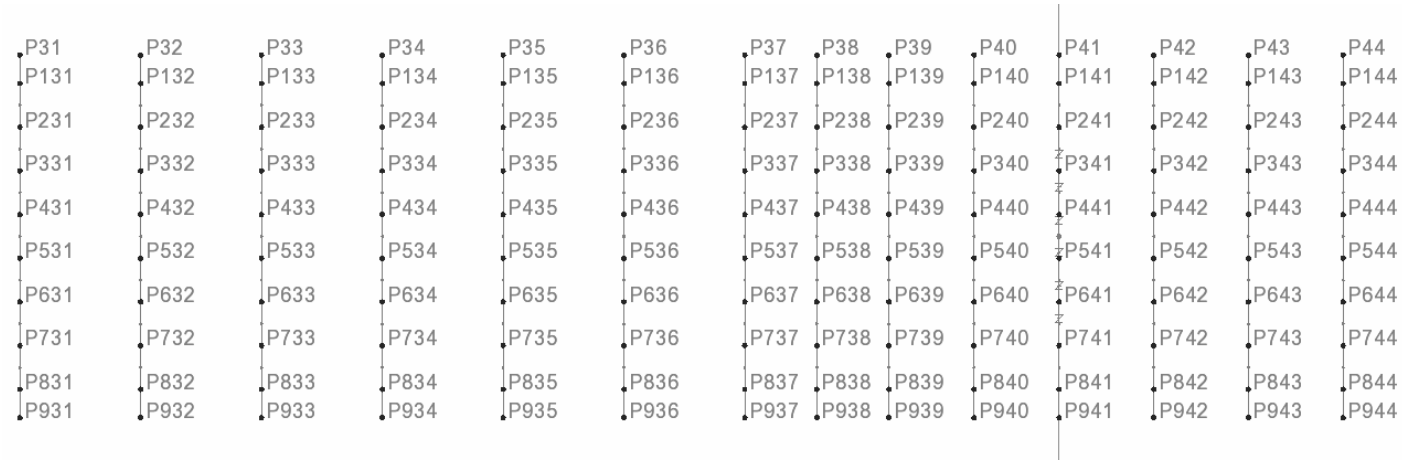
Casting stage 3 - Transversal beams OK (TB-OK) & Edge beams (EB):



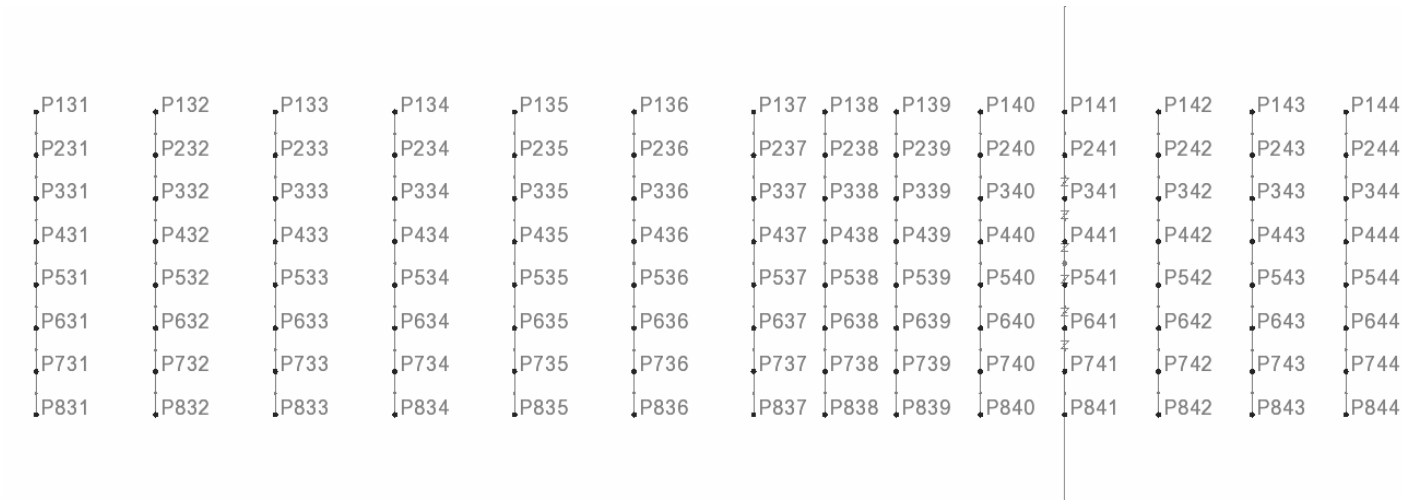
Casting stage 3 - Transversal beams UK (TB-UK):



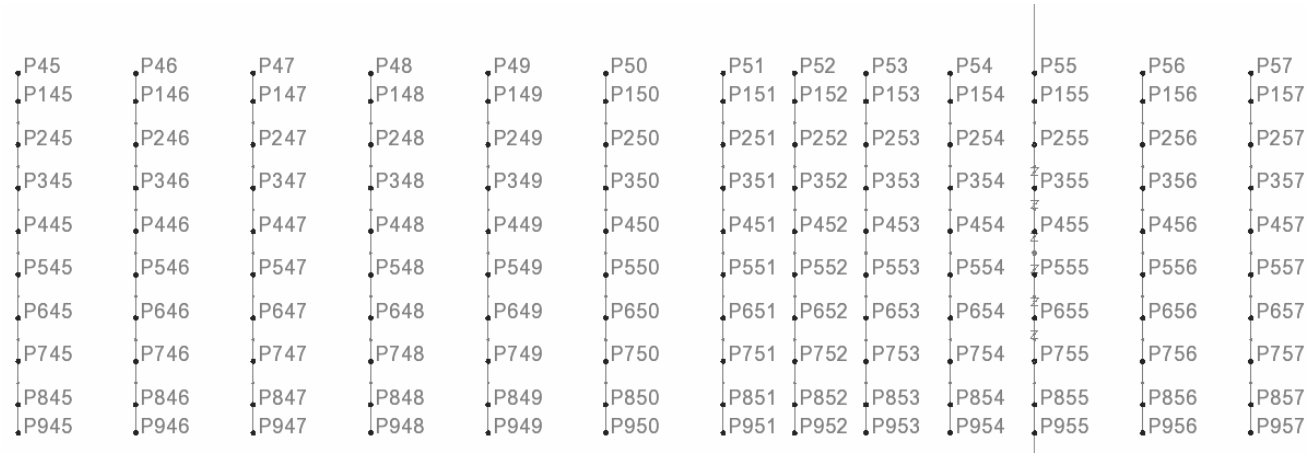
Casting stage 4 - Transversal beams OK (TB-OK) & Edge beams (EB):



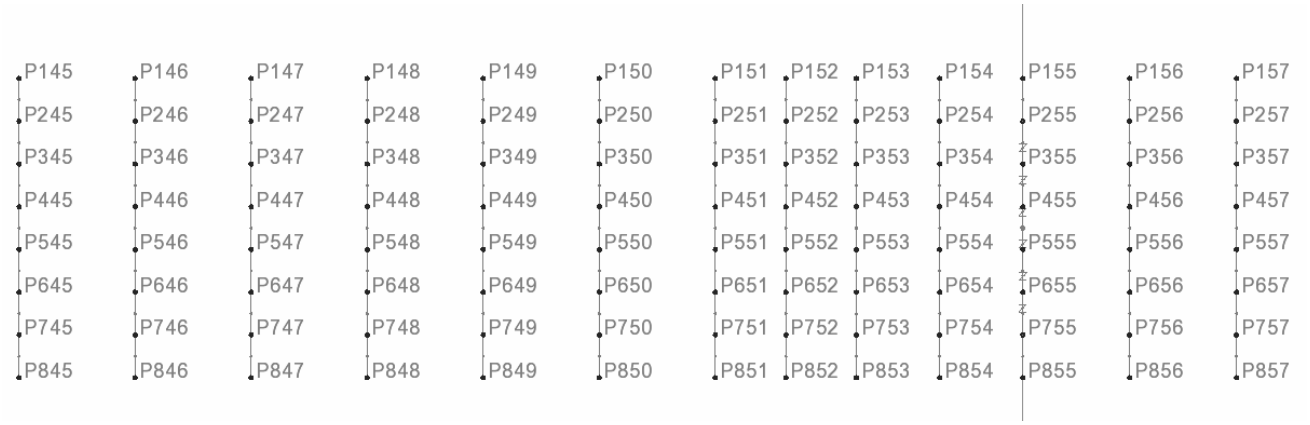
Casting stage 4 - Transversal beams UK (TB-UK):



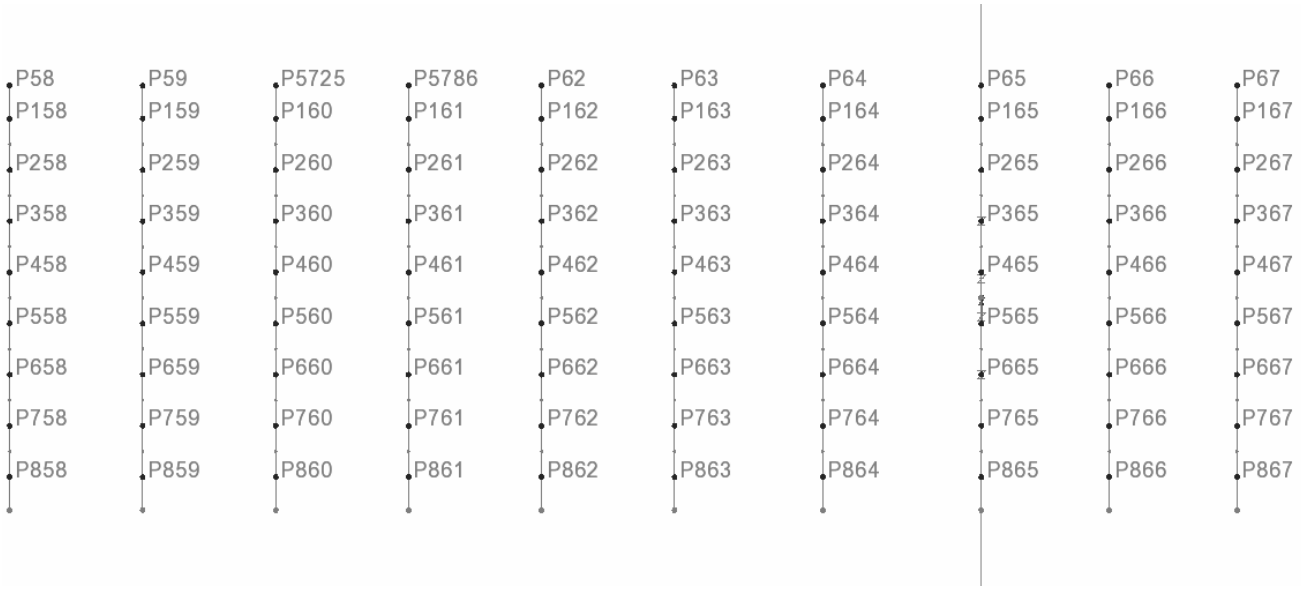
Casting stage 5 - Transversal beams OK (TB-OK) & Edge beams (EB):



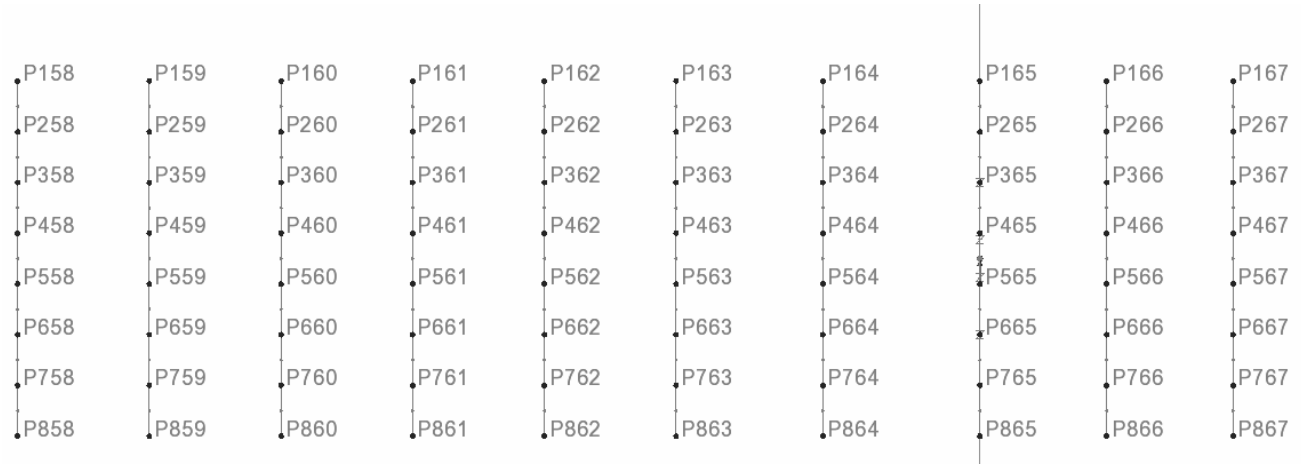
Casting stage 5 - Transversal beams UK (TB-UK):



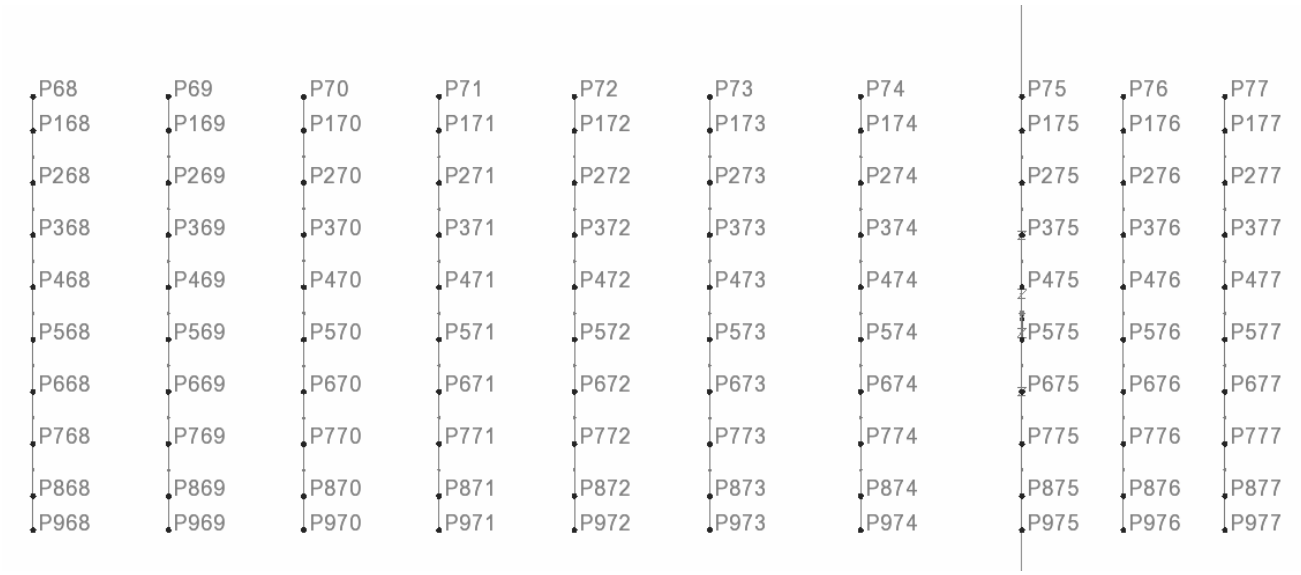
Casting stage 6 - Transversal beams OK (TB-OK) & Edge beams (EB):



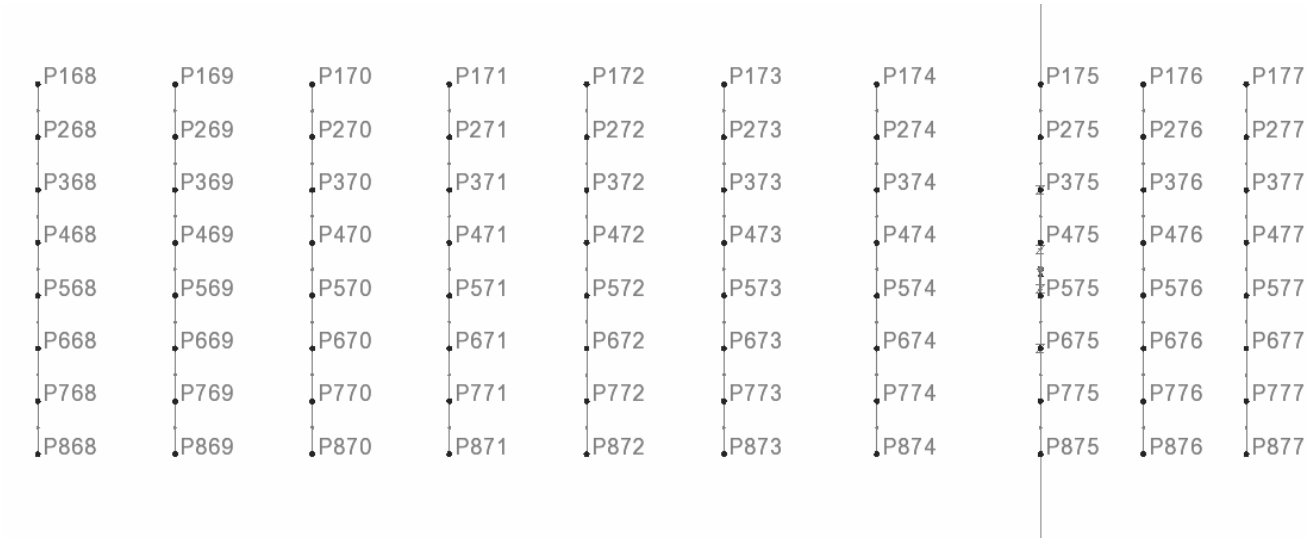
Casting stage 6 - Transversal beams UK (TB-UK):



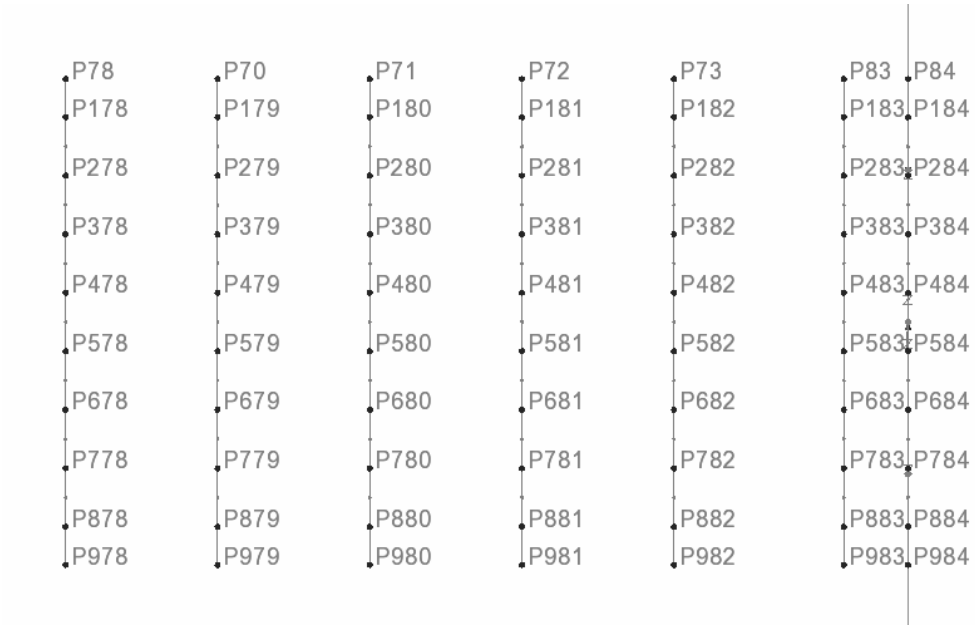
Casting stage 7 - Transversal beams OK (TB-OK) & Edge beams (EB):



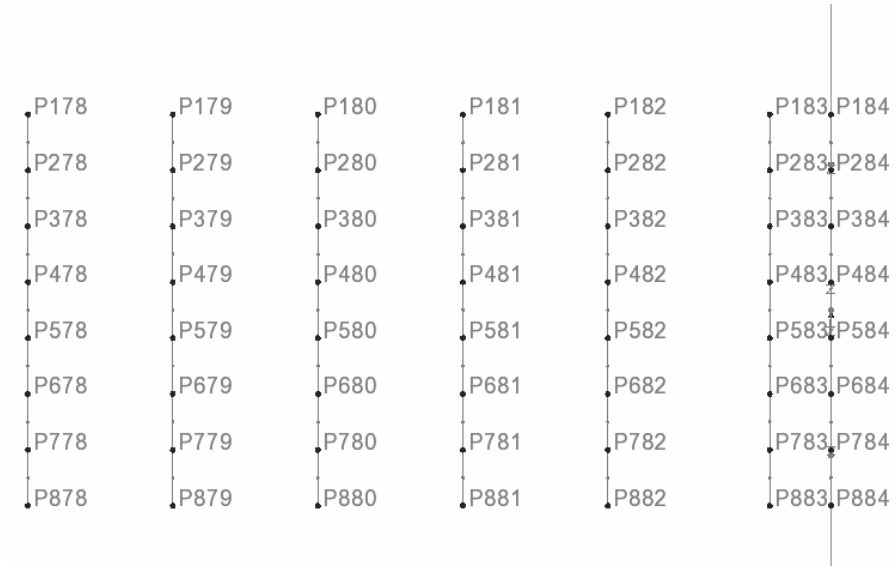
Casting stage 7 - Transversal beams UK (TB-UK):



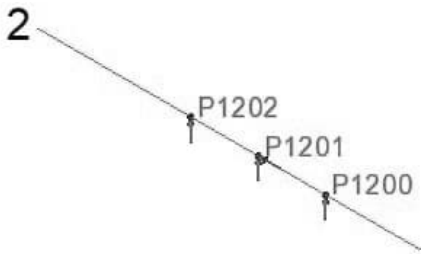
Casting stage 8 - Transversal beams OK (TB-OK) & Edge beams (EB):

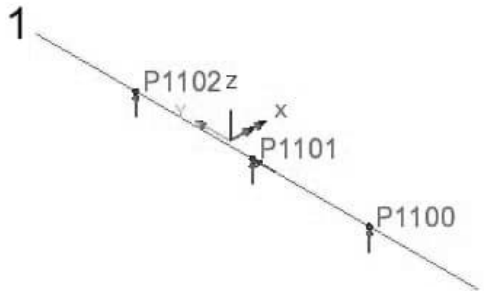


Casting stage 8 - Transversal beams UK (TB-UK):

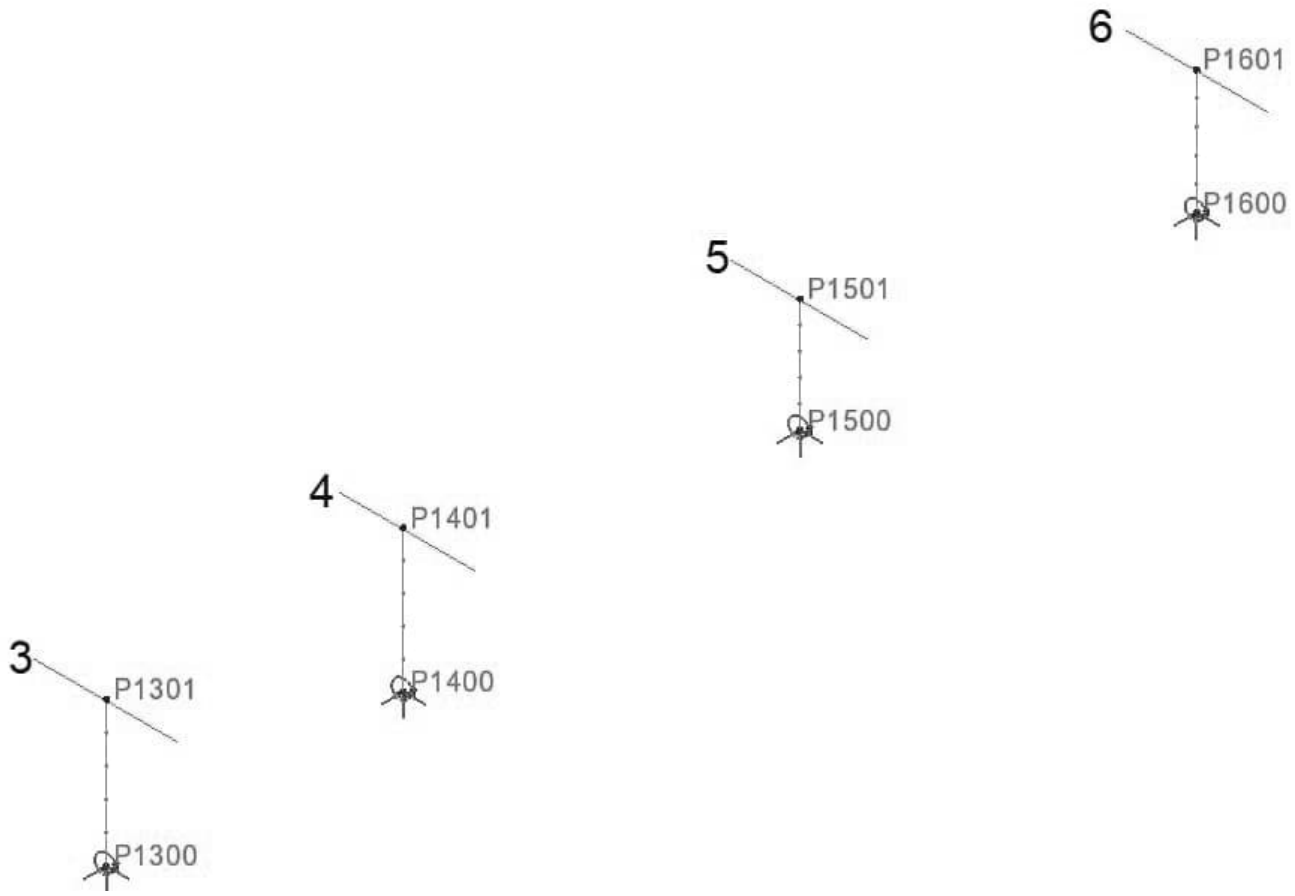


Supernodes & Bearings : Supports 1-2

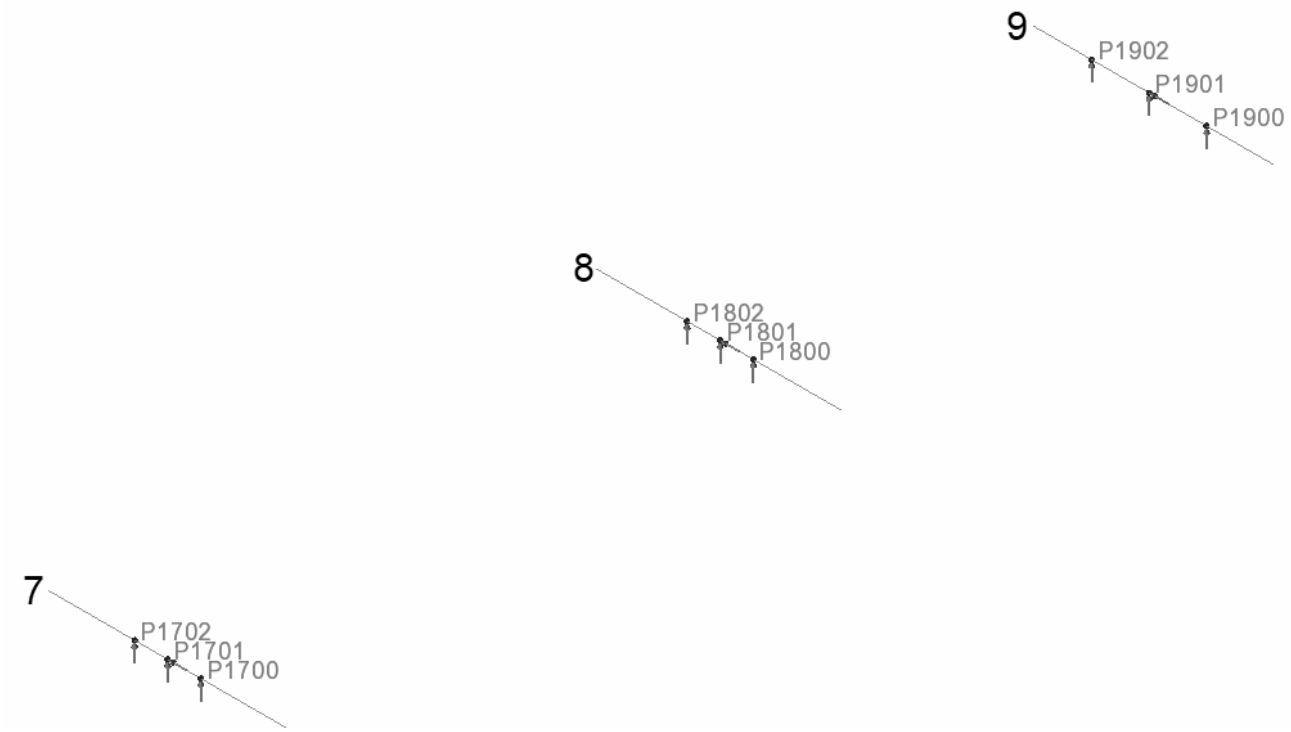




Columns: Supports 3-6

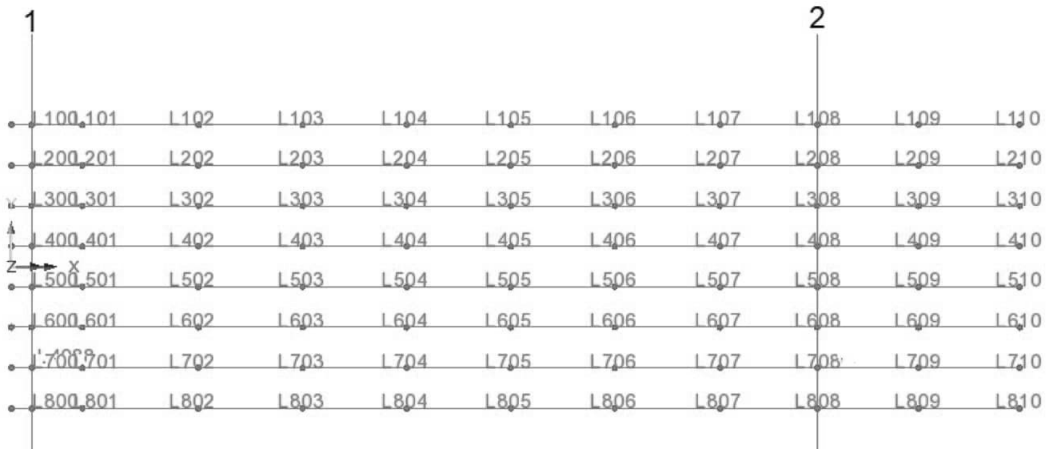


Supernodes & Bearings : Supports 7-9

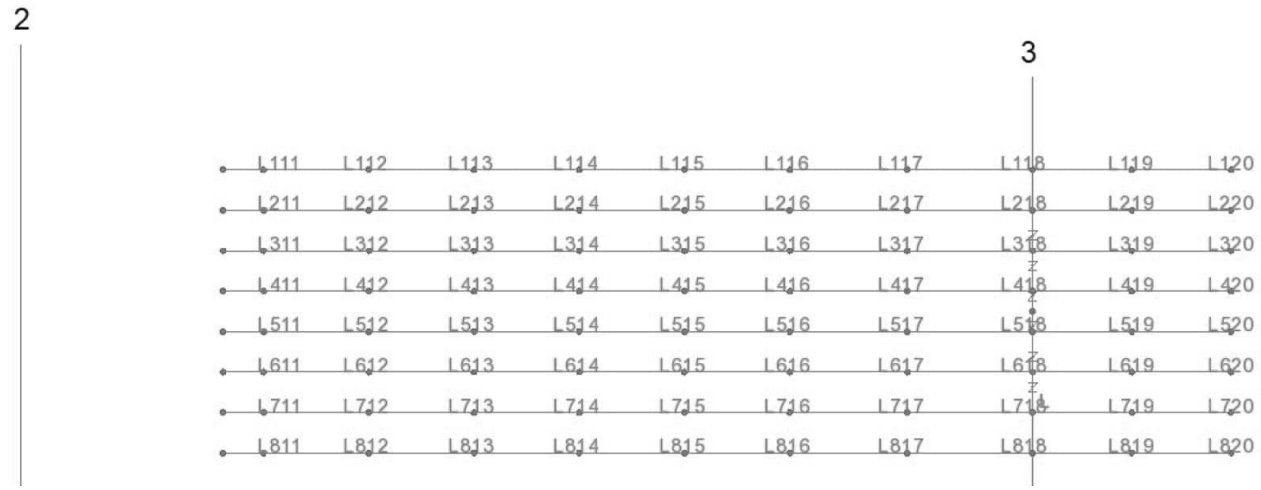


2.2.1.2 Geometry : LINES

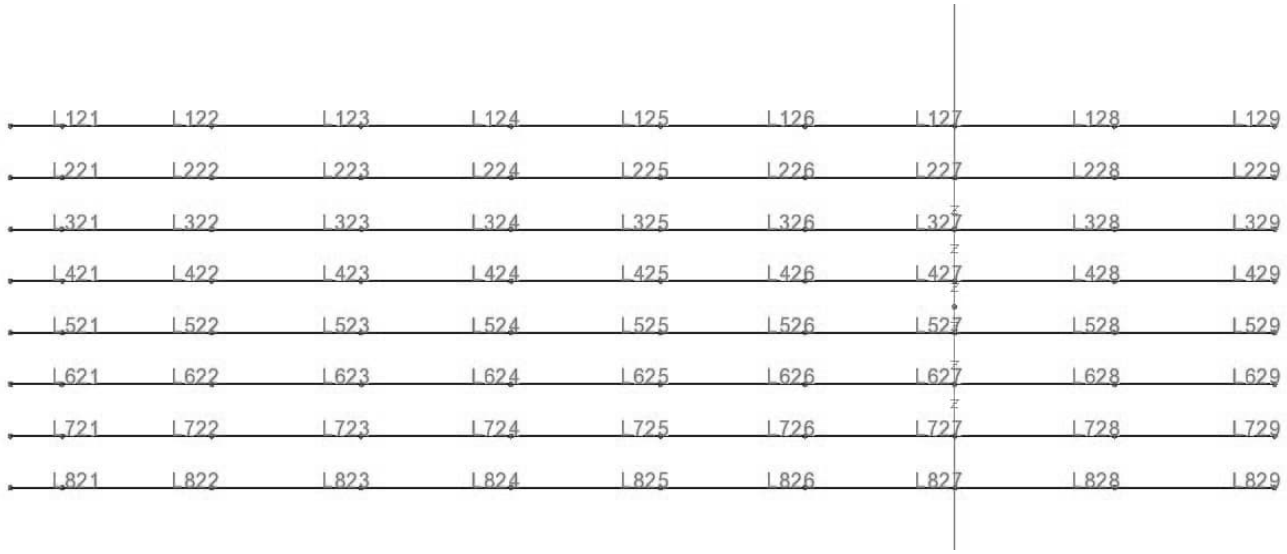
Casting stage 1 - Longitudinal beams (LB):



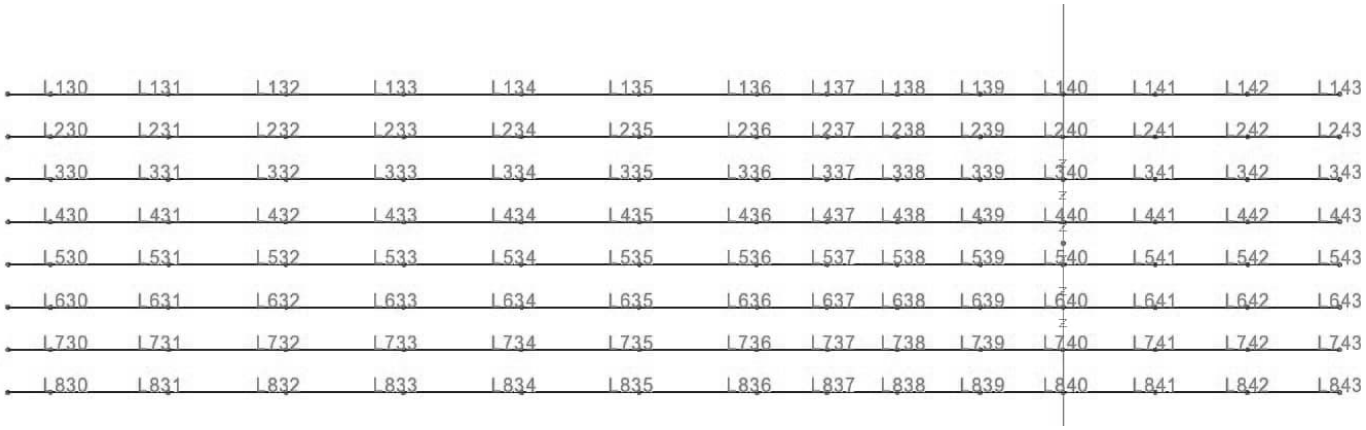
Casting stage2 - Longitudinal beams (LB):



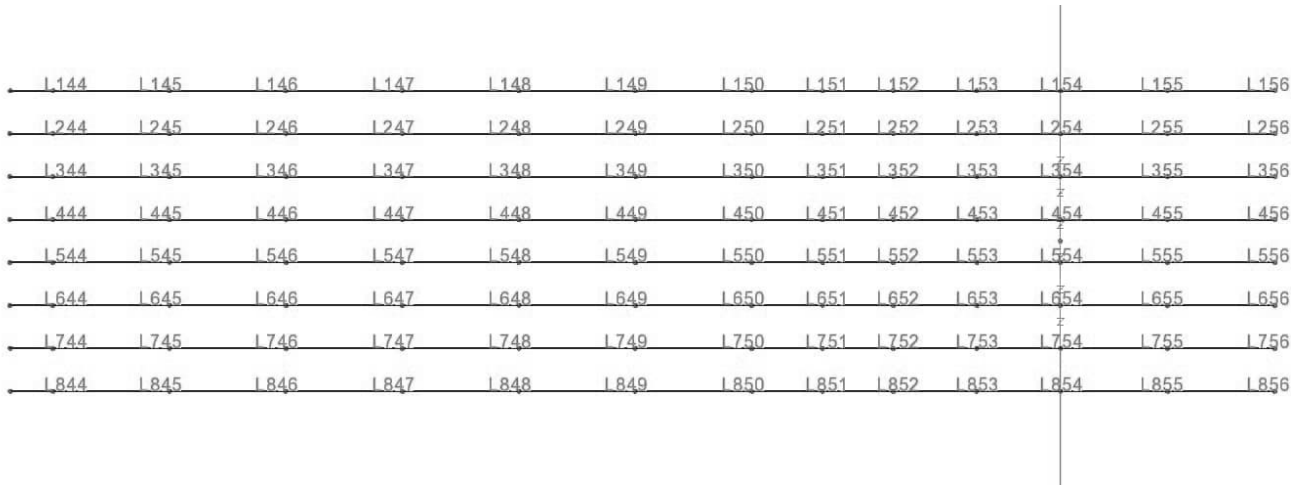
Castinng stage 3 - Longitudinal beams (LB):



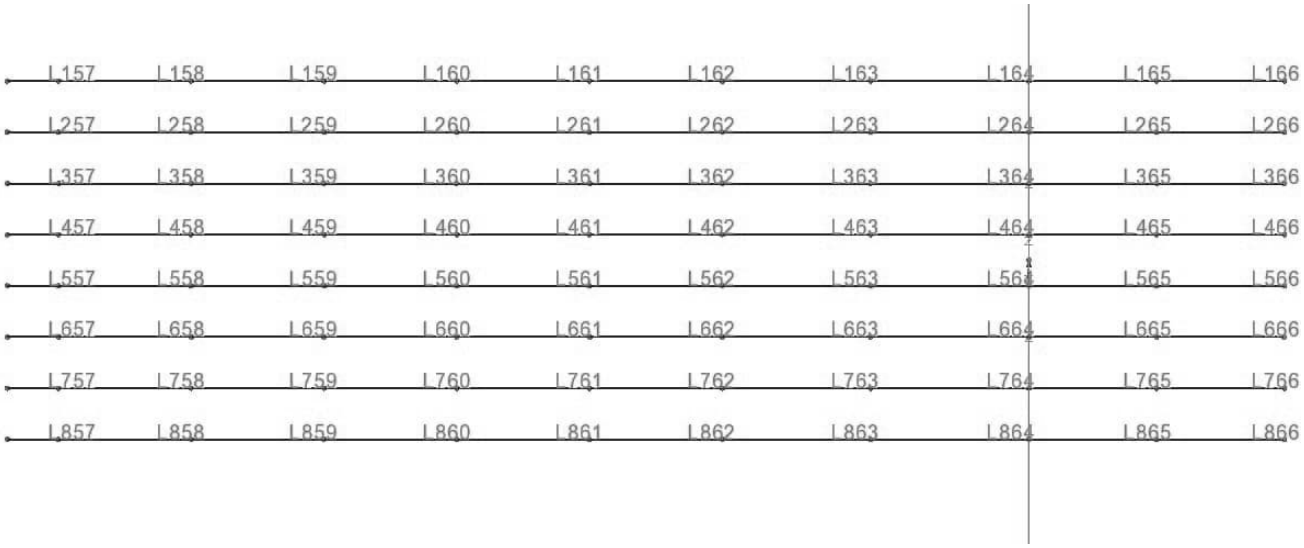
Casting stage 4 - Longitudinal beams (LB):



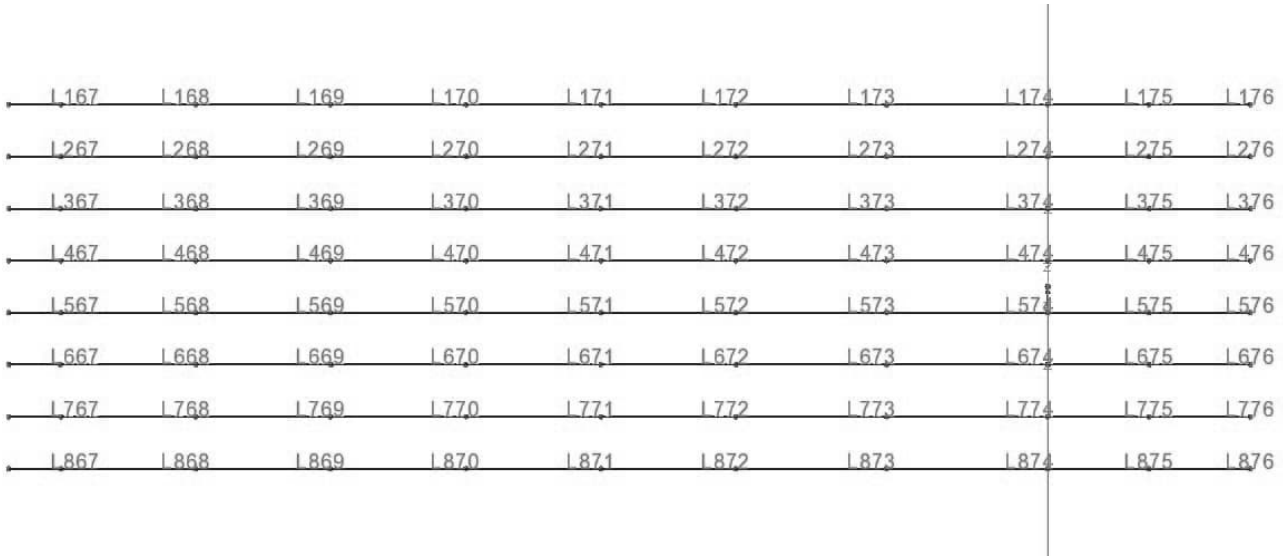
Casting stage 5 - Longitudinal beams (LB):



Casting stage 6 - Longitudinal beams (LB):

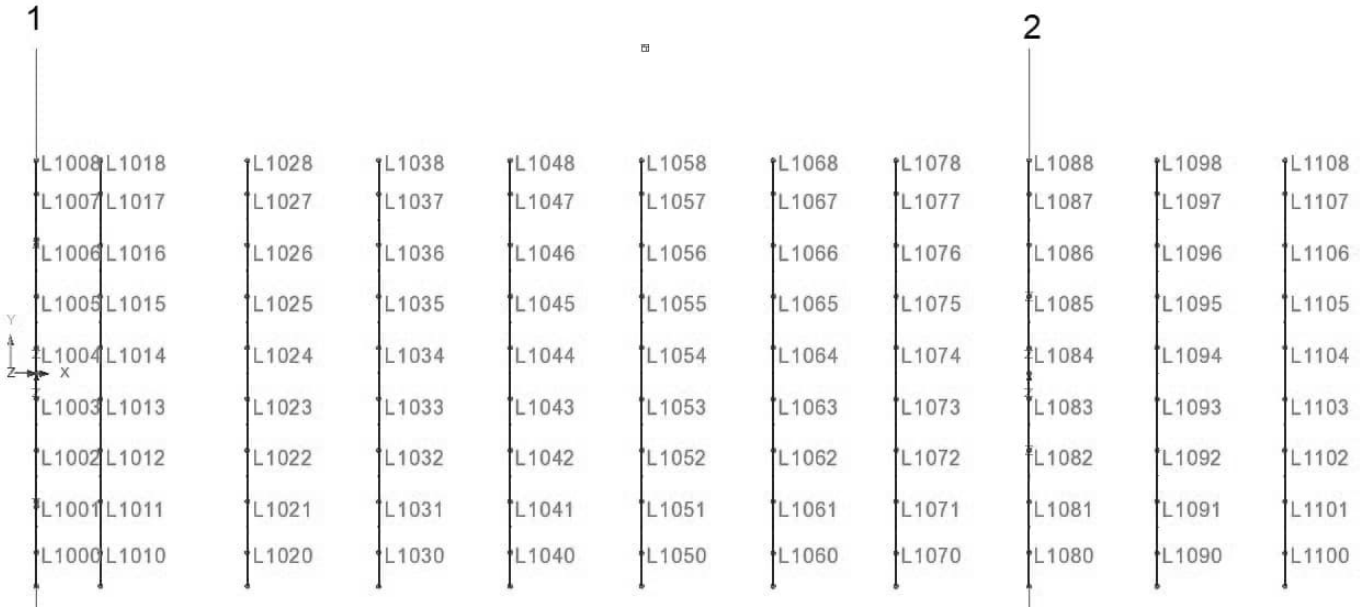


Casting stage 7 - Longitudinal beams (LB):

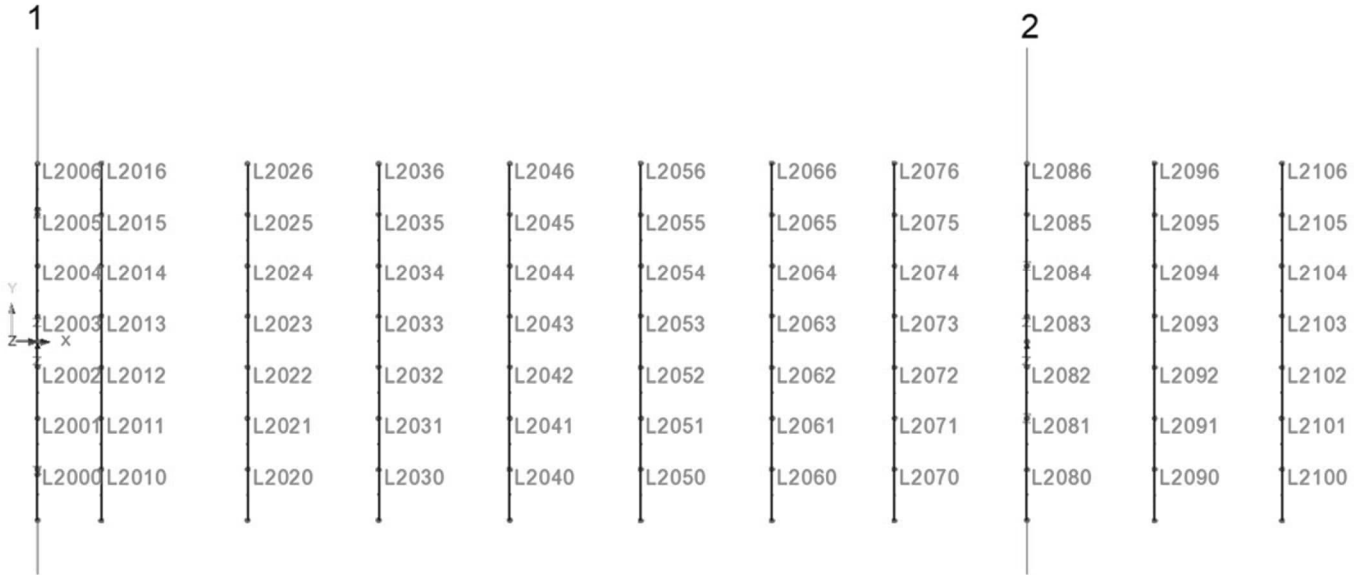


Casting stage 8 - Longitudinal beams (LB):

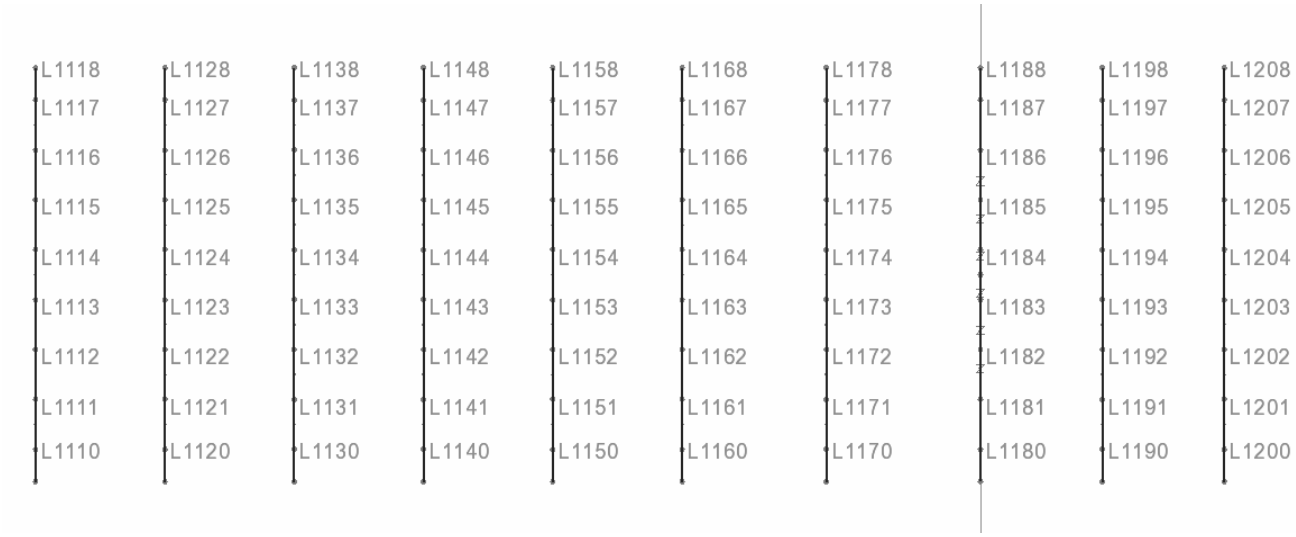
Casting stage 1 - Transversal beams OK (TB-OK) & Edge beams (EB):



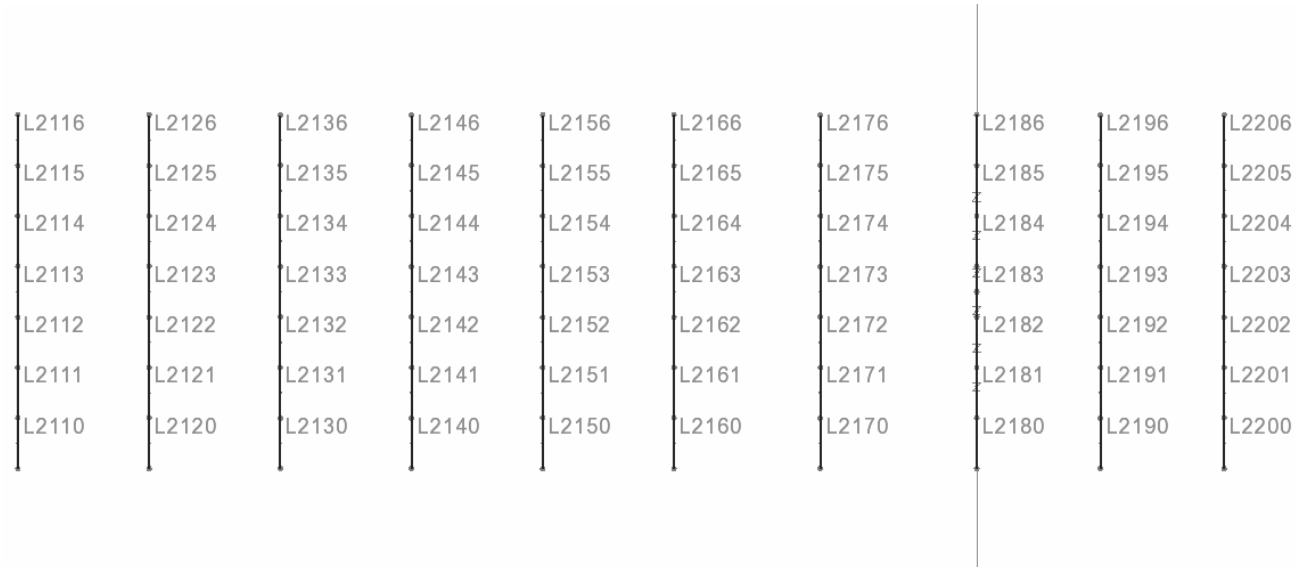
Casting stage 1 - Transversal beams UK (TB-UK):



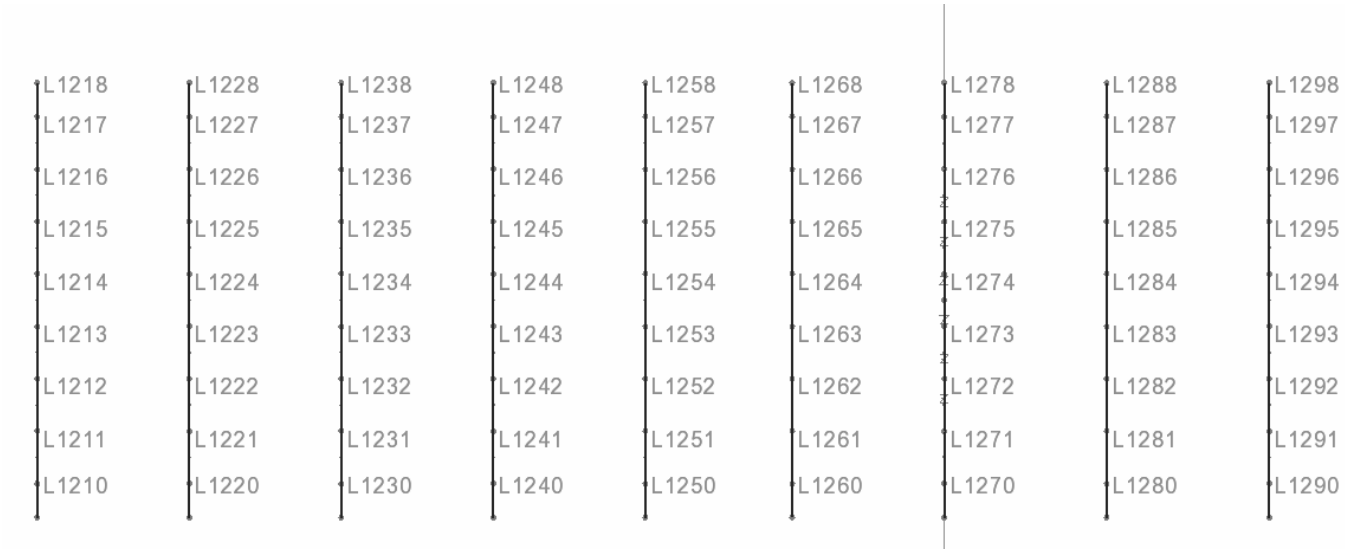
Casting stage 2 - Transversal beams OK (TB-OK) & Edge beams (EB):



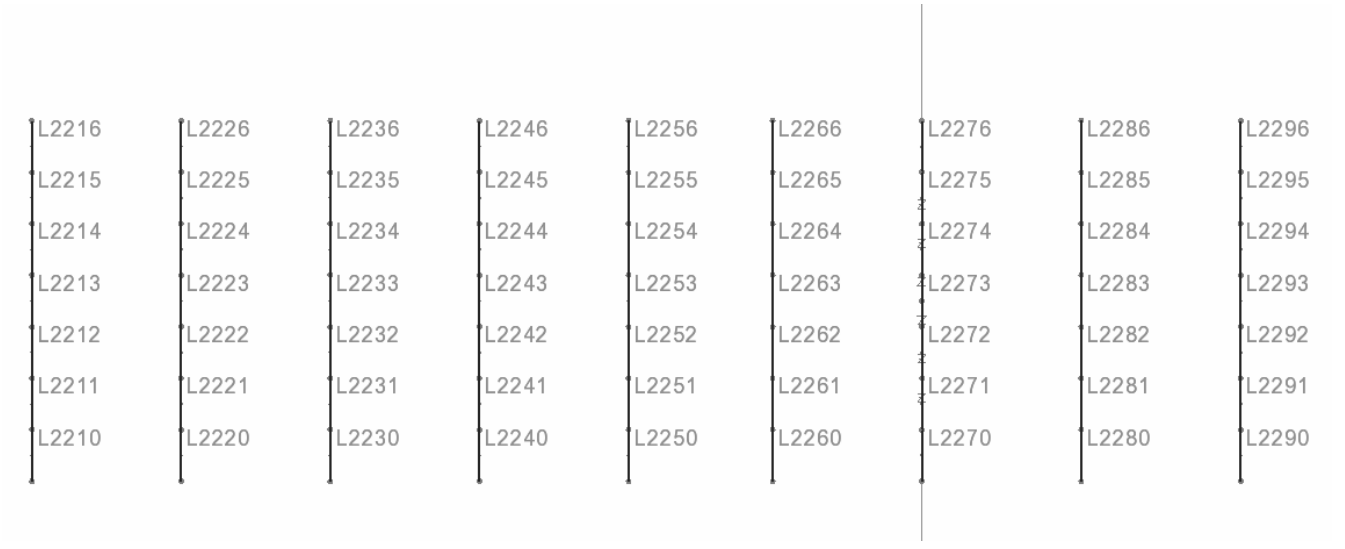
Casting stage 2 - Transversal beams UK (TB-UK):



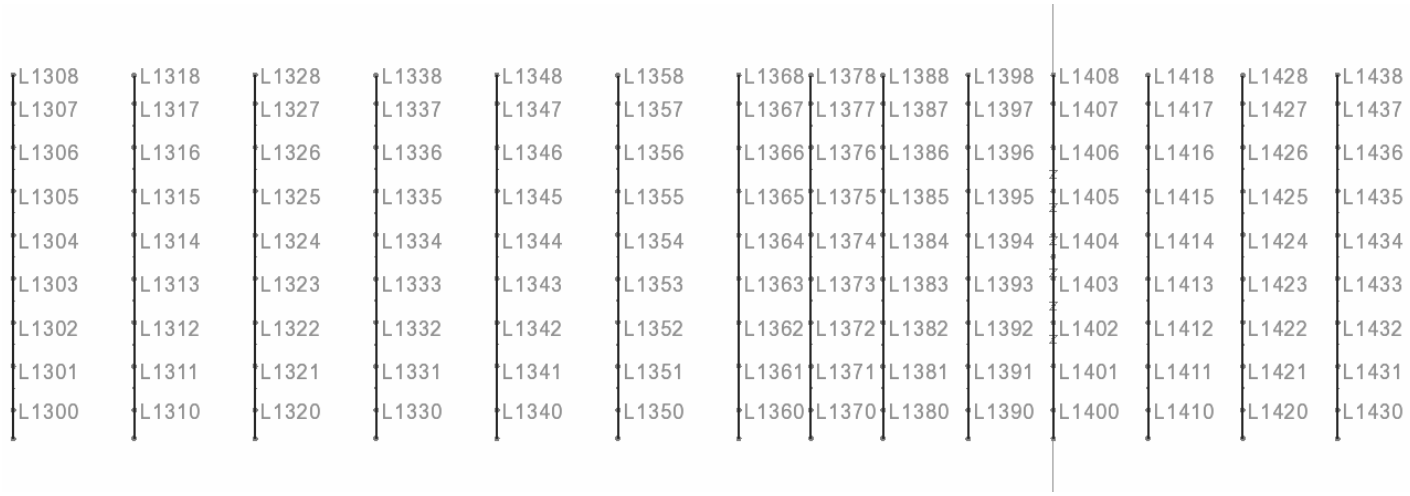
Casting stage 3 - Transversal beams OK (TB-OK) & Edge beams (EB):



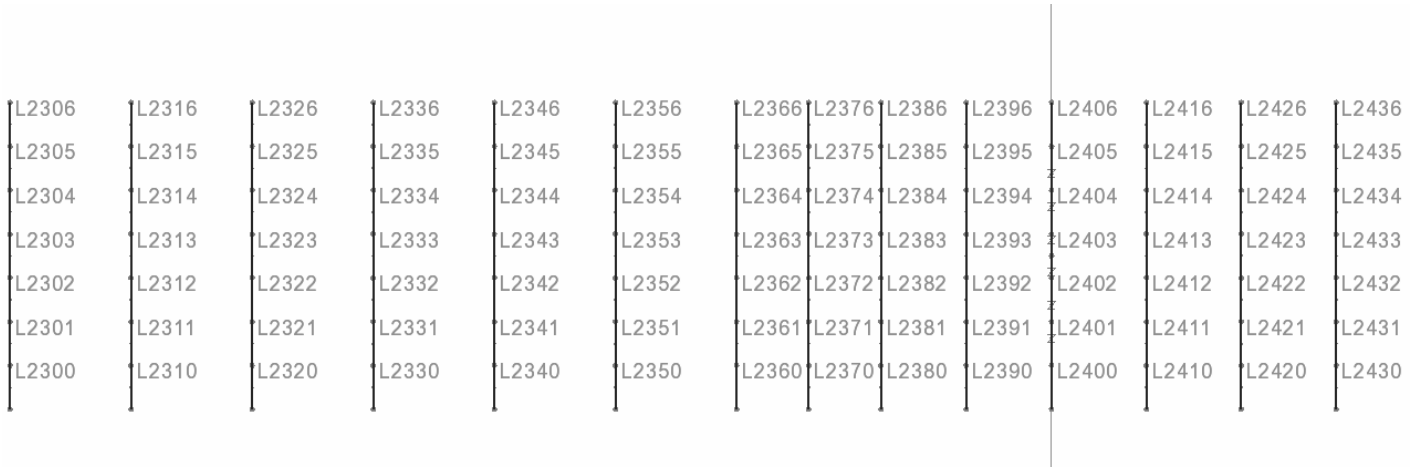
Casting stage 3 - Transversal beams UK (TB-UK):



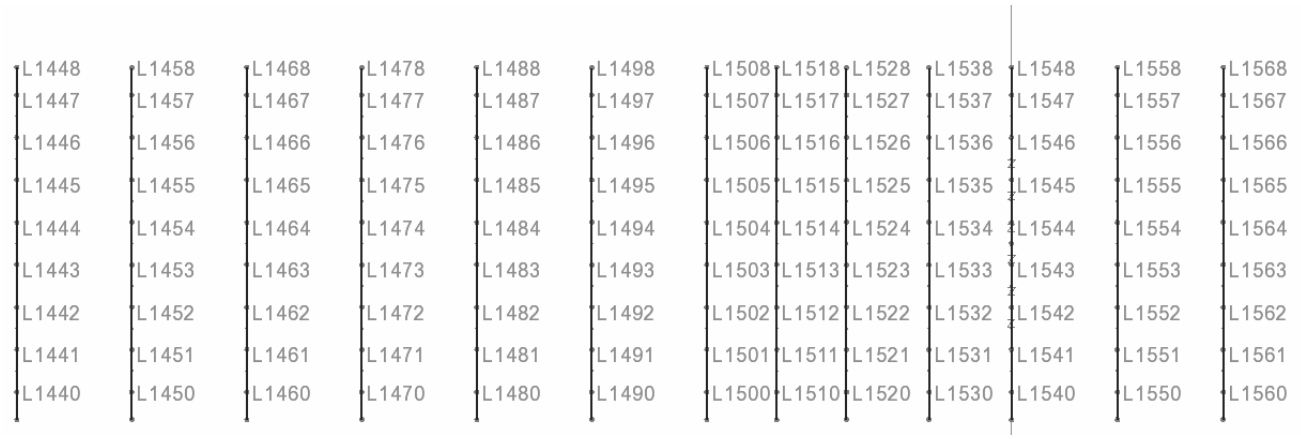
Casting stage 4 - Transversal beams OK (TB-OK) & Edge beams (EB):



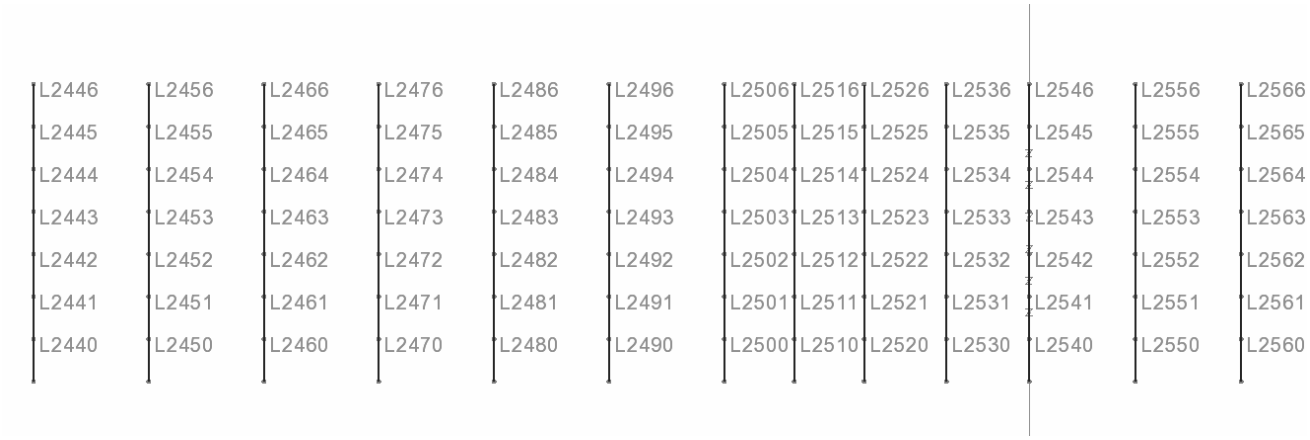
Casting stage 4 - Transversal beams UK (TB-UK):



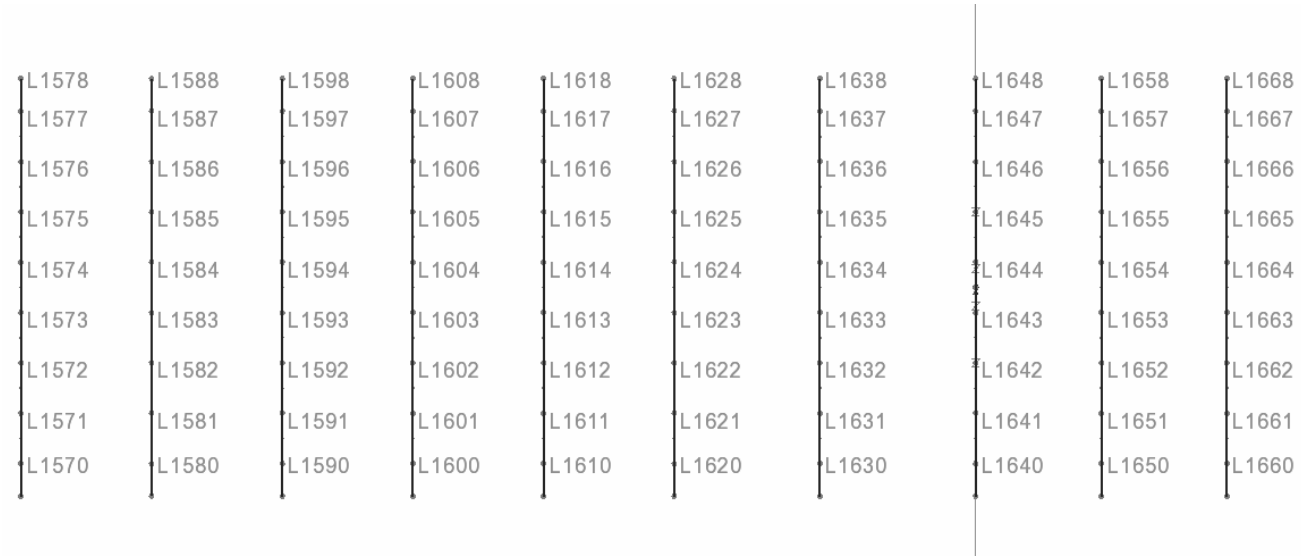
Casting stage 5 - Transversal beams OK (TB-OK) & Edge beams (EB):



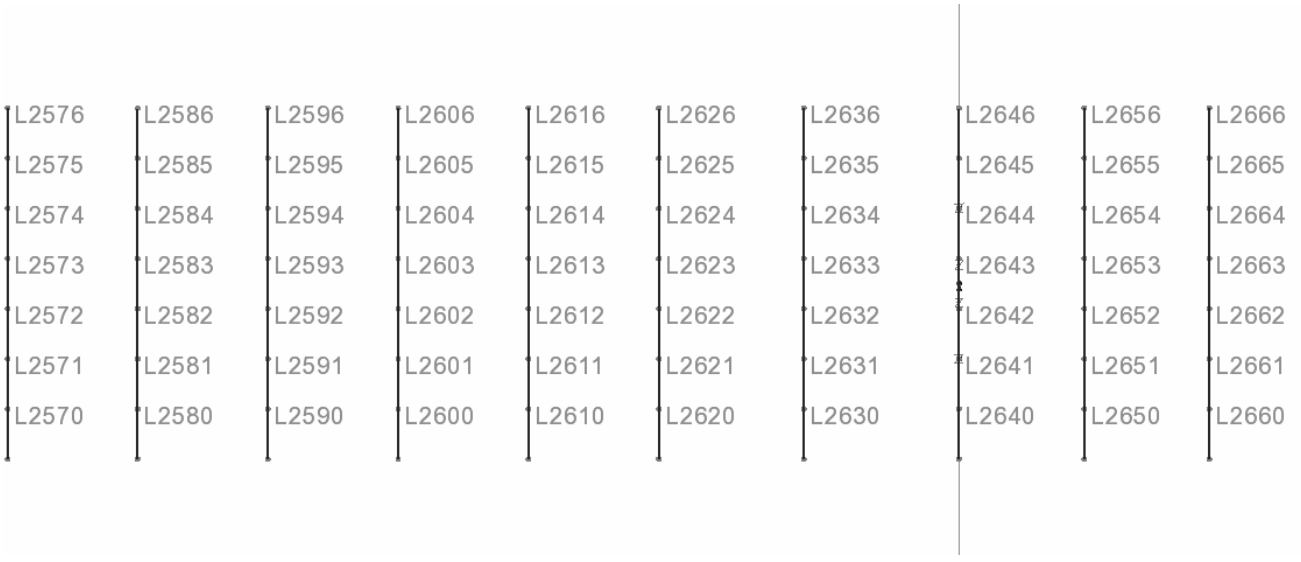
Casting stage 5 - Transversal beams UK (TB-UK):



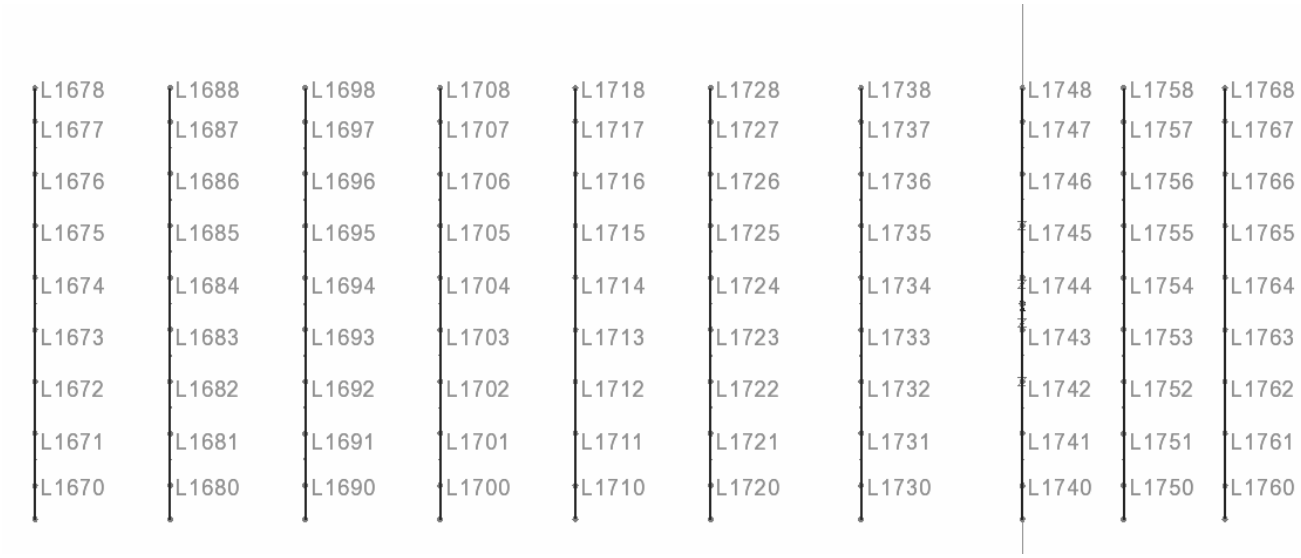
Casting stage 6 - Transversal beams OK (TB-OK) & Edge beams (EB):



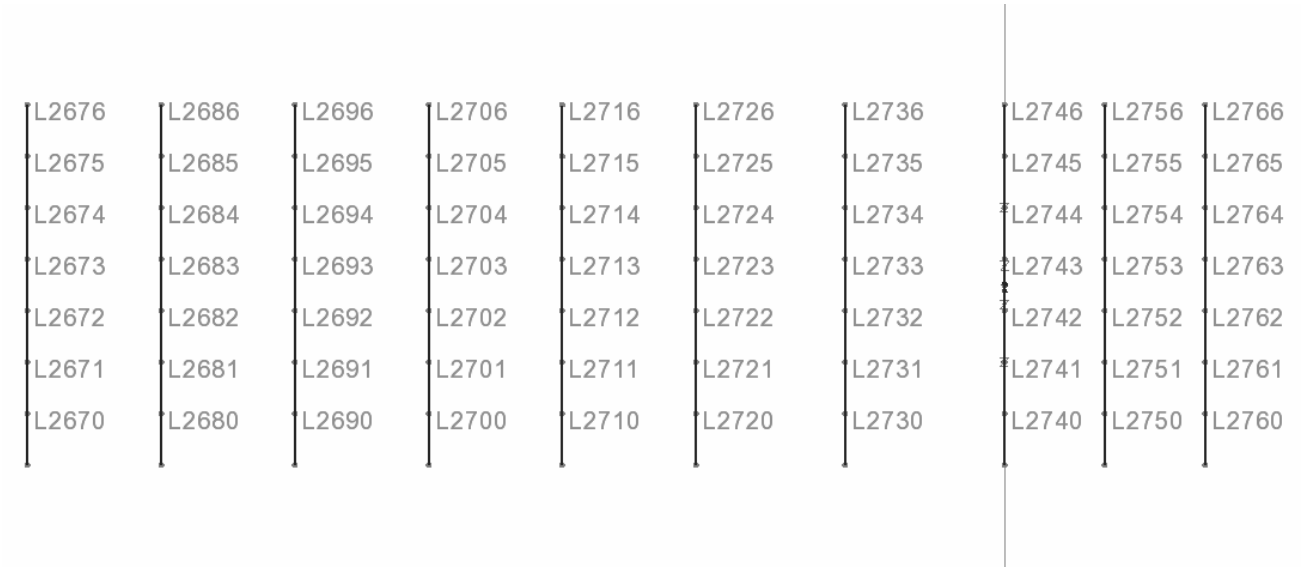
Casting stage 6 - Transversal beams UK (TB-UK):



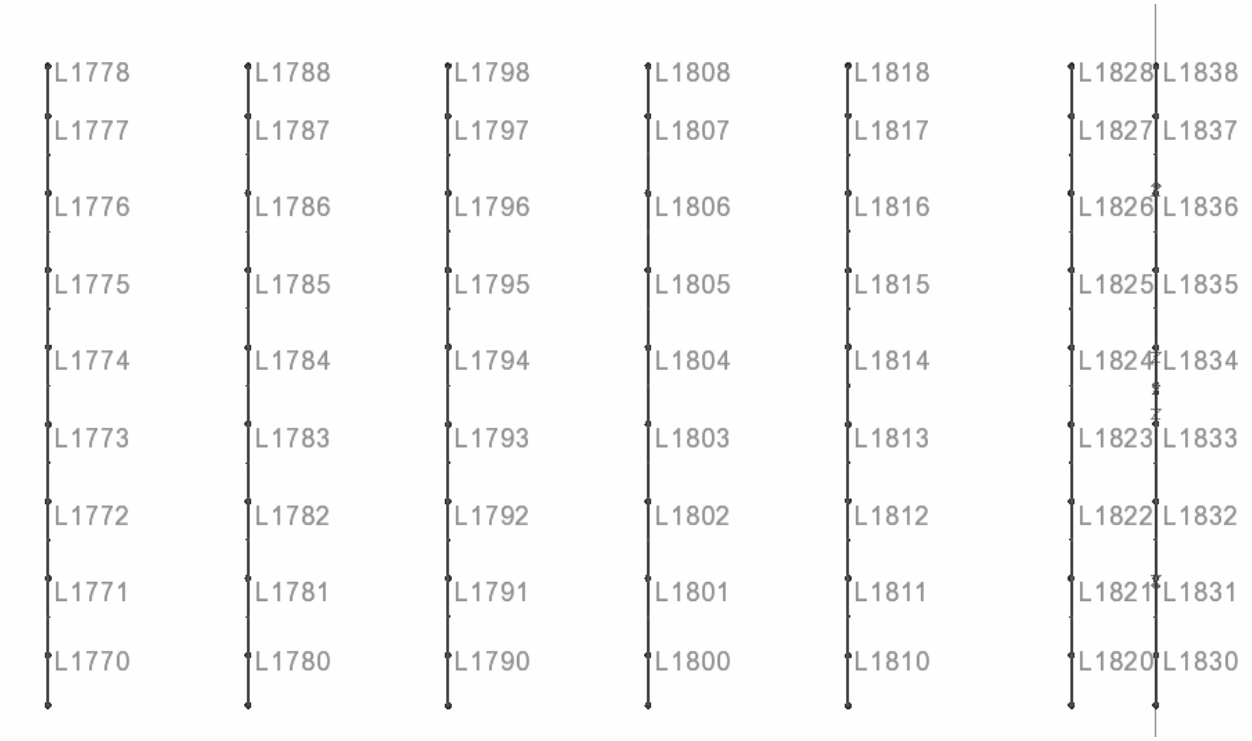
Casting stage 7 - Transversal beams OK (TB-OK) & Edge beams (EB):



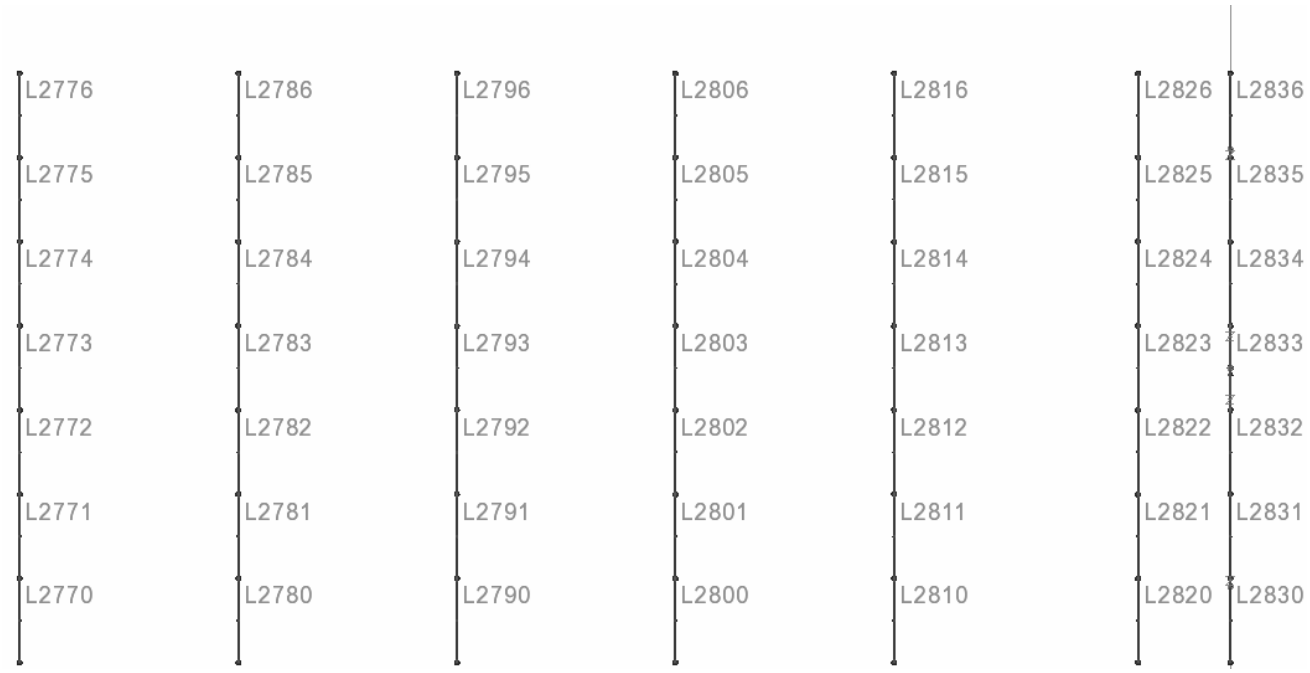
Casting stage 7 - Transversal beams UK (TB-UK):



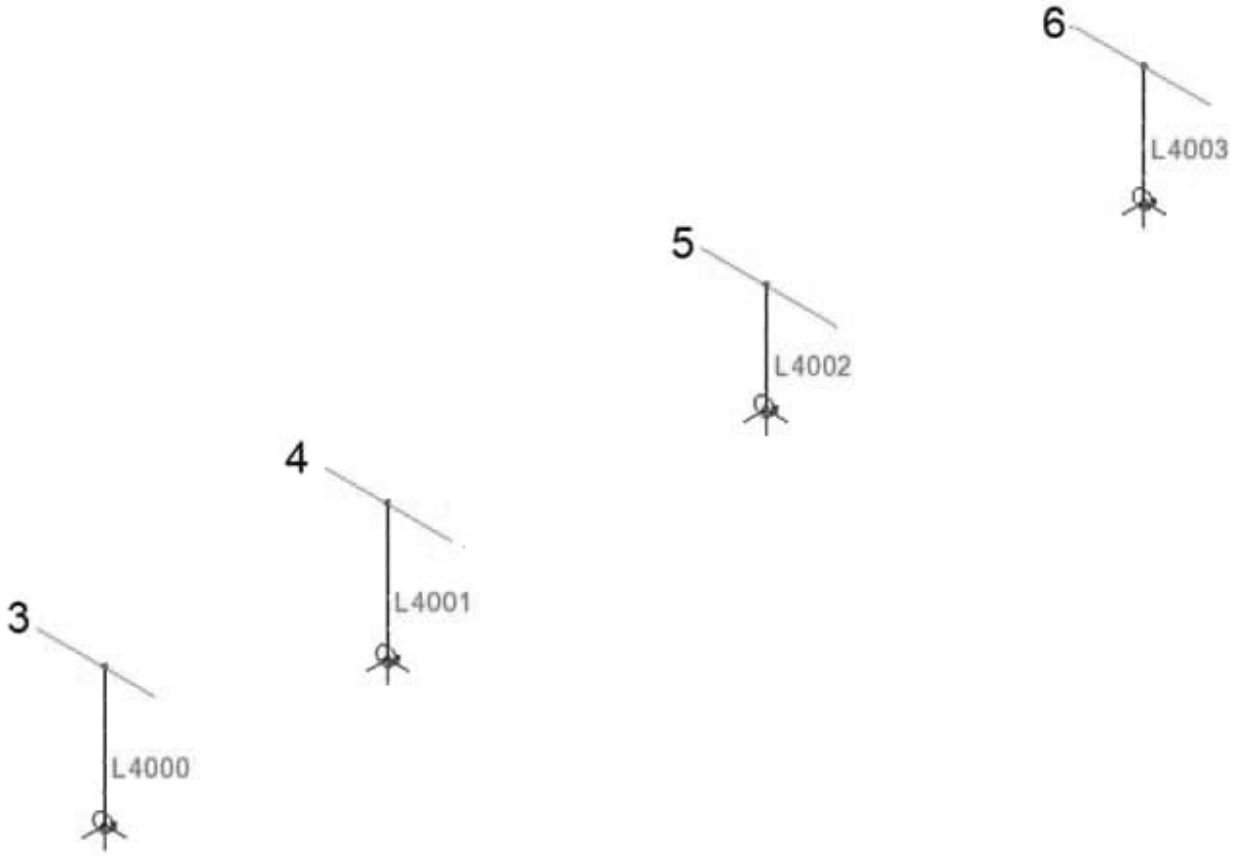
Casting stage 8 - Transversal beams OK (TB-OK) & Edge beams (EB):



Casting stage 8 - Transversal beams UK (TB-UK):

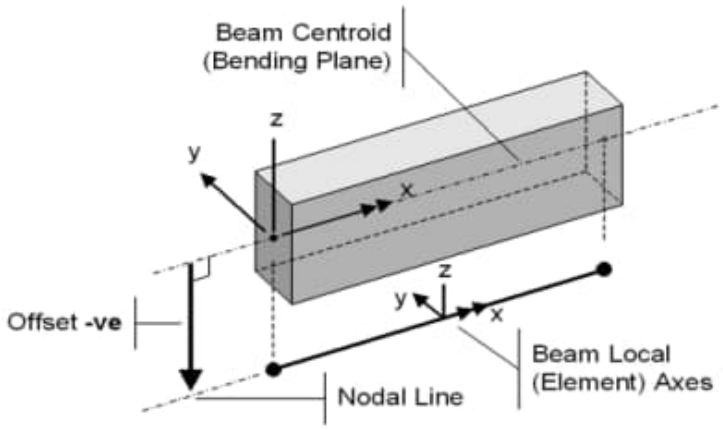


Columns: Supports 3-6



2.3 CROSS SECTION PROPERTIES

Principal sketch of geometry associated to 3D beam (”Thick beam” / BMS3) elements are seen below.

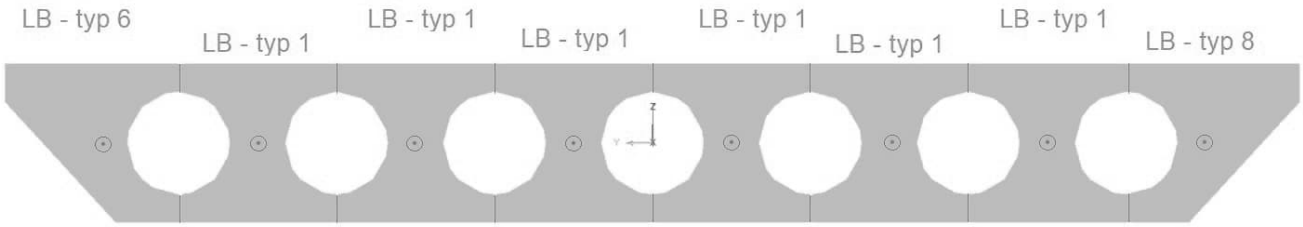


2.3.1 Longitudinal beams (LB)

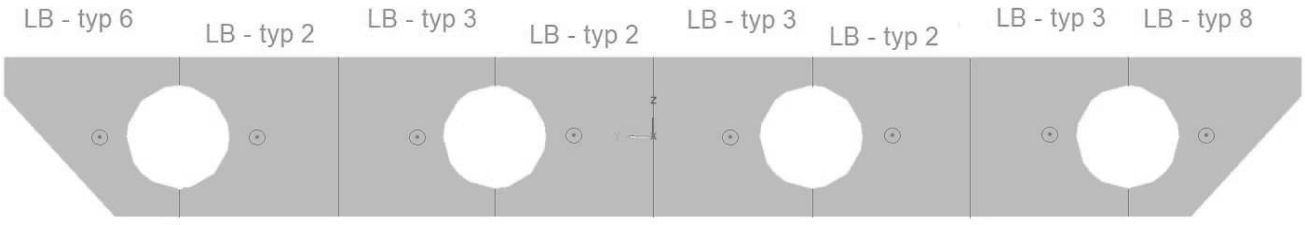
There are a total of 8 different types according to the reporting below.

The main beams are defined with a cross-section labeled "Arbitrary Section." Cross-section constants are determined using the function "*Section Property Calculator.*"

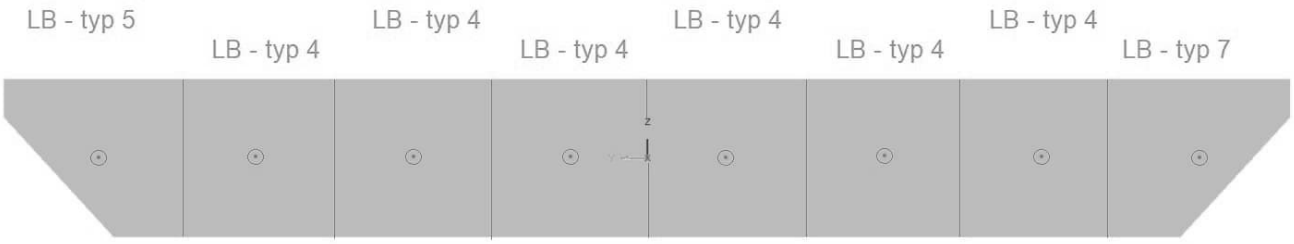
In order to avoid torsion in the beam, a fictitious torsional stiffness corresponding to $K_v = 10^{-6}$ m^4 is manually introduced.



TYPE SECTION 1
Cross section with 8 void tubes.

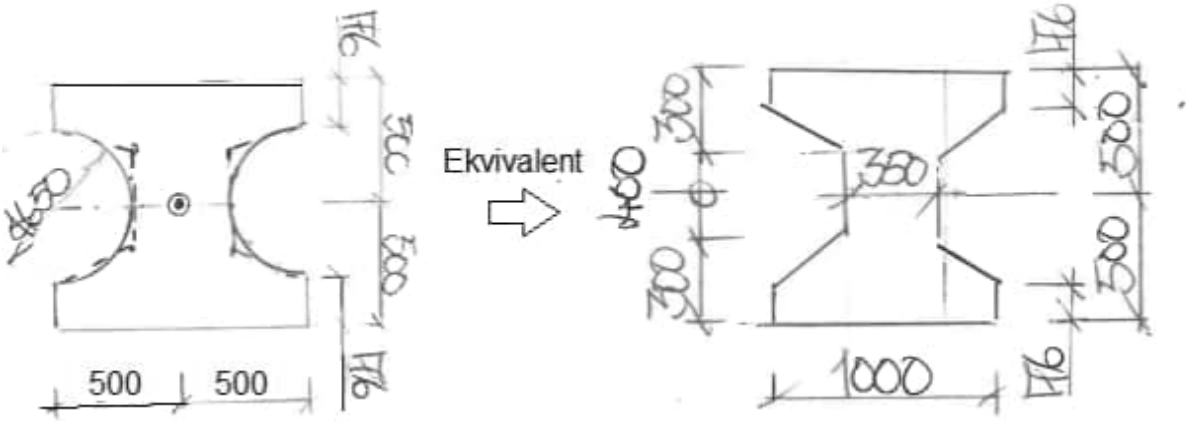


TYPE SECTION 2
Cross section with 4 void tubes.

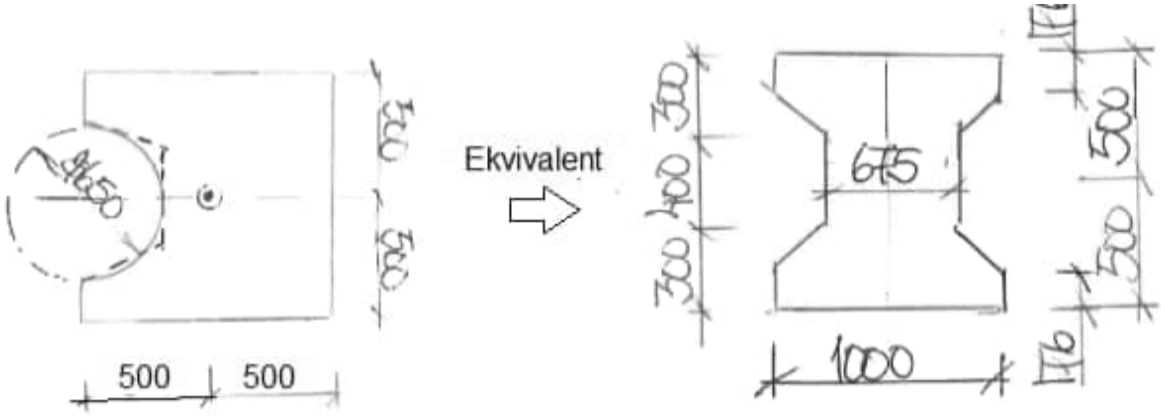


TYPE SECKTION 3
Massive cross section.

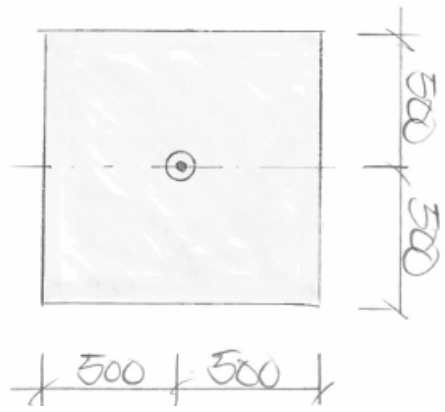
The geometry of these beams is presented below. In the check of resistance, however, simplified equivalent cross sections are applied.



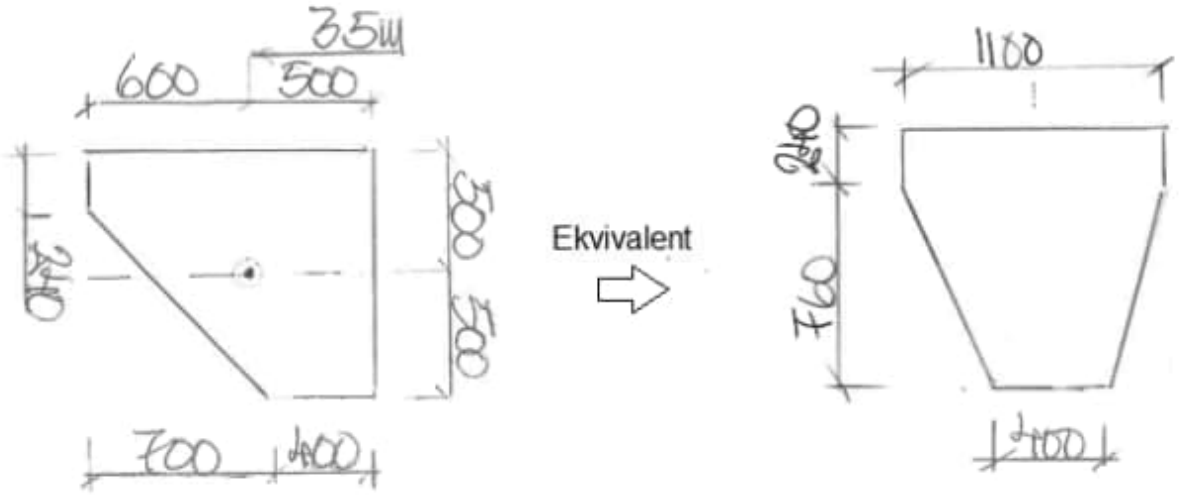
LB – type 1



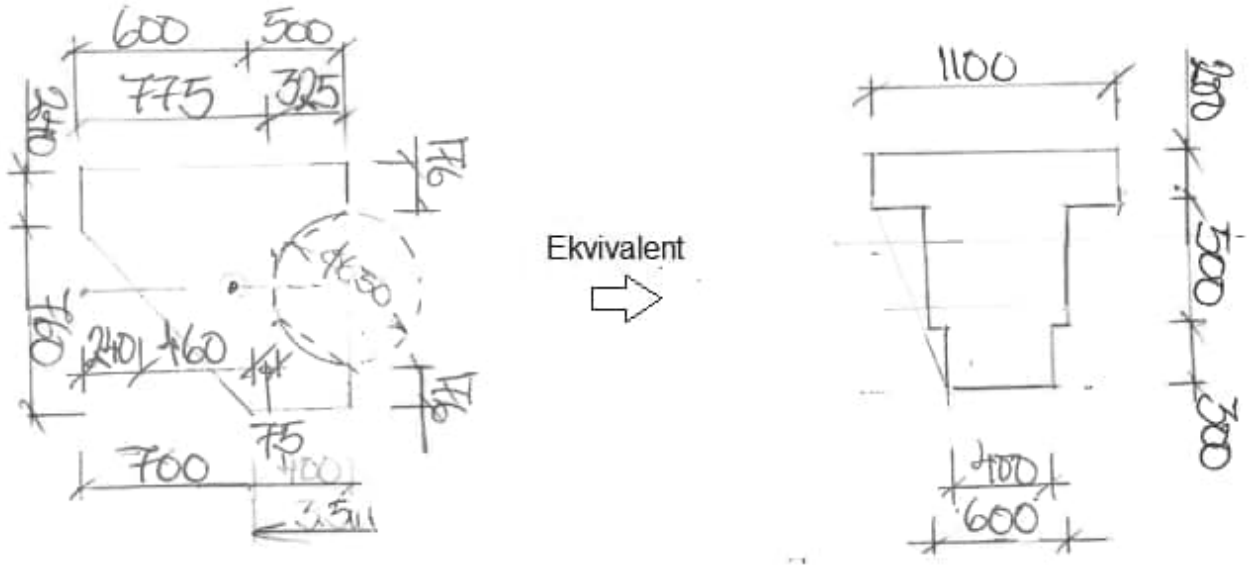
LB – type 2
Measurements same for LB – typ 3



LB – type 4

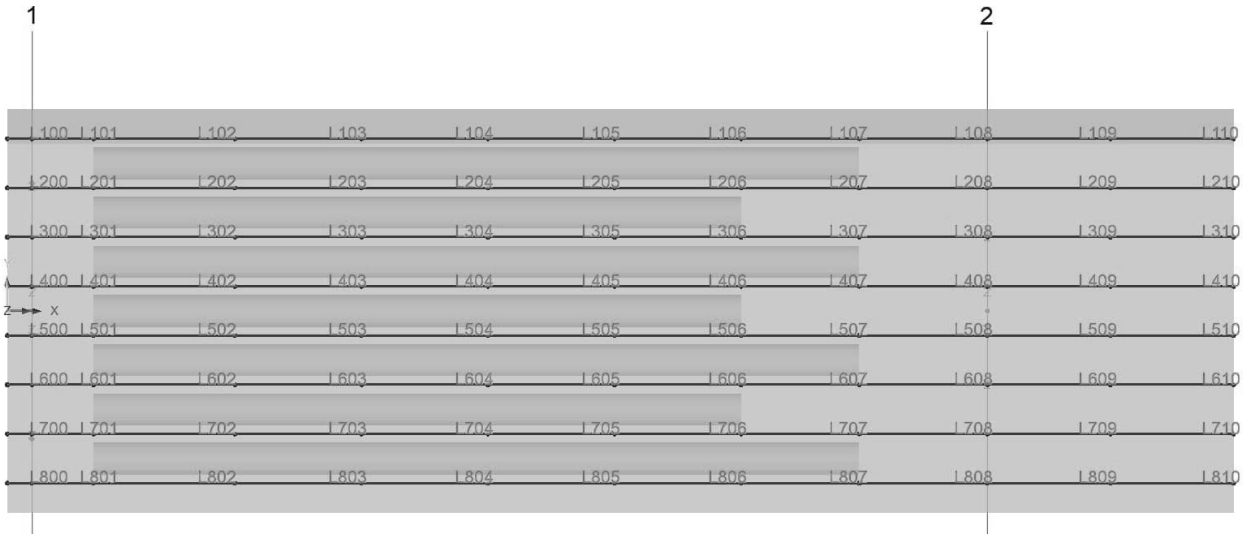


LB – type 5
Measurements same as LB – typ 7

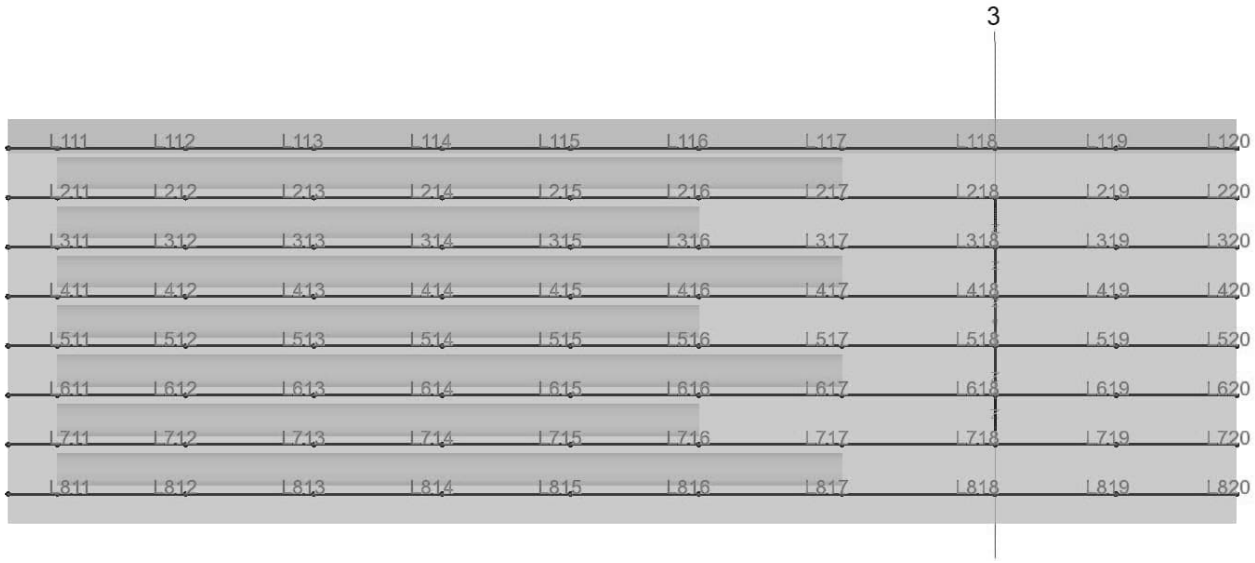


LB – type 6
Measurements as LB – type 8

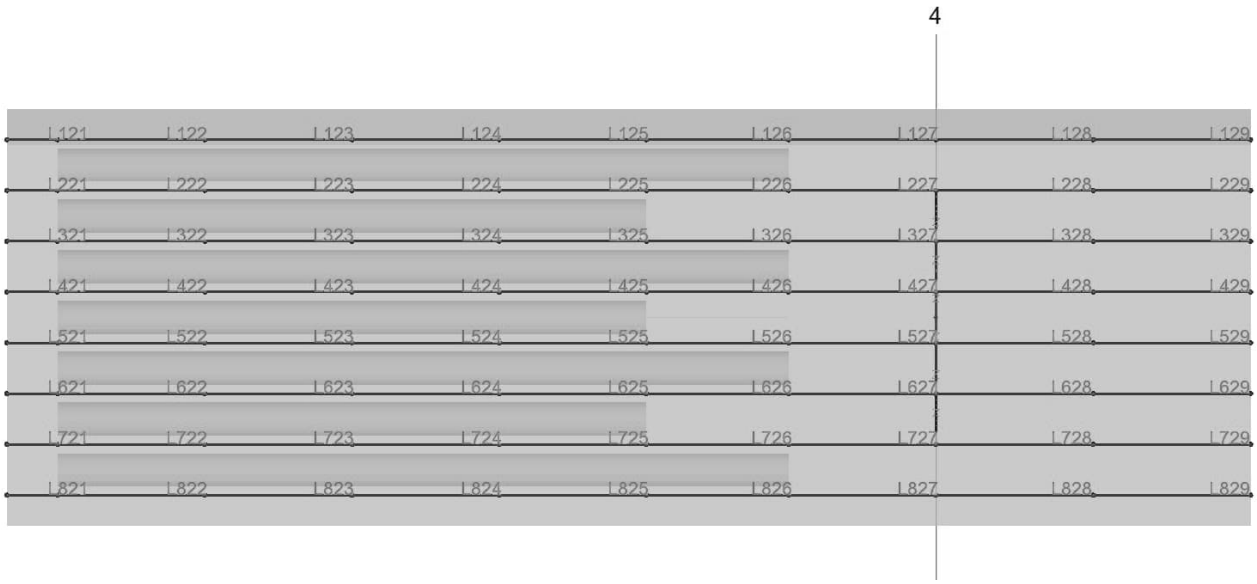
Casting stage 1 - Longitudinal beams (LB):



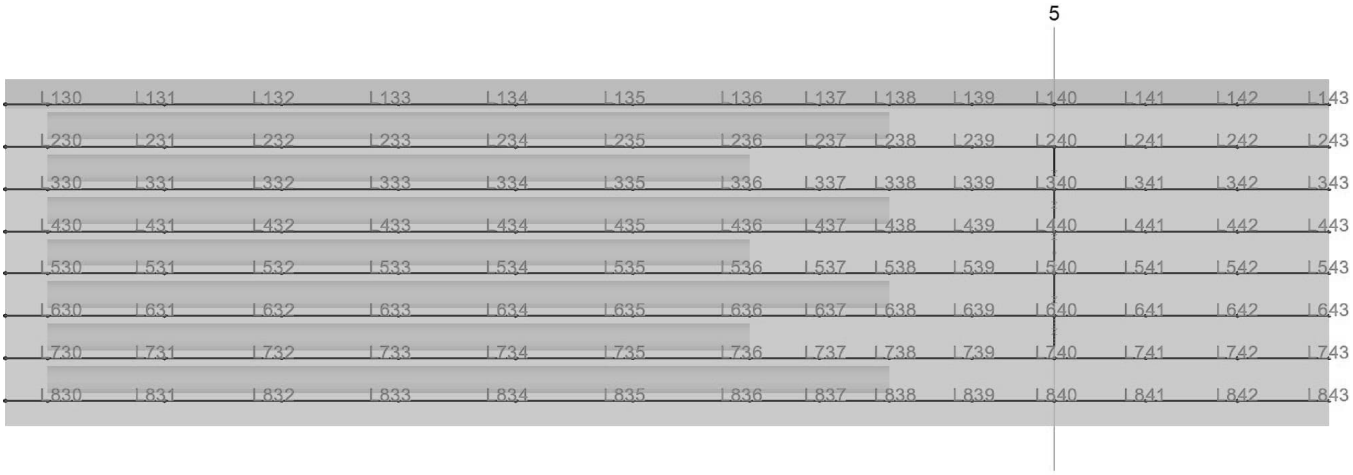
Casting stage 2 - Longitudinal beams (LB):



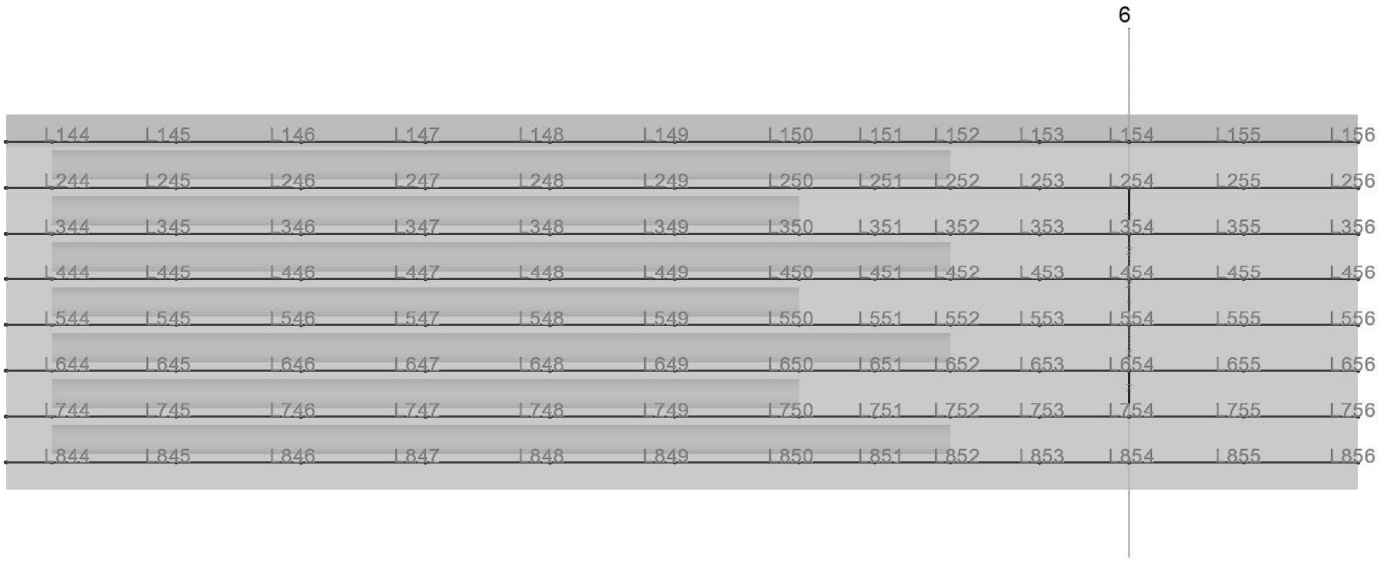
Casting stage 3 - Longitudinal beams (LB):



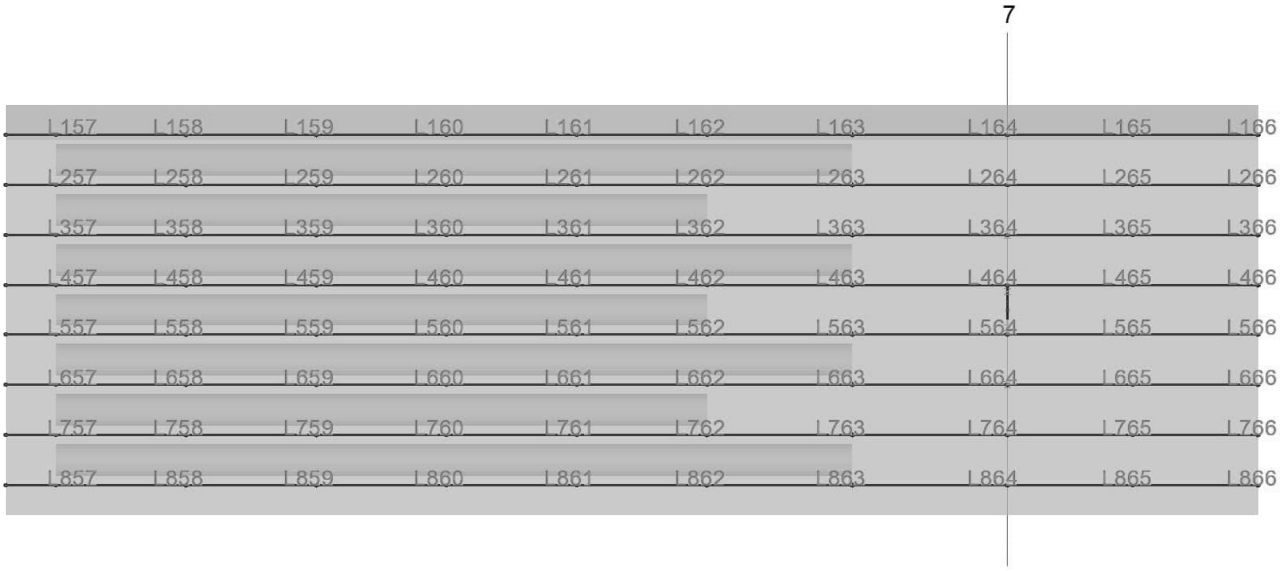
Casting stage 4 - Longitudinal beams (LB):



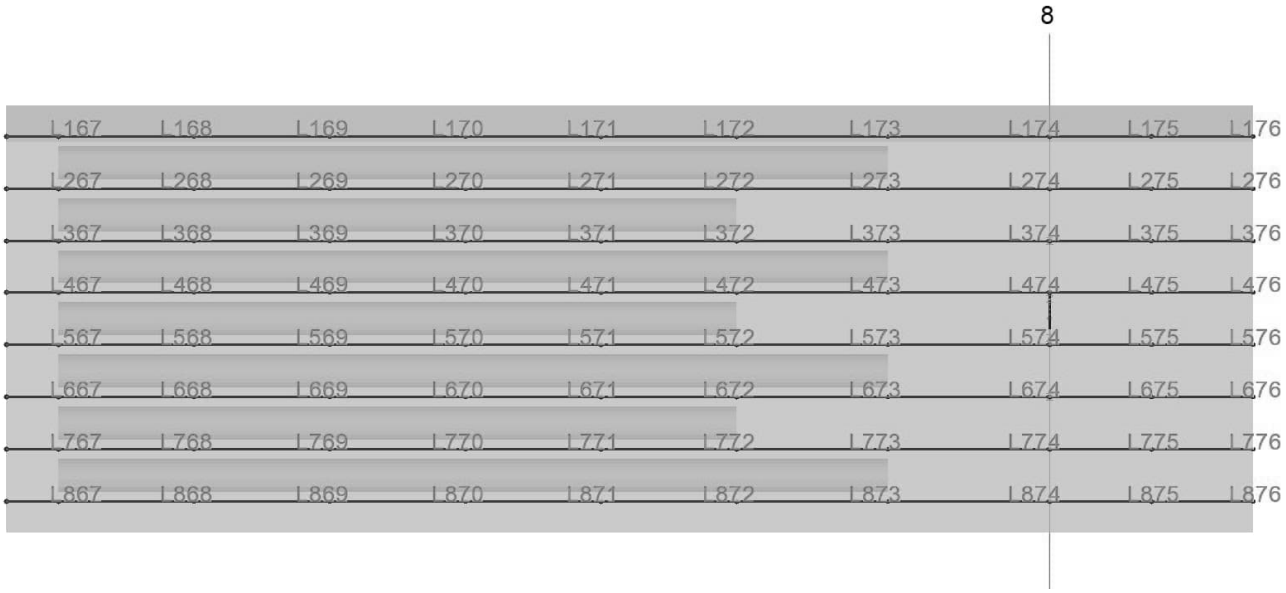
Casting stage 5 - Longitudinal beams (LB):



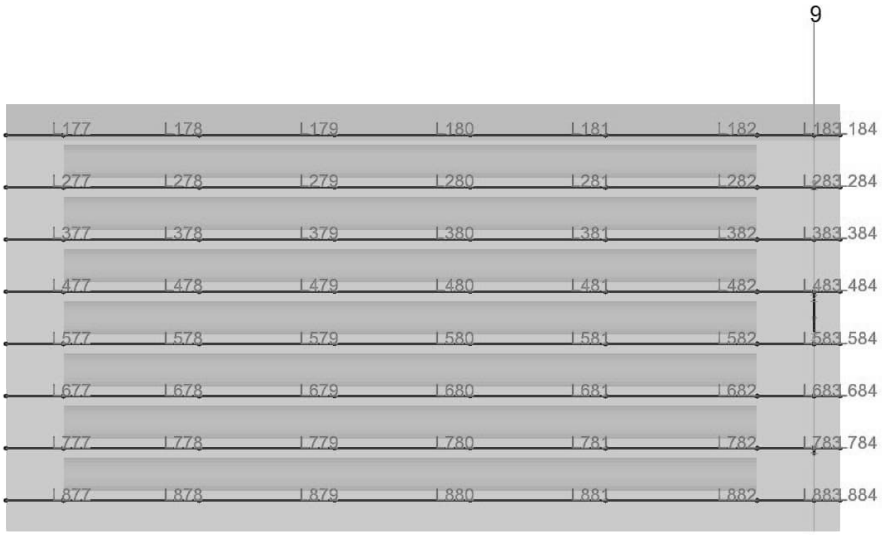
Casting stage 6 - Longitudinal beams (LB):



Casting stage 7 - Longitudinal beams (LB):



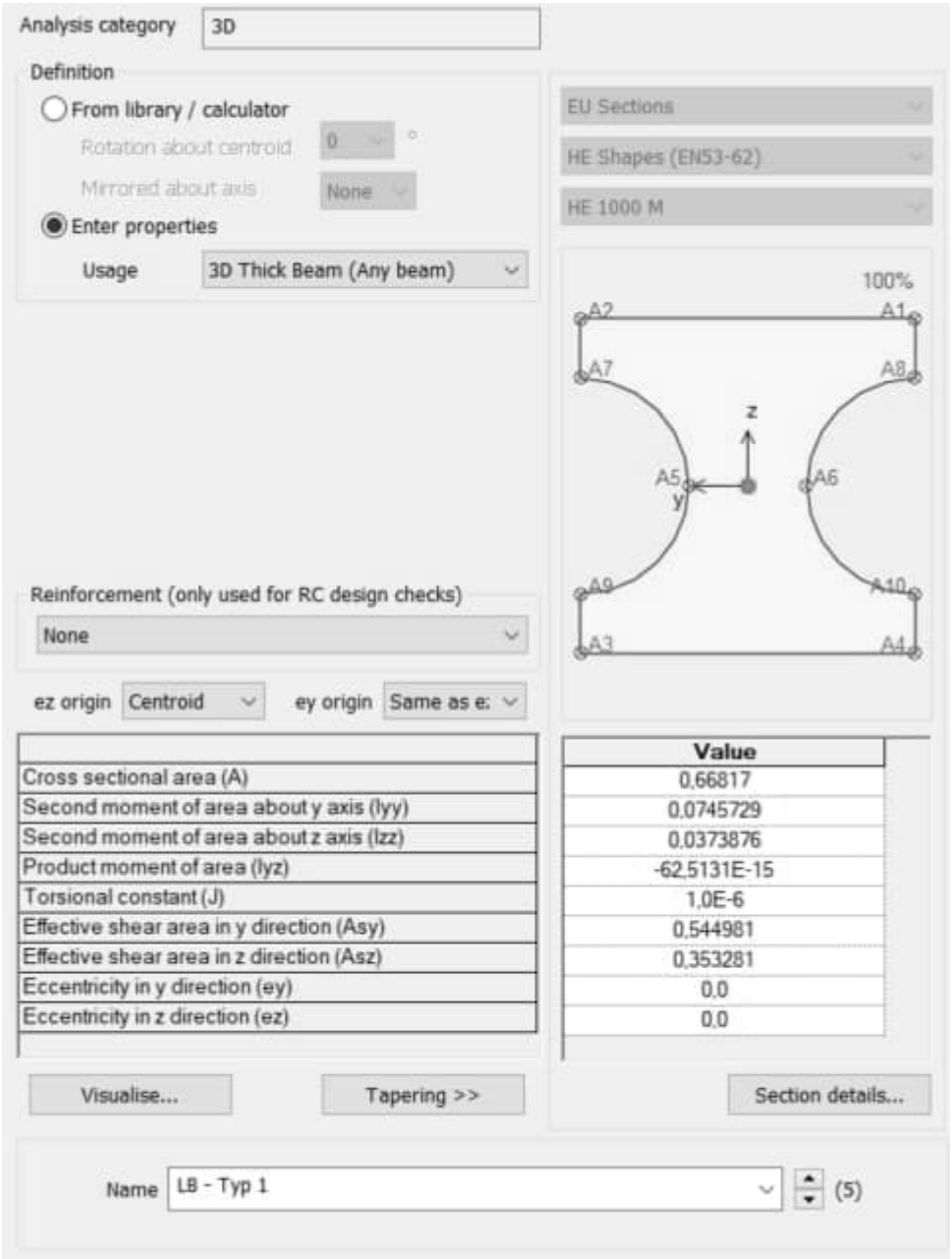
Casting stage 8 - Longitudinal beams (LB):



2.3.1.1 LB – Type 1

Punkt	y	z
A1	-0.500	0.500
A2	0.500	0.500
A3	0.500	-0.500
A4	-0.500	-0.500
A5	0.175	0
-	m	m

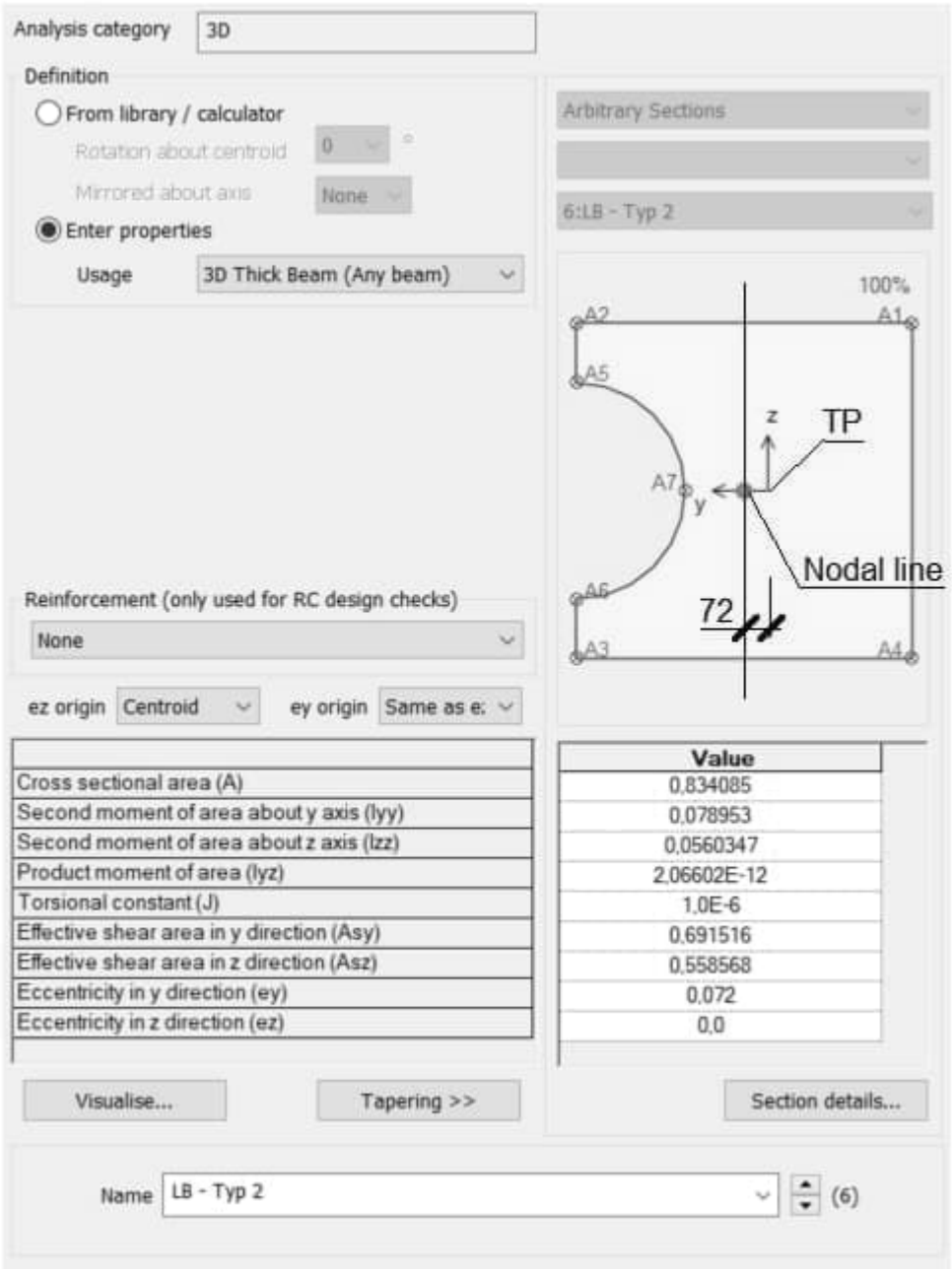
Punkt	y	z
A6	-0.175	0
A7	0.500	0.325
A8	-0.500	0.325
A9	0.500	-0.325
A10	-0.500	-0.325
-		



2.3.1.2 LB – Type 2

Punkt	y	z
A1	-0.428	0.500
A2	0.572	0.500
A3	0.572	-0.500
A4	-0.428	-0.500
-	m	m

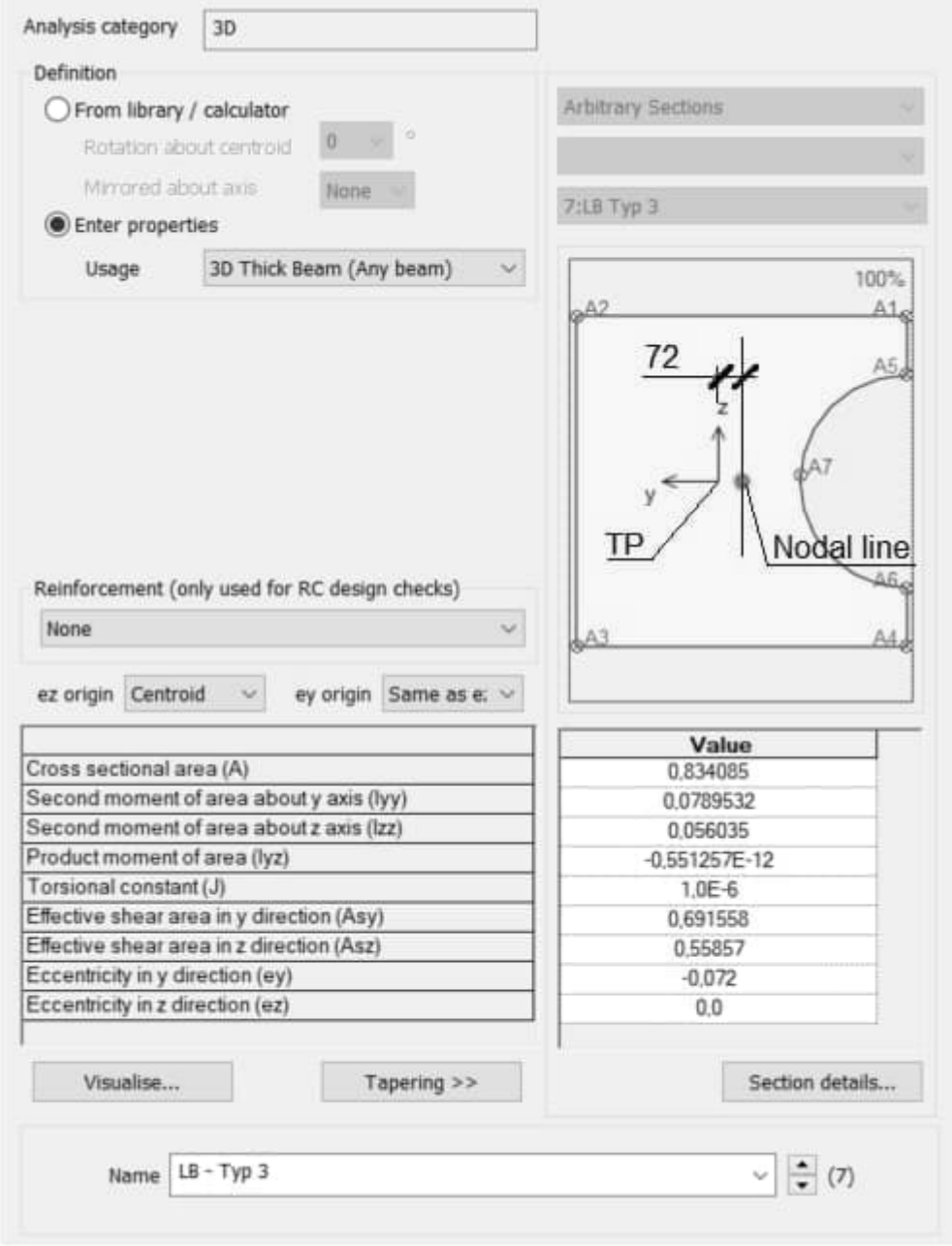
Punkt	y	z
A5	0.572	0.325
A6	0.572	-0.325
A7	0.247	0
-	m	m



2.3.1.3 LB – Type 3

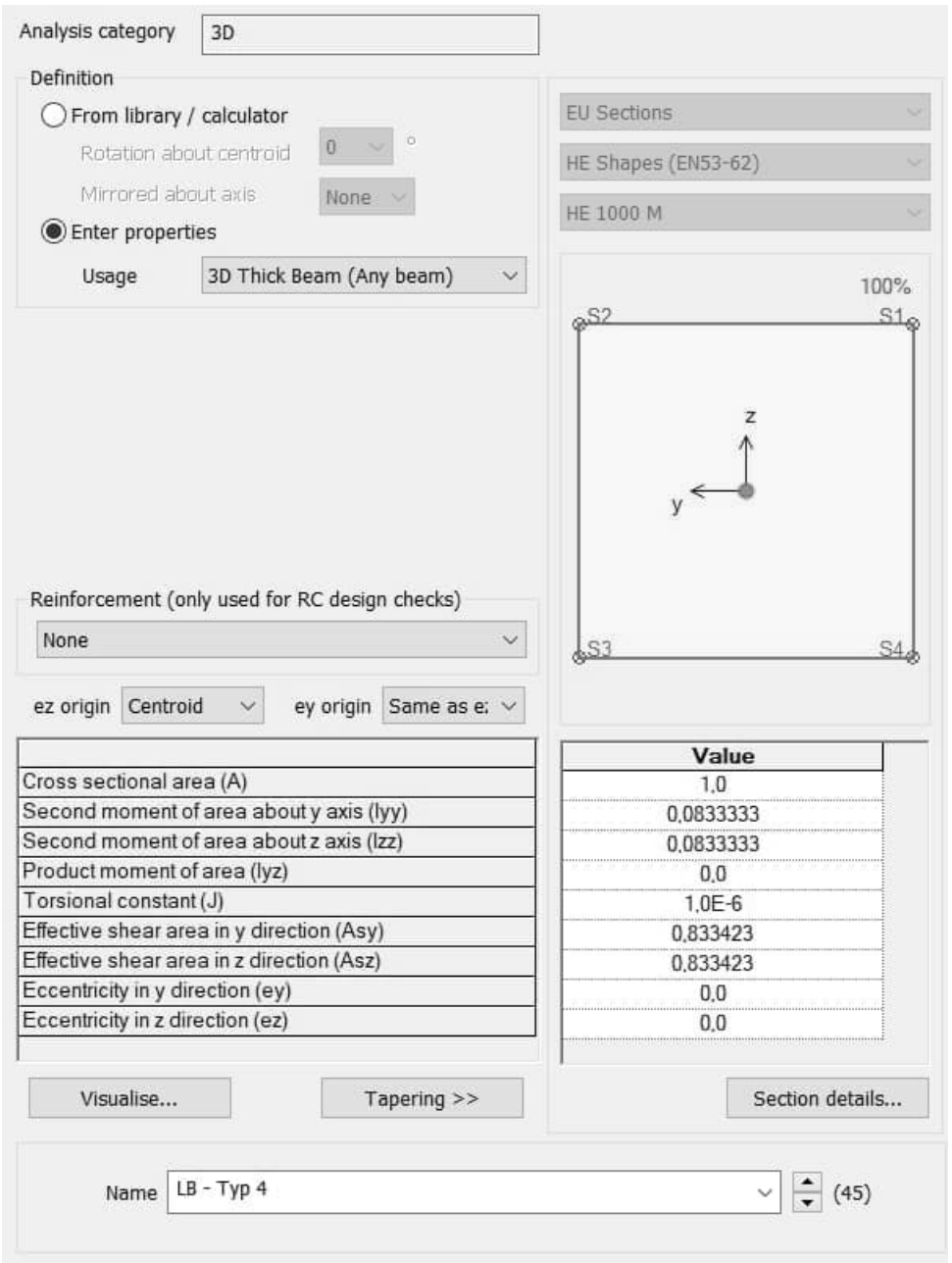
Punkt	y	z
A1	-0.572	0.500
A2	0.428	0.500
A3	0.428	-0.500
A4	-0.572	-0.500
-	m	m

Punkt	y	z
A5	-0.572	0.325
A6	-0.572	-0.325
A7	-0.247	0
-	m	m



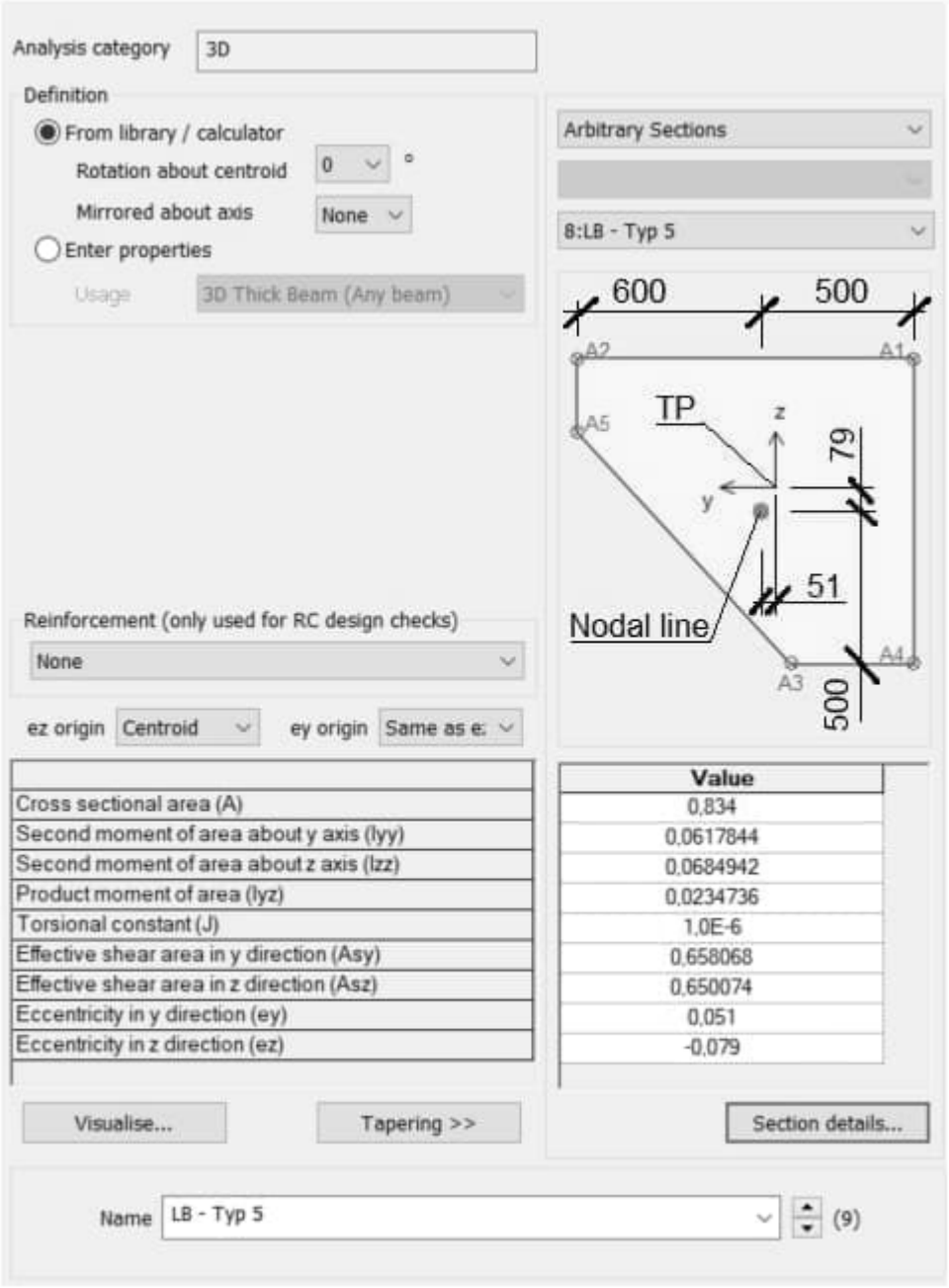
2.3.1.4 LB – Type 4

Punkt	y	z
S1	-0.500	0.500
S2	0.500	0.500
S3	0.500	-0.500
S4	-0.500	-0.500
-	m	m



2.3.1.5 LB – Type 5

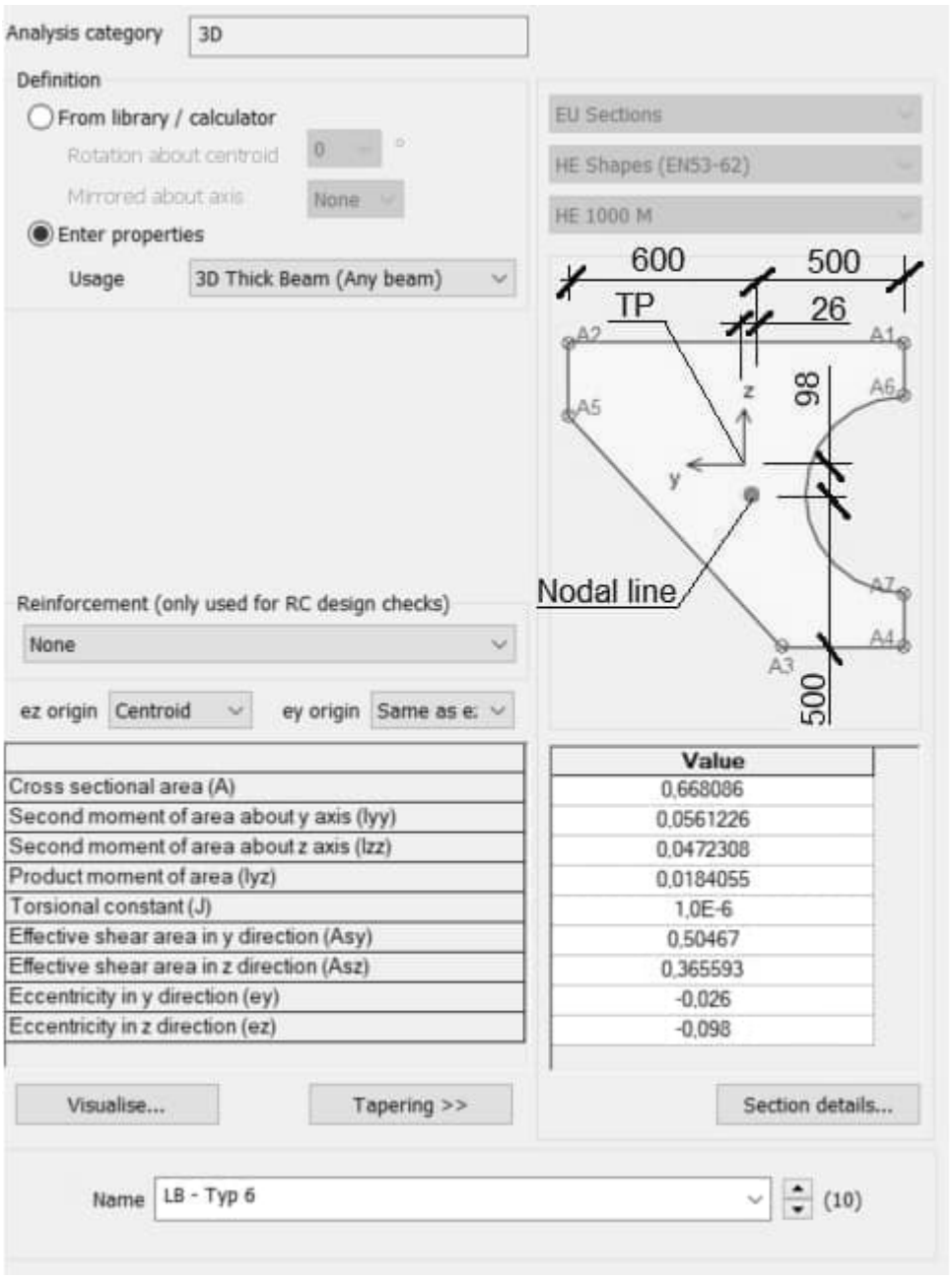
Punkt	y	z
A1	-0.449	0.421
A2	0.651	0.421
A3	-0.049	-0.579
A4	-0.449	-0.579
A5	0.651	0.181
-	m	m



2.3.1.6 LB – Type 6

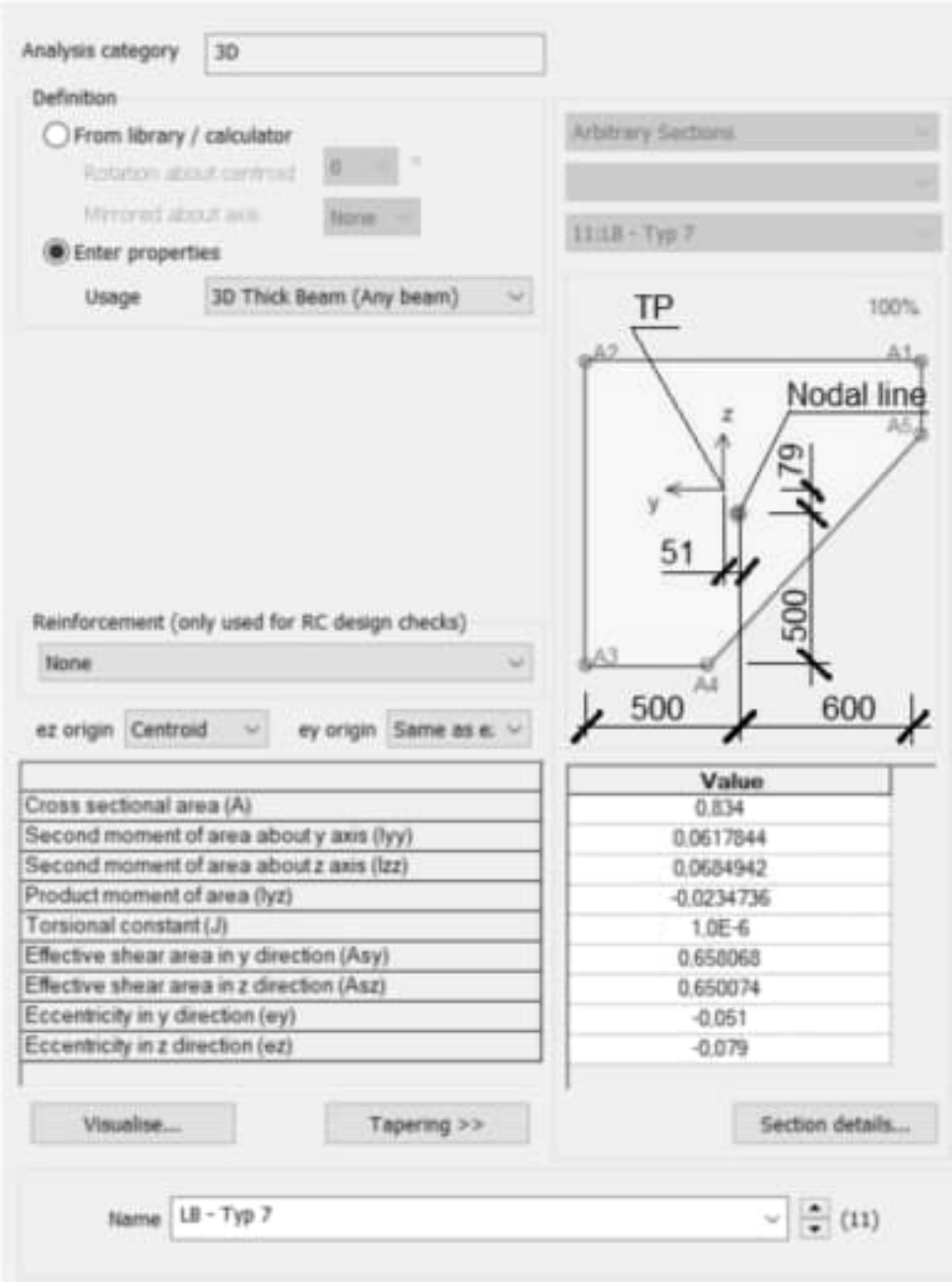
Punkt	y	z
A1	-0.526	0.402
A2	0.574	0.402
A3	-0.126	-0.598
A4	-0.526	-0.598
-	m	m

Punkt	y	z
A5	0.574	0.162
A6	-0.526	0.227
A7	-0.526	-0.423
-	m	m



2.3.1.7 LB – Type 7

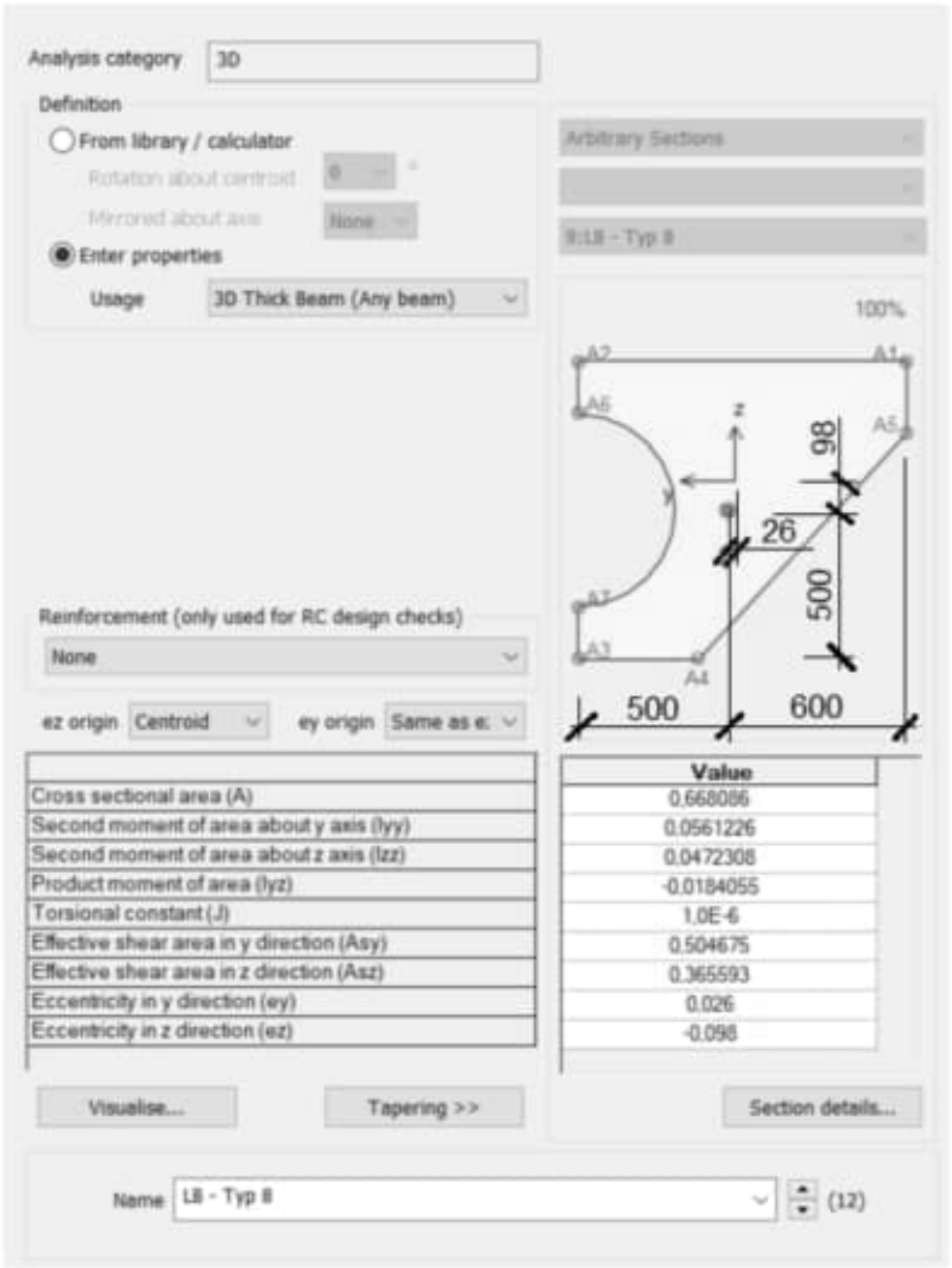
Punkt	y	Z
A1	-0.449	0.421
A2	0.651	0.421
A3	-0.049	-0.579
A4	-0.449	-0.579
A5	0.651	0.181
-	m	m



2.3.1.8 LB – Type 8

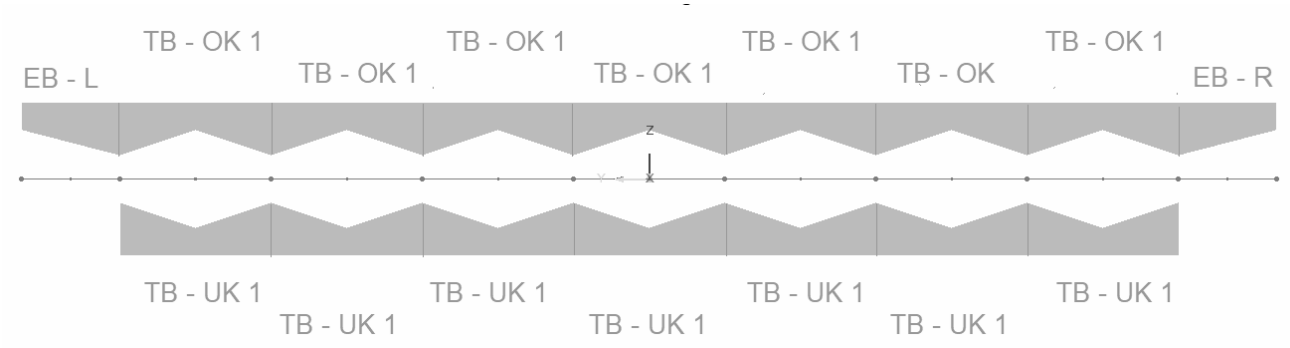
Punkt	y	z
A1	-0.526	0.402
A2	0.574	0.402
A3	-0.126	-0.598
A4	-0.526	-0.598
-	m	m

Punkt	y	z
A5	0.574	0.162
A6	-0.526	0.227
A7	-0.526	-0.423
-	m	m

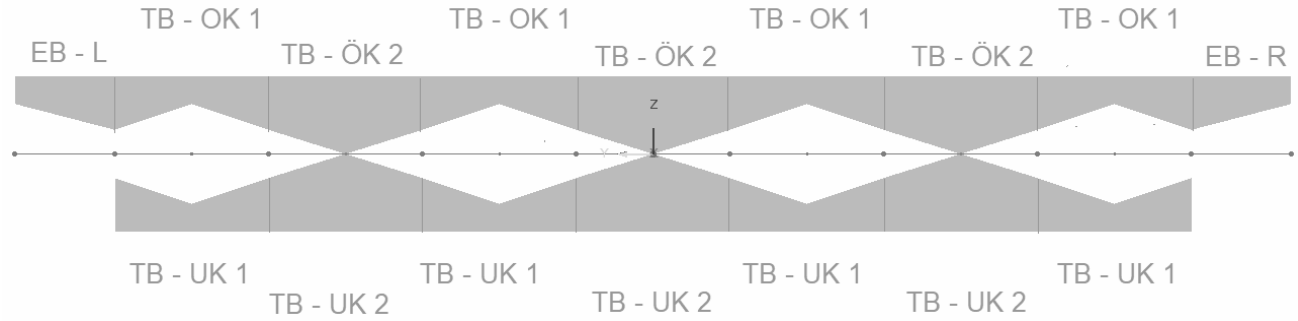


2.3.2 Transversal beams (TB)

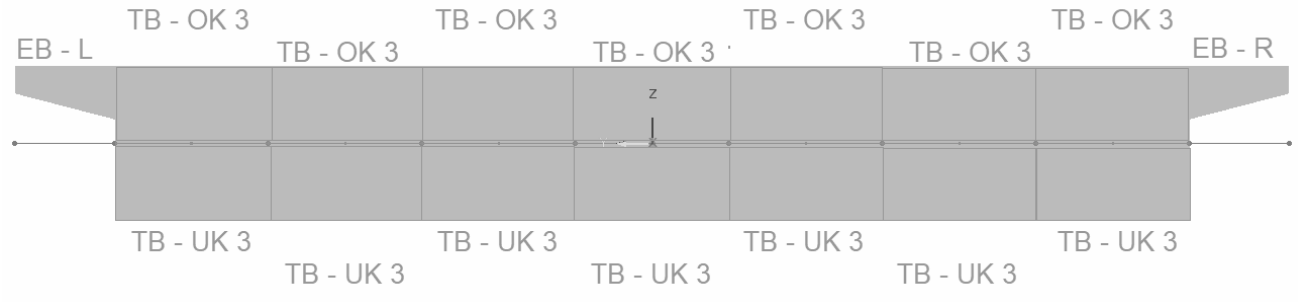
There are a total of 8 different types according to the reporting below.



TYPE SECTION 1
Cross section with 8 void tubes.

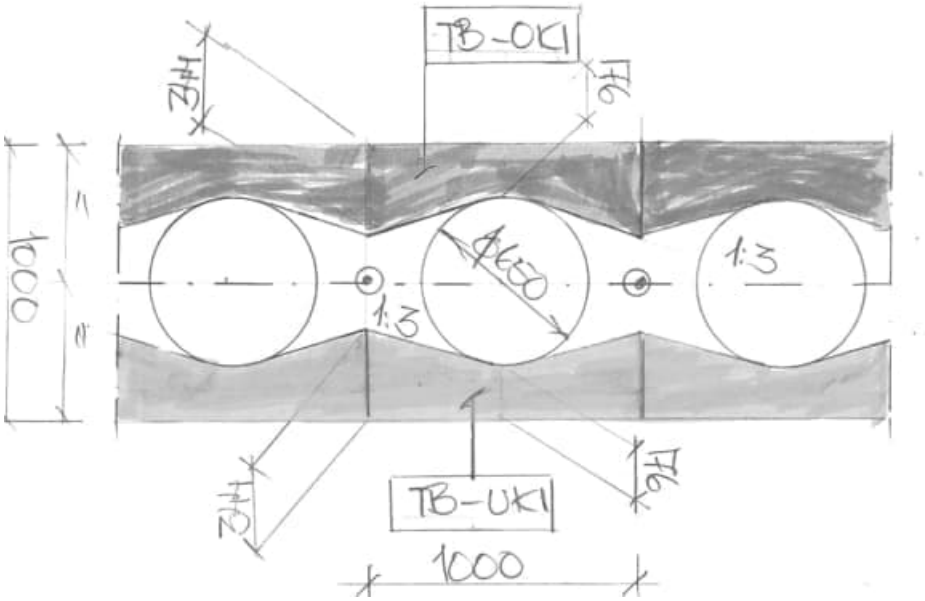


TYPE SECTION 2
Cross section with 4 void tubes.

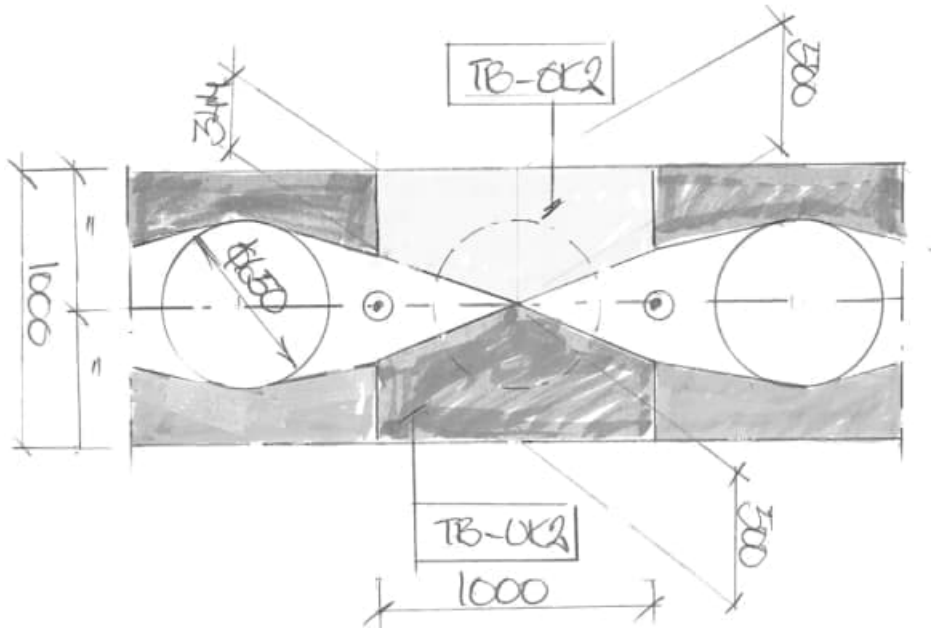


TYPE SECTION 3
Massive cross section.

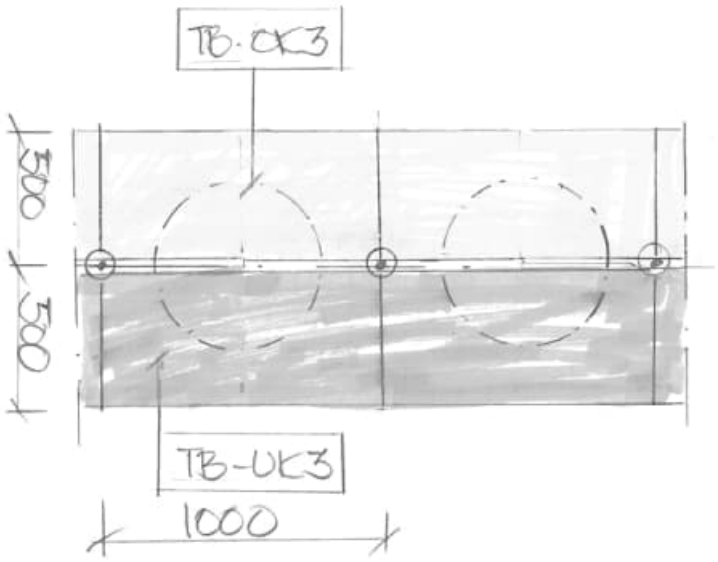
2.3.2.1 Thickness transversal beams



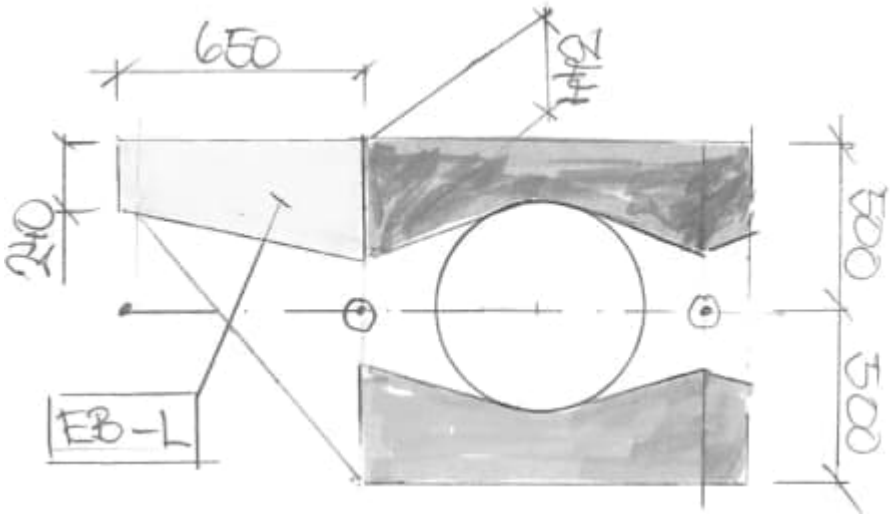
TB – OK 1 & TB – UK 1



TB – OK 2 & TB – UK 2



TB – OK 3 & TB – UK 3

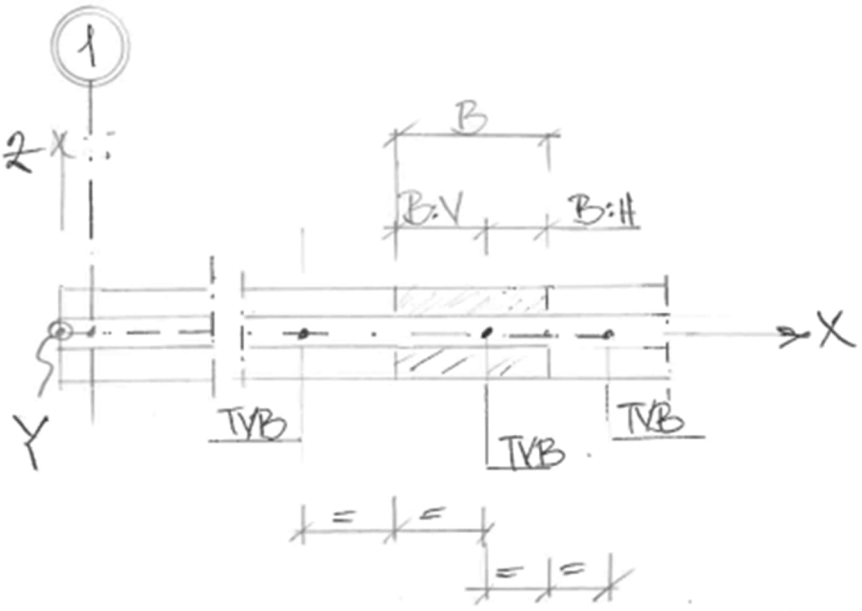


EB – L
Mått gäller även EB – R

2.3.2.2 Width transversal beams

The fictitious transverse beams have different widths depending on the distance at which they are located from each other.

A review of how the total width (denoted "B:TOT") is distributed for each transverse beam. A simplified width is then chosen (denoted "Selected B"). In total, 5 different simplified widths are applied for the fictitious transverse beams (B = 1.0 m; B = 1.50 m; B = 2.0 m; B = 2.5 m; B = 3.0 m).



Casting stage 1:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
0	x	x	x	No	Bridge end		x	x
0,50	0,500	0,625	1,13	Yes	Support 1		1,0	3
1,75	0,625	1,435	2,06	Yes	-		2,0	3
4,62	1,435	1,285	2,72	Yes	-		2,5	1
7,19	1,285	1,285	2,57	Yes	-		2,5	1
9,76	1,285	1,285	2,57	Yes	-	→	2,5	1
12,33	1,285	1,285	2,57	Yes	-		2,5	1
14,90	1,285	1,300	2,59	Yes	-		2,5	1
17,50	1,300	1,200	2,50	Yes	-		2,5	2
19,90	1,200	1,250	2,45	Yes	Support 2		2,5	3
22,40	1,250	1,250	2,50	Yes	-		2,5	3
24,90	1,250	0,500	1,75	Yes	Casting joint		2.0	3
m	m	m	m		-		m	-

Casting stage 2:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
24,90	x	x	x	No	Casting joint		x	x
25,90	0,500	1,300	1,80	Yes	Support 2		2,0	1
28,50	1,300	1,300	2,60	Yes	-		2,5	1
31,10	1,300	1,300	2,60	Yes	-		2,5	1
33,70	1,300	1,300	2,60	Yes	-		2,5	1
36,30	1,300	1,300	2,60	Yes	-	→	2,5	1
38,90	1,300	1,450	2,75	Yes	-		2,5	1
41,80	1,450	1,550	3,00	Yes	-		3,0	2
44,90	1,550	1,225	2,78	Yes	Support 3		3,0	3
47,35	1,225	1,225	2,45	Yes	-		2,5	3
49,80	1,225	0,500	1,73	Yes	Casting joint		1,5	3
m	m	m	m	-	-		m	-

Casting stage 3:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
49,80	x	x	x	No	Casting joint		x	x
50,80	0,500	1,450	1,95	Yes	-		2,0	1
53,70	1,450	1,450	2,90	Yes	-		3,0	1
56,60	1,450	1,450	2,90	Yes	-		3,0	1
59,50	1,450	1,450	2,90	Yes	-		3,0	1
62,40	1,450	1,400	2,85	Yes	-	→	3,0	1
65,20	1,400	1,450	2,85	Yes	-		3,0	2
68,10	1,450	1,550	3,00	Yes	Support 4		3,0	3
71,20	1,550	1,550	3,10	Yes	-		3,0	3
74,30	1,550	0,400	1,95	Yes	Casting joint		2,0	3
m	m	m	m	-	-		m	-

Casting stage 4:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
74,30	x	x	x	No	Casting joint		x	x
75,30	0,500	1,385	1,89	Yes	-		2,0	1
78,07	1,385	1,380	2,77	Yes	-		3,0	1
80,83	1,380	1,385	2,77	Yes	-		3,0	1
83,60	1,385	1,385	2,77	Yes	-		3,0	1
86,37	1,385	1,380	2,77	Yes	-	→	3,0	1
89,13	1,380	1,385	2,77	Yes	-		3,0	1
91,90	1,385	0,825	2,21	Yes	-		2,0	1
93,55	0,825	0,825	1,65	Yes	-		1,5	2
95,20	0,825	0,975	1,80	Yes	-		2,0	2
97,15	0,975	0,975	1,95	Yes	-		2,0	3
99,10	0,975	1,085	2,06	Yes	Support 5		2,0	3
101,27	1,085	1,080	2,17	Yes	-		2,0	3
103,43	1,080	1,085	2,17	Yes	-		2,0	3
105,60	1,085	0,500	1,58	Yes	Casting stage		1,5	3
m	m	m	m	-	-		m	-

Casting stage 5:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
105,60	x	x	x	No	Casting stage		x	x
106,60	0,500	1,360	1,86	Yes	-		2,0	1
109,32	1,360	1,355	2,72	Yes	-		3,0	1
112,03	1,355	1,360	2,72	Yes	-		3,0	1
114,75	1,360	1,360	2,72	Yes	-		3,0	1
117,47	1,360	1,355	2,72	Yes	-	→	3,0	1
120,18	1,355	1,360	2,72	Yes	-		3,0	1
122,90	1,360	0,825	2,19	Yes	-		2,0	1
124,55	0,825	0,825	1,65	Yes	-		1,5	2
126,20	0,825	0,975	1,80	Yes	-		2,0	2
128,15	0,975	0,975	1,95	Yes	-		2,0	3
130,10	0,975	1,250	2,22	Yes	Support 6		2,0	3
132,60	1,250	1,250	2,50	Yes	-		2,5	3
135,10	1,250	0,500	1,75	Yes	Casting stage		1,5	3
m	m	m	m	-	-		m	-

Casting stage 6:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
135,10	x	x	x	No	Casting stage		x	x
136,10	0,500	1,300	1,80	Yes	-		2,0	1
138,70	1,300	1,300	2,60	Yes	-		2,5	1
141,30	1,300	1,300	2,60	Yes	-		2,5	1
143,90	1,300	1,300	2,60	Yes	-		2,5	1
146,50	1,300	1,300	2,60	Yes	-	→	2,5	1
149,10	1,300	1,450	2,75	Yes	-		3,0	1
152,00	1,450	1,550	3,00	Yes	-		3,0	2
155,10	1,550	1,250	2,80	Yes	Support 7		3,0	3
157,60	1,250	1,250	2,50	Yes	-		2,5	3
160,10	1,250	0,500	1,75	Yes	Casting stage		1,5	3
m	m	m	m	-	-		m	-

Casting stage 7:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
160,10	x	x	x	No	Casting stage		x	x
161,10	0,500	1,300	1,80	Yes	-		2,0	1
163,70	1,300	1,300	2,60	Yes	-		2,5	1
166,30	1,300	1,300	2,60	Yes	-		2,5	1
168,90	1,300	1,300	2,60	Yes	-		2,5	1
171,50	1,300	1,300	2,60	Yes	-	→	2,5	1
174,10	1,300	1,450	2,75	Yes	-		3,0	1
177,00	1,450	1,550	3,00	Yes	-		3,0	2
180,10	1,550	0,975	2,53	Yes	Support 8		2,5	3
182,05	0,975	0,975	1,95	Yes	-		2,0	3
184,00	0,975	0,550	1,52	Yes	Casting stage		1,5	3
m	m	m	m	-	-		m	-

Casting stage 8:

X	B:V	B:H	B:TOT	TVB	Remark		Chosen B	Section type
184,00	x	x	x	No	Casting stage		x	x
185,10	0,550	1,300	1,85	Yes	-		2,0	1
187,70	1,300	1,300	2,60	Yes	-		2.5	1
190,30	1,300	1,300	2,60	Yes	-		2,5	1
192,90	1,300	1,300	2,60	Yes	-		2,5	1
195,50	1,300	1,450	2,75	Yes	-	→	2,5	1
198,40	1,450	0,550	2,00	Yes	-		2,0	1
199,50	0,550	0,500	1,05	Yes	Support 9		1,0	3
200,00	x	x	x	No	Broände		x	x
m	m	m	m	-	-		m	-

2.3.2.3 Defintion transversal beams

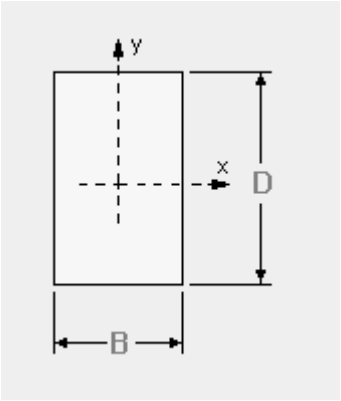
The occurring fictitious beams are both of even thickness and tapered.

The tapered beams are designated as "Multiple Varying Section".

These are either tapered with two break points (designated "2 sections") or three break points (designated "sections").

Determination of cross-sectional constants is carried out by the "Section property calculator". In this case, only solid rectangular cross-sections occur (designated "RSS" or "Rectangular Solid Section").

The rectangular cross-sections are defined by thickness (designated "D") and width (designated "B").



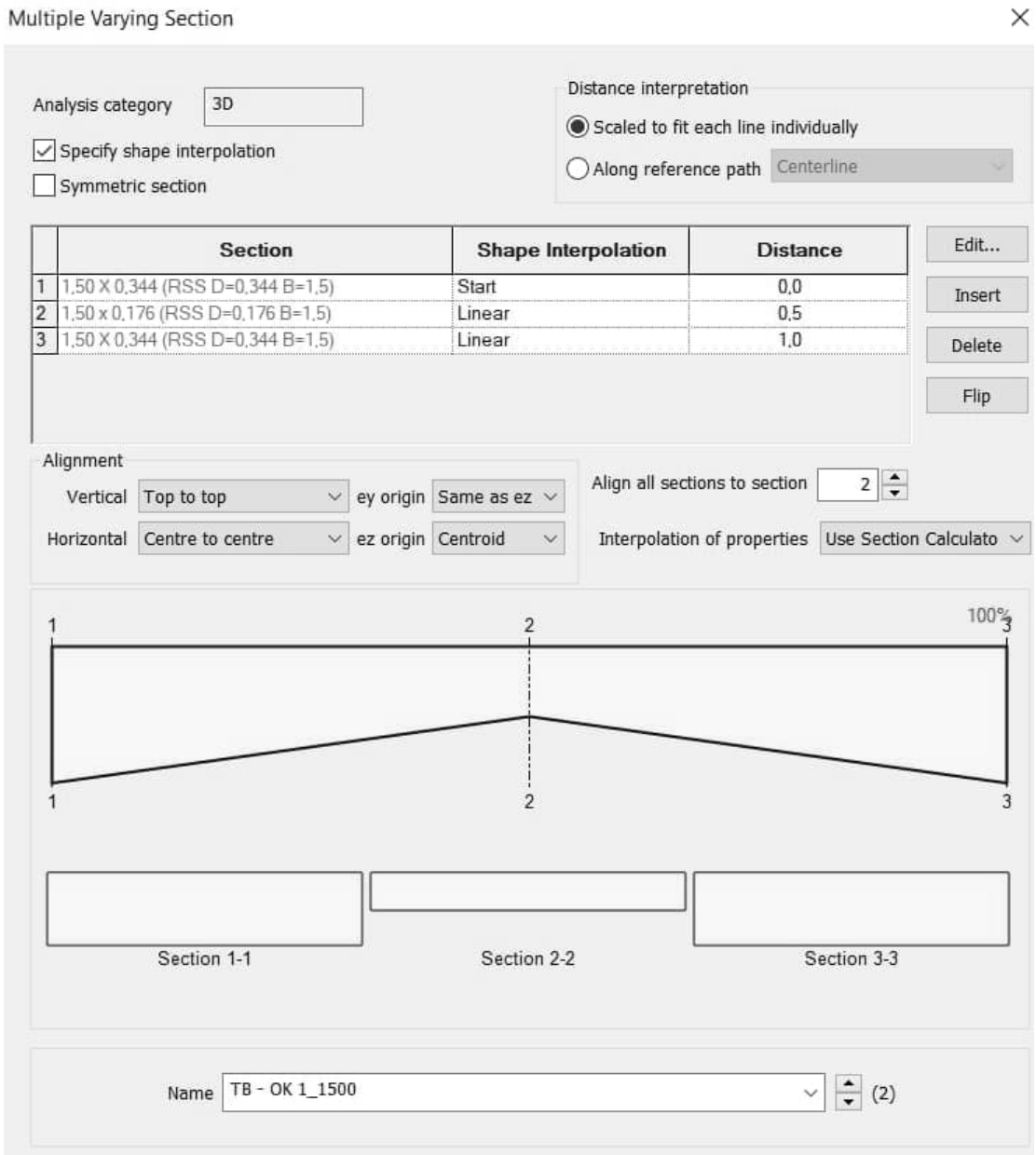
2.3.2.1 TB – OK1

This transversal beam is designated 'Multiple varying: 3 sections' with geometry as below.

TB – OK 1_1500:

Section	D	B	Section
1	0.344	1.500	RSS D = 0.344 B = 1.5
2	0.176	1.500	RSS D = 0.176 B = 1.5
3	0.344	1.500	RSS D = 0.344 B = 1.5
-	m	m	-

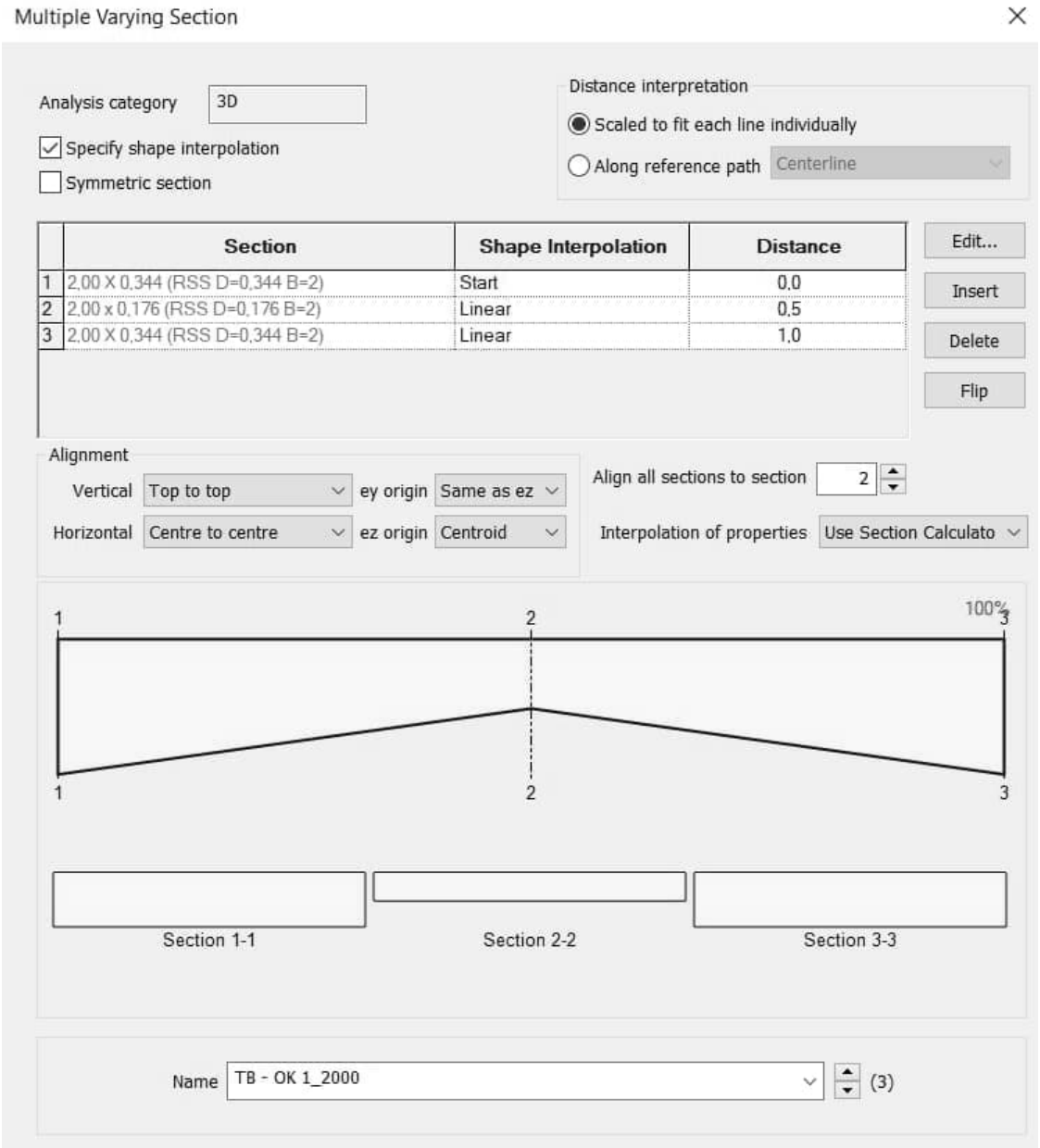
Eccentricity in z direction (ez): -0.412 m



TB – OK 1_2000:

Section	D	B	Section
1	0.344	2.000	RSS D = 0.344 B = 2.0
2	0.176	2.000	RSS D = 0.176 B = 2.0
3	0.344	2.000	RSS D = 0.500 B = 2.0
-	m	m	-

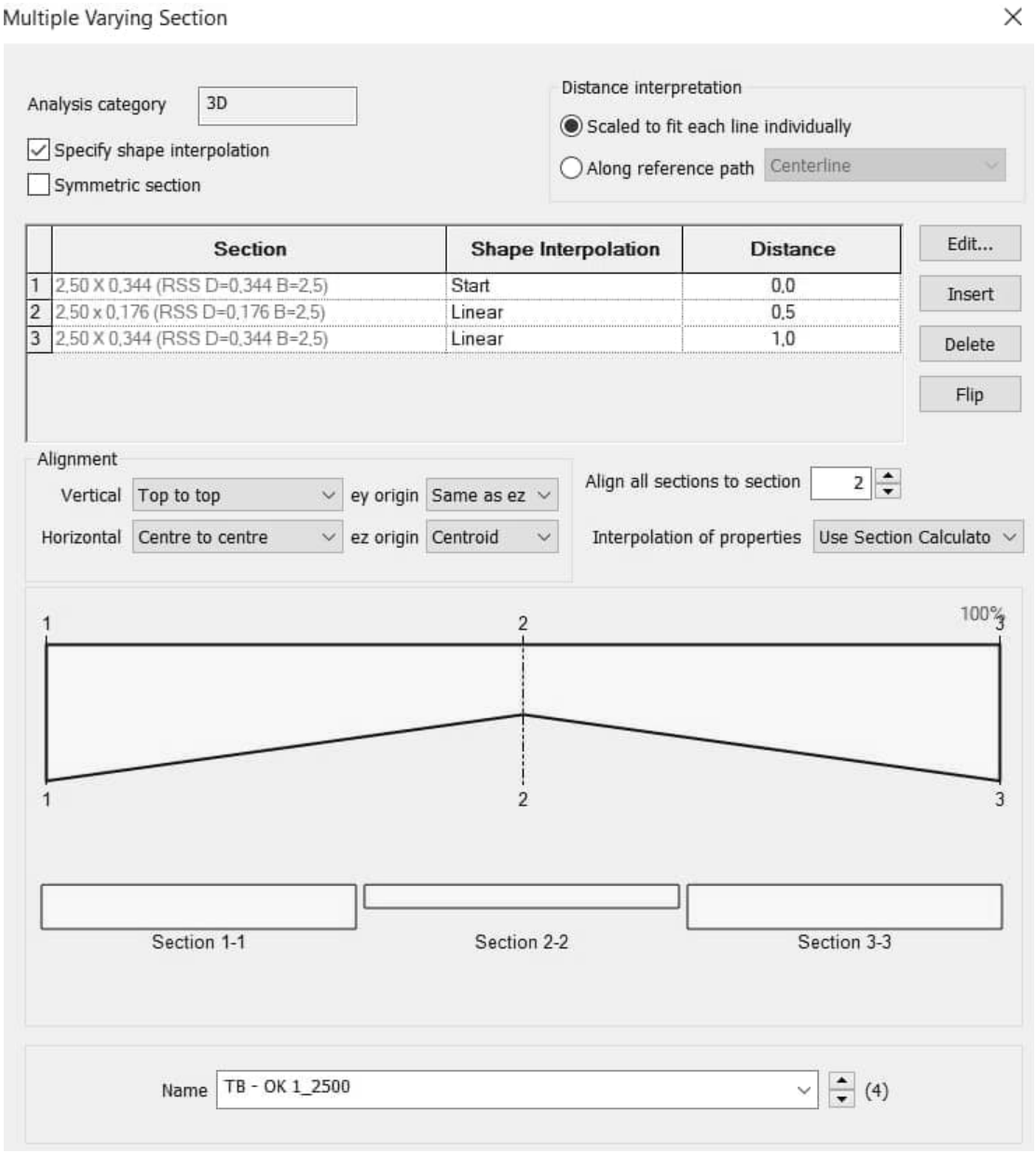
Eccentricity in z direction (ez): -0.412 m



TB – OK 1_2500:

Section	D	B	Section
1	0.344	2.500	RSS D = 0.344 B = 2.5
2	0.176	2.500	RSS D = 0.176 B = 2.5
3	0.344	2.500	RSS D = 0.344 B = 2.5
-	m	m	-

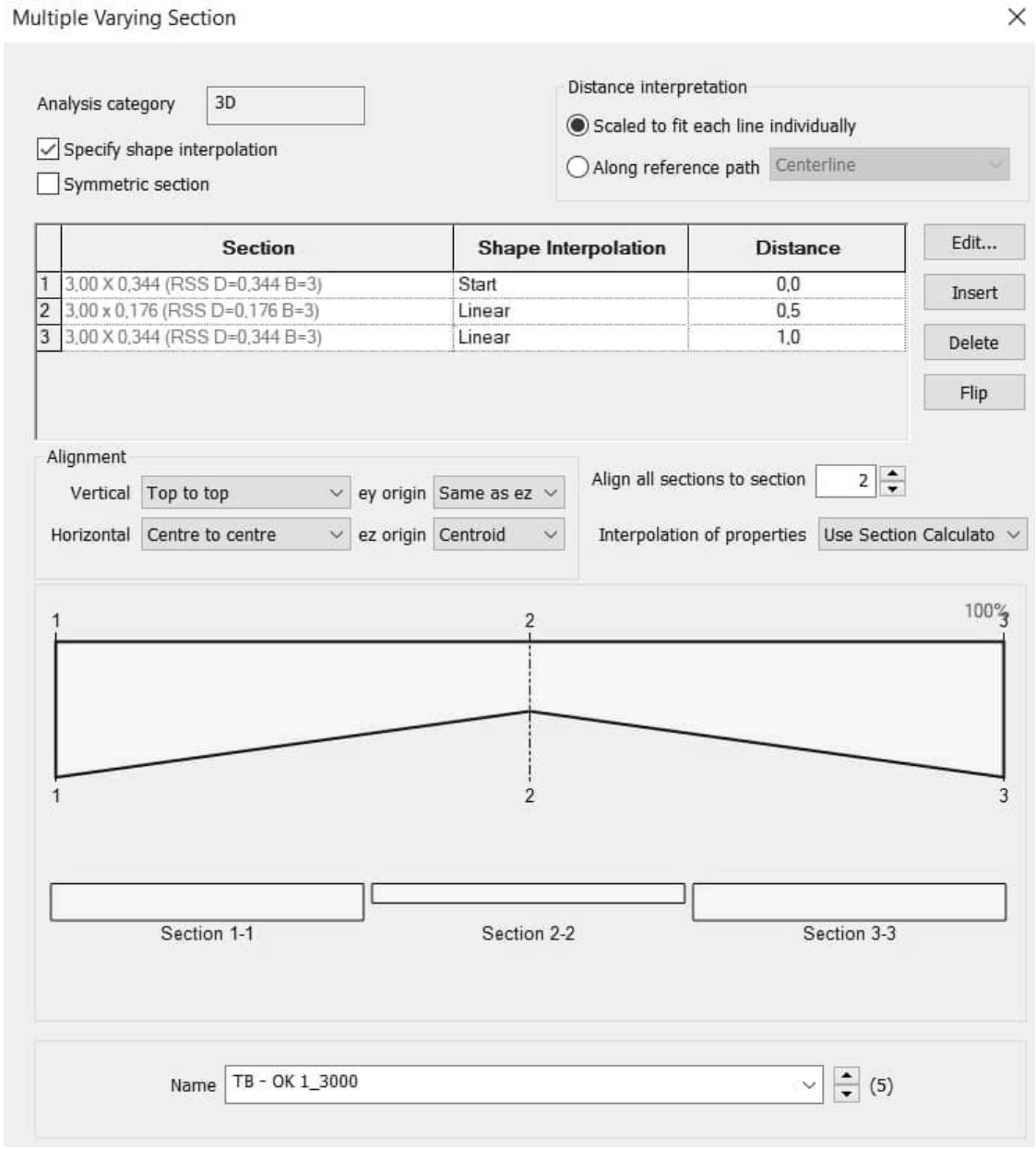
Eccentricity in z direction (ez): -0.412 m



TB – OK 1_3000:

Section	D	B	Section
1	0.344	3.000	RSS D = 0.344 B = 3.0
2	0.176	3.000	RSS D = 0.176 B = 3.0
3	0.344	3.000	RSS D = 0.344 B = 3.0
-	m	m	-

Eccentricity in z direction (ez): -0.412 m



2.3.2.2 TB – OK2

This transversal beam is designated 'Multiple varying: 3 sections' with geometry as below.

TB – OK 2_1500:

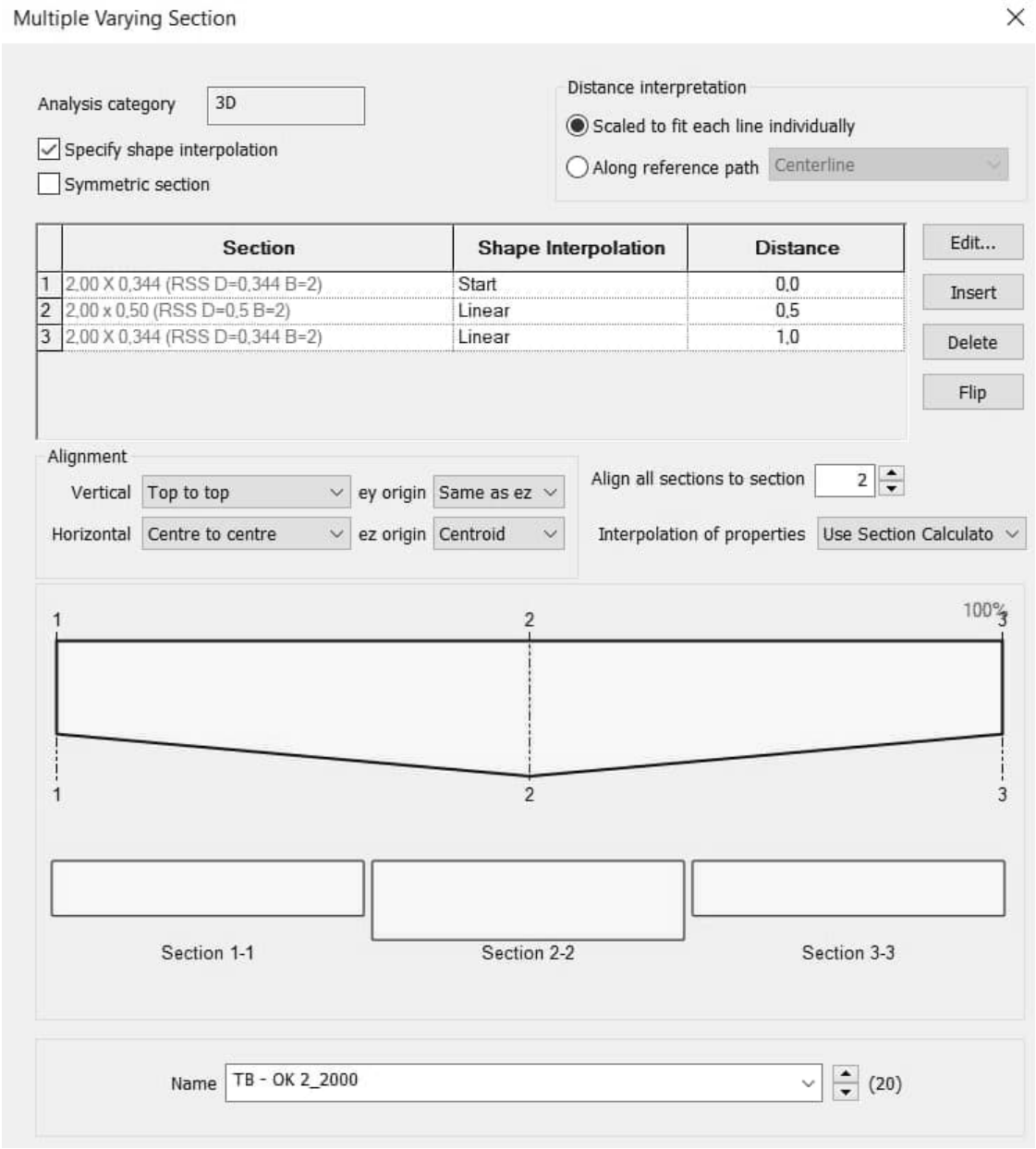
Section	D	B	Section
1	0.344	1.500	RSS D = 0.344 B = 1.5
2	0.500	1.500	RSS D = 0.500 B = 1.5
3	0.344	1.500	RSS D = 0.344 B = 1.5
-	m	m	-

Eccentricity in z direction (ez): -0.250 m

TB – OK 2_2000:

Section	D	B	Section
1	0.344	2.000	RSS D = 0.344 B = 2.0
2	0.500	2.000	RSS D = 0.500 B = 2.0
3	0.344	2.000	RSS D = 0.344 B = 2.0
-	m	m	-

Eccentricity in z direction (ez): -0.250 m



TB – OK 2_2500:

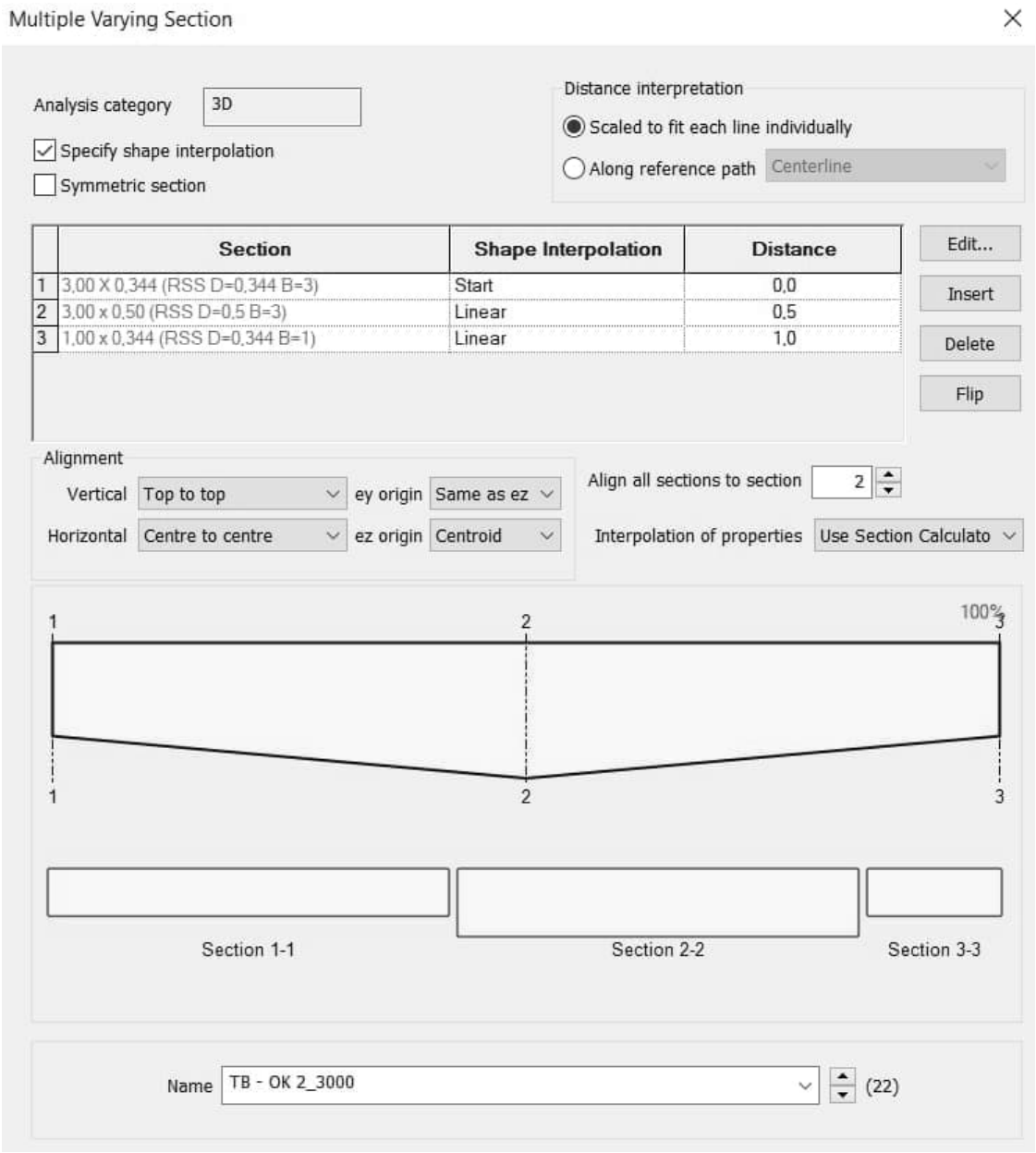
Section	D	B	Section
1	0.344	2.500	RSS D = 0.344 B = 2.5
2	0.500	2.500	RSS D = 0.500 B = 2.5
3	0.344	2.500	RSS D = 0.344 B = 2.5
-	m	m	-

Eccentricity in z direction (ez): -0.250 m

TB – OK 2_3000:

Section	D	B	Section
1	0.344	3.000	RSS D = 0.344 B = 3.0
2	0.500	3.000	RSS D = 0.500 B = 3.0
3	0.344	3.000	RSS D = 0.344 B = 3.0
-	m	m	-

Eccentricity in z direction (ez): -0.250 m



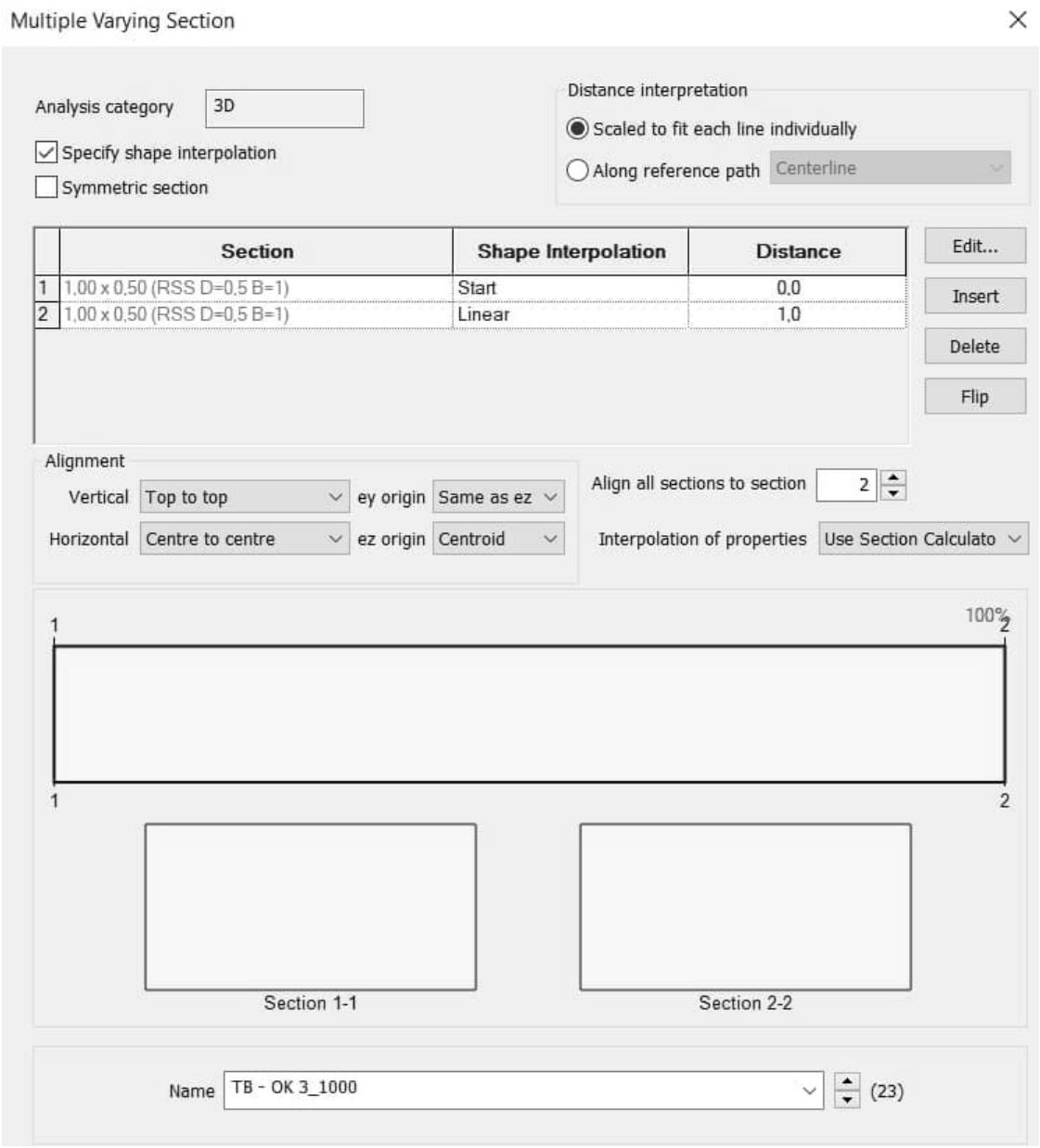
2.3.2.3 TB – OK3

This transversal beam is designated 'Multiple varying: 2 sections' with geometry as below.

TB – OK 3_1000:

Section	D	B	Section
1	0.500	1.000	RSS D = 0.500 B = 1.0
2	0.500	1.000	RSS D = 0.500 B = 1.0
-	m	m	-

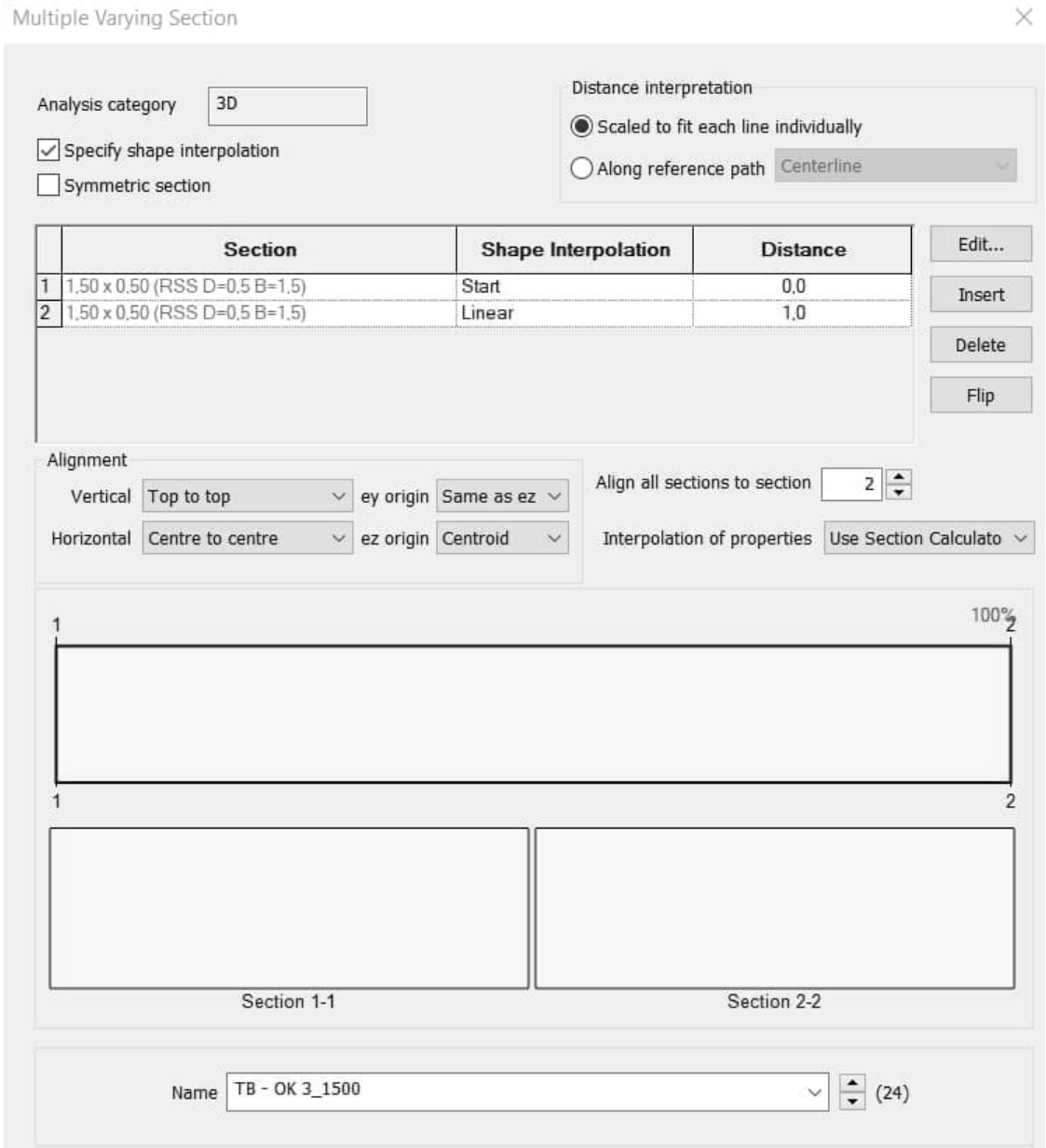
Eccentricity in z direction (ez): -0.250 m



TB – OK 3_1500:

Section	D	B	Section
1	0.500	1.500	RSS D = 0.500 B = 1.5
2	0.500	1.500	RSS D = 0.500 B = 1.5
-	m	m	-

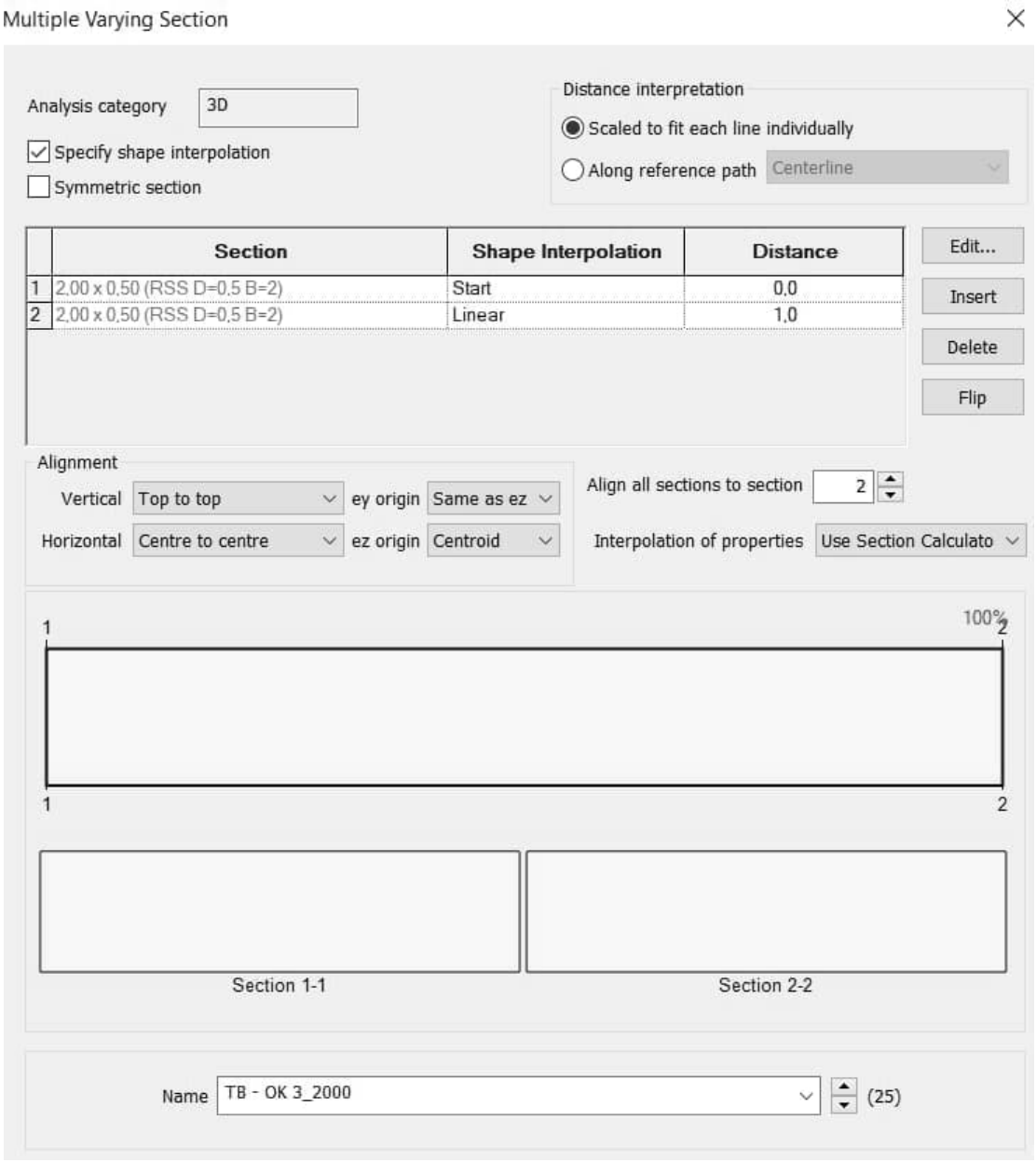
Eccentricity in z direction (ez): -0.250 m



TB – OK 3_2000:

Section	D	B	Section
1	0.500	2.000	RSS D = 0.500 B = 2.0
2	0.500	2.000	RSS D = 0.500 B = 2.0
-	m	m	-

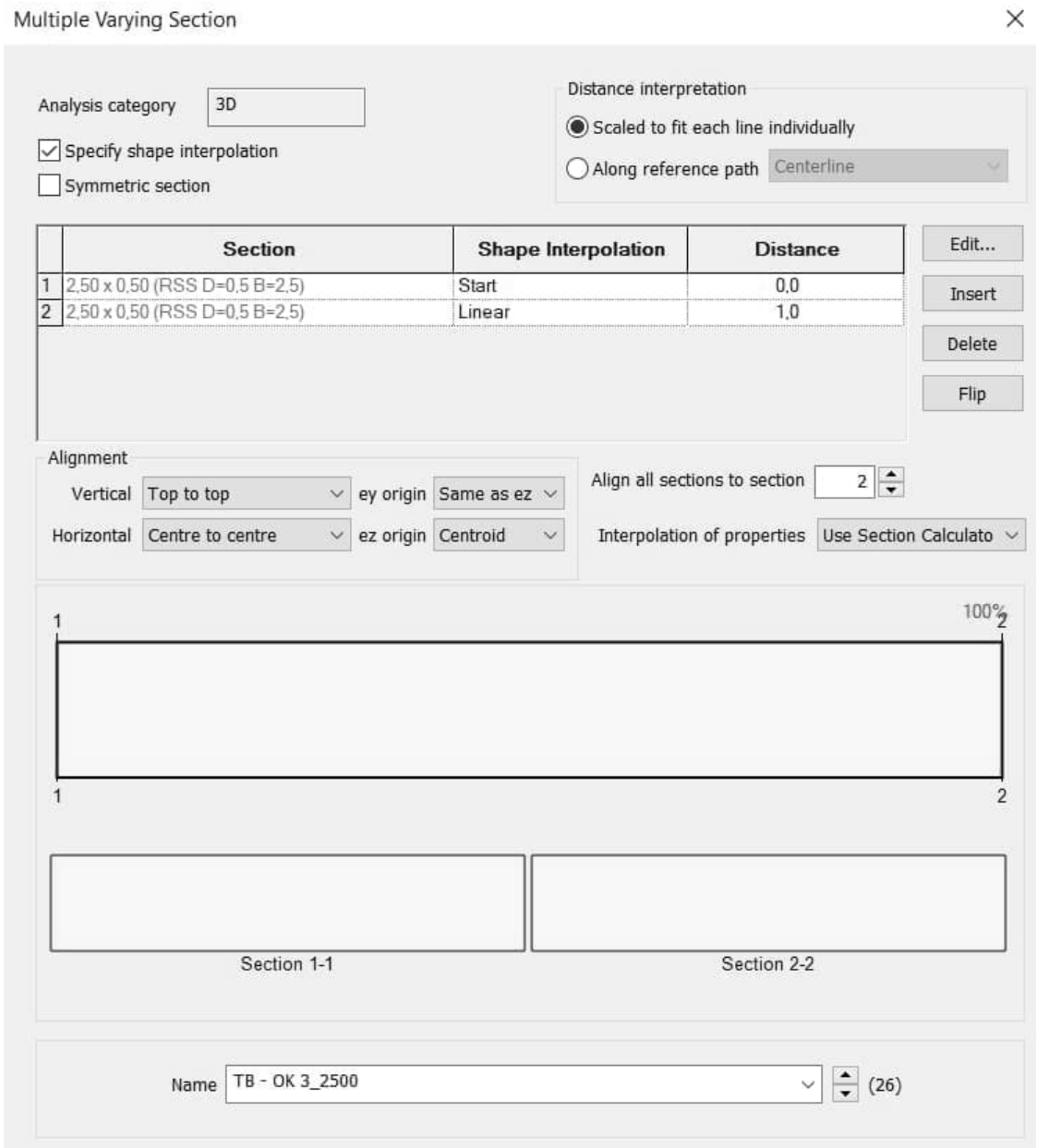
Eccentricity in z direction (ez): -0.250 m



TB – OK 3_2500:

Section	D	B	Section
1	0.500	2.500	RSS D = 0.500 B = 2.5
2	0.500	2.500	RSS D = 0.500 B = 2.5
-	m	m	-

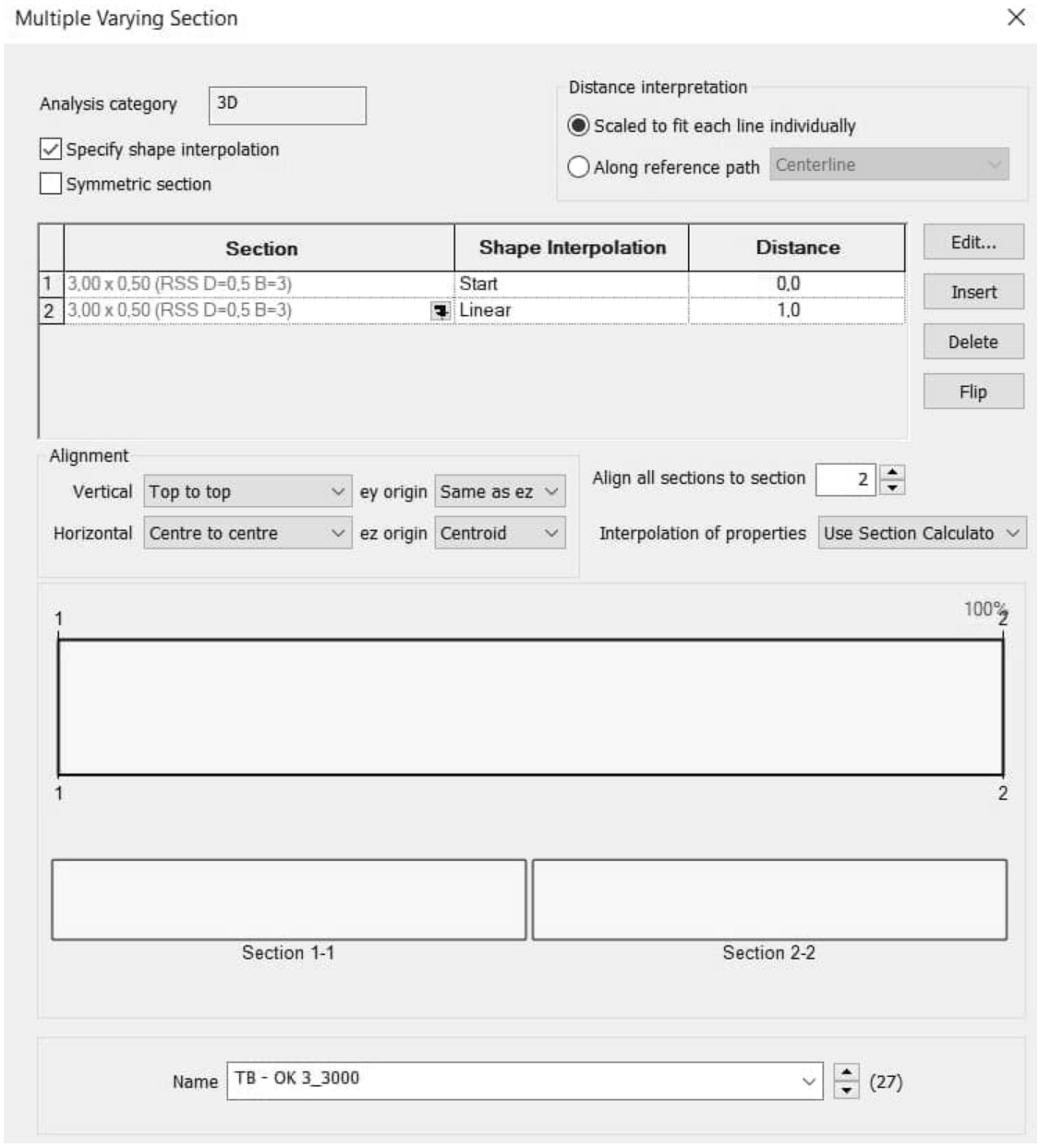
Eccentricity in z direction (ez): -0.250 m



TB – OK 3_3000:

Section	D	B	Section
1	0.500	3.000	RSS D = 0.500 B = 3.0
2	0.500	3.000	RSS D = 0.500 B = 3.0
-	m	m	-

Eccentricity in z direction (ez): -0.250 m



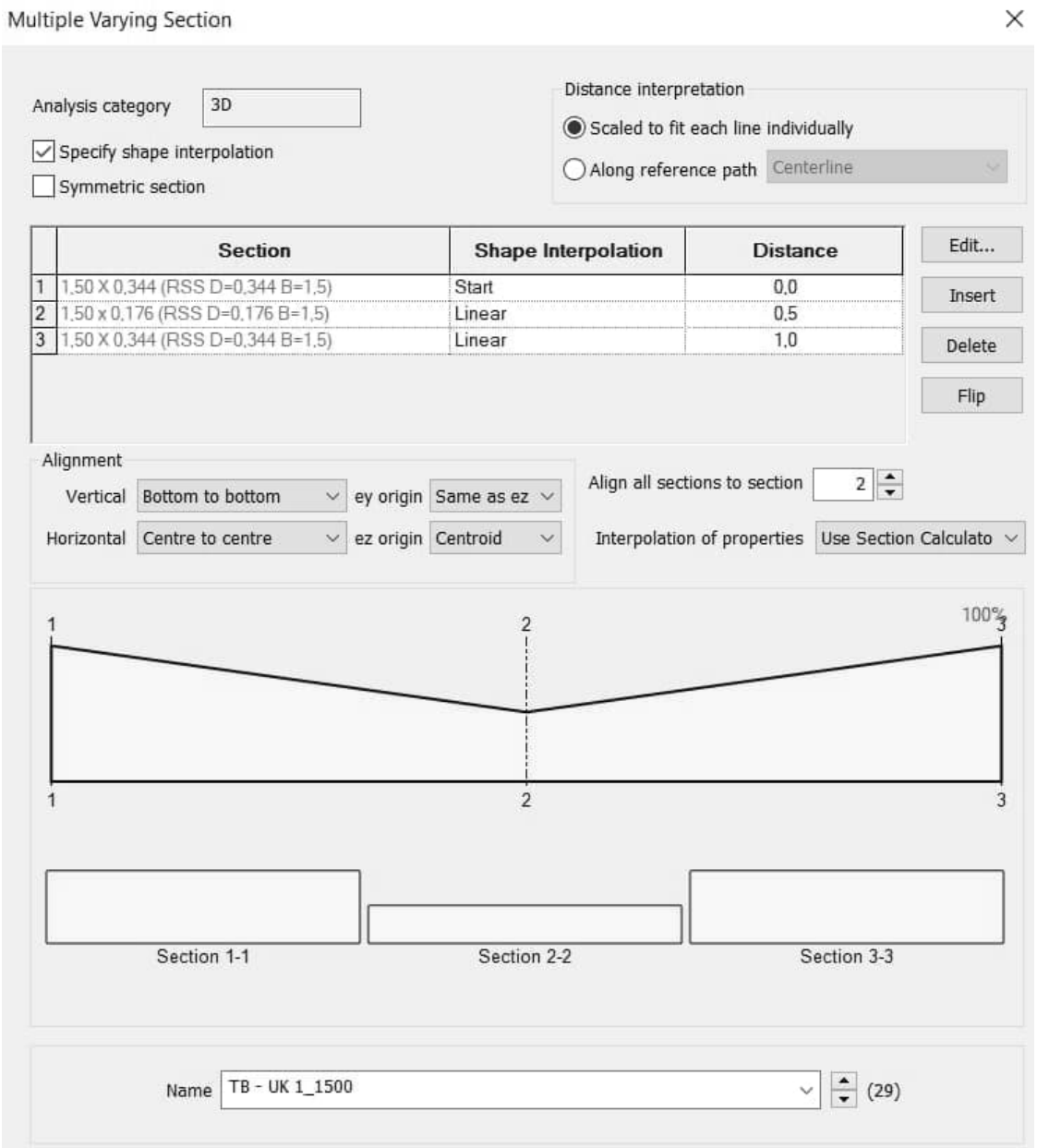
2.3.2.4 TB – UK1

This transversal beam is designated 'Multiple varying: 3 sections' with geometry as below.

TB – UK 1_1500:

Section	D	B	Section
1	0.344	1.500	RSS D = 0.344 B = 1.5
2	0.176	1.500	RSS D = 0.176 B = 1.5
3	0.344	1.500	RSS D = 0.500 B = 1.5
-	m	m	-

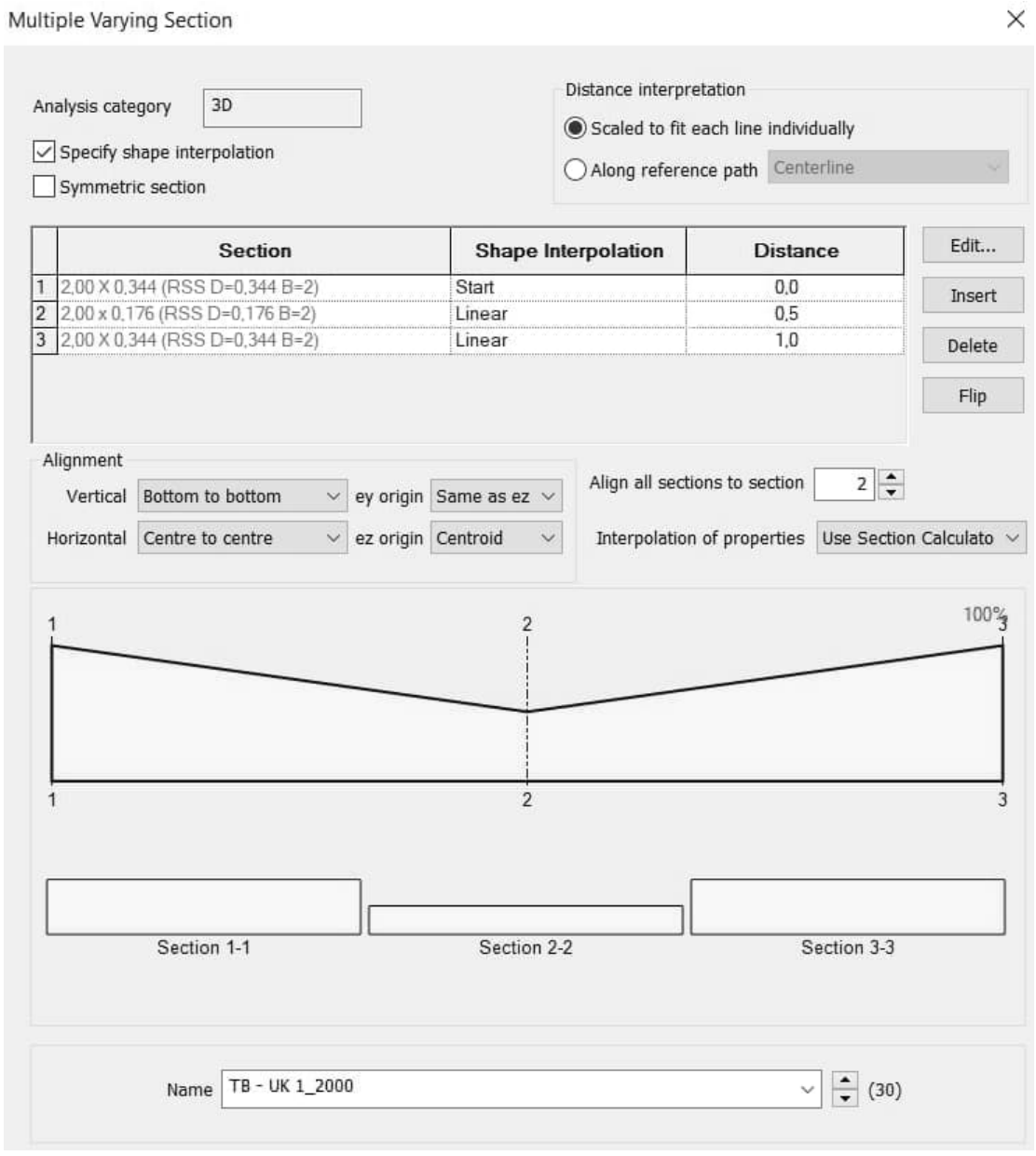
Eccentricity in z direction (ez): +0.412 m



TB – UK 1_2000:

Section	D	B	Section
1	0.344	2.000	RSS D = 0.344 B = 2.0
2	0.176	2.000	RSS D = 0.176 B = 2.0
3	0.344	2.000	RSS D = 0.500 B = 2.0
-	m	m	-

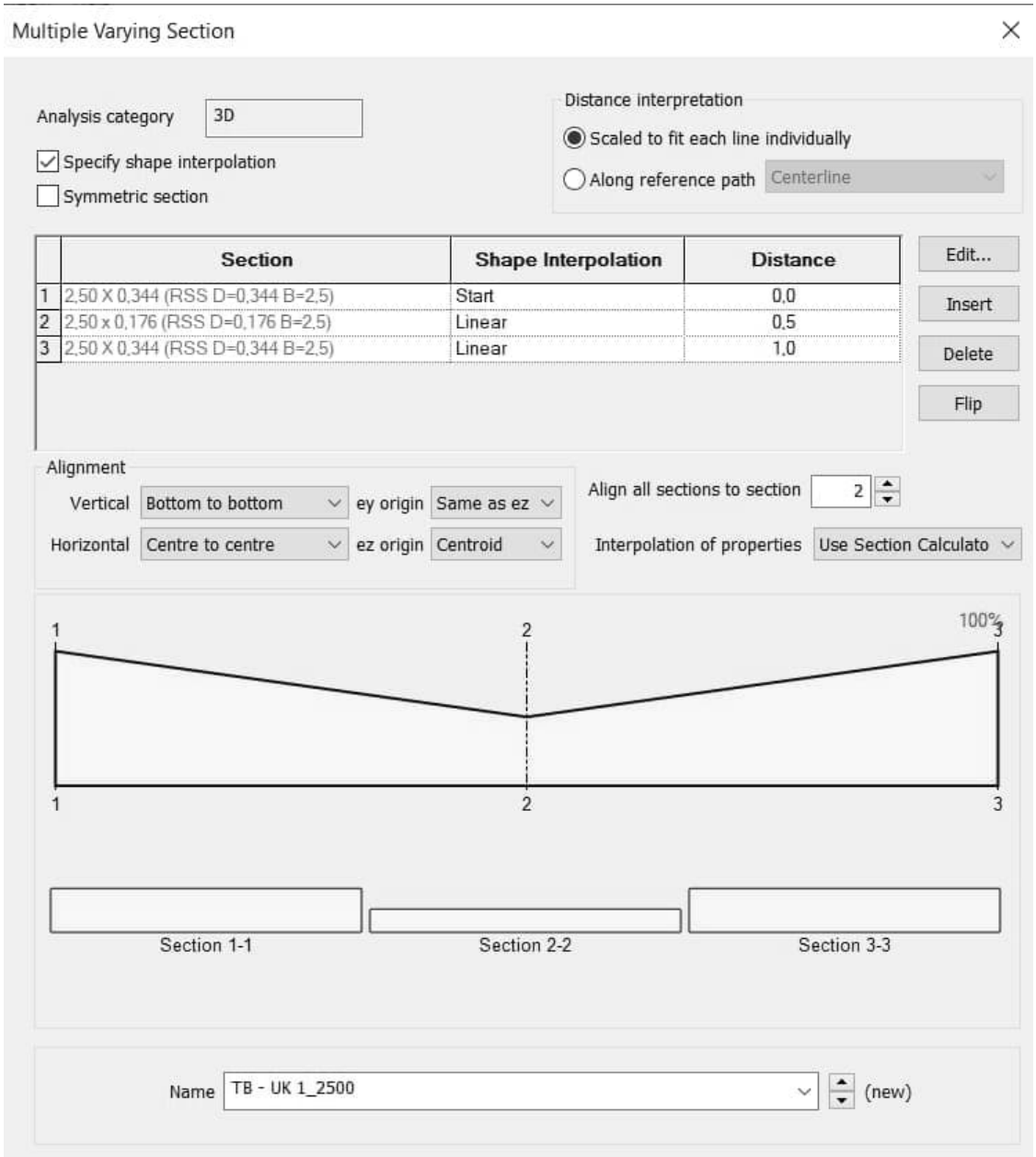
Eccentricity in z direction (ez): +0.412 m



TB – UK 1_2500:

Section	D	B	Section
1	0.344	2.500	RSS D = 0.344 B = 2.5
2	0.176	2.500	RSS D = 0.176 B = 2.5
3	0.344	2.500	RSS D = 0.500 B = 2.5
-	m	m	-

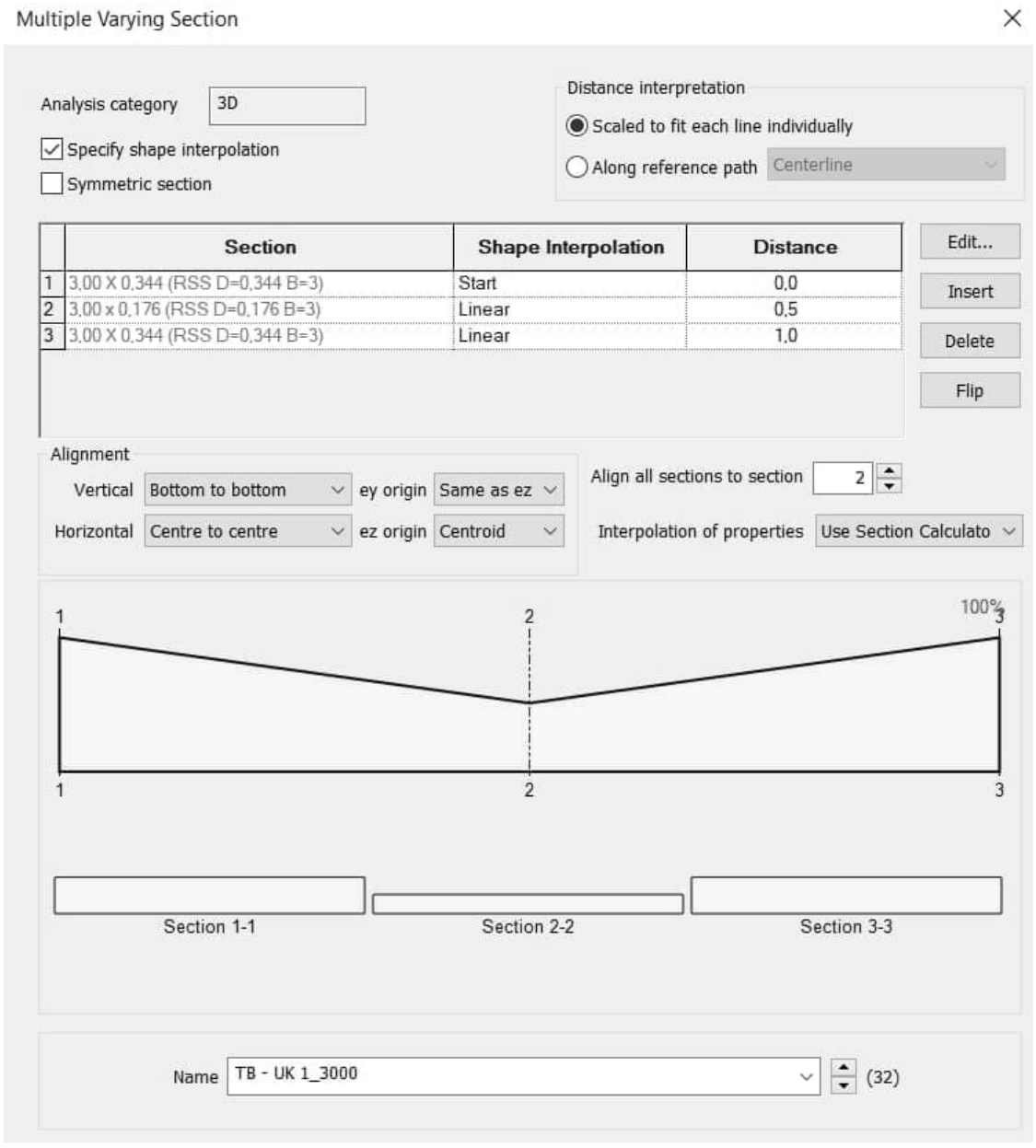
Eccentricity in z direction (ez): +0.412 m



TB – UK 1_3000:

Section	D	B	Section
1	0.344	3.000	RSS D = 0.344 B = 3.0
2	0.176	3.000	RSS D = 0.176 B = 3.0
3	0.344	3.000	RSS D = 0.500 B = 3.0
-	m	m	-

Eccentricity in z direction (ez): +0.412 m



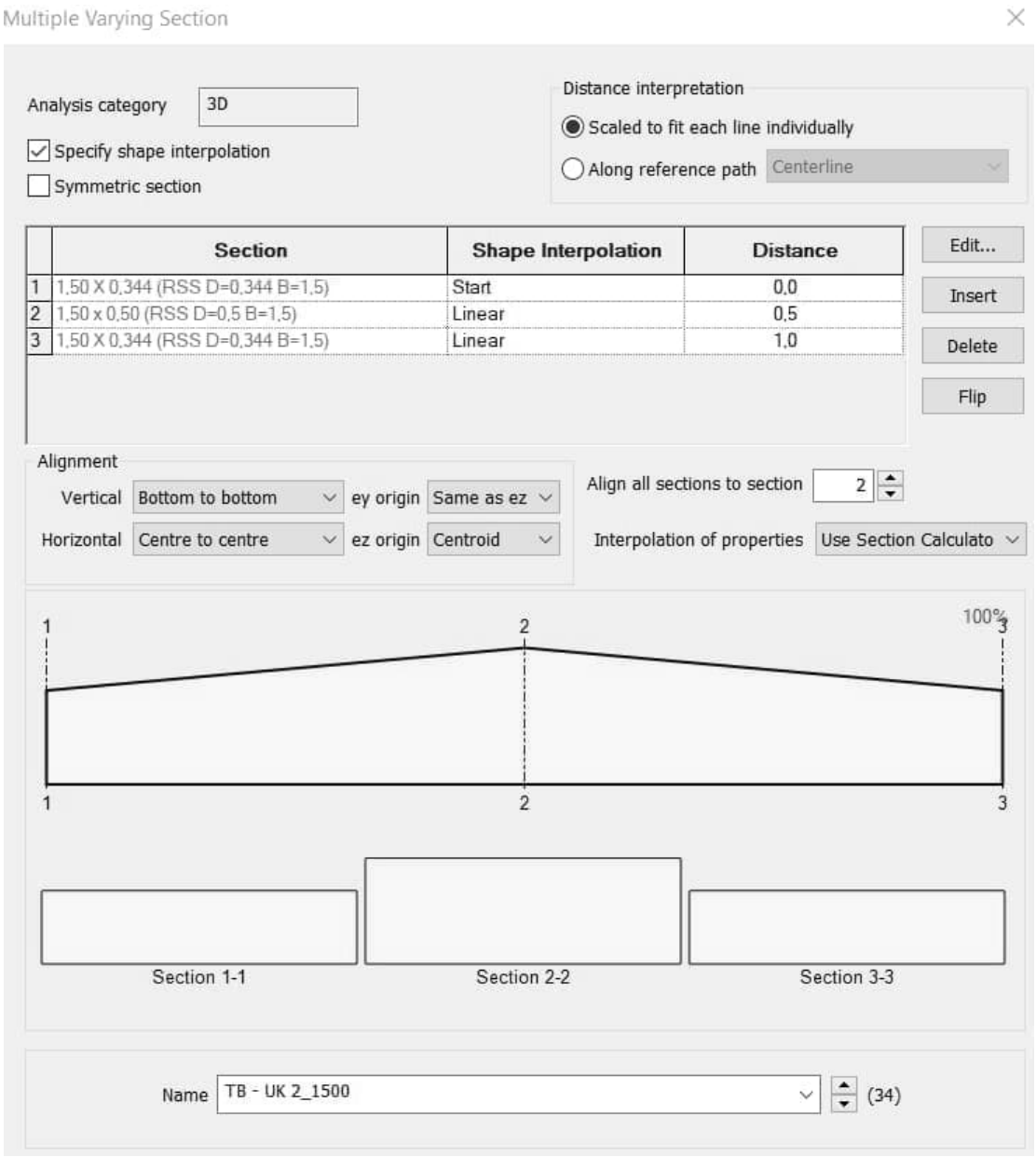
2.3.2.5 TB – UK2

This transversal beam is designated 'Multiple varying: 3 sections' with geometry as below.

TB – UK 2_1500:

Section	D	B	Section
1	0.344	1.500	RSS D = 0.344 B = 1.5
2	0.500	1.500	RSS D = 0.500 B = 1.5
3	0.344	1.500	RSS D = 0.344 B = 1.5
-	m	m	-

Eccentricity in z direction (ez): +0.250 m



TB – UK 2_2000:

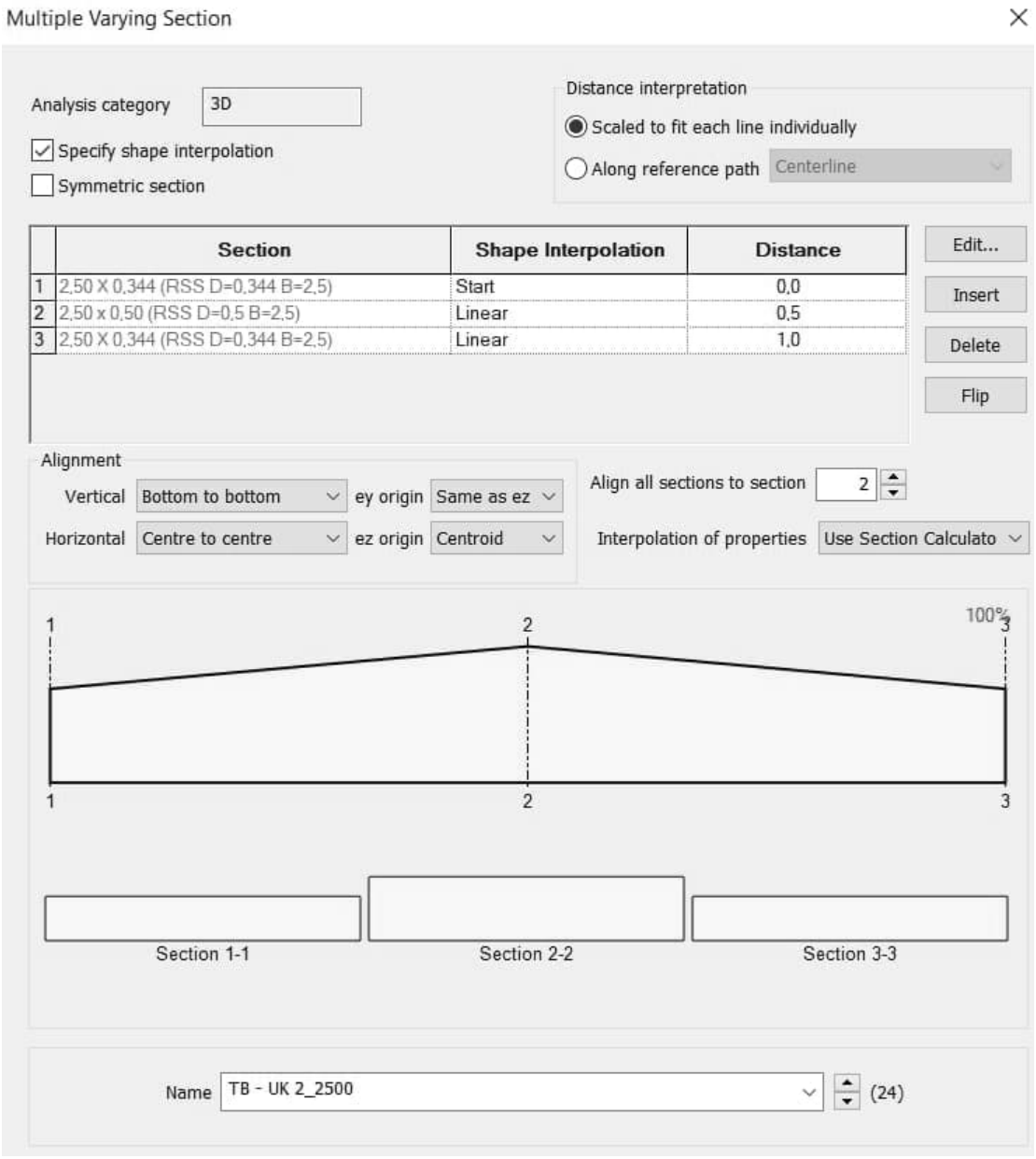
Section	D	B	Section
1	0.344	2.000	RSS D = 0.344 B = 2.0
2	0.500	2.000	RSS D = 0.500 B = 2.0
3	0.344	2.000	RSS D = 0.344 B = 2.0
-	m	m	-

Eccentricity in z direction (ez): +0.250 m

TB – UK 2_2500:

Section	D	B	Section
1	0.344	2.500	RSS D = 0.344 B = 2.5
2	0.500	2.500	RSS D = 0.500 B = 2.5
3	0.344	2.500	RSS D = 0.344 B = 2.5
-	m	m	-

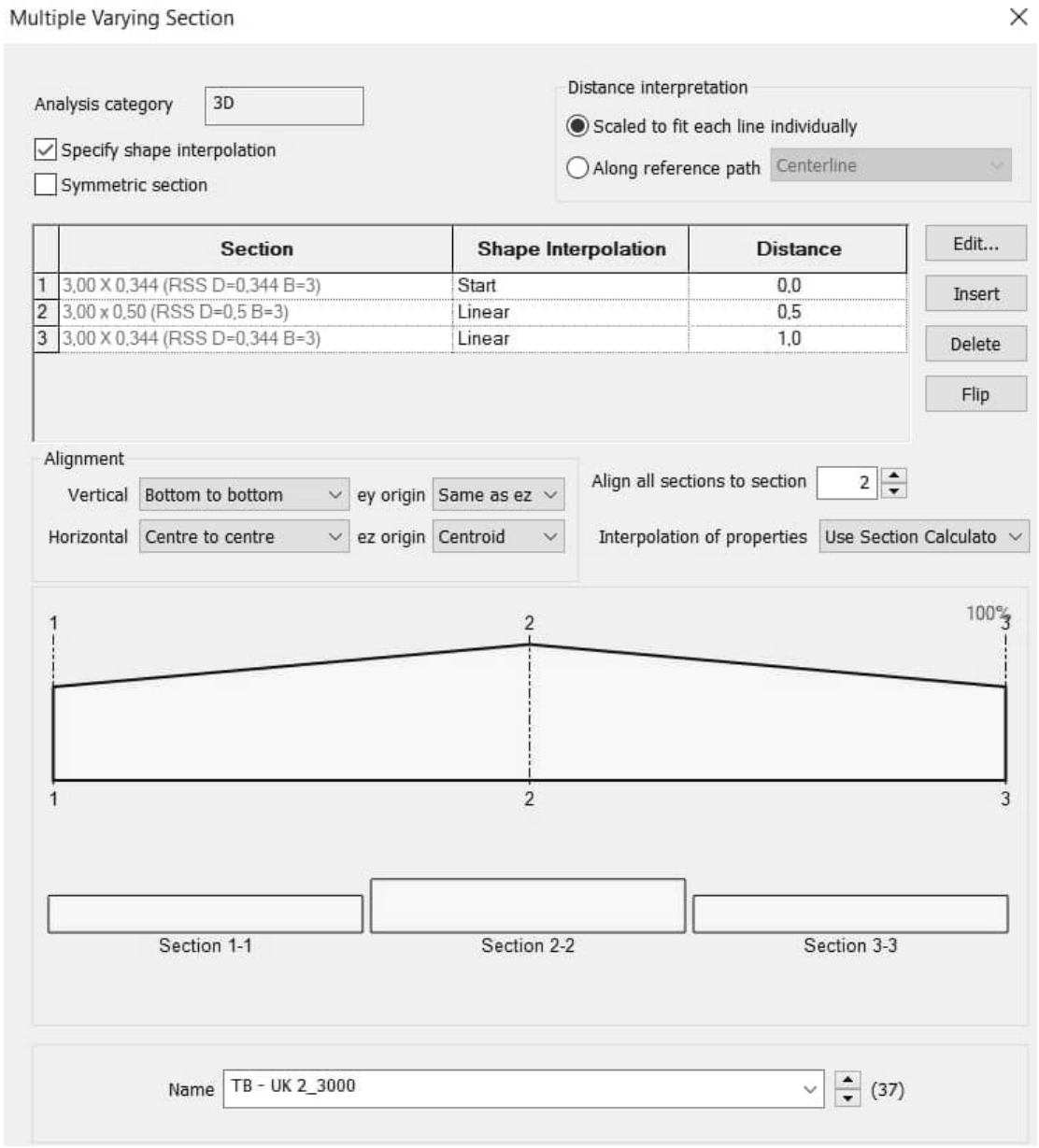
Eccentricity in z direction (ez): +0.250 m



TB – UK 2_3000:

Section	D	B	Section
1	0.344	3.000	RSS D = 0.344 B = 3.0
2	0.500	3.000	RSS D = 0.500 B = 3.0
3	0.344	3.000	RSS D = 0.344 B = 3.0
-	m	m	-

Eccentricity in z direction (ez): +0.250 m



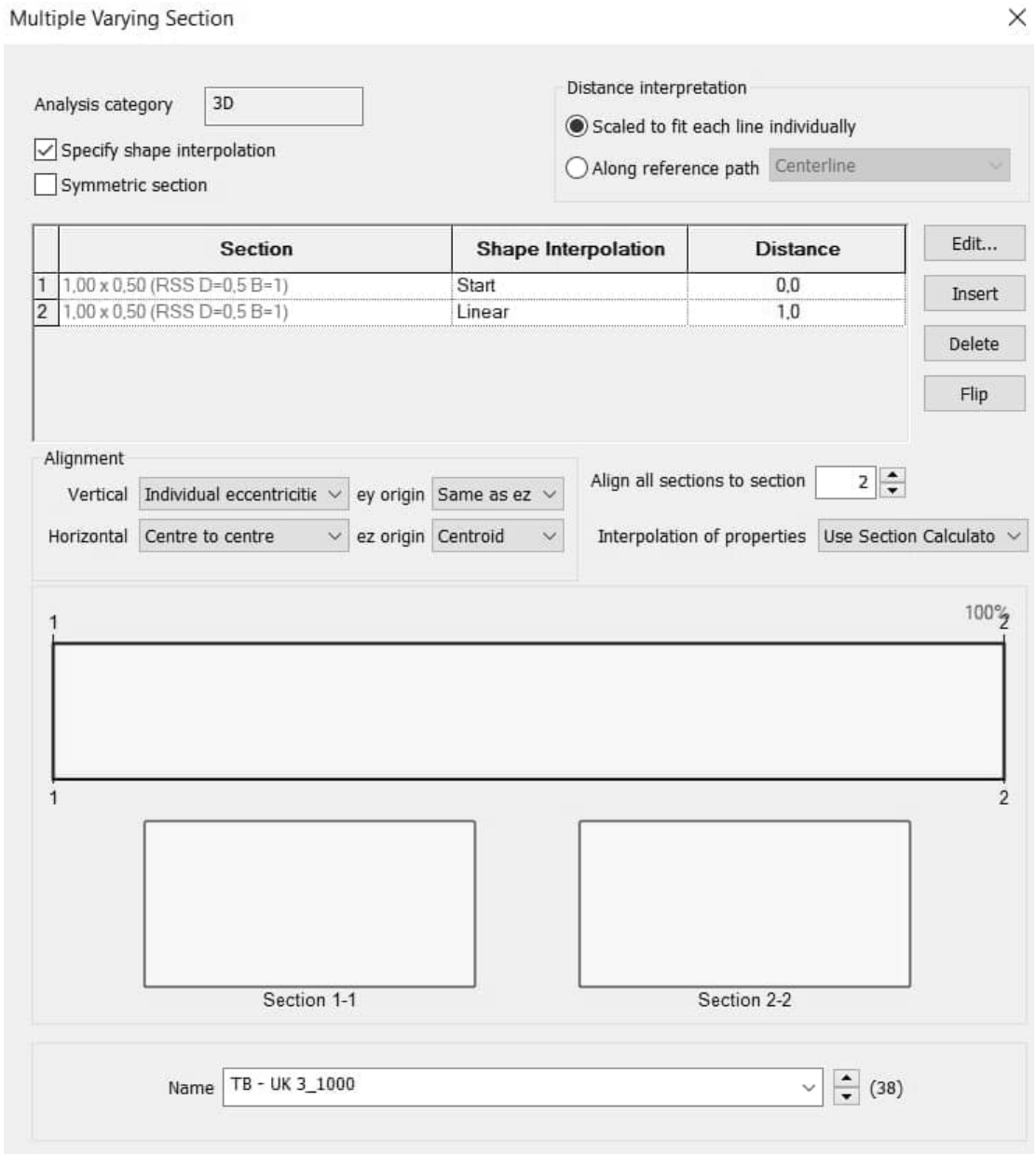
2.3.2.6 TB – UK3

This transversal beam is designated 'Multiple varying: 2 sections' with geometry as below.

TB – UK 3_1000:

Section	D	B	Section
1	0.500	1.000	RSS D = 0.500 B = 1.0
2	0.500	1.000	RSS D = 0.500 B = 1.0
-	m	m	-

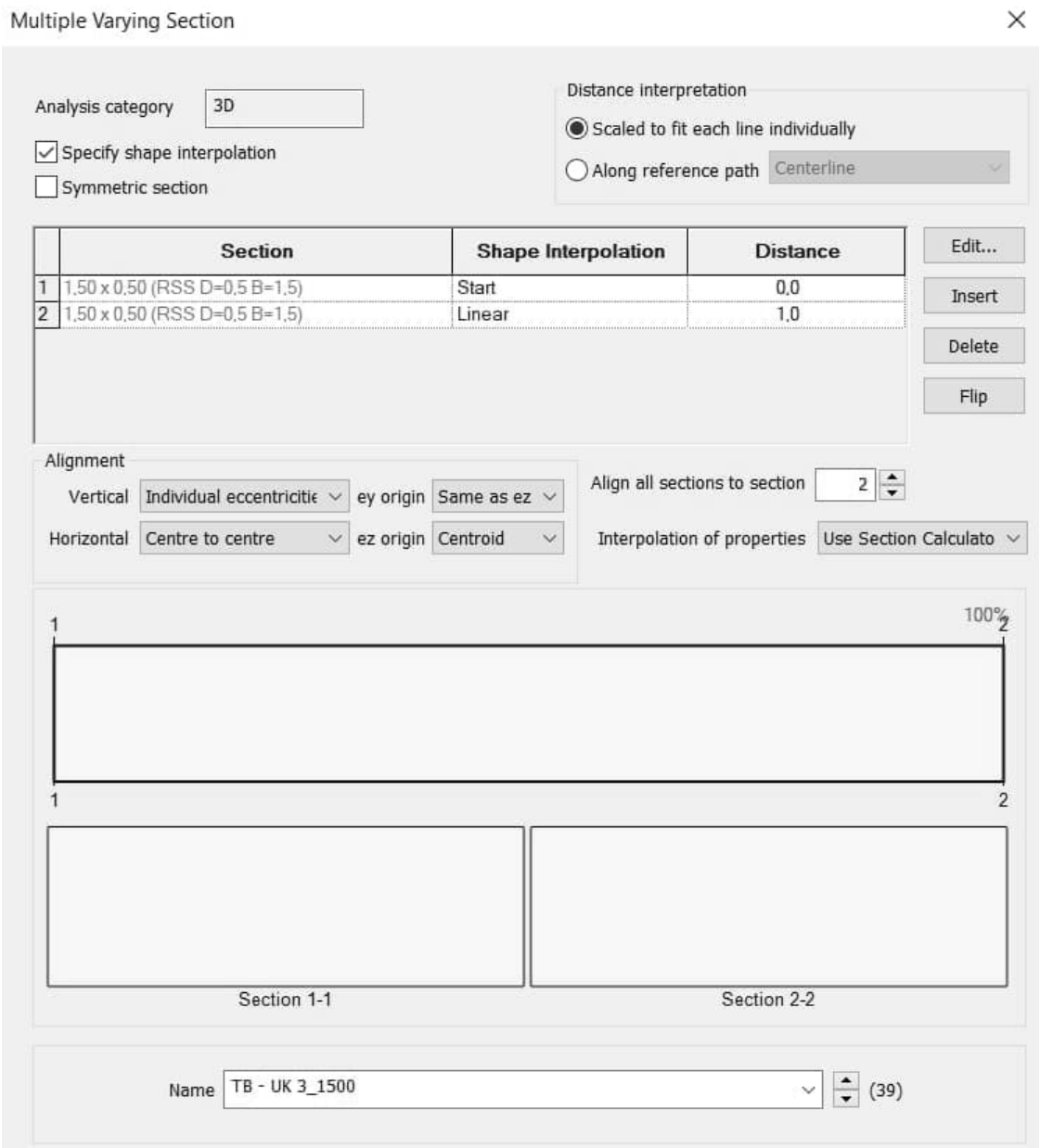
Eccentricity in z direction (ez): +0.25 m



TB – UK 3_1500:

Section	D	B	Section
1	0.500	1.500	RSS D = 0.500 B = 1.5
2	0.500	1.500	RSS D = 0.500 B = 1.5
-	m	m	-

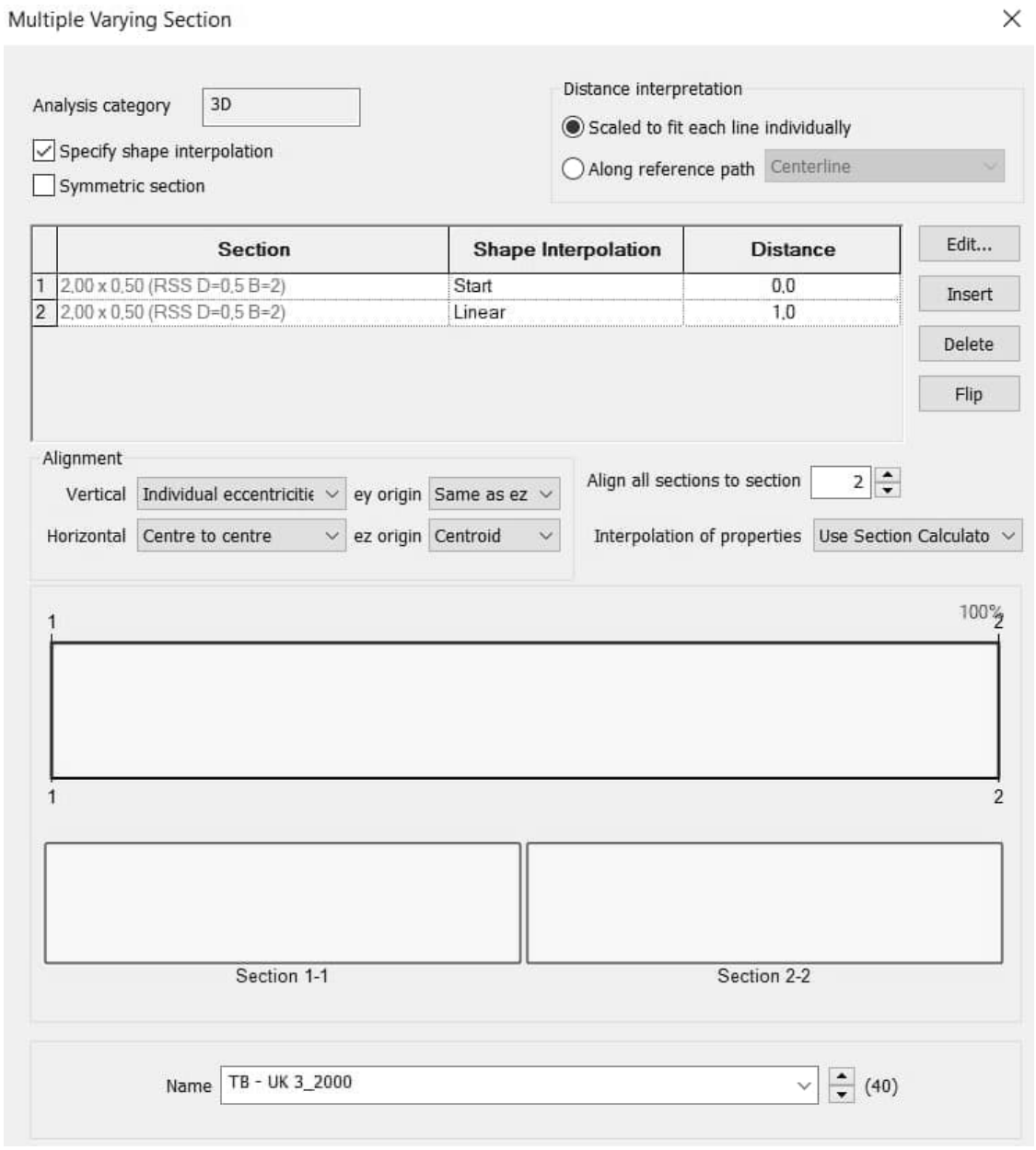
Eccentricity in z direction (ez): +0.25 m



TB – UK 3_2000:

Section	D	B	Section
1	0.500	2.000	RSS D = 0.500 B = 2.0
2	0.500	2.000	RSS D = 0.500 B = 2.0
-	m	m	-

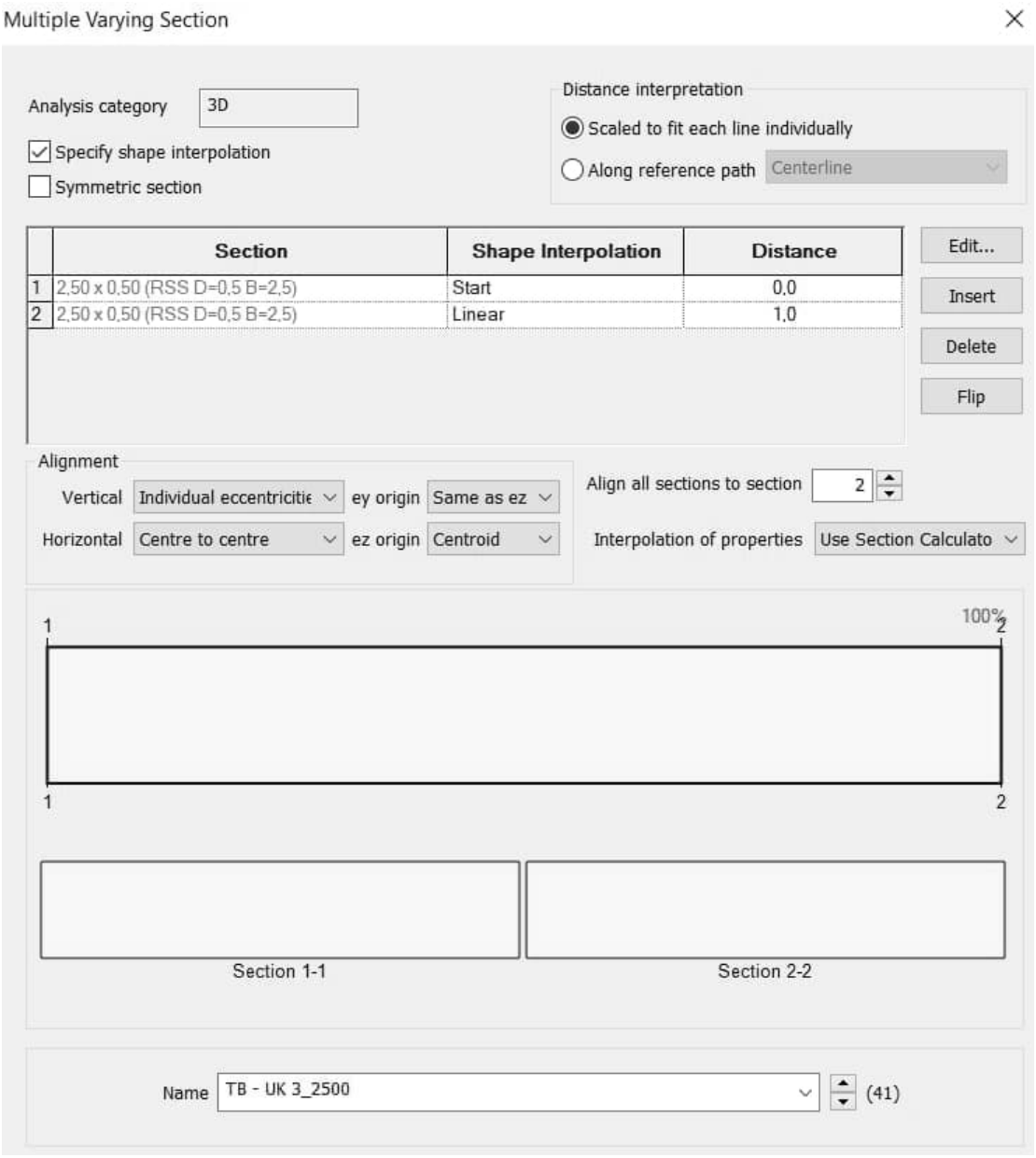
Eccentricity in z direction (ez): +0.25 m



TB – UK 3_2500:

Section	D	B	Section
1	0.500	2.500	RSS D = 0.500 B = 2.5
2	0.500	2.500	RSS D = 0.500 B = 2.5
-	m	m	-

Eccentricity in z direction (ez): +0.25 m



TB – UK 3_3000:

Section	D	B	Section
1	0.500	3.000	RSS D = 0.500 B = 3.0
2	0.500	3.000	RSS D = 0.500 B = 3.0
-	m	m	-

2.3.2.7 EB – L

This transversal beam is designated 'Multiple varying: 2 sections' with geometry as below.

EB – L_1000:

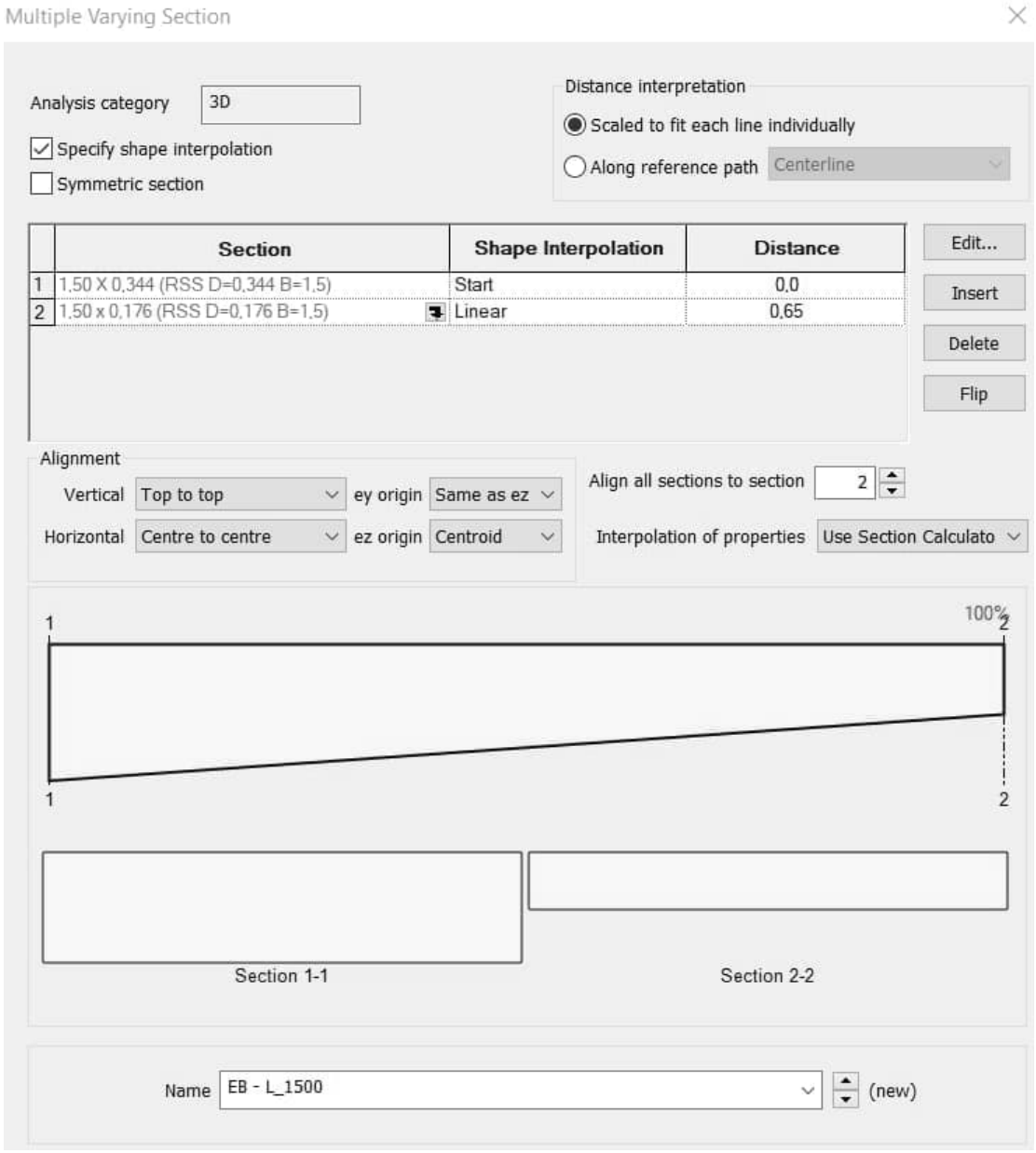
Section	D	B	Section
1	0.344	1.000	RSS D = 0.344 B = 1.0
2	0.176	1.000	RSS D = 0.176 B = 1.0
-	m	m	-

Eccentricity in z direction (ez): -0.412 m

EB – L_1500:

Section	D	B	Section
1	0.344	1.500	RSS D = 0.344 B = 1.5
2	0.176	1.500	RSS D = 0.176 B = 1.5
-	m	m	-

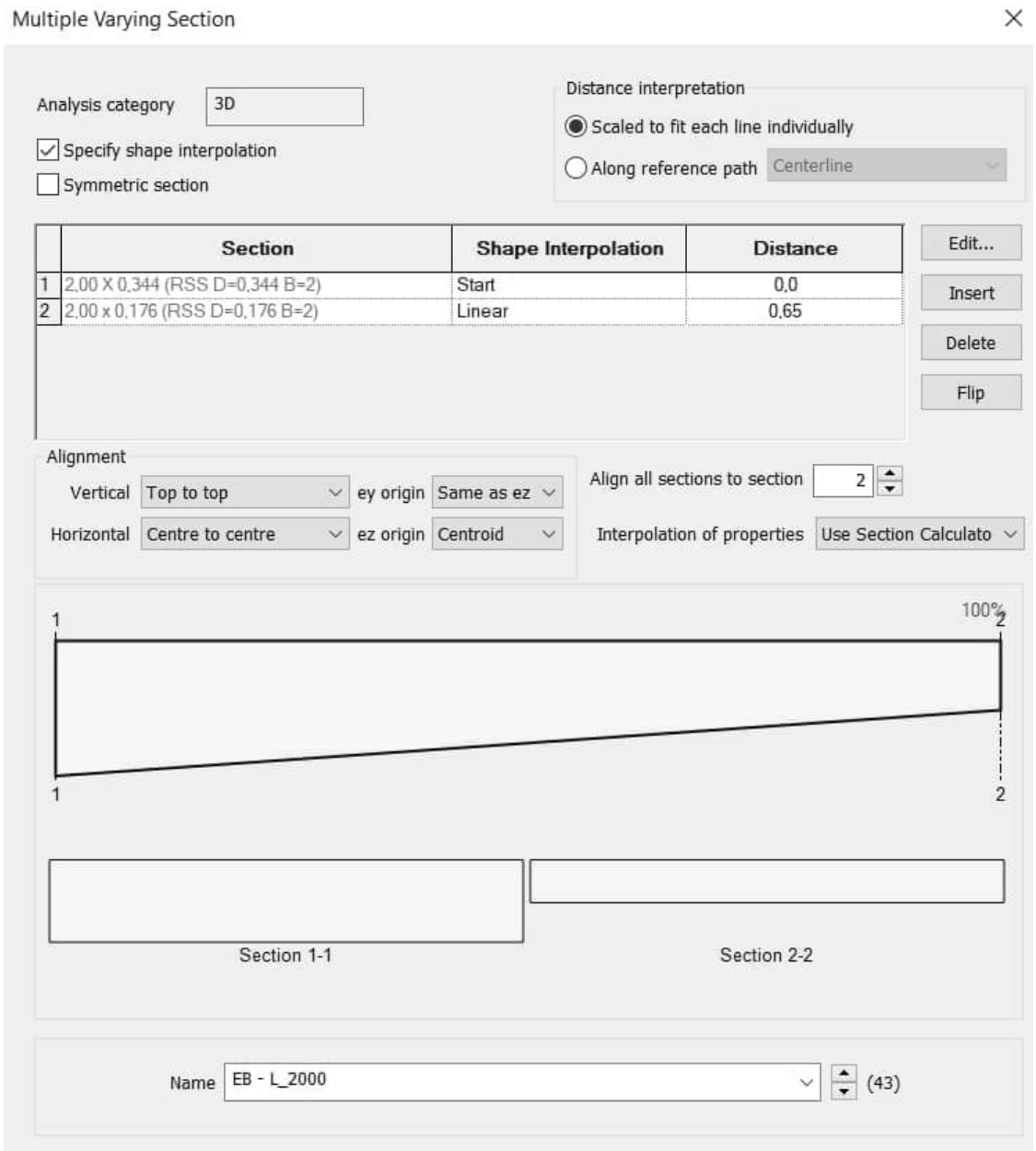
Eccentricity in z direction (ez): -0.412 m



EB – L_2000:

Section	D	B	Section
1	0.344	2.000	RSS D = 0.344 B = 2.0
2	0.176	2.000	RSS D = 0.176 B = 2.0
-	m	m	-

Eccentricity in z direction (ez): -0.412 m



EB – L_2500:

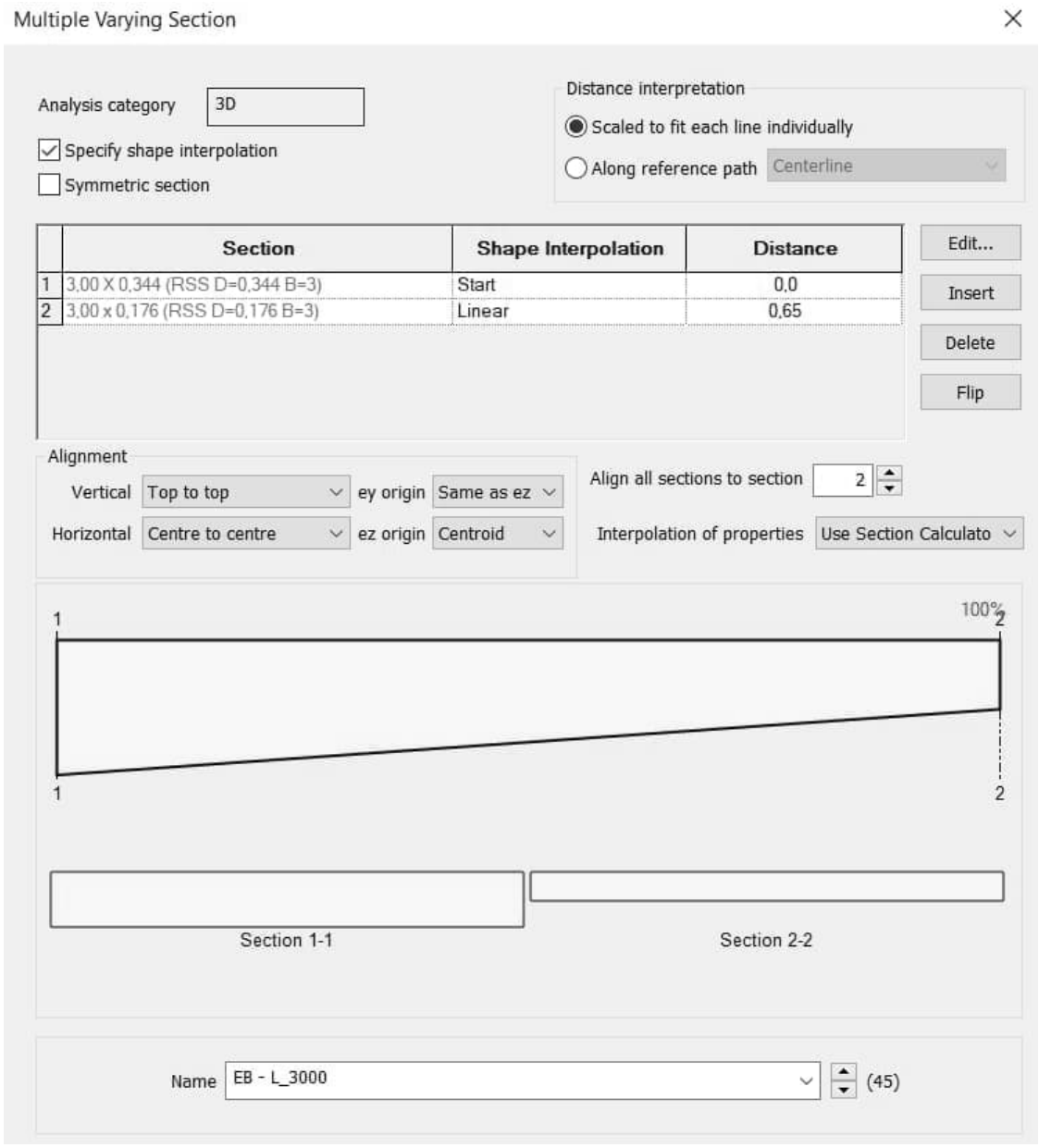
Section	D	B	Section
1	0.344	2.500	RSS D = 0.344 B = 2.5
2	0.176	2.500	RSS D = 0.176 B = 2.5
-	m	m	-

Eccentricity in z direction (ez): -0.412 m

EB – L_3000:

Section	D	B	Section
1	0.344	3.000	RSS D = 0.344 B = 3.0
2	0.176	3.000	RSS D = 0.176 B = 3.0
-	m	m	-

Eccentricity in z direction (ez): -0.412 m



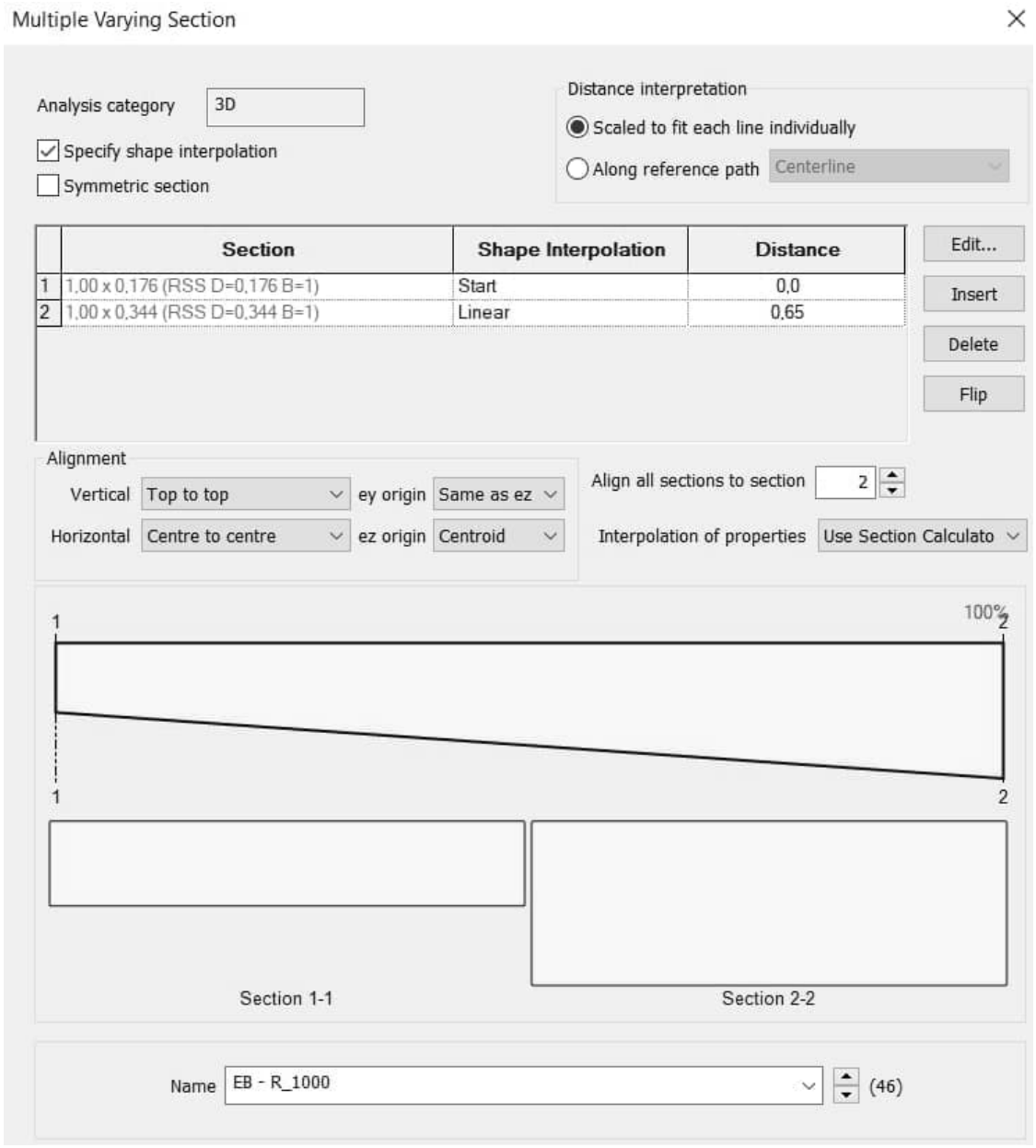
2.3.2.8 EB – R

This transversal beam is designated 'Multiple varying: 2 sections' with geometry as below.

EB – L_1000:

Section	D	B	Section
1	0.176	1.000	RSS D = 0.176 B = 1.0
2	0.344	1.000	RSS D = 0.344 B = 1.0
-	m	m	-

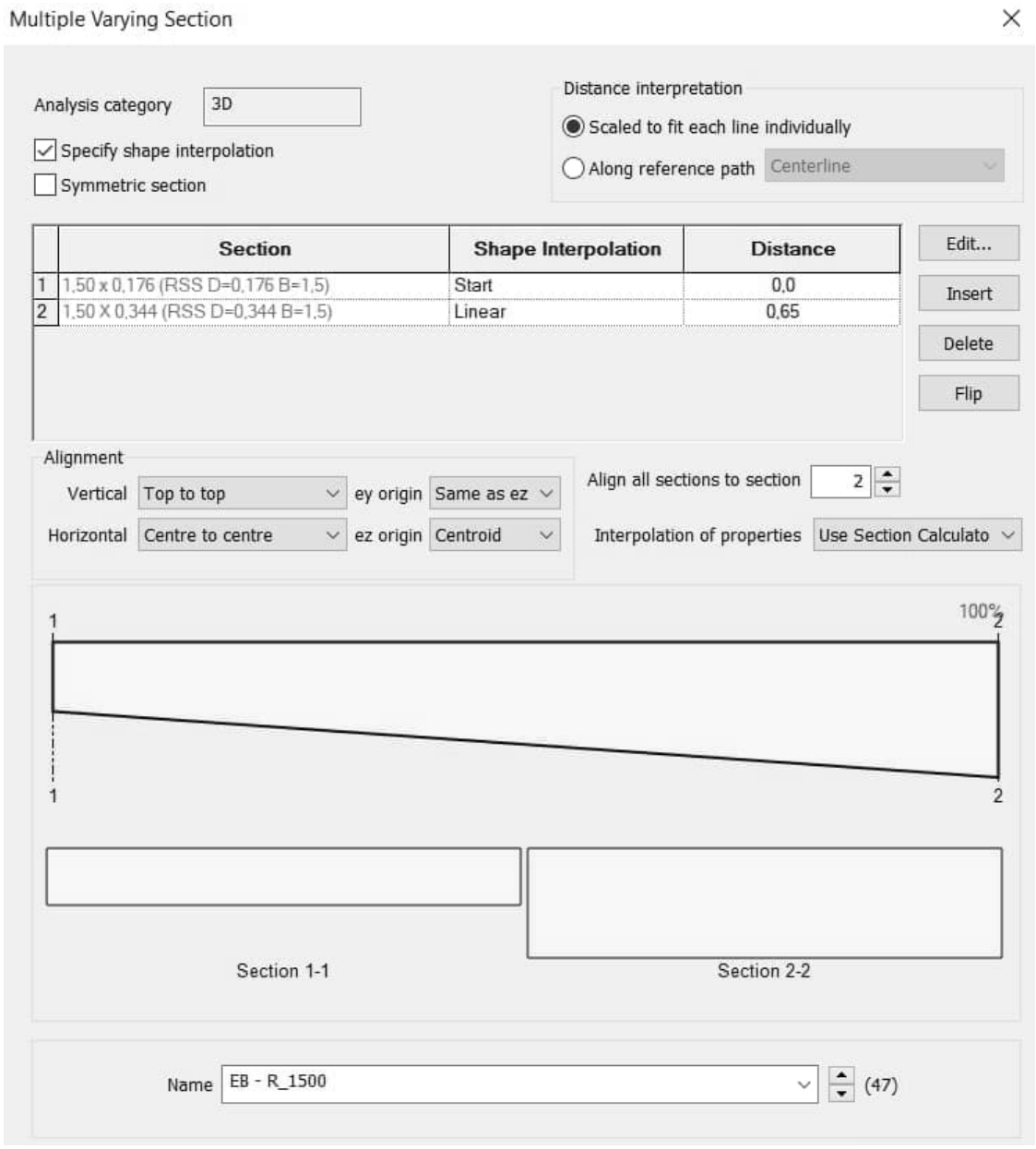
Eccentricity in z direction (ez): -0.412 m



EB – R_1500:

Section	D	B	Section
1	0.176	1.500	RSS D = 0.176 B = 1.5
2	0.344	1.500	RSS D = 0.344 B = 1.5
-	m	m	-

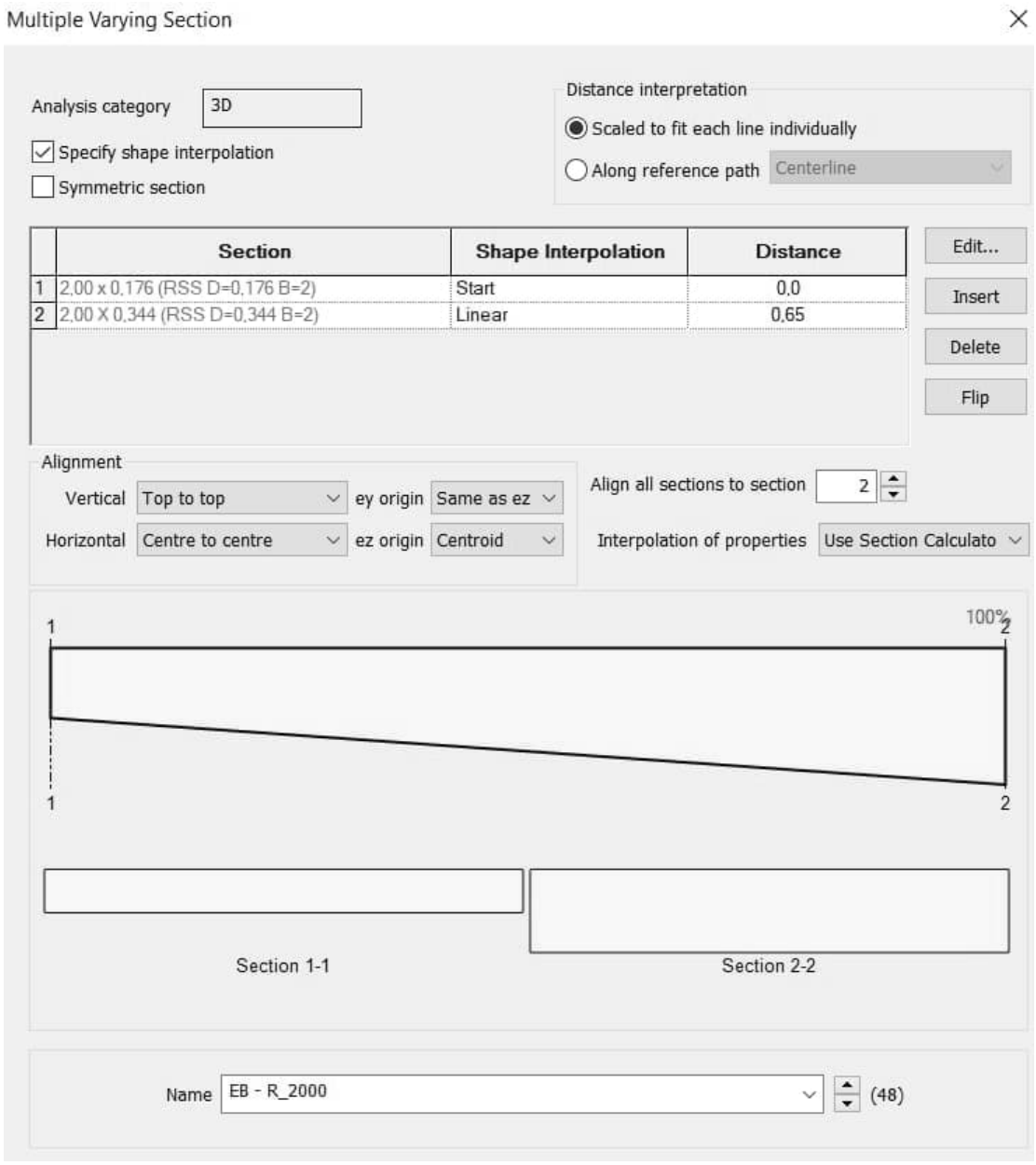
Eccentricity in z direction (ez): -0.412 m



EB – R_2000:

Section	D	B	Section
1	0.176	2.000	RSS D = 0.176 B = 2.0
2	0.344	2.000	RSS D = 0.344 B = 2.0
-	m	m	-

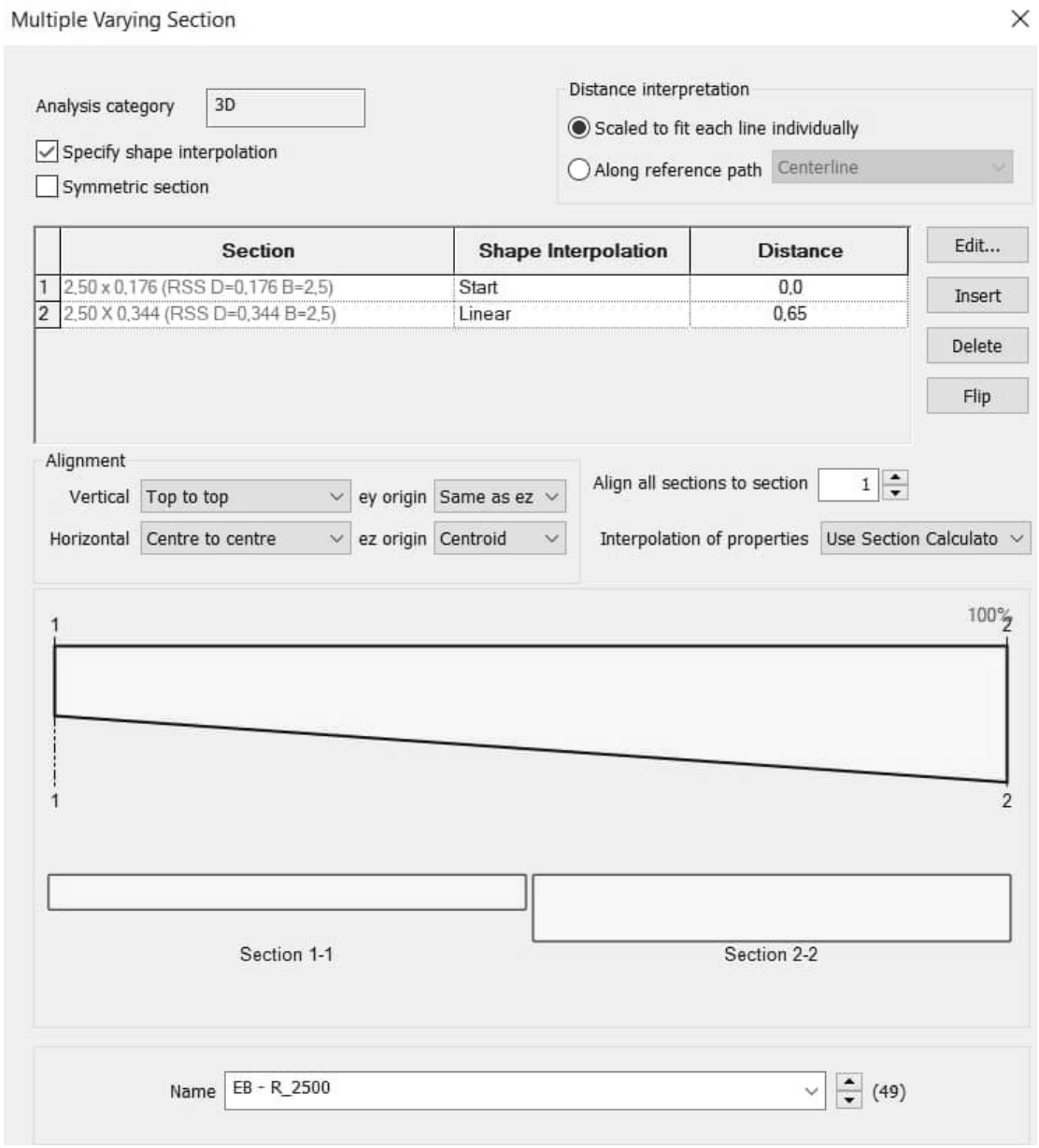
Eccentricity in z direction (ez): -0.412 m



EB – R_2500:

Section	D	B	Section
1	0.176	2.500	RSS D = 0.176 B = 2.5
2	0.344	2.500	RSS D = 0.344 B = 2.5
-	m	m	-

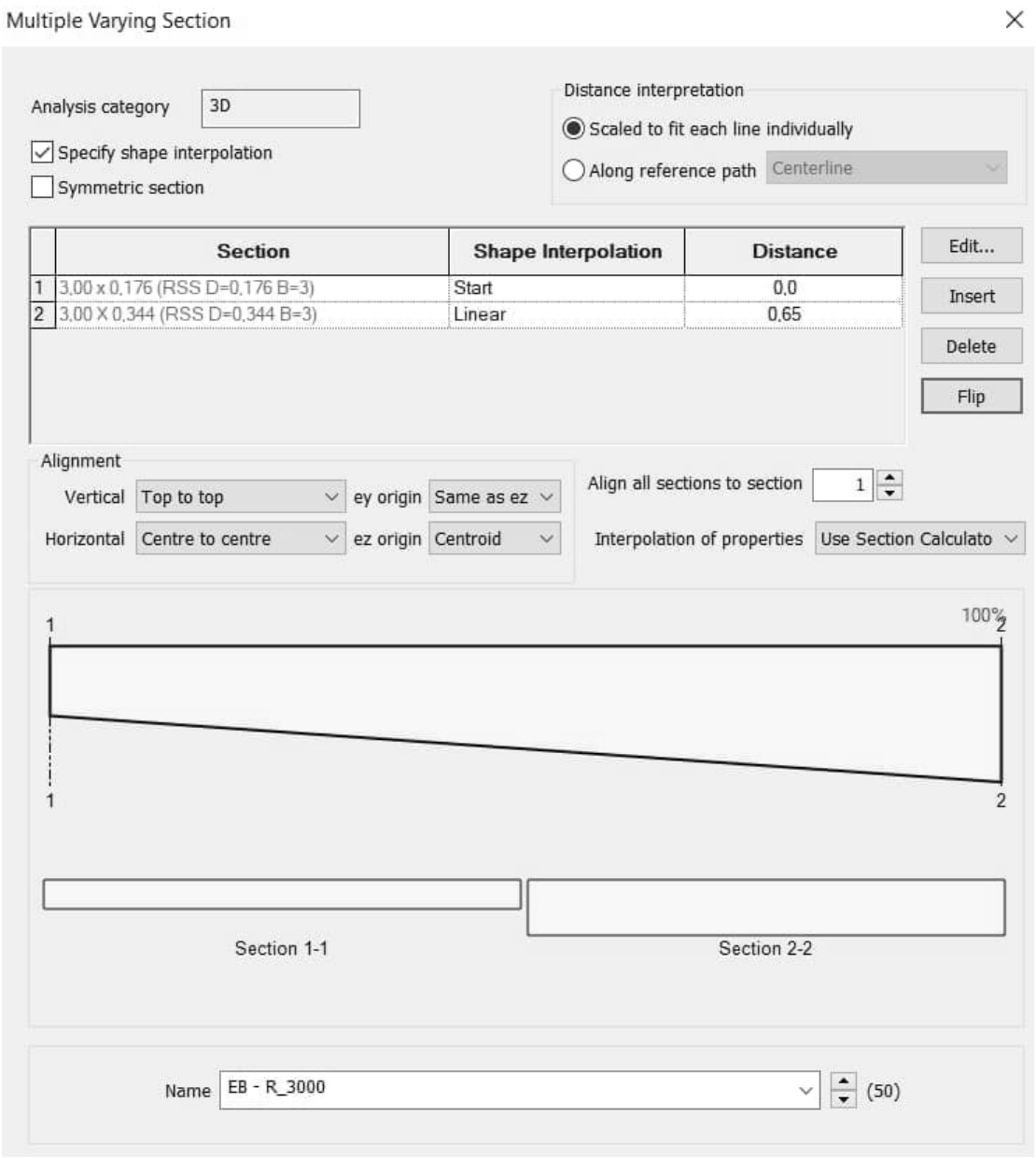
Eccentricity in z direction (ez): -0.412 m



EB – R_3000:

Section	D	B	Section
1	0.176	3.000	RSS D = 0.176 B = 3.0
2	0.344	3.000	RSS D = 0.344 B = 3.0
-	m	m	-

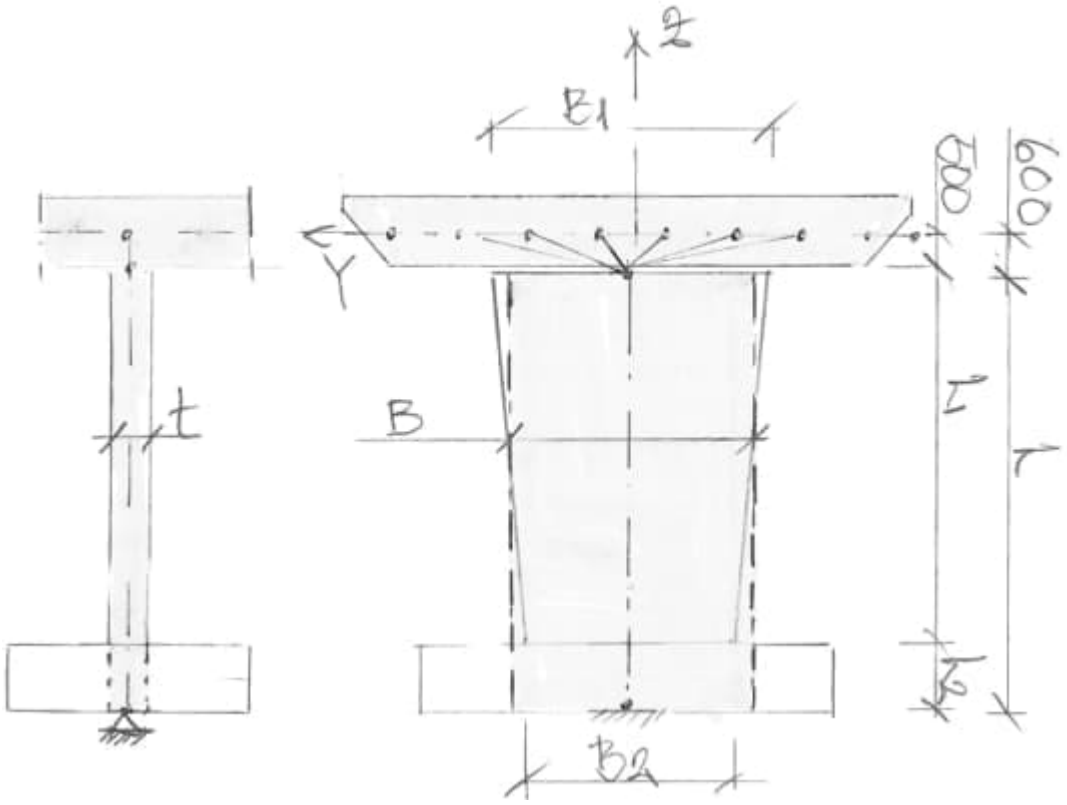
Eccentricity in z direction (ez): -0.412 m



2.3.3 Column (CL)

There are a total of 4 pillars belonging to Support 3-6. These have varying lengths, but they are modeled with a constant simplified geometry B x L x t as shown below. This simplification is considered possible because the pillars have significant slenderness in the length direction. The existing boundary conditions also contribute to this.

B	L	t
3.90	12.67	0.60
3.90	11.48	0.60
3.90	9.32	0.60
3.90	10.08	0.60
m	m	m



Simplified cross section.

Section	D	B	Section
4	0.600	3.900	RSS D =0.6 B = 3.9
-	m	m	-

Geometric Line

Analysis category: 3D

Definition

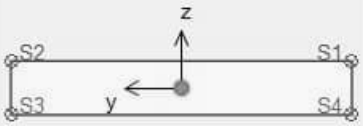
- From library / calculator
  - Rotation about centroid: 0 °
  - Mirrored about axis: None
- Enter properties
  - Usage: 3D Thick Beam (Any beam)

Parametric Sections

Rectangular Sections

6:Column (RSS D=0,6 B=3,9)

100%



Reinforcement (only used for RC design checks)

None

ez origin: Centroid ey origin: Same as e:

	Value
Cross sectional area (A)	2,34
Second moment of area about y axis (Iyy)	0,0702
Second moment of area about z axis (Izz)	2,96595
Product moment of area (Iyz)	0,0
Torsional constant (J)	0,253592
Effective shear area in y direction (Asy)	1,95003
Effective shear area in z direction (Asz)	1,95125
Eccentricity in y direction (ey)	0,0
Eccentricity in z direction (ez)	0,0

Visualise... | Tapering >> | Section details...

Name: Pelare (17)

2.4 MATERIAL

According to common calculation practice, prestressed structural elements shall be given higher stiffness than non-prestressed ones. In the calculation, non-prestressed structural elements are assumed to be cracked, which results in reduced stiffness. In the calculation, the E-modulus for non-prestressed structural elements is reduced to 0.6Eck = 20400 MPa.

The longitudinal beams (LB) are modeled as uncracked and with weight.

Other beams are modeled as cracked and weightless.

2.4.1 Material longitudinal beams (uncreacked)

Isotropic

Plastic Creep Damage Shrinkage Viscous Two phase Ko Initialisation

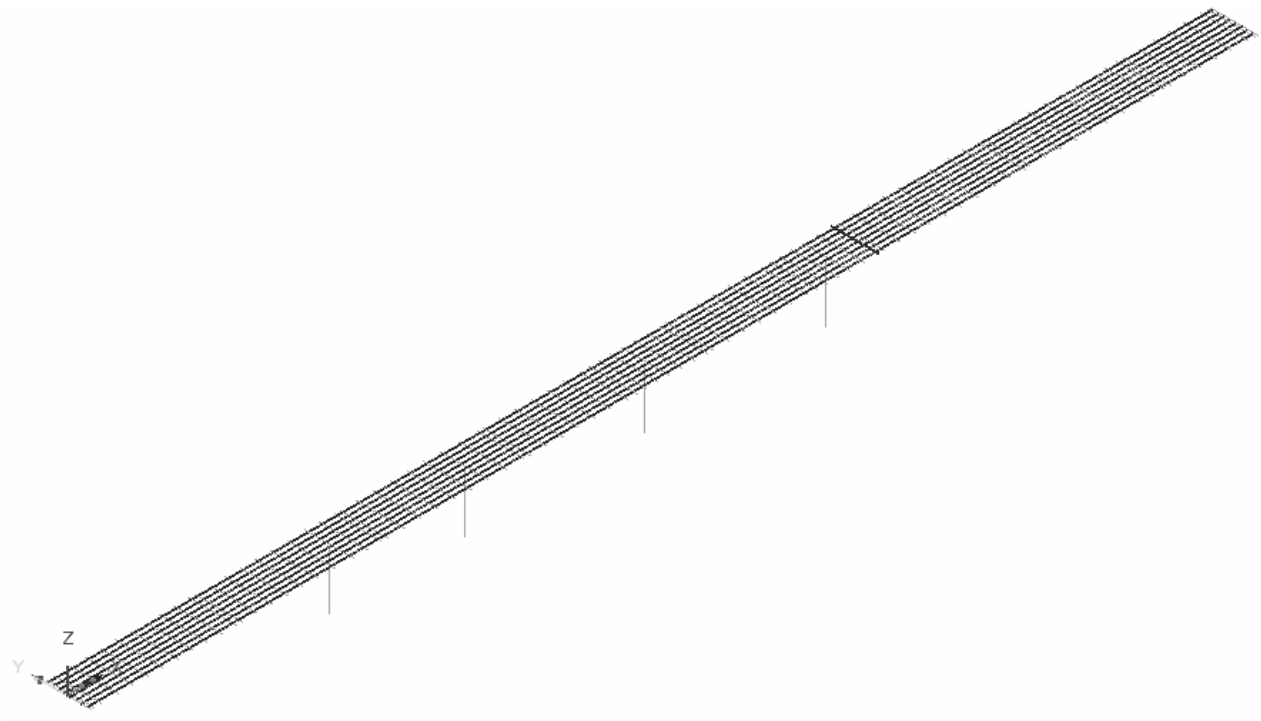
Elastic

Dynamic properties

Thermal expansion

	Value
Young's modulus	34,0E6
Poisson's ratio	0,2
Mass density	2,4
Coefficient of thermal expansion	10,0E-6

Name Uncracked concrete (4)



2.4.2 Material transversal beams (cracked)

Isotropic

Plastic | Creep | Damage | Shrinkage | Viscous | Two phase | Ko Initialisation

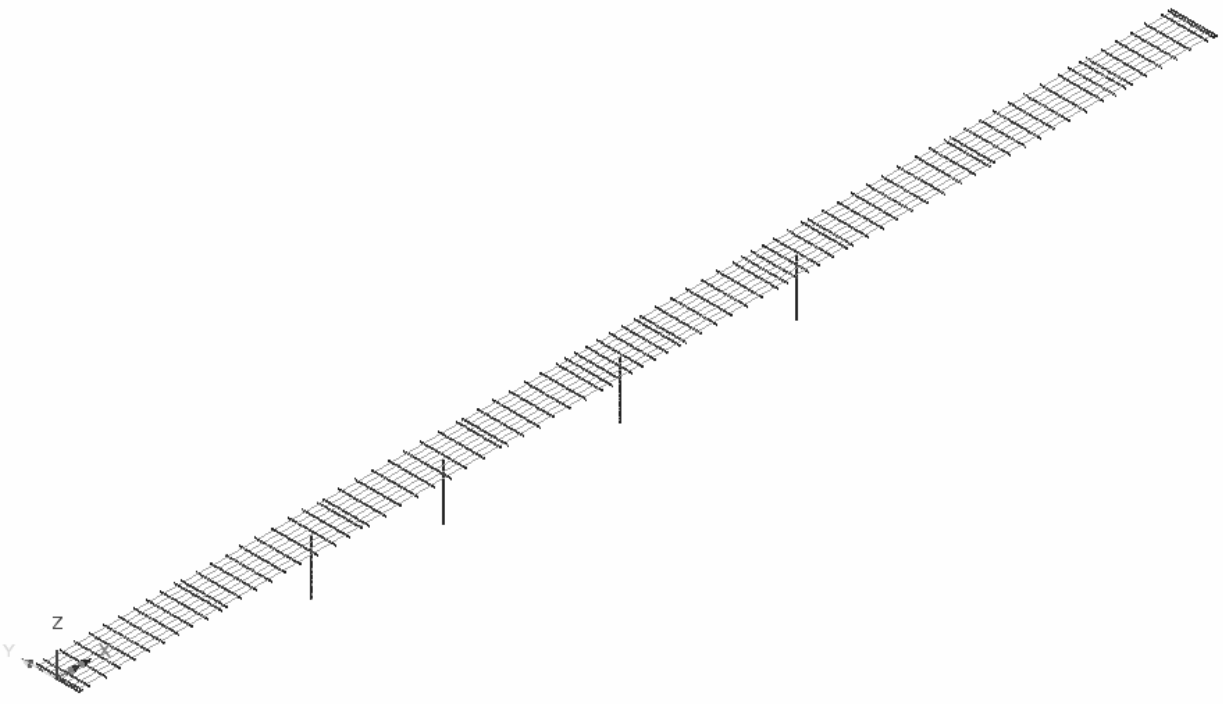
Elastic

Dynamic properties

Thermal expansion

	Value
Young's modulus	20,42E6
Poisson's ratio	0,2
Mass density	1,0E-3
Coefficient of thermal expansion	10,0E-6

Name: Cracked concrete (5)



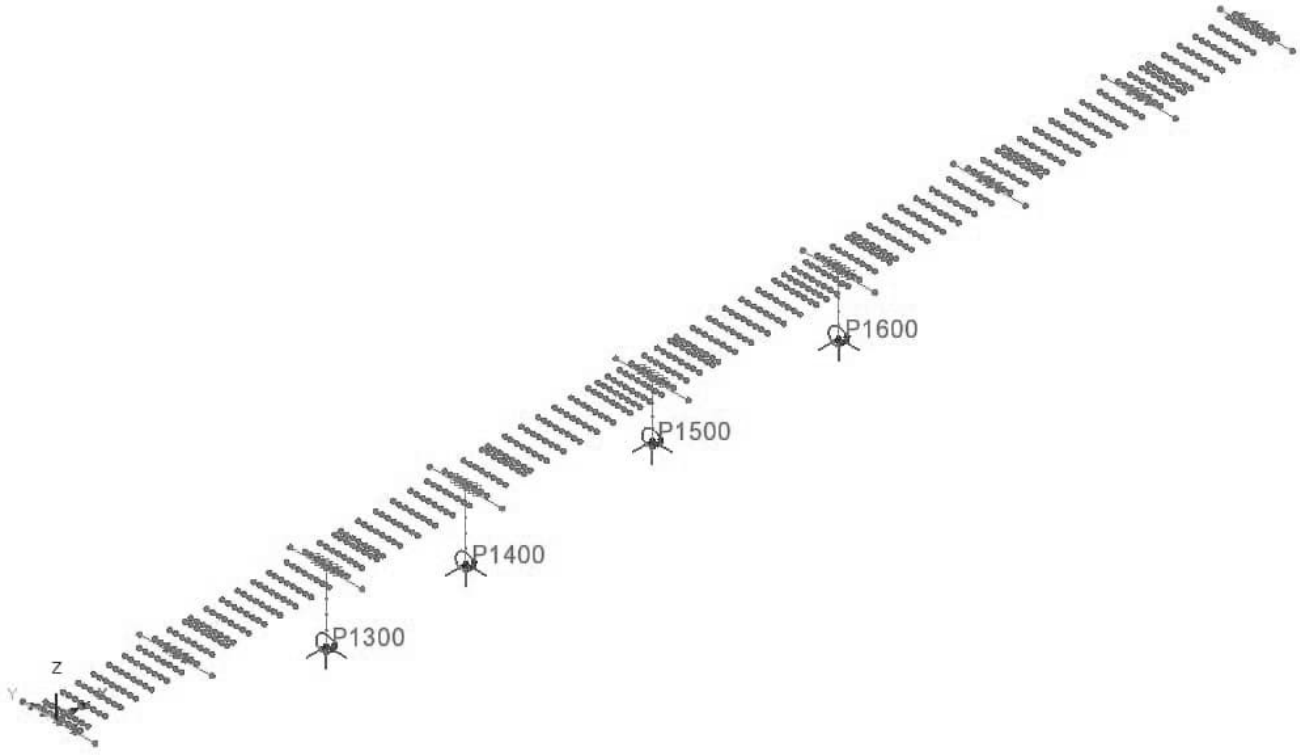
2.5 BOUNDARY CONDITIONS

2.5.1 Foundation

Support 3-6 är modelelled with *Point Supports.*

The boundary conditions in these “super-nodes” are modelled according to global coordinate system as shown in sketch.

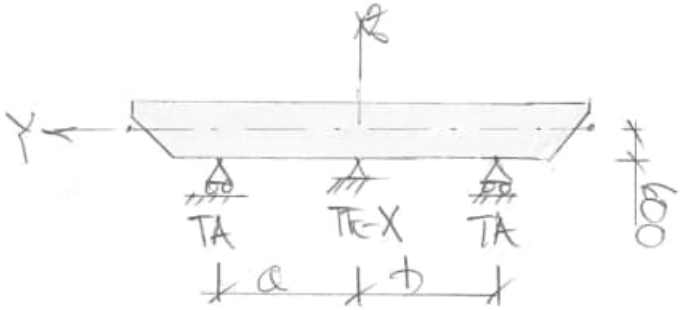
Support	Point	Direction	TX	TY	TZ	RX	RY	RZ
3	P1300	Global	Fixed	Fixed	Fixed	Fixed	Free	Free
4	P1400	Global	Fixed	Fixed	Fixed	Fixed	Free	Free
5	P1500	Global	Fixed	Fixed	Fixed	Fixed	Free	Free
6	P1600	Global	Fixed	Fixed	Fixed	Fixed	Free	Free
-	-	-	kN/m	kN/m	kN/m	kNm/rad	kNm/rad	kNm/rad



Overview

2.5.2 Bearings

Bearings at support 1, 2, 7, 8 and 9 are modeled with *Point Supports*. A total of 3 are present at each support with appearance as shown below.

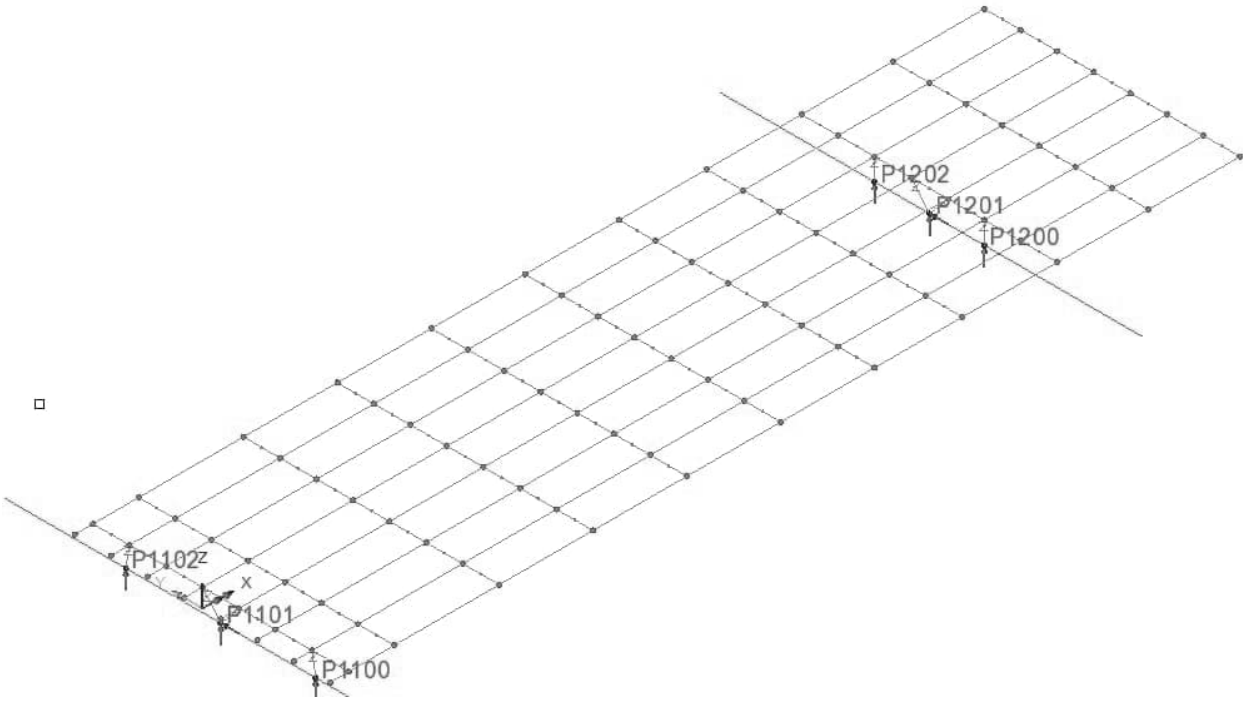


Support	a	b
1	2600	2600
2	1500	1500
7	1500	1500
8	1500	1500
9	2600	2600
-	mm	mm

These layers are modeled in the global coordinate system with boundary conditions as described below.

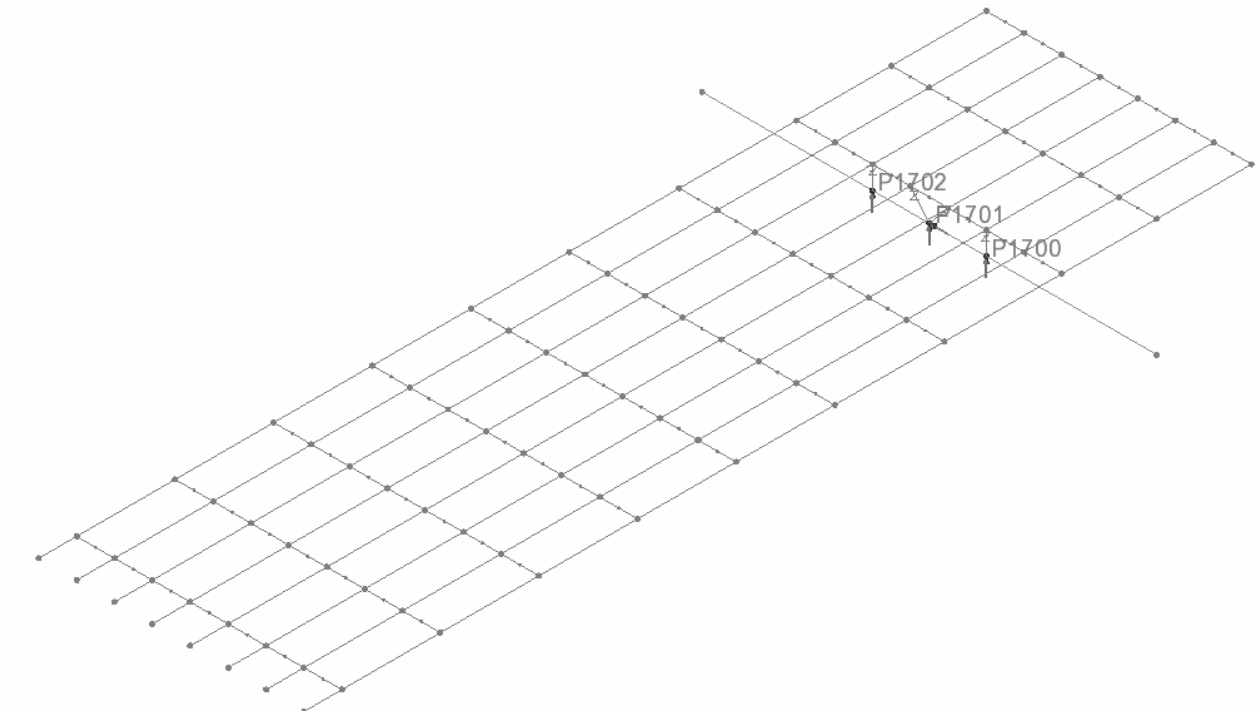
Bearing	Direction	TX	TY	TZ	RX	RY	RZ
TA	Global	Free	Free	Fixed	Free	Free	Free
TE-X	Global	Free	Fixed	Fixed	Free	Free	Free
-	-	kN/m	kN/m	kN/m	kNm/rad	kNm/rad	kNm/rad

Overview of bearings at casting stage 1:
Support 1 & 2



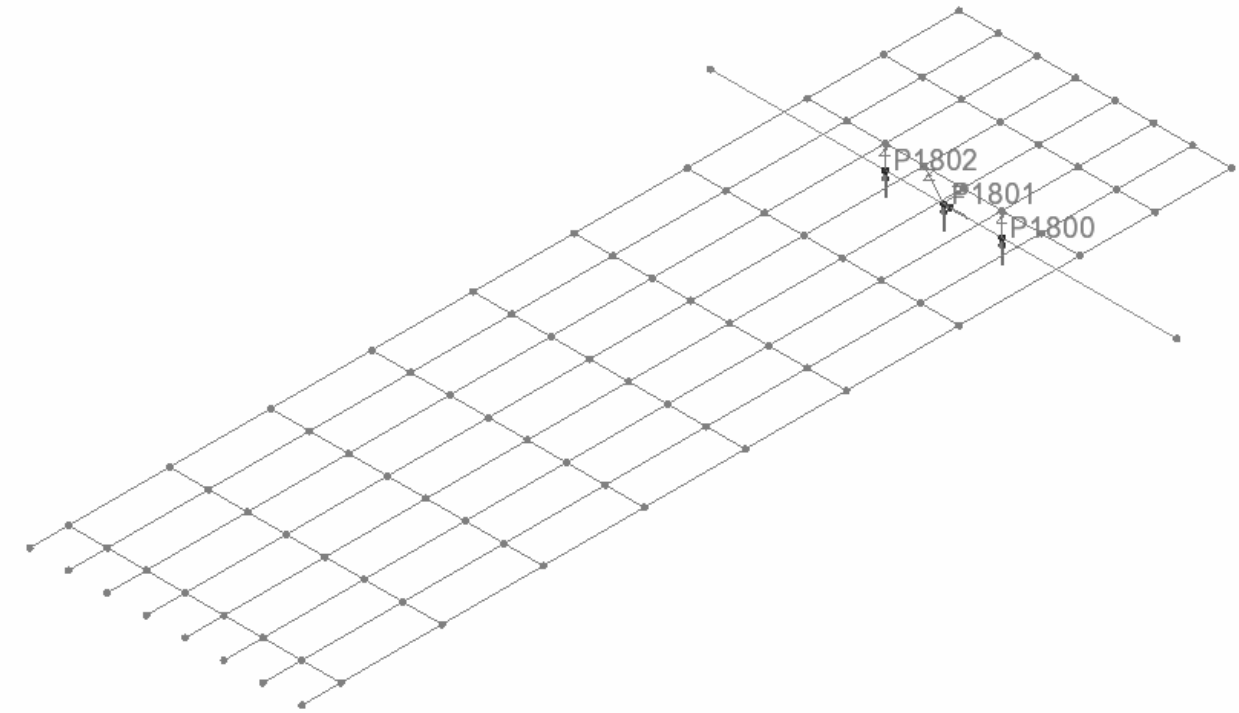
Support	Typ	Point
1	TA	P1100
1	TE-X	P1101
1	TA	P1102
2	TA	P1200
2	TE-X	P1201
2	TA	P1202

Overview of bearings at casting stage 6:
Support 7



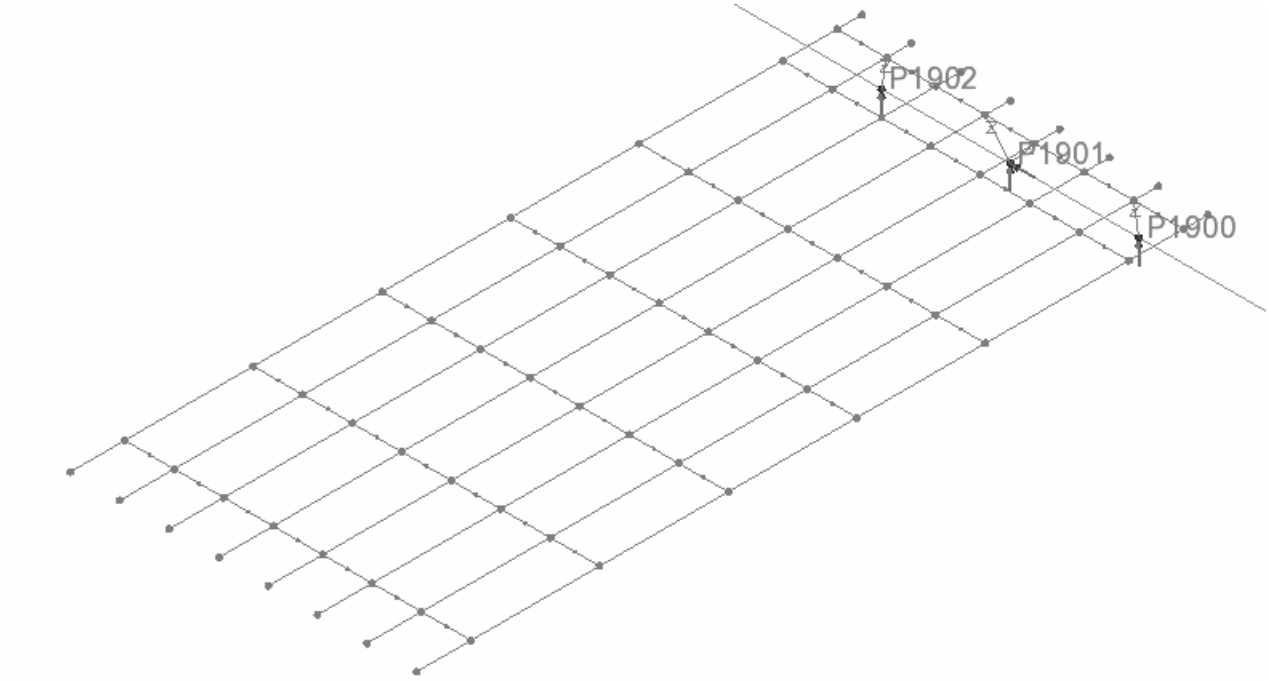
Support	Typ	Point
7	TA	P1700
7	TE-X	P1701
7	TA	P1702

Overview of bearings at casting stage 7:
Support 8



Support	Typ	Point
8	TA	P1800
8	TE-X	P1801
8	TA	P1802

Overview of bearings at casting stage 8:
Support 9



Support	Typ	Point
9	TA	P1900
9	TE-X	P1901
9	TA	P1902

2.6 MESH

In the model, 3D beam elements (BMI21) and Joint elements (JSH4) are used. The latter are used to connect columns to the bridge deck at Support 3-6 to the bridge deck.

2.6.1 Beam element (BMI21)

Longitudinal beams, transversal beams, and columns are modeled as 3D beam elements.

The beam elements are modeled with varying node division within each subarea according to the presentation below.

Name	Divisions	End release: Start	End release: End	Structure
Element 1	1	None	None	LB
Element 2	2	None	None	TB & EB
Element 5	5	None	None	Pelare

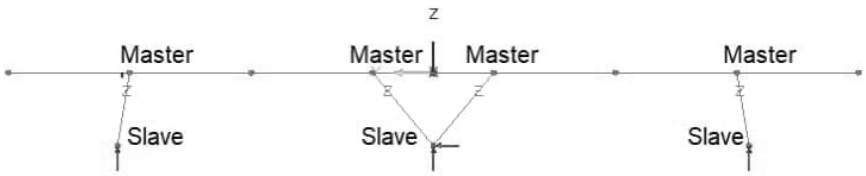
2.6.2 Joint element (JSH4): rigid link from bearing to longitudinal beams

Nodes for bearings are rigidly connected to the longitudinal girders (LB) of the bridge deck.

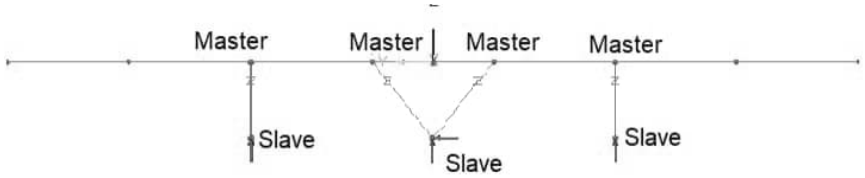
The controlling node is designated “Master” while the adapting node is designated “Slave”.

The properties of the Joint element (JSH4) are retrieved and specified in the node designated “Master”. All these nodes are assigned material properties designated “Joint material” in the table below.

Name	u	v	w	THx	THy	Thz
”Joint material”	Fixed	Fixed	Fixed	Free	Free	Free
-	kN/m	kN/m	kN/m	kNm/rad	kNm/rad	kNm/rad



Rigid link at end supports
Support 1 and 9



Rigid link intermediate supports
Support 2, 7 and 8

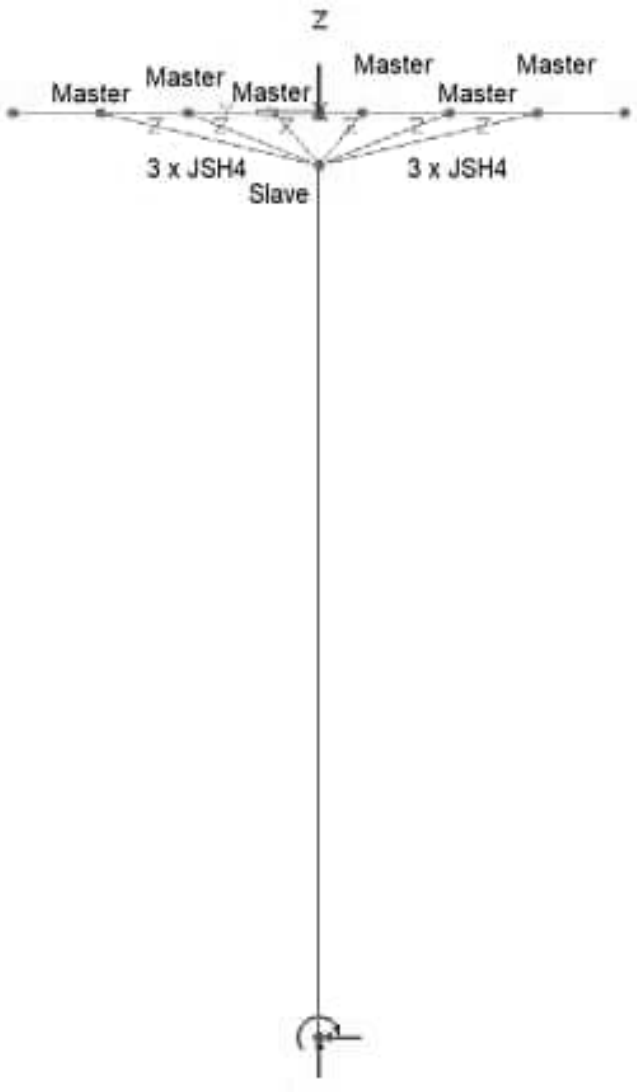
2.6.3 Joint element (JSH4): rigid link from column to transversal beams

Nodes for bearings are rigidly connected to the transverse beams of the bridge deck TB-UK.

The controlling node is designated "Master" while the adapting node is designated "Slave".

The properties of the Joint element (JSH4) are retrieved/indicated in the node designated "Master". All of these nodes are assigned material properties designated "Joint material" in the table below.

Name	u	v	w	THx	THy	Thz
"Joint material"	Fixed	Fixed	Fixed	Free	Free	Free
-	kN/m	kN/m	kN/m	kNm/rad	kNm/rad	kNm/rad



Ridig connection intermeditate supports
Support 3-6

2.7 STAGED CONSTRUCTION

There are a total of 8 construction stages.

The geometric model is the same for these systems, however, it is allowed that boundary conditions, material properties, cross-section constants, and loads vary between the different static systems.

Analysis 9 is referred to as "Base Analysis" and corresponds to the static system in the operational phase. The other analyses are based on this one.

Nr	Analysis	Stage
1	1	I
2	2	II
3	3	III
4	4	IV
5	5	V
6	6	VI
7	7	VII
8	8	VIII
9	9 *	Driftskede

* = ”Definition of base analysis”

The redistribution occurs so that the static system that exists in the "construction stage" transitions to that which exists for the continuous static system present in the "operational stage". The simplified method according to SS-EN 1992-2 section KK.7 is used to study the impact of staged construction.

For the check, it has been assumed that there are 2 months (60 days) between the time (t_0) of casting stage until the formwork removal of the adjoining casting stage (t_c).

$$S(t) \approx \sum_{i=1}^{8} S_{0,i} + \left(S_c - \sum_{i=1}^{8} S_{0,i} \right) \cdot \frac{\varphi(t) - \varphi(60days)}{1 + 0.8 \cdot \varphi(t)}$$

S_c : forces static system operational stage

$S_{0,i}$: forces static system during construction stages

$\varphi(60\text{days}) = 0.4$

$\varphi(120\text{ years}) = 1.4$

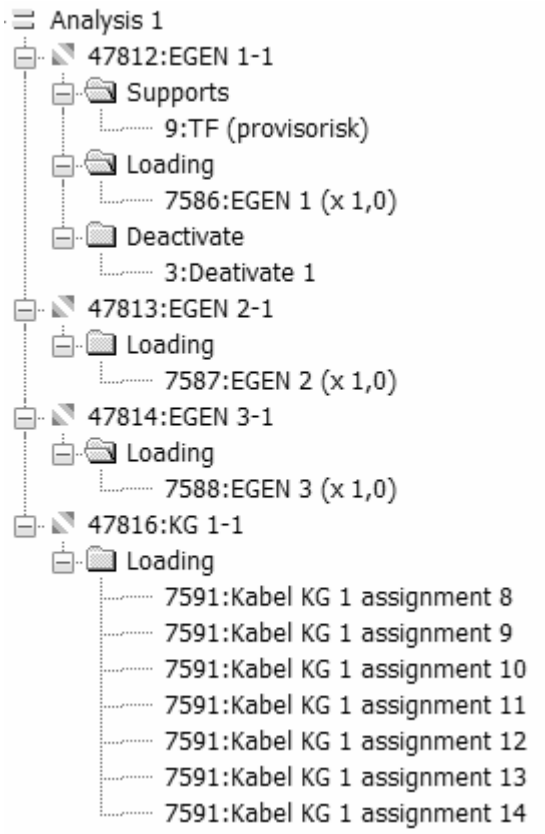
$$S(120years) \approx \sum_{i=1}^{8} S_{0,i} + \left(S_c - \sum_{i=1}^{8} S_{0,i} \right) \cdot \frac{1.4 - 0.4}{1 + 0.8 \cdot 1.4} = \sum_{i=1}^{8} S_{0,i} + 0.47 \cdot \left(S_c - \sum_{i=1}^{8} S_{0,i} \right)$$

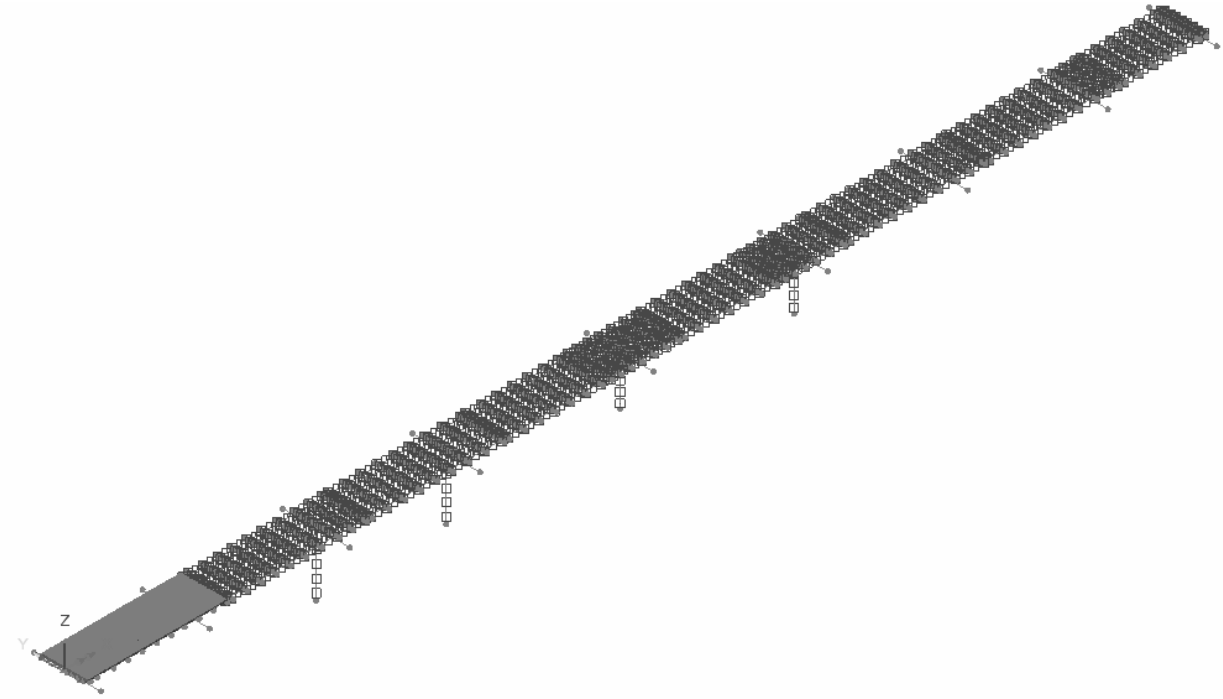
M_c : static system ”operational stage” (Analysis 9)

M_0 : static system ”construction stage” (Analysis 1-8)

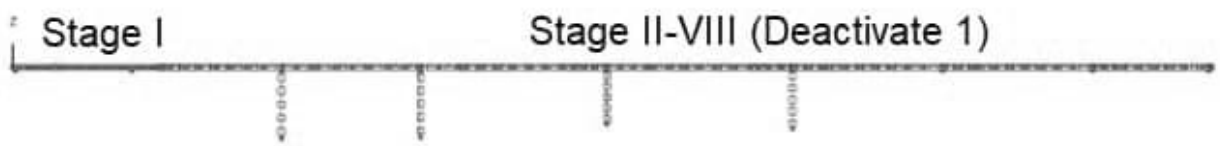
$\rightarrow \quad M(t = 120years) = 0.47\, M_c + 0.53 M_0$

Analysis 1:
(Only STAGE I is "active" while STAGE II-VIII are "deactive")



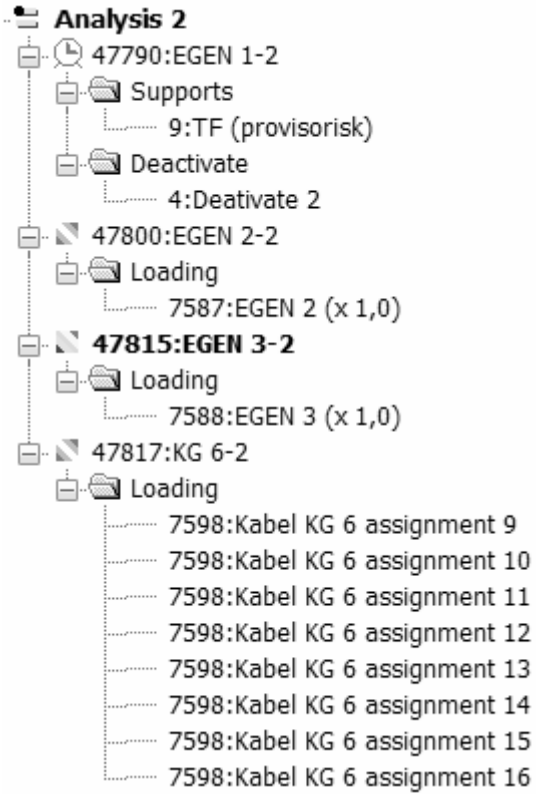


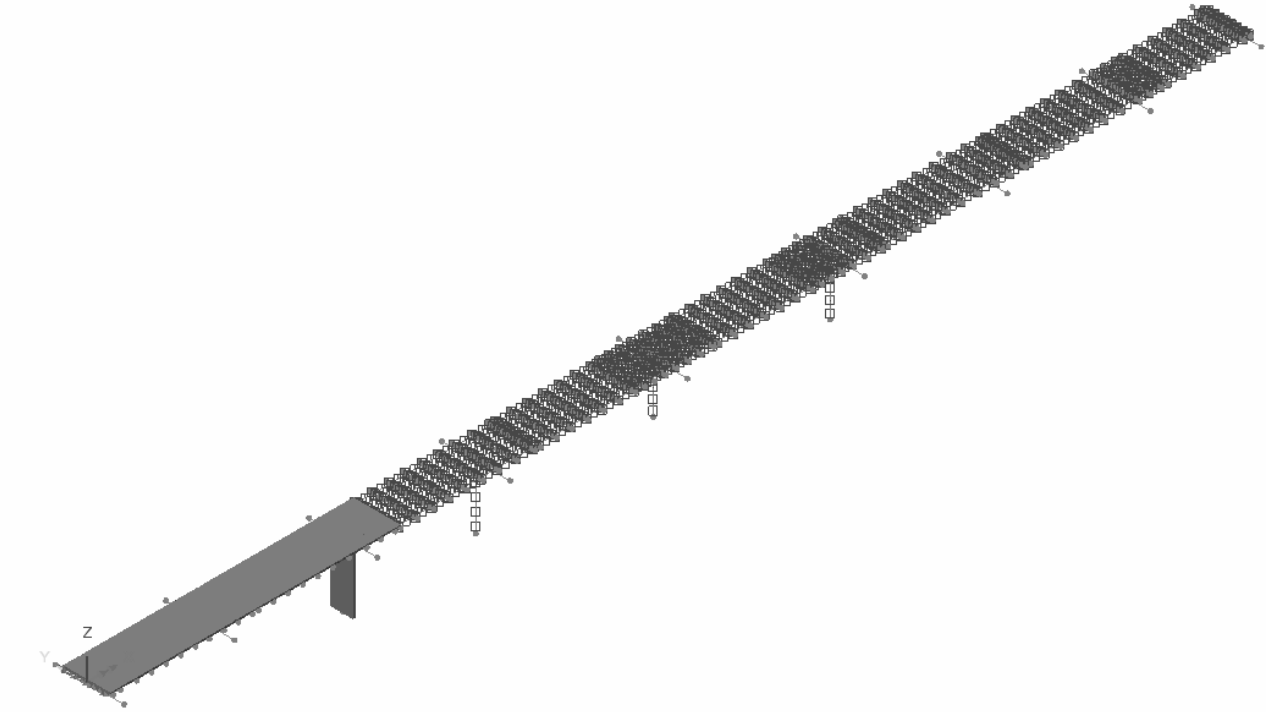
OVERVIEW



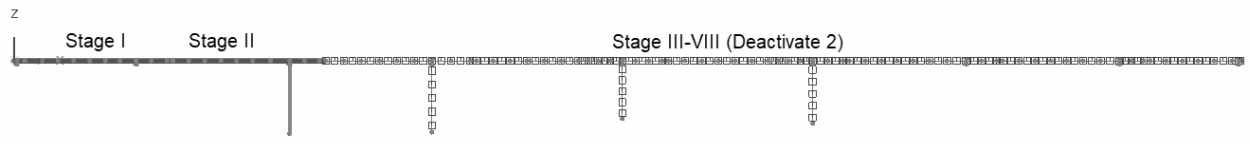
ELEVATION

Analysis 2:
(Only STAGE I-II is "active" while STAGE III-VIII are "deactive")



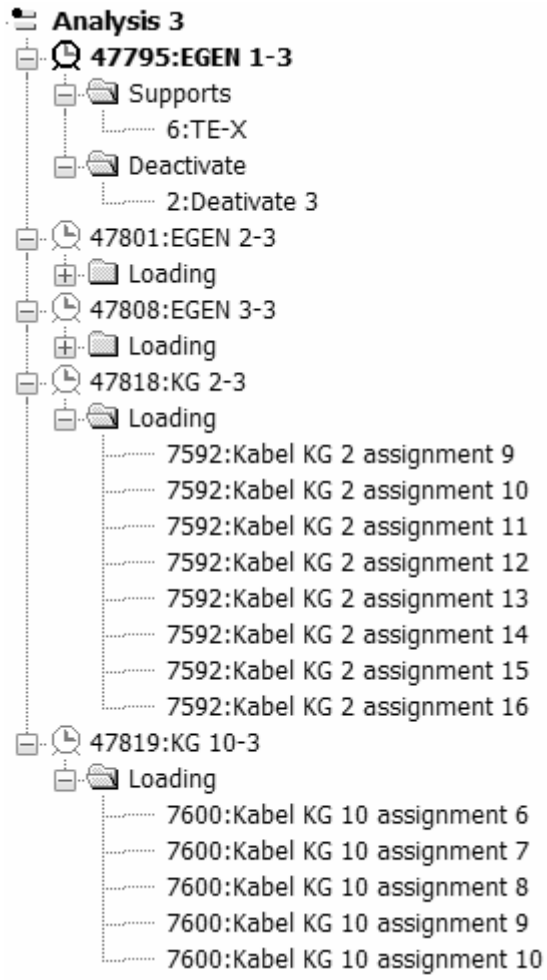


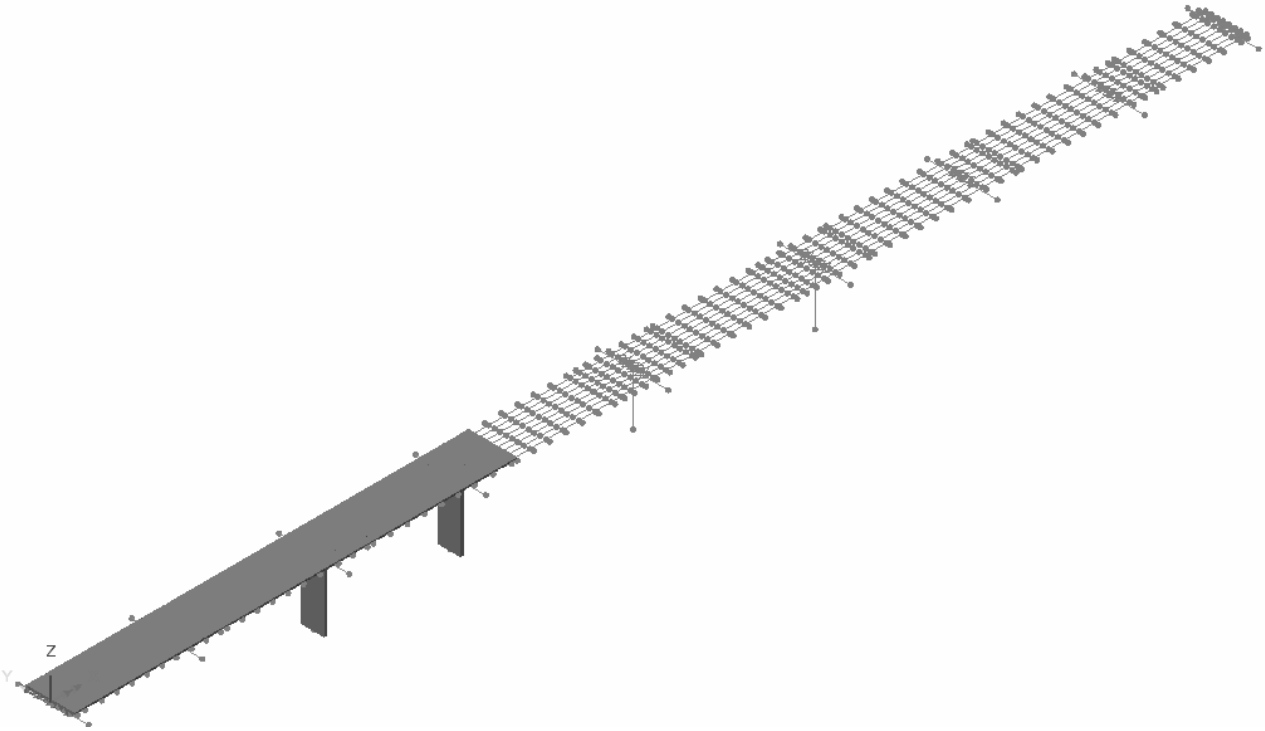
OVERVIEW



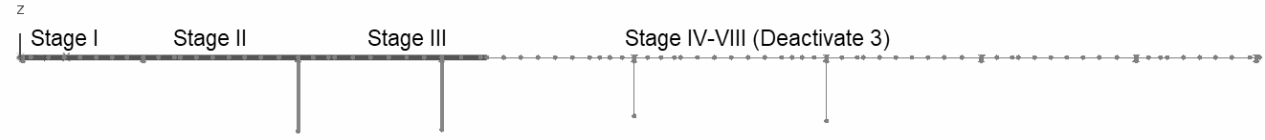
ELEVATION

Analysis 3:
(Only STAGE I-III is "active" while STAGE IV-VIII are "deactive")



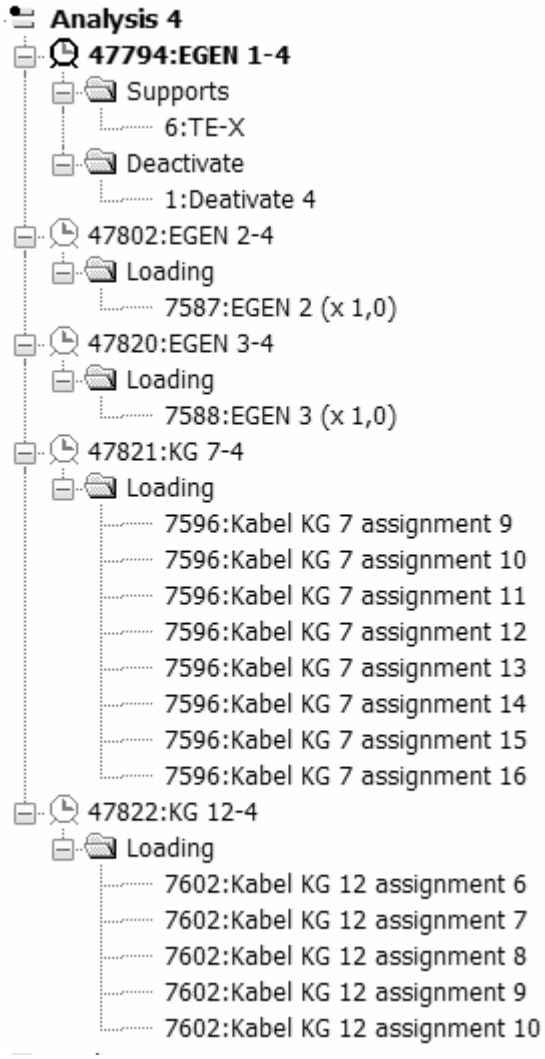


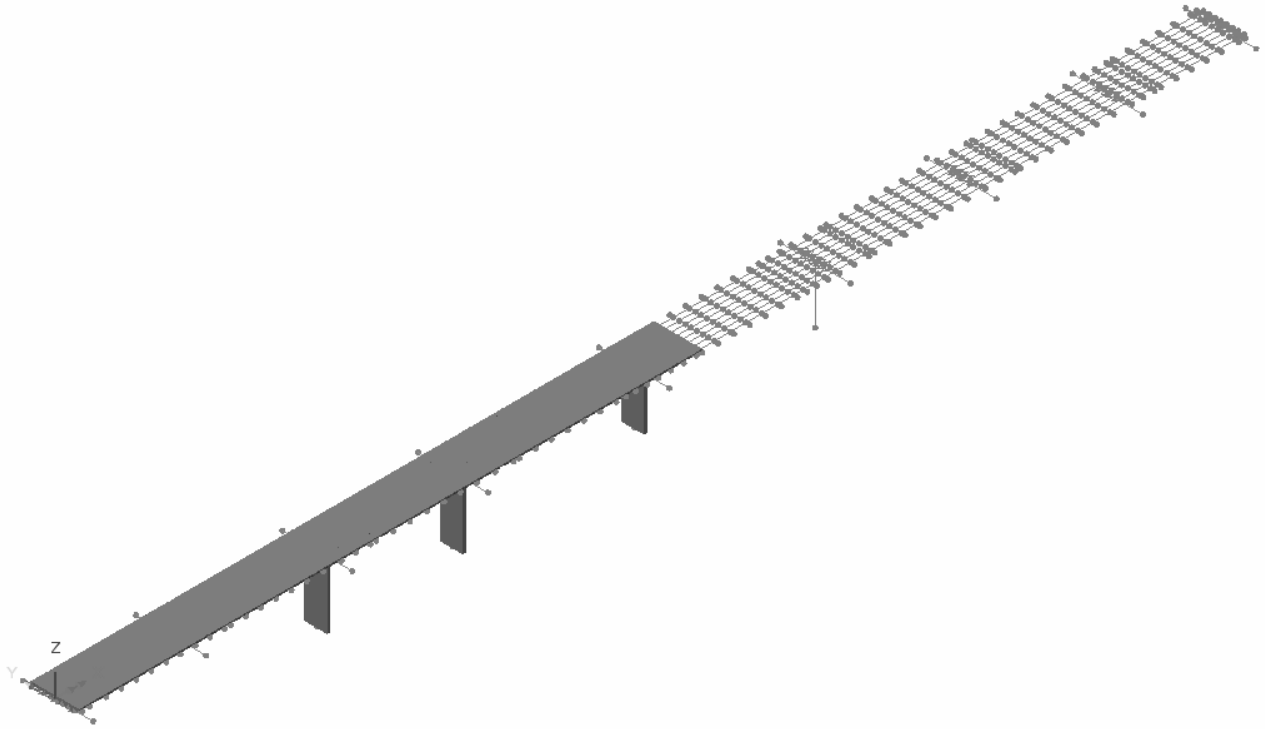
OVERVIEW



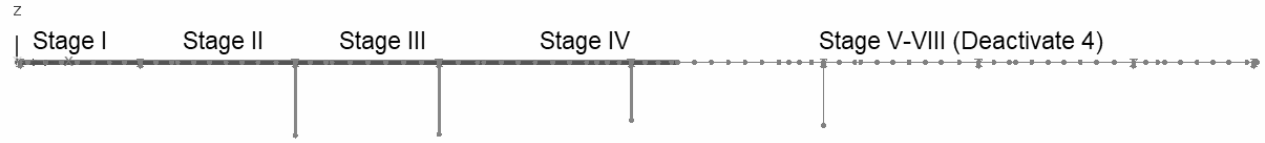
ELEVATION

Analysis 4:
(Only STAGE I-IV is "active" while STAGE V-VIII are "deactive")



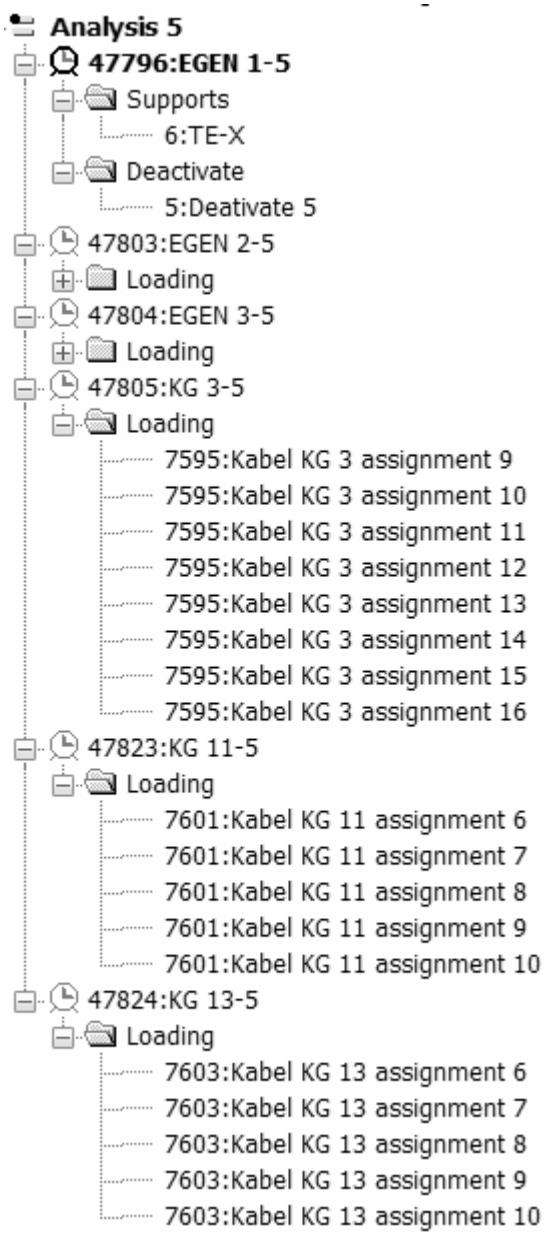


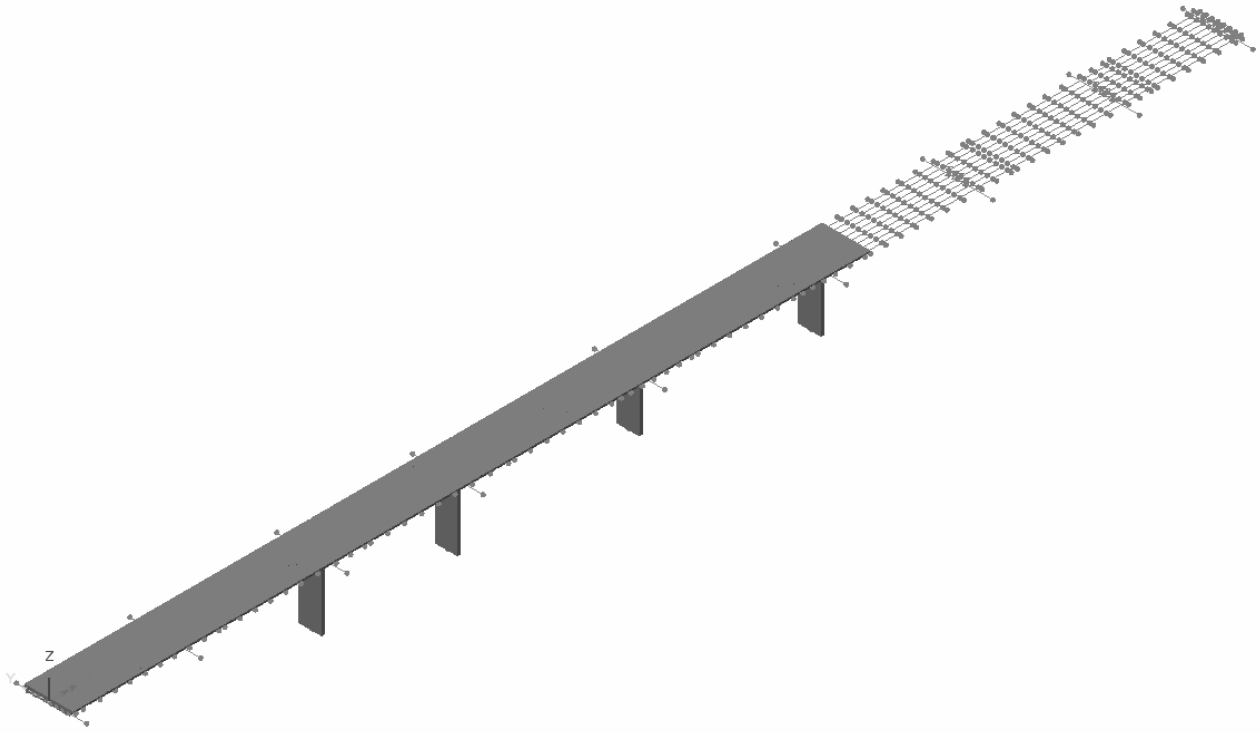
OVERVIEW



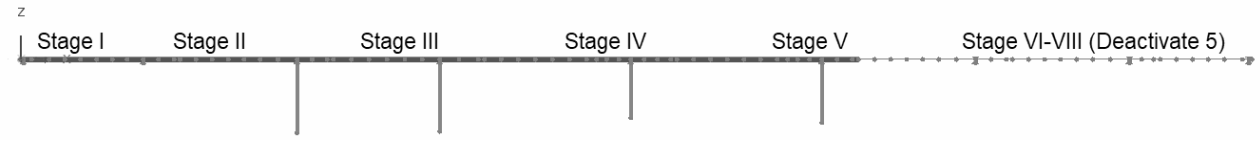
ELEVATION

Analysis 5:
(Only STAGE I-V is "active" while STAGE VI-VIII are "deactive")



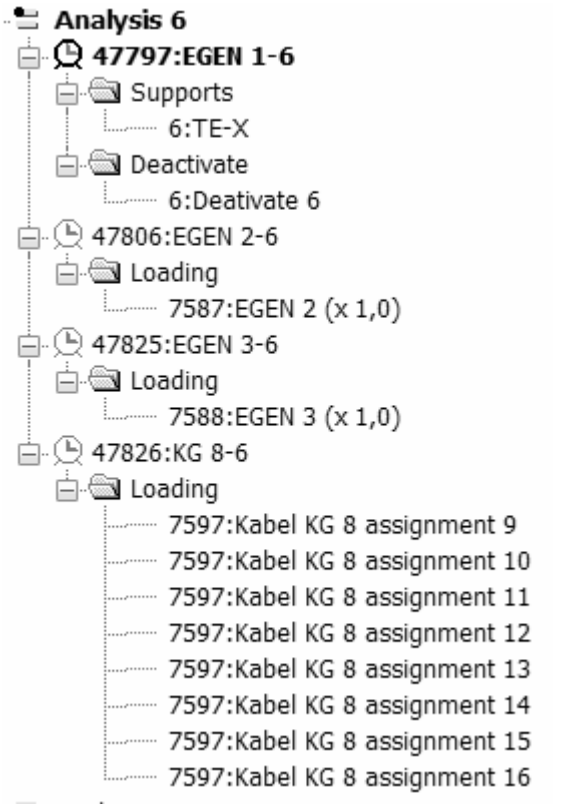


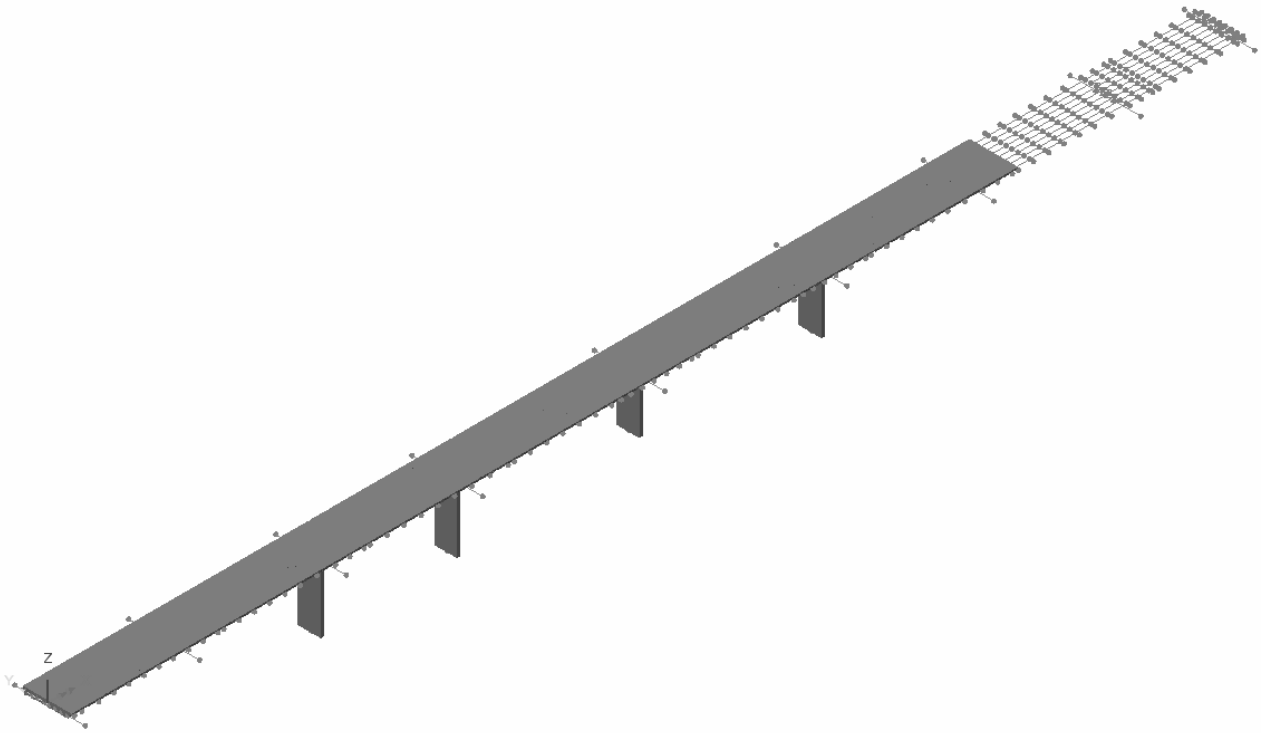
OVERVIEW



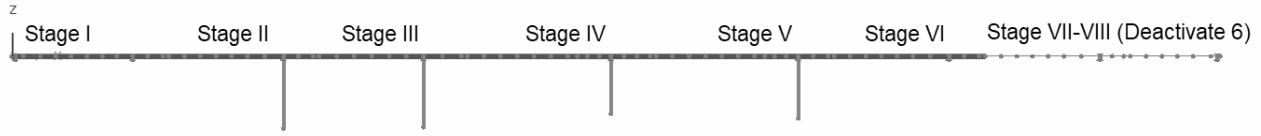
ELEVATION

Analysis 6:
(Only STAGE I-VI is "active" while STAGE VII-VIII are "deactive")



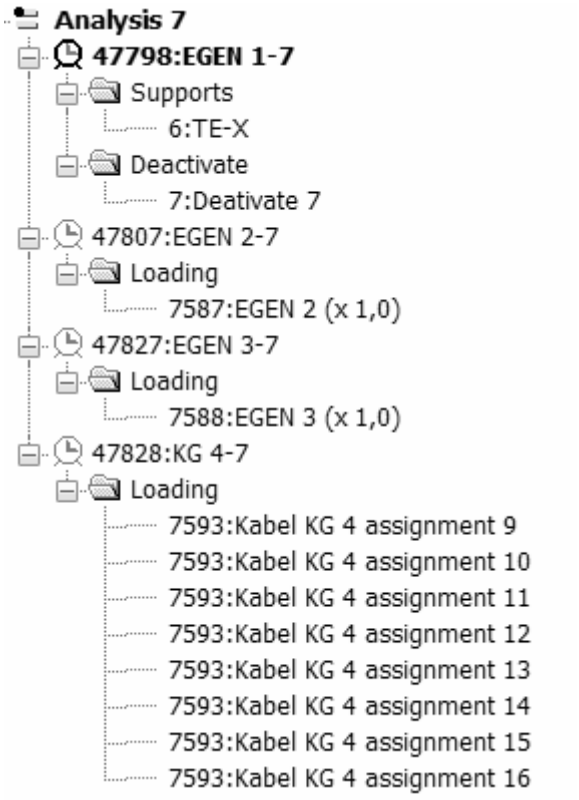


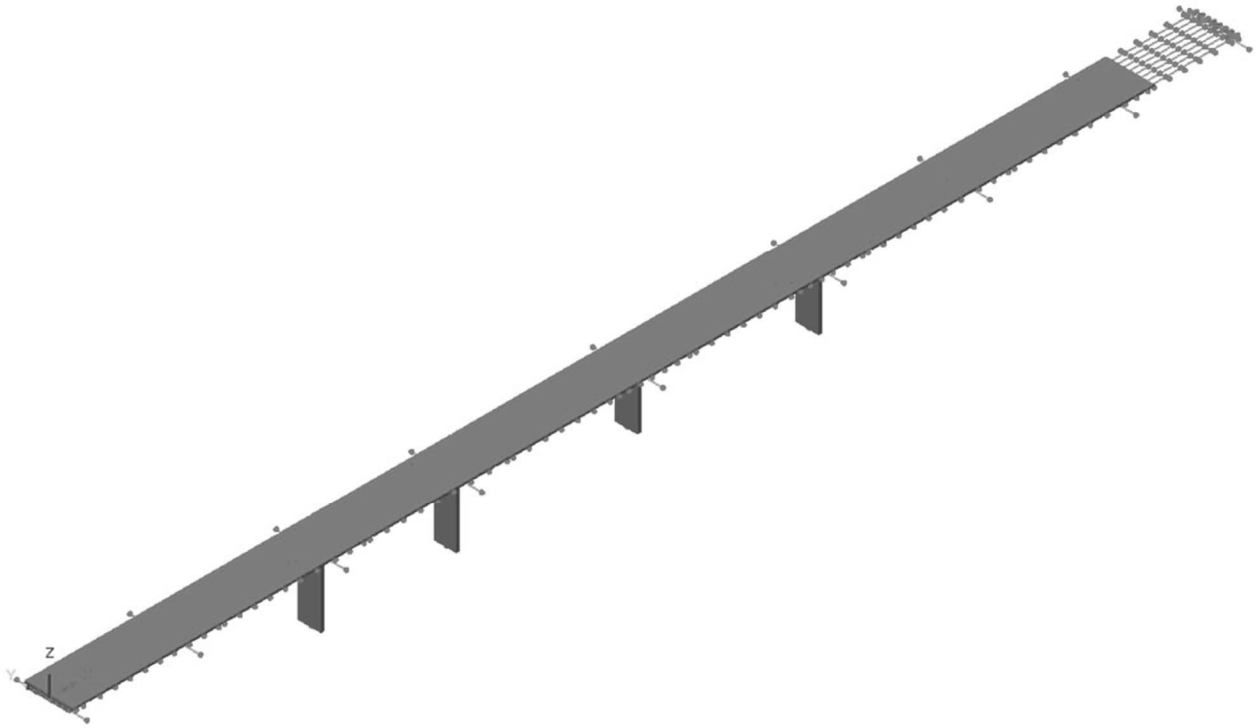
OVERVIEW



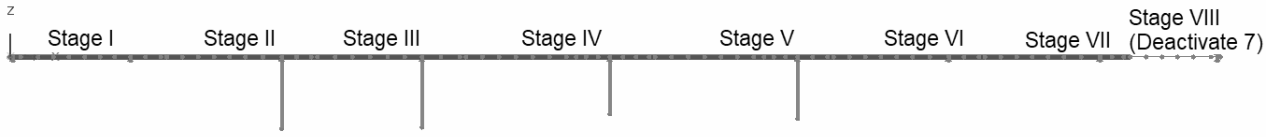
ELEVATION

Analysis 7:
(Only STAGE I-VII is "active" while STAGE VIII is "deactive")



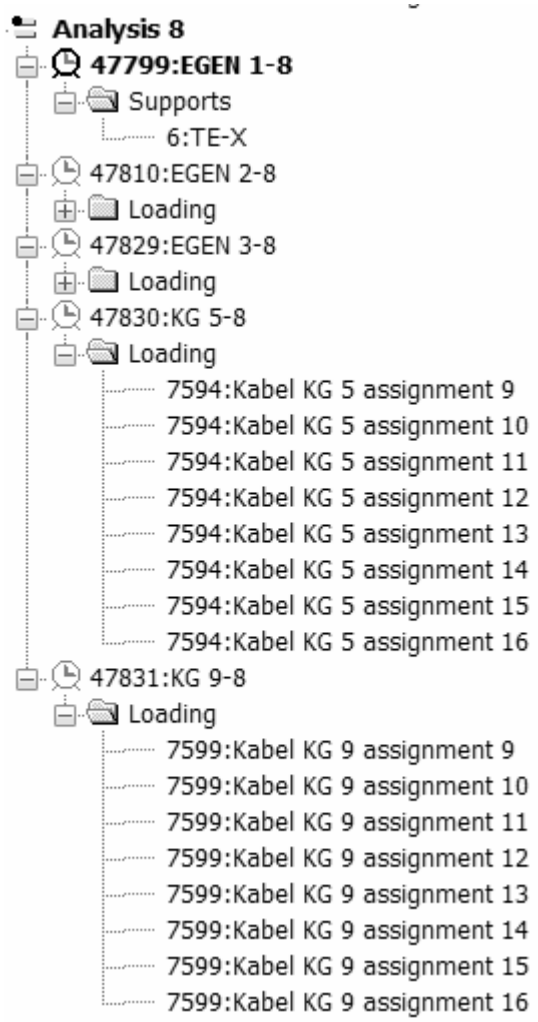


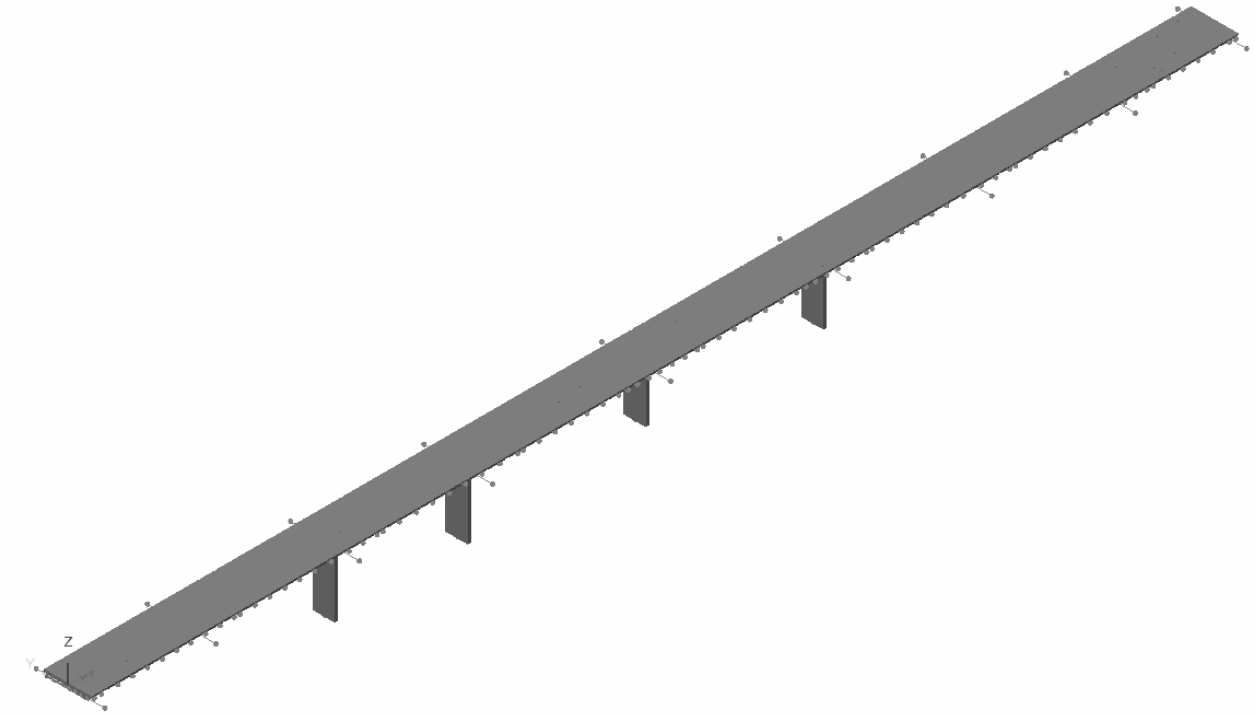
OVERVIEW



ELEVATION

Analysis 8:
(All stages are "active")





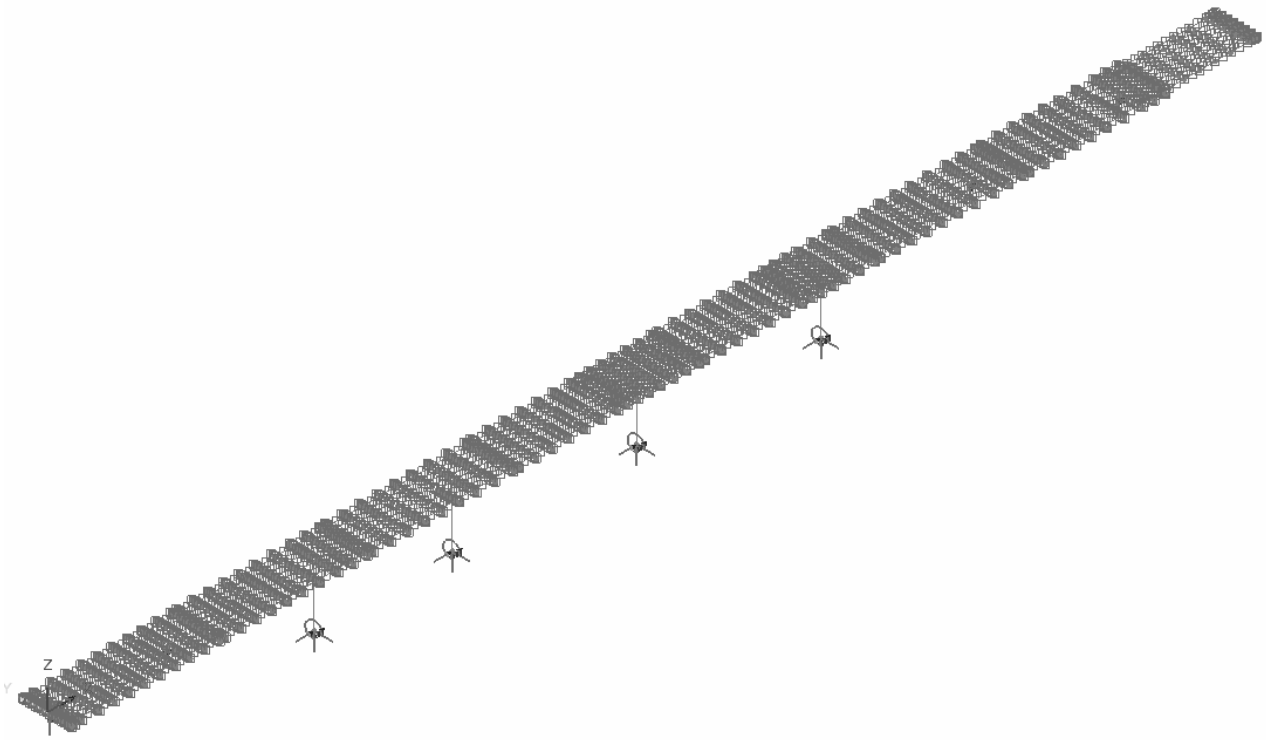
OVERVIEW

ELEVATION

2.8 SEARCH AREA

Discrete load can be applied to structure as geometrical load areas. These are area are termed Search Area.

In this case, a Search Area is defined for longitudinal beams (LB) and transversal beams at the top (TB-OK).



Search area : Deck
All LB and TB-OK

3. LOADS

Not all loads are considered. Only the above are appied.

3.1 DEAD WEIGHT

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

3.1.1 Load bridge deck excl. edge beam

The loads belonging to the bridge deck, excluding edge beams, are introduced as line loads along the longitudinal beams (LB).

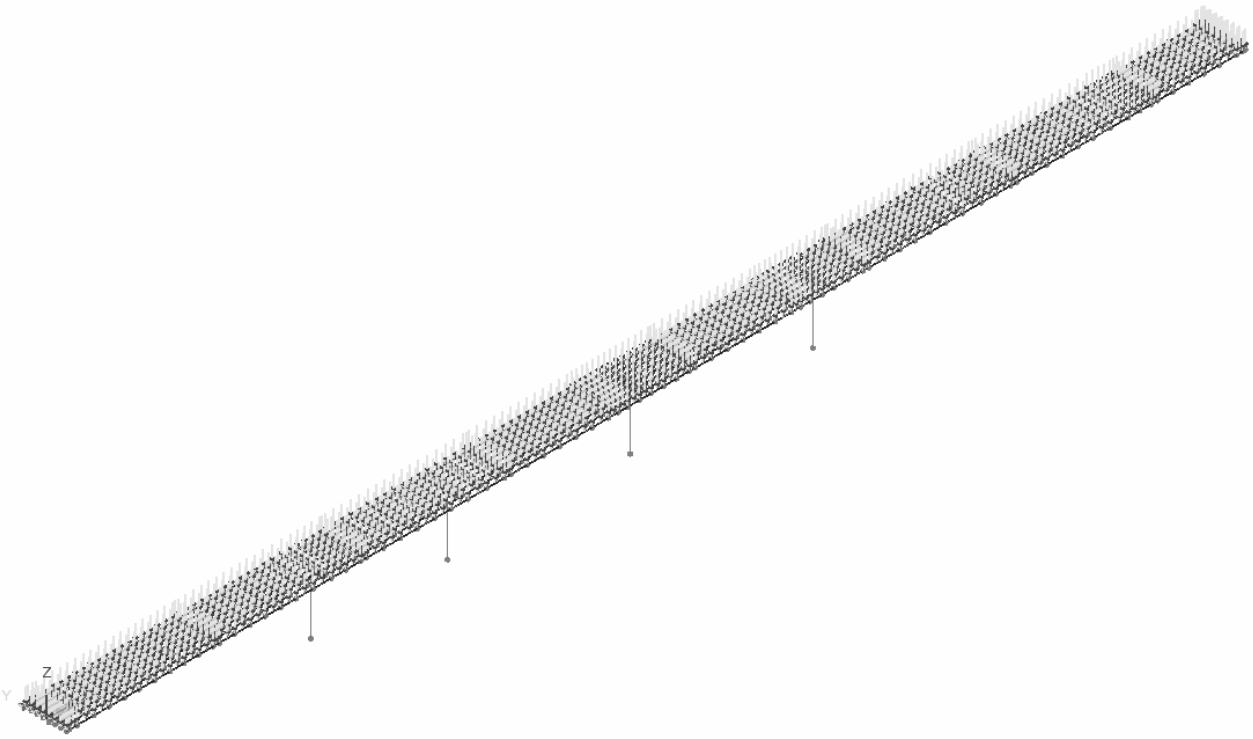
Load : EGEN 1

Structural loading : Body force

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

Load case : EGEN 1

Loading assignment: Assign to lines (LB 1-8)



Overview 3D

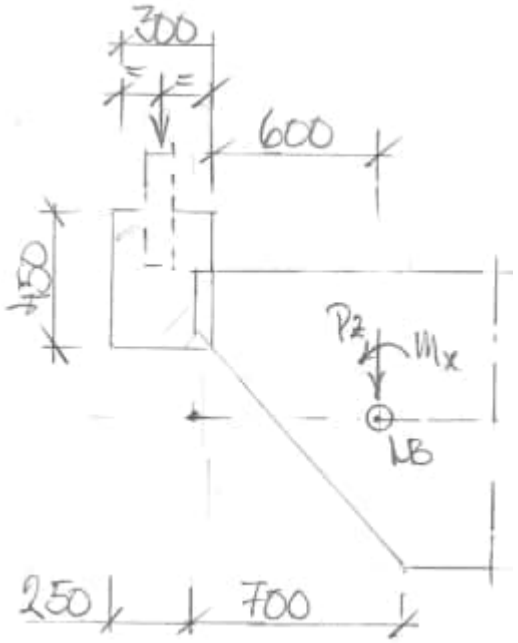
3.1.2 Edge beam + railing: left side

The load belonging to the edge beam including the railing is applied as a line load along the longitudinal beam (LB 1) nearest the left side. The effect of eccentric load placement is accounted for by applying an equivalent line moment.

$$p_{railing} = 0.5\frac{kN}{m}$$

$$\rightarrow p_z = p_{railing} + p_{EB} = 0.5\frac{kN}{m} + 0.45m \cdot 0.30m \cdot 24\frac{kN}{m^3} = -4\frac{kN}{m}$$

$$\rightarrow m_x = p_z \cdot (0.6m + 0.15m) = -3\frac{kNm}{m}$$



Load : EGEN 2

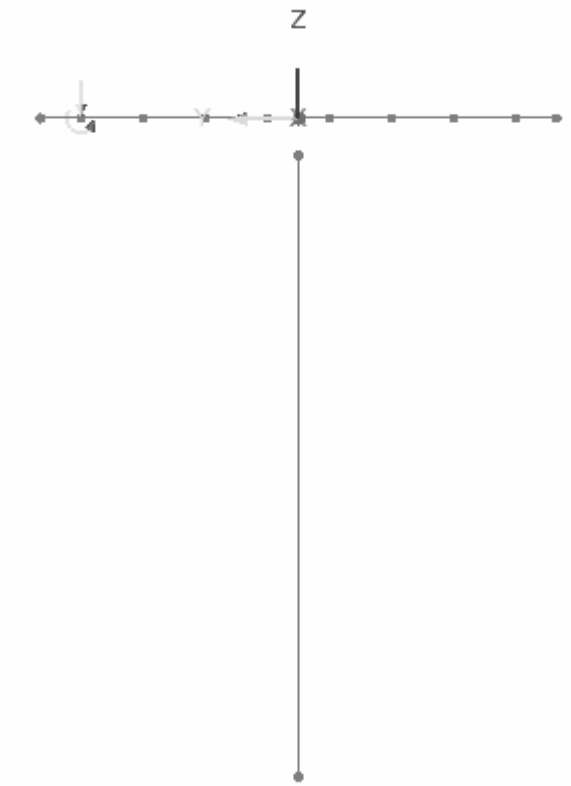
Structural loading : Global distributed

Load Z direction: -4 kN/m

Moment about X axis: -3 kN/m

Load case : EGEN 2

Loading assignment: Assign to lines (LB 1)

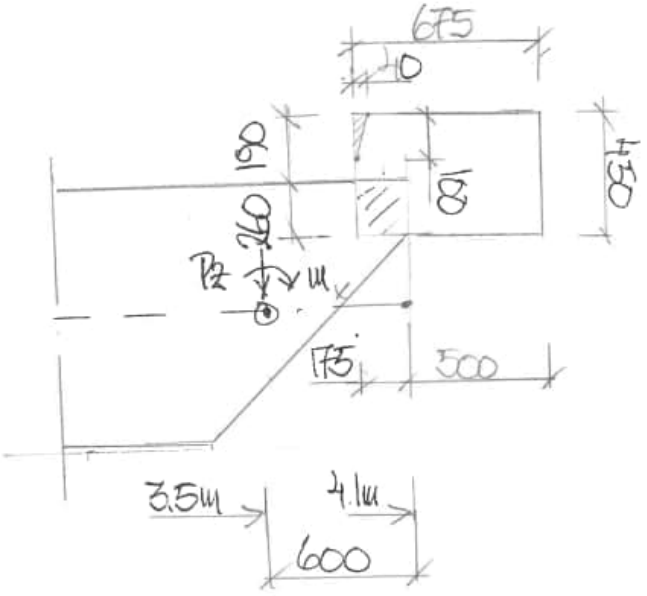


3.1.3 Edge beam: right side

The load belonging to the edge beam including the railing is applied as a line load along the longitudinal beam (LB 8) nearest the right side. The effect of eccentric load placement is accounted for by applying an equivalent line moment.

$$\rightarrow p_z = p_{KB} = (0.675m \cdot 0.45m - 0.175m \cdot 0.26m - 0.02m \cdot 0.10m) \cdot 24\frac{kN}{m^3} = -6\frac{kN}{m}\left(-4\frac{kN}{m}\right)$$

$$\rightarrow m_x = -p_z \cdot (0.6m + 0.25m) = 5\frac{kNm}{m}\left(3\frac{kNm}{m}\right)$$



Load : EGEN 3

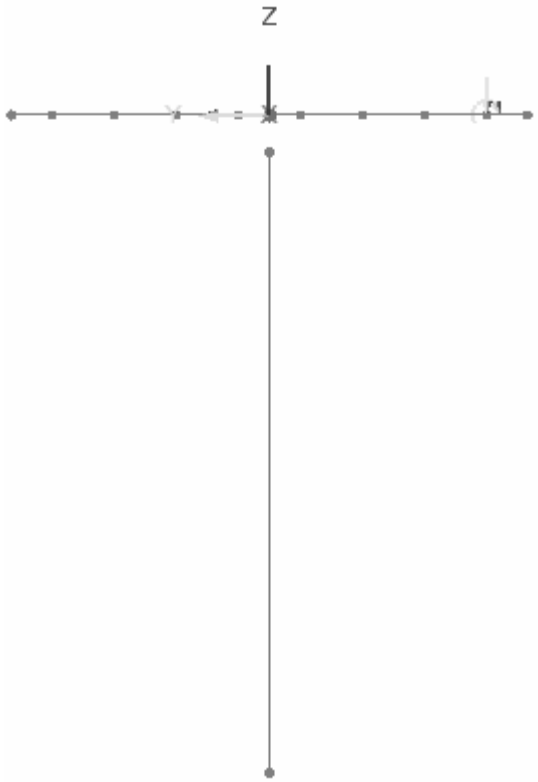
Structural loading : Global distributed

Load Z direction: -4 kN/m

Moment about X axis: +3 kN/m

Load case : EGEN 3

Loading assignment: Assign to lines (LB 8)



3.1.4 Load combinations

Load combination basis EGEN-E:
(Static system ”Analysis 1” → ”Analysis 8”)

Load case	Factor
EGEN 1-1	1.00
EGEN 2-1	1.00
EGEN 3-1	1.00
EGEN 1-2	1.00
EGEN 2-2	1.00
EGEN 3-2	1.00
EGEN 1-3	1.00
EGEN 2-3	1.00
EGEN 3-3	1.00
EGEN 1-4	1.00
EGEN 2-4	1.00
EGEN 3-4	1.00
EGEN 1-5	1.00
EGEN 2-5	1.00
EGEN 3-5	1.00
EGEN 1-6	1.00
EGEN 2-6	1.00
EGEN 3-6	1.00
EGEN 1-7	1.00
EGEN 2-7	1.00
EGEN 3-7	1.00
EGEN 1-8	1.00
EGEN 2-8	1.00
EGEN 3-8	1.00

Basic load combination EGEN-C:
(Static system ”Analysis 9”)

Load case	Factor
EGEN 1	1.00
EGEN 2	1.00
EGEN 3	1.00

Basic load combination EGEN :

Load case	Factor
EGEN-E	0.51
EGEN-C	0.49

3.2 SURFACING

Thickness pavement with a thickness of 90 mm is considered.

$$q_{beläggg} = \gamma_{beläggg} \cdot t = 22\frac{kN}{m^3} \cdot 0.09m = 1.8kPa \rightarrow p_z = q_{beläggg} \cdot b = 1.8kPa \cdot 1m = 1.8\frac{kN}{m}$$

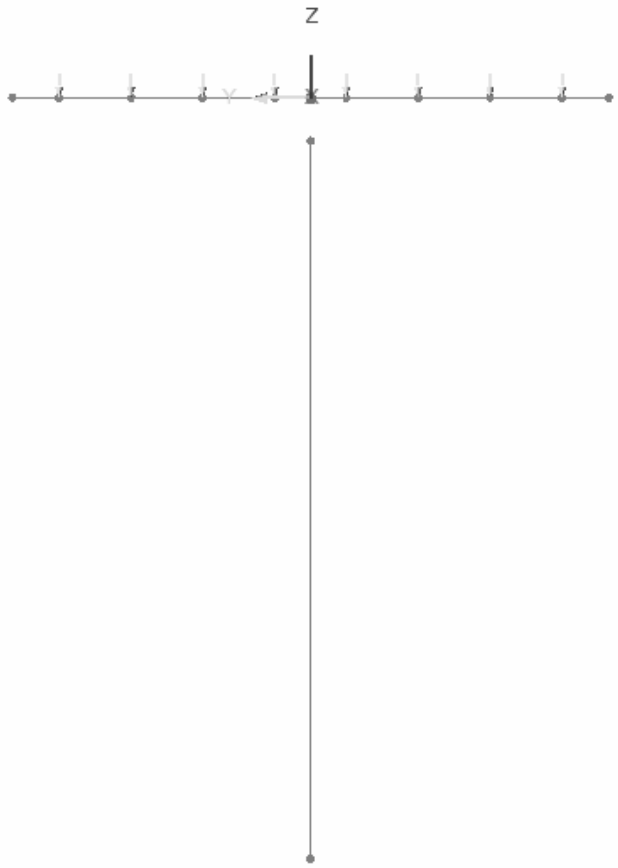
Load : SURFACE

Structural loading : Global distributed

Load Z direction: -1.8 kN/m

Load case : BELAGG

Loading assignment: Assign to lines



3.3 CREEP

Total creep is determined according to SS-EN 1992-1-1 §3.1.4 and TRVINFRA-00227 section 7.1.6.4 for RH 80% at time t_1.

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

$t_0 = 5\ days$

$t_2 = 120\ years$

Bridge consists of parts with different thicknesses as seen below.

The bridge beam has different widths at top and bottom. When determining creep, the average value is applied.

$$b = \frac{6.8m + 8.2m}{2} = 7.5\ m$$

Bridge deck (t = 1.0 m; b = 7.5 m):

$\phi(t_1 = 5days, t_0) = 0.40$

$\phi(t_2 = 120år, t_0) = 1.40$

$$\varepsilon_{cc}(t_1, t_0) = \phi(t_1, t_0) \cdot \frac{\sigma_c}{E_c}$$

To study the effect concrete stiffness according to SS-EN 1992-1-1 5.8.7 creep values seen below are used.

Load cases	φ
Permanent	1.4
Variable excluding temperature	0
Temperature	0.3*

* = According to Swedish work practice

$$E^{system} = \frac{E_{cm}}{1 + \phi}$$

Instead of adjusting E-modulus the load coefficients are adjusted.

$$f_{Shrinkage} = \frac{1}{1 + \varphi_{ef}} = \frac{1}{1 + 1.4} = 0.42$$

$$f_{Temp} = \frac{1}{1 + \varphi_{ef}} = \frac{1}{1 + 0.3} = 0.77$$

3.4 SHRINKAGE

Total shrinkage according to SS-EN 1992-1-1 §3.1.4 and TRVINFRA-00227 section 7.1.6.4 for RH 80% at time t_2.

Determination of load effect from shrinkage should consider the reduced concrete stiffness from creep.

$t_s = 0\ days$

$t_2 = 120\ years$

The bridge beam has different widths at top and bottom. When determining the cryptal, the average value is applied.

$$b = \frac{6.8m + 8.2m}{2} = 7.5\ m$$

Superstructure:
Shrinkage $\varepsilon_{cs} = 0.023\%$ is applied to all construction parts for safety. The movement corresponds to that which occurs due to an imaginary temperature load ∴ T = -23°C.

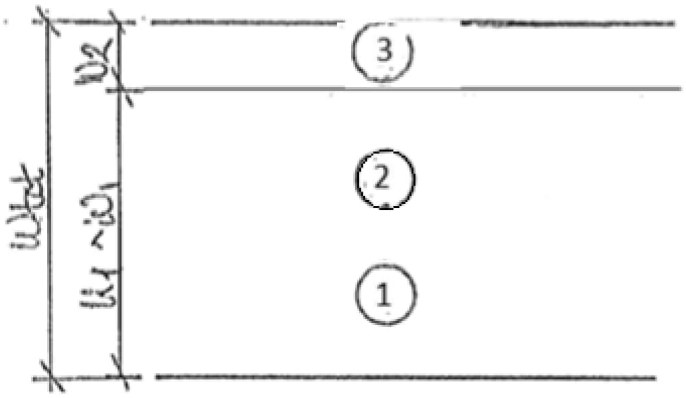
Remark
The existing static model causes negligible restraint forces to be considered as arising from shrinkage. This means that the load case is not introduced in the static model, but it is considered when determining long-term losses in prestressing reinforcement in the serviceability limit state.

3.5 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§.

3.5.1 Indelning av körbana i lastfält



Total traffic width : $w_{tot} = 8.0\,m$

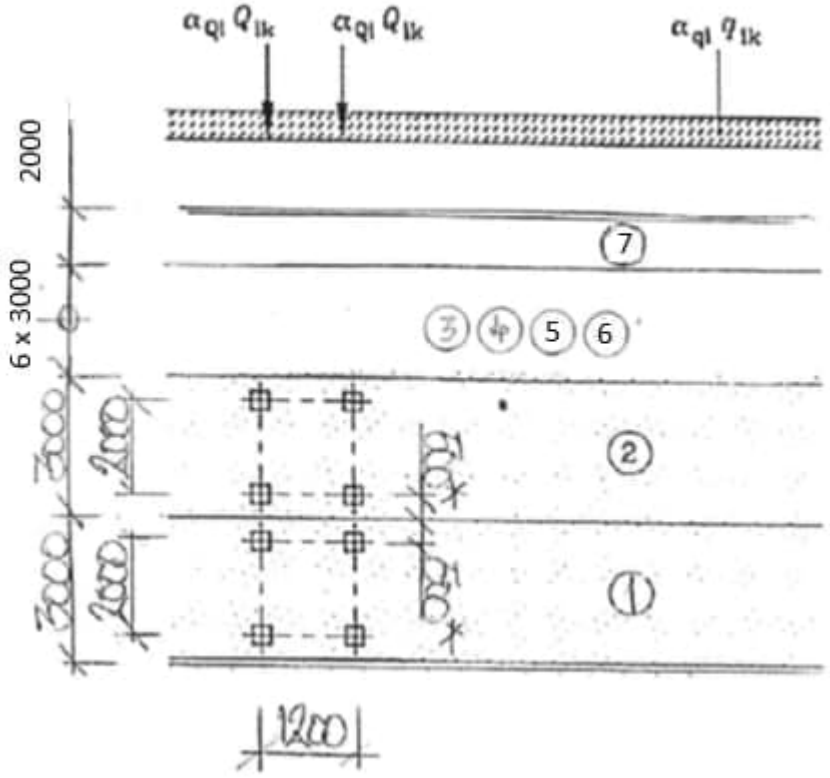
Number of traffic lanes : $n_1 = Integer\left[\frac{w_{tot}}{3.0m}\right] = 2\ lanes$

Full traffic width : $w_1 = 3.0m$

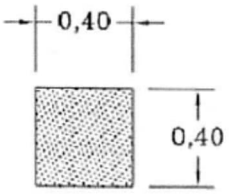
Remaining width : $w_2 = 2.0m$

3.5.2 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.



Axle loads:

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	100	0	0	No load
-	kN	-	kN	-

Surface loads:

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

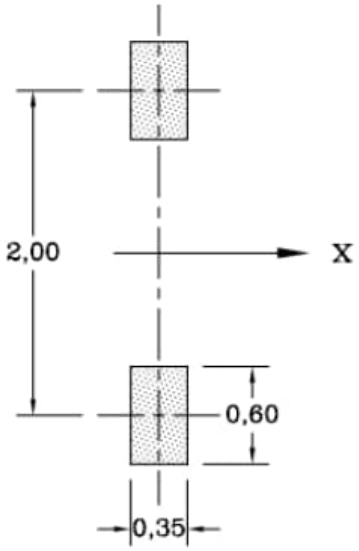
$q'_k = \alpha_q \cdot q_k$: characteristic value including national adaptation factor

Traffic lane	q_k	α_q	q'_k
1	9.0	0.8	7.2
2-3	2.5	1.0	2.5
-	kPa	-	kPa

Remark
Evaluation is performed using Vehicle Load Optimisation (VLO), see section 3.7.4.

3.5.3 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

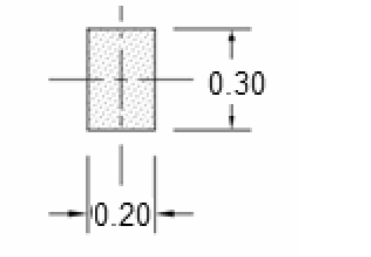
TSFS Chapter 11 Section 4 states that the same contact surface as LM 1 may be used.

3.5.4 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.)]

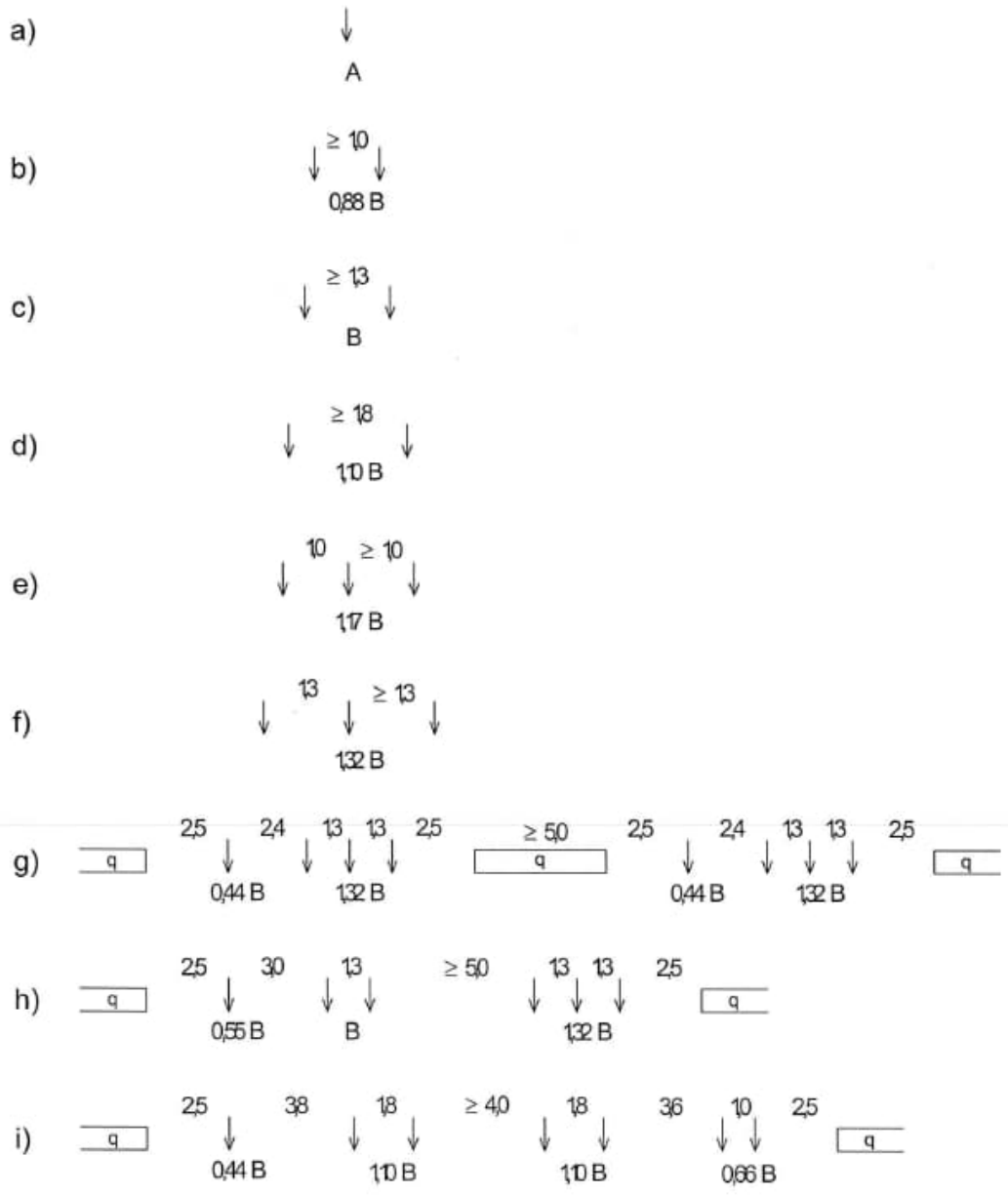
A´= A·(1 + ε_{dyn}) = 180 kN·(1+0.25) = 225 kN : single load including dynamic factor

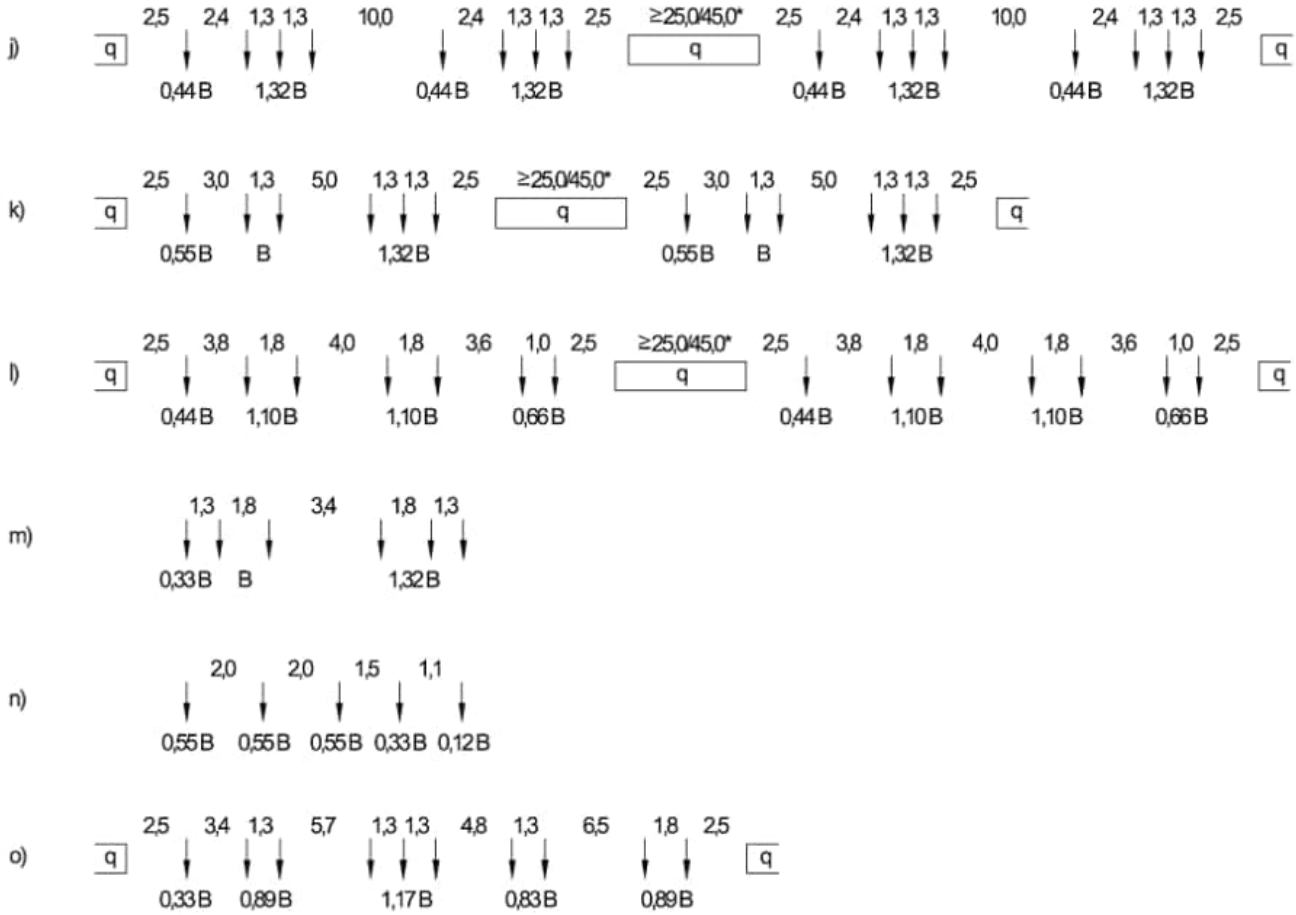
B´= B·(1 + ε_{dyn}) = 300 kN·(1+0.25) = 375 kN : tandem load including dynamic factor

$p = 5\frac{kN}{m}$: 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)





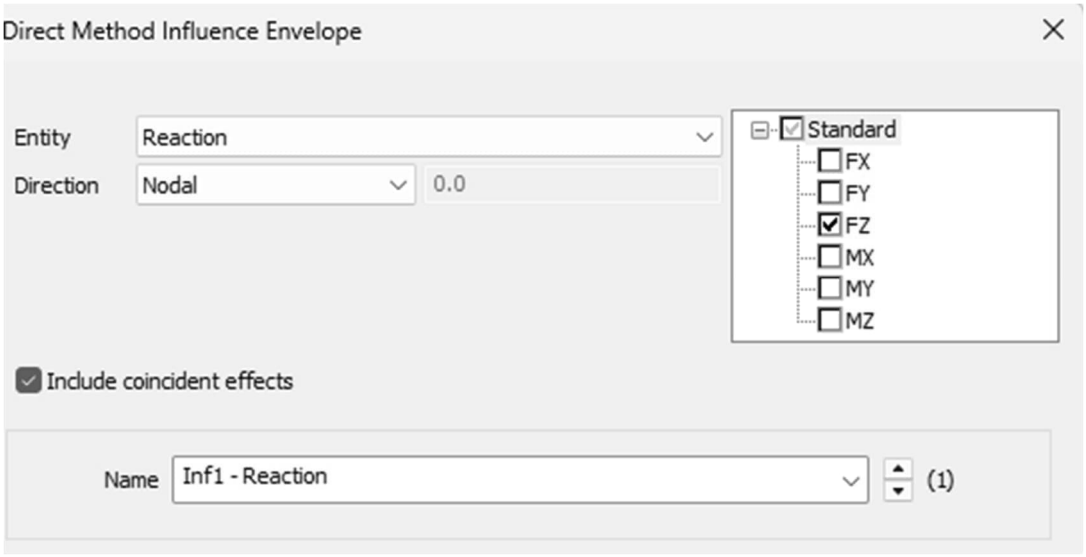
Note:
Evaluation is carried out with the script Vehicle Load Optimization (VLO), see sections 3.5.3 and 3.5.4.
Since there is no motorway, * = 45 m is applied according to TRVINFRA-00331 section 8.3.2.2.1 for vehicle types j, k, and l.

3.5.5 Vehicle Load Optimization (VLO)

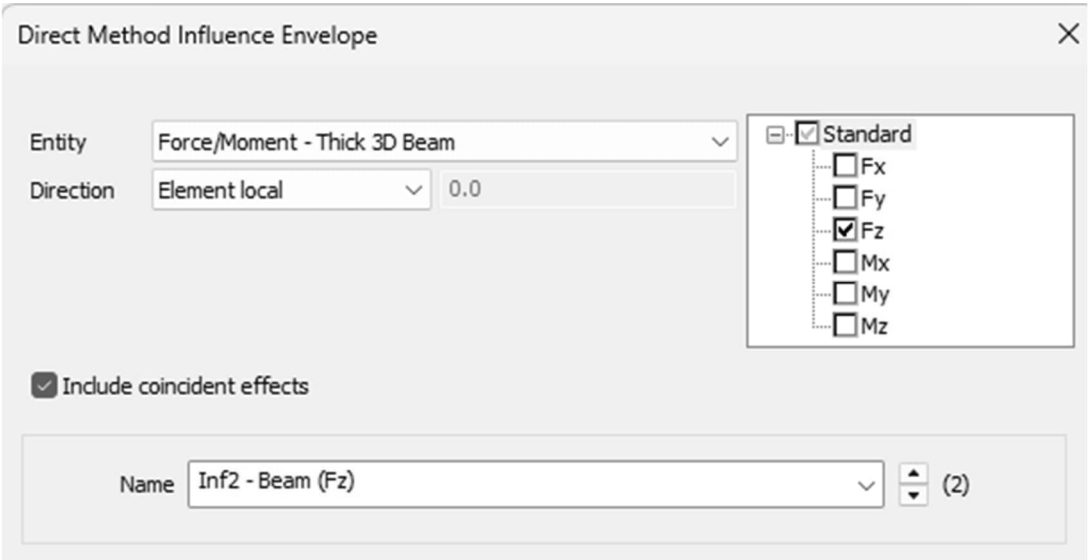
3.5.5.1 Influence components

Influence surfaces are created using *Direct Method Influence Envelope.* This is done by applying *Influence components* seen below.

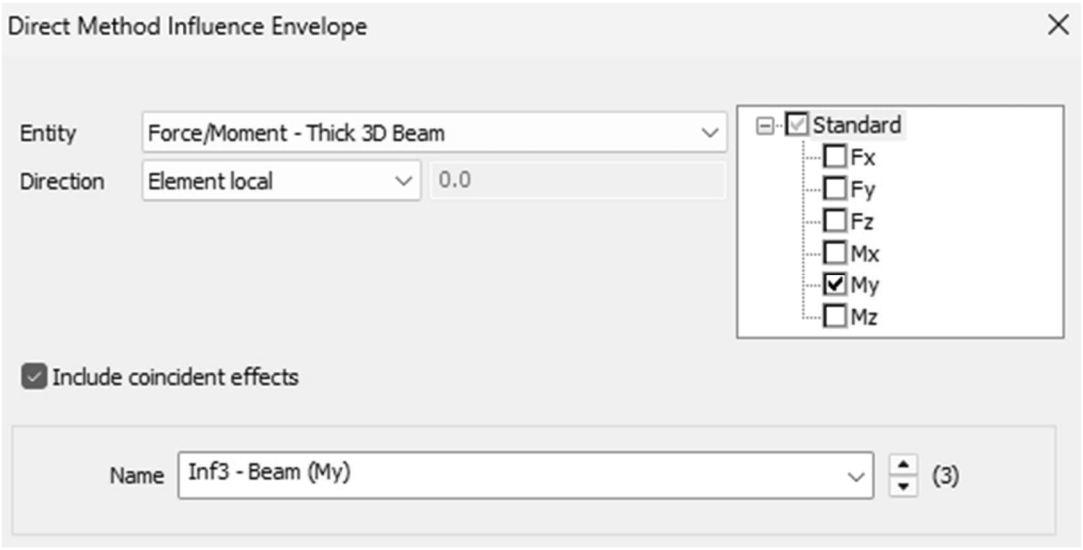
Inf1 – Reactions :



Inf2 – Beam (Fz):

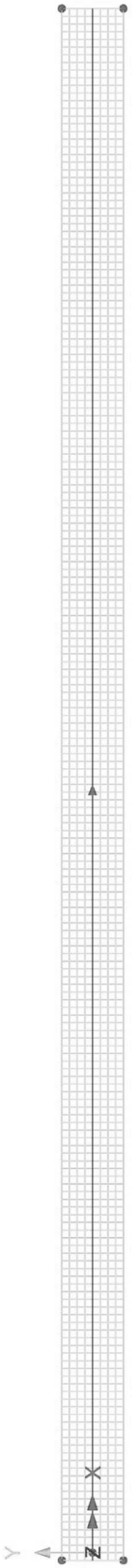


Inf3 – Beam (My):


Direct Method Influence Envelope
Entity
Force/Moment - Thick 3D Beam
Direction
Element local
0.0
Standard
Fx
Fy
Fz
Mx
My
Mz
Include coincident effects
Name
Inf3 - Beam (My)
(3)

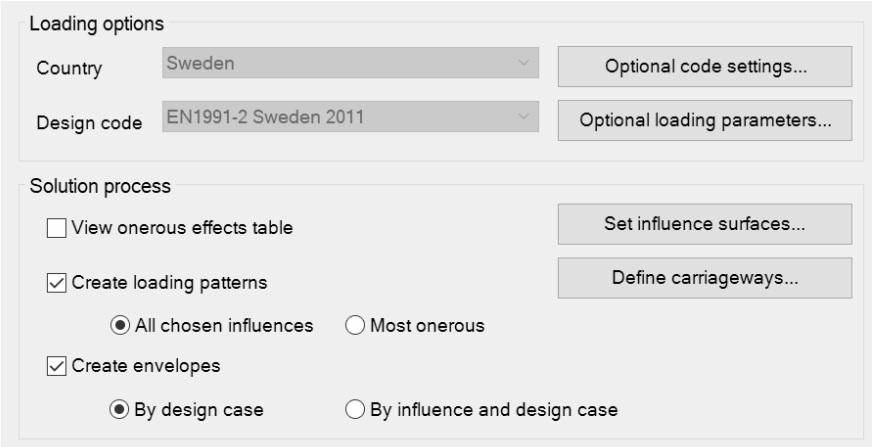
Influence surfaces :

Search area:	Superstructure
Definition type:	Grid
Path:	Centerline
Transverse width:	8.0 m
Longitudinal spacing:	0.5 m
Transversal spacing:	0.5 m

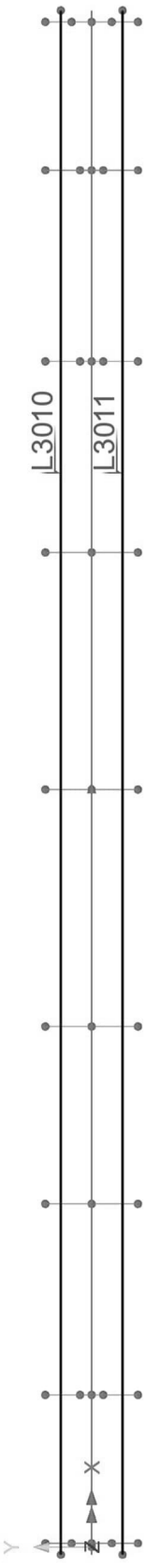


PLAN

Vehicle load optimisation options:



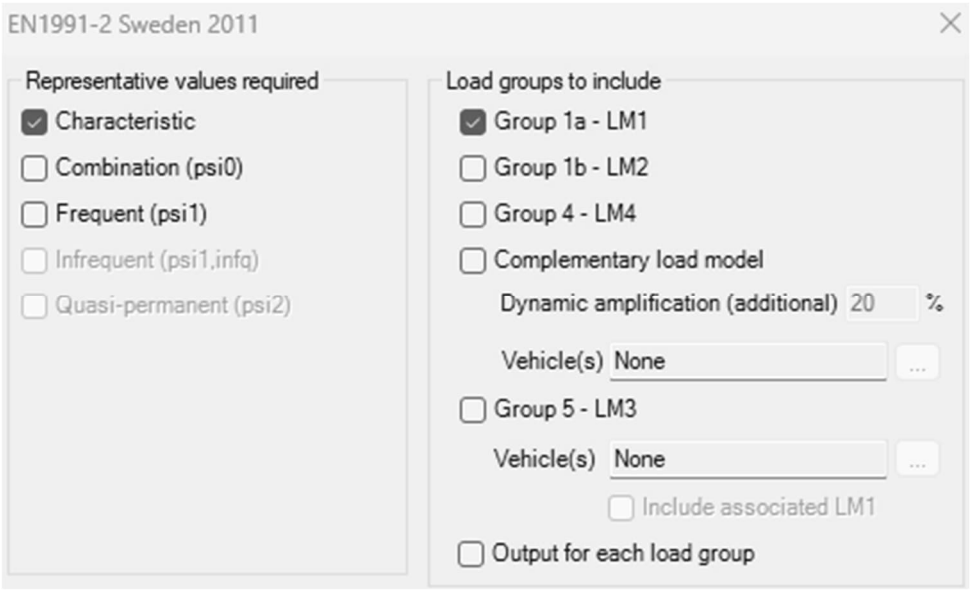
Vehicle longitudinal incremental movement:	0.50 m
Vehicle transverse incremental movement:	0.50 m
Vehicle direction:	both
Definition of carriageway (kerbs):	L3010 & L3011
Influence surfaces:	Include all (positive & negative)



PLAN

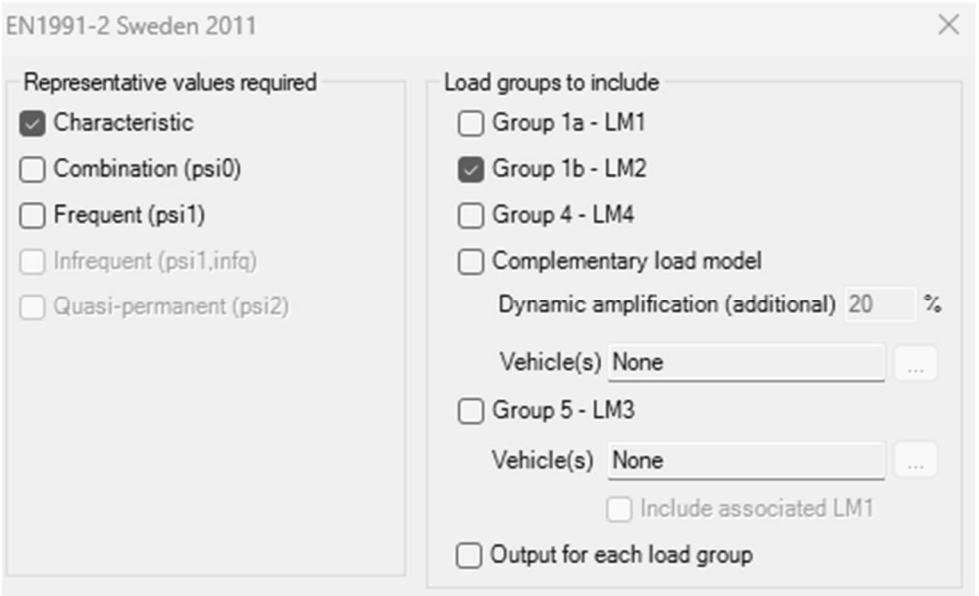
3.5.5.2 Envelope : LM 1

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



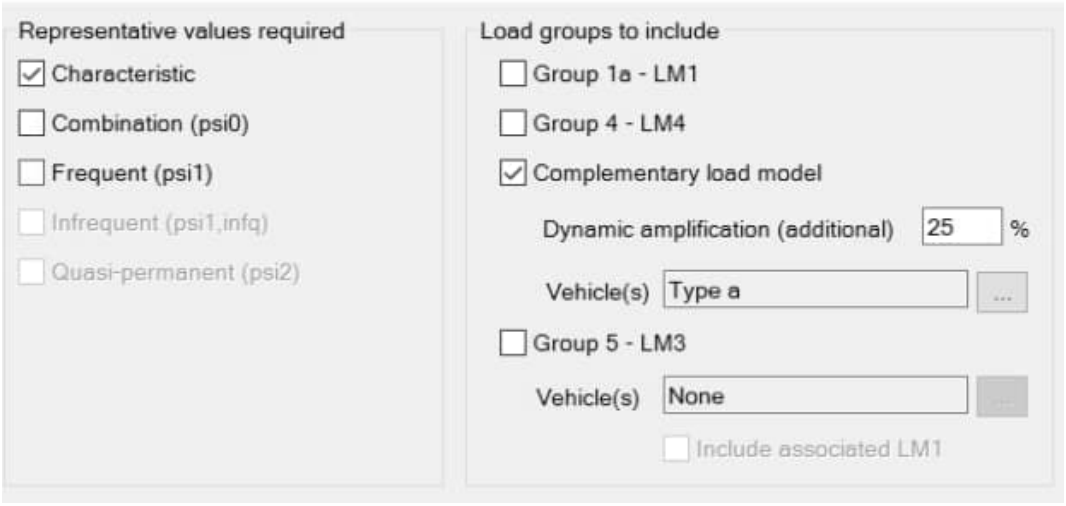
3.5.5.3 Envelope : LM 2

Load model 2 (LM2) defined in SS-EN 1991-2 section 4.3.3.



3.7.5.4 Envelope : EG A

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

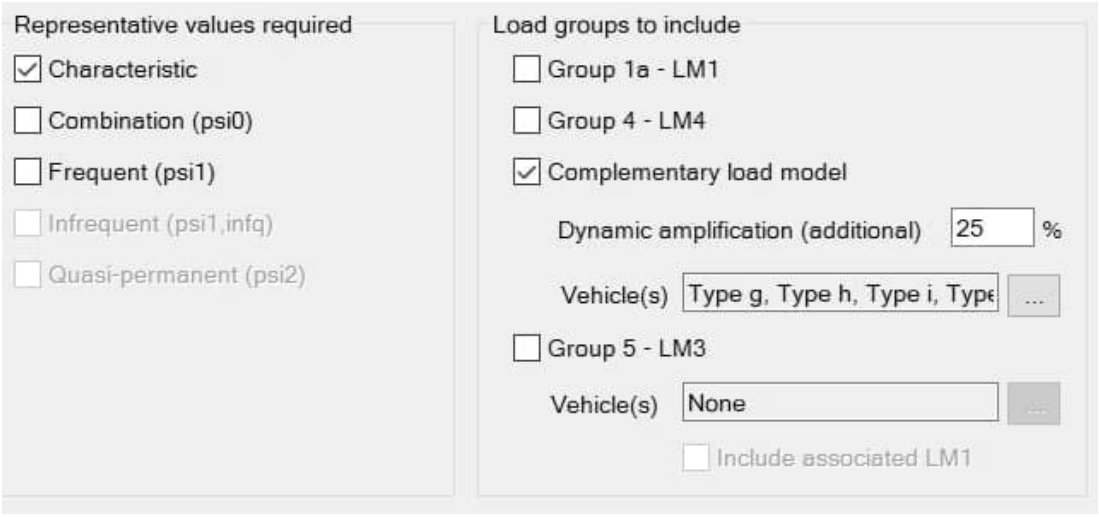


Dynamic amplification (additional): 25 %

Vehicle selection: Type a

3.5.5.5 Envelope : EG B

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



Dynamic amplification (additional): 25 %

Vehicle selection: Type b → o

3.5.5.6 Combined traffic load (TRAFIK)

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

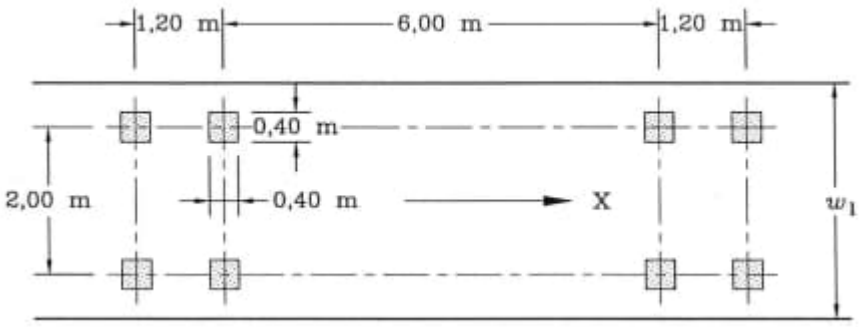
The envelope is used to identify the most onerous load effect.

Envelope TRAFIK :

Envelope
LM 1
LM 2
EG A
EG B

3.5.5.7 Fatigue model

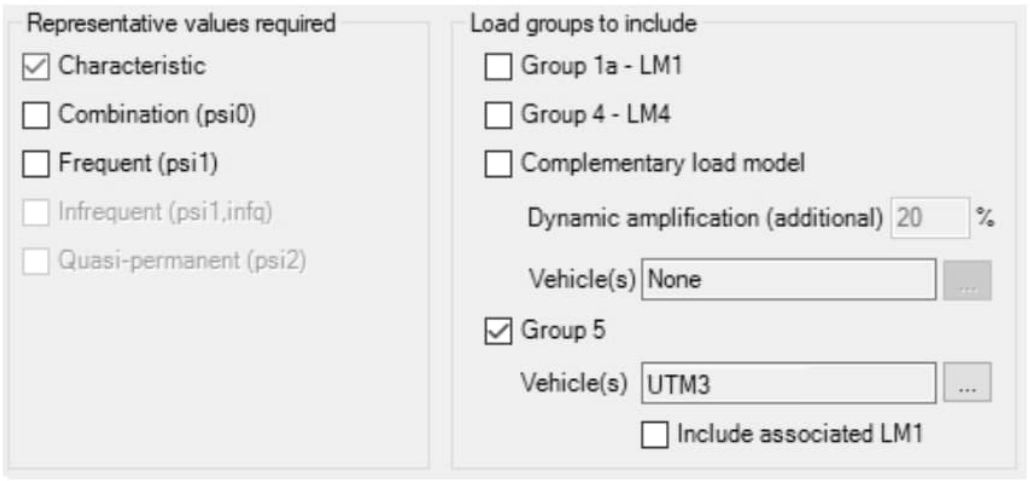
Fatigue model 3 (UTM3) defined in SS-EN 1991-2 section 4.6.4. The load is defined in Group 5 (special vehicle) in present version of software.

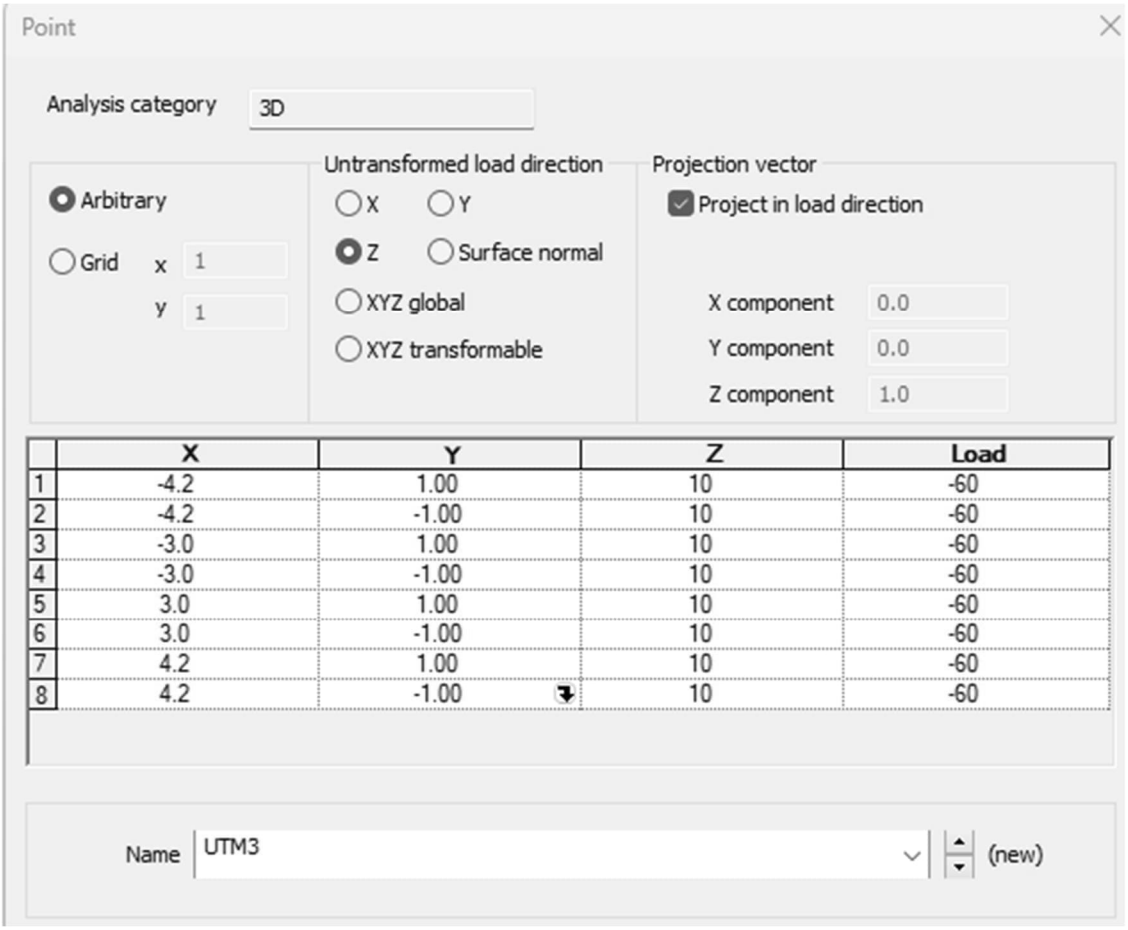


Q_k = 120 kN : characteristic value including nation adaptation factors.

The load definition:

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





	X	Y	Z	Load
1	-4.2	1.00	10	-60
2	-4.2	-1.00	10	-60
3	-3.0	1.00	10	-60
4	-3.0	-1.00	10	-60
5	3.0	1.00	10	-60
6	3.0	-1.00	10	-60
7	4.2	1.00	10	-60
8	4.2	-1.00	10	-60

3.6 BRAKING LAOD

Load acts at level of surfacing.

Braking load is defined by SS-EN 1991-2 §4.4.1.

Load acts at level of surfacing.

L = 19.1 m + 25.0m + 23.2 m + 31.0 m +31.0 m + 25.0 m + 25.0 m +19.1 m= 198.4 m

Load modell LM 1 :

$$Q_{lk} = 0.6\alpha_{Q1} \cdot (2Q_{ik}) + 0.1\alpha_{q1} \cdot q_{1k} \cdot w_1 \cdot L$$

$$180kN \cdot \alpha_{Q1} \leq Q_{lk} \leq 900kN$$

$$Q_{broms} = 0.6 \cdot (2 \cdot 270kN) + 0.1 \cdot 7.2kPa \cdot 3.0m \cdot 198.4m = 324\ kN + 429\ kN = 753\ kN$$

Load model EG B = 300 kN (see TSFS chapter 11 §2) :

Vehicule j.) is the heaviest with $\sum Q_{EG\ B} = 7.04B$.

$$Q_{lk} = 0.35 \cdot \sum Q_{EG\ B} + 0.1 \cdot p \cdot L_q$$

$$Q_{lk} \leq 500kN$$

$$Q_{broms} = 0.35 \cdot 7.04 \cdot 300kN + 0.1 \cdot 5\frac{kN}{m} \cdot (198.4\ m - 50.0m) = 739kN + 74kN = 813kN$$

Load definition in static model:

The load case is distributed from support 4-6 along longitudinal beams (LB 3 → LB 6).

Distance from support 4 to support 6 is L = 62 m.

$$p_x = \frac{1}{4} \cdot \frac{Q_{broms}}{L} = \frac{813kN}{4 \cdot 62.0m} = 3.3\frac{kN}{m}$$

$$m_y = p_x \cdot (0.50m + t_{bel}) = 3.3\frac{kN}{m} \cdot (0.5m + 0.09m) = 1.9\frac{kN}{m}$$

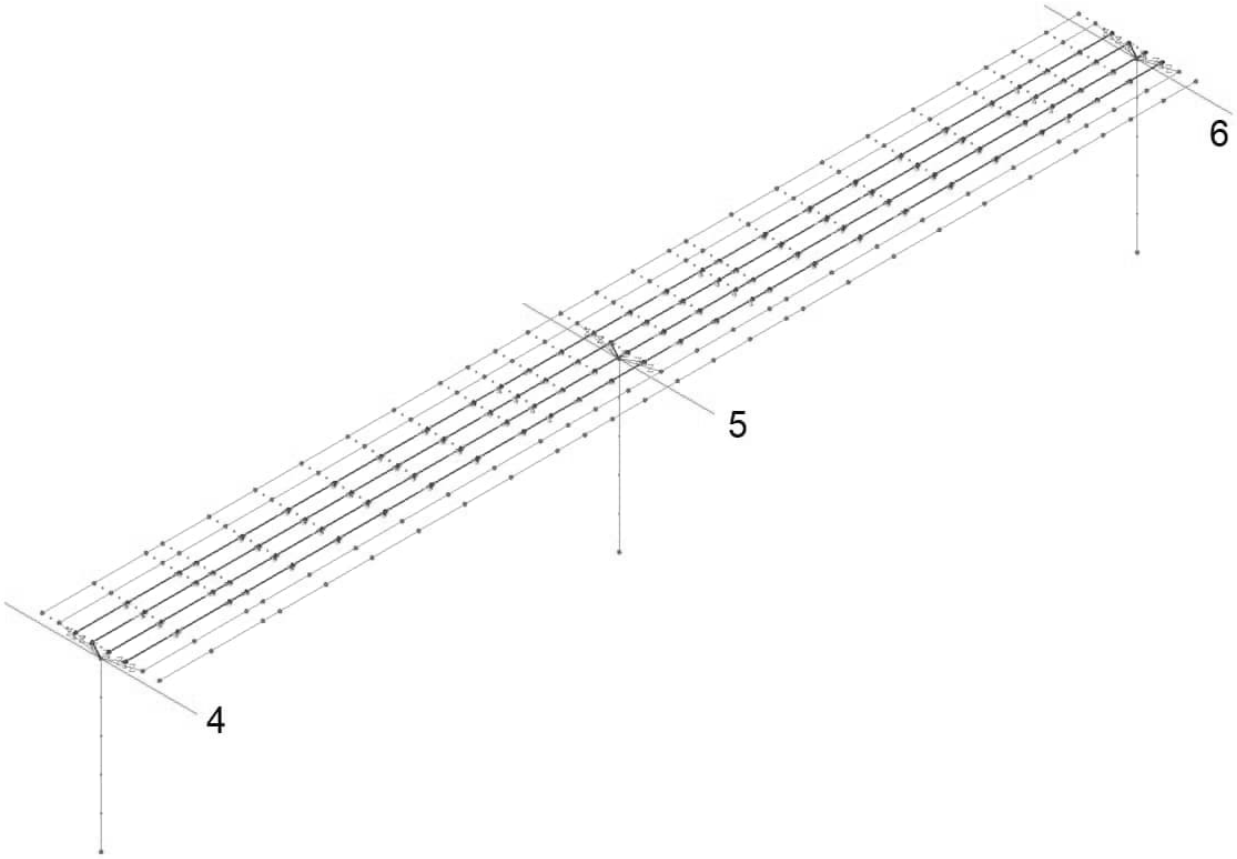
Load case : BROMS+

Structural loading : Global distributed

Load X direction: +3.3 kN/m

Moment about Y axis: +1.9 kNm/m

Loading assignment: Assign to lines



3.7 TEMPERATURE

The effect of temperature shall be considered in the serviceability limit state according to SS-EN 1992-1-1 §2.3.1.2.

Location: Bollnäs → T_0 (-) = -22°C

Maximum temperature: T+ = +25°C

Minimum temperature: T- = T_0 (-) = -38°C

Inspection shows that the effect of uneven temperature change does not need to be considered.

The static system causes only movement due to uniform temperature change in the longitudinal direction.

No restraint forces are considered to occur, thus load case is ignored in static model.

3.8 PRESTRESS

Analysis of pre tensioned cable is studied at times : t_0 (5 days), t_1(30 days) and t_2 (120 years).

Initial prestress loss at time t_0 is only due to friction.

Determination of time loses (η_t) is made in separate program. Preliminary analysis will use losses seen below.

Time	η_t	Load combination	Load case
t0	0 %	PT-T0	1.00 x PT-T0
t1	6 %	PT-T1	0.95 x PT-T0
t2	16 %	PT-T2	0.85 x PT-T0

3.8.1 General

Vid bestämning av uppspänningsförluster tillämpas μ = 0.25 och k = 0.0030.
Materialegenskaper enligt nedan tillämpas vid bärighetsberäkning.

Material VSL 12ϕ13:

$f_{p0.2k} = 1600MPa$: stress at elongation 0.2 %

$f_{pk} = 1800MPa$: ultimate stress

$E_{sk} = 200GPa$: E-modulus

$A_p = 12 \cdot 93mm^2 = 1110mm^2$: cabel area

$F_u = 1110mm^2 \cdot 1800MPa = 2000kN$: ultimate load

Slip during locking:
4 mm

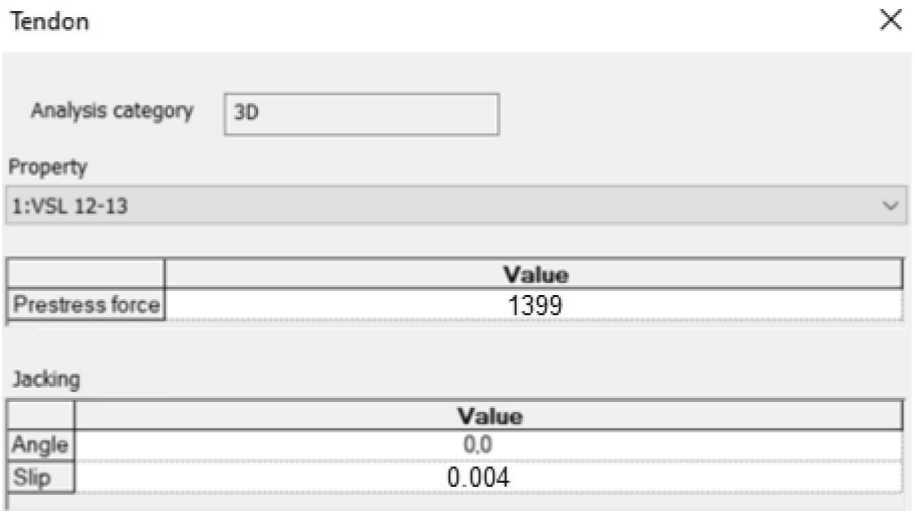
Permissible stress before locking :
See SS-EN 1992-1-1 section 5.10.2.1

$\sigma_{p,max}^{före} = 1260MPa \rightarrow P_{före} = 1260MPa \cdot 1110mm^2 = 1399kN$

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

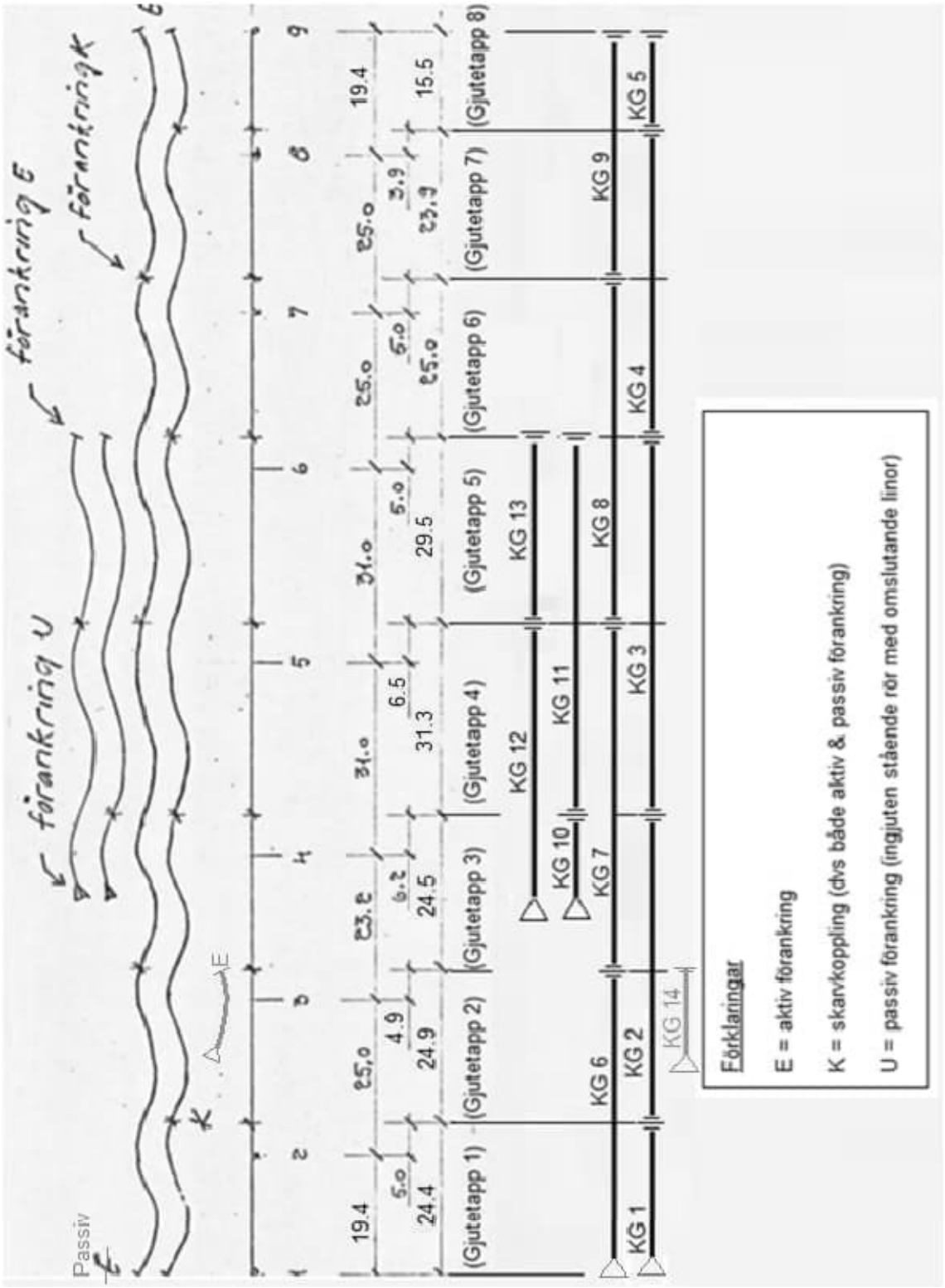
$\sigma_{p,max}^{efter} = 1170MPa \rightarrow P_{efter} = 1170MPa \cdot 1110mm^2 = 1299kN$

Prestress force and slip are applied at active anchors according to the presentation below.



3.8.2 Cabel position: theoretical

Overview of cable routing for all cast stages according to the figure below.



ELEVATION

Cabel positions:

Nr.	KG1	KG2		KG3		KG4		KG5
1	112	212	312	412	512	612	712	812
2	132	232	332	432	532	632	732	832
3	141	241	341	441	541	641	741	841
4	151	251	351	451	551	651	751	851
5	162	262	362	462	562	662	762	862
6	171	271	371	471	571	671	771	871
7	181	281	381	481	581	681	781	881
8	182	282	382	482	582	682	782	882

Nr.	KG 6		KG 7		KG 8		KG 9	
9	111	211	311	411	511	611	711	811
10	121	221	321	421	521	621	721	821
11	122	222	322	422	522	622	722	822
12	131	231	331	431	531	631	731	831
13	142	242	342	442	542	642	742	842
14	152	252	352	452	552	652	752	852
15	161	261	361	461	561	661	761	861
16	172	272	372	472	572	672	772	872

Nr.	KG 10	KG 11	
17	313	413	513
18	333	433	533
19	353	453	553
20	363	463	563
21	383	483	583

Nr.	KG 12		KG 13		KG 14
22	323	423	523	623	223
23	334	434	534	634	253
24	343	443	543	643	273
25	364	464	564	664	-
26	373	473	573	673	-

Explanations:

y(+) : distance from center of individual cable to bottom of beam

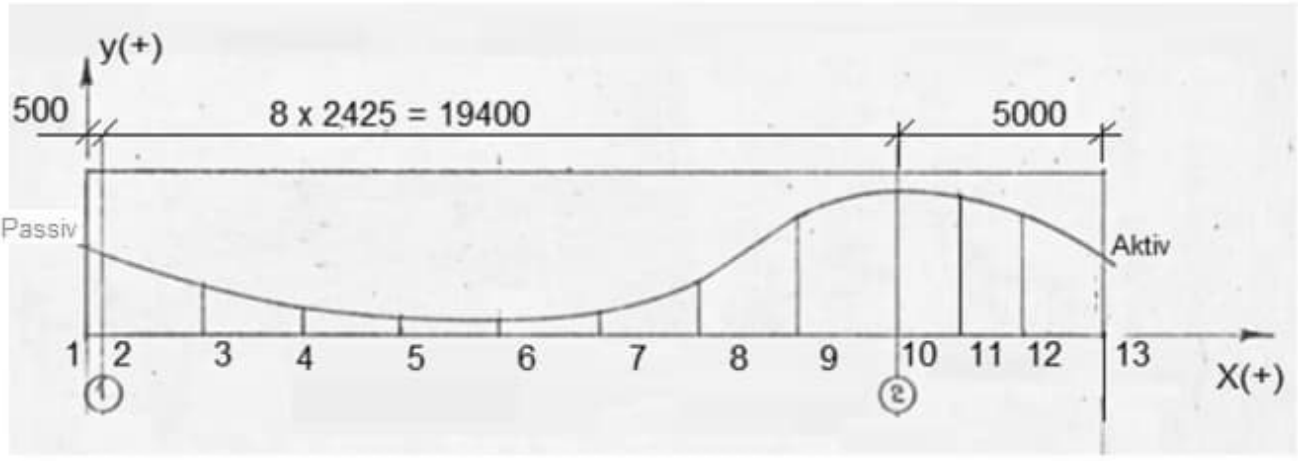
ymed (+) : distance from center of average location of cabel group to bottom of beam

Casting stage 1: KG 1 – 8 cables

						K 112 K 182	K 132 K 162	K 141 K 151 K 171	K 181	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	0,500	-	1	0,200	0	810	660	360	210	529
1:V		-	2	0,500	0,300	761	633	363	235	514
1:H	19,400	2,425	2	0,500	0	761	633	363	235	514
-		-	-	1,712	1,212	565	525	375	335	455
-		2,425	3	2,925	2,425	435	435	365	365	400
-		2,425	4	5,350	4,850	300	300	300	300	300
-		2,425	5	7,775	7,275	220	220	220	220	220
-		2,425	6	10,200	9,700	200	200	0	200	200
-		2,425	7	12,625	12,125	270	270	270	270	270
-		2,425	8	15,050	14,550	400	400	400	400	400
-		2,425	9	17,475	16,975	660	660	660	660	660
2:V		2,425	10	19,900	19,400	890	890	890	890	890
2:H	5,000	-	10	19,900	0	890	890	890	890	890
-		1,562	11	21,462	1,562	840	840	740	740	790
-		1,563	12	23,025	3,125	750	750	550	550	650
-		1,875	13	24,900	5,000	630	630	330	330	480
-	m	m	-	m	m	mm	mm	mm	mm	mm

Manual verification:

$$y_{med}(+) = \frac{761mm \cdot 2 + 633mm \cdot 2 + 363mm \cdot 3 + 235mm \cdot 1}{8} = 514mm$$



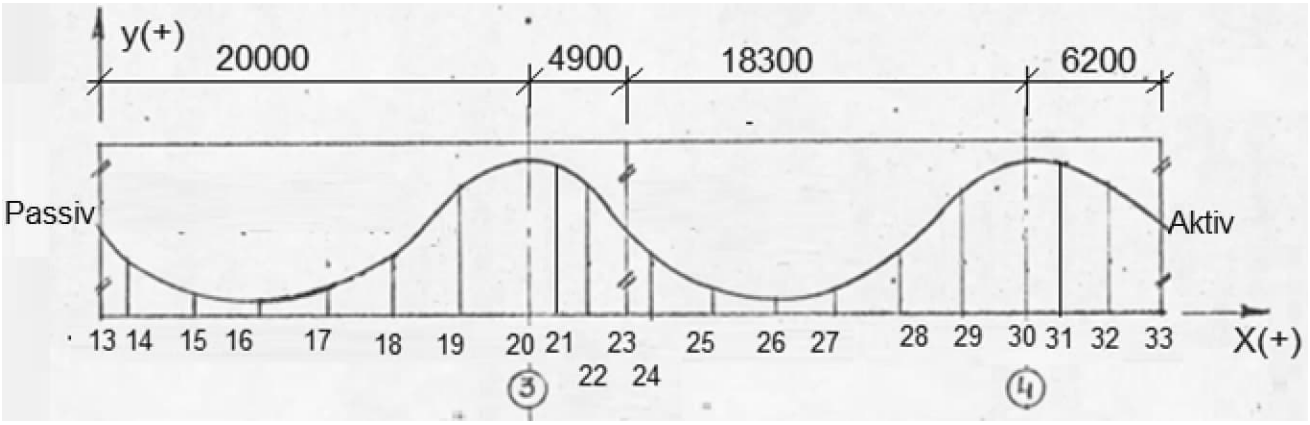
ELEVATION

Casting stage → 3: KG 2 – 8 cables

						K 212/312 K 232/332 K 262/362 K 282/382	K 241/341 K 251/351 K 271/371	K 281/381	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	20,000	-	13	24,900	0	630	330	330	480
-		1,250	14	26,150	1,250	505	235	235	370
-		3,125	15	29,275	4,375	170	170	170	170
-		3,125	16	32,400	7,500	90	90	90	90
-		3,125	17	35,525	10,625	170	170	170	170
-		3,125	18	38,650	13,750	380	380	380	380
-		3,125	19	41,775	16,875	650	650	650	650
3:V		3,125	20	44,900	20,000	860	840	840	850
3:H	4,900	-	20	44,900	0	860	840	840	850
-		1,450	21	46,350	1,450	810	650	650	730
-		1,450	22	47,800	2,900	750	450	450	600
-		2,000	23	49,800	4,900	570	270	270	420
-	18,300	-	23	49,800	0	570	270	270	420
-		0,900	24	50,700	0,900	440	240	240	340
-		2,900	25	53,600	3,800	210	190	190	200
-		2,900	26	56,500	6,700	150	150	150	150
-		2,900	27	59,400	9,600	250	250	250	250
-		2,900	28	62,300	12,500	500	500	500	500
-		2,900	29	65,200	15,400	770	770	770	770
4:V		2,900	30	68,100	18,300	910	910	910	910
4:H	6,200	-	30	68,100	0	910	910	910	910
-		1,937	31	70,037	1,937	850	850	850	850
-		1,938	32	71,975	3,875	740	740	685	733
-		2,325	33	74,300	6,200	600	600	475	584
-	m	m	-	m	m	mm	mm	mm	mm

Manual verification:

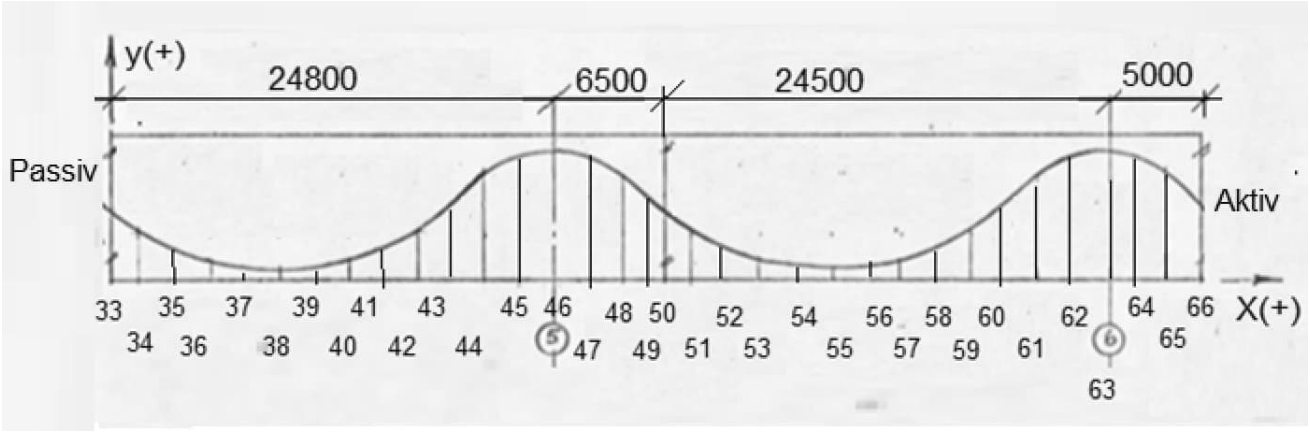
$$y_{med}(+) = \frac{600mm \cdot 4 + 600mm \cdot 3 + 475mm \cdot 1}{8} = 584mm$$


y(+)
20000
4900
18300
6200
Passiv
Aktiv
13 14 15 16 17 18 19 20 21 23 25 26 27 28 29 30 31 32 33
X(+)
22 24
3
4

ELEVATION

Casting stage 4 → 5: KG 3 – 8 cables

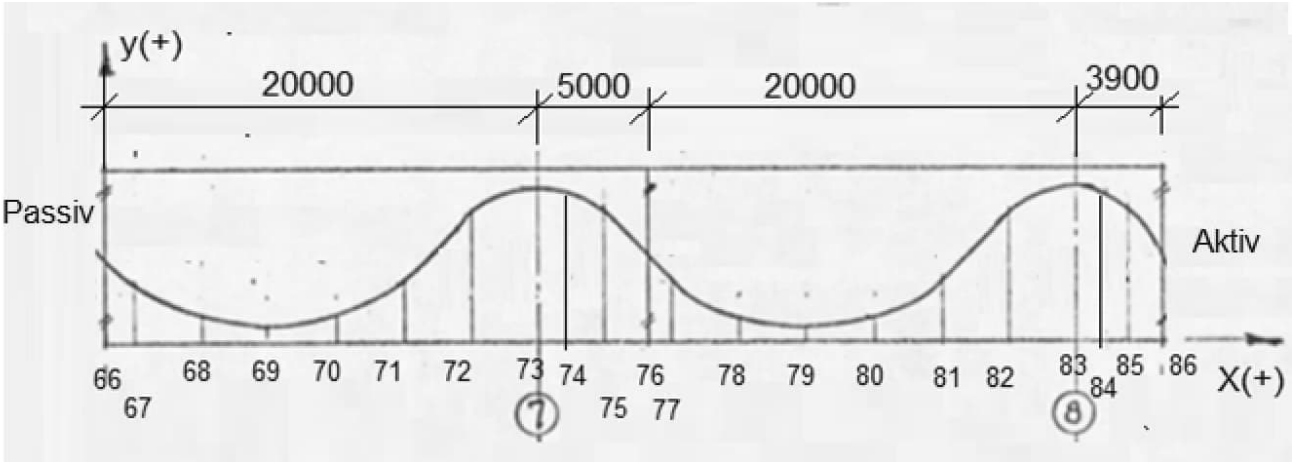
						K 441/541 K 432/532 K 471/571 K 462/562 K 451/551	K 482/582 K 412/512	K 481/K581	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	24,800	-	33	74,300	0	600	600	475	584
-		1,550	34	75,850	1,550	520	450	380	485
-		1,938	35	77,788	3,488	420	260	300	365
-		1,938	36	79,725	5,425	325	250	130	282
-		1,938	37	81,663	7,363	245	110	220	208
-		1,938	38	83,600	9,300	185	80	185	159
-		1,938	39	85,538	11,238	185	80	185	159
-		1,938	40	87,475	13,175	210	150	210	195
-		1,938	41	89,413	15,113	290	285	290	289
-		1,938	42	91,350	17,050	430	430	430	430
-		1,938	43	93,288	18,988	550	550	550	550
-		1,938	44	95,225	20,925	670	670	670	670
-		1,938	45	97,163	22,863	810	810	810	810
5:V		1,938	46	99,100	24,800	900	900	900	900
5:H	6,500	-	46	99,100	0	900	900	900	900
-		1,937	47	101,037	1,937	820	820	820	820
-		1,938	48	102,975	3,875	720	720	670	714
-		1,937	49	104,912	5,812	620	620	500	605
-		0,688	50	105,600	6,500	585	585	460	569
-	24,500	-	50	105,600	0	585	585	460	569
-		1,250	51	106,850	1,250	515	475	475	500
-		1,938	52	108,788	3,188	380	280	280	343
-		1,938	53	110,725	5,125	265	100	100	203
-		1,938	54	112,663	7,063	210	80	80	161
-		1,938	55	114,600	9,000	185	80	185	159
-		1,938	56	116,538	10,938	240	110	240	208
-		1,938	57	118,475	12,875	295	140	295	256
-		1,938	58	120,413	14,813	350	230	350	320
-		1,938	59	122,350	16,750	440	380	440	425
-		1,938	60	124,288	18,688	550	550	550	550
-		1,938	61	126,225	20,625	670	670	670	670
-		1,938	62	128,163	22,563	785	785	785	785
6:V		1,938	63	130,100	24,500	880	880	880	880
6:H	5,000	-	63	130,100	0	880	880	880	880
-		1,562	64	131,662	1,562	870	870	870	870
-		1,563	65	133,225	3,125	870	870	870	870
-		1,875	66	135,100	5,000	760	760	680	750
-	m	m	-	m	m	mm	mm	mm	mm


y(+)
24800
6500
24500
5000
Passiv
Aktiv
X(+)
33 35 37 39 41 43 45 46 48 50 52 54 56 58 60 62 64 66
34 36 38 40 42 44 47 49 51 53 55 57 59 61 63 65

ELEVATION

Casting stage 6 → 7: KG 4 – 8 cables

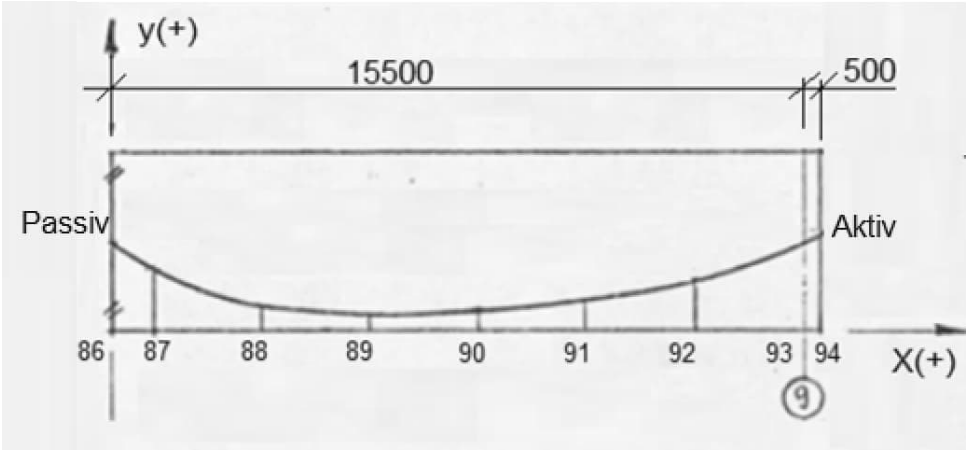
						K 612/712 K 632/732 K 662/762 K 682/782	K 641/741 K 651/751 K 671/771	K 681/K781	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	20,000	-	66	135,100	0	760	760	680	750
-		1,250	67	136,350	1,250	555	555	460	543
-		3,125	68	139,475	4,375	250	250	250	250
-		3,125	69	142,600	7,500	150	150	150	150
-		3,125	70	145,725	10,625	200	200	200	200
-		3,125	71	148,850	13,750	340	340	340	340
-		3,125	72	151,975	16,875	600	600	600	600
7:V		3,125	73	155,100	20,000	870	870	870	870
7:H	5,000	-	73	155,100	0	870	870	870	870
-		1,562	74	156,662	1,562	740	855	855	798
-		1,563	75	158,225	3,125	510	790	790	650
-		1,875	76	160,100	5,000	340	640	640	490
-	20,000	-	76	160,100	0	340	640	640	490
-		1,250	77	161,350	1,250	270	490	490	380
-		3,125	78	164,475	4,375	170	170	170	170
-		3,125	79	167,600	7,500	90	90	90	90
-		3,125	80	170,725	10,625	170	170	170	170
-		3,125	81	173,850	13,750	370	370	370	370
-		3,125	82	176,975	16,875	650	650	650	650
8:V		3,125	83	180,100	20,000	850	850	850	850
8:H	3,900	-	83	180,100	0	850	850	850	850
-		1,218	84	181,318	1,218	850	750	750	800
-		1,219	85	182,537	2,437	810	510	510	660
		1,463	86	184,000	3,900	655	355	355	505
-	m	m	-	m	m	mm	mm	mm	mm


y(+)
20000
5000
20000
3900
Passiv
Aktiv
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
82
83
84
85
86
X(+)
7
8

ELEVATION

Casting stage 8: KG 5 – 8 cables

						K 812 K 832 K 862 K 882	K 841 K 851 K 871	K 881	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	15,500	-	86	184,000	0	655	355	355	505
-		0,975	87	184,975	0,975	475	325	325	400
-		2,421	88	187,396	3,396	275	265	265	270
-		2,421	89	189,817	5,817	200	200	200	200
-		2,421	90	192,237	8,237	220	220	220	220
-		2,421	91	194,658	10,658	300	300	300	300
-		2,421	92	197,079	13,079	400	400	400	400
9:V		2,421	93	199,500	15,500	630	380	380	505
9:H	0,500	-	93	199,500	0	630	380	380	505
		0,300	94	199,800	0,300	660	360	360	510
-	m	m	-	m	m	mm	mm	mm	mm



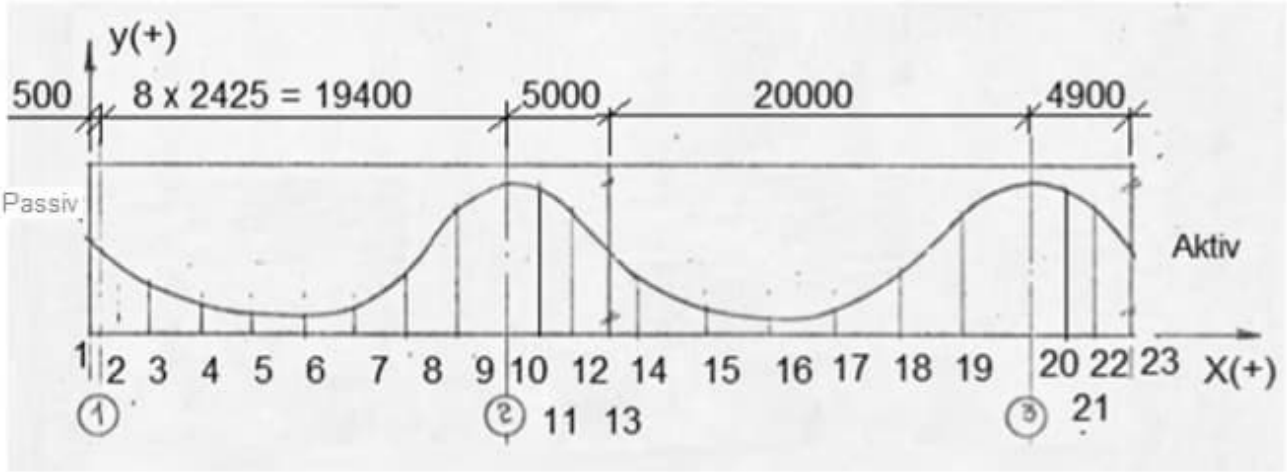
ELEVATION

Casting stage 1 → 2: KG 6 – 8 cables

						K 122/222 K 142/242 K 152/252 K 172/272	K 121/221 K 131/231 K 161/261	K 111/211	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	0,500	-	1	0,200	0	660	360	210	491
1:V		-	2	0,500	0,300	633	363	235	482
1:H	19,400	2,425	2	0,500	0	633	363	235	482
-		-	-	1,712	1,212	525	375	335	445
-		2,425	3	2,925	2,425	435	365	365	400
-		2,425	4	5,350	4,850	300	300	300	300
-		2,425	5	7,775	7,275	220	220	220	220
-		2,425	6	10,200	9,700	200	200	200	200
-		2,425	7	12,625	12,125	270	270	270	270
-		2,425	8	15,050	14,550	400	400	400	400
-		2,425	9	17,475	16,975	660	660	660	660
2:V		2,425	10	19,900	19,400	890	890	890	890
2:H	5,000	-	10	19,900	0	890	890	890	890
-		1,562	11	21,462	1,562	840	740	740	790
-		1,563	12	23,025	3,125	750	550	550	650
-		1,875	13	24,900	5,000	630	330	330	480
-	20,000	-	13	24,900	0	630	330	330	480
-		1,250	14	26,150	1,250	505	235	235	370
-		3,125	15	29,275	4,375	170	170	170	170
-		3,125	16	32,400	7,500	90	90	90	90
-		3,125	17	35,525	10,625	170	170	170	170
-		3,125	18	38,650	13,750	380	380	380	380
-		3,125	19	41,775	16,875	650	650	650	650
3:V		3,125	20	44,900	20,000	860	840	840	850
3:H	4,900	-	20	44,900	0	860	840	840	850
-		1,450	21	46,350	1,450	810	650	650	730
-		1,450	22	47,800	2,900	750	450	450	600
-		2,000	23	49,800	4,900	570	270	270	420
-	m	m	-	m	m	mm	mm	mm	mm

Manual verification:

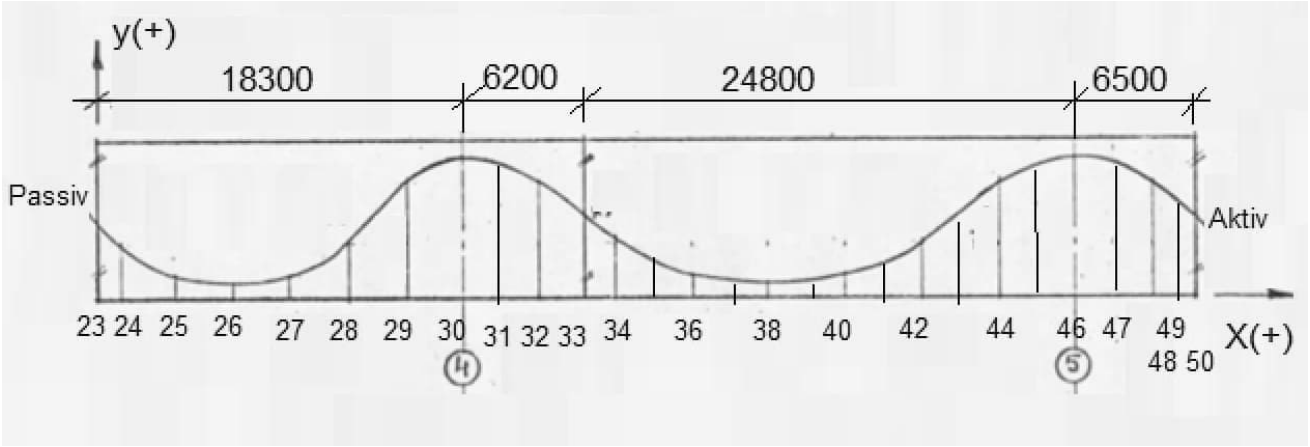
$$y_{med}(+) = \frac{810mm \cdot 4 + 650mm \cdot 3 + 650mm \cdot 1}{8} = 730mm$$


y(+)
500
8 x 2425 = 19400
5000
20000
4900
Passiv
Aktiv
1 2 3 4 5 6 7 8 9 10 12 14 15 16 17 18 19 20 22 23 X(+)
1
2
11 13
3
21

ELEVATION

Casting stage 3 → 4: KG 7 – 8 cables

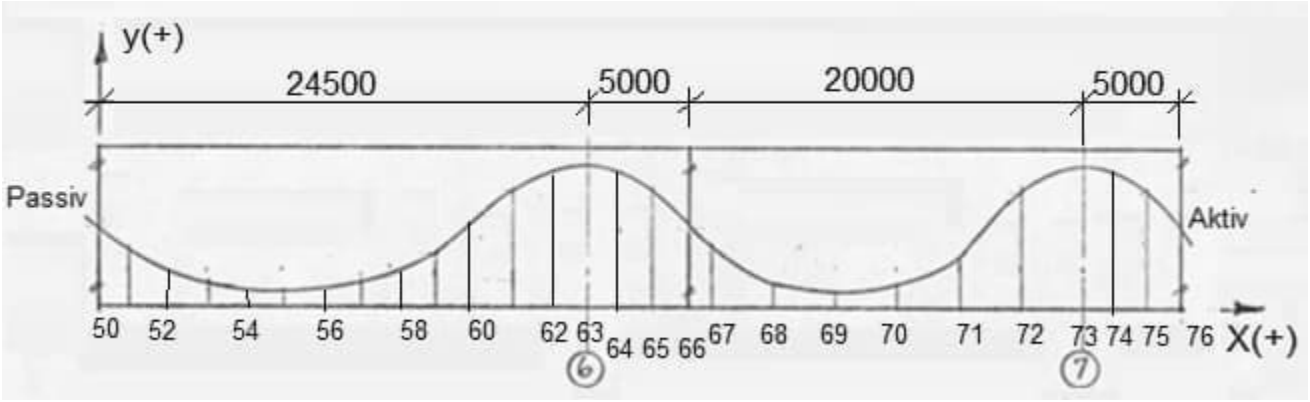
						K 322/422 K 342/442 K 352/452 K 372/472	K 321/421 K 331/431 K 361/461	K 311/411	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	18,300	-	23	49,800	0	570	270	270	420
-		0,900	24	50,700	0,900	440	240	240	340
-		2,900	25	53,600	3,800	210	190	190	200
-		2,900	26	56,500	6,700	150	150	150	150
-		2,900	27	59,400	9,600	250	250	250	250
-		2,900	28	62,300	12,500	500	500	500	500
-		2,900	29	65,200	15,400	770	770	770	770
4:V		2,900	30	68,100	18,300	910	910	910	910
4:H	6,200	-	30	68,100	0	910	910	910	910
-		1,937	31	70,037	1,937	850	850	850	850
-		1,938	32	71,975	3,875	740	740	685	733
-		2,325	33	74,300	6,200	600	600	475	584
-	24,800	-	33	74,300	0	600	600	475	584
-		1,550	34	75,850	1,550	450	520	380	468
-		1,938	35	77,788	3,488	260	460	300	340
-		1,938	36	79,725	5,425	130	325	250	218
-		1,938	37	81,663	7,363	110	245	220	174
-		1,938	38	83,600	9,300	80	185	185	133
-		1,938	39	85,538	11,238	80	185	185	133
-		1,938	40	87,475	13,175	150	210	210	180
-		1,938	41	89,413	15,113	285	290	290	288
-		1,938	42	91,350	17,050	430	430	430	430
-		1,938	43	93,288	18,988	550	550	550	550
-		1,938	44	95,225	20,925	670	670	670	670
-		1,938	45	97,163	22,863	810	810	810	810
5:V		1,938	46	99,100	24,800	900	900	900	900
5:H	6,500	-	46	99,100	0	900	900	900	900
-		1,937	47	101,037	1,937	820	820	820	820
-		1,938	48	102,975	3,875	720	720	670	714
-		1,937	49	104,912	5,812	620	620	500	605
-		0,688	50	105,600	6,500	585	585	460	569
-	m	m	-	m	m	mm	mm	mm	mm


y(+)
18300
6200
24800
6500
Passiv
Aktiv
23 24 25 26 27 28 29 30 31 32 33 34 36 38 40 42 44 46 47 49 48 50
X(+)
4
5

ELEVATION

Casting stage 5 → 6: KG 8 – 8 cables

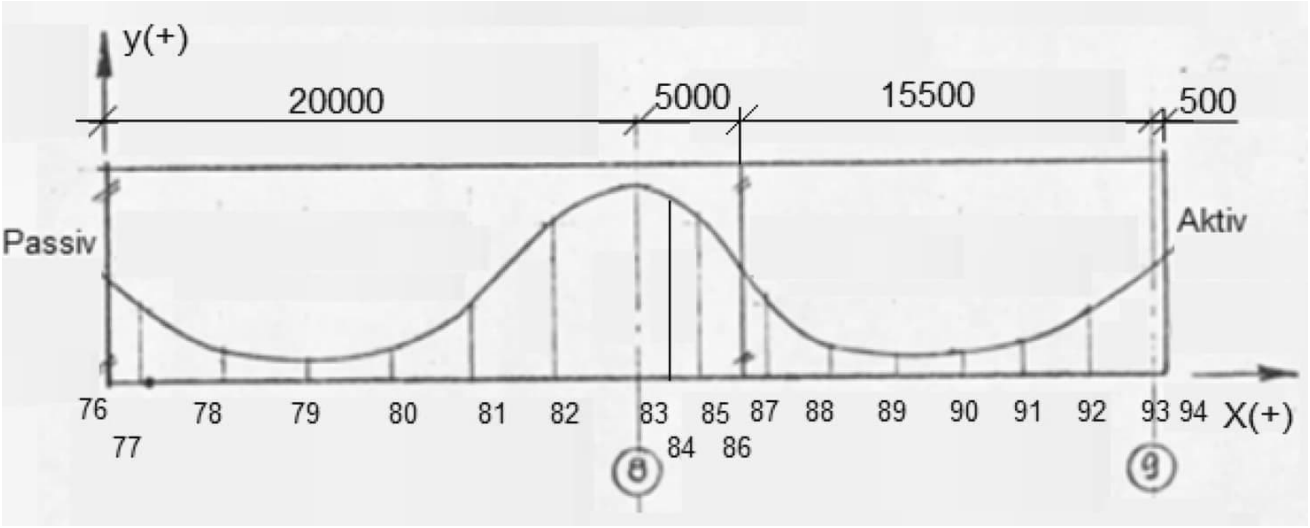
						K 522/622 K 542/642 K 552/652 K 572/672	K 521/621	K 531/631 K 561/661	K 511/611	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	24,500	-	50	105,600	0	585	585	585	460	569
-		1,250	51	106,850	1,250	475	515	515	380	478
-		1,938	52	108,788	3,188	280	380	380	260	315
-		1,938	53	110,725	5,125	100	265	265	190	173
-		1,938	54	112,663	7,063	80	210	210	190	143
-		1,938	55	114,600	9,000	80	185	185	185	133
-		1,938	56	116,538	10,938	110	240	240	240	175
-		1,938	57	118,475	12,875	140	295	295	295	218
-		1,938	58	120,413	14,813	230	350	350	350	290
-		1,938	59	122,350	16,750	380	440	440	440	410
-		1,938	60	124,288	18,688	550	550	550	550	550
-		1,938	61	126,225	20,625	670	670	670	670	670
-		1,938	62	128,163	22,563	785	785	785	785	785
6:V		1,938	63	130,100	24,500	880	880	880	880	880
6:H	5,000	-	63	130,100	0	880	880	880	880	880
-		1,562	64	131,662	1,562	870	870	870	870	870
-		1,563	65	133,225	3,125	845	845	800	845	834
-		1,875	66	135,100	5,000	680	760	605	680	671
-	20,000	-	66	135,100	0	680	760	605	680	671
-		1,250	67	136,350	1,250	450	555	440	450	461
-		3,125	68	139,475	4,375	250	250	250	250	250
-		3,125	69	142,600	7,500	150	150	150	150	150
-		3,125	70	145,725	10,625	200	200	200	200	200
-		3,125	71	148,850	13,750	340	340	340	340	340
-		3,125	72	151,975	16,875	600	600	600	600	600
7:V		3,125	73	155,100	20,000	870	870	870	870	870
7:H	5,000	-	73	155,100	0	870	870	870	870	870
-		1,562	74	156,662	1,562	740	855	855	855	798
-		1,563	75	158,225	3,125	510	790	790	790	650
-		1,875	76	160,100	5,000	340	640	640	640	490
-	m	m	-	m	m	mm	mm	mm	mm	mm


y(+)
24500
5000
20000
5000
Passiv
Aktiv
50 52 54 56 58 60 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 X(+)
6
7

ELEVATION

Casting stage 7 → 8: KG 9 – 8 cables

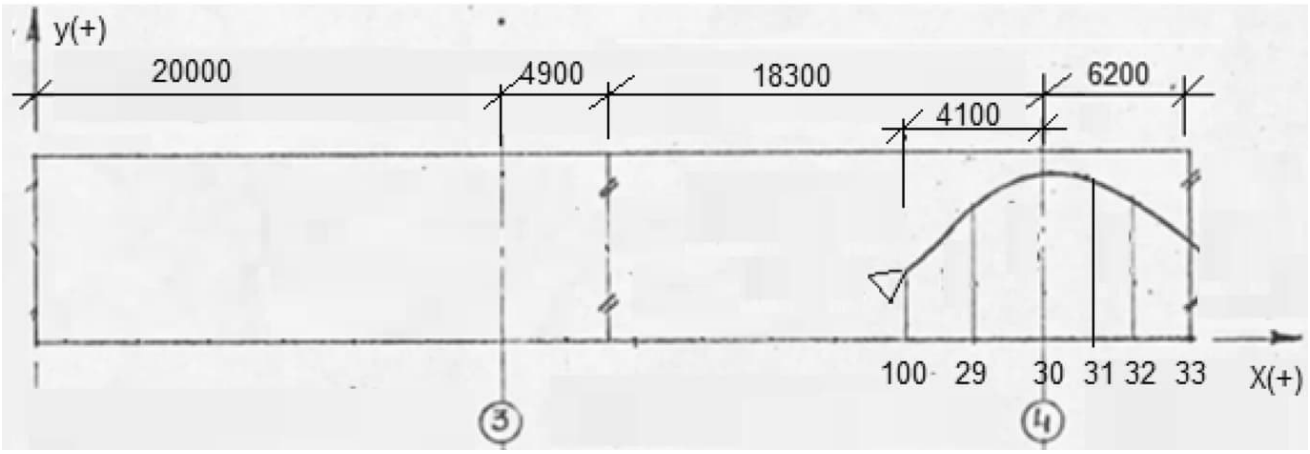
						K 722/822 K 742/842 K 752/852 K 772/872	K 721/821 K 731/831 K 761/861	K 711/811	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y(+)	y(+)	y_{med}(+)
-	20,000	-	76	160,100	0	340	640	640	490
-		1,250	77	161,350	1,250	270	490	490	380
-		3,125	78	164,475	4,375	170	170	170	170
-		3,125	79	167,600	7,500	90	90	90	90
-		3,125	80	170,725	10,625	170	170	170	170
-		3,125	81	173,850	13,750	370	370	370	370
-		3,125	82	176,975	16,875	650	650	650	650
8:V		3,125	83	180,100	20,000	850	850	850	850
8:H	3,900	-	83	180,100	0	850	850	850	850
-		1,218	84	181,318	1,218	850	750	750	800
-		1,219	85	182,537	2,437	810	510	510	660
		1,463	86	184,000	3,900	655	355	355	505
-	15,500	-	86	184,000	0	655	355	355	505
-		0,975	87	184,975	0,975	475	325	325	400
-		2,421	88	187,396	3,396	275	265	265	270
-		2,421	89	189,817	5,817	200	200	200	200
-		2,421	90	192,237	8,237	220	220	220	220
-		2,421	91	194,658	10,658	300	300	300	300
-		2,421	92	197,079	13,079	400	400	400	400
9:V		2,421	93	199,500	15,500	620	380	380	500
9:H	0,500	-	93	199,500	0	620	380	380	500
		0,300	94	199,800	0,300	660	360	360	510
-	m	m	-	m	m	mm	mm	mm	mm


y(+)
20000
5000
15500
500
Passiv
Aktiv
76
77
78
79
80
81
82
83
84
85
86
87
88
89
90
91
92
93
94
X(+)
8
9

ELEVATION

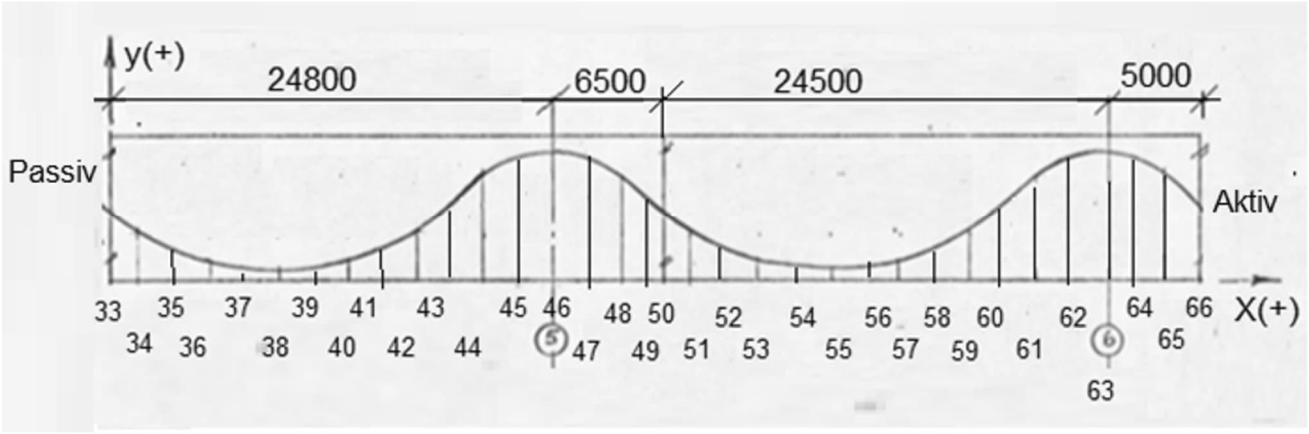
Casting stage 3: KG 10 – 5 cables

						K 313 K 333 K 353 K 363 K 383	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y_{med}(+)
-	18,300	-	23	49,800	0	x	-
-		0,900	24	50,700	0,900	x	-
-		2,900	25	53,600	3,800	x	-
-		2,900	26	56,500	6,700	x	-
-		2,900	27	59,400	9,600	x	-
-		2,900	28	62,300	12,500	x	-
		1,700	100	64,000	14,200	450	450
-		1,200	29	65,200	15,400	665	665
4:V		2,900	30	68,100	18,300	805	805
4:H	6,200	-	30	68,100	0	805	805
-		1,937	31	70,037	1,937	680	680
-		1,938	32	71,975	3,875	440	440
-		2,325	33	74,300	6,200	300	300
-	m	m	-	m	m	mm	mm



Casting stage 4-5: KG 11 – 5 cables

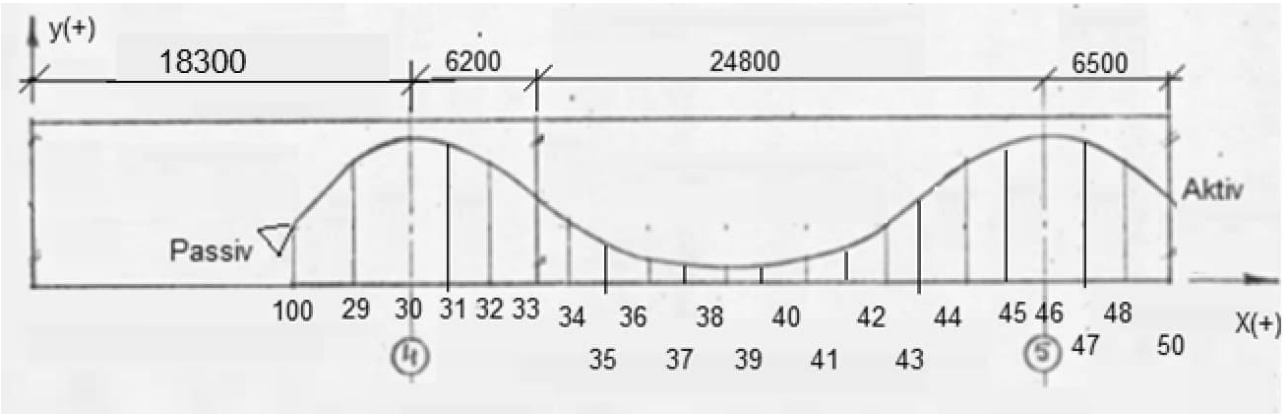
						K 413/513 K 433/533 K 453/543 K 463/563 K 483/583	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y_{med}(+)
-	24,800	-	33	74,300	0	300	300
-		1,550	34	75,850	1,550	230	230
-		1,938	35	77,788	3,488	170	170
-		1,938	36	79,725	5,425	130	130
-		1,938	37	81,663	7,363	110	110
-		1,938	38	83,600	9,300	80	80
-		1,938	39	85,538	11,238	80	80
-		1,938	40	87,475	13,175	90	90
-		1,938	41	89,413	15,113	145	145
-		1,938	42	91,350	17,050	275	275
-		1,938	43	93,288	18,988	410	410
-		1,938	44	95,225	20,925	540	540
-		1,938	45	97,163	22,863	670	670
5:V		1,938	46	99,100	24,800	795	795
5:H	6,500	-	46	99,100	0	795	795
-		1,937	47	101,037	1,937	650	650
-		1,938	48	102,975	3,875	470	470
-		1,937	49	104,912	5,812	330	330
-		0,688	50	105,600	6,500	285	285
-	24,500	-	50	105,600	0	285	285
-		1,250	51	106,850	1,250	215	215
-		1,938	52	108,788	3,188	150	150
-		1,938	53	110,725	5,125	80	80
-		1,938	54	112,663	7,063	80	80
-		1,938	55	114,600	9,000	80	80
-		1,938	56	116,538	10,938	110	110
-		1,938	57	118,475	12,875	140	140
-		1,938	58	120,413	14,813	210	210
-		1,938	59	122,350	16,750	320	320
-		1,938	60	124,288	18,688	420	420
-		1,938	61	126,225	20,625	540	540
-		1,938	62	128,163	22,563	655	655
6:V		1,938	63	130,100	24,500	750	750
6:H	5,000	-	63	130,100	0	750	750
-		1,562	64	131,662	1,562	680	680
-		1,563	65	133,225	3,125	555	555
-		1,875	66	135,100	5,000	410	410
-	m	m	-	m	m	mm	mm


y(+)
24800
6500
24500
5000
Passiv
Aktiv
X(+)
33 35 37 39 41 43 45 46 48 50 52 54 56 58 60 62 64 66
34 36 38 40 42 44 5 47 49 51 53 55 57 59 61 6 65
63

ELEVATION

Casting stage 3 → 4: KG 12 – 5 cables

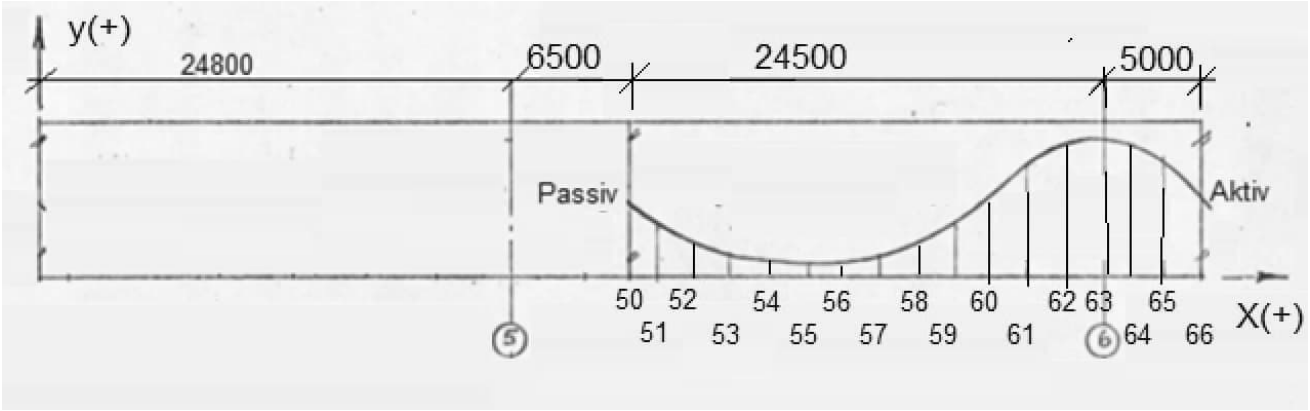
						K 323/423 K 334/434 K 343/443 K 364/464 K 373/473	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y_{med}(+)
-	18,300	-	23	49,800	0	x	-
-		0,900	24	50,700	0,900	x	-
-		2,900	25	53,600	3,800	x	-
-		2,900	26	56,500	6,700	x	-
-		2,900	27	59,400	9,600	x	-
-		2,900	28	62,300	12,500	x	-
-		1,700	100	64,000	14,200	450	450
-		1,200	29	65,200	15,400	665	665
4:V		2,900	30	68,100	18,300	805	805
4:H	6,200	-	30	68,100	0	805	805
-		1,937	31	70,037	1,937	680	680
-		1,938	32	71,975	3,875	440	440
-		2,325	33	74,300	6,200	300	300
-	24,800	-	33	74,300	0	300	300
-		1,550	34	75,850	1,550	230	230
-		1,938	35	77,788	3,488	170	170
-		1,938	36	79,725	5,425	130	130
-		1,938	37	81,663	7,363	110	110
-		1,938	38	83,600	9,300	80	80
-		1,938	39	85,538	11,238	80	80
-		1,938	40	87,475	13,175	90	90
-		1,938	41	89,413	15,113	145	145
-		1,938	42	91,350	17,050	275	275
-		1,938	43	93,288	18,988	410	410
-		1,938	44	95,225	20,925	540	540
-		1,938	45	97,163	22,863	670	670
5:V		1,938	46	99,100	24,800	795	795
5:H	6,500	-	46	99,100	0	795	795
-		1,937	47	101,037	1,937	650	650
-		1,938	48	102,975	3,875	470	470
-		1,937	49	104,912	5,812	330	330
-		0,688	50	105,600	6,500	285	285
-	m	m	-	m	m	mm	mm


y(+)
18300
6200
24800
6500
Aktiv
Passiv
100 29 30 31 32 33 34 36 38 40 42 44 45 46 48
35 37 39 41 43 47 50
X(+)

ELEVATION

Casting stage 5: KG 13 – 5 cables

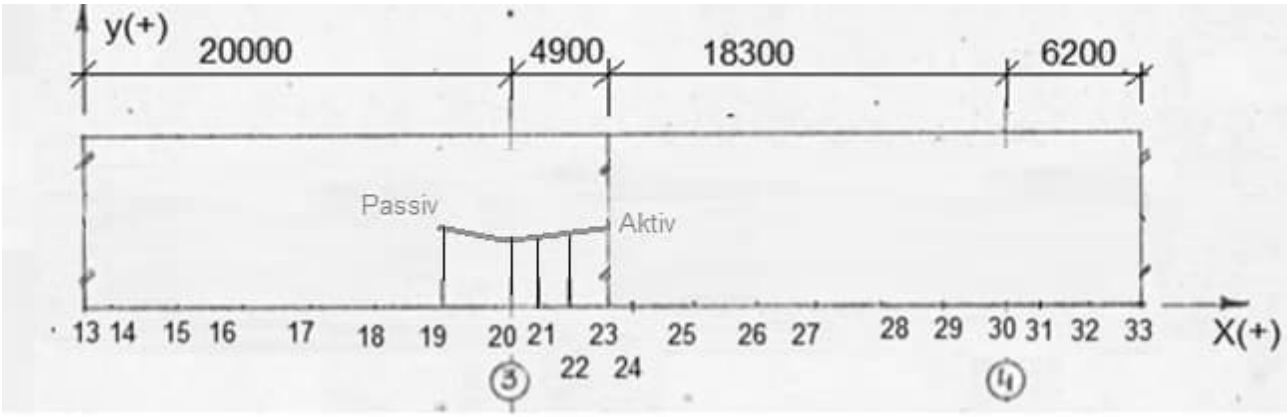
						K 523/623 K 534/634 K 543/643 K 564/664 K 573/673	
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)	y_{med}(+)
-	24,500	-	50	105,600	0	285	285
-		1,250	51	106,850	1,250	215	215
-		1,938	52	108,788	3,188	150	150
-		1,938	53	110,725	5,125	80	80
-		1,938	54	112,663	7,063	80	80
-		1,938	55	114,600	9,000	80	80
-		1,938	56	116,538	10,938	110	110
-		1,938	57	118,475	12,875	140	140
-		1,938	58	120,413	14,813	210	210
-		1,938	59	122,350	16,750	320	320
-		1,938	60	124,288	18,688	420	420
-		1,938	61	126,225	20,625	540	540
-		1,938	62	128,163	22,563	655	655
6:V		1,938	63	130,100	24,500	750	750
6:H	5,000	-	63	130,100	0	750	750
-		1,562	64	131,662	1,562	680	680
-		1,563	65	133,225	3,125	555	555
-		1,875	66	135,100	5,000	410	410
-	m	m	-	m	m	mm	mm



ELEVATION

Casting stage 2 → 3: KG 14 – 3 cables

						K 223 K 253 K 273
Stöd	L	ΔL	Nr	X(+)	x(+)	y(+)
- 3:V		- 2,000	19 20	42,900 44,900	18,000 20,000	450 200
3:H - - -	4,900	- 1,450 1,450 2,000	20 21 22 23	44,900 46,350 47,800 49,800	0 1,450 2,900 4,900	200 210 270 455
-	m	m	-	m	m	mm



ELEVATION

3.8.3 Cabel position: static system

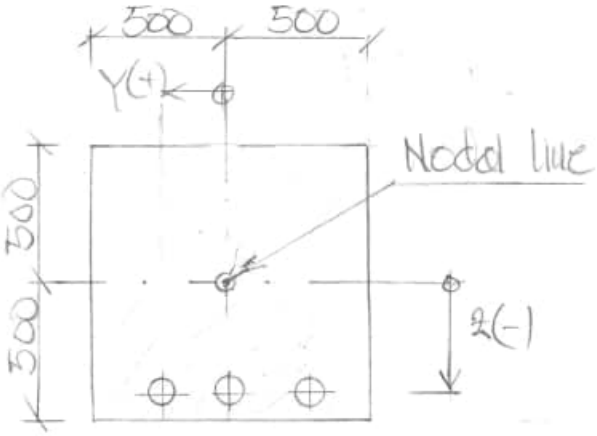
In the static model, tension cables VSL 12ϕ13 are introduced in the 8 longitudinal beams (LB 1-8) with the principal distribution as follows.

Span	LB 1	LB 2	LB 3	LB 4	LB 5	LB 6	LB 7	LB 8	Total
1	2	2	2	2	2	2	2	2	16
2	2 + 1[1.)]	2	2	2	2 + 1[1.)]	2	2	2 + 1[1.)]	16 + 3[1.)]
3	2 + 1[1.)]	2	2	2	2 + 1[1.)]	2	2	2 + 1[1.)]	16 + 3[1.)]
4	3	3	4	3	3	4	3	3	26
5	3	3	4	3	3	4	3	3	26
6	2	2	2	2	2	2	2	2	16
7	2	2	2	2	2	2	2	2	16
8	2	2	2	2	2	2	2	2	16
-	st	st	st	st	st	st	st	st	st

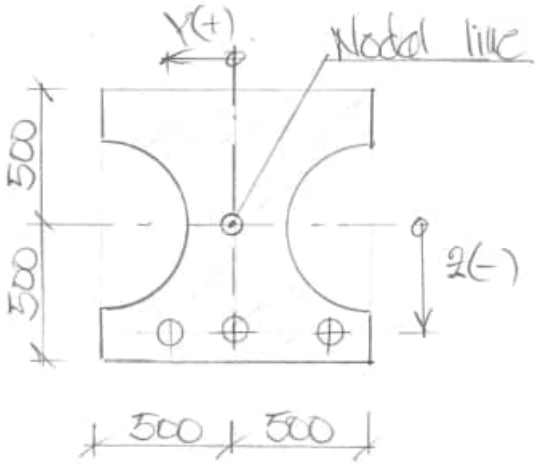
Cables are placed centrally sideways for each longitudinal beam, i.e., y = 0 m.
This simplification does not affect the center of gravity of the prestressing cables.

Notes
1.) Local addition on each side of support 3 of KG 14.

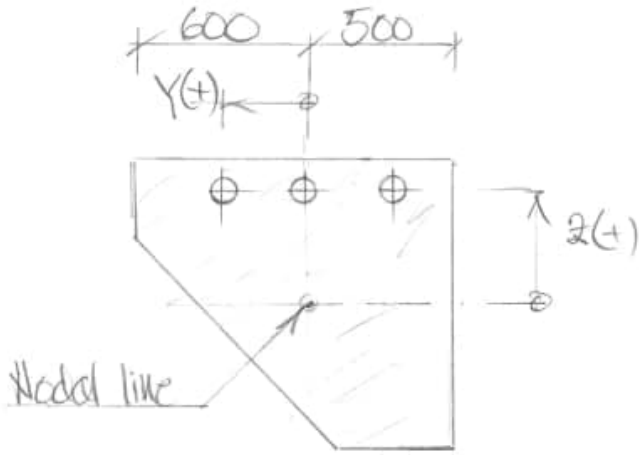
Cables are introduced into the different cross-section types as shown below.



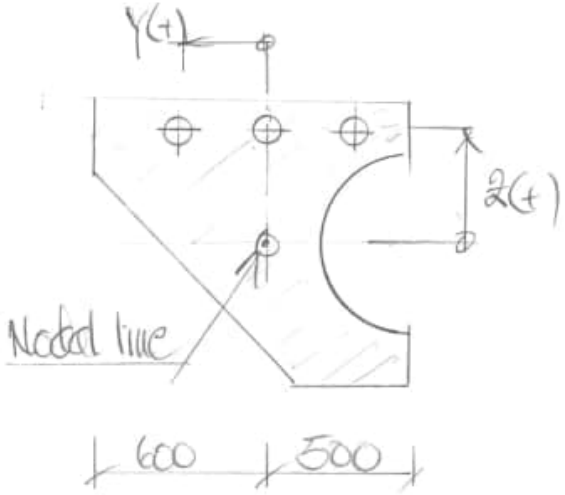
LB – type 4



LB – type 1
Applies to type 2 & 3 also.



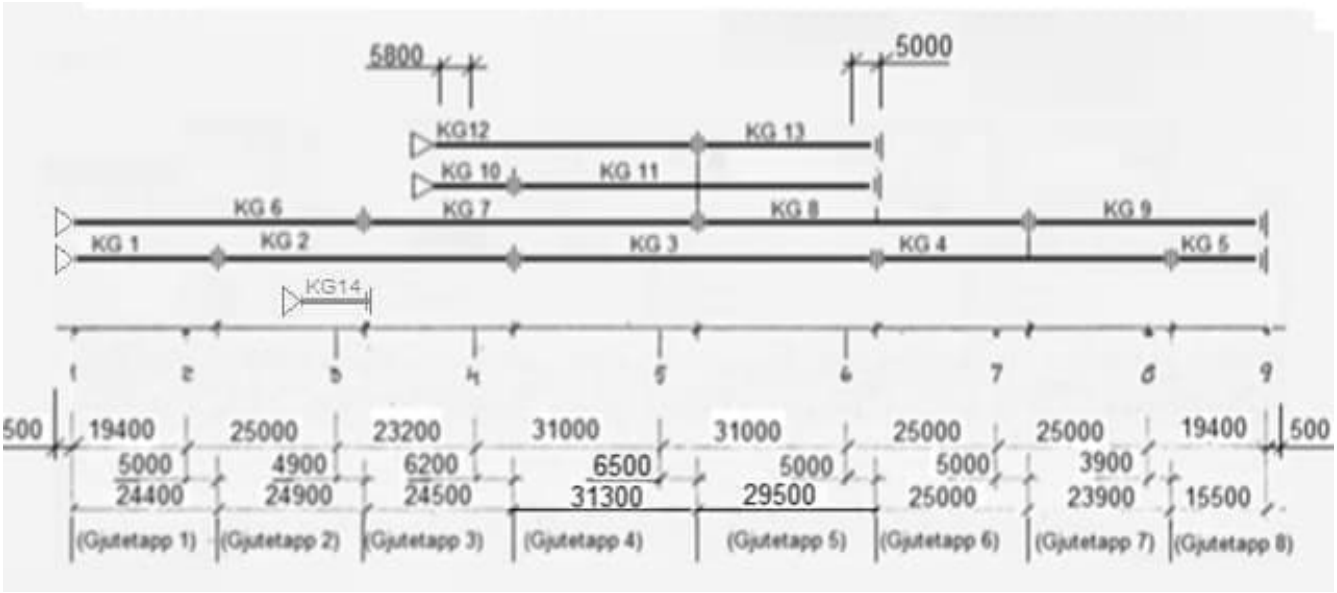
LB – type 5
Appies to type 7.



LB – type 6
Applies to type 8.

3.8.4 Tendon loadcases

Below is shown how prestressing reinforcement is incorporated in the static model.



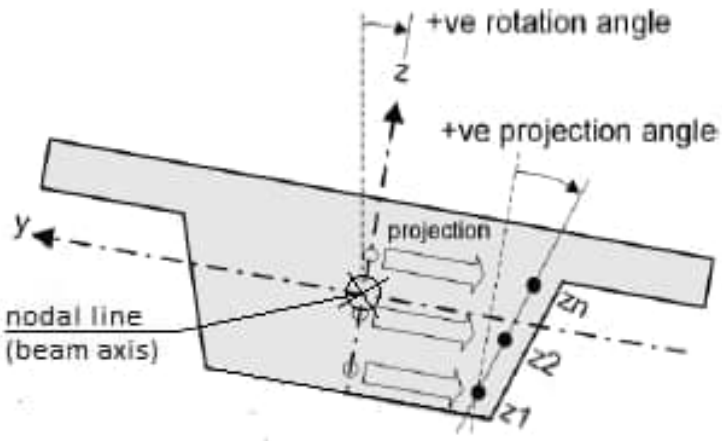
Summary input prestress:

Tendon load	Area	Total cables	Slip	Left side	Right side	Max. prestress before	Min. prestress after	L
KG 1	1110	8	4	Passiv	Aktiv	1350	1299	24.7[1.)]
KG 2	1110	8	4	Passiv	Aktiv	1350	1299	49.4
KG 3	1110	8	4	Passiv	Aktiv	1350	1299	60.8
KG 4	1110	8	4	Passiv	Aktiv	1350	1299	48.9
KG 5	1110	8	4	Passiv	Aktiv	1350	1299	15.8[1.)]
KG 6	1110	8	4	Passiv	Aktiv	1350	1299	49.7[1.)]
KG 7	1110	8	4	Passiv	Aktiv	1350	1299	55.8
KG 8	1110	8	4	Passiv	Aktiv	1350	1299	54.5
KG 9	1110	8	4	Passiv	Aktiv	1350	1299	39.7[1.)]
KG 10	1110	5	4	Passiv	Aktiv	1350	1299	12.0
KG 11	1110	5	4	Passiv	Aktiv	1350	1299	60.8
KG 12	1110	5	4	Passiv	Aktiv	1350	1299	43.3
KG 13	1110	5	4	Passiv	Aktiv	1350	1299	29.5
KG 14	1110	3	4	Passiv	Aktiv	1350	1299	6.9
-	mm^2	-	mm	-	-	kN	kN	m

[1.)] Cable ends 0.2 m from end of bridge.

3.8.4.1 Load definition

Profies used in statict modell, see page A3:46-52.



Principal sketch

3.8.4.2 Tendon profile

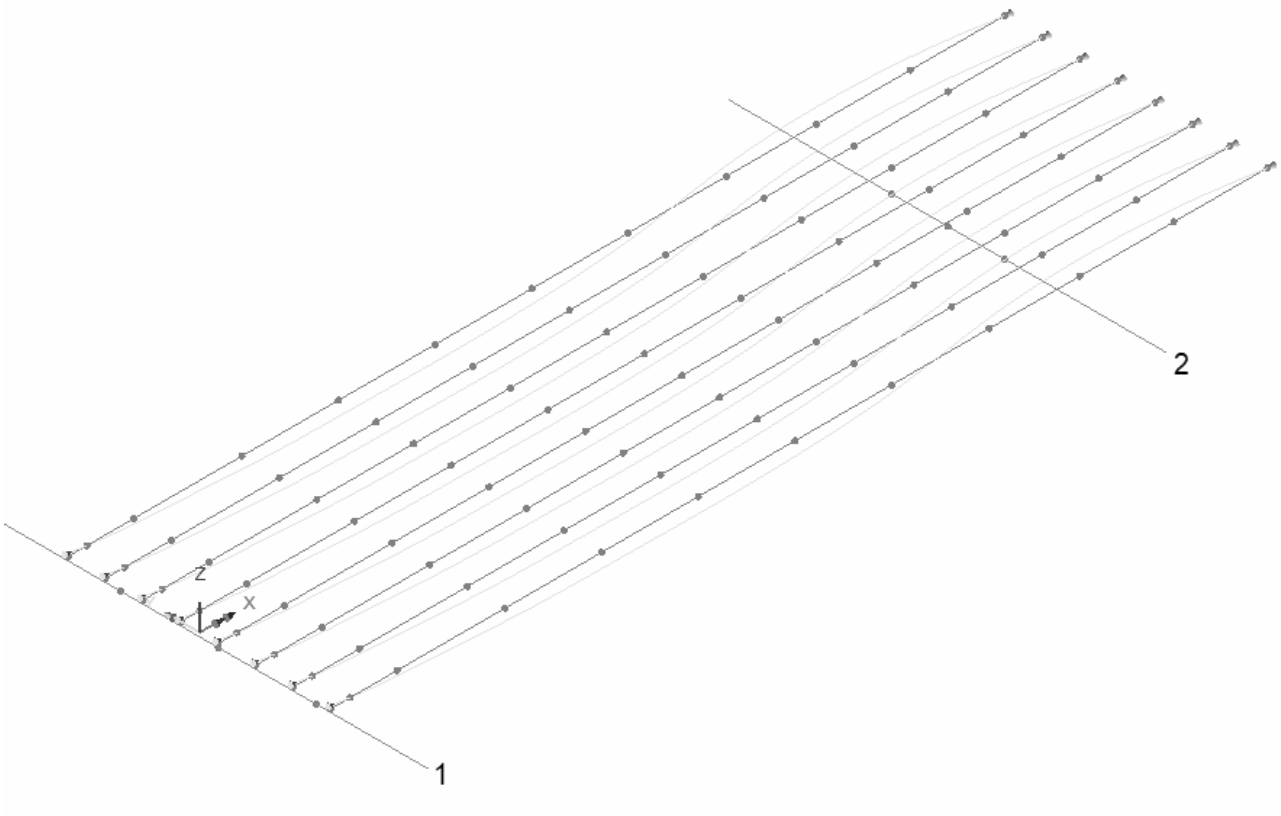
Spread sheet input for KG 1:

x(+)	y(+)		z(+)	Remark
0	0,529		0,029	Passive anchorage
0,300	0,514		0,014	Support 1
1,512	0,455		-0,045	-
2,725	0,400		-0,100	-
5,150	0,300		-0,200	-
7,575	0,220	→	-0,280	-
10,000	0,200		-0,300	-
12,425	0,270		-0,230	-
14,850	0,400		-0,100	-
17,275	0,660		0,160	-
19,700	0,890		0,390	Support 2
21,262	0,790		0,290	-
22,825	0,650		0,150	-
24,700	0,480		-0,020	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0.2 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation
Visualizatiion



3D-view
Visualizatiion

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	1	”Assignment 2”
LB 3	1	”Assignment 3”
LB 4	1	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	1	”Assignment 6”
LB 7	1	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

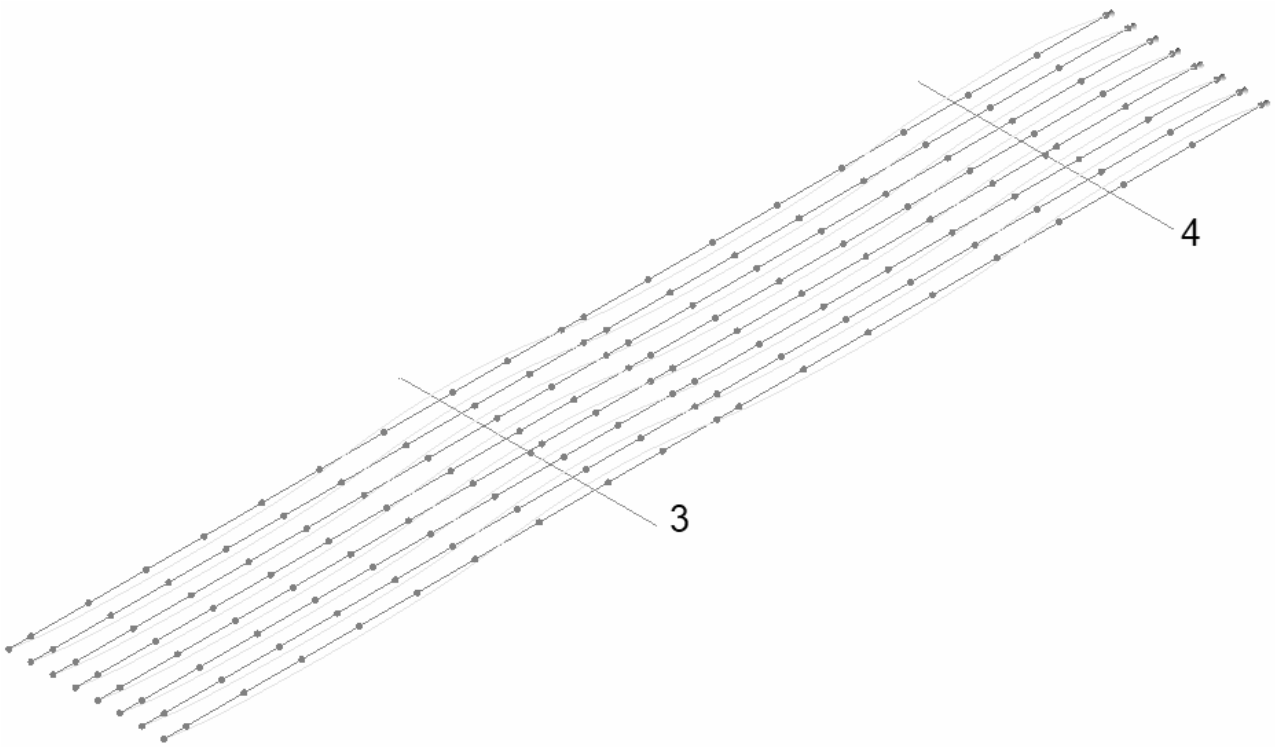
Spread sheet input for KG 2:

x(+)	y(+)		z(+)	Remark
0	0,480		-0,020	Passive anchorage
1,250	0,370		-0,130	-
4,375	0,170		-0,330	-
7,500	0,090		-0,410	-
10,625	0,170		-0,330	-
13,750	0,380		-0,120	-
16,875	0,650		0,150	-
20,000	0,850		0,350	Support 3
21,450	0,730	→	0,230	-
22,900	0,600		0,100	-
24,900	0,420		-0,080	-
25,800	0,340		-0,160	-
28,700	0,200		-0,300	-
31,600	0,150		-0,350	-
34,500	0,250		-0,250	-
37,400	0,500		0,000	-
40,300	0,770		0,270	-
43,200	0,910		0,410	Support 4
45,137	0,850		0,350	-
47,075	0,733		0,233	-
49,400	0,584		0,084	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	1	”Assignment 2”
LB 3	1	”Assignment 3”
LB 4	1	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	1	”Assignment 6”
LB 7	1	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

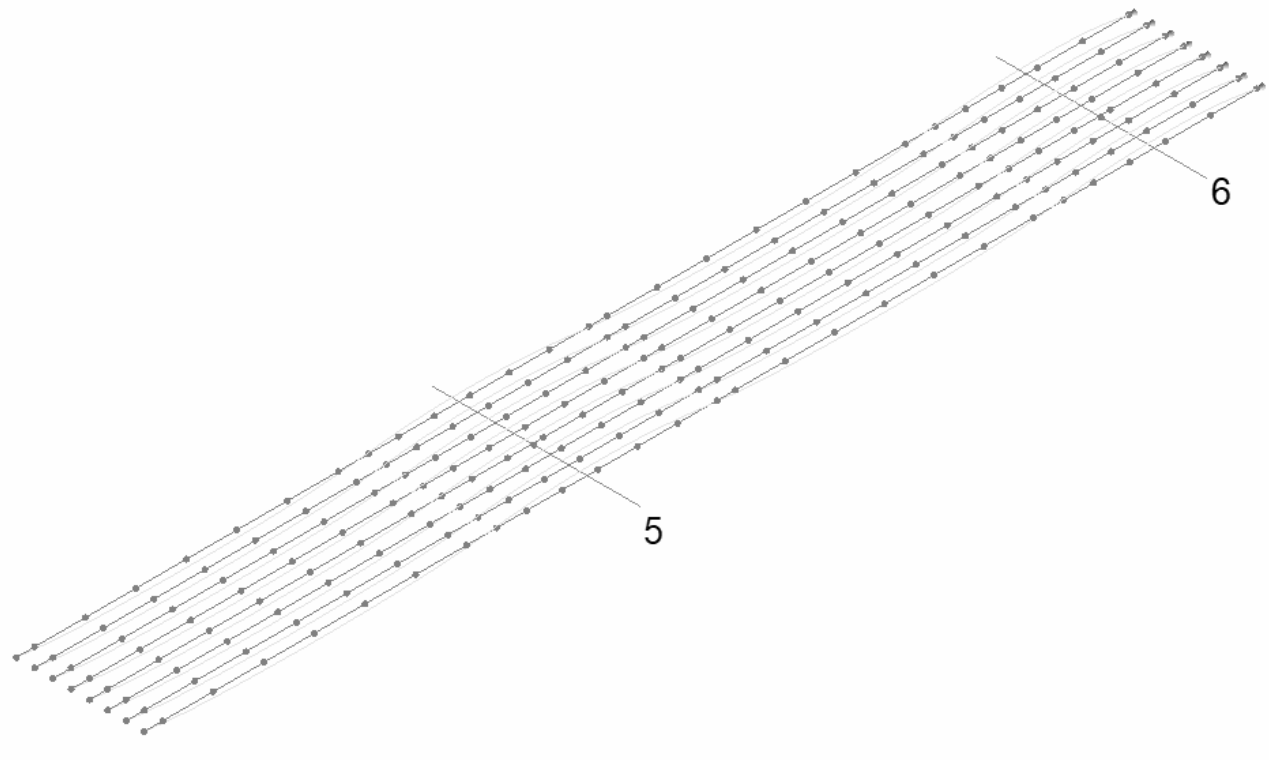
Spread sheet input for KG 3:

x(+)	y(+)		z(+)	Remark
0	0,584		0,084	Passive anchorage
1,550	0,485		-0,015	-
5,425	0,282		-0,218	-
9,300	0,159		-0,341	-
13,175	0,195		-0,305	-
17,050	0,430		-0,070	-
20,925	0,670		0,170	-
24,800	0,900		0,400	Support 5
28,675	0,714	→	0,214	-
32,550	0,500		0,000	-
36,425	0,203		-0,297	-
40,300	0,159		-0,341	-
44,175	0,256		-0,244	-
48,050	0,425		-0,075	-
51,925	0,670		0,170	-
55,800	0,880		0,380	Support 6
58,925	0,870		0,370	-
60,800	0,750		0,250	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	1	”Assignment 2”
LB 3	1	”Assignment 3”
LB 4	1	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	1	”Assignment 6”
LB 7	1	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

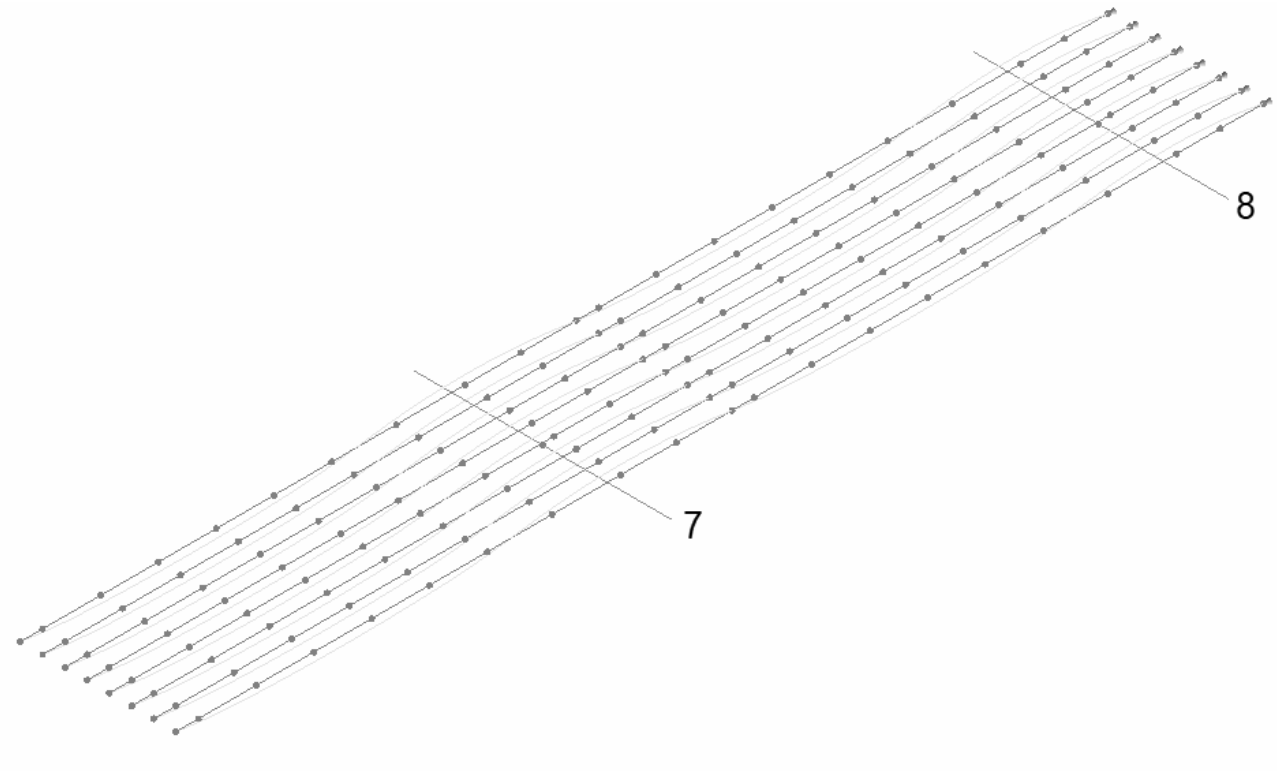
Spread sheet input for KG 4:

x(+)	y(+)		z(+)	Remark
0	0,750		0,250	Passive anchorage
1,250	0,543		0,043	= 2/8
4,375	0,250		-0,250	-
7,500	0,150		-0,350	-
10,625	0,200		-0,300	-
13,750	0,340		-0,160	-
16,875	0,600		0,100	-
20,000	0,870		0,370	Support 7
21,562	0,798	→	0,298	-
23,125	0,650		0,150	-
25,000	0,490		-0,010	-
26,250	0,380		-0,120	-
29,375	0,170		-0,330	-
32,500	0,090		-0,410	-
35,625	0,170		-0,330	-
38,750	0,370		-0,130	-
41,875	0,650		0,150	-
45,000	0,850		0,350	Support 8
46,218	0,800		0,300	-
47,437	0,660		0,160	-
48,900	0,505		0,005	Active anchorage

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	1	”Assignment 2”
LB 3	1	”Assignment 3”
LB 4	1	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	1	”Assignment 6”
LB 7	1	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

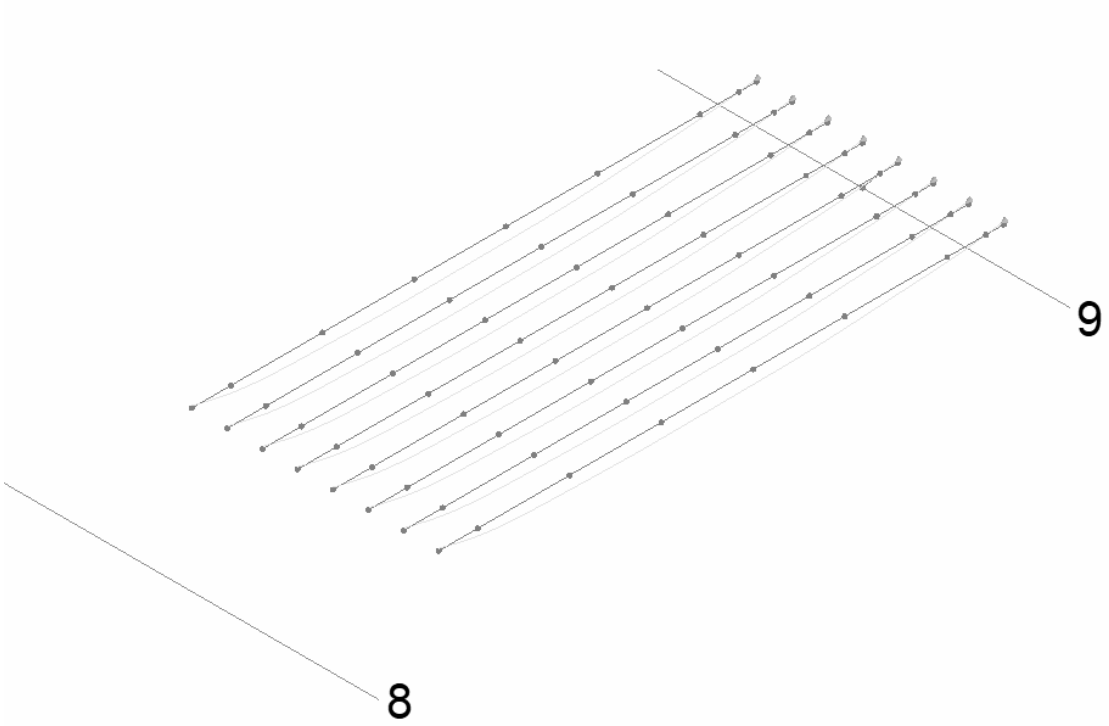
Spread sheet input for KG 5:

x(+)	y(+)		z(+)	Remark
0	0,505		0,005	Passive anchorage
0,975	0,400		-0,100	-
3,396	0,270		-0,230	-
5,817	0,200		-0,300	-
8,237	0,220		-0,280	-
10,658	0,300	→	-0,200	-
13,079	0,400		-0,100	-
15,500	0,505		0,005	Support 9
15,800	0,510		0,010	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beam	No of cables
LB 1	1
LB 2	1
LB 3	1
LB 4	1
LB 5	1
LB 6	1
LB 7	1
LB 8	1
-	pcs

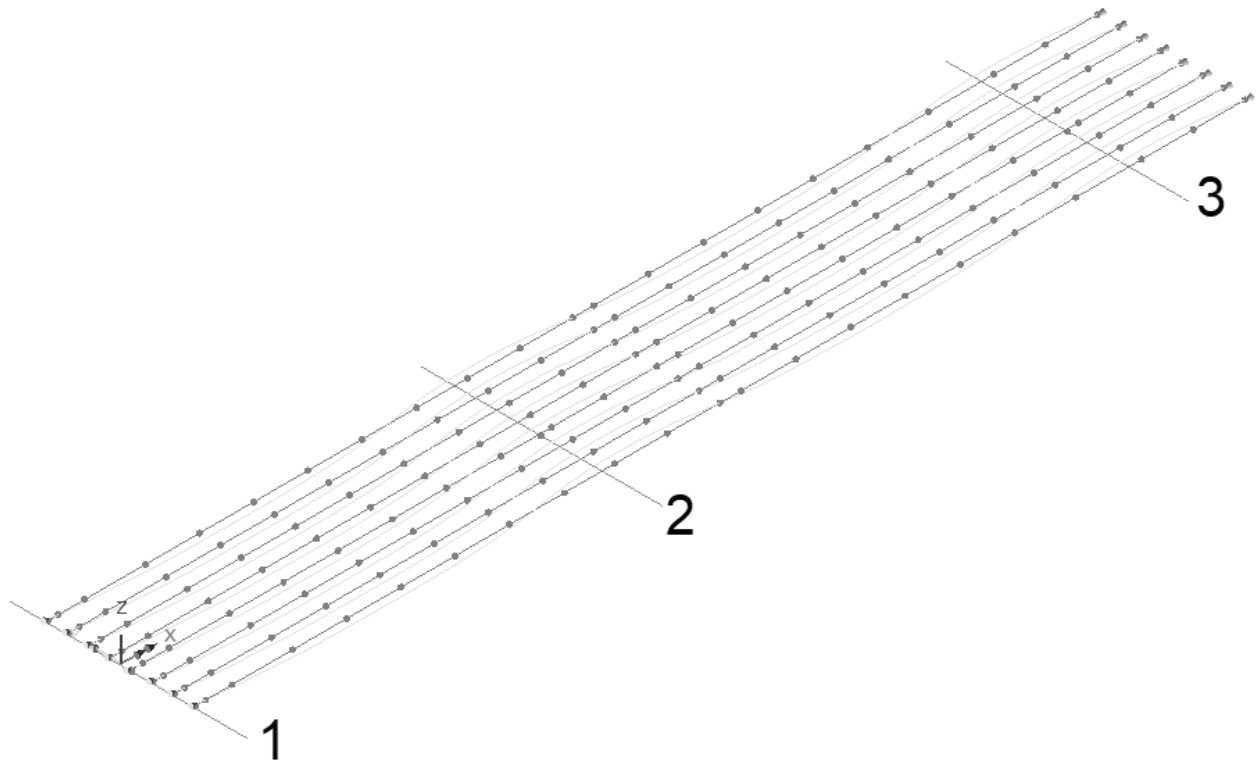
Spread sheet input for KG 6:

x(+)	y(+)		z(+)	Remark
0	0,491		-0,009	Passive anchorage
0,300	0,482		-0,018	Support 1
1,512	0,445		-0,055	-
2,725	0,400		-0,100	-
5,150	0,300		-0,200	-
7,575	0,220		-0,280	-
10,000	0,200		-0,300	-
12,425	0,270		-0,230	-
14,850	0,400		-0,100	-
17,275	0,660		0,160	Support 2
19,700	0,890	→	0,390	-
21,262	0,790		0,290	-
22,825	0,650		0,150	-
24,700	0,480		-0,020	-
25,950	0,370		-0,130	-
29,075	0,170		-0,330	-
32,200	0,090		-0,410	-
35,325	0,170		-0,330	-
38,450	0,380		-0,120	-
41,575	0,650		0,150	-
44,700	0,850		0,350	Support 3
46,150	0,730		0,230	-
47,600	0,600		0,100	-
49,600	0,420		-0,080	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0.2 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beam	No of cables
LB 1	1
LB 2	1
LB 3	1
LB 4	1
LB 5	1
LB 6	1
LB 7	1
LB 8	1
-	pcs

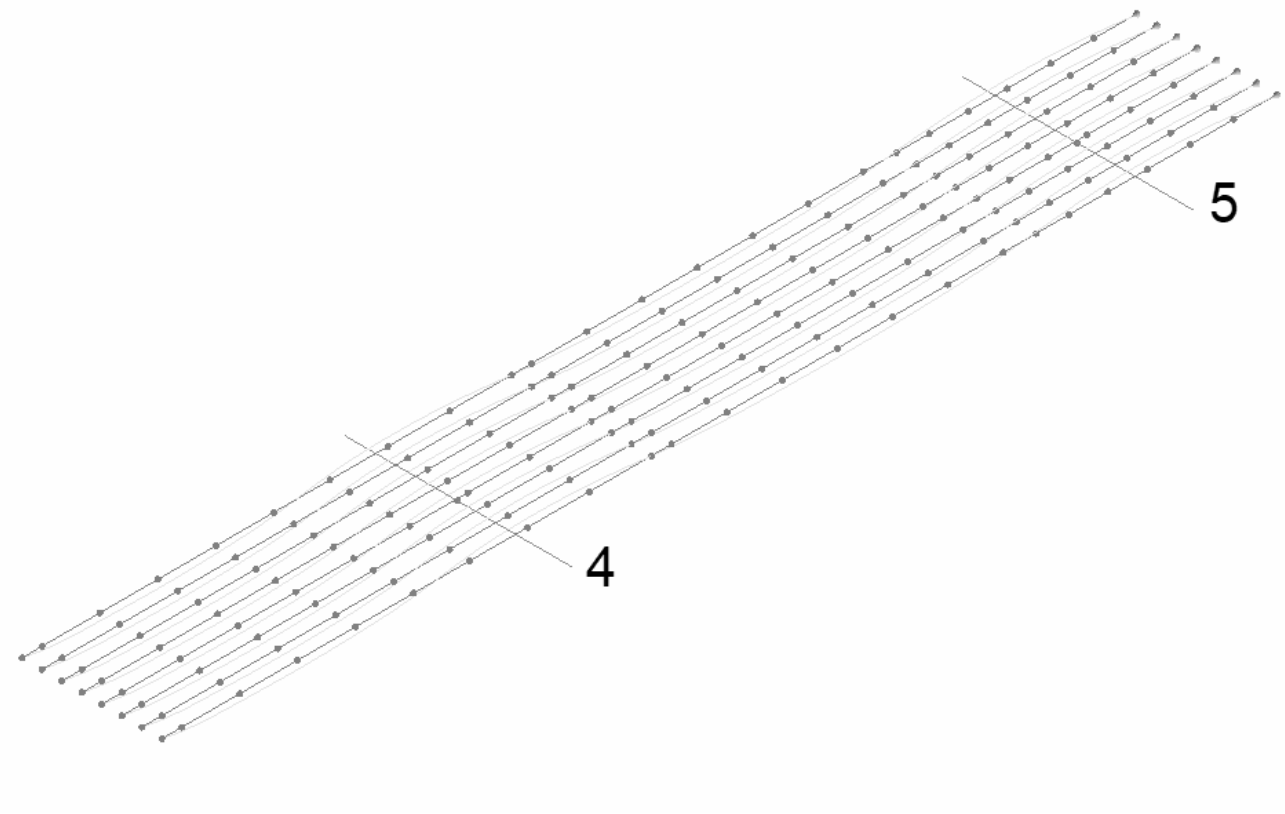
Spread sheet input for KG 7:

x(+)	y(+)	z(+)	Remark
0	0,420	-0,080	Passive anchorage
0,900	0,340	-0,160	-
3,800	0,200	-0,300	-
6,700	0,150	-0,350	-
9,600	0,250	-0,250	-
12,500	0,500	0	-
15,400	0,770	0,270	-
18,300	0,910	0,410	Support 4
22,175	0,733	0,233	-
26,050	0,468	-0,032	-
29,925	0,218	-0,282	-
33,800	0,133	-0,367	-
37,675	0,180	-0,320	-
39,613	0,288	-0,212	-
41,550	0,430	-0,070	-
45,425	0,670	0,170	-
49,300	0,900	0,400	Support 5
53,175	0,714	0,214	-
55,112	0,605	0,105	-
55,800	0,569	0,069	Active anchorage
m	m	m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	1	”Assignment 2”
LB 3	1	”Assignment 3”
LB 4	1	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	1	”Assignment 6”
LB 7	1	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

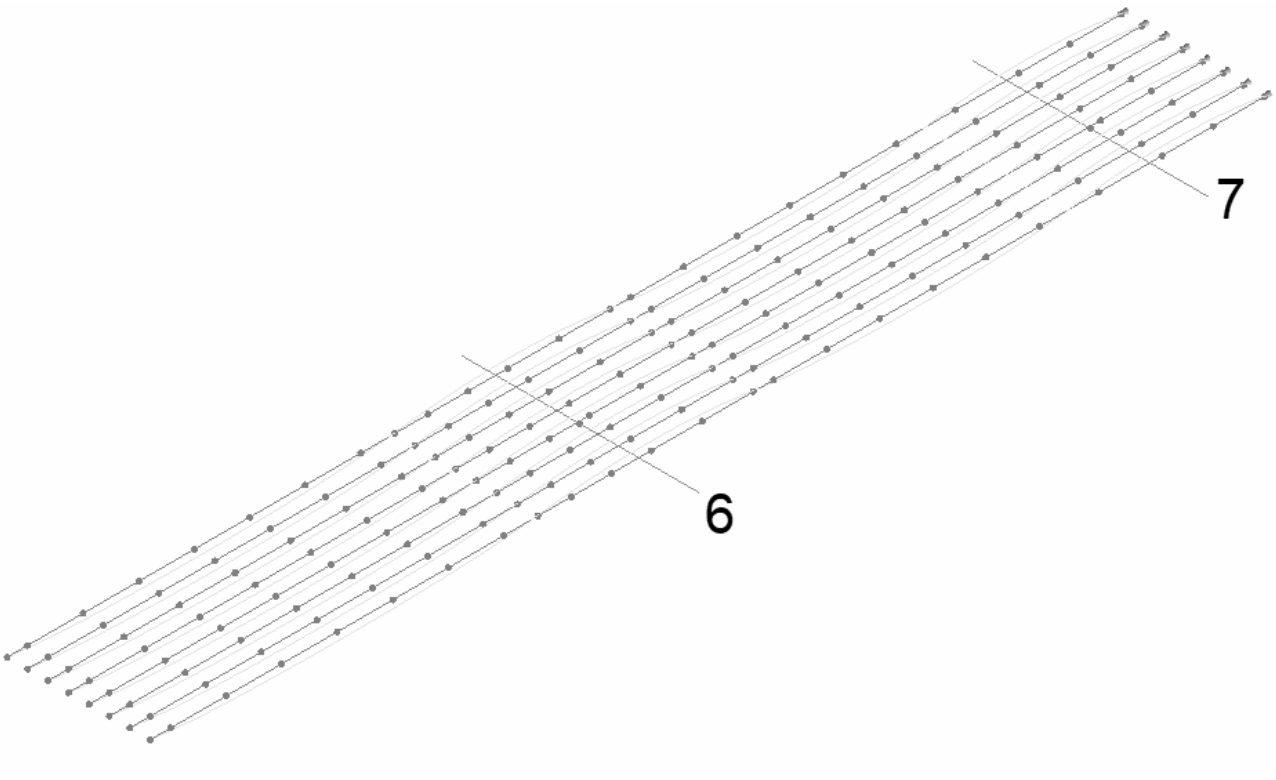
Spread sheet input for KG 8:

x(+)	y(+)		z(+)	Remark
0	0,569		0,069	Passive anchorage
1,250	0,478		-0,022	-
5,125	0,173		-0,327	-
9,000	0,133		-0,367	-
12,875	0,218		-0,282	-
16,750	0,410	→	-0,090	-
20,625	0,670		0,170	-
24,500	0,880		0,380	Support 6
27,625	0,834		0,334	-
30,750	0,461		-0,039	-
33,875	0,250		-0,250	-
37,000	0,150		-0,350	-
40,125	0,200		-0,300	-
43,250	0,340		-0,160	-
46,375	0,600		0,100	-
49,500	0,870		0,370	Support 7
52,625	0,650		0,150	-
54,500	0,490		-0,010	-
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

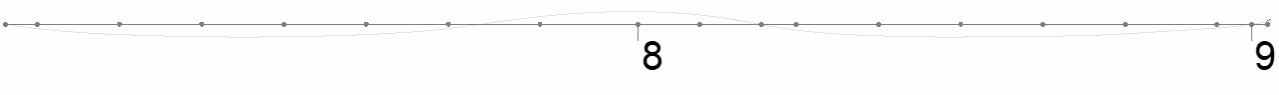
Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	1	”Assignment 2”
LB 3	1	”Assignment 3”
LB 4	1	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	1	”Assignment 6”
LB 7	1	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

Spread sheet input for KG 9:

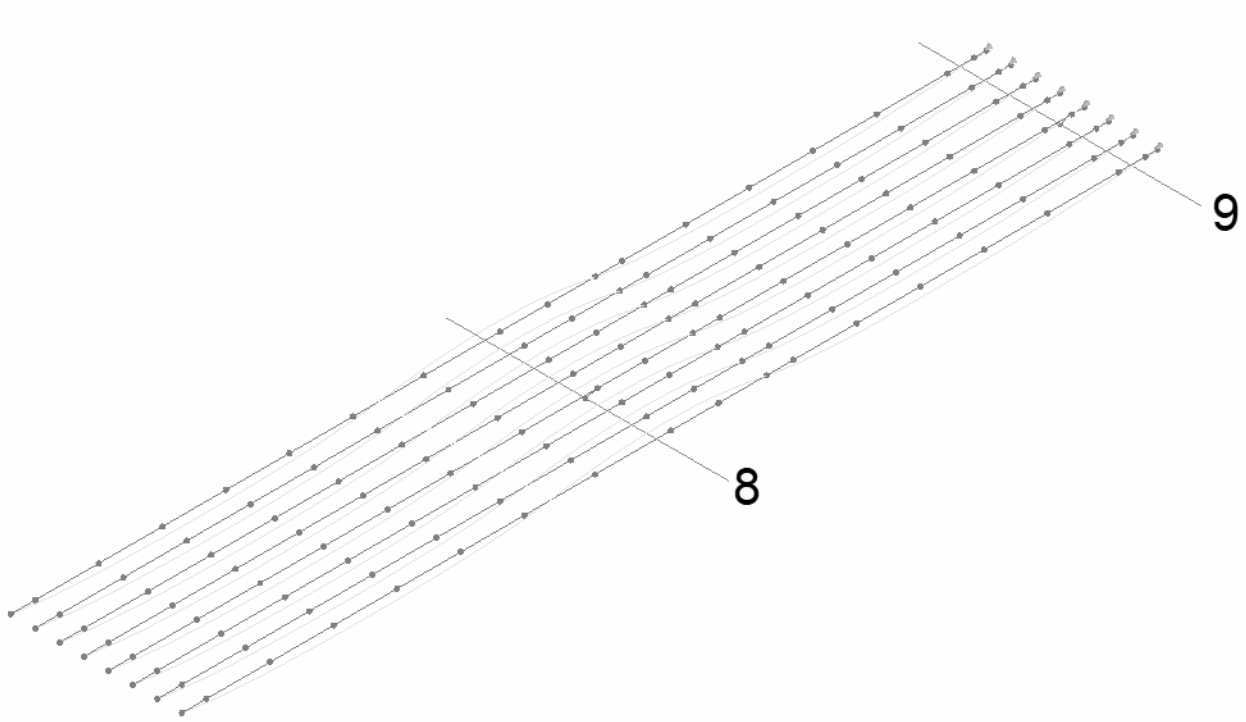
x(+)	y(+)		z(+)	Remark
0	0,490		-0,010	Passive anchorage
1,250	0,380		-0,120	-
4,375	0,170		-0,330	-
7,500	0,090		-0,410	-
10,625	0,170		-0,330	-
13,750	0,370		-0,130	-
16,875	0,650		0,150	-
20,000	0,850		0,350	Support 8
21,218	0,800	→	0,300	-
22,437	0,660		0,160	-
23,900	0,505		0,005	-
24,875	0,400		-0,100	-
27,296	0,270		-0,230	-
29,717	0,200		-0,300	-
32,137	0,220		-0,280	-
34,558	0,300		-0,200	-
36,979	0,400		-0,100	-
39,400	0,500		0	Suppor t9
39,700	0,510		0,010	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes



Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	1	”Assignment 2”
LB 3	1	”Assignment 3”
LB 4	1	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	1	”Assignment 6”
LB 7	1	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

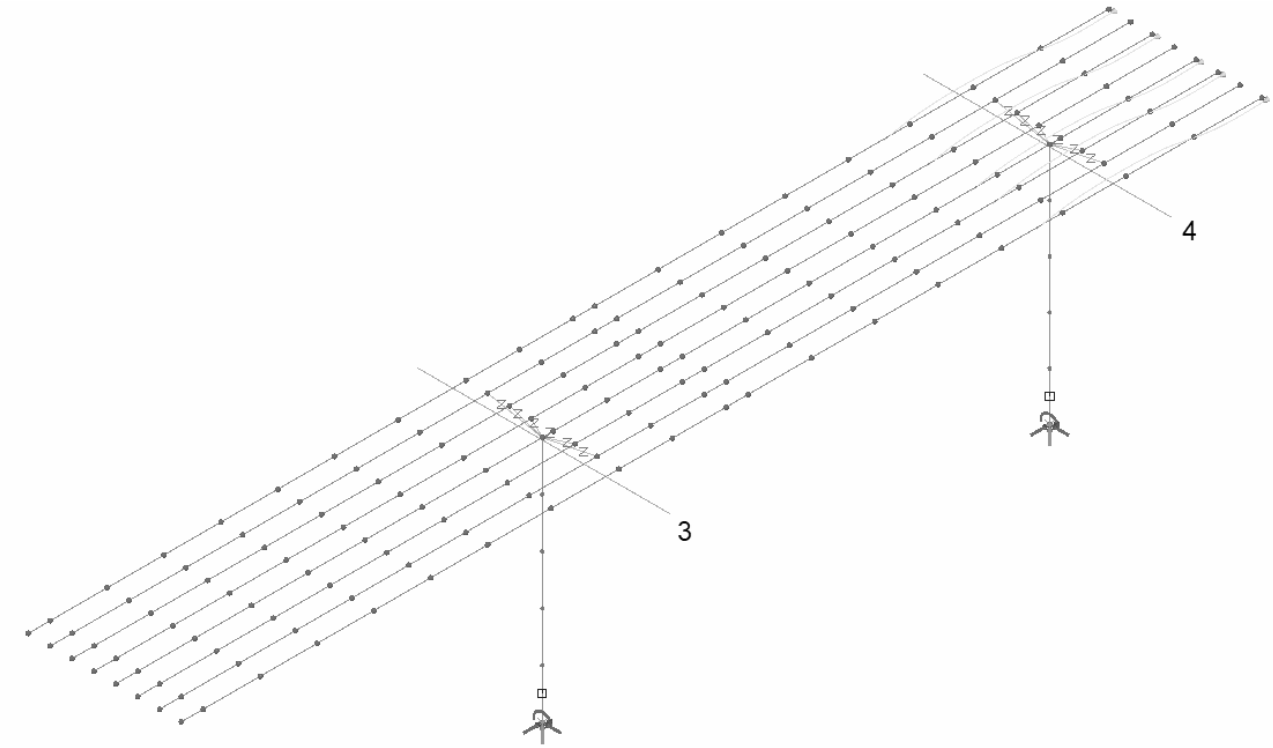
Spread sheet input for KG 10:

x(+)	y(+)		z(+)	Remark
39,100	0,450		-0,050	Passive anchorage
40,300	0,665		0,165	-
43,200	0,805		0,305	Support 4
45,137	0,680	→	0,180	-
47,075	0,440		-0,060	-
49,400	0,300		-0,200	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	0	-
LB 3	1	”Assignment 2”
LB 4	0	-
LB 5	1	”Assignment 3”
LB 6	1	”Assignment 4”
LB 7	0	-
LB 8	1	”Assignment 5”
-	pcs	-

Spread sheet input for KG 11:

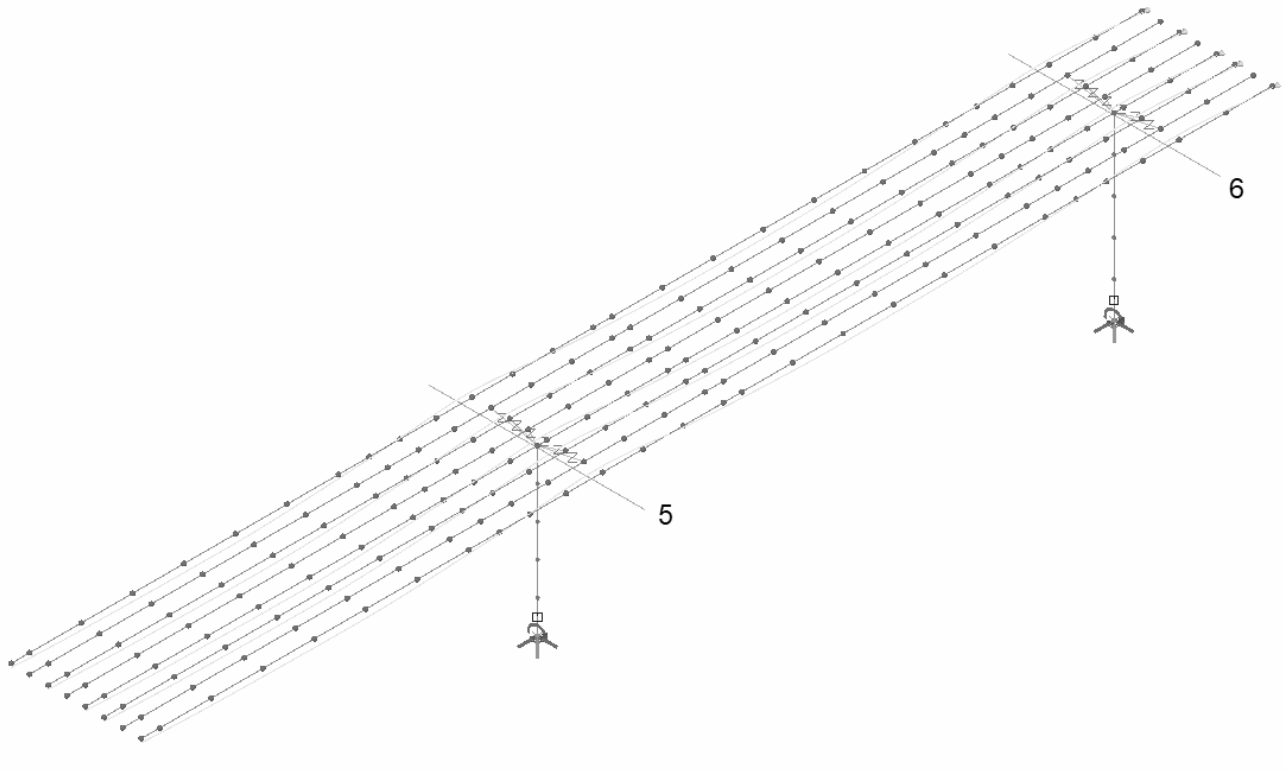
x(+)	y(+)
0	0,300
1,550	0,230
5,425	0,130
9,300	0,080
13,175	0,090
17,050	0,275
20,925	0,540
24,800	0,795
28,675	0,470
32,550	0,215
36,425	0,080
40,300	0,080
44,175	0,140
48,050	0,320
51,925	0,540
55,800	0,750
58,925	0,555
60,800	0,410
m	m

z(+)	Remark
-0,200	Passive anchorage
-0,270	-
-0,370	-
-0,420	-
-0,410	-
-0,225	-
0,040	-
0,295	Support 5
-0,030	-
-0,285	-
-0,420	-
-0,420	-
-0,360	-
-0,180	-
0,040	-
0,250	Support 6
0,055	-
-0,090	Active anchorage
m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	0	-
LB 3	1	”Assignment 2”
LB 4	0	-
LB 5	1	”Assignment 3”
LB 6	1	”Assignment 4”
LB 7	0	-
LB 8	1	”Assignment 5”
-	pcs	-

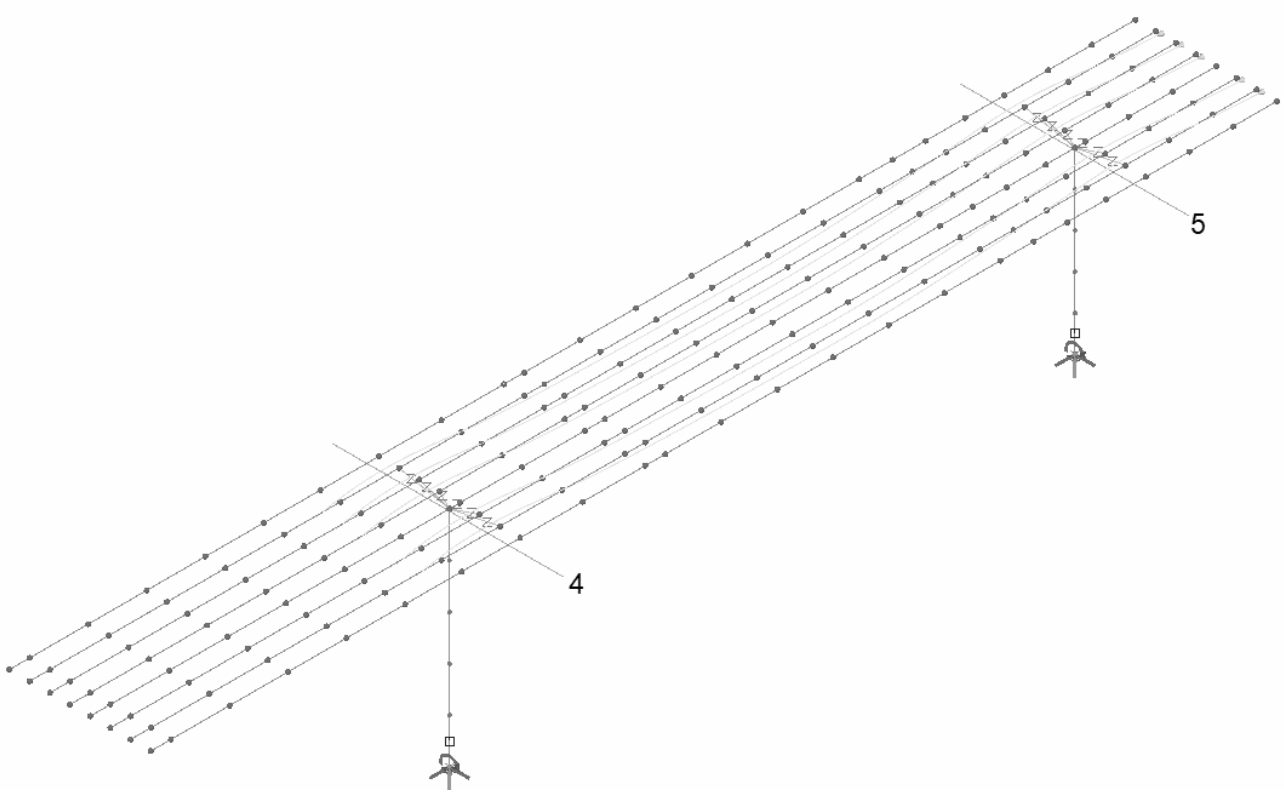
Spread sheet input for KG 12:

x(+)	y(+)		z(+)	Remark
14,200	0,450		-0,050	Passive anchorage
15,400	0,665		0,165	-
18,300	0,805		0,305	Support4
22,175	0,440		-0,060	-
26,050	0,230	→	-0,270	-
29,925	0,130		-0,370	-
33,800	0,080		-0,420	-
37,675	0,090		-0,410	-
41,550	0,275		-0,225	-
45,425	0,540		0,040	-
49,300	0,795		0,295	Support5
53,175	0,470		-0,030	-
55,800	0,285		-0,215	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	0	-
LB 2	1	”Assignment 1”
LB 3	1	”Assignment 2”
LB 4	1	”Assignment 3”
LB 5	0	-
LB 6	1	”Assignment 4”
LB 7	1	”Assignment 5”
LB 8	0	-
-	pcs	-

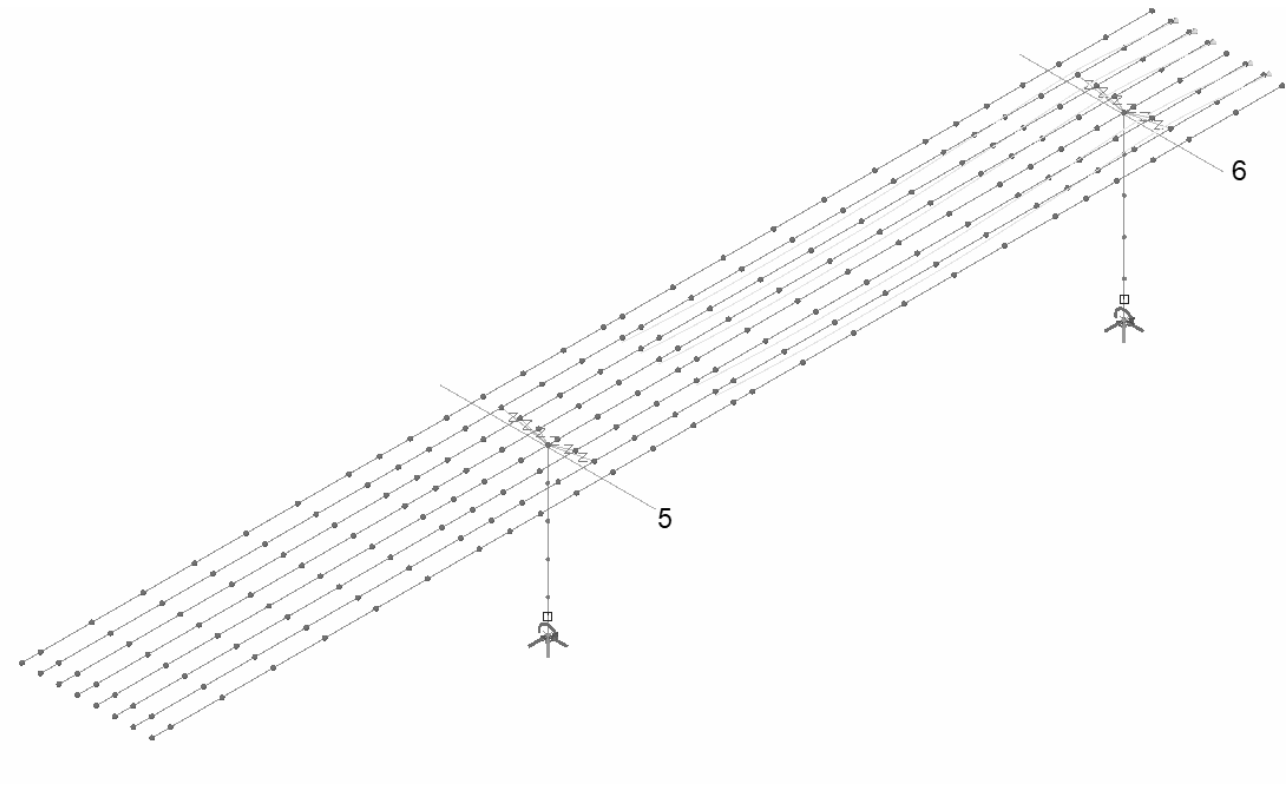
Spread sheet input for KG 13:

x(+)	y(+)		z(+)	Remark
31,300	0,285		-0,215	Passive anchorage
32,550	0,215		-0,285	-
36,425	0,080	→	-0,420	-
40,300	0,080		-0,420	-
44,175	0,140		-0,360	-
48,050	0,320		-0,180	-
51,925	0,540		0,040	-
55,800	0,750		0,250	Support 6
58,925	0,555		0,055	-
60,800	0,410		-0,090	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	0	-
LB 2	1	”Assignment 1”
LB 3	1	”Assignment 2”
LB 4	1	”Assignment 3”
LB 5	0	-
LB 6	1	”Assignment 4”
LB 7	1	”Assignment 5”
LB 8	0	-
-	pcs	-

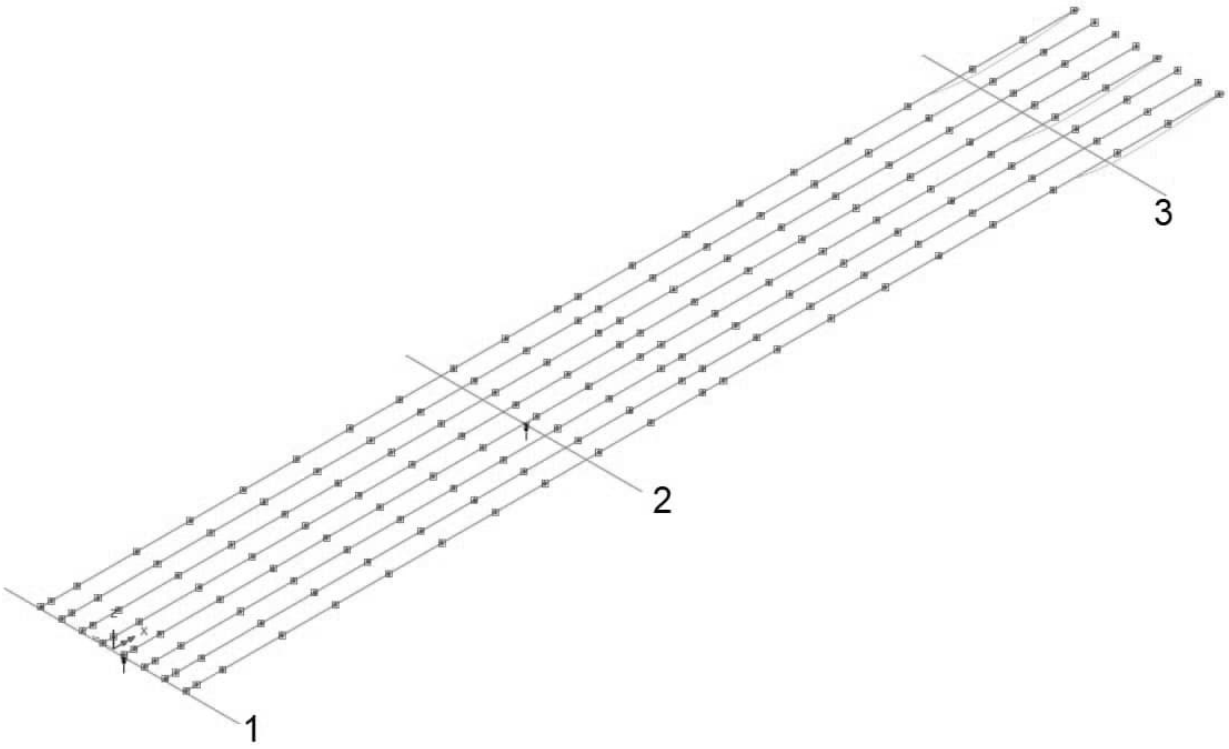
Spread sheet input for KG 14:

x(+)	y(+)		z(+)	Remark
18,000	0,450		-0,050	Passive anchorage
20,000	0,200		-0,300	Support 3
21,450	0,210	→	-0,290	-
22,900	0,270		-0,230	-
24,900	0,455		-0,045	Active anchorage
m	m		m	-

Offset distance from end 1 (start): 18.0 m

Jacking at end 1 (start): no
Jacking at end 2 (end): yes

Elevation



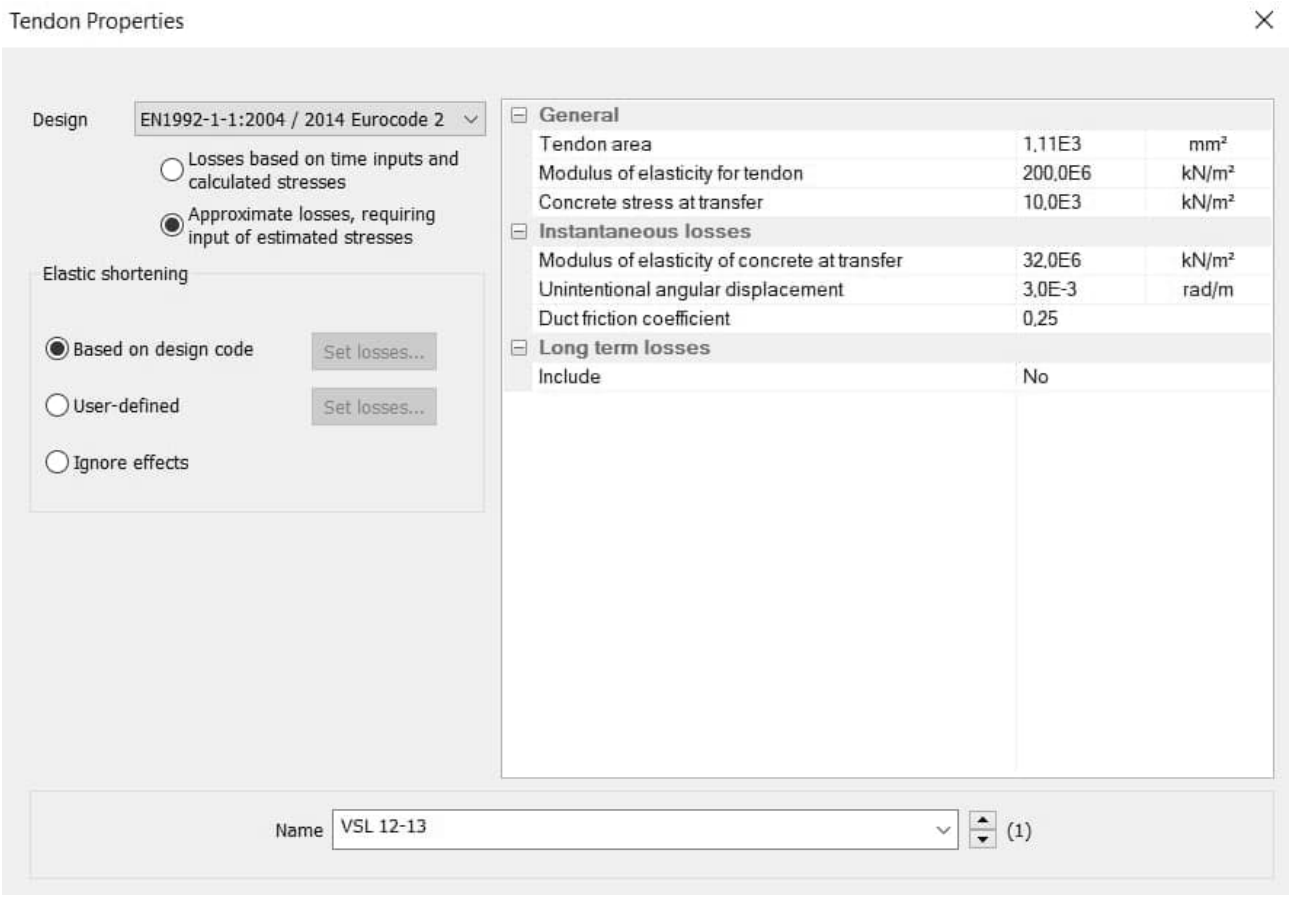
3D-view

Disitribution of cables above.

Beams	Number of cables	Designation
LB 1	1	”Assignment 1”
LB 2	0	”Assignment 2”
LB 3	0	”Assignment 3”
LB 4	0	”Assignment 4”
LB 5	1	”Assignment 5”
LB 6	0	”Assignment 6”
LB 7	0	”Assignment 7”
LB 8	1	”Assignment 8”
-	pcs	-

3.8.4.3 Tendon properties

Calculation of 'long term losses' is not done with LUSAS but separately. Hence 'Include: No' in the table below.



Friction coefficients during tensioning of cables:

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

μ = 0.25

$$k = 0.003 \frac{rad}{m}$$

3.8.5 Load combination

Load combination basis PT-T0E:
(Static system ”Analysis 1” → ”Analysis 8”)

Load case	Factor
KG 1-1	1.00
KG 2-3	1.00
KG 3-5	1.00
KG 4-7	1.00
KG 5-8	1.00
KG 6-2	1.00
KG 7-4	1.00
KG 8-6	1.00
KG 9-8	1.00
KG 10-3	1.00
KG 11-5	1.00
KG 12-4	1.00
KG 13-5	1.00
KG 14-2	1.00

Load combination basis PT-T0C:
(Static system ”Analysis 9”)

Load case	Factor
KG 1	1.00
KG 2	1.00
KG 3	1.00
KG 4	1.00
KG 5	1.00
KG 6	1.00
KG 7	1.00
KG 8	1.00
KG 9	1.00
KG 10	1.00
KG 11	1.00
KG 12	1.00
KG 13	1.00
KG 14	1.00

Basic load combination *PT-T0 :*

Load case	Factor
PT-T0E	0.53
PT-T0C	0.47

3.9 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.

3.14.1 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).

A1 (construction loads)
All load factors are greater than set C.

A2 (geotechnical loads)

- Load coefficient earth pressure:
  $\psi\gamma_{\mathrm{ULS-A}} = \gamma_{\mathrm{d}} \cdot 1.35 \cdot \eta_{\mathrm{sup.G}} = 1.0 \cdot 0.89 \cdot 1.35 \cdot 1.1 = 1.49$ ← dimensioning
  $\psi\gamma_{\mathrm{ULS-B}} = \gamma_{\mathrm{d}} \cdot 0.89 \cdot 1.35 \cdot \eta_{\mathrm{sup.G}} = 1.0 \cdot 0.89 \cdot 1.35 \cdot 1.1 = 1.33$

- Load coefficient surcharge:
  $\psi\gamma_{\mathrm{ULS-A}} = \gamma_{\mathrm{d}} \cdot \psi_0 \cdot 1.50 = 1.0 \cdot 0.75 \cdot 1.50 = 1.13$
  $\psi\gamma_{\mathrm{ULS-B}} = \gamma_{\mathrm{d}} \cdot 1.50 = 1.0 \cdot 1.50 = 1.50$ ← dimensioning

3.14.1 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).

A1 (construction loads)
All load factors are greater than set C.

A2 (geotechnical loads)

- Load coefficient earth pressure:

  $\psi\gamma_{\mathrm{ULS-A}} = \gamma_{\mathrm{d}} \cdot 1.35 \cdot \eta_{\mathrm{sup.G}} = 1.0 \cdot 0.89 \cdot 1.35 \cdot 1.1 = 1.49$ ← dimensioning

  $\psi\gamma_{\mathrm{ULS-B}} = \gamma_{\mathrm{d}} \cdot 0.89 \cdot 1.35 \cdot \eta_{\mathrm{sup.G}} = 1.0 \cdot 0.89 \cdot 1.35 \cdot 1.1 = 1.33$

- Load coefficient surcharge:

  $\psi\gamma_{\mathrm{ULS-A}} = \gamma_{\mathrm{d}} \cdot \psi_0 \cdot 1.50 = 1.0 \cdot 0.75 \cdot 1.50 = 1.13$

  $\psi\gamma_{\mathrm{ULS-B}} = \gamma_{\mathrm{d}} \cdot 1.50 = 1.0 \cdot 1.50 = 1.50$ ← dimensioning

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).

A1 (construction loads)
All load factors are less than set B.

A2 (geotechnical loads)

- Load coefficient earth pressure: $\psi\gamma_{jord} = \gamma_d \cdot 1.1 \cdot \eta_{sup.G} = 0.91 \cdot 1.1 \cdot 1.1 = 1.10$

- Load coefficient surcharge: $\psi\gamma_{\text{över}} = \gamma_{\text{d}} \cdot 1.40 = 0.91 \cdot 1.40 = 1.27$

Load combination smart *ULS-PERM :*

Load case	Permanent factor	Variable factor
EGEN	1.00	1.20
BELÄGG	1.00	1.20
JORD	1.00	1.20
STOD	0	$1.2 \cdot f_{STOD} = 0.40$
KRYMP	0	$1.2 \cdot_{SKRYMP} = 0.40$

Load combination smart *ULS-VAR :*
(Load cases to consider : 5 / Variable loadcases : 1)

Load case	Permanent factor	Variable factor
TRAFIK	1.13	1.50
BROMS	1.13	1.50
SIDO	1.13	1.50
TEMP	$0.90 f_{TEMP} = 0.70$	$1.5 \cdot f_{TEMP} = 1.2$
VIND	0.45	1.50

For STR load case TEMP may be neglected, see SS-EN 1992-1-1 section 2.3.1.2(2).

Load combination smart *ULS-0 :*

Load case	Permanent factor	Variable factor
ULS-PERM	1.00	1.00
ULS-VAR	0	1.00

Load combination smart *ULS :*

Load case	Permanent factor	Variable factor
ULS-PERM	1	0
PT	1	1.35
ULS-VAR	0	1

3.14.2 Service state (SLS)

The serviceability limit state is divided into 3 load combinations depending 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 eq. 6.14b is presented below.

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

The truck combination SLS:F according to EN 1990 eq. 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 eq. 6.16b is presented below.

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

In design, load factors belonging to equations 6.14a, 6.15b, and 6.16b are applied; for derivation, see page A3:137.

Nr	Load		$\psi\gamma_{SLS-K}$	$\psi\gamma_{SLS-F}$	$\psi\gamma_{SLS-Q}$
	Permanent loads				
1	Egentyngd	max	1,00	1,00	1,00
		min	1,00	1,00	1,00
2	Beläggning	max	1,10	1,10	1,10
		min	0,90	0,90	0,90
3	Överfyllnad	max	1,10	1,10	1,10
		min	0,90	0,90	0,90
4	Jordtryck	max	1,10	1,10	1,10
		min	0,90	0,90	0,90
5	Vattentryck	max	1,00	1,00	1,00
		min	1,00	1,00	1,00
6	Stödförskjutning	max	1,00	1,00	1,00
		min	1,00	1,00	1,00
7	Krympning	max	1,00	1,00	1,00
		min	1,00	1,00	1,00
8	Spännkraft	max	1,00	1,00	1,00
		min	1,00	1,00	1,00
	Variable loads				
	Lastmodell LM 1 :				
9	Boggiesystem		0.75/1.00	0/0.75	0
10	Utbredd last		0.40/1.00	0/0.40	0
11	Bromskraft		0.56/0.75	0/0.56	0
12	Sidokraft		0.56/0.75	0/0.56	0
13	Centrifugalkraft		0.56/0.75	0/0.56	0
	Lastmodell LM 2 :				
14	Enstaka axellast		0.75/1.00	0/0.75	0
	Typfordon EG A/B :				
15	Typfordon EG A/B		0.75/1.00	0/0.75	0
20	Bromskraft		0.56/0.75	0/0.56	0
22	Sidokraft		0.56/0.75	0/0.56	0
22	Centrifugalkraft		0.56/0.75	0/0.56	0
16	Temperatur		0.60/1.00	0.50/0.60	0.50
	Vindlaster:				
17	Vindlast mot bro		0.30/1.00	0/0.30	0
18	Vindlast mot trafik		0.30/1.00	0/0.30	0
19	Överlast		0.75/1.00	0/0.75	0

Load combination smart SLS-PERM *:*

Loadcase	Permanent factor	Variable factor
EGEN	1.00	1.00
BELÄGG	0.90	1.20
JORD	0.90	1.20
STOD	0	$1.0 \cdot f_{STOD} = 0.33$
KRYMP	0	$1.0 \cdot f_{KRYMP} = 0.33$

Load combination smart *SLS-K-VAR :*
(Load cases to consider : 5 / Variable loadcases : 1)

Loadcase	Permanent factor	Variable factor
TRAFIK	0.75	1.00
BROMS	0.56	0.75
SIDO	0.56	0.75
TEMP	$0.60 f_{TEMP} = 0.50$	$1.0 \cdot f_{TEMP} = 0.80$
VIND	0.60	1.00

Load combination smart *SLS-F-VAR :*

Load case	Permanent factor	Variable factor
TRAFIK	0	0.75
BROMS	0	0.56
SIDO	0	0.56
TEMP	0	$0.60 f_{TEMP} = 0.50$
VIND	0	0.30

Load combination smart *SLS-K0 :*

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

Load combination smart *SLS-K:*

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

Load combination smart *SLS-F0 :*

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

Load combination smart *SLS-F :*

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

Load combination smart *SLS-Q0 :*

Load case	Permanent factor	Variable factor
SLS-PERM	1	1
TEMP	0	$0.50f_{TEMP} = 0.40$

Load combination smart *SLS-Q :*

Load case	Permanent factor	Variable factor
SLS-PERM	1	1
PT	1	1
TEMP	0	$0.50f_{TEMP} = 0.40$

3.14.3 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.

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

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.

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	Spännkraft	max	1.00
		min	1.00

Variable loads:

Nr	Load	$\psi\gamma_{UTM}$
	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 *:*
(FAT-0 is identical but does not contain load case PT-t0)

Load case	Permanent factor	Variable factor
EGEN	1.00	0
BELÄGG	1.00	0
JORD	-	-
STOD	-	-
KRYMP	-	-
PT-t0	0.84	-
VIND	-	-
UTM	-	1.00
OVER	-	-
TEMP	-	-

Load cases BELÄGG, STOD and KRYMP are not fatigue loads, thus load coefficient 1.0 is applied.

Load cases pretension is not a fatigue loads, thus load coefficient lowest load value of value is assumed PT-t2 (= 0.84·PT-t0) is applied.

Load case JORD is not a fatigue load, thus load coefficient highest load coefficient is applied.

Load cases TEMP, VIND and OVER are not fatigue loads, thus load is not considered.

During verification STR, the load case TEMP can be neglected according to SS-EN 1992-1-1 section 2.3.1.2(2).