

RC slab bridge

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## **1. GENERAL / MEASUREMENTS**

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## 1.1 CONSTRUCTION TYPE

### Superstructure:

Slab bridge in one span with end-shields and bearings.

Superstructure is assumed constructed using continuous scaffolding and cast in one stage.

Superstructure is assumed divided in two parts with a longitudinal dilation joint at center of bridge.

Future replacement of bearings is intended to be performed against temporary supports acting against transversal beams at location of supports.

### Foundation:

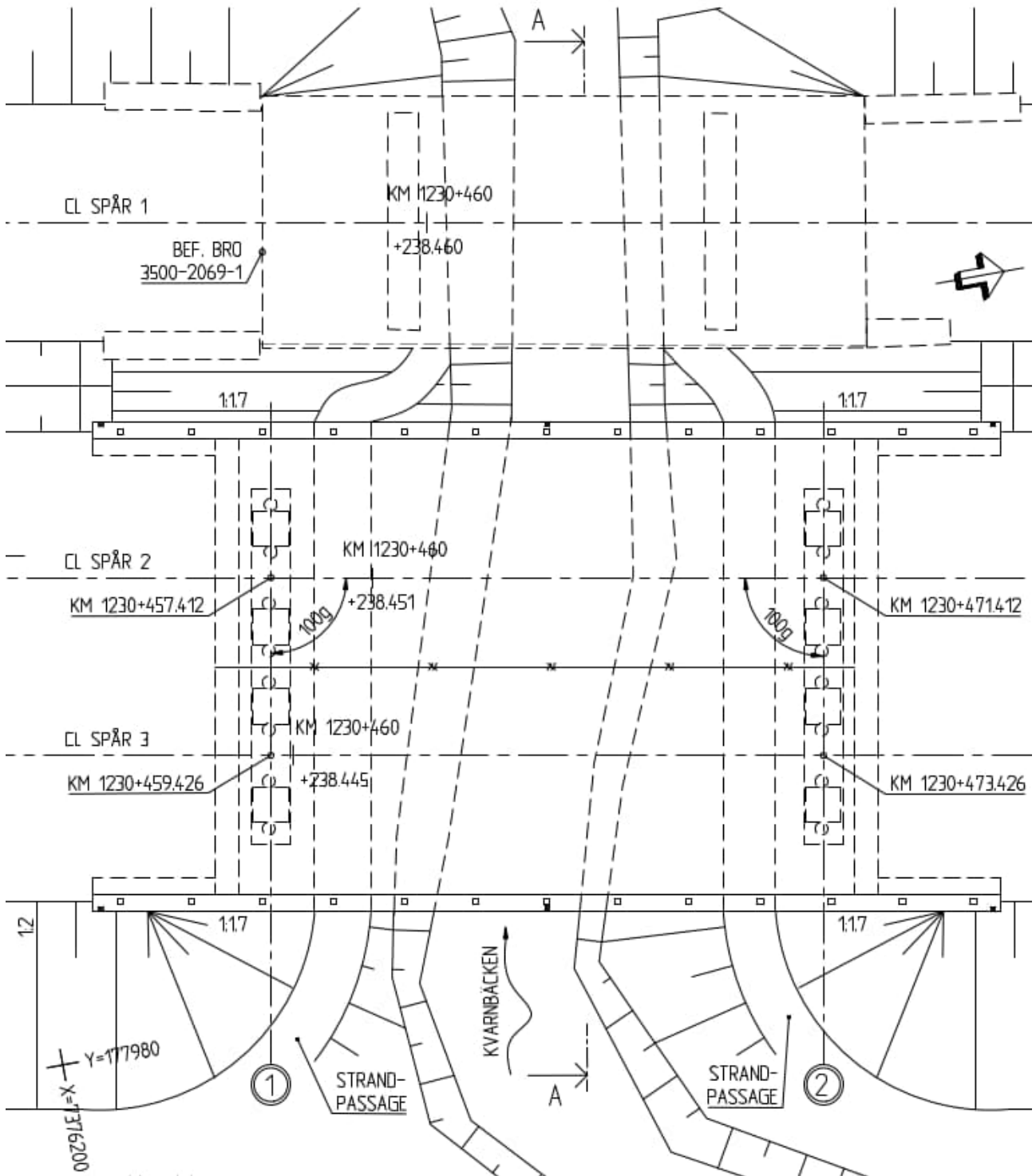
Foundation is carried out with point bearing steel piles. The piles are drilled vertically, at least 500 mm into crack-free rock.

The piles are assumed to be executed as RD-piles (or equivalent) with welded joints.

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## 1.2 MEASUREMENTS

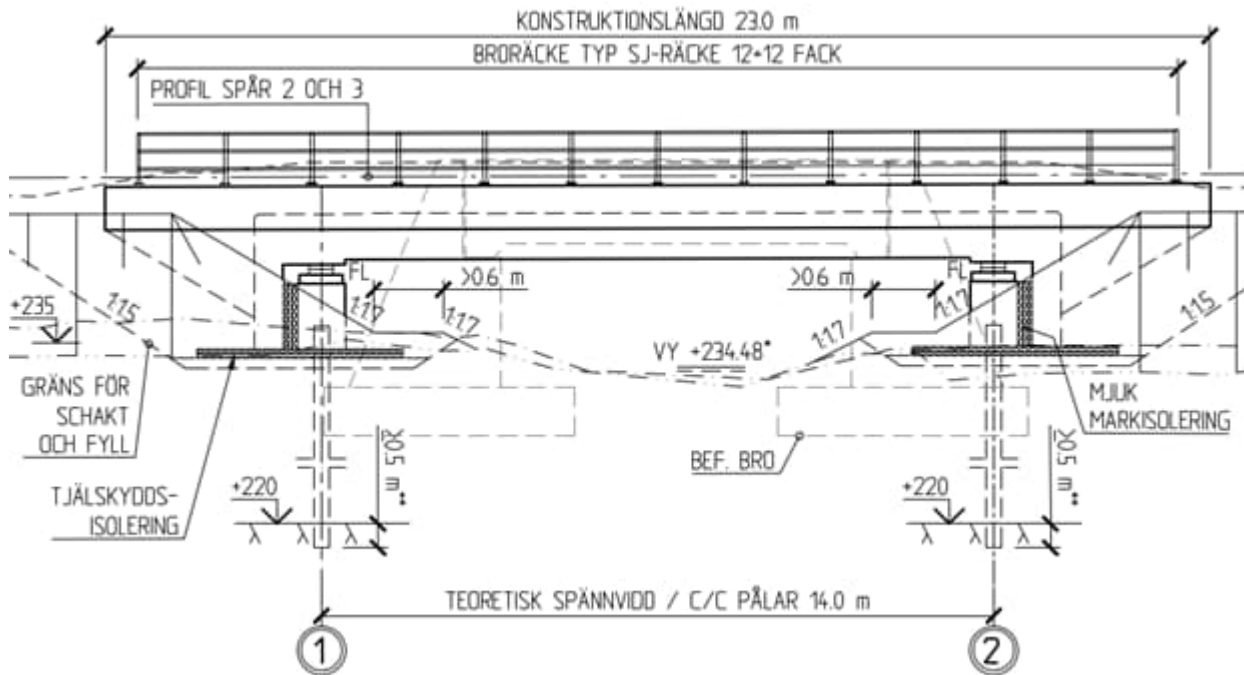
### 1.2.1 Theoretical geometry



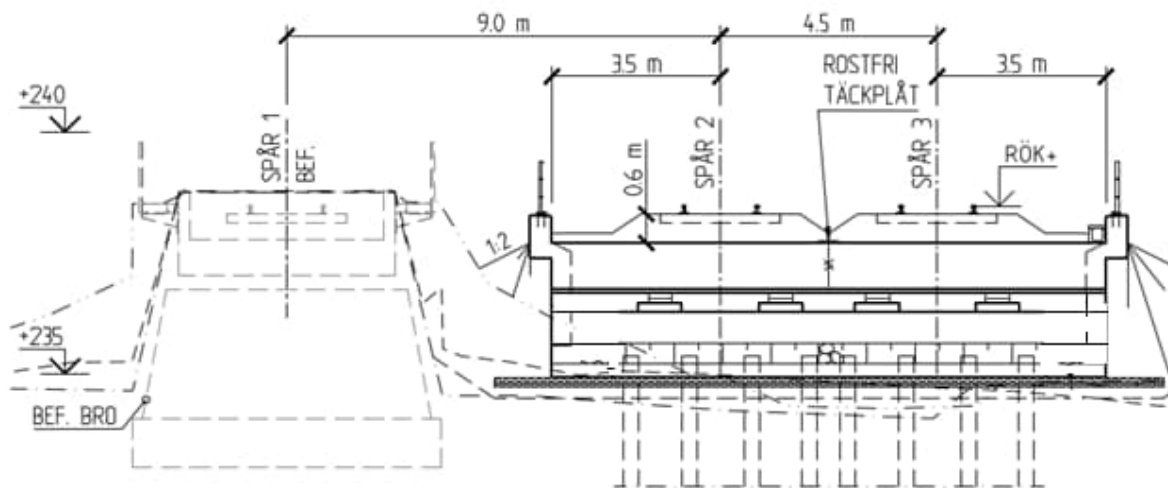
## PLAN

### Overview

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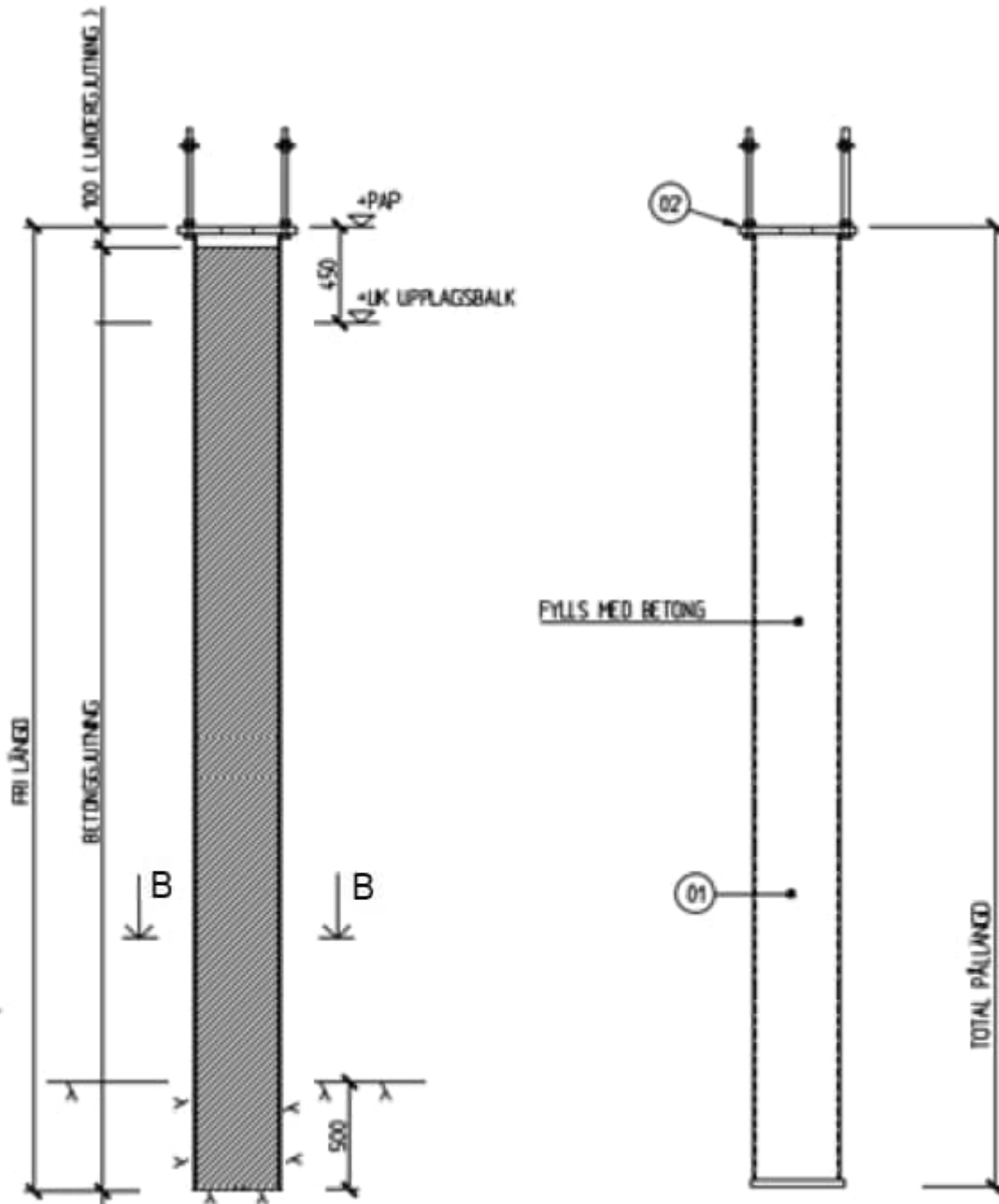


## ELEVATION



## SECTION A-A

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**DETAIL 1**

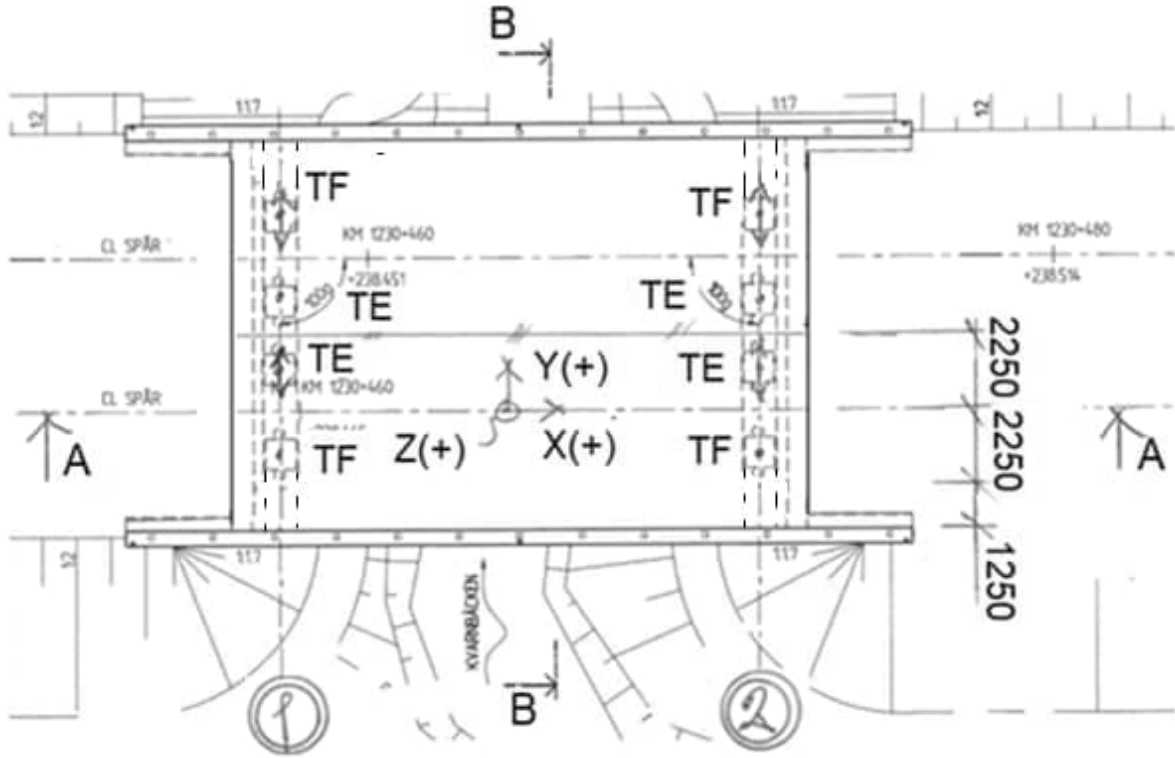
Pile assumed hinged againsts rock.



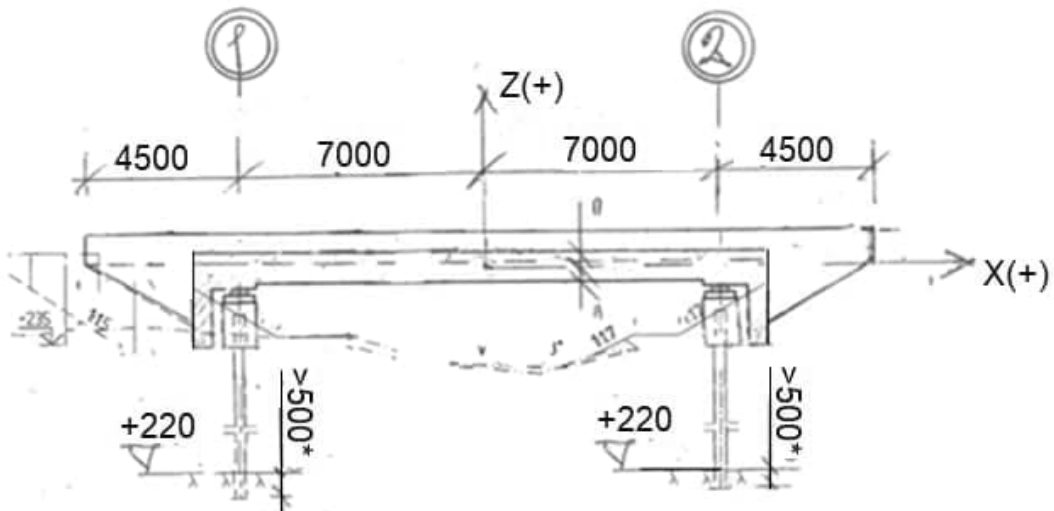
**SECTION B-B**

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1.2.2 Simplified geometry calculations

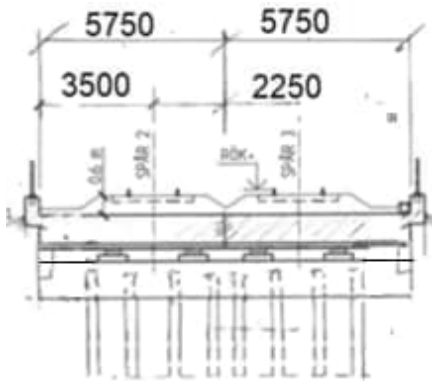


PLAN

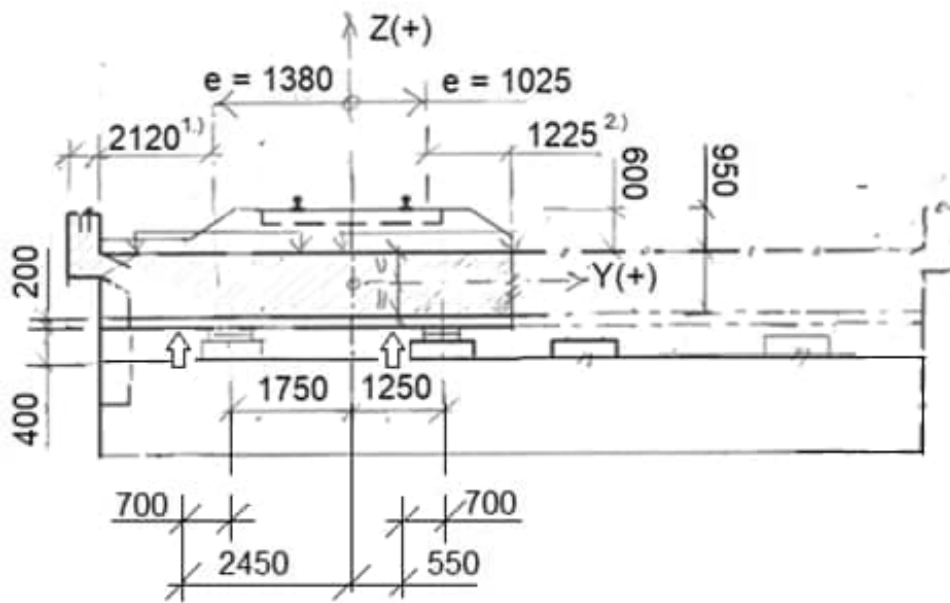


SECTION A-A

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SECTION B-B

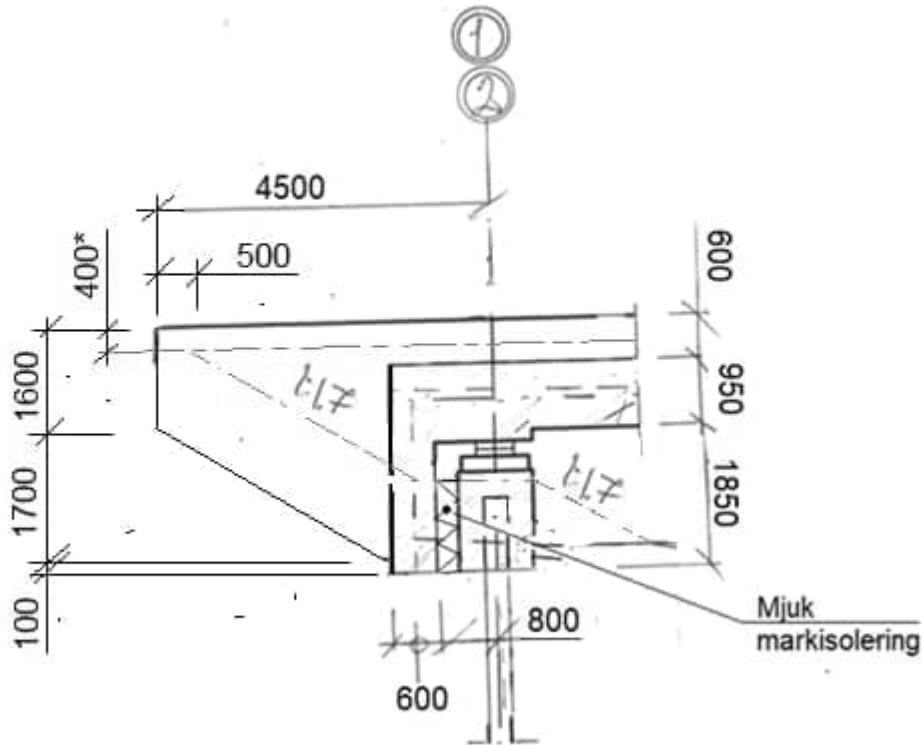


DETAIL 1

Cross section

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\* = applied with regard to possible tract adjustmenets.



DETAIL 2  
Longitudinal

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### 1.3 FOUNDATION

Foundation is performed using drilled point bearing steel piles RD  $\phi$ 270 x 12.5 with topp plate and permanently remaining drill bit (Symmetrix, DTH, ULTRA, MINICON or equivalent).

	Support 1	Support 2
Section (track 22)	1230+457.4	1230+471.4
Level top of track	+238.44	+238.49
Level bottom of track	+238.24	+238.29
Level top of RC slab	+237.64	+237.69
Level bottom end-shield	+234.84	+234.89
Level bottom of bearing RC beam	+234.84	+234.89
Level top of pile	+235.44	+235.40
Level rock	+220.00	+220.00
Level bottom of pile	+219.50	+219.50
Pile length	~15	~15
-	m	m

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#### 1.4 CODE OCH TENDER DOCUMENTS

Document	Ver.	Name
TRVINFRA-00226	4.0	Bro och broliknande konstruktion, Allmänna krav
TRVINFRA-00227	4.0	Bro och broliknande konstruktion, Byggande
TRVINFRA-00229	2.0	Geokonstruktion, Administrativa regler
TRVINFRA-00230	2.0	Geokonstruktion, Dimensionering och utformning
TRVINFRA-00331	2.0	Bro och broliknande konstruktion, bärighetsberäkning
SS 137006:2015	-	Betongkonstruktioner – Utförande – Tillämpning av SS-EN 13670:2009
AMA 23	-	AMA Anläggning 23
TDOK 2023:0125	1.0	TRVAMA Anläggning 23

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## 1.5 TECHNICAL SERVICE LIFE

Technical life span 20 years ( L20 ) for railing.

Technical life span 120 years ( L100 ) for all else.

## 1.6 MILJÖ

Exposure class according to TSFS 2018:57 section 5.3.2.3 and SS-EN 206-1. 1.

In TSFS 2021:57 figure 1.1 the road environment is defined, however does not act.

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A1:12
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## 1.7 MATERIAL

### 1.7.1 Concrete

Concrete (see SS-EN 1992-1-1, Table 3.1):

C30/37 (  $f_{ck} = 30 \text{ MPa}$  ) - RC bearing beam

C35/45 (  $f_{ck} = 35 \text{ MPa}$  ) - all other parts

### 1.7.2 Reinforcement

Material coefficients see SS-EN 1992-1-1:

$\gamma_s$  1,15 [SS-EN 1992-1-1, 2.4.2.4]

$\gamma_{s,fat}$  1,15 [SS-EN 1992-1-1, 2.4.2.4]

$\gamma_{s,Exc}$  1,0 [SS-EN 1992-1-1, 2.4.2.4]

Reinforcement K500-CT:

$f_{yk}$  500 MPa [SS-EN 10080:2005]

$E_{sk}$  200 GPa [SS-EN 10080:2005]

$\Delta\sigma_{Rsk}$  162,5 MPa [SS-EN 1992-1-1, Tabele 6.3N]

### 1.7.3 Steel pile

Steel pile RDT $\phi$ 320 x 12.5 with top plate and permanently remaining drill bit (Symmetrix, DTH, ULTRA, MINICON or equivalent) with properties seen below.

Steel pile: S550 J2H (  $f_{yk} = 550 \text{ MPa}$  )

Top plate: S355 J2 (  $f_{yk} = 345 \text{ MPa}$  )

Concrete (inside): C35/45

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#### 1.7.4 Soil material

##### Ballast:

Ballast of makadam according to AMA DCH.31 (requirements of material see TRVINFRA-00019) with thickness 0.6 m from bottom of track (minimum requirements see TDOK 2015:0198).

TRVINFRA-00230 tables A1-1 and A1-4 gives material properties  $\phi_k = 45^\circ$ ,  $\gamma = 17 \frac{kN}{m^3}$ ,

$\gamma' = 11 \frac{kN}{m^3}$  and  $E_k = 50$  MPa.

##### Under ballast:

Under ballast of blasted rock according to AMA DCH.15 with thickness 1.0 m is assumed (minimum requirement 0.8 m according to TDOK 2015:0198).

TRVINFRA-00230 tables A1-1 and A1-4 gives material properties  $\phi_k = 45^\circ$ ,  $\gamma = 19 \frac{kN}{m^3}$ ,

$\gamma' = 13 \frac{kN}{m^3}$  and  $E_k = 50$  MPa.

##### Backfill:

Coarse crushed blasted rock according to AMA CEB.524 is used to level of under ballast.

TRVINFRA-00230 tables A1-1 and A1-4 gives material properties  $\phi_k = 45^\circ$ ,  $\gamma = 20 \frac{kN}{m^3}$ ,

$\gamma' = 13 \frac{kN}{m^3}$  and  $E_k = 50$  MPa.

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## 1.8 GEOTECHNICAL CLASS

Geotechnical class GK2.

## 1.9 SAFETY CLASS

Safety class according to TSFS 2018:57 chapter 2 table 2.1 and TRVINFRA-00227 section 7.1.2.

Geotechnical resistance: SK 2

Wingwall: SK 2

Bridge structure: SK 3

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## 1.10 TB OCH SPRICKKRITERIER

TRVINFRA-00227 section 5.3.2.1 states use SS-EN 206:2013+A1:2016.

### Class identification bridge components :

Construction part	Exposure class <sup>1.)</sup>	Life span	max vct <sub>ekv</sub> <sup>2.)</sup>	ζ <sup>3.)</sup>
<b>Substructure</b>				
▫ Wingwall towards filling	XC2/XF3	L100	0.50	1.0
▫ Wingwall from filling	XC4/XF3	L100	0.50	1.2
▫ Endshield towards filling	XC2/XF3	L100	0.50	1.0
▫ Endshield from filling	XC4/XF3	L100	0.50	1.2
▫ Bottom support beam	XC2/XF3	L100	0.50	1.0
▫ Other parts parts support beam	XC2/XF3	L100	0.50	1.0
<b>Superstructure:</b>				
▫ Edge beam	XC4/XF3	L100	0.50	1.2
▫ Bridge deck	XC4/XF3	L100	0.50	1.2

#### Footnotes:

- 1.) TRVINFRA-00227 section 5.3.2.3
- 2.) TSFS 2018:57 table 12.1
- 3.) TSFS 2018:57 table 12.3

### Concrete strength classes :

Construction part	Concrete	vct <sub>ekv</sub>
Support beam	C30/37	0.50
Other parts of bridge	C35/45	0.40

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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

$\Delta c_{dev}$  : 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 parts	$c_{min,dur}$ <sup>1.)</sup>	$c_{min,b}$ <sup>2.)</sup>	$c_{min}$	$\Delta c_{dev}$ <sup>3.)</sup>	$c_{nom}$	$W_{k,till}$ <sup>4.)</sup>
<b>Substructure</b>						
▫ Wingwall towards filling	20	20	20	10	30	0.40
▫ Wingwall from filling	25	20	25	10	35	0.30
▫ Endshield towards filling	20	20	20	10	30	0.40
▫ Endshield from filling	25	20	25	10	35	0.30
▫ Bottom support beam	20	20	20	10	45 <sup>5.)</sup>	0.40
▫ Other parts parts support beam	20	20	20	10	30	0.40
<b>Superstructure:</b>						
▫ Edge beam	25	20	25	10	35	0.30
▫ Bridge deck	25	20	25	10	35	0.30
	mm	mm	mm	mm	mm	mm

Fotnotes:

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 table 12.2

5.) TSFS chapter 12 section 2§  $k_1 = c_{min} + 15$  mm when casting against building foil.

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## **2. SYSTEM ANALYSIS**

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2.5	BOUNDARY CONDITIONS	page 2:25
2.6	MESH	page 2:26-29
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## 2.1 GENERAL

Bron är en slakarmerad plattbro med ändskärm som tillverkas rak.

Bron grundläggs på borrade spetsburna vertikala stålrörspålar. Dessa förutsätts ledat anslutna i berg.

Två olika systemberäkningar ett betecknad primärt (överbyggnad) statiskt system och sekundär (påelement).

The bridge is a reinforced concrete slab bridge with end abutments, constructed straight.

The bridge is founded on drilled steel piles. These are assumed to be hinged against rock.

Two different system calculations, one designated primary (superstructure) static system and secondary (pile element).

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### 2.1.1 Primary analysis (superstructure)

The superstructure is divided by longitudinal expansion joint at centre. However, this does not apply to the substructure.

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

Wingwalls are not modelled in the static model; they are considered statically inactive in the vertical plane. This is because stiffness in vertical direction is considered negligible due to cracking. Minimum reinforcement is used to limit the crack width. Wingwalls are replaced with line loads in the static model.

Traffic load evaluation is performed using the FEM-program function Moving Load Analysis.

The bridge deck and abutments consist of high-node shell elements (QTS8). These shell elements are modelled with isotropic material properties corresponding to uncracked concrete in all areas except for the bridge deck locally over each transverse beam. In this area, orthotropic shell elements without stiffness in the transverse direction are used. This is because the transverse beams replace this stiffness.

Transversal beams at supports are modelled as 3D beam elements (BMX21). These beam elements are modelled with isotropic material properties corresponding to uncracked concrete.

To achieve correct load distribution in the bridge deck, the fixed bearing (TF) at support 2 is replaced with a movable bearing (RX). The unilaterally movable bearing (TE) is also replaced with an all-sided movable bearing (TA).

### Attachments:

Attachment	Name
1	Input receipt
2	Results bearing forces
3	Results bridge deck incl. end-shield
4	Results transversal beams at supports

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:4
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### 2.1.2 Secondary analysis (steel piles)

See separate presentation, pile design.

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## 2.2 SKETCH SYSTEM ANALYSIS

There are 2 static systems. The primary (superstructure) and secondary (pile elements).

The secondary static system is described in calculation section B (Foundation).

This section only describes the primary static system.

To describe geometry first POINTS are defined.

Beam elements are defined by applying attributes to LINES.

Shell elements are defined by applying attributes to SURFACES.

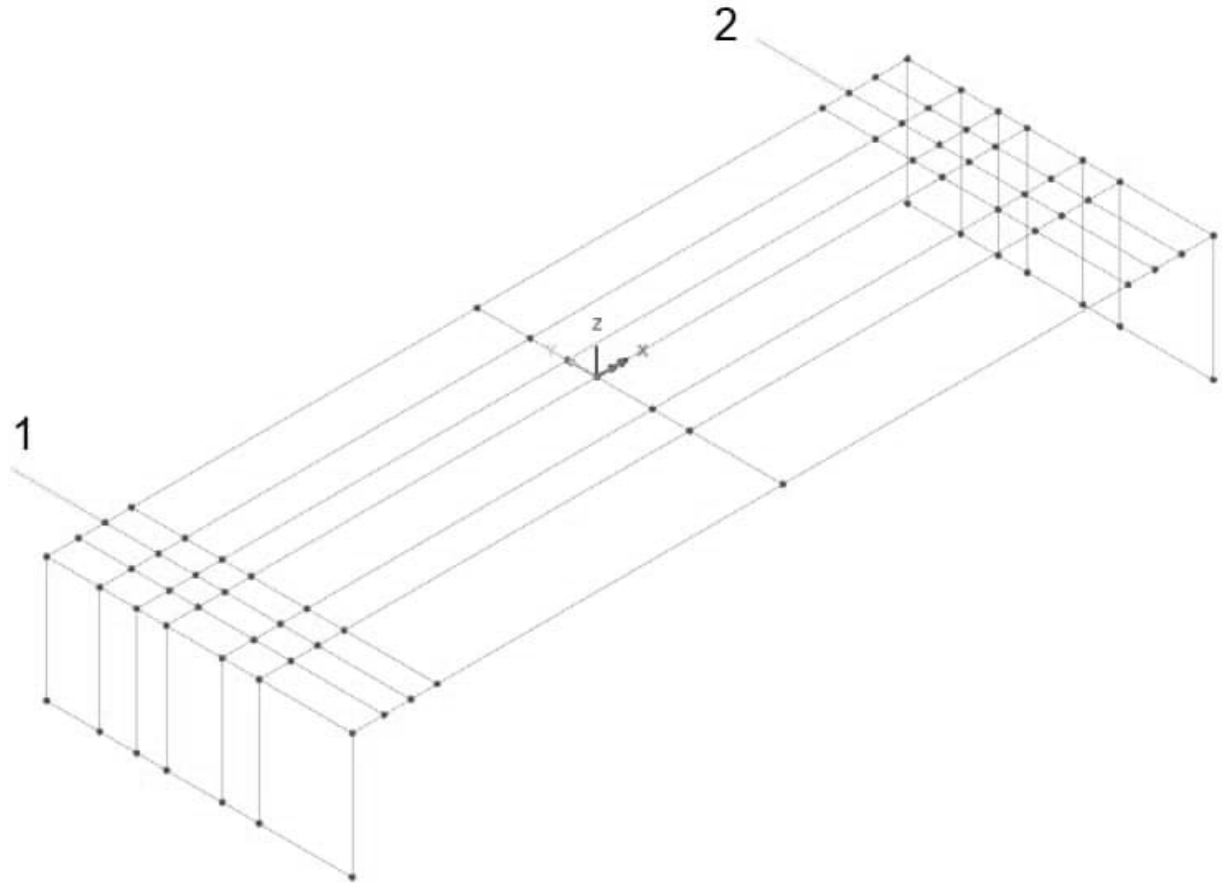
Attached pictures are retrieved from graphical sketches generated by FEM-program of POINTS, LINES and SURFACES.

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

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

All LINES need to describe SURFACE are found in attachment 1.

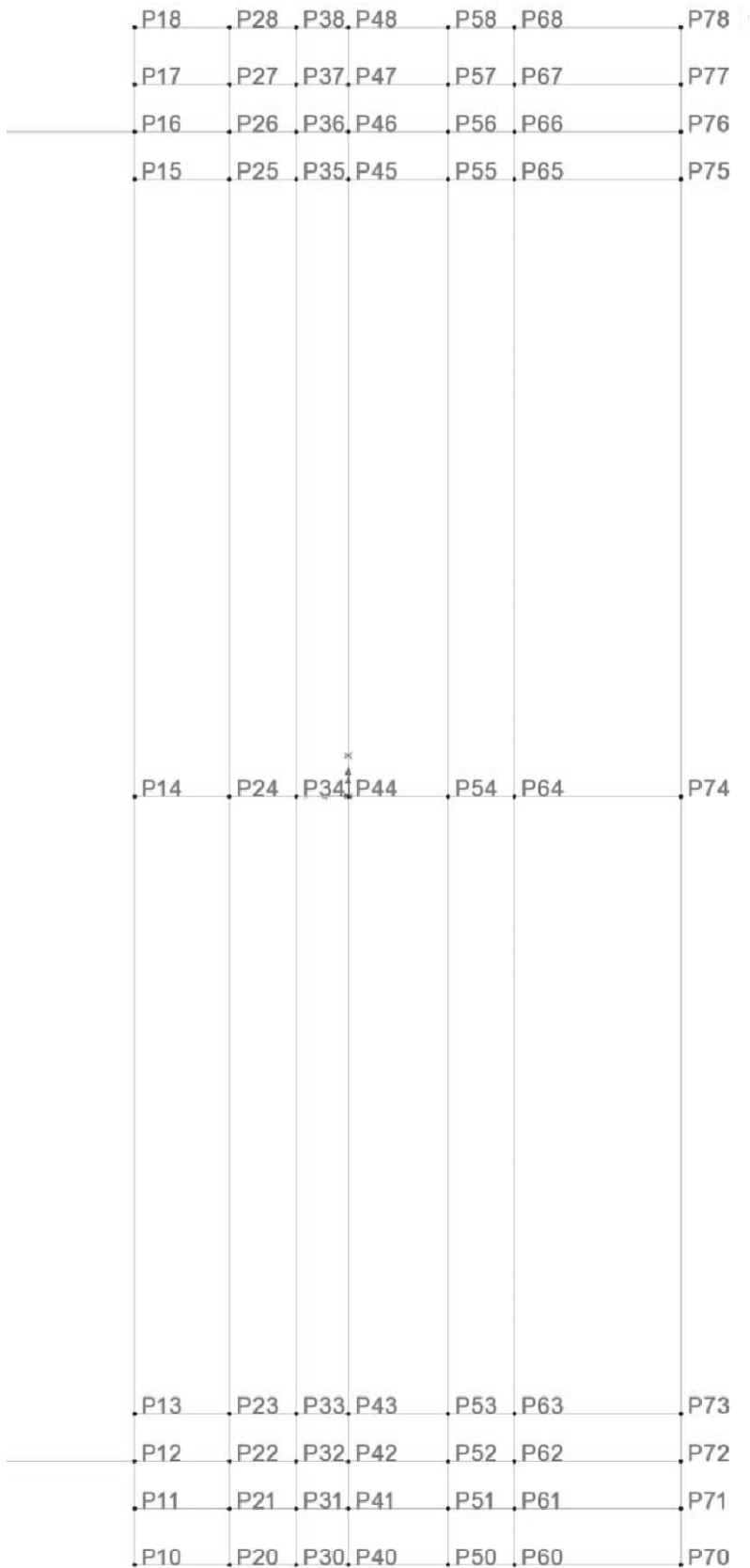
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:6
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Overview 3D  
Geometry

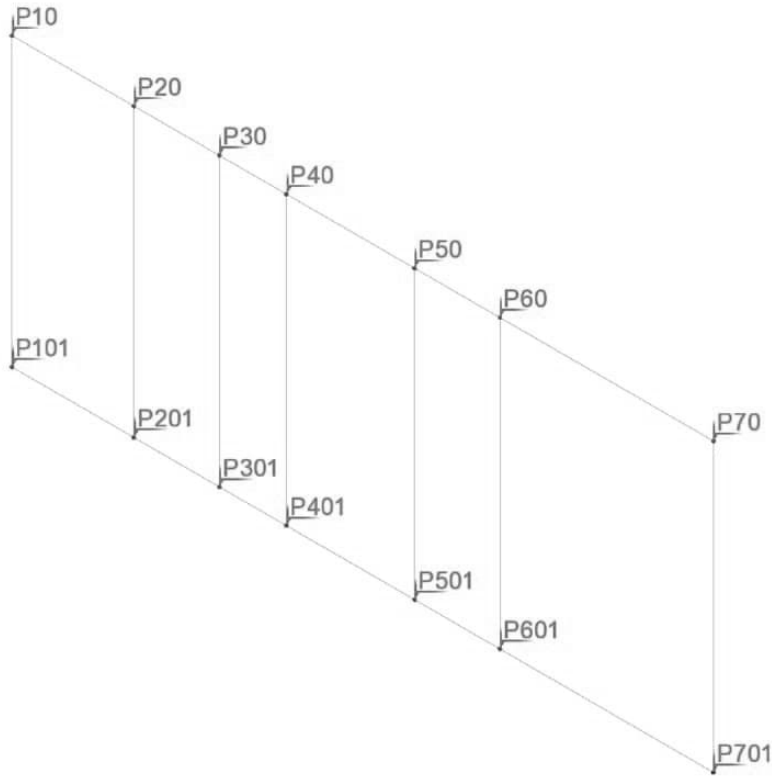
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:7
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### 2.2.1 Geometry : POINTS

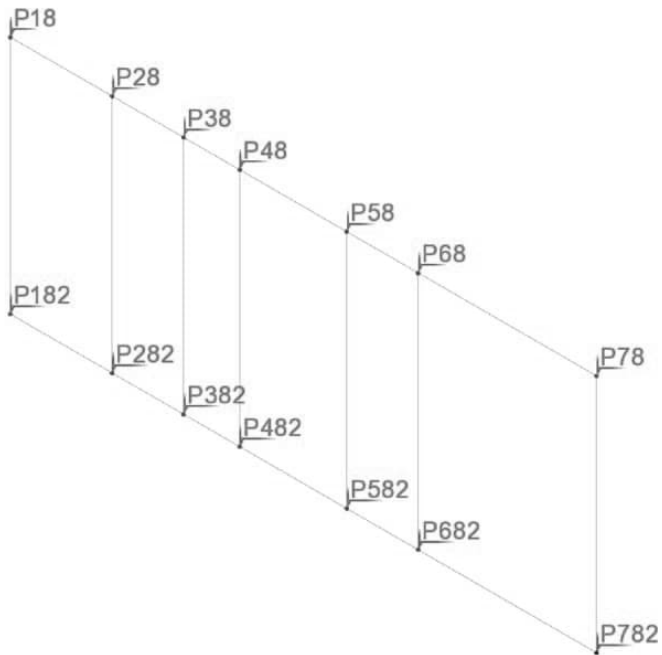


### Bridge deck

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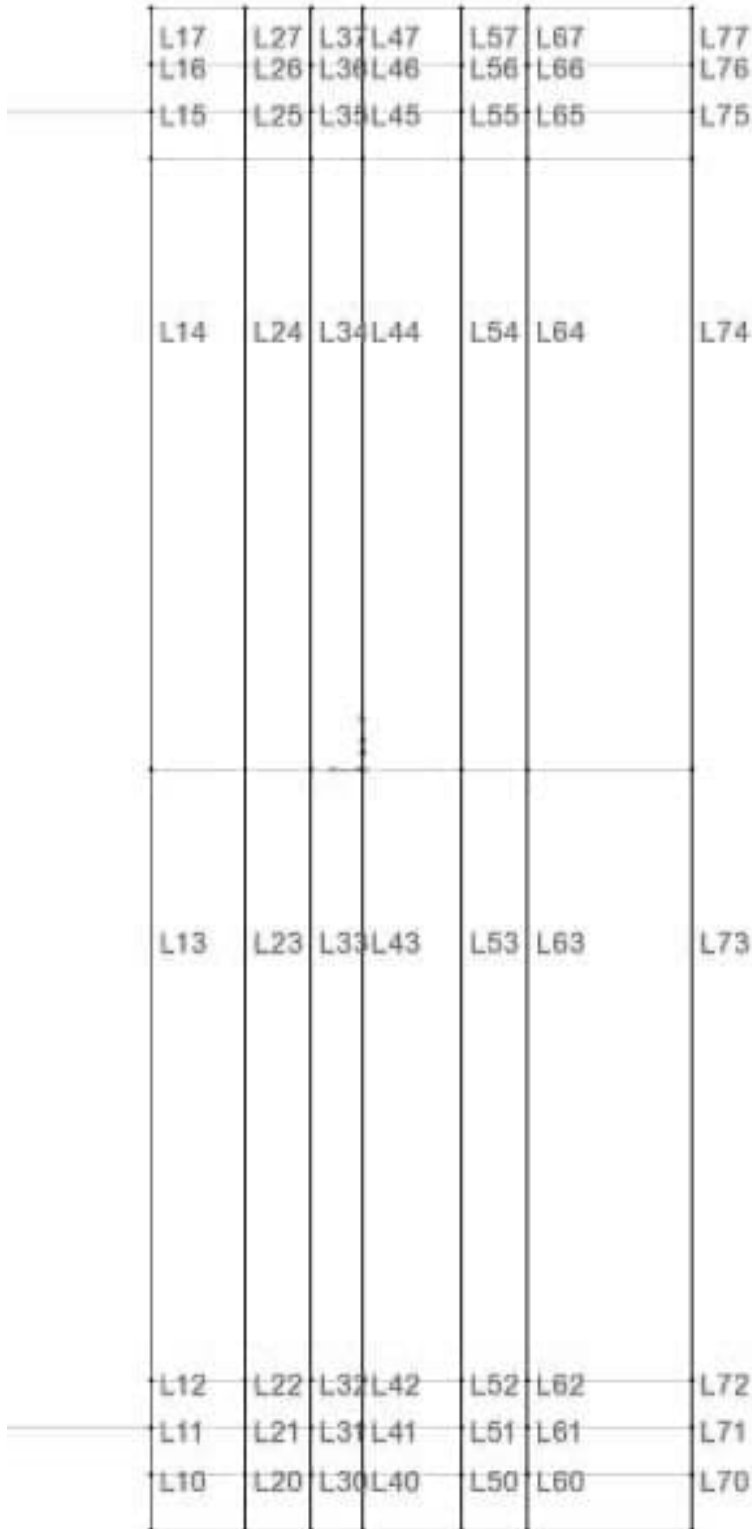
End shield – support 1



End shield - support 2

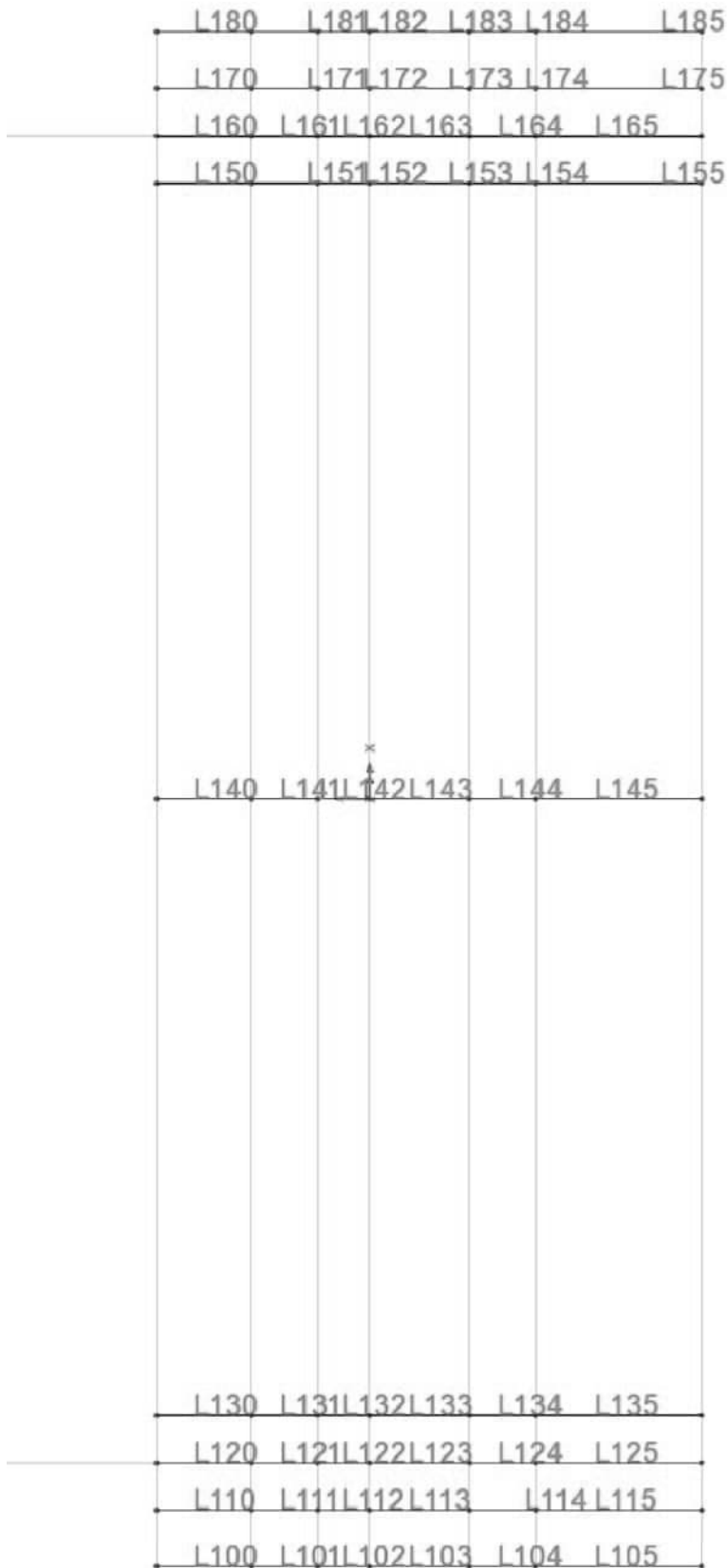
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:9
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### 2.2.2 Geometry : LINES



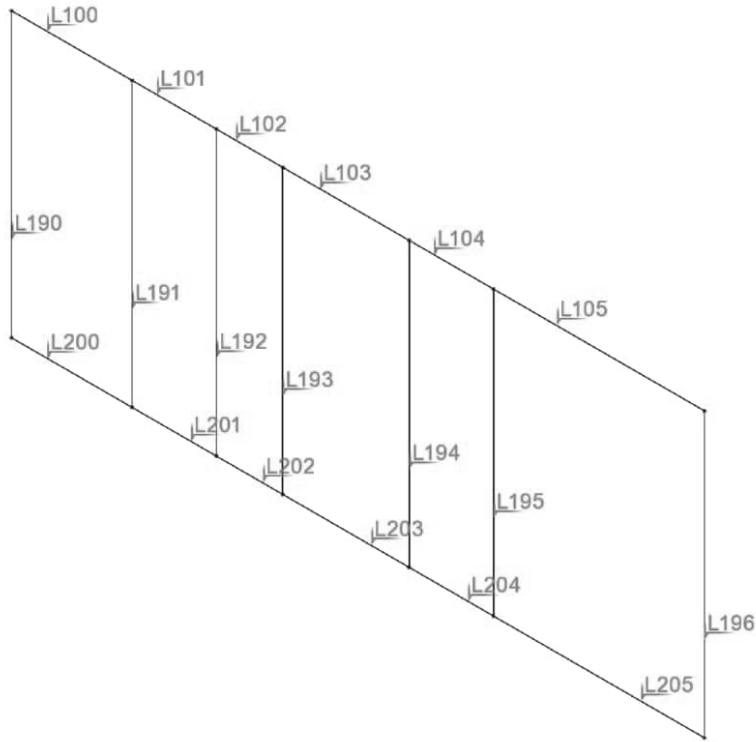
### Bridge deck Longitudinal lines

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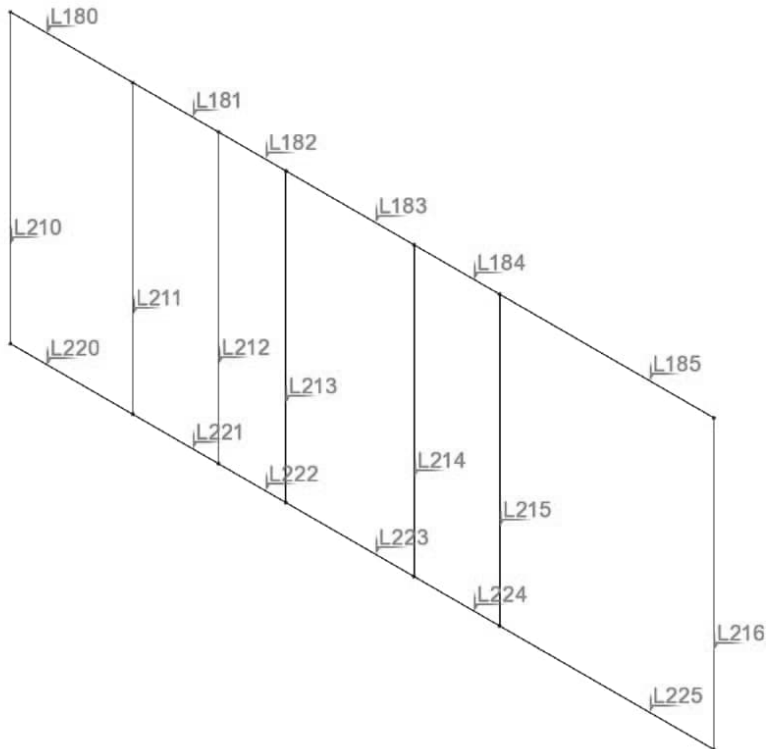


Bridge deck  
Transversal lines

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End shield - support 1



End shield – support 2

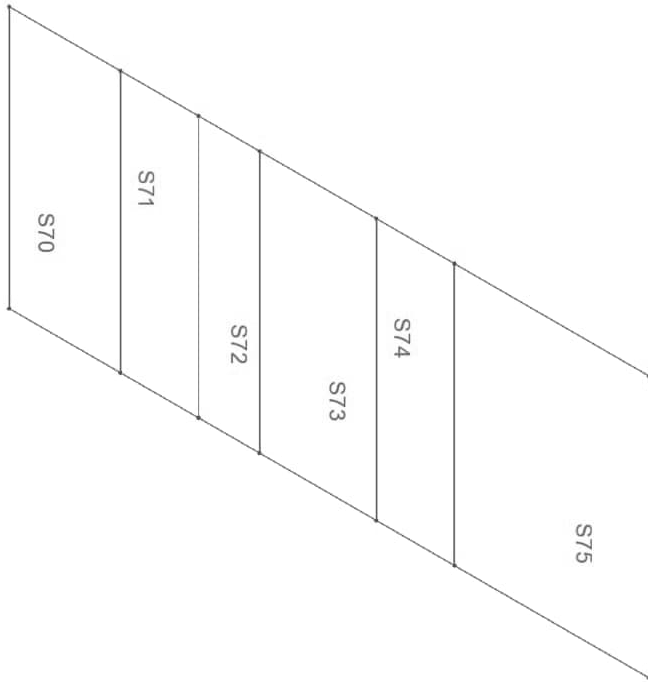
	Part A – CALCULATION ASSUMPTIONS				Status :	Page: A2:12
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### 2.2.3 Geometry : SURFACES

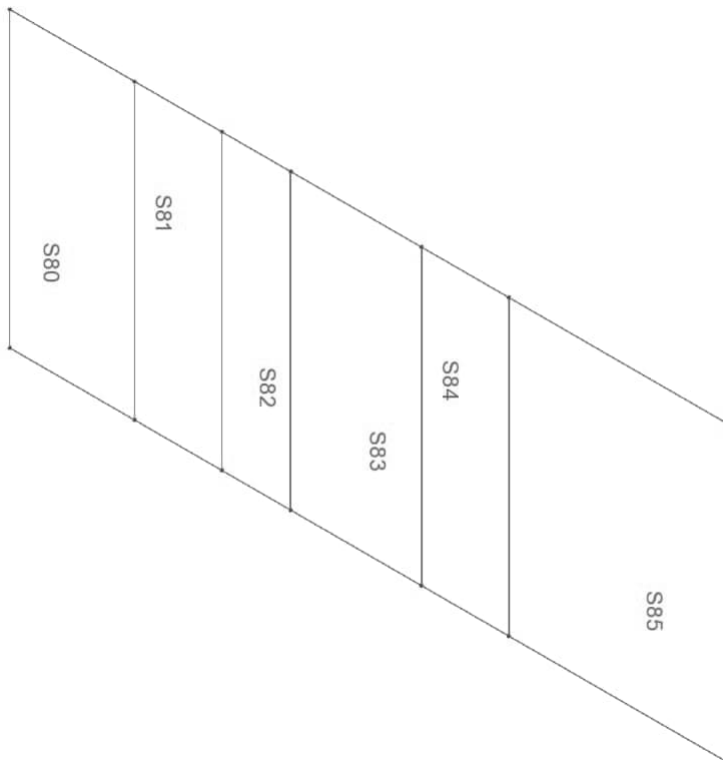
S17	S27	S37	S47	S57	S67
S16	S26	S36	S46	S56	S66
S15	S25	S35	S45	S55	S65
		S34	S44	S54	S64
S14	S24				
			S43	S53	S63
S13	S23	S33			
S12	S22	S32	S42	S52	S62
S11	S21	S31	S41	S51	S61
S10	S20	S30	S40	S50	S60

### Bridge deck

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End shield – support 1



End shield – support 2

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:14
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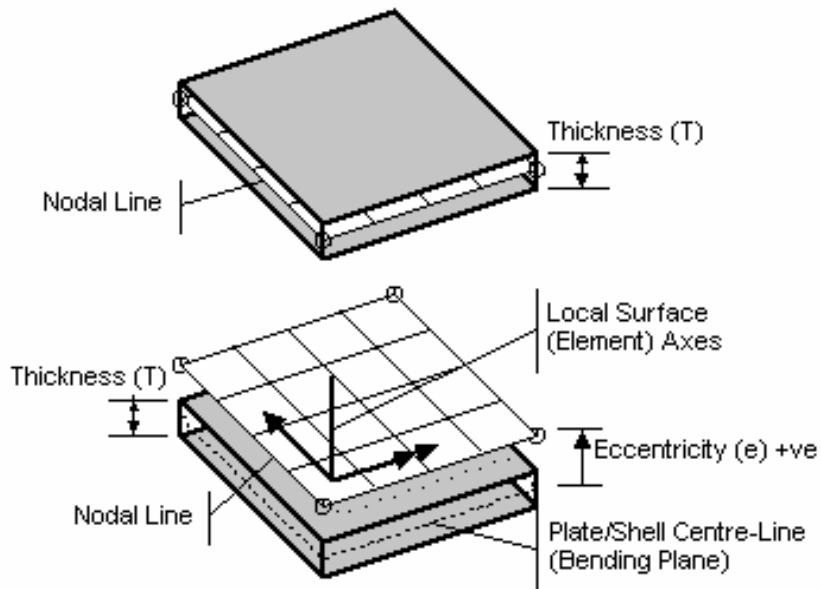
### 2.3 CROSS SECTION PROPERTIES

There are 2 different types of constructions – shell elements and beam elements. Geometric properties are applied to these.

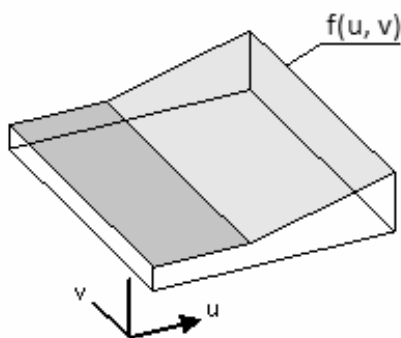
	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:15
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### 2.3.1 Shell element

Principle figures of geometry associated to shell elements ("Thick shell" / QTS4) are seen below.

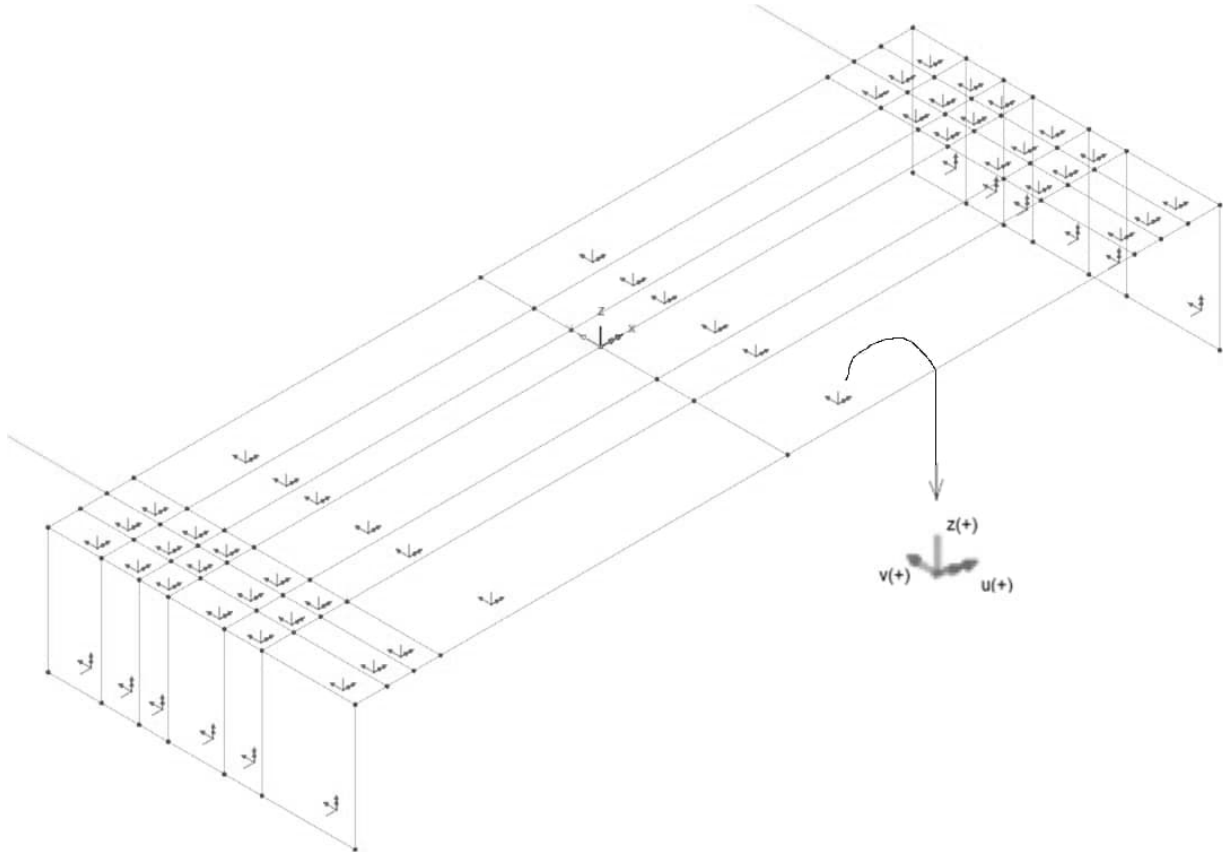


Varying thickness in shell element is handled using "Function variation". This makes it possible to create a function  $f(u, v)$  as seen below.



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Local coordinate system (u,v) according to sketch below:

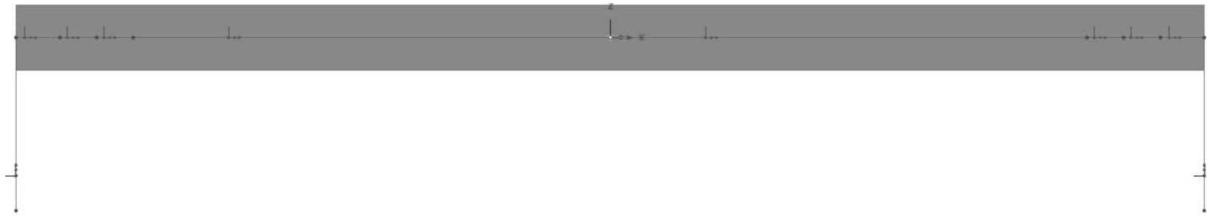


Surface geometry :

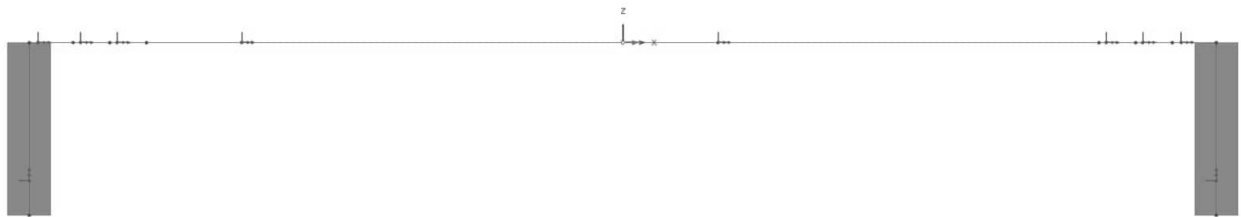
Attribute	t	ez	Remark
t = 0.95 m	0.95	0	Bridge deck
t = 0.60 m	0.60	0	End shield
-	m	m	-

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Bridge deck:



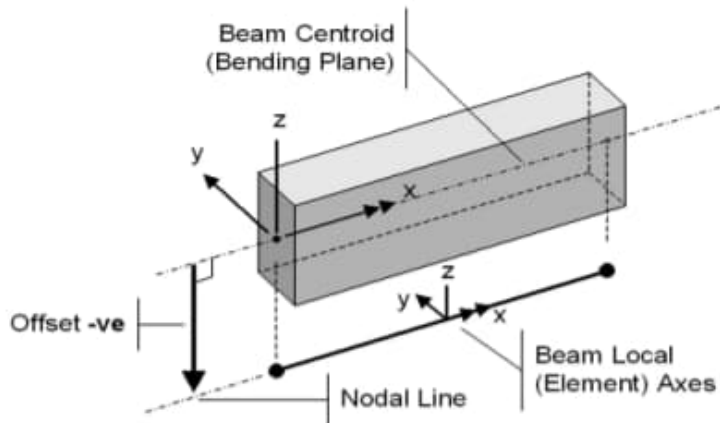
End shields:



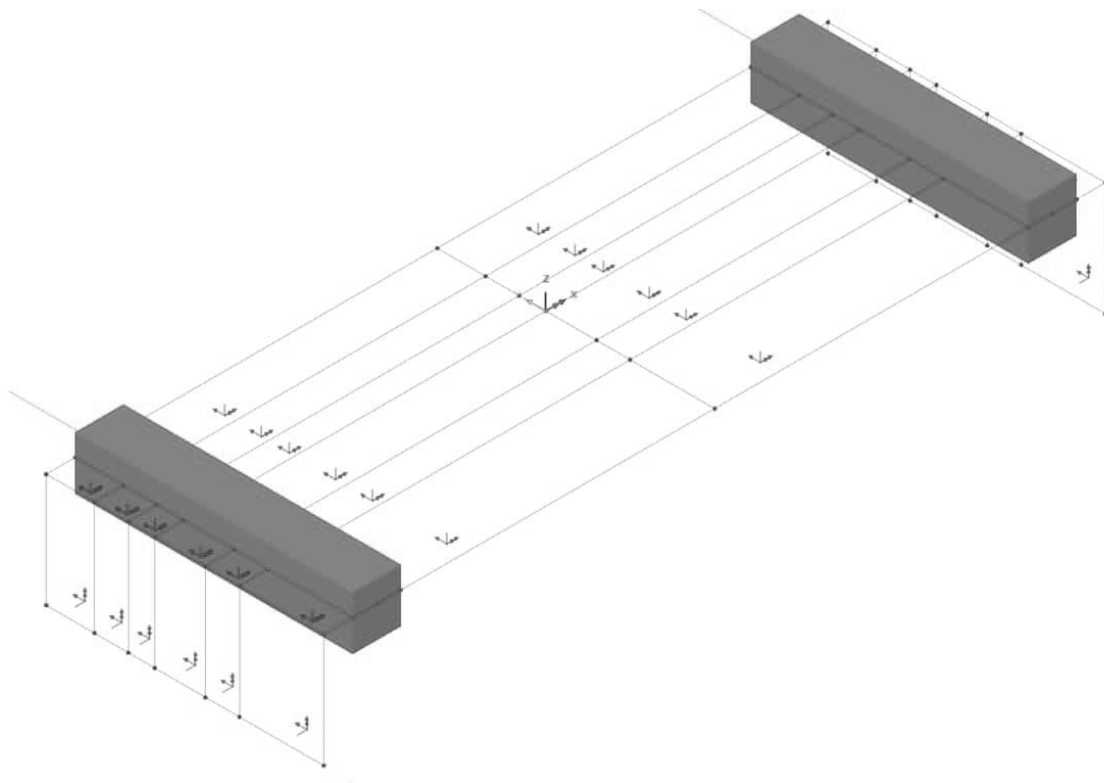
	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:18
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### 2.3.2 Beam elements

Principal sketch of geometry associated to 3D beam elements ( "Thick beam" BMX21) are seen below.



Transversal beam (TVB) is added at both supports .



### Overview Transversal beams

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Geometric Line



Analysis category

Definition

From library / calculator  
 Enter properties

Rotation about centroid  °    Mirrored about axis

Reinforcement (only used for RC design checks)

ez origin     ey origin

	Value
Cross sectional area (A)	1.1
Second moment of area about y axis (Iyy)	0.110917
Second moment of area about z axis (Izz)	0.0916667
Product moment of area (Iyz)	0.0
Torsional constant (J)	0.169401
Effective shear area in y direction (Asy)	0.916775
Effective shear area in z direction (Asz)	0.916757
Eccentricity in y direction (ey)	0.0
Eccentricity in z direction (ez)	0.1

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

Name  (3)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:20
		Date :	Created :

## 2.4 MATERIAL

Material properties seen below are to be used for all parts.

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

- Shell element a location of transversal beam at supports (TVB) → orthotropic weightless concrete C35/45
- All other shell elements → isotropic concrete C35/45
- Transversal beams (TVB) → isotropic concrete C35/C45

### Remark

The orthotropic shell elements are used to avoid considering stiffness and weight in the transverse direction when already included in the transversal beams.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:21
		Date :	Created :

### 2.4.1 Material: Isotropic concrete C35/45

$$E = 34 \cdot 10^3 \text{ MPa}$$

Elastic

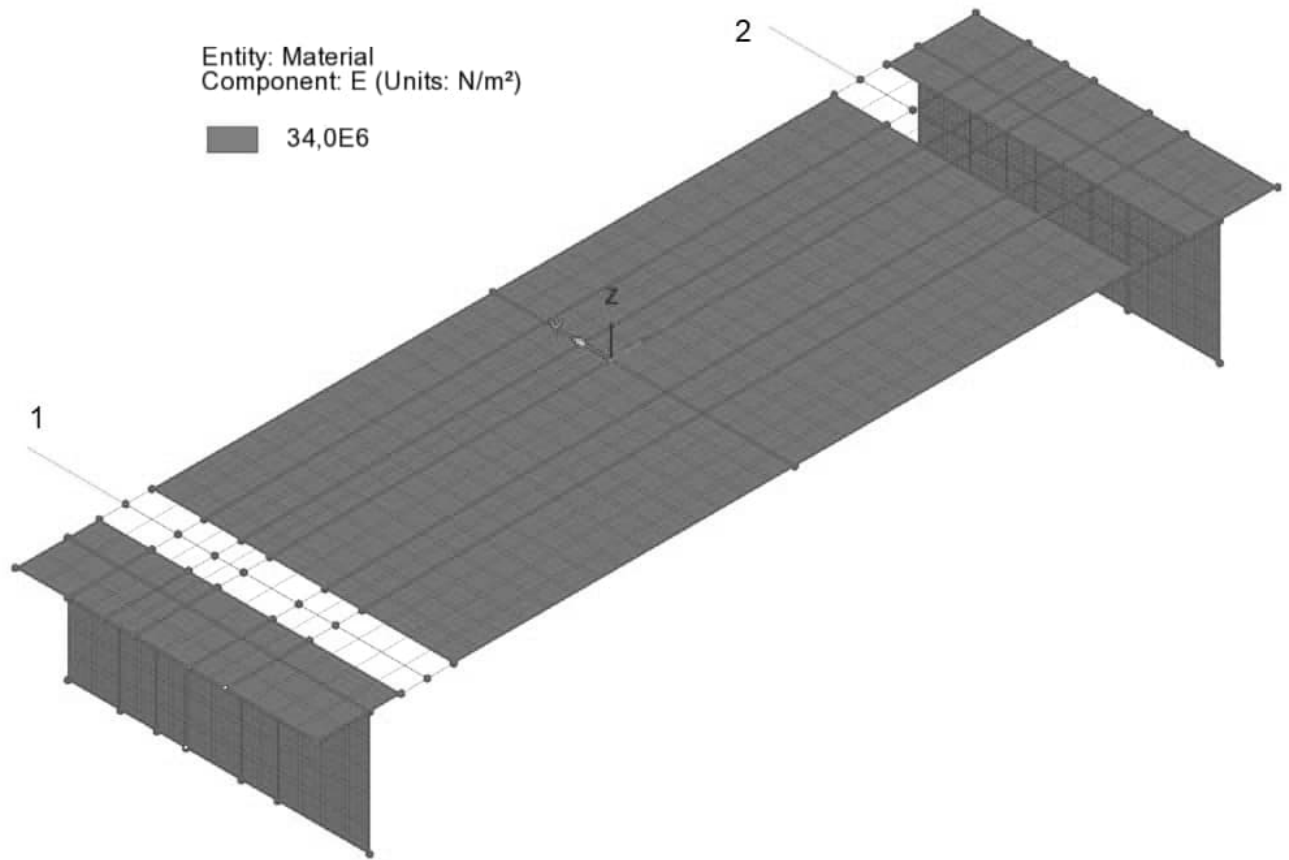
Dynamic properties

Thermal expansion

	Value
Young's modulus	34.0E6
Poisson's ratio	0,2
Mass density	2,5
Coefficient of thermal expansion	10,0E-6

Name  (4)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:22
		Date :	Created :



Overview  
Material *C35/45 Isotropic*

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:23
		Date :	Created :

### 2.4.2 Material: Orthotropic concrete C35/45

The orthotropic concrete has negligible stiffness in the transverse direction (Y-direction). The negligible stiffness is modelled as  $E_{cm}/1000$ . The material is also modelled as weightless. The material is used locally over the transverse beams (TVB) in order to ensure that the weight and stiffness of the bridge deck are not considered for either shell elements or beam elements.

The material is applied only to shell elements within an area of 1.0 m at each support line.

$$E_x = 34 \cdot 10^6 \text{ kPa}$$

$$E_y = 34 \cdot 10^3 \text{ kPa}$$

Orthotropic ×

Plastic   
 Creep   
 Damage   
 Shrinkage   
 Viscous   
 Two phase

Elastic

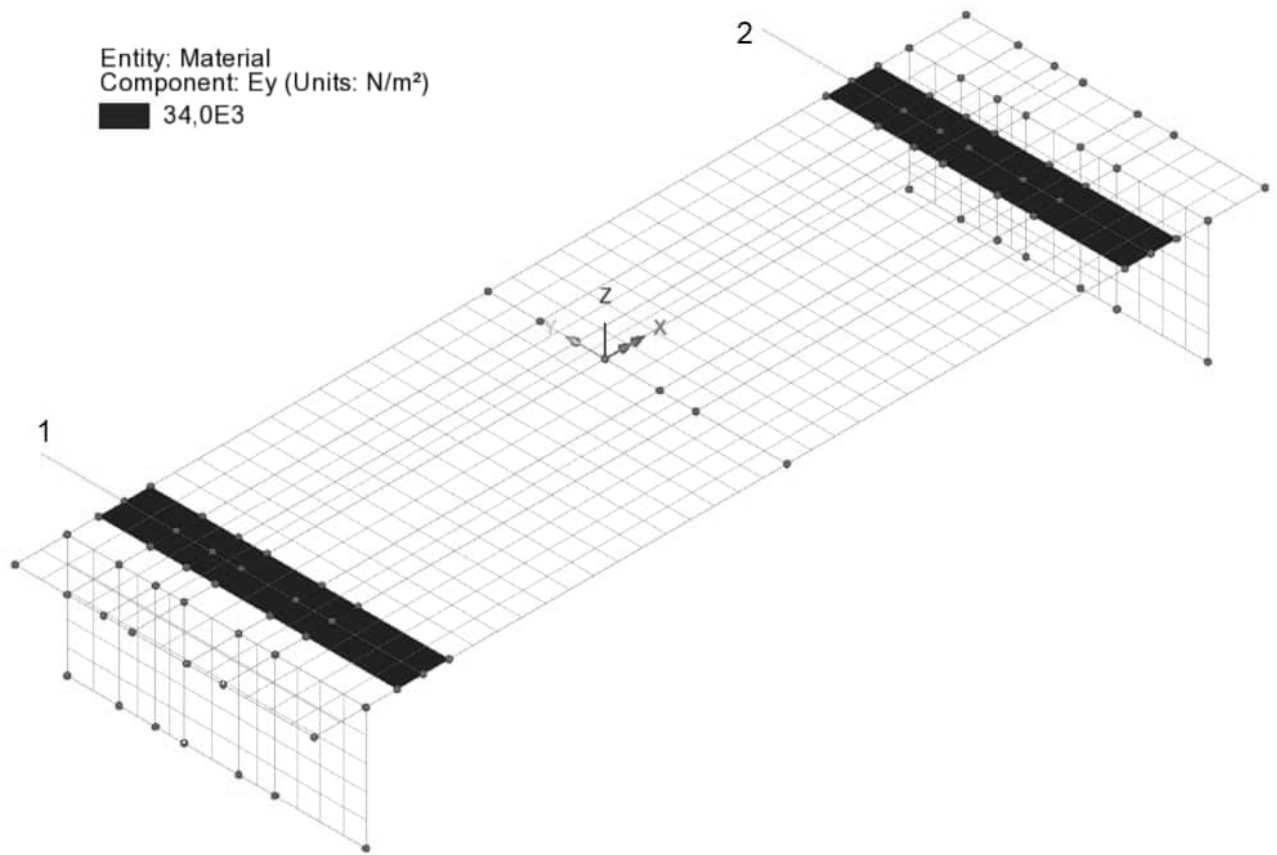
Model: 5 - Thick ▼

Thermal expansion  
 Dynamic properties

	Value
Young's modulus x	34,0E6
Young's modulus y	34,0E3
Shear modulus xy	14,0E3
Shear modulus yz	14,0E3
Shear modulus xz	14,0E6
Poisson's ratio xy	1,0E-3
Angle of orthotropy	0,0
Mass density	1,0E-3

Name: C35/45 viktlos ortotrop ▼ ▲ (2)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A2:24
	RC slab bridge	Date :	Created :



### Overview

Material *C35/45 Orthotropic*

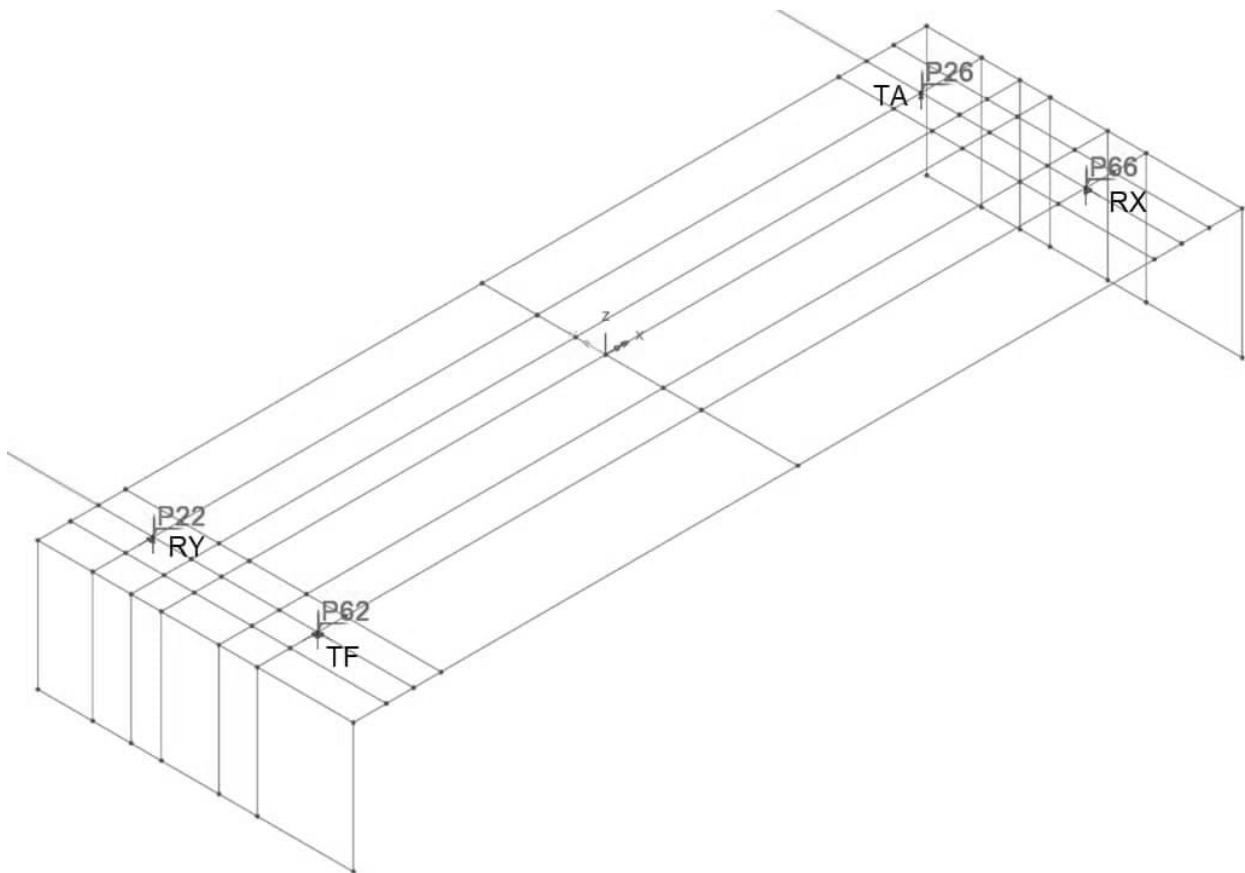
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:25
		Date :	Created :

## 2.5 BOUNDARY CONDITIONS

In the static model, the following boundary conditions are applied at the position for each layer. The selection of boundary conditions provides correct load effects when determining load effects in the superstructure.

Bearing	X:movement	Y:movment	Z:movement
TA	Free	Free	Fixed
TF	Fixed	Fixed	Fixed
RX	Free	Fixed	Fixed
RY	Fixed	Free	Fixed

Table  
Definition bearings.



	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:26
		Date :	Created :

## 2.6 MESH

### 2.6.1 Shell element ( QTS8 ): linear

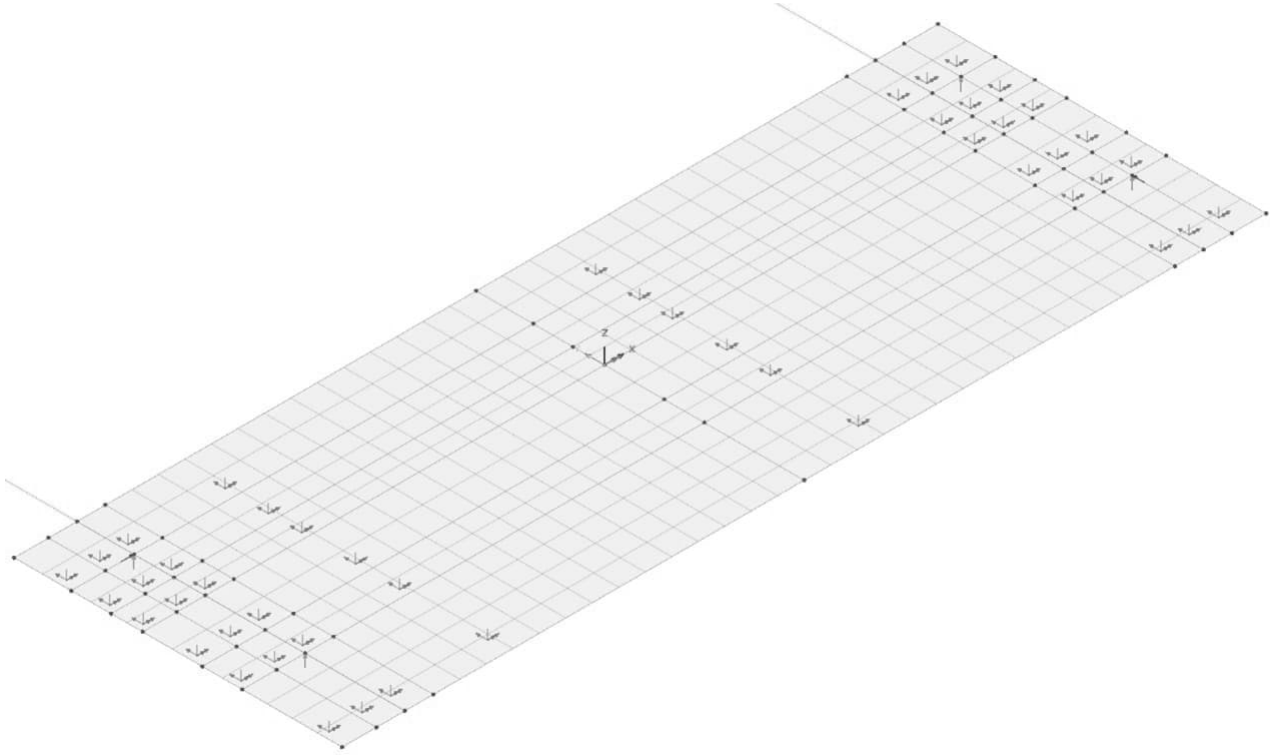
Bridge is modelled using shell elements.

High node elements are chosen ( ”Thick shell” / QTS8 ) to limit the number of elements while maintaining accuracy.

Type	x-divisions	y-divisions
Element 1 x 2	1	2
Element 1 x 4	1	4
Element 5 x 2	5	2
Element 5 x 4	5	4
Element 14 x 1	14	1
Element 14 x 2	14	2
Element 14 x 4	14	4

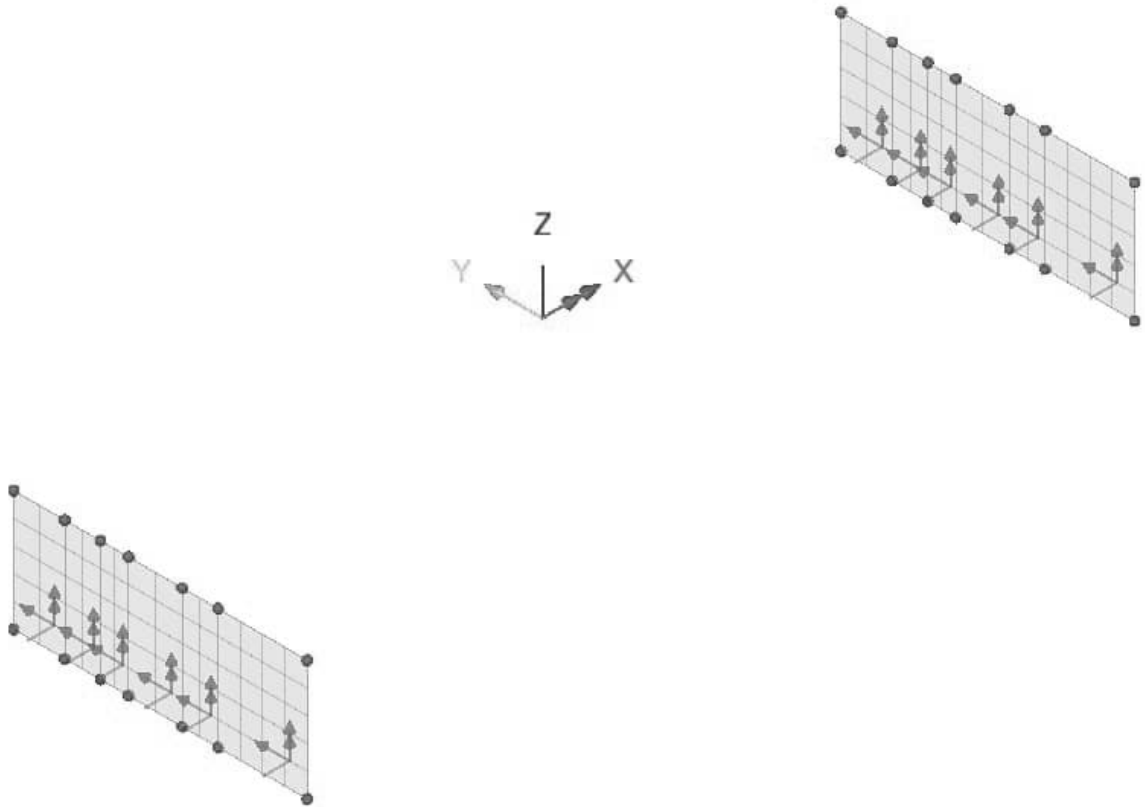
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:27
		Date :	Created :

Bridge deck:



	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:28
		Date :	Created :

End shields:



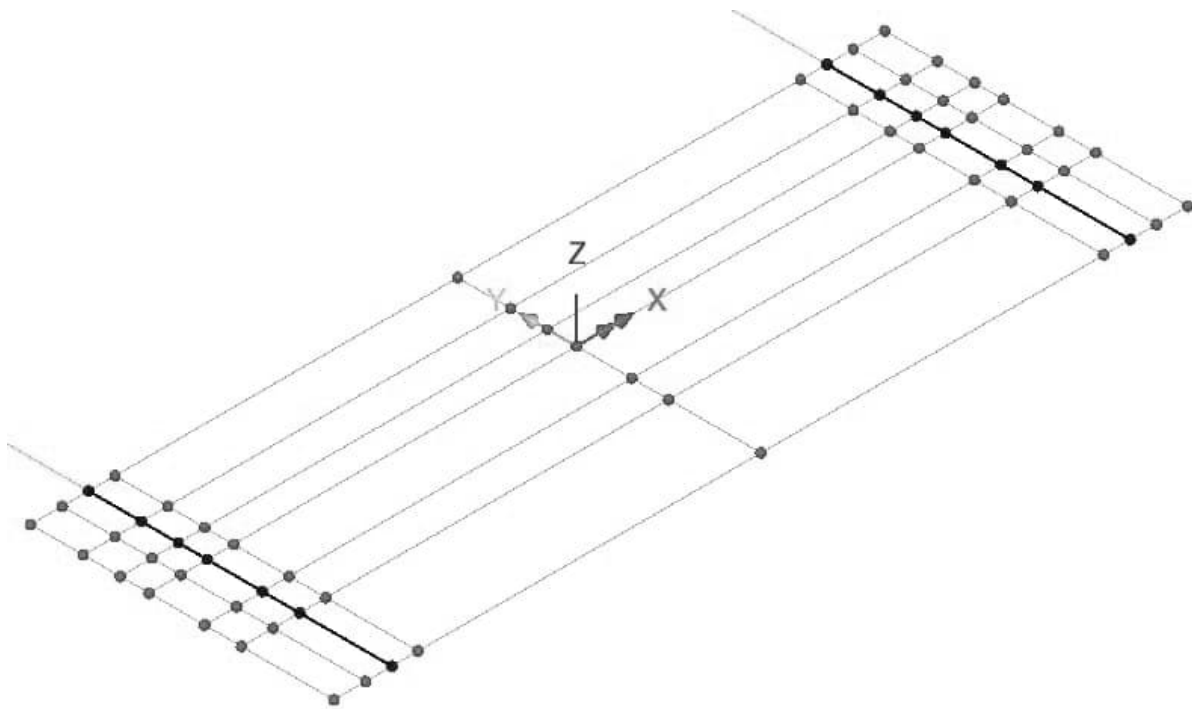
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:29
		Date :	Created :

### 2.6.2 Beam element (BMX21) : linear

Studied bridge uses beam elements (" Beam element" / BMX21) for support beam.

Typ	Divisions	End release: Start	End release: End	Structure
Element 2	2	None	None	TVB
Element 4	4	None	None	TVB

Tvärbalkar (TVB):

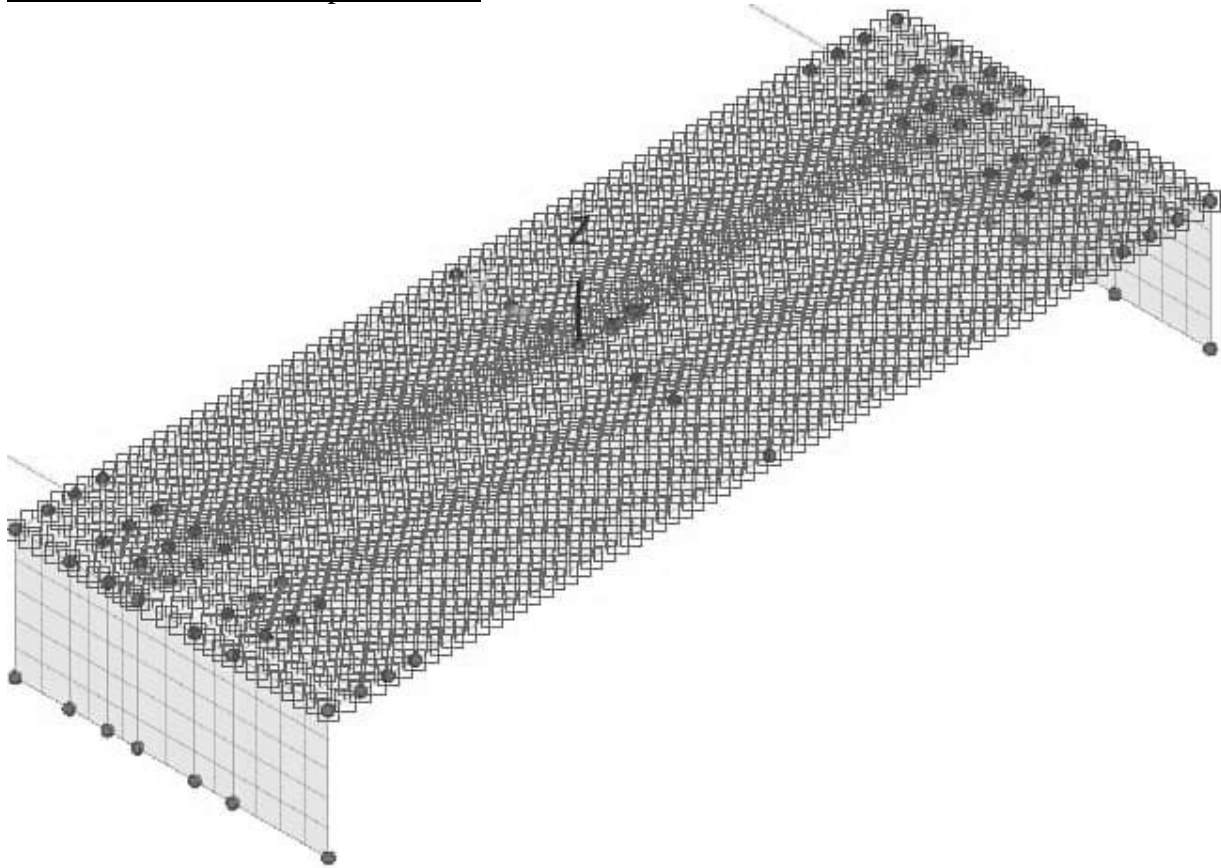


	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:30
		Date :	Created :

## 2.7 SEARCH AREA

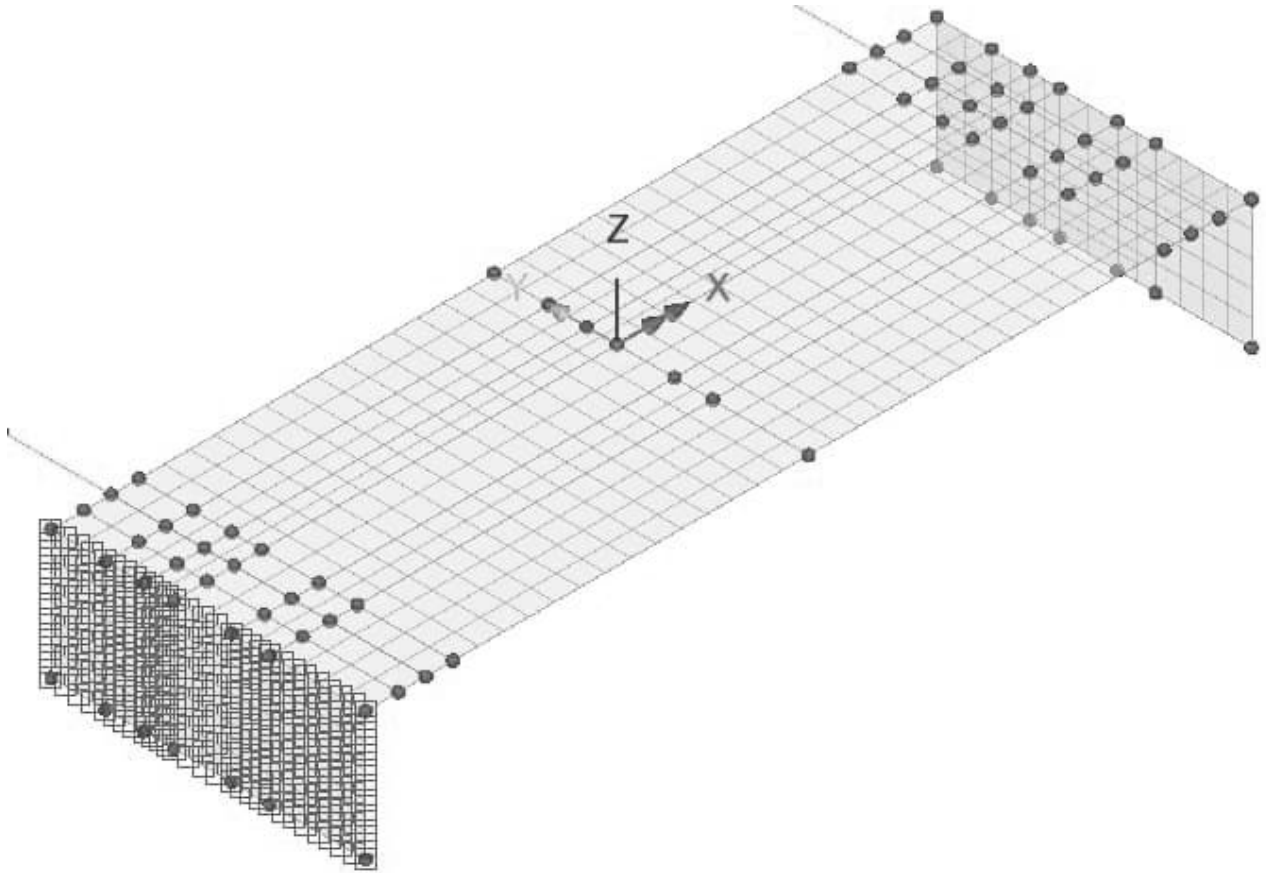
Discrete load can be applied to structure as geometrical load areas, termed *Search Area*.

### 2.7.1 Search area : Superstructure



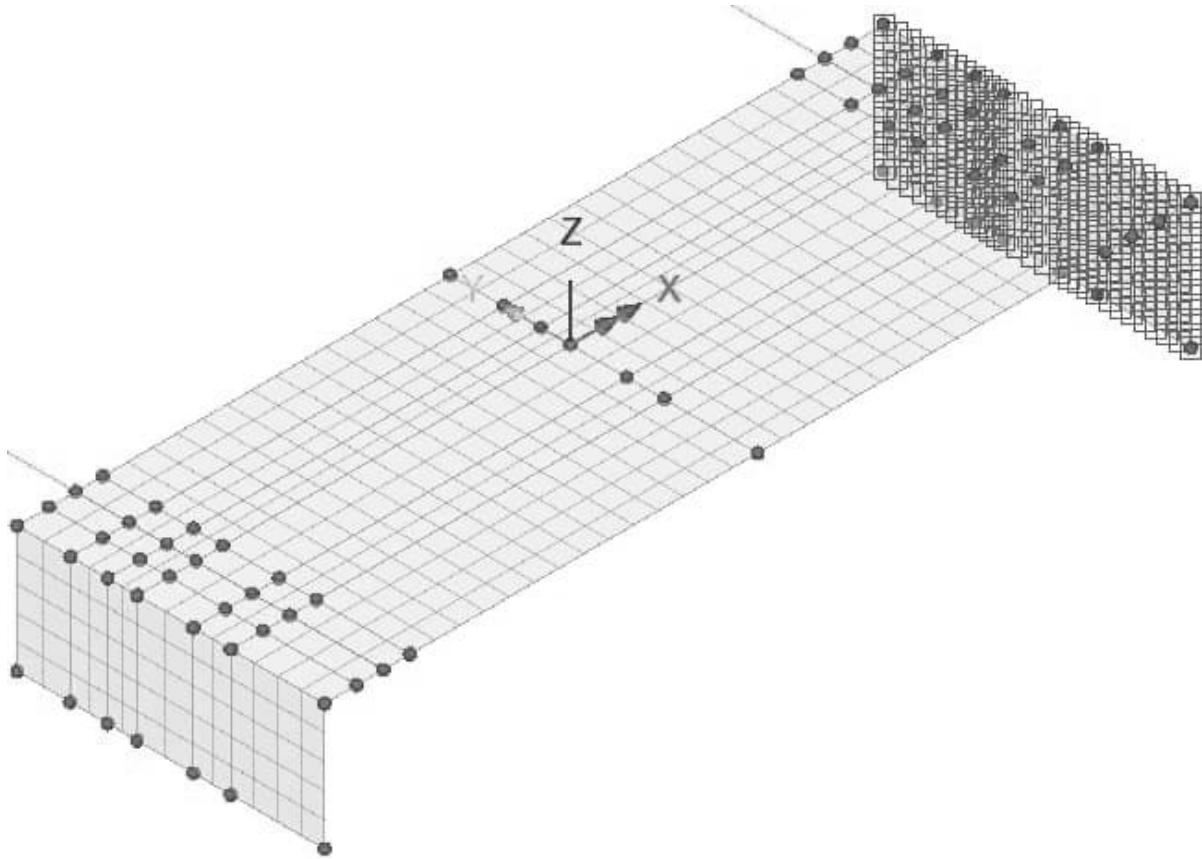
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A2:31
		Date :	Created :

2.7.2      Search area : End shield 1



	Part A – CALCULATION ASSUMPTIONS RC slab bridge	Status :	Page: A2:32
		Date :	Created :

2.7.3      Search area : End shield 2



	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:1
	RC slab bridge	Date :	Created :

### **3. LOADS**

3.1	DEAD WEIGHT	page 3:2-10
3.2	BALLAST	page 3:11-12
3.3	EARTH PRESSURE	page 3:13-40
3.4	SUPPORT SETTLEMENT	page 3:41
3.5	CREEP	page 3:42-45
3.6	SHRINKAGE	page 3:46-49
3.7	TRAFFIC LOAD	page 3:50-80
3.8	BRAKING LOAD	page 3:81-94
3.9	LATERAL LOAD	page 3:95-96
3.10	CENTRIFUGAL FORCE	page 3:97
3.11	WIND LOAD	page 3:98-101
3.12	SURCHARGE	page 3:102-115
3.13	TEMPERATURE	page 3:116-120
3.14	IMPACT MISS ALIGNMENT OF PILES	page 3:121-123
3.15	LOAD COMBINATIONS	page 3:124-136

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:2
		Date :	Created :

### 3.1 DEAD WEIGHT

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

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:3
		Date :	Created :

### 3.1.1 End shield

Load case : EGEN 1

Structural loading : Body ovforce

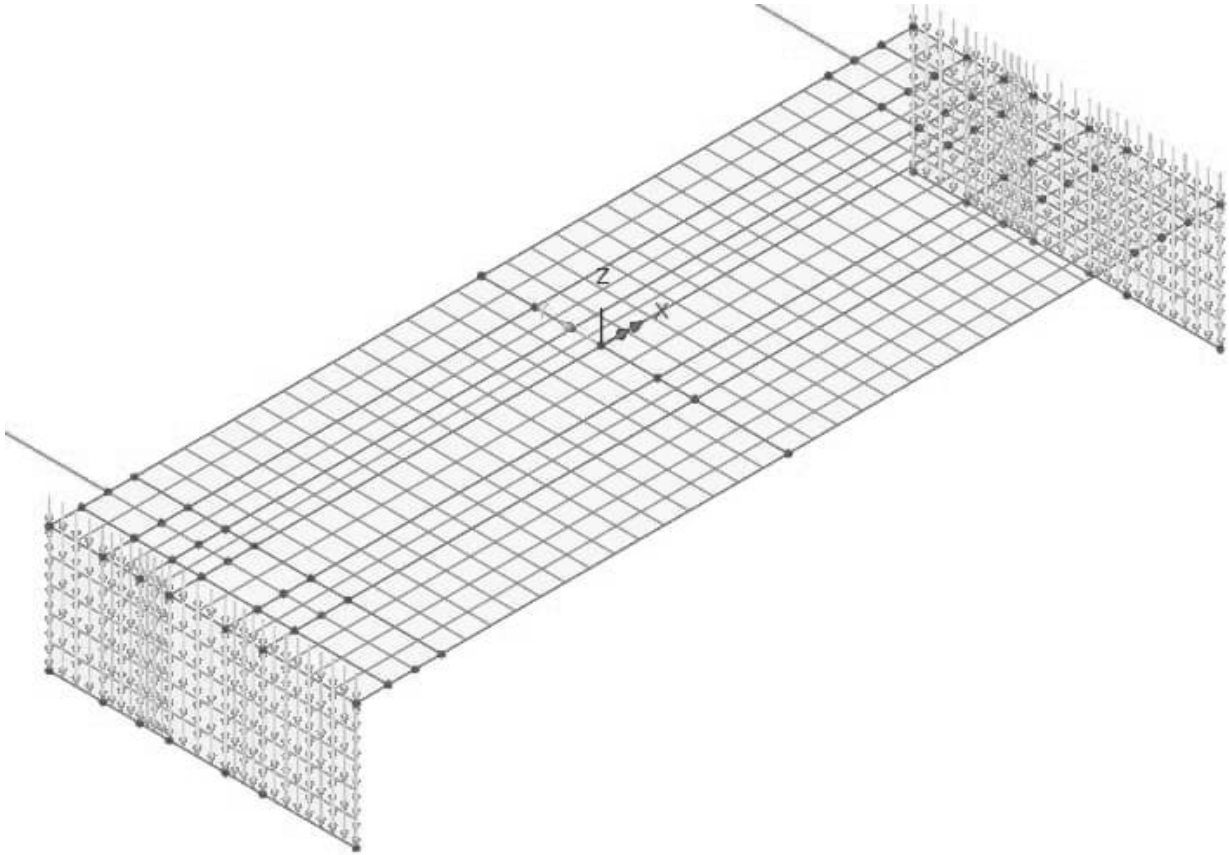
Linear acceleration in Z (  $a_z$  ) :  $-10 \frac{m}{s^2}$

Component	Value
Linear acceleration in X	0,0
Linear acceleration in Y	0,0
Linear acceleration in Z	-10,0
Angular velocity about X axis	0,0
Angular velocity about Y axis	0,0
Angular velocity about Z axis	0,0
Angular acceleration about X axis	0,0
Angular acceleration about Y axis	0,0
Angular acceleration about Z axis	0,0

Name  (2)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:4
	RC slab bridge	Date :	Created :



Overview 3D

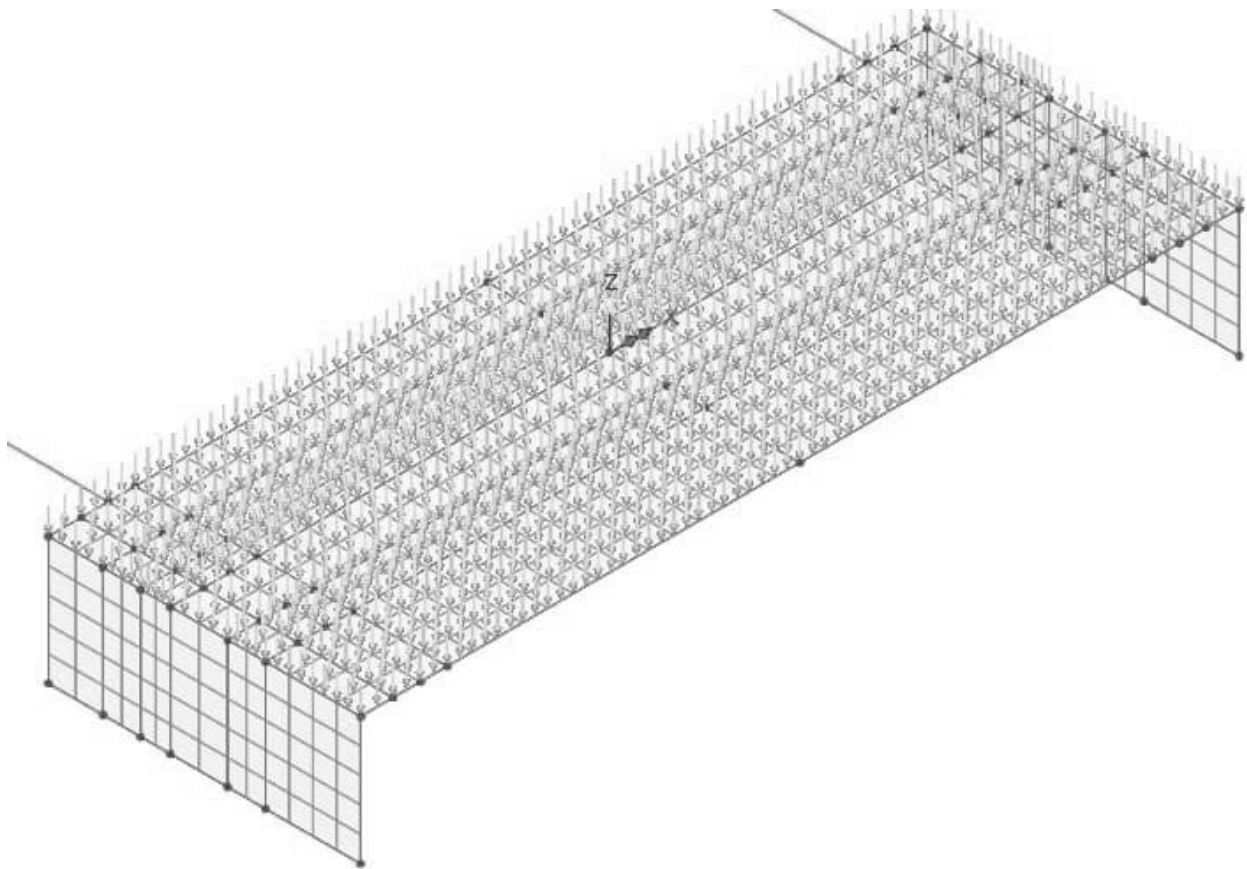
	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:5
	RC slab bridge	Date :	Created :

### 3.1.2 Bridge deck

Load case : EGEN 2

Structural loading : Body force

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



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:6
		Date :	Created :

### 3.1.3 Edge beam incl. railing

On each edge beam a fictive line load is applied as seen below. The load includes railing.

$$p_{r\ddot{a}cke} = 0.5 \frac{kN}{m} \quad : \text{railing}$$

$$\rightarrow p_z = p_{r\ddot{a}cke} + p_{KB} = 0.5 \frac{kN}{m} + 0.40m \cdot 0.60m \cdot 25 \frac{kN}{m^3} = -6.5 \frac{kN}{m}$$

Global Distributed
×

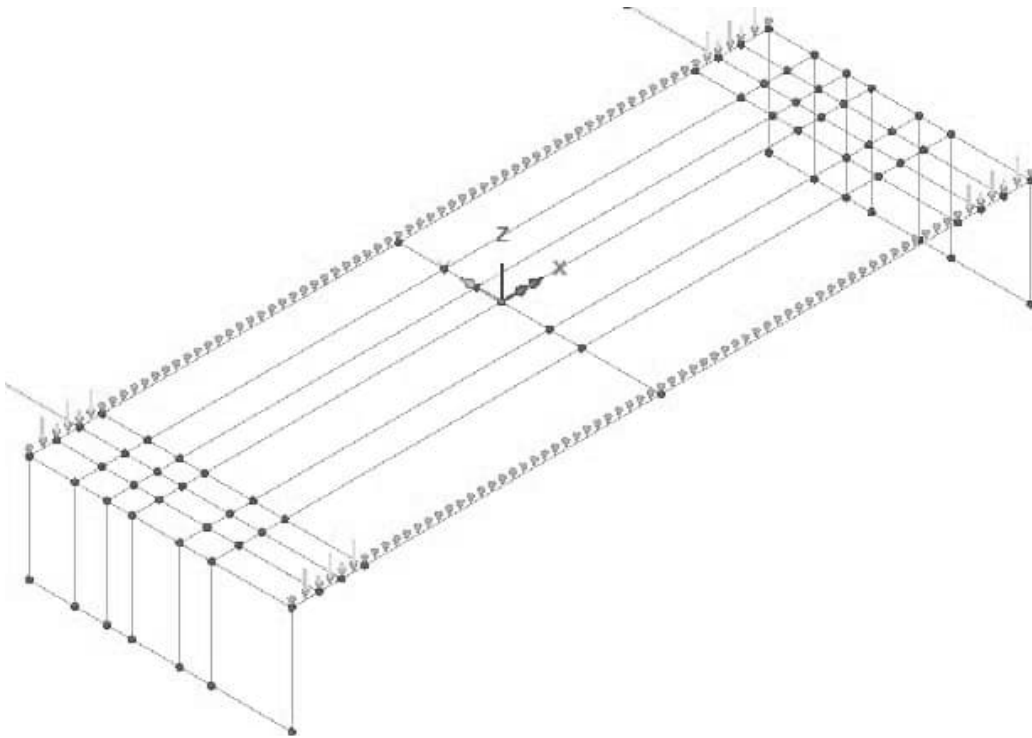
Analysis category

Total    
 Per unit length    
 Per unit area

Component	Value
X Direction	0.0
Y Direction	0.0
Z Direction	-6.5
Moment about X axis	0.0
Moment about Y axis	0.0
Moment about Z axis	0.0

Name  (10)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:7
	RC slab bridge	Date :	Created :



### Overview 3D

### Remark

The effect of eccentricity ( $x_{tp} = 1.35$  m) according to page A3:35 is not considered. Considered negligible.

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:8
	RC slab bridge	Date :	Created :

### 3.1.4 Wingwalls

All wingwalls are considered identical ( $\therefore L = 3.1 \text{ m}$ ).

$$P_z = -71 \text{ kN}$$

: page A3:35

Load is distributed along height of end shield ( $\therefore h_s = 2.4 \text{ m}$ ).

$$p_z = \frac{P_z}{h_s} = -\frac{71 \text{ kN}}{2.4 \text{ m}} = -30 \frac{\text{kN}}{\text{m}}$$

Global Distributed ✕

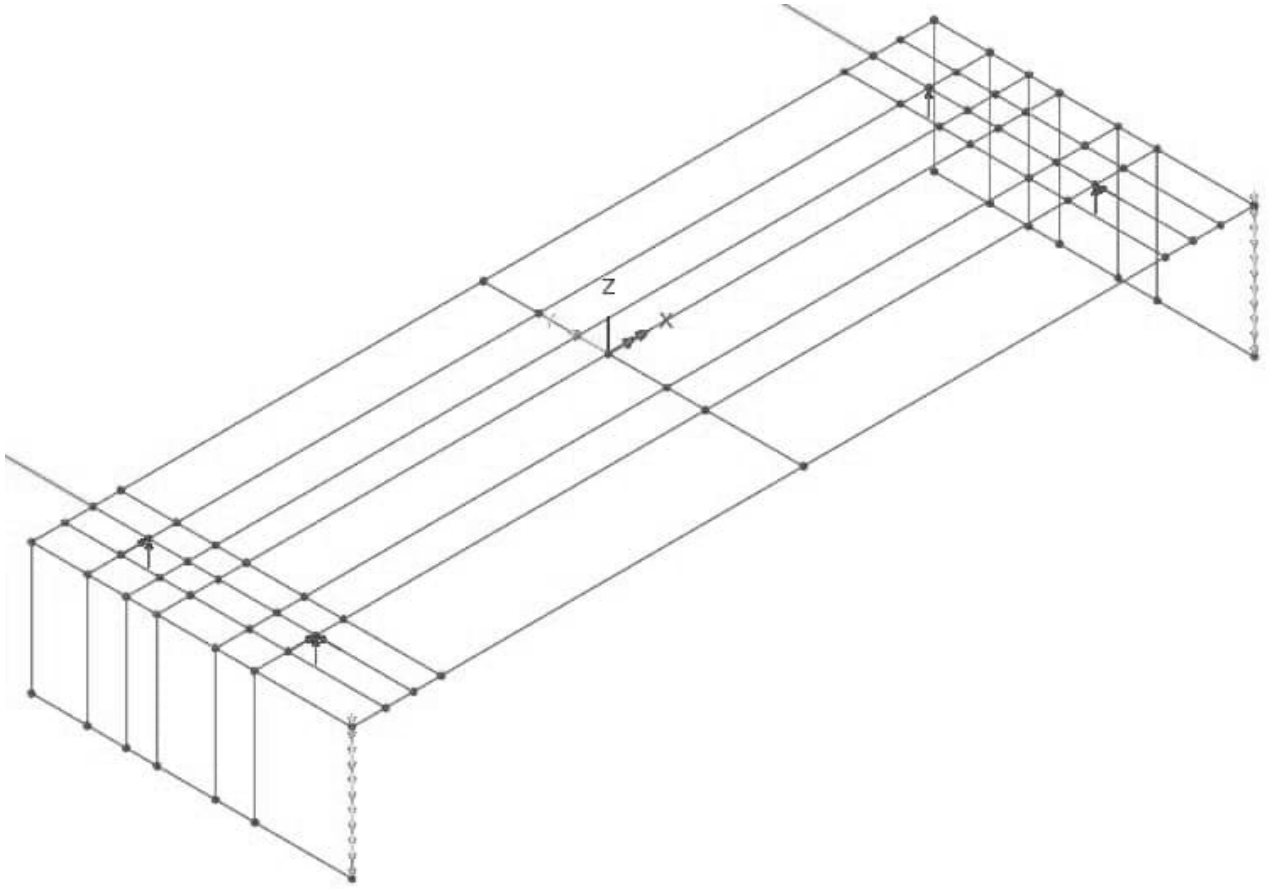
Analysis category

Total
  Per unit length
  Per unit area

Component	Value
X Direction	0,0
Y Direction	0,0
Z Direction	-30,0
Moment about X axis	0,0
Moment about Y axis	0,0
Moment about Z axis	0,0

Name  (11)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:9
	RC slab bridge	Date :	Created :



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:10
		Date :	Created :

### 3.1.6 Summary dead weight ( EGEN )

Basic load combination EGEN :

Load case	Factor
EGEN 1	1.00
EGEN 2	1.00
EGEN 3	1.00
EGEN 4	1.00

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:11
	RC slab bridge	Date :	Created :

### 3.2 BALLAST

Minimum thickness ballast 600 mm. Track longitudinal inclination 0.3% and deck 1.0% to dewater deck, will result in varying ballast thickness as seen below.

$$L = 1.4 \text{ m} + 14.0 \text{ m} + 1.4 \text{ m} = 16 \text{ m} \rightarrow (1.0\% - 0.3\%) \cdot L = 0.12 \text{ m}$$

$$\gamma = 20 \frac{\text{kN}}{\text{m}^3}$$

$$q_{ballast.1} = 20 \frac{\text{kN}}{\text{m}^3} \cdot 0.60 \text{ m} = 12 \text{ kPa}$$

$$q_{ballast.2} = 20 \frac{\text{kN}}{\text{m}^3} \cdot 0.72 \text{ m} = 14 \text{ kPa}$$

#### Load case : BALLAST

Structural loading : Discrete 4 node patch

Surface load (  $q_z$  ) : -14 kPa  $\rightarrow$  -12 kPa

Search Area : Brobana

Loads outside search area : Include full load

Patch
✕

Analysis category

Patch type

8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction

X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector

Project in load direction  
 Project for prestress

X component

Y component

Z component

Patch load divisions

Use default

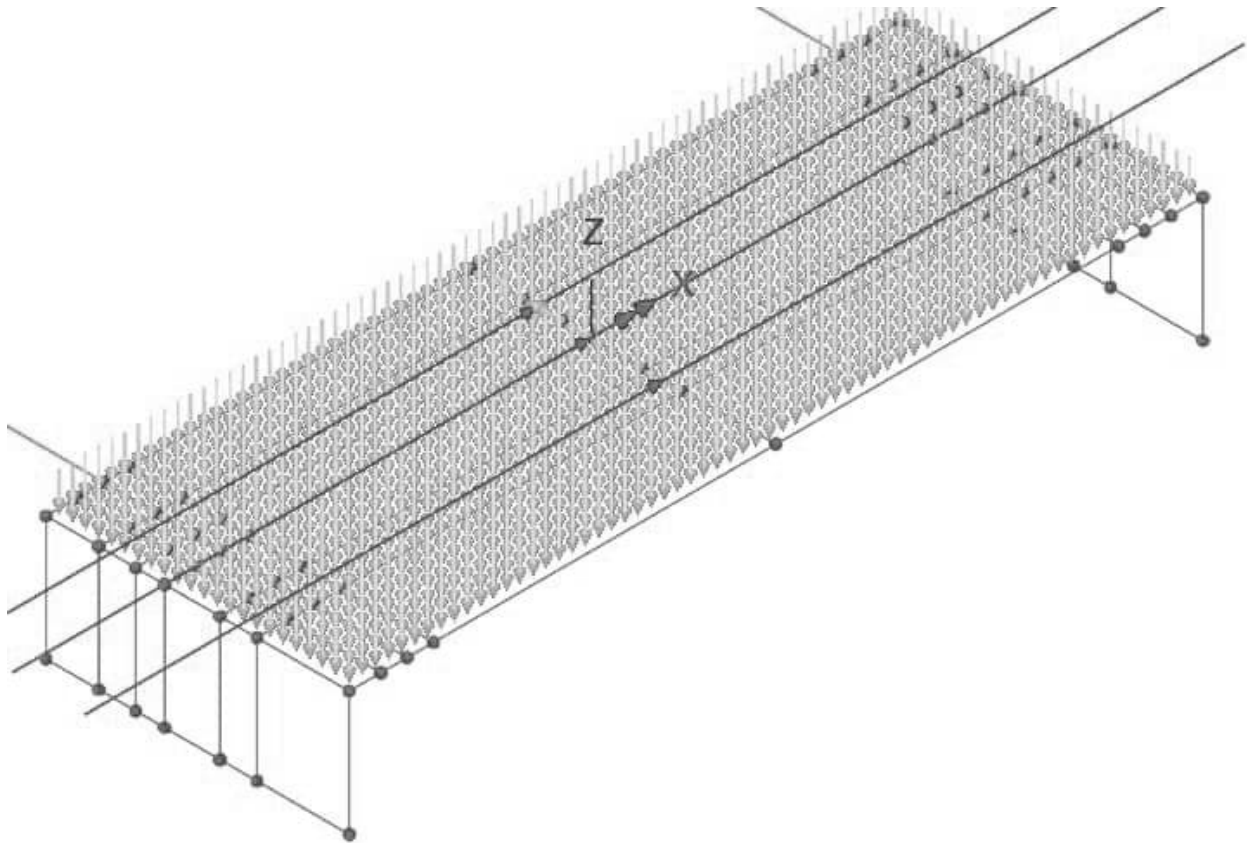
Number of divisions in

Number of divisions in y

	X	Y	Z	Load
1	-8,1	-3,5	0,0	-14,0
2	8,1	-3,5	0,0	-12,0
3	8,1	2,25	0,0	-12,0
4	-8,1	2,25	0,0	-14,0

Name  (23)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:12
	RC slab bridge	Date :	Created :



### Overview 3D

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:13
	RC slab bridge	Date :	Created :

### 3.3 EARTH PRESSURE

Earth pressure in filling corresponds to coarse crushed blasted rock (AMA CEB.524).

$$\varphi_k = 45^\circ$$

$$\gamma = 20 \frac{\text{kN}}{\text{m}^3}$$

$$\gamma' = 10 \frac{\text{kN}}{\text{m}^3}$$

$$X_d = \frac{1}{\gamma_m} \cdot \eta \cdot \bar{X} \equiv \frac{1}{\gamma_m} \cdot X_k$$

Earth pressure coefficient for design method 2 ( D2 ) :

Design coefficients associated to  $A1 + M1 + R2$  according to SS-EN 1997-1 section 2.4.7.3.4.3 is applied.

$$\gamma_{m.D2} = 1.0 \quad : \text{ see TSFS chapter 38 table 38.3 for M1}$$

$$\rightarrow \varphi_d = \text{artctan} \left( \frac{\tan \varphi_k}{\gamma_{m.D2}} \right) = \text{arctan} \left( \frac{\tan 45^\circ}{1.0} \right) = 45^\circ$$

$$K_0 = 1 - \sin(\varphi_d) = 0.29$$

$$K_a = \tan^2 \left( 45^\circ - \frac{\varphi_d}{2} \right) = 0.17$$

$$K_p = \tan^2 \left( 45^\circ + \frac{\varphi_d}{2} \right) = 5.82$$

Earth pressure for design method 3 ( D3 ) :

Design coefficients associated to  $A1(\text{design loads}) + A2(\text{geotechnical loads}) + M2 + R3$  according to SS-EN 1997-1 section 2.4.7.3.4.4 is applied.

$$\gamma_{m.D3} = 1.3 \quad : \text{ see TSFS chapter 8 table 38.3 för M2}$$

$$\rightarrow \varphi_d = \text{artctan} \left( \frac{\tan \varphi_k}{\gamma_m} \right) = \text{arctan} \left( \frac{\tan 45^\circ}{1.3} \right) = 38^\circ$$

$$K_0 = 1 - \sin(\varphi_d) = 0.38$$

$$K_a = \tan^2 \left( 45^\circ - \frac{\varphi_d}{2} \right) = 0.24$$

$$K_p = \tan^2 \left( 45^\circ + \frac{\varphi_d}{2} \right) = 4.20$$

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:14
	RC slab bridge	Date :	Created :

Earth pressure in FEM-analysis:

$$K_o = 1 - \sin(\varphi_d)$$

$$K_a = \tan^2\left(45^\circ - \frac{\varphi_d}{2}\right)$$

$$K_p = \tan^2\left(45^\circ + \frac{\varphi_d}{2}\right)$$

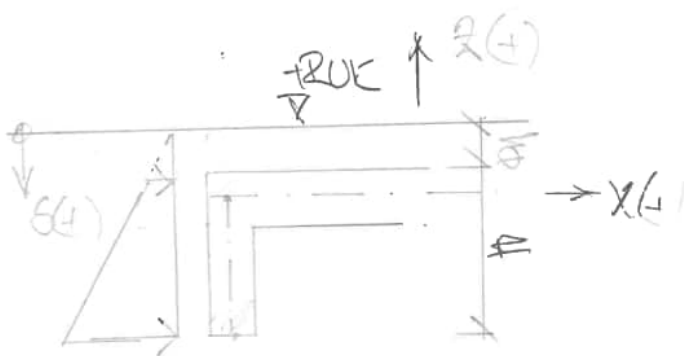
$\varphi_d$	$K_a$	$K_o$	$K_p$	Metod
(38°)	(0.24)	(0.38)	(4.20)	D3
45°	0.17	0.29	5.82	D2

During design earth press coefficients associated to method D2 will used applied, however the load coefficients are adjusted according to verification, see section 3.13.1.

$$h_b = 0.60m$$

$$H = 2.80m$$

$$q_{vilo}(s) = K_o \cdot \gamma \cdot s = 0.29 \cdot 20 \frac{kN}{m^3} \cdot s(+) = s(+) \cdot 5.8kPa$$



	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:15
	RC slab bridge	Date :	Created :

### 3.3.1 Load against abutment 1

$q_{vilo} (0m) = 0kPa$  : level bottom of track

$q_{vilo} (0.6m) = 3.4m \cdot 5.8 \frac{kN}{m^3} = 4kPa$  : level top of end shield

$q_{vilo} (3.4m) = 3.4m \cdot 5.8 \frac{kN}{m^3} = 20kPa$  : level bottom of end shield

#### Load case: JORD.1

Structural loading : Discrete 4 node patch

Surface load (  $q_x$  ) : +4 kPa → +20 kPa

Search Area : End shield 1

Loads outside search area : Include full load

Patch ✕

Analysis category

Patch type

8 node patch
  4 node patch
  Multi-patch
  Straight
  Curve
  Multi-straight

Load direction

X
  Z  
 Y
  XYZ  
 Patch x  
 Patch y  
 Surface normal

Projection vector

Project in load direction  
 Project for prestress

X component   
 Y component   
 Z component

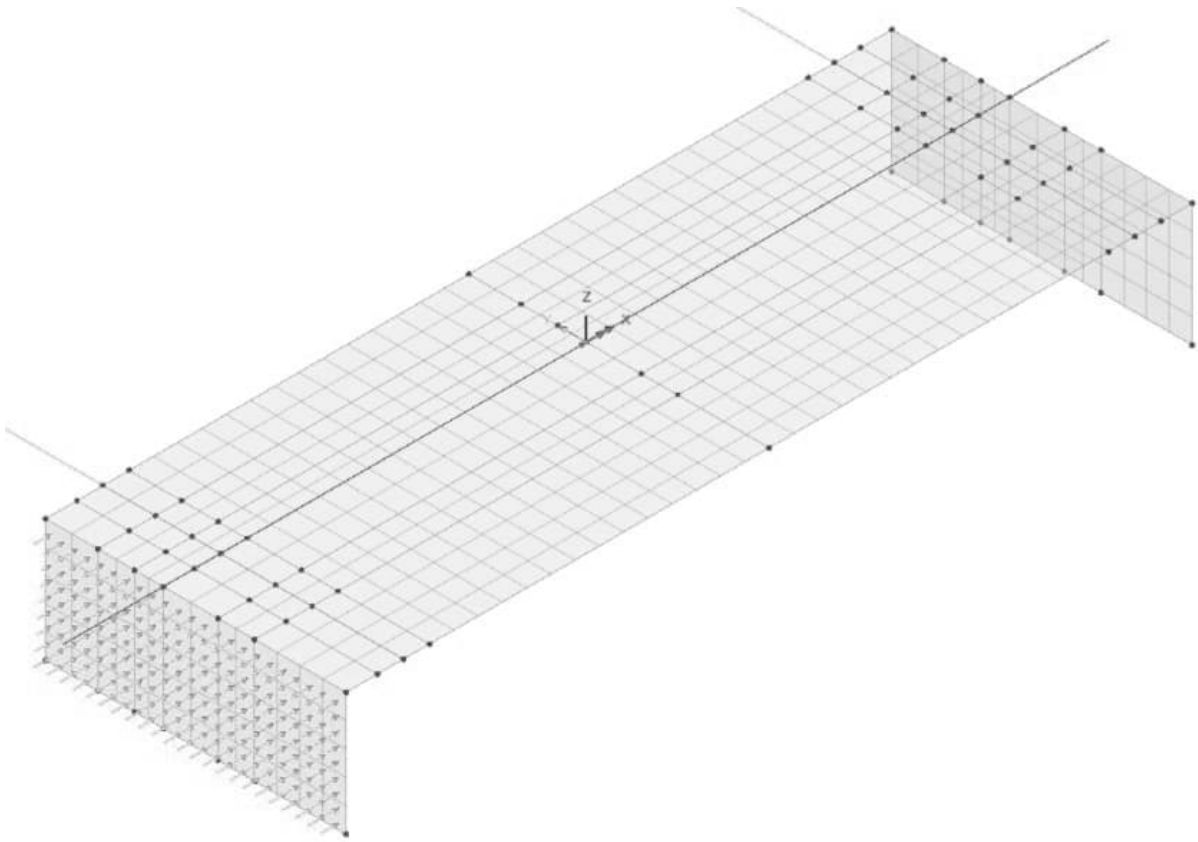
Patch load divisions

Use default  
 Number of divisions in   
 Number of divisions in y

	X	Y	Z	Load
1	-10,0	2,25	-2,35	20,0
2	-10,0	-3,5	-2,35	20,0
3	-10,0	-3,5	0,45	4,0
4	-10,0	2,25	0,45	4,0

Name  (13)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:16
	RC slab bridge	Date :	Created :



### Overview 3D

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:17
	RC slab bridge	Date :	Created :

### 3.3.2 Load against abutment 2

$q_{vilo} (0m) = 0kPa$  : level bottom of track

$q_{vilo} (0.6m) = 3.4m \cdot 5.8 \frac{kN}{m^3} = 4kPa$  : level top of end shield

$q_{vilo} (3.4m) = 3.4m \cdot 5.8 \frac{kN}{m^3} = 20kPa$  : level bottom of end shield

#### Load case : JORD 2

Structural loading : Discrete 4 node patch

Surface load (  $q_x$  ) : -4 kPa → -20 kPa

Search Area : End shield 2

Loads outside search area : Include full load

Patch ×

Analysis category

Patch type  
 8 node patch  4 node patch  Multi-patch  Straight  Curve  Multi-straight

Load direction  
 X  Z  
 Y  XYZ  
 Patch x  
 Patch y  
 Surface normal

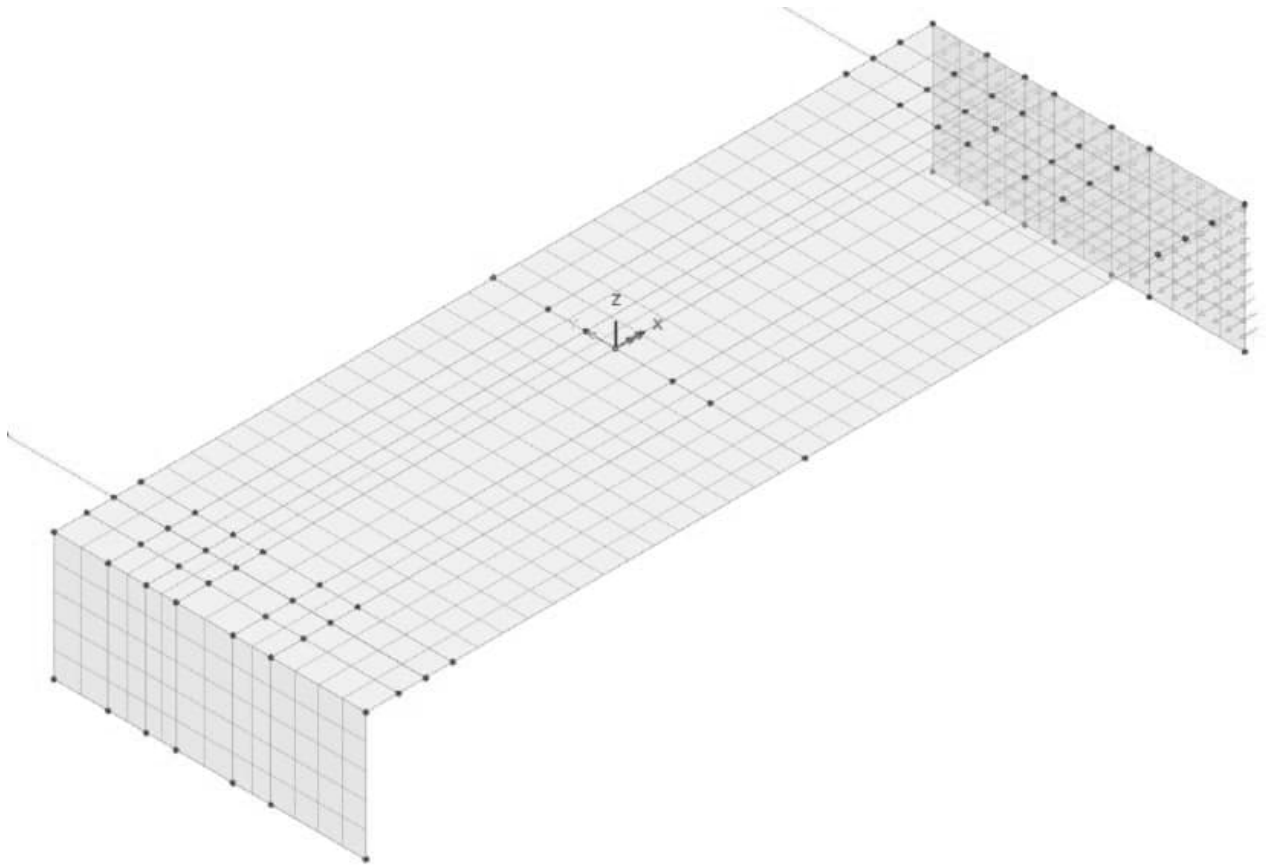
Projection vector  
 Project in load direction  
 Project for prestress  
 X component   
 Y component   
 Z component

Patch load divisions  
 Use default  
 Number of divisions in   
 Number of divisions in y

	X	Y	Z	Load
1	10,0	2,25	-2,35	-20,0
2	10,0	-3,5	-2,35	-20,0
3	10,0	-3,5	0,45	-4,0
4	10,0	2,25	0,45	-4,0

Name  (14)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:18
	RC slab bridge	Date :	Created :



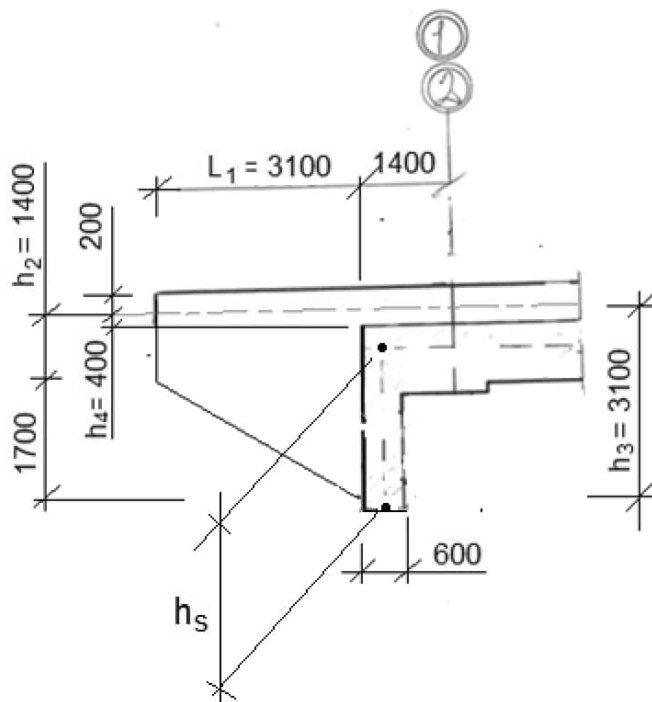
### Overview 3D

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:19
	RC slab bridge	Date :	Created :

### 3.3.3 Load against wingwalls

Design software K2.002 is used to determine earth pressure against wingwalls according to Cullman's theory. All wingwalls are assumed to have same length ( $L = 3.1$  m).

A load increase due to wind and lateral load is considered.



Load is distributed over height of end shield ( $\therefore h_s = 2.4$  m).

#### Resulting earth pressure:

$$H_{jord} = 55 \text{ kN}$$

: see page A3:34

$$M_{jord} = 70 \text{ kNm}$$

: see page A3:34

#### Earth pressure is distributed along height of end shield ( $h_s$ ):

$$N_{jord} = \frac{55 \text{ kN}}{2.4 \text{ m}} = 23 \frac{\text{kN}}{\text{m}}$$

$$M_{jord} = \frac{70 \text{ kNm}}{2.4 \text{ m}} = 30 \frac{\text{kNm}}{\text{m}}$$

Objekt : L = 3.1 m

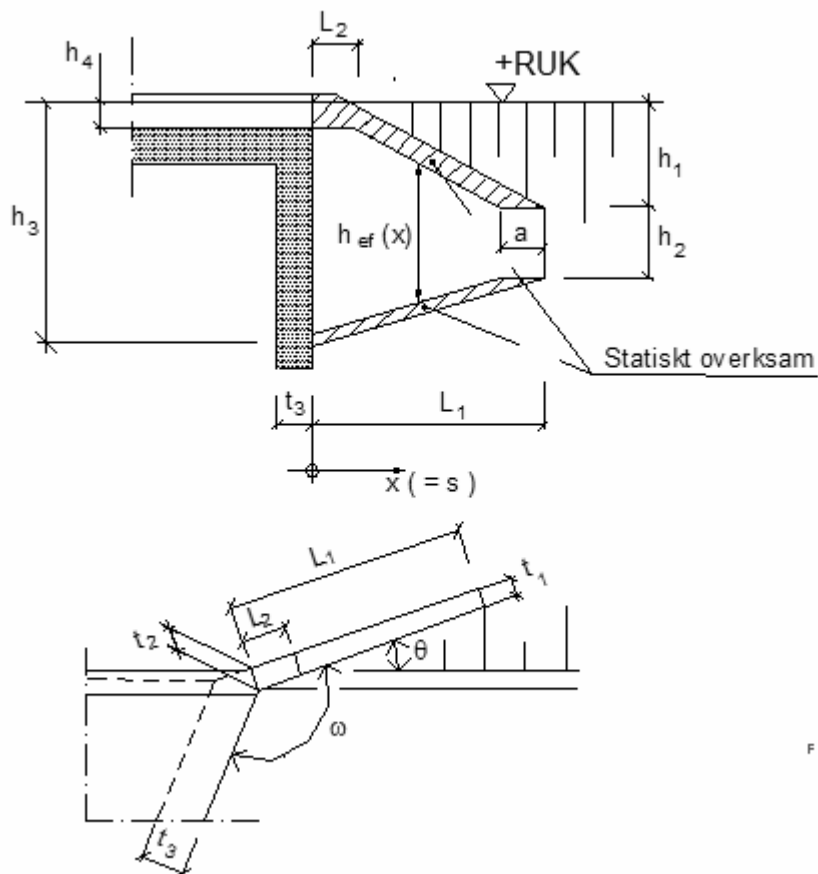
### TEORI

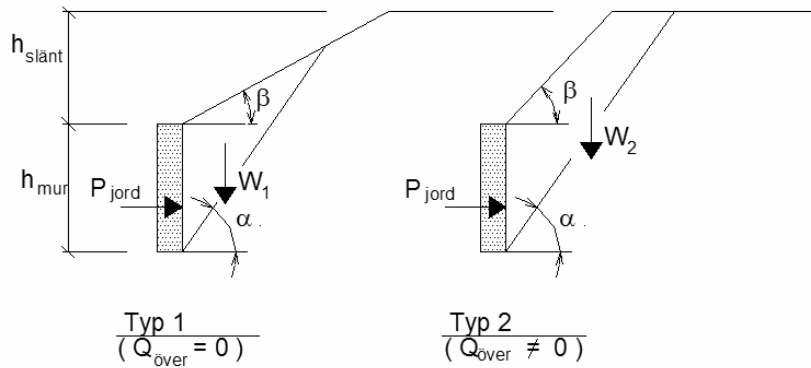
Vid bestämning av dimensionerande lasteffekt i vingmur tillämpas Culmans metod för bestämning av lasteffekt av jordfyllning. Detta sker då Rankine's metod inte är fungerar i brunten slänt.

Vid bestämning av överlastens bidrag tillämpas dock Rankine's metod. Vid kontroll tillämpas lastspridning (1:N) genom fyllning. Vanligen är  $N = 1$  dimensionerande för låga vingmurar men bör kontrolleras.

Lasteffekten från jordfyllning och överlast adderas trots att brottvinkel ( $\alpha$ ) kan variera mellan dem. Denna förenkling anses dock på säker sida.

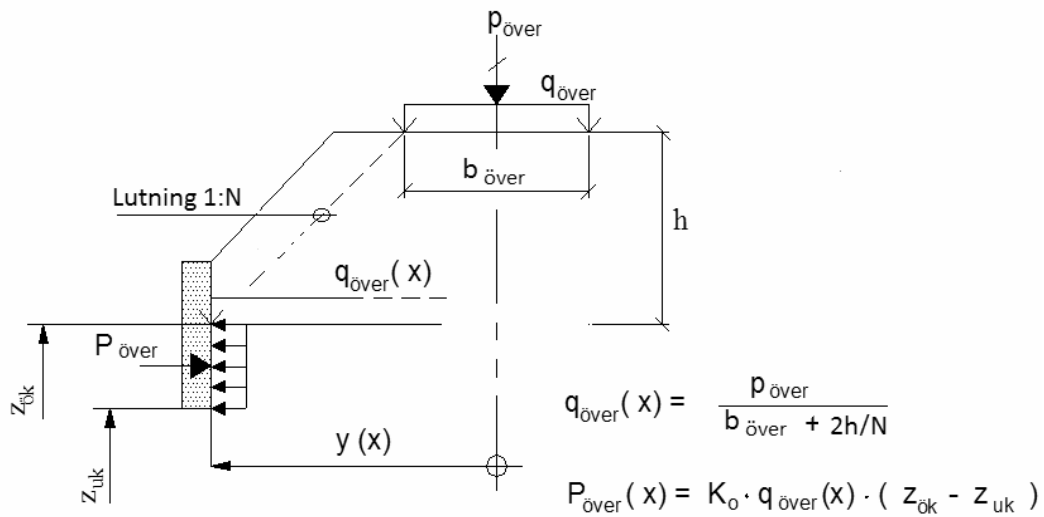
### PRINCIPFIGUR





Culmansmetod

(Tillämpas för bestämning av jordtryck.)



Överlast i friktionsmaterial enligt Rankine

(Tillämpas för bestämmings av överlast.)

**INDATA****Geometri :**

$L_1 = 3.1\text{m}$

$L_2 = 0.5\text{m}$

$h_1 = 0.4\text{m}$

$h_2 = 1.4\text{m}$

$h_3 = 3.1\text{m}$

$h_4 = 0.4\text{m}$

$t_1 = 0.40\text{m}$

$t_2 = 0.40\text{m}$

$t_3 = 0.60\text{m}$

Vinkel vinge-ramben på baksidan :

$\omega = 90^\circ$

Vinkel vinge-vägbankskrön på baksidan :

$\theta = 1^\circ$

Avstånd till brytpunkt för effektiv höjd :

$a = 0.80\text{m}$

**Material :**

Jordmaterial :

$\gamma_{\text{jord}} = 20 \frac{\text{kN}}{\text{m}^3}$

$K_o = 0.29$

$K_a = 0.17$

$\gamma_{\psi;\text{jord.ULS}} = 1.31$

$\gamma_{\psi;\text{jord.SLS}} = 1.0$

Betong :

$\gamma_{\text{btg}} = 25 \frac{\text{kN}}{\text{m}^3}$

**Laster :**

Överlast :

$p_{\text{över}} = 1.6 \frac{4 \cdot 250\text{kN}}{6.4\text{m}} = 250 \cdot \frac{\text{kN}}{\text{m}}$

$b_{\text{över}} = 3.0\text{m} - (0.7\text{m} - 0.2\text{m}) = 2.5\text{m}$

$y_{\text{start}} = 2.12\text{m}$

$N = 1$

$\gamma_{\psi_{\text{över.ULS}}} = 1.67$

$\gamma_{\psi_{\text{över.SLS}}} = 0$

**BERÄKNING****Lastintensitet av jordtryck enligt Culmans metod :**

$$\text{Nivå överkant vingmur : } \quad \text{mur}_{\text{ök}}(x) = \text{linterp} \left[ \left( \begin{array}{c} 0 \\ L_2 \\ L_1 \end{array} \right), \left( \begin{array}{c} h_3 \\ h_3 \\ h_3 - h_1 \end{array} \right), x \right]$$

$$\text{Nivå underkant vingmur : } \quad \text{mur}_{\text{uk}}(x) = \text{linterp} \left[ \left( \begin{array}{c} 0 \\ L_1 \end{array} \right), \left( \begin{array}{c} 0 \\ h_3 - h_1 - h_2 \end{array} \right), x \right]$$

$$\text{Vingmurens höjd : } \quad h_{\text{mur}}(x) = \text{mur}_{\text{ök}}(x) - \text{mur}_{\text{uk}}(x)$$

$$\text{Släntens höjd : } \quad h_{\text{slänt}}(x) = \text{linterp} \left[ \left( \begin{array}{c} 0 \\ L_2 \\ L_1 \end{array} \right), \left( \begin{array}{c} 0 \\ 0 \\ h_1 \end{array} \right), x \right]$$

$$\text{Friktionsvinkel: } \quad \varphi = \text{asin}(1 - K_0)$$

Lutning hos slänten ned till överkant vingmur mätt vinkelrätt mot vingen :

$$\beta = \text{atan} \left[ \frac{h_1}{(L_1 - L_2) \tan(\theta)} \right]$$

Vertikallast för brottfigur typ 1 (= brottlinje i slänt) :

$$W_1 = h_{\text{mur}}(x) \cdot \sin\left(\frac{\pi}{2} - \alpha\right) \cdot \left( h_{\text{mur}}(x) \cdot \cos\left(\frac{\pi}{2} - \alpha\right) + \frac{h_{\text{mur}}(x) \cdot \sin\left(\frac{\pi}{2} - \alpha\right)}{\tan(\alpha - \beta)} \right) \cdot \frac{\gamma_{\text{jord}}}{2}$$

Vertikallaster för brottfigur typ 2 (= brottlinje hamnar ovanför slänt) :

$$W_2 = \left[ (h_{\text{mur}}(x) + h_{\text{slänt}}(x))^2 \cdot \tan\left(\frac{\pi}{2} - \alpha\right) - \frac{h_{\text{slänt}}(x)^2}{\tan(\beta)} \right] \cdot \frac{\gamma_{\text{jord}}}{2}$$

Viljordtrycksresultant enligt Culmann under inverkan av jordlast :

$$P_o = \begin{cases} W_{jord} \leftarrow W_1 & \text{if } (h_{mur}(x) + h_{slänt}(x)) \cdot \tan(90^\circ - \alpha) < \frac{h_{slänt}(x)}{\tan(\beta)} \\ W_{jord} \leftarrow W_2 & \text{otherwise} \\ P_{aktiv} \leftarrow W_{jord} \cdot \tan(\alpha - \varphi) \\ P_{vilo} \leftarrow P_{aktiv} \cdot \frac{K_o}{K_a} \end{cases}$$

Utvärdera största last av jordtryck genom att kontrollera  $N_\alpha$  antal vinklar mellan  $\varphi$  och  $90^\circ$ .

$$P_{jord} = \begin{cases} N_\alpha \leftarrow 20 \text{st} \\ \Delta\alpha \leftarrow \frac{90^\circ - \varphi}{N_\alpha - 1} \\ \alpha \leftarrow \varphi \\ P_{max} \leftarrow P_o(s, \alpha) \\ \text{for } i \in 2 .. N_\alpha \\ \quad \begin{cases} \alpha \leftarrow \alpha + \Delta\alpha \\ P_{vilo} \leftarrow P_o \\ \text{if } P_{vilo} > P_{max} \\ \quad \begin{cases} P_{max} \leftarrow P_{vilo} \\ \alpha_{max} \leftarrow \alpha \end{cases} \end{cases} \end{cases}$$

Snitt där jordlast bestäms ( totalt 10 st )

$$\Delta_x = \frac{L_1 - L_2}{6}$$

$$x = \left( 0 \quad \frac{1}{3}L_2 \quad \frac{2}{3}L_2 \quad L_2 \quad L_2 + \Delta_x \quad L_2 + 2 \cdot \Delta_x \quad L_2 + 3 \cdot \Delta_x \quad L_2 + 4 \cdot \Delta_x \quad L_2 + 5 \Delta_x \quad L_1 \right)$$

Skapa funktion för resultatet av de 10 st beräknade snitten :

$$P_{vilo}(x) = \text{lspline}(P_{jord}, x)$$

**Lastintensitet för överlast i friktionsmaterial enligt Rankine :**

Nivå överkant belastningshöjd mot vingmur :

$$y_{\text{slut}} = y_{\text{start}} + L_1 \cdot \sin(\theta)$$

$$y_{\text{mitt}} = \frac{y_{\text{start}} + y_{\text{slut}}}{2}$$

$$z_{\text{start}} = h_3 - N \cdot (y_{\text{start}} - 0.5b_{\text{över}})$$

$$z_{\text{slut}} = h_3 - N \cdot (y_{\text{slut}} - 0.5b_{\text{över}})$$

$$z_{\text{ök}}(x) = \text{linterp} \left[ \begin{pmatrix} 0 \\ L_1 \end{pmatrix}, \begin{pmatrix} z_{\text{start}} \\ z_{\text{slut}} \end{pmatrix}, x \right]$$

Nivå underkant vingmur :

$$z_{\text{uk}}(x) = \text{linterp} \left[ \begin{pmatrix} 0 \\ L_1 \end{pmatrix}, \begin{pmatrix} 0 \\ h_3 - h_1 - h_2 \end{pmatrix}, x \right]$$

Effektiv belastningshöjd mot vingmur :  $h_{\text{över}}(x) = z_{\text{ök}}(x) - z_{\text{uk}}(x)$

Skärningspunkt mellan  $z_{\text{ök}}(x)$  och  $z_{\text{uk}}(x)$  :

$$x_{\text{skär}} = 0.5L_1$$

Given

$$z_{\text{ök}}(x_{\text{skär}}) = z_{\text{uk}}(x_{\text{skär}})$$

$$x_{\text{skär}} = \text{Find}(x_{\text{skär}})$$

Belastninglängd mot vingmur :

$$L_{\text{över}} = \text{if}(x_{\text{skär}} > L_1, L_1, x_{\text{skär}})$$

$$x_{\text{start}} = 0\text{m}$$

$$x_{\text{mitt}} = \frac{L_{\text{över}}}{2}$$

$$x_{\text{slut}} = L_{\text{över}}$$

Vertikal lastintensitet på nivå där lastspridning 1:1 belastar vingmur :

$$q_{\text{över}}(s) = \begin{cases} 0\text{kPa} & \text{if } s > L_{\text{över}} \\ \frac{P_{\text{över}}}{2 \cdot \left[ y_{\text{start}} + (y_{\text{slut}} - y_{\text{start}}) \cdot \frac{x}{L_1} \right]} & \text{otherwise} \end{cases}$$

Lastintensitet mot vingmur :

$$P_{\text{över}} = K_0 \cdot q_{\text{över}}(x) \cdot h_{\text{över}}(x)$$

**Snittkrafter jordtryck + överlast :**

$$H'_{\text{jord}} = \int_x^{L_1} p_{\text{vilo}}(s) ds$$

$$M'_{\text{jord}} = \int_x^{L_1} (s-x) \cdot p_{\text{vilo}}(s) ds$$

$$H'_{\text{över}} = \begin{cases} 0 \text{ kN} & \text{if } x > L_{\text{över}} \\ \int_x^{L_{\text{över}}} p_{\text{över}} ds & \text{otherwise} \end{cases}$$

$$M'_{\text{över}} = \begin{cases} 0 \text{ kNm} & \text{if } x > L_{\text{över}} \\ \int_x^{L_{\text{över}}} (s-x) \cdot p_{\text{över}} ds & \text{otherwise} \end{cases}$$

**Lastkombinering - Lk ULS och Lk SLS :****Snittkraft i frontmur för inspänningssnitt**

$$N'_{\text{ULS.front}} = (\gamma \psi_{\text{jord.ULS}} \cdot H'_{\text{jord}}(x=0\text{m}) + \gamma \psi_{\text{över.ULS}} \cdot H'_{\text{över}}(x=0\text{m})) \cdot \sin(\omega)$$

$$M'_{\text{ULS.front}} = \gamma \psi_{\text{jord.ULS}} \cdot M'_{\text{jord}}(x=0\text{m}) + \gamma \psi_{\text{över.ULS}} \cdot M'_{\text{över}}(x=0\text{m}) + N'_{\text{ULS.front}} \cdot \frac{t_3}{2}$$

$$N'_{\text{SLS.front}} = (\gamma \psi_{\text{jord.SLS}} \cdot H'_{\text{jord}}(x=0\text{m}) + \gamma \psi_{\text{över.SLS}} \cdot H'_{\text{över}}(x=0\text{m})) \cdot \sin(\omega)$$

$$M'_{\text{SLS.front}} = \gamma \psi_{\text{jord.SLS}} \cdot M'_{\text{jord}}(x=0\text{m}) + \gamma \psi_{\text{över.SLS}} \cdot M'_{\text{över}}(x=0\text{m}) + N'_{\text{SLS.front}} \cdot \frac{t_3}{2}$$

**Snittkrafter i vingmur :**

$$Q'_{\text{ULS}} = \gamma \psi_{\text{jord.ULS}} \cdot H'_{\text{jord}} + \gamma \psi_{\text{över.ULS}} \cdot H'_{\text{över}}$$

$$M'_{\text{ULS}} = \gamma \psi_{\text{jord.ULS}} \cdot M'_{\text{jord}} + \gamma \psi_{\text{över.ULS}} \cdot M'_{\text{över}}$$

$$M'_{\text{SLS}} = \gamma \psi_{\text{jord.SLS}} \cdot M'_{\text{jord}} + \gamma \psi_{\text{över.SLS}} \cdot M'_{\text{över}}$$

**Beräkning av effektiv höjd :**

$$\Delta h = h_3 - h_2 - h_1$$

Nivå överkant effektiv vingmur :

$$\text{Nivå}_{\text{ök}}(x) = \text{linterp} \left[ \begin{pmatrix} 0m \\ L_2 \\ L_1 - a \\ L_1 \end{pmatrix}, \begin{pmatrix} h_3 - h_4 \\ h_3 - h_4 \\ h_3 - h_1 \\ h_3 - h_1 \end{pmatrix}, x \right]$$

Nivå underkant effektiv vingmur :

$$\text{Nivå}_{\text{uk}}(x) = \text{linterp} \left[ \begin{pmatrix} 0 \\ L_1 - L_2 \\ L_1 \end{pmatrix}, \begin{pmatrix} \frac{a}{L_1} \cdot \Delta h \\ \Delta h \\ \Delta h \end{pmatrix}, x \right]$$

$$\text{Effektiv höjd vingmur : } h_{\text{ef}}(x) = \text{Nivå}_{\text{ök}}(x) - \text{Nivå}_{\text{uk}}(x)$$

**Dimensionerande snittkrafter ( Lk ULS och Lk SLS ) fördelade på effektiv höjd :**Snittkraft i frontmur för inspänningssnitt :

$$H_{ef} = h_{ef}(0m)$$

$$N_{ULS.front} = \frac{N'_{ULS.front}}{H_{ef}}$$

$$M_{ULS.front} = \frac{M'_{ULS.front}}{H_{ef}}$$

$$N_{SLS.front} = \frac{N'_{SLS.front}}{H_{ef}}$$

$$M_{SLS.front} = \frac{M'_{SLS.front}}{H_{ef}}$$

Snittkrafter i vingmur :

$$Q_{ULS(x)} = \frac{Q'_{ULS}}{h_{ef}(x)}$$

$$M_{ULS(x)} = \frac{M'_{ULS}}{h_{ef}(x)}$$

$$M_{SLS(s)} = \frac{M'_{SLS}}{h_{ef}(x)}$$

**Egenvikt vingmur :**

$$t(x) = t_2 - \frac{t_2 - t_1}{L_1} \cdot x$$

$$A(x) = h_{mur}(x) \cdot t(x)$$

$$V_{egen} = \gamma_{btg} \int_0^{L_1} A(x) dx$$

$$M_{egen} = \gamma_{btg} \int_0^{L_1} A(x) \cdot s dx$$

**RESULTAT****Mellansresultat :**Dimensionerande friktionsvinkel tillhörande  $K_0$ :

$$\varphi = 45^\circ$$

Lutning hos slänten ned till överkant vingmur mätt vinkelrätt mot vingen :

$$\beta = 84^\circ$$

Belastningsyta för överlast :

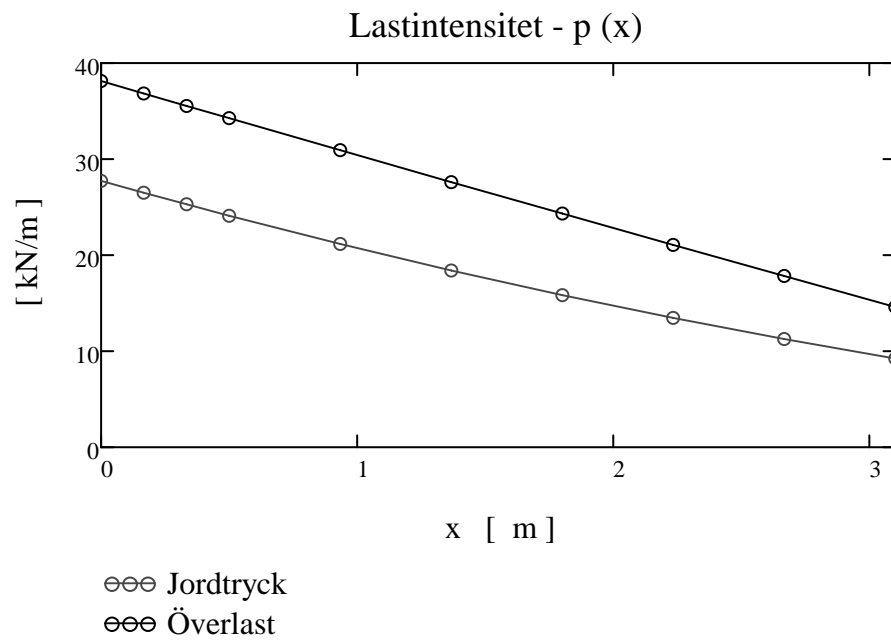
x	$Z_{ök}(x)$	$Z_{uk}(x)$	$y(x)$	Snitt
0	2,230	0	2,120	Vingrot
1,550	2,203	0,650	2,147	0.5L <sub>över</sub>
3,100	2,176	1,300	2,174	L <sub>över</sub>
m	m	m	m	-

Utvärdering av jordtryck + överlast samt tillhörande farligaste brottvinkel redovisad i tabellform :

x	$P_{jord}$	$\alpha_{tillh}$	$P_{över}$
0	28	66	38
0,17	26	66	37
0,33	25	66	36
0,50	24	66	34
0,93	21	66	31
1,37	18	66	28
1,80	16	66	24
2,23	13	66	21
2,67	11	66	18
3,10	9	66	15
m	kN/m	grader	kN/m

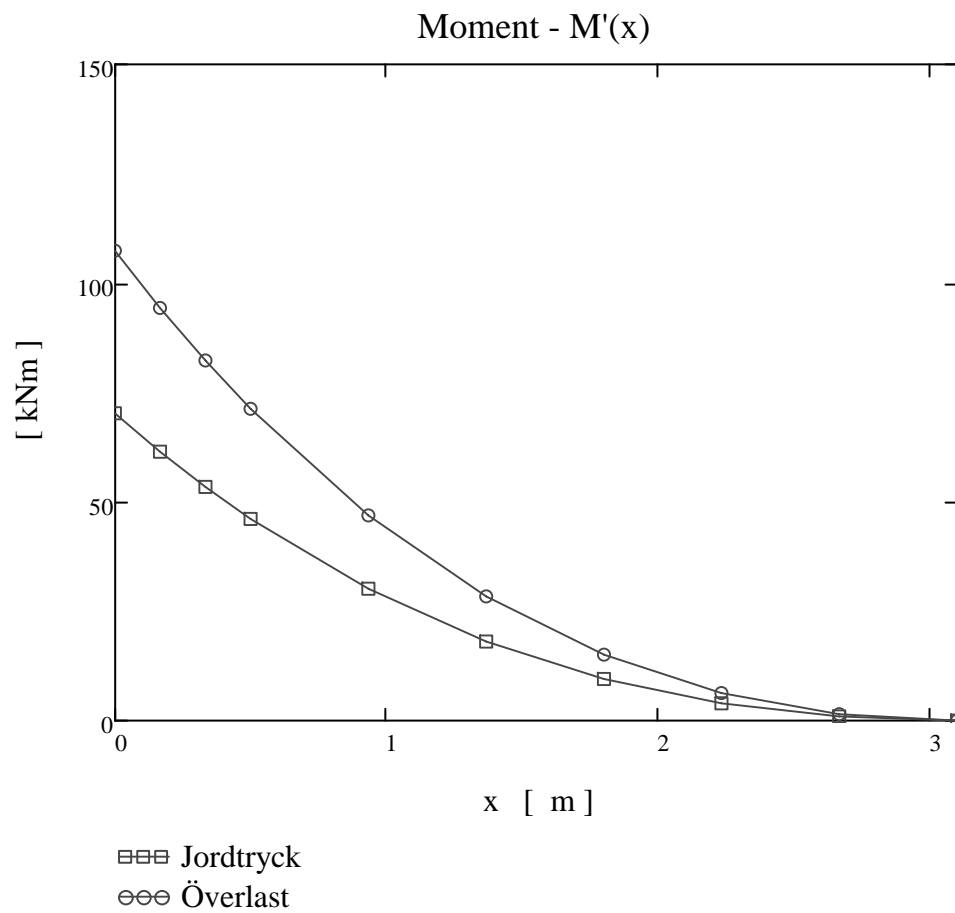
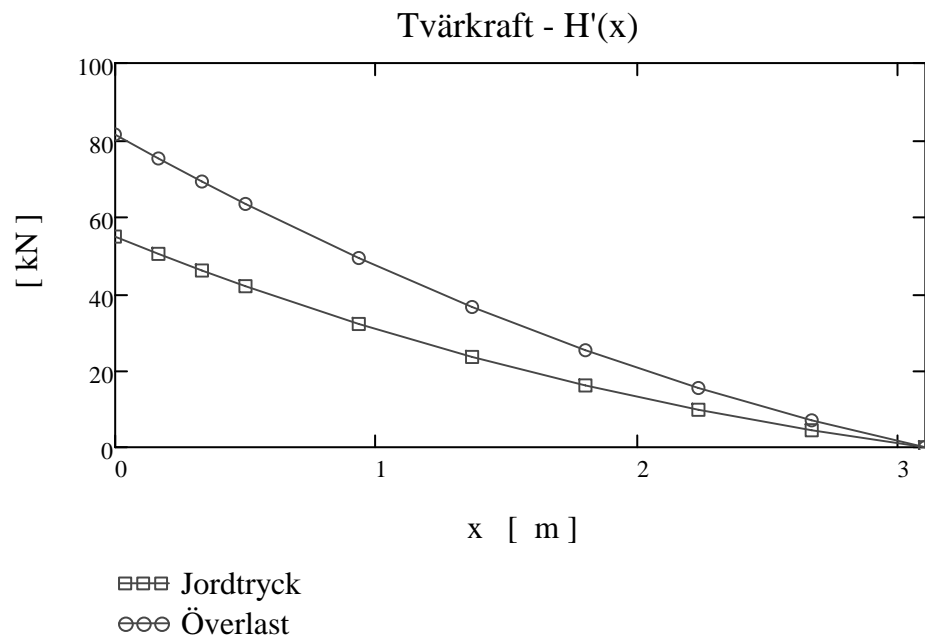
PROG K2.003 / 2002-01-30 ( T073 )

Utvärdering av jordtryck + överlast i diagramform :



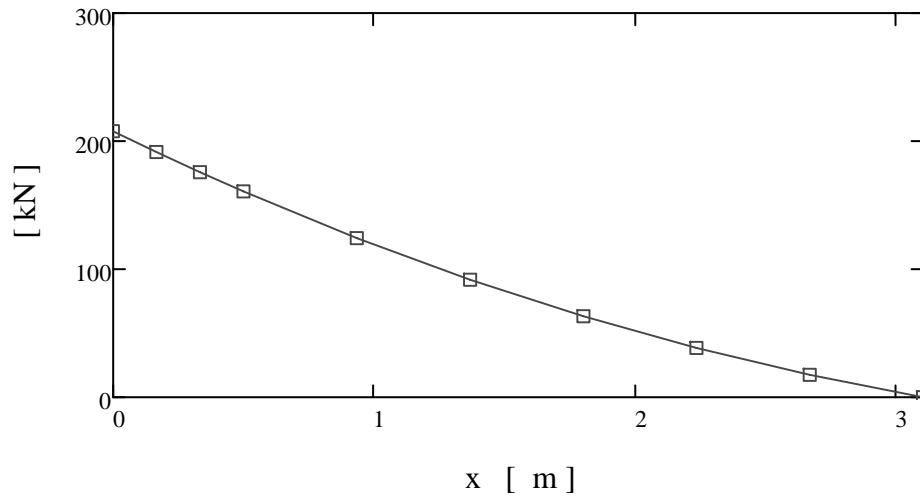
PROG K2.003 / 2002-01-30 ( T073 )

Uvärdering av snittkrafter tillhörande jordtryck + överlast i diagramform :

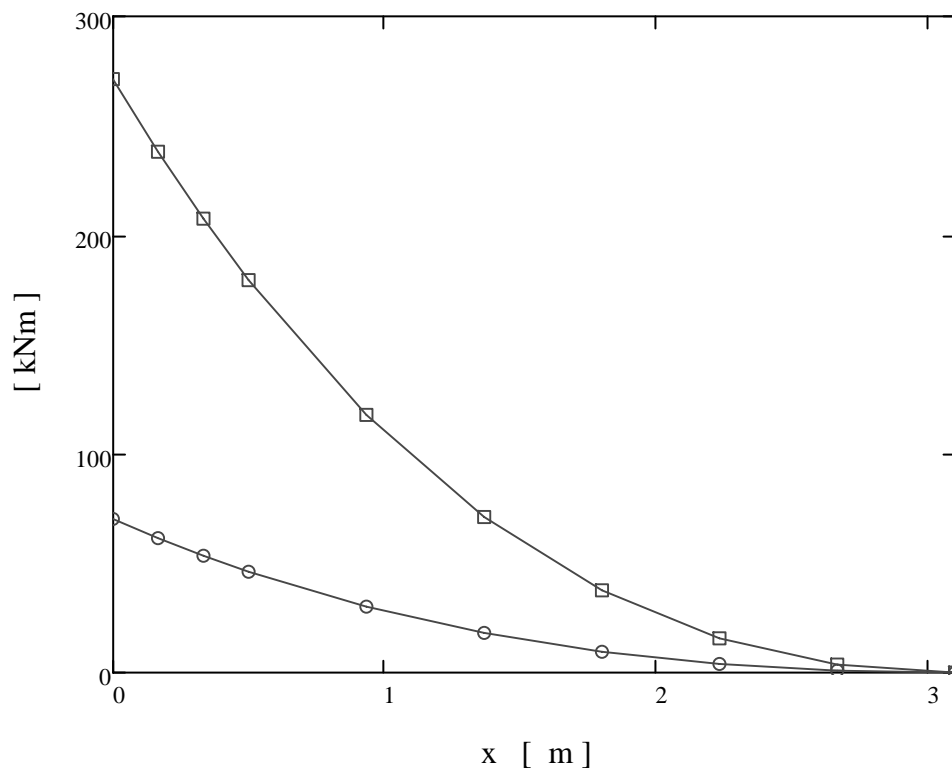


PROG K2.003 / 2002-01-30 ( T073 )

Uvärdering av dimensionerande snittkrafter för Lk ULS och Lk SLS i diagramform :

Tvärkraft -  $Q'(x)$ 

□□□ Lk ULS

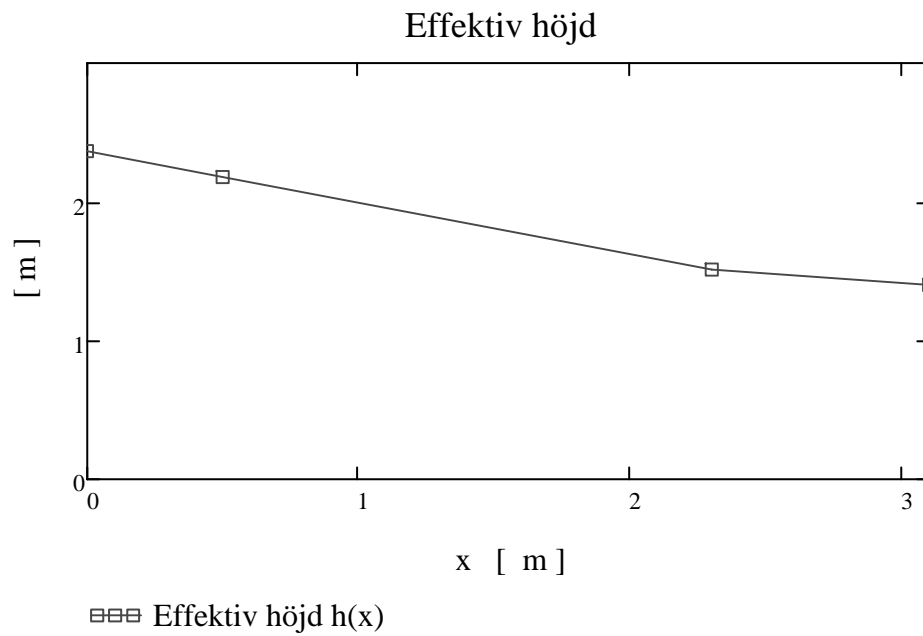
Moment -  $M'(x)$ 

□□□ Lk ULS

○○○ Lk SLS

PROG K2.003 / 2002-01-30 ( T073 )

Uvärdering av effektivhöjd i diagramform :



**Resultat :**

Resultande snittkrafter för vingmur inspänningssnitt :

$$H'_{\text{jord}}(0\cdot\text{m}) = 55\cdot\text{kN}$$

$$M'_{\text{jord}}(0\cdot\text{m}) = 70\cdot\text{kNm}$$

$$H'_{\text{över}}(0\cdot\text{m}) = 81\cdot\text{kN}$$

$$M'_{\text{över}}(0\cdot\text{m}) = 107\cdot\text{kNm}$$

Dimensionerande snittkrafter i frontmur för inspänningssnitt för delade på höjden  $H_{\text{ef}} = 2.365\text{m}$  :

$N_{\text{ULS}}$	$M_{\text{ULS}}$	$N_{\text{SLS}}$	$M_{\text{SLS}}$
88	141	23	37
kN/m	kNm/m	kN/m	kNm/m

Dimensionerande snittkrafter i vingmur :

x	$Q_{\text{ULS}}$	$M_{\text{ULS}}$	$M_{\text{SLS}}$	t (x)
0	88	115	30	0,400
0,17	83	103	27	0,400
0,33	78	93	24	0,400
0,50	74	82	21	0,400
0,93	62	58	15	0,400
1,37	49	38	10	0,400
1,80	37	22	6	0,400
2,23	25	10	3	0,400
2,67	13	3	1	0,400
3,10	0	0	0	0,400
m	kN/m	kNm/m	kNm/m	m

Egenvikt vingmur :

Egenvikt ger upphov till en triangulär linjelast med största intensiteten enligt nedan :

$$V_{\text{egen}} = 71 \cdot \text{kN}$$

$$M_{\text{egen}} = 96 \cdot \text{kNm}$$

$$x_{\text{tp}} = \frac{M_{\text{egen}}}{V_{\text{egen}}}$$

$$x_{\text{tp}} = 1.35 \text{ m}$$

Last vinkelrät mot frontmur / ramben av egentyngd + jordtryck + överlast :

Egenvikt ger upphov till en triangulär linjelast med största intensiteten enligt nedan :

$$p_{\text{egen}} = M_{\text{egen}} \cdot \frac{6}{H_{\text{ef}}^2} \cdot \sin(\omega)$$

$$p_{\text{egen}} = 103 \cdot \frac{\text{kN}}{\text{m}}$$

Jordtryck + överlast ger upphov till en rektangulär linjelast med intensiteten enligt nedan :

$$p_{\text{jord}} = -\frac{H'_{\text{jord}}(0\text{m})}{H_{\text{ef}}} \cdot \cos(\omega)$$

$$p_{\text{jord}} = -0 \cdot \frac{\text{kN}}{\text{m}}$$

$$p_{\text{över}} = -\frac{H'_{\text{över}}(0\text{m})}{H_{\text{ef}}} \cdot \cos(\omega)$$

$$p_{\text{över}} = -0 \cdot \frac{\text{kN}}{\text{m}}$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:36
		Date :	Created :

Load case : JORD 3-1

$$p_y = -23 \frac{kN}{m}$$

$$m_z = +30 \frac{kNm}{m}$$

Global Distributed ×

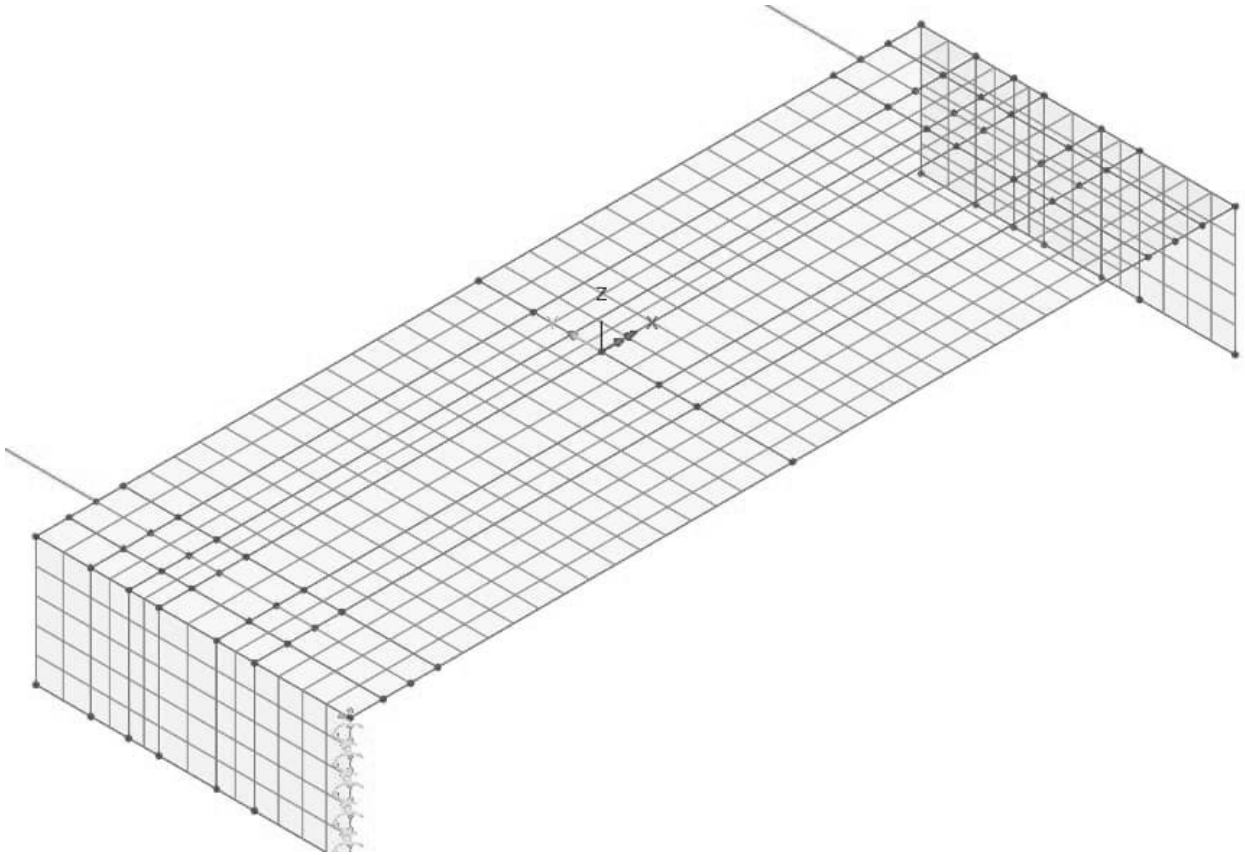
Analysis category

Total
  Per unit length
  Per unit area

Component	Value
X Direction	0.0
Y Direction	-23.0
Z Direction	0.0
Moment about X axis	0.0
Moment about Y axis	0.0
Moment about Z axis	30.0

Name  (14)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:37
		Date :	Created :



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:38
		Date :	Created :

Load case : JORD 3-2

$$p_y = -23 \frac{kN}{m}$$

$$m_z = -30 \frac{kNm}{m}$$

Global Distributed ×

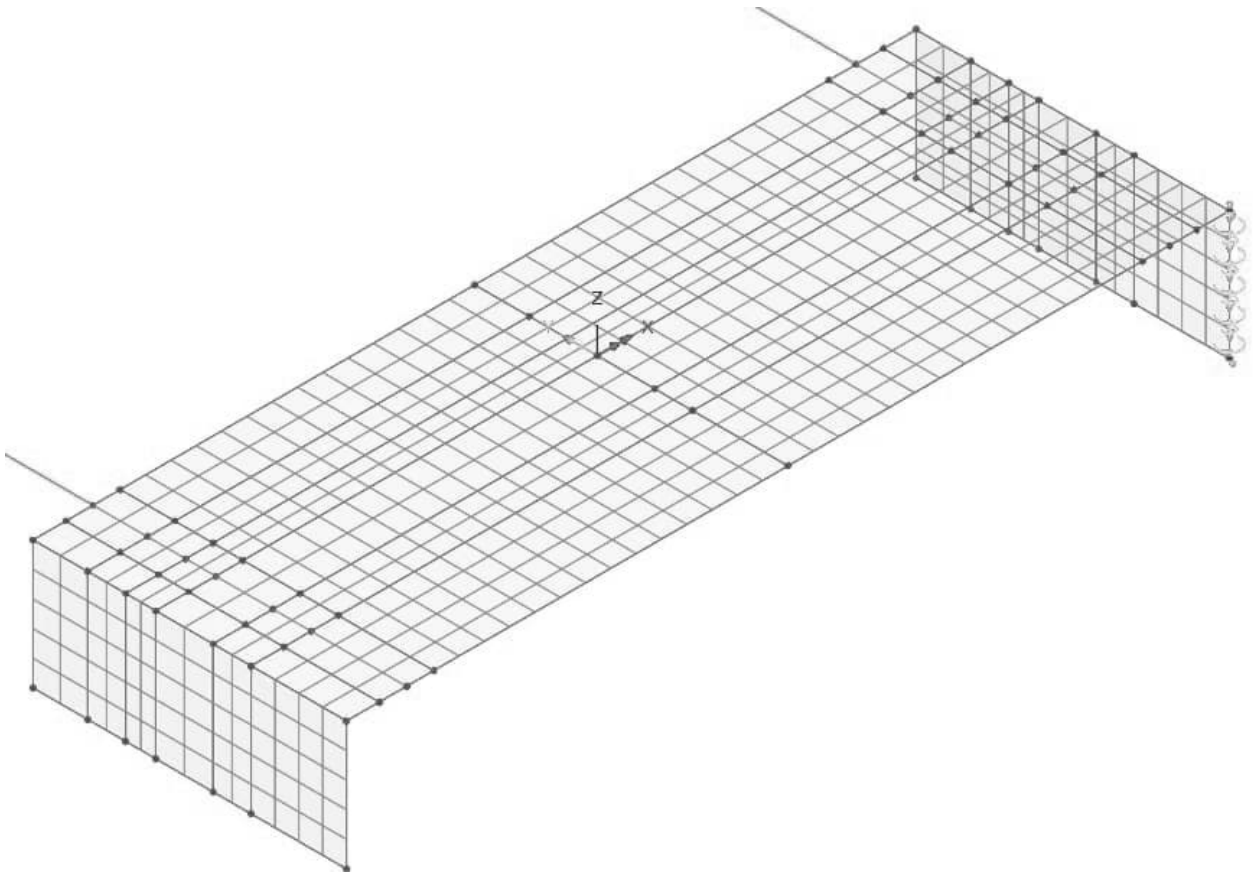
Analysis category

Total
  Per unit length
  Per unit area

Component	Value
X Direction	0.0
Y Direction	-23.0
Z Direction	0.0
Moment about X axis	0.0
Moment about Y axis	0.0
Moment about Z axis	-30.0

Name  (15)

	Part A – CALCULATION ASSUMPTIONS RC slab bridge	Status :	Page: A3:39
		Date :	Created :



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:40
		Date :	Created :

### 3.3.4 Load combination earth pressure: JORD

Basic load combination JORD.:

Load case	Factor
JORD 1	1
JORD 2	1
JORD 3-1	1
JORD 3-2	1

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:41
		Date :	Created :

### 3.4 SUPPORT SETTLEMENT

Load effect of support settlement shall be considered in TRVINFRA-00227 section 7.2.1.1.1.1.

Only horizontal support displacement in the longitudinal direction of the bridge needs to be considered. Additionally, it is stated that horizontal and vertical support displacements do not need to be combined.

When designing superstructure, the effect of support settlement is not considered.

Not when designing piles support settlement is movement occurs. No associating load effect arises in piles.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:42
		Date :	Created :

### 3.5 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  $t_0$ .

The effect should be considered in the serviceability limit state according to SS-EN 1992-1-1 §2.3.2.2(1).

If this is done, a gradual crack development may be applied according to SS-EN 1992-1-1 §5.4(3).

The effect does not need to be considered in the ultimate limit state according to SS-EN 1992-1-1 §2.3.2.2(2).

If this is done, a reduced stiffness may be applied according to SS-EN 1992-1-1 §5.4(3).

$$t_0 = 5 \text{ days}$$

$$t_1 = 120 \text{ years}$$

Creep is determined using program PROG A001.

For  $b = 5.75 \text{ m}$  and  $t = 0.95 \text{ m} \rightarrow \phi(t_1, t_0) = 1.94$  according to page A3:45.

Creep value  $\phi(t_1, t_0) = 1.9$  is used on all structural parts on safe side.

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

The effect of reduced stiffness according SS-EN 1992-1-1 5.8.7 is considered as see in table below.

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

Last	$\phi$	f
Permanent	1.9	0.34
Variable excl. Temperature	0	1.00
Temperature	0.3*	0.77

\* = According to swedish praxis.

#### Remark.

TRVINFRA-00227 section 7.2.1.1.2.4 states no reduction is permissible for uneven temperature variation over height of cross section is permissible. This since variation has very short duration (only over a day).

**Objekt: Överbyggnad****Betong ( C30/37, C35/45, C40/50 och C45/55 ):**

BTG = "C35/45"

Relativ fuktighet : RH = 80%

Tvärsnittetsbredd : b = 7.5m

Tvärsnitteshöjd : h = 1.0m

Tvärsnittsarea :  $A_c = b \cdot h = 7.5 \cdot m^2$ 

Omkrets i kontakt med "luft" : u = 2 · b = 15 m

Bärverkets ekvivalenta tjocklek :  $h_0 = \frac{2 \cdot A_c}{u} = 1 \text{ m}$ Studerad tidpunkt för bestämning av krypning :  $t_1 = 70\text{år}$      $t_1 = 25550 \cdot \text{dag}$  (60 dag)Tidpunkt för pålastning (= formrivning) :  $t_0 = 30\text{dag}$ 

Indatakvitto

 $f_{cm} = 43 \cdot \text{MPa}$

**BERÄKNING**

Uttryck för bestämning av kryptalet är hämtat från SS-EN 1992-1-1 Bilaga B.1.

$$\alpha_1 = \left( \frac{35\text{MPa}}{f_{\text{cm}}} \right)^{0.7} = 0.87$$

$$\alpha_2 = \left( \frac{35\text{MPa}}{f_{\text{cm}}} \right)^{0.2} = 0.96$$

$$\alpha_3 = \left( \frac{35\text{MPa}}{f_{\text{cm}}} \right)^{0.5} = 0.9$$

$$\varphi_{\text{RH}} = \begin{cases} 1 + \frac{1 - \text{RH}}{0.1 \sqrt[3]{\frac{h_0}{\text{mm}}}} & \text{if } f_{\text{cm}} \leq 35\text{MPa} \\ \left( 1 + \frac{1 - \text{RH}}{0.1 \sqrt[3]{\frac{h_0}{\text{mm}}}} \cdot \alpha_1 \right) \cdot \alpha_2 & \text{otherwise} \end{cases} = 1.13$$

$$\beta_0 = \frac{1}{0.1 + t_0^{0.20}} = 0.48$$

$$\beta_{f_{\text{cm}}} = \frac{16.8}{\sqrt{\frac{f_{\text{cm}}}{\text{MPa}}}} = 2.56$$

PROG A.001 / 2011-09-02 ( T001 )

$$\beta_H = \begin{cases} \text{if } f_{cm} \leq 35\text{MPa} \\ \left| \begin{array}{l} \beta_{H,max} \leftarrow 1500 \\ \beta_H \leftarrow \beta_{H,max} \text{ if } 1.5 \cdot \left[ 1 + (0.012 \cdot 100RH)^{18} \right] \cdot \frac{h_0}{\text{mm}} + 250 > \beta_{H,max} \\ \beta_H \leftarrow 1.5 \cdot \left[ 1 + (0.012 \cdot 100RH)^{18} \right] \cdot \frac{h_0}{\text{mm}} + 250 \text{ otherwise} \end{array} \right. \\ \text{if } f_{cm} > 35\text{MPa} \\ \left| \begin{array}{l} \beta_{H,max} \leftarrow 1500 \cdot \alpha_3 \\ \beta_H \leftarrow \beta_{H,max} \text{ if } 1.5 \cdot \left[ 1 + (0.012 \cdot 100RH)^{18} \right] \cdot \frac{h_0}{\text{mm}} + 250 > \beta_{H,max} \\ \beta_H \leftarrow 1.5 \cdot \left[ 1 + (0.012 \cdot 100RH)^{18} \right] \cdot \frac{h_0}{\text{mm}} + 250 \cdot \alpha_3 \text{ otherwise} \end{array} \right. \\ \beta_H \end{cases}$$

$$\beta_H = 1353$$

$$\beta_c = \left( \frac{t_1 - t_0}{\beta_H + t_1 - t_0} \right)^{0.3} = 0.98 \quad (0.3)$$

$$\varphi_{t0} = \varphi_{RH} \cdot \beta_{fcm} \cdot \beta_0 = 1.39 \quad (1.4)$$

$$\varphi_{t1} = \varphi_{t0} \cdot \beta_c = 1.4 \quad (0.4)$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:46
		Date :	Created :

### 3.6 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  $t_1$ .

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

$$t_s = 0 \text{ days}$$

$$t_1 = 120 \text{ years}$$

Shrinkage is determined using program PROG A002 after time  $t_1$ .

In studied bridge different thickness varies, but geometry seen below is used on safe side.

For  $b = 5.75 \text{ m}$  and  $t = 0.95 \text{ m} \rightarrow \varepsilon_{cs}(t_1) = 0.024\%$  according to page A3:49.

Shrinkage  $\varepsilon_{cs}=0.024\%$  is applied to all construction parts for safety. The movement corresponds to that which occurs due to an imaginary temperature load  $\therefore T = -24^\circ\text{C}$ .

The load effect is used when designing piles but is not considered when designing superstructure since generated only movement.

#### Remark

The effect of support is considered in the serviceability limit state (SLS) according to SS-EN 1992-1-1 §2.3.2.2(1). If this occurs, a gradual crack development may be applied according to SS-EN 1992-1-1 §5.4(3).

Reduction due to cracking is not credited on the safe side; however, the effect of creep is considered.

The effect of support is not considered in the ultimate limit state (ULS) according to SS-EN 1992-1-1 §2.3.2.2(2).

**Objekt: Plattbro****Betong ( C30/37, C35/45, C40/50 och C45/55 ):**

BTG = "C35/45"

**Relativ fuktighet ( se KBB avsnitt B.3.3.6 ):**

RH = 80%

**Tvärsnittetsbredd :**

$$b = 5.75\text{m}$$

**Tvärsnitteshöjd :**

$$h = 0.95\text{m}$$

**Tvärsnittsarea :**

$$A_c = b \cdot h = 5.46 \cdot \text{m}^2$$

**Omkrets i kontakt med "luft" :**

$$u = 2 \cdot b = 11.5 \text{ m}$$

**Bärverkets ekvivalenta tjocklek :**

$$h_0 = \frac{2 \cdot A_c}{u} = 0.95 \text{ m}$$

**Studerad tidpunkt för bestämning av krympning :**

$$t_1 = 120 \text{ år}$$

$$t_1 = 43800 \cdot \text{dag}$$

**Tidpunkt för pålastning ( = formrivning ):**

$$t_0 = 5 \text{ dag}$$

**Cementklass ( S, N, R ) :**

Klass = "N"

**Betongens ålder då uttorkningskrympning påbörjas :**

$$t_s = 0 \text{ dag}$$

Indatakvitto

$$f_{cm} = 43 \cdot \text{MPa}$$

$$f_{ck} = 35 \cdot \text{MPa}$$

$$f_{ck.kub} = 45 \cdot \text{MPa}$$

**BERÄKNING****Grundvärdet för krympning från uttorkning ( SS-EN 1992-1-1 Bilaga B.2 )**

$$\alpha_{ds1} = \begin{cases} 3.0 & \text{if Klass} = \text{"S"} \\ 4.0 & \text{if Klass} = \text{"N"} \\ 6.0 & \text{if Klass} = \text{"R"} \end{cases} = 4.00$$

$$\alpha_{ds2} = \begin{cases} 0.13 & \text{if Klass} = \text{"S"} \\ 0.12 & \text{if Klass} = \text{"N"} \\ 0.11 & \text{if Klass} = \text{"R"} \end{cases} = 0.12$$

$$RH_0 = 100\%$$

$$\beta_{RH} = 1.55 \cdot \left[ 1 - \left( \frac{RH}{RH_0} \right)^3 \right] = 0.76$$

$$\epsilon_{cd,0} = 0.85 \cdot \left[ (220 + 110 \cdot \alpha_{ds1}) \cdot e^{-\alpha_{ds2} \cdot \frac{f_{cm}}{f_{cmo}}} \right] \cdot 10^{-6} \cdot \beta_{RH} = 0.025\%$$

**Grundvärdet för krympning från uttorkning ( SS-EN 1992-1-1 avsnitt 3.1.4 ekv. 3.9 och 3.10 )**

$$k_h = \text{linterp} \left[ \left( 0 \ 100 \ 200 \ 300 \ 500 \ 10^4 \right) \text{mm}^T, (1.00 \ 1.00 \ 0.85 \ 0.75 \ 0.70 \ 0.70)^T, h_0 \right] = 0.70$$

$$\beta_{ds} = \frac{t_1 - t_s}{t_1 - t_s + 0.04 \sqrt{\left( \frac{h_0}{\text{mm}} \right)^3}} = 0.97$$

$$\epsilon_{cd} = \beta_{ds} \cdot k_h \cdot \epsilon_{cd,0} = 0.017\%$$

**Autogen krympning ( SS-EN 1992-1-1 avsnitt 3.1.4 ekv. 3.11, 3.12 och 3.13 )**

$$k_h = \text{linterp} \left[ \left( 0 \ 100 \ 200 \ 300 \ 500 \ 10^4 \right) \text{mm}^T, \left( 1.00 \ 1.00 \ 0.85 \ 0.75 \ 0.70 \ 0.70 \right) \text{h}_0^T \right] = 0.70$$

$$\beta_{as} = 1 - e^{-0.2 \cdot \sqrt{t_1}} = 1.00$$

$$\epsilon_{ca,\alpha} = 2.5 \cdot \left( \frac{f_{ck}}{\text{MPa}} - 10 \right) \cdot 10^{-6} = 0.006\%$$

$$\epsilon_{ca} = \beta_{as} \cdot \epsilon_{ca,\alpha} = 0.006\%$$

**Total krympning ( SS-EN 1992-1-1 avsnitt 3.1.4 ekv. 3.8 )**

$$\epsilon_{cs} = \epsilon_{cd} + \epsilon_{ca} = 0.024\%$$



	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:51
		Date :	Created :

### 3.7.2 Dynamic contribution

Dynamic contribution is determined according to SS EN 1991-2 section 6.4.5.2 with the condition of careful maintenance (TSFS 2018:57).

$$L_{\Phi} = 14m$$

$$\frac{1.44}{\sqrt{L_{\Phi}} - 0.2} + 0.82 = \frac{1.44}{\sqrt{14} - 0.2} + 0.82 = 1.23 < 1.67 \rightarrow \Phi_2 = 1.23$$

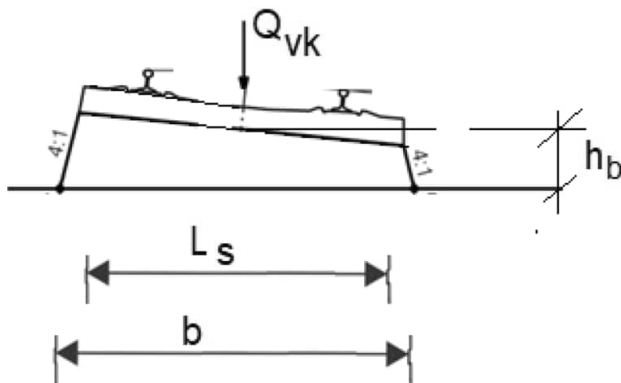
According to SS-EN 1991-2 section 6.4.5.4 (2), dynamic contribution does not need to be considered for foundations. For this bridge, the pile load capacity and geotechnical capacity will be checked without dynamic contribution.

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:52
	RC slab bridge	Date :	Created :

### 3.7.3 Transverse load distribution

A very conservative load distribution for distribution length (b) through sleepers and ballast is carried out according to SS-EN 1991-2 section 6.3.6.3, see the presentation below.

$$b = L_s + 2 \cdot \frac{h_b}{4} = 2250\text{mm} + 2 \cdot \frac{400\text{mm}}{4} = 2450\text{mm}$$

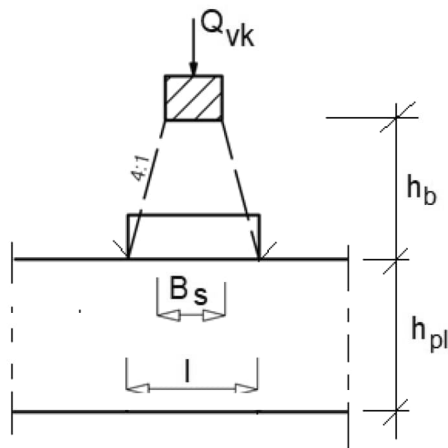


	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:53
	RC slab bridge	Date :	Created :

### 3.7.4 Longitudinal load distribution

A very conservative load distribution length ( $l$ ) through sleepers and ballast occurs according to SS-EN 1991-2 section 6.3.6.3, see the presentation below.

$$l = B_s + 2 \cdot \frac{h_b}{4} = 320mm + 2 \cdot \frac{400mm}{4} = 520mm$$



When determining the design load capacity corresponding to LM 71, however, the point load ( $Q_{vk}$ ) is distributed over a distribution length of 1.60 m according to common calculation practice.

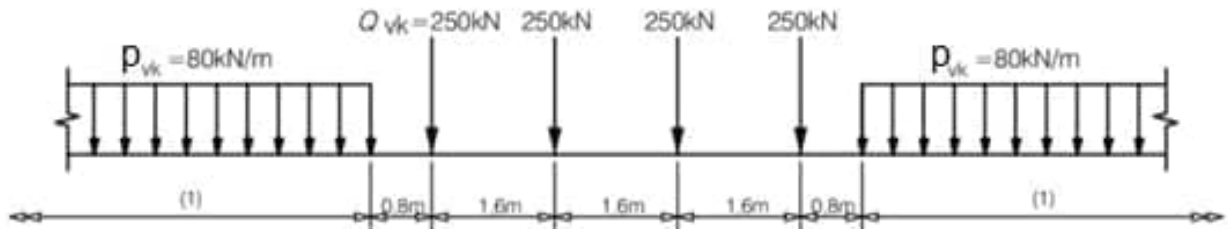
This is considered possible because the load is also spread in the bridge deck slab. For a load distribution of 1:1.7, a distribution width corresponding to 1.6 m is obtained, as shown below.

$$l' = l + 2 \cdot \frac{h_{pl}}{1.7} = 520mm + 2 \cdot \frac{900mm}{1.7} = 1.6m$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:54
		Date :	Created :

### 3.7.5 Load modell LM 71

Characteristic values of vertical loads according to EN 1991-2 section 6.3.2.



Adaption factor for "malmbanan":  $\alpha = 1,60$

Design speed:  $v = 120 \text{ km/h}$

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:55
	RC slab bridge	Date :	Created :

Train load is modelled as line loads and point loads in the system calculation according to the presentation below.

This is done by creating 4 line loads (∴ wagon) and 8 point loads (∴ locomotive).

In these loads, neither the impact of dynamic addition ( $\Phi_2$ ) nor the adaptation factor ( $\alpha$ ) is considered. These are instead considered when determining load coefficients.

Line loads apply the distance of 1435 mm between the rails (s) on the safe side.

Train Loading
✕

**Train load details**

Rail loading type Load Model 71 L1 (m) = 10

Track gauge, s (m) 1,435 L2 (m) = 10

All loads are per track  
i.e. half per rail

Direction of travel →

Track Gauge, s

L1    0.8m    1.8m    1.5m    1.5m    0.8m    L2

Include dynamic factor

Standard maintained track       Carefully maintained track

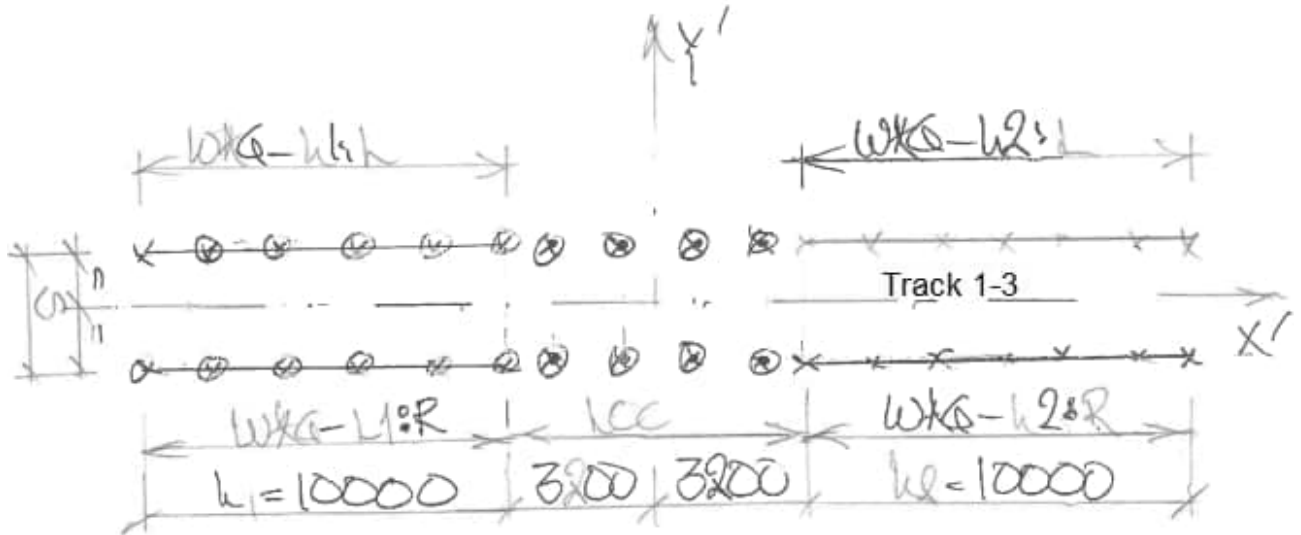
Dimension, L (m) 10,5      Dynamic factor = 1,0

Include alpha factor

Alpha factor to apply, 1,0

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:56
	RC slab bridge	Date :	Created :

The most dangerous load condition is obtained by applying these loads along the track lines (track 1-3). This is done with the function "Moving Load Analysis." All loads are "Discrete load" (loads tied to the coordinate system) which are combined into a "Compound load" as shown below.



## PLAN

*Discrete loads*

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:57
		Date :	Created :

Discrete point load - LOC :

Point ×

Analysis category

Arbitrary  
 Grid x   
                   y

Untransformed load direction  
 X    Y  
 Z    Surface normal  
 XYZ global  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
 X component   
 Y component   
 Z component

	X	Y	Z	Load
1	-2,4	-0,7175	0,0	-125,0
2	-0,8	-0,7175	0,0	-125,0
3	0,8	-0,7175	0,0	-125,0
4	2,4	-0,7175	0,0	-125,0
5	2,4	0,7175	0,0	-125,0
6	0,8	0,7175	0,0	-125,0
7	-0,8	0,7175	0,0	-125,0
8	-2,4	0,7175	0,0	-125,0

Name  (16)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:58
	RC slab bridge	Date :	Created :

Discrete patch load - WAG-L1:L :

Patch ×

Analysis category

Patch type  
 8 node patch  4 node patch  Multi-patch  Straight  Curve  Multi-straight

Load direction  
 X  Z  
 Y  XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
 X component   
 Y component   
 Z component

Patch load divisions  
 Use default  
 Number of divisions in   
 Number of divisions in y

	X	Y	Z	Load
1	-13,2	-0,7175	0,0	-40,0
2	-3,2	-0,7175	0,0	-40,0

Name  (5)

Discrete patch load - WAG-L1:R :

Patch ×

Analysis category

Patch type  
 8 node patch  4 node patch  Multi-patch  Straight  Curve  Multi-straight

Load direction  
 X  Z  
 Y  XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
 X component   
 Y component   
 Z component

Patch load divisions  
 Use default  
 Number of divisions in   
 Number of divisions in y

	X	Y	Z	Load
1	-13,2	0,7175	0,0	-40,0
2	-3,2	0,7175	0,0	-40,0

Name  (4)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:59
	RC slab bridge	Date :	Created :

Discrete patch load - WAG-L2:L :

Patch
×

Analysis category

Patch type

8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction

X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector

Project in load direction  
 Project for prestress

X component   
Y component   
Z component

Patch load divisions

Use default  
Number of divisions in   
Number of divisions in y

	X	Y	Z	Load
1	3,2	0,7175	0,0	-40,0
2	13,2	0,7175	0,0	-40,0

Name  (7)

Discrete patch load - WAG-L2:R :

Patch
×

Analysis category

Patch type

8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction

X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector

Project in load direction  
 Project for prestress

X component   
Y component   
Z component

Patch load divisions

Use default  
Number of divisions in   
Number of divisions in y

	X	Y	Z	Load
1	3,2	-0,7175	0,0	-40,0
2	13,2	-0,7175	0,0	-40,0

Name  (6)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:60
		Date :	Created :

Compound load – LM 71:

Compound

Analysis category

Included

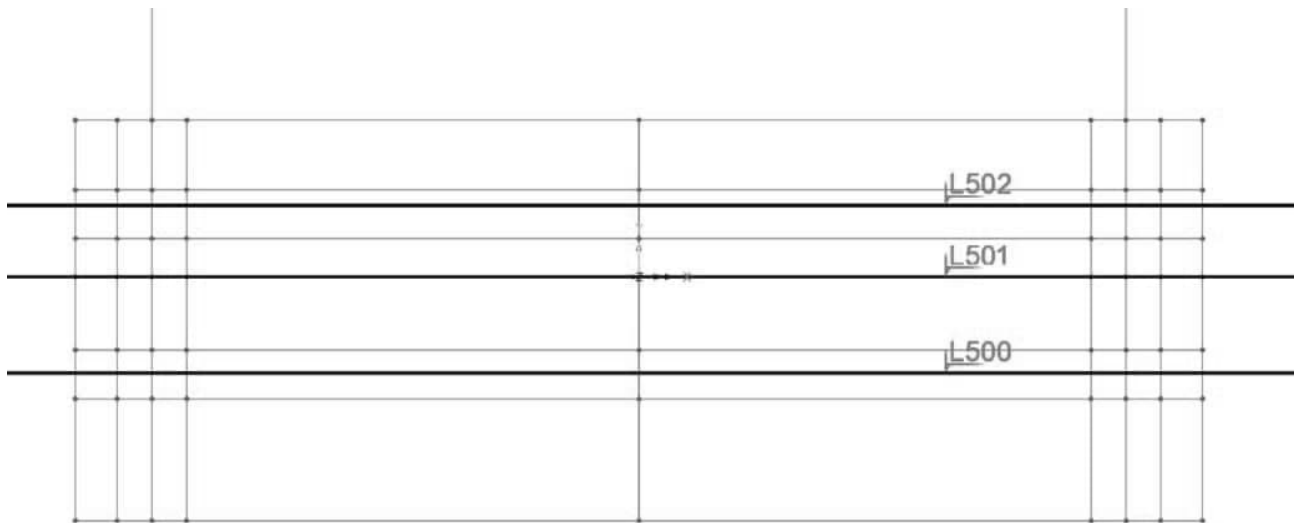
Component	x offse	y offse	z offse	Factor	Transformati
16.LOC	0.0	0.0	0.0	1.0	None
4.WAG-L1-R	0.0	0.0	0.0	1.0	None
5.WAG-L1-IL	0.0	0.0	0.0	1.0	None
6.WAG-L2-R	0.0	0.0	0.0	1.0	None
7.WAG-L2-L	0.0	0.0	0.0	1.0	None

Name  (8)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:61
		Date :	Created :

Track location (Track 1-3):

Track	e	Line
1	+1.380	L500
2	0	L501
3	-1.025	L502
-	m	m



PLAN  
Track 1-3

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:62
		Date :	Created :

Load attribute.:

Load attribute nr	Load attribute	Type
8	LM 71	Compound load

Load cases.:

Loadcase	Line	Track
LM 71 - T1	500	FB1
LM 71 - T2	501	FB2
LM 71 - T3	502	FB3

Envelope LM71.:

Envelope
LM71 - T1
LM71 - T2
LM71 - T3

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:63
		Date :	Created :

### 3.7.6 Load model SW/0

Train load SW/0 according to SS-EN 1991-2 section 6.3.3.

Load model SW/0 only applies to continuous beams according to SS-EN 1991-2 section 6.3.3(1), which is why the train load is omitted.

### 3.7.7 Load model SW/2

Train load SW/2 according to SS-EN 1991-2 section 6.3.3.

According to TSFS 2018:57 chapter 1 §12 load model SW/2 does not need to be considered on tracks where adaptation factor  $\alpha \geq 1.33$ , thus this load model is neglected.

### 3.7.8 Empty wagons

Empty wagons according to SS-EN 1991-2 section 6.3.4.

Consists of a uniformly distributed vertical load with a characteristic value of 10 kN/m. Used only for the verification of lateral stability for wind load. This load is not considered governing for this type of bridge, which is why the train load is omitted.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:64
		Date :	Created :

### 3.7.9 Track replacement machine

According to TRVINFRA-00227, 7.1.6.2.1.3-r, bridges with tracks in ballast shall be designed for track replacement machine.

Total weight track replacement machine:  $Q_{vk} = 900 \text{ kN}$

Dynamic contribution:  $D = 1.2$

Distance from top of track to concrete deck:  $H = 0.80 \text{ m}$

Longitudinal distribution length (l) through ballast:

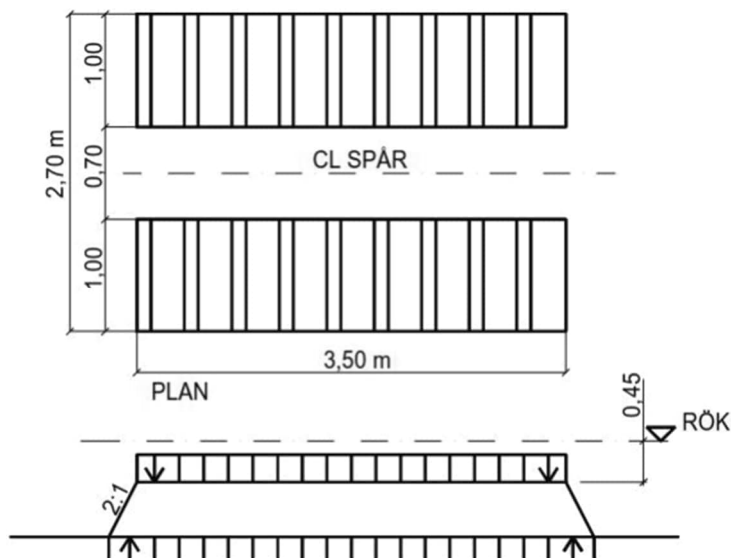
$$l = 3.5 \text{ m} + 0.8 \text{ m} - 0.45 \text{ m} = 3.85 \text{ m}$$

Transversal distribution width (b) through ballast:

$$b = 2 \cdot (1.0 \text{ m} + 0.8 \text{ m} - 0.45 \text{ m}) = 2 \cdot 1.35 \text{ m} = 2.7 \text{ m}$$

Equivalent load in system analysis:

$$q_{spär} = D \cdot \frac{Q_{vk}}{b \cdot l} = 1.2 \cdot \frac{900 \text{ kN}}{3.85 \text{ m} \cdot 2.7 \text{ m}} = 104 \text{ kPa}$$



	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:65
		Date :	Created :

### 3.7.10 Fatigue model

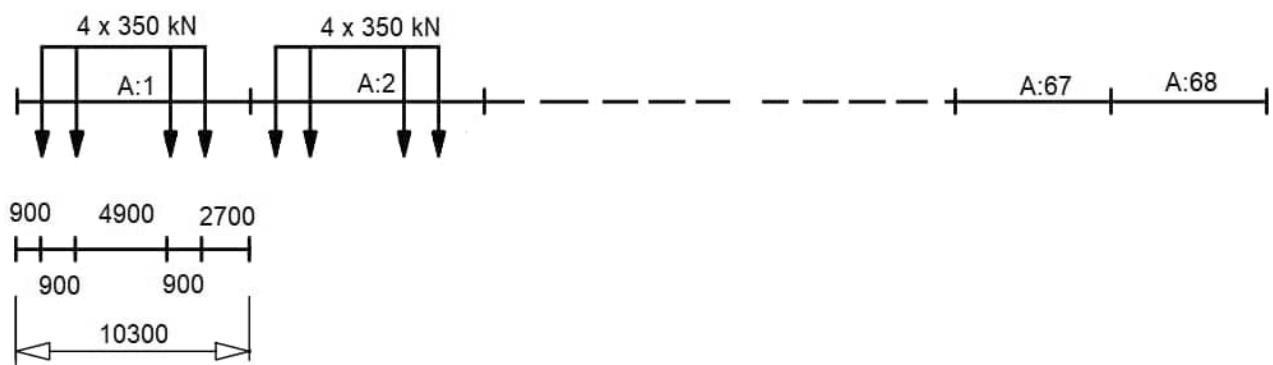
Bridge is designed with fatigue assumptions seen below.

Design conditions:

- Training: type 13S
- Traffic volume:  $V_{01} = 59.8 \cdot 10^6 \frac{\text{ton}}{\text{year}}$
- Equivalent load cycles  $\lambda$ -method:  $N = 10^6$
- Train speed (v):  $60 \frac{\text{km}}{\text{h}} \therefore 17 \frac{\text{m}}{\text{s}}$
- Magnification factor (K):  $\frac{v}{160 \text{m/s}} = \frac{17}{160} = 0.11$
- Dynamic factor :

$$\Phi_2 = 1 + \frac{1}{2} \cdot \left( \frac{K}{1-K+K^4} + \frac{1}{2} \cdot 0.56 e^{-\frac{L}{100}} \right) = 1 + \frac{1}{2} \cdot \left( \frac{0.11}{1-0.11+0.11^4} + \frac{1}{2} \cdot 0.56 e^{-\frac{14}{100}} \right) = 1.08$$

$$\sum Q = 95200 \text{ kN} \quad L = 68 \times 10.3 \text{ m} = 700.4 \text{ m} \quad v = 60 \text{ km/h}$$

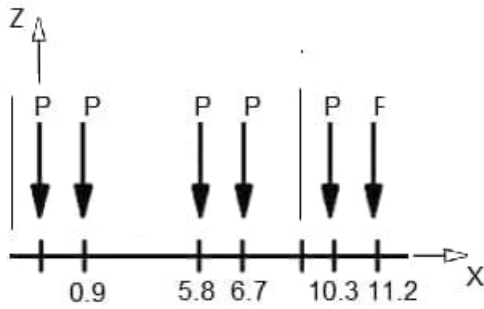


Train type 3S  
"Malmbanan"

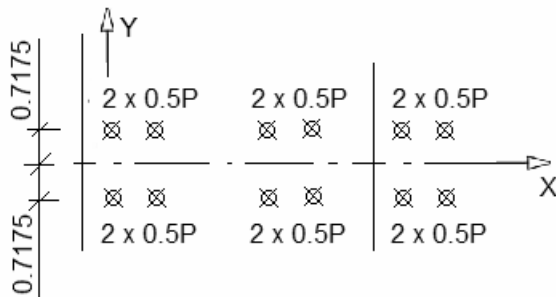
	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:66
	RC slab bridge	Date :	Created :

The most dangerous loading condition is obtained by applying the normal track position (track 2) for train type 13S with the function "Moving Load Analysis".

Train loads are modelled as "Discrete point load" (loads tied to the coordinate system).



### ELEVATION



### PLAN

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:67
		Date :	Created :

Discrete point load – TAG 13S :

Point

Analysis category

Arbitrary  
 Grid x   
y

Untransformed load direction  
 X  Y  
 Z  Surface normal  
 XYZ global  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
X component   
Y component   
Z component

	X	Y	Z	Load
1	0,0	0,7175	0,0	-175,0
2	0,9	0,7175	0,0	-175,0
3	5,8	0,7175	0,0	-175,0
4	6,7	0,7175	0,0	-175,0
5	10,3	0,7175	0,0	-175,0
6	11,2	0,7175	0,0	-175,0
7	0,0	-0,7175	0,0	-175,0
8	0,9	-0,7175	0,0	-175,0
9	5,8	-0,7175	0,0	-175,0
10	6,7	-0,7175	0,0	-175,0
11	10,3	-0,7175	0,0	-175,0
12	11,2	-0,7175	0,0	-175,0

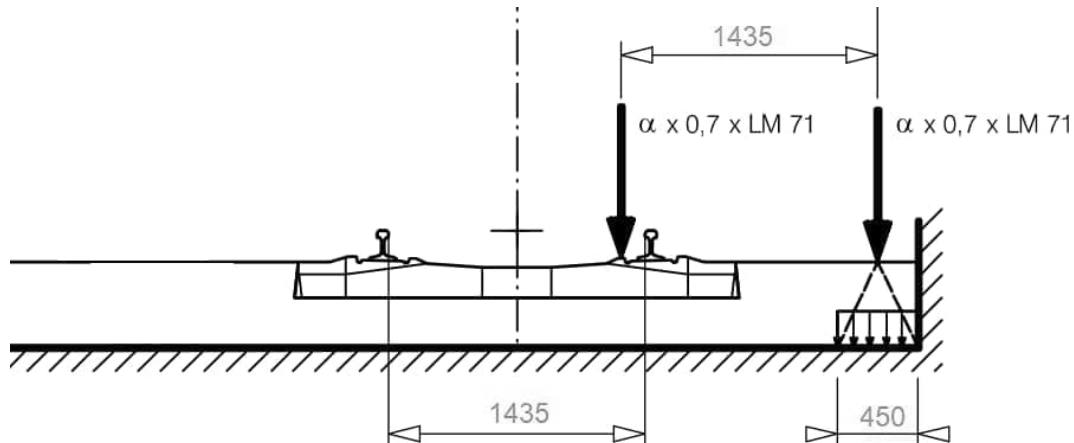
Name  (30)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:68
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### 3.7.11 Derailment load (accident load)

Design situations according to SS-EN 1991-2 section 6.7.1(2).

#### 3.7.11.1 Design situation I (ACC I)



Line load (W1 → W4):

$$p_{OLYCK} = \alpha \cdot 0.7 \cdot p_{vk} = 1.6 \cdot 0.7 \cdot 80 \frac{kN}{m} = 89 \frac{kN}{m}$$

Point load (L1):

$$P_{OLYCK} = \alpha \cdot 0.7 \cdot P_{vk} = 1.6 \cdot 0.7 \cdot 250kN = 280kN$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:69
		Date :	Created :

Discrete point load – L1.:

Point

Analysis category

Arbitrary  
 Grid x   
Y

Untransformed load direction  
 X  Y  
 Z  Surface normal  
 XYZ global  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
X component   
Y component   
Z component

	X	Y	Z	Load
1	-2.4	-3.275	0,0	-280
2	-0.8	-3.275	0,0	-280
3	0.8	-3.275	0,0	-280
4	2.4	-3.275	0,0	-280
5	2.4	-1.840	0,0	-280
6	0.8	-1.840	0,0	-280
7	-0.8	-1.840	0,0	-280
8	-2.4	-1.840	0,0	-280

Name  (30)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:70
	RC slab bridge	Date :	Created :

Discrete patch load – W1.:

Patch ✕

Analysis category

Patch type  
 8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction  
 X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
X component:   
Y component:   
Z component:

Patch load divisions  
 Use default  
Number of divisions in x:   
Number of divisions in y:

	X	Y	Z	Load
1	-8,1	3,275	0,0	-89,0
2	-3,2	3,275	0,0	-89,0

Name  (27)

Discrete patch load – W2:

Patch ✕

Analysis category

Patch type  
 8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction  
 X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
X component:   
Y component:   
Z component:

Patch load divisions  
 Use default  
Number of divisions in x:   
Number of divisions in y:

	X	Y	Z	Load
1	3,2	3,275	0,0	-89,0
2	8,1	3,275	0,0	-89,0

Name  (26)

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:71
	RC slab bridge	Date :	Created :

Discrete patch load – W3:

Patch ✕

Analysis category

Patch type  
 8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction  
 X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
X component   
Y component   
Z component

Patch load divisions  
 Use default  
Number of divisions in x   
Number of divisions in y

	X	Y	Z	Load
1	-8,1	1,84	0,0	-89,0
2	-3,2	1,84	0,0	-89,0

Name  (28)

Discrete patch load – W4:

Patch ✕

Analysis category

Patch type  
 8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction  
 X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
X component   
Y component   
Z component

Patch load divisions  
 Use default  
Number of divisions in x   
Number of divisions in y

	X	Y	Z	Load
1	3,2	1,84	0,0	-89,0
2	8,1	1,84	0,0	-89,0

Name  (29)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:72
		Date :	Created :

Compound load:

Compound
×

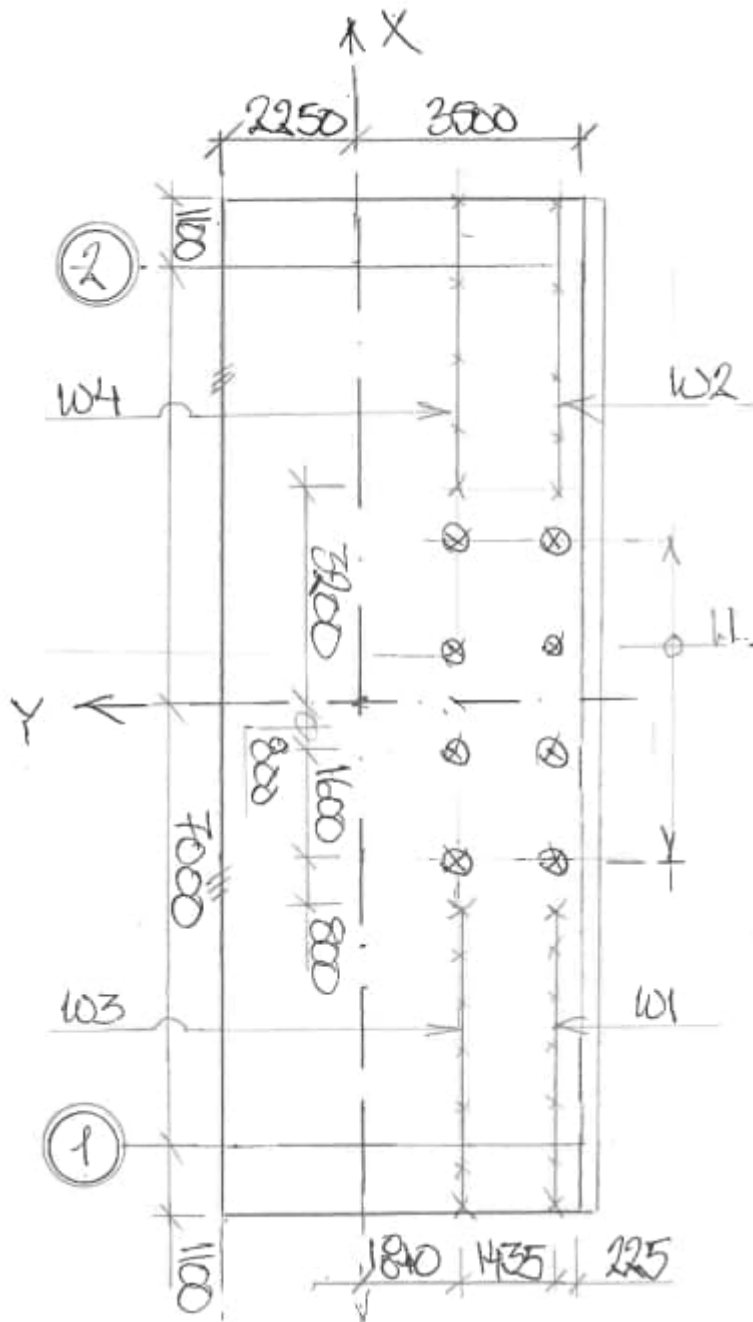
Analysis category

Included

Component	x offset	y offset	z offset	Factor	Transformation
27:W1	0,0	0,0	0,0	1,0	None
26:W2	0,0	0,0	0,0	1,0	None
28:W3	0,0	0,0	0,0	1,0	None
29:W4	0,0	0,0	0,0	1,0	None
31:L1	0,0	0,0	0,0	1,0	None

Name  ▼ ▲ (new)

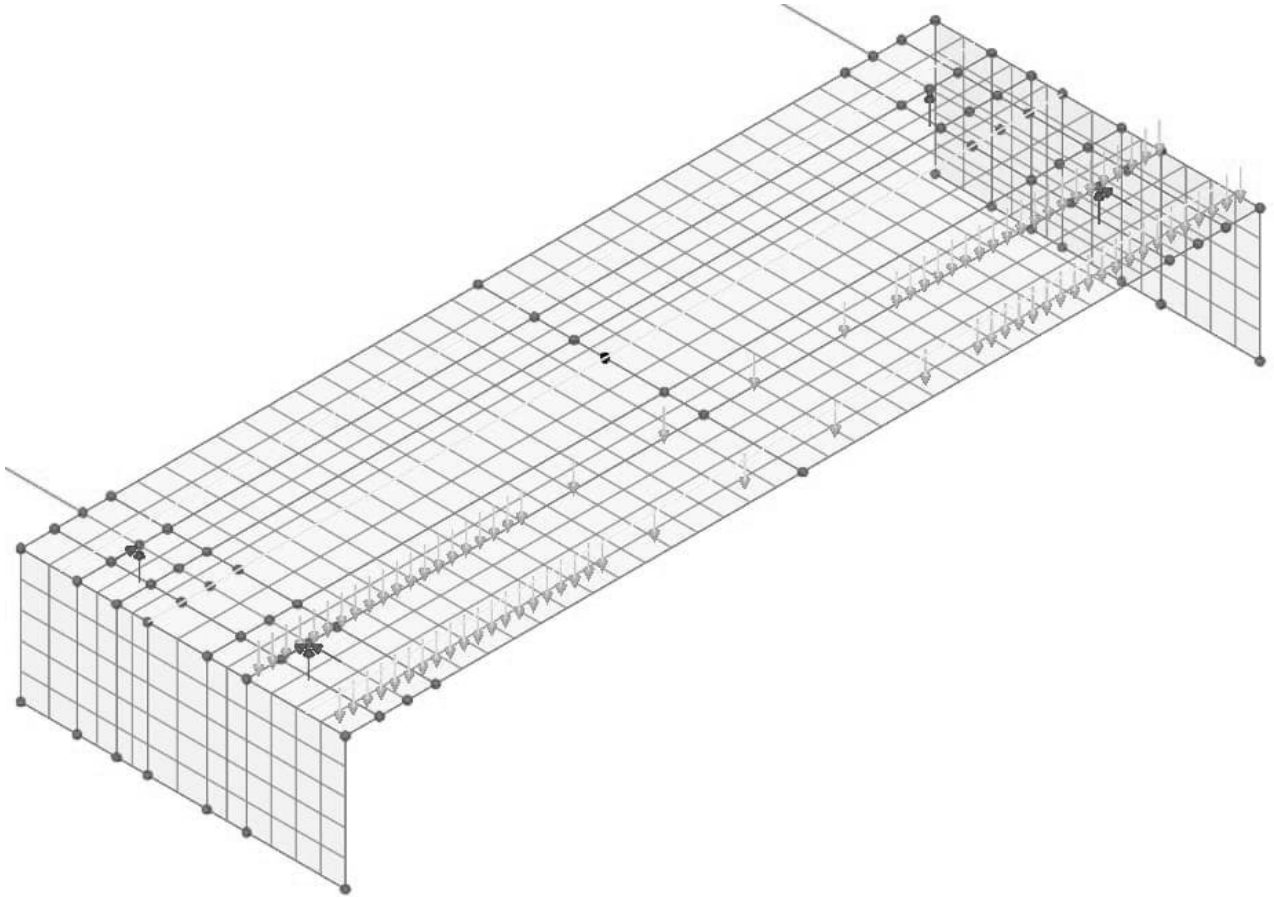
	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:73
	RC slab bridge	Date :	Created :



PLAN

Studied load position.

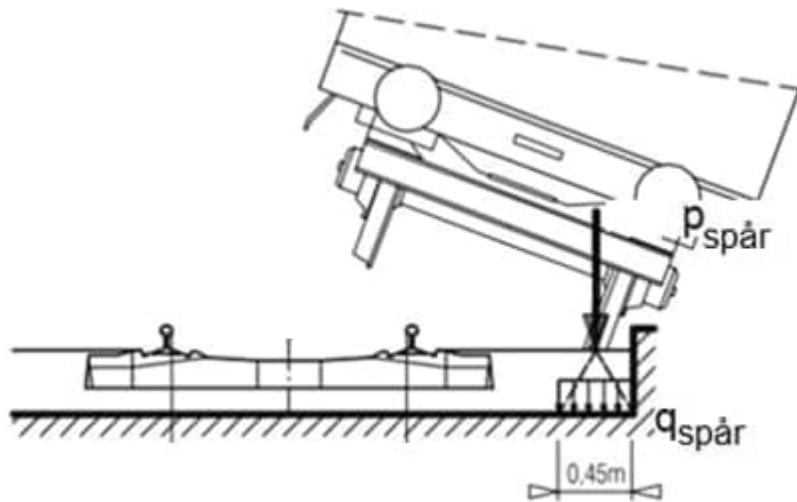
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:74
		Date :	Created :



Overview 3D  
Visualization loads.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:75
		Date :	Created :

### 3.7.11.2 Design situation II (ACC\_II)



Line load (W5 och W6):

$$p_{OLYCK} = \alpha \cdot 1.4 \cdot p_{vk} = 1.6 \cdot 1.4 \cdot 80 \frac{kN}{m} = 179 \frac{kN}{m}$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:76
		Date :	Created :

Discrete patch load – W5.:

Patch

Analysis category:

Patch type  
 8 node patch  
 4 node patch  
 Multi-patch  
 Straight  
 Curve  
 Multi-straight

Load direction  
 X  
 Z  
 Y  
 XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector  
 Project in load direction  
 Project for prestress  
X component:   
Y component:   
Z component:

Patch load divisions  
 Use default  
Number of divisions in x:   
Number of divisions in y:

	X	Y	Z	Load
1	-8,1	3,275	0,0	-179,0
2	8,1	3,275	0,0	-179,0

Name:  (12)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:77
		Date :	Created :

Compound load – ACC\_II:

Compound

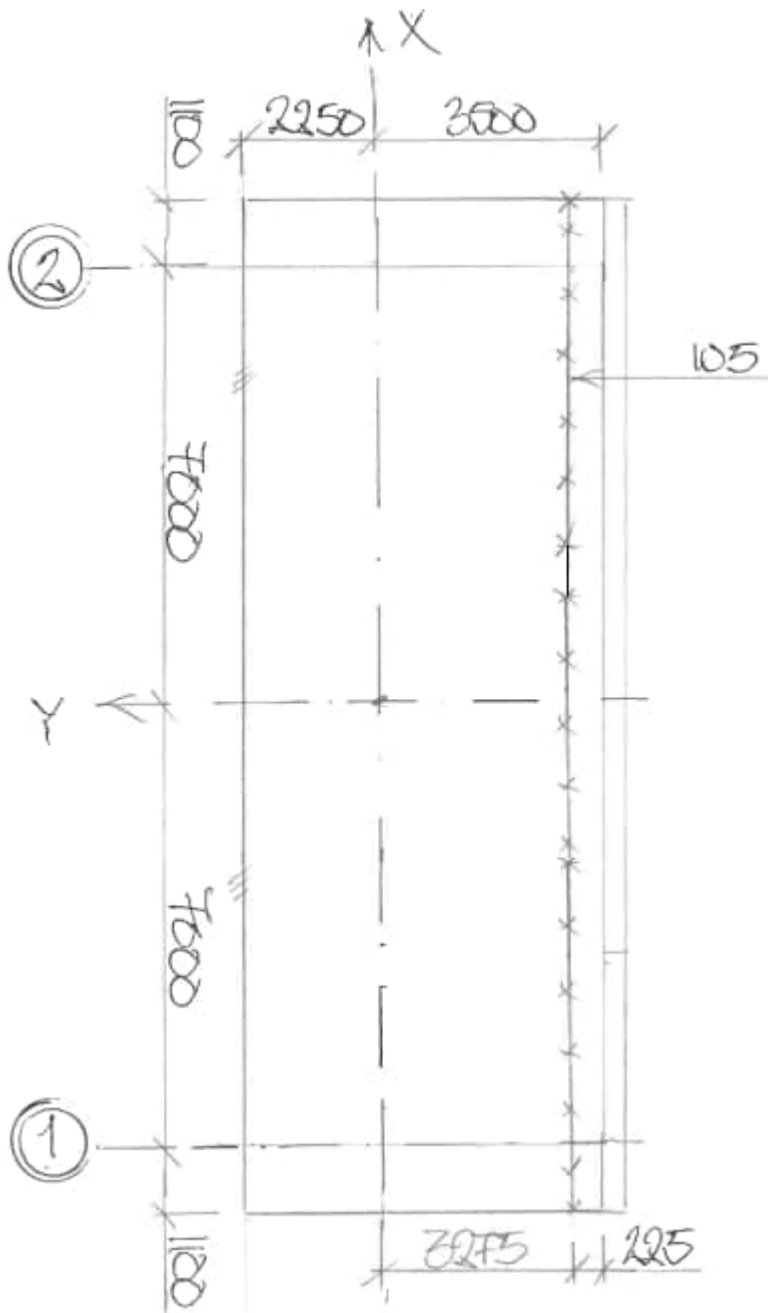
Analysis category

Included

Component	x offset	y offset	z offset	Factor	Transformation
12:W5	0.0	0.0	0.0	1.0	None

Name  (25)

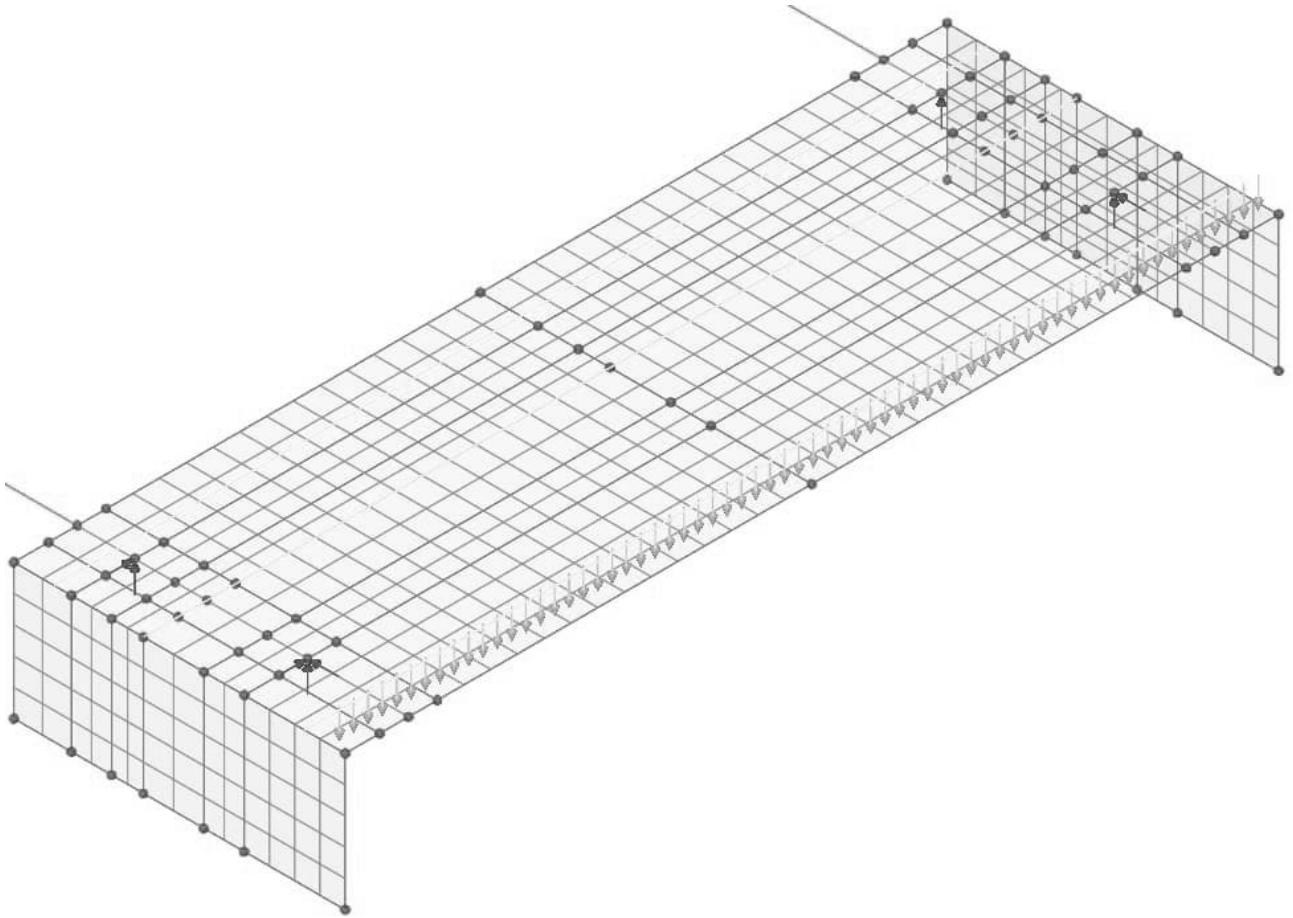
	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:78
	RC slab bridge	Date :	Created :



PLAN

Studied load position.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:79
		Date :	Created :



Overview 3D  
Visualization loads.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:80
		Date :	Created :

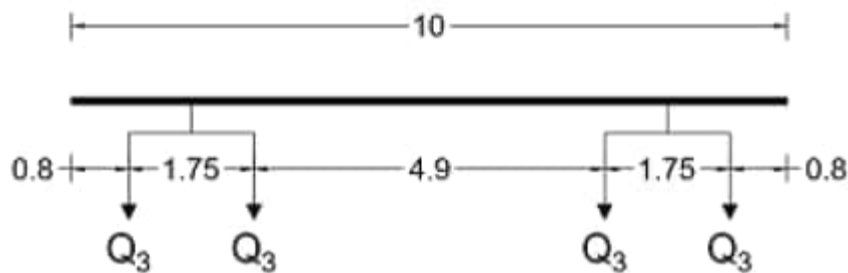
### 3.7.12 Load resistance calculation

TRVINFRA-00227 section 7.1.5.3 states that a load resistance calculation shall be performed for the superstructure as a load effect comparison of only vertical traffic loads according to TRVINFRA-0331 section 7.1.5.3.

The track is designated track segment 117 according to TRVINFRA-00331 table 8-4.

Verification is carried out only for train load TLM3 at the speed  $v = 60$  km/h with dynamic supplement according to TRVINFRA-00331 section 8.3.3.2.5.

In the calculation report, the maximum permissible axle load  $Q_3$  is determined according to the figure below.



	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:81
		Date :	Created :

### 3.8 BRAKING LOAD

Braking and acceleration load according to SS-EN 1991-2 section 6.5.3.

Load act at level top of track.

Max braking load: 6000 kN

Max acceleration load: 1000 kN

Bridge length:  $L_{bro} = 1.4 \text{ m} + 14 \text{ m} + 1.4 \text{ m} = 16.8 \text{ m}$

Load length:  $L_{broms} = L_{bro} = 16.8 \text{ m}$

Load effect excluding interaction between track and bridge deck :

Braking load :  $Q_b = 20 \text{ kN/m} \cdot \alpha \cdot L_{broms} = 538 \text{ kN}$

Acceleration load:  $Q_a = 33 \text{ kN/m} \cdot \alpha \cdot L_{broms} = 887 \text{ kN}$

$\rightarrow Q_{broms}^{red} = 887 \text{ kN}$

Load effect including interaction between track and brodge deck :

The impact of continuous ballast and fully welded rails provides a reduction ( $\eta$ ). Requirements for a simplified calculation method according to SS-EN 1991-2, section 6.5.4.6.1. The determination of the reduced braking force is performed with calculation program L1\_010, where all formulas and partial results are presented.

Reduktionsfaktor:

$\eta = 66\%$

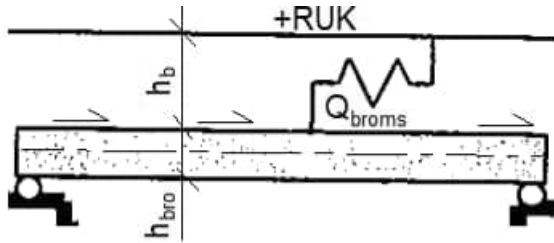
: see page A3:75

$\rightarrow$  According to common technical calculation practice, 50% is applied.

Reduced braking load t:

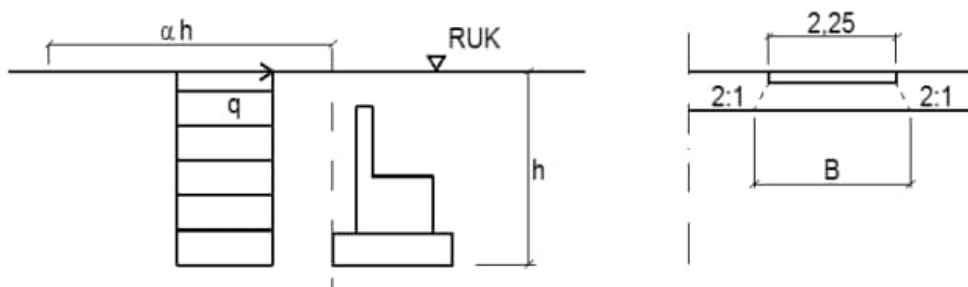
$Q_{broms} = 0.50 \times 887 \text{ kN} = 444 \text{ kN}$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:82
		Date :	Created :



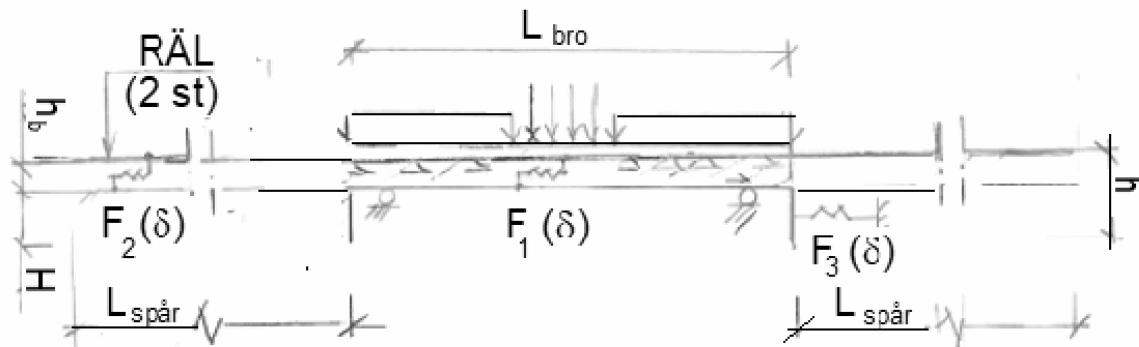
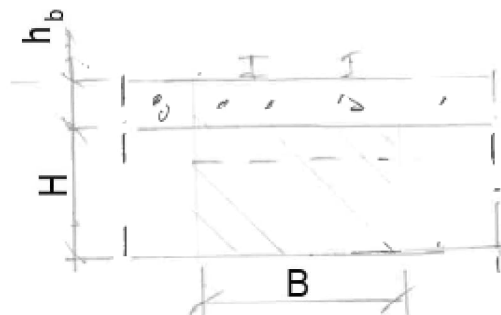
Remark

Load is assumed to act at level top of bridge deck.



Remark

According to TRVINFRA-00227 section 7.1.6.2.1.3 (1a), it states that the bridge superstructure does not need to be designed for the addition of braking load behind the support.

**Objekt: Bro Murjek****PRINCIPFIGUR****Längdsektion****Tvärsektion**

**TEORI**

Samverkan mellan bro och spårkonstruktion gör att en del av bromskraften upptas av spårkonstruktionen utanför bron, se även SS-EN 1991-2 avsnitt 6.5.3 och avsnitt 6.5.4.

Spårkonstruktionen bärförmåga beror på faktorer nedan:

- (1) Bärförmåga mellan slippers och räl. Denna beror på infästningsanordningens effektivitet.
- (2) Bärförmåga mellan slippers och ballast. Denna beror på bärförmågan i de förekommande horisontella brotytorna. Inuti ballast eller mellan ballast och brobana. Skillnaden i bärförmågan är således mycket stor mellan belastat och obelastat spår.

SS-EN 1991-2 avsnitt 6.5.4.6.1 anger att en förenklad beräkningsmetod är möjlig om kraven för metoden är uppfyllda. Metoden medger att rälsspänning inte behöver beaktas. Då bärförmågan mellan slippers och räl är relativt liten och dessutom beror på effektiviteten hos infästningsanordning så försummas dess bidrag vid bestämning av hur stor bromslast som belastar bron.

TRVINFRA-00227 tabell 7.1-6 (p) anger att den förenklade metoden får användas för samtliga järnvägsbroar kortare än 36 m.

"UIC Code 774-3 R: Track/bridge interaction" avsnitt 3.3 "Simplified rules" anger att bärförmågan i spårkonstruktion ( $L_{\text{spår}}$ ) motsvarande minst 100 m får användas om angivna krav är uppfyllda.

TRVINFRA-00227 tabell 7.1-6 (o) anger att största bärförmåga mellan slippers och räl sker för förskjutning  $u_0 = 0.5$  mm.

TRVINFRA-00227 tabell 7.1-6 (o) anger att största bärförmåga mellan slippers och ballast sker för förskjutning  $u_0 = 2.0$  mm.

TSFS:2018:57 kapitel 11 §15 anger att största bärförmåga mellan slippers/ballast/bro varierar från 20 kN/m till 40 kN/m för obelastat spår. Denna stora variation beror på effektivitet i infästningsanordningar. På säkra sidan tillämpas 20 kN/m vilket överensstämmer med förenklad metod enligt SS-EN 1992-1 avsnitt 6.5.4.6.1 (2).

TSFS:2018:57 kapitel 11 §15 anger att största bärförmåga mellan slippers/ballast/bro varierar från 50 kN/m till 60 kN/m för belastat spår. Vid bestämning av bromslast på bro tillämpas 60 kN/m vilket överensstämmer med förenklad metod enligt SS-EN 1992-1 avsnitt 6.5.4.6.1 (2).

Största mothållande jordtryck mot bank uppträder vid förskjutning ( $\delta$ ) motsvarande  $H/200$  enligt TRVINFRA-00227 avsnitt 7.2.1.1.2.1.

I denna beräkningsmodell har inverkan av axiell deformation i räl försumrats. Detta då inte entydligt angivits i gällande regelverk om detta är beaktad i den bärförmåga gällande regelverk anger. Om inverkan önskas måste dock noggrann FEM-analys utföras. Eller så väljs ett lägre värde på  $L_{\text{spår}}$  än 100 m.

**Observera att om  $L_{\text{spår}} = 0$  m väljs behövs ingen FEM-analys dock bör aldrig reduktion överstiga mera än 50 % enligt äldre gängse teknisk beräkningspraxis.**

**INDATA****Geometri**

$$L_{\text{spår}} = 0\text{m}$$

$$h_b = 0.60\text{m}$$

$$H = 2.80\text{m}$$

$$B = 5.75\text{m}$$

$$L_{\text{bro}} = 16.8\text{m}$$

**Jordmaterial:**

$$K_p = 5.82$$

$$K_0 = 0.29$$

$$\gamma_b = 20 \frac{\text{kN}}{\text{m}^3}$$

**Fjäder belastad ballast på bro (fjäder:1)**

$$\Delta_{p,1} = 2\text{mm}$$

$$p_1 = 60 \frac{\text{kN}}{\text{m}}$$

**Fjäder ballast utanför bro (fjäder:2)**

$$\Delta_{p,2} = 2\text{mm}$$

$$p_2 = 20 \frac{\text{kN}}{\text{m}}$$

**Laster:**

(Accelerationslast är dimensionerande)

$$\alpha = 1.6$$

$$p_{\text{broms}} = \alpha \cdot 33 \frac{\text{kN}}{\text{m}} = 53 \cdot \frac{\text{kN}}{\text{m}}$$

**BERÄKNING****Total belastningslängd:**

$$h = \begin{cases} 0\text{m} & \text{if } L_{\text{spår}} = 0\text{m} \\ H + h_b & \text{otherwise} \end{cases} \quad h = 0\text{-m}$$

$$L_{\text{broms}} = L_{\text{bro}} + 1.5 \cdot h = 16.8\text{ m}$$

**Total bromslast:**

$$P_{\text{broms.tot}} = p_{\text{broms}} \cdot L_{\text{broms}} = 887 \cdot \text{kN}$$

**Funktion - fjäder 1 (belastad räl):**

$$P_{1.\text{max}} = p_1 \cdot L_{\text{broms}} = 1008 \cdot \text{kN}$$

$$F_1 = \begin{cases} F_1 \leftarrow 0\text{kN} & \text{if } \delta < 0\text{mm} \\ F_1 \leftarrow P_{1.\text{max}} & \text{if } \delta > \Delta_{p.1} \\ F_1 \leftarrow P_{1.\text{max}} \frac{\delta}{\Delta_{p.1}} & \text{otherwise} \end{cases}$$

**Funktion - fjäder 2 (obelastad räl):**

$$P_{2.\text{max}} = \begin{cases} 0\text{kN} & \text{if } (2L_{\text{spår}} - 1.5h) < 0\text{m} \\ p_2 \cdot (2L_{\text{spår}} - 1.5h) & \text{otherwise} \end{cases} \quad P_{2.\text{max}} = 0 \cdot \text{kN}$$

$$F_2 = \begin{cases} F_2 \leftarrow 0\text{kN} & \text{if } \delta < 0\text{mm} \\ F_2 \leftarrow P_{2.\text{max}} & \text{if } \delta > \Delta_{p.2} \\ F_2 \leftarrow P_{2.\text{max}} \frac{\delta}{\Delta_{p.2}} & \text{otherwise} \end{cases}$$

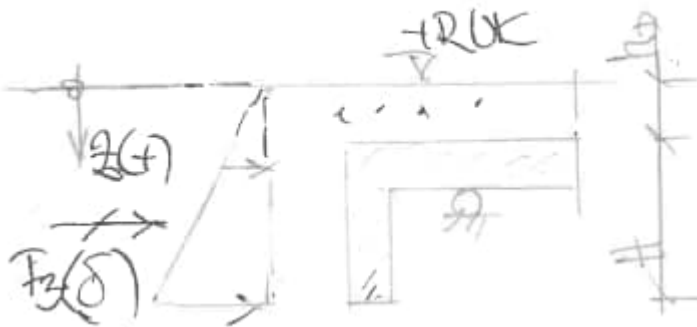
**Funktion - fjäder 3 (ändskärm):**

$$\Delta_{p.3} = \frac{H}{200} = 14 \cdot \text{mm}$$

$$K_3 = \begin{cases} K_3 \leftarrow 0 & \text{if } \delta < 0 \text{ mm} \\ K_3 \leftarrow 0 & \text{if } \delta > \Delta_{p.3} \\ K_3 \leftarrow (K_p - K_0) \cdot \frac{\delta}{\Delta_{p.3}} & \text{otherwise} \end{cases}$$

$$F_3(\delta) = \int_{h_b}^{(h_b+H)} B \cdot \gamma_b \cdot K_3 \cdot z \, dz$$

$$F_3(\Delta_{p.3}) = 3561 \cdot \text{kN}$$



**Total bromslast:**(Tillhörande belastningslängd  $L_{bro}$ )

$$P_{broms.tot} = 887 \cdot \text{kN}$$

**Fördelning av total bromslast:**

Given

$$P_{broms.tot} = F_1(u) + F_2(u) + F_3(u)$$

$$u_1 = \text{Find}(\delta)$$

$$u_1 = 1.2 \cdot \text{mm} \quad : \text{förskjutning vid jämvikt}$$

$$F_1(u_1) = 590 \cdot \text{kN} \quad : \text{last ballast på belastat spår}$$

$$F_2(u_1) = 0 \cdot \text{kN} \quad : \text{last ballast på obelastat spår}$$

$$F_3(u_1) = 298 \cdot \text{kN} \quad : \text{last ändskärm}$$

$$P_{broms.tot} - F_1(u_1) - F_2(u_1) - F_3(u_1) = 0 \cdot \text{kN}$$

**RESULTAT****Oreducerad bromslast utan samverkan:**

$$P_{broms.ored} = P_{broms.tot} = 887 \cdot \text{kN}$$

**Reducerad bromslast med samverkan:**

(Motsvarar last mot ändskärm)

$$P_{broms.red} = F_3(u_1) = 298 \cdot \text{kN}$$

$$\eta_{red} = 1 - \frac{P_{broms.red}}{P_{broms.ored}} = 66 \cdot \%$$

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:89
	RC slab bridge	Date :	Created :

Studied load cases:

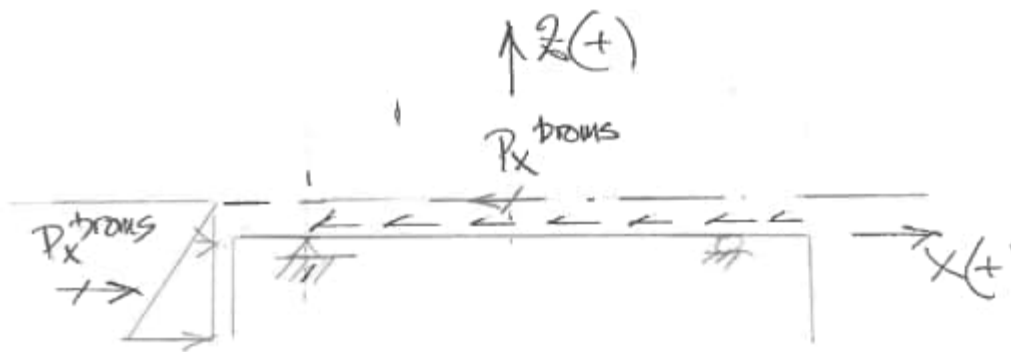
Two load cases are studied, designated "BROMS 1" and "BROMS 2," depending on the direction of the braking load.

The braking load on the bridge is applied as a fictitious line load in the brake in the position of its system line. When determining this load, it is distributed over the width (B).

$$p_x = \frac{Q_{broms}}{B} = \frac{444kN}{5.75m} = 77 \frac{kN}{m}$$

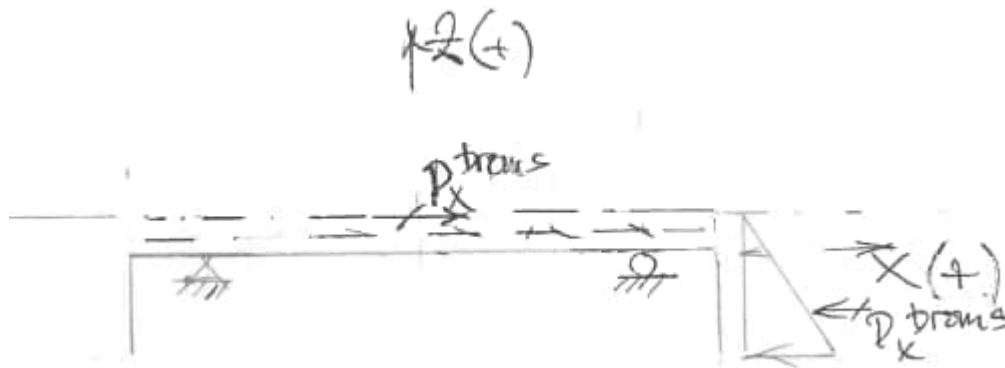
$$m_y = p_x \cdot \frac{h_{bro}}{2} = 77 \frac{kN}{m} \cdot \frac{0.95m}{2} = 37 \frac{kNm}{m}$$

The resisting load at each end screen corresponds to weighted values (f) of earth pressure at rest "JORD 1" and "JORD 2," respectively.



**BROMS 1**

( Load case: f · "JORD 1" och "BROMS -")



**BROMS 2**

( Load case: f · "JORD 2" och "BROMS +")

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:90
		Date :	Created :

Load case : BROMS+.

Global Distributed ×

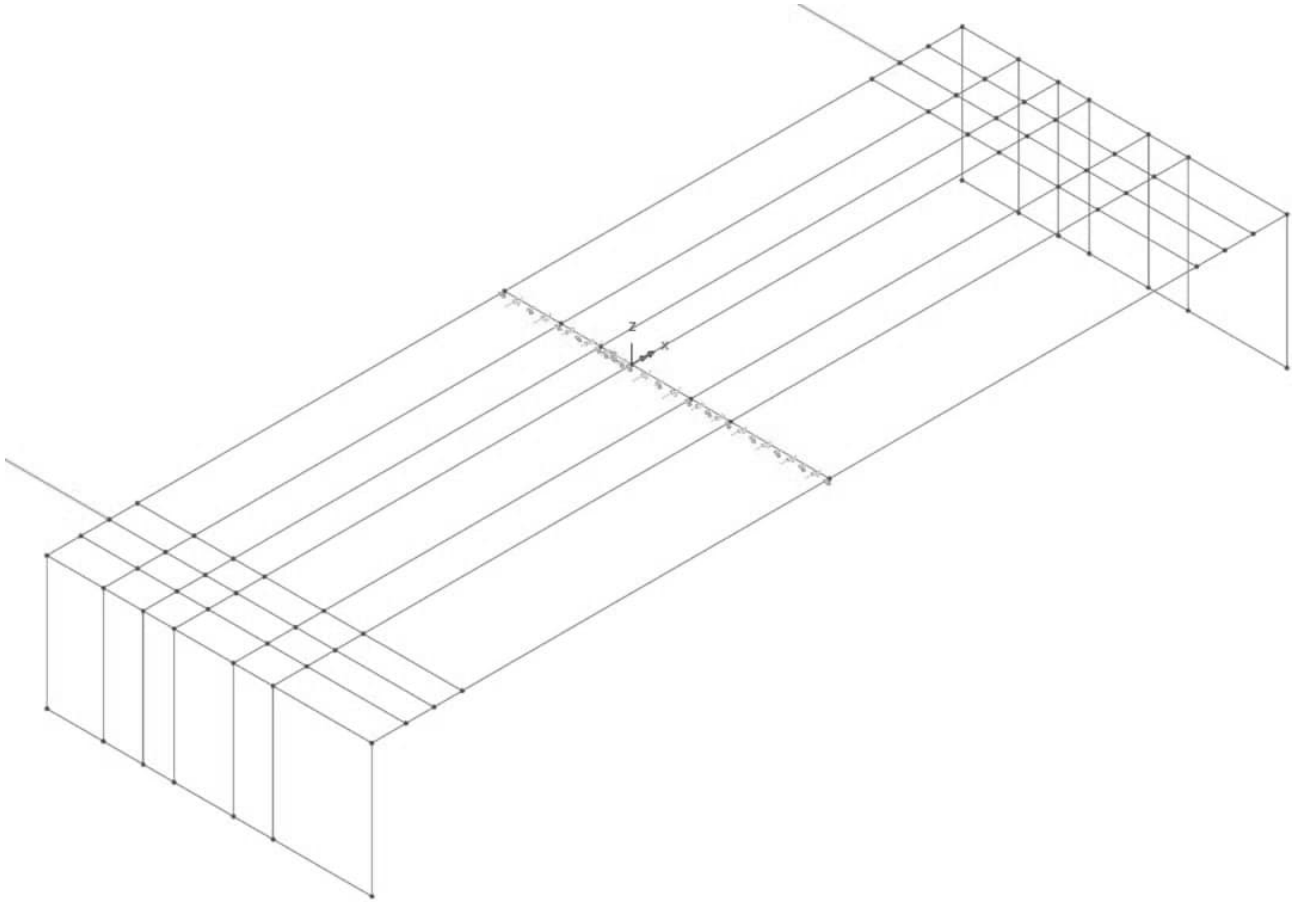
Analysis category

Total
  Per unit length
  Per unit area

Component	Value
X Direction	77.0
Y Direction	0.0
Z Direction	0.0
Moment about X axis	0.0
Moment about Y axis	37.0
Moment about Z axis	0.0

Name  (17)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:91
		Date :	Created :



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:92
		Date :	Created :

Loadcase : BROMS-

Global Distributed ✕

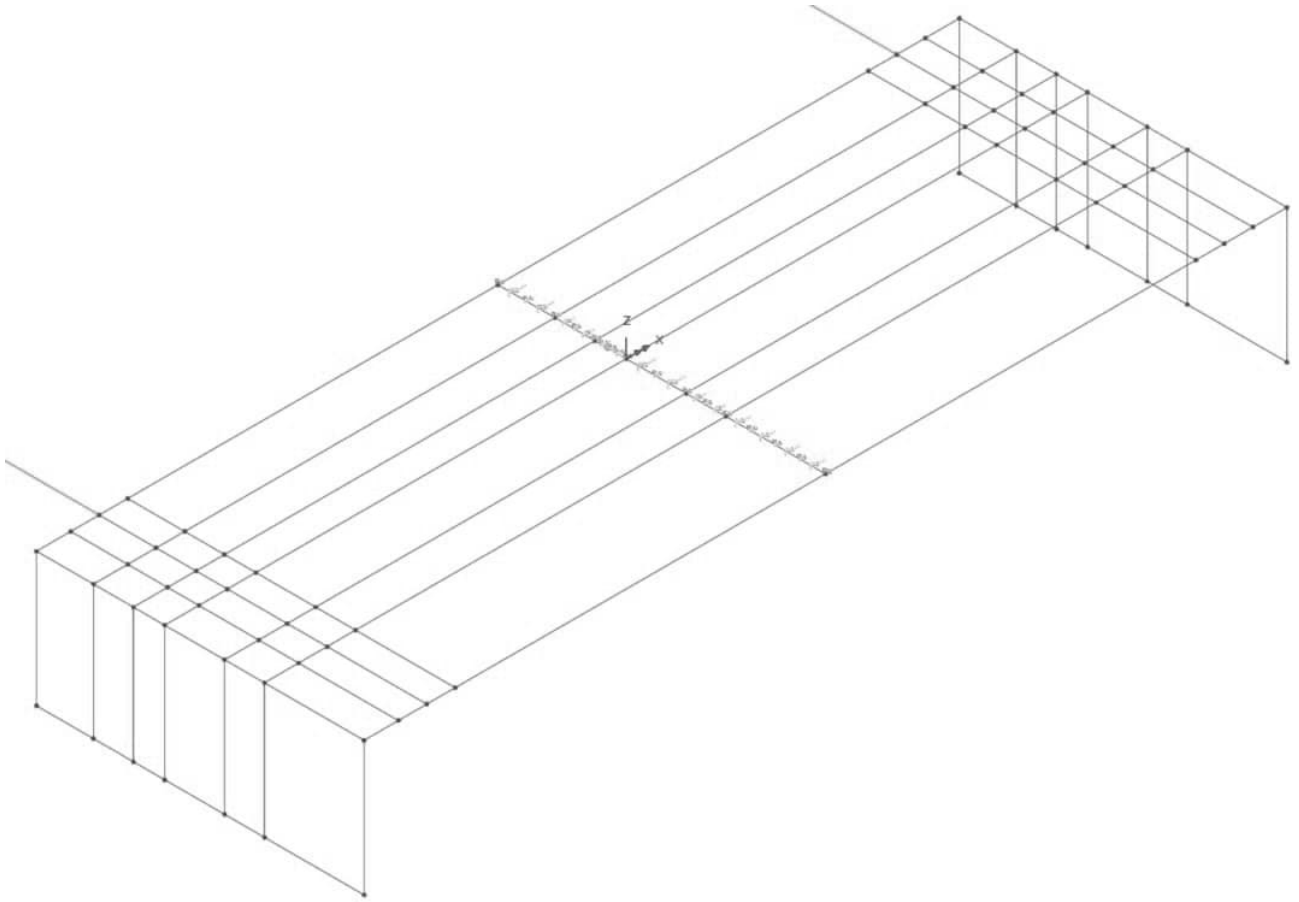
Analysis category

Total
  Per unit length
  Per unit area

Component	Value
X Direction	-77,0
Y Direction	0,0
Z Direction	0,0
Moment about X axis	0,0
Moment about Y axis	-37,0
Moment about Z axis	0,0

Name  (3)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:93
		Date :	Created :



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:94
		Date :	Created :

### 3.8.2.2 Load combinations

#### Basic load combination BROMS 1.:

Load case	Factor
JORD 1	2.30 <sup>1.)</sup>
BROMS-	1.0

#### Fotnote:

1.) Effect of reaktions force (Fx) for load case BROMS- and JORD .

$$\frac{Fx(BROMS-)}{Fx(JORD 1)} = \frac{444kN}{193kN} = 2.30$$

#### Basic loadcombination BROMS 2.:

Load case	Factor
JORD 2	2.30 <sup>2.)</sup>
BROMS-	1.0

#### Fotnot2:

2.) Effect of reaktions force (Fx) for load case BROMS+ and JORD .

$$\frac{Fx(BROMS+)}{Fx(JORD 2)} = \frac{444kN}{193kN} = 2.30$$

#### Envelope BROMS:

Load case
BROMS 1
BROMS 2

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:95
	RC slab bridge	Date :	Created :

### 3.9 LATERAL LOAD

Lateral load according to SS-EN 1991-2 section 6.5.2.

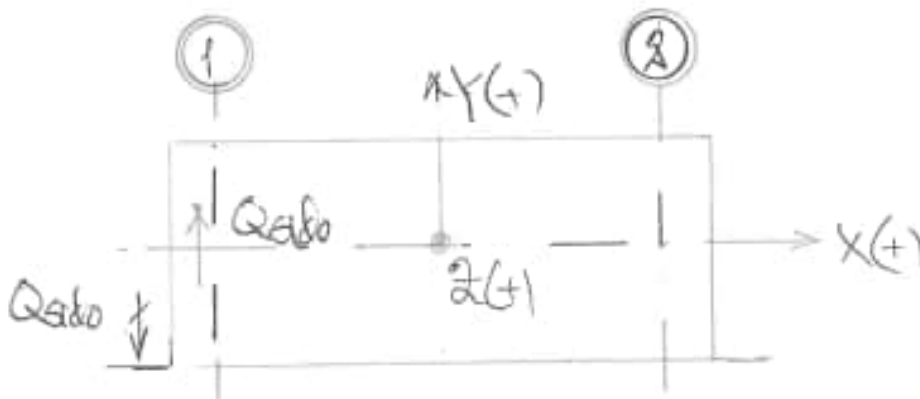
Load acts at top of track.

$$\rightarrow Q_{sido} = 100kN \cdot \alpha = 100kN \cdot 1.6 = 160 kN$$

Two loadcase are studied. They are termed "SIDO 1" and "SIDO 2". They are used depending on where lateral load acts. The lateral load is transferred to wingwall using increased earthpressure ( $\Delta p$ ) due to movement.

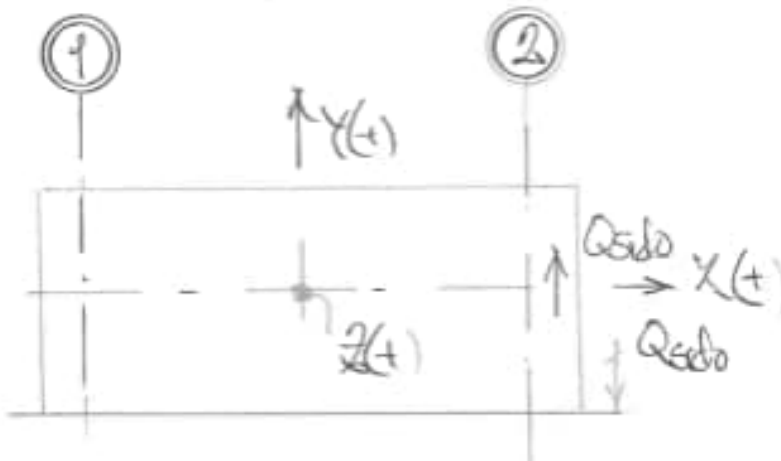
The lateral force is introduced into static modell using weighted value (f) of earthpressure "JORD 3-1" respektive "JORD 3-2".

$$f = \frac{Q_{sido}}{H_{jord}} = \frac{160kN}{55kN} = 2,9$$



#### SIDO 1

( Load case : f · "JORD 3-1" )



#### SIDO 2

( Load case: f · "JORD 3-2" )

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:96
		Date :	Created :

Basic load combination SIDO 1:

Loadcase	Factor
JORD 3-1	2,9

Basic load combination SIDO 2:

Load case	Factor
JORD 3-2	2,9

Envelope SIDO:

Load case
SIDO 1
SIDO 2

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:97
		Date :	Created :

### 3.10 CENTRIFUGAL FORCE

Centrifugal force according to SS-EN 1991-2 section 6.5.1, however track is not constructed with radius thus load case is not considered.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:98
		Date :	Created :

### 3.11 WIND LOAD

Wind load according to EN 1991-1-4 chapter 8.

Duration coefficients (see SS-EN 1990 appendix A2 table A2.1):

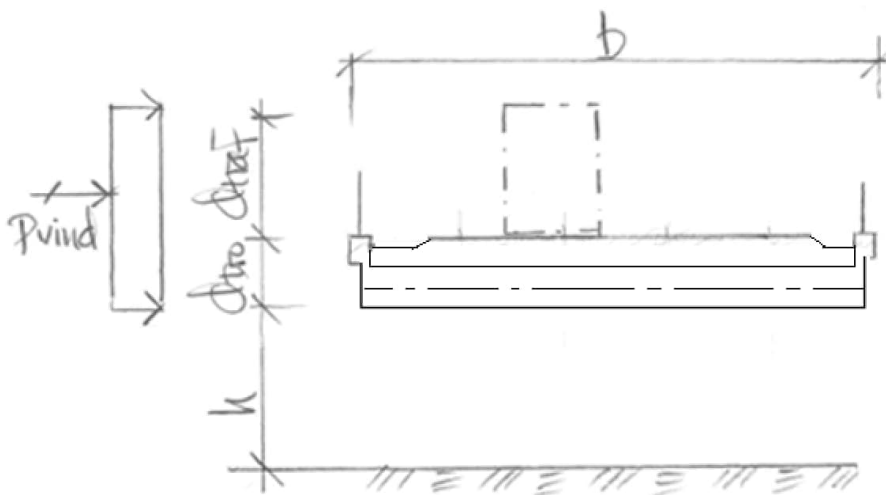
$$\psi_k = 1.00$$

$$\psi_0 = 0.30$$

$$\psi_1 = 0.20$$

$$\psi_2 = 0$$

Load intensity:



Terrain type II according to SS-EN 1991-1-4 table 4.1 is applied on safe side.

$h = 3$  m but 4 m is used on safe side.

$$v_b(\text{"Location"; } z = 10\text{m; } z_0 = 0.05\text{m}) = 23 \frac{\text{m}}{\text{s}} \quad : \text{ TSFS chapter 7 sketch 7.1}$$

$$q_p(h = 4\text{m, Terrain type II, } v_b = 23 \frac{\text{m}}{\text{s}}) = 0.54\text{kPa} \quad : \text{ TSFS chapter 7 sketch 7.1}$$

$$q_b = \frac{1}{2} \cdot \rho \cdot v_b^2 = \frac{1}{2} \cdot 1.25 \frac{\text{kg}}{\text{m}^3} \cdot \left(23 \frac{\text{m}}{\text{s}}\right)^2 = 0.33 \frac{\text{kN}}{\text{m}^2} \quad : \text{ SS-EN 1991-1-4 chapter 4.5}$$

$$c_e = \frac{q_p}{q_b} = \frac{0.54\text{kPa}}{0.33\text{kPa}} = 1.64 \quad : \text{ SS-EN 1991-1-4 section 4.5}$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:99
		Date :	Created :

$$d_{bro} = 0.95m + 0.60m = 1.55m \quad : \text{construction height}$$

$$d_{traf} = 4.0m + 0.2 = 4.2m \quad : \text{train height above level bottom of track}$$

see SS-EN 1991-4 section 8.3.1 (3)

$$d_{tot} = 1.5m + 4.2m = 5.75m$$

$$\rightarrow \frac{b_{bro}}{d_{tot}} = \frac{1.55m}{5.75m} = 1.91$$

$$c_{f.x} \left( \frac{b_{bro}}{d_{tot}} = 1.91 \right) = 1.9 \quad : \text{SS-EN 1991-1-4 sketech 8.3}$$

$$C = c_e \cdot c_{f.x} = 1.64 \cdot 1.9 = 3.1$$

$$\frac{A_{ref.x}}{L} = d_{tot}$$

Wind load against bridge :

$$\frac{A_{ref.x}^{bro}}{L} \equiv d_{bro}$$

$$p_{vind}^{bro} = \frac{F_w}{L} = \frac{1}{2} \cdot \rho \cdot v_b^2 \cdot C \cdot \frac{A_{ref.x}^{bro}}{L} = \frac{1}{2} \cdot 1.25 \frac{kg}{m^3} \cdot \left(23 \frac{m}{s}\right)^2 \cdot 3.1 \cdot 1.55m = 1.6 \frac{kN}{m}$$

Wind load against train :

$$\frac{A_{ref.x}^{traf}}{L} \equiv d_{traf}$$

$$p_{vind}^{traf} = \frac{F_w}{L} = \frac{1}{2} \cdot \rho \cdot v_b^2 \cdot C \cdot \frac{A_{ref.x}^{traf}}{L} = \frac{1}{2} \cdot 1.25 \frac{kg}{m^3} \cdot \left(23 \frac{m}{s}\right)^2 \cdot 3.1 \cdot 4.2m = 4.3 \frac{kN}{m}$$

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Studied load case:

Studied load cases is termed "VIND" and acts in transversal direction.

Wind load consist of forces against both bridge and train on safe side.

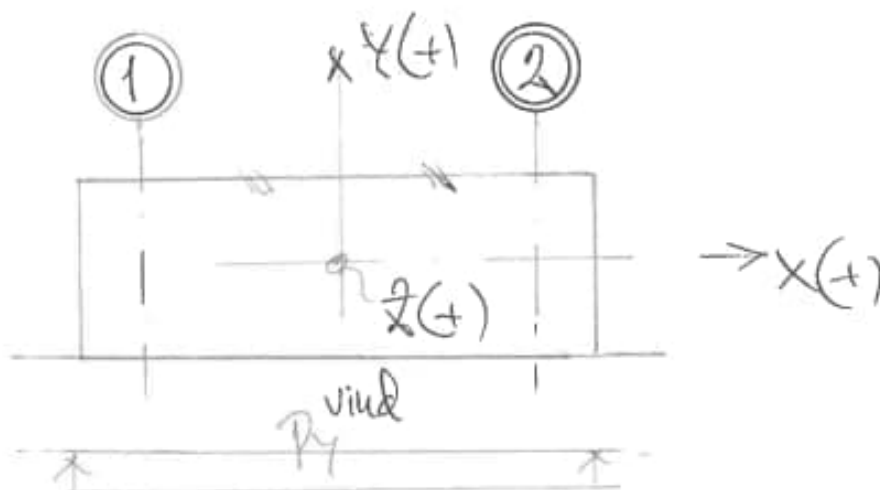
Load is applied at center of track (e = 0 m) which is reasonable simplification.

$$p_y = p_{vind}^{bro} + p_{vind}^{traf} = 1.6 \frac{kN}{m} + 4.3 \frac{kN}{m} = 6 \frac{kN}{m}$$

$$m_{vind}^{bro} = 1.6 \frac{kN}{m} \cdot \left(1.55m - \frac{0.95m}{2}\right) = 2 \frac{kNm}{m}$$

$$m_{vind}^{traf} = 4.3 \frac{kN}{m} \cdot \left(\frac{4.2m}{2} + 0.60m + \frac{0.95mm}{2}\right) = 14 \frac{kNm}{m}$$

$$m_x = -m_{vind}^{bro} - m_{vind}^{traf} = -2 \frac{kNm}{m} - 14 \frac{kNm}{m} = -16 \frac{kN}{m}$$



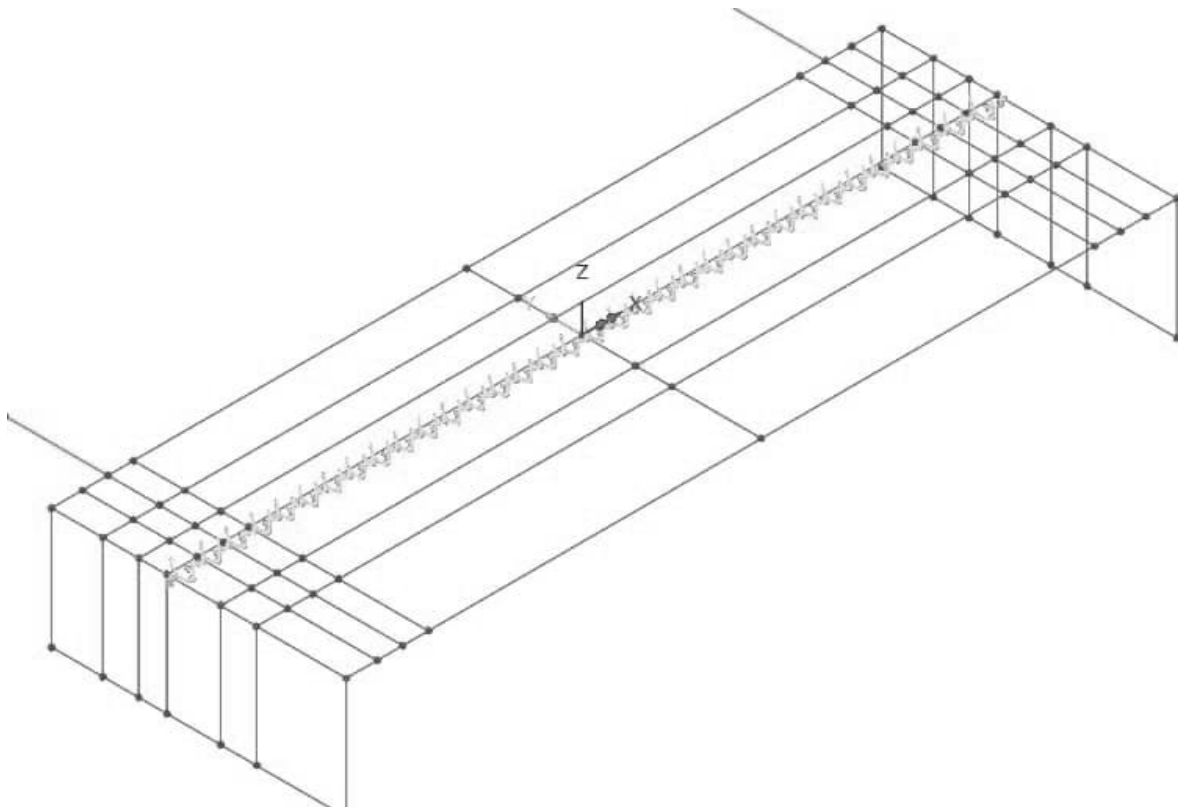
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:101
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Load : VIND

Structural loading : Global distributed

Load per unit length in Y direction (  $p_y$  ) :  $6 \frac{kN}{m}$

Moment about X axis (  $m_x$  ) :  $-16 \frac{kNm}{m}$

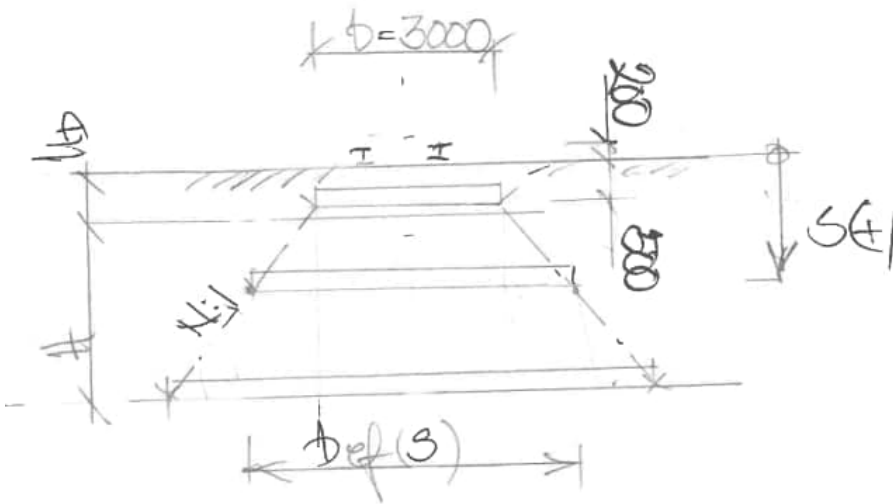


Overview 3D

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:102
	RC slab bridge	Date :	Created :

### 3.12 SURCHARGE

Surcharge according to SS-EN 1991-2 section 6.3.6.4 with even distribution of train load associated to LM71 (axles c/c 1.6 m) in longitudinal direction and width (b) 3.0 m in transversal direction a distance of 0.7 m from level top of track.



	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:103
		Date :	Created :

### 3.12.1 Load effect on end shields

Load effect on endshield assumes load distribution 2:1 ( $\therefore N = 2$ ) in ballast.

$$q_{\text{over}}(s) = \alpha \cdot \frac{Q_{vk}}{(b+s-0.50m) \cdot l} = 1.6 \cdot \frac{250kN}{(2.5m+s) \cdot 1.6m}$$

$$q_{\text{over}}(0.6m) = 1.6 \cdot \frac{250kN}{(2.5m+0.6m) \cdot 1.6m} = 81kPa \quad : \text{ level top endshield } b_{\text{over}} = 3.1 \text{ m}$$

$$q_{\text{over}}(3.4m) = 1.6 \cdot \frac{250kN}{(2.5m+3.4m) \cdot 1.6m} = 43kPa \quad : \text{ level bottom of endshield } b_{\text{over}} = 5.9 \text{ m}$$

$$q_{\text{over}}^{\text{med}} = \frac{43kPa+81kPa}{2} = 62kPa \quad : \text{ average width } b_{\text{over}} = 4.5 \text{ m}$$

In the static model the average value of load is applied ( $q_{\text{over}}^{\text{med}}$ ) on load width ( $b_{\text{over}}$ ) corresponding to width of end shields ( $B = 5.75 \text{ m}$ ) on safe side.

$$q_x^{\text{over}} = K_0 \cdot q_{\text{over}}^{\text{med}} = 0.29 \cdot 62kPa = 18kPa$$

Surcharge is introduced into static model as weighed (f) earth pressure "JORD 1" and "JORD 2".

$$f = \frac{F_{x_{\text{over}}}}{F_{x_{\text{jord}}}} = \frac{289kN}{193kN} = 1.50$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:104
		Date :	Created :

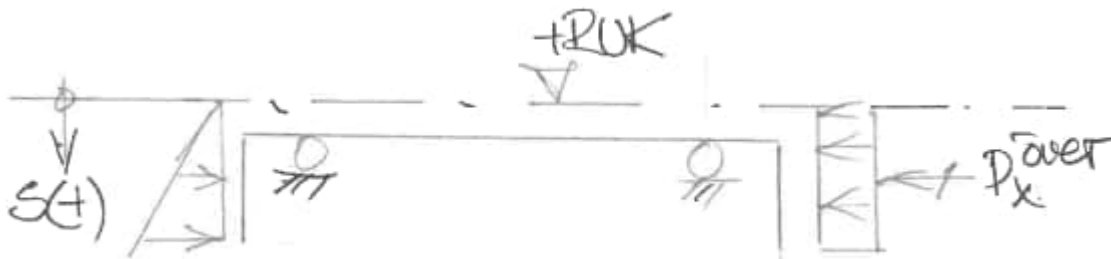
Studied load cases:

Two load cases are studied, termed "OVER 1" and "OVER 2". Used depending on direction of surcharge.



OVER 1

( Load case: f · "JORD 2" och "OVER +" )



OVER 2

( Load case: f · "JORD 1" och "OVER -" )

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:105
	RC slab bridge	Date :	Created :

Load case : OVER+

Structural loading : Discrete 4 node patch

Surface load (  $q_x$  ) : +18 kPa

Search Area : End shield 1

Loads outside search area : Include full load

Patch ×

Analysis category

Patch type

8 node patch
  4 node patch
  Multi-patch
  Straight
  Curve
  Multi-straight

Load direction

X
  Z  
 Y
  XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

Projection vector

Project in load direction  
 Project for prestress

X component

Y component

Z component

Patch load divisions

Use default

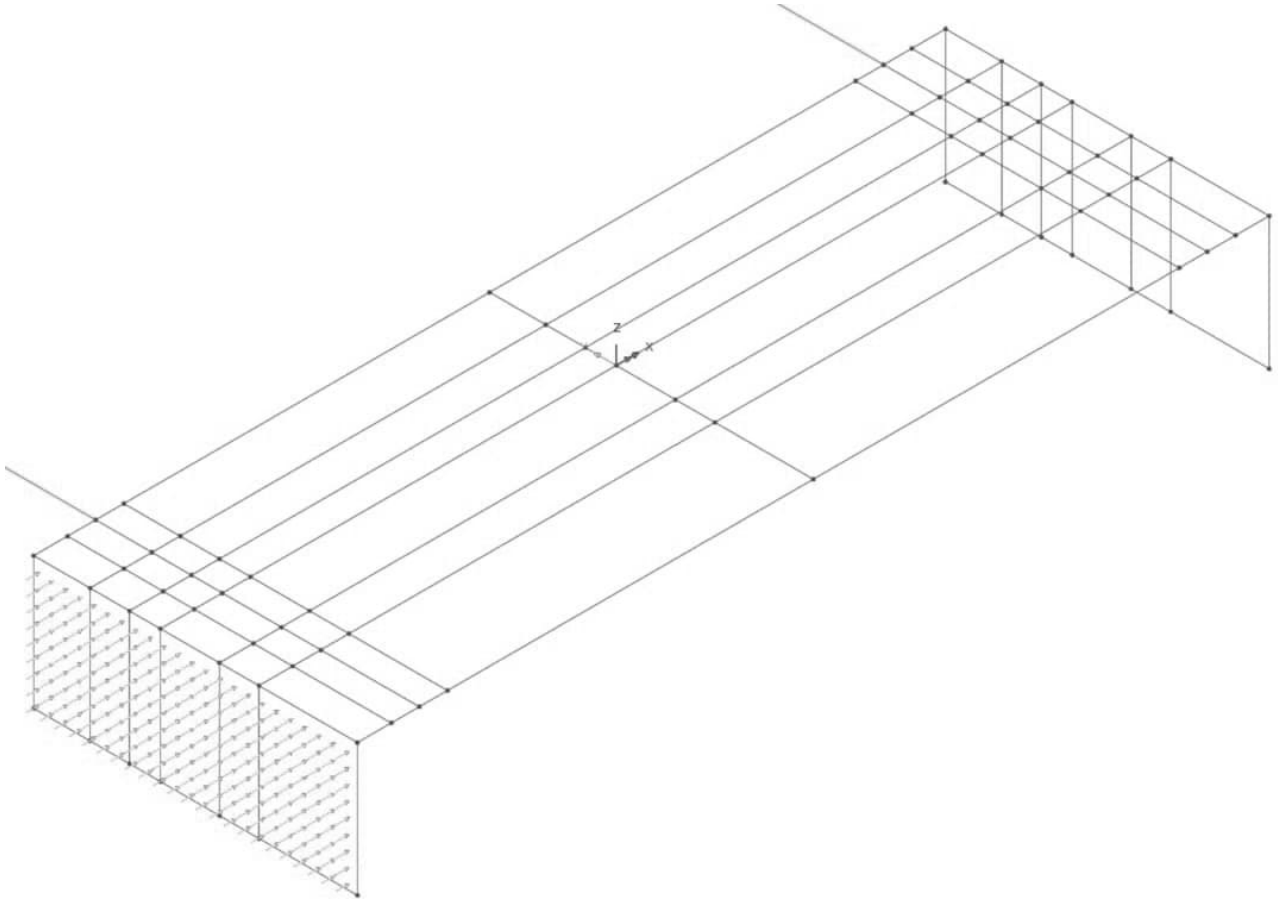
Number of divisions in

Number of divisions in y

	X	Y	Z	Load
1	-10,0	2,25	-2,35	18,0
2	-10,0	-3,5	-2,35	18,0
3	-10,0	-3,5	0,45	18,0
4	-10,0	2,25	0,45	18,0

Name  (19)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:106
		Date :	Created :



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:107
		Date :	Created :

Load case : OVER-

Structural loading : Discrete 4 node patch

Surface load (  $q_x$  ) : -18 kPa

Search Area : End shield 2

Loads outside search area : Include full load

Patch ×

Analysis category

Patch type  
 8 node patch  4 node patch  Multi-patch  Straight  Curve  Multi-straight

Load direction  
 X  Z  
 Y  XYZ global  
 Patch x  
 Patch y  
 Surface normal  
 XYZ transformable

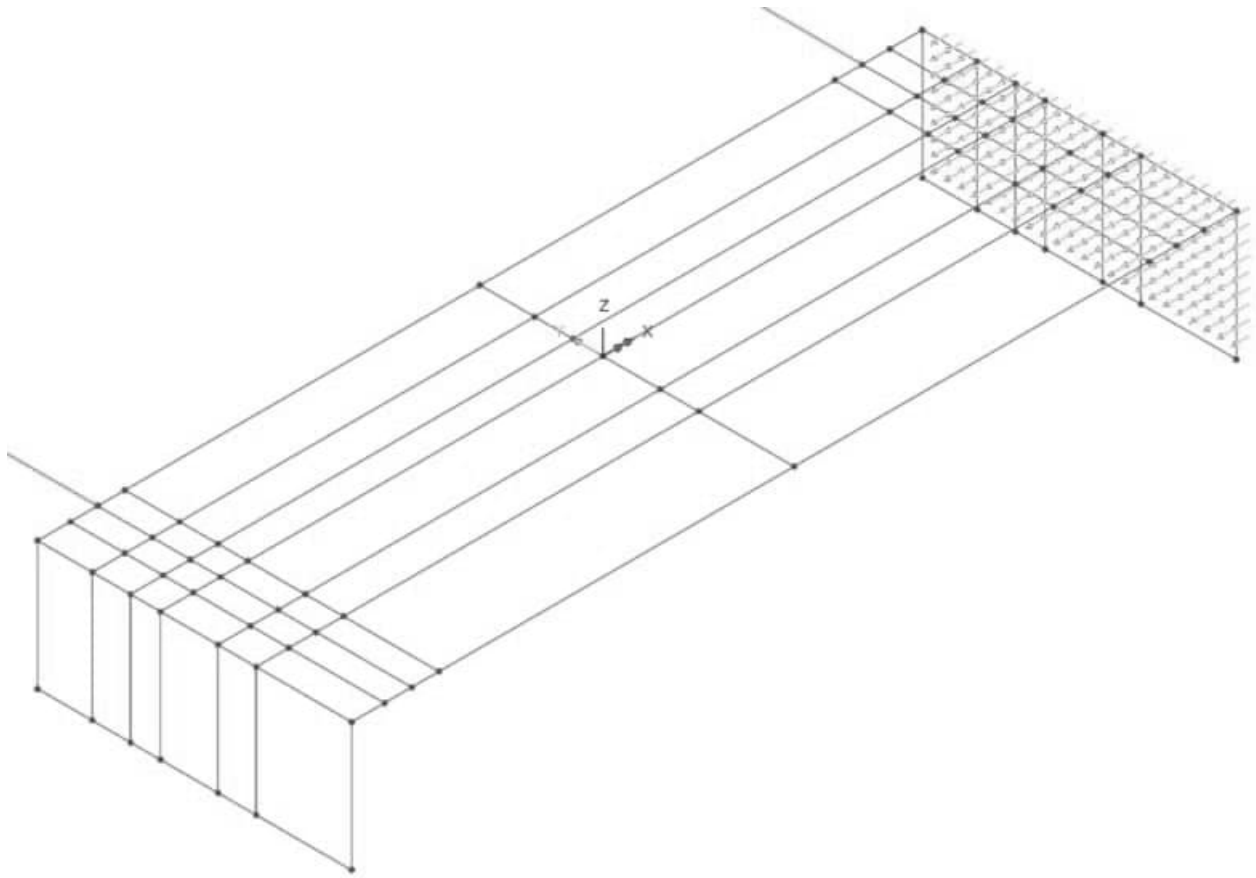
Projection vector  
 Project in load direction  
 Project for prestress  
X component   
Y component   
Z component

Patch load divisions  
 Use default  
Number of divisions in   
Number of divisions in y

	X	Y	Z	Load
1	10,0	2,25	-2,35	-18,0
2	10,0	-3,5	-2,35	-18,0
3	10,0	-3,5	0,45	-18,0
4	10,0	2,25	0,45	-18,0

Name  (20)

	Part A – CALCULATION ASSUMPTIONS RC slab bridge	Status :	Page: A3:108
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Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:109
		Date :	Created :

Basic load combination OVER 1 :

Load case	Factor
JORD 2	1.50
OVER+	1.0

Basic load combination OVER 2 :

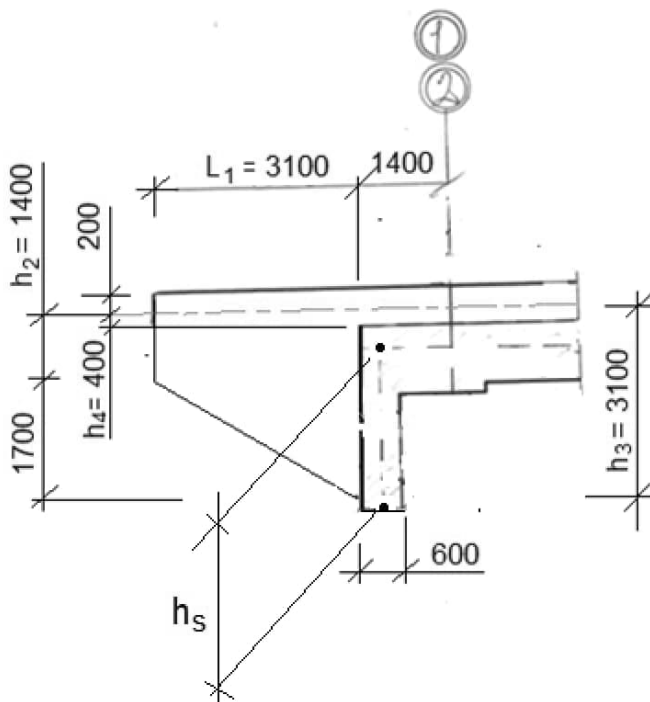
Load case	Factor
JORD 1	1.50
OVER-	1.0

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:110
	RC slab bridge	Date :	Created :

### 3.12.2 Load effect on wingwalls

Program K2.003 is used to determine earthpressure againts wingwalls ordtryck mot vingmurar according to Culmans´s method. All wingwalls are assumed to have the same length ( $L = 3.1$  m).

The low height of the wing wall and the large side distance in relation to the track center have shown that the design load effect on wing walls occurs for load distribution 1:1.



Last fördelas längs inspänningssnitt mot ändskärm ( $\therefore h_s = 2.4$  m).

Total load:

$$H_{\text{över}} = 81 \text{ kN} \quad : \text{ see page A3:34}$$

$$M_{\text{över}} = 107 \text{ kNm} \quad : \text{ see page A3:34}$$

Load distributed over height of end shield ( $h_s$ ):

$$N_{\text{över}} = \frac{81 \text{ kN}}{2.4 \text{ m}} = 34 \frac{\text{kN}}{\text{m}}$$

$$M_{\text{över}} = \frac{107 \text{ kNm}}{2.4 \text{ m}} = 45 \frac{\text{kNm}}{\text{m}}$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:111
		Date :	Created :

Load case : OVER 3

$$p_y = -34 \frac{kN}{m}$$

$$m_z = +45 \frac{kNm}{m}$$

Global Distributed ×

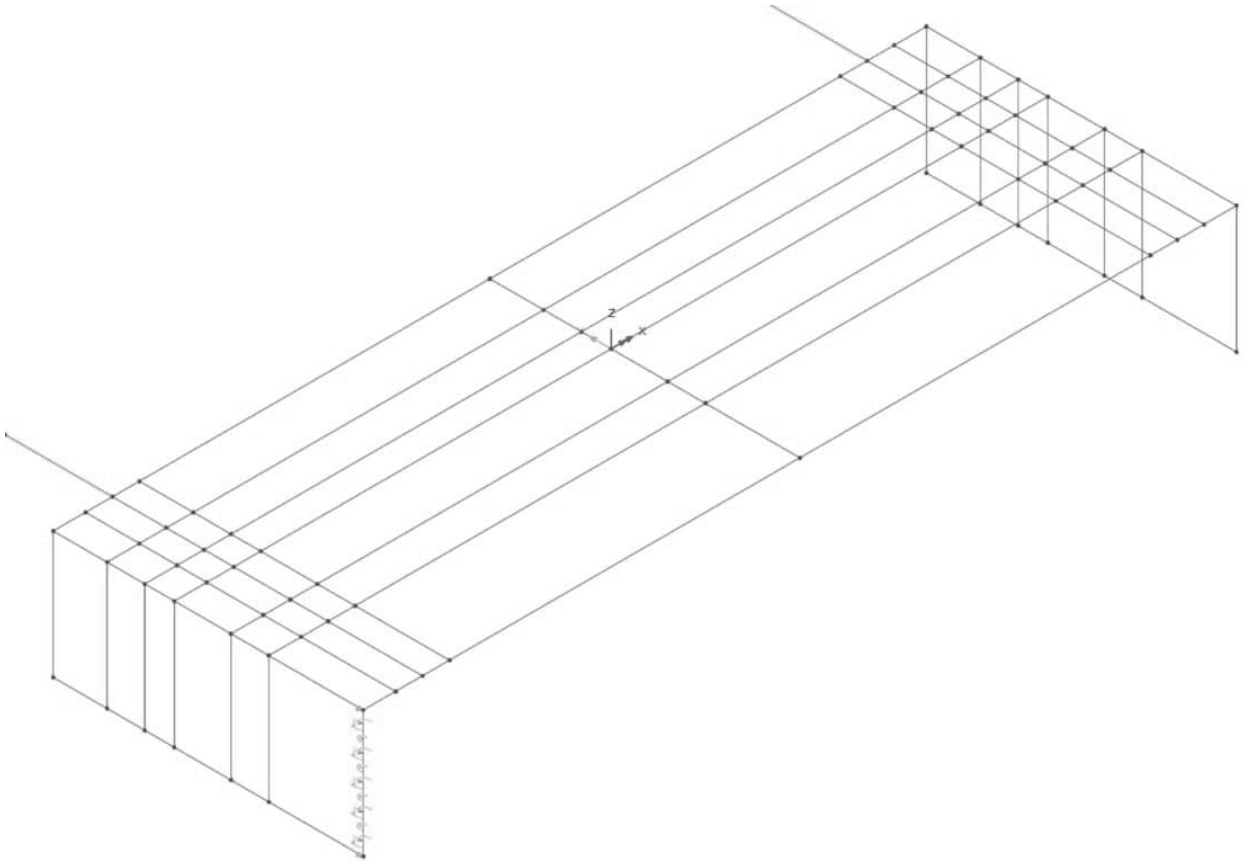
Analysis category

Total
  Per unit length
  Per unit area

Component	Value
X Direction	0.0
Y Direction	-34.0
Z Direction	0.0
Moment about X axis	0.0
Moment about Y axis	0.0
Moment about Z axis	45.0

Name  (21)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:112
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### Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:113
		Date :	Created :

Load case : OVER 4

$$p_y = -34 \frac{kN}{m}$$

$$m_z = -45 \frac{kNm}{m}$$

Global Distributed ×

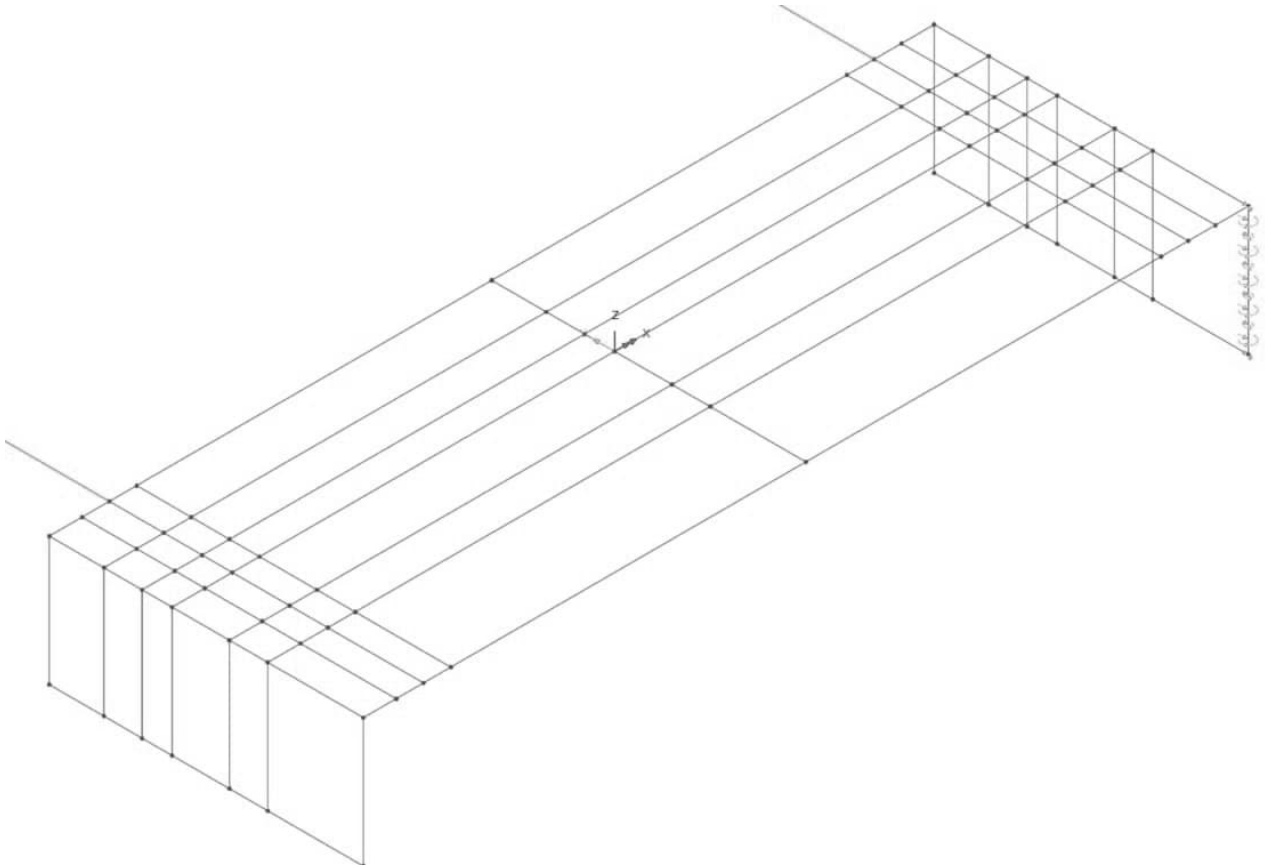
Analysis category

Total
  Per unit length
  Per unit area

Component	Value
X Direction	0,0
Y Direction	-34,0
Z Direction	0,0
Moment about X axis	0,0
Moment about Y axis	0,0
Moment about Z axis	-45,0

Name  (22)

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:114
		Date :	Created :



Overview 3D

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:115
		Date :	Created :

### 3.12.3 Load combination

#### Load combination smart OVER.:

Load case	Permanent factor	Variable factor
OVER 1	0	1
OVER 2	0	1
OVER 3	0	1
OVER 4	0	1

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:116
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### 3.13 TEMPERATURE

Temperature effects on bridges are specified in TSFS 2018:57 section B.3.2.5 and EN 1991-1-5 chapter 6.

The effect of gradual crack development is allowed according to SS-EN 1992-1-1 §5.4(3) when determining load effects. This is managed by applying reduced stiffness.

Assembly temperature:  $T_0 = +10^{\circ}\text{C}$  : EN 1991-1-5A.1(3)

Linear expansion coefficient:  $\alpha = 12 \cdot 10^{-6}$

Concrete bridge (concrete slab)  $\Rightarrow$  type 3

Location : "Location"

$T_{max} = +32^{\circ}\text{C}$  : TSFS chapter 8 sketch 8.1

$T_{min} = -44^{\circ}\text{C}$  : TSFS chapter 8 sketch 8.2

#### Duration coefficients :

Coefficients see SS-EN 1990/A1 table A2.3.

$$\psi_0 = 0.60$$

$$\psi_1 = 0.60$$

$$\psi_2 = 0.50$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:117
		Date :	Created :

### 3.13.1 Uniform temperature over entire bridge (JTEMP)

Uniform temperature change across the entire bridge is given by EN 1991-1-5 section 6.1.3.3. This temperature change is seasonal and mainly causes translation with movement from the bridge's center of motion towards the respective end abutments. Only movements occur from these loads, which means that the temperature load is not included in the static model.

Function according to SS-EN 1991-1-5 sketch 6.1 (type 3):

$$T_e(T) = \text{interp}\left[(-50 \ 0 \ 30 \ 50)^T \cdot ^\circ\text{C}, (-42 \ 7 \ 32 \ 52)^T \cdot ^\circ\text{C}, T\right]$$

$$T_{e.\text{max}} = T_e(T_{\text{max}}) = 34^\circ\text{C}$$

$$T_{e.\text{min}} = T_e(T_{\text{min}}) = -36^\circ\text{C}$$

$$T^+ = T_{e.\text{max}} - T_0 = +34^\circ\text{C} - 10^\circ\text{C} = +24^\circ\text{C}$$

$$T^- = T_{e.\text{min}} - T_0 = -36^\circ\text{C} - 10^\circ\text{C} = -46^\circ\text{C}$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:118
		Date :	Created :

### 3.13.2 Uneven temperature difference between different structural parts

Temperature difference between different structural parts is considered according to TRVINFRA-00227 section 7.2.1.1.2.4.

This load case is disregarded as it is not considered that there are different structural parts with different temperatures that give rise to constraint loads.

### 3.13.3 Uneven temperature difference across the cross-section

Uneven temperature difference across the cross-section is considered according to SS-EN 1991-1-5 section 6.1.4.

This load case is disregarded as it only causes translation but no constraint loads.

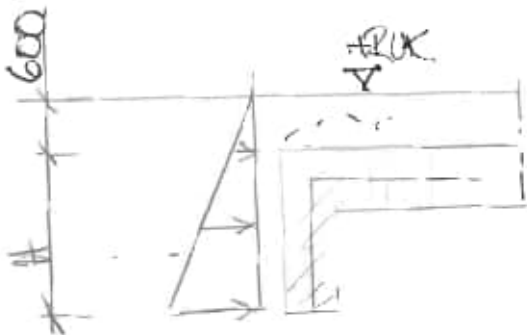
	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:119
		Date :	Created :

### 3.13.4 Increased earth pressure due to movement

Increased earth pressure caused by the horizontal movement of the frame legs against the fill is calculated according to TRVINFRA-00227, 7.2.1.1.2.1 and according to SS-EN 1997-1 appendix C, Table C.2 and Figure C.4.

Passive earth pressure associated movement  $v_p = H/200 = 2800 \text{ mm}/200 = 14 \text{ mm}$ .

$$\Delta p = (p_p - p_0) \cdot v \cdot \frac{200}{H}$$



$$v_t = \Delta T \cdot \alpha \cdot \frac{L}{2} = (24^\circ\text{C} + 46^\circ\text{C}) \cdot 1.2 \cdot 10^{-5} \cdot \frac{16800}{2} = 7\text{mm}$$

$$\frac{v_t}{v_p} = \frac{7\text{mm}}{14\text{mm}} = 0.50 \rightarrow \Delta p = 0.50 \cdot (p_p - p_0)$$

$$F_{x_{vilo}} = 193\text{kN}$$

: see page A3:16

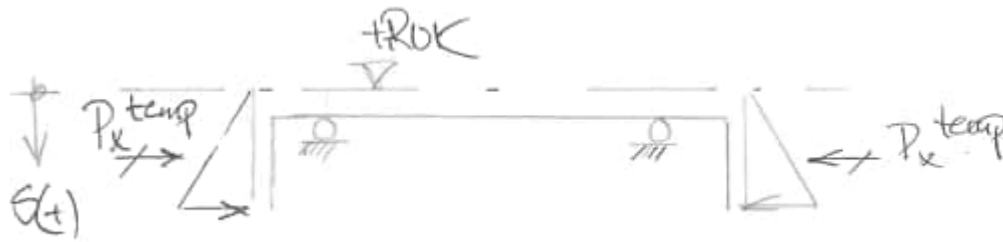
$$\rightarrow F_{x_{passiv}} = \frac{K_p}{K_0} \cdot F_{x_{vilo}} = \frac{5.82}{0.29} \cdot 193\text{kN} = 3873\text{kN}$$

$$P_x^{temp} = 0.5 \cdot (F_{x_{passiv}} - F_{x_{vilo}}) = 0.5 \cdot (3873\text{kN} - 193\text{kN}) = 1840\text{kN}$$

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:120
	RC slab bridge	Date :	Created :

Increased earth pressure is introduced in the static model as weighted values (f) of the at-rest earth pressure "JORD 1" and "JORD 2".

$$f = \frac{P_x^{temp}}{F_{x_{jord}}} = \frac{1840kN}{193kN} = 9.5$$



Basic load combination TEMP.:

Load case	Factor
JORD 1	9.5
JORD 2	9.5

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:121
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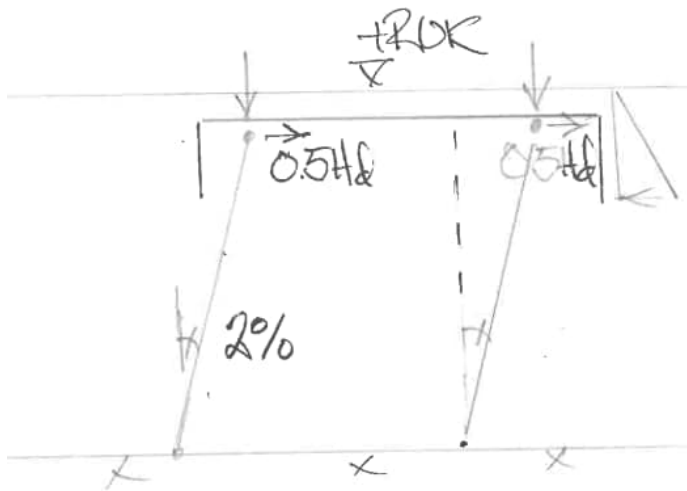
### 3.14 IMPACT MISS ALIGNMENT OF PILES

The studied bridge assumes that end shields can maintain global stability.

If piles are installed with eccentricity, the load on the end diaphragms increases.

To account for the effect of inclined pile installation, 2% in the same direction is assumed with a design load effect of 1500 kN in each pile (a total of 8 piles is assumed). At a late stage of design, a deviation on the safe side was encountered, as a detailed check showed that 1363 kN was obtained in each pile.

This fictitious load is considered only in the ultimate limit state (ULS).



Detailed verification of vertical load (ULS):

Load	Support 1	Support 2	$\psi_{\gamma_{ULS}}$	Remark.
EGEN	1506	1496	1,20	Appendix 3 page 5
BALLAST	624	587	1,56	Appendix 3 page 5
LM71	1804	1804	1,50	See below
-	kN	kN	-	-

$$\Rightarrow \Sigma 10904 \text{ kN} \therefore 8 \times 1363 \text{ kN}$$

$$\Sigma F_{Z_{LM71}} = \alpha \cdot \Phi_2 \cdot \left[ 4 \times 250 \text{ kN} + 80 \frac{\text{kN}}{\text{m}} \cdot (16.8 \text{ m} - 6.4 \text{ m}) \right] = 1.6 \cdot 1.23 \cdot 1832 \text{ kN} = 3608 \text{ kN}$$

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:122
		Date :	Created :

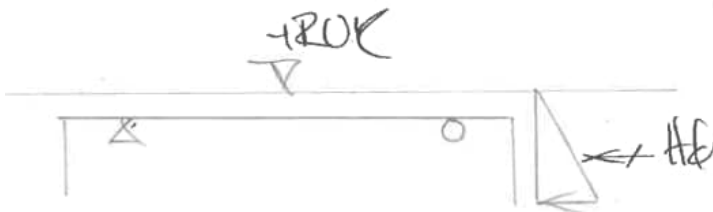
The load effect on the end walls arises from the applied load effect ( $H_d$ ) as shown below.

$$H_d = 8 \times 1500 \text{ kN} \cdot 2\% = 240 \text{ kN}$$

Two load cases are studied, designated “SNED+” and “SNED-”, depending on the direction of the slope.

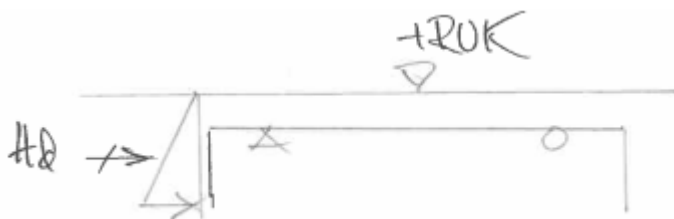
These load cases give rise to an increased earth pressure against the respective end wall. This is handled through weighted values ( $f$ ) of the at-rest earth pressure “JORD 1” and “JORD 2”.

$$f = \frac{H_d}{F x_{jord}} = \frac{240 \text{ kN}}{193 \text{ kN}} = 1.24$$



#### SNED-

( Load case:  $f \cdot$  ”JORD 2” )



#### SNED+

( Load case:  $f \cdot$  ”JORD 1” )

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:123
		Date :	Created :

Basic load combination SNED- :

Load case	Factor
JORD 2	1.24

Basic load combination SNED+ :

Load case	Factor
JORD 1	1.24

Envelope SNED :

Load case
SNED+
SNED-

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:124
		Date :	Created :

### 3.15 LOAD COEFFICIENTS

A derivation of applied load factor tables, see RKFM section 7.3 LOAD COMBINATIONS.

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:125
		Date :	Created :

### 3.15.1 Ultimate state ULS

When designing loads both on the bridge and on piles, D2 and Sk3 apply.

In the static model, these load factors are applied in the design of the load combination ULS.

#### Permanent loads:

Nr	Loads		$\Psi_{\gamma_{ULS}}$
1	Deadweight	max	1.20
		min	1.00
2	Ballast	max	1.56
		min	0.70
3	Filling	max	1.20
		min	1.00
4	Earthpressure	max	1.20
		min	1.00
5	Water pressure	max	1.20
		min	1.00
6	Support settlement	max	1.20
		min	0
7	Shrinkage	max	1.20
		min	0
8	Pretension	max	1.20
		min	1.00
*	Effect inclined piles <sup>1.)</sup>		-

#### Footnote:

<sup>1.)</sup> Fictive load, see page A3:153-155.

	Part A – CALCULATION ASSUMPTIONS	Status :	Page: A3:126
	RC slab bridge	Date :	Created :

Variable loads:

The least favorable variable load is given the higher value. The others are given the lower value.

Nr	Loads	$\Psi\gamma_{ULS-B}$
	<u>Load model LM71:a</u>	
9	Vertikallast LM71	1.50/0.75
9	Bromskraft	1.50/0.75
9	Sidokraft	0.75/0.75
9	Centrifugalkraft	0.75/0.75
	<u>Load model LM71:b</u>	
10	Vertikallast LM71	1.50/0.75
10	Bromskraft	0.75/0.75
10	Sidokraft	1.50/0.75
10	Centrifugalkraft	1.50/0.75
	<u>Load modell empty wagon</u>	
11	Vertikallast tomvagn	1.50/1.50
11	Sidokraft	1.50/1.50
11	Centrifugalkraft	1.50/1.20
	<u>Load model machine track replacement</u>	
12	Machine track replacement	1.50/1.20
13	Surcharge (LM71)	1.50/1.20
	<u>Temperature</u>	
14	Temperature load	1.50/0.90
	<u>Wind loads</u>	
15	Wind load bridge	1.50/0.45
16	Wind load train	1.50/0.45

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:127
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Load combination smart ULS-PERM:

Load case	Permanent factor	Variable factor
EGEN	1.00	0.20
BALLAST	0.70	0.86
JORD	1.00	0.20
SNED	1.00	0

Load combination smart LM.71:a:

( Load cases to consider :3 / Variable load cases : all )

Load case	Permanent factor	Variable factor
LM 71	1.97 = 1.0 · 1.97 <sup>2.)</sup>	0
BROMS	1.0	0
SIDO	0.50	0

Load combination smart LM.71:b:

( Load cases to consider :3 / Variable load cases : all )

Load case	Permanent factor	Variable factor
LM 71	1.97 = 1.0 · 1.97 <sup>2.)</sup>	0
BROMS	0.50	0
SIDO	1.0	0

Envelope LM 71-ULS:

Load case
LM 71:a
LM 71:b

Footnote:

<sup>2.)</sup> Factor dynamics and adaption factor  $f = \Phi_2 \cdot \alpha = 1.23 \cdot 1.6 = 1.97$

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Load combination smart ULS-VAR:

( Load cases to consider : 4 / Variable load cases : 1 )

Load case	Permanent factor	Variable factor
LM 71-ULS	0.75	0.75
OVER	1.20	0.30
TEMP	0.90	0.60
VIND	0.45	1.05

Load combination smart ULS:

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

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### 3.15.2 Service state (SLS)

Two load combinations studied in the serviceability limit state. They have different load factors depending on their duration. The load combinations are presented below.

Load combinations	Description
SLS:K	Characteristic
SLS:F	Frequent
SLS:Q	Quasi permanent

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:130
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Permanent loads:

Nr	Loads		$\Psi\gamma_{SLS-Q}$	$\Psi\gamma_{SLS-F}$
1	Deadweight	max	1.00	1.00
		min	1.00	1.00
2	Ballast	max	1.30	1.30
		min	0.70	0.70
3	Filling	max	1.00	1.00
		min	1.00	1.00
4	Earthpressure	max	1.00	1.00
		min	1.00	1.00
5	Water pressure	max	1.00	1.00
		min	0	0
6	Support settlement	max	1.00	1.00
		min	0	0
7	Shrinkage	max	1.00	1.00
		min	1.00	0
8	Pretension	max	1.00	1.10
		min	1.00	0.90

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:131
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Variable loads:

Nr	Loads	$\Psi\gamma_{SLS-Q}$	$\Psi\gamma_{SLS-F}$
	<u>Load model LM71:a</u>		
9	Vertikallast LM71	-	0.80
9	Bromskraft	-	0.80
9	Sidokraft	-	0.40
9	Centrifugalkraft	-	0.40
	<u>Load model LM71:b</u>		
10	Vertikallast LM71	-	0.80
10	Bromskraft	-	0.40
10	Sidokraft	-	0.80
10	Centrifugalkraft	-	0.80
	<u>Load modell empty wagon</u>		
11	Vertikallast tomvagn	-	0.80
11	Sidokraft	-	0.80
11	Centrifugalkraft	-	0.80
	<u>Load model machine track replacement</u>		
12	Machine track replacement	-	0.80
13	Surcharge (LM71)	-	0.80
	<u>Temperature</u>		
14	Temperature load	0.50	0.60
	<u>Wind loads</u>		
15	Wind load bridge	-	0.20
16	Wind load train	-	0.20

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:132
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Load combination smart SLS-PERM.:

Load case	Permanent factor	Variable factor
EGEN	1.00	0
BALLAST	0.70	0.60
JORD	1.00	0

Load combination smart SLS-F-VAR.:

Load case	Permanent factor	Variable factor
LM 71	$1.58 = 0.80 \cdot 1.97^{3)}$	0
BROMS	0.80	0
SIDO	0.40	0
TEMP	0.60	0
OVER	0.80	0
VIND	0.20	0

Footnote:

<sup>1.)</sup> Factor due to dynamics and adaption of vertical load  $f = \Phi_2 \cdot \alpha = 1.23 \cdot 1.6 = 1.97$

Load combination smart SLS-F.:

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

Load combination smart SLS-Q.:

Load case	Permanent factor	Variable factor
SLS-PERM	1	0
TEMP	0	0.50

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:133
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### 3.15.3 Accident load combination

Accident load is termed  $A_d$  and acts during derrailing of train.

#### Permanent loads:

Nr	Loads		$\psi\gamma_{EXC}$
1	Deadweight	max	1.00
		min	1.00
2	Ballast	max	1.30
		min	0.70
3	Filling	max	1.00
		min	1.00
4	Earthpressure	max	1.00
		min	1.00
5	Water pressure	max	1,00
		min	1.00
6	Support settlement	max	1.00
		min	0
7	Shrinkage	max	1.00
		min	0
8	Pretension	max	1.10
		min	0.90

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:134
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Variable loads:

Nr	Loads	$\Psi\gamma_{EXC}$
	<u>Load model LM71:a</u>	
9	Vertikallast LM71	0.80
9	Bromskraft	0.80
9	Sidokraft	0.40
9	Centrifugalkraft	0.40
	<u>Load model LM71:b</u>	
10	Vertikallast LM71	0.80
10	Bromskraft	0.40
10	Sidokraft	0.80
10	Centrifugalkraft	0.80
	<u>Load modell empty wagon:</u>	
11	Vertikallast tomvagn	0.80
11	Sidokraft	0.80
11	Centrifugalkraft	0.80
	<u>Load model machine track replacement :</u>	
12	Machine track replacement	0.80
13	Surcharge (LM71)	0.80
	<u>Temperature :</u>	
14	Temperature load	0.60
	<u>Wind loads:</u>	
15	Wind load bridge	0.20
16	Wind load train	0.20
17	Accident load	1.00

	Part A – CALCULATION ASSUMPTIONS  RC slab bridge	Status :	Page: A3:135
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### 3.14.4 Fatigue state (UTM)

#### Permanent loads:

Nr	Load	$\Psi\gamma_{UTM}$
1	Deadweight	1.00
2	Ballast	1.00
3	Filling	1.00
4	Earthpressure	1.00
5	Water pressure	1,00
6	Support settlement	-
7	Shrinkage	-
8	Pretension	1.00

#### Variable loads:

Nr	Load	$\Psi\gamma_{UTM}$
13	Surcharge (LM71)	0.80
	<u>Wind loads :</u>	
15	Wind load bridge	0.20
16	Wind load train	0.20
18	Train type 13S	1.00

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Load combination smart FAT.:

Loadcase	Permanent factor	Variable factor
EGEN	1.00	0
BALLAST	1.00	0
JORD	1.00	0
TAG 13	1.08 <sup>4.)</sup>	-
OVER	- 5.)	-
VIND	- 5.)	-

Fotnotes

4.) Dynamic factor  $\Phi_2 = 1.08$

5.) Not considered as fatigue loads. Reasonable simplification.