

## Sheeting structure verification

### Input data (Stage of construction 1)

#### Settings

(input for current task)

#### Materials and standards

Concrete structures :	EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 :	standard
Circle pile shear :	simplified method
Steel structures :	EN 1993-1-1 (EC3)
Partial factor on bearing capacity of steel cross section :	$\gamma_{M0} = 1,00$
Timber structures :	EN 1995-1-1 (EC5)
Partial factor for timber property :	$\gamma_M = 1,30$
Modif. factor of load duration and moisture content :	$k_{mod} = 0,50$
Coeff. of effective width for shear stress :	$k_{cr} = 0,67$

#### Pressure analysis

Verification methodology :	according to EN 1997
Active earth pressure calculation :	Coulomb
Passive earth pressure calculation :	Caquot-Kerisel
Analysis method :	dependent pressures
Earthquake analysis :	Mononobe-Okabe
Modulus of subsoil reaction :	standard
Consider reduction of the modulus of subsoil reaction for a braced sheeting	
Design approach :	2 - reduction of actions and resistances

Partial factors on actions (A)			
Permanent design situation			
		Unfavourable	Favourable
Permanent actions :	$\gamma_G =$	1,35 [-]	1,00 [-]
Variable actions :	$\gamma_Q =$	1,50 [-]	0,00 [-]
Water load :	$\gamma_w =$	1,35 [-]	

Partial factors for resistances (R)			
Permanent design situation			
Reduction coeff. of internal stability of anchors :	$\gamma_{Ris} =$	1,30 [-]	
Partial factor on earth resistance :	$\gamma_{Re} =$	1,40 [-]	

Partial factors for variable actions			
Permanent design situation			
Factor for combination value :	$\psi_0 =$	0,70 [-]	
Factor for frequent value :	$\psi_1 =$	0,50 [-]	
Factor for quasi-permanent value :	$\psi_2 =$	0,30 [-]	

#### Anchors

Verification methodology : Limit states (LSD)

Reduction coefficients			
Reduction. coeff of steel strength :	$\gamma_s =$	1,10 [-]	
Reduction coefficient of pull out resistance (soil) :	$\gamma_e =$	1,35 [-]	
Reduction coefficient of pull out resistance (grouting) :	$\gamma_c =$	1,35 [-]	

## Geometry of structure

Structure length = 13,00 m

Cross-section name : Pile curtain d = 0,80 m, a = 1,40 m

Material of pile : concrete

Computed coefficient of pressure reduction below the ditch = 1,00

Area of cross-section  $A = 3,59E-01 \text{ m}^2/\text{m}$

Moment of inertia  $I = 1,44E-02 \text{ m}^4/\text{m}$

## Material of structure

Analysis of concrete structures carried out according to the standard EN 1992-1-1 (EC2).

### Concrete: C 25/30

Cylinder compressive strength  $f_{ck} = 25,00 \text{ MPa}$

Tensile strength  $f_{ctm} = 2,60 \text{ MPa}$

Elasticity modulus  $E_{cm} = 31000,00 \text{ MPa}$

Shear modulus  $G = 12917,00 \text{ MPa}$

### Longitudinal reinforcement: B500B

Yield strength  $f_{yk} = 500,00 \text{ MPa}$


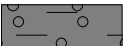

### Transverse reinforcement: B500B

Yield strength  $f_{yk} = 500,00 \text{ MPa}$



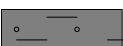
## Modulus of reaction

Modulus of subsoil reaction is computed by method Schmitt.

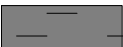

### Basic soil parameters


No.	Name	Pattern	$\Phi_{ef}$ [°]	$C_{ef}$ [kPa]	$\gamma$ [kN/m <sup>3</sup> ]	$\gamma_{su}$ [kN/m <sup>3</sup> ]	$\delta$ [°]
1	Glina		16,20	2,80	18,00	10,00	16,20
2	Zameljen prod		34,00	1,00	19,00	11,00	34,00
3	Siva zbita peščena		30,00	8,00	19,00	11,00	30,00

### Soil parameters to compute pressure at rest


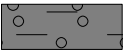
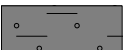
No.	Name	Pattern	Type calculation	$\Phi_{ef}$ [°]	$\nu$ [-]	OCR [-]	$K_r$ [-]
1	Glina		cohesive	-	0,30	-	-
2	Zameljen prod		cohesionless	34,00	-	-	-
3	Siva zbita peščena		cohesive	-	0,30	-	-

### Parameters of soils to compute modulus of subsoil reaction (Schmitt)

No.	Name	Pattern	$\nu$ [-]	$E_{oed}$ [MPa]	$E_{def}$ [MPa]
1	Glina		0,30	-	5,00
2	Zameljen prod		0,30	-	15,00

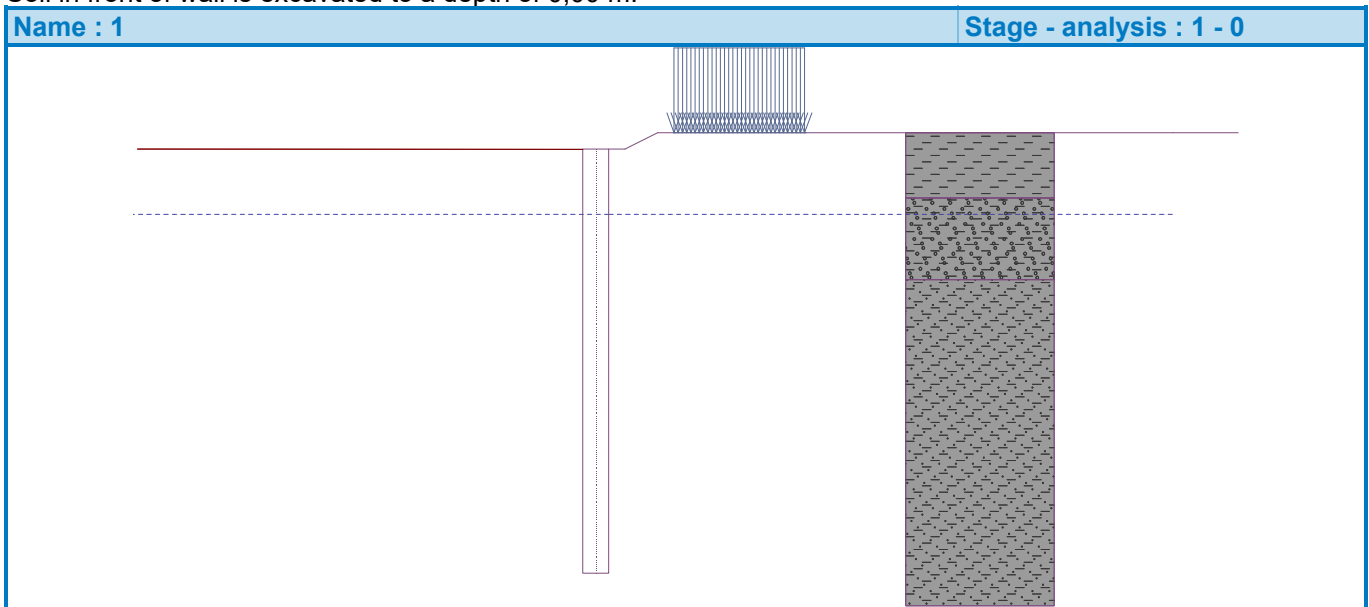
No.	Name	Pattern	$\nu$ [-]	$E_{oed}$ [MPa]	$E_{def}$ [MPa]
3	Siva zbita peščena		0,30	-	18,00

Geological profile and assigned soils

No.	Thickness of layer $t$ [m]	Depth $z$ [m]	Assigned soil	Pattern
1	1,50	0,00 .. 1,50	Glina	
2	2,50	1,50 .. 4,00	Zameljen prod	
3	-	4,00 .. $\infty$	Siva zbita peščena	

Excavation

Soil in front of wall is excavated to a depth of 0,00 m.



Terrain profile

No.	Coordinates $x$ [m]	Depth $z$ [m]
1	0,00	0,00
2	0,50	0,00
3	1,50	-0,50
4	2,50	-0,50

Origin [0,0] is located in upper right edge of construction.  
Positive coordinate  $+z$  has downward direction.

Water influence

GWT behind the structure lies at a depth of 2,00 m  
GWT in front of the structure lies at a depth of 2,00 m  
Subgrade at the heel is permeable.  
Hydraulic gradient = 0,00

Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m <sup>2</sup> ]	Mag.2 [kN/m <sup>2</sup> ]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	Yes		variable	20,00		2,00	4,00	on terrain

No.	Name
1	Prometna obtežba

Global settings

Number of FEs to discretize wall = 100

Analysis of depending pressures : reduce according to analysis settings

Minimum pressure is considered as  $\sigma_{a,min} = 0,20\sigma_z$

Settings of the stage of construction

Design situation : permanent

Analysis results (Stage of construction 1)

Distribution of pressures acting on the structure (in front and behind the wall)

Depth [m]	T <sub>a,p</sub> [kPa]	T <sub>k,p</sub> [kPa]	T <sub>p,p</sub> [kPa]	T <sub>a,z</sub> [kPa]	T <sub>k,z</sub> [kPa]	T <sub>p,z</sub> [kPa]
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.01	0.00	-0.04	-6.08	0.05	4.22	6.38
0.08	0.00	-0.55	-8.03	0.29	5.17	8.32
0.08	0.00	-0.55	-8.03	9.35	9.35	9.35
0.15	0.00	-1.04	-9.92	10.11	10.11	10.22
0.15	0.00	-1.05	-9.95	10.20	10.20	10.24
0.22	0.00	-1.65	-12.24	11.13	11.13	12.54
0.23	0.00	-1.72	-12.52	11.38	11.38	12.81
0.26	0.00	-1.91	-13.23	12.34	12.34	13.53
0.33	0.00	-2.45	-15.28	15.09	15.09	15.58
0.33	0.00	-2.45	-15.28	15.12	15.12	15.58
0.38	0.00	-2.82	-16.71	16.93	16.93	17.00
0.38	0.00	-2.82	-16.71	16.93	16.93	17.00
0.40	0.00	-3.04	-17.54	18.04	18.04	18.19
0.57	-1.72	-4.30	-22.38	19.95	19.95	22.67
0.65	-2.58	-4.94	-24.79	20.91	20.91	25.09
0.99	-6.13	-7.55	-34.78	24.87	24.87	35.07
1.30	-9.40	-9.95	-43.95	28.51	28.51	45.66
1.50	-11.49	-11.49	-49.84	30.85	30.85	52.46
1.50	-6.80	-11.82	-153.63	15.04	22.90	204.97
1.95	-9.27	-15.59	-201.44	17.35	27.64	252.78
1.99	-9.50	-15.94	-205.92	17.57	28.07	257.26
2.00	-9.54	-16.01	-206.76	17.61	28.13	258.10
2.60	-11.45	-18.92	-243.67	19.30	30.21	295.01
3.25	-13.52	-22.07	-283.65	21.12	32.33	334.99
3.90	-15.59	-25.22	-323.64	22.95	34.51	374.98
4.00	-15.91	-25.71	-329.79	23.23	34.85	381.13
4.00	-11.58	-24.99	-256.69	20.36	34.02	293.14
4.55	-13.68	-27.59	-280.71	22.20	35.90	317.17
5.20	-16.17	-30.65	-309.11	24.37	38.24	345.57
5.85	-18.65	-33.72	-337.50	26.54	40.70	373.96
6.50	-21.13	-36.78	-365.90	28.71	43.27	402.36

--

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
7.15	-23.62	-39.84	-394.29	30.88	45.92	430.75
7.76	-25.95	-42.72	-420.98	32.92	48.49	457.44
7.76	-25.95	-42.72	-420.98	29.14	48.49	457.44
7.80	-26.10	-42.91	-422.69	29.29	48.66	459.15
8.45	-28.59	-45.97	-451.08	31.78	51.45	487.54
9.10	-31.07	-49.04	-479.48	34.26	54.29	515.94
9.75	-33.56	-52.10	-507.87	36.74	57.17	544.33
10.40	-36.04	-55.17	-536.27	39.23	60.08	572.73
11.05	-38.52	-58.23	-564.66	41.71	63.01	601.12
11.70	-41.01	-61.29	-593.06	44.20	65.97	629.52
12.35	-43.49	-64.36	-621.45	46.68	68.94	657.91
13.00	-45.98	-67.42	-649.85	49.17	71.93	686.31

#### Distributions of the modulus of subsoil reaction and internal forces on the structure

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-1.32	0.00	0.00	-0.00
0.01	3.50	0.00	-1.31	-4.57	0.02	-0.00
0.65	3.50	0.00	-1.14	11.99	-4.67	0.99
1.30	3.50	0.00	-0.96	15.20	-13.51	6.78
1.95	15.12	0.00	-0.79	-10.22	-11.82	16.14
2.60	15.12	15.12	-0.64	-7.99	-5.68	21.73
3.25	15.12	15.12	-0.50	-4.94	-1.52	23.96
3.90	15.12	15.12	-0.39	-2.53	0.87	24.09
4.55	19.28	19.28	-0.30	-3.30	3.60	22.60
5.20	19.28	19.28	-0.23	-1.40	5.09	19.71
5.85	19.28	19.28	-0.18	-0.10	5.54	16.21
6.50	19.28	19.28	-0.15	0.71	5.31	12.66
7.15	19.28	19.28	-0.13	1.15	4.69	9.39
7.80	19.28	19.28	-0.11	1.32	3.87	6.60
8.45	19.28	19.28	-0.11	1.30	3.00	4.37
9.10	19.28	19.28	-0.11	1.18	2.19	2.69
9.75	19.28	19.28	-0.11	0.98	1.48	1.50
10.40	19.28	19.28	-0.11	0.77	0.91	0.73
11.05	19.28	19.28	-0.11	0.55	0.48	0.28
11.70	19.28	19.28	-0.11	0.34	0.19	0.07
12.35	19.28	19.28	-0.12	0.15	0.04	0.00
13.00	19.28	19.28	-0.12	-0.04	0.00	0.00

#### Maximum values of internal forces acting on the structure

Maximum shear force = 15,86 kN/m  
Maximum moment = 24,22 kNm/m  
Maximum displacement = 1,3 mm

#### Maximum internal forces on cross-section

Maximum shear force = 22,20 kN  
Maximum moment = 33,91 kNm

#### Terrain settlement behind the structure

Terrain settlement  $\delta_{\max}$  = 0,6 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	0,7
2	0,90	0,9
3	1,79	1,0
4	2,69	1,0
5	3,59	1,0
6	4,49	1,0
7	5,38	0,9
8	6,28	0,7
9	7,18	0,5
10	8,08	0,3
11	8,97	0,0
12	8,97	0,0

### Dimensioning No. 1 (Stage of construction 1)

#### Failure by heave

Favourable weight of soil  $\sigma_{stb} = 220,95 \text{ kPa}$

Unfavourable water pressure  $u_{dst} = 0,00 \text{ kPa}$

**Verification of failure by heave is SATISFACTORY**

#### Verification of failure by piping


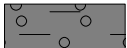
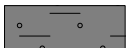
Critical hydraulic gradient  $i_c = 0,67$

Hydraulic gradient  $i = 0,00$

**Verification of failure by piping is SATISFACTORY**

### Input data (Stage of construction 2)

#### Geological profile and assigned soils

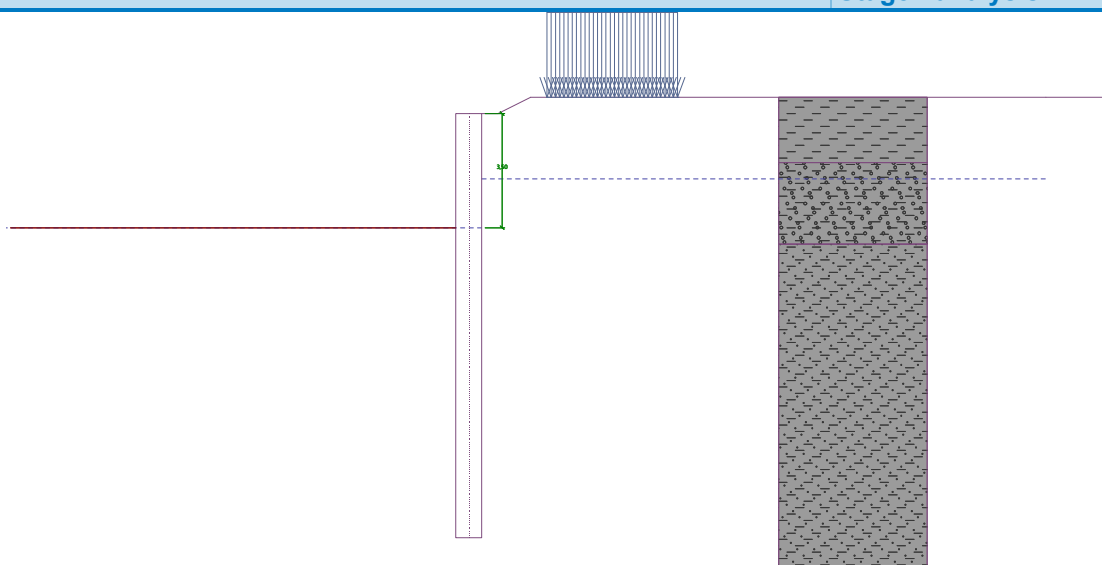
No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	1,50	0,00 .. 1,50	Glina	
2	2,50	1,50 .. 4,00	Zameljen prod	
3	-	4,00 .. ∞	Siva zbita peščena	

#### Excavation

Soil in front of wall is excavated to a depth of 3,50 m.

Name : 2

Stage - analysis : 2 - 0



### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	0,50	0,00
3	1,50	-0,50
4	2,50	-0,50

Origin [0,0] is located in upper right edge of construction.  
Positive coordinate +z has downward direction.

### Water influence

GWT behind the structure lies at a depth of 2,00 m  
GWT in front of the structure lies at a depth of 3,50 m  
Subgrade at the heel is permeable.  
Hydraulic gradient = 0,07

### Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m <sup>2</sup> ]	Mag.2 [kN/m <sup>2</sup> ]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	No	No	variable	20,00		2,00	4,00	on terrain

No.	Name
1	Prometna obtežba

### Settings of the stage of construction

Design situation : permanent

### Analysis results (Stage of construction 2)

#### Distribution of pressures acting on the structure (in front and behind the wall)

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	0.00	0.00	0.00	0.00	4.00	6.38
0.01	0.00	0.00	0.00	0.05	4.22	6.38
0.08	0.00	0.00	0.00	0.29	5.17	8.32
0.08	0.00	0.00	0.00	8.97	8.97	8.97
0.15	0.00	0.00	0.00	9.74	9.74	10.22

--

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.15	0.00	0.00	0.00	9.83	9.83	10.24
0.22	0.00	0.00	0.00	10.76	10.76	12.54
0.23	0.00	0.00	0.00	11.01	11.01	12.81
0.26	0.00	0.00	0.00	11.97	11.97	13.53
0.33	0.00	0.00	0.00	14.72	14.72	15.58
0.33	0.00	0.00	0.00	14.75	14.75	15.58
0.38	0.00	0.00	0.00	16.56	16.56	17.00
0.39	0.00	0.00	0.00	17.55	17.55	17.55
0.57	0.00	0.00	0.00	19.59	19.59	22.67
0.68	0.00	0.00	0.00	20.96	20.96	26.10
0.99	0.00	0.00	0.00	24.54	24.54	35.07
1.37	0.00	0.00	0.00	29.00	29.00	47.99
1.50	0.00	0.00	0.00	30.55	30.55	52.46
1.50	0.00	0.00	0.00	14.91	22.90	204.97
1.99	0.00	0.00	0.00	17.44	28.07	257.26
2.00	0.00	0.00	0.00	17.48	28.13	258.10
2.05	0.00	0.00	0.00	18.35	28.87	261.92
2.74	0.00	0.00	0.00	29.67	38.26	311.70
3.42	0.00	0.00	0.00	40.99	47.56	361.48
3.50	0.00	0.00	0.00	42.29	48.64	367.22
3.50	0.00	-0.00	-3.65	42.29	48.64	367.23
3.82	0.00	-1.47	-22.25	42.59	49.33	388.12
4.00	-0.52	-2.26	-32.35	42.75	49.71	399.46
4.00	0.00	-2.20	-45.47	39.96	48.86	309.11
4.11	0.00	-2.66	-49.76	40.11	49.08	313.89
4.79	0.00	-5.67	-77.66	41.13	50.58	345.00
5.47	0.00	-8.69	-105.56	42.15	52.23	376.10
5.93	0.00	-10.71	-124.32	42.83	53.43	397.01
6.16	-0.80	-11.70	-133.46	43.17	54.01	407.21
6.84	-3.24	-14.71	-161.37	44.18	55.90	438.32
7.53	-5.68	-17.72	-189.27	45.20	57.87	469.42
7.99	-7.32	-19.74	-208.01	45.89	59.25	490.32
7.99	-7.32	-19.74	-208.01	42.21	59.25	490.32
8.21	-8.12	-20.73	-217.17	42.65	59.92	500.53
8.89	-10.56	-23.74	-245.07	43.98	62.03	531.63
9.58	-13.01	-26.75	-272.97	45.31	64.18	562.74
10.26	-15.45	-29.76	-300.87	46.64	66.38	593.85
10.95	-17.89	-32.77	-328.77	47.97	68.60	624.95
11.63	-20.33	-35.78	-356.67	49.30	70.84	656.06
12.32	-22.77	-38.80	-384.58	50.63	73.10	687.16
13.00	-25.21	-41.81	-412.48	51.96	75.38	718.27

**Distributions of the modulus of subsoil reaction and internal forces on the structure**

Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-25.46	0.00	-0.00	-0.00
0.65	0.00	0.00	-23.00	20.56	-8.84	2.22



--	--

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
1.30	0.00	0.00	-20.53	28.20	-24.69	12.84
1.95	0.00	0.00	-18.08	17.22	-37.70	33.65
2.60	0.00	0.00	-15.66	27.41	-52.06	62.45
3.25	0.00	0.00	-13.31	38.16	-73.37	102.84
3.50	0.00	0.00	-12.44	42.23	-83.26	122.08
3.51	0.00	0.00	-12.39	38.09	-83.81	123.25
3.90	0.00	0.00	-11.05	16.05	-94.37	158.28
4.55	0.00	0.00	-8.94	-27.12	-86.18	218.18
5.20	0.00	0.00	-7.04	-52.66	-60.25	266.67
5.85	19.28	0.00	-5.39	-71.51	-17.97	292.69
6.50	19.28	0.00	-4.01	-46.88	20.22	291.09
7.15	19.28	0.00	-2.91	-27.55	44.13	269.50
7.80	19.28	0.00	-2.06	-13.13	57.10	236.10
8.45	19.28	0.00	-1.44	-6.49	63.76	196.62
9.10	19.28	0.00	-1.01	0.31	65.59	154.35
9.75	19.28	19.28	-0.72	9.53	62.46	112.34
10.40	19.28	19.28	-0.54	15.79	54.05	74.25
11.05	19.28	19.28	-0.42	19.33	42.53	42.74
11.70	19.28	19.28	-0.35	21.29	29.27	19.34
12.35	19.28	19.28	-0.30	22.54	15.00	4.91
13.00	19.28	19.28	-0.26	23.59	-0.00	0.00

#### Maximum values of internal forces acting on the structure

Maximum shear force = 94,97 kN/m  
Maximum moment = 295,07 kNm/m  
Maximum displacement = 25,5 mm

#### Maximum internal forces on cross-section

Maximum shear force = 132,96 kN  
Maximum moment = 413,09 kNm

#### Terrain settlement behind the structure

Terrain settlement  $\delta_{\max}$  = 13,5 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	12,9
2	0,90	16,4
3	1,79	18,9
4	2,69	20,3
5	3,59	20,6
6	4,49	19,9
7	5,38	18,1
8	6,28	15,2
9	7,18	11,2
10	8,08	6,1
11	8,97	0,0
12	8,97	0,0

## Dimensioning No. 1 (Stage of construction 2)

### Failure by heave

Favourable weight of soil  $\sigma_{\text{stb}} = 162,45 \text{ kPa}$

Unfavourable water pressure  $u_{\text{dst}} = 20,25 \text{ kPa}$

Verification of failure by heave is **SATISFACTORY**

### Verification of failure by piping


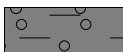

Critical hydraulic gradient  $i_c = 0,73$

Hydraulic gradient  $i = 0,07$

Verification of failure by piping is **SATISFACTORY**

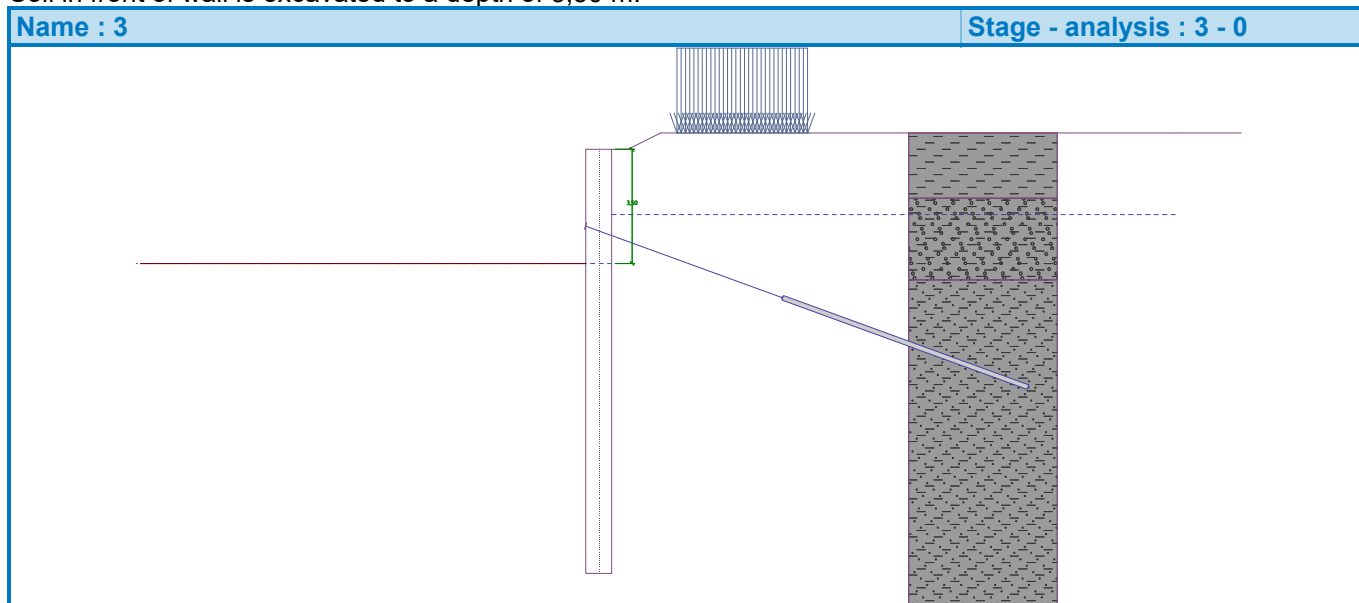
## Input data (Stage of construction 3)

### Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	1,50	0,00 .. 1,50	Glina	
2	2,50	1,50 .. 4,00	Zameljen prod	
3	-	4,00 .. $\infty$	Siva zbita peščena	

### Excavation

Soil in front of wall is excavated to a depth of 3,50 m.



### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	0,50	0,00
3	1,50	-0,50
4	2,50	-0,50

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

## Water influence

GWT behind the structure lies at a depth of 2,00 m  
GWT in front of the structure lies at a depth of 3,50 m  
Subgrade at the heel is permeable.  
Hydraulic gradient = 0,07

## Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m <sup>2</sup> ]	Mag.2 [kN/m <sup>2</sup> ]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	No	No	variable	20,00		2,00	4,00	on terrain

No.	Name
1	Prometna obtežba

## Input anchors

No.	New anchor	Depth z [m]	Name	Post-stressing	Force F [kN]
1	Yes	2,50	Anchor No. : 1 (user-defined)		30,00

## List of the new anchors

### Anchor No. : 1 (user-defined)

Anchor type : prestressed bar

Production set : user-defined

Depth : z = 2,50 m  
Free length : l = 6,00 m  
Root length : l<sub>k</sub> = 8,00 m  
Slope : α = 20,00 °  
Spacing : b = 1,40 m  
Area of cross-section : A = 791,00 mm<sup>2</sup>  
Elasticity modulus : E = 210000,00 MPa  
Pre-stressing force : F = 30,00 kN  
Tension strength : R<sub>t</sub> = 500,00 kN  
Pull out resistance (soil) : calculate from bond strength  
Diameter of root : d = 140,0 mm  
Bond strength : f = 150,00 kPa  
Pull out resistance (grouting) : calculate from concrete strength  
Standard for concrete structures : EN 1992-1-1 (EC2)  
Concrete strength in compression : f<sub>ck</sub> = 20,00 MPa  
Coefficient of cohesion : η<sub>1</sub> = 1,00

## Settings of the stage of construction

Design situation : permanent

## Analysis results (Stage of construction 3)

### Distribution of pressures acting on the structure (in front and behind the wall)

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	0.00	0.00	0.00	0.00	4.00	6.38
0.01	0.00	0.00	0.00	0.05	4.22	6.38
0.08	0.00	0.00	0.00	0.29	5.17	8.32
0.08	0.00	0.00	0.00	8.97	8.97	8.97
0.15	0.00	0.00	0.00	9.74	9.74	10.22
0.15	0.00	0.00	0.00	9.83	9.83	10.24
0.22	0.00	0.00	0.00	10.76	10.76	12.54
0.23	0.00	0.00	0.00	11.01	11.01	12.81
0.26	0.00	0.00	0.00	11.97	11.97	13.53

--

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.33	0.00	0.00	0.00	14.72	14.72	15.58
0.33	0.00	0.00	0.00	14.75	14.75	15.58
0.38	0.00	0.00	0.00	16.56	16.56	17.00
0.39	0.00	0.00	0.00	17.55	17.55	17.55
0.57	0.00	0.00	0.00	19.59	19.59	22.67
0.68	0.00	0.00	0.00	20.96	20.96	26.10
0.99	0.00	0.00	0.00	24.54	24.54	35.07
1.37	0.00	0.00	0.00	29.00	29.00	47.99
1.50	0.00	0.00	0.00	30.55	30.55	52.46
1.50	0.00	0.00	0.00	14.91	22.90	204.97
1.99	0.00	0.00	0.00	17.44	28.07	257.26
2.00	0.00	0.00	0.00	17.48	28.13	258.10
2.05	0.00	0.00	0.00	18.35	28.87	261.92
2.74	0.00	0.00	0.00	29.67	38.26	311.70
3.42	0.00	0.00	0.00	40.99	47.56	361.48
3.50	0.00	0.00	0.00	42.29	48.64	367.22
3.50	0.00	-0.00	-3.65	42.29	48.64	367.23
3.82	0.00	-1.47	-22.25	42.59	49.33	388.12
4.00	-0.52	-2.26	-32.35	42.75	49.71	399.46
4.00	0.00	-2.20	-45.47	39.96	48.86	309.11
4.11	0.00	-2.66	-49.76	40.11	49.08	313.89
4.79	0.00	-5.67	-77.66	41.13	50.58	345.00
5.47	0.00	-8.69	-105.56	42.15	52.23	376.10
5.93	0.00	-10.71	-124.32	42.83	53.43	397.01
6.16	-0.80	-11.70	-133.46	43.17	54.01	407.21
6.84	-3.24	-14.71	-161.37	44.18	55.90	438.32
7.53	-5.68	-17.72	-189.27	45.20	57.87	469.42
7.99	-7.32	-19.74	-208.01	45.89	59.25	490.32
7.99	-7.32	-19.74	-208.01	42.21	59.25	490.32
8.21	-8.12	-20.73	-217.17	42.65	59.92	500.53
8.89	-10.56	-23.74	-245.07	43.98	62.03	531.63
9.58	-13.01	-26.75	-272.97	45.31	64.18	562.74
10.26	-15.45	-29.76	-300.87	46.64	66.38	593.85
10.95	-17.89	-32.77	-328.77	47.97	68.60	624.95
11.63	-20.33	-35.78	-356.67	49.30	70.84	656.06
12.32	-22.77	-38.80	-384.58	50.63	73.10	687.16
13.00	-25.21	-41.81	-412.48	51.96	75.38	718.27

Distributions of the modulus of subsoil reaction and internal forces on the structure

Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-24.97	6.38	0.00	0.00
0.65	0.00	0.00	-22.54	25.09	-10.13	2.63
1.30	0.00	3.50	-20.12	29.64	-27.78	14.71
1.95	0.00	15.12	-17.71	22.81	-43.54	37.76
2.47	0.00	15.12	-15.81	30.27	-57.23	63.80
2.50	0.00	15.12	-15.70	30.73	-58.14	65.53

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
2.50	0.00	15.12	-15.70	30.73	-38.01	65.53
2.60	0.00	15.12	-15.34	32.26	-41.16	69.49
3.25	0.00	15.12	-13.04	42.20	-65.36	103.78
3.50	0.00	15.12	-12.19	45.95	-76.21	121.18
3.51	0.00	15.12	-12.14	41.79	-76.81	122.25
3.90	0.00	15.12	-10.84	19.25	-88.72	154.84
4.55	0.00	19.28	-8.78	-24.05	-82.75	211.76
5.20	0.00	19.28	-6.92	-50.49	-58.52	258.64
5.85	19.28	19.28	-5.31	-68.67	-17.50	283.99
6.50	19.28	19.28	-3.97	-45.24	19.23	282.63
7.15	19.28	19.28	-2.89	-26.81	42.37	261.98
7.80	19.28	19.28	-2.06	-13.02	55.06	229.84
8.45	19.28	0.00	-1.45	-6.63	61.67	191.80
9.10	19.28	0.00	-1.02	0.06	63.63	150.84
9.75	19.28	19.28	-0.73	8.94	60.85	110.00
10.40	19.28	19.28	-0.55	15.19	52.83	72.84
11.05	19.28	19.28	-0.44	18.77	41.68	42.00
11.70	19.28	19.28	-0.37	20.82	28.76	19.03
12.35	19.28	19.28	-0.31	22.15	14.77	4.84
13.00	19.28	19.28	-0.27	23.29	0.00	-0.00

#### Maximum values of internal forces acting on the structure

Maximum shear force = 89,73 kN/m  
 Maximum moment = 286,35 kNm/m  
 Maximum displacement = 25,0 mm

#### Maximum internal forces on cross-section

Maximum shear force = 125,62 kN  
 Maximum moment = 400,89 kNm

#### Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	2,50	-15,7	30,00

#### Terrain settlement behind the structure

Terrain settlement  $\delta_{\max}$  = 13,2 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	12,6
2	0,90	16,1
3	1,79	18,6
4	2,69	19,9
5	3,59	20,3
6	4,49	19,5
7	5,38	17,8
8	6,28	14,9
9	7,18	11,0
10	8,08	6,0
11	8,97	0,0

	Coordinates x [m]	Settlement z [mm]
12	8,97	0,0

### Dimensioning No. 1 (Stage of construction 3)

#### Failure by heave

Favourable weight of soil  $\sigma_{\text{stb}} = 162,45 \text{ kPa}$

Unfavourable water pressure  $u_{\text{dst}} = 20,25 \text{ kPa}$

**Verification of failure by heave is SATISFACTORY**

#### Verification of failure by piping




Critical hydraulic gradient  $i_c = 0,73$

Hydraulic gradient  $i = 0,07$

**Verification of failure by piping is SATISFACTORY**

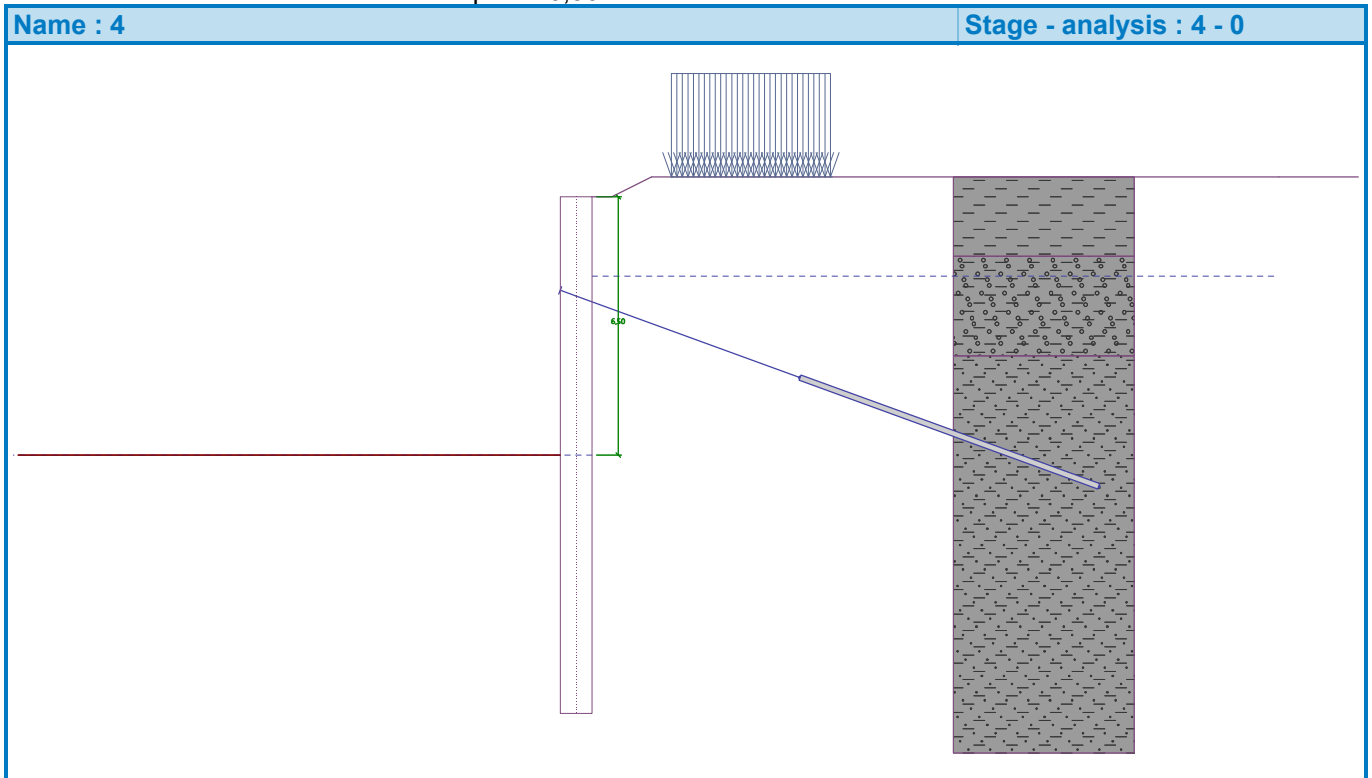
### Input data (Stage of construction 4)

#### Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	1,50	0,00 .. 1,50	Glina	
2	2,50	1,50 .. 4,00	Zameljen prod	
3	-	4,00 .. ∞	Siva zbita peščena	

#### Excavation

Soil in front of wall is excavated to a depth of 6,50 m.



### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	0,50	0,00
3	1,50	-0,50
4	2,50	-0,50

Origin [0,0] is located in upper right edge of construction.  
Positive coordinate +z has downward direction.

### Water influence

GWT behind the structure lies at a depth of 2,00 m  
GWT in front of the structure lies at a depth of 6,50 m  
Subgrade at the heel is permeable.  
Hydraulic gradient = 0,26

### Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m <sup>2</sup> ]	Mag.2 [kN/m <sup>2</sup> ]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	No	No	variable	20,00		2,00	4,00	on terrain

No.	Name
1	Prometna obtežba

### Input anchors

No.	New anchor	Depth z [m]	Name	Post-stressing	Force F [kN]
1	No	2,50	Anchor No. : 1 (user-defined)		342,23

### Settings of the stage of construction

Design situation : permanent

### Analysis results (Stage of construction 4)

#### Distribution of pressures acting on the structure (in front and behind the wall)

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	0.00	0.00	0.00	0.00	4.00	6.38
0.01	0.00	0.00	0.00	0.05	4.22	6.38
0.08	0.00	0.00	0.00	0.29	5.17	8.32
0.08	0.00	0.00	0.00	8.97	8.97	8.97
0.15	0.00	0.00	0.00	9.74	9.74	10.22
0.15	0.00	0.00	0.00	9.83	9.83	10.24
0.22	0.00	0.00	0.00	10.76	10.76	12.54
0.23	0.00	0.00	0.00	11.01	11.01	12.81
0.26	0.00	0.00	0.00	11.97	11.97	13.53
0.33	0.00	0.00	0.00	14.72	14.72	15.58
0.33	0.00	0.00	0.00	14.75	14.75	15.58
0.38	0.00	0.00	0.00	16.56	16.56	17.00
0.39	0.00	0.00	0.00	17.55	17.55	17.55
0.57	0.00	0.00	0.00	19.59	19.59	22.67
0.68	0.00	0.00	0.00	20.96	20.96	26.10
0.99	0.00	0.00	0.00	24.54	24.54	35.07
1.37	0.00	0.00	0.00	29.00	29.00	47.99
1.50	0.00	0.00	0.00	30.55	30.55	52.46

--

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
1.50	0.00	0.00	0.00	14.91	22.90	204.97
1.99	0.00	0.00	0.00	17.44	28.07	257.26
2.00	0.00	0.00	0.00	17.48	28.13	258.10
2.05	0.00	0.00	0.00	18.38	28.91	262.47
2.74	0.00	0.00	0.00	30.06	38.86	319.28
3.42	0.00	0.00	0.00	41.74	48.72	376.10
4.00	0.00	0.00	0.00	51.63	57.12	424.18
4.00	0.00	0.00	0.00	49.04	56.23	327.85
4.11	0.00	0.00	0.00	50.91	57.75	334.28
4.79	0.00	0.00	0.00	63.07	67.71	376.04
5.47	0.00	0.00	0.00	75.23	77.82	417.81
6.16	0.00	0.00	0.00	87.39	88.06	459.57
6.50	0.00	0.00	0.00	93.47	93.47	480.45
6.50	0.00	-0.00	-25.08	93.48	93.48	480.46
6.84	0.00	-1.24	-36.53	91.74	92.62	497.20
7.53	0.00	-3.71	-59.43	88.26	91.48	530.69
8.06	0.00	-5.62	-77.18	85.56	90.66	556.64
8.06	0.00	-5.62	-77.18	81.89	90.66	556.64
8.21	0.00	-6.18	-82.33	81.17	90.42	564.19
8.89	0.00	-8.65	-105.24	78.00	89.41	597.68
9.46	0.00	-10.71	-124.32	75.36	88.60	625.58
9.58	-0.33	-11.12	-128.14	74.84	88.44	631.17
10.26	-2.34	-13.59	-151.04	71.67	87.52	664.67
10.95	-4.34	-16.06	-173.94	68.50	86.62	698.16
11.63	-6.35	-18.54	-196.85	65.33	85.75	731.65
12.32	-8.35	-21.01	-219.75	62.16	84.89	765.15
13.00	-10.35	-23.48	-242.65	58.99	84.05	798.64

**Distributions of the modulus of subsoil reaction and internal forces on the structure**

Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.17	-29.65	3.27	0.00	0.00
0.65	0.00	0.00	-28.94	20.56	-9.06	2.35
1.30	0.00	0.00	-28.23	28.20	-24.90	13.12
1.95	0.00	0.00	-27.54	17.22	-37.91	34.06
2.47	0.00	0.00	-27.01	25.51	-48.91	56.45
2.50	0.00	0.00	-26.98	26.02	-49.68	57.93
2.50	0.00	0.00	-26.98	26.02	180.03	57.93
2.60	0.00	0.00	-26.88	27.73	177.34	40.06
3.25	0.00	0.00	-26.25	38.82	155.71	-68.58
3.90	0.00	0.00	-25.55	49.92	126.87	-160.81
4.55	0.00	0.00	-24.70	58.81	92.22	-232.37
5.20	0.00	0.00	-23.64	70.36	50.24	-279.08
5.85	0.00	0.00	-22.31	81.92	0.75	-296.06
6.50	0.00	0.00	-20.71	93.40	-55.88	-278.65
6.50	0.00	0.00	-20.69	68.25	-56.52	-278.20
7.15	0.00	0.00	-18.83	43.34	-92.57	-229.18



--

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
7.80	0.00	0.00	-16.74	18.27	-112.59	-161.62
8.45	0.00	0.00	-14.50	-10.29	-114.68	-86.72
9.10	0.00	0.00	-12.18	-35.05	-99.95	-16.09
9.75	0.00	0.00	-9.84	-59.82	-69.11	39.73
10.40	0.00	0.00	-7.54	-84.59	-22.18	70.27
11.05	19.28	0.00	-5.30	-50.70	23.02	68.37
11.70	19.28	0.00	-3.13	-14.12	44.03	45.30
12.35	19.28	19.28	-1.00	25.25	41.59	16.17
13.00	0.00	19.28	1.12	95.27	-0.00	0.00

#### Maximum values of internal forces acting on the structure

Maximum shear force = 180,03 kN/m  
Maximum moment = 296,06 kNm/m  
Maximum displacement = 29,6 mm

#### Maximum internal forces on cross-section

Maximum shear force = 252,04 kN  
Maximum moment = 414,48 kNm

#### Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	2,50	-27,0	342,23

#### Terrain settlement behind the structure

Terrain settlement  $\delta_{\max} = 37,2$  mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	14,3
2	0,90	26,2
3	1,79	35,2
4	2,69	41,3
5	3,59	44,3
6	4,49	44,4
7	5,38	41,5
8	6,28	35,6
9	7,18	26,7
10	8,08	14,8
11	8,97	0,0
12	8,97	0,0

#### Dimensioning No. 1 (Stage of construction 4)

##### Failure by heave

Favourable weight of soil  $\sigma_{\text{stb}} = 111,15$  kPa  
Unfavourable water pressure  $u_{\text{dst}} = 60,75$  kPa

Verification of failure by heave is **SATISFACTORY**



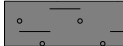
##### Verification of failure by piping

Critical hydraulic gradient  $i_c = 0,73$   
Hydraulic gradient  $i = 0,26$

Verification of failure by piping is **SATISFACTORY**

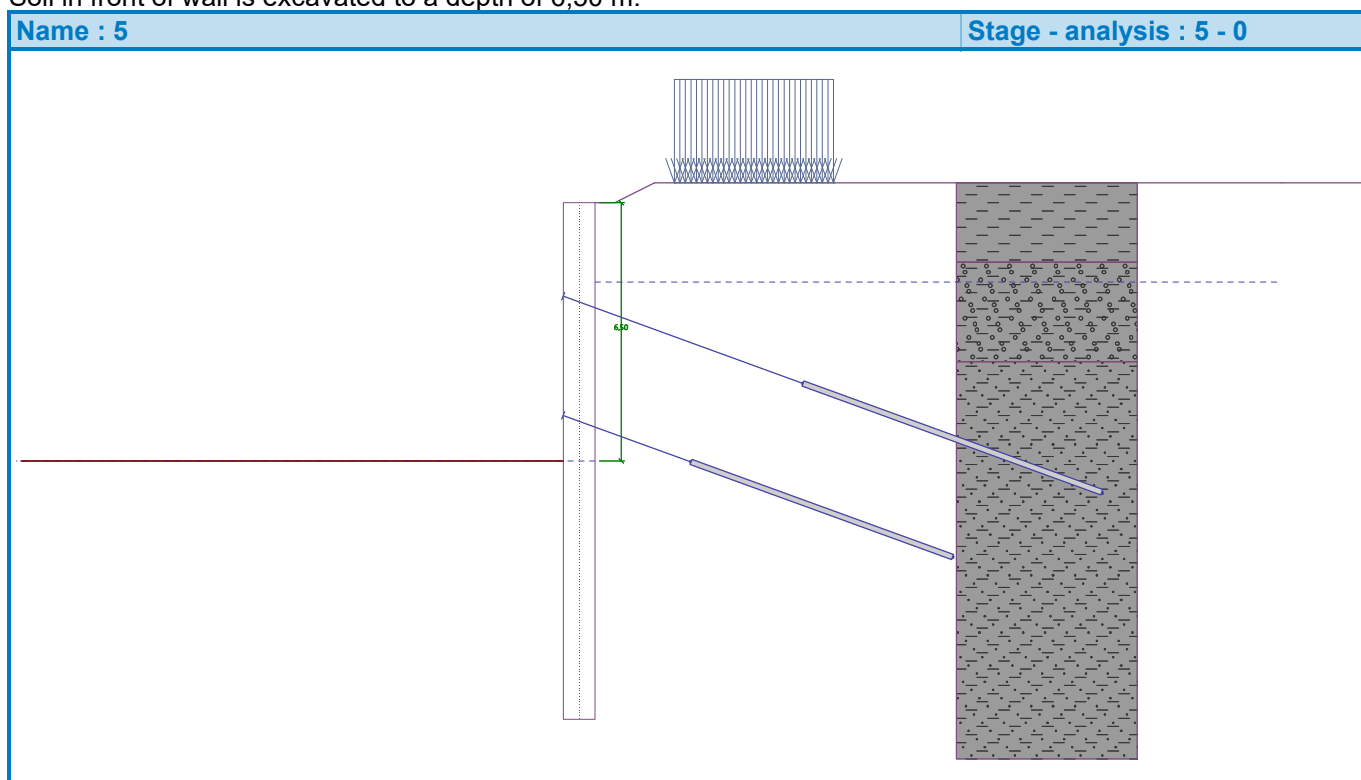
## Input data (Stage of construction 5)

### Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	1,50	0,00 .. 1,50	Glina	
2	2,50	1,50 .. 4,00	Zameljen prod	
3	-	4,00 .. ∞	Siva zbita peščena	

### Excavation

Soil in front of wall is excavated to a depth of 6,50 m.



### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	0,50	0,00
3	1,50	-0,50
4	2,50	-0,50

Origin [0,0] is located in upper right edge of construction.  
Positive coordinate +z has downward direction.

### Water influence

GWT behind the structure lies at a depth of 2,00 m  
GWT in front of the structure lies at a depth of 6,50 m  
Subgrade at the heel is permeable.  
Hydraulic gradient = 0,26

Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m <sup>2</sup> ]	Mag.2 [kN/m <sup>2</sup> ]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	Yes		variable	20,00		2,00	4,00	on terrain

No.	Name
1	Prometna obtežba

Input anchors

No.	New anchor	Depth z [m]	Name	Post-stressing	Force F [kN]
1	No	2,50	Anchor No. : 1 (user-defined)		339,71
2	Yes	5,50	Anchor No. : 2 (user-defined)		30,00

List of the new anchors

Anchor No. : 2 (user-defined)

Anchor type : prestressed bar

Production set : user-defined

Depth : z = 5,50 m

Free length : l = 3,00 m

Root length : l<sub>k</sub> = 7,00 m

Slope : α = 20,00 °

Spacing : b = 1,40 m

Area of cross-section : A = 791,00 mm<sup>2</sup>

Elasticity modulus : E = 210000,00 MPa

Pre-stressing force : F = 30,00 kN

Tension strength : R<sub>t</sub> = 500,00 kN

Pull out resistance (soil) : calculate from bond strength

Diameter of root : d = 140,0 mm

Bond strength : f = 150,00 kPa

Pull out resistance (grouting) : calculate from concrete strength

Standard for concrete structures : EN 1992-1-1 (EC2)

Concrete strength in compression : f<sub>ck</sub> = 20,00 MPa

Coefficient of cohesion : η<sub>1</sub> = 1,00

Settings of the stage of construction

Design situation : permanent

Analysis results (Stage of construction 5)

Distribution of pressures acting on the structure (in front and behind the wall)

Depth [m]	T <sub>a,p</sub> [kPa]	T <sub>k,p</sub> [kPa]	T <sub>p,p</sub> [kPa]	T <sub>a,z</sub> [kPa]	T <sub>k,z</sub> [kPa]	T <sub>p,z</sub> [kPa]
0.00	0.00	0.00	0.00	0.00	4.00	6.38
0.01	0.00	0.00	0.00	0.05	4.22	6.38
0.08	0.00	0.00	0.00	0.29	5.17	8.32
0.08	0.00	0.00	0.00	8.97	8.97	8.97
0.15	0.00	0.00	0.00	9.74	9.74	10.22
0.15	0.00	0.00	0.00	9.83	9.83	10.24
0.22	0.00	0.00	0.00	10.76	10.76	12.54
0.23	0.00	0.00	0.00	11.01	11.01	12.81
0.26	0.00	0.00	0.00	11.97	11.97	13.53
0.33	0.00	0.00	0.00	14.72	14.72	15.58
0.33	0.00	0.00	0.00	14.75	14.75	15.58
0.38	0.00	0.00	0.00	16.56	16.56	17.00
0.39	0.00	0.00	0.00	17.55	17.55	17.55

--

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.57	0.00	0.00	0.00	19.59	19.59	22.67
0.68	0.00	0.00	0.00	20.96	20.96	26.10
0.99	0.00	0.00	0.00	24.54	24.54	35.07
1.37	0.00	0.00	0.00	29.00	29.00	47.99
1.50	0.00	0.00	0.00	30.55	30.55	52.46
1.50	0.00	0.00	0.00	14.91	22.90	204.97
1.99	0.00	0.00	0.00	17.44	28.07	257.26
2.00	0.00	0.00	0.00	17.48	28.13	258.10
2.05	0.00	0.00	0.00	18.38	28.91	262.47
2.74	0.00	0.00	0.00	30.06	38.86	319.28
3.42	0.00	0.00	0.00	41.74	48.72	376.10
4.00	0.00	0.00	0.00	51.63	57.12	424.18
4.00	0.00	0.00	0.00	49.04	56.23	327.85
4.11	0.00	0.00	0.00	50.91	57.75	334.28
4.79	0.00	0.00	0.00	63.07	67.71	376.04
5.47	0.00	0.00	0.00	75.23	77.82	417.81
6.16	0.00	0.00	0.00	87.39	88.06	459.57
6.50	0.00	0.00	0.00	93.47	93.47	480.45
6.50	0.00	-0.00	-25.08	93.48	93.48	480.46
6.84	0.00	-1.24	-36.53	91.74	92.62	497.20
7.53	0.00	-3.71	-59.43	88.26	91.48	530.69
8.06	0.00	-5.62	-77.18	85.56	90.66	556.64
8.06	0.00	-5.62	-77.18	81.89	90.66	556.64
8.21	0.00	-6.18	-82.33	81.17	90.42	564.19
8.89	0.00	-8.65	-105.24	78.00	89.41	597.68
9.46	0.00	-10.71	-124.32	75.36	88.60	625.58
9.58	-0.33	-11.12	-128.14	74.84	88.44	631.17
10.26	-2.34	-13.59	-151.04	71.67	87.52	664.67
10.95	-4.34	-16.06	-173.94	68.50	86.62	698.16
11.63	-6.35	-18.54	-196.85	65.33	85.75	731.65
12.32	-8.35	-21.01	-219.75	62.16	84.89	765.15
13.00	-10.35	-23.48	-242.65	58.99	84.05	798.64

Distributions of the modulus of subsoil reaction and internal forces on the structure

Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.17	-29.66	4.00	0.00	0.00
0.65	0.00	0.17	-28.92	20.56	-9.10	2.36
1.30	0.00	0.17	-28.19	28.20	-24.95	13.16
1.95	0.00	0.00	-27.47	17.22	-37.97	34.16
2.47	0.00	15.12	-26.92	26.87	-49.45	55.78
2.50	0.00	15.12	-26.89	27.40	-50.26	57.28
2.50	0.00	15.12	-26.89	27.40	177.75	57.28
2.60	0.00	15.12	-26.79	29.17	174.92	39.64
3.25	0.00	15.12	-26.13	40.67	152.23	-67.09
3.90	0.00	15.12	-25.41	52.13	122.07	-156.64
4.55	0.00	19.28	-24.54	62.02	85.53	-224.71

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
5.20	0.00	19.28	-23.46	73.76	41.39	-266.37
5.50	0.00	19.28	-22.88	79.16	18.45	-275.38
5.50	0.00	19.28	-22.88	79.16	38.58	-275.38
5.85	0.00	19.28	-22.13	85.34	9.80	-283.90
6.50	0.00	19.28	-20.54	96.57	-48.96	-271.64
6.50	0.00	19.28	-20.52	71.42	-49.68	-271.24
7.15	0.00	19.28	-18.68	46.12	-87.64	-225.97
7.80	0.00	19.28	-16.62	20.60	-109.31	-161.01
8.45	0.00	19.28	-14.41	-8.44	-112.76	-87.73
9.10	0.00	19.28	-12.11	-33.68	-99.07	-17.95
9.75	0.00	19.28	-9.80	-58.89	-68.98	37.60
10.40	0.00	19.28	-7.52	-84.06	-22.52	68.27
11.05	19.28	19.28	-5.30	-50.41	22.28	66.77
11.70	19.28	0.00	-3.14	-14.32	43.01	44.47
12.35	19.28	19.28	-1.03	24.18	40.84	15.94
13.00	0.00	19.28	1.07	94.41	-0.00	0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 177,75 kN/m  
Maximum moment = 284,45 kNm/m  
Maximum displacement = 29,7 mm

Maximum internal forces on cross-section

Maximum shear force = 248,85 kN  
Maximum moment = 398,23 kNm

Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	2,50	-26,9	339,71
2	5,50	-22,9	30,00

Terrain settlement behind the structure

Terrain settlement  $\delta_{max}$  = 37,0 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	14,3
2	0,90	26,2
3	1,79	35,1
4	2,69	41,1
5	3,59	44,1
6	4,49	44,2
7	5,38	41,3
8	6,28	35,4
9	7,18	26,6
10	8,08	14,8
11	8,97	0,0
12	8,97	0,0

## Dimensioning No. 1 (Stage of construction 5)

### Failure by heave

Favourable weight of soil  $\sigma_{\text{stb}} = 111,15 \text{ kPa}$

Unfavourable water pressure  $u_{\text{dst}} = 60,75 \text{ kPa}$

Verification of failure by heave is **SATISFACTORY**

### Verification of failure by piping


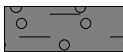

Critical hydraulic gradient  $i_c = 0,73$

Hydraulic gradient  $i = 0,26$

Verification of failure by piping is **SATISFACTORY**

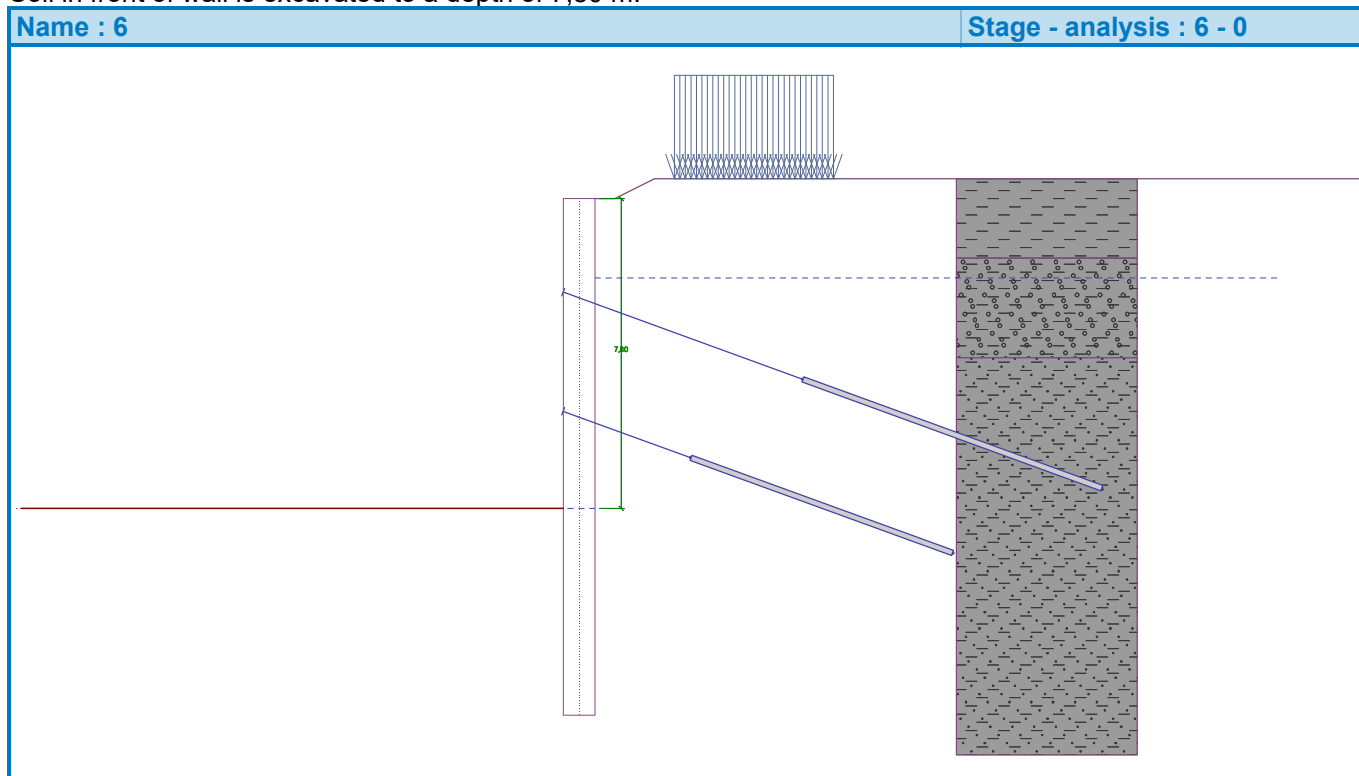
## Input data (Stage of construction 6)

### Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	1,50	0,00 .. 1,50	Glina	
2	2,50	1,50 .. 4,00	Zameljen prod	
3	-	4,00 .. ∞	Siva zbita peščena	

### Excavation

Soil in front of wall is excavated to a depth of 7,80 m.



### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	0,50	0,00

No.	Coordinates x [m]	Depth z [m]
3	1,50	-0,50
4	2,50	-0,50

Origin [0,0] is located in upper right edge of construction.  
Positive coordinate +z has downward direction.

#### Water influence

GWT behind the structure lies at a depth of 2,00 m  
GWT in front of the structure lies at a depth of 7,80 m  
Subgrade at the heel is permeable.  
Hydraulic gradient = 0,36

#### Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m <sup>2</sup> ]	Mag.2 [kN/m <sup>2</sup> ]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	No	No	variable	20,00		2,00	4,00	on terrain

No.	Name
1	Prometna obtežba

#### Input anchors

No.	New anchor	Depth z [m]	Name	Post-stressing	Force F [kN]
1	No	2,50	Anchor No. : 1 (user-defined)		332,63
2	No	5,50	Anchor No. : 2 (user-defined)		278,82

#### Settings of the stage of construction

Design situation : permanent

#### Analysis results (Stage of construction 6)

##### Distribution of pressures acting on the structure (in front and behind the wall)

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	0.00	0.00	0.00	0.00	4.00	6.38
0.01	0.00	0.00	0.00	0.05	4.22	6.38
0.08	0.00	0.00	0.00	0.29	5.17	8.32
0.08	0.00	0.00	0.00	8.97	8.97	8.97
0.15	0.00	0.00	0.00	9.74	9.74	10.22
0.15	0.00	0.00	0.00	9.83	9.83	10.24
0.22	0.00	0.00	0.00	10.76	10.76	12.54
0.23	0.00	0.00	0.00	11.01	11.01	12.81
0.26	0.00	0.00	0.00	11.97	11.97	13.53
0.33	0.00	0.00	0.00	14.72	14.72	15.58
0.33	0.00	0.00	0.00	14.75	14.75	15.58
0.38	0.00	0.00	0.00	16.56	16.56	17.00
0.39	0.00	0.00	0.00	17.55	17.55	17.55
0.57	0.00	0.00	0.00	19.59	19.59	22.67
0.68	0.00	0.00	0.00	20.96	20.96	26.10
0.99	0.00	0.00	0.00	24.54	24.54	35.07
1.37	0.00	0.00	0.00	29.00	29.00	47.99
1.50	0.00	0.00	0.00	30.55	30.55	52.46
1.50	0.00	0.00	0.00	14.91	22.90	204.97
1.99	0.00	0.00	0.00	17.44	28.07	257.26

--

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
2.00	0.00	0.00	0.00	17.48	28.13	258.10
2.05	0.00	0.00	0.00	18.40	28.93	262.76
2.74	0.00	0.00	0.00	30.28	39.19	323.44
3.42	0.00	0.00	0.00	42.16	49.35	384.12
4.00	0.00	0.00	0.00	52.21	58.01	435.46
4.00	0.00	0.00	0.00	49.74	57.09	335.87
4.11	0.00	0.00	0.00	51.65	58.66	342.71
4.79	0.00	0.00	0.00	64.05	68.92	387.22
5.47	0.00	0.00	0.00	76.44	79.32	431.72
6.16	0.00	0.00	0.00	88.84	89.86	476.23
6.84	0.00	0.00	0.00	101.23	101.23	520.73
7.53	0.00	0.00	0.00	113.63	113.63	565.24
7.80	0.00	0.00	0.00	118.59	118.59	583.04
7.80	0.00	-0.00	-25.08	118.59	118.59	583.05
8.05	0.00	-0.78	-32.31	116.03	116.03	595.30
8.05	0.00	-0.78	-32.31	112.35	114.24	595.30
8.21	0.00	-1.31	-37.17	110.71	113.36	603.54
8.89	0.00	-3.48	-57.34	103.87	109.76	637.71
9.58	0.00	-5.66	-77.50	97.03	106.19	671.87
10.26	0.00	-7.83	-97.66	90.20	102.67	706.04
10.95	0.00	-10.01	-117.82	83.36	99.17	740.21
11.17	0.00	-10.71	-124.32	81.16	98.05	751.22
11.63	-1.20	-12.18	-137.98	76.52	95.70	774.37
12.32	-2.96	-14.36	-158.14	69.69	92.25	808.54
13.00	-4.72	-16.54	-178.30	62.85	88.81	842.71

**Distributions of the modulus of subsoil reaction and internal forces on the structure**

Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-25.63	6.38	-0.00	-0.00
0.65	0.00	0.17	-25.87	21.09	-9.54	2.53
1.30	0.00	0.17	-26.12	28.57	-25.68	13.71
1.95	0.00	0.76	-26.39	27.98	-43.25	36.16
2.47	0.00	0.00	-26.62	25.64	-58.97	62.75
2.50	0.00	0.00	-26.64	26.17	-59.75	64.53
2.50	0.00	0.00	-26.64	26.17	163.52	64.53
2.60	0.00	0.00	-26.68	27.90	160.82	48.31
3.25	0.00	0.00	-27.02	39.19	139.01	-49.53
3.90	0.00	0.00	-27.30	50.48	109.87	-130.81
4.55	0.00	0.00	-27.47	59.71	74.72	-191.17
5.20	0.00	0.00	-27.45	71.48	32.09	-226.30
5.50	0.00	0.00	-27.37	76.92	9.83	-232.63
5.50	0.00	0.00	-27.37	76.92	196.97	-232.63
5.85	0.00	0.00	-27.22	83.26	168.94	-296.73
6.50	0.00	0.00	-26.70	95.04	110.99	-388.12
7.15	0.00	0.00	-25.83	106.81	45.39	-439.36
7.80	0.00	0.00	-24.55	118.52	-27.39	-445.58



--

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
7.80	0.00	0.00	-24.53	93.35	-28.24	-445.36
8.45	0.00	0.00	-22.83	64.08	-78.58	-409.81
9.10	0.00	0.00	-20.73	38.43	-111.90	-347.00
9.75	0.00	0.00	-18.30	12.79	-128.54	-267.96
10.40	0.00	0.00	-15.63	-12.86	-128.52	-183.51
11.05	0.00	0.00	-12.77	-38.51	-111.82	-104.49
11.70	0.00	0.00	-9.82	-64.16	-78.46	-41.75
12.35	19.28	0.00	-6.82	-76.68	-28.89	-6.39
13.00	0.96	0.00	-3.82	42.63	-0.00	0.00

#### Maximum values of internal forces acting on the structure

Maximum shear force = 196,97 kN/m  
Maximum moment = 448,76 kNm/m  
Maximum displacement = 27,5 mm

#### Maximum internal forces on cross-section

Maximum shear force = 275,76 kN  
Maximum moment = 628,27 kNm

#### Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	2,50	-26,6	332,63
2	5,50	-27,4	278,82

### Dimensioning No. 1 (Stage of construction 6)

#### Failure by heave

Favourable weight of soil  $\sigma_{stb}$  = 88,92 kPa  
Unfavourable water pressure  $u_{dst}$  = 78,30 kPa

Verification of failure by heave is **SATISFACTORY**

#### Verification of failure by piping

Critical hydraulic gradient  $i_c$  = 0,73  
Hydraulic gradient  $i$  = 0,36

Verification of failure by piping is **SATISFACTORY**

### Dimensioning No. 1

#### Distribution of forces on construction

	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
0.00	-29.66	-1.32	-0.00	0.00	-0.00	0.00
0.01	-29.65	-1.32	-0.05	-0.00	0.00	0.00
0.01	-29.65	-1.32	-0.05	-0.00	0.00	0.00
0.01	-29.64	-1.31	-0.11	0.02	-0.00	0.01
0.65	-28.94	-1.14	-10.13	-4.67	0.99	2.63
1.30	-28.23	-0.96	-27.78	-13.51	6.78	14.71
1.95	-27.54	-0.79	-43.54	-11.82	16.14	37.76
2.47	-27.01	-0.67	-58.97	-6.77	20.92	63.80
2.50	-26.98	-0.66	-59.75	-6.52	21.11	65.53
2.50	-26.98	-0.66	-49.43	180.03	21.11	65.53
2.60	-26.88	-0.64	-52.06	177.34	21.73	69.49

	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
3.25	-27.02	-0.50	-73.37	155.71	-68.58	103.78
3.50	-27.13	-0.46	-83.26	145.63	-105.63	122.08
3.50	-27.13	-0.46	-83.26	145.63	-105.63	122.08
3.50	-27.14	-0.46	-83.58	145.29	-106.81	122.75
3.50	-27.14	-0.46	-83.58	145.29	-106.81	122.75
3.51	-27.14	-0.45	-83.81	145.04	-107.70	123.25
3.51	-27.14	-0.45	-83.81	145.04	-107.70	123.25
3.90	-27.30	-0.39	-94.37	126.87	-160.81	158.28
4.55	-27.47	-0.30	-86.18	92.22	-232.37	218.18
5.20	-27.45	-0.23	-60.25	50.24	-279.08	266.67
5.50	-27.37	-0.21	-42.62	28.30	-290.77	282.08
5.50	-27.37	-0.21	-42.62	196.97	-290.77	282.08
5.85	-27.22	-0.18	-17.97	168.94	-296.73	292.69
6.50	-26.71	-0.15	-55.88	111.37	-387.65	291.16
6.50	-26.71	-0.15	-55.88	111.37	-387.65	291.16
6.50	-26.70	-0.15	-56.20	110.99	-388.12	291.09
6.50	-26.70	-0.15	-56.52	110.61	-388.54	291.00
6.50	-26.70	-0.15	-56.52	110.61	-388.54	291.00
7.15	-25.83	-0.13	-92.57	45.39	-439.36	269.50
7.80	-24.55	-0.11	-112.51	57.04	-445.58	236.32
7.80	-24.54	-0.11	-112.59	57.10	-445.47	236.10
7.80	-24.53	-0.11	-112.65	57.14	-445.36	235.87
7.80	-24.53	-0.11	-112.65	57.14	-445.36	235.87
8.45	-22.83	-0.11	-114.68	63.76	-409.81	196.62
9.10	-20.73	-0.11	-111.90	65.59	-347.00	154.35
9.75	-18.30	-0.11	-128.54	62.46	-267.96	112.34
10.40	-15.63	-0.11	-128.52	54.05	-183.51	74.25
11.05	-12.77	-0.11	-111.82	42.53	-104.49	68.37
11.70	-9.82	-0.11	-78.46	44.03	-41.75	45.30
12.35	-6.82	-0.12	-28.89	41.59	-6.39	16.17
13.00	-3.82	1.12	-0.00	0.00	-0.00	0.00

#### Maximum values of internal forces

Maximum displacement = -29,7 mm  
 Minimum displacement = 1,1 mm  
 Maximum bending moment = 295,07 kNm/m  
 Minimum bending moment = -448,76 kNm/m  
 Maximum shear force = 196,97 kN/m

#### Verification of RC cross section (Pile curtain $d = 0,80$ m, $a = 1,40$ m)

All construction stages are taken into the analysis.  
 Partial factor on load = 1,00

#### Verification of cross section in bending:

Reinforcement - 12 pc bars 25,0 mm; cover 80,0 mm  
 Type of structure (reinforcement ratio) : beam  
 Reinforcement ratio  $\rho = 0,586 \% > 0,135 \% = \rho_{\min}$   
 Load :  $M_{Ed} = 628,27$  kNm  
 Bearing capacity :  $M_{Rd} = 717,31$  kNm

**Designed pile reinforcement is SATISFACTORY**

### Verification of cross section in shear:

Shear reinf. - profile 10,0 mm; spacing 150,0 mm

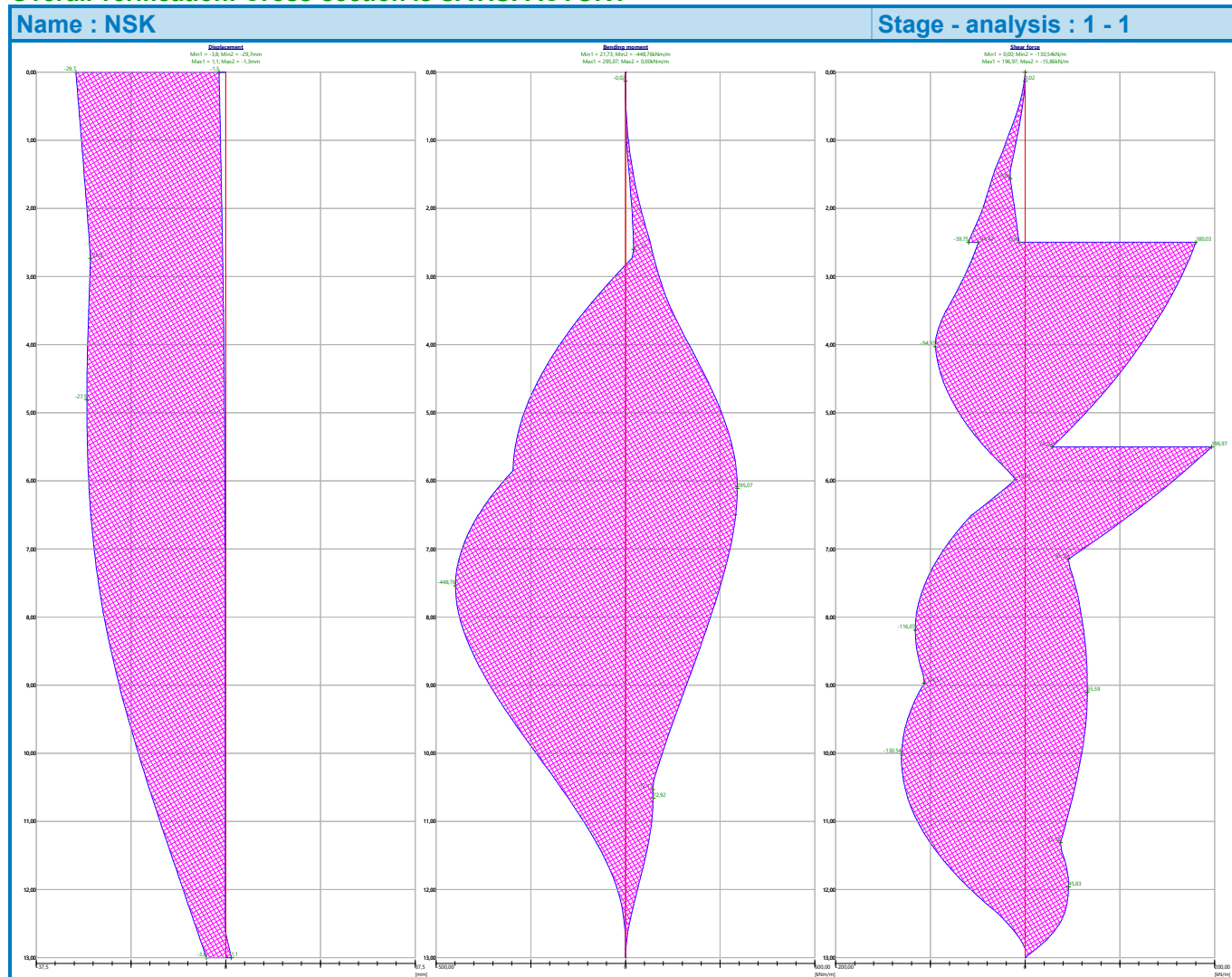
$$A_{sw} = 2 \times 523,6 = 1047,2 \text{ mm}^2$$

$$b_w = 0,70 \text{ m}; d = 0,64 \text{ m}$$

$$\text{Ultimate shear force: } V_{Rd} = 655,64 \text{ kN} > 275,76 \text{ kN} = V_{Ed}$$

**Cross-section is SATISFACTORY.**

**Overall verification: Cross-section is SATISFACTORY**



### Verification of anchors

Anchor	Stage	Depth z [m]	Max. force F [kN]	Anchor strength R <sub>t</sub> [kN]	Pull-out res. (soil) R <sub>e</sub> [kN]	Pull-out res. (grouting) R <sub>c</sub> [kN]	Verification
1	4	2,50	342,23	454,55	390,95	731,33	is satisfactory (87,54 %)
1	5	2,50	339,71	454,55	390,95	731,33	is satisfactory (86,89 %)
2	6	5,50	278,82	454,55	342,08	639,91	is satisfactory (81,51 %)
1	6	2,50	332,63	454,55	390,95	731,33	is satisfactory (85,08 %)

Anchor with max. utilization - Nr. 1. (Stage 4; z = 2,50 m)

Utilization is 87,54 %

**Anchors bearing capacity is SATISFACTORY**