

## Analysis of anti-slide pile

### 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 :  $\gamma_{M0} = 1,00$

#### Pressure analysis

Verification methodology : according to EN 1997  
Active earth pressure calculation : Coulomb  
Passive earth pressure calculation : Caquot-Kerisel  
Earthquake analysis : Mononobe-Okabe  
Modulus of subsoil reaction : standard  
Consider reduction of the modulus of subsoil reaction for a braced sheeting  
Pressures below the slip surface : standard  
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		
Partial factor on earth resistance :	$\gamma_{Re} =$	1,40 [-]

Partial factors on actions (A)				
Seismic design situation				
		Unfavourable	Favourable	
Permanent actions :	$\gamma_G =$	1,10 [-]	1,00	[-]
Variable actions :	$\gamma_Q =$	1,10 [-]	0,00	[-]
Water load :	$\gamma_w =$	1,10 [-]		

Partial factors for resistances (R)		
Seismic design situation		
Partial factor on earth resistance :	$\gamma_{Re} =$	1,20 [-]

#### Anchors

Verification methodology : Limit states (LSD)

Reduction coefficients			
Reduction. coeff of steel strength :	$\gamma_s =$	1,35	[-]
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 = 12,00 m

Cross-section name : Pile curtain d = 0,60 m, a = 1,50 m

Material of pile : concrete

Computed coefficient of pressure reduction below the ditch = 0,84

Area of cross-section  $A = 1,88E-01 \text{ m}^2/\text{m}$

Moment of inertia  $I = 4,24E-03 \text{ m}^4/\text{m}$

## Forces above the slip surface

Depth of slip surface  $h_{s1} = 3,00 \text{ m}$

Input of active horizontal force : active pressure

Input of passive horizontal force : springs

Coeff. of increase of active pressure = 1,00

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

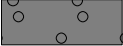
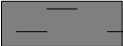


### Transverse reinforcement: B500B

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



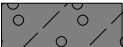
## Modulus of reaction

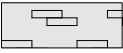
Modulus of subsoil reaction is computed by method Schmitt.

## Basic soil parameters

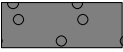

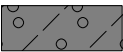

No.	Name	Pattern	$\varphi_{ef}$ [°]	$c_{ef}$ [kPa]	$\gamma$ [kN/m <sup>3</sup> ]	$\gamma_{su}$ [kN/m <sup>3</sup> ]	$\delta$ [°]
1	Tamponsko nasutje - novo		38,00	1,00	20,00	11,00	25,00
2	Melj-glina		27,00	5,00	19,00	10,00	27,00
3	Melj-glina s prehodi v preperino trdne podlage		30,00	10,00	20,00	11,00	30,00
4	Trdna podlaga (kamnina)		35,00	50,00	23,00	14,00	35,00

## Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	$\varphi_{ef}$ [°]	$\nu$ [-]	OCR [-]	$K_r$ [-]
1	Tamponsko nasutje - novo		cohesionless	38,00	-	-	-
2	Melj-glina		cohesive	-	0,30	-	-
3	Melj-glina s prehodi v preperino trdne podlage		cohesive	-	0,30	-	-

No.	Name	Pattern	Type calculation	$\varphi_{ef}$ [°]	$\nu$ [-]	OCR [-]	$K_r$ [-]
4	Trdna podlaga (kamnina)		cohesive	-	0,20	-	-

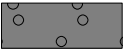

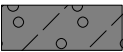

Parameters of soils to compute modulus of subsoil reaction (Schmitt)

No.	Name	Pattern	$\nu$ [-]	$E_{oed}$ [MPa]	$E_{def}$ [MPa]
1	Tamponsko nasutje - novo		0,30	-	45,00
2	Melj-glina		0,30	-	10,00
3	Melj-glina s prehodi v preperino trdne podlage		0,30	-	30,00
4	Trdna podlaga (kamnina)		0,20	-	100,00

Pile fixed into the rock

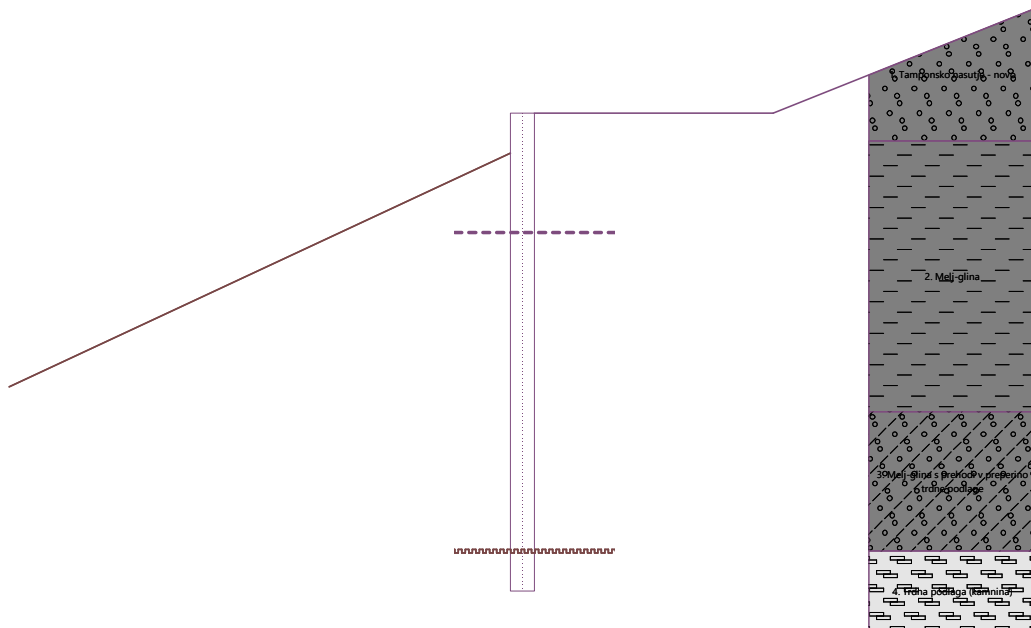
Length of wall in the rock  $l = 1,00$  m  
Bearing capacity of rock  $R = 2000,00$  kPa

Geological profile and assigned soils

No.	Thickness of layer $t$ [m]	Depth $z$ [m]	Assigned soil	Pattern
1	0,70	0,00 .. 0,70	Tamponsko nasutje - novo	
2	6,80	0,70 .. 7,50	Melj-glina	
3	3,50	7,50 .. 11,00	Melj-glina s prehodi v preperino trdne podlage	
4	-	11,00 .. $\infty$	Trdna podlaga (kamnina)	

Name : 1

Stage - analysis : 1 - 0



### Excavation

Soil in front of wall is excavated to a depth of 1,00 m.

Soil slope in front of structure  $\beta = -25,00^\circ$

### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	6,00	0,00
3	16,00	-4,00
4	17,00	-4,00

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

Positive coordinate +z has downward direction.

### Water influence

Ground water table is located below the structure.

### 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)

#### Pressure above the slip surface

Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
0	0,00	-
3,00	0,00	-
3,00	0,00	-

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Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
3,00	0,00	-

Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.19	0.77
0.70	2.80
0.75	2.98
1.00	3.94
1.00	3.94
2.40	12.48
2.40	12.49
3.00	17.01

Distribution of pressures acting on the structure (in front and behind the wall) - below the slip surface

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
3.00	-5.48	-10.91	-49.95	14.29	20.77	170.74
4.89	-14.57	-21.25	-89.96	26.31	33.73	269.71
6.33	-21.44	-29.07	-120.23	35.41	43.54	420.23
7.50	-27.06	-35.45	-144.96	47.88	51.55	543.18
7.50	-19.88	-35.78	-189.73	32.68	51.55	703.78
7.72	-20.86	-37.04	-195.85	33.95	53.13	734.40
8.42	-23.99	-41.09	-215.39	40.09	58.16	832.16
10.99	-35.48	-55.99	-287.31	62.67	76.68	1003.76
11.00	Rock	Rock	Rock	Rock	Rock	Rock
12.00	Rock	Rock	Rock	Rock	Rock	Rock

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	-0.53	0.00	-0.00	0.00
0.60	0.00	0.00	-0.52	2.40	-0.72	0.14
1.00	0.00	0.00	-0.52	3.92	-1.98	0.66
1.00	11.11	0.00	-0.52	-1.81	-1.98	0.67
1.20	11.11	0.00	-0.51	-1.86	-1.62	1.03
1.80	11.11	0.00	-0.51	-2.02	-0.46	1.66
2.40	11.11	0.00	-0.51	-2.23	0.81	1.56
3.00	11.11	0.00	-0.51	-1.62	1.96	0.72
3.00	11.11	11.11	-0.51	-1.41	1.98	0.70
3.60	11.11	11.11	-0.51	-0.67	2.60	-0.69
4.20	11.11	11.11	-0.51	0.12	2.77	-2.32
4.80	11.11	11.11	-0.51	1.05	2.42	-3.90
5.40	11.11	11.11	-0.49	2.22	1.45	-5.10
6.00	11.11	11.11	-0.46	3.69	-0.30	-5.49
6.60	11.11	11.11	-0.42	5.49	-3.04	-4.54

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]
7.20	11.11	11.11	-0.37	7.55	-6.94	-1.61
7.80	48.07	48.07	-0.31	-13.28	-4.88	2.89
8.40	48.07	48.07	-0.25	-7.41	1.28	3.79
9.00	48.07	48.07	-0.21	-2.49	4.21	1.99
9.60	48.07	48.07	-0.17	1.93	4.37	-0.71
10.20	48.07	48.07	-0.14	6.51	1.87	-2.72
10.80	48.07	48.07	-0.09	11.75	-3.57	-2.37
11.40	185.31	0.00	-0.04	-7.17	-1.39	-0.13
12.00	0.00	185.31	0.01	2.54	0.00	-0.00

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

Maximum shear force = 8,86 kN/m  
Maximum moment = 5,50 kNm/m  
Maximum displacement = 0,5 mm  
Displacement in the depth of slip surface = 0,5 mm

#### Maximum internal forces on cross-section

Maximum shear force = 13,29 kN  
Maximum moment = 8,26 kNm

#### Verification of rock bearing capacity

Bearing capacity of rock  $R = 2000,00$  kPa  
Partial factor on rock bearing capacity  $\gamma_{Rr} = 1,40$   
Max. stress  $\sigma = 12,96$  kPa  
Design bearing capacity of rock  $R_d = 1428,57$  kPa

**Bearing capacity of rock is SATISFACTORY**

#### Verification of rock bearing capacity

Bearing capacity of rock  $R = 2000,00$  kPa  
Partial factor on rock bearing capacity  $\gamma_{Rr} = 1,40$   
Max. stress  $\sigma = 12,96$  kPa  
Design bearing capacity of rock  $R_d = 1428,57$  kPa

**Bearing capacity of rock is SATISFACTORY**

#### Terrain settlement behind the structure

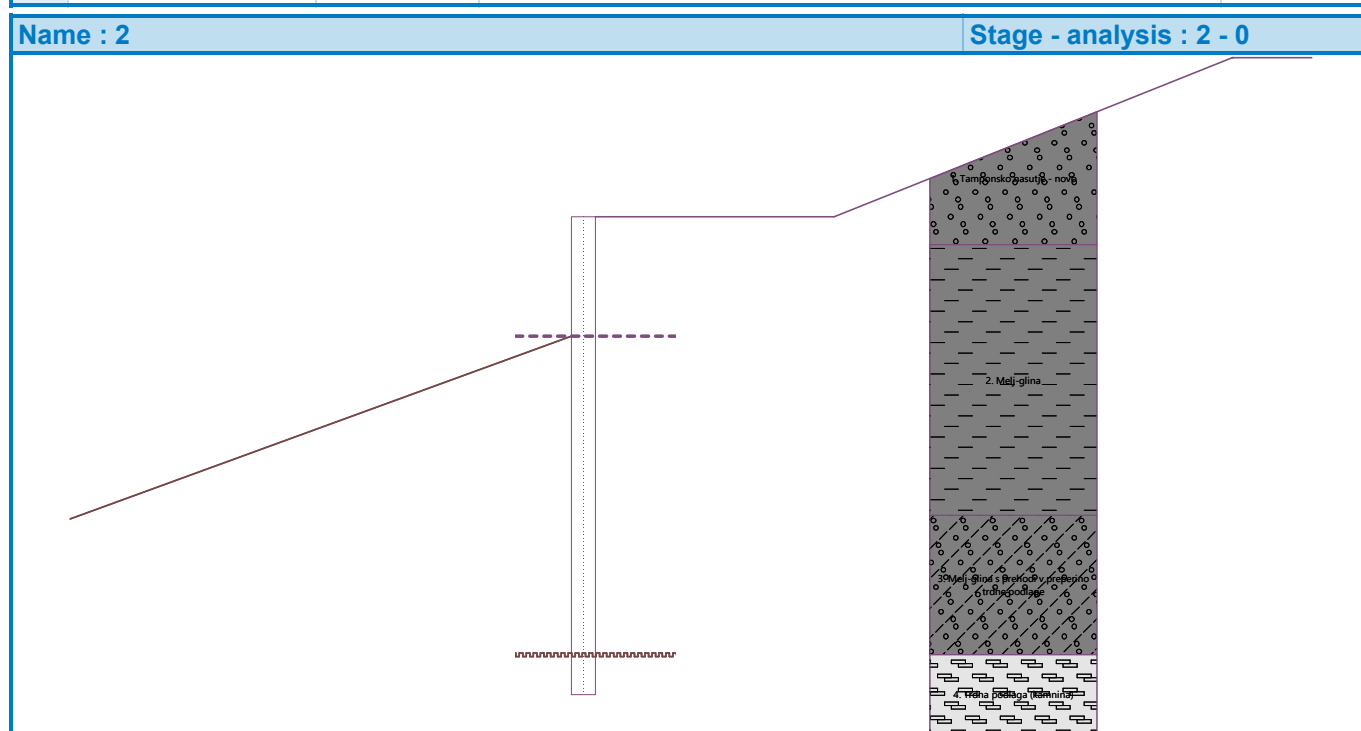
Terrain settlement  $\delta_{max} = 0,5$  mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	0,3
2	1,14	0,4
3	2,28	0,6
4	3,42	0,6
5	4,56	0,7
6	5,70	0,7
7	6,84	0,6
8	7,98	0,5
9	9,12	0,4
10	10,26	0,2
11	11,40	0,0
12	11,40	0,0

## Input data (Stage of construction 2)

### Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,70	0,00 .. 0,70	Tamponsko nasutje - novo	
2	6,80	0,70 .. 7,50	Melj-glina	
3	3,50	7,50 .. 11,00	Melj-glina s prehodi v preperino trdne podlage	
4	-	11,00 .. ∞	Trdna podlaga (kamnina)	



### Forces above the slip surface

#### Excavation

Soil in front of wall is excavated to a depth of 3,00 m.

Soil slope in front of structure  $\beta = -20,00^\circ$

#### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	6,00	0,00
3	16,00	-4,00
4	17,00	-4,00

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

Positive coordinate +z has downward direction.

#### Water influence

Ground water table is located below the structure.

## Settings of the stage of construction

Design situation : permanent

## Analysis results (Stage of construction 2)

### Pressure above the slip surface

Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
0	0,00	-
3,00	0,00	-
3,00	0,00	-
3,00	0,00	-

### Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.19	0.77
0.70	2.80
0.75	2.98
2.40	12.48
2.40	12.49
3.00	17.01

### Distribution of pressures acting on the structure (in front and behind the wall) - below the slip surface

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
3.00	0.00	-0.00	-9.99	17.01	17.01	17.01
3.01	0.00	-0.06	-8.65	14.35	20.84	171.26
3.51	0.00	-2.92	-21.22	17.55	24.28	197.56
3.78	0.00	-4.46	-27.99	19.27	26.14	211.71
3.96	-0.51	-5.44	-32.27	20.35	27.31	220.66
4.89	-5.26	-10.78	-55.73	26.31	33.73	269.71
6.33	-12.50	-18.94	-91.55	35.41	43.54	420.23
7.50	-18.41	-25.60	-120.80	47.88	51.55	543.18
7.50	-12.03	-25.80	-159.27	32.68	51.55	703.78
7.72	-13.06	-27.12	-166.48	33.95	53.13	734.40
8.42	-16.34	-31.34	-189.49	40.09	58.16	832.16
10.99	-28.43	-46.86	-274.18	62.67	76.68	1003.76
11.00	Rock	Rock	Rock	Rock	Rock	Rock
12.00	Rock	Rock	Rock	Rock	Rock	Rock

### 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	-12.61	0.00	-0.00	0.00
0.60	0.00	0.00	-11.34	2.40	-0.72	0.14
1.20	0.00	0.00	-10.08	5.58	-3.06	1.18
1.80	0.00	0.00	-8.82	9.03	-7.44	4.22
2.40	0.00	0.00	-7.57	12.48	-13.89	10.52



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]
3.00	0.00	0.00	-6.36	16.98	-22.67	21.28
3.01	0.00	0.00	-6.32	5.64	-22.83	21.69
3.60	0.00	0.00	-5.19	-5.29	-22.93	35.41
4.20	0.00	0.00	-4.13	-16.47	-16.41	47.55
4.80	11.11	0.00	-3.19	-20.02	-3.97	53.75
5.40	11.11	0.00	-2.41	-10.87	5.21	53.10
6.00	11.11	0.00	-1.76	-3.33	9.39	48.49
6.60	11.11	0.00	-1.25	3.91	9.34	42.66
7.20	11.11	0.00	-0.86	11.26	4.73	38.22
7.80	48.07	0.00	-0.57	-20.32	7.96	35.93
8.40	48.07	0.00	-0.38	-9.47	16.69	28.21
9.00	48.07	48.07	-0.26	2.20	19.01	17.08
9.60	48.07	48.07	-0.20	9.44	15.36	6.56
10.20	48.07	48.07	-0.15	14.86	8.04	-0.62
10.80	48.07	48.07	-0.10	20.32	-2.49	-2.45
11.40	185.31	0.00	-0.04	-7.72	-1.53	-0.15
12.00	0.00	185.31	0.01	2.64	0.00	-0.00

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

Maximum shear force = 23,66 kN/m  
 Maximum moment = 54,16 kNm/m  
 Maximum displacement = 12,6 mm  
 Displacement in the depth of slip surface = 6,4 mm

#### Maximum internal forces on cross-section

Maximum shear force = 35,50 kN  
 Maximum moment = 81,24 kNm

#### Verification of rock bearing capacity

Bearing capacity of rock  $R = 2000,00$  kPa  
 Partial factor on rock bearing capacity  $\gamma_{Rr} = 1,40$   
 Max. stress  $\sigma = 13,89$  kPa  
 Design bearing capacity of rock  $R_d = 1428,57$  kPa

**Bearing capacity of rock is SATISFACTORY**

#### Verification of rock bearing capacity

Bearing capacity of rock  $R = 2000,00$  kPa  
 Partial factor on rock bearing capacity  $\gamma_{Rr} = 1,40$   
 Max. stress  $\sigma = 13,89$  kPa  
 Design bearing capacity of rock  $R_d = 1428,57$  kPa

**Bearing capacity of rock is SATISFACTORY**

#### Terrain settlement behind the structure

Terrain settlement  $\delta_{max} = 4,1$  mm

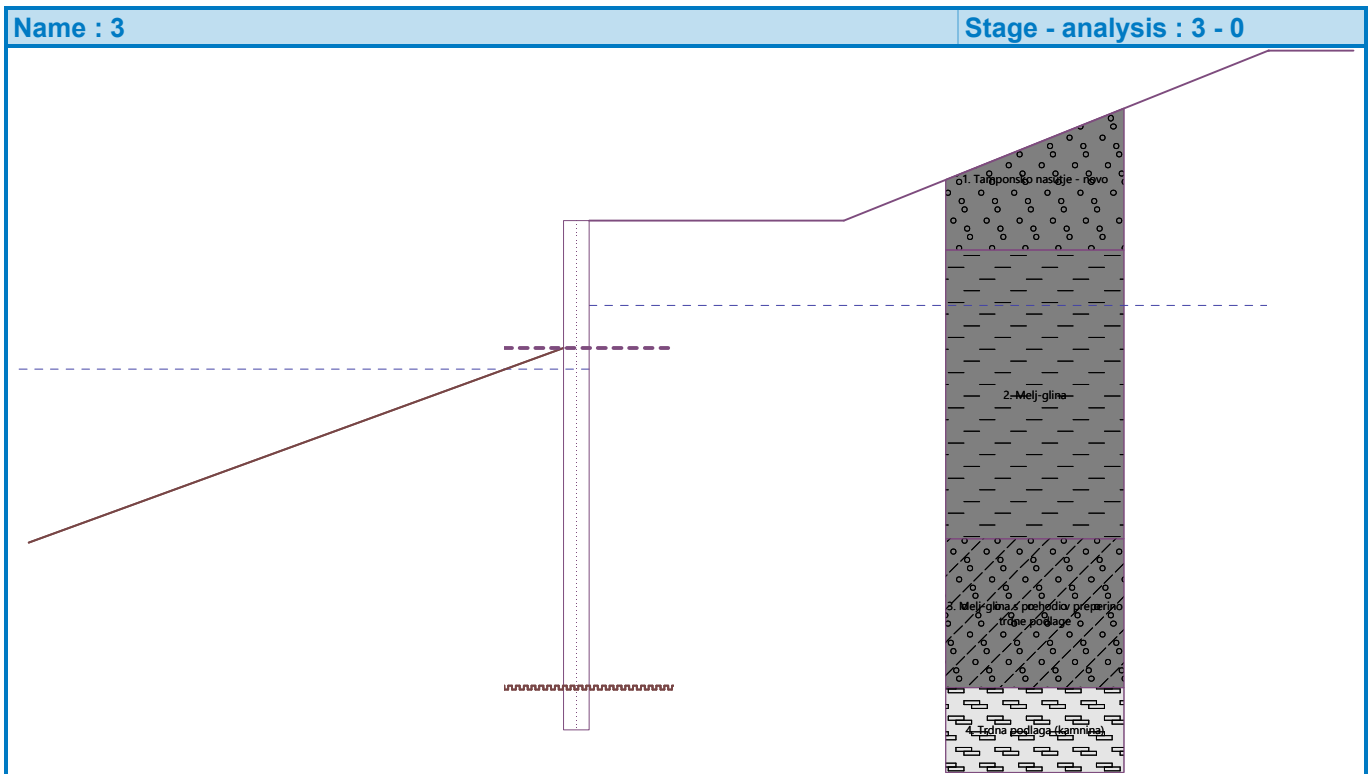
	Coordinates x [m]	Settlement z [mm]
1	0,00	6,3
2	1,14	7,1
3	2,28	7,6
4	3,42	7,8

	Coordinates x [m]	Settlement z [mm]
5	4,56	7,7
6	5,70	7,2
7	6,84	6,4
8	7,98	5,3
9	9,12	3,9
10	10,26	2,1
11	11,40	0,0
12	11,40	0,0

### Input data (Stage of construction 3)

#### Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,70	0,00 .. 0,70	Tamponsko nasutje - novo	
2	6,80	0,70 .. 7,50	Melj-glina	
3	3,50	7,50 .. 11,00	Melj-glina s prehodi v preperino trdne podlage	
4	-	11,00 .. ∞	Trdna podlaga (kamnina)	



#### Forces above the slip surface

##### Excavation

Soil in front of wall is excavated to a depth of 3,00 m.

Soil slope in front of structure  $\beta = -20,00^\circ$

### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	6,00	0,00
3	16,00	-4,00
4	17,00	-4,00

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 not permeable.

### Settings of the stage of construction

Design situation : permanent

### Analysis results (Stage of construction 3)

#### Pressure above the slip surface

Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
0	0,00	-
3,00	0,00	-
3,00	0,00	-
3,00	0,00	-

#### Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.19	0.77
0.70	2.80
0.75	2.98
2.00	9.46
2.40	16.45
2.40	16.47
3.00	26.93

#### Distribution of pressures acting on the structure (in front and behind the wall) - below the slip surface

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
3.00	0.00	-0.00	-9.99	26.93	26.93	26.93
3.01	0.00	-0.06	-8.65	22.77	26.05	152.33
3.50	0.00	-2.85	-20.88	29.96	31.93	168.74
3.53	0.00	-2.92	-21.22	30.05	32.02	169.45
4.04	0.00	-4.46	-27.99	31.77	33.88	183.60
4.18	-0.01	-4.88	-29.80	32.23	34.37	187.38
7.50	-8.84	-14.82	-73.47	43.32	46.33	278.70
7.50	-3.57	-14.94	-100.00	35.24	46.33	366.67
10.99	-12.59	-26.52	-163.20	46.44	60.15	635.10

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Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
11.00	Rock	Rock	Rock	Rock	Rock	Rock
12.00	Rock	Rock	Rock	Rock	Rock	Rock

**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	-36.87	0.00	0.00	0.00
0.60	0.00	0.00	-33.63	2.40	-0.72	0.14
1.20	0.00	0.00	-30.39	5.32	-3.00	1.17
1.80	0.00	0.00	-27.16	8.42	-7.12	4.11
2.40	0.00	0.00	-23.93	16.45	-14.11	10.23
3.00	0.00	0.00	-20.76	26.86	-27.02	22.17
3.01	0.00	0.00	-20.66	14.09	-27.35	22.66
3.60	0.00	0.00	-17.60	8.10	-33.84	40.76
4.20	0.00	0.00	-14.58	2.21	-36.93	62.17
4.80	0.00	0.00	-11.73	-3.67	-36.49	84.37
5.40	0.00	0.00	-9.12	-9.55	-32.53	105.25
6.00	0.00	0.00	-6.78	-15.44	-25.03	122.69
6.60	0.00	0.00	-4.79	-21.32	-14.00	134.58
7.20	11.11	0.00	-3.16	-6.68	-4.80	139.61
7.80	0.00	0.00	-1.91	-69.23	16.12	139.13
8.40	48.07	0.00	-1.04	-29.61	45.75	119.12
9.00	48.07	0.00	-0.49	-3.28	54.93	88.12
9.60	48.07	0.00	-0.18	11.46	52.01	55.60
10.20	48.07	48.07	-0.02	30.76	38.62	27.74
10.80	48.07	48.07	0.05	38.46	17.61	10.64
11.40	0.00	9.27	0.10	1.27	9.98	3.79
12.00	0.00	185.31	0.13	23.92	0.00	0.00

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

Maximum shear force = 55,10 kN/m  
Maximum moment = 141,04 kNm/m  
Maximum displacement = 36,9 mm  
Displacement in the depth of slip surface = 20,7 mm

**Maximum internal forces on cross-section**

Maximum shear force = 82,65 kN  
Maximum moment = 211,56 kNm

**Verification of rock bearing capacity**

Bearing capacity of rock R = 2000,00 kPa  
Partial factor on rock bearing capacity  $\gamma_{Rr}$  = 1,40  
Max. stress  $\sigma$  = 23,92 kPa  
Design bearing capacity of rock  $R_d$  = 1428,57 kPa

**Bearing capacity of rock is SATISFACTORY**

**Verification of rock bearing capacity**

Bearing capacity of rock R = 2000,00 kPa  
Partial factor on rock bearing capacity  $\gamma_{Rr}$  = 1,40  
Max. stress  $\sigma$  = 23,92 kPa

Design bearing capacity of rock  $R_d = 1428,57 \text{ kPa}$

**Bearing capacity of rock is SATISFACTORY**

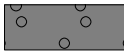

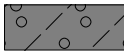

**Terrain settlement behind the structure**

Terrain settlement  $\delta_{\max} = 13,4 \text{ mm}$

	Coordinates x [m]	Settlement z [mm]
1	0,00	18,4
2	1,14	21,4
3	2,28	23,3
4	3,42	24,2
5	4,56	23,9
6	5,70	22,6
7	6,84	20,3
8	7,98	16,8
9	9,12	12,3
10	10,26	6,7
11	11,40	0,0
12	11,40	0,0

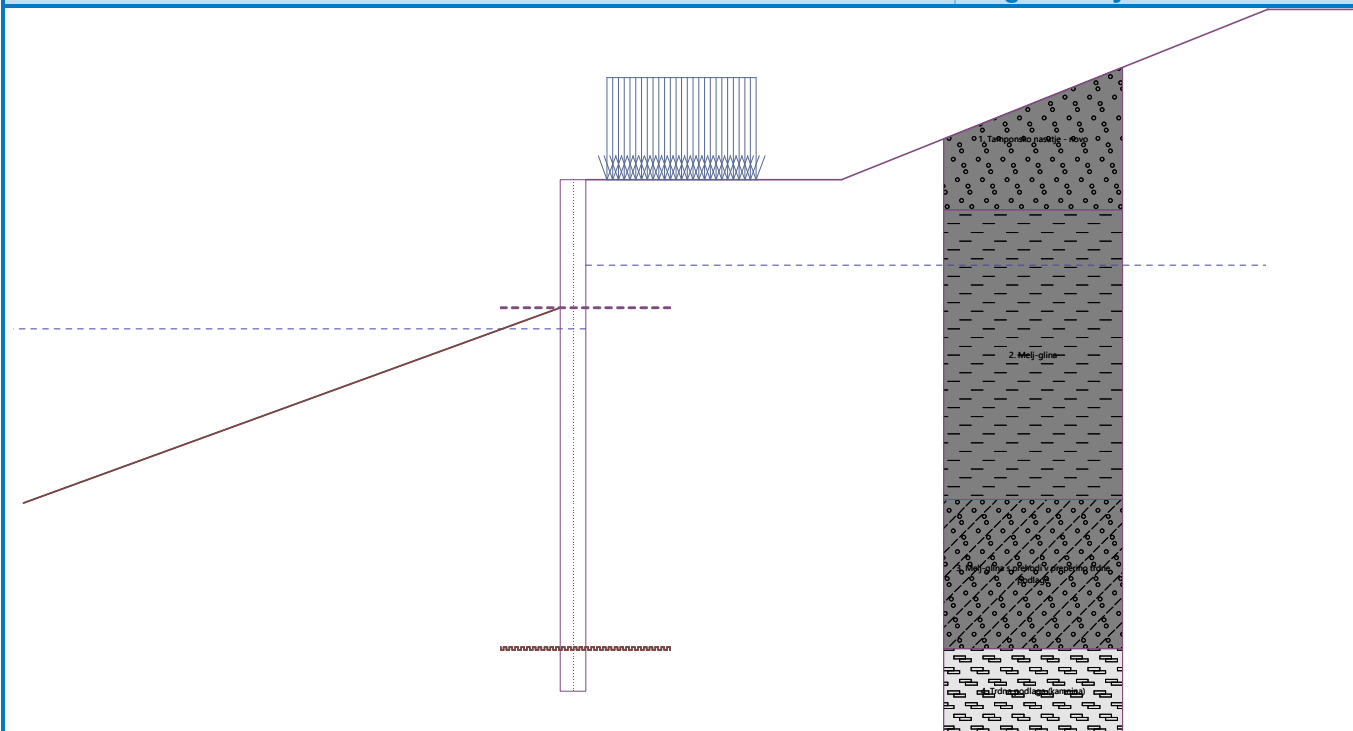
#### Input data (Stage of construction 4)

**Geological profile and assigned soils**

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,70	0,00 .. 0,70	Tamponsko nasutje - novo	
2	6,80	0,70 .. 7,50	Melj-glina	
3	3,50	7,50 .. 11,00	Melj-glina s prehodi v preperino trdne podlage	
4	-	11,00 .. ∞	Trdna podlaga (kamnina)	

Name : 4

Stage - analysis : 4 - 0



### Forces above the slip surface

#### Excavation

Soil in front of wall is excavated to a depth of 3,00 m.

Soil slope in front of structure  $\beta = -20,00^\circ$

#### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	6,00	0,00
3	16,00	-4,00
4	17,00	-4,00

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 not permeable.

#### 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	14,00		0,50	3,50	on terrain

No.	Name
1	Prometna obtežba

#### Settings of the stage of construction

Design situation : permanent

## Analysis results (Stage of construction 4)

### Pressure above the slip surface

Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
0	0,00	-
3,00	0,00	-
3,00	0,00	-
3,00	0,00	-

### Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.00	0.00
0.19	0.77
0.39	1.56
0.39	5.33
0.70	6.93
0.70	5.76
0.75	6.15
0.75	6.31
2.00	15.44
2.00	15.44
2.40	22.32
2.40	16.45
2.40	22.35
3.00	32.66

### Distribution of pressures acting on the structure (in front and behind the wall) - below the slip surface

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
3.00	0.00	-0.00	-9.99	32.65	32.65	32.65
3.01	0.00	-0.06	-8.65	27.58	29.36	152.33
3.50	0.00	-2.85	-20.88	34.66	34.66	168.74
3.50	0.00	-2.85	-20.88	34.67	34.67	168.74
3.53	0.00	-2.92	-21.22	34.75	34.75	169.45
3.53	0.00	-2.93	-21.27	34.77	34.77	169.55
4.04	0.00	-4.46	-27.99	36.35	36.35	183.60
4.18	-0.01	-4.88	-29.80	36.78	36.78	187.38
4.24	-0.17	-5.05	-30.55	36.96	36.96	188.95
4.94	-2.04	-7.16	-39.83	39.15	39.15	208.36
5.65	-3.92	-9.27	-49.11	41.34	41.34	227.76
5.75	-4.19	-9.58	-50.45	41.66	41.66	230.55
5.75	-4.19	-9.58	-50.45	37.47	41.07	230.55
6.35	-5.79	-11.39	-58.39	39.49	43.03	247.17
7.06	-7.67	-13.50	-67.67	41.85	45.39	266.57
7.50	-8.84	-14.82	-73.47	43.32	46.89	278.70
7.50	-3.57	-14.94	-100.00	35.24	46.89	366.67

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Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
7.76	-4.26	-15.82	-104.79	36.09	47.89	387.03
8.47	-6.08	-18.16	-117.58	38.36	50.59	441.32
9.18	-7.91	-20.50	-130.36	40.62	53.31	495.61
9.88	-9.73	-22.85	-143.14	42.89	56.04	549.91
10.59	-11.55	-25.19	-155.93	45.15	58.79	604.20
10.99	-12.59	-26.52	-163.20	46.44	60.36	635.10
11.00	Rock	Rock	Rock	Rock	Rock	Rock
11.29	Rock	Rock	Rock	Rock	Rock	Rock
12.00	Rock	Rock	Rock	Rock	Rock	Rock

#### 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	-69.18	0.00	-0.00	-0.00
0.60	0.00	0.00	-63.31	6.41	-1.42	0.21
1.20	0.00	0.00	-57.45	9.61	-5.93	2.30
1.80	0.00	0.00	-51.59	13.98	-13.00	7.84
2.40	0.00	0.00	-45.75	22.32	-23.51	18.54
3.00	0.00	0.00	-40.00	32.59	-39.88	37.12
3.01	0.00	0.00	-39.83	18.89	-40.30	37.85
3.60	0.00	0.00	-34.29	12.79	-49.57	64.35
4.20	0.00	0.00	-28.78	6.76	-55.44	96.04
4.80	0.00	0.00	-23.54	0.74	-57.69	130.16
5.40	0.00	0.00	-18.66	-5.29	-56.32	164.54
6.00	0.00	0.00	-14.23	-15.44	-50.10	196.83
6.60	0.00	0.00	-10.33	-21.32	-39.07	223.76
7.20	0.00	0.00	-7.05	-27.21	-24.51	243.01
7.80	0.00	0.00	-4.43	-69.23	4.21	250.86
8.40	0.00	0.00	-2.49	-78.17	48.43	235.33
9.00	48.07	0.00	-1.19	-36.82	86.46	193.19
9.60	48.07	0.00	-0.41	0.41	96.29	137.26
10.20	48.07	48.07	-0.01	32.52	86.54	81.35
10.80	48.07	48.07	0.17	49.65	61.14	36.53
11.40	0.00	185.31	0.24	51.48	30.37	9.08
12.00	0.00	185.31	0.28	51.42	0.00	-0.00

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

Maximum shear force = 96,29 kN/m  
 Maximum moment = 250,87 kNm/m  
 Maximum displacement = 69,2 mm  
 Displacement in the depth of slip surface = 40,0 mm

#### Maximum internal forces on cross-section

Maximum shear force = 144,44 kN  
 Maximum moment = 376,30 kNm

#### Verification of rock bearing capacity

Bearing capacity of rock R = 2000,00 kPa  
 Partial factor on rock bearing capacity  $\gamma_{Rr}$  = 1,40



Max. stress  $\sigma = 51,68 \text{ kPa}$   
 Design bearing capacity of rock  $R_d = 1428,57 \text{ kPa}$

**Bearing capacity of rock is SATISFACTORY**

#### Verification of rock bearing capacity

Bearing capacity of rock  $R = 2000,00 \text{ kPa}$   
 Partial factor on rock bearing capacity  $\gamma_{Rr} = 1,40$   
 Max. stress  $\sigma = 51,68 \text{ kPa}$   
 Design bearing capacity of rock  $R_d = 1428,57 \text{ kPa}$

**Bearing capacity of rock is SATISFACTORY**



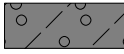

#### Terrain settlement behind the structure

Terrain settlement  $\delta_{\max} = 26,5 \text{ mm}$

	Coordinates x [m]	Settlement z [mm]
1	0,00	34,5
2	1,14	40,5
3	2,28	44,5
4	3,42	46,3
5	4,56	46,1
6	5,70	43,7
7	6,84	39,2
8	7,98	32,6
9	9,12	23,8
10	10,26	13,0
11	11,40	0,0
12	11,40	0,0

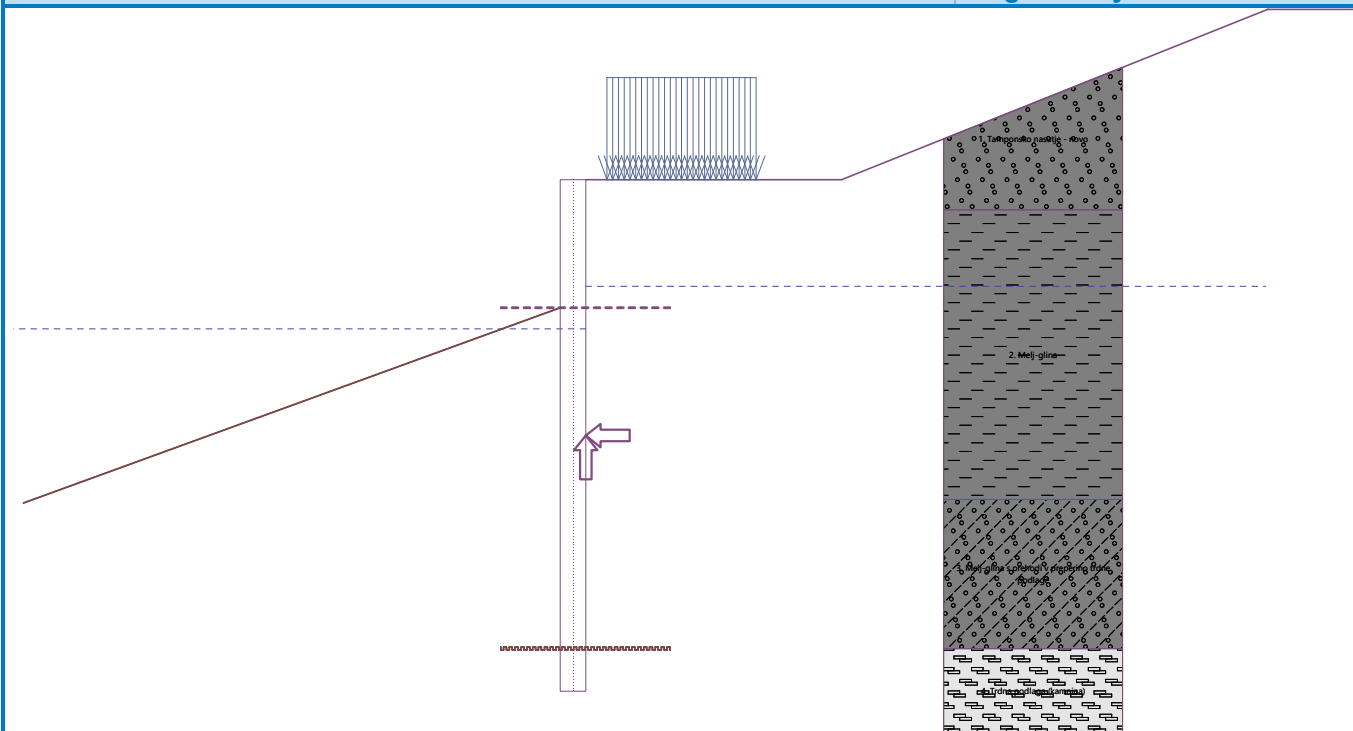
#### Input data (Stage of construction 5)

##### Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,70	0,00 .. 0,70	Tamponsko nasutje - novo	
2	6,80	0,70 .. 7,50	Melj-glina	
3	3,50	7,50 .. 11,00	Melj-glina s prehodi v preperino trdne podlage	
4	-	11,00 .. ∞	Trdna podlaga (kamnina)	

Name : 5

Stage - analysis : 5 - 0



### Forces above the slip surface

#### Excavation

Soil in front of wall is excavated to a depth of 3,00 m.

Soil slope in front of structure  $\beta = -20,00^\circ$

#### Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	6,00	0,00
3	16,00	-4,00
4	17,00	-4,00

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 2,50 m

GWT in front of the structure lies at a depth of 3,50 m

Subgrade at the heel is not permeable.

#### 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	14,00		0,50	3,50	on terrain

No.	Name
1	Prometna obtežba

#### Earthquake

Factor of horizontal acceleration  $K_h = 0,0200$

Factor of vertical acceleration  $K_v = 0,0100$

Water below the GWT is restricted.

### Settings of the stage of construction

Design situation : seismic

### Analysis results (Stage of construction 5)

#### Pressure above the slip surface

Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
0	0,00	-
3,00	0,00	-
3,00	0,00	-
3,00	0,00	-

#### Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	1.55
0.00	1.55
0.19	1.51
0.39	2.33
0.39	3.27
0.70	4.53
0.70	3.20
0.75	3.27
0.75	3.31
2.40	12.94
2.40	10.17
2.40	11.47
2.40	12.94
2.50	13.52
2.50	15.06
3.00	22.00

#### Distribution of pressures acting on the structure (in front and behind the wall) - below the slip surface

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
3.00	0.00	-0.00	-11.66	19.16	19.16	19.16
3.01	-0.06	-0.06	-3.47	18.60	26.78	167.43
3.50	-0.64	-2.85	-18.36	24.32	32.01	187.63
3.50	-1.30	-2.85	-11.99	24.65	32.34	187.63
3.53	-1.30	-2.92	-12.42	24.72	32.40	188.52
3.53	-1.29	-2.93	-12.48	24.73	32.41	188.64
4.04	-1.22	-4.46	-21.00	26.03	33.81	206.15
4.18	-1.22	-4.88	-23.30	26.38	34.18	210.86
4.24	-1.33	-5.05	-24.25	26.52	34.34	212.82
4.94	-2.76	-7.16	-36.02	28.32	36.47	237.00
5.65	-4.19	-9.27	-47.79	30.11	38.75	261.17
5.72	-4.33	-9.48	-48.94	30.29	38.98	263.53
5.72	-4.33	-9.48	-48.94	29.36	38.98	263.53

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
6.35	-5.62	-11.39	-59.56	31.02	41.12	285.35
7.05	-7.03	-13.48	-71.20	32.82	43.53	309.24
7.06	-7.05	-13.50	-71.34	32.85	43.56	309.80
7.50	-7.94	-14.82	-78.69	33.99	45.11	339.20
7.50	-3.58	-14.94	-109.65	27.08	45.11	445.04
7.76	-4.10	-15.82	-115.63	27.74	46.15	469.68
8.47	-5.49	-18.16	-131.58	29.51	48.92	535.38
9.18	-6.88	-20.50	-147.53	31.27	51.73	601.08
9.88	-8.26	-22.85	-163.48	33.04	54.54	666.78
10.59	-9.65	-25.19	-179.44	34.80	57.38	732.48
10.99	-10.44	-26.52	-188.51	35.81	58.99	769.87
11.00	Rock	Rock	Rock	Rock	Rock	Rock
11.29	Rock	Rock	Rock	Rock	Rock	Rock
12.00	Rock	Rock	Rock	Rock	Rock	Rock

#### 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	-65.39	1.55	-0.00	-0.00
0.60	0.00	0.00	-59.91	4.12	-1.43	0.34
1.20	0.00	0.00	-54.43	5.95	-4.06	1.91
1.80	0.00	0.00	-48.96	9.44	-8.67	5.62
2.40	0.00	0.00	-43.51	12.94	-15.39	12.74
3.00	0.00	0.00	-38.13	21.95	-25.96	24.80
3.01	0.00	11.11	-37.97	35.78	-26.11	25.27
3.60	0.00	11.11	-32.74	28.37	-43.22	45.93
4.20	0.00	11.11	-27.53	16.72	-56.73	76.30
4.80	0.00	11.11	-22.52	5.66	-63.42	112.72
5.40	0.00	11.11	-17.82	-4.90	-63.63	151.19
6.00	0.00	11.11	-13.54	-15.96	-57.37	187.87
6.60	0.00	11.11	-9.77	-25.81	-44.84	218.86
7.20	0.00	11.11	-6.60	-35.51	-26.45	240.56
7.80	0.00	48.07	-4.09	-72.18	5.63	247.94
8.40	48.07	48.07	-2.24	-84.70	54.12	230.42
9.00	48.07	48.07	-1.03	-30.75	87.35	186.40
9.60	48.07	48.07	-0.32	1.06	95.55	130.62
10.20	48.07	48.07	0.03	35.24	83.32	75.94
10.80	48.07	48.07	0.17	49.15	57.30	33.35
11.40	0.00	185.31	0.22	48.46	27.31	8.03
12.00	0.00	185.31	0.24	44.25	0.00	0.00

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

Maximum shear force = 95,55 kN/m  
Maximum moment = 248,09 kNm/m  
Maximum displacement = 65,4 mm  
Displacement in the depth of slip surface = 38,1 mm

### Maximum internal forces on cross-section

Maximum shear force = 143,33 kN

Maximum moment = 372,14 kNm

### Verification of rock bearing capacity

Max. stress  $\sigma$  = 50,83 kPa

Design bearing capacity of rock  $R_d$  = 2000,00 kPa

**Bearing capacity of rock is SATISFACTORY**

### Verification of rock bearing capacity

Max. stress  $\sigma$  = 50,83 kPa

Design bearing capacity of rock  $R_d$  = 2000,00 kPa

**Bearing capacity of rock is SATISFACTORY**

### Terrain settlement behind the structure

Terrain settlement  $\delta_{\max}$  = 25,1 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	32,6
2	1,14	38,4
3	2,28	42,2
4	3,42	43,9
5	4,56	43,7
6	5,70	41,4
7	6,84	37,2
8	7,98	30,9
9	9,12	22,6
10	10,26	12,3
11	11,40	0,0
12	11,40	0,0

## 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	-69.18	-0.53	-0.00	0.00	-0.00	0.00
0.60	-63.31	-0.52	-1.43	-0.72	0.14	0.34
1.00	-59.44	-0.52	-4.13	-1.98	0.66	1.29
1.00	-59.36	-0.52	-4.19	-1.98	0.67	1.33
1.20	-57.45	-0.51	-5.93	-1.62	1.03	2.30
1.80	-51.59	-0.51	-13.00	-0.46	1.66	7.84
2.40	-45.75	-0.51	-23.51	0.81	1.56	18.54
3.00	-40.00	-0.51	-39.88	1.96	0.72	37.12
3.00	-40.00	-0.51	-39.88	1.96	0.72	37.12
3.00	-39.93	-0.51	-40.10	1.98	0.70	37.44
3.00	-39.93	-0.51	-40.10	1.98	0.70	37.44
3.01	-39.83	-0.51	-40.30	1.99	0.68	37.85
3.01	-39.83	-0.51	-40.30	1.99	0.68	37.85
3.60	-34.29	-0.51	-49.57	2.60	-0.69	64.35
4.20	-28.78	-0.51	-56.73	2.77	-2.32	96.04

	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
4.80	-23.54	-0.51	-63.42	2.42	-3.90	130.16
5.40	-18.66	-0.49	-63.63	5.21	-5.10	164.54
6.00	-14.23	-0.46	-57.37	9.39	-5.49	196.83
6.60	-10.33	-0.42	-44.84	9.34	-4.54	223.76
7.20	-7.05	-0.37	-26.45	4.73	-1.61	243.01
7.80	-4.43	-0.31	-4.88	16.12	2.89	250.86
8.40	-2.49	-0.25	1.28	54.12	3.79	235.33
9.00	-1.19	-0.21	4.21	87.35	1.99	193.19
9.60	-0.41	-0.17	4.37	96.29	-0.71	137.26
10.20	-0.15	0.03	1.87	86.54	-2.72	81.35
10.80	-0.10	0.17	-3.57	61.14	-2.45	36.53
11.40	-0.04	0.24	-1.53	30.37	-0.15	9.08
12.00	0.01	0.28	0.00	0.00	-0.00	0.00

#### Maximum values of internal forces

Maximum displacement = -69,2 mm  
 Minimum displacement = 0,3 mm  
 Maximum bending moment = 250,87 kNm/m  
 Minimum bending moment = -5,50 kNm/m  
 Maximum shear force = 96,29 kN/m

#### Verification of RC cross section (Pile curtain $d = 0,60$ m, $a = 1,50$ 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  $\rho = 1,042 \% > 0,135 \% = \rho_{\min}$

Load :  $M_{Ed} = 376,30$  kNm

Bearing capacity :  $M_{Rd} = 447,78$  kNm

**Designed pile reinforcement is SATISFACTORY**

#### Verification of cross section in shear:

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

$A_{sw} = 2 \times 523,6 = 1047,2$  mm<sup>2</sup>

$b_w = 0,53$  m;  $d = 0,48$  m

Ultimate shear force:  $V_{Rd} = 491,73$  kN  $> 144,44$  kN  $= V_{Ed}$

**Cross-section is SATISFACTORY.**

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

#### Verification of lagging 1

##### Input data

Concrete : C 30/37

Longitudinal reinforcement : B500B

Transverse reinforcement : B500B

Cross section type : rectangle  $b \times h = 150,0 \times 1750,0$  mm

structure section (0,00-1,75 m)

Type of load : rectangle

#### Verification of RC cross section ( $b = 1,75$ m; $h = 0,15$ m)

All construction stages are taken into the analysis.

Partial factor on load = 1,00

Reinforcement - 18 pc bars 7,0 mm; cover 100,0 mm

Shear reinf. - 2 profile 7,0 mm; distance 100,0 mm

Reinforcement ratio  $\rho = 0,85 \% > 0,15 \% = \rho_{\min}$

Position of neutral axis  $x = 0,01 \text{ m} < 0,03 \text{ m} = x_{\max}$

Ultimate shear force  $V_{Rd} = 57,51 \text{ kN} > 17,87 \text{ kN} = V_{Ed}$

Ultimate moment  $M_{Rd} = 12,71 \text{ kNm} > 6,70 \text{ kNm} = M_{Ed}$

**Cross-section is SATISFACTORY.**

Lagging scheme

