

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 = 9,00 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 $f_{yk} = 500,00 \text{ MPa}$



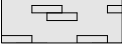
Transverse reinforcement: B500B

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



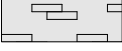
Modulus of reaction

Modulus of subsoil reaction is computed by method Schmitt.




Basic soil parameters

No.	Name	Pattern	Φ_{ef} [°]	C_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ [°]
1	Tamponsko nasutje - novo		38,00	1,00	20,00	11,00	25,00
2	Melj-glina		25,00	4,00	19,00	10,00	25,00
3	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	Φ_{ef} [°]	ν [-]	OCR [-]	K_r [-]
1	Tamponsko nasutje - novo		cohesionless	38,00	-	-	-
2	Melj-glina		cohesive	-	0,30	-	-
3	Trdna podlaga (kamnina)		cohesive	-	0,20	-	-

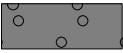


Parameters of soils to compute modulus of subsoil reaction (Schmitt)

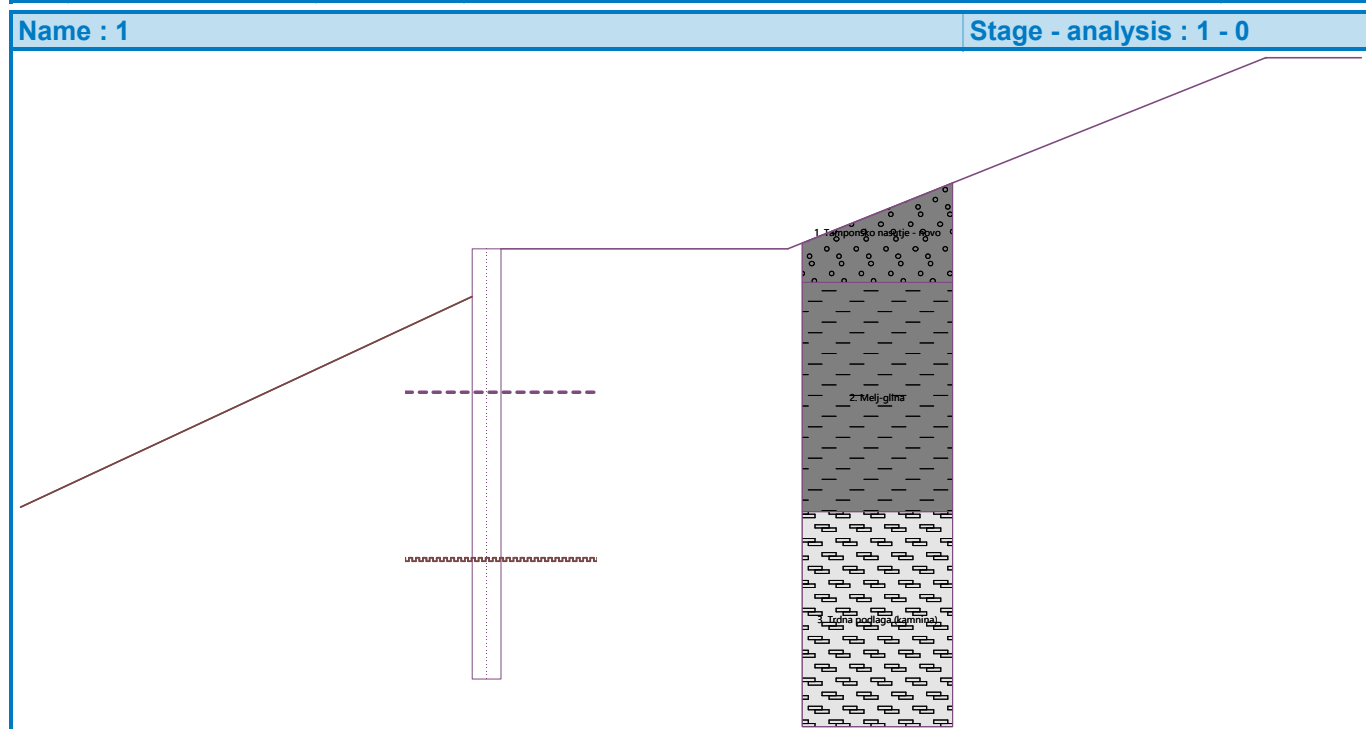
No.	Name	Pattern	ν [-]	E_{oed} [MPa]	E_{def} [MPa]
1	Tamponsko nasutje - novo		0,30	-	45,00
2	Melj-glina		0,30	-	10,00
3	Trdna podlaga (kamnina)		0,20	-	100,00

Pile fixed into the rock

Length of wall in the rock $l = 2,50$ 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	4,80	0,70 .. 5,50	Melj-glina	
3	-	5,50 .. ∞	Trdna podlaga (kamnina)	



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	-
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
1.00	3.94
1.00	3.94
2.40	15.09
2.40	15.10
3.00	20.04

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	-6.96	-10.85	-40.71	16.84	20.77	143.62
5.35	-19.19	-23.61	-81.91	33.15	36.86	247.89
5.50	-19.96	-24.41	-84.50	34.17	37.87	260.03
5.50	0.00	-14.68	-296.42	17.67	22.09	838.76
5.83	0.00	-15.97	-313.23	18.93	23.67	918.76
6.49	0.00	-18.59	-347.42	21.50	26.87	1081.52
6.50	Rock	Rock	Rock	Rock	Rock	Rock

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Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
9.00	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 ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-0.94	0.00	-0.00	-0.00
0.45	0.00	0.00	-0.87	1.80	-0.41	0.06
0.90	0.00	0.00	-0.81	3.56	-1.62	0.49
0.99	0.00	0.00	-0.79	3.90	-1.95	0.65
1.00	0.00	0.00	-0.79	-2.86	-1.98	0.67
1.35	11.11	0.00	-0.74	-3.76	-0.63	1.12
1.80	11.11	0.00	-0.68	-2.38	0.75	1.07
2.25	11.11	0.00	-0.61	-1.01	1.52	0.54
2.70	11.11	0.00	-0.55	0.44	1.65	-0.20
2.97	11.11	0.00	-0.52	1.33	1.41	-0.62
3.00	11.11	0.00	-0.51	1.42	1.37	-0.66
3.00	11.11	0.00	-0.51	0.31	1.37	-0.67
3.15	11.11	0.00	-0.49	0.75	1.29	-0.86
3.60	11.11	0.00	-0.43	2.13	0.64	-1.32
4.05	11.11	0.00	-0.36	3.53	-0.63	-1.35
4.50	11.11	11.11	-0.30	5.44	-2.61	-0.66
4.95	11.11	11.11	-0.23	7.59	-5.54	1.14
5.40	11.11	11.11	-0.16	9.68	-9.43	4.48
5.85	185.31	0.00	-0.11	-16.51	-4.42	8.15
6.30	185.31	0.00	-0.06	-7.92	0.98	8.78
6.75	185.31	0.00	-0.03	-4.68	3.73	7.69
7.20	185.31	0.00	-0.00	-0.69	4.86	5.69
7.65	0.00	185.31	0.01	1.68	4.59	3.52
8.10	0.00	185.31	0.02	3.04	3.50	1.68
8.55	0.00	185.31	0.02	3.91	1.92	0.44
9.00	0.00	185.31	0.02	4.63	-0.00	0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 10,32 kN/m
Maximum moment = 8,83 kNm/m
Maximum displacement = 0,9 mm
Displacement in the depth of slip surface = 0,5 mm

Maximum internal forces on cross-section

Maximum shear force = 15,49 kN
Maximum moment = 13,25 kNm

Verification of rock bearing capacity

Bearing capacity of rock R = 2000,00 kPa
Partial factor on rock bearing capacity γ_{Rr} = 1,40
Max. stress σ = 6,86 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 $R = 2000,00 \text{ kPa}$

Partial factor on rock bearing capacity $\gamma_{Rr} = 1,40$

Max. stress $\sigma = 6,86 \text{ kPa}$

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

Bearing capacity of rock is SATISFACTORY

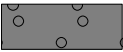


Terrain settlement behind the structure

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

	Coordinates x [m]	Settlement z [mm]
1	0,00	0,5
2	0,71	0,6
3	1,42	0,7
4	2,12	0,8
5	2,83	0,8
6	3,54	0,8
7	4,25	0,7
8	4,96	0,6
9	5,66	0,4
10	6,37	0,2
11	7,08	0,0
12	7,08	0,0

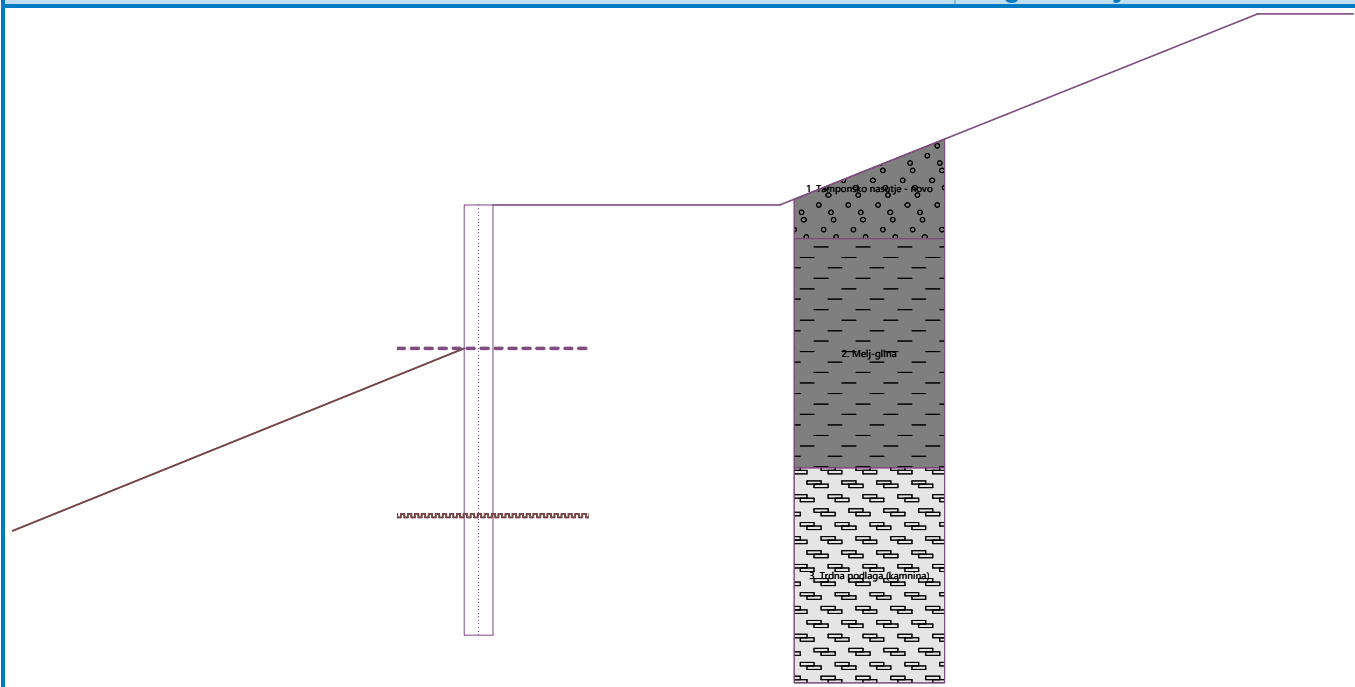
Input data (Stage of construction 2)

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	4,80	0,70 .. 5,50	Melj-glina	
3	-	5,50 .. ∞	Trdna podlaga (kamnina)	

Name : 2

Stage - analysis : 2 - 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 $\beta = -22,00^\circ$

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
2.40	15.09
2.40	15.10
3.00	20.04

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	-7.11	20.04	20.04	20.04
3.01	0.00	-0.06	-6.17	16.91	20.84	144.06
3.43	0.00	-2.41	-14.38	19.84	23.74	162.83
3.61	0.00	-3.39	-17.78	21.06	24.93	170.59
3.75	-0.47	-4.16	-20.47	22.02	25.88	176.73
5.35	-9.08	-13.09	-51.62	33.15	36.86	247.89
5.50	-9.87	-13.91	-54.48	34.17	37.87	260.03
5.50	0.00	-8.35	-226.62	17.67	22.09	838.76
6.49	0.00	-12.35	-282.56	21.50	26.87	1081.52
6.50	Rock	Rock	Rock	Rock	Rock	Rock
9.00	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	-13.32	0.00	0.00	0.00
0.45	0.00	0.00	-12.18	1.80	-0.41	0.06
0.90	0.00	0.00	-11.04	4.25	-1.69	0.49
1.35	0.00	0.00	-9.90	7.50	-4.33	1.79
1.80	0.00	0.00	-8.77	10.75	-8.44	4.61
2.25	0.00	0.00	-7.64	14.01	-14.01	9.60
2.70	0.00	0.00	-6.53	17.57	-21.09	17.44
2.97	0.00	0.00	-5.87	19.80	-26.13	23.80
3.00	0.00	0.00	-5.81	20.01	-26.65	24.49
3.01	0.00	0.00	-5.77	10.69	-26.90	24.97
3.15	0.00	0.00	-5.44	9.00	-28.24	28.72
3.60	0.00	0.00	-4.40	3.38	-31.02	42.15
4.05	0.00	0.00	-3.43	-2.23	-31.28	56.26
4.50	0.00	0.00	-2.54	-7.84	-29.02	69.92
4.95	11.11	0.00	-1.76	-0.04	-26.98	82.35
5.40	11.11	0.00	-1.11	7.84	-28.79	94.76
5.85	185.31	0.00	-0.60	-101.38	11.69	100.89
6.30	185.31	0.00	-0.24	-35.55	41.48	87.82
6.75	185.31	9.27	-0.02	-3.66	49.49	66.89
7.20	0.00	185.31	0.10	18.94	48.53	44.68
7.65	0.00	185.31	0.15	27.40	37.85	25.10

Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
8.10	0.00	185.31	0.16	29.24	24.92	10.95
8.55	0.00	185.31	0.15	27.83	12.01	2.66
9.00	0.00	185.31	0.14	25.51	0.00	-0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 49,51 kN/m
Maximum moment = 101,51 kNm/m
Maximum displacement = 13,3 mm
Displacement in the depth of slip surface = 5,8 mm

Maximum internal forces on cross-section

Maximum shear force = 74,26 kN
Maximum moment = 152,27 kNm

Verification of rock bearing capacity

Bearing capacity of rock R = 2000,00 kPa
Partial factor on rock bearing capacity γ_{Rr} = 1,40
Max. stress σ = 29,24 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 γ_{Rr} = 1,40
Max. stress σ = 29,24 kPa
Design bearing capacity of rock R_d = 1428,57 kPa

Bearing capacity of rock is SATISFACTORY

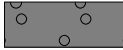


Terrain settlement behind the structure

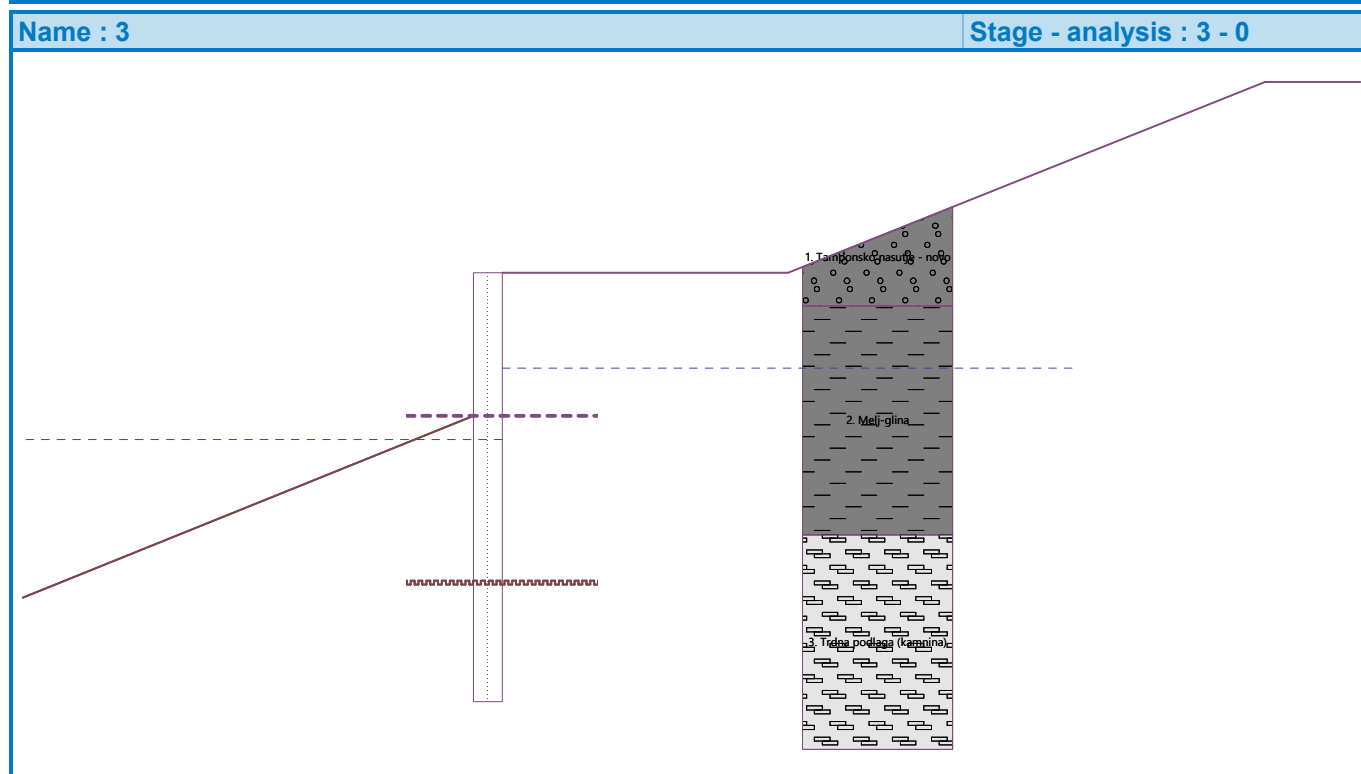
Terrain settlement δ_{max} = 6,3 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	6,6
2	0,71	8,2
3	1,42	9,3
4	2,12	9,9
5	2,83	10,0
6	3,54	9,6
7	4,25	8,7
8	4,96	7,3
9	5,66	5,4
10	6,37	2,9
11	7,08	0,0
12	7,08	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	4,80	0,70 .. 5,50	Melj-glina	
3	-	5,50 .. ∞	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 $\beta = -22,00^\circ$

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
2.00	11.79
2.40	18.93
2.40	18.94
3.00	29.63

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	-7.11	29.63	29.63	29.63
3.01	0.00	-0.06	-6.17	25.04	26.05	128.92
3.43	0.00	-2.41	-14.38	31.39	31.53	141.33
3.50	0.00	-2.78	-15.67	32.39	32.39	143.28
3.71	0.00	-3.39	-17.78	33.14	33.14	148.10
3.80	0.00	-3.67	-18.77	33.49	33.49	150.37
5.50	-4.79	-8.64	-36.10	39.68	39.68	189.94
5.50	0.00	-5.18	-182.39	17.01	28.08	535.44
5.80	0.00	-5.92	-192.62	17.01	28.95	556.32
6.49	0.00	-7.62	-216.44	17.01	30.99	659.69
6.50	Rock	Rock	Rock	Rock	Rock	Rock
9.00	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 ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-20.85	0.00	0.00	0.00
0.45	0.00	0.00	-19.14	1.80	-0.41	0.06
0.90	0.00	0.00	-17.44	4.18	-1.68	0.49
1.35	0.00	0.00	-15.74	7.29	-4.26	1.78
1.80	0.00	0.00	-14.04	10.41	-8.25	4.54
2.25	0.00	0.00	-12.34	16.25	-13.98	9.44
2.70	0.00	0.00	-10.66	24.28	-23.10	17.64

Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
2.97	0.00	0.00	-9.67	29.10	-30.30	24.82
3.00	0.00	0.00	-9.57	29.56	-31.06	25.62
3.01	0.00	0.00	-9.51	18.86	-31.48	26.18
3.15	0.00	0.00	-9.01	18.26	-34.00	30.64
3.60	0.00	0.00	-7.41	16.06	-41.76	47.72
4.05	0.00	0.00	-5.88	13.11	-48.32	68.04
4.50	0.00	0.00	-4.46	10.15	-53.56	91.01
4.95	0.00	0.00	-3.17	7.20	-57.46	116.04
5.40	11.11	0.00	-2.07	7.97	-60.22	142.51
5.85	0.00	0.00	-1.19	-177.42	-7.33	161.67
6.30	185.31	0.00	-0.54	-91.05	57.51	148.45
6.75	185.31	0.00	-0.13	-24.10	82.05	115.99
7.20	0.00	185.31	0.11	20.39	80.24	78.93
7.65	0.00	185.31	0.22	40.89	65.91	45.70
8.10	0.00	185.31	0.26	48.83	45.37	20.53
8.55	0.00	185.31	0.27	50.69	22.86	5.14
9.00	0.00	185.31	0.27	50.83	-0.00	0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 82,96 kN/m
 Maximum moment = 161,67 kNm/m
 Maximum displacement = 20,8 mm
 Displacement in the depth of slip surface = 9,6 mm

Maximum internal forces on cross-section

Maximum shear force = 124,44 kN
 Maximum moment = 242,51 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 $\sigma = 50,83$ 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 $\sigma = 50,83$ kPa
 Design bearing capacity of rock $R_d = 1428,57$ kPa

Bearing capacity of rock is SATISFACTORY

Terrain settlement behind the structure

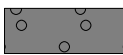

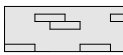
Terrain settlement $\delta_{max} = 10,4$ mm

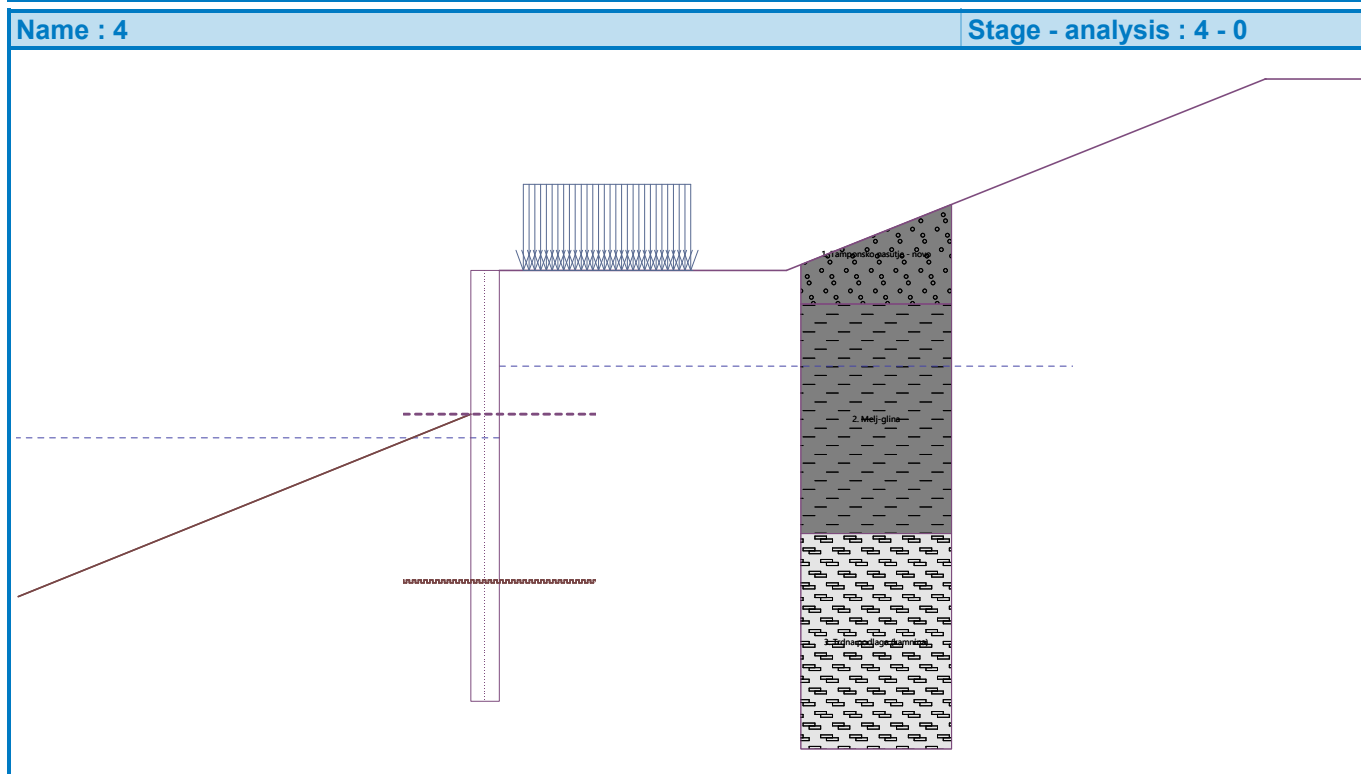
	Coordinates x [m]	Settlement z [mm]
1	0,00	10,3
2	0,71	13,0
3	1,42	14,9
4	2,12	15,9

	Coordinates x [m]	Settlement z [mm]
5	2,83	16,1
6	3,54	15,5
7	4,25	14,1
8	4,96	11,8
9	5,66	8,7
10	6,37	4,8
11	7,08	0,0
12	7,08	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	4,80	0,70 .. 5,50	Melj-glina	
3	-	5,50 .. ∞	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 $\beta = -22,00^\circ$

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 ²]	Mag.2 [kN/m ²]	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	7.98
2.00	18.31
2.00	18.31
2.40	25.33
2.40	18.93
2.40	25.35
3.00	35.85

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	-7.11	35.85	35.85	35.85
3.01	0.00	-0.06	-6.17	30.27	30.27	128.92
3.18	0.00	-0.98	-9.39	32.72	32.72	133.80
3.43	0.00	-2.41	-14.38	36.50	36.50	141.33
3.50	0.00	-2.78	-15.67	37.48	37.48	143.28
3.50	0.00	-2.78	-15.67	37.49	37.49	143.28
3.71	0.00	-3.39	-17.77	38.19	38.19	148.09
3.71	0.00	-3.39	-17.78	38.19	38.19	148.10
3.80	0.00	-3.67	-18.77	38.52	38.52	150.37
4.24	-1.22	-4.94	-23.18	39.98	39.98	160.44
4.76	-2.71	-6.49	-28.59	41.77	41.77	172.79
5.29	-4.21	-8.04	-33.99	43.56	43.56	185.14
5.50	-4.79	-8.64	-36.10	44.26	44.26	189.94
5.50	0.00	-5.19	-182.43	17.01	29.22	535.53
5.80	0.00	-5.92	-192.62	17.01	29.97	556.32
5.82	0.00	-5.98	-193.52	17.01	30.04	560.21
6.35	0.00	-7.28	-211.73	17.01	31.41	639.23
6.49	0.00	-7.62	-216.44	17.01	31.78	659.69
6.50	Rock	Rock	Rock	Rock	Rock	Rock
6.88	Rock	Rock	Rock	Rock	Rock	Rock
7.41	Rock	Rock	Rock	Rock	Rock	Rock
7.94	Rock	Rock	Rock	Rock	Rock	Rock
8.47	Rock	Rock	Rock	Rock	Rock	Rock
9.00	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 ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-34.98	0.00	-0.00	-0.00
0.45	0.00	0.00	-32.17	5.63	-0.58	0.07
0.90	0.00	0.00	-29.36	9.57	-3.93	1.01
1.35	0.00	0.00	-26.55	13.15	-9.04	3.86
1.80	0.00	0.00	-23.75	16.72	-15.76	9.38
2.25	0.00	0.00	-20.97	22.69	-24.40	18.32
2.70	0.00	0.00	-18.21	30.59	-36.39	31.86
2.97	0.00	0.00	-16.58	35.33	-45.29	42.86
3.00	0.00	0.00	-16.42	35.78	-46.21	44.05
3.01	0.00	0.00	-16.31	24.08	-46.73	44.88
3.15	0.00	0.00	-15.50	23.45	-49.97	51.46
3.60	0.00	0.00	-12.87	21.14	-60.03	76.25
4.05	0.00	0.00	-10.36	18.07	-68.85	105.30
4.50	0.00	0.00	-8.02	14.99	-76.29	138.01
4.95	0.00	0.00	-5.88	11.92	-82.35	173.76
5.40	0.00	0.00	-4.02	8.85	-87.02	211.91
5.85	0.00	0.00	-2.47	-177.42	-33.94	243.00

Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
6.30	0.00	0.00	-1.30	-192.90	49.38	239.79
6.75	185.31	0.00	-0.50	-92.20	118.87	199.74
7.20	0.00	185.31	0.00	1.34	129.49	142.33
7.65	0.00	185.31	0.29	52.85	116.20	86.18
8.10	0.00	185.31	0.43	80.20	85.60	40.32
8.55	0.00	185.31	0.52	95.66	45.78	10.50
9.00	0.00	185.31	0.58	107.65	0.00	0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 129,49 kN/m
 Maximum moment = 246,20 kNm/m
 Maximum displacement = 35,0 mm
 Displacement in the depth of slip surface = 16,4 mm

Maximum internal forces on cross-section

Maximum shear force = 194,23 kN
 Maximum moment = 369,30 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 $\sigma = 144,38$ 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 $\sigma = 144,38$ kPa
 Design bearing capacity of rock $R_d = 1428,57$ kPa

Bearing capacity of rock is SATISFACTORY

Terrain settlement behind the structure

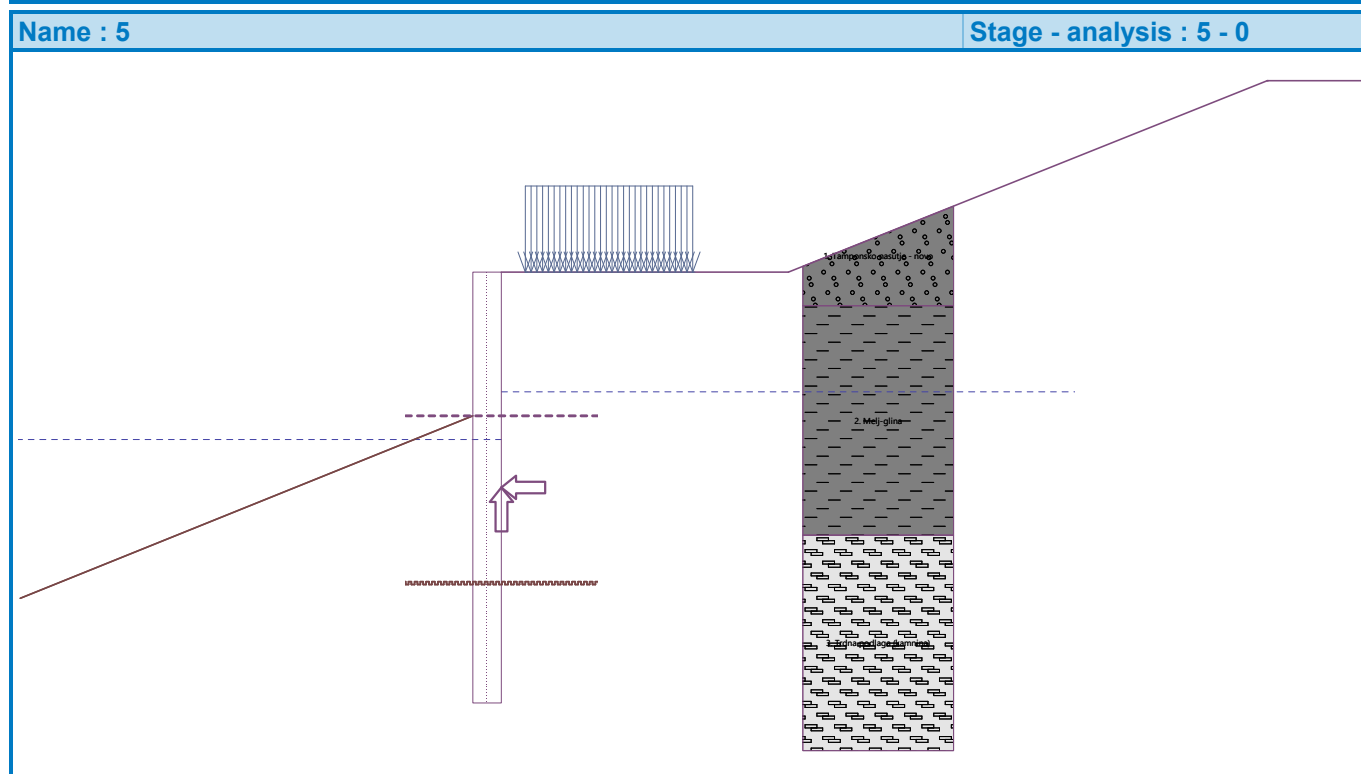
Terrain settlement $\delta_{\max} = 18,0$ mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	17,2
2	0,71	22,0
3	1,42	25,3
4	2,12	27,2
5	2,83	27,6
6	3,54	26,6
7	4,25	24,2
8	4,96	20,3
9	5,66	15,0
10	6,37	8,2
11	7,08	0,0
12	7,08	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	4,80	0,70 .. 5,50	Melj-glina	
3	-	5,50 .. ∞	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 $\beta = -22,00^\circ$

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 ²]	Mag.2 [kN/m ²]	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	1.22
0.00	1.22
0.19	1.18
0.39	2.00
0.39	2.94
0.70	4.21
0.70	3.90
2.40	14.79
2.40	12.30
2.40	13.71
2.40	14.79
2.50	15.43
2.50	16.54
3.00	23.64

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	-8.29	21.61	21.61	21.61
3.01	-0.06	-0.06	-1.11	19.98	26.78	147.59
3.18	-0.22	-0.98	-5.12	21.96	28.54	153.54
3.43	-0.48	-2.41	-11.32	25.03	31.29	162.74
3.50	-0.47	-2.78	-12.92	25.82	32.01	165.12

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Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
3.50	-0.96	-2.78	-5.92	26.04	32.22	165.12
3.71	-0.93	-3.39	-8.75	26.62	32.75	171.05
3.71	-0.93	-3.39	-8.75	26.62	32.76	171.06
3.80	-0.92	-3.67	-10.09	26.89	33.03	173.86
4.24	-1.85	-4.94	-16.00	28.10	34.22	186.28
4.76	-2.99	-6.49	-23.26	29.58	35.81	201.52
5.29	-4.14	-8.04	-30.51	31.07	37.48	216.76
5.47	-4.52	-8.56	-32.93	31.56	38.05	221.84
5.47	-4.52	-8.56	-32.93	30.55	38.05	221.84
5.50	-4.58	-8.64	-33.34	30.64	38.15	222.68
5.50	-0.50	-5.18	-205.78	13.14	26.42	626.99
5.82	-0.45	-5.98	-219.41	13.90	27.27	685.43
6.35	-0.38	-7.28	-241.72	15.14	28.71	781.06
6.49	-0.36	-7.62	-247.49	15.47	29.09	805.81
6.50	Rock	Rock	Rock	Rock	Rock	Rock
6.88	Rock	Rock	Rock	Rock	Rock	Rock
7.41	Rock	Rock	Rock	Rock	Rock	Rock
7.94	Rock	Rock	Rock	Rock	Rock	Rock
8.47	Rock	Rock	Rock	Rock	Rock	Rock
9.00	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	-30.08	1.22	-0.00	0.00
0.45	0.00	0.00	-27.71	3.18	-0.72	0.13
0.90	0.00	0.00	-25.34	5.18	-2.54	0.84
1.35	0.00	0.00	-22.97	8.06	-5.52	2.60
1.80	0.00	0.00	-20.61	10.95	-9.80	6.00
2.25	0.00	0.00	-18.26	13.83	-15.38	11.62
2.70	0.00	0.00	-15.92	19.38	-22.66	20.08
2.97	0.00	0.00	-14.54	23.22	-28.41	26.95
3.00	0.00	0.00	-14.40	23.58	-29.02	27.69
3.01	0.00	11.11	-14.31	41.05	-29.41	28.22
3.15	0.00	11.11	-13.62	38.07	-34.79	32.59
3.60	0.00	11.11	-11.37	35.75	-50.71	51.85
4.05	0.00	11.11	-9.20	27.08	-64.84	78.00
4.50	0.00	11.11	-7.15	18.88	-75.16	109.65
4.95	0.00	11.11	-5.26	11.15	-81.90	145.13
5.40	0.00	11.11	-3.61	3.92	-85.28	182.88
5.85	0.00	185.31	-2.23	-161.63	-38.60	213.57
6.30	185.31	185.31	-1.18	-188.36	43.51	213.00
6.75	185.31	185.31	-0.45	-76.22	101.08	178.70
7.20	0.00	9.27	-0.00	0.03	116.28	128.45
7.65	0.00	185.31	0.26	47.26	104.82	77.87
8.10	0.00	185.31	0.39	72.22	77.34	36.46

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Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
8.55	0.00	185.31	0.47	86.43	41.42	9.50
9.00	0.00	185.31	0.53	97.50	0.00	-0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 116,30 kN/m
 Maximum moment = 217,85 kNm/m
 Maximum displacement = 30,1 mm
 Displacement in the depth of slip surface = 14,4 mm

Maximum internal forces on cross-section

Maximum shear force = 174,45 kN
 Maximum moment = 326,77 kNm

Verification of rock bearing capacity

Max. stress σ = 118,29 kPa
 Design bearing capacity of rock R_d = 2000,00 kPa

Bearing capacity of rock is SATISFACTORY

Verification of rock bearing capacity

Max. stress σ = 118,29 kPa
 Design bearing capacity of rock R_d = 2000,00 kPa

Bearing capacity of rock is SATISFACTORY

Terrain settlement behind the structure

Terrain settlement δ_{\max} = 15,7 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	14,8
2	0,71	19,0
3	1,42	21,9
4	2,12	23,6
5	2,83	24,0
6	3,54	23,1
7	4,25	21,0
8	4,96	17,7
9	5,66	13,0
10	6,37	7,1
11	7,08	0,0
12	7,08	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	-34.98	-0.94	-0.00	0.00	-0.00	0.00
0.45	-32.17	-0.87	-0.72	-0.41	0.06	0.13
0.90	-29.36	-0.81	-3.93	-1.62	0.49	1.01
0.99	-28.80	-0.79	-4.82	-1.95	0.65	1.40
1.00	-28.76	-0.79	-4.89	-1.98	0.66	1.43
1.00	-28.71	-0.79	-4.97	-1.98	0.67	1.47

	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
1.35	-26.55	-0.74	-9.04	-0.63	1.12	3.86
1.80	-23.75	-0.68	-15.76	0.75	1.07	9.38
2.25	-20.97	-0.61	-24.40	1.52	0.54	18.32
2.70	-18.21	-0.55	-36.39	1.65	-0.20	31.86
2.97	-16.58	-0.52	-45.29	1.41	-0.62	42.86
3.00	-16.42	-0.51	-46.21	1.37	-0.66	44.05
3.00	-16.42	-0.51	-46.21	1.37	-0.66	44.05
3.00	-16.37	-0.51	-46.47	1.37	-0.67	44.42
3.00	-16.37	-0.51	-46.47	1.37	-0.67	44.42
3.01	-16.31	-0.51	-46.73	1.36	-0.68	44.88
3.01	-16.31	-0.51	-46.73	1.36	-0.68	44.88
3.15	-15.50	-0.49	-49.97	1.29	-0.86	51.46
3.60	-12.87	-0.43	-60.03	0.64	-1.32	76.25
4.05	-10.36	-0.36	-68.85	-0.63	-1.35	105.30
4.50	-8.02	-0.30	-76.29	-2.61	-0.66	138.01
4.95	-5.88	-0.23	-82.35	-5.54	1.14	173.76
5.40	-4.02	-0.16	-87.02	-9.43	4.48	211.91
5.85	-2.47	-0.11	-38.60	11.69	8.15	243.00
6.30	-1.30	-0.06	0.98	57.51	8.78	239.79
6.75	-0.50	-0.02	3.73	118.87	7.69	199.74
7.20	-0.00	0.11	4.86	129.49	5.69	142.33
7.65	0.01	0.29	4.59	116.20	3.52	86.18
8.10	0.02	0.43	3.50	85.60	1.68	40.32
8.55	0.02	0.52	1.92	45.78	0.44	10.50
9.00	0.02	0.58	-0.00	0.00	-0.00	0.00

Maximum values of internal forces

Maximum displacement = -35,0 mm
 Minimum displacement = 0,6 mm
 Maximum bending moment = 246,20 kNm/m
 Minimum bending moment = -1,41 kNm/m
 Maximum shear force = 129,49 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 : $M_{Ed} = 369,30$ 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

$A_{sw} = 2 \times 523,6 = 1047,2$ mm²

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

Ultimate shear force: $V_{Rd} = 491,73$ kN $> 194,23$ 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 $b \times h = 150,0 \times 1750,0 \text{ mm}$

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

Type of load : rectangle

Verification of RC cross section ($b = 1,75 \text{ m}$; $h = 0,15 \text{ m}$)

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 $V_{Rd} = 57,51 \text{ kN} > 21,43 \text{ kN} = V_{Ed}$

Ultimate moment $M_{Rd} = 12,71 \text{ kNm} > 8,04 \text{ kNm} = M_{Ed}$

Cross-section is SATISFACTORY.

Lagging scheme

