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 :	γ_{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 :	γ_G =	1,35	[–]	1,00	[–]
Variable actions :	γ_Q =	1,50	[–]	0,00	[–]
Water load :	γ_w =	1,35	[–]		

Partial factors for resistances (R)			
Permanent design situation			
Partial factor on earth resistance :	γ_{Re} =	1,40	[–]

Partial factors on actions (A)					
Seismic design situation					
		Unfavourable		Favourable	
Permanent actions :	γ_G =	1,10	[–]	1,00	[–]
Variable actions :	γ_Q =	1,10	[–]	0,00	[–]
Water load :	γ_w =	1,10	[–]		

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

Anchors

Verification methodology : Limit states (LSD)

Reduction coefficients			
Reduction. coeff of steel strength :	γ_s =	1,35	[–]
Reduction coefficient of pull out resistance (soil) :	γ_e =	1,35	[–]
Reduction coefficient of pull out resistance (grouting) :	γ_c =	1,35	[–]

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Geometry of structure

Structure length = 12,25 m

Cross-section name : Pile curtain d = 0,80 m, a = 1,50 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 1,00
Area of cross-section A = 3,35E-01 m^2/m
Moment of inertia I = 1,34E-02 m^4/m

Forces above the slip surface

Depth of slip surface h_{s1} = 4,00 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 MPa
Tensile strength f_{ctm} = 2,60 MPa
Elasticity modulus E_{cm} = 31000,00 MPa
Shear modulus G = 12917,00 MPa

Longitudinal reinforcement: B500B
Yield strength f_{yk} = 500,00 MPa

Transverse reinforcement: B500B
Yield strength f_{yk} = 500,00 MPa

Modulus of reaction

Modulus of subsoil reaction is computed by method Schmitt.

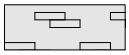
Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]	γ_{su} [kN/m³]	δ [°]
1	Tamponsko nasutje		35,00	1,00	20,00	11,00	23,00
2	Meljasta glina		22,00	2,00	18,00	9,00	22,00
3	Meljasta glina – trdno kons. st.		30,00	5,00	19,00	10,00	30,00
4	Lapor – trdna podlaga		35,00	50,00	23,00	14,00	35,00

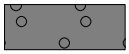
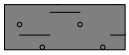
Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	φ_{ef} [°]	v [–]	OCR [–]	K_r [–]
1	Tamponsko nasutje		cohesionless	35,00	-	-	-
2	Meljasta glina		cohesive	-	0,30	-	-
3	Meljasta glina – trdno kons. st.		cohesive	-	0,30	-	-

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No.	Name	Pattern	Type calculation	φ_{ef} [°]	v [–]	OCR [–]	K_r [–]
4	Lapor – trdna podlaga		cohesive	-	0,20	-	-

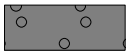
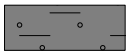
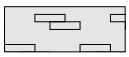
Parameters of soils to compute modulus of subsoil reaction (Schmitt)

No.	Name	Pattern	v [–]	E_{oed} [MPa]	E_{def} [MPa]
1	Tamponsko nasutje		0,30	-	40,00
2	Meljasta glina		0,30	-	5,00
3	Meljasta glina – trdno kons. st.		0,30	-	20,00
4	Lapor – trdna podlaga		0,20	-	100,00

Pile fixed into the rock

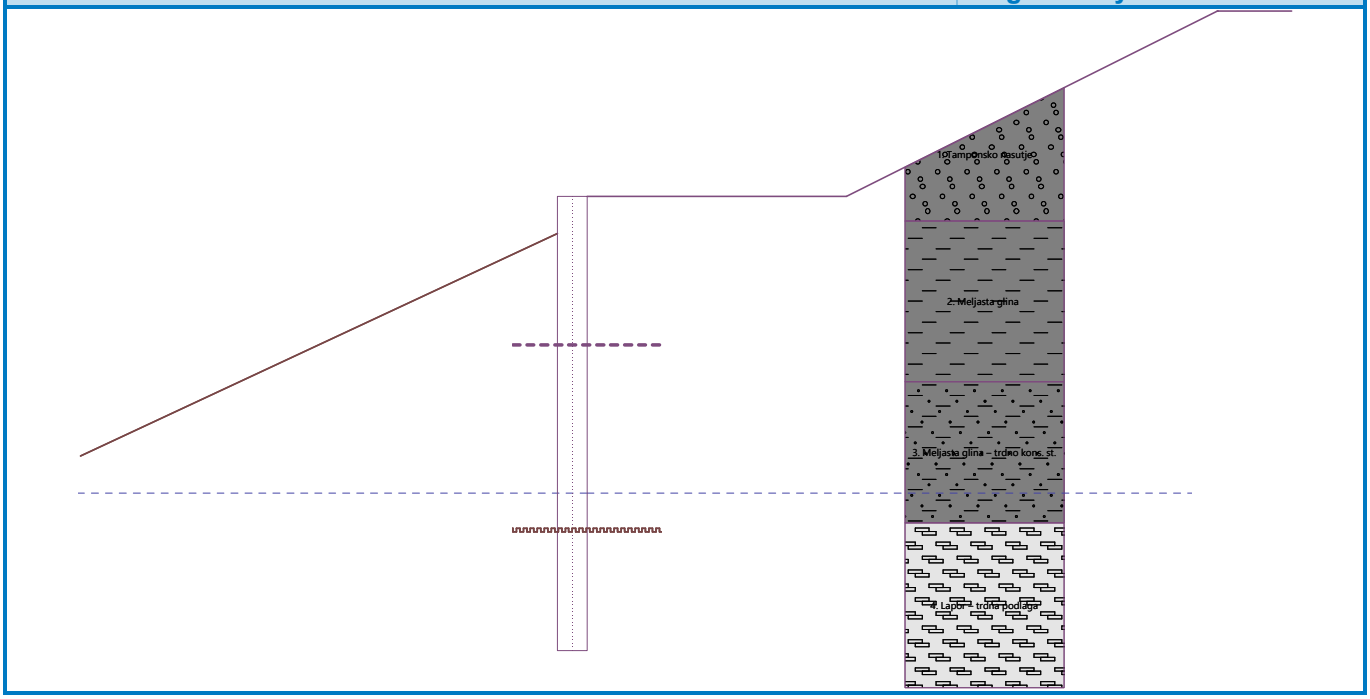
Length of wall in the rock l = 3,25 m
Bearing capacity of rock R = 2000,00 kPa

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,66	0,00 .. 0,66	Tamponsko nasutje	
2	4,34	0,66 .. 5,00	Meljasta glina	
3	3,80	5,00 .. 8,80	Meljasta glina – trdno kons. st.	
4	-	8,80 .. ∞	Lapor – trdna podlaga	

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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 $\beta = -25{,}00\ °$

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	7,00	0,00
3	17,00	-5,00
4	18,00	-5,00

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 8,00 m
GWT in front of the structure lies at a depth of 8,00 m
Subgrade at the heel is not permeable.

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	-
4,00	0,00	-

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Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
4,00	0,00	-
4,00	0,00	-

Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.18	0.73
0.66	2.91
0.66	3.81
1.00	6.84
1.00	6.84
3.50	29.16
3.50	29.17
4.00	33.62

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]
4.00	-15.50	-16.19	-32.61	33.62	33.62	176.00
5.00	-21.42	-21.59	-42.66	42.55	42.55	217.98
5.00	-14.56	-24.83	-130.00	26.30	39.14	378.34
6.43	-21.78	-34.19	-175.17	35.73	50.77	486.11
7.66	-28.03	-42.29	-214.26	43.89	60.83	709.96
8.00	-29.73	-44.49	-224.87	48.30	63.57	770.71
8.80	-31.86	-47.24	-238.19	53.83	66.99	846.96
8.80	0.00	-28.00	-490.19	31.26	39.08	1584.43
8.99	0.00	-28.55	-497.29	31.80	39.75	1624.15
9.00	Rock	Rock	Rock	Rock	Rock	Rock
12.25	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	-5.15	0.00	0.00	-0.00
0.61	0.00	0.00	-4.67	2.69	-0.80	0.16
0.98	0.00	0.00	-4.39	6.66	-2.61	0.74
1.00	0.00	0.00	-4.37	4.40	-2.76	0.81
1.23	0.00	0.00	-4.20	4.15	-3.70	1.52
1.84	0.00	0.00	-3.73	3.46	-6.03	4.53
2.45	0.00	0.00	-3.27	2.77	-7.94	8.83
3.06	3.58	0.00	-2.81	4.08	-9.70	14.17
3.68	3.58	0.00	-2.36	7.83	-13.35	21.11
4.00	3.58	0.00	-2.14	9.77	-16.17	25.83
4.00	3.58	0.00	-2.13	9.82	-16.25	25.96
4.29	3.58	0.00	-1.94	11.52	-19.27	30.98
4.90	3.58	0.00	-1.54	15.10	-27.43	45.17

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Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
5.51	22.71	0.00	-1.18	-25.38	-12.39	57.87
6.13	22.71	0.00	-0.88	-18.42	0.96	61.15
6.74	22.71	22.71	-0.63	-11.44	10.38	57.45
7.35	22.71	22.71	-0.43	-1.44	14.21	49.61
7.96	22.71	22.71	-0.28	6.53	12.56	41.16
8.57	22.71	22.71	-0.16	12.37	6.69	35.08
9.19	150.32	0.00	-0.07	-11.06	9.99	30.92
9.80	150.32	0.00	-0.02	-2.48	13.94	23.33
10.41	0.00	150.32	0.02	2.96	13.66	14.71
11.03	0.00	150.32	0.04	6.38	10.73	7.13
11.64	0.00	150.32	0.06	8.81	6.05	1.92
12.25	0.00	150.32	0.07	10.94	-0.00	0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 27,43 kN/m
Maximum moment = 61,15 kNm/m
Maximum displacement = 5,1 mm
Displacement in the depth of slip surface = 2,1 mm

Maximum internal forces on cross-section

Maximum shear force = 41,15 kN
Maximum moment = 91,73 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 = 13,25 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 = 13,25 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} = 2,1 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	2,5
2	1,03	3,1
3	2,06	3,4
4	3,09	3,6
5	4,12	3,6
6	5,15	3,4
7	6,18	3,1
8	7,21	2,6
9	8,24	1,9

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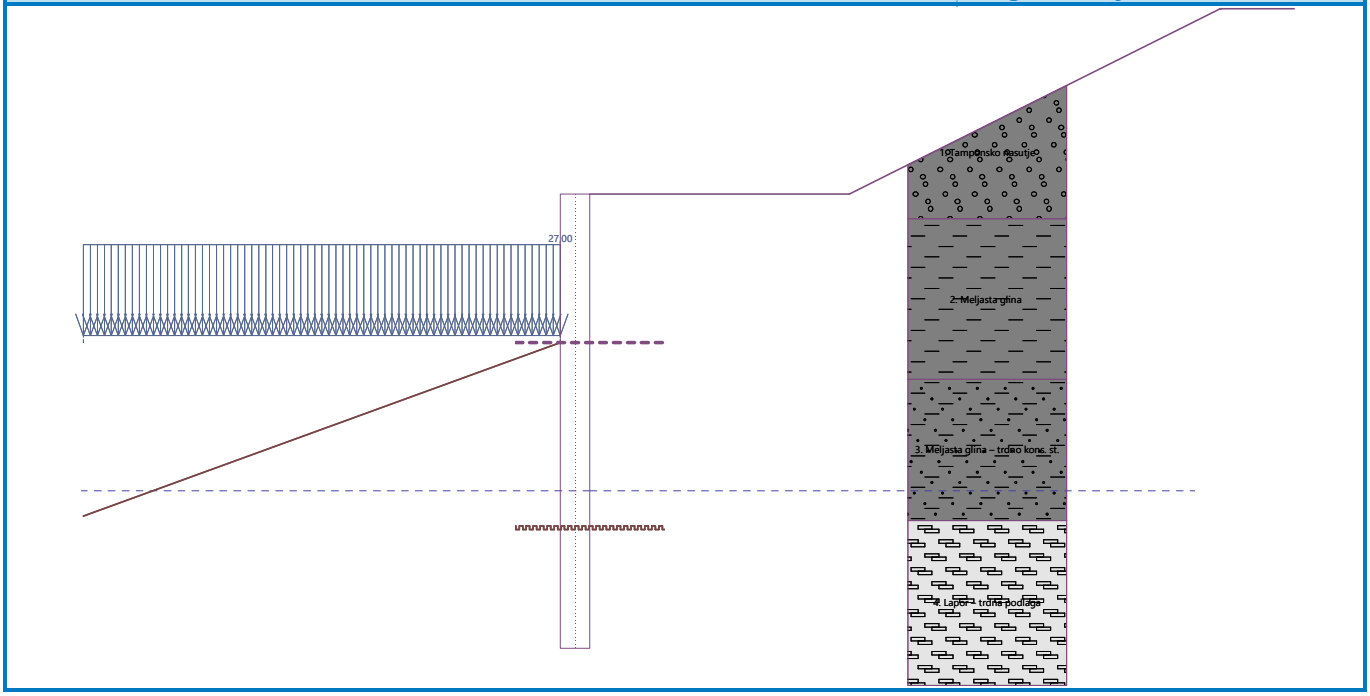
	Coordinates x [m]	Settlement z [mm]
10	9,27	1,0
11	10,31	0,0
12	10,31	0,0

Input data (Stage of construction 2)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,66	0,00 .. 0,66	Tamponsko nasutje	
2	4,34	0,66 .. 5,00	Meljasta glina	
3	3,80	5,00 .. 8,80	Meljasta glina – trdno kons. st.	
4	-	8,80 .. ∞	Lapor – trdna podlaga	

Name : 2 | Stage - analysis : 2 - 0



Forces above the slip surface

Excavation

Soil in front of wall is excavated to a depth of 4,00 m.
Ditch bottom surcharge = 27,00 kPa
Soil slope in front of structure β = -20,00 °

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	7,00	0,00

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No.	Coordinates x [m]	Depth z [m]
3	17,00	-5,00
4	18,00	-5,00

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 8,00 m
GWT in front of the structure lies at a depth of 8,00 m
Subgrade at the heel is not permeable.

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	-
4,00	0,00	-
4,00	0,00	-
4,00	0,00	-

Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.18	0.73
0.66	2.91
0.66	3.81
3.50	29.16
3.50	29.17
4.00	33.62

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]
4.00	0.00	-0.00	-3.37	33.62	33.62	33.62
4.01	-10.74	-11.64	-32.26	33.71	33.71	176.42
4.23	-12.69	-13.02	-36.43	35.66	35.66	185.56
4.23	-9.76	-13.02	-36.43	35.66	35.66	185.56
4.31	-10.31	-13.52	-37.94	36.36	36.36	188.88
4.37	-10.74	-13.91	-39.11	36.91	36.91	191.44
5.00	-15.15	-17.91	-51.20	42.55	42.55	217.98
5.00	-7.79	-18.04	-99.22	26.30	39.14	378.34
6.43	-15.38	-27.79	-152.40	35.73	50.77	486.11
7.66	-21.95	-36.22	-198.44	43.89	60.83	709.96
8.00	-23.73	-38.51	-210.93	48.30	63.57	770.71
8.80	-25.97	-41.39	-226.61	53.83	66.99	846.96
8.80	0.00	-24.38	-477.10	31.26	39.08	1584.43

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Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
8.83	0.00	-24.46	-478.25	31.34	39.17	1589.91
8.99	0.00	-24.95	-485.38	31.80	39.75	1624.15
9.00	Rock	Rock	Rock	Rock	Rock	Rock
12.25	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	-14.36	0.00	0.00	-0.00
0.61	0.00	0.00	-13.02	2.69	-0.80	0.16
1.23	0.00	0.00	-11.69	8.85	-4.51	1.61
1.84	0.00	0.00	-10.35	14.32	-11.60	6.37
2.45	0.00	0.00	-9.03	19.79	-22.05	16.50
3.06	0.00	0.00	-7.72	25.25	-35.84	34.06
3.68	0.00	0.00	-6.44	30.72	-52.98	61.09
4.00	0.00	0.00	-5.79	33.59	-63.30	79.73
4.01	3.58	0.00	-5.75	1.52	-63.45	80.87
4.29	3.58	0.00	-5.21	4.15	-64.22	98.31
4.90	3.58	0.00	-4.08	9.80	-68.52	138.79
5.51	22.71	0.00	-3.07	-61.48	-30.40	169.94
6.13	22.71	0.00	-2.21	-42.11	1.14	178.29
6.74	22.71	0.00	-1.51	-26.38	21.93	170.73
7.35	22.71	0.00	-0.96	-14.13	34.17	153.17
7.96	22.71	22.71	-0.56	-0.22	39.15	130.24
8.57	22.71	22.71	-0.27	13.39	34.86	107.15
9.19	150.32	7.52	-0.07	-10.89	39.00	85.56
9.80	0.00	7.52	0.04	0.45	40.53	60.84
10.41	0.00	150.32	0.10	15.72	37.61	36.37
11.03	0.00	150.32	0.13	19.91	26.52	16.60
11.64	0.00	150.32	0.14	21.75	13.69	4.23
12.25	0.00	150.32	0.15	22.93	0.00	-0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 68,52 kN/m
Maximum moment = 178,29 kNm/m
Maximum displacement = 14,4 mm
Displacement in the depth of slip surface = 5,8 mm

Maximum internal forces on cross-section

Maximum shear force = 102,77 kN
Maximum moment = 267,44 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 = 22,93 kPa
Design bearing capacity of rock R_d = 1428,57 kPa

Bearing capacity of rock is SATISFACTORY

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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	=	22,93	kPa
Design bearing capacity of rock	R_d	=	1428,57	kPa

Bearing capacity of rock is SATISFACTORY

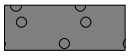
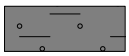
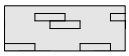
Terrain settlement behind the structure

Terrain settlement δ_{max} = 5,7 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	7,1
2	1,03	8,5
3	2,06	9,4
4	3,09	9,8
5	4,12	9,8
6	5,15	9,3
7	6,18	8,3
8	7,21	7,0
9	8,24	5,1
10	9,27	2,8
11	10,31	0,0
12	10,31	0,0

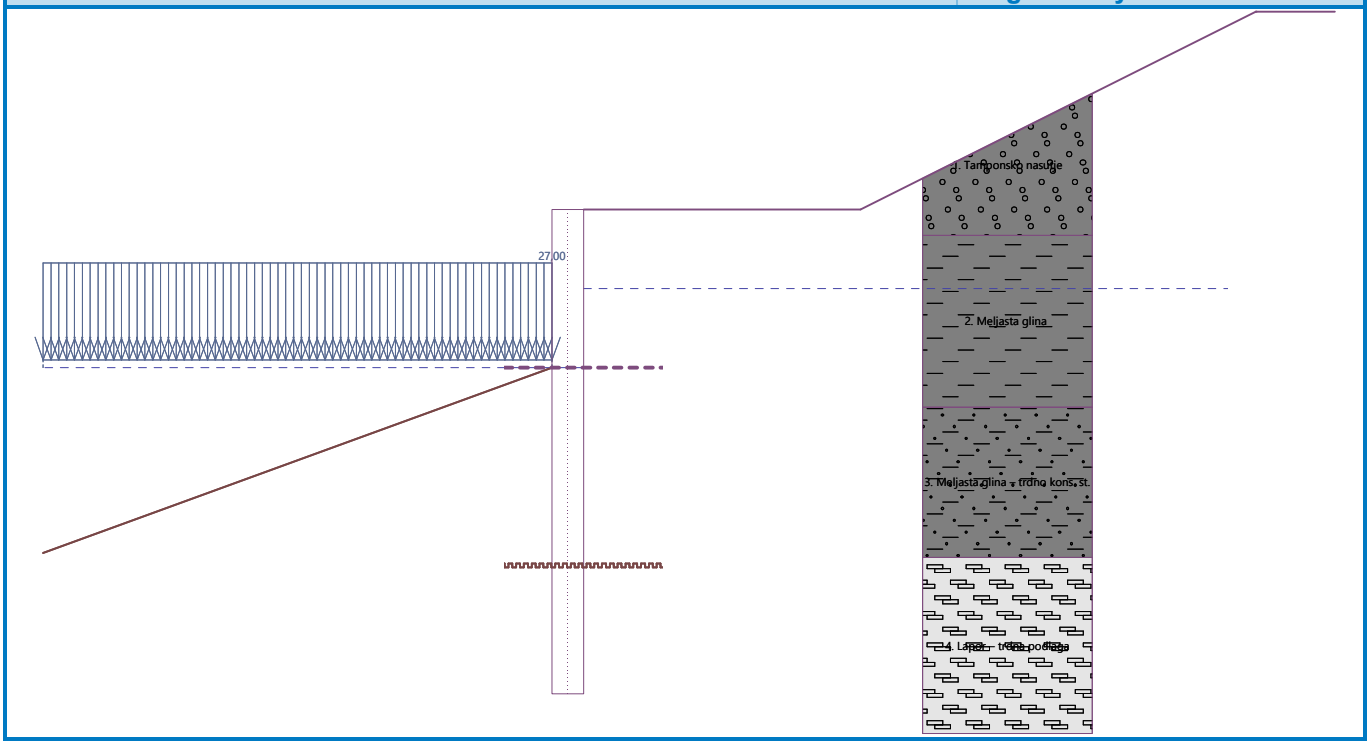
Input data (Stage of construction 3)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,66	0,00 .. 0,66	Tamponsko nasutje	
2	4,34	0,66 .. 5,00	Meljasta glina	
3	3,80	5,00 .. 8,80	Meljasta glina – trdno kons. st.	
4	-	8,80 .. ∞	Lapor – trdna podlaga	

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Name : 3	Stage - analysis : 3 - 0



Forces above the slip surface

Excavation

Soil in front of wall is excavated to a depth of 4,00 m.
Ditch bottom surcharge = 27,00 kPa
Soil slope in front of structure β = -20,00 °

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	7,00	0,00
3	17,00	-5,00
4	18,00	-5,00

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 4,00 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	-
4,00	0,00	-

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Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
4,00	0,00	-
4,00	0,00	-

Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.18	0.73
0.66	2.91
0.66	3.81
2.00	15.77
3.50	42.71
3.50	42.73
4.00	51.70

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]
4.00	0.00	-0.00	-3.36	51.70	51.70	51.70
4.01	-10.70	-11.61	-32.16	51.74	51.74	148.50
4.46	-12.69	-13.02	-36.43	53.73	53.73	157.86
4.46	-9.76	-13.02	-36.43	53.73	53.73	157.86
4.61	-10.31	-13.52	-37.94	54.43	54.43	161.18
4.70	-10.60	-13.78	-38.73	54.80	54.80	162.91
5.00	-11.66	-14.74	-41.63	56.16	56.16	169.29
5.00	-7.08	-14.81	-81.58	43.92	47.57	285.40
5.04	-7.20	-14.93	-82.27	44.04	47.72	286.80
5.04	-5.37	-14.93	-82.27	44.04	47.72	286.80
5.66	-7.12	-17.18	-94.55	46.22	50.40	311.68
5.82	-7.57	-17.75	-97.66	46.77	51.08	317.98
8.80	-15.90	-28.46	-156.05	57.12	63.85	436.31
8.80	0.00	-16.74	-365.12	27.00	45.58	811.81
8.95	0.00	-17.19	-371.84	27.00	46.12	824.71
8.99	0.00	-17.30	-373.39	27.00	46.25	832.15
9.00	Rock	Rock	Rock	Rock	Rock	Rock
12.25	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	-27.05	0.00	-0.00	-0.00
0.61	0.00	0.00	-24.75	2.69	-0.80	0.16
1.23	0.00	0.00	-22.45	8.85	-4.51	1.61
1.84	0.00	0.00	-20.15	14.32	-11.60	6.37
2.45	0.00	0.00	-17.85	23.85	-22.98	16.65
3.06	0.00	0.00	-15.58	34.85	-40.96	35.88
3.68	0.00	0.00	-13.33	45.86	-65.67	68.19

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Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
4.00	0.00	0.00	-12.18	51.62	-81.32	91.74
4.01	0.00	0.00	-12.11	19.56	-81.80	93.20
4.29	0.00	0.00	-11.15	18.16	-86.96	116.29
4.90	0.00	0.00	-9.07	15.03	-97.12	172.76
5.51	0.00	0.00	-7.15	-45.92	-75.15	226.66
6.13	0.00	0.00	-5.43	-55.80	-44.00	263.46
6.74	22.71	0.00	-3.95	-60.80	-6.91	279.15
7.35	22.71	0.00	-2.72	-32.92	21.50	273.81
7.96	22.71	0.00	-1.73	-10.63	34.56	255.94
8.57	22.71	0.00	-0.98	6.42	35.59	233.92
9.19	150.32	0.00	-0.44	-65.81	71.06	204.15
9.80	150.32	0.00	-0.08	-11.63	93.53	152.06
10.41	0.00	150.32	0.15	21.97	89.51	94.95
11.03	0.00	150.32	0.28	42.60	69.26	45.69
11.64	0.00	150.32	0.38	56.84	38.62	12.21
12.25	0.00	150.32	0.46	69.18	0.00	-0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 97,12 kN/m
Maximum moment = 279,56 kNm/m
Maximum displacement = 27,1 mm
Displacement in the depth of slip surface = 12,2 mm

Maximum internal forces on cross-section

Maximum shear force = 145,69 kN
Maximum moment = 419,33 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 $\sigma = 79,76$ 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 $\sigma = 79,76$ kPa
Design bearing capacity of rock $R_d = 1428,57$ kPa

Bearing capacity of rock is SATISFACTORY

Terrain settlement behind the structure

Terrain settlement $\delta_{max} = 12,1$ mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	13,3
2	1,03	16,3
3	2,06	18,4
4	3,09	19,5
5	4,12	19,6

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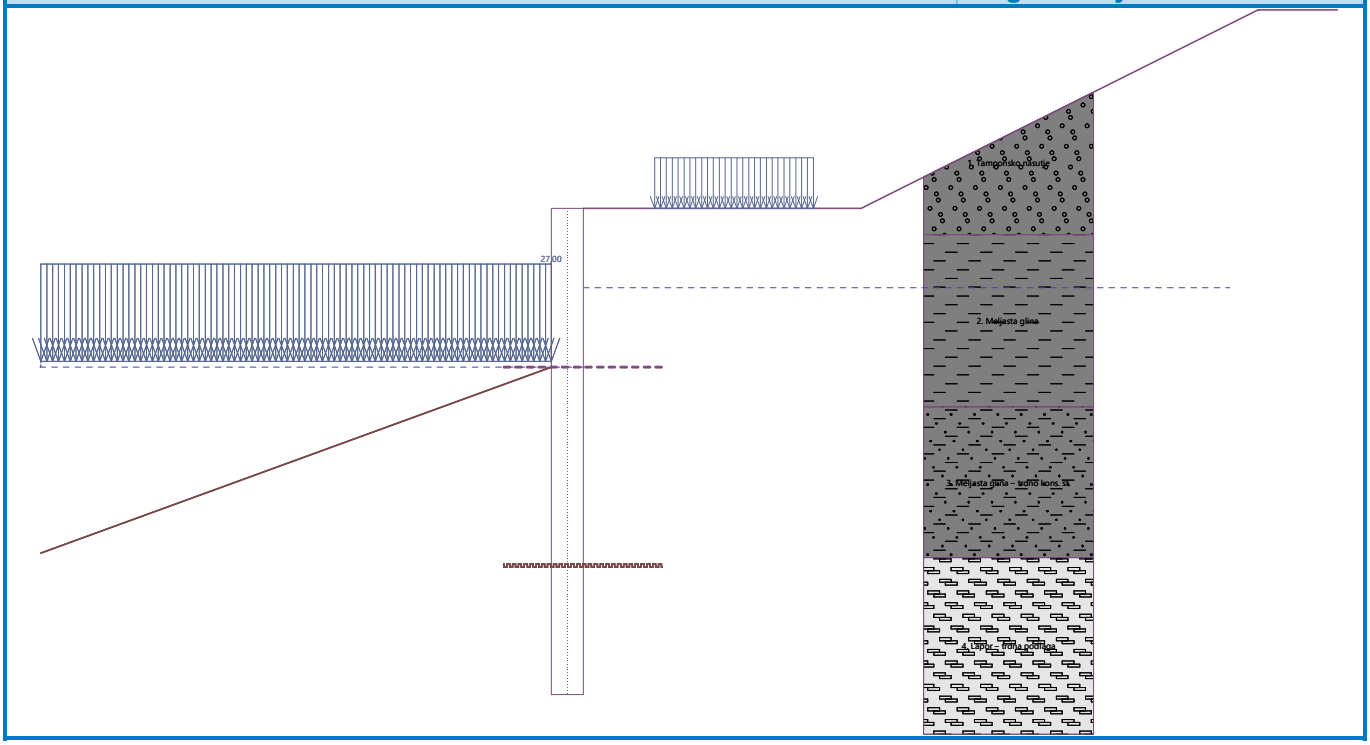
	Coordinates x [m]	Settlement z [mm]
6	5,15	18,7
7	6,18	16,9
8	7,21	14,1
9	8,24	10,4
10	9,27	5,7
11	10,31	0,0
12	10,31	0,0

Input data (Stage of construction 4)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,66	0,00 .. 0,66	Tamponsko nasutje	
2	4,34	0,66 .. 5,00	Meljasta glina	
3	3,80	5,00 .. 8,80	Meljasta glina – trdno kons. st.	
4	-	8,80 .. ∞	Lapor – trdna podlaga	

Name : 4 | **Stage - analysis : 4 - 0**



Forces above the slip surface

Excavation

Soil in front of wall is excavated to a depth of 4,00 m.
Ditch bottom surcharge = 27,00 kPa
Soil slope in front of structure β = -20,00 °

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Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	7,00	0,00
3	17,00	-5,00
4	18,00	-5,00

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 4,00 m
Subgrade at the heel is not permeable.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [kN/m^2]	Mag.2 [kN/m^2]	Ord.x x [m]	Length l [m]	Depth z [m]
1	Yes		variable	14,00		1,80	4,00	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	-
4,00	0,00	-
4,00	0,00	-
4,00	0,00	-

Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	0.00
0.00	0.00
0.18	0.73
0.66	2.91
0.66	3.81
1.01	6.90
1.01	14.76
2.00	23.04
2.00	23.04
3.50	49.08
3.50	42.71
3.50	49.10
4.00	57.76

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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]
4.00	0.00	-0.00	-3.36	57.76	57.76	57.76
4.01	-10.70	-11.61	-32.16	57.80	57.80	148.50
4.32	-12.09	-12.60	-35.16	59.01	59.01	155.08
4.46	-12.69	-13.02	-36.43	59.52	59.52	157.86
4.46	-9.76	-13.02	-36.43	59.52	59.52	157.86
4.61	-10.31	-13.52	-37.94	60.13	60.13	161.18
4.70	-10.60	-13.78	-38.73	60.45	60.45	162.91
5.00	-11.66	-14.74	-41.63	61.62	61.62	169.29
5.00	-7.08	-14.81	-81.58	47.75	50.58	285.40
5.04	-7.20	-14.93	-82.27	47.86	50.70	286.80
5.04	-5.40	-14.97	-82.44	47.89	50.73	287.15
5.66	-7.12	-17.18	-94.55	49.82	52.89	311.68
5.76	-7.41	-17.55	-96.57	50.14	53.25	315.77
5.82	-7.57	-17.75	-97.66	50.31	53.46	317.98
6.49	-9.43	-20.14	-110.69	52.39	55.89	344.38
7.21	-11.44	-22.73	-124.81	54.64	58.62	373.00
7.64	-12.66	-24.30	-133.37	56.00	60.32	390.35
7.64	-12.66	-24.30	-133.37	53.10	60.32	390.35
7.93	-13.46	-25.32	-138.93	54.09	61.42	401.62
8.65	-15.47	-27.91	-153.06	56.59	64.29	430.23
8.80	-15.90	-28.46	-156.05	57.12	64.90	436.31
8.80	0.00	-16.74	-365.12	27.00	46.63	811.81
8.95	0.00	-17.19	-371.84	27.00	47.13	824.71
8.99	0.00	-17.30	-373.39	27.00	47.25	832.15
9.00	Rock	Rock	Rock	Rock	Rock	Rock
9.37	Rock	Rock	Rock	Rock	Rock	Rock
10.09	Rock	Rock	Rock	Rock	Rock	Rock
10.81	Rock	Rock	Rock	Rock	Rock	Rock
11.53	Rock	Rock	Rock	Rock	Rock	Rock
12.25	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	-39.83	0.00	-0.00	-0.00
0.61	0.00	0.00	-36.50	2.69	-0.80	0.16
1.23	0.00	0.00	-33.18	16.58	-5.94	1.74
1.84	0.00	0.00	-29.85	21.68	-17.65	8.81
2.45	0.00	0.00	-26.53	30.85	-33.43	24.15
3.06	0.00	0.00	-23.24	41.49	-55.58	51.08
3.68	0.00	0.00	-19.99	52.12	-84.25	93.57
4.00	0.00	0.00	-18.32	57.69	-101.87	123.39
4.01	0.00	0.00	-18.22	25.62	-102.46	125.23
4.29	0.00	0.00	-16.83	24.06	-109.26	154.19
4.90	0.00	0.00	-13.80	20.56	-122.92	225.41

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Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
5.51	0.00	0.00	-10.99	-42.27	-103.35	295.88
6.13	0.00	0.00	-8.43	-52.37	-74.37	350.62
6.74	0.00	0.00	-6.20	-62.46	-39.20	385.71
7.35	22.71	0.00	-4.31	-65.92	1.98	397.19
7.96	22.71	0.00	-2.77	-34.16	32.24	385.76
8.57	22.71	0.00	-1.58	-7.29	44.54	361.41
9.19	150.32	0.00	-0.72	-108.71	107.34	318.96
9.80	150.32	0.00	-0.15	-22.08	145.44	238.84
10.41	0.00	150.32	0.21	32.23	140.23	149.95
11.03	0.00	150.32	0.44	66.05	109.37	72.46
11.64	0.00	150.32	0.60	89.76	61.36	19.44
12.25	0.00	150.32	0.73	110.45	-0.00	0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 146,45 kN/m
Maximum moment = 397,19 kNm/m
Maximum displacement = 39,8 mm
Displacement in the depth of slip surface = 18,3 mm

Maximum internal forces on cross-section

Maximum shear force = 219,68 kN
Maximum moment = 595,78 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 = 130,91 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 = 130,91 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} = 18,2 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	19,5
2	1,03	24,1
3	2,06	27,3
4	3,09	29,0
5	4,12	29,2
6	5,15	28,0
7	6,18	25,3
8	7,21	21,2
9	8,24	15,6

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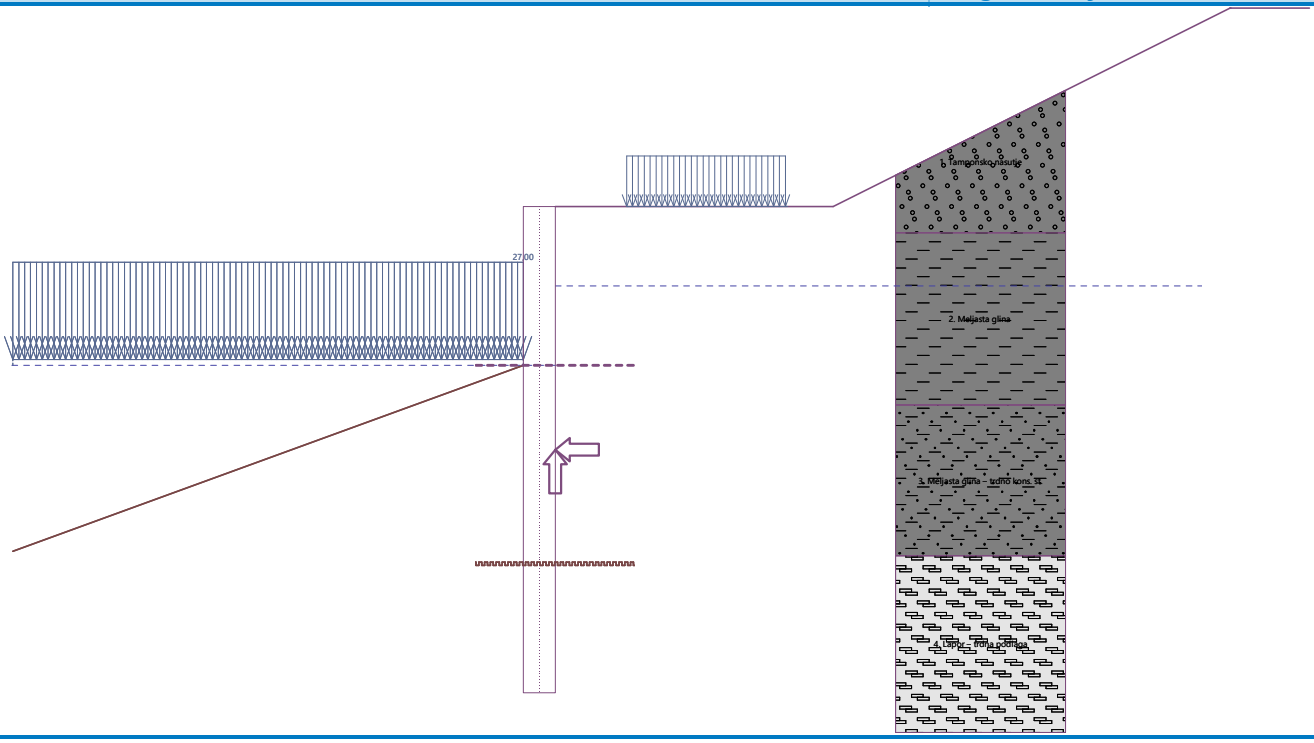
	Coordinates x [m]	Settlement z [mm]
10	9,27	8,5
11	10,31	0,0
12	10,31	0,0

Input data (Stage of construction 5)

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	0,66	0,00 .. 0,66	Tamponsko nasutje	
2	4,34	0,66 .. 5,00	Meljasta glina	
3	3,80	5,00 .. 8,80	Meljasta glina – trdno kons. st.	
4	-	8,80 .. ∞	Lapor – trdna podlaga	

Name : 5 | Stage - analysis : 5 - 0



Forces above the slip surface

Excavation

Soil in front of wall is excavated to a depth of 4,00 m.
Ditch bottom surcharge = 27,00 kPa
Soil slope in front of structure β = -20,00 °

Terrain profile

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

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No.	Coordinates x [m]	Depth z [m]
2	7,00	0,00
3	17,00	-5,00
4	18,00	-5,00

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 4,00 m
Subgrade at the heel is not permeable.

Input surface surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [kN/m2]	Mag.2 [kN/m2]	Ord.x x [m]	Length l [m]	Depth z [m]
1	No	No	variable	14,00		1,80	4,00	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	-
4,00	0,00	-
4,00	0,00	-
4,00	0,00	-

Active pressure - above slip surface

Depth [m]	Active pressure [kPa]
0.00	1.57
0.00	1.57
0.18	1.53
0.66	3.80
0.66	5.13
1.01	7.56
1.01	9.29
2.00	16.12
2.00	18.09
3.50	39.42
3.50	34.80
3.50	36.22

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Depth [m]	Active pressure [kPa]
3.50	39.43
4.00	46.52

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]
4.00	0.00	-0.00	-3.92	43.84	43.84	43.84
4.01	-10.52	-11.36	-11.36	46.94	48.14	158.40
4.32	-11.61	-12.43	-15.63	47.99	49.05	166.52
4.46	-12.07	-12.88	-17.44	48.44	49.45	169.94
4.46	-9.68	-12.88	-17.44	48.44	49.45	169.94
4.61	-10.11	-13.42	-19.59	48.97	49.93	174.03
4.70	-10.33	-13.70	-20.71	49.24	50.18	176.16
5.00	-11.14	-14.74	-24.85	50.26	51.10	184.03
5.00	-7.15	-14.81	-80.76	39.24	51.10	305.79
5.04	-7.24	-14.93	-81.63	39.34	51.23	307.54
5.04	-5.77	-14.97	-81.84	39.36	51.26	307.97
5.66	-7.08	-17.18	-97.00	41.00	53.51	338.53
5.76	-7.29	-17.55	-99.52	41.27	53.88	343.63
5.82	-7.41	-17.75	-100.89	41.42	54.10	346.38
6.49	-8.82	-20.14	-117.20	43.18	56.62	379.28
7.21	-10.35	-22.73	-134.88	45.09	59.45	414.94
7.64	-11.27	-24.30	-145.60	46.25	61.22	436.56
7.64	-11.27	-24.30	-145.60	45.61	61.22	436.56
7.93	-11.87	-25.32	-152.56	46.39	62.36	450.59
8.65	-13.40	-27.91	-170.24	48.35	65.32	486.25
8.80	-13.73	-28.46	-174.00	48.77	65.96	493.82
8.80	-0.60	-16.74	-417.23	23.92	47.69	919.48
8.95	-0.58	-17.19	-425.47	23.91	48.21	935.77
8.99	-0.57	-17.30	-427.36	23.90	48.33	944.73
9.00	Rock	Rock	Rock	Rock	Rock	Rock
9.37	Rock	Rock	Rock	Rock	Rock	Rock
10.09	Rock	Rock	Rock	Rock	Rock	Rock
10.81	Rock	Rock	Rock	Rock	Rock	Rock
11.53	Rock	Rock	Rock	Rock	Rock	Rock
12.25	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	-35.74	1.57	-0.00	-0.00
0.61	0.00	0.00	-32.78	3.58	-1.39	0.36
1.23	0.00	0.00	-29.82	10.79	-5.88	2.36
1.84	0.00	0.00	-26.86	15.00	-13.78	8.26
2.45	0.00	0.00	-23.92	24.49	-25.87	20.08
3.06	0.00	0.00	-20.99	33.20	-43.53	41.06
3.68	0.00	0.00	-18.10	41.90	-66.53	74.49

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Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
4.00	0.00	0.00	-16.60	46.47	-80.72	98.09
4.01	0.00	3.58	-16.52	41.64	-81.39	99.55
4.29	0.00	3.58	-15.27	38.29	-92.32	123.33
4.90	0.00	3.58	-12.56	30.88	-113.50	186.60
5.51	0.00	22.71	-10.02	-30.81	-102.89	253.72
6.13	0.00	22.71	-7.71	-49.65	-78.22	309.82
6.74	0.00	22.71	-5.67	-67.66	-42.27	347.33
7.35	22.71	22.71	-3.95	-59.42	0.54	359.66
7.96	22.71	22.71	-2.55	-31.88	28.16	350.04
8.57	22.71	22.71	-1.47	-10.11	40.68	328.30
9.19	150.32	150.32	-0.68	-94.97	96.64	289.29
9.80	150.32	0.00	-0.15	-22.15	130.46	217.48
10.41	0.00	150.32	0.19	28.12	127.48	136.96
11.03	0.00	150.32	0.40	59.68	99.90	66.35
11.64	0.00	150.32	0.55	81.99	56.24	17.83
12.25	0.00	150.32	0.68	101.53	0.00	-0.00

Maximum values of internal forces acting on the structure

Maximum shear force = 132,71 kN/m
Maximum moment = 359,66 kNm/m
Maximum displacement = 35,7 mm
Displacement in the depth of slip surface = 16,6 mm

Maximum internal forces on cross-section

Maximum shear force = 199,06 kN
Maximum moment = 539,49 kNm

Verification of rock bearing capacity

Max. stress σ = 113,49 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 = 113,49 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} = 16,5 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	17,5
2	1,03	21,7
3	2,06	24,6
4	3,09	26,1
5	4,12	26,3
6	5,15	25,3
7	6,18	22,8
8	7,21	19,1

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	Coordinates x [m]	Settlement z [mm]
9	8,24	14,1
10	9,27	7,7
11	10,31	0,0
12	10,31	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	-39.83	-5.15	-0.00	0.00	-0.00	-0.00
0.61	-36.50	-4.67	-1.39	-0.80	0.16	0.36
0.98	-34.51	-4.39	-3.55	-2.61	0.74	1.23
1.00	-34.42	-4.38	-3.69	-2.71	0.79	1.29
1.00	-34.38	-4.37	-3.76	-2.76	0.81	1.32
1.00	-34.38	-4.37	-3.76	-2.76	0.81	1.32
1.23	-33.18	-4.20	-5.94	-3.70	1.52	2.36
1.84	-29.85	-3.73	-17.65	-6.03	4.53	8.81
2.45	-26.53	-3.27	-33.43	-7.94	8.83	24.15
3.06	-23.24	-2.81	-55.58	-9.70	14.17	51.08
3.68	-19.99	-2.36	-84.25	-13.35	21.11	93.57
4.00	-18.32	-2.14	-101.87	-16.17	25.83	123.39
4.00	-18.32	-2.14	-101.87	-16.17	25.83	123.39
4.00	-18.28	-2.13	-102.21	-16.25	25.96	124.21
4.00	-18.28	-2.13	-102.21	-16.25	25.96	124.21
4.01	-18.22	-2.12	-102.46	-16.35	26.12	125.23
4.01	-18.22	-2.12	-102.46	-16.35	26.12	125.23
4.29	-16.83	-1.94	-109.26	-19.27	30.98	154.19
4.90	-13.80	-1.54	-122.92	-27.43	45.17	225.41
5.51	-10.99	-1.18	-103.35	-12.39	57.87	295.88
6.13	-8.43	-0.88	-78.22	1.14	61.15	350.62
6.74	-6.20	-0.63	-42.27	21.93	57.45	385.71
7.35	-4.31	-0.43	0.54	34.17	49.61	397.19
7.96	-2.77	-0.28	12.56	39.15	41.16	385.76
8.57	-1.58	-0.16	6.69	44.54	35.08	361.41
9.19	-0.72	-0.07	9.99	107.34	30.92	318.96
9.80	-0.15	0.04	13.94	145.44	23.33	238.84
10.41	0.02	0.21	13.66	140.23	14.71	149.95
11.03	0.04	0.44	10.73	109.37	7.13	72.46
11.64	0.06	0.60	6.05	61.36	1.92	19.44
12.25	0.07	0.73	-0.00	0.00	-0.00	0.00

Maximum values of internal forces

Maximum displacement = -39,8 mm
Minimum displacement = 0,7 mm
Maximum bending moment = 397,19 kNm/m
Minimum bending moment = 0,00 kNm/m
Maximum shear force = 146,45 kN/m

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Verification of RC cross section (Pile curtain d = 0,80 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 - 16 pc bars 25,0 mm; cover 80,0 mm
Type of structure (reinforcement ratio) : beam
Reinforcement ratio ρ = 0,781 % > 0,135 % = ρ_{min}
Load : M_{Ed} = 595,78 kNm
Bearing capacity : M_{Rd} = 914,37 kNm

Designed pile reinforcement is SATISFACTORY

Verification of cross section in shear:

Shear reinf. - profile 12,0 mm; spacing 200,0 mm
A_{sw} = 2 x 565,5 = 1131,0 mm^2
b_w = 0,70 m; d = 0,64 m
Ultimate shear force: V_{Rd} = 708,09 kN > 219,68 kN = V_{Ed}

Cross-section is SATISFACTORY.

Overall verification: Cross-section is SATISFACTORY

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