



Sheeting structure verification

Input data

Project

Date : 28.10.2015

Settings

(input for current task)

Materials and standards

Concrete structures : CSN 73 1201 R
Steel structures : EN 1993-1-1 (EC3)
Partial factor on bearing capacity of steel cross section : $\gamma_{M0} = 1,00$

Excavations

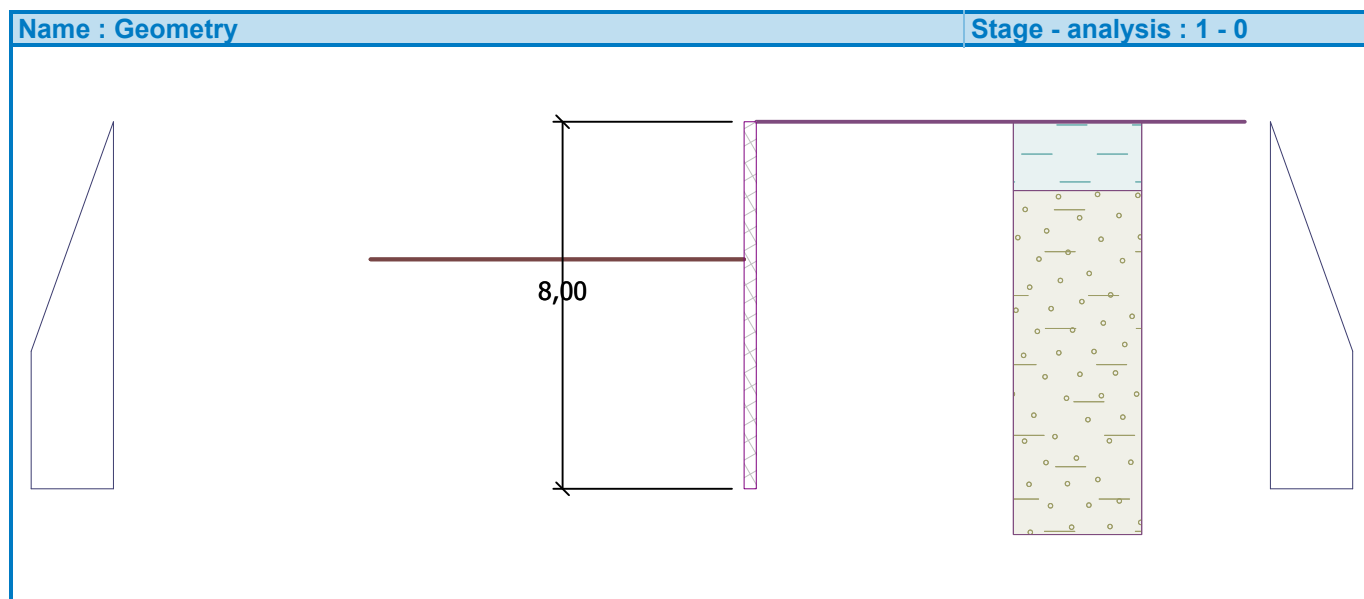
Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Caquot-Kerisel
Analysis method : dependent pressures
Earthquake analysis : Mononobe-Okabe
Modulus of subsoil reaction : input
Verification methodology : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor for internal stability of anchors :	$SF_a =$	1,50	[-]

Geometry of structure

Structure length = 8,00 m

Cross-section name : RC rectangular wall h = 0,30 m
Area of cross-section A = 3,00E-01 m²/m
Moment of inertia I = 2,25E-03 m⁴/m
Elastic modulus E = 27000,00 MPa
Shear modulus G = 11340,00 MPa



Material of structure

Analysis of concrete structures carried out according to the standard CSN 73 1201 R.

Concrete : B 20



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Designer: Ing. John Williams

Compressive strength $R_{bd} = 11,50 \text{ MPa}$
Tensile strength $R_{btd} = 0,90 \text{ MPa}$
Elasticity modulus $E_b = 27000,00 \text{ MPa}$
Shear modulus $G = 11340,00 \text{ MPa}$

Longitudinal steel : 10 216 E

Compressive strength $R_{scd} = 190,00 \text{ MPa}$
Tensile strength $R_{sd} = 190,00 \text{ MPa}$

Distribution of the modulus of subsoil reaction (in front and behind the wall)

Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]
0.00	0.00	0.00
5.00	10.00	10.00
8.00	10.00	10.00

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ [°]
1	Clayey sand		29,00	5,00	18,00	10,00	15,00
2	Clay with high plasticity		15,00	5,00	20,50	10,50	15,00

Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	φ_{ef} [°]	ν [-]	OCR [-]	K_r [-]
1	Clayey sand		cohesive	-	0,30	-	-
2	Clay with high plasticity		cohesive	-	0,30	-	-

Soil parameters

Clayey sand

Unit weight : $\gamma = 18,00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 29,00^\circ$
Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 15,00^\circ$
Soil : cohesive
Poisson's ratio : $\nu = 0,30$
Saturated unit weight : $\gamma_{sat} = 20,00 \text{ kN/m}^3$

Clay with high plasticity

Unit weight : $\gamma = 20,50 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 15,00^\circ$
Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 15,00^\circ$
Soil : cohesive
Poisson's ratio : $\nu = 0,30$
Saturated unit weight : $\gamma_{sat} = 20,50 \text{ kN/m}^3$



Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	1,50	Clay with high plasticity	
2	-	Clayey sand	

Excavation

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

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Global settings

Number of FEs to discretize wall = 30

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

Settings of the stage of construction

Design situation : permanent

Analysis results (Stage of construction 1)

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

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	14.29
0.61	0.00	0.00	0.00	2.49	5.33	40.61
1.50	-0.00	-0.00	-0.00	9.15	13.18	79.34
1.50	0.00	0.00	0.00	6.15	13.18	158.04
3.00	-0.00	-0.00	-0.00	12.48	24.75	278.58
3.00	-0.00	-0.00	-20.77	12.48	24.75	278.58
3.92	-0.00	-7.07	-94.36	17.46	31.82	352.17
8.00	-22.23	-38.57	-422.55	39.69	63.32	680.36

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	-10.69	0.00	0.00	-0.00
0.27	0.00	0.00	-10.14	1.09	-0.15	0.01
0.53	0.00	0.00	-9.60	2.19	-0.58	0.10
0.80	0.00	0.00	-9.05	3.93	-1.40	0.36
1.07	0.00	0.00	-8.51	5.92	-2.71	0.89
1.33	0.00	0.00	-7.97	7.91	-4.56	1.85
1.60	0.00	0.00	-7.43	6.57	-6.49	3.33
1.87	0.00	0.00	-6.89	7.70	-8.39	5.31
2.13	0.00	0.00	-6.35	8.82	-10.59	7.83
2.40	0.00	0.00	-5.83	9.95	-13.09	10.98
2.67	0.00	0.00	-5.32	11.07	-15.90	14.84



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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]
2.93	0.00	0.00	-4.82	12.20	-19.00	19.49
2.99	0.00	0.00	-4.72	12.44	-19.70	20.59
3.01	0.00	0.00	-4.68	-9.04	-19.73	20.98
3.20	6.40	0.00	-4.35	-15.79	-17.27	24.40
3.47	6.93	0.00	-3.90	-15.59	-13.08	28.43
3.73	7.47	0.00	-3.47	-15.13	-8.97	31.36
4.00	8.00	0.00	-3.09	-14.49	-5.01	33.21
4.27	8.53	0.00	-2.73	-13.73	-1.25	34.03
4.53	9.07	0.00	-2.42	-12.92	2.31	33.88
4.80	9.60	0.00	-2.14	-12.12	5.65	32.81
5.07	10.00	0.00	-1.89	-11.12	8.75	30.88
5.33	10.00	10.00	-1.68	-8.77	11.54	28.00
5.60	10.00	10.00	-1.49	-5.08	13.37	24.66
5.87	10.00	10.00	-1.33	-1.92	14.29	20.95
6.13	10.00	10.00	-1.20	0.80	14.43	17.11
6.40	10.00	10.00	-1.08	3.16	13.90	13.32
6.67	10.00	10.00	-0.98	5.23	12.77	9.75
6.93	10.00	10.00	-0.88	7.10	11.13	6.55
7.20	10.00	10.00	-0.80	8.82	9.00	3.86
7.47	10.00	10.00	-0.71	10.46	6.43	1.79
7.73	10.00	10.00	-0.63	12.05	3.43	0.47
8.00	10.00	10.00	-0.56	13.64	0.00	0.00

Maximum shear force = 19,73 kN/m
Maximum moment = 34,03 kNm/m
Maximum displacement = 10,7 mm

Input data (Stage of construction 2)

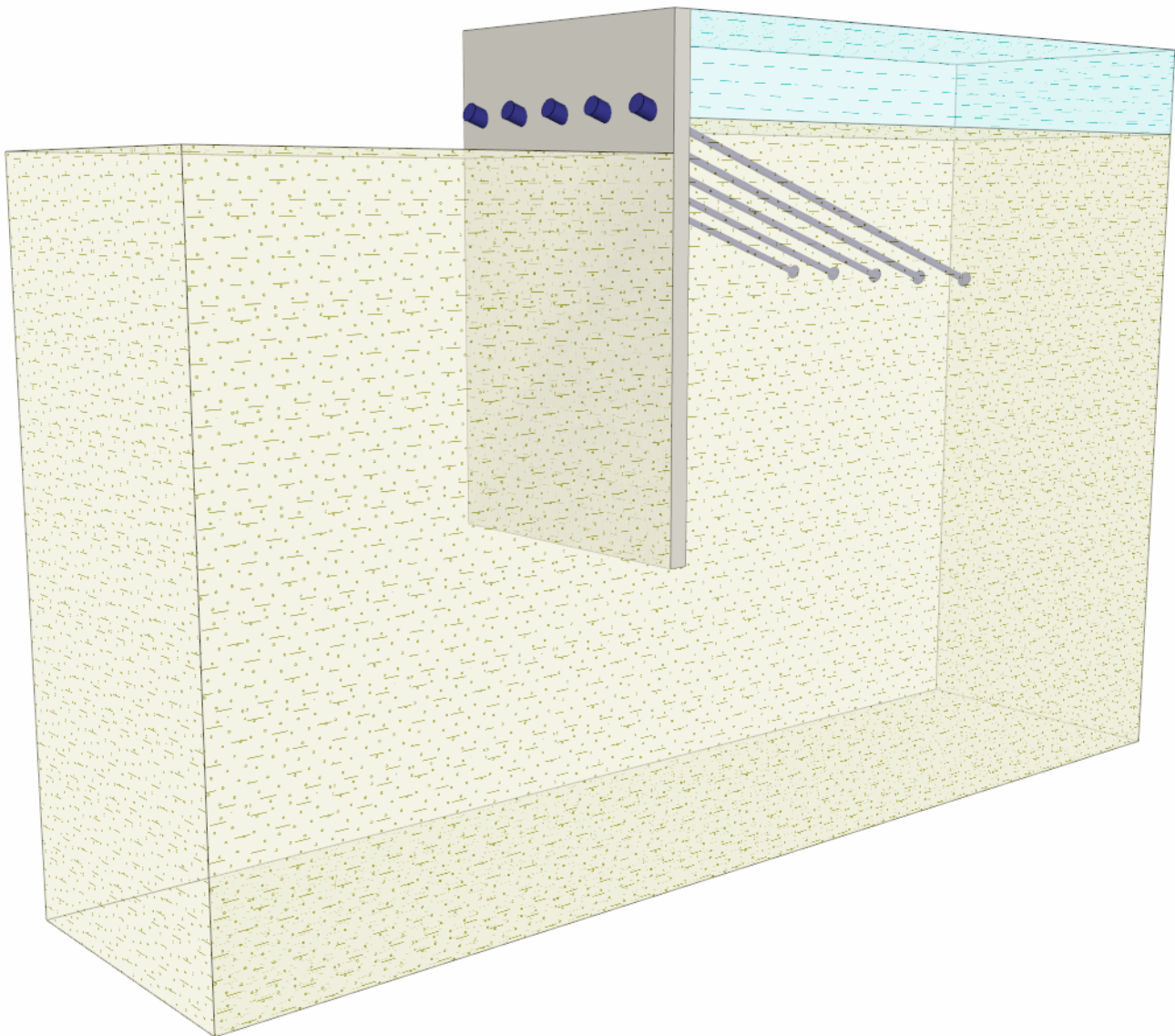
Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	1,50	Clay with high plasticity	
2	-	Clayey sand	



Name : Profile and assignment

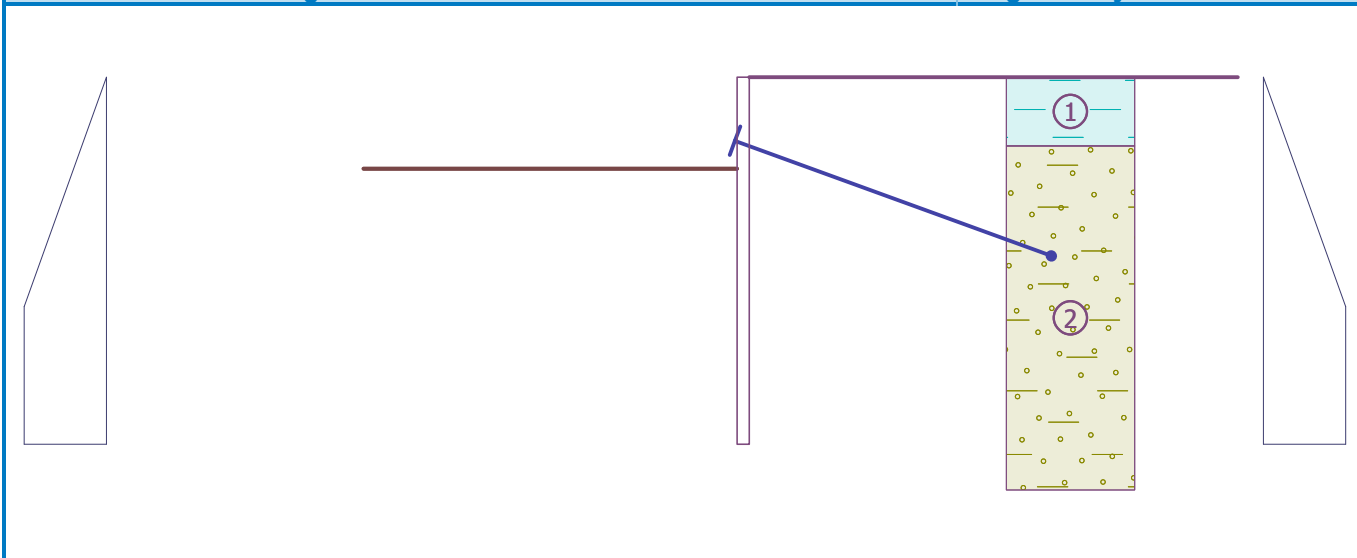
Stage - analysis : 2 - 0





Name : Profile and assignment

Stage - analysis : 2 - 0



Excavation

Soil in front of wall is excavated to a depth of 2,00 m.

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input anchors

No.	New anchor	Depth z [m]	Length l [m]	Root l _k [m]	Slope α [°]	Spacing b [m]
1	Yes	1,50	7,00	0,01	20,00	1,00

No.	Stiffness k [kN/m]	Diameter d [mm]	Area A [mm ²]	Elast.modulus E [MPa]	Post-stressing	Force F [kN]
1		20,0		210000,00		55,00

Settings of the stage of construction

Design situation : permanent

Analysis results (Stage of construction 2)

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

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	14.29
0.61	0.00	0.00	0.00	2.49	5.33	40.61
1.50	-0.00	-0.00	-0.00	9.15	13.18	79.34
1.50	0.00	0.00	0.00	6.15	13.18	158.04
2.00	-0.00	-0.00	-0.00	7.95	17.04	198.22
2.00	-0.00	-0.00	-20.77	7.95	17.04	198.23
2.92	-0.00	-7.07	-94.36	12.80	24.10	271.81
8.00	-27.67	-46.29	-502.91	39.69	63.32	680.36



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	-1.91	0.01	-0.00	-0.00
0.27	0.00	0.53	-1.89	5.50	-0.73	0.04
0.53	0.00	1.07	-1.86	10.44	-2.86	0.47
0.80	0.00	1.60	-1.84	15.48	-6.31	1.64
1.07	0.00	2.13	-1.81	20.21	-11.07	3.90
1.33	0.00	2.67	-1.79	24.37	-17.01	7.60
1.50	0.00	3.00	-1.79	24.49	-21.09	10.77
1.50	0.00	3.00	-1.79	24.49	30.60	10.77
1.60	0.00	3.20	-1.78	24.56	28.14	7.84
1.87	0.00	3.73	-1.78	26.53	21.33	1.21
1.99	0.00	3.98	-1.78	27.26	18.01	-1.21
2.01	4.02	4.02	-1.78	20.15	17.54	-1.57
2.13	4.27	4.27	-1.78	19.56	15.09	-3.58
2.40	4.80	4.80	-1.77	17.93	10.09	-6.94
2.67	5.33	5.33	-1.76	15.89	5.59	-9.03
2.93	5.87	5.87	-1.74	13.54	1.67	-9.99
3.20	6.40	6.40	-1.71	10.96	-1.59	-10.00
3.47	6.93	6.93	-1.67	8.25	-4.15	-9.22
3.73	7.47	7.47	-1.62	5.53	-5.98	-7.86
4.00	8.00	8.00	-1.56	2.85	-7.09	-6.11
4.27	8.53	8.53	-1.49	0.29	-7.50	-4.15
4.53	9.07	9.07	-1.42	-2.10	-7.25	-2.17
4.80	9.60	9.60	-1.35	-4.30	-6.39	-0.34
5.07	10.00	10.00	-1.28	-6.20	-4.99	1.19
5.33	10.00	10.00	-1.21	-7.18	-3.21	2.29
5.60	10.00	10.00	-1.14	-5.82	-1.48	2.91
5.87	10.00	10.00	-1.08	-4.52	-0.10	3.11
6.13	10.00	10.00	-1.02	-3.29	0.94	2.99
6.40	10.00	10.00	-0.96	-2.12	1.66	2.64
6.67	10.00	10.00	-0.90	-1.01	2.08	2.13
6.93	10.00	10.00	-0.85	0.05	2.21	1.56
7.20	10.00	10.00	-0.80	1.07	2.06	0.98
7.47	10.00	10.00	-0.75	2.08	1.64	0.48
7.73	10.00	10.00	-0.70	3.07	0.95	0.13
8.00	10.00	10.00	-0.65	4.05	-0.00	0.00

Maximum shear force = 30,60 kN/m
Maximum moment = 10,77 kNm/m
Maximum displacement = 1,9 mm

Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	1,50	-1,8	55,00

Internal stability of anchor system - partial results

$E_A = 13,43 \text{ kN/m}$ $\delta = 11,93^\circ$
Depth of theoretical footing under bottom of the pit $H_0 = 0,42 \text{ m}$



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Row of anchors	E_{A1} [kN/m]	δ_1 [°]	G [kN/m]	C [kN/m]	θ [°]	Included rows of anchors	Q [kN/m]	F [kN/m]	FK_{MAX} [kN]
1	35,22	23,96	398,85	33,73	-12,64		417,22	309,75	309,75

Internal stability of anchor system check

No.	Anchor force [kN]	Max.allow.force in anchor [kN]	Factor of safety
1	55,00	309,75	5,63

Decisive anchor row : 1

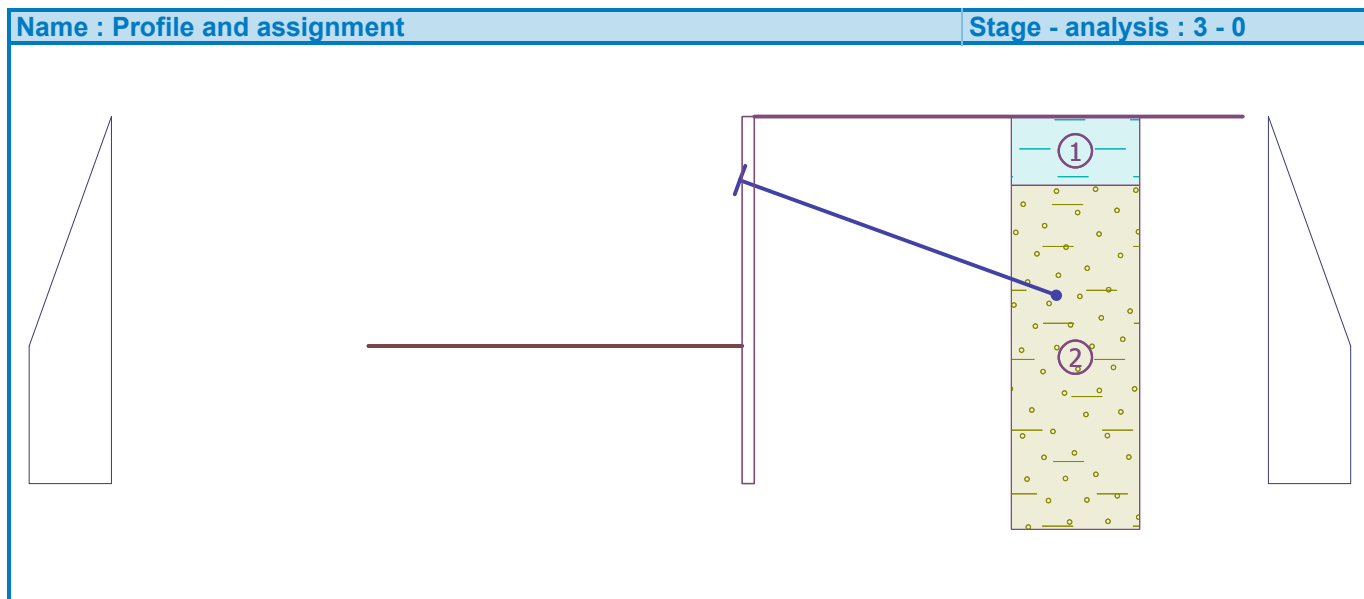
Required safety fact. $FS = 1,50 < 5,63 = FS_{minim.}$

Overall verification of internal stability is SATISFACTORY

Input data (Stage of construction 3)

Geological profile and assigned soils

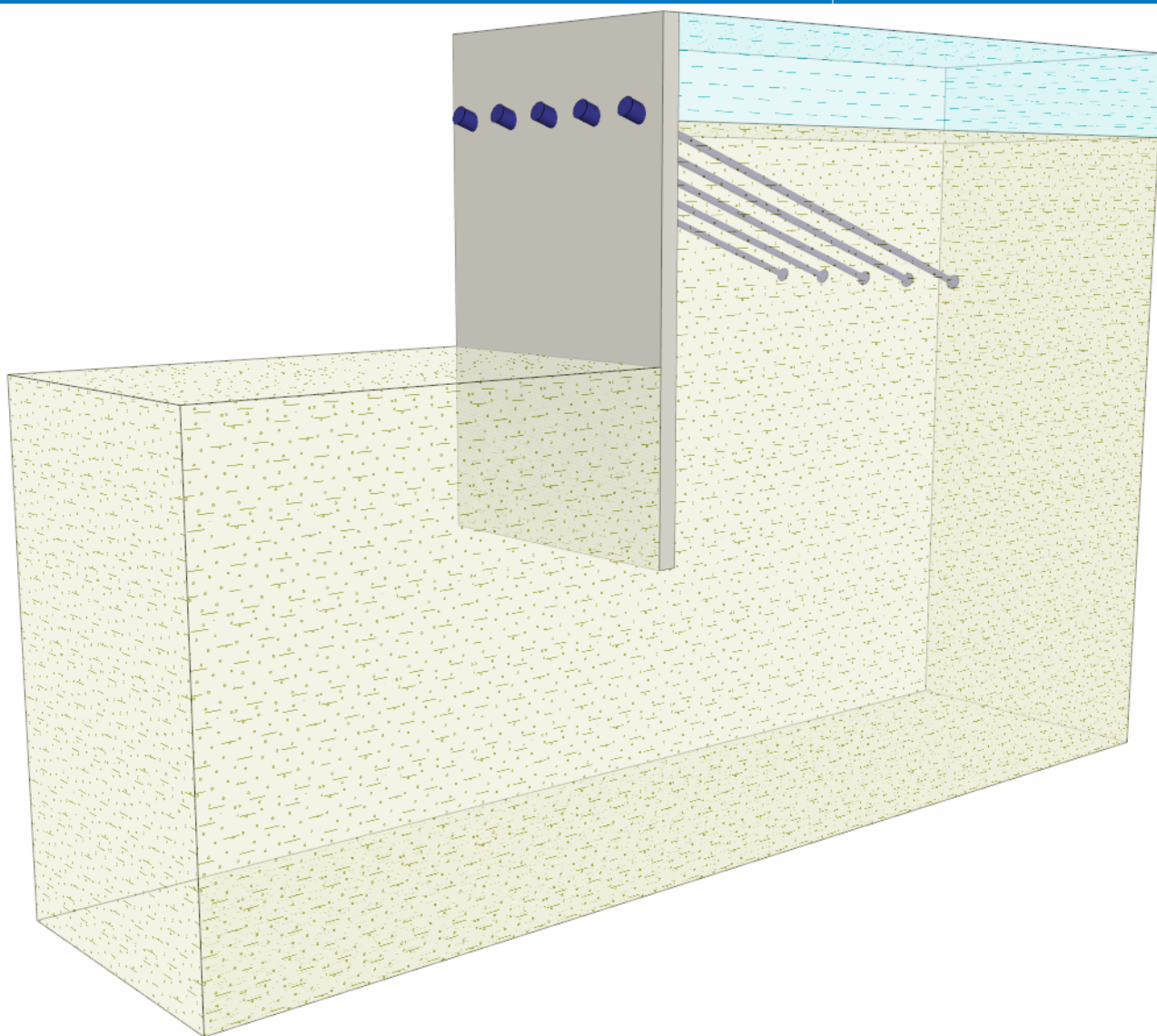
No.	Layer [m]	Assigned soil	Pattern
1	1,50	Clay with high plasticity	
2	-	Clayey sand	





Name : Profile and assignment

Stage - analysis : 3 - 0



Excavation

Soil in front of wall is excavated to a depth of 5,00 m.

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input anchors

No.	New anchor	Depth z [m]	Length l [m]	Root l _k [m]	Slope α [°]	Spacing b [m]
1	No	1,50	7,00	0,01	20,00	1,00

No.	Stiffness k [kN/m]	Diameter d [mm]	Area A [mm ²]	Elast.modulus E [MPa]	Post-stressing	Force F [kN]
1		20,0		210000,00		68,46



Settings of the stage of construction

Design situation : permanent

Analysis results (Stage of construction 3)

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

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	14.29
0.61	0.00	0.00	0.00	2.49	5.33	40.61
1.50	-0.00	-0.00	-0.00	9.15	13.18	79.34
1.50	0.00	0.00	0.00	6.15	13.18	158.04
5.00	-0.00	-0.00	-0.00	23.37	40.18	439.29
5.00	-0.00	-0.00	-20.77	23.37	40.18	439.30
5.92	-0.00	-7.07	-94.36	28.35	47.24	512.88
8.00	-11.34	-23.14	-261.84	39.69	63.32	680.36

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	-2.02	0.01	0.00	0.00
0.27	0.00	0.53	-2.23	5.32	-0.72	0.04
0.53	0.00	1.07	-2.44	9.83	-2.74	0.45
0.80	0.00	1.60	-2.65	14.18	-5.95	1.56
1.07	0.00	2.13	-2.86	17.98	-10.25	3.67
1.33	0.00	2.67	-3.08	20.95	-15.45	7.05
1.50	0.00	3.00	-3.21	20.18	-18.88	9.91
1.50	0.00	3.00	-3.21	20.18	45.45	9.91
1.60	0.00	3.20	-3.30	19.71	43.45	5.47
1.87	0.00	3.73	-3.53	20.01	38.15	-5.43
2.13	0.00	4.27	-3.75	20.69	32.72	-14.91
2.40	0.00	4.80	-3.96	21.91	27.03	-22.91
2.67	0.00	5.33	-4.15	22.19	21.15	-29.35
2.93	0.00	5.87	-4.30	20.92	15.40	-34.24
3.20	0.00	6.40	-4.42	19.20	10.05	-37.64
3.47	0.00	6.93	-4.50	17.17	5.20	-39.68
3.73	0.00	0.00	-4.54	17.13	0.65	-40.18
4.00	0.00	0.00	-4.53	18.45	-4.10	-39.72
4.27	0.00	0.00	-4.49	19.76	-9.19	-37.96
4.53	0.00	0.00	-4.40	21.07	-14.64	-34.79
4.80	0.00	0.00	-4.28	22.38	-20.43	-30.12
4.99	0.00	0.00	-4.17	23.32	-24.77	-25.83
5.01	0.00	0.00	-4.16	1.85	-25.02	-25.33
5.07	0.00	0.00	-4.13	-2.39	-25.01	-23.91
5.33	10.00	0.00	-3.95	-16.86	-22.32	-17.83
5.60	10.00	0.00	-3.75	-15.49	-18.00	-12.46
5.87	10.00	0.00	-3.54	-13.99	-14.07	-8.19
6.13	10.00	0.00	-3.32	-12.40	-10.55	-4.92
6.40	10.00	0.00	-3.09	-10.76	-7.46	-2.53
6.67	10.00	0.00	-2.87	-9.10	-4.81	-0.90
6.93	10.00	0.00	-2.64	-7.42	-2.60	0.08



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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]
7.20	10.00	0.00	-2.41	-5.75	-0.85	0.53
7.47	10.00	10.00	-2.18	-3.52	0.54	0.36
7.73	10.00	10.00	-1.96	1.01	0.87	0.14
8.00	10.00	10.00	-1.73	5.54	0.00	0.00

Maximum shear force = 45,45 kN/m

Maximum moment = 40,18 kNm/m

Maximum displacement = 4,5 mm

Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	1,50	-3,2	68,46

Internal stability of anchor system - partial results

$E_A = 97,31 \text{ kN/m}$ $\delta = 14,04^\circ$

Depth of theoretical footing under bottom of the pit $H_0 = 1,32 \text{ m}$

Row of anchors	E_{A1} [kN/m]	δ_1 [°]	G [kN/m]	C [kN/m]	θ [°]	Included rows of anchors	Q [kN/m]	F [kN/m]	FK_{MAX} [kN]
1	35,22	23,96	629,90	35,07	20,22		549,74	190,56	190,56

Internal stability of anchor system check

No.	Anchor force [kN]	Max.allow.force in anchor [kN]	Factor of safety
1	68,46	190,56	2,78

Decisive anchor row : 1

Required safety fact. $FS = 1,50 < 2,78 = FS_{minim.}$

Overall verification of internal stability is SATISFACTORY

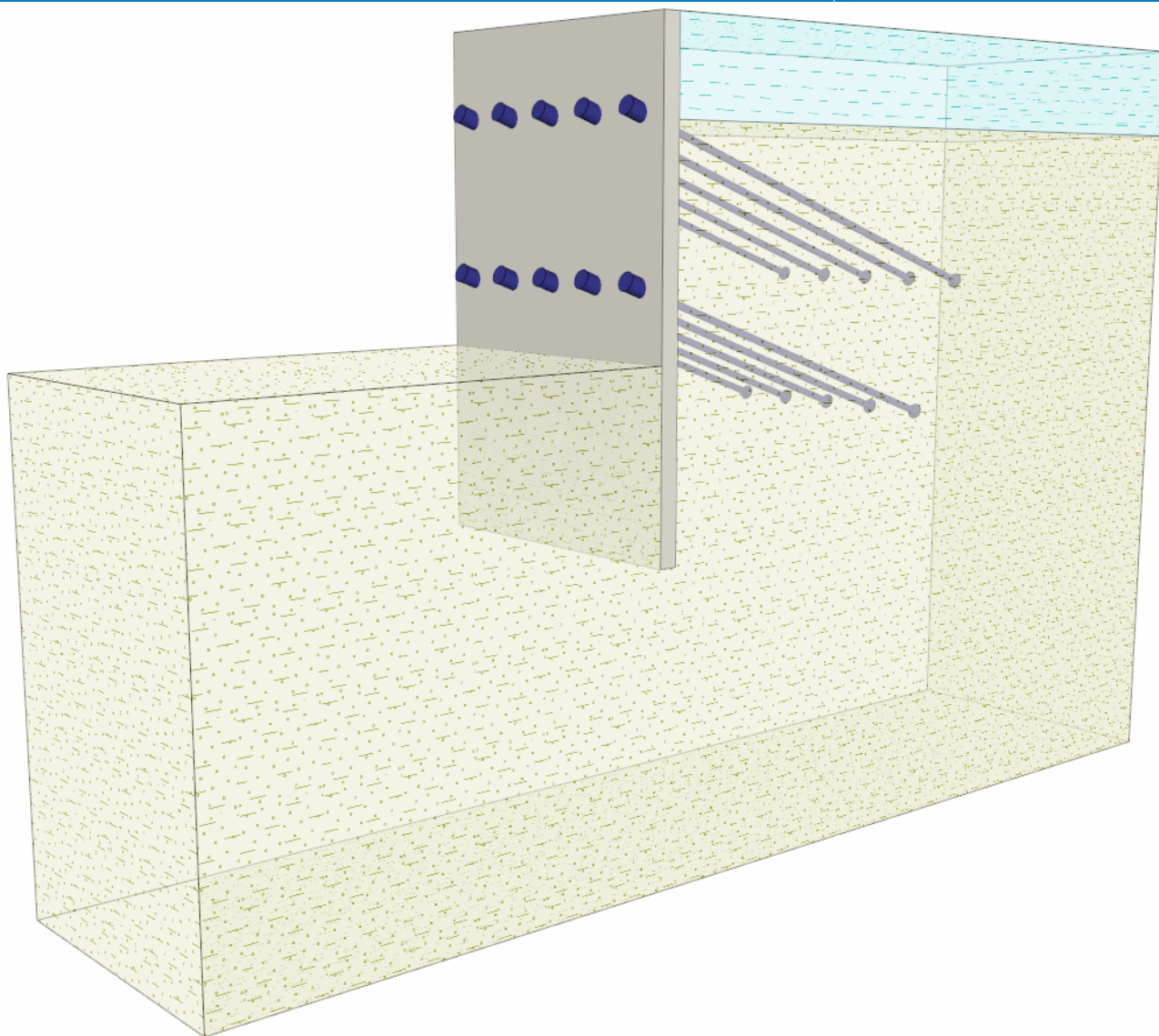
Input data (Stage of construction 4)

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	1,50	Clay with high plasticity	
2	-	Clayey sand	

Name : Profile and assignment

Stage - analysis : 4 - 0



Excavation

Soil in front of wall is excavated to a depth of 5,00 m.

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input anchors

No.	New anchor	Depth z [m]	Length l [m]	Root l_k [m]	Slope α [°]	Spacing b [m]
1	No	1,50	7,00	0,01	20,00	1,00
2	Yes	4,00	6,00	0,01	20,00	1,00



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No.	Stiffness k [kN/m]	Diameter d [mm]	Area A [mm ²]	Elast.modulus E [MPa]	Post-stressing	Force F [kN]
1		20,0		210000,00		60,07
2		20,0		210000,00		70,98

Settings of the stage of construction

Design situation : permanent

Analysis results (Stage of construction 4)

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

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	14.29
0.61	0.00	0.00	0.00	2.49	5.33	40.61
1.50	-0.00	-0.00	-0.00	9.15	13.18	79.34
1.50	0.00	0.00	0.00	6.15	13.18	158.04
5.00	-0.00	-0.00	-0.00	23.37	40.18	439.29
5.00	-0.00	-0.00	-20.77	23.37	40.18	439.30
5.92	-0.00	-7.07	-94.36	28.35	47.24	512.88
8.00	-11.34	-23.14	-261.84	39.69	63.32	680.36

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	-1.90	0.01	0.00	-0.00
0.27	0.00	0.53	-1.97	5.45	-0.73	0.04
0.53	0.00	1.07	-2.04	10.25	-2.83	0.46
0.80	0.00	1.60	-2.12	15.03	-6.20	1.61
1.07	0.00	2.13	-2.19	19.40	-10.79	3.83
1.33	0.00	2.67	-2.27	23.10	-16.46	7.42
1.50	0.00	3.00	-2.32	22.87	-20.30	10.48
1.50	0.00	3.00	-2.32	22.87	36.15	10.48
1.60	0.00	3.20	-2.36	22.73	33.87	6.98
1.87	0.00	3.73	-2.45	24.03	27.63	-1.25
2.13	0.00	4.27	-2.55	25.84	20.98	-7.76
2.40	0.00	4.80	-2.63	28.30	13.76	-12.42
2.67	0.00	5.33	-2.70	29.89	6.00	-15.08
2.93	0.00	5.87	-2.76	29.96	-1.98	-15.63
3.20	0.00	6.40	-2.80	29.56	-9.92	-14.06
3.47	0.00	6.93	-2.83	28.76	-17.69	-10.38
3.73	0.00	7.47	-2.84	29.77	-25.50	-4.65
4.00	0.00	8.00	-2.86	31.86	-33.71	3.21
4.00	0.00	8.00	-2.86	31.86	32.99	3.21
4.27	0.00	8.53	-2.87	33.56	24.26	-4.45
4.53	0.00	9.07	-2.88	34.88	15.14	-9.73
4.80	0.00	9.60	-2.88	35.84	5.71	-12.53
4.99	0.00	9.98	-2.87	36.33	-1.15	-12.97
5.01	0.00	10.00	-2.87	14.78	-1.66	-12.94
5.07	0.00	10.00	-2.86	10.23	-2.37	-12.82
5.33	10.00	10.00	-2.84	5.34	-4.42	-12.13



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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]
5.60	10.00	10.00	-2.80	3.54	-5.60	-10.77
5.87	10.00	10.00	-2.75	1.83	-6.31	-9.17
6.13	10.00	10.00	-2.69	0.22	-6.58	-7.43
6.40	10.00	10.00	-2.62	-1.29	-6.43	-5.68
6.67	10.00	10.00	-2.55	-2.72	-5.89	-4.02
6.93	10.00	10.00	-2.47	-4.07	-4.98	-2.56
7.20	10.00	10.00	-2.39	-5.38	-3.72	-1.38
7.47	10.00	0.00	-2.31	-5.37	-2.34	-0.36
7.73	10.00	10.00	-2.23	-4.47	-0.98	-0.12
8.00	10.00	10.00	-2.15	-2.86	0.00	-0.00

Maximum shear force = 36,15 kN/m
Maximum moment = 15,63 kNm/m
Maximum displacement = 2,9 mm

Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	1,50	-2,3	60,07
2	4,00	-2,9	70,98

Internal stability of anchor system - partial results

$E_A = 97,31 \text{ kN/m}$ $\delta = 14,04^\circ$
Depth of theoretical footing under bottom of the pit $H_0 = 1,32 \text{ m}$

Row of anchors	E_{A1} [kN/m]	δ_1 [°]	G [kN/m]	C [kN/m]	θ [°]	Included rows of anchors	Q [kN/m]	F [kN/m]	FK_{MAX} [kN]
1	35,22	23,96	629,90	35,07	20,22		549,74	190,56	190,56
2	88,84	26,32	649,57	28,25	2,70	1	485,58	274,70	274,70

Internal stability of anchor system check

No.	Anchor force [kN]	Max.allow.force in anchor [kN]	Factor of safety
1	60,07	190,56	3,17
2	70,98	274,70	3,87

Decisive anchor row : 1
Required safety fact. $FS = 1,50 < 3,17 = FS_{minim.}$

Overall verification of internal stability is SATISFACTORY

Input data (Stage of construction 5)

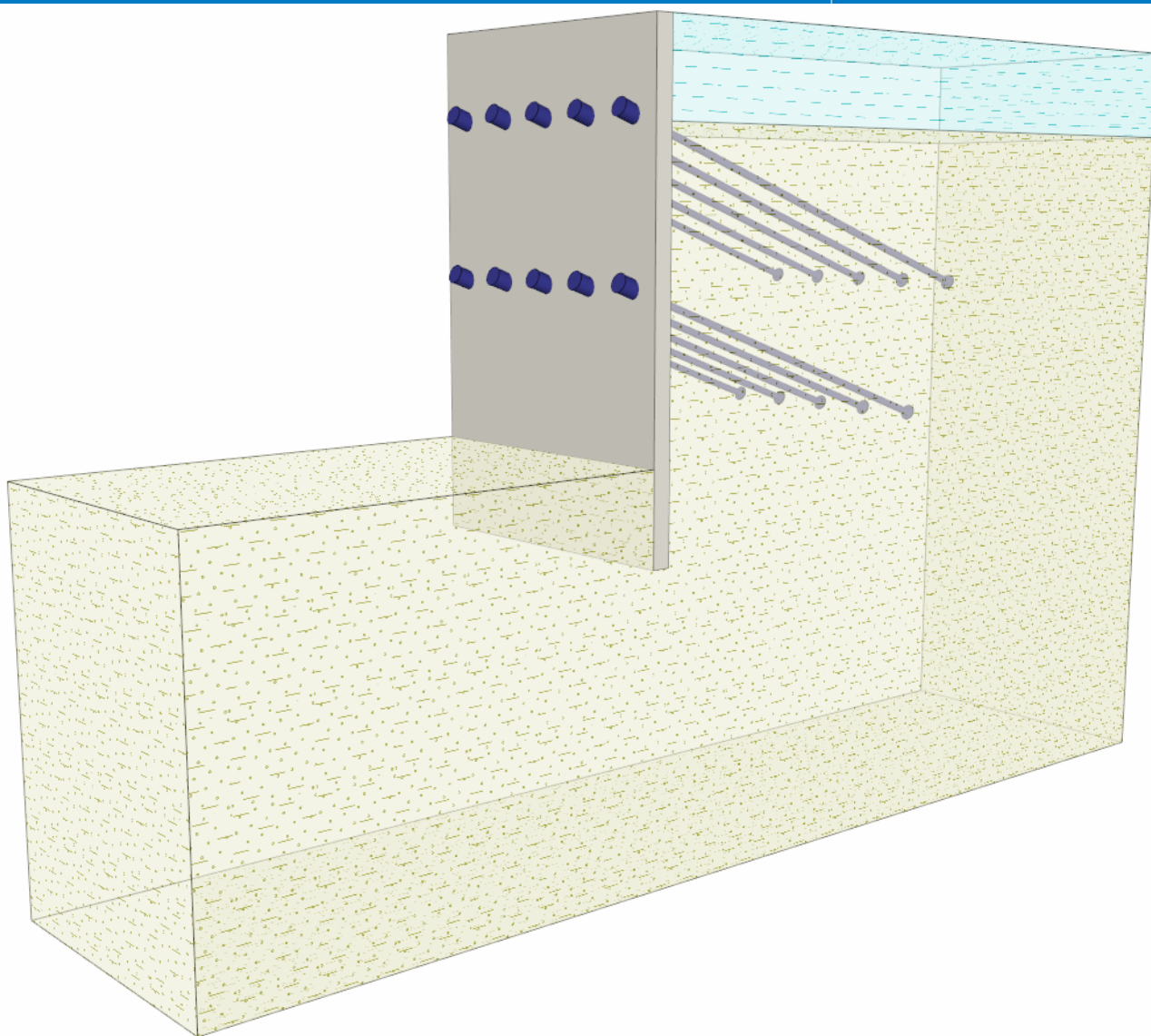
Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	1,50	Clay with high plasticity	
2	-	Clayey sand	



Name : Profile and assignment

Stage - analysis : 5 - 0



Excavation

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

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Input anchors

No.	New anchor	Depth z [m]	Length l [m]	Root l_k [m]	Slope α [°]	Spacing b [m]
1	No	1,50	7,00	0,01	20,00	1,00
2	No	4,00	6,00	0,01	20,00	1,00



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No.	Stiffness k [kN/m]	Diameter d [mm]	Area A [mm ²]	Elast.modulus E [MPa]	Post-stressing	Force F [kN]
1		20,0		210000,00		57,07
2		20,0		210000,00		81,24

Settings of the stage of construction

Design situation : permanent

Analysis results (Stage of construction 5)

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

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	14.29
0.61	0.00	0.00	0.00	2.49	5.33	40.61
1.50	-0.00	-0.00	-0.00	9.15	13.18	79.34
1.50	0.00	0.00	0.00	6.15	13.18	158.04
6.50	-0.00	-0.00	-0.00	31.53	51.75	559.83
6.50	-0.00	-0.00	-20.77	31.53	51.75	559.83
7.42	-0.00	-7.07	-94.36	36.52	58.82	633.42
8.00	-3.18	-11.57	-141.30	39.69	63.32	680.36

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	-0.95	0.01	0.00	0.00
0.27	0.00	0.53	-1.14	5.90	-0.79	0.05
0.53	0.00	1.07	-1.32	11.02	-3.06	0.51
0.80	0.00	1.60	-1.50	16.01	-6.67	1.76
1.07	0.00	2.13	-1.69	20.47	-11.54	4.13
1.33	0.00	2.67	-1.88	24.14	-17.49	7.96
1.50	0.00	3.00	-2.01	23.81	-21.49	11.21
1.50	0.00	3.00	-2.01	23.81	32.13	11.21
1.60	0.00	3.20	-2.08	23.61	29.76	8.11
1.87	0.00	3.73	-2.29	24.62	23.32	1.02
2.13	0.00	4.27	-2.50	26.02	16.56	-4.33
2.40	0.00	4.80	-2.71	27.92	9.36	-7.82
2.67	0.00	5.33	-2.91	28.80	1.80	-9.33
2.93	0.00	5.87	-3.10	27.99	-5.78	-8.81
3.20	0.00	6.40	-3.27	26.53	-13.05	-6.30
3.47	0.00	6.93	-3.45	24.48	-19.86	-1.92
3.73	0.00	7.47	-3.62	24.02	-26.33	4.23
4.00	0.00	8.00	-3.79	24.39	-32.80	12.09
4.00	0.00	8.00	-3.79	24.39	43.54	12.09
4.27	0.00	8.53	-3.98	24.13	37.07	1.32
4.53	0.00	9.07	-4.16	23.23	30.75	-7.74
4.80	0.00	0.00	-4.34	22.90	24.70	-14.79
5.07	0.00	0.00	-4.50	24.25	18.42	-20.55
5.33	0.00	0.00	-4.64	25.61	11.77	-24.58
5.60	0.00	0.00	-4.75	26.96	4.76	-26.79
5.87	0.00	0.00	-4.83	28.32	-2.61	-27.09



Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
6.13	0.00	0.00	-4.88	29.67	-10.34	-25.37
6.40	0.00	0.00	-4.90	31.02	-18.43	-21.54
6.49	0.00	0.00	-4.90	31.49	-21.31	-19.71
6.51	0.00	0.00	-4.90	10.16	-21.64	-19.37
6.67	0.00	0.00	-4.89	-1.72	-22.31	-15.85
6.93	10.00	0.00	-4.86	-18.07	-19.66	-10.55
7.20	10.00	0.00	-4.82	-18.29	-14.80	-5.95
7.47	10.00	0.00	-4.78	-18.45	-9.90	-2.65
7.73	10.00	0.00	-4.73	-18.57	-4.97	-0.66
8.00	10.00	0.00	-4.68	-18.69	0.00	-0.00

Maximum shear force = 43,54 kN/m
Maximum moment = 27,09 kNm/m
Maximum displacement = 4,9 mm

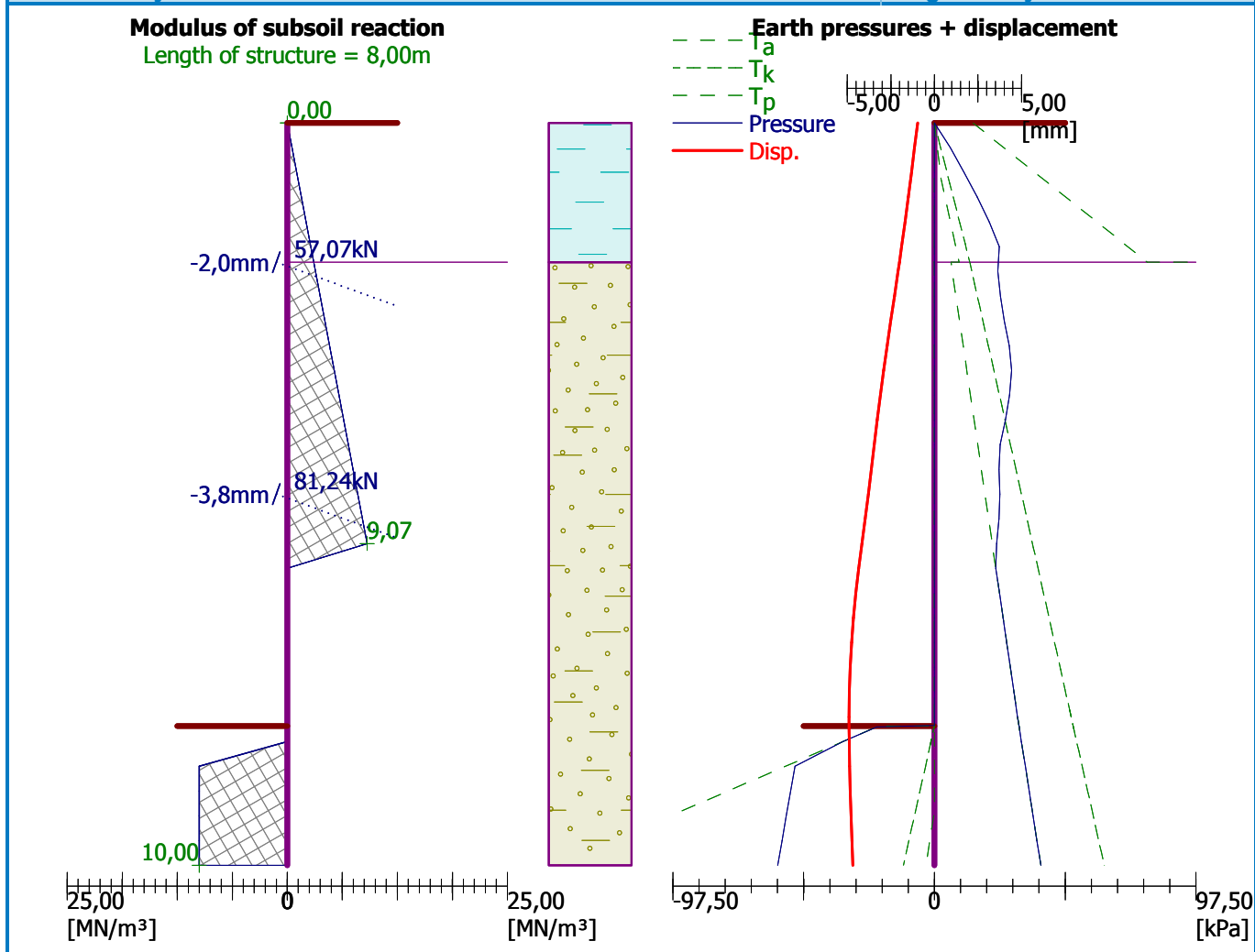
Anchors forces

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	1,50	-2,0	57,07
2	4,00	-3,8	81,24



Name : Analysis

Stage - analysis : 5 - -1



Internal stability of anchor system - partial results

$$E_A = 159,89 \text{ kN/m} \quad \delta = 14,27^\circ$$

Depth of theoretical footing under bottom of the pit $H_0 = 1,50 \text{ m}$

Row of anchors	E_{A1} [kN/m]	δ_1 [°]	G [kN/m]	C [kN/m]	θ [°]	Included rows of anchors	Q [kN/m]	F [kN/m]	FK_{MAX} [kN]
1	35,22	23,96	729,43	38,79	31,94		639,93	130,70	130,70
2	88,84	26,32	734,89	29,85	19,03	1	346,32	173,99	173,99

Internal stability of anchor system check

No.	Anchor force [kN]	Max.allow.force in anchor [kN]	Factor of safety
1	57,07	130,70	2,29
2	81,24	173,99	2,14

Decisive anchor row : 2

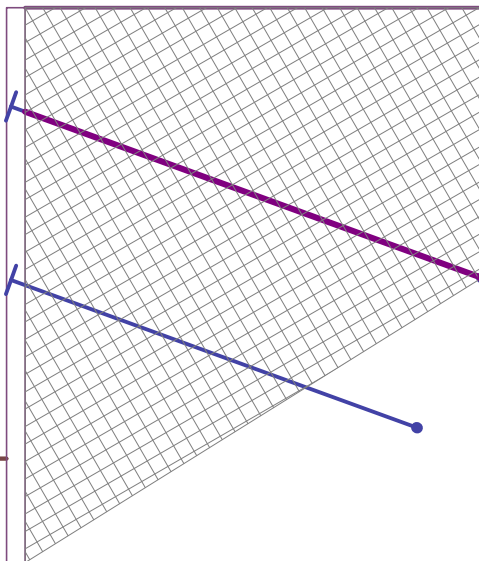
Required safety fact. $FS = 1,50 < 2,14 = FS_{minim.}$

Overall verification of internal stability is SATISFACTORY



Name : Internal stability

Stage - analysis : 5 - -1



Slope stability analysis

Input data

Project

Settings

(input for current task)

Stability analysis

Earthquake analysis : Standard

Verification methodology : according to EN 1997

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 sliding resistance (on slip surface) :	$\gamma_{Rs} =$	1,10 [-]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-20,00	93,50	-0,30	93,50	-0,30	100,00
		0,00	100,00	24,00	100,00		



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No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
2		-0,30	93,50	-0,30	92,00	0,00	92,00
		0,00	98,50	0,00	100,00		
3		0,00	98,50	24,00	98,50		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	Clayey sand		29,00	5,00	18,00
2	Clay with high plasticity		15,00	5,00	20,50

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [-]
1	Clayey sand		20,00		
2	Clay with high plasticity		20,50		

Soil parameters

Clayey sand

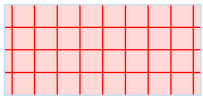
Unit weight : $\gamma = 18,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 29,00^\circ$
 Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
 Saturated unit weight : $\gamma_{sat} = 20,00 \text{ kN/m}^3$

Clay with high plasticity

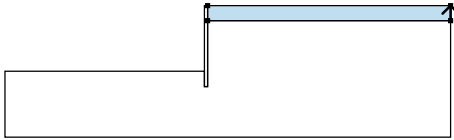
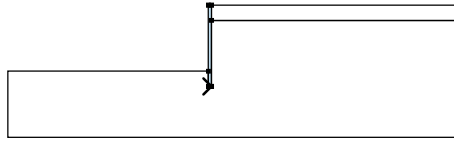
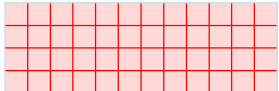
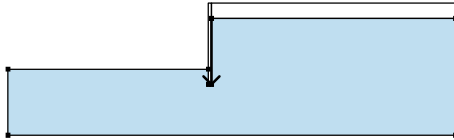
Unit weight : $\gamma = 20,50 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 15,00^\circ$
 Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
 Saturated unit weight : $\gamma_{sat} = 20,50 \text{ kN/m}^3$



Rigid bodies

No.	Name	Sample	γ [kN/m ³]
1	Wall material		23,00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		24,00	98,50	24,00	100,00	Clay with high plasticity 
		0,00	100,00	0,00	98,50	
2		-0,30	92,00	0,00	92,00	Wall material 
		0,00	98,50	0,00	100,00	
		-0,30	100,00	-0,30	93,50	
3		0,00	98,50	0,00	92,00	Clayey sand 
		-0,30	92,00	-0,30	93,50	
		-20,00	93,50	-20,00	87,00	
		24,00	87,00	24,00	98,50	

Anchors

No.	Origin		Length and slope / coordinates		Anchor spacing	Diameter / area	Elastic modulus	Tensile strength	Active in compress	Force
	x [m]	z [m]	l [m] / x [m]	α [°] / z [m]	b [m]	d [mm] / A [mm ²]	E [MPa]	F _c [kN]		F [kN]
1	-0,30	98,50	l = 7,00	$\alpha = 20,00$	1,00	d =			No	57,07
2	-0,30	96,00	l = 6,00	$\alpha = 20,00$	1,00	d =			No	81,24

Water

Water type : No water

Tensile crack

Tensile crack not inputted.

Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters					
Center :	x =	-0,74 [m]	Angles :	$\alpha_1 =$	-32,43 [°]
	z =	102,05 [m]		$\alpha_2 =$	78,32 [°]
Radius :	R =	10,13 [m]			
The slip surface after optimization.					



Slope stability verification (Bishop)

Sum of active forces : $F_a = 529,45 \text{ kN/m}$

Sum of passive forces : $F_p = 828,30 \text{ kN/m}$

Sliding moment : $M_a = 5363,32 \text{ kNm/m}$

Resisting moment : $M_p = 7627,85 \text{ kNm/m}$

Utilization : 70,3 %

Slope stability ACCEPTABLE

Dimensioning No. 1

	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	-10.69	-0.95	-0.00	0.00	-0.00	0.00
0.27	-10.14	-1.14	-0.79	-0.15	0.01	0.05
0.53	-9.60	-1.32	-3.06	-0.58	0.10	0.51
0.80	-9.05	-1.50	-6.67	-1.40	0.36	1.76
1.07	-8.51	-1.69	-11.54	-2.71	0.89	4.13
1.33	-7.97	-1.79	-17.49	-4.56	1.85	7.96
1.50	-7.63	-1.79	-21.49	-5.76	2.78	11.21
1.50	-7.63	-1.79	-5.76	45.45	2.78	11.21
1.60	-7.43	-1.78	-6.49	43.45	3.33	8.11
1.87	-6.89	-1.78	-8.39	38.15	-5.43	5.31
1.99	-6.64	-1.78	-9.41	35.64	-9.82	6.48
2.01	-6.60	-1.78	-9.57	35.23	-10.53	6.67
2.13	-6.35	-1.78	-10.59	32.72	-14.91	7.83
2.40	-5.83	-1.77	-13.09	27.03	-22.91	10.98
2.67	-5.32	-1.76	-15.90	21.15	-29.35	14.84
2.93	-4.82	-1.74	-19.00	15.40	-34.24	19.49
2.99	-4.72	-1.74	-19.70	14.26	-34.96	20.59
3.01	-4.68	-1.73	-19.73	13.86	-35.22	20.98
3.20	-4.42	-1.71	-17.27	10.05	-37.64	24.40
3.47	-4.50	-1.67	-19.86	5.20	-39.68	28.43
3.73	-4.54	-1.62	-26.33	0.65	-40.18	31.36
4.00	-4.53	-1.56	-33.71	-4.10	-39.72	33.21
4.00	-4.53	-1.56	-7.09	43.54	-39.72	33.21
4.27	-4.49	-1.49	-9.19	37.07	-37.96	34.03
4.53	-4.40	-1.42	-14.64	30.75	-34.79	33.88
4.80	-4.34	-1.35	-20.43	24.70	-30.12	32.81
4.99	-4.46	-1.30	-24.77	20.22	-25.83	31.43
5.01	-4.47	-1.30	-25.02	19.75	-25.33	31.29
5.07	-4.50	-1.28	-25.01	18.42	-23.91	30.88
5.33	-4.64	-1.21	-22.32	11.77	-24.58	28.00
5.60	-4.75	-1.14	-18.00	13.37	-26.79	24.66
5.87	-4.83	-1.08	-14.07	14.29	-27.09	20.95
6.13	-4.88	-1.02	-10.55	14.43	-25.37	17.11
6.40	-4.90	-0.96	-18.43	13.90	-21.54	13.32
6.49	-4.90	-0.94	-21.31	13.51	-19.71	12.08
6.51	-4.90	-0.94	-21.64	13.44	-19.37	11.87
6.67	-4.89	-0.90	-22.31	12.77	-15.85	9.75
6.93	-4.86	-0.85	-19.66	11.13	-10.55	6.55
7.20	-4.82	-0.80	-14.80	9.00	-5.95	3.86



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Geotechnics and foundation - project reports
Designer: Ing. John Williams

	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
7.47	-4.78	-0.71	-9.90	6.43	-2.65	1.79
7.73	-4.73	-0.63	-4.97	3.43	-0.66	0.47
8.00	-4.68	-0.56	-0.00	0.00	-0.00	0.00

Maximum values of internal forces

Maximum displacement = -10,7 mm
Minimum displacement = -0,6 mm
Maximum bending moment = 34,03 kNm/m
Minimum bending moment = -40,18 kNm/m
Maximum shear force = 45,45 kN/m

Verification of RC cross section (RC rectangular wall h = 0,30 m)

All construction stages are taken into the analysis.
Reduct. coefficient of bearing capacity = 1,00

Reinforcement ratio $\mu_{st} = 1,41 \% > 0,16 \% = \mu_{st,min}$
Position of neutral axis $x_u = 0,07 \text{ m} < 0,13 \text{ m} = x_{u,lim}$
Ultimate shear force $Q_u = 108,00 \text{ kN} > 45,45 \text{ kN} = Q_d$
Ultimate moment $M_u = 159,53 \text{ kNm} > 40,18 \text{ kNm} = M_d$

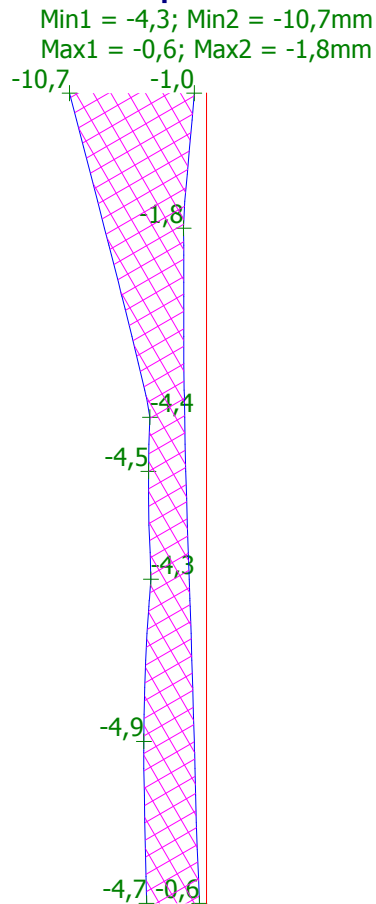
Cross-section is SATISFACTORY.



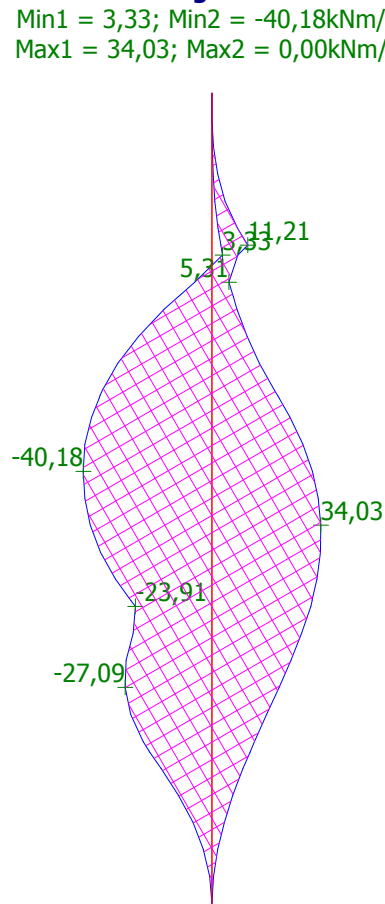
Name : Dimensioning

Stage - analysis : 1 - 1

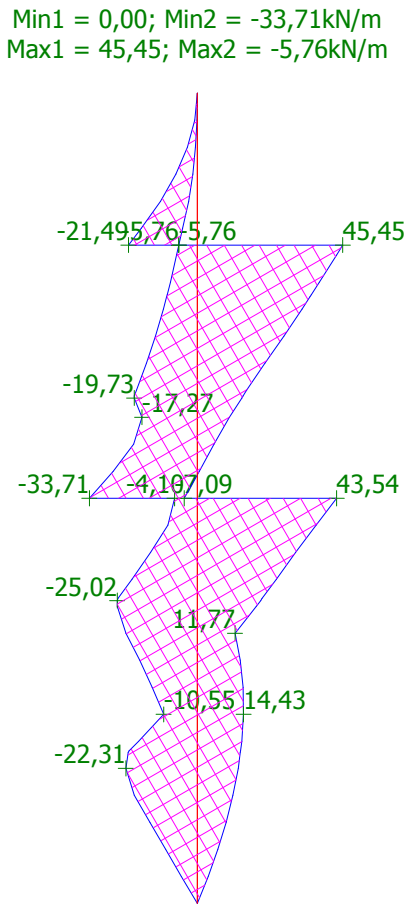
Displacement



Bending moment



Shear force



-12,5 0 12,5 [mm] -50,00 0 50,00 [kNm/m] 50,00 0 50,00 [kN/m]