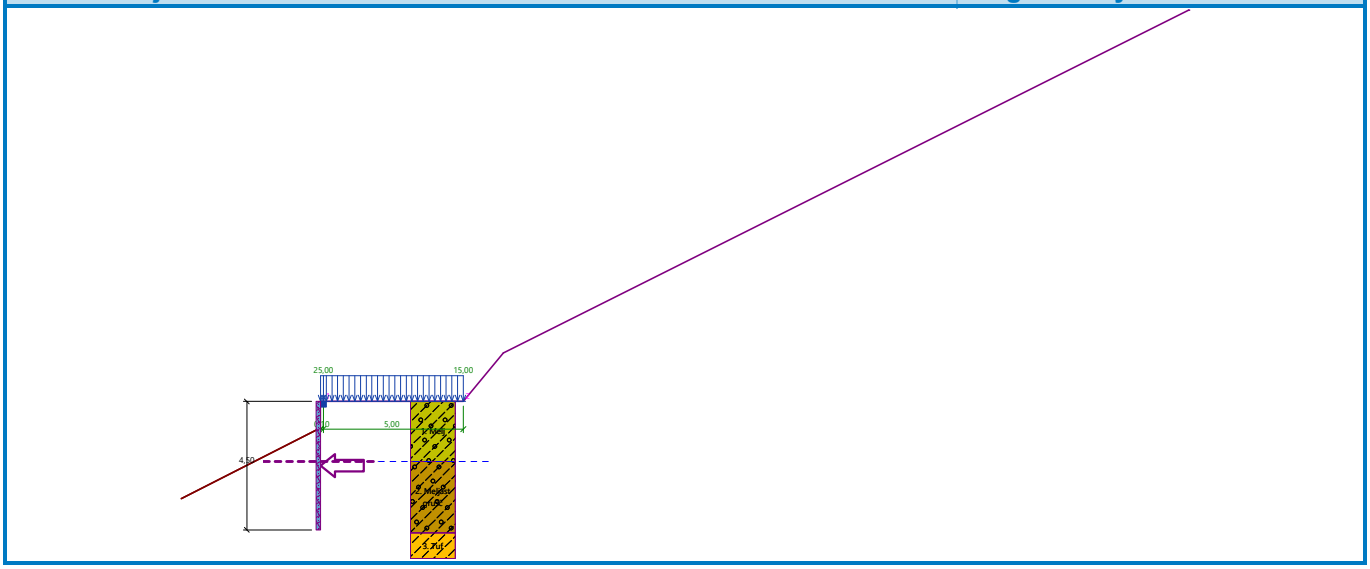
Analysis of anti-slide pile

Input data

Project : Plaz na 104 08 do Ovčjaka, Bele Vode
Part : Jekleni profili
Author : BLAN d.o.o.
Project number : GM - 213/2024

Name : Project	Stage - analysis : 1 - 0



Settings

Slovenia - EN 1997

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	[–]		

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

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	[–]

Geometry of structure

Structure length = 4,50 m

Cross-section name : I-section : HE 160 A, a = 1,00 m
Computed coefficient of pressure reduction below the ditch = 0,74
Area of cross-section A = 3,88E-03 m^2/m
Moment of inertia I = 1,67E-05 m^4/m
Sectional modulus W = 2,201E-04 m^3/m
Plastic sectional modulus W_{pl} = 2,451E-04 m^3/m

Forces above the slip surface

Depth of slip surface h_{s1} = 2,10 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 0,00 kN/m
Passive horizontal force P = 0,00 kN/m

Distribution of active force : triangle
Distribution of passive force : triangle

Material of structure

Structural steel: EN 10025 : Fe 360
Yield strength f_y = 235,00 MPa
Elasticity modulus E = 210000,00 MPa
Shear modulus G = 81000,00 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	Melj		29,10	3,00	20,00	10,00	20,00
2	Meljast grušč		32,50	1,00	20,00	10,00	22,00
3	Tuf		41,60	100,00	26,50	16,50	26,00

All soils are considered as cohesionless for at rest pressure analysis.

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

No.	Name	Pattern	ν [–]	E_{oed} [MPa]	E_{def} [MPa]
1	Melj		0,30	40,00	-
2	Meljast grušč		0,20	50,00	-
3	Tuf		0,10	100,00	-

Soil parameters

Melj

Unit weight :	γ =	20,00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	29,10 °
Cohesion of soil :	c_{ef} =	3,00 kPa
Angle of friction struc.-soil :	δ =	20,00 °
Soil :	cohesionless	
Oedometric modulus :	E_{oed} =	40,00 MPa
Saturated unit weight :	γ_{sat} =	20,00 kN/m^3

Meljast grušč

Unit weight :	γ =	20,00 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	32,50 °
Cohesion of soil :	c_{ef} =	1,00 kPa
Angle of friction struc.-soil :	δ =	22,00 °
Soil :	cohesionless	
Oedometric modulus :	E_{oed} =	50,00 MPa
Saturated unit weight :	γ_{sat} =	20,00 kN/m^3

Tuf

Unit weight :	γ =	26,50 kN/m^3
Stress-state :	effective	
Angle of internal friction :	φ_{ef} =	41,60 °
Cohesion of soil :	c_{ef} =	100,00 kPa
Angle of friction struc.-soil :	δ =	26,00 °
Soil :	cohesionless	
Oedometric modulus :	E_{oed} =	100,00 MPa
Saturated unit weight :	γ_{sat} =	26,50 kN/m^3

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	2,10	0,00 .. 2,10	Melj	
2	2,50	2,10 .. 4,60	Meljast grušč	
3	-	4,60 .. ∞	Tuf	

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Excavation

Soil in front of wall is excavated to a depth of 1,00 m.
Soil slope in front of structure β = -27,00 °

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	5,00	0,00
3	6,40	-1,70
4	30,40	-13,70
5	31,40	-13,70

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 2,10 m

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		permanent	15,00		0,00	5,00	on terrain

No.	Name
1	PROMET

Input line surcharges

No.	Surcharge new	Surcharge change	Action	Mag.1 [kN/m]	Ord.x x [m]	Depth z [m]
1	Yes		permanent	25,00	0,10	on terrain

No.	Name
1	BETONSKA GREDA

Earthquake

Factor of horizontal acceleration K_h = 0,2000
Factor of vertical acceleration K_v = 0,0000

Water below the GWT is restricted.

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

Pressure above the slip surface

Depth [m]	Passive pressure [kPa]	Active pressure [kPa]
0	0,00	0,00
1,00	0,00	0,00
1,00	0,00	0,00
2,10	0,00	0,00

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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]
2.10	-3.54	-6.02	-32.10	13.37	14.38	145.80
2.11	-6.03	-6.04	-19.60	20.14	20.14	111.65
2.14	-6.14	-6.25	-20.85	20.51	20.51	113.68
2.36	-6.74	-7.42	-27.90	22.58	22.58	125.20
2.57	-7.34	-8.59	-34.96	24.65	24.65	136.71
2.72	-7.77	-9.42	-39.95	26.12	26.12	144.84
2.78	-7.94	-9.75	-41.93	26.70	26.70	151.40
2.79	-7.95	-9.76	-42.02	26.73	26.73	151.70
3.00	-8.55	-10.93	-49.08	28.80	28.80	175.05
3.21	-9.15	-12.10	-56.14	30.87	30.87	198.40
3.43	-9.76	-13.28	-63.20	32.95	32.95	221.75
3.64	-10.36	-14.45	-70.26	35.02	35.02	245.10
3.86	-10.96	-15.62	-77.32	37.09	37.09	268.45
4.07	-11.57	-16.79	-84.37	39.17	39.17	291.80
4.29	-12.17	-17.96	-91.43	41.24	41.24	315.15
4.50	-12.77	-19.13	-98.49	43.31	43.31	338.51

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

Depth [m]	kh,p [MN/m³]	kh,z [MN/m³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-0.03	0.00	-0.00	-0.00
0.23	0.00	0.00	-0.03	0.00	-0.00	0.00
0.45	0.00	0.00	-0.04	0.00	-0.00	0.00
0.68	0.00	0.00	-0.04	0.00	-0.00	0.00
0.90	0.00	0.00	-0.05	0.00	-0.00	0.00
0.99	0.00	0.00	-0.05	0.00	-0.00	0.00
1.00	0.00	0.00	-0.05	0.00	0.00	-0.00
1.13	0.00	0.00	-0.05	0.00	0.00	-0.00
1.35	0.00	0.00	-0.06	0.00	0.00	-0.00
1.58	0.00	0.00	-0.06	0.00	0.00	-0.00
1.80	0.00	0.00	-0.07	0.00	0.00	-0.00
2.03	0.00	0.00	-0.07	0.00	0.00	-0.00
2.10	0.00	0.00	-0.07	0.00	0.00	-0.00
2.12	0.00	0.00	-0.07	0.31	-0.01	0.00
2.25	188.30	0.00	-0.08	0.06	0.01	-0.00
2.48	188.30	0.00	-0.08	0.03	0.00	-0.01
2.70	188.30	0.00	-0.09	0.01	-0.00	-0.01
2.93	188.30	0.00	-0.09	0.00	-0.00	-0.01
3.15	188.30	0.00	-0.10	-0.00	-0.00	-0.00
3.38	188.30	0.00	-0.10	-0.00	-0.00	-0.00
3.60	188.30	0.00	-0.11	0.00	-0.00	-0.00
3.83	188.30	0.00	-0.11	0.00	-0.00	-0.00
4.05	188.30	0.00	-0.12	0.00	-0.00	-0.00
4.28	188.30	0.00	-0.12	-0.01	-0.00	-0.00
4.50	188.30	0.00	-0.13	-0.03	0.00	-0.00

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Maximum values of internal forces acting on the structure

Maximum shear force = 0,02 kN/m
Maximum moment = 0,01 kNm/m
Maximum displacement = 0,1 mm
Displacement in the depth of slip surface = 0,1 mm

Maximum internal forces on cross-section

Maximum shear force = 0,02 kN
Maximum moment = 0,01 kNm

Terrain settlement behind the structure

Terrain settlement δ_{max} = 0,1 mm

	Coordinates x [m]	Settlement z [mm]
1	0,00	0,1
2	0,33	0,1
3	0,66	0,2
4	0,99	0,2
5	1,32	0,2
6	1,65	0,2
7	1,99	0,2
8	2,32	0,1
9	2,65	0,1
10	2,98	0,1
11	3,31	0,0

Utilization of passive pressure

Maximum passive pressure R_{max} = 141,51 kN/m
Mobilized passive pressure R_{mob} = 76,09 kN/m

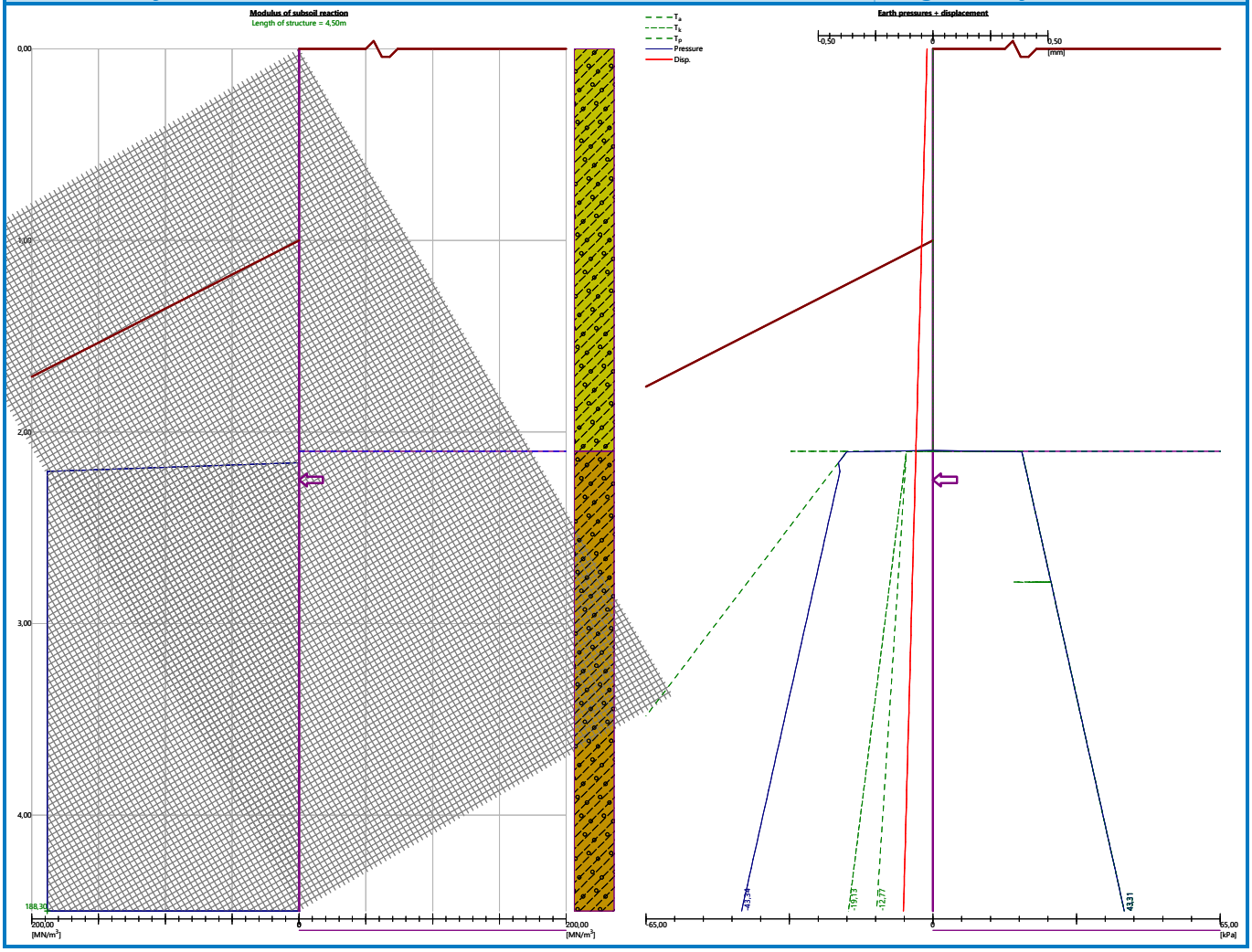
Requested safety factor SF_p = 1,50 < 1,86

Overall verification of passive pressure utilization is SATISFACTORY

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Name : Analysis

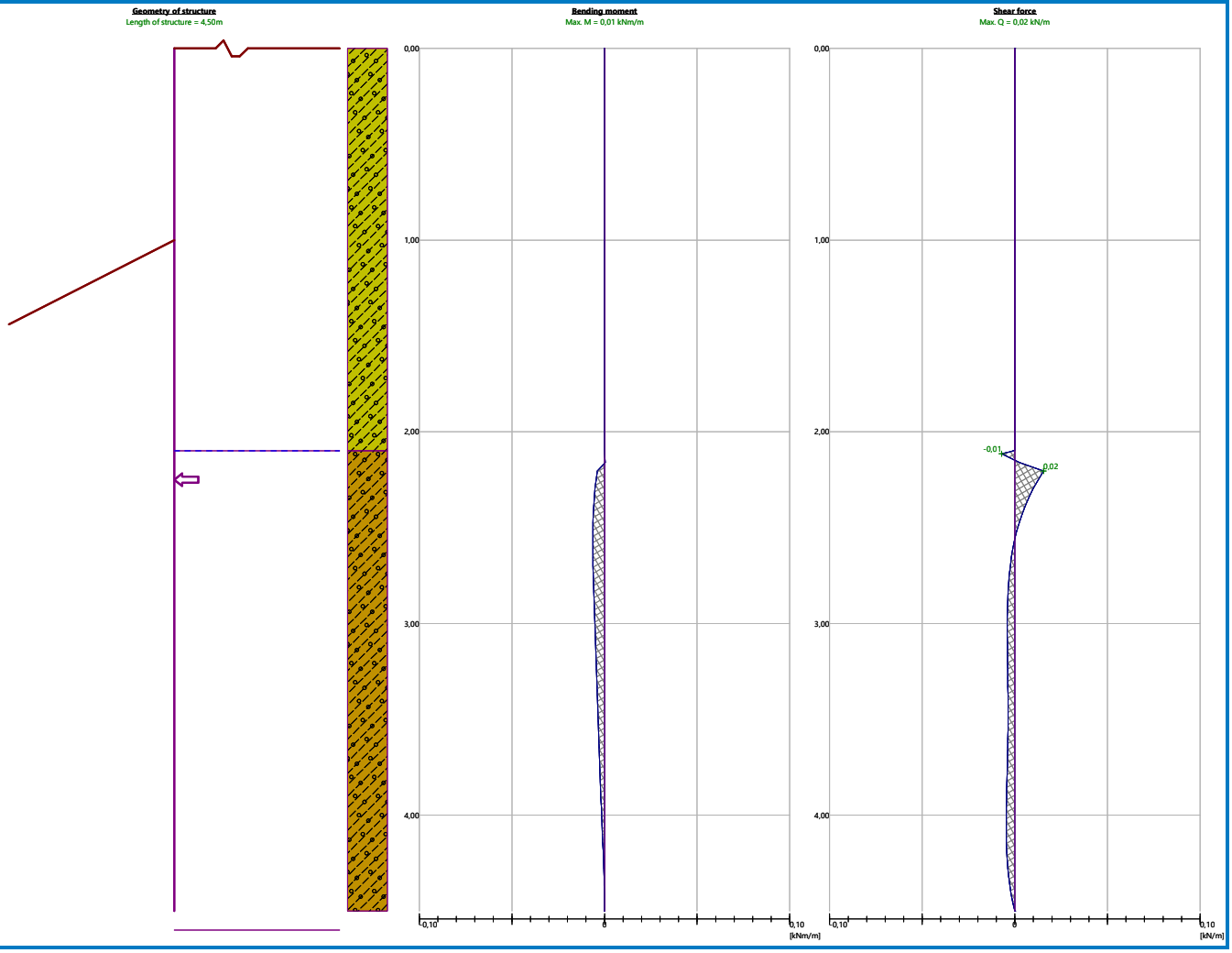
Stage - analysis : 1 - -1



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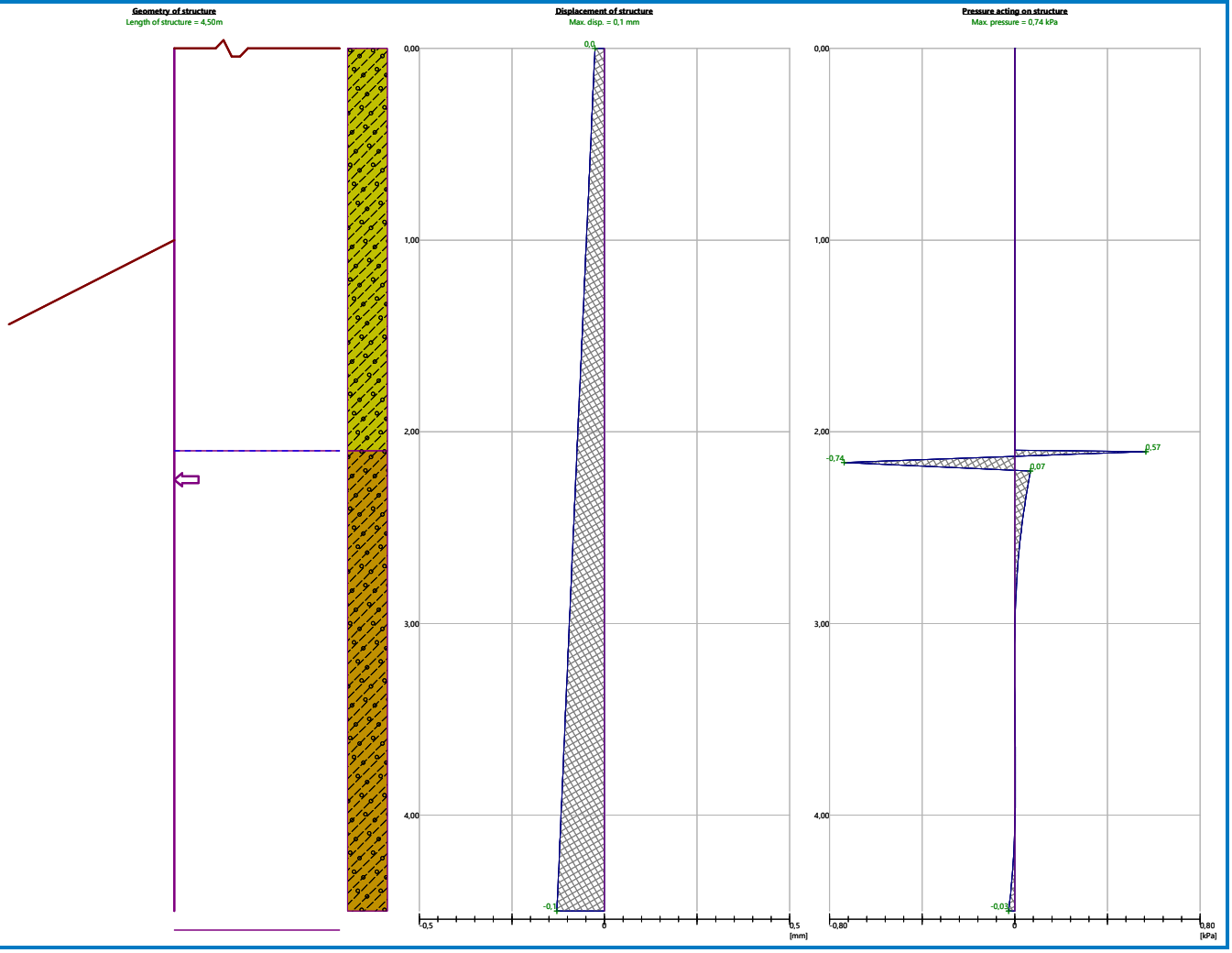
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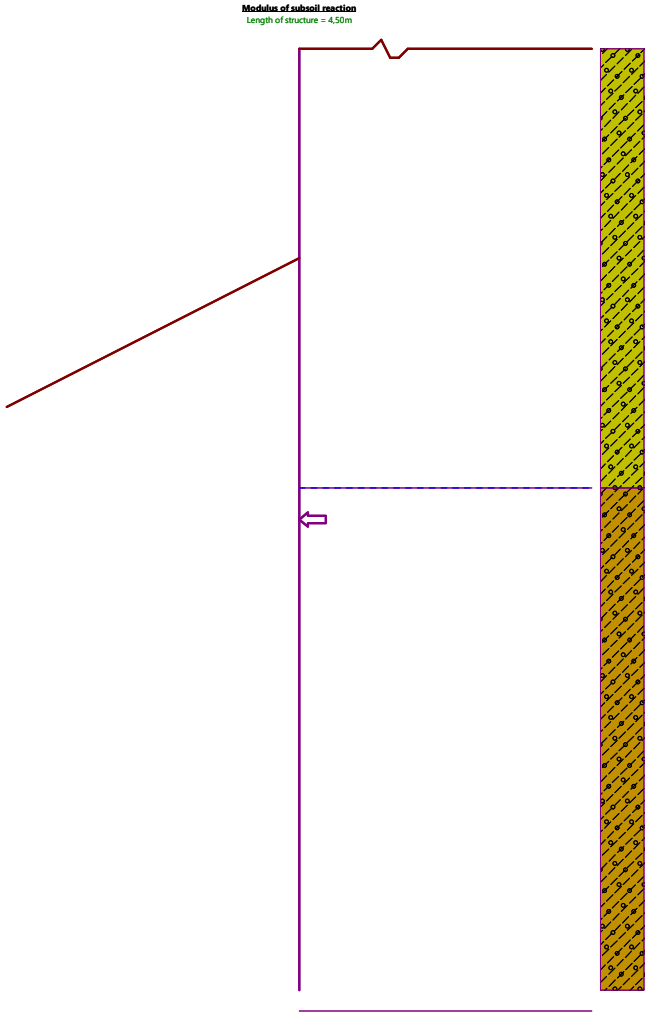
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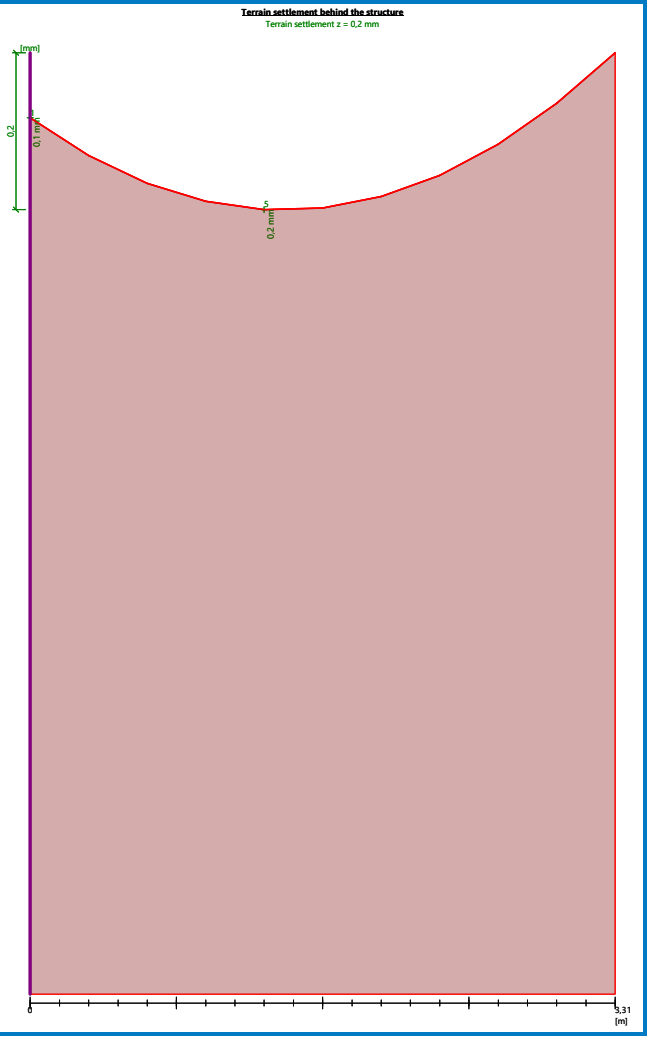
Stage - analysis : 1 - -1



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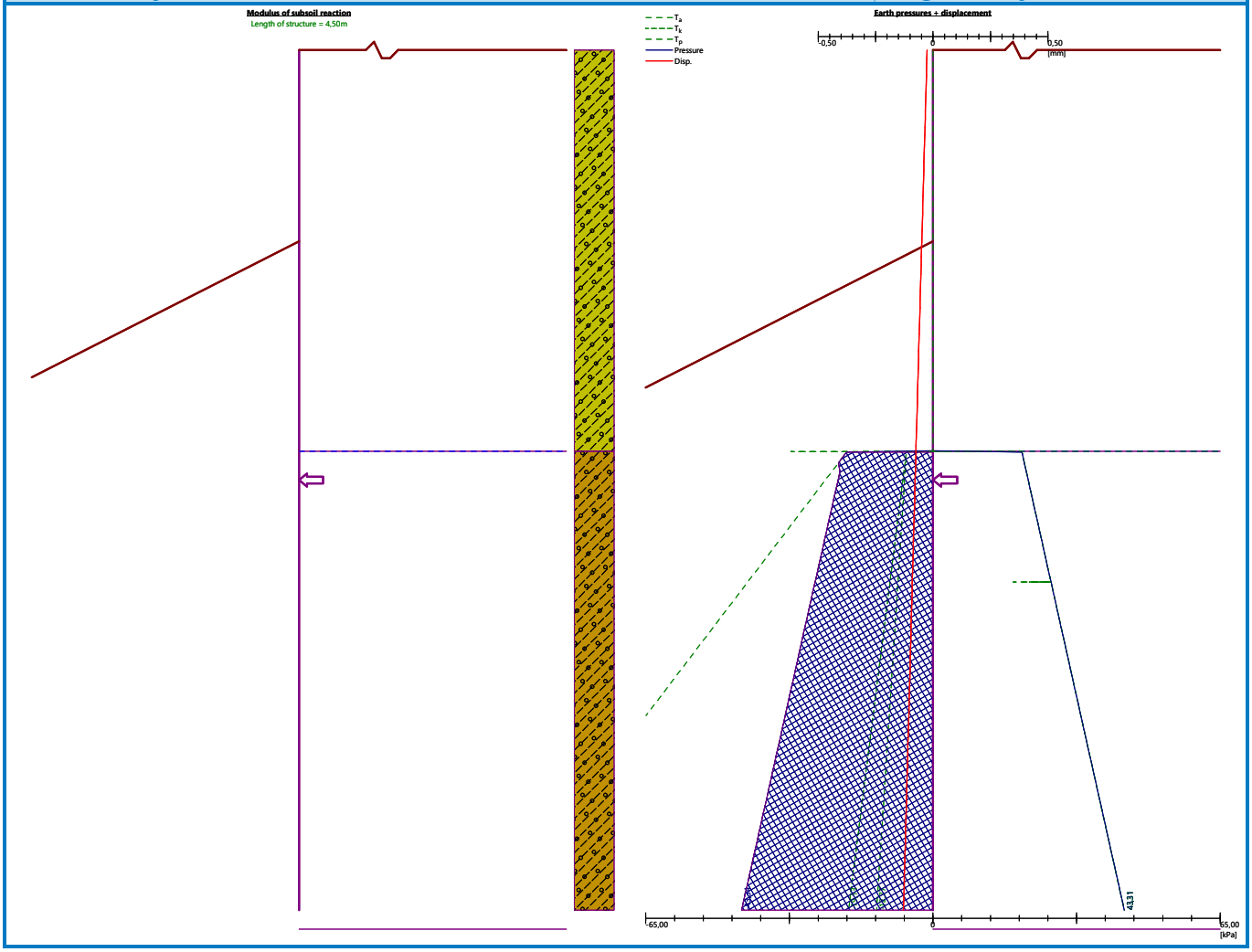
Name : Analysis	Stage - analysis : 1 - -1





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Name : Analysis	Stage - analysis : 1 - -1



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	-0.03	-0.03	-0.00	-0.00	-0.00	-0.00
0.23	-0.03	-0.03	-0.00	-0.00	0.00	0.00
0.45	-0.04	-0.04	-0.00	-0.00	0.00	0.00
0.68	-0.04	-0.04	-0.00	-0.00	0.00	0.00
0.90	-0.05	-0.05	-0.00	-0.00	0.00	0.00
0.99	-0.05	-0.05	-0.00	-0.00	0.00	0.00
1.00	-0.05	-0.05	0.00	0.00	0.00	0.00
1.00	-0.05	-0.05	0.00	0.00	-0.00	-0.00
1.13	-0.05	-0.05	0.00	0.00	-0.00	-0.00
1.35	-0.06	-0.06	0.00	0.00	-0.00	-0.00
1.58	-0.06	-0.06	0.00	0.00	-0.00	-0.00
1.80	-0.07	-0.07	0.00	0.00	-0.00	-0.00
2.03	-0.07	-0.07	0.00	0.00	-0.00	-0.00
2.10	-0.07	-0.07	0.00	0.00	-0.00	-0.00
2.10	-0.07	-0.07	-0.00	-0.00	0.00	0.00

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	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
2.12	-0.07	-0.07	-0.01	-0.01	0.00	0.00
2.25	-0.08	-0.08	0.01	0.01	-0.00	-0.00
2.48	-0.08	-0.08	0.00	0.00	-0.01	-0.01
2.70	-0.09	-0.09	-0.00	-0.00	-0.01	-0.01
2.93	-0.09	-0.09	-0.00	-0.00	-0.01	-0.01
3.15	-0.10	-0.10	-0.00	-0.00	-0.00	-0.00
3.38	-0.10	-0.10	-0.00	-0.00	-0.00	-0.00
3.60	-0.11	-0.11	-0.00	-0.00	-0.00	-0.00
3.83	-0.11	-0.11	-0.00	-0.00	-0.00	-0.00
4.05	-0.12	-0.12	-0.00	-0.00	-0.00	-0.00
4.28	-0.12	-0.12	-0.00	-0.00	-0.00	-0.00
4.50	-0.13	-0.13	0.00	0.00	-0.00	-0.00

Maximum values of internal forces

Maximum displacement = -0,1 mm
Minimum displacement = 0,0 mm
Maximum bending moment = 0,00 kNm/m
Minimum bending moment = -0,01 kNm/m
Maximum shear force = 0,02 kN/m

Verification of steel section according to EN 1993-1-1

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

Internal forces per I-section

M_{max} = 0,01 kNm; Q = 0,00 kN
Q_{max} = 0,02 kN; M = 0,00 kNm

Verification of max. moment M_{max} + Q:

Verification of bending:

$M_{max}/M_{c,Rd}$ = 0,000 ≤ 1 **Is satisfactory**

Verification of shear:

$Q/V_{c,Rd}$ = 0,000 ≤ 1 **Is satisfactory**

Verification of plane state of stress:

Normal stress $\sigma_{x,Ed}$ = 0,03 MPa
Shear stress τ_{Ed} = 0,00 MPa

Verification: $(\sigma_{x,Ed}/(f_y/\gamma_{M0}))^2 + 3*(\tau_{Ed}/(f_y/\gamma_{M0}))^2$ = 0,000 ≤ 1 **Is satisfactory**

Verification of max. shear force Q_{max} + M:

Verification of bending:

$M/M_{c,Rd}$ = 0,000 ≤ 1 **Is satisfactory**

Verification of shear:

$Q_{max}/V_{c,Rd}$ = 0,000 ≤ 1 **Is satisfactory**

Verification of plane state of stress:

Normal stress $\sigma_{x,Ed}$ = 0,02 MPa
Shear stress τ_{Ed} = 0,02 MPa

Verification: $(\sigma_{x,Ed}/(f_y/\gamma_{M0}))^2 + 3*(\tau_{Ed}/(f_y/\gamma_{M0}))^2$ = 0,000 ≤ 1 **Is satisfactory**

Cross section is SATISFACTORY

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