Analysis of anti-slide pile

Input data

Project

Task : Sanacija plazu na LC 310071 Vukovski vrh-Poličkі vrk pri Vukovski vrh 7
Part : KP-1
Description : Delovni plato (h=6.0 m)
Customer : Občina Pesnica
Author : Geoing d.o.o.
Date : 11.8.2024

Settings

(input for current task)

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 : standard
Steel structures : EN 1993-1-1 (EC3)
Partial factor on bearing capacity of steel cross section : γ_{M0} = 1,00

Pressure analysis

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
Verification methodology : Safety factors (ASD)

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 = 7,00 m

Cross-section name : I-cross-section : I(IPN) 200; a = 1,00 m
Computed coefficient of pressure reduction below the ditch = 0,64
Area of cross-section A = 3,34E-03 m^2/m
Moment of inertia I = 2,14E-05 m^4/m
Elastic modulus E = 210000,00 MPa
Shear modulus G = 81000,00 MPa
Sectional modulus W = 2,132E-04 m^3/m
Plastic sectional modulus W_{pl} = 2,481E-04 m^3/m

Input pressure acting on structure

Depth of slip surface h_{s1} = 1,70 m

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 : as active force

Material of structure

Structural steel: EN 10025 : Fe 360
Yield strength f_y = 235,00 MPa

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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/m^3]	γ_{su} [kN/m^3]	δ [°]
1	Glina		17,50	0,00	19,00	9,00	17,50

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

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

No.	Name	Pattern	ν [–]	E_{oed} [MPa]	E_{def} [MPa]
1	Glina		0,40	3,00	-

Soil parameters

Glina

Unit weight : γ = 19,00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 17,50 °
Cohesion of soil : c_{ef} = 0,00 kPa
Angle of friction struc.-soil : δ = 17,50 °
Soil : cohesionless
Oedometric modulus : E_{oed} = 3,00 MPa
Saturated unit weight : γ_{sat} = 19,00 kN/m^3

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	-	0,00 .. ∞	Glina	

Excavation

Soil in front of wall is excavated to a depth of 1,70 m.
Soil slope in front of structure β = -7,00 °

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

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	11,00		0,50	4,00	on terrain

Global settings

Number of FEs to discretize wall = 40
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0{,}20\sigma_z$

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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
1,70	0,00	0,00
1,70	0,00	0,00
1,70	0,00	0,00

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	0.00
0.00	0.00	0.00	0.00	0.00	0.00	0.00
0.16	0.00	0.00	0.00	0.00	0.00	0.00
0.28	0.00	0.00	0.00	0.00	0.00	0.00
0.56	0.00	0.00	0.00	0.00	0.00	0.00
0.84	0.00	0.00	0.00	0.00	0.00	0.00
1.12	0.00	0.00	0.00	0.00	0.00	0.00
1.40	0.00	0.00	0.00	0.00	0.00	0.00
1.68	0.00	0.00	0.00	0.00	0.00	0.00
1.70	0.00	0.00	0.00	0.00	0.00	0.00
1.71	-0.05	-0.08	-0.22	12.22	18.25	51.16
1.96	-1.27	-2.02	-5.63	13.53	20.02	58.64
2.24	-2.63	-4.20	-11.69	15.01	22.02	67.01
2.52	-3.99	-6.38	-17.74	16.48	24.06	75.39
2.80	-5.36	-8.56	-23.80	17.95	26.12	83.77
3.08	-6.72	-10.74	-29.86	19.43	28.22	92.14
3.36	-8.08	-12.92	-35.92	20.90	30.34	100.52
3.64	-9.45	-15.09	-41.98	22.38	32.49	108.90
3.92	-10.81	-17.27	-48.04	23.85	34.66	117.28
4.20	-12.17	-19.45	-54.10	25.32	36.86	125.65
4.48	-13.54	-21.63	-60.16	26.80	39.07	134.03
4.76	-14.88	-23.77	-66.12	28.25	41.27	142.27
4.76	-14.90	-23.81	-66.22	25.72	41.30	142.41
5.04	-16.26	-25.99	-72.27	27.23	43.55	150.78
5.32	-17.63	-28.17	-78.33	28.74	45.81	159.16
5.60	-18.99	-30.34	-84.39	30.25	48.08	167.54
5.88	-20.35	-32.52	-90.45	31.77	50.37	175.91
6.16	-21.72	-34.70	-96.51	33.28	52.66	184.29
6.44	-23.08	-36.88	-102.57	34.79	54.96	192.67
6.72	-24.44	-39.06	-108.63	36.30	57.26	201.04
7.00	-25.81	-41.24	-114.69	37.82	59.58	209.42

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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	-10.72	0.00	0.00	0.00
0.17	0.00	0.00	-10.32	0.00	0.00	-0.00
0.35	0.00	0.00	-9.92	0.00	0.00	-0.00
0.53	0.00	0.00	-9.52	0.00	0.00	-0.00
0.70	0.00	0.00	-9.12	0.00	-0.00	0.00
0.88	0.00	0.00	-8.72	0.00	-0.00	0.00
1.05	0.00	0.00	-8.32	0.00	-0.00	0.00
1.23	0.00	0.00	-7.92	0.00	-0.00	0.00
1.40	0.00	0.00	-7.52	0.00	-0.00	0.00
1.57	0.00	0.00	-7.12	0.00	-0.00	0.00
1.69	0.00	0.00	-6.85	0.00	-0.00	0.00
1.72	0.00	0.00	-6.79	11.87	-0.06	0.00
1.75	0.00	0.00	-6.72	11.35	-0.43	0.01
1.93	0.00	0.00	-6.32	8.48	-2.17	0.24
2.10	0.00	0.00	-5.92	5.61	-3.40	0.74
2.27	0.00	0.00	-5.53	2.75	-4.13	1.40
2.45	0.00	0.00	-5.15	-0.12	-4.36	2.15
2.63	0.00	0.00	-4.78	-2.98	-4.09	2.90
2.80	0.00	0.00	-4.43	-5.85	-3.32	3.56
2.98	3.50	0.00	-4.11	-5.40	-2.28	3.99
3.15	3.50	0.00	-3.81	-4.80	-1.39	4.31
3.33	3.50	0.00	-3.54	-4.30	-0.60	4.48
3.50	3.50	0.00	-3.30	-3.91	0.12	4.52
3.67	3.50	0.00	-3.10	-3.63	0.78	4.44
3.85	3.50	3.50	-2.92	-3.03	1.38	4.21
4.03	3.50	3.50	-2.77	-1.99	1.82	3.93
4.20	3.50	3.50	-2.65	-1.14	2.09	3.59
4.38	3.50	3.50	-2.56	-0.45	2.23	3.21
4.55	3.50	3.50	-2.48	0.09	2.26	2.81
4.72	3.50	3.50	-2.43	0.50	2.21	2.42
4.90	3.50	3.50	-2.39	0.80	2.09	2.04
5.08	3.50	3.50	-2.37	1.00	1.93	1.69
5.25	3.50	3.50	-2.36	1.13	1.75	1.37
5.42	3.50	3.50	-2.36	1.19	1.54	1.08
5.60	3.50	3.50	-2.36	1.20	1.33	0.83
5.78	3.50	3.50	-2.38	1.18	1.12	0.61
5.95	3.50	3.50	-2.39	1.13	0.92	0.43
6.13	3.50	3.50	-2.41	1.06	0.73	0.29
6.30	3.50	3.50	-2.44	0.98	0.55	0.18
6.47	3.50	3.50	-2.46	0.88	0.39	0.10
6.65	3.50	3.50	-2.49	0.79	0.24	0.04
6.83	3.50	3.50	-2.51	0.69	0.11	0.01
7.00	3.50	3.50	-2.54	0.59	0.00	-0.00

Maximum shear force = 4,36 kN/m
Maximum moment = 4,52 kNm/m
Maximum displacement = 10,7 mm
Displacement in the depth of slip surface = 6,8 mm

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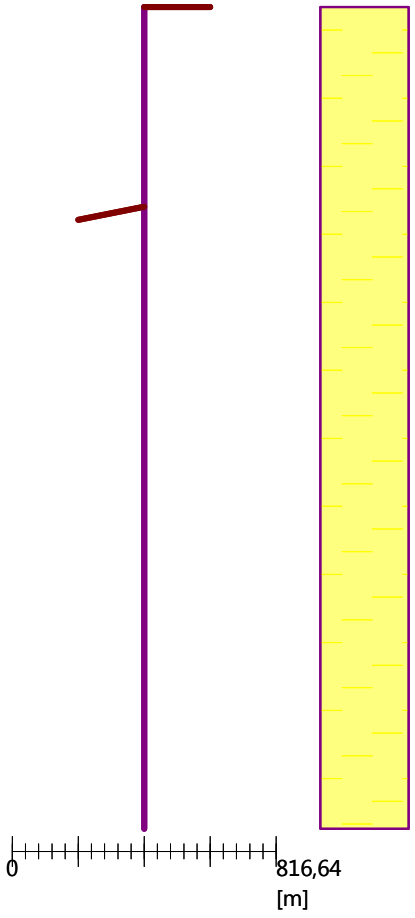
Terrain settlement behind the structure

Terrain settlement δ_{max} = 8,2 mm

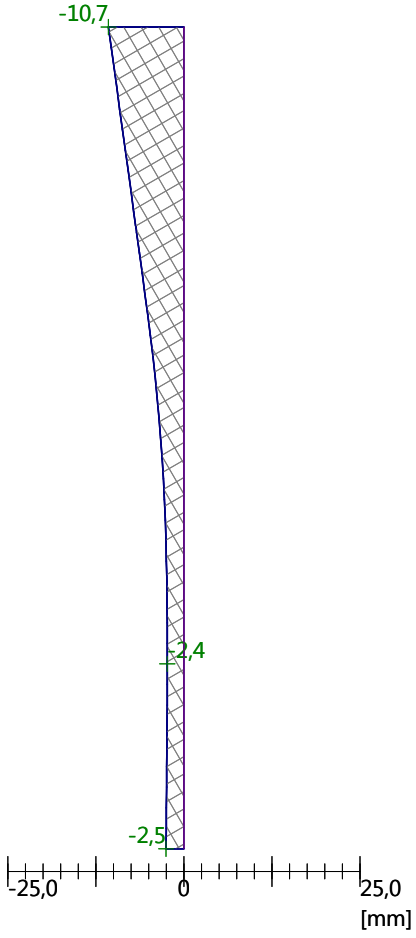
	Coordinate x [m]	Settlement z [mm]
1	0,00	6,6
2	0,51	8,9
3	1,03	10,5
4	1,54	11,5
5	2,05	11,8
6	2,57	11,5
7	3,08	10,5
8	3,59	8,9
9	4,11	6,6
10	4,62	3,6
11	5,13	0,0
12	5,13	0,0

Name : Analysis | **Stage - analysis : 1 - -1**

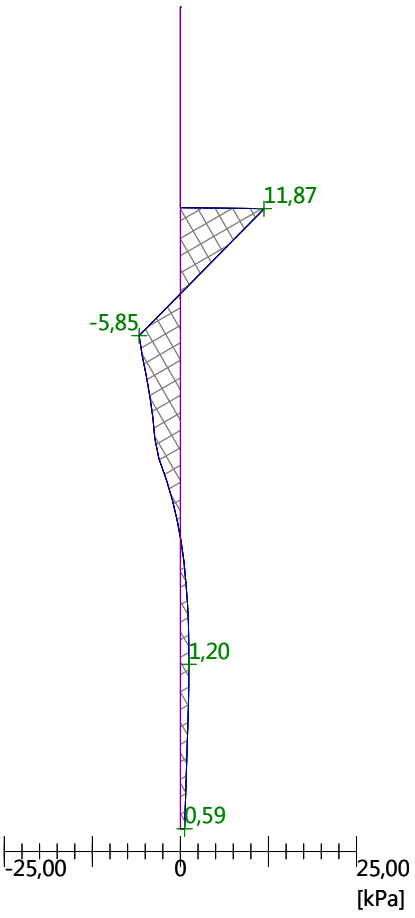
Geometry of structure
Length of structure = 7,00m



Displacement of structure
Max. disp. = 10,7 mm



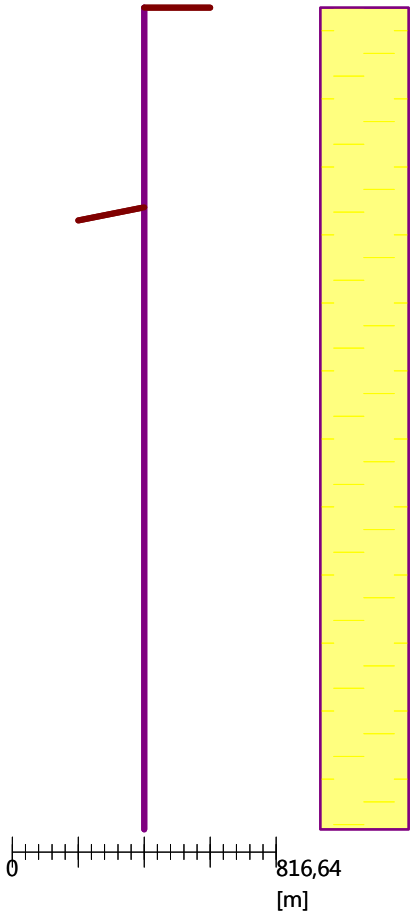
Pressure acting on structure
Max. pressure = 11,87 kPa



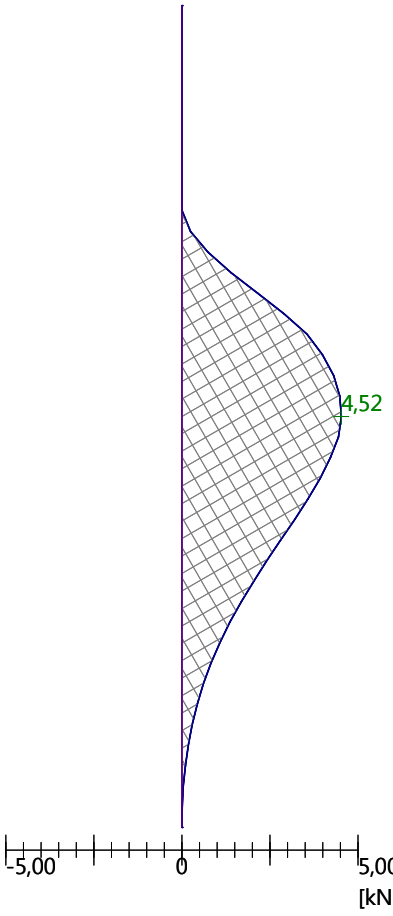
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Name : Analysis	Stage - analysis : 1 - -1

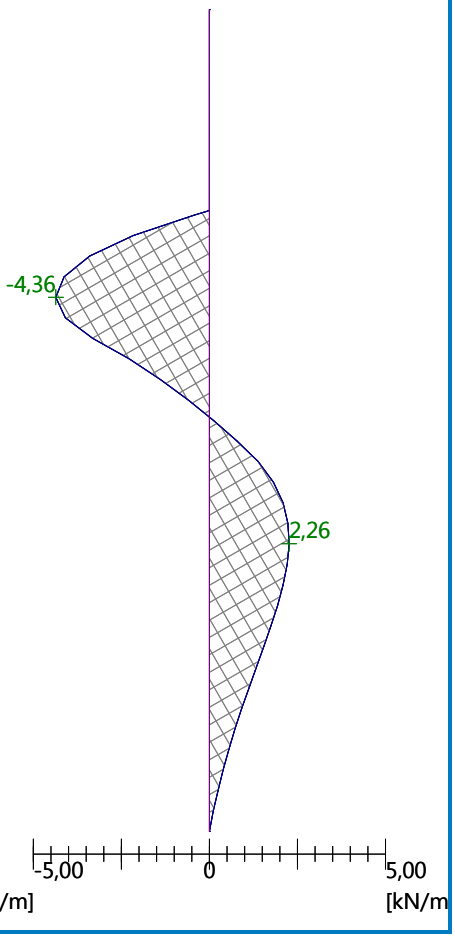
Geometry of structure
Length of structure = 7,00m



Bending moment
Max. M = 4,52 kNm/m

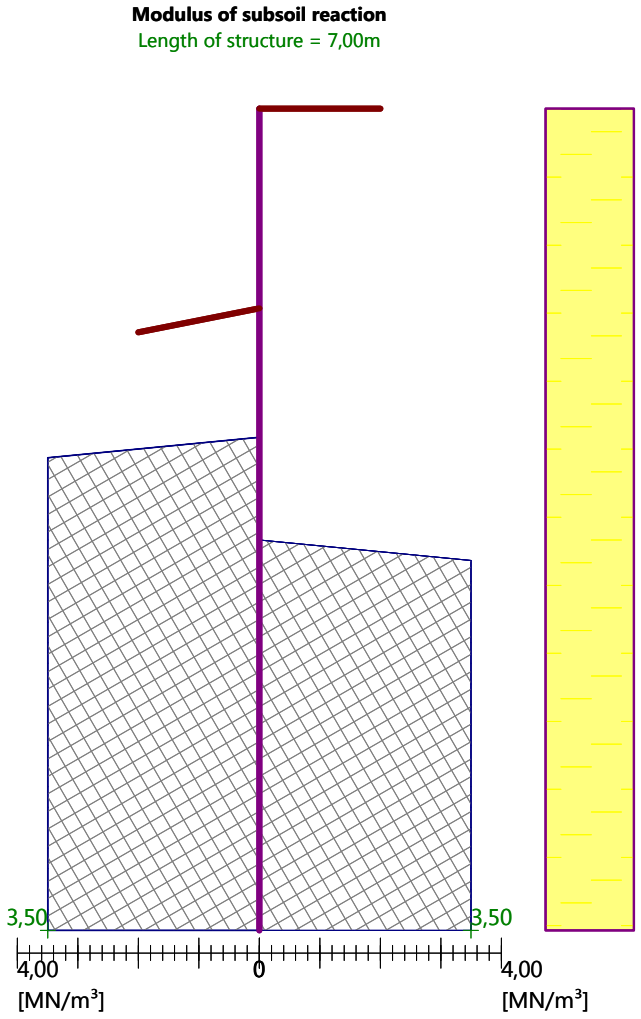


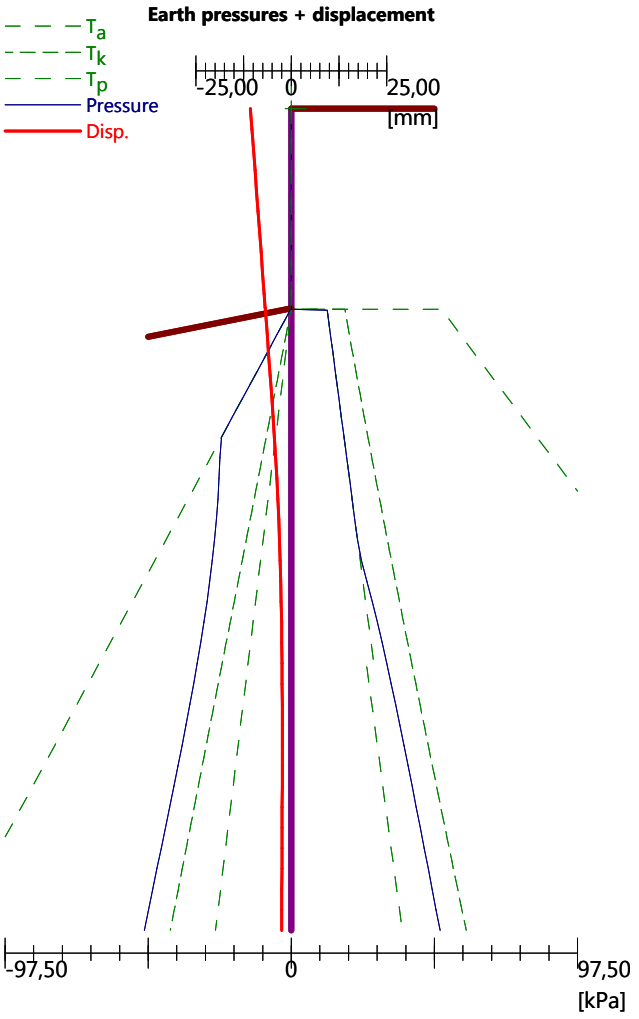
Shear force
Max. Q = 4,36 kN/m



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Name : Analysis	Stage - analysis : 1 - -1





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	-10.72	-10.72	0.00	0.00	0.00	0.00
0.17	-10.32	-10.32	0.00	0.00	-0.00	-0.00
0.35	-9.92	-9.92	0.00	0.00	-0.00	-0.00
0.53	-9.52	-9.52	0.00	0.00	-0.00	-0.00
0.70	-9.12	-9.12	-0.00	-0.00	0.00	0.00
0.88	-8.72	-8.72	-0.00	-0.00	0.00	0.00
1.05	-8.32	-8.32	-0.00	-0.00	0.00	0.00
1.23	-7.92	-7.92	-0.00	-0.00	0.00	0.00
1.40	-7.52	-7.52	-0.00	-0.00	0.00	0.00
1.57	-7.12	-7.12	-0.00	-0.00	0.00	0.00
1.69	-6.85	-6.85	-0.00	-0.00	0.00	0.00
1.70	-6.83	-6.83	0.00	0.00	0.00	0.00
1.71	-6.82	-6.82	0.00	0.00	-0.00	-0.00
1.72	-6.79	-6.79	-0.06	-0.06	0.00	0.00
1.75	-6.72	-6.72	-0.43	-0.43	0.01	0.01
1.93	-6.32	-6.32	-2.17	-2.17	0.24	0.24

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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]
2.10	-5.92	-5.92	-3.40	-3.40	0.74	0.74
2.27	-5.53	-5.53	-4.13	-4.13	1.40	1.40
2.45	-5.15	-5.15	-4.36	-4.36	2.15	2.15
2.63	-4.78	-4.78	-4.09	-4.09	2.90	2.90
2.80	-4.43	-4.43	-3.32	-3.32	3.56	3.56
2.98	-4.11	-4.11	-2.28	-2.28	3.99	3.99
3.15	-3.81	-3.81	-1.39	-1.39	4.31	4.31
3.33	-3.54	-3.54	-0.60	-0.60	4.48	4.48
3.50	-3.30	-3.30	0.12	0.12	4.52	4.52
3.67	-3.10	-3.10	0.78	0.78	4.44	4.44
3.85	-2.92	-2.92	1.38	1.38	4.21	4.21
4.03	-2.77	-2.77	1.82	1.82	3.93	3.93
4.20	-2.65	-2.65	2.09	2.09	3.59	3.59
4.38	-2.56	-2.56	2.23	2.23	3.21	3.21
4.55	-2.48	-2.48	2.26	2.26	2.81	2.81
4.72	-2.43	-2.43	2.21	2.21	2.42	2.42
4.90	-2.39	-2.39	2.09	2.09	2.04	2.04
5.08	-2.37	-2.37	1.93	1.93	1.69	1.69
5.25	-2.36	-2.36	1.75	1.75	1.37	1.37
5.42	-2.36	-2.36	1.54	1.54	1.08	1.08
5.60	-2.36	-2.36	1.33	1.33	0.83	0.83
5.78	-2.38	-2.38	1.12	1.12	0.61	0.61
5.95	-2.39	-2.39	0.92	0.92	0.43	0.43
6.13	-2.41	-2.41	0.73	0.73	0.29	0.29
6.30	-2.44	-2.44	0.55	0.55	0.18	0.18
6.47	-2.46	-2.46	0.39	0.39	0.10	0.10
6.65	-2.49	-2.49	0.24	0.24	0.04	0.04
6.83	-2.51	-2.51	0.11	0.11	0.01	0.01
7.00	-2.54	-2.54	0.00	0.00	-0.00	-0.00

Maximum values of internal forces

Maximum displacement = -10,7 mm
Minimum displacement = -2,4 mm
Maximum bending moment = 4,52 kNm/m
Minimum bending moment = 0,00 kNm/m
Maximum shear force = 2,26 kN/m

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

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

Internal forces per 1 I-profile

M_{max} = 4,52 kNm; Q = 0,12 kN
Q_{max} = 4,36 kN; M = 2,15 kNm

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

Verification of bending:

$M_{max}/M_{c,Rd} = 0,090 \leq 1$ **Is satisfied**

Verification of shear:

$Q/V_{c,Rd} = 0,001 \leq 1$ **Is satisfied**

Verification of plane state of stress:

Normal stress $\sigma_{x,Ed}$ = 18,75 MPa

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Shear stress τ_{Ed} = 0,07 MPa

Verification: $(\sigma_{x,Ed}/(f_y/\gamma_{M0}))^2 + 3*(\tau_{Ed}/(f_y/\gamma_{M0}))^2 = 0,006 \leq 1$ **Is satisfied**

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

Verification of bending:

$M/M_{c,Rd} = 0,043 \leq 1$ **Is satisfied**

Verification of shear:

$Q_{max}/V_{c,Rd} = 0,025 \leq 1$ **Is satisfied**

Verification of plane state of stress:

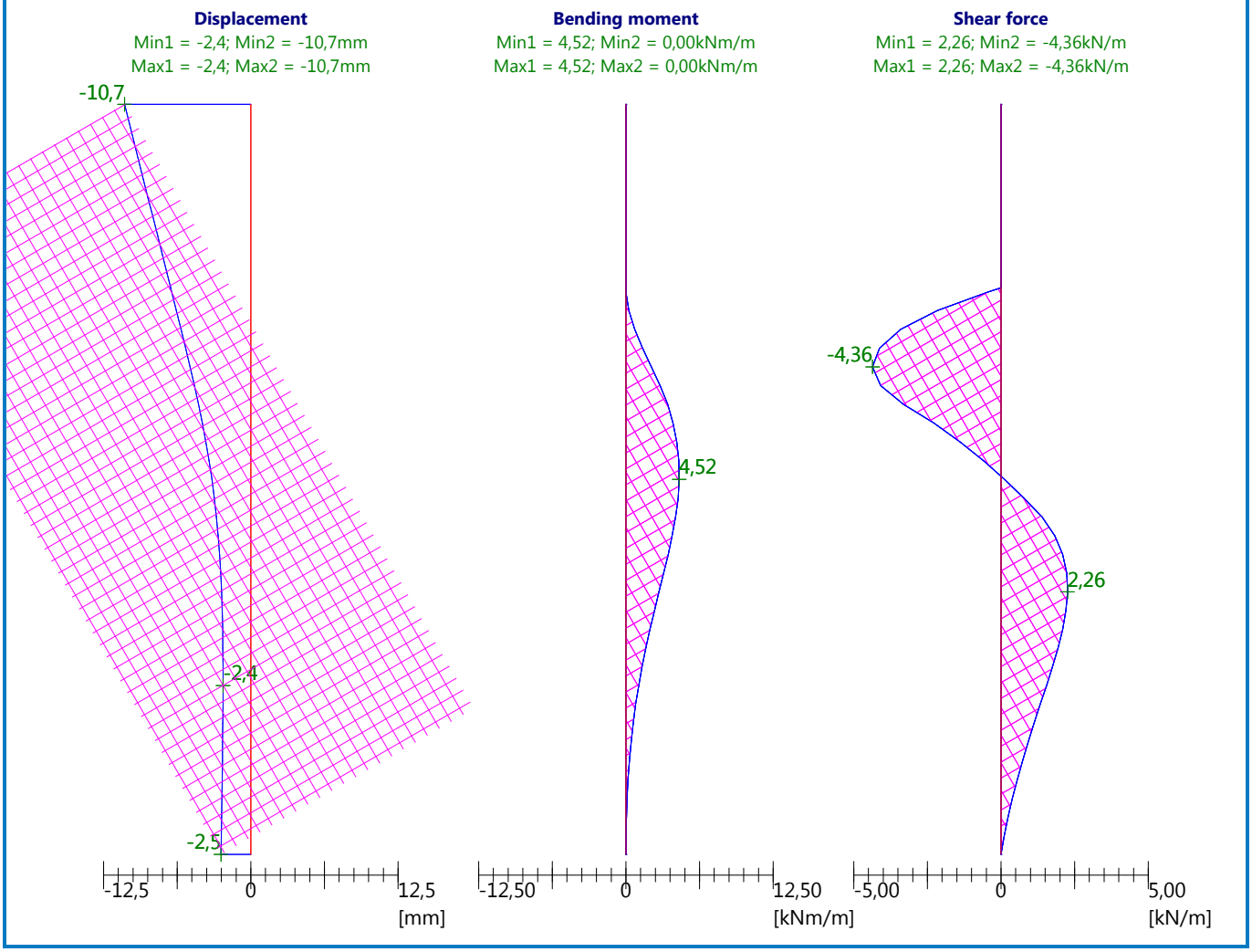
Normal stress $\sigma_{x,Ed}$ = 8,92 MPa

Shear stress τ_{Ed} = 2,61 MPa

Verification: $(\sigma_{x,Ed}/(f_y/\gamma_{M0}))^2 + 3*(\tau_{Ed}/(f_y/\gamma_{M0}))^2 = 0,002 \leq 1$ **Is satisfied**

Cross section is SATISFACTORY

Name : Dimensioning | **Stage - analysis : 1 - 1**



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