# Analysis of anti-slide pile

## Input data

### Project

Task : Sanacija plazu na LC 440291 Zg,Gruškovje-Straža pri hiši Zg.Gruškovje 6
Description : Delovni plato (h=5.0 m)
Customer : Občina Oplotnica
Author : GEOING d.o.o.
Date : 05/08/2025

### 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 : $\gamma_{M0}$ = 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 : | $\gamma_s$ = | 1,35 | [–] |
| Reduction coefficient of pull out resistance (soil) : | $\gamma_e$ = | 1,35 | [–] |
| Reduction coefficient of pull out resistance (grouting) : | $\gamma_c$ = | 1,35 | [–] |

### Geometry of structure

Structure length = 5,00 m

Cross-section name : I-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 $m^3/m$

### Forces above the slip surface

Depth of slip surface $h_{s1}$ = 3,50 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**



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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 | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m3] | $\gamma_{su}$ [kN/m3] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | Glina | | 15,00 | 1,00 | 19,00 | 9,00 | 15,00 |
| 2 | Preperina | | 30,00 | 10,00 | 21,00 | 11,00 | 30,00 |
| 3 | Hribina | | 34,00 | 30,00 | 23,00 | 13,00 | 34,00 |

## Soil parameters to compute pressure at rest

| No. | Name | Pattern | Type calculation | $\varphi_{ef}$ [°] | $\nu$ [–] | OCR [–] | $K_r$ [–] |
|---|---|---|---|---|---|---|---|
| 1 | Glina | | cohesive | - | 0,40 | - | - |
| 2 | Preperina | | cohesive | - | 0,25 | - | - |
| 3 | Hribina | | cohesive | - | 0,20 | - | - |

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

| No. | Name | Pattern | $\nu$ [–] | $E_{oed}$ [MPa] | $E_{def}$ [MPa] |
|---|---|---|---|---|---|
| 1 | Glina | | 0,40 | 3,00 | - |
| 2 | Preperina | | 0,25 | 20,00 | - |
| 3 | Hribina | | 0,20 | 50,00 | - |

## Soil parameters

**Glina**

Unit weight : $\gamma$ = 19,00 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 15,00 °
Cohesion of soil : $c_{ef}$ = 1,00 kPa
Angle of friction struc.-soil : $\delta$ = 15,00 °
Soil : cohesive
Poisson's ratio : $\nu$ = 0,40
Oedometric modulus : $E_{oed}$ = 3,00 MPa
Saturated unit weight : $\gamma_{sat}$ = 19,00 kN/m3

**Preperina**

Unit weight : $\gamma$ = 21,00 kN/m3
Stress-state : effective



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Angle of internal friction : $\varphi_{ef}$ = 30,00 °
Cohesion of soil : $c_{ef}$ = 10,00 kPa
Angle of friction struc.-soil : $\delta$ = 30,00 °
Soil : cohesive
Poisson's ratio : $\nu$ = 0,25
Oedometric modulus : $E_{oed}$ = 20,00 MPa
Saturated unit weight : $\gamma_{sat}$ = 21,00 kN/m$^3$

**Hribina**
Unit weight : $\gamma$ = 23,00 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 34,00 °
Cohesion of soil : $c_{ef}$ = 30,00 kPa
Angle of friction struc.-soil : $\delta$ = 34,00 °
Soil : cohesive
Poisson's ratio : $\nu$ = 0,20
Oedometric modulus : $E_{oed}$ = 50,00 MPa
Saturated unit weight : $\gamma_{sat}$ = 23,00 kN/m$^3$

## Geological profile and assigned soils

| No. | Thickness of layer t [m] | Depth z [m] | Assigned soil | Pattern |
|---|---|---|---|---|
| 1 | 6,00 | 0,00 .. 6,00 | Glina | |
| 2 | 1,20 | 6,00 .. 7,20 | Hribina | |
| 3 | - | 7,20 .. ∞ | Hribina | |

## Excavation

Soil in front of wall is excavated to a depth of 1,50 m.
Soil slope in front of structure $\beta$ = -14,50 °

## 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 $\sigma_{a,min} = 0{,}20\sigma_z$

## Settings of the stage of construction

Design situation : permanent


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## Analysis results

### Pressure above the slip surface

| Depth [m] | Passive pressure [kPa] | Active pressure [kPa] |
|---|---|---|
| 0 | 0,00 | 0,00 |
| 1,50 | 0,00 | 0,00 |
| 1,50 | 0,00 | 0,00 |
| 3,50 | 0,00 | 0,00 |

### Distribution of pressures acting on the structure (in front and behind the wall) - above slip surface

| 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 |
| 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.13 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.20 | 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 |
| 1.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.64 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.60 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2.80 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.20 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.40 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |
| 3.50 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 | 0.00 |

### Distribution of pressures acting on the structure (in front and behind the wall) - below the slip surface

| Depth [m] | Ta,p [kPa] | Tk,p [kPa] | Tp,p [kPa] | Ta,z [kPa] | Tk,z [kPa] | Tp,z [kPa] |
|---|---|---|---|---|---|---|
| 3.50 | -9.16 | -13.73 | -28.37 | 23.33 | 28.15 | 91.14 |
| 3.60 | -9.65 | -14.41 | -29.72 | 23.92 | 30.76 | 93.69 |
| 3.80 | -10.63 | -15.78 | -32.43 | 25.09 | 32.23 | 98.80 |
| 4.00 | -11.62 | -17.16 | -35.13 | 26.27 | 33.71 | 103.90 |
| 4.20 | -12.60 | -18.53 | -37.84 | 27.44 | 35.20 | 109.01 |
| 4.40 | -13.58 | -19.90 | -40.54 | 28.61 | 36.71 | 114.11 |
| 4.60 | -14.57 | -21.27 | -43.25 | 29.79 | 38.22 | 119.22 |
| 4.61 | -14.63 | -21.36 | -43.41 | 27.03 | 38.31 | 119.52 |



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| Depth [m] | Ta,p [kPa] | Tk,p [kPa] | Tp,p [kPa] | Ta,z [kPa] | Tk,z [kPa] | Tp,z [kPa] |
|---|---|---|---|---|---|---|
| 4.80 | -15.55 | -22.65 | -45.95 | 28.17 | 39.74 | 124.32 |
| 5.00 | -16.53 | -24.02 | -48.66 | 29.37 | 41.26 | 129.43 |

## 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 | -3.37 | 0.00 | 0.00 | 0.00 |
| 0.25 | 0.00 | 0.00 | -3.32 | 0.00 | 0.00 | -0.00 |
| 0.50 | 0.00 | 0.00 | -3.27 | 0.00 | 0.00 | -0.00 |
| 0.75 | 0.00 | 0.00 | -3.22 | 0.00 | -0.00 | -0.00 |
| 1.00 | 0.00 | 0.00 | -3.17 | 0.00 | -0.00 | -0.00 |
| 1.25 | 0.00 | 0.00 | -3.12 | 0.00 | 0.00 | -0.00 |
| 1.50 | 0.00 | 0.00 | -3.08 | 0.00 | -0.00 | -0.00 |
| 1.50 | 0.00 | 0.00 | -3.08 | 0.00 | 0.00 | 0.00 |
| 1.75 | 0.00 | 0.00 | -3.03 | 0.00 | 0.00 | -0.00 |
| 2.00 | 0.00 | 0.00 | -2.98 | 0.00 | 0.00 | -0.00 |
| 2.25 | 0.00 | 0.00 | -2.93 | 0.00 | 0.00 | -0.00 |
| 2.50 | 0.00 | 0.00 | -2.88 | 0.00 | 0.00 | -0.00 |
| 2.75 | 0.00 | 0.00 | -2.83 | 0.00 | 0.00 | -0.00 |
| 3.00 | 0.00 | 0.00 | -2.79 | 0.00 | 0.00 | -0.00 |
| 3.25 | 0.00 | 0.00 | -2.74 | 0.00 | 0.00 | -0.00 |
| 3.50 | 0.00 | 0.00 | -2.69 | 0.00 | 0.00 | -0.00 |
| 3.50 | 3.50 | 0.00 | -2.69 | 0.20 | 0.02 | -0.00 |
| 3.75 | 3.50 | 0.00 | -2.64 | 0.12 | -0.02 | 0.00 |
| 4.00 | 3.50 | 0.00 | -2.59 | 0.04 | -0.04 | 0.01 |
| 4.25 | 3.50 | 0.00 | -2.55 | -0.04 | -0.04 | 0.02 |
| 4.50 | 3.50 | 0.00 | -2.50 | -0.12 | -0.02 | 0.03 |
| 4.75 | 3.50 | 3.50 | -2.45 | -0.10 | 0.04 | 0.01 |
| 5.00 | 3.50 | 3.50 | -2.41 | 0.42 | -0.00 | -0.00 |

Maximum shear force = 0,04 kN/m
Maximum moment = 0,03 kNm/m
Maximum displacement = 3,4 mm
Displacement in the depth of slip surface = 2,7 mm

## Terrain settlement behind the structure

Terrain settlement $\delta_{max}$ = 5,1 mm

| | Coordinate x [m] | Settlement z [mm] |
|---|---|---|
| 1 | 0,00 | 2,9 |
| 2 | 0,38 | 4,5 |
| 3 | 0,77 | 5,6 |
| 4 | 1,15 | 6,3 |
| 5 | 1,53 | 6,7 |
| 6 | 1,92 | 6,6 |
| 7 | 2,30 | 6,1 |
| 8 | 2,69 | 5,2 |
| 9 | 3,07 | 3,9 |
| 10 | 3,45 | 2,1 |
| 11 | 3,84 | 0,0 |

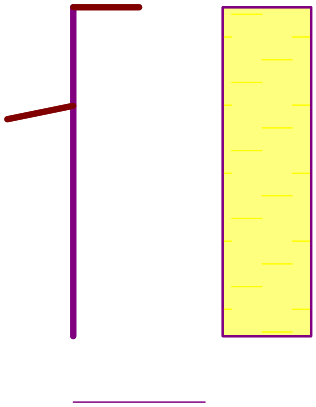


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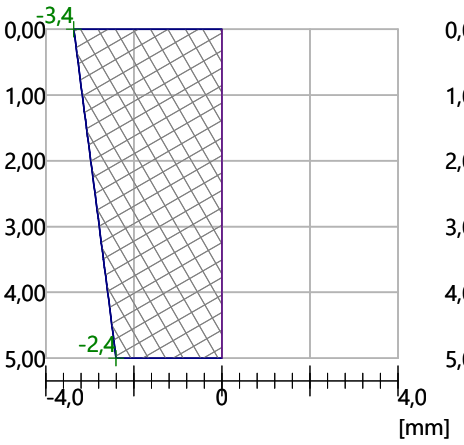
| | Coordinate x [m] | Settlement z [mm] |
|---|---|---|
| 12 | 3,84 | 0,0 |

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

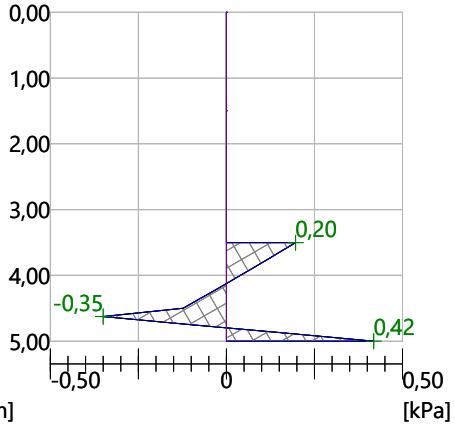
**Geometry of structure**
Length of structure = 5,00m



**Displacement of structure**
Max. disp. = 3,4 mm

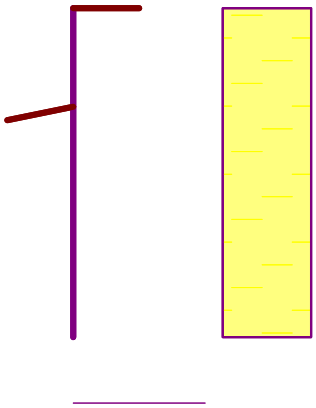



**Pressure acting on structure**
Max. pressure = 0,42 kPa

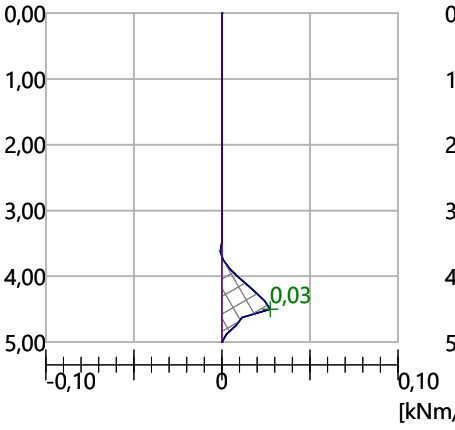



**Name : Analysis** | **Stage - analysis : 1 - -1**

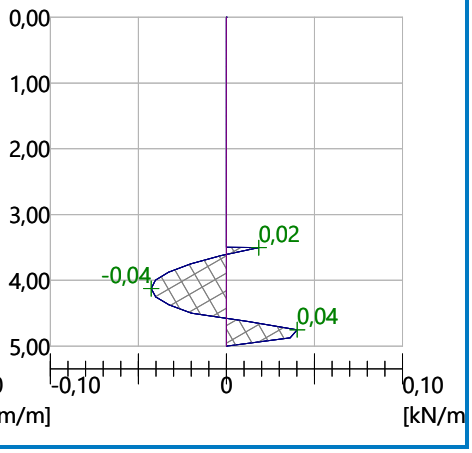
**Geometry of structure**
Length of structure = 5,00m



**Bending moment**
Max. M = 0,03 kNm/m



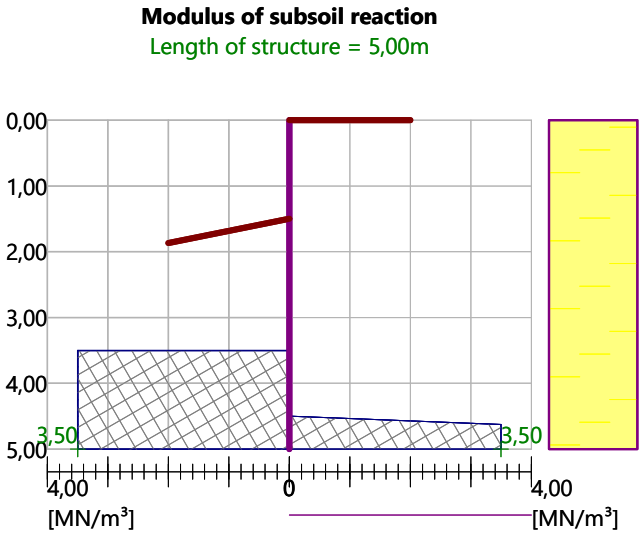

**Shear force**
Max. Q = 0,04 kN/m

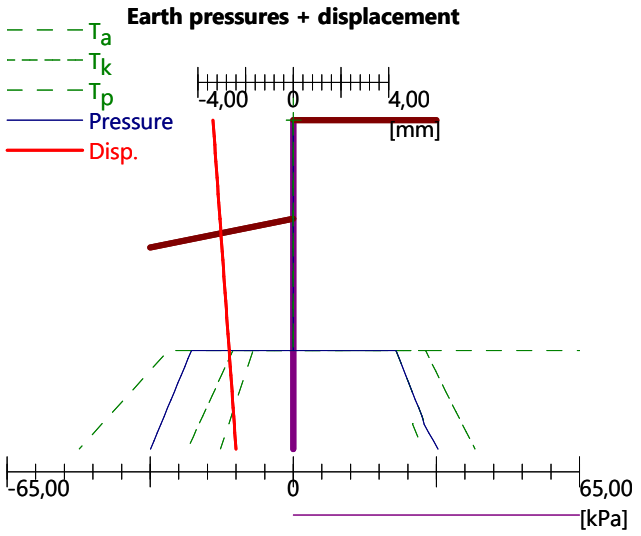





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| Name : Analysis | Stage - analysis : 1 - -1 |
|---|---|




## 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 | -3.37 | -3.37 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.25 | -3.32 | -3.32 | 0.00 | 0.00 | -0.00 | -0.00 |
| 0.50 | -3.27 | -3.27 | 0.00 | 0.00 | -0.00 | -0.00 |
| 0.75 | -3.22 | -3.22 | -0.00 | -0.00 | -0.00 | -0.00 |
| 1.00 | -3.17 | -3.17 | -0.00 | -0.00 | -0.00 | -0.00 |
| 1.25 | -3.12 | -3.12 | 0.00 | 0.00 | -0.00 | -0.00 |
| 1.50 | -3.08 | -3.08 | -0.00 | -0.00 | -0.00 | -0.00 |
| 1.50 | -3.08 | -3.08 | 0.00 | 0.00 | 0.00 | 0.00 |
| 1.75 | -3.03 | -3.03 | 0.00 | 0.00 | -0.00 | -0.00 |
| 2.00 | -2.98 | -2.98 | 0.00 | 0.00 | -0.00 | -0.00 |
| 2.25 | -2.93 | -2.93 | 0.00 | 0.00 | -0.00 | -0.00 |
| 2.50 | -2.88 | -2.88 | 0.00 | 0.00 | -0.00 | -0.00 |
| 2.75 | -2.83 | -2.83 | 0.00 | 0.00 | -0.00 | -0.00 |
| 3.00 | -2.79 | -2.79 | 0.00 | 0.00 | -0.00 | -0.00 |
| 3.25 | -2.74 | -2.74 | 0.00 | 0.00 | -0.00 | -0.00 |
| 3.50 | -2.69 | -2.69 | 0.00 | 0.00 | -0.00 | -0.00 |
| 3.50 | -2.69 | -2.69 | 0.02 | 0.02 | -0.00 | -0.00 |
| 3.75 | -2.64 | -2.64 | -0.02 | -0.02 | 0.00 | 0.00 |
| 4.00 | -2.59 | -2.59 | -0.04 | -0.04 | 0.01 | 0.01 |
| 4.25 | -2.55 | -2.55 | -0.04 | -0.04 | 0.02 | 0.02 |
| 4.50 | -2.50 | -2.50 | -0.02 | -0.02 | 0.03 | 0.03 |
| 4.75 | -2.45 | -2.45 | 0.04 | 0.04 | 0.01 | 0.01 |
| 5.00 | -2.41 | -2.41 | -0.00 | -0.00 | -0.00 | -0.00 |

### Maximum values of internal forces

Maximum displacement = -3,4 mm
Minimum displacement = -2,4 mm
Maximum bending moment = 0,03 kNm/m
Minimum bending moment = 0,00 kNm/m
Maximum shear force = 0,04 kN/m



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## 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-section**

$M_{max}$ = 0,03 kNm; Q = 0,02 kN
$Q_{max}$ = 0,04 kN; M = 0,01 kNm

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

**Verification of bending:**

$M_{max}/M_{c,Rd}$ = 0,001 ≤ 1 **Is satisfactory**

**Verification of shear:**

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

**Verification of plane state of stress:**

Normal stress $\sigma_{x,Ed}$ = 0,11 MPa
Shear stress $\tau_{Ed}$ = 0,01 MPa

Verification: $(\sigma_{x,Ed}/(f_y/\gamma_{M0}))^2 + 3*(\tau_{Ed}/(f_y/\gamma_{M0}))^2 = 0,000 \leq 1$ **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 $\sigma_{x,Ed}$ = 0,06 MPa
Shear stress $\tau_{Ed}$ = 0,03 MPa

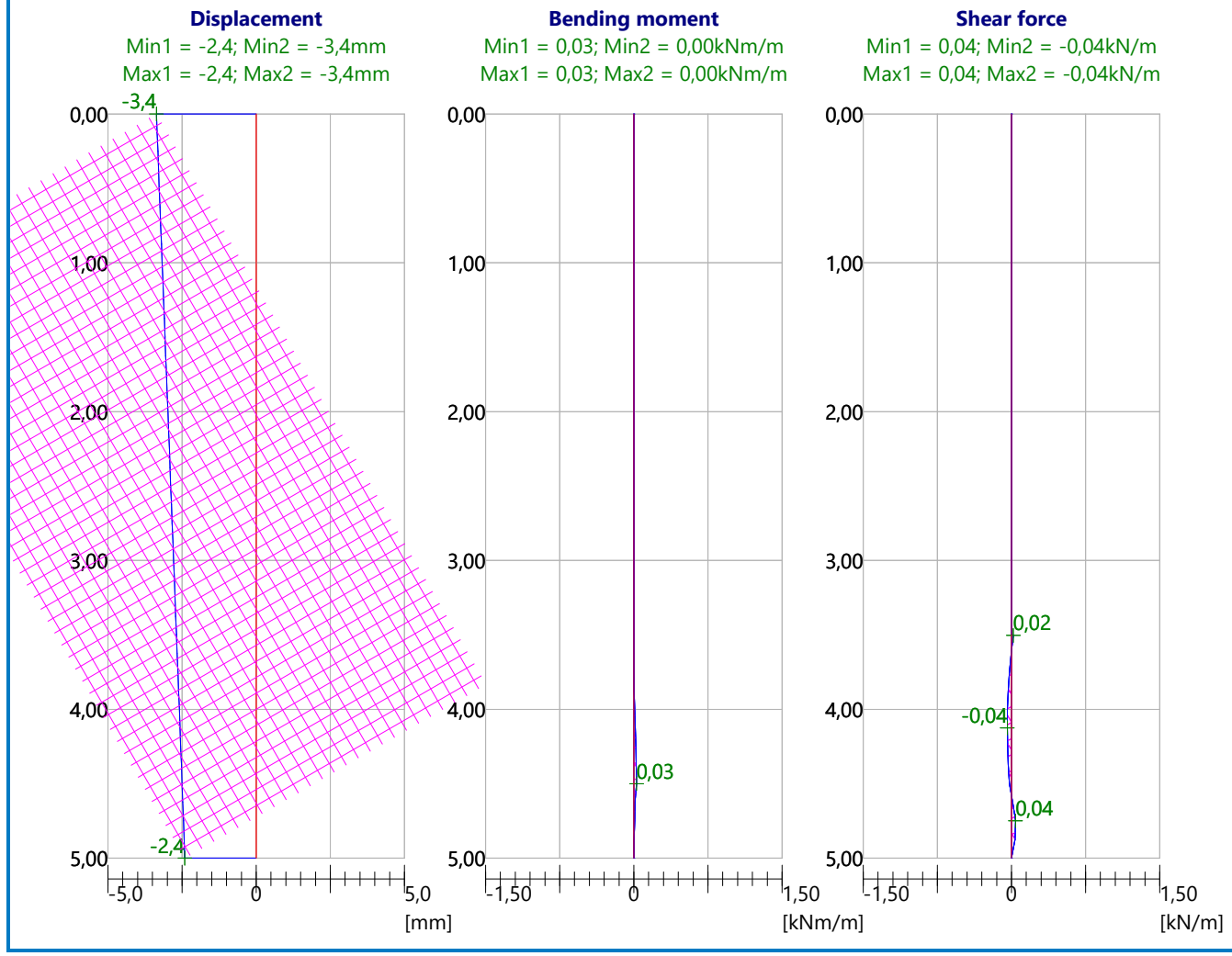
Verification: $(\sigma_{x,Ed}/(f_y/\gamma_{M0}))^2 + 3*(\tau_{Ed}/(f_y/\gamma_{M0}))^2 = 0,000 \leq 1$ **Is satisfactory**

**Cross section is SATISFACTORY**



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






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