



Cantilever wall analysis

Input data

Project

Task : Ureditev ceste s pločnikom, Globoko - Bojsno
Part : Oporna konstrukcija
Customer : Občina Brežice, Cesta prvih borcev 18, 8250 Brežice
Date : 27.11.2020
Project ID : 39
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Settings

Slovenia - EN 1997

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 : standard

Wall analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Caquot-Kerisel
Earthquake analysis : Mononobe-Okabe
Shape of earth wedge : Calculate as skew
Base key : The base key is considered as inclined footing bottom
Allowable eccentricity : 0,333
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 overturning :	$\gamma_{Rv} =$	1,40 [-]	
Partial factor on sliding resistance :	$\gamma_{Rh} =$	1,10 [-]	
Partial factor on bearing capacity :	$\gamma_{Re} =$	1,40 [-]	

Partial factors for variable actions			
Permanent design situation			
Factor for combination value :	$\psi_0 =$	0,70 [-]	
Factor for frequent value :	$\psi_1 =$	0,50 [-]	
Factor for quasi-permanent value :	$\psi_2 =$	0,30 [-]	

Material of structure

Unit weight $\gamma = 23,00 \text{ kN/m}^3$

Analysis of concrete structures carried out according to the standard EN 1992-1-1 (EC2).

Concrete: C 25/30

Cylinder compressive strength $f_{ck} = 25,00 \text{ MPa}$

Tensile strength $f_{ctm} = 2,60 \text{ MPa}$



Longitudinal steel: B500

Yield strength

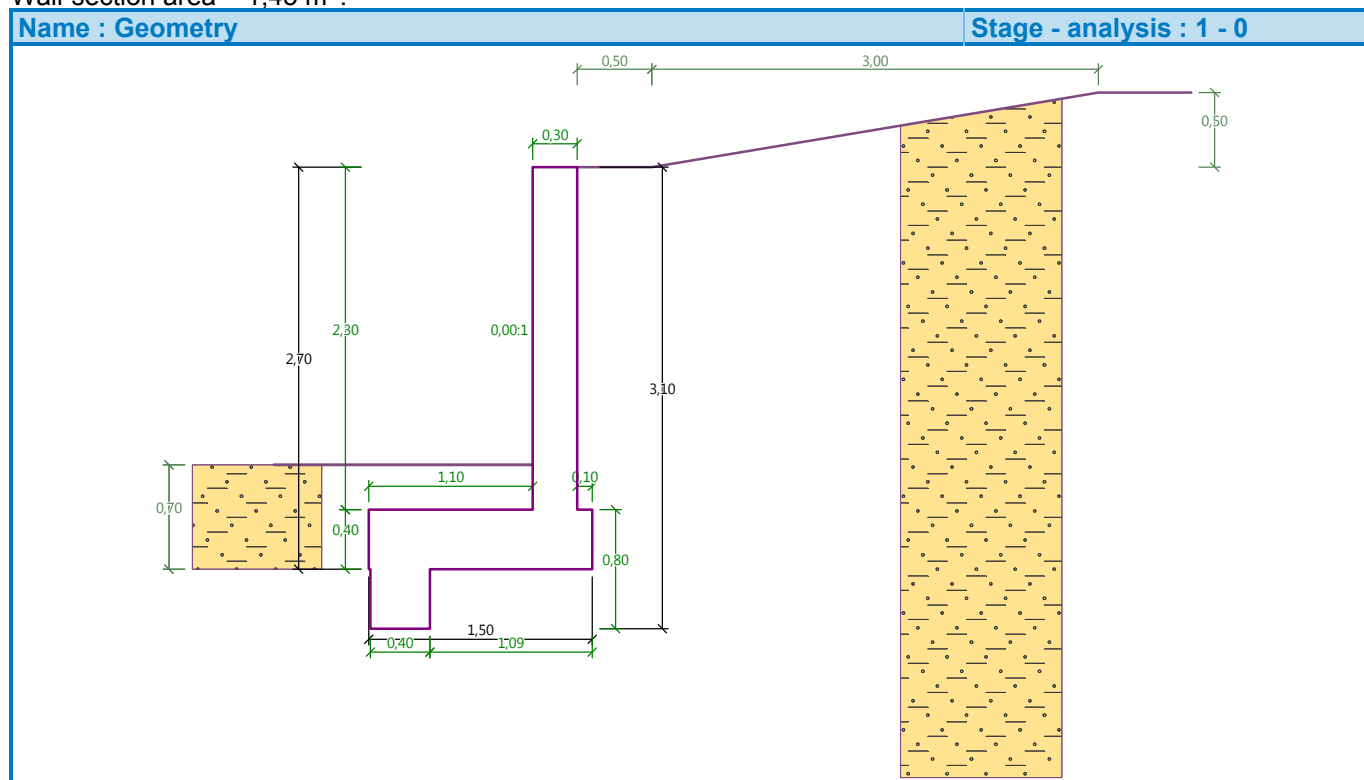
$$f_{yk} = 500,00 \text{ MPa}$$

Geometry of structure

No.	Coordinate X [m]	Depth Z [m]
1	0,00	0,00
2	0,00	2,30
3	0,10	2,30
4	0,10	2,70
5	-0,99	2,70
6	-0,99	3,10
7	-1,39	3,10
8	-1,39	2,70
9	-1,40	2,70
10	-1,40	2,30
11	-0,30	2,30
12	-0,30	0,00

The origin [0,0] is located at the most upper right point of the wall.

Wall section area = 1,45 m².



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ [°]
1	Sandy clay (CS), firm consistency		26,00	0,00	18,50	8,50	17,30

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

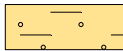


Soil parameters

Sandy clay (CS), firm consistency

Unit weight : $\gamma = 18,50 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 26,00^\circ$
 Cohesion of soil : $c_{ef} = 0,00 \text{ kPa}$
 Angle of friction struc.-soil : $\delta = 17,30^\circ$
 Soil : cohesionless
 Saturated unit weight : $\gamma_{sat} = 18,50 \text{ kN/m}^3$

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	-	0,00 .. ∞	Sandy clay (CS), firm consistency	

Foundation

Type of foundation : soil from geological profile

Terrain profile

No.	Coordinates x [m]	Depth z [m]
1	0,00	0,00
2	0,50	0,00
3	3,50	-0,50
4	4,50	-0,50

Origin [0,0] is located in upper right edge of construction.
 Positive coordinate +z has downward direction.

Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

Resistance on front face of the structure: 1/2 pass., 1/2 at rest
 Soil on front face of the structure - Sandy clay (CS), firm consistency
 Angle of friction struc.-soil $\delta = 17,30^\circ$
 Soil thickness in front of structure $h = 0,70 \text{ m}$

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : permanent
 The wall is free to move. Active earth pressure is therefore assumed.

Verification No. 1

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - wall	0,00	-0,80	33,35	0,93	1,000	1,000	1,350
FF resistance	-25,38	0,03	-6,91	0,08	1,350	1,000	1,000
Weight - earth wedge	0,00	-0,46	0,18	1,43	1,000	1,000	1,350
Active pressure	25,05	-0,87	11,57	1,44	1,350	1,350	1,350

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 37,81 \text{ kNm/m}$



Overturning moment $M_{ovr} = 30,62 \text{ kNm/m}$

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 18,72 \text{ kN/m}$

Active horizontal force $H_{act} = 8,43 \text{ kN/m}$

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 43,16 kPa

Bearing capacity of foundation soil

Design load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [-]	Stress [kPa]
1	6,74	53,96	8,43	0,083	43,16
2	7,54	39,80	8,43	0,126	35,50

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	4,01	38,18	-0,33

Verification of foundation soil

Stress in the footing bottom : trapezoid

Eccentricity verification

Max. eccentricity of normal force $e = 0,126$

Maximum allowable eccentricity $e_{alw} = 0,333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Bearing capacity of foundation soil $R = 240,00 \text{ kPa}$

Partial factor on bearing capacity $\gamma_{Rv} = 1,40$

Max. stress at footing bottom $\sigma = 53,94 \text{ kPa}$

Bearing capacity of foundation soil $R_d = 171,43 \text{ kPa}$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning No. 1

Wall stem check - front reinf.

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. moment	Coeff. norm.force	Coeff. shear for.
Weight - wall	0,00	-1,15	15,86	0,15	1,000	1,350	1,000
FF resistance	-1,87	-0,10	-0,51	0,00	1,000	1,000	1,000
Pressure at rest	27,54	-0,76	0,00	0,30	1,350	1,000	1,350

Wall stem check - front reinf.

Front reinforcement is not required.



Wall stem check - back reinf.

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. moment	Coeff. norm.force	Coeff. shear for.
Weight - wall	0,00	-1,15	15,86	0,15	1,000	1,350	1,000
FF resistance	-1,87	-0,10	-0,51	0,00	1,000	1,000	1,000
Pressure at rest	27,54	-0,76	0,00	0,30	1,350	1,000	1,350

Wall stem check - back reinf.

Wall check at the construction joint 2,30 m from the wall crest

Reinforcement and dimensions of the cross-section

6,60 prof. 12,0 mm, cover 50,0 mm

Inputted reinforcement area = 746,4 mm²

Required reinforcement area = 329,9 mm²

Cross-section width = 1,00 m

Cross-section height = 0,30 m

Reinforcement ratio ρ = 0,31 % > 0,14 % = ρ_{min}

Position of neutral axis x = 0,04 m < 0,15 m = x_{max}

Ultimate shear force V_{Rd} = 112,30 kN > 35,31 kN = V_{Ed}

Ultimate moment M_{Rd} = 82,35 kNm > 28,16 kNm = M_{Ed}

Cross-section is SATISFACTORY.

Wall jump check

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Weight - wall	0,00	-0,80	33,35	0,93	1,350
FF resistance	-25,38	0,03	-6,91	0,08	1,000
Weight - earth wedge	0,00	-0,46	0,18	1,43	1,350
Active pressure	25,05	-0,87	11,57	1,44	1,350

Wall jump check

Reinforcement and dimensions of the cross-section

6,60 prof. 12,0 mm, cover 50,0 mm

Inputted reinforcement area = 746,4 mm²

Required reinforcement area = 465,1 mm²

Cross-section width = 1,00 m

Cross-section height = 0,40 m

Reinforcement ratio ρ = 0,22 % > 0,14 % = ρ_{min}

Position of neutral axis x = 0,02 m < 0,21 m = x_{max}

Ultimate shear force V_{Rd} = 140,86 kN > 34,72 kN = V_{Ed}

Ultimate moment M_{Rd} = 108,48 kNm > 28,16 kNm = M_{Ed}

Cross-section is SATISFACTORY.