

Cantilever wall analysis

Input data

Date : 11. 11. 2024

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

Wall analysis

Verification methodology : according to EN 1997
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
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 20/25

Cylinder compressive strength $f_{ck} = 20,00 \text{ MPa}$
Tensile strength $f_{ctm} = 2,20 \text{ MPa}$
Elasticity modulus $E_{cm} = 30000,00 \text{ MPa}$

Longitudinal reinforcement: B500B

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

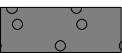
Geometry of structure

No.	Coordinate X [m]	Depth Z [m]
1	0,00	0,00
2	0,00	1,70
3	0,10	1,70
4	0,10	2,10
5	-0,70	2,10
6	-0,70	1,70
7	-0,25	1,70
8	-0,25	0,00

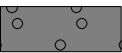
The origin [0,0] is located at the most upper right point of the wall.

Wall section area = 0,75 m².

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ [°]
1	Pusta do peščena glina (CL, CI)		18,00	8,00	20,00	10,00	18,00
2	Pusta do peščena glina (CL, CI) tgk		22,00	11,00	21,00	11,00	21,00
3	Dobro granuliran kamniti drobljenec		38,50	0,00	21,00	11,00	21,00

Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	φ_{ef} [°]	ν [-]	OCR [-]	K_r [-]
1	Pusta do peščena glina (CL, CI)		cohesive	-	0,40	-	-
2	Pusta do peščena glina (CL, CI) tgk		cohesive	-	0,40	-	-
3	Dobro granuliran kamniti drobljenec		cohesionless	38,50	-	-	-

Soil parameters

Pusta do peščena glina (CL, CI)

Unit weight : $\gamma = 20,00$ kN/m³
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 18,00$ °
 Cohesion of soil : $c_{ef} = 8,00$ kPa
 Angle of friction struc.-soil : $\delta = 18,00$ °
 Soil : cohesive
 Poisson's ratio : $\nu = 0,40$
 Oedometric modulus : $E_{oed} = 9,50$ MPa
 Saturated unit weight : $\gamma_{sat} = 20,00$ kN/m³

Pusta do peščena glina (CL, CI) tgk

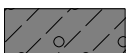
Unit weight : $\gamma = 21,00$ kN/m³
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 22,00$ °
 Cohesion of soil : $c_{ef} = 11,00$ kPa
 Angle of friction struc.-soil : $\delta = 21,00$ °

Soil : cohesive
 Poisson's ratio : $\nu = 0,40$
 Oedometric modulus : $E_{\text{oed}} = 9,50 \text{ MPa}$
 Saturated unit weight : $\gamma_{\text{sat}} = 21,00 \text{ kN/m}^3$

Dobro granuliran kamniti drobljenec

Unit weight : $\gamma = 21,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{\text{ef}} = 38,50^\circ$
 Cohesion of soil : $c_{\text{ef}} = 0,00 \text{ kPa}$
 Angle of friction struc.-soil : $\delta = 21,00^\circ$
 Soil : cohesionless
 Oedometric modulus : $E_{\text{oed}} = 355,50 \text{ MPa}$
 Saturated unit weight : $\gamma_{\text{sat}} = 21,00 \text{ kN/m}^3$

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	2,00	0,00 .. 2,00	Pusta do peščena glina (CL, CI)	
2	1,00	2,00 .. 3,00	Pusta do peščena glina (CL, CI) tgk	
3	-	3,00 .. ∞	Pusta do peščena glina (CL, CI)	

Foundation

Type of foundation : input parameters of contact base-soil

Parameters

Angle of friction base-soil $\psi = 22,00^\circ$
 Cohesion base-soil $a = 11,00 \text{ kPa}$

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

Resistance on front face of the structure: passive

Soil on front face of the structure - Dobro granuliran kamniti drobljenec

Angle of friction struc.-soil $\delta = 0,00^\circ$

Soil thickness in front of structure $h = 0,80 \text{ m}$

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.

Reduction of soil/soil friction angle : do not reduce

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	17,14	0,50	1,000	1,000	1,350
Weight - soil	0,00	-0,60	3,78	0,23	1,000	1,000	1,350
FF resistance	-29,99	-0,27	0,02	-0,23	1,000	1,000	1,350

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - earth wedge	0,00	-0,45	0,14	0,73	1,000	1,000	1,350
Active pressure	5,45	-0,40	3,62	0,76	1,350	1,350	1,350

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 9,44$ kNm/m

Overturning moment $M_{ovr} = -5,03$ kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 17,53$ kN/m

Active horizontal force $H_{act} = -22,64$ kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 41,67 kPa

Horizontal deformation of wall top

Deformation due to earth pressure $\delta_s = 0,16$ mm

Deformation due to wall inclination $\delta_b = 0,00$ mm

Total deformation $\delta_{tot} = 0,16$ mm

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	-11,04	33,33	-33,13	0,000	41,67
2	-7,86	25,96	-22,64	0,000	32,45

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-8,18	24,69	-24,54

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0,000$

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

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Ultimate bearing capacity of found. soil $R = 260,00$ kPa

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

Max. stress at footing bottom $\sigma = 41,67$ kPa

Allowable bearing capacity of foundation soil $R_d = 185,71$ 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	-0,85	9,77	0,12	1,000	1,350	1,000
FF resistance	-7,46	-0,13	0,00	0,00	1,000	1,000	1,000
Pressure at rest	19,24	-0,57	0,00	0,25	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	-0,85	9,77	0,12	1,000	1,350	1,000
FF resistance	-7,46	-0,13	0,00	0,00	1,000	1,000	1,000
Pressure at rest	19,24	-0,57	0,00	0,25	1,350	1,000	1,350

Wall stem check - back reinf.

Wall check at the construction joint 1,70 m from the wall crest

Reinforcement and dimensions of the cross-section

5 prof. 20,0 mm, cover 30,0 mm

Inputted reinforcement area = 1570,8 mm²Required reinforcement area = 273,0 mm²

Cross-section width = 1,00 m

Cross-section height = 0,25 m

Reinforcement ratio ρ = 0,75 % > 0,13 % = ρ_{min} Position of neutral axis x = 0,05 m < 0,13 m = x_{max} Ultimate shear force V_{Rd} = 122,69 kN > 18,51 kN = V_{Ed} Ultimate moment M_{Rd} = 126,74 kNm > 13,71 kNm = M_{Ed} **Cross-section is SATISFACTORY.****Wall stem check - back reinf. - V_{Ed}**

Wall check at the construction joint 1,60 m from the wall crest

Reinforcement and dimensions of the cross-section

5 prof. 20,0 mm, cover 30,0 mm

Inputted reinforcement area = 1570,8 mm²Required reinforcement area = 273,0 mm²

Cross-section width = 1,00 m

Cross-section height = 0,25 m

Ultimate shear force V_{Rd} = 122,69 kN > 18,82 kN = V_{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	17,14	0,50	1,350
Weight - soil	0,00	-0,60	3,78	0,23	1,350
FF resistance	-29,99	-0,27	0,02	-0,23	1,350

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Weight - earth wedge	0,00	-0,45	0,14	0,73	1,350
Active pressure	5,45	-0,40	3,62	0,76	1,350

Wall jump check

Reinforcement and dimensions of the cross-section

5 prof. 20,0 mm, cover 30,0 mm

Inputted reinforcement area = 1570,8 mm²

Required reinforcement area = 468,0 mm²

Cross-section width = 1,00 m

Cross-section height = 0,40 m

Reinforcement ratio ρ = 0,44 % > 0,13 % = ρ_{min}

Position of neutral axis x = 0,06 m < 0,22 m = x_{max}

Ultimate shear force V_{Rd} = 155,23 kN > 14,61 kN = V_{Ed}

Ultimate moment M_{Rd} = 228,37 kNm > 13,71 kNm = M_{Ed}

Cross-section is SATISFACTORY.