Cantilever wall analysis

Input data

Project

Date : 11/2/2005

Material of structure

Unit weight γ = 23.00 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 MPa
Tensile strength	f_{ct}	=	2.20 MPa
Elasticity modulus	E_{cm}	=	29000.00 MPa

Longitudinal steel : B500

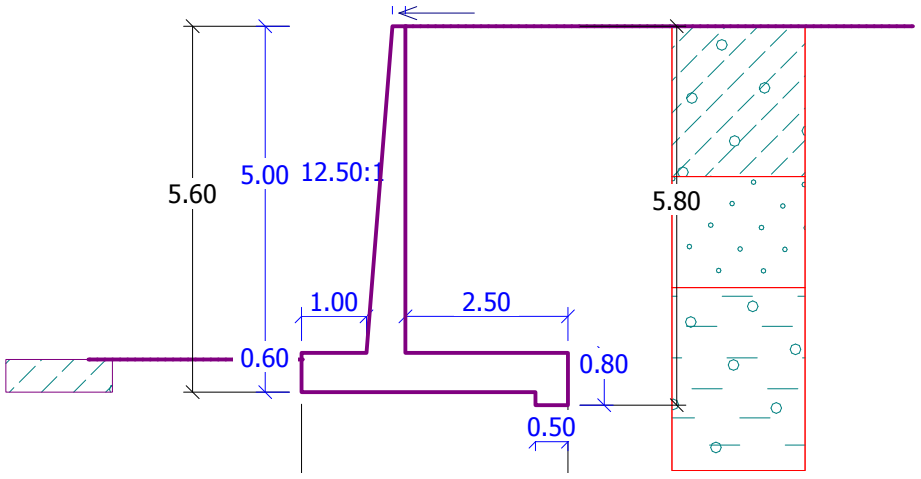
Yield strength	f_{yk}	=	500.00 MPa
Elasticity modulus	E	=	200000.00 MPa

Geometry of structure

No.	Coordinate X [m]	Depth Z [m]
1	0.00	0.00
2	0.00	5.00
3	2.50	5.00
4	2.50	5.60
5	2.50	5.80
6	2.00	5.80
7	2.00	5.60
8	-1.60	5.60
9	-1.60	5.00
10	-0.60	5.00
11	-0.20	0.00

The origin [0,0] is located at the most upper right point of the wall.
Wall section area = 4.56 m^2.

Name : Geometry | **Stage : 1**



Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]	γ_{su} [kN/m^3]	δ [°]
1	Soil No. 1		29.00	10000.00	19.00	9.00	15.00
2	Soil No. 2		31.50	0.00	17.50	7.50	15.00
3	Soil No. 3		27.00	10.00	19.50	9.50	15.00

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

Soil parameters

Soil No. 1

Unit weight : γ = 19.00 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 29.00 °
Cohesion of soil : c_{ef} = 10000.00 kPa
Angle of friction struc.-soil : δ = 15.00 °
Soil : cohesionless
Saturated unit weight : γ_{sat} = 19.00 kN/m^3

Soil No. 2

Unit weight : γ = 17.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 31.50 °
Cohesion of soil : c_{ef} = 0.00 kPa
Angle of friction struc.-soil : δ = 15.00 °
Soil : cohesionless
Saturated unit weight : γ_{sat} = 17.50 kN/m^3

Soil No. 3

Unit weight : γ = 19.50 kN/m^3
Stress-state : effective
Angle of internal friction : φ_{ef} = 27.00 °
Cohesion of soil : c_{ef} = 10.00 kPa
Angle of friction struc.-soil : δ = 15.00 °
Soil : cohesionless
Saturated unit weight : γ_{sat} = 19.50 kN/m^3

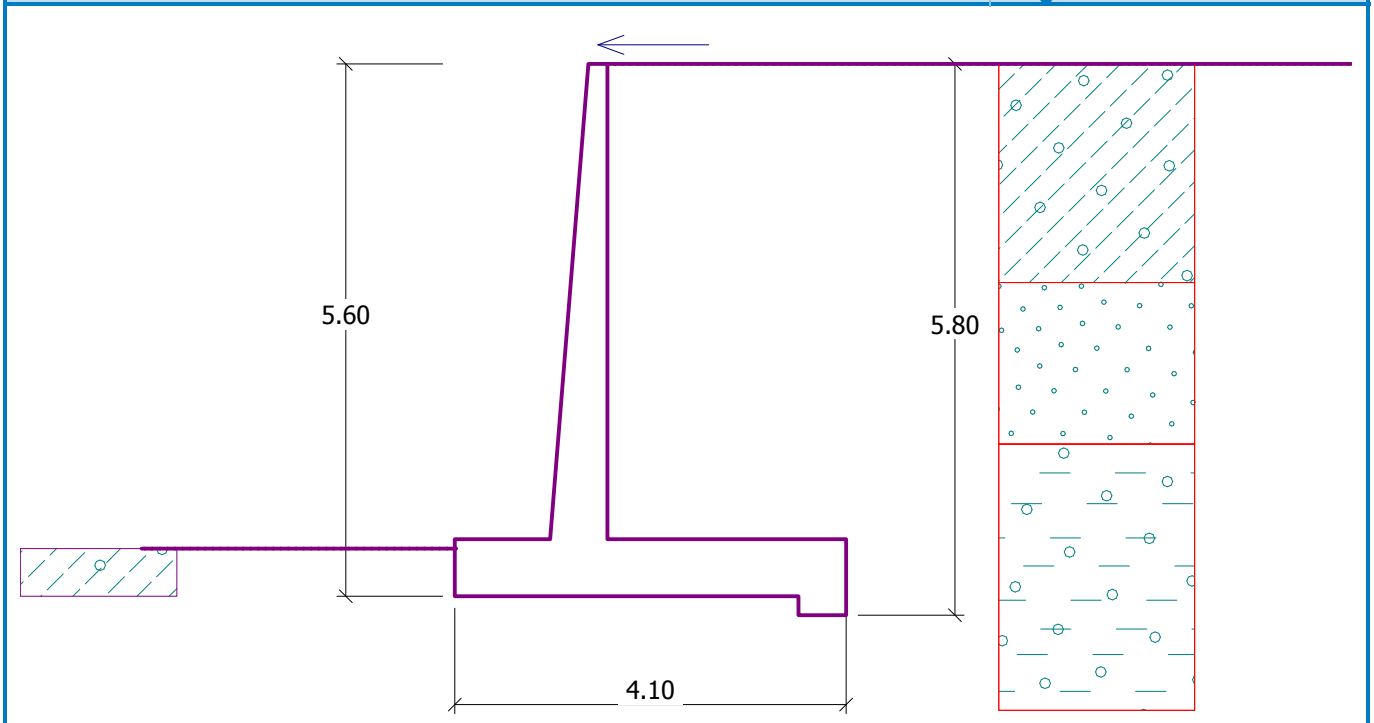
Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	2.30	Soil No. 1	
2	1.70	Soil No. 2	
3	-	Soil No. 3	

Terrain profile

Terrain behind the structure is flat.

Name : Terrain | **Stage : 1**



Water influence

Ground water table is located below the structure.

Resistance on front face of the structure

Resistance on front face of the structure: at rest
Soil on front face of the structure - Soil No. 1
Soil thickness in front of structure h = 0.50 m
Terrain in front of structure is flat.

Applied forces acting on the structure

No.	Force new	Force modification	Name	Action	F_x [kN/m]	F_z [kN/m]	M [kNm/m]	x [m]	z [m]
1	YES		Force No. 1	permanent	-30.00	0.00	0.00	-0.10	-0.20

Global settings

Verification methodology : Analysis according to EN 1997
Input of patial factors : Standard
Design approach : 1 - reduction of actions and materials

Partial factors on actions (F)	Fact.	Combination 1 [–]		Combination 2 [–]	
		Unfavourable	Favourable	Unfavourable	Favourable
Permanent actions	γ_G	1.35	1.00	1.00	1.00
Variable actions	γ_Q	1.50	0.00	1.30	0.00
Water actions	γ_w	1.30		1.00	

Partial factors for soil parameters (M)	Fact.	Combination 1 [–]	Combination 2 [–]
Partial factor for intenal friction	$\gamma_{m\phi}$	1.00	1.25
Partial factor for effective cohesion	γ_{mc}	1.00	1.25
Partial factor for undrained shear strength	γ_{mcu}	1.00	1.40
Partial factor for Poisson's ratio	γ_{mv}	1.00	1.00

Partial factors for variable actions	Fact.	[–]
Factor for combination value	ψ_0	0.70
Factor for frequent value	ψ_1	0.50
Factor for quasi-permanent value	ψ_2	0.30

Active earth pressure calculation - Coulomb
Passive earth pressure calculation - Caqout-Kerisel
Standard for concrete structures - EN 1992 1-1 (EC2)

Settings of the stage of construction

Combination : basic
The wall is free to move. Active earth pressure is therefore assumed.
The base key is considered as inclined footing bottom.

Verification No. 1

Pressure at rest on front face of the structure - partial results

Layer No.	Thickness [m]	α [°]	ϕ_d [°]	c_d [kPa]	γ [kN/m³]	K_r	Comment
1	0.50	0.00	29.00	10000.00	19.00	0.515	

Pressure at rest distribution on front face of the structure

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.50	9.50	0.00	4.89	4.89	0.00

Active pressure behind the structure - partial results

Layer No.	Thickness [m]	α [°]	ϕ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
1	0.72	0.00	29.00	10000.00	19.00	15.00	0.313	
2	1.58	30.28	29.00	10000.00	19.00	29.00	0.679	
3	1.70	30.28	31.50	0.00	17.50	31.50	0.663	
4	1.00	30.28	27.00	10.00	19.50	27.00	0.694	
5	0.60	0.00	27.00	10.00	19.50	15.00	0.337	
6	0.20	0.00	27.00	10.00	19.50	15.00	0.337	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.72	13.65	0.00	0.00	0.00	0.00
2	0.72	13.65	0.00	0.00	0.00	0.00
	2.30	43.70	0.00	0.00	0.00	0.00
3	2.30	43.70	0.00	28.97	13.70	25.53
	4.00	73.45	0.00	48.69	23.02	42.91
4	4.00	73.45	0.00	42.07	22.74	35.40
	5.00	92.95	0.00	55.61	30.06	46.79
5	5.00	92.95	0.00	20.68	19.98	5.35
	5.60	104.65	0.00	24.63	23.79	6.37
6	5.60	104.65	0.00	24.63	23.79	6.37
	5.80	108.55	0.00	25.95	25.06	6.72

Forces acting on construction - combination 1

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	-1.34	104.88	1.80	1.000	1.000	1.350
FF resistance	-1.22	-0.17	0.00	0.00	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.00	99.17	2.44	1.000	1.000	1.350
Active pressure	75.63	-1.40	104.09	3.41	1.000	1.350	1.350
Force No. 1	30.00	-5.80	0.00	1.50	1.350	1.350	1.350

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 785.35 kNm/m
Overturning moment M_{ovr} = 340.68 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 209.16 kN/m
Active horizontal force H_{act} = 124.42 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom :130.71kPa

Pressure at rest on front face of the structure - partial results

Layer No.	Thickness [m]	α [°]	ϕ_d [°]	c_d [kPa]	γ [kN/m^3]	K_r	Comment
1	0.50	0.00	23.91	8000.00	19.00	0.595	

Pressure at rest distribution on front face of the structure

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.50	9.50	0.00	5.65	5.65	0.00

Active pressure behind the structure - partial results

Layer No.	Thickness [m]	α [°]	ϕ_d [°]	c_d [kPa]	γ [kN/m^3]	δ_d [°]	K_a	Comment
1	0.72	0.00	23.91	8000.00	19.00	12.37	0.382	
2	1.58	30.28	23.91	8000.00	19.00	23.91	0.722	
3	1.70	30.28	26.12	0.00	17.50	26.12	0.702	
4	1.00	30.28	22.18	8.00	19.50	22.18	0.739	
5	0.60	0.00	22.18	8.00	19.50	12.32	0.407	
6	0.20	0.00	22.18	8.00	19.50	12.32	0.407	

Active pressure distribution behind the structure (without surcharge)

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	0.00	0.00	0.00	0.00	0.00
	0.72	13.65	0.00	0.00	0.00	0.00
2	0.72	13.65	0.00	0.00	0.00	0.00
	2.30	43.70	0.00	0.00	0.00	0.00
3	2.30	43.70	0.00	30.66	16.97	25.54
	4.00	73.45	0.00	51.54	28.52	42.93

Layer No.	Start [m] End [m]	σz [kPa]	σw [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
4	4.00	73.45	0.00	46.75	28.49	37.07
	5.00	92.95	0.00	61.17	37.27	48.50
5	5.00	92.95	0.00	28.41	27.76	6.06
	5.60	104.65	0.00	33.18	32.41	7.08
6	5.60	104.65	0.00	33.18	32.41	7.08
	5.80	108.55	0.00	34.77	33.97	7.42

Forces acting on construction - combination 2

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	-1.34	104.88	1.80	1.000	1.000	1.000
FF resistance	-1.41	-0.17	0.00	0.00	1.000	1.000	1.000
Weight - earth wedge	0.00	-2.00	99.17	2.44	1.000	1.000	1.000
Active pressure	96.24	-1.37	106.38	3.42	1.000	1.000	1.000
Force No. 1	30.00	-5.80	0.00	1.50	1.000	1.000	1.000

Verification of complete wall

Check for overturning stability

Resisting moment M_{res} = 794.21 kNm/m
Overturning moment M_{ovr} = 305.77 kNm/m

Wall for overturning is SATISFACTORY

Check for slip

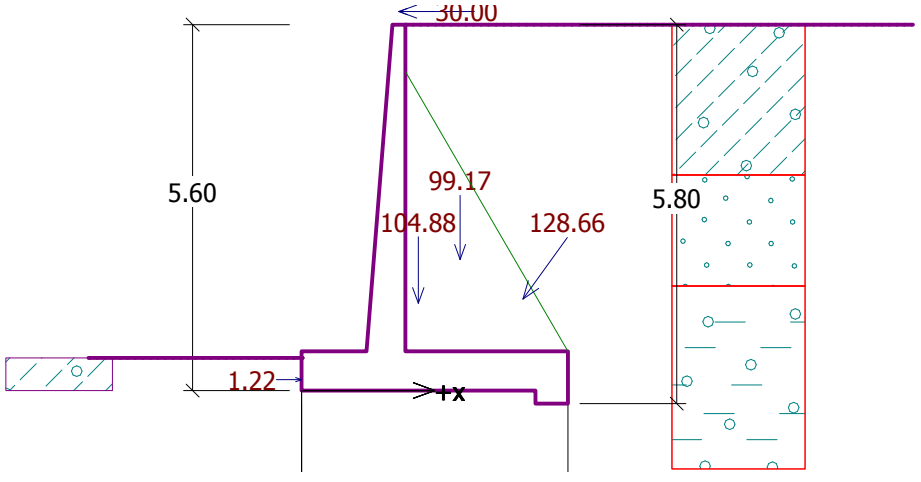
Resisting horizontal force H_{res} = 153.58 kN/m
Active horizontal force H_{act} = 109.55 kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom :102.31kPa

Name : Verification | **Stage : 1; Analysis : 1**



Bearing capacity of foundation soil

Forces acting at the centre of the footing bottom

Numbe	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [m]	Stress [kPa]
1	170.31	422.37	120.63	0.44	130.71

Bearing capacity of foundation soil check

Eccentricity verification
Max. eccentricity of normal force e = 436.7 mm
Maximum allowable eccentricity e_{alw} = 1354.6 mm

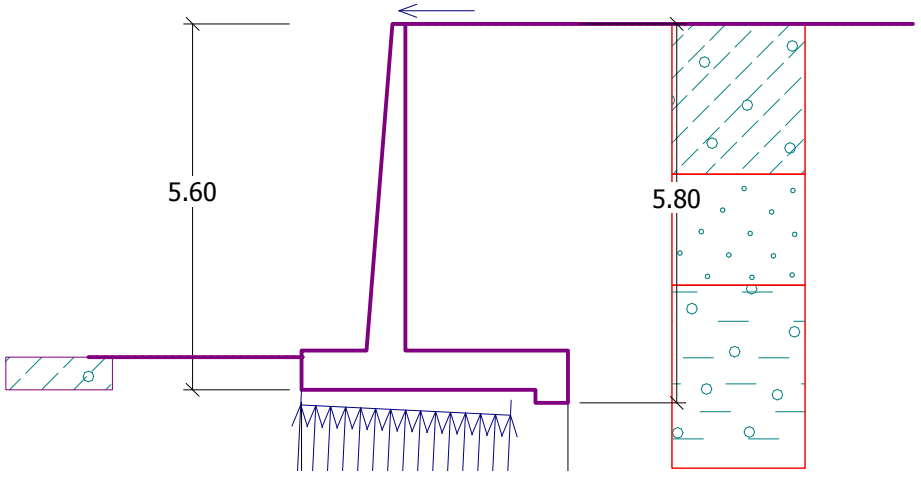
Eccentricity of the normal force is SATISFACTORY

Footing bottom bearing capacity verification
Max. stress at footing bottom σ = 130.71 kPa
Bearing capacity of foundation soil R_d = 180.00 kPa

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap. Stage : 1



Dimensioning No. 1

Forces acting on construction - combination 1

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	-2.08	45.98	0.38	1.000	1.350	1.000
Pressure at rest	118.80	-1.65	0.00	0.60	1.350	1.000	1.350
Force No. 1	30.00	-5.20	0.00	0.50	1.350	1.000	1.350

Forces acting on construction - combination 2

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	-2.08	45.98	0.38	1.000	1.000	1.000
Pressure at rest	137.35	-1.66	0.00	0.60	1.000	1.000	1.000
Force No. 1	30.00	-5.20	0.00	0.50	1.000	1.000	1.000

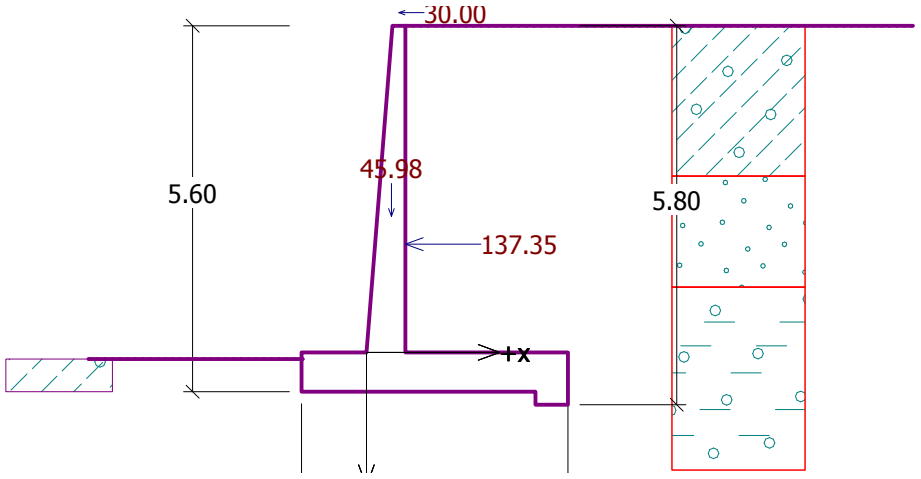
Wall stem check

Reinforcement and dimensions of the cross-section
Bar diameter = 20.0 mm
Number of bars = 14
Reinforcement cover = 30.0 mm
Cross-section width = 1.00 m

Cross-section depth = 0.60 m
Reinforcement ratio ρ = 0.79 % > 0.13 % = ρ_{min}
Ultimate moment M_{Rd} = 933.56 kNm > 471.29 kNm = M_{Ed}

Cross-section is SATISFACTORY.

Name : Dimensioning | **Stage : 1; Dimensioning : 1**



Dimensioning No. 2

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. Z [m]	F_{vert} [kN/m]	App.Pt. X [m]	Design coefficient
Weight - wall	0.00	-1.34	104.88	1.80	1.350
FF resistance	-1.22	-0.17	0.00	0.00	1.000
Weight - earth wedge	0.00	-2.00	99.17	2.44	1.350
Active pressure	75.63	-1.40	104.09	3.41	1.350
Force No. 1	30.00	-5.80	0.00	1.50	1.350

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. Z [m]	F_{vert} [kN/m]	App.Pt. X [m]	Design coefficient
Weight - wall	0.00	-1.34	104.88	1.80	1.000
FF resistance	-1.41	-0.17	0.00	0.00	1.000
Weight - earth wedge	0.00	-2.00	99.17	2.44	1.000
Active pressure	96.24	-1.37	106.38	3.42	1.000
Force No. 1	30.00	-5.80	0.00	1.50	1.000

Front wall jump check

Reinforcement and dimensions of the cross-section
Bar diameter = 16.0 mm
Number of bars = 6
Reinforcement cover = 30.0 mm
Cross-section width = 1.00 m
Cross-section depth = 0.60 m
Reinforcement ratio ρ = 0.21 % > 0.13 % = ρ_{min}
Ultimate moment M_{Rd} = 284.46 kNm > 93.38 kNm = M_{Ed}

Cross-section is SATISFACTORY.