

Cantilever wall analysis

Input data

Project

Date : 25.1.2017 r/

Settings

Standard - EN 1997 - DA2

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

Verification methodology : according to EN 1997

Design approach : 2 - reduction of actions and resistances

Partial factors on actions (A)			
Transient 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)			
Transient design situation			
Partial factor on overturning :		$\gamma_{Re} =$	1,40 [-]
Partial factor on sliding resistance :		$\gamma_{Rh} =$	1,10 [-]
Partial factor on bearing capacity :		$\gamma_{Rv} =$	1,40 [-]

Material of structure

Unit weight $\gamma = 23,56 \text{ kN/m}^3$

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 $f_{ct} = 2,60 \text{ MPa}$

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	3,20
3	2,00	3,20
4	2,00	3,60
5	-0,30	3,60
6	-0,30	3,20
7	-0,30	0,00

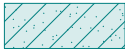
The origin [0,0] is located at the most upper right point of the wall.
Wall section area = 1,88 m².

Basic soil parameters

No.	Name	Pattern	Φ_{ef} [°]	C_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ [°]
1	Трошен камък		26,00	0,00	20,00	12,00	10,00

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

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	-	Трошен камък	

Terrain profile

Terrain behind the structure is flat.

Water influence

GWT behind the structure lies at a depth of 2,20 m
Uplift in foot. bottom due to different pressures is not considered.

Input surface surcharges

No.	Surcharge new	change	Action	Mag.1 [kN/m ²]	Mag.2 [kN/m ²]	Ord.x x [m]	Length l [m]	Depth z [m]
1	YES		variable	5,00		0,00	2,00	on terrain
2	YES		variable	10,00		2,00	5,00	on terrain

No.	Name
1	Пешеходци
2	Автомобили

Resistance on front face of the structure

Resistance on front face of the structure: at rest
Soil on front face of the structure - Трошен камък
Soil thickness in front of structure $h = 1,00$ m
Terrain in front of structure is flat.

Settings of the stage of construction

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

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/m ³]	K_r	Comment
1	0,60	0,00	26,00	0,00	20,00	0,562	
2	0,00	0,00	26,00	0,00	20,00	0,562	
3	0,40	0,00	26,00	0,00	20,00	0,562	

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
	0,60	12,00	0,00	6,74	6,74	0,00
2	0,60	12,00	0,00	6,74	6,74	0,00
	0,60	12,03	0,00	6,75	6,75	0,00
3	0,60	12,03	0,00	6,75	6,75	0,00
	1,00	20,00	0,00	11,23	11,23	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	2,20	32,00	26,00	0,00	20,00	26,00	0,737	
2	1,00	32,00	26,00	0,00	12,00	26,00	0,737	
3	0,40	0,00	26,00	0,00	12,00	10,00	0,359	

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
	2,20	44,00	0,00	32,42	17,18	27,49
2	2,20	44,00	0,00	32,42	17,18	27,49
	3,20	56,00	10,00	41,26	21,86	34,99
3	3,20	56,00	10,00	20,11	19,80	3,49
	3,60	60,80	14,00	21,83	21,50	3,79

Water pressure distribution

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0,00	0,00	0,00
2	2,20	0,00	0,00
3	3,20	10,00	0,00
4	3,60	14,00	0,00

Pressure profile due to surcharge - Пешеходци

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0,00	0,00	0,00
2	0,00	0,00	0,00
3	0,02	0,00	0,00
4	0,02	0,91	1,46
5	2,20	0,88	1,41
6	3,20	0,87	1,39
7	3,20	1,74	0,30
8	3,20	0,00	0,00
9	3,60	0,00	0,00

Pressure profile due to surcharge - Автомобили

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0,00	0,00	0,00
2	0,00	0,00	0,00
3	0,02	0,00	0,00
4	0,98	0,00	0,00
5	0,98	1,77	2,84
6	2,20	1,68	2,69
7	3,20	1,60	2,57
8	3,20	3,21	0,57
9	3,20	3,21	0,57
10	3,60	3,14	0,55

Forces acting on construction

Name	F _{hor} [kN/m]	App.Pt. z [m]	F _{vert} [kN/m]	App.Pt. x [m]	Coeff. overturn.	Coeff. sliding	Coeff. stress
Weight - wall	0,00	-1,12	44,30	0,64	1,000	1,000	1,350
FF resistance	-5,62	-0,33	0,00	0,00	1,000	1,000	1,000
Weight - earth wedge	0,00	-1,63	50,51	0,92	1,000	1,000	1,350
Active pressure	46,68	-1,27	62,94	1,63	1,350	1,350	1,350
Water pressure	9,80	-0,47	0,00	0,30	1,350	1,350	1,350
Uplift pressure	0,00	-3,60	0,00	0,30	1,000	1,000	1,000
Пешеходци	2,82	-2,00	4,52	1,30	1,500	1,500	1,500
Автомобили	5,03	-1,19	6,24	1,62	1,500	1,500	1,500

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 169,39$ kNm/m

Overturning moment $M_{ovr} = 101,60$ kNm/m

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 86,87$ kN/m

Active horizontal force $H_{act} = 82,41$ kN/m

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Maximum stress in footing bottom : 162,34 kPa

Bearing capacity of foundation soil

Forces acting at the centre of the footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [m]	Stress [kPa]
1	101,81	229,10	82,41	0,44	162,34
2	89,76	195,91	82,41	0,46	141,59

Bearing capacity of foundation soil check

Eccentricity verification

Max. eccentricity of normal force $e = 458,2$ mm

Maximum allowable eccentricity $e_{alw} = 759,0$ mm

Eccentricity of the normal force is SATISFACTORY

Footing bottom bearing capacity verification

Design bearing capacity of foundation soil $R = 250,00 \text{ kPa}$

Partial factor on earth resistance $\gamma_{Rv} = 1,40$

Max. stress at footing bottom $\sigma = 162,34 \text{ kPa}$

Bearing capacity of foundation soil $R_d = 178,57 \text{ kPa}$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Dimensioning 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/m ³]	K_r	Comment
1	0,60	0,00	26,00	0,00	20,00	0,562	

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
	0,60	11,98	0,00	6,73	6,73	0,00

Pressure at rest behind the structure - partial results

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m ³]	K_r	Comment
1	2,20	0,00	26,00	0,00	20,00	0,562	
2	1,00	0,00	26,00	0,00	12,00	0,562	

Pressure at rest 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
	2,20	44,00	0,00	24,71	24,71	0,00
2	2,20	44,00	0,00	24,71	24,71	0,00
	3,20	55,99	9,99	31,44	31,44	0,00

Water pressure distribution

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0,00	0,00	0,00
2	2,20	0,00	0,00
3	3,20	9,99	0,00

Pressure profile due to surcharge - Пешеходци

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0,00	0,00	0,00
2	0,11	2,60	0,00
3	0,23	2,40	0,00
4	0,34	2,21	0,00
5	0,46	2,02	0,00

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Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
6	0,57	1,84	0,00
7	0,69	1,67	0,00
8	0,80	1,51	0,00
9	0,91	1,37	0,00
10	1,03	1,23	0,00
11	1,14	1,11	0,00
12	1,26	1,00	0,00
13	1,37	0,90	0,00
14	1,49	0,81	0,00
15	1,60	0,73	0,00
16	1,71	0,66	0,00
17	1,83	0,59	0,00
18	1,94	0,54	0,00
19	2,06	0,49	0,00
20	2,17	0,44	0,00
21	2,20	0,43	0,00
22	2,28	0,40	0,00
23	2,40	0,36	0,00
24	2,51	0,33	0,00
25	2,63	0,30	0,00
26	2,74	0,28	0,00
27	2,86	0,25	0,00
28	2,97	0,23	0,00
29	3,08	0,21	0,00
30	3,20	0,20	0,00

Pressure profile due to surcharge - Автомобили

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0,00	0,00	0,00
2	0,11	0,29	0,00
3	0,23	0,58	0,00
4	0,34	0,85	0,00
5	0,46	1,11	0,00
6	0,57	1,36	0,00
7	0,69	1,58	0,00
8	0,80	1,78	0,00
9	0,91	1,96	0,00
10	1,03	2,12	0,00
11	1,14	2,25	0,00
12	1,26	2,36	0,00
13	1,37	2,45	0,00
14	1,49	2,52	0,00
15	1,60	2,58	0,00
16	1,71	2,62	0,00
17	1,83	2,64	0,00
18	1,94	2,65	0,00
19	2,06	2,66	0,00

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
20	2,17	2,65	0,00
21	2,20	2,65	0,00
22	2,28	2,63	0,00
23	2,40	2,61	0,00
24	2,51	2,59	0,00
25	2,63	2,55	0,00
26	2,74	2,52	0,00
27	2,86	2,48	0,00
28	2,97	2,43	0,00
29	3,08	2,39	0,00
30	3,20	2,34	0,00

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	-1,60	22,61	0,15	1,000	1,350	1,000
FF resistance	-2,01	-0,20	0,00	0,00	1,000	1,000	1,000
Pressure at rest	55,23	-1,10	0,00	0,30	1,350	1,000	1,350
Water pressure	4,99	-0,33	0,00	0,30	1,350	1,000	1,350
Uplift pressure	0,00	-3,20	0,00	0,30	1,000	1,000	1,000
Пешеходци	3,04	-2,21	0,00	0,30	1,500	0,000	1,500
Автомобили	6,67	-1,34	0,00	0,30	1,500	0,000	1,500

Wall stem check

Reinforcement and dimensions of the cross-section

Bar diameter = 16,0 mm

Number of bars = 5

Reinforcement cover = 30,0 mm

Cross-section width = 1,00 m

Cross-section depth = 0,30 m

Reinforcement ratio $\rho = 0,38 \% > 0,14 \% = \rho_{min}$

Position of neutral axis $x = 0,03 \text{ m} < 0,16 \text{ m} = x_{max}$

Ultimate shear force $V_{Rd} = 125,17 \text{ kN} > 93,83 \text{ kN} = V_{Ed}$

Ultimate moment $M_{Rd} = 108,79 \text{ kNm} > 107,03 \text{ kNm} = M_{Ed}$

Cross-section is SATISFACTORY.