



Verification of reinforced masonry wall

Input data

Project

Date : 30.10.2015

Settings

(input for current task)

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 : standard
Reinforced masonry : EN 1996-1-1 (EC6)

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 : Safety factors (ASD)

Safety factors			
Permanent design situation			
Safety factor for overturning :	SF _o =	1,50	[-]
Safety factor for sliding resistance :	SF _s =	1,50	[-]
Safety factor for bearing capacity :	SF _b =	1,00	[-]

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 $f_{ctm} = 2,20 \text{ MPa}$
Longitudinal steel : B420
Yield strength $f_{yk} = 420,00 \text{ MPa}$

Types of blocks

No.	Name block	Width b [m]	Height h [m]
1	140 x 200	0,14	0,20
2	190 x 200	0,19	0,20
3	290 x 200	0,29	0,20

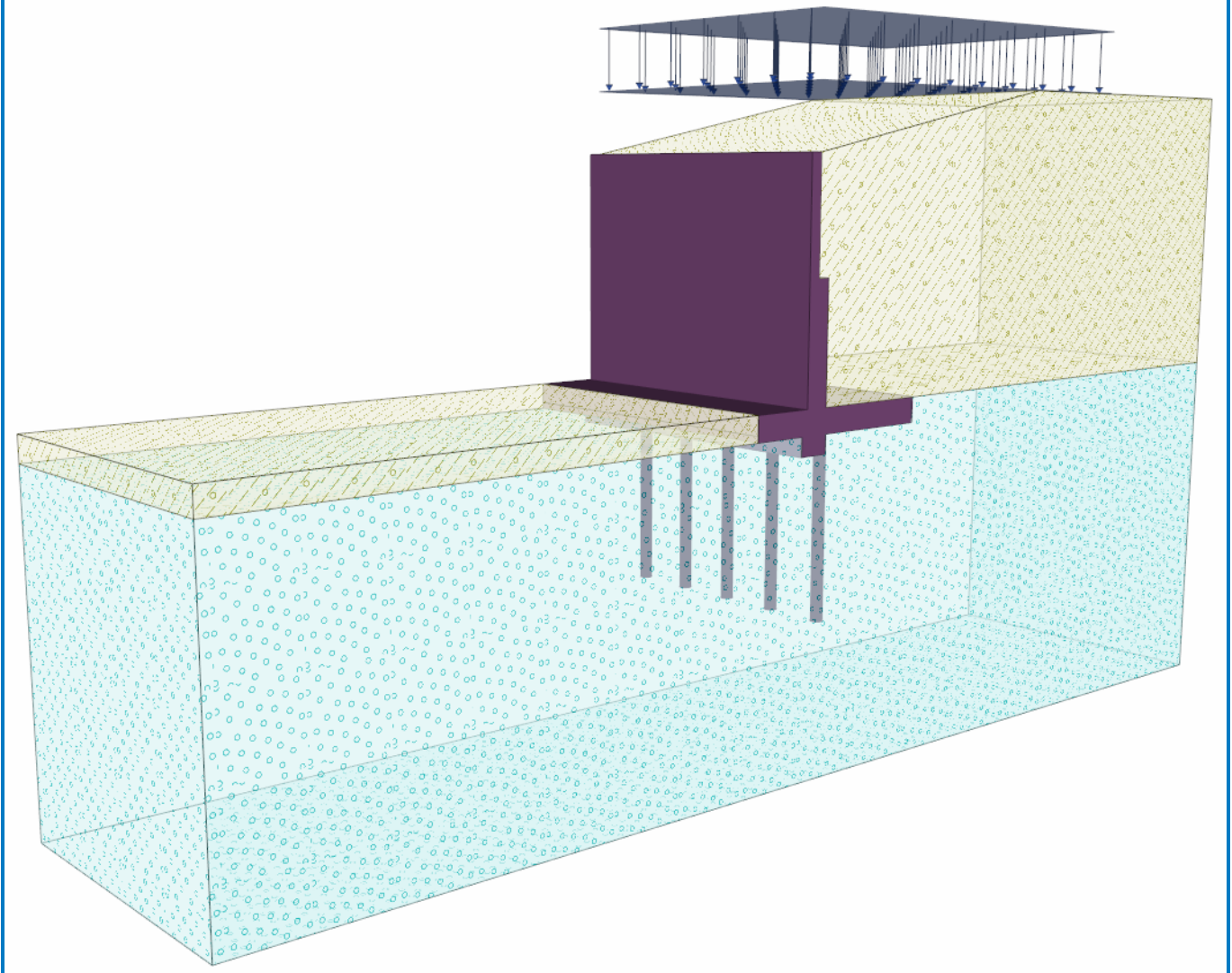
Geometry

No.	Coordinate X [m]	Depth Z [m]
1	0,00	0,00
2	0,00	1,80
3	0,19	1,80
4	0,19	3,70
5	2,13	3,70
6	2,13	4,10
7	0,19	4,10



Name : Geometry

Stage - analysis : 1 - 0



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		27,00	3,00	19,00	9,00	14,00
2	Soil No. 2		34,00	0,00	19,00	9,00	17,00

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

Soil parameters

Soil No. 1

Unit weight : $\gamma = 19,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\phi_{ef} = 27,00^\circ$
 Cohesion of soil : $C_{ef} = 3,00 \text{ kPa}$
 Angle of friction struc.-soil : $\delta = 14,00^\circ$
 Soil : cohesionless
 Saturated unit weight : $\gamma_{sat} = 19,00 \text{ kN/m}^3$



Soil No. 2

Unit weight : $\gamma = 19,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{\text{ef}} = 34,00^\circ$
 Cohesion of soil : $c_{\text{ef}} = 0,00 \text{ kPa}$
 Angle of friction struc.-soil : $\delta = 17,00^\circ$
 Soil : cohesionless
 Saturated unit weight : $\gamma_{\text{sat}} = 19,00 \text{ kN/m}^3$

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	4,00	Soil No. 1	
2	-	Soil No. 2	

Foundation

Type of foundation : soil from geological profile

Terrain profile

Terrain behind construction has the slope 1: 5,00 (slope angle is $11,31^\circ$).
 Embankment height is 1,00 m, embankment length is 5,00 m.

Water influence

Ground water table is located below the structure.

Input surface surcharges

No.	Surcharge		Action	Mag.1 [kN/m ²]	Mag.2 [kN/m ²]	Ord.x x [m]	Length l [m]	Depth z [m]
	new	change						
1	Yes		permanent	17,00				on terrain

No.	Name
1	Surcharge No. 1

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 $h = 0,40 \text{ m}$
 Terrain in front of structure is flat.

Base anchorage

Geometry

Spacing $x = 1,80 \text{ m}$
 Depth $h = 3,00 \text{ m}$
 Hole diameter $d = 0,20 \text{ m}$
 Spacing of holes $v = 1,00 \text{ m}$

Input pull out resistance $T_p = 100,00 \text{ kN/m}$
 Input strength of reinforcement $R_t = 100,00 \text{ kN}$

Settings of the stage of construction

Design situation : permanent
 Active pressure acts on the wall and stem.



Verification No. 1

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	-0,91	58,47	1,42	1,000
FF resistance	-2,54	0,07	0,00	0,00	1,000
Weight - earth wedge	0,00	-1,90	84,36	1,98	1,000
Active pressure	73,75	-1,24	75,95	2,76	1,000
Surcharge No. 1	33,38	-2,05	38,21	2,45	1,000
Surcharge No. 1	0,00	-4,14	7,09	1,40	1,000
Base anchorage	0,00	0,00	100,00	1,80	1,000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 742,90$ kNm/m

Overturning moment $M_{ovr} = 160,36$ kNm/m

Safety factor = 4,63 > 1,50

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 245,57$ kN/m

Active horizontal force $H_{act} = 104,59$ kN/m

Safety factor = 2,35 > 1,50

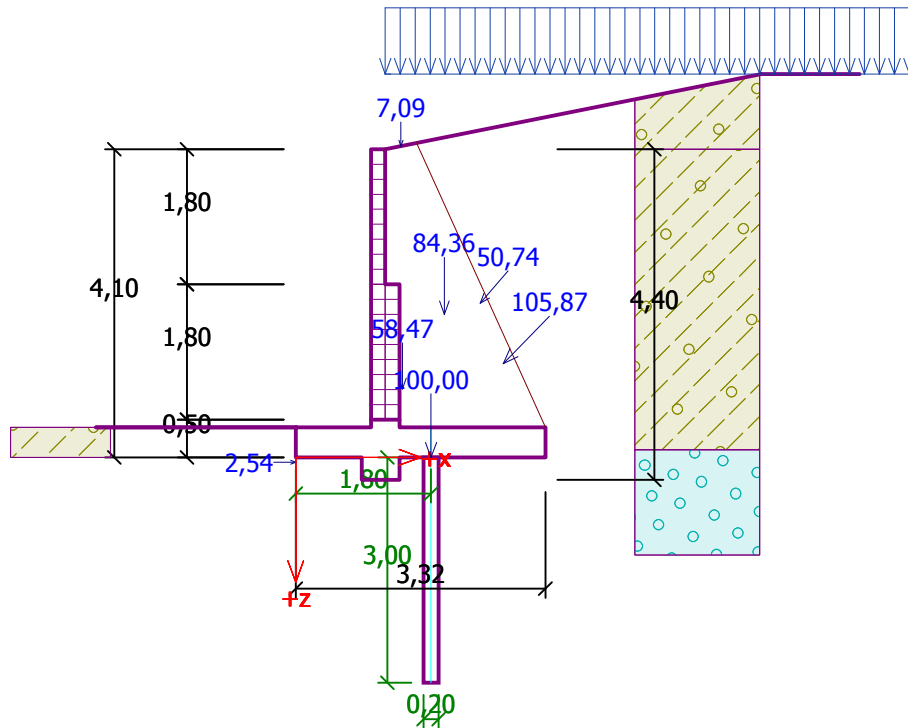
Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



Name : Verification

Stage - analysis : 1 - 1



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	21,83	364,08	104,59	0,018	113,77

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	21,83	364,08	104,59

Verification of foundation soil

Eccentricity verification

Max. eccentricity of normal force $e = 0,018$

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

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom $\sigma = 113,77$ kPa

Bearing capacity of foundation soil $R_d = 120,00$ kPa

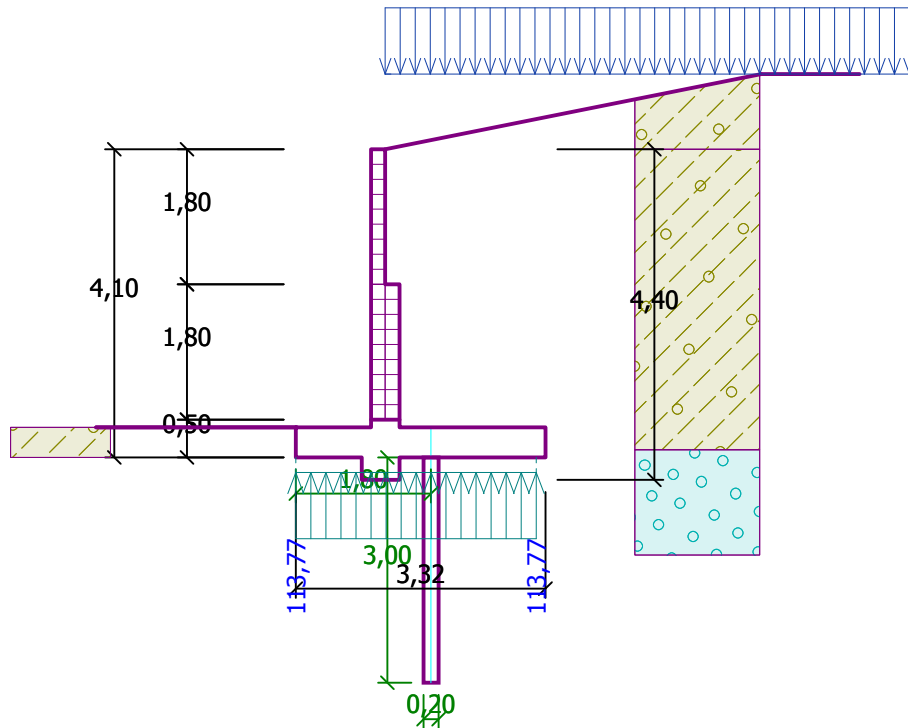
Safety factor = $1,05 > 1,00$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY

Name : Bearing cap.

Stage - analysis : 1 - -1



Dimensioning No. 1

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	-1,50	23,59	0,16	1,000
Weight - earth wedge	0,00	-1,94	0,76	0,25	1,000
Active pressure	37,88	-1,09	14,63	0,33	1,000
Surcharge No. 1	23,49	-1,75	9,41	0,29	1,000

Verification of the joint, 3,60 m from the top.

Back face reinforcement :

Diameter = 20,0 mm

Spacing = 300,0 mm

Cover = 30,0 mm

There is no reinforcement on the front face.

Wall aspect ratio: 9,47

Verification of cross section in compression:

Ultimate normal force $N_{Rd} = 80,73 \text{ kN/m} > 48,39 \text{ kN/m} = N_{Ed}$

Cross section is SATISFACTORY

Verification of cross section in bending:

Ultimate bending moment $M_{Rd} = 133,52 \text{ kNm/m} > 80,03 \text{ kNm/m} = M_{Ed}$

Cross section is SATISFACTORY.

Verification of cross section in shear:

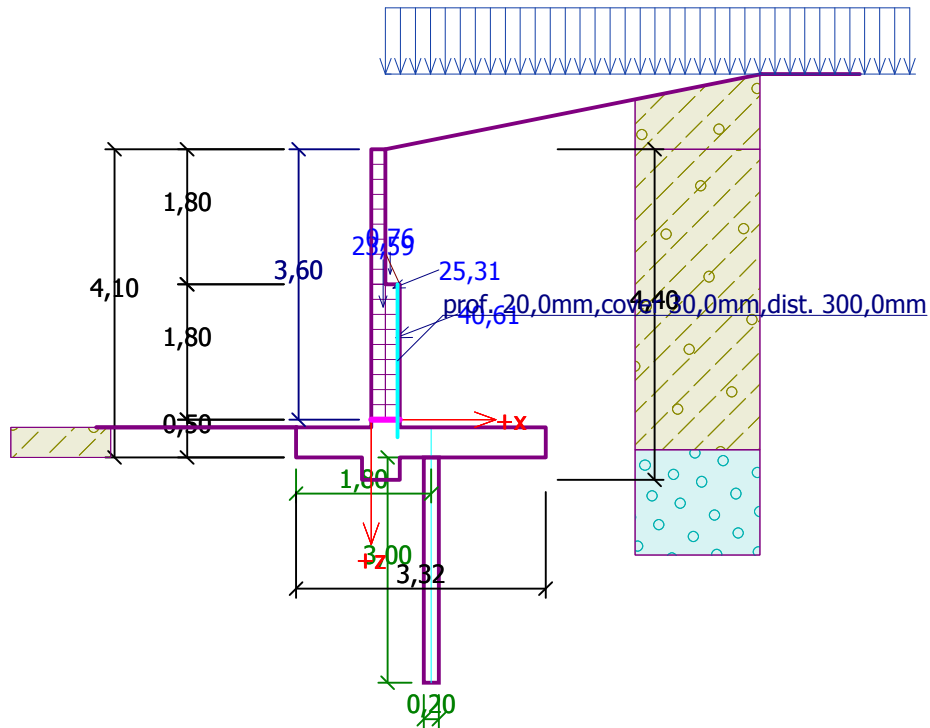
Ultimate shear force $V_{Rd} = 67,26 \text{ kN/m} > 61,38 \text{ kN/m} = V_{Ed}$

Cross section is SATISFACTORY.



Name : Dimensioning

Stage - analysis : 1 - 1



Dimensioning No. 2

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	6,99	0,10	1,000
Active pressure	4,75	-0,38	1,18	0,19	1,000
Surcharge No. 1	9,74	-0,75	2,62	0,19	1,000

Verification of the joint, 1,60 m from the top.

Back face reinforcement :

Diameter = 16,0 mm

Spacing = 300,0 mm

Cover = 30,0 mm

There is no reinforcement on the front face.

Wall aspect ratio: 9,47

Verification of cross section in compression:

Ultimate normal force $N_{Rd} = 45,04 \text{ kN/m} > 10,80 \text{ kN/m} = N_{Ed}$

Cross section is SATISFACTORY

Verification of cross section in bending:

Ultimate bending moment $M_{Rd} = 36,37 \text{ kNm/m} > 8,72 \text{ kNm/m} = M_{Ed}$

Cross section is SATISFACTORY.

Verification of cross section in shear:

Ultimate shear force $V_{Rd} = 27,78 \text{ kN/m} > 14,49 \text{ kN/m} = V_{Ed}$

Cross section is SATISFACTORY.



Slope stability analysis

Input data

Project

Settings

(input for current task)

Stability analysis

Earthquake analysis : Standard

Verification methodology : according to EN 1997

Design approach : 2 - reduction of actions and resistances

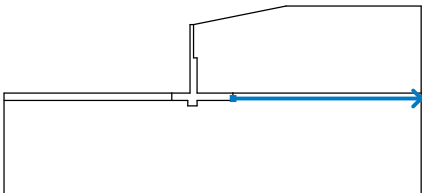
Partial factors on actions (A)			
Permanent design situation			
		Unfavourable	Favourable
Permanent actions :	$\gamma_G =$	1,35 [-]	1,00 [-]
Variable actions :	$\gamma_Q =$	1,50 [-]	0,00 [-]
Water load :	$\gamma_w =$	1,35 [-]	

Partial factors for resistances (R)			
Permanent design situation			
Partial factor on sliding resistance (on slip surface) :	$\gamma_{Rs} =$	1,10	[-]


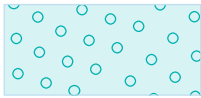
Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-10,25	-3,70	-1,19	-3,70	-0,19	-3,70
		-0,19	0,00	0,00	0,00	5,00	1,00
		12,30	1,00				
2		0,00	0,00	0,00	-1,80	0,19	-1,80
		0,19	-3,70	2,13	-3,70		
3		-10,25	-4,10	-1,19	-4,10	-1,19	-3,70
4		-1,19	-4,10	-0,31	-4,10	-0,31	-4,40
		0,19	-4,40	0,19	-4,10	2,13	-4,10
		2,13	-4,00	2,13	-3,70	12,30	-3,70


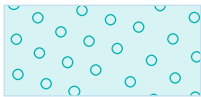


No.	Interface location	Coordinates of interface points [m]			
		x	z	x	z
5		2,13	-4,00	12,30	-4,00

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m ³]
1	Soil No. 1		27,00	3,00	19,00
2	Soil No. 2		34,00	0,00	19,00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m ³]	γ_s [kN/m ³]	n [-]
1	Soil No. 1		19,00		
2	Soil No. 2		19,00		

Soil parameters


Soil No. 1

Unit weight : $\gamma = 19,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 27,00^\circ$
 Cohesion of soil : $c_{ef} = 3,00 \text{ kPa}$
 Saturated unit weight : $\gamma_{sat} = 19,00 \text{ kN/m}^3$

Soil No. 2

Unit weight : $\gamma = 19,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 34,00^\circ$
 Cohesion of soil : $c_{ef} = 0,00 \text{ kPa}$
 Saturated unit weight : $\gamma_{sat} = 19,00 \text{ kN/m}^3$

Rigid bodies

No.	Name	Sample	γ [kN/m ³]
1	Wall material		23,00



Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		12,30	-3,70	12,30	1,00	Soil No. 1
		5,00	1,00	0,00	0,00	
		0,00	-1,80	0,19	-1,80	
		0,19	-3,70	2,13	-3,70	
2		12,30	-4,00	12,30	-3,70	Soil No. 1
		2,13	-3,70	2,13	-4,00	
3		-1,19	-4,10	-1,19	-3,70	Soil No. 1
		-10,25	-3,70	-10,25	-4,10	
4		-0,31	-4,10	-0,31	-4,40	Wall material
		0,19	-4,40	0,19	-4,10	
		2,13	-4,10	2,13	-4,00	
		2,13	-3,70	0,19	-3,70	
		0,19	-1,80	0,00	-1,80	
		0,00	0,00	-0,19	0,00	
		-0,19	-3,70	-1,19	-3,70	
5		2,13	-4,00	2,13	-4,10	Soil No. 2
		0,19	-4,10	0,19	-4,40	
		-0,31	-4,40	-0,31	-4,10	
		-1,19	-4,10	-10,25	-4,10	
		-10,25	-9,40	12,30	-9,40	
		12,30	-4,00			

Surcharge

No.	Type	Type of action	Location z [m]	Origin x [m]	Length l [m]	Width b [m]	Slope α [°]	Magnitude	
								q, q ₁ , f, F	q ₂ unit
1	strip	permanent	on terrain	x = 0,00	l = 12,30		0,00	17,00	kN/m ²

Surcharges

No.	Name
1	Surcharge No. 1

Water

Water type : No water

Tensile crack

Tensile crack not inputted.



Earthquake

Earthquake not included.

Settings of the stage of construction

Design situation : permanent

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-1,23	[m]	Angles :	$\alpha_1 =$	-30,37	[°]
	z =	3,34	[m]		$\alpha_2 =$	73,34	[°]
Radius :	R =	8,16	[m]	The slip surface after optimization.			

Slope stability verification (Bishop)

Sum of active forces : $F_a = 348,45$ kN/m

Sum of passive forces : $F_p = 476,49$ kN/m

Sliding moment : $M_a = 2843,36$ kNm/m

Resisting moment : $M_p = 3534,67$ kNm/m

Utilization : 80,4 %

Slope stability ACCEPTABLE