



Gravity wall analysis

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
Masonry (stone) wall : 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
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 : 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	2,00
3	0,40	2,00
4	0,40	2,60
5	-1,35	2,60
6	-1,35	2,00
7	-0,90	2,00
8	-0,50	0,00

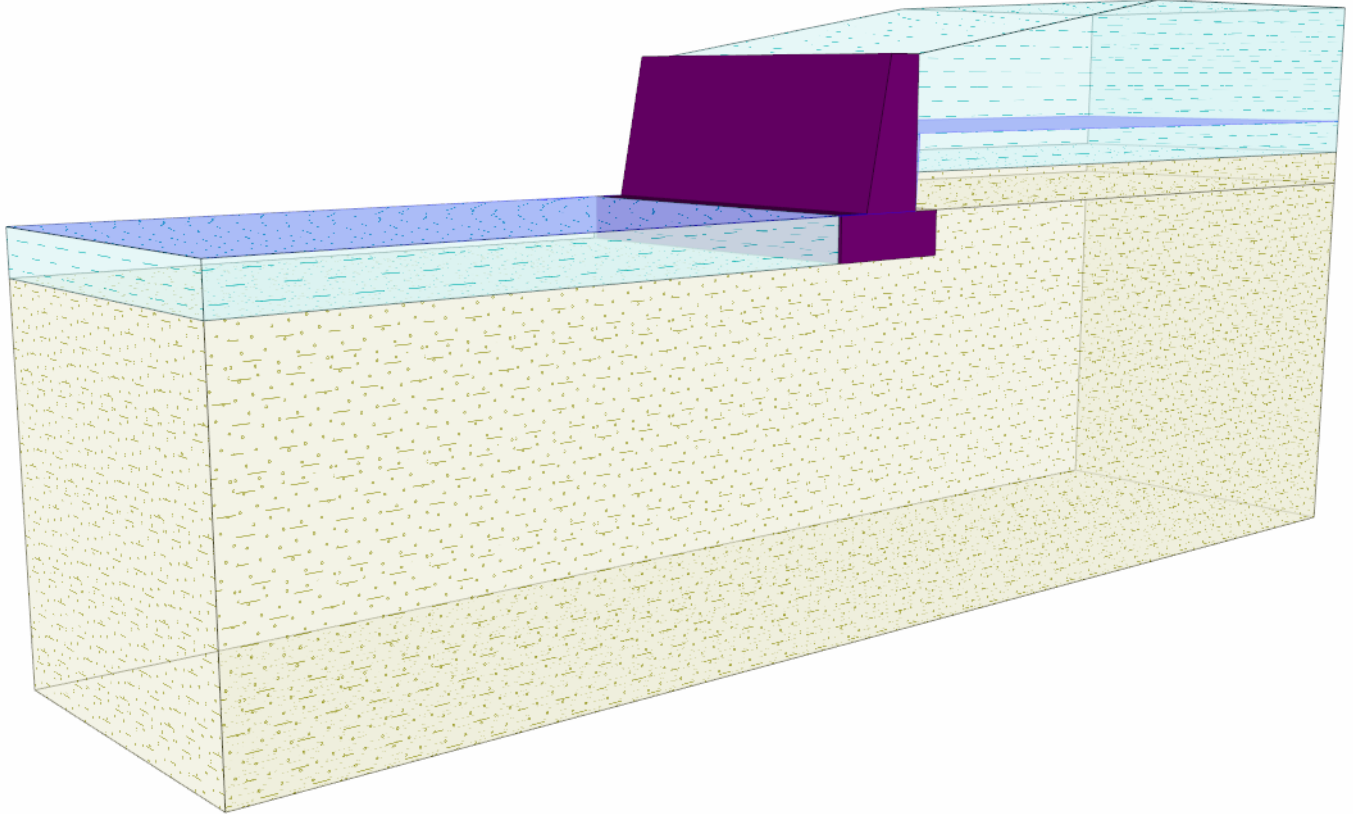
The origin [0,0] is located at the most upper right point of the wall.

Wall section area = 2,45 m².



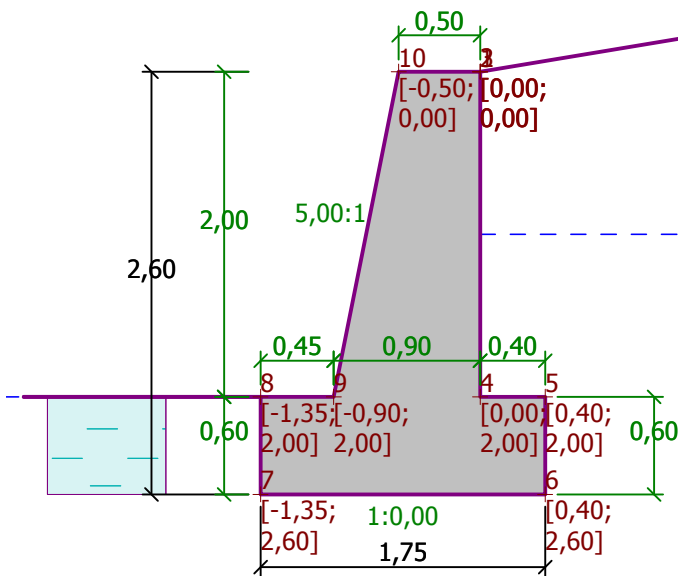
Name : Geometry

Stage - analysis : 1 - 0



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		29,00	5,00	18,00	10,00	15,00
2	Soil No. 2		15,00	5,00	20,50	10,50	15,00

Soil parameters to compute pressure at rest

No.	Name	Pattern	Type calculation	φ_{ef} [°]	ν [-]	OCR [-]	K_r [-]
1	Soil No. 1		cohesive	-	0,30	-	-
2	Soil No. 2		cohesive	-	0,30	-	-

Soil parameters

Soil No. 1

Unit weight : $\gamma = 18,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 29,00^\circ$
 Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
 Angle of friction struc.-soil : $\delta = 15,00^\circ$
 Soil : cohesive
 Poisson's ratio : $\nu = 0,30$
 Saturated unit weight : $\gamma_{sat} = 20,00 \text{ kN/m}^3$

Soil No. 2

Unit weight : $\gamma = 20,50 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\varphi_{ef} = 15,00^\circ$
 Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
 Angle of friction struc.-soil : $\delta = 15,00^\circ$
 Soil : cohesive
 Poisson's ratio : $\nu = 0,30$
 Saturated unit weight : $\gamma_{sat} = 20,50 \text{ kN/m}^3$

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	1,50	Soil No. 2	
2	-	Soil No. 1	

Foundation

Type of foundation : soil from geological profile

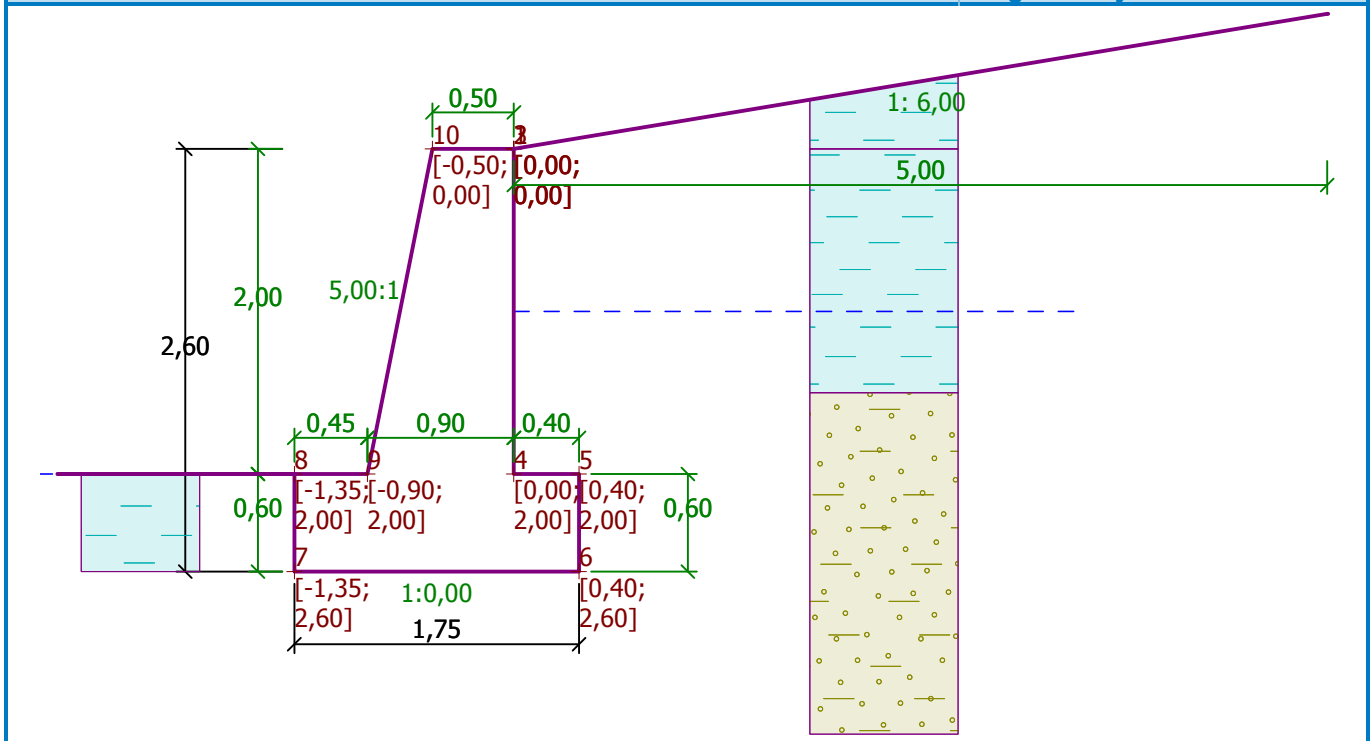
Terrain profile

Terrain behind construction has the slope 1: 6,00 (slope angle is 9,46 °).
 Embankment height is 0,83 m, embankment length is 5,00 m.



Name : Terrain

Stage - analysis : 1 - 0



Water influence

GWT behind the structure lies at a depth of 1,00 m
GWT in front of the structure lies at a depth of 2,00 m
Subgrade at the heel is not permeable.
Uplift in foot. bottom due to different pressures is not considered.

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. 2
Soil thickness in front of structure $h = 0,60$ m
Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : permanent

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	-1,15	45,85	0,96	1,000
FF resistance	-0,81	-0,20	0,00	0,00	1,000
Weight - earth wedge	0,00	-0,90	1,82	1,48	1,000
Active pressure	15,57	-0,96	11,78	1,57	1,000
Water pressure	11,00	-0,59	0,00	1,35	1,000
Uplift pressure	0,00	-2,60	0,00	1,35	1,000

Verification of complete wall

Check for overturning stability

Resisting moment $M_{res} = 64,99$ kNm/m



Overturning moment $M_{Ovr} = 21,27 \text{ kNm/m}$

Safety factor = 3,06 > 1,50

Wall for overturning is SATISFACTORY

Check for slip

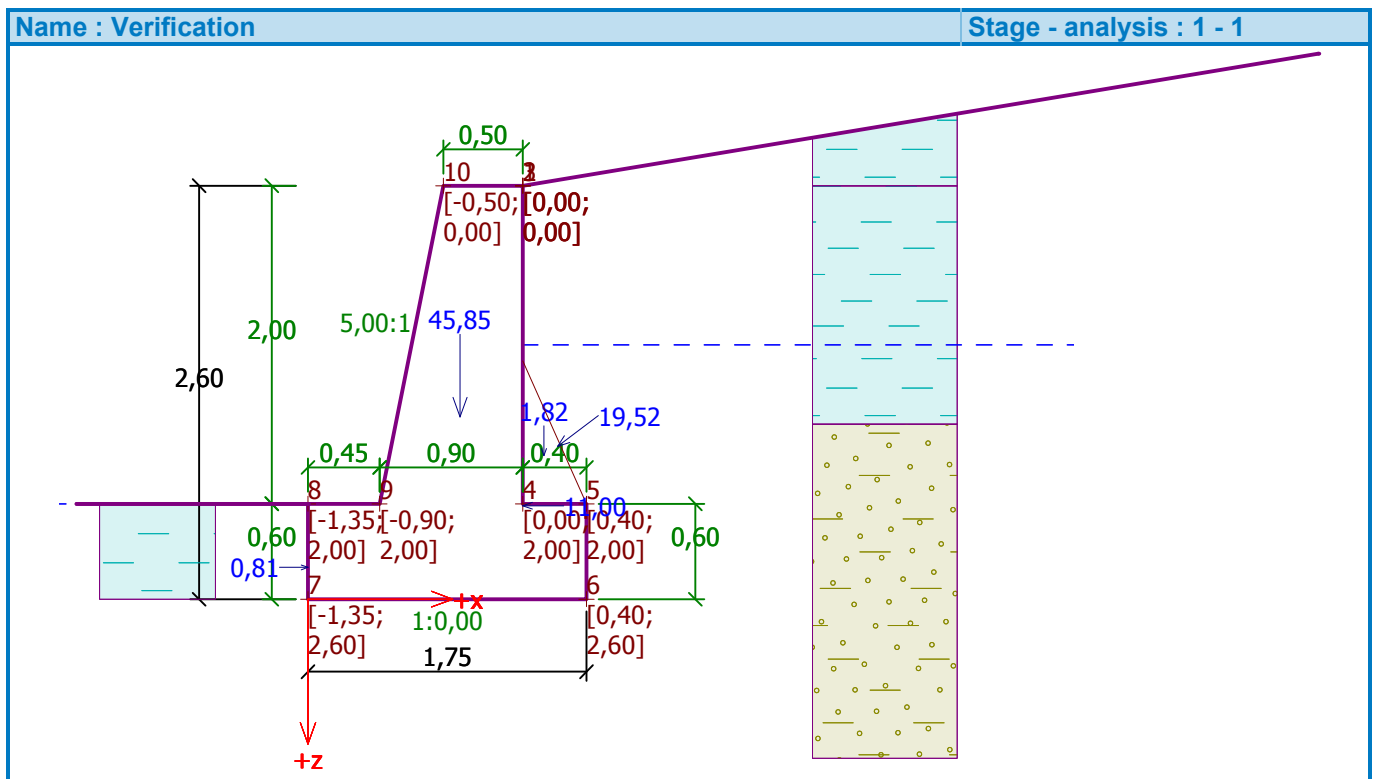
Resisting horizontal force $H_{res} = 40,31 \text{ kN/m}$

Active horizontal force $H_{act} = 25,76 \text{ kN/m}$

Safety factor = 1,56 > 1,50

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY



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	8,28	59,44	25,76	0,080	40,40

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	8,28	59,44	25,76

Verification of foundation soil

Eccentricity verification

Max. eccentricity of normal force $e = 0,080$

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

Eccentricity of the normal force is SATISFACTORY



Verification of bearing capacity

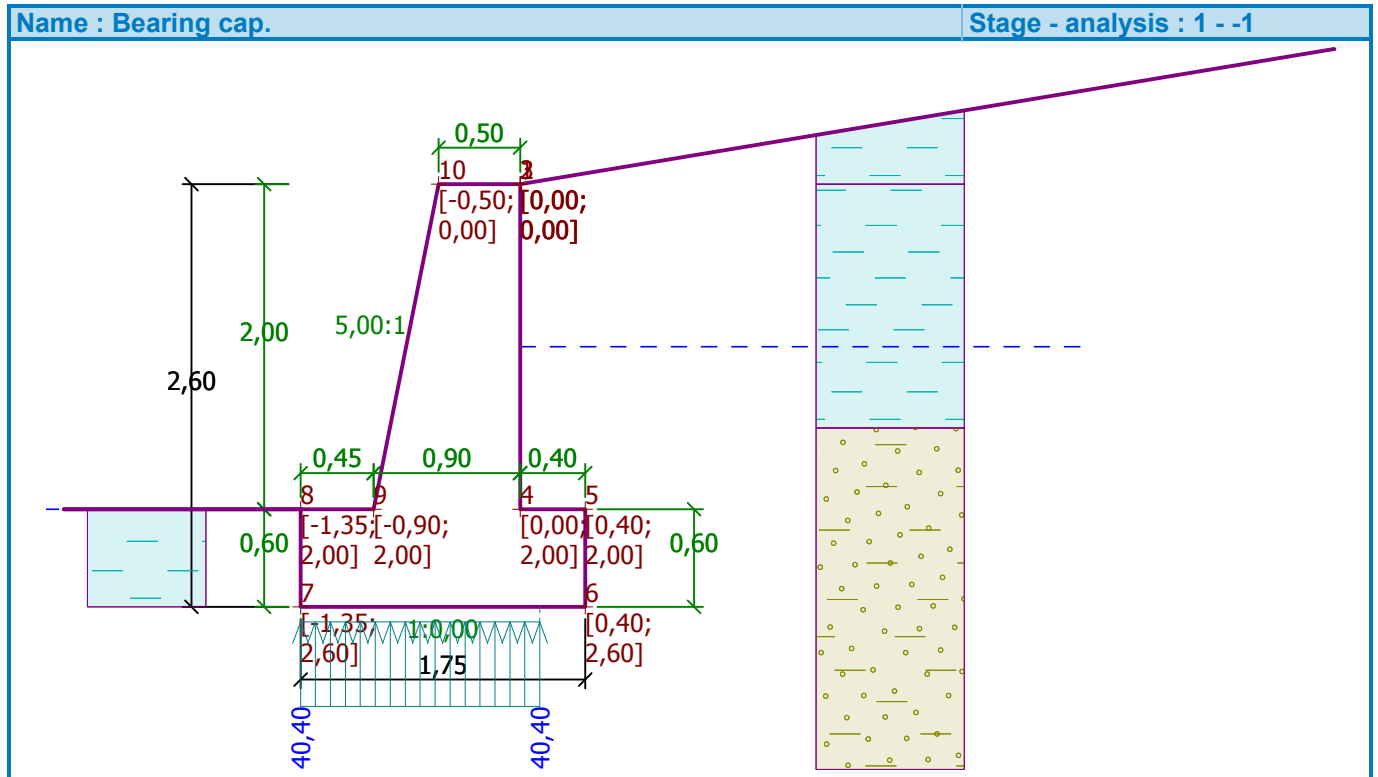
Max. stress at footing bottom $\sigma = 40,40 \text{ kPa}$

Bearing capacity of foundation soil $R_d = 120,00 \text{ kPa}$

Safety factor = $2,97 > 1,00$

Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



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	-0,90	32,17	0,54	1,000
Active pressure	7,40	-0,66	1,98	0,90	1,000
Water pressure	4,99	-0,33	0,00	0,90	1,000
Uplift pressure	0,00	-2,00	0,00	0,90	1,000

Wall stem check

Cross-section depth $h = 0,90 \text{ m}$

Ultimate shear force $V_{Rd} = 503,92 \text{ kN/m} > 12,39 \text{ kN/m} = V_{Ed}$

Ultimate compressive force $N_{Rd} = 7892,39 \text{ kN/m} > 34,16 \text{ kN/m} = N_{Ed}$

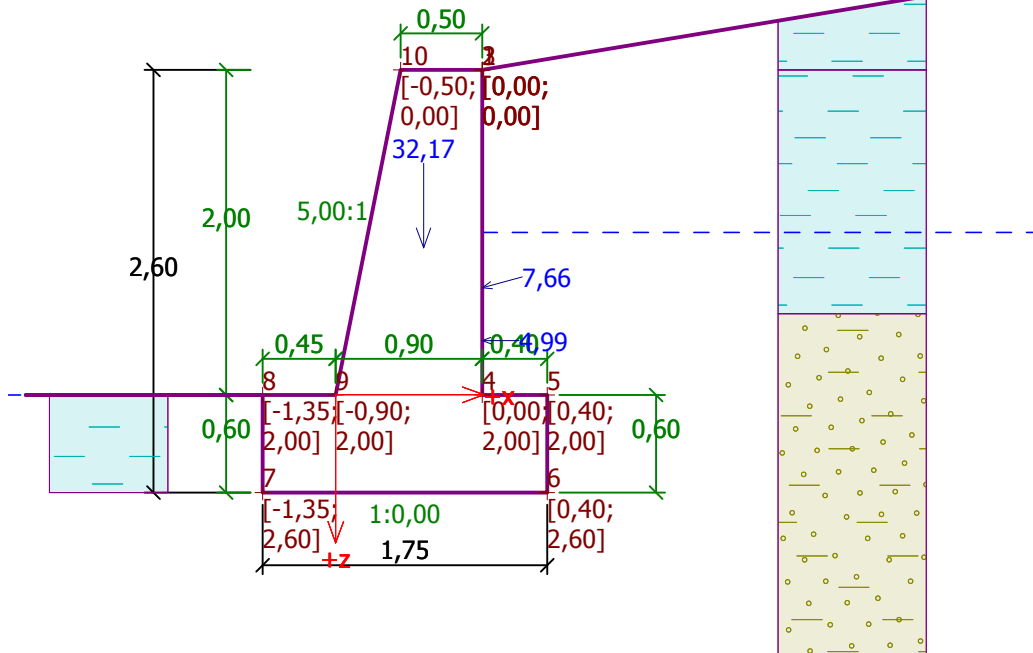
Ultimate moment $M_{Rd} = 15,31 \text{ kNm/m} > 2,73 \text{ kNm/m} = M_{Ed}$

Cross-section bearing capacity 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	-0,47	13,80	0,40	1,000
Active pressure	1,38	-0,15	0,37	0,70	1,000
Water pressure	0,00	-1,00	0,00	0,70	1,000

Wall check at the construction joint 1,00 m from the wall crest

Cross-section depth $h = 0,70$ m

Ultimate shear force $V_{Rd} = 387,98$ kN/m $> 1,38$ kN/m = V_{Ed}

Ultimate compressive force $N_{Rd} = 6612,26$ kN/m $> 14,17$ kN/m = N_{Ed}

Ultimate moment $M_{Rd} = -4,95$ kNm/m $> -0,57$ kNm/m = M_{Ed}

Cross-section bearing capacity is SATISFACTORY

Dimensioning No. 3

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	-1,15	45,85	0,96	1,000
FF resistance	-0,81	-0,20	0,00	0,00	1,000
Weight - earth wedge	0,00	-0,90	1,82	1,48	1,000
Active pressure	15,57	-0,96	11,78	1,57	1,000
Water pressure	11,00	-0,59	0,00	1,35	1,000
Uplift pressure	0,00	-2,60	0,00	1,35	1,000



Front wall jump check

Reinforcement and dimensions of the cross-section:

Bar diameter = 20,0 mm

Number of bars = 5

Reinforcement cover = 30,0 mm

Cross-section width = 1,00 m

Cross-section depth = 0,60 m

Reinforcement ratio $\rho = 0,28 \% > 0,13 \% = \rho_{min}$

Position of neutral axis $x = 0,06 \text{ m} < 0,35 \text{ m} = x_{max}$

Ultimate shear force $V_{Rd} = 190,76 \text{ kN} > 14,50 \text{ kN} = V_{Ed}$

Ultimate moment $M_{Rd} = 364,96 \text{ kNm} > 3,40 \text{ kNm} = M_{Ed}$

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		-10,00	98,00	-1,35	98,00	-0,90	98,00
		-0,50	100,00	0,00	100,00	5,00	100,83
		10,00	100,83				
2		0,00	100,00	0,00	98,50	10,00	98,50



No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
3		0,00	98,50	0,00	98,00	0,40	98,00
4		-10,00	97,40	-1,35	97,40	-1,35	98,00
5		-1,35	97,40	0,40	97,40	0,40	98,00
		10,00	98,00				

Soil parameters - effective stress state

No.	Name	Pattern	ϕ_{ef} [°]	c_{ef} [kPa]	γ [kN/m ³]
1	Soil No. 1		29,00	5,00	18,00
2	Soil No. 2		15,00	5,00	20,50

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m ³]	γ_s [kN/m ³]	n [-]
1	Soil No. 1		20,00		
2	Soil No. 2		20,50		

Soil parameters

Soil No. 1

Unit weight : $\gamma = 18,00 \text{ kN/m}^3$
 Stress-state : effective
 Angle of internal friction : $\phi_{ef} = 29,00^\circ$
 Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
 Saturated unit weight : $\gamma_{sat} = 20,00 \text{ kN/m}^3$

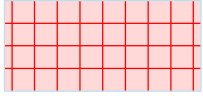
Soil No. 2

Unit weight : $\gamma = 20,50 \text{ kN/m}^3$
 Stress-state : effective

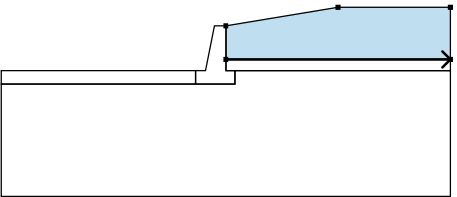

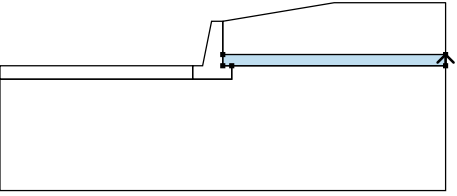

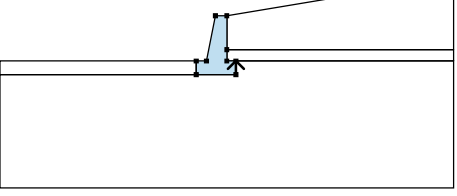
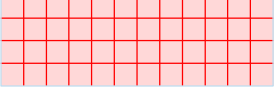
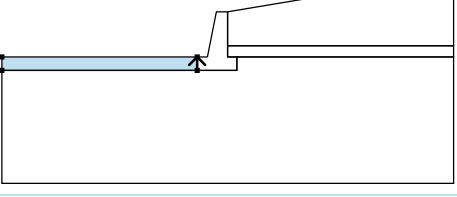

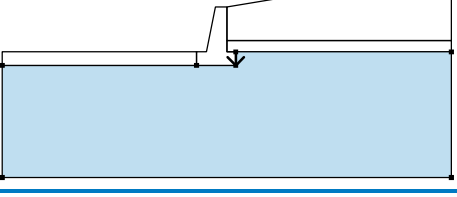



Angle of internal friction : $\varphi_{ef} = 15,00^\circ$
 Cohesion of soil : $c_{ef} = 5,00 \text{ kPa}$
 Saturated unit weight : $\gamma_{sat} = 20,50 \text{ kN/m}^3$

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		0,00	98,50	10,00	98,50	Soil No. 2 
		10,00	100,83	5,00	100,83	
		0,00	100,00			
2		10,00	98,00	10,00	98,50	Soil No. 1 
		0,00	98,50	0,00	98,00	
		0,40	98,00			
3		0,40	97,40	0,40	98,00	Wall material 
		0,00	98,00	0,00	98,50	
		0,00	100,00	-0,50	100,00	
		-0,90	98,00	-1,35	98,00	
		-1,35	97,40			
4		-1,35	97,40	-1,35	98,00	Soil No. 2 
		-10,00	98,00	-10,00	97,40	
5		0,40	98,00	0,40	97,40	Soil No. 1 
		-1,35	97,40	-10,00	97,40	
		-10,00	92,40	10,00	92,40	
		10,00	98,00			

Water

Water type : GWT



No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-10,00	98,00	0,00	98,00	0,05	99,00
		10,00	99,00				

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 =	-1,02	[m]	Angles :	$\alpha_1 =$	-36,25	[°]
	z =	101,50	[m]		$\alpha_2 =$	77,13	[°]
Radius :	R =	4,34	[m]				
The slip surface after optimization.							

Slope stability verification (Bishop)

Sum of active forces : $F_a = 86,61$ kN/m

Sum of passive forces : $F_p = 122,90$ kN/m

Sliding moment : $M_a = 375,87$ kNm/m

Resisting moment : $M_p = 484,90$ kNm/m

Utilization : 77,5 %

Slope stability ACCEPTABLE



Name : Calcul

Stage - analysis : 1 - 1

