RAPORT LLOGARITJEVE STATIKE PER PRITAT

Hartim projekti për mbrojtjen me Prita Malore të Përroit të Lekebibajt (Mërturit)

BOE: “NET GROUP”shpk &”ARABEL STUDIO”shpk

Ing. Valter Begaj

FAZA PROJEKT ZBATIM

TETOR 2022

I. HYRJE

Ne kete raport jepen llogaritjet statike per secilen Pritat malore qe do te ndertohen ne lumen e Lekbibaj.

Te dhenat qe jane perdorur me llogaritje jane marre nga Raporti gjeologjik ku jepen karakteristikat e shtresave si dhe nga raporti hidroteknik ku jane dhene nivelet e ujit.

Pritat jane llogaritur duke marre parasyshysh dhe sizmiken.

Llogaritjet jane bere me programin GEO5 Gabions.

Me poshte jepen te dhenat dhe rezultatet per secilen nga Pritat malore.

II. PRITA "L2", "L4", "L5", "L6", "L7", "C1", "C2", H=9m

Gabion analysis

Input data

Settings

Standard - safety factors

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			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.00	[–]
Safety factor for sliding resistance :	SF_s =	1.00	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for mesh strength :	SF_n =	1.00	[–]

Reduction coefficients			
Seismic design situation			
Reduction coeff. of friction between blocks :	γ_f =	1.50	[–]

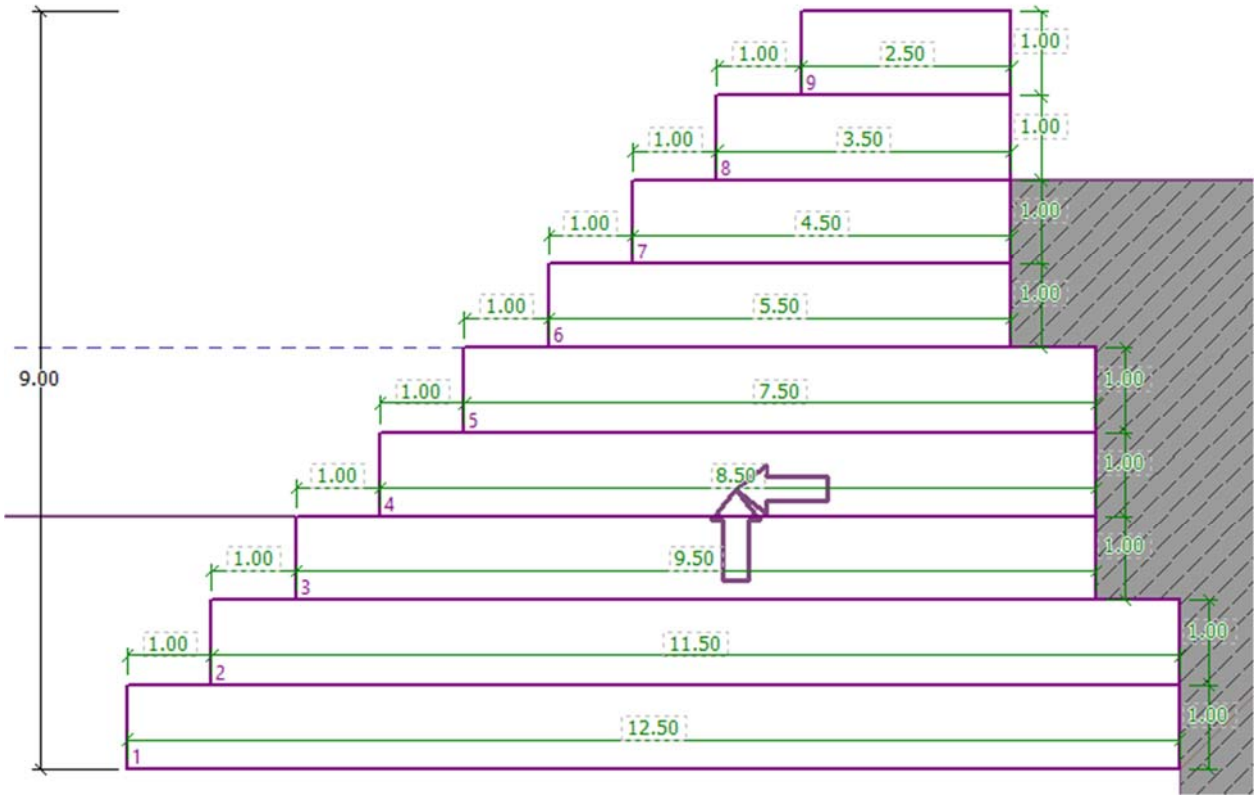
Material of blocks - filling

No.	Name	γ [kN/m³]	φ [°]	c [kPa]
1	Material No. 1	26.00	36.00	0.00

Material of blocks - mesh

No.	Name	Strength overh. R_t [kN/m]	Spacing of vert. meshes v [m]	Bear.cap. of front joint R_s [kN/m]
1	Material No. 1	150.00	1.00	58.00

Geometry of structure



No.	Width b [m]	Height h [m]	Offset a [m]	Material
9	2.50	1.00	1.00	Material No. 1
8	3.50	1.00	1.00	Material No. 1
7	4.50	1.00	1.00	Material No. 1
6	5.50	1.00	1.00	Material No. 1
5	7.50	1.00	1.00	Material No. 1
4	8.50	1.00	1.00	Material No. 1
3	9.50	1.00	1.00	Material No. 1
2	11.50	1.00	1.00	Material No. 1
1	12.50	1.00	-	Material No. 1

Gabion slope = 0.00 °

Overall height = 9.00 m

Overall wall volume = 65.50 m^3/m

Soil parameters

ZHAVORRE

Unit weight : γ = 21.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 36.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Angle of friction struc.-soil : δ = 24.00 °

Soil : cohesionless

Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Backfill

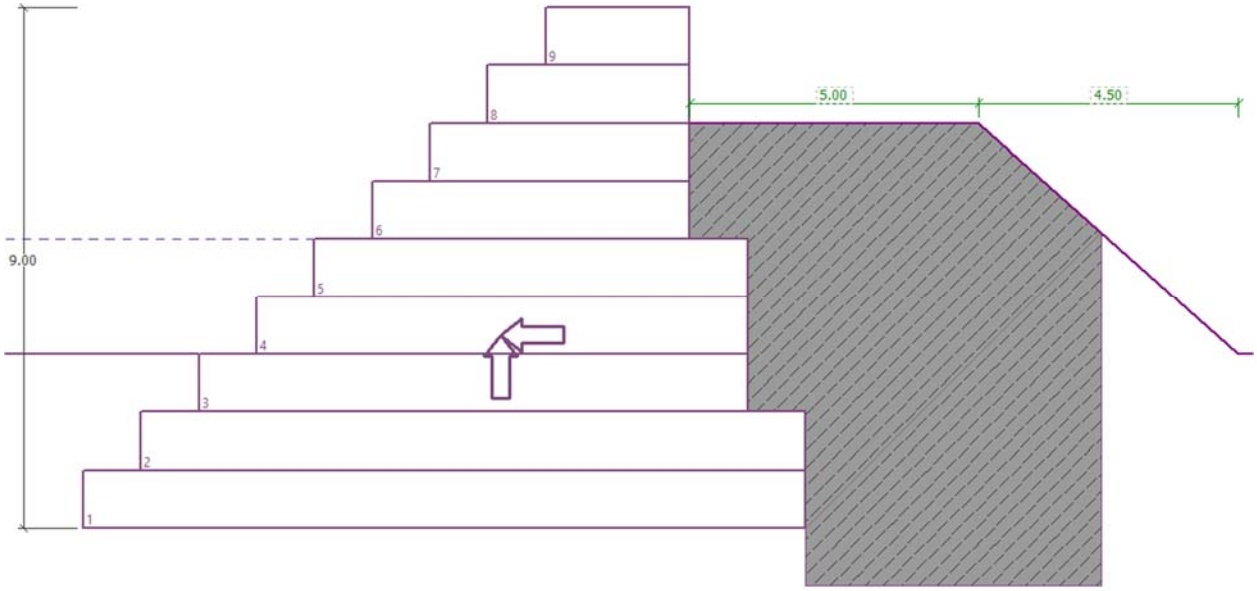
Assigned soil : ZHAVORRE

Slope = 45.00 °

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	20.00	0.00 .. 20.00	ZHAVORRE	
2	-	20.00 .. ∞	ZHAVORRE	

Terrain profile



Depth of terrain below the top of wall h = 2.00 m.

No.	Coordinates x [m]	Depth z [m]
1	0.00	0.00
2	5.00	0.00
3	9.50	4.00
4	10.50	4.00

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

Water influence

GWT behind the structure lies at a depth of -4.00 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 - ZHAVORRE

Soil thickness in front of structure h = 3.00 m

Terrain in front of structure is flat.

Earthquake

Factor of horizontal acceleration K_h = 0.1200

Factor of vertical acceleration K_v = 0.0600

Water below the GWT is restricted.

Global settings

Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Earthquake effects (active earth pressure) - partial results

Layer No.	Thickness [m]	φ_d [°]	β [°]	ψ [°]	K_a	K_{ae}	$K_{ae}-K_a$	Comment
1	0.04	36.00	0.00	13.70	0.235	0.412	0.177	
2	0.96	36.00	0.00	13.70	0.572	1.034	0.462	
3	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
4	1.00	36.00	0.00	13.70	0.235	0.412	0.177	
5	0.04	36.00	0.00	13.70	0.235	0.412	0.177	
6	0.96	36.00	0.00	13.70	0.572	1.034	0.462	
7	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
8	1.00	36.00	0.00	13.70	0.235	0.412	0.177	
9	1.00	36.00	0.00	13.70	0.235	0.412	0.177	

Earthquake effects (active earth pressure)

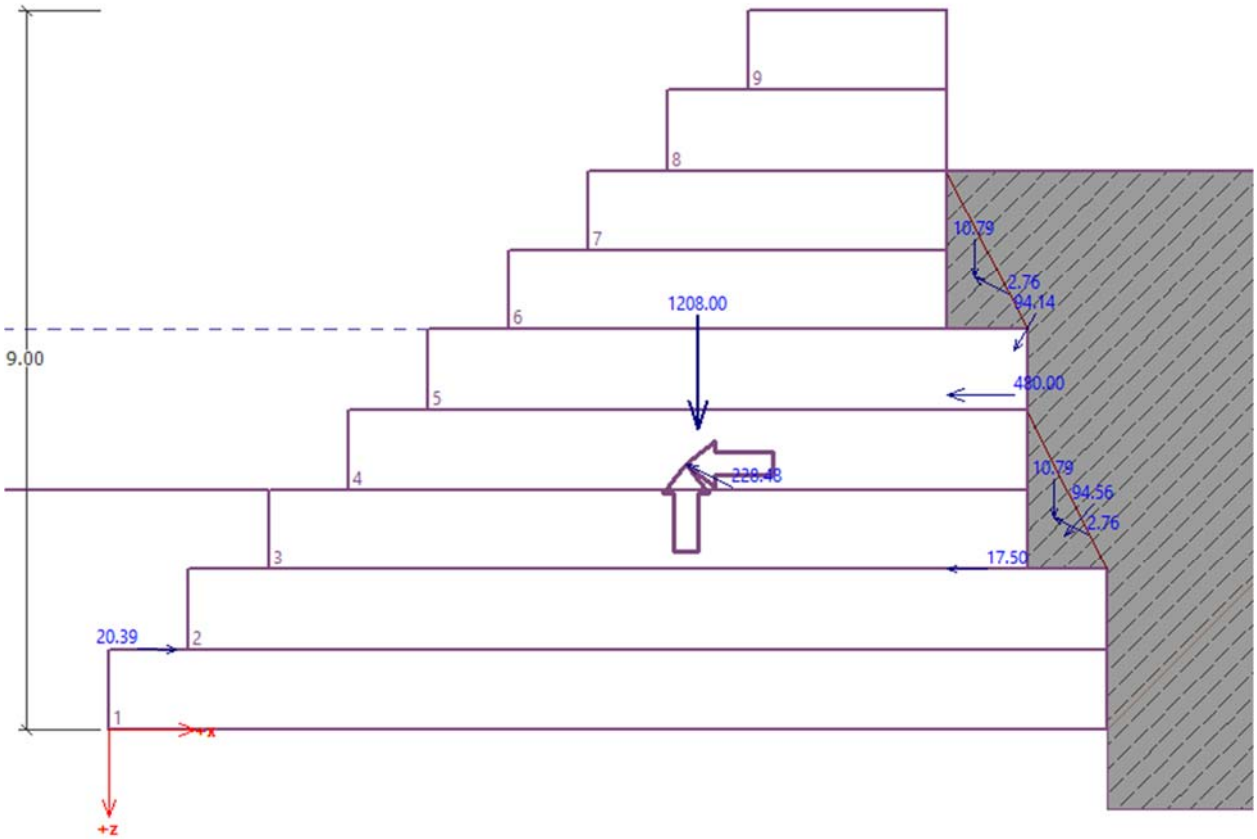
Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_D [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vertical comp. [kPa]
1	0.00	0.00	72.38	12.80	11.69	5.21
	0.04	0.39	71.99	12.73	11.63	5.18
2	0.04	0.39	71.99	33.24	15.09	29.62
	1.00	10.34	62.04	28.65	13.01	25.53
3	1.00	10.34	62.04	28.65	13.01	25.53
	2.00	20.68	51.70	23.87	10.84	21.27
4	2.00	20.68	51.70	9.14	8.35	3.72
	3.00	31.02	41.36	7.31	6.68	2.97
5	3.00	31.02	41.36	7.31	6.68	2.97
	3.04	31.41	40.97	7.25	6.62	2.95
6	3.04	31.41	40.97	18.92	8.59	16.86
	4.00	41.36	31.02	14.32	6.50	12.76
7	4.00	41.36	31.02	14.32	6.50	12.76
	5.00	51.70	20.68	9.55	4.34	8.51
8	5.00	51.70	20.68	3.66	3.34	1.49
	6.00	62.04	10.34	1.83	1.67	0.74
9	6.00	62.04	10.34	1.83	1.67	0.74
	7.00	72.38	0.00	0.00	0.00	0.00

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	-3.77	1208.00	7.37	1.000
Earthq.- constr.	204.36	-3.32	-102.18	7.22	1.000
FF resistance	-20.39	-1.00	0.04	0.83	1.000

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Weight - earth wedge	0.00	-2.65	10.79	11.83	1.000
Earthquake - soil wedge	2.47	-2.65	-1.24	11.83	1.000
Weight - earth wedge	0.00	-5.65	10.79	10.83	1.000
Earthquake - soil wedge	2.47	-5.65	-1.24	10.83	1.000
Active pressure	62.73	-2.42	70.77	11.96	1.000
Water pressure	480.00	-4.19	0.00	10.50	1.000
Uplift pressure	0.00	-7.00	0.00	10.50	1.000
Earthq.- act.pressure	49.67	-4.74	79.97	11.33	1.000
Dyn. water pressure at the front	17.50	-2.00	0.00	10.50	1.000

Verification of complete wall



Check for overturning stability

Resisting moment M_{res} = 10135.79 kNm/m

Overturning moment M_{ovr} = 3111.60 kNm/m

Safety factor = 3.26 > 1.00

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 926.86 kN/m

Active horizontal force H_{act} = 798.81 kN/m

Safety factor = 1.16 > 1.00

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	949.01	1275.71	798.81	0.060	115.85

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	949.01	1275.71	798.81

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force e = 0.060

Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom σ = 115.85 kPa

Bearing capacity of foundation soil R_d = 200.00 kPa

Safety factor = 1.73 > 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	-1.31	273.00	2.65	1.000
Earthq.- constr.	32.76	-1.31	-16.38	2.65	1.000
Active pressure	1.18	-0.33	0.53	4.50	1.000
Water pressure	125.00	-1.67	0.00	4.50	1.000
Uplift pressure	0.00	-1.00	0.00	4.50	1.000
Earthq.- act.pressure	0.84	-0.67	0.37	4.50	1.000

Verification of construction joint above the block No.: 6

Check for overturning stability

Resisting moment M_{res} = 685.30 kNm/m

Overturning moment M_{ovr} = 252.18 kNm/m

Safety factor = 2.72 > 1.00

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 187.10 kN/m

Active horizontal force H_{act} = 159.78 kN/m

Safety factor = 1.17 > 1.00

Joint for slip is SATISFACTORY

Maximum pressure on the bottom block	=	76.56	kPa
Red.Coeff. by offset of top block	=	0.00	
Average value of pressure on face	=	4.37	kPa
Shear force transferred by friction	=	124.73	kN/m

Bearing capacity against transverse pressure:

Joint bear.capacity	=	58.00	kN/m
Computed stress-state	=	2.18	kN/m

Safety factor = 26.56 > 1.00

Transverse pressure check is SATISFACTORY

Joint btw. blocks check:

Mesh material bear.capacity	=	150.00	kN/m
Computed stress-state	=	37.23	kN/m

Safety factor = 4.03 > 1.00

Joint between blocks is SATISFACTORY

Slope stability analysis

Input data

Project

Settings

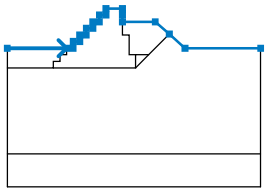
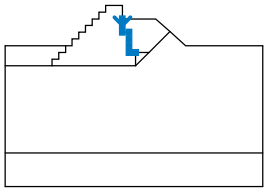
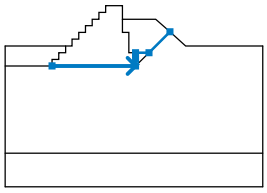
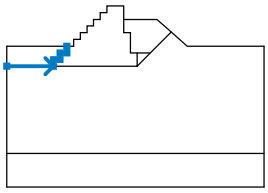
Standard - safety factors

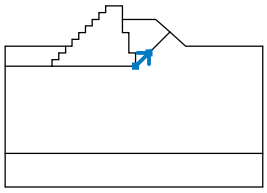
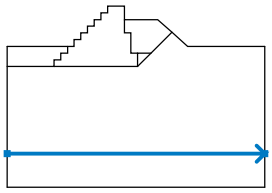
Stability analysis

Earthquake analysis :	Standard
Verification methodology :	Safety factors (ASD)

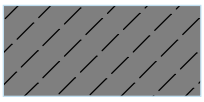
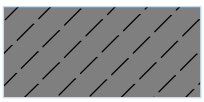
Safety factors			
Seismic design situation			
Safety factor :	SF_s =	1.00	[–]

Interface

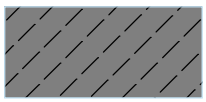
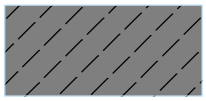
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-17.50	-4.00	-8.50	-4.00	-7.50	-4.00
		-7.50	-3.00	-6.50	-3.00	-6.50	-2.00
		-5.50	-2.00	-5.50	-1.00	-4.50	-1.00
		-4.50	0.00	-3.50	0.00	-3.50	1.00
		-2.50	1.00	-2.50	2.00	0.00	2.00
		0.00	1.00	0.00	0.00	5.00	0.00
		7.12	-1.88	9.50	-4.00	21.00	-4.00
2		0.00	0.00	0.00	-1.00	0.00	-2.00
		1.00	-2.00	1.00	-3.00	1.00	-4.00
		1.00	-5.00	2.00	-5.00		
3		-10.50	-7.00	2.00	-7.00	2.00	-6.00
		2.00	-5.00	4.00	-5.00	7.12	-1.88
4		-17.50	-7.00	-10.50	-7.00	-10.50	-6.00
		-9.50	-6.00	-9.50	-5.00	-8.50	-5.00
		-8.50	-4.00				

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
5		2.00	-7.00	4.00	-5.00		
6		-17.50	-20.00	21.00	-20.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m³]
1	ZHAVORRE		36.00	0.00	21.00
2	GAFORRE		38.00	0.00	23.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m³]	γ_s [kN/m³]	n [–]
1	ZHAVORRE		21.00		
2	GAFORRE		23.00		

Soil parameters

ZHAVORRE

Unit weight : γ = 21.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 36.00 °

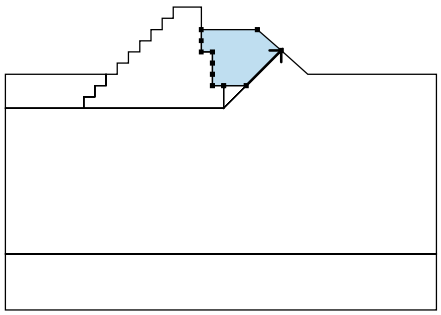
Cohesion of soil : c_{ef} = 0.00 kPa

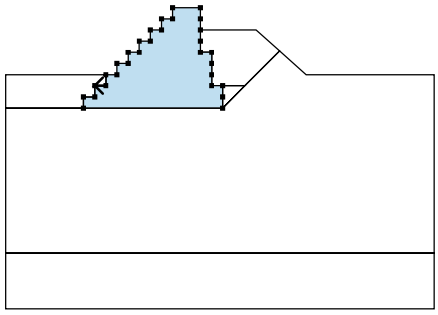
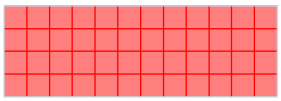
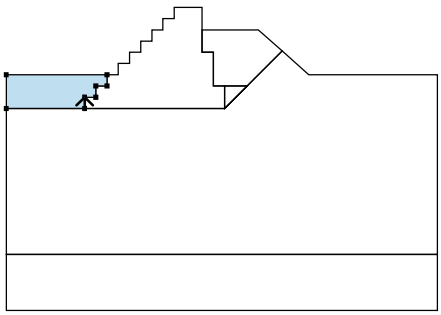
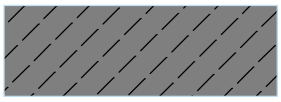
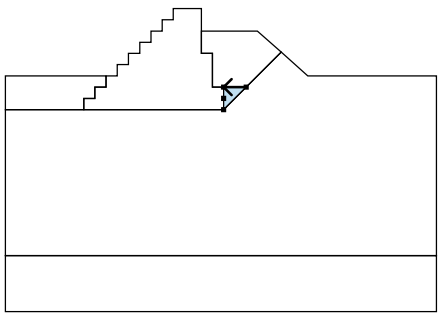
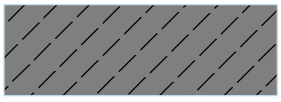
Saturated unit weight : γ_{sat} = 21.00 kN/m^3

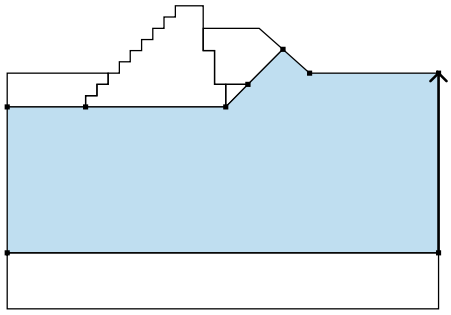
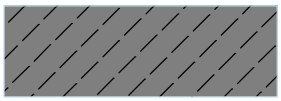
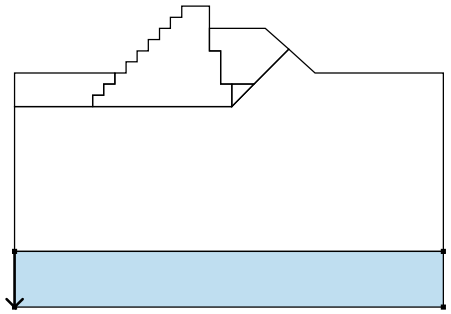
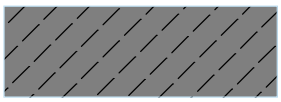
Rigid bodies

No.	Name	Sample	γ [kN/m^3]
1	Material of structure		26.00

Assigning and surfaces

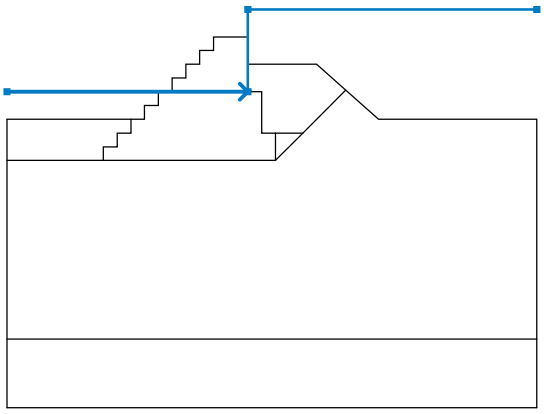
No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		4.00	-5.00	7.12	-1.88	ZHAVORRE
		5.00	0.00	0.00	0.00	
		0.00	-1.00	0.00	-2.00	
		1.00	-2.00	1.00	-3.00	
		1.00	-4.00	1.00	-5.00	
		2.00	-5.00			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
2		-8.50	-5.00	-9.50	-5.00	Material of structure
		-9.50	-6.00	-10.50	-6.00	
		-10.50	-7.00	2.00	-7.00	
		2.00	-6.00	2.00	-5.00	
		1.00	-5.00	1.00	-4.00	
		1.00	-3.00	1.00	-2.00	
		0.00	-2.00	0.00	-1.00	
		0.00	0.00	0.00	1.00	
		0.00	2.00	-2.50	2.00	
		-2.50	1.00	-3.50	1.00	
		-3.50	0.00	-4.50	0.00	
		-4.50	-1.00	-5.50	-1.00	
		-5.50	-2.00	-6.50	-2.00	
		-6.50	-3.00	-7.50	-3.00	
		-7.50	-4.00	-8.50	-4.00	
3		-10.50	-7.00	-10.50	-6.00	ZHAVORRE
		-9.50	-6.00	-9.50	-5.00	
		-8.50	-5.00	-8.50	-4.00	
		-17.50	-4.00	-17.50	-7.00	
4		4.00	-5.00	2.00	-5.00	ZHAVORRE
		2.00	-6.00	2.00	-7.00	
						

No.	Surface position	Coordinates of surface points [m]				Assigned
		x	z	x	z	soil
5		21.00	-20.00	21.00	-4.00	ZHAVORRE
		9.50	-4.00	7.12	-1.88	
		4.00	-5.00	2.00	-7.00	
		-10.50	-7.00	-17.50	-7.00	
		-17.50	-20.00			
6		-17.50	-20.00	-17.50	-25.00	ZHAVORRE
		21.00	-25.00	21.00	-20.00	
						

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-17.50	-2.00	0.00	-2.00	0.00	4.00
		21.00	4.00				

Tensile crack

Tensile crack not input.

Earthquake

Horizontal seismic coefficient : K_h = 0.1200

Vertical seismic coefficient : K_v = 0.0600

Settings of the stage of construction

Design situation : seismic

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	-5.36	[m]	Angles :	α_1 =	-42.23	[°]
	z =	9.15	[m]		α_2 =	48.52	[°]
Radius :	R =	17.76	[m]				
The slip surface after optimization.							

Slope stability verification (Bishop)

Sum of active forces : F_a = 866.78 kN/m

Sum of passive forces : F_p = 1276.46 kN/m

Sliding moment : M_a = 15394.02 kNm/m

Resisting moment : M_p = 22669.92 kNm/m

Factor of safety = 1.47 > 1.00

Slope stability ACCEPTABLE

III. PRITA "L3", "C3" H=8m

Gabion analysis

Input data

Settings

Standard - safety factors

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			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.00	[–]
Safety factor for sliding resistance :	SF_s =	1.00	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for mesh strength :	SF_n =	1.00	[–]

Reduction coefficients			
Seismic design situation			
Reduction coeff. of friction between blocks :	γ_f =	1.50	[–]

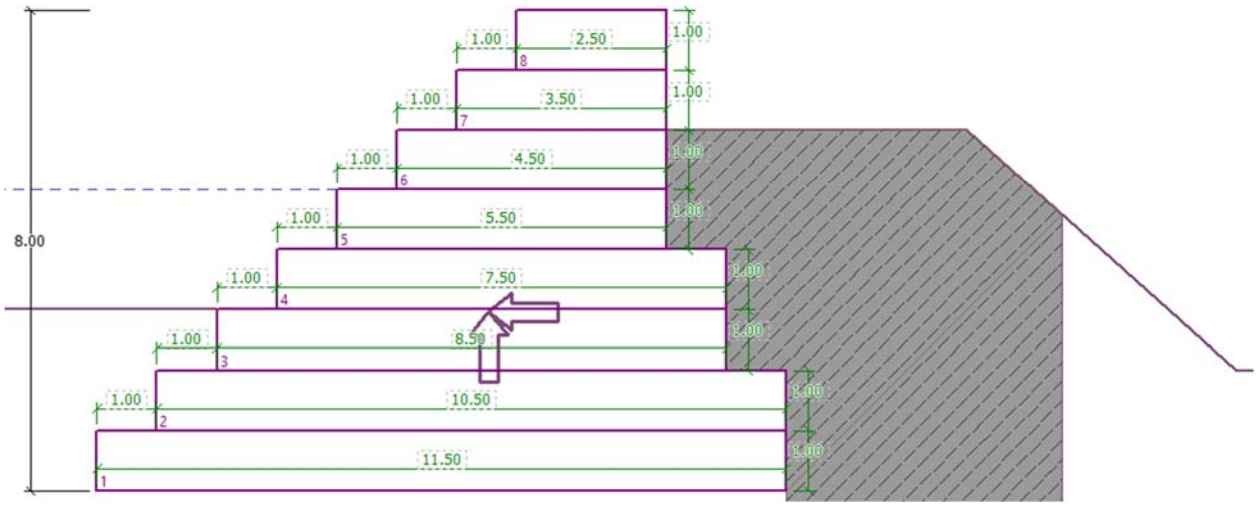
Material of blocks - filling

No.	Name	γ [kN/m³]	φ [°]	c [kPa]
1	Material No. 1	26.00	36.00	0.00

Material of blocks - mesh

No.	Name	Strength overh. R_t [kN/m]	Spacing of vert. meshes v [m]	Bear.cap. of front joint R_s [kN/m]
1	Material No. 1	150.00	1.00	58.00

Geometry of structure



No.	Width b [m]	Height h [m]	Offset a [m]	Material
8	2.50	1.00	1.00	Material No. 1
7	3.50	1.00	1.00	Material No. 1
6	4.50	1.00	1.00	Material No. 1
5	5.50	1.00	1.00	Material No. 1
4	7.50	1.00	1.00	Material No. 1
3	8.50	1.00	1.00	Material No. 1
2	10.50	1.00	1.00	Material No. 1
1	11.50	1.00	-	Material No. 1

Gabion slope = 0.00 °

Overall height = 8.00 m

Overall wall volume = 54.00 m^3/m

Soil parameters

ZHAVORRE

Unit weight : γ = 21.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 36.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Angle of friction struc.-soil : δ = 24.00 °

Soil : cohesionless

Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Backfill

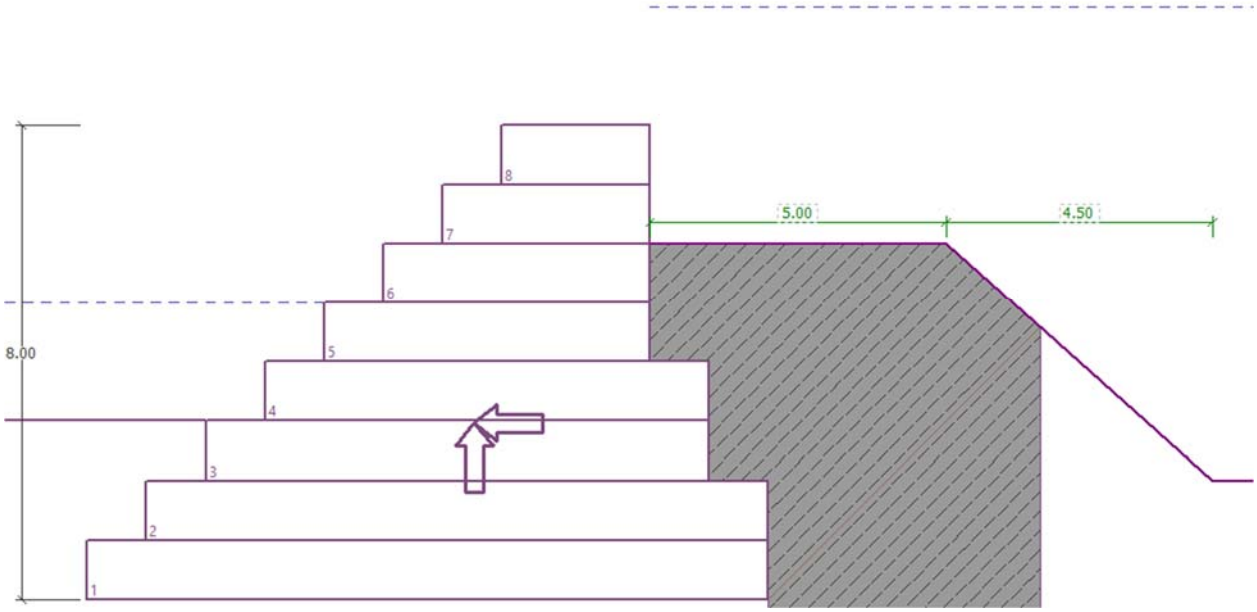
Assigned soil : ZHAVORRE

Slope = 45.00 °

Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	20.00	0.00 .. 20.00	ZHAVORRE	
2	-	20.00 .. ∞	ZHAVORRE	

Terrain profile



Depth of terrain below the top of wall h = 2.00 m.

No.	Coordinates x [m]	Depth z [m]
1	0.00	0.00
2	5.00	0.00
3	9.50	4.00
4	10.50	4.00

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

Water influence

GWT behind the structure lies at a depth of -4.00 m

GWT in front of the structure lies at a depth of 1.00 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 - ZHAVORRE

Soil thickness in front of structure h = 3.00 m

Terrain in front of structure is flat.

Earthquake

Factor of horizontal acceleration K_h = 0.1200

Factor of vertical acceleration K_v = 0.0600

Water below the GWT is restricted.

Global settings

Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$

Settings of the stage of construction

Design situation : seismic

Verification No. 1

Earthquake effects (active earth pressure) - partial results

Layer No.	Thickness [m]	φ_d [°]	β [°]	ψ [°]	K_a	K_{ae}	$K_{ae}-K_a$	Comment
1	0.04	36.00	0.00	13.70	0.235	0.412	0.177	
2	0.96	36.00	0.00	13.70	0.572	1.034	0.462	
3	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
4	0.04	36.00	0.00	13.70	0.235	0.412	0.177	
5	0.96	36.00	0.00	13.70	0.572	1.034	0.462	
6	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
7	1.00	36.00	0.00	13.70	0.235	0.412	0.177	
8	1.00	36.00	0.00	13.70	0.235	0.412	0.177	

Earthquake effects (active earth pressure)

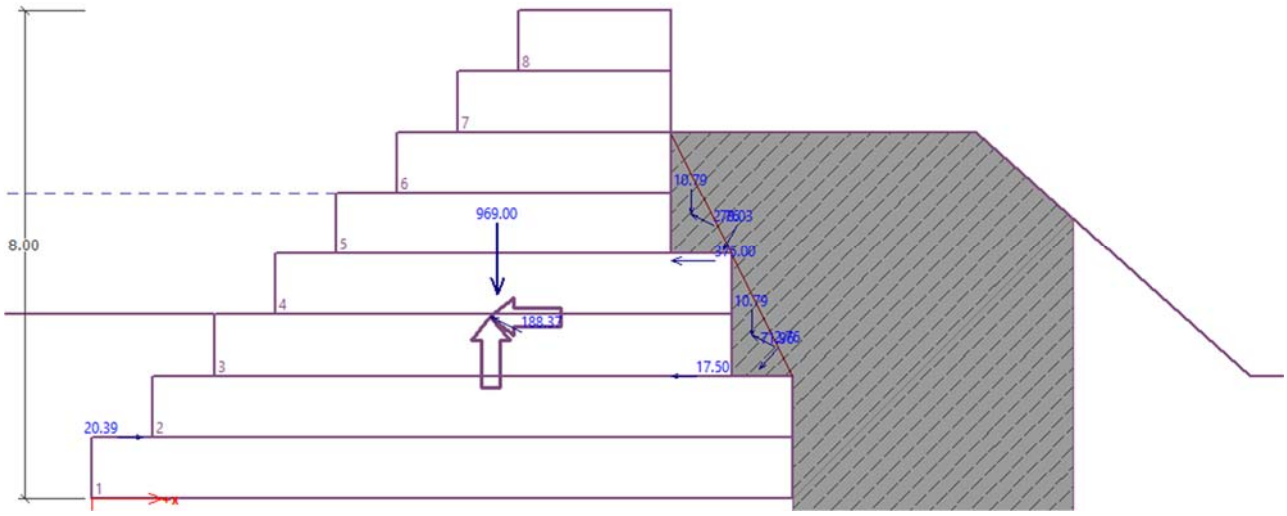
Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_D [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vertical comp. [kPa]
1	0.00	0.00	62.04	10.97	10.02	4.46
	0.04	0.39	61.65	10.90	9.96	4.43
2	0.04	0.39	61.65	28.47	12.92	25.37
	1.00	10.34	51.70	23.87	10.84	21.27
3	1.00	10.34	51.70	23.87	10.84	21.27
	2.00	20.68	41.36	19.10	8.67	17.02
4	2.00	20.68	41.36	7.31	6.68	2.97
	2.04	21.07	40.97	7.25	6.62	2.95
5	2.04	21.07	40.97	18.92	8.59	16.86
	3.00	31.02	31.02	14.32	6.50	12.76
6	3.00	31.02	31.02	14.32	6.50	12.76
	4.00	41.36	20.68	9.55	4.34	8.51

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_D [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vertical comp. [kPa]
7	4.00	41.36	20.68	3.66	3.34	1.49
	5.00	51.70	10.34	1.83	1.67	0.74
8	5.00	51.70	10.34	1.83	1.67	0.74
	6.00	62.04	0.00	0.00	0.00	0.00

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	-3.33	969.00	6.66	1.000
Earthq.- constr.	168.48	-2.96	-84.24	6.54	1.000
FF resistance	-20.39	-1.00	0.04	0.83	1.000
Weight - earth wedge	0.00	-2.65	10.79	10.83	1.000
Earthquake - soil wedge	2.47	-2.65	-1.24	10.83	1.000
Weight - earth wedge	0.00	-4.65	10.79	9.83	1.000
Earthquake - soil wedge	2.47	-4.65	-1.24	9.83	1.000
Active pressure	46.41	-2.11	55.00	10.96	1.000
Water pressure	375.00	-3.89	0.00	9.50	1.000
Uplift pressure	0.00	-6.00	0.00	9.50	1.000
Earthq.- act.pressure	37.84	-4.06	68.24	10.36	1.000
Dyn. water pressure at the front	17.50	-2.00	0.00	9.50	1.000

Verification of complete wall



Check for overturning stability

Resisting moment M_{res} = 7408.03 kNm/m

Overturning moment M_{ovr} = 2242.02 kNm/m

Safety factor = 3.30 > 1.00

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 746.28 kN/m

Active horizontal force H_{act} = 629.78 kN/m

Safety factor = 1.18 > 1.00

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	740.17	1027.16	629.78	0.063	102.12

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	740.17	1027.16	629.78

Verification of foundation soil

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force e = 0.063

Maximum allowable eccentricity e_{alw} = 0.333

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom σ = 102.12 kPa

Bearing capacity of foundation soil R_d = 200.00 kPa

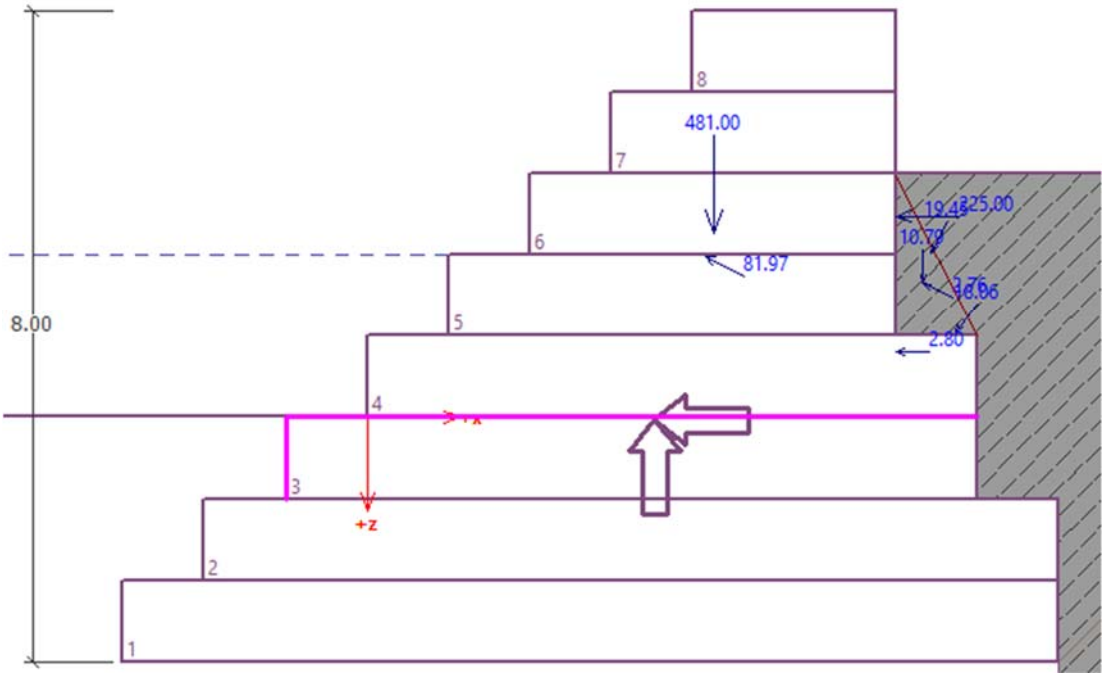
Safety factor = 1.96 > 1.00

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	-2.99	785.00	5.87	1.000
Earthq.- constr.	132.60	-2.63	-66.30	5.75	1.000
FF resistance	-9.06	-0.67	0.01	0.50	1.000
Weight - earth wedge	0.00	-1.65	10.79	9.83	1.000
Earthquake - soil wedge	2.47	-1.65	-1.24	9.83	1.000
Weight - earth wedge	0.00	-3.65	10.79	8.83	1.000
Earthquake - soil wedge	2.47	-3.65	-1.24	8.83	1.000
Active pressure	33.43	-1.74	49.22	9.89	1.000
Water pressure	325.00	-3.41	0.00	8.50	1.000
Uplift pressure	0.00	-5.00	0.00	8.50	1.000
Earthq.- act.pressure	26.70	-3.35	50.37	9.28	1.000
Dyn. water pressure at the front	11.20	-1.60	0.00	8.50	1.000

Verification of construction joint above the block No.: 1

Check for overturning stability

Resisting moment M_{res} = 5360.56 kNm/m

Overturning moment M_{ovr} = 1629.82 kNm/m

Safety factor = 3.29 > 1.00

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 608.42 kN/m

Active horizontal force H_{act} = 524.81 kN/m

Safety factor = 1.16 > 1.00

Joint for slip is SATISFACTORY

Maximum pressure on the bottom block = 93.99 kPa

Red.Coeff. by offset of top block = 0.00

Average value of pressure on face = 4.37 kPa

Shear force transferred by friction = 405.62 kN/m

Bearing capacity against transverse pressure:

Joint bear.capacity = 58.00 kN/m

Computed stress-state = 2.18 kN/m

Safety factor = 26.56 > 1.00

Transverse pressure check is SATISFACTORY

Joint btw. blocks check:

Mesh material bear.capacity = 150.00 kN/m

Computed stress-state = 121.37 kN/m

Safety factor = 1.24 > 1.00

Joint between blocks is SATISFACTORY

Slope stability analysis

Input data

Project

Settings

Standard - safety factors

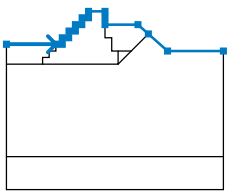
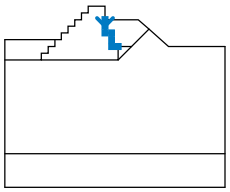
Stability analysis

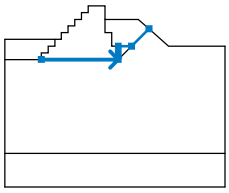
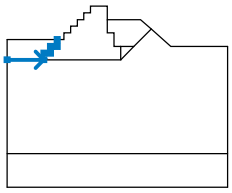
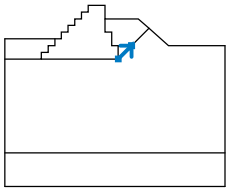
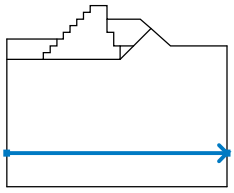
Earthquake analysis : Standard

Verification methodology : Safety factors (ASD)

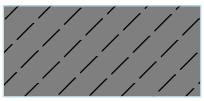
Safety factors			
Seismic design situation			
Safety factor :	SF_s =	1.00	[–]

Interface

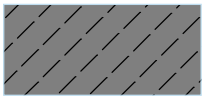
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-15.00	-3.00	-7.50	-3.00	-6.50	-3.00
		-6.50	-2.00	-5.50	-2.00	-5.50	-1.00
		-4.50	-1.00	-4.50	0.00	-3.50	0.00
		-3.50	1.00	-2.50	1.00	-2.50	2.00
		0.00	2.00	0.00	1.00	0.00	0.00
		5.00	0.00	6.59	-1.41	9.50	-4.00
		18.00	-4.00				
2		0.00	0.00	0.00	-1.00	0.00	-2.00
		1.00	-2.00	1.00	-3.00	1.00	-4.00
		2.00	-4.00				

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
3		-9.50	-6.00	2.00	-6.00	2.00	-5.00
		2.00	-4.00	4.00	-4.00	6.59	-1.41
4		-15.00	-6.00	-9.50	-6.00	-9.50	-5.00
		-8.50	-5.00	-8.50	-4.00	-7.50	-4.00
		-7.50	-3.00				
5		2.00	-6.00	4.00	-4.00		
6		-15.00	-20.00	18.00	-20.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	ZHAVORRE		36.00	0.00	21.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m3]	γ_s [kN/m3]	n [–]
1	ZHAVORRE		21.00		

Soil parameters

ZHAVORRE

Unit weight : γ = 21.00 kN/m3

Stress-state : effective

Angle of internal friction : φ_{ef} = 36.00 °

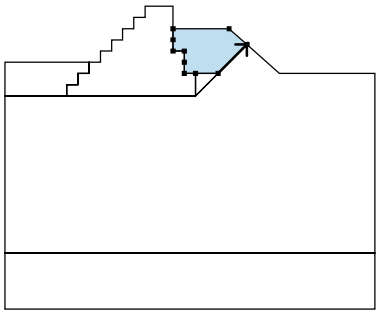
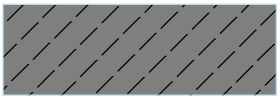
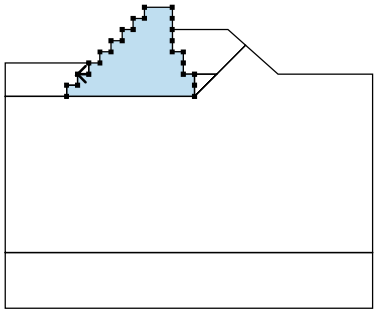
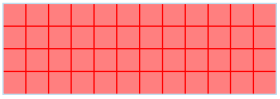
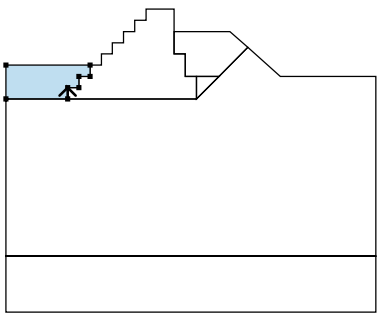
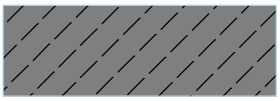
Cohesion of soil : c_{ef} = 0.00 kPa

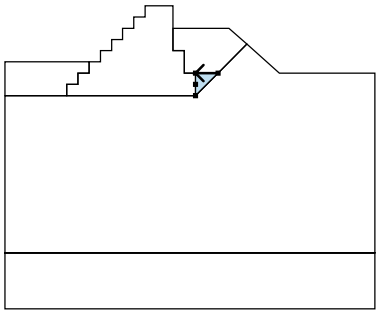
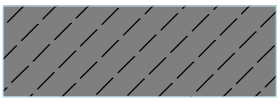
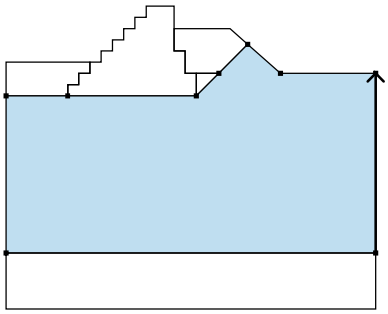
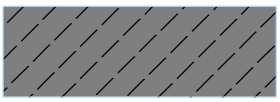
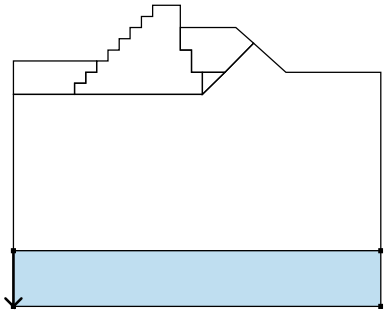
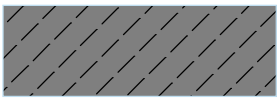
Saturated unit weight : γ_{sat} = 21.00 kN/m3

Rigid bodies

No.	Name	Sample	γ [kN/m3]
1	Material of structure		26.00

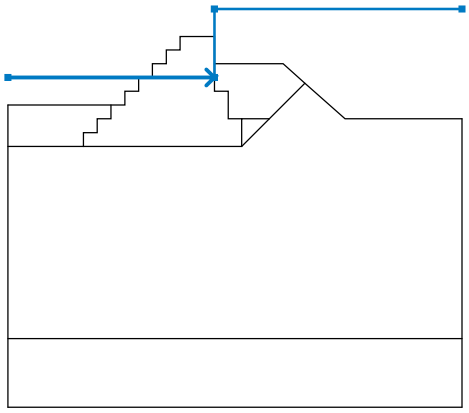
Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		4.00	-4.00	6.59	-1.41	ZHAVORRE
		5.00	0.00	0.00	0.00	
		0.00	-1.00	0.00	-2.00	
		1.00	-2.00	1.00	-3.00	
		1.00	-4.00	2.00	-4.00	
2		-7.50	-4.00	-8.50	-4.00	Material of structure
		-8.50	-5.00	-9.50	-5.00	
		-9.50	-6.00	2.00	-6.00	
		2.00	-5.00	2.00	-4.00	
		1.00	-4.00	1.00	-3.00	
		1.00	-2.00	0.00	-2.00	
		0.00	-1.00	0.00	0.00	
		0.00	1.00	0.00	2.00	
		-2.50	2.00	-2.50	1.00	
		-3.50	1.00	-3.50	0.00	
		-4.50	0.00	-4.50	-1.00	
		-5.50	-1.00	-5.50	-2.00	
		-6.50	-2.00	-6.50	-3.00	
		-7.50	-3.00			
3		-9.50	-6.00	-9.50	-5.00	ZHAVORRE
		-8.50	-5.00	-8.50	-4.00	
		-7.50	-4.00	-7.50	-3.00	
		-15.00	-3.00	-15.00	-6.00	

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
4		4.00	-4.00	2.00	-4.00	ZHAVORRE
		2.00	-5.00	2.00	-6.00	
						
5		18.00	-20.00	18.00	-4.00	ZHAVORRE
		9.50	-4.00	6.59	-1.41	
		4.00	-4.00	2.00	-6.00	
		-9.50	-6.00	-15.00	-6.00	
		-15.00	-20.00			
6		-15.00	-20.00	-15.00	-25.00	ZHAVORRE
		18.00	-25.00	18.00	-20.00	
						

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-15.00	-1.00	0.00	-1.00	0.00	4.00
		18.00	4.00				

Tensile crack

Tensile crack not input.

Earthquake

Horizontal seismic coefficient : K_h = 0.1200

Vertical seismic coefficient : K_v = 0.0600

Settings of the stage of construction

Design situation : seismic

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	3.28	[m]	Angles :	α_1 =	-59.07	[°]
	z =	6.03	[m]		α_2 =	55.19	[°]

Slip surface parameters				
Radius :	R =	17.57	[m]	
The slip surface after optimization.				

Slope stability verification (Bishop)

Sum of active forces : F_a = 259.89 kN/m

Sum of passive forces : F_p = 1923.99 kN/m

Sliding moment : M_a = 4566.26 kNm/m

Resisting moment : M_p = 33804.57 kNm/m

Factor of safety = 7.40 > 1.00

Slope stability ACCEPTABLE

IV. PRITA "L1", H=13m

Gabion analysis

Input data

Settings

Standard - safety factors

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			
Seismic design situation			
Safety factor for overturning :	SF_o =	1.00	[–]
Safety factor for sliding resistance :	SF_s =	1.00	[–]
Safety factor for bearing capacity :	SF_b =	1.00	[–]
Safety factor for mesh strength :	SF_n =	1.00	[–]

Reduction coefficients			
Seismic design situation			
Reduction coeff. of friction between blocks :	γ_f =	1.50	[–]

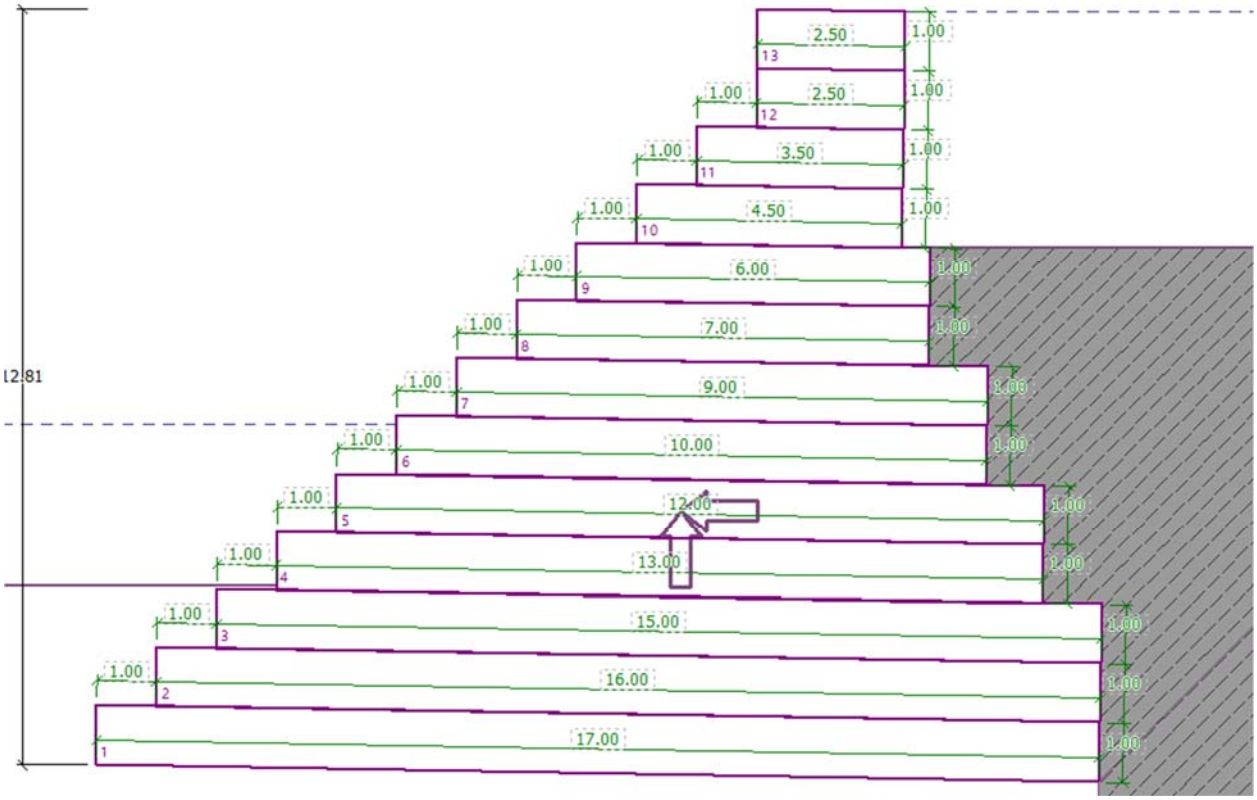
Material of blocks - filling

No.	Name	γ [kN/m³]	φ [°]	c [kPa]
1	GABION	26.00	36.00	0.00

Material of blocks - mesh

No.	Name	Strength overh. R_t [kN/m]	Spacing of vert. meshes v [m]	Bear.cap. of front joint R_s [kN/m]
1	GABION	150.00	1.00	58.00

Geometry of structure



No.	Width b [m]	Height h [m]	Offset a [m]	Material
13	2.50	1.00	0.00	GABION
12	2.50	1.00	1.00	GABION
11	3.50	1.00	1.00	GABION
10	4.50	1.00	1.00	GABION
9	6.00	1.00	1.00	GABION

No.	Width b [m]	Height h [m]	Offset a [m]	Material
8	7.00	1.00	1.00	GABION
7	9.00	1.00	1.00	GABION
6	10.00	1.00	1.00	GABION
5	12.00	1.00	1.00	GABION
4	13.00	1.00	1.00	GABION
3	15.00	1.00	1.00	GABION
2	16.00	1.00	1.00	GABION
1	17.00	1.00	-	GABION

Gabion slope = 1.00 °

Overall height = 12.81 m

Overall wall volume = 118.00 m^3/m

Soil parameters

ZHAVORR

Unit weight : γ = 21.00 kN/m^3

Stress-state : effective

Angle of internal friction : φ_{ef} = 36.00 °

Cohesion of soil : c_{ef} = 0.00 kPa

Angle of friction struc.-soil : δ = 24.00 °

Soil : cohesionless

Saturated unit weight : γ_{sat} = 21.00 kN/m^3

Backfill

Assigned soil : ZHAVORR

Slope = 45.00 °

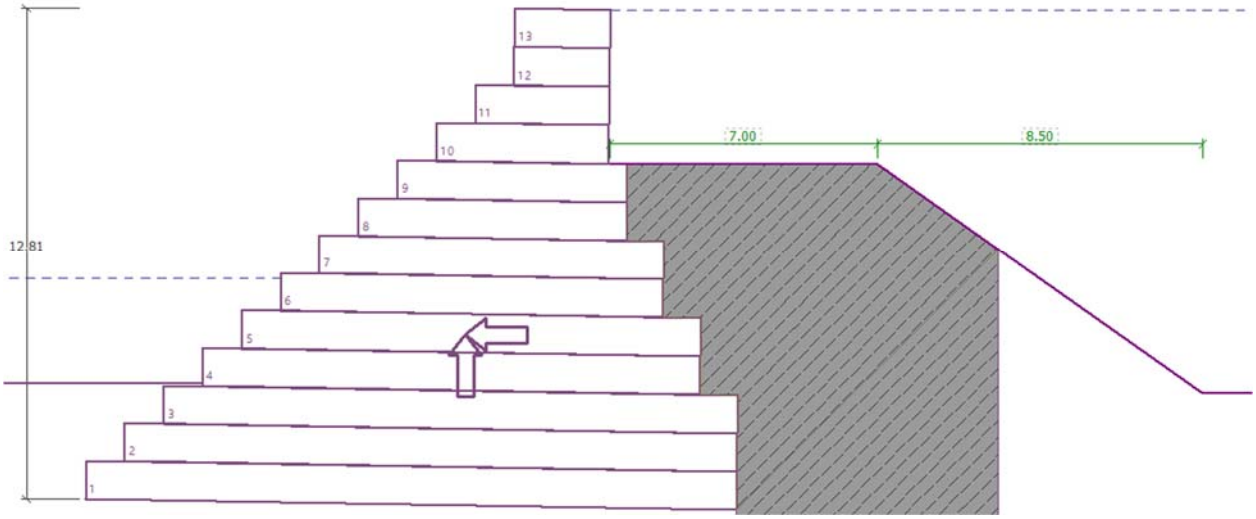
Geological profile and assigned soils

No.	Thickness of layer t [m]	Depth z [m]	Assigned soil	Pattern
1	30.00	0.00 .. 30.00	ZHAVORR	
2	-	30.00 .. ∞	ZHAVORR	

Foundation

Type of foundation : soil from geological profile

Terrain profile



Depth of terrain below the top of wall h = 4.00 m.

No.	Coordinates x [m]	Depth z [m]
1	0.00	0.00
2	7.00	0.00
3	15.50	6.00
4	16.50	6.00

Origin [0,0] is located in upper right edge of construction.

Positive coordinate +z has downward direction.

Water influence

GWT behind the structure lies at a depth of -4.00 m

GWT in front of the structure lies at a depth of 3.00 m

Subgrade at the heel is not permeable.

Uplift in foot. bottom due to different pressures is considered as linear.

Resistance on front face of the structure

Resistance on front face of the structure: at rest

Soil on front face of the structure - GABION

Soil thickness in front of structure h = 3.00 m

Terrain in front of structure is flat.

Earthquake

Factor of horizontal acceleration K_h = 0.1200

Factor of vertical acceleration K_v = 0.0600

Water below the GWT is restricted.

Global settings

Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$

Settings of the stage of construction

Design situation : seismic

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	0.04	1.00	38.00	0.00	13.00	0.384	
2	0.02	1.00	38.00	0.00	13.00	0.384	
3	0.96	1.00	38.00	0.00	13.00	0.384	
4	0.02	1.00	38.00	0.00	13.00	0.384	
5	0.96	1.00	38.00	0.00	13.00	0.384	
6	0.02	1.00	38.00	0.00	13.00	0.384	
7	0.98	1.00	38.00	0.00	13.00	0.384	

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
	0.04	0.46	0.00	0.18	0.18	0.01
2	0.04	0.46	0.00	0.18	0.18	0.01
	0.05	0.69	0.00	0.26	0.26	0.01
3	0.05	0.69	0.00	0.26	0.26	0.01
	1.02	13.23	0.00	5.09	5.08	0.23
4	1.02	13.23	0.00	5.09	5.08	0.23
	1.04	13.46	0.00	5.18	5.17	0.23
5	1.04	13.46	0.00	5.18	5.17	0.23
	2.00	26.00	0.00	10.00	9.99	0.45
6	2.00	26.00	0.00	10.00	9.99	0.45
	2.02	26.23	0.00	10.09	10.08	0.46

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
7	2.02	26.23	0.00	10.09	10.08	0.46
	3.00	39.00	0.00	15.00	14.99	0.68

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	0.01	89.00(45.00)	36.00	0.00	11.00	24.00	0.932	MODIFIED
2	0.12	-1.00	36.00	0.00	11.00	24.00	0.228	
3	0.88	27.00	36.00	0.00	11.00	36.00	0.572	
4	1.00	27.00	36.00	0.00	11.00	36.00	0.572	
5	0.02	27.00	36.00	0.00	11.00	36.00	0.572	
6	0.12	-1.00	36.00	0.00	11.00	24.00	0.228	
7	0.86	27.00	36.00	0.00	11.00	36.00	0.572	
8	0.03	27.00	36.00	0.00	11.00	36.00	0.572	
9	1.00	27.00	36.00	0.00	11.00	36.00	0.572	
10	0.02	27.00	36.00	0.00	11.00	36.00	0.572	
11	0.12	-1.00	36.00	0.00	11.00	24.00	0.228	
12	0.88	27.00	36.00	0.00	11.00	36.00	0.572	
13	0.96	27.00	36.00	0.00	11.00	36.00	0.572	
14	0.04	27.00	36.00	0.00	11.00	36.00	0.572	
15	0.02	27.00	36.00	0.00	11.00	36.00	0.572	
16	1.00	-1.00	36.00	0.00	11.00	24.00	0.228	
17	1.00	-1.00	36.00	0.00	11.00	24.00	0.228	
18	1.00	-1.00	36.00	0.00	11.00	24.00	0.228	

Active pressure distribution behind the structure (without surcharge)

Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$

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	40.00	0.00	0.00	0.00
	0.01	0.09	40.08	0.08	-0.03	0.08
2	0.01	0.09	40.08	0.02	0.02	0.01
	0.13	1.40	41.27	0.32	0.29	0.12
3	0.13	1.40	41.27	0.80	0.36	0.71
	1.01	11.09	50.08	6.34	2.88	5.65
4	1.01	11.09	50.08	6.34	2.88	5.65
	2.01	22.09	60.08	12.63	5.73	11.25
5	2.01	22.09	60.08	12.63	5.73	11.25
	2.03	22.28	60.25	12.74	5.78	11.35
6	2.03	22.28	60.25	5.08	4.67	1.98
	2.14	23.59	61.45	5.38	4.95	2.10
7	2.14	23.59	61.45	13.49	6.12	12.02
	3.00	33.00	70.00	18.87	8.57	16.81
8	3.00	33.00	70.00	18.87	8.57	16.81
	3.03	33.28	70.00	19.03	8.64	16.96
9	3.03	33.28	70.00	19.03	8.64	16.96
	4.02	44.27	70.00	25.32	11.49	22.56
10	4.02	44.27	70.00	25.32	11.49	22.56
	4.04	44.47	70.00	25.43	11.54	22.66
11	4.04	44.47	70.00	10.14	9.33	3.96
	4.16	45.78	70.00	10.44	9.61	4.08
12	4.16	45.78	70.00	26.18	11.88	23.33
	5.04	55.46	70.00	31.72	14.40	28.26
13	5.04	55.46	70.00	31.72	14.40	28.26
	6.00	66.00	70.00	37.74	17.13	33.63
14	6.00	66.00	70.00	37.74	17.13	33.63
	6.04	66.46	70.00	38.01	17.25	33.86

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_W [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
15	6.04	66.46	70.00	38.01	17.25	33.86
	6.06	66.66	70.00	38.12	17.30	33.96
16	6.06	66.66	70.00	15.19	13.99	5.94
	7.06	77.65	70.00	17.70	16.29	6.92
17	7.06	77.65	70.00	17.70	16.29	6.92
	8.06	88.65	70.00	20.21	18.60	7.90
18	8.06	88.65	70.00	20.21	18.60	7.90
	9.06	99.65	70.00	22.72	20.91	8.88

Earthquake effects (active earth pressure) - partial results

Layer No.	Thickness [m]	φ_d [°]	β [°]	ψ [°]	K_a	K_{ae}	K_{ae}-K_a	Comment
1	0.01	36.00	0.00	13.70	0.932	1.625	0.693	
2	0.12	36.00	0.00	13.70	0.228	0.403	0.175	
3	0.88	36.00	0.00	13.70	0.572	1.034	0.462	
4	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
5	0.02	36.00	0.00	13.70	0.572	1.034	0.462	
6	0.12	36.00	0.00	13.70	0.228	0.403	0.175	
7	0.86	36.00	0.00	13.70	0.572	1.034	0.462	
8	0.03	36.00	0.00	13.70	0.572	1.034	0.462	
9	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
10	0.02	36.00	0.00	13.70	0.572	1.034	0.462	
11	0.12	36.00	0.00	13.70	0.228	0.403	0.175	
12	0.88	36.00	0.00	13.70	0.572	1.034	0.462	
13	0.96	36.00	0.00	13.70	0.572	1.034	0.462	
14	0.04	36.00	0.00	13.70	0.572	1.034	0.462	
15	0.02	36.00	0.00	13.70	0.572	1.034	0.462	

Layer No.	Thickness [m]	φ_d [°]	β [°]	ψ [°]	K_a	K_{ae}	$K_{ae}-K_a$	Comment
16	1.00	36.00	0.00	13.70	0.228	0.403	0.175	
17	1.00	36.00	0.00	13.70	0.228	0.403	0.175	
18	1.00	36.00	0.00	13.70	0.228	0.403	0.175	

Earthquake effects (active earth pressure)

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_D [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vertical comp. [kPa]
1	0.00	0.00	93.67	64.96	-25.38	59.80
	0.01	0.08	93.59	64.90	-25.36	59.74
2	0.01	0.08	93.59	16.34	15.04	6.38
	0.13	1.32	92.35	16.13	14.84	6.30
3	0.13	1.32	92.35	42.65	19.36	38.00
	1.01	10.42	83.25	38.44	17.45	34.25
4	1.01	10.42	83.25	38.44	17.45	34.25
	2.01	20.76	72.91	33.67	15.28	30.00
5	2.01	20.76	72.91	33.67	15.28	30.00
	2.03	20.94	72.73	33.58	15.25	29.92
6	2.03	20.94	72.73	12.70	11.69	4.96
	2.14	22.18	71.50	12.48	11.49	4.88
7	2.14	22.18	71.50	33.01	14.99	29.42
	3.00	31.02	62.65	28.93	13.13	25.78
8	3.00	31.02	62.65	28.93	13.13	25.78
	3.03	31.28	62.39	28.81	13.08	25.67
9	3.03	31.28	62.39	28.81	13.08	25.67
	4.02	41.62	52.05	24.04	10.91	21.42
10	4.02	41.62	52.05	24.04	10.91	21.42
	4.04	41.80	51.87	23.95	10.87	21.34

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_D [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vertical comp. [kPa]
11	4.04	41.80	51.87	9.06	8.34	3.54
	4.16	43.03	50.64	8.84	8.14	3.45
12	4.16	43.03	50.64	23.38	10.61	20.83
	5.04	52.14	41.53	19.18	8.71	17.09
13	5.04	52.14	41.53	19.18	8.71	17.09
	6.00	62.04	31.63	14.61	6.63	13.01
14	6.00	62.04	31.63	14.61	6.63	13.01
	6.04	62.48	31.20	14.40	6.54	12.84
15	6.04	62.48	31.20	14.40	6.54	12.84
	6.06	62.66	31.02	14.32	6.50	12.76
16	6.06	62.66	31.02	5.42	4.98	2.12
	7.06	72.99	20.68	3.61	3.32	1.41
17	7.06	72.99	20.68	3.61	3.32	1.41
	8.06	83.33	10.34	1.81	1.66	0.71
18	8.06	83.33	10.34	1.81	1.66	0.71
	9.06	93.67	0.00	0.00	0.00	0.00

Water pressure distribution

Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
1	0.00	40.00	2291.60
2	0.01	40.08	2296.25
3	0.01	40.08	-0.70
4	0.13	41.27	-0.72
5	1.01	50.08	-0.87
6	2.01	60.08	-1.05
7	2.01	60.08	3441.88
8	2.03	60.25	3451.87

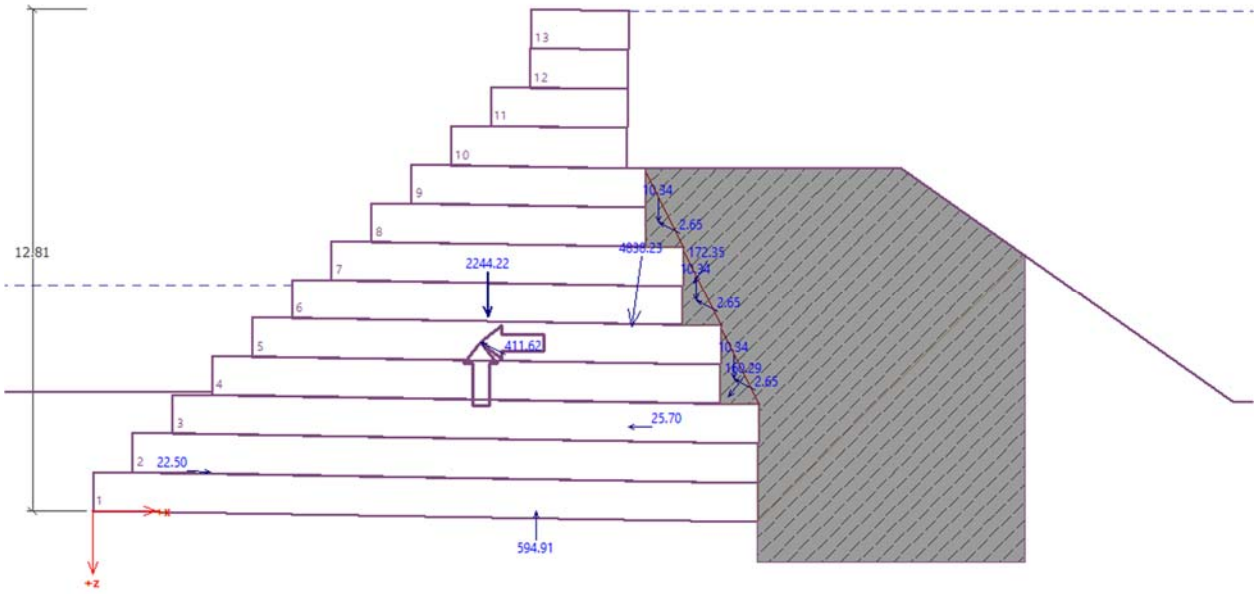
Point No.	Depth [m]	Hor. comp. [kPa]	Vert. comp. [kPa]
9	2.03	60.25	-1.05
10	2.14	61.45	-1.07
11	3.00	70.00	-1.22
12	3.03	70.00	-1.22
13	4.02	70.00	-1.22
14	4.02	70.00	4010.30
15	4.04	70.00	4010.30
16	4.04	70.00	-1.22
17	4.16	70.00	-1.22
18	5.04	70.00	-1.22
19	6.00	70.00	-1.22
20	6.04	70.00	-1.22
21	6.04	70.00	4010.30
22	6.06	70.00	4010.30
23	6.06	70.00	-1.22
24	7.06	70.00	-1.22
25	8.06	70.00	-1.22
26	9.06	70.00	-1.22

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	-4.93	2244.22	10.11	1.000
Earthq.- constr.	368.16	-4.29	-184.08	9.92	1.000
FF resistance	-22.48	-1.00	1.02	3.02	1.000
Weight - earth wedge	0.00	-3.34	10.34	16.39	1.000
Earthquake - soil wedge	2.37	-3.34	-1.18	16.39	1.000
Weight - earth wedge	0.00	-5.36	10.34	15.43	1.000

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Earthquake - soil wedge	2.37	-5.36	-1.18	15.43	1.000
Weight - earth wedge	0.00	-7.38	10.34	14.46	1.000
Earthquake - soil wedge	2.37	-7.38	-1.18	14.46	1.000
Earthquake - soil wedge	0.00	-8.76	0.00	13.69	1.000
Active pressure	104.36	-2.91	121.66	16.24	1.000
Water pressure	669.14	-4.70	4791.73	13.79	1.000
Uplift pressure	0.00	0.00	-594.91	11.33	1.000
Earthq.- act.pressure	85.04	-5.82	149.91	15.38	1.000
Dyn. water pressure at the front	25.70	-2.13	0.00	13.69	1.000

Verification of complete wall



Check for overturning stability

Resisting moment M_{res} = 91643.97 kNm/m

Overturning moment M_{ovr} = 12329.68 kNm/m

Safety factor = 7.43 > 1.00

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 4778.92 kN/m

Active horizontal force H_{act} = 1122.39 kN/m

Safety factor = 4.26 > 1.00

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Dimensioning No. 1

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	0.01	89.00(45.00)	36.00	0.00	11.00	24.00	0.932	MODIFIED
2	0.12	-1.00	36.00	0.00	11.00	24.00	0.228	
3	0.88	27.00	36.00	0.00	11.00	36.00	0.572	
4	1.00	27.00	36.00	0.00	11.00	36.00	0.572	
5	0.02	27.00	36.00	0.00	11.00	36.00	0.572	
6	0.12	-1.00	36.00	0.00	11.00	24.00	0.228	
7	0.86	27.00	36.00	0.00	11.00	36.00	0.572	
8	0.03	27.00	36.00	0.00	11.00	36.00	0.572	
9	1.00	27.00	36.00	0.00	11.00	36.00	0.572	
10	0.02	27.00	36.00	0.00	11.00	36.00	0.572	
11	0.12	-1.00	36.00	0.00	11.00	24.00	0.228	
12	0.88	27.00	36.00	0.00	11.00	36.00	0.572	
13	0.96	27.00	36.00	0.00	11.00	36.00	0.572	
14	0.04	27.00	36.00	0.00	11.00	36.00	0.572	

Layer No.	Thickness [m]	α [°]	φ_d [°]	c_d [kPa]	γ [kN/m³]	δ_d [°]	K_a	Comment
15	0.02	27.00	36.00	0.00	11.00	36.00	0.572	
16	1.00	-1.00	36.00	0.00	11.00	24.00	0.228	
17	1.00	-1.00	36.00	0.00	11.00	24.00	0.228	

Active pressure distribution behind the structure (without surcharge)

Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$

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	40.00	0.00	0.00	0.00
	0.01	0.09	40.08	0.08	-0.03	0.08
2	0.01	0.09	40.08	0.02	0.02	0.01
	0.13	1.40	41.27	0.32	0.29	0.12
3	0.13	1.40	41.27	0.80	0.36	0.71
	1.01	11.09	50.08	6.34	2.88	5.65
4	1.01	11.09	50.08	6.34	2.88	5.65
	2.01	22.09	60.08	12.63	5.73	11.25
5	2.01	22.09	60.08	12.63	5.73	11.25
	2.03	22.28	60.25	12.74	5.78	11.35
6	2.03	22.28	60.25	5.08	4.67	1.98
	2.14	23.59	61.45	5.38	4.95	2.10
7	2.14	23.59	61.45	13.49	6.12	12.02
	3.00	33.00	70.00	18.87	8.57	16.81
8	3.00	33.00	70.00	18.87	8.57	16.81
	3.03	33.28	70.00	19.03	8.64	16.96
9	3.03	33.28	70.00	19.03	8.64	16.96
	4.02	44.27	70.00	25.32	11.49	22.56

Layer No.	Start [m] End [m]	σ_z [kPa]	σ_w [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vert. comp. [kPa]
10	4.02	44.27	70.00	25.32	11.49	22.56
	4.04	44.47	70.00	25.43	11.54	22.66
11	4.04	44.47	70.00	10.14	9.33	3.96
	4.16	45.78	70.00	10.44	9.61	4.08
12	4.16	45.78	70.00	26.18	11.88	23.33
	5.04	55.46	70.00	31.72	14.40	28.26
13	5.04	55.46	70.00	31.72	14.40	28.26
	6.00	66.00	70.00	37.74	17.13	33.63
14	6.00	66.00	70.00	37.74	17.13	33.63
	6.04	66.46	70.00	38.01	17.25	33.86
15	6.04	66.46	70.00	38.01	17.25	33.86
	6.06	66.66	70.00	38.12	17.30	33.96
16	6.06	66.66	70.00	15.19	13.99	5.94
	7.06	77.65	70.00	17.70	16.29	6.92
17	7.06	77.65	70.00	17.70	16.29	6.92
	8.06	88.65	70.00	20.21	18.60	7.90

Earthquake effects (active earth pressure) - partial results

Layer No.	Thickness [m]	φ_d [°]	β [°]	ψ [°]	K_a	K_{ae}	K_{ae}-K_a	Comment
1	0.01	36.00	0.00	13.70	0.932	1.625	0.693	
2	0.12	36.00	0.00	13.70	0.228	0.403	0.175	
3	0.88	36.00	0.00	13.70	0.572	1.034	0.462	
4	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
5	0.02	36.00	0.00	13.70	0.572	1.034	0.462	
6	0.12	36.00	0.00	13.70	0.228	0.403	0.175	
7	0.86	36.00	0.00	13.70	0.572	1.034	0.462	

Layer No.	Thickness [m]	φ_d [°]	β [°]	ψ [°]	K_a	K_{ae}	$K_{ae}-K_a$	Comment
8	0.03	36.00	0.00	13.70	0.572	1.034	0.462	
9	1.00	36.00	0.00	13.70	0.572	1.034	0.462	
10	0.02	36.00	0.00	13.70	0.572	1.034	0.462	
11	0.12	36.00	0.00	13.70	0.228	0.403	0.175	
12	0.88	36.00	0.00	13.70	0.572	1.034	0.462	
13	0.96	36.00	0.00	13.70	0.572	1.034	0.462	
14	0.04	36.00	0.00	13.70	0.572	1.034	0.462	
15	0.02	36.00	0.00	13.70	0.572	1.034	0.462	
16	1.00	36.00	0.00	13.70	0.228	0.403	0.175	
17	1.00	36.00	0.00	13.70	0.228	0.403	0.175	

Earthquake effects (active earth pressure)

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_D [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vertical comp. [kPa]
1	0.00	0.00	83.33	57.79	-22.58	53.20
	0.01	0.08	83.25	57.73	-22.56	53.14
2	0.01	0.08	83.25	14.54	13.38	5.68
	0.13	1.32	82.01	14.32	13.18	5.60
3	0.13	1.32	82.01	37.87	17.19	33.74
	1.01	10.42	72.91	33.67	15.28	30.00
4	1.01	10.42	72.91	33.67	15.28	30.00
	2.01	20.76	62.57	28.89	13.12	25.74
5	2.01	20.76	62.57	28.89	13.12	25.74
	2.03	20.94	62.39	28.81	13.08	25.67
6	2.03	20.94	62.39	10.89	10.03	4.26
	2.14	22.18	61.16	10.68	9.83	4.17

Layer No.	Start [m] End [m]	σ_Z [kPa]	σ_D [kPa]	Pressure [kPa]	Hor. comp. [kPa]	Vertical comp. [kPa]
7	2.14	22.18	61.16	28.24	12.82	25.16
	3.00	31.02	52.31	24.16	10.97	21.52
8	3.00	31.02	52.31	24.16	10.97	21.52
	3.03	31.28	52.05	24.04	10.91	21.42
9	3.03	31.28	52.05	24.04	10.91	21.42
	4.02	41.62	41.71	19.26	8.74	17.16
10	4.02	41.62	41.71	19.26	8.74	17.16
	4.04	41.80	41.53	19.18	8.71	17.09
11	4.04	41.80	41.53	7.25	6.68	2.83
	4.16	43.03	40.30	7.04	6.48	2.75
12	4.16	43.03	40.30	18.61	8.45	16.58
	5.04	52.14	31.20	14.40	6.54	12.84
13	5.04	52.14	31.20	14.40	6.54	12.84
	6.00	62.04	21.29	9.83	4.46	8.76
14	6.00	62.04	21.29	9.83	4.46	8.76
	6.04	62.48	20.86	9.63	4.37	8.58
15	6.04	62.48	20.86	9.63	4.37	8.58
	6.06	62.66	20.68	9.55	4.33	8.51
16	6.06	62.66	20.68	3.61	3.32	1.41
	7.06	72.99	10.34	1.81	1.66	0.71
17	7.06	72.99	10.34	1.81	1.66	0.71
	8.06	83.33	0.00	0.00	0.00	0.00

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	-4.58	1972.22	9.32	1.000

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Earthq.- constr.	315.12	-3.96	-157.56	9.14	1.000
FF resistance	-9.99	-0.67	0.45	2.01	1.000
Weight - earth wedge	0.00	-2.36	10.34	15.38	1.000
Earthquake - soil wedge	2.37	-2.36	-1.18	15.38	1.000
Weight - earth wedge	0.00	-4.38	10.34	14.41	1.000
Earthquake - soil wedge	2.37	-4.38	-1.18	14.41	1.000
Weight - earth wedge	0.00	-6.39	10.34	13.45	1.000
Earthquake - soil wedge	2.37	-6.39	-1.18	13.45	1.000
Earthquake - soil wedge	0.00	-7.78	0.00	12.67	1.000
Active pressure	84.60	-2.56	113.28	15.17	1.000
Water pressure	599.15	-4.24	4792.96	12.77	1.000
Uplift pressure	0.00	0.00	-559.91	10.67	1.000
Earthq.- act.pressure	67.97	-5.12	123.63	14.30	1.000
Dyn. water pressure at the front	17.92	-1.74	0.00	12.67	1.000

Verification of construction joint above the block No.: 1

Check for overturning stability

Resisting moment M_{res} = 82031.38 kNm/m

Overturning moment M_{ovr} = 10380.90 kNm/m

Safety factor = 7.90 > 1.00

Joint for overturning stability is SATISFACTORY

Check for slip

Resisting horizontal force H_{res} = 4599.34 kN/m

Active horizontal force H_{act} = 971.54 kN/m

Safety factor = 4.73 > 1.00

Joint for slip is SATISFACTORY

Maximum pressure on the bottom block = 395.65 kPa
Red.Coeff. by offset of top block = 0.00
Average value of pressure on face = 4.37 kPa
Shear force transferred by friction = 3066.23 kN/m

Bearing capacity against transverse pressure:

Joint bear.capacity = 58.00 kN/m
Computed stress-state = 2.18 kN/m

Safety factor = 26.57 > 1.00

Transverse pressure check is SATISFACTORY

Joint btw. blocks check:

Mesh material bear.capacity = 150.00 kN/m
Computed stress-state = 2.18 kN/m

Safety factor = 68.72 > 1.00

Joint between blocks is SATISFACTORY

Slope stability analysis

Input data

Project

Settings

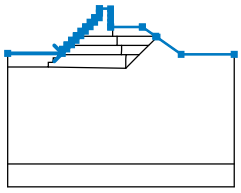
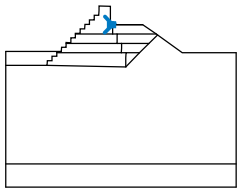
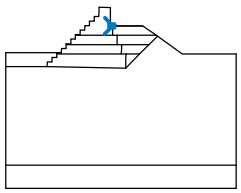
Standard - safety factors

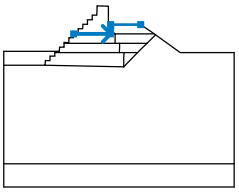
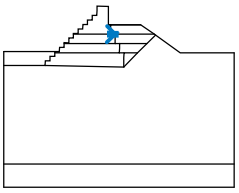
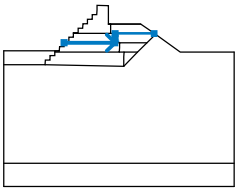
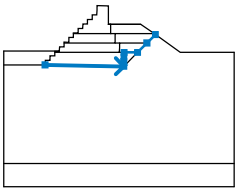
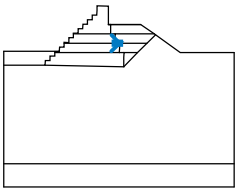
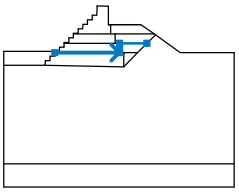
Stability analysis

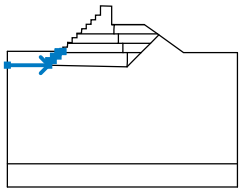
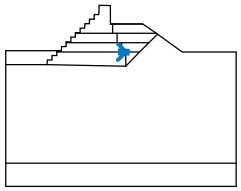
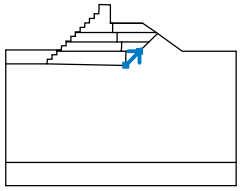
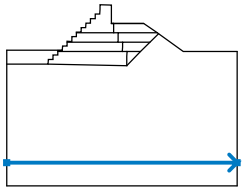
Earthquake analysis : Standard
Verification methodology : Safety factors (ASD)

Safety factors			
Seismic design situation			
Safety factor :	SF_s =	1.00	[–]

Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-22.65	-5.76	-10.64	-5.76	-10.62	-4.82
		-9.62	-4.83	-9.60	-4.02	-9.60	-3.83
		-8.60	-3.85	-8.59	-2.85	-7.59	-2.87
		-7.57	-2.01	-7.57	-1.87	-6.57	-1.89
		-6.55	-0.89	-5.55	-0.90	-5.53	0.10
		-4.53	0.08	-4.52	1.08	-3.52	1.06
		-3.50	2.06	-2.50	2.04	-2.48	3.04
		-2.46	4.04	-0.03	4.00	-0.03	3.00
		-0.03	2.00	-0.03	1.00	-0.03	0.00
		0.00	0.00	7.00	0.00	7.01	-0.01
		9.88	-2.03	10.15	-2.22	15.50	-6.00
		27.18	-6.00				
2		-0.03	0.00	0.47	-0.01		
3		0.00	0.00	0.47	-0.01		

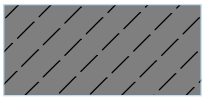
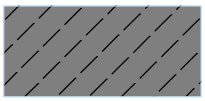
No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
4		-7.57	-2.01	0.43	-2.01	0.45	-1.01
		0.47	-0.01	7.01	-0.01		
5		0.43	-2.01	1.43	-2.03		
6		-9.60	-4.02	1.40	-4.02	1.41	-3.03
		1.43	-2.03	9.88	-2.03		
7		-13.69	-8.76	3.31	-9.06	3.32	-8.06
		3.34	-7.06	3.36	-6.06	6.31	-6.06
		8.33	-4.04	10.15	-2.22		
8		1.40	-4.02	2.39	-4.04		
9		-11.64	-6.04	2.36	-6.04	2.38	-5.04
		2.39	-4.04	8.33	-4.04		

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
10		-22.65	-8.76	-13.69	-8.76	-13.67	-7.76
		-12.67	-7.78	-12.66	-6.78	-11.66	-6.80
		-11.64	-6.04	-11.64	-5.80	-10.64	-5.82
		-10.64	-5.76				
11		2.36	-6.04	3.36	-6.06		
12		3.31	-9.06	6.31	-6.06		
13		-22.65	-30.00	27.18	-30.00		

Soil parameters - effective stress state

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]
1	ZHAVORR		36.00	0.00	21.00
2	GABION		38.00	0.00	23.00

Soil parameters - uplift

No.	Name	Pattern	γsat [kN/m3]	γs [kN/m3]	n [–]
1	ZHAVORR		21.00		
2	GABION		23.00		

Soil parameters

ZHAVORR

Unit weight : $\gamma = 21.00$ kN/m^3

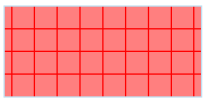
Stress-state : effective

Angle of internal friction : $\varphi_{ef} = 36.00$ °

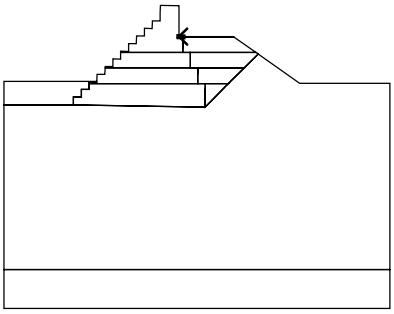
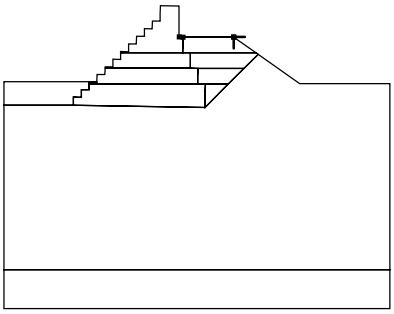
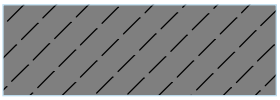
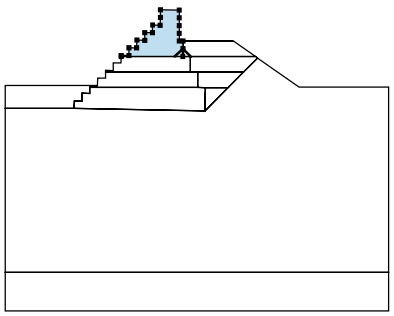
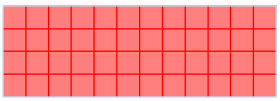
Cohesion of soil : $c_{ef} = 0.00$ kPa

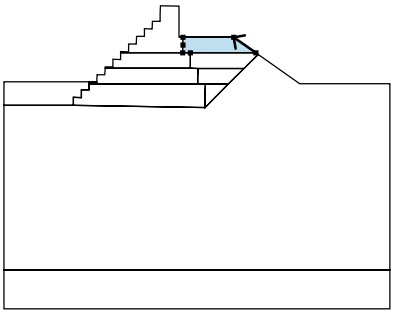
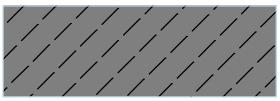
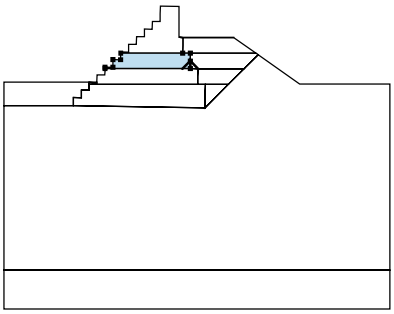
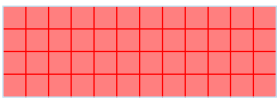
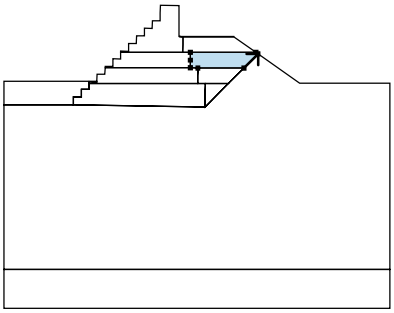
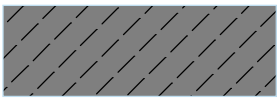
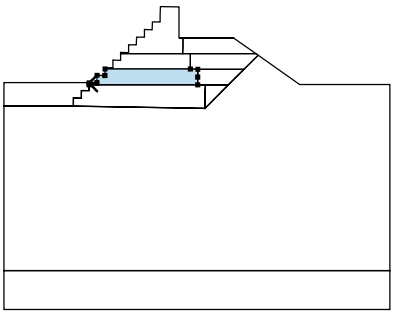
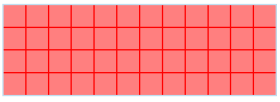
Saturated unit weight : $\gamma_{sat} = 21.00$ kN/m^3

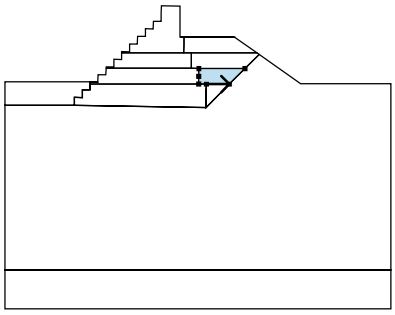
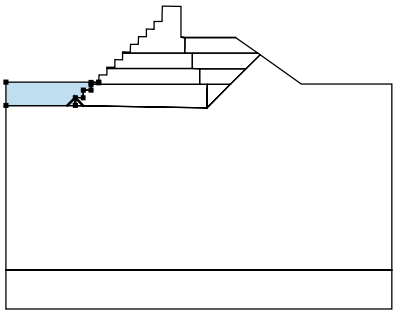
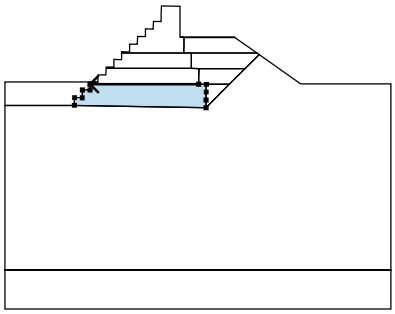
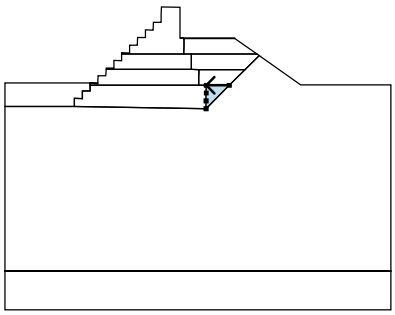
Rigid bodies

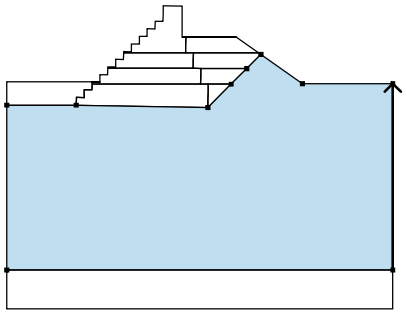
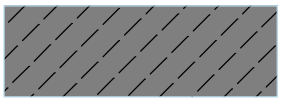
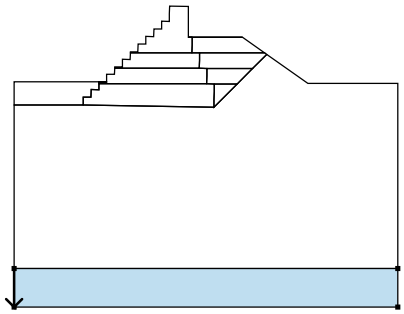
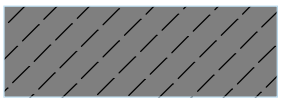
No.	Name	Sample	γ [kN/m3]
1	Material of structure		26.00

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned
		x	z	x	z	soil
1		0.00	0.00	-0.03	0.00	Material of structure
		0.47	-0.01			
2		7.01	-0.01	7.00	0.00	ZHAVORR
		0.00	0.00	0.47	-0.01	
3		0.43	-2.01	0.45	-1.01	Material of structure
		0.47	-0.01	-0.03	0.00	
		-0.03	1.00	-0.03	2.00	
		-0.03	3.00	-0.03	4.00	
		-2.46	4.04	-2.48	3.04	
		-2.50	2.04	-3.50	2.06	
		-3.52	1.06	-4.52	1.08	
		-4.53	0.08	-5.53	0.10	
		-5.55	-0.90	-6.55	-0.89	
		-6.57	-1.89	-7.57	-1.87	
		-7.57	-2.01			

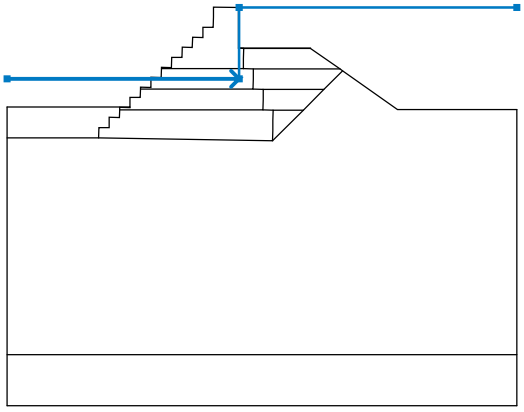
No.	Surface position	Coordinates of surface points [m]				Assigned
		x	z	x	z	soil
4		9.88	-2.03	7.01	-0.01	ZHAVORR
		0.47	-0.01	0.45	-1.01	
		0.43	-2.01	1.43	-2.03	
5		1.40	-4.02	1.41	-3.03	Material of structure
		1.43	-2.03	0.43	-2.01	
		-7.57	-2.01	-7.59	-2.87	
		-8.59	-2.85	-8.60	-3.85	
		-9.60	-3.83	-9.60	-4.02	
6		8.33	-4.04	10.15	-2.22	ZHAVORR
		9.88	-2.03	1.43	-2.03	
		1.41	-3.03	1.40	-4.02	
		2.39	-4.04			
7		-10.64	-5.82	-11.64	-5.80	Material of structure
		-11.64	-6.04	2.36	-6.04	
		2.38	-5.04	2.39	-4.04	
		1.40	-4.02	-9.60	-4.02	
		-9.62	-4.83	-10.62	-4.82	
		-10.64	-5.76			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
8		3.36	-6.06	6.31	-6.06	ZHAVORR
		8.33	-4.04	2.39	-4.04	
		2.38	-5.04	2.36	-6.04	
9		-13.69	-8.76	-13.67	-7.76	GABION
		-12.67	-7.78	-12.66	-6.78	
		-11.66	-6.80	-11.64	-6.04	
		-11.64	-5.80	-10.64	-5.82	
		-10.64	-5.76	-22.65	-5.76	
		-22.65	-8.76			
10		2.36	-6.04	-11.64	-6.04	Material of structure
		-11.66	-6.80	-12.66	-6.78	
		-12.67	-7.78	-13.67	-7.76	
		-13.69	-8.76	3.31	-9.06	
		3.32	-8.06	3.34	-7.06	
		3.36	-6.06			
11		6.31	-6.06	3.36	-6.06	ZHAVORR
		3.34	-7.06	3.32	-8.06	
		3.31	-9.06			

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
12		27.18	-30.00	27.18	-6.00	ZHAVORR
		15.50	-6.00	10.15	-2.22	
		8.33	-4.04	6.31	-6.06	
		3.31	-9.06	-13.69	-8.76	
		-22.65	-8.76	-22.65	-30.00	
13		-22.65	-30.00	-22.65	-35.00	ZHAVORR
		27.18	-35.00	27.18	-30.00	
						

Water

Water type : GWT

No.	GWT location	Coordinates of GWT points [m]					
		x	z	x	z	x	z
1		-22.65	-3.00	0.03	-3.00	0.03	4.00
		27.18	4.00				

Tensile crack

Tensile crack not input.

Earthquake

Horizontal seismic coefficient : K_h = 0.1200

Vertical seismic coefficient : K_v = 0.0600

Settings of the stage of construction

Design situation : seismic

Results (Stage of construction 1)

Analysis 1

Circular slip surface

Slip surface parameters							
Center :	x =	5.96	[m]	Angles :	α_1 =	-67.45	[°]
	z =	2.99	[m]		α_2 =	66.80	[°]
Radius :	R =	22.82	[m]				
The slip surface after optimization.							

Slope stability verification (Bishop)

Sum of active forces : F_a = 709.38 kN/m

Sum of passive forces : F_p = 5049.33 kN/m

Sliding moment : M_a = 16188.08 kNm/m

Resisting moment : M_p = 115225.70 kNm/m

Factor of safety = 7.12 > 1.00

Slope stability ACCEPTABLE

Valter Begaj

Digitally signed by Valter Begaj
Date: 2023.04.20 16:44:59 +02'00'