



Analysis of Redi Rock wall

Input data

Project

Task : Verification for PC Redi-Rock Wall
Part : Section 1-1 with 25% reinf. coverage
Customer : Pärnu Graniit
Author : Kenneth Knox
Date : 05/02/19
Project ID : Mustla Bridge, Estonia
Project number : 18-5599

Settings

Standard - EN 1997 - DA1

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
Internal stability : Standard - straight slip surface
Reduction coeff. of contact first block - base : 1.00
Verification methodology : according to EN 1997
Design approach : 1 - reduction of actions and soil parameters

Partial factors on actions (A)					
Permanent design situation					
		Combination 1		Combination 2	
		Unfavourable	Favourable	Unfavourable	Favourable
Permanent actions :	$\gamma_G =$	1.35 [-]	1.00 [-]	1.00 [-]	1.00 [-]
Variable actions :	$\gamma_Q =$	1.50 [-]	0.00 [-]	1.30 [-]	0.00 [-]
Water load :	$\gamma_w =$	1.35 [-]		1.00 [-]	

Partial factors for soil parameters (M)			
Permanent design situation			
		Combination 1	Combination 2
Partial factor on internal friction :	$\gamma_\phi =$	1.00 [-]	1.25 [-]
Partial factor on effective cohesion :	$\gamma_c =$	1.00 [-]	1.25 [-]
Partial factor on undrained shear strength :	$\gamma_{cu} =$	1.00 [-]	1.40 [-]
Partial factor on Poisson's ratio :	$\gamma_v =$	1.00 [-]	1.00 [-]

Partial factors for variable actions		
Permanent design situation		
Factor for combination value :	$\psi_0 =$	0.70 [-]
Factor for frequent value :	$\psi_1 =$	0.50 [-]
Factor for quasi-permanent value :	$\psi_2 =$	0.30 [-]

Blocks

No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m ³]
1	Top block 24 straight	457.2	609.6	16.97
2	Block 28 PC	457.2	711.2	18.85
3	Block 41 PC	457.2	1028.7	18.85



No.	Description	Height h [mm]	Width w [mm]	Unit weight γ [kN/m ³]
4	Top block 28	457.2	711.2	18.85
5	Top block 41	457.2	1028.7	18.85
6	Top block 24 straight garden	457.2	609.6	12.57

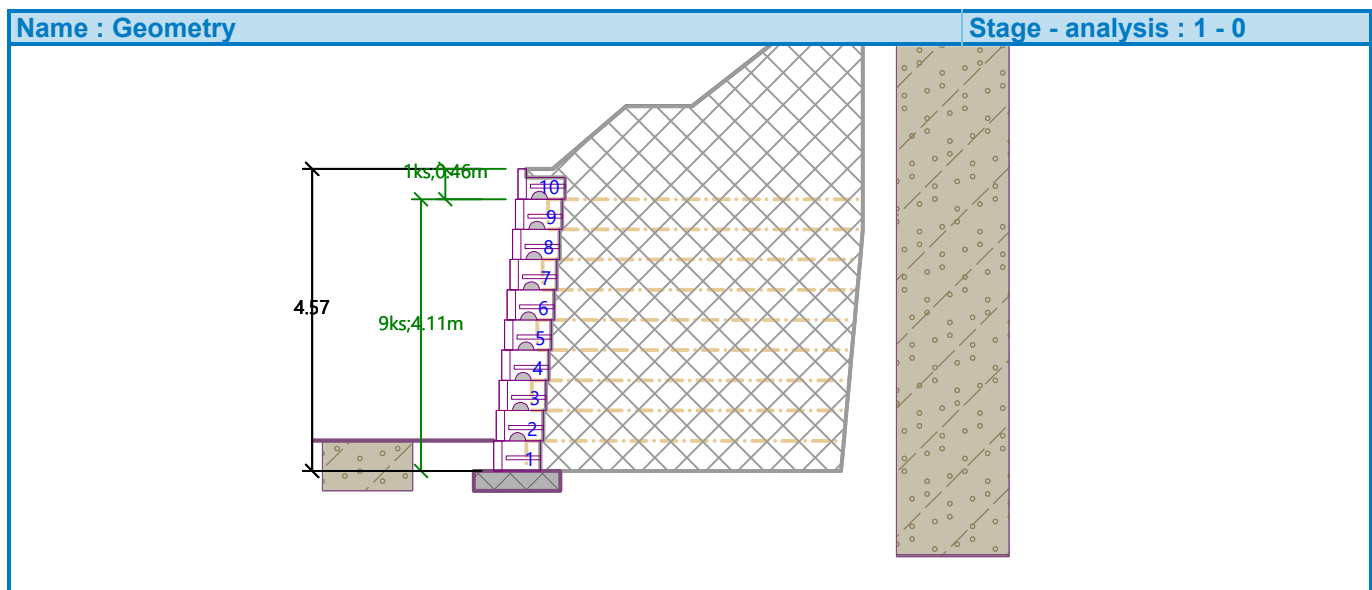
No.	Description	Min. shear strength $F_{\min}$ [kN/m]	Max. shear strength $F_{\max}$ [kN/m]	Friction f [°]
1	Top block 24 straight	88.45	164.56	44.00
2	Block 28 PC	88.45	164.56	44.00
3	Block 41 PC	88.45	164.56	44.00
4	Top block 28	88.45	164.56	44.00
5	Top block 41	88.45	164.56	44.00
6	Top block 24 straight garden	88.45	164.56	44.00

Setbacks

No.	Setback s [mm]
1	0.254
2	9.525
3	41.275
6	82.550

Geometry

No. group	Description	Count	Setback s [mm]
1	Block 28 PC	9	41.3
2	Top block 28	1	-



Base

Geometry

Upper setback $a_1 = 0.30$ m

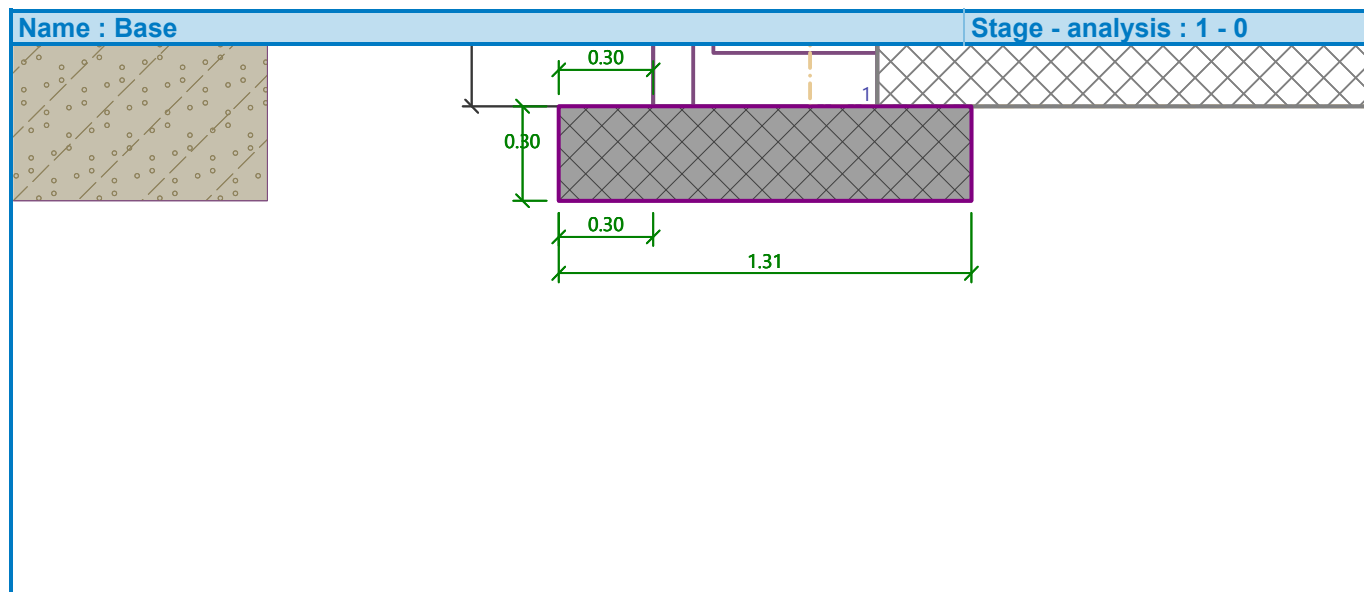
Lower setback $a_2 = 0.30$ m



Height $h = 0.30$ m
Width $b = 1.31$ m

Material

Soil creating foundation - Compacted stone levelling pad



Types of reinforcements

No.	Name	Type of reinforcement	Line type	Tensile strength		
				T_{ult} [kN/m]	R_t [kN/m]	R_{con} [kN/m]
1	Miragrid 5XT	Miragrid 5XT	-----	68.59	30.20	31.73
2	Miragrid 8XT	Miragrid 8XT	-----	107.99	49.53	49.96
3	Miragrid 10XT	Miragrid 10XT	-----	138.64	63.59	62.57
4	Miragrid 20XT	Miragrid 20XT	~~~~~	200.01	95.72	88.00
5	Miragrid 24XT	Miragrid 24XT	~~~~~	400.09	200.18	154.12

Reinforcement details

1. Miragrid 5XT

Short-term char. strength	$T_{ult} = 68.59$ kN/m
Creep red. factor	$RF_{CR} = 1.58$
Durability red. factor	$RF_D = 1.15$
Installation damage red. factor	$RF_{ID} = 1.25$
Long-term design strength	$R_t = 30.20$ kN/m
Coefficient of direct slip along reinforcement	$C_{ds} = 0.67$
Coefficient of interaction of soil and geo-reinforcement	$C_i = 0.67$
Scale correction factor	$\alpha = 0.8$
Long-term strength reduction factor	$CR_{Cr} = 0.532$
Analysis of long-term strength	$R_{con} = 31.73$ kN/m

2. Miragrid 8XT

Short-term char. strength	$T_{ult} = 107.99$ kN/m
Creep red. factor	$RF_{CR} = 1.58$
Durability red. factor	$RF_D = 1.15$



Installation damage red. factor	RF_{ID}	=	1.20
Long-term design strength	R_t	=	49.53 kN/m
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67
Scale correction factor	α	=	0.8
Long-term strength reduction factor	CR_{cr}	=	0.532
Analysis of long-term strength	R_{con}	=	49.96 kN/m

3. Miragrid 10XT

Short-term char. strength	T_{ult}	=	138.64 kN/m
Creep red. factor	RF_{CR}	=	1.58
Durability red. factor	RF_D	=	1.15
Installation damage red. factor	RF_{ID}	=	1.20
Long-term design strength	R_t	=	63.59 kN/m
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67
Scale correction factor	α	=	0.8
Long-term strength reduction factor	CR_{cr}	=	0.519
Analysis of long-term strength	R_{con}	=	62.57 kN/m

4. Miragrid 20XT

Short-term char. strength	T_{ult}	=	200.01 kN/m
Creep red. factor	RF_{CR}	=	1.58
Durability red. factor	RF_D	=	1.15
Installation damage red. factor	RF_{ID}	=	1.15
Long-term design strength	R_t	=	95.72 kN/m
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67
Scale correction factor	α	=	0.8
Long-term strength reduction factor	CR_{cr}	=	0.506
Analysis of long-term strength	R_{con}	=	88.00 kN/m

5. Miragrid 24XT

Short-term char. strength	T_{ult}	=	400.09 kN/m
Creep red. factor	RF_{CR}	=	1.58
Durability red. factor	RF_D	=	1.15
Installation damage red. factor	RF_{ID}	=	1.10
Long-term design strength	R_t	=	200.18 kN/m
Coefficient of direct slip along reinforcement	C_{ds}	=	0.67
Coefficient of interaction of soil and geo-reinforcement	C_i	=	0.67
Scale correction factor	α	=	0.8
Long-term strength reduction factor	CR_{cr}	=	0.443
Analysis of long-term strength	R_{con}	=	154.12 kN/m

Reinforcements

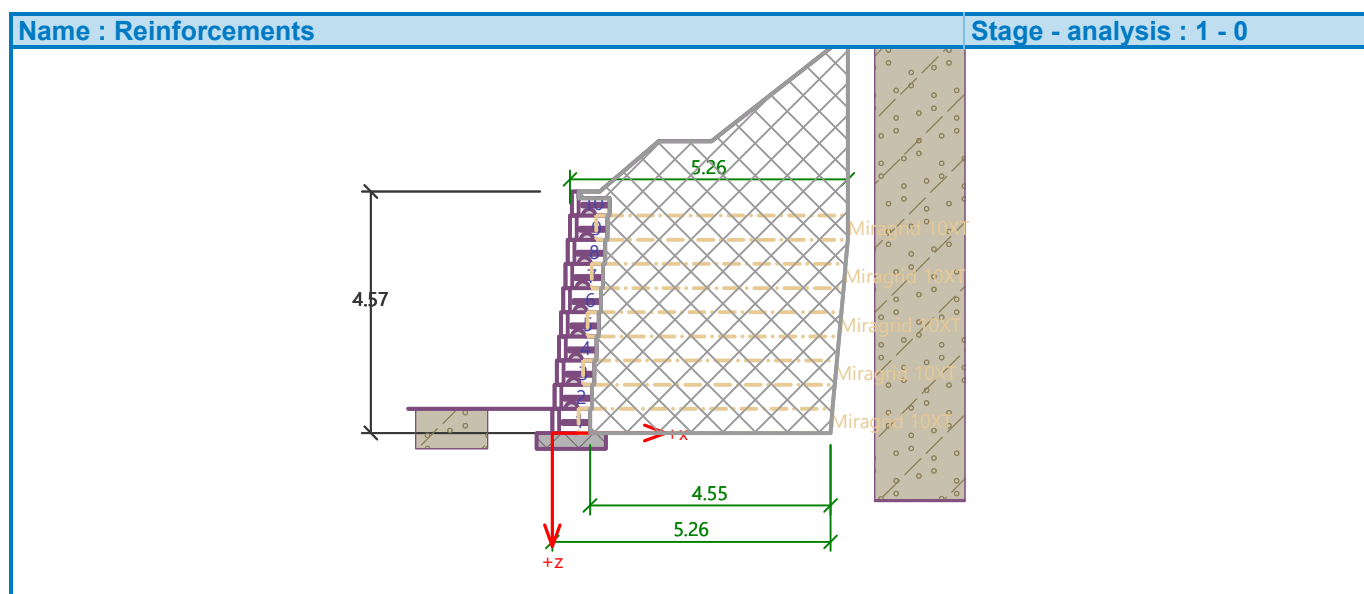
Input mode : 1 reinforcement type
 Reinf. installation : in every other row of blocks (25%)
 Type of reinforcement : Miragrid 10XT
 Top reinforcement : straight (25%)
 Reinforcement geometry : identical length of reinforcements
 Length of reinforcement $l = 4.55$ m
 Reinforced soil - Engineered Reinforced Fill

Reinforcements

No.	Consider	Name	Length of reinforcement l [m]	End pt. coordinate l_k [m]
1	Yes	Miragrid 10XT	4.55	



No.	Consider	Name	Length of reinforcement l [m]	End pt. coordinate l_k [m]
2	No			
3	Yes	Miragrid 10XT	4.55	
4	No			
5	Yes	Miragrid 10XT	4.55	
6	No			
7	Yes	Miragrid 10XT	4.55	
8	No			
9	Yes	Miragrid 10XT	4.55	
10	No			



Basic soil parameters

No.	Name	Pattern	Φ_{ef} [°]	C_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ [°]
1	silty SAND (Upfill)		32.00	0.00	17.00	8.00	20.00
2	silty SAND (In-situ)		30.00	0.00	17.00	8.00	20.00
3	gravelly silty SAND (Glacial)		32.00	0.00	17.00	8.00	20.67
4	weak LIMESTONE (Bedrock)		35.00	0.00	20.00	11.00	20.67
5	Engineered Reinforced Fill		35.00	0.00	18.00	10.00	23.67
6	Compacted stone levelling pad		35.00	0.00	18.00	10.00	23.67

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

Soil parameters

silty SAND (Upfill)



Unit weight : $\gamma = 17.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{\text{ef}} = 32.00^\circ$
Cohesion of soil : $c_{\text{ef}} = 0.00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 20.00^\circ$
Saturated unit weight : $\gamma_{\text{sat}} = 18.00 \text{ kN/m}^3$

silty SAND (In-situ)

Unit weight : $\gamma = 17.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{\text{ef}} = 30.00^\circ$
Cohesion of soil : $c_{\text{ef}} = 0.00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 20.00^\circ$
Saturated unit weight : $\gamma_{\text{sat}} = 18.00 \text{ kN/m}^3$

gravelly silty SAND (Glacial)

Unit weight : $\gamma = 17.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{\text{ef}} = 32.00^\circ$
Cohesion of soil : $c_{\text{ef}} = 0.00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 20.67^\circ$
Saturated unit weight : $\gamma_{\text{sat}} = 18.00 \text{ kN/m}^3$

weak LIMESTONE (Bedrock)

Unit weight : $\gamma = 20.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{\text{ef}} = 35.00^\circ$
Cohesion of soil : $c_{\text{ef}} = 0.00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 20.67^\circ$
Saturated unit weight : $\gamma_{\text{sat}} = 21.00 \text{ kN/m}^3$

Engineered Reinforced Fill

Unit weight : $\gamma = 18.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{\text{ef}} = 35.00^\circ$
Cohesion of soil : $c_{\text{ef}} = 0.00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 23.67^\circ$
Saturated unit weight : $\gamma_{\text{sat}} = 20.00 \text{ kN/m}^3$

Compacted stone levelling pad

Unit weight : $\gamma = 18.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{\text{ef}} = 35.00^\circ$
Cohesion of soil : $c_{\text{ef}} = 0.00 \text{ kPa}$
Angle of friction struc.-soil : $\delta = 23.67^\circ$
Saturated unit weight : $\gamma_{\text{sat}} = 20.00 \text{ kN/m}^3$

Geological profile and assigned soils

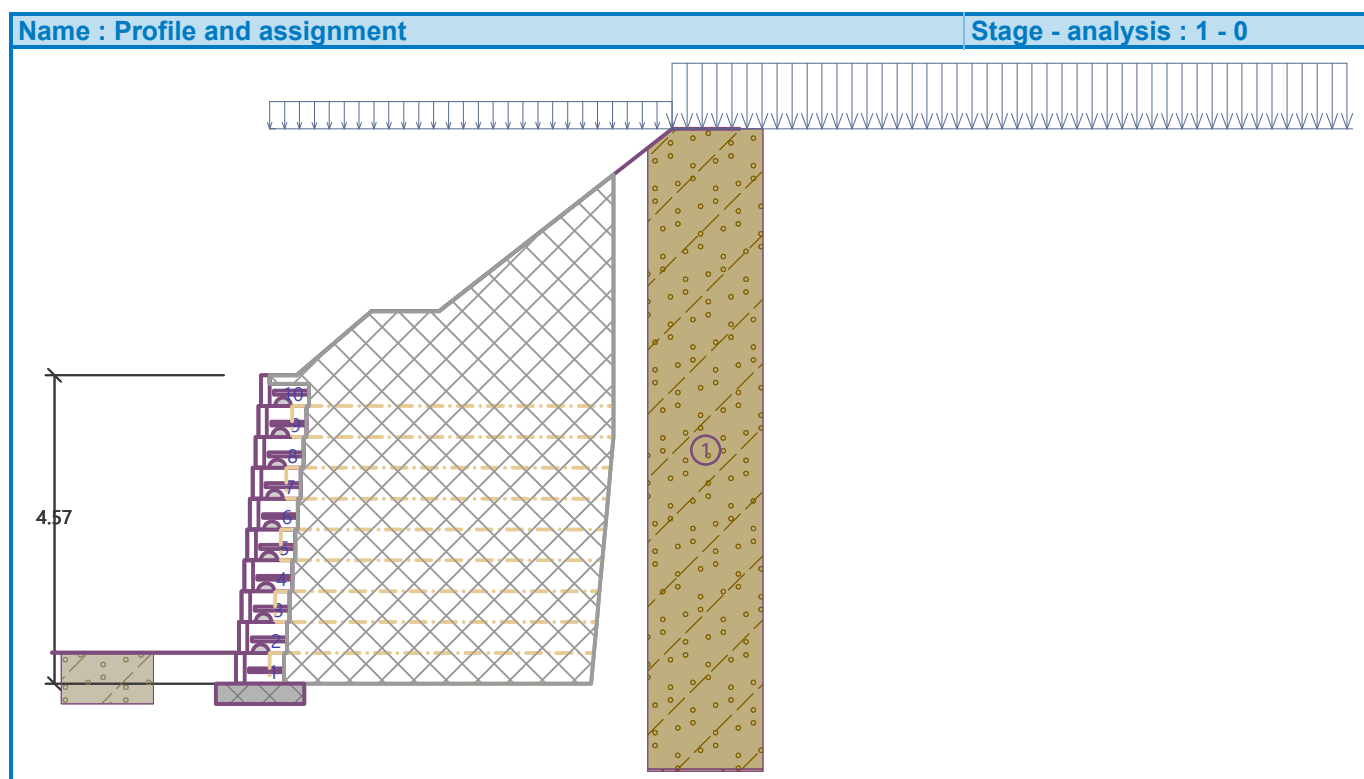
Position information

Terrain elevation = 82.27 m
GPS : N 59.0465330; E 25.4254490
N 59°2'47.52'; E 25°25'31.62'

Geological profile and assigned soils



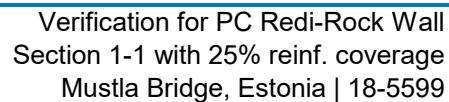
No.	Thickness of layer t [m]	Depth z [m]	Altitude [m]	Assigned soil	Pattern
1	5.84	0.00 .. 5.84	82.27 .. 76.43	silty SAND (Upfill)	
2	0.65	5.84 .. 6.49	76.43 .. 75.78	silty SAND (In-situ)	
3	0.60	6.49 .. 7.09	75.78 .. 75.18	gravelly silty SAND (Glacial)	
4	-	7.09 .. ∞	75.18 .. -	weak LIMESTONE (Bedrock)	



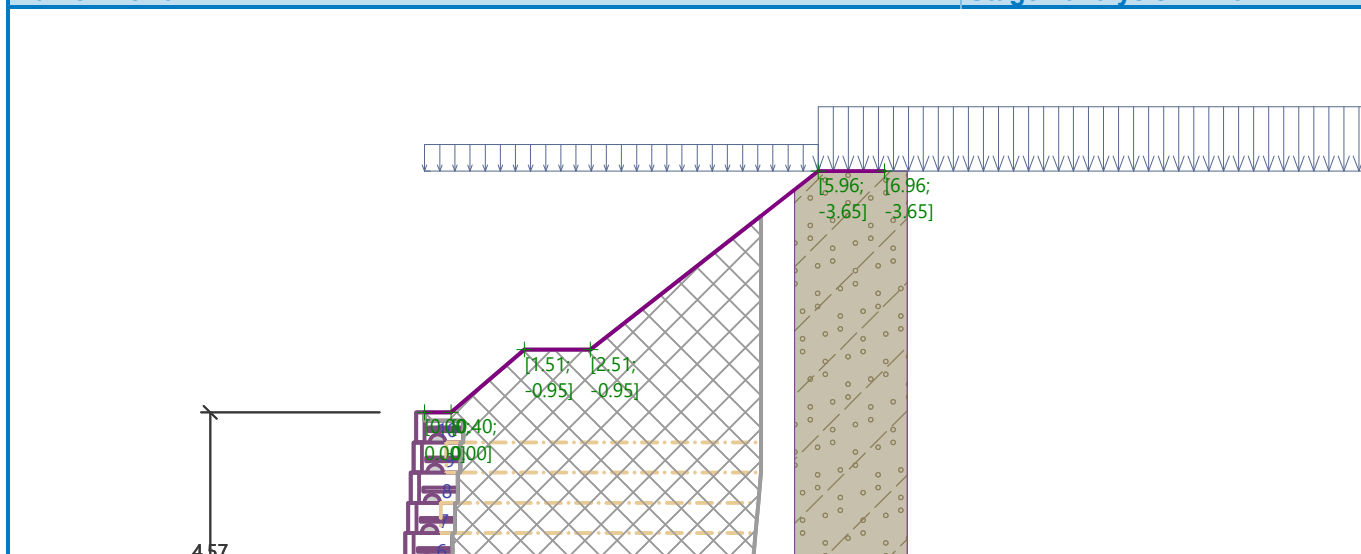
Terrain profile

No.	Coordinate x [m]	Depth z [m]
1	0.00	0.00
2	0.40	0.00
3	1.51	-0.95
4	2.51	-0.95
5	5.96	-3.65
6	6.96	-3.65

Origin [0,0] is located in upper right edge of construction.
Positive coordinate +z has downward direction.



Stage - analysis : 1 - 0

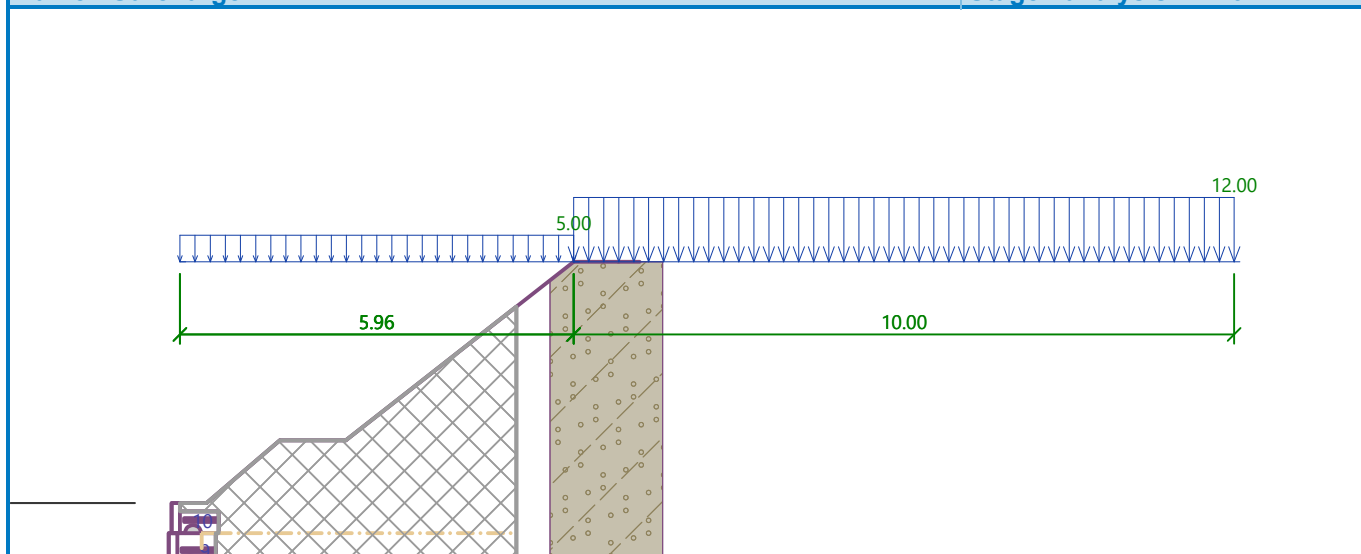


Ground water table is located below the structure.

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		variable	12.00		5.96	10.00	on terrain
2	Yes		variable	5.00		0.00	5.96	on terrain

No.	Name
1	Traffic Load
2	Pedestrian Load

Stage - analysis : 1 - 0



Resistance on front face of the structure: not considered
Soil on front face of the structure - silty SAND (Upfill)



Soil thickness in front of structure $h = 0.76 \text{ m}$

Terrain in front of structure is flat.

Settings of the stage of construction

Design situation : permanent

Verification No. 1

Forces acting on construction - combination 1

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - reinforced soil	0.00	-3.05	494.55	3.37	1.000	1.000	1.350
Active pressure	133.78	-2.69	83.59	5.59	1.350	1.350	1.350
Traffic Load	21.27	-3.82	13.29	5.59	1.500	1.500	1.500
Pedestrian Load	1.42	-7.18	0.89	5.59	1.500	1.500	1.500
Weight - wall	0.00	-2.23	59.90	0.54	1.000	1.000	1.350

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability

Resisting moment $M_{res} = 2446.87 \text{ kNm/m}$

Overturning moment $M_{ovr} = 623.78 \text{ kNm/m}$

Wall for overturning is SATISFACTORY

Check for slip

Resisting horizontal force $H_{res} = 394.77 \text{ kN/m}$

Active horizontal force $H_{act} = 214.63 \text{ kN/m}$

Wall for slip is SATISFACTORY

Overall check - WALL is SATISFACTORY

Forces acting on construction - combination 2

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Coeff. overtur.	Coeff. sliding	Coeff. stress
Weight - reinforced soil	0.00	-3.05	494.55	3.37	1.000	1.000	1.000
Active pressure	170.98	-2.70	85.47	5.59	1.000	1.000	1.000
Traffic Load	27.81	-3.82	13.90	5.59	1.300	1.300	1.300
Pedestrian Load	1.85	-7.12	0.93	5.59	1.300	1.300	1.300
Weight - wall	0.00	-2.23	59.90	0.54	1.000	1.000	1.000

Verification of complete wall

Place of verification : bottom of blocks

Check for overturning stability

Resisting moment $M_{res} = 2282.65 \text{ kNm/m}$

Overturning moment $M_{ovr} = 616.16 \text{ kNm/m}$

Wall for overturning is SATISFACTORY

Check for slip

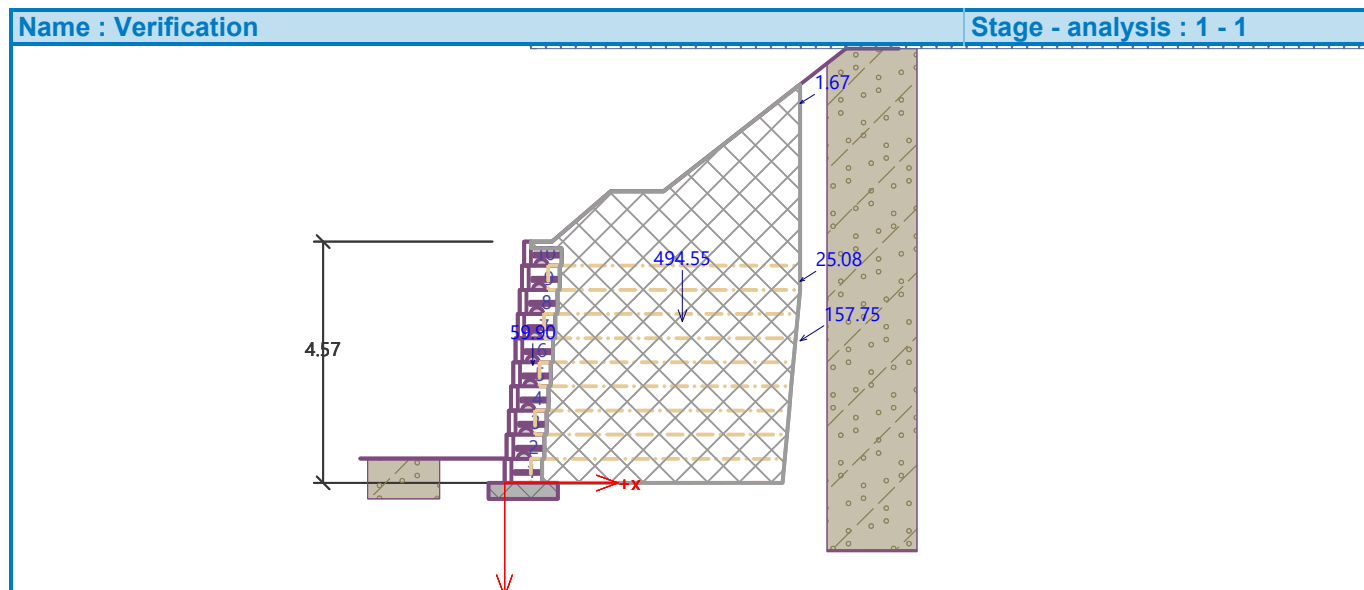
Resisting horizontal force $H_{res} = 302.34 \text{ kN/m}$

Active horizontal force $H_{act} = 209.54 \text{ kN/m}$

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	-95.20	882.62	214.63	0.000	167.76
2	-11.75	688.56	214.63	0.000	130.88
3	67.59	659.19	209.54	0.019	130.37
4	67.59	659.19	209.54	0.019	130.37

Service load acting at the center of footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]
1	-76.01	652.22	156.47

Verification of foundation soil

Place of verification : bottom of blocks

Stress in the footing bottom : rectangle

Eccentricity verification

Max. eccentricity of normal force $e = 0.000$

Maximum allowable eccentricity $e_{alw} = 0.333$

Eccentricity of the normal force is SATISFACTORY

Verification of bearing capacity

Max. stress at footing bottom $\sigma = 167.76 \text{ kPa}$

Bearing capacity of foundation soil $R_d = 200.00 \text{ kPa}$

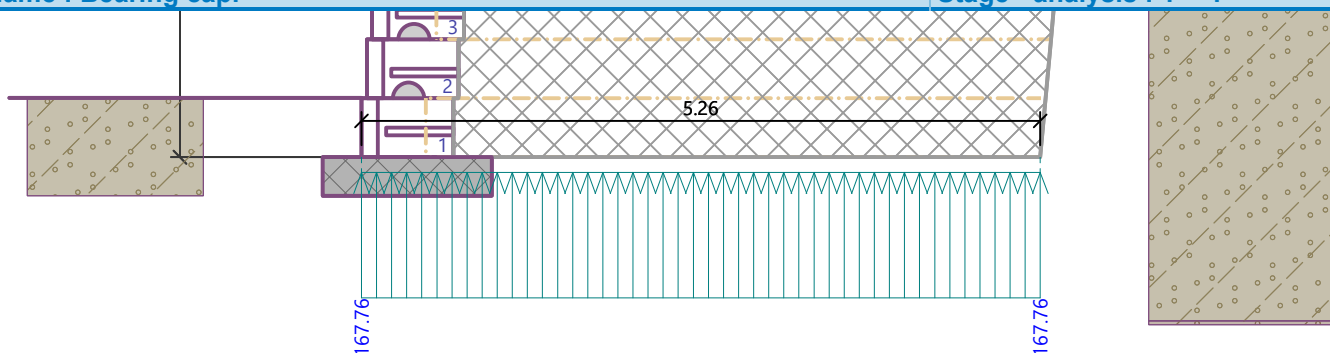
Bearing capacity of foundation soil is SATISFACTORY

Overall verification - bearing capacity of found. soil is SATISFACTORY



Name : Bearing cap.

Stage - analysis : 1 - -1



Verification of slip on georeinforcement No. 1

Forces acting on construction (verification of reinforcement No.: 1)

Name	F_{hor} [kN/m]	App.Pt. z [m]	F_{vert} [kN/m]	App.Pt. x [m]	Design coefficient
Weight - wall	0.00	-2.23	59.60	-1.19	1.000
Active pressure	170.60	-2.65	84.75	4.55	1.000
Traffic Load	26.98	-3.69	13.43	4.55	1.300
Pedestrian Load	2.59	-6.70	1.30	4.55	1.300
Weight - reinforced soil	0.00	-2.94	460.75	2.52	1.000
Pedestrian Load	0.00	-5.52	23.81	1.16	0.000

Verification against slip along geotextile No.: 1

Inclination of slip surface = 90.00 °
 Overall normal force acting on reinforcement = 564.64 kN/m
 Coefficient of reduction of slip along
 geo-textile = 0.92
 Resistance along geo-reinforcement = 323.72 kN/m
 Wall resistance = 41.74 kN/m
 Overall bearing capacity of reinforcements = 0.00 kN/m

Results for the most unfavorable combination - No. 2

Check for slip:

Resisting horizontal force H_{res} = 365.45 kN/m

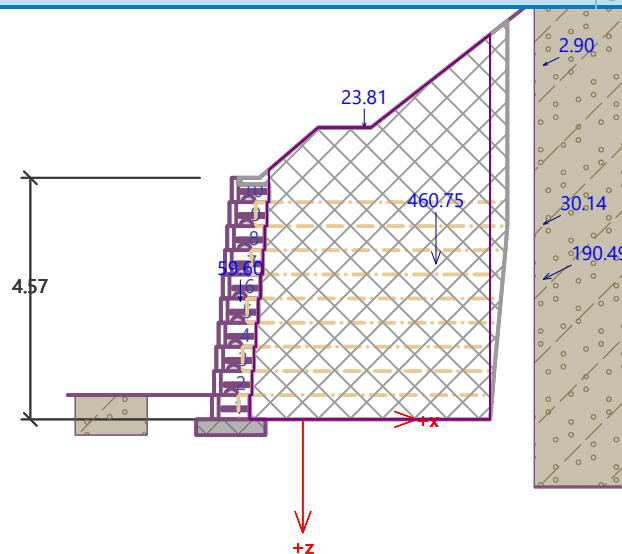
Active horiz. force H_{act} = 209.05 kN/m

Slip along geotextile is SATISFACTORY



Name : Slip on georeinf.

Stage - analysis : 1 - 1



Calculation of internal stability No. 1

Calculated forces and strength of reinforcements

No.	Name	F_x [kN/m]	Depth z [m]	R_t [kN/m]	Utiliz. [%]	T_p [kN/m]	Utiliz. [%]	R_{con} [kN/m]	Utiliz. [%]
1	Miragrid 10XT	-7.93	4.57	15.90	49.90	84.87	9.35	15.64	50.71
2	Miragrid 10XT	-14.42	4.11	15.90	90.74	75.51	19.10	15.64	92.21
3	Miragrid 10XT	-13.07	3.66	15.90	82.21	66.93	19.53	15.64	83.55
4	Miragrid 10XT	-11.17	3.20	15.90	70.25	58.87	18.97	15.64	71.39
5	Miragrid 10XT	-8.97	2.74	15.90	56.45	51.31	17.49	15.64	57.37
6	Miragrid 10XT	-7.96	2.29	15.90	50.09	44.26	17.99	15.64	50.91
7	Miragrid 10XT	-6.98	1.83	15.90	43.90	37.72	18.50	15.64	44.61
8	Miragrid 10XT	-5.99	1.37	15.90	37.71	31.69	18.91	15.64	38.32
9	Miragrid 10XT	-5.01	0.91	15.90	31.51	26.17	19.14	15.64	32.03
10	Miragrid 10XT	-5.62	0.46	15.90	35.32	21.16	26.54	15.64	35.90

Check for tensile strength (reinforcement No.2)

Tension strength $R_t = 15.90$ kN/m

Force in reinforcement $F_x = 14.42$ kN/m

Reinforcement for tensile strength is SATISFACTORY

Check for pull out resistance (reinforcement No.10)

Pull out resistance $T_p = 21.16$ kN/m

Force in reinforcement $F_x = 5.62$ kN/m

Reinforcement for pull out resistance is SATISFACTORY

Verification of connection strength (reinforcement No.2)

Connection strength $R_{con} = 15.64$ kN/m

Force in reinforcement $F_x = 14.42$ kN/m

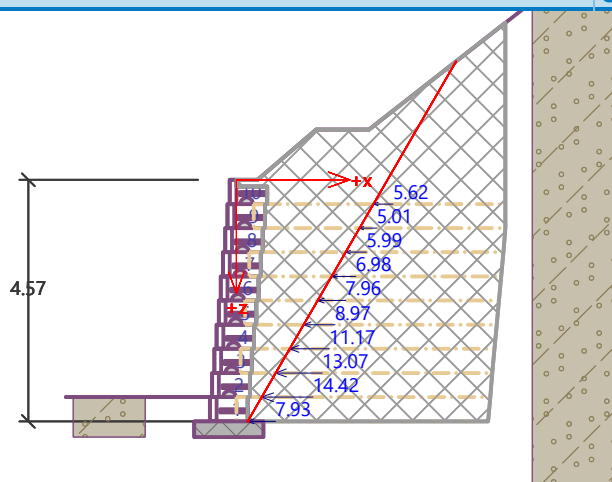
Connection strength is SATISFACTORY

Overall verification - reinforcement is SATISFACTORY



Name : Internal stability

Stage - analysis : 1 - 1



Slope stability analysis

Input data

Project

Settings

Standard - EN 1997 - DA1

Stability analysis

Earthquake analysis : Standard

Verification methodology : according to EN 1997

Design approach : 1 - reduction of actions and soil parameters

Partial factors on actions (A)

Permanent design situation

		Combination 1		Combination 2	
		Unfavourable	Favourable	Unfavourable	Favourable
Permanent actions :	$\gamma_G =$	1.35 [-]	1.00 [-]	1.00 [-]	1.00 [-]
Variable actions :	$\gamma_Q =$	1.50 [-]	0.00 [-]	1.30 [-]	0.00 [-]
Water load :	$\gamma_w =$	1.35 [-]		1.00 [-]	

Partial factors for soil parameters (M)

Permanent design situation

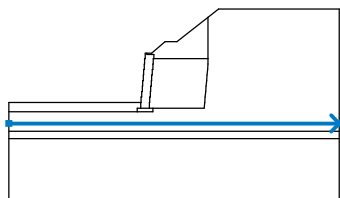
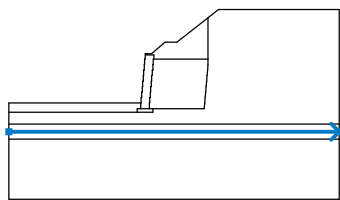
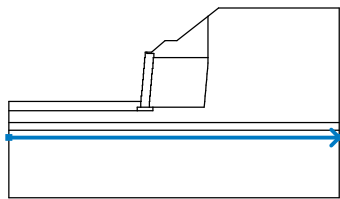
		Combination 1		Combination 2	
Partial factor on internal friction :	$\gamma_\phi =$	1.00 [-]		1.25 [-]	
Partial factor on effective cohesion :	$\gamma_c =$	1.00 [-]		1.25 [-]	
Partial factor on undrained shear strength :	$\gamma_{cu} =$	1.00 [-]		1.40 [-]	



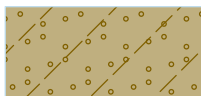
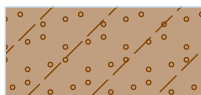
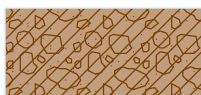
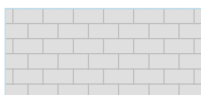
Interface

No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
1		-11.43	78.16	-0.50	78.16	-0.46	78.16
		-0.46	78.61	-0.42	78.61	-0.42	79.07
		-0.37	79.07	-0.37	79.53	-0.33	79.53
		-0.33	79.98	-0.29	79.98	-0.29	80.44
		-0.25	80.44	-0.25	80.90	-0.21	80.90
		-0.21	81.36	-0.17	81.36	-0.17	81.81
		-0.13	81.81	-0.13	82.27	0.00	82.27
		0.40	82.27	1.51	83.22	2.51	83.22
		5.09	85.24	5.96	85.92	15.96	85.92
2		-0.80	77.40	0.51	77.40	0.51	77.70
		4.76	77.70	4.80	78.16	4.85	78.61
		4.89	79.07	4.93	79.53	4.97	79.98
		5.01	80.44	5.05	80.90	5.09	81.36
		5.09	81.81	5.09	85.24		
3		0.00	82.27	0.00	82.14	0.58	82.14
4		-0.50	77.70	0.21	77.70	0.21	78.16
		0.25	78.16	0.25	78.61	0.30	78.61
		0.30	79.07	0.34	79.07	0.34	79.53
		0.38	79.53	0.38	79.98	0.42	79.98
		0.42	80.44	0.46	80.44	0.46	80.90
		0.50	80.90	0.50	81.36	0.54	81.36
		0.54	81.81	0.58	81.81	0.58	82.14
5		0.58	81.81	5.09	81.81		
6		-11.43	77.40	-0.80	77.40	-0.80	77.70
		-0.50	77.70	-0.50	78.16		
7		0.21	77.70	0.51	77.70		

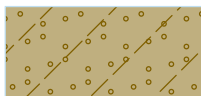


No.	Interface location	Coordinates of interface points [m]					
		x	z	x	z	x	z
8		-11.43	76.43	15.96	76.43		
9		-11.43	75.78	15.96	75.78		
10		-11.43	75.18	15.96	75.18		

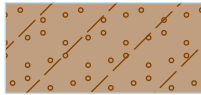
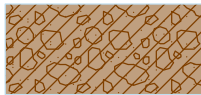
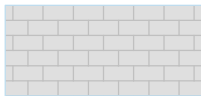
Soil parameters - effective stress state

No.	Name	Pattern	ϕ_{ef} [°]	c_{ef} [kPa]	γ [kN/m ³]
1	silty SAND (Upfill)		32.00	0.00	17.00
2	silty SAND (In-situ)		30.00	0.00	17.00
3	gravelly silty SAND (Glacial)		32.00	0.00	17.00
4	weak LIMESTONE (Bedrock)		35.00	0.00	20.00
5	Engineered Reinforced Fill		35.00	0.00	18.00
6	Compacted stone levelling pad		35.00	0.00	18.00

Soil parameters - uplift

No.	Name	Pattern	γ_{sat} [kN/m ³]	γ_s [kN/m ³]	n [—]
1	silty SAND (Upfill)		18.00		



No.	Name	Pattern	γ_{sat} [kN/m ³]	γ_s [kN/m ³]	n [-]
2	silty SAND (In-situ)		18.00		
3	gravelly silty SAND (Glacial)		18.00		
4	weak LIMESTONE (Bedrock)		21.00		
5	Engineered Reinforced Fill		20.00		
6	Compacted stone levelling pad		20.00		

Soil parameters

silty SAND (Upfill)

Unit weight : $\gamma = 17.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\phi_{ef} = 32.00^\circ$
Cohesion of soil : $c_{ef} = 0.00 \text{ kPa}$
Saturated unit weight : $\gamma_{sat} = 18.00 \text{ kN/m}^3$

silty SAND (In-situ)

Unit weight : $\gamma = 17.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\phi_{ef} = 30.00^\circ$
Cohesion of soil : $c_{ef} = 0.00 \text{ kPa}$
Saturated unit weight : $\gamma_{sat} = 18.00 \text{ kN/m}^3$

gravelly silty SAND (Glacial)

Unit weight : $\gamma = 17.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\phi_{ef} = 32.00^\circ$
Cohesion of soil : $c_{ef} = 0.00 \text{ kPa}$
Saturated unit weight : $\gamma_{sat} = 18.00 \text{ kN/m}^3$

weak LIMESTONE (Bedrock)

Unit weight : $\gamma = 20.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\phi_{ef} = 35.00^\circ$
Cohesion of soil : $c_{ef} = 0.00 \text{ kPa}$
Saturated unit weight : $\gamma_{sat} = 21.00 \text{ kN/m}^3$

Engineered Reinforced Fill

Unit weight : $\gamma = 18.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\phi_{ef} = 35.00^\circ$

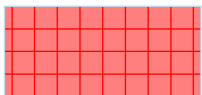


Cohesion of soil : $c_{ef} = 0.00 \text{ kPa}$
Saturated unit weight : $\gamma_{sat} = 20.00 \text{ kN/m}^3$

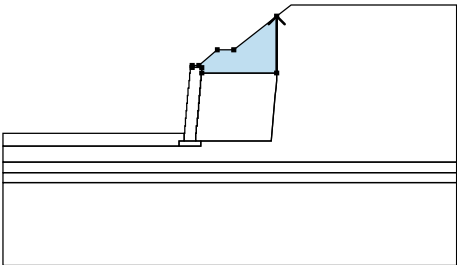
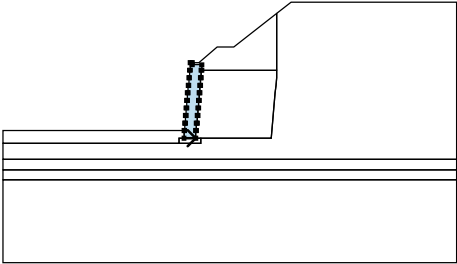
Compacted stone levelling pad

Unit weight : $\gamma = 18.00 \text{ kN/m}^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef} = 35.00^\circ$
Cohesion of soil : $c_{ef} = 0.00 \text{ kPa}$
Saturated unit weight : $\gamma_{sat} = 20.00 \text{ kN/m}^3$

Rigid bodies

No.	Name	Sample	γ [kN/m ³]
1	Wall material		18.85

Assigning and surfaces

No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
1		5.09	81.81	5.09	85.24	Engineered Reinforced Fill 
		2.51	83.22	1.51	83.22	
		0.40	82.27	0.00	82.27	
		0.00	82.14	0.58	82.14	
		0.58	81.81			
2		-0.50	77.70	0.21	77.70	Wall material 
		0.21	78.16	0.25	78.16	
		0.25	78.61	0.30	78.61	
		0.30	79.07	0.34	79.07	
		0.34	79.53	0.38	79.53	
		0.38	79.98	0.42	79.98	
		0.42	80.44	0.46	80.44	
		0.46	80.90	0.50	80.90	
		0.50	81.36	0.54	81.36	
		0.54	81.81	0.58	81.81	
		0.58	82.14	0.00	82.14	
		0.00	82.27	-0.13	82.27	
		-0.13	81.81	-0.17	81.81	
		-0.17	81.36	-0.21	81.36	
		-0.21	80.90	-0.25	80.90	
		-0.25	80.44	-0.29	80.44	
		-0.29	79.98	-0.33	79.98	
		-0.33	79.53	-0.37	79.53	
		-0.37	79.07	-0.42	79.07	
		-0.42	78.61	-0.46	78.61	
		-0.46	78.16	-0.50	78.16	



No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
3		0.51	77.70	4.76	77.70	Engineered Reinforced Fill
		4.80	78.16	4.85	78.61	
		4.89	79.07	4.93	79.53	
		4.97	79.98	5.01	80.44	
		5.05	80.90	5.09	81.36	
		5.09	81.81	0.58	81.81	
		0.54	81.81	0.54	81.36	
		0.50	81.36	0.50	80.90	
		0.46	80.90	0.46	80.44	
		0.42	80.44	0.42	79.98	
		0.38	79.98	0.38	79.53	
		0.34	79.53	0.34	79.07	
		0.30	79.07	0.30	78.61	
		0.25	78.61	0.25	78.16	
		0.21	78.16	0.21	77.70	
4		-0.80	77.40	-0.80	77.70	silty SAND (Upfill)
		-0.50	77.70	-0.50	78.16	
		-11.43	78.16	-11.43	77.40	
5		0.21	77.70	-0.50	77.70	Compacted stone levelling pad
		-0.80	77.70	-0.80	77.40	
		0.51	77.40	0.51	77.70	
6		15.96	76.43	15.96	85.92	silty SAND (Upfill)
		5.96	85.92	5.09	85.24	
		5.09	81.81	5.09	81.36	
		5.05	80.90	5.01	80.44	
		4.97	79.98	4.93	79.53	
		4.89	79.07	4.85	78.61	
		4.80	78.16	4.76	77.70	
		0.51	77.70	0.51	77.40	
		-0.80	77.40	-11.43	77.40	
		-11.43	76.43			
7		15.96	75.78	15.96	76.43	silty SAND (In-situ)
		-11.43	76.43	-11.43	75.78	



No.	Surface position	Coordinates of surface points [m]				Assigned soil
		x	z	x	z	
8		15.96	75.18	15.96	75.78	gravelly silty SAND (Glacial)
		-11.43	75.78	-11.43	75.18	
9		-11.43	75.18	-11.43	70.18	weak LIMESTONE (Bedrock)
		15.96	70.18	15.96	75.18	

Reinforcements

No.	Point to the left		Point to the right		Length L [m]	Strength R _t [kN/m]	Pull out resist.	End of reinf.
	x [m]	z [m]	x [m]	z [m]				
1	0.21	77.70	4.76	77.70	4.55	15.90	C = 0.67	Fixed
2	0.25	78.16	4.80	78.16	4.55	15.90	C = 0.67	Fixed
3	0.30	78.61	4.85	78.61	4.55	15.90	C = 0.67	Fixed
4	0.34	79.07	4.89	79.07	4.55	15.90	C = 0.67	Fixed
5	0.38	79.53	4.93	79.53	4.55	15.90	C = 0.67	Fixed
6	0.42	79.98	4.97	79.98	4.55	15.90	C = 0.67	Fixed
7	0.46	80.44	5.01	80.44	4.55	15.90	C = 0.67	Fixed
8	0.50	80.90	5.05	80.90	4.55	15.90	C = 0.67	Fixed
9	0.54	81.36	5.09	81.36	4.55	15.90	C = 0.67	Fixed
10	0.58	81.81	5.13	81.81	4.55	15.90	C = 0.67	Fixed

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	variable	on terrain	x = 5.96	l = 10.00		0.00	12.00	kN/m ²
2	strip	variable	on terrain	x = 0.00	l = 5.96		0.00	5.00	kN/m ²

Surcharges

No.	Name
1	Traffic Load
2	Pedestrian Load

Water

Water type : No water

Tensile crack

Tensile crack not input.

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 =	-1.51 [m]	Angles :	α_1 =	-22.59 [°]
	z =	89.35 [m]		α_2 =	73.56 [°]
Radius :	R =	12.12 [m]			
The slip surface after optimization.					

Reinforcement bearing capacity

Combination 1

Reinforcement Bearing capacity [kN/m]

1	15.90
2	15.90
3	15.90
4	0.00
5	0.00
6	0.00
7	0.00
8	0.00
9	0.00
10	0.00

Combination 2

Reinforcement Bearing capacity [kN/m]

1	15.90
2	15.90
3	15.90
4	0.00
5	0.00
6	0.00
7	0.00
8	0.00
9	0.00
10	0.00

Slope stability verification (Bishop)

Combination 1

Sum of active forces : $F_a = 554.50$ kN/m

Sum of passive forces : $F_p = 744.49$ kN/m

Sliding moment : $M_a = 6437.77$ kNm/m

Resisting moment : $M_p = 8643.50$ kNm/m

Utilization : 74.5 %

Slope stability ACCEPTABLE

Combination 2

Sum of active forces : $F_a = 467.22$ kN/m

Sum of passive forces : $F_p = 557.64$ kN/m

Sliding moment : $M_a = 5662.73$ kNm/m

Resisting moment : $M_p = 6758.60$ kNm/m

Utilization : 83.8 %

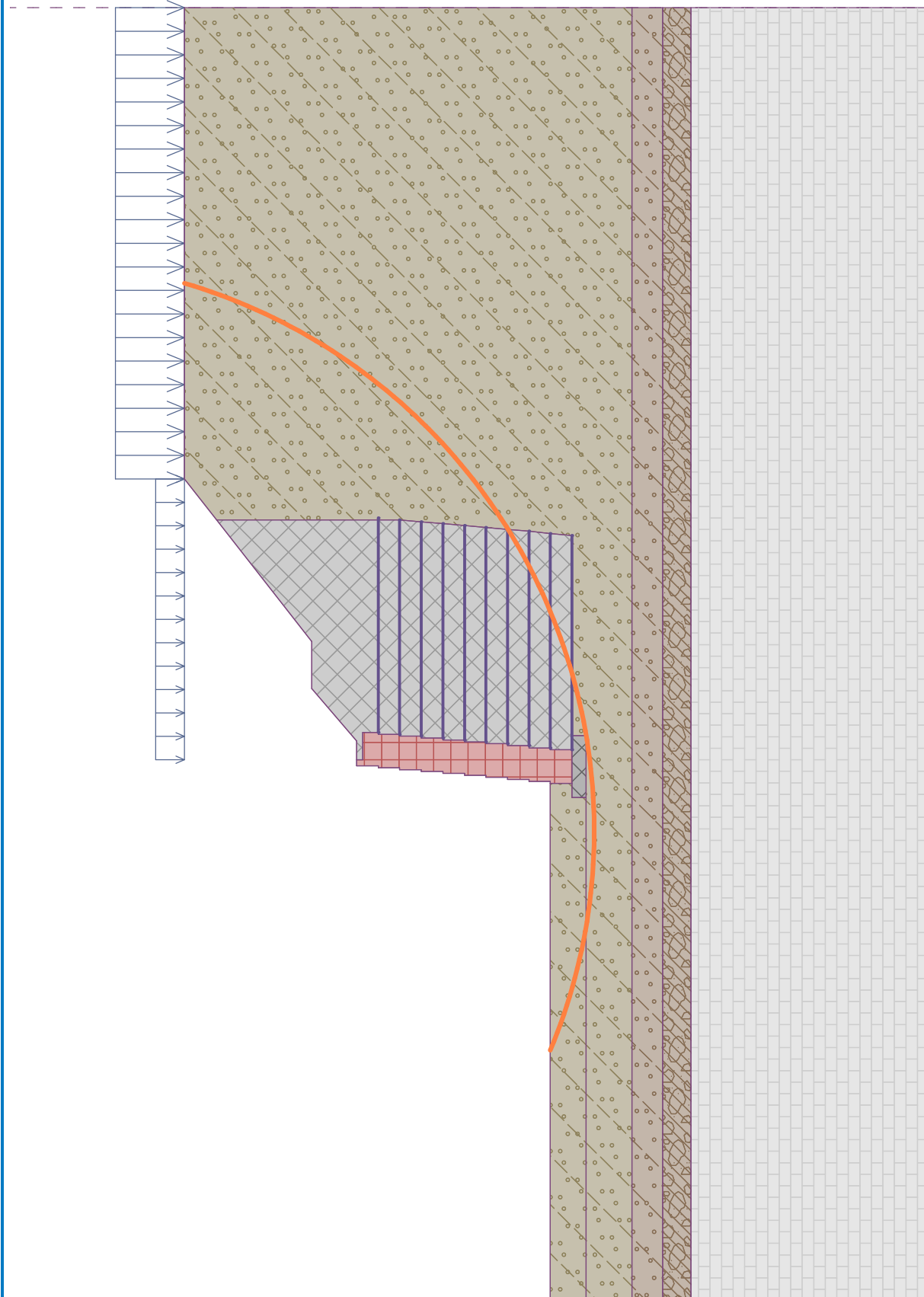
Slope stability ACCEPTABLE

Optimized slip surface for : Combination 2



Name : Analysis

Stage - analysis : 1 - 1



1:50

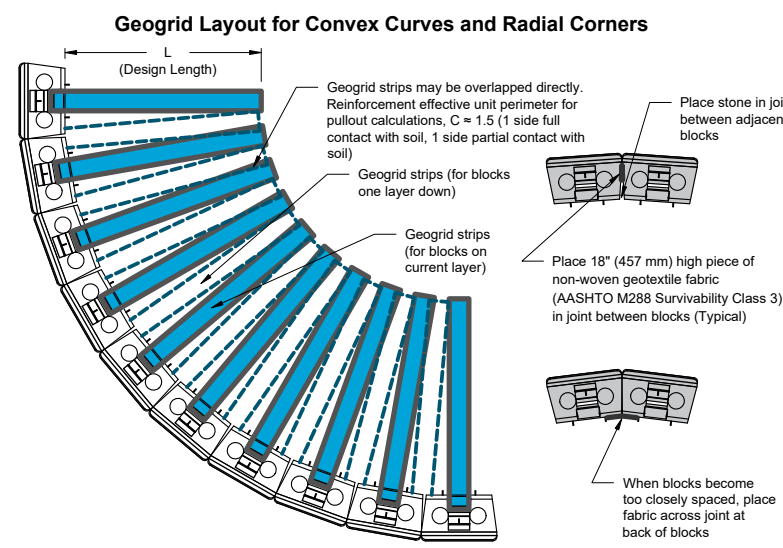
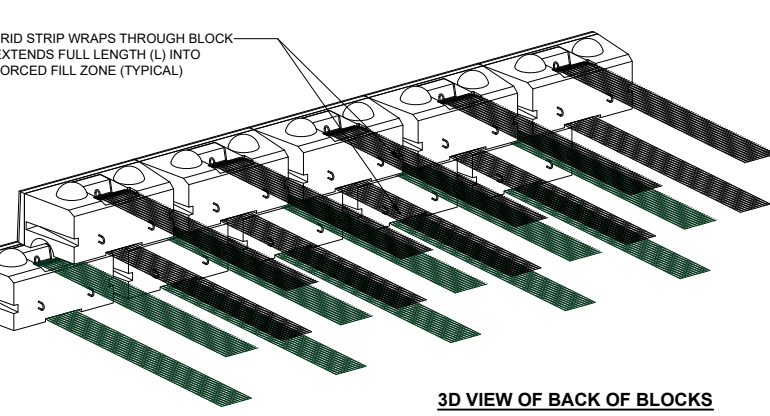


LEGEND:

- ### POSITIVE CONNECTION BLOCKS

- ## GROUND LINES

- ### POSITIVE CONNECTION (PC) DETAILS



Minimum radius for bottom row			
Number of columns	Height of wall	Radius from face of block	Distance between blocks ¹
1	4" (9.84 in.)	15" (38.14 cm)	5.13" (13 cm)
2	3" (2.95 in.)	15" (38.14 cm)	0.21" (5 mm)
3	4.6" (1.37 m)	14.10" (3.58 m)	0.28" (7 mm)
4	6" (1.83 m)	15" (38.14 cm)	0.38" (9 mm)
5	7.4" (2.29 m)	15" (38.14 cm)	0.43" (11 mm)
6	9" (2.74 m)	15" (38.14 cm)	0.50" (13 mm)
7	10" (3.20 m)	15" (38.14 cm)	0.57" (15 mm)
8	12" (3.06 m)	15" (38.14 cm)	0.63" (16 mm)
9	15" (4.11 m)	15" (38.14 cm)	0.70" (18 mm)
10	15" (4.11 m)	16" (40.64 cm)	0.75" (19 mm)
11	16" (4.07 m)	16" (40.64 cm)	0.83" (21 mm)
12	18" (4.59 m)	16" (40.64 cm)	0.88" (22 mm)
13	19" (4.94 m)	16" (40.64 cm)	0.96" (24 mm)
14	21" (4.40 m)	16" (40.64 cm)	1.01" (26 mm)

This drawing is for reference only. Determination of the suitability and/or manner of use of any details contained in this document is the sole responsibility of the design engineer of record. Final project designs, including all construction details, shall be prepared by a licensed professional engineer using the actual project information.

- 10) BRIDGE FOUNDATIONS
- It must be ensured that the foundations of the proposed bridge are founded below the formation level of the Redi-Rock wall to ensure no loading is transferred to the retaining wall, and that the foundations do not rely on the retaining structures and reinforced backfill for support (including lateral support). If the surcharge on the retained side of the retaining wall is to exceed 12kN/m² the Principal Designer must inform Geoman Ltd. prior to construction to allow this design to be reviewed.

FOR CONSTRUCTION

F	Additional details added for section w. obstruction	KK	16/05/19
E	Line of Wall 1 moved, added section to w. obstruction	KK	03/05/19
O	Leveling pad changed from C20/25 to granular fill	KK	19/03/19
D	Approved geogrid removed, CXX 160/30 only	KK	19/03/19
B	Additional approved geogrids added	KK	22/02/19
A	For Approval - soil conditions added	KK	13/02/19
0	Issued for Planning Approval	KK	21/11/18
Rev.	Issue / Revision:	Drawn:	Date:



RED+ROCK

Designer:



—

MUSTI A BRIDGE ESTONIA

Client: _____

PÁRNU **GRANIÍT**

Drawing Title:
REDI-ROCK RETAINING WALLS
(SHEET 1 OF 2)

Designed:	KK	Date:	16/05/19	Project No: 18-5599
Drawn:	KK	Date:	16/05/19	

Checked:	<i>[Signature]</i>	Date:	16/05/19	Scale: AS INDICATED @ A1
Drawing No: SK18-5500-01				Revision:

Drawing No: SK18-5599-01

















