Analysis of nailed slope

Input data

Project
Date : 18.9.2006

Geometry of structure
Thickness of concrete cover = 0.20 m

No.	Depth Z [m]	Coordinate X [m]
1	0.00	0.00
2	7.00	-2.00

Type of nails

No.	Name	Tensile strength R_t [kN]	Pull out resistance T_p [kN/m]	Nail head strength R_f [kN]
1	Typ høebu è. 1	235.62	18.85	22.62

Geometry of nails
Overall number of nails - 6
Inclination of nails from horizontal dir. = 10.00 °

Nail	Depth [m]	Depth of joint [m]	Length [m]	Dist. [m]	Type of nail
1	1.00	0.50	3.00	1.00	Typ høebu è. 1
2	2.00	0.50	3.00	1.00	Typ høebu è. 1
3	3.00	0.50	3.00	1.00	Typ høebu è. 1
4	4.00	0.50	3.00	1.00	Typ høebu è. 1
5	5.00	0.50	3.00	1.00	Typ høebu è. 1
6	6.00	1.00	3.00	1.00	Typ høebu è. 1

Material of structure
Analysis of concrete structures carried out according to the standard CSN 73 1201 R.

Concrete : B 20

Compressive strength	R_{bd}	= 11.50	MPa
Tensile strength	R_{btd}	= 0.90	MPa
Elastic modulus	E_b	= 27000.00	MPa

Longitudinal steel : 10 216 E

Tensile strength	R_{sd}	= 190.00	MPa
Compressive strength	R_{scd}	= 190.00	MPa
Elastic modulus	E_s	= 210000.00	MPa

Soil parameters
Clay

Unit weight :	γ	= 19,50	kN/m^3
Stress-state :	effective		
Angle of intern. friction :	φ_{ef}	= 27,00	°
Cohesion of soil :	c_{ef}	= 10,00	kPa
Angle of friction struc.-soil :	δ	= 15,00	°
Soil :	cohesive		
Poisson's ratio :	ν	= 0,35	

Saturated unit weight : γ_{sat} = 19,50 kN/m^3

Silty Gravel
Unit weight : γ = 19,50 kN/m^3
Stress-state : effective
Angle of intern. friction : φ_{ef} = 27,00 °
Cohesion of soil : c_{ef} = 10,00 kPa
Angle of friction struc.-soil : δ = 15,00 °
Soil : cohesive
Poisson's ratio : ν = 0,35
Saturated unit weight : γ_{sat} = 19,50 kN/m^3

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	2.00	Clay	
2	3.00	Silty Gravel	
3	-	Clay	

Terrain profile
Terrain behind construction has the slope 1: 3.73 (slope angle is 15.00 °).
Embankment height is 0.54 m, embankment length is 2.00 m.

Water influence
Ground water table is located below the structure.

Analysis settings
Active earth pressure calculation - Coulomb (CSN 730037)
Passive earth pressure calculation - Caqout-Kerisel (CSN 730037)
Standard for concrete structures - CSN 73 1201 R
Analysis carried out according to CSN 730037 standard (with reduction of soil input parameters).
Internal stability verified according to factor of safety.
Factor of safety for plane slip surface SF_1 = 1.30
Factor of safety for broken slip surface SF_2 = 1.30

Reduction coeff. of active earth pressure to check for nails bear. capacity k_n = 0.85.

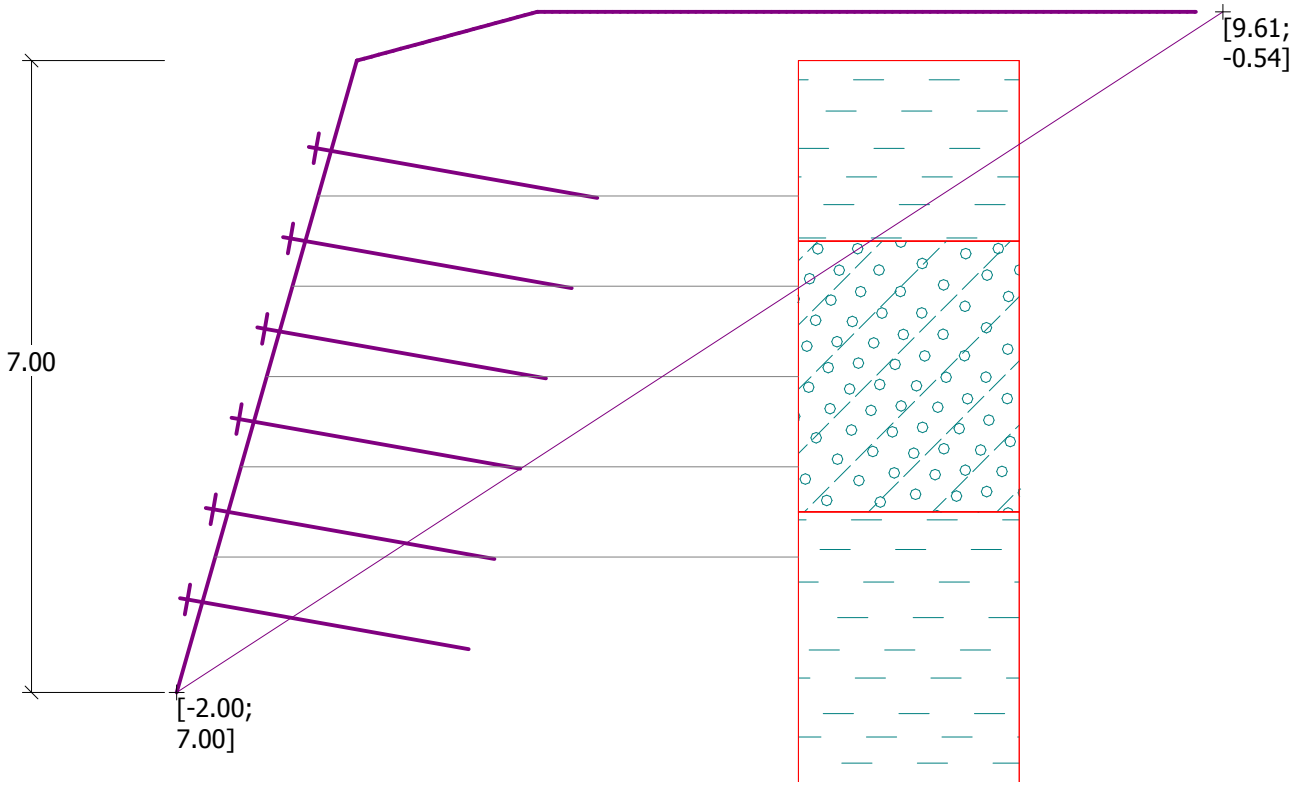
Verification No. 1

Plane slip surface after optimization :
Slip surface angle = 33.00 °
Origin of slip surface at a depth of = 7.00 m

Gravity force = 685.46 kN/m
Overall force carried by nails behind slip surf. = 101.88 kN/m
Forces on slip surf. driving (grav.force) = 373.33 kN/m
Forces on slip surf. driving (pressure) = 0.00 kN/m
Forces on slip surf. resist. (soil) = 466.76 kN/m
Forces on slip surf. resist. (nails) = 74.51 kN/m

Factor of safety Fh/Fm = 1.45 > 1.30
Stability of slip surface is SATISFACTORY

Name : Internal stability | **Stage : 1; Verification : 1**



Verification No. 2

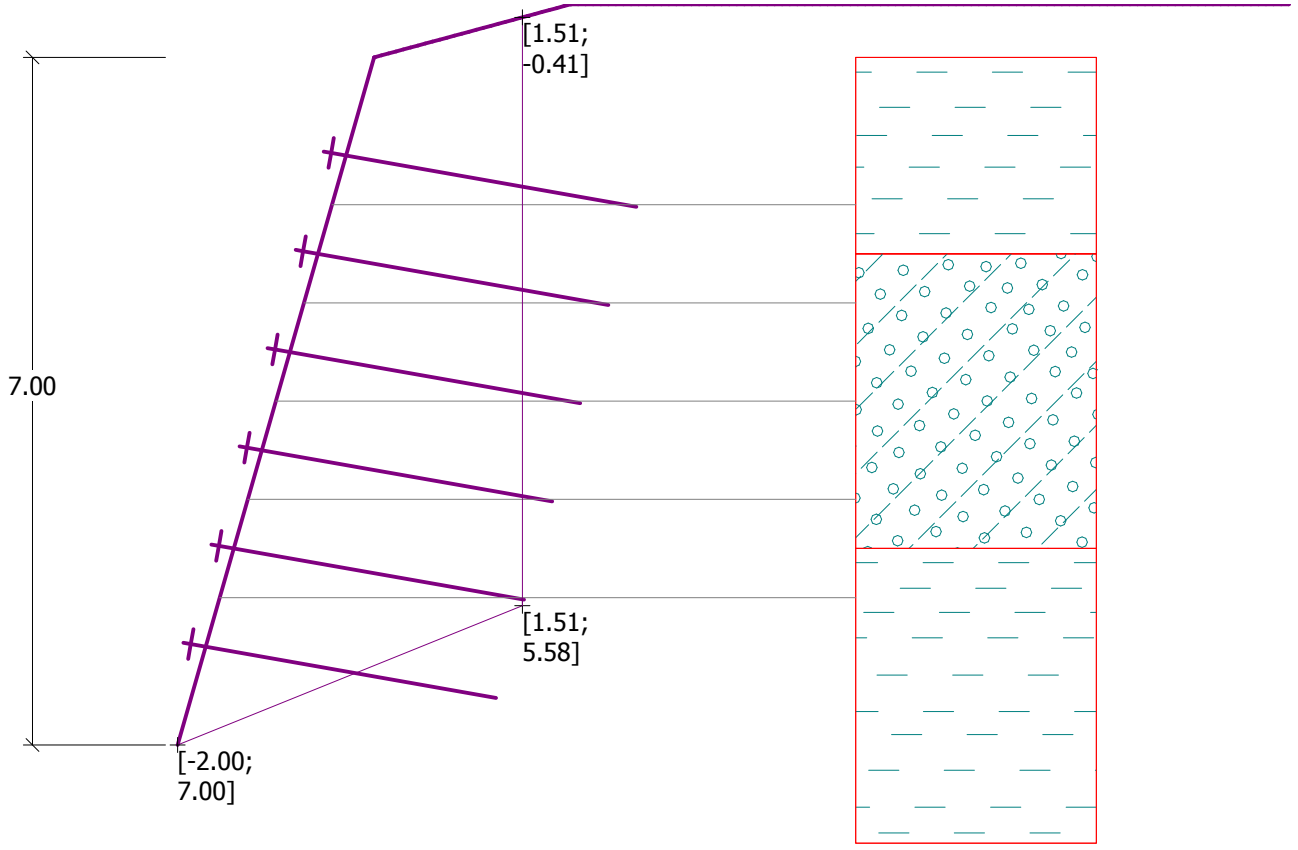
Broken slip surface after optimization :

Slip surface angle = 22.00 °
Origin of slip surface at a depth of = 7.00 m

Gravity force	= 299.88	kN/m
Overall force carried by nails behind slip surf.	= 51.79	kN/m
Forces on slip surf. driving (grav.force)	= 112.34	kN/m
Forces on slip surf. driving (pressure)	= 79.24	kN/m
Forces on slip surf. resist. (soil)	= 193.49	kN/m
Forces on slip surf. resist. (nails)	= 43.92	kN/m

Factor of safety Fh/Fm = 1.24 < 1.30
Stability of slip surface is NOT SATISFACTORY

Name : Internal stability | **Stage : 1; Verification : 2**



Verification No. 3

Horizontal pressure on structure:

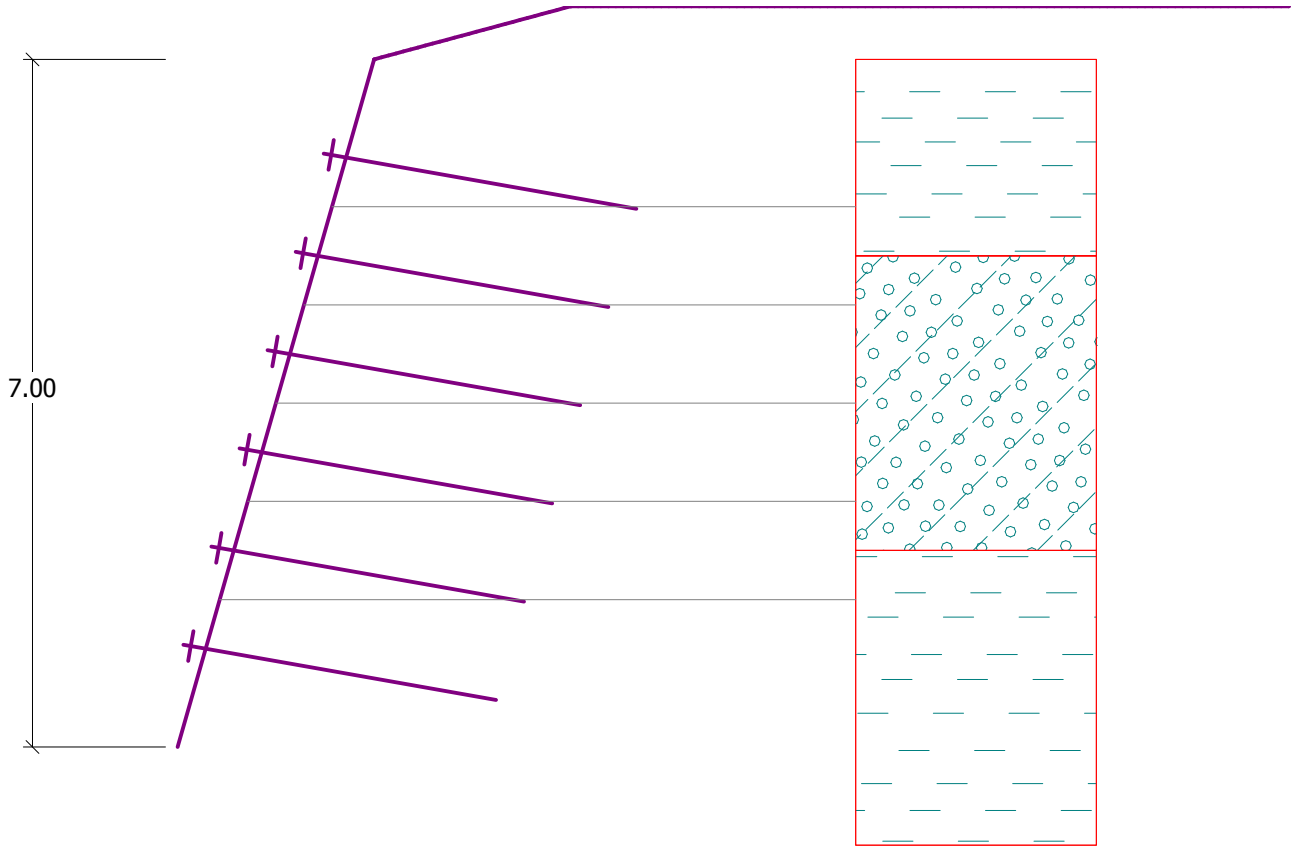
Point	Depth [m]	Pressure [kPa]
1	0.00	0.00
2	1.52	0.00
3	2.00	3.21
4	2.57	7.08
5	5.00	19.95
6	7.00	30.55

Verification of nails bearing capacity

Nail	Nail bearing capacity [kN]	Nail force [kN]
1	56.55	0.00
2	56.55	2.78
3	56.55	8.06
4	56.55	12.64
5	56.55	17.22
6	56.55	34.40

Bearing capacity of nails is SATISFACTORY

Name : Internal stability | **Stage : 1; Verification : 3**



Verification No. 1

Forces acting on construction

Name	F_{hor} [kN/m]	App.Pt. Z [m]	F_{vert} [kN/m]	App.Pt. X [m]	Design coefficient
Gravity force	0.00	-3.45	434.72	2.52	1.000
Active pressure	107.35	-1.47	23.80	3.43	1.000

Verification of complete wall

Check for overturning stability
Resisting moment M_{res} = 1058.09 kNm/m
Overturning moment M_{ovr} = 157.52 kNm/m

Wall for overturning is SATISFACTORY

Check for slip
Resisting horizontal force H_{res} = 208.41 kN/m
Active horizontal force H_{act} = 107.35 kN/m

Wall for slip is SATISFACTORY

Forces acting at the centre of footing bottom
Overall moment M = -306.68 kNm/m
Normal force N = 458.52 kN/m
Shear force Q = 107.35 kN/m

Overall check - WALL is SATISFACTORY

Bearing capacity of foundation soil

Forces acting at the centre of the footing bottom

No.	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [m]	Stress [kPa]
1	-306.68	458.52	107.35	0.00	147.75

Bearing capacity of foundation soil check

Eccentricity verification
Max. eccentricity of normal force e = 0.0 mm
Maximum allowable eccentricity e_{alw} = 1024.1 mm

Eccentricity of the normal force is SATISFACTORY

Footing bottom bearing capacity verification
Max. stress at footing bottom σ = 147.75 kPa
Bearing capacity of foundation soil R_d = 140.00 kPa

Bearing capacity of foundation soil is NOT SATISFACTORY

Overall verification - bearing capacity of found. soil is NOT SATISFACTORY

Dimensioning No. 1

Depth [m]	Horiz.pres. [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	5.79	0.00
0.33	0.00	5.79	-1.93
0.67	0.00	5.79	-3.86
1.00	0.00	5.79	-5.79
1.00	0.00	-11.57	-5.79
1.50	0.00	-11.57	0.00
1.50	0.00	-11.57	-0.00
1.52	0.00	-11.57	0.28
1.52	0.00	-11.57	0.28
2.00	3.21	-12.34	5.91
2.00	3.21	12.90	5.91
2.50	6.59	10.45	0.00
2.50	6.59	10.45	-0.00
2.57	7.08	9.95	-0.74
2.57	7.08	9.95	-0.74
3.00	9.35	6.44	-4.28
3.00	9.35	-6.00	-4.28
3.50	12.00	-11.34	0.00
4.00	14.65	-18.00	7.28
4.00	14.65	18.44	7.28
4.50	17.30	10.45	0.00
5.00	19.95	1.14	-2.95
5.00	19.95	-0.70	-2.95
5.50	22.60	-11.34	0.00
6.00	25.25	-23.30	8.60

Depth [m]	Horiz.pres. [kPa]	Shear Force [kN/m]	Moment [kNm/m]
6.00	25.25	22.11	8.60
6.33	27.02	13.40	2.67
6.67	28.78	4.10	-0.26
6.67	28.78	4.10	-0.26
7.00	30.55	-5.79	0.00

Dimensioning of concrete cover in section 6.00 m. (max.moment)

Analysis performed for vertical reinforcement
Reinforcement and dimensions of the cross-section:
Bar diameter = 12.0 mm
Number of bars = 5
Reinforcement cover = 20.0 mm
Cross-section width = 1.00 m
Cross-section depth = 0.20 m

Reinforcement ratio	μ_{st}	=	0.28	%	>	0.16	%	= $\mu_{st,min}$
Position of neutral axis	x_u	=	0.01	m	<	0.09	m	= $x_{u,lim}$
Ultimate moment	M_u	=	16.74	kNm	>	8.60	kNm	= M_d

Cross-section is SATISFACTORY.