

## Analysis of nailed slope

### Input data

#### Project

Date : 9/18/2006

#### 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	Nail type No. 1	235.62	18.85	22.62

#### Geometry of nails

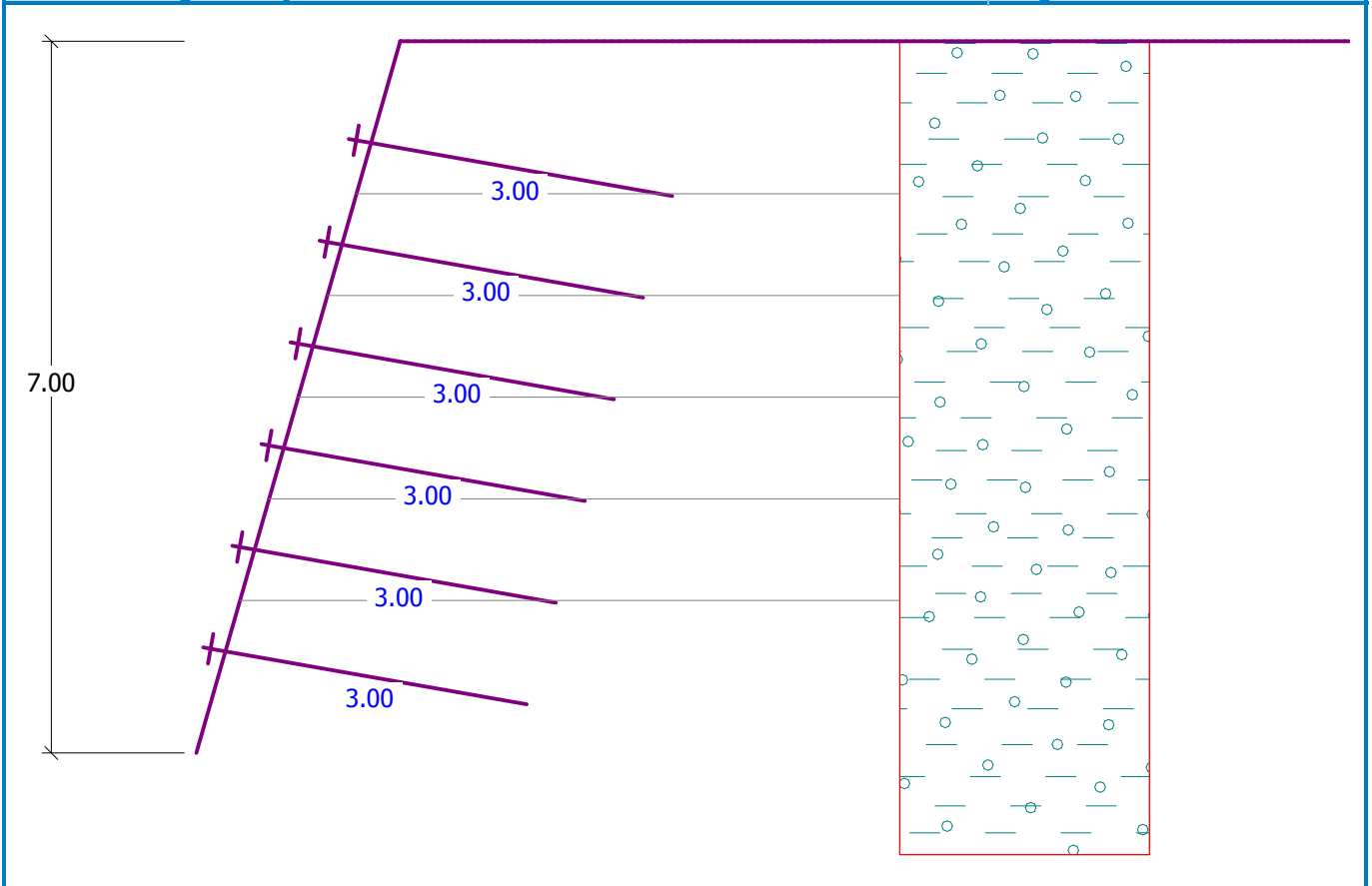
Overall number of nails - 6

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	Nail type No. 1
2	2.00	0.50	3.00	1.00	Nail type No. 1
3	3.00	0.50	3.00	1.00	Nail type No. 1
4	4.00	0.50	3.00	1.00	Nail type No. 1
5	5.00	0.50	3.00	1.00	Nail type No. 1
6	6.00	1.00	3.00	1.00	Nail type No. 1

Name : Nails geometry

Stage : 1



**Material of structure**

Analysis of concrete structures carried out according to the standard EN 1992 1-1 (EC2).

Concrete : C 20/25  
 Cylinder compressive strength  $f_{ck} = 20.00$  MPa  
 Tensile strength  $f_{ct} = 2.20$  MPa  
 Elasticity modulus  $E_{cm} = 29000.00$  MPa  
 Longitudinal steel : B500  
 Yield strength  $f_{yk} = 500.00$  MPa  
 Elasticity modulus  $E = 200000.00$  MPa

**Soil parameters**

**Soil No. 1**

Unit weight :  $\gamma = 19.50$  kN/m<sup>3</sup>  
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 27.00$  °  
 Cohesion of soil :  $c_{ef} = 12.00$  kPa  
 Angle of friction struc.-soil :  $\delta = 15.00$  °  
 Soil : cohesive  
 Poisson's ratio :  $\nu = 0.35$   
 Saturated unit weight :  $\gamma_{sat} = 19.50$  kN/m<sup>3</sup>

**Geological profile and assigned soils**

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

### Terrain profile

Terrain behind the structure is flat.

### Water influence

Ground water table is located below the structure.

### Global settings

Active earth pressure calculation - Coulomb  
Passive earth pressure calculation - Caquot-Kerisel  
Standard for concrete structures - EN 1992 1-1 (EC2)

### Settings of the stage of construction

Analysis carried out according to classical theory (safety factor)

Safety factor for slip = 1.50  
Safety factor for overturning = 1.50  
Factor of safety for bearing capacity = 1.00

Internal stability verified according to factor of safety.

Factor of safety for plane slip surface  $SF_1 = 1.20$

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 = 40.00 °

Origin of slip surface at a depth of = 7.00 m

Gravity force = 432.86 kN/m

Overall force carried by nails behind slip surf. = 78.39 kN/m

Forces on slip surf. driving (grav.force) = 278.24 kN/m

Forces on slip surf. driving (pressure) = 0.00 kN/m

Forces on slip surf. resist. (soil) = 330.23 kN/m

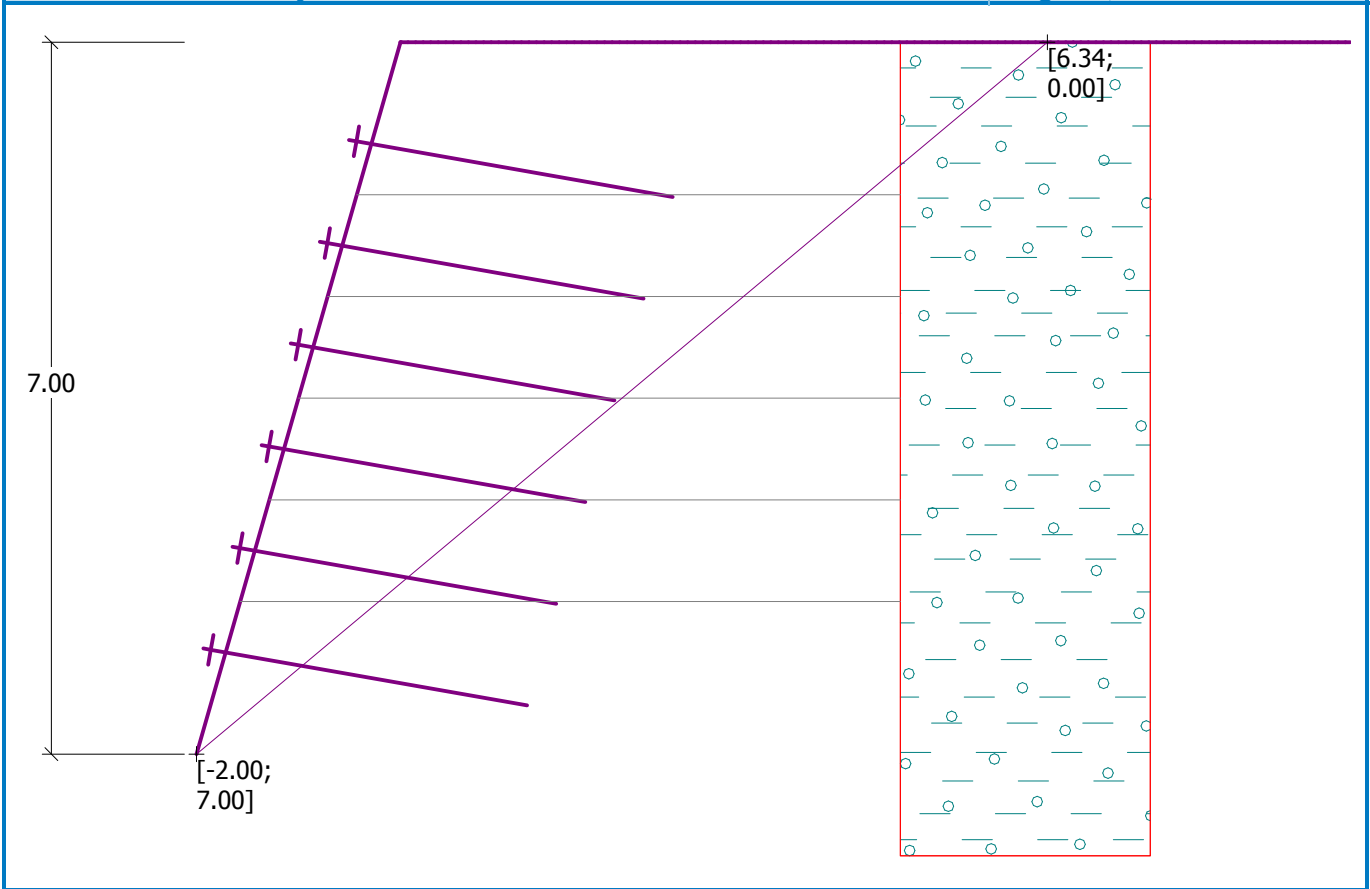
Forces on slip surf. resist. (nails) = 50.39 kN/m

Factor of safety  $F_h/F_m = 1.37 > 1.20$

**Stability of slip surface is SATISFACTORY**

Name : Internal stability

Stage : 1; Verification : 1



## Verification No. 2

### Broken slip surface after optimization :

Slip surface angle = 32.00 °  
Origin of slip surface at a depth of = 7.00 m

Gravity force = 292.21 kN/m  
Overall force carried by nails behind slip surf. = 54.22 kN/m  
Forces on slip surf. driving (grav.force) = 154.85 kN/m  
Forces on slip surf. driving (pressure) = 25.25 kN/m  
Forces on slip surf. resist. (soil) = 198.21 kN/m  
Forces on slip surf. resist. (nails) = 40.30 kN/m

Factor of safety  $F_h/F_m = 1.32 > 1.30$

**Stability of slip surface is SATISFACTORY**

## Verification No. 3

### Horizontal pressure on structure:

Point	Depth [m]	Pressure [kPa]
1	0.00	0.00
2	3.21	0.00
3	7.00	17.56

### Verification of nails bearing capacity

Nail	Nail bearing capacity [kN]	Nail force [kN]
1	56.55	0.00

Nail	Nail bearing capacity [kN]	Nail force [kN]
2	56.55	0.00
3	56.55	0.17
4	56.55	3.17
5	56.55	7.16
6	56.55	18.24

**Bearing capacity of nails is SATISFACTORY**

### 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	417.15	2.52	1.000
Active pressure	33.78	-1.32	6.60	3.48	1.000

#### Verification of complete wall

##### Check for overturning stability

Resisting moment  $M_{res} = 1072.82$  kNm/m

Overturning moment  $M_{ovr} = 44.71$  kNm/m

Safety factor = 23.99 > 1.50

**Wall for overturning is SATISFACTORY**

##### Check for slip

Resisting horizontal force  $H_{res} = 253.15$  kN/m

Active horizontal force  $H_{act} = 33.78$  kN/m

Safety factor = 7.49 > 1.50

**Wall for slip is SATISFACTORY**

##### Forces acting at the centre of footing bottom

Overall moment  $M = -370.60$  kNm/m

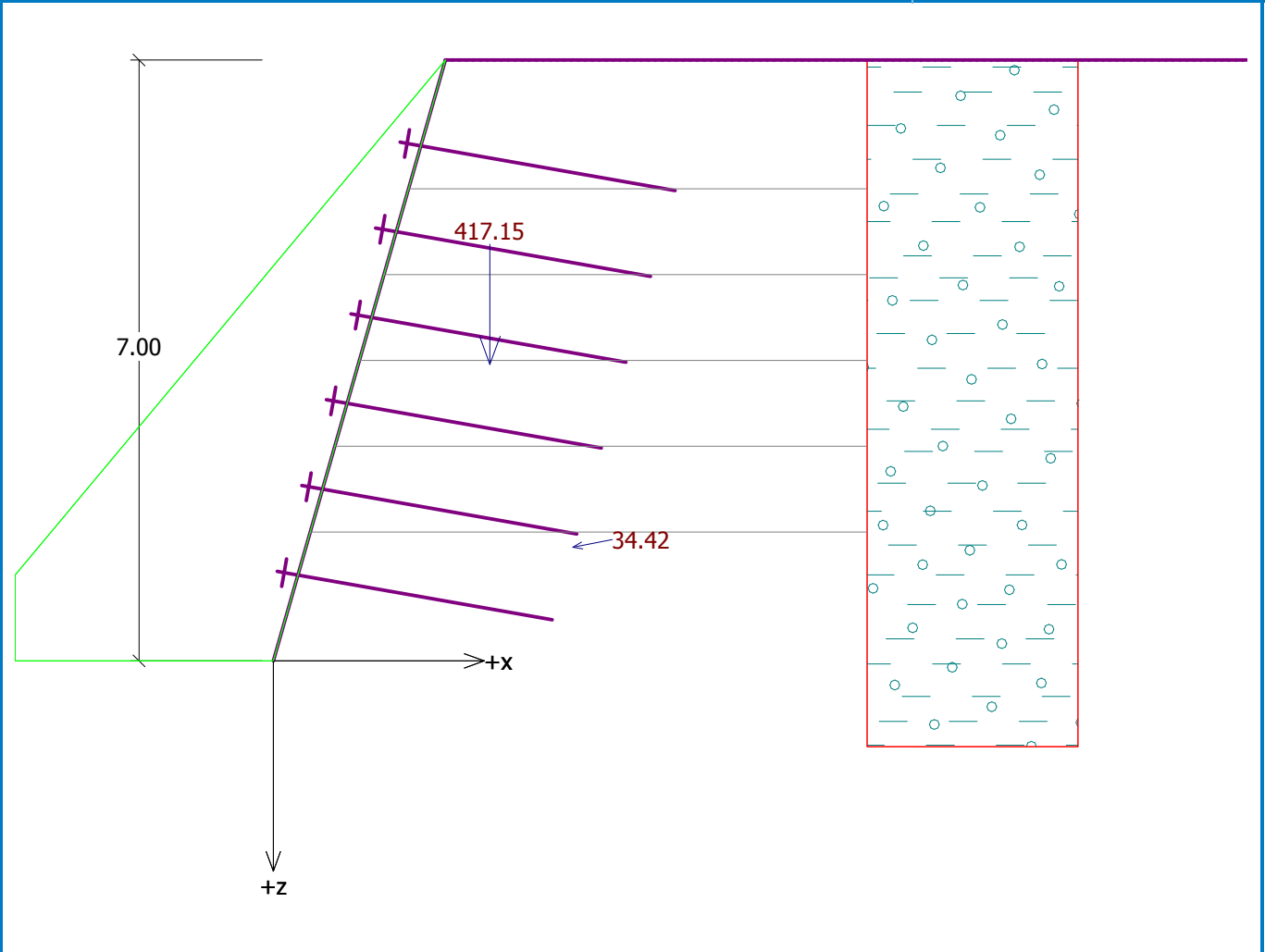
Normal force  $N = 423.75$  kN/m

Shear force  $Q = 33.78$  kN/m

**Overall check - WALL is SATISFACTORY**

Name : Verification

Stage : 1; Analysis : 1



### Bearing capacity of foundation soil

Forces acting at the centre of the footing bottom

Number	Moment [kNm/m]	Norm. force [kN/m]	Shear Force [kN/m]	Eccentricity [m]	Stress [kPa]
1	-370.60	423.75	33.78	0.00	136.55

### 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  $\sigma = 136.55$  kPa  
Bearing capacity of foundation soil  $R_d = 140.00$  kPa

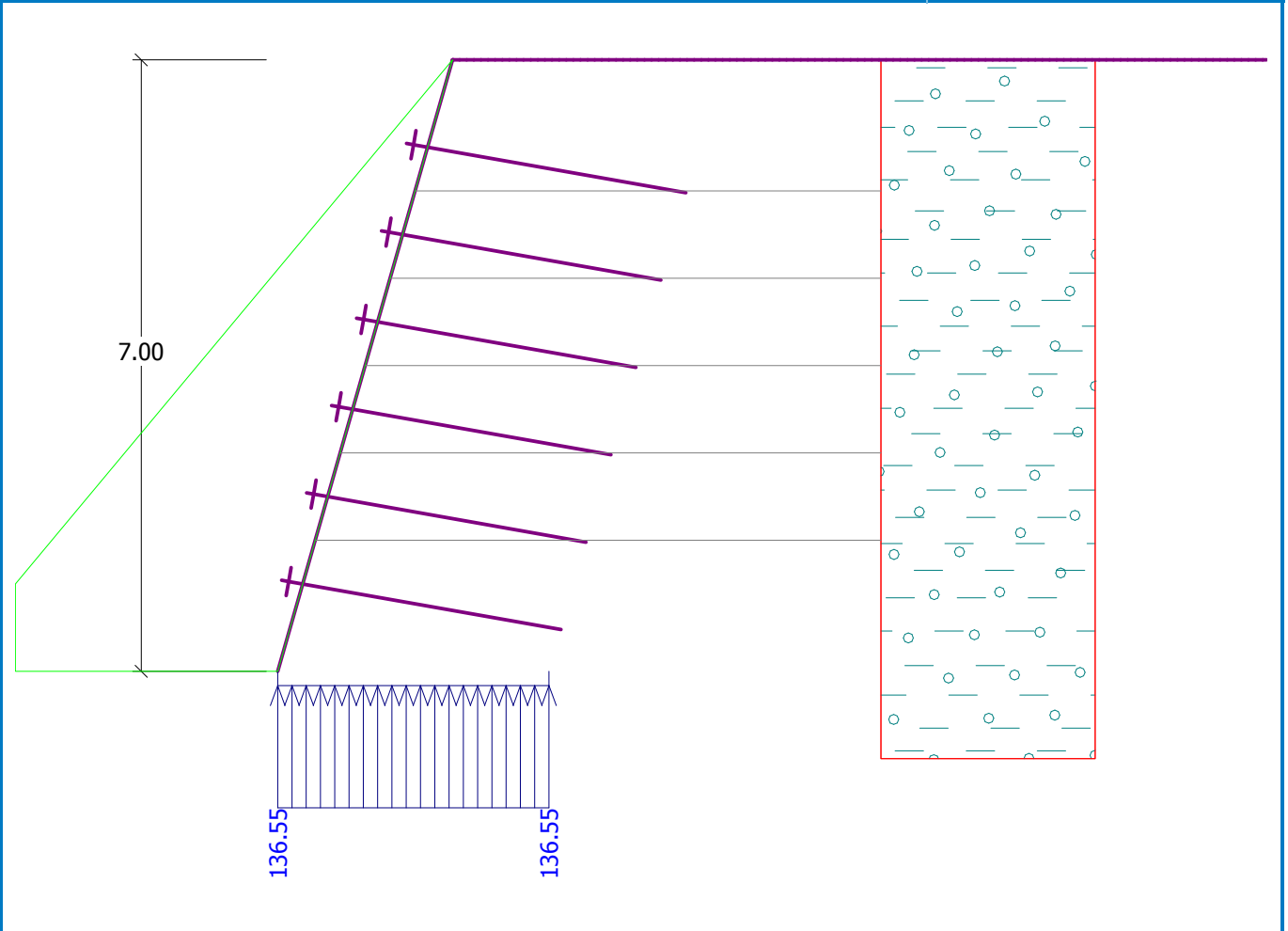
Safety factor = 1.03 > 1.00

**Bearing capacity of foundation soil is SATISFACTORY**

**Overall verification - bearing capacity of found. soil is SATISFACTORY**

Name : Bearing cap.

Stage : 1



### Dimensioning No. 1

Depth [m]	Horiz.pres. [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	3.25	0.00
0.33	0.00	3.25	-1.08
0.33	0.00	3.25	-1.08
0.67	0.00	3.25	-2.17
1.00	0.00	3.25	-3.25
1.00	0.00	-6.51	-3.25
1.50	0.00	-6.51	0.00
2.00	0.00	-6.51	3.25
2.00	0.00	6.51	3.25
2.50	0.00	6.51	0.00
3.00	0.00	6.51	-3.25
3.00	0.00	-6.47	-3.25
3.21	0.00	-6.47	-1.91
3.21	0.00	-6.47	-1.91
3.50	1.35	-6.67	0.00
4.00	3.67	-7.92	3.60
4.00	3.67	8.31	3.60
4.50	5.99	5.89	0.00

Depth [m]	Horiz.pres. [kPa]	Shear Force [kN/m]	Moment [kNm/m]
5.00	8.30	2.32	-2.10
5.00	8.30	-1.94	-2.10
5.50	10.62	-6.67	0.00
6.00	12.93	-12.55	4.76
6.00	12.93	11.99	4.76
6.33	14.48	7.43	1.51
6.67	16.02	2.34	-0.14
6.67	16.02	2.34	-0.14
7.00	17.56	-3.25	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  $\rho = 0.32 \% > 0.13 \% = \rho_{min}$

Ultimate moment  $M_{Rd} = 40.51 \text{ kNm/m} > 4.76 \text{ kNm/m} = M_{Ed}$

**Cross-section is SATISFACTORY.**

