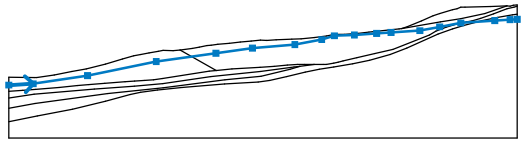
# Slope stability analysis

## Input data

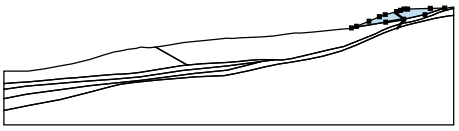
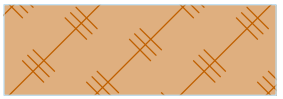
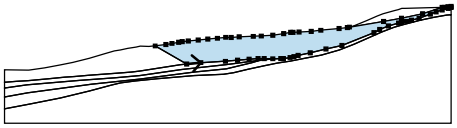
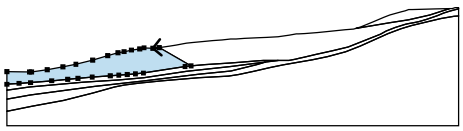
### Water

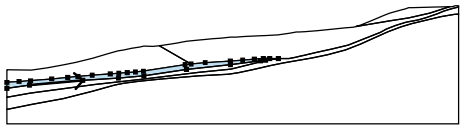
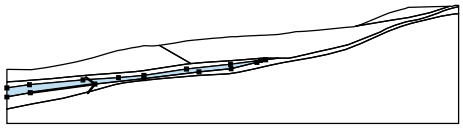
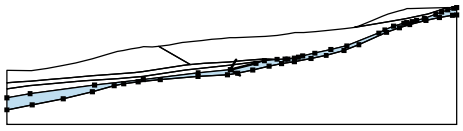
Water type : GWT

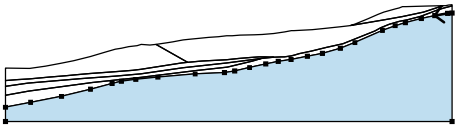
| No. | GWT location | Coordinates of GWT points [m] | | | | | |
|---|---|---|---|---|---|---|---|
| | | x | z | x | z | x | z |
| 1 |  | 0.00 | 11.05 | 7.54 | 11.46 | 24.20 | 13.98 |
| | | 45.31 | 18.26 | 63.63 | 20.84 | 74.88 | 22.42 |
| | | 87.91 | 23.51 | 96.19 | 25.04 | 100.08 | 26.21 |
| | | 106.22 | 26.49 | 113.02 | 26.95 | 117.51 | 27.24 |
| | | 126.32 | 27.79 | 132.43 | 28.96 | 138.91 | 30.15 |
| | | 149.38 | 30.86 | 154.03 | 31.15 | 156.25 | 31.29 |

## Input data (Stage of construction 3)

### Assigning and surfaces

| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| 1 |  | 132.59 | 30.45 | 138.93 | 31.50 | 1□ □ □ |
| | | 146.27 | 33.09 | 153.12 | 35.37 |  |
| | | 148.07 | 35.21 | 140.18 | 35.03 | |
| | | 138.95 | 35.01 | 137.78 | 34.57 | |
| | | 136.39 | 34.19 | 132.43 | 33.08 | |
| | | 130.41 | 32.32 | 126.81 | 30.80 | |
| | | 122.47 | 29.00 | 120.70 | 28.45 | |
| 2 |  | 63.73 | 15.55 | 68.61 | 16.01 | 2□ □ □ □ (□ □ ) |
| | | 77.28 | 16.47 | 81.57 | 16.82 |  |
| | | 85.59 | 17.21 | 88.71 | 17.42 | |
| | | 90.88 | 17.43 | 93.87 | 17.36 | |
| | | 96.65 | 17.39 | 97.60 | 17.45 | |
| | | 99.90 | 17.81 | 101.26 | 18.12 | |
| | | 102.75 | 18.52 | 106.94 | 19.48 | |
| | | 112.50 | 20.76 | 118.08 | 22.04 | |
| | | 129.24 | 26.49 | 131.27 | 27.59 | |
| | | 134.31 | 28.85 | 137.83 | 29.88 | |
| | | 138.92 | 30.10 | 140.73 | 30.48 | |
| | | 142.36 | 30.83 | 145.04 | 31.57 | |
| | | 148.95 | 32.95 | 151.03 | 33.77 | |
| | | 153.13 | 34.48 | 155.23 | 35.05 | |
| | | 156.25 | 35.28 | 156.25 | 35.69 | |
| | | 155.08 | 35.62 | 154.03 | 35.35 | |
| | | 153.12 | 35.37 | 146.27 | 33.09 | |
| | | 138.93 | 31.50 | 132.59 | 30.45 | |
| | | 120.70 | 28.45 | 119.93 | 28.30 | |
| | | 117.05 | 27.98 | 110.67 | 27.34 | |
| | | 107.33 | 26.98 | 103.09 | 26.69 | |
| | | 100.95 | 26.64 | 100.07 | 26.63 | |
| | | 97.67 | 26.19 | 93.84 | 25.64 | |
| | | 89.79 | 25.32 | 87.02 | 25.21 | |
| | | 82.12 | 25.02 | 79.33 | 24.83 | |
| | | 77.36 | 24.86 | 74.46 | 24.54 | |
| | | 71.16 | 24.26 | 67.76 | 23.92 | |
| | | 64.24 | 23.56 | 62.16 | 23.35 | |
| | | 60.93 | 23.16 | 58.56 | 22.73 | |
| | | 56.43 | 22.35 | 52.68 | 21.85 | |
| 3 |  | 52.68 | 21.85 | 50.47 | 21.63 | 2□ □ □ □ |
| | | 47.45 | 21.77 | 46.00 | 21.40 |  |
| | | 43.11 | 20.99 | 40.51 | 20.44 | |
| | | 38.42 | 20.09 | 34.89 | 19.09 | |
| | | 29.72 | 17.52 | 23.87 | 16.04 | |
| | | 19.38 | 15.21 | 14.00 | 14.20 | |
| | | 8.53 | 13.42 | 7.81 | 13.42 | |
| | | 0.00 | 13.51 | 0.00 | 9.16 | |
| | | 4.21 | 9.48 | 8.21 | 9.71 | |
| | | 15.48 | 10.36 | 21.05 | 10.87 | |

| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| | | 24.56 | 11.18 | 29.52 | 11.60 | |
| | | 35.74 | 12.08 | 38.72 | 12.30 | |
| | | 41.63 | 12.50 | 44.47 | 12.73 | |
| | | 47.24 | 13.03 | 61.64 | 15.34 | |
| | | 63.73 | 15.55 | | | |
| 4 |  | 7.81 | 8.22 | 26.31 | 9.83 | 3□ □ □ □ □ □ □ |
| | | 38.60 | 10.67 | 47.38 | 11.46 | |
| | | 62.10 | 13.65 | 77.36 | 15.26 | |
| | | 87.69 | 16.63 | 89.46 | 16.83 | |
| | | 93.87 | 17.36 | 90.88 | 17.43 | |
| | | 88.71 | 17.42 | 85.59 | 17.21 | |
| | | 81.57 | 16.82 | 77.28 | 16.47 | |
| | | 68.61 | 16.01 | 63.73 | 15.55 | |
| | | 61.64 | 15.34 | 47.24 | 13.03 | |
| | | 44.47 | 12.73 | 41.63 | 12.50 | |
| | | 38.72 | 12.30 | 35.74 | 12.08 | |
| | | 29.52 | 11.60 | 24.56 | 11.18 | |
| | | 21.05 | 10.87 | 15.48 | 10.36 | |
| | | 8.21 | 9.71 | 4.21 | 9.48 | |
| | | 0.00 | 9.16 | 0.00 | 7.12 | |
| 5 |  | 8.08 | 5.43 | 30.44 | 8.42 | 4-1□ □ □ □ □ □ □ □ □ |
| | | 47.42 | 10.27 | 66.44 | 12.66 | |
| | | 77.57 | 13.79 | 86.51 | 15.97 | |
| | | 89.46 | 16.83 | 87.69 | 16.63 | |
| | | 77.36 | 15.26 | 62.10 | 13.65 | |
| | | 47.38 | 11.46 | 38.60 | 10.67 | |
| | | 26.31 | 9.83 | 7.81 | 8.22 | |
| | | 0.00 | 7.12 | 0.00 | 3.95 | |
| 6 |  | 86.51 | 15.97 | 77.57 | 13.79 | 4-2□ □ □ □ □ □ □ □ □ |
| | | 66.44 | 12.66 | 47.42 | 10.27 | |
| | | 30.44 | 8.42 | 8.08 | 5.43 | |
| | | 0.00 | 3.95 | 0.00 | -0.21 | |
| | | 8.79 | 1.52 | 19.57 | 3.60 | |
| | | 29.73 | 6.12 | 37.25 | 8.17 | |
| | | 40.56 | 8.88 | 45.62 | 9.54 | |
| | | 53.28 | 10.32 | 66.36 | 11.44 | |
| | | 76.64 | 11.95 | 80.20 | 12.52 | |
| | | 85.40 | 13.68 | 91.09 | 15.01 | |
| | | 95.44 | 15.88 | 99.89 | 16.57 | |
| | | 105.64 | 17.61 | 110.93 | 18.70 | |
| | | 117.14 | 20.43 | 122.26 | 22.42 | |
| | | 131.90 | 26.71 | 136.33 | 28.35 | |
| | | 139.95 | 29.45 | 145.52 | 30.84 | |
| | | 150.19 | 31.90 | 154.74 | 32.64 | |
| | | 156.25 | 32.81 | 156.25 | 35.28 | |
| | | 155.23 | 35.05 | 153.13 | 34.48 | |
| | | 151.03 | 33.77 | 148.95 | 32.95 | |
| | | 145.04 | 31.57 | 142.36 | 30.83 | |
| | | 140.73 | 30.48 | 138.92 | 30.10 | |
| | | 137.83 | 29.88 | 134.31 | 28.85 | |

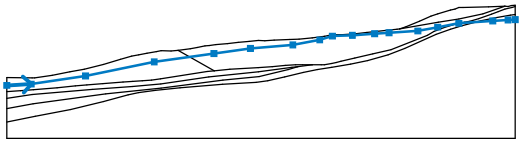
| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| | | 131.27 | 27.59 | 129.24 | 26.49 | |
| | | 118.08 | 22.04 | 112.50 | 20.76 | |
| | | 106.94 | 19.48 | 102.75 | 18.52 | |
| | | 101.26 | 18.12 | 99.90 | 17.81 | |
| | | 97.60 | 17.45 | 96.65 | 17.39 | |
| | | 93.87 | 17.36 | 89.46 | 16.83 | |
| 7 |  | 154.74 | 32.64 | 150.19 | 31.90 | 4-3□ □ □ □ □ □ □ □ □ |
| | | 145.52 | 30.84 | 139.95 | 29.45 |  |
| | | 136.33 | 28.35 | 131.90 | 26.71 | |
| | | 122.26 | 22.42 | 117.14 | 20.43 | |
| | | 110.93 | 18.70 | 105.64 | 17.61 | |
| | | 99.89 | 16.57 | 95.44 | 15.88 | |
| | | 91.09 | 15.01 | 85.40 | 13.68 | |
| | | 80.20 | 12.52 | 76.64 | 11.95 | |
| | | 66.36 | 11.44 | 53.28 | 10.32 | |
| | | 45.62 | 9.54 | 40.56 | 8.88 | |
| | | 37.25 | 8.17 | 29.73 | 6.12 | |
| | | 19.57 | 3.60 | 8.79 | 1.52 | |
| | | 0.00 | -0.21 | 0.00 | -5.21 | |
| | | 156.25 | -5.21 | 156.25 | 32.81 | |

## Anti-Slide piles

| No. | Anti-Slide pile | Point | | Length | Pile spacing | Cross-section | Pile bearing capacity | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | new | x [m] | z [m] | l [m] | b [m] | [m] | istributio along the pile | Max. bearing capacity $V_u$ [kN] | Gradient K [–] | Passive force direction |
| 1 | No | 34.85 | 19.08 | 15.06 | 2.50 | d = 1.50 | constant | 1432.74 | | perpendicular to pile |
| 2 | No | 110.74 | 27.35 | 11.00 | 3.00 | d = 1.00 | constant | 704.70 | | perpendicular to pile |
| 3 | No | 132.02 | 32.93 | 9.00 | 3.00 | d = 1.00 | constant | 704.70 | | perpendicular to pile |

## Water

Water type : GWT

| No. | GWT location | Coordinates of GWT points [m] | | | | | |
|---|---|---|---|---|---|---|---|
| | | x | z | x | z | x | z |
| 1 |  | 0.00 | 11.05 | 7.54 | 11.46 | 24.20 | 13.98 |
| | | 45.31 | 18.26 | 63.63 | 20.84 | 74.88 | 22.42 |
| | | 87.91 | 23.51 | 96.19 | 25.04 | 100.08 | 26.21 |
| | | 106.22 | 26.49 | 113.02 | 26.95 | 117.51 | 27.24 |
| | | 126.32 | 27.79 | 132.43 | 28.96 | 138.91 | 30.15 |
| | | 149.38 | 30.86 | 154.03 | 31.15 | 156.25 | 31.29 |

## Tensile crack

Tensile crack not input.

### Earthquake

Earthquake not included.

### Settings of the stage of construction

Design situation : permanent

## Results (Stage of construction 3)

### Analysis 1 (stage 3)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 56.87 | 22.43 | 58.38 | 18.67 | 60.94 | 17.15 | 64.04 | 16.43 | 82.95 | 17.10 |
| 89.34 | 17.46 | 94.53 | 17.55 | 95.74 | 17.62 | 97.07 | 17.76 | 102.94 | 18.69 |
| 107.56 | 19.62 | 112.98 | 20.91 | 117.97 | 22.23 | 125.68 | 25.20 | 131.91 | 28.07 |
| 139.26 | 31.18 | 142.59 | 35.08 | | | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 2 (110.74; 27.35 [m])

| | | |
|---|---|---|
| Horizontal active force: | 340.30 | kN/m |
| Horizontal passive force: | 198.77 | kN/m |
| Depth of slip surface: | 6.97 | m |
| The length of pile below terrain: | 11.00 | m |

Anti-Slide Pile No. 3 (132.02; 32.93 [m])

| | | |
|---|---|---|
| Horizontal active force: | 148.66 | kN/m |
| Horizontal passive force: | 20.03 | kN/m |
| Depth of slip surface: | 4.81 | m |
| The length of pile below terrain: | 9.00 | m |

**Slope stability verification (ITFM)**
Factor of safety = 1.54 > 1.30
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Analysis 2 (stage 3)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 20.67 | 15.45 | 25.42 | 12.44 | 32.11 | 11.81 | 47.07 | 13.38 | 73.56 | 16.94 |
| 83.87 | 17.13 | 103.76 | 18.93 | 114.82 | 21.35 | 122.05 | 23.73 | 129.20 | 27.19 |
| 139.23 | 30.56 | 143.09 | 34.04 | 143.16 | 35.10 | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])

| | | |
|---|---|---|
| Horizontal active force: | 502.07 | kN/m |
| Horizontal passive force: | 323.38 | kN/m |
| Depth of slip surface: | 6.98 | m |
| The length of pile below terrain: | 15.06 | m |

Anti-Slide Pile No. 2 (110.74; 27.35 [m])

| | | |
|---|---|---|
| Horizontal active force: | 386.71 | kN/m |
| Horizontal passive force: | 316.45 | kN/m |

Depth of slip surface: 6.89 m
The length of pile below terrain: 11.00 m

Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Horizontal active force: 150.60 kN/m
Horizontal passive force: 84.17 kN/m
Depth of slip surface: 4.79 m
The length of pile below terrain: 9.00 m

**Slope stability verification (ITFM)**
Factor of safety = 2.11 > 1.30
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Analysis 3 (stage 3)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 119.73 | 28.28 | 122.28 | 26.06 | 123.88 | 25.74 | 130.81 | 27.50 | 134.60 | 28.98 |
| 138.14 | 30.60 | 141.10 | 32.53 | 142.78 | 35.09 | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 2 (110.74; 27.35 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Horizontal active force: 167.60 kN/m
Horizontal passive force: 34.18 kN/m
Depth of slip surface: 4.96 m
The length of pile below terrain: 9.00 m

**Slope stability verification (ITFM)**
Factor of safety = 1.80 > 1.30
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Piles verification 1 (stage 3)

Anti-Slide pile : Anti-Slide Pile No. 1 (34.85; 19.08 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013

Verification methodology : according to Chinese standards

## Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

## Geometry of structure

Structure length = 15.60 m

Cross-section name : Pile curtain d = 1.50 m; a = 2.50 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.90
Area of cross-section A = 7.07E-01 $m^2/m$
Moment of inertia I = 9.94E-02 $m^4/m$
Elastic modulus E = 31500.00 MPa
Shear modulus G = 12600.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 7.20 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 502.07 kN/m
Passive horizontal force P = 323.38 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C35**
Compressive strength $f_{ck}$ = 23.40 MPa
Tensile strength $f_{tk}$ = 2.20 MPa
Elasticity modulus $E_c$ = 31500.00 MPa
Shear modulus G = 12600.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

Unit weight : $\gamma$ = 17.70 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.60 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 10.00 MN/m$^4$

**2**□ □ □ □

Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 8.00 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.50 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

**3**□ □ □ □ □ □ □

Unit weight : $\gamma$ = 19.00 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 24.00 °
Cohesion of soil : $c_{ef}$ = 15.00 kPa
Angle of friction struc.-soil : $\delta$ = 8.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 21.00 kN/m$^3$
Parameter : m = 20.00 MN/m$^4$

**4-1**□ □ □ □ □ □ □ □ □

Unit weight : $\gamma$ = 17.80 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 11.50 °
Cohesion of soil : $c_{ef}$ = 16.00 kPa
Angle of friction struc.-soil : $\delta$ = 4.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$

Parameter : m = 80.00 MN/m4

**4-2□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 21.50 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 18.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 23.00 kN/m3
Parameter : K = 300.00 MN/m3

**4-3□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 25.70 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 100.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 25.80 kN/m3
Parameter : K = 700.00 MN/m3

**2□ □ □ □ (□ □)**

Unit weight : $\gamma$ = 18.20 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.00 °
Cohesion of soil : $c_{ef}$ = 8.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m3
Parameter : m = 4.00 MN/m4

## Pile fixed into the rock

Length of wall in the rock l = 5.30 m
Uniaxial compressive strength $f_{rk}$ = 8000.00 kPa
Horizontal coefficient K = 0.50
Reduction parameter $\nu$ = 0.30

## Geological profile and assigned soils

**Position information**
Terrain elevation = 19.08 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 7.22 | 0.00 .. 7.22 | 19.08 .. 11.86 | 2□ □ □ □ | |
| 2 | 1.61 | 7.22 .. 8.83 | 11.86 .. 10.25 | 3□ □ □ □ □ □ □ | |
| 3 | 1.48 | 8.83 .. 10.31 | 10.25 .. 8.77 | 4-1□ □ □ □ □ □ □ □ □ | |
| 4 | 1.26 | 10.31 .. 11.57 | 8.77 .. 7.51 | 4-2□ □ □ □ □ □ □ □ □ | |

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 5 | - | 11.57 .. ∞ | 7.51 .. - | 4-3□ □ □ □ □ □ □ □ □ |  |

## Excavation

Soil in front of wall is excavated to a depth of 0.23 m.

## Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -4.38 | 1.33 |
| 3 | -10.23 | 2.81 |
| 4 | -14.72 | 3.64 |
| 5 | -20.10 | 4.65 |
| 6 | -25.57 | 5.43 |
| 7 | -26.29 | 5.43 |
| 8 | -34.10 | 5.34 |
| 9 | -35.10 | 5.34 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

## Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.24 |
| 3 | 2.82 | -1.01 |
| 4 | 4.91 | -1.36 |
| 5 | 7.51 | -1.91 |
| 6 | 10.40 | -2.32 |
| 7 | 11.85 | -2.69 |
| 8 | 14.87 | -2.55 |
| 9 | 17.08 | -2.77 |
| 10 | 20.83 | -3.27 |
| 11 | 22.96 | -3.65 |
| 12 | 25.33 | -4.08 |
| 13 | 26.56 | -4.27 |
| 14 | 28.64 | -4.48 |
| 15 | 32.16 | -4.84 |
| 16 | 35.56 | -5.18 |
| 17 | 38.86 | -5.46 |
| 18 | 41.76 | -5.78 |
| 19 | 43.73 | -5.75 |
| 20 | 46.52 | -5.94 |
| 21 | 51.42 | -6.13 |
| 22 | 54.19 | -6.24 |
| 23 | 58.24 | -6.56 |
| 24 | 62.07 | -7.11 |
| 25 | 64.47 | -7.55 |

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 26 | 65.35 | -7.56 |
| 27 | 67.49 | -7.61 |
| 28 | 71.73 | -7.90 |
| 29 | 75.07 | -8.26 |
| 30 | 81.45 | -8.90 |
| 31 | 84.33 | -9.22 |
| 32 | 85.10 | -9.37 |
| 33 | 86.87 | -9.92 |
| 34 | 91.21 | -11.72 |
| 35 | 94.81 | -13.24 |
| 36 | 96.83 | -14.00 |
| 37 | 100.79 | -15.11 |
| 38 | 102.18 | -15.49 |
| 39 | 103.35 | -15.93 |
| 40 | 104.58 | -15.95 |
| 41 | 112.47 | -16.13 |
| 42 | 117.52 | -16.29 |
| 43 | 118.43 | -16.27 |
| 44 | 119.48 | -16.54 |
| 45 | 120.65 | -16.61 |
| 46 | 121.65 | -16.61 |

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 2.79 m
GWT in front of the structure lies at a depth of 3.09 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

### Settings of the stage of construction

Design situation : permanent

## Analysis results

### Pressure above the slip surface

| Depth [m] | Passive pressure [kPa] | Active pressure [kPa] |
|---|---|---|
| 0 | 0.00 | 69.73 |
| 0.23 | 0.00 | 69.73 |
| 0.23 | 46.40 | 69.73 |
| 7.20 | 46.40 | 69.73 |

### Distributions of the modulus of subsoil reaction and internal forces on the structure

| Depth [m] | kh,p [MN/m3] | kh,z [MN/m3] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | -24.61 | 24.82 | 0.00 | 0.00 |
| 0.78 | 0.00 | 0.00 | -22.59 | 24.82 | -19.36 | 7.55 |
| 1.56 | 0.00 | 0.00 | -20.58 | 24.82 | -38.72 | 30.20 |
| 2.34 | 0.00 | 0.00 | -18.56 | 24.82 | -58.07 | 67.95 |
| 3.12 | 0.00 | 0.00 | -16.57 | 24.82 | -77.43 | 120.79 |
| 3.90 | 0.00 | 0.00 | -14.59 | 24.82 | -96.79 | 188.74 |
| 4.68 | 0.00 | 0.00 | -12.65 | 24.82 | -116.15 | 271.79 |
| 5.46 | 0.00 | 0.00 | -10.77 | 24.82 | -135.51 | 369.93 |
| 6.24 | 0.00 | 0.00 | -8.96 | 24.82 | -154.86 | 483.18 |
| 7.02 | 0.00 | 0.00 | -7.24 | 24.82 | -174.22 | 611.52 |
| 7.80 | 0.00 | 0.00 | -5.64 | -13.68 | -187.87 | 756.97 |
| 8.58 | 0.00 | 0.00 | -4.19 | -22.96 | -173.58 | 898.41 |
| 9.36 | 0.00 | 0.00 | -2.91 | 96.39 | -226.53 | 1048.40 |
| 10.14 | 0.00 | 0.00 | -1.84 | 91.06 | -299.64 | 1253.87 |
| 10.92 | 444.00 | 0.00 | -1.01 | -439.72 | 23.51 | 1376.04 |
| 11.70 | 844.00 | 0.00 | -0.44 | -367.20 | 305.70 | 1242.96 |
| 12.48 | 844.00 | 0.00 | -0.11 | -93.11 | 473.53 | 925.22 |
| 13.26 | 844.00 | 700.00 | 0.04 | 113.82 | 462.80 | 547.40 |
| 14.04 | 844.00 | 700.00 | 0.08 | 179.66 | 319.85 | 236.75 |
| 14.82 | 844.00 | 700.00 | 0.07 | 170.86 | 148.87 | 54.12 |
| 15.60 | 844.00 | 700.00 | 0.05 | 142.19 | 0.00 | 0.00 |

Maximum shear force = 491.51 kN/m
Maximum moment = 1376.04 kNm/m
Maximum displacement = 24.6 mm
Displacement in the depth of slip surface = 6.9 mm

**Soil verification in depth 0.00 m**

Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

**Rock verification in depth 0.00 m**

Max. stress $\sigma$ = 0.00 kPa
Design bearing capacity of rock $R_d$ = 1200.00 kPa

**Bearing capacity of rock is SATISFACTORY**

## Dimensioning No. 1

### Distribution of forces on construction

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | -24.61 | -24.61 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.78 | -22.59 | -22.59 | -19.36 | -19.36 | 7.55 | 7.55 |
| 1.56 | -20.58 | -20.58 | -38.72 | -38.72 | 30.20 | 30.20 |
| 2.34 | -18.56 | -18.56 | -58.07 | -58.07 | 67.95 | 67.95 |
| 3.12 | -16.57 | -16.57 | -77.43 | -77.43 | 120.79 | 120.79 |
| 3.90 | -14.59 | -14.59 | -96.79 | -96.79 | 188.74 | 188.74 |
| 4.68 | -12.65 | -12.65 | -116.15 | -116.15 | 271.79 | 271.79 |

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 5.46 | -10.77 | -10.77 | -135.51 | -135.51 | 369.93 | 369.93 |
| 6.24 | -8.96 | -8.96 | -154.86 | -154.86 | 483.18 | 483.18 |
| 7.02 | -7.24 | -7.24 | -174.22 | -174.22 | 611.52 | 611.52 |
| 7.80 | -5.64 | -5.64 | -187.87 | -187.87 | 756.97 | 756.97 |
| 8.58 | -4.19 | -4.19 | -173.58 | -173.58 | 898.41 | 898.41 |
| 9.36 | -2.91 | -2.91 | -226.53 | -226.53 | 1048.40 | 1048.40 |
| 10.14 | -1.84 | -1.84 | -299.64 | -299.64 | 1253.87 | 1253.87 |
| 10.92 | -1.01 | -1.01 | 23.51 | 23.51 | 1376.04 | 1376.04 |
| 11.70 | -0.44 | -0.44 | 305.70 | 305.70 | 1242.96 | 1242.96 |
| 12.48 | -0.11 | -0.11 | 473.53 | 473.53 | 925.22 | 925.22 |
| 13.26 | 0.04 | 0.04 | 462.80 | 462.80 | 547.40 | 547.40 |
| 14.04 | 0.08 | 0.08 | 319.85 | 319.85 | 236.75 | 236.75 |
| 14.82 | 0.07 | 0.07 | 148.87 | 148.87 | 54.12 | 54.12 |
| 15.60 | 0.05 | 0.05 | 0.00 | 0.00 | 0.00 | 0.00 |

### Maximum values of internal forces

Maximum displacement = -24.6 mm
Minimum displacement = 0.1 mm
Maximum bending moment = 1376.04 kNm/m
Minimum bending moment = 0.00 kNm/m
Maximum shear force = 491.51 kN/m

### Verification of RC cross section (Pile curtain d = 1.50 m; a = 2.50 m)

All construction stages are taken into the analysis.
Partial factor on load = 1.25

### Verification of cross section in bending:

Reinforcement - 26 pc bars 32.0 mm; cover 40.0 mm
Type of structure (reinforcement ratio) : beam
Reinforcement ratio $\rho$ = 0.592 % > 0.200 % = $\rho_{min}$
Load : M = 4300.12 kNm
Bearing capacity : $M_u$ = 4479.77 kNm

**Designed pile reinforcement is SATISFACTORY**

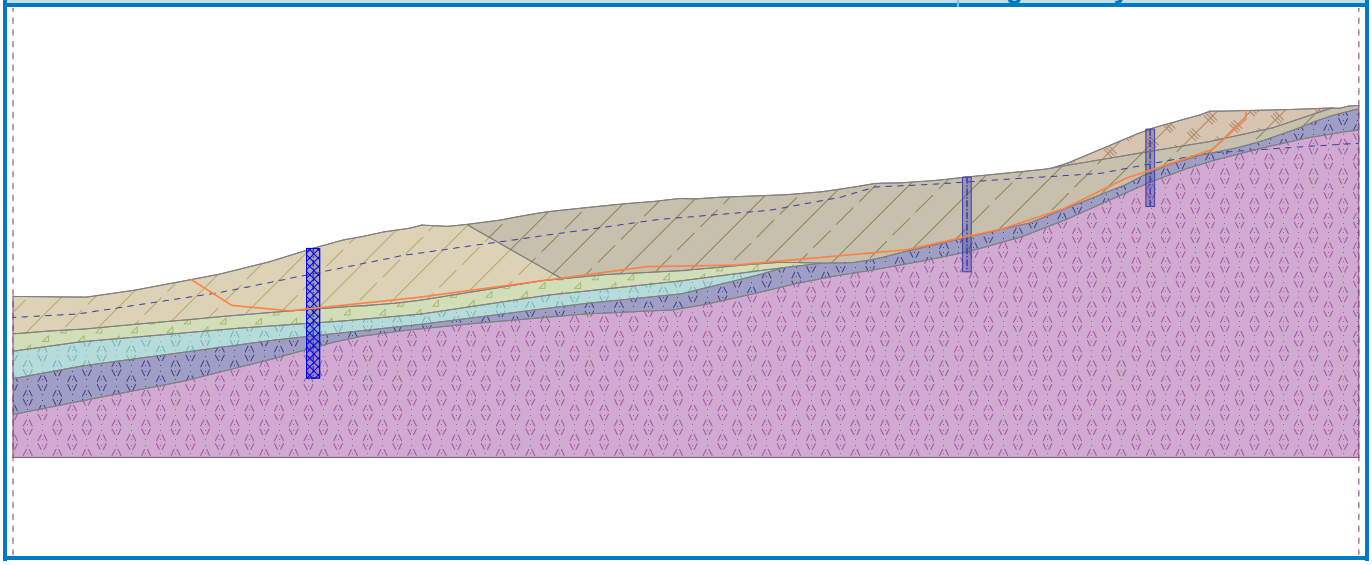
### Verification of cross section in shear:

Shear reinf. - 2 profile 16.0 mm; distance 200.0 mm
$A_{sv}$ = 2010.6 mm$^2$
Ultimate shear force: $V_u$ = 2610.99 kN > 1535.96 kN = V

**Cross-section is SATISFACTORY.**
only minimal shear reinforcement

**Overall verification: Cross-section is SATISFACTORY**

| Name : Piles verification | Stage - analysis : 3 - 1 |
|---|---|



### Piles verification 2 (stage 3)

Anti-Slide pile : Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 11.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete

Computed coefficient of pressure reduction below the ditch = 0.60

| | | | |
|---|---|---|---|
| Area of cross-section | A | = 2.62E-01 | $m^2/m$ |
| Moment of inertia | I | = 1.64E-02 | $m^4/m$ |
| Elastic modulus | E | = 30000.00 | MPa |
| Shear modulus | G | = 12000.00 | MPa |

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 6.89 m

Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 386.71 kN/m
Passive horizontal force P = 316.45 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**

| | | | |
|---|---|---|---|
| Compressive strength | $f_{ck}$ | = 20.10 | MPa |
| Tensile strength | $f_{tk}$ | = 2.01 | MPa |
| Elasticity modulus | $E_c$ | = 30000.00 | MPa |
| Shear modulus | G | = 12000.00 | MPa |

**Longitudinal steel: HRB400**

Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**

Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

Unit weight : $\gamma$ = 17.70 kN/m³

| | |
|---|---|
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 5.60 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 10.00 MN/m$^4$ |

**2□ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 18.20 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 8.00 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.50 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 4.00 MN/m$^4$ |

**3□ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 19.00 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 24.00 ° |
| Cohesion of soil : | $c_{ef}$ = 15.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 8.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 21.00 kN/m$^3$ |
| Parameter : | m = 20.00 MN/m$^4$ |

**4-1□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.80 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 11.50 ° |
| Cohesion of soil : | $c_{ef}$ = 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 4.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 80.00 MN/m$^4$ |

**4-2□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 21.50 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 23.00 kN/m$^3$ |
| Parameter : | K = 300.00 MN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 25.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |

Saturated unit weight : $\gamma_{sat}$ = 25.80 kN/m$^3$
Parameter : K = 700.00 MN/m$^3$

**2□ □ □ □ (□ □ )**
Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.00 °
Cohesion of soil : $c_{ef}$ = 8.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

## Pile fixed into the rock

Length of wall in the rock l = 4.11 m
Uniaxial compressive strength $f_{rk}$ = 8000.00 kPa
Horizontal coefficient K = 0.50
Reduction parameter $\nu$ = 0.30

## Geological profile and assigned soils

**Position information**
Terrain elevation = 27.35 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 6.93 | 0.00 .. 6.93 | 27.35 .. 20.42 | 2□ □ □ □ (□ □ ) | |
| 2 | 1.68 | 6.93 .. 8.61 | 20.42 .. 18.74 | 4-2□ □ □ □ □ □ □ □ | |
| 3 | - | 8.61 .. ∞ | 18.74 .. - | 4-3□ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.06 m.

### Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -2.91 | 0.31 |
| 3 | -7.15 | 0.60 |
| 4 | -9.29 | 0.65 |
| 5 | -10.17 | 0.66 |
| 6 | -12.57 | 1.10 |
| 7 | -16.40 | 1.65 |
| 8 | -20.45 | 1.97 |
| 9 | -23.22 | 2.08 |
| 10 | -28.12 | 2.27 |
| 11 | -30.91 | 2.46 |
| 12 | -32.88 | 2.43 |
| 13 | -35.78 | 2.75 |
| 14 | -39.08 | 3.03 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 15 | -42.48 | 3.37 |
| 16 | -46.00 | 3.73 |
| 17 | -48.08 | 3.94 |
| 18 | -49.31 | 4.13 |
| 19 | -51.68 | 4.56 |
| 20 | -53.81 | 4.94 |
| 21 | -57.56 | 5.44 |
| 22 | -59.77 | 5.66 |
| 23 | -62.79 | 5.52 |
| 24 | -64.24 | 5.89 |
| 25 | -67.13 | 6.30 |
| 26 | -69.73 | 6.85 |
| 27 | -71.82 | 7.20 |
| 28 | -75.35 | 8.20 |
| 29 | -80.52 | 9.77 |
| 30 | -86.37 | 11.25 |
| 31 | -90.86 | 12.08 |
| 32 | -96.24 | 13.09 |
| 33 | -101.71 | 13.87 |
| 34 | -102.43 | 13.87 |
| 35 | -110.24 | 13.78 |
| 36 | -111.24 | 13.78 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

**Terrain profile**

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.06 |
| 3 | 5.81 | -0.63 |
| 4 | 8.69 | -0.95 |
| 5 | 9.46 | -1.10 |
| 6 | 11.23 | -1.65 |
| 7 | 15.57 | -3.45 |
| 8 | 19.17 | -4.97 |
| 9 | 21.19 | -5.73 |
| 10 | 25.15 | -6.84 |
| 11 | 26.54 | -7.22 |
| 12 | 27.71 | -7.66 |
| 13 | 28.94 | -7.68 |
| 14 | 36.83 | -7.86 |
| 15 | 41.88 | -8.02 |
| 16 | 42.79 | -8.00 |
| 17 | 43.84 | -8.27 |
| 18 | 45.01 | -8.34 |
| 19 | 46.01 | -8.34 |

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 0.52 m
GWT in front of the structure lies at a depth of 0.59 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

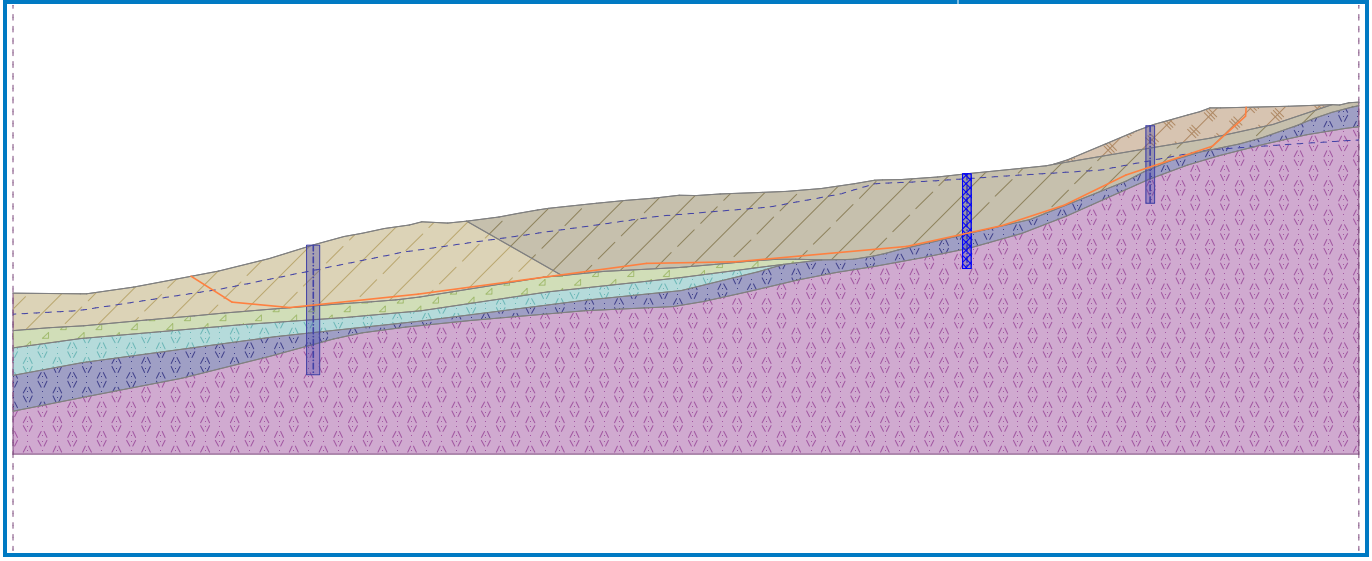
### Settings of the stage of construction

Design situation : permanent

## Analysis results

## Dimensioning No. 1

| Name : Piles verification | Stage - analysis : 3 - 2 |
|---|---|



### Piles verification 3 (stage 3)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards

Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

## Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

## Geometry of structure

Structure length = 9.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.60
Area of cross-section A = 2.62E-01 $m^2/m$
Moment of inertia I = 1.64E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 4.79 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 150.60 kN/m
Passive horizontal force P = 84.17 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

Unit weight : $\gamma$ = 17.70 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.60 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 10.00 MN/m$^4$

**2**□ □ □ □

Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 8.00 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.50 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

**3**□ □ □ □ □ □ □

Unit weight : $\gamma$ = 19.00 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 24.00 °
Cohesion of soil : $c_{ef}$ = 15.00 kPa
Angle of friction struc.-soil : $\delta$ = 8.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 21.00 kN/m$^3$
Parameter : m = 20.00 MN/m$^4$

**4-1**□ □ □ □ □ □ □ □ □

Unit weight : $\gamma$ = 17.80 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 11.50 °
Cohesion of soil : $c_{ef}$ = 16.00 kPa
Angle of friction struc.-soil : $\delta$ = 4.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$

Parameter : m = 80.00 MN/m4

**4-2□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 21.50 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 18.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 23.00 kN/m3
Parameter : K = 300.00 MN/m3

**4-3□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 25.70 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 100.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 25.80 kN/m3
Parameter : K = 700.00 MN/m3

**2□ □ □ □ (□ □)**

Unit weight : $\gamma$ = 18.20 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.00 °
Cohesion of soil : $c_{ef}$ = 8.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m3
Parameter : m = 4.00 MN/m4

## Pile fixed into the rock

Length of wall in the rock l = 4.00 m
Uniaxial compressive strength $f_{rk}$ = 8000.00 kPa
Horizontal coefficient K = 0.50
Reduction parameter $\nu$ = 0.30

## Geological profile and assigned soils

**Position information**
Terrain elevation = 32.93 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 2.67 | 0.00 .. 2.67 | 32.93 .. 30.26 | 1□ □ □ | |
| 2 | 2.33 | 2.67 .. 5.00 | 30.26 .. 27.93 | 2□ □ □ □ (□ □) | |
| 3 | 1.17 | 5.00 .. 6.17 | 27.93 .. 26.76 | 4-2□ □ □ □ □ □ □ □ □ | |
| 4 | - | 6.17 .. ∞ | 26.76 .. - | 4-3□ □ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.19 m.

### Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -1.11 | 0.42 |
| 3 | -4.71 | 1.94 |
| 4 | -9.05 | 3.74 |
| 5 | -10.82 | 4.29 |
| 6 | -11.59 | 4.44 |
| 7 | -14.47 | 4.76 |
| 8 | -20.85 | 5.40 |
| 9 | -24.19 | 5.76 |
| 10 | -28.43 | 6.05 |
| 11 | -30.57 | 6.10 |
| 12 | -31.45 | 6.11 |
| 13 | -33.85 | 6.55 |
| 14 | -37.68 | 7.10 |
| 15 | -41.73 | 7.42 |
| 16 | -44.50 | 7.53 |
| 17 | -49.40 | 7.72 |
| 18 | -52.19 | 7.91 |
| 19 | -54.16 | 7.88 |
| 20 | -57.06 | 8.20 |
| 21 | -60.36 | 8.48 |
| 22 | -63.76 | 8.82 |
| 23 | -67.28 | 9.18 |
| 24 | -69.36 | 9.39 |
| 25 | -70.59 | 9.58 |
| 26 | -72.96 | 10.01 |
| 27 | -75.09 | 10.39 |
| 28 | -78.84 | 10.89 |
| 29 | -81.05 | 11.11 |
| 30 | -84.07 | 10.97 |
| 31 | -85.52 | 11.34 |
| 32 | -88.41 | 11.75 |
| 33 | -91.01 | 12.30 |
| 34 | -93.10 | 12.65 |
| 35 | -96.63 | 13.65 |
| 36 | -101.80 | 15.22 |
| 37 | -107.65 | 16.70 |
| 38 | -112.14 | 17.53 |
| 39 | -117.52 | 18.54 |
| 40 | -122.99 | 19.32 |
| 41 | -123.71 | 19.32 |
| 42 | -131.52 | 19.23 |
| 43 | -132.52 | 19.23 |

Origin [0,0] is located at the ditch bottom.

Positive coordinate +z has downward direction.

### Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.20 |
| 3 | 3.87 | -1.26 |
| 4 | 5.26 | -1.64 |
| 5 | 6.43 | -2.08 |
| 6 | 7.66 | -2.10 |
| 7 | 15.55 | -2.28 |
| 8 | 20.60 | -2.44 |
| 9 | 21.51 | -2.42 |
| 10 | 22.56 | -2.69 |
| 11 | 23.73 | -2.76 |
| 12 | 24.73 | -2.76 |

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 3.95 m
GWT in front of the structure lies at a depth of 4.14 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

### Settings of the stage of construction

Design situation : permanent

## Analysis results

### Pressure above the slip surface

| Depth [m] | Passive pressure [kPa] | Active pressure [kPa] |
|---|---|---|
| 0 | 0.00 | 31.44 |
| 0.19 | 0.00 | 31.44 |
| 0.19 | 18.30 | 31.44 |
| 4.79 | 18.30 | 31.44 |

### Distributions of the modulus of subsoil reaction and internal forces on the structure

| Depth [m] | kh,p [MN/m$^3$] | kh,z [MN/m$^3$] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | -6.85 | 13.87 | 0.00 | 0.00 |
| 0.45 | 0.00 | 0.00 | -6.24 | 13.87 | -6.24 | 1.40 |
| 0.90 | 0.00 | 0.00 | -5.63 | 13.87 | -12.48 | 5.62 |
| 1.35 | 0.00 | 0.00 | -5.03 | 13.87 | -18.72 | 12.64 |
| 1.80 | 0.00 | 0.00 | -4.43 | 13.87 | -24.96 | 22.47 |
| 2.25 | 0.00 | 0.00 | -3.83 | 13.87 | -31.20 | 35.10 |
| 2.70 | 0.00 | 0.00 | -3.26 | 13.87 | -37.44 | 50.55 |
| 3.15 | 0.00 | 0.00 | -2.70 | 13.87 | -43.69 | 68.80 |

| Depth [m] | kh,p [MN/m3] | kh,z [MN/m3] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 3.60 | 0.00 | 0.00 | -2.18 | 13.87 | -49.93 | 89.87 |
| 4.05 | 0.00 | 0.00 | -1.69 | 13.87 | -56.17 | 113.74 |
| 4.50 | 0.00 | 0.00 | -1.24 | 13.87 | -62.41 | 140.42 |
| 4.95 | 0.00 | 0.00 | -0.86 | 37.67 | -72.39 | 170.20 |
| 5.40 | 300.00 | 0.00 | -0.54 | -152.45 | -12.46 | 191.26 |
| 5.85 | 300.00 | 0.00 | -0.31 | -80.67 | 39.11 | 184.05 |
| 6.30 | 700.00 | 0.00 | -0.14 | -89.12 | 71.58 | 159.15 |
| 6.75 | 700.00 | 0.00 | -0.05 | -20.79 | 94.78 | 120.57 |
| 7.20 | 700.00 | 700.00 | -0.00 | 37.14 | 91.28 | 77.45 |
| 7.65 | 700.00 | 700.00 | 0.01 | 59.84 | 68.19 | 41.19 |
| 8.10 | 700.00 | 700.00 | 0.01 | 58.07 | 41.05 | 16.64 |
| 8.55 | 700.00 | 700.00 | 0.00 | 45.61 | 17.43 | 3.68 |
| 9.00 | 700.00 | 700.00 | -0.01 | 31.31 | 0.00 | -0.00 |

Maximum shear force = 96.86 kN/m
Maximum moment = 191.26 kNm/m
Maximum displacement = 6.8 mm
Displacement in the depth of slip surface = 1.0 mm

**Soil verification in depth 0.00 m**

Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

**Rock verification in depth 0.00 m**

Max. stress $\sigma$ = 0.00 kPa
Design bearing capacity of rock $R_d$ = 1200.00 kPa

**Bearing capacity of rock is SATISFACTORY**

## Dimensioning No. 1

### Distribution of forces on construction

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | -6.85 | -6.85 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.45 | -6.24 | -6.24 | -6.24 | -6.24 | 1.40 | 1.40 |
| 0.90 | -5.63 | -5.63 | -12.48 | -12.48 | 5.62 | 5.62 |
| 1.35 | -5.03 | -5.03 | -18.72 | -18.72 | 12.64 | 12.64 |
| 1.80 | -4.43 | -4.43 | -24.96 | -24.96 | 22.47 | 22.47 |
| 2.25 | -3.83 | -3.83 | -31.20 | -31.20 | 35.10 | 35.10 |
| 2.70 | -3.26 | -3.26 | -37.44 | -37.44 | 50.55 | 50.55 |
| 3.15 | -2.70 | -2.70 | -43.69 | -43.69 | 68.80 | 68.80 |
| 3.60 | -2.18 | -2.18 | -49.93 | -49.93 | 89.87 | 89.87 |
| 4.05 | -1.69 | -1.69 | -56.17 | -56.17 | 113.74 | 113.74 |
| 4.50 | -1.24 | -1.24 | -62.41 | -62.41 | 140.42 | 140.42 |
| 4.95 | -0.86 | -0.86 | -72.39 | -72.39 | 170.20 | 170.20 |
| 5.40 | -0.54 | -0.54 | -12.46 | -12.46 | 191.26 | 191.26 |
| 5.85 | -0.31 | -0.31 | 39.11 | 39.11 | 184.05 | 184.05 |
| 6.30 | -0.14 | -0.14 | 71.58 | 71.58 | 159.15 | 159.15 |
| 6.75 | -0.05 | -0.05 | 94.78 | 94.78 | 120.57 | 120.57 |

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 7.20 | -0.00 | -0.00 | 91.28 | 91.28 | 77.45 | 77.45 |
| 7.65 | 0.01 | 0.01 | 68.19 | 68.19 | 41.19 | 41.19 |
| 8.10 | 0.01 | 0.01 | 41.05 | 41.05 | 16.64 | 16.64 |
| 8.55 | 0.00 | 0.00 | 17.43 | 17.43 | 3.68 | 3.68 |
| 9.00 | -0.01 | -0.01 | 0.00 | 0.00 | -0.00 | -0.00 |

### Maximum values of internal forces

Maximum displacement = -6.8 mm
Minimum displacement = 0.0 mm
Maximum bending moment = 191.26 kNm/m
Minimum bending moment = 0.00 kNm/m
Maximum shear force = 96.86 kN/m

### Verification of RC cross section (Pile curtain d = 1.00 m; a = 3.00 m)

All construction stages are taken into the analysis.
Partial factor on load = 1.25

### Verification of cross section in bending:

Reinforcement - 10 pc bars 25.0 mm; cover 40.0 mm
Type of structure (reinforcement ratio) : beam
Reinforcement ratio $\rho$ = 0.312 % > 0.200 % = $\rho_{min}$
Load : M = 717.21 kNm
Bearing capacity : $M_u$ = 721.63 kNm

**Designed pile reinforcement is SATISFACTORY**

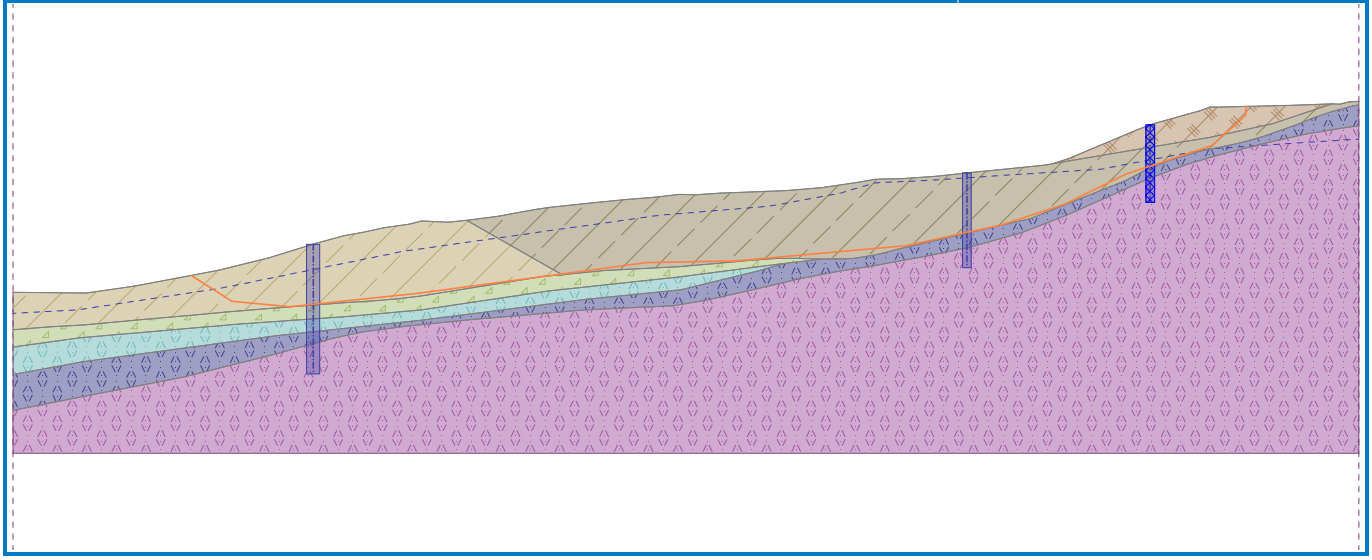
### Verification of cross section in shear:

Ultimate shear force: $V_u$ = 707.52 kN > 363.21 kN = V

**Cross-section is SATISFACTORY.**

**Overall verification: Cross-section is SATISFACTORY**

| Name : Piles verification | Stage - analysis : 3 - 3 |
|---|---|



### Piles verification 4 (stage 3)

Anti-Slide pile : Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Analysis : Calculation 1 (slip surface polygonal)
Method : ITFM

# Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 11.00 m

Cross-section name : Pile curtain d = 1.20 m; a = 3.00 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.66
Area of cross-section A = 3.77E-01 $m^2/m$
Moment of inertia I = 3.39E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

### Forces above the slip surface

Depth of slip surface $h_{s1}$ = 6.97 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 340.30 kN/m
Passive horizontal force P = 198.77 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

### Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □
Unit weight : $\gamma$ = 17.70 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.60 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 10.00 MN/m$^4$

**2**□ □ □ □
Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 8.00 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.50 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

**3**□ □ □ □ □ □ □
Unit weight : $\gamma$ = 19.00 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 24.00 °
Cohesion of soil : $c_{ef}$ = 15.00 kPa
Angle of friction struc.-soil : $\delta$ = 8.00 °

| | |
|---|---|
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 21.00 kN/m$^3$ |
| Parameter : | m = 20.00 MN/m$^4$ |

**4-1□ □ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.80 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 11.50 ° |
| Cohesion of soil : | $c_{ef}$ = 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 4.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 80.00 MN/m$^4$ |

**4-2□ □ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 21.50 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 23.00 kN/m$^3$ |
| Parameter : | K = 300.00 MN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 25.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 25.80 kN/m$^3$ |
| Parameter : | K = 700.00 MN/m$^3$ |

**2□ □ □ □ (□ □)**

| | |
|---|---|
| Unit weight : | $\gamma$ = 18.20 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 5.00 ° |
| Cohesion of soil : | $c_{ef}$ = 8.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 4.00 MN/m$^4$ |

## Pile fixed into the rock

| | | | |
|---|---|---|---|
| Length of wall in the rock | l | = 4.03 | m |
| Uniaxial compressive strength | $f_{rk}$ | = 8000.00 | kPa |
| Horizontal coefficient | K | = 0.50 | |
| Reduction parameter | $\nu$ | = 0.30 | |

## Geological profile and assigned soils

**Position information**
Terrain elevation = 27.35 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 6.93 | 0.00 .. 6.93 | 27.35 .. 20.42 | 2□ □ □ □ (□ □ ) |  |
| 2 | 1.68 | 6.93 .. 8.61 | 20.42 .. 18.74 | 4-2□ □ □ □ □ □ □ □ □ |  |
| 3 | - | 8.61 .. ∞ | 18.74 .. - | 4-3□ □ □ □ □ □ □ □ □ |  |

## Excavation

Soil in front of wall is excavated to a depth of 0.06 m.

## Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -2.91 | 0.31 |
| 3 | -7.15 | 0.60 |
| 4 | -9.29 | 0.65 |
| 5 | -10.17 | 0.66 |
| 6 | -12.57 | 1.10 |
| 7 | -16.40 | 1.65 |
| 8 | -20.45 | 1.97 |
| 9 | -23.22 | 2.08 |
| 10 | -28.12 | 2.27 |
| 11 | -30.91 | 2.46 |
| 12 | -32.88 | 2.43 |
| 13 | -35.78 | 2.75 |
| 14 | -39.08 | 3.03 |
| 15 | -42.48 | 3.37 |
| 16 | -46.00 | 3.73 |
| 17 | -48.08 | 3.94 |
| 18 | -49.31 | 4.13 |
| 19 | -51.68 | 4.56 |
| 20 | -53.81 | 4.94 |
| 21 | -57.56 | 5.44 |
| 22 | -59.77 | 5.66 |
| 23 | -62.79 | 5.52 |
| 24 | -64.24 | 5.89 |
| 25 | -67.13 | 6.30 |
| 26 | -69.73 | 6.85 |
| 27 | -71.82 | 7.20 |
| 28 | -75.35 | 8.20 |
| 29 | -80.52 | 9.77 |
| 30 | -86.37 | 11.25 |
| 31 | -90.86 | 12.08 |
| 32 | -96.24 | 13.09 |
| 33 | -101.71 | 13.87 |
| 34 | -102.43 | 13.87 |
| 35 | -110.24 | 13.78 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 36 | -111.24 | 13.78 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

### Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.06 |
| 3 | 5.81 | -0.63 |
| 4 | 8.69 | -0.95 |
| 5 | 9.46 | -1.10 |
| 6 | 11.23 | -1.65 |
| 7 | 15.57 | -3.45 |
| 8 | 19.17 | -4.97 |
| 9 | 21.19 | -5.73 |
| 10 | 25.15 | -6.84 |
| 11 | 26.54 | -7.22 |
| 12 | 27.71 | -7.66 |
| 13 | 28.94 | -7.68 |
| 14 | 36.83 | -7.86 |
| 15 | 41.88 | -8.02 |
| 16 | 42.79 | -8.00 |
| 17 | 43.84 | -8.27 |
| 18 | 45.01 | -8.34 |
| 19 | 46.01 | -8.34 |

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 0.52 m
GWT in front of the structure lies at a depth of 0.59 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

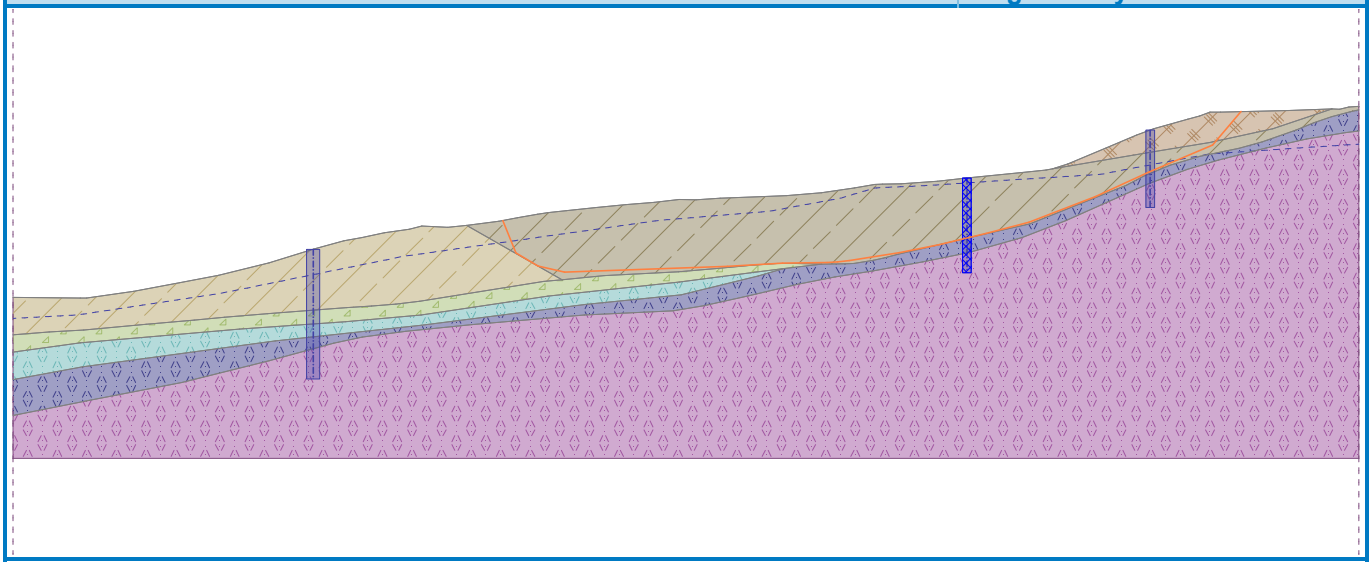
### Settings of the stage of construction

Design situation : permanent

## Analysis results

## Dimensioning No. 1

| Name : Piles verification | Stage - analysis : 3 - 4 |
|---|---|



### Piles verification 5 (stage 3)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 1 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 9.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.60
Area of cross-section A = 2.62E-01 $m^2/m$
Moment of inertia I = 1.64E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 5.00 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 148.66 kN/m
Passive horizontal force P = 20.03 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 17.70 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 5.60 ° |
| Cohesion of soil : | $c_{ef}$ | = | 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 2.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 20.00 kN/m$^3$ |
| Parameter : | m | = | 10.00 MN/m$^4$ |

**2**□ □ □ □

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 18.20 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 8.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 2.50 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 20.00 kN/m$^3$ |
| Parameter : | m | = | 4.00 MN/m$^4$ |

**3**□ □ □ □ □ □ □

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 19.00 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 24.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 15.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 8.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 21.00 kN/m$^3$ |
| Parameter : | m | = | 20.00 MN/m$^4$ |

**4-1**□ □ □ □ □ □ □ □ □

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 17.80 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 11.50 ° |
| Cohesion of soil : | $c_{ef}$ | = | 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 4.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 20.00 kN/m$^3$ |
| Parameter : | m | = | 80.00 MN/m$^4$ |

**4-2**□ □ □ □ □ □ □ □ □

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 21.50 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 30.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 10.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 23.00 kN/m$^3$ |
| Parameter : | K | = | 300.00 MN/m$^3$ |

**4-3**□ □ □ □ □ □ □ □ □

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 25.70 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 30.00 ° |

| | | | |
|---|---|---|---|
| Cohesion of soil : | $c_{ef}$ | = | 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 10.00 ° |
| Soil : | | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ | = | 25.80 kN/m$^3$ |
| Parameter : | K | = | 700.00 MN/m$^3$ |

**2□ □ □ □ (□ □ )**

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 18.20 kN/m$^3$ |
| Stress-state : | | | effective |
| Angle of internal friction : | $\varphi_{ef}$ | = | 5.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 8.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 2.00 ° |
| Soil : | | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ | = | 20.00 kN/m$^3$ |
| Parameter : | m | = | 4.00 MN/m$^4$ |

## Pile fixed into the rock

| | | | |
|---|---|---|---|
| Length of wall in the rock | l | = 4.00 | m |
| Uniaxial compressive strength | $f_{rk}$ | = 8000.00 | kPa |
| Horizontal coefficient | K | = 0.50 | |
| Reduction parameter | $\nu$ | = 0.30 | |

## Geological profile and assigned soils

**Position information**
Terrain elevation = 32.93 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 2.67 | 0.00 .. 2.67 | 32.93 .. 30.26 | 1□ □ □ | |
| 2 | 2.33 | 2.67 .. 5.00 | 30.26 .. 27.93 | 2□ □ □ □ (□ □ ) | |
| 3 | 1.17 | 5.00 .. 6.17 | 27.93 .. 26.76 | 4-2□ □ □ □ □ □ □ □ | |
| 4 | - | 6.17 .. ∞ | 26.76 .. - | 4-3□ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.19 m.

### Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -1.11 | 0.42 |
| 3 | -4.71 | 1.94 |
| 4 | -9.05 | 3.74 |
| 5 | -10.82 | 4.29 |
| 6 | -11.59 | 4.44 |
| 7 | -14.47 | 4.76 |
| 8 | -20.85 | 5.40 |
| 9 | -24.19 | 5.76 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 10 | -28.43 | 6.05 |
| 11 | -30.57 | 6.10 |
| 12 | -31.45 | 6.11 |
| 13 | -33.85 | 6.55 |
| 14 | -37.68 | 7.10 |
| 15 | -41.73 | 7.42 |
| 16 | -44.50 | 7.53 |
| 17 | -49.40 | 7.72 |
| 18 | -52.19 | 7.91 |
| 19 | -54.16 | 7.88 |
| 20 | -57.06 | 8.20 |
| 21 | -60.36 | 8.48 |
| 22 | -63.76 | 8.82 |
| 23 | -67.28 | 9.18 |
| 24 | -69.36 | 9.39 |
| 25 | -70.59 | 9.58 |
| 26 | -72.96 | 10.01 |
| 27 | -75.09 | 10.39 |
| 28 | -78.84 | 10.89 |
| 29 | -81.05 | 11.11 |
| 30 | -84.07 | 10.97 |
| 31 | -85.52 | 11.34 |
| 32 | -88.41 | 11.75 |
| 33 | -91.01 | 12.30 |
| 34 | -93.10 | 12.65 |
| 35 | -96.63 | 13.65 |
| 36 | -101.80 | 15.22 |
| 37 | -107.65 | 16.70 |
| 38 | -112.14 | 17.53 |
| 39 | -117.52 | 18.54 |
| 40 | -122.99 | 19.32 |
| 41 | -123.71 | 19.32 |
| 42 | -131.52 | 19.23 |
| 43 | -132.52 | 19.23 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

**Terrain profile**

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.20 |
| 3 | 3.87 | -1.26 |
| 4 | 5.26 | -1.64 |
| 5 | 6.43 | -2.08 |
| 6 | 7.66 | -2.10 |
| 7 | 15.55 | -2.28 |
| 8 | 20.60 | -2.44 |

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 9 | 21.51 | -2.42 |
| 10 | 22.56 | -2.69 |
| 11 | 23.73 | -2.76 |
| 12 | 24.73 | -2.76 |

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 3.95 m
GWT in front of the structure lies at a depth of 4.14 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

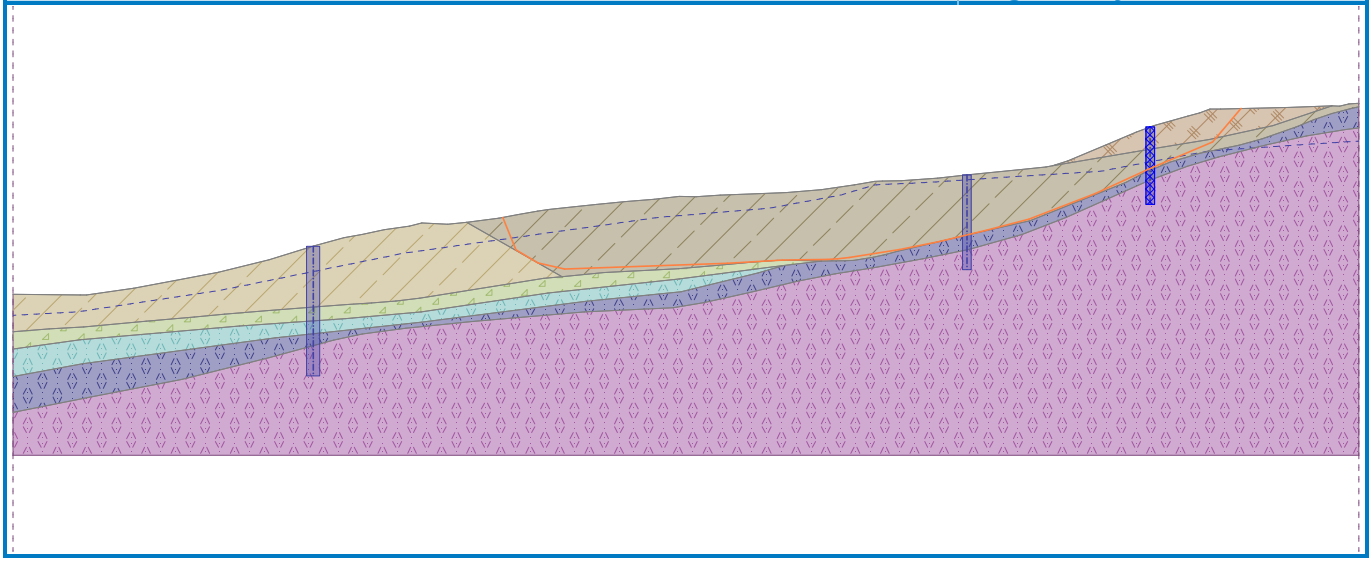
### Settings of the stage of construction

Design situation : permanent

## Analysis results

## Dimensioning No. 1

| Name : Piles verification | Stage - analysis : 3 - 5 |
|---|---|



### Piles verification 6 (stage 3)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 3 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

## Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

## Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

## Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

## Geometry of structure

Structure length = 9.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.60
Area of cross-section A = 2.62E-01 $m^2/m$
Moment of inertia I = 1.64E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 4.96 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 167.60 kN/m
Passive horizontal force P = 34.18 kN/m

Distribution of active force : trapezoid
Distribution of passive force : trapezoid
Ratio of end values = 1.00

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

### Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

### Soil parameters

**1**□ □ □

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 17.70 kN/m$^3$ |
| Stress-state : | | effective |
| Angle of internal friction : | $\varphi_{ef}$ = | 5.60 ° |
| Cohesion of soil : | $c_{ef}$ = | 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 2.00 ° |
| Soil : | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = | 20.00 kN/m$^3$ |
| Parameter : | m = | 10.00 MN/m$^4$ |

**2**□ □ □ □

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 18.20 kN/m$^3$ |
| Stress-state : | | effective |
| Angle of internal friction : | $\varphi_{ef}$ = | 8.00 ° |
| Cohesion of soil : | $c_{ef}$ = | 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 2.50 ° |
| Soil : | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = | 20.00 kN/m$^3$ |
| Parameter : | m = | 4.00 MN/m$^4$ |

**3**□ □ □ □ □ □ □

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 19.00 kN/m$^3$ |
| Stress-state : | | effective |
| Angle of internal friction : | $\varphi_{ef}$ = | 24.00 ° |
| Cohesion of soil : | $c_{ef}$ = | 15.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 8.00 ° |
| Soil : | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = | 21.00 kN/m$^3$ |

Parameter : m = 20.00 MN/m4

**4-1□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 17.80 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 11.50 °
Cohesion of soil : $c_{ef}$ = 16.00 kPa
Angle of friction struc.-soil : $\delta$ = 4.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m3
Parameter : m = 80.00 MN/m4

**4-2□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 21.50 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 18.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 23.00 kN/m3
Parameter : K = 300.00 MN/m3

**4-3□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 25.70 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 100.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 25.80 kN/m3
Parameter : K = 700.00 MN/m3

**2□ □ □ □ (□ □)**

Unit weight : $\gamma$ = 18.20 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.00 °
Cohesion of soil : $c_{ef}$ = 8.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m3
Parameter : m = 4.00 MN/m4

## Pile fixed into the rock

Length of wall in the rock l = 4.04 m
Uniaxial compressive strength $f_{rk}$ = 8000.00 kPa
Horizontal coefficient K = 0.50
Reduction parameter $\nu$ = 0.30

## Geological profile and assigned soils

**Position information**
Terrain elevation = 32.93 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 2.67 | 0.00 .. 2.67 | 32.93 .. 30.26 | 1□ □ □ | |
| 2 | 2.33 | 2.67 .. 5.00 | 30.26 .. 27.93 | 2□ □ □ □ (□ □ ) | |
| 3 | 1.17 | 5.00 .. 6.17 | 27.93 .. 26.76 | 4-2□ □ □ □ □ □ □ □ □ | |
| 4 | - | 6.17 .. ∞ | 26.76 .. - | 4-3□ □ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.19 m.

## Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -1.11 | 0.42 |
| 3 | -4.71 | 1.94 |
| 4 | -9.05 | 3.74 |
| 5 | -10.82 | 4.29 |
| 6 | -11.59 | 4.44 |
| 7 | -14.47 | 4.76 |
| 8 | -20.85 | 5.40 |
| 9 | -24.19 | 5.76 |
| 10 | -28.43 | 6.05 |
| 11 | -30.57 | 6.10 |
| 12 | -31.45 | 6.11 |
| 13 | -33.85 | 6.55 |
| 14 | -37.68 | 7.10 |
| 15 | -41.73 | 7.42 |
| 16 | -44.50 | 7.53 |
| 17 | -49.40 | 7.72 |
| 18 | -52.19 | 7.91 |
| 19 | -54.16 | 7.88 |
| 20 | -57.06 | 8.20 |
| 21 | -60.36 | 8.48 |
| 22 | -63.76 | 8.82 |
| 23 | -67.28 | 9.18 |
| 24 | -69.36 | 9.39 |
| 25 | -70.59 | 9.58 |
| 26 | -72.96 | 10.01 |
| 27 | -75.09 | 10.39 |
| 28 | -78.84 | 10.89 |
| 29 | -81.05 | 11.11 |
| 30 | -84.07 | 10.97 |
| 31 | -85.52 | 11.34 |
| 32 | -88.41 | 11.75 |
| 33 | -91.01 | 12.30 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 34 | -93.10 | 12.65 |
| 35 | -96.63 | 13.65 |
| 36 | -101.80 | 15.22 |
| 37 | -107.65 | 16.70 |
| 38 | -112.14 | 17.53 |
| 39 | -117.52 | 18.54 |
| 40 | -122.99 | 19.32 |
| 41 | -123.71 | 19.32 |
| 42 | -131.52 | 19.23 |
| 43 | -132.52 | 19.23 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

### Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.20 |
| 3 | 3.87 | -1.26 |
| 4 | 5.26 | -1.64 |
| 5 | 6.43 | -2.08 |
| 6 | 7.66 | -2.10 |
| 7 | 15.55 | -2.28 |
| 8 | 20.60 | -2.44 |
| 9 | 21.51 | -2.42 |
| 10 | 22.56 | -2.69 |
| 11 | 23.73 | -2.76 |
| 12 | 24.73 | -2.76 |

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 3.95 m
GWT in front of the structure lies at a depth of 4.14 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

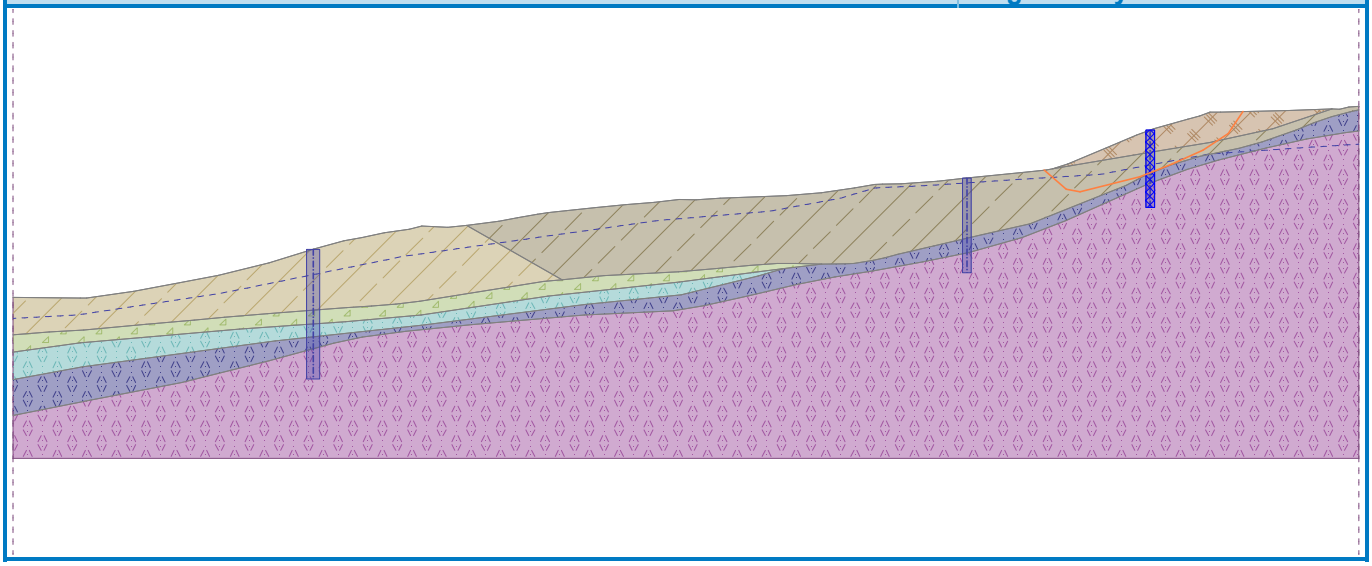
### Settings of the stage of construction

Design situation : permanent

## Analysis results

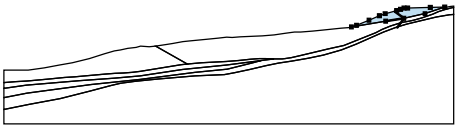
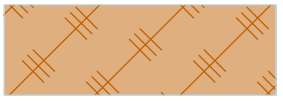
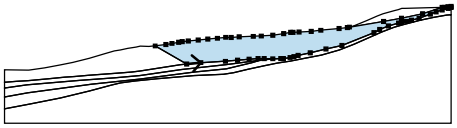
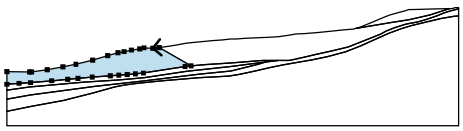
## Dimensioning No. 1

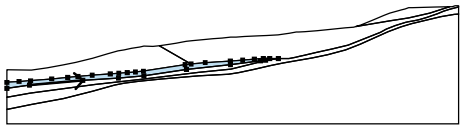
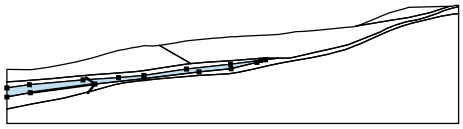
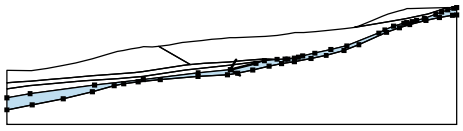
| Name : Piles verification | Stage - analysis : 3 - 6 |
|---|---|

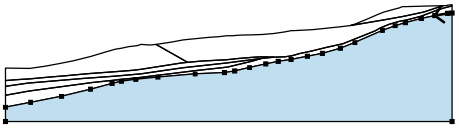


## Input data (Stage of construction 4)

### Assigning and surfaces

| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| 1 |  | 132.59 | 30.45 | 138.93 | 31.50 | 1□ □ □ |
| | | 146.27 | 33.09 | 153.12 | 35.37 |  |
| | | 148.07 | 35.21 | 140.18 | 35.03 | |
| | | 138.95 | 35.01 | 137.78 | 34.57 | |
| | | 136.39 | 34.19 | 132.43 | 33.08 | |
| | | 130.41 | 32.32 | 126.81 | 30.80 | |
| | | 122.47 | 29.00 | 120.70 | 28.45 | |
| 2 |  | 63.73 | 15.55 | 68.61 | 16.01 | 2□ □ □ □ (□ □ ) |
| | | 77.28 | 16.47 | 81.57 | 16.82 |  |
| | | 85.59 | 17.21 | 88.71 | 17.42 | |
| | | 90.88 | 17.43 | 93.87 | 17.36 | |
| | | 96.65 | 17.39 | 97.60 | 17.45 | |
| | | 99.90 | 17.81 | 101.26 | 18.12 | |
| | | 102.75 | 18.52 | 106.94 | 19.48 | |
| | | 112.50 | 20.76 | 118.08 | 22.04 | |
| | | 129.24 | 26.49 | 131.27 | 27.59 | |
| | | 134.31 | 28.85 | 137.83 | 29.88 | |
| | | 138.92 | 30.10 | 140.73 | 30.48 | |
| | | 142.36 | 30.83 | 145.04 | 31.57 | |
| | | 148.95 | 32.95 | 151.03 | 33.77 | |
| | | 153.13 | 34.48 | 155.23 | 35.05 | |
| | | 156.25 | 35.28 | 156.25 | 35.69 | |
| | | 155.08 | 35.62 | 154.03 | 35.35 | |
| | | 153.12 | 35.37 | 146.27 | 33.09 | |
| | | 138.93 | 31.50 | 132.59 | 30.45 | |
| | | 120.70 | 28.45 | 119.93 | 28.30 | |
| | | 117.05 | 27.98 | 110.67 | 27.34 | |
| | | 107.33 | 26.98 | 103.09 | 26.69 | |
| | | 100.95 | 26.64 | 100.07 | 26.63 | |
| | | 97.67 | 26.19 | 93.84 | 25.64 | |
| | | 89.79 | 25.32 | 87.02 | 25.21 | |
| | | 82.12 | 25.02 | 79.33 | 24.83 | |
| | | 77.36 | 24.86 | 74.46 | 24.54 | |
| | | 71.16 | 24.26 | 67.76 | 23.92 | |
| | | 64.24 | 23.56 | 62.16 | 23.35 | |
| | | 60.93 | 23.16 | 58.56 | 22.73 | |
| | | 56.43 | 22.35 | 52.68 | 21.85 | |
| 3 |  | 52.68 | 21.85 | 50.47 | 21.63 | 2□ □ □ □ |
| | | 47.45 | 21.77 | 46.00 | 21.40 |  |
| | | 43.11 | 20.99 | 40.51 | 20.44 | |
| | | 38.42 | 20.09 | 34.89 | 19.09 | |
| | | 29.72 | 17.52 | 23.87 | 16.04 | |
| | | 19.38 | 15.21 | 14.00 | 14.20 | |
| | | 8.53 | 13.42 | 7.81 | 13.42 | |
| | | 0.00 | 13.51 | 0.00 | 9.16 | |
| | | 4.21 | 9.48 | 8.21 | 9.71 | |
| | | 15.48 | 10.36 | 21.05 | 10.87 | |

| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| | | 24.56 | 11.18 | 29.52 | 11.60 | |
| | | 35.74 | 12.08 | 38.72 | 12.30 | |
| | | 41.63 | 12.50 | 44.47 | 12.73 | |
| | | 47.24 | 13.03 | 61.64 | 15.34 | |
| | | 63.73 | 15.55 | | | |
| 4 |  | 7.81 | 8.22 | 26.31 | 9.83 | 3□ □ □ □ □ □ □ |
| | | 38.60 | 10.67 | 47.38 | 11.46 | |
| | | 62.10 | 13.65 | 77.36 | 15.26 | |
| | | 87.69 | 16.63 | 89.46 | 16.83 | |
| | | 93.87 | 17.36 | 90.88 | 17.43 | |
| | | 88.71 | 17.42 | 85.59 | 17.21 | |
| | | 81.57 | 16.82 | 77.28 | 16.47 | |
| | | 68.61 | 16.01 | 63.73 | 15.55 | |
| | | 61.64 | 15.34 | 47.24 | 13.03 | |
| | | 44.47 | 12.73 | 41.63 | 12.50 | |
| | | 38.72 | 12.30 | 35.74 | 12.08 | |
| | | 29.52 | 11.60 | 24.56 | 11.18 | |
| | | 21.05 | 10.87 | 15.48 | 10.36 | |
| | | 8.21 | 9.71 | 4.21 | 9.48 | |
| | | 0.00 | 9.16 | 0.00 | 7.12 | |
| 5 |  | 8.08 | 5.43 | 30.44 | 8.42 | 4-1□ □ □ □ □ □ □ □ □ |
| | | 47.42 | 10.27 | 66.44 | 12.66 | |
| | | 77.57 | 13.79 | 86.51 | 15.97 | |
| | | 89.46 | 16.83 | 87.69 | 16.63 | |
| | | 77.36 | 15.26 | 62.10 | 13.65 | |
| | | 47.38 | 11.46 | 38.60 | 10.67 | |
| | | 26.31 | 9.83 | 7.81 | 8.22 | |
| | | 0.00 | 7.12 | 0.00 | 3.95 | |
| 6 |  | 86.51 | 15.97 | 77.57 | 13.79 | 4-2□ □ □ □ □ □ □ □ □ |
| | | 66.44 | 12.66 | 47.42 | 10.27 | |
| | | 30.44 | 8.42 | 8.08 | 5.43 | |
| | | 0.00 | 3.95 | 0.00 | -0.21 | |
| | | 8.79 | 1.52 | 19.57 | 3.60 | |
| | | 29.73 | 6.12 | 37.25 | 8.17 | |
| | | 40.56 | 8.88 | 45.62 | 9.54 | |
| | | 53.28 | 10.32 | 66.36 | 11.44 | |
| | | 76.64 | 11.95 | 80.20 | 12.52 | |
| | | 85.40 | 13.68 | 91.09 | 15.01 | |
| | | 95.44 | 15.88 | 99.89 | 16.57 | |
| | | 105.64 | 17.61 | 110.93 | 18.70 | |
| | | 117.14 | 20.43 | 122.26 | 22.42 | |
| | | 131.90 | 26.71 | 136.33 | 28.35 | |
| | | 139.95 | 29.45 | 145.52 | 30.84 | |
| | | 150.19 | 31.90 | 154.74 | 32.64 | |
| | | 156.25 | 32.81 | 156.25 | 35.28 | |
| | | 155.23 | 35.05 | 153.13 | 34.48 | |
| | | 151.03 | 33.77 | 148.95 | 32.95 | |
| | | 145.04 | 31.57 | 142.36 | 30.83 | |
| | | 140.73 | 30.48 | 138.92 | 30.10 | |
| | | 137.83 | 29.88 | 134.31 | 28.85 | |

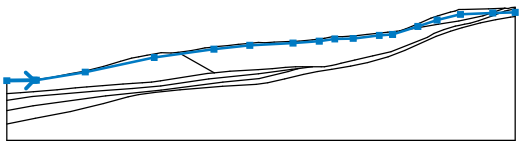
| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| | | 131.27 | 27.59 | 129.24 | 26.49 | |
| | | 118.08 | 22.04 | 112.50 | 20.76 | |
| | | 106.94 | 19.48 | 102.75 | 18.52 | |
| | | 101.26 | 18.12 | 99.90 | 17.81 | |
| | | 97.60 | 17.45 | 96.65 | 17.39 | |
| | | 93.87 | 17.36 | 89.46 | 16.83 | |
| 7 |  | 154.74 | 32.64 | 150.19 | 31.90 | 4-3□ □ □ □ □ □ □ □ □ |
| | | 145.52 | 30.84 | 139.95 | 29.45 |  |
| | | 136.33 | 28.35 | 131.90 | 26.71 | |
| | | 122.26 | 22.42 | 117.14 | 20.43 | |
| | | 110.93 | 18.70 | 105.64 | 17.61 | |
| | | 99.89 | 16.57 | 95.44 | 15.88 | |
| | | 91.09 | 15.01 | 85.40 | 13.68 | |
| | | 80.20 | 12.52 | 76.64 | 11.95 | |
| | | 66.36 | 11.44 | 53.28 | 10.32 | |
| | | 45.62 | 9.54 | 40.56 | 8.88 | |
| | | 37.25 | 8.17 | 29.73 | 6.12 | |
| | | 19.57 | 3.60 | 8.79 | 1.52 | |
| | | 0.00 | -0.21 | 0.00 | -5.21 | |
| | | 156.25 | -5.21 | 156.25 | 32.81 | |

## Anti-Slide piles

| No. | Anti-Slide pile | Point | | Length | Pile spacing | Cross-section | Pile bearing capacity | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | new | x [m] | z [m] | l [m] | b [m] | [m] | istributio along the pile | Max. bearing capacity $V_u$ [kN] | Gradient K [–] | Passive force direction |
| 1 | No | 34.85 | 19.08 | 15.06 | 2.50 | d = 1.50 | constant | 1432.74 | | perpendicular to pile |
| 2 | No | 110.74 | 27.35 | 11.00 | 3.00 | d = 1.00 | constant | 704.70 | | perpendicular to pile |
| 3 | No | 132.02 | 32.93 | 9.00 | 3.00 | d = 1.00 | constant | 704.70 | | perpendicular to pile |

## Water

Water type : GWT

| No. | GWT location | Coordinates of GWT points [m] | | | | | |
|---|---|---|---|---|---|---|---|
| | | x | z | x | z | x | z |
| 1 |  | 0.00 | 13.13 | 8.35 | 13.25 | 9.07 | 13.26 |
| | | 24.09 | 15.78 | 45.31 | 20.26 | 63.63 | 22.84 |
| | | 74.71 | 24.02 | 87.93 | 24.70 | 96.03 | 25.27 |
| | | 100.81 | 25.93 | 106.43 | 26.10 | 114.47 | 27.05 |
| | | 118.55 | 27.35 | 126.32 | 29.79 | 132.20 | 31.74 |
| | | 139.43 | 33.50 | 149.32 | 33.93 | 156.25 | 34.16 |

## Tensile crack

Tensile crack not input.

### Earthquake

Earthquake not included.

### Settings of the stage of construction

Design situation : accidental

## Results (Stage of construction 4)

### Analysis 1 (stage 4)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 56.87 | 22.43 | 58.38 | 18.67 | 60.94 | 17.15 | 64.04 | 16.43 | 82.95 | 17.10 |
| 89.34 | 17.46 | 94.53 | 17.55 | 95.74 | 17.62 | 97.07 | 17.76 | 102.94 | 18.69 |
| 107.56 | 19.62 | 112.98 | 20.91 | 117.97 | 22.23 | 125.68 | 25.20 | 131.91 | 28.07 |
| 139.26 | 31.18 | 142.59 | 35.08 | | | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 2 (110.74; 27.35 [m])

| | | |
|---|---|---|
| Horizontal active force: | 424.40 | kN/m |
| Horizontal passive force: | 372.79 | kN/m |
| Depth of slip surface: | 6.97 | m |
| The length of pile below terrain: | 11.00 | m |

Anti-Slide Pile No. 3 (132.02; 32.93 [m])

| | | |
|---|---|---|
| Horizontal active force: | 113.69 | kN/m |
| Horizontal passive force: | 66.66 | kN/m |
| Depth of slip surface: | 4.81 | m |
| The length of pile below terrain: | 9.00 | m |

**Slope stability verification (ITFM)**
Factor of safety = 1.44 > 1.05
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Analysis 2 (stage 4)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 20.67 | 15.45 | 25.42 | 12.44 | 32.11 | 11.81 | 47.07 | 13.38 | 73.56 | 16.94 |
| 83.87 | 17.13 | 103.76 | 18.93 | 114.82 | 21.35 | 122.05 | 23.73 | 129.20 | 27.19 |
| 139.23 | 30.56 | 143.09 | 34.04 | 143.16 | 35.10 | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])

| | | |
|---|---|---|
| Horizontal active force: | 329.70 | kN/m |
| Horizontal passive force: | 280.40 | kN/m |
| Depth of slip surface: | 6.98 | m |
| The length of pile below terrain: | 15.06 | m |

Anti-Slide Pile No. 2 (110.74; 27.35 [m])

| | | |
|---|---|---|
| Horizontal active force: | 431.92 | kN/m |
| Horizontal passive force: | 412.49 | kN/m |

Depth of slip surface: 6.89 m
The length of pile below terrain: 11.00 m

Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Horizontal active force: 122.18 kN/m
Horizontal passive force: 103.76 kN/m
Depth of slip surface: 4.79 m
The length of pile below terrain: 9.00 m

**Slope stability verification (ITFM)**
Factor of safety = 1.88 > 1.05
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Analysis 3 (stage 4)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 119.73 | 28.28 | 122.28 | 26.06 | 123.88 | 25.74 | 130.81 | 27.50 | 134.60 | 28.98 |
| 138.14 | 30.60 | 141.10 | 32.53 | 142.78 | 35.09 | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 2 (110.74; 27.35 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Horizontal active force: 128.48 kN/m
Horizontal passive force: 0.00 kN/m The slope in front of anti-slide pile is not satisfactory.
Depth of slip surface: 4.96 m
The length of pile below terrain: 9.00 m

**Slope stability verification (ITFM)**
Factor of safety = 1.39 > 1.05
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Piles verification 1 (stage 4)

Anti-Slide pile : Anti-Slide Pile No. 1 (34.85; 19.08 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013

Verification methodology : according to Chinese standards

## Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

## Geometry of structure

Structure length = 15.06 m

Cross-section name : Pile curtain d = 1.50 m; a = 2.50 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.90
Area of cross-section A = 7.07E-01 $m^2/m$
Moment of inertia I = 9.94E-02 $m^4/m$
Elastic modulus E = 31500.00 MPa
Shear modulus G = 12600.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 7.20 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 329.70 kN/m
Passive horizontal force P = 280.40 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C35**
Compressive strength $f_{ck}$ = 23.40 MPa
Tensile strength $f_{tk}$ = 2.20 MPa
Elasticity modulus $E_c$ = 31500.00 MPa
Shear modulus G = 12600.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

Unit weight : $\gamma$ = 17.70 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.60 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 10.00 MN/m$^4$

**2**□ □ □ □

Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 8.00 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.50 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

**3**□ □ □ □ □ □ □

Unit weight : $\gamma$ = 19.00 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 24.00 °
Cohesion of soil : $c_{ef}$ = 15.00 kPa
Angle of friction struc.-soil : $\delta$ = 8.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 21.00 kN/m$^3$
Parameter : m = 20.00 MN/m$^4$

**4-1**□ □ □ □ □ □ □ □ □

Unit weight : $\gamma$ = 17.80 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 11.50 °
Cohesion of soil : $c_{ef}$ = 16.00 kPa
Angle of friction struc.-soil : $\delta$ = 4.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$

Parameter : m = 80.00 MN/m4

**4-2□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 21.50 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 18.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 23.00 kN/m3
Parameter : K = 300.00 MN/m3

**4-3□ □ □ □ □ □ □ □ □**

Unit weight : $\gamma$ = 25.70 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 30.00 °
Cohesion of soil : $c_{ef}$ = 100.00 kPa
Angle of friction struc.-soil : $\delta$ = 10.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 25.80 kN/m3
Parameter : K = 700.00 MN/m3

**2□ □ □ □ (□ □)**

Unit weight : $\gamma$ = 18.20 kN/m3
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.00 °
Cohesion of soil : $c_{ef}$ = 8.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m3
Parameter : m = 4.00 MN/m4

## Pile fixed into the rock

Length of wall in the rock l = 5.30 m
Uniaxial compressive strength $f_{rk}$ = 8000.00 kPa
Horizontal coefficient K = 0.50
Reduction parameter $\nu$ = 0.30

## Geological profile and assigned soils

**Position information**
Terrain elevation = 19.08 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 7.22 | 0.00 .. 7.22 | 19.08 .. 11.86 | 2□ □ □ □ | |
| 2 | 1.61 | 7.22 .. 8.83 | 11.86 .. 10.25 | 3□ □ □ □ □ □ □ | |
| 3 | 1.48 | 8.83 .. 10.31 | 10.25 .. 8.77 | 4-1□ □ □ □ □ □ □ □ □ | |
| 4 | 1.26 | 10.31 .. 11.57 | 8.77 .. 7.51 | 4-2□ □ □ □ □ □ □ □ □ | |

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 5 | - | 11.57 .. ∞ | 7.51 .. - | 4-3□ □ □ □ □ □ □ □ □ |  |

## Excavation

Soil in front of wall is excavated to a depth of 0.23 m.

## Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -4.38 | 1.33 |
| 3 | -10.23 | 2.81 |
| 4 | -14.72 | 3.64 |
| 5 | -20.10 | 4.65 |
| 6 | -25.57 | 5.43 |
| 7 | -26.29 | 5.43 |
| 8 | -34.10 | 5.34 |
| 9 | -35.10 | 5.34 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

## Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.24 |
| 3 | 2.82 | -1.01 |
| 4 | 4.91 | -1.36 |
| 5 | 7.51 | -1.91 |
| 6 | 10.40 | -2.32 |
| 7 | 11.85 | -2.69 |
| 8 | 14.87 | -2.55 |
| 9 | 17.08 | -2.77 |
| 10 | 20.83 | -3.27 |
| 11 | 22.96 | -3.65 |
| 12 | 25.33 | -4.08 |
| 13 | 26.56 | -4.27 |
| 14 | 28.64 | -4.48 |
| 15 | 32.16 | -4.84 |
| 16 | 35.56 | -5.18 |
| 17 | 38.86 | -5.46 |
| 18 | 41.76 | -5.78 |
| 19 | 43.73 | -5.75 |
| 20 | 46.52 | -5.94 |
| 21 | 51.42 | -6.13 |
| 22 | 54.19 | -6.24 |
| 23 | 58.24 | -6.56 |
| 24 | 62.07 | -7.11 |
| 25 | 64.47 | -7.55 |

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 26 | 65.35 | -7.56 |
| 27 | 67.49 | -7.61 |
| 28 | 71.73 | -7.90 |
| 29 | 75.07 | -8.26 |
| 30 | 81.45 | -8.90 |
| 31 | 84.33 | -9.22 |
| 32 | 85.10 | -9.37 |
| 33 | 86.87 | -9.92 |
| 34 | 91.21 | -11.72 |
| 35 | 94.81 | -13.24 |
| 36 | 96.83 | -14.00 |
| 37 | 100.79 | -15.11 |
| 38 | 102.18 | -15.49 |
| 39 | 103.35 | -15.93 |
| 40 | 104.58 | -15.95 |
| 41 | 112.47 | -16.13 |
| 42 | 117.52 | -16.29 |
| 43 | 118.43 | -16.27 |
| 44 | 119.48 | -16.54 |
| 45 | 120.65 | -16.61 |
| 46 | 121.65 | -16.61 |

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 0.87 m
GWT in front of the structure lies at a depth of 1.19 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

### Settings of the stage of construction

Design situation : accidental

## Analysis results

### Pressure above the slip surface

| Depth [m] | Passive pressure [kPa] | Active pressure [kPa] |
|---|---|---|
| 0 | 0.00 | 45.79 |
| 0.23 | 0.00 | 45.79 |
| 0.23 | 40.23 | 45.79 |
| 7.20 | 40.23 | 45.79 |

### Distributions of the modulus of subsoil reaction and internal forces on the structure

| Depth [m] | kh,p [MN/m3] | kh,z [MN/m3] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | -5.42 | 6.85 | 0.00 | 0.00 |
| 0.75 | 0.00 | 0.00 | -4.96 | 6.85 | -5.16 | 1.94 |
| 1.51 | 0.00 | 0.00 | -4.51 | 6.85 | -10.31 | 7.76 |
| 2.26 | 0.00 | 0.00 | -4.05 | 6.85 | -15.47 | 17.47 |
| 3.01 | 0.00 | 0.00 | -3.60 | 6.85 | -20.62 | 31.06 |
| 3.77 | 0.00 | 0.00 | -3.16 | 6.85 | -25.78 | 48.53 |
| 4.52 | 0.00 | 0.00 | -2.72 | 6.85 | -30.94 | 69.88 |
| 5.27 | 0.00 | 0.00 | -2.30 | 6.85 | -36.09 | 95.12 |
| 6.02 | 0.00 | 0.00 | -1.89 | 6.85 | -41.25 | 124.24 |
| 6.78 | 0.00 | 0.00 | -1.51 | 6.85 | -46.40 | 157.24 |
| 7.53 | 0.00 | 0.00 | -1.16 | -12.99 | -64.76 | 197.39 |
| 8.28 | 0.00 | 0.00 | -0.84 | -8.70 | -56.59 | 242.87 |
| 9.04 | 0.00 | 0.00 | -0.56 | 102.53 | -71.79 | 285.95 |
| 9.79 | 908.72 | 0.00 | -0.34 | -294.43 | -66.39 | 354.71 |
| 10.54 | 444.00 | 0.00 | -0.18 | -65.97 | 81.84 | 338.60 |
| 11.29 | 444.00 | 300.00 | -0.08 | -2.25 | 108.71 | 262.75 |
| 12.05 | 844.00 | 700.00 | -0.03 | 12.17 | 116.09 | 176.40 |
| 12.80 | 844.00 | 700.00 | -0.01 | 43.42 | 92.79 | 96.29 |
| 13.55 | 844.00 | 700.00 | -0.01 | 47.00 | 57.59 | 39.51 |
| 14.31 | 844.00 | 700.00 | -0.01 | 38.73 | 24.92 | 8.84 |
| 15.06 | 844.00 | 700.00 | -0.02 | 27.30 | 0.00 | 0.00 |

Maximum shear force = 116.09 kN/m
Maximum moment = 360.45 kNm/m
Maximum displacement = 5.4 mm
Displacement in the depth of slip surface = 1.3 mm

**Soil verification in depth 0.00 m**

Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

**Rock verification in depth 0.00 m**

Max. stress $\sigma$ = 0.00 kPa
Design bearing capacity of rock $R_d$ = 1200.00 kPa

**Bearing capacity of rock is SATISFACTORY**

## Dimensioning No. 1

### Distribution of forces on construction

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | -5.42 | -5.42 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.75 | -4.96 | -4.96 | -5.16 | -5.16 | 1.94 | 1.94 |
| 1.51 | -4.51 | -4.51 | -10.31 | -10.31 | 7.76 | 7.76 |
| 2.26 | -4.05 | -4.05 | -15.47 | -15.47 | 17.47 | 17.47 |
| 3.01 | -3.60 | -3.60 | -20.62 | -20.62 | 31.06 | 31.06 |
| 3.77 | -3.16 | -3.16 | -25.78 | -25.78 | 48.53 | 48.53 |
| 4.52 | -2.72 | -2.72 | -30.94 | -30.94 | 69.88 | 69.88 |

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 5.27 | -2.30 | -2.30 | -36.09 | -36.09 | 95.12 | 95.12 |
| 6.02 | -1.89 | -1.89 | -41.25 | -41.25 | 124.24 | 124.24 |
| 6.78 | -1.51 | -1.51 | -46.40 | -46.40 | 157.24 | 157.24 |
| 7.53 | -1.16 | -1.16 | -64.76 | -64.76 | 197.39 | 197.39 |
| 8.28 | -0.84 | -0.84 | -56.59 | -56.59 | 242.87 | 242.87 |
| 9.04 | -0.56 | -0.56 | -71.79 | -71.79 | 285.95 | 285.95 |
| 9.79 | -0.34 | -0.34 | -66.39 | -66.39 | 354.71 | 354.71 |
| 10.54 | -0.18 | -0.18 | 81.84 | 81.84 | 338.60 | 338.60 |
| 11.29 | -0.08 | -0.08 | 108.71 | 108.71 | 262.75 | 262.75 |
| 12.05 | -0.03 | -0.03 | 116.09 | 116.09 | 176.40 | 176.40 |
| 12.80 | -0.01 | -0.01 | 92.79 | 92.79 | 96.29 | 96.29 |
| 13.55 | -0.01 | -0.01 | 57.59 | 57.59 | 39.51 | 39.51 |
| 14.31 | -0.01 | -0.01 | 24.92 | 24.92 | 8.84 | 8.84 |
| 15.06 | -0.02 | -0.02 | 0.00 | 0.00 | 0.00 | 0.00 |

### Maximum values of internal forces

Maximum displacement = -5.4 mm
Minimum displacement = 0.0 mm
Maximum bending moment = 360.45 kNm/m
Minimum bending moment = 0.00 kNm/m
Maximum shear force = 116.09 kN/m

### Verification of RC cross section (Pile curtain d = 1.50 m; a = 2.50 m)

All construction stages are taken into the analysis.
Partial factor on load = 1.00

### Verification of cross section in bending:

Reinforcement - 26 pc bars 32.0 mm; cover 40.0 mm
Type of structure (reinforcement ratio) : beam
Reinforcement ratio $\rho$ = 0.592 % > 0.200 % = $\rho_{min}$
Load : M = 901.14 kNm
Bearing capacity : $M_u$ = 4479.77 kNm

**Designed pile reinforcement is SATISFACTORY**

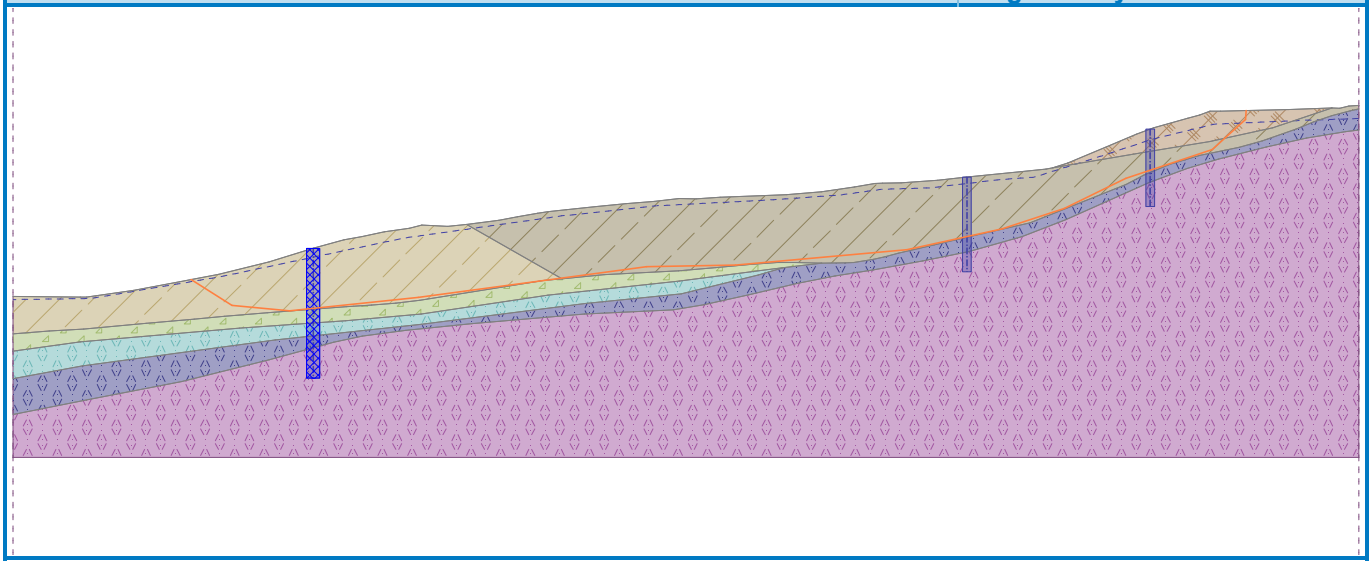
### Verification of cross section in shear:

Ultimate shear force: $V_u$ = 1742.40 kN > 290.22 kN = V

**Cross-section is SATISFACTORY.**

**Overall verification: Cross-section is SATISFACTORY**

| Name : Piles verification | Stage - analysis : 4 - 1 |
|---|---|



### Piles verification 2 (stage 4)

Anti-Slide pile : Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 11.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete

Computed coefficient of pressure reduction below the ditch = 0.60
Area of cross-section A = 2.62E-01 $m^2/m$
Moment of inertia I = 1.64E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 6.89 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 431.92 kN/m
Passive horizontal force P = 412.49 kN/m

Distribution of active force : triangle
Distribution of passive force : triangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Determine modulus of subsoil reaction by method "m".
Displacement at the ditch $v_b$ = 0.00 mm

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 5.60 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |

**2□ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 18.20 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 8.00 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.50 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |

**3□ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 19.00 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 24.00 ° |
| Cohesion of soil : | $c_{ef}$ = 15.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 8.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 21.00 kN/m$^3$ |

**4-1□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.80 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 11.50 ° |
| Cohesion of soil : | $c_{ef}$ = 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 4.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |

**4-2□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 21.50 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 23.00 kN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 25.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 25.80 kN/m$^3$ |

**2□ □ □ □ (□ □)**

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 18.20 kN/m$^3$ |
| Stress-state : | | effective |
| Angle of internal friction : | $\varphi_{ef}$ = | 5.00 ° |
| Cohesion of soil : | $c_{ef}$ = | 8.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 2.00 ° |
| Soil : | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = | 20.00 kN/m$^3$ |

## Geological profile and assigned soils

**Position information**
Terrain elevation = 27.35 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 6.93 | 0.00 .. 6.93 | 27.35 .. 20.42 | 2□ □ □ □ (□ □ ) | |
| 2 | 1.68 | 6.93 .. 8.61 | 20.42 .. 18.74 | 4-2□ □ □ □ □ □ □ □ □ | |
| 3 | - | 8.61 .. ∞ | 18.74 .. - | 4-3□ □ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.06 m.

### Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -2.91 | 0.31 |
| 3 | -7.15 | 0.60 |
| 4 | -9.29 | 0.65 |
| 5 | -10.17 | 0.66 |
| 6 | -12.57 | 1.10 |
| 7 | -16.40 | 1.65 |
| 8 | -20.45 | 1.97 |
| 9 | -23.22 | 2.08 |
| 10 | -28.12 | 2.27 |
| 11 | -30.91 | 2.46 |
| 12 | -32.88 | 2.43 |
| 13 | -35.78 | 2.75 |
| 14 | -39.08 | 3.03 |
| 15 | -42.48 | 3.37 |
| 16 | -46.00 | 3.73 |
| 17 | -48.08 | 3.94 |
| 18 | -49.31 | 4.13 |
| 19 | -51.68 | 4.56 |
| 20 | -53.81 | 4.94 |
| 21 | -57.56 | 5.44 |
| 22 | -59.77 | 5.66 |
| 23 | -62.79 | 5.52 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 24 | -64.24 | 5.89 |
| 25 | -67.13 | 6.30 |
| 26 | -69.73 | 6.85 |
| 27 | -71.82 | 7.20 |
| 28 | -75.35 | 8.20 |
| 29 | -80.52 | 9.77 |
| 30 | -86.37 | 11.25 |
| 31 | -90.86 | 12.08 |
| 32 | -96.24 | 13.09 |
| 33 | -101.71 | 13.87 |
| 34 | -102.43 | 13.87 |
| 35 | -110.24 | 13.78 |
| 36 | -111.24 | 13.78 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

### Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.06 |
| 3 | 5.81 | -0.63 |
| 4 | 8.69 | -0.95 |
| 5 | 9.46 | -1.10 |
| 6 | 11.23 | -1.65 |
| 7 | 15.57 | -3.45 |
| 8 | 19.17 | -4.97 |
| 9 | 21.19 | -5.73 |
| 10 | 25.15 | -6.84 |
| 11 | 26.54 | -7.22 |
| 12 | 27.71 | -7.66 |
| 13 | 28.94 | -7.68 |
| 14 | 36.83 | -7.86 |
| 15 | 41.88 | -8.02 |
| 16 | 42.79 | -8.00 |
| 17 | 43.84 | -8.27 |
| 18 | 45.01 | -8.34 |
| 19 | 46.01 | -8.34 |

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 0.68 m
GWT in front of the structure lies at a depth of 0.80 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$

Coefficient of importance of structure $\gamma_0$ = 1.00

### Settings of the stage of construction

Design situation : accidental

## Analysis results

### Pressure above the slip surface

| Depth [m] | Passive pressure [kPa] | Active pressure [kPa] |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 0.06 | 0.00 | 1.09 |
| 0.06 | 0.00 | 1.09 |
| 6.89 | 120.74 | 125.33 |

### Distributions of the modulus of subsoil reaction and internal forces on the structure

| Depth [m] | kh,p [MN/m$^3$] | kh,z [MN/m$^3$] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | -4.74 | 0.00 | -0.00 | -0.00 |
| 0.55 | 0.00 | 0.00 | -4.41 | 0.45 | -0.12 | 0.02 |
| 1.10 | 0.00 | 0.00 | -4.08 | 0.90 | -0.49 | 0.18 |
| 1.65 | 0.00 | 0.00 | -3.76 | 1.35 | -1.11 | 0.61 |
| 2.20 | 0.00 | 0.00 | -3.43 | 1.80 | -1.98 | 1.45 |
| 2.75 | 0.00 | 0.00 | -3.10 | 2.25 | -3.09 | 2.83 |
| 3.30 | 0.00 | 0.00 | -2.78 | 2.70 | -4.45 | 4.90 |
| 3.85 | 0.00 | 0.00 | -2.46 | 3.15 | -6.06 | 7.78 |
| 4.40 | 0.00 | 0.00 | -2.14 | 3.60 | -7.92 | 11.61 |
| 4.95 | 0.00 | 0.00 | -1.83 | 4.05 | -10.02 | 16.53 |
| 5.50 | 0.00 | 0.00 | -1.53 | 4.50 | -12.37 | 22.68 |
| 6.05 | 0.00 | 0.00 | -1.25 | 4.95 | -14.97 | 30.19 |
| 6.60 | 0.00 | 0.00 | -0.98 | 5.40 | -17.81 | 39.19 |
| 7.15 | 0.00 | 0.00 | -0.74 | -27.87 | -28.30 | 51.84 |
| 7.70 | 0.00 | 0.00 | -0.53 | -27.00 | -13.21 | 63.23 |
| 8.25 | 0.00 | 0.00 | -0.36 | -26.14 | 1.41 | 66.46 |
| 8.80 | 218.50 | 0.00 | -0.23 | -37.78 | 18.15 | 61.02 |
| 9.35 | 232.25 | 0.00 | -0.13 | -18.08 | 33.29 | 46.36 |
| 9.90 | 246.00 | 247.50 | -0.07 | 7.28 | 37.41 | 25.92 |
| 10.45 | 259.75 | 261.25 | -0.02 | 34.07 | 25.94 | 7.81 |
| 11.00 | 273.50 | 275.00 | 0.02 | 60.55 | -0.00 | -0.00 |

Maximum shear force = 37.41 kN/m
Maximum moment = 66.46 kNm/m
Maximum displacement = 4.7 mm
Displacement in the depth of slip surface = 0.9 mm

**Soil verification in depth 0.00 m**

Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

**Soil verification in depth 0.00 m**

Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa

Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

## Dimensioning No. 1

### Distribution of forces on construction

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | -4.74 | -4.74 | -0.00 | -0.00 | -0.00 | -0.00 |
| 0.55 | -4.41 | -4.41 | -0.12 | -0.12 | 0.02 | 0.02 |
| 1.10 | -4.08 | -4.08 | -0.49 | -0.49 | 0.18 | 0.18 |
| 1.65 | -3.76 | -3.76 | -1.11 | -1.11 | 0.61 | 0.61 |
| 2.20 | -3.43 | -3.43 | -1.98 | -1.98 | 1.45 | 1.45 |
| 2.75 | -3.10 | -3.10 | -3.09 | -3.09 | 2.83 | 2.83 |
| 3.30 | -2.78 | -2.78 | -4.45 | -4.45 | 4.90 | 4.90 |
| 3.85 | -2.46 | -2.46 | -6.06 | -6.06 | 7.78 | 7.78 |
| 4.40 | -2.14 | -2.14 | -7.92 | -7.92 | 11.61 | 11.61 |
| 4.95 | -1.83 | -1.83 | -10.02 | -10.02 | 16.53 | 16.53 |
| 5.50 | -1.53 | -1.53 | -12.37 | -12.37 | 22.68 | 22.68 |
| 6.05 | -1.25 | -1.25 | -14.97 | -14.97 | 30.19 | 30.19 |
| 6.60 | -0.98 | -0.98 | -17.81 | -17.81 | 39.19 | 39.19 |
| 7.15 | -0.74 | -0.74 | -28.30 | -28.30 | 51.84 | 51.84 |
| 7.70 | -0.53 | -0.53 | -13.21 | -13.21 | 63.23 | 63.23 |
| 8.25 | -0.36 | -0.36 | 1.41 | 1.41 | 66.46 | 66.46 |
| 8.80 | -0.23 | -0.23 | 18.15 | 18.15 | 61.02 | 61.02 |
| 9.35 | -0.13 | -0.13 | 33.29 | 33.29 | 46.36 | 46.36 |
| 9.90 | -0.07 | -0.07 | 37.41 | 37.41 | 25.92 | 25.92 |
| 10.45 | -0.02 | -0.02 | 25.94 | 25.94 | 7.81 | 7.81 |
| 11.00 | 0.02 | 0.02 | -0.00 | -0.00 | -0.00 | -0.00 |

### Maximum values of internal forces

Maximum displacement = -4.7 mm
Minimum displacement = 0.0 mm
Maximum bending moment = 66.46 kNm/m
Minimum bending moment = 0.00 kNm/m
Maximum shear force = 37.41 kN/m

### Verification of RC cross section (Pile curtain d = 1.00 m; a = 3.00 m)

All construction stages are taken into the analysis.
Partial factor on load = 1.00

### Verification of cross section in bending:

Reinforcement - 24 pc bars 25.0 mm; cover 40.0 mm
Type of structure (reinforcement ratio) : beam
Reinforcement ratio $\rho$ = 0.750 % > 0.200 % = $\rho_{min}$
Load : M = 199.37 kNm
Bearing capacity : $M_u$ = 1590.53 kNm

**Designed pile reinforcement is SATISFACTORY**

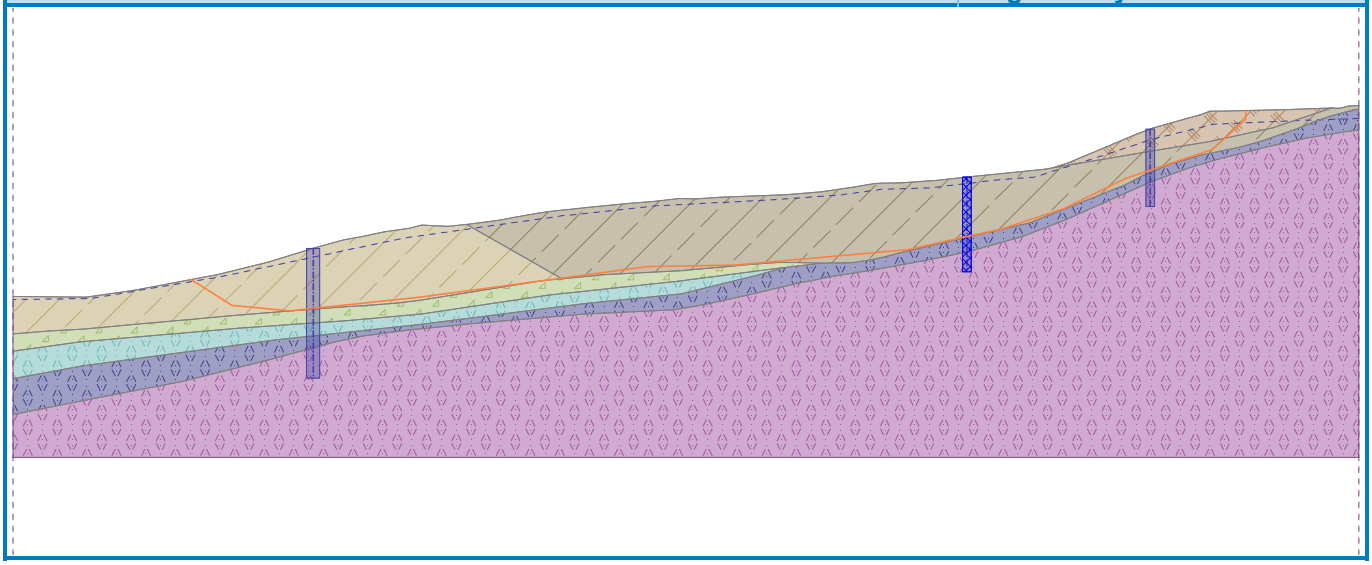
### Verification of cross section in shear:

Ultimate shear force: $V_u$ = 707.52 kN > 112.23 kN = V

**Cross-section is SATISFACTORY.**

**Overall verification: Cross-section is SATISFACTORY**

| Name : Piles verification | Stage - analysis : 4 - 2 |
|---|---|



### Piles verification 3 (stage 4)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 9.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete

Computed coefficient of pressure reduction below the ditch = 0.60

| | | | |
|---|---|---|---|
| Area of cross-section | A | = 2.62E-01 | $m^2/m$ |
| Moment of inertia | I | = 1.64E-02 | $m^4/m$ |
| Elastic modulus | E | = 30000.00 | MPa |
| Shear modulus | G | = 12000.00 | MPa |

### Forces above the slip surface

Depth of slip surface $h_{s1}$ = 4.79 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 122.18 kN/m
Passive horizontal force P = 103.76 kN/m

Distribution of active force : triangle
Distribution of passive force : triangle

### Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**

| | | | |
|---|---|---|---|
| Compressive strength | $f_{ck}$ | = 20.10 | MPa |
| Tensile strength | $f_{tk}$ | = 2.01 | MPa |
| Elasticity modulus | $E_c$ | = 30000.00 | MPa |
| Shear modulus | G | = 12000.00 | MPa |

**Longitudinal steel: HRB400**

Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**

Yield strength $f_{yk}$ = 400.00 MPa

### Modulus of reaction

### Modulus of reaction

Determine modulus of subsoil reaction by method "m".
Displacement at the ditch $v_b$ = 0.00 mm

### Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

### Soil parameters

**1**□ □ □

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 5.60 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |

**2□ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 18.20 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 8.00 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.50 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |

**3□ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 19.00 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 24.00 ° |
| Cohesion of soil : | $c_{ef}$ = 15.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 8.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 21.00 kN/m$^3$ |

**4-1□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.80 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 11.50 ° |
| Cohesion of soil : | $c_{ef}$ = 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 4.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |

**4-2□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 21.50 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 23.00 kN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 25.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 25.80 kN/m$^3$ |

**2□ □ □ □ (□ □)**

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 18.20 kN/m$^3$ |
| Stress-state : | effective | |
| Angle of internal friction : | $\varphi_{ef}$ = | 5.00 ° |
| Cohesion of soil : | $c_{ef}$ = | 8.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 2.00 ° |
| Soil : | cohesionless | |
| Saturated unit weight : | $\gamma_{sat}$ = | 20.00 kN/m$^3$ |

## Geological profile and assigned soils

**Position information**
Terrain elevation = 32.93 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 2.67 | 0.00 .. 2.67 | 32.93 .. 30.26 | 1□ □ □ | |
| 2 | 2.33 | 2.67 .. 5.00 | 30.26 .. 27.93 | 2□ □ □ □ (□ □ ) | |
| 3 | 1.17 | 5.00 .. 6.17 | 27.93 .. 26.76 | 4-2□ □ □ □ □ □ □ □ □ | |
| 4 | - | 6.17 .. ∞ | 26.76 .. - | 4-3□ □ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.19 m.

### Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -1.11 | 0.42 |
| 3 | -4.71 | 1.94 |
| 4 | -9.05 | 3.74 |
| 5 | -10.82 | 4.29 |
| 6 | -11.59 | 4.44 |
| 7 | -14.47 | 4.76 |
| 8 | -20.85 | 5.40 |
| 9 | -24.19 | 5.76 |
| 10 | -28.43 | 6.05 |
| 11 | -30.57 | 6.10 |
| 12 | -31.45 | 6.11 |
| 13 | -33.85 | 6.55 |
| 14 | -37.68 | 7.10 |
| 15 | -41.73 | 7.42 |
| 16 | -44.50 | 7.53 |
| 17 | -49.40 | 7.72 |
| 18 | -52.19 | 7.91 |
| 19 | -54.16 | 7.88 |
| 20 | -57.06 | 8.20 |
| 21 | -60.36 | 8.48 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 22 | -63.76 | 8.82 |
| 23 | -67.28 | 9.18 |
| 24 | -69.36 | 9.39 |
| 25 | -70.59 | 9.58 |
| 26 | -72.96 | 10.01 |
| 27 | -75.09 | 10.39 |
| 28 | -78.84 | 10.89 |
| 29 | -81.05 | 11.11 |
| 30 | -84.07 | 10.97 |
| 31 | -85.52 | 11.34 |
| 32 | -88.41 | 11.75 |
| 33 | -91.01 | 12.30 |
| 34 | -93.10 | 12.65 |
| 35 | -96.63 | 13.65 |
| 36 | -101.80 | 15.22 |
| 37 | -107.65 | 16.70 |
| 38 | -112.14 | 17.53 |
| 39 | -117.52 | 18.54 |
| 40 | -122.99 | 19.32 |
| 41 | -123.71 | 19.32 |
| 42 | -131.52 | 19.23 |
| 43 | -132.52 | 19.23 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

### Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.20 |
| 3 | 3.87 | -1.26 |
| 4 | 5.26 | -1.64 |
| 5 | 6.43 | -2.08 |
| 6 | 7.66 | -2.10 |
| 7 | 15.55 | -2.28 |
| 8 | 20.60 | -2.44 |
| 9 | 21.51 | -2.42 |
| 10 | 22.56 | -2.69 |
| 11 | 23.73 | -2.76 |
| 12 | 24.73 | -2.76 |

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 1.11 m
GWT in front of the structure lies at a depth of 1.42 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40

Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

### Settings of the stage of construction

Design situation : accidental

## Analysis results

### Pressure above the slip surface

| Depth [m] | Passive pressure [kPa] | Active pressure [kPa] |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 0.19 | 0.00 | 2.02 |
| 0.19 | 0.00 | 2.02 |
| 4.79 | 45.09 | 50.99 |

### Distributions of the modulus of subsoil reaction and internal forces on the structure

| Depth [m] | kh,p [MN/m3] | kh,z [MN/m3] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | -2.61 | 0.00 | -0.00 | -0.00 |
| 0.45 | 0.00 | 0.00 | -2.42 | 0.72 | -0.16 | 0.02 |
| 0.90 | 0.00 | 0.00 | -2.24 | 1.44 | -0.65 | 0.19 |
| 1.35 | 0.00 | 0.00 | -2.05 | 2.17 | -1.46 | 0.66 |
| 1.80 | 0.00 | 0.00 | -1.87 | 2.89 | -2.60 | 1.56 |
| 2.25 | 0.00 | 0.00 | -1.68 | 3.61 | -4.06 | 3.05 |
| 2.70 | 0.00 | 0.00 | -1.50 | 4.33 | -5.85 | 5.26 |
| 3.15 | 0.00 | 0.00 | -1.32 | 5.05 | -7.96 | 8.36 |
| 3.60 | 0.00 | 0.00 | -1.14 | 5.78 | -10.40 | 12.47 |
| 4.05 | 0.00 | 0.00 | -0.97 | 6.50 | -13.16 | 17.76 |
| 4.50 | 0.00 | 0.00 | -0.80 | 7.22 | -16.24 | 24.36 |
| 4.95 | 3.81 | 3.96 | -0.65 | 43.35 | -25.16 | 32.86 |
| 5.40 | 0.00 | 0.00 | -0.51 | -27.34 | -20.76 | 44.57 |
| 5.85 | 0.00 | 0.00 | -0.38 | -26.64 | -8.62 | 51.17 |
| 6.30 | 152.75 | 0.00 | -0.28 | -33.65 | 3.94 | 52.03 |
| 6.75 | 164.00 | 0.00 | -0.20 | -22.68 | 16.57 | 47.21 |
| 7.20 | 175.25 | 0.00 | -0.14 | -13.28 | 24.61 | 37.78 |
| 7.65 | 186.50 | 191.25 | -0.09 | -0.39 | 28.27 | 25.48 |
| 8.10 | 197.75 | 202.50 | -0.06 | 14.12 | 25.14 | 13.21 |
| 8.55 | 209.00 | 213.75 | -0.03 | 27.85 | 15.70 | 3.78 |
| 9.00 | 220.25 | 225.00 | 0.00 | 42.12 | -0.00 | 0.00 |

Maximum shear force = 28.27 kN/m
Maximum moment = 52.20 kNm/m
Maximum displacement = 2.6 mm
Displacement in the depth of slip surface = 0.7 mm

**Soil verification in depth 0.00 m**

Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

**Soil verification in depth 0.00 m**

Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

## Dimensioning No. 1

### Distribution of forces on construction

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | -2.61 | -2.61 | -0.00 | -0.00 | -0.00 | -0.00 |
| 0.45 | -2.42 | -2.42 | -0.16 | -0.16 | 0.02 | 0.02 |
| 0.90 | -2.24 | -2.24 | -0.65 | -0.65 | 0.19 | 0.19 |
| 1.35 | -2.05 | -2.05 | -1.46 | -1.46 | 0.66 | 0.66 |
| 1.80 | -1.87 | -1.87 | -2.60 | -2.60 | 1.56 | 1.56 |
| 2.25 | -1.68 | -1.68 | -4.06 | -4.06 | 3.05 | 3.05 |
| 2.70 | -1.50 | -1.50 | -5.85 | -5.85 | 5.26 | 5.26 |
| 3.15 | -1.32 | -1.32 | -7.96 | -7.96 | 8.36 | 8.36 |
| 3.60 | -1.14 | -1.14 | -10.40 | -10.40 | 12.47 | 12.47 |
| 4.05 | -0.97 | -0.97 | -13.16 | -13.16 | 17.76 | 17.76 |
| 4.50 | -0.80 | -0.80 | -16.24 | -16.24 | 24.36 | 24.36 |
| 4.95 | -0.65 | -0.65 | -25.16 | -25.16 | 32.86 | 32.86 |
| 5.40 | -0.51 | -0.51 | -20.76 | -20.76 | 44.57 | 44.57 |
| 5.85 | -0.38 | -0.38 | -8.62 | -8.62 | 51.17 | 51.17 |
| 6.30 | -0.28 | -0.28 | 3.94 | 3.94 | 52.03 | 52.03 |
| 6.75 | -0.20 | -0.20 | 16.57 | 16.57 | 47.21 | 47.21 |
| 7.20 | -0.14 | -0.14 | 24.61 | 24.61 | 37.78 | 37.78 |
| 7.65 | -0.09 | -0.09 | 28.27 | 28.27 | 25.48 | 25.48 |
| 8.10 | -0.06 | -0.06 | 25.14 | 25.14 | 13.21 | 13.21 |
| 8.55 | -0.03 | -0.03 | 15.70 | 15.70 | 3.78 | 3.78 |
| 9.00 | 0.00 | 0.00 | -0.00 | -0.00 | 0.00 | 0.00 |

### Maximum values of internal forces

Maximum displacement = -2.6 mm
Minimum displacement = 0.0 mm
Maximum bending moment = 52.20 kNm/m
Minimum bending moment = 0.00 kNm/m
Maximum shear force = 28.27 kN/m

### Verification of RC cross section (Pile curtain d = 1.00 m; a = 3.00 m)

All construction stages are taken into the analysis.
Partial factor on load = 1.00

### Verification of cross section in bending:

Reinforcement - 22 pc bars 25.0 mm; cover 40.0 mm
Type of structure (reinforcement ratio) : beam
Reinforcement ratio $\rho$ = 0.688 % > 0.200 % = $\rho_{min}$
Load : M = 156.60 kNm
Bearing capacity : $M_u$ = 1469.23 kNm

**Designed pile reinforcement is SATISFACTORY**

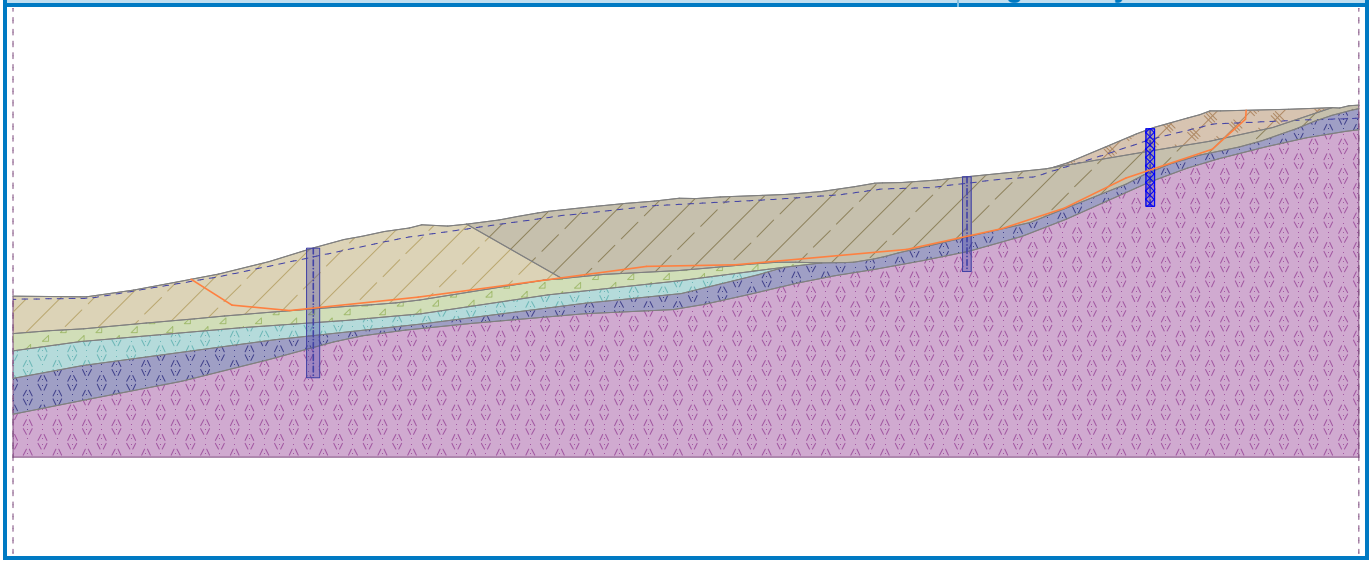
### Verification of cross section in shear:

Ultimate shear force: $V_u$ = 707.52 kN > 84.82 kN = V

**Cross-section is SATISFACTORY.**

**Overall verification: Cross-section is SATISFACTORY**

| Name : Piles verification | Stage - analysis : 4 - 3 |
|---|---|



### Piles verification 4 (stage 4)

Anti-Slide pile : Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Analysis : Calculation 1 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 11.00 m

Cross-section name : Pile curtain d = 1.20 m; a = 3.00 m

Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.66
Area of cross-section A = 3.77E-01 $m^2/m$
Moment of inertia I = 3.39E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 6.97 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 424.40 kN/m
Passive horizontal force P = 372.79 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 17.70 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 5.60 ° |
| Cohesion of soil : | $c_{ef}$ | = | 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 2.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 20.00 kN/m$^3$ |
| Parameter : | m | = | 10.00 MN/m$^4$ |

**2□ □ □ □**

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 18.20 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 8.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 2.50 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 20.00 kN/m$^3$ |
| Parameter : | m | = | 4.00 MN/m$^4$ |

**3□ □ □ □ □ □ □**

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 19.00 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 24.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 15.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 8.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 21.00 kN/m$^3$ |
| Parameter : | m | = | 20.00 MN/m$^4$ |

**4-1□ □ □ □ □ □ □ □ □**

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 17.80 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 11.50 ° |
| Cohesion of soil : | $c_{ef}$ | = | 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 4.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 20.00 kN/m$^3$ |
| Parameter : | m | = | 80.00 MN/m$^4$ |

**4-2□ □ □ □ □ □ □ □ □**

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 21.50 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 30.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 10.00 ° |
| Soil : | cohesionless | | |
| Saturated unit weight : | $\gamma_{sat}$ | = | 23.00 kN/m$^3$ |
| Parameter : | K | = | 300.00 MN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □**

| | | | |
|---|---|---|---|
| Unit weight : | $\gamma$ | = | 25.70 kN/m$^3$ |
| Stress-state : | effective | | |
| Angle of internal friction : | $\varphi_{ef}$ | = | 30.00 ° |
| Cohesion of soil : | $c_{ef}$ | = | 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ | = | 10.00 ° |

Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 25.80 kN/m$^3$
Parameter : K = 700.00 MN/m$^3$

**2□ □ □ □ (□ □ )**
Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.00 °
Cohesion of soil : $c_{ef}$ = 8.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

## Pile fixed into the rock

Length of wall in the rock l = 4.03 m
Uniaxial compressive strength $f_{rk}$ = 8000.00 kPa
Horizontal coefficient K = 0.50
Reduction parameter $\nu$ = 0.30

## Geological profile and assigned soils

**Position information**
Terrain elevation = 27.35 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 6.93 | 0.00 .. 6.93 | 27.35 .. 20.42 | 2□ □ □ □ (□ □ ) | |
| 2 | 1.68 | 6.93 .. 8.61 | 20.42 .. 18.74 | 4-2□ □ □ □ □ □ □ □ | |
| 3 | - | 8.61 .. ∞ | 18.74 .. - | 4-3□ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.06 m.

## Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -2.91 | 0.31 |
| 3 | -7.15 | 0.60 |
| 4 | -9.29 | 0.65 |
| 5 | -10.17 | 0.66 |
| 6 | -12.57 | 1.10 |
| 7 | -16.40 | 1.65 |
| 8 | -20.45 | 1.97 |
| 9 | -23.22 | 2.08 |
| 10 | -28.12 | 2.27 |
| 11 | -30.91 | 2.46 |
| 12 | -32.88 | 2.43 |
| 13 | -35.78 | 2.75 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 14 | -39.08 | 3.03 |
| 15 | -42.48 | 3.37 |
| 16 | -46.00 | 3.73 |
| 17 | -48.08 | 3.94 |
| 18 | -49.31 | 4.13 |
| 19 | -51.68 | 4.56 |
| 20 | -53.81 | 4.94 |
| 21 | -57.56 | 5.44 |
| 22 | -59.77 | 5.66 |
| 23 | -62.79 | 5.52 |
| 24 | -64.24 | 5.89 |
| 25 | -67.13 | 6.30 |
| 26 | -69.73 | 6.85 |
| 27 | -71.82 | 7.20 |
| 28 | -75.35 | 8.20 |
| 29 | -80.52 | 9.77 |
| 30 | -86.37 | 11.25 |
| 31 | -90.86 | 12.08 |
| 32 | -96.24 | 13.09 |
| 33 | -101.71 | 13.87 |
| 34 | -102.43 | 13.87 |
| 35 | -110.24 | 13.78 |
| 36 | -111.24 | 13.78 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

**Terrain profile**

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.06 |
| 3 | 5.81 | -0.63 |
| 4 | 8.69 | -0.95 |
| 5 | 9.46 | -1.10 |
| 6 | 11.23 | -1.65 |
| 7 | 15.57 | -3.45 |
| 8 | 19.17 | -4.97 |
| 9 | 21.19 | -5.73 |
| 10 | 25.15 | -6.84 |
| 11 | 26.54 | -7.22 |
| 12 | 27.71 | -7.66 |
| 13 | 28.94 | -7.68 |
| 14 | 36.83 | -7.86 |
| 15 | 41.88 | -8.02 |
| 16 | 42.79 | -8.00 |
| 17 | 43.84 | -8.27 |
| 18 | 45.01 | -8.34 |
| 19 | 46.01 | -8.34 |

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 0.68 m
GWT in front of the structure lies at a depth of 0.80 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

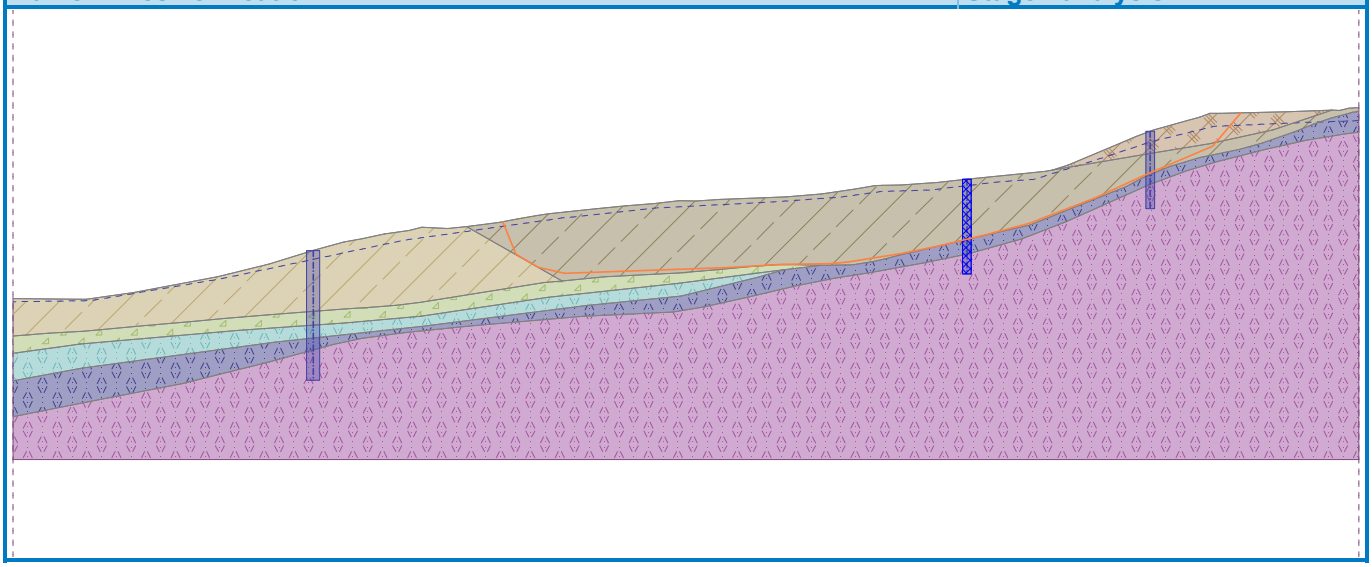
### Settings of the stage of construction

Design situation : accidental

## Analysis results

## Dimensioning No. 1

| Name : Piles verification | Stage - analysis : 4 - 4 |
|---|---|



### Piles verification 5 (stage 4)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 1 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015

Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

## Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

## Geometry of structure

Structure length = 9.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.60
Area of cross-section A = 2.62E-01 $m^2/m$
Moment of inertia I = 1.64E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 4.81 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 113.69 kN/m
Passive horizontal force P = 66.66 kN/m

Distribution of active force : triangle
Distribution of passive force : triangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Determine modulus of subsoil reaction by method "m".
Displacement at the ditch $v_b$ = 0.00 mm

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □

Unit weight : $\gamma$ = 17.70 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.60 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$

**2**□ □ □ □

Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 8.00 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.50 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$

**3**□ □ □ □ □ □ □

Unit weight : $\gamma$ = 19.00 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 24.00 °
Cohesion of soil : $c_{ef}$ = 15.00 kPa
Angle of friction struc.-soil : $\delta$ = 8.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 21.00 kN/m$^3$

**4-1**□ □ □ □ □ □ □ □ □

Unit weight : $\gamma$ = 17.80 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 11.50 °
Cohesion of soil : $c_{ef}$ = 16.00 kPa
Angle of friction struc.-soil : $\delta$ = 4.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$

**4-2□ □ □ □ □ □ □ □ □**

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 21.50 kN/m$^3$ |
| Stress-state : | | effective |
| Angle of internal friction : | $\varphi_{ef}$ = | 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = | 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 10.00 ° |
| Soil : | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = | 23.00 kN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □**

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 25.70 kN/m$^3$ |
| Stress-state : | | effective |
| Angle of internal friction : | $\varphi_{ef}$ = | 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = | 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 10.00 ° |
| Soil : | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = | 25.80 kN/m$^3$ |

**2□ □ □ □ (□ □ )**

| | | |
|---|---|---|
| Unit weight : | $\gamma$ = | 18.20 kN/m$^3$ |
| Stress-state : | | effective |
| Angle of internal friction : | $\varphi_{ef}$ = | 5.00 ° |
| Cohesion of soil : | $c_{ef}$ = | 8.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = | 2.00 ° |
| Soil : | | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = | 20.00 kN/m$^3$ |

## Geological profile and assigned soils

**Position information**

Terrain elevation = 32.93 m

**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 2.67 | 0.00 .. 2.67 | 32.93 .. 30.26 | 1□ □ □ | |
| 2 | 2.33 | 2.67 .. 5.00 | 30.26 .. 27.93 | 2□ □ □ □ (□ □ ) | |
| 3 | 1.17 | 5.00 .. 6.17 | 27.93 .. 26.76 | 4-2□ □ □ □ □ □ □ □ □ | |
| 4 | - | 6.17 .. ∞ | 26.76 .. - | 4-3□ □ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.19 m.

## Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -1.11 | 0.42 |
| 3 | -4.71 | 1.94 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 4 | -9.05 | 3.74 |
| 5 | -10.82 | 4.29 |
| 6 | -11.59 | 4.44 |
| 7 | -14.47 | 4.76 |
| 8 | -20.85 | 5.40 |
| 9 | -24.19 | 5.76 |
| 10 | -28.43 | 6.05 |
| 11 | -30.57 | 6.10 |
| 12 | -31.45 | 6.11 |
| 13 | -33.85 | 6.55 |
| 14 | -37.68 | 7.10 |
| 15 | -41.73 | 7.42 |
| 16 | -44.50 | 7.53 |
| 17 | -49.40 | 7.72 |
| 18 | -52.19 | 7.91 |
| 19 | -54.16 | 7.88 |
| 20 | -57.06 | 8.20 |
| 21 | -60.36 | 8.48 |
| 22 | -63.76 | 8.82 |
| 23 | -67.28 | 9.18 |
| 24 | -69.36 | 9.39 |
| 25 | -70.59 | 9.58 |
| 26 | -72.96 | 10.01 |
| 27 | -75.09 | 10.39 |
| 28 | -78.84 | 10.89 |
| 29 | -81.05 | 11.11 |
| 30 | -84.07 | 10.97 |
| 31 | -85.52 | 11.34 |
| 32 | -88.41 | 11.75 |
| 33 | -91.01 | 12.30 |
| 34 | -93.10 | 12.65 |
| 35 | -96.63 | 13.65 |
| 36 | -101.80 | 15.22 |
| 37 | -107.65 | 16.70 |
| 38 | -112.14 | 17.53 |
| 39 | -117.52 | 18.54 |
| 40 | -122.99 | 19.32 |
| 41 | -123.71 | 19.32 |
| 42 | -131.52 | 19.23 |
| 43 | -132.52 | 19.23 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

**Terrain profile**

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.20 |

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 3 | 3.87 | -1.26 |
| 4 | 5.26 | -1.64 |
| 5 | 6.43 | -2.08 |
| 6 | 7.66 | -2.10 |
| 7 | 15.55 | -2.28 |
| 8 | 20.60 | -2.44 |
| 9 | 21.51 | -2.42 |
| 10 | 22.56 | -2.69 |
| 11 | 23.73 | -2.76 |
| 12 | 24.73 | -2.76 |

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 1.11 m
GWT in front of the structure lies at a depth of 1.42 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

### Settings of the stage of construction

Design situation : accidental

## Analysis results

### Pressure above the slip surface

| Depth [m] | Passive pressure [kPa] | Active pressure [kPa] |
|---|---|---|
| 0 | 0.00 | 0.00 |
| 0.19 | 0.00 | 1.86 |
| 0.19 | 0.00 | 1.86 |
| 4.81 | 28.83 | 47.24 |

### Distributions of the modulus of subsoil reaction and internal forces on the structure

| Depth [m] | kh,p [MN/m3] | kh,z [MN/m3] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | 0.00 | 0.00 | -7.52 | 0.00 | 0.00 | 0.00 |
| 0.45 | 0.00 | 0.00 | -6.99 | 1.83 | -0.41 | 0.06 |
| 0.90 | 0.00 | 0.00 | -6.47 | 3.65 | -1.64 | 0.49 |
| 1.35 | 0.00 | 0.00 | -5.94 | 5.48 | -3.70 | 1.66 |
| 1.80 | 0.00 | 0.00 | -5.41 | 7.31 | -6.58 | 3.95 |
| 2.25 | 0.00 | 0.00 | -4.89 | 9.13 | -10.28 | 7.71 |
| 2.70 | 0.00 | 0.00 | -4.37 | 10.96 | -14.80 | 13.32 |
| 3.15 | 0.00 | 0.00 | -3.85 | 12.79 | -20.14 | 21.15 |
| 3.60 | 0.00 | 0.00 | -3.34 | 14.61 | -26.31 | 31.57 |
| 4.05 | 0.00 | 0.00 | -2.85 | 16.44 | -33.29 | 44.95 |
| 4.50 | 0.00 | 0.00 | -2.37 | 18.27 | -41.10 | 61.66 |

| Depth [m] | kh,p [MN/m3] | kh,z [MN/m3] | Displacement [mm] | Pressure [kPa] | Shear Force [kN/m] | Moment [kNm/m] |
|---|---|---|---|---|---|---|
| 4.95 | 3.81 | 3.96 | -1.92 | 33.44 | -51.50 | 82.18 |
| 5.40 | 0.00 | 0.00 | -1.51 | -27.34 | -46.05 | 105.39 |
| 5.85 | 0.00 | 0.00 | -1.13 | -26.64 | -33.90 | 123.37 |
| 6.30 | 152.75 | 0.00 | -0.81 | -114.79 | -10.77 | 134.41 |
| 6.75 | 164.00 | 0.00 | -0.54 | -79.24 | 32.81 | 128.81 |
| 7.20 | 175.25 | 0.00 | -0.33 | -46.90 | 61.09 | 107.12 |
| 7.65 | 186.50 | 0.00 | -0.16 | -17.91 | 75.57 | 75.87 |
| 8.10 | 197.75 | 202.50 | -0.02 | 28.88 | 74.70 | 41.02 |
| 8.55 | 209.00 | 213.75 | 0.10 | 82.54 | 49.69 | 12.13 |
| 9.00 | 220.25 | 225.00 | 0.22 | 139.19 | -0.00 | 0.00 |

Maximum shear force = 78.16 kN/m
Maximum moment = 134.41 kNm/m
Maximum displacement = 7.5 mm
Displacement in the depth of slip surface = 2.1 mm

**Soil verification in depth 0.00 m**
Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

**Soil verification in depth 0.00 m**
Active pressure behind the structure = 0.00 kPa
Passive pressure in front of the structure = 0.00 kPa
Max. stress $\sigma$ = 0.00 kPa
Soil design bearing capacity $R_d$ = 0.00 kPa

**Bearing capacity of rock is SATISFACTORY**

## Dimensioning No. 1

### Distribution of forces on construction

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 0.00 | -7.52 | -7.52 | 0.00 | 0.00 | 0.00 | 0.00 |
| 0.45 | -6.99 | -6.99 | -0.41 | -0.41 | 0.06 | 0.06 |
| 0.90 | -6.47 | -6.47 | -1.64 | -1.64 | 0.49 | 0.49 |
| 1.35 | -5.94 | -5.94 | -3.70 | -3.70 | 1.66 | 1.66 |
| 1.80 | -5.41 | -5.41 | -6.58 | -6.58 | 3.95 | 3.95 |
| 2.25 | -4.89 | -4.89 | -10.28 | -10.28 | 7.71 | 7.71 |
| 2.70 | -4.37 | -4.37 | -14.80 | -14.80 | 13.32 | 13.32 |
| 3.15 | -3.85 | -3.85 | -20.14 | -20.14 | 21.15 | 21.15 |
| 3.60 | -3.34 | -3.34 | -26.31 | -26.31 | 31.57 | 31.57 |
| 4.05 | -2.85 | -2.85 | -33.29 | -33.29 | 44.95 | 44.95 |
| 4.50 | -2.37 | -2.37 | -41.10 | -41.10 | 61.66 | 61.66 |
| 4.95 | -1.92 | -1.92 | -51.50 | -51.50 | 82.18 | 82.18 |
| 5.40 | -1.51 | -1.51 | -46.05 | -46.05 | 105.39 | 105.39 |
| 5.85 | -1.13 | -1.13 | -33.90 | -33.90 | 123.37 | 123.37 |
| 6.30 | -0.81 | -0.81 | -10.77 | -10.77 | 134.41 | 134.41 |
| 6.75 | -0.54 | -0.54 | 32.81 | 32.81 | 128.81 | 128.81 |
| 7.20 | -0.33 | -0.33 | 61.09 | 61.09 | 107.12 | 107.12 |

| | Disp. min [mm] | Disp. max [mm] | Shear force min. [kN/m] | Shear force max [kN/m] | Moment min. [kNm/m] | Moment max. [kNm/m] |
|---|---|---|---|---|---|---|
| 7.65 | -0.16 | -0.16 | 75.57 | 75.57 | 75.87 | 75.87 |
| 8.10 | -0.02 | -0.02 | 74.70 | 74.70 | 41.02 | 41.02 |
| 8.55 | 0.10 | 0.10 | 49.69 | 49.69 | 12.13 | 12.13 |
| 9.00 | 0.22 | 0.22 | -0.00 | -0.00 | 0.00 | 0.00 |

### Maximum values of internal forces

Maximum displacement = -7.5 mm
Minimum displacement = 0.2 mm
Maximum bending moment = 134.41 kNm/m
Minimum bending moment = 0.00 kNm/m
Maximum shear force = 78.16 kN/m

### Verification of RC cross section (Pile curtain d = 1.00 m; a = 3.00 m)

All construction stages are taken into the analysis.
Partial factor on load = 1.00

### Verification of cross section in bending:

Reinforcement - 22 pc bars 25.0 mm; cover 40.0 mm
Type of structure (reinforcement ratio) : beam
Reinforcement ratio $\rho$ = 0.688 % > 0.200 % = $\rho_{min}$
Load : M = 403.22 kNm
Bearing capacity : $M_u$ = 1469.23 kNm

**Designed pile reinforcement is SATISFACTORY**

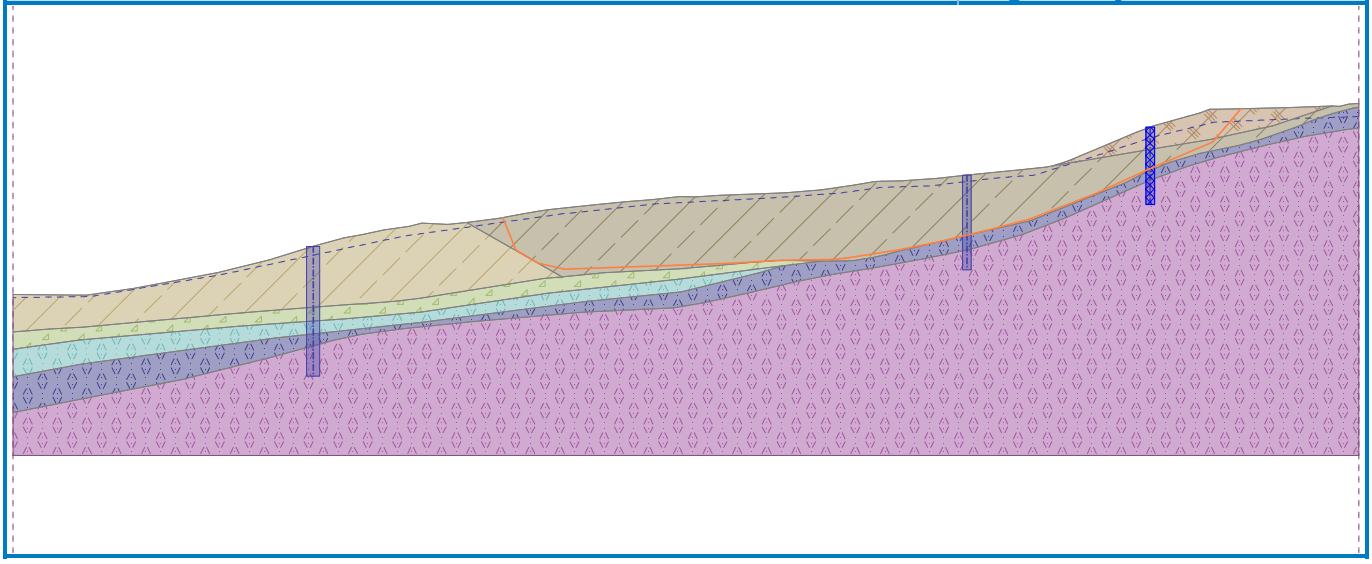
### Verification of cross section in shear:

Ultimate shear force: $V_u$ = 707.52 kN > 234.48 kN = V

**Cross-section is SATISFACTORY.**

**Overall verification: Cross-section is SATISFACTORY**

| Name : Piles verification | Stage - analysis : 4 - 5 |
|---|---|



### Piles verification 6 (stage 4)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 3 (slip surface polygonal)
Method : ITFM

# Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 9.00 m

Cross-section name : Pile curtain d = 1.00 m; a = 3.00 m
Material of pile : concrete
Computed coefficient of pressure reduction below the ditch = 0.60
Area of cross-section A = 2.62E-01 $m^2/m$
Moment of inertia I = 1.64E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

### Forces above the slip surface

Depth of slip surface $h_{s1}$ = 4.96 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 128.48 kN/m
Passive horizontal force P = 0.00 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

### Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m$^3$] | $\gamma_{su}$ [kN/m$^3$] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □
Unit weight : $\gamma$ = 17.70 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.60 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 10.00 MN/m$^4$

**2**□ □ □ □
Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 8.00 °
Cohesion of soil : $c_{ef}$ = 13.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.50 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

**3**□ □ □ □ □ □ □
Unit weight : $\gamma$ = 19.00 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 24.00 °
Cohesion of soil : $c_{ef}$ = 15.00 kPa
Angle of friction struc.-soil : $\delta$ = 8.00 °

| | |
|---|---|
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 21.00 kN/m$^3$ |
| Parameter : | m = 20.00 MN/m$^4$ |

**4-1□ □ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.80 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 11.50 ° |
| Cohesion of soil : | $c_{ef}$ = 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 4.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 80.00 MN/m$^4$ |

**4-2□ □ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 21.50 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 23.00 kN/m$^3$ |
| Parameter : | K = 300.00 MN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 25.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 25.80 kN/m$^3$ |
| Parameter : | K = 700.00 MN/m$^3$ |

**2□ □ □ □ (□ □)**

| | |
|---|---|
| Unit weight : | $\gamma$ = 18.20 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 5.00 ° |
| Cohesion of soil : | $c_{ef}$ = 8.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 4.00 MN/m$^4$ |

## Pile fixed into the rock

| | | | |
|---|---|---|---|
| Length of wall in the rock | l | = 4.04 | m |
| Uniaxial compressive strength | $f_{rk}$ | = 8000.00 | kPa |
| Horizontal coefficient | K | = 0.50 | |
| Reduction parameter | $\nu$ | = 0.30 | |

## Geological profile and assigned soils

**Position information**
Terrain elevation = 32.93 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 2.67 | 0.00 .. 2.67 | 32.93 .. 30.26 | 1□ □ □ |  |
| 2 | 2.33 | 2.67 .. 5.00 | 30.26 .. 27.93 | 2□ □ □ □ (□ □ ) |  |
| 3 | 1.17 | 5.00 .. 6.17 | 27.93 .. 26.76 | 4-2□ □ □ □ □ □ □ □ □ |  |
| 4 | - | 6.17 .. ∞ | 26.76 .. - | 4-3□ □ □ □ □ □ □ □ □ |  |

## Excavation

Soil in front of wall is excavated to a depth of 0.19 m.

## Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -1.11 | 0.42 |
| 3 | -4.71 | 1.94 |
| 4 | -9.05 | 3.74 |
| 5 | -10.82 | 4.29 |
| 6 | -11.59 | 4.44 |
| 7 | -14.47 | 4.76 |
| 8 | -20.85 | 5.40 |
| 9 | -24.19 | 5.76 |
| 10 | -28.43 | 6.05 |
| 11 | -30.57 | 6.10 |
| 12 | -31.45 | 6.11 |
| 13 | -33.85 | 6.55 |
| 14 | -37.68 | 7.10 |
| 15 | -41.73 | 7.42 |
| 16 | -44.50 | 7.53 |
| 17 | -49.40 | 7.72 |
| 18 | -52.19 | 7.91 |
| 19 | -54.16 | 7.88 |
| 20 | -57.06 | 8.20 |
| 21 | -60.36 | 8.48 |
| 22 | -63.76 | 8.82 |
| 23 | -67.28 | 9.18 |
| 24 | -69.36 | 9.39 |
| 25 | -70.59 | 9.58 |
| 26 | -72.96 | 10.01 |
| 27 | -75.09 | 10.39 |
| 28 | -78.84 | 10.89 |
| 29 | -81.05 | 11.11 |
| 30 | -84.07 | 10.97 |
| 31 | -85.52 | 11.34 |
| 32 | -88.41 | 11.75 |
| 33 | -91.01 | 12.30 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 34 | -93.10 | 12.65 |
| 35 | -96.63 | 13.65 |
| 36 | -101.80 | 15.22 |
| 37 | -107.65 | 16.70 |
| 38 | -112.14 | 17.53 |
| 39 | -117.52 | 18.54 |
| 40 | -122.99 | 19.32 |
| 41 | -123.71 | 19.32 |
| 42 | -131.52 | 19.23 |
| 43 | -132.52 | 19.23 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

### Terrain profile

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.20 |
| 3 | 3.87 | -1.26 |
| 4 | 5.26 | -1.64 |
| 5 | 6.43 | -2.08 |
| 6 | 7.66 | -2.10 |
| 7 | 15.55 | -2.28 |
| 8 | 20.60 | -2.44 |
| 9 | 21.51 | -2.42 |
| 10 | 22.56 | -2.69 |
| 11 | 23.73 | -2.76 |
| 12 | 24.73 | -2.76 |

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 1.11 m
GWT in front of the structure lies at a depth of 1.42 m
Subgrade at the heel is not permeable.

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

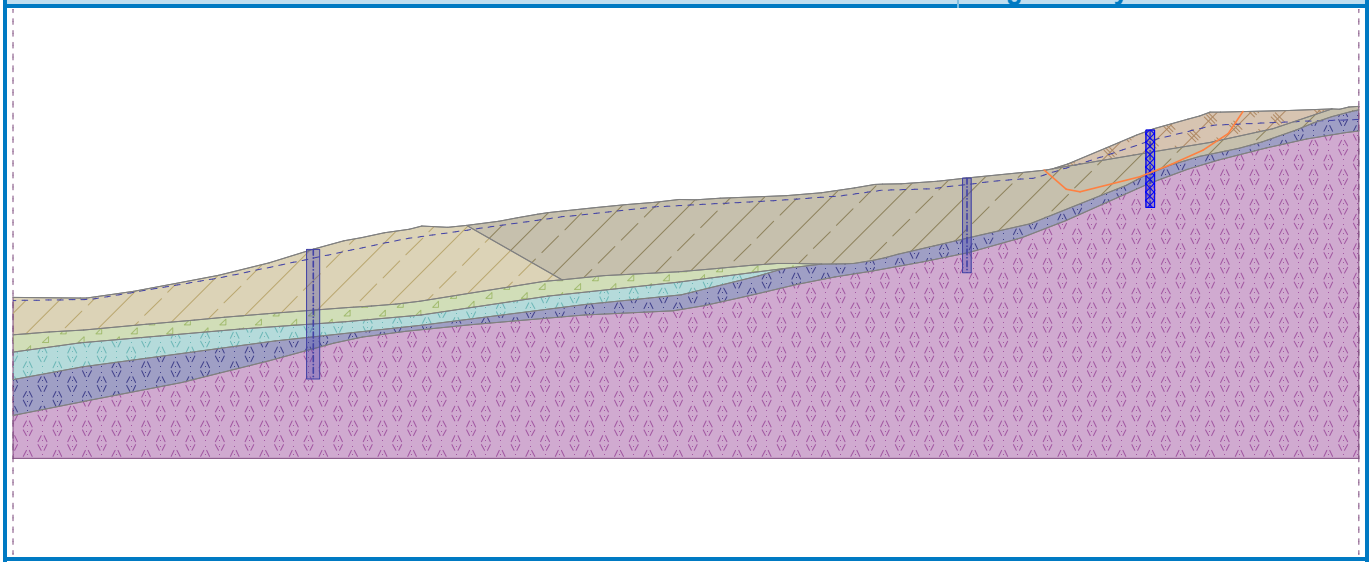
### Settings of the stage of construction

Design situation : accidental

## Analysis results

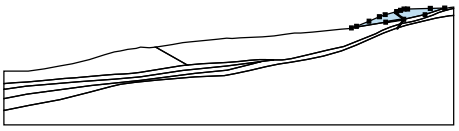
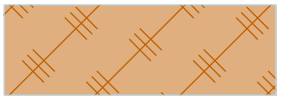
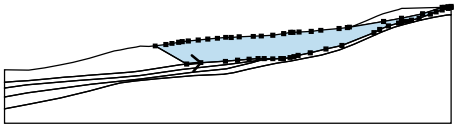
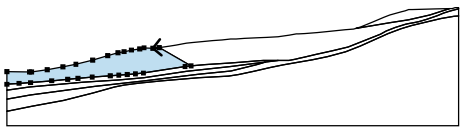
## Dimensioning No. 1

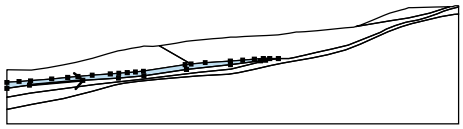
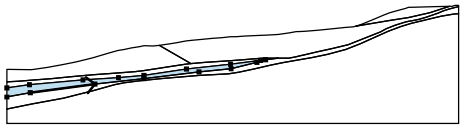
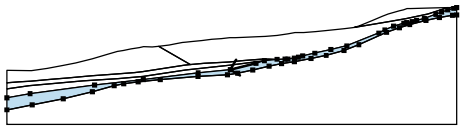
| Name : Piles verification | Stage - analysis : 4 - 6 |
|---|---|

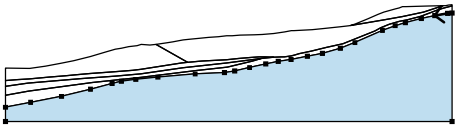


## Input data (Stage of construction 5)

### Assigning and surfaces

| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| 1 |  | 132.59 | 30.45 | 138.93 | 31.50 | 1□ □ □ |
| | | 146.27 | 33.09 | 153.12 | 35.37 |  |
| | | 148.07 | 35.21 | 140.18 | 35.03 | |
| | | 138.95 | 35.01 | 137.78 | 34.57 | |
| | | 136.39 | 34.19 | 132.43 | 33.08 | |
| | | 130.41 | 32.32 | 126.81 | 30.80 | |
| | | 122.47 | 29.00 | 120.70 | 28.45 | |
| 2 |  | 63.73 | 15.55 | 68.61 | 16.01 | 2□ □ □ □ (□ □ ) |
| | | 77.28 | 16.47 | 81.57 | 16.82 |  |
| | | 85.59 | 17.21 | 88.71 | 17.42 | |
| | | 90.88 | 17.43 | 93.87 | 17.36 | |
| | | 96.65 | 17.39 | 97.60 | 17.45 | |
| | | 99.90 | 17.81 | 101.26 | 18.12 | |
| | | 102.75 | 18.52 | 106.94 | 19.48 | |
| | | 112.50 | 20.76 | 118.08 | 22.04 | |
| | | 129.24 | 26.49 | 131.27 | 27.59 | |
| | | 134.31 | 28.85 | 137.83 | 29.88 | |
| | | 138.92 | 30.10 | 140.73 | 30.48 | |
| | | 142.36 | 30.83 | 145.04 | 31.57 | |
| | | 148.95 | 32.95 | 151.03 | 33.77 | |
| | | 153.13 | 34.48 | 155.23 | 35.05 | |
| | | 156.25 | 35.28 | 156.25 | 35.69 | |
| | | 155.08 | 35.62 | 154.03 | 35.35 | |
| | | 153.12 | 35.37 | 146.27 | 33.09 | |
| | | 138.93 | 31.50 | 132.59 | 30.45 | |
| | | 120.70 | 28.45 | 119.93 | 28.30 | |
| | | 117.05 | 27.98 | 110.67 | 27.34 | |
| | | 107.33 | 26.98 | 103.09 | 26.69 | |
| | | 100.95 | 26.64 | 100.07 | 26.63 | |
| | | 97.67 | 26.19 | 93.84 | 25.64 | |
| | | 89.79 | 25.32 | 87.02 | 25.21 | |
| | | 82.12 | 25.02 | 79.33 | 24.83 | |
| | | 77.36 | 24.86 | 74.46 | 24.54 | |
| | | 71.16 | 24.26 | 67.76 | 23.92 | |
| | | 64.24 | 23.56 | 62.16 | 23.35 | |
| | | 60.93 | 23.16 | 58.56 | 22.73 | |
| | | 56.43 | 22.35 | 52.68 | 21.85 | |
| 3 |  | 52.68 | 21.85 | 50.47 | 21.63 | 2□ □ □ □ |
| | | 47.45 | 21.77 | 46.00 | 21.40 |  |
| | | 43.11 | 20.99 | 40.51 | 20.44 | |
| | | 38.42 | 20.09 | 34.89 | 19.09 | |
| | | 29.72 | 17.52 | 23.87 | 16.04 | |
| | | 19.38 | 15.21 | 14.00 | 14.20 | |
| | | 8.53 | 13.42 | 7.81 | 13.42 | |
| | | 0.00 | 13.51 | 0.00 | 9.16 | |
| | | 4.21 | 9.48 | 8.21 | 9.71 | |
| | | 15.48 | 10.36 | 21.05 | 10.87 | |

| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| | | 24.56 | 11.18 | 29.52 | 11.60 | |
| | | 35.74 | 12.08 | 38.72 | 12.30 | |
| | | 41.63 | 12.50 | 44.47 | 12.73 | |
| | | 47.24 | 13.03 | 61.64 | 15.34 | |
| | | 63.73 | 15.55 | | | |
| 4 |  | 7.81 | 8.22 | 26.31 | 9.83 | 3□ □ □ □ □ □ □ |
| | | 38.60 | 10.67 | 47.38 | 11.46 | |
| | | 62.10 | 13.65 | 77.36 | 15.26 | |
| | | 87.69 | 16.63 | 89.46 | 16.83 | |
| | | 93.87 | 17.36 | 90.88 | 17.43 | |
| | | 88.71 | 17.42 | 85.59 | 17.21 | |
| | | 81.57 | 16.82 | 77.28 | 16.47 | |
| | | 68.61 | 16.01 | 63.73 | 15.55 | |
| | | 61.64 | 15.34 | 47.24 | 13.03 | |
| | | 44.47 | 12.73 | 41.63 | 12.50 | |
| | | 38.72 | 12.30 | 35.74 | 12.08 | |
| | | 29.52 | 11.60 | 24.56 | 11.18 | |
| | | 21.05 | 10.87 | 15.48 | 10.36 | |
| | | 8.21 | 9.71 | 4.21 | 9.48 | |
| | | 0.00 | 9.16 | 0.00 | 7.12 | |
| 5 |  | 8.08 | 5.43 | 30.44 | 8.42 | 4-1□ □ □ □ □ □ □ □ □ |
| | | 47.42 | 10.27 | 66.44 | 12.66 | |
| | | 77.57 | 13.79 | 86.51 | 15.97 | |
| | | 89.46 | 16.83 | 87.69 | 16.63 | |
| | | 77.36 | 15.26 | 62.10 | 13.65 | |
| | | 47.38 | 11.46 | 38.60 | 10.67 | |
| | | 26.31 | 9.83 | 7.81 | 8.22 | |
| | | 0.00 | 7.12 | 0.00 | 3.95 | |
| 6 |  | 86.51 | 15.97 | 77.57 | 13.79 | 4-2□ □ □ □ □ □ □ □ □ |
| | | 66.44 | 12.66 | 47.42 | 10.27 | |
| | | 30.44 | 8.42 | 8.08 | 5.43 | |
| | | 0.00 | 3.95 | 0.00 | -0.21 | |
| | | 8.79 | 1.52 | 19.57 | 3.60 | |
| | | 29.73 | 6.12 | 37.25 | 8.17 | |
| | | 40.56 | 8.88 | 45.62 | 9.54 | |
| | | 53.28 | 10.32 | 66.36 | 11.44 | |
| | | 76.64 | 11.95 | 80.20 | 12.52 | |
| | | 85.40 | 13.68 | 91.09 | 15.01 | |
| | | 95.44 | 15.88 | 99.89 | 16.57 | |
| | | 105.64 | 17.61 | 110.93 | 18.70 | |
| | | 117.14 | 20.43 | 122.26 | 22.42 | |
| | | 131.90 | 26.71 | 136.33 | 28.35 | |
| | | 139.95 | 29.45 | 145.52 | 30.84 | |
| | | 150.19 | 31.90 | 154.74 | 32.64 | |
| | | 156.25 | 32.81 | 156.25 | 35.28 | |
| | | 155.23 | 35.05 | 153.13 | 34.48 | |
| | | 151.03 | 33.77 | 148.95 | 32.95 | |
| | | 145.04 | 31.57 | 142.36 | 30.83 | |
| | | 140.73 | 30.48 | 138.92 | 30.10 | |
| | | 137.83 | 29.88 | 134.31 | 28.85 | |

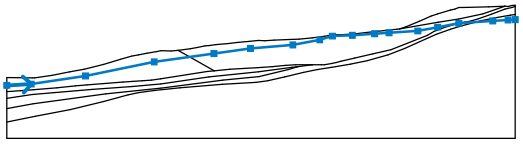
| No. | Surface position | Coordinates of surface points [m] | | | | Assigned soil |
|---|---|---|---|---|---|---|
| | | x | z | x | z | |
| | | 131.27 | 27.59 | 129.24 | 26.49 | |
| | | 118.08 | 22.04 | 112.50 | 20.76 | |
| | | 106.94 | 19.48 | 102.75 | 18.52 | |
| | | 101.26 | 18.12 | 99.90 | 17.81 | |
| | | 97.60 | 17.45 | 96.65 | 17.39 | |
| | | 93.87 | 17.36 | 89.46 | 16.83 | |
| 7 |  | 154.74 | 32.64 | 150.19 | 31.90 | 4-3□ □ □ □ □ □ □ □ □ |
| | | 145.52 | 30.84 | 139.95 | 29.45 |  |
| | | 136.33 | 28.35 | 131.90 | 26.71 | |
| | | 122.26 | 22.42 | 117.14 | 20.43 | |
| | | 110.93 | 18.70 | 105.64 | 17.61 | |
| | | 99.89 | 16.57 | 95.44 | 15.88 | |
| | | 91.09 | 15.01 | 85.40 | 13.68 | |
| | | 80.20 | 12.52 | 76.64 | 11.95 | |
| | | 66.36 | 11.44 | 53.28 | 10.32 | |
| | | 45.62 | 9.54 | 40.56 | 8.88 | |
| | | 37.25 | 8.17 | 29.73 | 6.12 | |
| | | 19.57 | 3.60 | 8.79 | 1.52 | |
| | | 0.00 | -0.21 | 0.00 | -5.21 | |
| | | 156.25 | -5.21 | 156.25 | 32.81 | |

## Anti-Slide piles

| No. | Anti-Slide pile | Point | | Length | Pile spacing | Cross-section | Pile bearing capacity | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | new | x [m] | z [m] | l [m] | b [m] | [m] | istributio along the pile | Max. bearing capacity $V_u$ [kN] | Gradient K [–] | Passive force direction |
| 1 | No | 34.85 | 19.08 | 15.06 | 2.50 | d = 1.50 | constant | 1432.74 | | perpendicular to pile |
| 2 | No | 110.74 | 27.35 | 11.00 | 3.00 | d = 1.00 | constant | 704.70 | | perpendicular to pile |
| 3 | No | 132.02 | 32.93 | 9.00 | 3.00 | d = 1.00 | constant | 704.70 | | perpendicular to pile |

## Water

Water type : GWT

| No. | GWT location | Coordinates of GWT points [m] | | | | | |
|---|---|---|---|---|---|---|---|
| | | x | z | x | z | x | z |
| 1 |  | 0.00 | 11.05 | 7.54 | 11.46 | 24.20 | 13.98 |
| | | 45.31 | 18.26 | 63.63 | 20.84 | 74.88 | 22.42 |
| | | 87.91 | 23.51 | 96.19 | 25.04 | 100.08 | 26.21 |
| | | 106.22 | 26.49 | 113.02 | 26.95 | 117.51 | 27.24 |
| | | 126.32 | 27.79 | 132.43 | 28.96 | 138.91 | 30.15 |
| | | 149.38 | 30.86 | 154.03 | 31.15 | 156.25 | 31.29 |

## Tensile crack

Tensile crack not input.

### Earthquake

Seismic fortification intensity : 7 degree (0.1g)
Factor of horizontal acceleration : $K_h$ = 0.1000
Seismic importance coefficient : $C_i$ = 1.0
Comprehensive influence factor : $C_z$ = 0.25
Distribution of horizontal earthquake : trapezoidal
Top value of the distribution map : a = 3.0
Bottom value of the distribution map : b = 1.0

### Settings of the stage of construction

Design situation : seismic

## Results (Stage of construction 5)

### Analysis 1 (stage 5)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 56.87 | 22.43 | 58.38 | 18.67 | 60.94 | 17.15 | 64.04 | 16.43 | 82.95 | 17.10 |
| 89.34 | 17.46 | 94.53 | 17.55 | 95.74 | 17.62 | 97.07 | 17.76 | 102.94 | 18.69 |
| 107.56 | 19.62 | 112.98 | 20.91 | 117.97 | 22.23 | 125.68 | 25.20 | 131.91 | 28.07 |
| 139.26 | 31.18 | 142.59 | 35.08 | | | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Horizontal active force: 345.36 kN/m
Horizontal passive force: 169.16 kN/m
Depth of slip surface: 6.97 m
The length of pile below terrain: 11.00 m

Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Horizontal active force: 155.15 kN/m
Horizontal passive force: 0.00 kN/m The slope in front of anti-slide pile is not satisfactory.
Depth of slip surface: 4.81 m
The length of pile below terrain: 9.00 m

**Slope stability verification (ITFM)**
Factor of safety = 1.13 > 1.05
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Analysis 2 (stage 5)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 20.67 | 15.45 | 25.42 | 12.44 | 32.11 | 11.81 | 47.07 | 13.38 | 73.56 | 16.94 |
| 83.87 | 17.13 | 103.76 | 18.93 | 114.82 | 21.35 | 122.05 | 23.73 | 129.20 | 27.19 |
| 139.23 | 30.56 | 143.09 | 34.04 | 143.16 | 35.10 | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

Anti-Slide Pile No. 1 (34.85; 19.08 [m])
Horizontal active force: 635.12 kN/m

Horizontal passive force: 360.04 kN/m
Depth of slip surface: 6.98 m
The length of pile below terrain: 15.06 m

Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Horizontal active force: 420.91 kN/m
Horizontal passive force: 312.50 kN/m
Depth of slip surface: 6.89 m
The length of pile below terrain: 11.00 m

Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Horizontal active force: 164.17 kN/m
Horizontal passive force: 61.37 kN/m
Depth of slip surface: 4.79 m
The length of pile below terrain: 9.00 m

**Slope stability verification (ITFM)**
Factor of safety = 1.37 > 1.05
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Analysis 3 (stage 5)

**Polygonal slip surface**

| Coordinates of slip surface points [m] | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| x | z | x | z | x | z | x | z | x | z |
| 119.73 | 28.28 | 122.28 | 26.06 | 123.88 | 25.74 | 130.81 | 27.50 | 134.60 | 28.98 |
| 138.14 | 30.60 | 141.10 | 32.53 | 142.78 | 35.09 | | | | |
| Analysis of the slip surface without optimization. | | | | | | | | | |

**The forces acting on the pile**

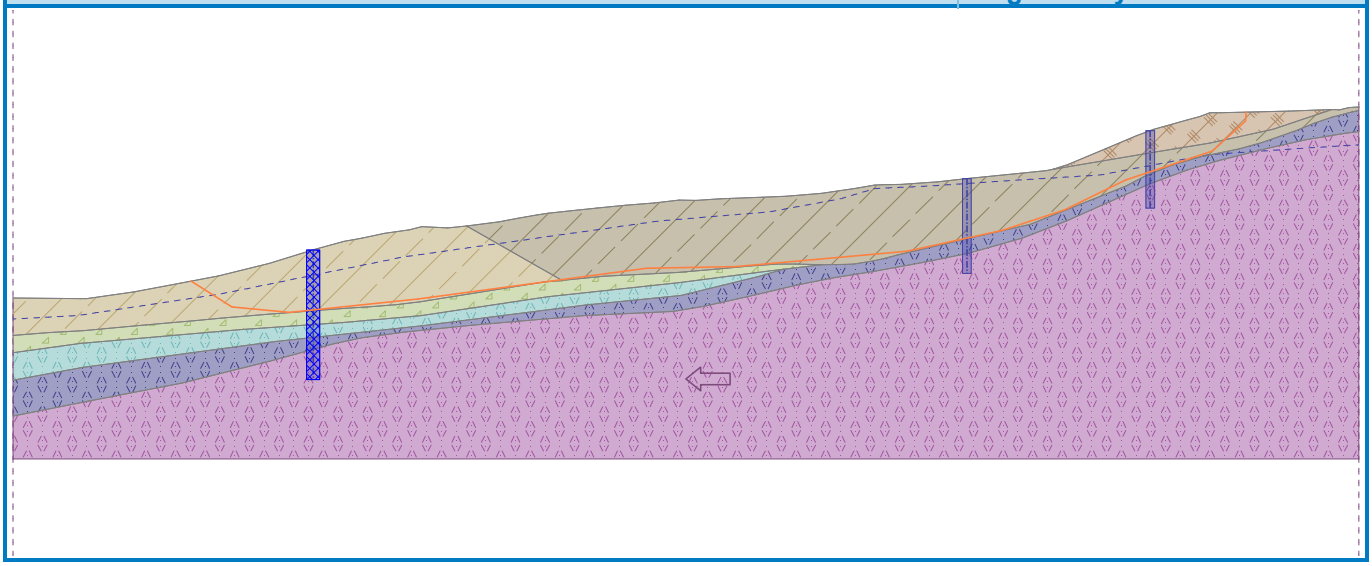
Anti-Slide Pile No. 1 (34.85; 19.08 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 2 (110.74; 27.35 [m])
The pile do not intersect slip surface, forces acting on pile cannot be computed.
Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Horizontal active force: 168.80 kN/m
Horizontal passive force: 43.44 kN/m
Depth of slip surface: 4.96 m
The length of pile below terrain: 9.00 m

**Slope stability verification (ITFM)**
Factor of safety = 1.41 > 1.05
**Slope stability ACCEPTABLE**
The increments of slip segment obliqueness is higher than 10 degrees. The results can be overestimated.

### Piles verification 1 (stage 5)

Anti-Slide pile : Anti-Slide Pile No. 1 (34.85; 19.08 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

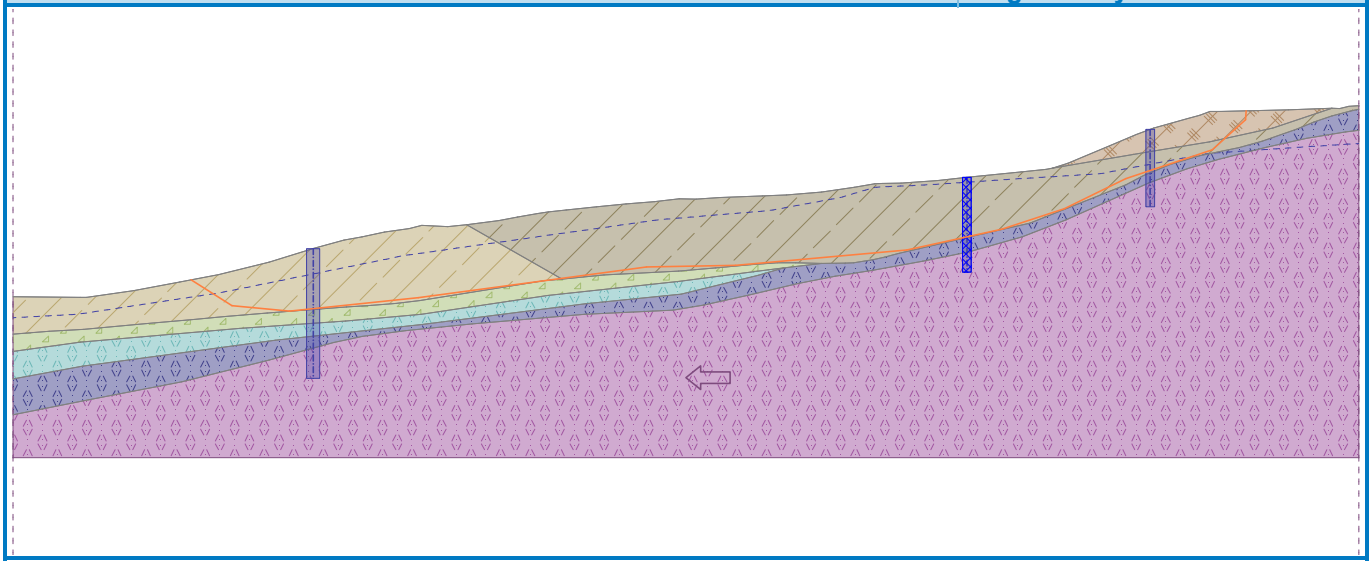
| Name : Piles verification | Stage - analysis : 5 - 1 |
|---|---|



## Piles verification 2 (stage 5)

Anti-Slide pile : Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

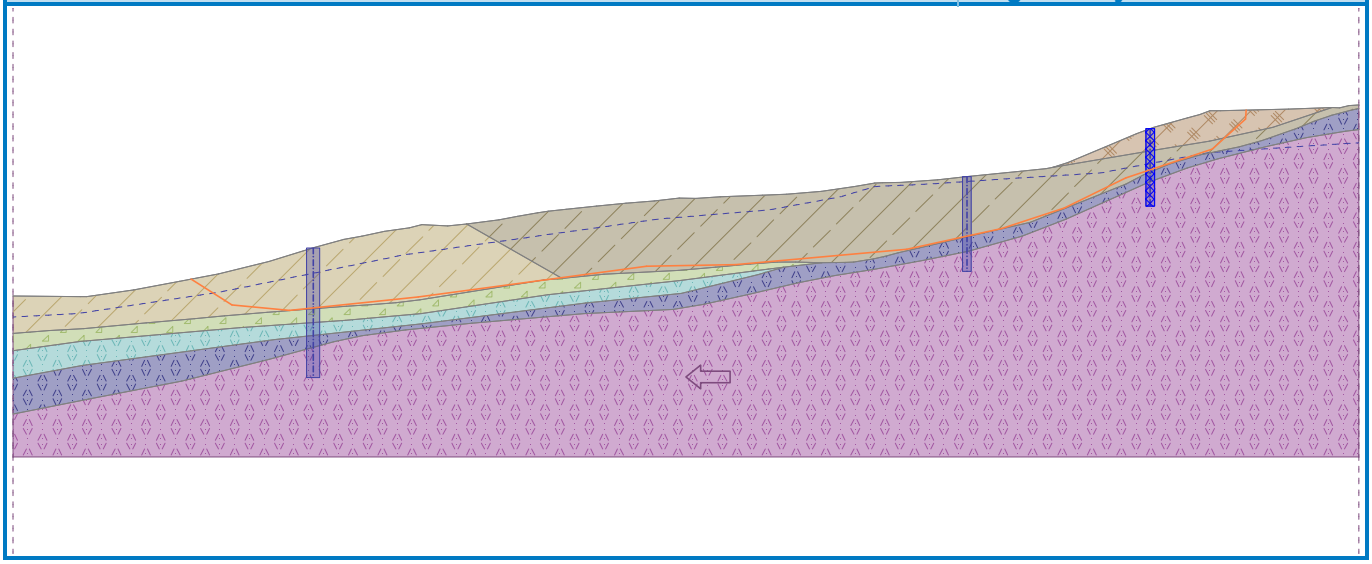
| Name : Piles verification | Stage - analysis : 5 - 2 |
|---|---|



## Piles verification 3 (stage 5)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 2 (slip surface polygonal)
Method : ITFM

| Name : Piles verification | Stage - analysis : 5 - 3 |
|---|---|



### Piles verification 4 (stage 5)

Anti-Slide pile : Anti-Slide Pile No. 2 (110.74; 27.35 [m])
Analysis : Calculation 1 (slip surface polygonal)
Method : ITFM

## Analysis of anti-slide pile

## Input data

### Settings

(input for current task)

### Materials and standards

Concrete structures : GB 50010-2010
Steel structures : GB 50017-2003

### Pressure analysis

Active earth pressure calculation : Coulomb
Passive earth pressure calculation : Mazindrani (Rankine)
Earthquake analysis : NB 35047 - 2015
Modulus of subsoil reaction : Chinese standards
Pressures below the slip surface : GB 50330-2013
Verification methodology : according to Chinese standards

### Anchors

Verification methodology : Safety factors (ASD)

| Safety factors | | | |
|---|---|---|---|
| Safety factor for steel strength : | $SF_t$ = | 2.20 | [–] |
| Safety factor for pull out resistance (soil) : | $SF_e$ = | 2.60 | [–] |
| Safety factor for pull out resistance (grouting) : | $SF_c$ = | 2.60 | [–] |

### Geometry of structure

Structure length = 11.00 m

Cross-section name : Pile curtain d = 1.20 m; a = 3.00 m
Material of pile : concrete

Computed coefficient of pressure reduction below the ditch = 0.66
Area of cross-section A = 3.77E-01 $m^2/m$
Moment of inertia I = 3.39E-02 $m^4/m$
Elastic modulus E = 30000.00 MPa
Shear modulus G = 12000.00 MPa

## Forces above the slip surface

Depth of slip surface $h_{s1}$ = 6.97 m
Input of active horizontal force : residual active force
Input of passive horizontal force : residual passive force

Active horizontal force T = 345.36 kN/m
Passive horizontal force P = 169.16 kN/m

Distribution of active force : rectangle
Distribution of passive force : rectangle

## Material of structure

Analysis of concrete structures carried out according to the standard GB 50010-2010.

**Concrete: C30**
Compressive strength $f_{ck}$ = 20.10 MPa
Tensile strength $f_{tk}$ = 2.01 MPa
Elasticity modulus $E_c$ = 30000.00 MPa
Shear modulus G = 12000.00 MPa

**Longitudinal steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

**Transverse steel: HRB400**
Yield strength $f_{yk}$ = 400.00 MPa

## Modulus of reaction

## Modulus of reaction

Modulus of subsoil reaction input as soil parameter.

## Basic soil parameters

| No. | Name | Pattern | $\varphi_{ef}$ [°] | $c_{ef}$ [kPa] | $\gamma$ [kN/m³] | $\gamma_{su}$ [kN/m³] | $\delta$ [°] |
|---|---|---|---|---|---|---|---|
| 1 | 1□ □ □ | | 5.60 | 13.00 | 17.70 | 10.00 | 2.00 |
| 2 | 2□ □ □ □ | | 8.00 | 13.00 | 18.20 | 10.00 | 2.50 |
| 3 | 3□ □ □ □ □ □ □ | | 24.00 | 15.00 | 19.00 | 11.00 | 8.00 |
| 4 | 4-1□ □ □ □ □ □ □ □ □ | | 11.50 | 16.00 | 17.80 | 10.00 | 4.00 |
| 5 | 4-2□ □ □ □ □ □ □ □ □ | | 30.00 | 18.00 | 21.50 | 13.00 | 10.00 |
| 6 | 4-3□ □ □ □ □ □ □ □ □ | | 30.00 | 100.00 | 25.70 | 15.80 | 10.00 |
| 7 | 2□ □ □ □ (□ □ ) | | 5.00 | 8.00 | 18.20 | 10.00 | 2.00 |

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

## Soil parameters

**1**□ □ □
Unit weight : $\gamma$ = 17.70 kN/m³

| | |
|---|---|
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 5.60 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 10.00 MN/m$^4$ |

**2□ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 18.20 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 8.00 ° |
| Cohesion of soil : | $c_{ef}$ = 13.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 2.50 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 4.00 MN/m$^4$ |

**3□ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 19.00 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 24.00 ° |
| Cohesion of soil : | $c_{ef}$ = 15.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 8.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 21.00 kN/m$^3$ |
| Parameter : | m = 20.00 MN/m$^4$ |

**4-1□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 17.80 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 11.50 ° |
| Cohesion of soil : | $c_{ef}$ = 16.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 4.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 20.00 kN/m$^3$ |
| Parameter : | m = 80.00 MN/m$^4$ |

**4-2□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 21.50 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 18.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |
| Saturated unit weight : | $\gamma_{sat}$ = 23.00 kN/m$^3$ |
| Parameter : | K = 300.00 MN/m$^3$ |

**4-3□ □ □ □ □ □ □ □ □**

| | |
|---|---|
| Unit weight : | $\gamma$ = 25.70 kN/m$^3$ |
| Stress-state : | effective |
| Angle of internal friction : | $\varphi_{ef}$ = 30.00 ° |
| Cohesion of soil : | $c_{ef}$ = 100.00 kPa |
| Angle of friction struc.-soil : | $\delta$ = 10.00 ° |
| Soil : | cohesionless |

Saturated unit weight : $\gamma_{sat}$ = 25.80 kN/m$^3$
Parameter : K = 700.00 MN/m$^3$

**2□ □ □ □ (□ □ )**
Unit weight : $\gamma$ = 18.20 kN/m$^3$
Stress-state : effective
Angle of internal friction : $\varphi_{ef}$ = 5.00 °
Cohesion of soil : $c_{ef}$ = 8.00 kPa
Angle of friction struc.-soil : $\delta$ = 2.00 °
Soil : cohesionless
Saturated unit weight : $\gamma_{sat}$ = 20.00 kN/m$^3$
Parameter : m = 4.00 MN/m$^4$

## Pile fixed into the rock

Length of wall in the rock l = 4.03 m
Uniaxial compressive strength $f_{rk}$ = 8000.00 kPa
Horizontal coefficient K = 0.50
Reduction parameter $\nu$ = 0.40

## Geological profile and assigned soils

**Position information**
Terrain elevation = 27.35 m
**Geological profile and assigned soils**

| No. | Thickness of layer t [m] | Depth z [m] | Altitude [m] | Assigned soil | Pattern |
|---|---|---|---|---|---|
| 1 | 6.93 | 0.00 .. 6.93 | 27.35 .. 20.42 | 2□ □ □ □ (□ □ ) | |
| 2 | 1.68 | 6.93 .. 8.61 | 20.42 .. 18.74 | 4-2□ □ □ □ □ □ □ □ | |
| 3 | - | 8.61 .. ∞ | 18.74 .. - | 4-3□ □ □ □ □ □ □ □ | |

## Excavation

Soil in front of wall is excavated to a depth of 0.06 m.

### Ditch bottom shape

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | -2.91 | 0.31 |
| 3 | -7.15 | 0.60 |
| 4 | -9.29 | 0.65 |
| 5 | -10.17 | 0.66 |
| 6 | -12.57 | 1.10 |
| 7 | -16.40 | 1.65 |
| 8 | -20.45 | 1.97 |
| 9 | -23.22 | 2.08 |
| 10 | -28.12 | 2.27 |
| 11 | -30.91 | 2.46 |
| 12 | -32.88 | 2.43 |
| 13 | -35.78 | 2.75 |
| 14 | -39.08 | 3.03 |

| No. | Coordinate x [m] | Depth z [m] |
|---|---|---|
| 15 | -42.48 | 3.37 |
| 16 | -46.00 | 3.73 |
| 17 | -48.08 | 3.94 |
| 18 | -49.31 | 4.13 |
| 19 | -51.68 | 4.56 |
| 20 | -53.81 | 4.94 |
| 21 | -57.56 | 5.44 |
| 22 | -59.77 | 5.66 |
| 23 | -62.79 | 5.52 |
| 24 | -64.24 | 5.89 |
| 25 | -67.13 | 6.30 |
| 26 | -69.73 | 6.85 |
| 27 | -71.82 | 7.20 |
| 28 | -75.35 | 8.20 |
| 29 | -80.52 | 9.77 |
| 30 | -86.37 | 11.25 |
| 31 | -90.86 | 12.08 |
| 32 | -96.24 | 13.09 |
| 33 | -101.71 | 13.87 |
| 34 | -102.43 | 13.87 |
| 35 | -110.24 | 13.78 |
| 36 | -111.24 | 13.78 |

Origin [0,0] is located at the ditch bottom.
Positive coordinate +z has downward direction.

**Terrain profile**

| No. | Coordinates x [m] | Depth z [m] |
|---|---|---|
| 1 | 0.00 | 0.00 |
| 2 | 0.10 | -0.06 |
| 3 | 5.81 | -0.63 |
| 4 | 8.69 | -0.95 |
| 5 | 9.46 | -1.10 |
| 6 | 11.23 | -1.65 |
| 7 | 15.57 | -3.45 |
| 8 | 19.17 | -4.97 |
| 9 | 21.19 | -5.73 |
| 10 | 25.15 | -6.84 |
| 11 | 26.54 | -7.22 |
| 12 | 27.71 | -7.66 |
| 13 | 28.94 | -7.68 |
| 14 | 36.83 | -7.86 |
| 15 | 41.88 | -8.02 |
| 16 | 42.79 | -8.00 |
| 17 | 43.84 | -8.27 |
| 18 | 45.01 | -8.34 |
| 19 | 46.01 | -8.34 |

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 0.52 m
GWT in front of the structure lies at a depth of 0.59 m
Subgrade at the heel is not permeable.

### Earthquake

Seismic fortification intensity : 7 degree (0.1g)

| | | | |
|---|---|---|---|
| Factor of horizontal acceleration | $K_h$ | = | 0.1000 |
| Factor of vertical acceleration | $K_v$ | = | 0.0000 |
| Meeting coefficient | $C_0$ | = | 0.5000 |
| Seismic importance coefficient | $C_i$ | = | 1.00 |
| Comprehensive influence factor | $C_z$ | = | 0.25 |
| Top value of the distribution map | a | = | 3.00 |
| Bottom value of the distribution map | b | = | 1.00 |

Water below the GWT is restricted.
Coefficient of seismic bearing capacity $\zeta_a = 1.30$

### Global settings

Number of FEs to discretize wall = 40
Analysis of depending pressures : do not reduce
Minimum dimensioning pressure is considered as $\sigma_{a,min} = 0.20\sigma_z$
Coefficient of importance of structure $\gamma_0 = 1.00$

### Settings of the stage of construction

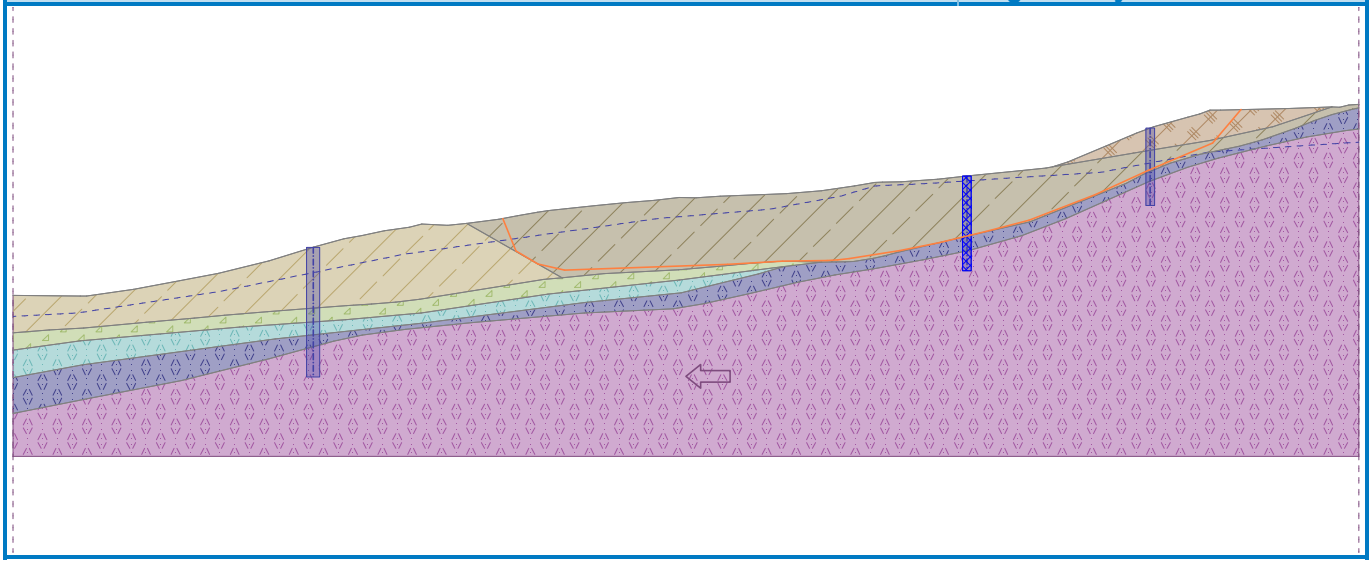
Design situation : seismic

## Analysis results

Warning - allowable range of input data exceeded during earthquake analysis!
The analysis is carried out with the modified value of terrain inclination $\beta$. ($\beta$=0.00°, $\beta_{modif}$=0.00°)

## Dimensioning No. 1

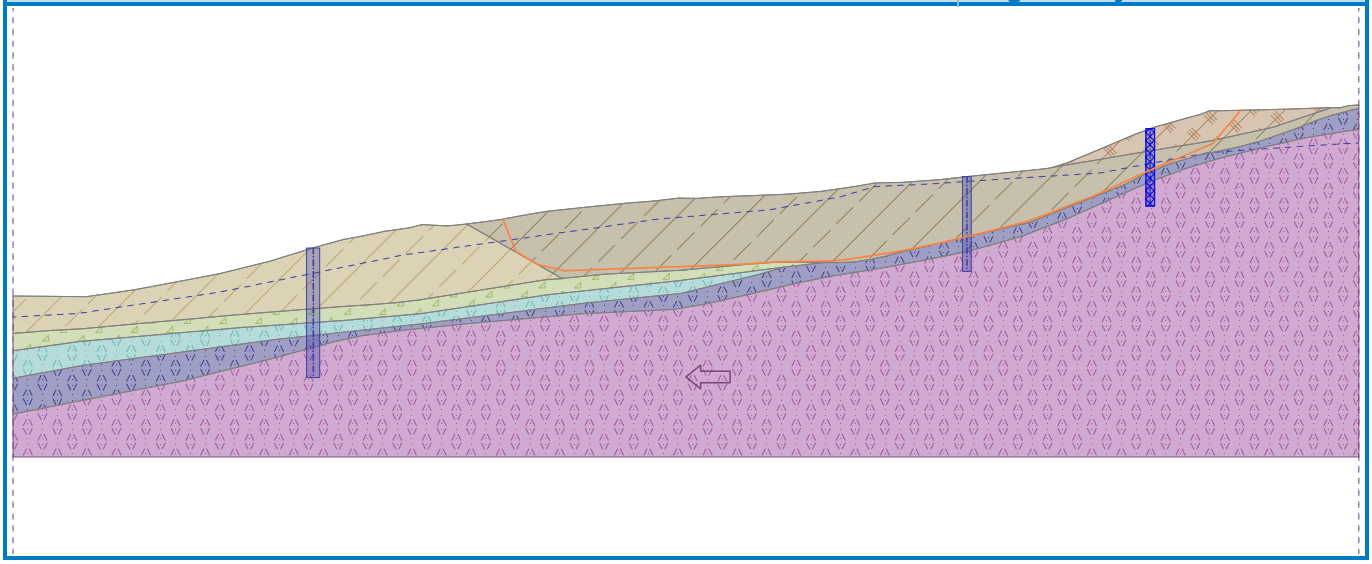
| Name : Piles verification | Stage - analysis : 5 - 4 |
|---|---|



### Piles verification 5 (stage 5)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 1 (slip surface polygonal)
Method : ITFM

| Name : Piles verification | Stage - analysis : 5 - 5 |
|---|---|



## Piles verification 6 (stage 5)

Anti-Slide pile : Anti-Slide Pile No. 3 (132.02; 32.93 [m])
Analysis : Calculation 3 (slip surface polygonal)
Method : ITFM

| Name : Piles verification | Stage - analysis : 5 - 6 |
|---|---|