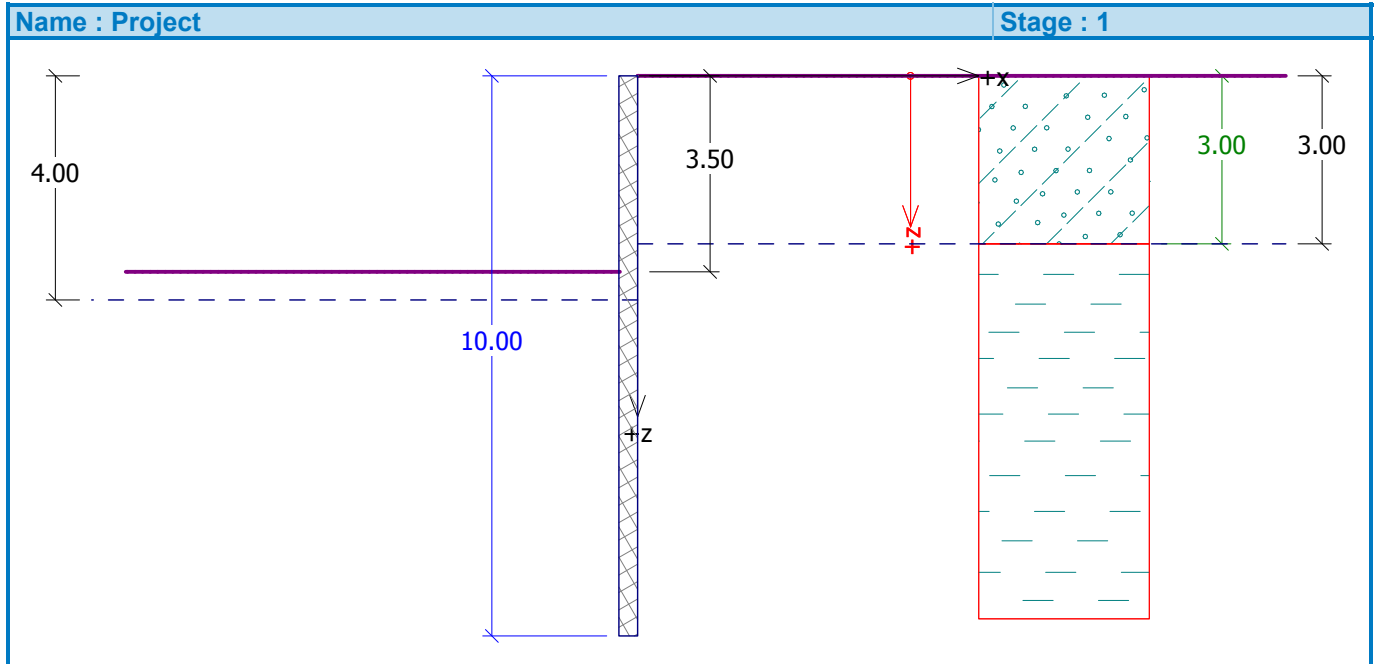


## Sheeting structure verification

### Input data

#### Project

Date : 11/2/2005



### Geometry of structure

Structure length = 10.00 m

Type of structure: Reinforced concrete rectangular wall

Standard : EN 1992 1-1 (EC2)

Material: C 20/25

Cross-section thickness  $h = 0.50$  m

Coeff. of press. reduc. in front of wall = 1.00

Area of cross-section  $A = 5.000E-01$  m<sup>2</sup>/m

Moment of inertia  $I = 1.042E-02$  m<sup>4</sup>/m

Elastic modulus  $E = 29000.00$  MPa

Shear modulus  $G = 11340.00$  MPa

Modulus of subsoil reaction determined according to the Schmitt theory.


### Basic soil parameters

No.	Name	Pattern	$\varphi_{ef}$ [°]	$c_{ef}$ [kPa]	$\gamma$ [kN/m <sup>3</sup> ]	$\gamma_{su}$ [kN/m <sup>3</sup> ]	$\delta_a$ [°]	$\delta_p$ [°]
1	Soil No. 1		29.00	4.00	18.00	8.00	20.00	20.00
2	Soil No. 2		19.00	10.00	21.00	11.00	15.00	15.00

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

### Parameters of soils to compute modulus of subsoil reaction (Schmitt)

No.	Name	Pattern	$\nu$ [-]	$E_{oed}$ [MPa]	$E_{def}$ [MPa]
1	Soil No. 1		0.30	-	10.00

No.	Name	Pattern	$\nu$ [-]	$E_{oed}$ [MPa]	$E_{def}$ [MPa]
2	Soil No. 2		0.40	-	4.50

### Soil parameters



#### Soil No. 1

Unit weight :  $\gamma = 18.00 \text{ kN/m}^3$   
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 29.00^\circ$   
 Cohesion of soil :  $c_{ef} = 4.00 \text{ kPa}$   
 Active friction angle :  $\delta_{act} = 20.00^\circ$   
 Passive friction angle :  $\delta_{pas} = 20.00^\circ$   
 Soil : cohesionless  
 Deformation modulus :  $E_{def} = 10.00 \text{ MPa}$   
 Poisson's ratio :  $\nu = 0.30$   
 Saturated unit weight :  $\gamma_{sat} = 18.00 \text{ kN/m}^3$

#### Soil No. 2

Unit weight :  $\gamma = 21.00 \text{ kN/m}^3$   
 Stress-state : effective  
 Angle of internal friction :  $\varphi_{ef} = 19.00^\circ$   
 Cohesion of soil :  $c_{ef} = 10.00 \text{ kPa}$   
 Active friction angle :  $\delta_{act} = 15.00^\circ$   
 Passive friction angle :  $\delta_{pas} = 15.00^\circ$   
 Soil : cohesionless  
 Deformation modulus :  $E_{def} = 4.50 \text{ MPa}$   
 Poisson's ratio :  $\nu = 0.40$   
 Saturated unit weight :  $\gamma_{sat} = 21.00 \text{ kN/m}^3$

### Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	3.00	Soil No. 1	
2	-	Soil No. 2	

### Excavation

Soil in front of wall is excavated to a depth of 3.50 m.

### Terrain profile

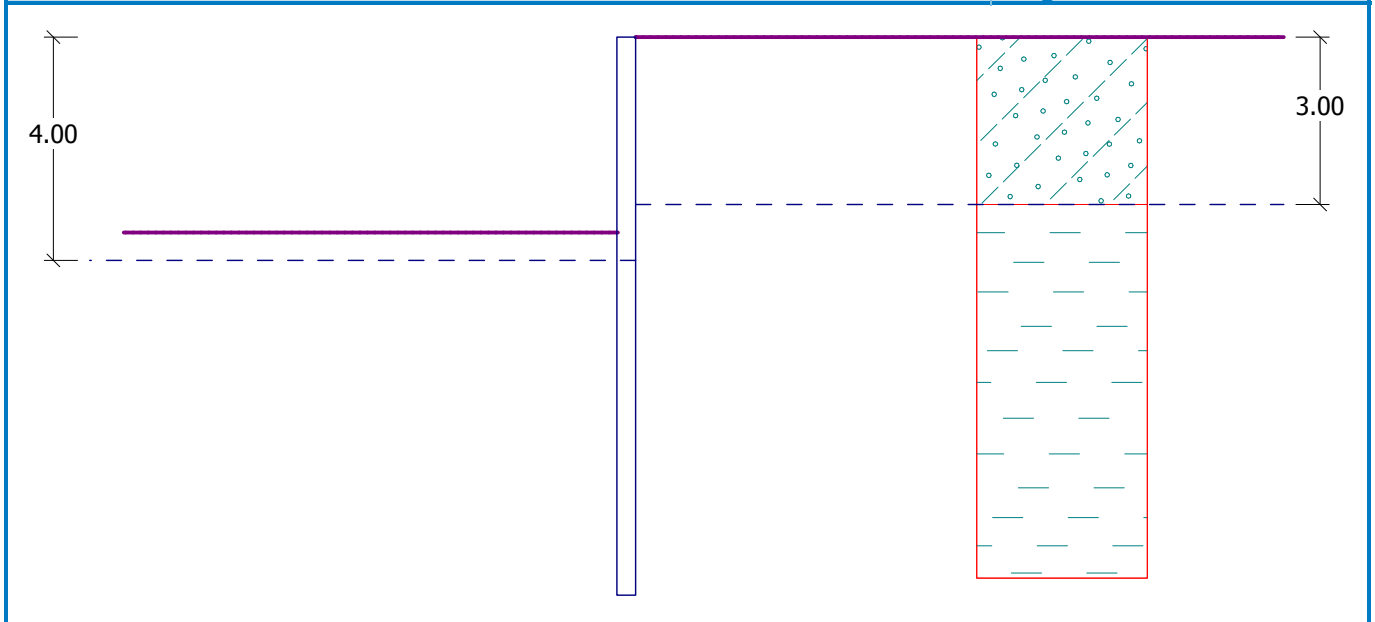
Terrain behind the structure is flat.

### Water influence

GWT behind the structure lies at a depth of 3.00 m  
 GWT in front of the structure lies at a depth of 4.00 m  
 Subgrade at the heel is not permeable.

Name : Water

Stage : 1



### Global settings

Verification methodology : Classical way  
Active earth pressure calculation - Coulomb  
Passive earth pressure calculation - Caquot-Kerisel  
Number of FEs to discretise wall = 30

### Settings of the stage of construction

Analysis carried out without reduction of input data.  
Minimum dimensioning pressure is considered as  $\sigma_{z,\min} = 0.20\sigma_z$ .

### Analysis results (Stage of construction 1)

#### Distribution of pressures acting on the structure (in front and behind the wall)

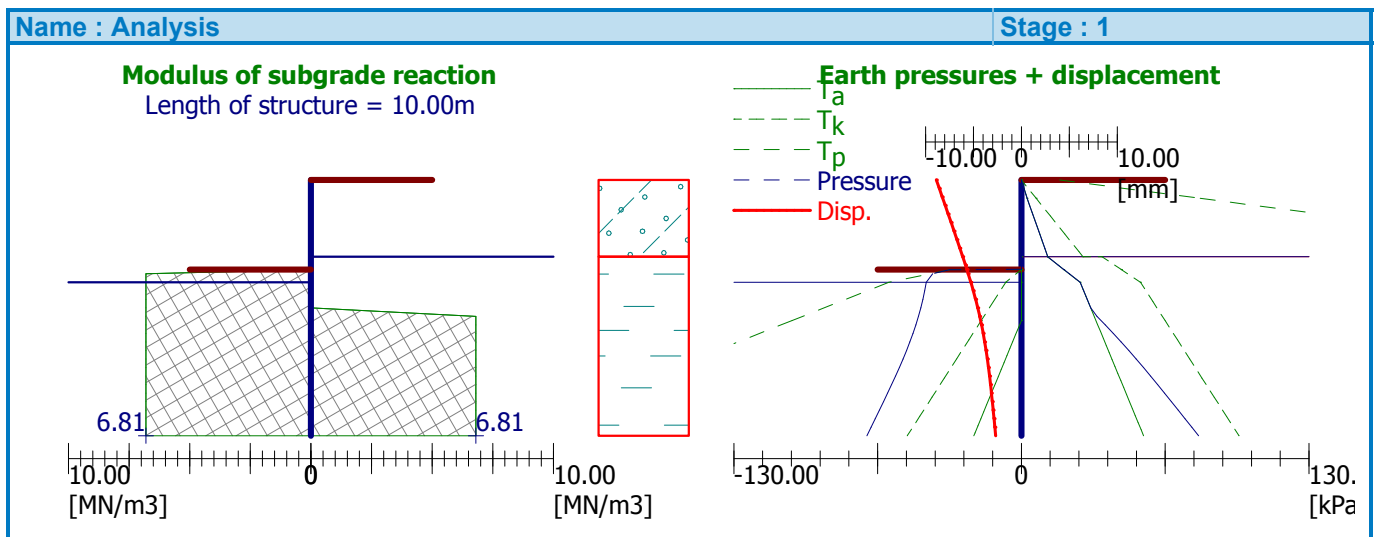
Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	17.21
0.72	0.00	0.00	0.00	2.58	6.66	80.84
3.00	-0.00	-0.00	-0.00	11.92	27.82	283.17
3.00	0.00	0.00	0.00	11.76	36.42	175.58
3.50	-0.00	-0.00	-0.00	19.15	45.13	195.20
3.50	-0.00	-0.00	-32.05	19.15	45.13	195.20
4.00	-0.00	-7.08	-59.96	26.54	53.84	214.82
5.50	-0.00	-18.18	-103.69	33.69	64.93	258.55
10.00	-21.54	-51.59	-235.39	55.23	98.35	390.25

#### Distributions of the modulus of subgrade reaction and internal forces along the structure

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-8.87	0.00	0.00	0.00
0.33	0.00	0.00	-8.56	1.20	-0.20	0.02
0.67	0.00	0.00	-8.26	2.40	-0.80	0.18
1.00	0.00	0.00	-7.95	3.74	-1.82	0.60
1.33	0.00	0.00	-7.64	5.10	-3.30	1.44
1.67	0.00	0.00	-7.33	6.46	-5.22	2.85

Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
2.00	0.00	0.00	-7.02	7.83	-7.61	4.98
2.33	0.00	0.00	-6.72	9.19	-10.44	7.97
2.67	0.00	0.00	-6.42	10.55	-13.73	11.99
3.00	0.00	0.00	-6.12	11.92	-17.48	17.18
3.33	0.00	0.00	-5.83	16.68	-22.24	23.75
3.49	0.00	0.00	-5.69	19.00	-25.04	27.45
3.51	0.00	0.00	-5.68	-13.31	-25.10	27.95
3.67	6.81	0.00	-5.55	-18.49	-22.57	31.59
4.00	6.81	0.00	-5.28	-16.45	-16.75	38.12
4.33	6.81	0.00	-5.02	-15.58	-11.41	42.81
4.67	6.81	0.00	-4.78	-14.82	-6.35	45.77
5.00	6.81	0.00	-4.55	-14.17	-1.52	47.08
5.33	6.81	6.81	-4.35	-12.41	3.02	46.39
5.67	6.81	6.81	-4.16	-9.83	6.72	44.74
6.00	6.81	6.81	-3.98	-7.48	9.60	42.00
6.33	6.81	6.81	-3.83	-5.33	11.73	38.43
6.67	6.81	6.81	-3.68	-3.39	13.18	34.26
7.00	6.81	6.81	-3.55	-1.61	14.01	29.71
7.33	6.81	6.81	-3.43	0.01	14.27	24.98
7.67	6.81	6.81	-3.32	1.51	14.01	20.25
8.00	6.81	6.81	-3.22	2.90	13.28	15.69
8.33	6.81	6.81	-3.13	4.21	12.09	11.45
8.67	6.81	6.81	-3.03	5.47	10.47	7.68
9.00	6.81	6.81	-2.94	6.68	8.45	4.52
9.33	6.81	6.81	-2.86	7.86	6.02	2.09
9.67	6.81	6.81	-2.77	9.04	3.21	0.55
10.00	6.81	6.81	-2.69	10.21	-0.00	-0.00

Maximum shear force = 25.10 kN/m  
Maximum moment = 47.08 kNm/m  
Maximum displacement = 8.9 mm



### Input data (Stage of construction 2)

#### Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	3.00	Soil No. 1	
2	-	Soil No. 2	

### Excavation

Soil in front of wall is excavated to a depth of 5.50 m.

### Terrain profile

Terrain behind the structure is flat.

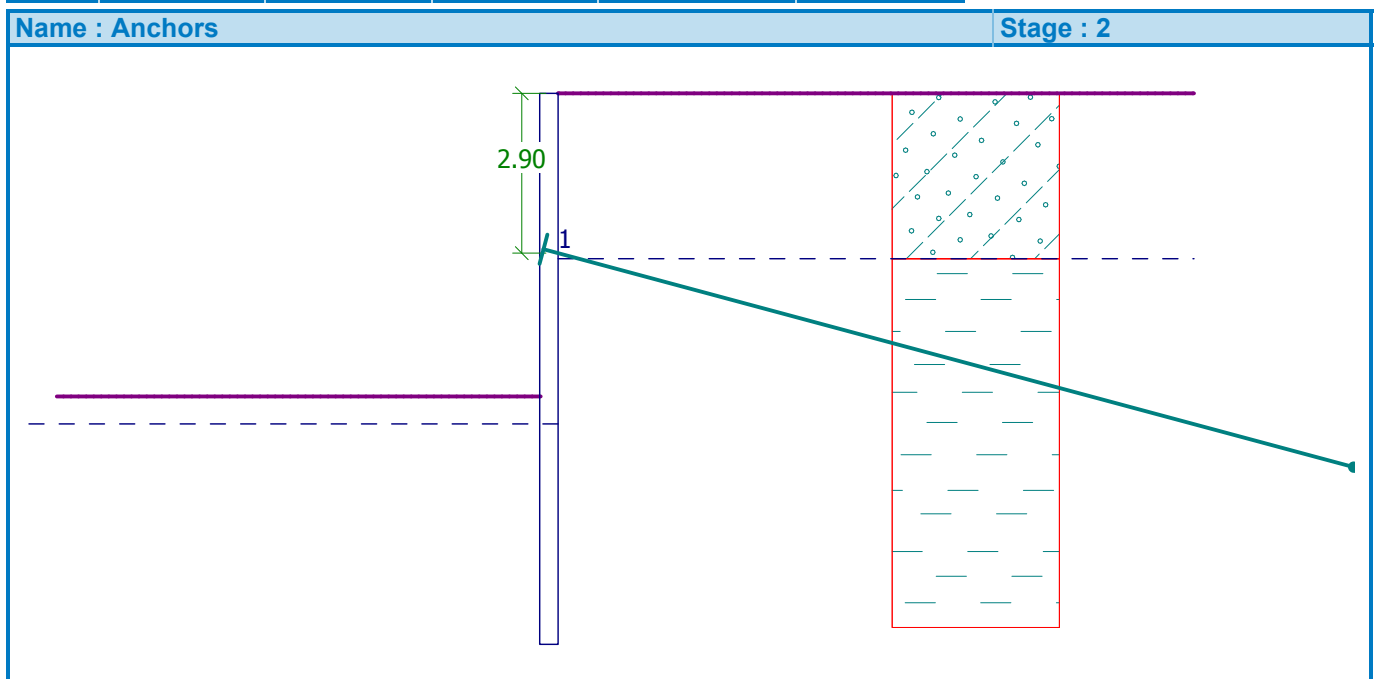
### Water influence

GWT behind the structure lies at a depth of 3.00 m  
GWT in front of the structure lies at a depth of 6.00 m  
Subgrade at the heel is not permeable.

### Input anchors

No.	New anchor	Depth z [m]	Length l [m]	Root l <sub>k</sub> [m]	Slope α [°]	Spacing b [m]
1	YES	2.90	15.00	0.01	15.00	1.00

No.	Diameter d [mm]	Area A [mm <sup>2</sup> ]	Modulus E [MPa]	Post-stressing	Force F [kN]
1	10.0		210000.00		185.00



### Settings of analysis

Analysis carried out without reduction of input data.  
Minimum dimensioning pressure is considered as  $\sigma_{z,min} = 0.20\sigma_z$ .

### Analysis results (Stage of construction 2)

Distribution of pressures acting on the structure (in front and behind the wall)

Depth [m]	Ta,p [kPa]	Tk,p [kPa]	Tp,p [kPa]	Ta,z [kPa]	Tk,z [kPa]	Tp,z [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	17.21
0.72	0.00	0.00	0.00	2.58	6.66	80.84
3.00	-0.00	-0.00	-0.00	11.92	27.82	283.17
3.00	0.00	0.00	0.00	11.76	36.42	175.58
5.50	-0.00	-0.00	-0.00	48.71	79.97	273.68
5.50	-0.00	-0.00	-32.05	48.71	79.97	273.68
6.00	-0.00	-7.08	-59.96	56.10	88.68	293.30
7.50	-0.00	-18.18	-103.69	63.25	99.77	337.03
10.00	-11.97	-36.76	-176.91	75.23	118.35	410.25

**Distributions of the modulus of subgrade reaction and internal forces along the structure**

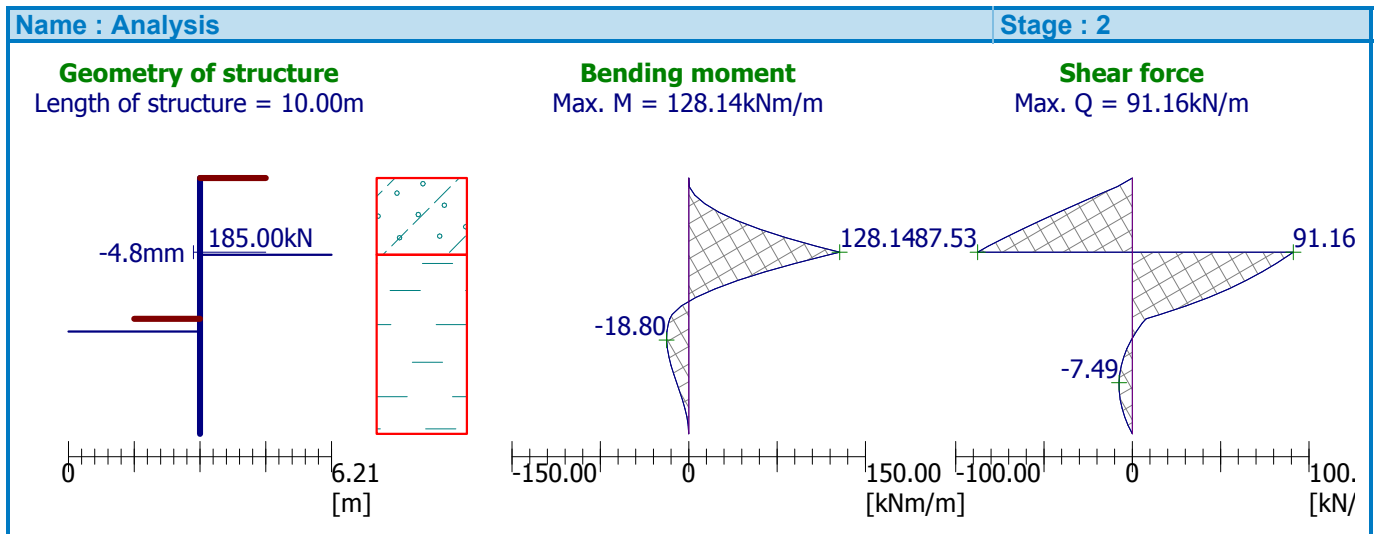
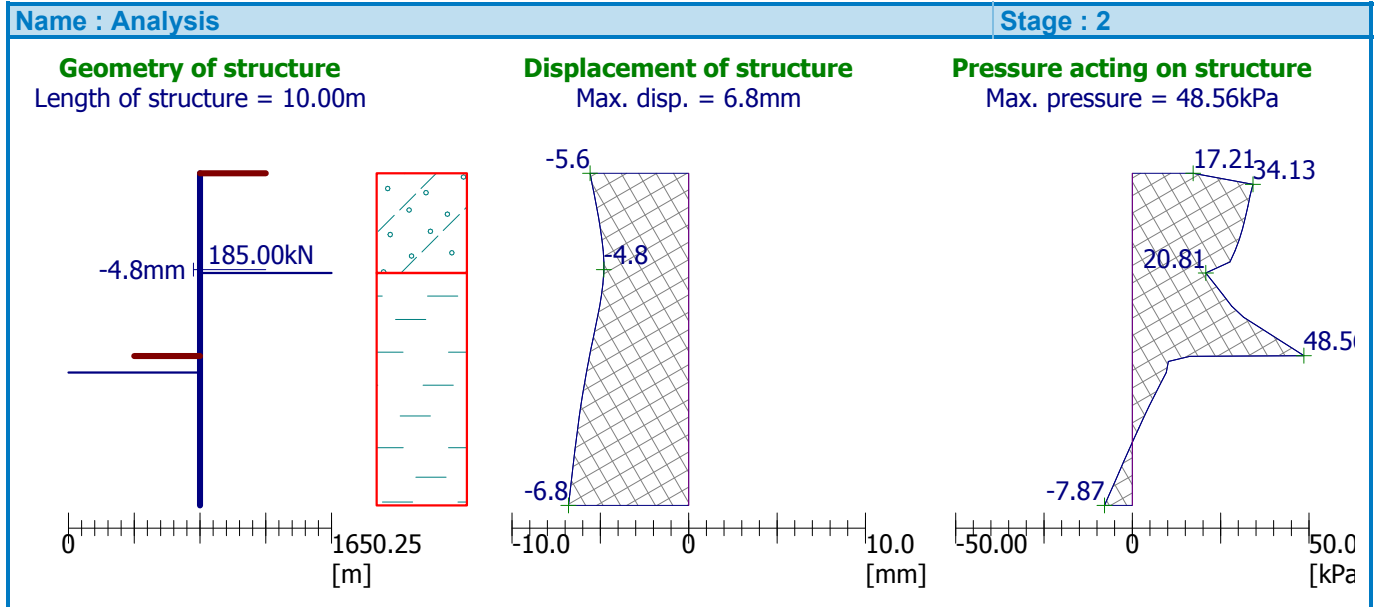
Depth [m]	kh,p [MN/m <sup>3</sup> ]	kh,z [MN/m <sup>3</sup> ]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
0.00	0.00	0.00	-5.59	17.21	0.00	0.00
0.33	0.00	10.62	-5.46	34.13	-8.45	0.36
0.67	0.00	10.62	-5.34	33.35	-19.70	5.07
1.00	0.00	10.62	-5.22	32.69	-30.70	13.48
1.33	0.00	10.62	-5.11	31.99	-41.49	25.53
1.67	0.00	10.62	-5.00	31.20	-52.02	41.13
2.00	0.00	10.62	-4.91	30.26	-62.27	60.20
2.33	0.00	10.62	-4.84	29.09	-72.17	82.62
2.67	0.00	10.62	-4.81	27.63	-81.63	108.28
2.90	0.00	7.95	-4.81	22.86	-87.53	128.14
2.90	0.00	7.95	-4.81	22.86	91.16	128.14
3.00	0.00	6.81	-4.81	20.81	88.98	119.14
3.33	0.00	6.81	-4.86	23.28	81.62	90.67
3.67	0.00	6.81	-4.94	25.74	73.45	64.79
4.00	0.00	6.81	-5.04	28.11	64.47	41.77
4.33	0.00	0.00	-5.16	31.47	54.60	22.36
4.67	0.00	0.00	-5.29	36.39	43.29	5.99
5.00	0.00	0.00	-5.42	41.32	30.34	-6.32
5.33	0.00	0.00	-5.55	46.25	15.75	-14.05
5.49	0.00	0.00	-5.61	48.56	8.32	-15.94
5.51	0.00	0.00	-5.62	16.25	7.67	-16.10
5.67	6.81	0.00	-5.68	10.19	5.59	-17.24
6.00	6.81	0.00	-5.79	9.59	2.29	-18.55
6.33	6.81	0.00	-5.90	7.96	-0.63	-18.80
6.67	6.81	0.00	-6.01	6.37	-3.02	-18.18
7.00	6.81	0.00	-6.11	4.83	-4.89	-16.84
7.33	6.81	0.00	-6.20	3.33	-6.25	-14.97
7.67	6.81	0.00	-6.28	1.86	-7.11	-12.72
8.00	6.81	0.00	-6.37	0.43	-7.49	-10.27
8.33	6.81	0.00	-6.44	-0.98	-7.40	-7.77
8.67	6.81	0.00	-6.52	-2.38	-6.84	-5.39
9.00	6.81	0.00	-6.59	-3.76	-5.81	-3.26
9.33	6.81	0.00	-6.66	-5.13	-4.33	-1.55
9.67	6.81	0.00	-6.74	-6.50	-2.39	-0.42
10.00	6.81	0.00	-6.81	-7.87	0.00	-0.00

Maximum shear force = 91.16 kN/m

Maximum moment = 128.14 kNm/m  
Maximum displacement = 6.8 mm

**Anchors forces**

No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	2.90	-4.8	185.00



**Internal stability of anchor system - partial results**

$E_A = 167.75 \text{ kN/m}$       $\delta = 15.09^\circ$

Row of anchors	$E_{A1}$ [kN/m]	$\delta_1$ [°]	G [kN/m]	C [kN/m]	$\theta$ [°]	Included rows of anchors	Q [kN/m]	F [kN/m]	$FK_{MAX}$ [kN]
1	99.34	19.80	1538.25	146.19	7.51		2132.87	510.66	510.66

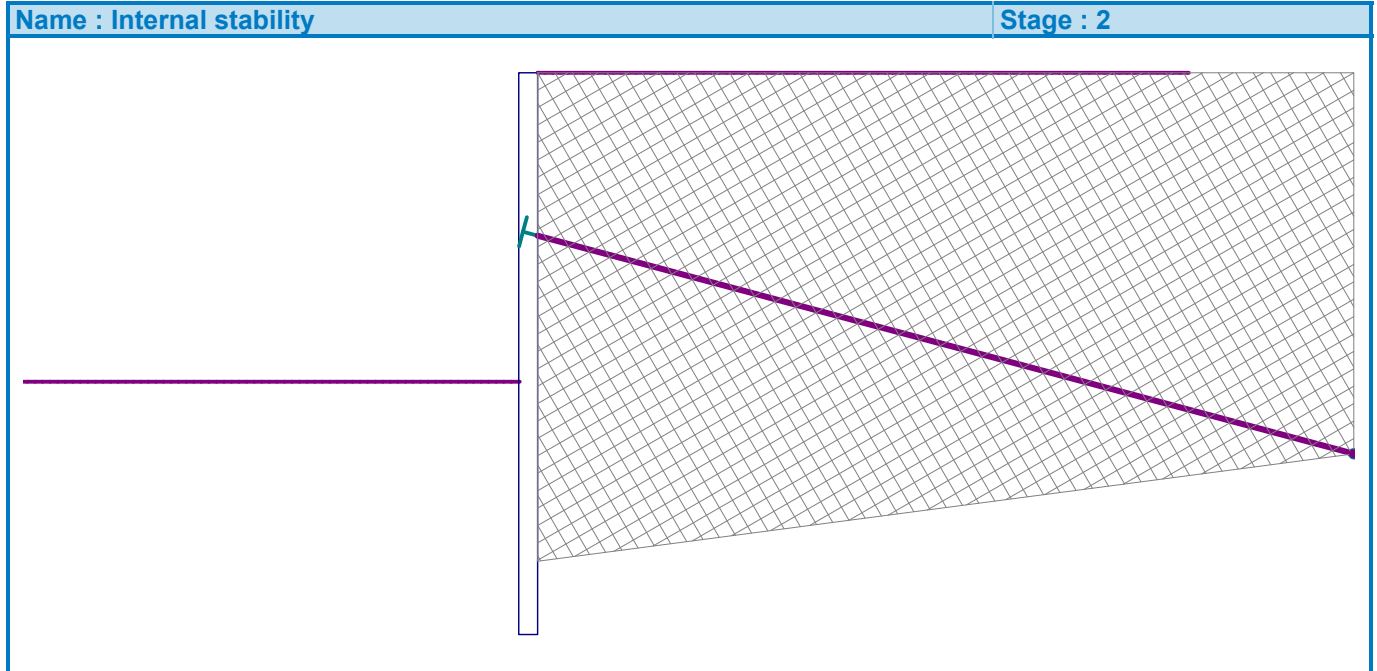
**Internal stability of anchor system check**

No.	Anchor force [kN]	Max.allow.force in anchor [kN]	Factor of safety
1	185.00	510.66	2.760

Decisive anchor row : 1

Required safety fact.  $FS = 1.50 < 2.76 = FS_{\text{minim}}$ .

**Overall verification of internal stability is SATISFACTORY**



### Envelope of internal forces No. 1

	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	-8.87	-5.59	0.00	0.00	0.00	0.00
0.33	-8.56	-5.46	-8.45	-0.20	0.02	0.36
0.67	-8.26	-5.34	-19.70	-0.80	0.18	5.07
1.00	-7.95	-5.22	-30.70	-1.82	0.60	13.48
1.33	-7.64	-5.11	-41.49	-3.30	1.44	25.53
1.67	-7.33	-5.00	-52.02	-5.22	2.85	41.13
2.00	-7.02	-4.91	-62.27	-7.61	4.98	60.20
2.33	-6.72	-4.84	-72.17	-10.44	7.97	82.62
2.67	-6.42	-4.81	-81.63	-13.73	11.99	108.28
2.90	-6.21	-4.81	-87.53	-16.35	15.62	128.14
2.90	-6.21	-4.81	-16.35	91.16	15.62	128.14
3.00	-6.12	-4.81	-17.48	88.98	17.18	119.14
3.33	-5.83	-4.86	-22.24	81.62	23.75	90.67
3.49	-5.69	-4.90	-25.04	77.78	27.45	78.50
3.51	-5.68	-4.90	-25.10	77.29	27.95	76.95
3.67	-5.55	-4.94	-22.57	73.45	31.59	64.79
4.00	-5.28	-5.04	-16.75	64.47	38.12	41.77
4.33	-5.16	-5.02	-11.41	54.60	22.36	42.81
4.67	-5.29	-4.78	-6.35	43.29	5.99	45.77
5.00	-5.42	-4.55	-1.52	30.34	-6.32	47.08
5.33	-5.55	-4.35	3.02	15.75	-14.05	46.39
5.49	-5.61	-4.26	4.76	8.32	-15.94	45.62
5.51	-5.62	-4.25	4.98	7.67	-16.10	45.52
5.67	-5.68	-4.16	5.59	6.72	-17.24	44.74
6.00	-5.79	-3.98	2.29	9.60	-18.55	42.00
6.33	-5.90	-3.83	-0.63	11.73	-18.80	38.43

	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
6.67	-6.01	-3.68	-3.02	13.18	-18.18	34.26
7.00	-6.11	-3.55	-4.89	14.01	-16.84	29.71
7.33	-6.20	-3.43	-6.25	14.27	-14.97	24.98
7.67	-6.28	-3.32	-7.11	14.01	-12.72	20.25
8.00	-6.37	-3.22	-7.49	13.28	-10.27	15.69
8.33	-6.44	-3.13	-7.40	12.09	-7.77	11.45
8.67	-6.52	-3.03	-6.84	10.47	-5.39	7.68
9.00	-6.59	-2.94	-5.81	8.45	-3.26	4.52
9.33	-6.66	-2.86	-4.33	6.02	-1.55	2.09
9.67	-6.74	-2.77	-2.39	3.21	-0.42	0.55
10.00	-6.81	-2.69	-0.00	0.00	-0.00	-0.00

**Maximum values**

Maximum displacement = -8.9 mm  
 Minimum displacement = -2.7 mm  
 Maximum bending moment = 128.14 kNm/m  
 Minimum bending moment = -18.80 kNm/m  
 Maximum shear force = 91.16 kN/m

