

Sheeting structure verification

Input data

Project

Date : 2.11.2005

Geometry of structure

Structure length = 8.00 m

Type of structure: Steel reinforced concrete rectangular wall

Standard : CSN 73 1201 R

Material: Concrete B 20

Cross-section thickness $h = 0.30$ m

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

Area of cross-section $A = 3.000E-01$ m²/m

Moment of inertia $I = 2.250E-03$ m⁴/m



Elastic modulus $E = 27000.00$ MPa

Shear modulus $G = 11340.00$ MPa



Distribution of the modulus of subgrade reaction (in front and behind the wall)

Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]
0.00	0.00	0.00
5.00	10.00	10.00
8.00	10.00	10.00

Basic soil parametres

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m ³]	γ_{su} [kN/m ³]	δ_a [°]	δ_p [°]
1	Clayey sand		29.00	5.00	18.00	10.00	15.00	0.00
2	Clay with high plasticity		15.00	5.00	20.50	10.50	15.00	0.00

Soil parametres to compute pressure at rest

No.	Name	Pattern	Type calculation	φ [°]	ν [-]	OCR [-]	K_r [-]
1	Clayey sand		cohesive	-	0.30	-	-
2	Clay with high plasticity		cohesive	-	0.30	-	-

Soil parameters

Clayey sand

Unit weight : $\gamma = 18,00$ kN/m³

Stress-state : effective

Angle of intern. friction : $\varphi_{ef} = 29,00$ °

Cohesion of soil : $c_{ef} = 5,00$ kPa

Active friction angle : $\delta_{act} = 15,00$ °

Passive friction angle : $\delta_{pas} = 0,00$ °

Soil : cohesive



Poisson's ratio : $\nu = 0,30$

Saturated unit weight : $\gamma_{\text{sat}} = 20,00 \text{ kN/m}^3$

Clay with high plasticity

Unit weight : $\gamma = 20,50 \text{ kN/m}^3$
 Stress-state : effective
 Angle of intern. friction : $\varphi_{\text{ef}} = 15,00^\circ$
 Cohesion of soil : $c_{\text{ef}} = 5,00 \text{ kPa}$
 Active friction angle : $\delta_{\text{act}} = 15,00^\circ$
 Passive friction angle : $\delta_{\text{pas}} = 0,00^\circ$
 Soil : cohesive
 Poisson's ratio : $\nu = 0,30$
 Saturated unit weight : $\gamma_{\text{sat}} = 20,50 \text{ kN/m}^3$

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	1.50	Clay with high plasticity	
2	-	Clayey sand	

Excavation

Soil in front of wall is excavated up to depth of 3.00 m.

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Analysis settings

Active earth pressure calculation - Coulomb (CSN 730037)
 Passive earth pressure calculation - Caquot-Kerisel (CSN 730037)
 Number of FEs to discretize wall = 30
 Analysis carried out without reduction of input data.
 Minimum dimensioning pressure is considered as $\sigma_{z,\text{min}} = 0.20\sigma_z$.

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	13.03
0.61	0.00	0.00	0.00	2.49	5.33	34.14
1.50	-0.00	-0.00	-0.00	9.15	13.18	65.22
1.50	0.00	0.00	0.00	6.15	13.18	107.13
3.00	-0.00	-0.00	-0.00	12.48	24.75	186.17
3.00	-0.00	-0.00	-17.12	12.48	24.75	186.18
3.92	-0.00	-7.07	-65.37	17.46	31.82	234.43
8.00	-22.23	-38.57	-280.58	39.69	63.32	449.64



Distributions of the modulus of subgrade reaction and internal forces along 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	-11.43	0.00	-0.00	-0.00
0.27	0.00	0.00	-10.84	1.09	-0.15	0.01
0.53	0.00	0.00	-10.25	2.19	-0.58	0.10
0.80	0.00	0.00	-9.65	3.93	-1.40	0.36
1.07	0.00	0.00	-9.06	5.92	-2.71	0.89
1.33	0.00	0.00	-8.47	7.91	-4.56	1.85
1.60	0.00	0.00	-7.88	6.57	-6.49	3.33
1.87	0.00	0.00	-7.29	7.70	-8.39	5.31
2.13	0.00	0.00	-6.71	8.82	-10.59	7.83
2.40	0.00	0.00	-6.14	9.95	-13.09	10.98
2.67	0.00	0.00	-5.59	11.07	-15.90	14.84
2.93	0.00	0.00	-5.05	12.20	-19.00	19.49
2.99	0.00	0.00	-4.94	12.44	-19.70	20.59
3.01	0.00	0.00	-4.90	-5.10	-19.77	20.98
3.20	0.00	0.00	-4.53	-14.08	-17.95	24.59
3.47	6.93	0.00	-4.04	-16.61	-13.63	28.57
3.73	7.47	0.00	-3.59	-15.98	-9.28	31.61
4.00	8.00	0.00	-3.17	-15.16	-5.12	33.51
4.27	8.53	0.00	-2.79	-14.23	-1.19	34.34
4.53	9.07	0.00	-2.45	-13.25	2.48	34.16
4.80	9.60	0.00	-2.16	-12.30	5.89	33.03
5.07	10.00	0.00	-1.90	-11.17	9.02	31.03
5.33	10.00	10.00	-1.67	-8.70	11.80	28.09
5.60	10.00	10.00	-1.48	-4.89	13.60	24.68
5.87	10.00	10.00	-1.32	-1.66	14.46	20.91
6.13	10.00	10.00	-1.18	1.07	14.53	17.03
6.40	10.00	10.00	-1.07	3.41	13.93	13.22
6.67	10.00	10.00	-0.97	5.43	12.74	9.66
6.93	10.00	10.00	-0.88	7.22	11.05	6.47
7.20	10.00	10.00	-0.79	8.85	8.91	3.80
7.47	10.00	10.00	-0.72	10.39	6.34	1.76
7.73	10.00	10.00	-0.64	11.89	3.37	0.46
8.00	10.00	10.00	-0.57	13.37	0.00	0.00

Maximum shear force = 19.77 kN/m
 Maximum moment = 34.34 kNm/m
 Maximum displacement = 11.4 mm

Input data (Stage of construction 5)

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	1.50	Clay with high plasticity	
2	-	Clayey sand	

Excavation

Soil in front of wall is excavated up to depth of 6.50 m.

Terrain profile

Terrain behind the structure is flat.

Water influence

Ground water table is located below the structure.

Inputted anchors

No.	New anchor	Depth z [m]	Length l [m]	Slope α [°]	Spacing b [m]
1	NO	1.50	7.00	20.00	1.00
2	NO	4.00	6.00	20.00	1.00

No.	Diameter d [mm]	Area A [mm ²]	Modulus E [MPa]	Post-stressing	Force F [kN]
1	20.0		210000.00		57.53
2	20.0		210000.00		82.41

Analysis settings

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 5)

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

Depth [m]	T _{a,p} [kPa]	T _{k,p} [kPa]	T _{p,p} [kPa]	T _{a,z} [kPa]	T _{k,z} [kPa]	T _{p,z} [kPa]
0.00	-0.00	-0.00	-0.00	0.00	0.00	13.03
0.61	0.00	0.00	0.00	2.49	5.33	34.14
1.50	-0.00	-0.00	-0.00	9.15	13.18	65.22
1.50	0.00	0.00	0.00	6.15	13.18	107.13
6.50	-0.00	-0.00	-0.00	31.53	51.75	370.60
6.50	-0.00	-0.00	-17.12	31.53	51.75	370.61
7.42	-0.00	-7.07	-65.37	36.52	58.82	418.86
8.00	-3.18	-11.57	-96.15	39.69	63.32	449.64

Distributions of the modulus of subgrade reaction and internal forces along 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	-1.23	0.01	-0.00	-0.00
0.27	0.00	0.53	-1.42	6.12	-0.82	0.05
0.53	0.00	1.07	-1.61	11.40	-3.17	0.53
0.80	0.00	1.60	-1.80	16.50	-6.89	1.81
1.07	0.00	2.13	-1.99	21.00	-11.90	4.27
1.33	0.00	2.67	-2.19	24.65	-17.99	8.21
1.50	0.00	3.00	-2.32	24.28	-22.08	11.55
1.50	0.00	3.00	-2.32	24.28	31.99	11.55
1.60	0.00	3.20	-2.40	24.05	29.57	8.47
1.87	0.00	3.73	-2.62	24.93	23.03	1.43
2.13	0.00	4.27	-2.84	26.25	16.20	-3.82
2.40	0.00	4.80	-3.05	28.11	8.94	-7.21

Depth [m]	kh,p [MN/m ³]	kh,z [MN/m ³]	Displacement [mm]	Pressure [kPa]	Shear Force [kN/m]	Moment [kNm/m]
2.67	0.00	5.33	-3.26	28.85	1.34	-8.61
2.93	0.00	5.87	-3.46	27.71	-6.20	-7.97
3.20	0.00	6.40	-3.65	25.87	-13.35	-5.36
3.47	0.00	6.93	-3.83	23.38	-19.93	-0.93
3.73	0.00	7.47	-4.01	24.10	-26.26	5.20
4.00	0.00	8.00	-4.20	24.29	-32.72	13.04
4.00	0.00	8.00	-4.20	24.29	44.72	13.04
4.27	0.00	8.53	-4.40	23.77	38.30	1.95
4.53	0.00	9.07	-4.61	22.54	32.12	-7.45
4.80	0.00	0.00	-4.81	22.90	26.18	-14.85
5.07	0.00	0.00	-4.98	24.25	19.89	-21.00
5.33	0.00	0.00	-5.14	25.61	13.24	-25.43
5.60	0.00	0.00	-5.26	26.96	6.23	-28.03
5.87	0.00	0.00	-5.36	28.32	-1.14	-28.72
6.13	0.00	0.00	-5.42	29.67	-8.87	-27.39
6.40	0.00	0.00	-5.44	31.02	-16.96	-23.96
6.49	0.00	0.00	-5.45	31.48	-19.77	-22.30
6.51	0.00	0.00	-5.45	13.95	-20.23	-21.90
6.67	0.00	0.00	-5.44	6.54	-21.83	-18.59
6.93	0.00	0.00	-5.42	-6.06	-21.90	-12.69
7.20	0.00	0.00	-5.38	-18.66	-18.60	-7.21
7.47	10.00	0.00	-5.34	-24.04	-12.88	-3.44
7.73	10.00	0.00	-5.29	-24.15	-6.45	-0.86
8.00	10.00	0.00	-5.24	-24.25	0.00	-0.00

Maximum shear force = 44.72 kN/m
 Maximum moment = 28.72 kNm/m
 Maximum displacement = 5.4 mm

Anchors forces

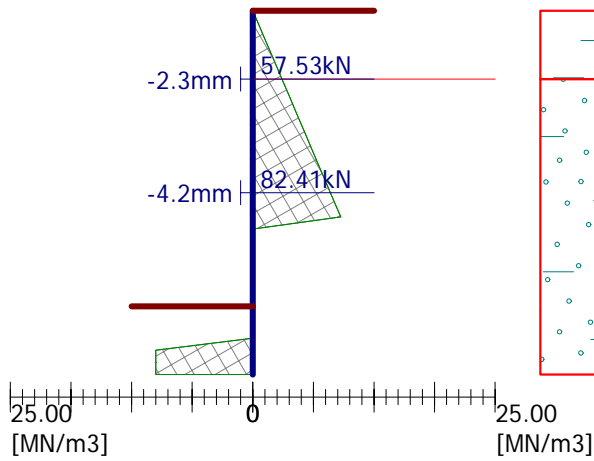
No.	Depth [m]	Displacement [mm]	Anchor force [kN]
1	1.50	-2.3	57.53
2	4.00	-4.2	82.41

Name : Analysis

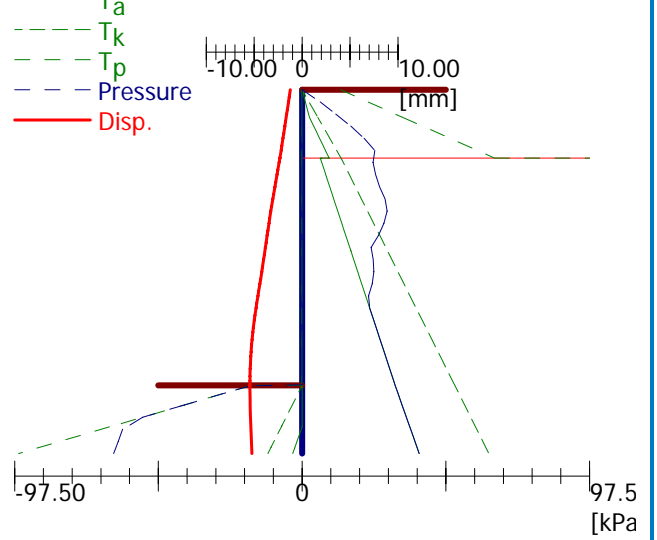
Stage : 5

Modulus of subgrade reaction

Length of structure = 8.00m



Earth pressures + displacement



Internal stability of anchor system - partial results

Row of anchors	EA [kN]	E1 [kN]	G [kN]	Included rows of anchors
1	159.89	35.19	728.81	
2	159.89	88.79	734.20	1

Internal stability of anchor system check

No.	Anchor force [kN]	Max.allow.force [kN]	Factor of safety
1	57.53	93.56	1.626
2	82.41	146.58	1.779

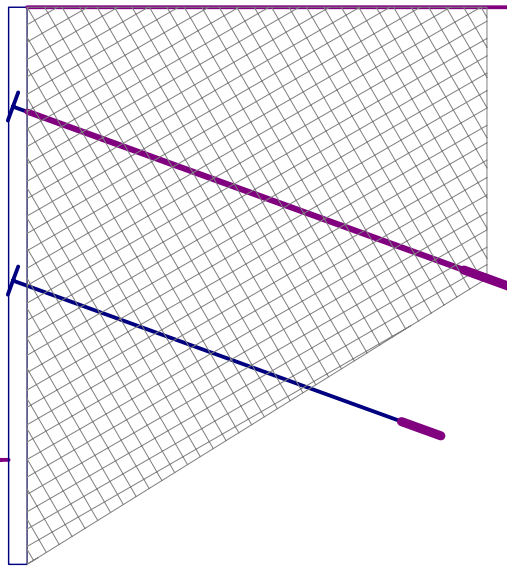
Decisive anchor row : 1

Required safety fact. $FS = 1.50 < 1.63 = FS_{minim.}$

Overall verification of internal stability is SATISFACTORY

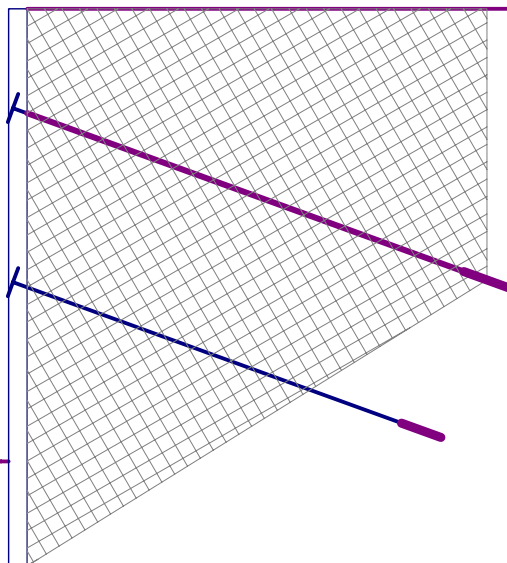
Name : Internal stability

Stage : 5



Name : Internal stability

Stage : 5



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	-11.43	-1.23	-0.00	0.00	-0.00	0.00
0.27	-10.84	-1.42	-0.82	-0.15	0.01	0.05
0.53	-10.25	-1.61	-3.17	-0.58	0.10	0.53
0.80	-9.65	-1.80	-6.89	-1.40	0.36	1.81
1.07	-9.06	-1.99	-11.90	-2.71	0.89	4.27
1.33	-8.47	-2.07	-17.99	-4.56	1.85	8.21
1.50	-8.10	-2.05	-22.08	-5.76	2.78	11.55
1.50	-8.10	-2.05	-5.76	45.56	2.78	11.55

	Disp. min [mm]	Disp. max [mm]	Shear force min. [kN/m]	Shear force max [kN/m]	Moment min. [kNm/m]	Moment max. [kNm/m]
1.60	-7.88	-2.04	-6.49	43.52	3.33	8.47
1.87	-7.29	-2.01	-8.39	38.15	-5.12	5.31
1.99	-7.03	-2.00	-9.41	35.62	-9.50	6.48
2.01	-6.98	-2.00	-9.57	35.21	-10.21	6.67
2.13	-6.71	-1.99	-10.59	32.68	-14.59	7.83
2.40	-6.14	-1.97	-13.09	27.00	-22.58	10.98
2.67	-5.59	-1.93	-15.90	21.14	-29.03	14.84
2.93	-5.05	-1.89	-19.00	15.49	-33.92	19.49
2.99	-4.94	-1.88	-19.70	14.40	-34.66	20.59
3.01	-4.90	-1.88	-19.77	14.01	-34.91	20.98
3.20	-4.83	-1.84	-17.95	10.34	-37.37	24.59
3.47	-4.91	-1.78	-19.93	5.79	-39.53	28.57
3.73	-4.95	-1.71	-26.26	1.41	-40.19	31.61
4.00	-4.93	-1.64	-33.29	-3.34	-39.94	33.51
4.00	-4.93	-1.64	-7.09	44.72	-39.94	33.51
4.27	-4.88	-1.55	-8.43	38.30	-38.38	34.34
4.53	-4.77	-1.47	-13.88	32.12	-35.42	34.16
4.80	-4.81	-1.39	-19.67	26.18	-30.95	33.03
4.99	-4.93	-1.33	-24.01	21.70	-26.80	31.61
5.01	-4.95	-1.32	-24.30	21.23	-26.32	31.46
5.07	-4.98	-1.30	-24.55	19.89	-24.93	31.03
5.33	-5.14	-1.22	-23.70	13.24	-25.43	28.09
5.60	-5.26	-1.15	-19.88	13.60	-28.03	24.68
5.87	-5.36	-1.08	-15.32	14.46	-28.72	20.91
6.13	-5.42	-1.01	-11.27	14.53	-27.39	17.03
6.40	-5.44	-0.95	-16.96	13.93	-23.96	13.22
6.49	-5.45	-0.93	-19.77	13.53	-22.30	12.02
6.51	-5.45	-0.92	-20.23	13.44	-21.90	11.75
6.67	-5.44	-0.89	-21.83	12.74	-18.59	9.66
6.93	-5.42	-0.83	-21.90	11.05	-12.69	6.47
7.20	-5.38	-0.78	-18.60	8.91	-7.21	3.80
7.47	-5.34	-0.72	-12.88	6.34	-3.44	1.76
7.73	-5.29	-0.64	-6.45	3.37	-0.86	0.46
8.00	-5.24	-0.57	-0.00	0.00	-0.00	0.00

Maximal values

Maximum displacement = -11.4 mm
 Maximum displacement = -0.6 mm
 Maximum bending moment = 34.34 kNm/m
 Minimum bending moment = -40.19 kNm/m
 Maximum shear force = 45.56 kN/m