Pile verification

Input data

Project

Date : 28.10.2015

Settings

(input for current task)

Materials and standards

Concrete structures : CSN 73 1201 R

Pile

Safety factors			
Permanent design situation			
Safety factor for compressive pile :	SF_{cp} =	1,50	[–]
Safety factor for tensile pile :	SF_{tp} =	2,00	[–]

Basic soil parameters

No.	Name	Pattern	φ_{ef} [°]	c_{ef} [kPa]	γ [kN/m^3]	ν [–]
1	Gravelly silt (MG), consistency firm		29,00	8,00	19,00	0,35
2	Sandy clay, consistency solid		24,50	14,00	18,50	0,35

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

No.	Name	Pattern	E_{oed} [MPa]	E_{def} [MPa]	γ_{sat} [kN/m^3]	γ_s [kN/m^3]	n [–]
1	Gravelly silt (MG), consistency firm		24,00	-	19,00	-	-
2	Sandy clay, consistency solid		8,00	-	19,00	-	-

Soil parameters

Gravelly silt (MG), consistency firm

Unit weight :	γ	=	19,00 kN/m^3
Angle of internal friction :	φ_{ef}	=	29,00 °
Cohesion of soil :	c_{ef}	=	8,00 kPa
Poisson's ratio :	ν	=	0,35
Oedometric modulus :	E_{oed}	=	24,00 MPa
Saturated unit weight :	γ_{sat}	=	19,00 kN/m^3

Sandy clay, consistency solid

Unit weight :	γ	=	18,50 kN/m^3
Angle of internal friction :	φ_{ef}	=	24,50 °
Cohesion of soil :	c_{ef}	=	14,00 kPa
Poisson's ratio :	ν	=	0,35
Oedometric modulus :	E_{oed}	=	8,00 MPa
Saturated unit weight :	γ_{sat}	=	19,00 kN/m^3

Geometry

Pile profile: circular

Dimensions

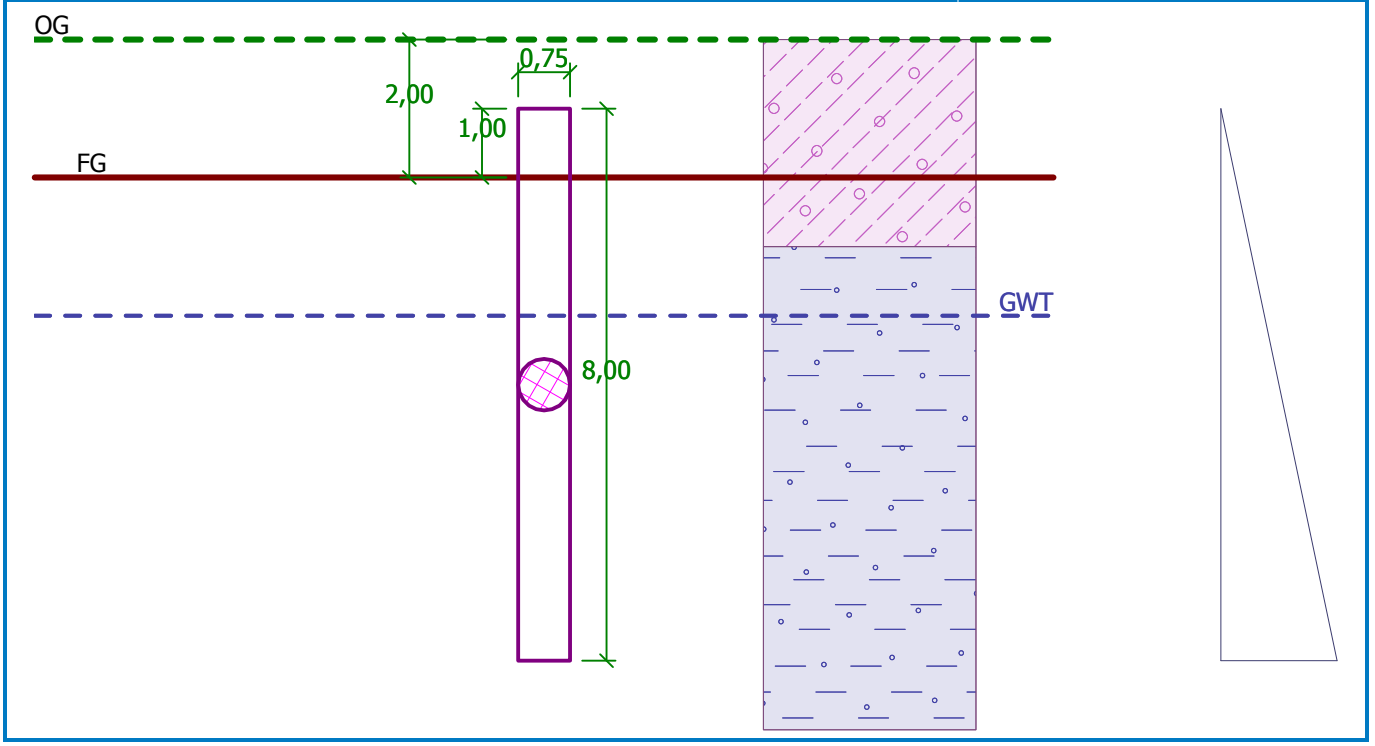
Diameter d = 0,75 m
Length l = 8,00 m

Cross-sectional characteristics
Area A = 1,00E+00 m^2
Moment of inertia I = 1,00E+00 m^4

Location
Off ground height h = 1,00 m
Depth of finished grade h_z = 2,00 m

Technology
Piles with excavation of soil from a bore hole
Pile type: continuous flight auger pile
Base resistance reduction = 0,80
Skin resistance reduction = 0,60

Name : Geometry | **Stage - analysis : 1 - 0**



Horizontal modulus of subsoil reaction

Depth [m]	k_h [MN/m³]
0.00	0.00
8.00	10.00

Material of structure

Unit weight γ = 23,56 kN/m^3
Analysis of concrete structures carried out according to the standard CSN 73 1201 R.

Concrete : B 20

Compressive strength	R_{bd}	= 11,50	MPa
Tensile strength	R_{btd}	= 0,90	MPa
Elasticity modulus	E_b	= 27000,00	MPa
Shear modulus	G	= 11340,00	MPa

Longitudinal steel : 10 216 E

Compressive strength R_{scd} = 190,00 MPa
Tensile strength R_{sd} = 190,00 MPa

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	3,00	Gravelly silt (MG), consistency firm	
2	-	Sandy clay, consistency solid	

Load

No.	Load new	Load change	Name	Type	N [kN]	M_x [kNm]	M_y [kNm]	H_x [kN]	H_y [kN]
1	Yes		Zatížení č. 1	Design	600,00	50,00	14,00	0,00	120,00

Ground water table

The ground water table is at a depth of 4,00 m from the original terrain.

Global settings

Analysis of vertical bearing capacity : spring method
Analysis type : analysis for drained conditions

Settings of the stage of construction

Design situation : permanent
Verification methodology : without reduction of soil parameters

Verification No. 1

Input data

Maximum displacement 50,0 mm
Coeff. of increase of limit skin friction due to technology 1

Depth of influence zone is post-computed.

Load settlement curve

No.	Load [kN]	Settlement [mm]
1	0,00	0,0
2	143,03	5,4
3	296,95	16,6
4	581,40	40,3
5	642,23	46,0
6	679,75	50,0

Analysis for load F = 143,03 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	143,03	1,00	0,00	0,00
1,00	143,03	1,00	0,00	0,00
1,70	123,76	0,87	19,27	0,13
2,40	112,23	0,78	30,80	0,22
3,10	105,84	0,74	37,19	0,26
3,80	99,46	0,70	43,57	0,30

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
4,50	93,08	0,65	49,95	0,35
5,20	86,70	0,61	56,33	0,39
5,90	80,32	0,56	62,71	0,44
6,60	73,94	0,52	69,09	0,48
7,30	67,57	0,47	75,46	0,53
8,00	61,19	0,43	81,84	0,57

Analysis for load F = 296,95 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	296,95	1,00	0,00	0,00
1,00	296,95	1,00	0,00	0,00
1,70	277,67	0,94	19,27	0,06
2,40	242,33	0,82	54,62	0,18
3,10	222,74	0,75	74,21	0,25
3,80	203,15	0,68	93,79	0,32
4,50	183,57	0,62	113,37	0,38
5,20	164,00	0,55	132,94	0,45
5,90	144,43	0,49	152,51	0,51
6,60	124,87	0,42	172,08	0,58
7,30	105,32	0,35	191,63	0,65
8,00	85,77	0,29	211,18	0,71

Analysis for load F = 581,40 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	581,40	1,00	0,00	0,00
1,00	581,40	1,00	0,00	0,00
1,70	562,12	0,97	19,27	0,03
2,40	526,78	0,91	54,62	0,09
3,10	479,01	0,82	102,39	0,18
3,80	431,25	0,74	150,15	0,26
4,50	383,50	0,66	197,89	0,34
5,20	335,77	0,58	245,63	0,42
5,90	288,03	0,50	293,37	0,50
6,60	240,28	0,41	341,11	0,59
7,30	192,58	0,33	388,82	0,67
8,00	144,85	0,25	436,55	0,75

Analysis for load F = 642,23 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	642,23	1,00	0,00	0,00
1,00	642,23	1,00	0,00	0,00
1,70	622,96	0,97	19,27	0,03
2,40	587,61	0,91	54,62	0,09
3,10	539,84	0,84	102,39	0,16
3,80	485,32	0,76	156,91	0,24

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
4,50	430,79	0,67	211,44	0,33
5,20	376,28	0,59	265,95	0,41
5,90	321,77	0,50	320,46	0,50
6,60	267,28	0,42	374,95	0,58
7,30	212,79	0,33	429,44	0,67
8,00	158,29	0,25	483,94	0,75

Analysis for load F = 679,98 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	679,98	1,00	0,00	0,00
1,00	679,98	1,00	0,00	0,00
1,70	660,71	0,97	19,27	0,03
2,40	625,37	0,92	54,62	0,08
3,10	577,60	0,85	102,39	0,15
3,80	523,07	0,77	156,91	0,23
4,50	463,81	0,68	216,18	0,32
5,20	404,54	0,59	275,44	0,41
5,90	345,29	0,51	334,69	0,49
6,60	286,06	0,42	393,93	0,58
7,30	226,82	0,33	453,16	0,67
8,00	167,60	0,25	512,38	0,75

Analysis for load F = 712,94 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	712,94	1,00	0,00	0,00
1,00	712,94	1,00	0,00	0,00
1,70	693,66	0,97	19,27	0,03
2,40	658,32	0,92	54,62	0,08
3,10	610,55	0,86	102,39	0,14
3,80	556,02	0,78	156,91	0,22
4,50	496,76	0,70	216,18	0,30
5,20	432,76	0,61	280,18	0,39
5,90	368,76	0,52	344,18	0,48
6,60	304,77	0,43	408,17	0,57
7,30	240,80	0,34	472,13	0,66
8,00	176,83	0,25	536,11	0,75

Analysis for load F = 741,06 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	741,06	1,00	0,00	0,00
1,00	741,06	1,00	0,00	0,00
1,70	721,78	0,97	19,27	0,03
2,40	686,44	0,93	54,62	0,07
3,10	638,67	0,86	102,39	0,14
3,80	584,14	0,79	156,91	0,21

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
4,50	524,88	0,71	216,18	0,29
5,20	460,88	0,62	280,18	0,38
5,90	392,15	0,53	348,91	0,47
6,60	323,41	0,44	417,65	0,56
7,30	254,69	0,34	486,37	0,66
8,00	185,98	0,25	555,07	0,75

Analysis for load F = 764,40 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	764,40	1,00	0,00	0,00
1,00	764,40	1,00	0,00	0,00
1,70	745,13	0,97	19,27	0,03
2,40	709,79	0,93	54,62	0,07
3,10	662,02	0,87	102,39	0,13
3,80	607,49	0,79	156,91	0,21
4,50	548,23	0,72	216,18	0,28
5,20	484,23	0,63	280,18	0,37
5,90	415,49	0,54	348,91	0,46
6,60	342,02	0,45	422,38	0,55
7,30	268,55	0,35	495,85	0,65
8,00	195,09	0,26	569,31	0,74

Analysis for load F = 782,92 kN

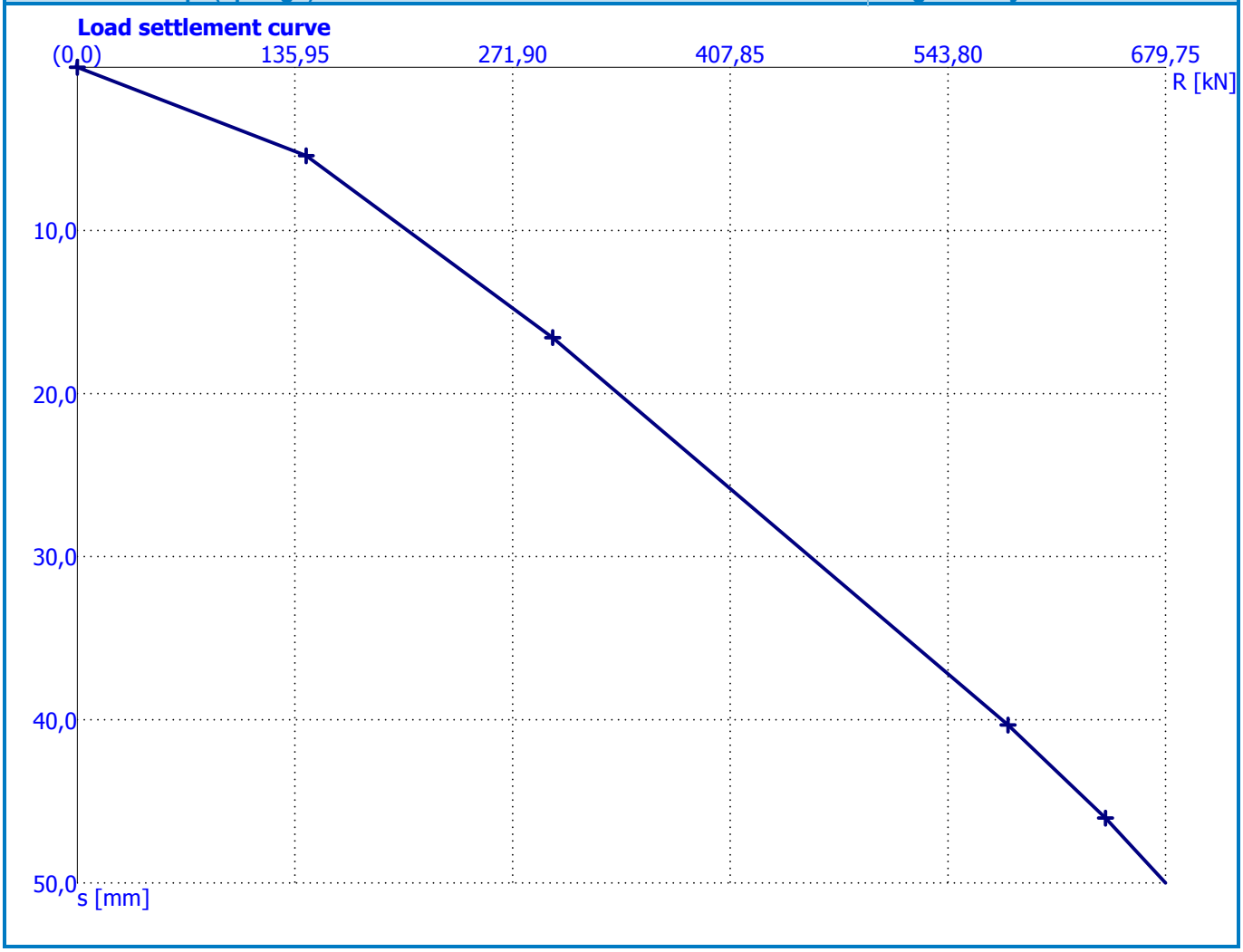
x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	782,92	1,00	0,00	0,00
1,00	782,92	1,00	0,00	0,00
1,70	763,65	0,98	19,27	0,02
2,40	728,30	0,93	54,62	0,07
3,10	680,54	0,87	102,39	0,13
3,80	626,01	0,80	156,91	0,20
4,50	566,74	0,72	216,18	0,28
5,20	502,74	0,64	280,18	0,36
5,90	434,01	0,55	348,91	0,45
6,60	360,54	0,46	422,38	0,54
7,30	282,34	0,36	500,59	0,64
8,00	204,13	0,26	578,79	0,74

Analysis for load F = 796,65 kN

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
0,00	796,65	1,00	0,00	0,00
1,00	796,65	1,00	0,00	0,00
1,70	777,37	0,98	19,27	0,02
2,40	742,03	0,93	54,62	0,07
3,10	694,26	0,87	102,39	0,13
3,80	639,73	0,80	156,91	0,20

x [m]	Norm. force [kN]	Rel. norm. [–]	Shear [kN]	Rel. shear [–]
4,50	580,47	0,73	216,18	0,27
5,20	516,47	0,65	280,18	0,35
5,90	447,74	0,56	348,91	0,44
6,60	374,27	0,47	422,38	0,53
7,30	296,06	0,37	500,59	0,63
8,00	213,12	0,27	583,53	0,73

Name : Vert. cap. (springs) | **Stage - analysis : 1 - 1**



Verification No. 1

Input data to compute pile horizontal bearing capacity

Analysis carried out with automatic selection of the most unfavourable load cases.
Horizontal bearing capacity verified in the direction of maximum load effect.

Distributions of internal forces and displacement of pile

Pile displacements and internal forces distributions:

Dist. [m]	Modulus k [MN/m³]	Displacement [mm]	Rotat. [mRad]	Stress [kPa]	Shear Force [kN]	Moment [kNm]
0.00	0.00	-38.45	6.49	9.61	-120.00	50.00

Dist. [m]	Modulus k [MN/m3]	Displacement [mm]	Rotat. [mRad]	Stress [kPa]	Shear Force [kN]	Moment [kNm]
0.40	0.50	-35.86	6.48	17.93	-117.21	97.44
0.40	0.50	-35.86	6.48	17.93	-117.21	97.44
0.80	1.00	-33.27	6.48	33.27	-109.44	142.75
0.80	1.00	-33.27	6.48	33.27	-109.44	142.75
1.20	1.50	-30.67	6.48	46.01	-97.45	184.09
1.20	1.50	-30.67	6.48	46.01	-97.45	184.09
1.60	2.00	-28.08	6.48	56.16	-82.03	219.94
1.60	2.00	-28.08	6.48	56.16	-82.03	219.94
2.00	2.50	-25.49	6.47	63.73	-63.95	249.08
2.00	2.50	-25.49	6.47	63.73	-63.95	249.08
2.40	3.00	-22.90	6.47	68.70	-43.98	270.59
2.40	3.00	-22.90	6.47	68.70	-43.98	270.59
2.80	3.50	-20.31	6.47	71.10	-22.92	283.89
2.80	3.50	-20.31	6.47	71.10	-22.92	283.89
3.20	4.00	-17.73	6.46	70.91	-1.52	288.68
3.20	4.00	-17.73	6.46	70.91	-1.52	288.68
3.60	4.50	-15.14	6.46	68.15	19.44	284.98
3.60	4.50	-15.14	6.46	68.15	19.44	284.98
4.00	5.00	-12.56	6.45	62.81	39.18	273.14
4.00	5.00	-12.56	6.45	62.81	39.18	273.14
4.40	5.50	-9.98	6.45	54.90	56.93	253.78
4.40	5.50	-9.98	6.45	54.90	56.93	253.78
4.80	6.00	-7.40	6.45	44.41	71.93	227.86
4.80	6.00	-7.40	6.45	44.41	71.93	227.86
5.20	6.50	-4.82	6.44	31.36	83.39	196.64
5.20	6.50	-4.82	6.44	31.36	83.39	196.64
5.60	7.00	-2.25	6.44	15.74	90.55	161.67
5.60	7.00	-2.25	6.44	15.74	90.55	161.67
6.00	7.50	0.33	6.44	-2.46	92.64	124.85
6.00	7.50	0.33	6.44	-2.46	92.64	124.85
6.40	8.00	2.90	6.44	-23.22	88.88	88.35
6.40	8.00	2.90	6.44	-23.22	88.88	88.35
6.80	8.50	5.48	6.44	-46.56	78.51	54.66
6.80	8.50	5.48	6.44	-46.56	78.51	54.66
7.20	9.00	8.05	6.43	-72.46	60.76	26.58
7.20	9.00	8.05	6.43	-72.46	60.76	26.58
7.60	9.50	10.63	6.43	-100.94	34.84	7.22
7.60	9.50	10.63	6.43	-100.94	34.84	7.22
8.00	10.00	13.20	6.43	-128.69	0.00	-0.00

Maximum internal force and deformation :

Pile head displacement = -38,5 mm
Max. pile displacement = 38,5 mm
Max. shear force = 120,00 kN
Maximum moment = 288,68 kNm

Dimensioning of reinforcement:

Reinforcement - 16 pc bars 20,0 mm; covering 40,0 mm
Type of structure (reinforcement ratio) : column

Reinforcement ratio μ_{st} = 1,138 % > 0,050 % = $\mu_{st,min}$

Load : N_d = -600,00 kN (compression) ; M_d = 288,68 kNm
Bearing capacity : N_u = -985,14 kN; M_u = 473,98 kNm

Designed pile reinforcement is SATISFACTORY

Verification of shear reinforcement:

Ultimate shear force: Q_u = 170,68 kN > 120,00 kN = Q_d
Cross-section is SATISFACTORY.

Name : Horizontal cap. | **Stage - analysis : 1 - 1**