Verification of pile group

Input data

Project

Description : Pile Group - Example 3
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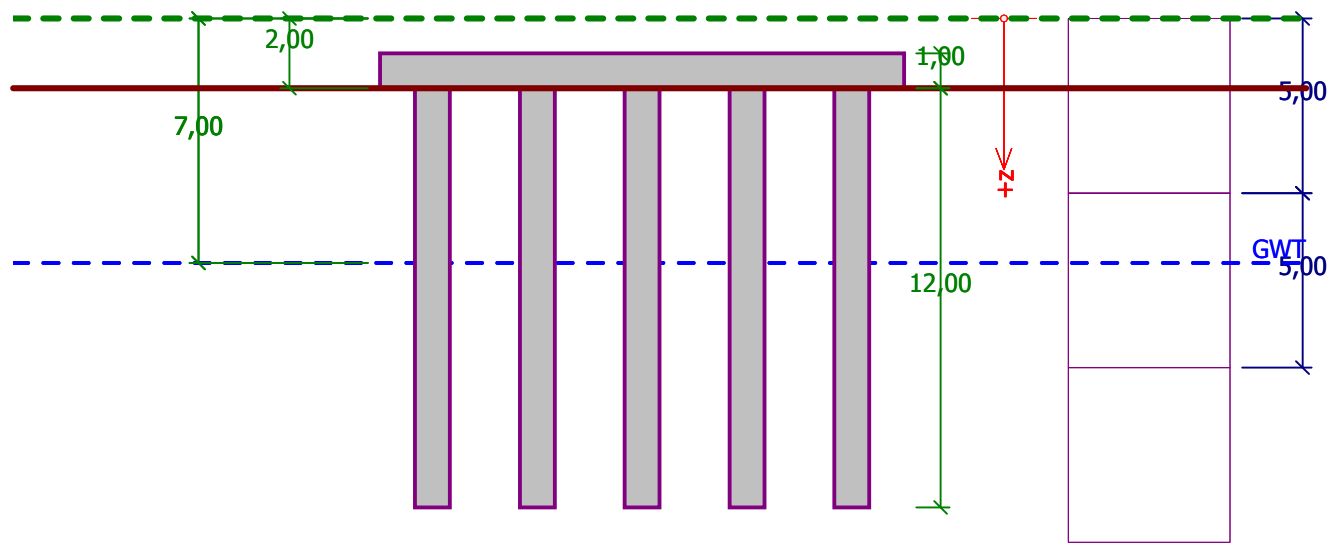
Date : 28.10.2015

Name : Pile Group - Example 3 | **Stage - analysis : 1 - 0**

Description : Static scheme of Pile Group - Spring method



Settings

(input for current task)

Materials and standards

Concrete structures : EN 1992-1-1 (EC2)
Coefficients EN 1992-1-1 : standard

Soil parameters

Silty sand (SM), medium dense

Unit weight :	γ	=	18,00 kN/m^3
Angle of internal friction :	φ_{ef}	=	29,00 °
Cohesion of soil :	c_{ef}	=	5,00 kPa
Oedometric modulus :	E_{oed}	=	13,50 MPa
Saturated unit weight :	γ_{sat}	=	20,00 kN/m^3

Sand with trace of fines (S-F), medium dense

Unit weight :	γ	=	17,50 kN/m^3
Angle of internal friction :	φ_{ef}	=	29,50 °
Cohesion of soil :	c_{ef}	=	0,00 kPa
Oedometric modulus :	E_{oed}	=	21,00 MPa
Saturated unit weight :	γ_{sat}	=	19,50 kN/m^3

Low plasticity silt (ML,MI), consistency firm

Unit weight :	γ	=	20,00 kN/m^3
Angle of internal friction :	φ_{ef}	=	21,00 °
Cohesion of soil :	c_{ef}	=	12,00 kPa

Oedometric modulus : E_{oed} = 8,50 MPa
Saturated unit weight : γ_{sat} = 22,00 kN/m^3

Construction

Width of pile cap	b_x	=	15,00	m
	b_y	=	15,00	m
Pile diameter	d	=	1,00	m
Number of piles	n_x	=	5	
	n_y	=	4	
Spacing of piles	s_x	=	3,00	m
	s_y	=	4,00	m

Geometry

Depth from ground surface	h_z	=	2,00	m
Pile head offset	h	=	0,00	m
Thickness of pile cap	t	=	1,00	m
Length of piles	l	=	12,00	m

Material of structure

Unit weight γ = 25,00 kN/m^3
Analysis of concrete structures carried out according to the standard EN 1992-1-1 (EC2).

Concrete : C 20/25

Cylinder compressive strength	f_{ck}	=	20,00	MPa
Tensile strength	f_{ctm}	=	2,20	MPa
Elasticity modulus	E_{cm}	=	30000,00	MPa
Shear modulus	G	=	12500,00	MPa

Longitudinal steel : B500

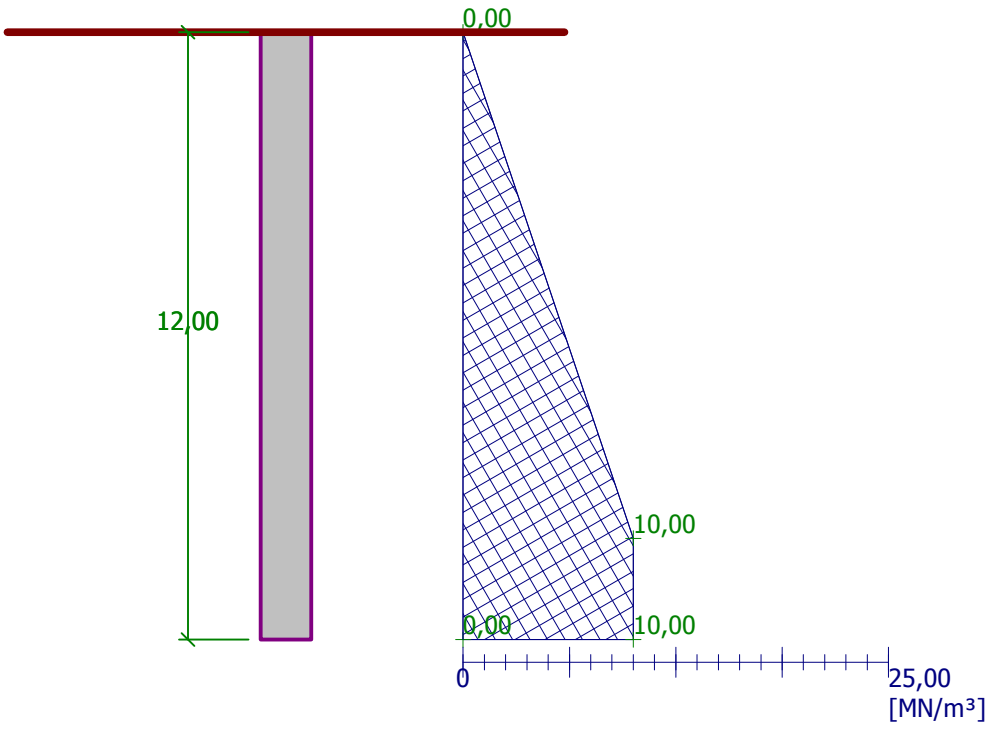
Yield strength	f_{yk}	=	500,00	MPa

Horizontal modulus of subsoil reaction

Depth [m]	k_h [MN/m^3]
0.00	0.00
10.00	10.00
12.00	10.00

Name : Pile Group - Example 3 | **Stage - analysis : 1 - 0**

Description : Horizontal modulus - Spring method



Determination of vertical springs

Typical load (for analysis of vertical springs) : 4_Q3:G1+G2+W4 (4)

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	5,00	Low plasticity silt (ML,MI), consistency firm	
2	5,00	Sand with trace of fines (S-F), medium dense	
3	-	Silty sand (SM), medium dense	

Load

No.	Load new	Load change	Name	Type	N [kN]	M_x [kNm]	M_y [kNm]	H_x [kN]	H_y [kN]	M_z [kNm]
1	Yes		1_G1+G2 (1)	Design	17355,00	0,00	1879,25	-0,05	0,08	0,00
2	Yes		2_W4:G1+G2 (2)	Design	18600,00	-162,00	1879,25	728,95	0,08	0,00
3	Yes		3_Q3:G1+G2 (3)	Design	19250,00	0,00	3499,25	1079,95	0,08	0,00
4	Yes		4_Q3:G1+G2+ (4)	Design	22500,00	-97,20	3499,25	1517,35	0,08	0,00
5	Yes		5_W4:G1+G2+ (5)	Design	23700,00	-162,00	3013,25	1484,95	0,08	0,00
6	Yes		1_G1+G2 (6)	Service	15165,00	0,00	1392,04	-0,04	0,06	0,00

No.	Load new	Load change	Name	Type	N [kN]	M_x [kNm]	M_y [kNm]	H_x [kN]	H_y [kN]	M_z [kNm]
7	Yes		2_W4:G1+G2 (7)	Service	16430,00	-108,00	1392,04	485,96	0,06	0,00
8	Yes		3_Q3:G1+G2 (8)	Service	17865,00	0,00	2472,04	719,96	0,06	0,00
9	Yes		4_Q3:G1+G2+ (9)	Service	21125,00	-64,80	2472,04	1011,56	0,06	0,00
10	Yes		5_W4:G1+G2+ (10)	Service	22075,00	-108,00	2148,04	989,96	0,06	0,00

Ground water table

The ground water table is at a depth of 7,00 m from the original terrain.

Global settings

Analysis type : spring method
Type of pile : floating piles - compute the stiffness of springs from soil parameters
Connection piles / pile cap : fixed
Modulus of subsoil reaction : input by distribution

Settings of the stage of construction

Design situation : permanent

Analysis results

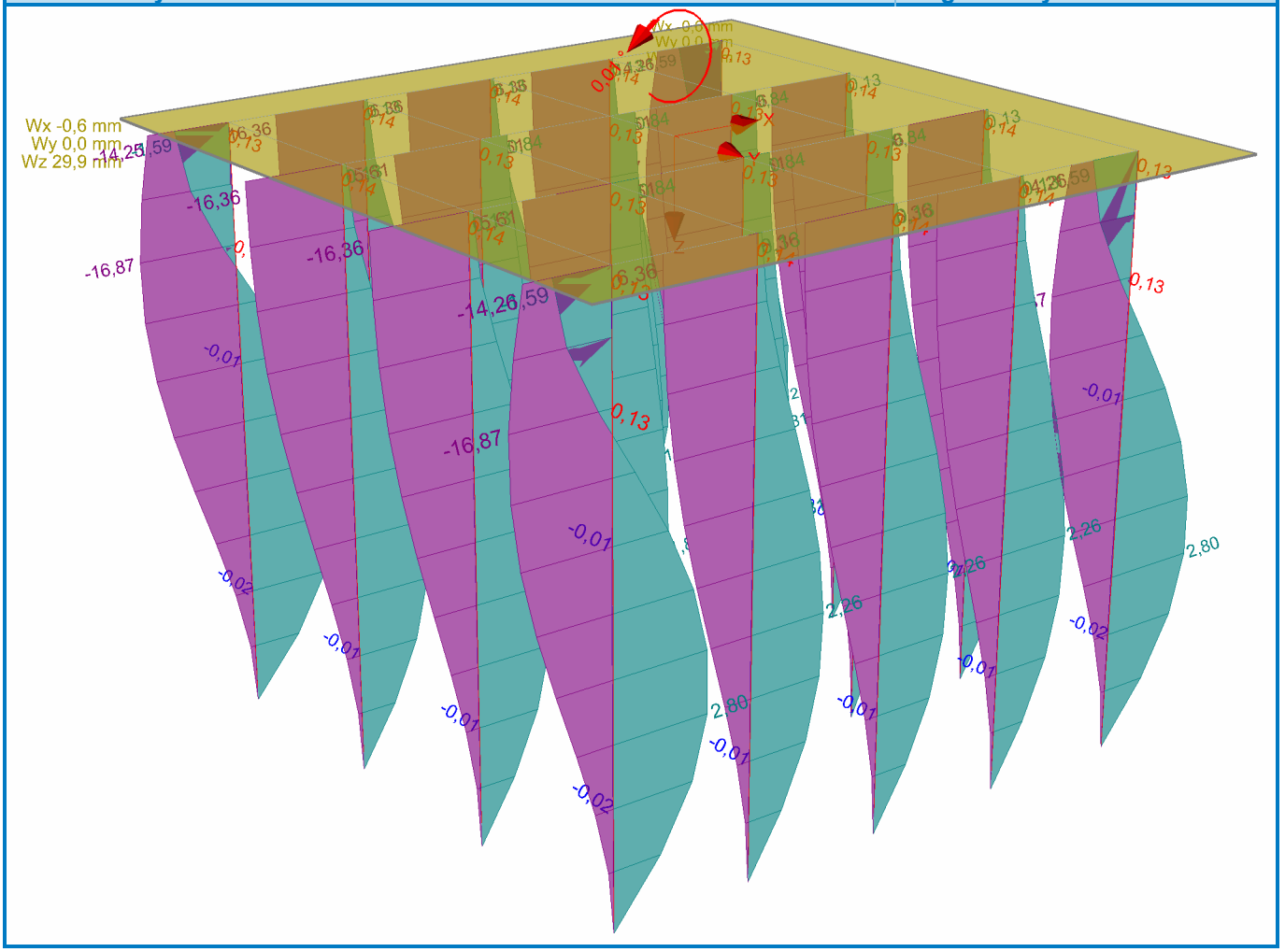
Maximum internal forces (all load cases)

Maximum compressive force = -2330,20 kN
Minimum compressive force = -431,63 kN
Max. bending moment = 483,39 kNm
Max. shear force = 119,69 kN

Maximum displacements (only service load cases)

Max. settlement = 34,7 mm
Maximum horizontal displacement of pile cap = 4,8 mm
Max. rotation of pile cap = 5,3E-03 °

Name : Analysis	Stage - analysis : 1 - -1



Verification No. 1

Dimensioning of piles - input data

Analysis carried out with an automatic selection of the most unfavorable LC.
Reinforcement designed for all piles in the group.

Dimensioning of reinforcement:

Reinforcement - 20 pc bars 26,0 mm; covering 60,0 mm
Type of structure (reinforcement ratio) : pile

Reinforcement ratio ρ = 1,352 % > 0,357 % = ρ_{min}

Load : N_{Ed} = -2330,20 kN (compression) ; M_{Ed} = 483,39 kNm
Bearing capacity : N_{Rd} = -7996,63 kN; M_{Rd} = 1658,86 kNm

Designed pile reinforcement is SATISFACTORY

Verification of shear reinforcement:

Ultimate shear force: V_{Rd} = 544,44 kN > 119,69 kN = V_{Ed}
Cross-section is SATISFACTORY.

Distribution of forces on construction

Depth [m]	Normal force N [kN] (tah)	Normal force N [kN] (tlak)	Shear force Q [kN]	Bending moment M [kNm]
0.00	-431.63	-2330.20	119.69	483.39
1.20	-451.17	-2312.03	114.48	342.91
2.40	-466.68	-2252.33	100.06	214.34
3.60	-477.47	-2144.06	79.02	123.53
4.80	-479.23	-1943.13	54.54	77.30
6.00	-476.39	-1698.73	29.90	45.39
7.20	-473.39	-1455.15	15.34	44.73
8.40	-471.85	-1226.51	8.56	43.53
9.60	-475.07	-1045.97	16.00	28.11
10.80	-481.65	-899.14	13.57	9.25
12.00	-496.72	-837.58	0.00	0.00

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Description : Dimensioning - Internal forces