

Pile verification

Input data

Project

Task : RO-RO vez v bazenu III
Part : 3/2 NGK - obalna konstrukcija
Description : Nosilnost pilotov 2032/22 mm
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Settings

Standard - no reduction of parameters

Materials and standards

Steel structures : EN 1993-1-1 (EC3)
Partial factor on bearing capacity of steel cross section : $\gamma_{M0} = 1,00$
Timber structures : EN 1995-1-1 (EC5)
Partial factor for timber property : $\gamma_M = 1,30$
Modif. factor of load duration and moisture content : $k_{mod} = 0,50$
Coeff. of effective width for shear stress : $k_{cr} = 0,67$





Pile


Analysis for drained conditions : NAVFAC DM 7.2
Load settlement curve : linear (Poulos)
Horizontal bearing capacity : Elastic subsoil (p-y method)
Verification methodology : Limit states (LSD)

Reduction coeff. of soil parameters			
Transient design situation			
Reduction coeff. of internal friction :	$\gamma_{m\phi} =$	1,00	[-]
Reduction coeff. of cohesion :	$\gamma_{mc} =$	1,00	[-]
Coefficient of unit weight :	$\gamma_{m\gamma} =$	1,00	[-]




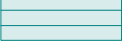

Reduction coeff. of bearing capacity			
Transient design situation			
Reduction coeff. of shaft resistance :	$\gamma_s =$	1,00	[-]
Reduction coeff. of base resistance :	$\gamma_b =$	1,00	[-]
Reduction coeff. of total resistance :	$\gamma_t =$	1,00	[-]
Reduction coeff. of resistance in tension :	$\gamma_{st} =$	1,00	[-]






Basic soil parameters

No.	Name	Pattern	γ [kN/m ³]	ν [-]
1	NA		21,00	0,30
2	Qals		19,00	0,40
3	Qalm		19,00	0,40
4	Preperina fliša		22,00	0,30






No.	Name	Pattern	γ [kN/m ³]	ν [-]
5	Fliš		25,00	0,30

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	NA		40,00	-	21,00	-	-
2	Qals		1,90	-	19,00	-	-
3	Qalm		0,60	-	19,00	-	-
4	Preperina fliša		46,00	-	22,00	-	-
5	Fliš		1400,00	-	25,00	-	-

No.	Name	Pattern	φ_{ef} [°]	δ [°]	K [-]	c_u [kPa]	α [-]
1	NA		36,00	-	-	-	-
2	Qals		22,00	-	-	-	-
3	Qalm		21,00	-	-	-	-
4	Preperina fliša		-	-	-	250,00	1,00
5	Fliš		-	-	-	5000,00	1,00

Parameters of soils to compute modulus of subsoil reaction

No.	Name	Pattern	k [MN/m ³]	β [°]
1	NA		110,00	9,00
2	Qals		2,00	5,00
3	Qalm		2,00	5,00
4	Preperina fliša		220,00	0,00
5	Fliš		400,00	0,00

Soil parameters

NA

Unit weight : $\gamma = 21,00 \text{ kN/m}^3$

Poisson's ratio : $\nu = 0,30$
 Oedometric modulus : $E_{oed} = 40,00 \text{ MPa}$
 Saturated unit weight : $\gamma_{sat} = 21,00 \text{ kN/m}^3$
 Coefficient : $k = 110,00 \text{ MN/m}^3$
 Angle of dispersion : $\beta = 9,00^\circ$
 Angle of internal friction : $\varphi_{ef} = 36,00^\circ$

Qals

Unit weight : $\gamma = 19,00 \text{ kN/m}^3$
 Poisson's ratio : $\nu = 0,40$
 Oedometric modulus : $E_{oed} = 1,90 \text{ MPa}$
 Saturated unit weight : $\gamma_{sat} = 19,00 \text{ kN/m}^3$
 Coefficient : $k = 2,00 \text{ MN/m}^3$
 Angle of dispersion : $\beta = 5,00^\circ$
 Angle of internal friction : $\varphi_{ef} = 22,00^\circ$

Qalm

Unit weight : $\gamma = 19,00 \text{ kN/m}^3$
 Poisson's ratio : $\nu = 0,40$
 Oedometric modulus : $E_{oed} = 0,60 \text{ MPa}$
 Saturated unit weight : $\gamma_{sat} = 19,00 \text{ kN/m}^3$
 Coefficient : $k = 2,00 \text{ MN/m}^3$
 Angle of dispersion : $\beta = 5,00^\circ$
 Angle of internal friction : $\varphi_{ef} = 21,00^\circ$

Preperina fliša

Unit weight : $\gamma = 22,00 \text{ kN/m}^3$
 Poisson's ratio : $\nu = 0,30$
 Oedometric modulus : $E_{oed} = 46,00 \text{ MPa}$
 Saturated unit weight : $\gamma_{sat} = 22,00 \text{ kN/m}^3$
 Coefficient : $k = 220,00 \text{ MN/m}^3$
 Angle of dispersion : $\beta = 0,00^\circ$
 Cohesion of soil : $c_u = 250,00 \text{ kPa}$
 Adhesion factor : $\alpha = 1,00$
 Angle of internal friction : $\varphi_{ef} = 21,00^\circ$

Fliš

Unit weight : $\gamma = 25,00 \text{ kN/m}^3$
 Poisson's ratio : $\nu = 0,30$
 Oedometric modulus : $E_{oed} = 1400,00 \text{ MPa}$
 Saturated unit weight : $\gamma_{sat} = 25,00 \text{ kN/m}^3$
 Coefficient : $k = 400,00 \text{ MN/m}^3$
 Angle of dispersion : $\beta = 0,00^\circ$
 Cohesion of soil : $c_u = 5000,00 \text{ kPa}$
 Adhesion factor : $\alpha = 1,00$
 Angle of internal friction : $\varphi_{ef} = 21,00^\circ$

Geometry

Pile profile: pipe pile

Dimensions

Diameter $d = 2,03 \text{ m}$
 Length $l = 22,30 \text{ m}$
 Thickness $t = 22,0 \text{ mm}$
 Coeff. of base reduction $c = 1,00$

Calculated cross-sectional characteristics

Area $A = 1,39E-01 \text{ m}^2$
Moment of inertia $I = 7,00E-02 \text{ m}^4$

Location

Off ground height $h = 0,00 \text{ m}$
Depth of finished grade $h_z = 1,30 \text{ m}$

Technology: Driven piles
Modulus of subsoil reaction assumed linear.






Material of structure

Unit weight $\gamma = 23,00 \text{ kN/m}^3$

Structural steel: EN 10248-1 : S 355 GP

Yield strength $f_y = 355,00 \text{ MPa}$
Ultimate tensile strength $f_u = 480,00 \text{ MPa}$
Elasticity modulus $E = 210000,00 \text{ MPa}$
Shear modulus $G = 81000,00 \text{ MPa}$

Geological profile and assigned soils

No.	Layer [m]	Assigned soil	Pattern
1	3,50	NA	
2	8,30	Qals	
3	8,70	Qalm	
4	3,10	Preperina fliša	
5	-	Fliš	

Load

No.	Load		Name	Type	N [kN]	M _x [kNm]	M _y [kNm]	H _x [kN]	H _y [kN]
	new	change							
1	Yes		MSN1	Design	-2253,00	-1437,00	-9302,00	-2599,00	74,00
2	Yes		MSN2	Design	2504,00	-1494,00	2791,00	403,00	153,00
3	Yes		MSN3	Design	1558,00	-3237,00	1096,00	142,00	-360,00
4	Yes		MSN4	Design	-2486,00	-1620,00	-9348,00	-2603,00	84,00
5	Yes		MSU1	Service	-1650,00	-1103,00	-6883,00	-1924,00	58,00
6	Yes		MSU2	Service	1799,00	-1095,00	2093,00	305,00	113,00
7	Yes		MSU3	Service	1568,00	-1226,00	2411,00	307,00	113,00
8	Yes		MSU4	Service	-1625,00	-1182,00	-6916,00	-1927,00	61,00

Ground water table

The ground water table is at a depth of 2,40 m from the original terrain.

Global settings

Analysis of vertical bearing capacity : analytical solution
Analysis type : analysis for drained conditions

Settings of the stage of construction

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

Verification No. 1

Verification of bearing capacity : NAVFAC DM 7.2

Analysis carried out with automatic selection of the most unfavourable load cases.
Factor determining critical depth $k_{dc} = 1,00$

Verification of compressive pile:
Most unfavorable load case No. 2. (MSN2)

Pile skin bearing capacity $R_s = 6525,28 \text{ kN}$
Pile base bearing capacity $R_b = 145644,63 \text{ kN}$

Pile bearing capacity $R_c = 152169,91 \text{ kN}$
Ultimate vertical force $V_d = 2504,00 \text{ kN}$

$$R_c = 152169,91 \text{ kN} > 2504,00 \text{ kN} = V_d$$

Pile compressive resistance is SATISFACTORY

Verification of tensile pile:
Most unfavorable load case No. 8. (MSU4)

Pile tensile resistance $R_{sdt} = 6525,28 \text{ kN}$
Pile self-weight $w_p = 973,88 \text{ kN}$
Maximum tensile load $V_d = 651,12 \text{ kN}$

$$R_c = 6525,28 \text{ kN} > 651,12 \text{ kN} = V_d$$

Pile tensile resistance is SATISFACTORY

Pile bearing capacity is SATISFACTORY

Verification No. 1

Analysis of load settlement curve - input data

Layer No.	E_s [MPa]
1	15,00
2	15,00
3	15,00
4	15,00

Maximum pile settlement $s_{lim} = 100,0 \text{ mm}$

Analysis of load settlement curve - results

Load at the onset of mobilization of skin friction $R_{yu} = 10022,21 \text{ kN}$
The settlement for the force R_{yu} $s_y = 43,8 \text{ mm}$
Total resistance $R_c = 14316,72 \text{ kN}$
Maximum settlement $s_{lim} = 100,0 \text{ mm}$

The settlement for maximum service load $V = 1799,00 \text{ kN}$ is $7,9 \text{ mm}$.

Verification No. 1

Maximum internal force and deformation :

Max. pile displacement = $422,4 \text{ mm}$

Max. shear force = 2604,36 kN
Maximum moment = 9487,33 kNm

Verification of steel section according to EN 1993-1-1

Verification of bending and axial stress - load No. 4:

$N = -2486,00 \text{ kN}; \quad M = 9487,33 \text{ kNm}$

$M/M_{c,Rd} + N/N_{c,Rd} = 0,438 \leq 1$ **Is satisfied**

Verification of shear:

$Q_{\max} = 2604,36 \text{ kN}$

$Q_{\max}/V_{c,Rd} = 0,183 \leq 1$ **Is satisfied**

Cross section is SATISFACTORY