

## Pile verification

### Input data

#### Project

Task : RO-RO vez v bazenu III  
Part : 3/2 NGK - obalna konstrukcija  
Description : Nosilnost pilotov 812,8/12,5 mm  
Customer : Luka Koper d.d.  
Author : Eva Lovrenčiči, u.d.i.g.  
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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	[-]




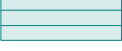

#### Basic soil parameters






No.	Name	Pattern	$\gamma$ [kN/m <sup>3</sup> ]	$\nu$ [-]
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	$\gamma$ [kN/m <sup>3</sup> ]	$\nu$ [-]
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]	$\gamma_{sat}$ [kN/m <sup>3</sup> ]	$\gamma_s$ [kN/m <sup>3</sup> ]	$n$ [-]
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	$\varphi_{ef}$ [°]	$\delta$ [°]	$K$ [-]	$c_u$ [kPa]	$\alpha$ [-]
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 <sup>3</sup> ]	$\beta$ [°]
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  $d = 0,81 \text{ m}$   
 Length  $l = 26,40 \text{ m}$   
 Thickness  $t = 12,5 \text{ mm}$   
 Coeff. of base reduction  $c = 1,00$



### Calculated cross-sectional characteristics

Area  $A = 3,13E-02 \text{ m}^2$   
Moment of inertia  $I = 2,49E-03 \text{ m}^4$

### 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	4,90	NA	
2	9,30	Qals	
3	9,60	Qalm	
4	3,90	Preperina fliša	
5	-	Fliš	

### Load

No.	Load		Name	Type	N [kN]	M <sub>x</sub> [kNm]	M <sub>y</sub> [kNm]	H <sub>x</sub> [kN]	H <sub>y</sub> [kN]
	new	change							
1	Yes		MSN1	Design	-2847,00	384,00	698,00	368,00	141,00
2	Yes		MSN2	Design	2505,00	-194,00	-502,00	-229,00	-162,00
3	Yes		MSN3	Design	-232,00	759,00	117,00	115,00	328,00
4	Yes		MSU1	Service	-1152,00	20,00	280,00	147,00	-4,00
5	Yes		MSU2	Service	-122,00	81,00	70,00	77,00	-27,00

### 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  $R_s = 2879,98 \text{ kN}$   
Pile base bearing capacity  $R_b = 23188,49 \text{ kN}$

Pile bearing capacity  $R_c = 26068,46 \text{ kN}$   
Ultimate vertical force  $V_d = 2505,00 \text{ kN}$

$$R_c = 26068,46 \text{ kN} > 2505,00 \text{ kN} = V_d$$

**Pile compressive resistance is SATISFACTORY**

Verification of tensile pile:  
Most unfavorable load case No. 1. (MSN1)

Pile tensile resistance  $R_{sdt} = 2879,98 \text{ kN}$   
Pile self-weight  $w_p = 182,52 \text{ kN}$   
Maximum tensile load  $V_d = 2664,48 \text{ kN}$

$$R_c = 2879,98 \text{ kN} > 2664,48 \text{ kN} = V_d$$

**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  $s_{lim} = 80,0 \text{ mm}$

### Analysis of load settlement curve - results

Load at the onset of mobilization of skin friction  $R_{yu} = 3533,68 \text{ kN}$   
The settlement for the force  $R_{yu}$   $s_y = 19,5 \text{ mm}$   
Total resistance  $R_c = 5395,80 \text{ kN}$   
Maximum settlement  $s_{lim} = 80,0 \text{ mm}$

## Verification No. 1

### Maximum internal force and deformation :

Max. pile displacement = 108,6 mm  
Max. shear force = 394,09 kN  
Maximum moment = 1362,39 kNm



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

#### Verification of bending and axial stress - load No. 3:

$N = -232,00 \text{ kN}; \quad M = 1362,39 \text{ kNm}$

$M/M_{c,Rd} + N/N_{c,Rd} = 0,645 \leq 1 \quad \text{Is satisfied}$

#### Verification of shear:

$Q_{\max} = 394,09 \text{ kN}$

$Q_{\max}/V_{c,Rd} = 0,123 \leq 1 \quad \text{Is satisfied}$

**Cross section is SATISFACTORY**