DEEP EXCAVATION

GEOTECHNICAL SOFTWARE & ENGINEERING

DeepFND – Foundation Piles Design Software

HelixPile – Helical Piles Design Software

DeepFND – Pile Rafts Verification Example

Case History: Pile Raft Foundation in Gdansk, Poland – DeepFND Analysis and Measured Settlements Comparison

Document Version 1.0.1.4

Released: June 27, 2020

www.deepexcavation.com

www.deepex.com

Introduction

This document examines a case history of a pile raft, constructed in Gdansk, Poland. A liquid gas terminal was constructed over 2 rectangular pile caps (71 m x 61.2 m x 0.9 m thick), each one of them supported by 180 reinforced concrete bored piles (diameter: 1 m and 0.62 m, pile depth: 26.5 m).

A model of the pile raft was created with our DeepFND software program. This document presents the software input and calculation results, as well as, a comparison with the measured displacements and estimations of different methods. Some information and data that were not included in the case history, had to be assumed.

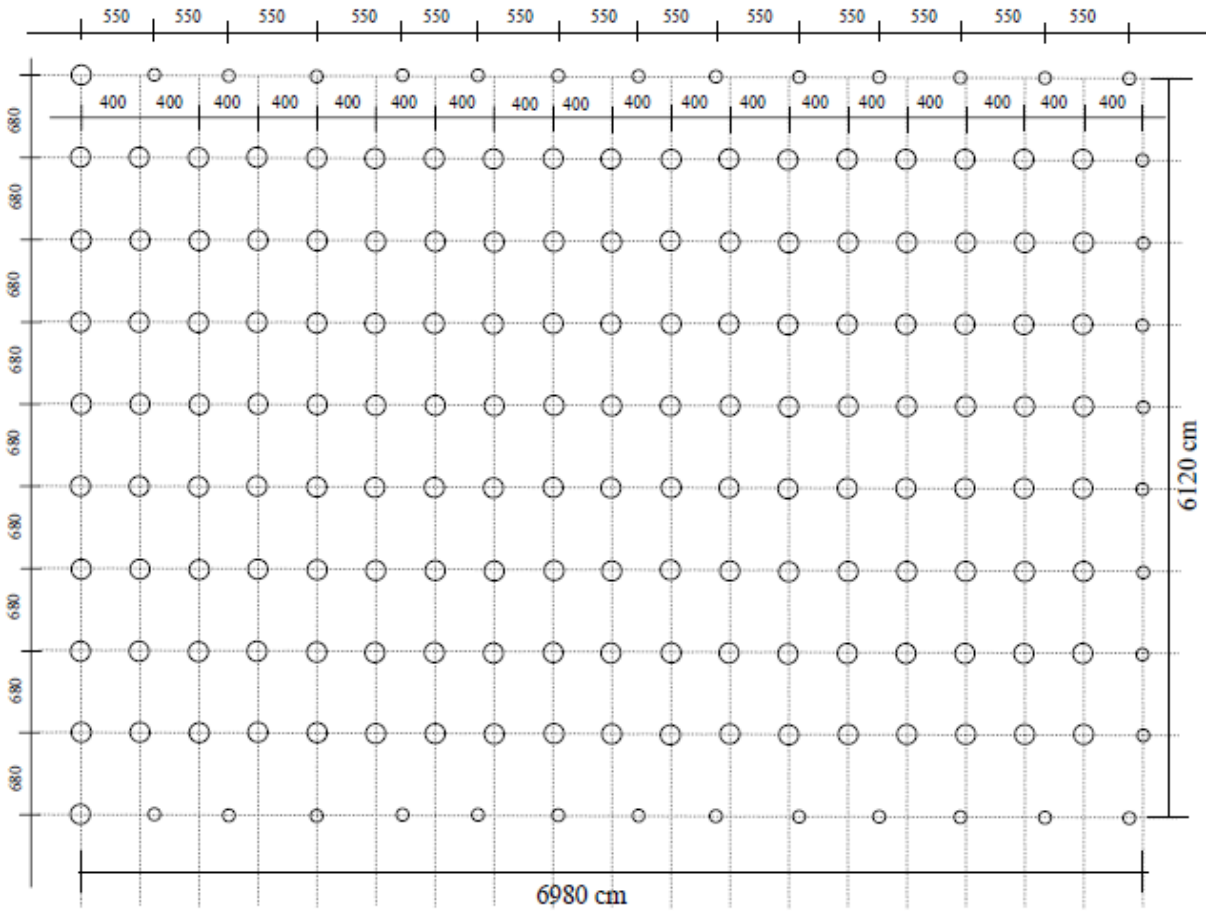


Figure 1: Pile Layout for the Liquid Gas Terminal Pile Raft

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

A. SOIL PROPERTIES AND STRATIGRAPHY

The piles were embedded in sand and alluvium soil layers. The following Table summarizes the estimated soil properties for all soil types. Figure 2 presents the soil properties and the soil layers, as defined within DeepFND software.

Table 1: Soil Properties and Soil Layers (Stratigraphy)

Soil Layer Top Elev. (m)	Soil (-)	Soil Type (-)	Friction Angle (deg)	Cohesion (c' or Su) (kPa)	Total Unit Weight (KN/m3)	Young's Modulus (kPa)	Poisson's Ratio (-)
5	1	Sand (Fill)	30	0	18	32000	0.35
2.9	2	Silty Sand	26	2.4	16	52000	0.45
-2.5	3	Soft Sand	28	0	17	9000	0.35
-7	4	Medium Sand	34	0	18	35000	0.35
-9.7 and -18	5	Medium Silt	28	14.5	19.6	32000	0.45
-11.9 And -23.6	6	Dense Clay (Undrained)	-	15	15	1300	0.45
-24	7	Sandy Clay (Undrained)	-	150	20	36000	0.32

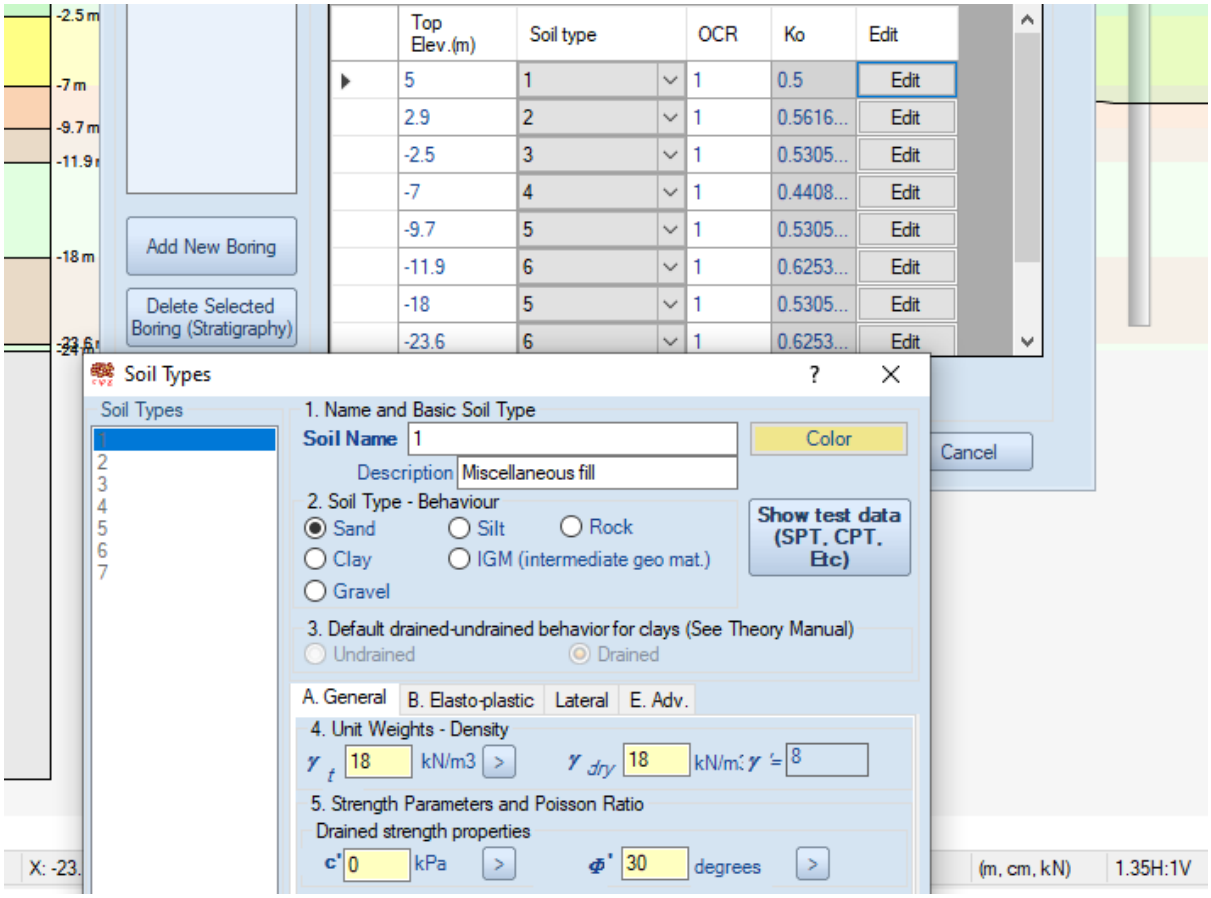


Figure 2: Soil Layers and Soil Properties (Soil 1) in DeepFND Software

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

B. PILE SECTION PROPERTIES AND PILE POSITIONS (LAYOUT)

In the original project, two types of piles where used:

- 1 m diameter reinforced concrete piles, distributed on the whole pile raft

- 0.62 m diameter reinforced concrete piles, used along the 3 raft sides

The following figures present the assumed pile section properties and pile locations (local X and Y coordinates for each pile center).

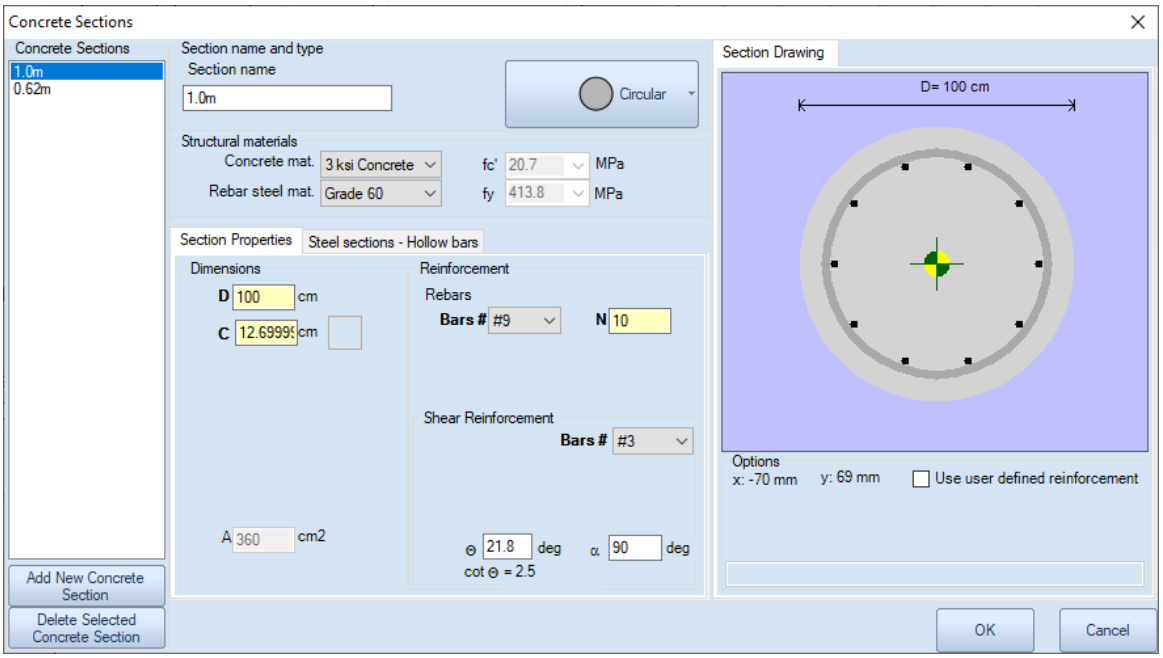
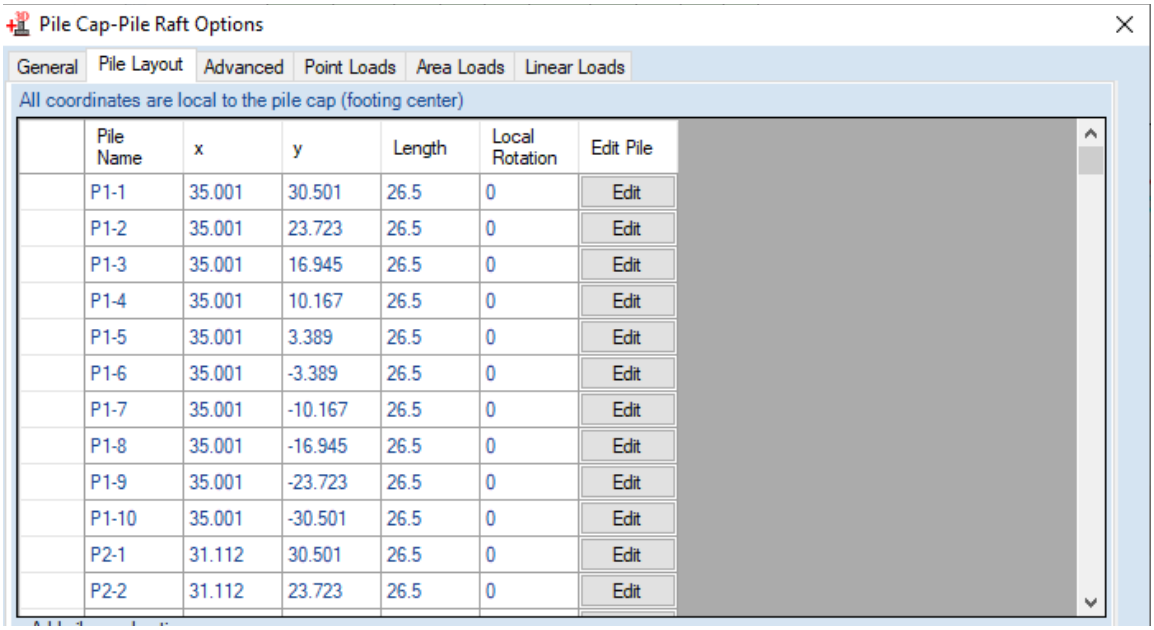


Figure 3: Pile Section Properties – 1m Diameter Reinforced Concrete Piles (DeepFND)



Pile Name	x	y	Length	Local Rotation	Edit Pile
P1-1	35.001	30.501	26.5	0	Edit
P1-2	35.001	23.723	26.5	0	Edit
P1-3	35.001	16.945	26.5	0	Edit
P1-4	35.001	10.167	26.5	0	Edit
P1-5	35.001	3.389	26.5	0	Edit
P1-6	35.001	-3.389	26.5	0	Edit
P1-7	35.001	-10.167	26.5	0	Edit
P1-8	35.001	-16.945	26.5	0	Edit
P1-9	35.001	-23.723	26.5	0	Edit
P1-10	35.001	-30.501	26.5	0	Edit
P2-1	31.112	30.501	26.5	0	Edit
P2-2	31.112	23.723	26.5	0	Edit

Figure 4: Generated Pile Locations (DeepFND)

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

C. PILE CAP DIMENSIONS AND EXTERNAL SURCHARGE

In DeepFND we simulated a 72 m x 63 m pile cap, with cap thickness = 0.9 m. We have assigned a 77kPa uniform area load on the entire pile cap surface, simulating the original examined pile cap. The following Figures present the pile cap dimensions and area load, as defined in DeepFND Software.

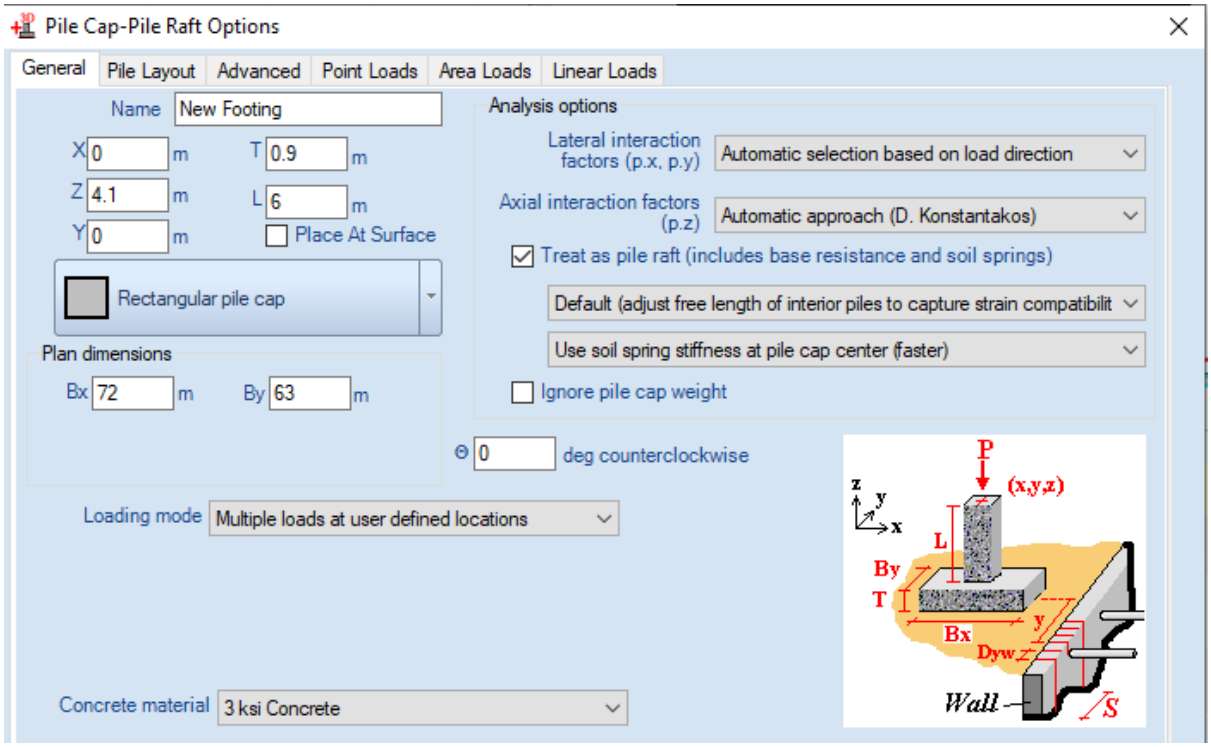


Figure 5: Pile Cap Dimensions (DeepFND Software)

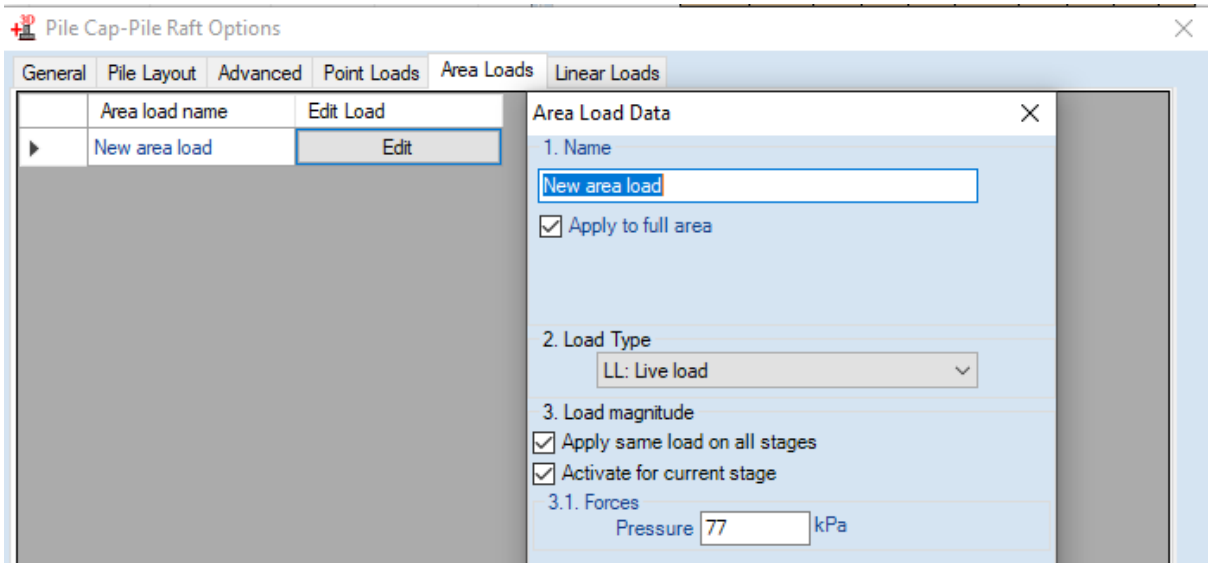


Figure 6: Assigned Area Surcharge on the Full Pile Cap Area (DeepFND Software)

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

D. GENERATED MODEL (TOP AND SIDE VIEWS)

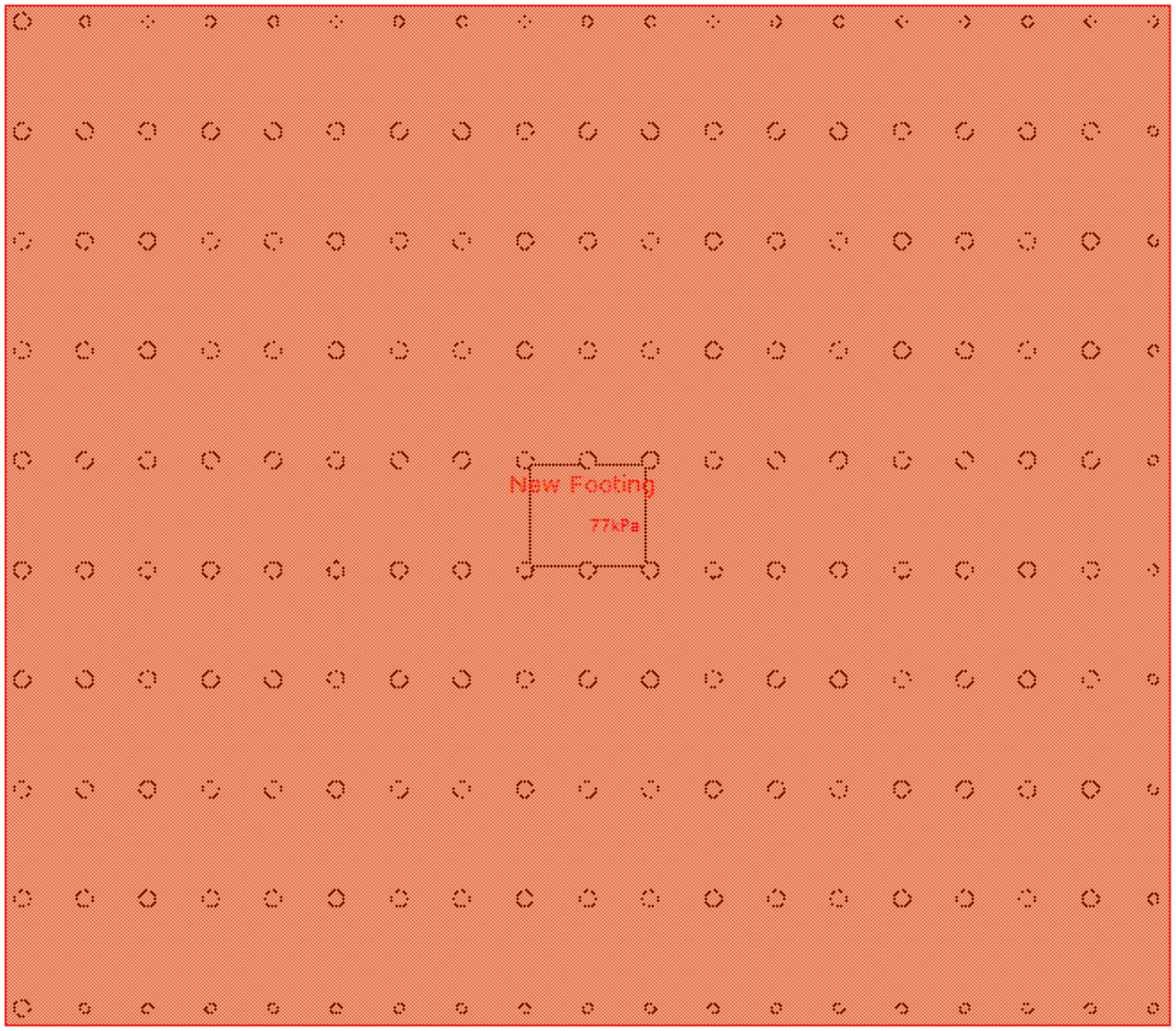


Figure 7: Generated Pile Raft Model – Top View (DeepFND)

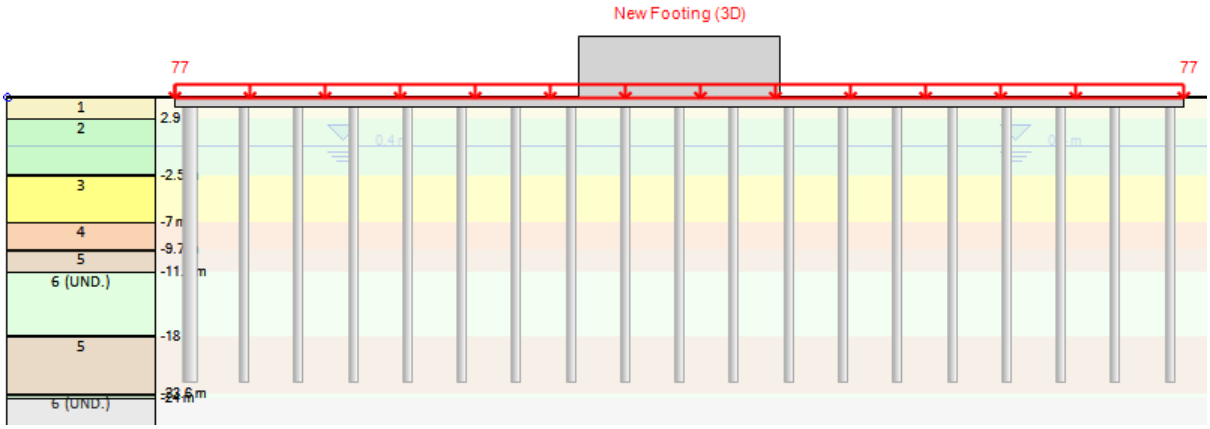


Figure 8: Generated Pile Raft Model – Side View (Raft Edge Pile Row) (DeepFND)

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

E: PILE RAFT ANALYSIS RESULTS – DEEPFND SOFTWARE

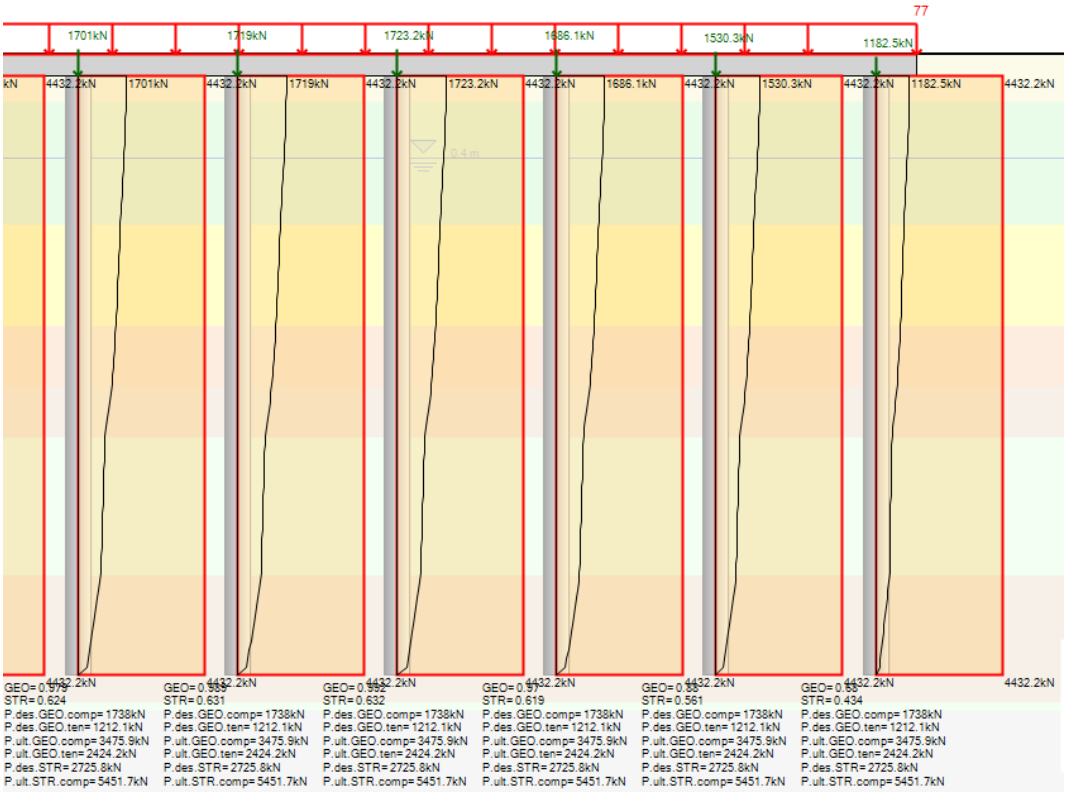


Figure 9: Calculated Pile Axial Forces, Load Distribution Along the Piles and Structural/Geotechnical Pile Capacities – Edge Piles

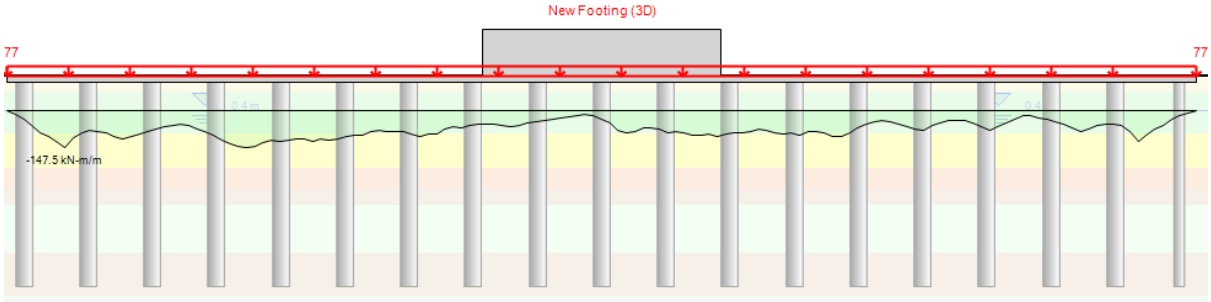


Figure 10: Pile Cap Moment Diagram (Myy) – Middle Piles

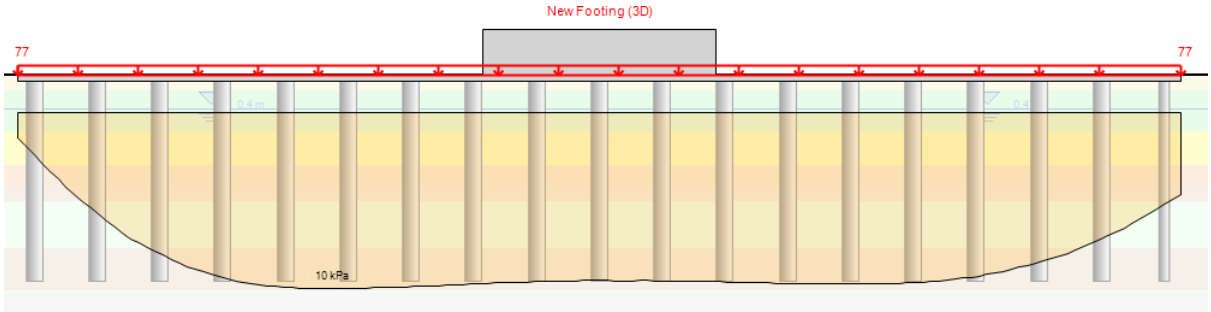


Figure 11: Soil Uplift Pressures below the Pile Cap (Pile Raft Analysis) – Middle Piles

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

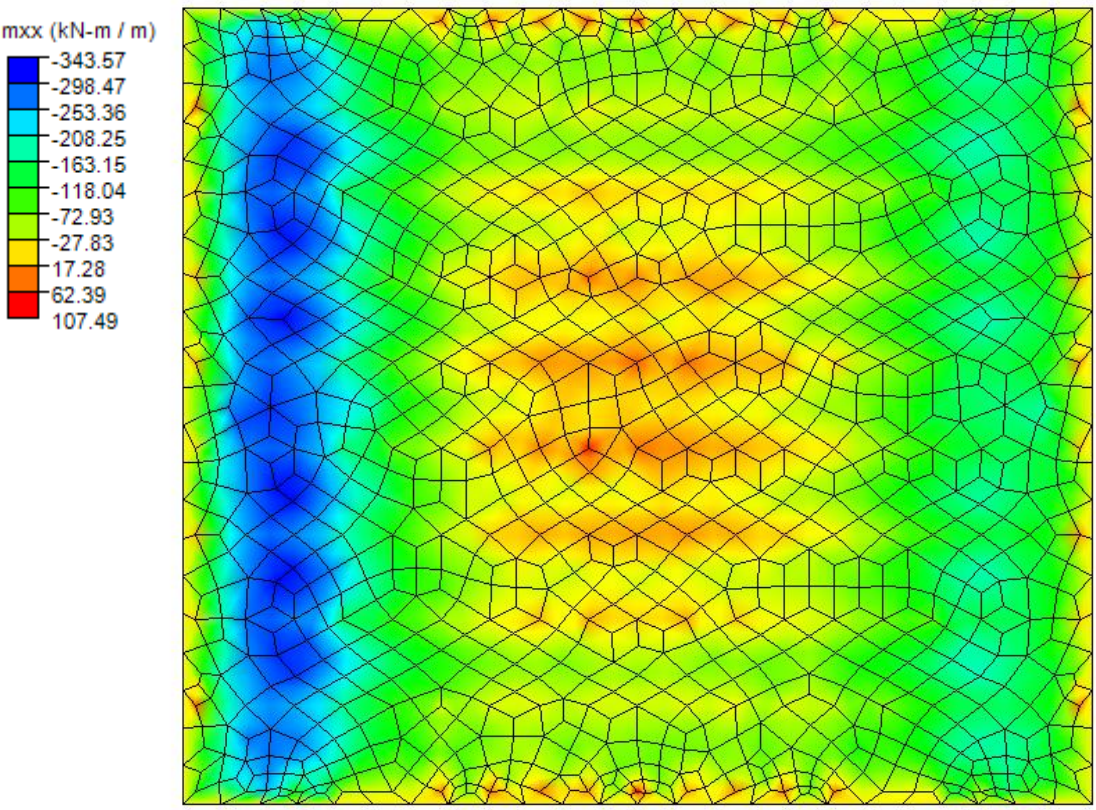


Figure 12: Pile Cap Moments (X direction) Shading

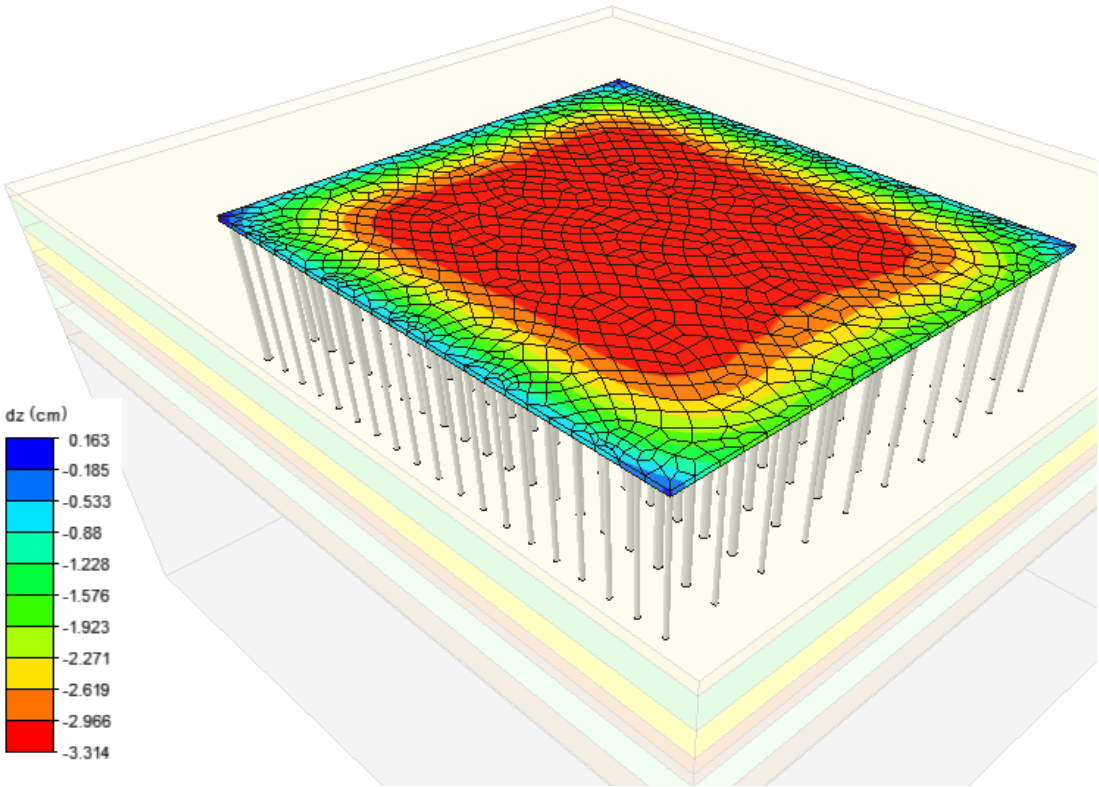


Figure 13: Pile Cap – 3D Model - Settlements Shading

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

F: DEEPFND PILE RAFT SETTLEMENTS VS MEASURED AND PREDICTED WITH OTHER METHODS

Pile raft settlements were measured during the project construction. DeepFND software predicted a maximum of 17 mm settlements at the last pile row location (closest to the pile raft edge), matching the measured settlement values (see Figure 14). Table 2 below, presents the predicted settlements at the middle of the pile raft, in comparison to values predicted from other methods and sources.

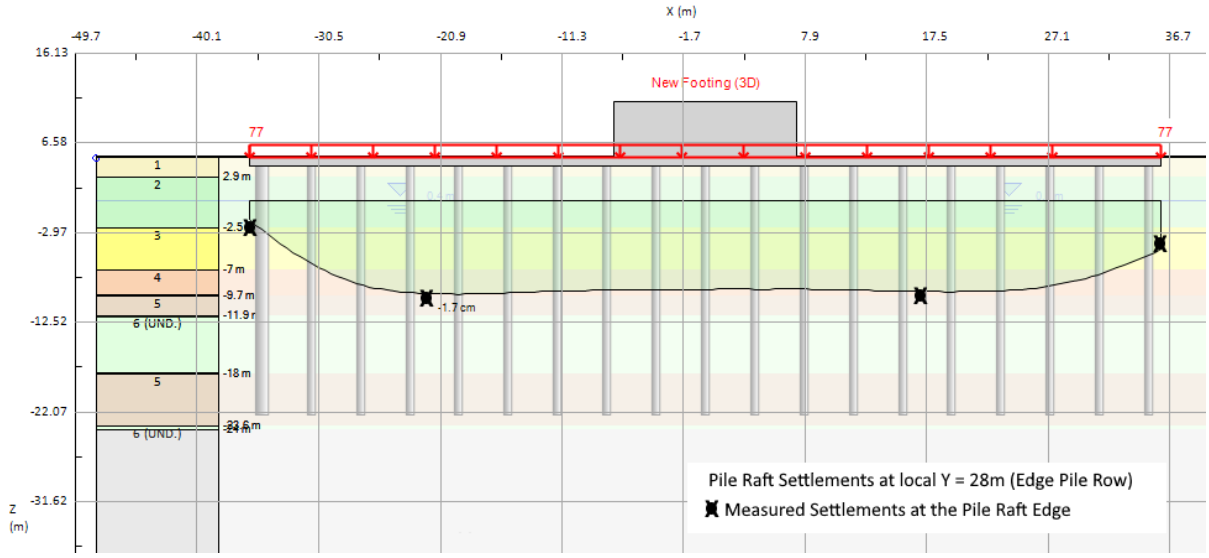


Figure 14: Predicted Settlements (DeepFND) VS Measured – Pile Raft Edge

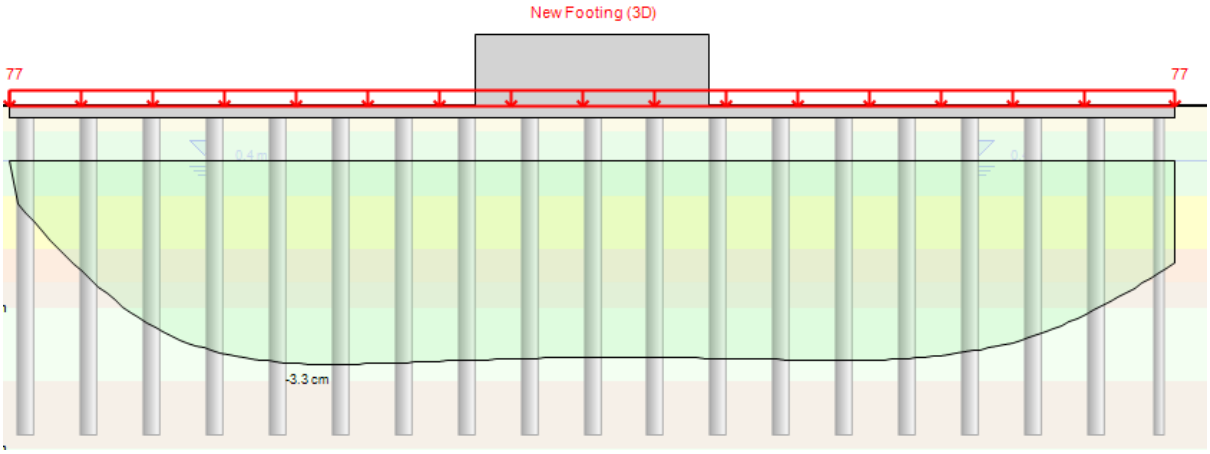


Figure 15: Predicted Settlements (DeepFND) – Pile Raft Middle

Table 2: Maximum Settlement Predictions with DeepFND and Other Methods

Method	Settlement (mm)
DeepFND – Pile Rafts Module (Non-Linear Soil Springs Method)	**33**
Equivalent Foundation According to Polish Code (PN-69)	32.7
Equivalent Foundation According to Tomlinson	30.9
Equivalent Foundation According to Poulos (Randolph Formula)	34
Equivalent Foundation According to Van Impe	33.4

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300

THANK YOU

DESIGN AND OPTIMIZE ANY DEEP FOUNDATION SYSTEM IN MINUTES AND GAIN A COMPETITIVE EDGE!

Learn tips and tricks of pile foundations design

CLICK HERE TO BOOK A FREE ONLINE PRESENTATION
E: training@deepexcavation.com

Learn from examples, videos and case studies

CLICK HERE FOR EXAMPLES, VIDEOS AND ARTICLES

Prices and Licensing Questions: sales@deepexcavation.com

Technical Support support@deepexcavation.com

www.deepexcavation.com
www.deepex.com
E: sales@deepexcavation.com
T: 1-206-279-3300