

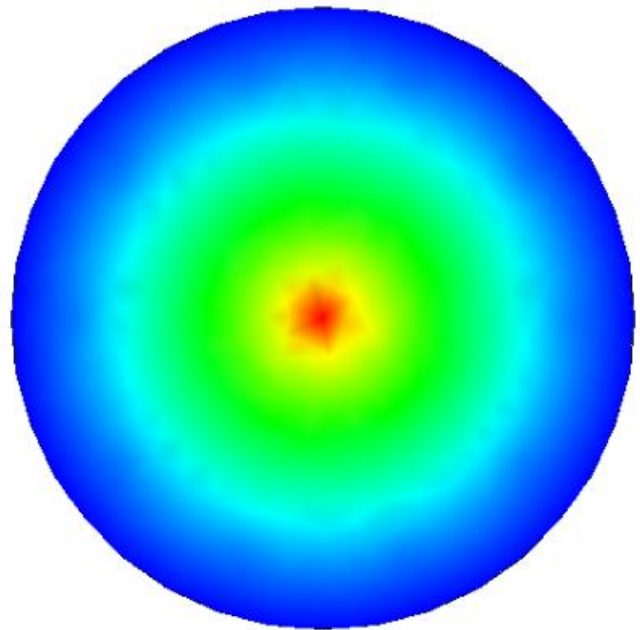
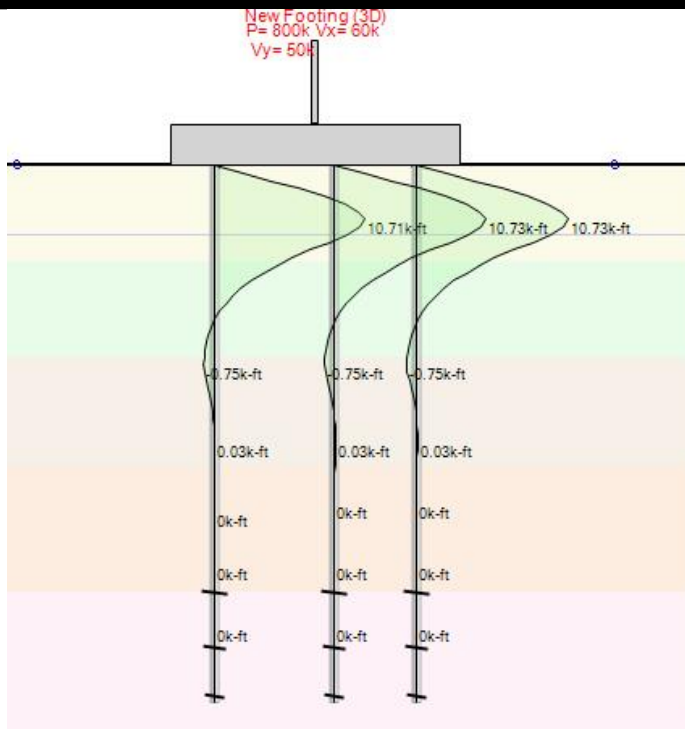


DEEP EXCAVATION

GEOTECHNICAL SOFTWARE & ENGINEERING

Helical Piles Design – Single Piles and Pile Group

Helical Piles – Vertical and Lateral Analysis of a Single Pile and a Pile Cap with 17 Piles



DeepFND
Foundation Piles
Design Software



HelixPile
Helical Piles
Design Software

Document Version: 1.0.1.2

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**INTRODUCTION: DEEPFND – FOUNDATION PILES DESIGN SOFTWARE
HELIXPILE – HELICAL PILES DESIGN SOFTWARE**

DeepFND and HelixPile are two similar, powerful software programs for the design and evaluation pile foundations. The programs can perform structural and geotechnical, lateral, and axial analysis of any foundation pile (single piles, pile groups and pile rafts).

The only difference between the two programs is the available pile types. DeepFND can design all pile sections and pile types (helical and non-helical – drilled, driven, caissons, micropiles, CFA piles and more), whereas HelixPile can design only helical piles.

Available Helical Pile Types (Both Programs): Steel pipes, Square solid and square hollow piles with unlimited helical plate configurations.

Available Non-Helical Pile Types (DeepFND Only): Circular, rectangular, circular Hollow, Octagon, Reinforced Concrete Piles, Steel Beams (Pipes, H Beams, Rectangular Hollow Sections, Channel Sections), Composite Sections, Belled Bottom Piles, Timber Piles (Wood) and more.

Pile Installation Methods: Helical Piles, Drilled, Driven, Caissons, Micropiles, Continuous Flight Auger (CFA Piles), Drilled-In-Displacement Piles.

Analysis Methods: Vesic 1974, Meyerhoff/Hansen, Eurocode 7, Spangler/Handy, Brinch/Hansen and more.

Bearing Capacity Equations: General and Helicap Equations (Helical Piles), FHWA GEC8 (CFA Piles), GEC10 (Drilled Piles), AASHTO-Norlund (Driven Piles) and more.

Lateral Pile Methods and PY Soil Models: Exact lateral loads or pushover analysis. Implemented PY Models: API and Reese Models (Sands), Soft and Stiff Models (Clays), Weak Model (Rocks).

Settlements and Pile Criteria: Option to perform settlement analysis and calculate structural capacities from pile acceptance criteria (Davisson’s, Butler-How, NYC code and more).

Structural Codes: ACI, AISC. ASD, LRFD, EUROCODES 2, 3 and 8, AS, CN and more.

Geotechnical Codes: AASHTO LRFD, EUROCODE 7, CN, DIN, BSEN and more.

Printed Reports: Reports exported in PDF and Word

Model Creation: Graphical (interactive interface), model wizard.

DeepFND Features and Capabilities

DeepFND is a powerful software for the design and analysis of any pile type. Perform Structural and Geotechnical design of any pile (Single Piles, Pile Groups and Pile Rafts), Lateral and Vertical Analysis of piles in a unique software package!

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HelixPile Features and Capabilities

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A. PROJECT DESCRIPTION – PILE SECTION – SOIL PROPERTIES

In this example we will design a helical pile (Steel pipe PP4.5x0.337 with 3 helixes - 12in, 14in and 16in diameter), installed in medium to dense sands, and soft to stiff, overconsolidated clays.

Table 1 and Table 2 below present the soil properties and stratigraphy that has been estimated and used within the DeepFND software. Table 3 presents the pipe section properties. The water table is at El: -5ft.

Table 1: Soil properties.

Soil Layer	Soil Type	General properties						
		ϕ' (deg)	c' or Su (psf)	γ (pcf)	E _{LOAD} (ksf)	E _{RELOAD} (ksf)	e50	Sub. Mod. (pci)
F	Soft Sand	30	0	120	300	900	-	30
O1	Soft Clay	-	400	105	120	360	0.02	-
V	Stiff Clay	-	1500	125	600	1800	0.005	-
S1	Medium Sand	34	0	125	400	1200	-	50
S2	Dense Sand	36	200	130	600	1800	-	100

Table 2: Stratigraphy.

Soil Layer	Elevation (ft)	OCR	Ko
F	0	1	0.5
O1	-7	1	0.562
V	-14	2.5	0.839
S1	-22	1	0.441
S2	-31	1	0.412

Table 3: Helical Pile Section Properties

Pile Type	Helical Pile (Steel Pipe with Helixes)
Pile Section	PP4.5x0.337
Steel Material	Fy = 80ksi
Pile Depth (Total)	39 ft
Helixes	3 Plates (D=12, 14 and 16 in), Thickness: 0.5in

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B. DEEPFND SOFTWARE – SOIL TYPES AND BORINGS

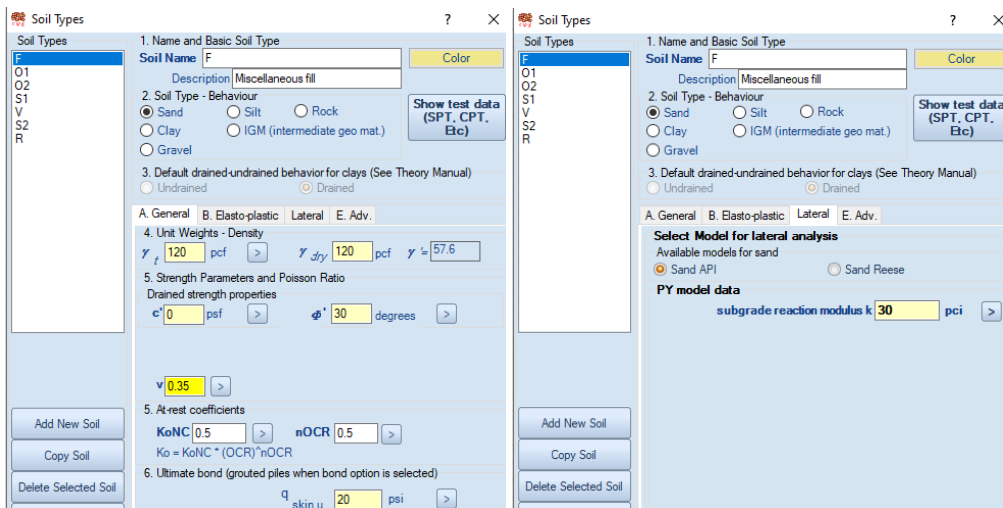


Figure 2: General soil properties – Top Fill Layer (Soil F)

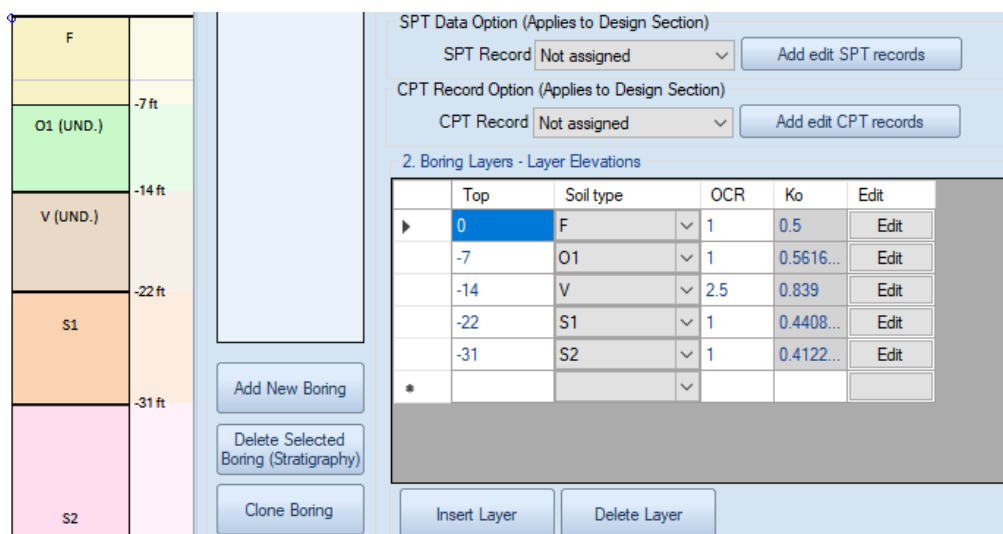


Figure 3: Soil Layers

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C. DEEPFND SOFTWARE – PILE SECTION PROPERTIES

The helical piles are installed to 39 ft depth. Figures 4 and 5 present the pile type and length, and the pile section properties respectively.

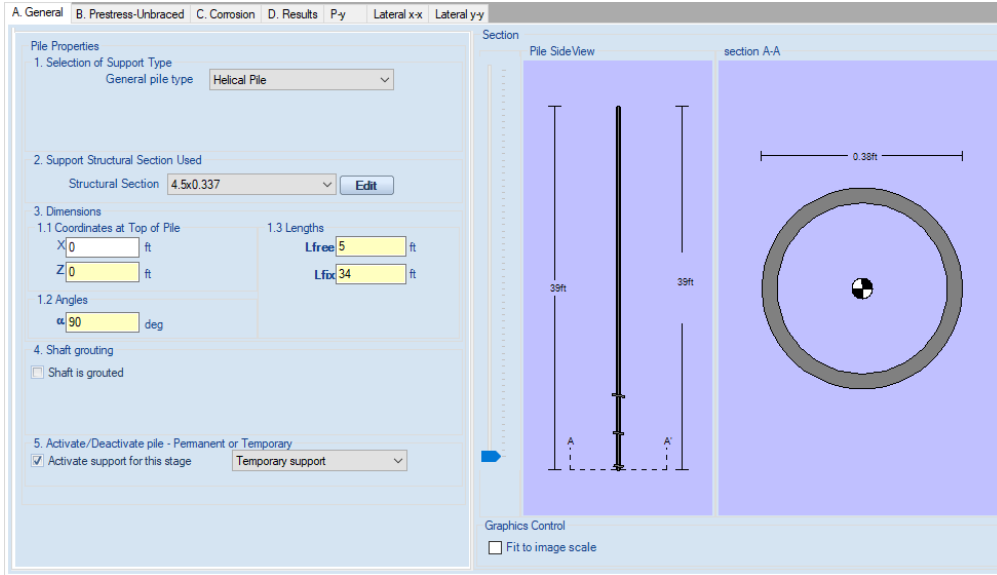


Figure 4: Pile Type, Position and Dimensions

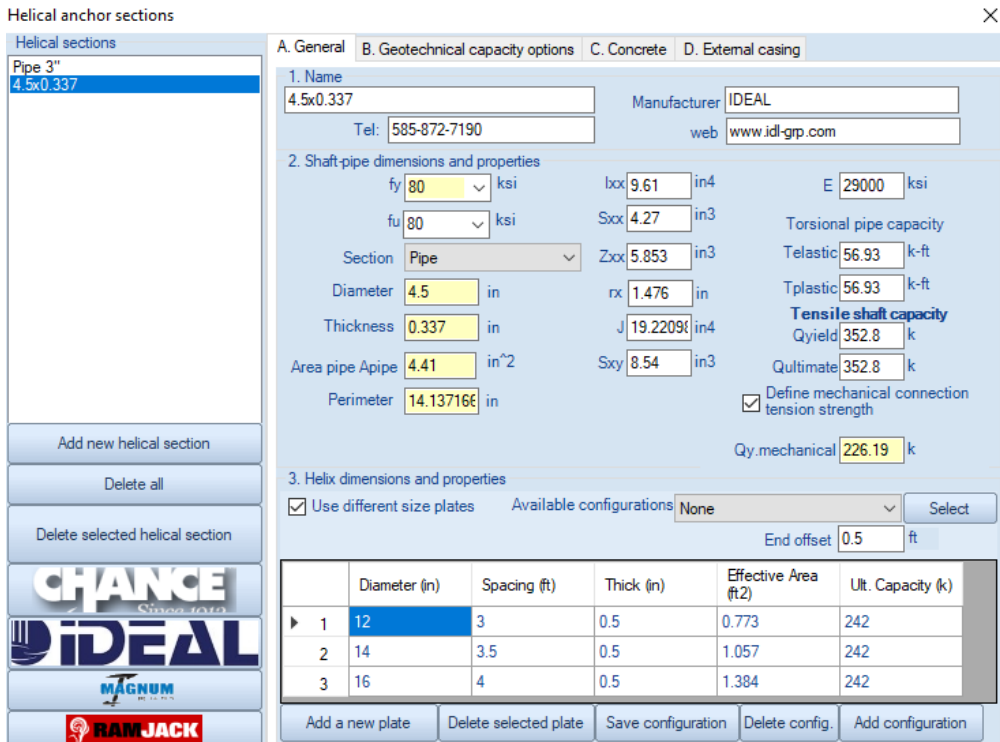


Figure 5: Pile Section Properties

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D.1. SINGLE PILE EXAMPLE – MODEL AND LOADS

In this case, we will design a single pile. Table 4 presents the external loads that are applied on the pile head. Figures 6 and 7 present the generated model and the pile depth optimization options respectively.

Table 4: Loads on the Pile Head (Tension and Compression)

STAGE/LOAD	Axial Load (Kips)	Lateral – X direction (Kips)	Lateral – Y direction (Kips)
Stage 0 (Compression)	80	5	5
Stage 1 (Tension)	-60	4	4

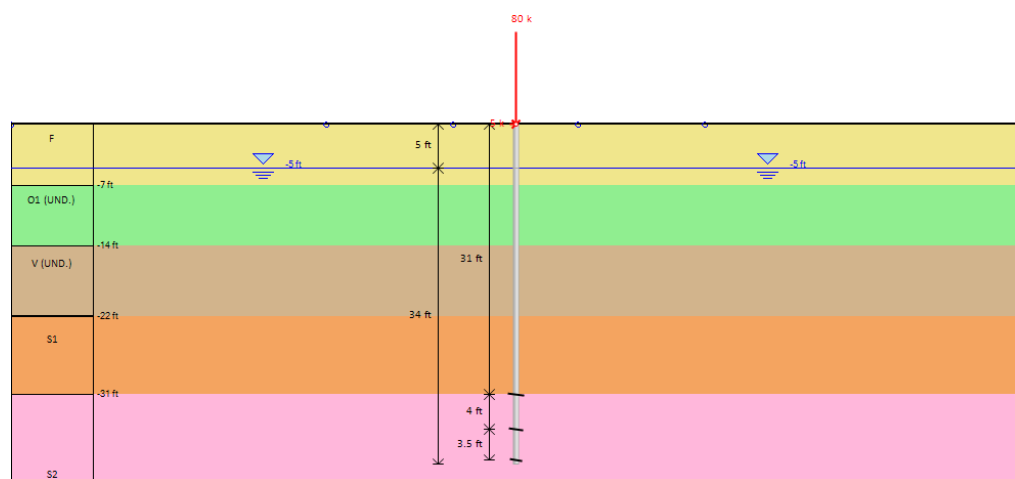


Figure 6: Single Pile – Generated Model (Stage 0 – Compression)

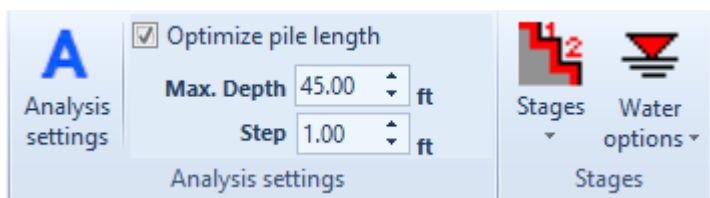


Figure 7: Pile Depth Optimization Settings

With the Pile Length Optimization option selected, the software starts from the pile free length L_{free} (5 ft in this example – defined in the Pile Properties dialog), and increased with the user-defined step length. On each step, the software calculates the design capacities (compression and tension), and compares them with the applied loads. The analysis stops when both the applied tension and compression loads are covered with the pile capacities at the examined depth, or when the maximum defined pile depth is reached.

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D.2. SINGLE PILE EXAMPLE – VERTICAL AND LATERAL ANALYSIS RESULTS

The optimized pile depth is 36 ft. Figures 8 to 10 present the calculated results in tables and graphs.

Extended vs Stage														
	Factored load comp. (k)	Factored load tension (k)	Capacity GEO. Comp. (k)	Capacity GEO. Tension (k)	Capacity STR. (k)	Comp. cylinder method (k)	Comp. plate method (k)	Tension cylinder method (k)	Tension plate method (k)	Stress check STR	Stress check GEO	Lat. Dx (in)	Lat. Fx (k)	Lat. M (k-ft)
▶ Stage 0	80	0	80.23	66.75	176.4	80.23	115.54	66.75	110.51	0.923	0.997	1.798	5	14.31
Stage 1	0	60	80.23	66.75	176.4	80.23	115.54	66.75	110.51	0.548	0.899	1.213	4	10.59

Figure 8: Analysis And Checking Summary Table

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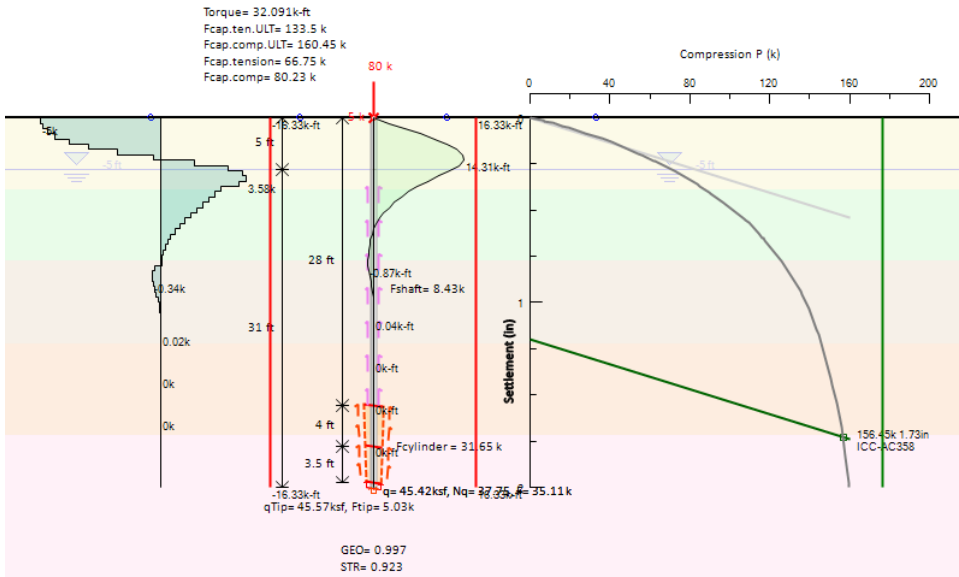


Figure 9: Pile Ultimate and Design Capacities, Wall Moment and Shear Graphs, Estimated Pile Settlements, Bearing Capacity (Cylinder Method)

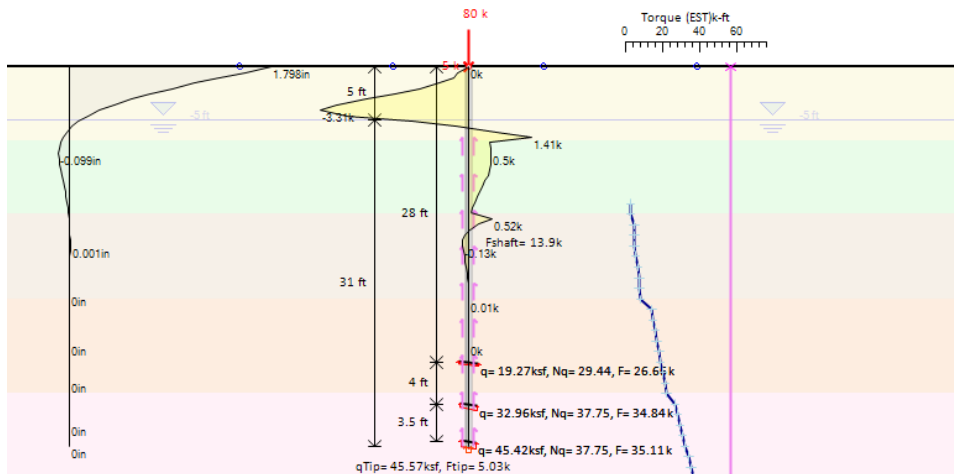


Figure 10: Axial load Distribution Along the Pile, Horizontal Soil Pressures and Pile Displacement Diagrams, Estimated Torque, Bearing Capacity (Individual Plates)

E.1. PILE GROUP EXAMPLE – DIMENSIONS AND LOADS

In this case, we will design a 3ft thick concrete circular pile cap (8ft Radius), supported by 17 helical piles. An 800 Kips vertical load and two lateral loads (a 60 Kips load along the local X axis and a 50 kips load along the local Y axis) are applied on the pile cap centroid. Figure 11 presents the pile cap dimensions and the loads applied on the cap centroid. Figure 12 presents the generated model (top view) with the axial load marked at the centroid.

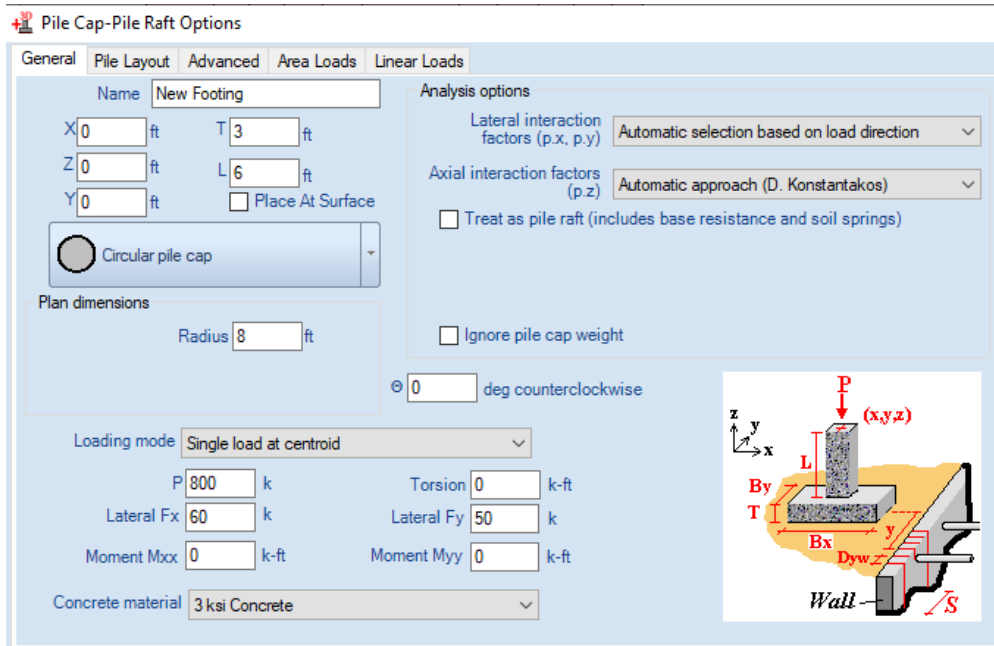


Figure 11: Pile Cap Dimensions and Loads at Centroid

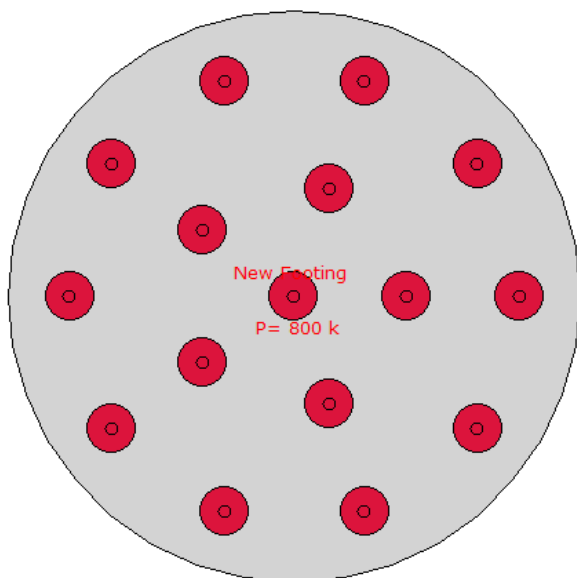


Figure 12: Model (Plan View)

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E.2. PILE GROUP – PILE LOCATIONS AND GENERATED MODEL 2D SECTION

In this case, 17 helical piles (PP4.5x0.337 with 3 helixes) have been distributed to the pile cap. Figures 13 and 14 present the piles layout (pile center local x and y coordinates) and the generated model (2D section – side view) respectively.

☰ Pile Cap-Pile Raft Options

General | **Pile Layout** | Advanced | Area Loads | Linear Loads

All coordinates are local to the pile cap (footing center)

	Pile Name	x	y	Length	Local Rotation	Edit Pile
▶	P1	6.312	0	39	0	Edit
	P2	5.10651...	3.71010...	39	0	Edit
	P3	1.95051...	6.00306...	39	0	Edit
	P4	-1.95051...	6.00306...	39	0	Edit
	P5	-5.10651...	3.71010...	39	0	Edit
	P6	-6.312	7.72971...	39	0	Edit
	P7	-5.10651...	-3.71010...	39	0	Edit
	P8	-1.95051...	-6.00306...	39	0	Edit
	P9	1.95051...	-6.00306...	39	0	Edit
	P10	5.10651...	-3.71010...	39	0	Edit
	P11	3.156	0	39	0	Edit
	P12	0.97525...	3.00153...	39	0	Edit

Figure 13: Pile Locations (Local X and Y Coordinates)

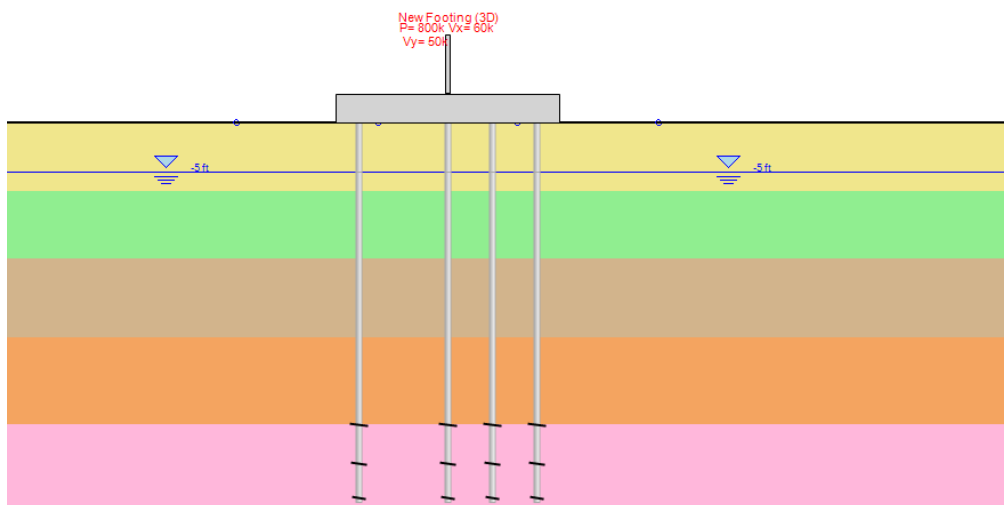


Figure 14: Generated Model – 2D Section Side View – Middle Pile Row

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E.3. PILE GROUP – ANALYSIS RESULTS (PILES SIDE VIEW)

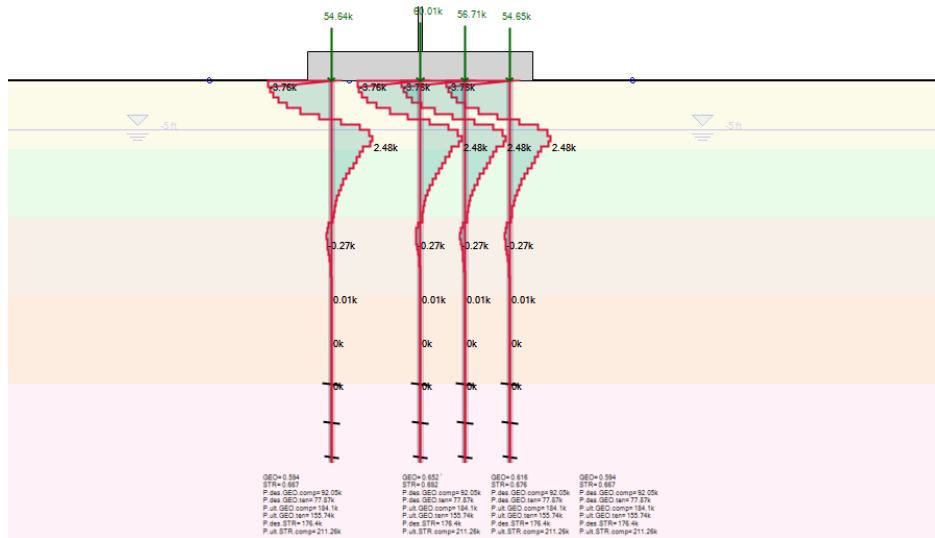


Figure 15: Pile Check Ratios, Shear Diagrams and Axial Forces (Middle Pile Row)

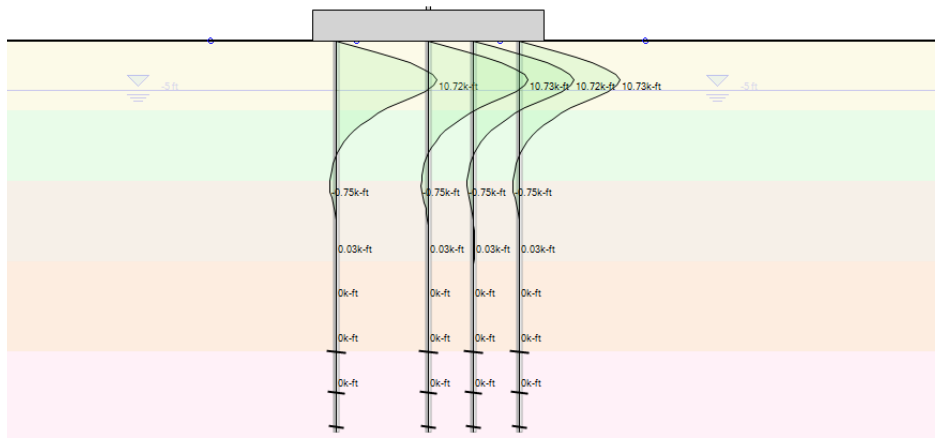


Figure 16: Pile Moment Diagrams – X-Axis (Middle Pile Row)

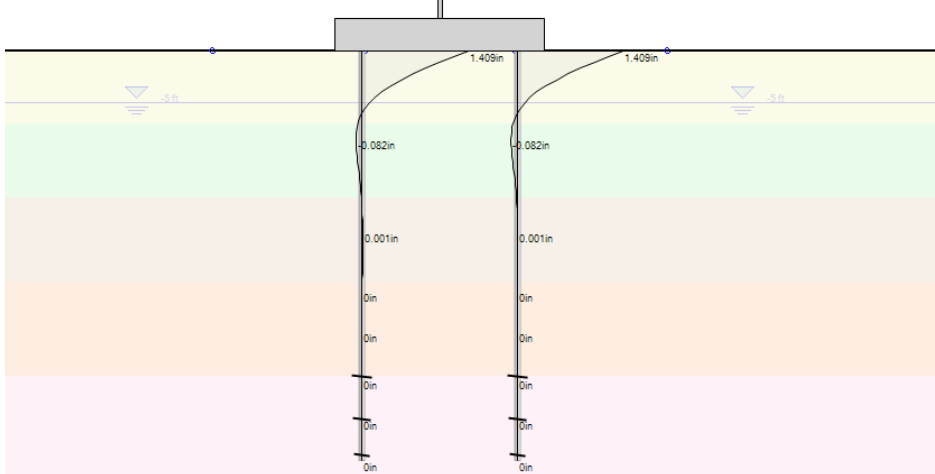


Figure 17: Pile Displacement Diagrams (Edge Pile Row)

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E.4. PILE GROUP – ANALYSIS RESULTS (PILE CAP AND 3D MODEL)

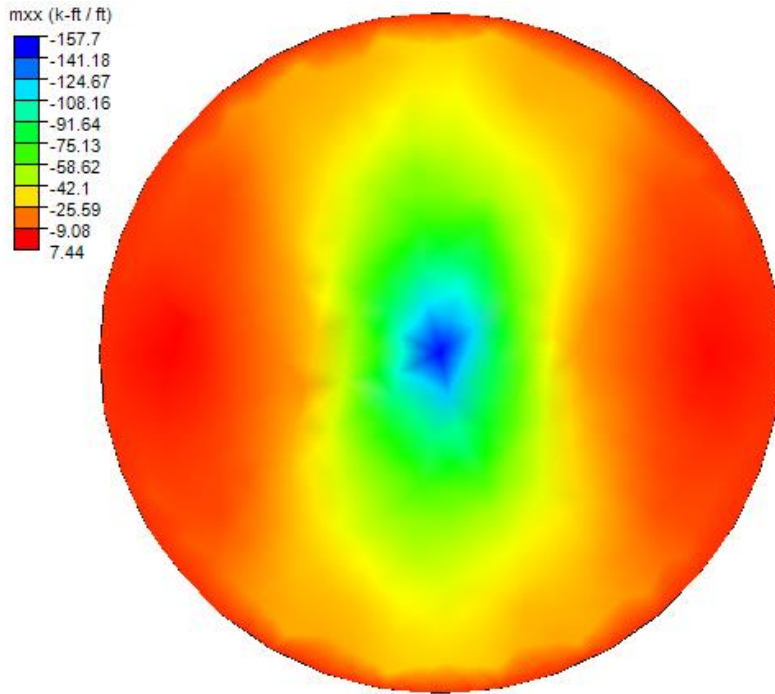


Figure 18: Pile Cap – Moments Shading (X-Direction)

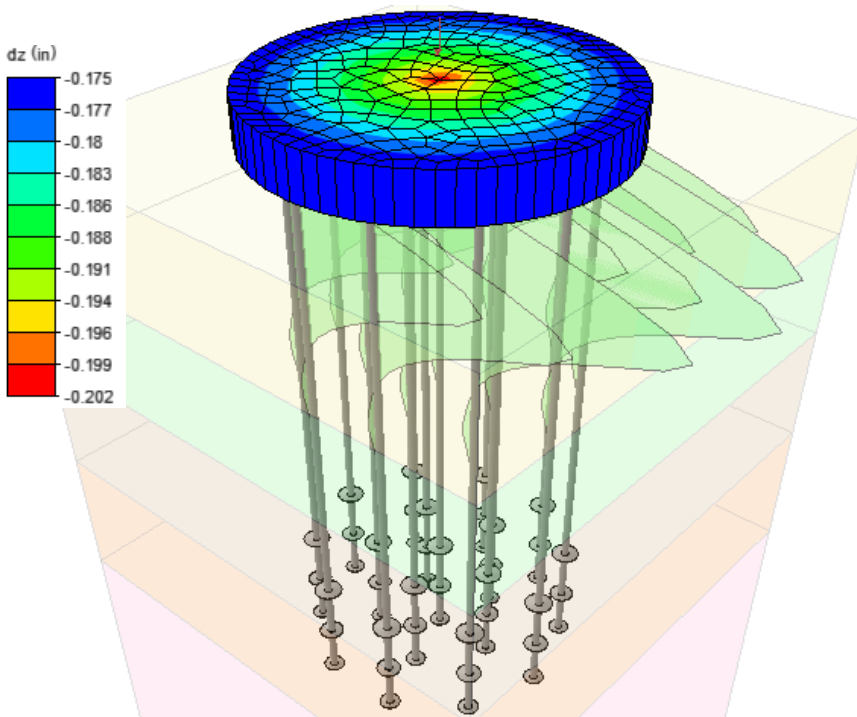


Figure 19: 3D Model – Pile Cap Settlements and Pile Moment Diagrams

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