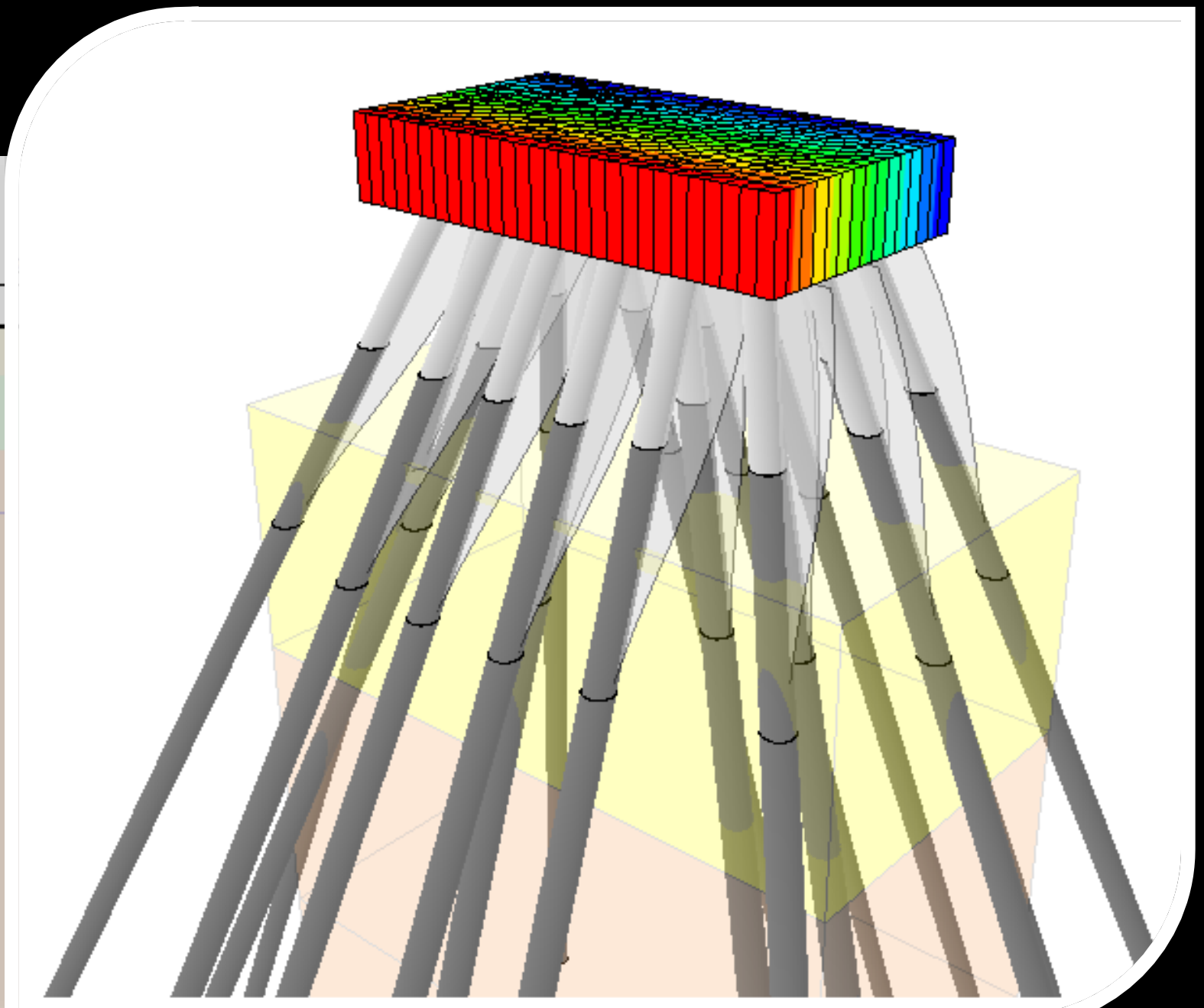
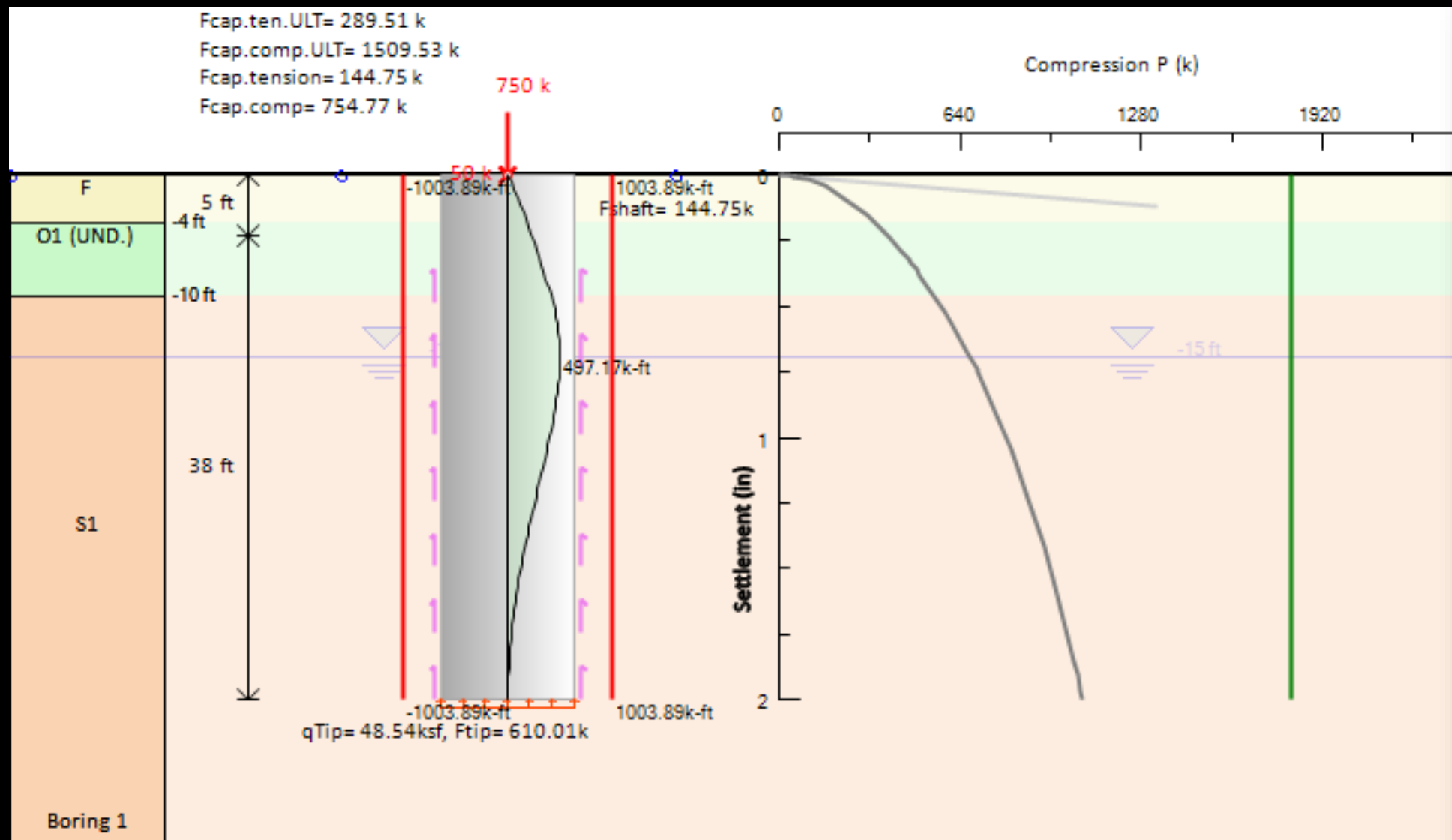


# Design of Deep Foundations - Methods and Software Application

Presentation: Dimitrios Mamoglou, Senior Engineer, Deep Excavation LLC  
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- Software solutions for excavation and foundation professionals
- Consulting Services - Design of deep excavations and pile foundations
- Virtual Reality applications for geotechnical engineers and contractors



DeepEX



HoloDeepEX



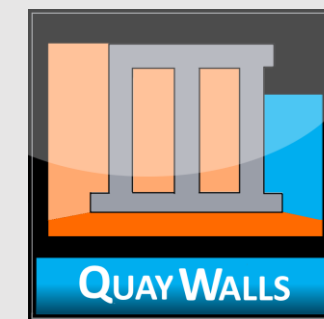
DeepFND



HelixPile



SnailPlus



QuayWalls



SiteMaster

## **PART 1: DeepFND/HelixPile Software Features and Analysis Methods**

**More information:**

**Click here to learn more:  
DeepFND - Features and Capabilities**

**Click here to learn more:  
HelixPile - Features and Capabilities**



Lateral and Vertical Analysis and Structural Design of all common pile types

Single Piles and Pile Groups

Non-Helical Piles

Installation Methods:

- ✓ Drilled Piles
- ✓ Driven Piles
- ✓ Caissons
- ✓ Micropiles
- ✓ CFA Piles
- ✓ Drilled-In-Displacement Piles

Pile Types:

- ✓ Concrete Sections: Rectangular, Circular, Circular Hollow, Octagon
  - ✓ Steel Sections (H-Beams, Pipes, Channels)
- ✓ Timber Piles (Wood)
- ✓ Belled Bottom
- ✓ Composite Section Along the Pile

Soil Springs & 3D Finite Element Analysis Methods

Single Piles and Pile Groups

Helical Piles

Pile Types - Helix Configuration - Casing:

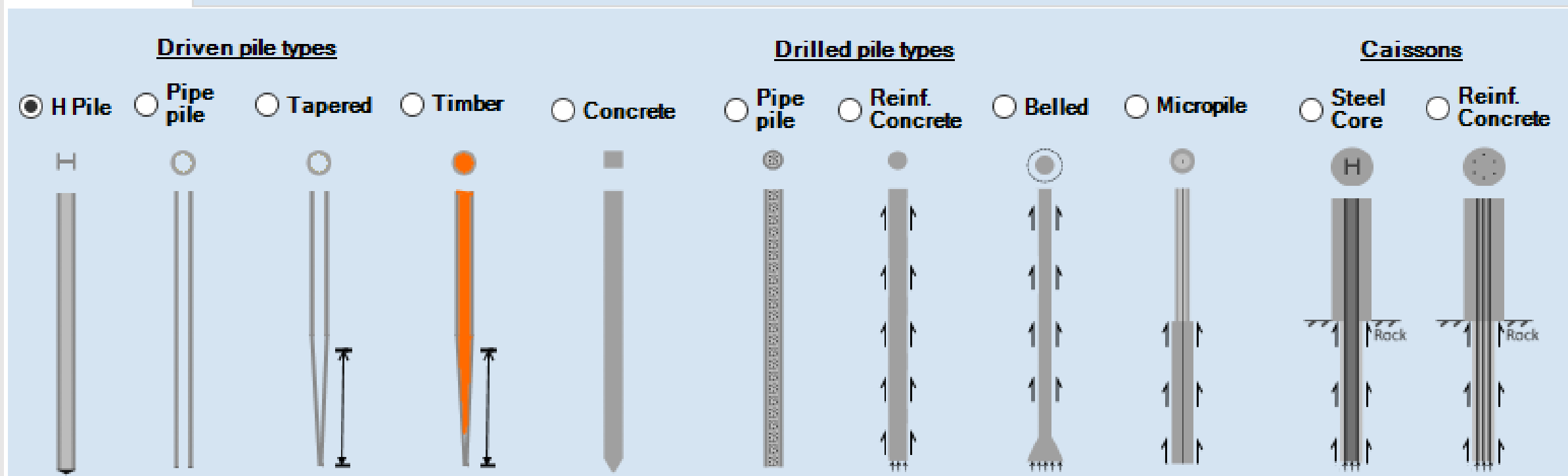
- ✓ Pipes
- ✓ Square Solid
- ✓ Square Hollow
- ✓ Include Several Helix Configurations on each Pile
- ✓ Use of External Casing
- ✓ Option to have Grouted Piles

Helical Piles also Analyzed with:



HelixPile: Helical Piles Design Software

Common pile types



Pile Sections:

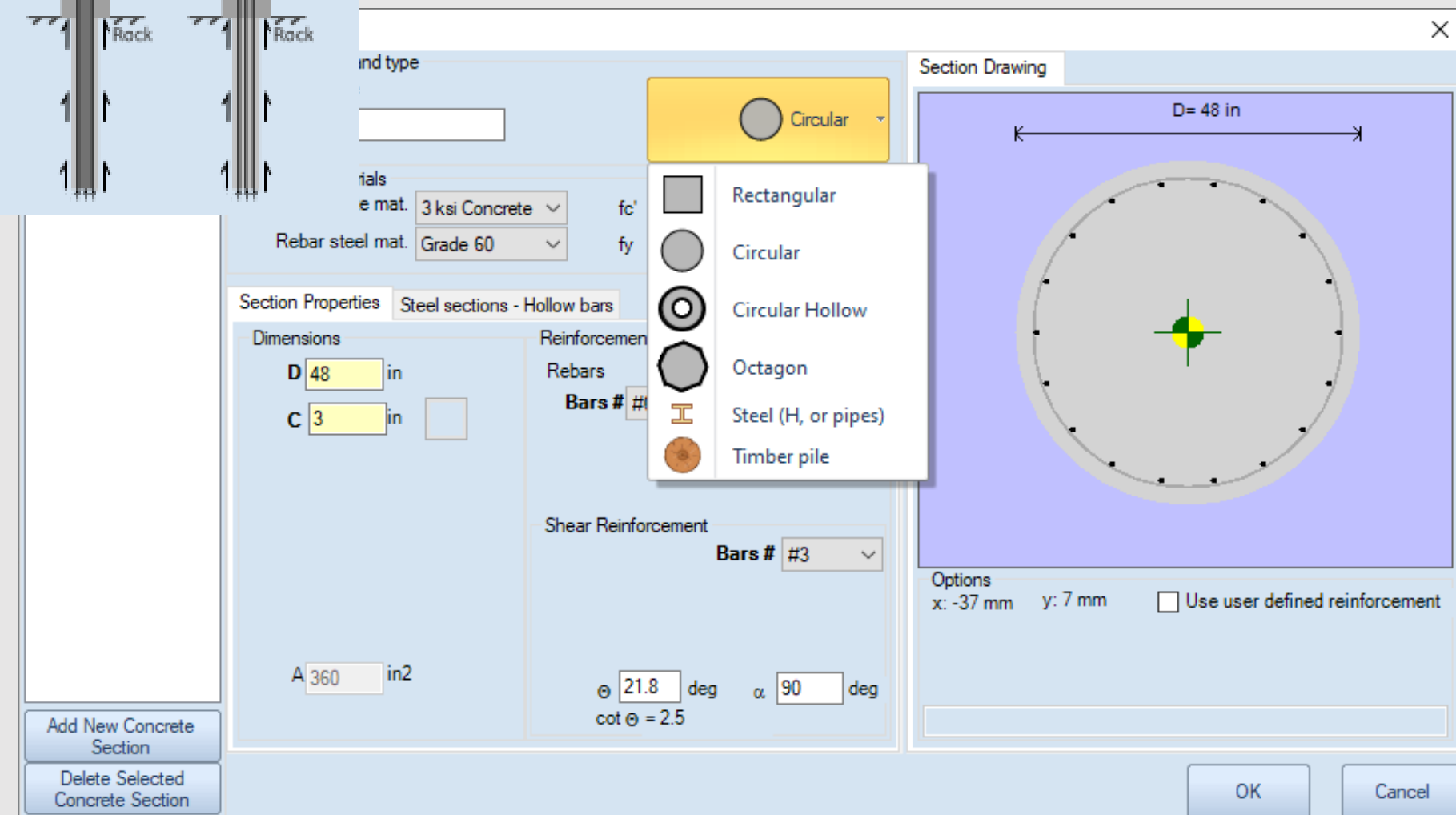
- Concrete Piles (Rectangular, Circular, Octagon)
- Circular Hollow Sections
- Composite Sections
- Steel Beams (Pipes, H beams, channel sections)
- Timber Piles (wood)
- Belled Bottom Piles

Installation Methods:

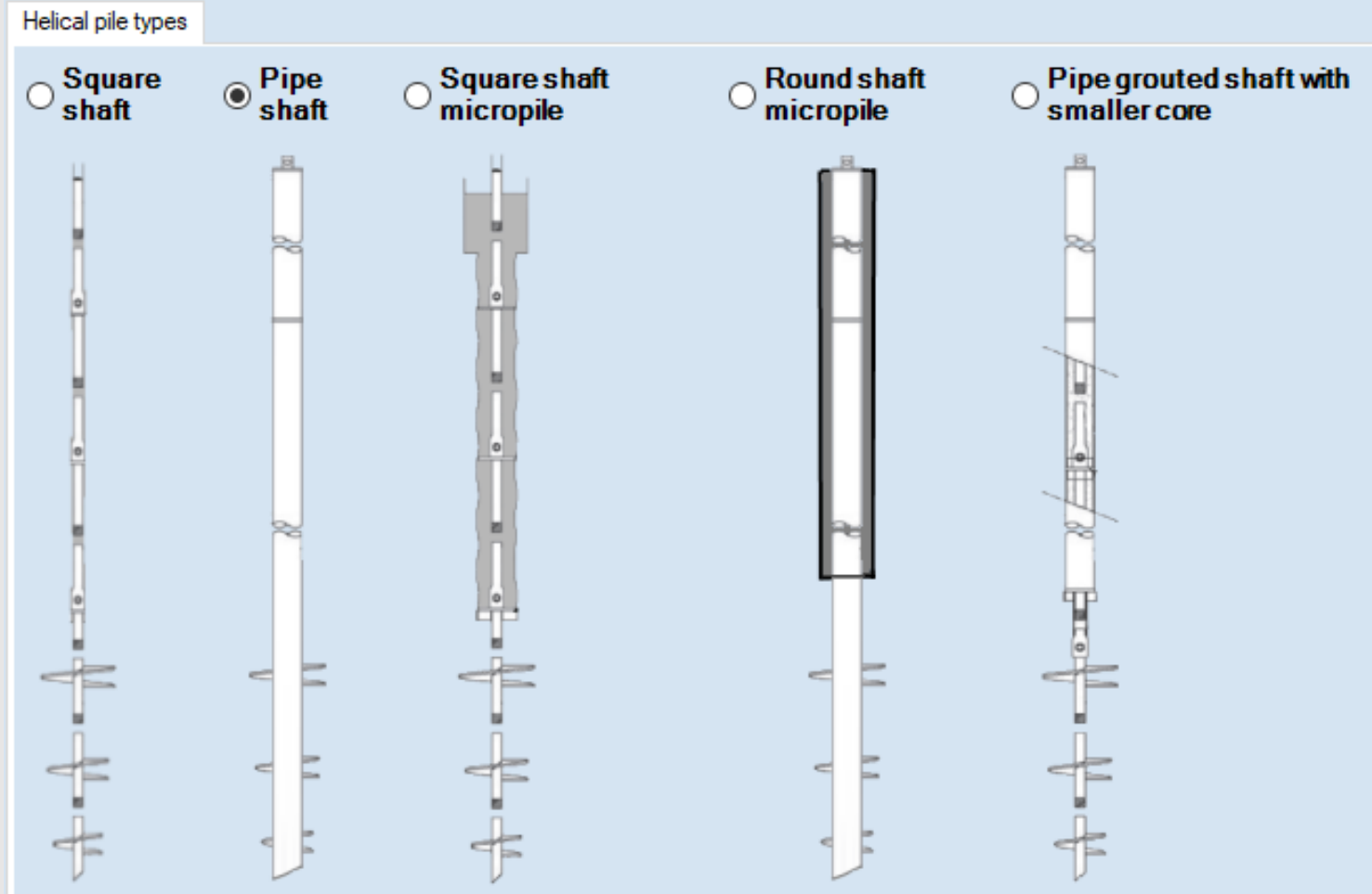
- Drilled Piles
- Driven Piles
- Caissons
- Continuous Flight Auger Piles (CFA)
- Drilled-In-Displacement Piles

Implemented Methods:

- FHWA GEC 8 and GEC 10
- AASHTO LRFD Norlund







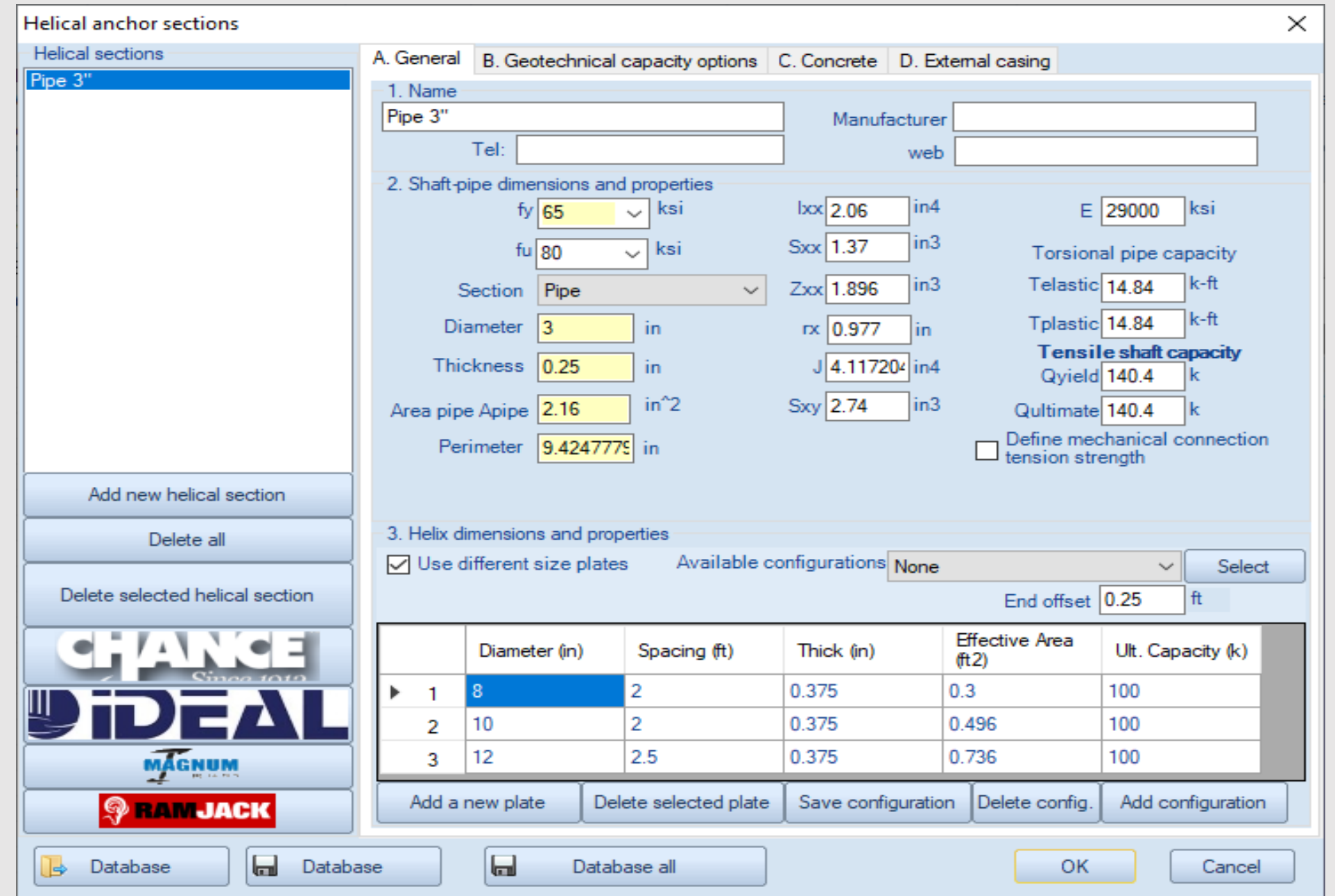
- ✓ Create and save to database multiple helical pile sections
- ✓ Each helical pile section can have multiple helix configurations
- ✓ Bearing capacity calculations, lateral pile analysis, installation torque estimation

### Available Helical Pile Types:

- Circular Hollow Piles
- Square Solid Piles
- Square Hollow Piles

### Bearing Capacity Methods for Helical Piles:

- Cylinder Method
- Individual Plate Method



**Helical anchor sections**

Helical sections

- Pipe 3"

Buttons: Add new helical section, Delete all, Delete selected helical section

Logos: CHANCE, IDEAL, MAGNUM, RAM-JACK

Database buttons: Database, Database, Database all, OK, Cancel

**Configuration Panel (Pipe 3")**

**A. General**

1. Name: Pipe 3" Manufacturer: \_\_\_\_\_ Tel: \_\_\_\_\_ web: \_\_\_\_\_

**2. Shaft-pipe dimensions and properties**

fy: 65 ksi lxx: 2.06 in<sup>4</sup> E: 29000 ksi  
 fu: 80 ksi Sxx: 1.37 in<sup>3</sup> Torsional pipe capacity  
 Section: Pipe Zxx: 1.896 in<sup>3</sup> Telastic: 14.84 k-ft  
 Diameter: 3 in rx: 0.977 in Tplastic: 14.84 k-ft  
 Thickness: 0.25 in J: 4.11720 in<sup>4</sup> **Tensile shaft capacity**  
 Area pipe A<sub>pipe</sub>: 2.16 in<sup>2</sup> Sxy: 2.74 in<sup>3</sup> Q<sub>yield</sub>: 140.4 k  
 Perimeter: 9.424777 in Q<sub>ultimate</sub>: 140.4 k  
 Define mechanical connection tension strength

**3. Helix dimensions and properties**

Use different size plates Available configurations: None Select  
 End offset: 0.25 ft

	Diameter (in)	Spacing (ft)	Thick (in)	Effective Area (ft <sup>2</sup> )	Ult. Capacity (k)
▶ 1	8	2	0.375	0.3	100
2	10	2	0.375	0.496	100
3	12	2.5	0.375	0.736	100

Buttons: Add a new plate, Delete selected plate, Save configuration, Delete config., Add configuration

- ✓ Create multiply soil types and define soil properties
- ✓ Soil properties estimation tools (NSPT values - test data)
- ✓ Create multiple borings and define the horizontal stratigraphy
- ✓ Add CPT logs and SPT Records - Estimate properties from records
- ✓ Custom Layer mode: Create inclined soil layers

**Soil Types**

Soil Types: F, O1, O2, S1, V, GT, R

1. Name and Basic Soil Type  
 Soil Name: F  
 Description: Miscellaneous fill

2. Soil Type - Behaviour  
 Sand  
 Silt  
 Rock  
 Clay  
 IGM (intermediate geo mat.)  
 Gravel

3. Default drained-undrained behavior for clays (See Theory Manual)  
 Undrained  
 Drained

A. General | B. Elasto-plastic | Lateral | E. Adv.

4. Unit Weights - Density  
 $\gamma_t$  120 pcf  
 $\gamma_{dry}$  120 pcf

5. Strength Parameters and Poisson Ratio  
 Drained strength properties  
 $c'$  0 psf  
 $\phi'$  30 degra  
 $\nu$  0.35

5. At-rest coefficients  
 $KoNC$  0.5  
 $nOCR$  0.5  
 $Ko = KoNC * (OCR)^{nOCR}$

6. Ultimate bond (grouted piles when bond option is s  
 $q_{skin.u}$  20 psf

Rock joints are open filled with gouge

Buttons: Add New Soil, Copy Soil, Delete Selected Soil, Delete all soils, Paste Soil, OK

**Soil Layers**

Available Borings: Boring 1

1. General Boring Information - Coordinates  
 Name: Boring 1  
 Coordinates X: 50 ft Y: 0 ft  
 The x coordinate controls where the boring is shown in your design section view. Each design section uses one boring (soil strata). You can use a different boring on each design section.

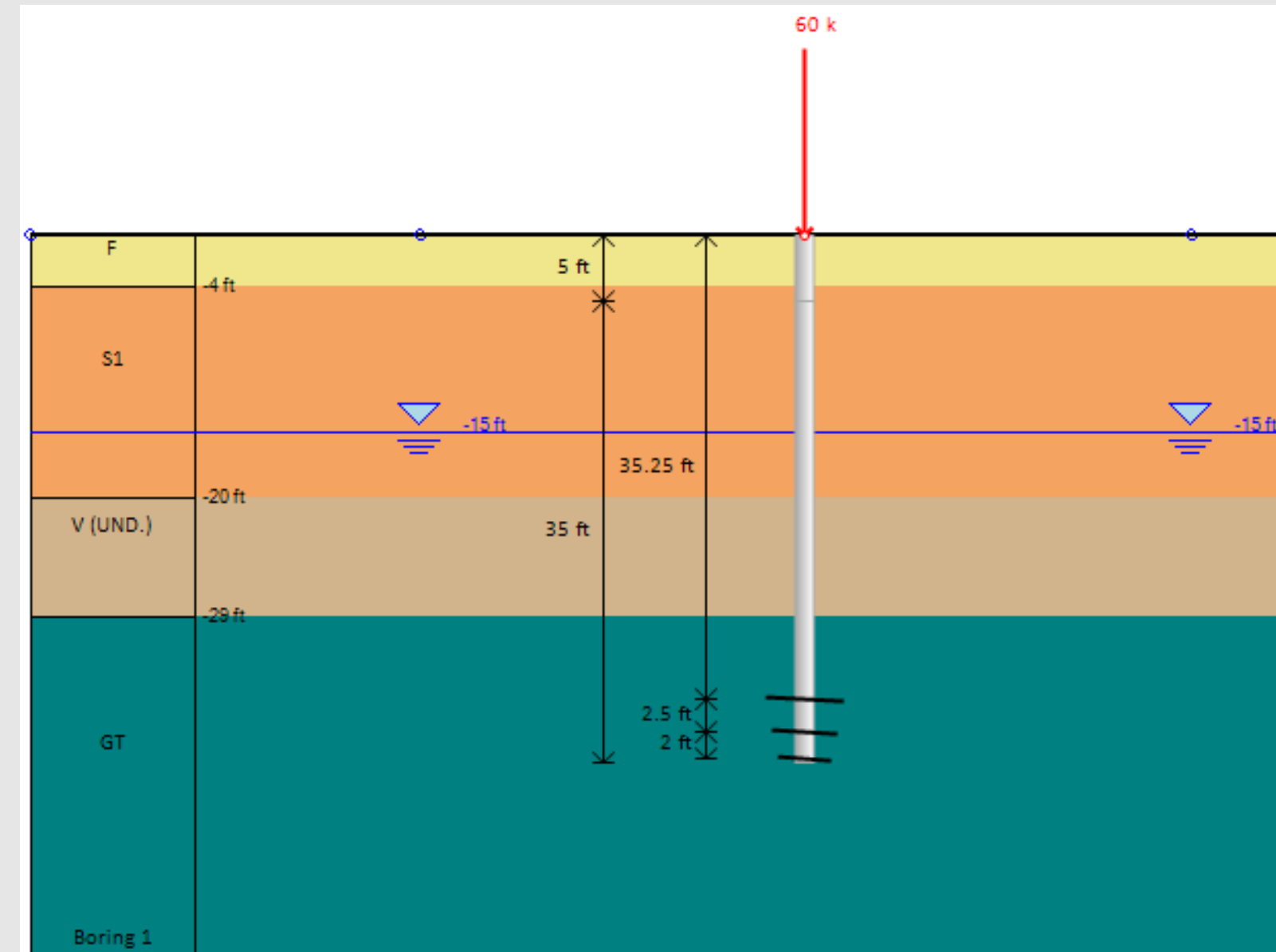
SPT Data Option (Applies to Design Section)  
 SPT Record: Not assigned  
 Add edit SPT records

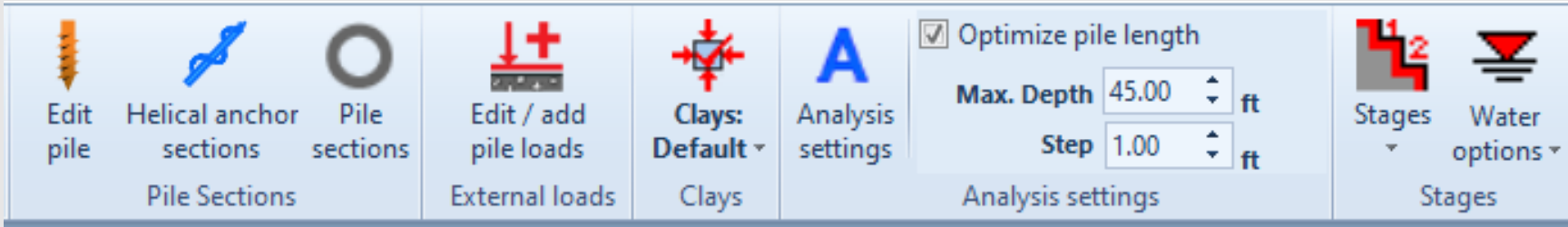
CPT Record Option (Applies to Design Section)  
 CPT Record: Not assigned  
 Add edit CPT records

2. Boring Layers - Layer Elevations

Top	Soil type	OCR	Ko	Edit
0	F	1	0.5	Edit
-4	S1	1	0.441	Edit
-20	V	1	0.531	Edit
-29	GT	1	0.412	Edit

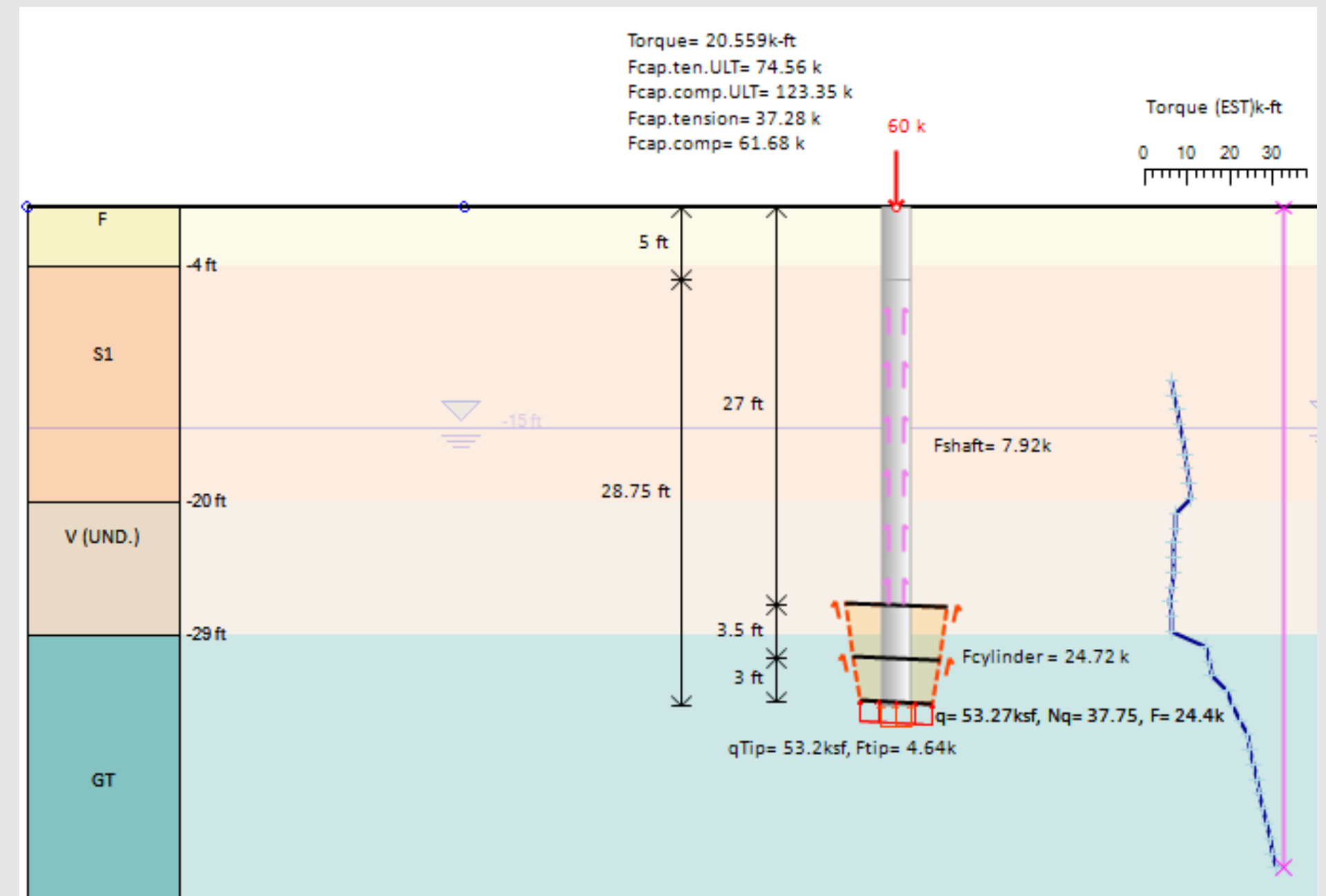
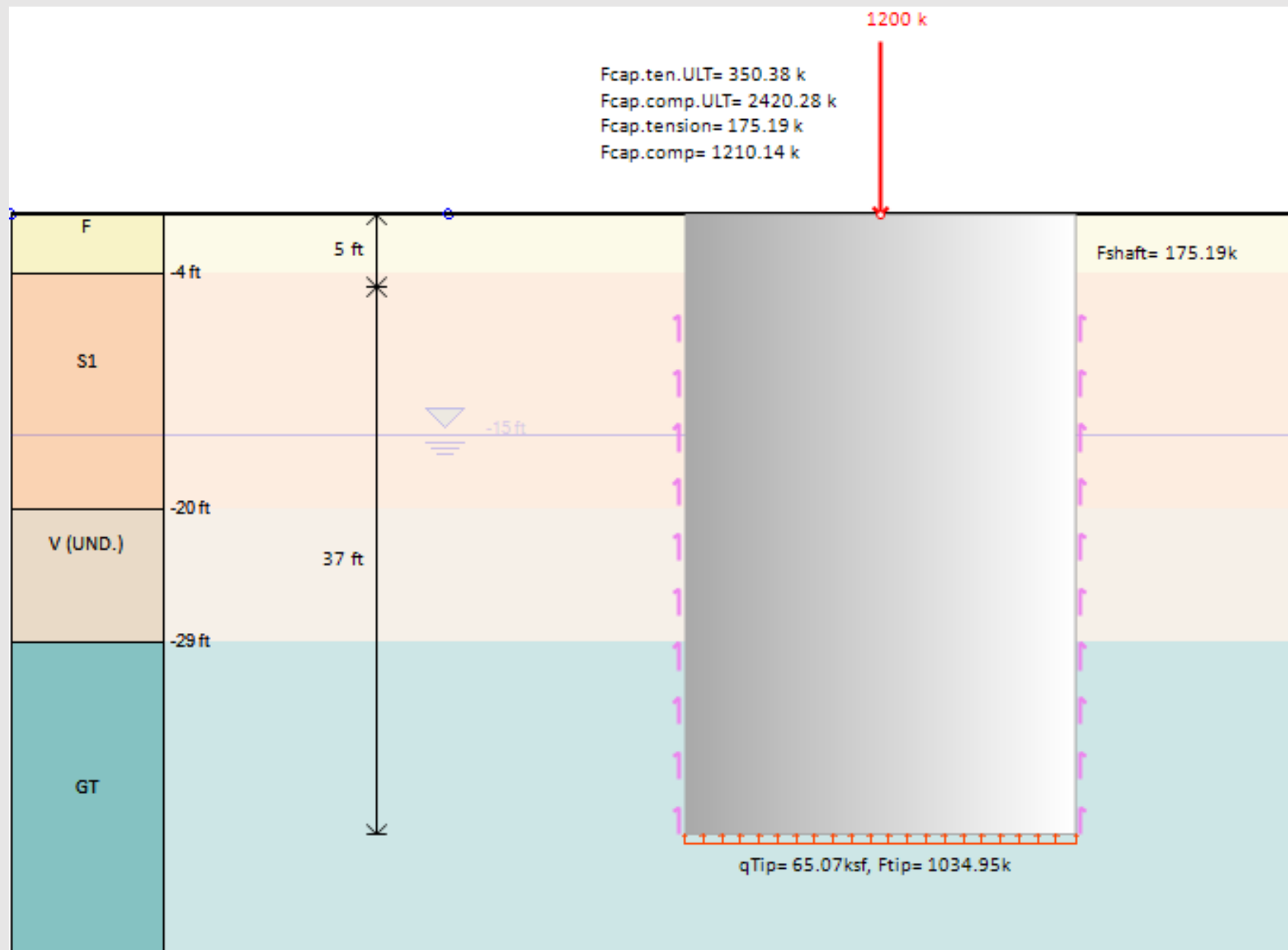
Buttons: Add New Boring, Delete Selected Boring (Stratigraphy), Clone Boring, Insert Layer, Delete Layer, OK, Cancel





Optimize pile length  
 Max. Depth: 45.00 ft  
 Step: 1.00 ft  
 Analysis settings

- ✓ Add axial loads on the pile head (tension - compression)
- ✓ Calculate tension - compression bearing capacity
- ✓ Optimize pile length for the defined tension and compression loads





- ✓ Option to estimate pile settlements
- ✓ Pile acceptance criteria: Davisson, ICC 355, NYC 2011, Butler-Hoy and more
- ✓ Estimate pile structural capacity from pile criteria
- ✓ Add and review Axial Load Tests

**Pile acceptance criteria**

Available criteria

- Elastic
- ICC-AC358

Acceptance criteria

1. Name  
Elastic Color

2. Set active/visible

Criterion is active (to be analyzed)

Criterion is visible (on graphs)

3. Equation

$$y = 0 + 0 D_{PL} + 0 D_S + 1 PL/AE$$

$D_{PL}$  = Plate diameter       $D_S$  = Shaft diameter

Average plate size v

Define maximum net settlement

Ultimate load criterion (Criteria determines ultimate load)

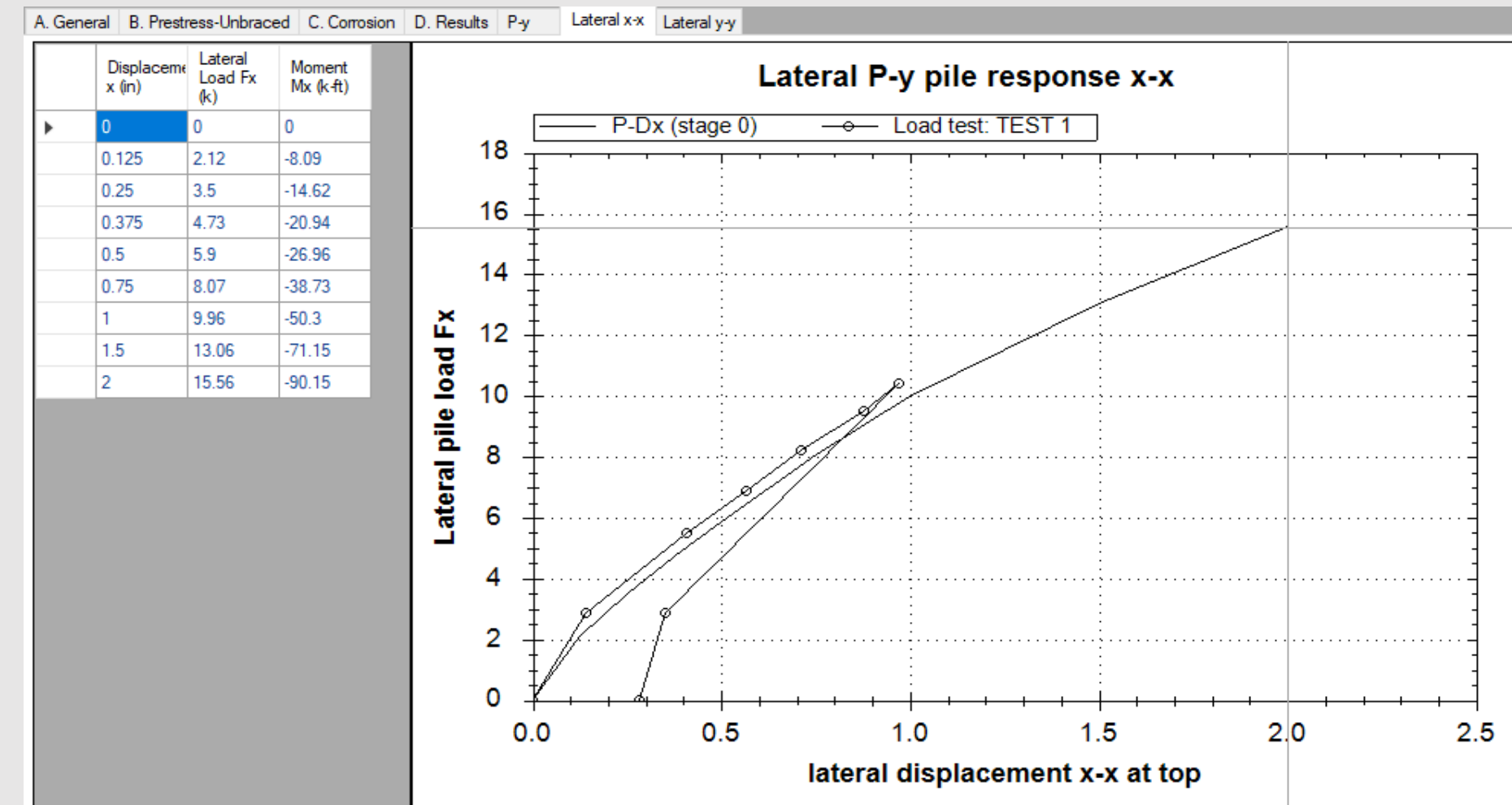
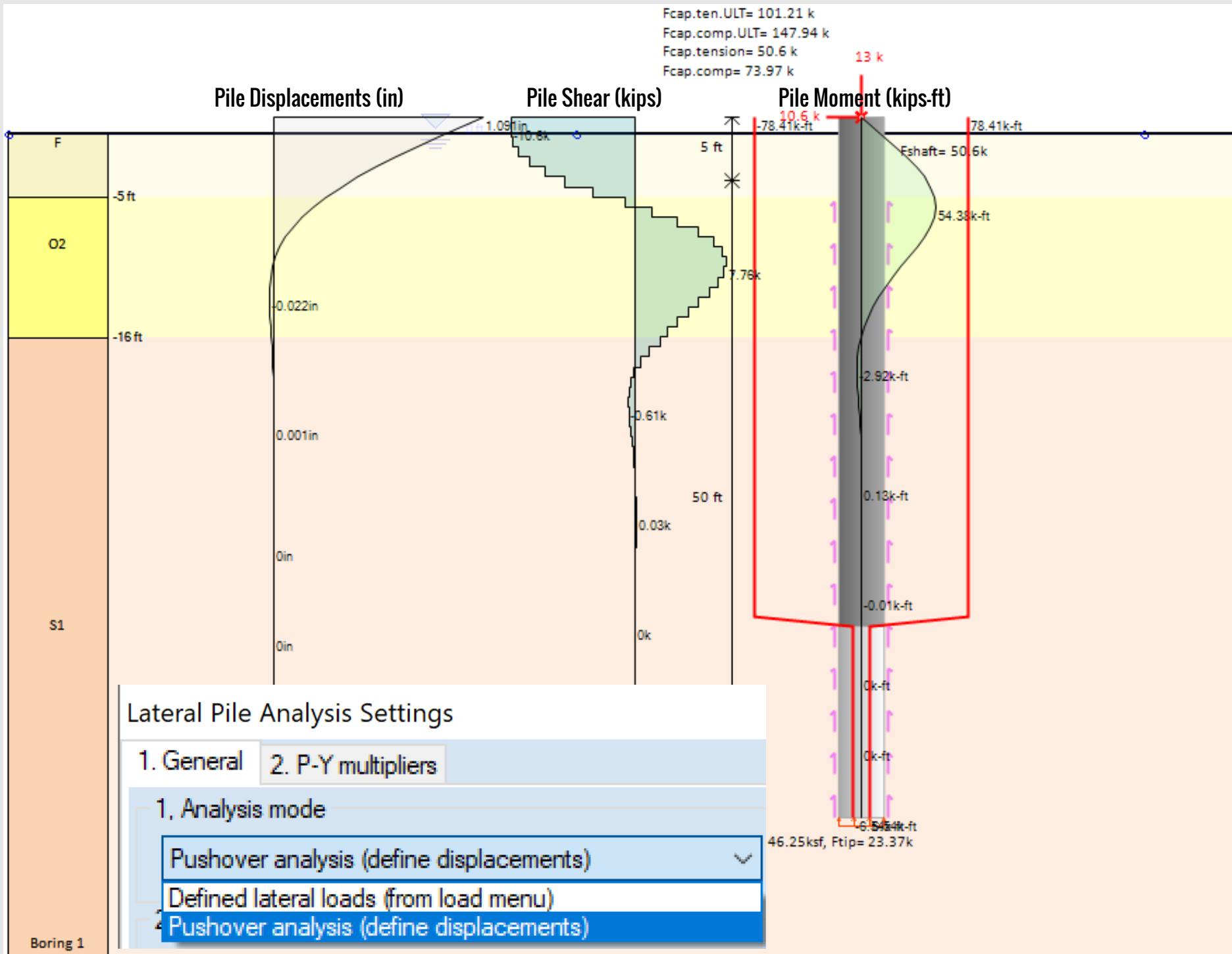
Determine load from criterion

Use deflection load slope

Buttons: Add new criteria, Delete criteria, Reset to Elastic, Reset to ICC355, Reset to Davisson, Butler-Hoy, NYC 2011-011, OK, Cancel



- ✓ Define lateral loads on the pile head (both local X and Y directions)
- ✓ Define lateral soil properties (implemented PY models for different soil types)
- ✓ Calculate lateral pile displacements for defined loads
- ✓ Perform pushover analysis
- ✓ Add and review lateral load tests
- ✓ Calculate pile moment and shear diagrams



- ✓ Structural Design Codes: ACI, AISC, LRFD, Eurocodes 2, 3 & 8, AS3600, AS 4100, CN + more
- ✓ Calculate moment capacity
- ✓ Perform all checks according to the selected design standard
- ✓ Export detailed report with all structural design calculations

Structural code options

Concrete Code Options

- 1:ACI 318-11
- 2:EC2-2004
- 3:EC2-German Annex
- 4:EC2-Cyprus Annex
- 5:EC2-French Annex
- 6:EC2-Austrian Annex
- 7:EC2-Italian Annex
- 8:EC2-Netherlands Annex
- 9:EC2-Czech Annex
- 10:EC2-Belgium Annex
- 11:EC2-Slovakian Annex
- 12:EC2-Danish Annex
- 13:EC2-Finish Annex
- 14:EC2-Swedish Annex
- 15:EC8-Greek Annex
- 16:EC8-Italian Annex
- 17:EC8-Austrian Annex
- 18:EC8-Bulgarian Annex
- 19:EC8-Cyprus Annex
- 20:EC8-Slovenian Annex
- 21:EC8-French Annex
- 22:EC2-Greek Annex
- 23:EC2-2004
- 24:AS 3600-2009
- 25:CN (China)

Steel Code Options

- 17:AISC 360-10 ALL.
- 1:ASD 1989
- 2:EC3 2005-CEN
- 3:LRFD 13th Edition 2005
- 4:NTC 2008
- 5:EC3 2005-Bulgaria
- 6:EC3 2005-Slovenia
- 7:EC3 2005-UK
- 8:EC3 2005-Norway
- 9:EC3 2005-Sweden
- 10:EC3 2005-Finland
- 11:EC3 2005-Denmark
- 12:EC3 2005-Portugal
- 13:EC3 2005-Germany DIN
- 14:EC3 2005-Singapore
- 15:EC3 2005-Greece
- 16:ANSI/AISC 360-10
- 17:AISC 360-10 ALL.
- 18:BS 5950-1:2000
- 19:AS/NZS 4100
- 20:CN (China)
- 21:ANSI/AISC 360-16
- 22:AISC 360-16 ALL.

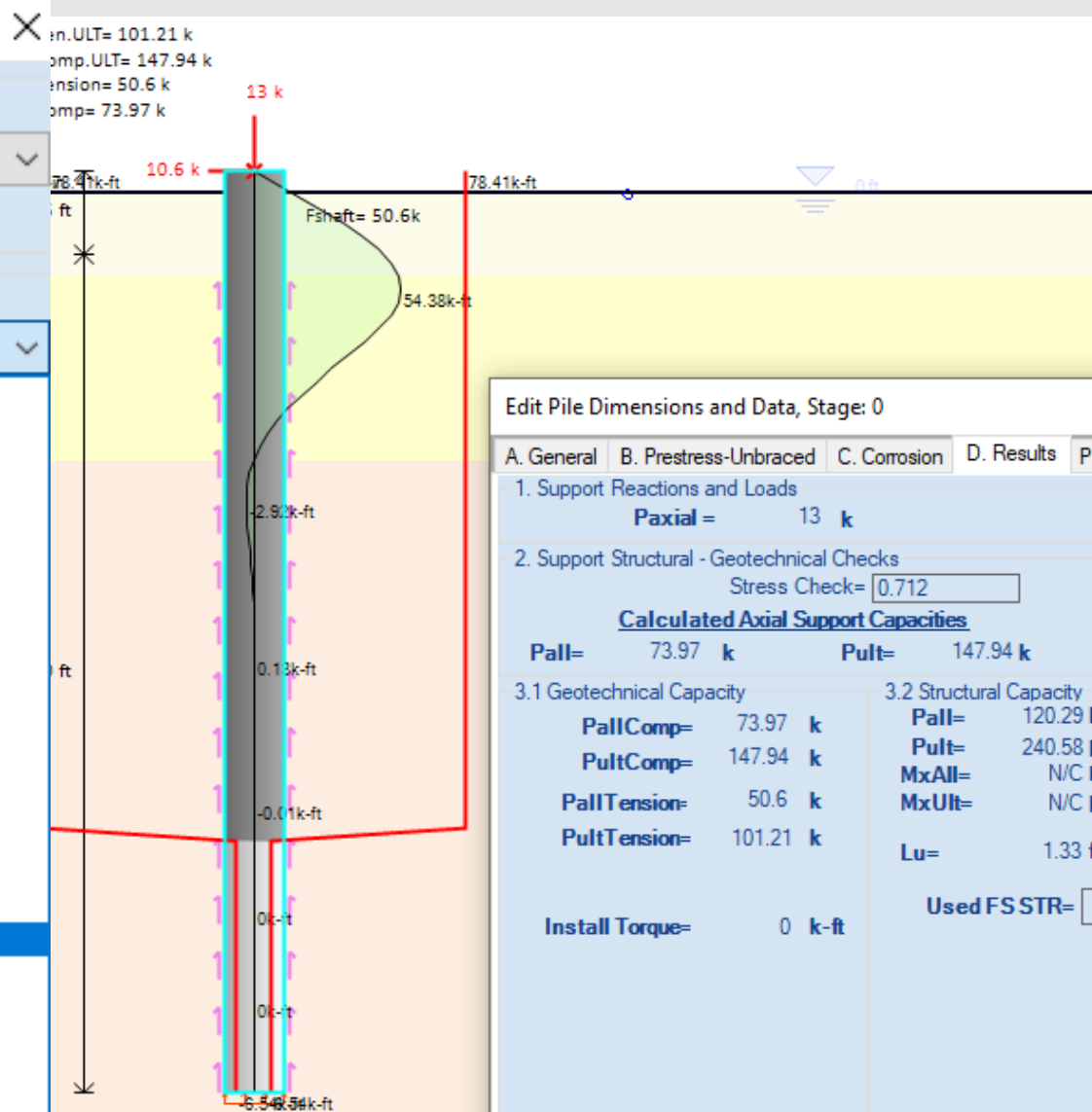
Structural code options

Concrete Code Options

- 1:ACI 318-11

Steel Code Options

- 17:AISC 360-10 ALL.



Edit Pile Dimensions and Data, Stage: 0

A. General B. Prestress-Unbraced C. Corrosion D. Results P-y

1. Support Reactions and Loads

Paxial = 13 k

2. Support Structural - Geotechnical Checks

Stress Check= 0.712

Calculated Axial Support Capacities

Pall=	73.97 k	Pult=	147.94 k
-------	---------	-------	----------

3.1 Geotechnical Capacity

PallComp=	73.97 k
PultComp=	147.94 k
PallTension=	50.6 k
PultTension=	101.21 k

3.2 Structural Capacity

Pall=	120.29 k
Pult=	240.58 k
MxAll=	N/C k
MxUlt=	N/C k
Lu=	1.33 ft

Install Torque= 0 k-ft

Used FSSTR=

calculations

Calculate pile capacities for stage : Stage 0

FS SHAFT.RESISTANCE = 2 (preliminary geotechnical)

FS BEARING.RESISTANCE = 2 (geotechnical)

Basic description of shaft strength calculations, stage: 0

Lateral earth stresses determined with Mitch-Clemence approach:

$k_h = 0.09 (e)^{0.08 \Phi} = \text{normal stress}$

Adhesion values determine from cohesion or undrained shear strength with the following method:

By using a tri-linear approach similar to API, where:

$\alpha \text{ c.factor.1} = 0.8$  when  $c$  is smaller than  $c = 1\text{ksf}$

$\alpha \text{ c.factor.2} = 0.5$  when  $c$  is greater than  $c = 2\text{ksf}$

A linear interpolation is assumed for intermediate values

$\beta = 90$  degrees. pile angle

## PART 2: DeepFND/HelixPile Additional Modules and Standard Packages

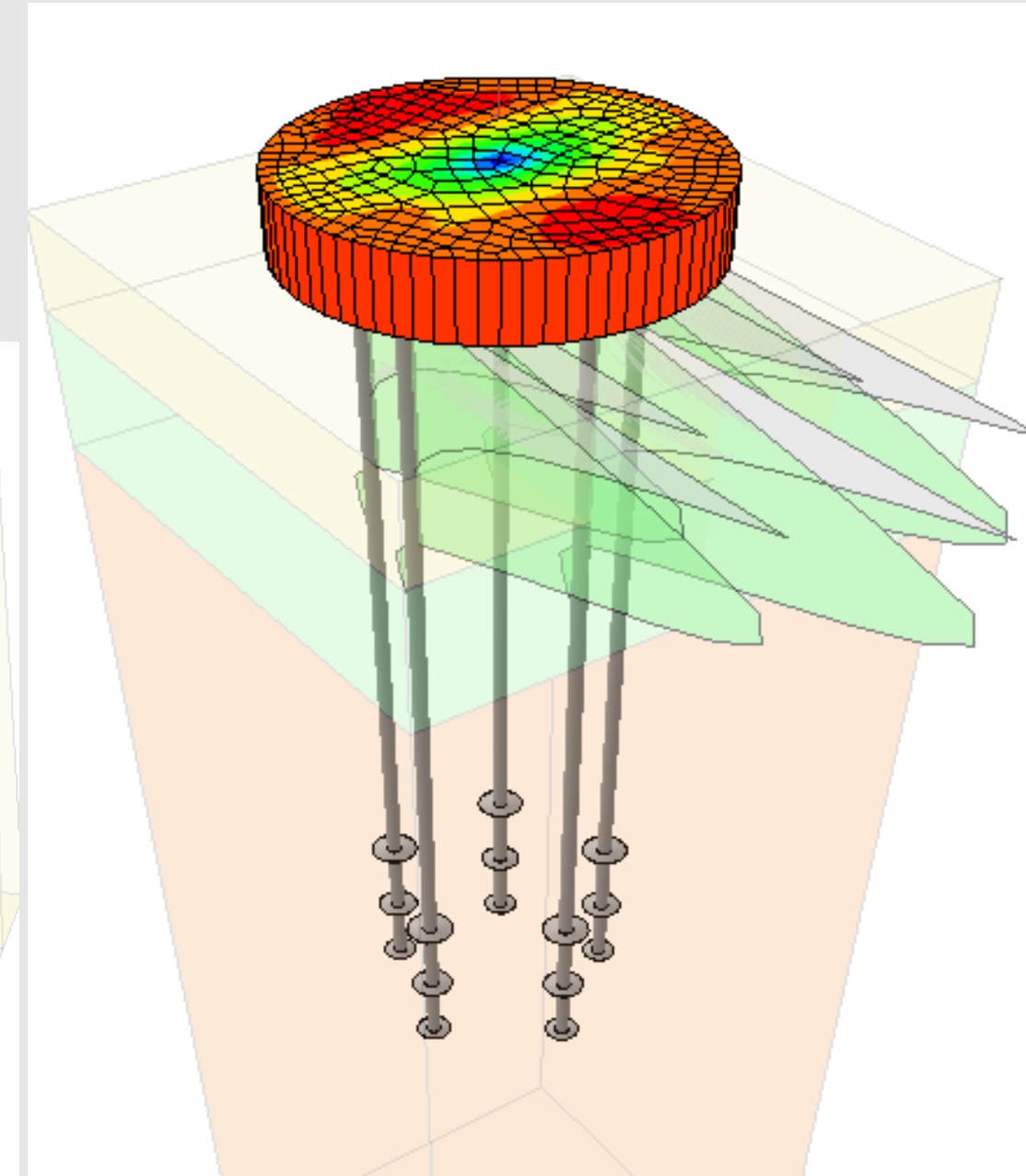
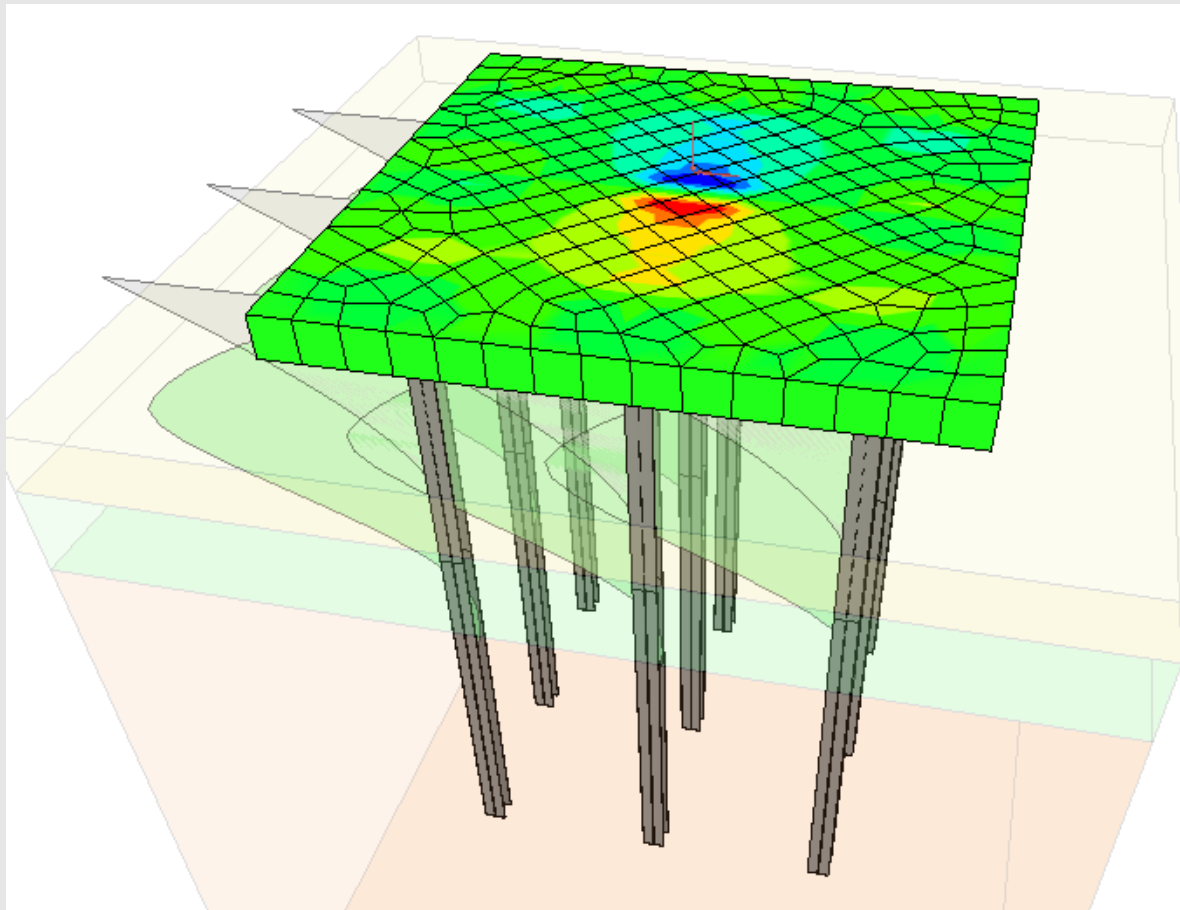
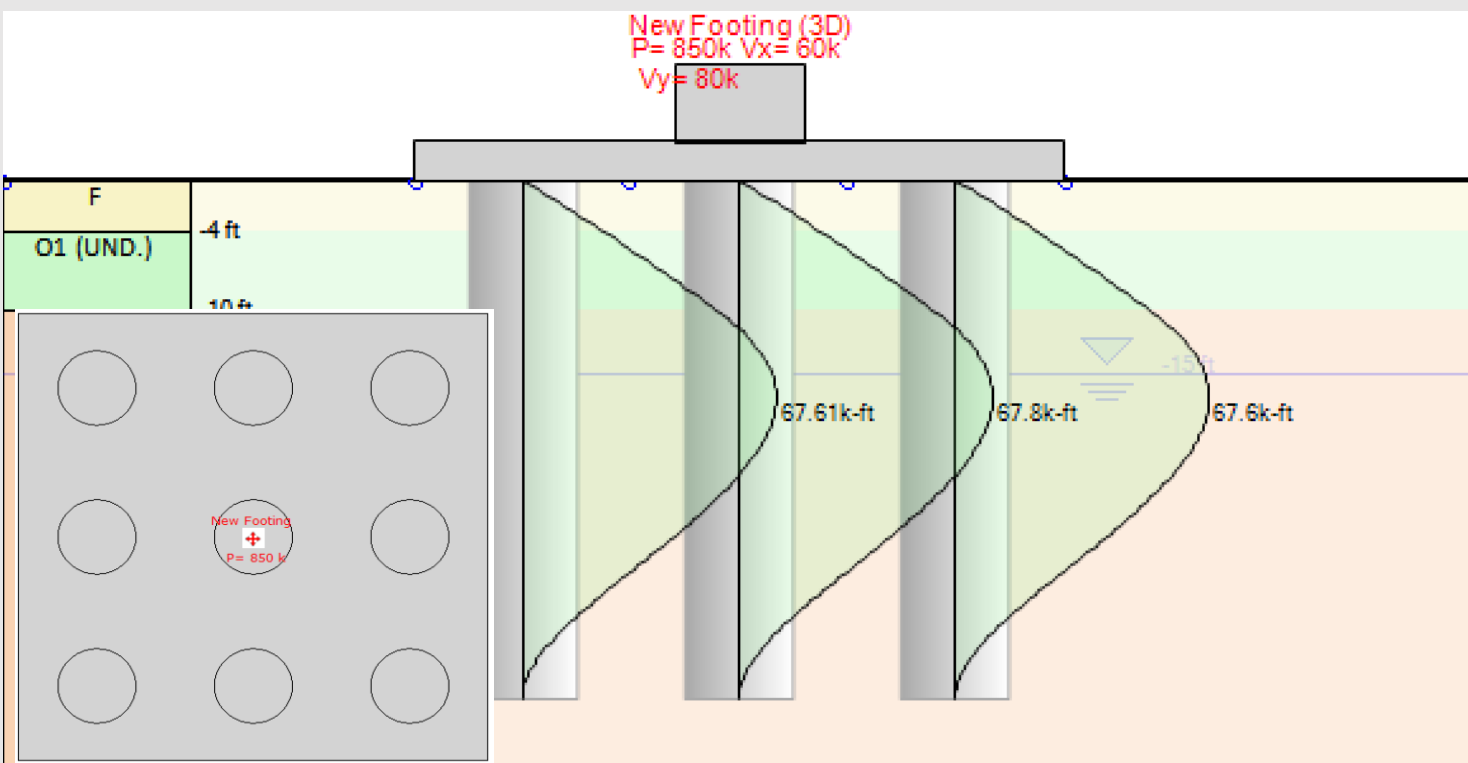
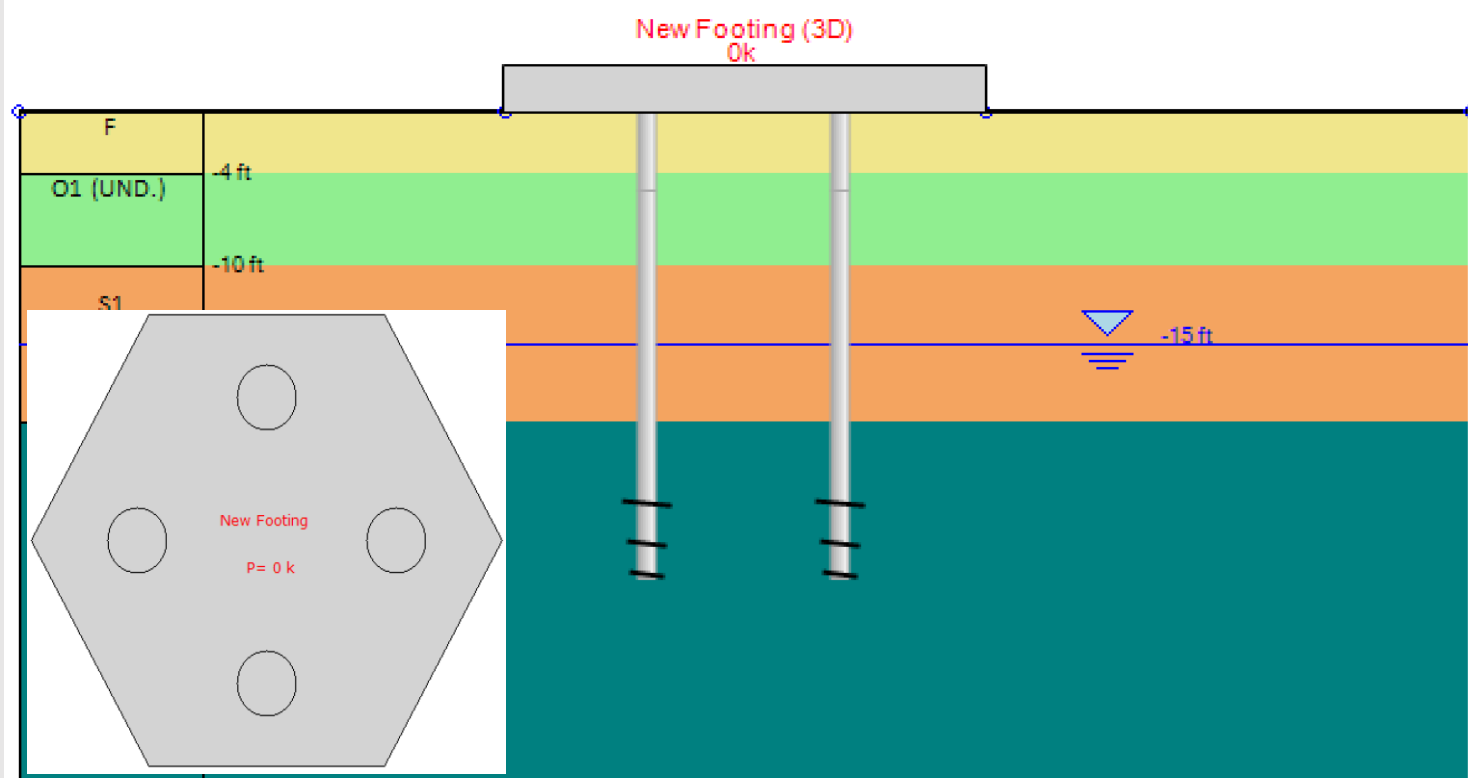
**More information:**

**Click here to learn more:  
DeepFND - Features and Capabilities**

**Click here to learn more:  
HelixPile - Features and Capabilities**

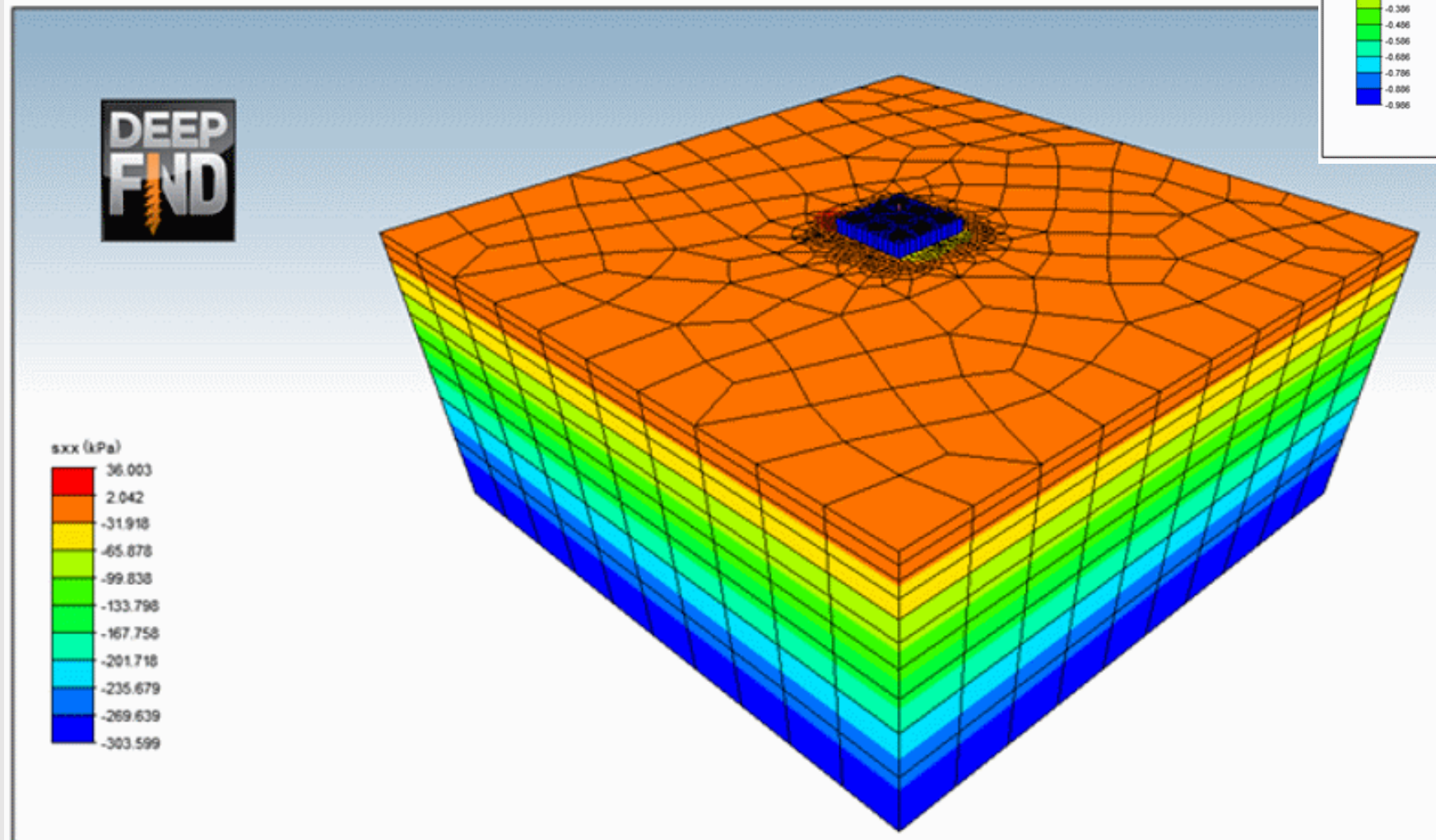
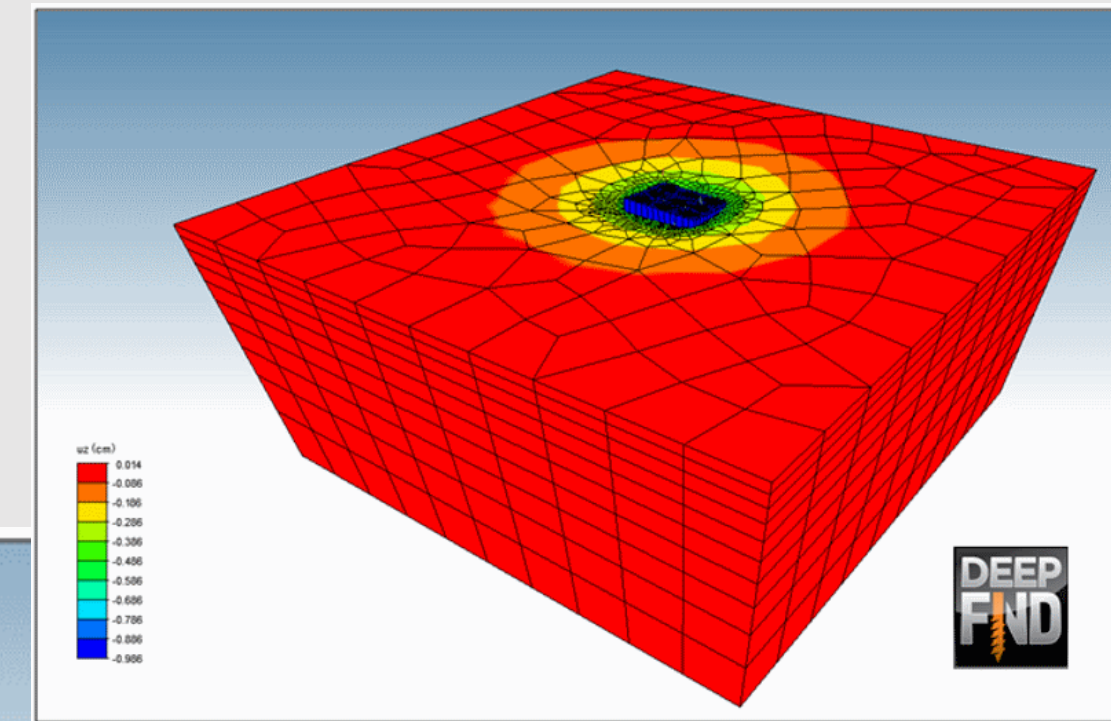
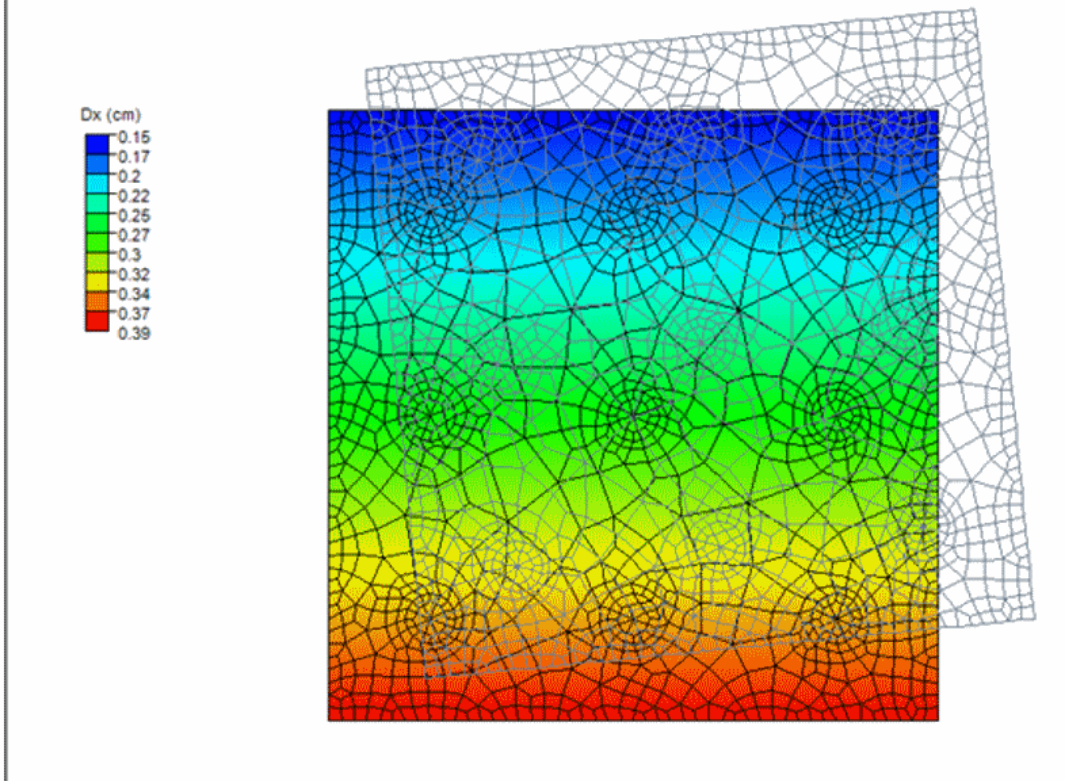
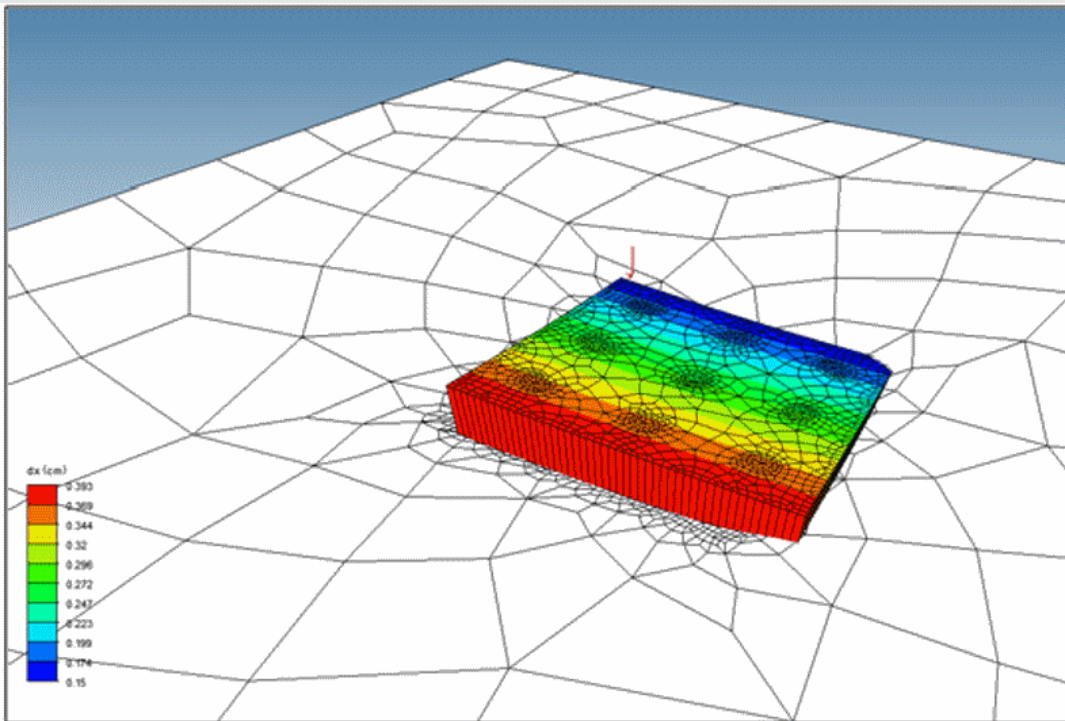


- ✓ Create pile caps of any shape
- ✓ Define pile configurations (positions, structural sections)
- ✓ Distribute the loads applied on the cap to each pile, according to the pile position
- ✓ Design all piles and the pile cap
- ✓ Top view/side section view/3D model
- ✓ Option that the pile cap behaves as pile raft



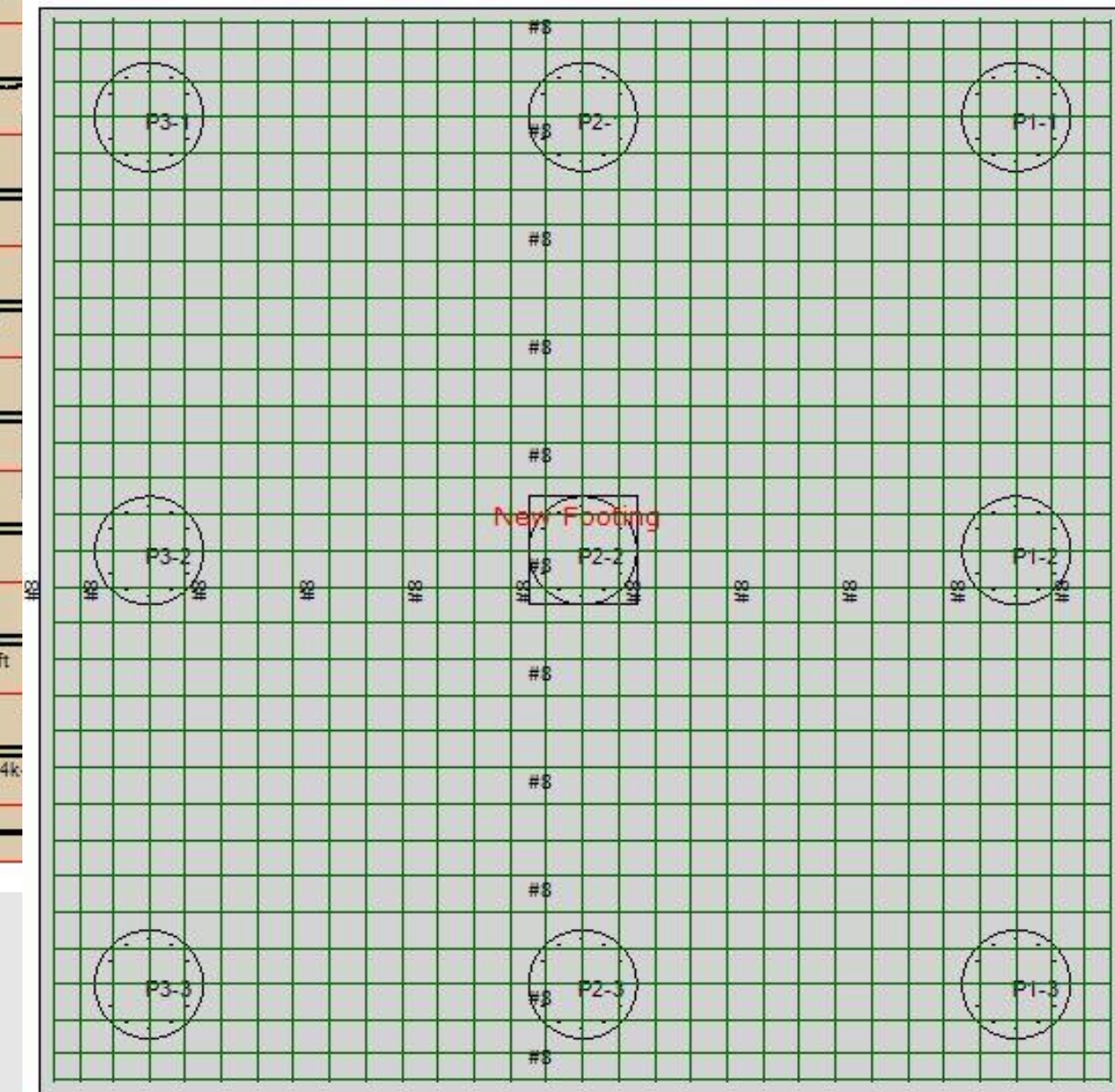
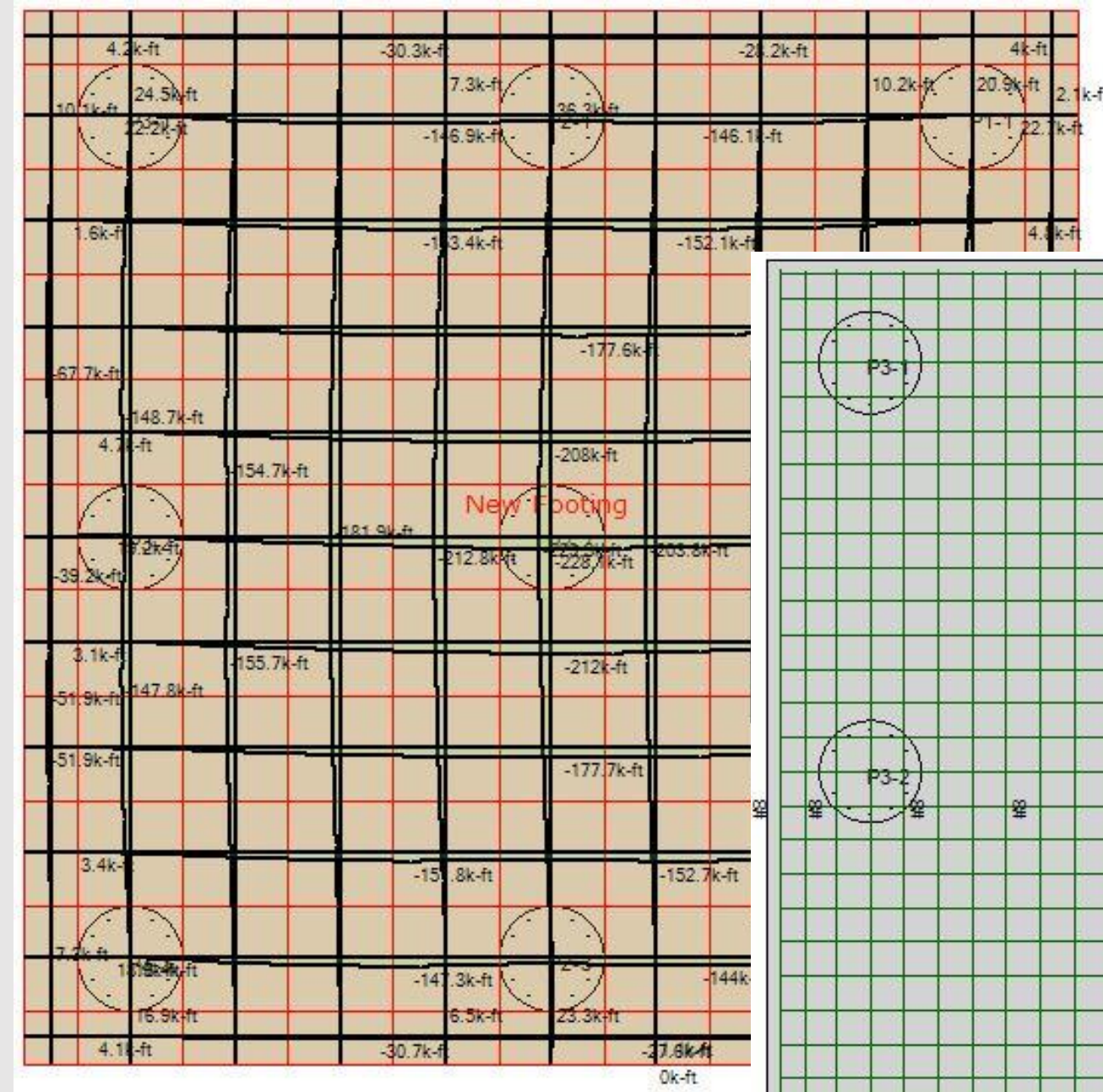
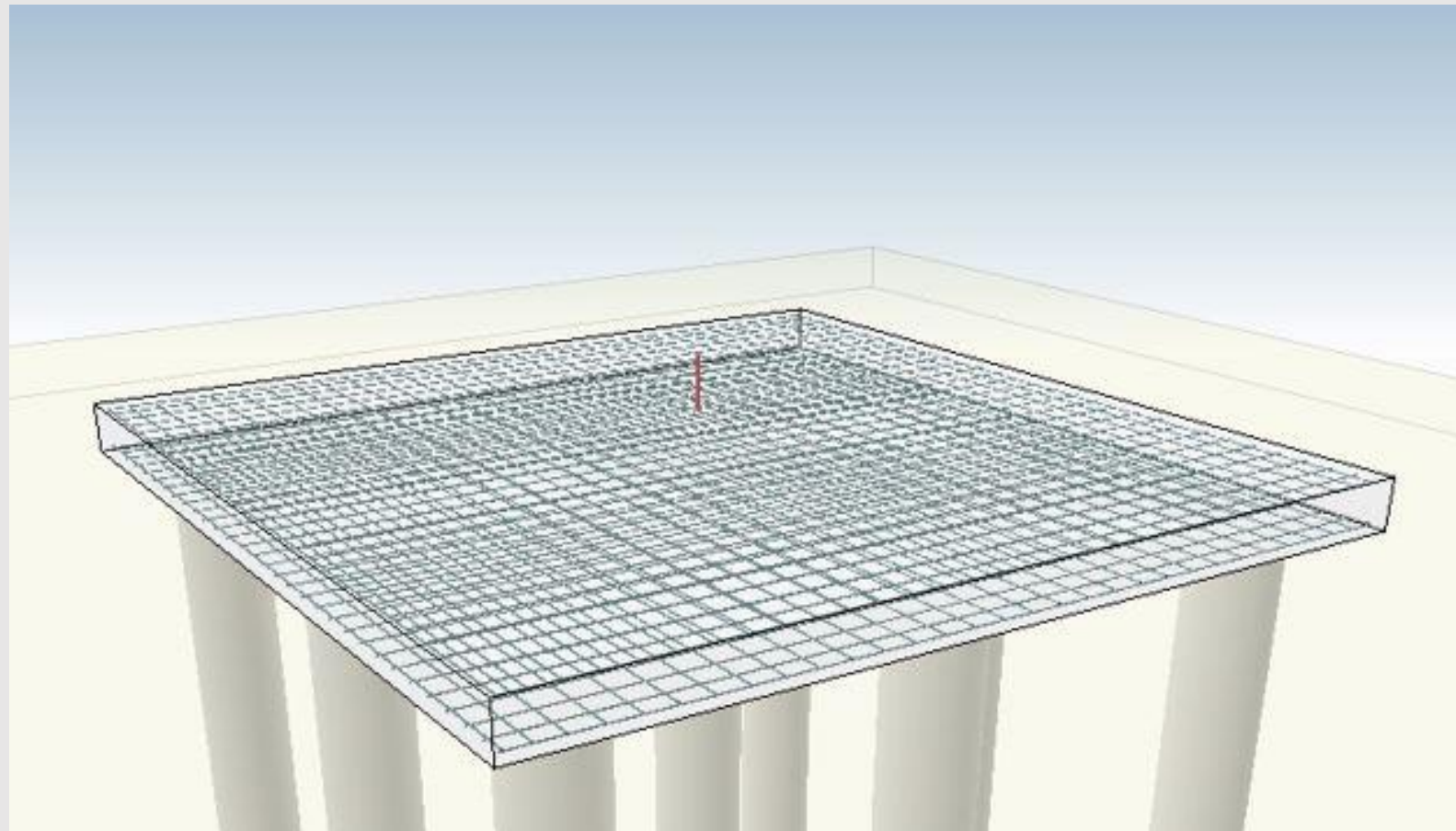


- ✓ Model the interaction effects of pile rafts and pile groups in a detailed manner
- ✓ Monitor stress and displacement/settlement at any location at the surface and within the soil medium
- ✓ Use sophisticated constitutive laws to simulate soil behavior
- ✓ Calculate the response of your foundation system under dynamic excitation





- ✓ Generate pile cap reinforcement strips
- ✓ Optimize cap reinforcement with a click of a button
- ✓ Calculate punching strength for concrete caps for each pile







## Standard DeepFND Software Packages



## Standard HelixPile Software Packages

DeepFND Versions	Single Piles	Groups&Rafts	Full
Single Foundation Piles Desing & Analysis	✓	✓	✓
Non-Helical Pile Sections	✓	✓	✓
Helical Pile Sections	✓	✓	✓
Axial Pile Analysis - Bearing Capacity	✓	✓	✓
Lateral Pile Analysis	✓	✓	✓
Settlement Analysis	✓	✓	✓
Torque Estimation	✓	✓	✓
Pile Groups	-	✓	✓
Pile Rafts	-	✓	✓
Pile Cap Analysis	-	✓	✓
3D Finite Element Analysis	-	Optional	✓
Pile Cap Design (Structural Checks)	-	Optional	✓
Deep Maintenance (12 Months)	✓	✓	✓
Cloud License (Network)	Optional	Optional	✓

**DeepFND Single Piles**  
Vertical and Lateral Analysis of Single Helical & Non-Helical Piles

**DeepFND (Groups & Rafts)**  
Vertical and Lateral Analysis of Single Helical & Non-Helical Piles  
Analysis or Pile Caps and Rafts (PY Spring Method)  
Optional Module: 3D Finite Element Analysis Method  
Optional Module: Pile Cap Design

**DeepFND Full**  
Vertical and Lateral Analysis of Single Helical & Non-Helical Piles  
Analysis or Pile Caps and Rafts (PY Spring Method)  
3D Finite Element Analysis Method  
Pile Cap Design

**HelixPile - Single Piles**  
Vertical and Lateral Analysis of Single Helical Piles

**HelixPile Full**  
Vertical and Lateral Analysis of Single Helical Piles  
Analysis or Pile Caps and Rafts (PY Spring Method)

- 1 Year of full Technical Support (training, questions, file reviews) is included in any software purchase
- Annual Maintenance (after the first year) starting from only \$650
- Discounts for Additional Licenses
- Additional Modules can be purchased and activated at any point in any software version
- Cloud Licenses (Network) options are available

# THANK YOU!

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

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