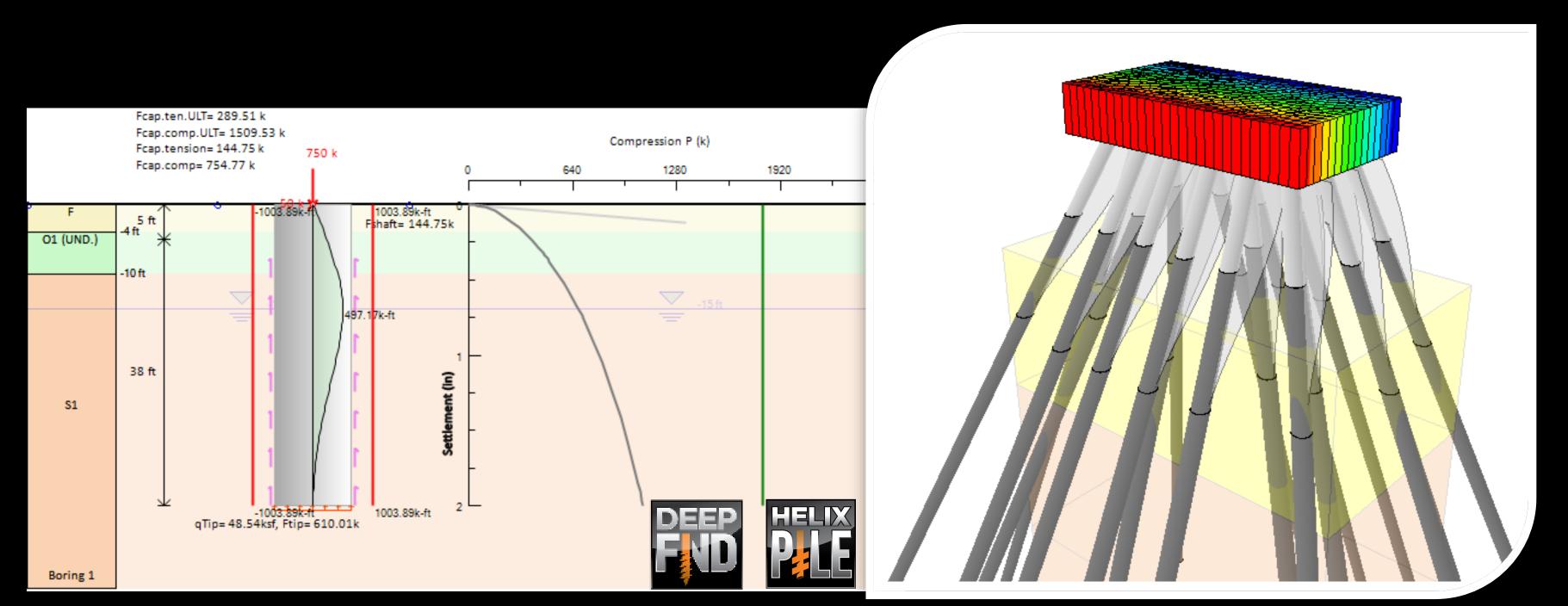


## **Design of Deep Foundations - Methods and Software Application**

Presentation: Dimitrios Mamoglou, Senior Engineer, Deep Excavation LLC mamoglou@deepexcavation.com - T: +1-206-279-3300



## RELIABLE GEOEXPERTISE



Deep Excavation LLC 240 W 35<sup>th</sup> Street, Suite 1004 New York, NY, 10001 USA Websites: <u>www.deepexcavation.com</u> <u>www.deepex.com</u>

- Software solutions for excavation and foundation professionals
- Consulting Services Design of deep excavations and pile foundations
- Virtual Reality applications for geotechnical engineers and contractors



Contact Information: <a href="mailto:sales@deepexcavation.com">sales@deepexcavation.com</a> <a href="mailto:training@deepexcavation.com">training@deepexcavation.com</a>



QuayWalls



SiteMaster





## DeepFND - Foundation Piles Design Software HelixPile - Helical Piles Design Software

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

More information:

Click here to learn more: DeepFND – Features and Capabilities



www.deepexcavation.com
www.deepex.com

Click here to learn more: HelixPile – Features and Capabilities



## DeepFND - Foundation Piles Design Software HelixPile - Helical Piles Design Software



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

## RELIABLE GEOEXPERTISE

www.deepexcavation.com www.deepex.com 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
- $\checkmark\,$  Option to have Grouted Piles

Helical Piles also Analyzed with:

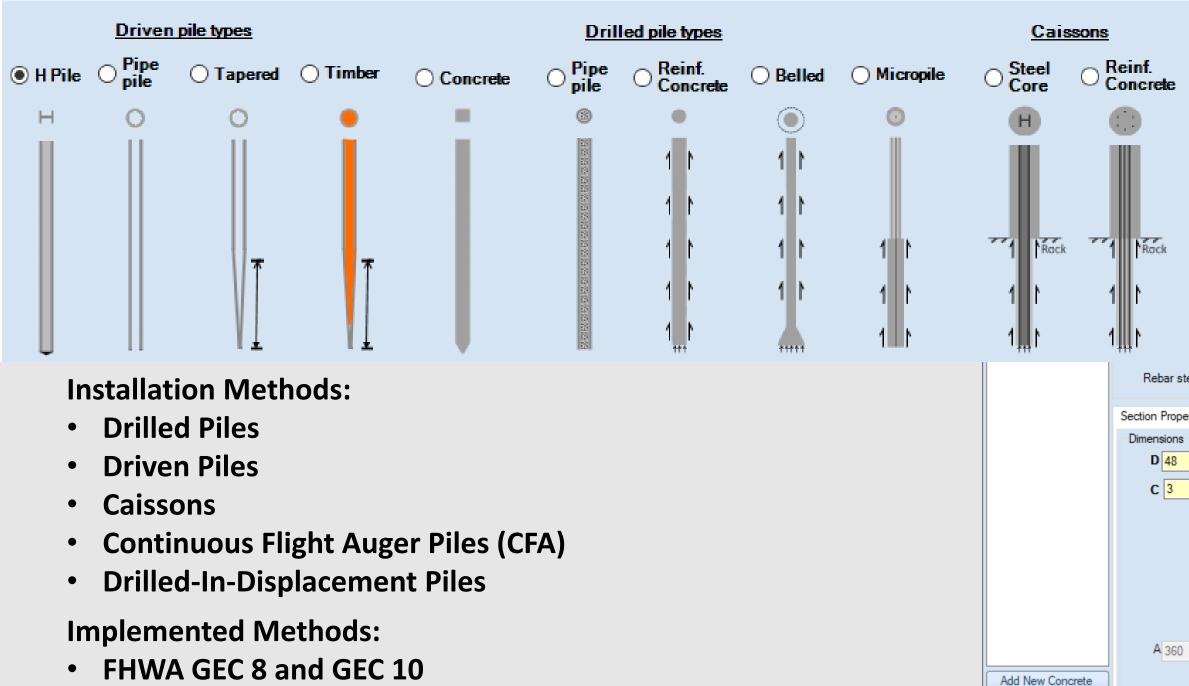


HelixPile: Helical Piles Design Software

GEOTECHNICAL SOFTWARE AND ENGINEERING

## DeepFND - Available Non-Helical Pile Types

#### Common pile types



AASHTO LRFD Norlund

## RELIABLE GEOEXPERTISE

# www.deepexcavation.com www.deepex.com

Section

Delete Selected Concrete Section

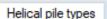
#### **Pile Sections:**

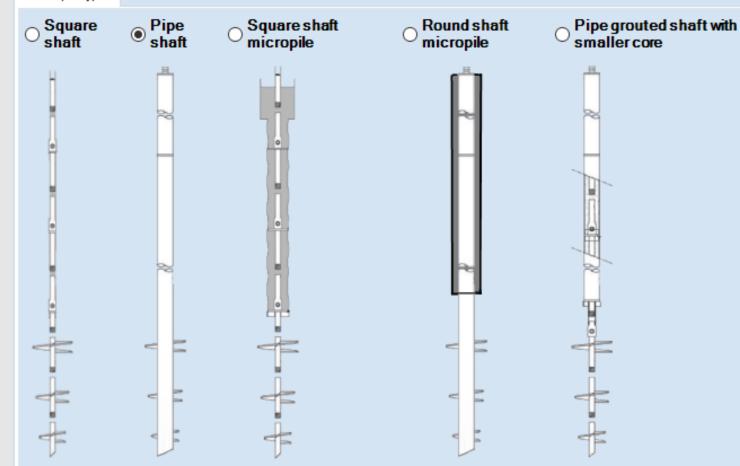
- Concrete Piles (Rectangular, Circular, Octagon)
- Circular Hollow Sections
- Composite Sections
- Steel Beams (Pipes, H beams, channel sections)
- Timber Piles (wood)
- Belled Bottom Piles

			X
ind type	_		Section Drawing
		Circular 🔹	D= 48 in
ials e mat. 3 ksi Concrete	✓ fc'	Rectangular	
eel mat. Grade 60	y fy	Circular	
erties Steel sections - H	ollow bars Reinforcemen	Circular Hollow	
in	Rebars (	Octagon	
in	Bars # #	Steel (H, or pipes)	
		Timber pile	
Shear Reinforcement Bars # #3 ~			Options
			x: -37 mm y: 7 mm Use user defined reinforcement
in2		deg α <mark>90 </mark> deg 5	
			OK Cancel

**GEOTECHNICAL SOFTWARE AND** ENGINEERING

## DeepFND/HelixPile - Available Helical Pile Types and Options





**Available Helical Pile Types:** 

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

**Bearing Capacity Methods for Helical Piles:** 

- **Cylinder Method**
- **Individual Plate Method**

# RELIABLE GEOEXPERTISE

## www.deepexcavation.com www.deepex.com

- ✓ Create and save to database multiple helical pile sections
- ✓ Bearing capacity calculations, lateral pile analysis, installation torque estimation

Helical sections	A. General	B. Geotech	nical capacity options	C. Concrete D. E	xternal casing	
Pipe 3"	-1. Name					
	Pipe 3"			Manufacture	er	
		Tel:		wel		
	2. Shaft-p	ipe dimension	ns and properties		-	
		fy <mark>65</mark>	🗸 ksi	lxx 2.06 in4	E	29000 ksi
		fu 80	🗸 ksi	Sxx 1.37 in3	B Torsion	al pipe capacity
	S	Section Pipe	, ~	Zxx 1.896 in3	B Telastic	14.84 k-ft
	Dia	ameter 3	in	rx 0.977 in	Tplastic	
	Thic	ckness 0.25	in	J 4.117204 in4		le shaft capacity 140.4 k
	Area pipe	e Apipe 2.16	in^2	Sxy 2.74 in3	-	
	Per	imeter 9.42	247775 in		Define me tension str	chanical connection
Add new helical section						
Delete all	- 3. Helix di	mensions and	properties			
		lifferent size		configurations None		✓ Select
Delete selected helical section					End offset	
		Diameter (in	) Spacing (ft)	Thick (in)	Effective Area (ft2)	Ult. Capacity (k)
Z Since 1019	▶ 1	8	2	0.375	0.3	100
PIDEAL	2	10	2	0.375	0.496	100
MAGNUM	3	12	2.5	0.375	0.736	100
	Add a	new plate	Delete selected plat	e Save configuration	on Delete config.	Add configuration

# ✓ Each helical pile section can have multiple helix configurations

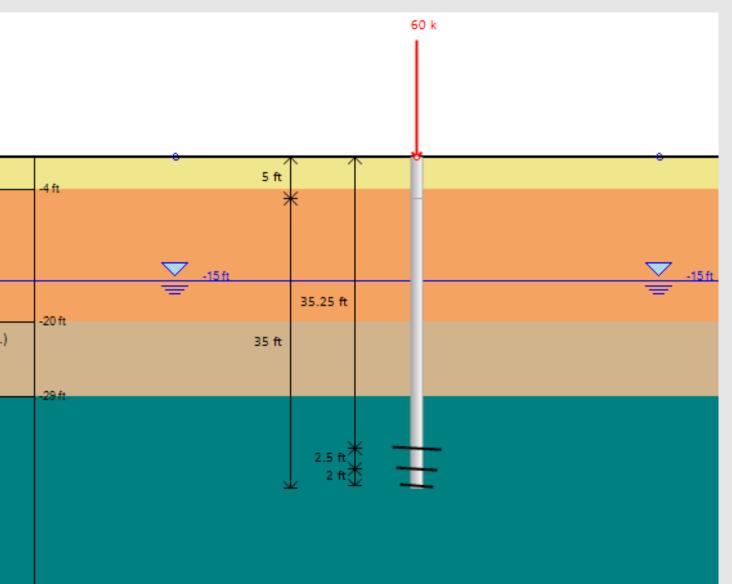
GEOTECHNICAL SOFTWARE AND ENGINEERING

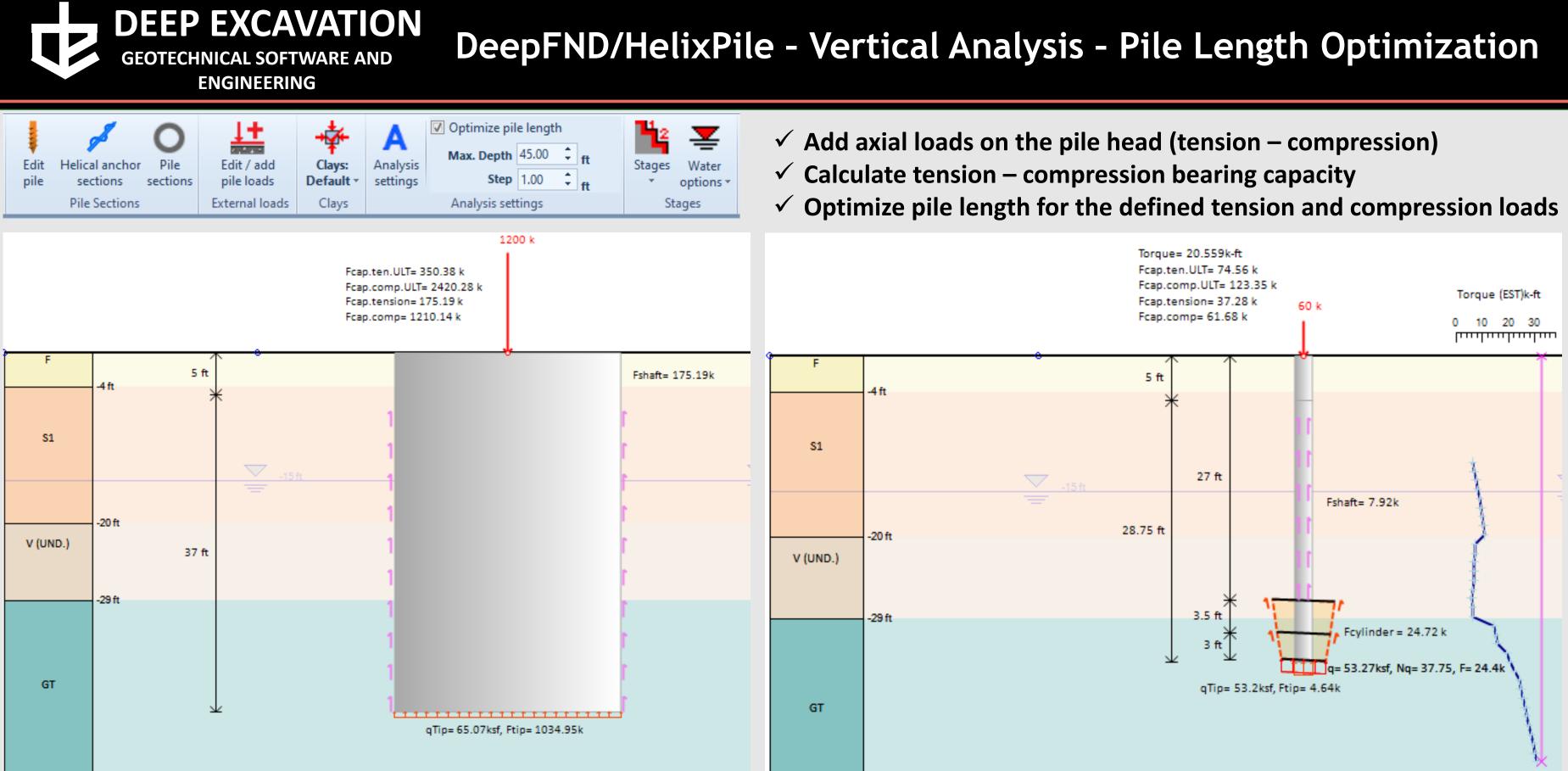
## DeepFND/HelixPile - Soils and Stratigraphy

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 2. Default default and a basis for allow (Clay)							•	✓ So ✓ Ci ✓ A	oil p reate dd C	e mult ropert e mult PT log m Laye
Add New Soil	<ul> <li>3. Default drained-undrained behavior for clays (Set Undrained Drained</li> <li>A. General B. Elasto-plastic Lateral E. Adv.</li> <li>4. Unit Weights - Density <ul> <li><i>f</i> 120</li> <li><i>f</i> 20</li> <li><i>f</i> 120</li> <li><i>f</i> 20</li> <li><i>f</i> 120</li> <li><i>f</i> 20</li> <li><i>f</i> 120</li> <li></li></ul></li></ul>	Soil Layers Available Borings Boring 1	Coo The Eacl eacl SP	General Boring Int Name Borin ordinates X x coordinate co h design section h design section T Data Option (A SPT Record T Record Option CPT Record Boring Layers - Li	ng 1 50 ft ntrols where th uses one bori pplies to Design Not assigned (Applies to Des Not assigned	Y 0 ne boring is ing (soil str n Section) sign Section	ata). You can us Add edit			X	F S1
Copy Soil Delete Selected Soil Delete all soils Paste Soil	Ko = KoNC * (OCR)^nOCR 6. Ultimate bond (grouted piles when bond option q <sub>skin.u</sub> 20 Rock joints are open filled with gouge	is s ps		Top 0 -4 -20 -29	Soil type F S1 V GT	<ul> <li>~ 1</li> <li>~ 1</li> <li>~ 1</li> <li>~ 1</li> <li>~ 1</li> </ul>	OCR Ko 0.5 0.441 0.531 0.412	Edit Edit Edit Edit Edit			V (UND
	ОК	Add New Boring Delete Selected Boring (Stratigraphy) Clone Boring		Insert Layer	Delete	Layer		K	ancel		GT

## RELIABLE GEOEXPERTISE

www.deepexcavation.com www.deepex.com iply soil types and define soil properties ies estimation tools (NSPT values - test data) iple borings and define the horizontal stratigraphy s and SPT Records - Estimate properties from records er mode: Create inclined soil layers





## RELIABLE GEOEXPERTISE

www.deepexcavation.com www.deepex.com

**GEOTECHNICAL SOFTWARE AND** ENGINEERING

RELIABLE

GEOEXPERTISE

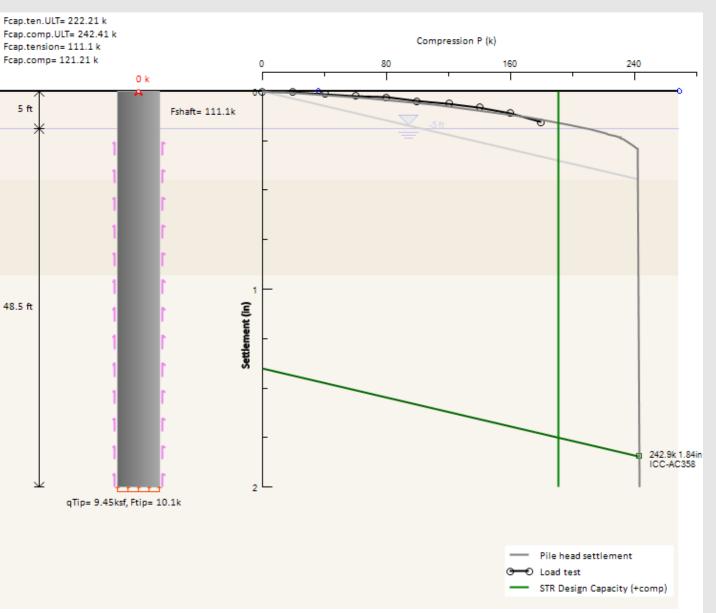
## **DeepFND/HelixPile - Settlement Analysis Options**

Pile acceptance criteria	×	✓ Es	t
Available criteria	Acceptance criteria	✓ Ad	
Elastic	1. Name		
ICC-AC358	Elastic Color		
	2. Set active/visible		
	Criterion is active (to be analyzed)	C1 (UND )	
	Criterion is visible (on graphs)	C1 (UND.)	
	3. Equation		
	$y = 0 + 0 D_{PL} + 0 D_{S} + 1 PL/AE$	C2 (UND.)	-12
	$D_{PL}$ = Plate diameter $D_{S}$ = Shaft diameter		-25
	Average plate size		2.0
	Define maximum net settlement		
	Ultimate load criterion (Criteria determines ultimate load)		
	Determine load from criterion	C3 (UND.)	
	Use deflection load slope		
Add new criteria			
	Reset to Elastic Reset to ICC355 Reset to Davisson		
Delete criteria	Butler-Hoy NYC 2011-011		
	OK Cancel	Boring 1	

- ✓ Option to estimate pile settlements
- imate pile structural capacity from pile criteria
- d and review Axial Load Tests

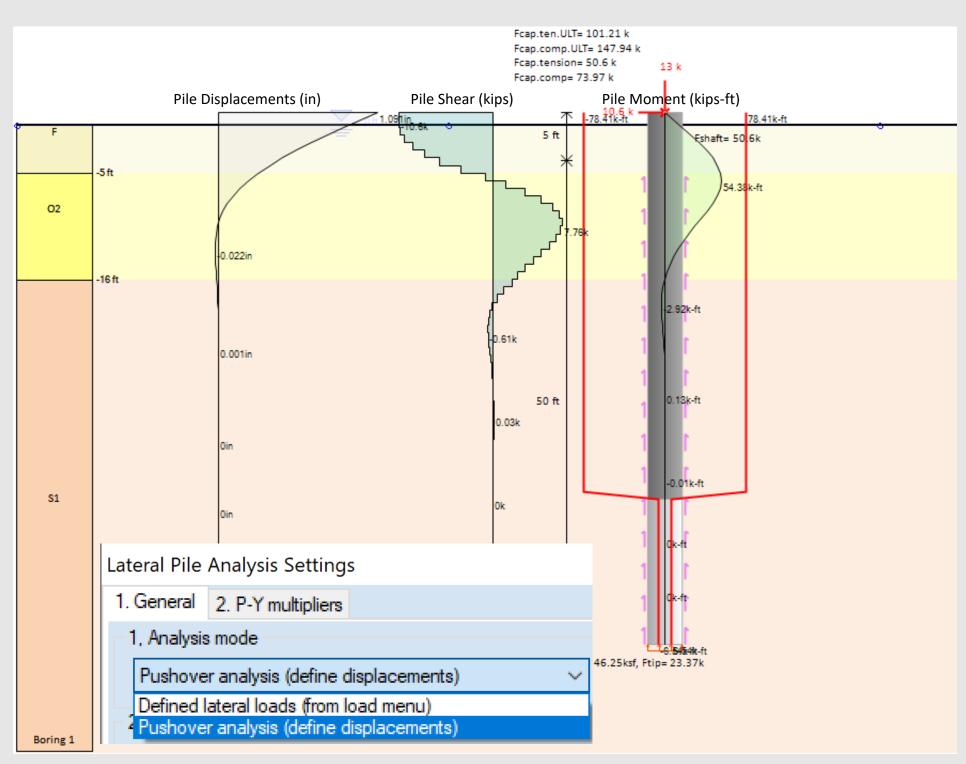
## www.deepexcavation.com www.deepex.com

# ✓ Pile acceptance criteria: Davisson, ICC 355, NYC 2011, Butler-Hoy and more



**GEOTECHNICAL SOFTWARE AND ENGINEERING** 

## **DeepFND/HelixPile - Lateral Pile Analysis Options**



- soil types)
- ✓ Calculate lateral pile displacements for defined loads ✓ Perform pushover analysis ✓ Add and review lateral load tests

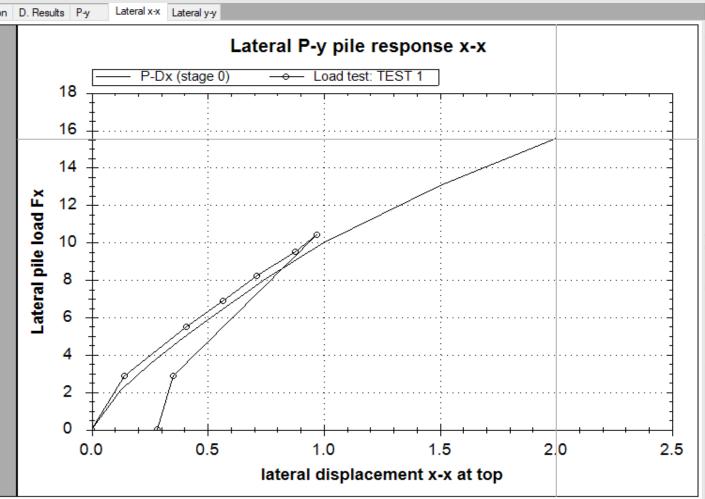
A. General B. Prestress-Unbraced C. Corrosio						
	Displaceme x (in)	Lateral Load Fx (k)	Moment Mx (k-ft)			
•	0	0	0			
	0.125	2.12	-8.09			
	0.25	3.5	-14.62			
	0.375	4.73	-20.94			
	0.5	5.9	-26.96			
	0.75	8.07	-38.73			
	1	9.96	-50.3			
	1.5	13.06	-71.15			
	2	15.56	-90.15			

## RELIABLE GEOEXPERTISE

#### www.deepexcavation.com www.deepex.com

✓ Define lateral loads on the pile head (both local X and Y directions) ✓ Define lateral soil properties (implemented PY models for different

#### ✓ Calculate pile moment and shear diagrams



**GEOTECHNICAL SOFTWARE AND** ENGINEERING

## DeepFND/HelixPile - Structural Design of Piles

Structural code options  $\times$ ✓ Structural Design Codes: ACI, AISC, LRFD, Eurocodes 2, 3 & 8, AS3600, AS 4100, CN + more Concrete Code Options ✓ Calculate moment capacity 1:ACI 318-11 ✓ Perform all checks according to the selected design standard 1:ACI 318-11 2:EC2-2004 3:EC2-German Annex ✓ Export detailed report with all structural design calculations 4:EC2-Cyprus Annex 5:EC2-French Annex 6:EC2-Austrian Annex Structural code options X an.ULT= 101.21 k 7:EC2-Italian Annex omp.ULT= 147.94 k Æ Concrete Code Options 8:EC2-Netherlands Annex ension= 50.6 k omp= 73.97 k 9:EC2-Czech Annex 10:EC2-Belgium Annex 1:ACI 318-11 10.6 11:EC2-Slovakian Annex Fshaft= 50.6k 12:EC2-Danish Annex FS 13:EC2-Finish Annex Steel Code Options 14:EC2-Swedish Annex 15:EC8-Greek Annex F: 17:AISC 360-10 ALL 16:EC8-Italian Annex 17:EC8-Austrian Annex 1:ASD 1989 Edit Pile Dimensions and Data, Stage: 0 18:EC8-Bulgarian Annex 2:EC3 2005-CEN 19:EC8-Cyprus Annex A. General B. Prestress-Unbraced C. Corrosion D. Results 3:LRFD 13th Edition 2005 20:EC8-Slovenian Annex Support Reactions and Loads 4:NTC 2008 La Paxial = 13 k 21:EC8-French Annex 5:EC3 2005-Bulgaria 22:EC2-Greek Annex 2. Support Structural - Geotechnical Checks 6:EC3 2005-Slovenia Stress Check= 0.712 23:EC2-2004 7:EC3 2005-UK Calculated Axial Support Capacitie 24:AS 3600-2009 8:EC3 2005-Norway Pall= 73.97 k 147.94 Pult= 25:CN (China) 9:EC3 2005-Sweden 3.2 Structural Capacity 3.1 Geotechnical Capacity 10:EC3 2005-Finland 120.29 k Pall= 73.97 k PallComp= 11:EC3 2005-Denmark 240.58 k Pult= 147.94 12:EC3 2005-Portugal N/C k MxAll= 50.6 k 13:EC3 2005-Germany DIN PallTension MxUlt= N/C k 14:EC3 2005-Singapore PultTension= 101.21 k 1.33 ft Lu= 15:EC3 2005-Greece 16:ANSI/AISC 360-10 Used FS STR= Install Torque= 0 k-f 17:AISC 360-10 ALL α 18:BS 5950-1:2000 19:AS/NZS 4100 20:CN (China) 21:ANSI/AISC 360-16 22:AISC 360-16 ALL

## RELIABLE GEOEXPERTISE

www.deepexcavation.com www.deepex.com

calculations × 📑		
alculate pile capacities for stage : Stage 0	^	
S SHAFT.RESISTANCE = 2 (preliminary geotechnical)		
S BEARING.RESISTANCE = 2 (geotechnical)		
asic description of shaft strength calculations, stage: 0		
ateral earth stresses determined with Mitch-Clemence approach:		
h = 0.09 (e ) <sup>0.08 Ф</sup> = normal stress		
dhesion values determine from cohesion or undrained shear strength with the following method:	:	
y using a tri-linear approach similar to API, where:		
c.factor.1 = 0.8 when c is smaller than c= 1ksf		
c.factor.2 = 0.5 when c is greater than c= 2ksf		
linear interpolation is assumed for intermediate values		
= 90 degrees. pile angle	> <sup>`</sup>	





## DeepFND - Foundation Piles Design Software HelixPile - Helical Piles Design Software

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

More information:

Click here to learn more: DeepFND – Features and Capabilities



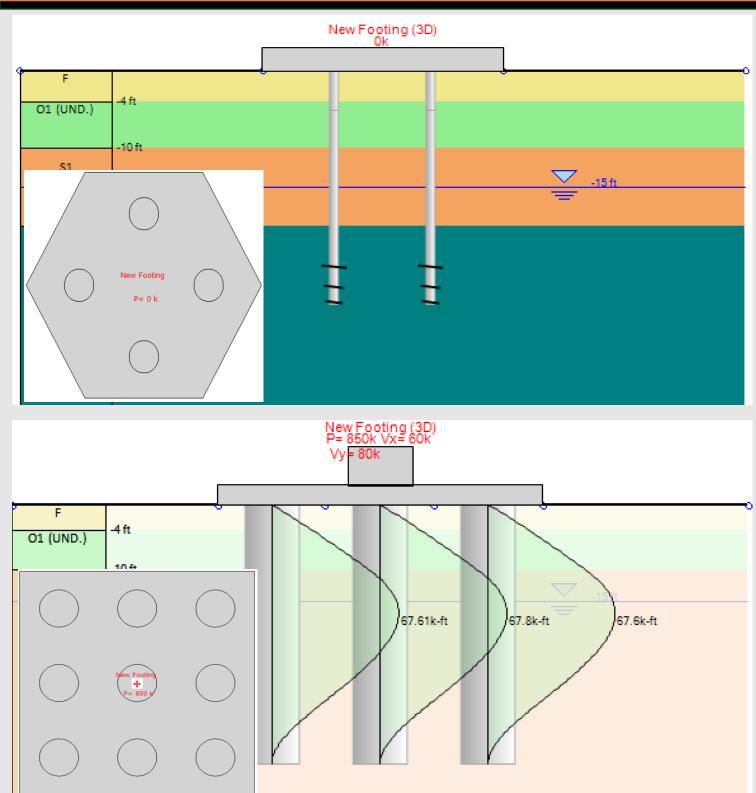
## RELIABLE GEOEXPERTISE

www.deepexcavation.com
www.deepex.com

Click here to learn more: HelixPile – Features and Capabilities

GEOTECHNICAL SOFTWARE AND ENGINEERING

## DeepFND/HelixPile - Pile Groups and Pile Rafts

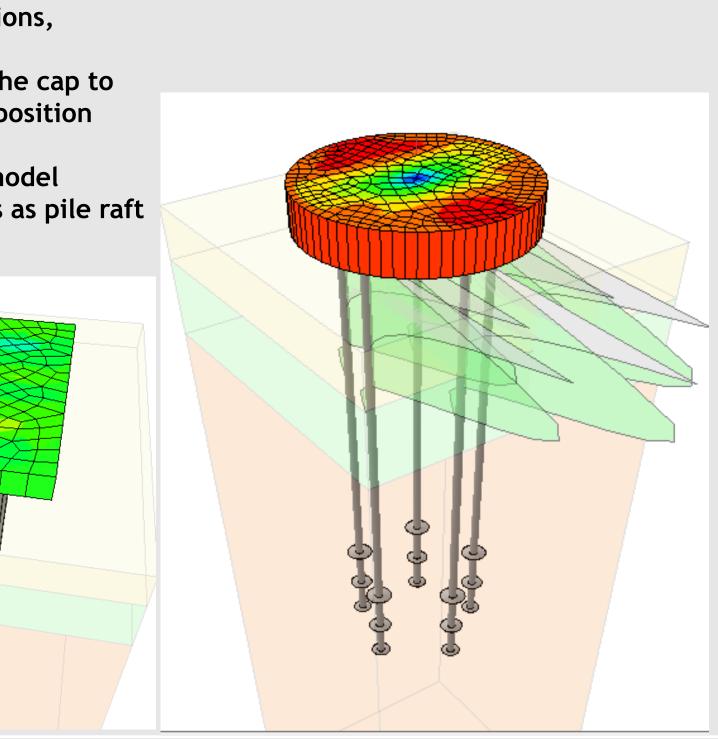


RELIABLE

GEOEXPERTISE

- 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
- $\checkmark$  Design all piles and the pile cap
- ✓ Top view/side section view/3D model
- $\checkmark$  Option that the pile cap behaves as pile raft







## **DeepFND/HelixPile - Software Versions**

#### **Standard DeepFND Software Packages**

#### **DeepFND – Single Piles**

Vertical and Lateral Analysis of **Single Non-Helical Piles Optional: Helical Piles Analysis** 

#### **DeepFND + Pile Groups**

Vertical and Lateral Analysis of **Single Non-Helical Piles** + Pile Caps with Pile Groups **Optional: Helical Piles Analysis** 

#### **Standard HelixPile Software Packages**

#### **HelixPile – Single Piles** Vertical and Lateral Analysis of **Single Helical Piles**

#### **HelixPile + Pile Groups**

Vertical and Lateral Analysis of **Single Helical Piles** + Pile Caps with Pile Groups

**DeepEX Licensing Options** 

- Single Licenses (activated in specific devices), Single USB Keys, Network USB Key Solutions
- 1 Year of full Technical Support (training, questions, file reviews) is included in any software purchase
- **Optional Annual Maintenance options (after the first year)** •
- **Discounts for Additional Licenses**
- Additional Modules can be purchased and activated at any point in any software version

RELIABLE GEOEXPERTISE

www.deepexcavation.com www.deepex.com



#### **DeepFND Full**

Vertical and Lateral Analysis of **Single Non-Helical Piles** + Pile Caps with Pile Groups + Pile Rafts **Optional: Helical Piles Analysis** 

#### **HelixPile Full**

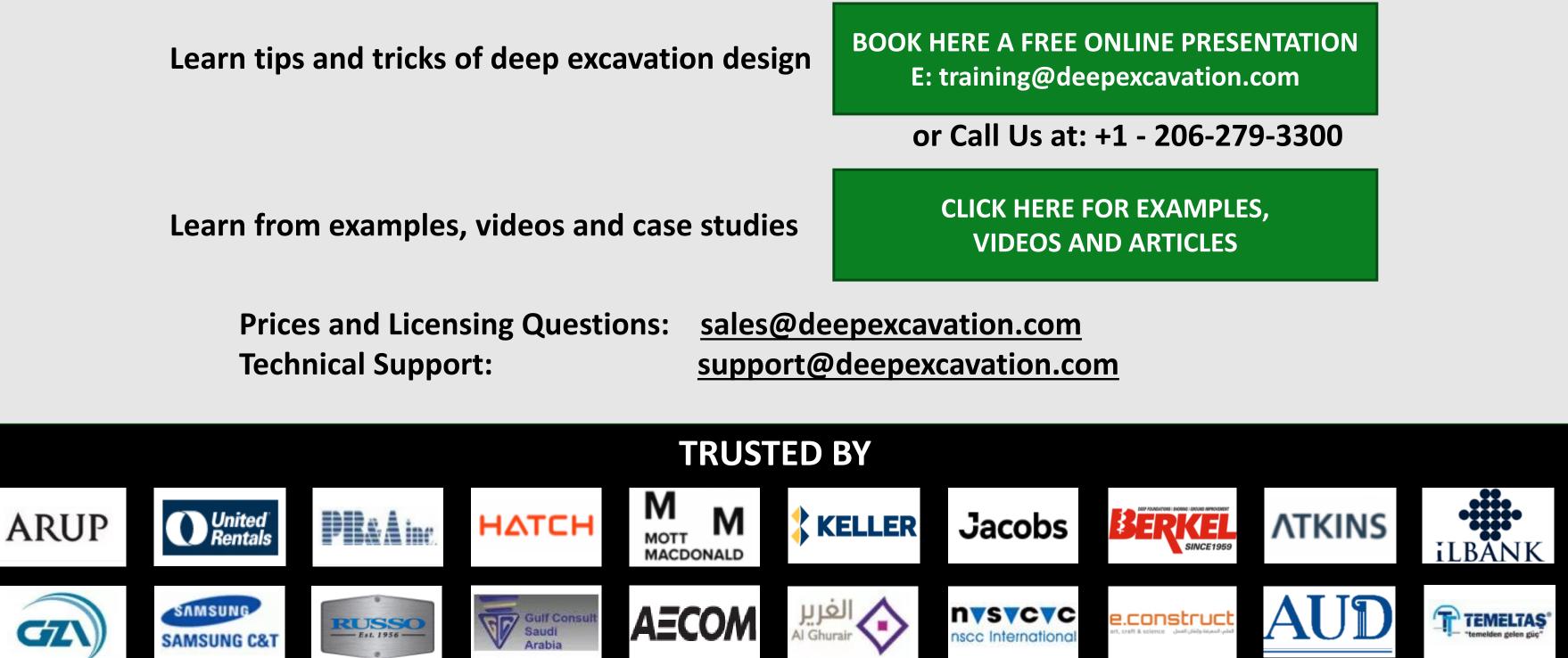
Vertical and Lateral Analysis of **Single Helical Piles** + Pile Caps with Pile Groups + Pile Rafts





## **THANK YOU!**

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



#### www.deepexcavation.com www.deepex.com