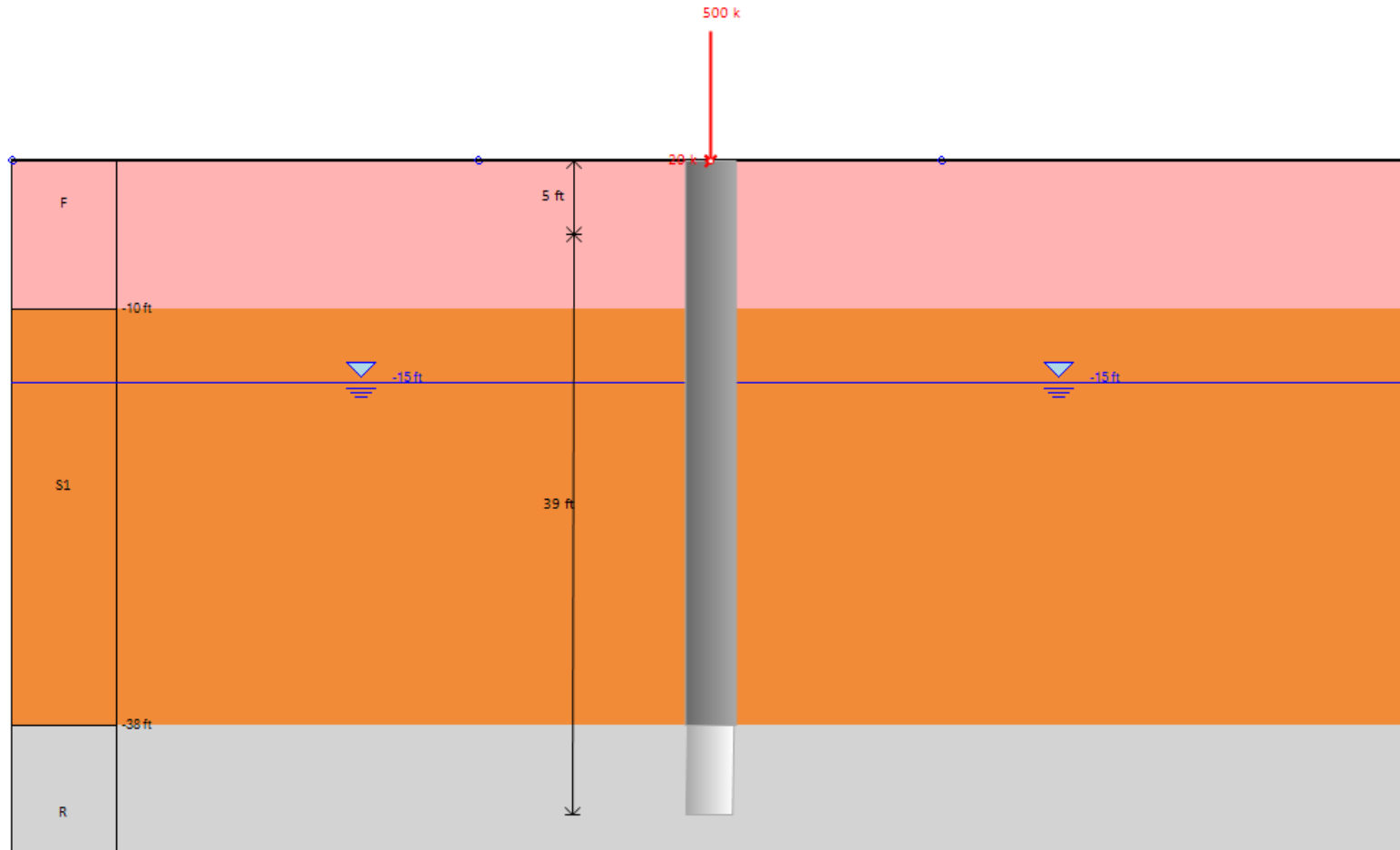


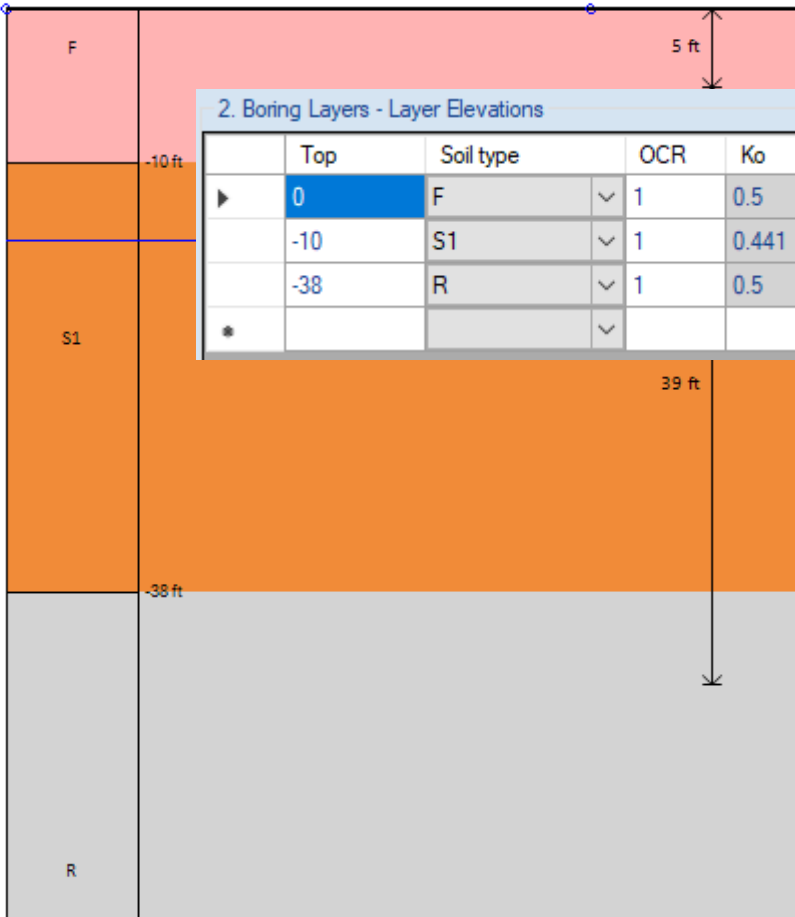
## Example 3: Micropiles Foundation Single Pile Analysis - Pile Depth Optimization - Pile Group



## A. Soil Properties and Stratigraphy (Soil Layers)

Soil	$\gamma_t$	$c'$	$S_u$	$\phi'$	$E_{exp}$	$k_{sub}$	$e_{SO}$	$Q_u$	RQD	$k_{rm}$
Name	(pcf)	(psf)	(psf)	(deg)	E= ksf	(pci)	-	(ksf)	(%)	-
F	120	0	-	30	E= 300, $\nu= 0.5$	30	-	-	-	-
S1	125	0	-	34	E= 400, $\nu= 0.5$	50	-	-	-	-
R	170	2000	-	30	E= 10000, -	-	-	1000	45	0.0005

Elev. (ft)	Soil (-)	$\gamma_t$ (pcf)	$C'$ or $S_u$ (psf)	$\phi'$ (deg)	$E_{oed}$ (ksf)	$m$ (-)	$k_{sub}$ (pci)
0	F - Sand	120	0	30	300	0.5	30
-10	S1 - Sand	125	0	34	400	0.5	50
-38	R - Rock	170	2000	30	10000	-	-



2. Boring Layers - Layer Elevations

	Top	Soil type	OCR	$K_o$	Edit
	0	F	1	0.5	Edit
	-10	S1	1	0.441	Edit
	-38	R	1	0.5	Edit

3. Elasto-plastic Lateral E. Adv.

Soil Density  
 $\gamma_t$  120 pcf  $\gamma_{dry}$  120 pcf  $\gamma'_s$  57.6

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

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

6. Ultimate bond (grouted piles when bond option is selected)  
 $q_{skin,u}$  20 psi

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

Select Model for lateral analysis  
 Available models for sand  
 Sand API  Sand Reese

PY model data  
 subgrade reaction modulus  $k$  30 pci

## B. Pile Section Properties and Initial Depth

**Pile Properties**

1. Selection of Support Type  
Type of Support: Non Helical Pile

Installation method: Micropile

3. Dimensions

1.1 Coordinates at top of pile  
X: 0 ft  
Z: 0 ft

1.2 Angles  
 $\alpha$ : 90 deg

2. Pile Sections

Length (ft)	Section Type	Edit
38	New-Section5	edit
6	1ft Micropile	edit

Section name and type  
Section name: New-Section5  
Circular

Non-prestressed section

Structural materials  
Concrete mat: 3 ksi Concrete  $f_c'$ : 3 ksi  
Rebar steel mat: Grade 60  $f_y$ : 60 ksi

Use GFRP rebars

Section Properties

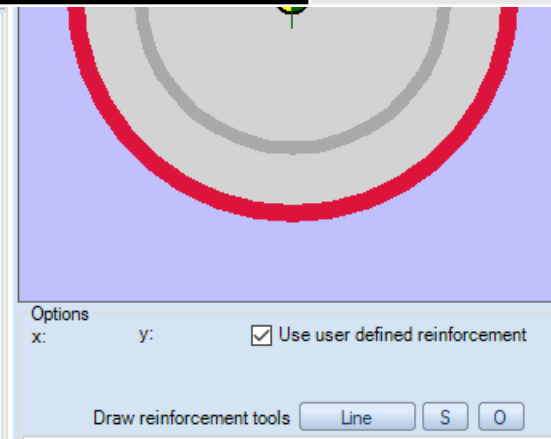
Dimensions  
D: 12 in  
C: 2 in  
A: 360 in<sup>2</sup>

Reinforcement  
Rebars: Bars # #3 N: 0

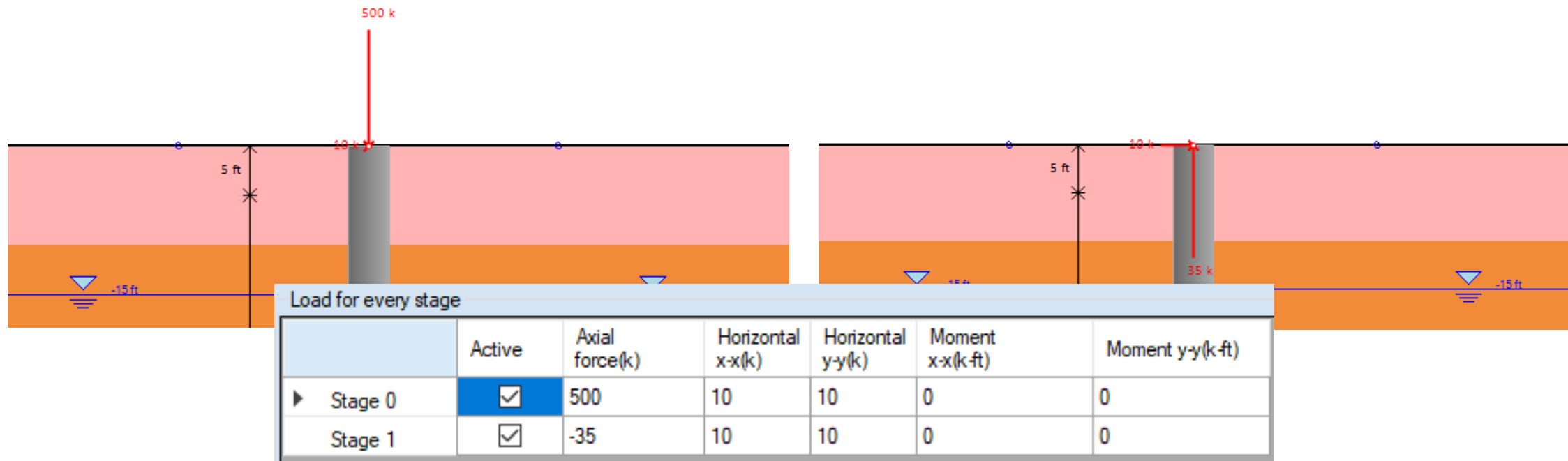
Shear Reinforcement: Bars # #3

sV: 0 in  
 $\theta$ : 21.8 deg  $\alpha$ : 90 deg  
cot  $\theta$  = 2.5

X-Coordinate	0	0
Section Type	Micropile with casing	Micropile without casing
Pile Width	1 ft + Casing	1 ft
Long. Reinforcement	1 #9 Bar	1 #9 Bar
Casing	PP13x0.5 Pipe	-
Concrete Material	3ksi Concrete	3ksi Concrete
Steel Material	60ksi Rebar Steel	60ksi Rebar Steel
Free Length	5ft	
Part Length	38ft	6ft



## C. Pile Loading



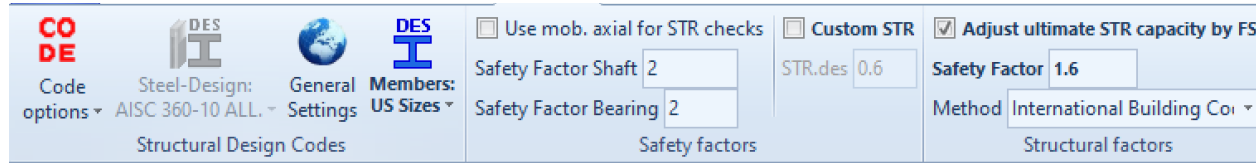
Stage 0: Compression

Stage 1: Tension

**Pile Depth Optimization: Perform Optimization for Selected Loads:  
Maximum Depth 50ft, Step: 1ft**

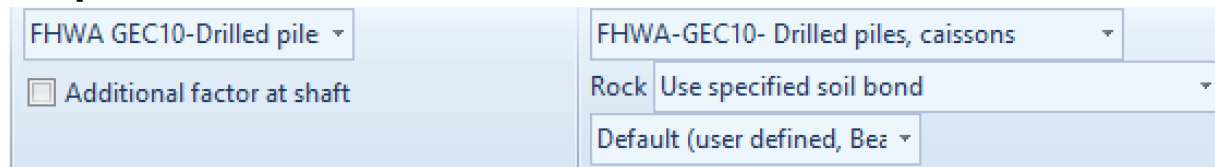
## D. Analysis Settings & Design Codes

**Service Conditions - shaft resistance & bearing capacity reduced by 2, structural capacities by 1.6**



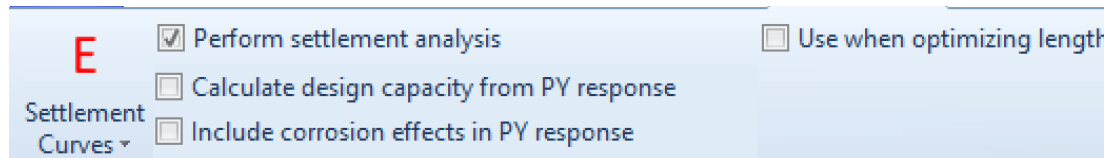
Use mob. axial for STR checks     Custom STR     Adjust ultimate STR capacity by FS  
 Safety Factor Shaft: 2    STR.des: 0.6    Safety Factor: 1.6  
 Safety Factor Bearing: 2    Method: International Building Co.  
 Structural Design Codes    Safety factors    Structural factors

**Capacity Calculation Method: FHWA GEC 10 for Drilled Piles & Micropiles**



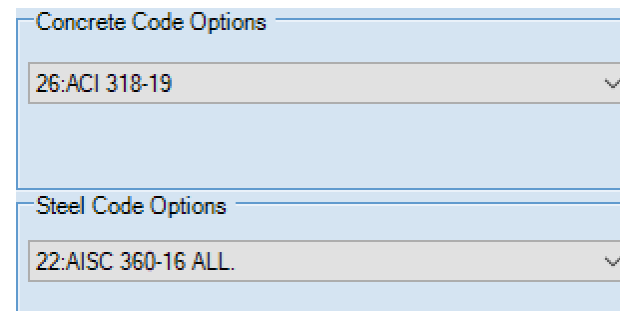
FHWA GEC10-Drilled pile    FHWA-GEC10- Drilled piles, caissons  
 Additional factor at shaft    Rock: Use specified soil bond  
 Default (user defined, Be

**Estimate Settlements**



Perform settlement analysis     Use when optimizing length  
 Calculate design capacity from PY response  
 Include corrosion effects in PY response

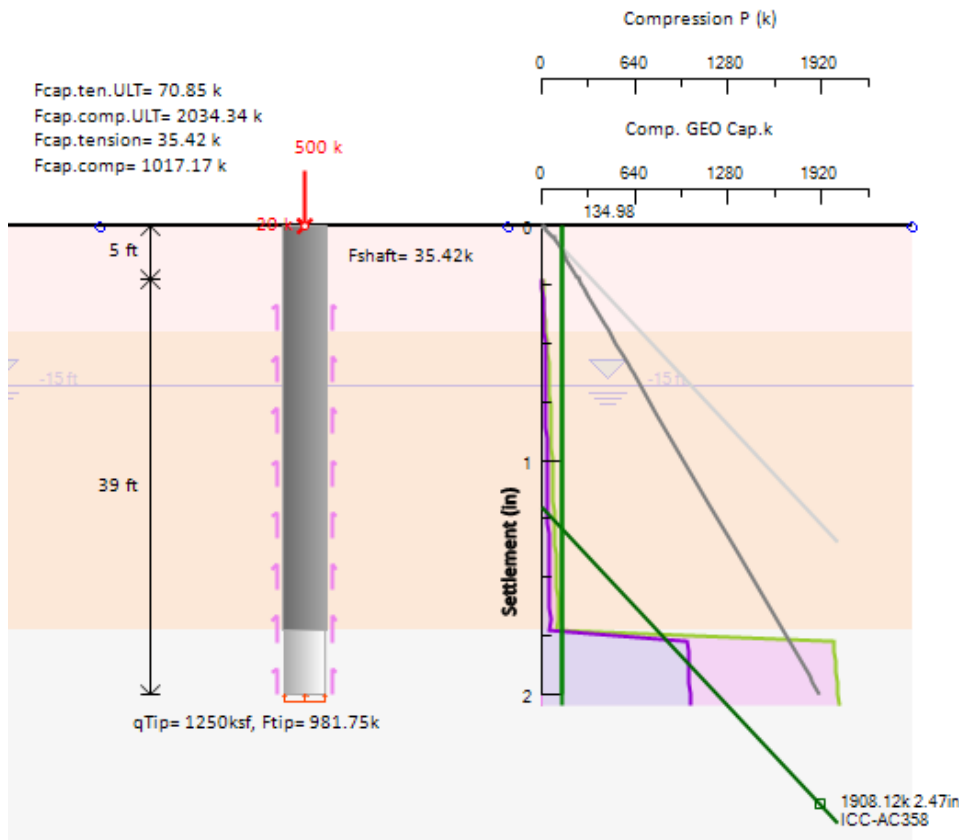
**Steel Code: AISC 360-16 Allowable**  
**Concrete Code: ACI 318-19**



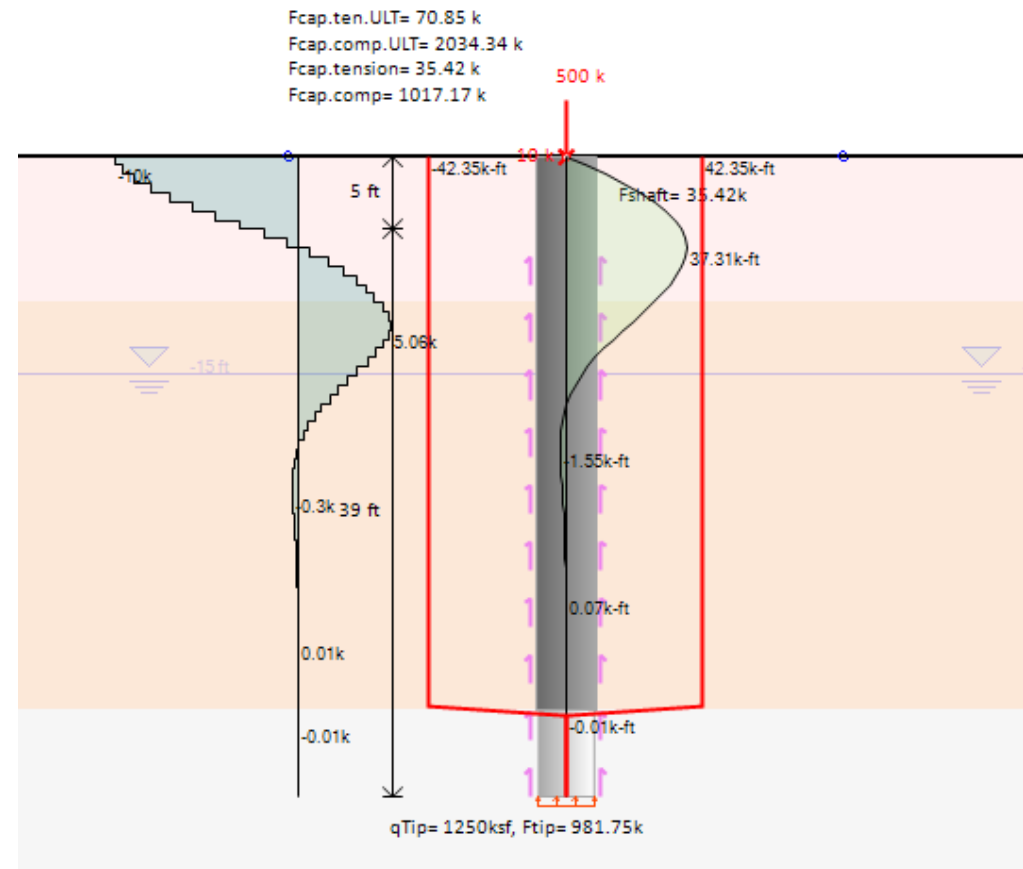
Concrete Code Options  
 26:ACI 318-19  
 Steel Code Options  
 22:AISC 360-16 ALL.

## E. Single Pile - Analysis Results

Optimized Pile Depth for Defined Loads: 44ft

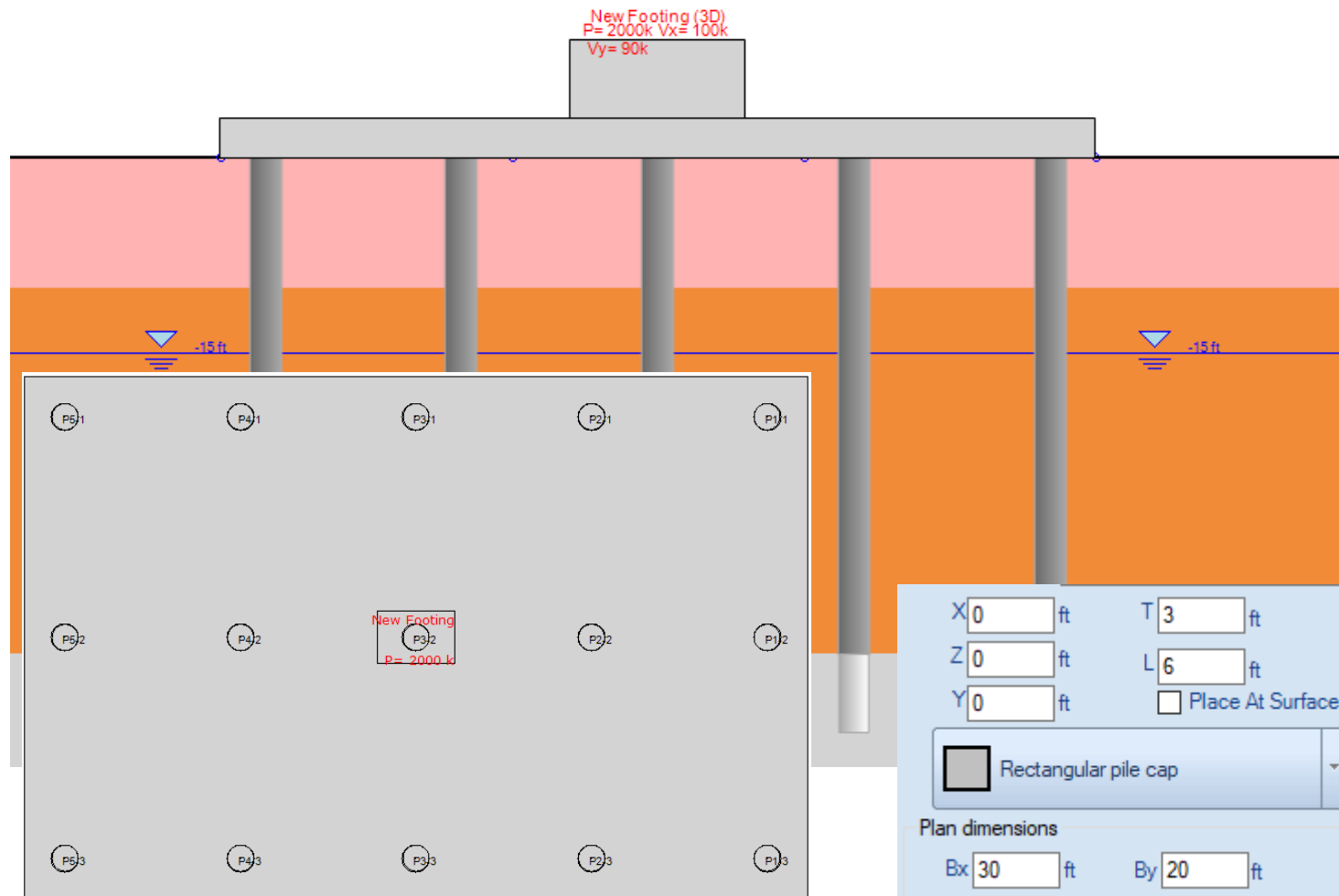


Calculated Capacities & Pile Settlement



Pile Moment & Displacement Graphs - X-direction

## F. Pile Cap Properties (Shape, size, pile locations, loading)



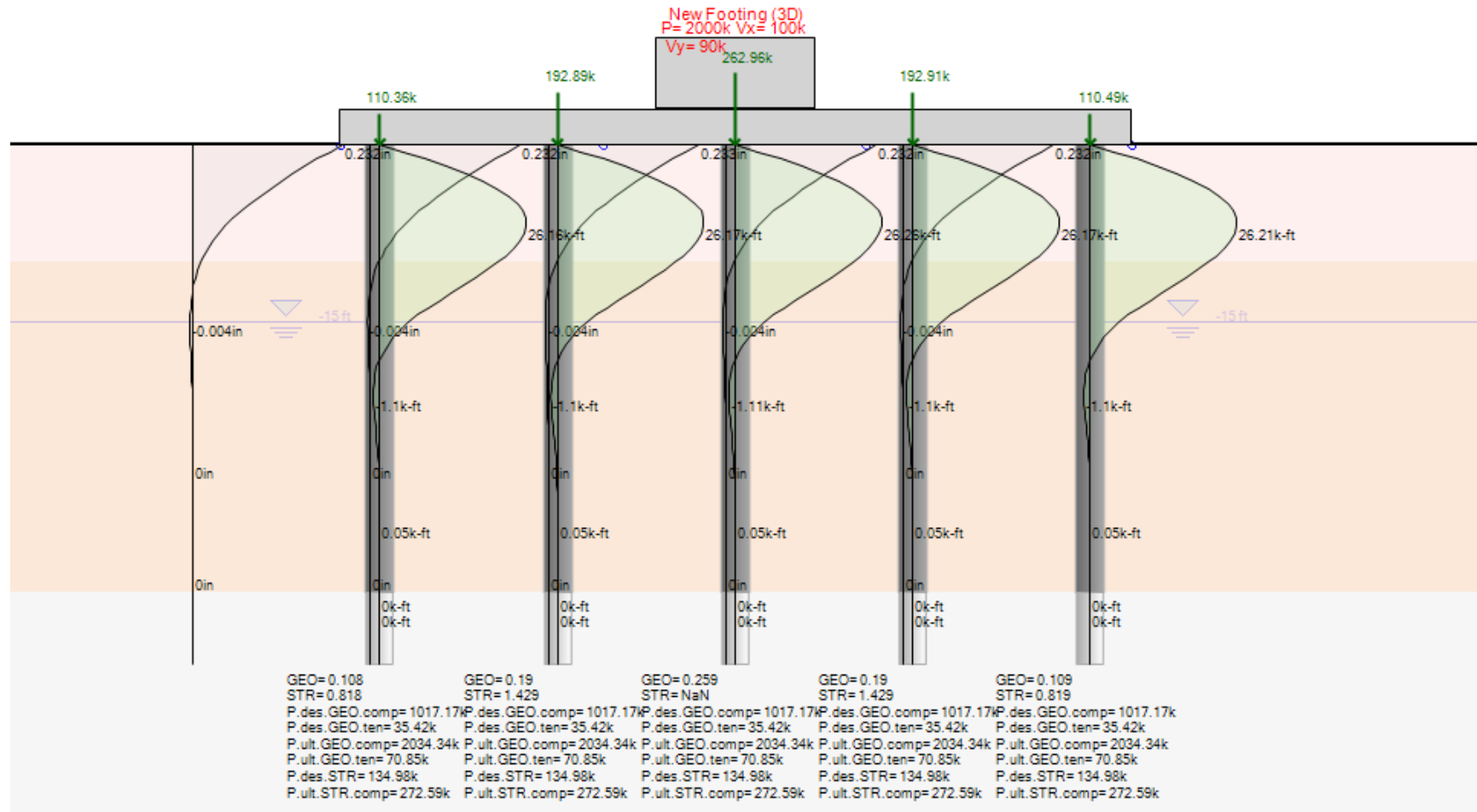
Loading mode: Single load at centroid  
 P:  k      Torsion:  k-ft  
 Lateral Fx:  k      Lateral Fy:  k  
 Moment Mxx:  k-ft      Moment Myy:  k-ft  
 Concrete material: 3 ksi Concrete

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

Pile Name	x	y	Length	Local Rotation	Edit Pile
P1-1	13.458	8.458	44	0	Edit
P1-2	13.458	0	44	0	Edit
P1-3	13.458	-8.458	44	0	Edit
P2-1	6.729	8.458	44	0	Edit
P2-2	6.729	0	44	0	Edit
P2-3	6.729	-8.458	44	0	Edit
P3-1	0	8.458	44	0	Edit
P3-2	0	0	44	0	Edit
P3-3	0	-8.458	44	0	Edit
P4-1	-6.729	8.458	44	0	Edit
P4-2	-6.729	0	44	0	Edit
P4-3	-6.729	-8.458	44	0	Edit
P5-1	-13.458	8.458	44	0	Edit
P5-2	-13.458	0	44	0	Edit

X:  ft      T:  ft  
 Z:  ft      L:  ft  
 Y:  ft       Place At Surface  
Rectangular pile cap  
 Plan dimensions  
 Bx:  ft      By:  ft

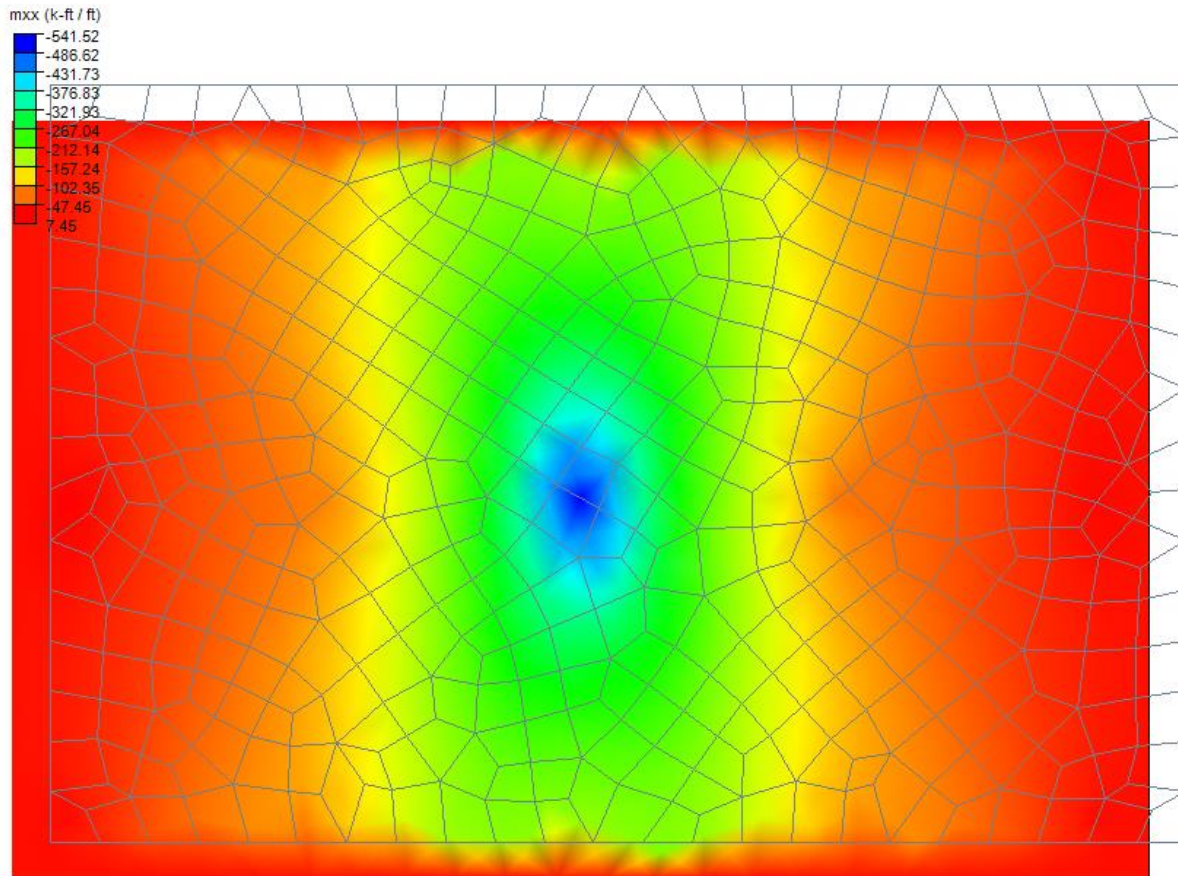
## G1. Pile Group Results (Elevation View)



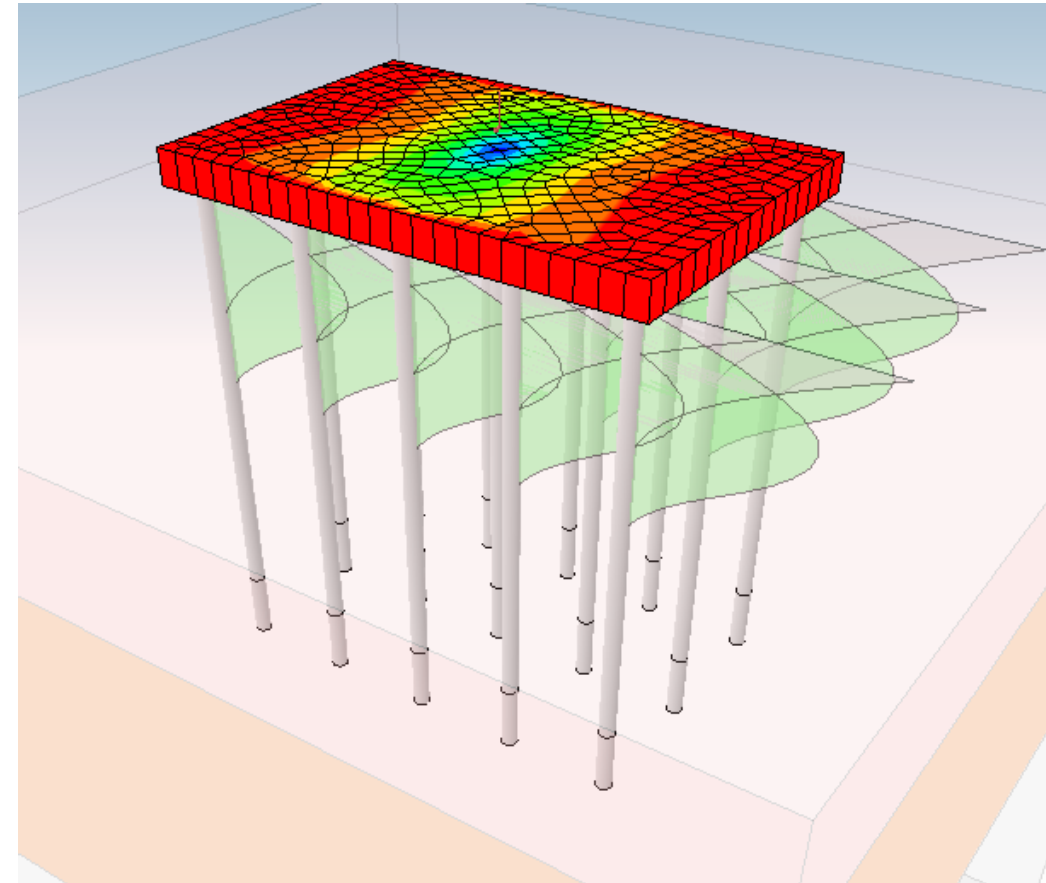
Pile Displacement & Moment Graphs (X-Direction), Pile Capacities & Checks



## G2. Pile Group Results (Top View & 3D)



FEM Mesh & Cap Moment Shadings



Cap Settlements & Pile Graphs - 3D Model

## Thank You!

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