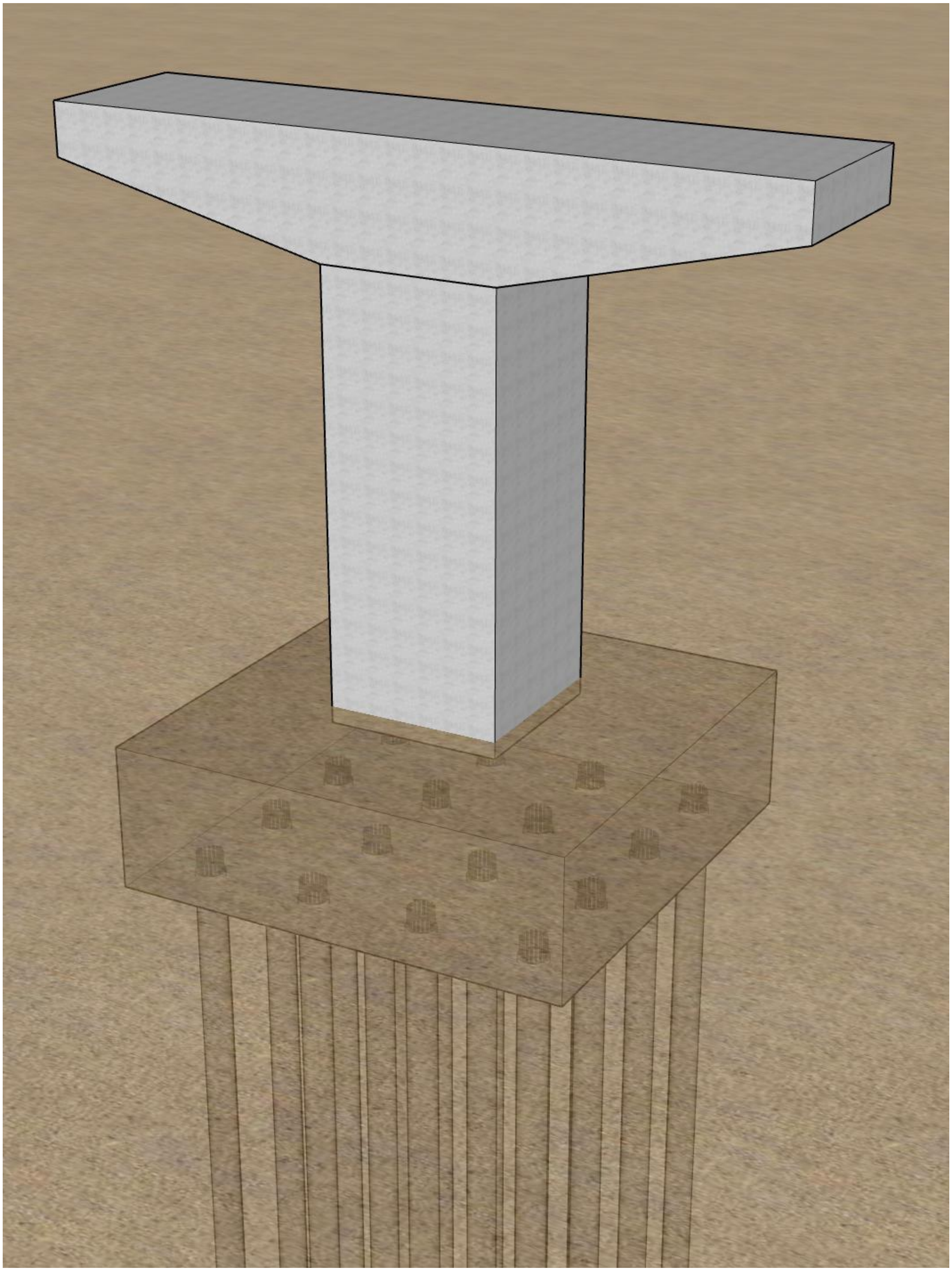
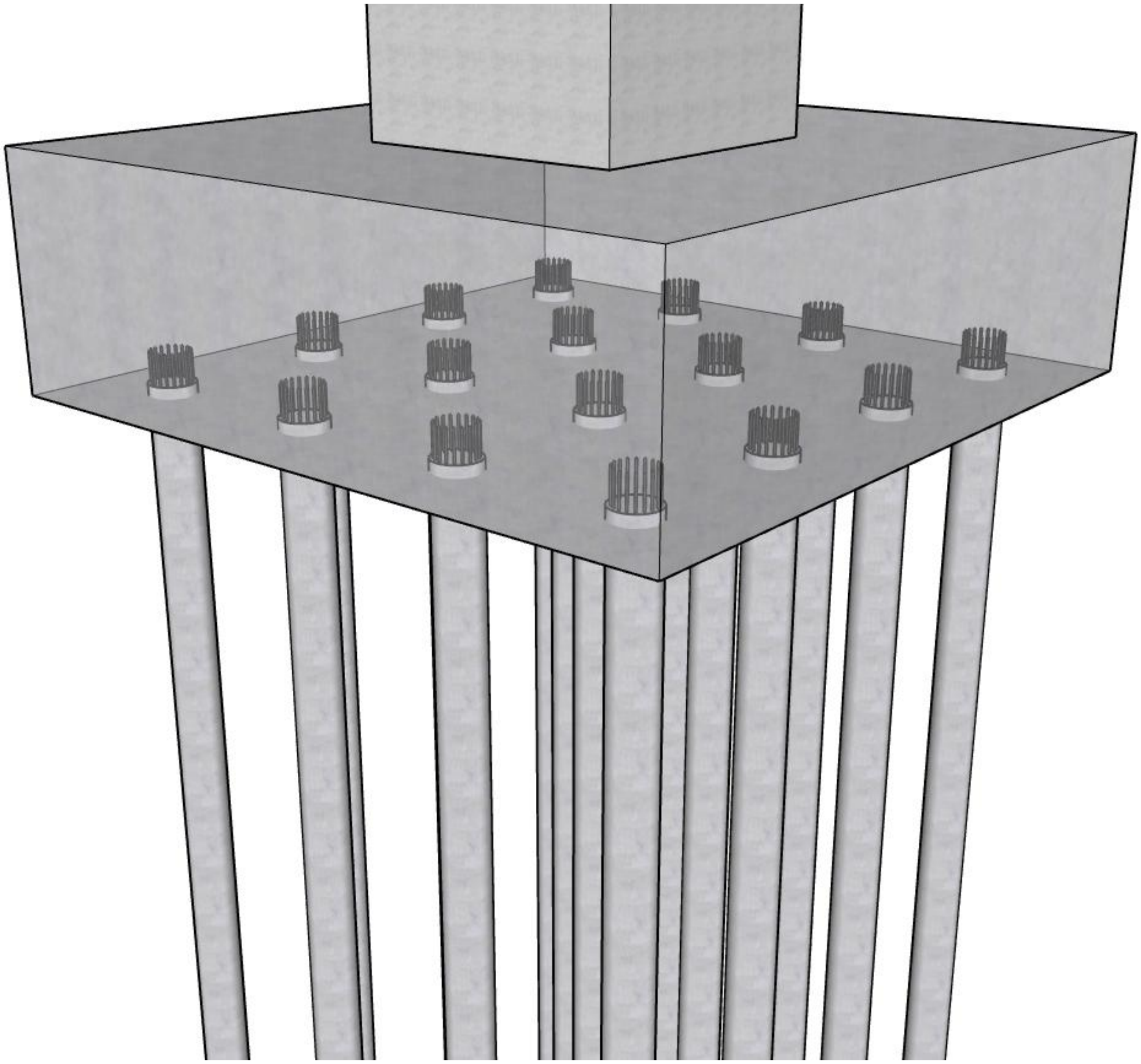
StructurePoint
CONCRETE SOFTWARE SOLUTIONS

spColumn spMats

Pile (Caisson) Analysis and Design for Bridge Pier Foundations (ACI 318-19)



Version: May-30-2025



Pile (Caisson) Analysis and Design for Bridge Pier Foundations (ACI 318-19)

Reinforced concrete piles and caissons are essential deep foundation elements used to transfer structural loads to deeper, more stable soil or rock layers, especially in challenging conditions where shallow foundations are inadequate. Commonly used in foundations for bridge piers, buildings, and industrial facilities, these elements provide critical support against axial and lateral forces. In this case study, a pile supported mat foundation (known as pile cap) shown below supports a highway bridge pier.

spMats from StructurePoint will be used to model and analyze the pile cap and determine the individual pile reactions. These reactions will then be exported to spColumn from StructurePoint using the "Export to spColumn CTI files" tool to design and optimize the piles for two scenarios: (1) piles pinned to the pile cap and (2) piles fixed to the pile cap. Additionally, a comparison between different transverse confinement types - tied and spiral reinforcement - will be conducted to evaluate their influence on pile capacity and behavior.

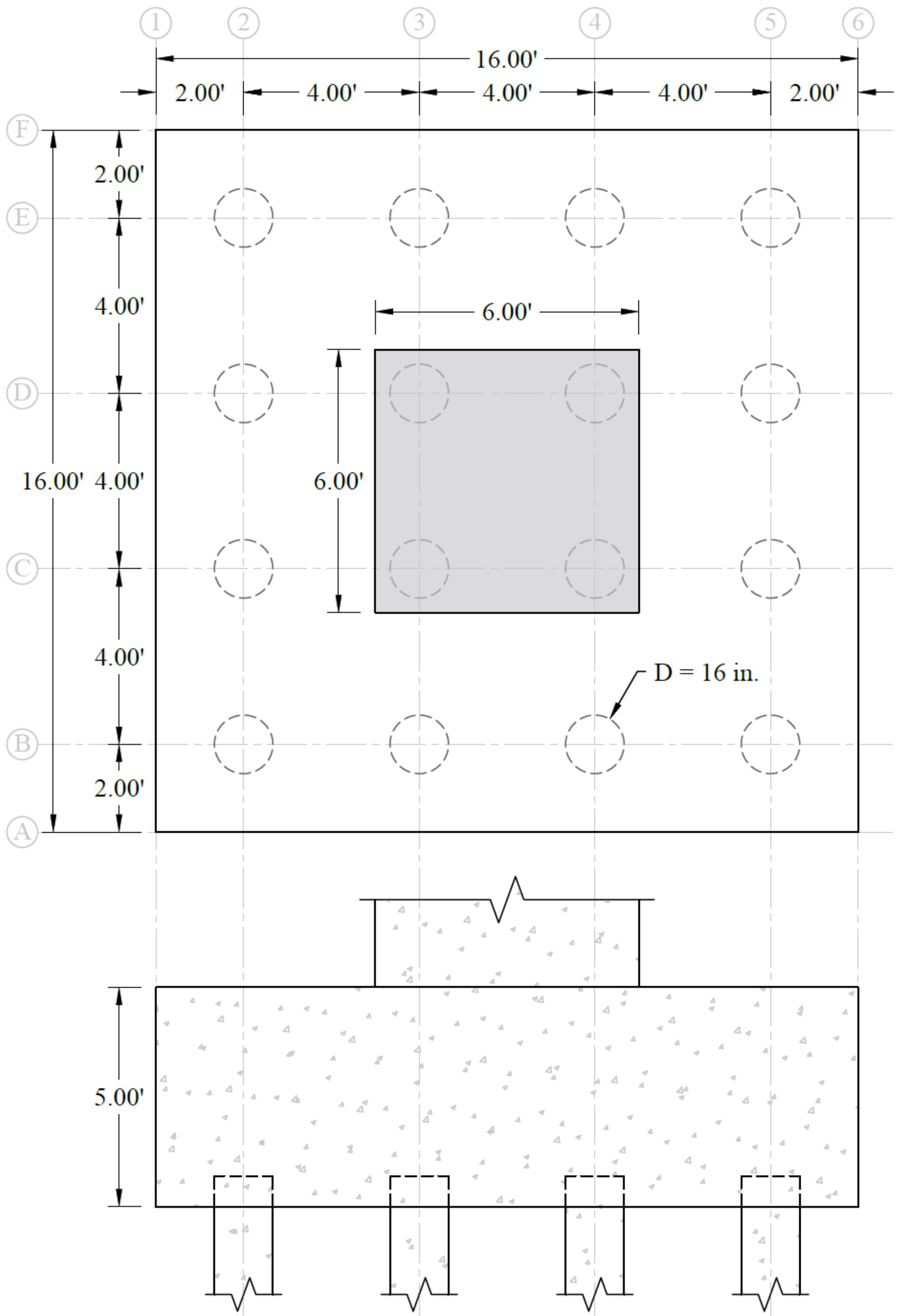


Figure 1 – Reinforced Concrete Piles and Pile Cap

Contents

Code

Building Code Requirements for Structural Concrete (ACI 318-19) and Commentary (ACI 318R-19)

References

- spMats Engineering Software Program Manual v10.50, STRUCTUREPOINT., 2025
- spColumn Engineering Software Program Manual v10.10a, STRUCTUREPOINT., 2025
- ACI Committee 543. ACI 543R-12: Guide to Design, Manufacture, and Installation of Concrete Piles. American Concrete Institute, 2012.
- FHWA-NHI-16-009. Drilled Shafts: Construction Procedures and LRFD Design Methods. Federal Highway Administration, 2018.
- AASHTO LRFD Bridge Design Specifications, 9th Edition. American Association of State Highway and Transportation Officials (AASHTO), 2020.

- Contact Support@StructurePoint.org to obtain supplementary materials (spColumn and spMats models: CS-Pile-Caisson-Design-ACI-318-19-P16-Fixed.colx, CS-Pile-Caisson-Design-ACI-318-19-P16-Pinned.colx and CS-Pile-Caisson-Design-ACI-318-19.matx)

Design Data

Foundation Geometry:

Width = 16'-0"

Length = 16'-0"

Thickness = 60 in.

Load, Load Cases, and Load Combinations:

Refer to Appendix

Soil Properties:

Allowable Bearing Capacity = 500 ksf

Subgrade Modulus, k_s = 7,000 kcf

Material Properties:

f'_c = 5 ksi

f_y = 60 ksi

1. Introduction

Reinforced concrete piles and caissons are deep foundation elements widely employed to transfer structural loads to competent soil or rock strata. These elements are essential in cases where surface soils lack sufficient bearing capacity to support applied loads. Among the most common pile types, cast-in-place concrete piles - such as drilled shafts or caissons - and precast driven piles are frequently used due to their ability to resist axial and lateral loads, provide settlement control, and accommodate complex subsurface conditions. Micropiles are used where the headroom or clearance is limited and usually for lower axial compression and tension capacity.

In bridge construction, reinforced concrete piles and caissons are often used to support bridge piers and pile caps, ensuring heavier loads from superstructures are transferred through water or poor soil conditions to stronger load bearing layers. These foundations are especially critical in river crossings and marine environments, where scour and erosion pose significant challenges. The integration of pile groups into pile caps provides a rigid platform to distribute superstructure loads and maintain structural integrity under vibratory loads, moving loads, wind forces, and seismic forces.

Beyond transportation infrastructure, reinforced concrete piles are extensively used in buildings, towers, storage tanks, chimneys, and heavy industrial facilities. They serve to support vertical loads and resist horizontal forces induced by wind, machinery, or seismic activity. Industrial applications often involve heavy equipment, reciprocating machinery, and dynamic loading, requiring pile foundations with enhanced durability and stiffness to secure equipment and meet serviceability and functionality requirements.

The use of advanced structural analysis software, such as spMats, facilitates the evaluation of pile-soil-structure interaction, the modeling of pile caps, and the accurate distribution of axial and bending forces among piles. Such tools support engineers in optimizing designs for safety, economy, and performance under service and ultimate load conditions. Additionally, spColumn can be used to design and investigate the capacity of reinforced concrete piles and caissons under combined axial and bending loads, enabling engineers to optimize pile sections by adjusting reinforcement configurations and material properties for improved strength and efficiency.

2. Method of Solution

Finite Element Analysis (FEA) will be employed using spMats to model the reinforced concrete pile cap and evaluate its interaction with the supported bridge pier and the underlying piles. The pile cap will be modeled as a mat foundation with appropriate boundary conditions and loading to reflect the bridge superstructure behavior. From the spMats analysis, the individual axial reactions in each pile will be extracted using the integrated "Export to spColumn CTI files" feature.

These reactions will be imported into spColumn, where the pile under the maximum tension and compression reactions will be evaluated. spColumn will be used to perform axial-bending interaction analysis, generate interaction diagrams, and develop the 3D failure surface for the selected pile section.

To finalize the design, a detailed investigation will be conducted in spColumn for two boundary conditions: (1) piles pinned to the pile cap, and (2) piles fixed to the pile cap. Additionally, the effect of transverse reinforcement confinement will be studied by comparing tied versus spiral reinforcement configurations to assess their impact on the section capacity.

3. Analysis using spMats

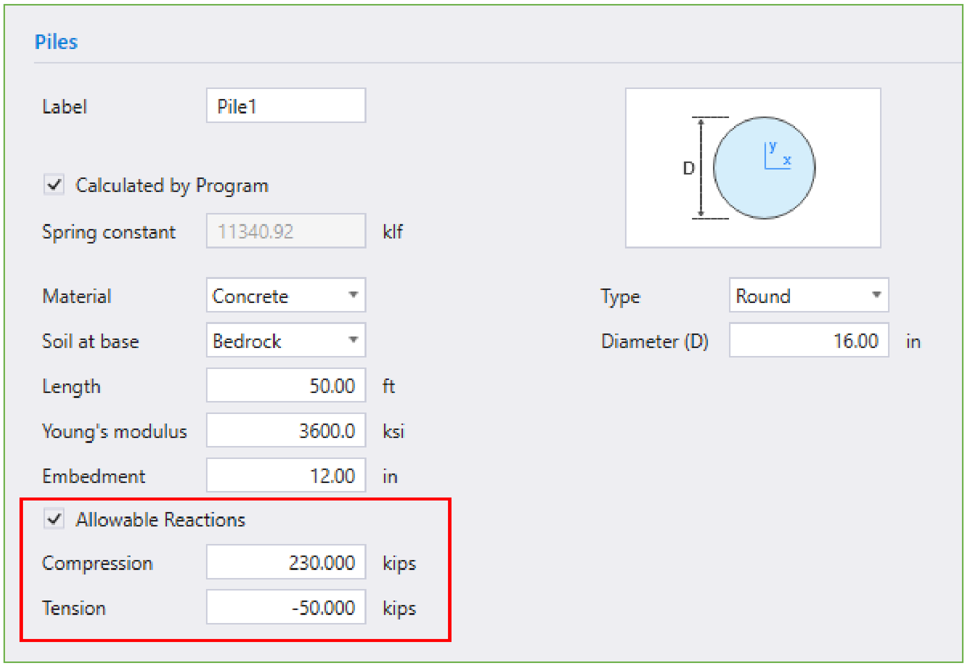


Figure 2 – Piles Properties (spMats)

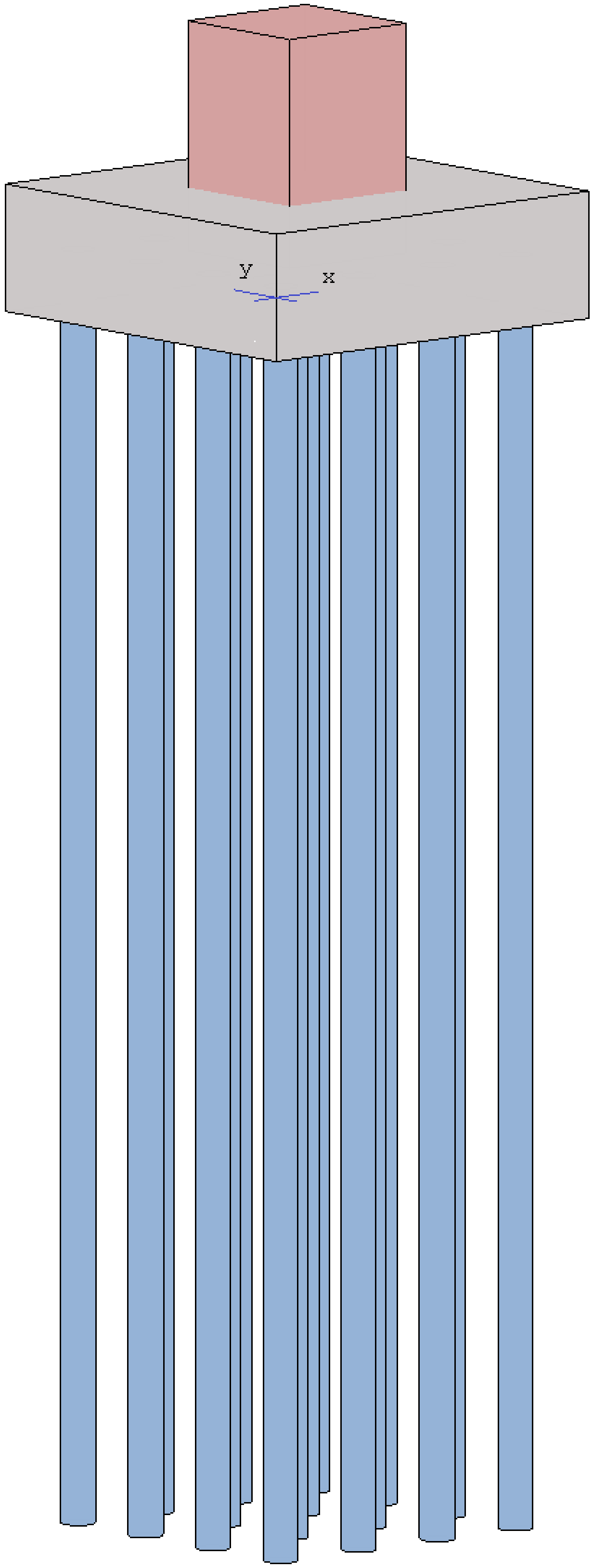


Figure 3 – 3D View Pile Cap Foundation (spMats)

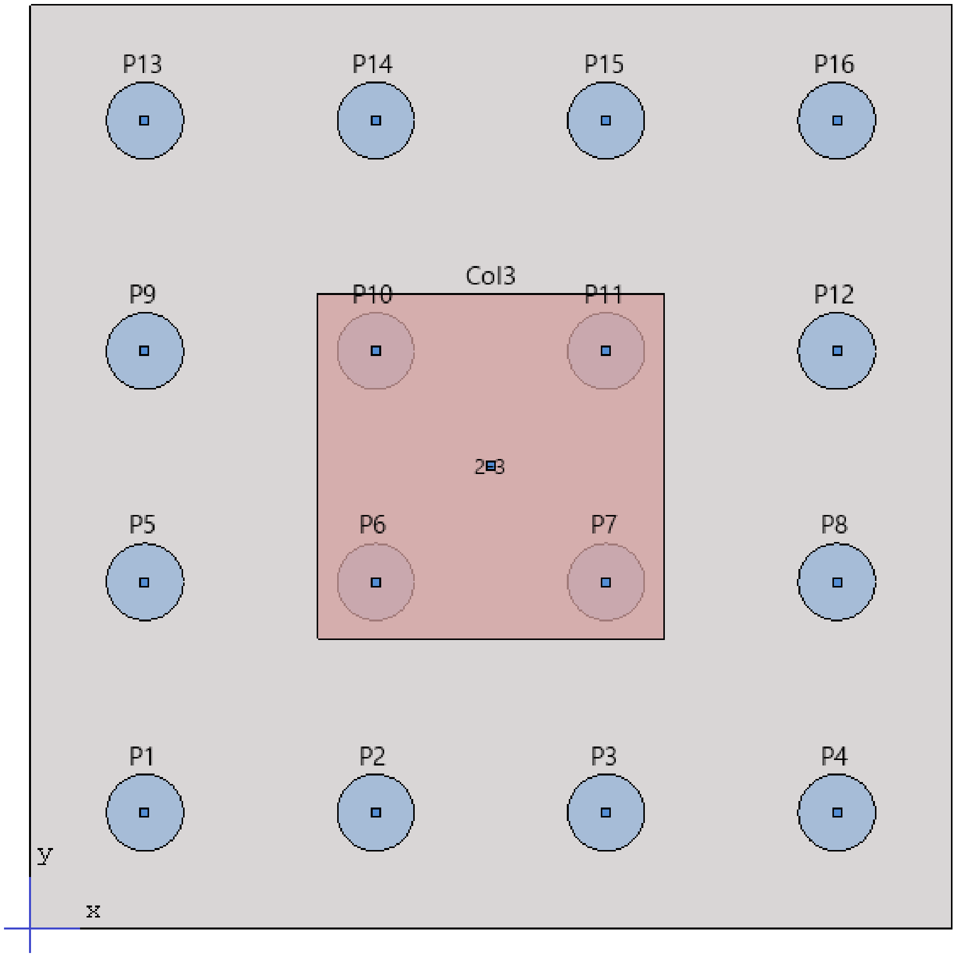


Figure 4 – Plan View Pile Cap Foundation (spMats)

In spMats, pile reactions are represented graphically with directional arrows - upward arrows for compression and downward arrows for tension following the program sign convention for coordinate axes. When allowable pile reactions are defined by the user as shown in Figure 2, the program will automatically evaluate each pile's reaction against the defined limits. Pile reactions that do not exceed the allowable values are displayed in blue, while those that exceed are highlighted in red to alert the user. A warning icon will also appear in the Contours tree to indicate that one or more pile reactions exceed the allowable limit. Note that allowable pile reactions, when specified, are only applicable to and compared with the Service pile reactions.

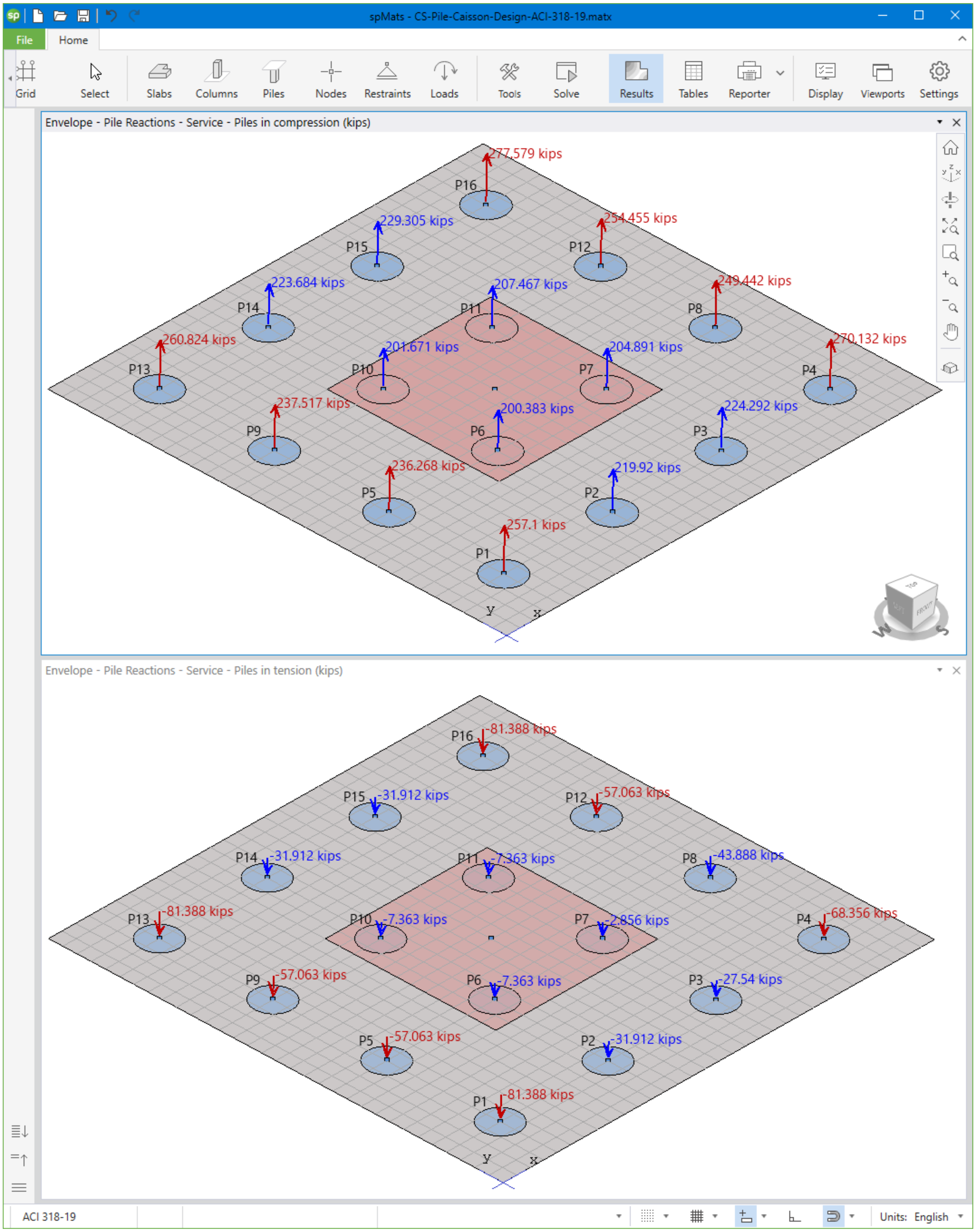


Figure 5 – Pile Service Reactions* (spMats)

* Pile reactions that do not exceed the allowable values are displayed in blue, while those that exceed are highlighted in red to alert the user.

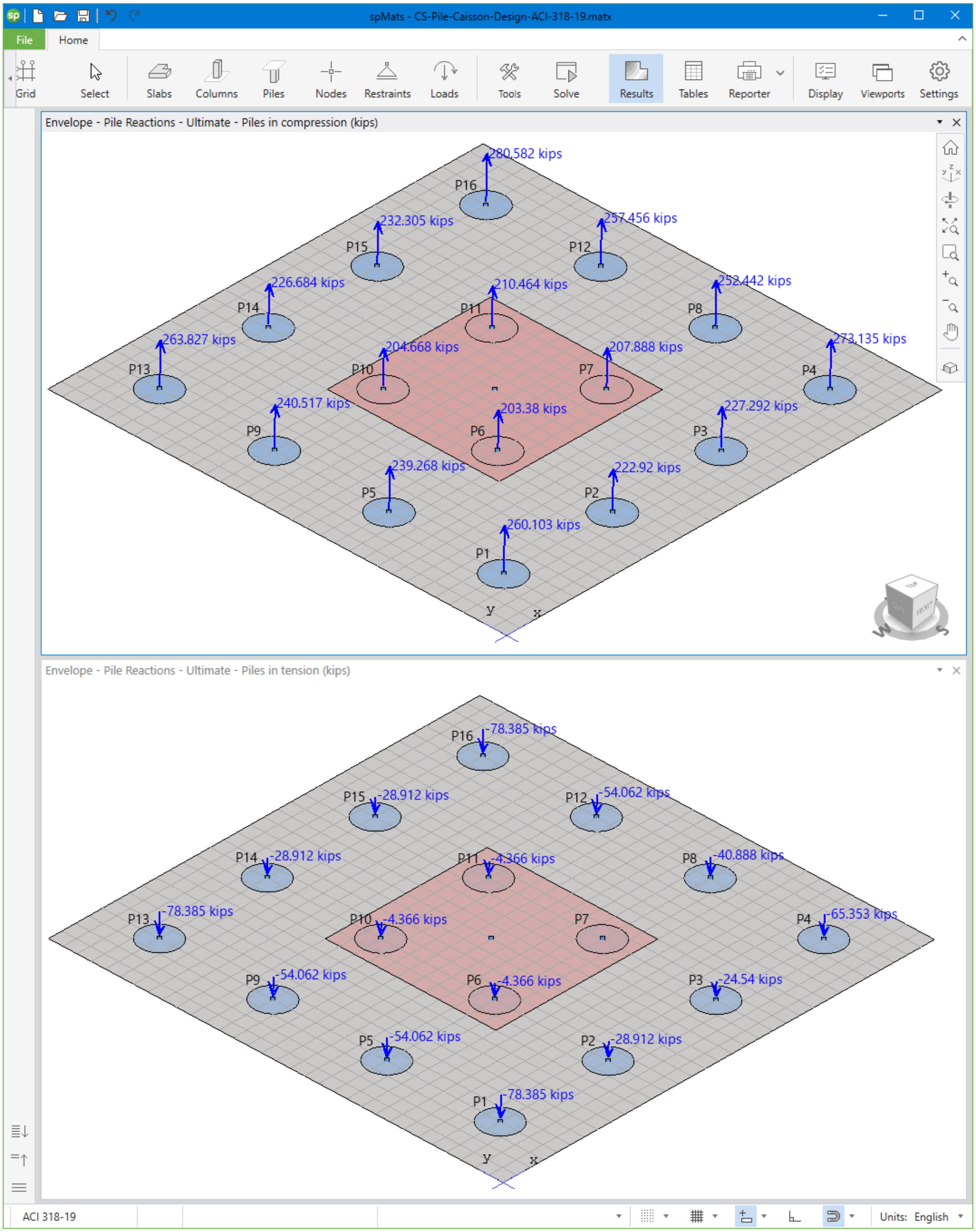
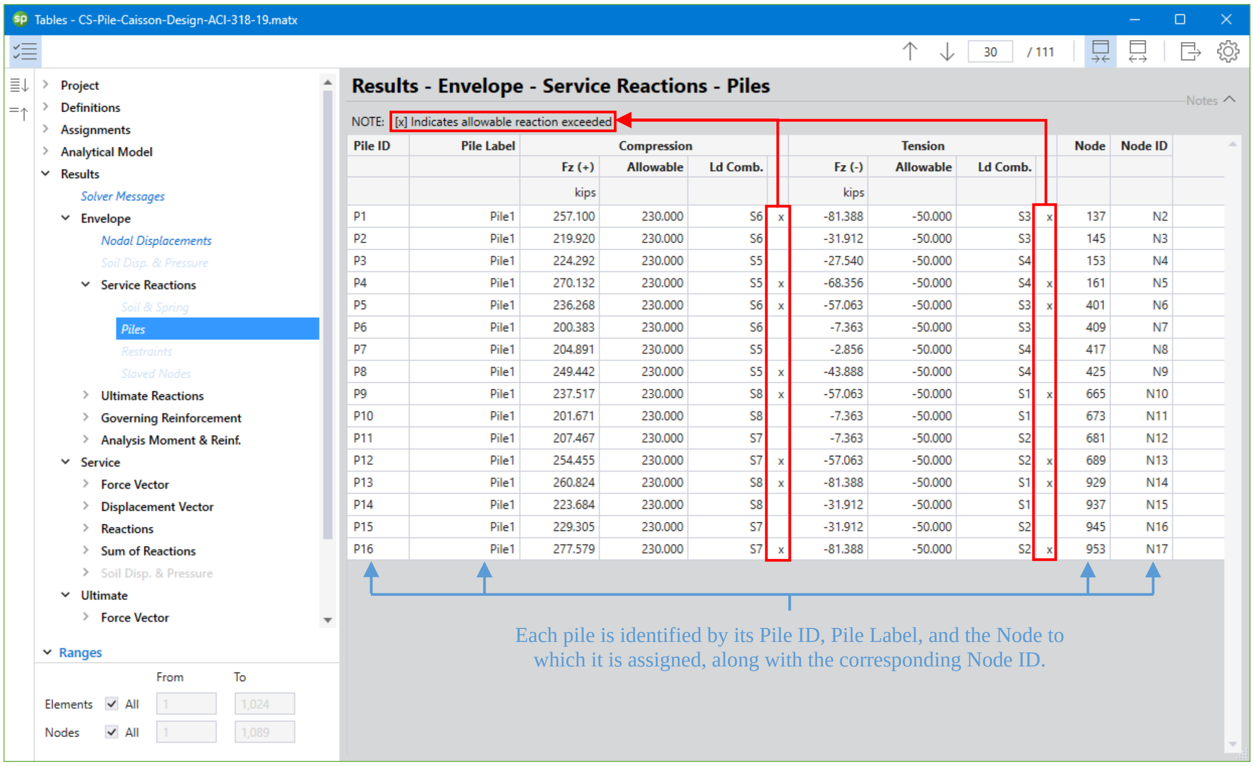


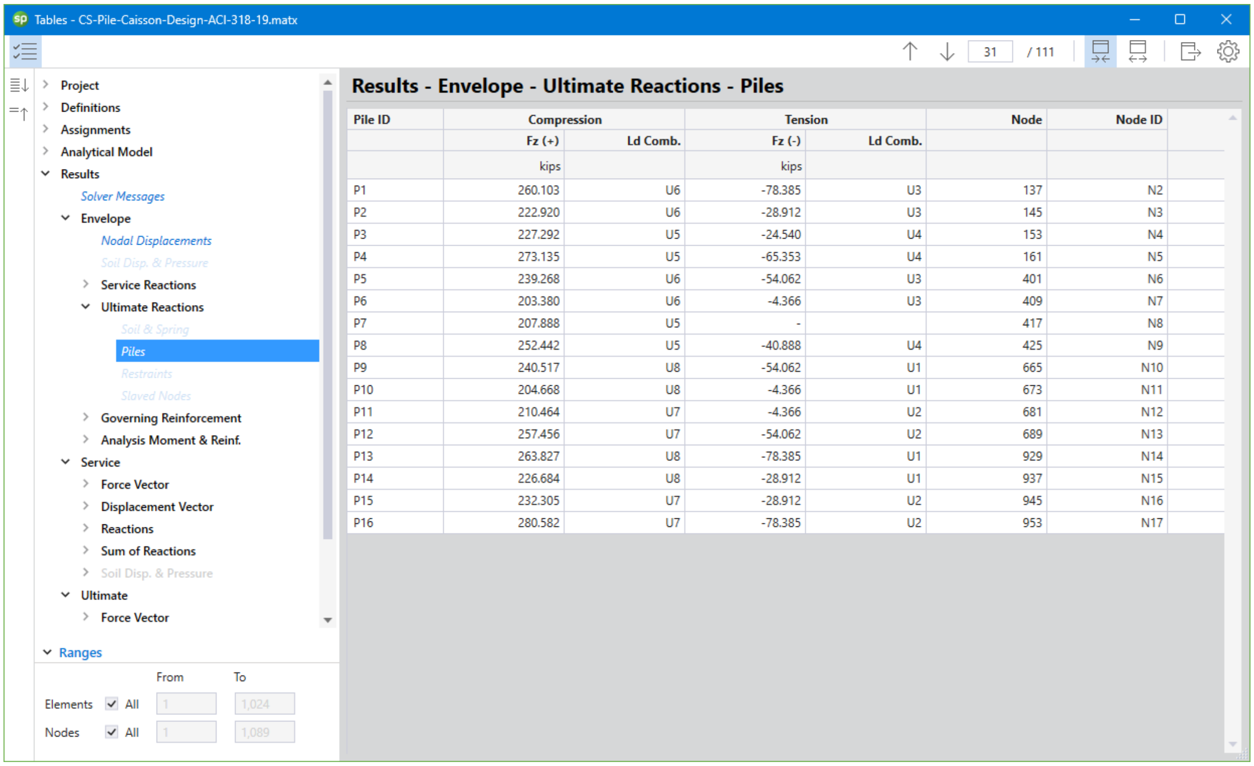
Figure 6 – Pile Ultimate Reactions (spMats)

In the tabular output, the program provides a summary of the individual pile reactions from service and ultimate load combinations. Each pile is identified by its Pile ID, Pile Label, and the Node to which it is assigned, along with the corresponding Node ID. The service reaction for each pile is compared against the user-defined allowable limits. If a pile's service reaction exceeds its allowable limit, an "x" mark is flagged in the corresponding row, indicating that the allowable reaction has been exceeded.



Pile ID	Pile Label	Compression				Tension				Node	Node ID
		Fz (+)	Allowable	Ld Comb.		Fz (-)	Allowable	Ld Comb.			
		kips				kips					
P1	Pile1	257.100	230.000	S6	x	-81.388	-50.000	S3	x	137	N2
P2	Pile1	219.920	230.000	S6		-31.912	-50.000	S3		145	N3
P3	Pile1	224.292	230.000	S5		-27.540	-50.000	S4		153	N4
P4	Pile1	270.132	230.000	S5	x	-68.356	-50.000	S4	x	161	N5
P5	Pile1	236.268	230.000	S6	x	-57.063	-50.000	S3	x	401	N6
P6	Pile1	200.383	230.000	S6		-7.363	-50.000	S3		409	N7
P7	Pile1	204.891	230.000	S5		-2.856	-50.000	S4		417	N8
P8	Pile1	249.442	230.000	S5	x	-43.888	-50.000	S4		425	N9
P9	Pile1	237.517	230.000	S8	x	-57.063	-50.000	S1	x	665	N10
P10	Pile1	201.671	230.000	S8		-7.363	-50.000	S1		673	N11
P11	Pile1	207.467	230.000	S7		-7.363	-50.000	S2		681	N12
P12	Pile1	254.455	230.000	S7	x	-57.063	-50.000	S2	x	689	N13
P13	Pile1	260.824	230.000	S8	x	-81.388	-50.000	S1	x	929	N14
P14	Pile1	223.684	230.000	S8		-31.912	-50.000	S1		937	N15
P15	Pile1	229.305	230.000	S7		-31.912	-50.000	S2		945	N16
P16	Pile1	277.579	230.000	S7	x	-81.388	-50.000	S2	x	953	N17

Figure 7 – Pile Service Reactions Table Output (spMats)



Results - Envelope - Ultimate Reactions - Piles

Pile ID	Compression		Tension		Node	Node ID
	Fz (+)	Ld Comb.	Fz (-)	Ld Comb.		
	kips		kips			
P1	260.103	U6	-78.385	U3	137	N2
P2	222.920	U6	-28.912	U3	145	N3
P3	227.292	U5	-24.540	U4	153	N4
P4	273.135	U5	-65.353	U4	161	N5
P5	239.268	U6	-54.062	U3	401	N6
P6	203.380	U6	-4.366	U3	409	N7
P7	207.888	U5	-		417	N8
P8	252.442	U5	-40.888	U4	425	N9
P9	240.517	U8	-54.062	U1	665	N10
P10	204.668	U8	-4.366	U1	673	N11
P11	210.464	U7	-4.366	U2	681	N12
P12	257.456	U7	-54.062	U2	689	N13
P13	263.827	U8	-78.385	U1	929	N14
P14	226.684	U8	-28.912	U1	937	N15
P15	232.305	U7	-28.912	U2	945	N16
P16	280.582	U7	-78.385	U2	953	N17

Figure 8 – Pile Ultimate Reactions Table Output (spMats)

4. Design and Investigation using spColumn

spMats provides the option to export piles and columns information from the foundation model to spColumn. Column Text Input (CTI) files are generated by spMats to include the section, materials, and the loads from the spMats foundation model required by spColumn for strength design and investigation of piles. Once the spMats foundation model is completed and successfully executed, the following steps illustrate the design of a sample pile.

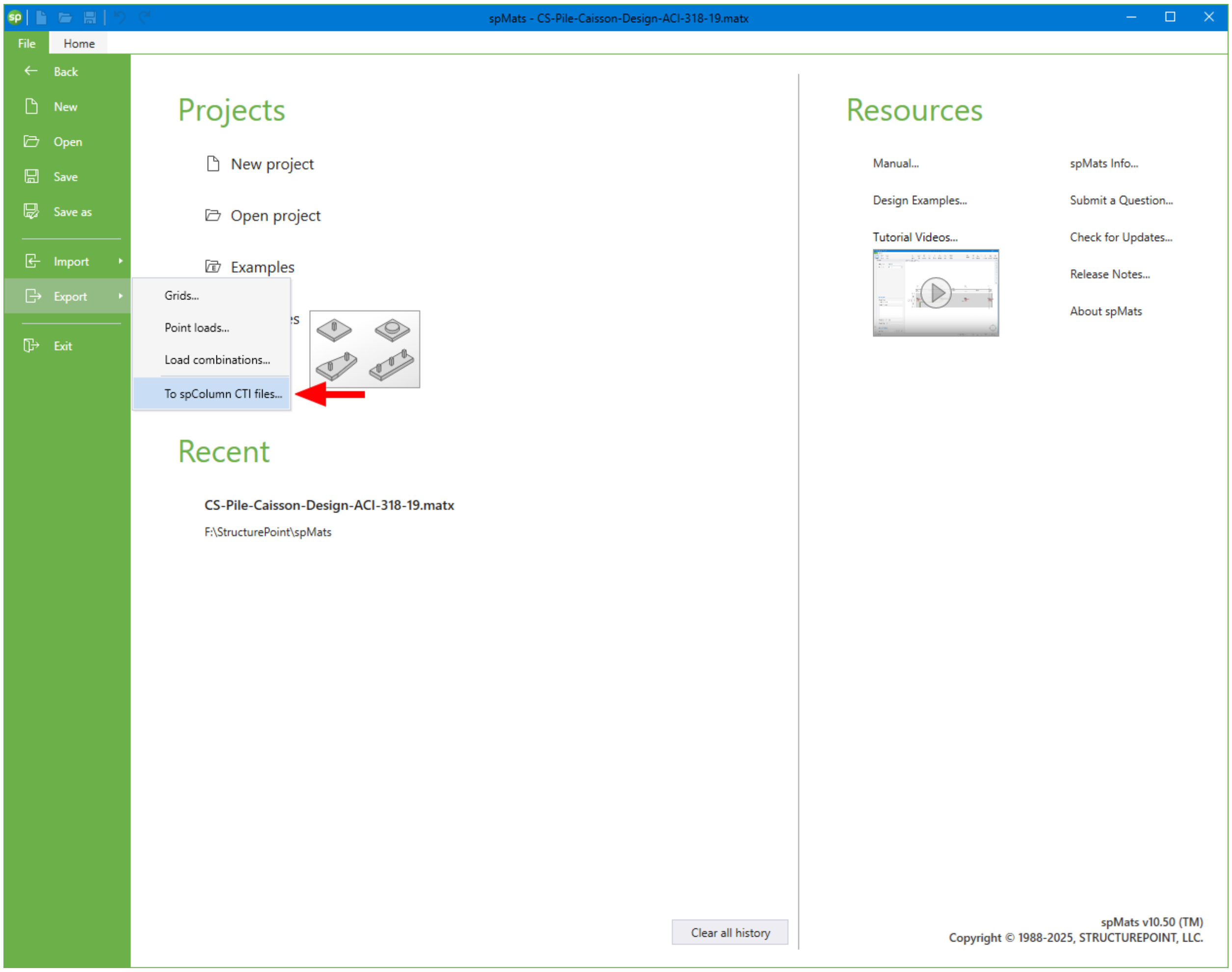


Figure 9 – Exporting spColumn CTI Files (spMats)

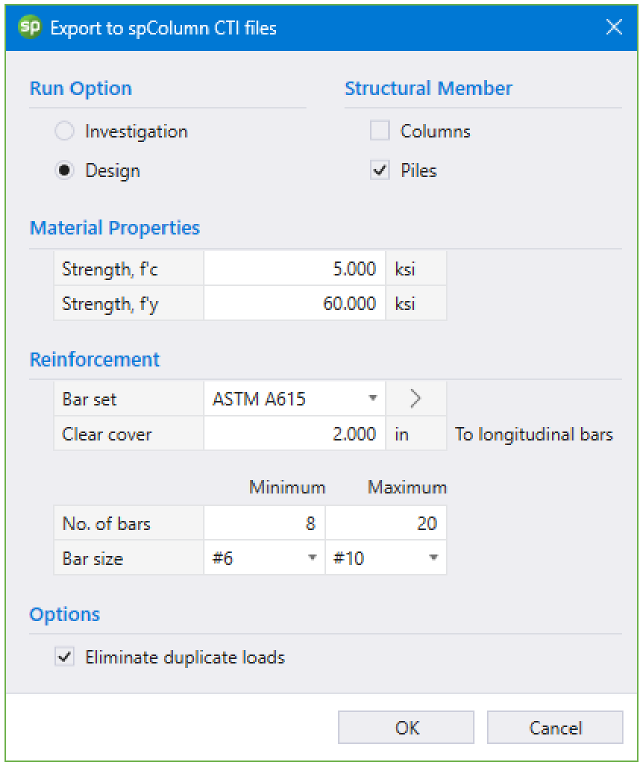


Figure 10 – Exporting CTI Files Dialog Box for Piles (spMats)

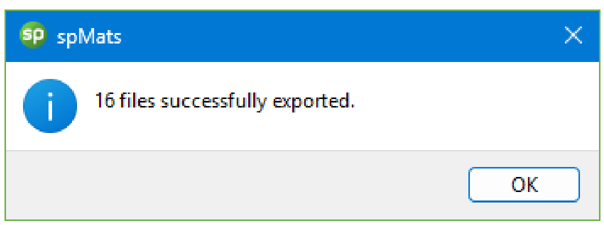


Figure 11 – Message Dialog Box (spMats)

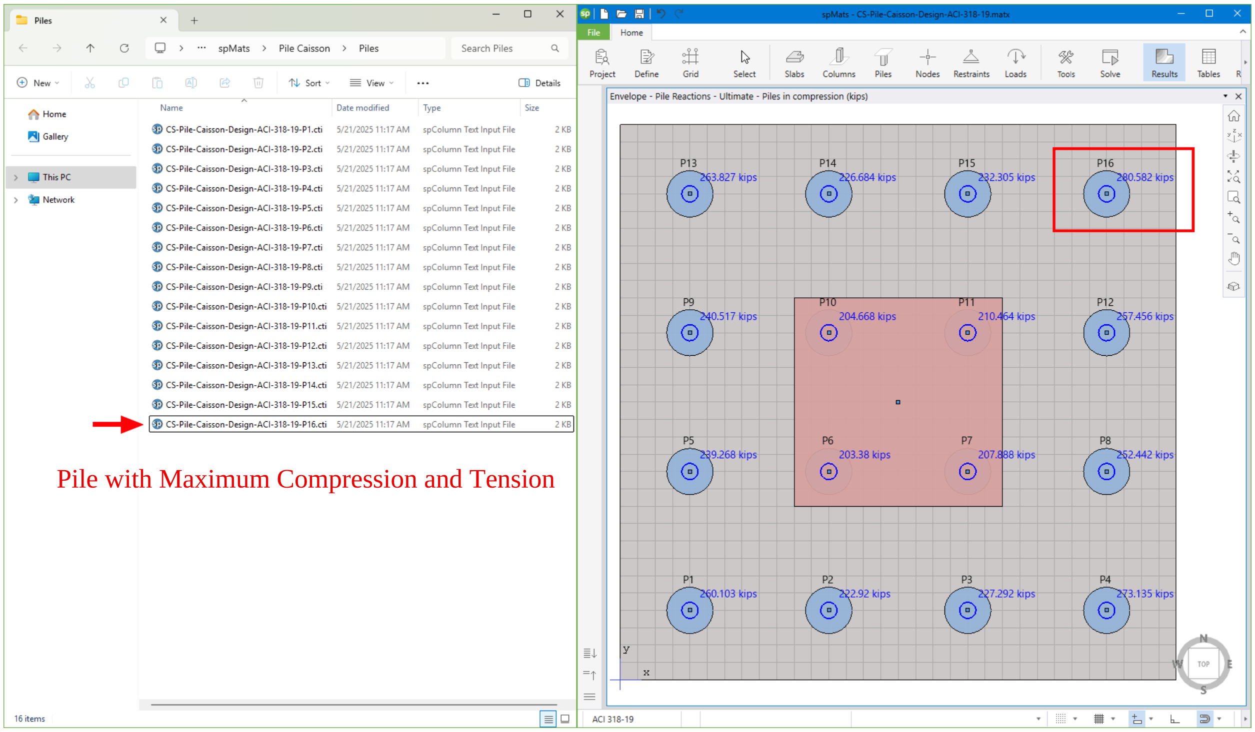


Figure 12 – Exported CTI Files (spMats)

After exporting spColumn input files, the pile design/investigation can proceed/modified to meet project specifications and criteria.

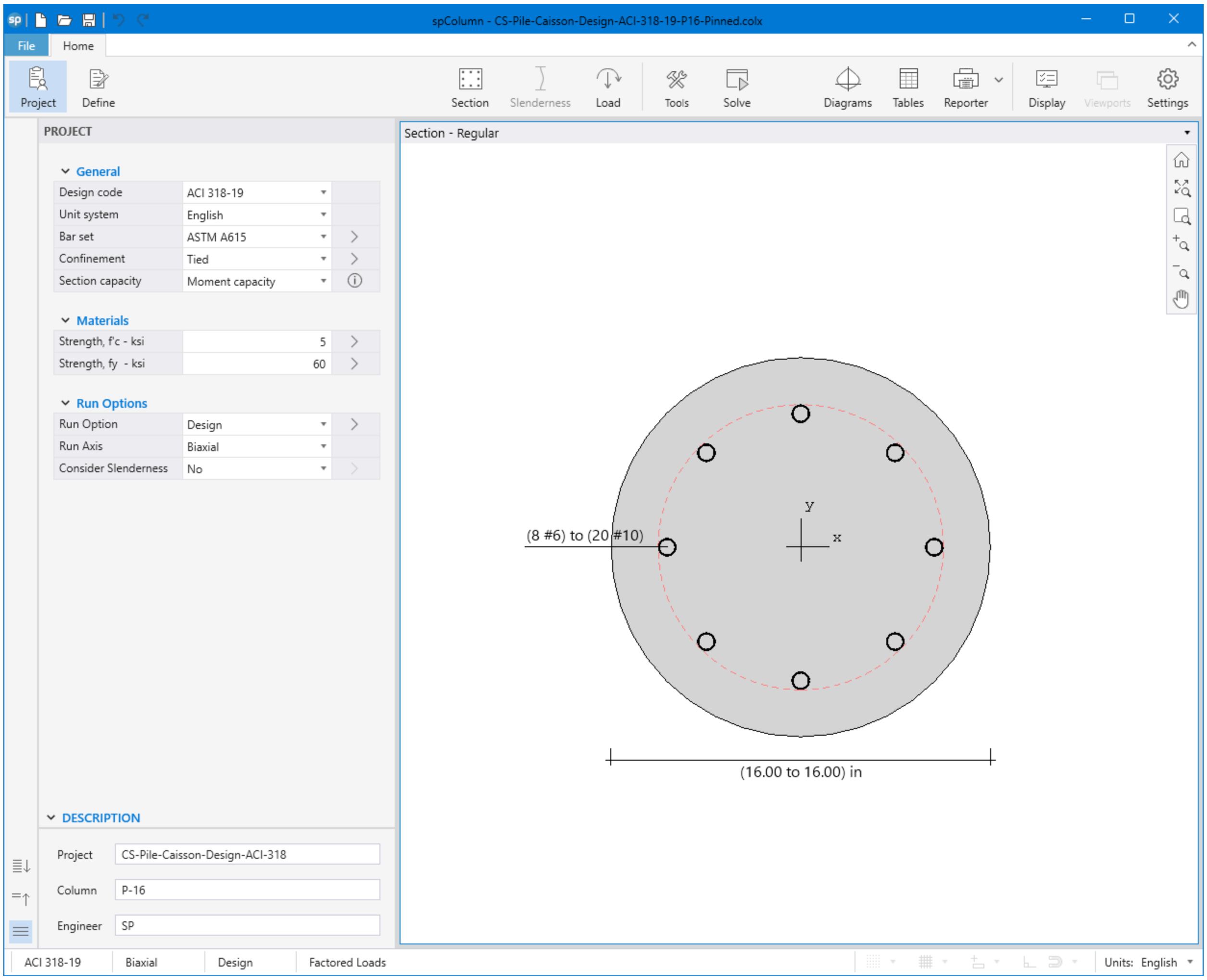


Figure 13 – spColumn Design Interface

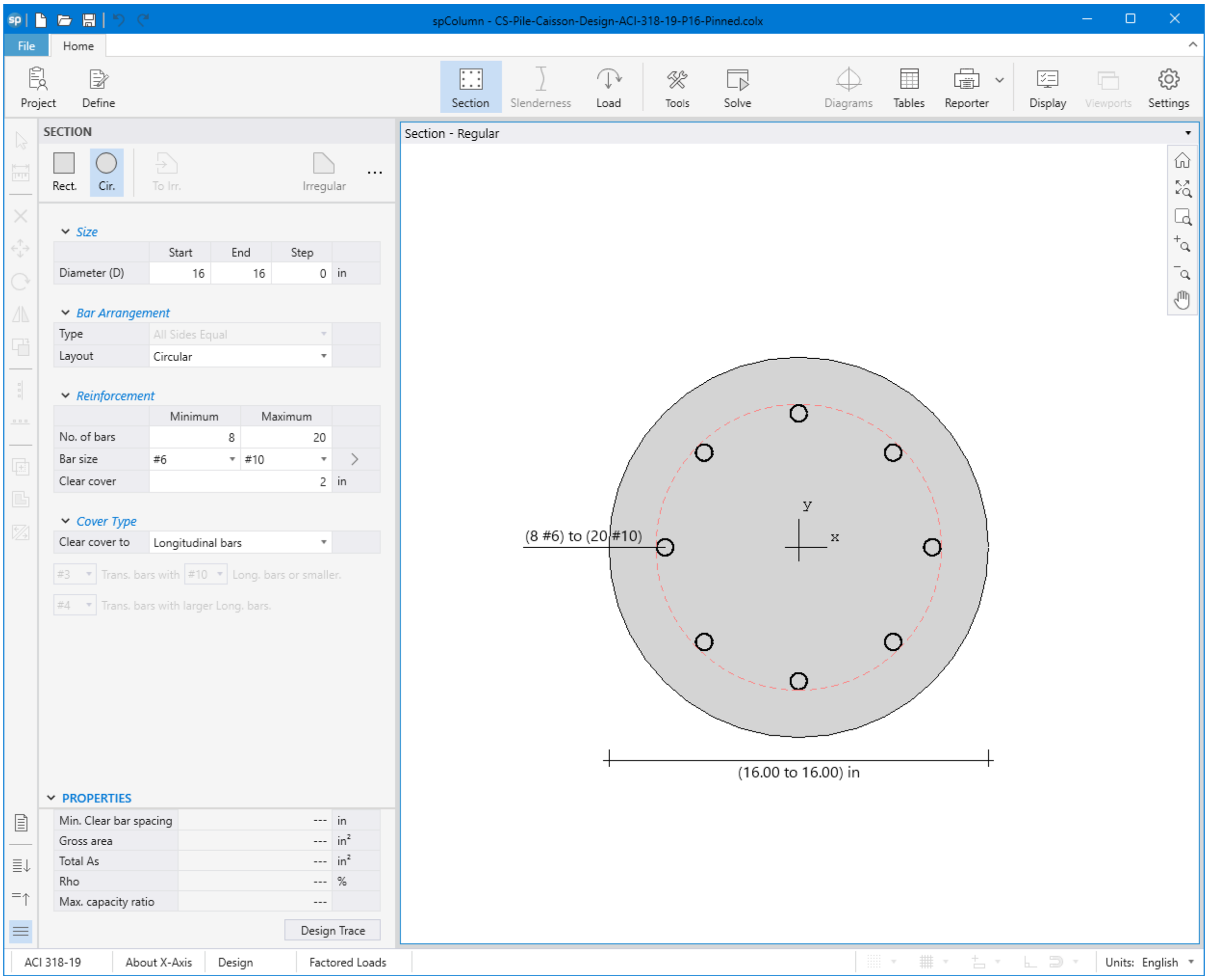
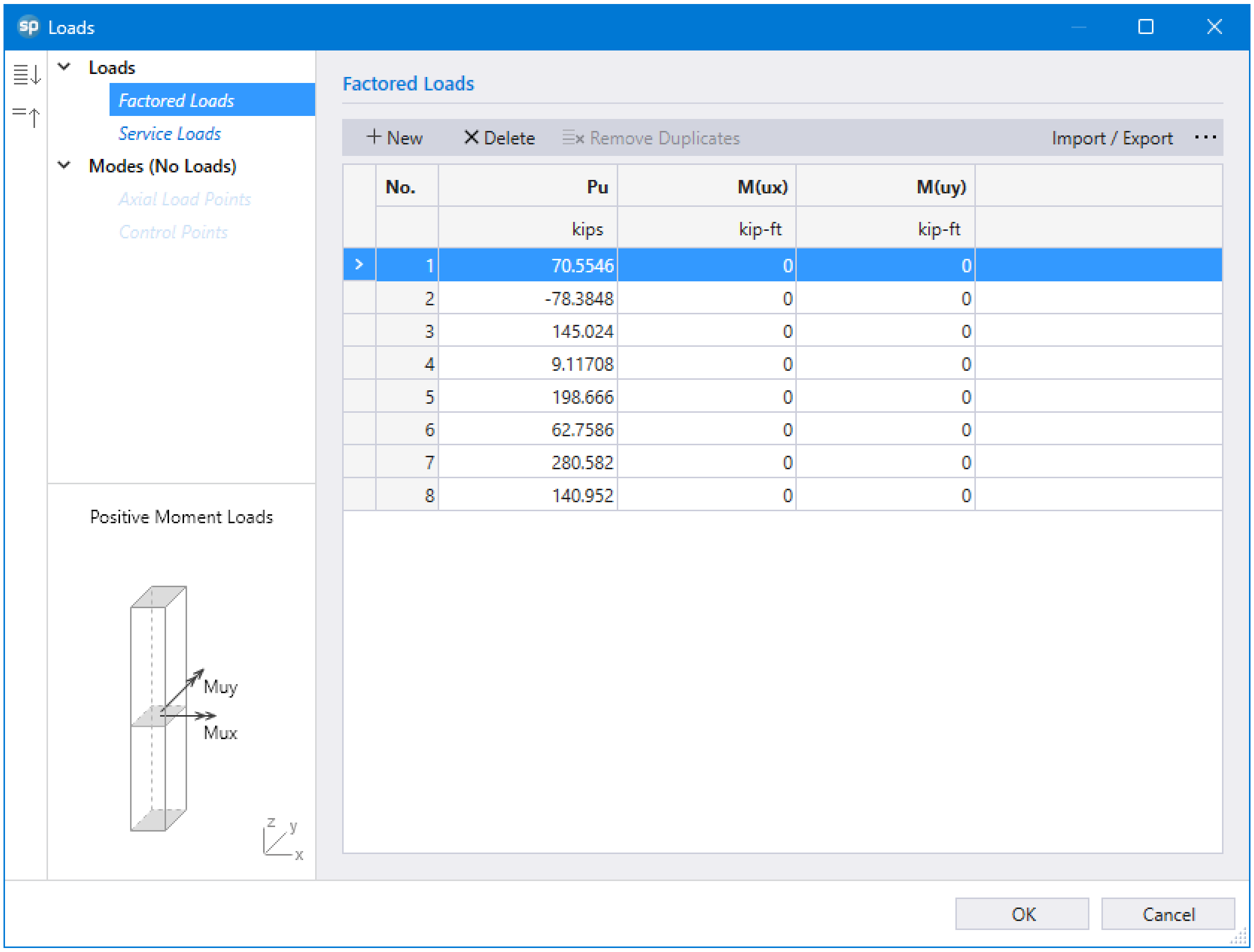


Figure 14 – spColumn Section Editor

4.1. When Pile is Pinned to the Pile Cap



No.	Pu (kips)	M(ux) (kip-ft)	M(uy) (kip-ft)
1	70.5546	0	0
2	-78.3848	0	0
3	145.024	0	0
4	9.11708	0	0
5	198.666	0	0
6	62.7586	0	0
7	280.582	0	0
8	140.952	0	0

Figure 15 – spColumn Factored Loads Imported from spMats

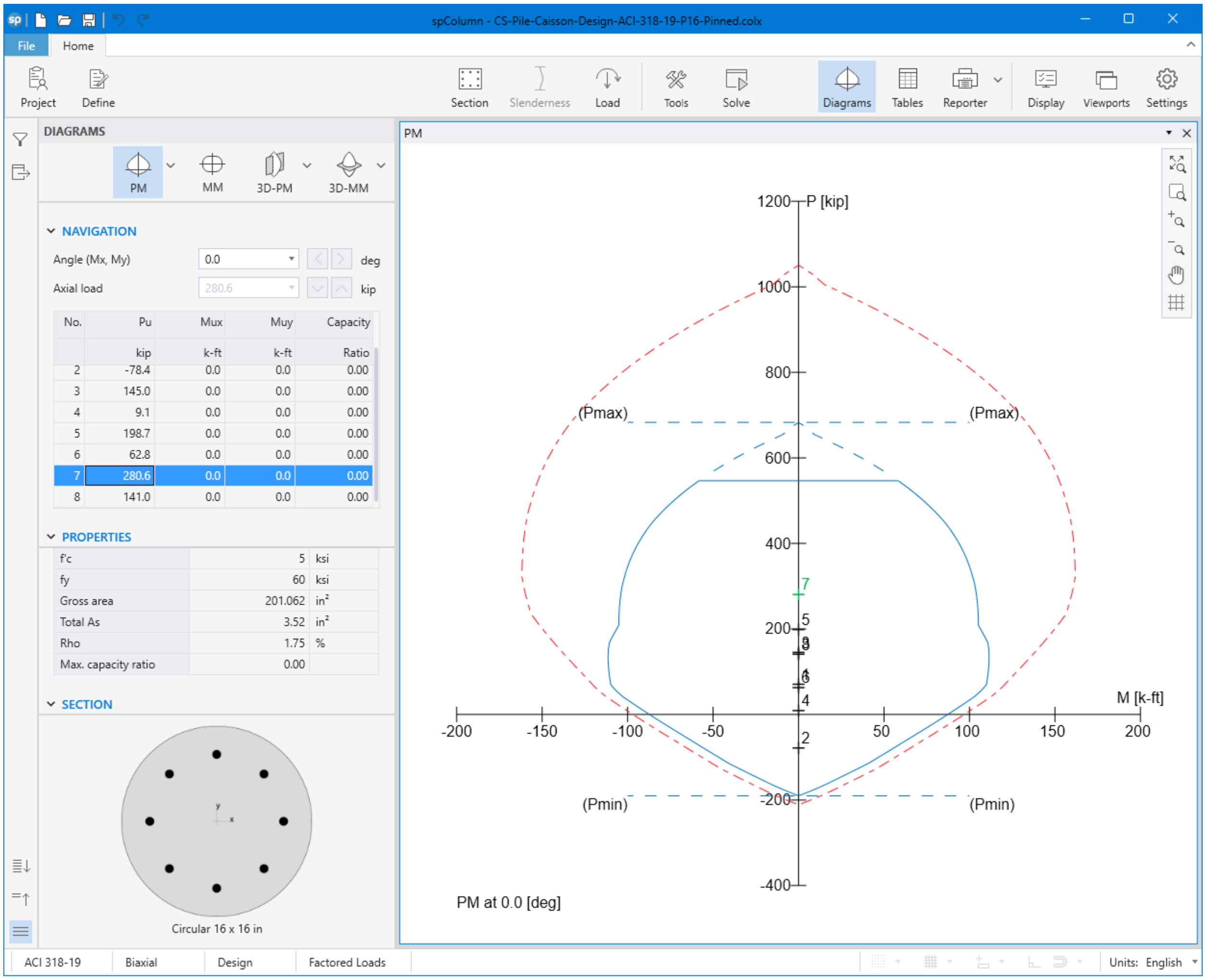


Figure 16 – Pile Section Interaction Diagram at 0° (spColumn)

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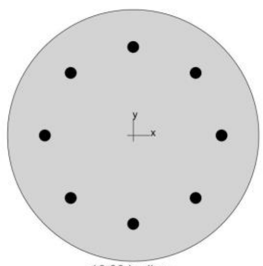


16.00 in diam.

General Information

Project	CS-Pile-C...gn-ACI-318
Column	P-16
Engineer	-
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Design
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Moment capacity

Materials

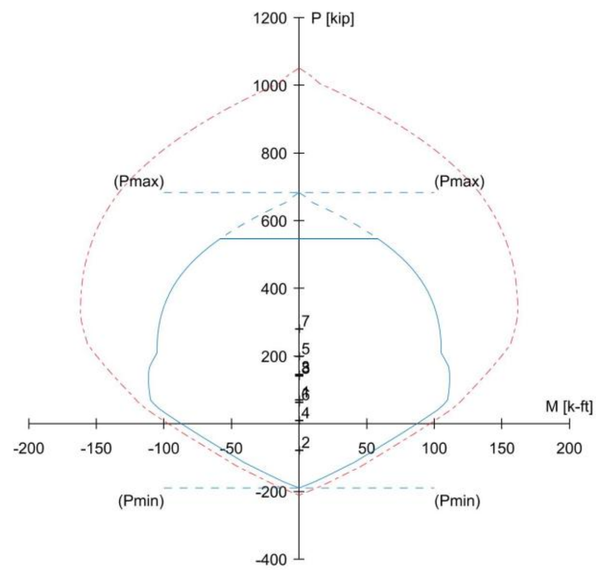
f'_c	5 ksi
E_c	4030.51 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	16 in
A_g	201.062 in²
I_x	3216.99 in⁴
I_y	3216.99 in⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Longitudal bars
Clear cover	2 in
Bars	8 #6
Confinement type	Tied
Total steel area, A_s	3.52 in²
Rho	1.75 %
Min. clear spacing	3.56 in



PM at 0.0 [deg]

No.	P_u	M_{ux}	M_{uy}	ϕP_n	ϕM_{nx}	ϕM_{ny}	Capacity
	kip	k-ft	k-ft	kip	k-ft	k-ft	Ratio
1	70.6	0.0	0.0	70.55	109.91	0.00	0.00
2	-78.4	0.0	0.0	-78.38	55.66	0.00	0.00
3	145.0	0.0	0.0	145.02	111.37	0.00	0.00
4	9.1	0.0	0.0	9.12	90.74	0.00	0.00
5	198.7	0.0	0.0	198.67	106.56	0.00	0.00
6	62.8	0.0	0.0	62.76	108.52	0.00	0.00
7	280.6	0.0	0.0	280.58	104.04	0.00	0.00
8	141.0	0.0	0.0	140.95	111.41	0.00	0.00

Max. Capacity Ratio: 0.00

Figure 17 – spColumn Output Report (When Pile is Pinned)

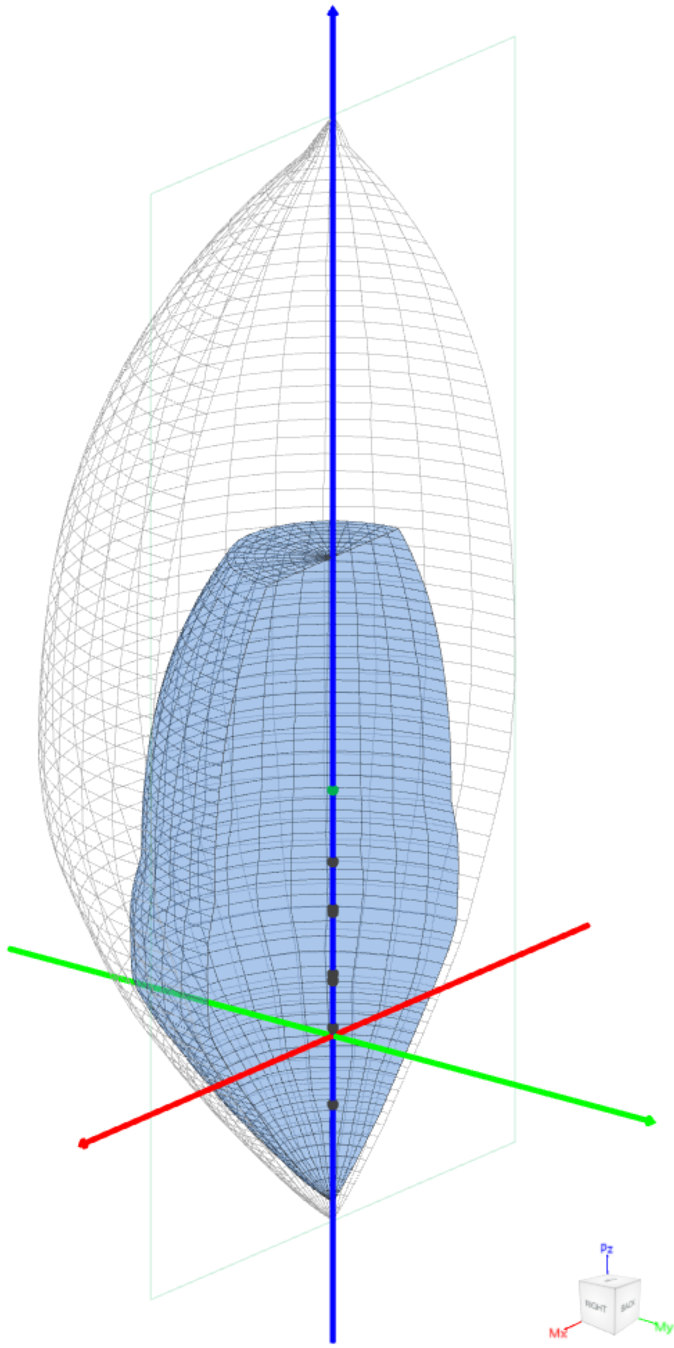
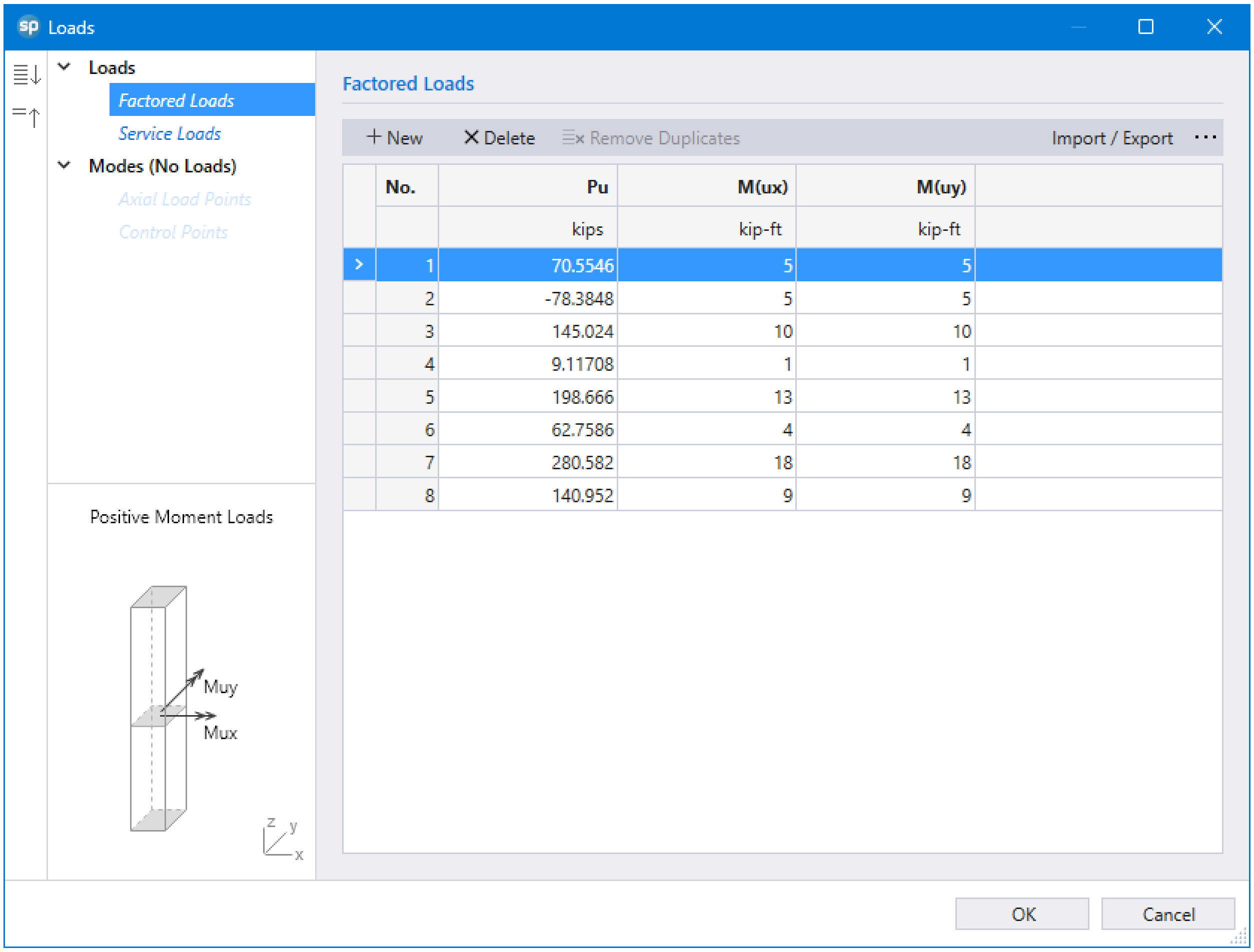


Figure 18 – Pile 3D Failure Surfaces (spColumn)

4.2. When Pile is Fixed to the Pile Cap



No.	Pu	M(ux)	M(uy)
	kips	kip-ft	kip-ft
1	70.5546	5	5
2	-78.3848	5	5
3	145.024	10	10
4	9.11708	1	1
5	198.666	13	13
6	62.7586	4	4
7	280.582	18	18
8	140.952	9	9

Figure 19 – spColumn Factored Loads Imported from spMats

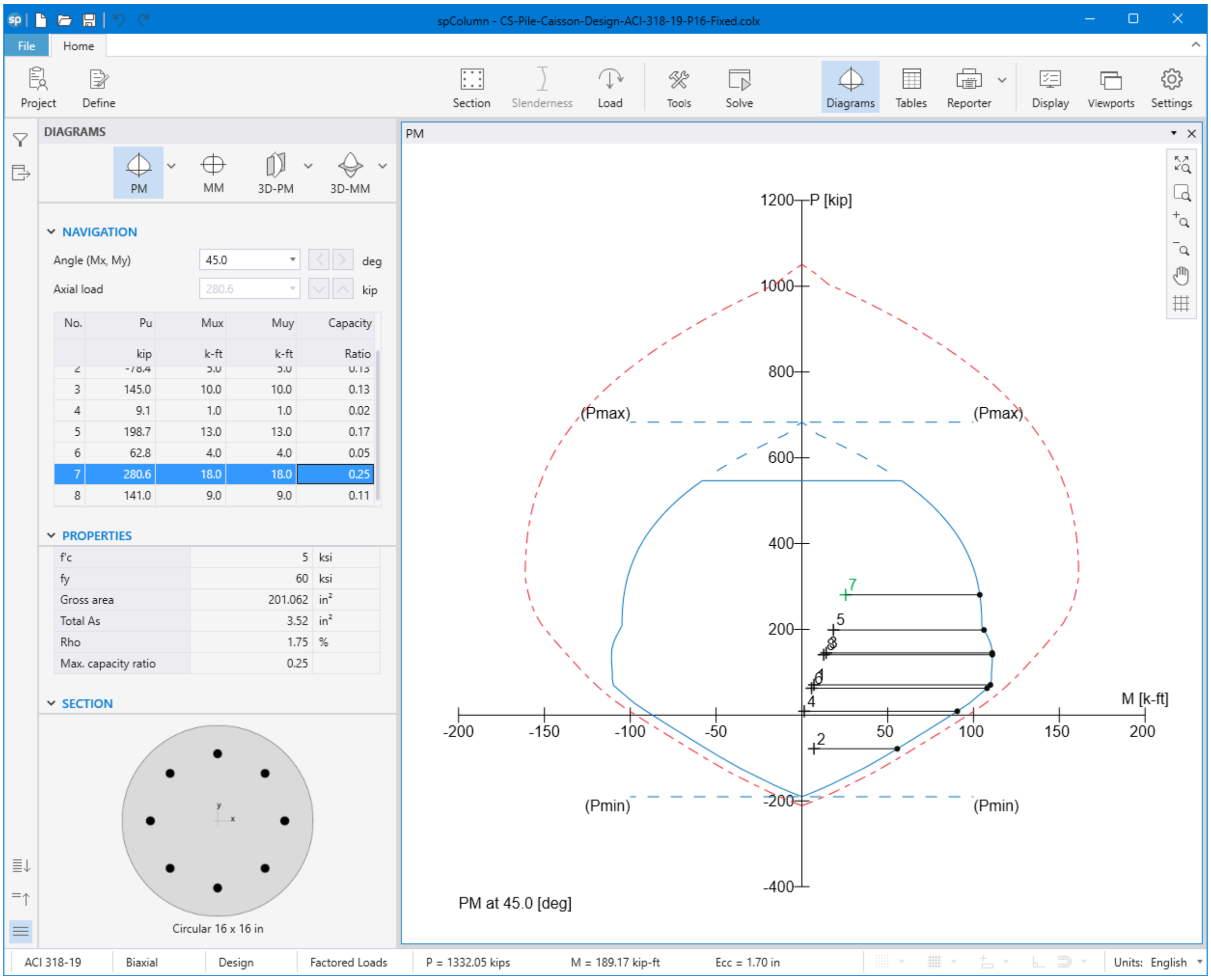


Figure 20 – Pile Section Interaction Diagram at 45° (spColumn)

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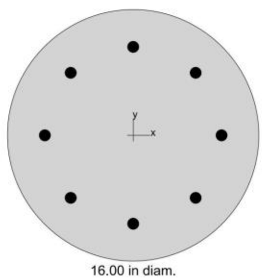


General Information

Project	CS-Pile-C...gn-ACI-318
Column	P-16
Engineer	SP
Code	ACI 318-19
Bar Set	ASTM A615
Units	English
Run Option	Design
Run Axis	Biaxial
Slenderness	Not Considered
Column Type	Structural
Capacity Method	Moment capacity

Materials

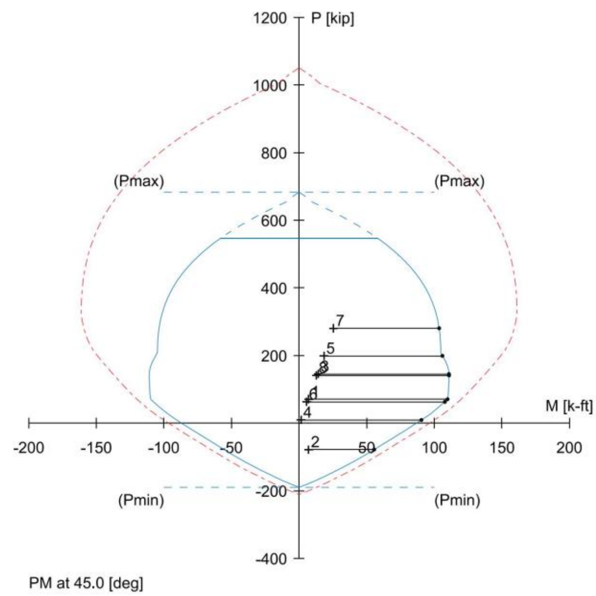
f'_c	5 ksi
E_c	4030.51 ksi
f_y	60 ksi
E_s	29000 ksi

Section

Type	Circular
Diameter	16 in
A_g	201.062 in²
I_x	3216.99 in⁴
I_y	3216.99 in⁴

Reinforcement

Pattern	All sides equal
Bar layout	Circular
Cover to	Longitudal bars
Clear cover	2 in
Bars	8 #6
Confinement type	Tied
Total steel area, A_s	3.52 in²
Rho	1.75 %
Min. clear spacing	3.56 in



No.	P_u	M_{ux}	M_{uy}	ϕP_n	ϕM_{nx}	ϕM_{ny}	Capacity
	kip	k-ft	k-ft	kip	k-ft	k-ft	Ratio
7	280.6	18.0	18.0	280.58	73.27	73.27	0.25
5	198.7	13.0	13.0	198.67	75.00	75.00	0.17
2	-78.4	5.0	5.0	-78.38	39.27	39.27	0.13
3	145.0	10.0	10.0	145.02	78.40	78.40	0.13
8	141.0	9.0	9.0	140.95	78.43	78.43	0.11
1	70.6	5.0	5.0	70.55	77.69	77.69	0.06
6	62.8	4.0	4.0	62.76	76.26	76.26	0.05
4	9.1	1.0	1.0	9.12	64.01	64.01	0.02

Max. Capacity Ratio: 0.25

Figure 21 – spColumn Output Report (When Pile is Fixed)

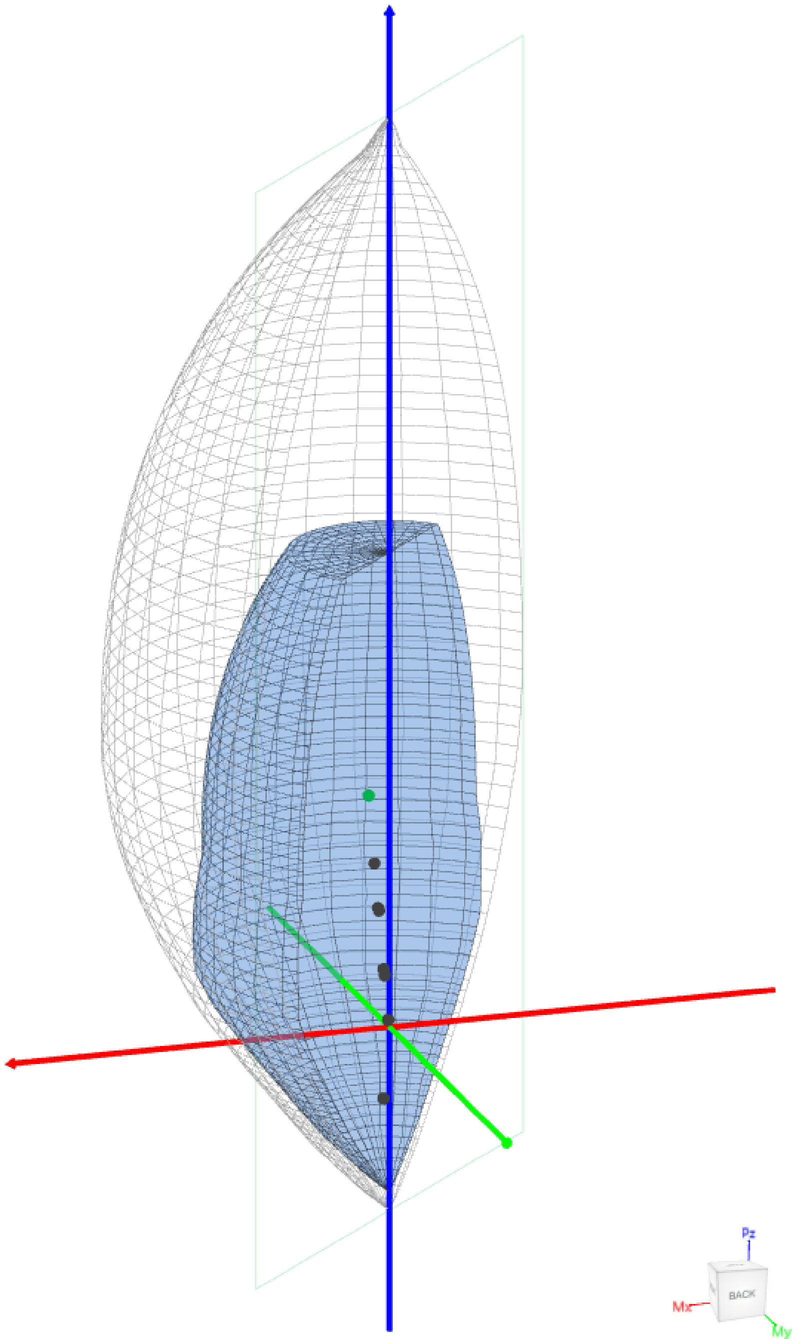


Figure 22 – Pile 3D Failure Surfaces (spColumn)

4.3. Spiral vs Tied Confinement

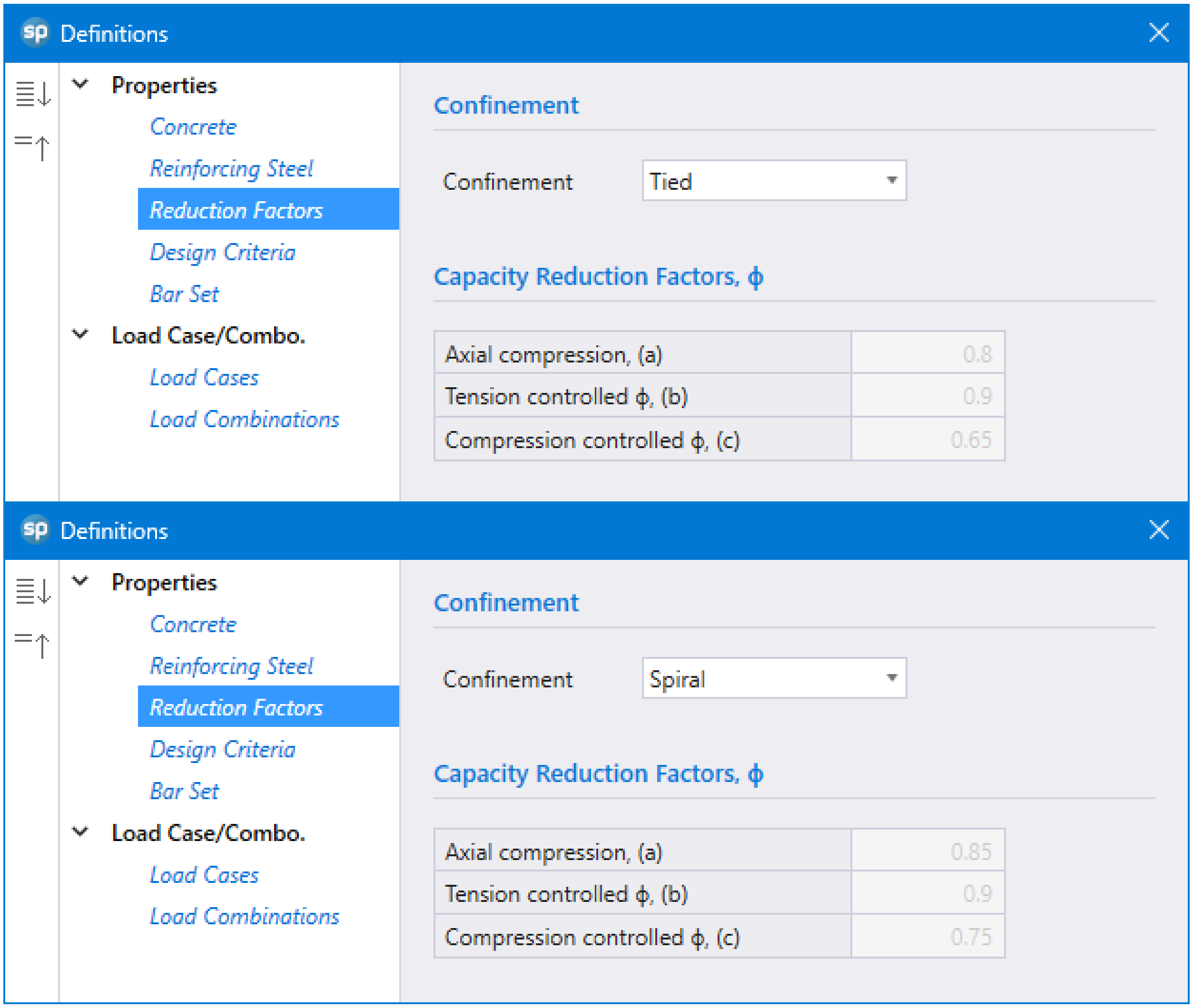


Figure 23 – Confinement Type (spColumn)

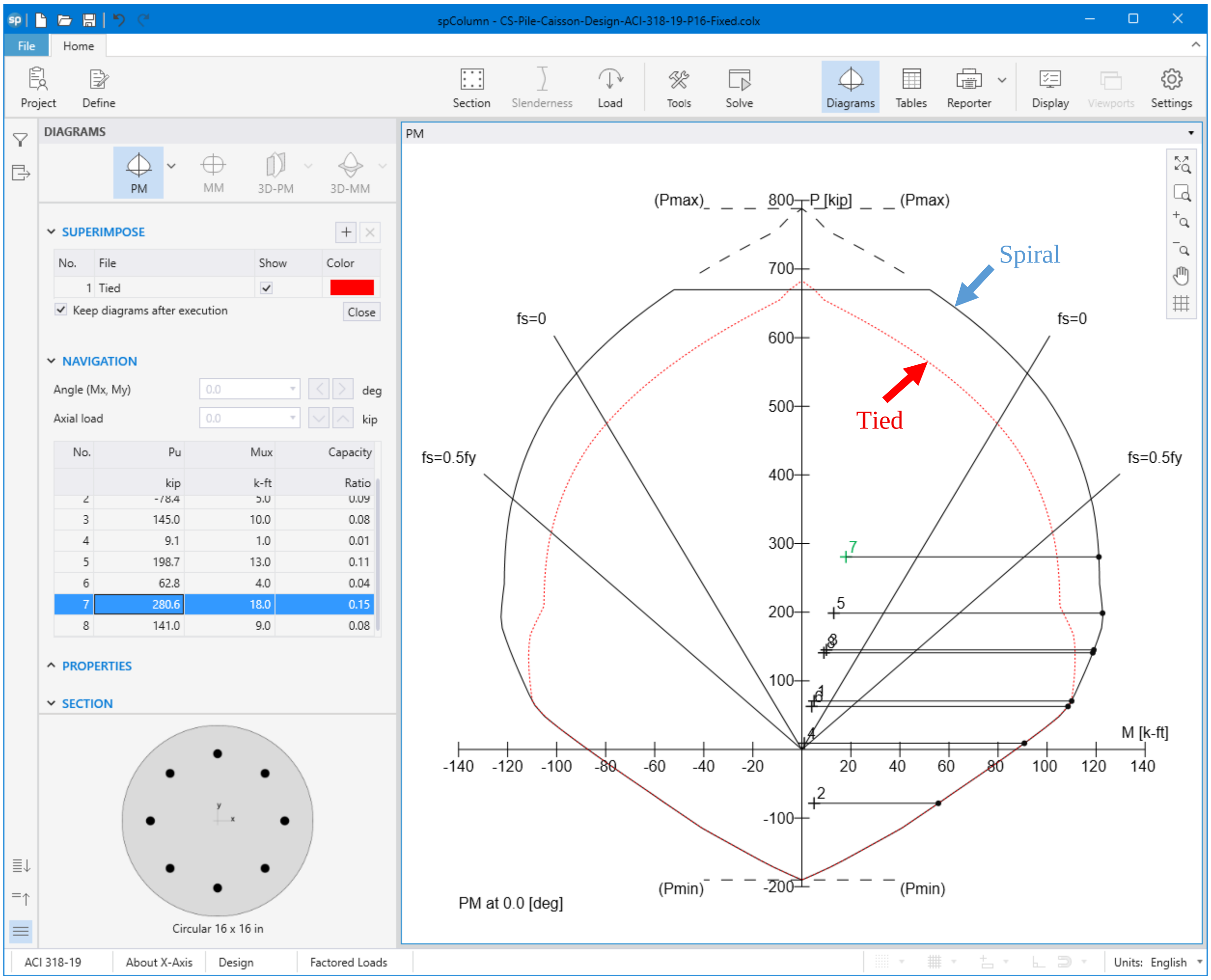


Figure 24 – Tied Confinement vs. Spiral Confinement (spColumn)

5. Summary and Conclusion

spMats provides an efficient platform to model pile-supported foundations by treating piles as vertical springs within a finite element model. This allows engineers to simulate load transfer, assess pile reactions, and verify performance under various load combinations. Additionally, spMats integrates with spColumn, enabling users to export pile reactions and cross-sectional and material properties for detailed design and investigation of individual piles.

The following table shows a summary of important model results

spMats Results Summary	
For Pile Cap	
$A_{s,provided}$ (for areas where $A_{s,min}$ governs)	#9 @ 8 in.
$A_{s,provided}$ (for areas where $A_{s,req}$ governs)	#9 @ 8 in. + #9 @ 8 in.
Maximum Uplift	0.125 in.
Maximum Settlement	0.331 in.
Punching Shear	Refer to Pile Cap Design Example
For Piles	
Pile Max. Comp. Reaction	280.58 kips
Pile Max. Tens. Reaction	78.39 kips
Pile Allow. Comp. Reaction	230.00 kips
Pile Allow. Tens. Reaction	50.00 kips
spColumn Results Summary	
Pile Diameter	16 in.
Pile Reinforcement	8 – #6
Pile Confinement	Tied Transverse Reinforcement

5.1. Pile Boundary Condition Effect

In spMats, piles are assumed to be pinned to the pile cap leading to axial reactions on the piles that require designing the pile as a compression or tension member. In some cases, piles are fixed to the pile cap, which requires them to resist bending moments in one or both principal axes, in addition to the axial reaction. In this scenario, the pile needs to be treated as a member subjected to biaxial bending (M_x and M_y) due to the moments from both directions of analysis. This requires an investigation of the pile P-M_x-M_y interaction diagram in two directions simultaneously (axial force interaction with biaxial bending). This case study (for the case where the pile is fixed to the pile cap) shows the generation of the three-dimensional failure surface (biaxial M_x-M_y interaction diagram). Generating the three-dimensional failure surface (interaction diagram) for a pile section subjected to a combined axial force and biaxial bending moments is tedious and challenging for engineers and the use of a computer aid can save time and eliminate errors. StucturePoint's spColumn program can, quickly, simply, and accurately generate the three-dimensional failure surface (interaction diagram) for all commonly encountered pile sections in addition to highly complex and irregular cross-sections.

5.2. Tied vs. Spiral Lateral Reinforcement

The choice between tied and spiral confinement in pile design directly influences the strength reduction factors (ϕ) applied in capacity calculations. Spiral-confined piles benefit from higher ϕ values, such as 0.85 for axial compression and 0.75 for compression-controlled sections compared to 0.80 and 0.65 respectively for tied confinement, providing greater usable strength under the same conditions. These values are automatically applied in spColumn based on the selected confinement type. For this case study, tied confinement is sufficient, as demonstrated in the interaction diagram in Section 4.3.

Confinement choices selected by the user dictate the reduction factors for tied, spiral, and user defined types. User must ensure the final designed section is detailed correctly on design drawings in accordance with the corresponding provisions for confinement in the selected code to match the assumptions made in the model.

5.3. Applied Loads Modeling Considerations

When using FEA to model structures like the bridge pier supported by a pile cap in this case study, engineering judgment is essential in accurately determining how loads from the superstructure are transferred to the foundation model. If axial forces and bending moments from the bridge pier are modeled as concentrated point loads applied to a single node, stress concentrations may appear at that location. These concentrations are often numerical artifacts rather than true physical behavior. To reduce such localized effects and achieve more representative results, users can convert these point loads into equivalent area loads distributed over the pier footprint. This distributes the applied forces across multiple nodes, helping to smooth stress gradients and improve model behavior. The approach demonstrated in this case study is an expedient and conservative option for illustration and educational purposes only. It should not be interpreted as a prescriptive or recommended method. Engineers are advised to exercise professional judgment and adapt modeling techniques based on project-specific requirements and conditions.

5.4. Pile Cap Reinforcement

spMats reports the required area of top and bottom flexural reinforcement per unit width [in.^{2}/ft (US Customary Units) or mm^2/m (Metric Units)] in both the X and Y directions. The total area of reinforcement in an element, then, can be obtained by multiplying the reported area of reinforcement by the width of the element.

A_{sx} reinforcement is placed along X-direction and calculated based on the greater of the design moment, M_{ux}, code minimum reinforcement ratio, or the base reinforcement ratio (if selected) specified by the user. Similarly, A_{sy} reinforcement is placed along Y-direction and calculated based on the greater of the design moment, M_{uy}, code minimum reinforcement ratio, or the base reinforcement ratio (if selected) specified by the user.

Using the conservative load application method in this case study, the provided reinforcement can be postulated based on the reinforcement contours in the following figures. The selection of the reinforcing bar size and spacing as well as the extent to which they are applied is left up to the engineer to choose based on project requirements and standard details. Figure 26 shows one possible reinforcement layout for illustration.

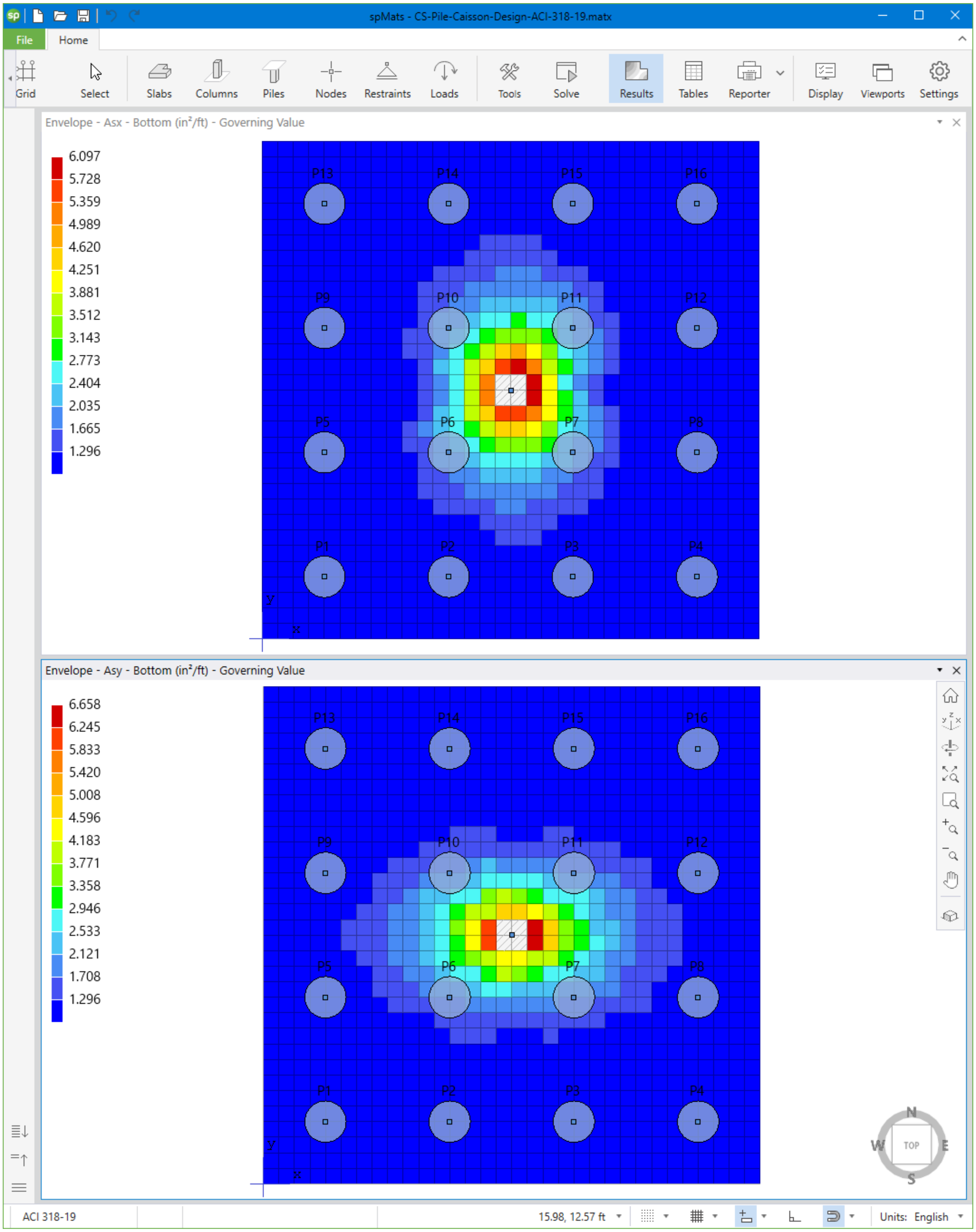


Figure 25 – Pile Cap Reinforcement (spMats)

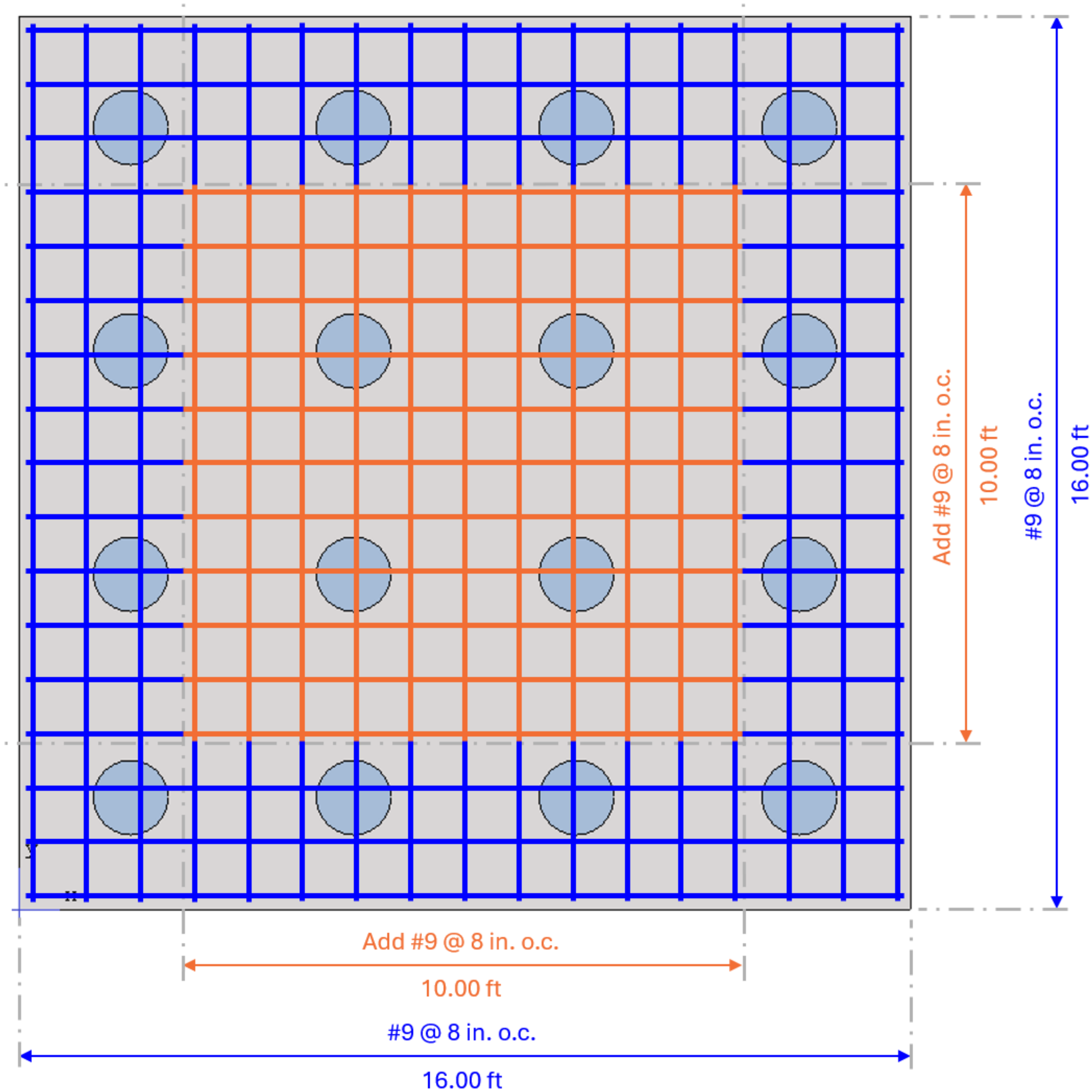


Figure 26 – Pile Cap Provided Reinforcement

5.5. Pile Settlement and Impact on Stiffness

The stiffness of each pile, represented by the spring constant K_p, plays a critical role in modeling pile-supported foundations. K_p is calculated as the ratio of the applied load Q_u to the corresponding settlement S, which depends on pile geometry, material properties, and soil conditions. For cohesionless soils, settlement is estimated using an empirical formula incorporating pile diameter D, length L, cross-sectional area A_p, and modulus of elasticity E_p. Accurate estimation of pile settlement is essential, as it directly influences the stiffness input into the finite element model and therefore affects the load distribution and reaction forces in the overall foundation system. A project geotechnical report may present the values for pile stiffness and the expected maximum compression and tension permissible capacities. In some instances, the corresponding settlement or uplift at various load levels may also be provided to inform the model input and definitions. More information about this topic can be found in Section 2.3.2.2. in spMats Manual.

6. Appendix – Loads, Cases, and Combinations

```
    BLOCK LoadCases
        TABLE LoadCase
            // Type        - Valid values: Dead, Live, Snow, Wind, EQ, Others
            // SelfWeight - Valid values: Yes, No
            Case    Type  Label  SelfWeight
               A    Dead     SW         Yes
               B  Others     EV          --
               C  Others    "1"          --
               D  Others    "2"          --
               E  Others    "3"          --
               F  Others    "4"          --
               G  Others    "5"          --
               H  Others    "6"          --
               I  Others    "7"          --
               J  Others    "8"          --
        END
    END

    BLOCK LoadCombinations
        TABLE ServiceLoadCombinations
            Label      A      B      C      D      E      F      G      H      I      J
               S1  1.000  1.200  1.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
               S2  1.000  1.200  0.000  1.000  0.000  0.000  0.000  0.000  0.000  0.000
               S3  1.000  1.200  0.000  0.000  1.000  0.000  0.000  0.000  0.000  0.000
               S4  1.000  1.200  0.000  0.000  0.000  1.000  0.000  0.000  0.000  0.000
               S5  1.000  1.200  0.000  0.000  0.000  0.000  1.000  0.000  0.000  0.000
               S6  1.000  1.200  0.000  0.000  0.000  0.000  0.000  1.000  0.000  0.000
               S7  1.000  1.200  0.000  0.000  0.000  0.000  0.000  0.000  1.000  0.000
               S8  1.000  1.200  0.000  0.000  0.000  0.000  0.000  0.000  0.000  1.000
        END
        TABLE UltimateLoadCombinations
            Label      A      B      C      D      E      F      G      H      I      J
               U1  1.250  1.300  1.000  0.000  0.000  0.000  0.000  0.000  0.000  0.000
               U2  1.250  1.300  0.000  1.000  0.000  0.000  0.000  0.000  0.000  0.000
               U3  1.250  1.300  0.000  0.000  1.000  0.000  0.000  0.000  0.000  0.000
               U4  1.250  1.300  0.000  0.000  0.000  1.000  0.000  0.000  0.000  0.000
               U5  1.250  1.300  0.000  0.000  0.000  0.000  1.000  0.000  0.000  0.000
               U6  1.250  1.300  0.000  0.000  0.000  0.000  0.000  1.000  0.000  0.000
               U7  1.250  1.300  0.000  0.000  0.000  0.000  0.000  0.000  1.000  0.000
               U8  1.250  1.300  0.000  0.000  0.000  0.000  0.000  0.000  0.000  1.000
        END
    END

    BLOCK Loads
        TABLE PointLoads
            Node  Case          Pz          Mx          My
              18     C    -300.000    2000.000    4000.000
              18     D    -300.000    2000.000   -4000.000
              18     E    -300.000   -2000.000    4000.000
              18     F    -300.000   -2000.000   -3300.000
              18     G   -2400.000    2000.000    4000.000
              18     H   -2400.000    2000.000   -3300.000
              18     I   -2400.000   -2200.000    4200.000
              18     J   -2400.000   -2200.000   -3300.000
        END
        TABLE AreaLoads
            Slab  Case        Wz
               1     B   -0.2000
        END
    END

END
```