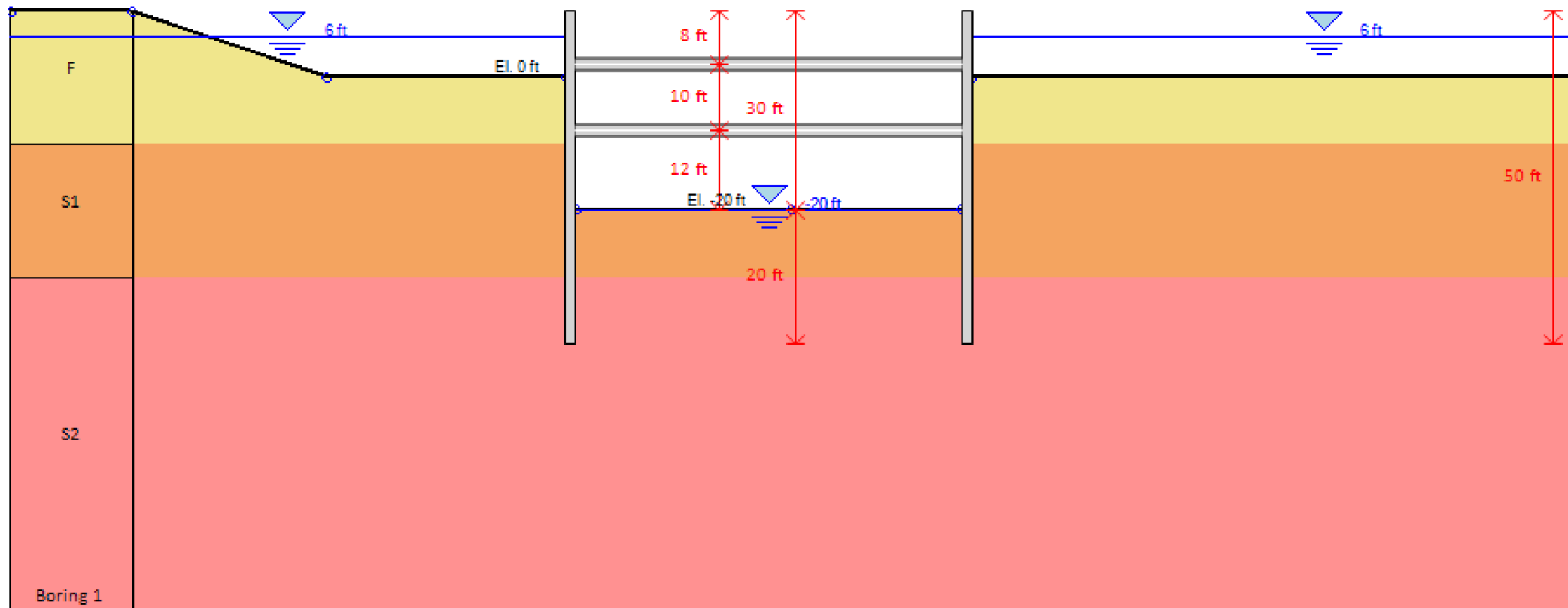
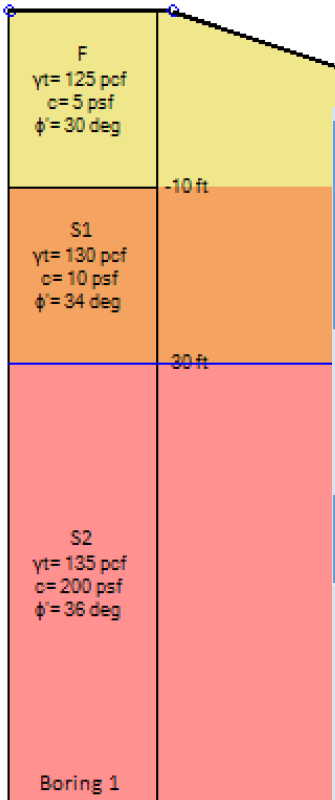


Example 4: Cofferdam - Sheet Pile Walls Limit Equilibrium – Non-Linear – Finite Element Analysis



A. Soil Properties and Stratigraphy (Soil Layers)

Elev. (ft)	Soil (-)	γ_t (pcf)	C' or S_u (psf)	ϕ' (deg)	E_{oed} (ksf)	E_{ur} (ksf)	m (-)
0	F - Sand	125	5	30	500	1500	0.5
-10	S1 - Sand	130	10	34	800	2400	0.4
-30	S2 - Sand	135	200	36	1200	3200	0.4



1. General Boring Information - Coordinates

Name: Boring 1

Coordinates X: -65.617 ft Y: 0 ft

The x coordinate controls where the boring is shown in your design. Each design section uses one boring (soil strata). You can use a different boring for each design section.

SPT Data Option (Applies to Design Section)

SPT Record: Not assigned [Add edit SPT records]

Pass same SPT log to boring (3D visualizations)

CPT Record Option (Applies to Design Section)

CPT Record: Not assigned [Add edit CPT records]

2. Boring Layers - Layer Elevations

	Top Elev. (ft)	Soil Type	OCR	K_o	Edit
	10	F	1	0.5	Edit
	-10	S1	1	0.4408...	Edit
	-30	S2	1	0.412	Edit
*					

A. General C. Elasto-plastic D. Bond E. Adv. F. Piles

4. Unit Weights - Density

γ_t 130 pcf γ_{bulk} 125 pcf $\gamma' = 67.6$

5. Strength Parameters and Poisson Ratio

Drained strength properties

c' 10 psf ϕ' 34 degrees

Peak - constant vol. (for estimation)

ϕ_{cv} Omitted degrees ϕ_{peak} Omitted degrees

ν 0.35

B. Wall Section Properties, Wall Position and Depth

Wall	Left Wall	Right Wall
X-Coordinate	X = 0	X = 50 ft
Top Elevation	Z = 10 ft	Z = 10 ft
Section Type	AZ 26 Sheet Piles	AZ 26 Sheet Piles
Steel Material	A50 Steel	A50 Steel
Depth	50 ft	50 ft

General Advanced features

1. Wall Name
Wall 1

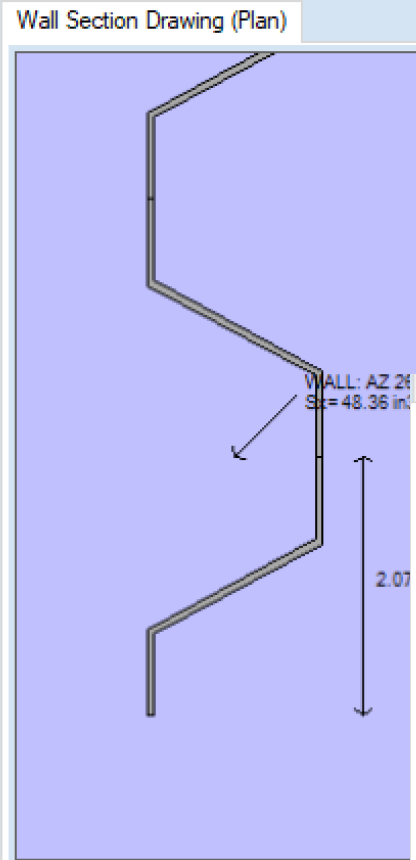
2. Wall Section Properties
Section Wall 1 Edit section data
 Use gravity wall section
Equivalent wall Thickness: 0.617 ft

3. Dimensions
Top EL. 10 ft
Depth L 50 ft
Bottom -40 ft
 Use custom passive Elev.
 Wall is permeable
 Include wall weight

4. 3D Wall Coordinates
xWall 0 ft Out-of-plane y 0 ft

7. Wall Nodes (Analysis Settings)
Number of Nodes nD (0- 100)

Limit equilibrium analyses use nD to divide wall into smaller elements. BEF uses Mesh DELTA as defined in the "Analysis Tab" in then main form and recalculates nD.



Section AZ 26

2. Sheet pile properties
Interlock type DH Select Interlock type

h 16.8098 in A 9.350078 in²/ft
b 24.8 in tf 0.511811 in
bcx 406.500 in/ft s 0.479921 in
Sxx 48.3600 in³/ft α 58.5 degrees

Unsupported Length Lx factor below excavation 5 x wall Width

MANUFACTURER: Arcelor, LuxembourgLuxembourg. SHAPE: Z
HOT/COLD ROLLED: HR



C. Support Section Properties and Elevations

Support	First Strut Row	Second Strut Row
Elevation	Z = 2 ft	Z = -8 ft
Hor. Spacing	10 ft	10 ft
Section Type	PP18X0.5 (Pipe)	PP18X0.5 (Pipe)
Steel Material	A50 Steel	A50 Steel
Depth	50 ft	50 ft

A. General | B. Options | C. Results | D. Notes | E. Envelope

1. Dimensions

1.1 Coordinates at Wall
 X 1.4 ft
 Z 2 ft

1.2 Angles
 α -180 deg

1.3 Lengths
 Lfree 48.6 ft
 Horizontal Spacing 10 ft
 Adjust structural stiffness

1.4 Prestress options
 Adjust Support Prestress
 0
 Apply ONLY to the section where support is applied 1st time
 Note: Negative value for struts

2. Support Type and Structural Section Used
 Structural Section PP18x0.5 Edit
 Allow tension

2. Unbraced Lengths Options
 Use user-defined unbraced lengths
 Horizontal Unbraced Length LuH 0 ft
 Vertical Unbraced Length LuV 0 ft

Use a steel I-Section

Use a pipe section PP18x0.5
Metric pipes write PMS12X19 in mm, press enter

Use hollow sections

Steel material A50

Double member options
 Single member
 Double member

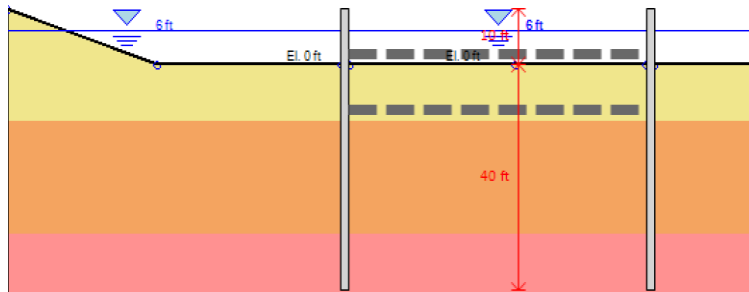
Model strut section as non-yielding (in nonlinear analysis)
 Edit strut properties manually

3. Section Dimensions - Mechanical Properties

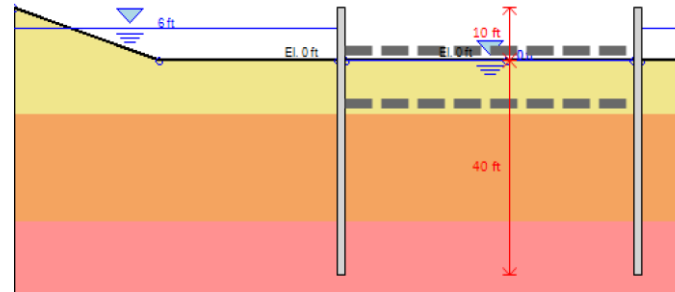
D 18 in A 27.49 in² fy 50 ksi E 29000 ksi
 tP 0.5 in

Ixx 1053.2 in⁴ Iyy 1053.2 in⁴ J 2106.3 in⁴ W 93.54 plf
 Sxx 117 in³ Syy 117 in³ Zxx 153.2 in³ Zyy 153.2 in³

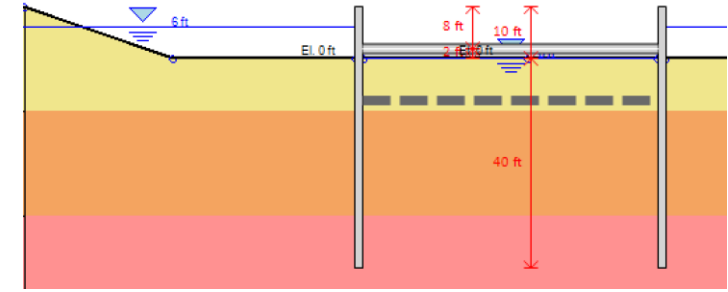
D. Model in Construction Stages



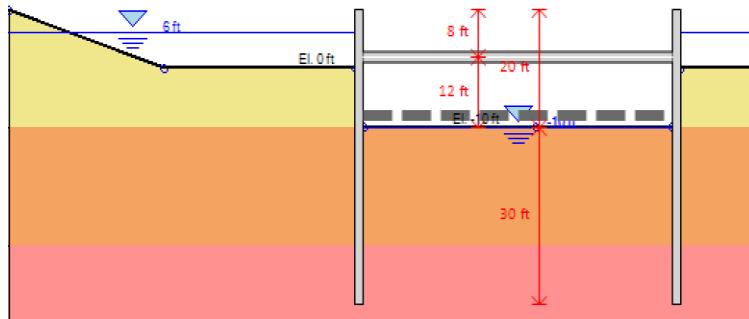
Stage 0: At-rest Conditions



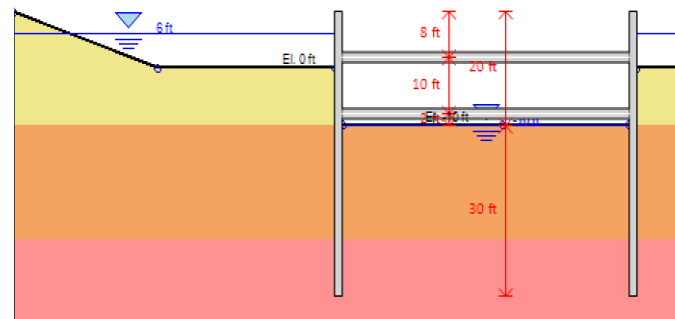
Stage 1: Dewatering



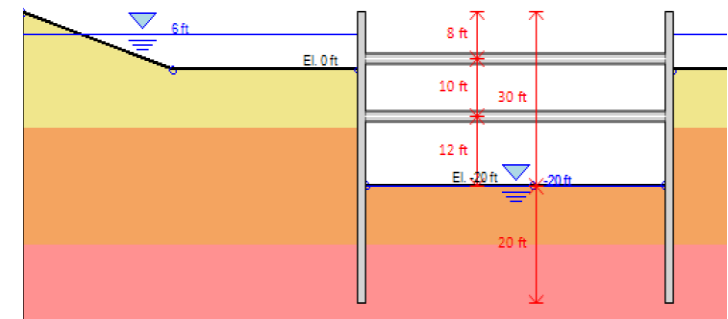
Stage 2: Support Installation



Stage 3: Excavation



Stage 4: Support Installation



Stage 5: Final Excavation

E. Analysis Settings & Design Codes

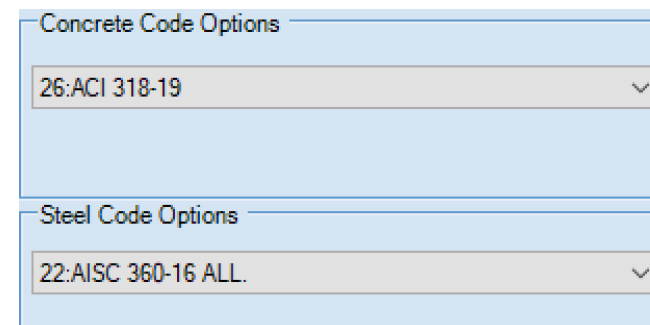
- Wall Friction: 50% of the soil friction
- Water Pressures: Simplified Flow
- Cantilever Method (LEM): Free Earth Method
- Beam Analysis Method: Blum's
- Soil Pressures: Active & Passive (Stages 0 to 3), FHWA Apparent (Stages 4 to 5)



The screenshot shows a software interface for analysis settings. It is divided into several sections:

- Water behaviour:** Includes 'Clays: Default', 'Analysis: Simple', and 'Wave Forces'.
- Include Wall Friction:** Features 'KaKp AUTO' and a 'Thrust options' dropdown set to '1st wall'. A text input field contains the value '50'.
- Limit Equilibrium Methods (Current Stage):** Includes 'Drive Pressures: FHWA', 'Resist Pressures: Passive', and 'Supports: Beam'. A 'Cantilever: Free-earth' dropdown is also present.
- Advanced Options:** Includes 'Beam: Blum's method' and an 'Advanced Options' dropdown.

- Steel Code: AISC 360-16 Allowable
- Concrete Code: ACI 318-19
- Analysis Code: None (Service Conditions)



The screenshot shows two dropdown menus for design code options:

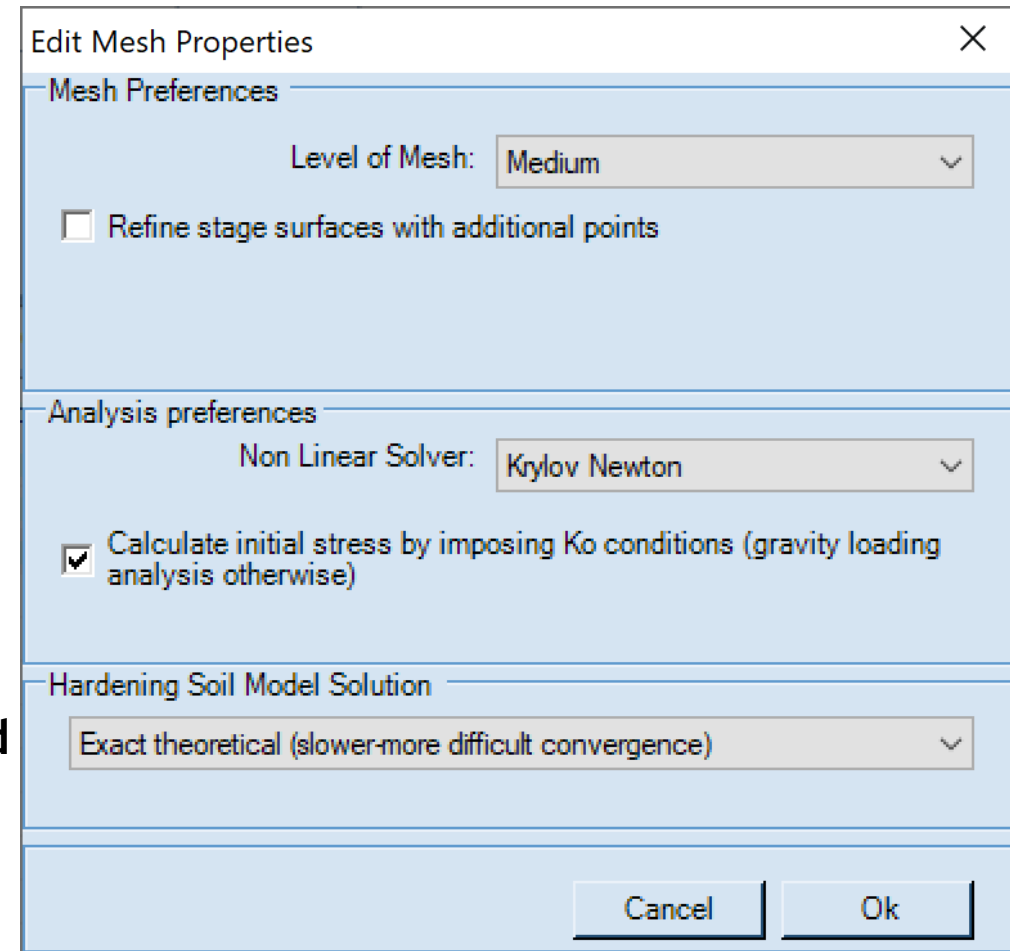
- Concrete Code Options:** The selected option is '26:ACI 318-19'.
- Steel Code Options:** The selected option is '22:AISC 360-16 ALL.'

E2. Additional FEM Analysis Settings & Tips

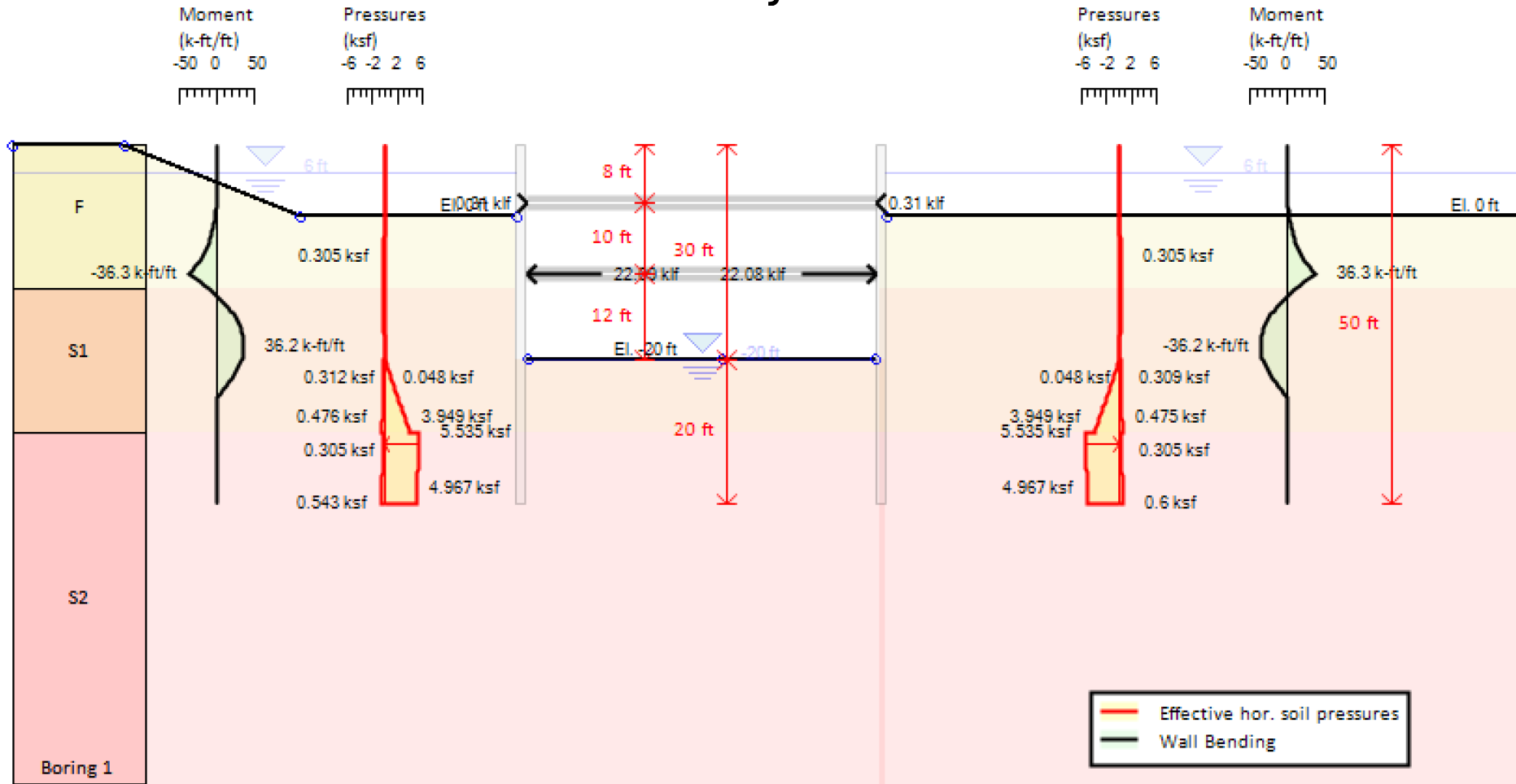
- **Generated Mesh Density: Medium**
- **Non-Linear Solver: Krylov Newton Method**
- **Hardening Soil Model: Exact Theoretical**

FEM Analysis - Model Convergence Tips:

- ✓ Always consider a small cohesion for frictional soils
- ✓ Always use wall friction for all your walls
- ✓ Create a strict staging
- ✓ Sometimes an initial stage with green field conditions (not activated walls) might be required
- ✓ Always assume realistic prestress values for the anchors (if used)

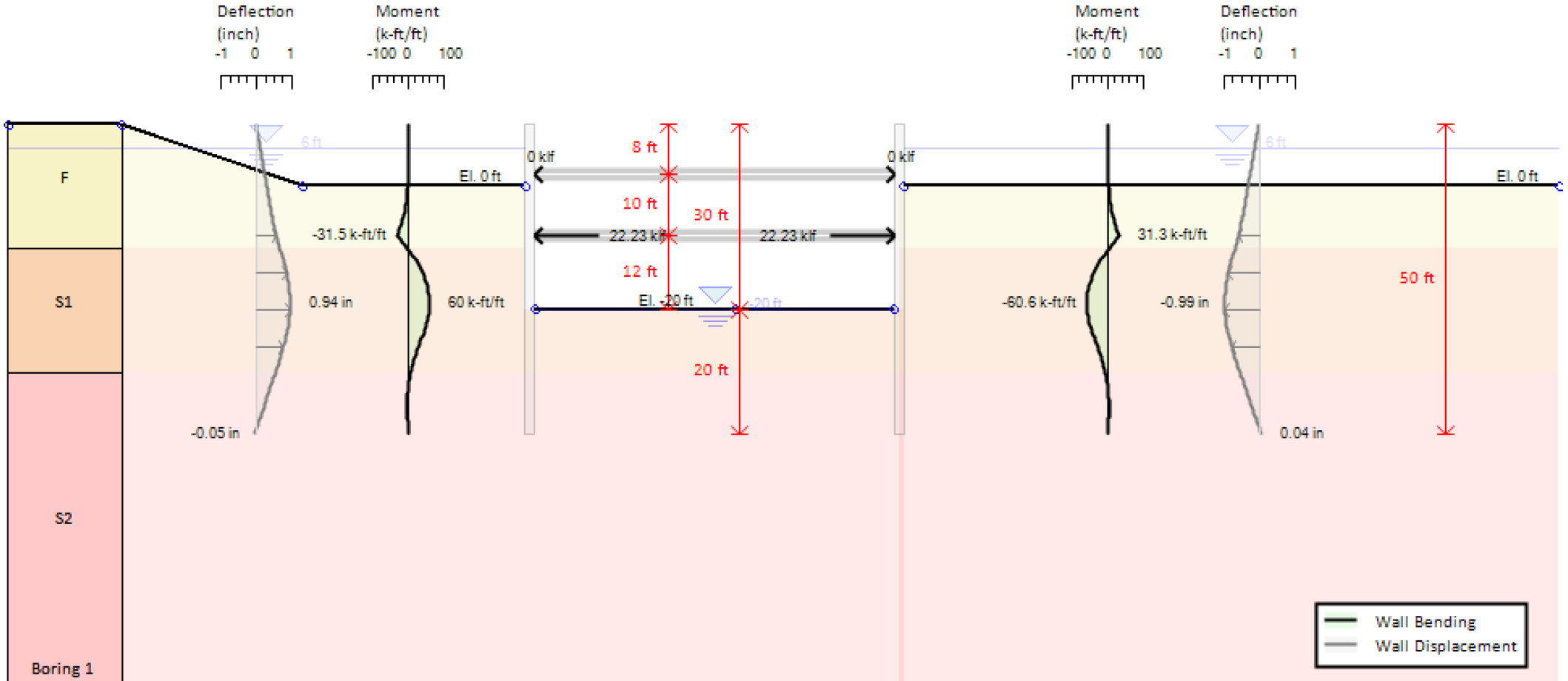


F. LEM Analysis Results



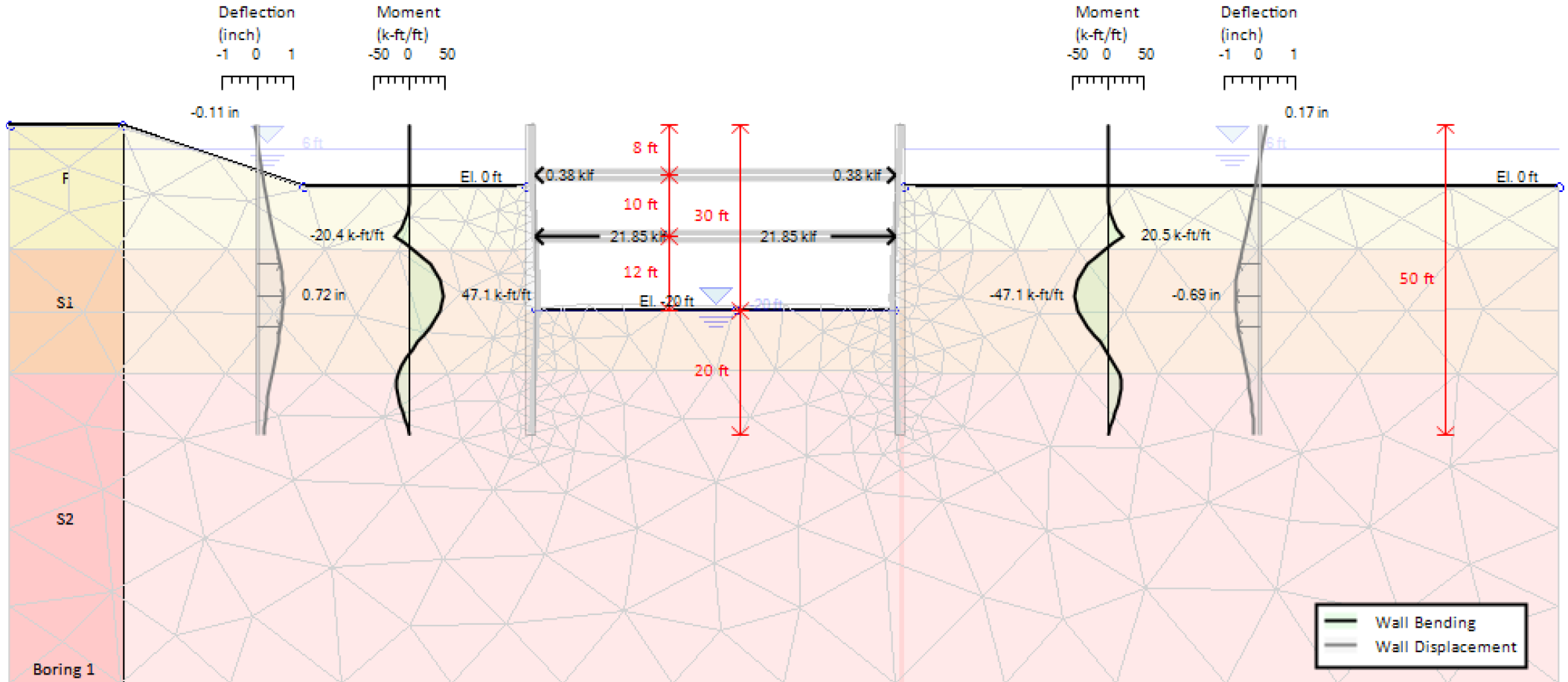
Wall Moments, Support Reactions & Soil Pressures - Stage 5

G. Non-Linear Analysis Results



Wall Moments, Displacements & Support Reactions - Stage 5

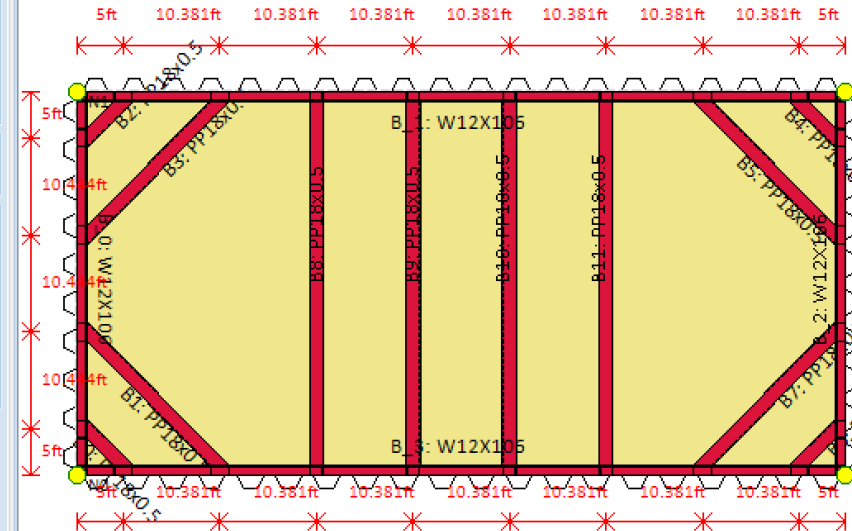
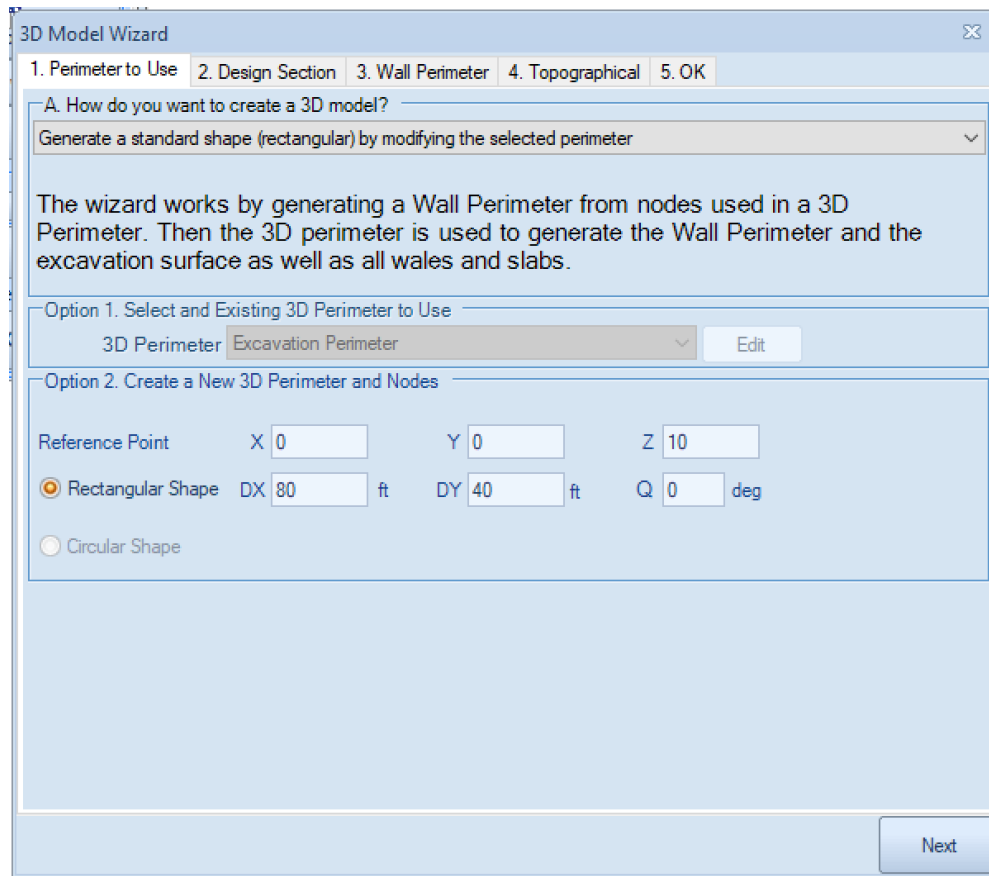
H. FEM Analysis Results



Wall Moments, Displacements & Support Reactions - Stage 5

I. 3D Frame Model Generation

- 3D model created with the 3D Model Wizard: 80ft x 40ft Excavation with Struts



X: -37.976 Y: 75.375

El. -8ft

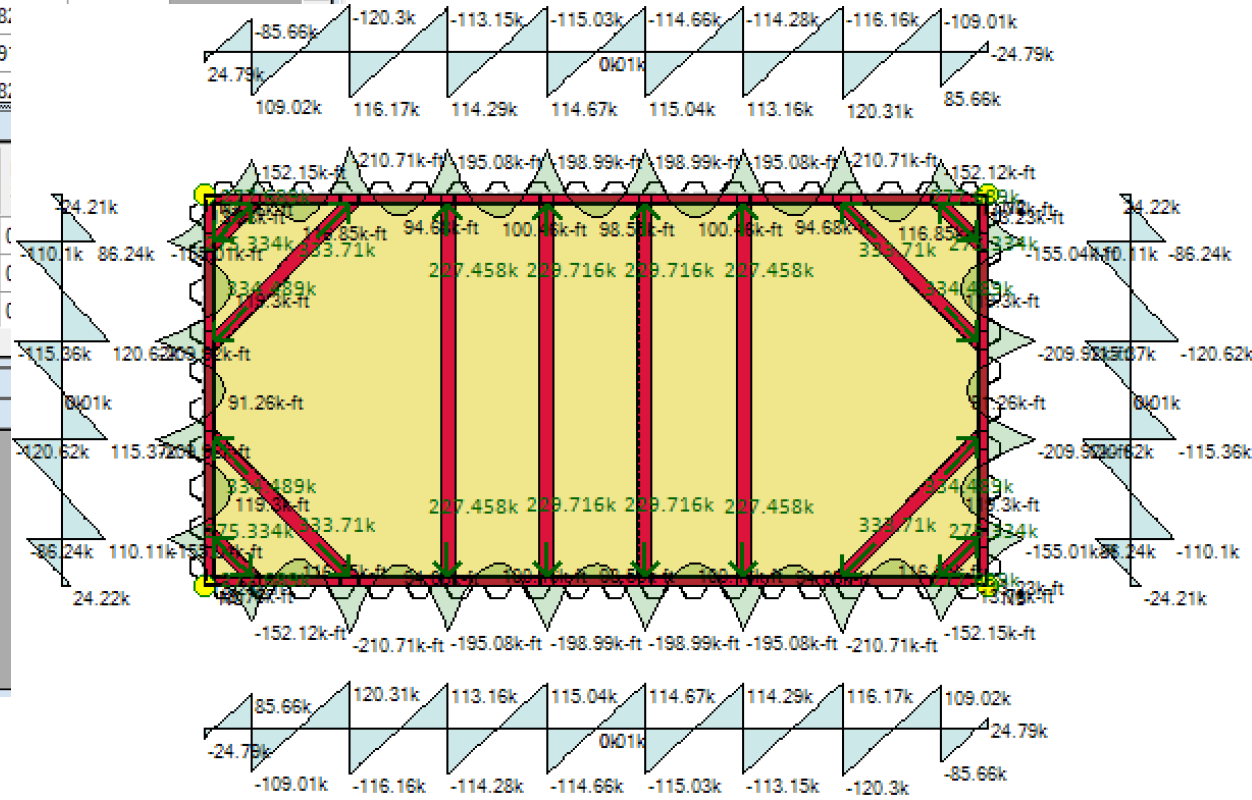
SCL:

J. 3D Model Analysis Results

Results for walers (3D)										
Name	Elev. (ft)	Moment (k-ft)	Shear (k)	Axial (k)	RAT	RAT M	RAT V	Length (ft)	Weight (k)	Section
A_0	2	53.66	30.83	117.09	0.21	0.21	0.257	41.333	4.3912	W12X106
A_1	2	53.86	30.75	116.68	0.21	0.21	0.257	82.667	8.78	
A_2	2	53.66	30.83	117.09	0.21	0.21	0.257	41.333	4.39	
A_3	2	53.86	30.75	116.68	0.21	0.21	0.257	82.667	8.78	

Results for steel connections (walers to struts)						
	Waler	Strut	Weld size (in)	Weld Length (in)	Stiffeners	RAT Welds
WALE: A_0-STRUT: A0	A_0	A0	0.375	21.445	4x5.796 ...	0.42
WALE: A_3-STRUT: A0	A_3	A0	0.375	0	4x5.796 ...	0.42
WALE: A_0-STRUT: A1	A_0	A1	0.375	21.445	4x5.796 ...	0.507

Results for struts and anchors (3D)						
Results for struts (3D)						
Name	Length (ft)	Moment (k-ft)	Axial force (k)	RAT	Weight (k)	Section
A0	5.549	0.36	70.96	0.044	0.5191	PP18x0....
A1	20.275	4.81	85.48	0.071	1.8965	PP18x0....
A2	5.549	0.36	70.96	0.044	0.5191	PP18x0....
A3	20.275	4.81	85.48	0.071	1.8965	PP18x0....



Waler - Strut - Steel Connections Checks, Wall Moment & Shear Diagrams

Thank You!

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