Appendix I

BMP Structural Design Report

BMP Structural Design Report - Northern Impoundment

San Jacinto River Waste Pits Site Harris County, Texas

International Paper Company and McGinnes Industrial Maintenance Corporation

June 14, 2022

→ **The Power of Commitment**

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1. Introduction

This Best Management Practice (BMP) Design Structural Report (Report) was prepared by GHD Services Inc. (GHD), on behalf of International Paper Company (IPC) and McGinnes Industrial Maintenance Corporation (MIMC; collectively referred to as the Respondents) for the Northern Impoundment of the San Jacinto River Waste Pits Superfund Site in Harris County, Texas (Site). The Northern Impoundment is located immediately north of the Interstate Highway-10 (I-10) Bridge over the San Jacinto River. The remedial activities described in the 2017 United States Environmental Protection Agency (EPA) Record of Decision (ROD) require the removal of the waste material within the Northern Impoundment, much of which is submerged in the river. The excavation depths to remove the waste material are anticipated to extend tens of feet (ft) below the riverbed. An engineered barrier or cofferdam (best management practice [BMP] wall) encircling the Northern Impoundment will be required to divert water around the Northern Impoundment and allow excavation of the waste material. This report summarizes the design criteria, geotechnical parameters, structural analysis and calculations, and various other considerations required to design the BMP.

The BMP will consist of a double sheet pile wall approximately 3,340 ft in length (i.e., two parallel sheet pile walls connected with tie-rod anchors). The proposed alignment presented in the Northern Impoundment 90% Remedial Design (90% RD) locates the BMP at least 30 ft away from the toe of the anticipated excavation slopes on all sides of the impoundment with the exception of locations along the southern extent, which is slightly less in some places, as shown on Figure 1-1. The area outside the excavation limits and directly adjacent to the sheet piles provides an intentional separation, hereafter referred to as a “bench,” and allows the BMP to be relatively independent of the excavation area. The bench is wider than 30 ft in several places and allows for potential over-excavation to deeper elevations, if necessary.

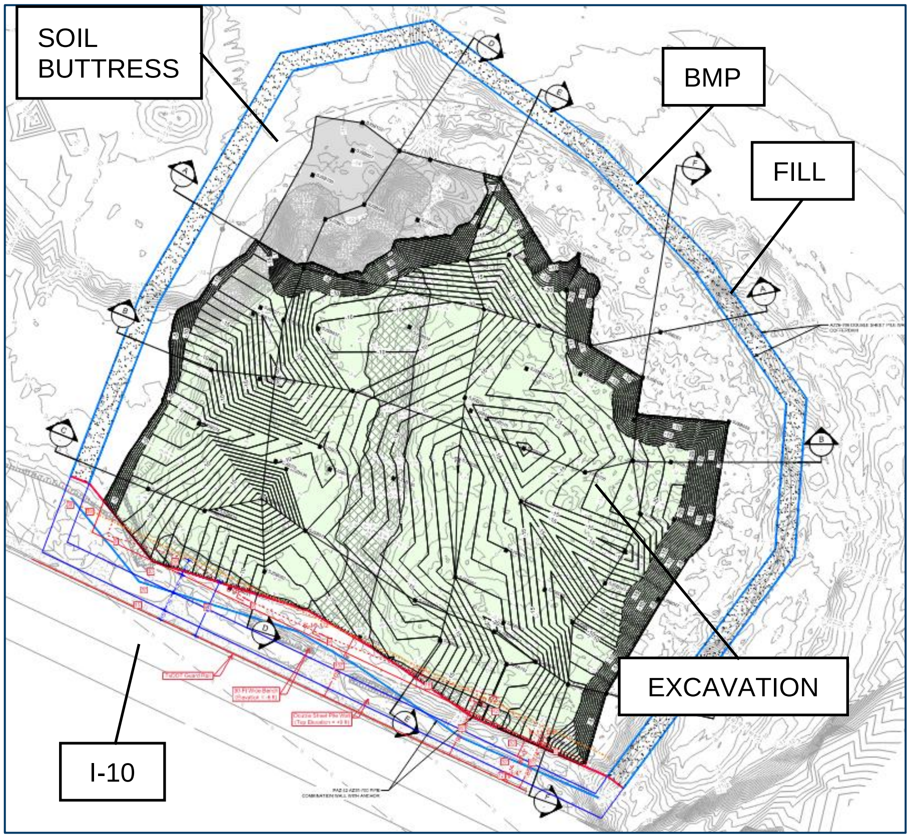

Figure 1-1 Northern Impoundment BMP Alignment - Plan View

The BMP will be a temporary structure, expected to remain in place for approximately 7 years. A typical cross-section of the BMP is shown on Figure 1-2.

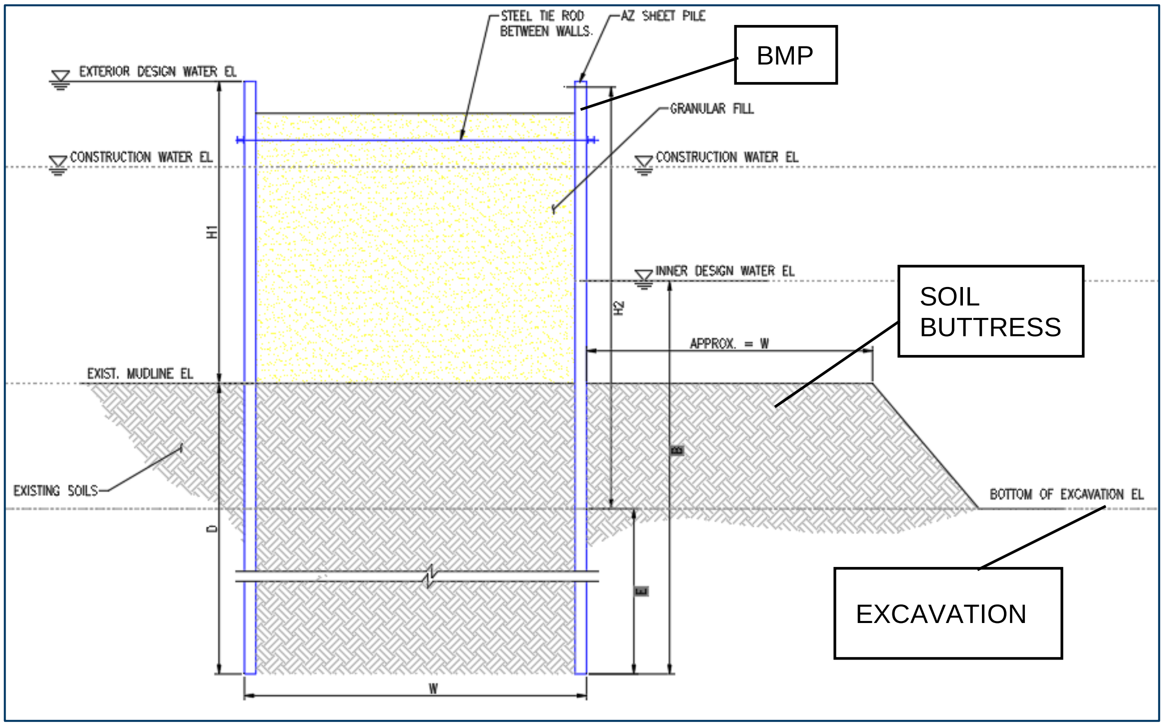

Figure 1-2 *Typical Cross*-Section of the BMP

2. Geotechnical Data

2.1 Geotechnical Investigations

In order to define the geotechnical conditions of the Northern Impoundment, four geotechnical investigations were conducted as listed, below:

- Remediation investigation (RI) in 2011.
- First Phase Pre-Design Investigation (PDI-1) in 2018.
- Second Phase Pre-Design Investigation (PDI-2) in 2019.
- Supplemental Design Investigation in 2021.

The Geotechnical Engineering Report (Appendix B of the 90% RD) includes additional details, field logs, laboratory results, and a summary of these investigations. During these four investigations, a total of 43 geotechnical boreholes were drilled. During the recent SDI, two piezometers were installed, and cone penetration tests (CPT) were also performed at 13 locations on or close to the alignment of the proposed BMP. Figure 2-1 shows the locations of the geotechnical soundings.

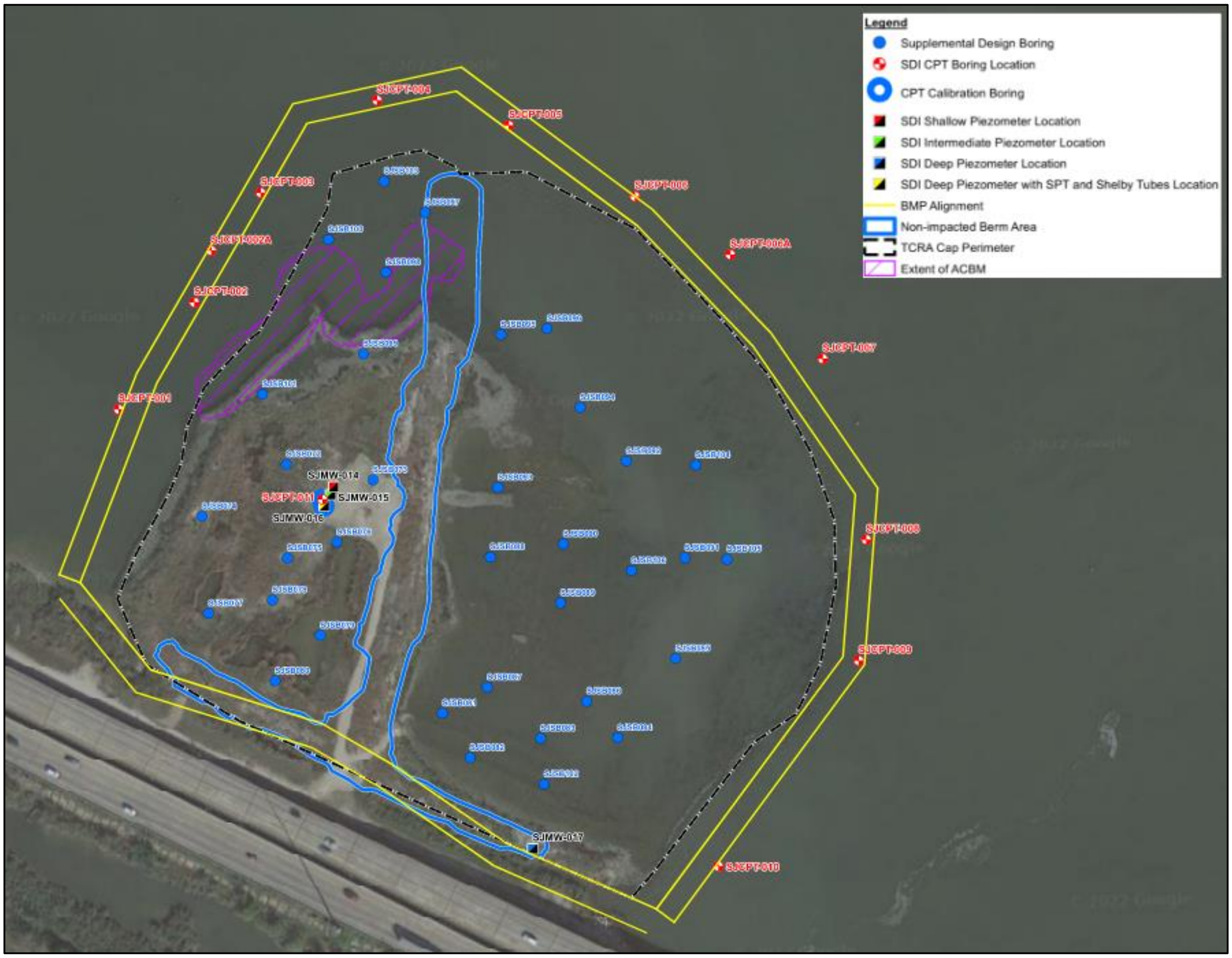

Figure 2-1 Locations of Geotechnical Soundings

2.2 Subsurface Geology

The geology in the vicinity of the Northern Impoundment is highly heterogeneous and critical for the design of the BMP. A detailed description of the Site geology is provided in Geotechnical Engineering Report (Appendix B of the 90% RD). The approximate subsurface stratigraphy within the Northern Impoundment, as determined from the various geotechnical investigations, is comprised of the following three layers.

Surficial Alluvium Sediments

The Surficial Alluvium Sediments are fairly heterogenous, consisting of silty sands, sands silts, lean clays, and sandy clays. The cohesive sediments are typically very soft to firm and the cohesionless granular sediments are loose-to-compact. The thickness of the sediments ranges between 10 to 30 ft.

Beaumont Clay Formation

The Beaumont Clay Formation was generally encountered starting at elevations ranging between -20 ft to -35 ft North American Vertical Datum of 1988 (NAVD88). This formation is composed of a stiff-to-very-stiff high plasticity clay (fat clay) and interspersed with seams or lenses of sandy materials. The formation extended to approximate elevations of -80 ft NAVD88 on the western side and -65 ft NAVD88 on the eastern side of the Northern Impoundment.

Beaumont Sand Formation

The Beaumont Sand Formation was generally encountered at elevations ranging between -50 ft to -70 ft NAVD88. This formation is essentially composed of compact-to-dense silty sand to clayey sand.

2.3 Hydraulic Conditions

During the SDI in 2021, piezometers were installed in borings SJMW-16 and SJMW-17 and the water levels were logged in these piezometers at regular time intervals. The monitored data show that the water level in the river fluctuates with the tides between elevations 0 to 3 ft NAVD88 (with an average of 1.5 ft) while the piezometric level in the Beaumont Sand fluctuates between elevations -4 to -2 ft NAVD88 (with an average value of approximately -2.5 ft).

2.4 Geotechnical Design Parameters

Figure 2-2 shows the grouping of available data from various geotechnical investigations for the Northern Impoundment into four sectors. The following sections outline the various geotechnical parameters recommended for the analysis of the BMP based on review of these four sectors.

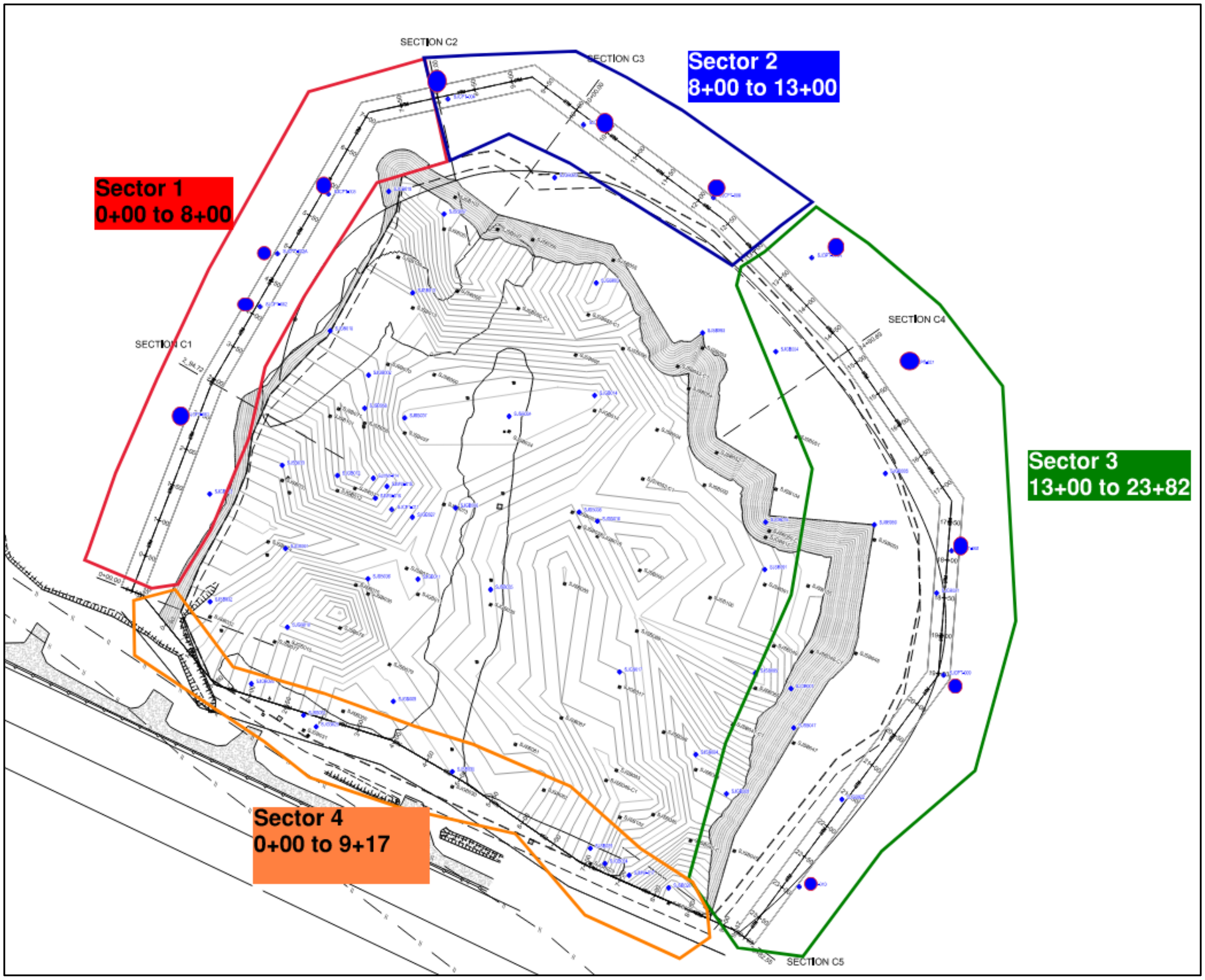

Figure 2-2 Grouping of Geotechnical Information

2.4.1 Saturated and Buoyant Unit weights, γ

The total unit weight, γ_s was estimated based on the water content values considering a specific density, G of 2.7. The variation of γ_s with elevation for the alluvium sediment, Beaumont Clay and Beaumont Sand is shown in Enclosure 1.A of Attachment 1.

Table 2-1 presents the saturated and buoyant unit weights to be considered in the analysis.

Table 2-1 Unit Weights

Sector	Saturated Unit weight (Buoyant Unit Weight), pounds per cubic feet (lb/ft^3)			
	Alluvions Sediments	**Beaumont Clay**	**Beaumont Sand**	**Fill**
1 to 4	118 (55.6)	125 (62.6)	130 (67.5)	130 (68)

2.4.2 Undrained Shear Strength, S_u

The undrained shear strength (S_u) profiles based on the vane test measurements and CPT soundings are shown in Attachment 1.

1. Alluvium Sediments: Enclosure 2.A1, 2.A2, 2.A3.
2. Beaumont Clay: Enclosure 2.B.

2.4.3 Undrained Modulus, E_u and Poisson coefficient, ν_u

The undrained elastic modulus E_u was estimated based on correlations with the undrained shear strength S_u. The E_u profiles shown in Attachment 1 for the Alluvium Sediments and Beaumont Clay layer (Enclosures 3.A1, 3.A2, 3.A3, and 3.B) were defined using Equations 2-1 and 2-2, below.

1. Alluvium Sediments: $E_u = 400.\ Su$ [2-1].
2. Beaumont Clay: $E_u = 300.\ Su$ [2-2].

Table 2-2 presents the E_u values to be considered in the analysis.

Table 2-2 Undrained Elastic Modulus

Sector	Undrained Elastic Modulus Eu, tsf			
	Alluvium Sediments	**Beaumont Clay**	**Beaumont Sand**	**Fill**
1 to 4	50 (Enclosure 3.A)	400 (for the first 10 ft following the Alluvium/Clay interface) 500 (for the remaining clay thickness) (Enclosure 3.B)	N/A	N/A

Undrained Poisson Coefficient $\nu_u = 0.5$ is to be considered in the design (corresponding to the theoretical value).

2.4.4 Drained modulus, E' and Poisson Coefficient, ν'

For the cohesive deposits (Alluvium Sediments and Beaumont Clay), the drained elastic modulus E' was evaluated from the undrained modulus (see Table 2-3) using the following theoretical equation:

$$E' = E_u.\ (1+\nu')/1.5 \qquad [2\text{-}3]$$

Assuming ν' (drained Poisson coefficient) value of 0.3, Equation 2-3 becomes:

$$E' = 0.87\ Eu$$

For cohesionless soils (Beaumont sand and cohesionless layers of the Alluvium Sediments), the drained elastic modulus was estimated using equation 2-4 based on correlations using the CPT results.

$$E' = 0.015.\ 10^{0.55Ic+1.68}.\ (q_t - \sigma_{vo}) \quad [2\text{-}4]$$

Where:

- q_t is the tip resistance.
- σ_{vo} is the total vertical stress.
- Ic is the CPT behavior index.

Table 2-3 presents E' values to be considered in the analysis.

Table 2-3 Drained Elastic Modulus

Sector	Drained Elastic Modulus E', tsf			
	Alluvium Sediments	Beaumont Clay	Beaumont Sand	Fill
1 to 4	43.5	0.87. Eu[1]	1040 (See Enclosure 3.C)	150

Notes:

[1] Refer to for values of E_u

Drained Poisson Coefficient ν' = 0.3 is to be considered in the design.

2.4.5 Effective Stress Parameters, ϕ' and c'

The friction angle ϕ' and the effective cohesion c' for both the cohesive Alluvium Sediments and the Beaumont Clay were defined based on a limited number of triaxial tests results.

The friction angle ϕ' for the cohesionless alluvium sediments and Beaumont Sand was defined from CPT results correlation presented in the literature - Equation 7-5. Enclosures 4.A and 4.C in Attachment 1 show ϕ' profiles as defined from this equation for cohesionless alluvium sediments and Beaumont sand, respectively.

$$\phi' = 17.6 + 11.\ \log((q_t - \sigma_{vo})/\sigma'_{vo}) \quad [2\text{-}5]$$

The effective strength parameters to be used in the design are presented in Table 2-4.

Table 2-4 Effective Strength Parameters

Sector	Alluvium Sediments		Beaumont Clay		Beaumont Sand		Fill	
	f', degree	c', psf	f', degree	c', psf	f', degree (°)	c', psf	f', degree	c', psf
1 to 4	26 (See Enclosure 4.A)	42	28 (See Enclosure 4.B)	150	37 (See Enclosure 4.C)	0	32	0

2.4.6 Over-Consolidation Ratio, OCR

The over-consolidation ratio ($OCR = \sigma'_p/\sigma'_{vo}$) values were defined from correlations-based CPT results (using Equation 2-6). The estimated OCR value profiles are shown in Enclosure 5.A of Attachment 1.

$$OCR = 0.33.\ (q_t - \sigma_{vo}) \quad [2\text{-}6]$$

Where:

- q_t is the tip resistance.
- σ_{vo} is the total vertical stress.

The OCR values to be used for the design are presented in Table 2-5.

Table 2-5 Over-Consolidation Ratio OCR

Sector	OCR			
	Alluvium Sediments	Beaumont Clay	Beaumont Sand	Fill
1 to 4	1.0	See Enclosure 5.A	N/A	N/A

2.4.7 Consolidation Parameters

The consolidation parameters based on consolidation tests are listed in Table 2-6.

Table 2-6 Consolidation Parameters

Sector	Parameters	Alluvium Sediments	Beaumont Clay	Beaumont Sand	Fill
1 to 4	Recompression, cr	0.04	0.02	N/A	N/A
	Compression Index, cc	0.32	0.25		
	Initial Void Ratio, eo	0.95	0.68		
	Pre-Consolidation pressure, σ'_p	$= \sigma'_{vo}$	Varies with OCR (See Enclosure 5.A)		

2.4.8 Hydraulic Conductivity

The hydraulic conductivity k profiles were derived from the CPT results and in-situ tests (Enclosure 6.A of Attachment 1). The k values suggested for the design are summarized below in Table 2-7.

Table 2-7 Hydraulic Conductivity

Sector	Hydraulic Conductivity, ft/day			
	Alluvium Sediments	Beaumont Clay	Beaumont Sand	Fill
1 to 4	1.1×10^{-3}	8.6×10^{-3}	0.9	3

2.4.9 Geotechnical Parameters Summary

A summary of the geotechnical parameters to be considered in the design are provided in Table 2-8.

Table 2-8 Geotechnical Parameters for Design

Definition	Unit	Alluvium Sediments	Beaumont Clay	Beaumont Sand	Fill
Unit weight (saturated), γ	lb/ft^3	118	125	130	130
Undrained Young Modulus, E_u	tsf	50 Enclosure 3.A	400 to 500 Enclosure 3.B	-	-
Drained Modulus, E'	tsf	43.5	0.87. E_u	1040	150
Undrained Poisson Coefficient, ν_u	-	0.5	0.5	-	-
Drained Poisson coefficient, ν'	-	0.3	0.3	0.3	0.3
Friction Angle, ϕ'	degree	26	28	37	30
Effective Cohesion, c'	Pounds per square feet (psf)	42	150	0	0
Undrained Shear Strength, S_u	tsf	Enclosures 2.A1 to 2.A3	Enclosure 2.B	-	-
Over-Consolidation Ratio, OCR	-	1	10 to 2	-	-
Hydraulic Conductivity, k	ft/day	1.1×10^{-3}	8.6×10^{-3}	0.9	3

Definition	Unit	Alluvium Sediments	Beaumont Clay	Beaumont Sand	Fill
Recompression Index, cr	-	0.03	0.03	-	-
Compression Index, cc	-	0.32	0.29	-	-
Initial void ratio, e_o	-	0.95	0.68	-	-
$cc/(1+e_o)$	-	0.16	0.15	-	-

3. Design Parameters

The following guidelines and standards were primarily used to develop the design of the BMP:

- American Society of Civil Engineers (ASCE) 7-16, Minimum Design Loads and Associated Criteria for Building and Other Structures.
- Engineering Manual (EM) 1110-2-2504, Design of Sheet Pile Walls by United States Army Corps of Engineers (USACE).
- American Institute of Steel Contractors (AISC) 360-16, Steel Construction Manual 15th Edition.

ASCE 7-16 categorizes structures into four Risk Categories (I through IV). During excavation season, the BMP may be considered similar to facilities that process, handle, or store toxic substances. Hence, the BMP is considered a Risk Category IV structure since its failure may pose a significant hazard to the community.

USACE EM 1110-2-2504 defines the following load case conditions based on severity and probability of occurrences during the design life of the structure:

- ***Usual:*** Service level loading experienced frequently such as static earth pressure, hydrostatic pressures after installation of the BMP and during excavation with normal water levels in the river.
- ***Unusual:*** Loads larger than those considered usual and experienced less frequently such as 100-year probability storm events and flood levels in the river.
- ***Extreme:*** Worst-case scenario loads, rarely experienced during the design life of the structure, such as hurricane level winds and flood levels in the river.

3.1 In-Situ Soil Parameters

The soil parameters required for the design and analysis of the BMP are discussed in Section 2.4. The subsurface soils include fine grained material that is expected to behave differently in drained (long-term) and undrained (short-term) condition. Both drained and undrained behaviors were analyzed.

3.2 River Water Levels

The loading from the river water with a density of 62.4 pounds per cubic feet (lb/ft^3) was applied as hydrostatic pressure. The different water elevations corresponding to various load case conditions are as follows:

- ***Usual*** +5 ft NAVD88.
- ***Unusual*** +9 ft NAVD88.
- ***Extreme*** +9 ft NAVD88.

3.3 River Flood Levels

Based on the Federal Emergency Management Agency's (FEMA) Flood Map (effective on January 16, 2017), the Northern Impoundment is designated as a special flood hazard area Zone AE. Based on the anticipated project duration, and as the excavation will be completed seasonally outside the flooding event season (November to April), FEMA flood load was not considered for the design of the BMP.

3.4 Scour

The presence of the BMP will affect the natural flow state of the San Jacinto River in the vicinity of the Northern Impoundment. The hydrodynamic analyses evaluating the effects of the BMP on the flow velocity and associated shear stress is provided in the Hydrodynamic Modeling Report (Appendix F of the 90% RD). The evaluation indicated that the BMP diverted flow to the north side of the Northern Impoundment, decreasing velocities adjacent to the I-10 Bridge. The increased flow also corresponded with increased shear stress at the southwest and north side of the BMP. The increased shear stress along the southwest corner will likely be mitigated by planned road improvements and elevation increase of the access road, which were not included in the hydrodynamic modeling

The 95th percentile shear stress with the BMP in place, has a maximum value of 2.3 pascals (Pa) and an average value of 0.11 Pa. The maximum value of the 95th percentile shear stress difference is 1.84 Pa with an average value difference of less than 0.01 Pa. The critical shear stress value of 0.15 Pa indicates that the particles are mobile and there is potential for scour or sediment deposition along the outside perimeter of the BMP.

The magnitude of scour and deposition is currently being determined. As large changes in the riverbed elevation will affect the design of the BMP, scour protection measures such as rock rip-rap may be required around the outside perimeter of the wall.

3.5 Wind

The 3-second gust design wind speeds and hurricane exposure are defined in ASCE 7-16 Chapter 26. The web-based hazard tool by ASCE (https://asce7hazardtool.online) provides site-specific information. The standard design wind speeds relate to a maximum recurrence interval (MRI) of 100-years. The wind speeds for Risk Category IV structure in hurricane exposure areas correspond to MRI of 3000-years. All wind speeds are defined at 33-ft above ground level.

- Design wind velocity, 3-second gust, MRI 100-years, V_{100} = 116 mile per hour (mph).
- Design wind velocity, 3-second gust, MRI 3000-years, V_{3000} = 154 mph.
- Exposure Category C.
- Wind directionality, $K_d = 0.85$ (solid freestanding wall).
- Topographic Factor, $K_{zt} = 1.0$.
- Ground Elevation Factor, $K_e = 1.0$.
- Velocity Pressure Exposure Coefficient, $K_z = 0.85$.

Velocity Pressure, $q_z = 0.00256\ K_z\ K_{zt}\ K_d\ K_e\ V^{2.}$

Using $V = V_{100}$, $qz_{100} = 24.89$ lb/ft^2 (Unusual load condition).

Using $V = V_{3000}$, $qz_{3000} = 43.87$ lb/ft^2 (Extreme load condition).

3.6 Vessel Impact

Given the heavy barge traffic in the San Jacinto River, the BMP will likely be exposed to potential barge impact. An impact could be the result of a barge coming off its mooring and drifting toward the BMP during a storm or it could be the result of a towed barge veering off course. The segment of the river around the BMP actively used by barges is shown on Figure 5-1. The barges traveling in the navigational waterway, either empty or loaded, would be likely to make contact with the BMP at an angle. The barges moored directly north of the BMP would be likely to make head-on contact with the BMP.

Impact Force

The kinetic energy from impact can be determined as follows, where velocity may be either the flow velocity or the navigation speed. The energy of impact will be lower for any impact angle other than head-on collision.

Kinetic Energy of Impact = 0.5 x Mass x (Velocity x cosine (α))^2

Where:

cosine (α) = directional factor for impact angle relative to the velocity vector.

= 1 for Head-on impact, i.e., 0 degrees relative to velocity vector.

The Kinetic Energy will be absorbed by the structure but the barge itself will absorb some energy and suffer damage. AASHTO[1] method to determine impact force absorbed by bridge piers is being used for evaluating the BMP. This method is conservative since the BMP have a larger profile area than the typical bridge piers to absorb impact and distribute the energy.

Figure 3-1 Navigational Waterway - Northern Impoundment

USACE developed design guidelines outlining minimum impact forces for hurricane protection structures in the New Orleans area.[2] These include structures in protected waterways not exposed to tidal surge (Zone 1A). The conditions at the Northern Impoundment are similar. The extreme load condition criterion for Zone 1A corresponds to an impact force of 400 kips from a light barge applied at the top of the wall with hydrostatic pressure induced by the 100-year still water level and wind load applied on any exposed portion of the wall. It should be noted that heavier vessels did not govern the design as the velocities of these vessels were considerably less.

AASHTO requires all bridge piers located in navigable waterway crossings to be designed for ship and barge impact. The required minimum impact load corresponds to a 195-ft long, 35-ft wide, and 12-ft tall empty hopper barge (displacement = 200-ton), drifting toward the structure. This barge size is representative of the barges in the area.

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[1] AASHTO LRFD Bridge Design Specifications, Section 3.14

[2] USACE Hurricane and Storm Damage Risk Reduction System Design Guidelines, Section 5.2.1.

The Texas Department of Transportation (TxDOT)'s design criteria for the dolphin and fender system protecting the I-10 Bridge piers includes impact from a 30,000-barrel (BBL) barge, one of the larger barges in the area. A typical 30,000 BBL barge is 300-ft long, 54-ft wide, and 12-ft tall. In laden condition, the barge is loaded to full capacity and displaces 30,000 BBL equivalent or approximately 168,500 cubic feet of water. Thus, the barge weighs approximately 5,250 US-tons or 10,500 kips in laden condition. In ballasted condition, the barge carries only fuel and ballast water, and weighs approximately 910 US-tons or 1,820 kips. It should be noted that, unlike the Northern Impoundment BMP, the I-10 Bridge piers are directly within the navigable waterway and have a higher likelihood of collisions. As such, it is understandable that TxDOT would utilize stringent criteria to avoid frequent repairs to the piers and prevent collapse of the I-10 Bridge overpass.

The head-on impact from the 54 ft wide, 30,000 BBL barge will be evaluated. An impact width of 50-ft will be assumed to account for variations in the barge bow shapes.

Impact Velocity

The hydrodynamic model (Appendix F) evaluated the flow velocities for three = storm conditions at 2-year, 10-year, and 1000-year recurrence intervals, both with and without the BMP present. The 95th percentile velocities for the river flow from the analysis report are summarized in Table 3-1.

Based upon this data, the barge impact criteria for the BMP will be evaluated for flow velocity of 2.20 feet per second (ft/s).

Table 3-1 95th Percentile Velocity - Hydrodynamic Model

95th Percentile Velocity feet per second (ft/s)	**Existing Conditions (No BMP)**			**With BMP in Place**		
	2-Year	**10-Year**	**100-Year**	**2-Year**	**10-Year**	**100-Year**
Maximum	2.21	1.45	0.73	2.16	2.20	1.04
Average	0.51	0.50	0.35	0.46	0.50	0.36

4. Load Combinations

The following load combinations (LC) are appropriate for the structural design in accordance with Allowable Stress Design in ASCE 7-16.

LC# 1	D + H + F
LC#1A	D + H + F + I
LC#5	D + H + F + 0.6W

Where:

D = Dead load.

F = Fluid load (hydrostatic pressure).

H = Lateral earth pressures (active and passive).

W = Wind Load on surface above water.

LC#1 was evaluated for both Usual and Unusual load conditions. LC#1A was used to evaluate the barge impact as extreme load condition with water level at +9 ft NAVD88. An impact at lower water levels will cause less rotation in the structure.

LC#5 combines wind load with other loads acting on the BMP. It is noted that wind load is applicable only to the exposed height of BMP above ground or water level. At the design water level for Unusual conditions (+9 ft NAVD88), the BMP exterior would not be exposed to wind.

A parametric evaluation was performed for the effect of wind loads on the design of BMP using LC#5. The 0.6 reduction factor for wind load was conservatively ignored for the evaluation. The net load ($F + W_{Exterior} - W_{Interior}$) on the BMP, calculated as sum of the hydrostatic load and the wind load applied to both interior (above ground) and exterior (above water level), was compared to the hydrostatic load with water level at +9 ft NAVD88 acting alone. The net load was determined to be lower. Given that D + H are common to both load cases, LC#5 did not govern over LC#1 and not evaluated further.

ASCE 7-16 recommends reduction in the load factor for resisting (passive) lateral earth pressure to 0.6. The intent of the reduction is to design structures resistant to overturning by reducing the resistance. Since the BMP wall was designed for overturning (rotational) stability with adequate embedment as described in Section 6, a reduction for lateral earth pressure was not considered.

5. Design Criteria

5.1 Failure Modes

The three primary failure modes for sheet pile wall systems are described below:

1. The unstable slopes may cause a deep-seated rotational failure of the entire soil mass. The slope failures are independent of the sheet pile embedment and location of the anchor system. This type of failure can be remedied by changing the geometry of the retained material or improving the soil strength.
2. The sheet piles with inadequate embedment depth can be subjected to rigid-body rotational failure due to the lateral pressures exerted by the retained material. The classical design procedures, such as the “free earth” Limit Equilibrium Method calculate the sheet pile embedment depths by balancing the active pressures behind the wall against the passive pressures provided by soil in front of the sheet piles. Adequate embedment depth is achieved at depth where the sum of horizontal forces and sum of moments is zero. Rigid-body rotational failure can be prevented by incorporating safety factors to decrease the passive pressures as appropriate for different loading conditions.
3. The sheet pile systems with stable slopes and adequate embedment may fail if the sheet pile sections, tie-rods, and/or the anchor components are overstressed or inadequately sized. Such failures can be prevented by incorporating safety factor in design by limiting the allowable stress as appropriate for different loading conditions.

5.2 Safety Factors

The following safety factors and allowable stress limits are adopted in the design of the BMP to prevent the failure modes described in Section 5.1.

5.2.1 Embedment Depth

EM 1110-2-2504 recommends the minimum safety factors provided in Table 5-1 to determine embedment depth for cantilever or anchored sheet pile wall systems. It should be noted that the safety factors are suitable for the “free earth” Limit Equilibrium Method where the sheet pile is considered a rigid body allowed to rotate about a point below ground level, and the active and passive pressures are balanced to determine the embedment depth. Adequate embedment depth is achieved at depth where the sum of horizontal forces and sum of moments is zero. The pressures, and resulting forces in the system, are considered independent of the wall displacement in the Limit Equilibrium Method.

The cantilever wall BMP presented in the 2020 Northern Impoundment 30% Remedial Design (30% RD) acted as both a floodwall and a retaining wall by maintaining differential water and soil elevations. However, the current BMP system in the new alignment primarily serves as a floodwall by maintaining a different water elevation between the excavation area and the San Jacinto River. The sheet piles are terminated in the fine grain soils of the Beaumont Clay layer. Hence, both the undrained (Q-Case) and drained (S-Case) conditions were evaluated to determine the stability of the BMP.

Table 5-1 Safety Factors for Passive Pressures - EM 1110-2-2504

Loading Case	Floodwalls	Retaining Walls		
	Fine-Grain Soils	Free-Draining Soils	Fine-Grain Soils	Free-Draining Soils
Usual	1.50 Q-Case 1.10 S-Case	1.50 S-Case	2.00 Q-Case 1.50 S-Case	1.50 S-Case
Unusual	1.25 Q-Case 1.10 S-Case	1.25 S-Case	1.75 Q-Case 1.25 S-Case	1.25 S-Case
Extreme	1.10 Q-Case 1.10 S-Case	1.10 S-Case	1.50 Q-Case 1.10 S-Case	1.10 S-Case

5.2.2 Sheet Pile Sections

EM 1110-2-2504 recommends the maximum allowable stresses for the sheet piles subject to different load case conditions, included in Table 5-2. By definition of the various load case conditions (Section 4), the BMP is subject to Unusual and Extreme load case conditions less frequently than the Usual load case conditions. Hence, the allowable stresses are increased for the more severe loading scenarios to avoid overly conservative design solutions for rare events.

Table 5-2 Allowable Stresses for Sheet Piles - EM 1110-2-2504

Load Case Conditions	Combined Bending and Axial Stress	Shear Stress
Usual	0.50 F_y	0.33 F_y
Unusual	0.67 F_y	0.44 F_y
Extreme	0.88 F_y	0.58 F_y

5.2.3 Tie-Rod Sections

The tie-rod sections, included in Table 5-3, are designed using allowable stress design methods in accordance with AISC 360. The tie-rods are critical to balance the forces and displacements of the BMP.

Table 5-3 Overstrength Factors for Tie-Rod - AISC 360

Limit State	Overstrength Factors
Tensile Yielding	1.67
Tensile Rupture	2.00
Tensile Rupture of Threaded Parts	2.00

If one tie-rod fails, the loads will be redistributed to the adjacent tie-rods. The tie-rod are designed for 150 percent of the demand loads, accounting for a tie-rod failure event where the loads are redistributed to adjacent tie-rods and preventing progressive failure and thereby, increasing the safety factor.

5.2.4 Walers

The walers are longitudinal beams connected to the tie-rods on the exterior face of the sheet piles. The walers distribute the loads from the sheet piles to the tie-rods and minimize variations in displacement along the BMP. In order to provide a continuous longitudinal beam, the individual waler beams will be spliced using bolted connections.

The walers are evaluated as simply supported multi-span beams with tie-rods providing the support reactions. The walers are also evaluated for condition with a longer span (150 percent) accounting for a tie-rod failure thus able to redistribute loads to the adjacent tie-rods. The walers are designed using the allowable stress design method in accordance with AISC 360, provided in Table 5-4.

Table 5-4 Overstrength Factor for Walers - AISC 360

Limit State	Overstrength Factors
Flexure or Bending Stress	1.67
Shear	1.67

5.3 Deflection

Total system displacement comprised of structural steel deformation, rotation and translation of the entire BMP and soil system was evaluated for the proposed BMP.

Neither EM 1110-2-2504 nor ASCE 7-16 provide guidance on limiting system deflection. For a cantilever sheet pile system, structural steel can deform significantly before structural failure occurs; hence, structural steel deformation could not be used as a limiting parameter in the previous submittal (30% RD).

The combination of tie-rod anchors and adequate embedment of sheet piles restrain the deflection in the sheet piles. The deflection at the top of the sheet pile translate to local deformations in the structure. These deformations are accounted for by the bending stress in the sheet piles and tensile stress in the tie-rods. The stresses will be limited within the allowable stress (Section 5.2) and within the elastic range (less than F_y) to avoid structural failure of the BMP.

5.4 Corrosion Protection

Design of the Northern Impoundment BMP structure is expected to be for temporary, short-term use. The sheet piles are assumed to remain in place for a period of approximately 7 years after installation. Figure 5-1 shows the five exposure zones typically considered for corrosion. It also shows a schematic for varying thickness loss along the height of the steel sheet piles exposed to marine environment.

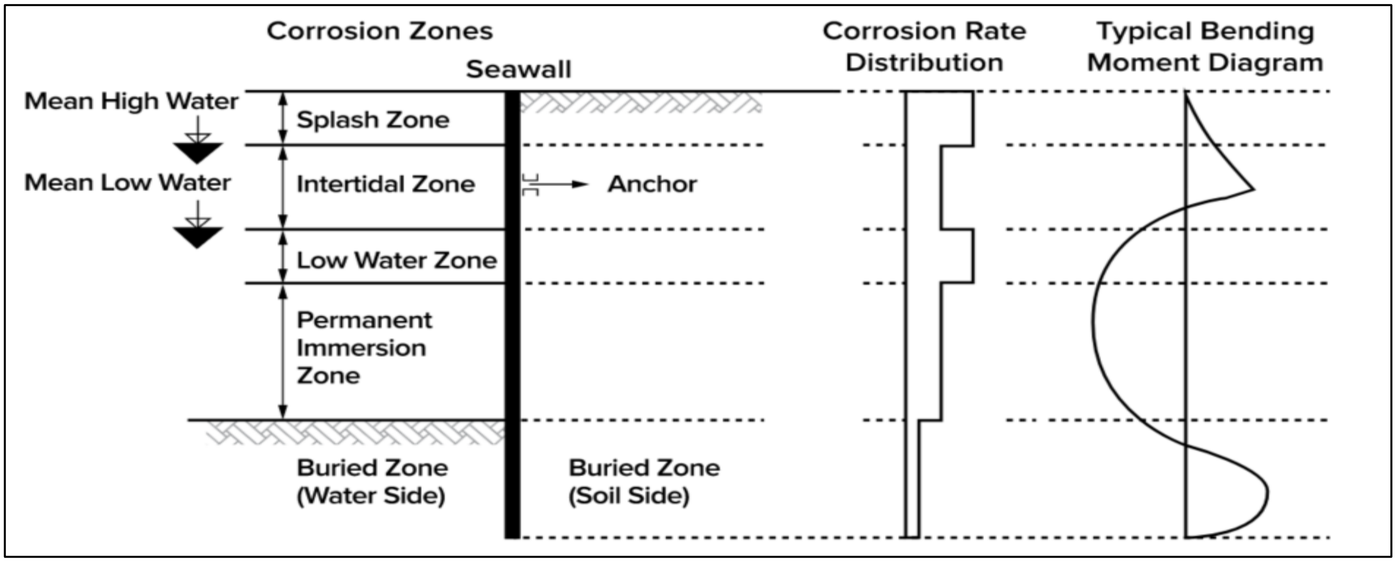

Figure 5-1 Typical Thickness Loss - Nucor Skyline Catalog, Ports & Marine Construction

The loss of thickness due to corrosion relative to different exposure conditions are listed in Table 5-5. The corrosion rates are representative of industry-wide accepted rates where Site-specific data is unavailable. Since the Northern Impoundment is located in brackish water, an average of total thickness loss for the river (0.008 inches) and seawater (0.027 inches) exposure is appropriate (these two values are indicated in bold font in Table 5-5, below). The duration of exposure to each zone varies significantly on the exterior and interior face of the BMP. It is conservative to assume the same thickness loss on both sides of the sheet pile. A uniform sacrificial thickness of 0.035-inches

(2 x 0.0175 inches) was included for each side of the sheet pile for the entire height of the wall. No additional maintenance will be required for the seven-year period.

Table 5-5 Loss of Thickness due to Corrosion

Description of Exposure[1]	Loss in 5 Years[1] (inches)	Loss in 25 Years[1] (inches)	Loss in 7 Years[2] (inches)
Common fresh water (river, ship canal) in the zone of high attack (water line).	0.006	0.022	**0.008**
Very polluted fresh water (sewage, industrial effluent) in the zone of high attack (water line).	0.012	0.051	0.016
Sea water in temperate climate in the zone of high attack (low water and splash zone).	0.022	0.074	**0.027**
Sea water in temperate climate in the zone of permanent immersion or in the intertidal zone.	0.010	0.035	0.013

Notes:

[1] Eurocode 3 - Design of Steel Structures, Part 5: Piling, BS EN 1993-5:2007.

[2] Interpolated between 5 Years and 25 Years.

6. BMP Design

6.1 Analysis

The BMP cross-sections were analyzed for stability and determining stress in the structural components using Plaxis 2D, a finite element software program developed by Bentley Systems, Inc. The program can model complex soil profiles, structural sections and perform soil-structure interaction analysis to achieve a solution with compatible forces and displacements. The analysis also incorporates a time variable simulating the various stages of construction, such as end of sheet pile installation, adding fill between the walls, installing tie-rods, dewatering the excavation area after BMP is installed, and excavation to allow for consolidation or dissipation of porewater pressures. The stages and consolidation periods assumed for the analysis are described in Section 6.2.

EM 1110-2-2504 recommends applying the safety factors (Section 5.2.1) to determine the effective soil parameters used to calculate passive pressures. This recommendation is suitable for the “free earth” Limit Equilibrium Method where the sheet pile is considered a rigid body allowed to rotate about a point below ground level, and the active and passive pressures are balanced to determine the embedment depth. The pressures, and resulting forces in the system, are considered independent of the wall displacement.

The finite element analyses using soil-structure interaction incorporate the non-linear behavior of the soil, wall displacements and flexibilities of the sheet pile and anchors. The active and passive pressures vary as the system flexes to achieve a solution by balancing the forces and displacements in the entire system. By inherently balancing the forces and displacements, the system achieves a larger safety factor against rotational failure than the Limit Equilibrium Method. Thus, the safety factors are not applied to determine effective soil parameters for calculating passive pressures.

For the purposes of the analyses, the water level in the fill material between the two sheet pile walls is assumed to be at the same level as the river. Porewater pressure distributions are recalculated in steady state flow calculations following changes in water levels. Final “dewatering” of excavations assumes a phreatic level approximately 1 foot below the excavation level in the excavation area. No dewatering from well points below the excavation or wall was considered.

The program provides outputs of resultant forces such as shear and moment for the sheet piles, tension force for the tie-rod, and deflection at each stage of analysis. The structural components are designed for the largest governing forces. The Plaxis outputs for each of the analysis sections (described Section 6.2) are included in Attachment 2.

6.2 Analysis Sections

The BMP behavior varies with the height of the sheet piles above riverbed and the subsurface strata. Hence, multiple cross-sections were evaluated to account for the variations in riverbed elevations, cross-slope of the riverbed along the BMP alignment, thickness of Alluvium Sediments, anticipated top of Beaumont Clay layers, and distance of the BMP to excavation. The extents of each section are shown on Figure 6-1. These extents are approximate and may change in the final design to accommodate design optimizations, and other considerations for standardizing construction to achieve an economical solution.

It should be noted that the proposed alignment for the BMP along the south side of the Northern Impoundment, parallel to I-10, had to be modified to achieve a working solution as described in Section 6.2.7.

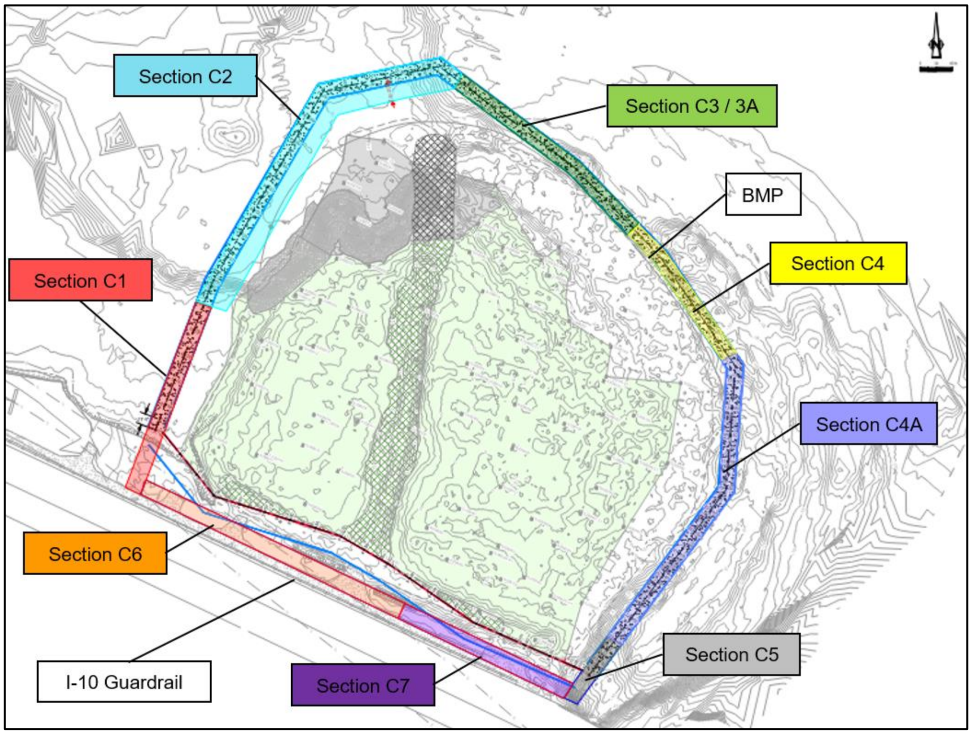

Figure 6-1 General Extents of the Analysis Cross-Sections

The following sections present the various cross-sections analyzed to determine the appropriate embedment depth for the sheet piles to achieve stability, size the sheet piles and tie-rods for the BMP. The cross-sections show distance on the horizontal axis and elevation (NAVD88) on the vertical axis. The sheet piles are typically centered at distance 0 on the horizontal axis as the sections are taken along the BMP alignment. The cross-sections also show the approximate excavation surface near the BMP. The distance to the excavation area varies along the BMP alignment but the cross-sections are considered representative for the extents shown in Section 6.2

6.2.1 Cross-Section C1

Cross-Section C1 (Figure 6-2) represents the Site condition where the riverbed is sloping away from the Northern Impoundment. The approximate retained height on the exterior and interior side is 19 ft and 16 ft, respectively.

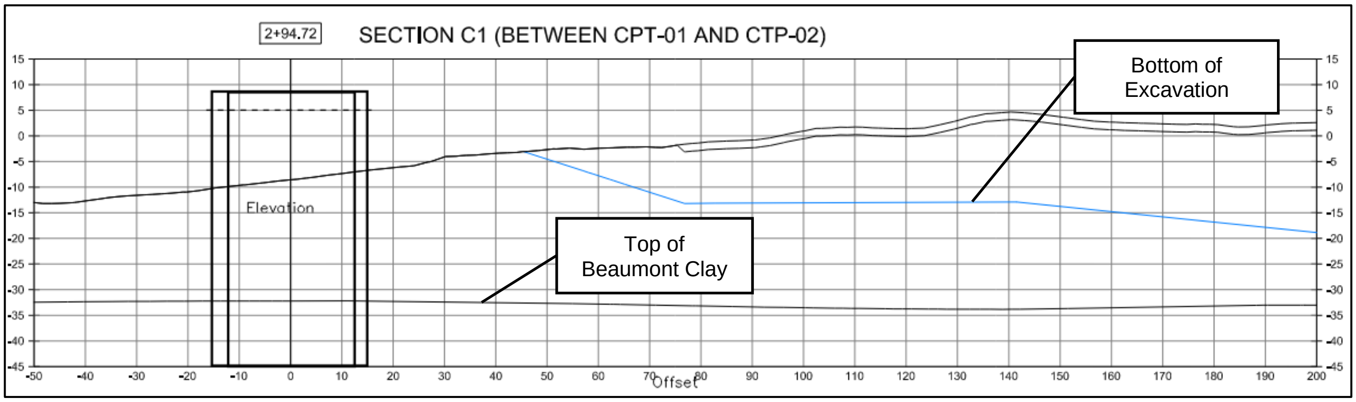

Figure 6-2 Analysis Section C1

The following stages of construction were defined for the analysis of Cross-Section C1:

1. Install exterior and interior sheet piles.
2. Fill between the sheet piles to elevation +3 ft NAVD88. Minimum time interval assumed as 10 days.
3. Install tie-rods at elevation +3 ft NAVD88.
4. Fill between the sheet piles to elevation +9 ft NAVD88. Minimum time interval assumed as 6 days.
5. Dewater to riverbed. Minimum time interval assumed as 4 days.
6. Excavate to 50 percent depth of material to be removed. Minimum time interval assumed as 14 days.
7. Dewater to final level (-20 ft NAVD88). Minimum time interval assumed as 3 days.
8. Excavate to 100 percent depth of material to be removed. Minimum time interval assumed as 14 days.

6.2.2 Cross-Section C2

Cross-Section C2 (Figure C-3) represents the site condition where the riverbed is fairly even along the BMP alignment. The approximate retained height on both the exterior and interior sides is 24 ft. The large height above the riverbed overstressed the sheet piles and tie-rods. Hence, a 30 ft wide bench raised up to elevation -10 ft NAVD88 is required on the interior side to reduce the stresses.

The sheet piles and tie-rods required for Cross-Section C2 are among the largest standard sections available. The tie-rods are required to be installed at elevation -5 ft NAVD88, significantly below the normal water levels in the river, which has the potential to pose a safety hazard during construction.

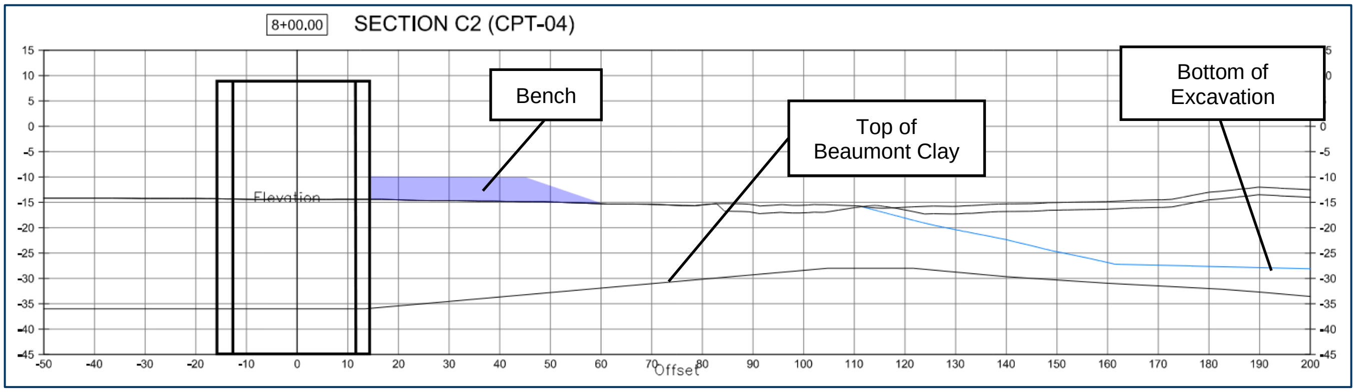

Figure 6-3 Analysis Section C2

The following stages of construction were defined for the analysis of Cross-Section C2:

1. Install exterior and interior sheet piles.
2. Fill between the sheet piles to elevation -7 ft NAVD88. Minimum time interval assumed as 7 days.
3. Install tie-rods at elevation -5 ft NAVD88.
4. Fill between the sheet piles to elevation -1 ft NAVD88. Minimum time interval assumed as 7 days.
5. Fill between the sheet piles to elevation +5 ft NAVD88. Minimum time interval assumed as 7 days.
6. Fill between the sheet piles to elevation +9 ft NAVD88. Minimum time interval assumed as 7 days.
7. Dewater to riverbed. Minimum time interval assumed as 4 days.
8. Excavate to 50 percent depth of material to be removed. Minimum time interval assumed as 14 days.
9. Dewater to final level (-29 ft NAVD88). Minimum time interval assumed as 3 days.
10. Excavate to 100 percent depth of material to be removed. Minimum time interval assumed as 14 days.

6.2.3 Cross-Section C3 and C3A

Cross-Sections C3 and C3A (Figure 6-4 and Figure 6-5, respectively) represent the site condition where the riverbed is fairly even along the BMP alignment. The riverbed starts sloping toward the excavation area along Cross-Section C3. The approximate retained height on both the exterior and interior sides is 14 ft.

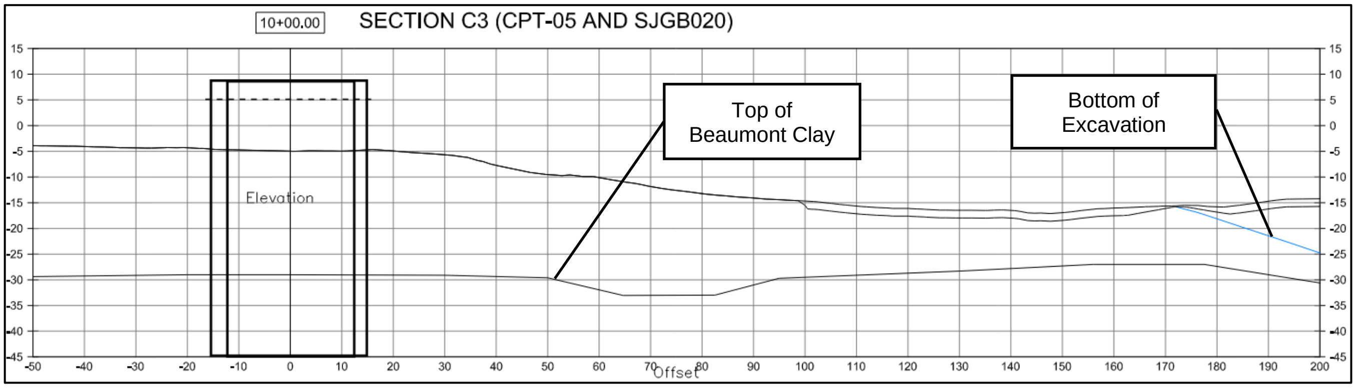

Figure 6-4 Analysis Section C3

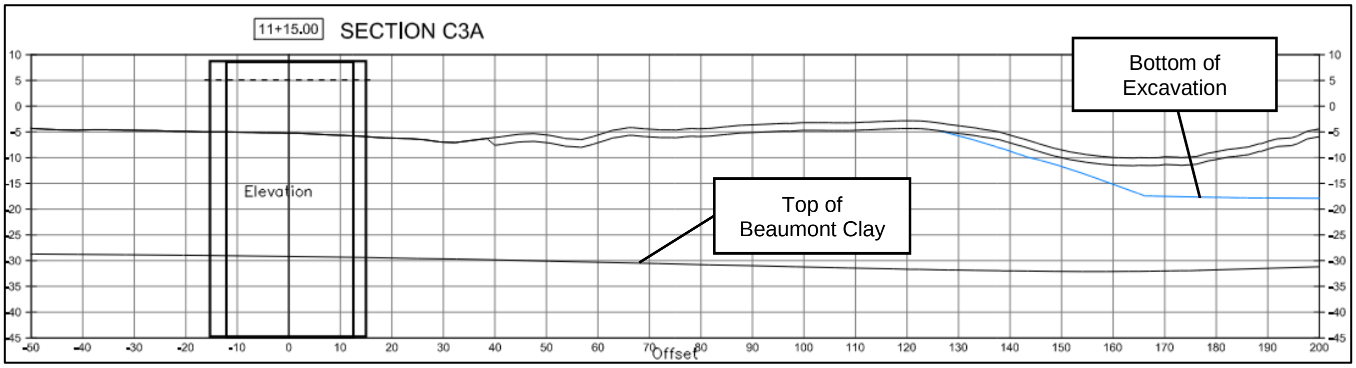

Figure 6-5 Analysis Section C3A

The following stages of construction stages were defined for the analysis of Cross-Section C3:

1. Install exterior and interior sheet piles.
2. Fill between the sheet piles to elevation 0 ft NAVD88. Minimum time interval assumed as 10 days.
3. Install tie-rods at elevation 0 ft NAVD88.

4. Fill between the sheet piles to elevation +3 ft NAVD88. Minimum time interval assumed as 3 days.
5. Fill between the sheet piles to elevation +9 ft NAVD88. Minimum time interval assumed as 10 days.
6. Dewater to riverbed. Minimum time interval assumed as 4 days.
7. Excavate to 50 percent depth of material to be removed. Minimum time interval assumed as 14 days.
8. Dewater to final level (-26 ft NAVD88). Minimum time interval assumed as 3 days.
9. Excavate to 100 percent depth of material to be removed. Minimum time interval assumed as 14 days.

The following stages of construction stages were defined for the analysis of Cross-Section C3A:

1. Install exterior and interior sheet piles.
2. Fill between the sheet piles to elevation 0 ft NAVD88. Minimum time interval assumed as 10 days.
3. Install tie-rods at elevation +3 ft NAVD88.
4. Fill between the sheet piles to elevation +9 ft NAVD88. Minimum time interval assumed as 6 days.
5. Dewater to riverbed. Minimum time interval assumed as 4 days.
6. Excavate to 50 percent depth of material to be removed. Minimum time interval assumed as 14 days.
7. Dewater to final level (-18 ft NAVD88). Minimum time interval assumed as 3 days.
8. Excavate to 100 percent depth of material to be removed. Minimum time interval assumed as 14 days.

6.2.4 Cross-Section C4

Cross-Section C4 (Figure 6-6) represents the site condition where the riverbed slopes away steeply from the Northern Impoundment. The approximate retained heights on the exterior and interior sides are 22 ft and 12 ft, respectively.

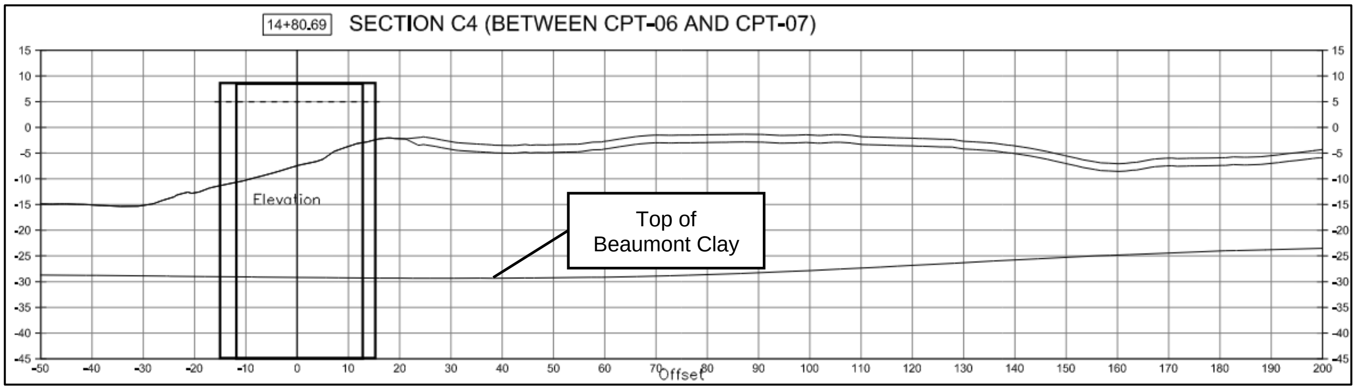

Figure 6-6 Analysis Section C4

The following stages of construction stages were defined for the analysis of Cross-Section C4:

1. Install exterior and interior sheet piles.
2. Fill between the sheet piles to elevation -3 ft NAVD88. Minimum time interval assumed as 10 days.
3. Install tie-rods at elevation 0 ft NAVD88.
4. Fill between the sheet piles to elevation +9 ft NAVD88. Minimum time interval assumed as 6 days.
5. Dewater to riverbed. Minimum time interval assumed as 4 days.
6. Excavate to 50 percent depth of material to be removed. Minimum time interval assumed as 14 days.
7. Dewater to final level (-22 ft NAVD88). Minimum time interval assumed as 3 days.
8. Excavate to 100 percent depth of material to be removed. Minimum time interval assumed as 14 days.

6.2.5 Cross-Section C4A

Cross-Section C4A (Figure 6-7) represents the Site condition where the riverbed slopes away from the Northern Impoundment. The approximate retained heights on the exterior and interior sides are 17 ft and 12 ft, respectively.

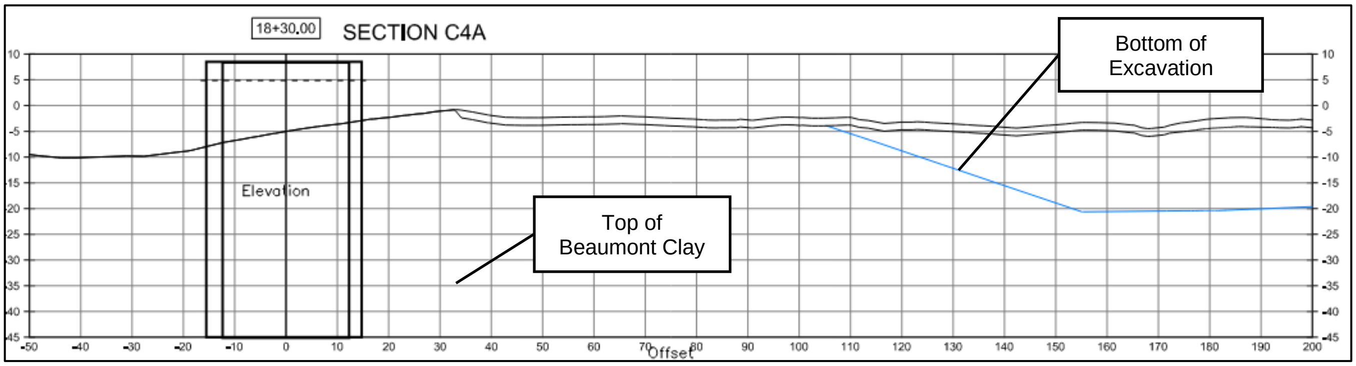

Figure 6-7 Analysis Section C4A

The following stages of construction stages were defined for the analysis of Cross-Section C4A:

1. Install exterior and interior sheet piles.
2. Fill between the sheet piles to elevation 0 ft NAVD88. Minimum time interval assumed as 10 days.
3. Install tie-rods at elevation +6 ft NAVD88.
4. Fill between the sheet piles to elevation +9 ft NAVD88. Minimum time interval assumed as 6 days.
5. Dewater to riverbed. Minimum time interval assumed as 4 days.
6. Excavate to 50 percent depth of material to be removed. Minimum time interval assumed as 14 days.
7. Dewater to final level (-21 ft NAVD88). Minimum time interval assumed as 3 days.
8. Excavate to 100 percent depth of material to be removed. Minimum time interval assumed as 14 days.

6.2.6 Cross-Section C5

Cross-Section C5 (Figure 6-8) represents the site condition where the riverbed slopes away steeply from the Northern Impoundment. The approximate retained heights on the exterior and interior sides are 24 ft and 17 ft, respectively.

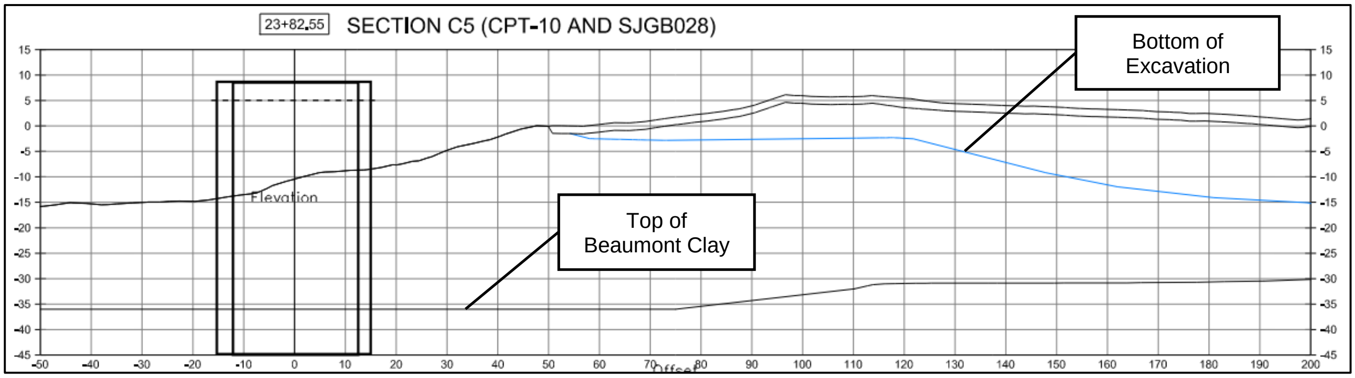

Figure 6-8 Analysis Section C5

The following stages of construction stages were defined for the analysis of Cross-Section C5:

1. Install exterior and interior sheet piles.
2. Fill between the sheet piles to elevation -1 ft NAVD88. Minimum time interval assumed as 10 days.
3. Install tie-rods at elevation 0 ft NAVD88.

4. Fill between the sheet piles to elevation +9 ft NAVD88. Minimum time interval assumed as 6 days.
5. Dewater to riverbed. Minimum time interval assumed as 4 days.
6. Excavate to 50 percent depth of material to be removed. Minimum time interval assumed as 14 days.
7. Dewater to final level (-16 ft NAVD88). Minimum time interval assumed as 3 days.
8. Excavate to 100 percent depth of material to be removed. Minimum time interval assumed as 14 days.

6.2.7 Cross-Section C6 and C7

Cross-Sections C6 and C7 (Figure 6-9 and Figure 6-10, respectively) represent the BMP cross-sections along the alignment parallel to the I-10 Bridge. In the original alignment, the BMP was placed directly at the edge of the existing berm (0 on the horizontal axis) and excavation limits extended to the sheet pile. The existing ground elevation is fairly even and close to Elevation +5 ft NAVD88.

The BMP design elevation at bottom of excavation is -14 ft NAVD88 and -20 ft NAVD88 for Section C6 and Section C7, respectively. Several concepts, as described below, were evaluated to determine a working solution along the original alignment. Due to the significantly large height retained above the anticipated excavation bottom, lack of a bench to keep the BMP design independent of the excavation depths, and active excavation along the face of the BMP, the concepts were considered unfeasible. Hence, the BMP was moved farther to the South, to allow maintaining a sloped bench beginning at Elevation 0 ft NAVD88 and extending into the excavation area.

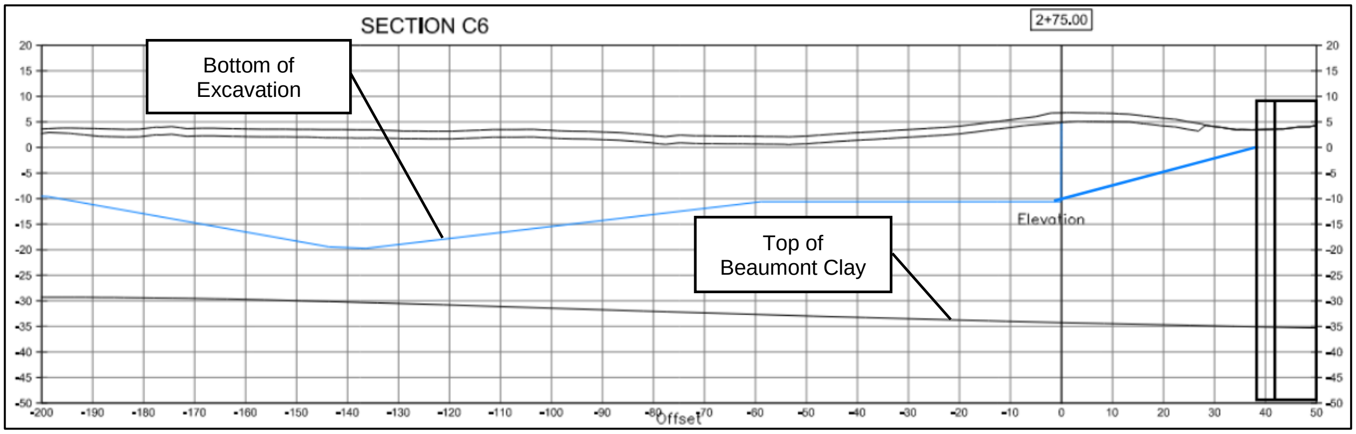

Figure 6-9 Analysis Section C6

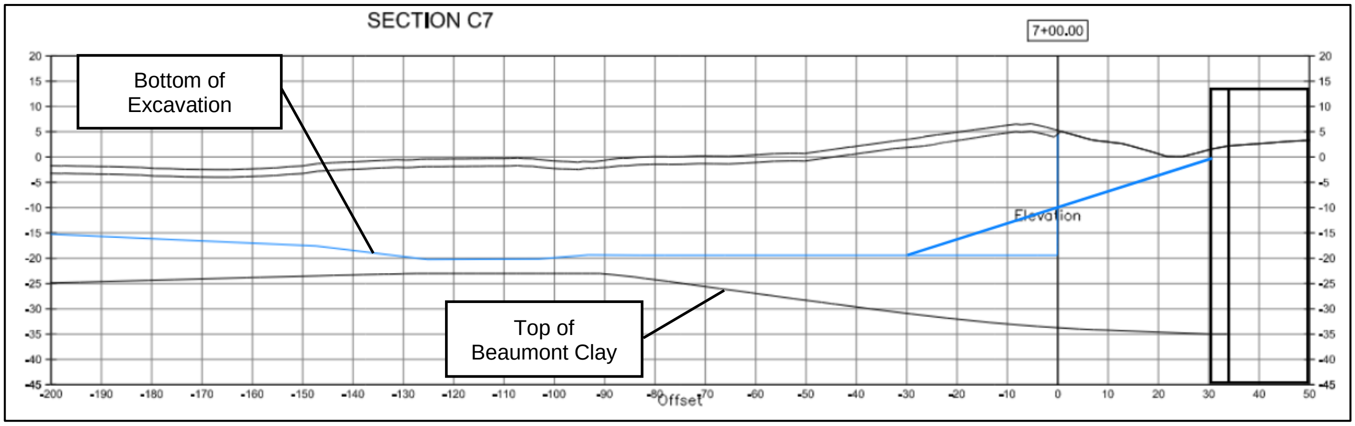

Figure 6-10 Analysis Section C7

In attempts to minimize the footprint of the southern wall and minimize encroaching onto the TxDOT right-of-way to the south of the Northern Impoundment, several different wall types were evaluated, as detailed below.

Alternative 1: Combination Wall With Tie-back Anchors

This alternative included a combination wall system of tubular pipe piles and Z-shaped sheet piles aligned along the excavation perimeter and connected to the Z-shaped sheet pile anchor walls with steel tie-rods for support. The steel piles would have had to have been driven deep into the hard sand layers to achieve adequate embedment depth for stability. The anchor walls also would have had to be placed farther back beyond the right-of-way to be located outside the estimated failure planes to avoid rotational failure.

In order to avoid driving into the sand layers due to concerns with driveability and associated vibrations related to large tubular sections (Section 6.6), this option was considered unfeasible.

Alternative 2: Cantilever Concrete Secant Pile

This alternative included overlapping concrete piles installed along the excavation perimeter. All piles would have had to be cast-in-place by drilling to the desired depth, placing reinforcement (secondary piles only), and pouring concrete. The primary unreinforced concrete piles would have been built first at regular spacing to allow for secondary reinforced concrete piles. After the primary piles had achieved the desired strength, the secondary reinforced concrete piles would have been built by coring through the edges of the primary piles, placing reinforcement, and pouring concrete to create an overlapping continuous concrete wall. The secondary piles could have only been drilled after the primary piles had achieved full strength. The piles would have been required to be embedded in the hard sand layers to achieve adequate embedment depth for stability.

There were concerns about constructability of this system since it would have required drilling deep into the sand layers and achieving quality overlap in the field to create a relatively watertight seam. The large cantilever height of the wall above the excavation area was also a concern for safety. Hence, this alternative was considered unfeasible.

Alternative 3: Concrete Secant Pile With Tieback Anchors

This alternative included installation of concrete piles similar to Alternative 2 combined with the tie-back anchors similar to Alternative 1. Due to the same concerns as Alternative 1 and Alternative 2, this option was considered unfeasible.

Alternative 4: Combination Wall With Brace Piles

This alternative included a combination wall system similar to Alternative 1 with the tie-back anchor system replaced by brace piles. The brace piles would have been 42 inch diameter, 1.5 inch wall thickness, and spaced at 10.5 ft spacing on-center, installed at an angle of 35 degrees (from vertical) within the excavation area. The brace piles would have had to be driven to Elevation -52 ft NAVD88 to achieve the required capacity to brace the combination wall.

Due to concerns with constructability of the combination wall, raker piles, and excavating around the brace piles to an elevation of -20 ft NAVD88, this option was considered unfeasible.

Alternative 5: Double Wall System

This alternative includes two sheet pile walls spaced 30 ft apart, connected with tie-rods and walers, and filled with aggregate. Similar to the other sections of the BMP, the sheet piles could be terminated in the Beaumont Clay layer. Due to lack of space to the south, the double wall would have had to be set at the edge of the excavation limits, which would have caused the large height retained above the excavation bottom to overstress the sheet piles and the tie-rod system. The retained height of less than 20-ft reduced the stresses. Building a soil bench from the bottom of the excavation to elevation -10 ft NAVD 88 reduced the retained height but encroached on the excavation area (bench width + 3:1 slope from edge of the bench to the excavation bottom).

In order to avoid encroaching on the limits of the excavation area and to avoid excavation along the face of the BMP altogether, the BMP had to be moved farther back beyond the TxDOT right-of-way boundary to allow for inclusion of the required bench and to reduce the retained height.

Design Section: Double Wall System Offset from Original Alignment

Ultimately, the wall type that proved to be structurally sound was the double wall system described in Alternative 5, set back from the edge of the excavation to provide a bench. Under this design, a reduced retained height is achieved by moving the wall alignment away from the excavation area. The approximate retained heights on the exterior and interior side are 7 ft and 9 ft, respectively.

The following stages of construction stages were defined for the analysis of Cross-Sections C6 and C7:

1. Install exterior and interior sheet piles.
2. Cut between the sheet piles to elevation 0 ft NAVD88.
3. Install tie-rods at elevation 0 ft NAVD88.
4. Fill between the sheet piles to elevation +9 ft NAVD88.
5. Dewater to riverbed. Minimum time interval assumed as 4 days.
6. Excavate to 50 percent depth of material to be removed. Maintain soil slope at 3H:1V from elevation 0 ft NAVD88 to excavation bottom. Minimum time interval assumed as 14 days.
7. Dewater to final level (-20 ft NAVD88). Minimum time interval assumed as 3 days.
8. Excavate to 100 percent depth of material to be removed. Maintain soil slope at 3H:1V from elevation 0 ft NAVD88 to excavation bottom. Minimum time interval assumed as 14 days.

6.3 Structural Components

The material grades used for design of the key structural components are summarized below:

– ***Sheet Piles***	ASTM A572	Grade 60 (Yield stress, F_y = 60 kilopounds for square inch [ksi]).
– ***Tie rods***	ASTM A615	Grade 120 (F_y = 120 ksi)).
– ***Walers***	ASTM A36	Grade 36 (F_y = 36 ksi).

For purposes of the design, the standard sections for sheet pile and tie-rods were selected from the Nucor Skyline Technical Product Manual. The manual also included the section properties used for design calculations. Alternative sections with equivalent properties are available from other manufacturers and may be used in construction.

The detailed calculations for the sheet pile, tie-rods, and walers are provided in Attachment 3.

6.4 Wind Load Evaluation

As described in Section 3.5, the design wind loads correspond to a 100-year storm (Unusual load condition) or the 3000-year hurricane level wind (Extreme load condition). Typically, the wind load is applied to the face of the BMP exposed above water or ground level. At the design water level for the Unusual and Extreme load conditions (i.e., Elevation +9 ft NAVD88) the exterior face of the BMP would not be exposed to the wind. Assuming the excavation area remained completely dewatered, the wind loads acting on the interior face of the BMP will be counteracted by the hydrostatic loads from the water on the outside.

A parametric evaluation was performed for the effect of wind loads on the design of BMP using LC#5 (Section 4). The 0.6 reduction factor for wind load was conservatively ignored for the evaluation. The net load ($F + W_{Exterior} - W_{Interior}$) on the BMP, calculated as sum of the hydrostatic load and the wind load applied to both interior (above ground) and exterior (above water level), was compared to the hydrostatic load with water level at +9 ft NAVD88 acting alone. There is low probability that the hurricane level winds will develop on-Site without an increase in water levels. Hence, combining hurricane level winds with normal water levels (i.e., Elevation +5 ft NAVD88) when the BMP is most exposed, is a conservative approach. The calculated net load was smaller than the hydrostatic loads corresponding to the Unusual condition water levels acting alone. Thus, the wind loads do not govern the design.

Additional details of various scenarios considered for the parametric evaluation are provided in Attachment 3.

6.5 Barge Impact

The barge impact loads were evaluated in Plaxis for two Cross-Sections (C2 and C4) as they represent the two largest exposed heights above the riverbed and are expected to be the most critical sections.

6.5.1 Analysis Model

A 400 ft long three-dimensional (3D) model was created with the same stratigraphy, material properties and stages as the analysis sections described in Section 6.2. The linear elastic plates representing the sheet piles are assigned orthotropic parameters to capture the difference in sheet pile stiffness of the vertical and horizontal directions. The barge impact load was applied at the middle of the model, as a static uniformly distributed load over a 50 ft x1 ft area at top of the wall (+9 ft NAVD88). Due to the instantaneous nature of the impact, the loads are evaluated using the undrained soil parameters and considered an Extreme load condition, with the impact at top of the wall with the water levels at +9 ft NAVD88.

The following two scenarios, enveloping multiple impact velocities and barge displacement (ballasted or laden) were evaluated. The loads correspond to higher velocities of flow for impact with a barge in ballasted condition, hence conservative for the analysis. However, for the laden condition, the loads represent the limiting loads.

Case 1: 20 kip/ft x 50 ft = 1000 kip:

- Corresponds to contact with 54 ft barge in ballasted condition at impact velocity of 3.8 ft/s.
- Contact with 54 ft barge in laden condition at impact velocity of 1.6 ft/s.

Case 2: 28 kip/ft x 50 ft = 1400 kip:

- Corresponds to contact with 54 ft barge in ballasted condition at impact velocity of 5.3 ft/s.
- Contact with 54 ft barge in laden condition at impact velocity of 2.2 ft/s.

6.5.2 Results

The barge impact loads caused localized deformation of the wall along with increase in soil shear strains. However, the strains did not indicate a global failure. In this scenario, there would be localized damage to the BMP on the exterior side due to limiting flexural capacity. The analysis results are summarized in Table 6-1.

Table 6-1 Barge Impact Analysis Output

Analysis Sections	Design Load (kip/ft)	Total Applied Force (kip)	Analysis Demands Per LF			DCR - Moment	DCR - Shear
			Moment (kip-ft)	Shear (kip)	Deflection (ft)		
C2, AZ 40-700N	20	1000	342.4	64.5	1.4	1.11	0.19
	28	1400	465.9	68.5	2.8	1.51	0.21
C4, AZ 26-700	20	1000	159.6	39.6	0.8	0.81	0.14
	28	1400	251.2	39.6	1.6	1.28	0.14

Detailed analyses, results, and plots are provided in Attachment 3.

As cross-Section C2 is not near the navigational waterway, it was evaluated for impact with barge in ballasted condition only, under the assumption that any impact would be from moored barges. Under this scenario, the sheet piles would be overstressed by 11 percent (moment capacity) at an impact velocity of 3.8 ft/s, beyond the 95th percentile maximum velocity expected in the river.

Cross-Section C4 is closer to the navigational waterway and would be expected to may potentially encounter impact with barges, ballasted or laden, as they are towed. Under this scenario, the sheet piles would be overstressed by 28 percent (moment capacity) at an impact velocity of 5.3 ft/s and 2.2 ft/s for barges in ballasted and laden condition, respectively. The limiting condition is representative of the navigation speeds as the 95th percentile maximum velocity in the river is expected to be 2.2 ft/s. The stresses could be lowered by utilizing a larger sheet pile section, such as AZ36-700N.

However, the impact loads reduce significantly at lower velocity of impact. The barges and tugboats typically slow down as the width of the navigational waterway reduces closer to the I-10 Bridge Pier. It is recommended that navigational signs be posted on the exterior face of the BMP to require marine vessels to reduce speeds along the eastern side of the BMP.

Also, in lieu of the BMP absorbing the impact, protective appurtenances such as rubber fenders on the exterior face of the BMP and/or sacrificial monopile dolphins (large diameter steel pipe piles) located away from the BMP, may be provided to protect the BMP from potential vessel impact.

6.6 Pile Driveability and Vibration Analysis

The BMP presented in the 30% RD included two cantilever wall alternatives; a combination wall with large diameter tubular pipe piles paired with intermediary Z-shaped sheet piles, and another with double H-beams. Both of the cantilever wall alternatives would have had to be driven in excess of elevation -80 ft NAVD88 to achieve adequate embedment for stability.

Pile driveability and vibration analyses were performed on these robust wall types and included in the 30% RD. The driveability of the cantilever walls was analyzed using GRLWEAP, a one-dimensional wave analysis equation program. The analysis indicated that a large diesel impact hammer would be required to install the BMP. The details of the GRLWEAP analysis are again included in the Geotechnical Engineering Report (Appendix B of the 90% RD). The analysis also indicated that the vibration caused by driving these robust piles would adversely impact the stability of ground slopes adjacent to the pile installation. These potential effects were further evaluated and described in detail in Attachment 4.

The concerns raised from the 30% RD Pile Driveability & Vibration Analysis are not applicable to the current design and alignment of the BMP. The 90% RD BMP design mitigates the adverse impacts of driving piles to deep elevations by terminating the sheet piles within the Beaumont Clay Formation.

6.7 Design Summary

The summary of the structural design for the various representative sections analyzed is provided in Table 6-2. The tie-rod spacing shown in the summary includes closer spacing than the spacing used in the analysis to incorporate additional safety factor against potential progressive failure described in Section 5.2.3. The closely spaced tie-rods increase the stiffness of the system, and the overall stresses and deflection in the BMP are expected to improve.

Table 6-2 Summary of BMP Design

Analysis Section	Sheet Pile Section		Tie Rod Section		Waler Section
	Nucor Skyline	Length (feet)	Diameter (inches)	Spacing (feet)	
C1	AZ26-700	50	2.25	5	MC 12X35
C2	AZ40-700	55	3.00	5	MC 18X45.8
C3	AZ26-700	50	2.25	5	MC 12X35
C3A	AZ26-700	50	2.25	5	MC 12X35
C4	AZ26-700	50	2.25	5	MC 12X35
C4A	AZ26-700	50	2.25	5	MC 12X35
C5	AZ26-700	60	2.25	5	MC 12X35
C6	AZ26-700	60	2.25	5	MC 12X35
C7	AZ26-700	60	2.25	5	MC 12X35

6.7.1 Analysis Notes

1. As the site conditions for Cross-Sections C3 and C3A have an overlap, it is recommended that the construction stages for Cross-Section 3 be followed for both as a conservative approach.
2. There is potential for the sheet piles to deflect towards the river before the tie-rods are installed. The sheet piles should be temporarily braced during fill and during tie-rod installation.
3. The interior side of Cross-Sections 6 and 7 should maintain the natural soils from elevation 0 ft NAVD88 to the bottom of the excavation at slope of 3H:1V.

7. Additional Considerations / Limitations

7.1 Barge Impact

The barge impact analyses showed that the sheet piles are overstressed due to impact from a laden 30,000 BBL barge 2.2 ft/s velocity. Although, the stresses in the sheet piles can be reduced by utilizing a larger steel section, barge impact is a rare event and other means to mitigate impacts need to be considered.

The impact loads reduce significantly at lower velocity of impact. The barges and tugboats typically slow down as the width of the navigational waterway narrows closer to the I-10 Bridge Piers. It is recommended that navigational signs be posted on the exterior face of the BMP to require reducing speeds along the eastern side of the BMP.

Also, in lieu of the BMP absorbing the impact, protective appurtenances, such as rubber fenders on the exterior face of the BMP and/or sacrificial monopile dolphins (large diameter steel pipe piles) located away from the BMP, may be provided to protect the BMP from potential vessel impact.

7.2 Seepage through Sheet Piles

The BMP is considered a temporary structure and will be removed after the remedial action (RA) is complete. The steel sheet piles, except for the interlocks are completely impervious. The Beaumont Clay Formation is also considered an impervious material for movement of water within the soils. The seepage or discharge through the sheet pile interlocks is proportional to the pressure drop across the interlocks in a horizontal plane. The vertical flow through the interlocks is negligible as the sheet piles will be terminated in the Beaumont Clay Formation and hence, no seepage is expected from under and/or around the sheet piles.

Figure 7-1 shows a general relationship[3] of discharge through interlocks and the pressure-drop across the sheet piles for the following three conditions. The example highlighted in the figure compares the anticipated seepage through the interlocks for the same pressure-drop for each of the three conditions:

1. Standard Interlocks, no sealant, or welds.
2. Interlocks filled with plugged soil during sheet pile installation.
3. Interlocks filled with filler material or sealants.

Compared to the standard interlocks, the interlocks filled with plugged soils during pile installation and those filled with a sealant material allow 70 percent and 25 percent of the seepage, respectively. However, at the maximum tested pressure-drop (approximately 100 kiloPascal, or 30 feet of standing water), the three interlock conditions allowed the same volume of seepage.

It is anticipated that the soft sediments will plug the interlocks of the sheet pile during installation. The fill material between the walls of the BMP will also create a pressure-gradient instead of an abrupt pressure-drop across the

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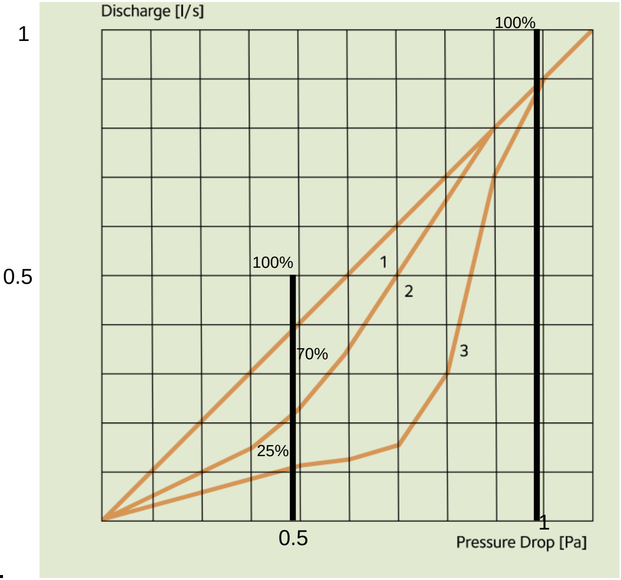
[3] Arcelor Mittal, Impervious Steel Sheet Pile Walls, Design & Practical Approach.

exterior sheet pile wall of the BMP. In addition, the two sets of interlocks (exterior and interior wall) at any vertical cross-section will minimize the potential of the seepage through the BMP.

During normal operations, any seepage from the river into the excavation area can be managed as part of the waste removal process. If the excavation area is flooded due to a heavy rain or storm, the pressure-drop between the exterior and interior side of the BMP will reduce and the resultant pressure-drop will still only allow seepage toward the interior of the BMP. The interlock seepage calculations are provided in Attachment 3. It is recommended that the interlocks be sealed to prevent seepage into the excavation area which would increase the volume of water required for treatment during the RA.



4.

Figure 7-1 Discharge - Pressure Drop Relationship, Arcelor Mittal

There are several proprietary interlock sealant materials available that reduce the amount of seepage through the interlocks. These materials are added to the interlocks required to cure in dry prior to forming pairs or installation. Some sealant materials expand after contacting water to form a tight joint, but due to the same expansion properties, they have a limited handling time for in-water installation. The performance of the sealant is highly dependent on the handling and installation procedures. Two proprietary materials - WADIT (bituminous material) and Sikaswell-S2 (Arcelor Mittal Roxan Plus system) may be viable alternatives for sealing interlocks and reducing seepage.

The interlocks may be made 100 percent impervious by welding all interlocks for the entire height above water and a few feet below the riverbed by excavating the soils after installing sheet piles. However, this requires field welding of the sheet piles and potentially performing the welds in wet conditions. Welding the sheet interlocks is not a preferred alternative as sheet piles would then not be able to be extracted from the Site without cutting all the welds after the RA is complete.

7.3 Foundation Substructure of I-10 Bridge

The BMP alignment along the south side by the I-10 Bridge had to be revised to avoid encroaching into the excavation area and reducing the stresses in the structural components. The revised alignment locates the BMP close to the fence / guardrails of the I-10 Bridge. The details of the bridge’s foundation substructure are unknown at the time of the 90% RD submittal. The BMP design and alignment will have to be reevaluated and potentially revised if the foundation substructure conflicts with the BMP sheet piles.

Paper Size ANSI B

0 30 60 90 120
Feet

N

Map Projection: Lambert Conformal Conic
Horizontal Datum: North American 1983
Grid: NAD 1983 StatePlane Texas South Central FIPS 4204 Feet

GHD

SAN JACINTO RIVER WASTE PITS SITE
HARRIS COUNTY, TEXAS

SUPPLEMENTAL DESIGN INVESTIGATION BORING LOCATIONS

Project No. **11215702**
Revision No. **-**
Date **Jun 8, 2022**

FIGURE 1

Q:\GIS\PROJECTS\11215000s\11215702\MISC003\11215702_202205_MISC003_GIS001.mxd
Print date: 08 Jun 2022 - 15:49

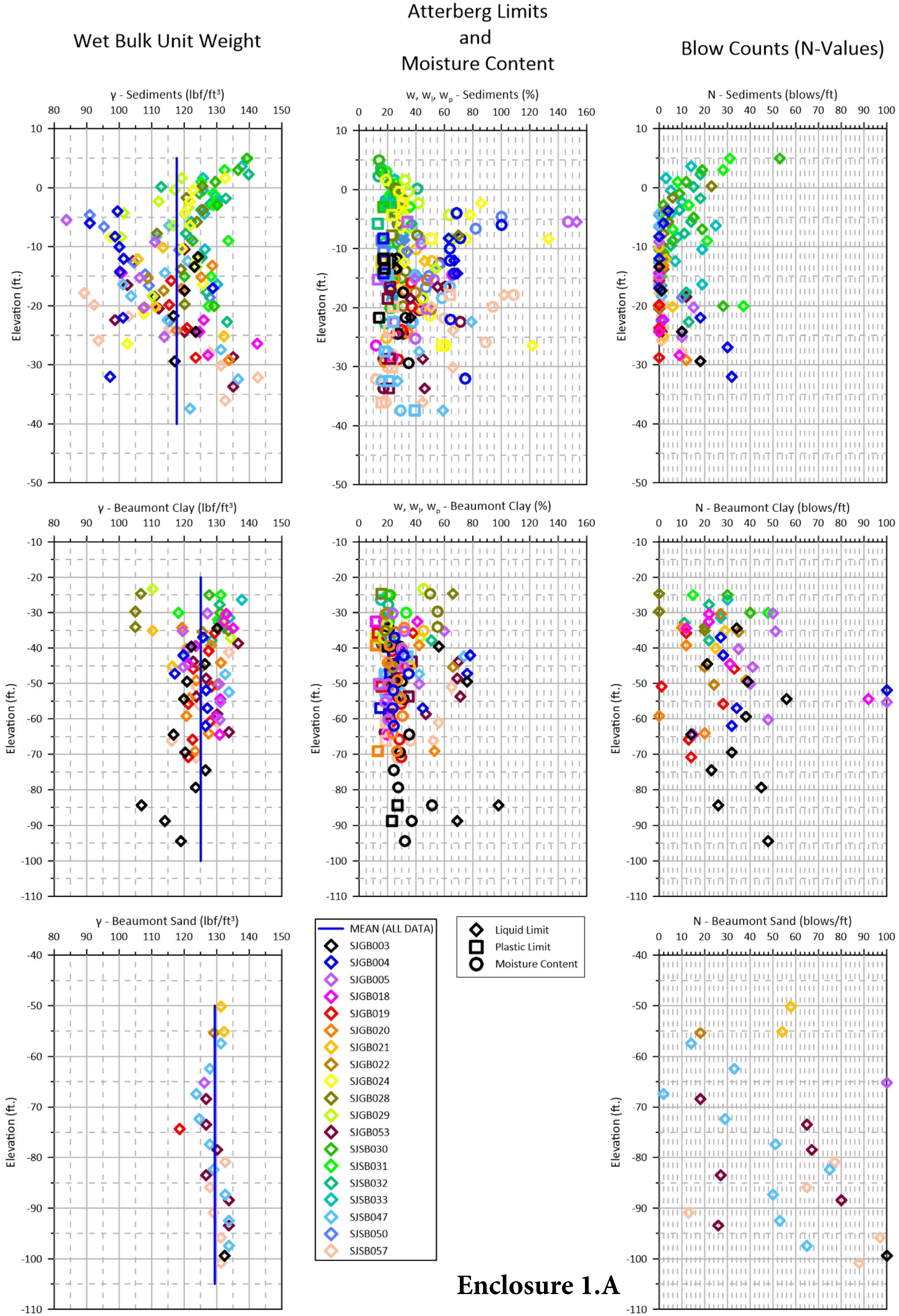
Data source: Imagery - Google, 2019.

Attachments

Attachment 1

Geotechnical Parameters and Data Profiles

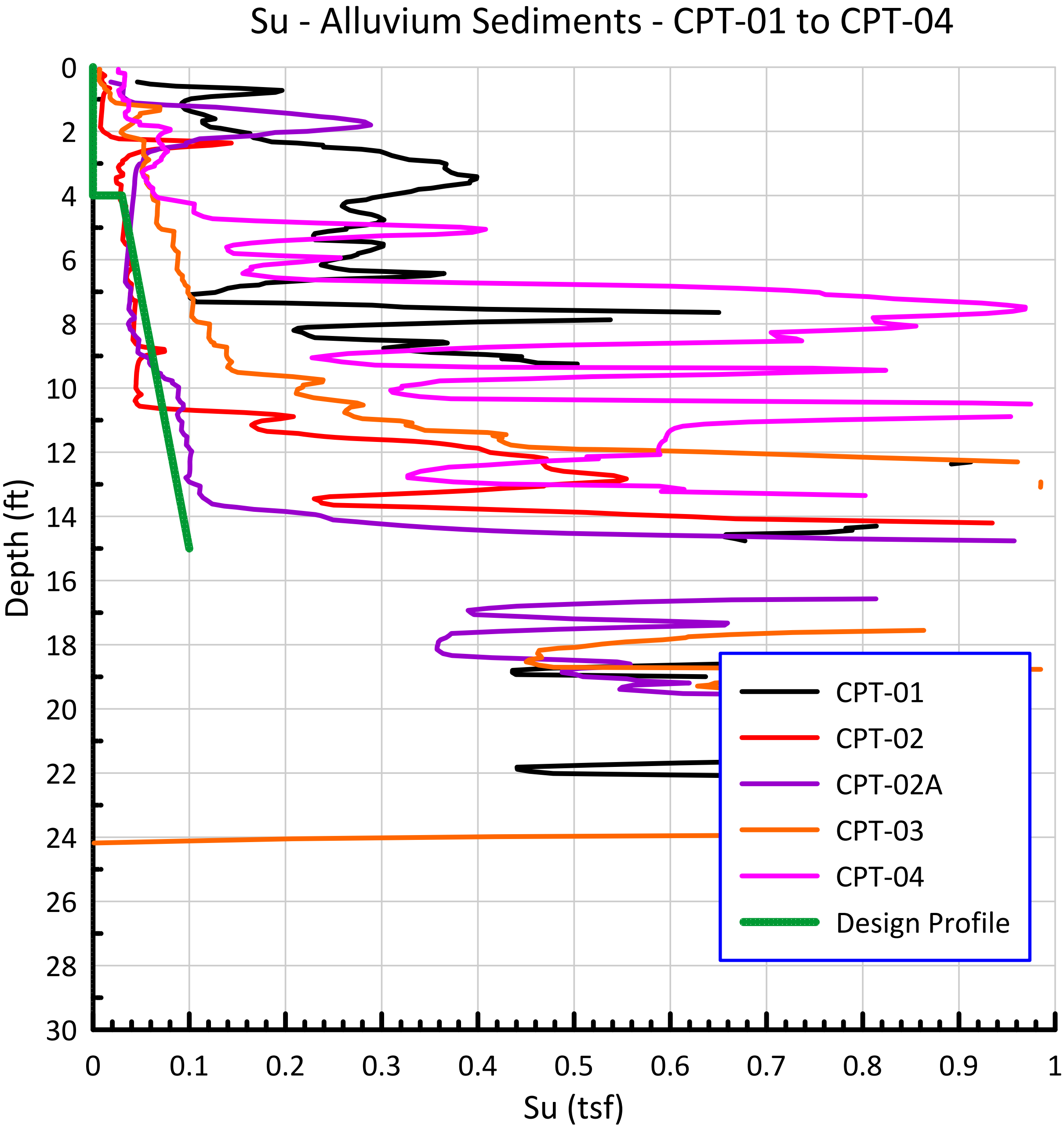
ENCLOSURE 1.A



Enclosure 1.A

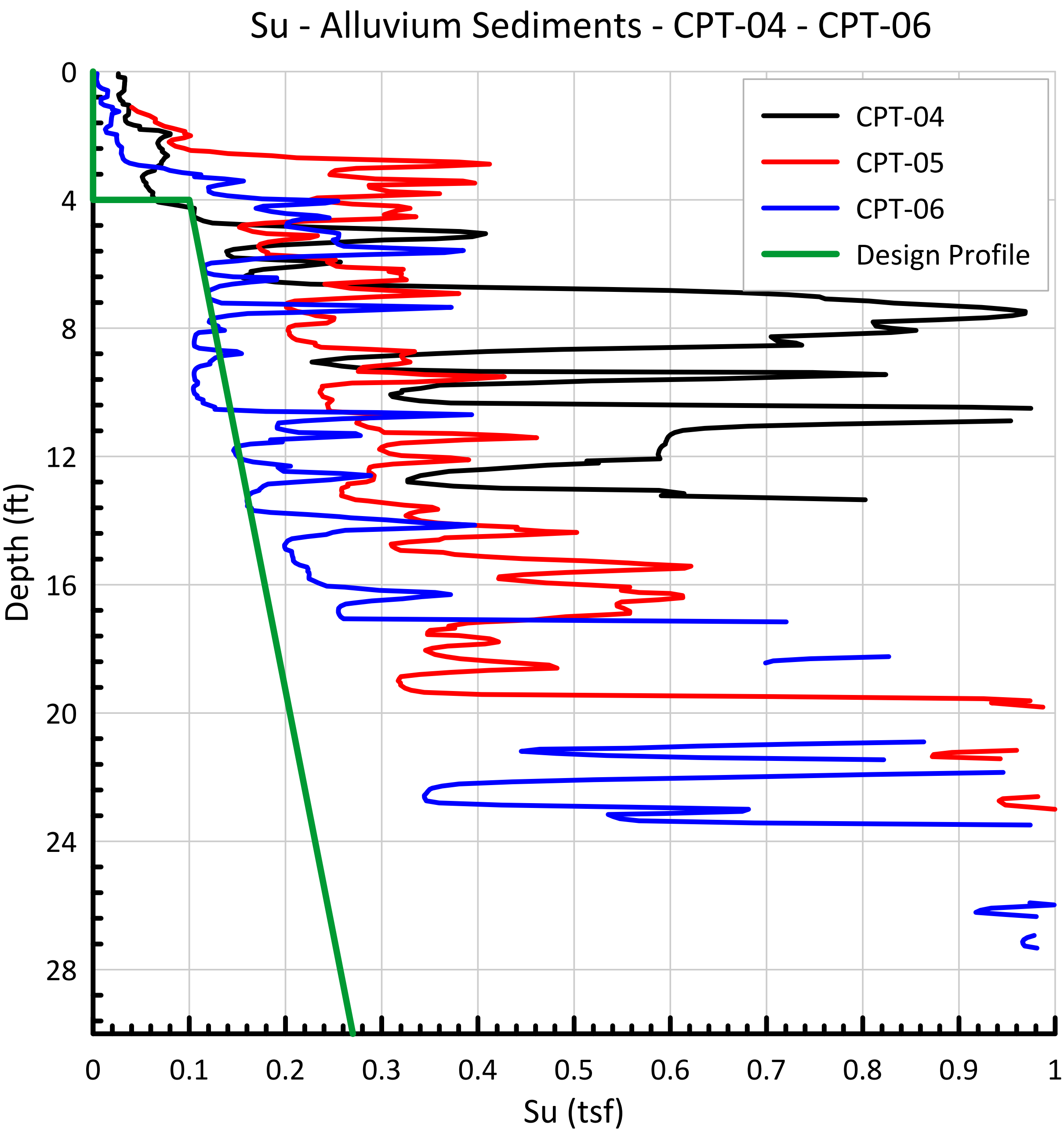
ENCLOSURE 2.A

Enclosure 2.A1



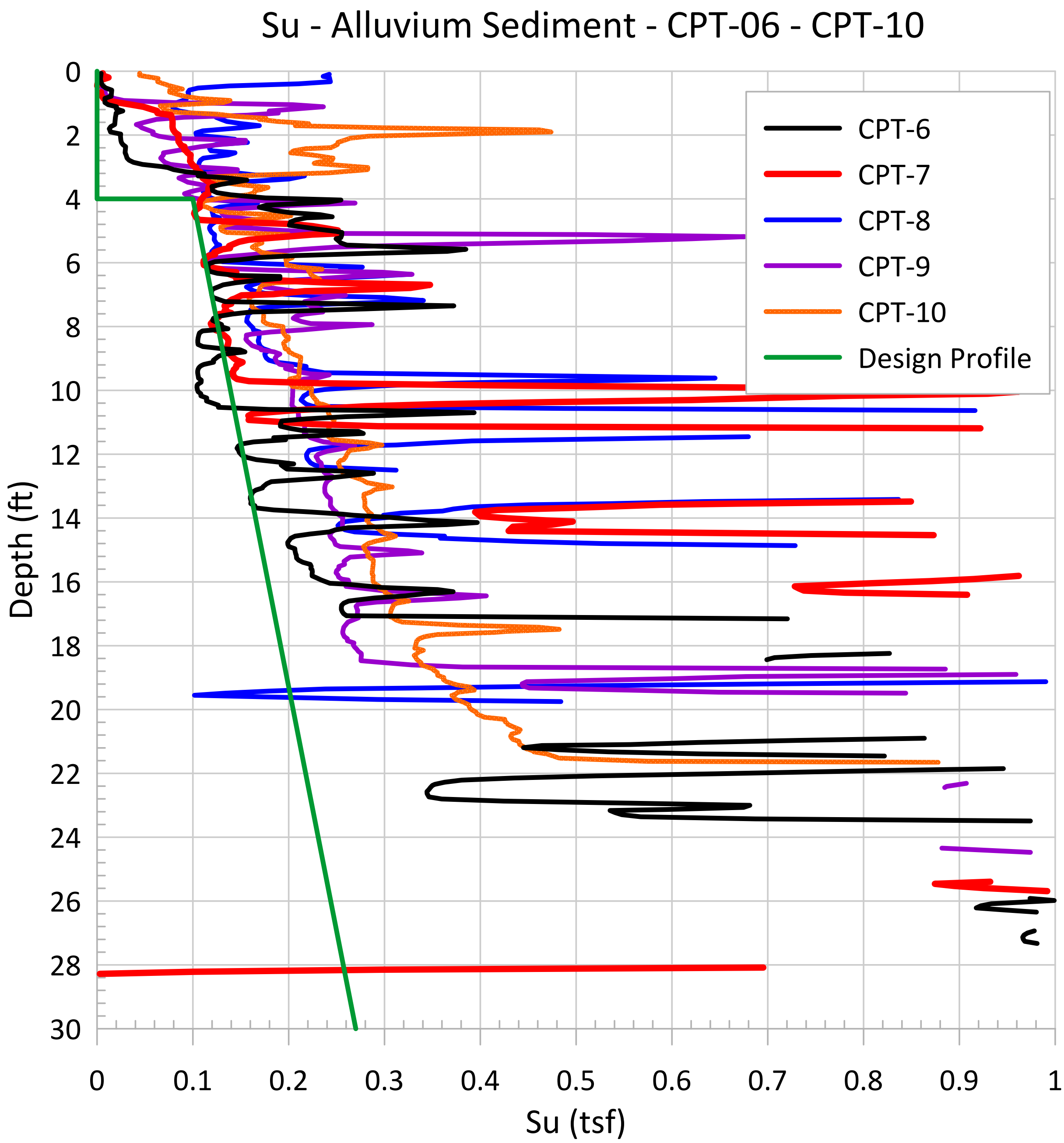
San Jacinto River Waste Pit
Northern Impoundment remedial Design
GHD Project No 11215702

Enclosure 2.A2



San Jacinto River Waste Pit
Northern Impoundment remedial Design
GHD Project No 11215702

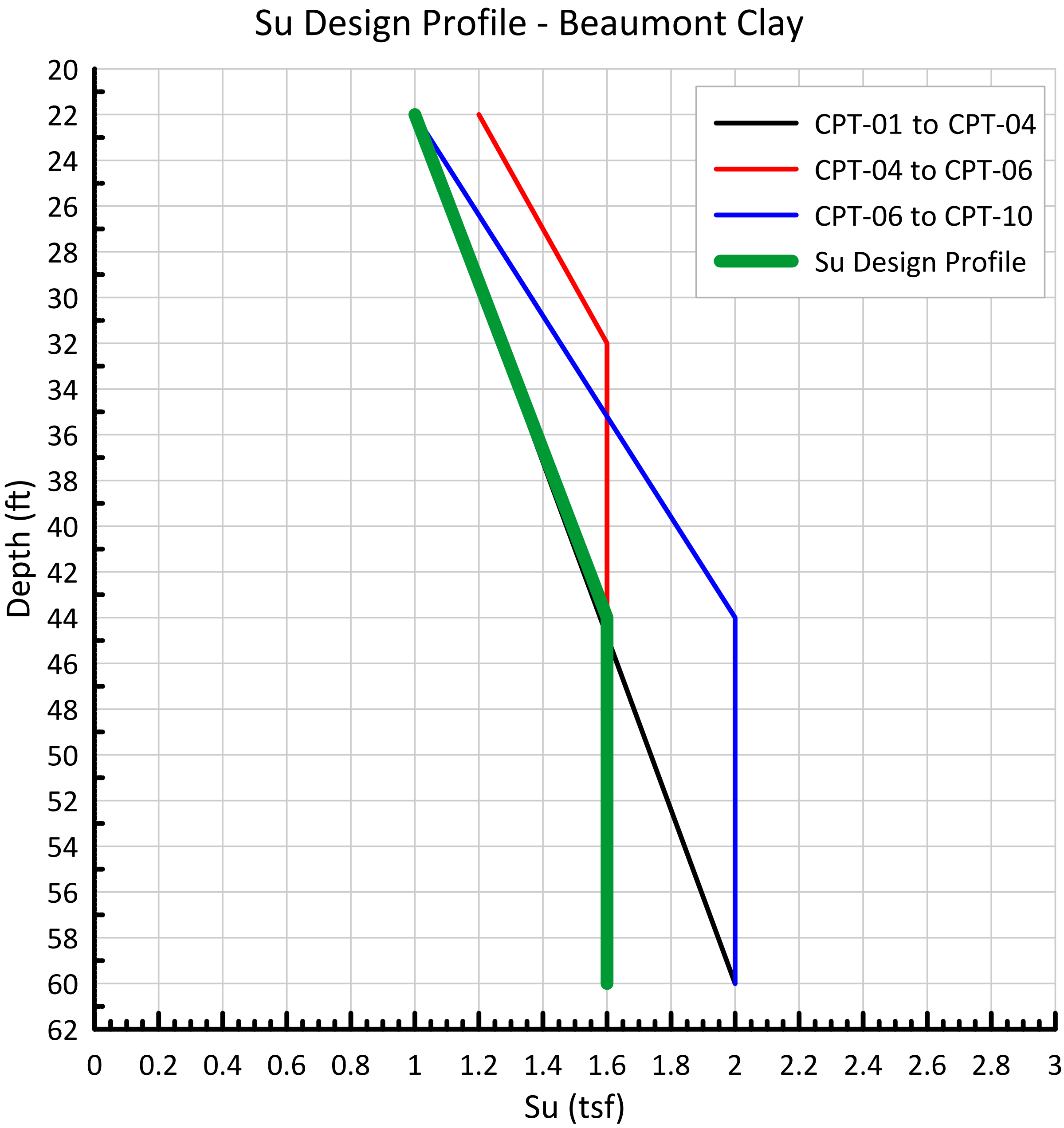
Enclosure 2.A3



San Jacinto River Waste Pit
Northern Impoundment remedial Design
GHD Project No 11215702

ENCLOSURE 2.B

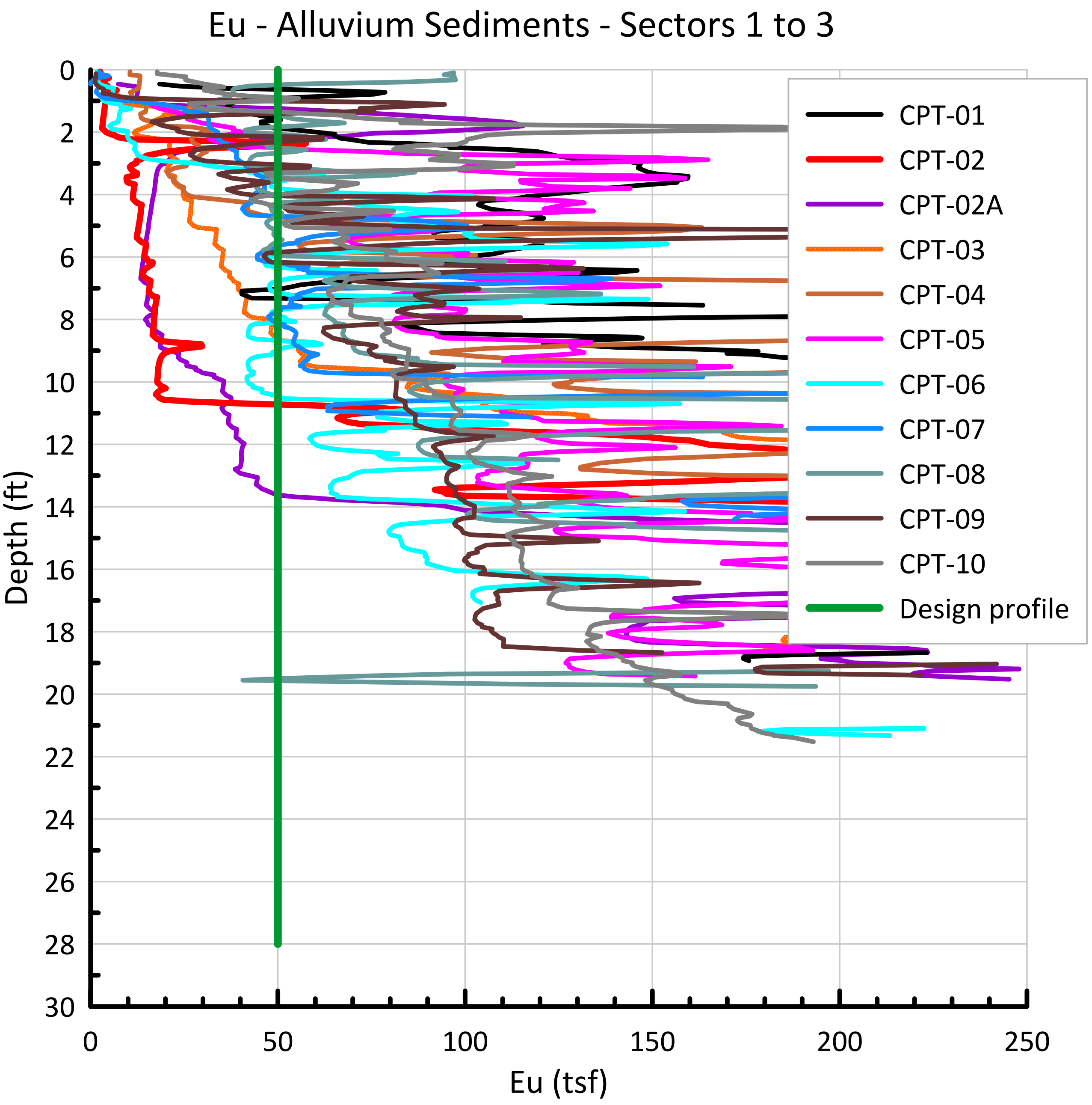
Enclosure 2.B



San Jacinto River Waste Pit
Northern Impoundment Remedial Design
GHD Project No 11215702

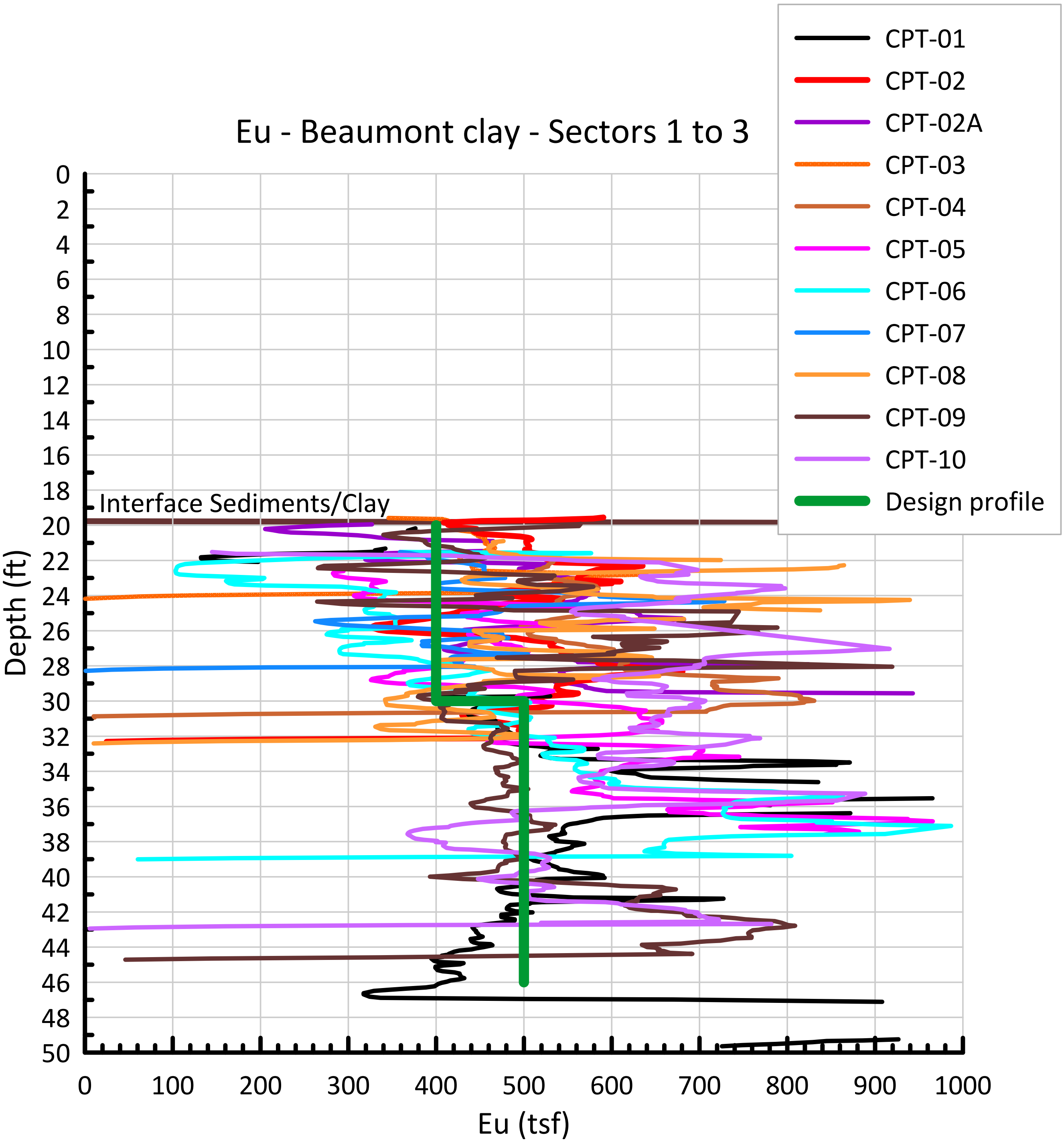
ENCLOSURE 3.A

Enclosure 3.A



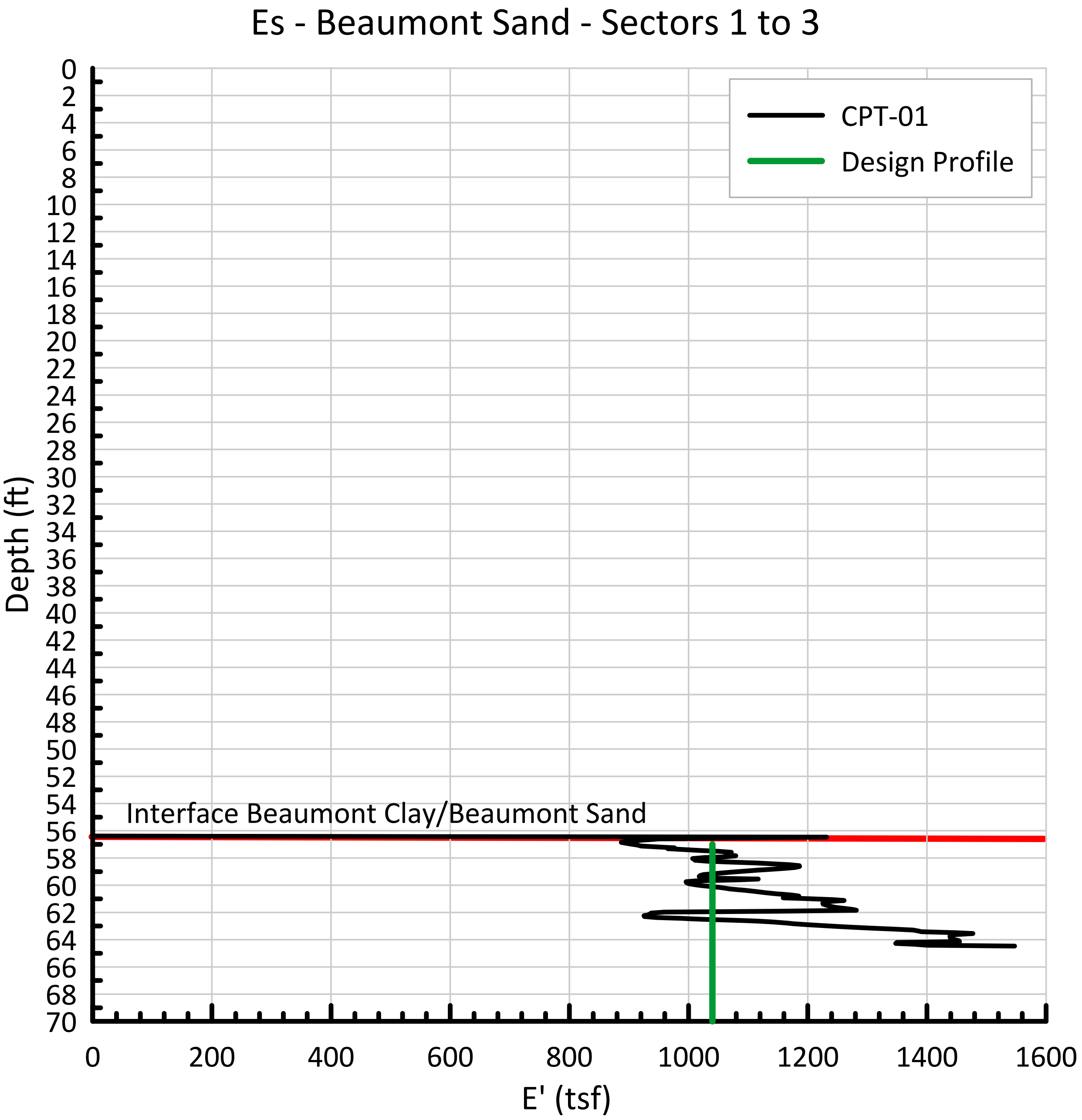
ENCLOSURE 3.B

Enclosure 3.B



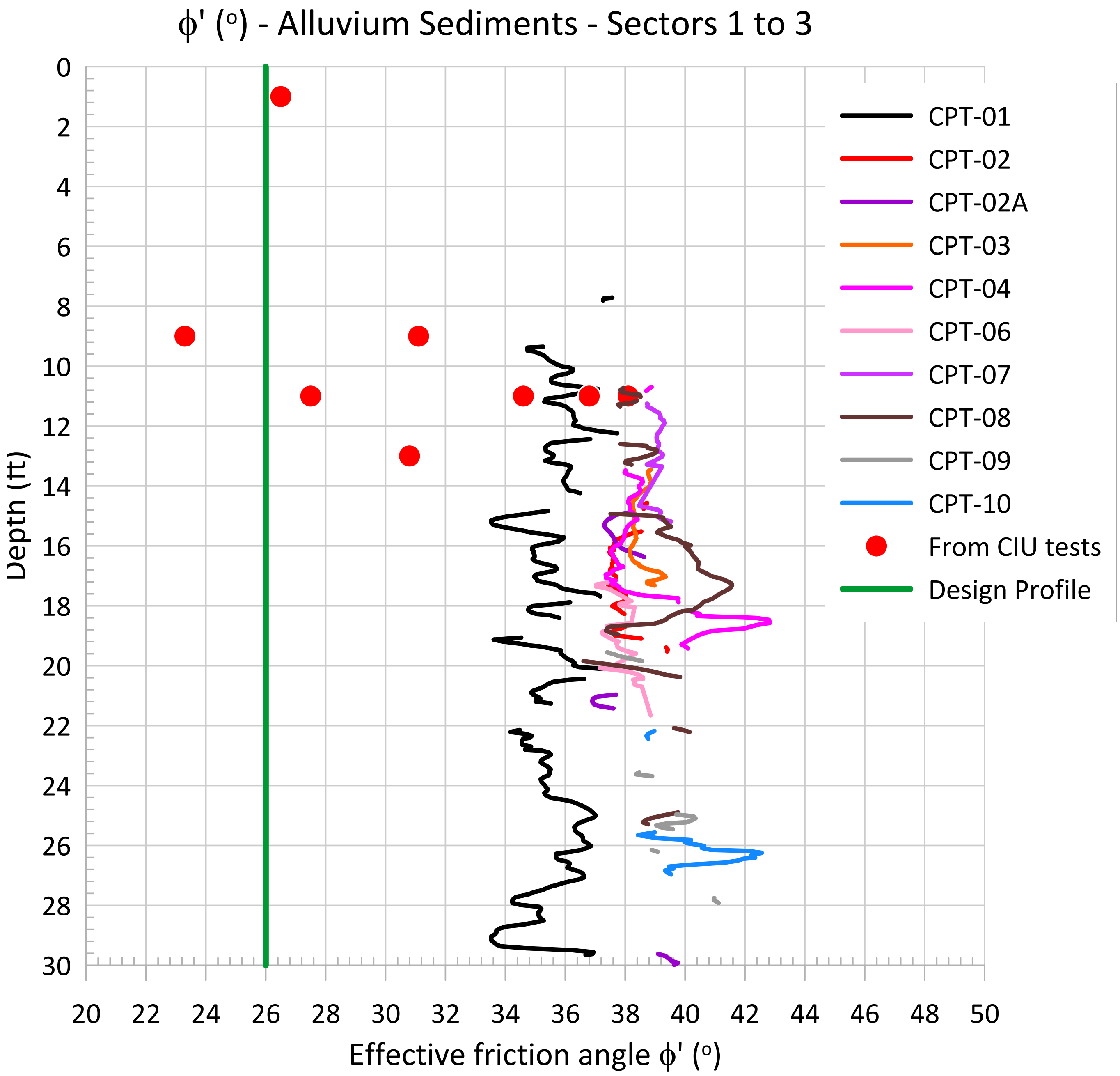
ENCLOSURE 3.C

Enclosure 3.C



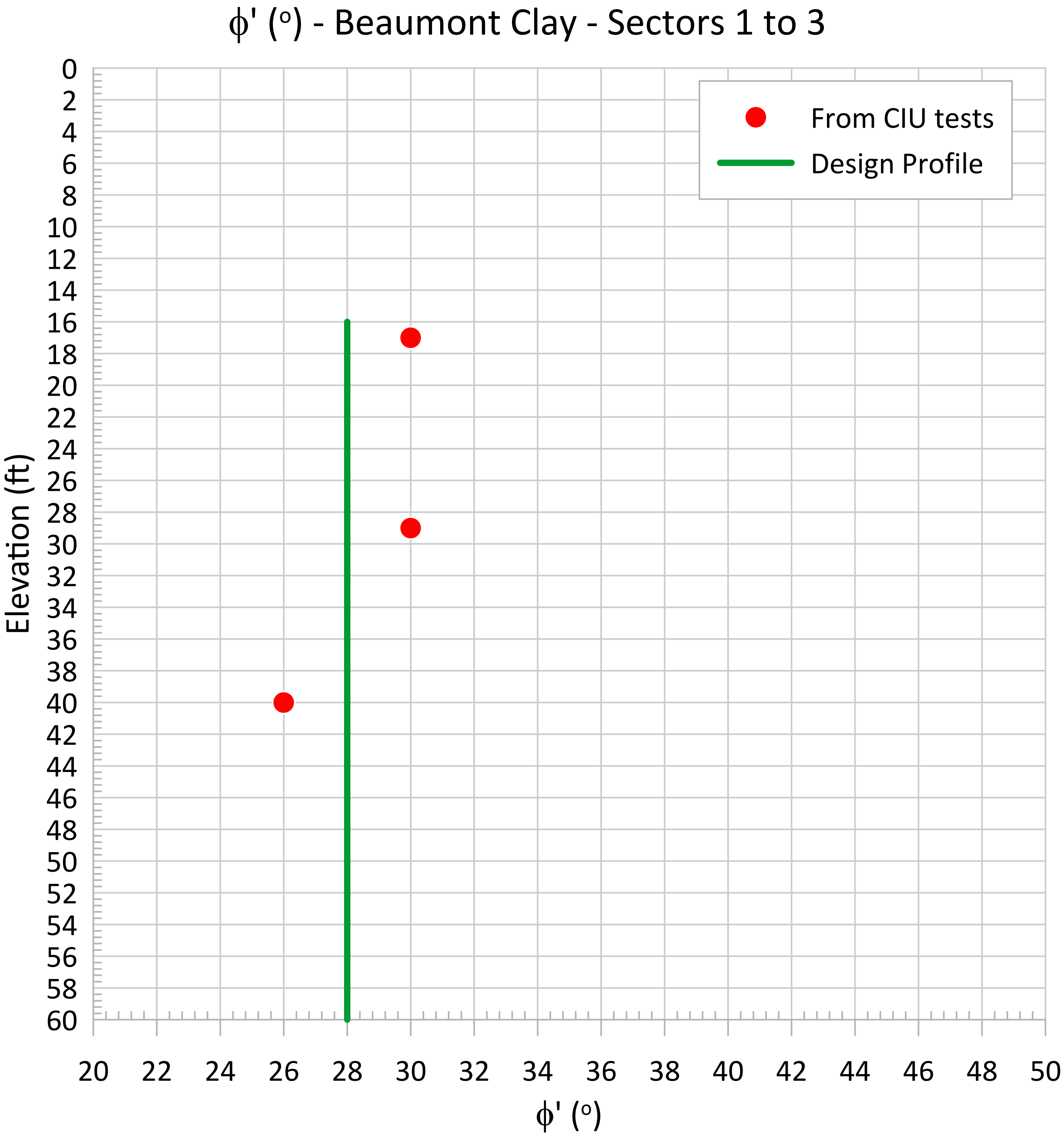
ENCLOSURE 4.A

Enclosure 4.A



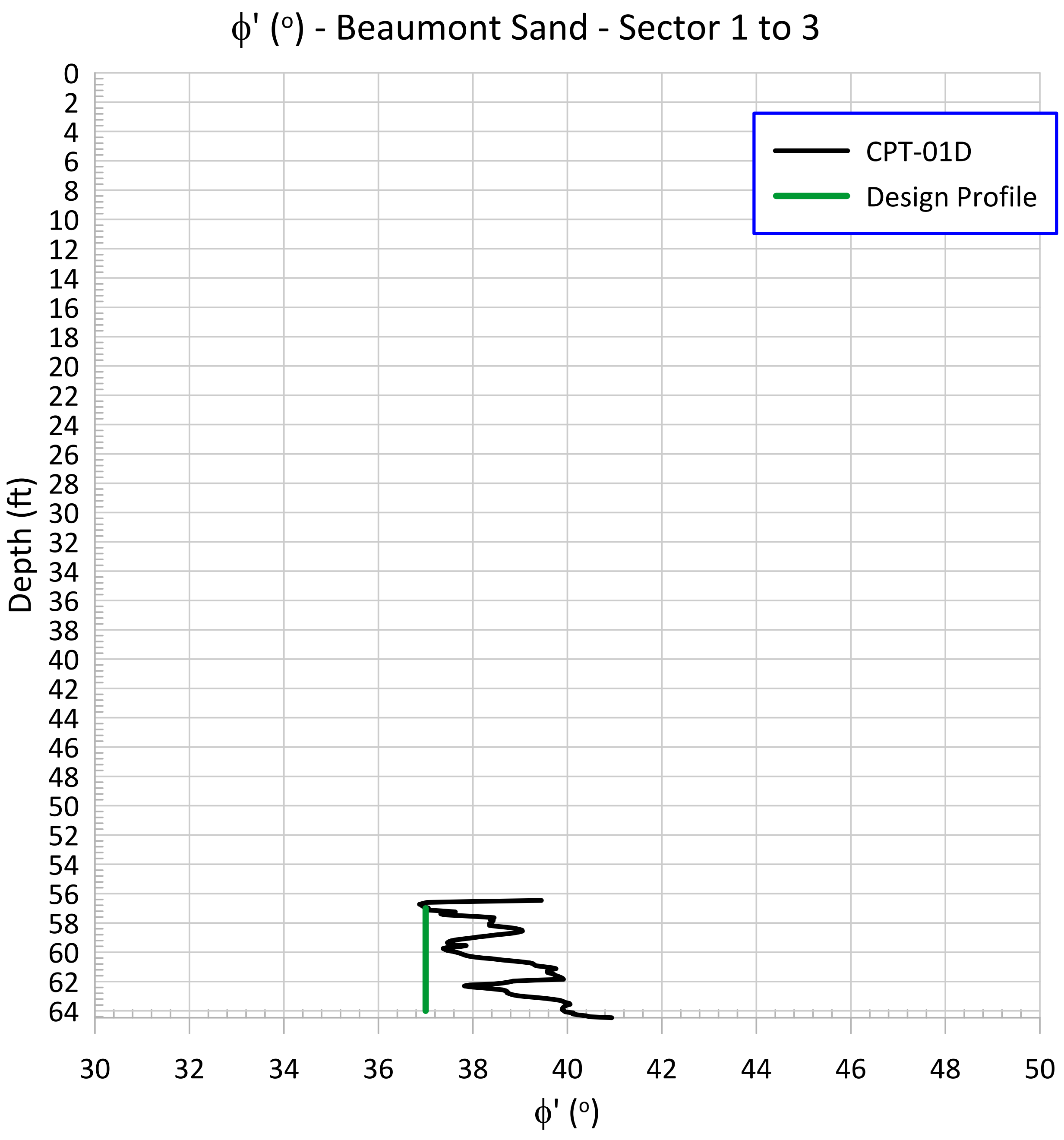
ENCLOSURE 4.B

Enclosure 4.B



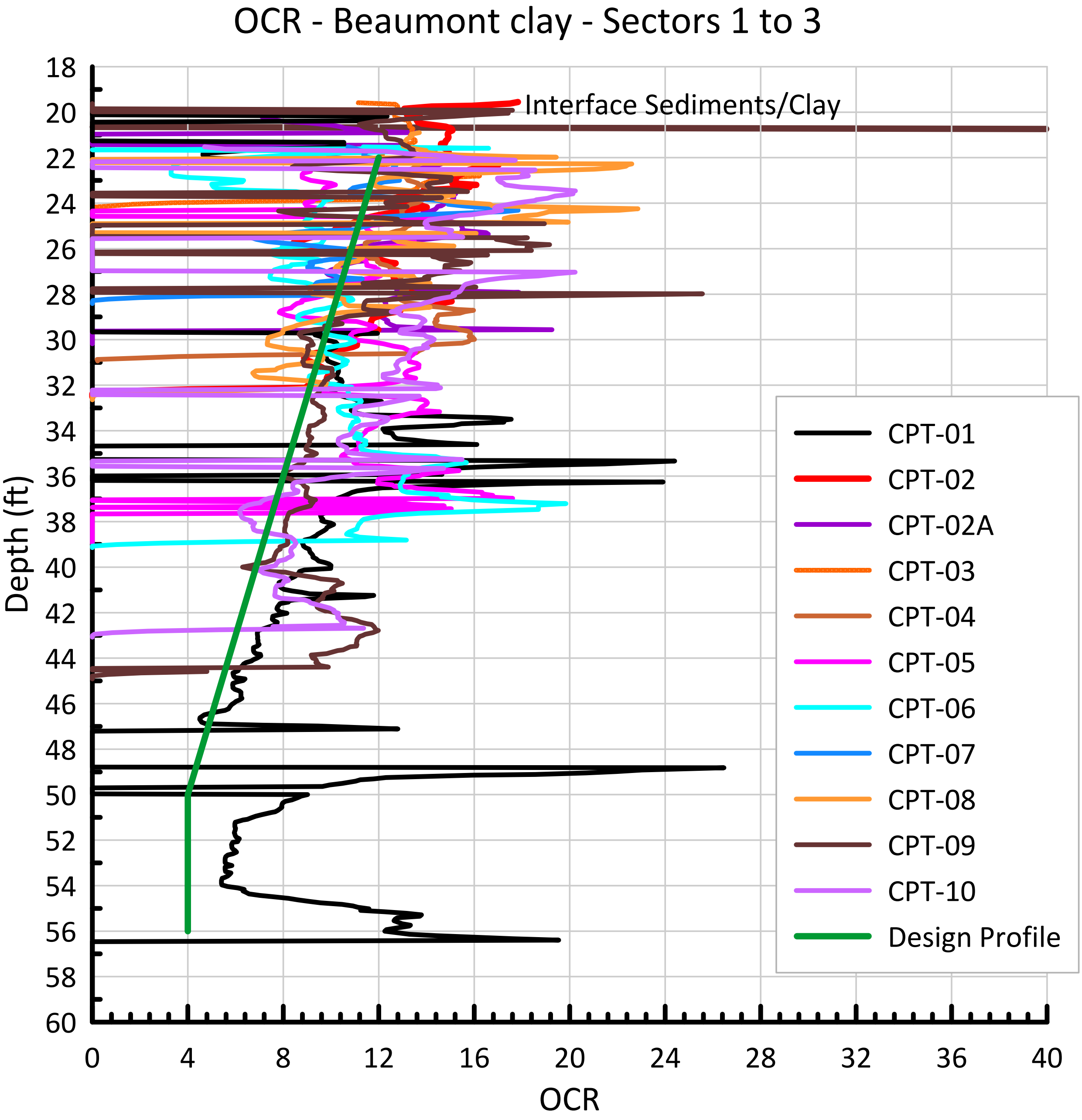
ENCLOSURE 4.C

Enclosure 4.C



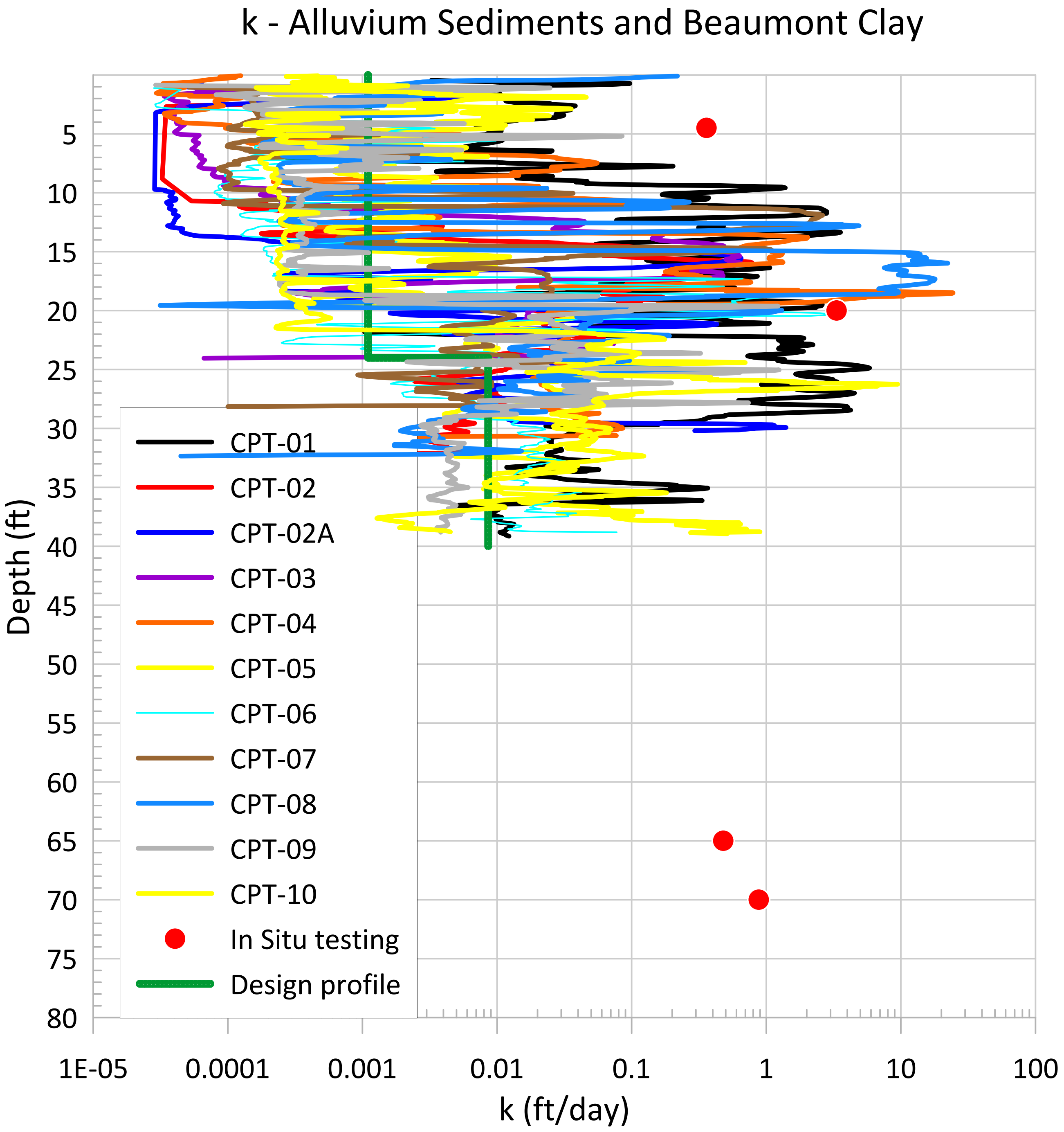
ENCLOSURE 5.A

Enclosure 5.A



ENCLOSURE 6.A

Enclosure 6.A



Attachment 2

BMP Analysis - PLAXIS Output

ATTACHMENT 2.1

Client	IP and MIMC	Job Number	11215702	Sheet	1	of	2
Project	San Jacinto River Waste Pits	Sheets by	J. Jeyakanthan	Date	5/27/2022		
Subject	Summary - PLAXIS Analysis Results	Checked by		Date			

Analysis Section	Drainage Condition	Stage	Sheet Pile		Embed in BCF (ft)	BSF Elev (ft)	Tie Rod		
			Length (ft)	Tip Elev (ft)			Dia (in)	Spacing (ft)	Elev (ft)
1	Drained	Usual	50	-41	8	-60	2.25	10	3
		Unusual							
	Undrained	Usual							
		Unusual							
2	Drained	Usual	55	-46	10	-48 to -70	3.00	6	-5
		Unusual							
	Undrained	Usual							
		Unusual							
3	Drained	Usual	49	-40	11	-48 to -66	2.25	6	0
		Unusual							
	Undrained	Usual							
		Unusual							
3A	Drained	Usual	49	-40	11	-48 to -66	2.25	10	3
		Unusual							
	Undrained	Usual							
		Unusual							
4	Drained	Usual	47	-38	6	-49	2.25	8	0
		Unusual							
	Undrained	Usual							
		Unusual							
4A	Drained	Usual	47	-38	6	-49	2.25	10	6
		Unusual							
	Undrained	Usual							
		Unusual							
5	Drained	Usual	57	-48	12	-54	2.25	6	0
		Unusual							
	Undrained	Usual							
		Unusual							
6	Drained	Usual	57	-48	12	-56	2.25	10	0
		Unusual							
	Undrained	Usual							
		Unusual							
7	Drained	Usual	61	-52	20	-62	2.25	5	0
		Unusual							
	Undrained	Usual							
		Unusual							

Notes:
Undrained = Undrained (Sediments + Beaumont Clay) + SS
Usual = Usual Load Condition, End of Excavation
Unusual = Unusual Load Condition, Water at Elev +9 ft
BCF = Beaumont Clay Formation
BSF = Beaumont Sand Formation
All Elevations in NAVD88

Client	IP and MIMC	Job Number	11215702	Sheet	2	of	2
Project	San Jacinto River Waste Pits	Sheets by	J. Jeyakanthan	Date	5/27/2022		
Subject	Summary - PLAXIS Analysis Results	Checked by		Date			

Analysis Section	Drainage Condition	Stage	Demand Loads			Deflection
			Moment	Shear	Tie Rod	
1	Drained	Usual	68000	7900	92270	0.59
		Unusual	84710	9260	114350	0.85
	Undrained	Usual	101900	9490	115600	0.66
		Unusual	114900	10890	130500	0.87
2	Drained	Usual				
		Unusual	120600	14950	138414	0.81
	Undrained	Usual	154300	18000	178360	0.88
		Unusual	172200	18840	172100	1.09
3	Drained	Usual	57960	10090	80330	0.46
		Unusual	73390	11270	93580	0.70
	Undrained	Usual	96130	12510	100200	0.60
		Unusual	111200	13140	105155	0.75
3A	Drained	Usual	67010	8715	94410	0.47
		Unusual	81980	9680	115550	0.69
	Undrained	Usual	98130	9980	118160	0.55
		Unusual	112300	11530	131300	0.71
4	Drained	Usual	56920	9372	96970	0.27
		Unusual	64330	9845	109450	0.29
	Undrained	Usual	78940	11820	122980	0.35
		Unusual	87600	11130	118730	0.18
4A	Drained	Usual	64900	6930	61800	0.38
		Unusual	75080	7200	76690	0.54
	Undrained	Usual	86480	7550	79070	0.22
		Unusual	93010	8550	90180	0.29
5	Drained	Usual	65980	9100	78980	0.46
		Unusual	79770	10330	87080	0.67
	Undrained	Usual	93730	10440	95110	0.40
		Unusual	102600	11190	98680	0.58
6	Drained	Usual	29000	5240	75460	0.27
		Unusual	38720	6200	92570	0.42
	Undrained	Usual	41500	6770	96700	0.31
		Unusual	50400	7430	108720	0.44
7	Drained	Usual	55000	7012	51500	0.45
		Unusual	88130	8870	65370	0.73
	Undrained	Usual	51330	7960	58660	0.42
		Unusual	71640	8740	65560	0.64

Units:
Moment = lb.ft per Lineal Feet
Shear = lb per Lineal Feet
Tie-Rod = lb
Deflection = ft

ATTACHMENT 2.2

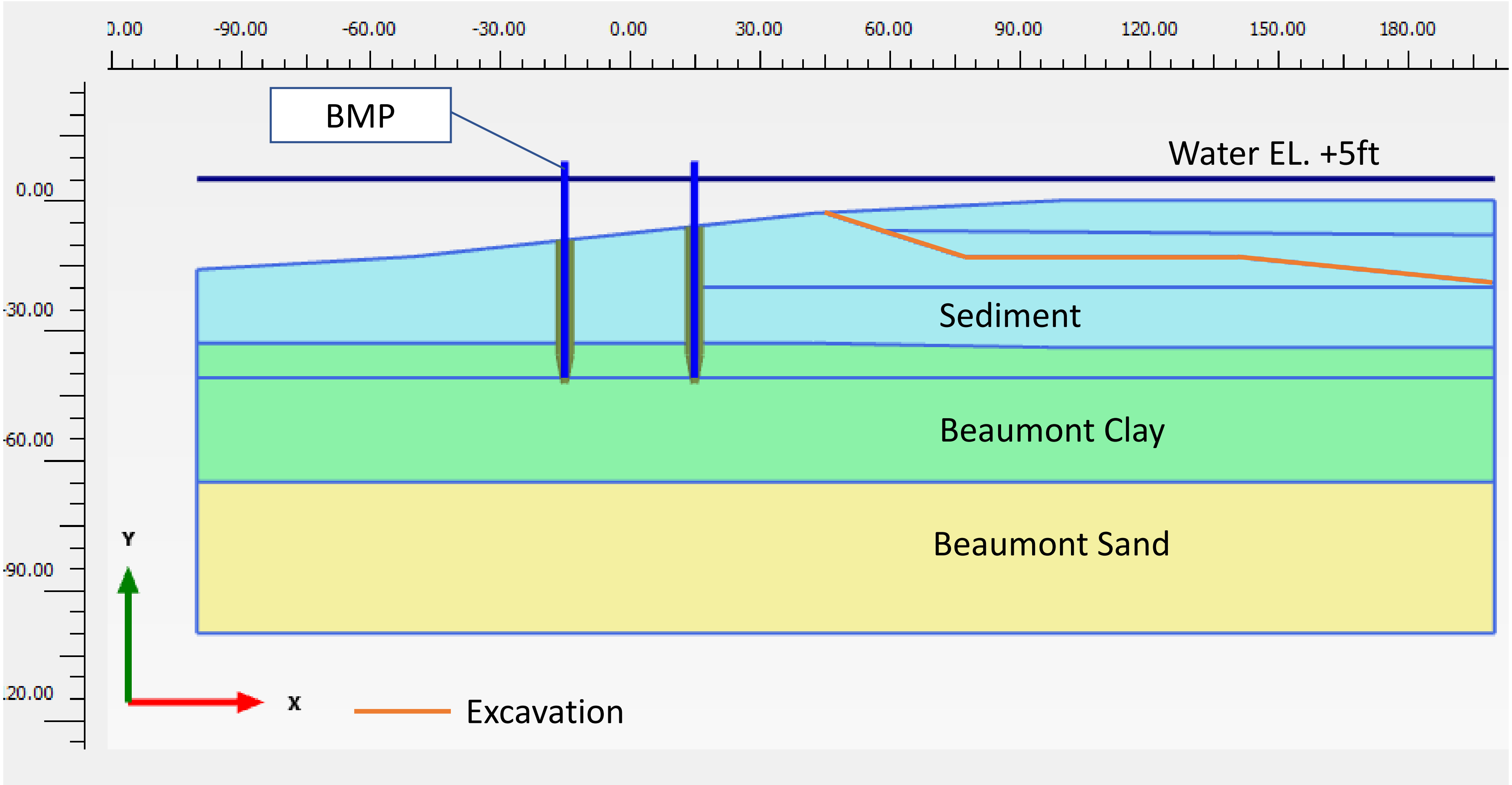
Client	IPC and MIMC	Job Number	11215702	Sheet	
Project	San Jacinto River Waste Pits Site	Sheets by	J. Jeyakanthan	Date	5/27/2022
Subject	Soil Parameters - PLAXIS Analysis	Checked by		Date	

Parameters		**Units**	**Sediment Hardening Soil**
Unsaturated unit weight	γ_unsat	lbf/ft^3	95
Saturated unit weight	γ_sat	lbf/ft^3	120
Secant stiffness in standard drained triaxial test	E_50^ref	lbf/ft^2	105000
Tangent stiffness for primary oedometer loading	E_oed^ref	lbf/ft^2	105000
Unloading / reloading stiffness	E_ur^ref	lbf/ft^2	315000
Power for stress-level dependency of stiffness	power (m)		0.5
Effective cohesion	c_ref	lbf/ft^2	42
Effective friction angle	φ (phi)	°	26
Saturated permeability - horizontal	k_x	ft/day	0.00113
Saturated permeability - vertical	k_y	ft/day	0.00113

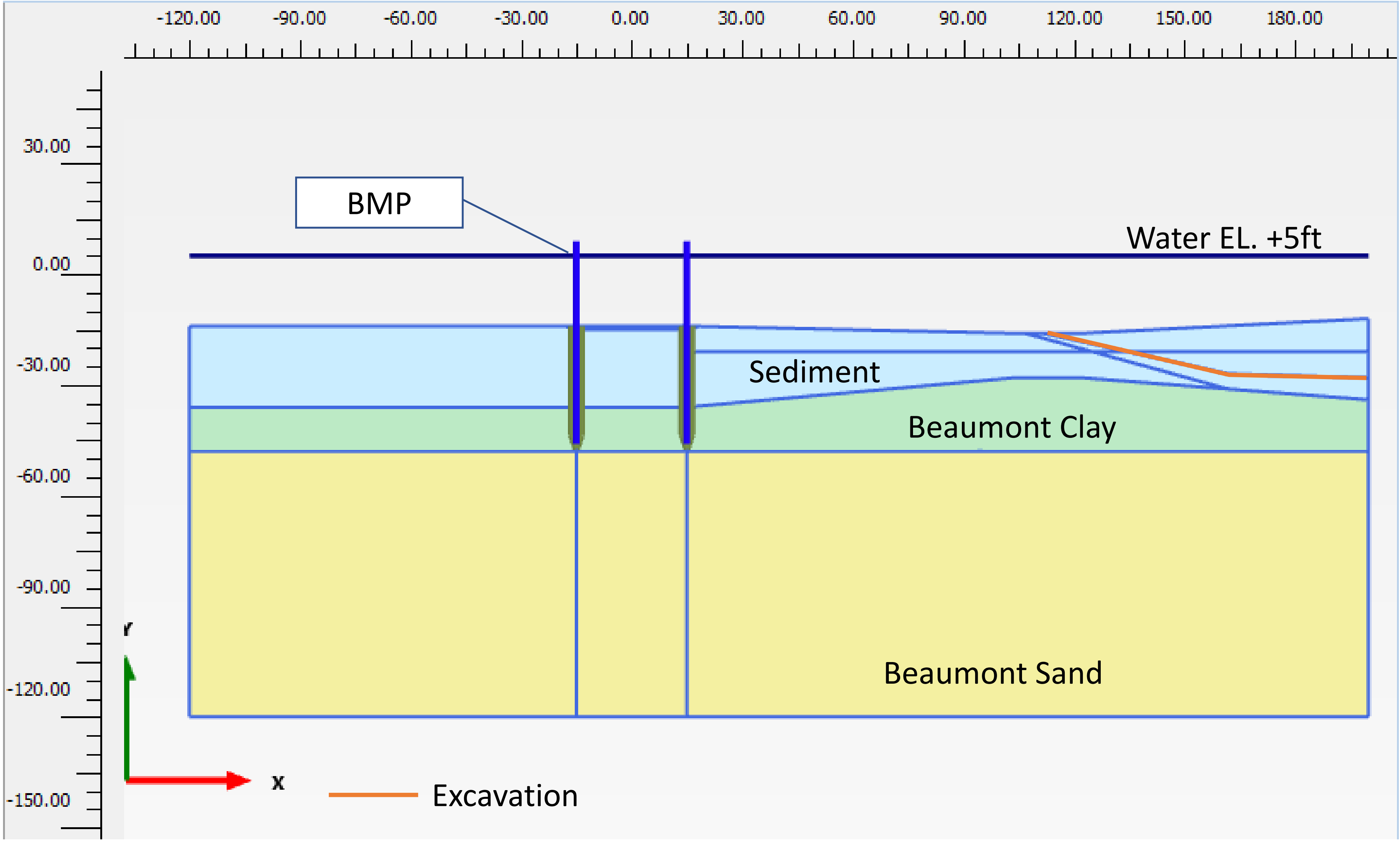
Parameters		**Units**	**Mohr-Coulomb**			
			BCF	**BSF**	**Fill**	**Rock fill**
Unsaturated unit weight	γ_unsat	lbf/ft^3	100	105	105	108
Saturated unit weight	γ_sat	lbf/ft^3	125	130	130	130
Effective Young's modulus	E	lbf/ft^2	8.60E+05	2.00E+06	300000	1044000
Effective Poisson's ratio	ν (nu)		0.3	0.3	0.3	0.3
Effective cohesion	c_ref	lbf/ft^2	150	0	0	0
Effective friction angle	ϕ (phi)	°	28	37	32	38
Saturated permeability - horizontal	k_x	ft/day	8.50E-03	0.88	3	3
Saturated permeability - vertical	k_y	ft/day	8.50E-03	0.88	3	3

BCF = Beaumont Clay Formation
BSF = Beaumont Sand Formation

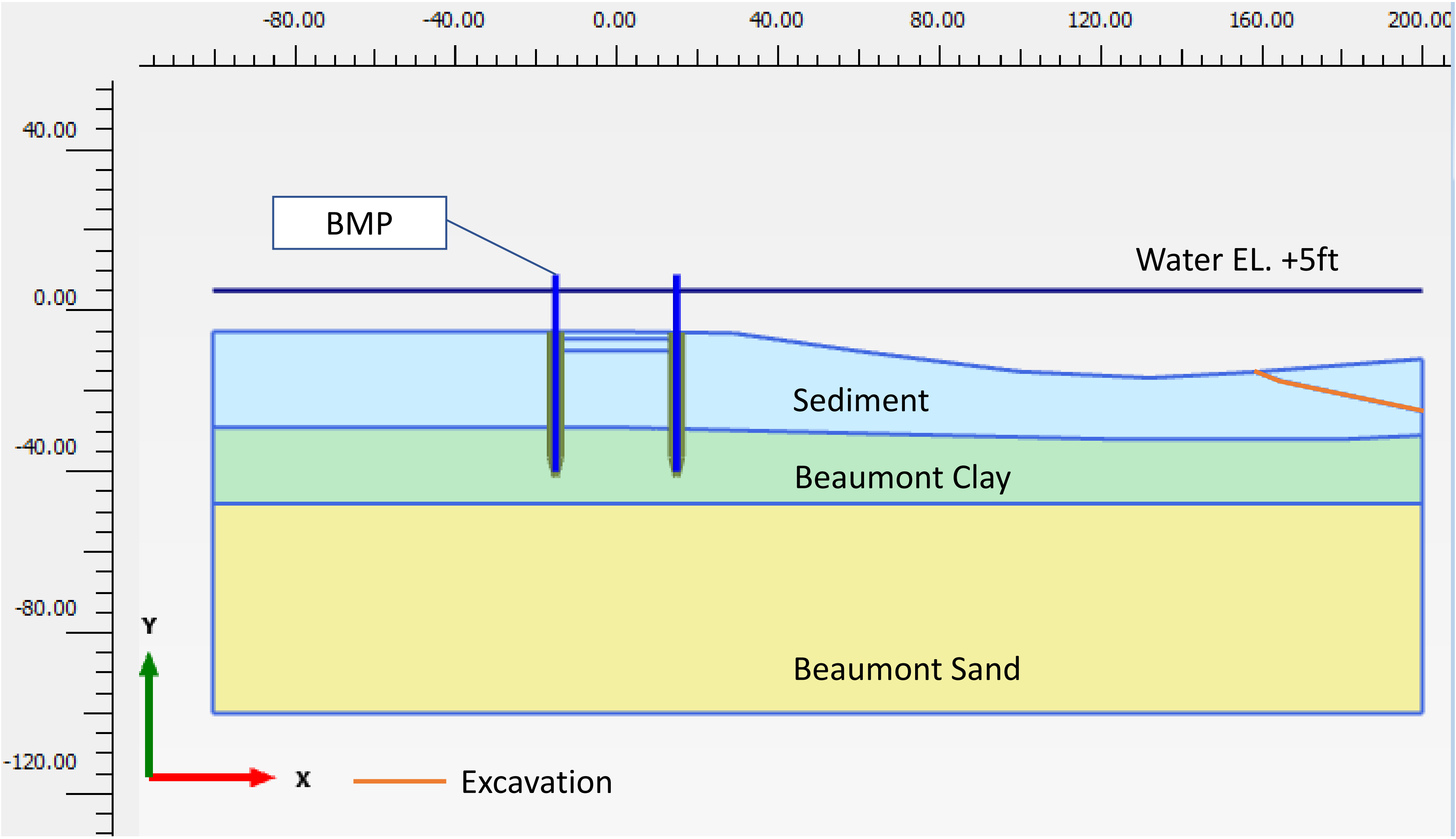
Section C1 Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



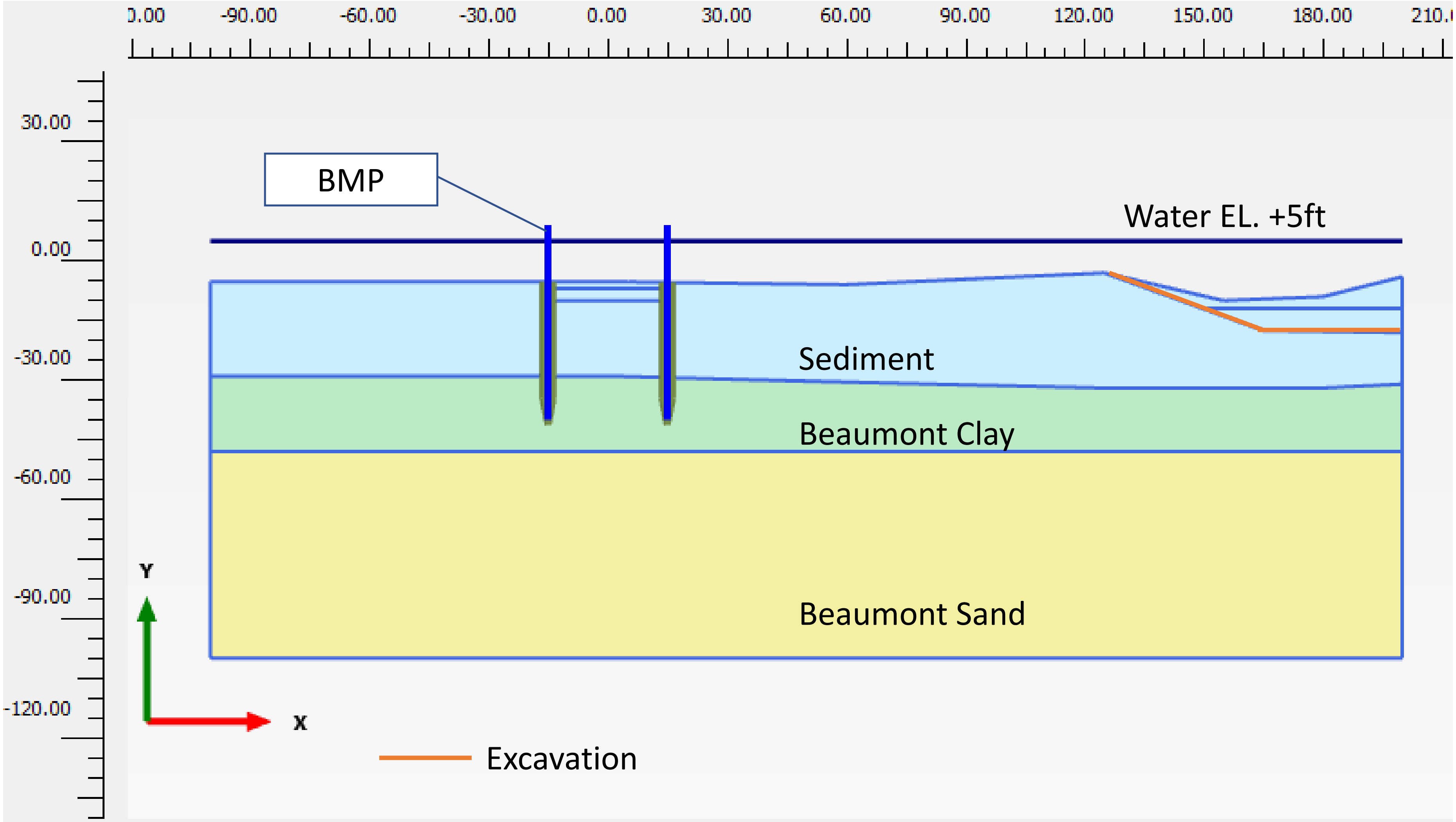
Section C2 Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



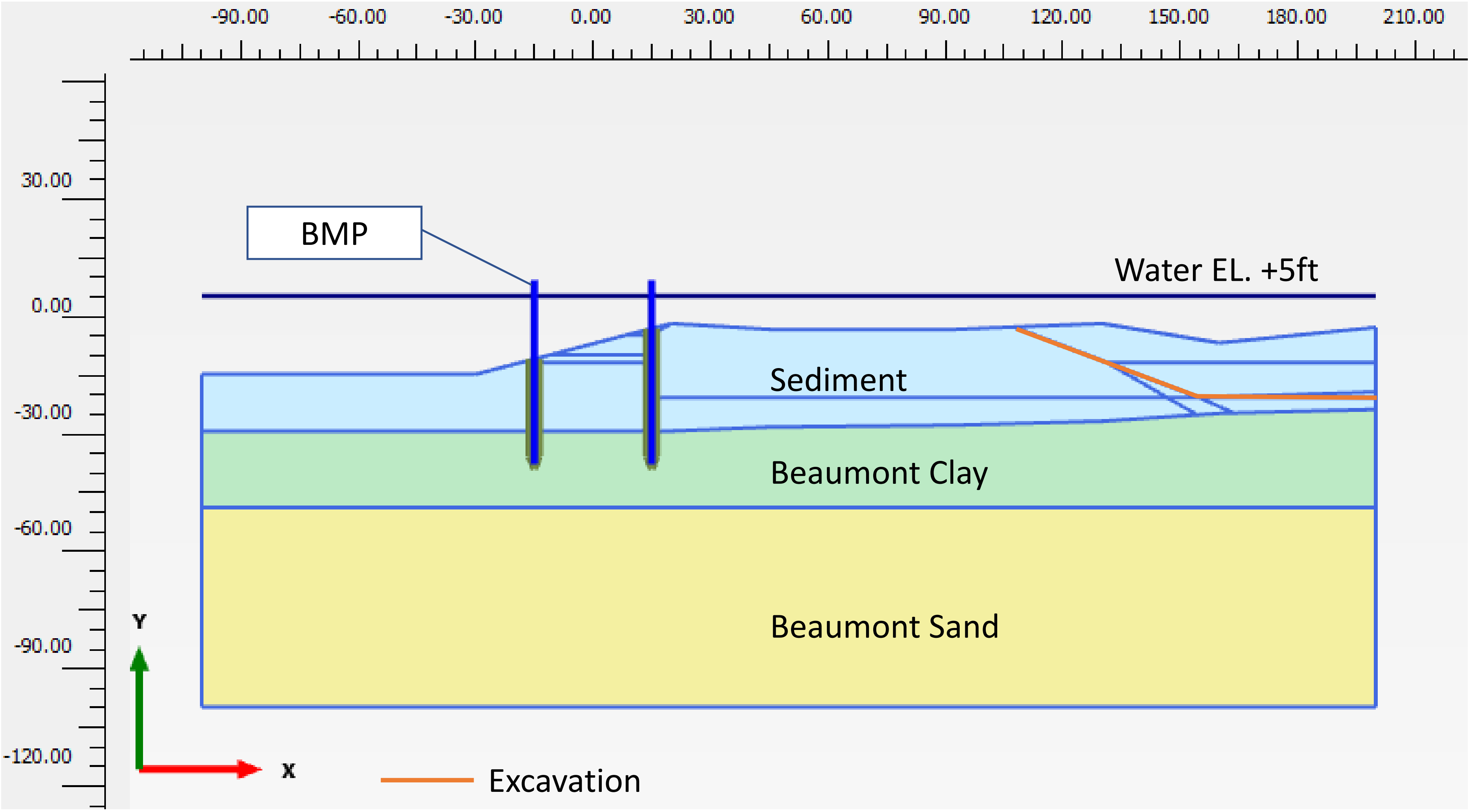
Section C3 Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



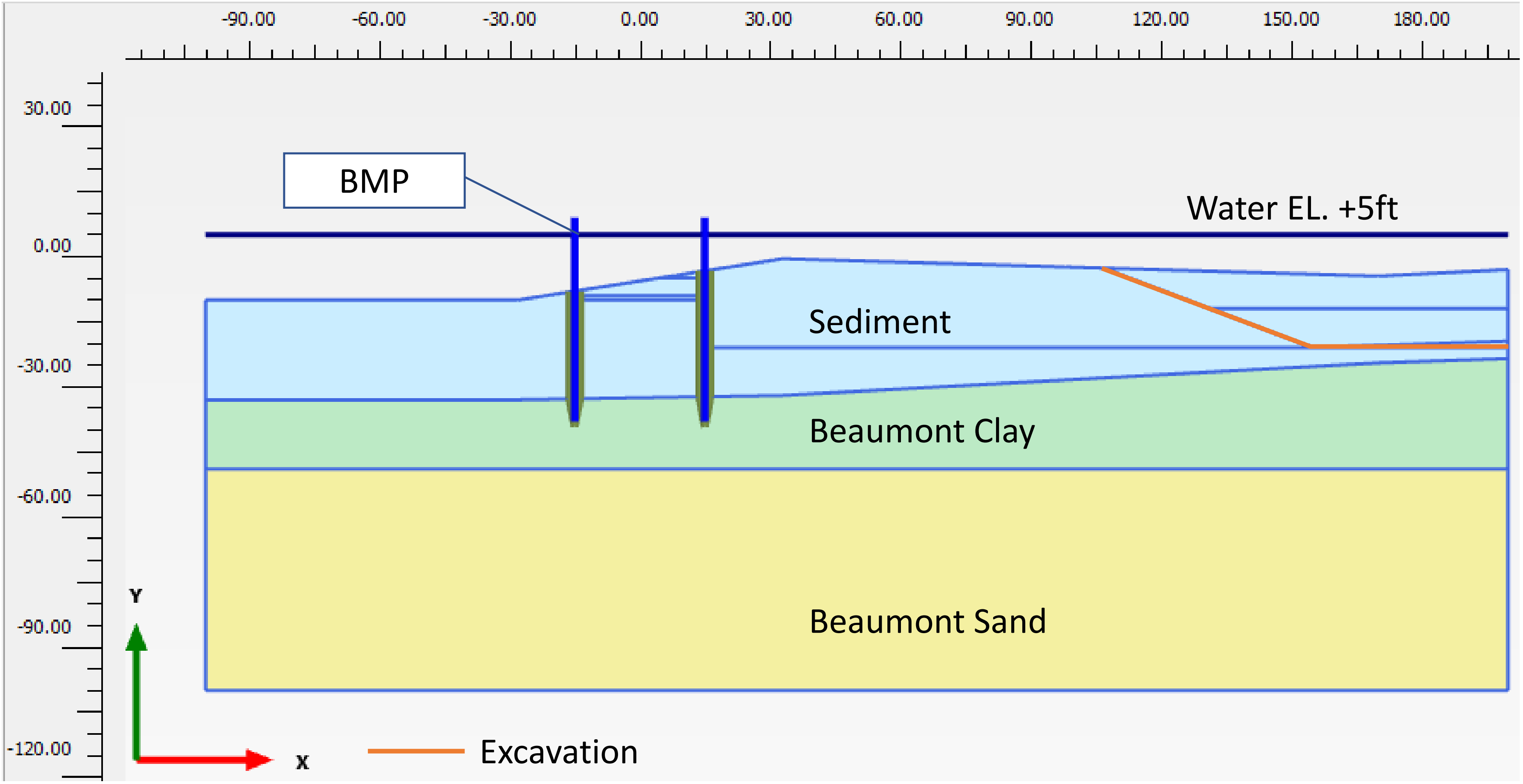
Section C3A Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



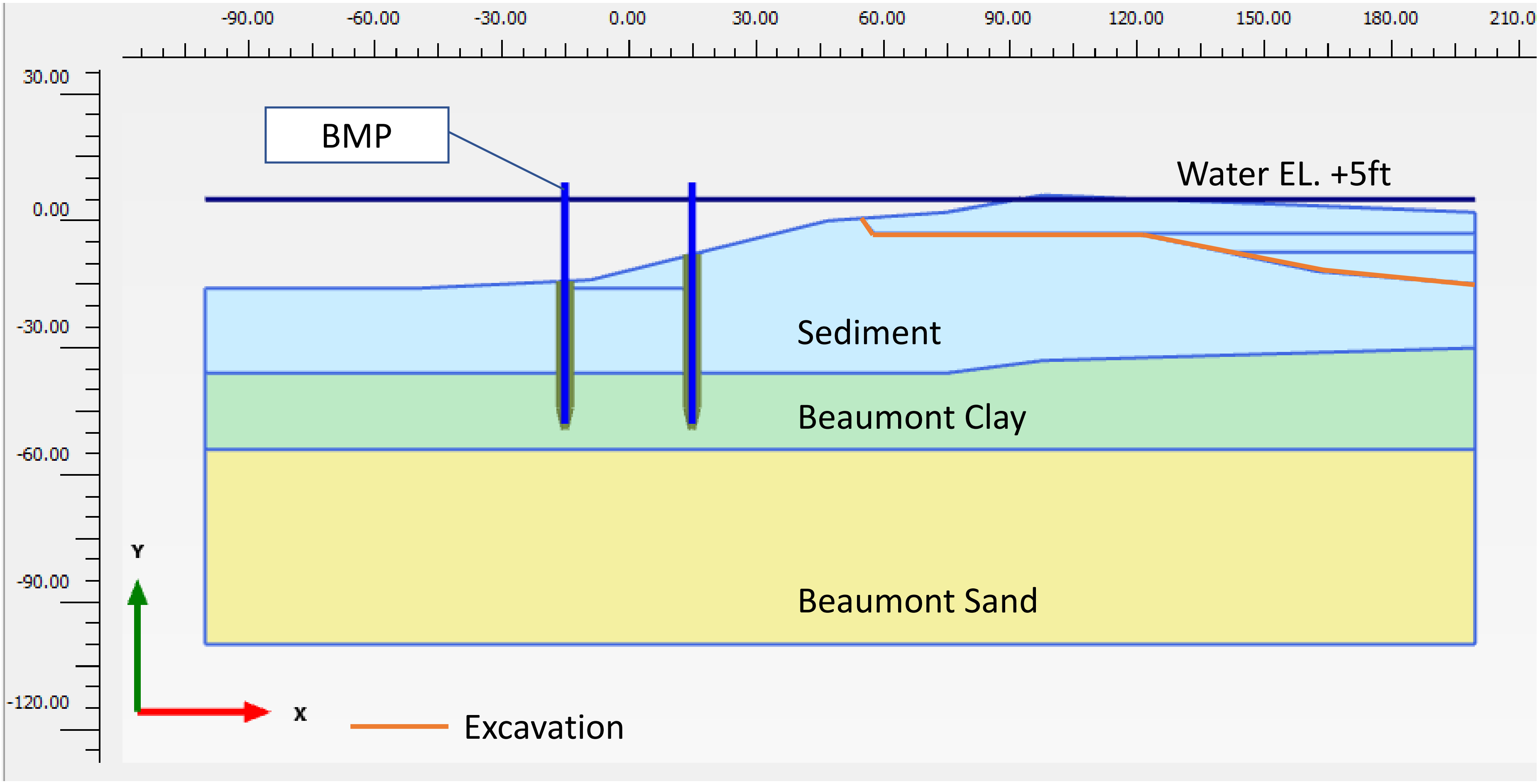
Section C4 Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



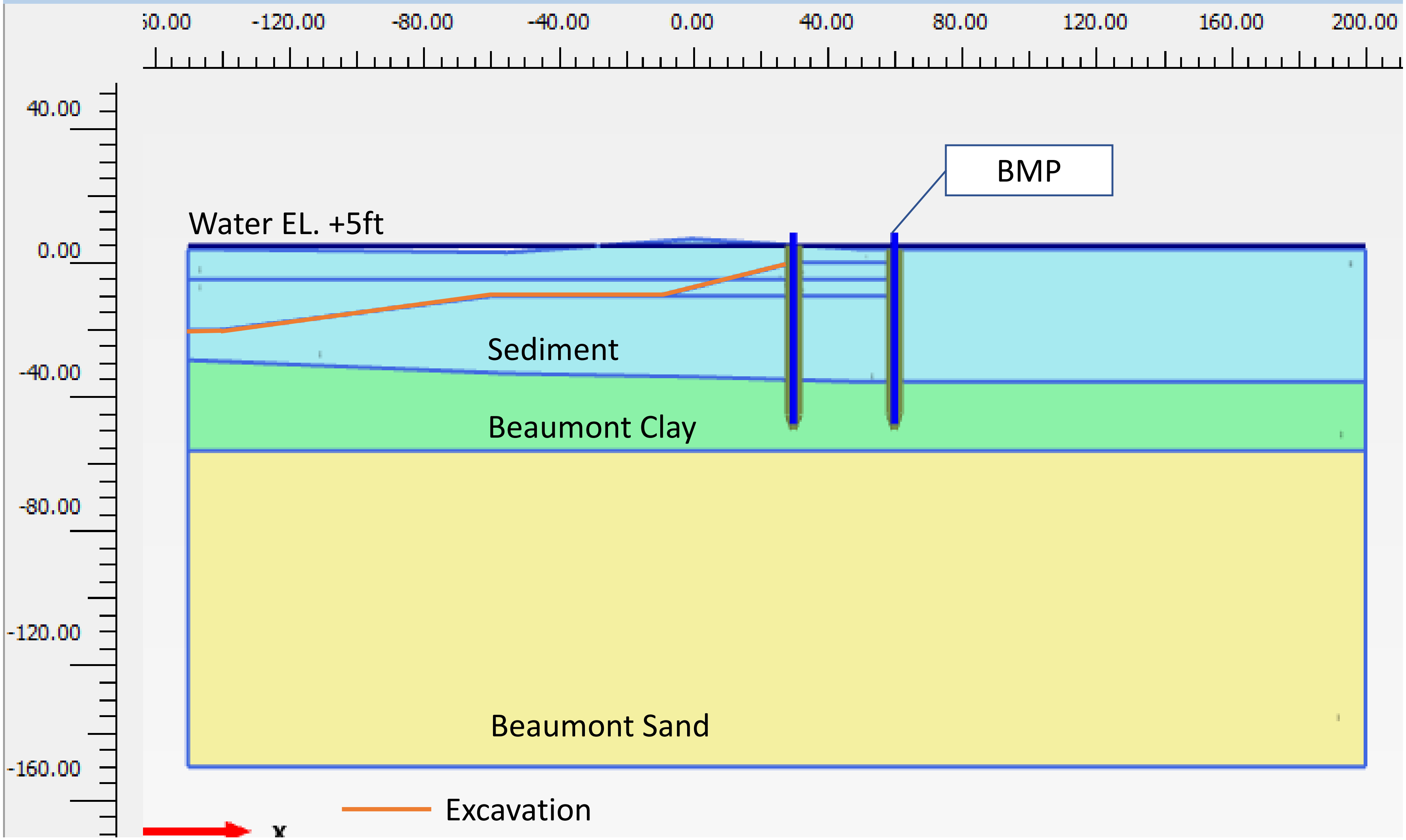
Section C4a Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



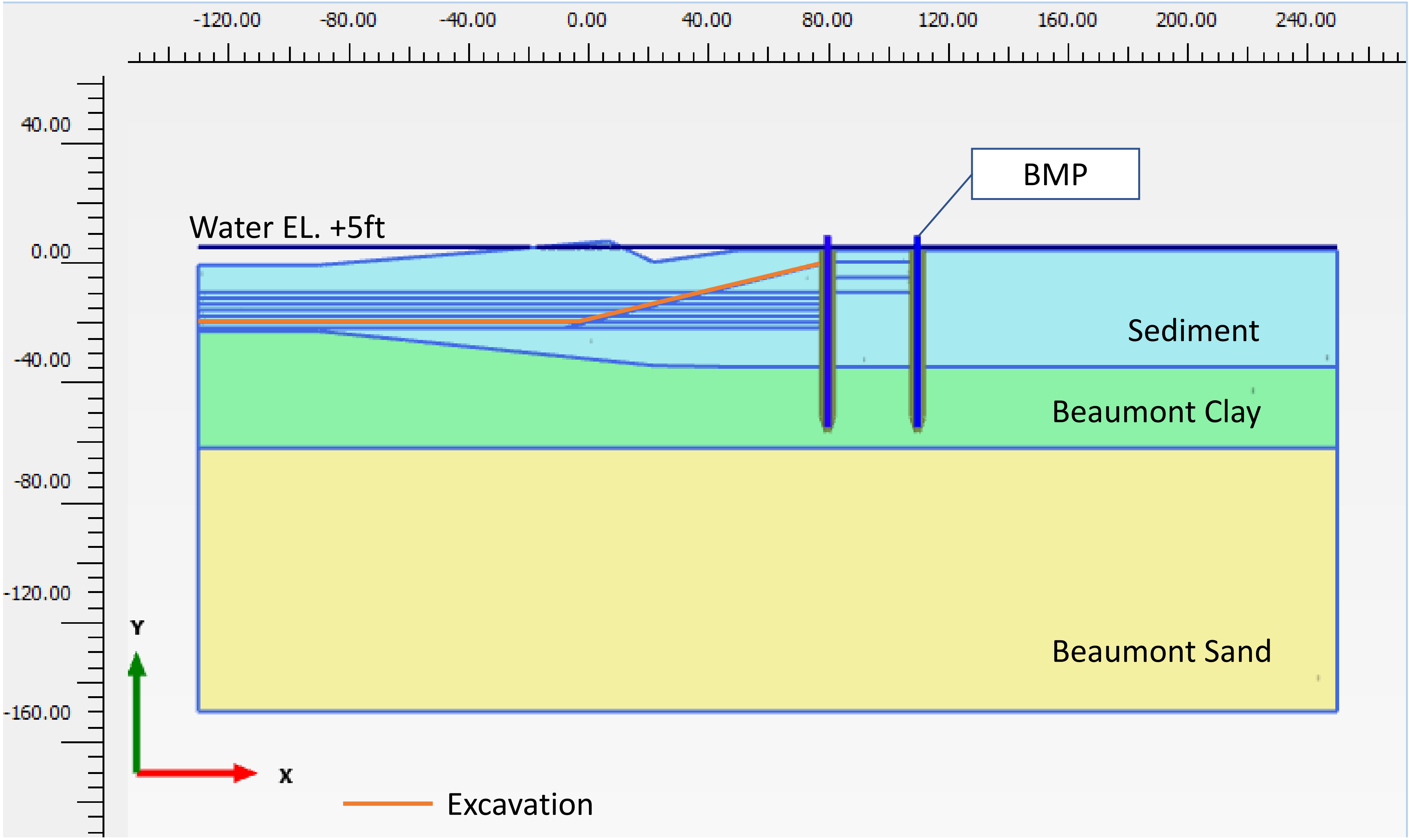
Section C5 Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



Section C6 Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)

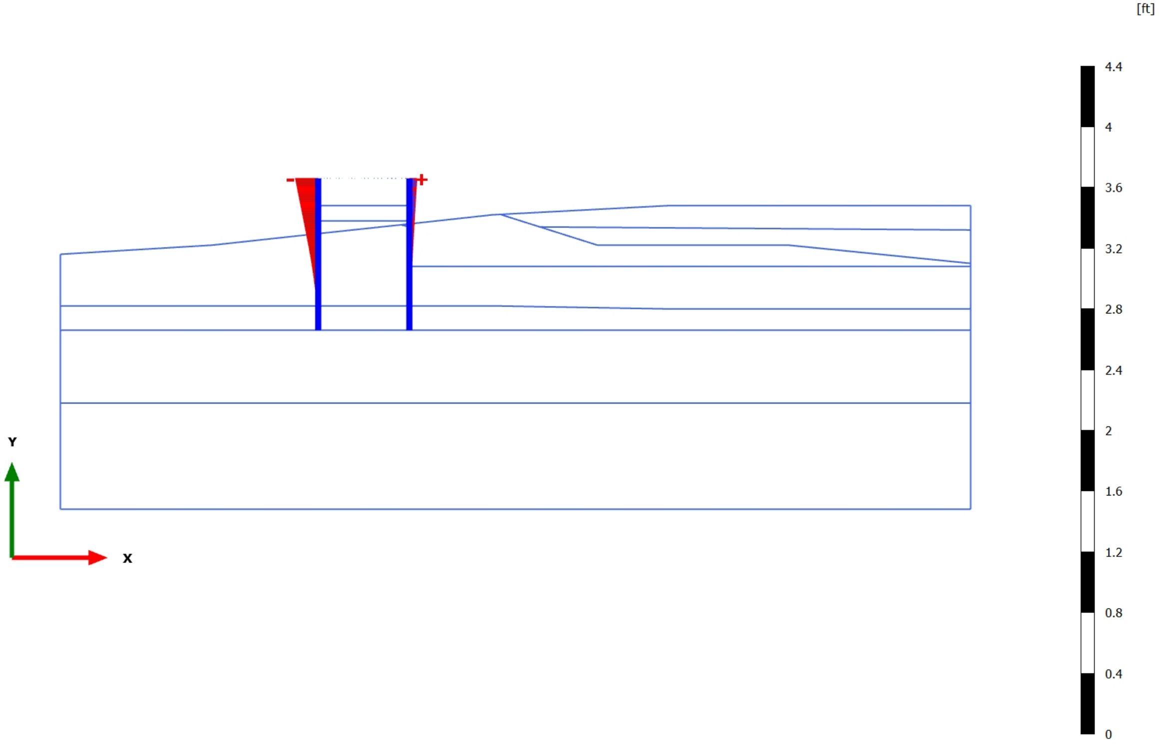


Section C7 Soil Profile with BMP @ Analysis Stage 0 (Sheet Pile Installation)



PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/37), Total displacements u_x

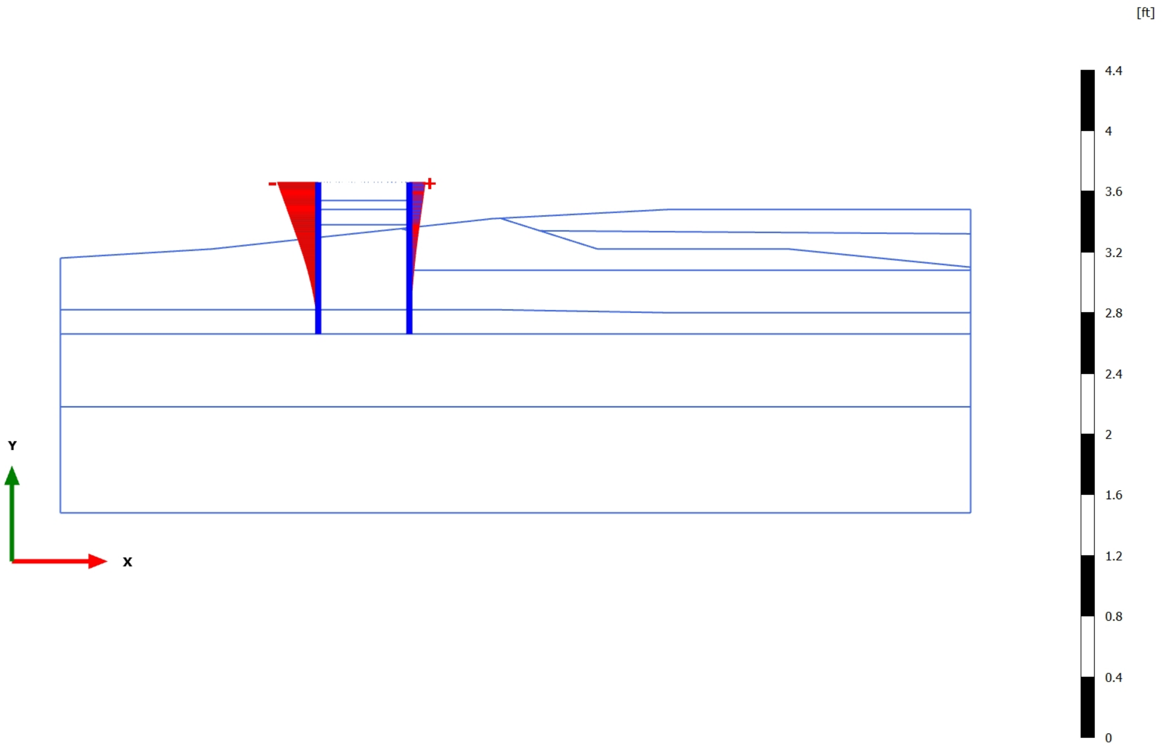


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.05007 ft (Element 2 at Node 1385)

Minimum value = -0.1504 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/62), Total displacements u_x

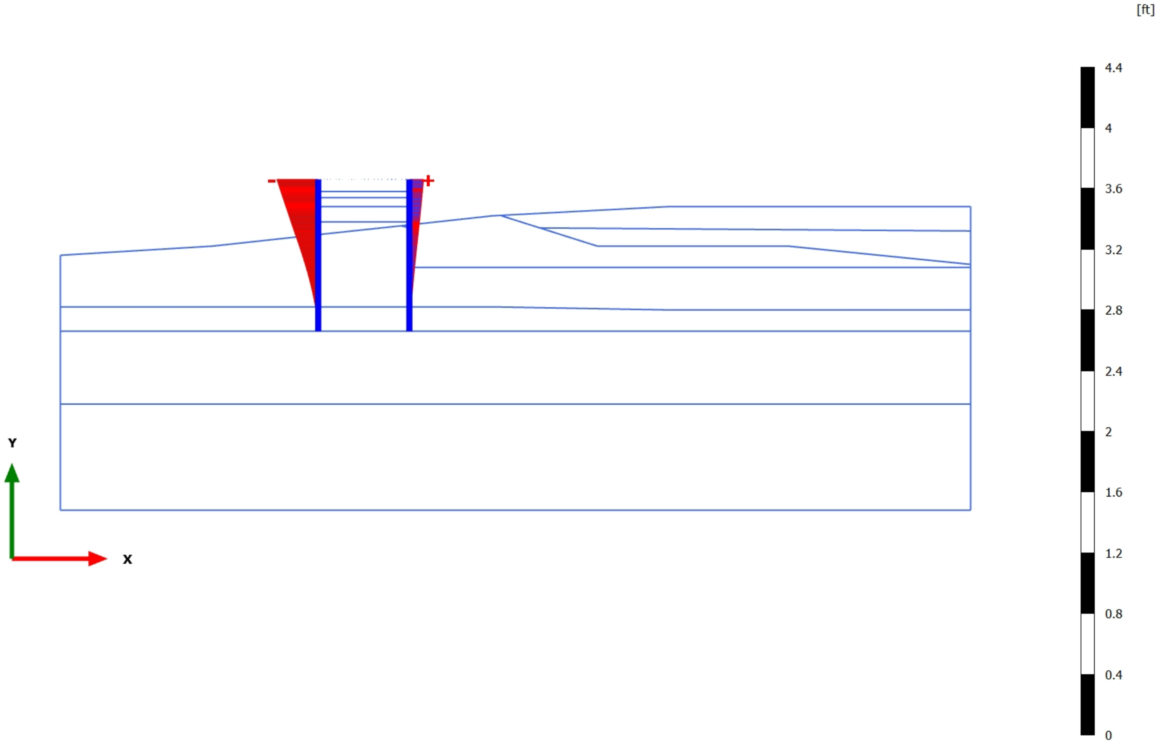


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1052 ft (Element 2 at Node 1385)

Minimum value = -0.2690 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Backfill 3 [Phase_5] (5/90), Total displacements u_x

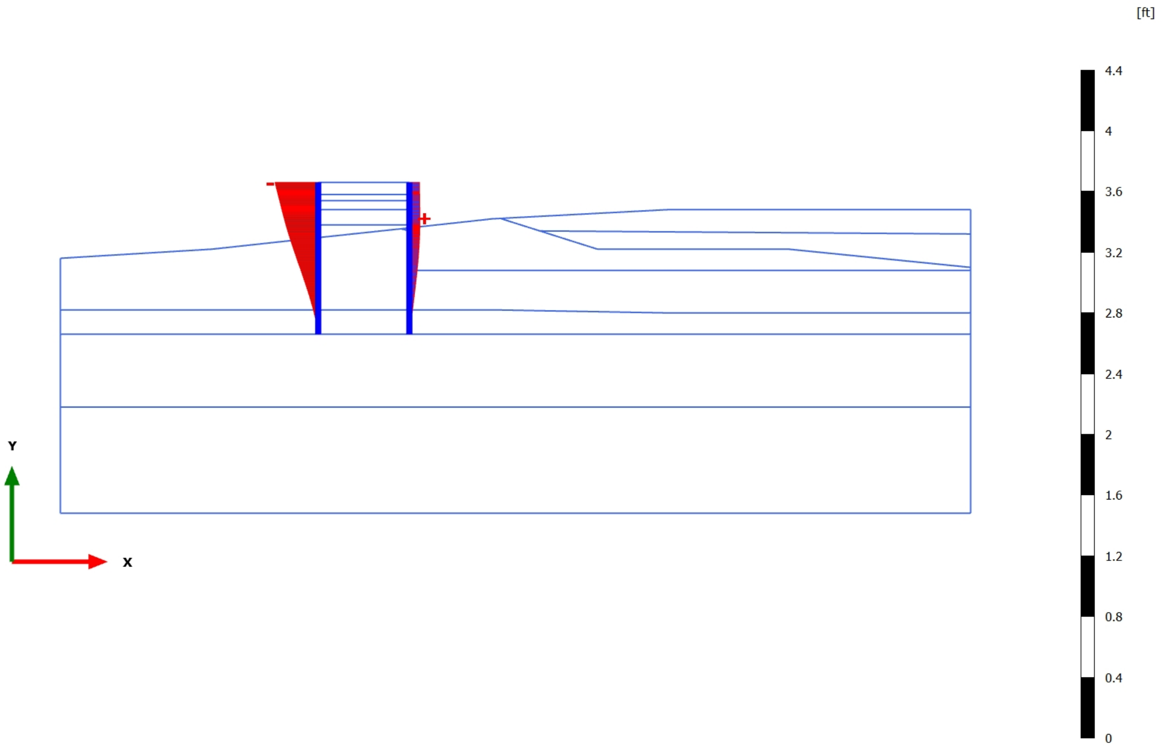


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.09479 ft (Element 2 at Node 1385)

Minimum value = -0.2733 ft (Element 1 at Node 4)

3.1.1.1.1.4 Calculation results, Plate, Backfill 4 [Phase_6] (6/105), Total displacements u_x

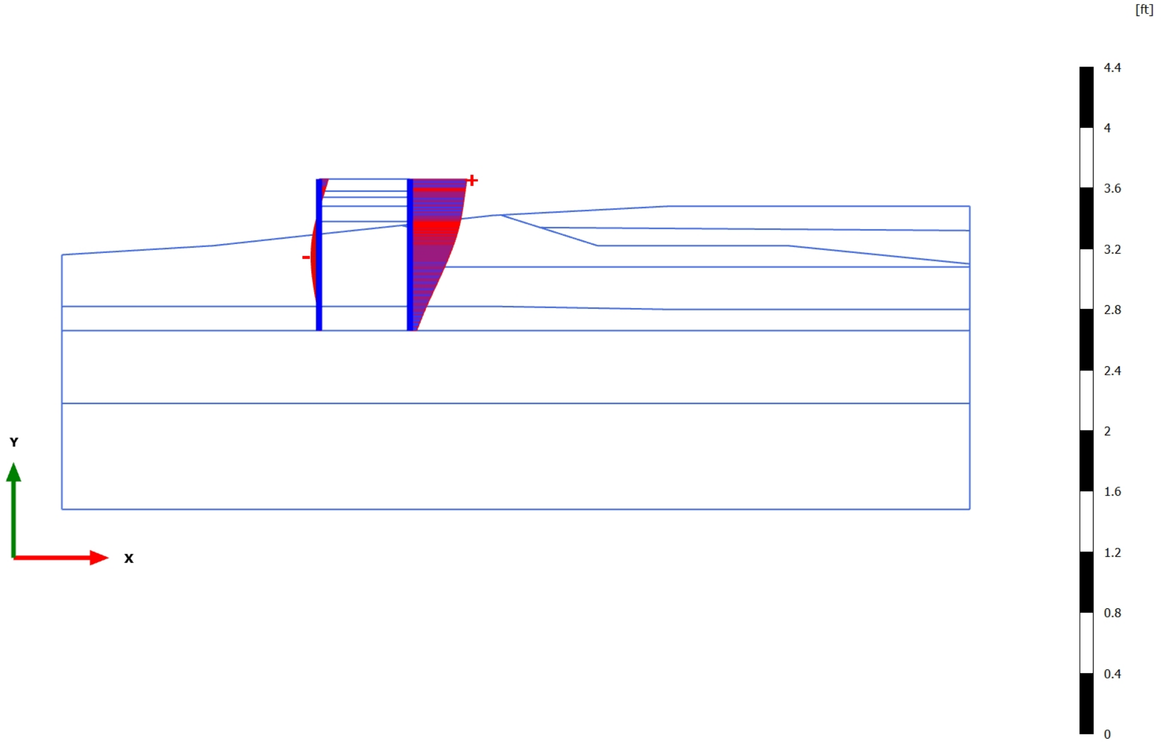


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.06989 ft (Element 16 at Node 1414)

Minimum value = -0.2854 ft (Element 1 at Node 4)

3.1.1.1.1.5 Calculation results, Plate, Dewater-SS [Phase_7] (7/145), Total displacements u_x

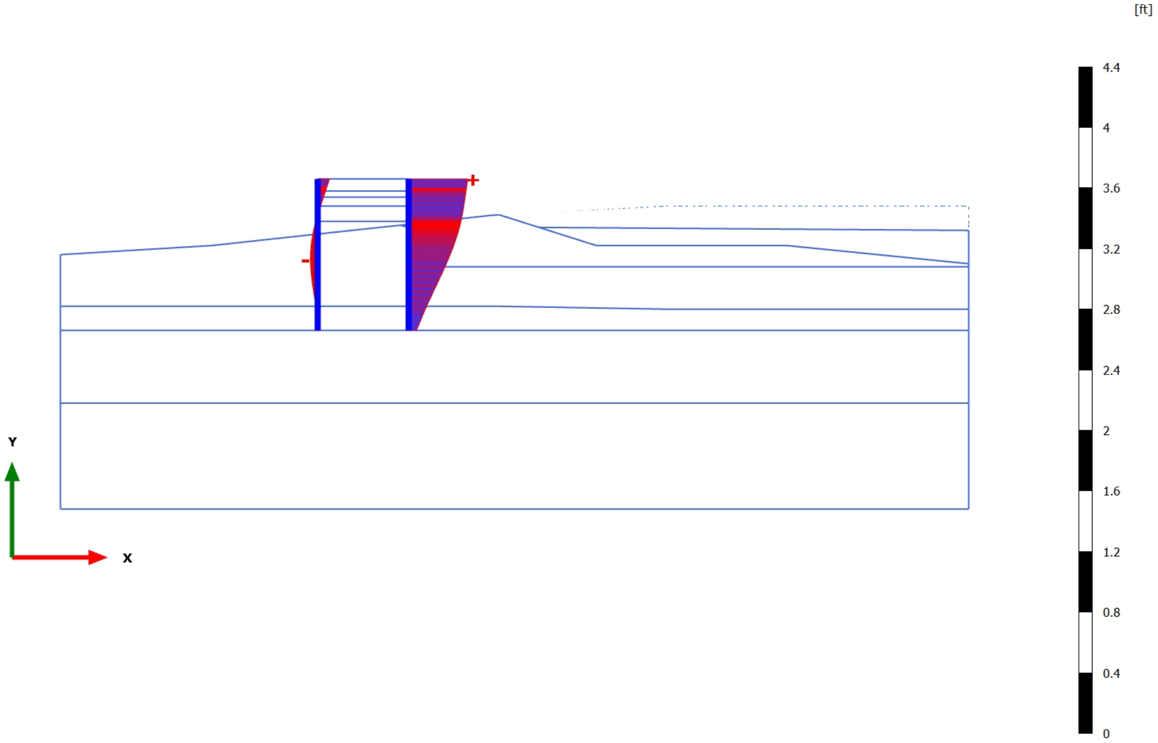


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3772 ft (Element 2 at Node 1385)

Minimum value = -0.05396 ft (Element 33 at Node 3919)

3.1.1.1.1.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/158), Total displacements u_x

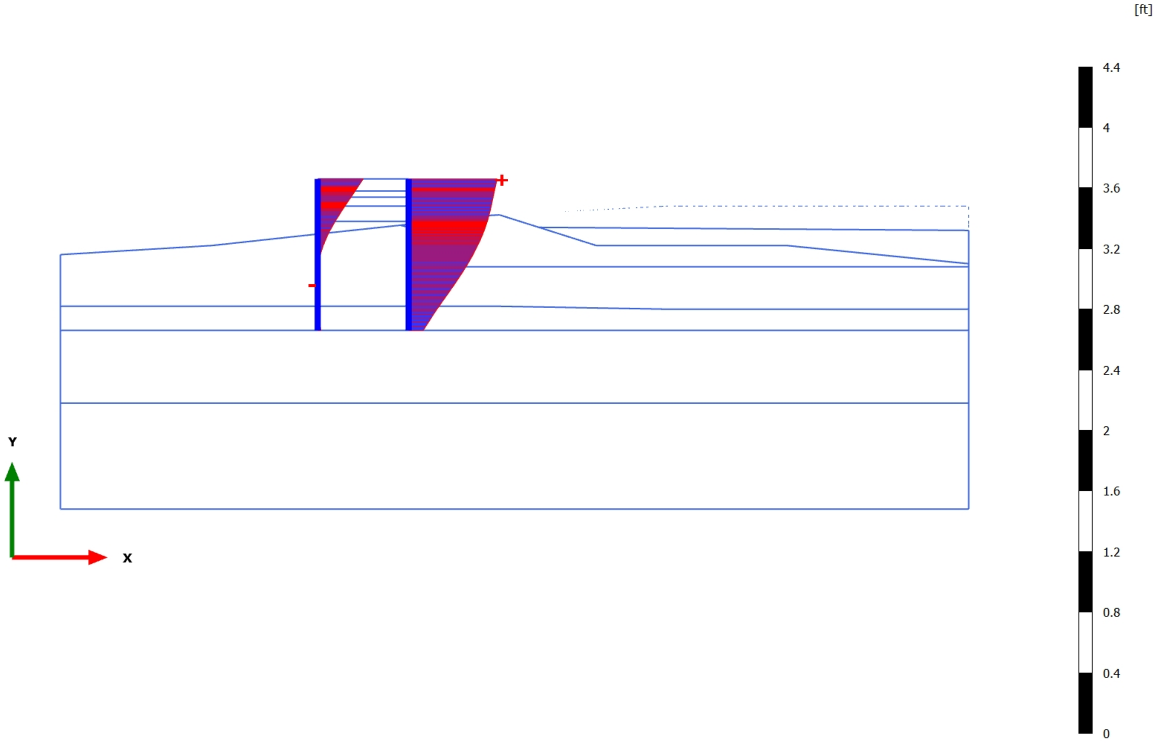


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3917 ft (Element 2 at Node 1385)

Minimum value = -0.04831 ft (Element 33 at Node 4245)

3.1.1.1.1.7 Calculation results, Plate, Dewater-SS [Phase_9] (9/178), Total displacements u_x

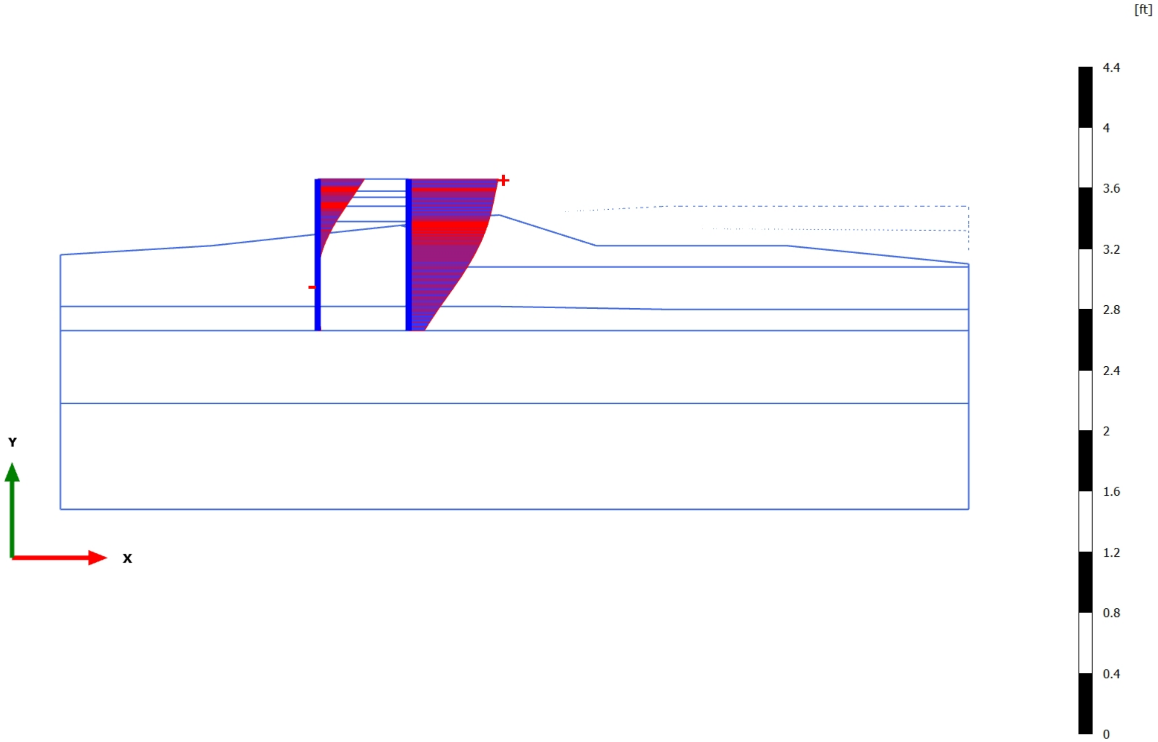


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5848 ft (Element 2 at Node 1385)

Minimum value = -6.012×10^{-3} ft (Element 37 at Node 6626)

3.1.1.1.1.8 Calculation results, Plate, Excavate 2 [Phase_10] (10/186), Total displacements u_x

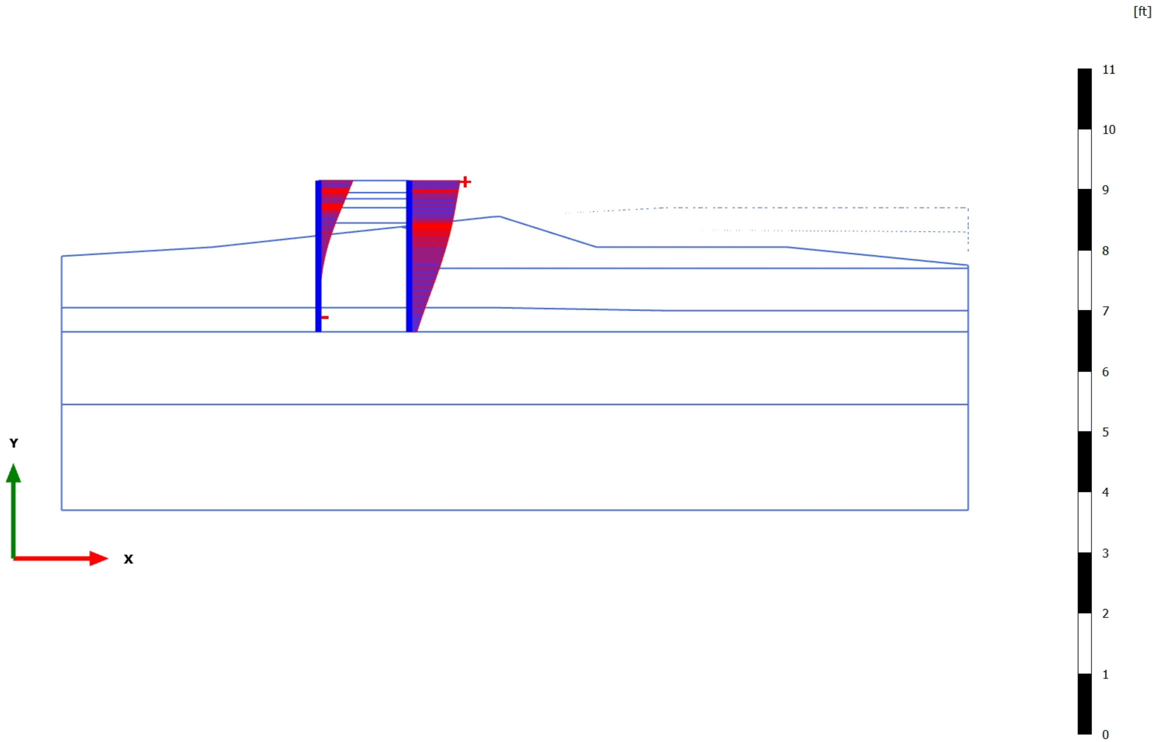


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5928 ft (Element 2 at Node 1385)

Minimum value = $-3.528 \cdot 10^{-3}$ ft (Element 37 at Node 7273)

3.1.1.1.1.9 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/216), Total displacements u_x

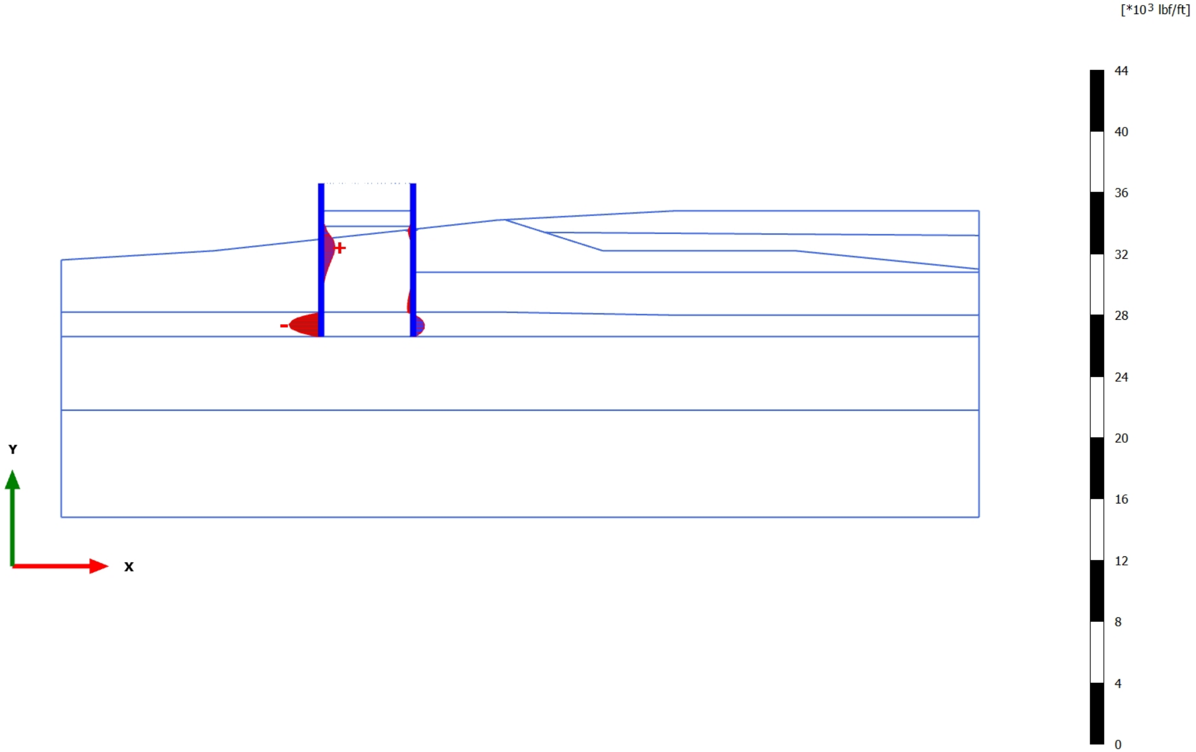


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.8432 ft (Element 2 at Node 1385)

Minimum value = 0.01973 ft (Element 46 at Node 9879)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/37), Shear forces Q

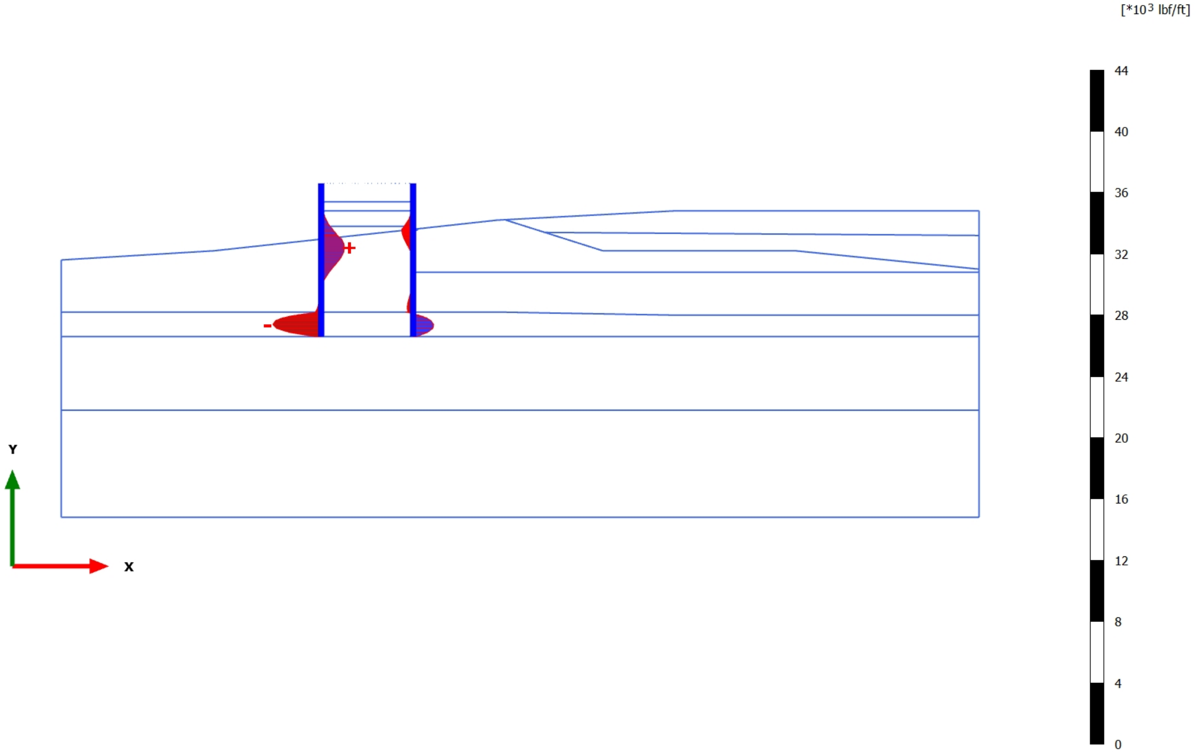


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 886.1 lbf/ft (Element 31 at Node 2720)

Minimum value = -2120 lbf/ft (Element 47 at Node 9880)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/62), Shear forces Q

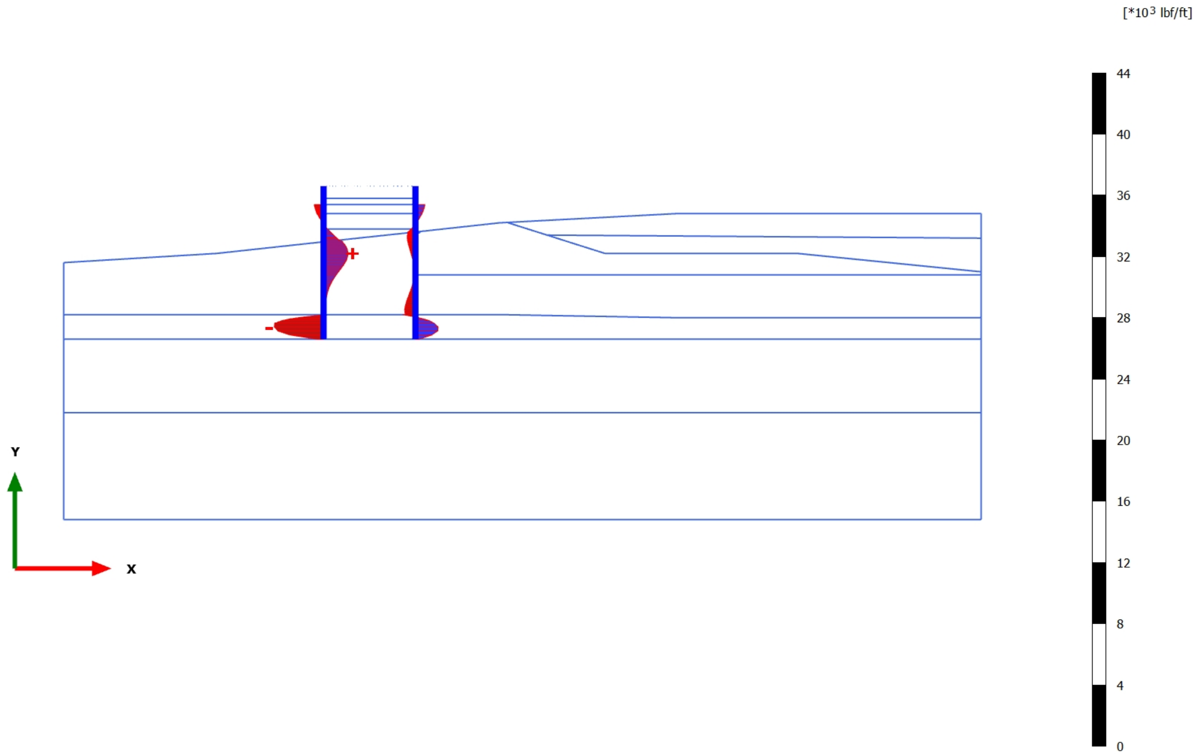


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 1512 lbf/ft (Element 31 at Node 2720)

Minimum value = -3174 lbf/ft (Element 47 at Node 9880)

3.1.2.1.3 Calculation results, Plate, Backfill 3 [Phase_5] (5/90), Shear forces Q

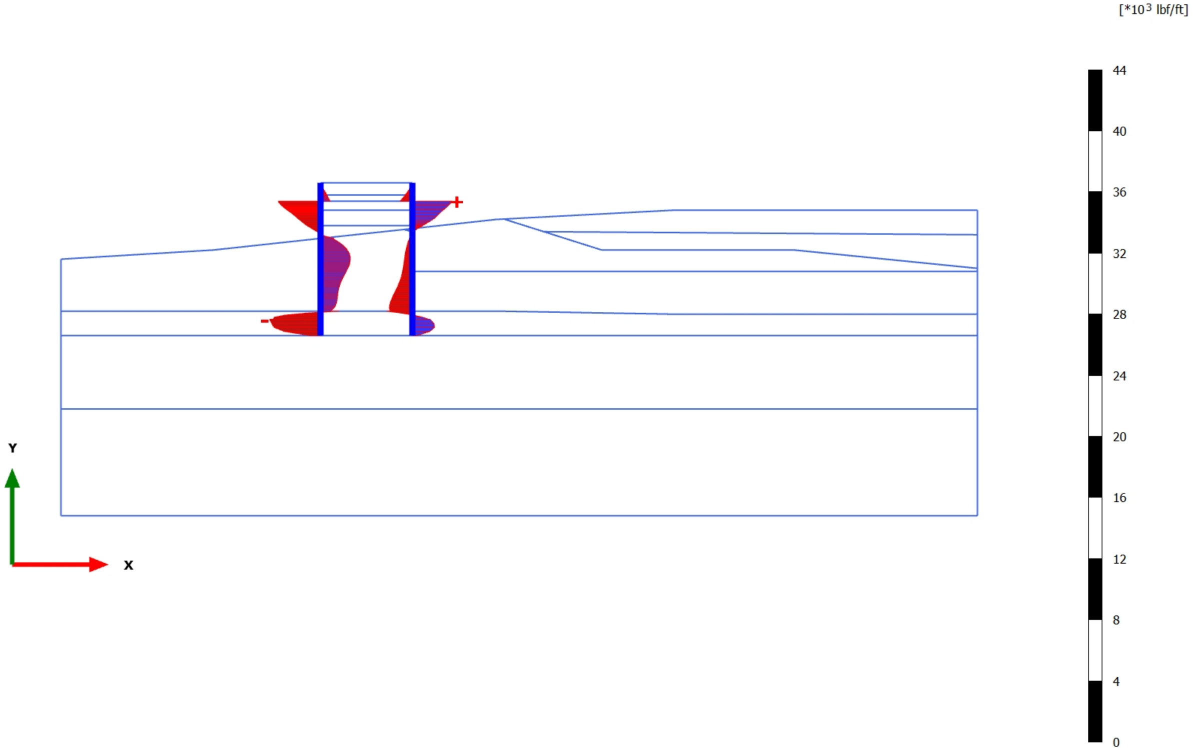


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 1587 lbf/ft (Element 31 at Node 2718)

Minimum value = -3229 lbf/ft (Element 47 at Node 9880)

3.1.2.1.4 Calculation results, Plate, Backfill 4 [Phase_6] (6/105), Shear forces Q

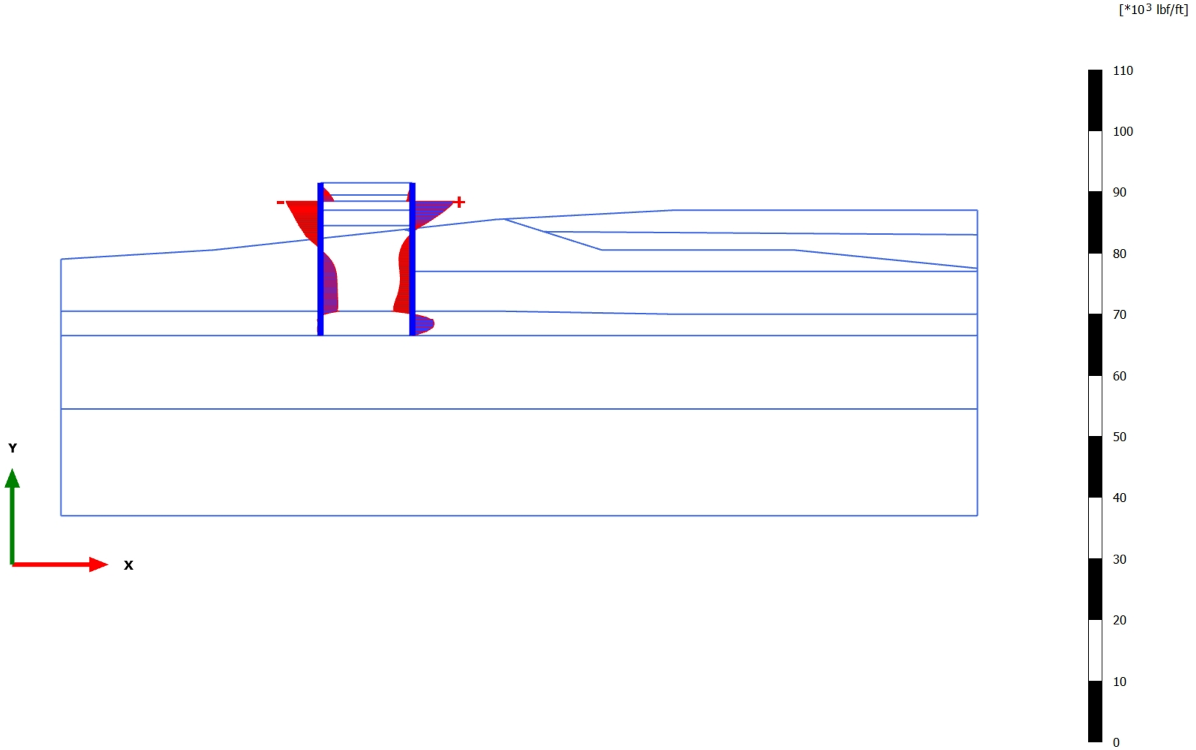


Shear forces Q (scaled up 5.00*10⁻³ times)

Maximum value = 2625 lbf/ft (Element 11 at Node 1407)

Minimum value = -3353 lbf/ft (Element 47 at Node 9879)

3.1.2.1.5 Calculation results, Plate, Dewater-SS [Phase_7] (7/145), Shear forces Q

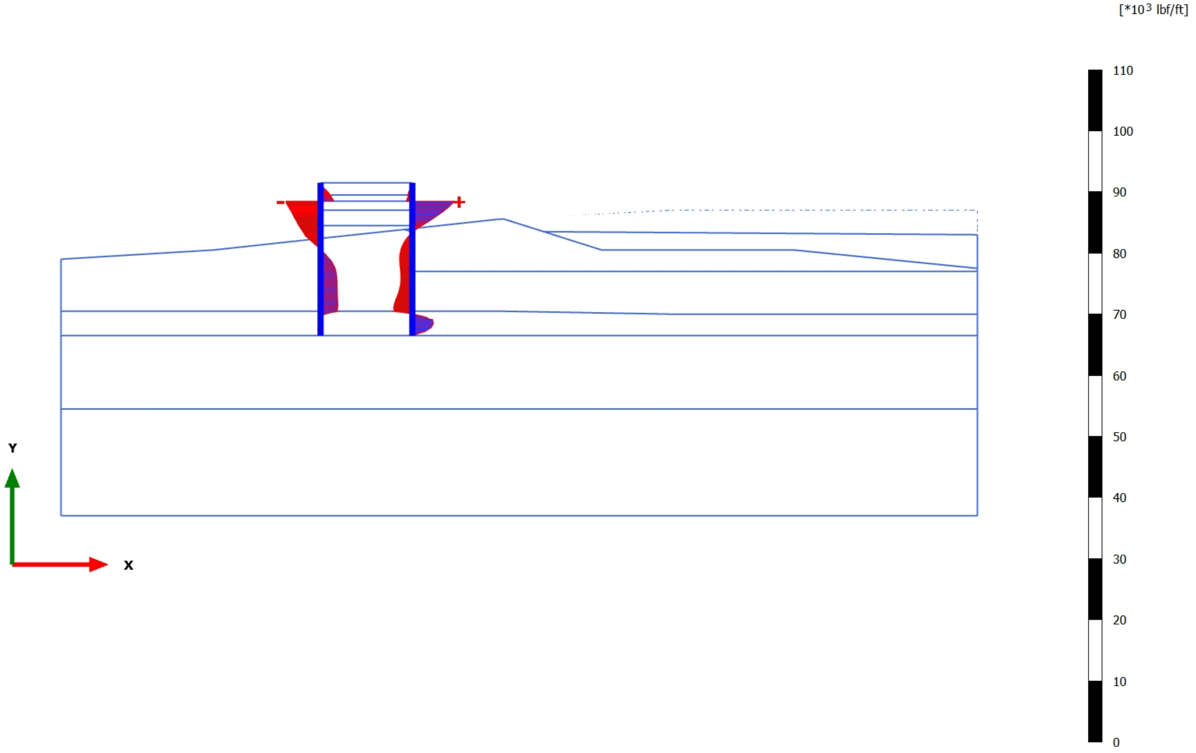


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 6909 lbf/ft (Element 11 at Node 1407)

Minimum value = -5716 lbf/ft (Element 9 at Node 21)

3.1.2.1.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/158), Shear forces Q

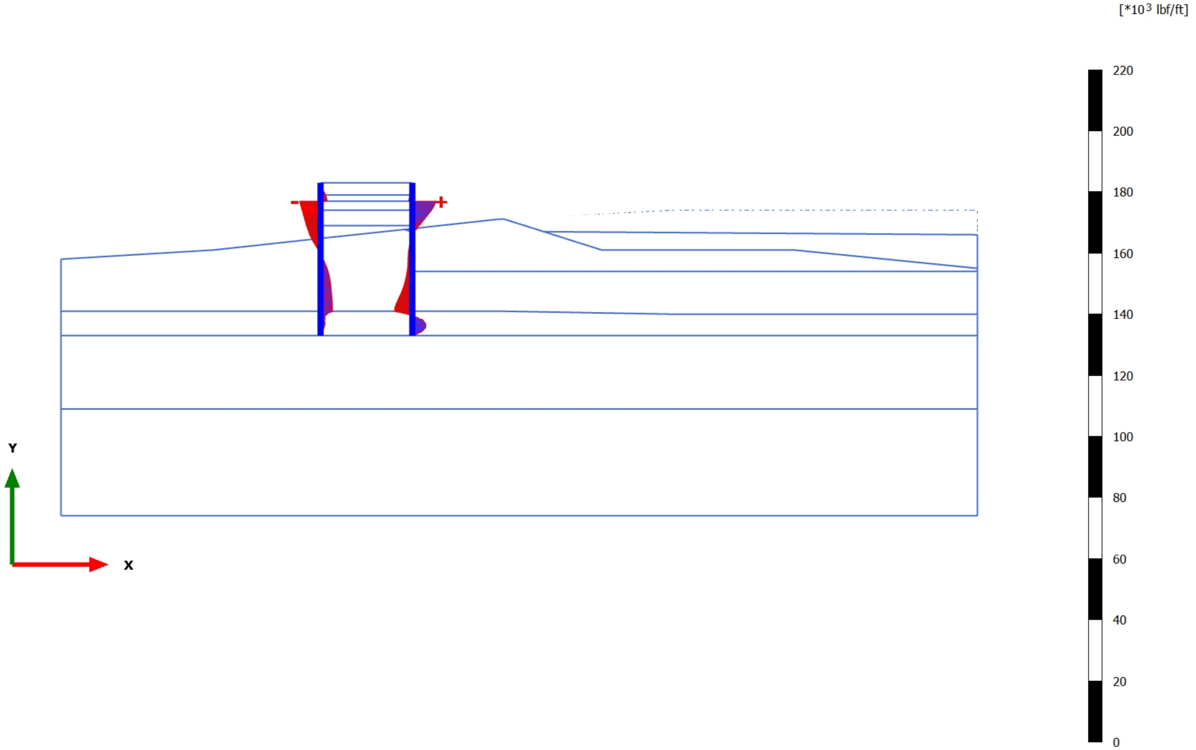


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 6898 lbf/ft (Element 11 at Node 1407)

Minimum value = -5747 lbf/ft (Element 9 at Node 21)

3.1.2.1.7 Calculation results, Plate, Dewater-SS [Phase_9] (9/178), Shear forces Q

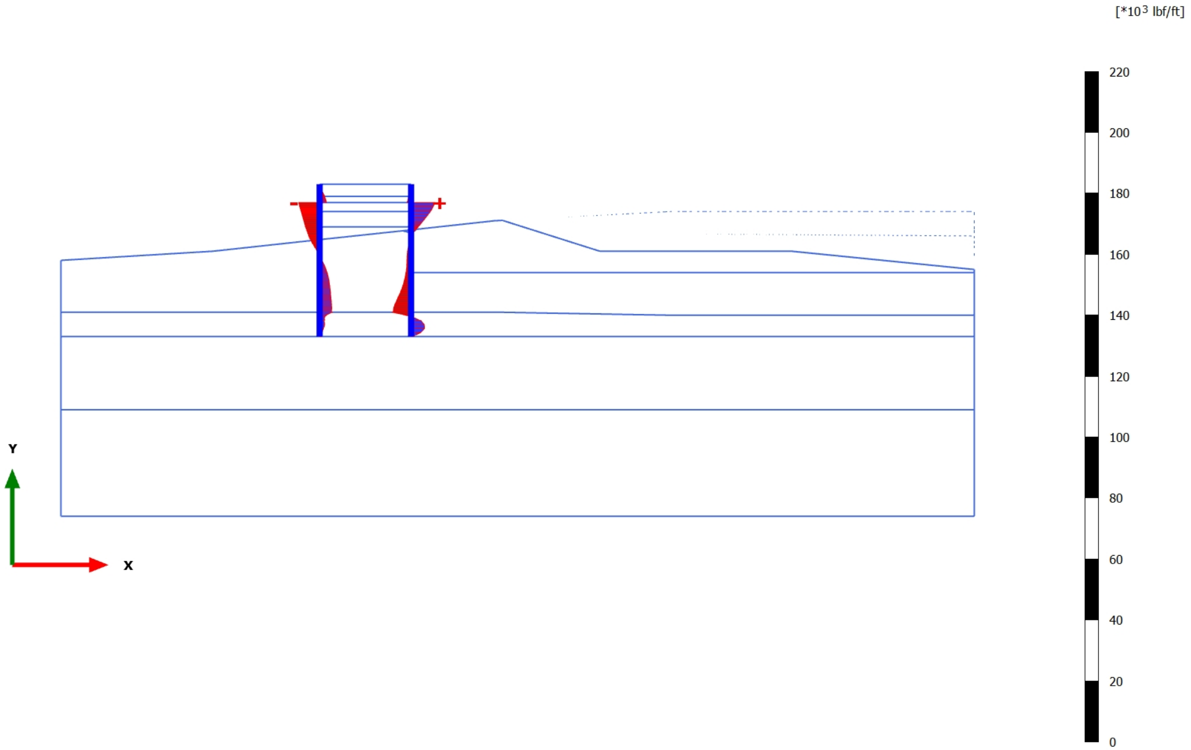


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 7893 lbf/ft (Element 11 at Node 1407)

Minimum value = -6899 lbf/ft (Element 9 at Node 21)

3.1.2.1.8 Calculation results, Plate, Excavate 2 [Phase_10] (10/186), Shear forces Q

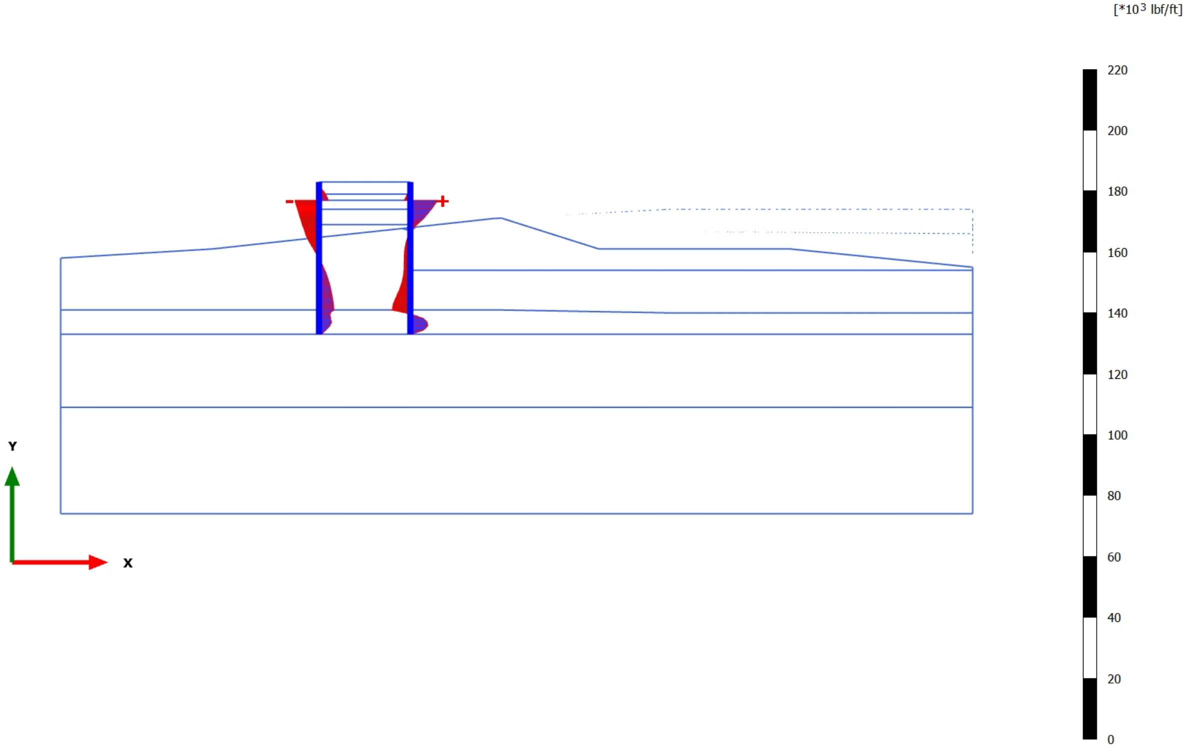


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 7895 lbf/ft (Element 11 at Node 1407)

Minimum value = -6909 lbf/ft (Element 9 at Node 21)

3.1.2.1.9 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/216), Shear forces Q

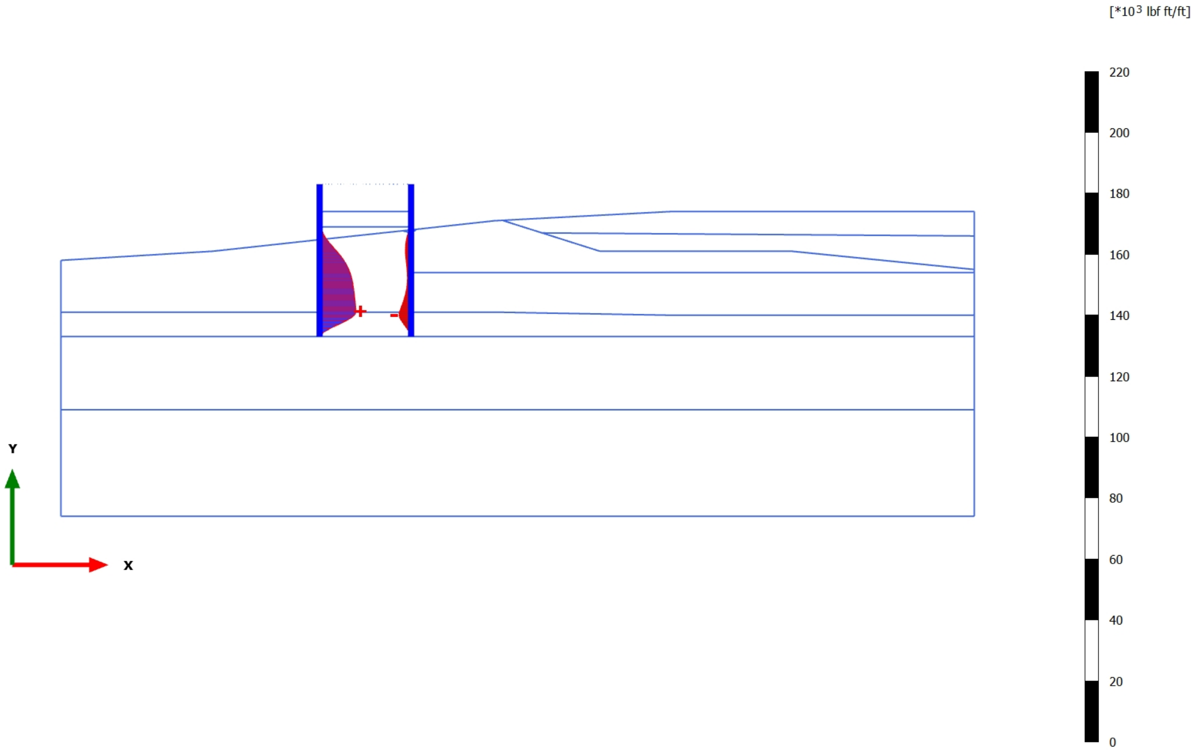


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 9007 lbf/ft (Element 11 at Node 1407)

Minimum value = -7998 lbf/ft (Element 9 at Node 21)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/37), Bending moments M

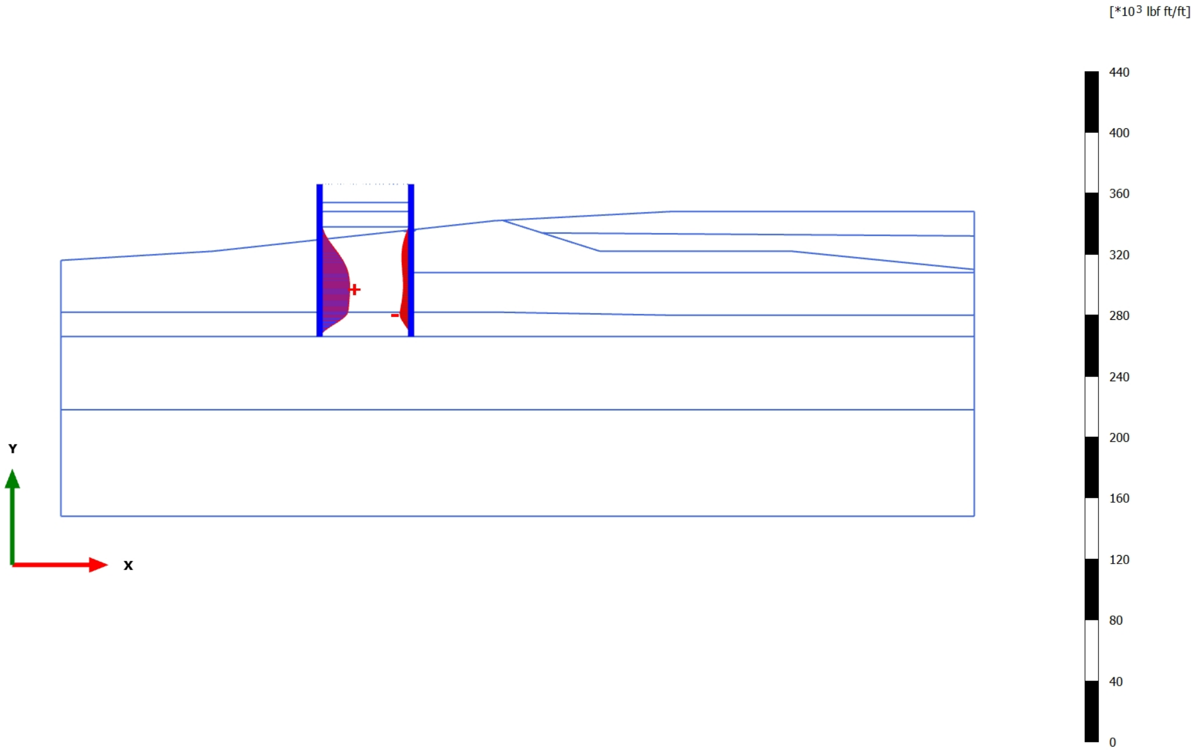


Bending moments M (scaled up 1.00*10^{-3} times)

Maximum value = 11.87*10^3 lbf ft/ft (Element 40 at Node 8824)

Minimum value = -3962 lbf ft/ft (Element 48 at Node 11017)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/62), Bending moments M

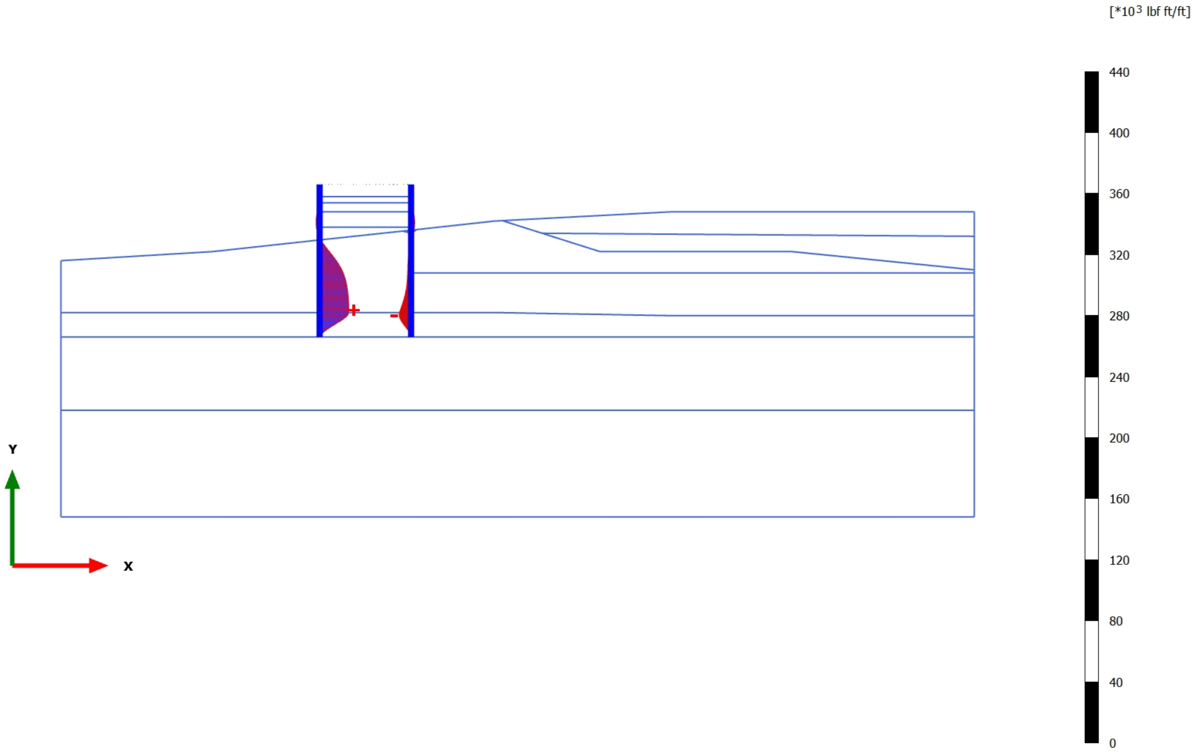


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $19.71*10^3$ lbf ft/ft (Element 37 at Node 6625)

Minimum value = -7316 lbf ft/ft (Element 48 at Node 11017)

3.1.2.2.3 Calculation results, Plate, Backfill 3 [Phase_5] (5/90), Bending moments M

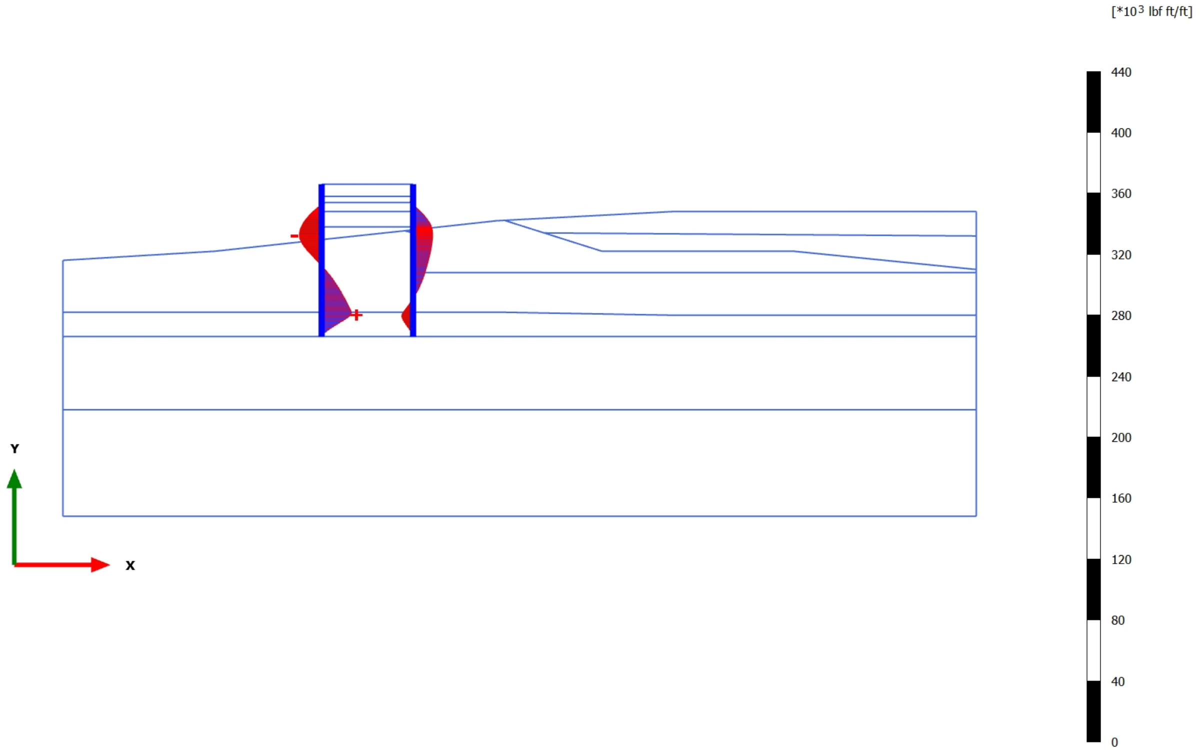


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $19.13*10^3$ lbf ft/ft (Element 40 at Node 8823)

Minimum value = -7834 lbf ft/ft (Element 48 at Node 11017)

3.1.2.2.4 Calculation results, Plate, Backfill 4 [Phase_6] (6/105), Bending moments M

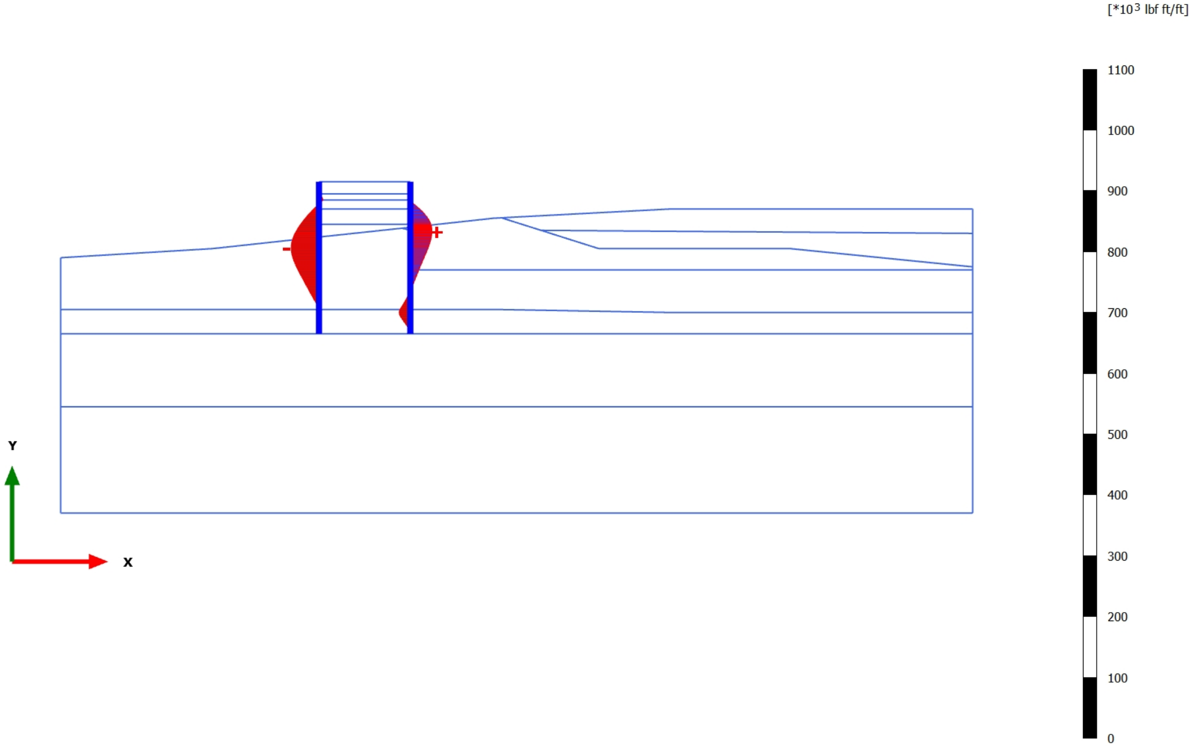


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $19.49*10^3$ lbf ft/ft (Element 46 at Node 9480)

Minimum value = $-14.66*10^3$ lbf ft/ft (Element 21 at Node 893)

3.1.2.2.5 Calculation results, Plate, Dewater-SS [Phase_7] (7/145), Bending moments M

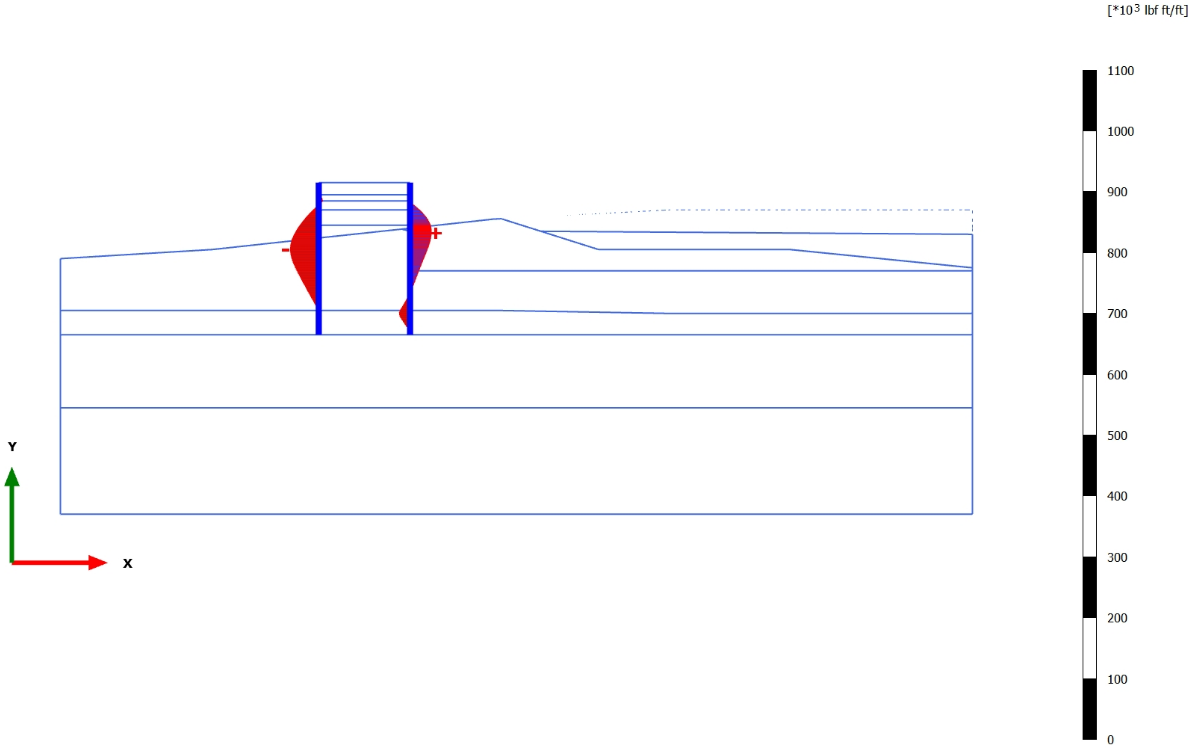


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 35.67*10^3 lbf ft/ft (Element 22 at Node 3382)

Minimum value = -45.87*10^3 lbf ft/ft (Element 31 at Node 2718)

3.1.2.2.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/158), Bending moments M

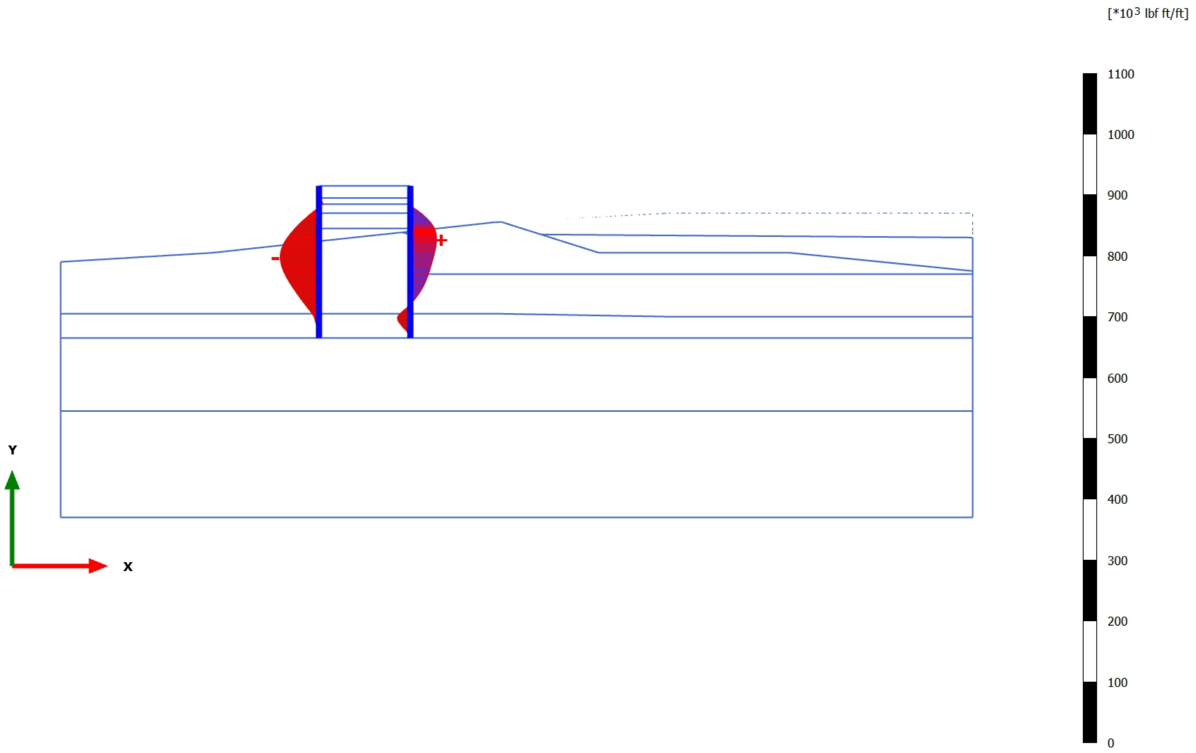


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 34.94*10^3 lbf ft/ft (Element 22 at Node 3382)

Minimum value = -46.63*10^3 lbf ft/ft (Element 31 at Node 2718)

3.1.2.2.7 Calculation results, Plate, Dewater-SS [Phase_9] (9/178), Bending moments M

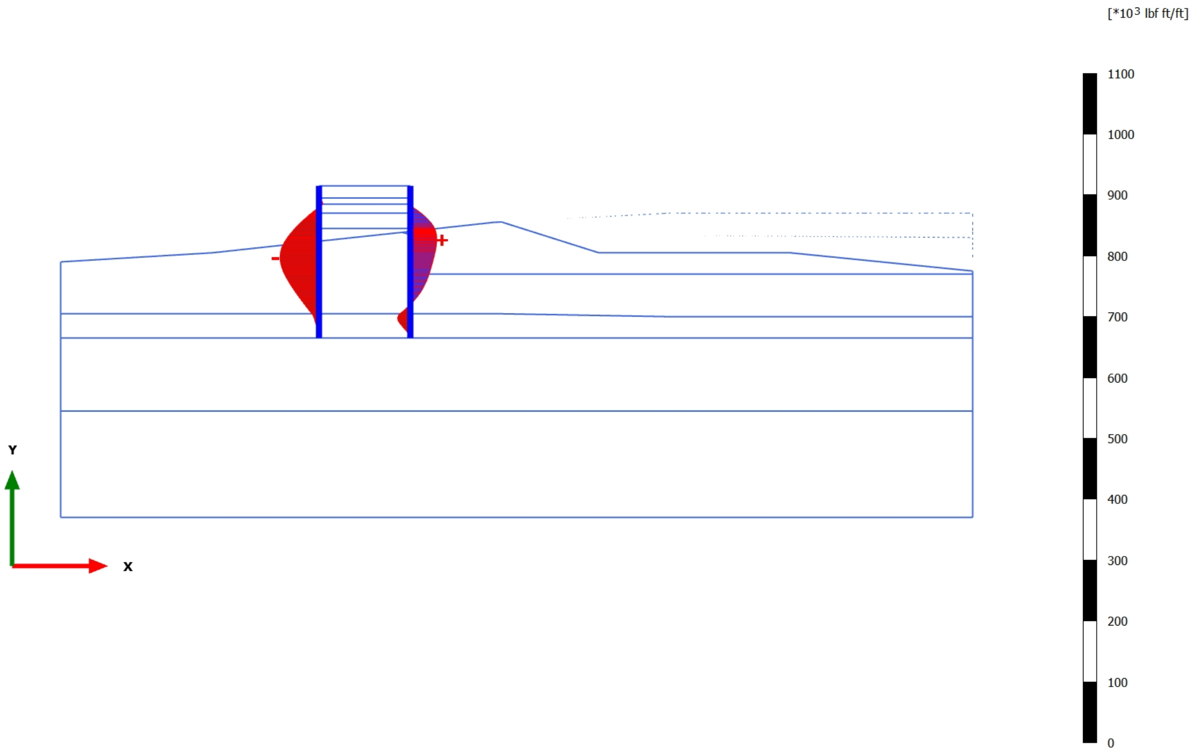


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 43.25*10^{3} lbf ft/ft (Element 23 at Node 3533)

Minimum value = -63.87*10^{3} lbf ft/ft (Element 32 at Node 3429)

3.1.2.2.8 Calculation results, Plate, Excavate 2 [Phase_10] (10/186), Bending moments M

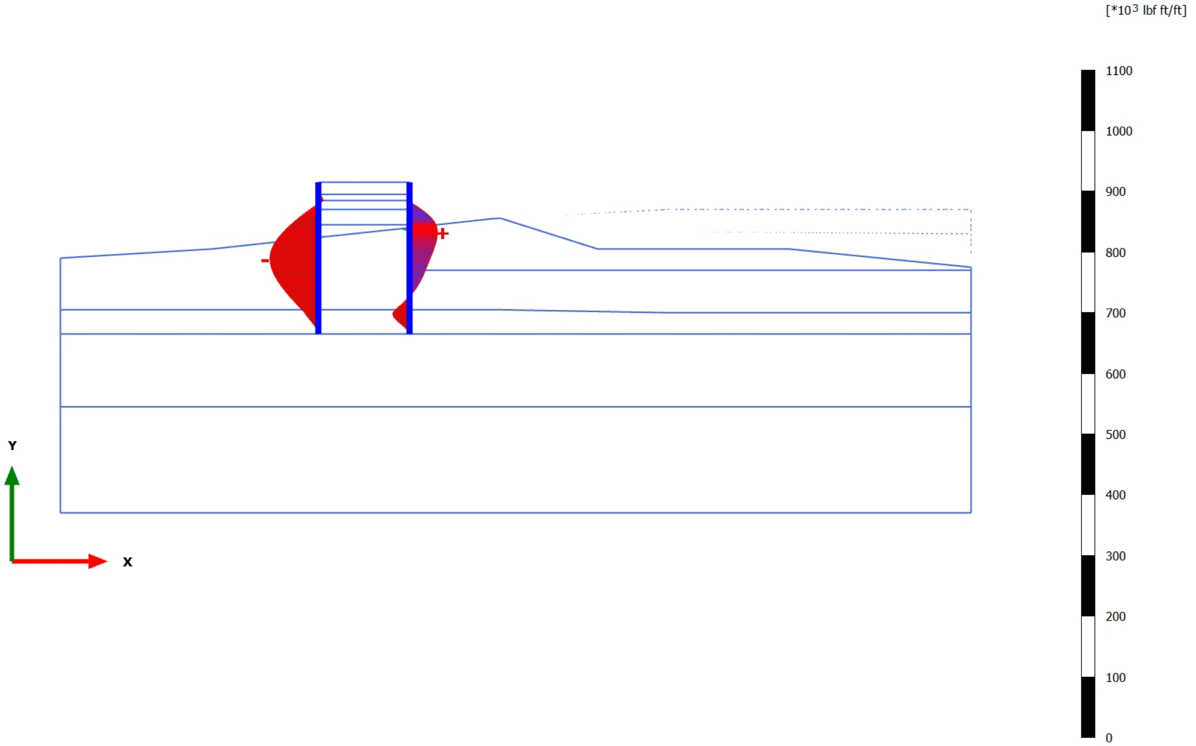


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 43.62*10^{3} lbf ft/ft (Element 23 at Node 3533)

Minimum value = -64.07*10^{3} lbf ft/ft (Element 32 at Node 3429)

3.1.2.2.9 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/216), Bending moments M



Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $46.13*10^3$ lbf ft/ft (Element 22 at Node 3383)

Minimum value = $-79.71*10^3$ lbf ft/ft (Element 33 at Node 3919)

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/90), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	6679.710	0.000	6679.710
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	6679.710	0.000	6679.710

3.2.1.1.4 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/105), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	34.081	0.000	34.081
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	34.081	0.000	34.081

3.2.1.1.5 Calculation results, Node-to-node anchor, Dewater-SS [Phase_7] (7/145), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	78.942	0.000	78.942
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	78.942	0.000	78.942

3.2.1.1.6 Calculation results, Node-to-node anchor, Excavate 1 [Phase_8] (8/158), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	79.149	0.000	79.149
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	79.149	0.000	79.149

3.2.1.1.7 Calculation results, Node-to-node anchor, Dewater-SS [Phase_9] (9/178), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	91.414	0.000	91.414
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	91.414	0.000	91.414

3.2.1.1.8 Calculation results, Node-to-node anchor, Excavate 2 [Phase_10] (10/186), Table of node-to-node anchors

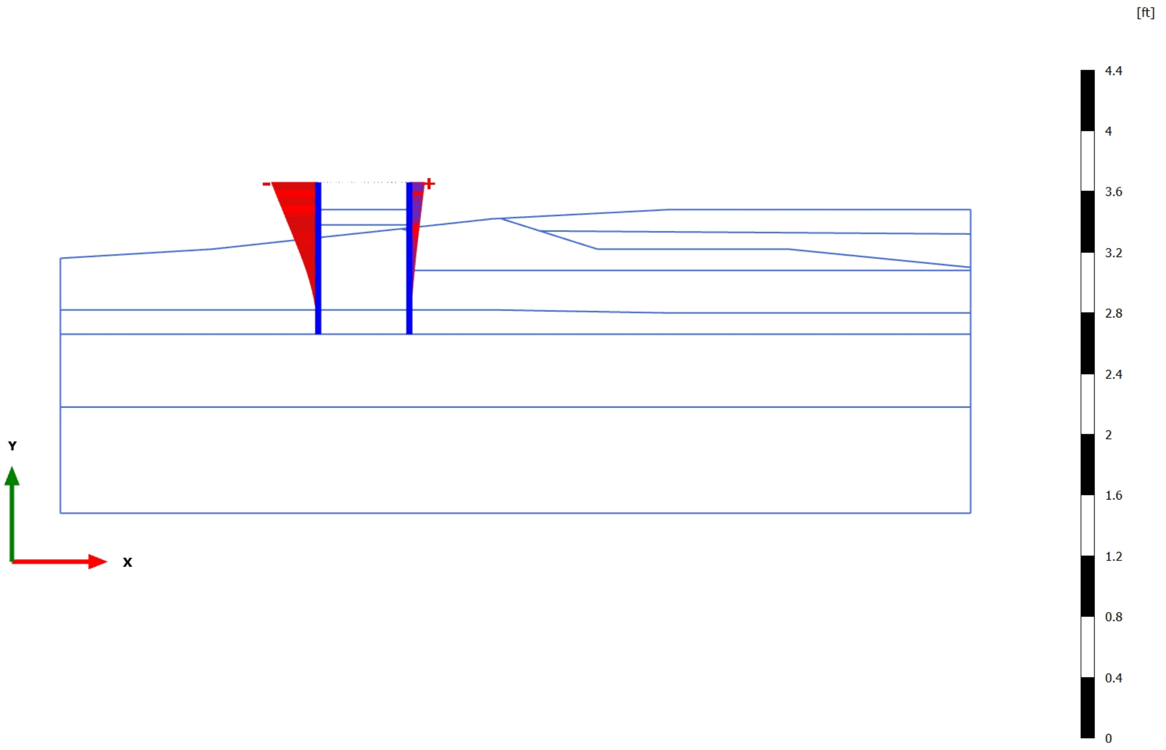
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	91.526	0.000	91.526
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	91.526	0.000	91.526

3.2.1.1.9 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/216), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	110.304	0.000	110.304
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	110.304	0.000	110.304

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/42), Total displacements u_x

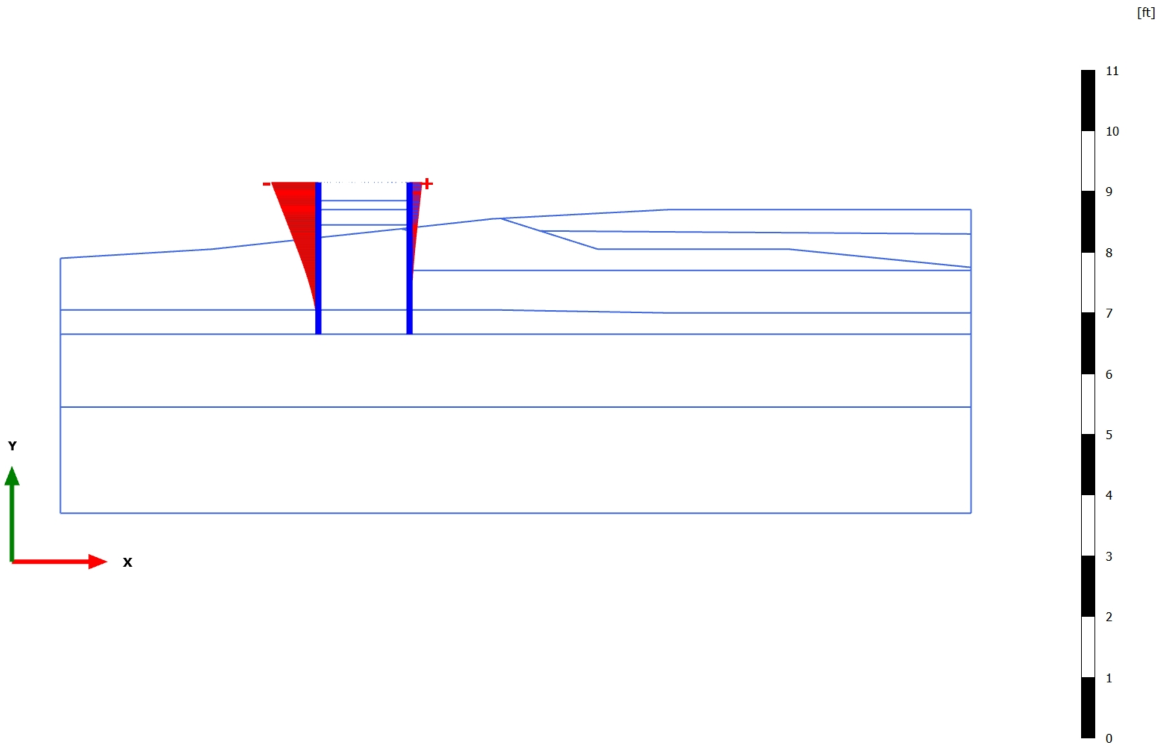


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1001 ft (Element 2 at Node 1385)

Minimum value = -0.3087 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/85), Total displacements u_x

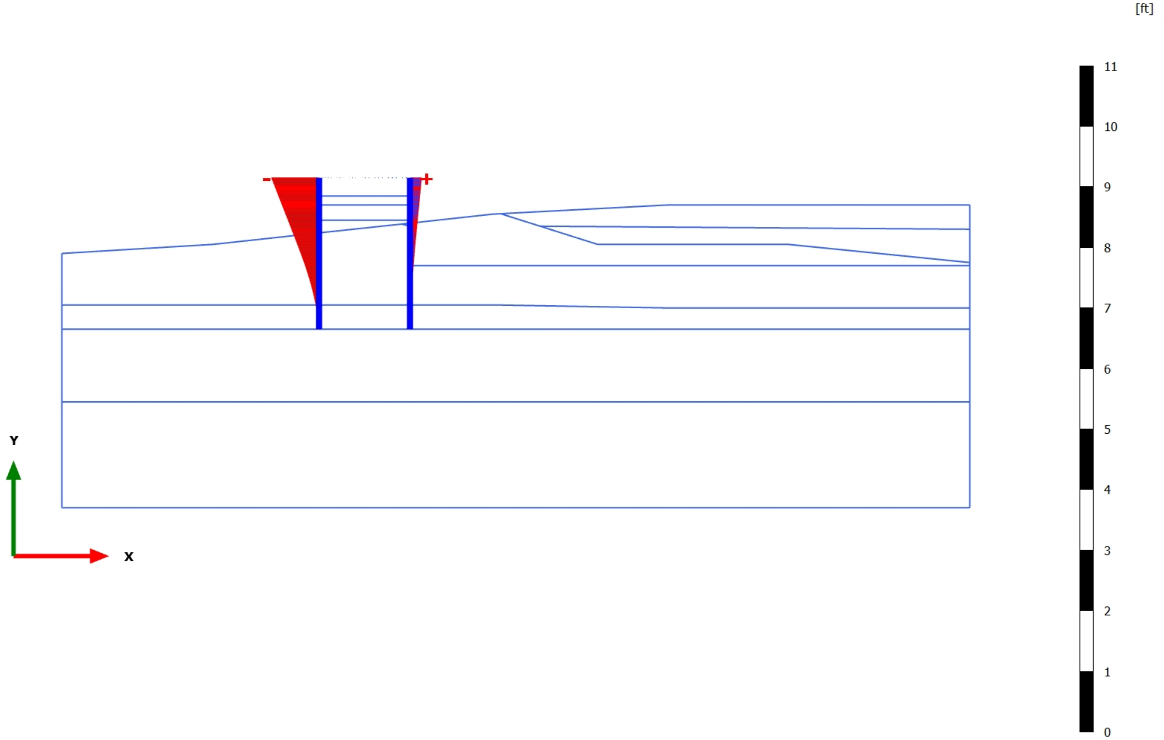


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.2044 ft (Element 2 at Node 1385)

Minimum value = -0.7734 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Consolidate [Phase_22] (22/167), Total displacements u_x

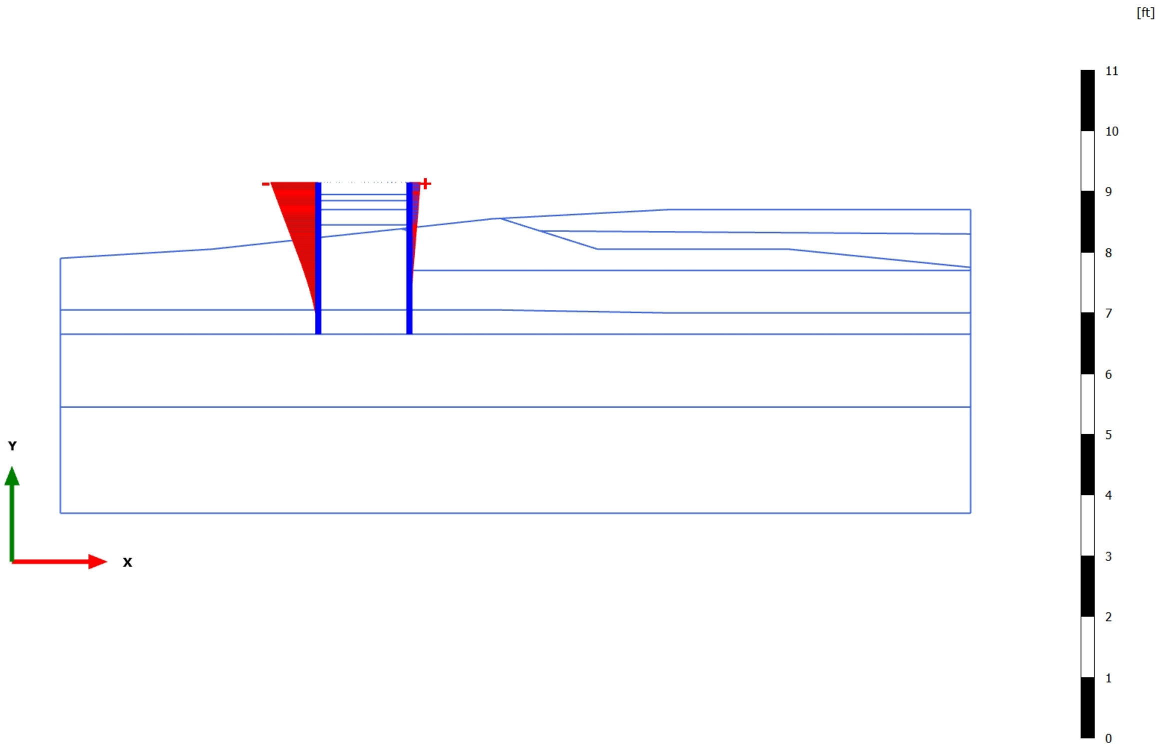


Total displacements u_x (scaled up 20.0 times) (Time 10.00 day)

Maximum value = 0.1912 ft (Element 2 at Node 1385)

Minimum value = -0.7843 ft (Element 1 at Node 4)

3.1.1.1.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/173), Total displacements u_x

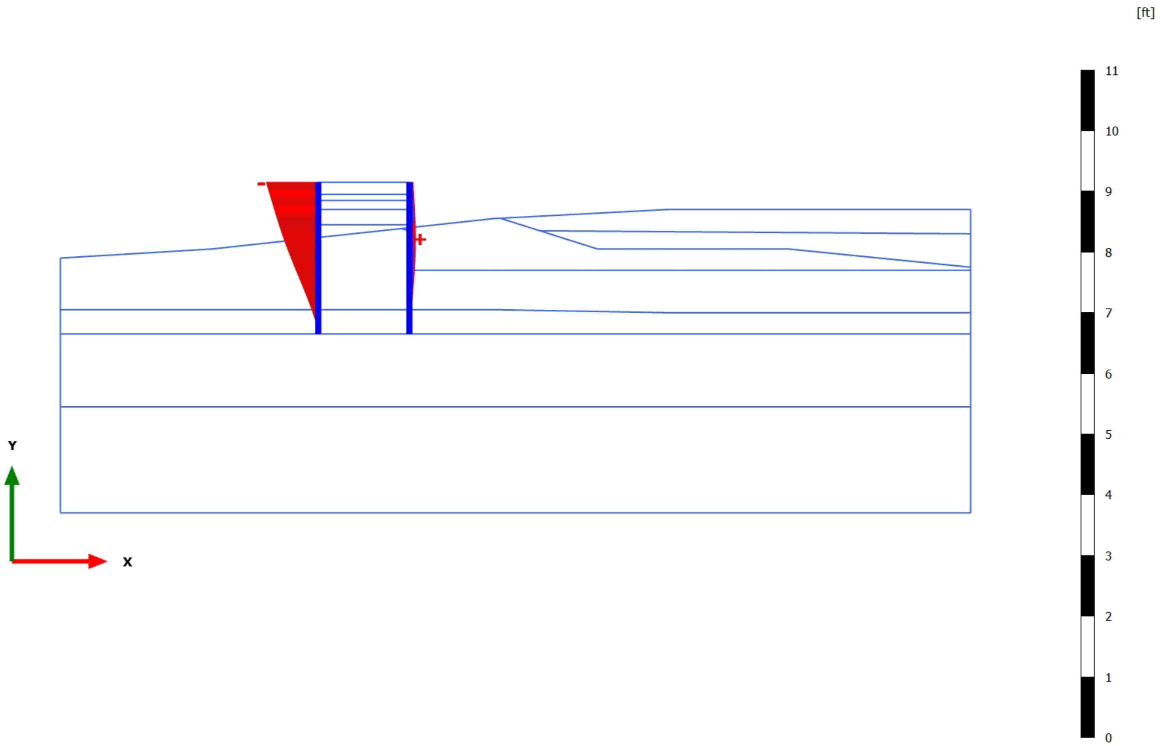


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.1819 ft (Element 2 at Node 1385)

Minimum value = -0.7852 ft (Element 1 at Node 4)

3.1.1.1.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/188), Total displacements u_x

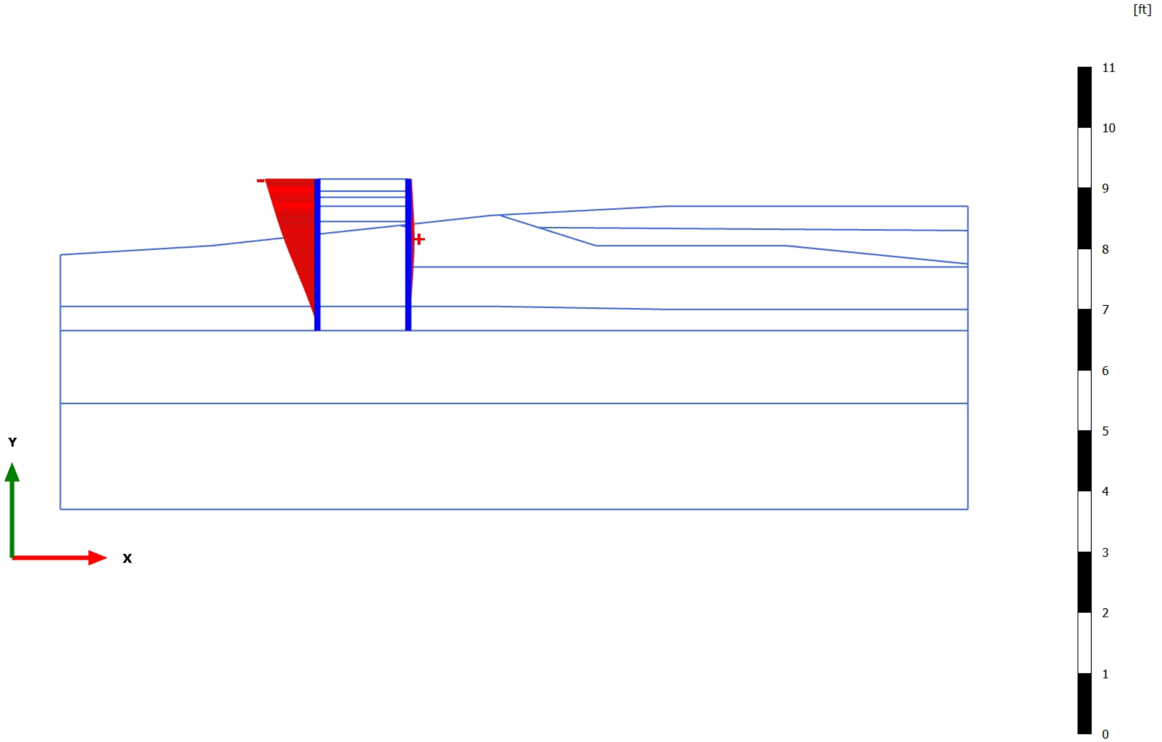


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.1029 ft (Element 24 at Node 3864)

Minimum value = -0.8560 ft (Element 1 at Node 4)

3.1.1.1.1.6 Calculation results, Plate, Consolidate [Phase_23] (23/201), Total displacements u_x

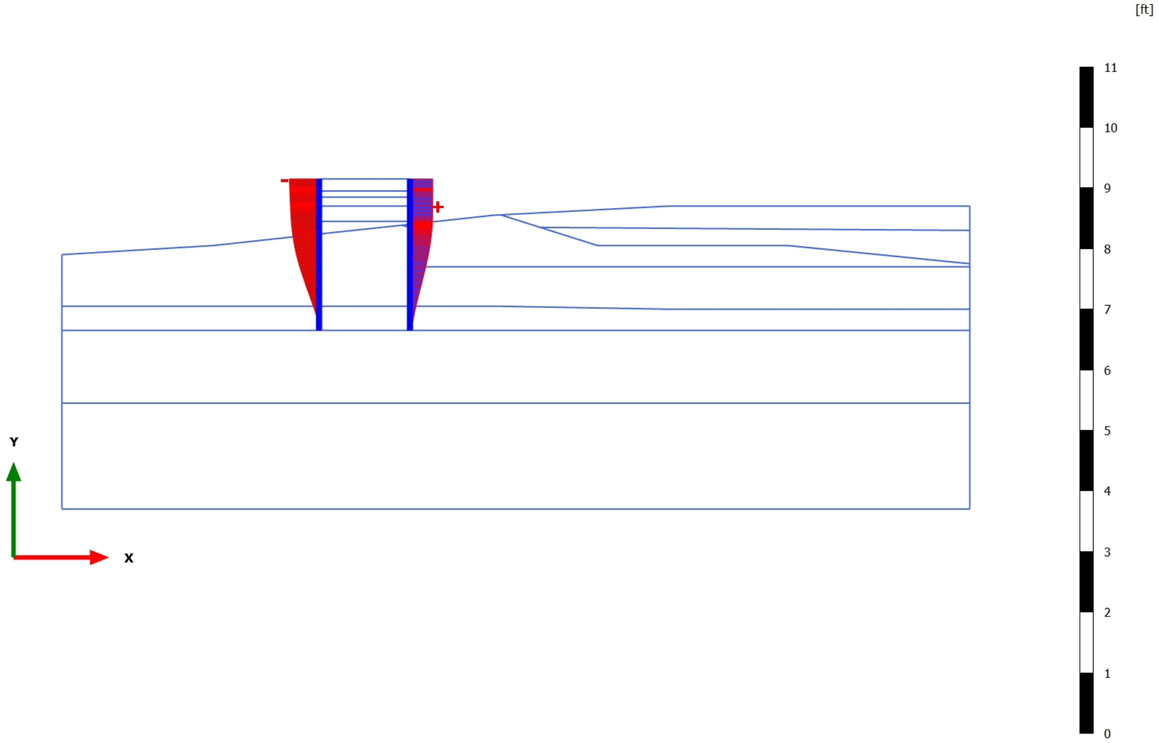


Total displacements u_x (scaled up 20.0 times) (Time 16.00 day)

Maximum value = 0.09710 ft (Element 24 at Node 3893)

Minimum value = -0.8652 ft (Element 1 at Node 4)

3.1.1.1.1.7 Calculation results, Plate, Dewater-SS [Phase_7] (7/217), Total displacements u_x

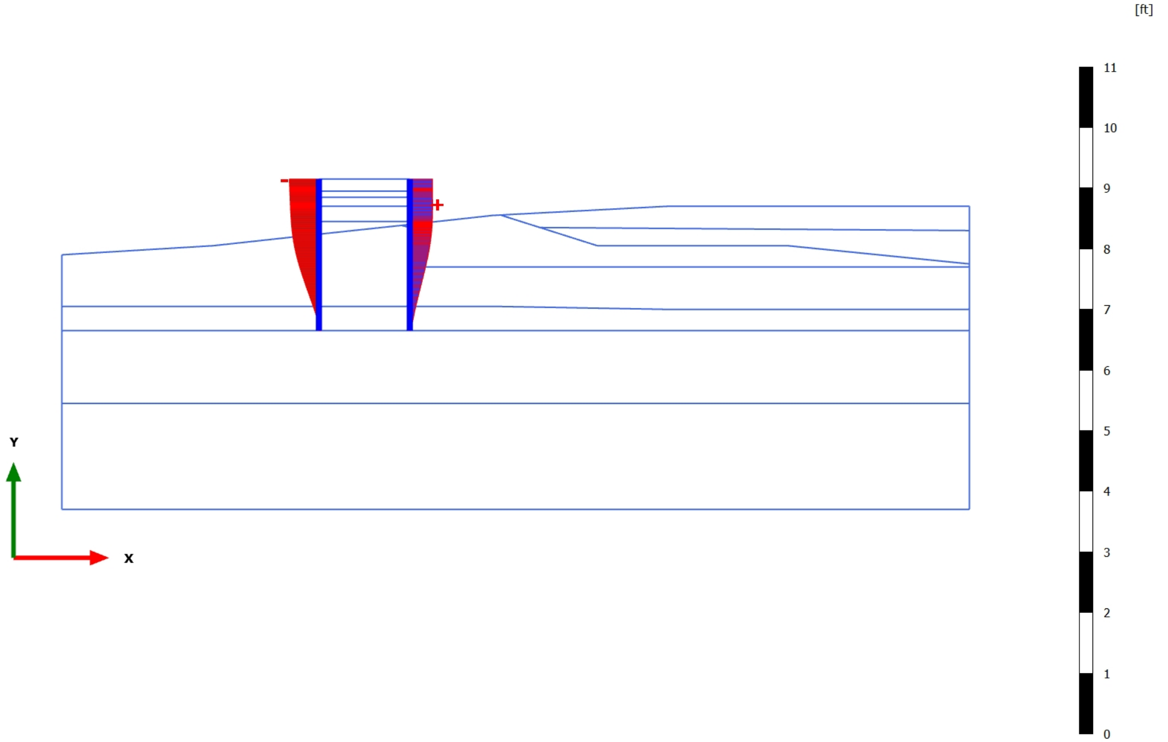


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.3784 ft (Element 11 at Node 1411)

Minimum value = -0.4928 ft (Element 1 at Node 4)

3.1.1.1.1.8 Calculation results, Plate, Consolidate [Phase_24] (24/236), Total displacements u_x

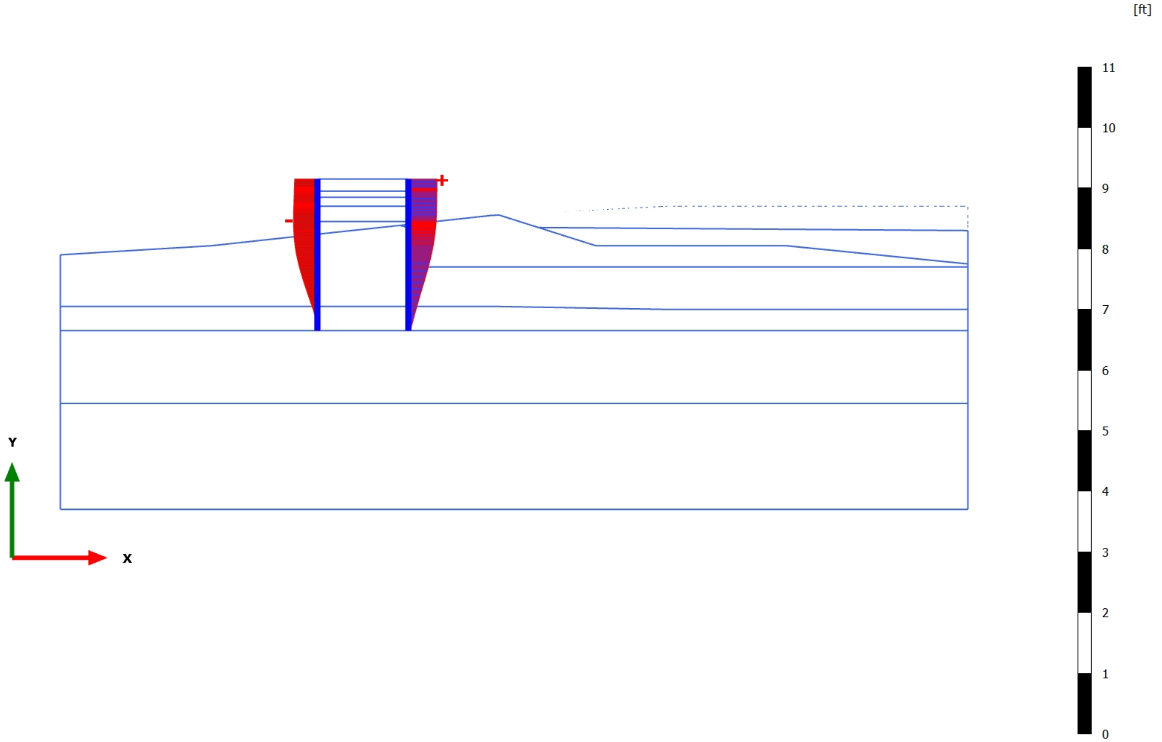


Total displacements u_x (scaled up 20.0 times) (Time 20.00 day)

Maximum value = 0.3791 ft (Element 11 at Node 1410)

Minimum value = -0.4918 ft (Element 1 at Node 4)

3.1.1.1.1.9 Calculation results, Plate, Excavate 1 [Phase_8] (8/242), Total displacements u_x

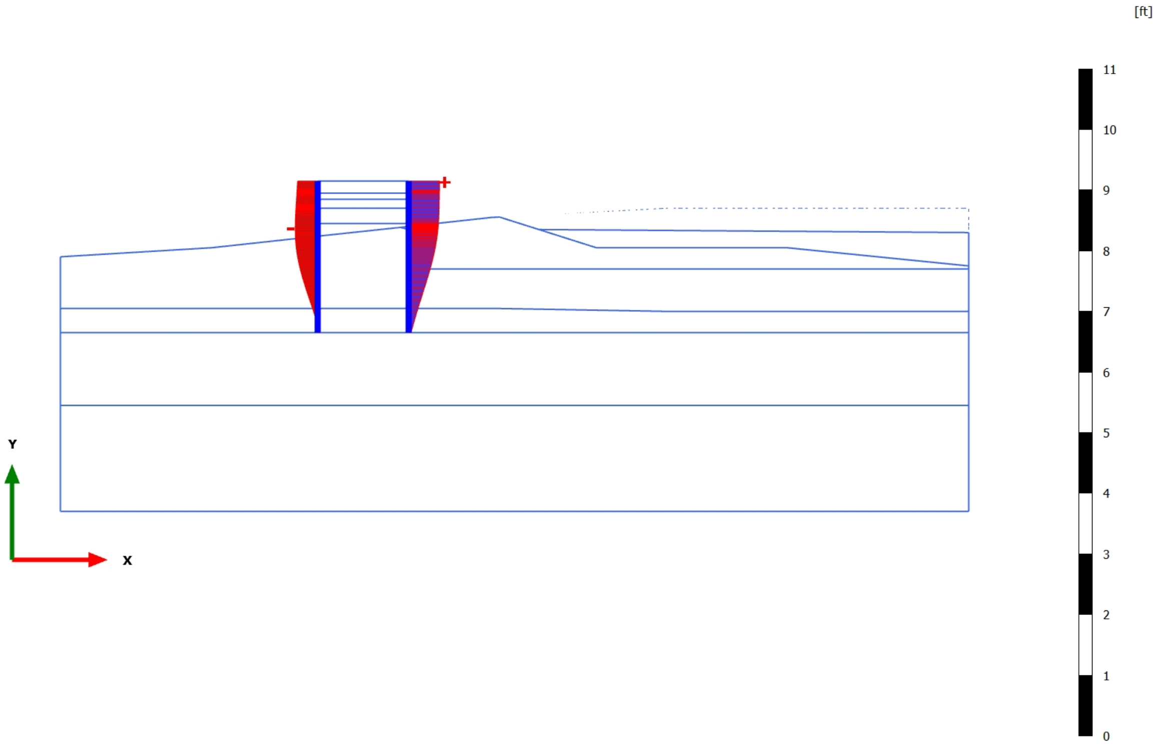


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.4772 ft (Element 2 at Node 1385)

Minimum value = -0.3962 ft (Element 15 at Node 434)

3.1.1.1.1.10 Calculation results, Plate, Dewater-SS [Phase_9] (9/250), Total displacements u_x

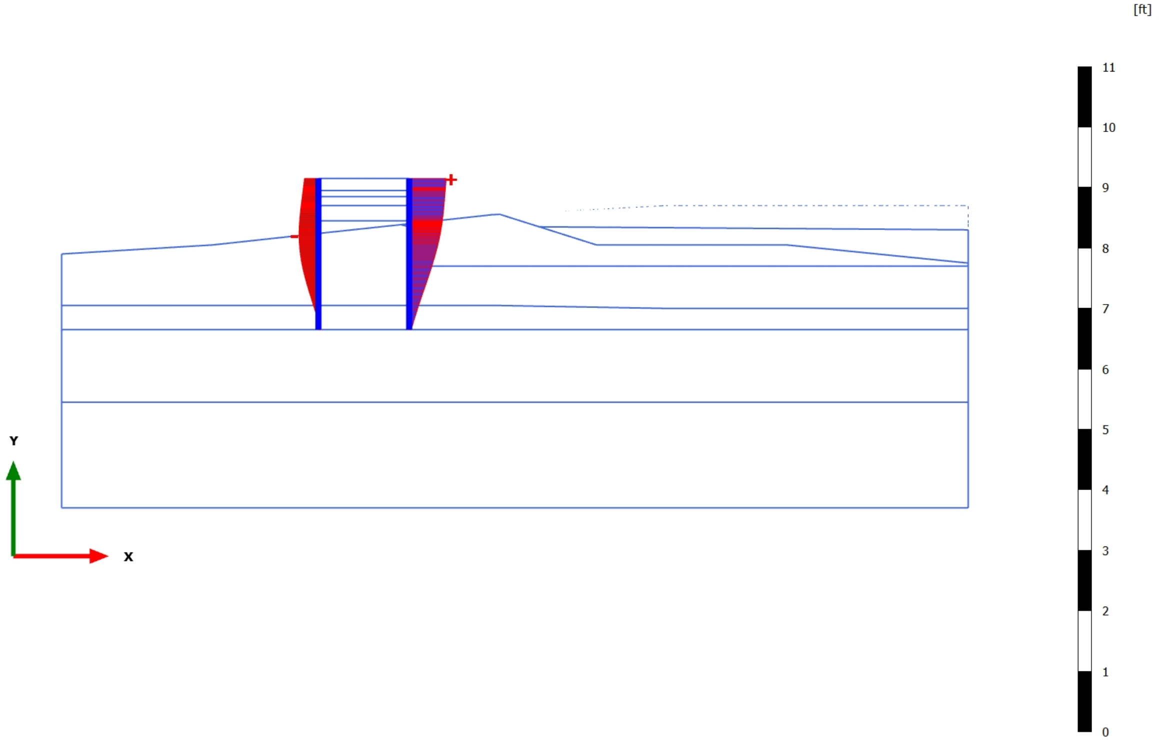


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.5145 ft (Element 2 at Node 1385)

Minimum value = -0.3729 ft (Element 20 at Node 645)

3.1.1.1.1.11 Calculation results, Plate, Consolidate [Phase_25] (25/272), Total displacements u_x

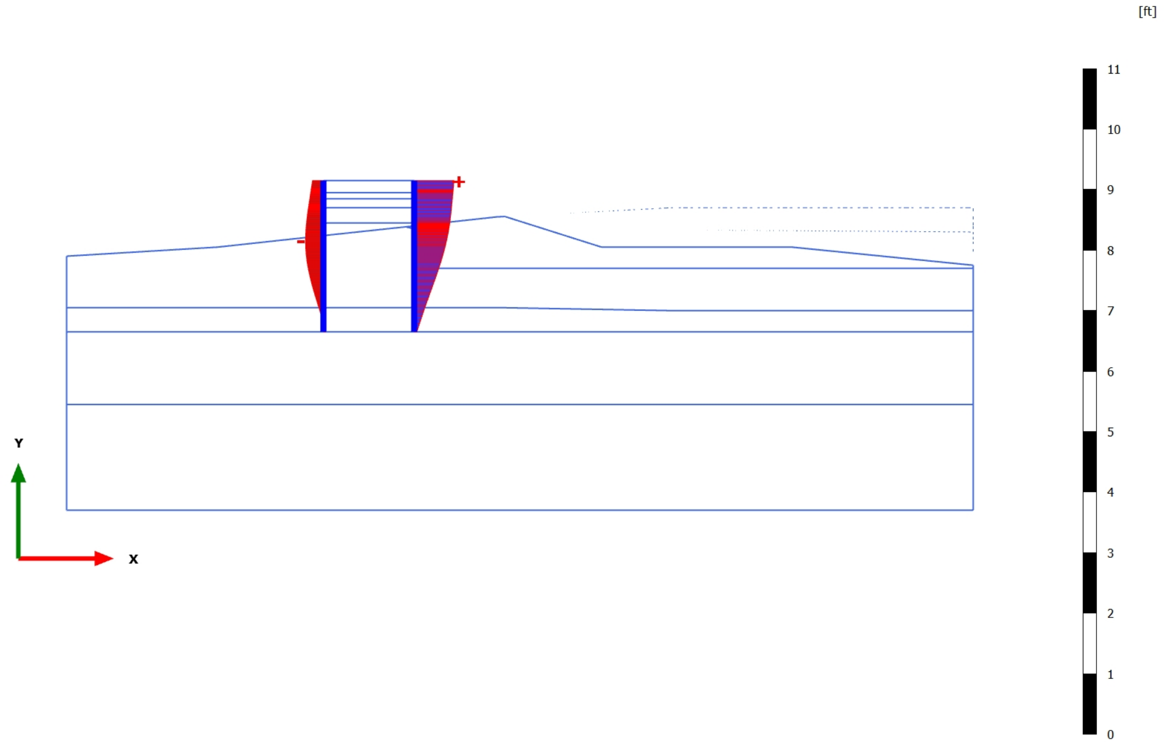


Total displacements u_x (scaled up 20.0 times) (Time 37.00 day)

Maximum value = 0.6159 ft (Element 2 at Node 1385)

Minimum value = -0.3212 ft (Element 30 at Node 2670)

3.1.1.1.1.12 Calculation results, Plate, Excavate 2 [Phase_10] (10/277), Total displacements u_x

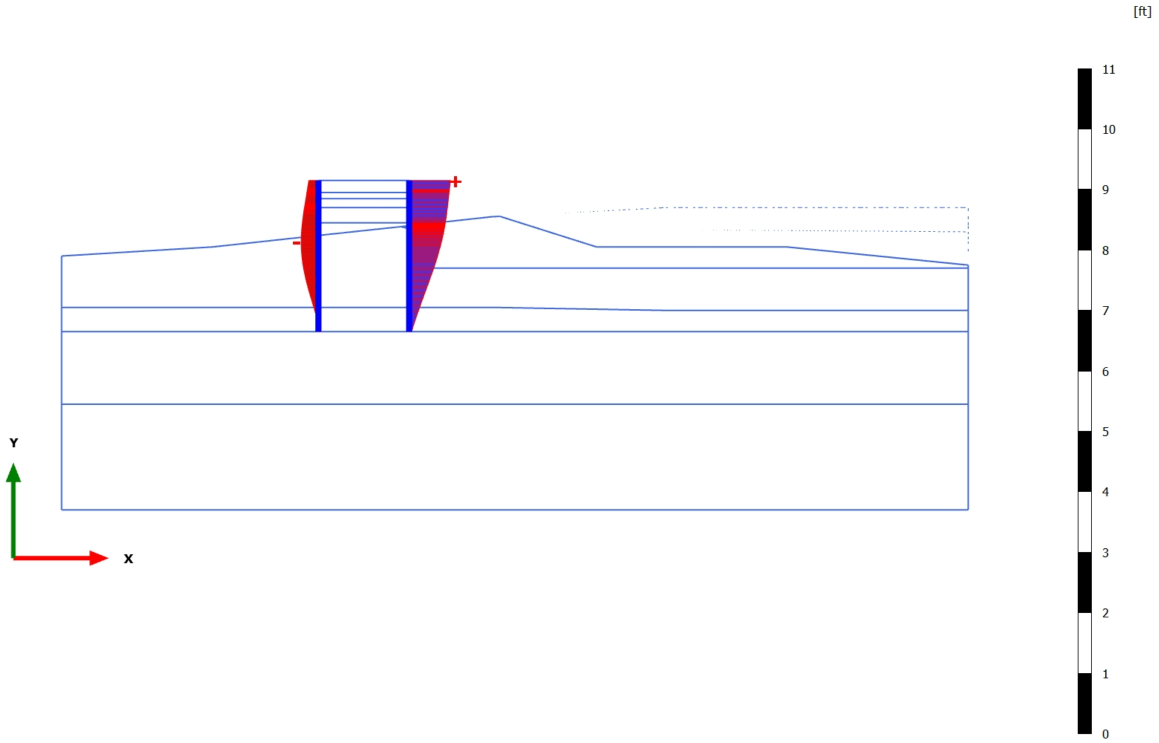


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.6611 ft (Element 2 at Node 1385)

Minimum value = -0.2964 ft (Element 30 at Node 2668)

3.1.1.1.1.13 Calculation results, Plate, Consolidate [Phase_26] (26/388), Total displacements u_x

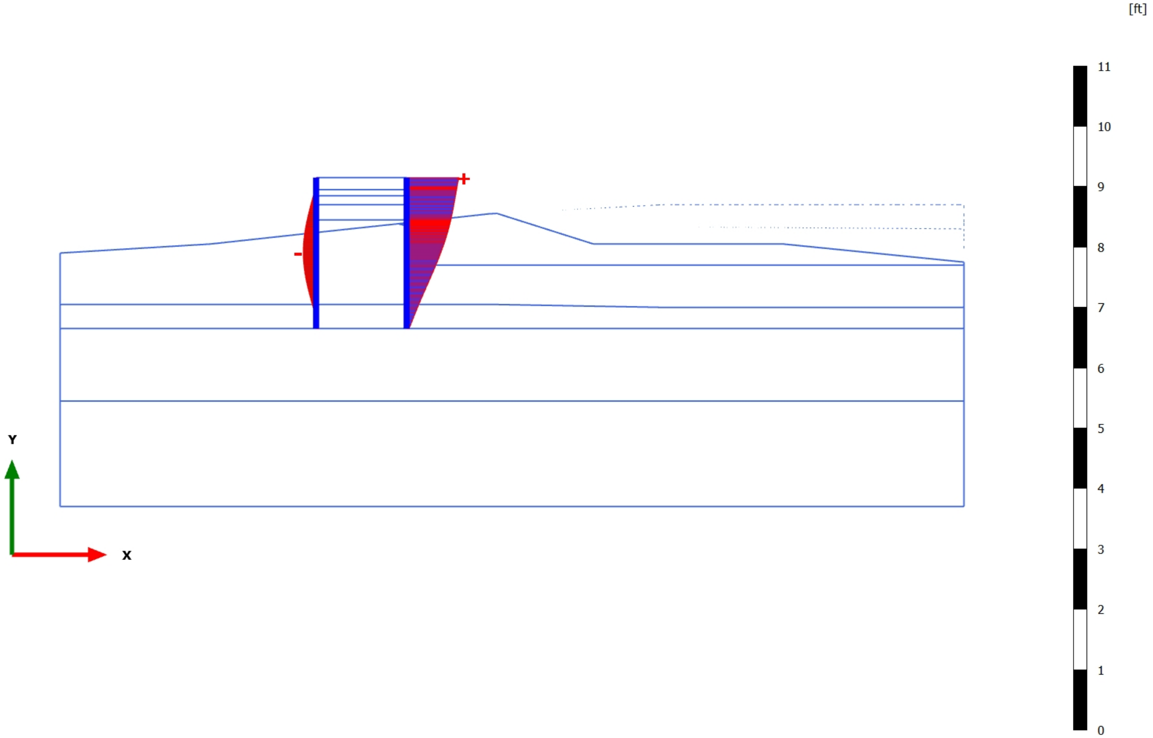


Total displacements u_x (scaled up 20.0 times) (Time 51.00 day)

Maximum value = 0.6852 ft (Element 2 at Node 1385)

Minimum value = -0.2860 ft (Element 30 at Node 2717)

3.1.1.1.1.14 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/402), Total displacements u_x

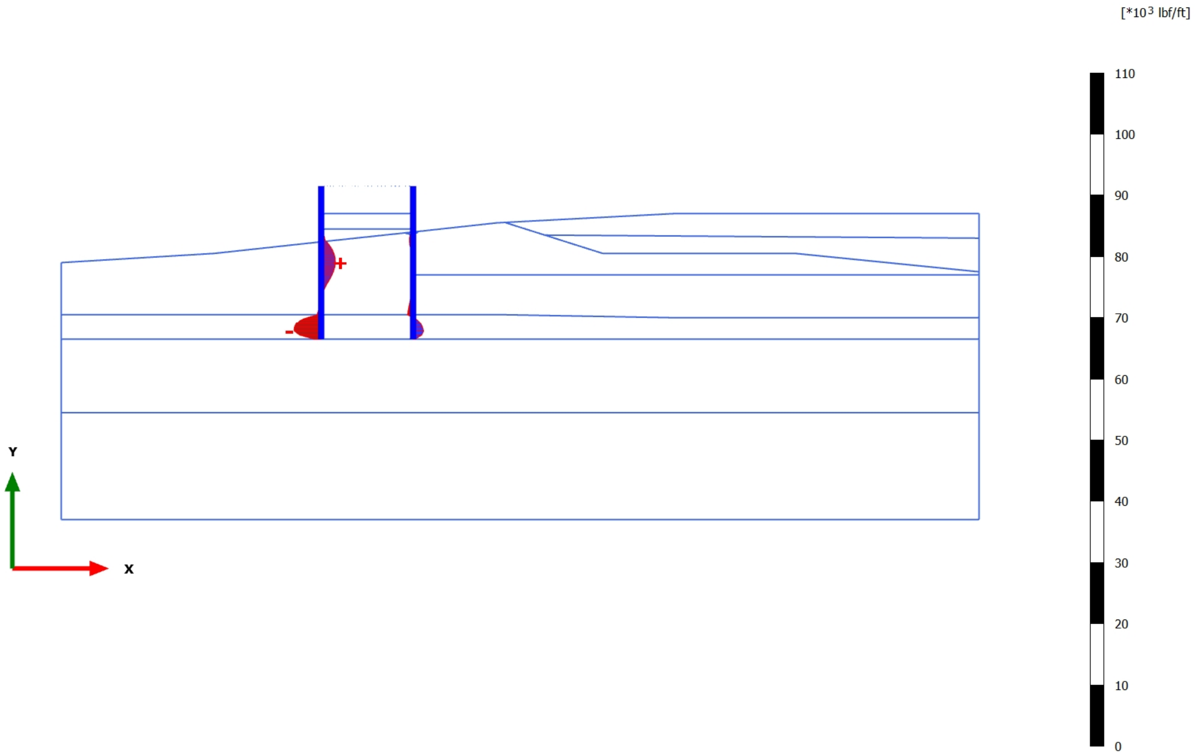


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.8674 ft (Element 2 at Node 1385)

Minimum value = -0.2153 ft (Element 33 at Node 3920)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/42), Shear forces Q

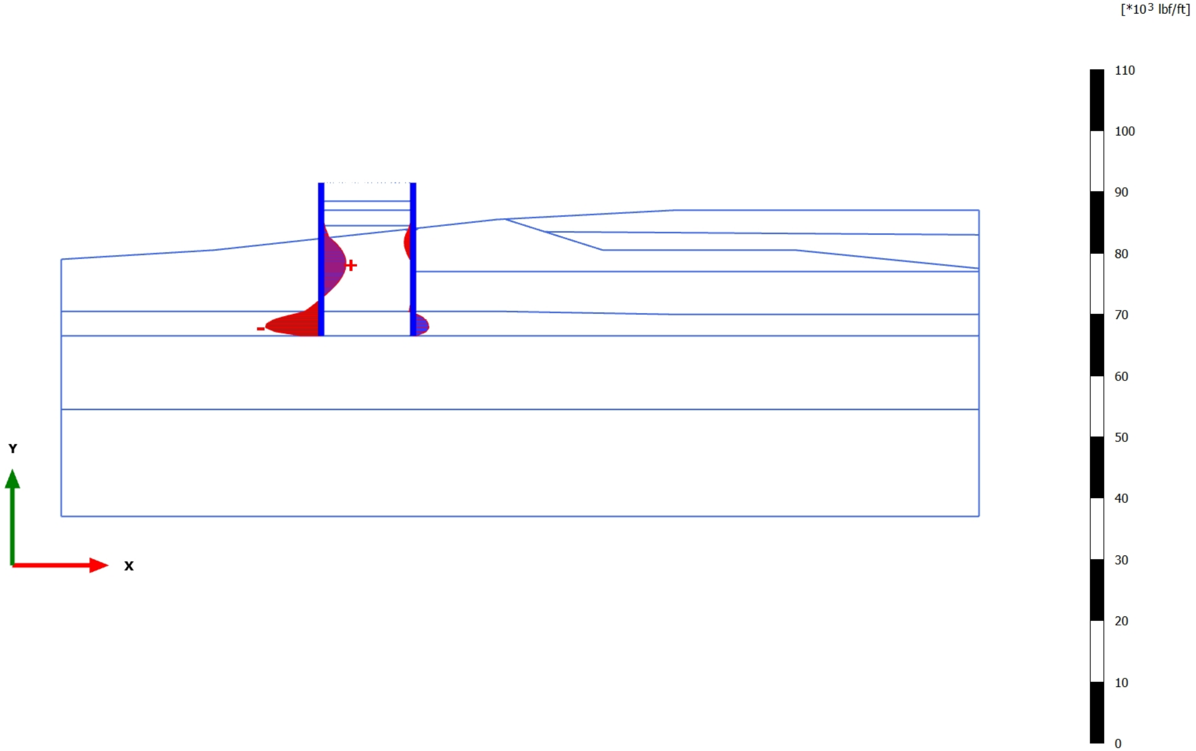


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 2302 lbf/ft (Element 33 at Node 3920)

Minimum value = -4446 lbf/ft (Element 47 at Node 9881)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/85), Shear forces Q

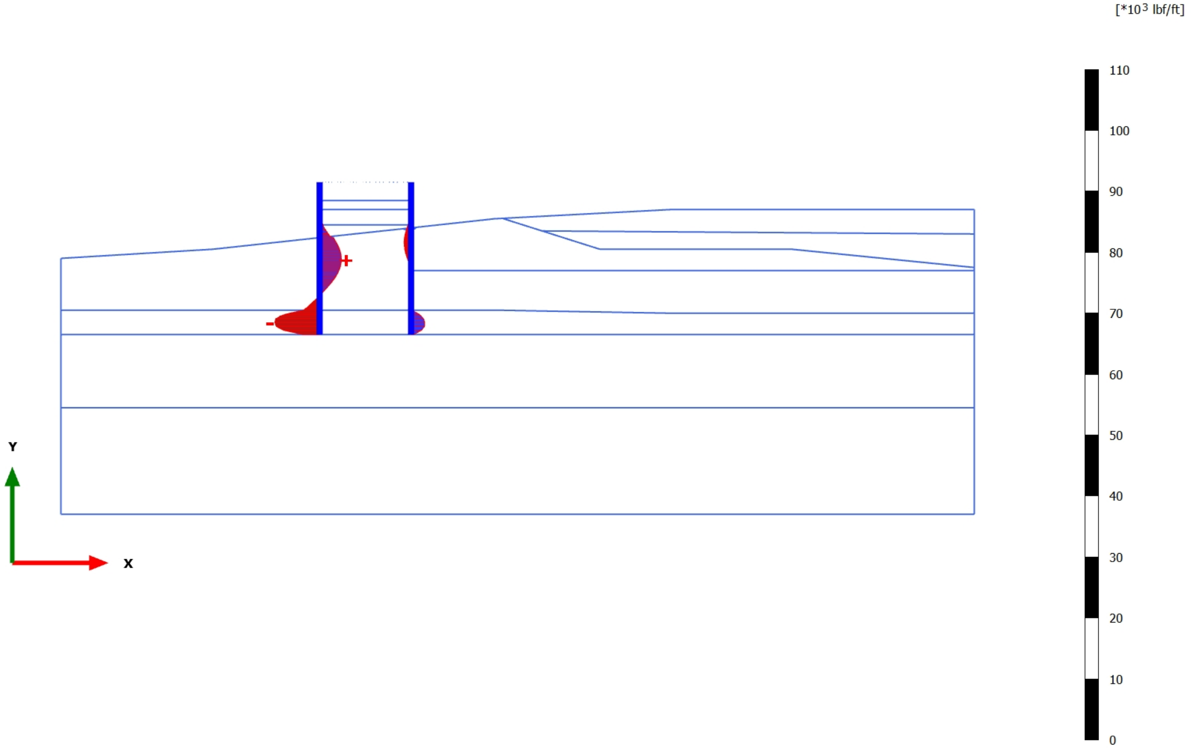


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 4046 lbf/ft (Element 33 at Node 4245)

Minimum value = -9131 lbf/ft (Element 47 at Node 9881)

3.1.2.1.3 Calculation results, Plate, Consolidate [Phase_22] (22/167), Shear forces Q

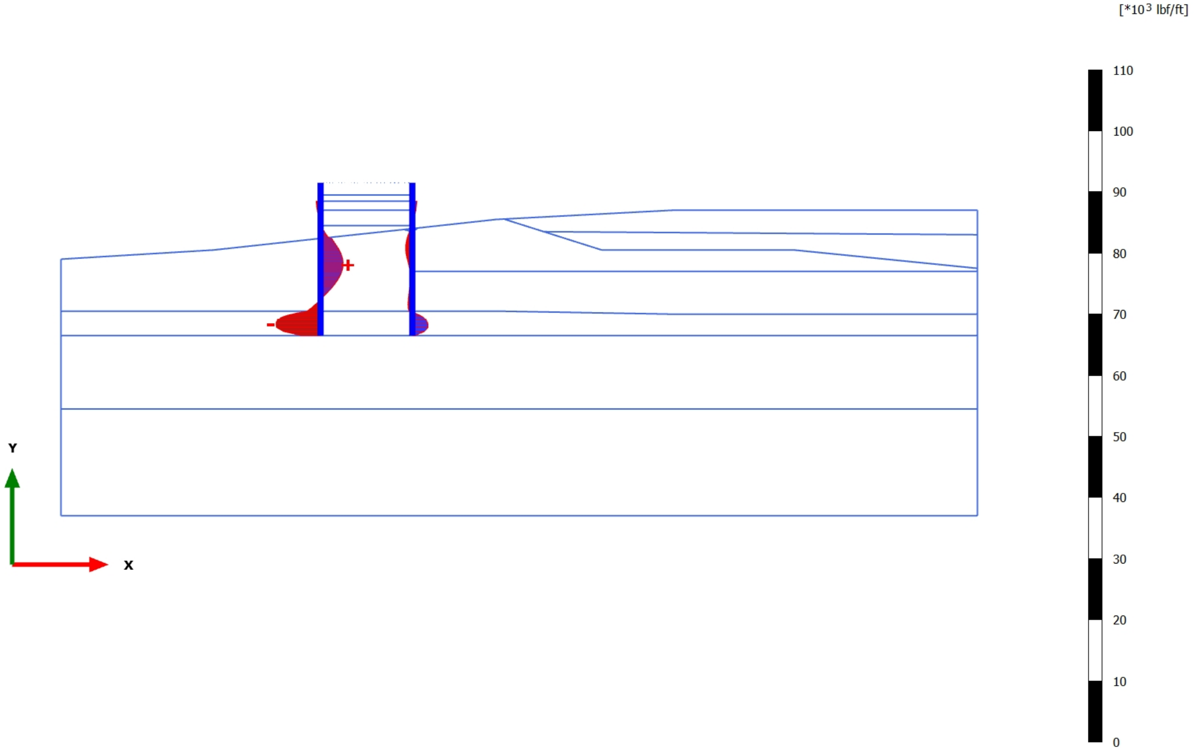


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 10.00 day)

Maximum value = 3561 lbf/ft (Element 33 at Node 3919)

Minimum value = -7371 lbf/ft (Element 47 at Node 9880)

3.1.2.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/173), Shear forces Q

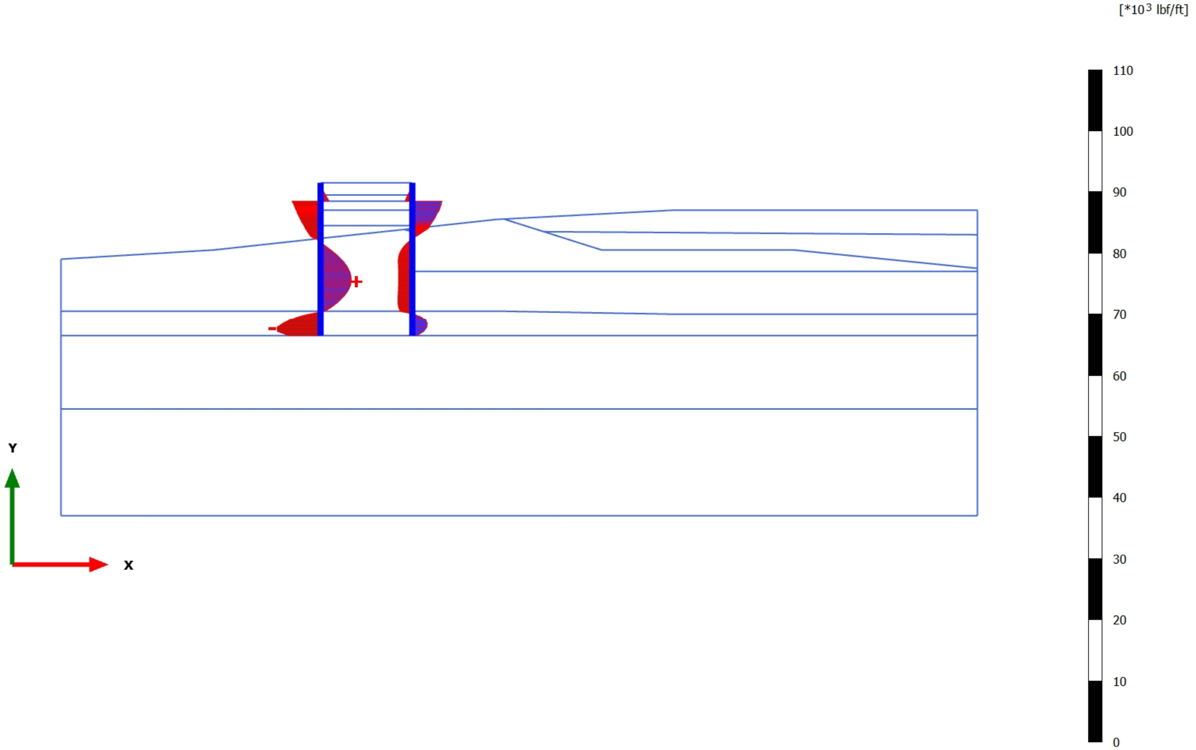


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 3692 lbf/ft (Element 33 at Node 4245)

Minimum value = -7319 lbf/ft (Element 47 at Node 9880)

3.1.2.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/188), Shear forces Q

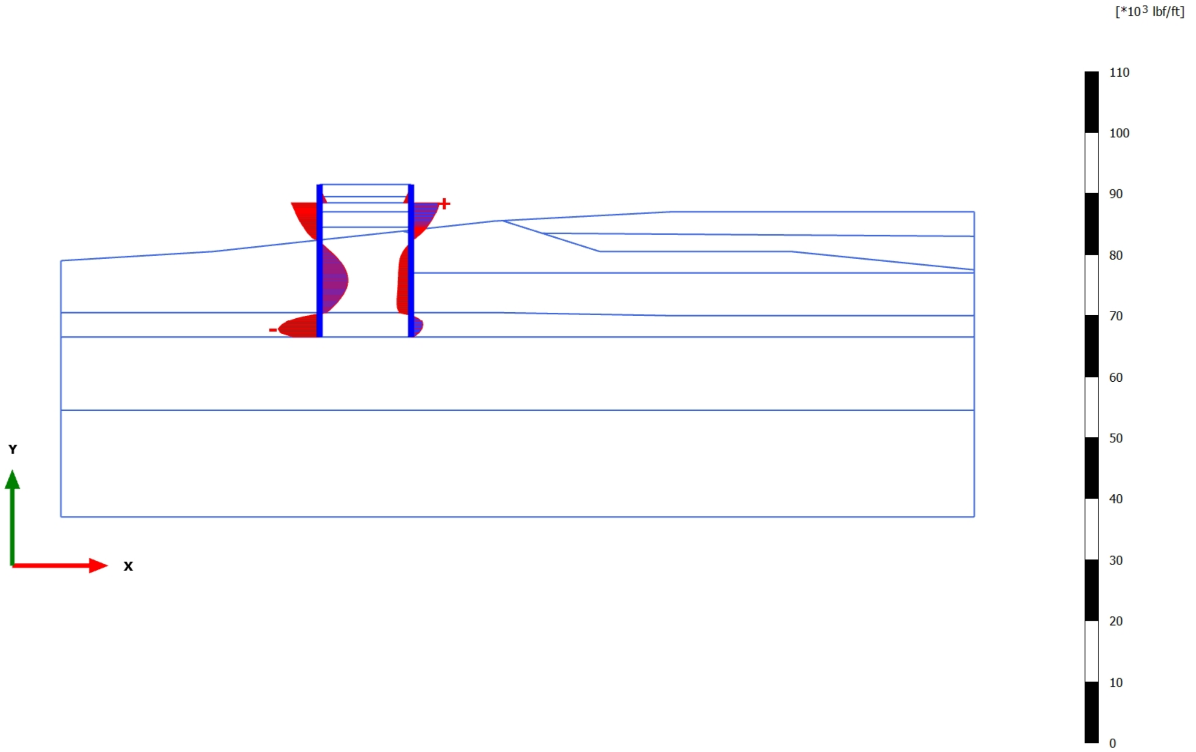


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 5023 lbf/ft (Element 36 at Node 6021)

Minimum value = -7167 lbf/ft (Element 47 at Node 9881)

3.1.2.1.6 Calculation results, Plate, Consolidate [Phase_23] (23/201), Shear forces Q

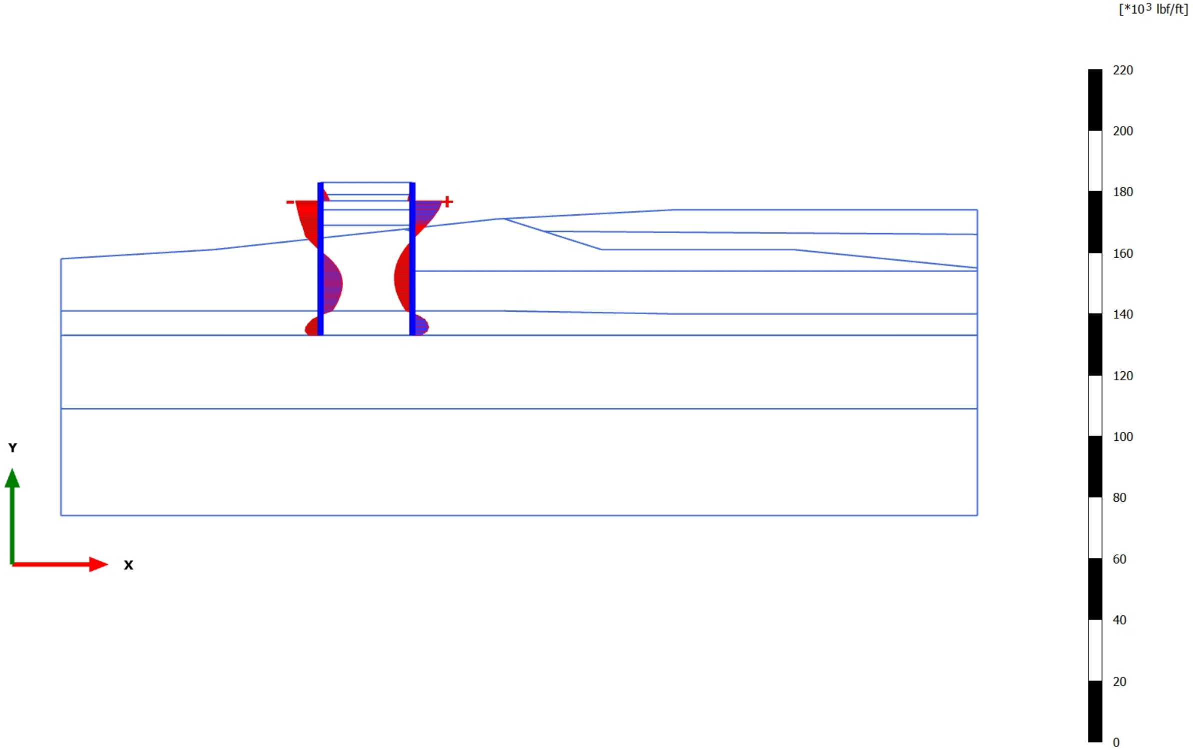


Shear forces Q (scaled up $2.00*10^{-3}$ times) (Time 16.00 day)

Maximum value = 4697 lbf/ft (Element 11 at Node 1407)

Minimum value = -6850 lbf/ft (Element 47 at Node 9881)

3.1.2.1.7 Calculation results, Plate, Dewater-SS [Phase_7] (7/217), Shear forces Q

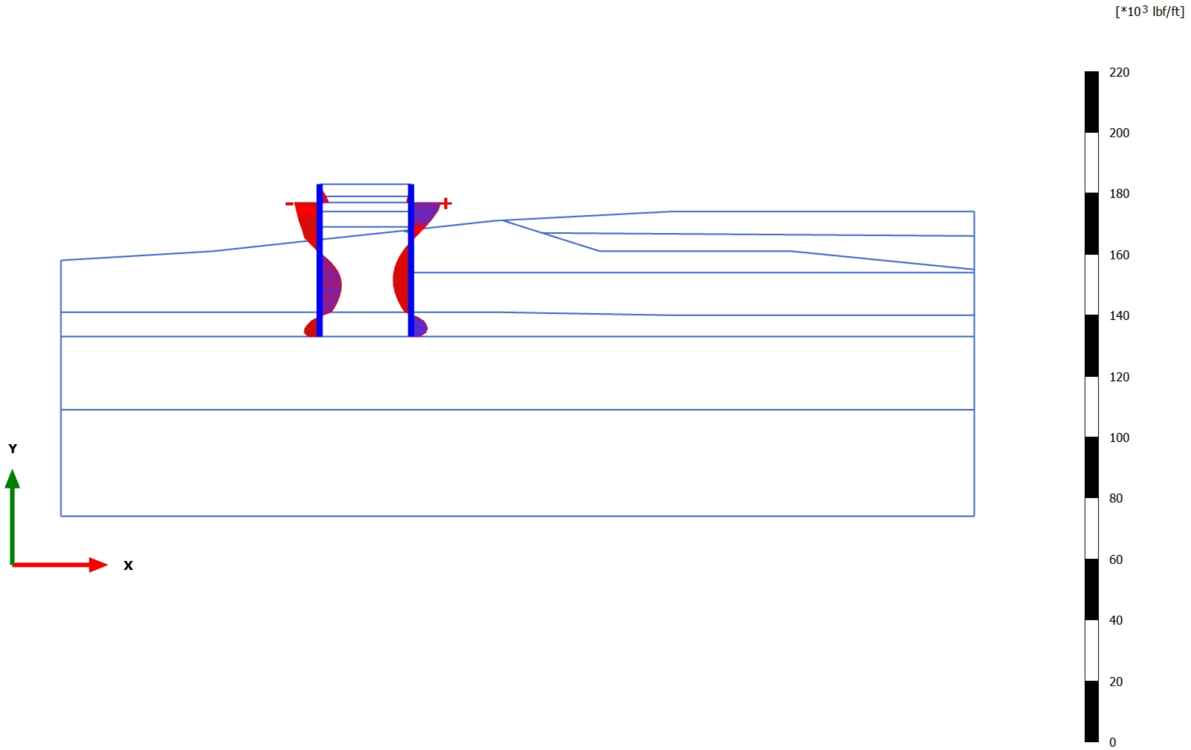


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 9712 lbf/ft (Element 11 at Node 1407)

Minimum value = -8317 lbf/ft (Element 9 at Node 21)

3.1.2.1.8 Calculation results, Plate, Consolidate [Phase_24] (24/236), Shear forces Q

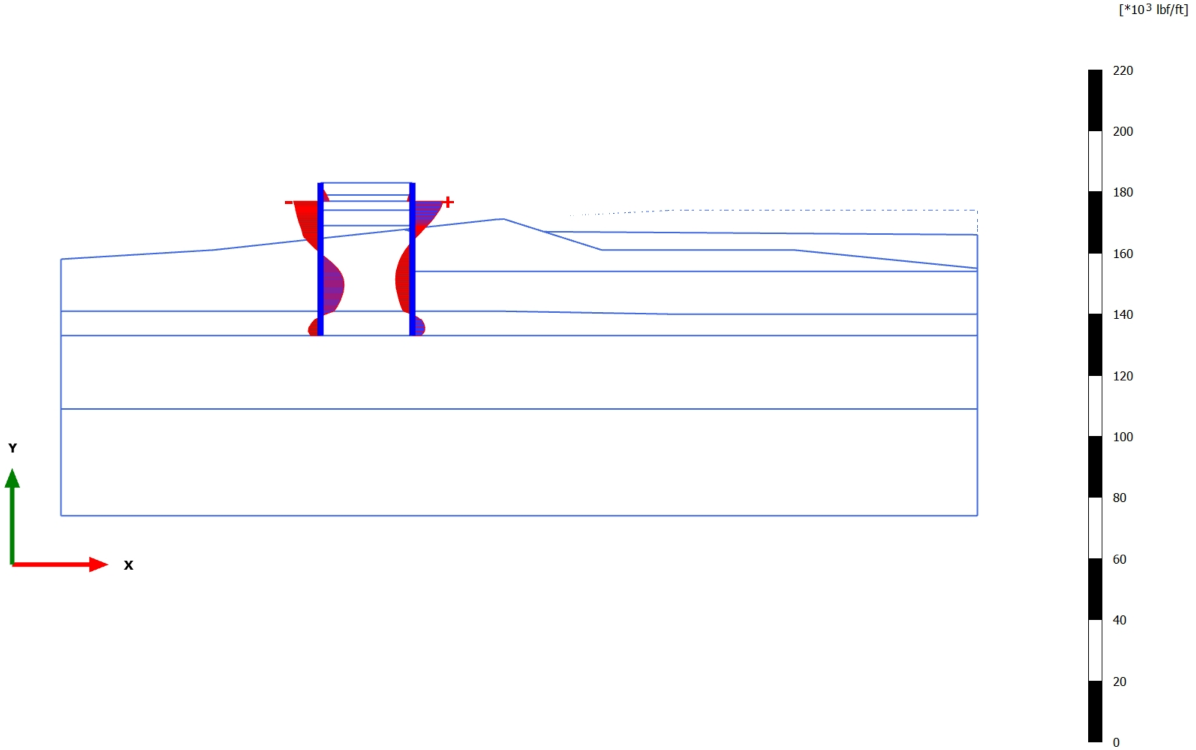


Shear forces Q (scaled up 1.00*10^{-3} times) (Time 20.00 day)

Maximum value = 9725 lbf/ft (Element 11 at Node 1407)

Minimum value = -8336 lbf/ft (Element 9 at Node 21)

3.1.2.1.9 Calculation results, Plate, Excavate 1 [Phase_8] (8/242), Shear forces Q

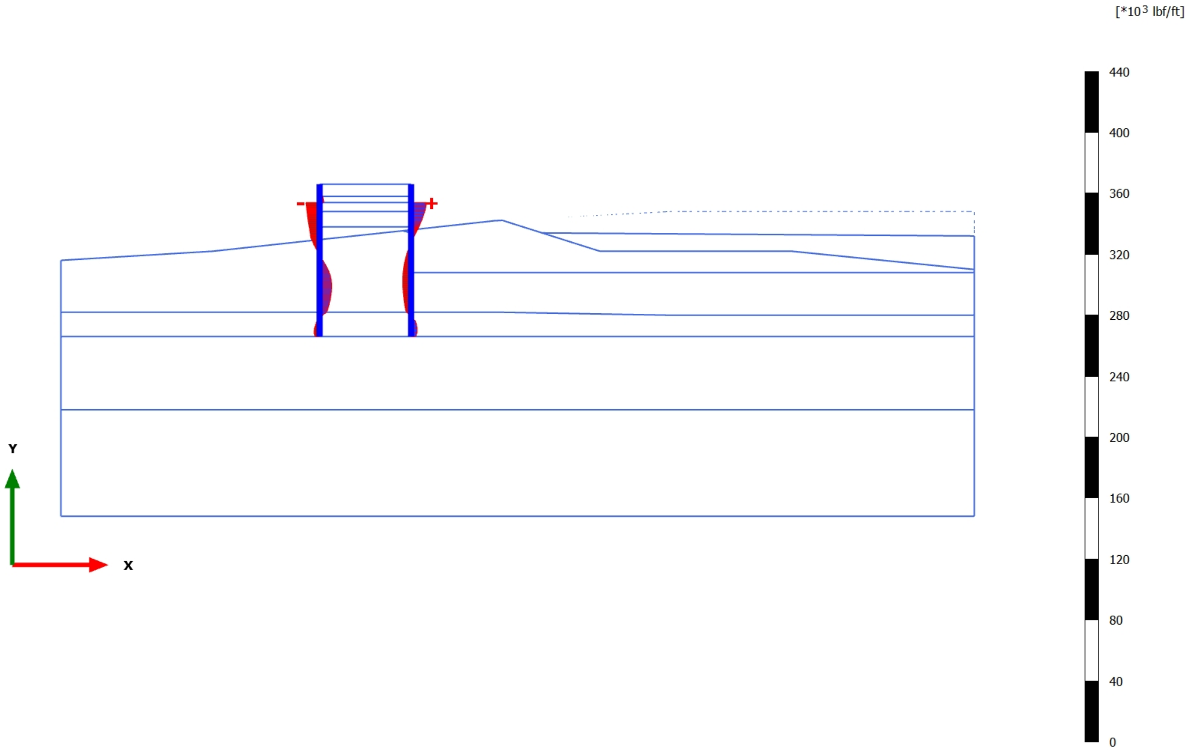


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = $10.05*10^{3}$ lbf/ft (Element 11 at Node 1407)

Minimum value = -8889 lbf/ft (Element 9 at Node 21)

3.1.2.1.10 Calculation results, Plate, Dewater-SS [Phase_9] (9/250), Shear forces Q

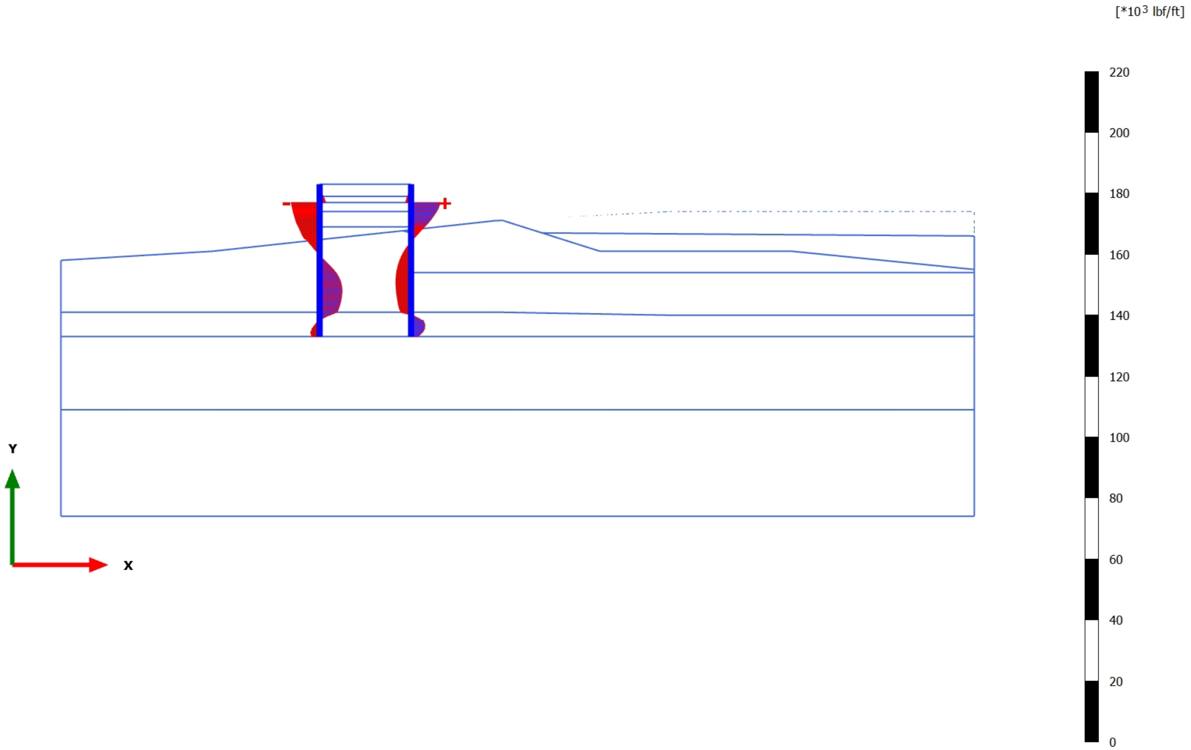


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 10.23*10^3 lbf/ft (Element 11 at Node 1407)

Minimum value = -9110 lbf/ft (Element 9 at Node 21)

3.1.2.1.11 Calculation results, Plate, Consolidate [Phase_25] (25/272), Shear forces Q

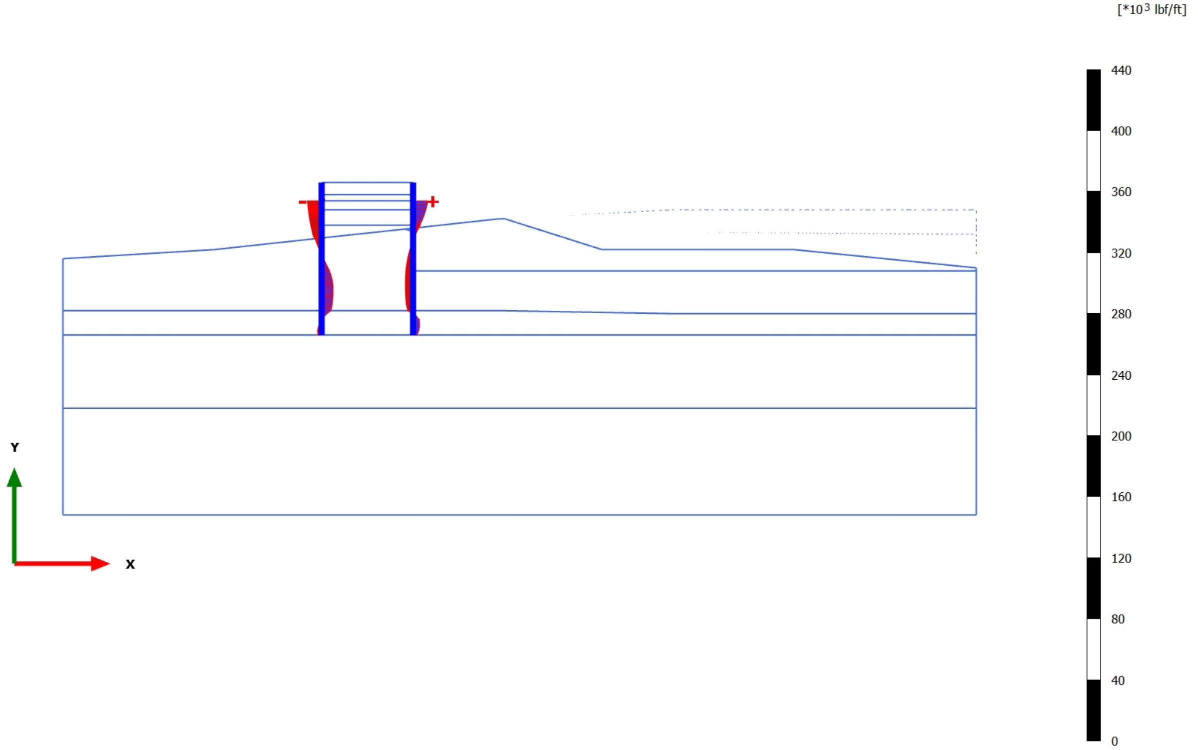


Shear forces Q (scaled up $1.00*10^{-3}$ times) (Time 37.00 day)

Maximum value = 9591 lbf/ft (Element 11 at Node 1407)

Minimum value = -9425 lbf/ft (Element 9 at Node 21)

3.1.2.1.12 Calculation results, Plate, Excavate 2 [Phase_10] (10/277), Shear forces Q

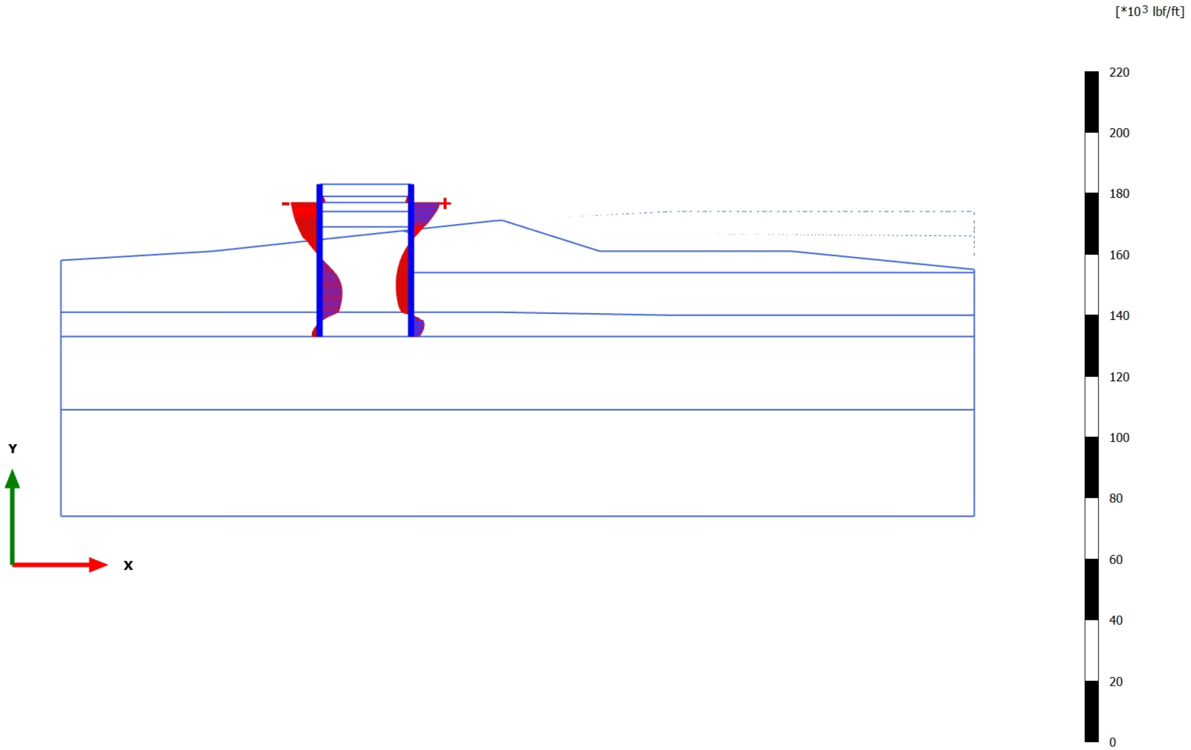


Shear forces Q (scaled up 0.500×10^{-3} times)

Maximum value = 9708 lbf/ft (Element 11 at Node 1407)

Minimum value = -9487 lbf/ft (Element 9 at Node 21)

3.1.2.1.13 Calculation results, Plate, Consolidate [Phase_26] (26/388), Shear forces Q

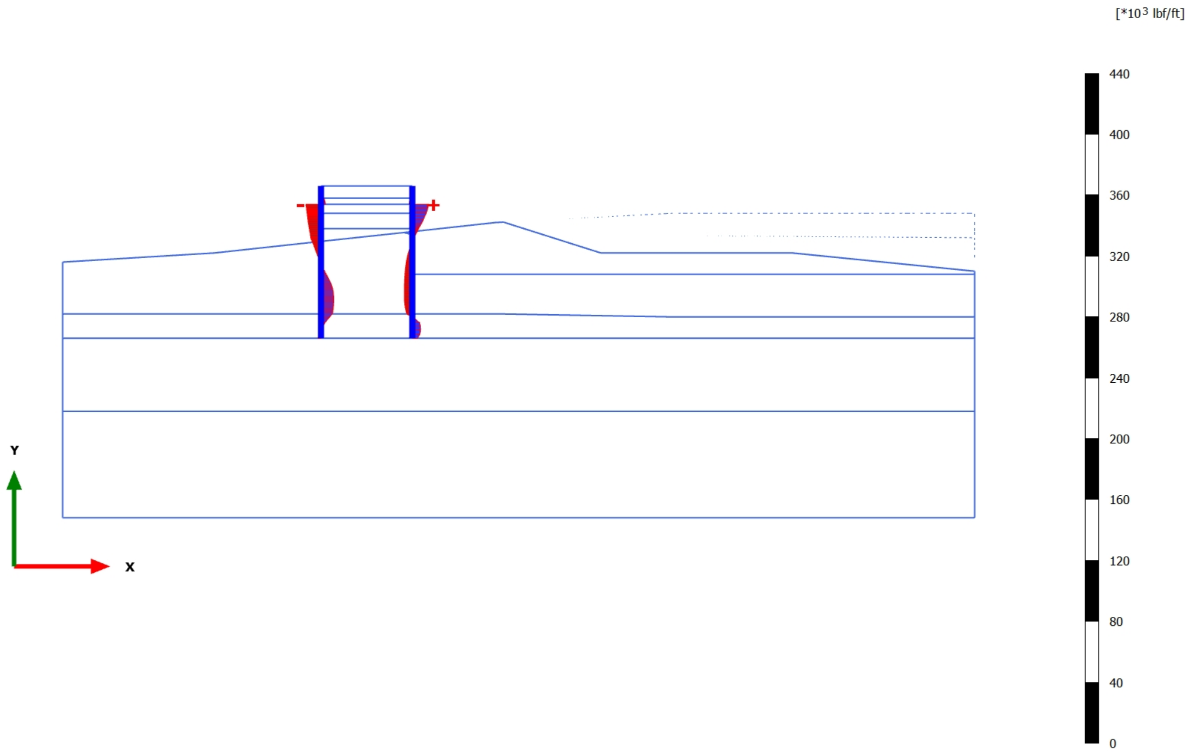


Shear forces Q (scaled up $1.00*10^{-3}$ times) (Time 51.00 day)

Maximum value = 9515 lbf/ft (Element 11 at Node 1407)

Minimum value = -9495 lbf/ft (Element 9 at Node 21)

3.1.2.1.14 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/402), Shear forces Q

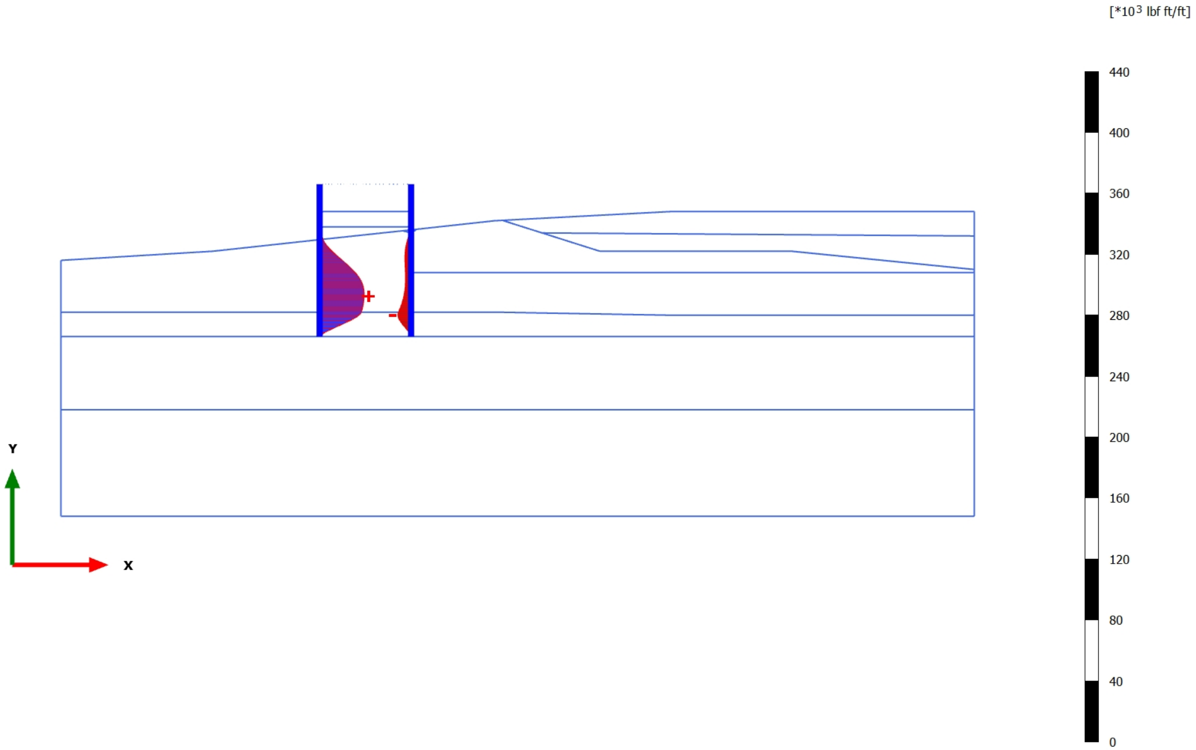


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 10.89*10^3 lbf/ft (Element 11 at Node 1407)

Minimum value = -10.09*10^3 lbf/ft (Element 9 at Node 21)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/42), Bending moments M

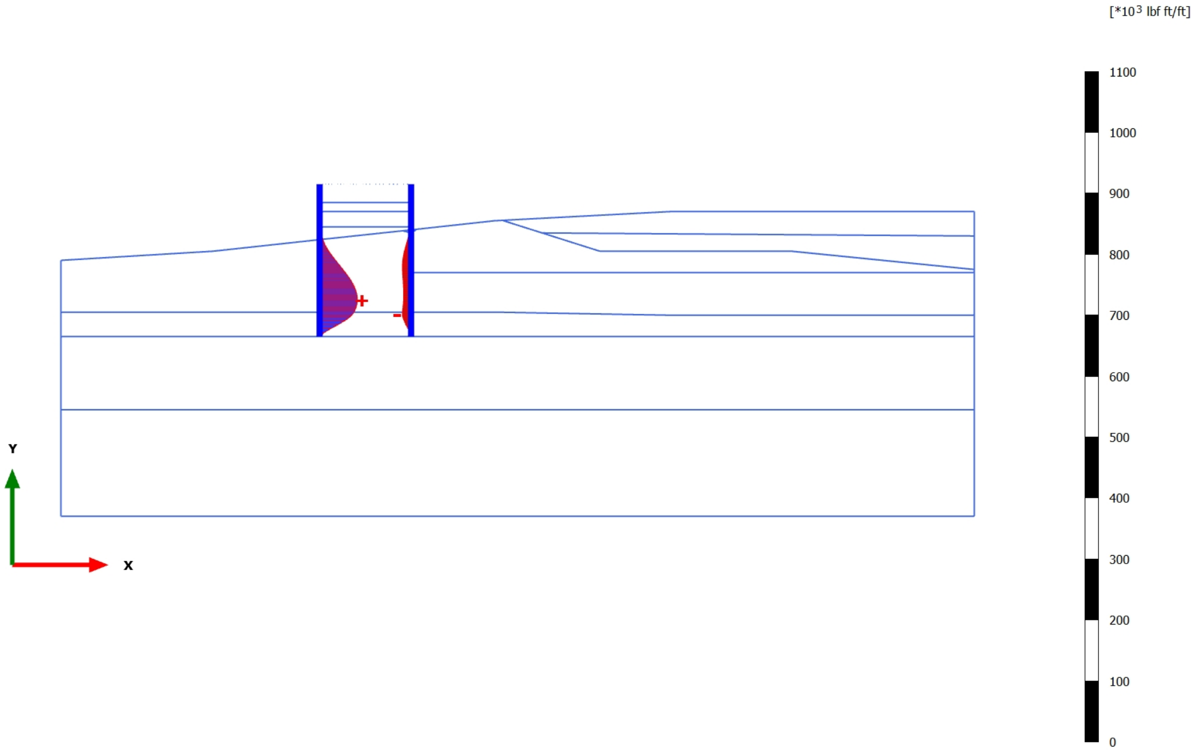


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 29.25*10^{3} lbf ft/ft (Element 38 at Node 7275)

Minimum value = -8696 lbf ft/ft (Element 48 at Node 11017)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/85), Bending moments M

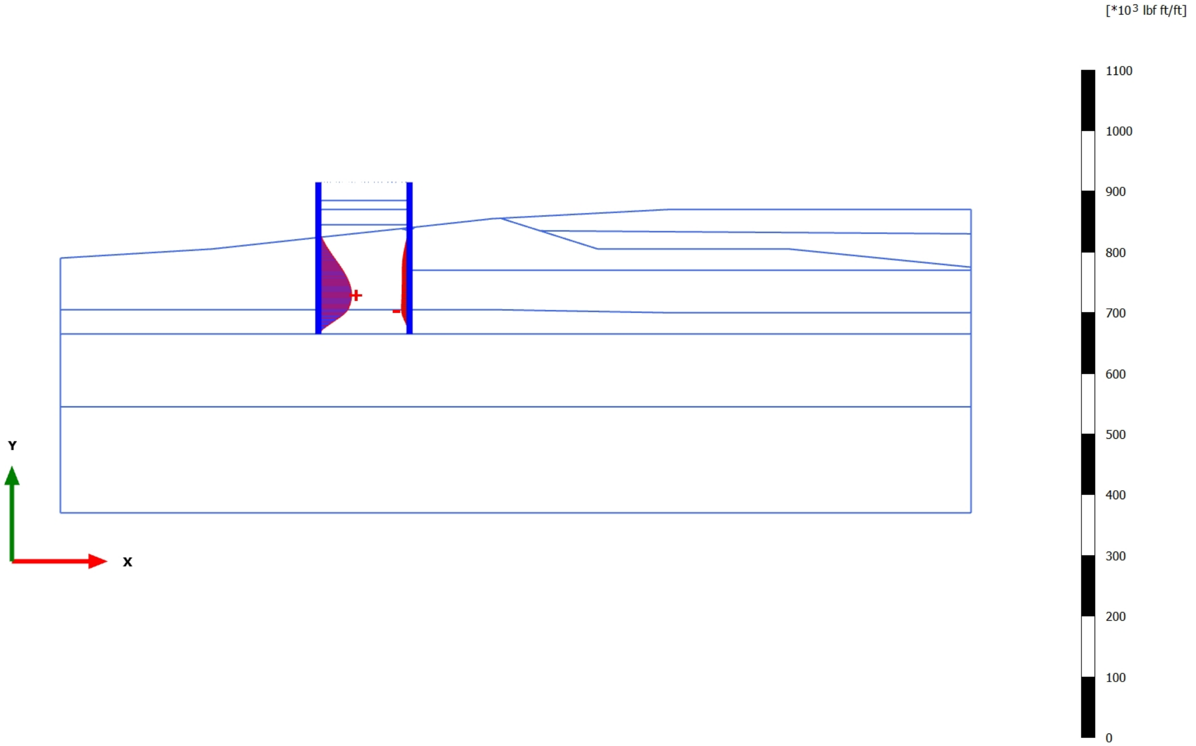


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $61.87*10^3$ lbf ft/ft (Element 39 at Node 8082)

Minimum value = $-14.35*10^3$ lbf ft/ft (Element 48 at Node 11017)

3.1.2.2.3 Calculation results, Plate, Consolidate [Phase_22] (22/167), Bending moments M

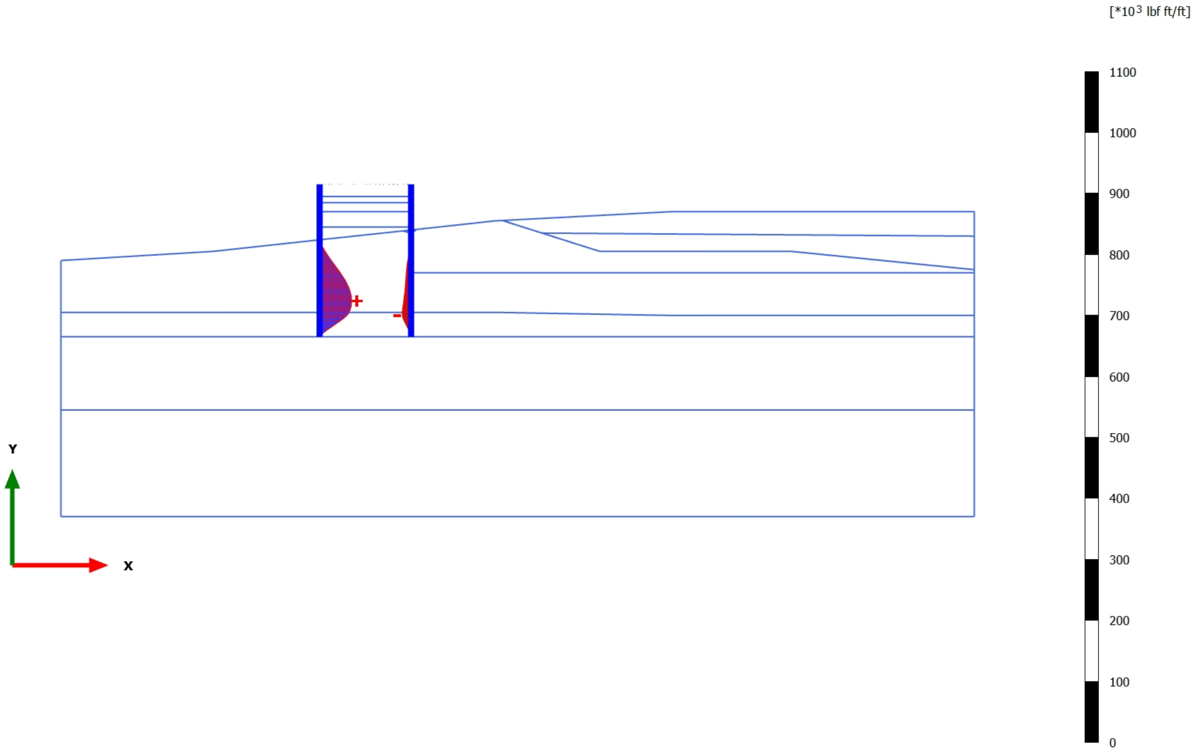


Bending moments M (scaled up 0.200*10^{-3} times) (Time 10.00 day)

Maximum value = 54.71*10^3 lbf ft/ft (Element 38 at Node 7276)

Minimum value = -13.27*10^3 lbf ft/ft (Element 48 at Node 11016)

3.1.2.2.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/173), Bending moments M

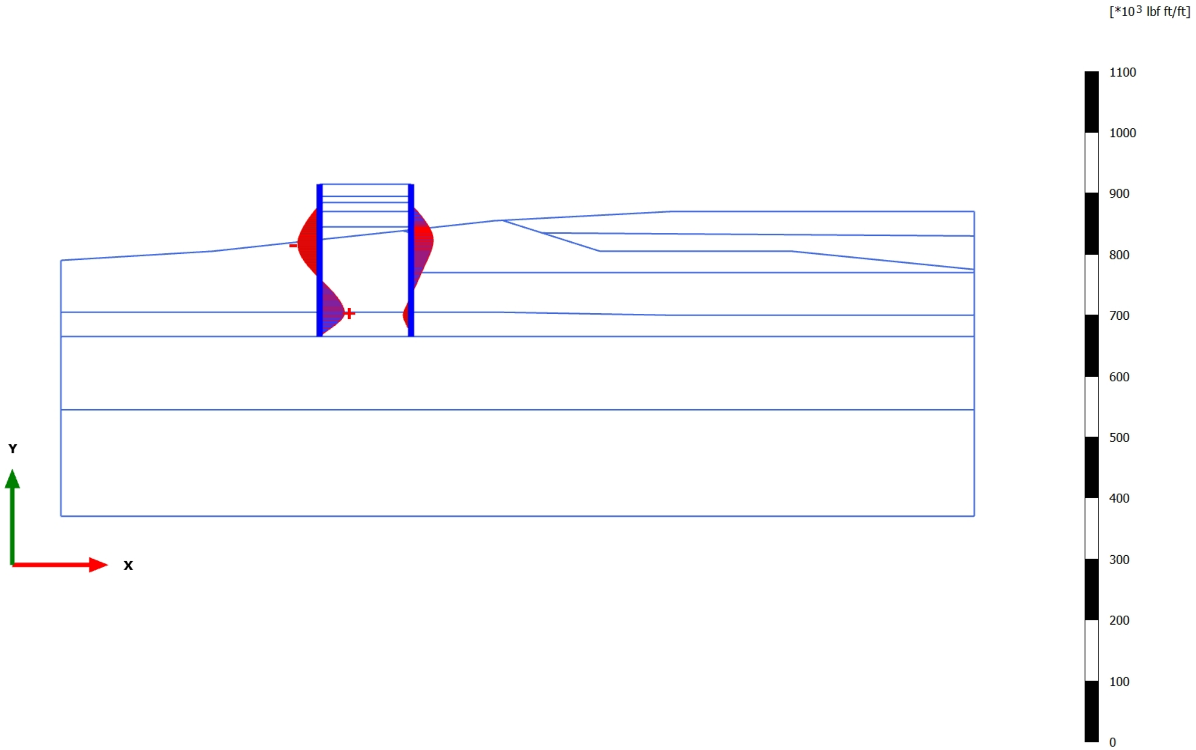


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $52.41*10^3$ lbf ft/ft (Element 39 at Node 8082)

Minimum value = $-14.55*10^3$ lbf ft/ft (Element 48 at Node 11017)

3.1.2.2.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/188), Bending moments M

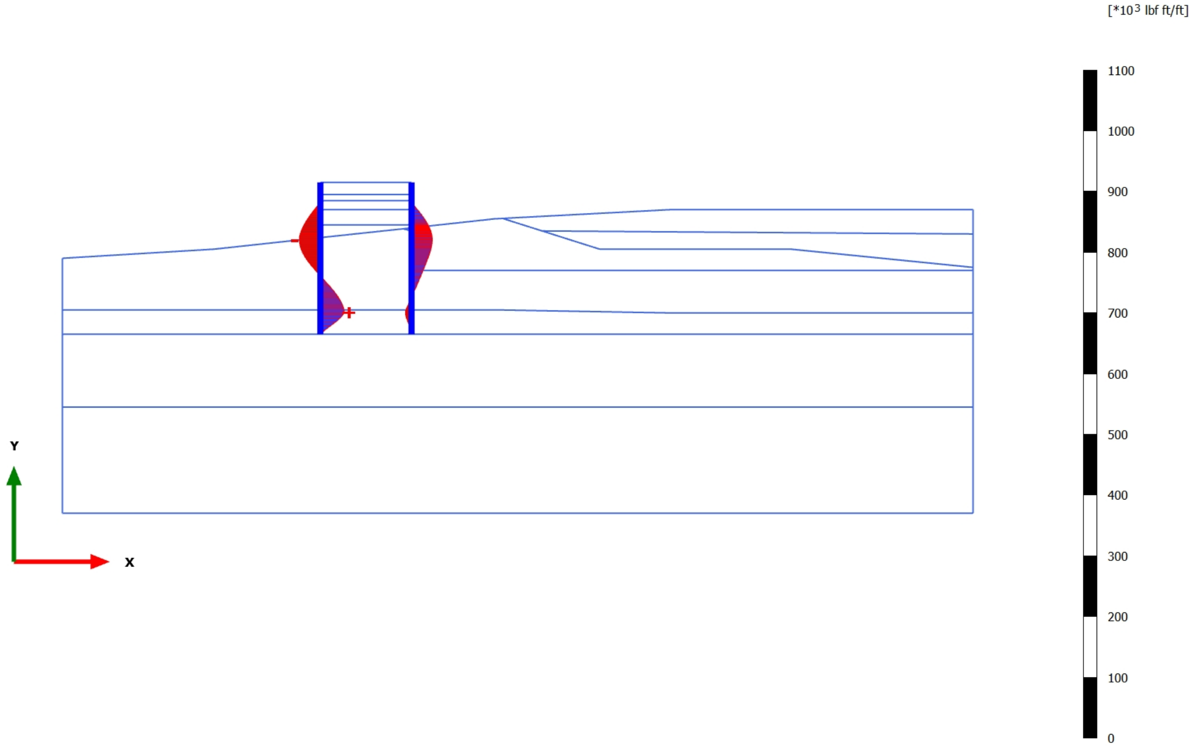


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $40.80*10^{3}$ lbf ft/ft (Element 40 at Node 9479)

Minimum value = $-35.96*10^{3}$ lbf ft/ft (Element 30 at Node 2668)

3.1.2.2.6 Calculation results, Plate, Consolidate [Phase_23] (23/201), Bending moments M

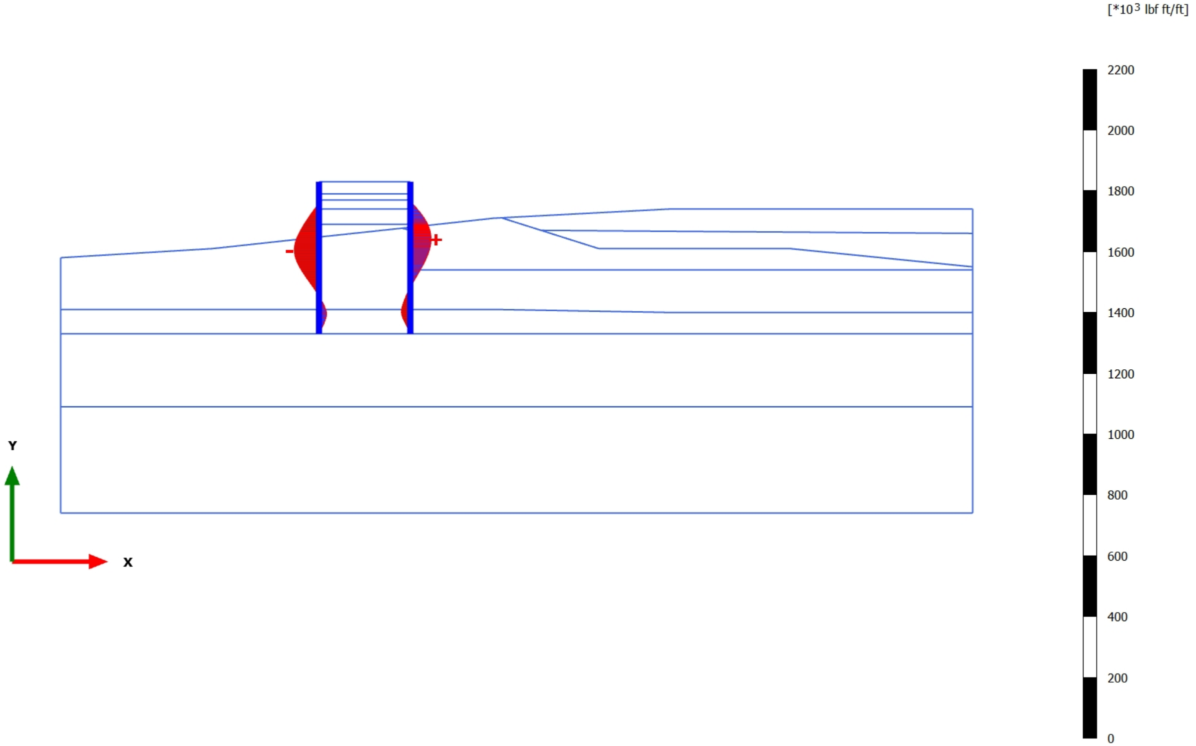


Bending moments M (scaled up 0.200*10^{-3} times) (Time 16.00 day)

Maximum value = 39.17*10^{3} lbf ft/ft (Element 46 at Node 9480)

Minimum value = -34.76*10^{3} lbf ft/ft (Element 30 at Node 2670)

3.1.2.2.7 Calculation results, Plate, Dewater-SS [Phase_7] (7/217), Bending moments M

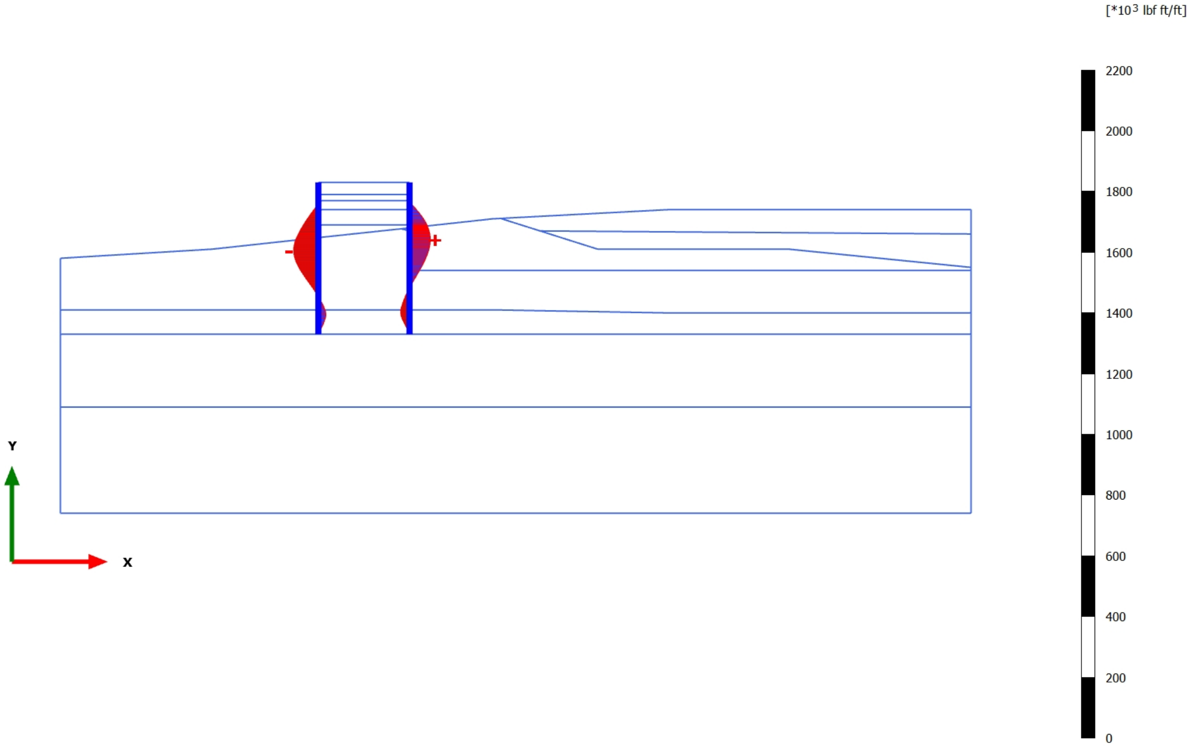


Bending moments M (scaled up 0.100*10⁻³ times)

Maximum value = 68.76*10³ lbf ft/ft (Element 24 at Node 3865)

Minimum value = -81.52*10³ lbf ft/ft (Element 32 at Node 3427)

3.1.2.2.8 Calculation results, Plate, Consolidate [Phase_24] (24/236), Bending moments M

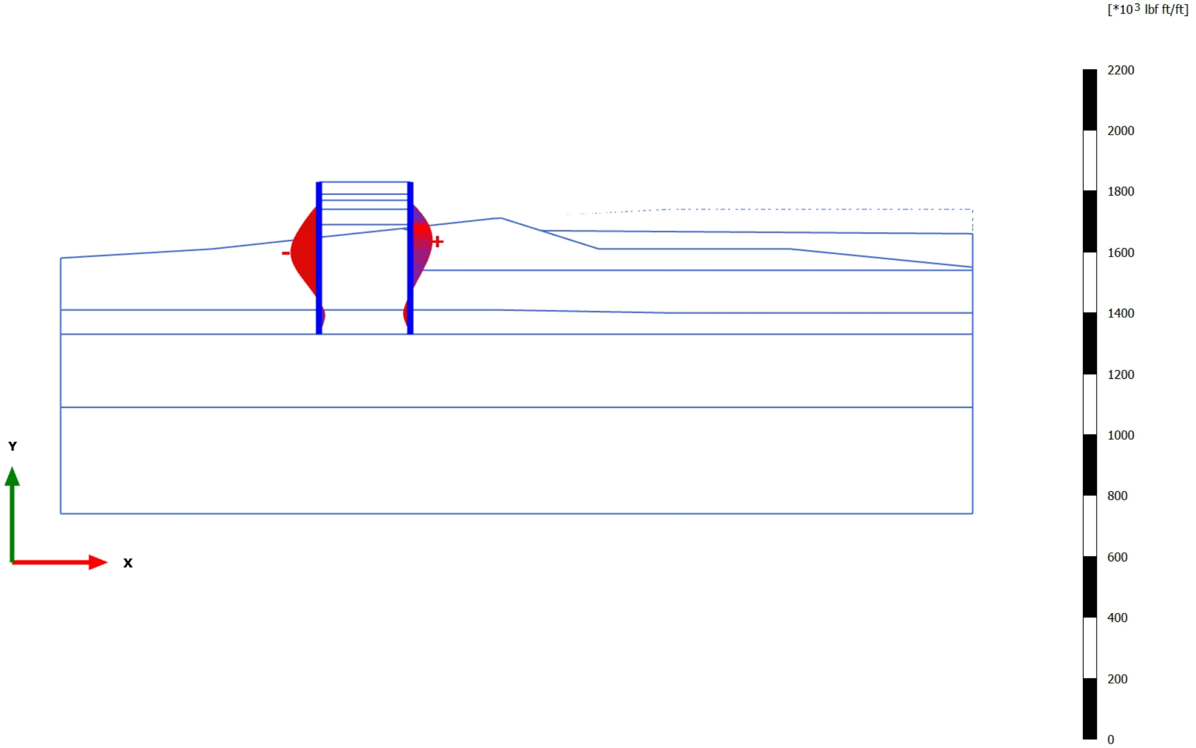


Bending moments M (scaled up 0.100*10⁻³ times) (Time 20.00 day)

Maximum value = 68.86*10³ lbf ft/ft (Element 24 at Node 3865)

Minimum value = -81.67*10³ lbf ft/ft (Element 31 at Node 3427)

3.1.2.2.9 Calculation results, Plate, Excavate 1 [Phase_8] (8/242), Bending moments M

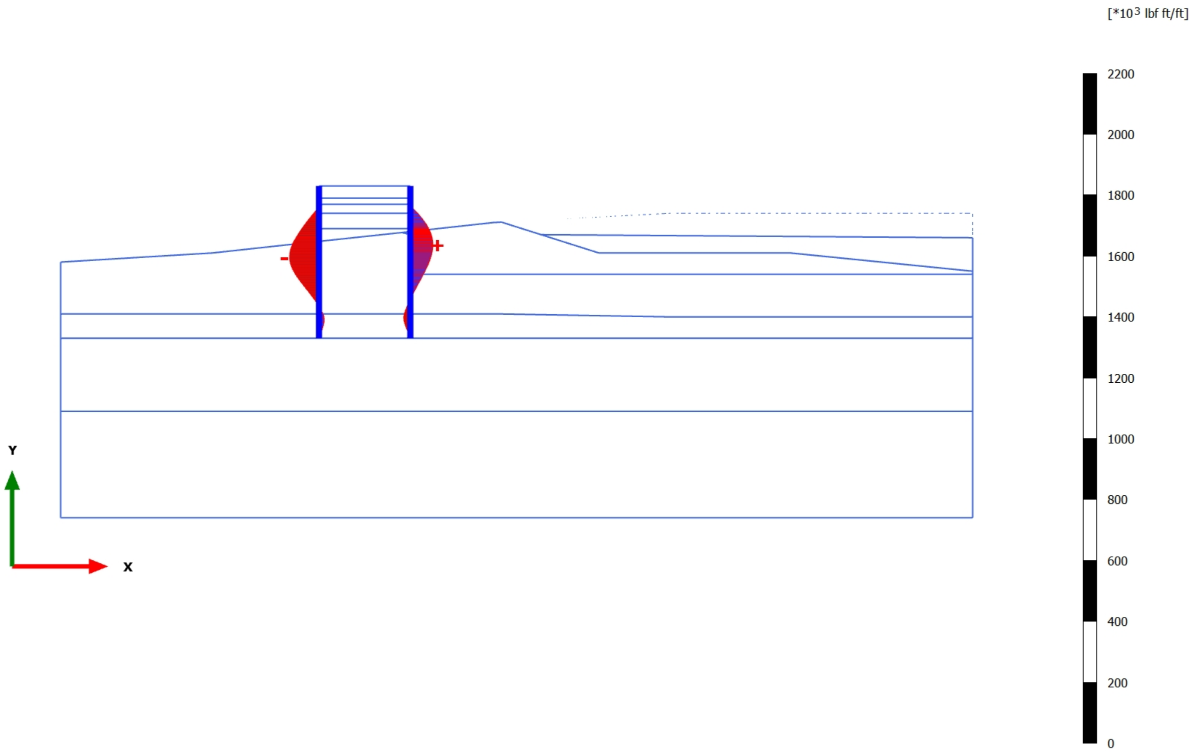


Bending moments M (scaled up $0.100*10^{-3}$ times)

Maximum value = $72.41*10^{3}$ lbf ft/ft (Element 24 at Node 3866)

Minimum value = $-92.74*10^{3}$ lbf ft/ft (Element 32 at Node 3430)

3.1.2.2.10 Calculation results, Plate, Dewater-SS [Phase_9] (9/250), Bending moments M

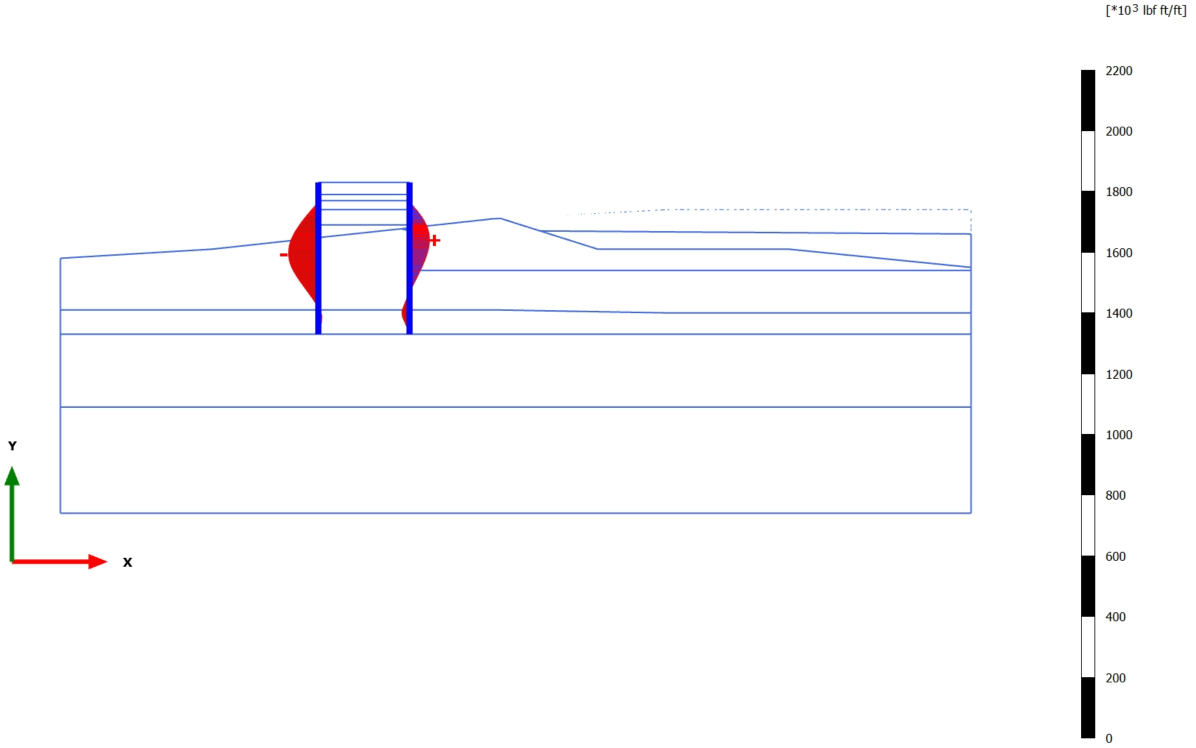


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 74.52*10^3 lbf ft/ft (Element 24 at Node 3866)

Minimum value = -96.96*10^3 lbf ft/ft (Element 32 at Node 3429)

3.1.2.2.11 Calculation results, Plate, Consolidate [Phase_25] (25/272), Bending moments M

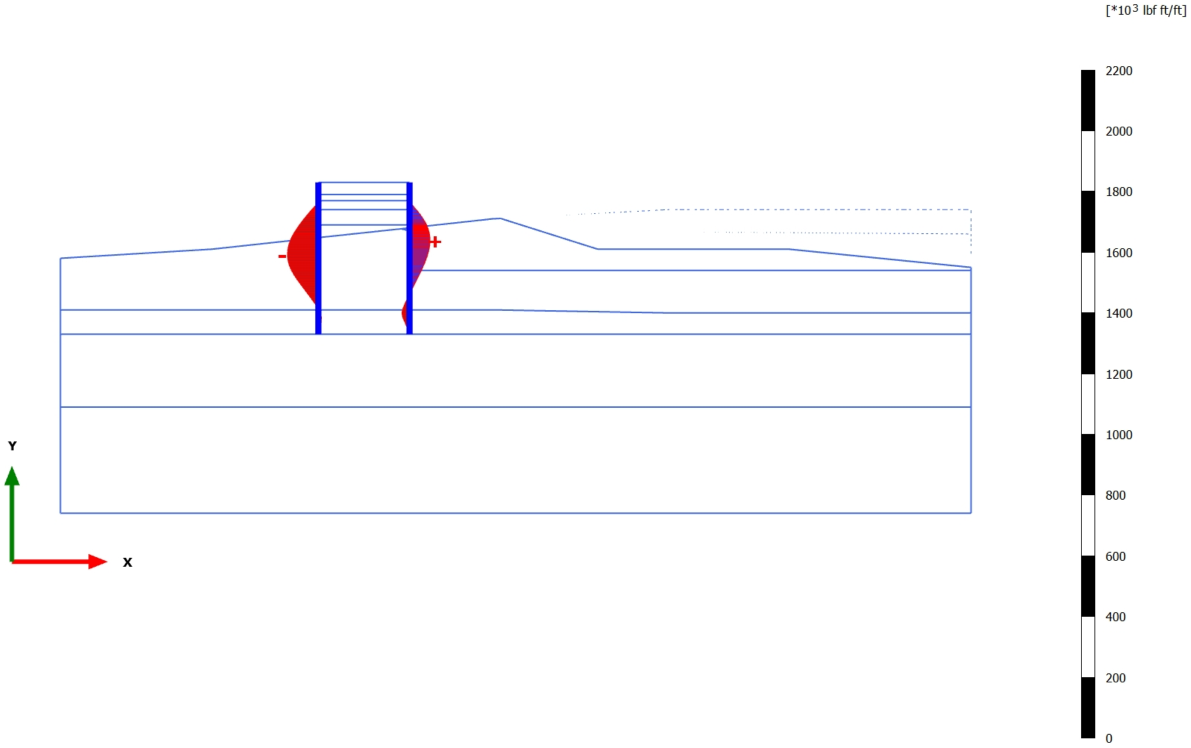


Bending moments M (scaled up $0.100*10^{-3}$ times) (Time 37.00 day)

Maximum value = $65.89*10^{3}$ lbf ft/ft (Element 24 at Node 3865)

Minimum value = $-98.30*10^{3}$ lbf ft/ft (Element 32 at Node 3429)

3.1.2.2.12 Calculation results, Plate, Excavate 2 [Phase_10] (10/277), Bending moments M

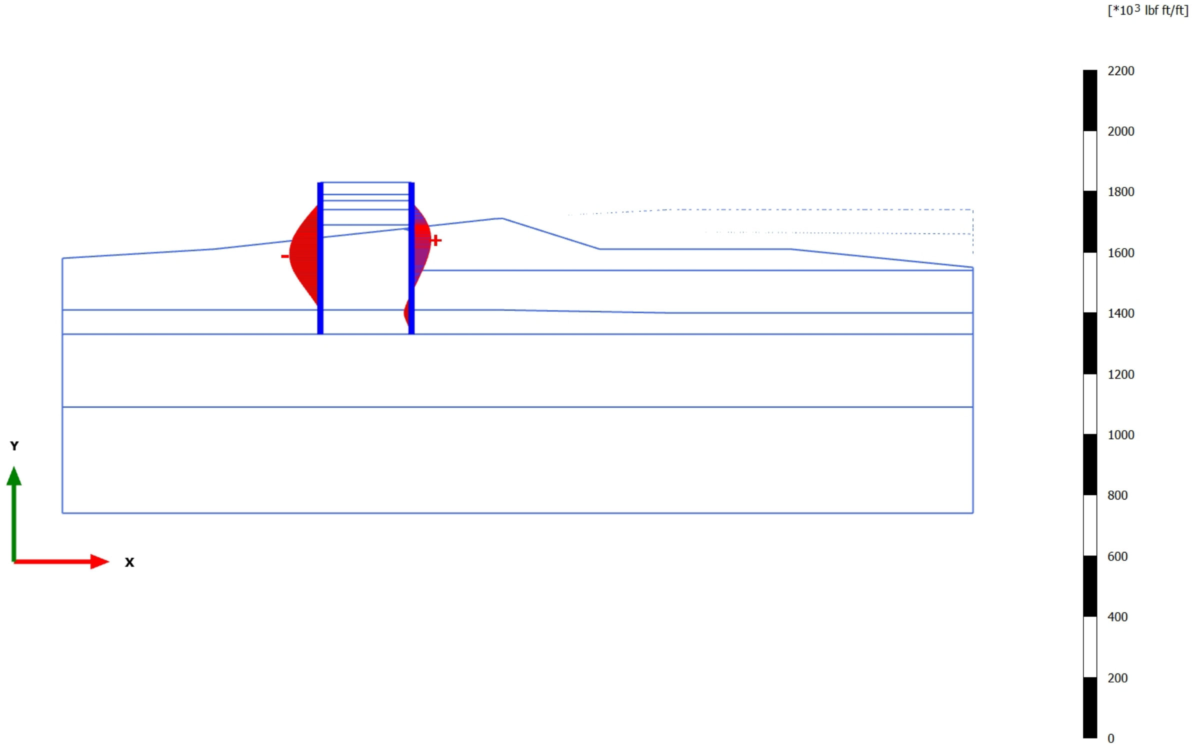


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 67.64*10^{3} lbf ft/ft (Element 24 at Node 3866)

Minimum value = -101.9*10^{3} lbf ft/ft (Element 32 at Node 3428)

3.1.2.2.13 Calculation results, Plate, Consolidate [Phase_26] (26/388), Bending moments M

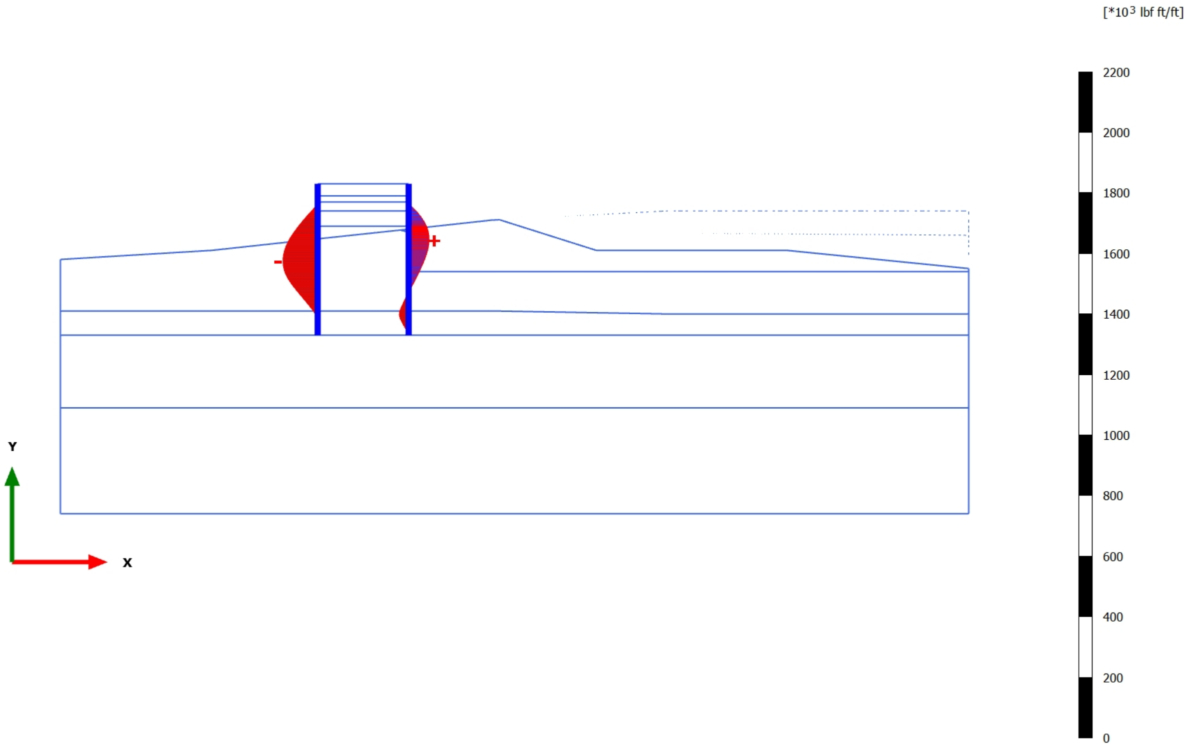


Bending moments M (scaled up 0.100×10^{-3} times) (Time 51.00 day)

Maximum value = 63.99×10^{3} lbf ft/ft (Element 24 at Node 3865)

Minimum value = -101.5×10^{3} lbf ft/ft (Element 32 at Node 3428)

3.1.2.2.14 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/402), Bending moments M



Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 67.83*10^3 lbf ft/ft (Element 24 at Node 3864)

Minimum value = -114.9*10^3 lbf ft/ft (Element 33 at Node 3919)

3.2.1.1.3 Calculation results, Node-to-node anchor, Consolidate [Phase_22] (22/167), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	1344.816	0.000	1690.653
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	1344.816	0.000	1690.653

3.2.1.1.4 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/173), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	8165.002	0.000	8165.002
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	8165.002	0.000	8165.002

3.2.1.1.5 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/188), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	60.696	0.000	60.696
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	60.696	0.000	60.696

3.2.1.1.6 Calculation results, Node-to-node anchor, Consolidate [Phase_23] (23/201), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	59.037	0.000	60.826
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	59.037	0.000	60.826

3.2.1.1.7 Calculation results, Node-to-node anchor, Dewater-SS [Phase_7] (7/217), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	112.247	0.000	112.247
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	112.247	0.000	112.247

3.2.1.1.8 Calculation results, Node-to-node anchor, Consolidate [Phase_24] (24/236), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	112.383	0.000	112.383
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	112.383	0.000	112.383

3.2.1.1.9 Calculation results, Node-to-node anchor, Excavate 1 [Phase_8] (8/242), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	117.162	0.000	117.162
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	117.162	0.000	117.162

3.2.1.1.10 Calculation results, Node-to-node anchor, Dewater-SS [Phase_9] (9/250), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	119.379	0.000	119.379
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	119.379	0.000	119.379

3.2.1.1.11 Calculation results, Node-to-node anchor, Consolidate [Phase_25] (25/272), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	113.890	0.000	119.676
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	113.890	0.000	119.676

3.2.1.1.12 Calculation results, Node-to-node anchor, Excavate 2 [Phase_10] (10/277), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	115.613	0.000	119.676
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	115.613	0.000	119.676

3.2.1.1.13 Calculation results, Node-to-node anchor, Consolidate [Phase_26] (26/388), Table of node-to-node anchors

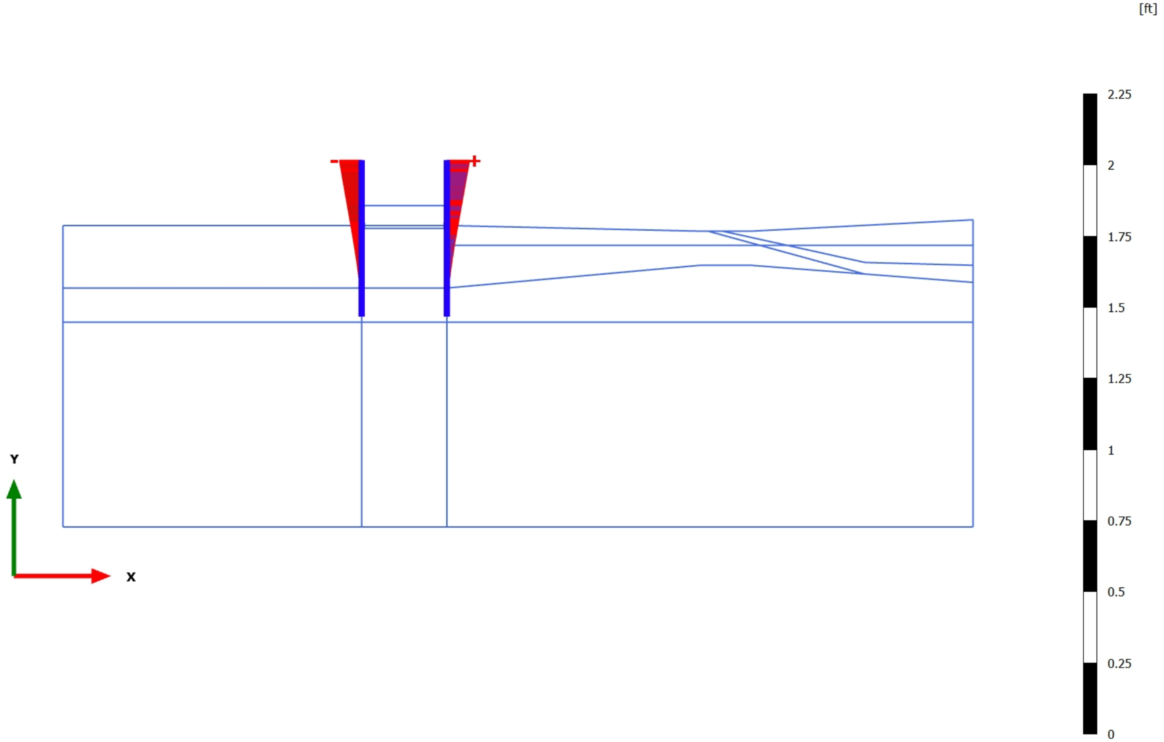
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	113.616	0.000	119.676
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	113.616	0.000	119.676

3.2.1.1.14 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/402), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	21	1	-15.000	3.000	130.503	0.000	130.503
Element 2-2 (Node-to-node anchor)	1407	2	15.000	3.000	130.503	0.000	130.503

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/51), Total displacements u_x

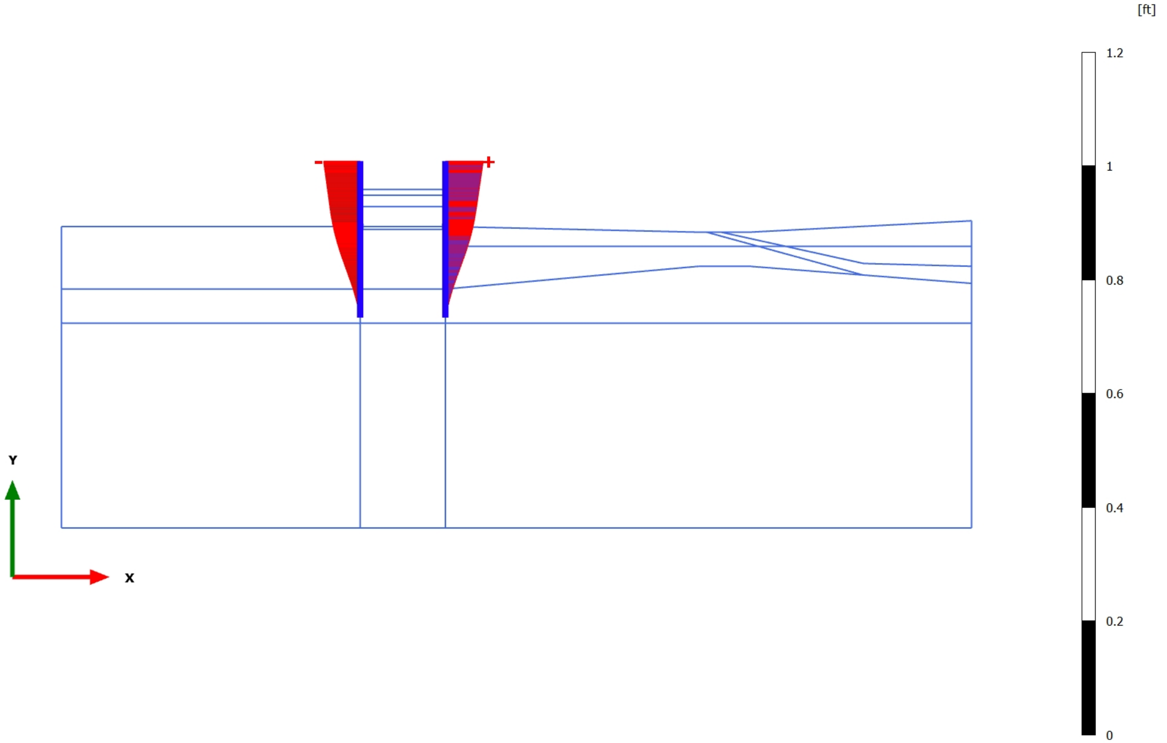


Total displacements u_x (scaled up 100 times)

Maximum value = 0.08043 ft (Element 2 at Node 2619)

Minimum value = -0.07866 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/69), Total displacements u_x

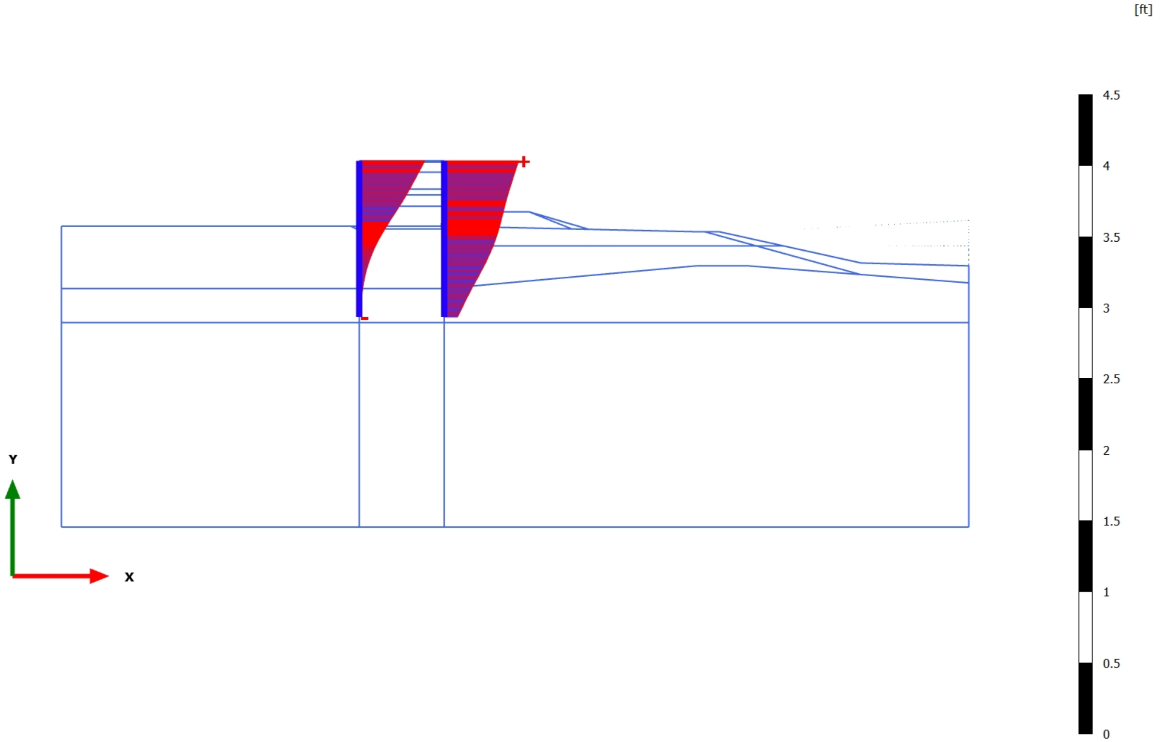


Total displacements u_x (scaled up 200 times)

Maximum value = 0.06669 ft (Element 2 at Node 2619)

Minimum value = -0.06433 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Excavation 2 [Phase_10] (10/71), Total displacements u_x

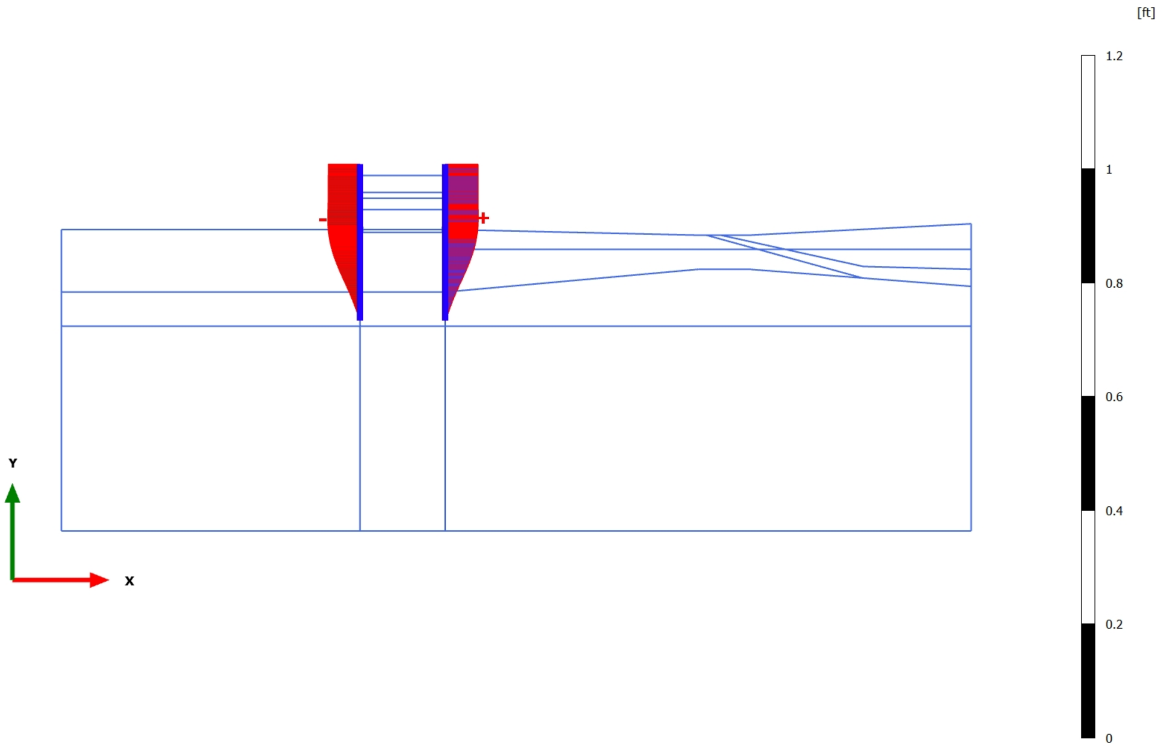


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5251 ft (Element 2 at Node 2619)

Minimum value = 4.972×10^{-3} ft (Element 68 at Node 23173)

3.1.1.1.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/116), Total displacements u_x

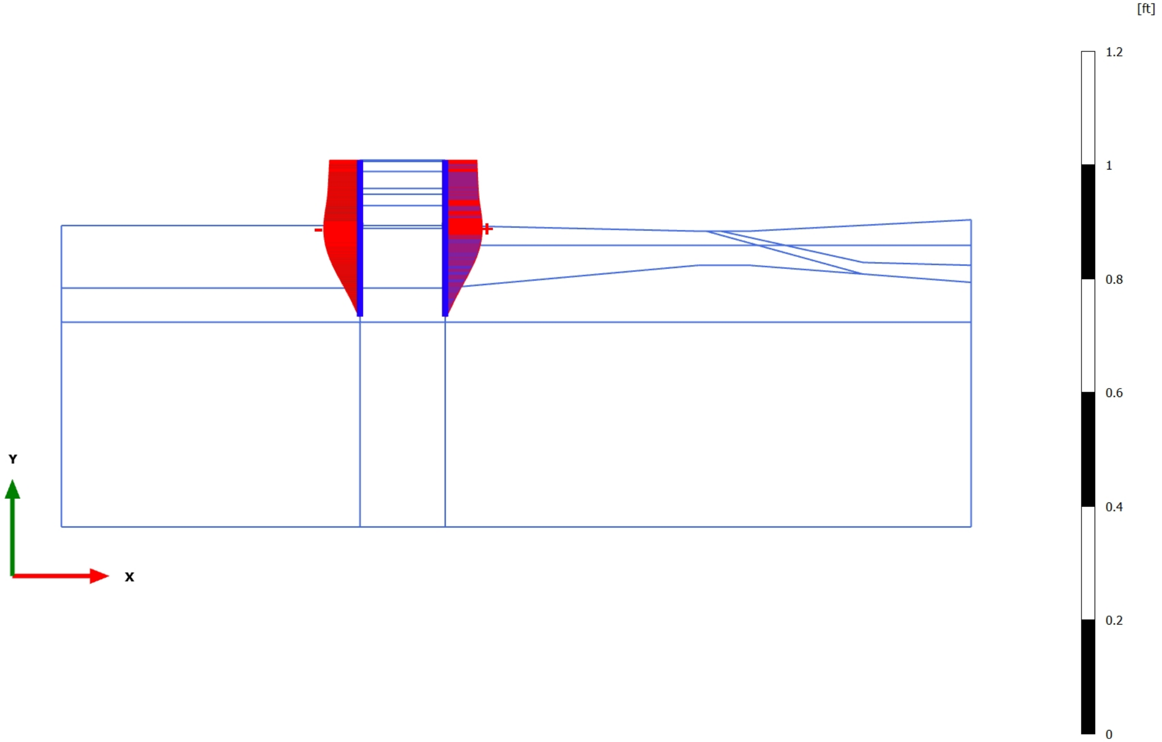


Total displacements u_x (scaled up 200 times)

Maximum value = 0.05826 ft (Element 24 at Node 11069)

Minimum value = -0.05676 ft (Element 23 at Node 651)

3.1.1.1.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/128), Total displacements u_x

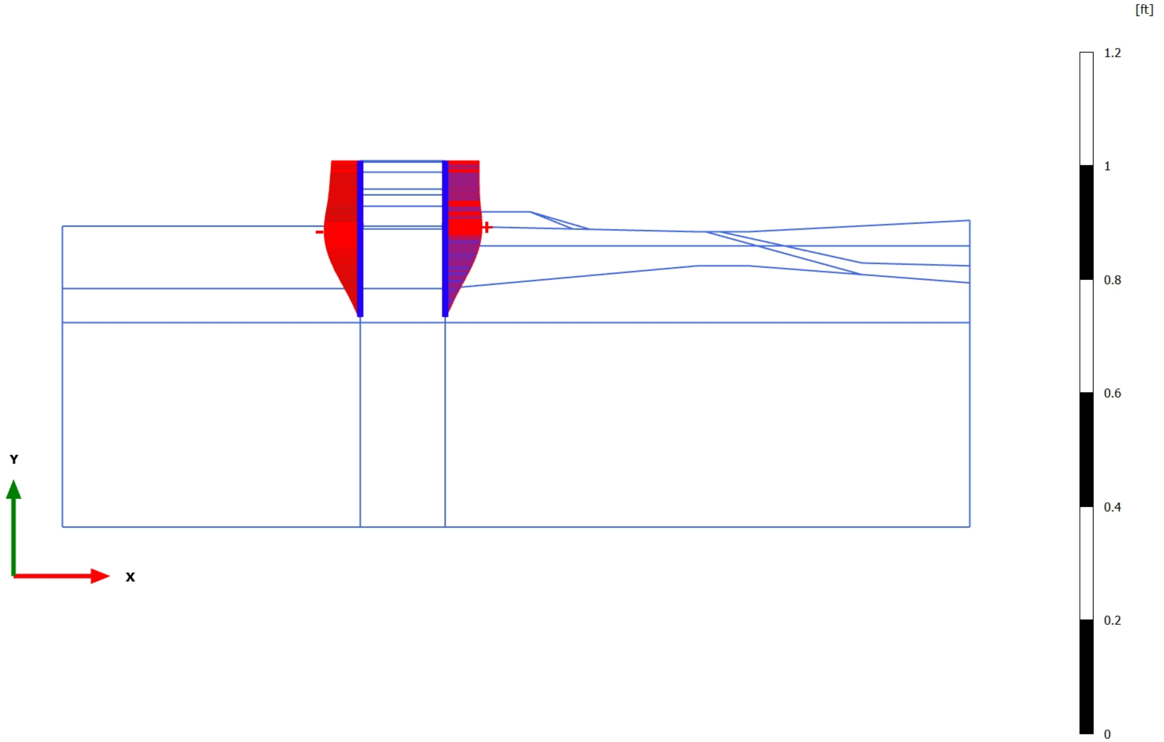


Total displacements u_x (scaled up 200 times)

Maximum value = 0.06519 ft (Element 37 at Node 14682)

Minimum value = -0.06379 ft (Element 46 at Node 6728)

3.1.1.1.1.6 Calculation results, Plate, Buttress fill [Phase_4] (7/153), Total displacements u_x

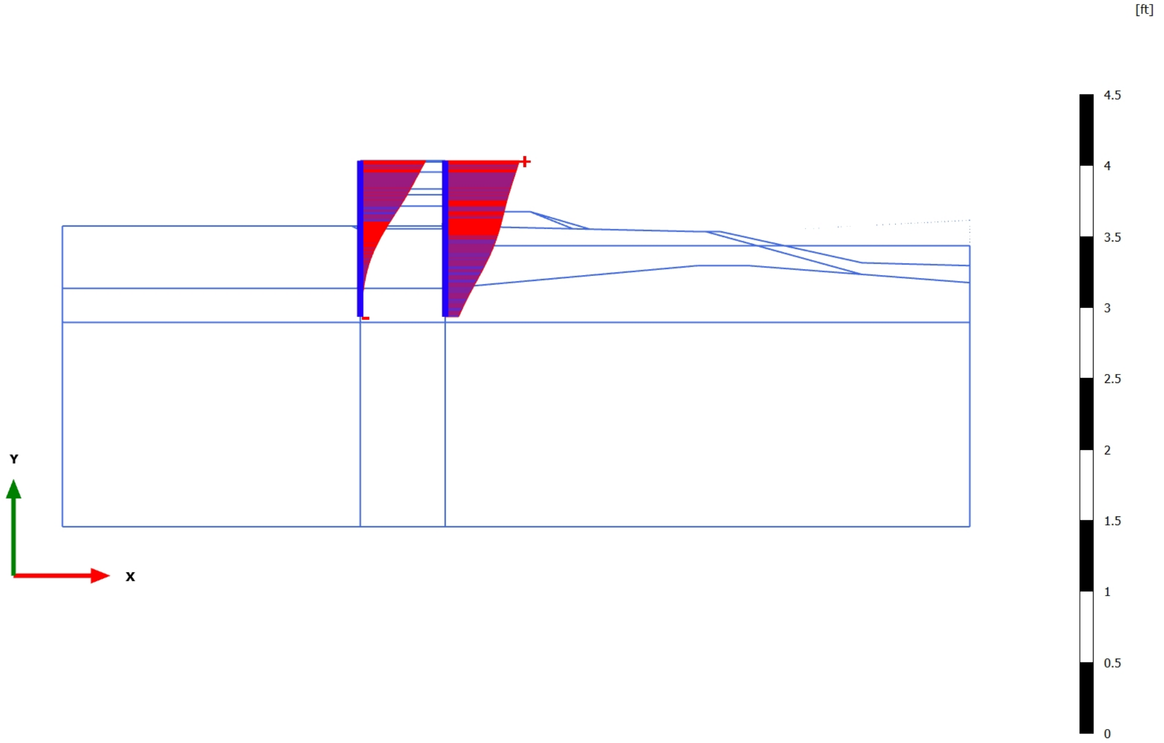


Total displacements u_x (scaled up 200 times)

Maximum value = 0.06475 ft (Element 33 at Node 13157)

Minimum value = -0.06354 ft (Element 46 at Node 7259)

3.1.1.1.1.7 Calculation results, Plate, Excavation 1 [Phase_8] (8/264), Total displacements u_x

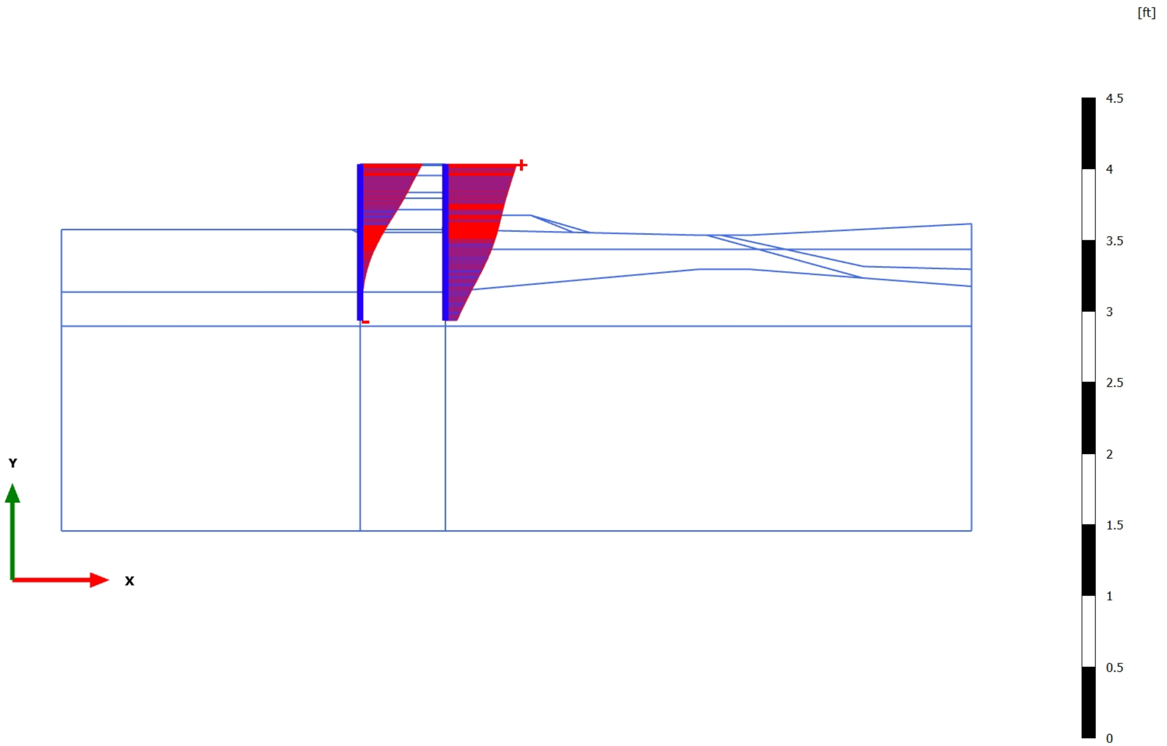


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5241 ft (Element 2 at Node 2619)

Minimum value = 4.373×10^{-3} ft (Element 68 at Node 23173)

3.1.1.1.1.8 Calculation results, Plate, Dewater [Phase_7] (4/392), Total displacements u_x

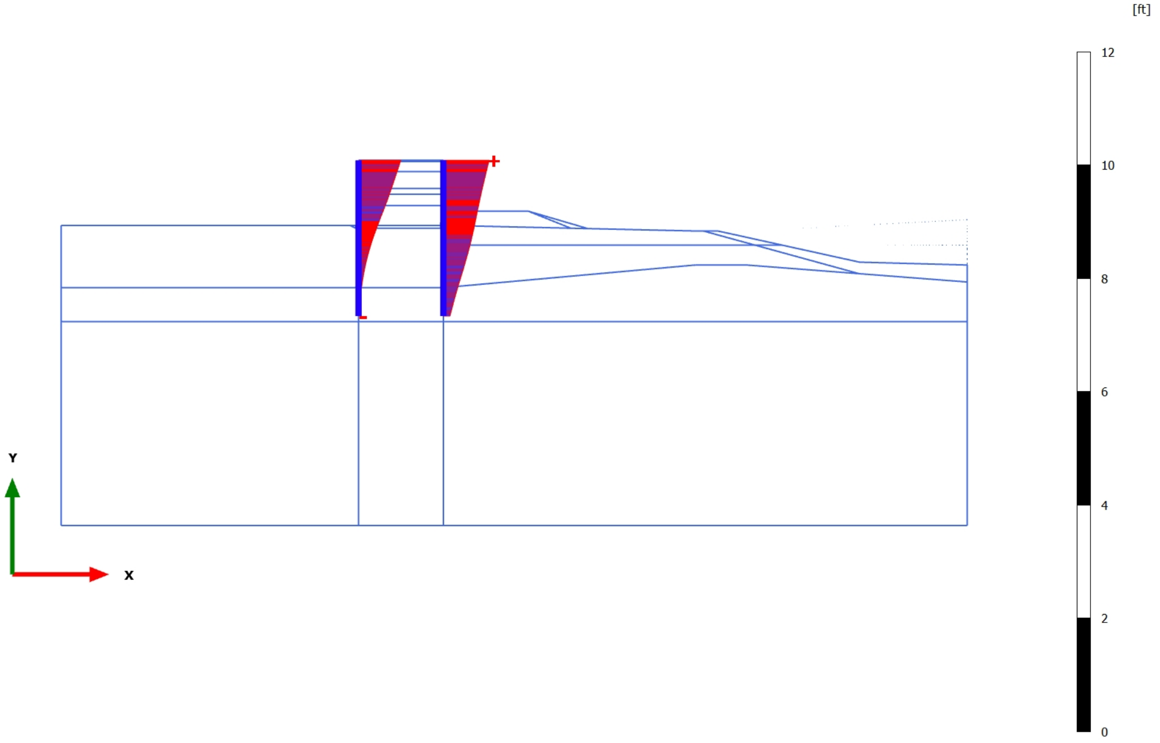


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5014 ft (Element 2 at Node 2619)

Minimum value = $4.551*10^{-3}$ ft (Element 68 at Node 23173)

3.1.1.1.1.9 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/443), Total displacements u_x

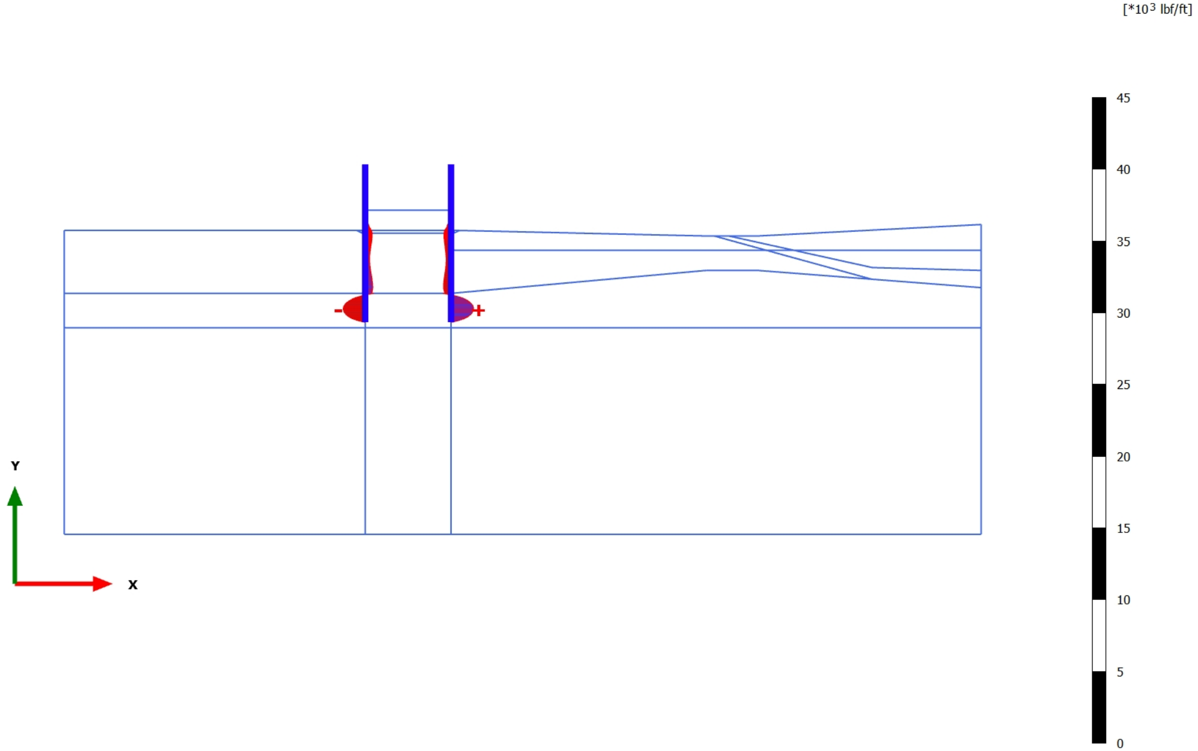


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.8069 ft (Element 2 at Node 2619)

Minimum value = 1.215×10^{-3} ft (Element 68 at Node 23173)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/51), Shear forces Q

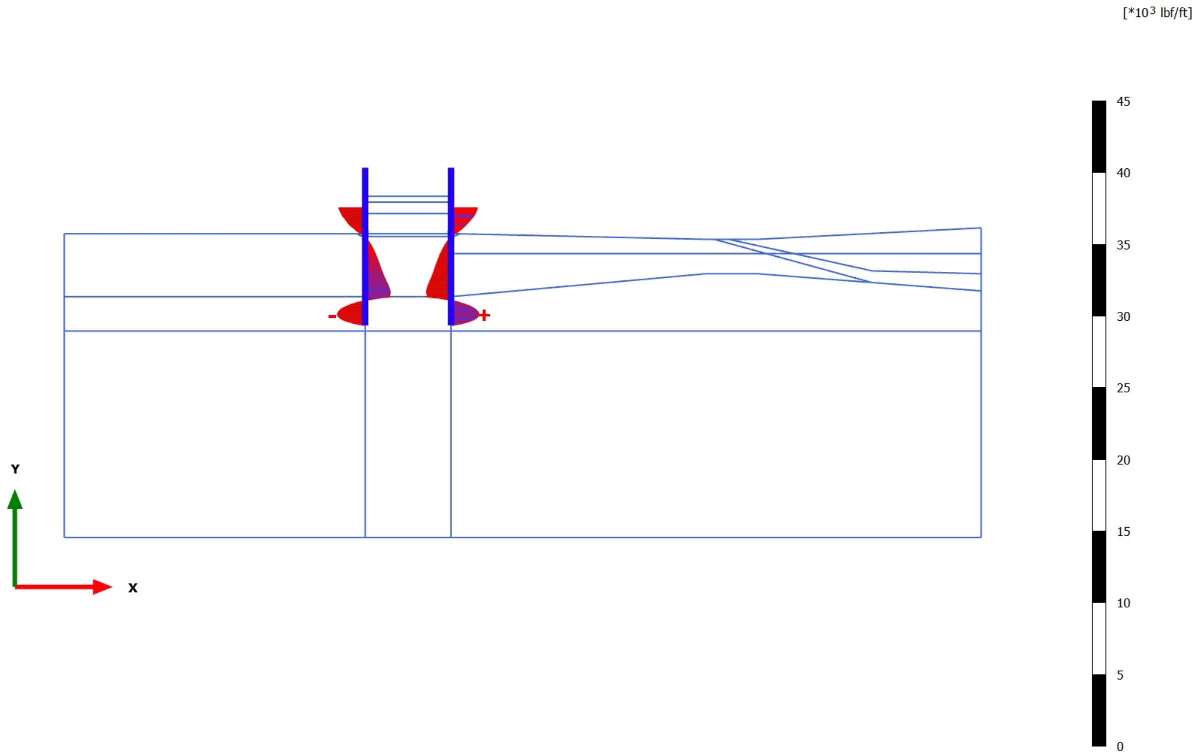


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 1572 lbf/ft (Element 71 at Node 27813)

Minimum value = -1530 lbf/ft (Element 67 at Node 22432)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/69), Shear forces Q

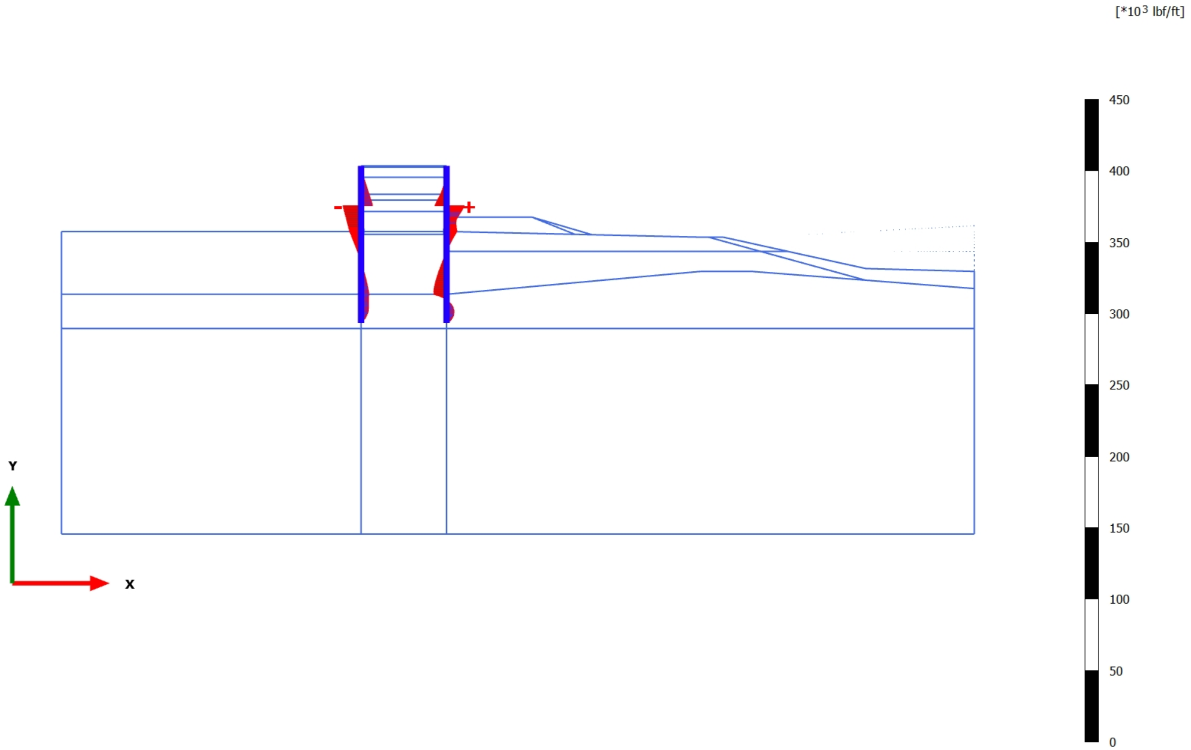


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 1958 lbf/ft (Element 71 at Node 27814)

Minimum value = -1940 lbf/ft (Element 67 at Node 22433)

3.1.2.1.3 Calculation results, Plate, Excavation 2 [Phase_10] (10/71), Shear forces Q

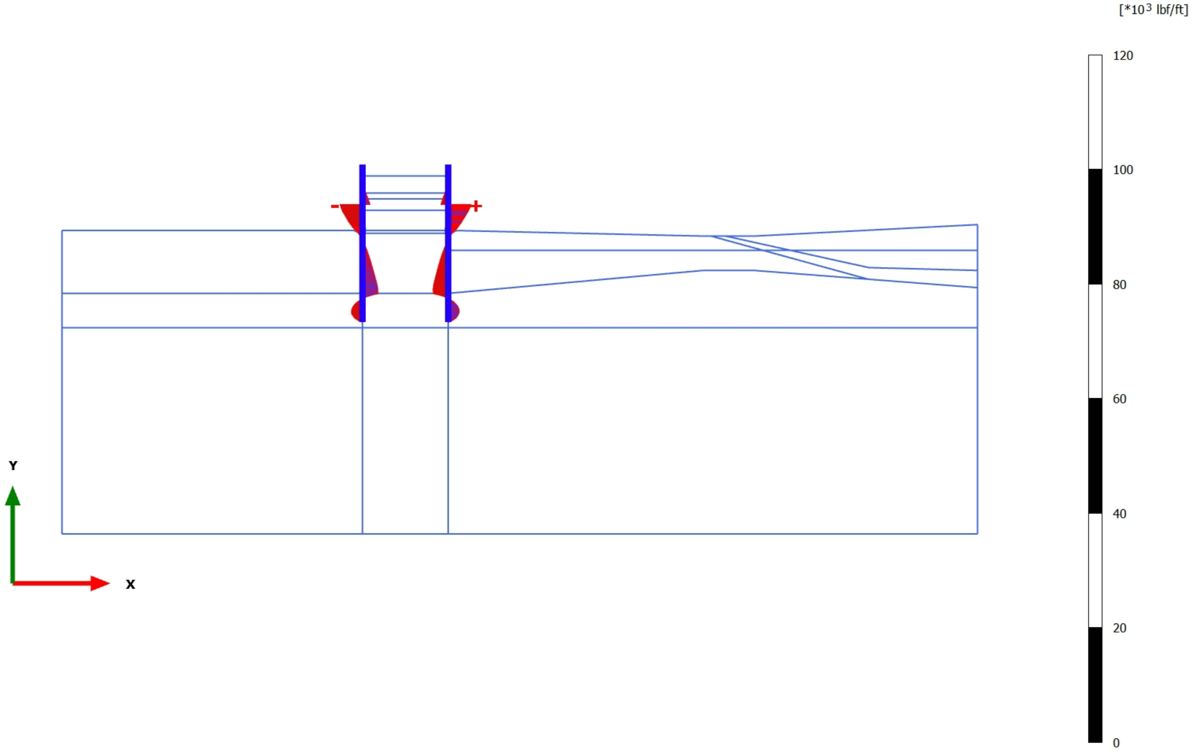


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 12.50*10^3 lbf/ft (Element 19 at Node 6009)

Minimum value = -12.71*10^3 lbf/ft (Element 20 at Node 279)

3.1.2.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/116), Shear forces Q

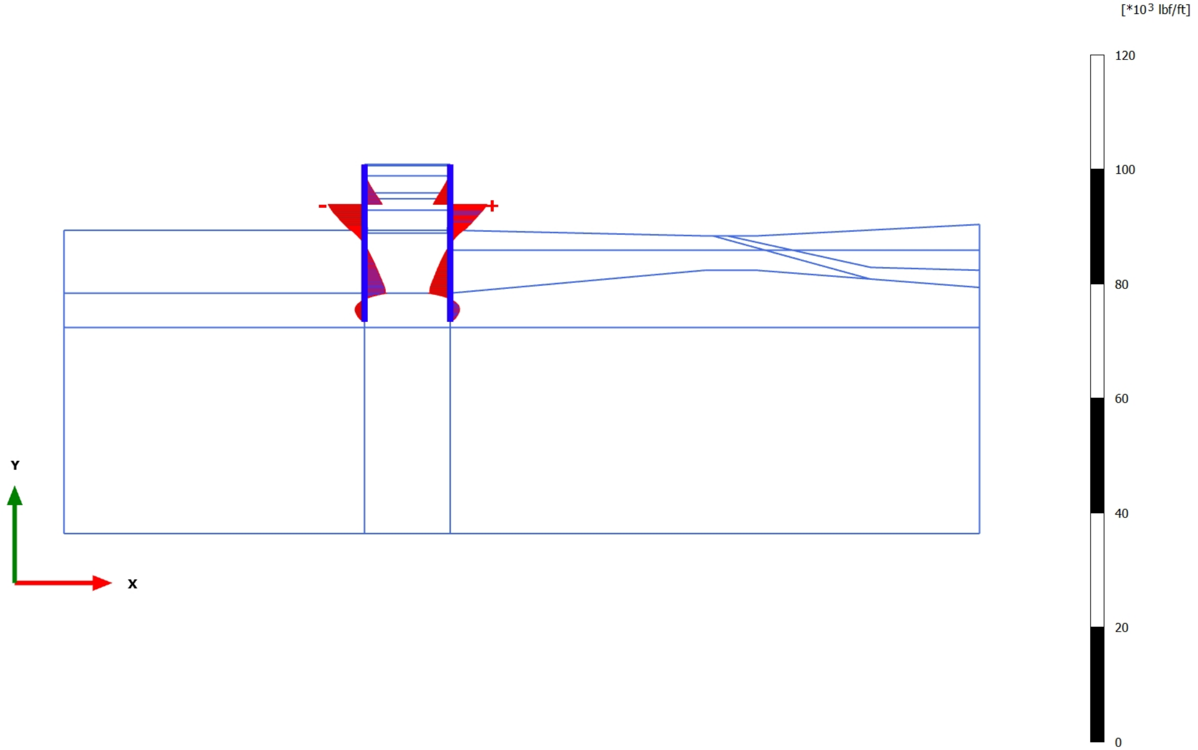


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 4008 lbf/ft (Element 19 at Node 6009)

Minimum value = -3960 lbf/ft (Element 20 at Node 279)

3.1.2.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/128), Shear forces Q

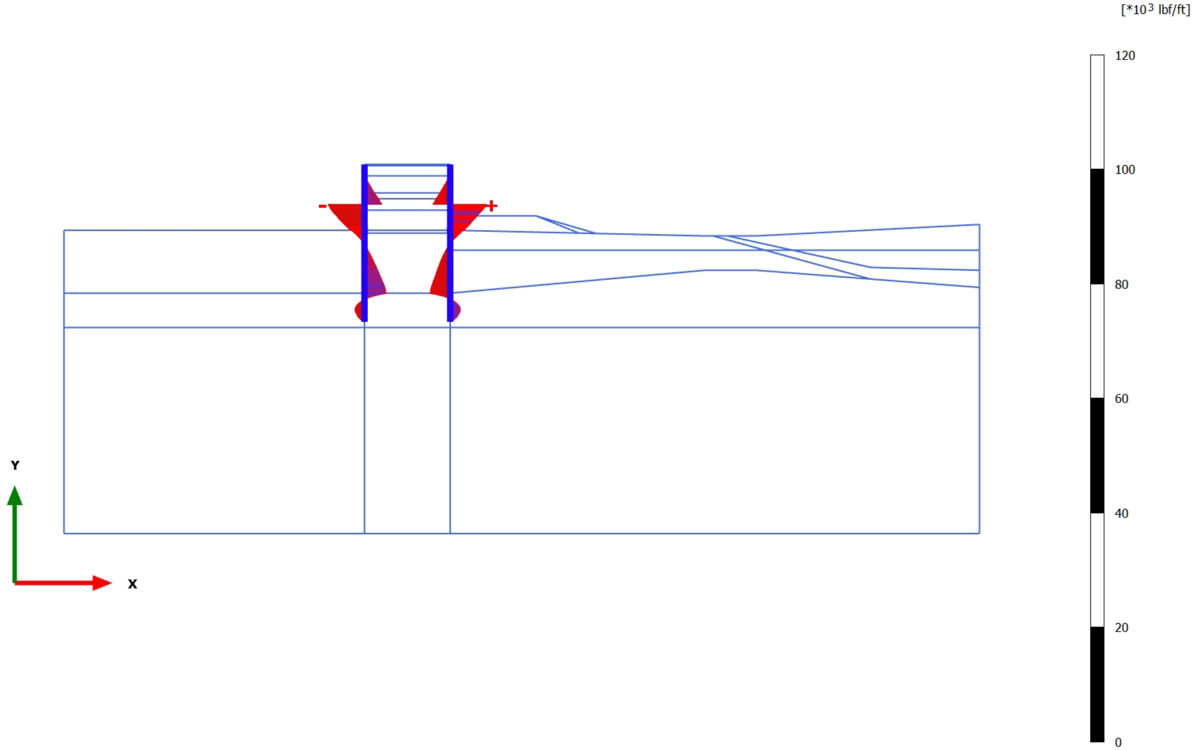


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 6491 lbf/ft (Element 19 at Node 6009)

Minimum value = -6383 lbf/ft (Element 20 at Node 279)

3.1.2.1.6 Calculation results, Plate, Buttress fill [Phase_4] (7/153), Shear forces Q

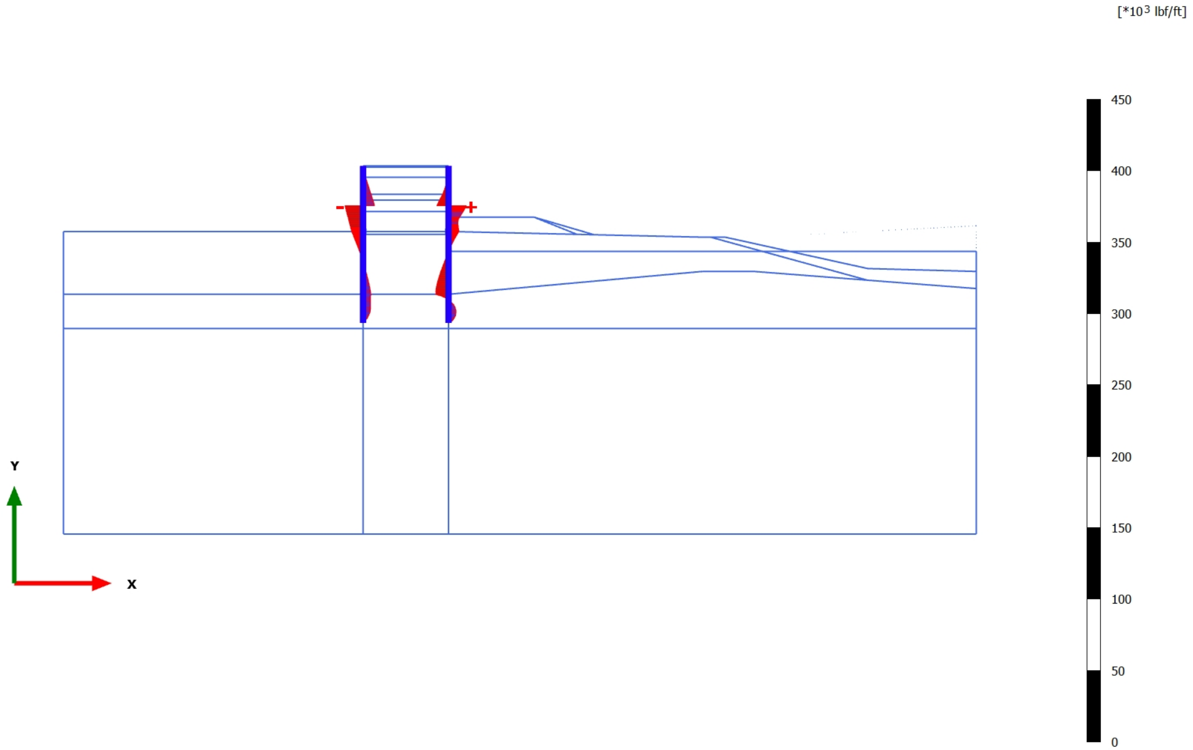


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 6403 lbf/ft (Element 19 at Node 6009)

Minimum value = -6404 lbf/ft (Element 20 at Node 279)

3.1.2.1.7 Calculation results, Plate, Excavation 1 [Phase_8] (8/264), Shear forces Q

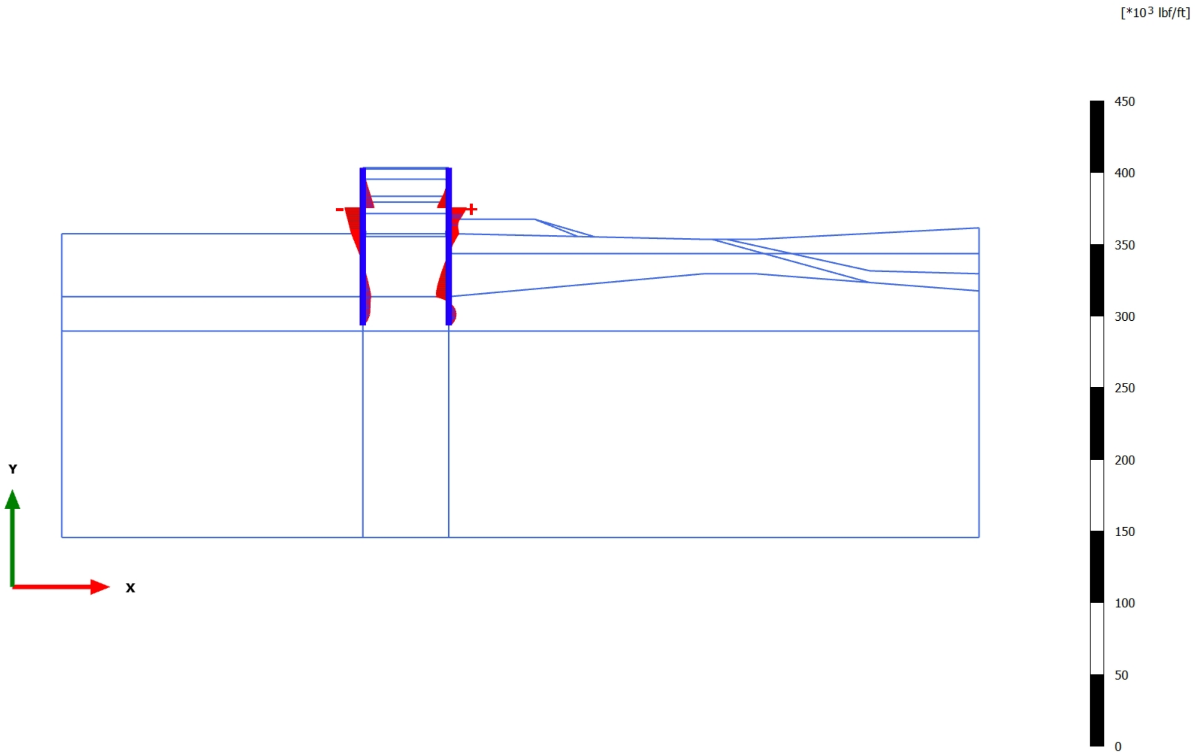


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $12.50*10^3$ lbf/ft (Element 19 at Node 6009)

Minimum value = $-12.71*10^3$ lbf/ft (Element 20 at Node 279)

3.1.2.1.8 Calculation results, Plate, Dewater [Phase_7] (4/392), Shear forces Q

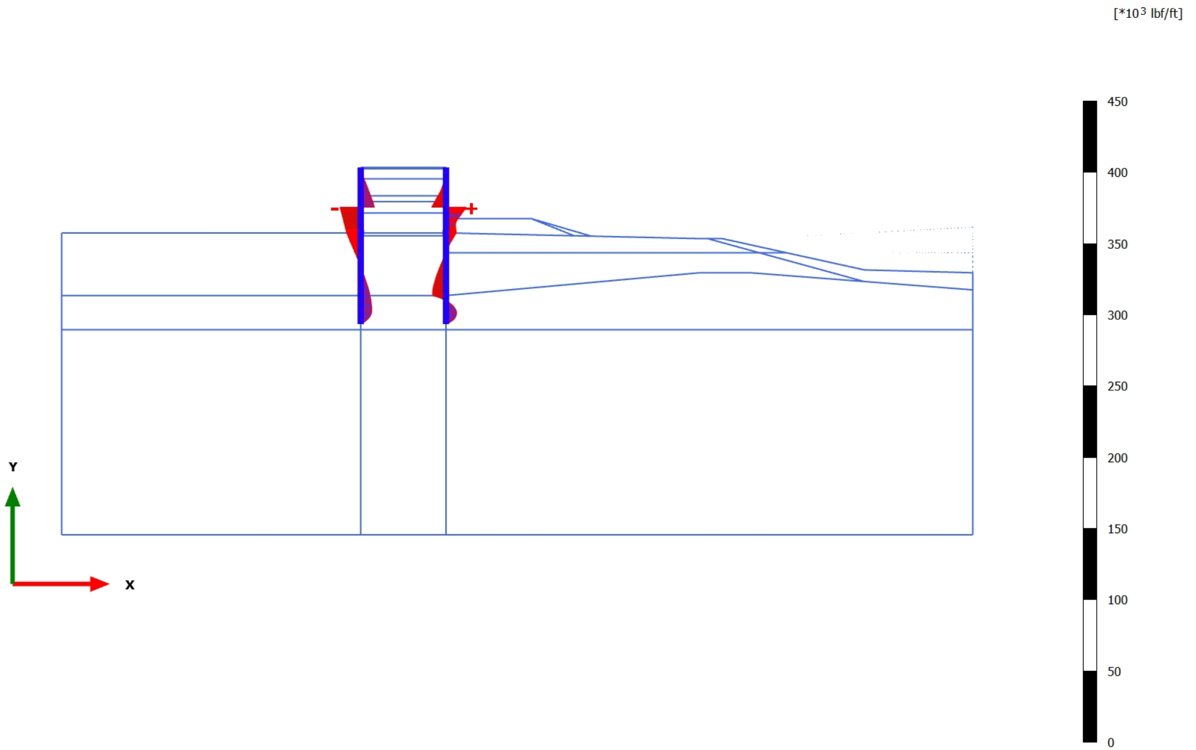


Shear forces Q (scaled up 0.500*10⁻³ times)

Maximum value = 12.43*10³ lbf/ft (Element 19 at Node 6009)

Minimum value = -12.62*10³ lbf/ft (Element 20 at Node 279)

3.1.2.1.9 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/443), Shear forces Q

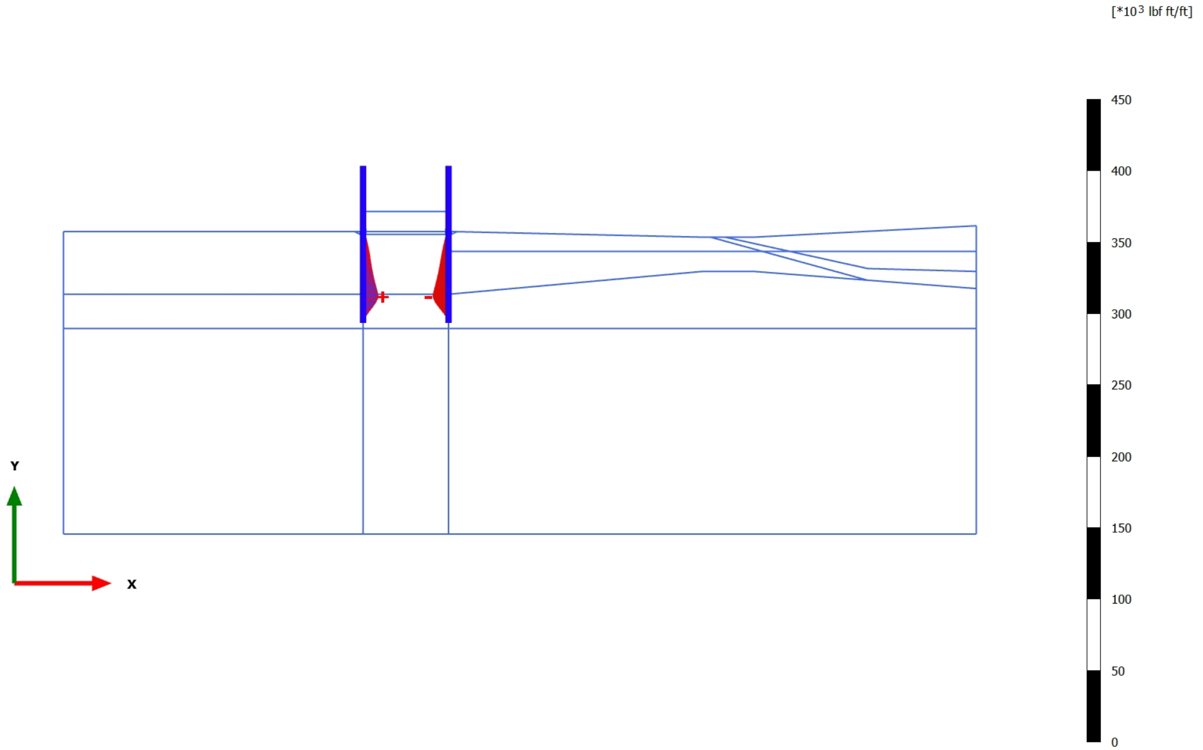


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $14.14*10^3$ lbf/ft (Element 19 at Node 6009)

Minimum value = $-14.60*10^3$ lbf/ft (Element 20 at Node 279)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/51), Bending moments M

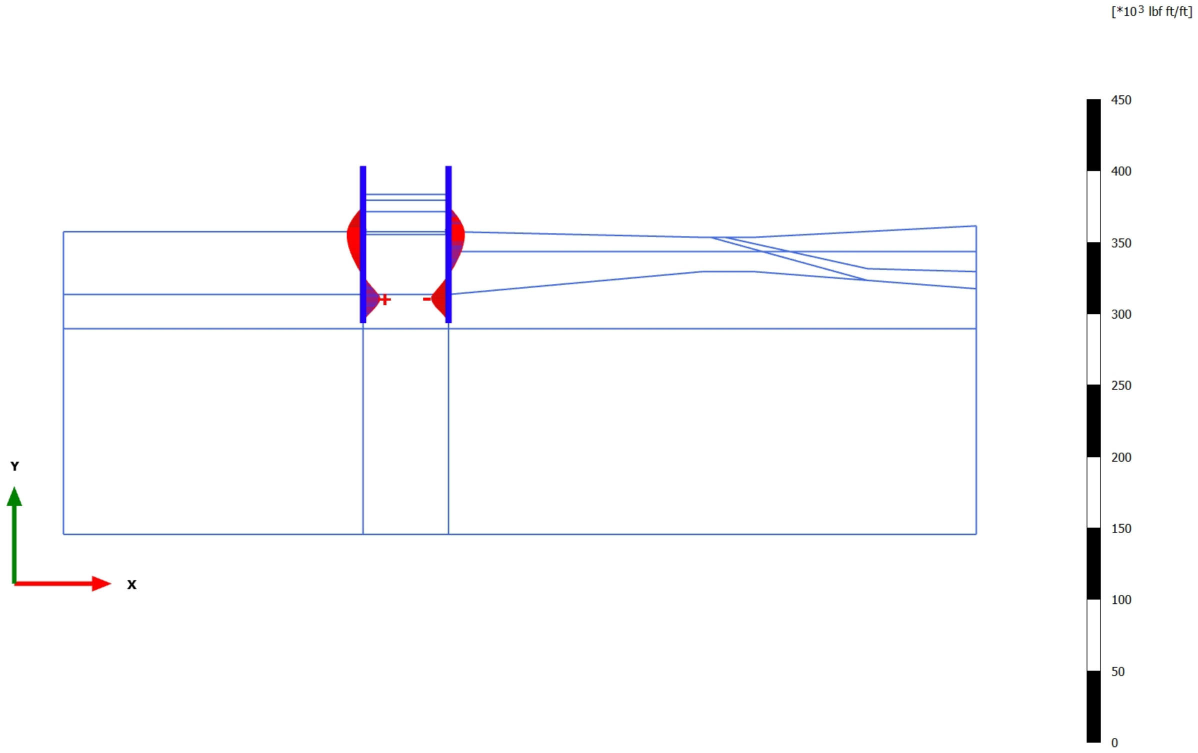


Bending moments M (scaled up 0.500*10⁻³ times)

Maximum value = 10.55*10³ lbf ft/ft (Element 65 at Node 21018)

Minimum value = -10.90*10³ lbf ft/ft (Element 69 at Node 26021)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/69), Bending moments M

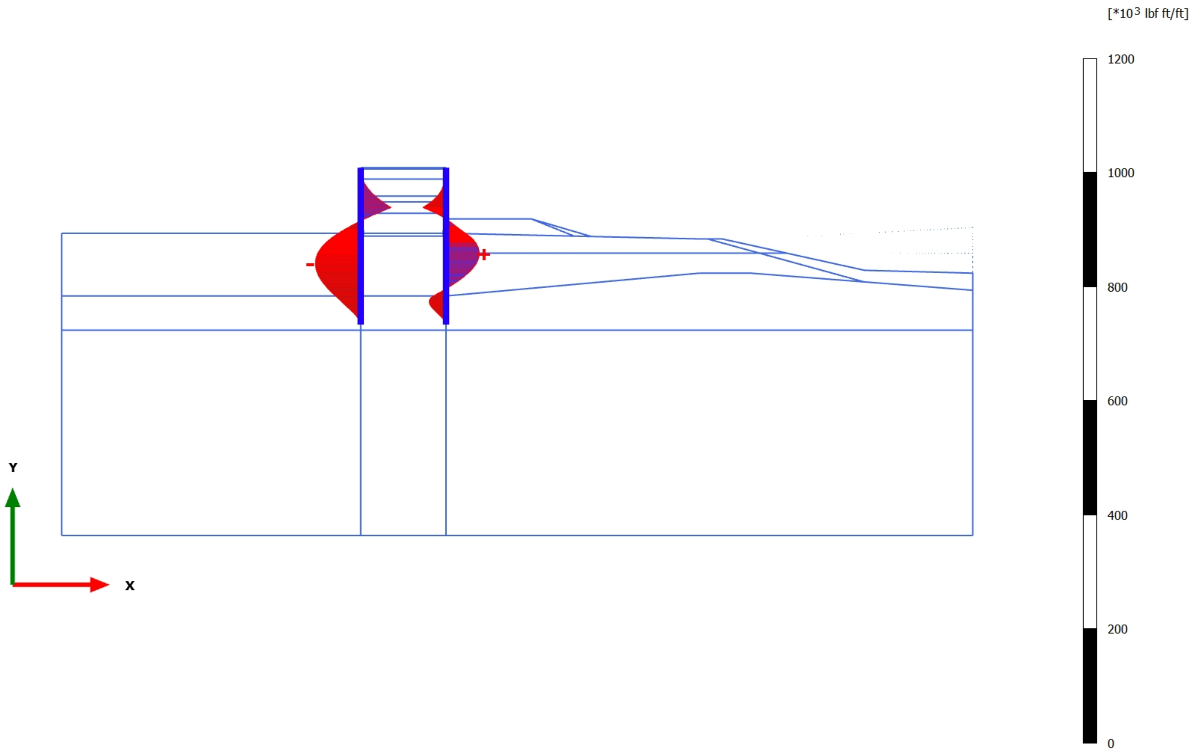


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.82*10^3$ lbf ft/ft (Element 65 at Node 21019)

Minimum value = $-12.01*10^3$ lbf ft/ft (Element 69 at Node 26022)

3.1.2.2.3 Calculation results, Plate, Excavation 2 [Phase_10] (10/71), Bending moments M

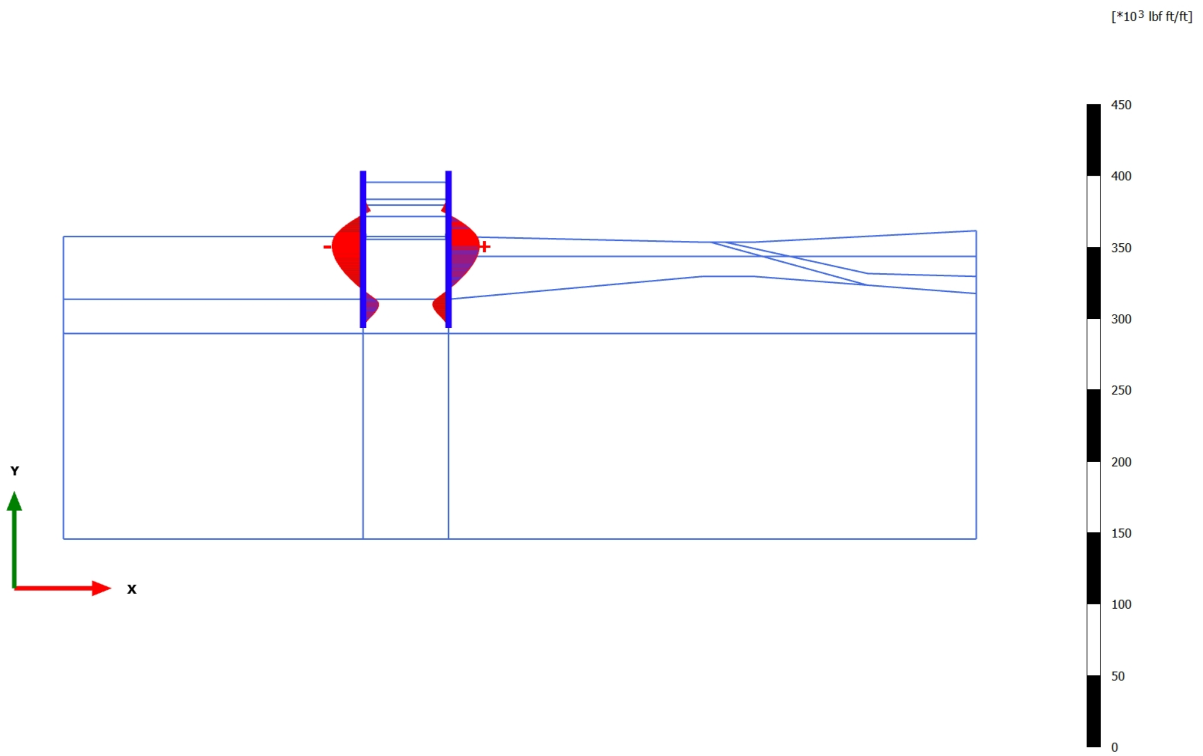


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 58.37*10^{3} lbf ft/ft (Element 43 at Node 21493)

Minimum value = -79.51*10^{3} lbf ft/ft (Element 56 at Node 16481)

3.1.2.2.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/116), Bending moments M

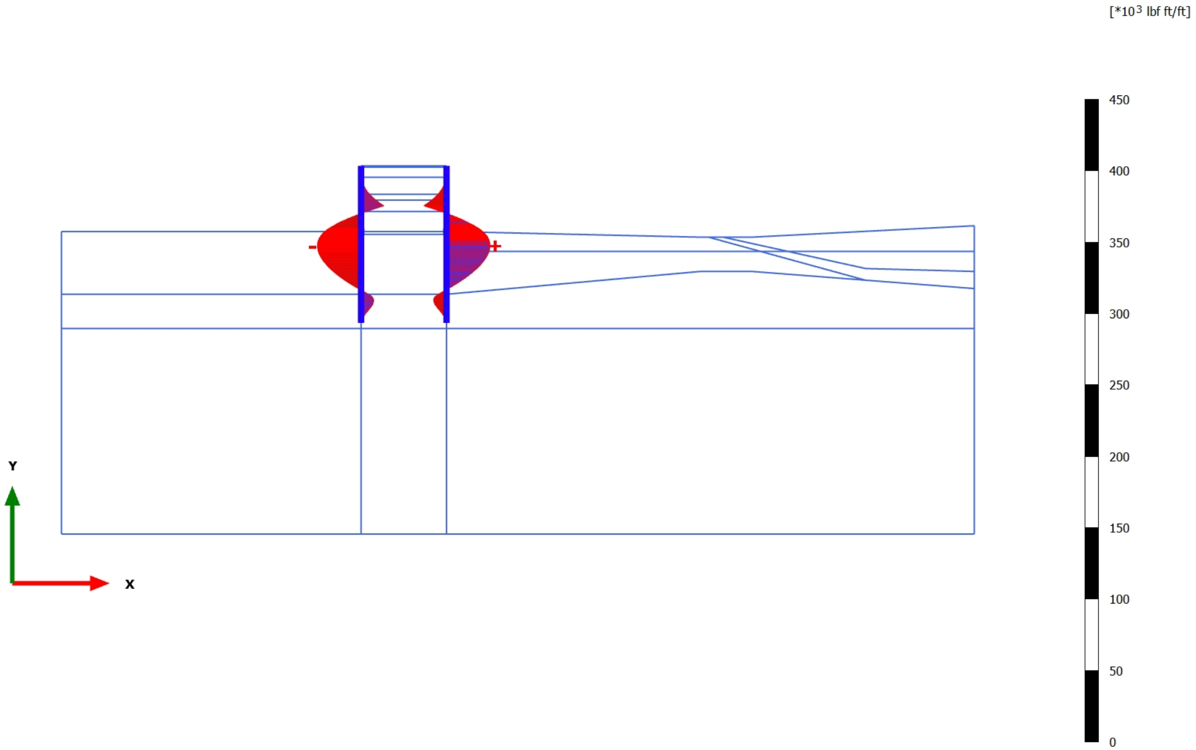


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $21.59*10^{3}$ lbf ft/ft (Element 41 at Node 19427)

Minimum value = $-21.63*10^{3}$ lbf ft/ft (Element 49 at Node 8528)

3.1.2.2.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/128), Bending moments M

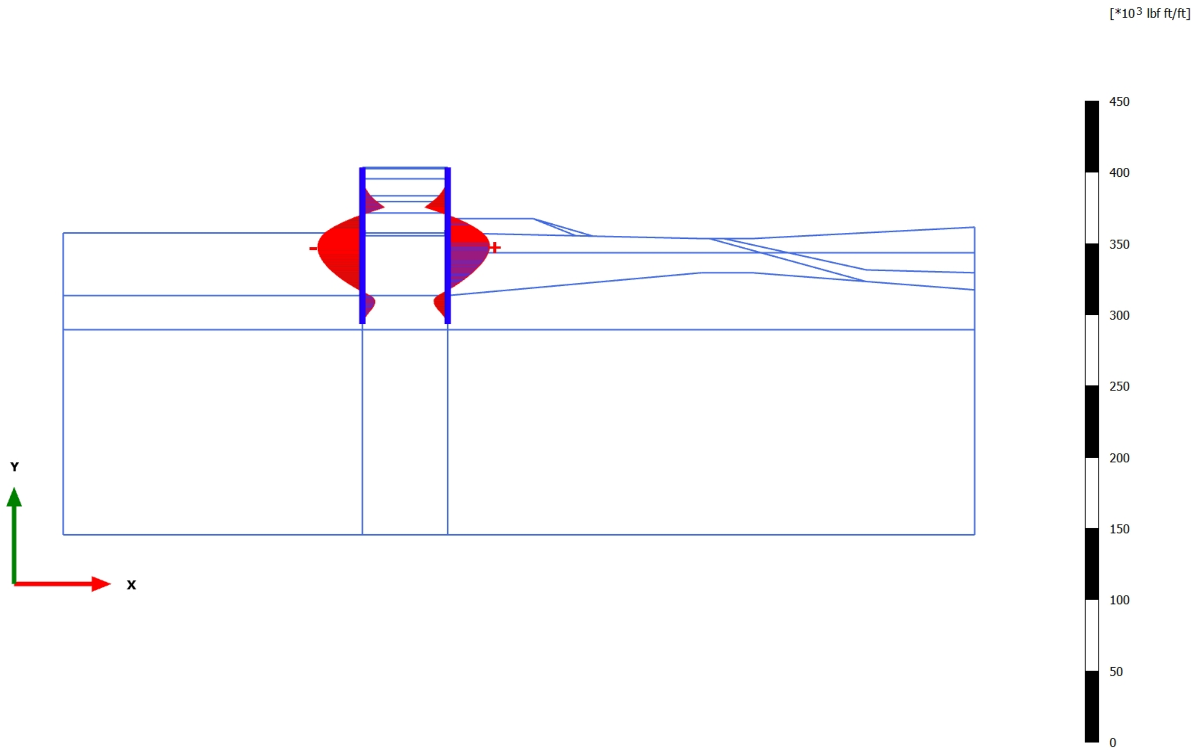


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $30.45*10^3$ lbf ft/ft (Element 41 at Node 20391)

Minimum value = $-30.57*10^3$ lbf ft/ft (Element 51 at Node 10150)

3.1.2.2.6 Calculation results, Plate, Buttress fill [Phase_4] (7/153), Bending moments M

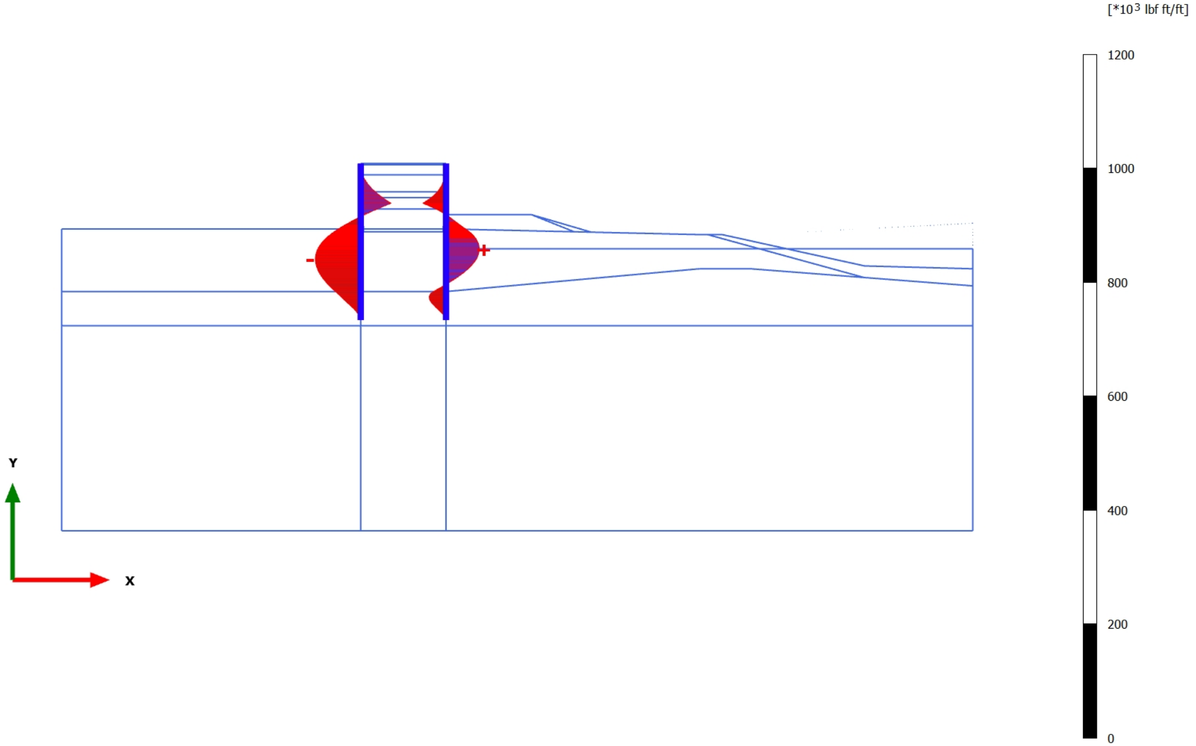


Bending moments M (scaled up 0.500*10⁻³ times)

Maximum value = 29.33*10³ lbf ft/ft (Element 42 at Node 20391)

Minimum value = -31.26*10³ lbf ft/ft (Element 51 at Node 10150)

3.1.2.2.7 Calculation results, Plate, Excavation 1 [Phase_8] (8/264), Bending moments M

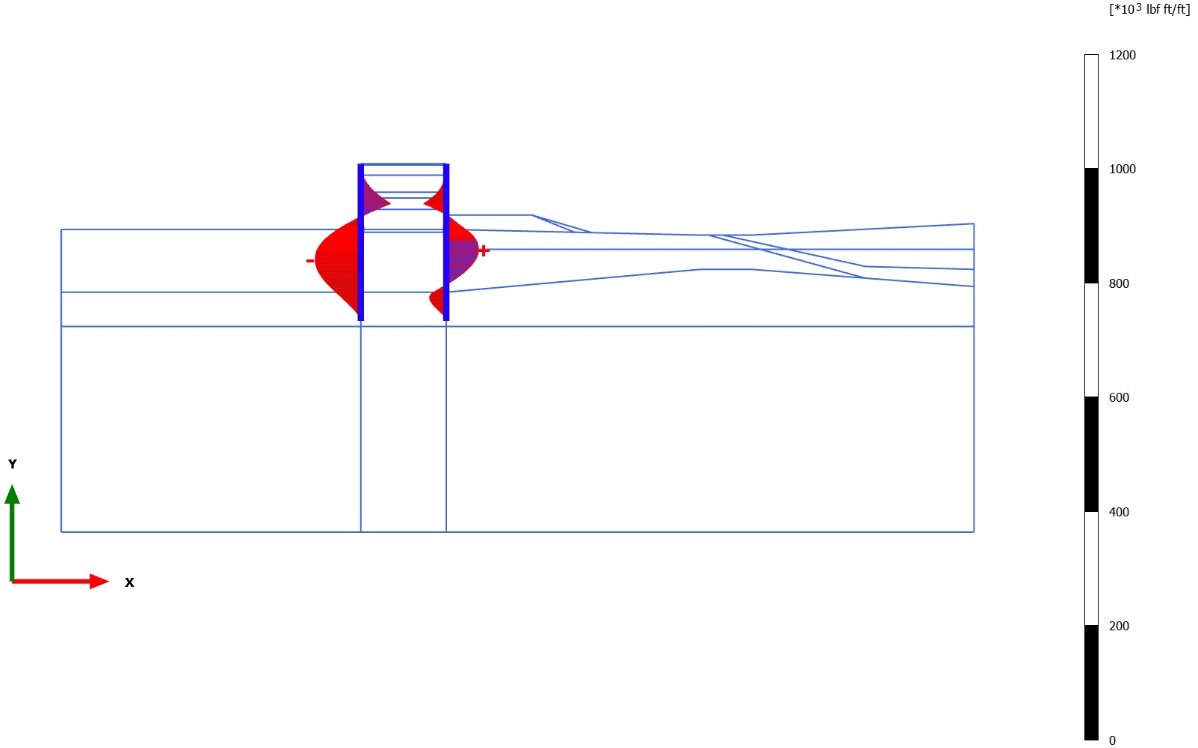


Bending moments M (scaled up 0.200×10^{-3} times)

Maximum value = 58.35×10^{3} lbf ft/ft (Element 42 at Node 21493)

Minimum value = -79.56×10^{3} lbf ft/ft (Element 56 at Node 16481)

3.1.2.2.8 Calculation results, Plate, Dewater [Phase_7] (4/392), Bending moments M

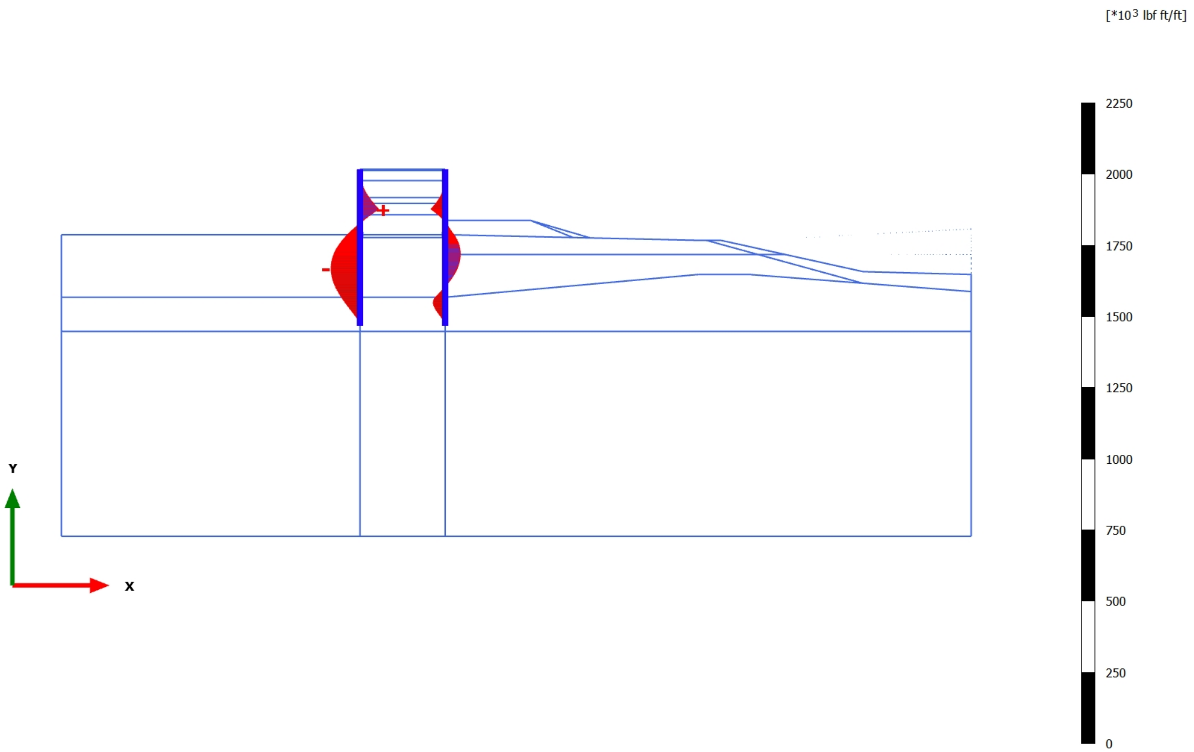


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $56.48*10^3$ lbf ft/ft (Element 42 at Node 21493)

Minimum value = $-79.91*10^3$ lbf ft/ft (Element 56 at Node 16481)

3.1.2.2.9 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/443), Bending moments M



Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 65.81*10^3 lbf ft/ft (Element 17 at Node 279)

Minimum value = -101.5*10^3 lbf ft/ft (Element 57 at Node 17928)

3.2.1.1.2 Calculation results, Node-to-node anchor, Backfill 2 [Phase_3] (3/69), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	12.093	0.000	12.093
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	12.093	0.000	12.093

3.2.1.1.3 Calculation results, Node-to-node anchor, Excavation 2 [Phase_10] (10/71), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	125.084	0.000	125.093
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	125.084	0.000	125.093

3.2.1.1.4 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/116), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	31.818	0.000	31.818
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	31.818	0.000	31.818

3.2.1.1.5 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/128), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	57.108	0.000	57.108
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	57.108	0.000	57.108

3.2.1.1.6 Calculation results, Node-to-node anchor, Buttress fill [Phase_4] (7/153), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	56.782	0.000	57.108
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	56.782	0.000	57.108

3.2.1.1.7 Calculation results, Node-to-node anchor, Excavation 1 [Phase_8] (8/264), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	125.085	0.000	125.085
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	125.085	0.000	125.085

3.2.1.1.8 Calculation results, Node-to-node anchor, Dewater [Phase_7] (4/392), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	123.318	0.000	123.318
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	123.318	0.000	123.318

3.2.1.1.9 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/443), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	146.008	0.000	146.008
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	146.008	0.000	146.008

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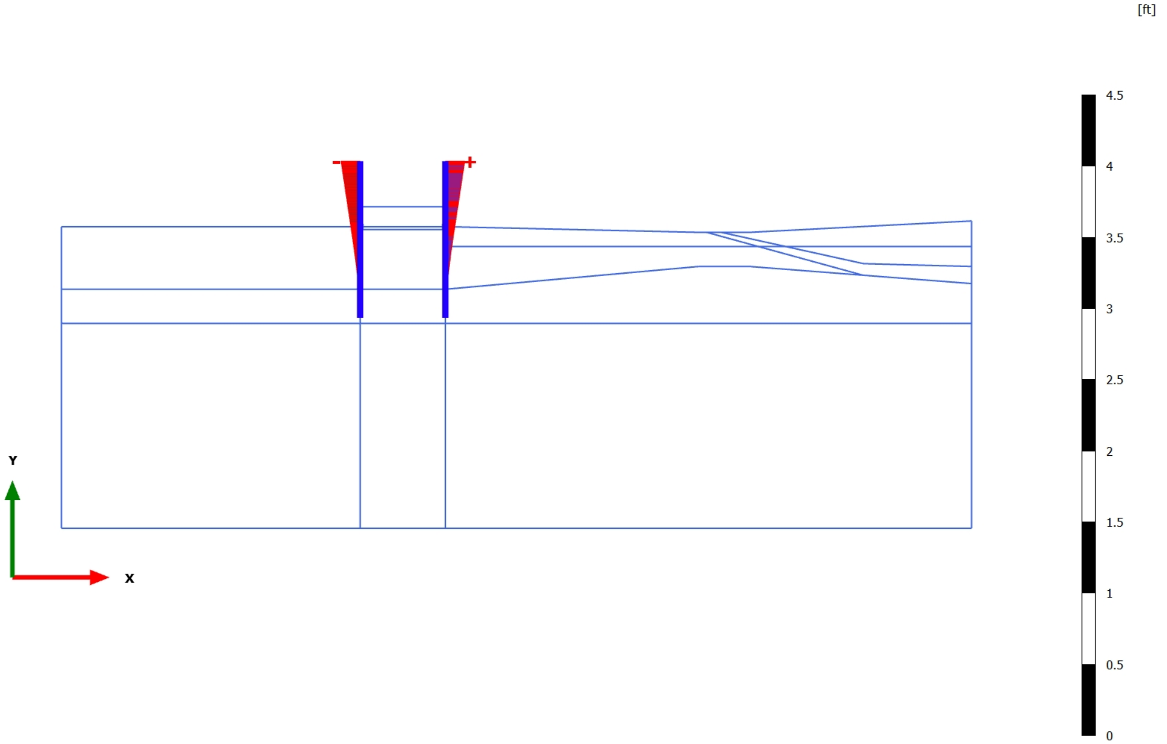
3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/33), Total displacements u_x

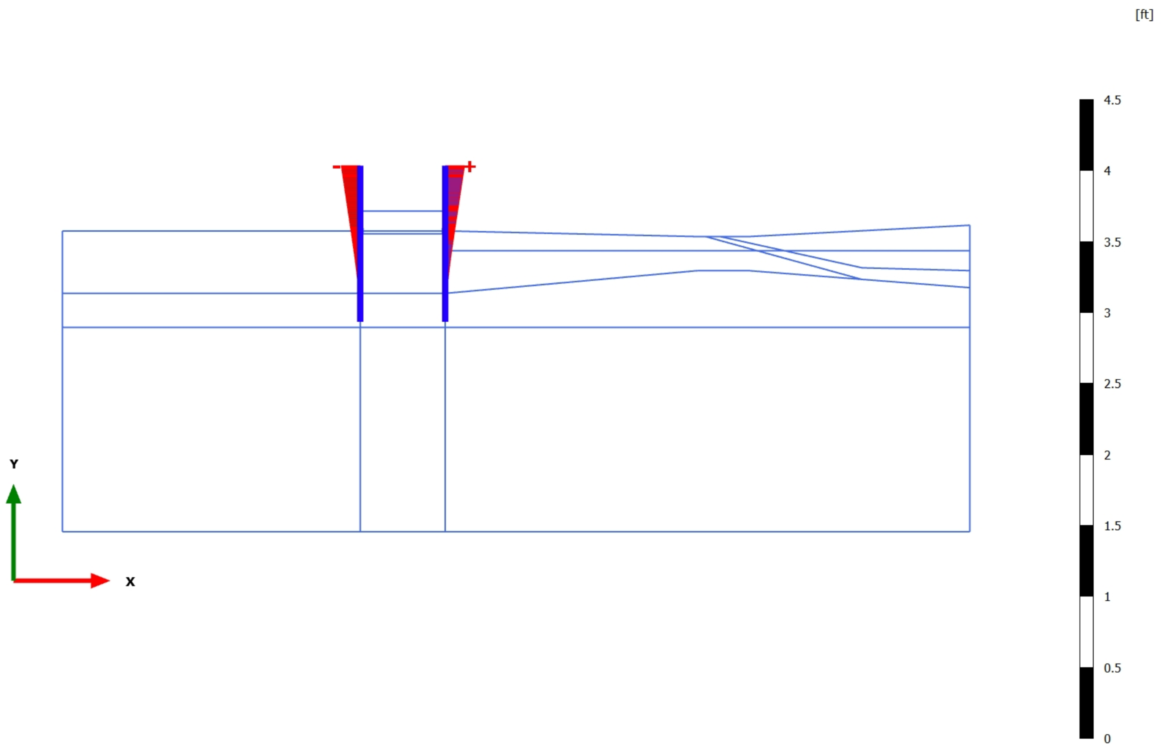


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1358 ft (Element 2 at Node 2619)

Minimum value = -0.1339 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Consoldate [Phase_26] (14/64), Total displacements u_x

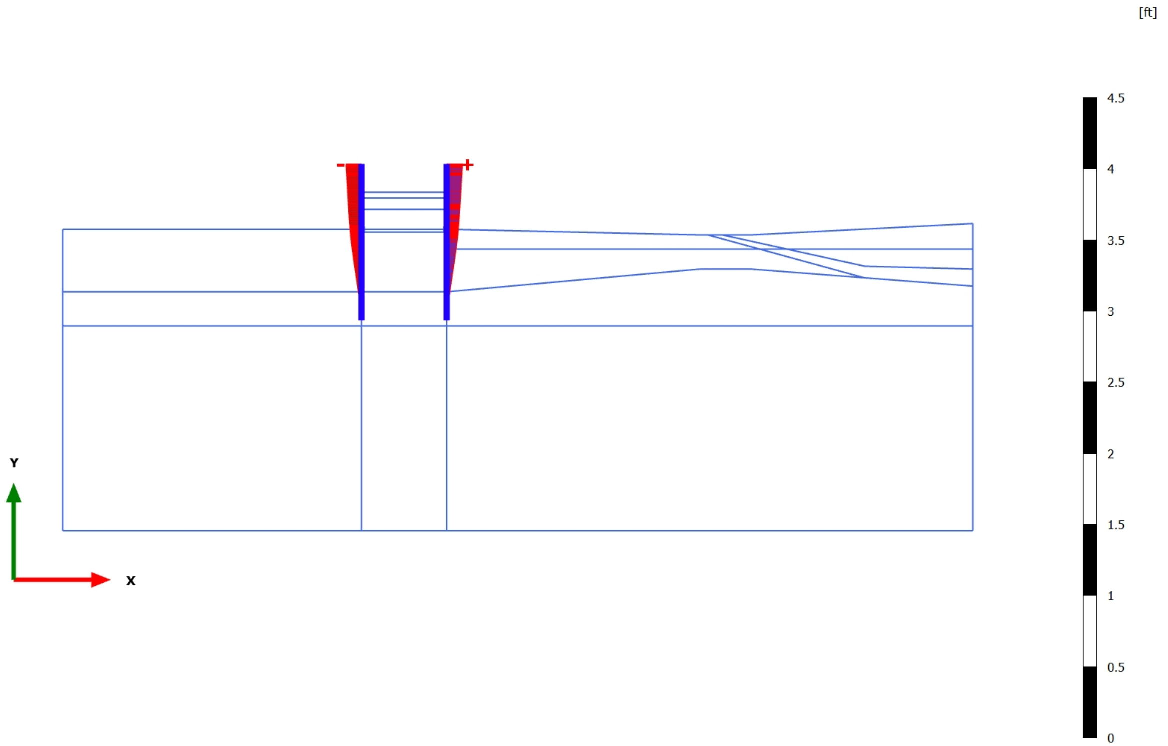


Total displacements u_x (scaled up 50.0 times) (Time 7.000 day)

Maximum value = 0.1362 ft (Element 2 at Node 2619)

Minimum value = -0.1336 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Backfill 2 [Phase_3] (3/80), Total displacements u_x

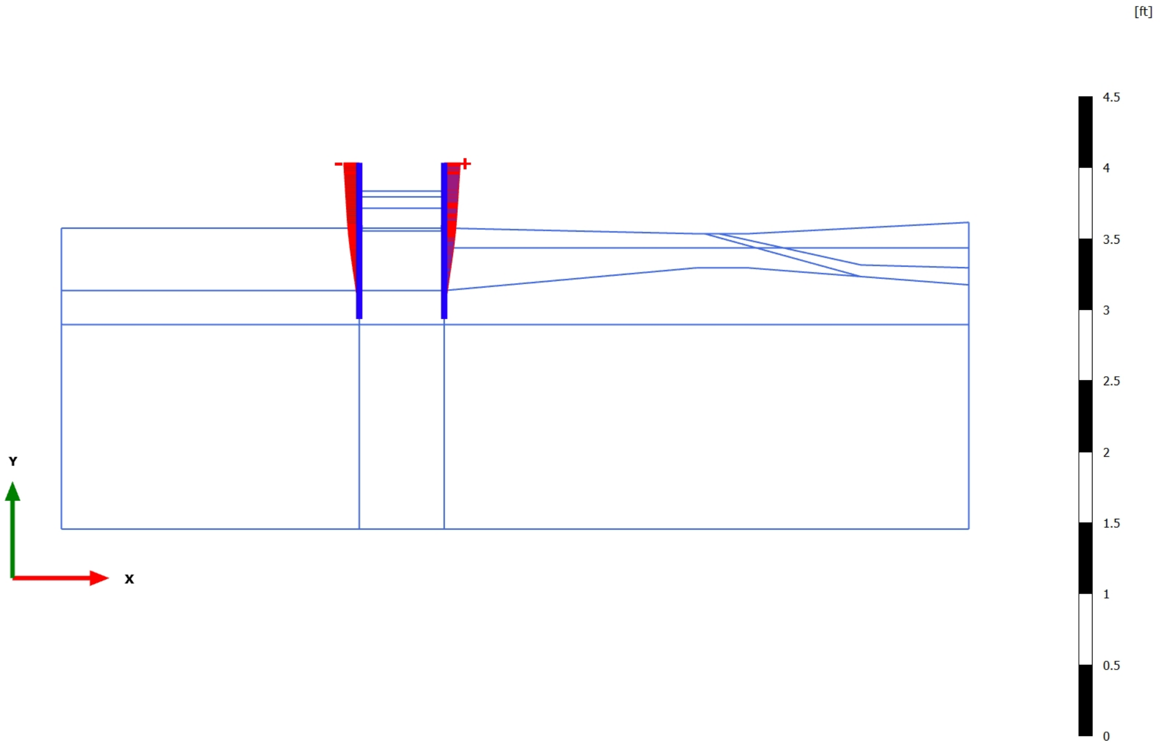


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1125 ft (Element 2 at Node 2619)

Minimum value = -0.1092 ft (Element 1 at Node 4)

3.1.1.1.1.4 Calculation results, Plate, Consolidate [Phase_25] (8/104), Total displacements u_x

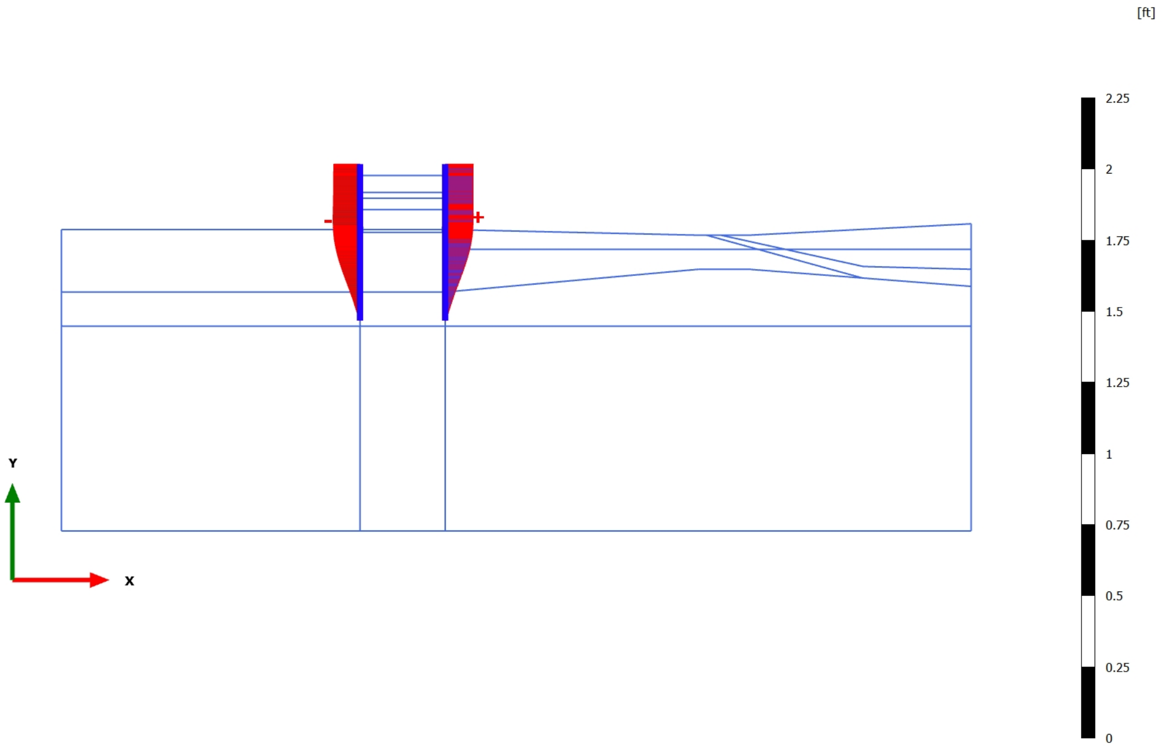


Total displacements u_x (scaled up 50.0 times) (Time 14.00 day)

Maximum value = 0.1135 ft (Element 2 at Node 2619)

Minimum value = -0.1095 ft (Element 1 at Node 4)

3.1.1.1.1.5 Calculation results, Plate, Backfill 3 [Phase_5] (5/114), Total displacements u_x

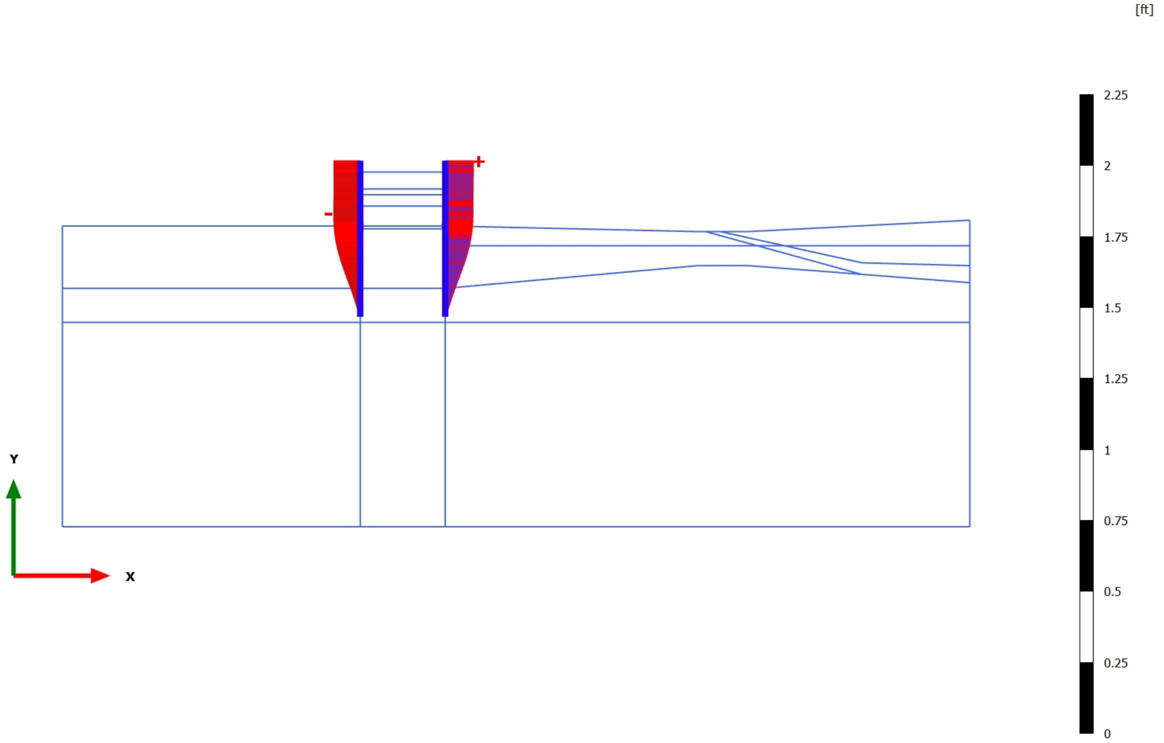


Total displacements u_x (scaled up 100 times)

Maximum value = 0.09854 ft (Element 24 at Node 11068)

Minimum value = -0.09472 ft (Element 25 at Node 654)

3.1.1.1.1.6 Calculation results, Plate, Consolidate [Phase_11] (15/128), Total displacements u_x

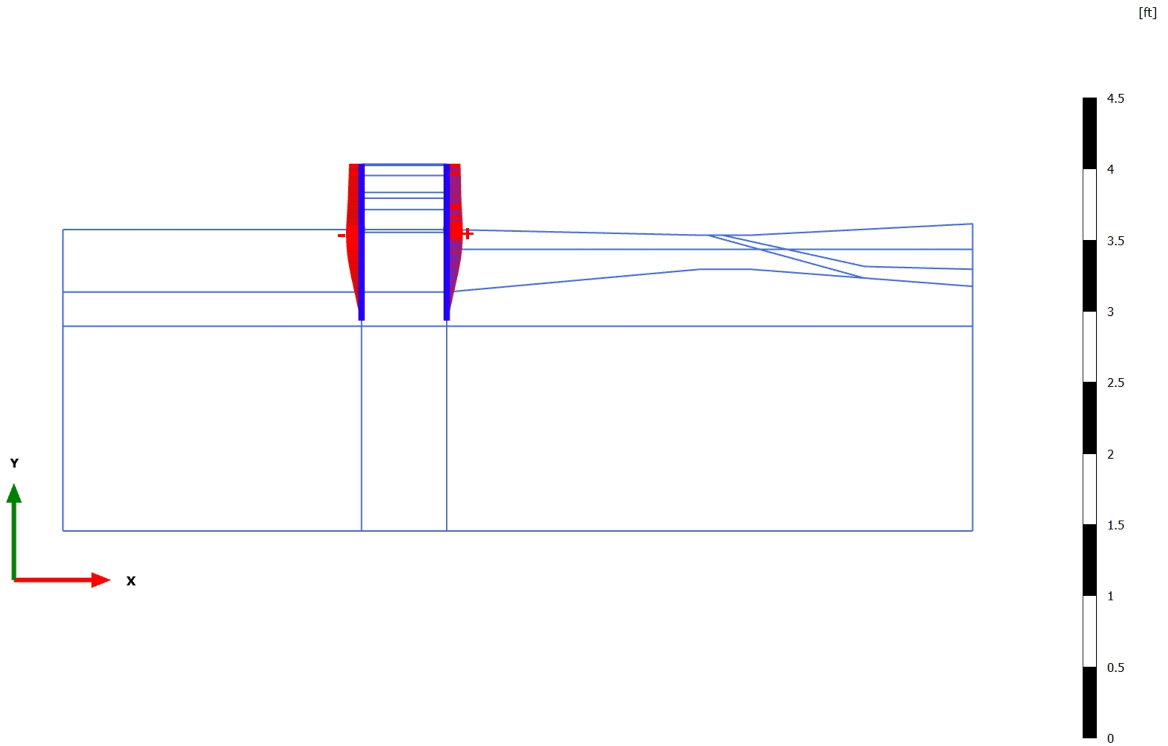


Total displacements u_x (scaled up 100 times) (Time 21.00 day)

Maximum value = 0.09993 ft (Element 2 at Node 2619)

Minimum value = -0.09386 ft (Element 23 at Node 458)

3.1.1.1.1.7 Calculation results, Plate, Backfill 4 [Phase_6] (6/139), Total displacements u_x

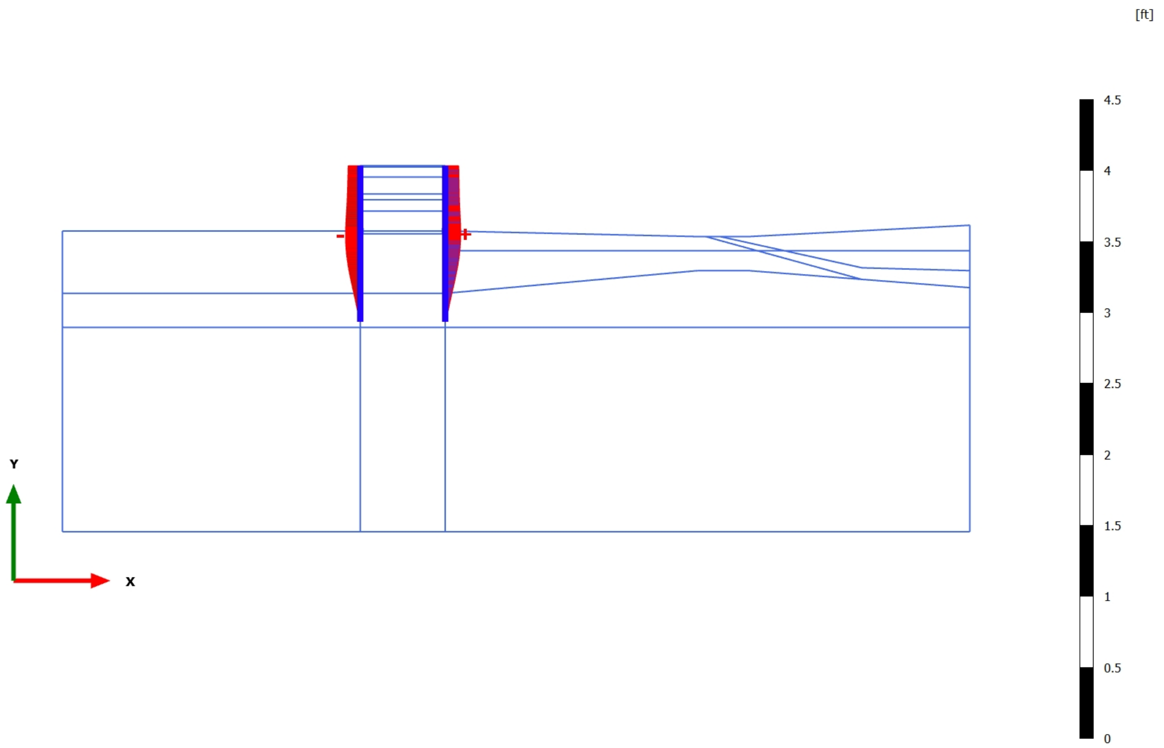


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1105 ft (Element 37 at Node 15455)

Minimum value = -0.1055 ft (Element 47 at Node 7262)

3.1.1.1.1.8 Calculation results, Plate, Consolidate [Phase_7] (10/156), Total displacements u_x

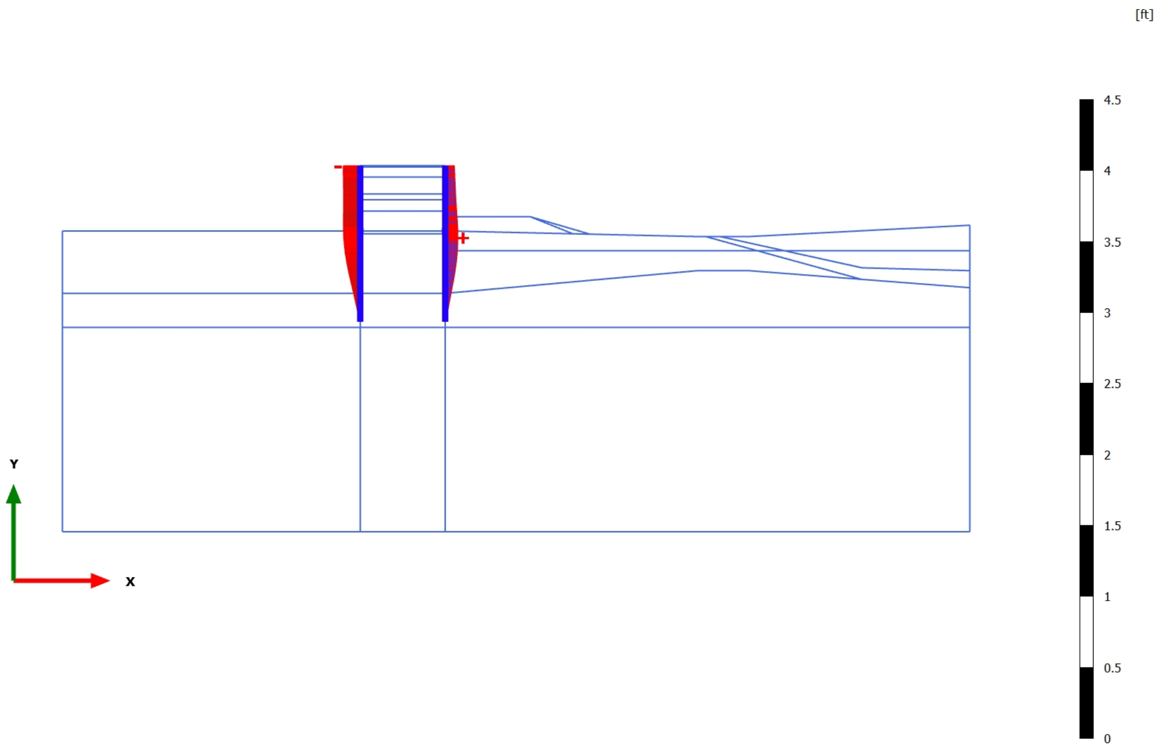


Total displacements u_x (scaled up 50.0 times) (Time 28.00 day)

Maximum value = 0.1094 ft (Element 37 at Node 14681)

Minimum value = -0.1039 ft (Element 46 at Node 6726)

3.1.1.1.1.9 Calculation results, Plate, Consolidate [Phase_16] (24/190), Total displacements u_x

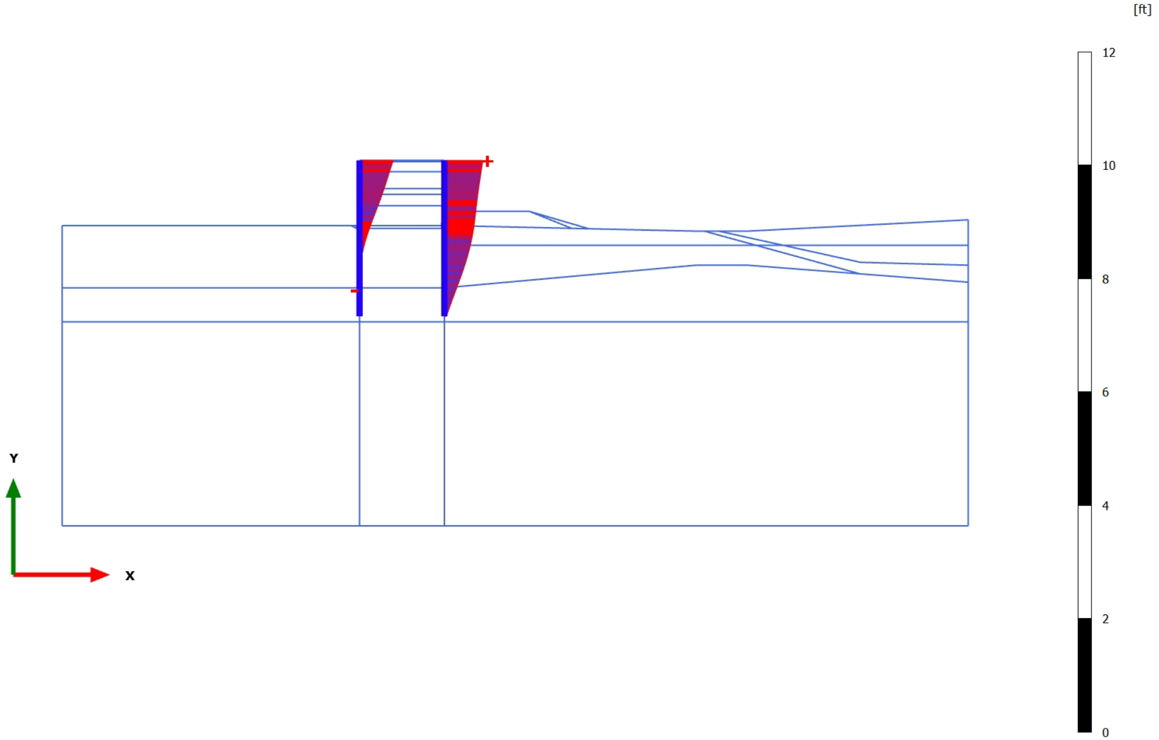


Total displacements u_x (scaled up 50.0 times) (Time 35.00 day)

Maximum value = 0.08939 ft (Element 39 at Node 17969)

Minimum value = -0.1206 ft (Element 1 at Node 4)

3.1.1.1.1.10 Calculation results, Plate, Dewater -SS [Phase_14] (16/239), Total displacements u_x

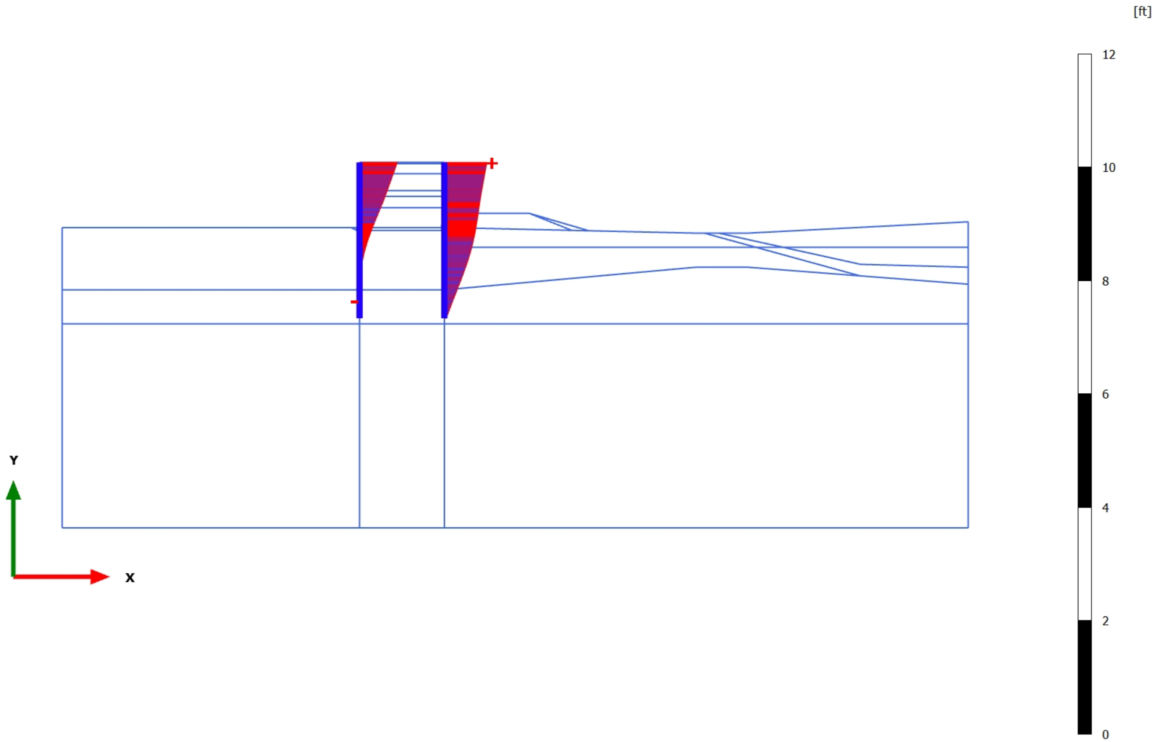


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.6791 ft (Element 2 at Node 2619)

Minimum value = -5.821×10^{-3} ft (Element 65 at Node 21018)

3.1.1.1.1.11 Calculation results, Plate, Consolidation [Phase_17] (17/254), Total displacements u_x

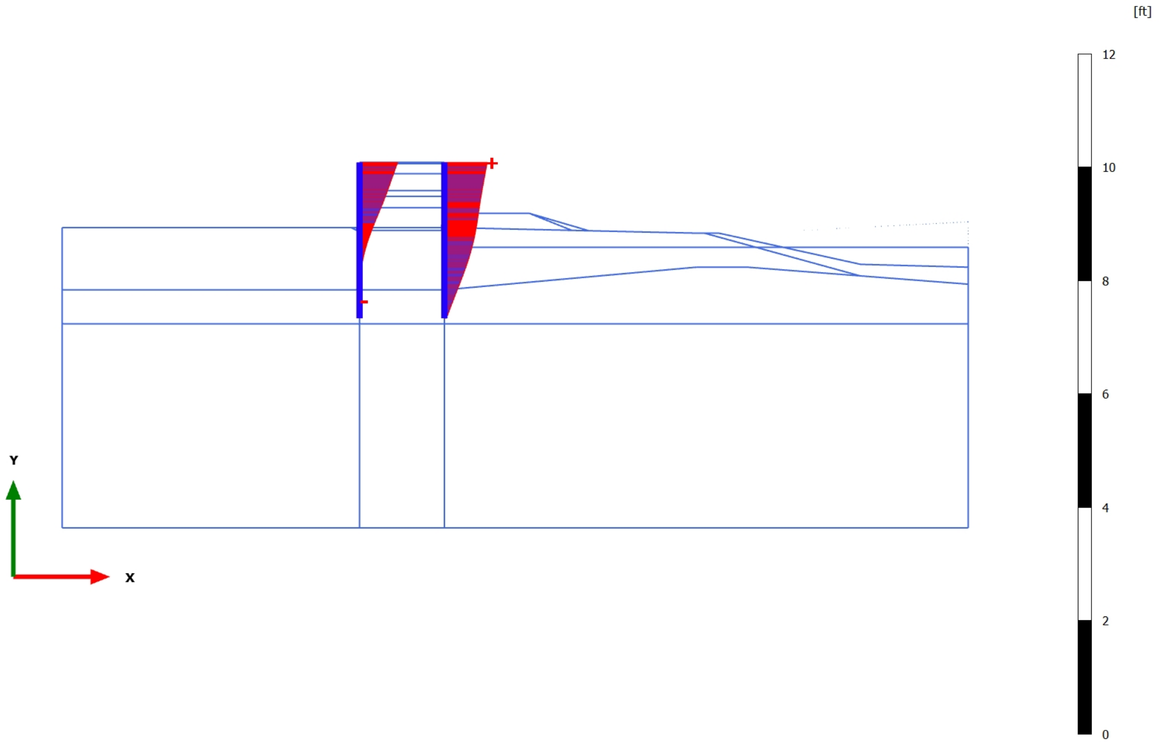


Total displacements u_x (scaled up 20.0 times) (Time 39.00 day)

Maximum value = 0.7510 ft (Element 2 at Node 2619)

Minimum value = -1.936×10^{-3} ft (Element 66 at Node 21359)

3.1.1.1.1.12 Calculation results, Plate, Excavation 1 [Phase_18] (18/257), Total displacements u_x

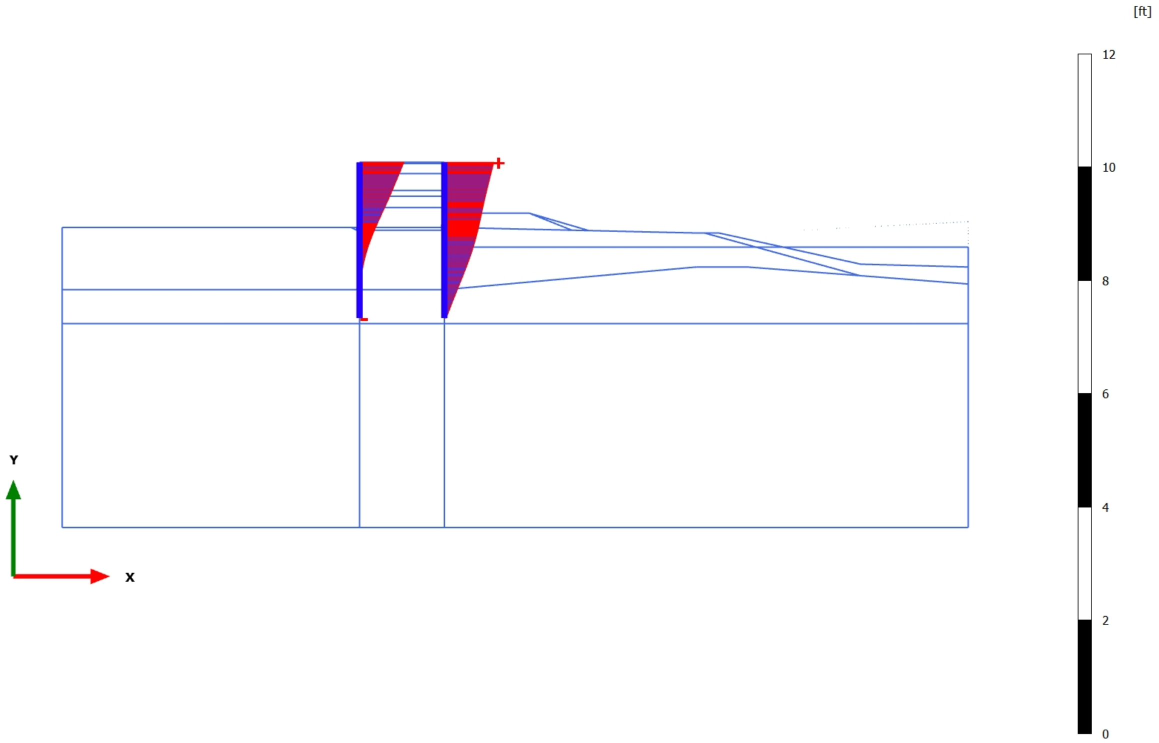


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.7570 ft (Element 2 at Node 2619)

Minimum value = 0.7529×10^{-3} ft (Element 66 at Node 21359)

3.1.1.1.1.13 Calculation results, Plate, Consolidation [Phase_20] (20/272), Total displacements u_x

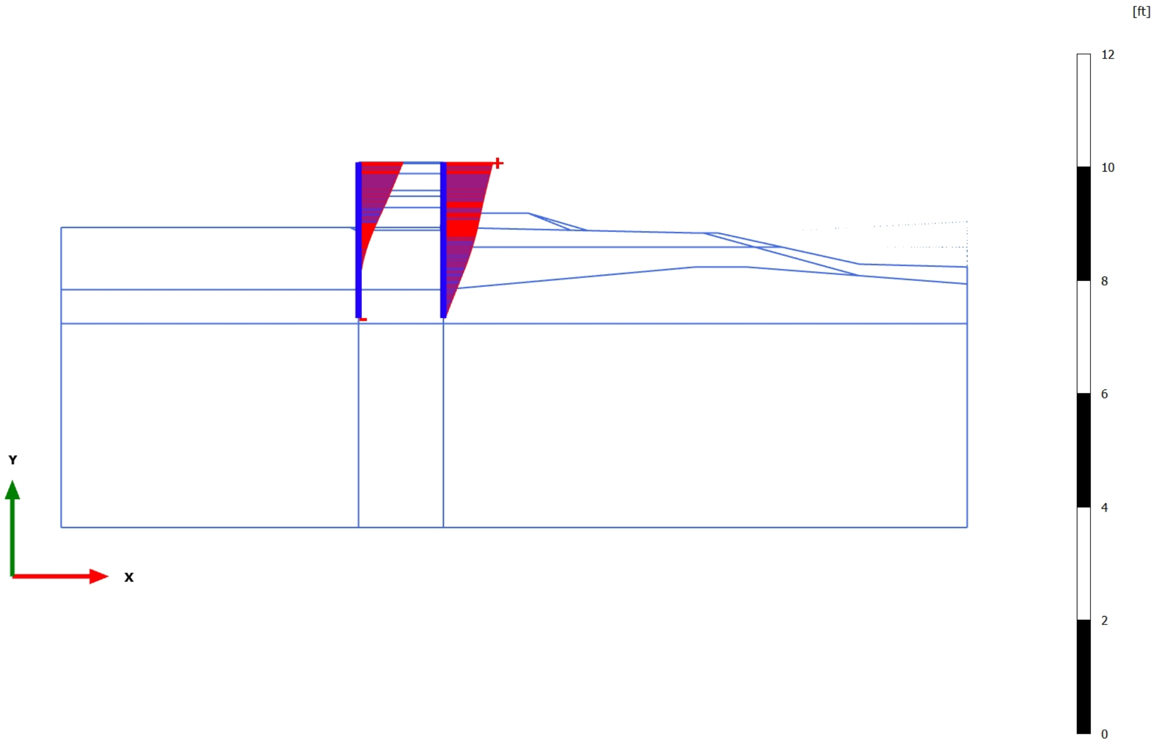


Total displacements u_x (scaled up 20.0 times) (Time 56.00 day)

Maximum value = 0.8733 ft (Element 2 at Node 2619)

Minimum value = 0.3124×10^{-3} ft (Element 68 at Node 23173)

3.1.1.1.1.14 Calculation results, Plate, Excavation 2 [Phase_21] (21/274), Total displacements u_x

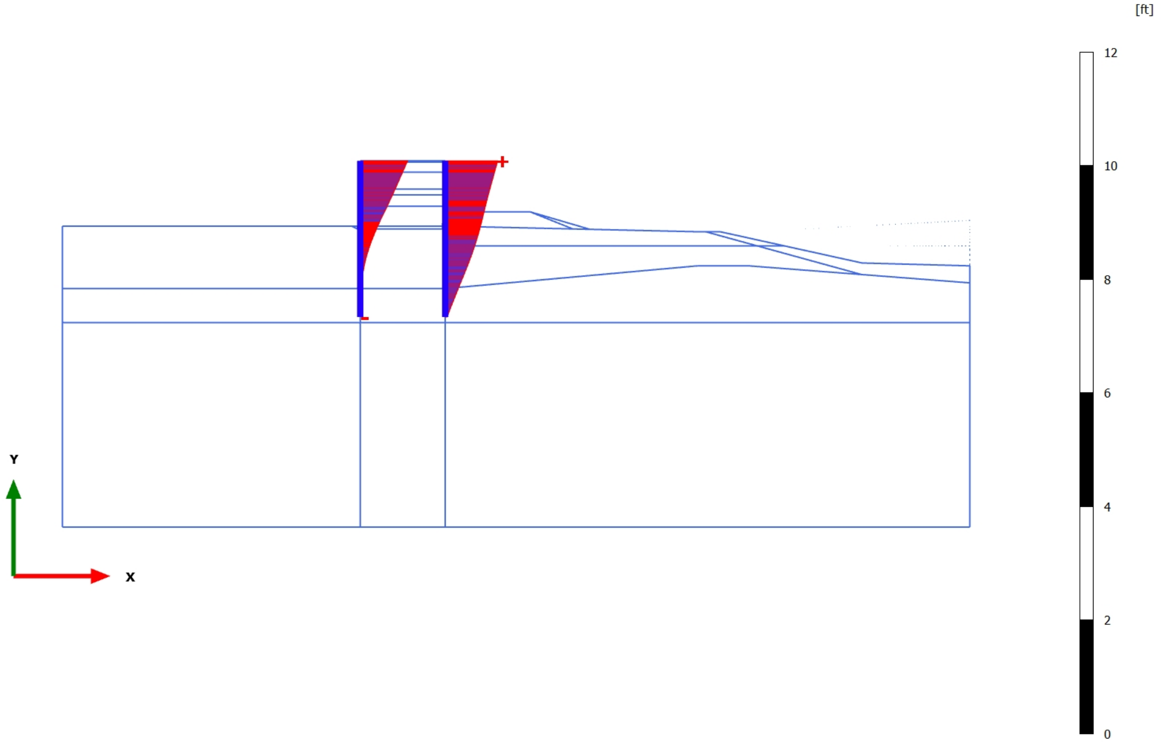


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.8765 ft (Element 2 at Node 2619)

Minimum value = $1.704*10^{-3}$ ft (Element 68 at Node 23173)

3.1.1.1.1.15 Calculation results, Plate, Consolidate [Phase_8] (11/286), Total displacements u_x

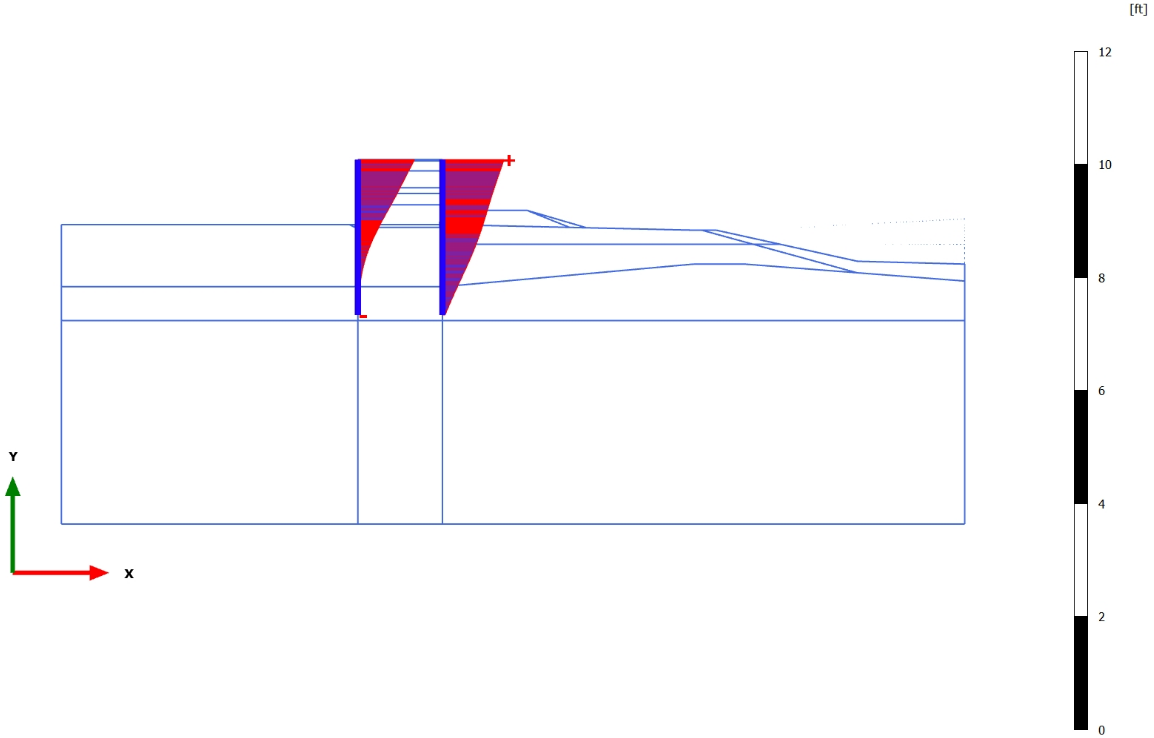


Total displacements u_x (scaled up 20.0 times) (Time 70.00 day)

Maximum value = 0.9277 ft (Element 2 at Node 2619)

Minimum value = 0.4384×10^{-3} ft (Element 68 at Node 23173)

3.1.1.1.1.16 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/294), Total displacements u_x

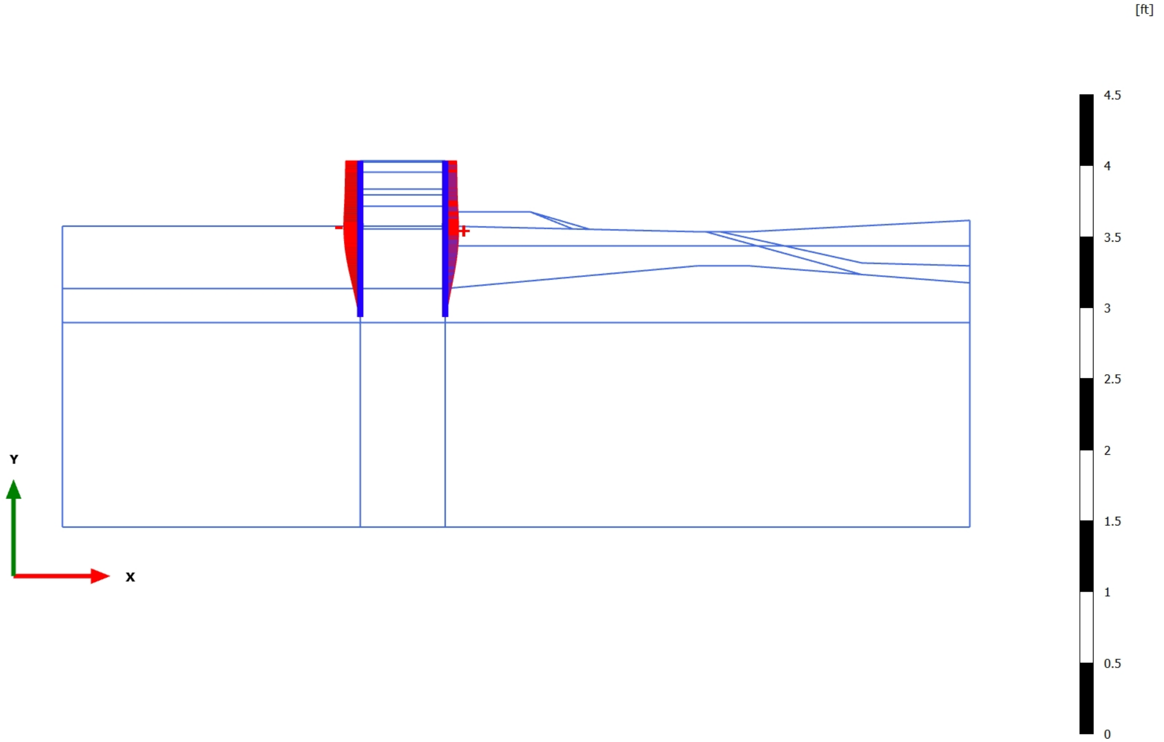


Total displacements u_x (scaled up 20.0 times)

Maximum value = 1.090 ft (Element 2 at Node 2619)

Minimum value = 8.200×10^{-3} ft (Element 68 at Node 23173)

3.1.1.1.1.17 Calculation results, Plate, Buttress fill [Phase_4] (7/452), Total displacements u_x

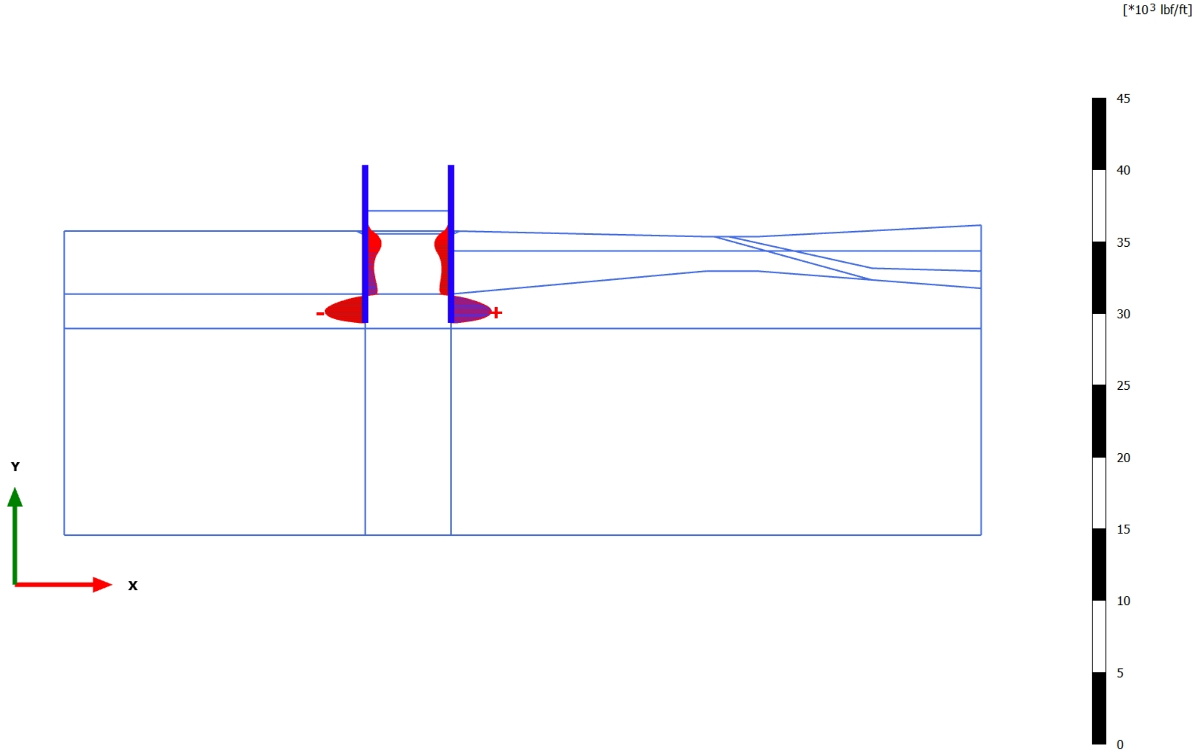


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.09433 ft (Element 38 at Node 15457)

Minimum value = -0.1159 ft (Element 34 at Node 5168)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/33), Shear forces Q

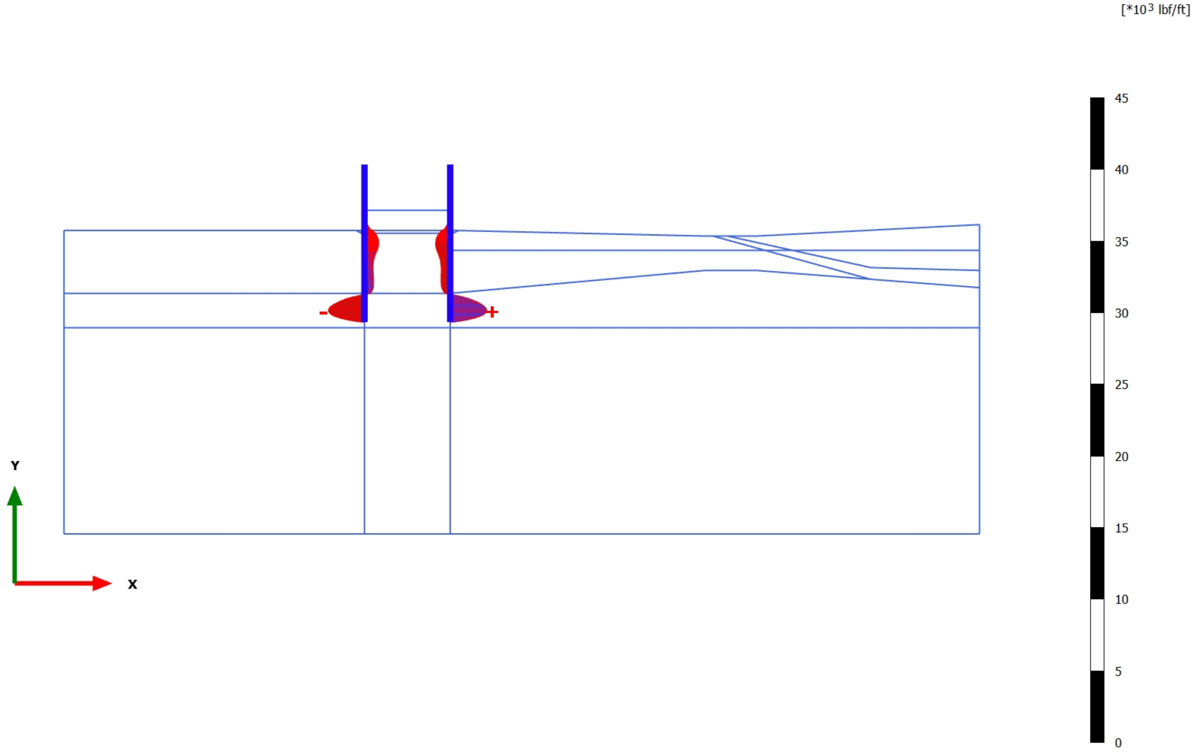


Shear forces Q (scaled up 5.00*10⁻³ times)

Maximum value = 2818 lbf/ft (Element 71 at Node 27814)

Minimum value = -2799 lbf/ft (Element 67 at Node 22433)

3.1.2.1.2 Calculation results, Plate, Consoldate [Phase_26] (14/64), Shear forces Q

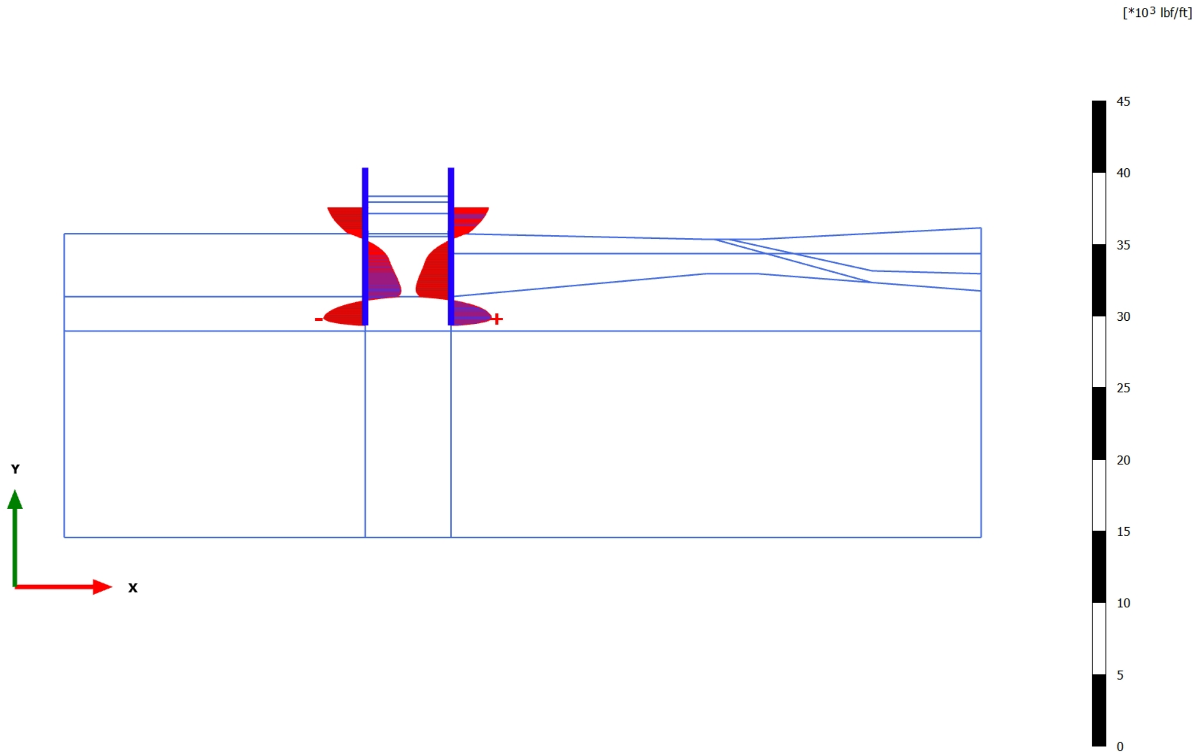


Shear forces Q (scaled up 5.00*10⁻³ times) (Time 7.000 day)

Maximum value = 2565 lbf/ft (Element 71 at Node 27814)

Minimum value = -2521 lbf/ft (Element 67 at Node 22433)

3.1.2.1.3 Calculation results, Plate, Backfill 2 [Phase_3] (3/80), Shear forces Q

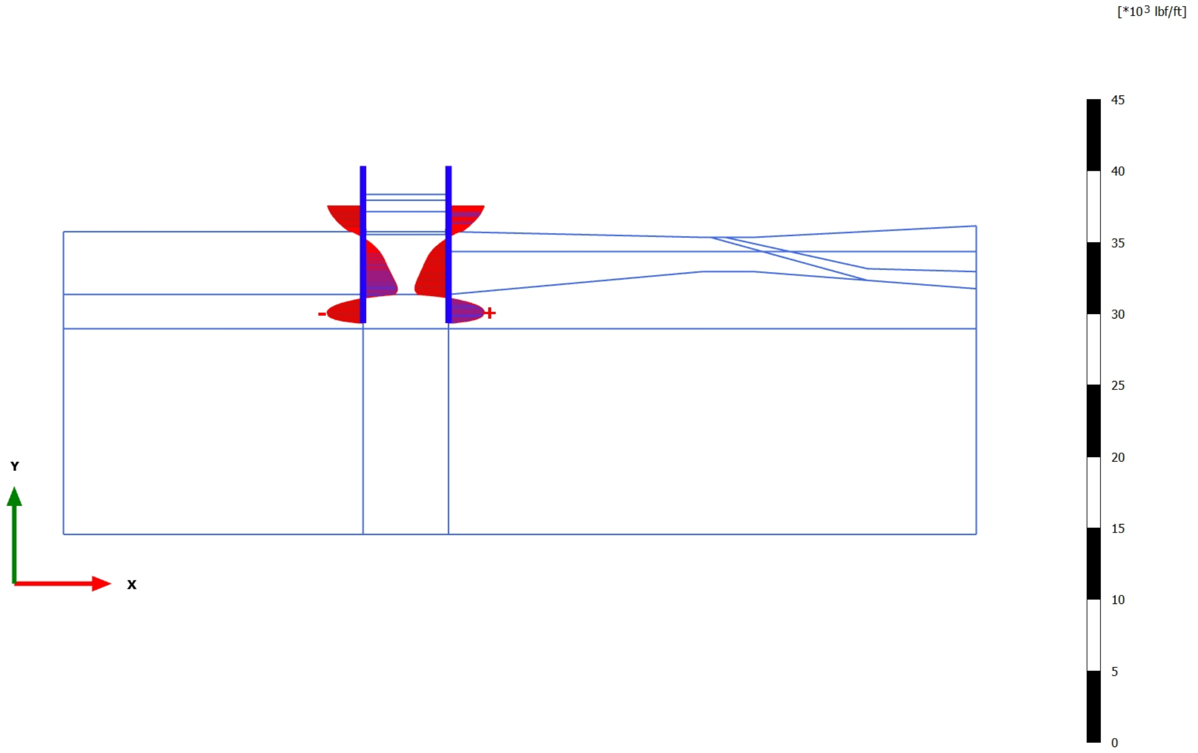


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 2849 lbf/ft (Element 72 at Node 28372)

Minimum value = -2916 lbf/ft (Element 68 at Node 23169)

3.1.2.1.4 Calculation results, Plate, Consolidate [Phase_25] (8/104), Shear forces Q

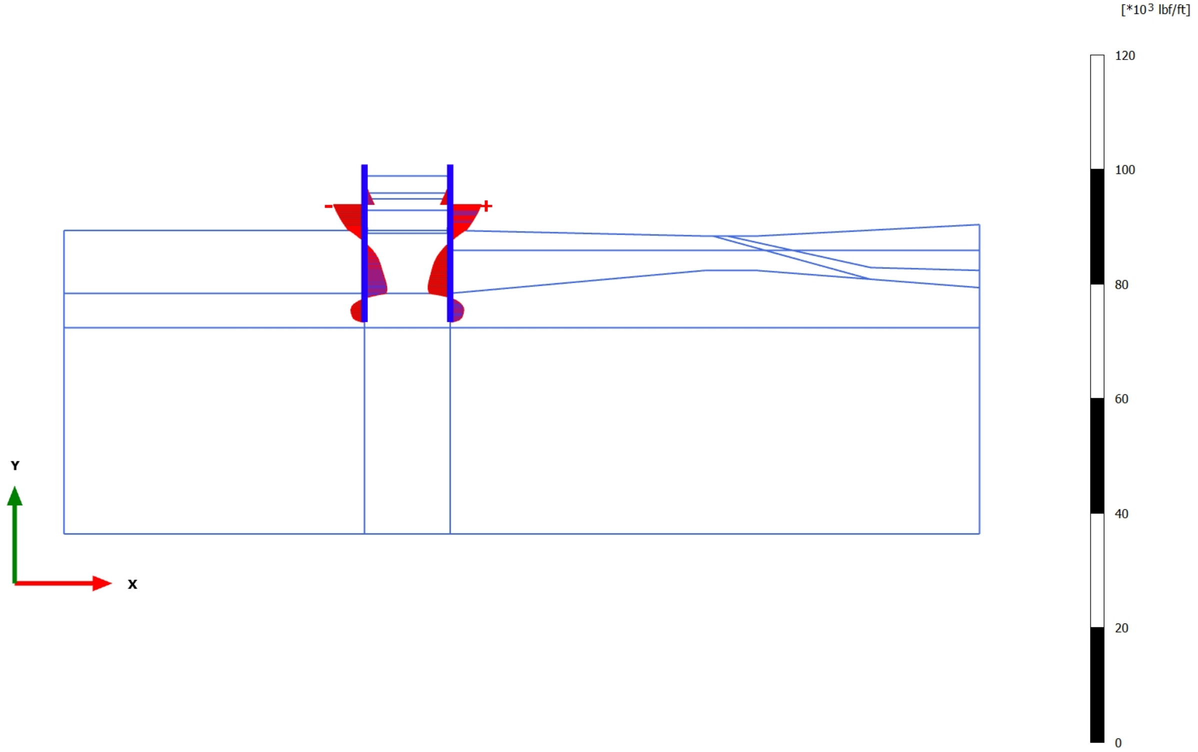


Shear forces Q (scaled up $5.00*10^{-3}$ times) (Time 14.00 day)

Maximum value = 2512 lbf/ft (Element 71 at Node 27814)

Minimum value = -2523 lbf/ft (Element 67 at Node 22433)

3.1.2.1.5 Calculation results, Plate, Backfill 3 [Phase_5] (5/114), Shear forces Q

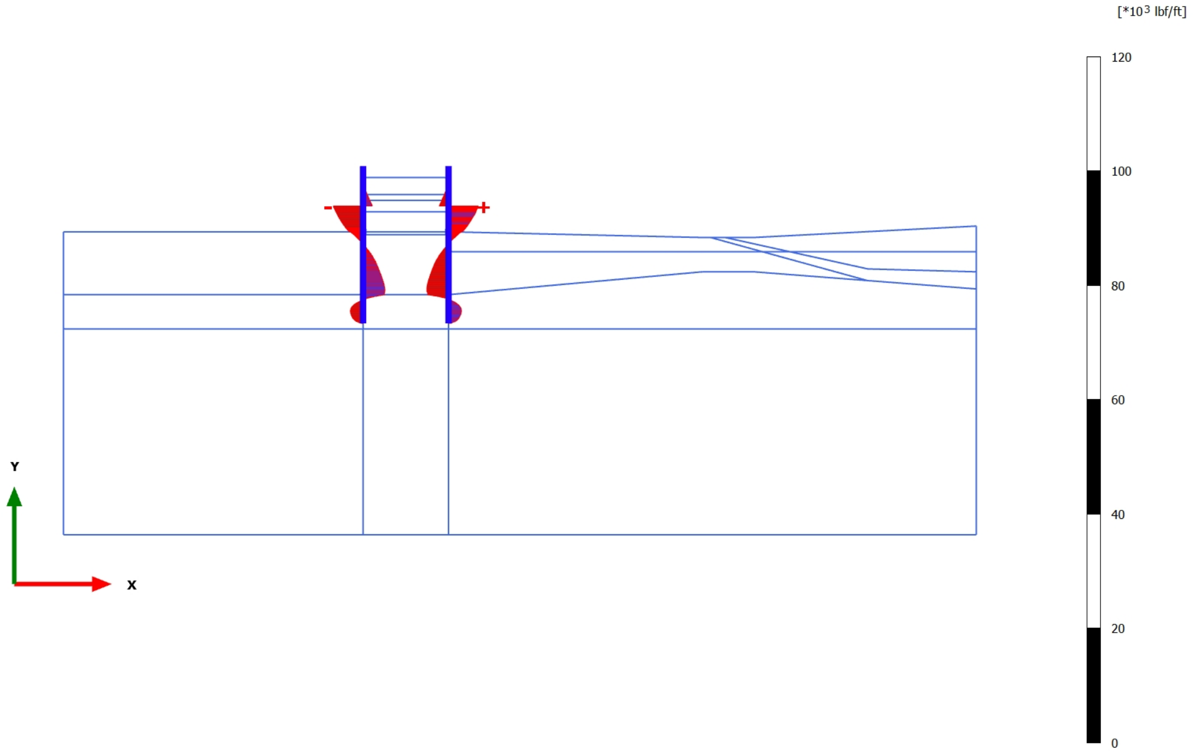


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 5450 lbf/ft (Element 19 at Node 6009)

Minimum value = -5446 lbf/ft (Element 20 at Node 279)

3.1.2.1.6 Calculation results, Plate, Consolidate [Phase_11] (15/128), Shear forces Q

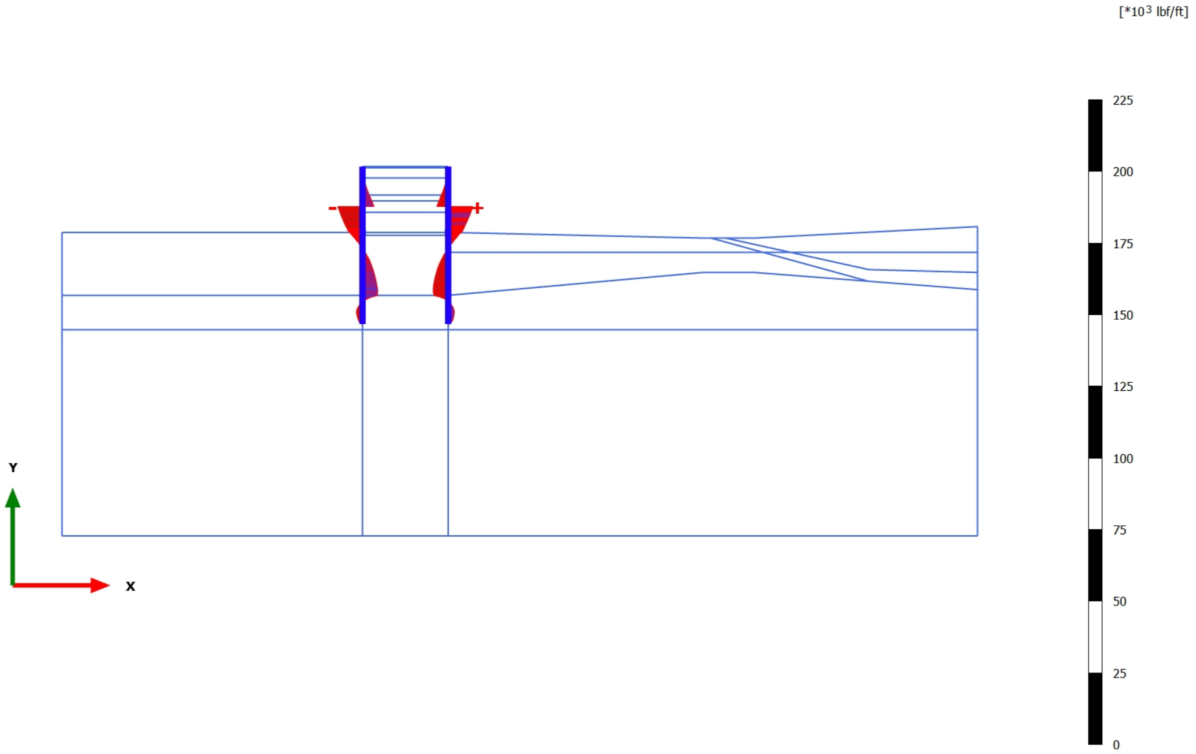


Shear forces Q (scaled up $2.00*10^{-3}$ times) (Time 21.00 day)

Maximum value = 5230 lbf/ft (Element 19 at Node 6009)

Minimum value = -5227 lbf/ft (Element 20 at Node 279)

3.1.2.1.7 Calculation results, Plate, Backfill 4 [Phase_6] (6/139), Shear forces Q

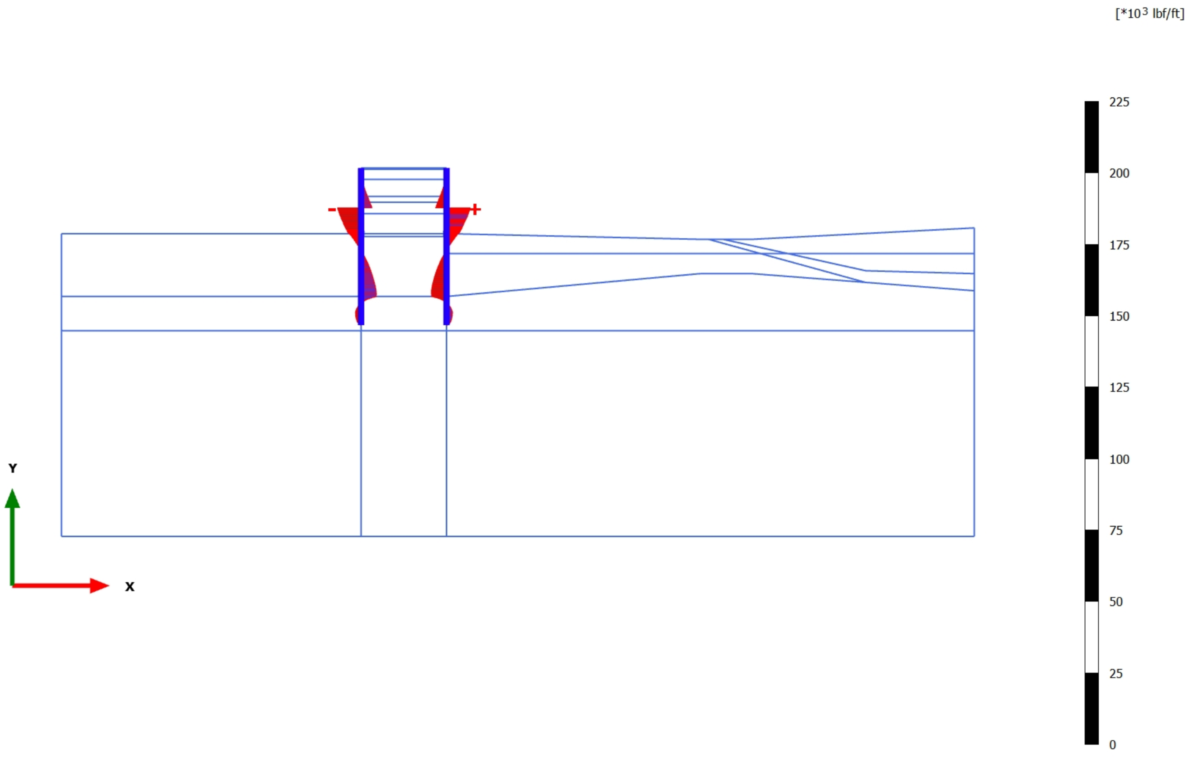


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8613 lbf/ft (Element 19 at Node 6009)

Minimum value = -8601 lbf/ft (Element 20 at Node 279)

3.1.2.1.8 Calculation results, Plate, Consolidate [Phase_7] (10/156), Shear forces Q

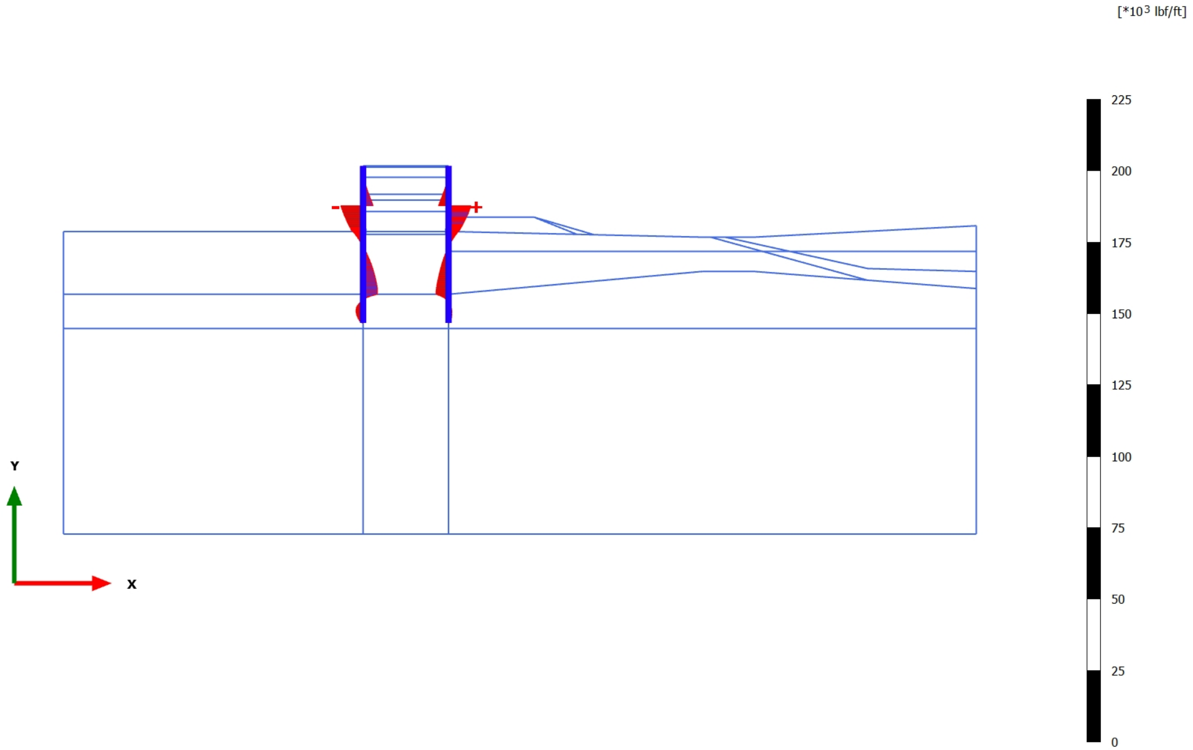


Shear forces Q (scaled up $1.00*10^{-3}$ times) (Time 28.00 day)

Maximum value = 8323 lbf/ft (Element 19 at Node 6009)

Minimum value = -8304 lbf/ft (Element 20 at Node 279)

3.1.2.1.9 Calculation results, Plate, Consolidate [Phase_16] (24/190), Shear forces Q

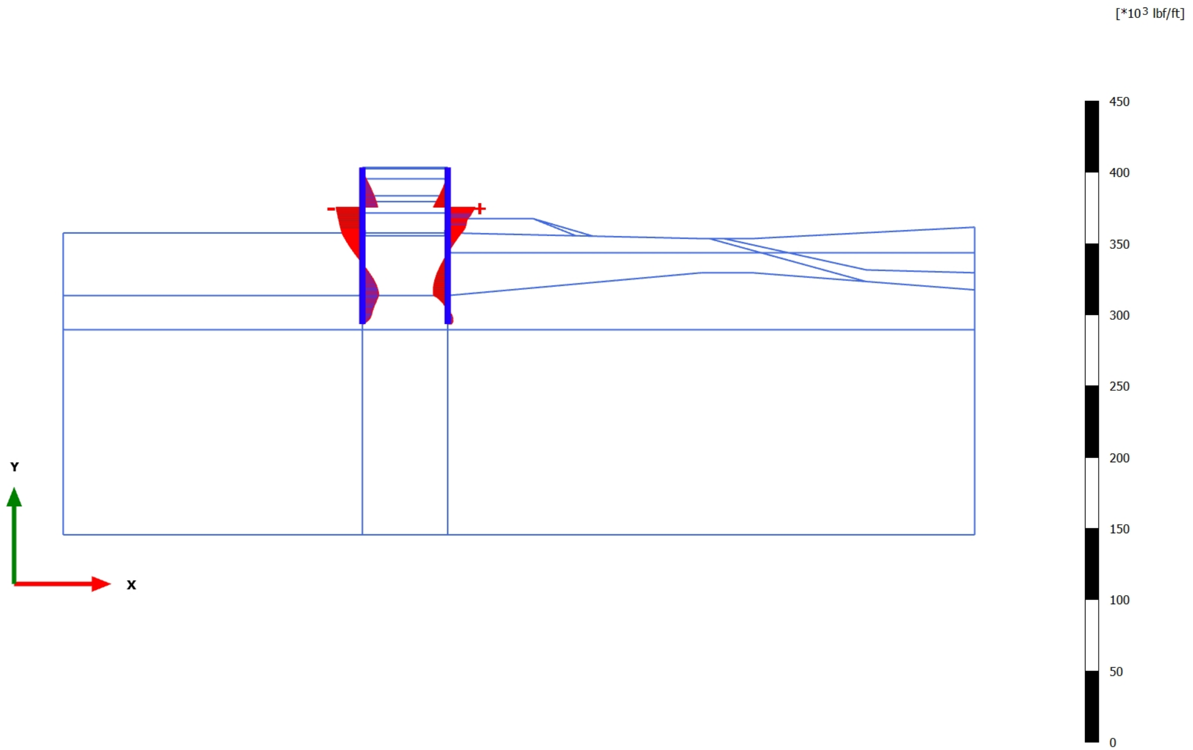


Shear forces Q (scaled up $1.00*10^{-3}$ times) (Time 35.00 day)

Maximum value = 7866 lbf/ft (Element 19 at Node 6009)

Minimum value = -7830 lbf/ft (Element 20 at Node 279)

3.1.2.1.10 Calculation results, Plate, Dewater -SS [Phase_14] (16/239), Shear forces Q

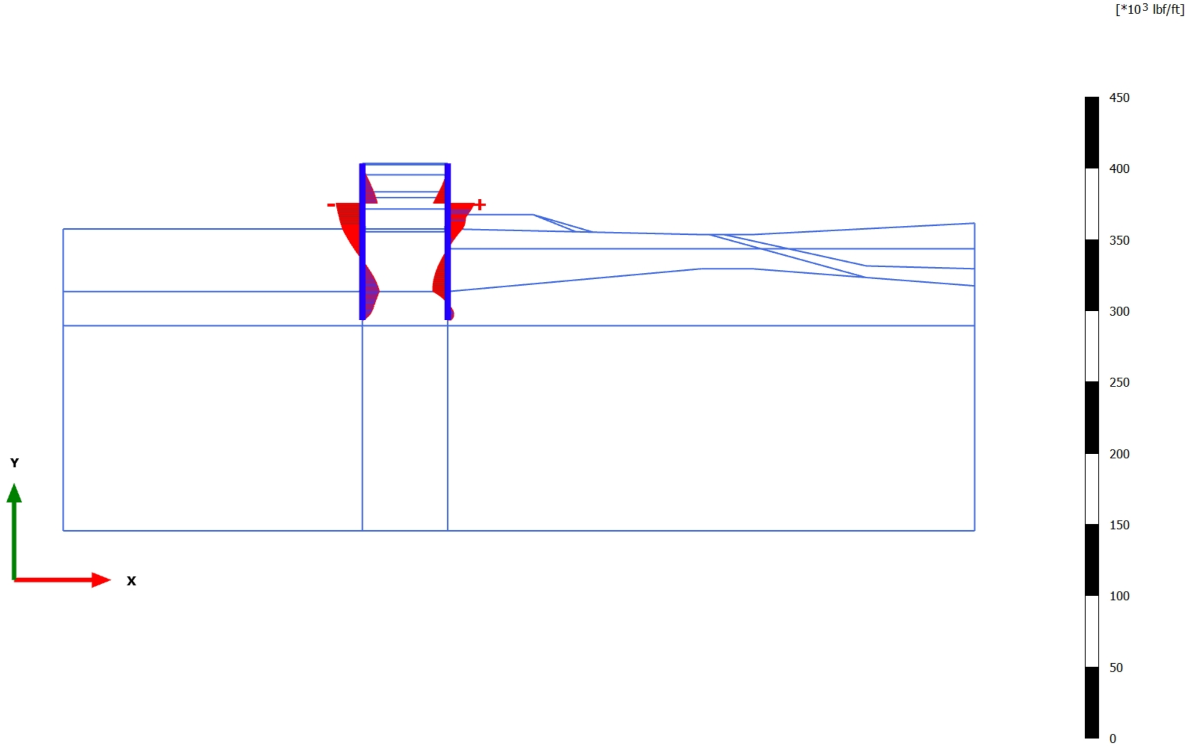


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $19.28*10^3$ lbf/ft (Element 19 at Node 6009)

Minimum value = $-18.58*10^3$ lbf/ft (Element 20 at Node 279)

3.1.2.1.11 Calculation results, Plate, Consolidation [Phase_17] (17/254), Shear forces Q

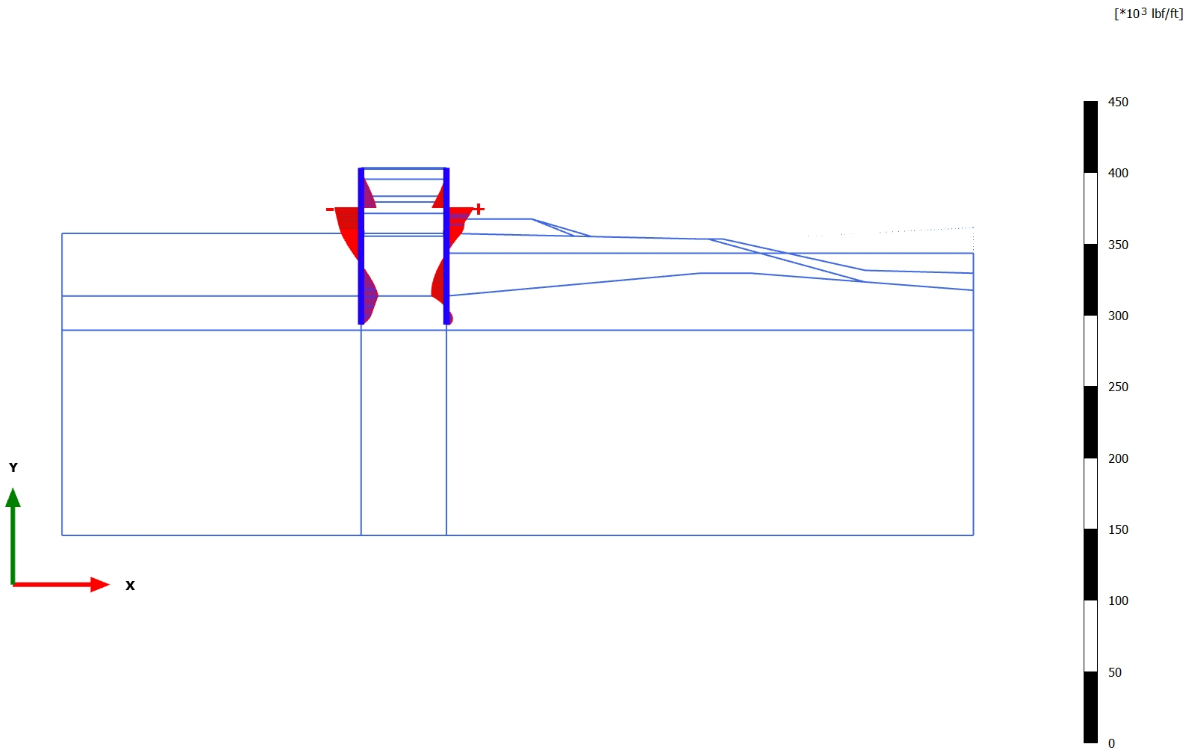


Shear forces Q (scaled up $0.500*10^{-3}$ times) (Time 39.00 day)

Maximum value = $18.88*10^3$ lbf/ft (Element 19 at Node 6009)

Minimum value = $-18.52*10^3$ lbf/ft (Element 20 at Node 279)

3.1.2.1.12 Calculation results, Plate, Excavation 1 [Phase_18] (18/257), Shear forces Q

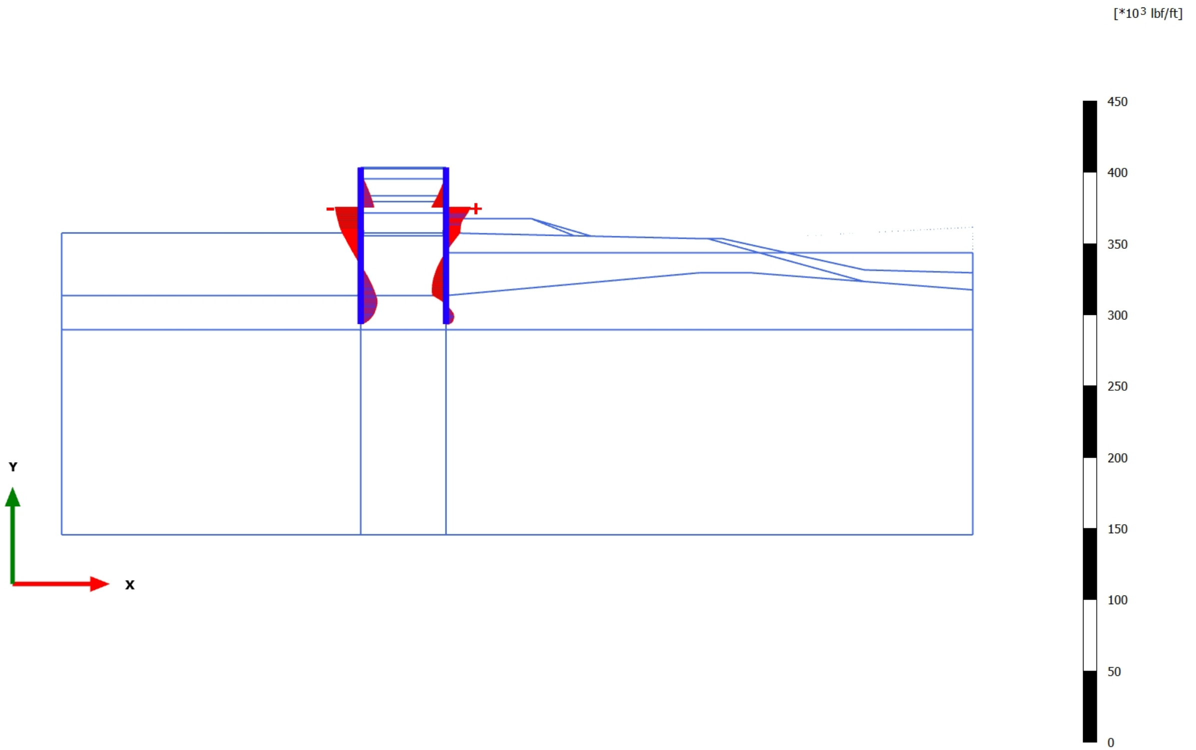


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $18.92*10^3$ lbf/ft (Element 19 at Node 6009)

Minimum value = $-18.54*10^3$ lbf/ft (Element 20 at Node 279)

3.1.2.1.13 Calculation results, Plate, Consolidation [Phase_20] (20/272), Shear forces Q

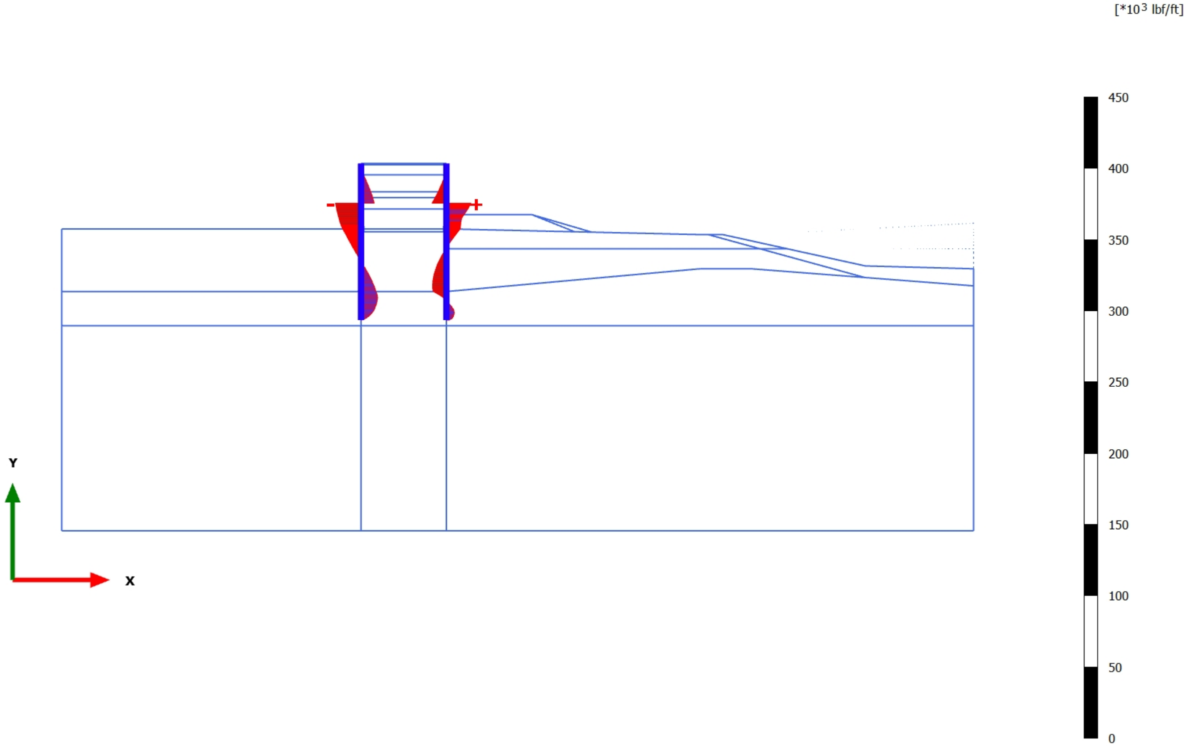


Shear forces Q (scaled up 0.500*10^{-3} times) (Time 56.00 day)

Maximum value = 17.24*10^3 lbf/ft (Element 19 at Node 6009)

Minimum value = -18.00*10^3 lbf/ft (Element 20 at Node 279)

3.1.2.1.14 Calculation results, Plate, Excavation 2 [Phase_21] (21/274), Shear forces Q

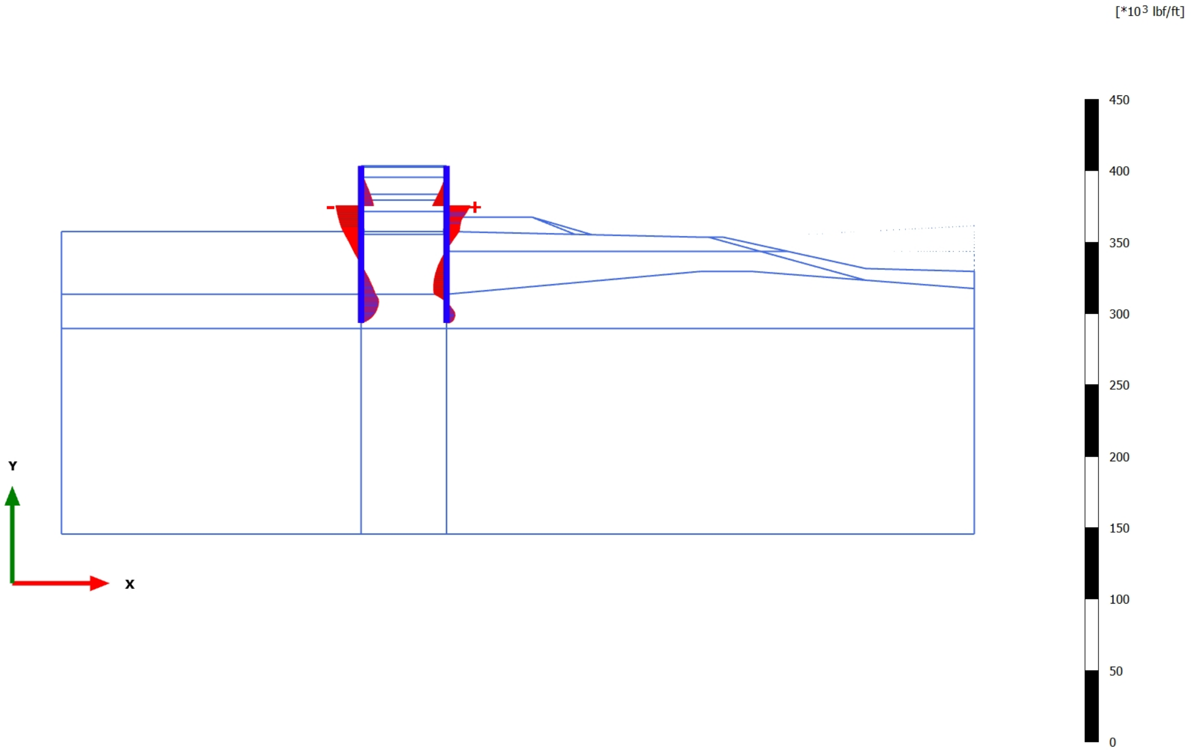


Shear forces Q (scaled up 0.500×10^{-3} times)

Maximum value = 17.27×10^{3} lbf/ft (Element 19 at Node 6009)

Minimum value = -18.00×10^{3} lbf/ft (Element 20 at Node 279)

3.1.2.1.15 Calculation results, Plate, Consolidate [Phase_8] (11/286), Shear forces Q

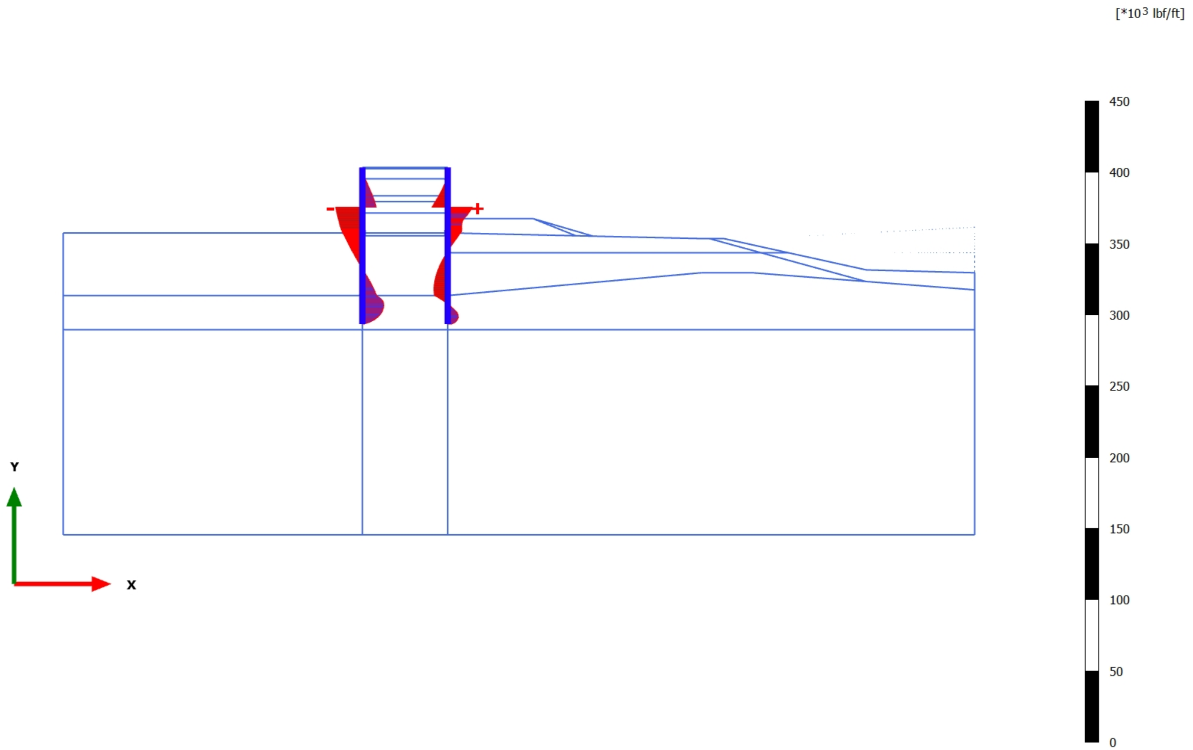


Shear forces Q (scaled up $0.500*10^{-3}$ times) (Time 70.00 day)

Maximum value = $16.56*10^3$ lbf/ft (Element 19 at Node 6009)

Minimum value = $-17.69*10^3$ lbf/ft (Element 20 at Node 279)

3.1.2.1.16 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/294), Shear forces Q

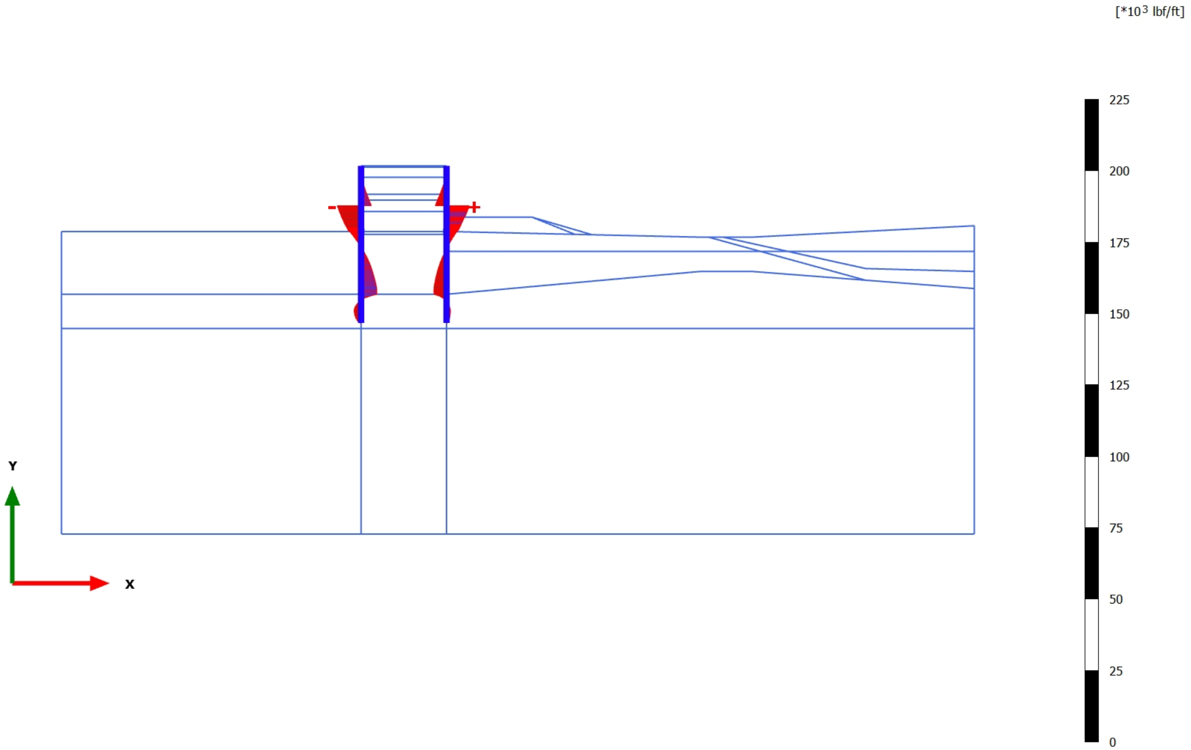


Shear forces Q (scaled up 0.500×10^{-3} times)

Maximum value = 17.46×10^3 lbf/ft (Element 19 at Node 6009)

Minimum value = -18.84×10^3 lbf/ft (Element 20 at Node 279)

3.1.2.1.17 Calculation results, Plate, Buttress fill [Phase_4] (7/452), Shear forces Q

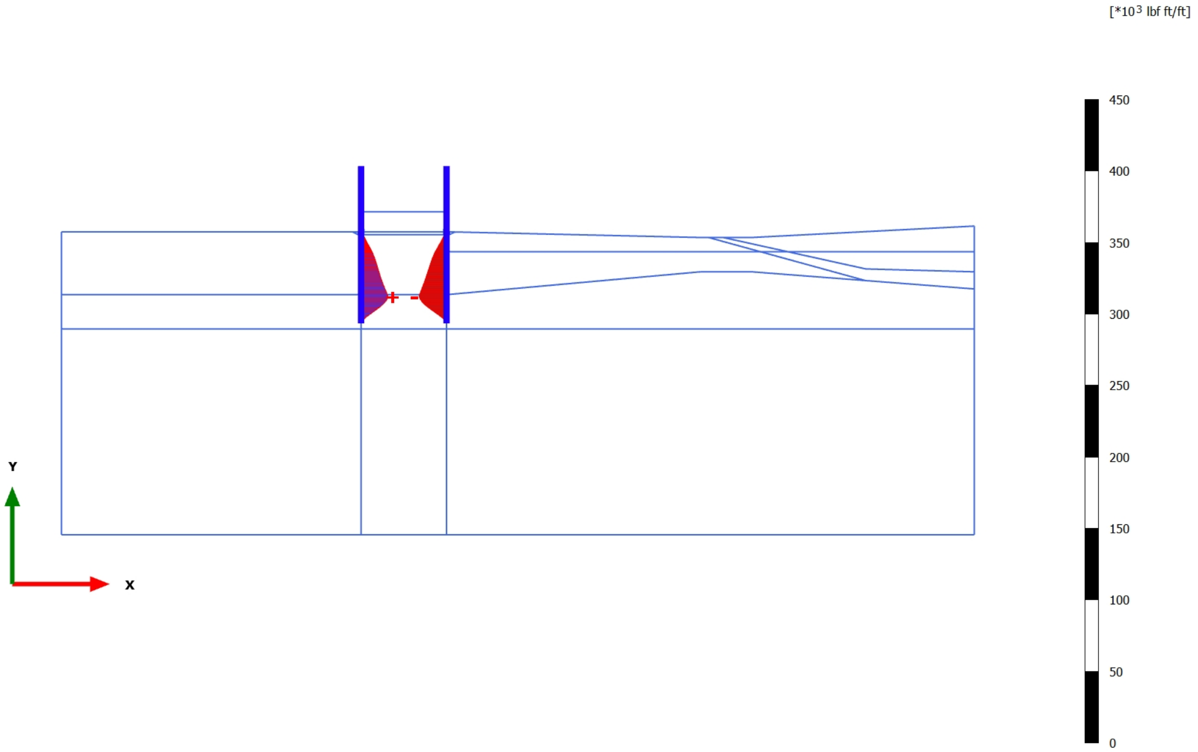


Shear forces Q (scaled up 1.00*10⁻³ times)

Maximum value = 7962 lbf/ft (Element 19 at Node 6009)

Minimum value = -8324 lbf/ft (Element 20 at Node 279)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/33), Bending moments M

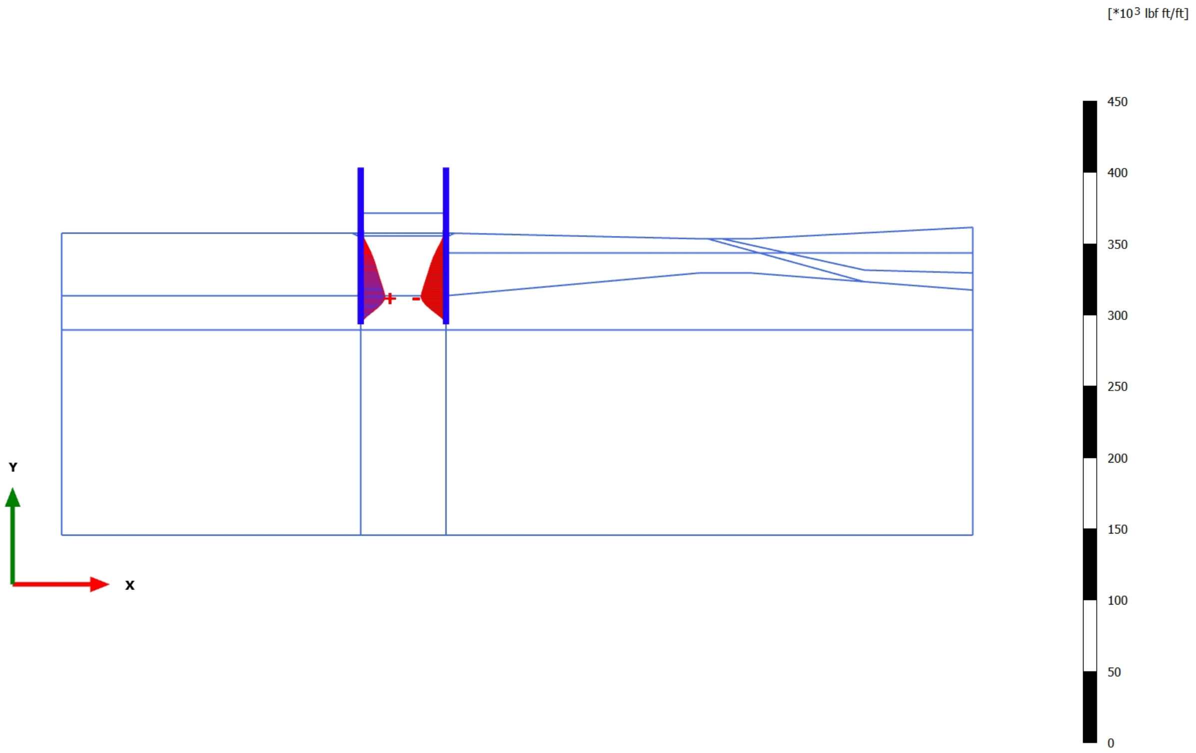


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $18.82*10^{3}$ lbf ft/ft (Element 65 at Node 21018)

Minimum value = $-19.19*10^{3}$ lbf ft/ft (Element 69 at Node 26021)

3.1.2.2.2 Calculation results, Plate, Consoldate [Phase_26] (14/64), Bending moments M

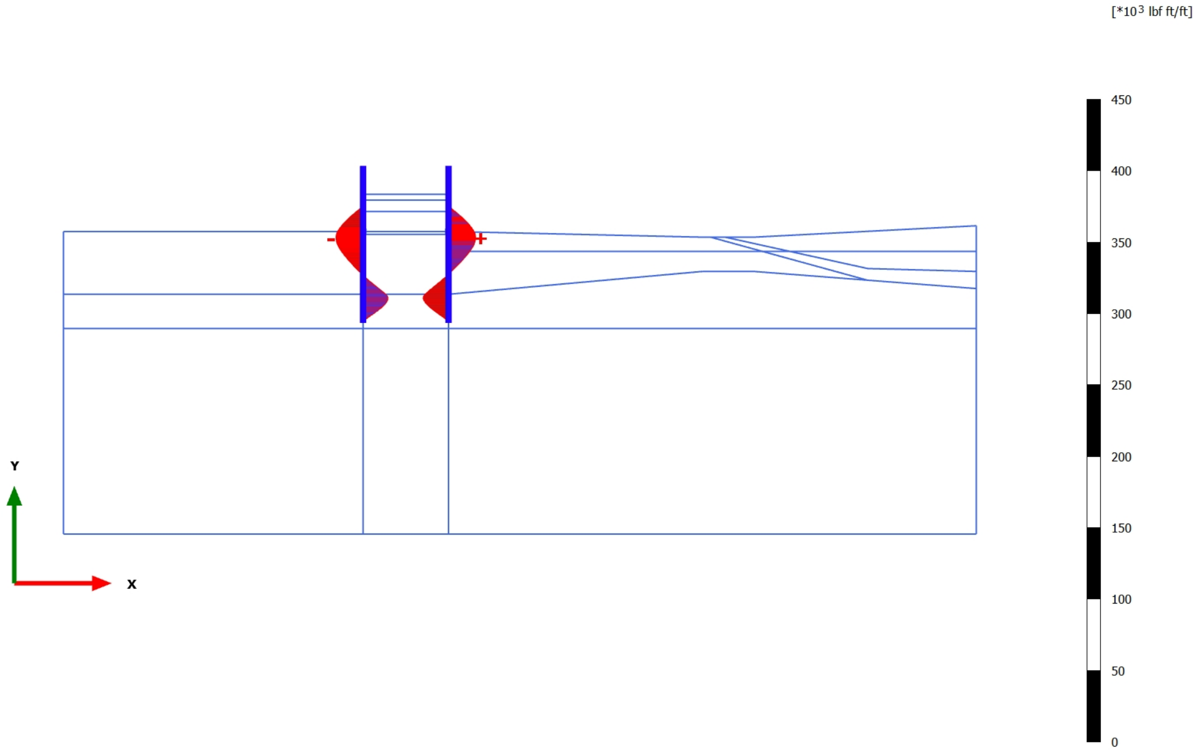


Bending moments M (scaled up 0.500*10^{-3} times) (Time 7.000 day)

Maximum value = 17.14*10^3 lbf ft/ft (Element 65 at Node 21018)

Minimum value = -17.55*10^3 lbf ft/ft (Element 69 at Node 26021)

3.1.2.2.3 Calculation results, Plate, Backfill 2 [Phase_3] (3/80), Bending moments M

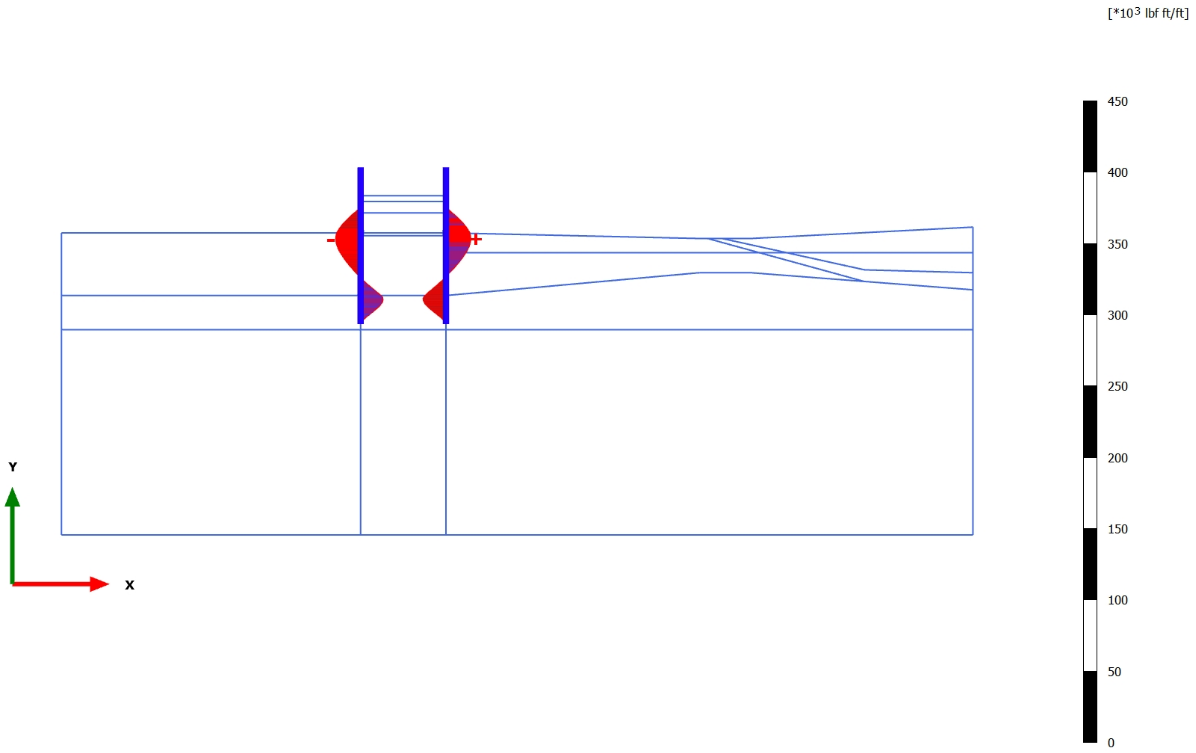


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $19.02*10^{3}$ lbf ft/ft (Element 39 at Node 17969)

Minimum value = $-19.02*10^{3}$ lbf ft/ft (Element 48 at Node 7754)

3.1.2.2.4 Calculation results, Plate, Consolidate [Phase_25] (8/104), Bending moments M

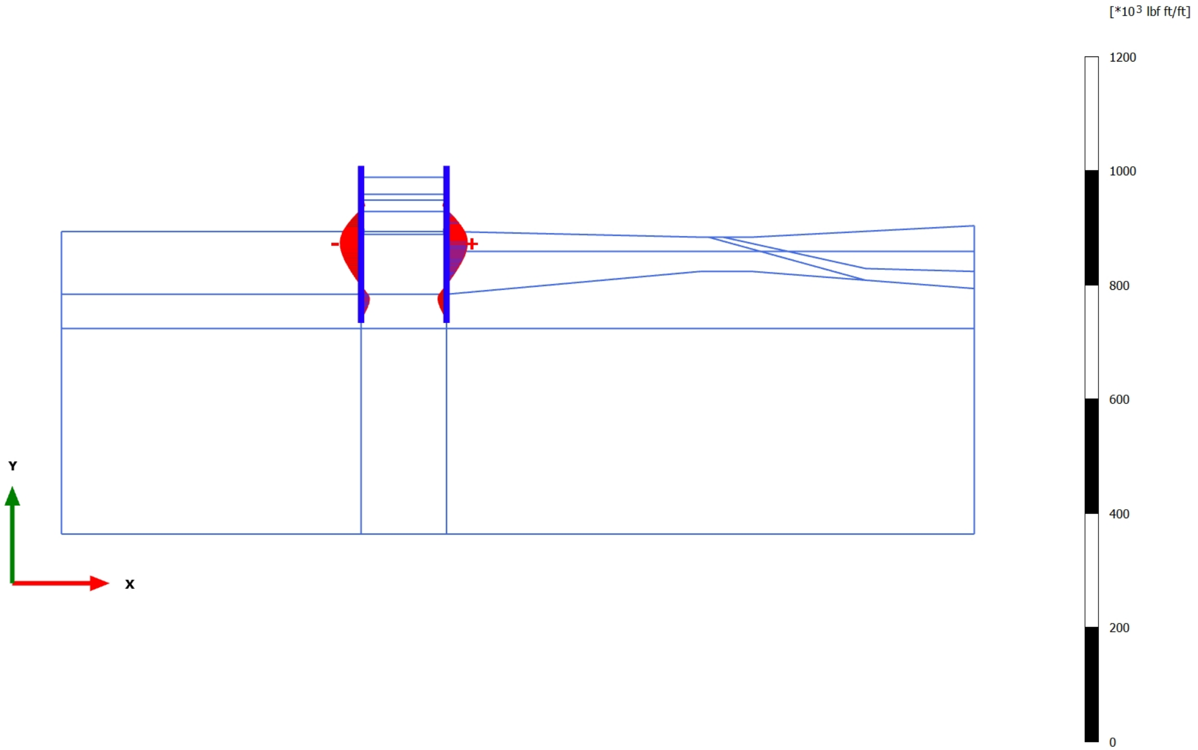


Bending moments M (scaled up 0.500*10^{-3} times) (Time 14.00 day)

Maximum value = 17.43*10^{3} lbf ft/ft (Element 39 at Node 17238)

Minimum value = -17.49*10^{3} lbf ft/ft (Element 47 at Node 7751)

3.1.2.2.5 Calculation results, Plate, Backfill 3 [Phase_5] (5/114), Bending moments M

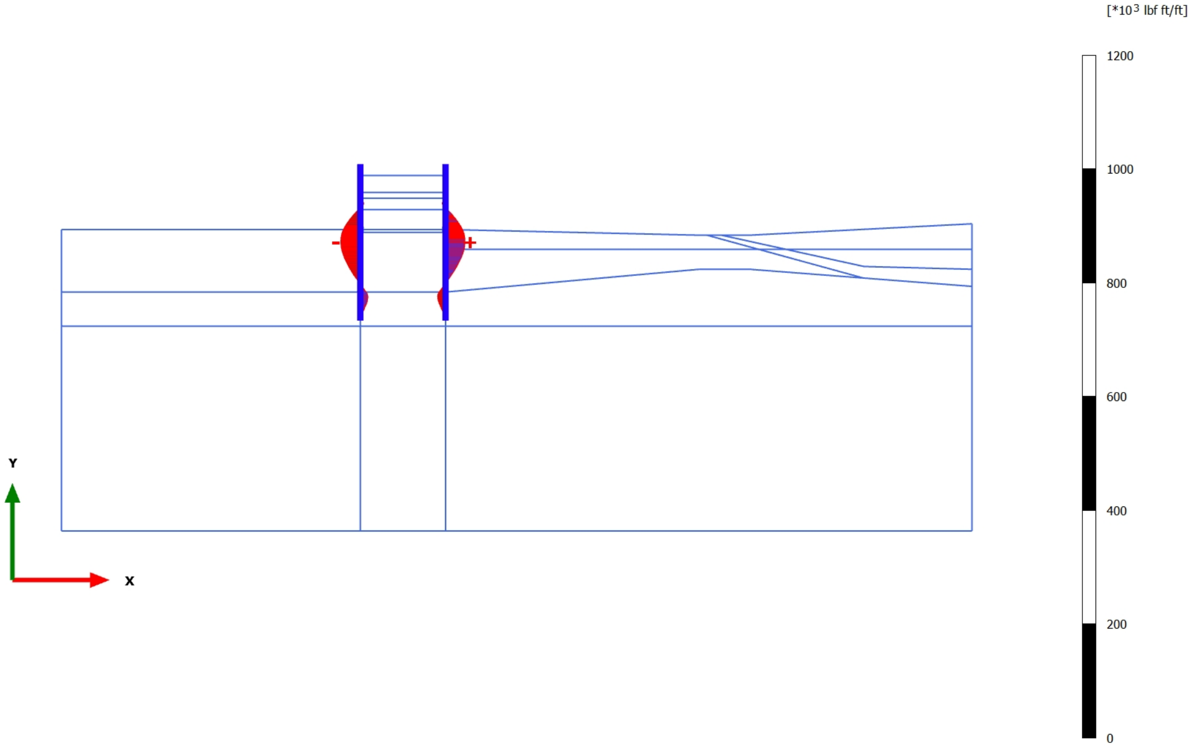


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $36.49*10^{3}$ lbf ft/ft (Element 41 at Node 19429)

Minimum value = $-36.57*10^{3}$ lbf ft/ft (Element 50 at Node 9212)

3.1.2.2.6 Calculation results, Plate, Consolidate [Phase_11] (15/128), Bending moments M

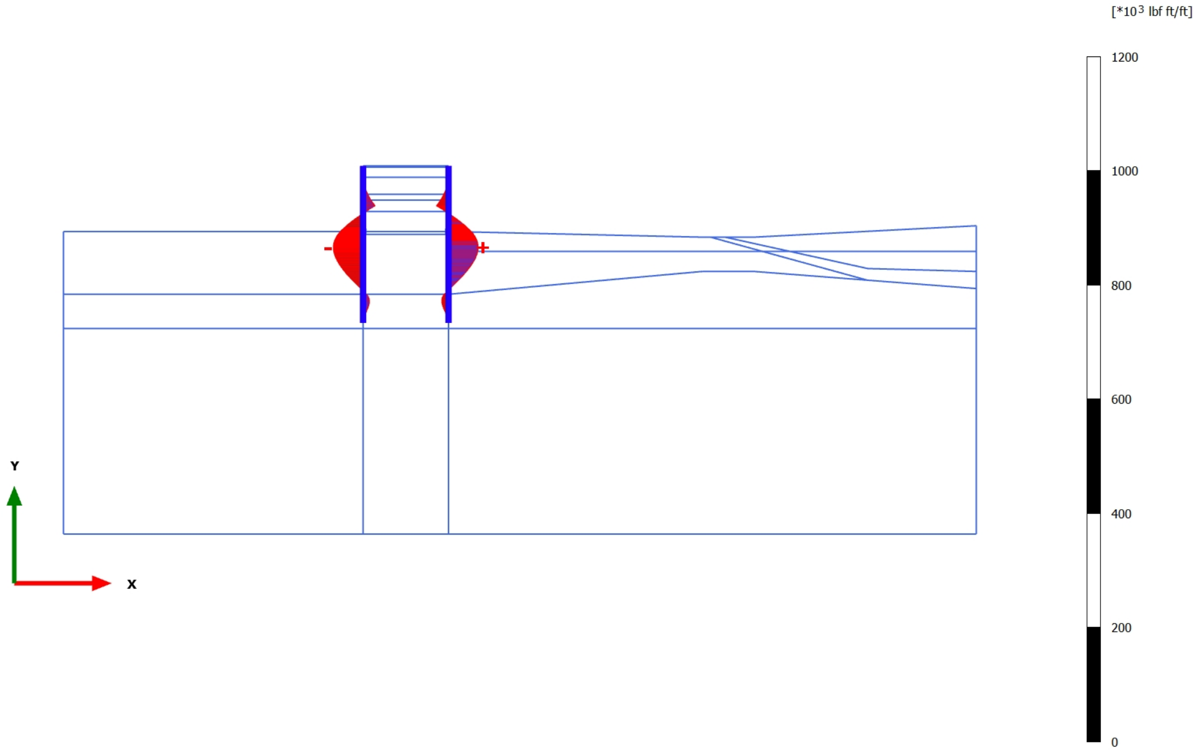


Bending moments M (scaled up 0.200*10^{-3} times) (Time 21.00 day)

Maximum value = 34.18*10^{3} lbf ft/ft (Element 41 at Node 19430)

Minimum value = -34.30*10^{3} lbf ft/ft (Element 51 at Node 10149)

3.1.2.2.7 Calculation results, Plate, Backfill 4 [Phase_6] (6/139), Bending moments M

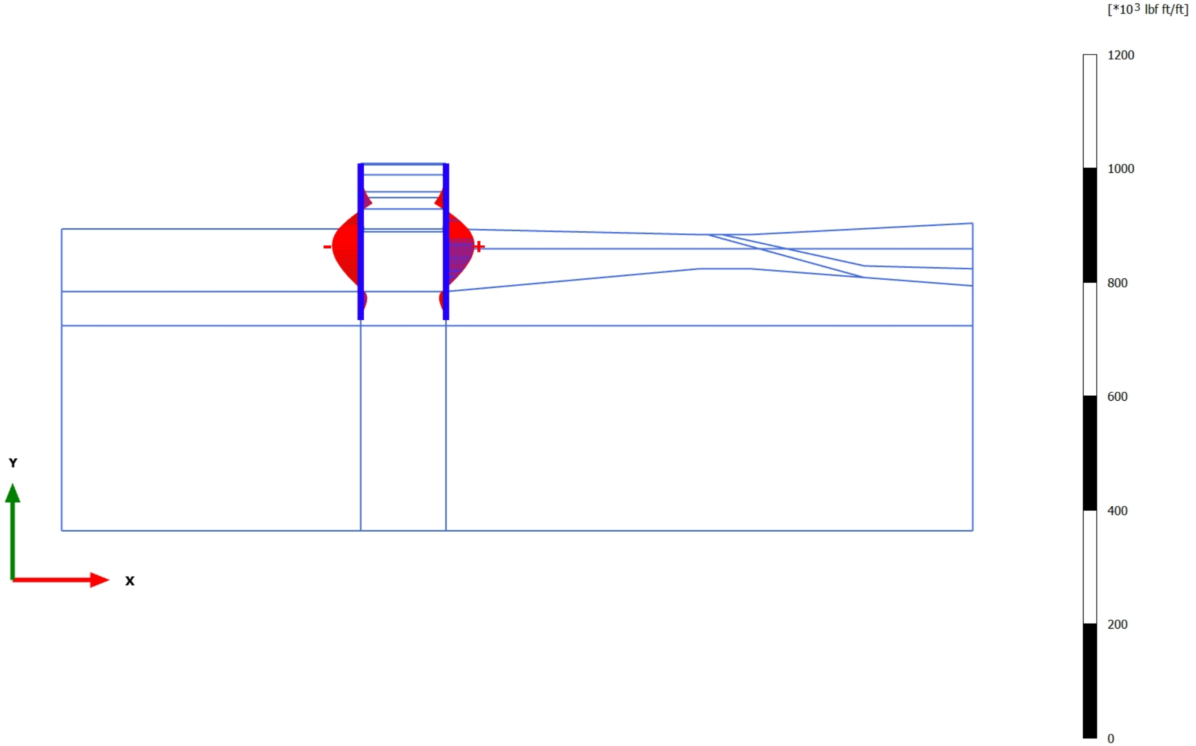


Bending moments M (scaled up 0.200*10⁻³ times)

Maximum value = 51.88*10³ lbf ft/ft (Element 42 at Node 20392)

Minimum value = -52.16*10³ lbf ft/ft (Element 52 at Node 10859)

3.1.2.2.8 Calculation results, Plate, Consolidate [Phase_7] (10/156), Bending moments M

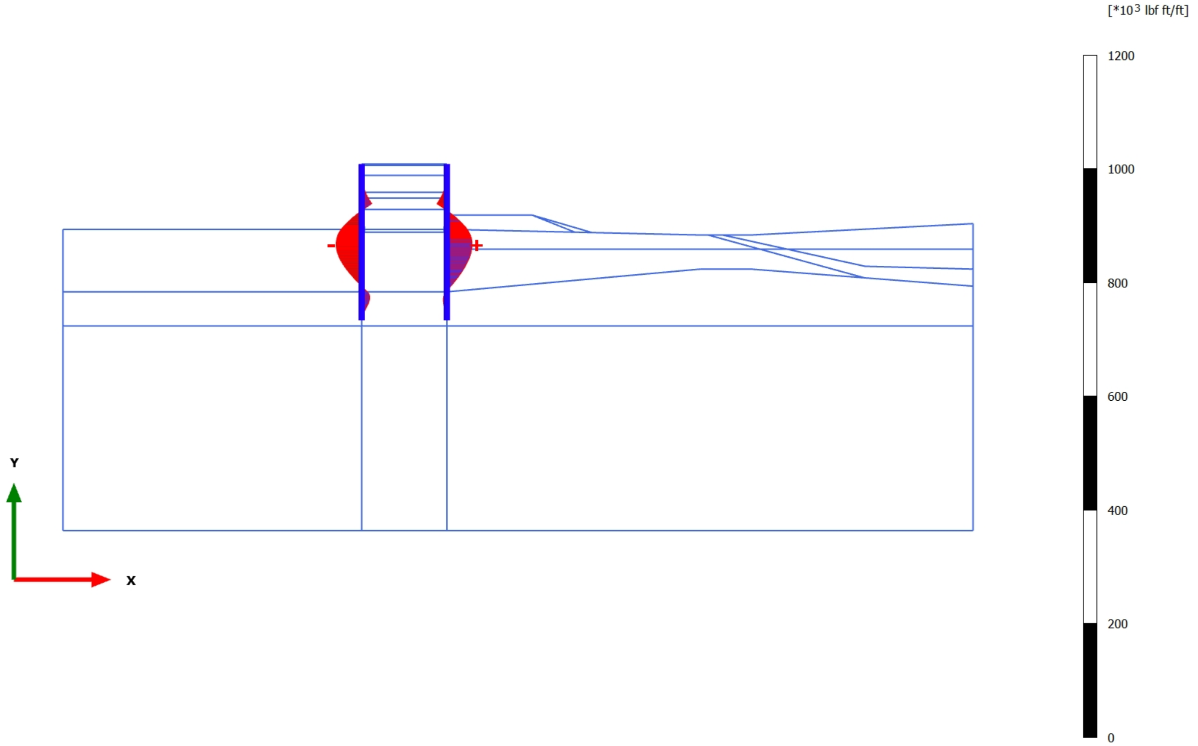


Bending moments M (scaled up 0.200*10-3 times) (Time 28.00 day)

Maximum value = 49.35*10³ lbf ft/ft (Element 42 at Node 20393)

Minimum value = -49.64*10³ lbf ft/ft (Element 52 at Node 10860)

3.1.2.2.9 Calculation results, Plate, Consolidate [Phase_16] (24/190), Bending moments M

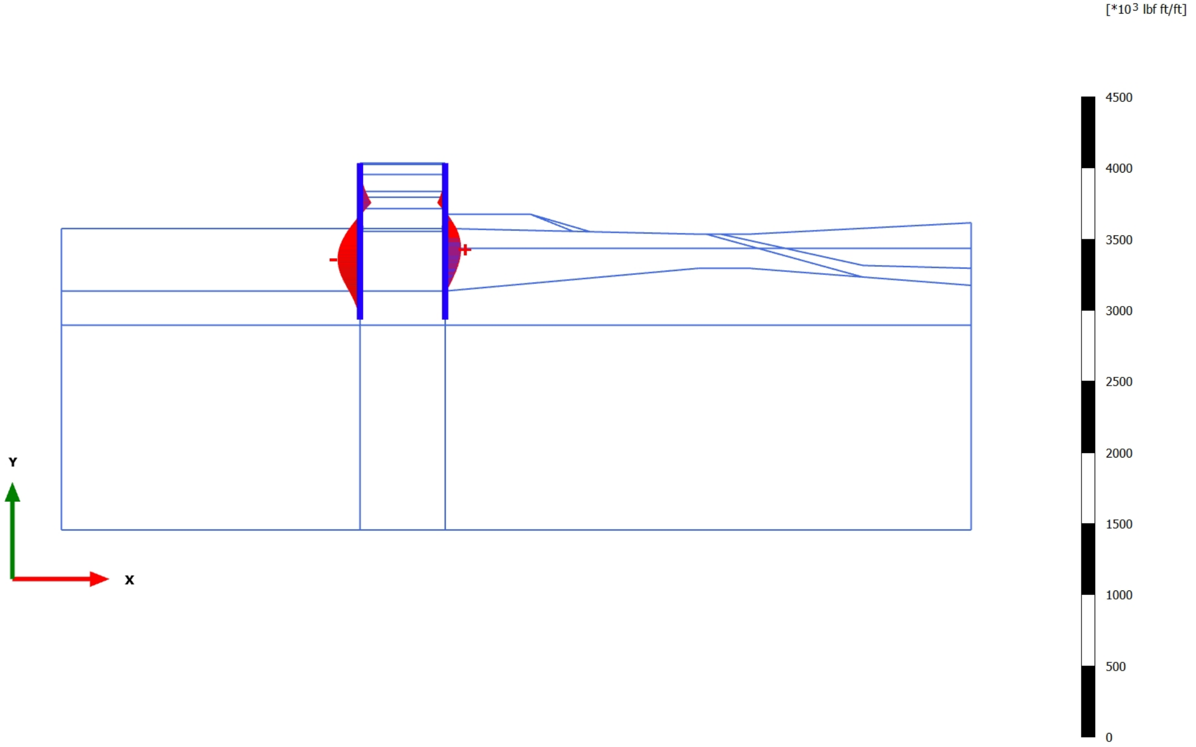


Bending moments M (scaled up 0.200*10^{-3} times) (Time 35.00 day)

Maximum value = 44.33*10^3 lbf ft/ft (Element 42 at Node 20392)

Minimum value = -44.85*10^3 lbf ft/ft (Element 52 at Node 10858)

3.1.2.2.10 Calculation results, Plate, Dewater -SS [Phase_14] (16/239), Bending moments M

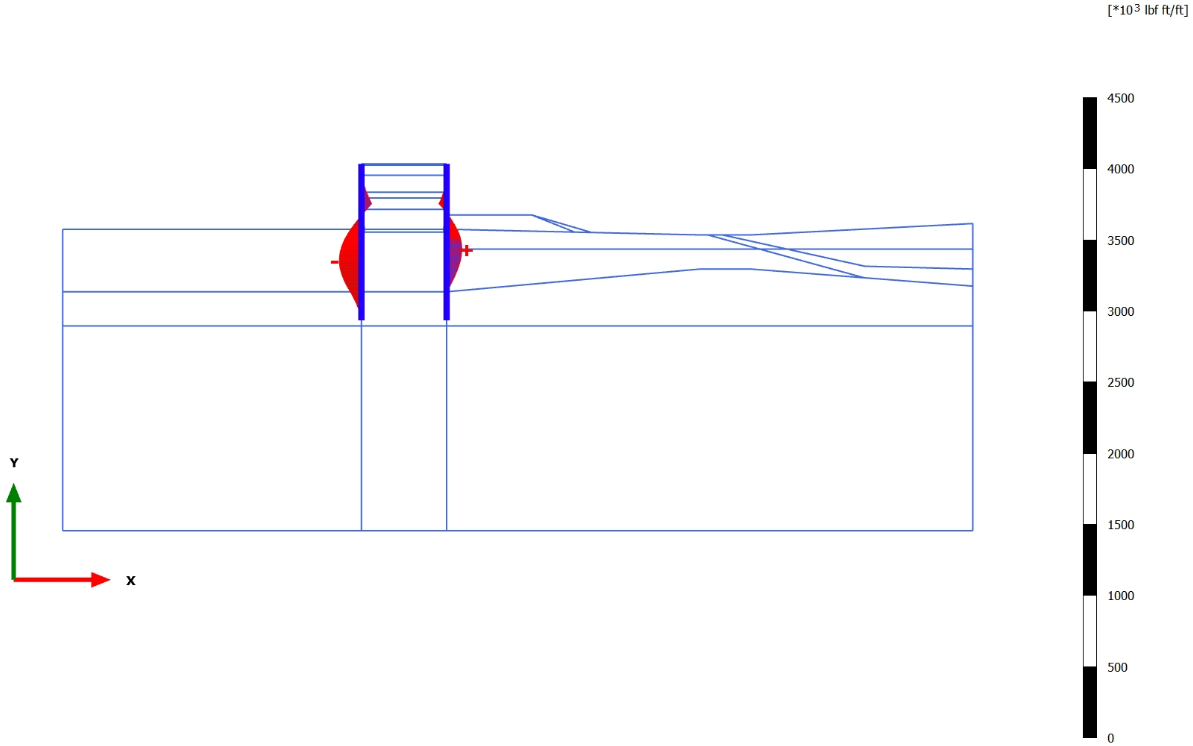


Bending moments M (scaled up $0.0500*10^{-3}$ times)

Maximum value = $109.0*10^3$ lbf ft/ft (Element 42 at Node 21493)

Minimum value = $-154.8*10^3$ lbf ft/ft (Element 56 at Node 16481)

3.1.2.2.11 Calculation results, Plate, Consolidation [Phase_17] (17/254), Bending moments M

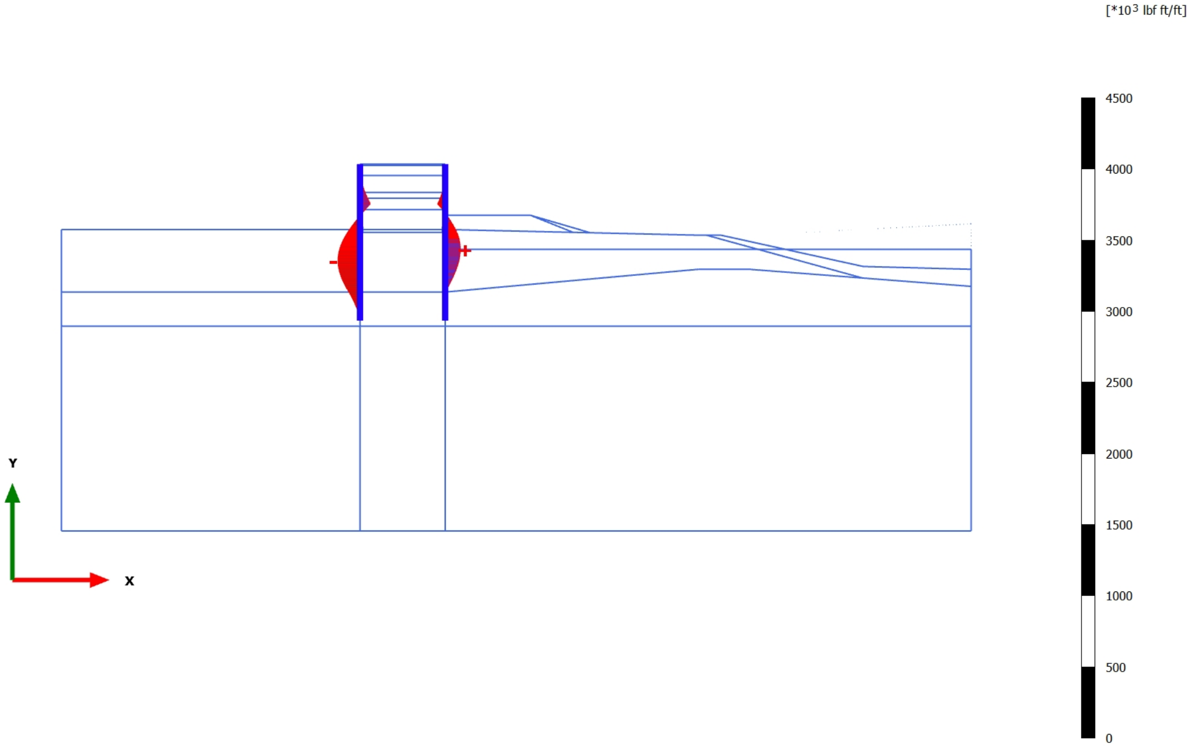


Bending moments M (scaled up $0.0500*10^{-3}$ times) (Time 39.00 day)

Maximum value = $106.1*10^{3}$ lbf ft/ft (Element 42 at Node 21493)

Minimum value = $-154.7*10^{3}$ lbf ft/ft (Element 56 at Node 16480)

3.1.2.2.12 Calculation results, Plate, Excavation 1 [Phase_18] (18/257), Bending moments M

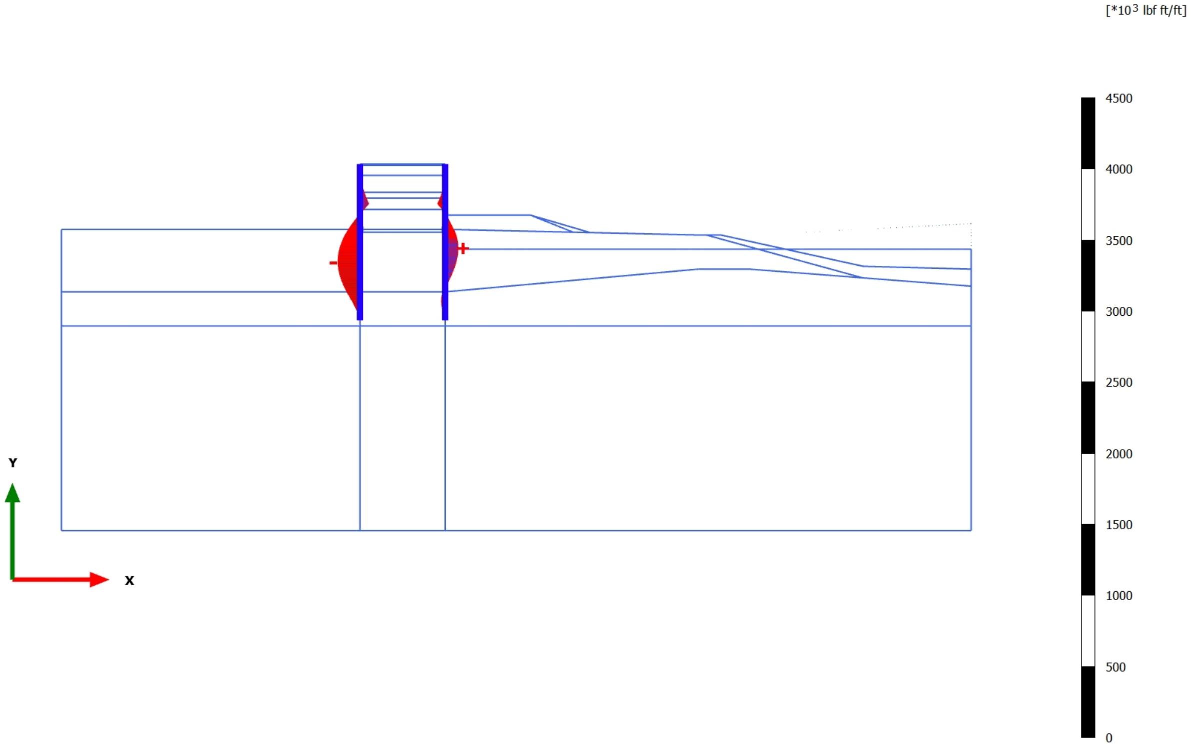


Bending moments M (scaled up $0.0500*10^{-3}$ times)

Maximum value = $106.2*10^3$ lbf ft/ft (Element 43 at Node 21493)

Minimum value = $-154.9*10^3$ lbf ft/ft (Element 56 at Node 16480)

3.1.2.2.13 Calculation results, Plate, Consolidation [Phase_20] (20/272), Bending moments M

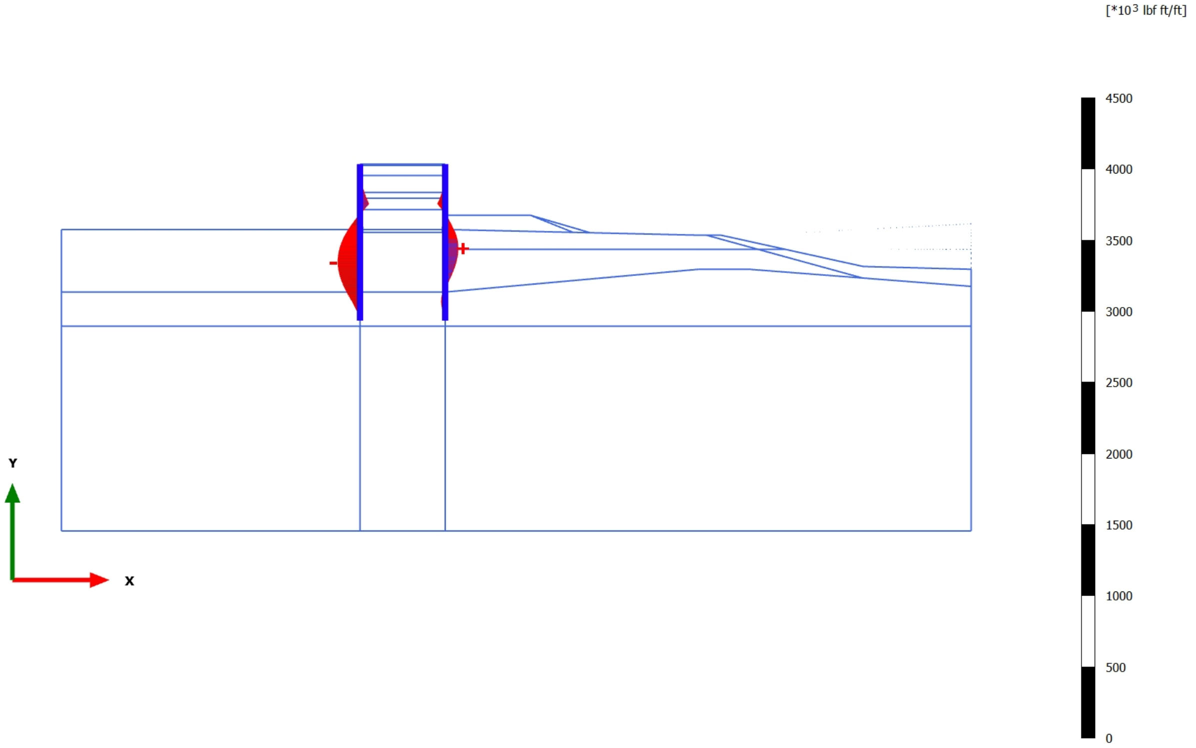


Bending moments M (scaled up 0.0500*10^{-3} times) (Time 56.00 day)

Maximum value = 89.79*10^{3} lbf ft/ft (Element 42 at Node 20394)

Minimum value = -154.3*10^{3} lbf ft/ft (Element 57 at Node 17925)

3.1.2.2.14 Calculation results, Plate, Excavation 2 [Phase_21] (21/274), Bending moments M

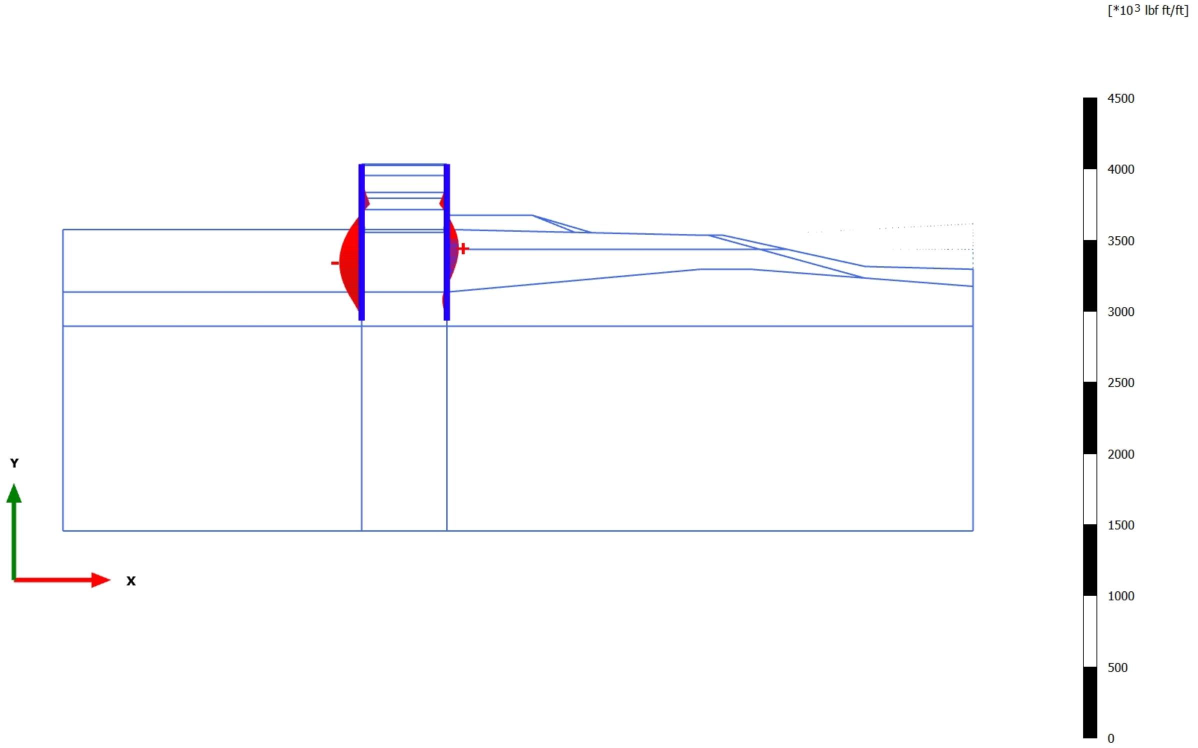


Bending moments M (scaled up $0.0500*10^{-3}$ times)

Maximum value = $89.83*10^{3}$ lbf ft/ft (Element 42 at Node 20394)

Minimum value = $-154.3*10^{3}$ lbf ft/ft (Element 57 at Node 17925)

3.1.2.2.15 Calculation results, Plate, Consolidate [Phase_8] (11/286), Bending moments M

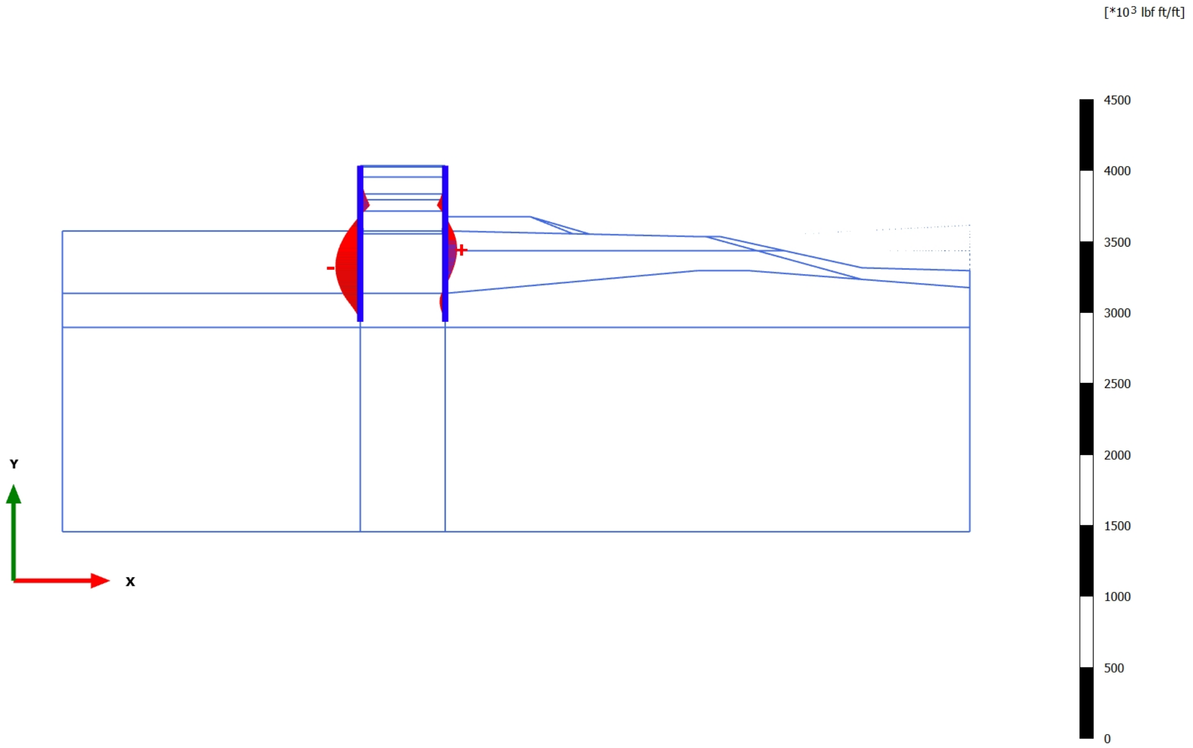


Bending moments M (scaled up 0.0500*10^{-3} times) (Time 70.00 day)

Maximum value = 80.92*10^3 lbf ft/ft (Element 42 at Node 20394)

Minimum value = -154.3*10^3 lbf ft/ft (Element 57 at Node 17925)

3.1.2.2.16 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/294), Bending moments M

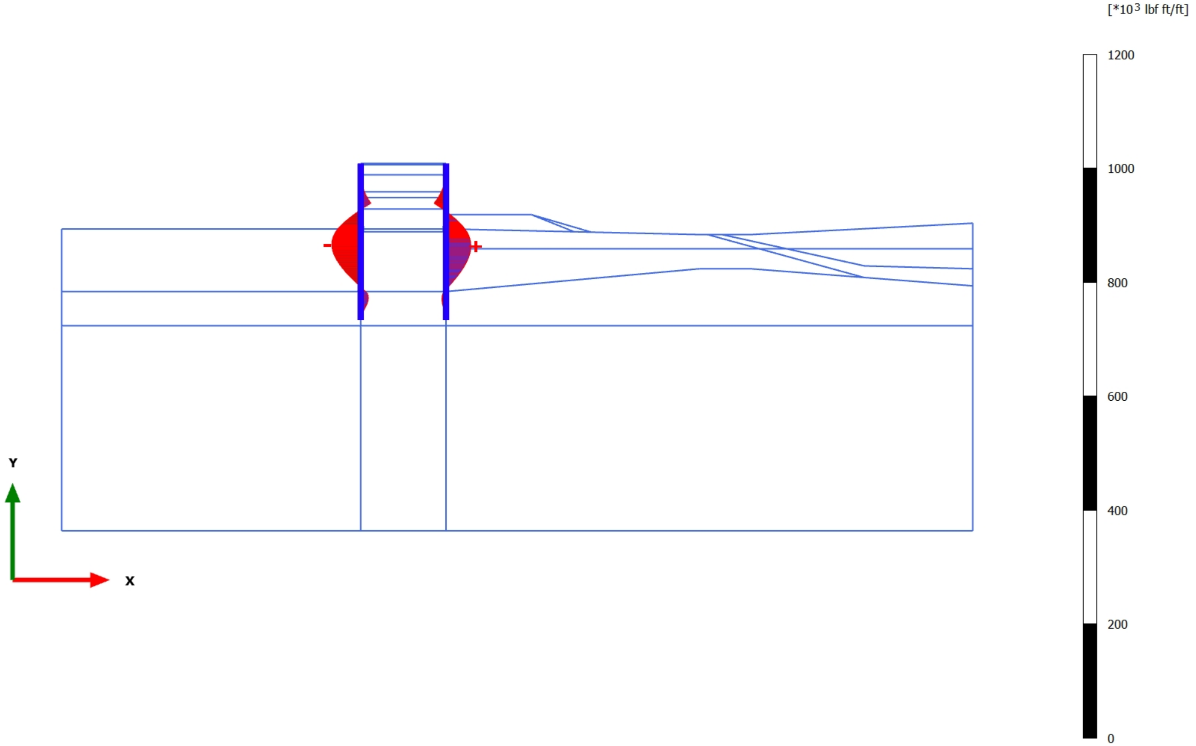


Bending moments M (scaled up 0.0500*10^{-3} times)

Maximum value = 80.90*10^3 lbf ft/ft (Element 42 at Node 20394)

Minimum value = -172.2*10^3 lbf ft/ft (Element 57 at Node 17926)

3.1.2.2.17 Calculation results, Plate, Buttress fill [Phase_4] (7/452), Bending moments M



Bending moments M (scaled up 0.200*10-3 times)

Maximum value = 43.59*10³ lbf ft/ft (Element 42 at Node 20393)

Minimum value = -50.61*10³ lbf ft/ft (Element 52 at Node 10858)

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 2 [Phase_3] (3/80), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	16.962	0.000	16.962
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	16.962	0.000	16.962

3.2.1.1.4 Calculation results, Node-to-node anchor, Consolidate [Phase_25] (8/104), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	16.002	0.000	17.056
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	16.002	0.000	17.056

3.2.1.1.5 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/114), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	43.081	0.000	43.081
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	43.081	0.000	43.081

3.2.1.1.6 Calculation results, Node-to-node anchor, Consolidate [Phase_11] (15/128), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	41.212	0.000	43.094
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	41.212	0.000	43.094

3.2.1.1.7 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/139), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	75.842	0.000	75.842
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	75.842	0.000	75.842

3.2.1.1.8 Calculation results, Node-to-node anchor, Consolidate [Phase_7] (10/156), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	73.172	0.000	75.842
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	73.172	0.000	75.842

3.2.1.1.9 Calculation results, Node-to-node anchor, Consolidate [Phase_16] (24/190), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	68.519	0.000	75.842
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	68.519	0.000	75.842

3.2.1.1.10 Calculation results, Node-to-node anchor, Dewater -SS [Phase_14] (16/239), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	177.112	0.000	177.112
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	177.112	0.000	177.112

3.2.1.1.11 Calculation results, Node-to-node anchor, Consolidation [Phase_17] (17/254), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	174.822	0.000	178.359
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	174.822	0.000	178.359

3.2.1.1.12 Calculation results, Node-to-node anchor, Excavation 1 [Phase_18] (18/257), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	175.087	0.000	178.359
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	175.087	0.000	178.359

3.2.1.1.13 Calculation results, Node-to-node anchor, Consolidation [Phase_20] (20/272), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	164.030	0.000	178.359
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	164.030	0.000	178.359

3.2.1.1.14 Calculation results, Node-to-node anchor, Excavation 2 [Phase_21] (21/274), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	164.128	0.000	178.359
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	164.128	0.000	178.359

3.2.1.1.15 Calculation results, Node-to-node anchor, Consolidate [Phase_8] (11/286), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	159.181	0.000	178.359
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	159.181	0.000	178.359

3.2.1.1.16 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_22] (22/294), Table of node-to-node anchors

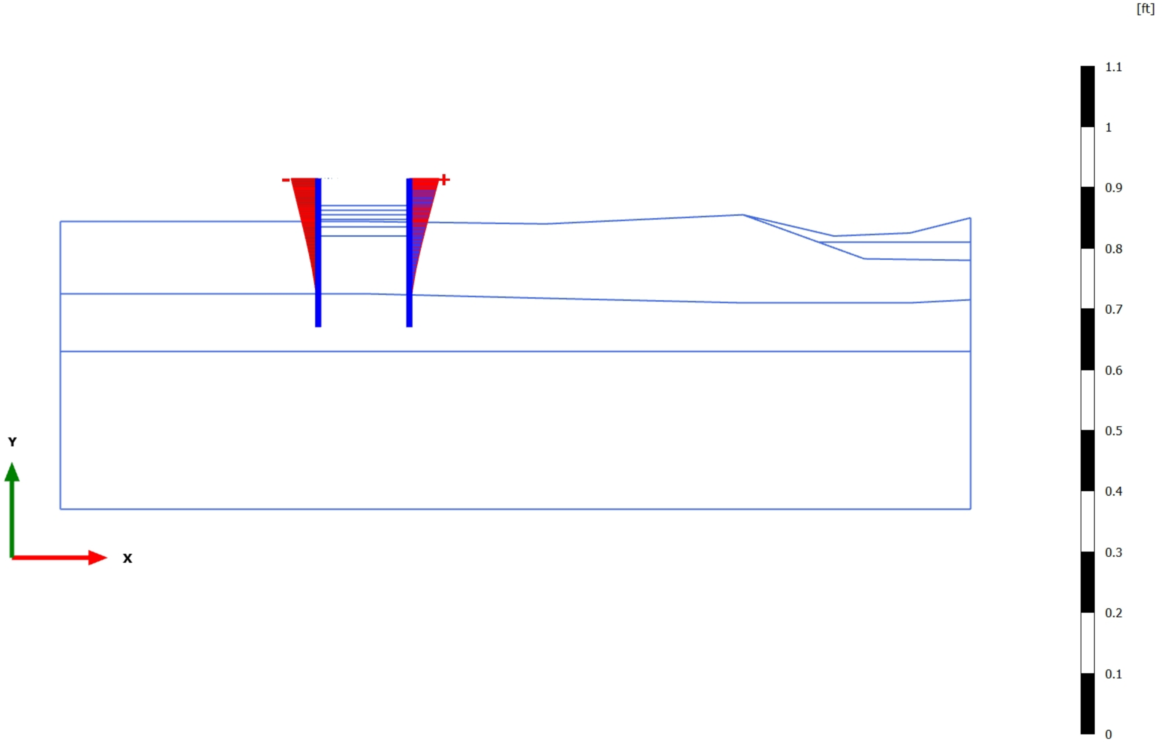
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	172.099	0.000	178.359
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	172.099	0.000	178.359

3.2.1.1.17 Calculation results, Node-to-node anchor, Buttress fill [Phase_4] (7/452), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_5_1	279	1	-15.000	-5.000	71.675	0.000	75.842
Element 4-4 (Node-to-node anchor)	6009	2	15.000	-5.000	71.675	0.000	75.842

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 2 [Phase_3] (3/15), Total displacements u_x

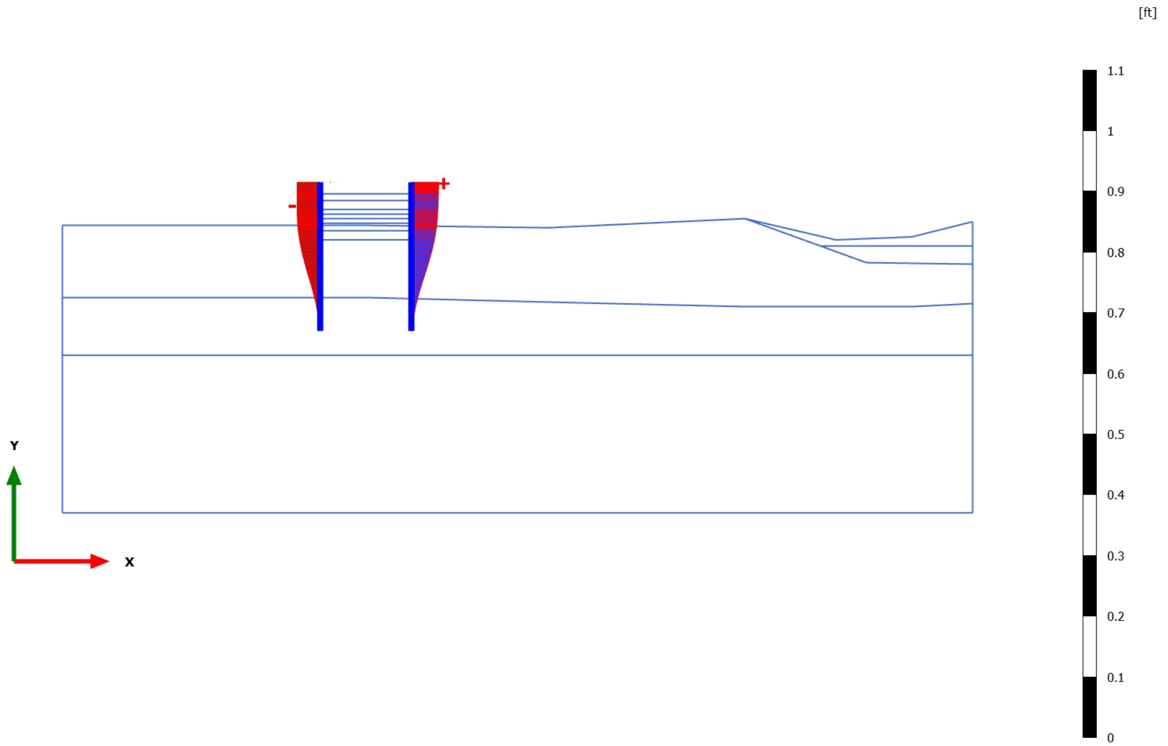


Total displacements u_x (scaled up 200 times)

Maximum value = 0.04919 ft (Element 2 at Node 325)

Minimum value = -0.04490 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/30), Total displacements u_x

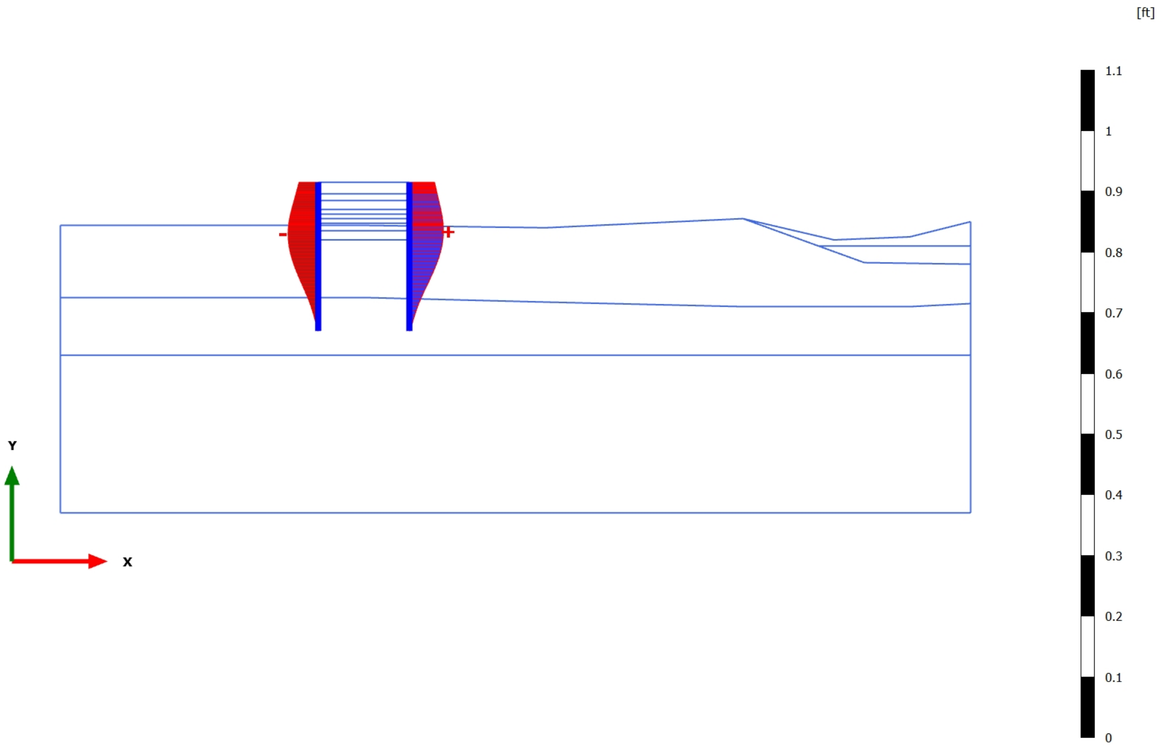


Total displacements u_x (scaled up 200 times)

Maximum value = 0.04535 ft (Element 2 at Node 325)

Minimum value = -0.03813 ft (Element 9 at Node 15)

3.1.1.1.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/43), Total displacements u_x

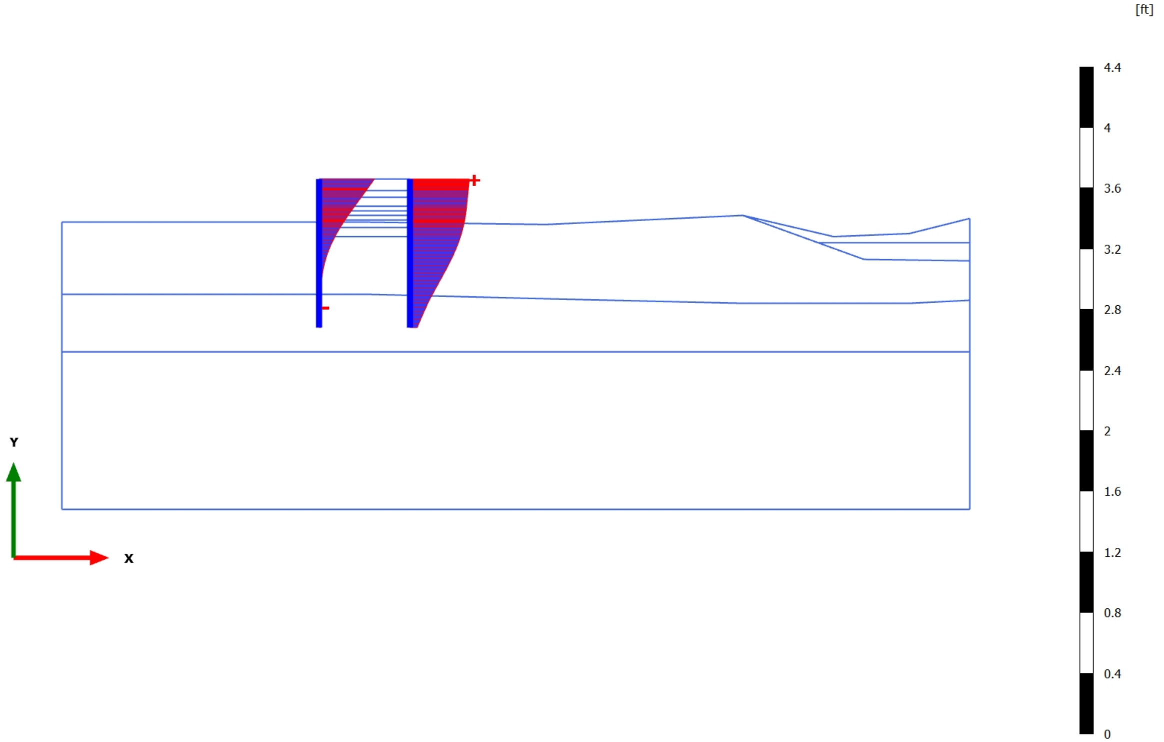


Total displacements u_x (scaled up 200 times)

Maximum value = 0.05630 ft (Element 20 at Node 4943)

Minimum value = -0.04987 ft (Element 21 at Node 4078)

3.1.1.1.1.4 Calculation results, Plate, Dewater-ss [Phase_16] (16/69), Total displacements u_x

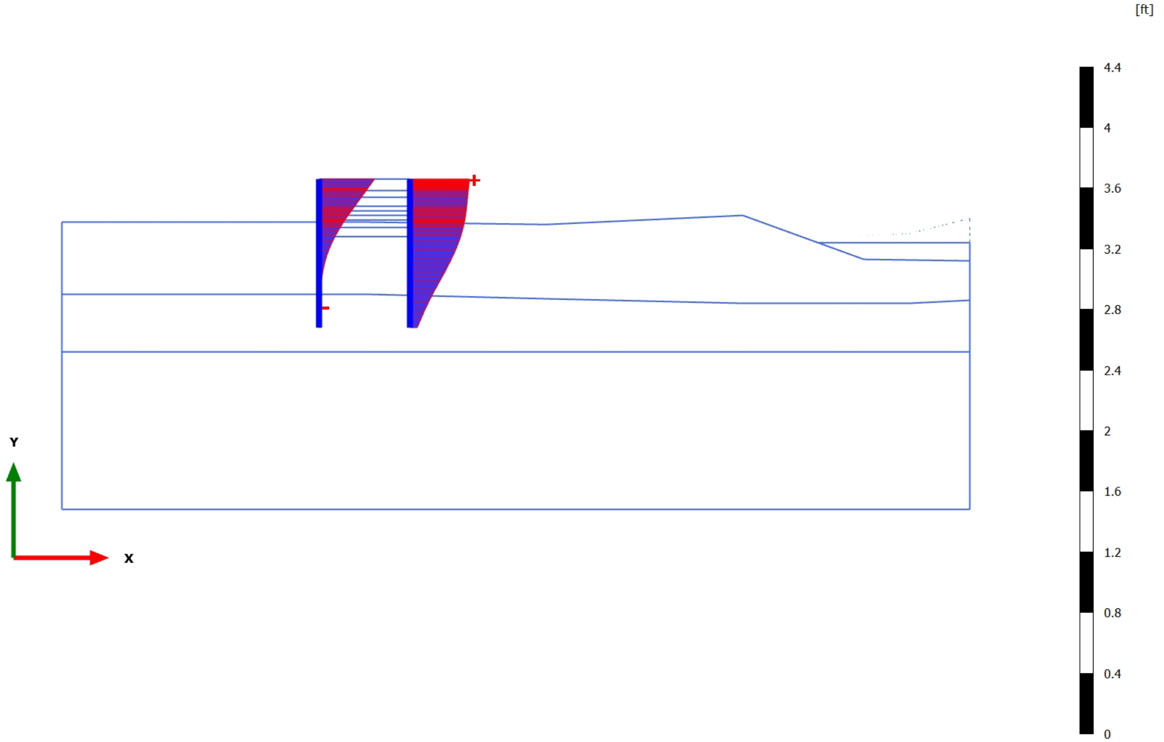


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3930 ft (Element 2 at Node 325)

Minimum value = 9.104×10^{-3} ft (Element 31 at Node 6112)

3.1.1.1.1.5 Calculation results, Plate, Excavate 1 [Phase_18] (18/72), Total displacements u_x

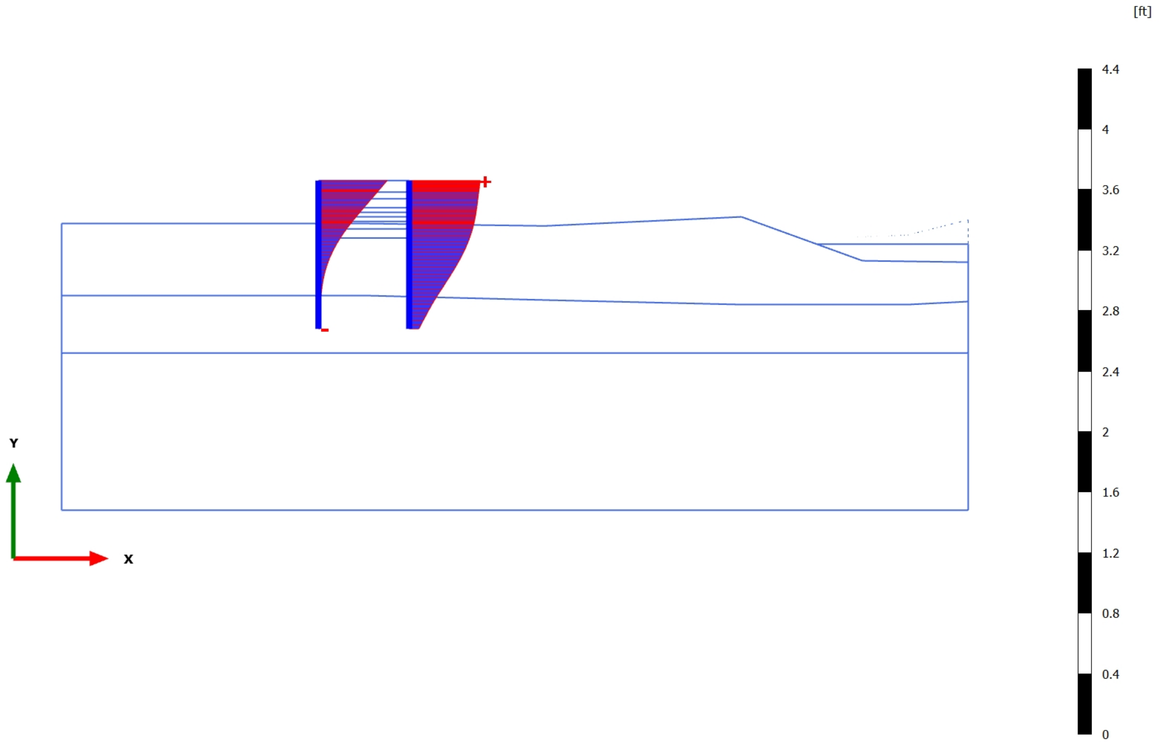


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3937 ft (Element 2 at Node 325)

Minimum value = $9.330*10^{-3}$ ft (Element 31 at Node 6112)

3.1.1.1.1.6 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/83), Total displacements u_x

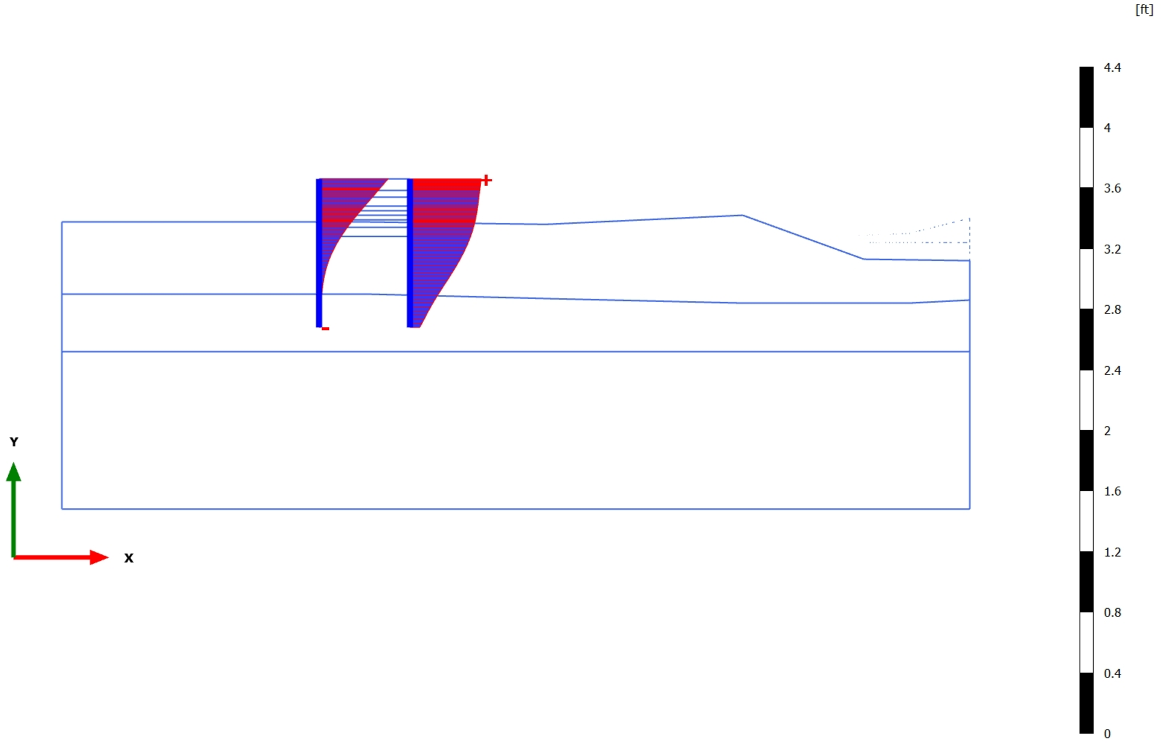


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4708 ft (Element 2 at Node 325)

Minimum value = 0.01061 ft (Element 32 at Node 6579)

3.1.1.1.1.7 Calculation results, Plate, Excavate 2 [Phase_21] (21/86), Total displacements u_x

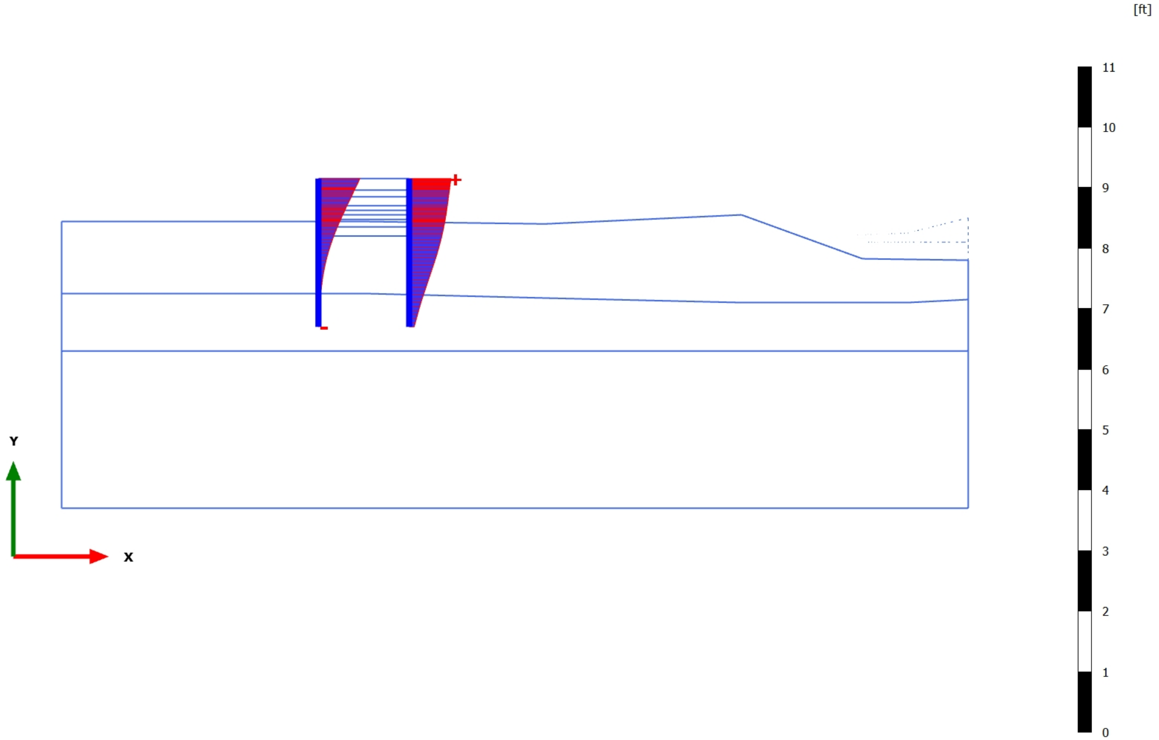


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4717 ft (Element 2 at Node 325)

Minimum value = 0.01081 ft (Element 32 at Node 6579)

3.1.1.1.1.8 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/101), Total displacements u_x

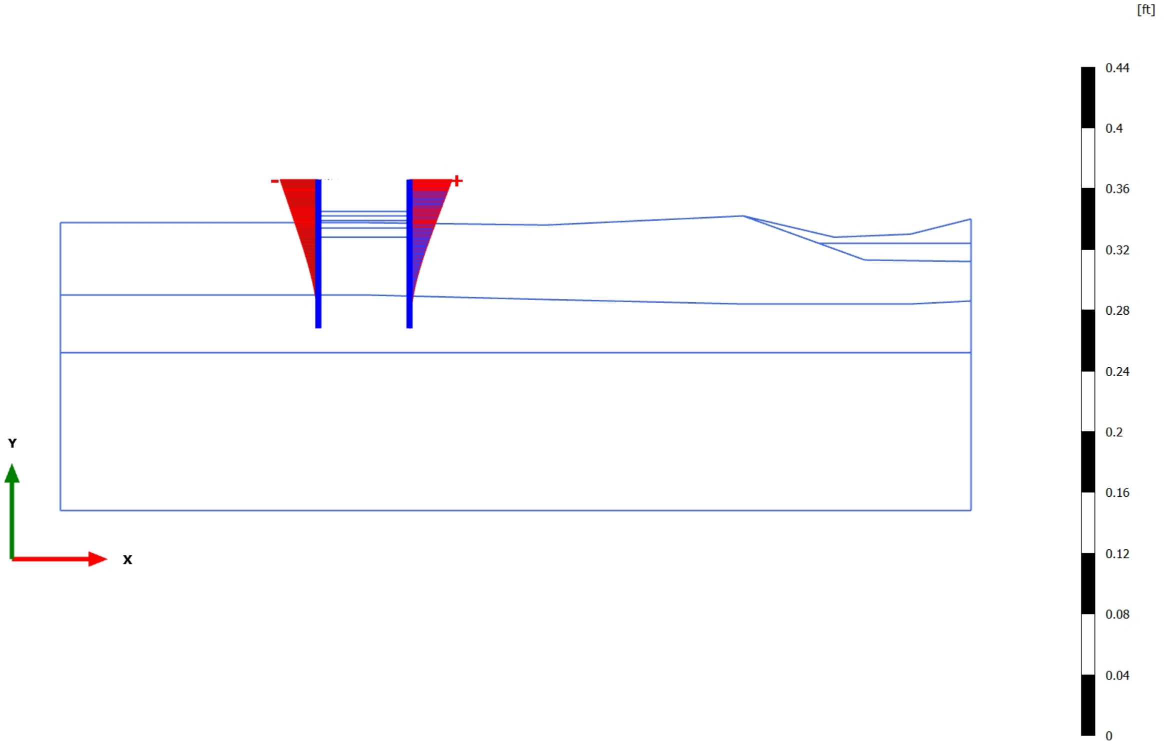


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.6932 ft (Element 2 at Node 325)

Minimum value = 9.973×10^{-3} ft (Element 32 at Node 6579)

3.1.1.1.1.9 Calculation results, Plate, Backfill 1 [Phase_2] (2/175), Total displacements u_x

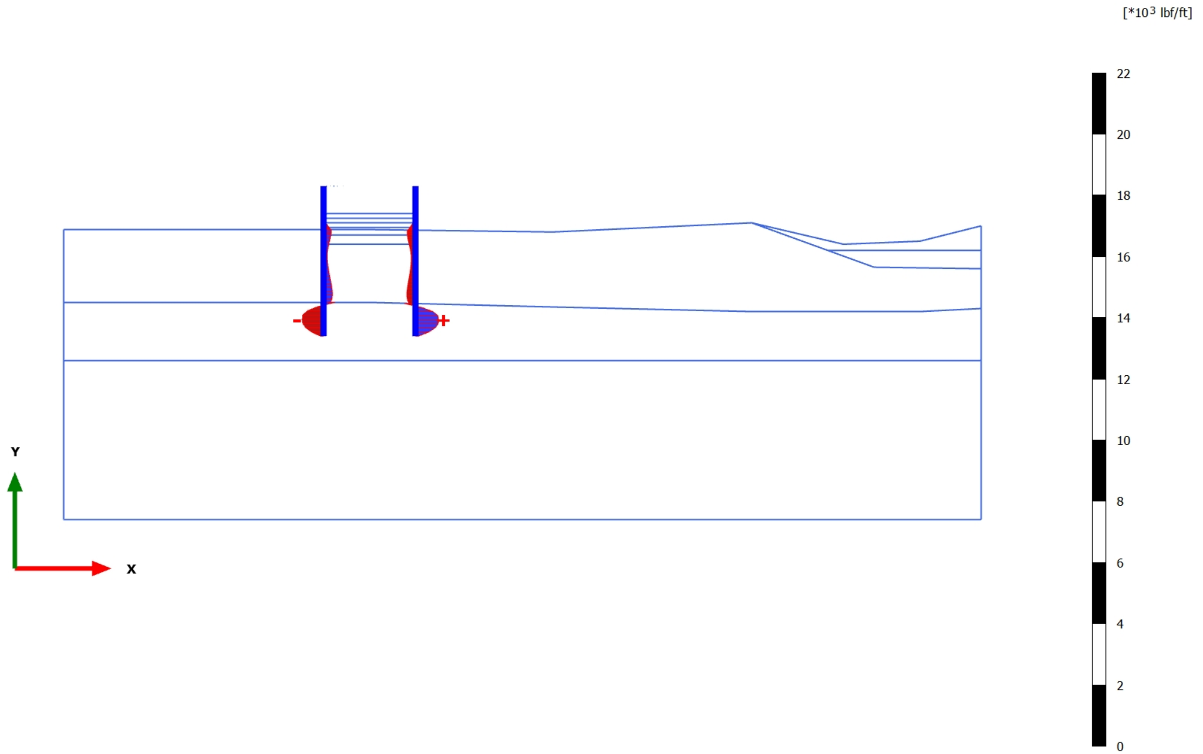


Total displacements u_x (scaled up 500 times)

Maximum value = 0.02820 ft (Element 2 at Node 325)

Minimum value = -0.02530 ft (Element 1 at Node 4)

3.1.2.1.1 Calculation results, Plate, Backfill 2 [Phase_3] (3/15), Shear forces Q

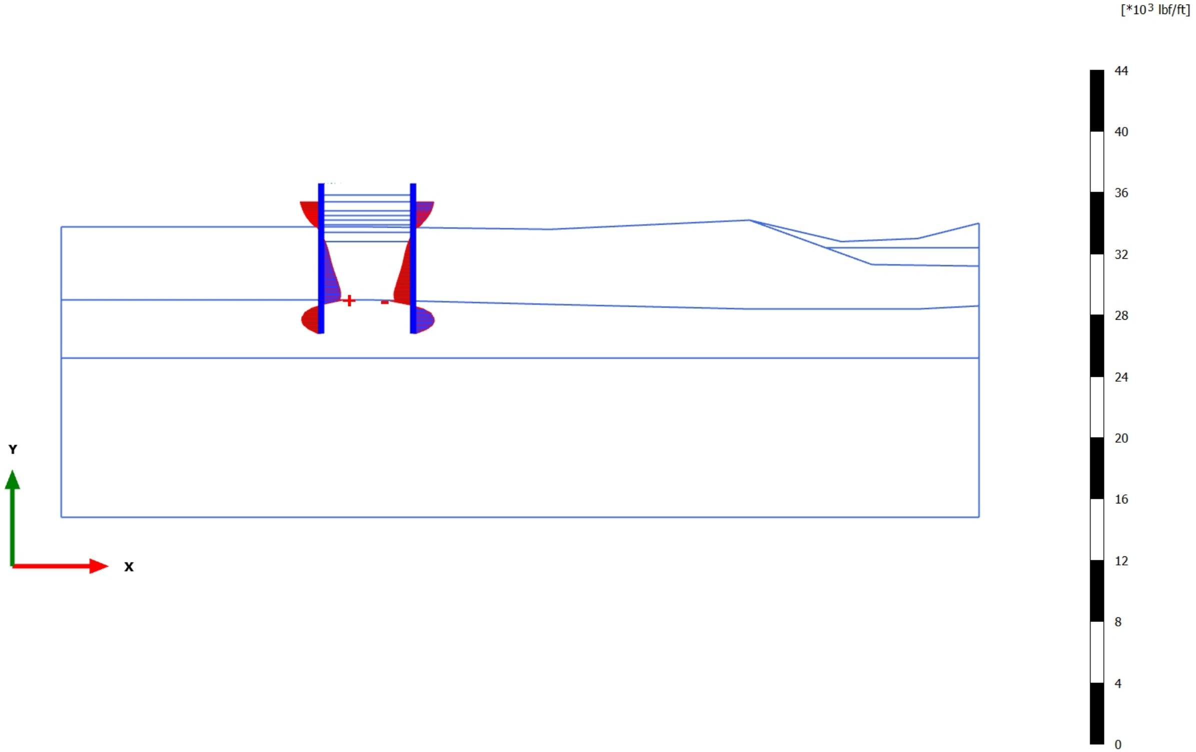


Shear forces Q (scaled up 0.0100 times)

Maximum value = 769.9 lbf/ft (Element 34 at Node 7384)

Minimum value = -712.1 lbf/ft (Element 32 at Node 6575)

3.1.2.1.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/30), Shear forces Q

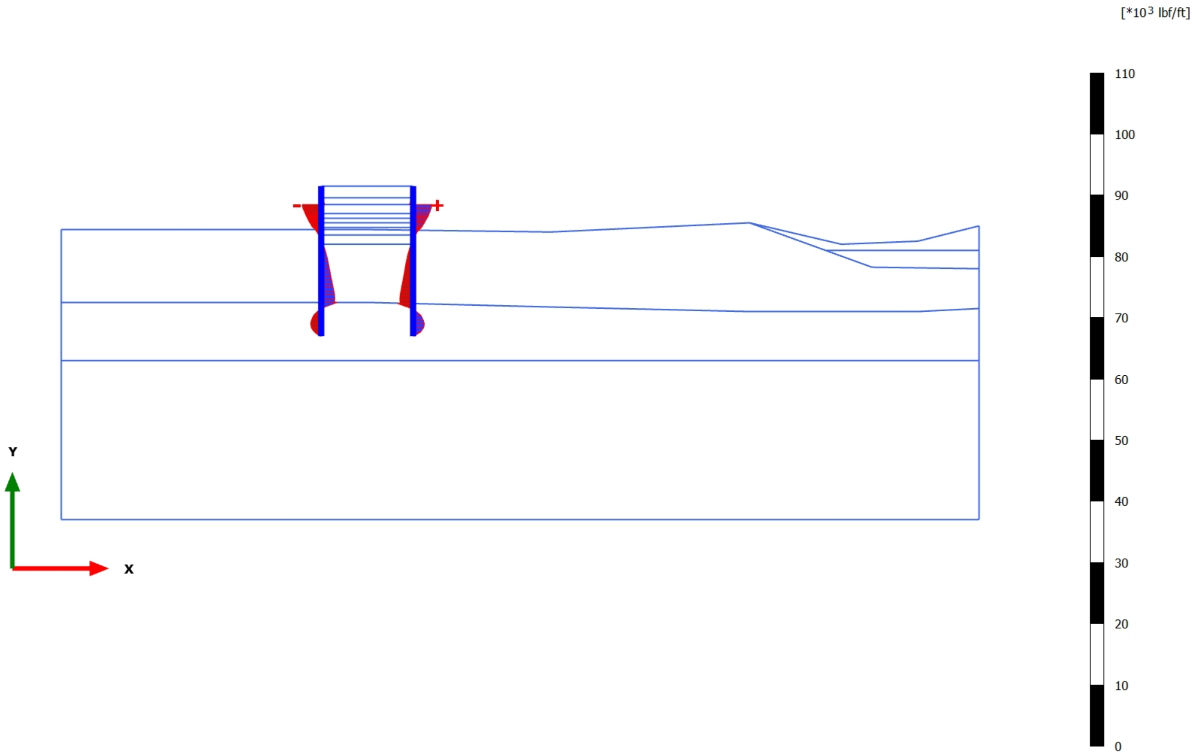


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 1548 lbf/ft (Element 31 at Node 6109)

Minimum value = -1523 lbf/ft (Element 33 at Node 6984)

3.1.2.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/43), Shear forces Q

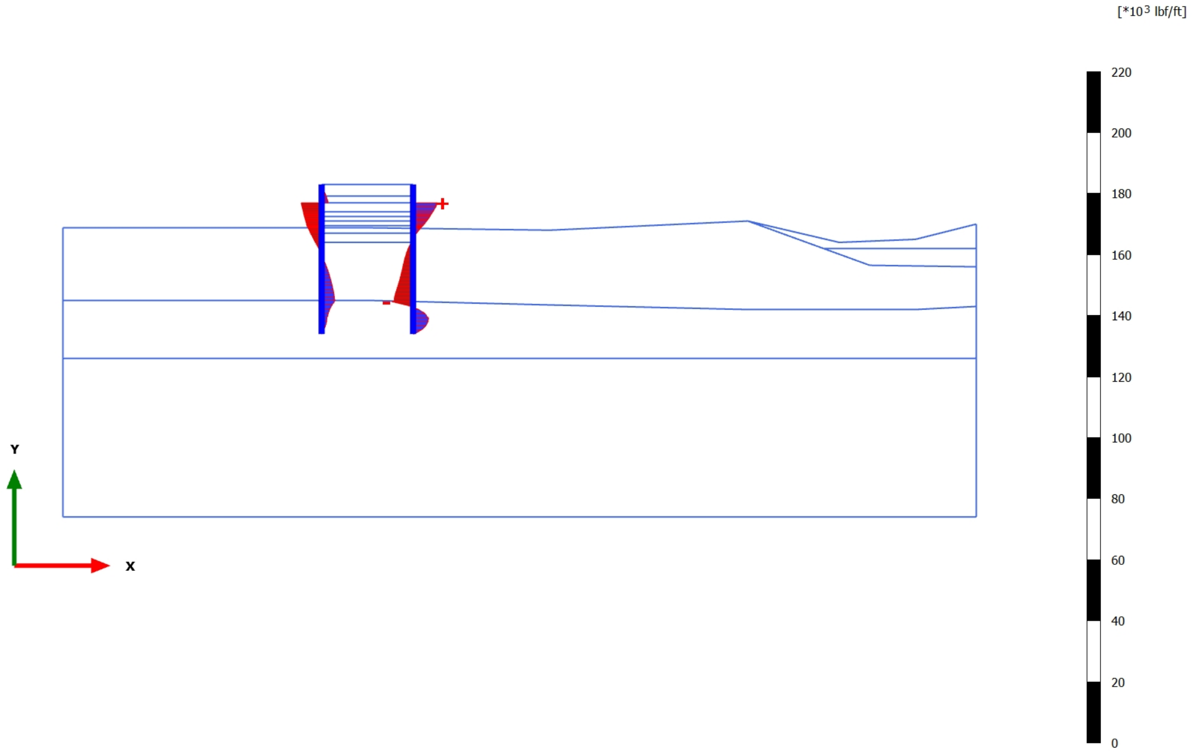


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 3137 lbf/ft (Element 10 at Node 411)

Minimum value = -3154 lbf/ft (Element 9 at Node 13)

3.1.2.1.4 Calculation results, Plate, Dewater-ss [Phase_16] (16/69), Shear forces Q

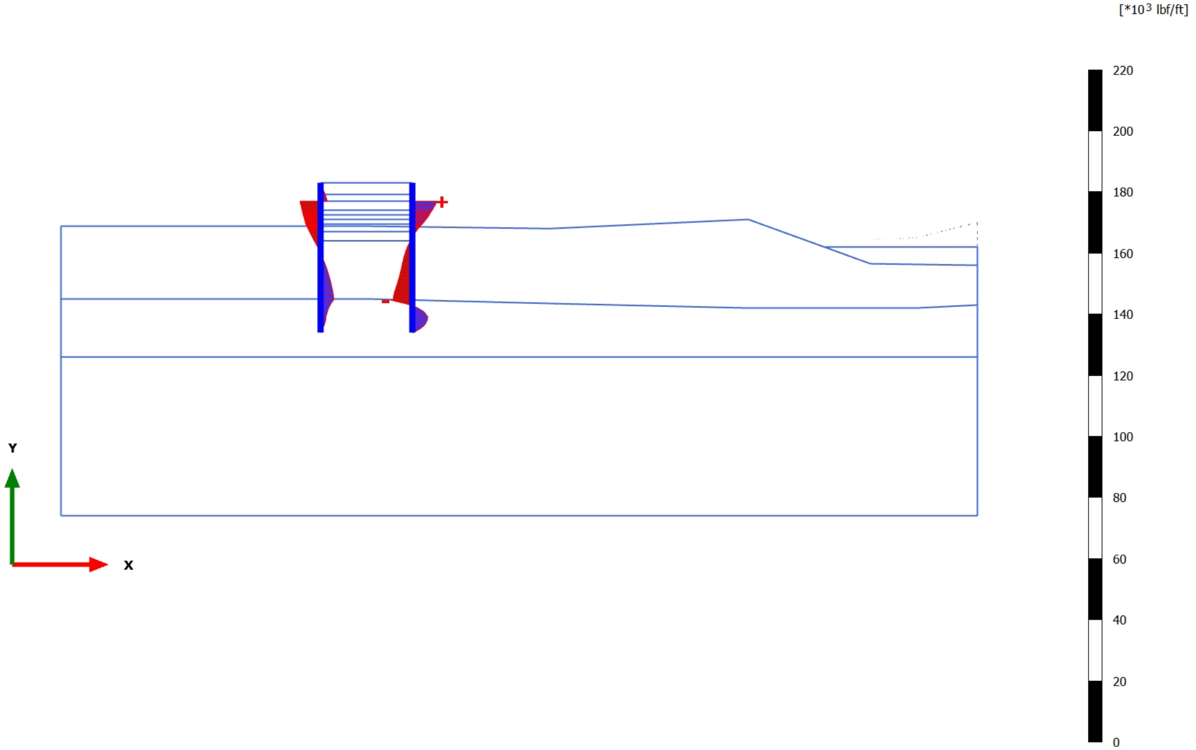


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8026 lbf/ft (Element 10 at Node 411)

Minimum value = -7177 lbf/ft (Element 33 at Node 6984)

3.1.2.1.5 Calculation results, Plate, Excavate 1 [Phase_18] (18/72), Shear forces Q

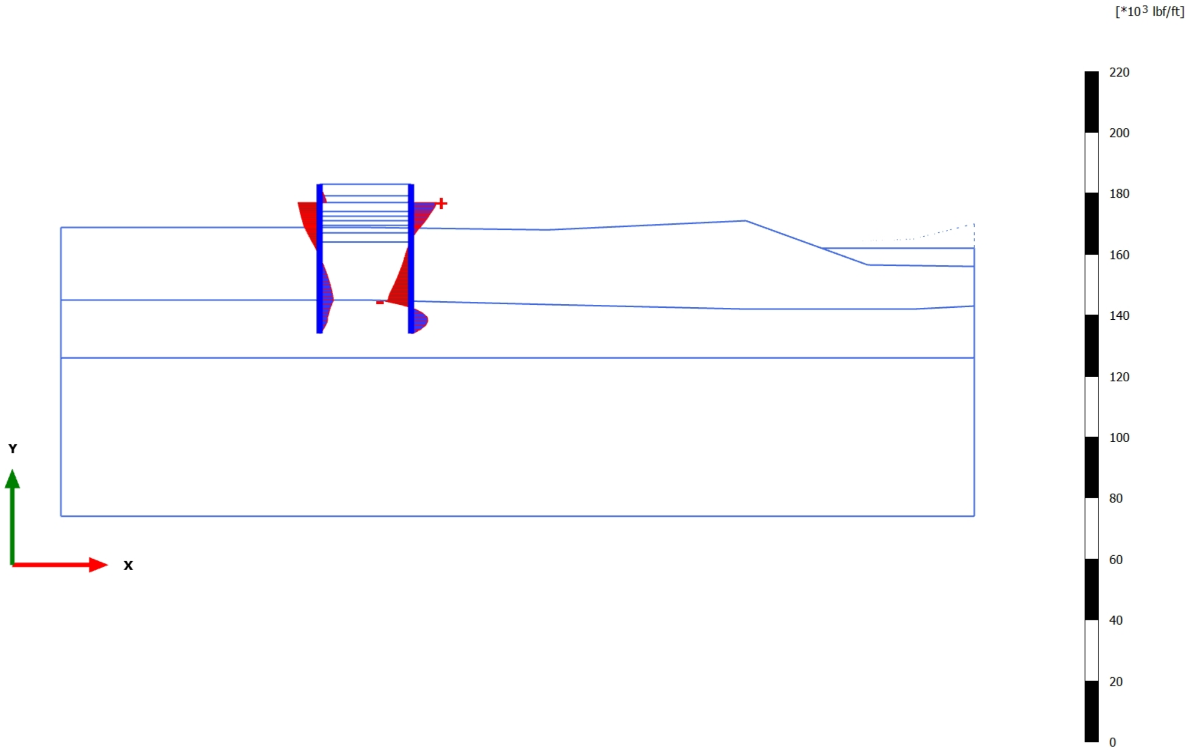


Shear forces Q (scaled up 1.00*10⁻³ times)

Maximum value = 8025 lbf/ft (Element 10 at Node 411)

Minimum value = -7166 lbf/ft (Element 33 at Node 6984)

3.1.2.1.6 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/83), Shear forces Q

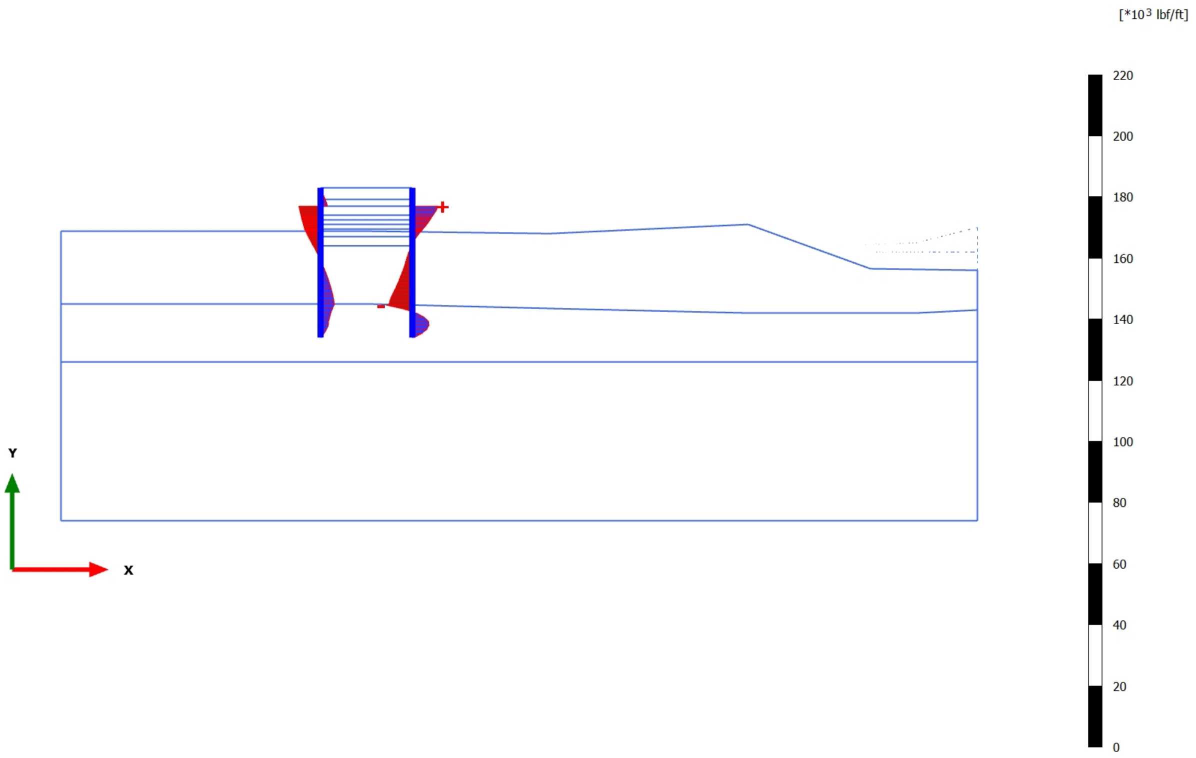


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8443 lbf/ft (Element 10 at Node 411)

Minimum value = -8723 lbf/ft (Element 33 at Node 6984)

3.1.2.1.7 Calculation results, Plate, Excavate 2 [Phase_21] (21/86), Shear forces Q

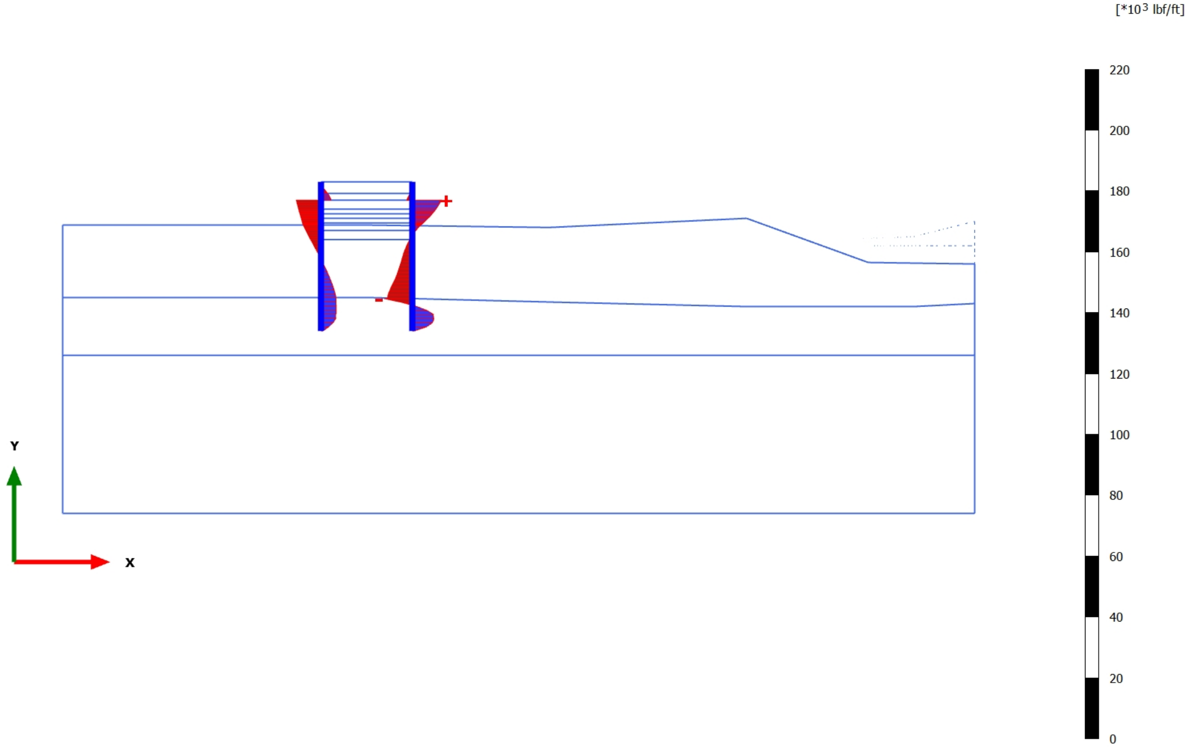


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8440 lbf/ft (Element 10 at Node 411)

Minimum value = -8715 lbf/ft (Element 33 at Node 6984)

3.1.2.1.8 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/101), Shear forces Q

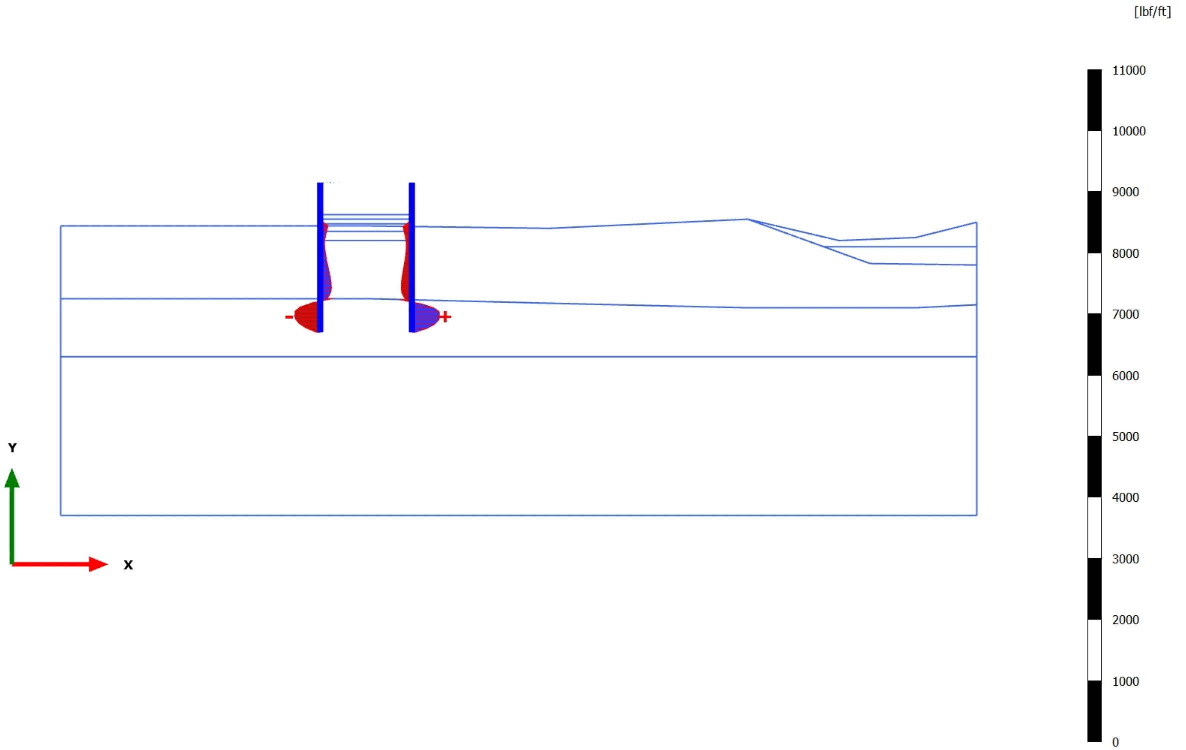


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 9659 lbf/ft (Element 10 at Node 411)

Minimum value = -9253 lbf/ft (Element 33 at Node 6984)

3.1.2.1.9 Calculation results, Plate, Backfill 1 [Phase_2] (2/175), Shear forces Q

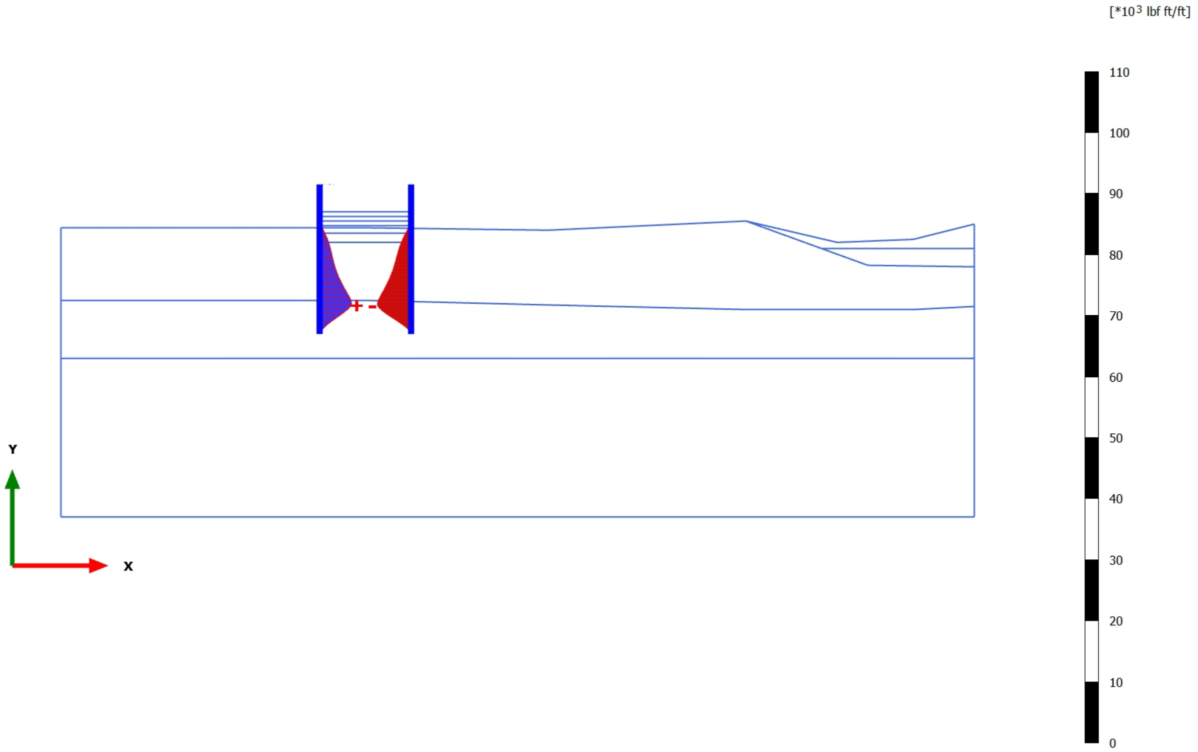


Shear forces Q (scaled up 0.0200 times)

Maximum value = 462.2 lbf/ft (Element 34 at Node 7384)

Minimum value = -425.5 lbf/ft (Element 32 at Node 6575)

3.1.2.2.1 Calculation results, Plate, Backfill 2 [Phase_3] (3/15), Bending moments M

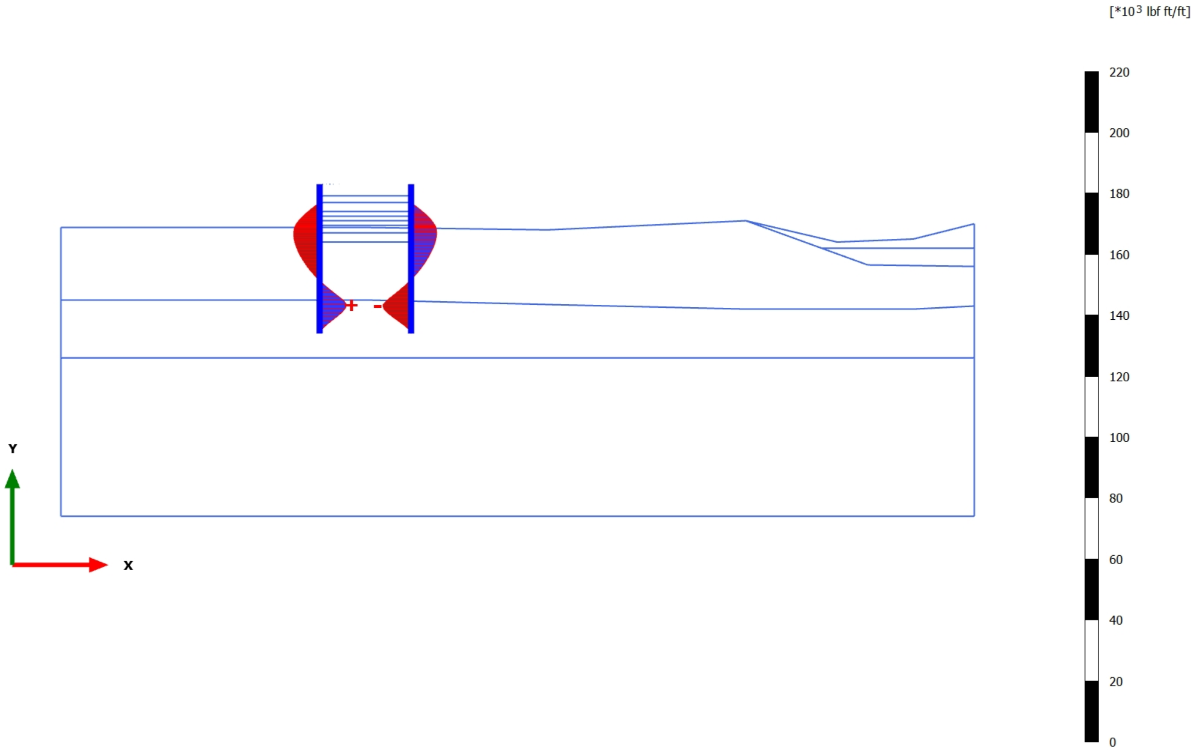


Bending moments M (scaled up 2.00*10^{-3} times)

Maximum value = 5236 lbf ft/ft (Element 31 at Node 6110)

Minimum value = -5526 lbf ft/ft (Element 33 at Node 6985)

3.1.2.2.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/30), Bending moments M

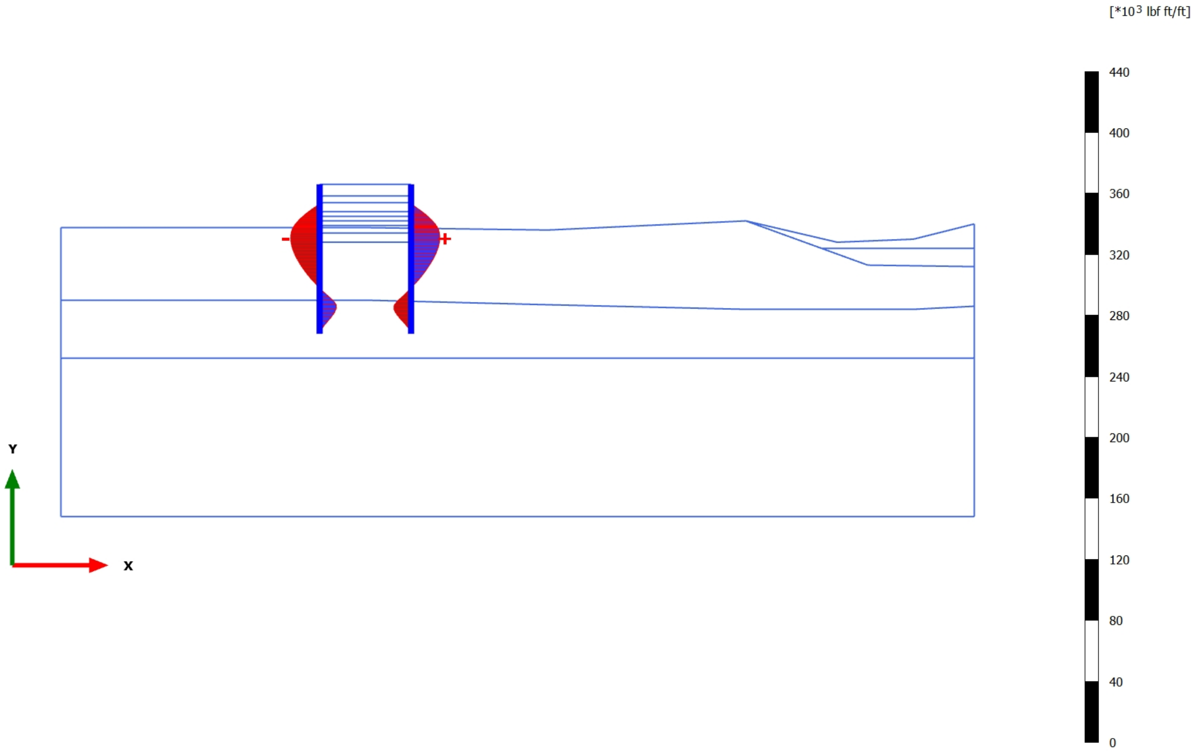


Bending moments M (scaled up $1.00*10^{-3}$ times)

Maximum value = 8797 lbf ft/ft (Element 31 at Node 6110)

Minimum value = -9258 lbf ft/ft (Element 33 at Node 6985)

3.1.2.2.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/43), Bending moments M

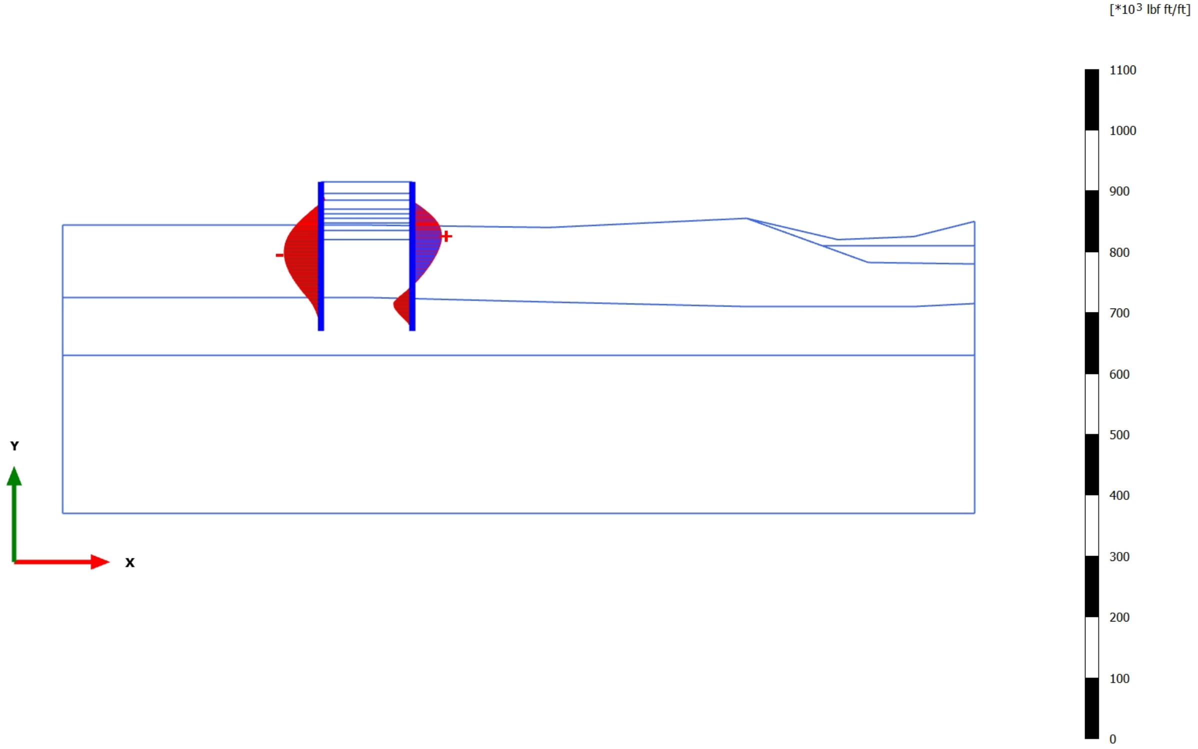


Bending moments M (scaled up 0.500×10^{-3} times)

Maximum value = 18.93×10^{3} lbf ft/ft (Element 22 at Node 4945)

Minimum value = -19.09×10^{3} lbf ft/ft (Element 21 at Node 4077)

3.1.2.2.4 Calculation results, Plate, Dewater-ss [Phase_16] (16/69), Bending moments M

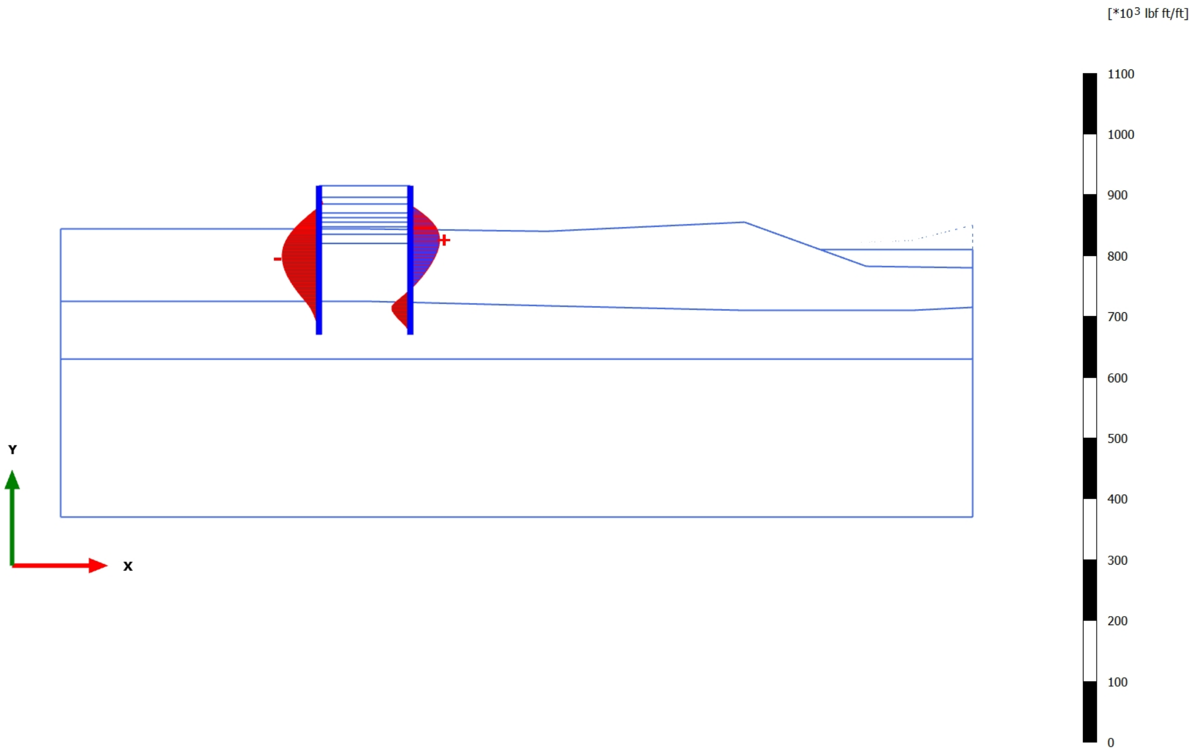


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $48.27*10^3$ lbf ft/ft (Element 22 at Node 4945)

Minimum value = $-60.69*10^3$ lbf ft/ft (Element 23 at Node 4823)

3.1.2.2.5 Calculation results, Plate, Excavate 1 [Phase_18] (18/72), Bending moments M

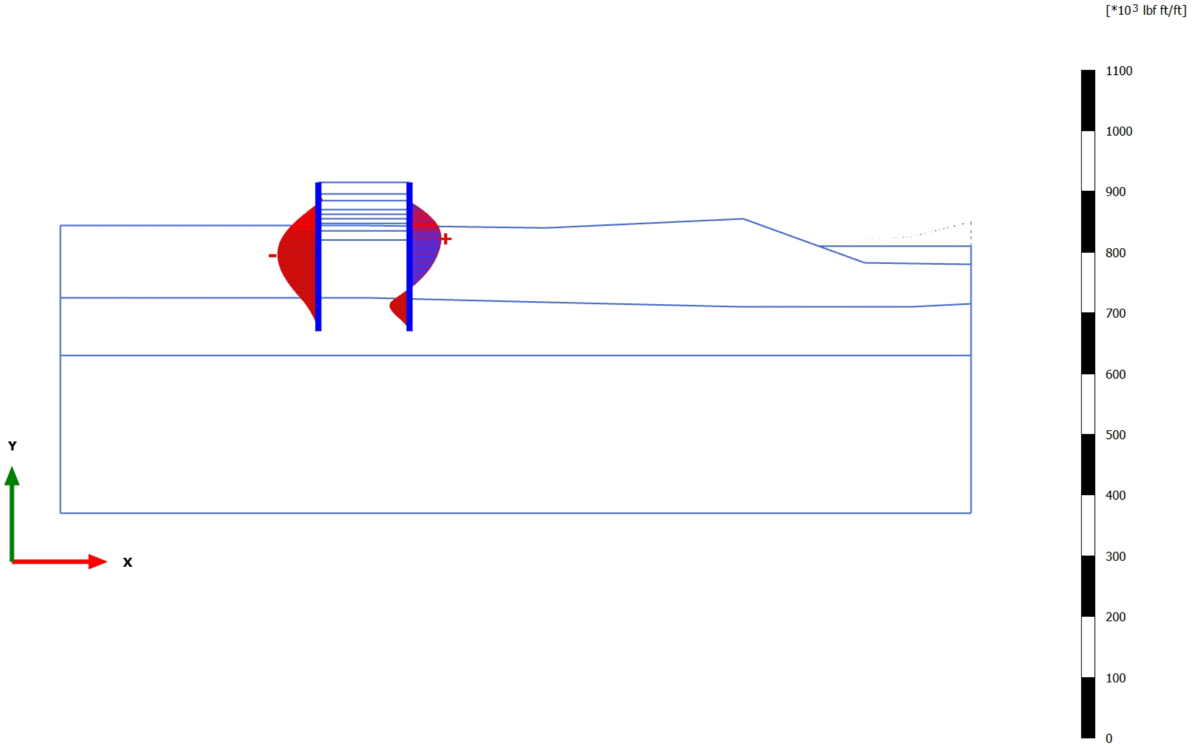


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $48.28*10^3$ lbf ft/ft (Element 22 at Node 4945)

Minimum value = $-60.67*10^3$ lbf ft/ft (Element 23 at Node 4823)

3.1.2.2.6 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/83), Bending moments M

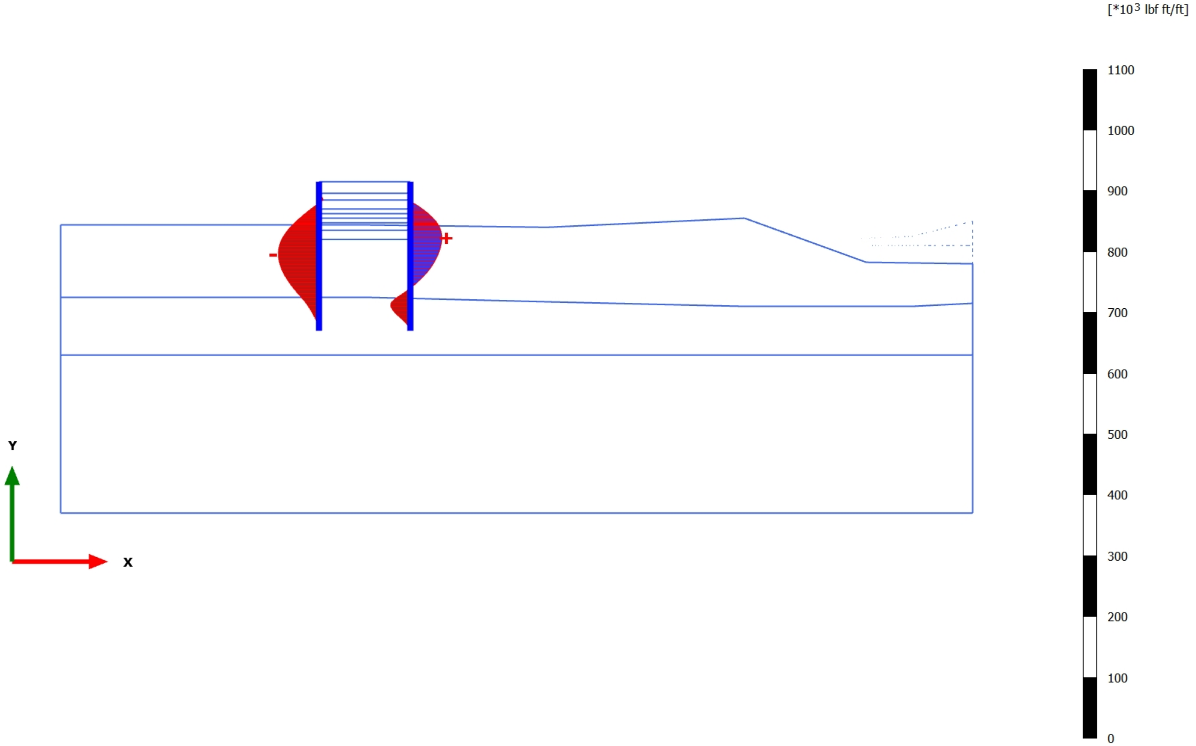


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 51.93*10^{3} lbf ft/ft (Element 22 at Node 4946)

Minimum value = -67.06*10^{3} lbf ft/ft (Element 24 at Node 4823)

3.1.2.2.7 Calculation results, Plate, Excavate 2 [Phase_21] (21/86), Bending moments M

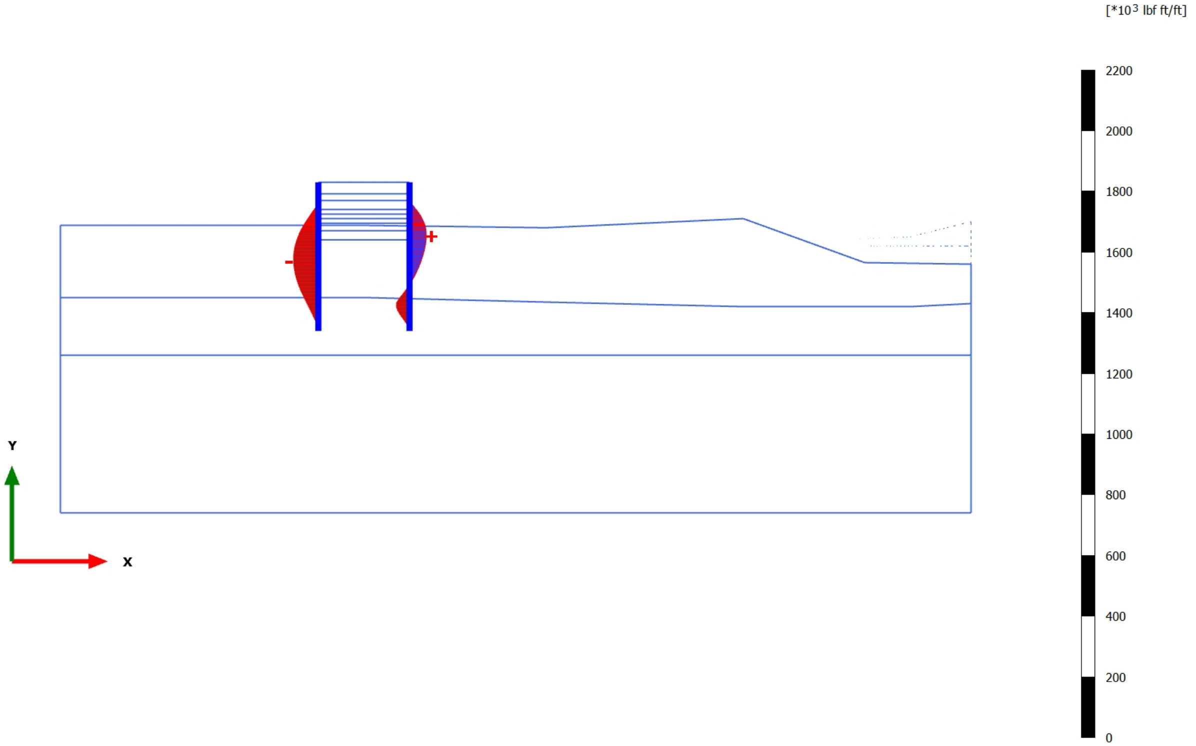


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 51.94*10^3 lbf ft/ft (Element 22 at Node 4946)

Minimum value = -67.01*10^3 lbf ft/ft (Element 24 at Node 4823)

3.1.2.2.8 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/101), Bending moments M

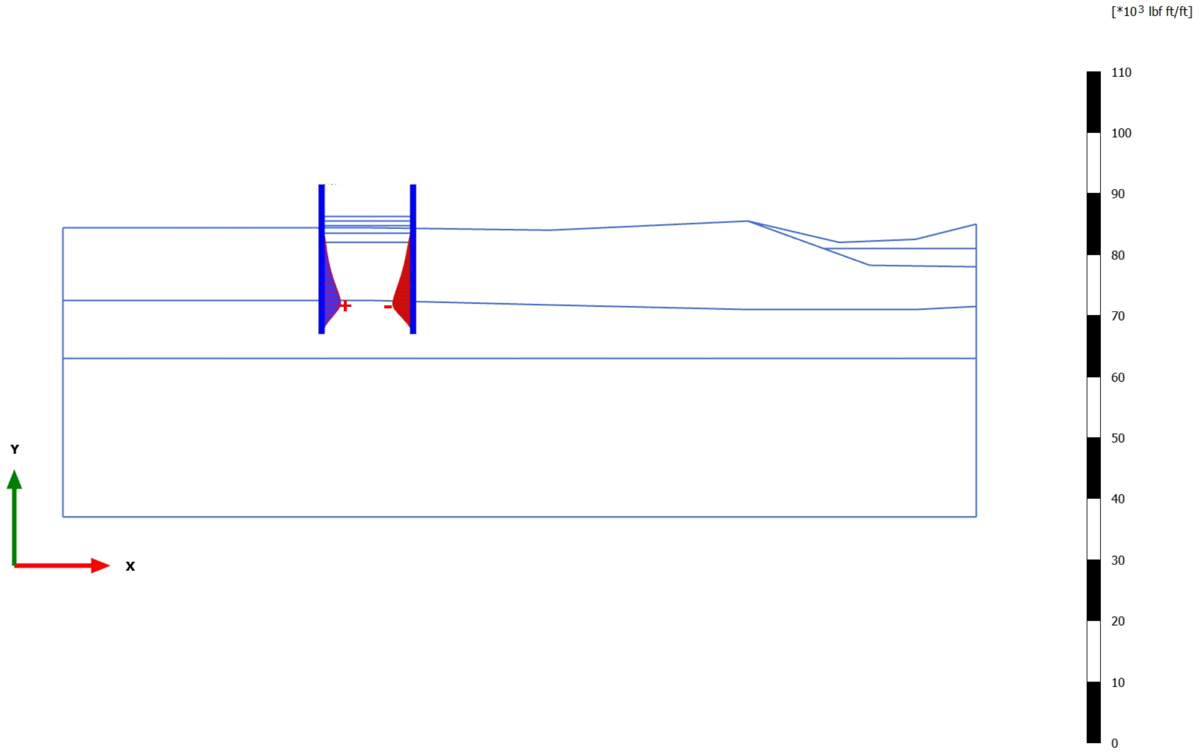


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 55.45*10^3 lbf ft/ft (Element 22 at Node 4945)

Minimum value = -81.79*10^3 lbf ft/ft (Element 24 at Node 4825)

3.1.2.2.9 Calculation results, Plate, Backfill 1 [Phase_2] (2/175), Bending moments M



Bending moments M (scaled up $2.00*10^{-3}$ times)

Maximum value = 3128 lbf ft/ft (Element 31 at Node 6110)

Minimum value = -3326 lbf ft/ft (Element 33 at Node 6985)

3.2.1.1.2 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/30), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	14.298	0.000	14.298
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	14.298	0.000	14.298

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/43), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	37.201	0.000	37.201
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	37.201	0.000	37.201

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater-ss [Phase_16] (16/69), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	89.443	0.000	89.443
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	89.443	0.000	89.443

3.2.1.1.5 Calculation results, Node-to-node anchor, Excavate 1 [Phase_18] (18/72), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	89.442	0.000	89.443
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	89.442	0.000	89.443

3.2.1.1.6 Calculation results, Node-to-node anchor, Dewater 2 - ss [Phase_19] (19/83), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	94.411	0.000	94.411
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	94.411	0.000	94.411

3.2.1.1.7 Calculation results, Node-to-node anchor, Excavate 2 [Phase_21] (21/86), Table of node-to-node anchors

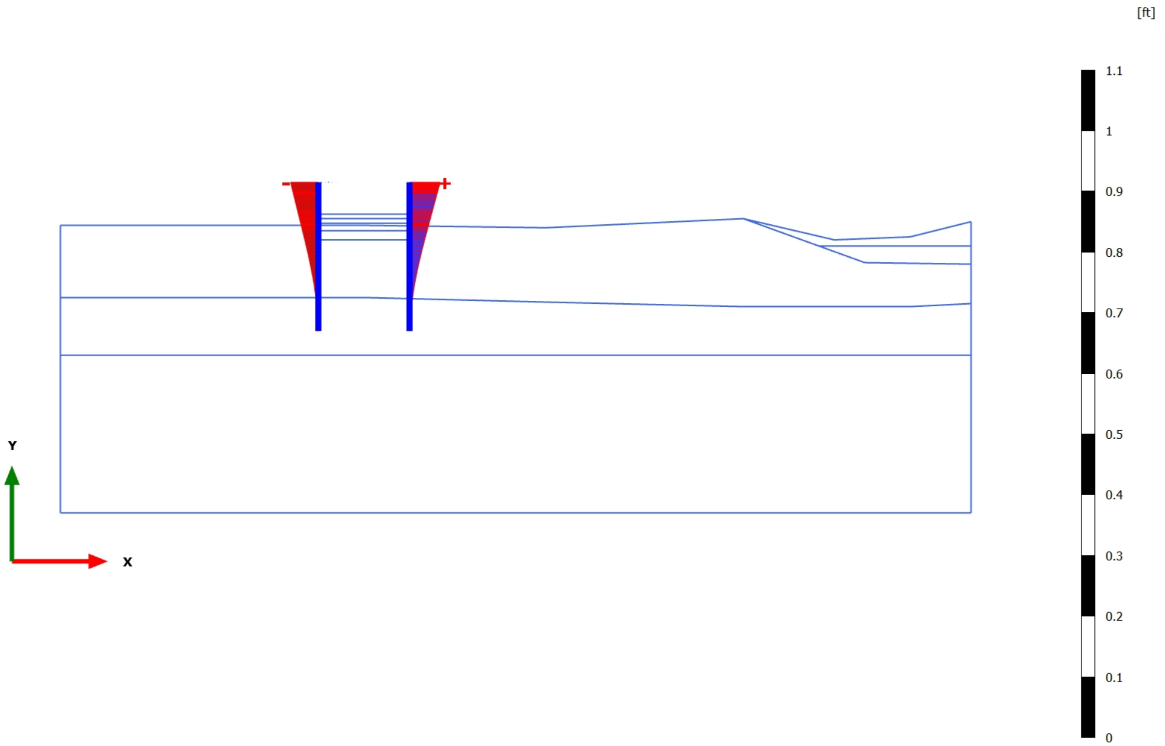
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	94.363	0.000	94.411
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	94.363	0.000	94.411

3.2.1.1.8 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_22] (22/101), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	115.272	0.000	115.272
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	115.272	0.000	115.272

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/20), Total displacements u_x

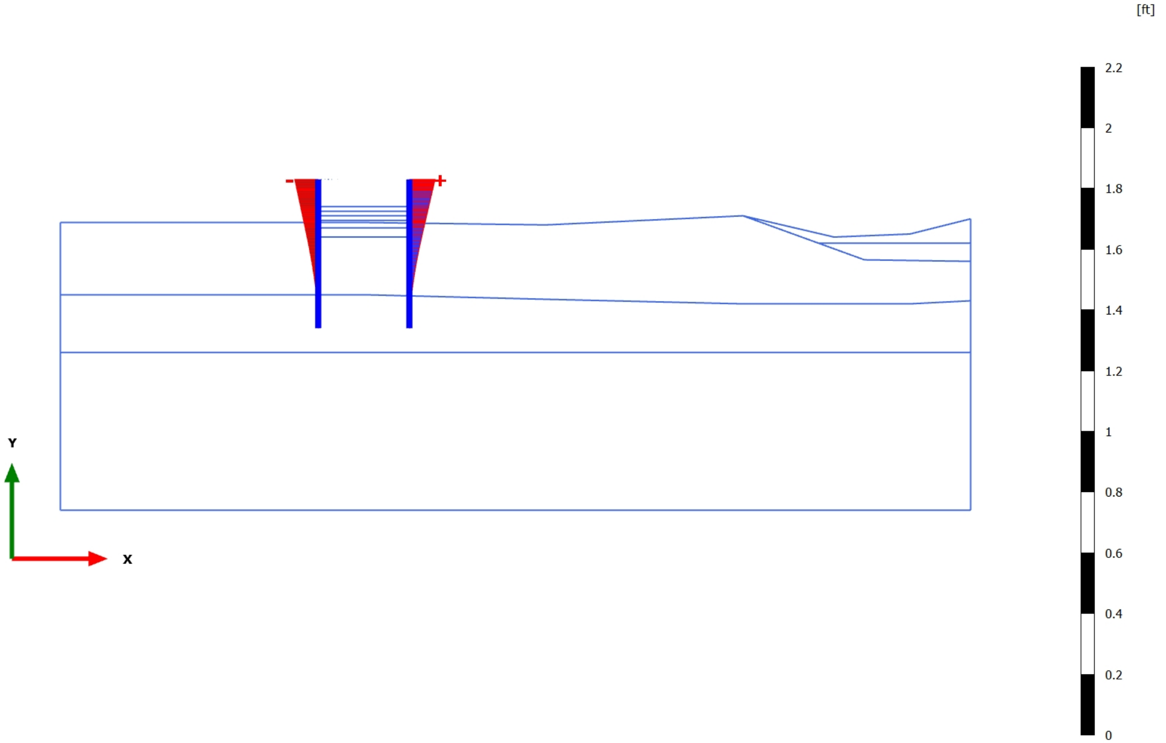


Total displacements u_x (scaled up 200 times)

Maximum value = 0.05057 ft (Element 2 at Node 325)

Minimum value = -0.04591 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/32), Total displacements u_x

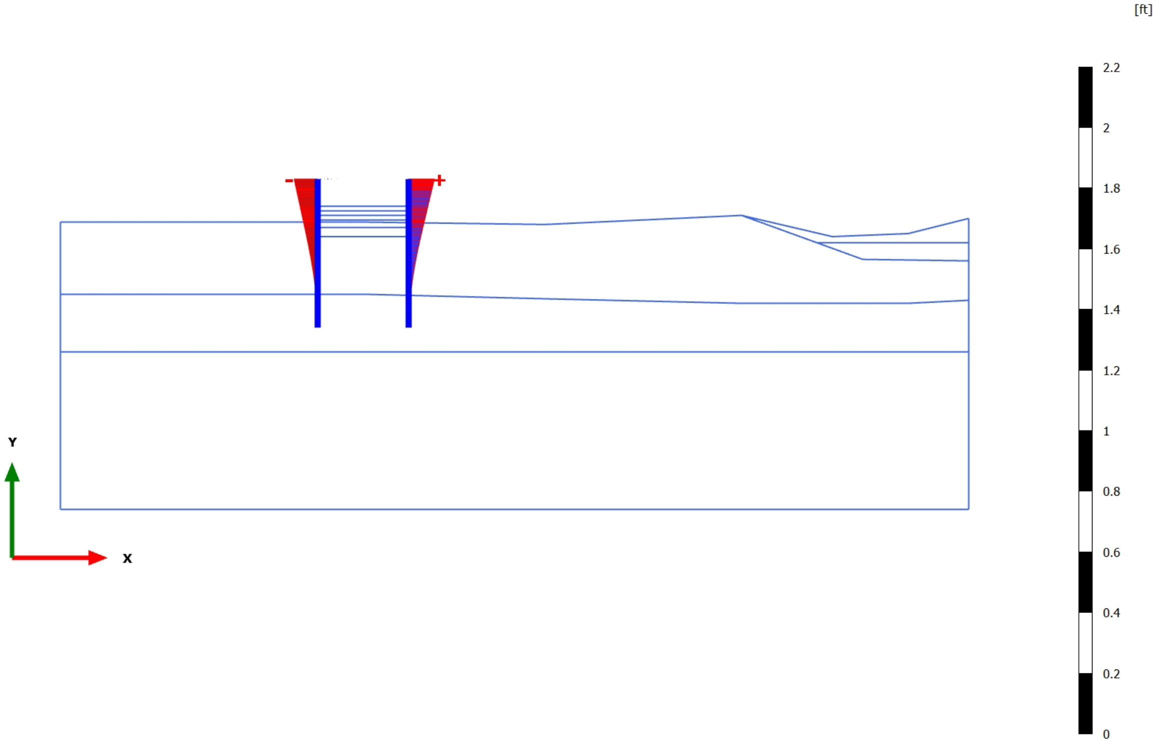


Total displacements u_x (scaled up 100 times)

Maximum value = 0.08521 ft (Element 2 at Node 325)

Minimum value = -0.07765 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Consolidate [Phase_25] (25/63), Total displacements u_x

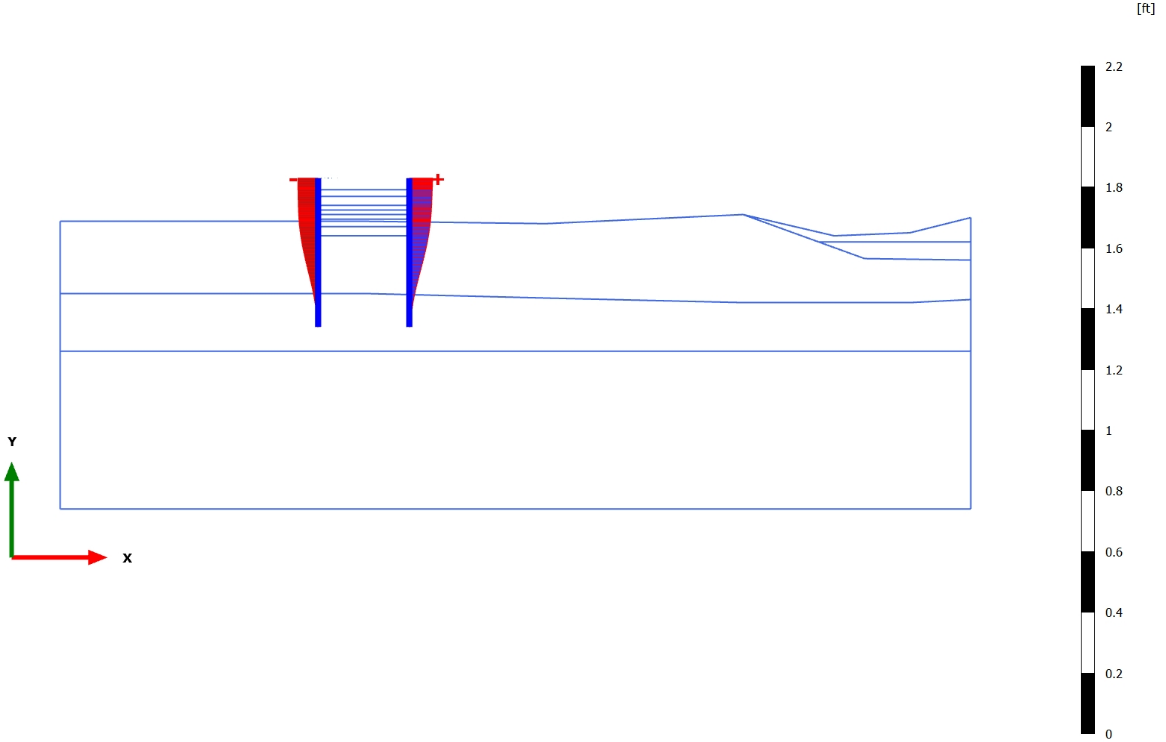


Total displacements u_x (scaled up 100 times) (Time 10.00 day)

Maximum value = 0.08532 ft (Element 2 at Node 325)

Minimum value = -0.07809 ft (Element 1 at Node 4)

3.1.1.1.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/76), Total displacements u_x

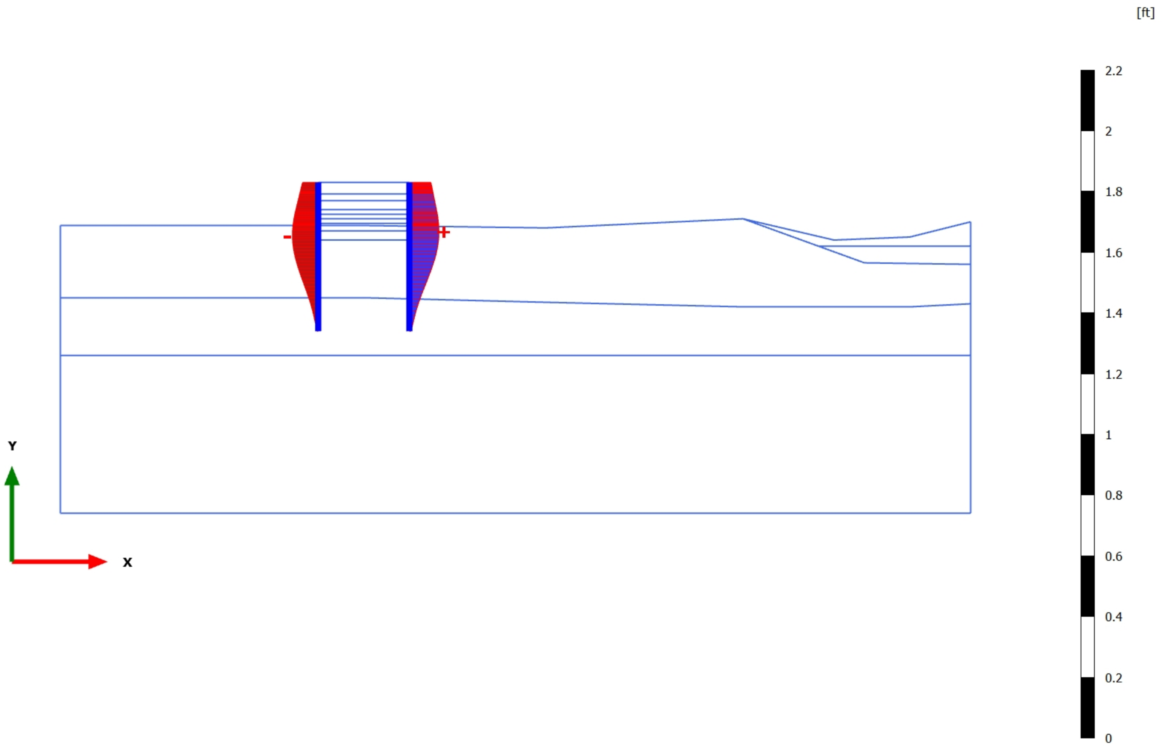


Total displacements u_x (scaled up 100 times)

Maximum value = 0.07756 ft (Element 2 at Node 325)

Minimum value = -0.06728 ft (Element 1 at Node 4)

3.1.1.1.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/85), Total displacements u_x

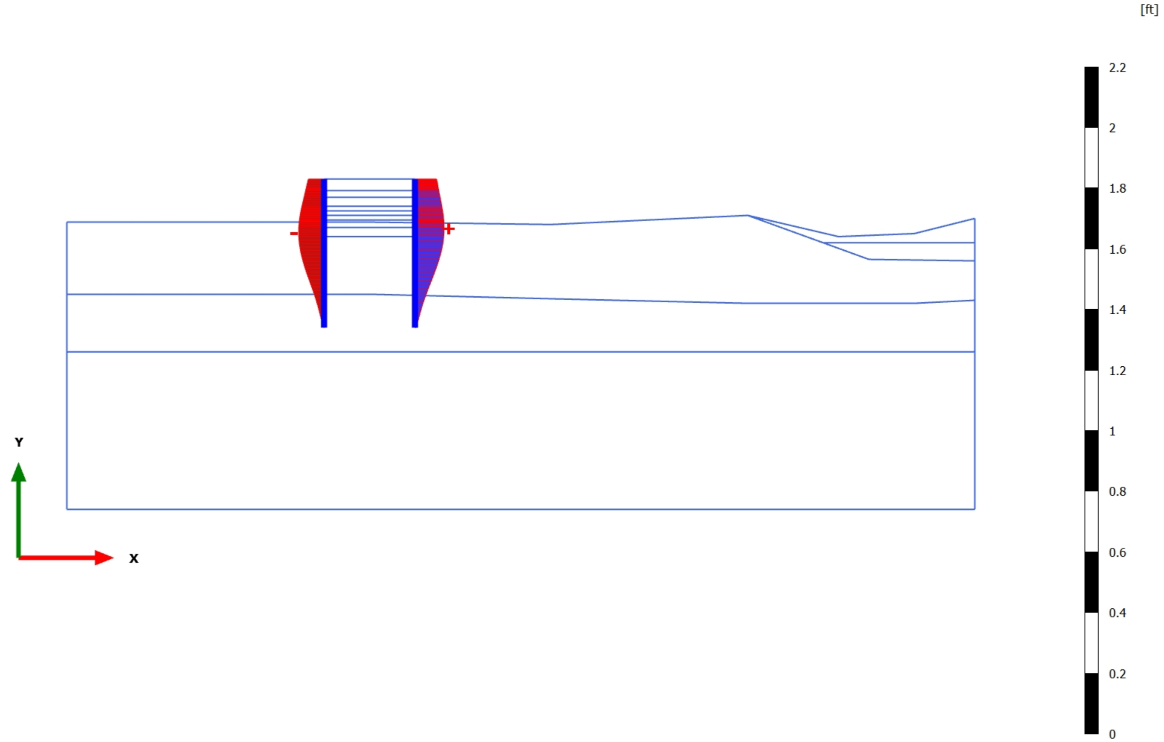


Total displacements u_x (scaled up 100 times)

Maximum value = 0.09790 ft (Element 20 at Node 4943)

Minimum value = -0.08540 ft (Element 21 at Node 4077)

3.1.1.1.1.6 Calculation results, Plate, Consolidate [Phase_26] (26/101), Total displacements u_x

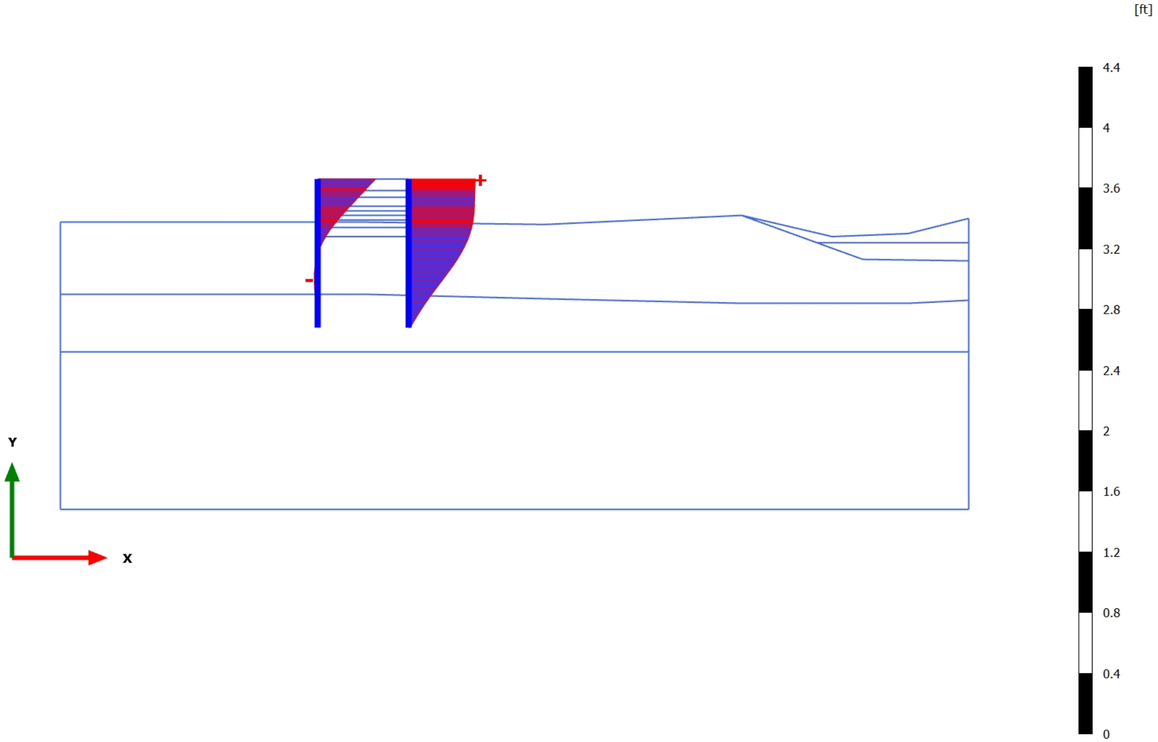


Total displacements u_x (scaled up 100 times) (Time 16.00 day)

Maximum value = 0.09651 ft (Element 20 at Node 4943)

Minimum value = -0.08423 ft (Element 21 at Node 4077)

3.1.1.1.1.7 Calculation results, Plate, Dewater-ss [Phase_16] (16/116), Total displacements u_x

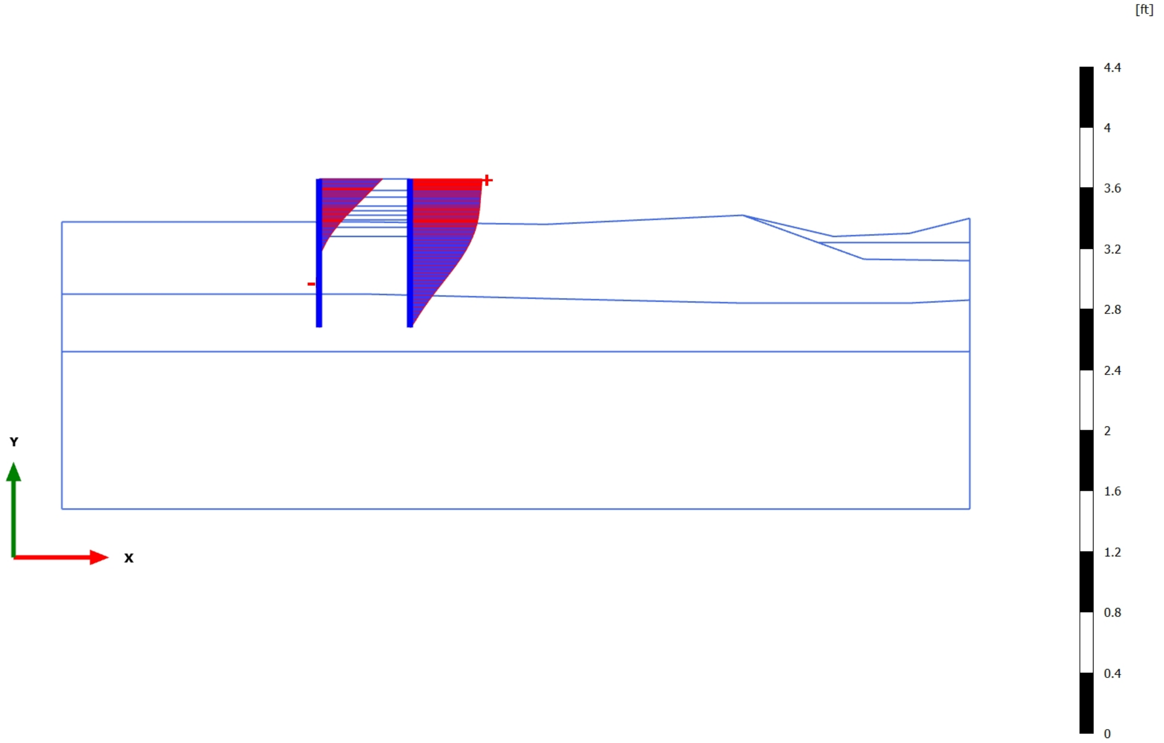


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4411 ft (Element 2 at Node 325)

Minimum value = -0.02363 ft (Element 25 at Node 5895)

3.1.1.1.1.8 Calculation results, Plate, Consolidate [Phase_17] (17/128), Total displacements u_x

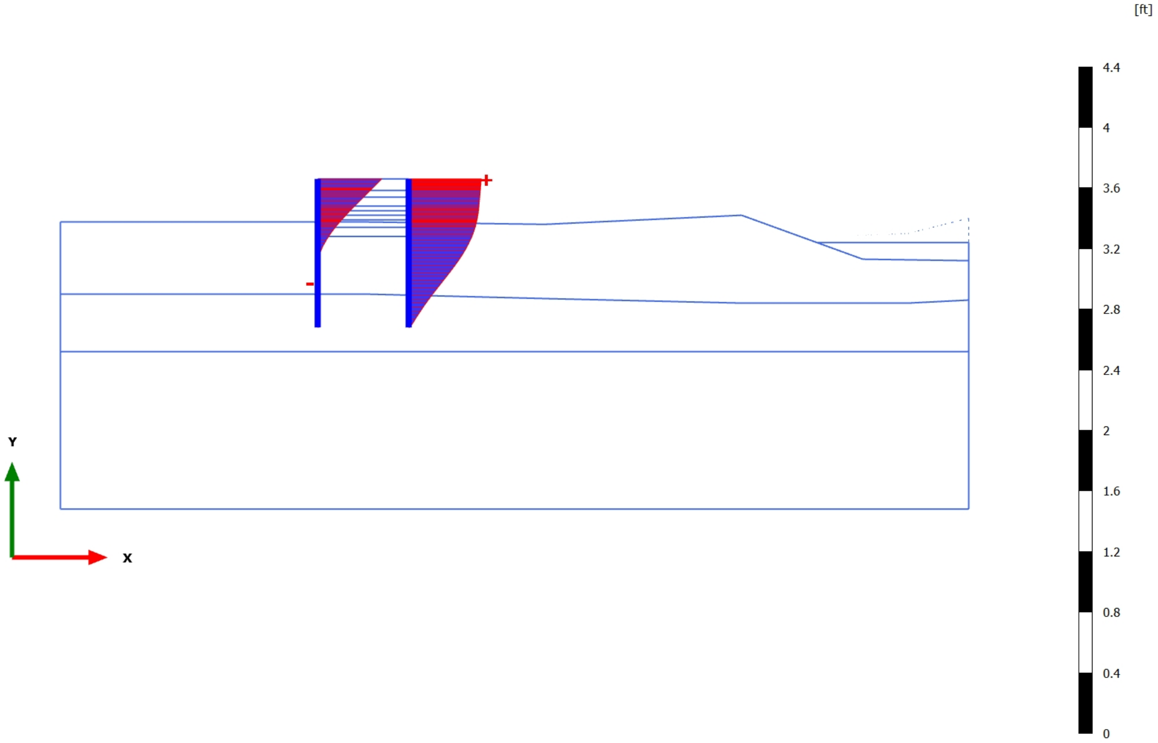


Total displacements u_x (scaled up 50.0 times) (Time 20.00 day)

Maximum value = 0.4779 ft (Element 2 at Node 325)

Minimum value = -0.01964 ft (Element 26 at Node 5896)

3.1.1.1.1.9 Calculation results, Plate, Excavate 1 [Phase_18] (18/131), Total displacements u_x

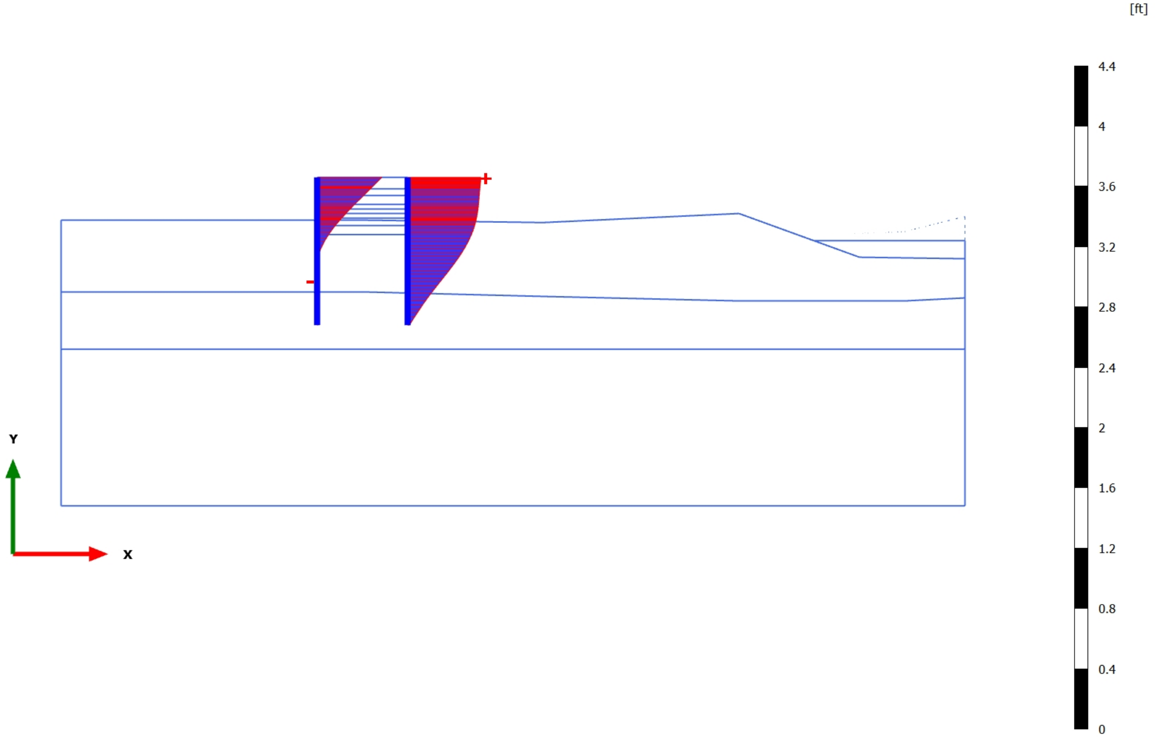


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4804 ft (Element 2 at Node 325)

Minimum value = -0.01872 ft (Element 26 at Node 5896)

3.1.1.1.1.10 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/134), Total displacements u_x

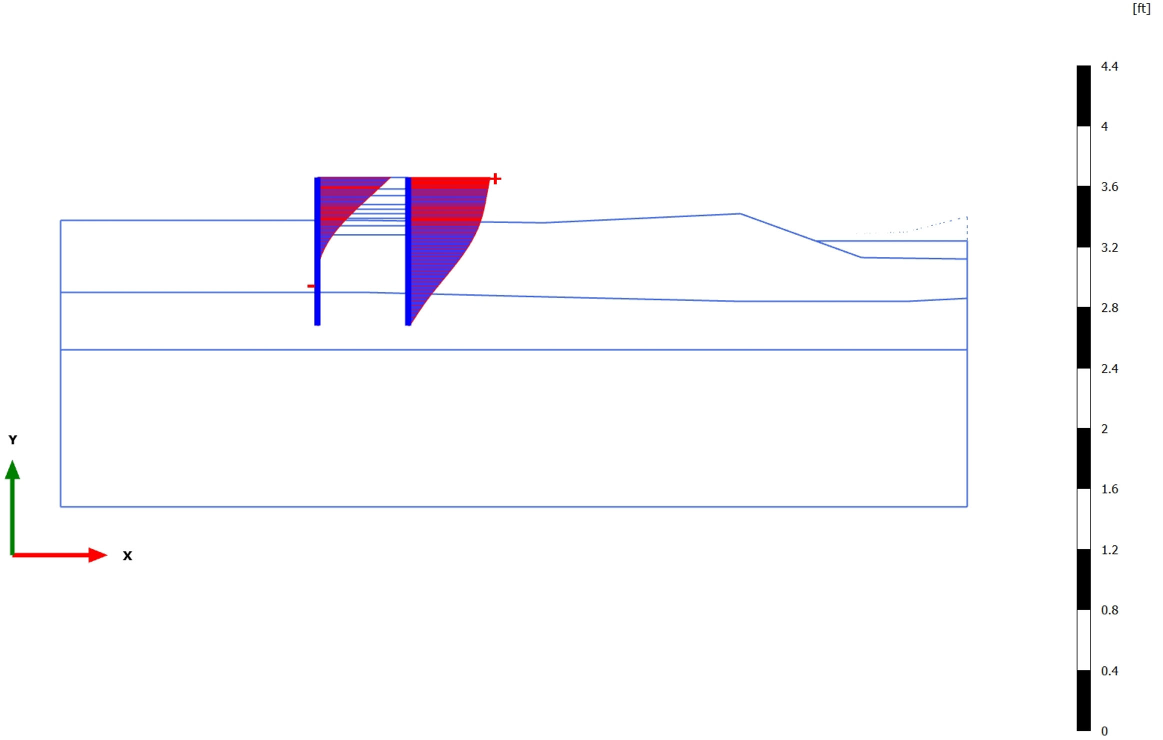


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4870 ft (Element 2 at Node 325)

Minimum value = -0.01621 ft (Element 26 at Node 5896)

3.1.1.1.1.11 Calculation results, Plate, Consolidate [Phase_20] (20/150), Total displacements u_x

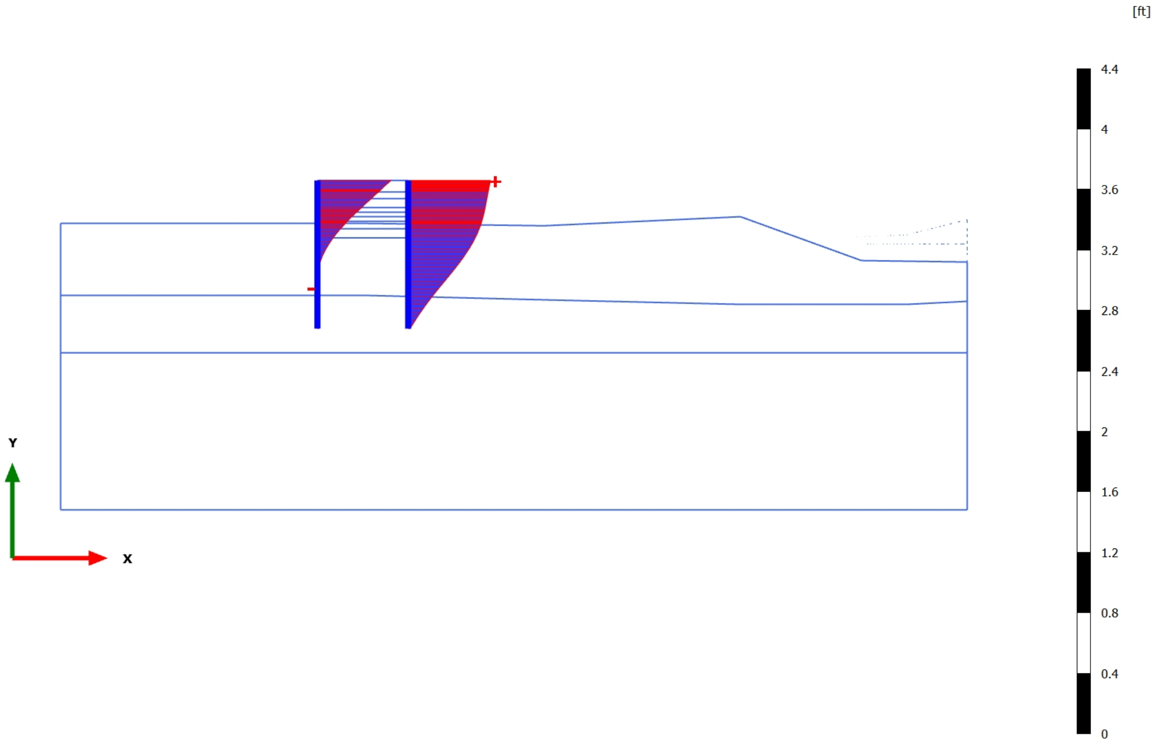


Total displacements u_x (scaled up 50.0 times) (Time 37.00 day)

Maximum value = 0.5430 ft (Element 2 at Node 325)

Minimum value = -9.043×10^{-3} ft (Element 26 at Node 5897)

3.1.1.1.1.12 Calculation results, Plate, Excavate 2 [Phase_21] (21/154), Total displacements u_x

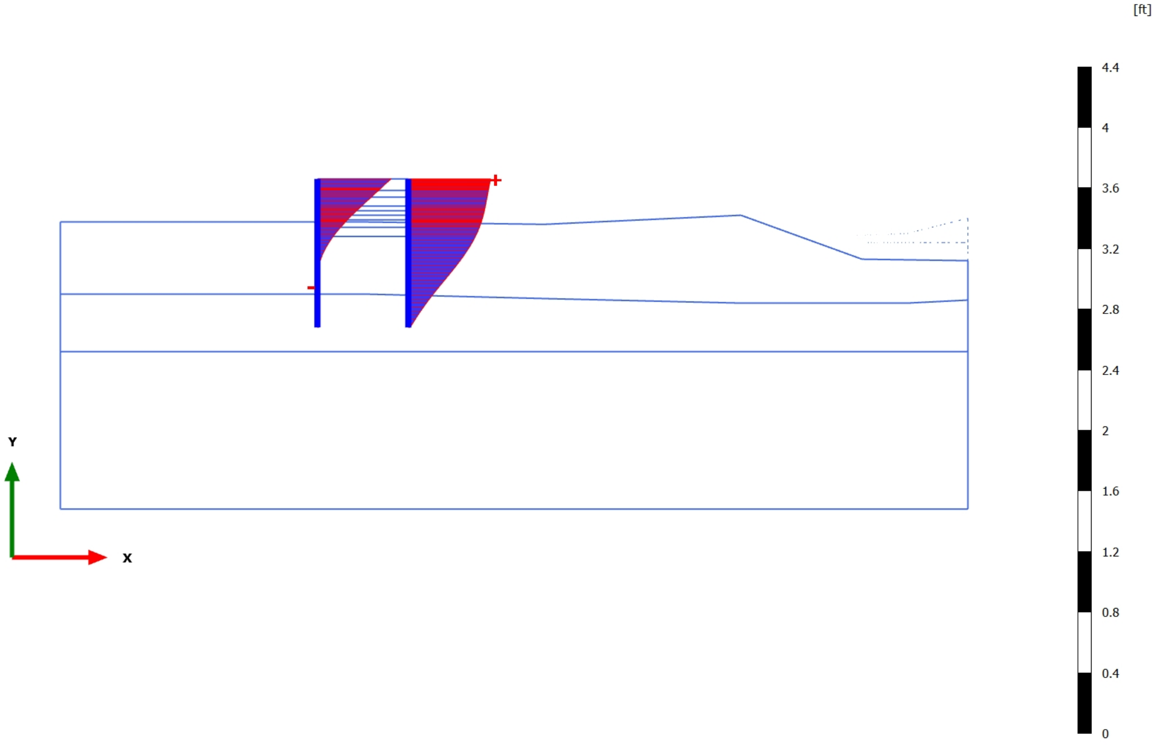


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5449 ft (Element 2 at Node 325)

Minimum value = -8.265×10^{-3} ft (Element 26 at Node 5897)

3.1.1.1.1.13 Calculation results, Plate, Consolidate [Phase_7] (7/178), Total displacements u_x

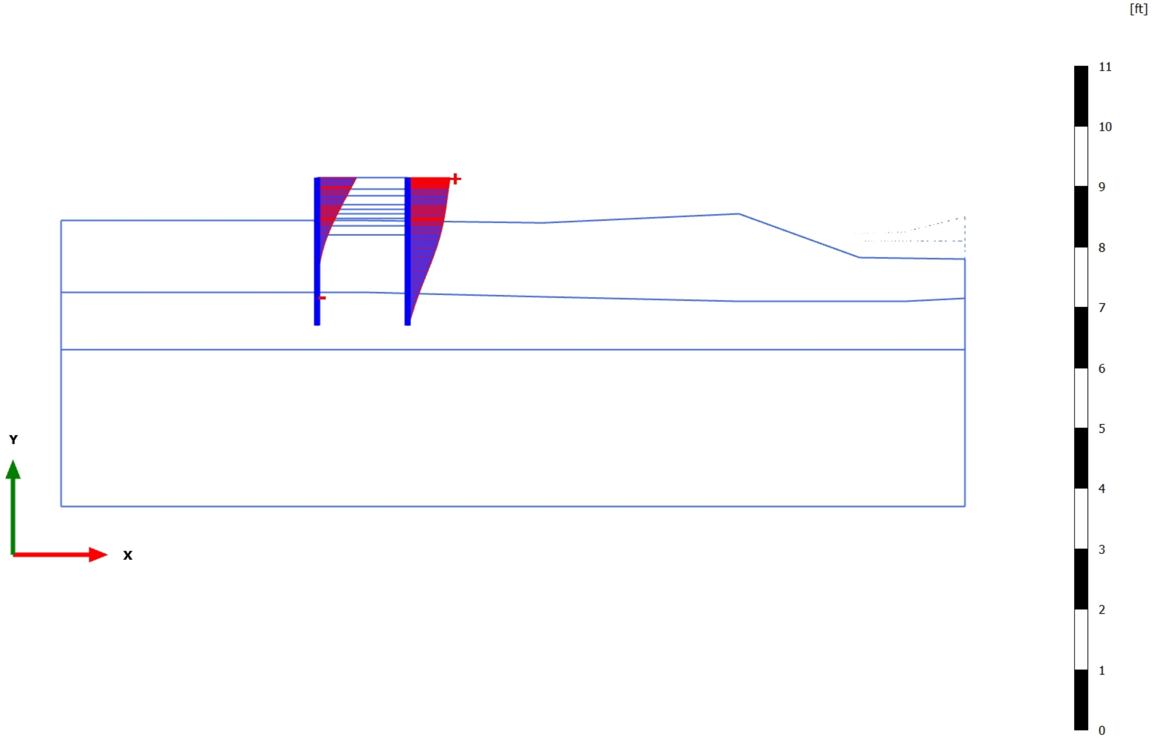


Total displacements u_x (scaled up 50.0 times) (Time 51.00 day)

Maximum value = 0.5449 ft (Element 2 at Node 325)

Minimum value = -8.266×10^{-3} ft (Element 26 at Node 5897)

3.1.1.1.1.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/188), Total displacements u_x

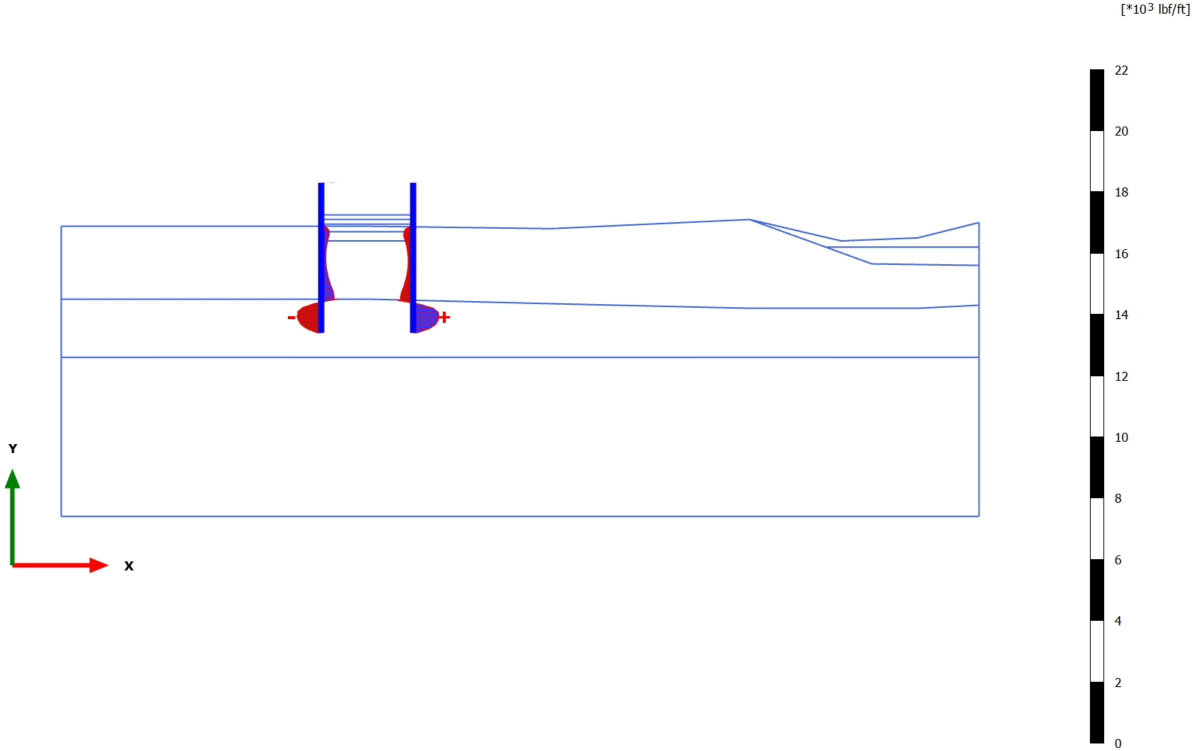


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.7063 ft (Element 2 at Node 325)

Minimum value = $3.691*10^{-3}$ ft (Element 31 at Node 6110)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/20), Shear forces Q

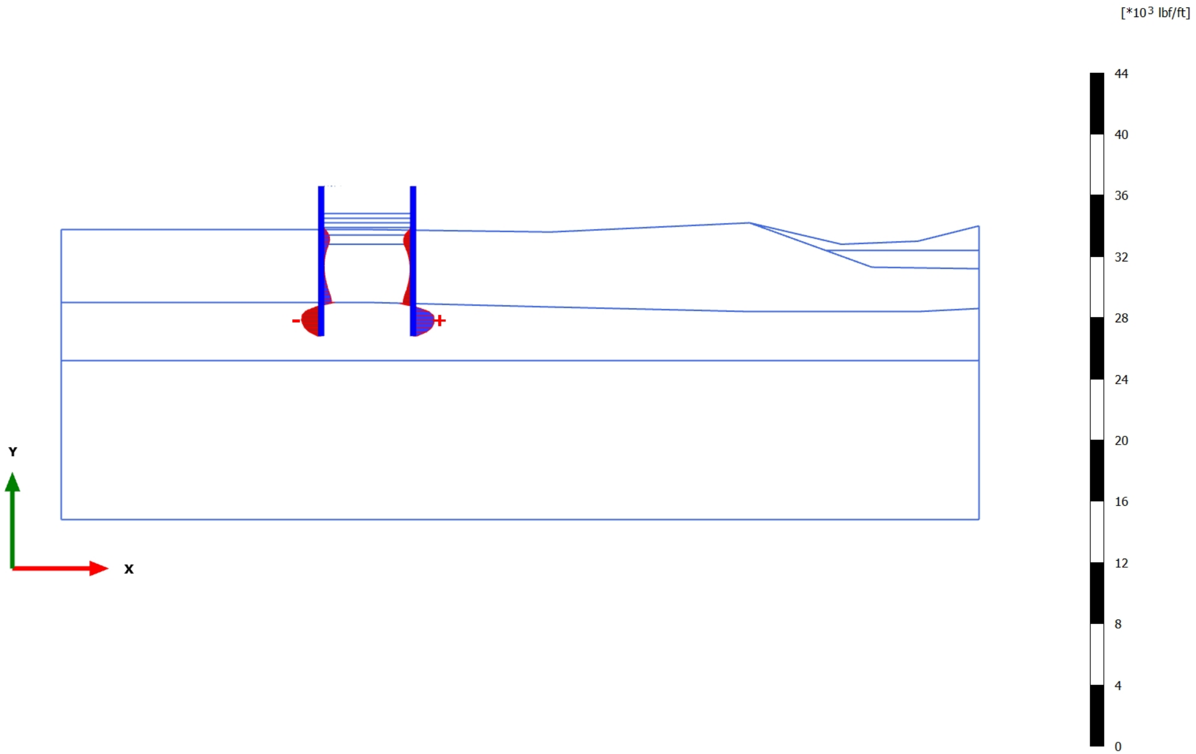


Shear forces Q (scaled up 0.0100 times)

Maximum value = 859.1 lbf/ft (Element 34 at Node 7384)

Minimum value = -804.9 lbf/ft (Element 32 at Node 6575)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/32), Shear forces Q

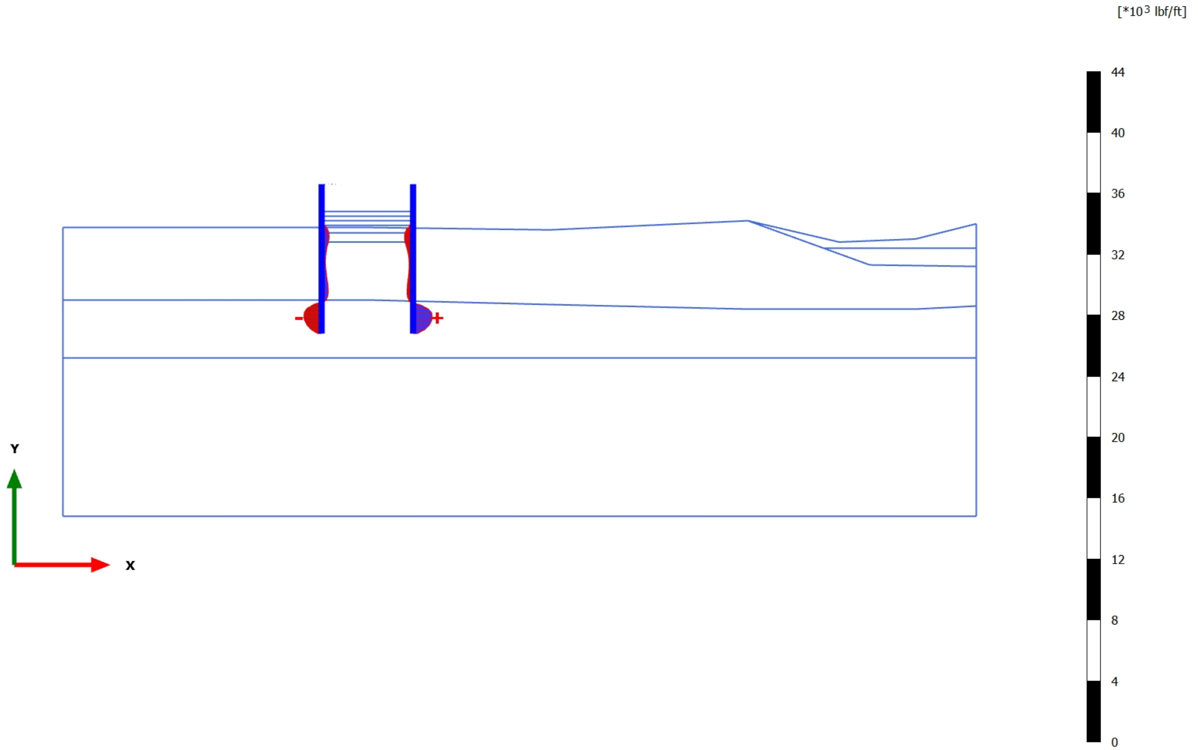


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 1410 lbf/ft (Element 34 at Node 7384)

Minimum value = -1314 lbf/ft (Element 32 at Node 6575)

3.1.2.1.3 Calculation results, Plate, Consolidate [Phase_25] (25/63), Shear forces Q

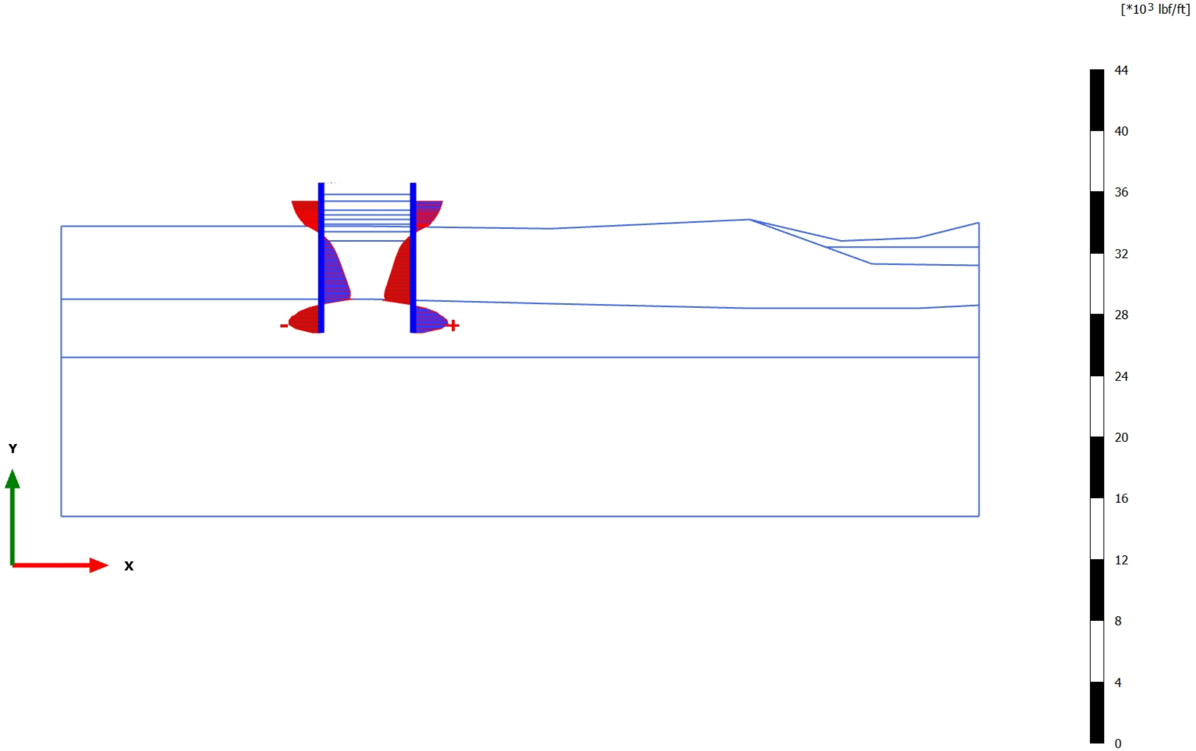


Shear forces Q (scaled up $5.00*10^{-3}$ times) (Time 10.00 day)

Maximum value = 1284 lbf/ft (Element 34 at Node 7384)

Minimum value = -1194 lbf/ft (Element 32 at Node 6575)

3.1.2.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/76), Shear forces Q

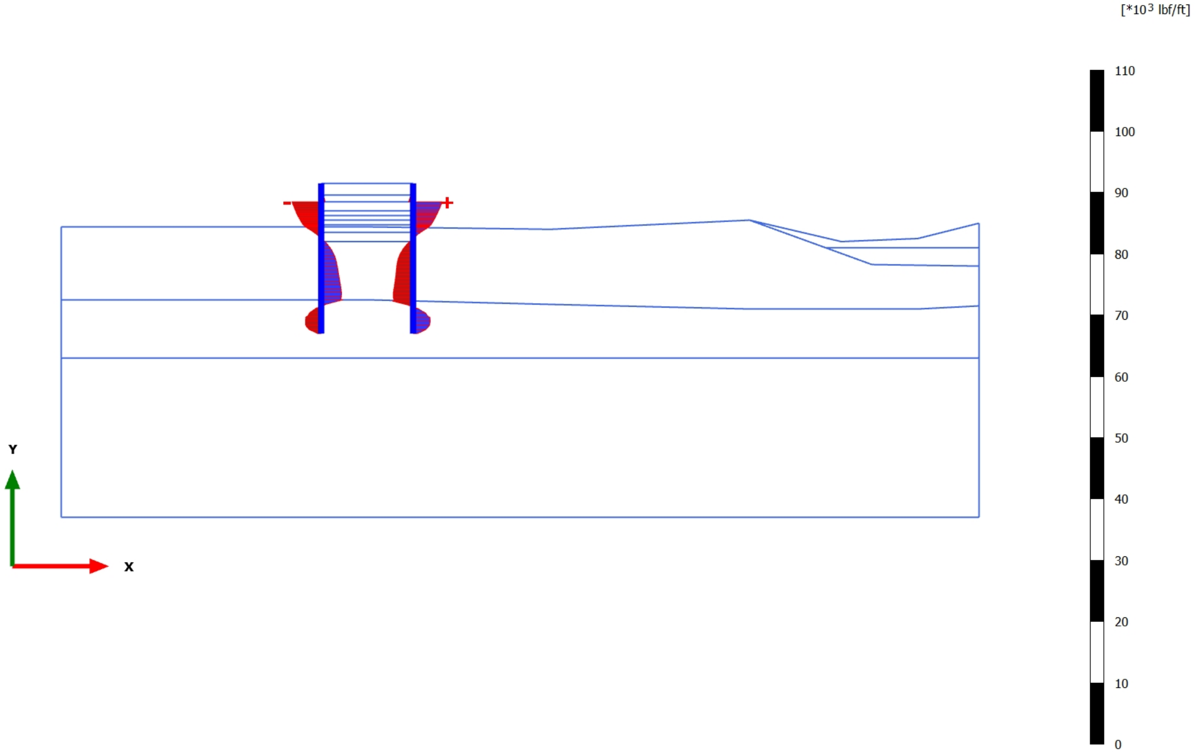


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 2290 lbf/ft (Element 34 at Node 7386)

Minimum value = -2124 lbf/ft (Element 32 at Node 6577)

3.1.2.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/85), Shear forces Q

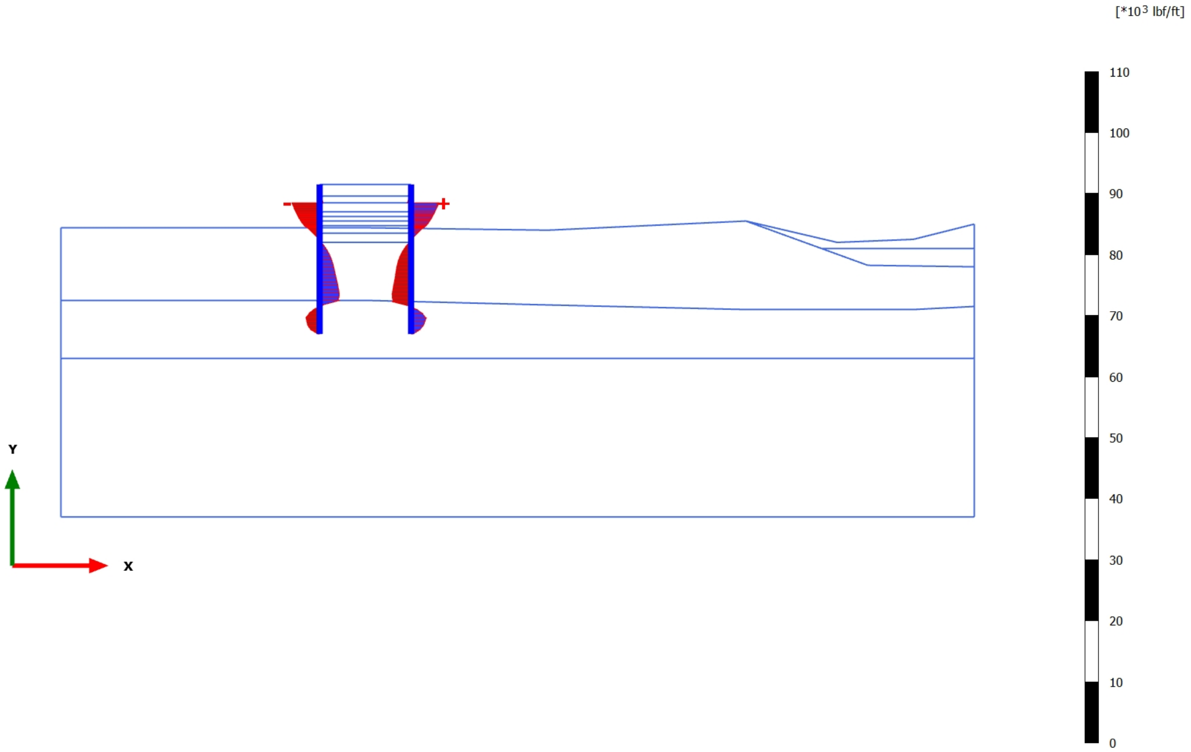


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 4758 lbf/ft (Element 10 at Node 411)

Minimum value = -4815 lbf/ft (Element 9 at Node 13)

3.1.2.1.6 Calculation results, Plate, Consolidate [Phase_26] (26/101), Shear forces Q

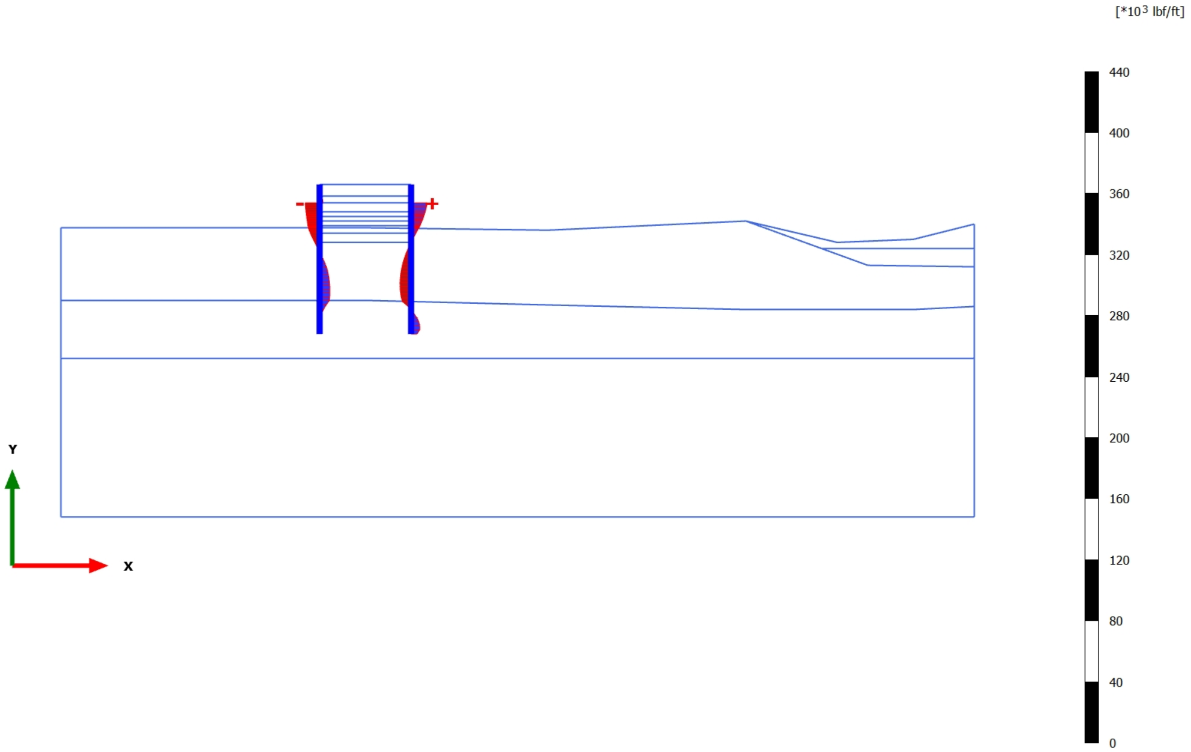


Shear forces Q (scaled up $2.00*10^{-3}$ times) (Time 16.00 day)

Maximum value = 4547 lbf/ft (Element 10 at Node 411)

Minimum value = -4590 lbf/ft (Element 9 at Node 13)

3.1.2.1.7 Calculation results, Plate, Dewater-ss [Phase_16] (16/116), Shear forces Q

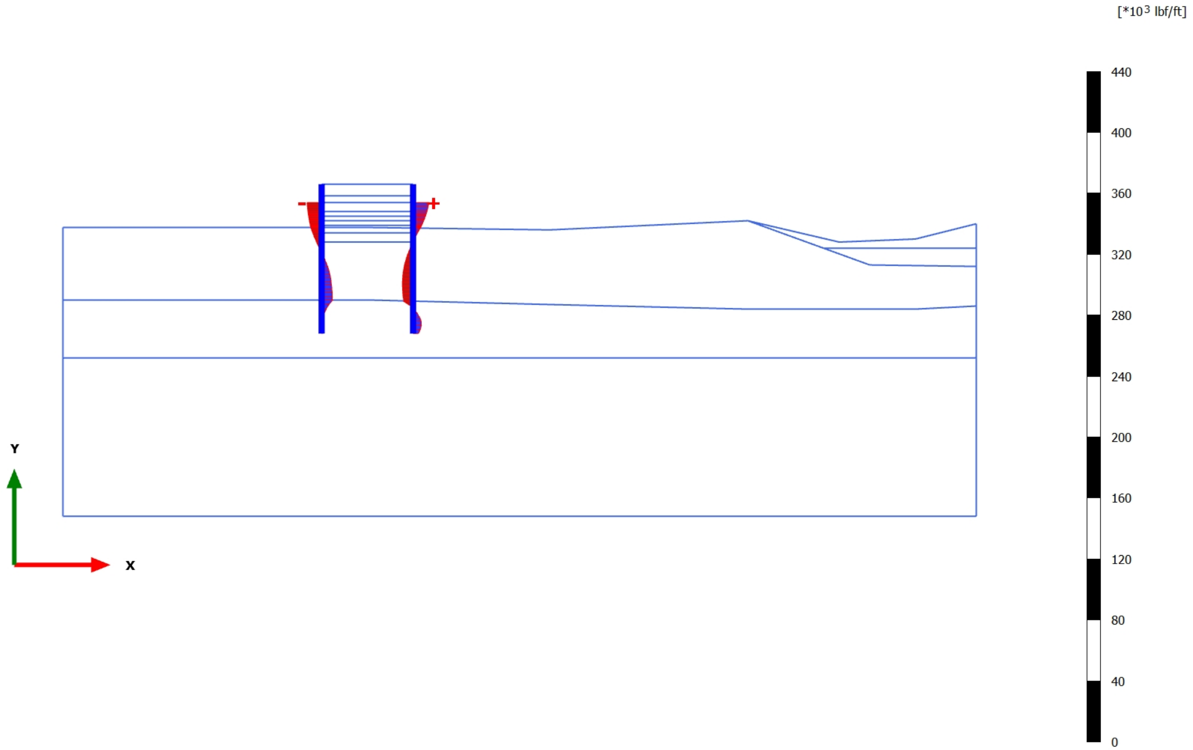


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.60*10^3$ lbf/ft (Element 10 at Node 411)

Minimum value = -9641 lbf/ft (Element 9 at Node 13)

3.1.2.1.8 Calculation results, Plate, Consolidate [Phase_17] (17/128), Shear forces Q

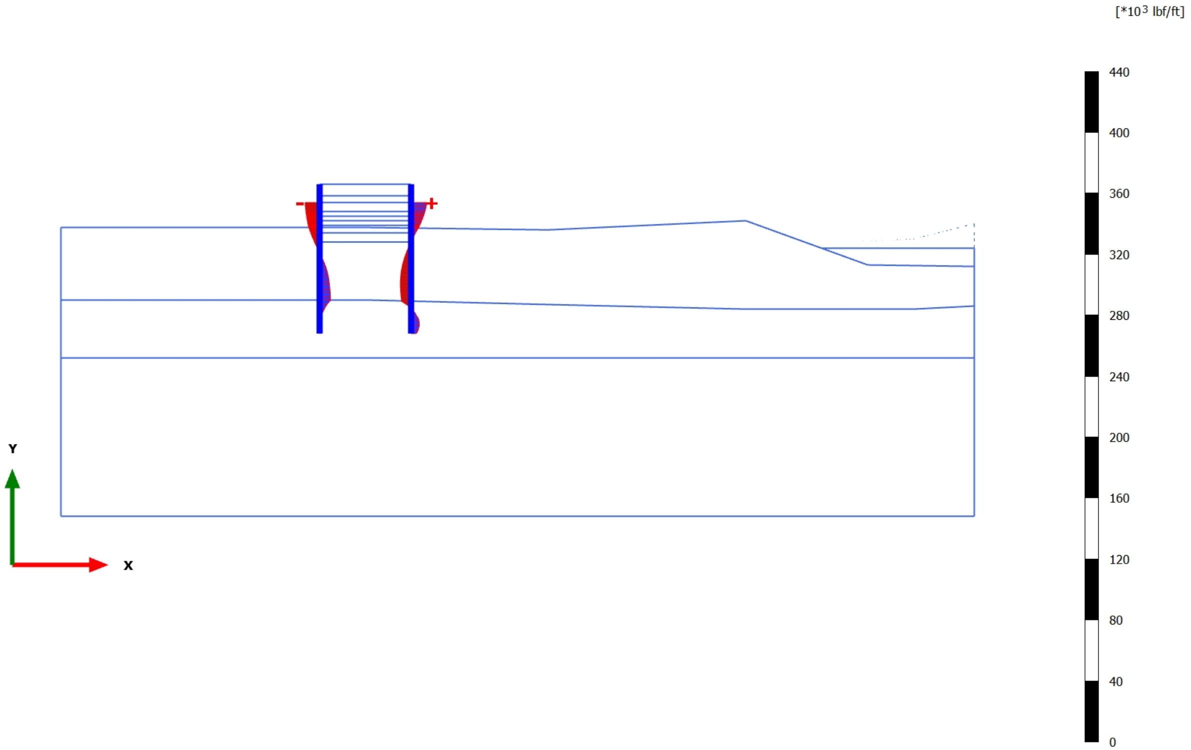


Shear forces Q (scaled up $0.500*10^{-3}$ times) (Time 20.00 day)

Maximum value = $10.42*10^3$ lbf/ft (Element 10 at Node 411)

Minimum value = -9717 lbf/ft (Element 9 at Node 13)

3.1.2.1.9 Calculation results, Plate, Excavate 1 [Phase_18] (18/131), Shear forces Q

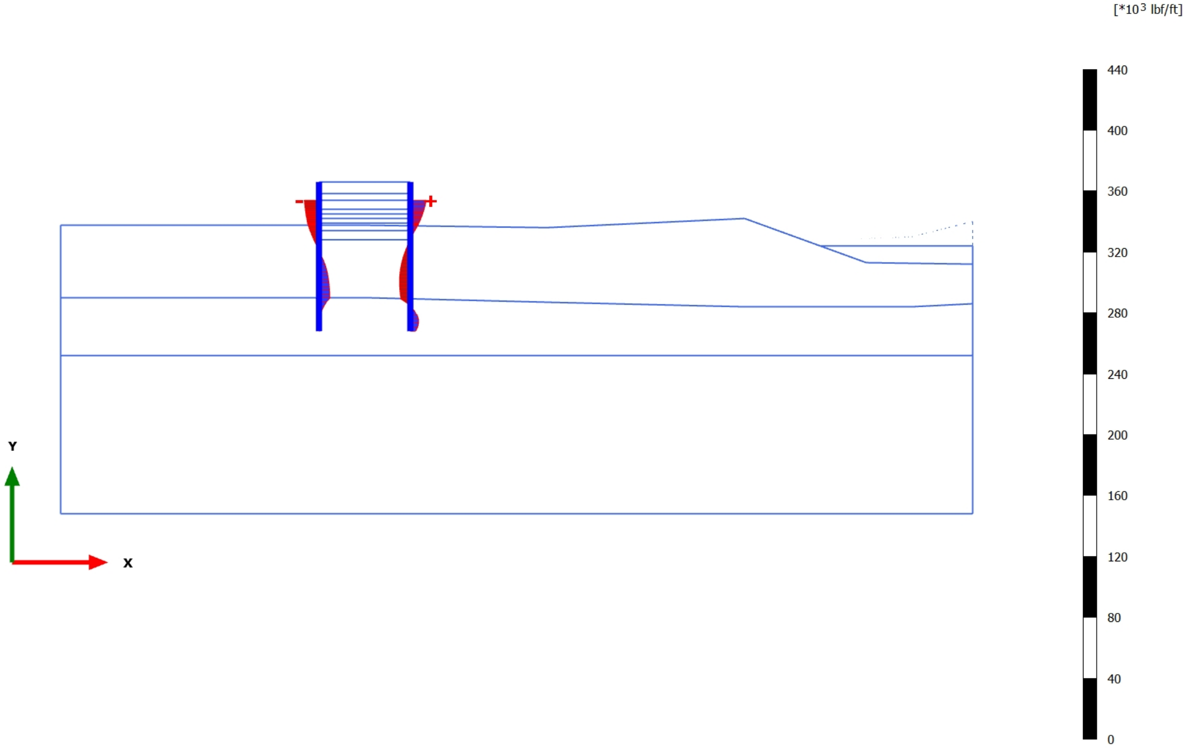


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.43*10^{3}$ lbf/ft (Element 10 at Node 411)

Minimum value = -9725 lbf/ft (Element 9 at Node 13)

3.1.2.1.10 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/134), Shear forces Q

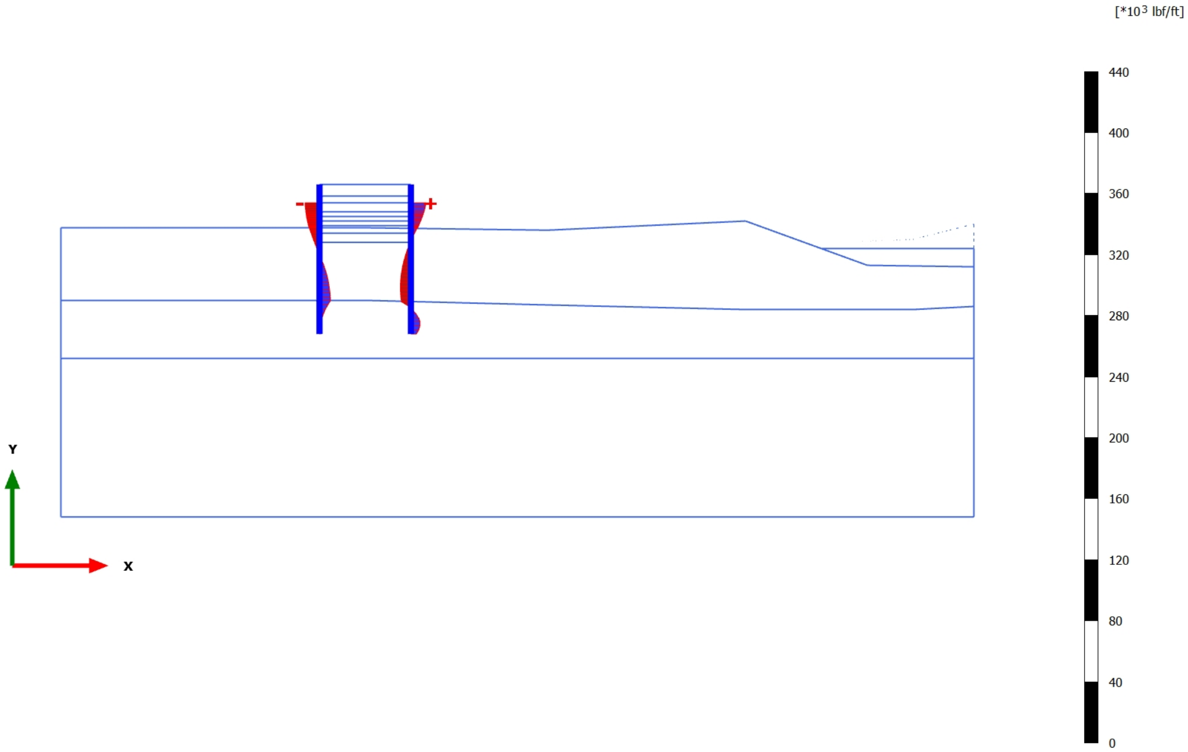


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.45*10^{3}$ lbf/ft (Element 10 at Node 411)

Minimum value = -9751 lbf/ft (Element 9 at Node 13)

3.1.2.1.11 Calculation results, Plate, Consolidate [Phase_20] (20/150), Shear forces Q

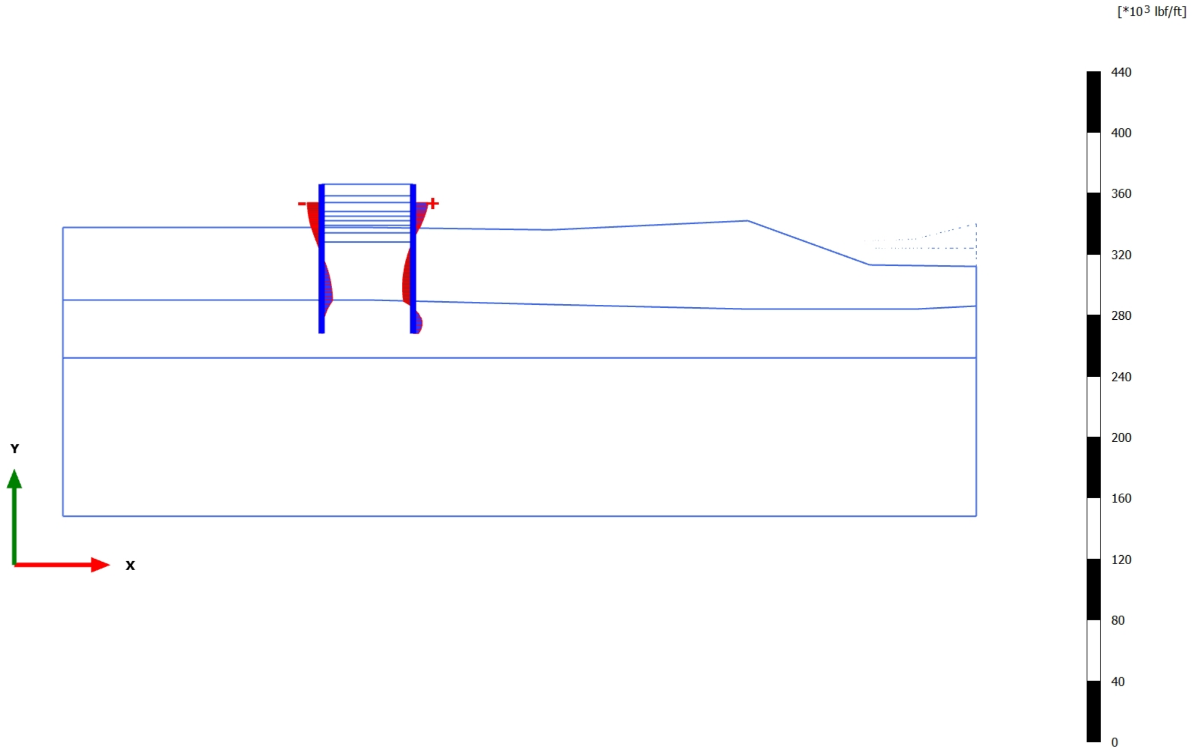


Shear forces Q (scaled up 0.500×10^{-3} times) (Time 37.00 day)

Maximum value = 9974 lbf/ft (Element 10 at Node 411)

Minimum value = -9718 lbf/ft (Element 9 at Node 13)

3.1.2.1.12 Calculation results, Plate, Excavate 2 [Phase_21] (21/154), Shear forces Q

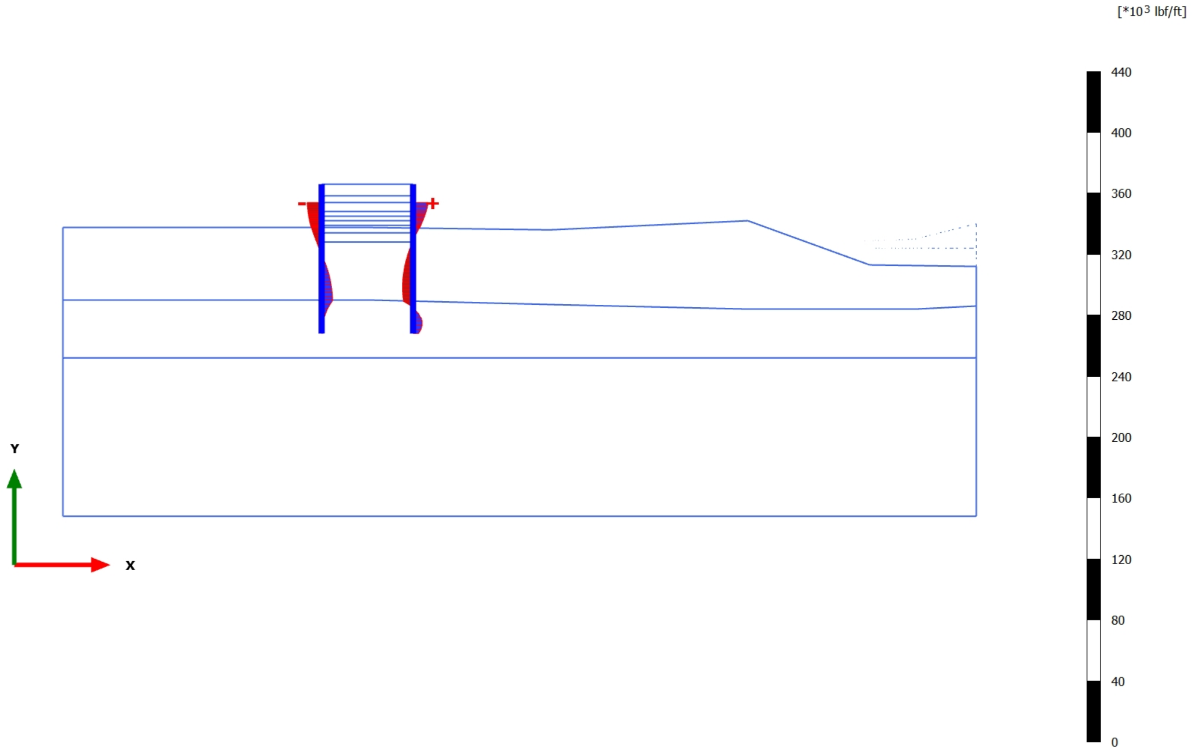


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 9978 lbf/ft (Element 10 at Node 411)

Minimum value = -9720 lbf/ft (Element 9 at Node 13)

3.1.2.1.13 Calculation results, Plate, Consolidate [Phase_7] (7/178), Shear forces Q

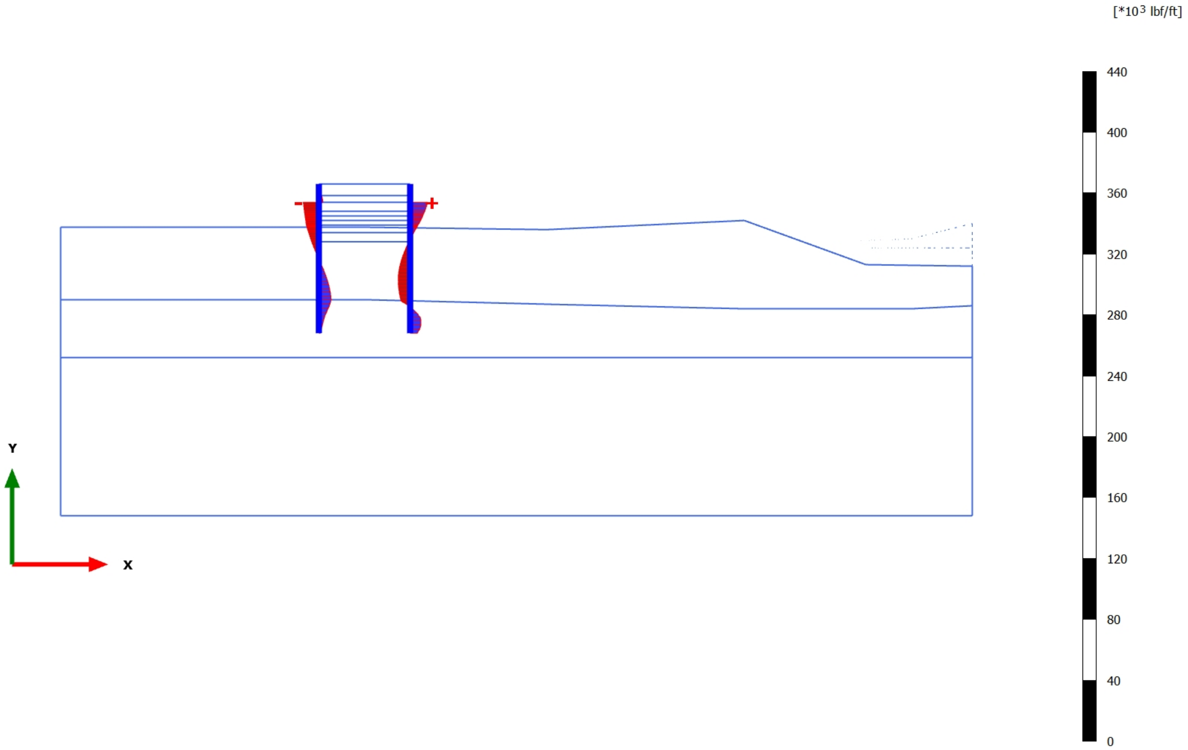


Shear forces Q (scaled up 0.500*10^{-3} times) (Time 51.00 day)

Maximum value = 9978 lbf/ft (Element 10 at Node 411)

Minimum value = -9720 lbf/ft (Element 9 at Node 13)

3.1.2.1.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/188), Shear forces Q

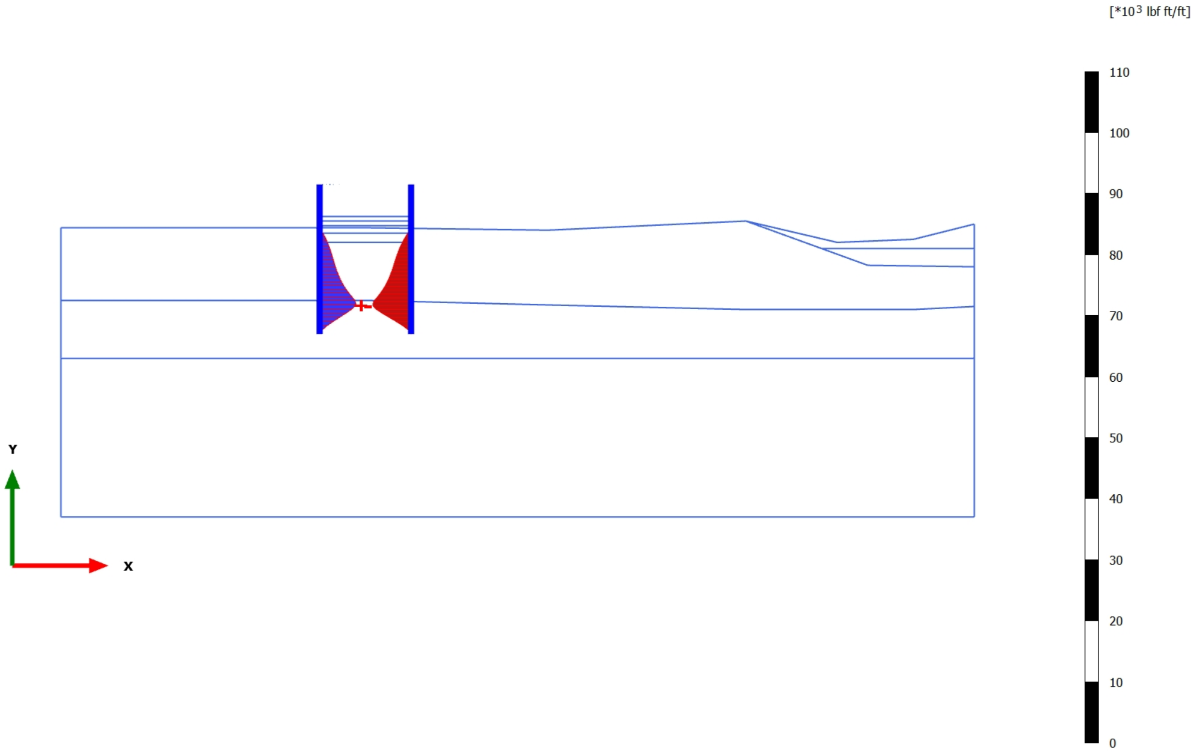


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 11.53*10^3 lbf/ft (Element 10 at Node 411)

Minimum value = -10.40*10^3 lbf/ft (Element 9 at Node 13)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/20), Bending moments M

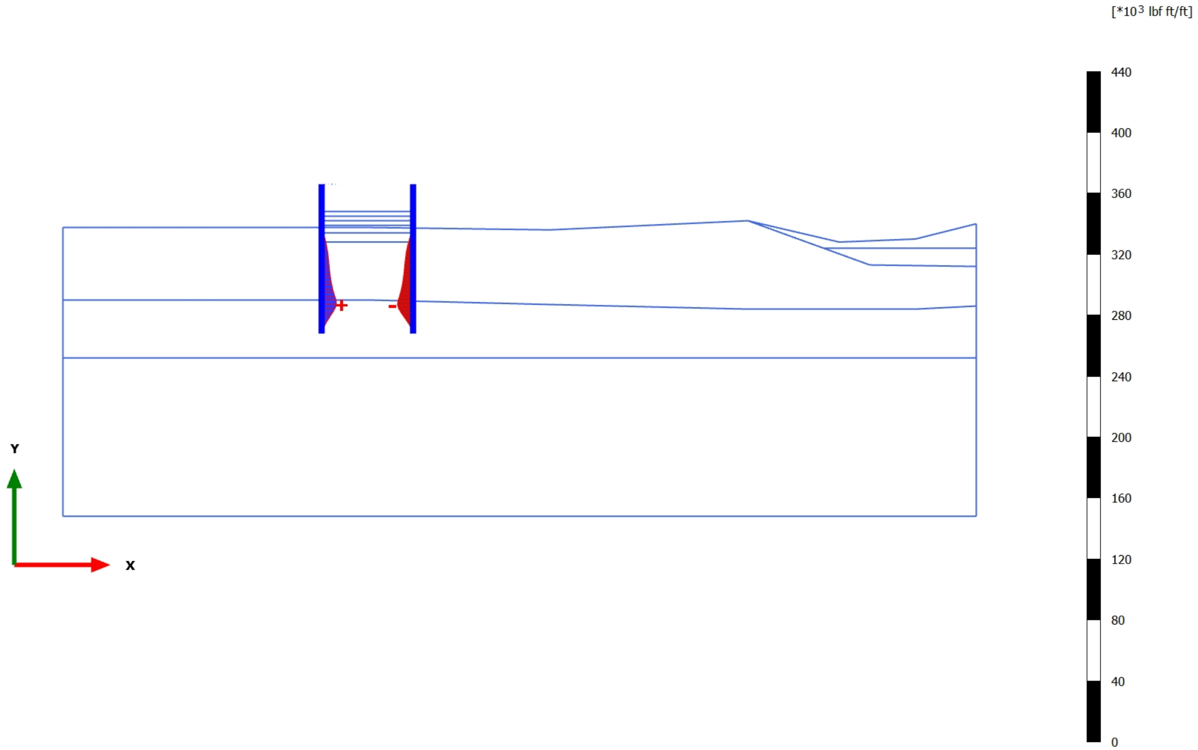


Bending moments M (scaled up $2.00*10^{-3}$ times)

Maximum value = 5976 lbf ft/ft (Element 31 at Node 6110)

Minimum value = -6294 lbf ft/ft (Element 33 at Node 6985)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/32), Bending moments M

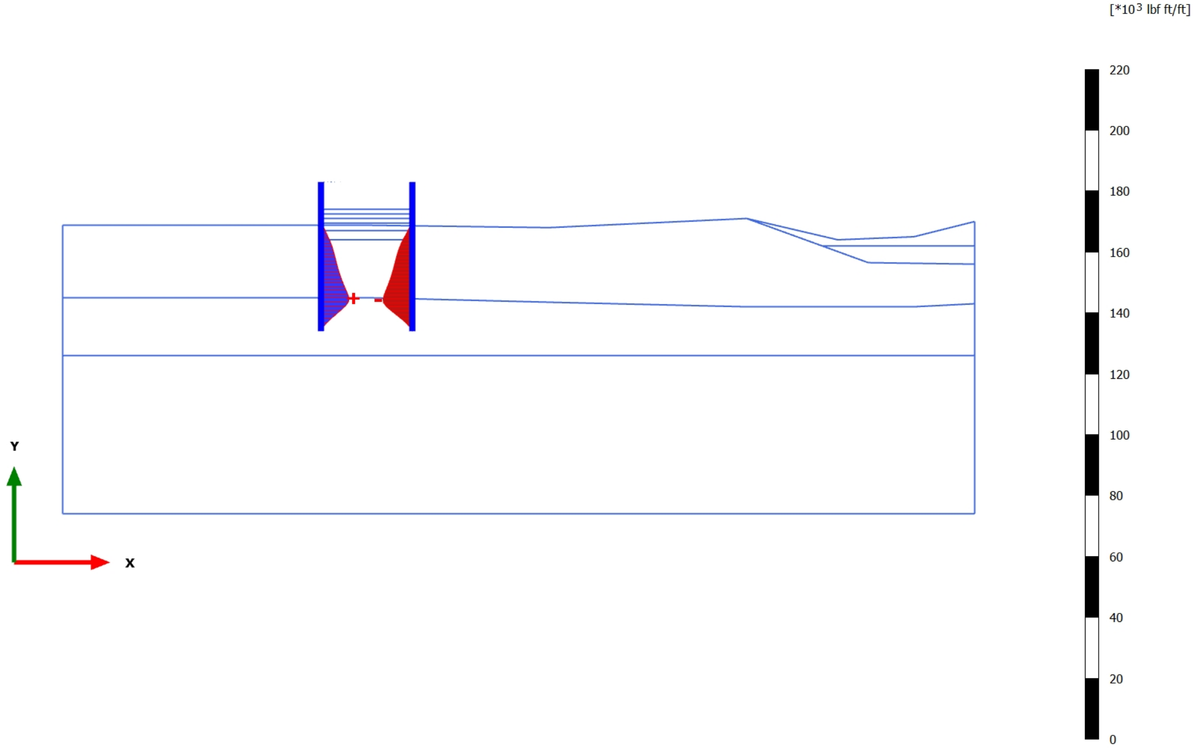


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = 9744 lbf ft/ft (Element 31 at Node 6110)

Minimum value = $-10.23*10^{3}$ lbf ft/ft (Element 33 at Node 6985)

3.1.2.2.3 Calculation results, Plate, Consolidate [Phase_25] (25/63), Bending moments M

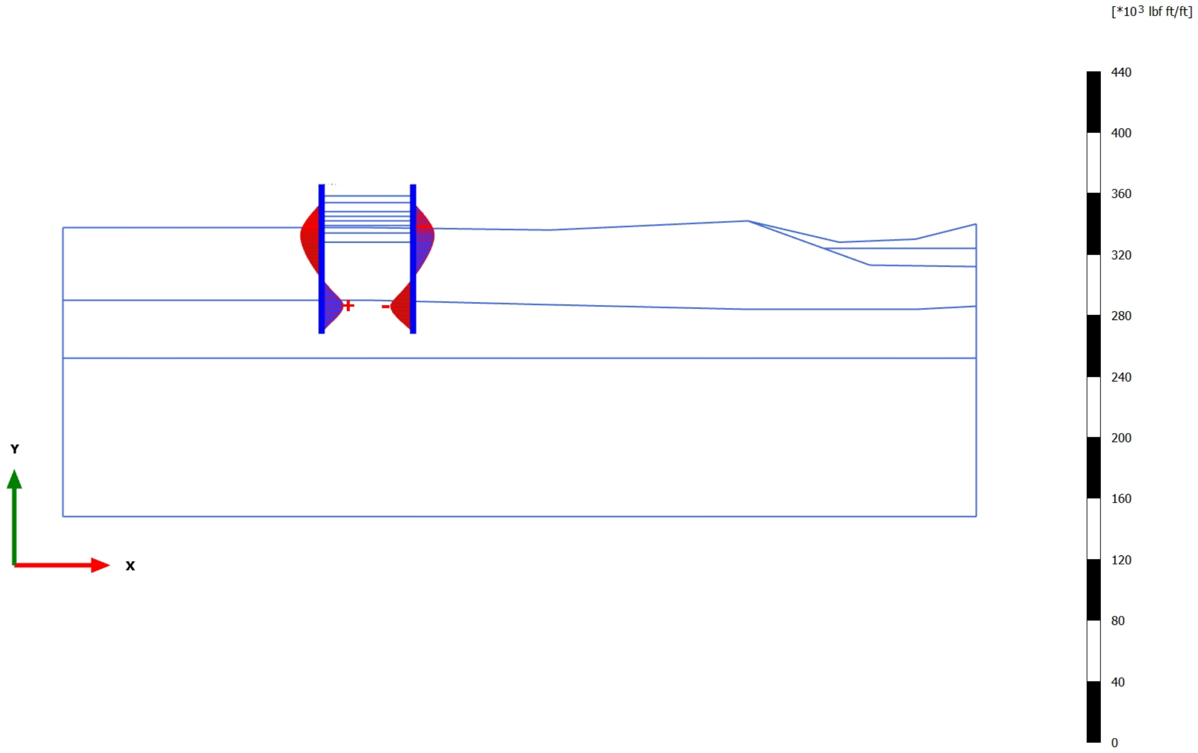


Bending moments M (scaled up 1.00*10^{-3} times) (Time 10.00 day)

Maximum value = 9177 lbf ft/ft (Element 31 at Node 6109)

Minimum value = -9631 lbf ft/ft (Element 33 at Node 6984)

3.1.2.2.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/76), Bending moments M

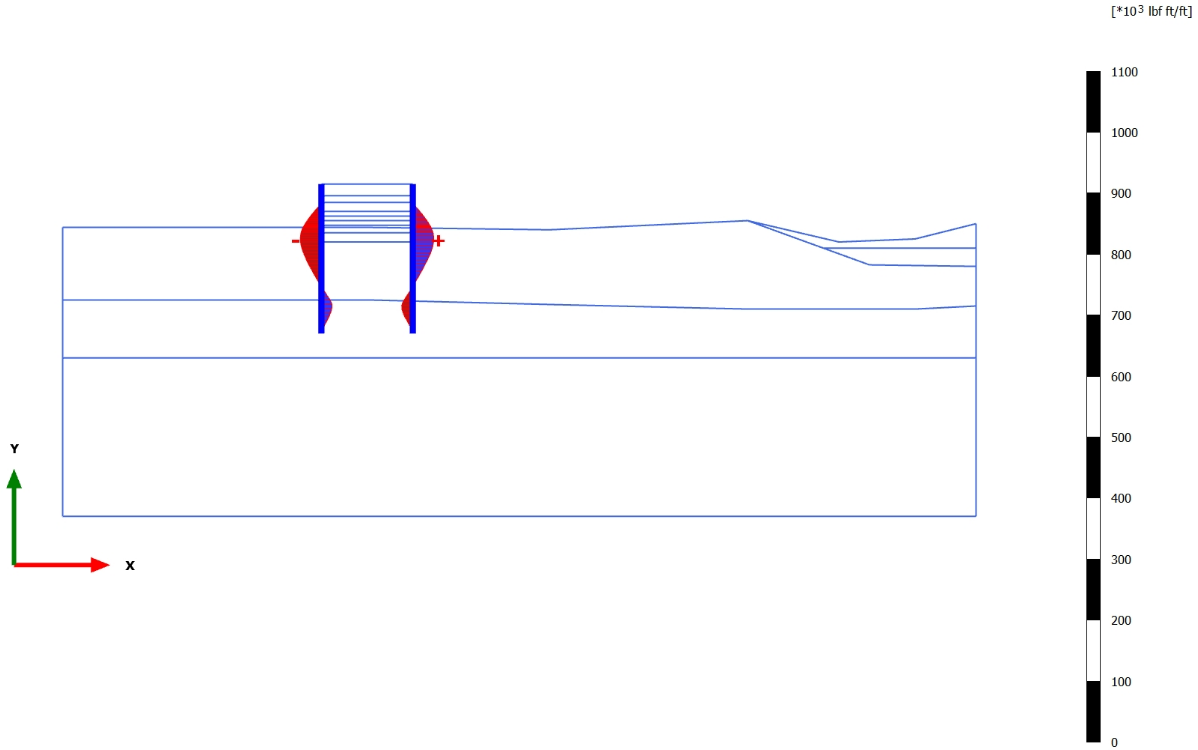


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 14.25*10^3 lbf ft/ft (Element 31 at Node 6110)

Minimum value = -14.76*10^3 lbf ft/ft (Element 33 at Node 6985)

3.1.2.2.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/85), Bending moments M

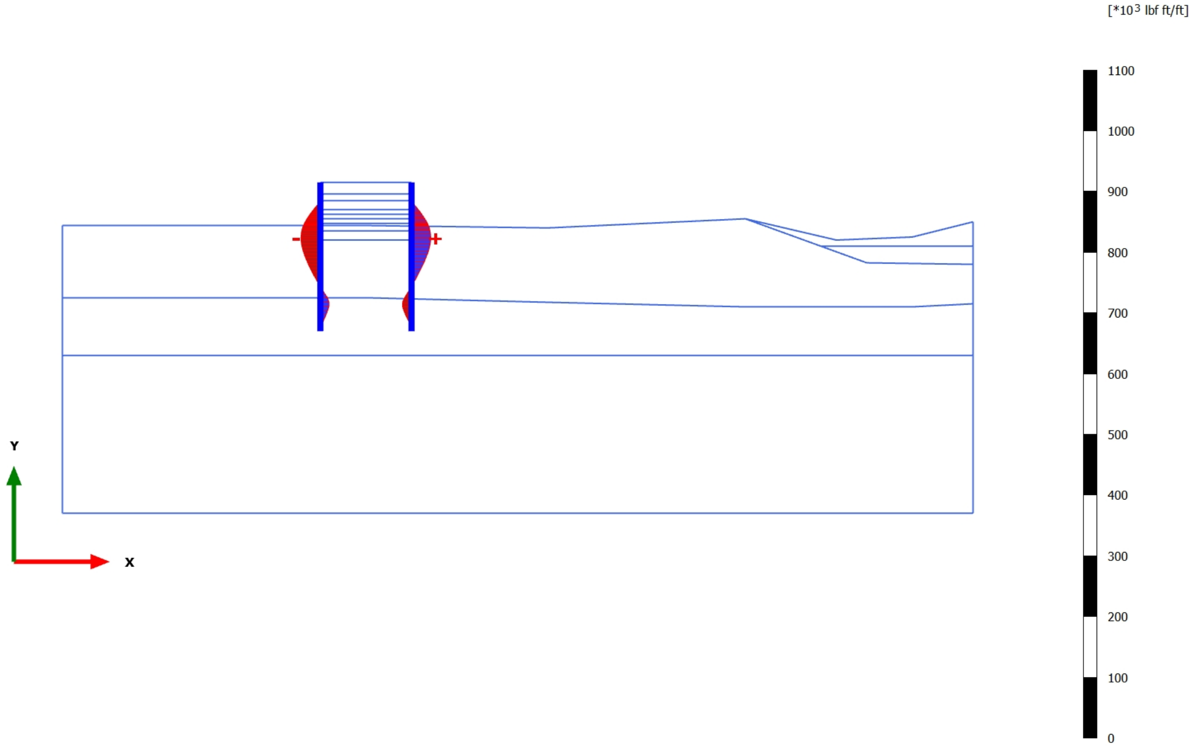


Bending moments M (scaled up 0.200×10^{-3} times)

Maximum value = 34.45×10^{3} lbf ft/ft (Element 22 at Node 4946)

Minimum value = -34.63×10^{3} lbf ft/ft (Element 21 at Node 4076)

3.1.2.2.6 Calculation results, Plate, Consolidate [Phase_26] (26/101), Bending moments M

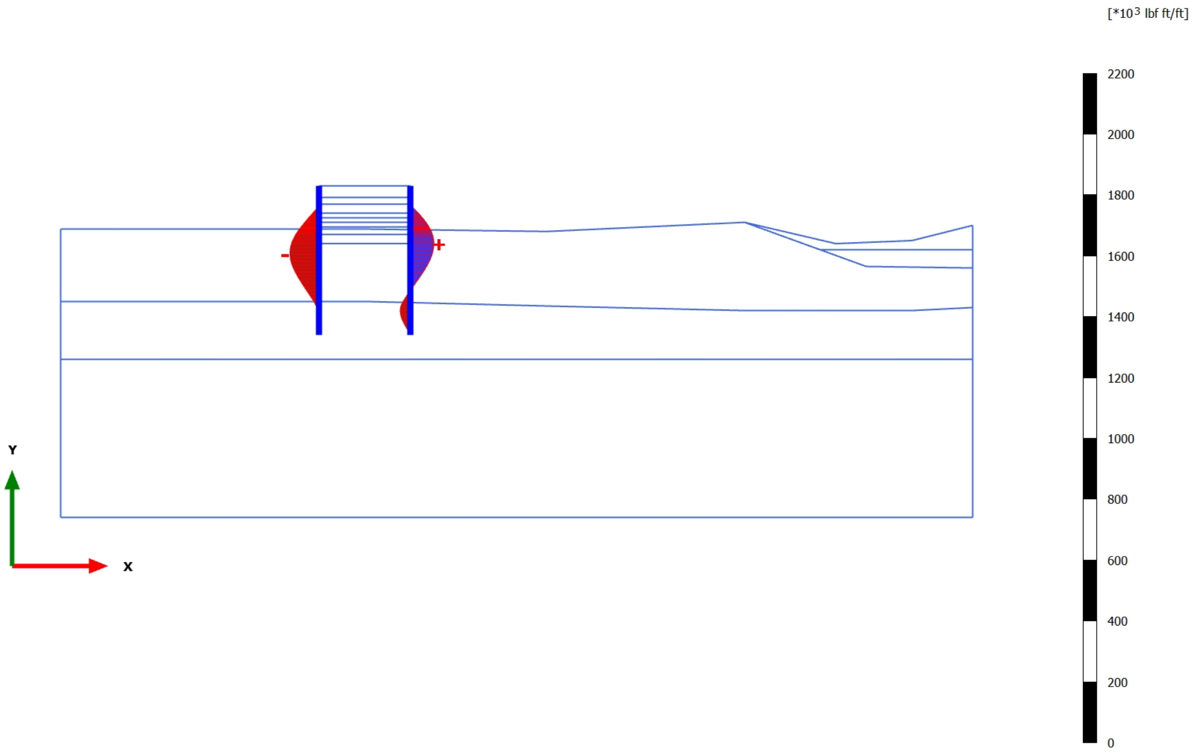


Bending moments M (scaled up 0.200×10^{-3} times) (Time 16.00 day)

Maximum value = 31.81×10^{3} lbf ft/ft (Element 22 at Node 4946)

Minimum value = -32.05×10^{3} lbf ft/ft (Element 21 at Node 4076)

3.1.2.2.7 Calculation results, Plate, Dewater-ss [Phase_16] (16/116), Bending moments M

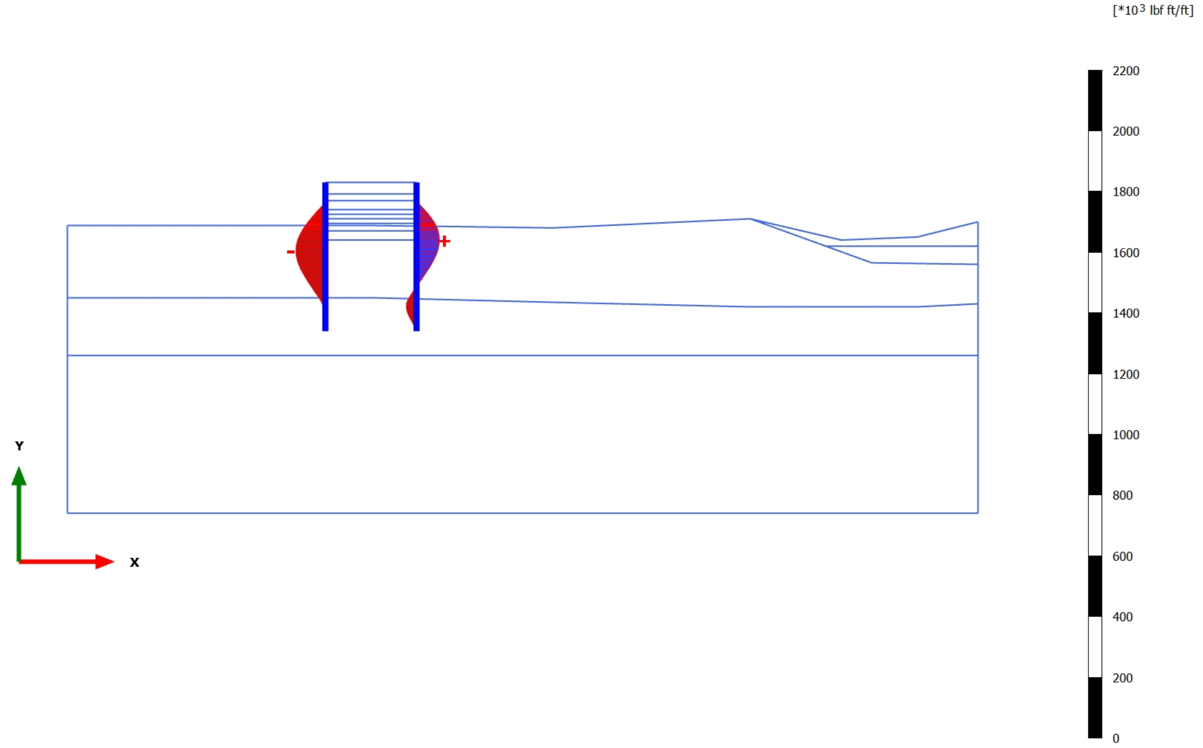


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 77.90*10^{3} lbf ft/ft (Element 22 at Node 5577)

Minimum value = -95.96*10^{3} lbf ft/ft (Element 23 at Node 4604)

3.1.2.2.8 Calculation results, Plate, Consolidate [Phase_17] (17/128), Bending moments M

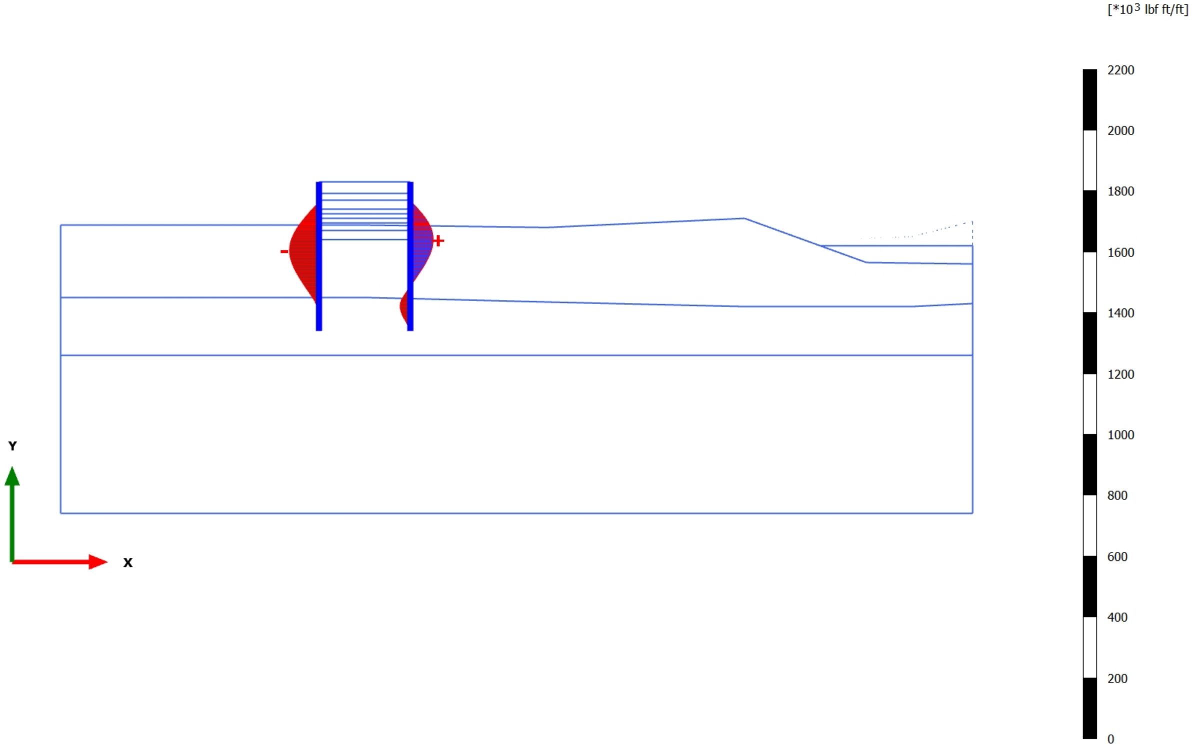


Bending moments M (scaled up 0.100*10^{-3} times) (Time 20.00 day)

Maximum value = 75.50*10^{3} lbf ft/ft (Element 22 at Node 5577)

Minimum value = -97.20*10^{3} lbf ft/ft (Element 23 at Node 4604)

3.1.2.2.9 Calculation results, Plate, Excavate 1 [Phase_18] (18/131), Bending moments M

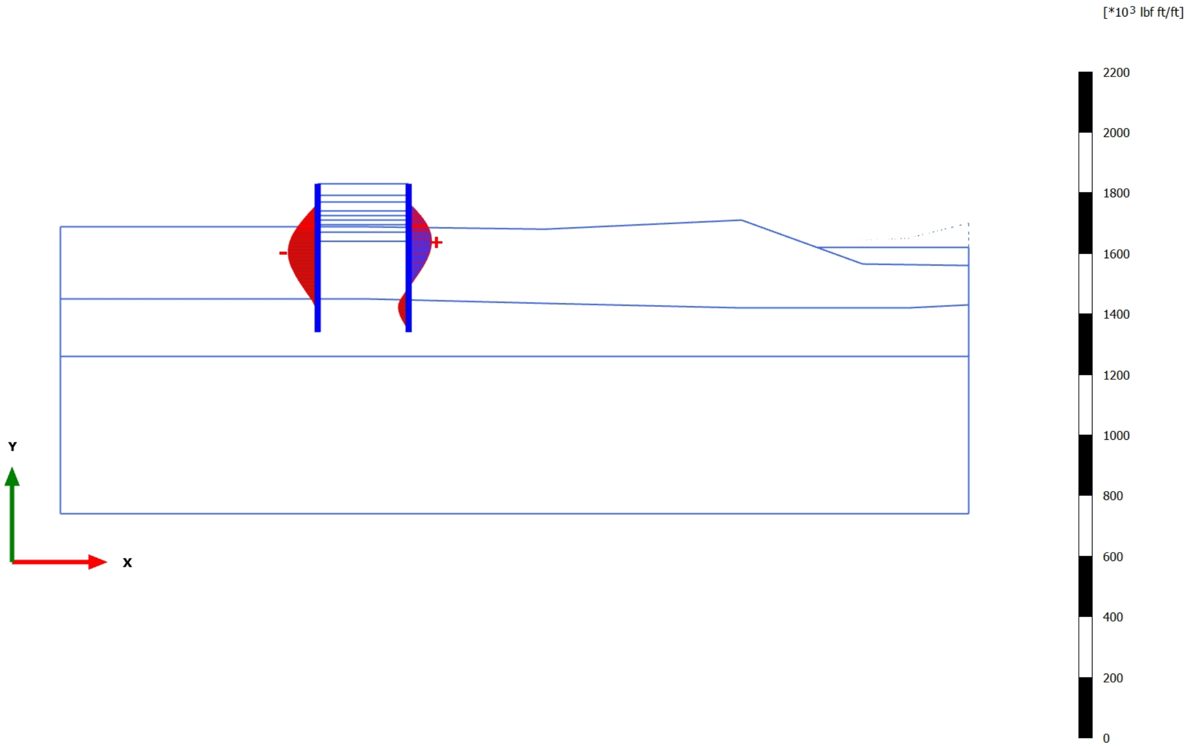


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 75.63*10^3 lbf ft/ft (Element 22 at Node 5577)

Minimum value = -97.38*10^3 lbf ft/ft (Element 23 at Node 4604)

3.1.2.2.10 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/134), Bending moments M

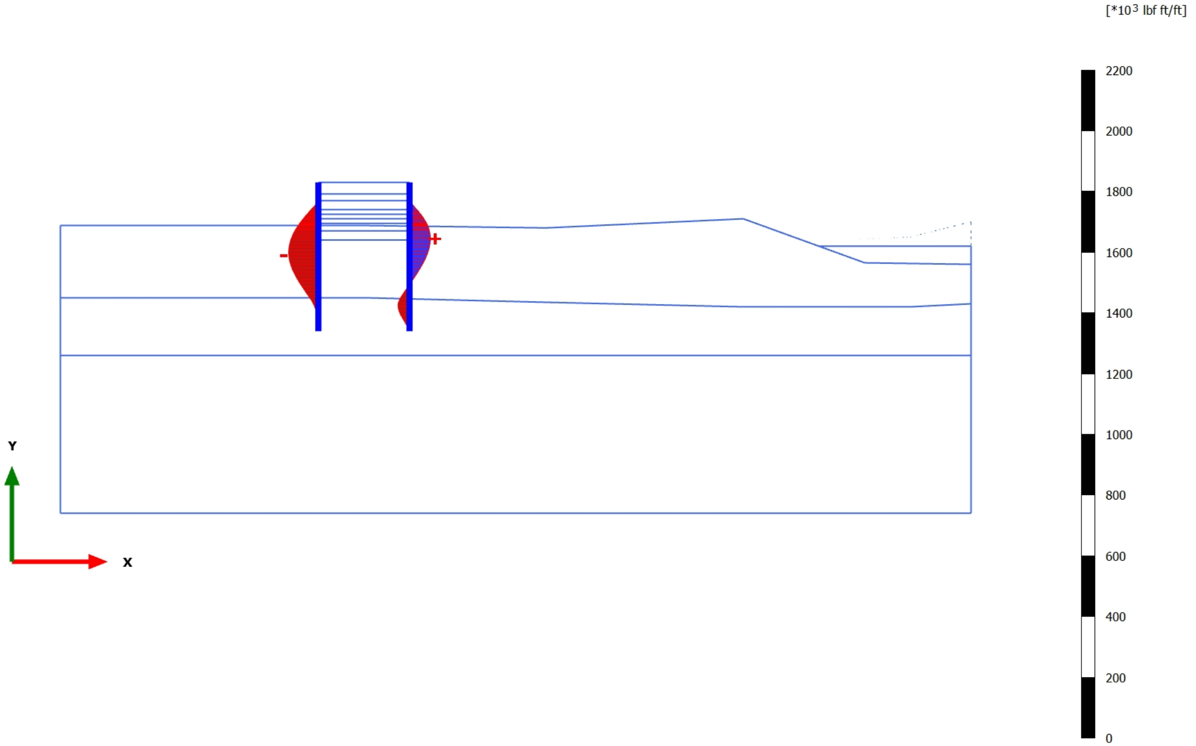


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 75.90*10^3 lbf ft/ft (Element 27 at Node 5577)

Minimum value = -97.86*10^3 lbf ft/ft (Element 23 at Node 4604)

3.1.2.2.11 Calculation results, Plate, Consolidate [Phase_20] (20/150), Bending moments M

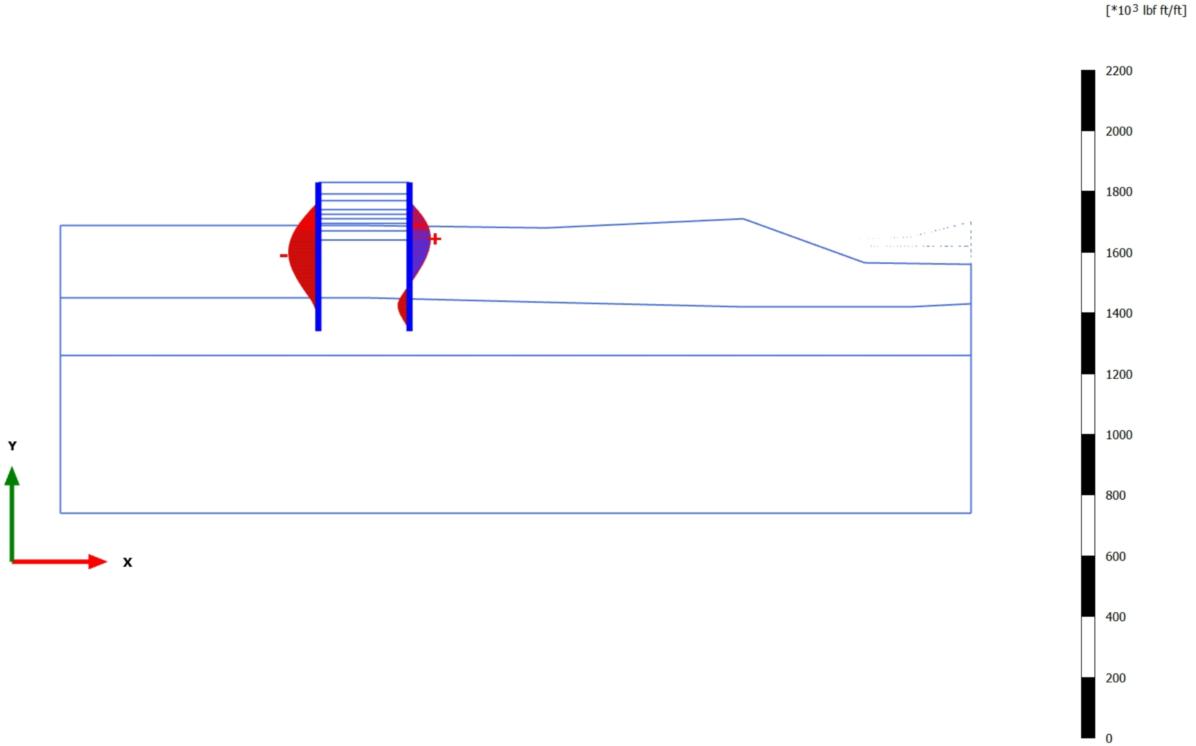


Bending moments M (scaled up $0.100*10^{-3}$ times) (Time 37.00 day)

Maximum value = $68.90*10^{3}$ lbf ft/ft (Element 22 at Node 4946)

Minimum value = $-98.01*10^{3}$ lbf ft/ft (Element 23 at Node 4823)

3.1.2.2.12 Calculation results, Plate, Excavate 2 [Phase_21] (21/154), Bending moments M

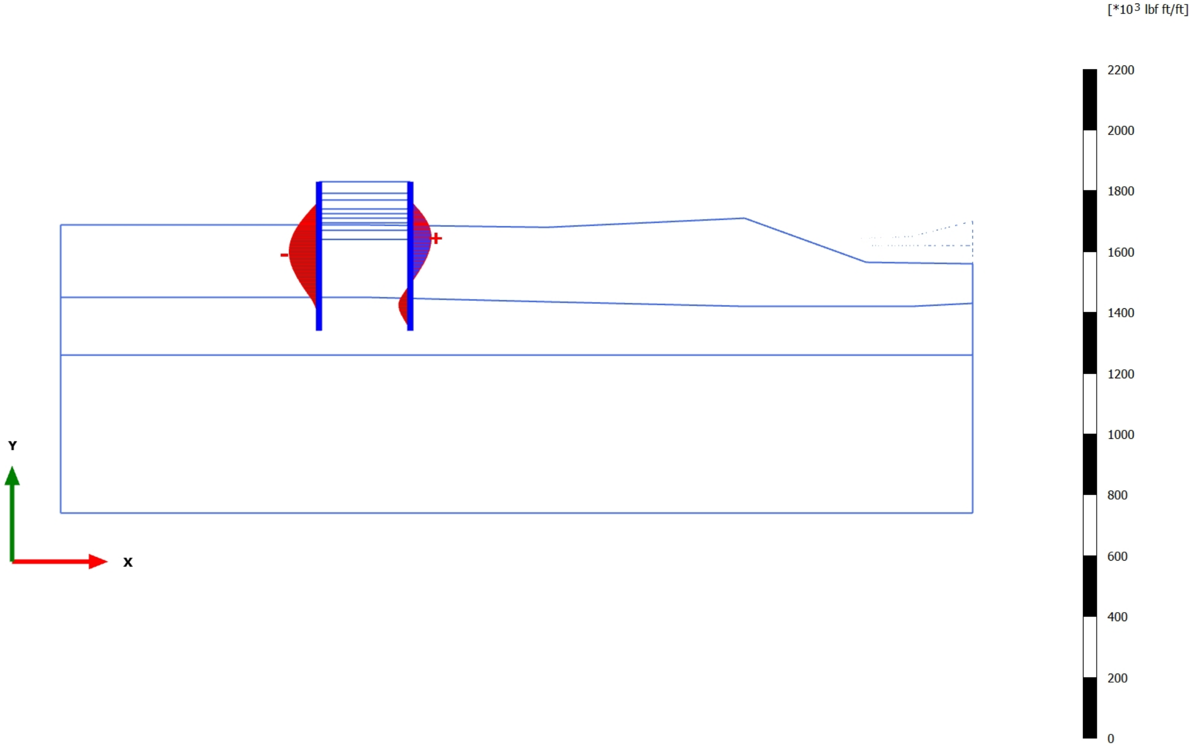


Bending moments M (scaled up $0.100*10^{-3}$ times)

Maximum value = $69.01*10^3$ lbf ft/ft (Element 22 at Node 4946)

Minimum value = $-98.13*10^3$ lbf ft/ft (Element 24 at Node 4823)

3.1.2.2.13 Calculation results, Plate, Consolidate [Phase_7] (7/178), Bending moments M

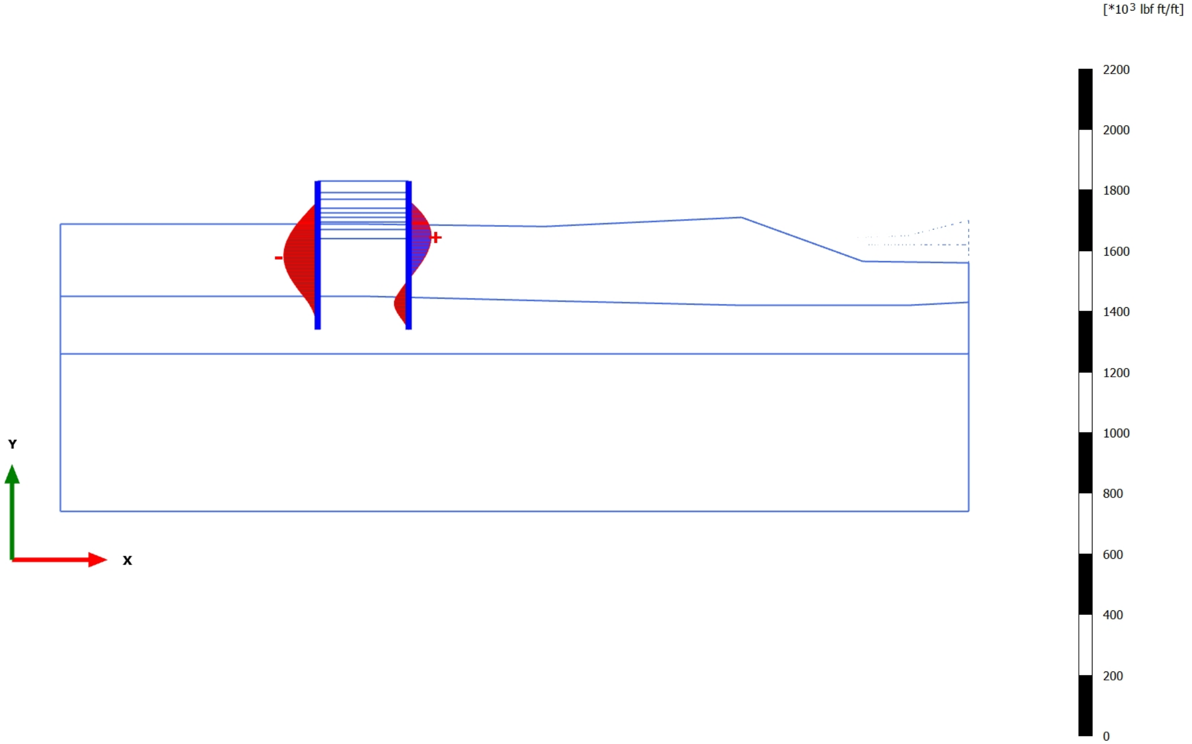


Bending moments M (scaled up 0.100*10^{-3} times) (Time 51.00 day)

Maximum value = 69.01*10^{3} lbf ft/ft (Element 22 at Node 4946)

Minimum value = -98.13*10^{3} lbf ft/ft (Element 24 at Node 4823)

3.1.2.2.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/188), Bending moments M



Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 74.73*10^{3} lbf ft/ft (Element 22 at Node 4946)

Minimum value = -112.3*10^{3} lbf ft/ft (Element 24 at Node 4824)

3.2.1.1.3 Calculation results, Node-to-node anchor, Consolidate [Phase_25] (25/63), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	-220.246	-220.246	39.821
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	-220.246	-220.246	39.821

3.2.1.1.4 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/76), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	19.787	-220.246	19.787
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	19.787	-220.246	19.787

3.2.1.1.5 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/85), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	54.668	-220.246	54.668
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	54.668	-220.246	54.668

3.2.1.1.6 Calculation results, Node-to-node anchor, Consolidate [Phase_26] (26/101), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	51.478	-220.246	54.668
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	51.478	-220.246	54.668

3.2.1.1.7 Calculation results, Node-to-node anchor, Dewater-ss [Phase_16] (16/116), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	117.881	-220.246	117.881
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	117.881	-220.246	117.881

3.2.1.1.8 Calculation results, Node-to-node anchor, Consolidate [Phase_17] (17/128), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	115.800	-220.246	118.164
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	115.800	-220.246	118.164

3.2.1.1.9 Calculation results, Node-to-node anchor, Excavate 1 [Phase_18] (18/131), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	115.918	-220.246	118.164
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	115.918	-220.246	118.164

3.2.1.1.10 Calculation results, Node-to-node anchor, Dewater 2 - ss [Phase_19] (19/134), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	116.224	-220.246	118.164
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	116.224	-220.246	118.164

3.2.1.1.11 Calculation results, Node-to-node anchor, Consolidate [Phase_20] (20/150), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	111.236	-220.246	118.164
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	111.236	-220.246	118.164

3.2.1.1.12 Calculation results, Node-to-node anchor, Excavate 2 [Phase_21] (21/154), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	111.329	-220.246	118.164
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	111.329	-220.246	118.164

3.2.1.1.13 Calculation results, Node-to-node anchor, Consolidate [Phase_7] (7/178), Table of node-to-node anchors

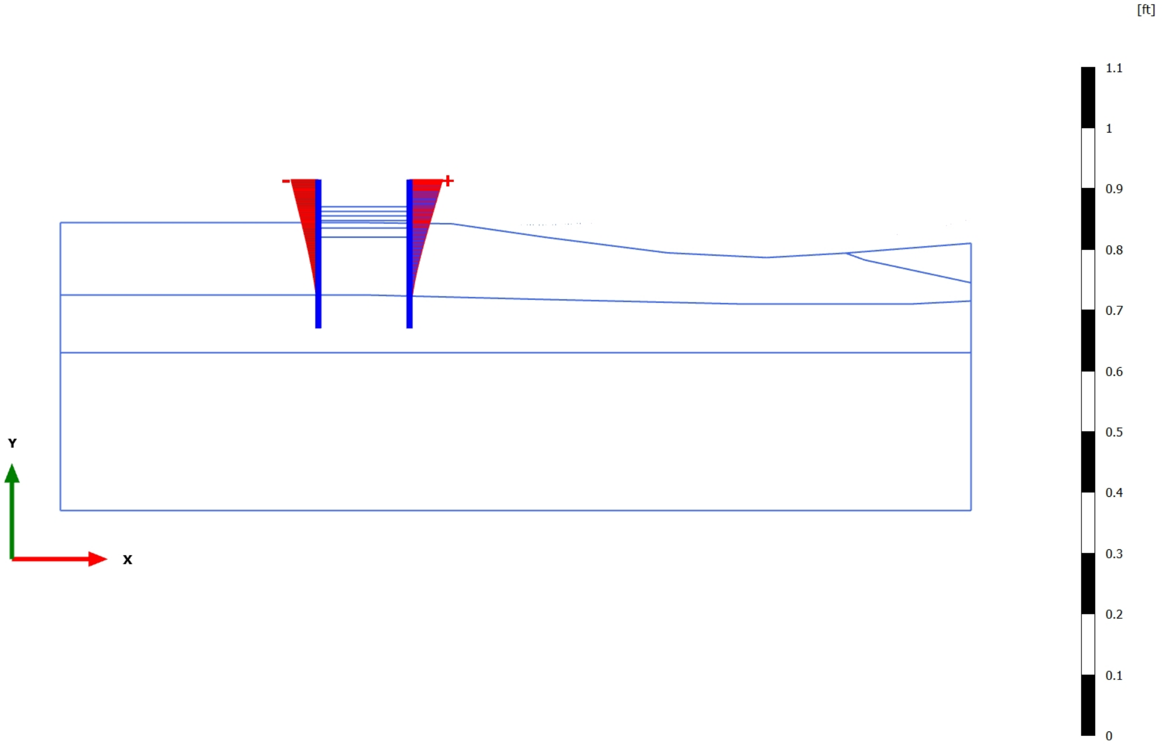
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	111.326	-220.246	118.164
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	111.326	-220.246	118.164

3.2.1.1.14 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_22] (22/188), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	13	1	-15.000	3.000	131.277	-220.246	131.277
Element 2-2 (Node-to-node anchor)	411	2	15.000	3.000	131.277	-220.246	131.277

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 2 [Phase_3] (3/17), Total displacements u_x

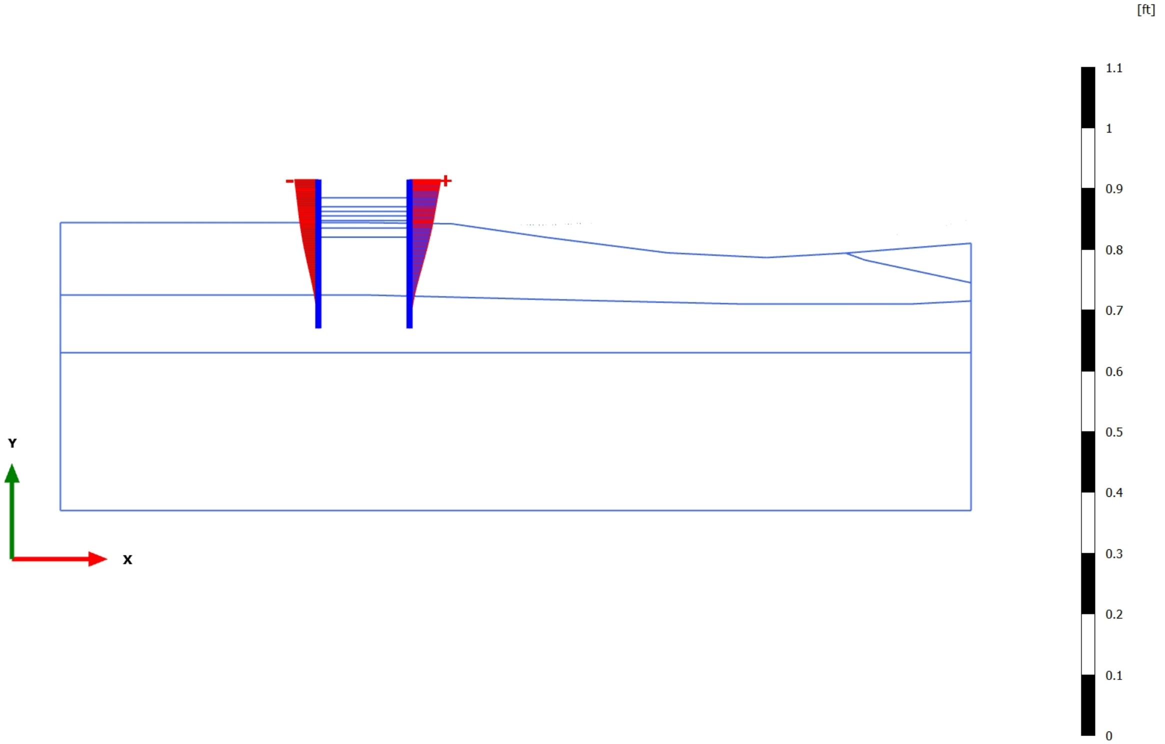


Total displacements u_x (scaled up 200 times)

Maximum value = 0.05490 ft (Element 2 at Node 637)

Minimum value = -0.04539 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/39), Total displacements u_x

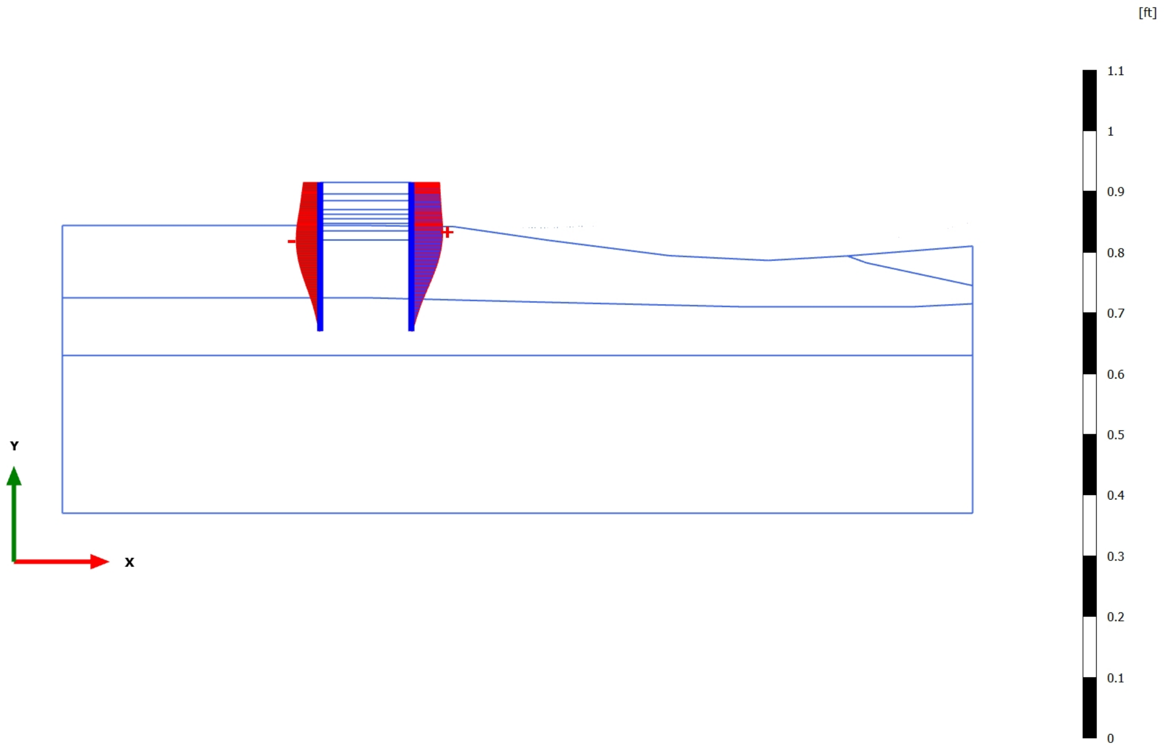


Total displacements u_x (scaled up 200 times)

Maximum value = 0.05172 ft (Element 2 at Node 637)

Minimum value = -0.03919 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/59), Total displacements u_x

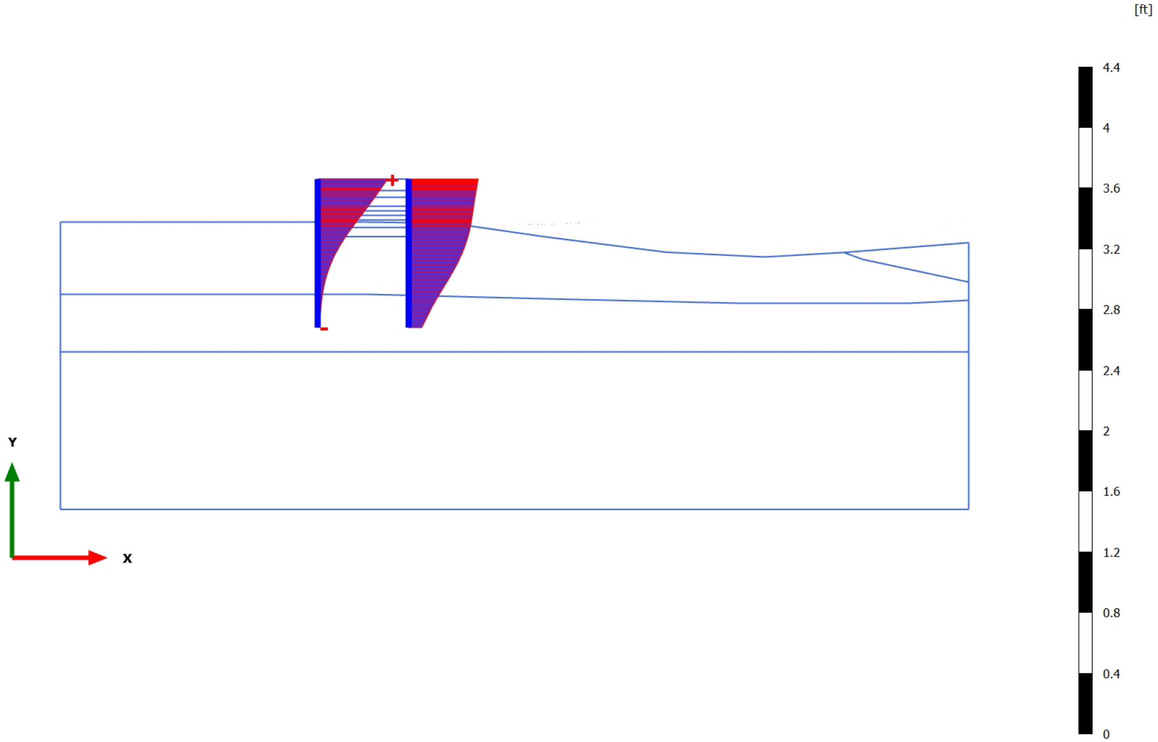


Total displacements u_x (scaled up 200 times)

Maximum value = 0.05176 ft (Element 20 at Node 7417)

Minimum value = -0.03979 ft (Element 21 at Node 6099)

3.1.1.1.1.4 Calculation results, Plate, Dewater 2 [Phase_19] (19/70), Total displacements u_x

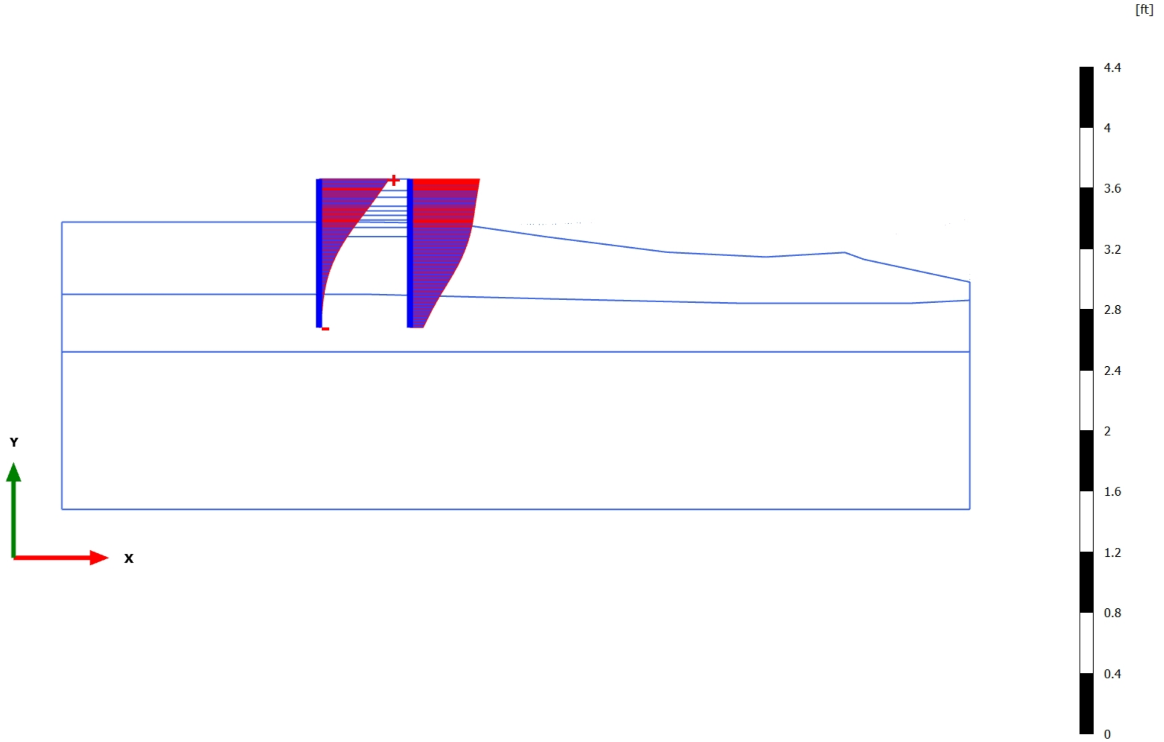


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4631 ft (Element 1 at Node 4)

Minimum value = 0.01092 ft (Element 37 at Node 11267)

3.1.1.1.1.5 Calculation results, Plate, Excavate 2 [Phase_21] (21/73), Total displacements u_x

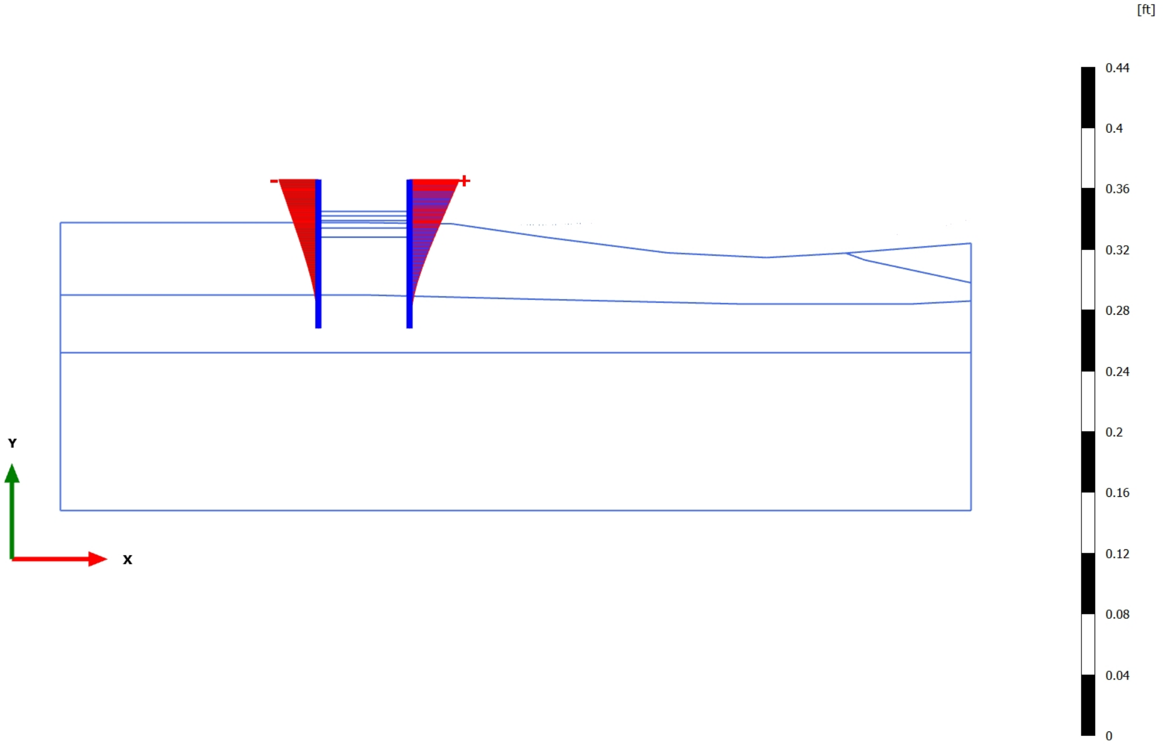


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4639 ft (Element 1 at Node 4)

Minimum value = 0.01119 ft (Element 37 at Node 11267)

3.1.1.1.1.6 Calculation results, Plate, Backfill 1 [Phase_2] (2/121), Total displacements u_x

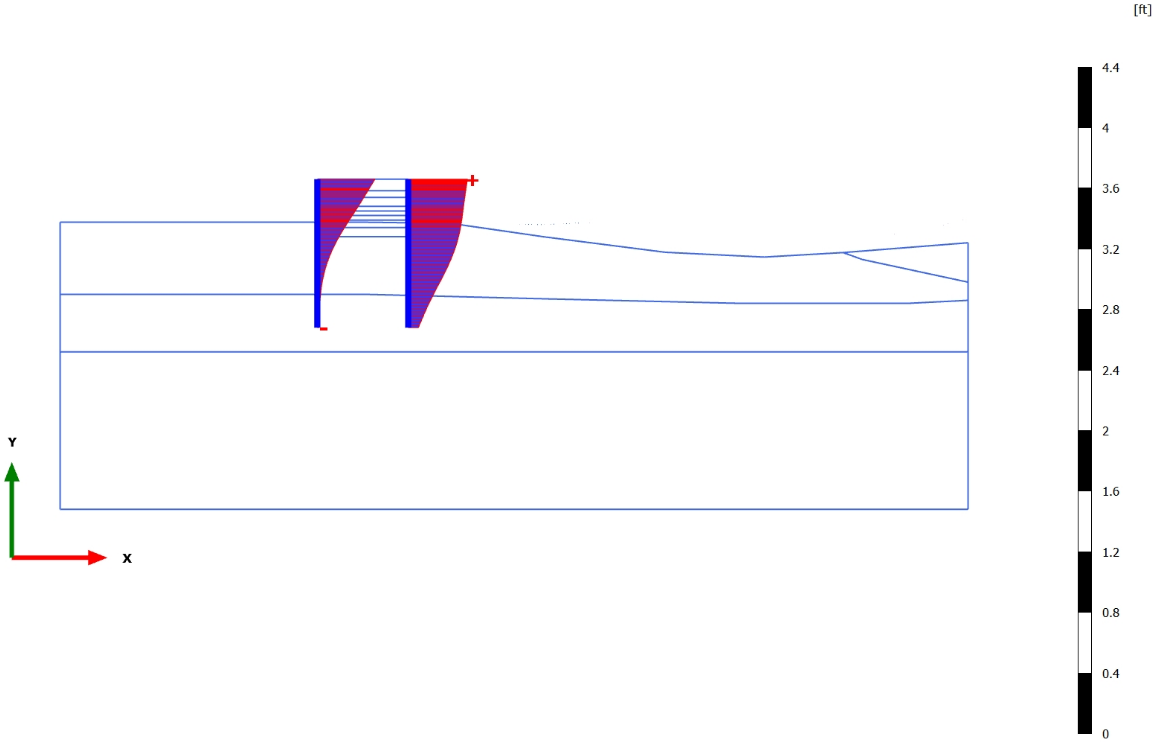


Total displacements u_x (scaled up 500 times)

Maximum value = 0.03290 ft (Element 2 at Node 637)

Minimum value = -0.02616 ft (Element 1 at Node 4)

3.1.1.1.1.7 Calculation results, Plate, Dewater [Phase_16] (16/165), Total displacements u_x

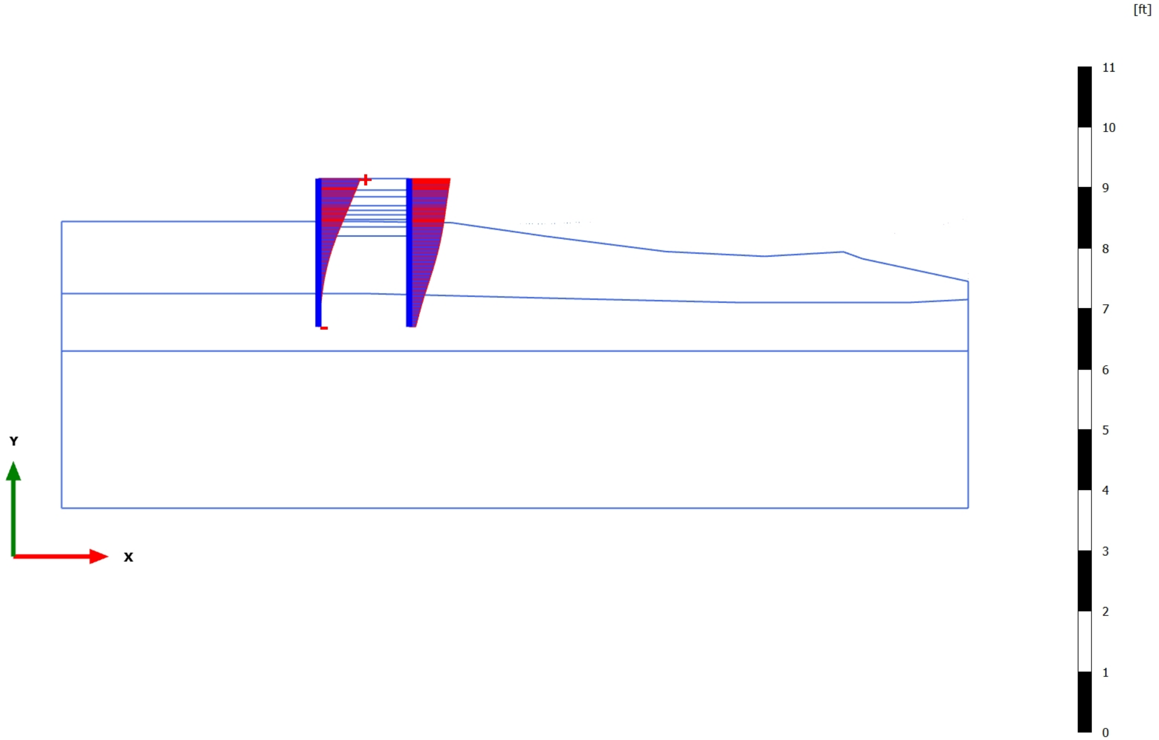


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3917 ft (Element 2 at Node 637)

Minimum value = 9.655×10^{-3} ft (Element 37 at Node 11267)

3.1.1.1.1.8 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/186), Total displacements u_x

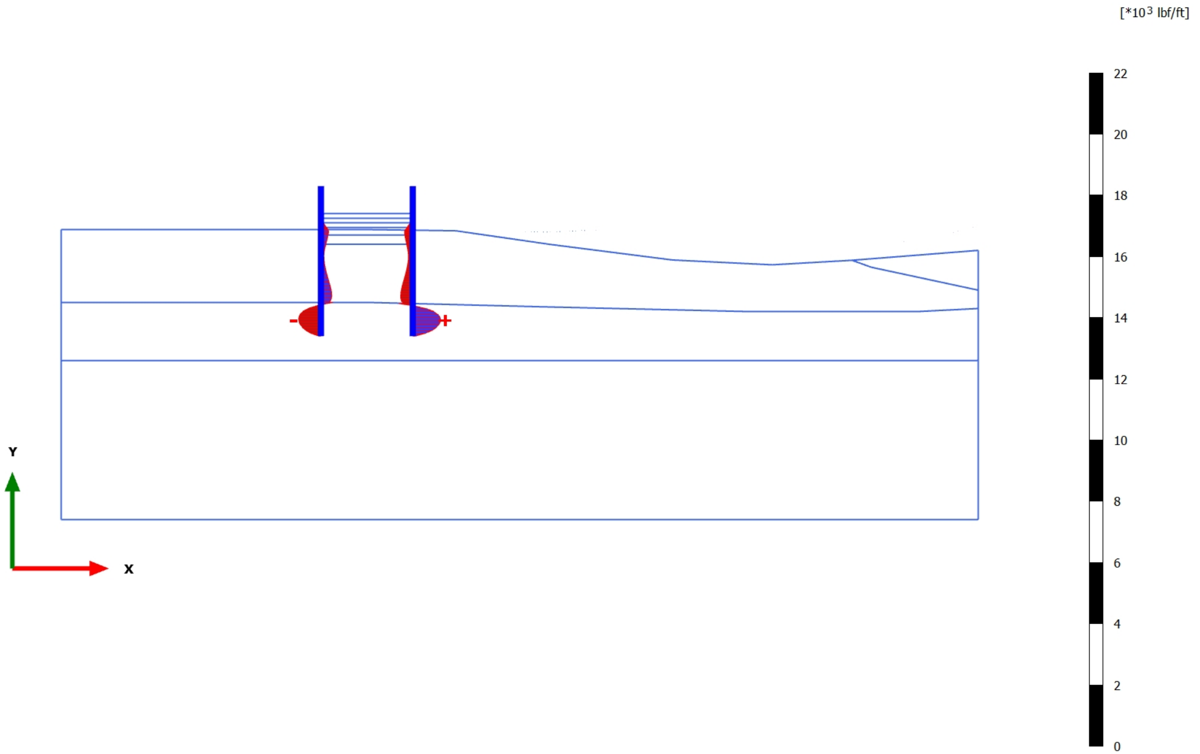


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.6971 ft (Element 1 at Node 4)

Minimum value = 0.01239 ft (Element 37 at Node 11267)

3.1.2.1.1 Calculation results, Plate, Backfill 2 [Phase_3] (3/17), Shear forces Q

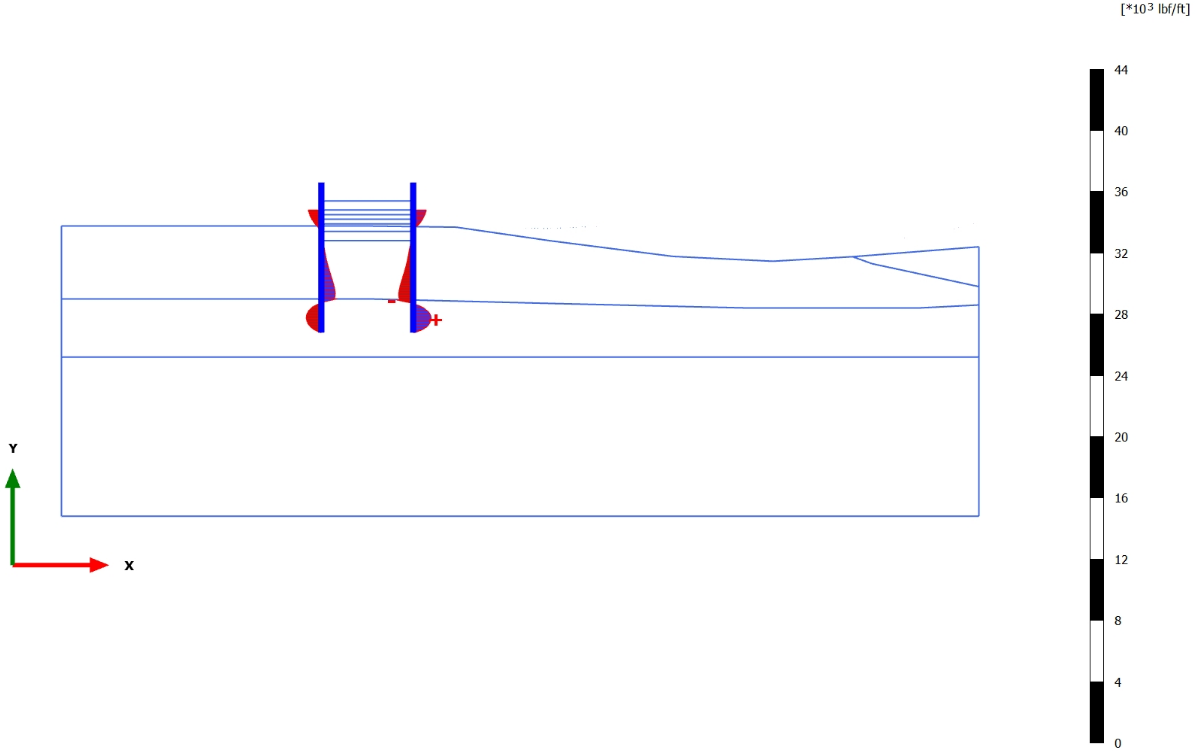


Shear forces Q (scaled up 0.0100 times)

Maximum value = 915.8 lbf/ft (Element 39 at Node 12896)

Minimum value = -733.0 lbf/ft (Element 36 at Node 10717)

3.1.2.1.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/39), Shear forces Q

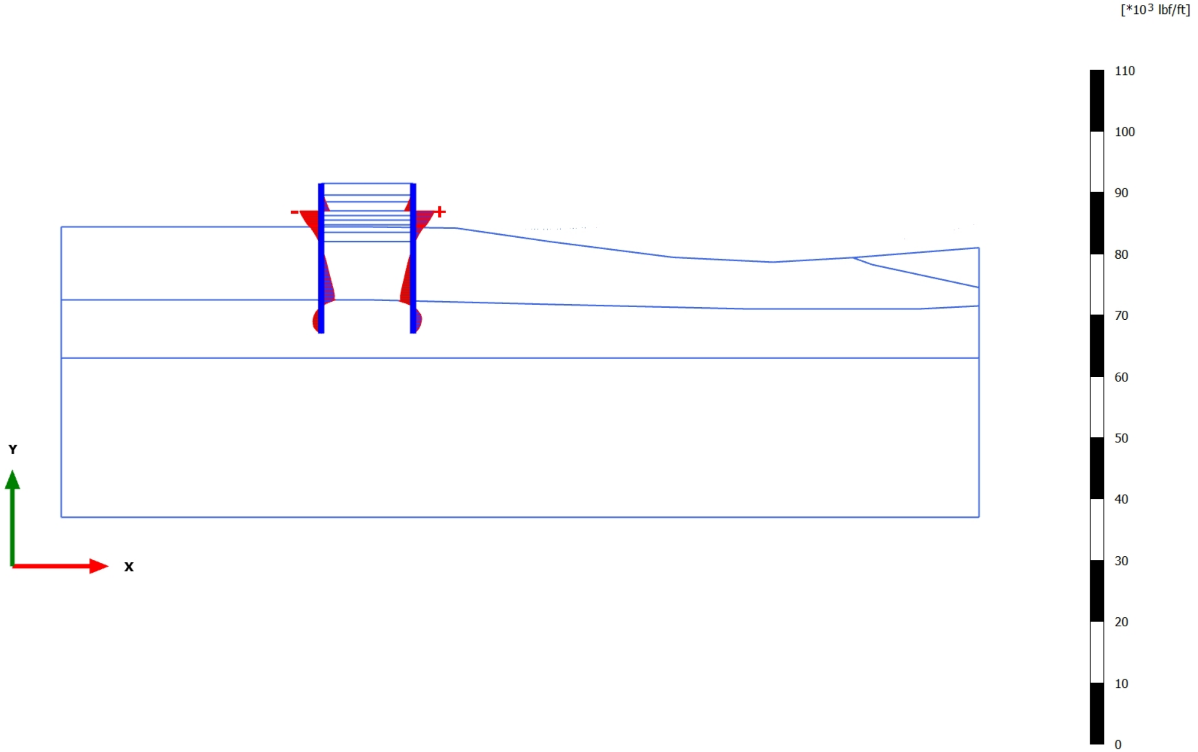


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 1182 lbf/ft (Element 39 at Node 12897)

Minimum value = -1093 lbf/ft (Element 38 at Node 12170)

3.1.2.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/59), Shear forces Q

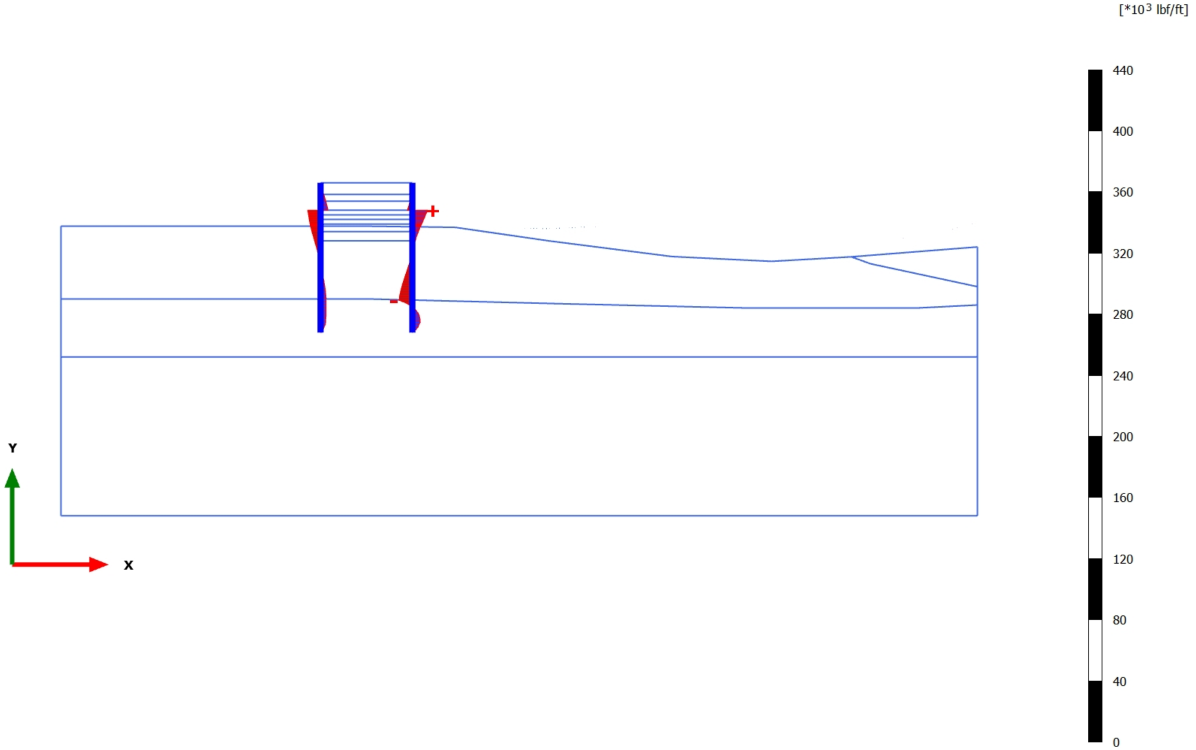


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 3533 lbf/ft (Element 12 at Node 1141)

Minimum value = -3541 lbf/ft (Element 11 at Node 18)

3.1.2.1.4 Calculation results, Plate, Dewater 2 [Phase_19] (19/70), Shear forces Q

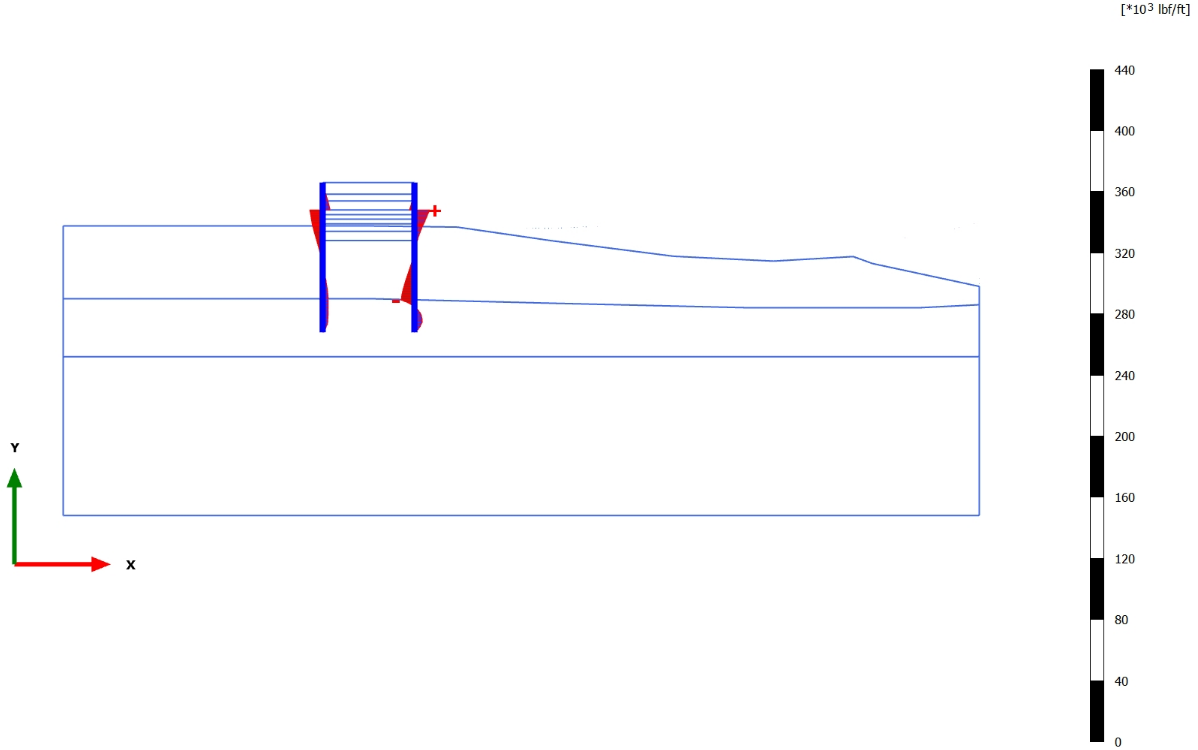


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.08*10^3$ lbf/ft (Element 12 at Node 1141)

Minimum value = -9094 lbf/ft (Element 38 at Node 12170)

3.1.2.1.5 Calculation results, Plate, Excavate 2 [Phase_21] (21/73), Shear forces Q

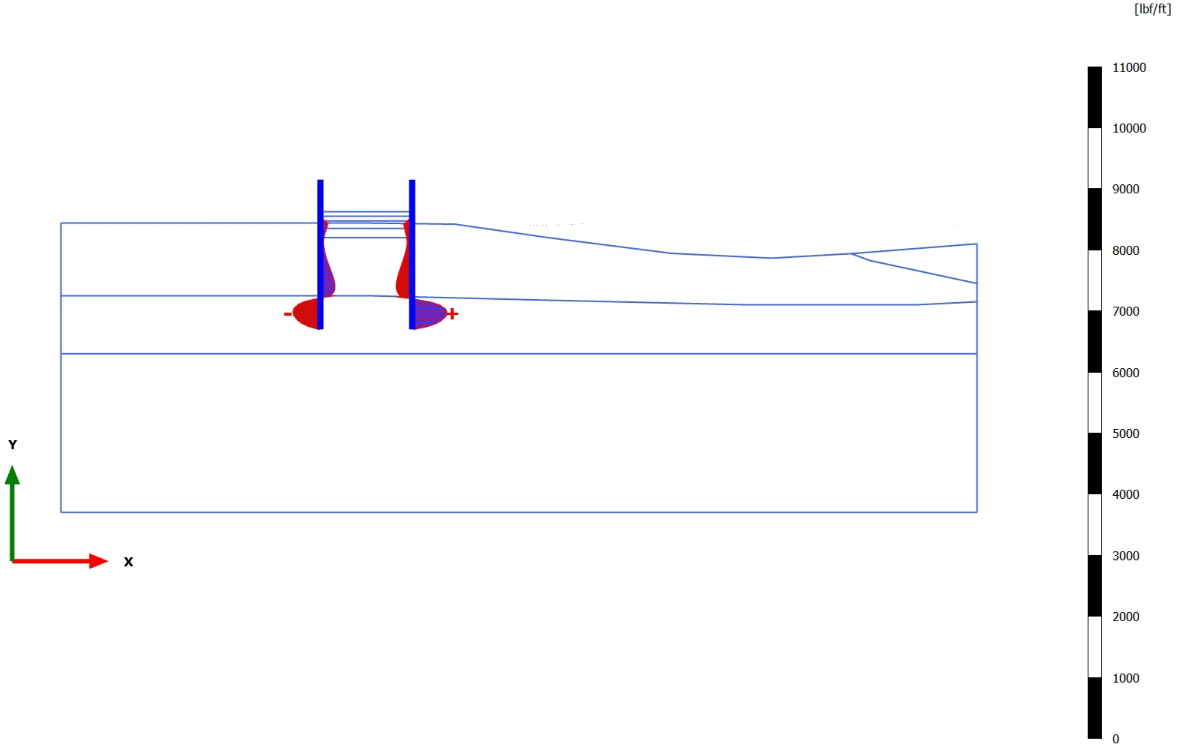


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.09*10^3$ lbf/ft (Element 12 at Node 1141)

Minimum value = -9091 lbf/ft (Element 38 at Node 12170)

3.1.2.1.6 Calculation results, Plate, Backfill 1 [Phase_2] (2/121), Shear forces Q

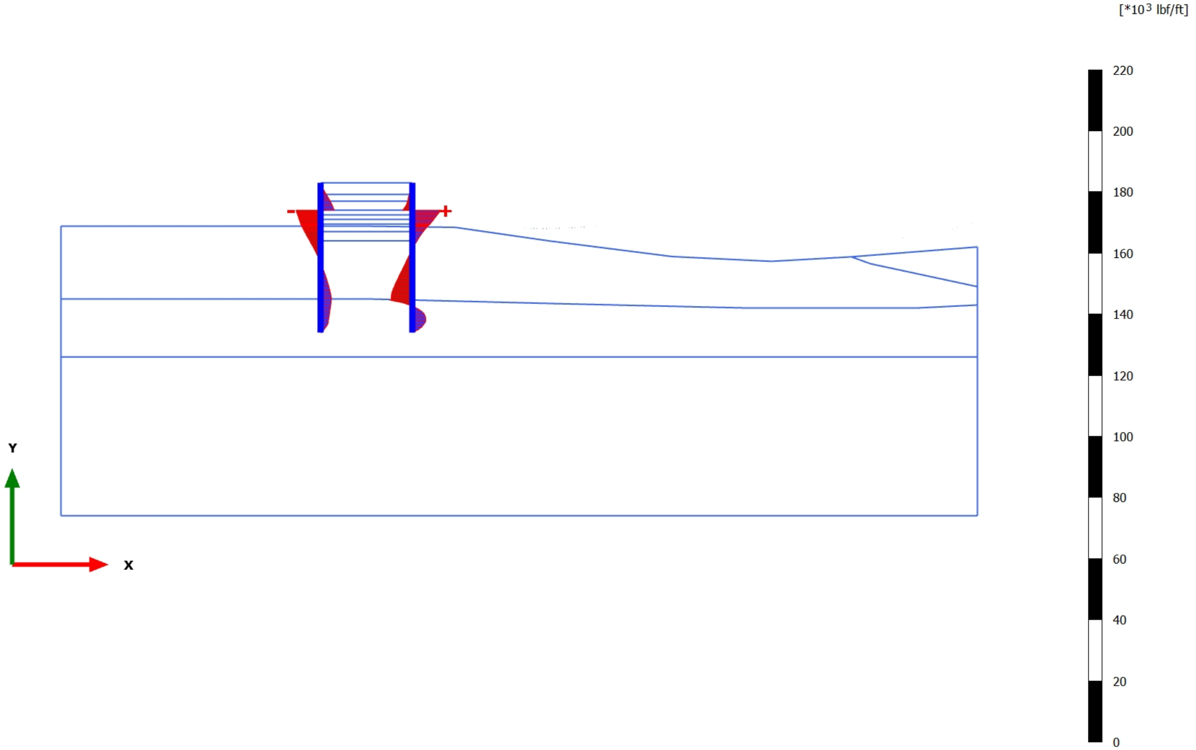


Shear forces Q (scaled up 0.0200 times)

Maximum value = 576.0 lbf/ft (Element 39 at Node 12896)

Minimum value = -451.7 lbf/ft (Element 36 at Node 10717)

3.1.2.1.7 Calculation results, Plate, Dewater [Phase_16] (16/165), Shear forces Q

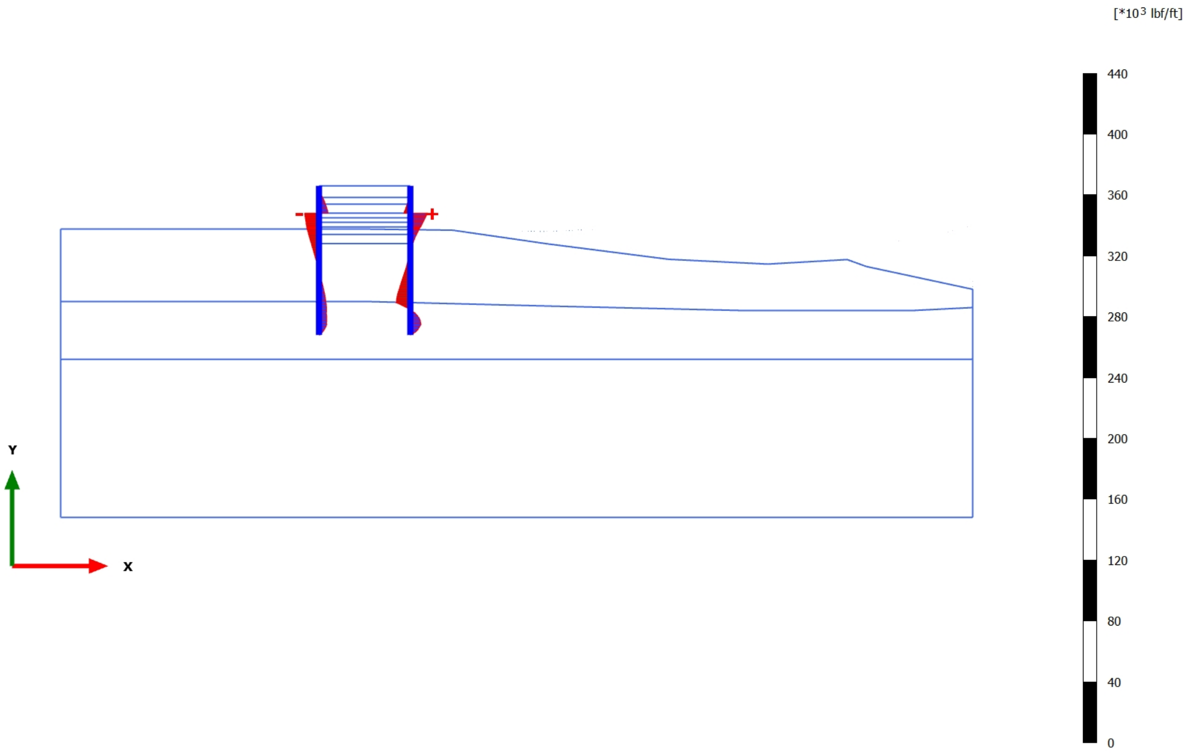


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 9446 lbf/ft (Element 12 at Node 1141)

Minimum value = -8113 lbf/ft (Element 11 at Node 18)

3.1.2.1.8 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/186), Shear forces Q

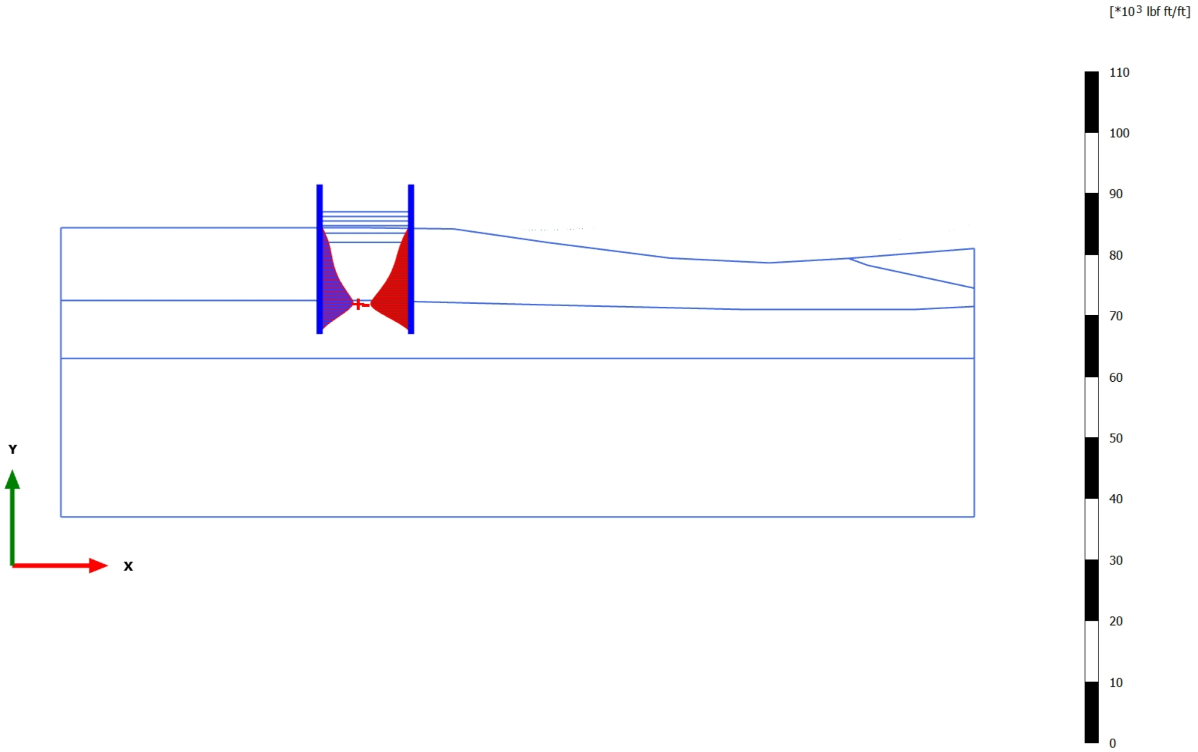


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.27*10^3$ lbf/ft (Element 12 at Node 1141)

Minimum value = -9584 lbf/ft (Element 11 at Node 18)

3.1.2.2.1 Calculation results, Plate, Backfill 2 [Phase_3] (3/17), Bending moments M

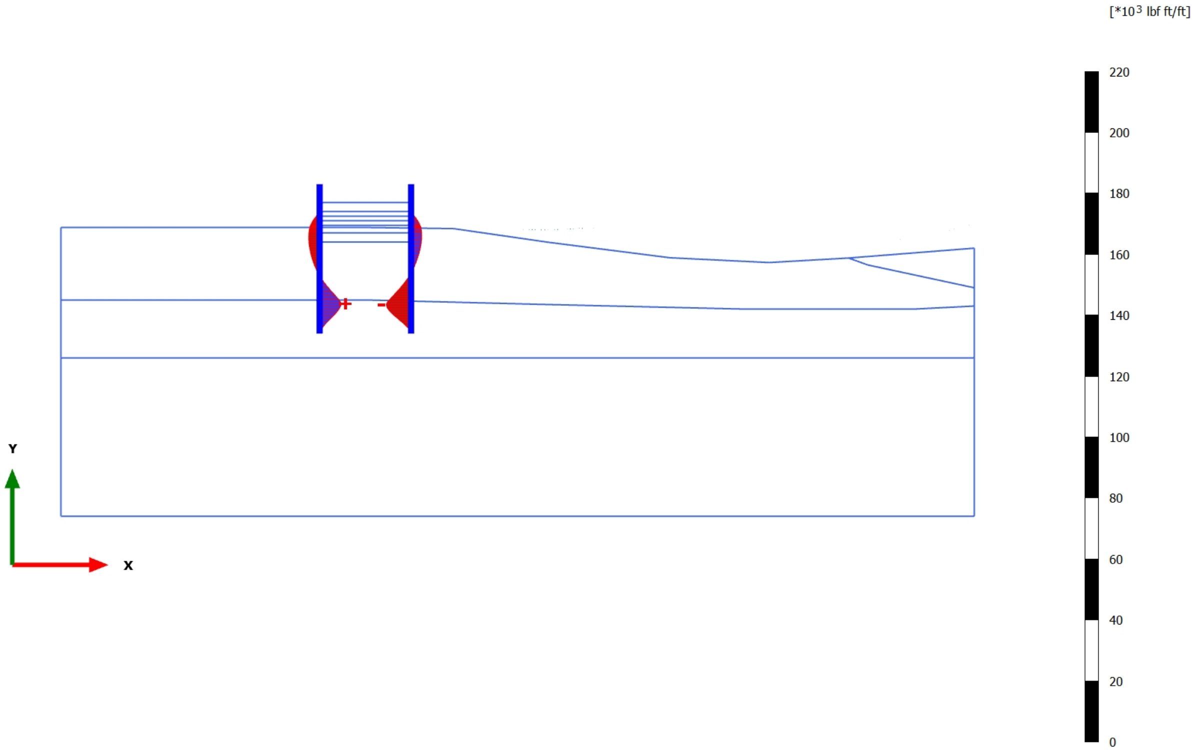


Bending moments M (scaled up $2.00*10^{-3}$ times)

Maximum value = 5526 lbf ft/ft (Element 35 at Node 10016)

Minimum value = -6658 lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/39), Bending moments M

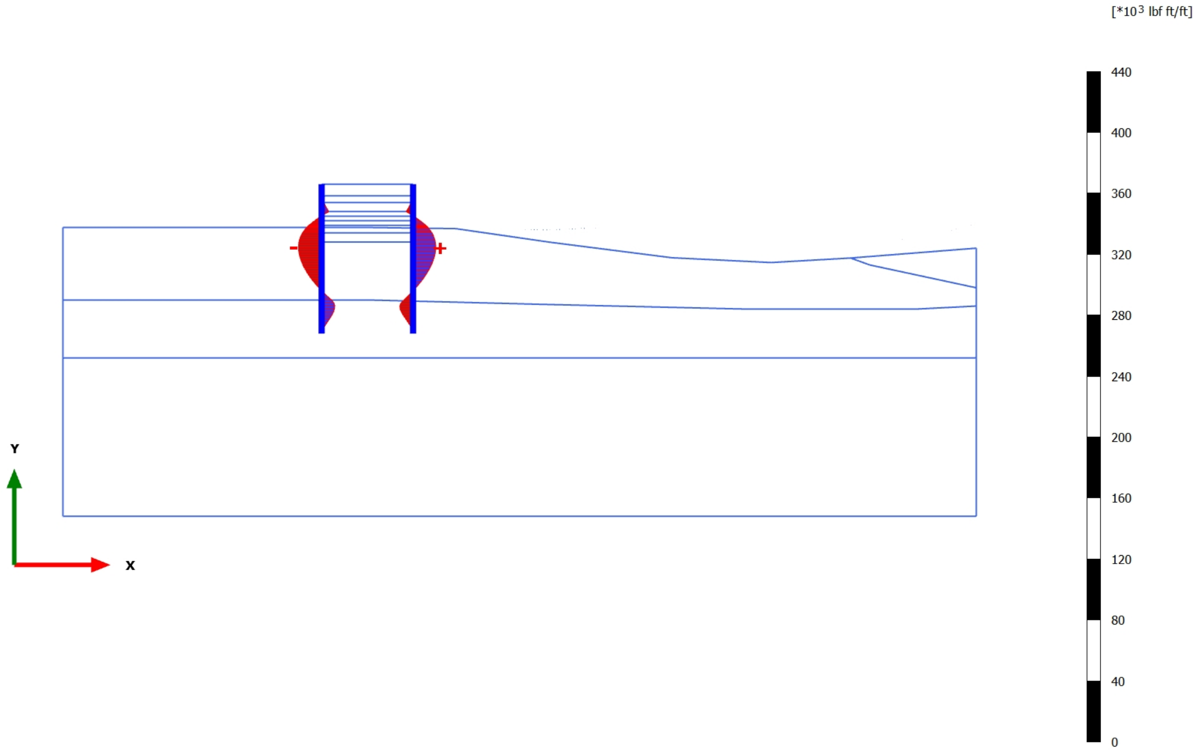


Bending moments M (scaled up $1.00*10^{-3}$ times)

Maximum value = 6974 lbf ft/ft (Element 35 at Node 10016)

Minimum value = -8104 lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/59), Bending moments M

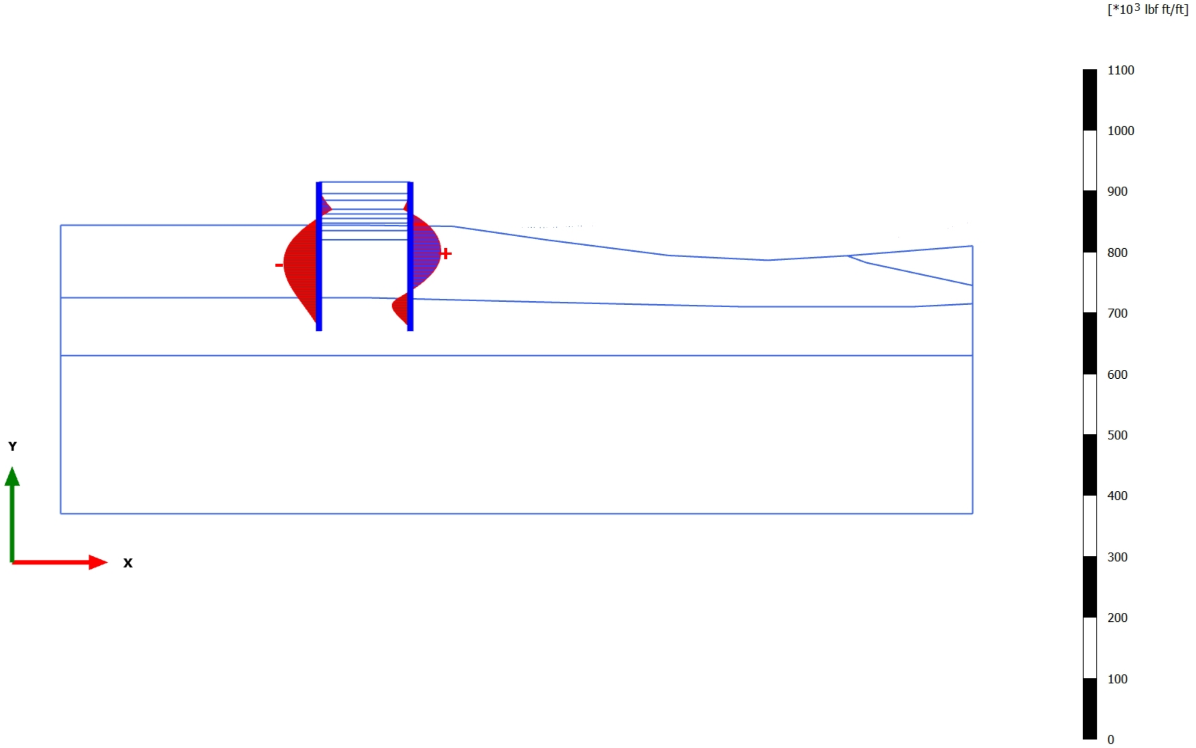


Bending moments M (scaled up 0.500×10^{-3} times)

Maximum value = 14.96×10^{3} lbf ft/ft (Element 29 at Node 8381)

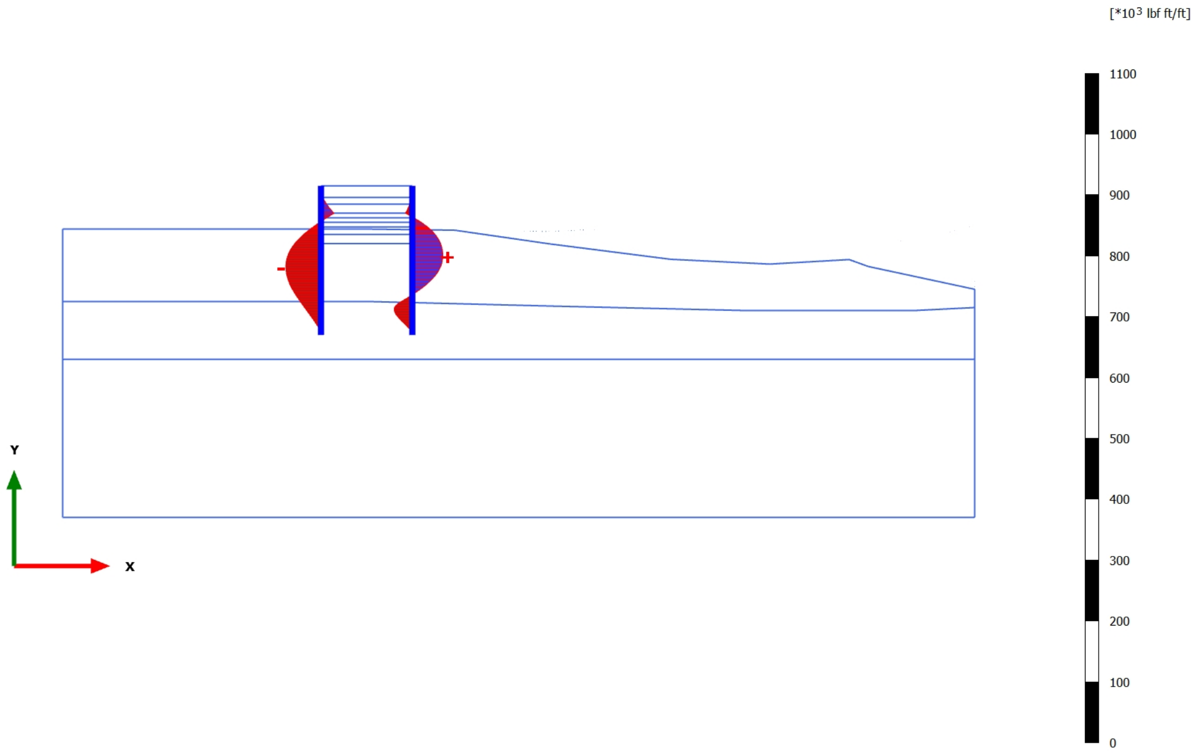
Minimum value = -15.28×10^{3} lbf ft/ft (Element 23 at Node 6101)

3.1.2.2.4 Calculation results, Plate, Dewater 2 [Phase_19] (19/70), Bending moments M



Bending moments M (scaled up 0.200*10^{-3} times)
Maximum value = 50.27*10^{3} lbf ft/ft (Element 30 at Node 8948)
Minimum value = -57.99*10^{3} lbf ft/ft (Element 25 at Node 7513)

3.1.2.2.5 Calculation results, Plate, Excavate 2 [Phase_21] (21/73), Bending moments M

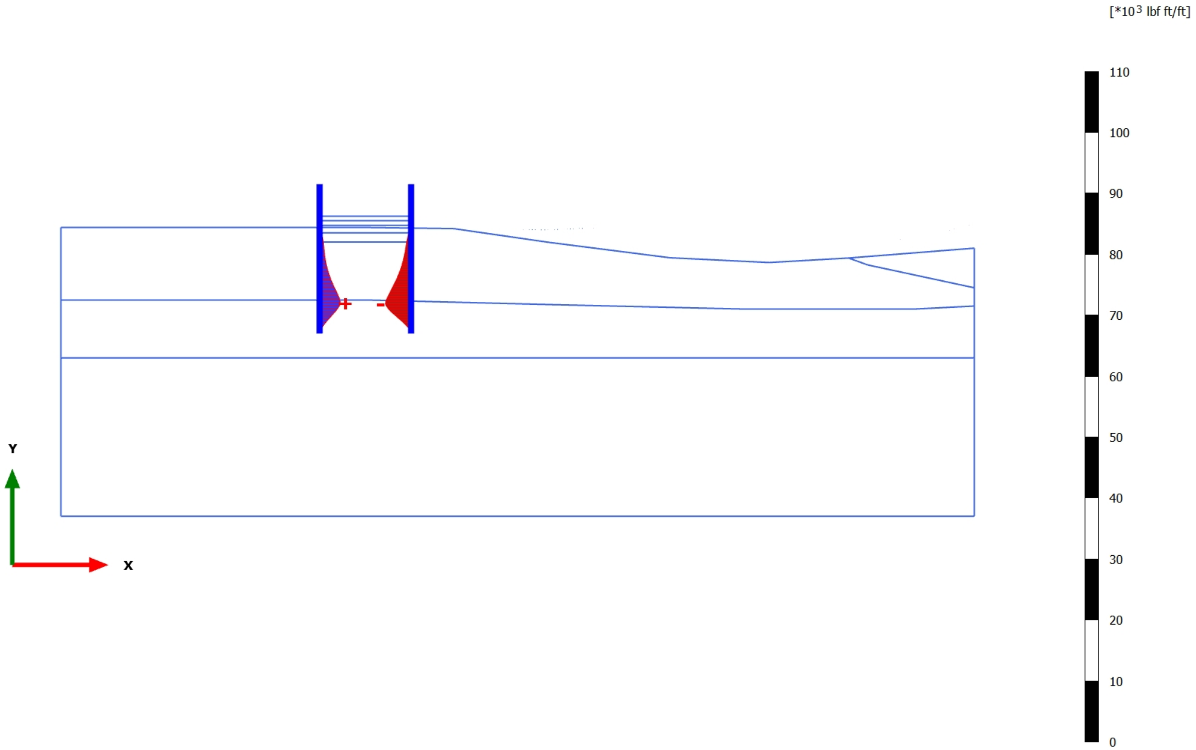


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 50.32*10^3 lbf ft/ft (Element 30 at Node 8948)

Minimum value = -57.96*10^3 lbf ft/ft (Element 25 at Node 7513)

3.1.2.2.6 Calculation results, Plate, Backfill 1 [Phase_2] (2/121), Bending moments M

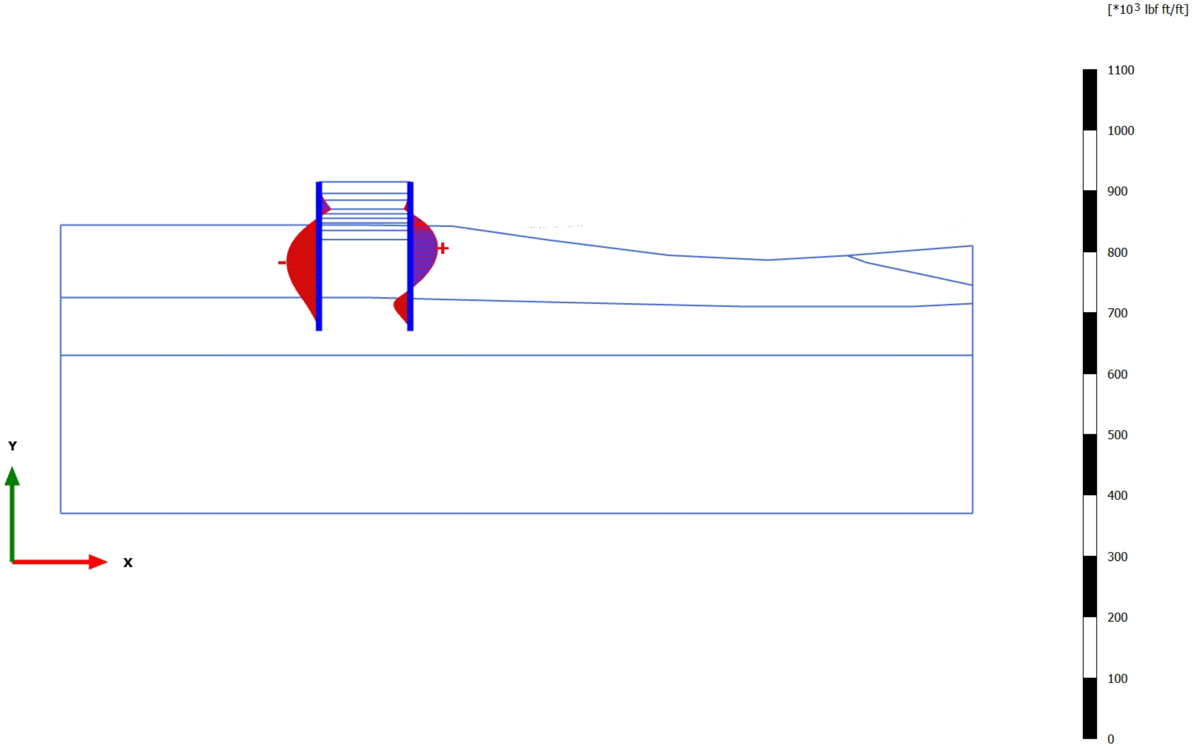


Bending moments M (scaled up 2.00*10^{-3} times)

Maximum value = 3408 lbf ft/ft (Element 35 at Node 10016)

Minimum value = -4204 lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.7 Calculation results, Plate, Dewater [Phase_16] (16/165), Bending moments M

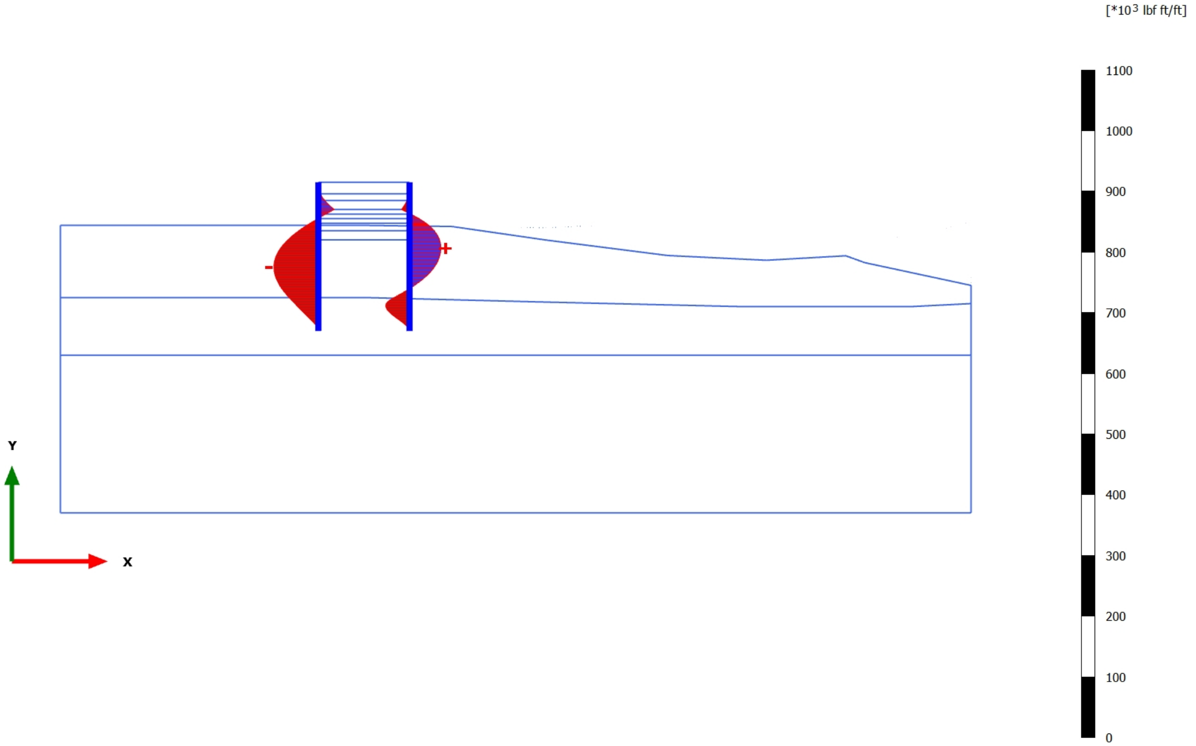


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $45.00*10^3$ lbf ft/ft (Element 29 at Node 8382)

Minimum value = $-53.03*10^3$ lbf ft/ft (Element 25 at Node 7512)

3.1.2.2.8 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/186), Bending moments M



Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 51.80*10^3 lbf ft/ft (Element 29 at Node 8382)

Minimum value = -73.39*10^3 lbf ft/ft (Element 25 at Node 7514)

3.2.1.1.2 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/39), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	5656.977	0.000	5656.977
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	5656.977	0.000	5656.977

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/59), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	29.575	0.000	29.575
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	29.575	0.000	29.575

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater 2 [Phase_19] (19/70), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	80.342	0.000	80.342
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	80.342	0.000	80.342

3.2.1.1.5 Calculation results, Node-to-node anchor, Excavate 2 [Phase_21] (21/73), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	80.334	0.000	80.347
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	80.334	0.000	80.347

3.2.1.1.7 Calculation results, Node-to-node anchor, Dewater [Phase_16] (16/165), Table of node-to-node anchors

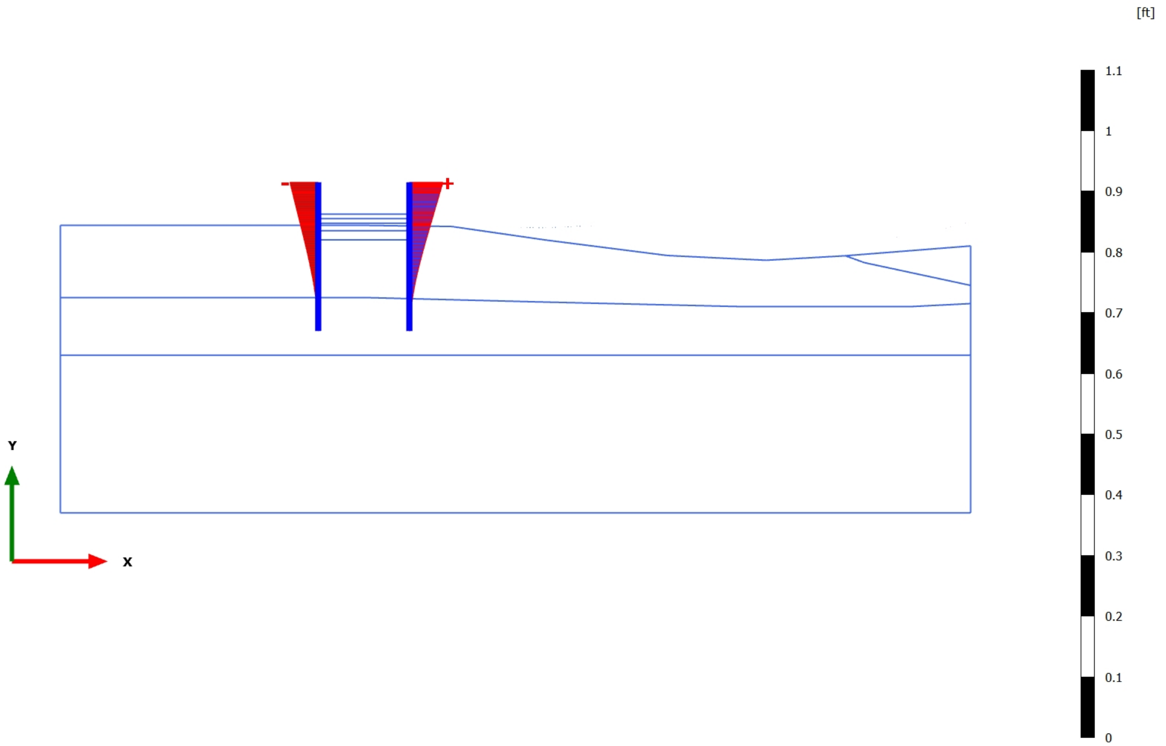
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	75.786	0.000	75.786
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	75.786	0.000	75.786

3.2.1.1.8 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_22] (22/186), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	93.585	0.000	93.585
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	93.585	0.000	93.585

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/28), Total displacements u_x

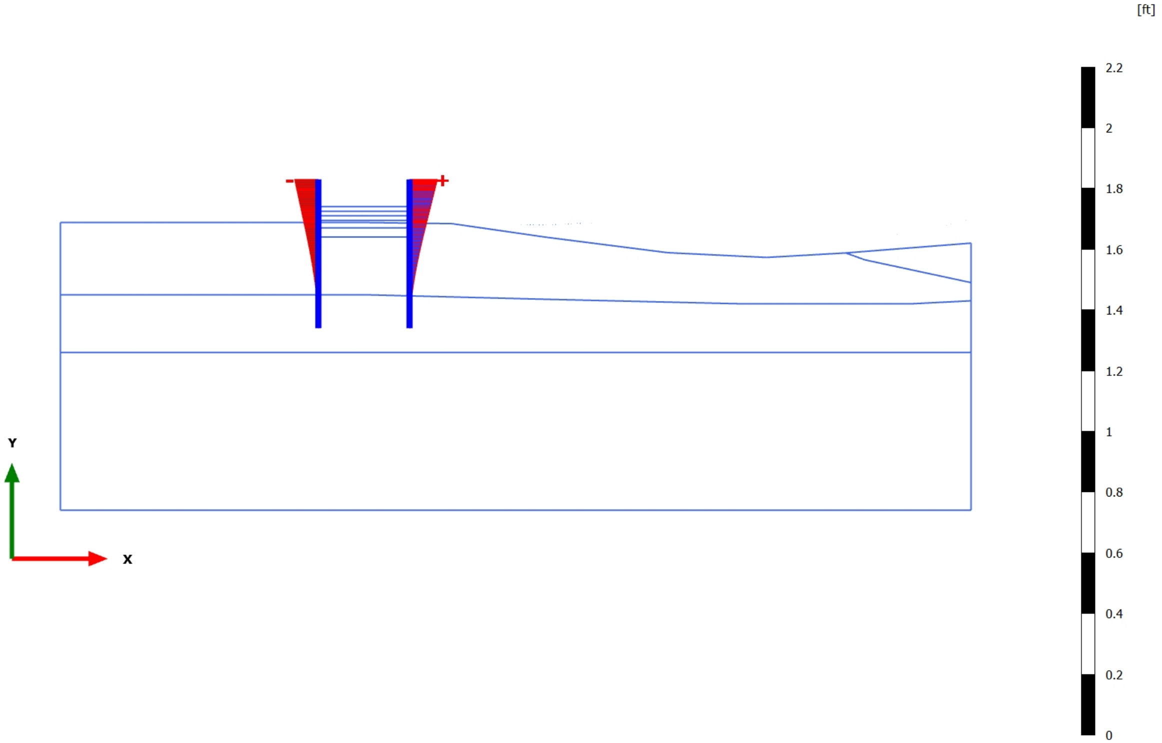


Total displacements u_x (scaled up 200 times)

Maximum value = 0.05564 ft (Element 2 at Node 637)

Minimum value = -0.04692 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/40), Total displacements u_x

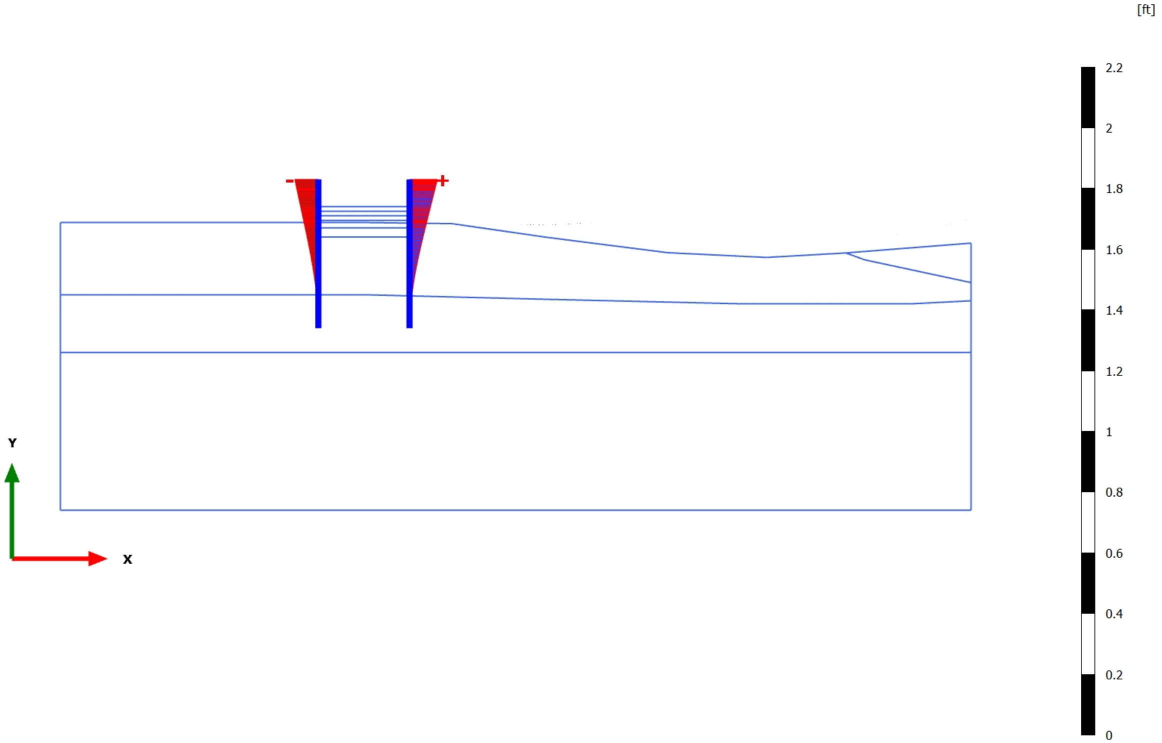


Total displacements u_x (scaled up 100 times)

Maximum value = 0.09222 ft (Element 2 at Node 637)

Minimum value = -0.07856 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Install tie [Phase_8] (4/44), Total displacements u_x

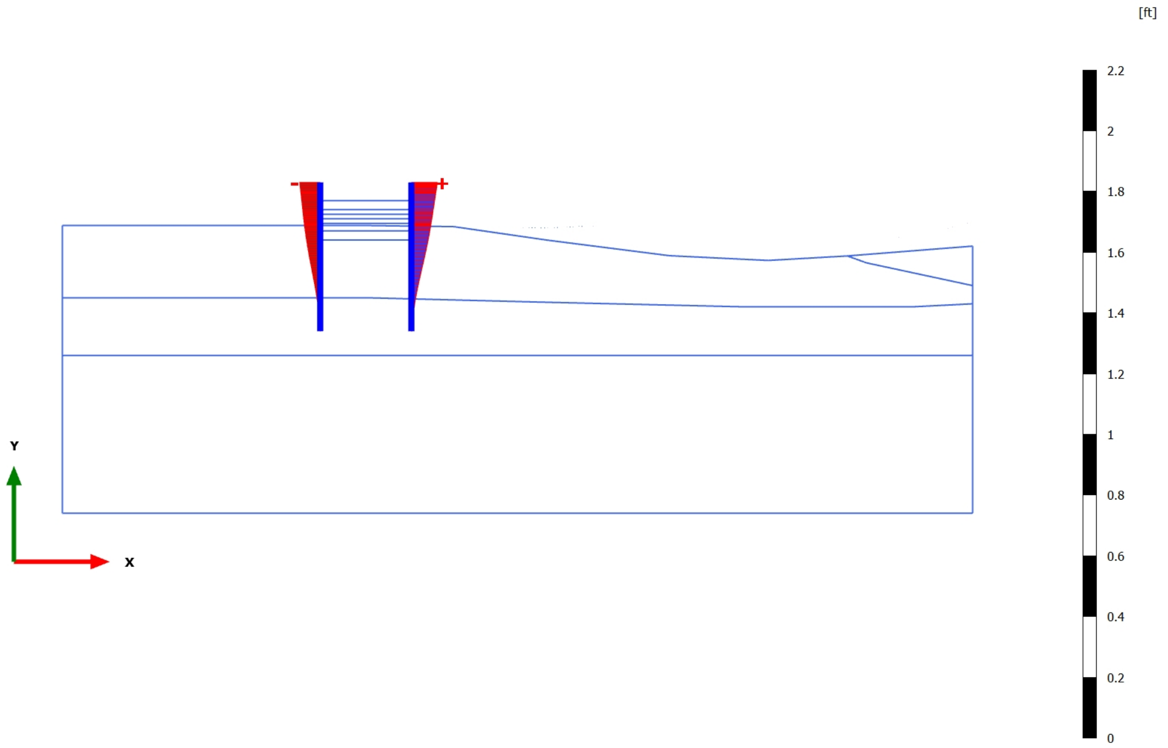


Total displacements u_x (scaled up 100 times)

Maximum value = 0.09218 ft (Element 2 at Node 637)

Minimum value = -0.07800 ft (Element 1 at Node 4)

3.1.1.1.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/52), Total displacements u_x

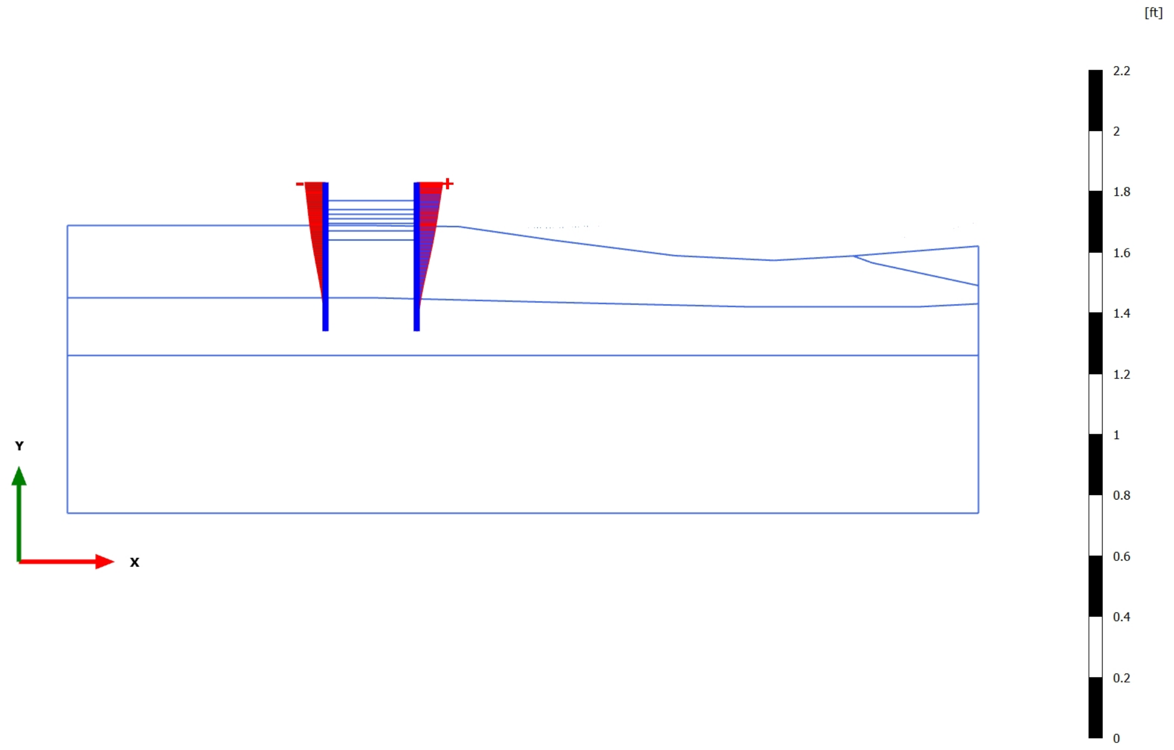


Total displacements u_x (scaled up 100 times)

Maximum value = 0.08622 ft (Element 2 at Node 637)

Minimum value = -0.06787 ft (Element 1 at Node 4)

3.1.1.1.1.5 Calculation results, Plate, Consolidate [Phase_9] (8/63), Total displacements u_x

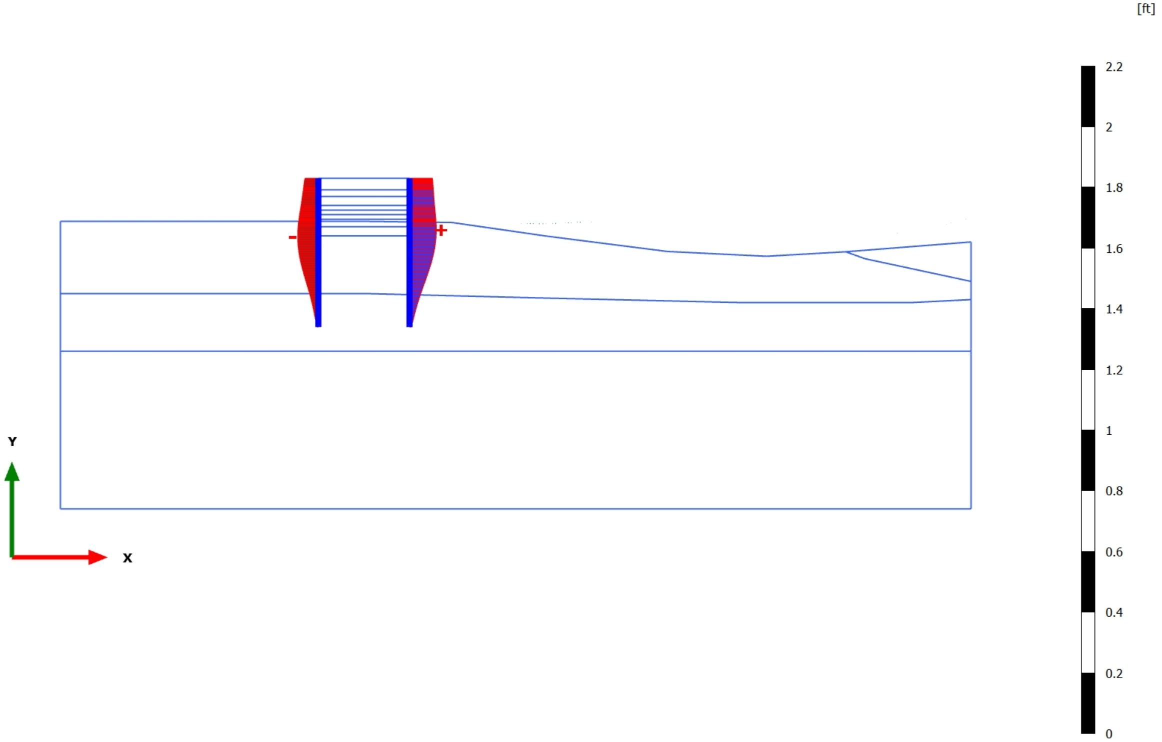


Total displacements u_x (scaled up 100 times) (Time 13.00 day)

Maximum value = 0.08624 ft (Element 2 at Node 637)

Minimum value = -0.06814 ft (Element 1 at Node 4)

3.1.1.1.1.6 Calculation results, Plate, Backfill 4 [Phase_6] (6/74), Total displacements u_x

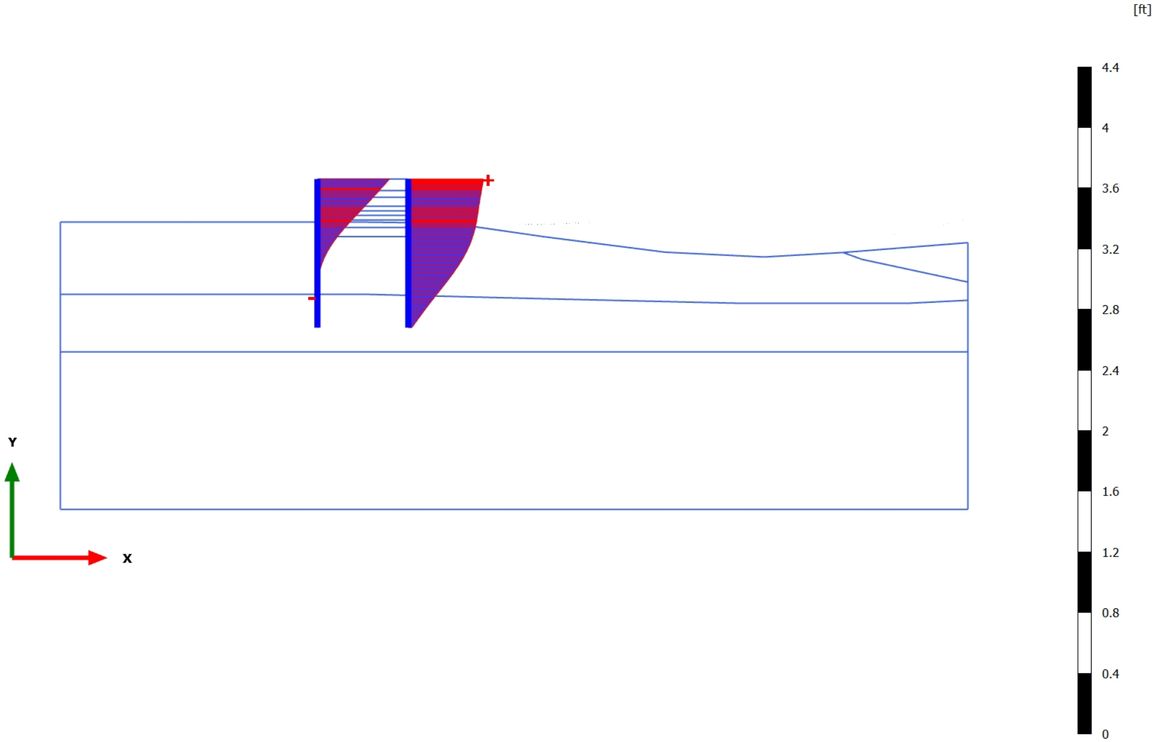


Total displacements u_x (scaled up 100 times)

Maximum value = 0.08835 ft (Element 22 at Node 7418)

Minimum value = -0.06837 ft (Element 21 at Node 6099)

3.1.1.1.1.7 Calculation results, Plate, Consolidate [Phase_17] (17/85), Total displacements u_x

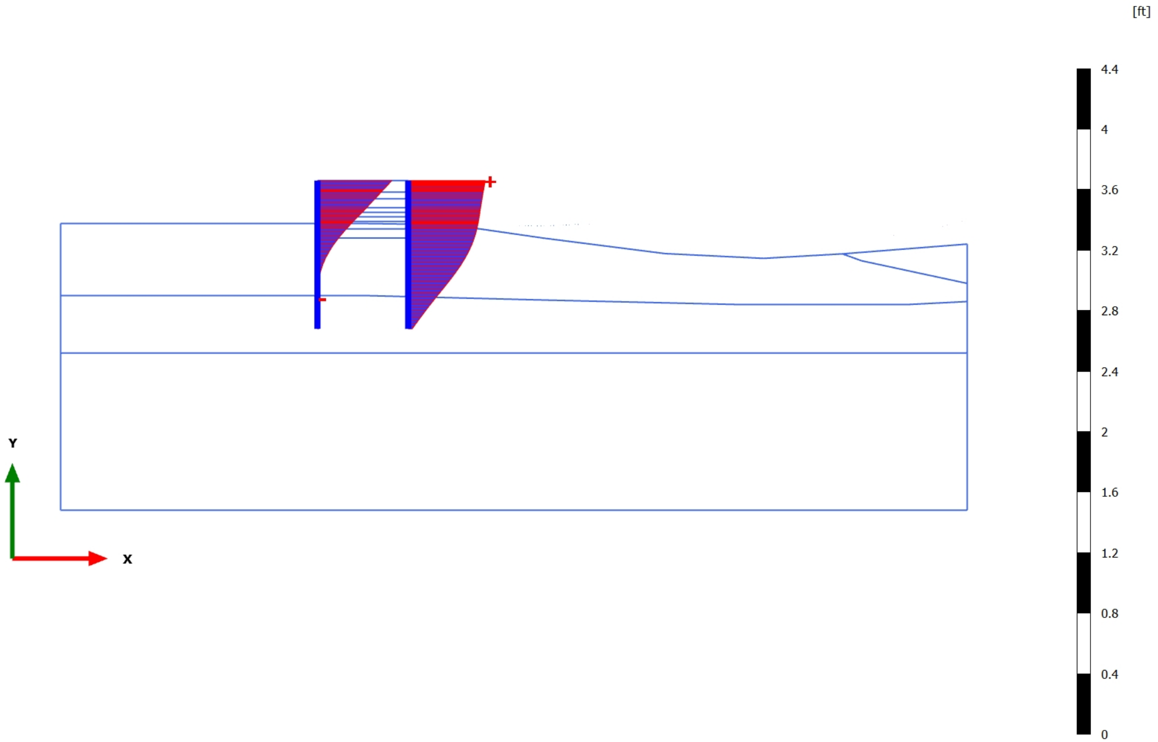


Total displacements u_x (scaled up 50.0 times) (Time 27.00 day)

Maximum value = 0.4975 ft (Element 2 at Node 637)

Minimum value = -3.118×10^{-3} ft (Element 35 at Node 10016)

3.1.1.1.1.8 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/89), Total displacements u_x

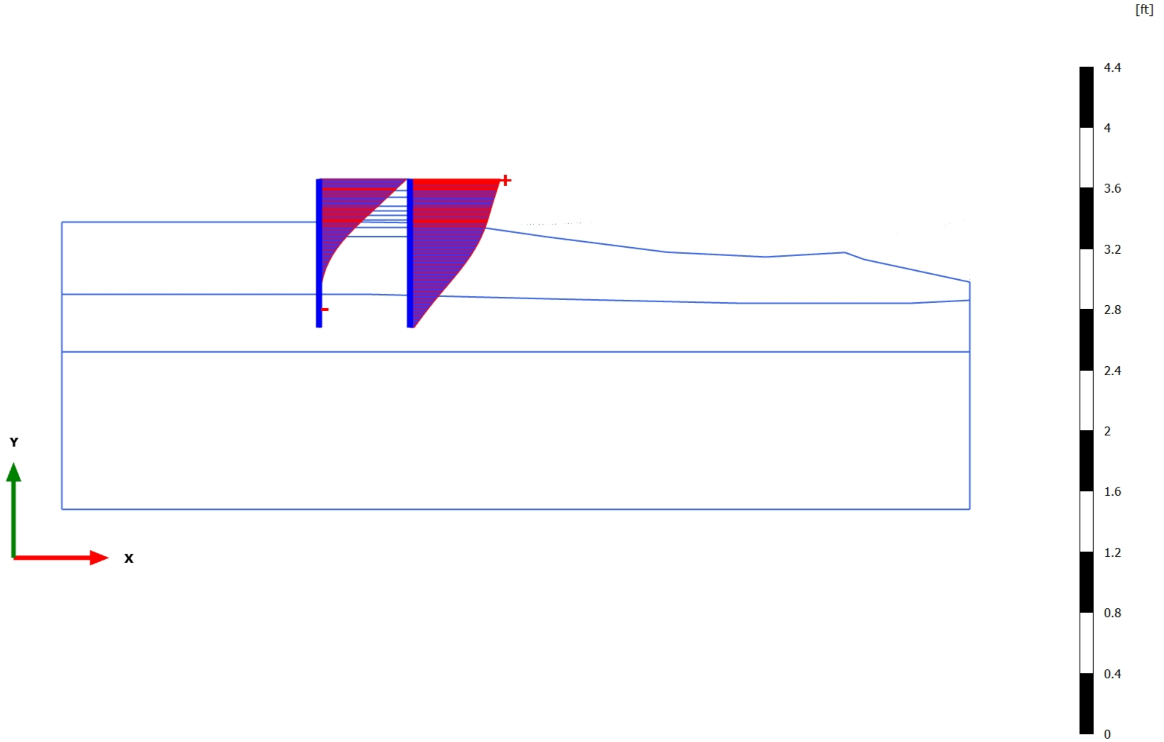


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5107 ft (Element 2 at Node 637)

Minimum value = 0.02568×10^{-3} ft (Element 35 at Node 10016)

3.1.1.1.1.9 Calculation results, Plate, Excavate 2 [Phase_21] (21/92), Total displacements u_x

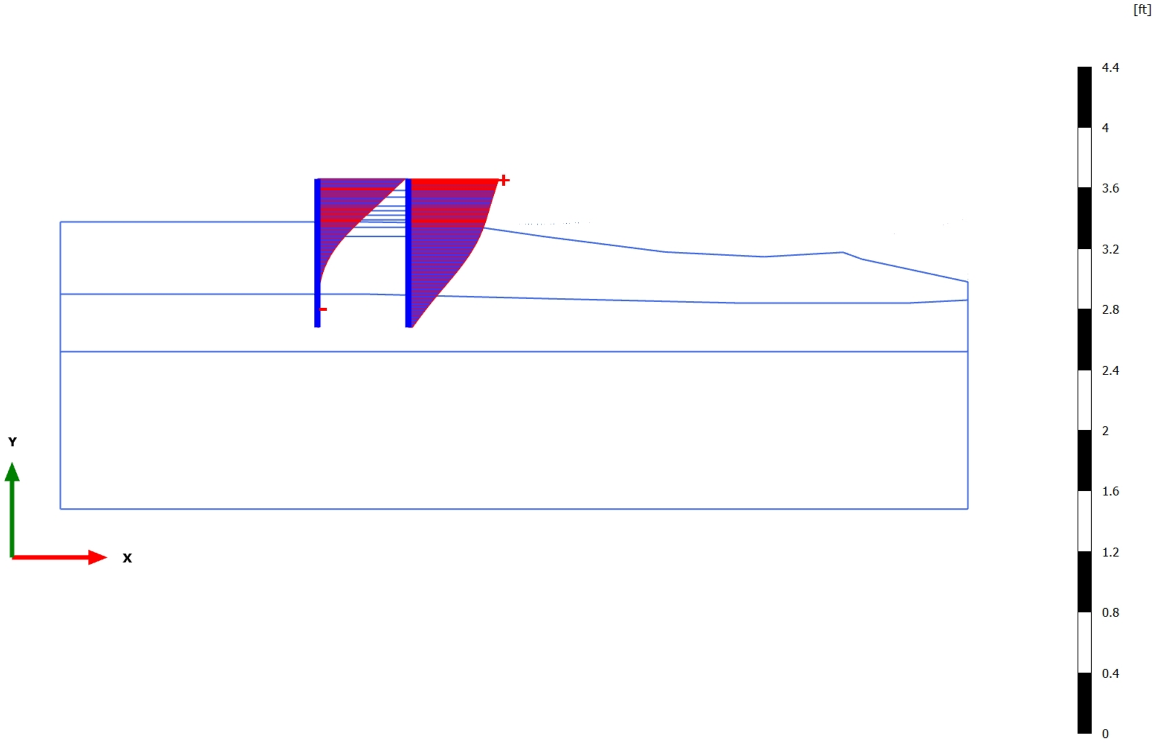


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5986 ft (Element 2 at Node 637)

Minimum value = 6.602×10^{-3} ft (Element 36 at Node 10718)

3.1.1.1.1.10 Calculation results, Plate, Consolidate [Phase_7] (7/98), Total displacements u_x

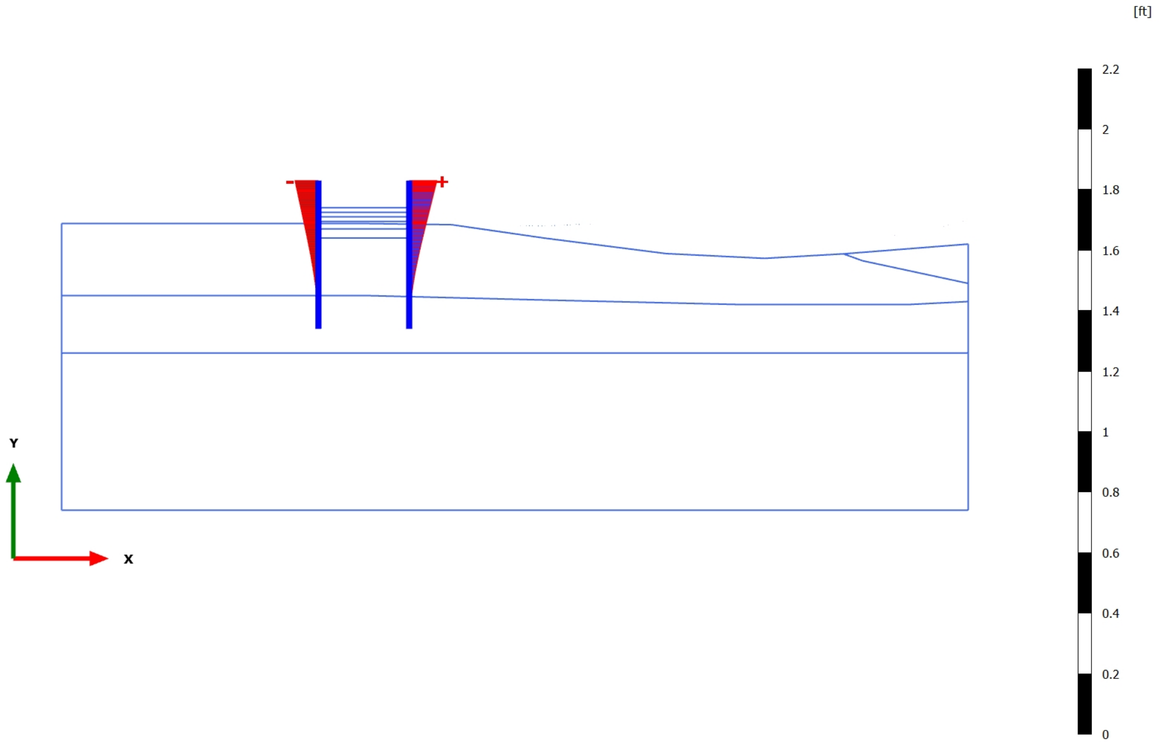


Total displacements u_x (scaled up 50.0 times) (Time 58.00 day)

Maximum value = 0.5987 ft (Element 2 at Node 637)

Minimum value = 6.593×10^{-3} ft (Element 36 at Node 10718)

3.1.1.1.1.11 Calculation results, Plate, Consolidate [Phase_25] (25/139), Total displacements u_x

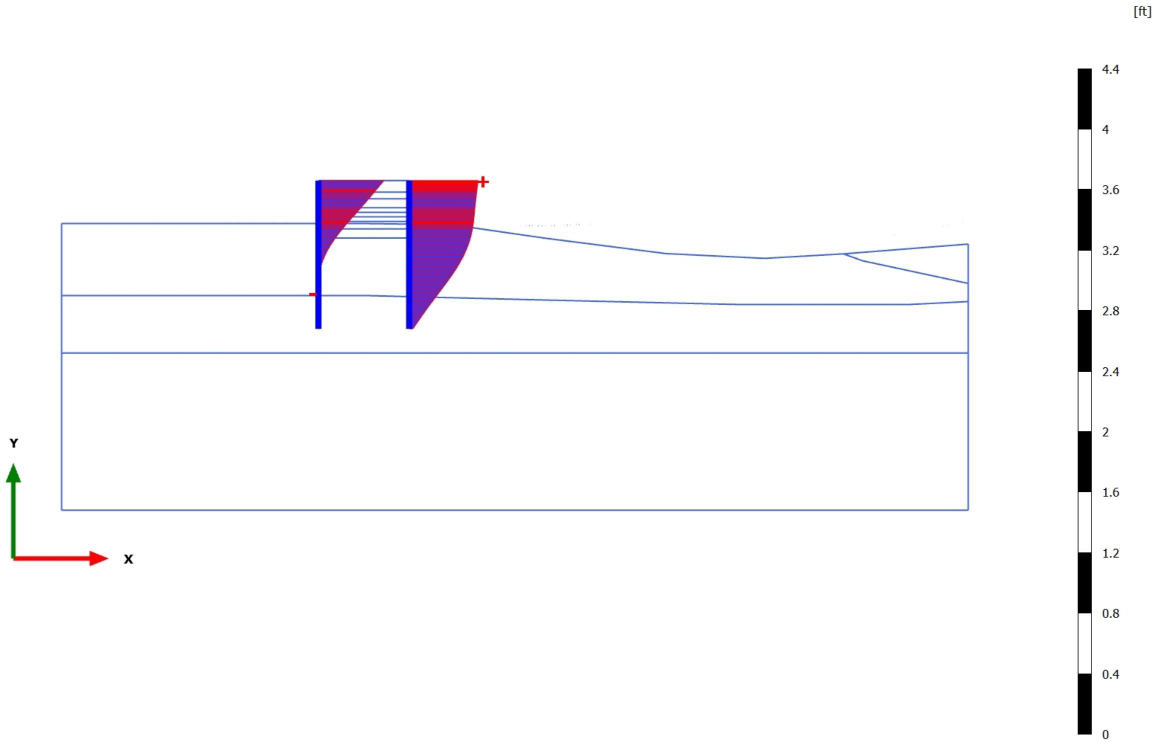


Total displacements u_x (scaled up 100 times) (Time 10.00 day)

Maximum value = 0.09219 ft (Element 2 at Node 637)

Minimum value = -0.07800 ft (Element 1 at Node 4)

3.1.1.1.1.12 Calculation results, Plate, Dewater-ss [Phase_16] (16/156), Total displacements u_x

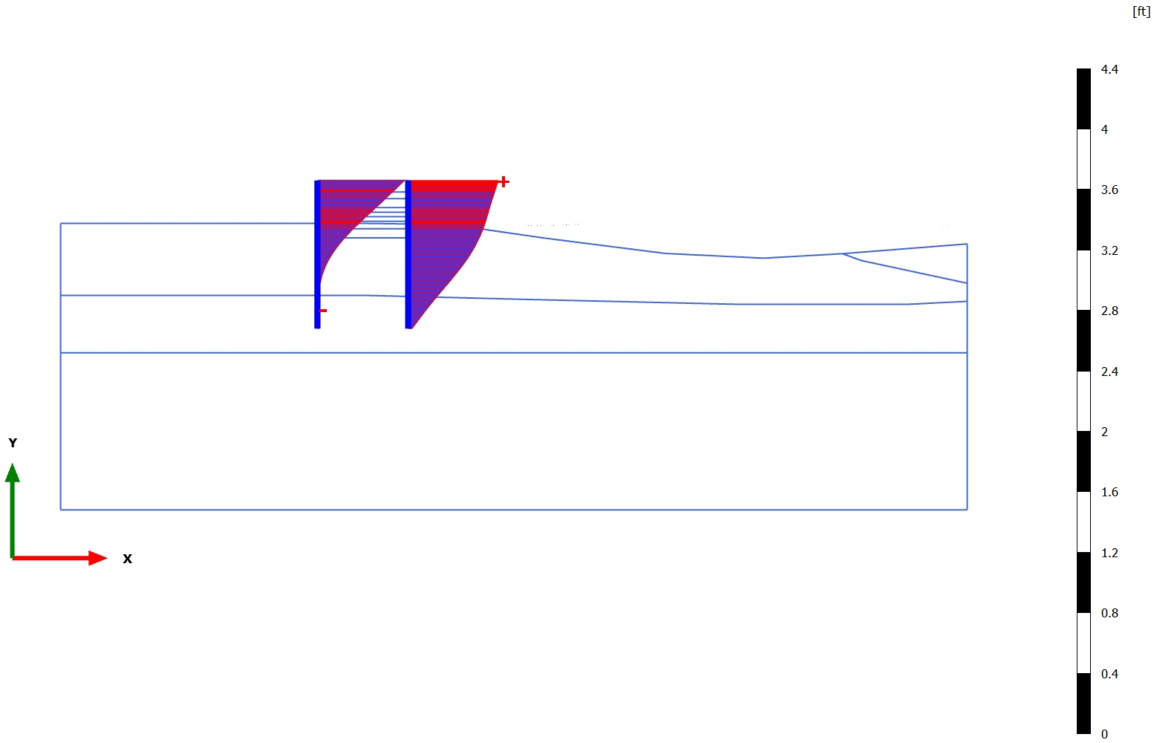


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4564 ft (Element 2 at Node 637)

Minimum value = -5.971×10^{-3} ft (Element 28 at Node 9792)

3.1.1.1.1.13 Calculation results, Plate, Consolidate [Phase_20] (20/172), Total displacements u_x

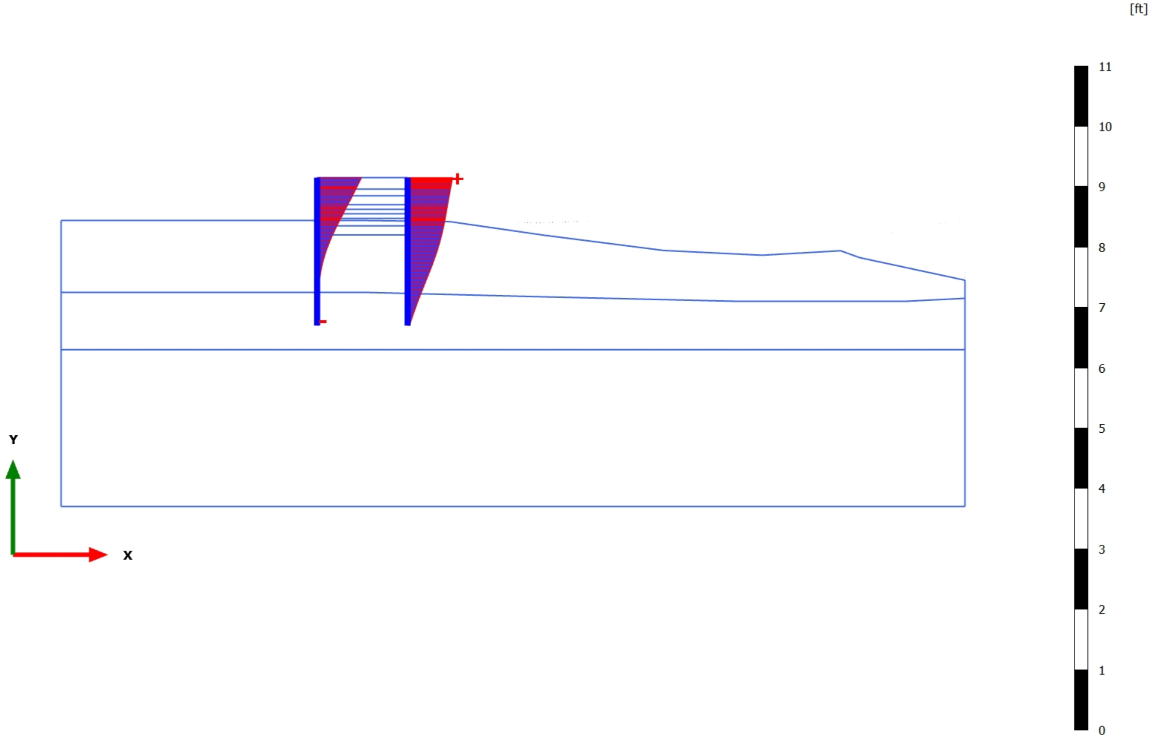


Total displacements u_x (scaled up 50.0 times) (Time 44.00 day)

Maximum value = 0.5970 ft (Element 2 at Node 637)

Minimum value = 5.879×10^{-3} ft (Element 36 at Node 10718)

3.1.1.1.1.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/180), Total displacements u_x

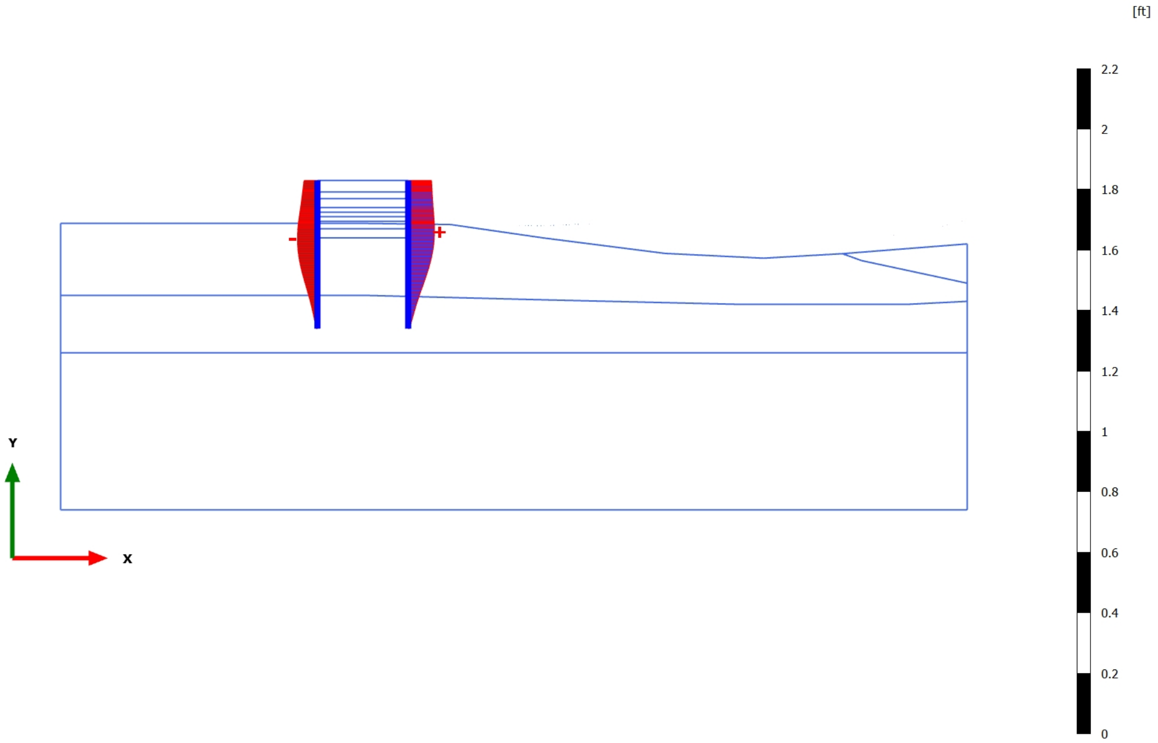


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.7482 ft (Element 2 at Node 637)

Minimum value = 0.01317 ft (Element 37 at Node 11265)

3.1.1.1.1.15 Calculation results, Plate, Consolidate [Phase_26] (26/217), Total displacements u_x

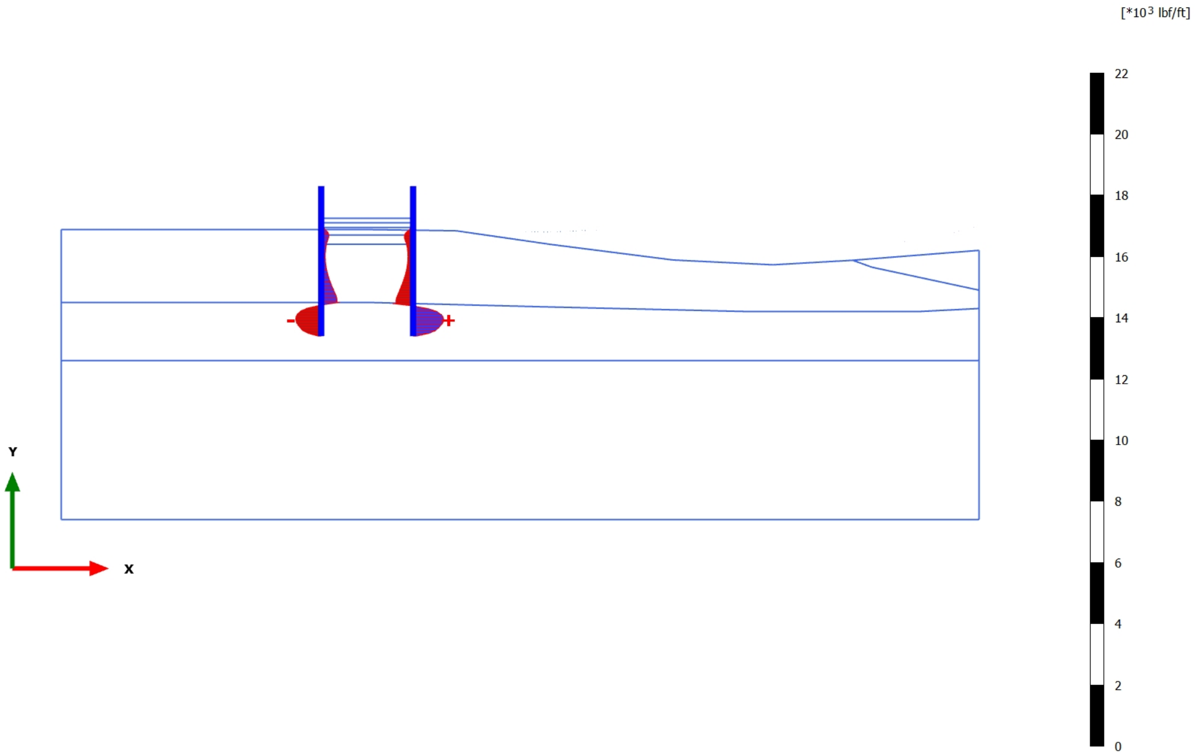


Total displacements u_x (scaled up 100 times) (Time 23.00 day)

Maximum value = 0.08730 ft (Element 22 at Node 7418)

Minimum value = -0.06647 ft (Element 21 at Node 6099)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/28), Shear forces Q

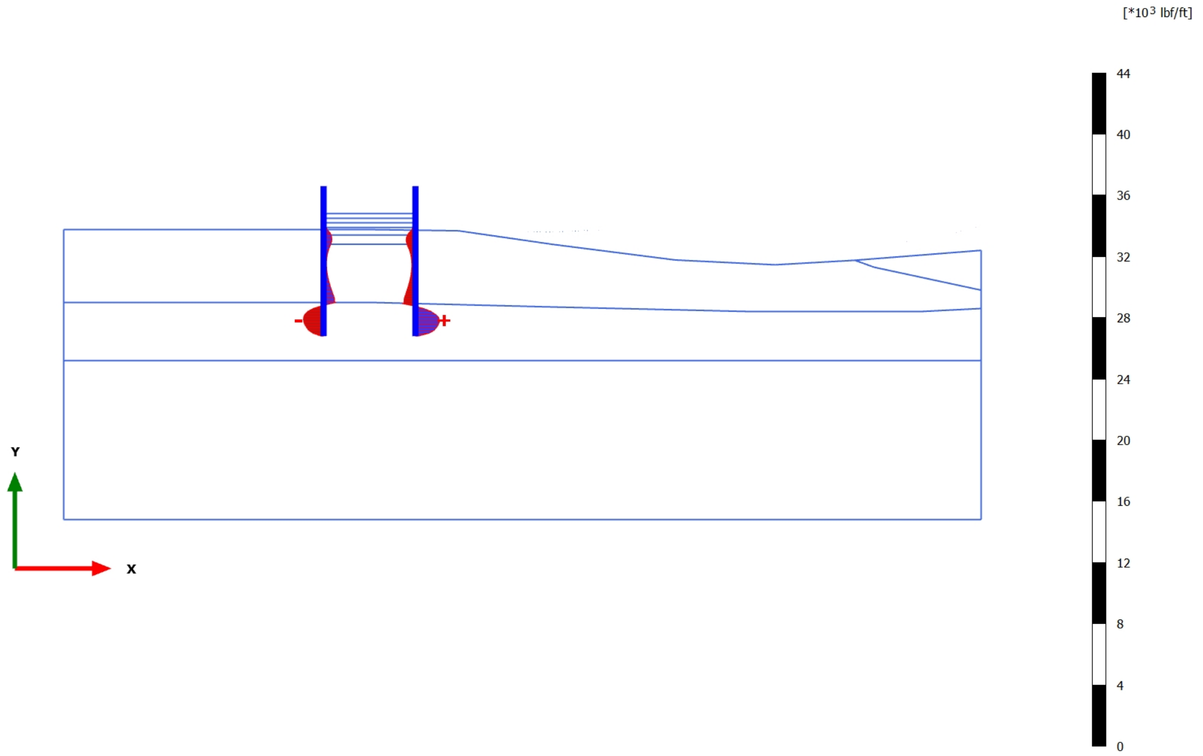


Shear forces Q (scaled up 0.0100 times)

Maximum value = 1003 lbf/ft (Element 39 at Node 12896)

Minimum value = -836.0 lbf/ft (Element 36 at Node 10717)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/40), Shear forces Q

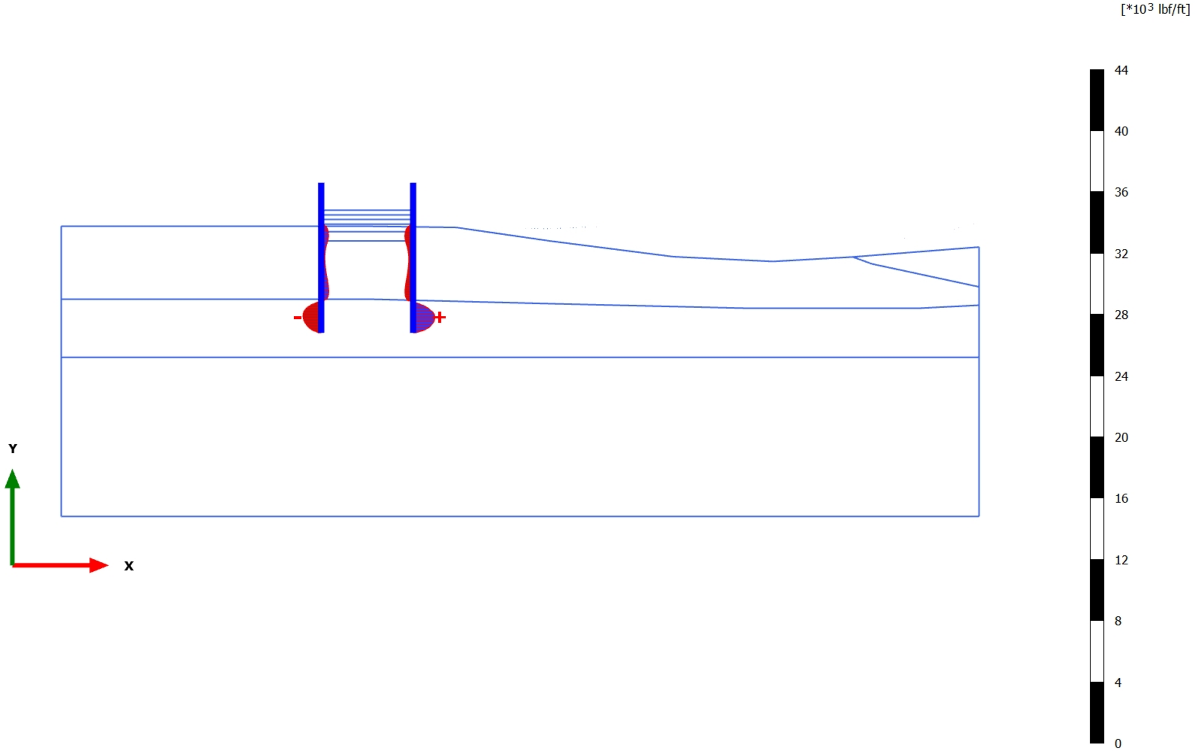


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 1571 lbf/ft (Element 39 at Node 12896)

Minimum value = -1327 lbf/ft (Element 36 at Node 10717)

3.1.2.1.3 Calculation results, Plate, Install tie [Phase_8] (4/44), Shear forces Q

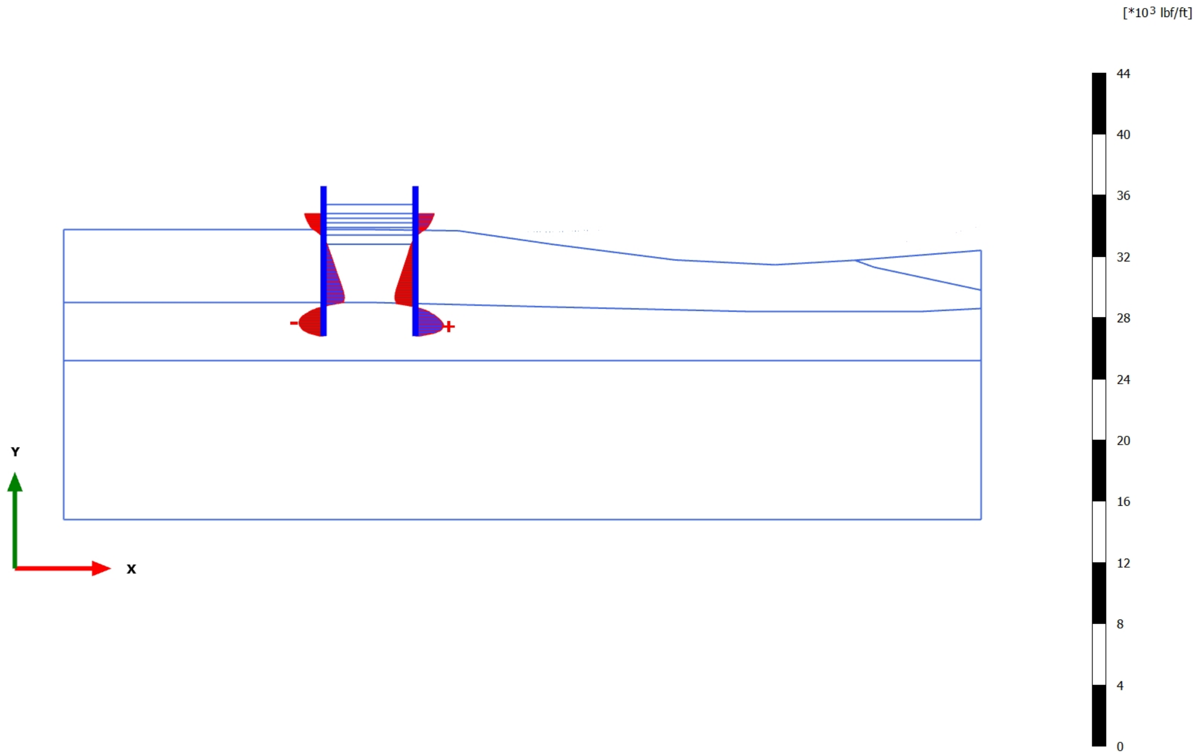


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 1435 lbf/ft (Element 39 at Node 12896)

Minimum value = -1203 lbf/ft (Element 36 at Node 10717)

3.1.2.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/52), Shear forces Q

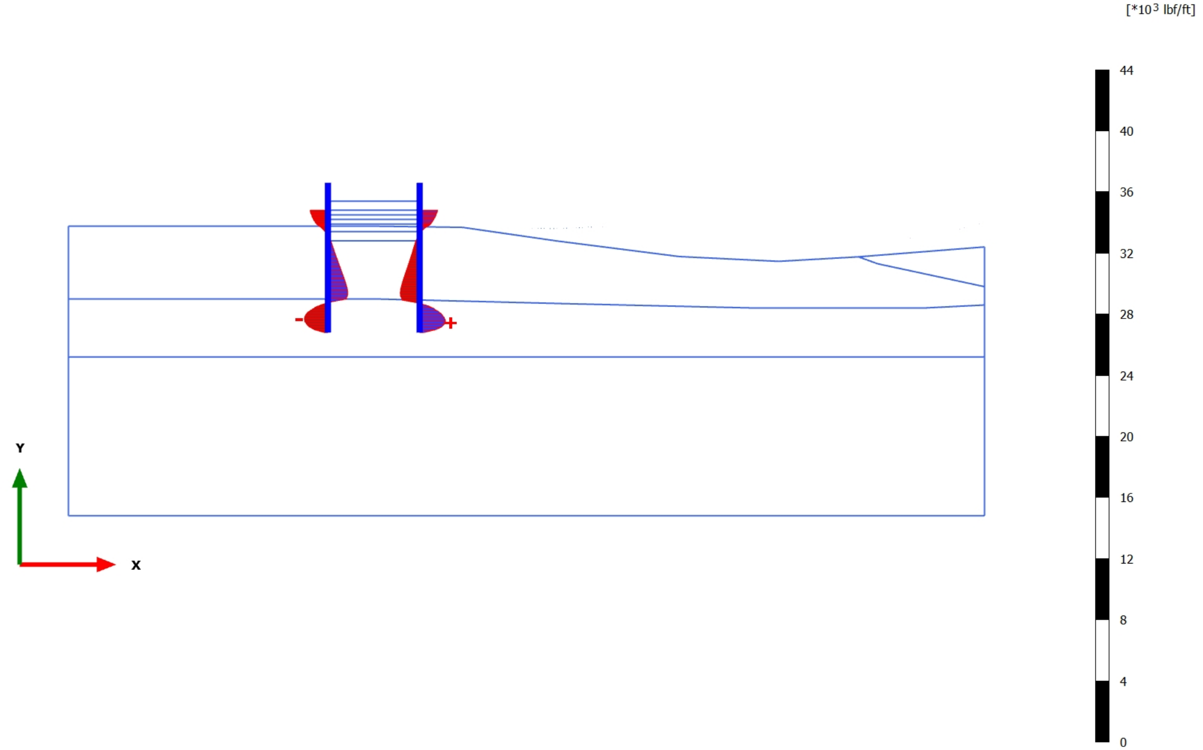


Shear forces Q (scaled up 5.00*10⁻³ times)

Maximum value = 1859 lbf/ft (Element 39 at Node 13040)

Minimum value = -1624 lbf/ft (Element 36 at Node 10716)

3.1.2.1.5 Calculation results, Plate, Consolidate [Phase_9] (8/63), Shear forces Q

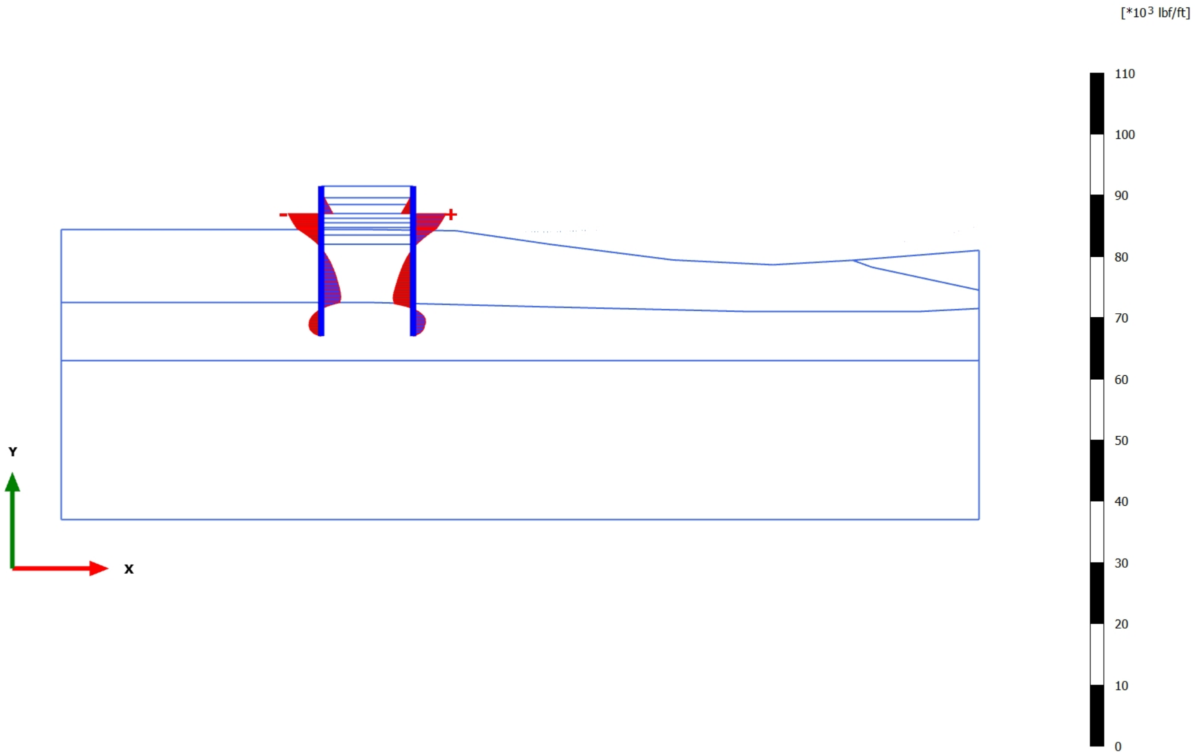


Shear forces Q (scaled up 5.00*10⁻³ times) (Time 13.00 day)

Maximum value = 1707 lbf/ft (Element 39 at Node 13040)

Minimum value = -1549 lbf/ft (Element 36 at Node 10716)

3.1.2.1.6 Calculation results, Plate, Backfill 4 [Phase_6] (6/74), Shear forces Q

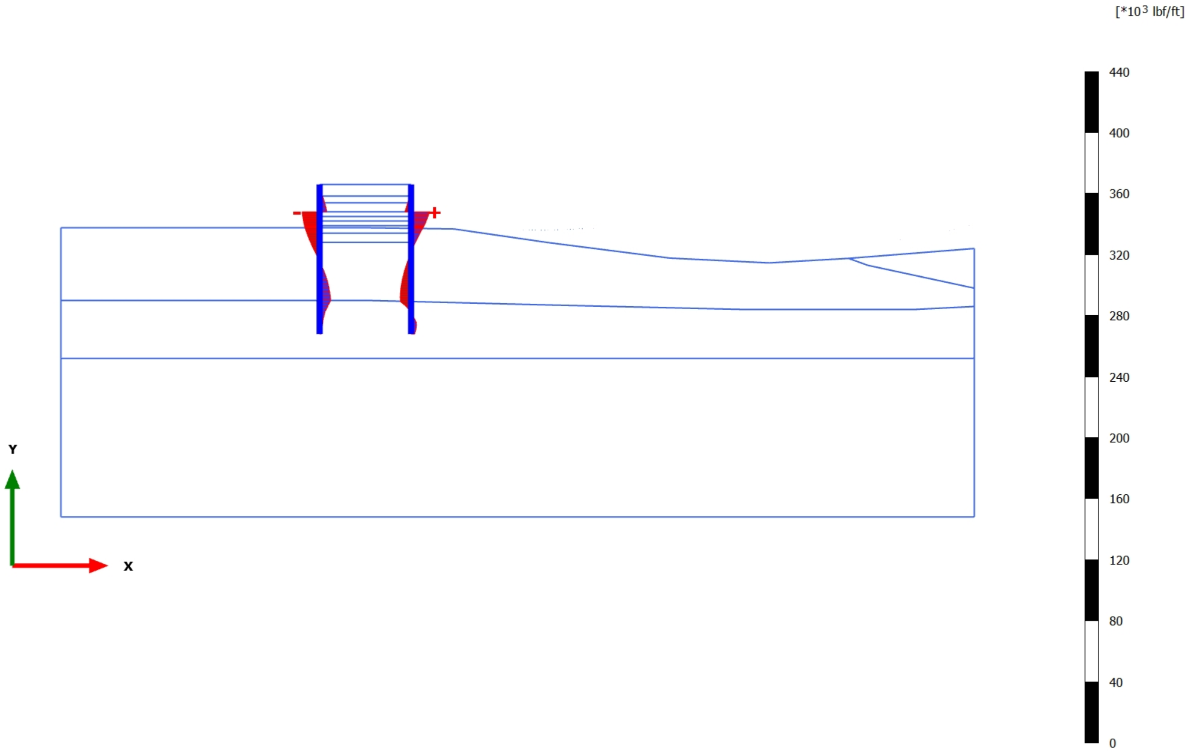


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 5418 lbf/ft (Element 12 at Node 1141)

Minimum value = -5446 lbf/ft (Element 11 at Node 18)

3.1.2.1.7 Calculation results, Plate, Consolidate [Phase_17] (17/85), Shear forces Q

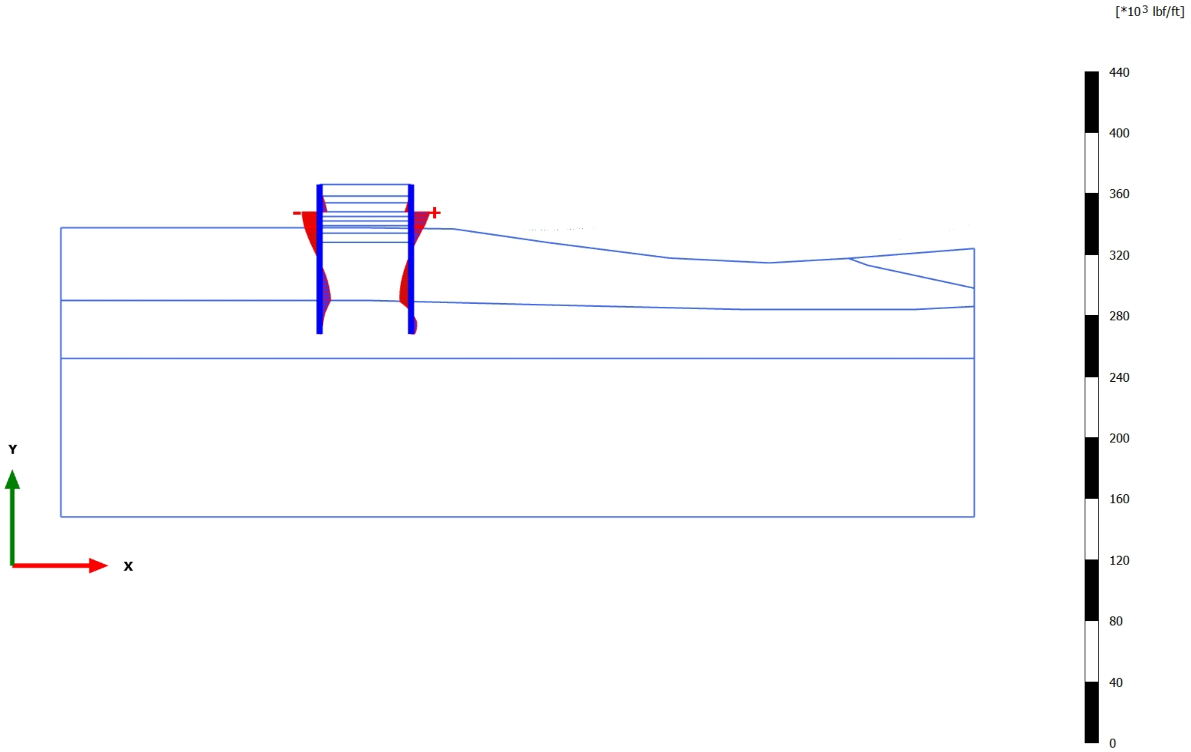


Shear forces Q (scaled up 0.500×10^{-3} times) (Time 27.00 day)

Maximum value = 12.24×10^3 lbf/ft (Element 12 at Node 1141)

Minimum value = -11.64×10^3 lbf/ft (Element 11 at Node 18)

3.1.2.1.8 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/89), Shear forces Q

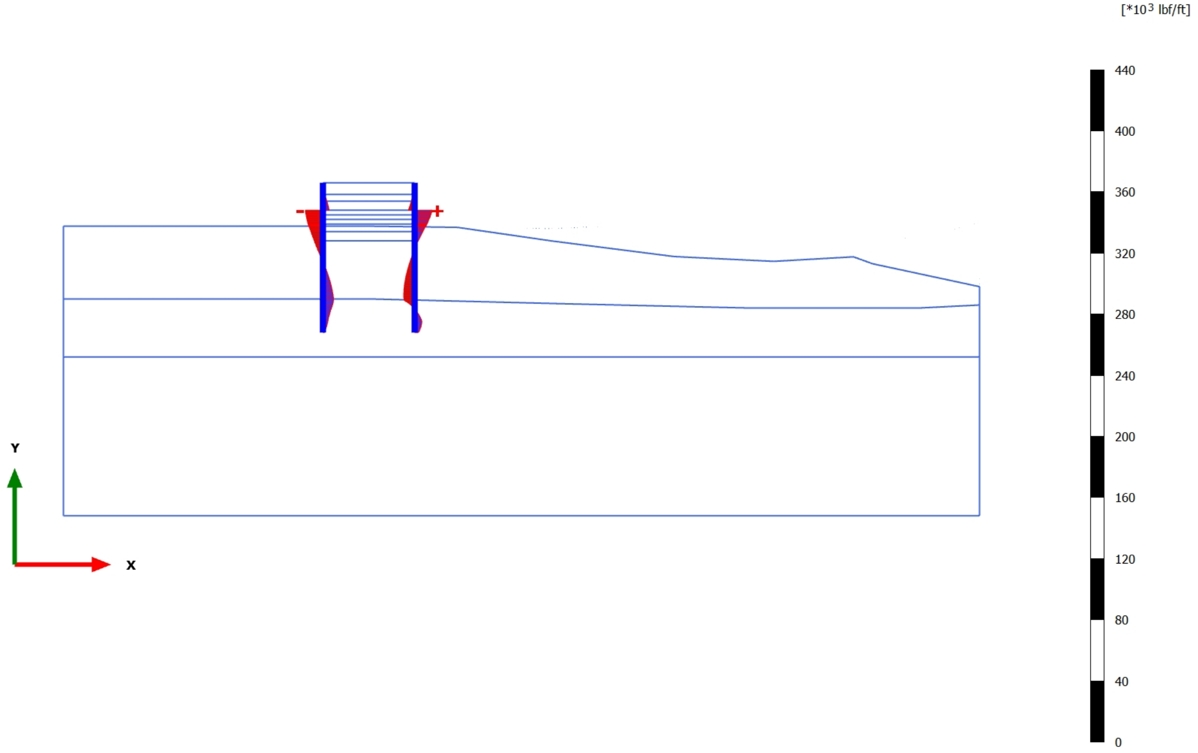


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 12.45*10^3 lbf/ft (Element 12 at Node 1141)

Minimum value = -11.78*10^3 lbf/ft (Element 11 at Node 18)

3.1.2.1.9 Calculation results, Plate, Excavate 2 [Phase_21] (21/92), Shear forces Q

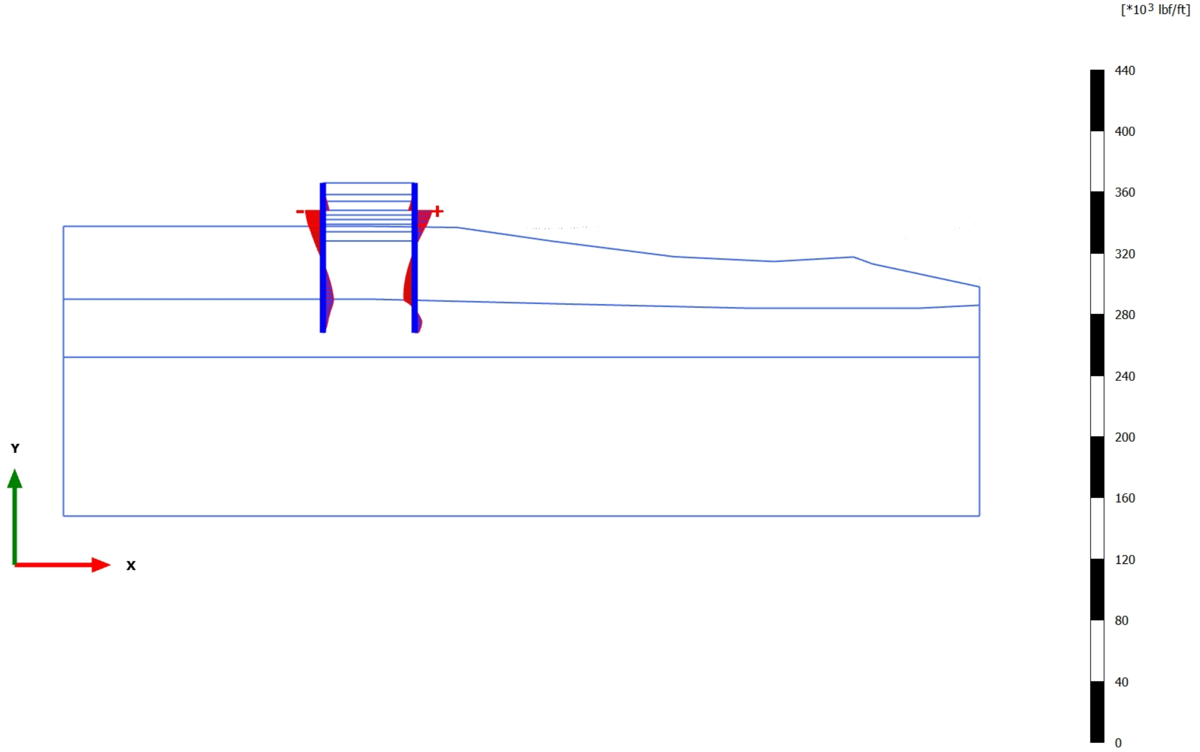


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.69*10^3$ lbf/ft (Element 12 at Node 1141)

Minimum value = $-11.68*10^3$ lbf/ft (Element 11 at Node 18)

3.1.2.1.10 Calculation results, Plate, Consolidate [Phase_7] (7/98), Shear forces Q

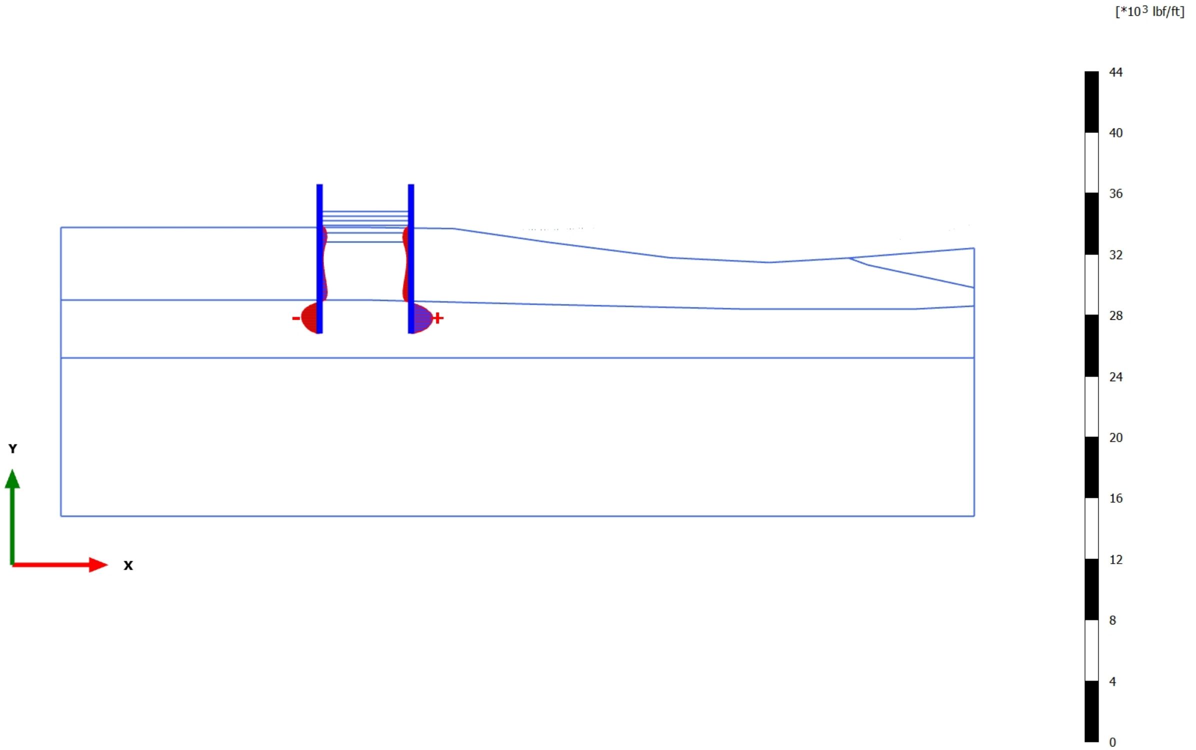


Shear forces Q (scaled up 0.500*10^{-3} times) (Time 58.00 day)

Maximum value = 11.69*10^3 lbf/ft (Element 12 at Node 1141)

Minimum value = -11.68*10^3 lbf/ft (Element 11 at Node 18)

3.1.2.1.11 Calculation results, Plate, Consolidate [Phase_25] (25/139), Shear forces Q

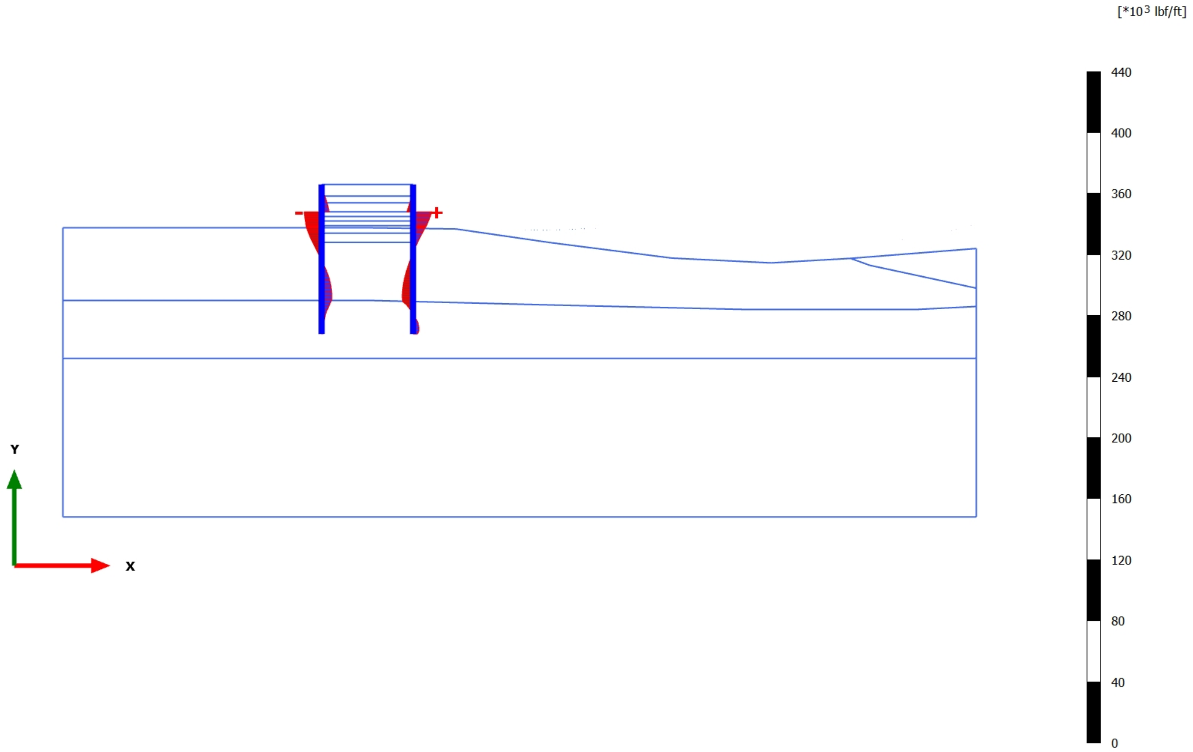


Shear forces Q (scaled up $5.00*10^{-3}$ times) (Time 10.00 day)

Maximum value = 1435 lbf/ft (Element 39 at Node 12896)

Minimum value = -1203 lbf/ft (Element 36 at Node 10717)

3.1.2.1.12 Calculation results, Plate, Dewater-ss [Phase_16] (16/156), Shear forces Q

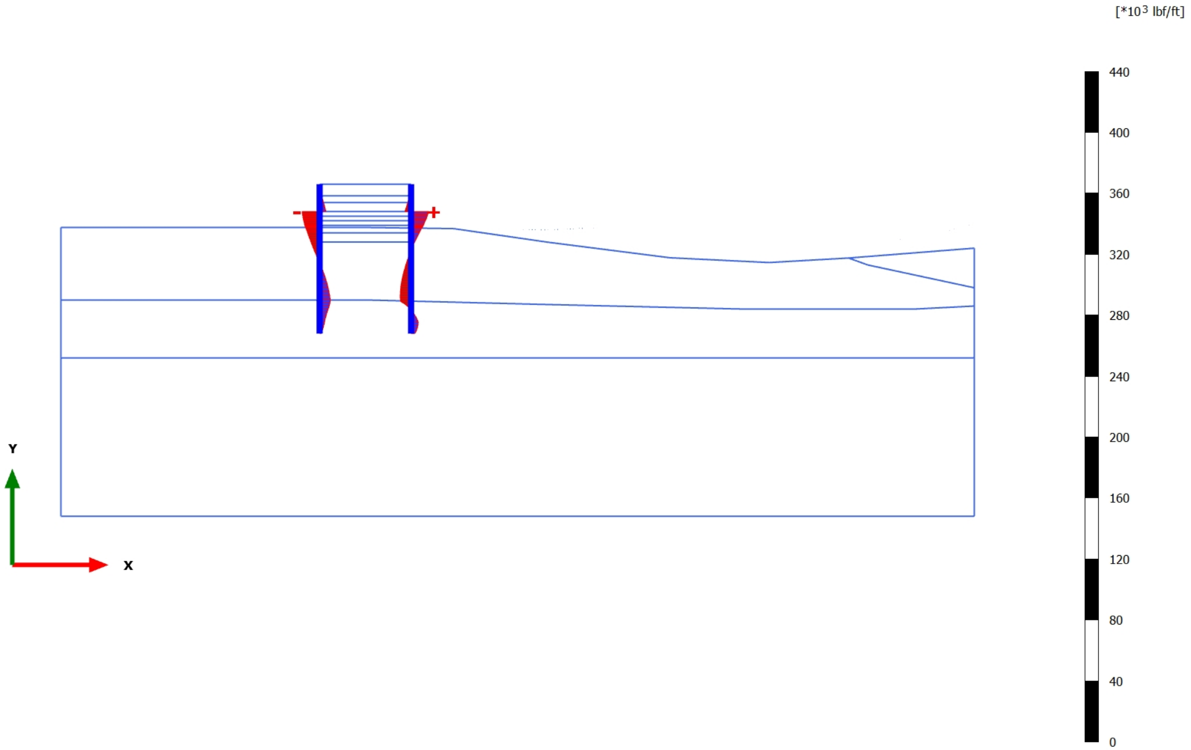


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 12.43*10^3 lbf/ft (Element 12 at Node 1141)

Minimum value = -11.64*10^3 lbf/ft (Element 11 at Node 18)

3.1.2.1.13 Calculation results, Plate, Consolidate [Phase_20] (20/172), Shear forces Q

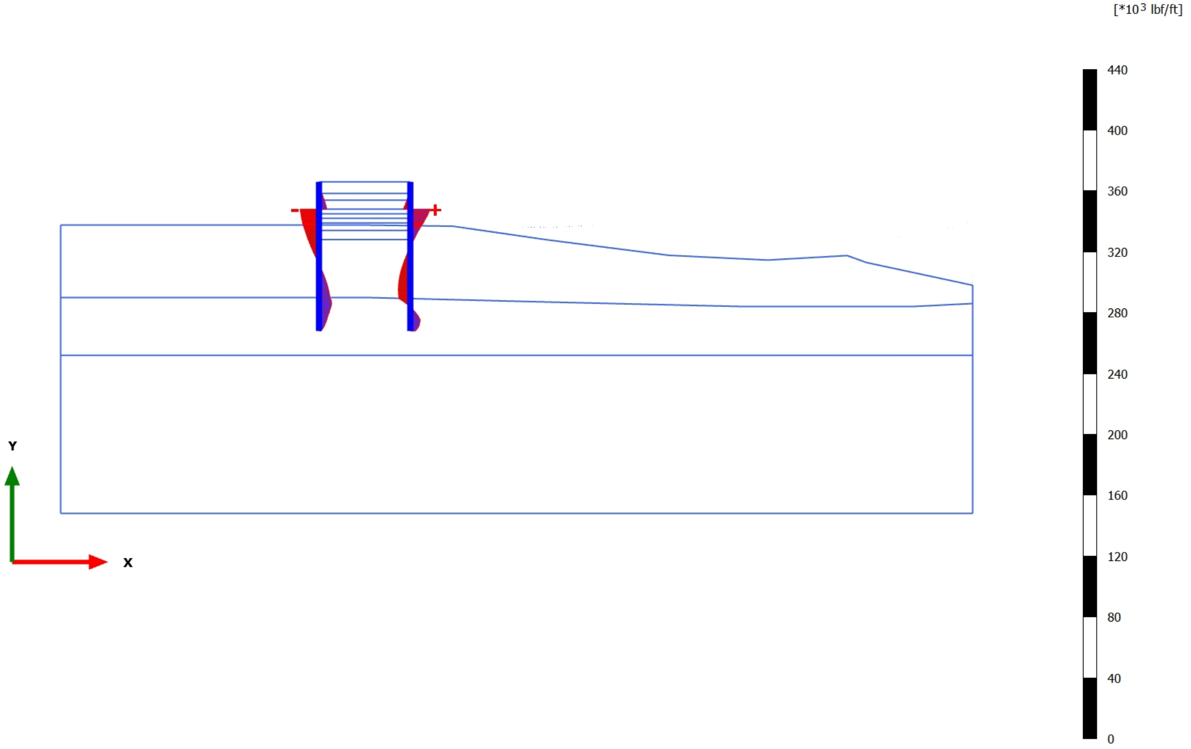


Shear forces Q (scaled up $0.500*10^{-3}$ times) (Time 44.00 day)

Maximum value = $11.68*10^{3}$ lbf/ft (Element 12 at Node 1141)

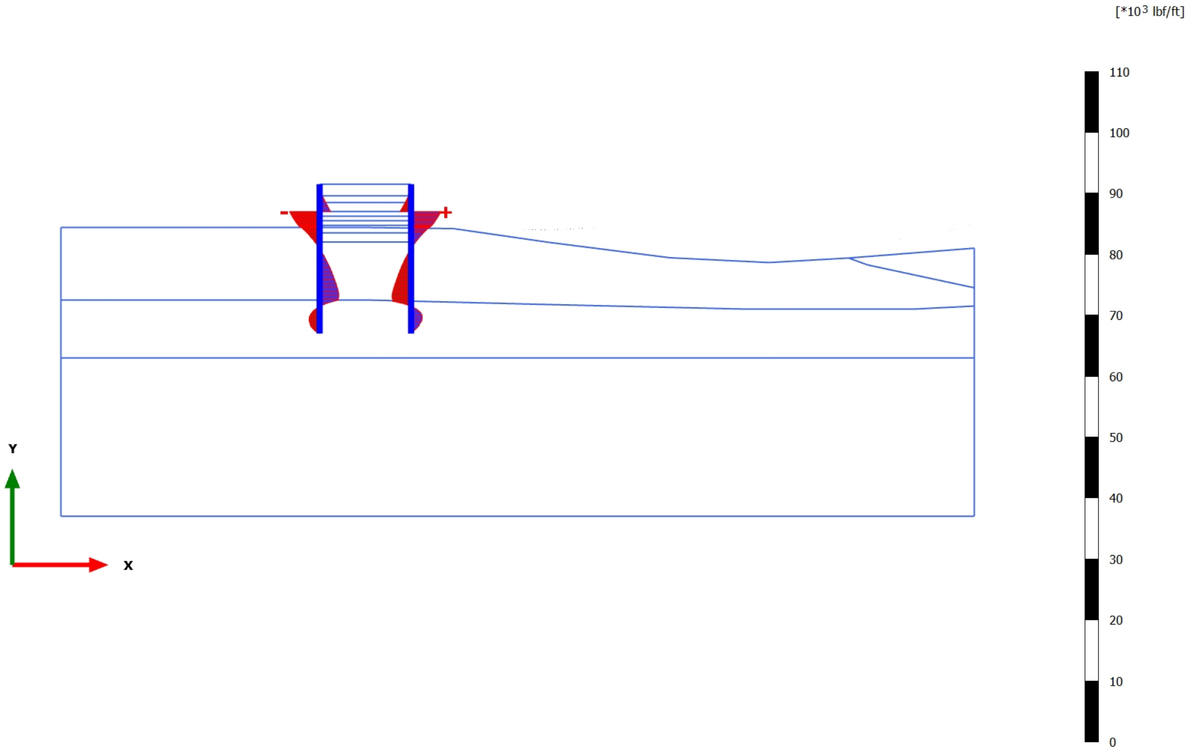
Minimum value = $-11.68*10^{3}$ lbf/ft (Element 11 at Node 18)

3.1.2.1.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/180), Shear forces Q



Shear forces Q (scaled up 0.500*10^{-3} times)
Maximum value = 13.14*10³ lbf/ft (Element 12 at Node 1141)
Minimum value = -12.54*10³ lbf/ft (Element 11 at Node 18)

3.1.2.1.15 Calculation results, Plate, Consolidate [Phase_26] (26/217), Shear forces Q

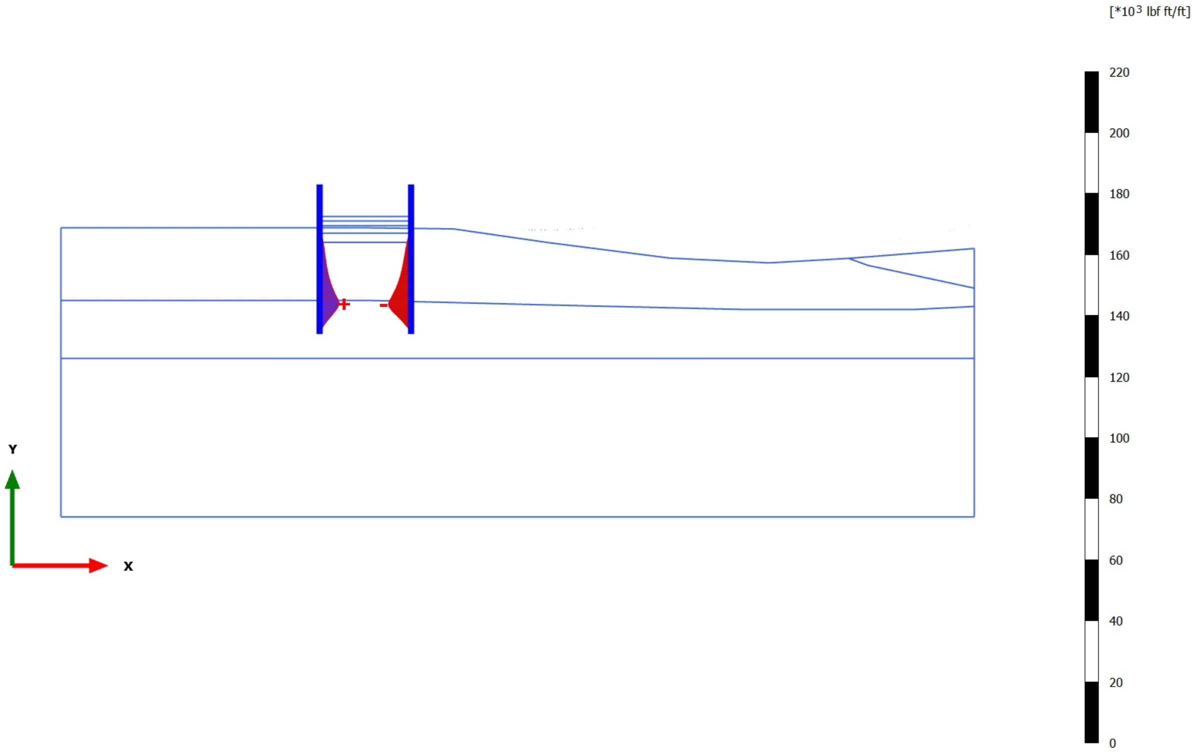


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 23.00 day)

Maximum value = 4967 lbf/ft (Element 12 at Node 1141)

Minimum value = -4971 lbf/ft (Element 11 at Node 18)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/28), Bending moments M

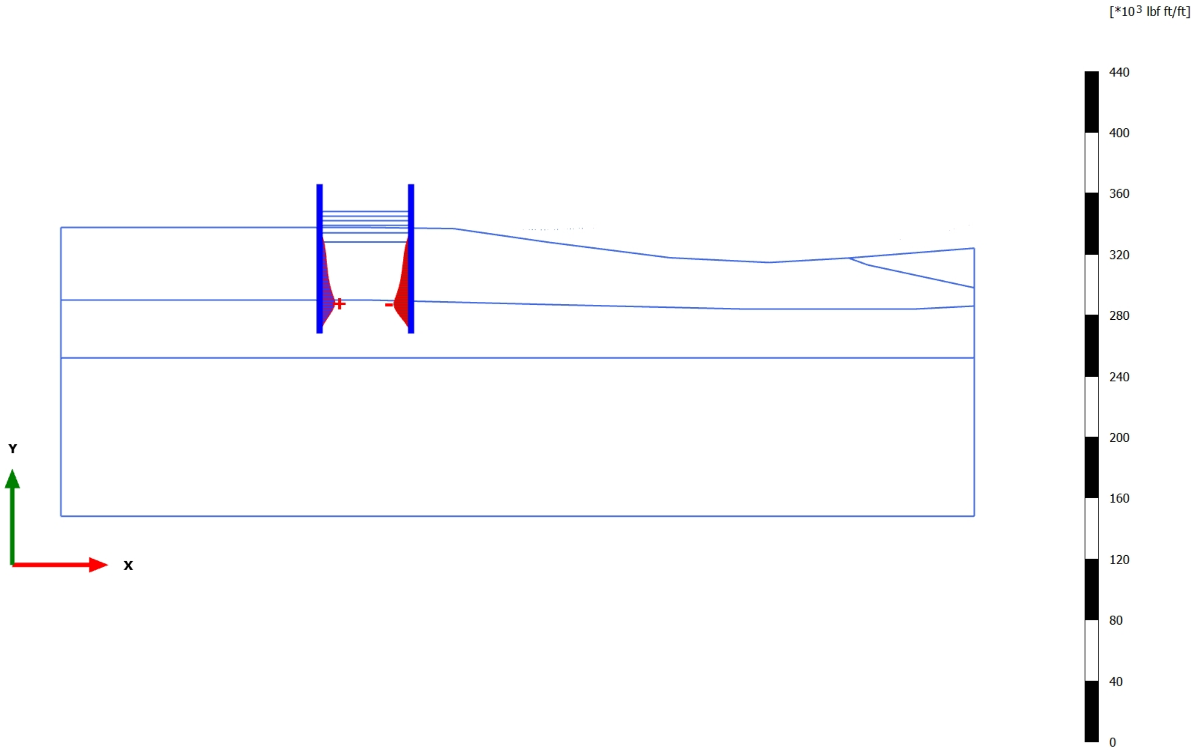


Bending moments M (scaled up $1.00*10^{-3}$ times)

Maximum value = 6415 lbf ft/ft (Element 35 at Node 10016)

Minimum value = -7453 lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/40), Bending moments M

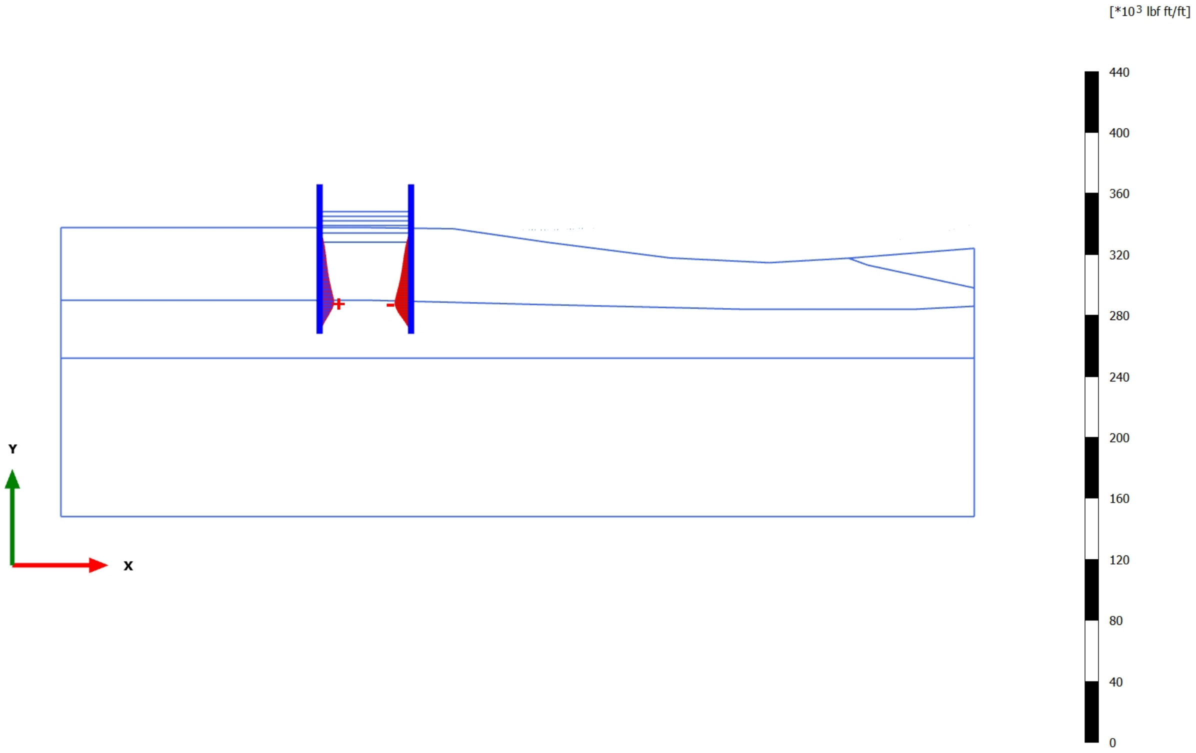


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.03*10^{3}$ lbf ft/ft (Element 35 at Node 10016)

Minimum value = $-11.36*10^{3}$ lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.3 Calculation results, Plate, Install tie [Phase_8] (4/44), Bending moments M

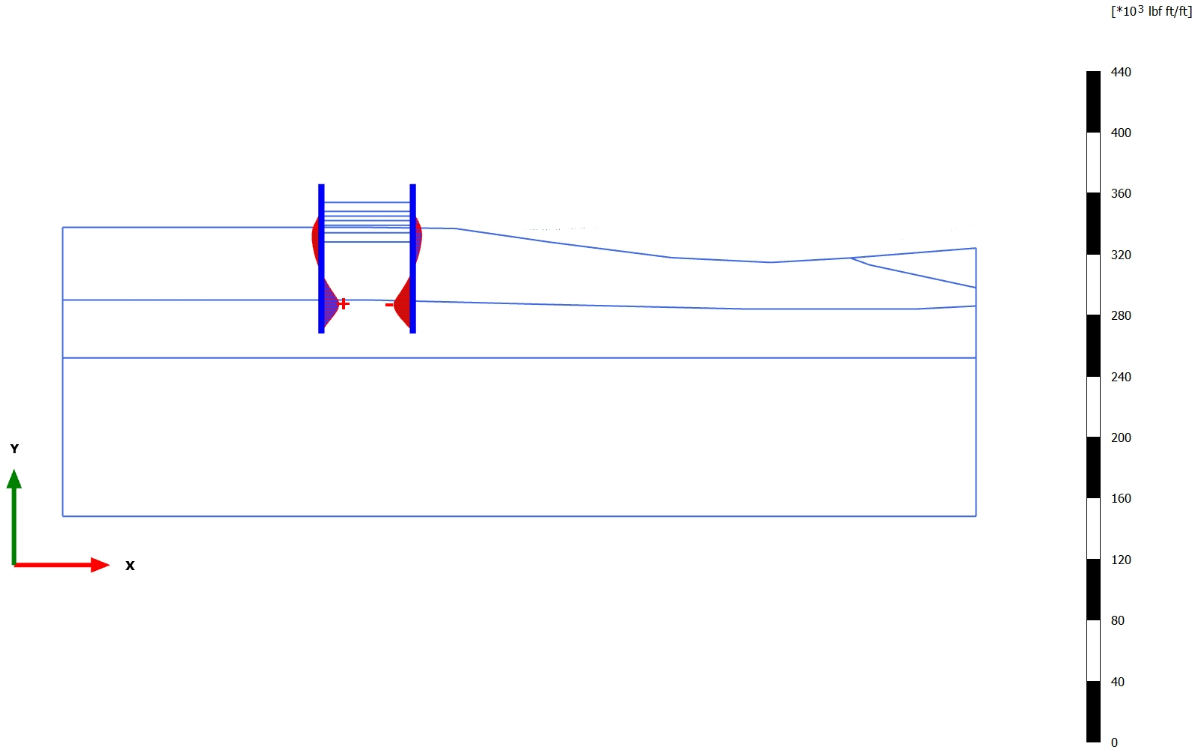


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = 9277 lbf ft/ft (Element 35 at Node 10016)

Minimum value = $-10.57*10^{3}$ lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/52), Bending moments M

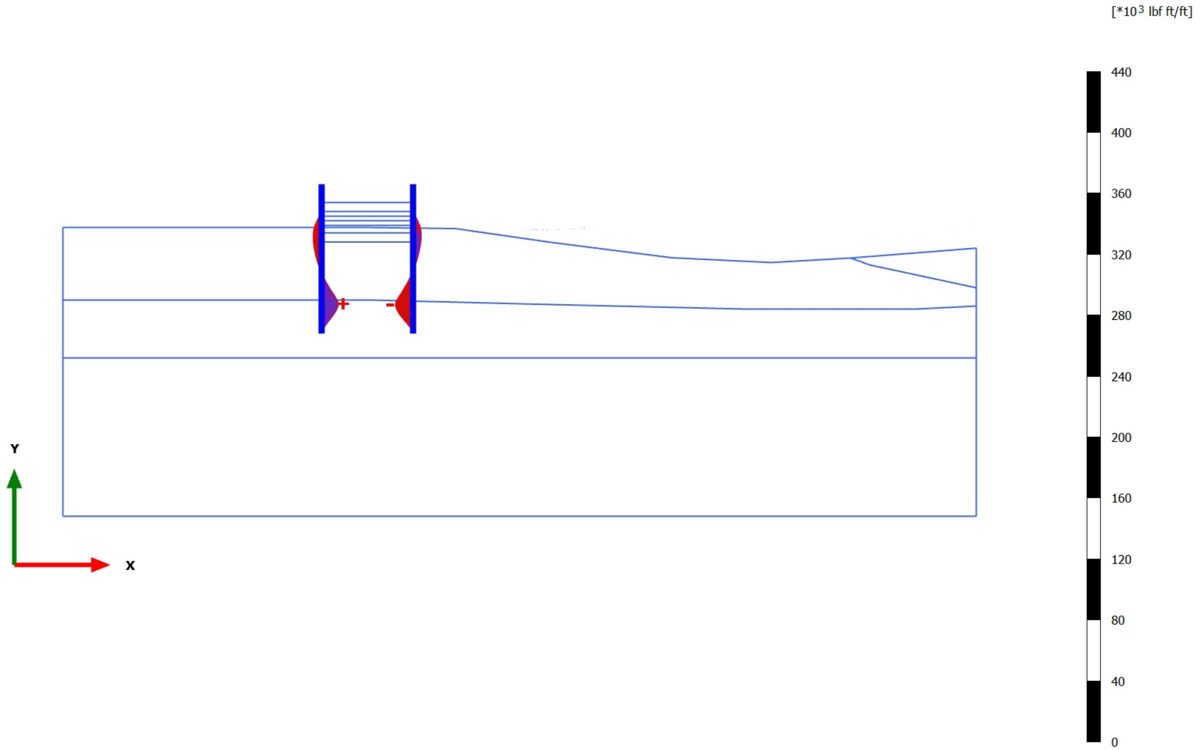


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.48*10^3$ lbf ft/ft (Element 35 at Node 10016)

Minimum value = $-12.48*10^3$ lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.5 Calculation results, Plate, Consolidate [Phase_9] (8/63), Bending moments M

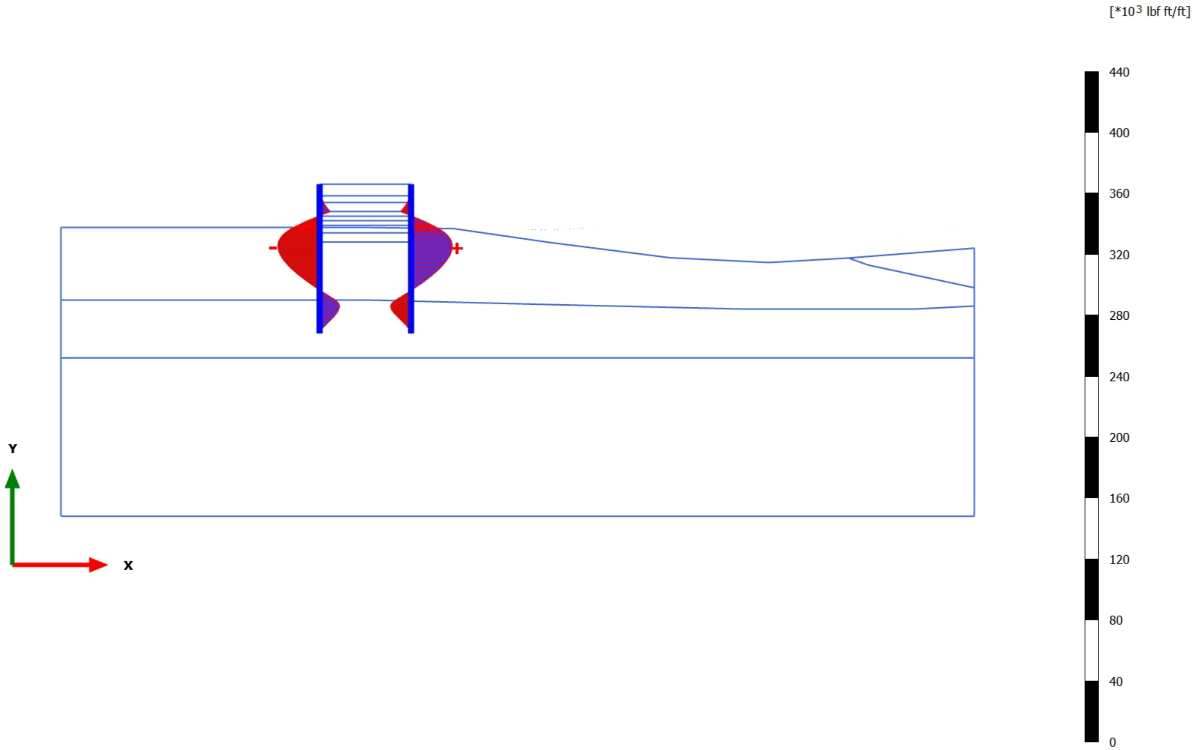


Bending moments M (scaled up $0.500*10^{-3}$ times) (Time 13.00 day)

Maximum value = $10.95*10^3$ lbf ft/ft (Element 35 at Node 10016)

Minimum value = $-11.64*10^3$ lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.6 Calculation results, Plate, Backfill 4 [Phase_6] (6/74), Bending moments M

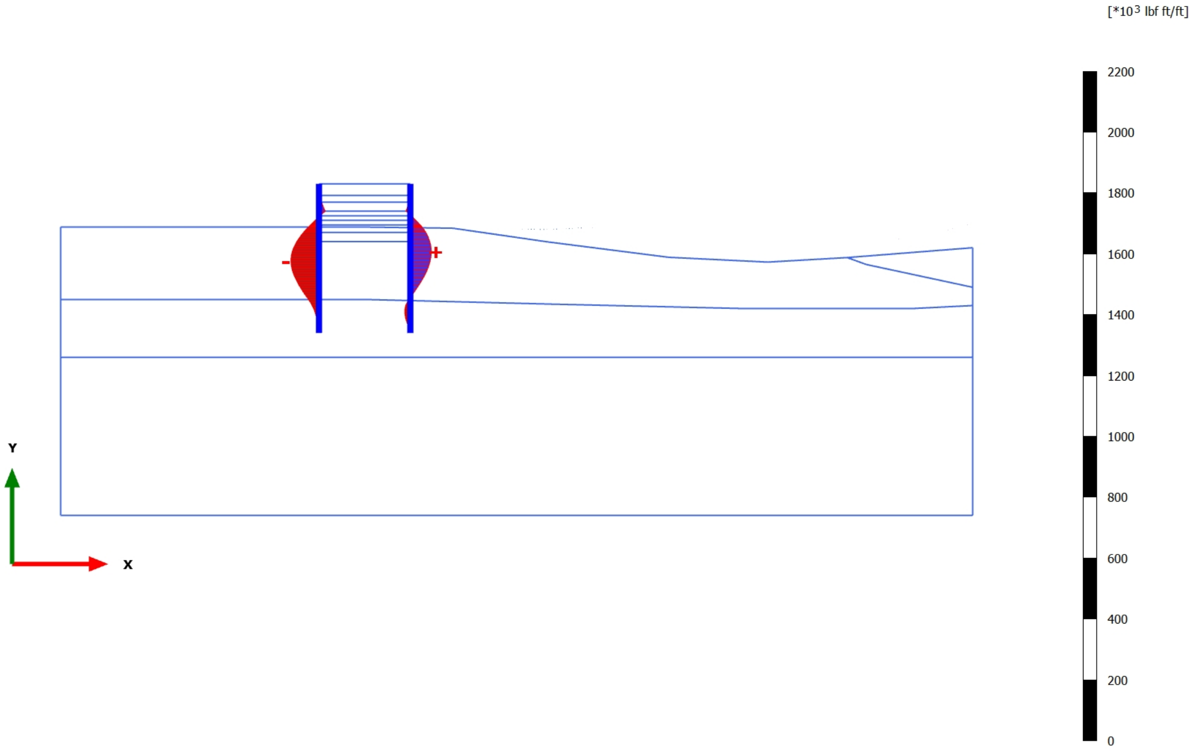


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $27.14*10^3$ lbf ft/ft (Element 29 at Node 8381)

Minimum value = $-27.48*10^3$ lbf ft/ft (Element 23 at Node 6101)

3.1.2.2.7 Calculation results, Plate, Consolidate [Phase_17] (17/85), Bending moments M

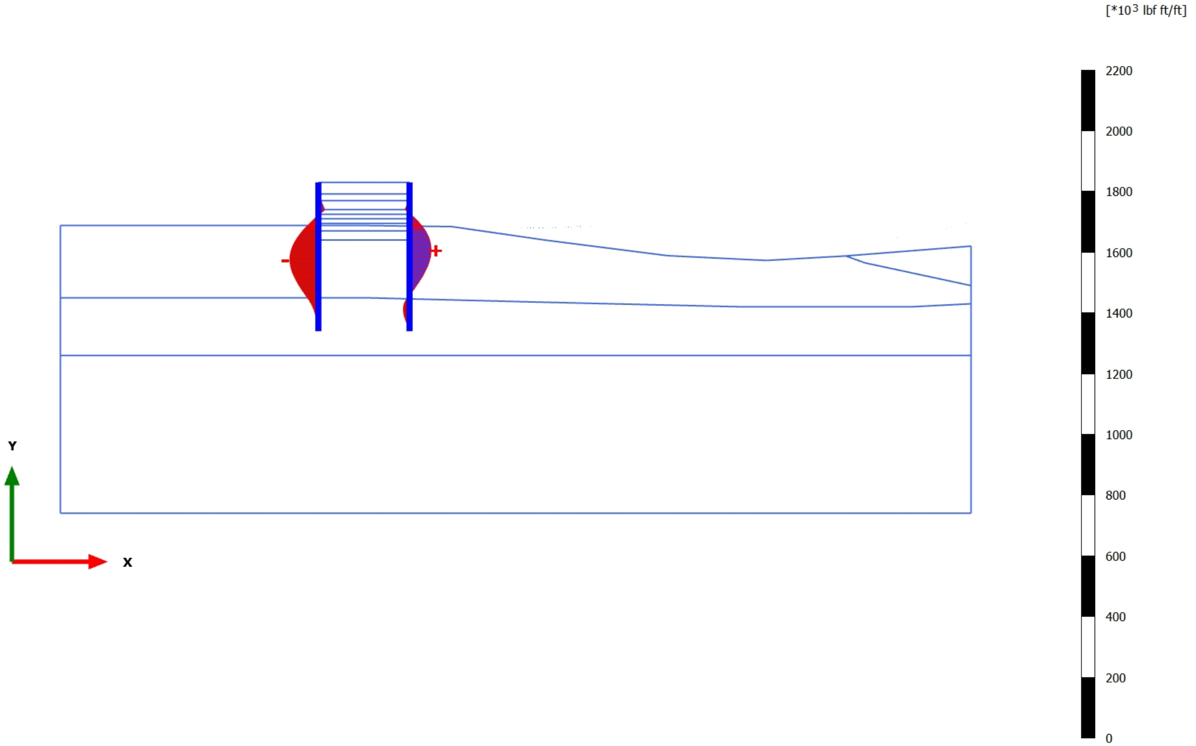


Bending moments M (scaled up $0.100*10^{-3}$ times) (Time 27.00 day)

Maximum value = $69.21*10^{3}$ lbf ft/ft (Element 29 at Node 8947)

Minimum value = $-92.57*10^{3}$ lbf ft/ft (Element 24 at Node 7511)

3.1.2.2.8 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/89), Bending moments M

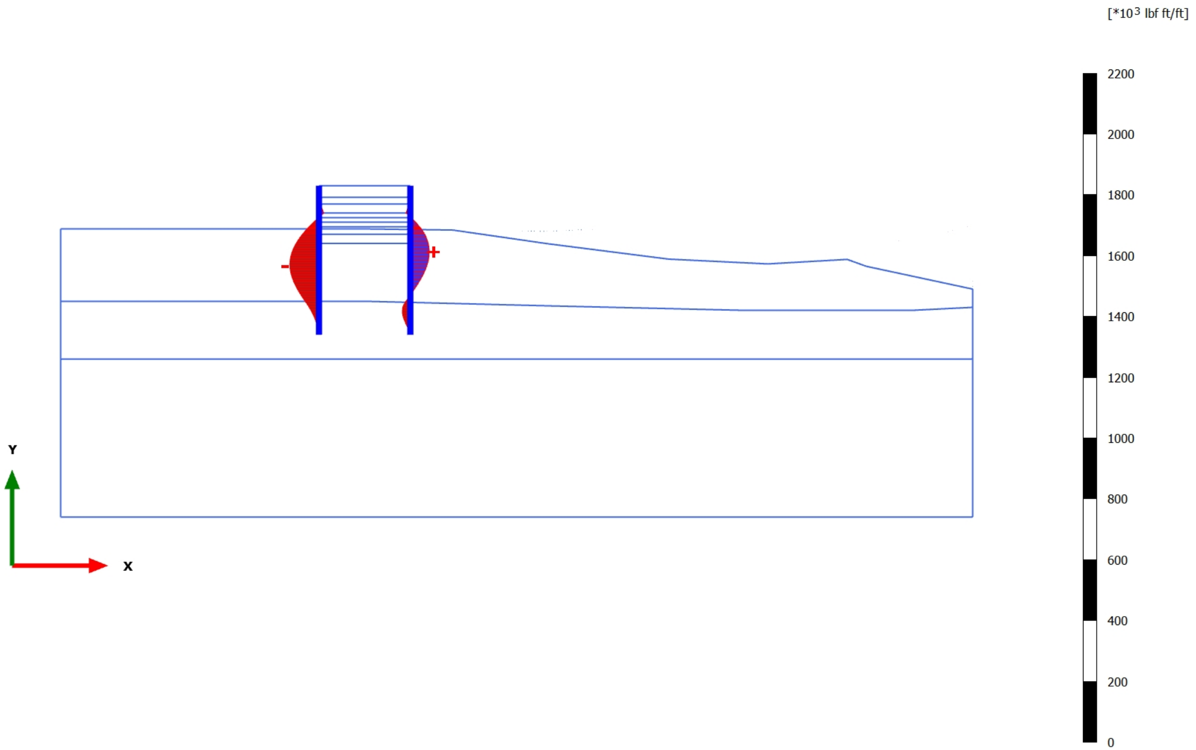


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 71.16*10^{3} lbf ft/ft (Element 29 at Node 8947)

Minimum value = -93.89*10^{3} lbf ft/ft (Element 25 at Node 7511)

3.1.2.2.9 Calculation results, Plate, Excavate 2 [Phase_21] (21/92), Bending moments M

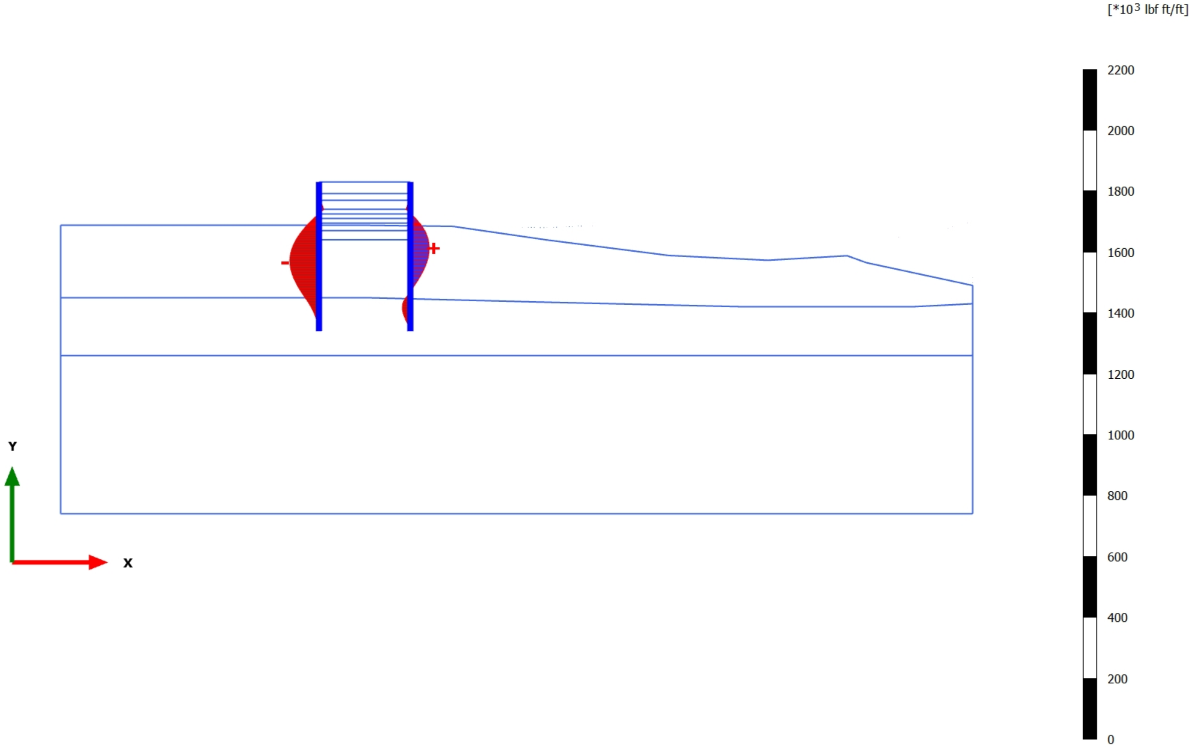


Bending moments M (scaled up $0.100*10^{-3}$ times)

Maximum value = $62.50*10^3$ lbf ft/ft (Element 29 at Node 8382)

Minimum value = $-96.13*10^3$ lbf ft/ft (Element 25 at Node 7512)

3.1.2.2.10 Calculation results, Plate, Consolidate [Phase_7] (7/98), Bending moments M

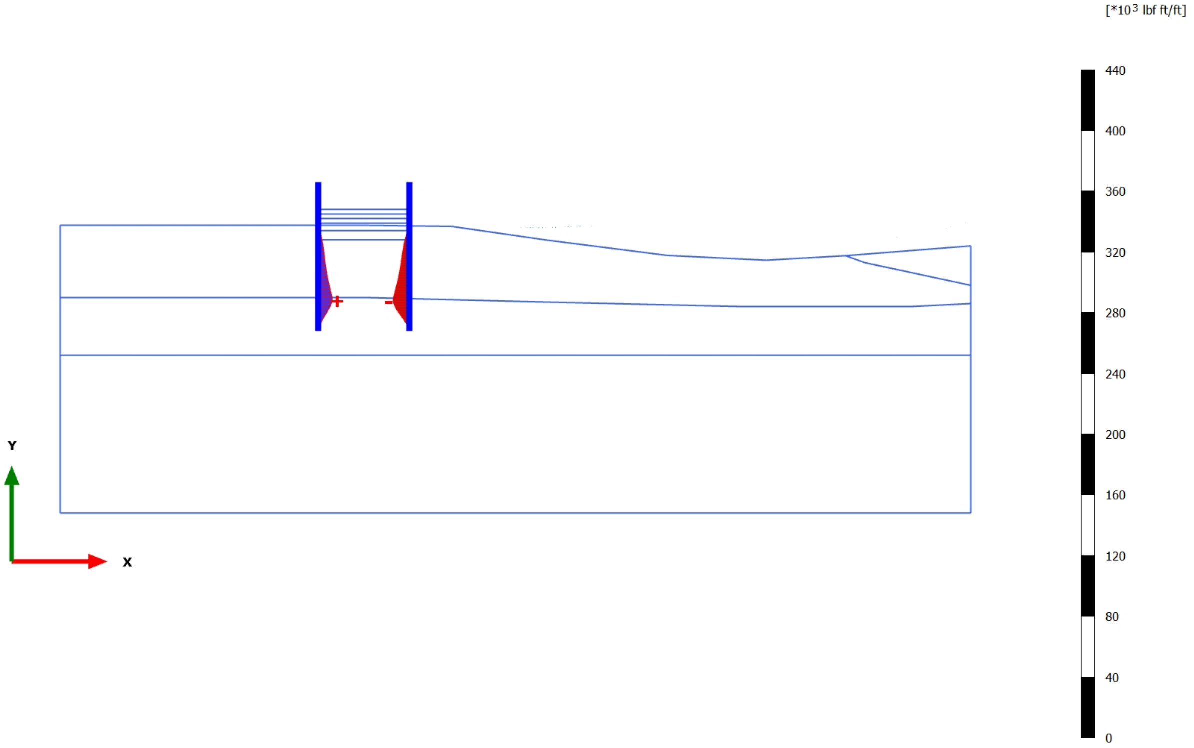


Bending moments M (scaled up 0.100*10^{-3} times) (Time 58.00 day)

Maximum value = 62.50*10^3 lbf ft/ft (Element 29 at Node 8382)

Minimum value = -96.14*10^3 lbf ft/ft (Element 25 at Node 7512)

3.1.2.2.11 Calculation results, Plate, Consolidate [Phase_25] (25/139), Bending moments M

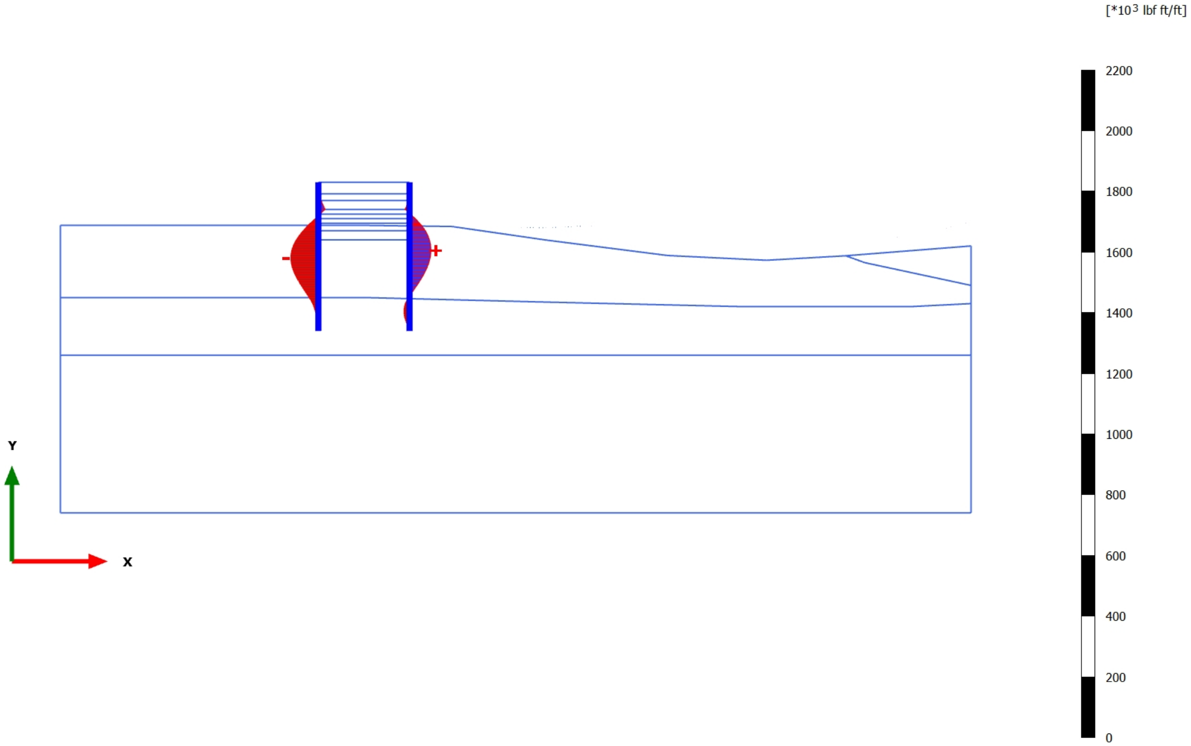


Bending moments M (scaled up 0.500*10^{-3} times) (Time 10.00 day)

Maximum value = 9276 lbf ft/ft (Element 35 at Node 10016)

Minimum value = -10.56*10^{3} lbf ft/ft (Element 38 at Node 12171)

3.1.2.2.12 Calculation results, Plate, Dewater-ss [Phase_16] (16/156), Bending moments M

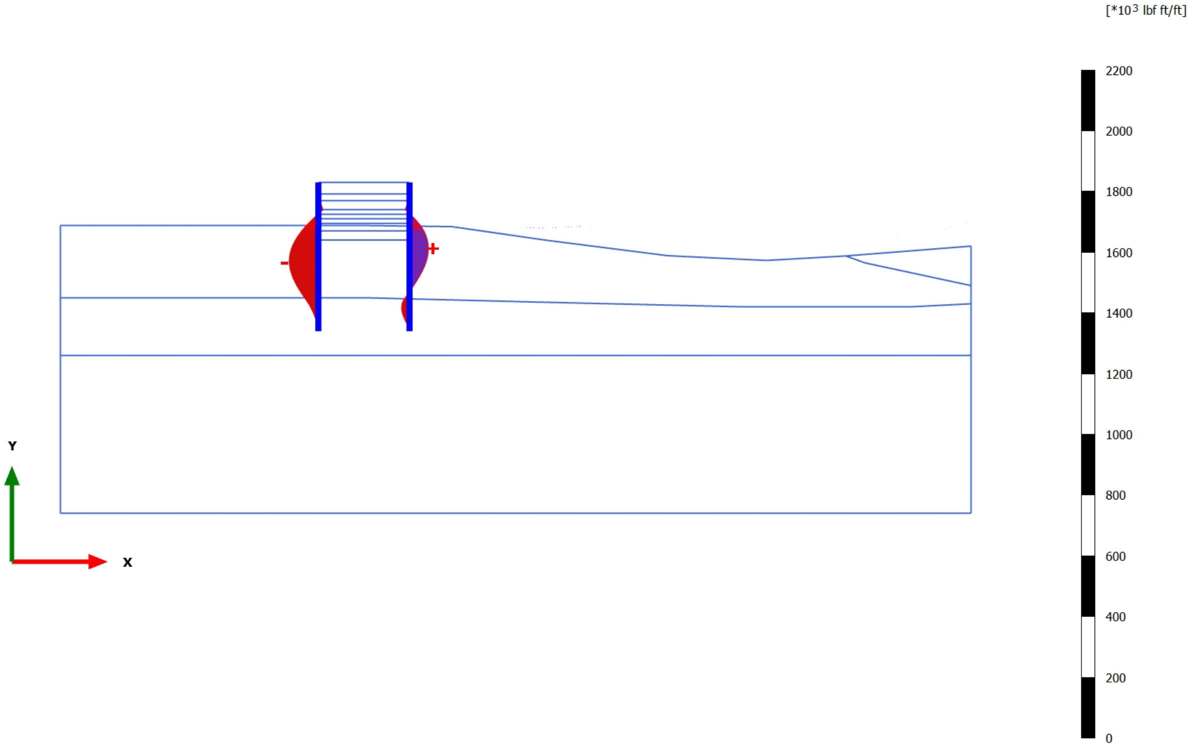


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 70.93*10^3 lbf ft/ft (Element 30 at Node 8947)

Minimum value = -90.90*10^3 lbf ft/ft (Element 24 at Node 6704)

3.1.2.2.13 Calculation results, Plate, Consolidate [Phase_20] (20/172), Bending moments M

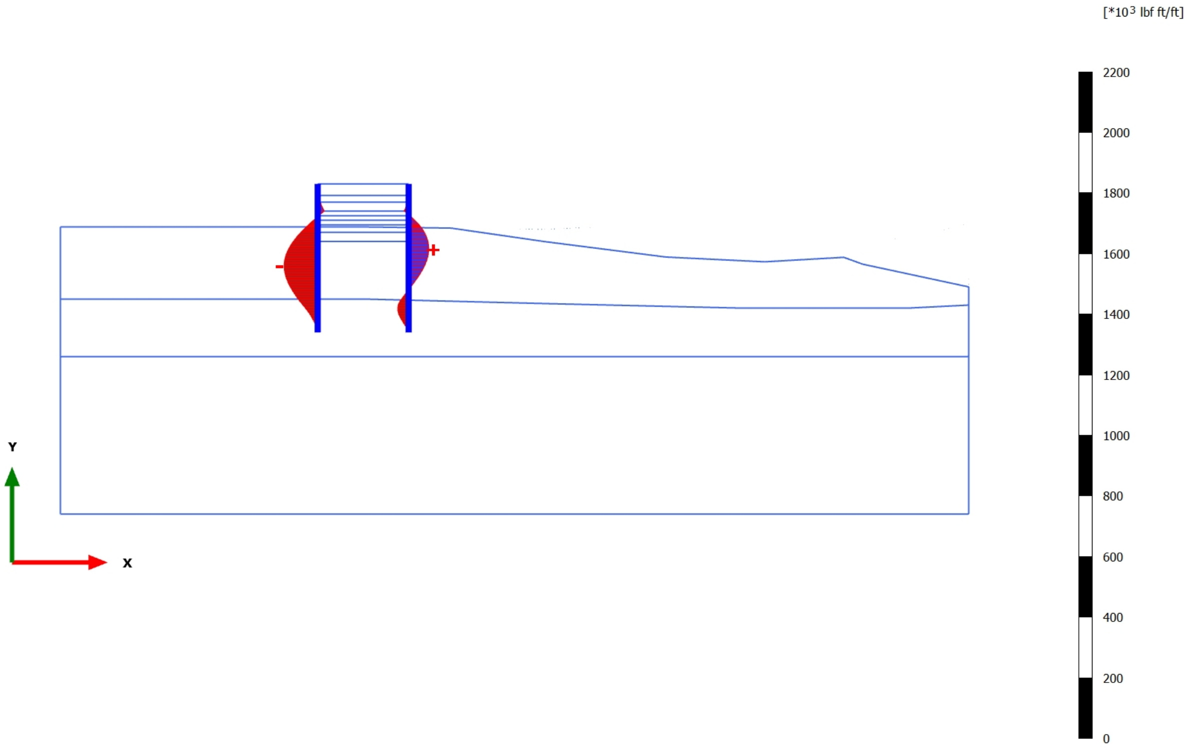


Bending moments M (scaled up 0.100*10^{-3} times) (Time 44.00 day)

Maximum value = 62.40*10^3 lbf ft/ft (Element 29 at Node 8382)

Minimum value = -96.10*10^3 lbf ft/ft (Element 25 at Node 7512)

3.1.2.2.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/180), Bending moments M

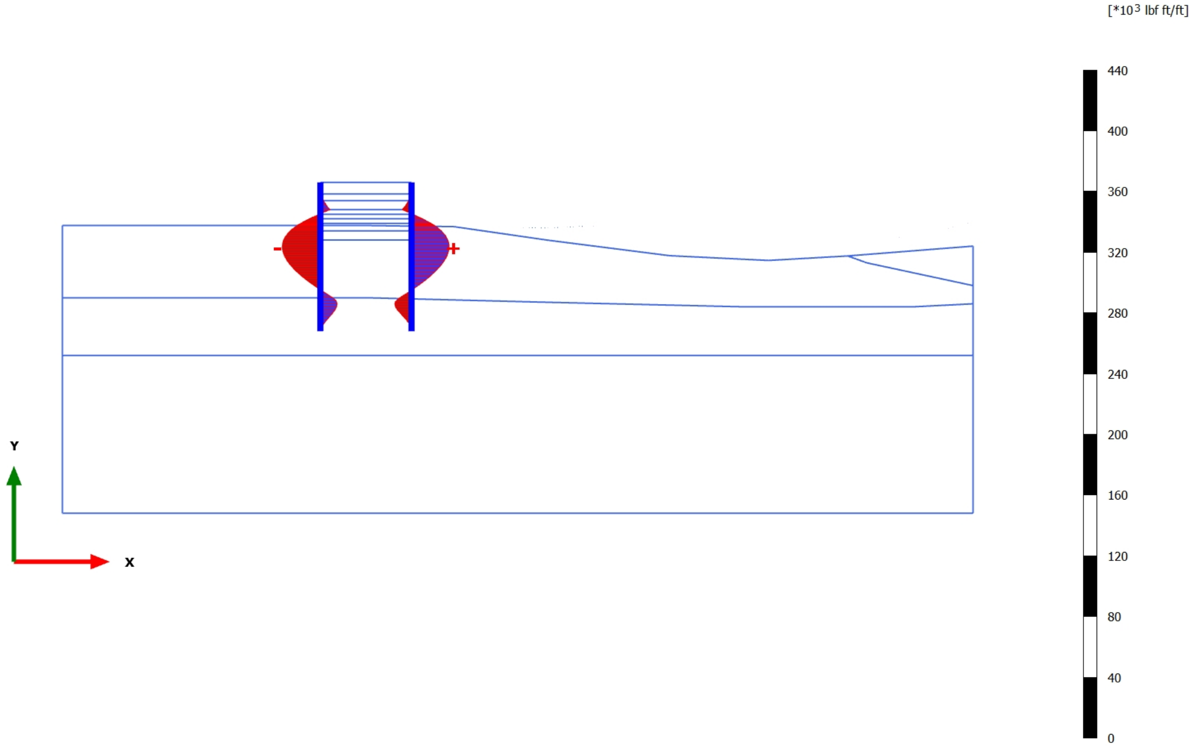


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 66.83*10^3 lbf ft/ft (Element 29 at Node 8382)

Minimum value = -111.2*10^3 lbf ft/ft (Element 25 at Node 7513)

3.1.2.2.15 Calculation results, Plate, Consolidate [Phase_26] (26/217), Bending moments M



Bending moments M (scaled up 0.500*10^{-3} times) (Time 23.00 day)

Maximum value = 24.79*10^{3} lbf ft/ft (Element 29 at Node 8382)

Minimum value = -25.14*10^{3} lbf ft/ft (Element 23 at Node 6100)

3.2.1.1.3 Calculation results, Node-to-node anchor, Install tie [Phase_8] (4/44), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	3.676	0.000	3.676
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	3.676	0.000	3.676

3.2.1.1.4 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/52), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	7964.177	0.000	7964.177
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	7964.177	0.000	7964.177

3.2.1.1.5 Calculation results, Node-to-node anchor, Consolidate [Phase_9] (8/63), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	7563.015	0.000	7964.177
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	7563.015	0.000	7964.177

3.2.1.1.6 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/74), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	44.247	0.000	44.247
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	44.247	0.000	44.247

3.2.1.1.7 Calculation results, Node-to-node anchor, Consolidate [Phase_17] (17/85), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	98.117	0.000	100.213
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	98.117	0.000	100.213

3.2.1.1.8 Calculation results, Node-to-node anchor, Dewater 2 - ss [Phase_19] (19/89), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	99.567	0.000	100.213
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	99.567	0.000	100.213

3.2.1.1.9 Calculation results, Node-to-node anchor, Excavate 2 [Phase_21] (21/92), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	94.469	0.000	100.213
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	94.469	0.000	100.213

3.2.1.1.10 Calculation results, Node-to-node anchor, Consolidate [Phase_7] (7/98), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	94.486	0.000	100.213
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	94.486	0.000	100.213

3.2.1.1.12 Calculation results, Node-to-node anchor, Dewater-ss [Phase_16] (16/156), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	99.455	0.000	99.455
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	99.455	0.000	99.455

3.2.1.1.13 Calculation results, Node-to-node anchor, Consolidate [Phase_20] (20/172), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	94.421	0.000	100.213
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	94.421	0.000	100.213

3.2.1.1.14 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_22] (22/180), Table of node-to-node anchors

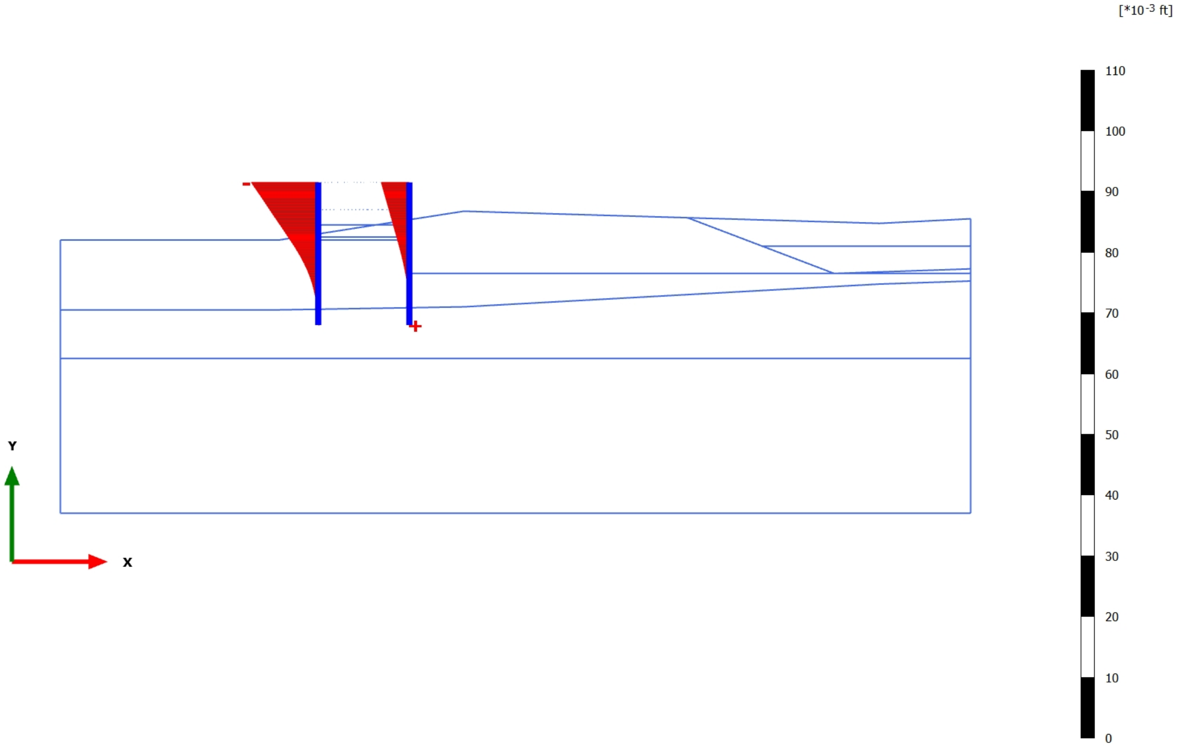
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	106.155	0.000	106.155
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	106.155	0.000	106.155

3.2.1.1.15 Calculation results, Node-to-node anchor, Consolidate [Phase_26] (26/217), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	18	1	-15.000	0.000	40.647	0.000	44.310
Element 3-3 (Node-to-node anchor)	1141	2	15.000	0.000	40.647	0.000	44.310

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/12), Total displacements u_x

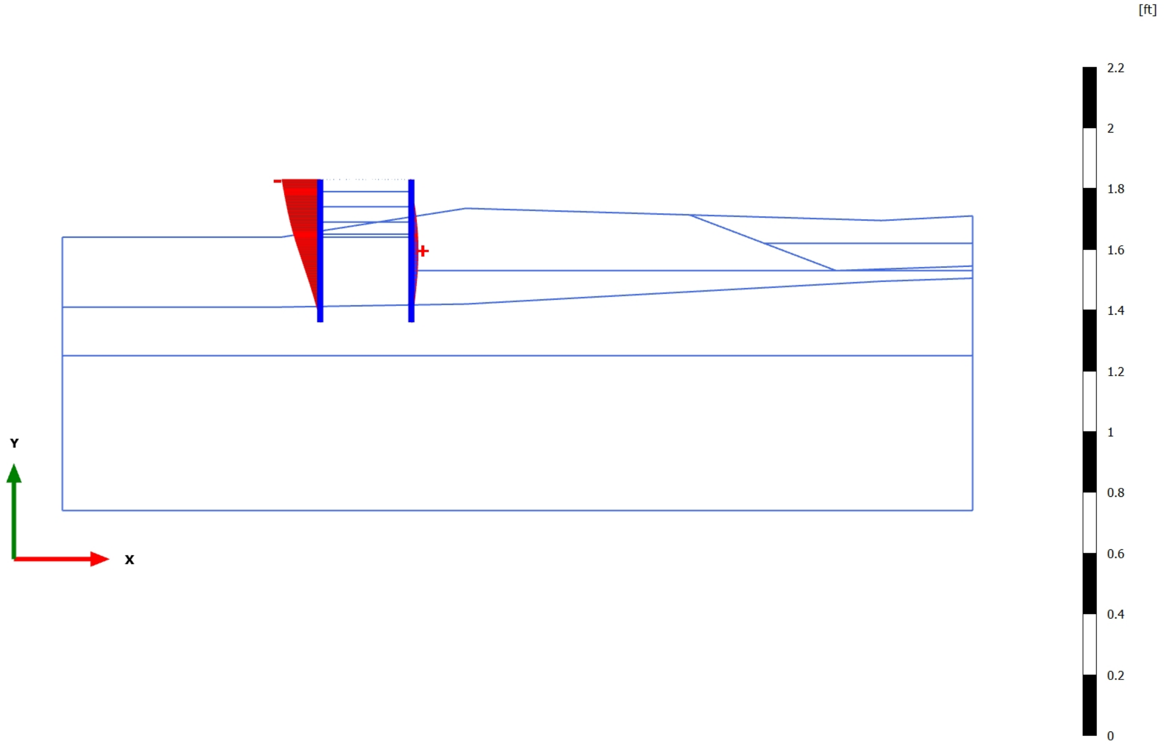


Total displacements u_x (scaled up 2.00×10^3 times)

Maximum value = 0.2947×10^{-3} ft (Element 32 at Node 11946)

Minimum value = -0.01101 ft (Element 1 at Node 17341)

3.1.1.1.1.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/38), Total displacements u_x

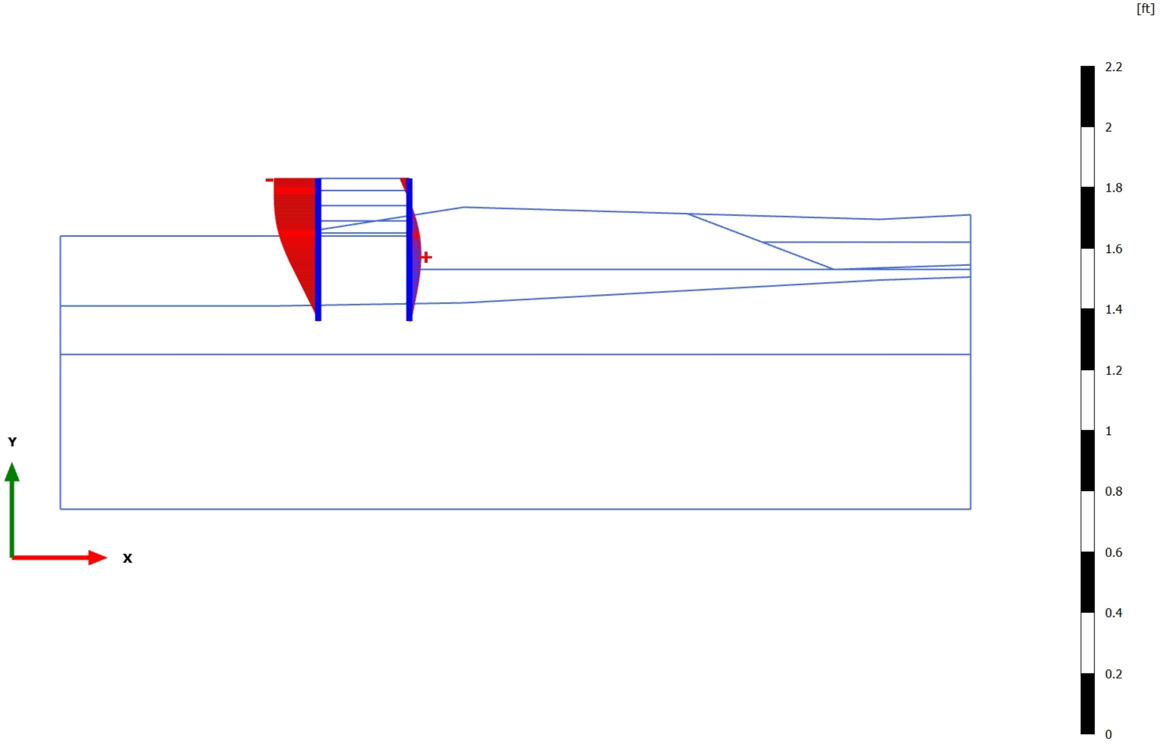


Total displacements u_x (scaled up 100 times)

Maximum value = 0.02237 ft (Element 20 at Node 13362)

Minimum value = -0.1263 ft (Element 1 at Node 17341)

3.1.1.1.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/52), Total displacements u_x

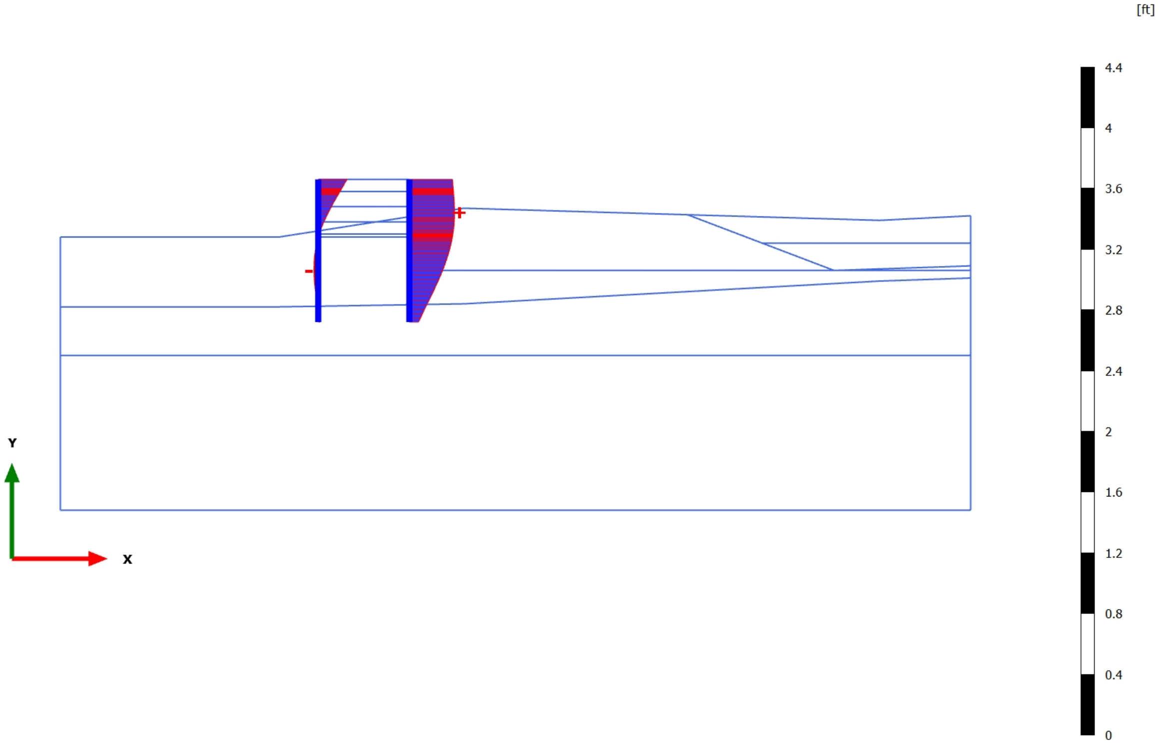


Total displacements u_x (scaled up 100 times)

Maximum value = 0.03851 ft (Element 20 at Node 13359)

Minimum value = -0.1457 ft (Element 1 at Node 17341)

3.1.1.1.1.4 Calculation results, Plate, Dewater [Phase_7] (7/84), Total displacements u_x

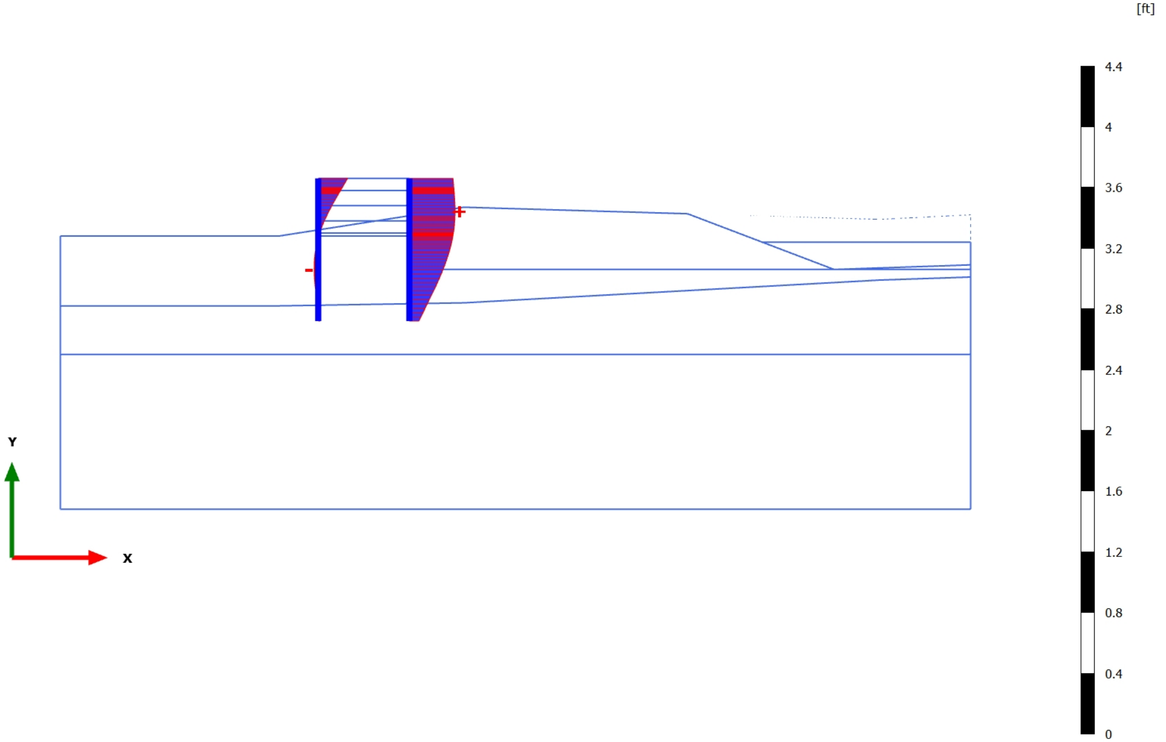


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.2986 ft (Element 9 at Node 14748)

Minimum value = -0.02892 ft (Element 26 at Node 14661)

3.1.1.1.1.5 Calculation results, Plate, Excavate 1 [Phase_8] (8/92), Total displacements u_x

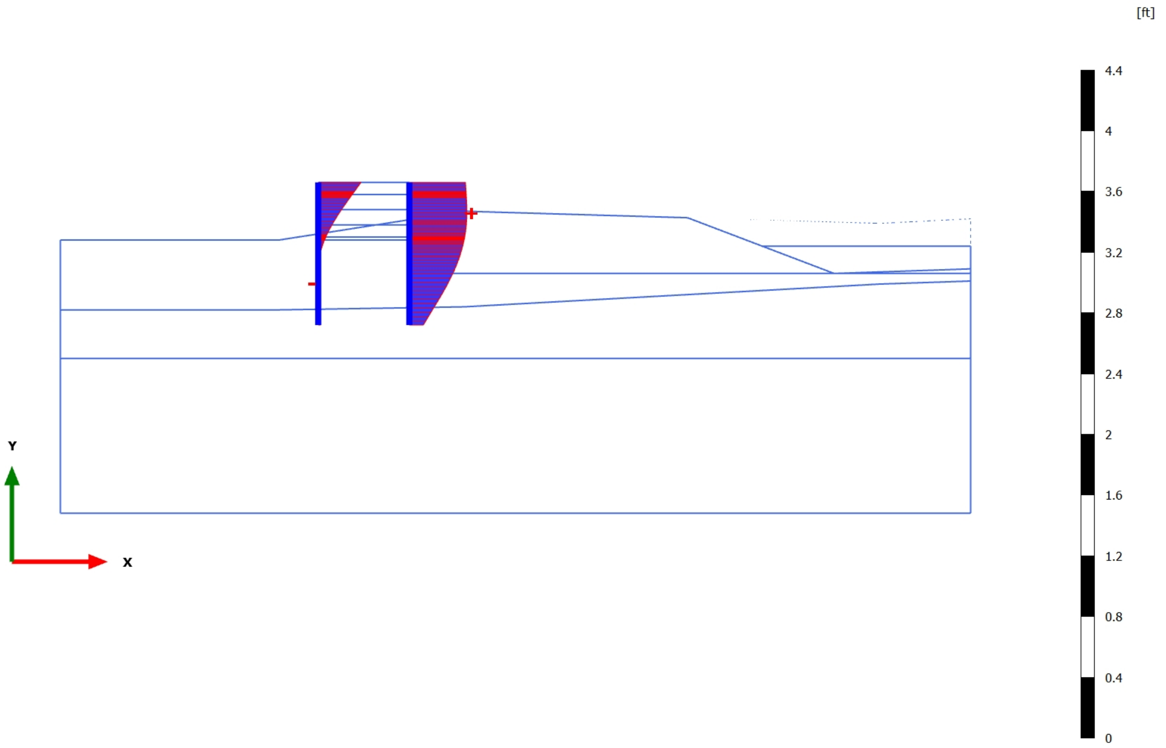


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3020 ft (Element 9 at Node 14748)

Minimum value = -0.02741 ft (Element 26 at Node 14661)

3.1.1.1.1.6 Calculation results, Plate, Dewater [Phase_9] (9/104), Total displacements u_x

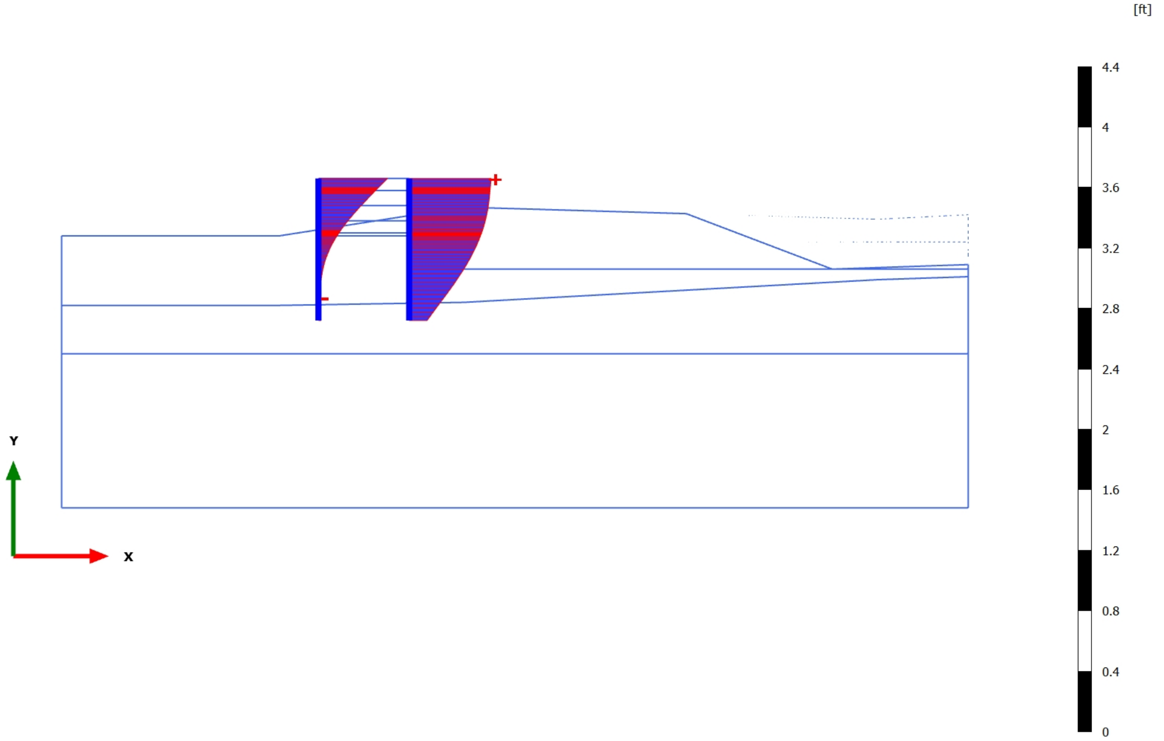


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3799 ft (Element 9 at Node 14747)

Minimum value = -0.01111 ft (Element 27 at Node 14199)

3.1.1.1.1.7 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/129), Total displacements u_x

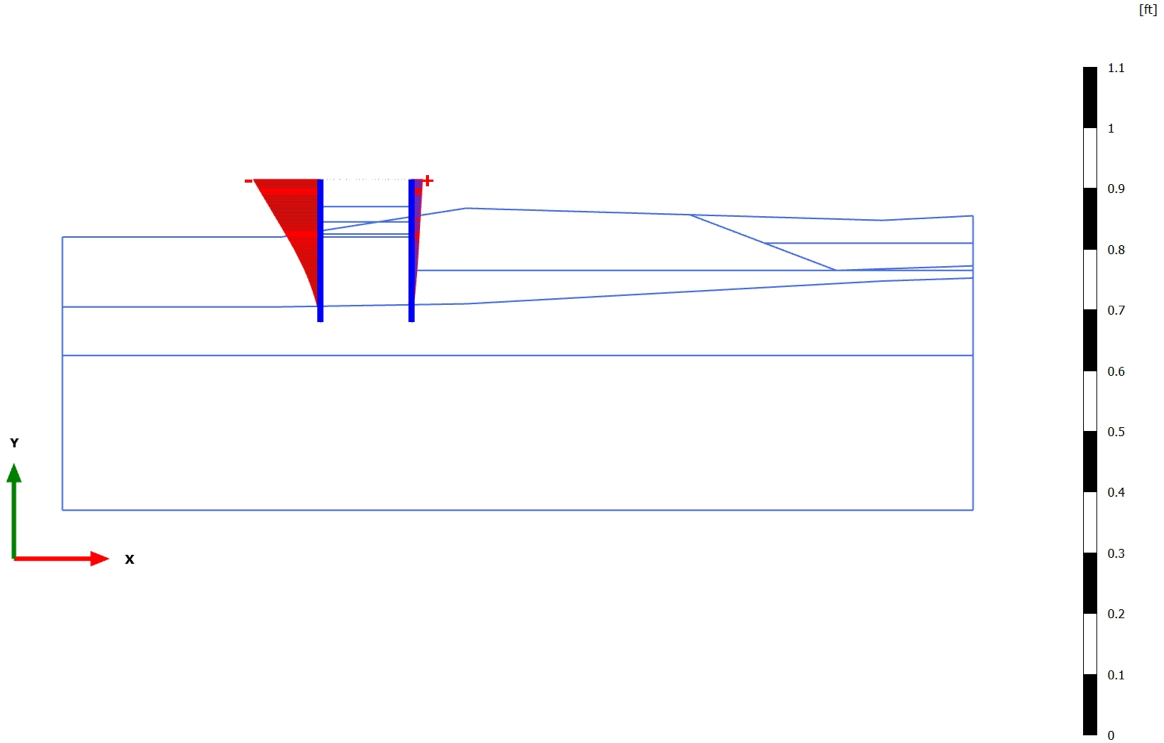


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.5429 ft (Element 2 at Node 14763)

Minimum value = 0.01252 ft (Element 29 at Node 13633)

3.1.1.1.1.8 Calculation results, Plate, Backfill 2 [Phase_3] (3/462), Total displacements u_x

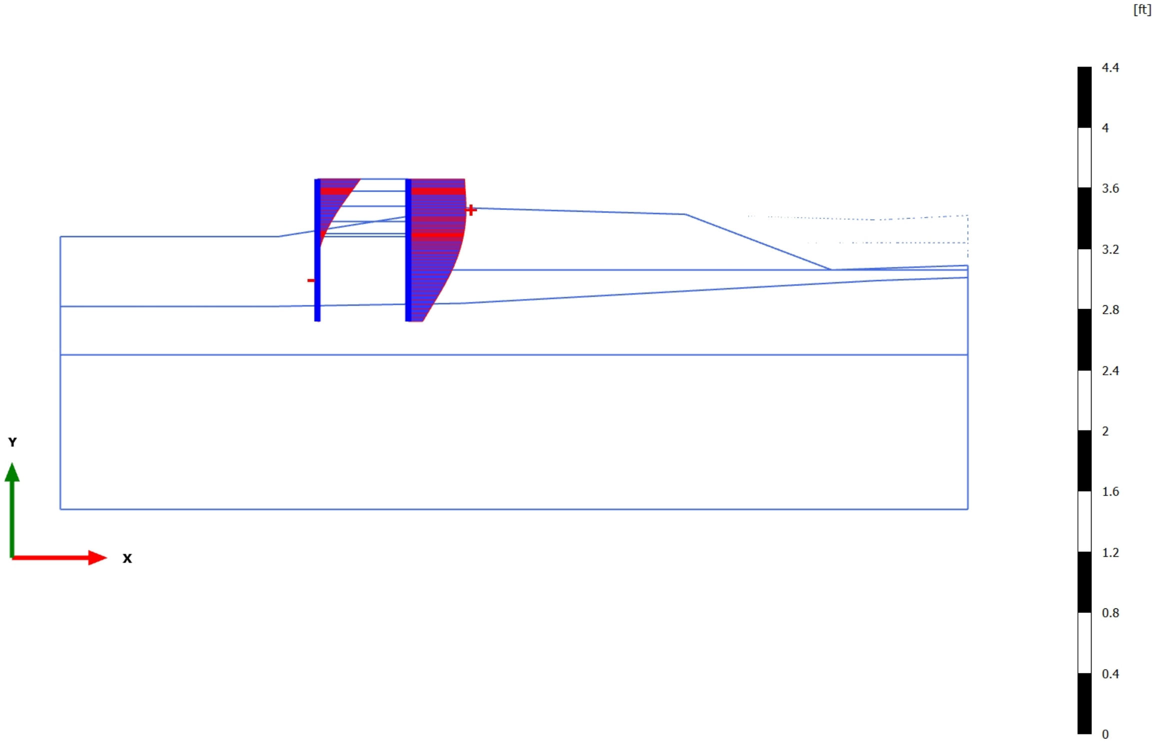


Total displacements u_x (scaled up 200 times)

Maximum value = 0.01823 ft (Element 2 at Node 14763)

Minimum value = -0.1107 ft (Element 1 at Node 17341)

3.1.1.1.1.9 Calculation results, Plate, Excavate 2 [Phase_10] (10/471), Total displacements u_x

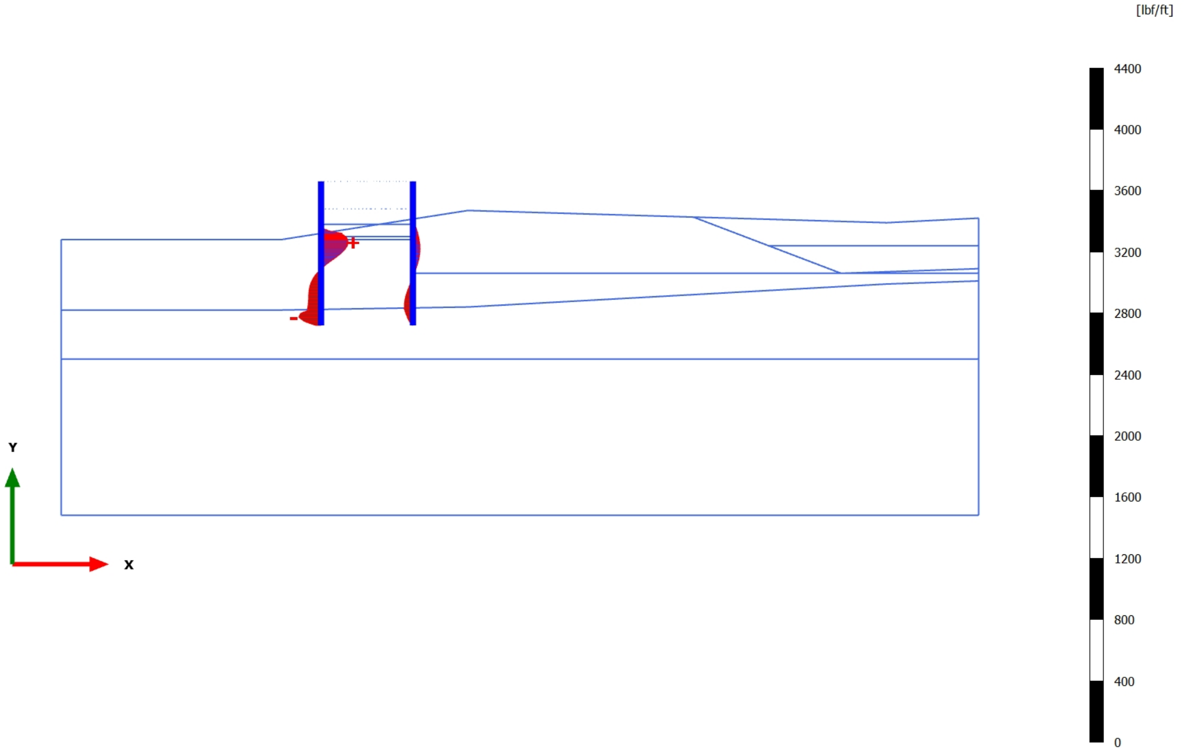


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3823 ft (Element 9 at Node 14747)

Minimum value = -0.01080 ft (Element 27 at Node 14199)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/12), Shear forces Q

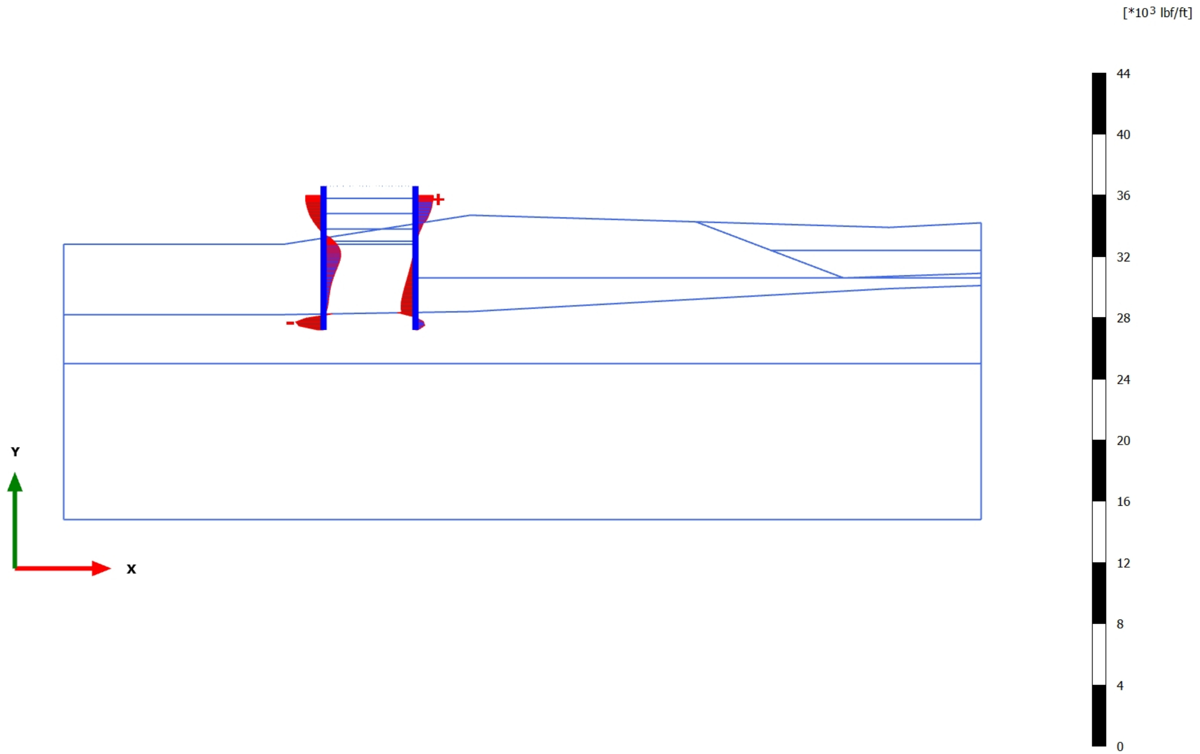


Shear forces Q (scaled up 0.0500 times)

Maximum value = 176.7 lbf/ft (Element 22 at Node 16161)

Minimum value = -146.4 lbf/ft (Element 33 at Node 13305)

3.1.2.1.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/38), Shear forces Q

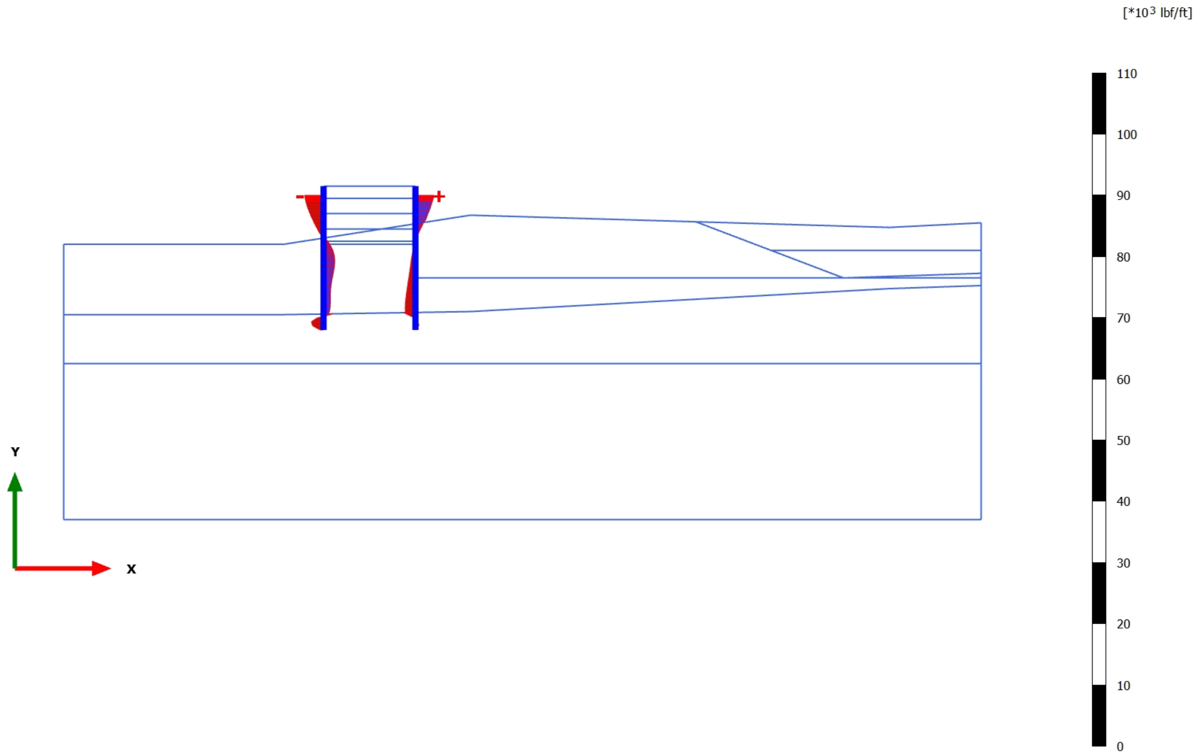


Shear forces Q (scaled up 5.00×10^{-3} times)

Maximum value = 1177 lbf/ft (Element 7 at Node 14758)

Minimum value = -1847 lbf/ft (Element 33 at Node 13305)

3.1.2.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/52), Shear forces Q

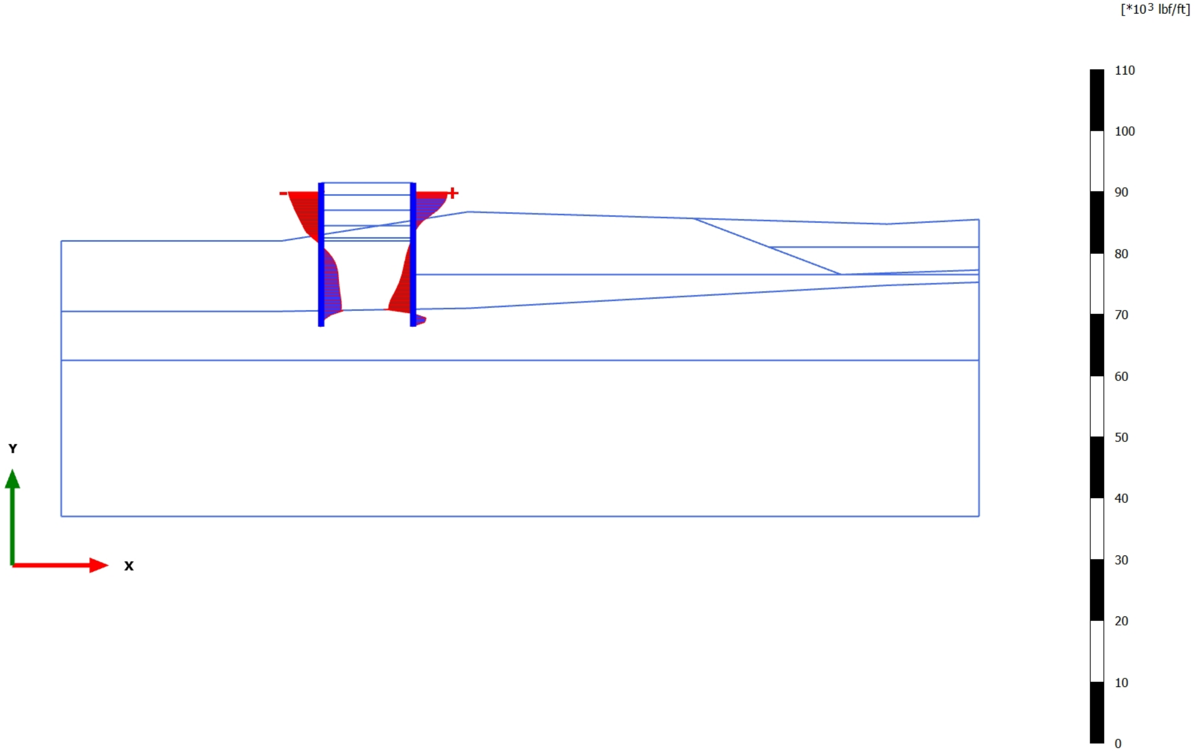


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 3017 lbf/ft (Element 4 at Node 14762)

Minimum value = -3097 lbf/ft (Element 3 at Node 17338)

3.1.2.1.4 Calculation results, Plate, Dewater [Phase_7] (7/84), Shear forces Q

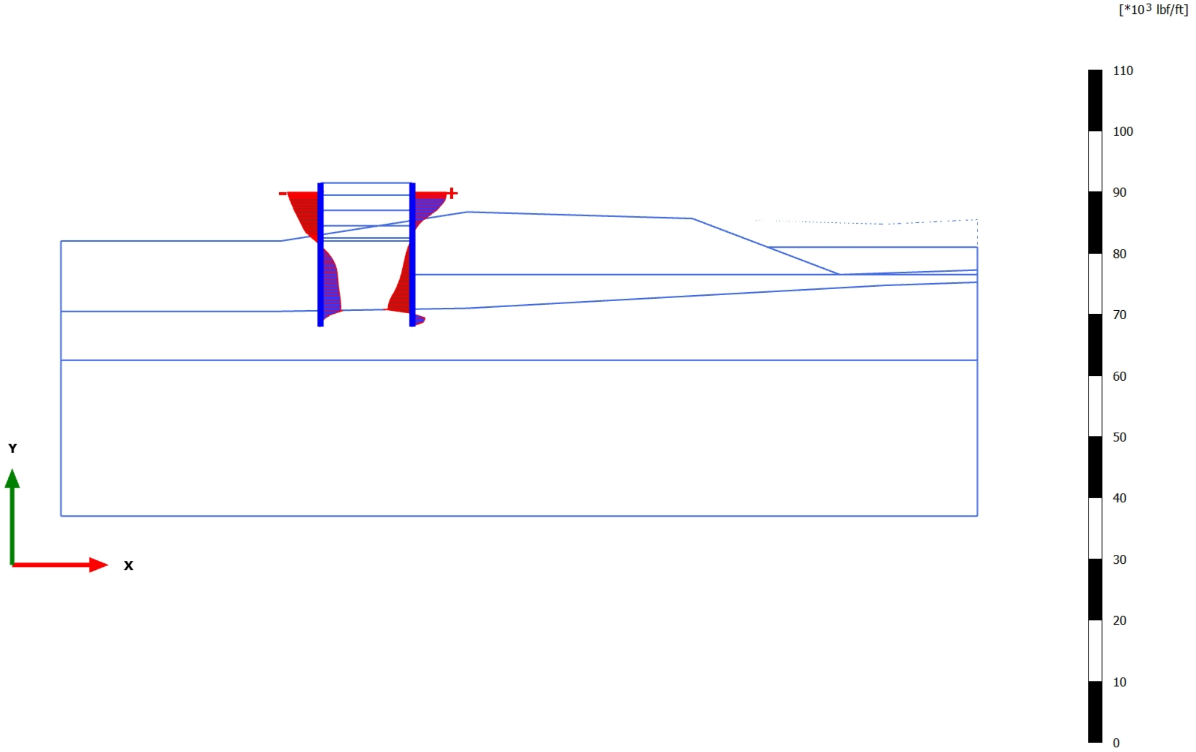


Shear forces Q (scaled up 2.00×10^{-3} times)

Maximum value = 5633 lbf/ft (Element 4 at Node 14762)

Minimum value = -5423 lbf/ft (Element 3 at Node 17338)

3.1.2.1.5 Calculation results, Plate, Excavate 1 [Phase_8] (8/92), Shear forces Q

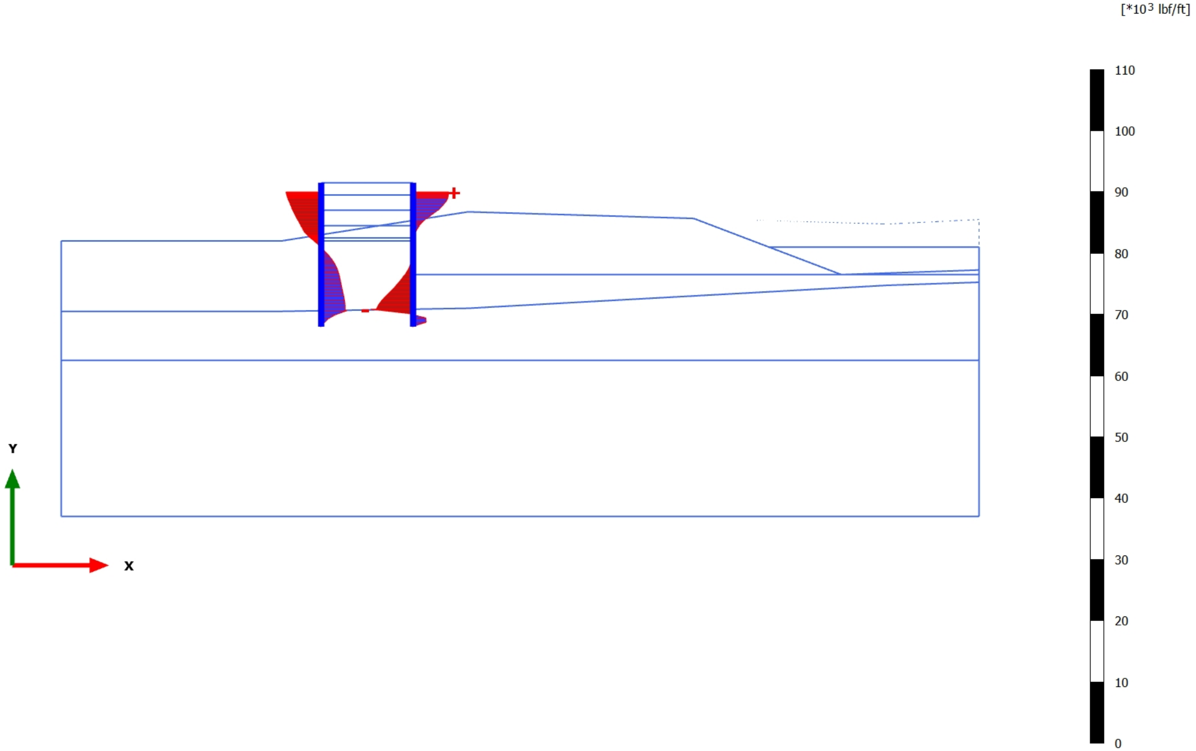


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 5648 lbf/ft (Element 4 at Node 14762)

Minimum value = -5440 lbf/ft (Element 3 at Node 17338)

3.1.2.1.6 Calculation results, Plate, Dewater [Phase_9] (9/104), Shear forces Q

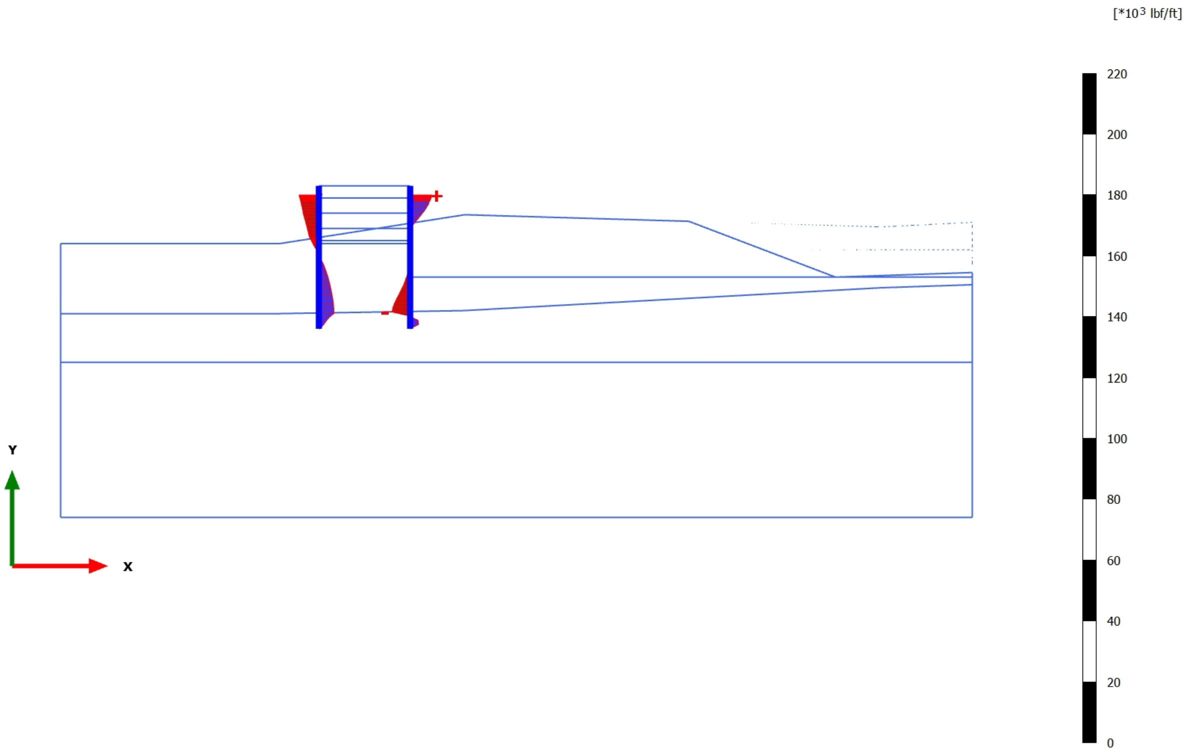


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 5832 lbf/ft (Element 4 at Node 14762)

Minimum value = -6958 lbf/ft (Element 32 at Node 12044)

3.1.2.1.7 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/129), Shear forces Q

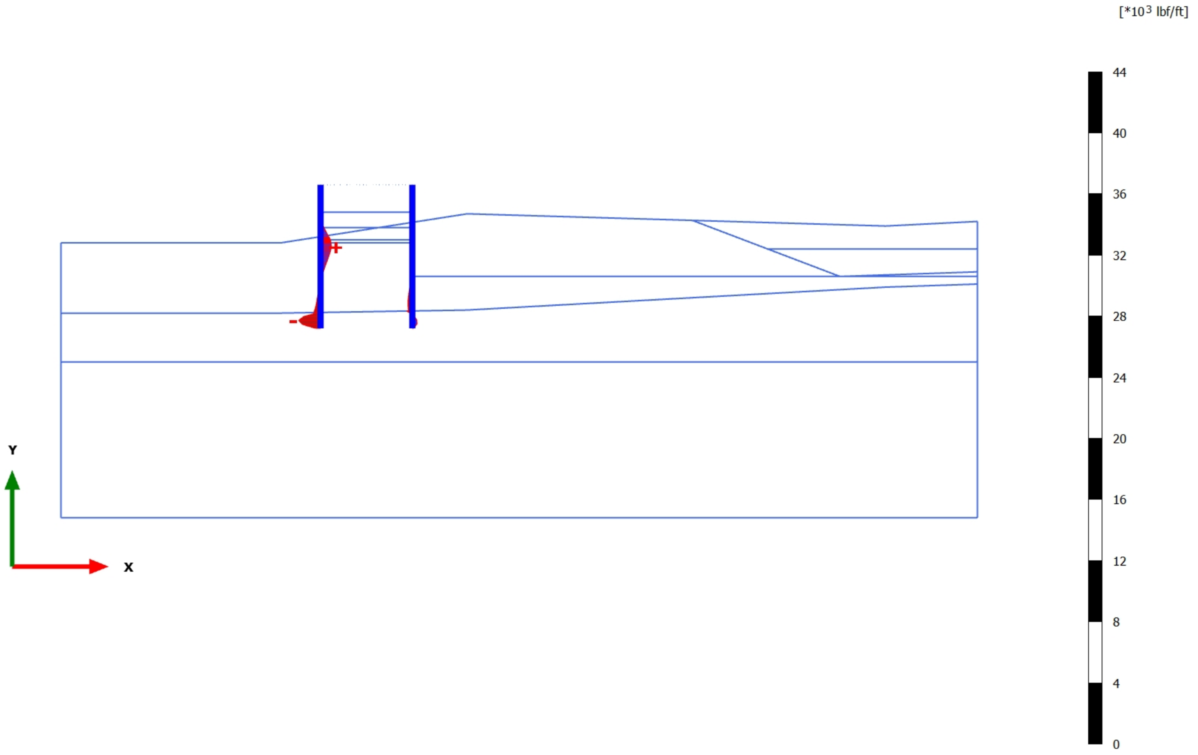


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 7197 lbf/ft (Element 4 at Node 14762)

Minimum value = -6648 lbf/ft (Element 32 at Node 12044)

3.1.2.1.8 Calculation results, Plate, Backfill 2 [Phase_3] (3/462), Shear forces Q

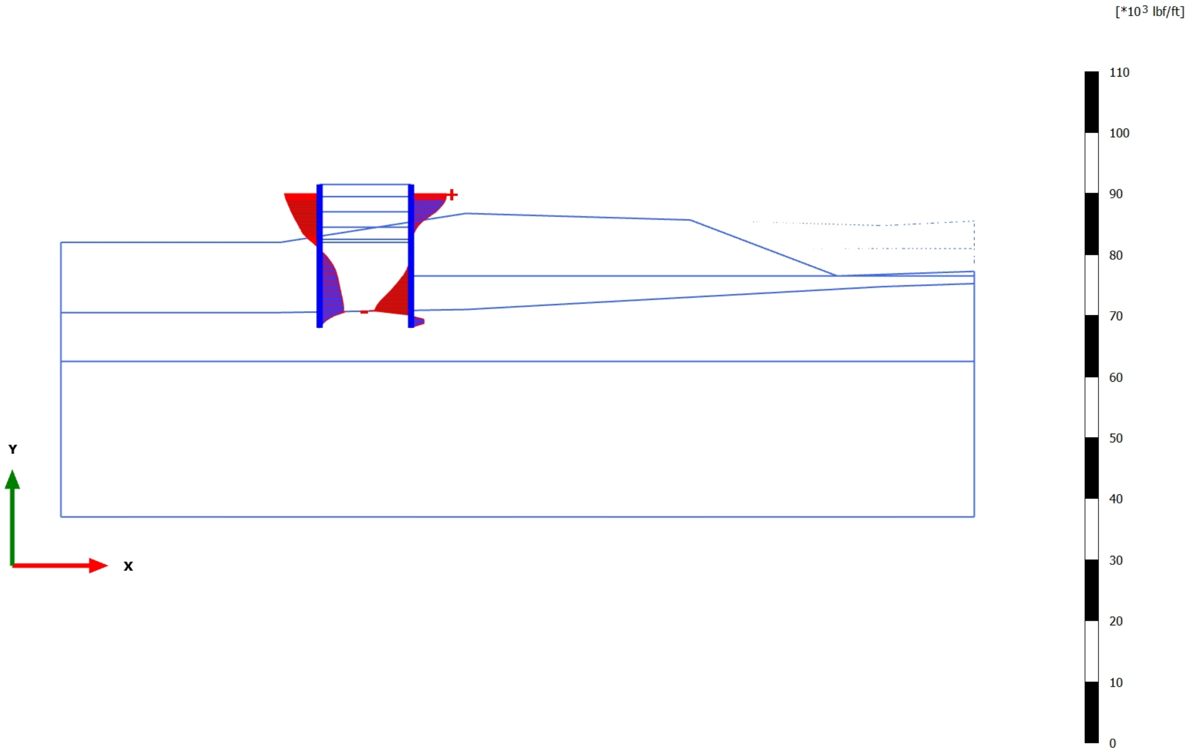


Shear forces Q (scaled up 5.00*10⁻³ times)

Maximum value = 698.5 lbf/ft (Element 22 at Node 16160)

Minimum value = -1454 lbf/ft (Element 33 at Node 13305)

3.1.2.1.9 Calculation results, Plate, Excavate 2 [Phase_10] (10/471), Shear forces Q

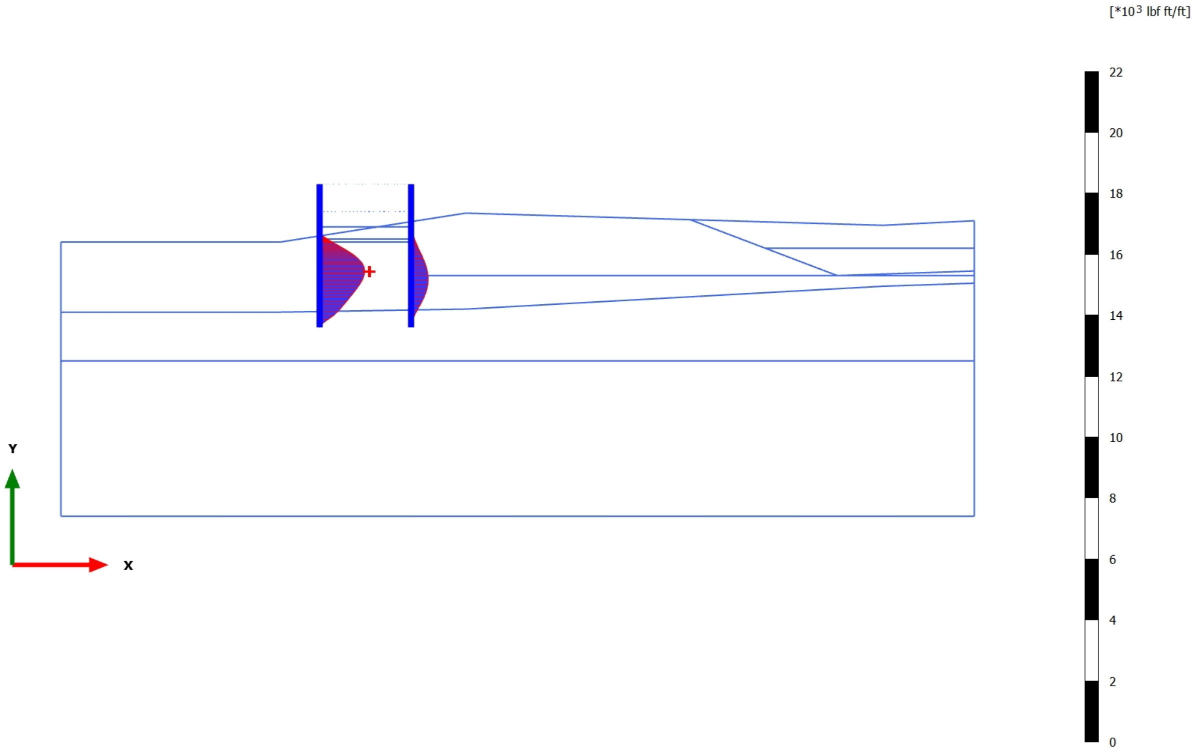


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 5846 lbf/ft (Element 4 at Node 14762)

Minimum value = -6929 lbf/ft (Element 32 at Node 12044)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/12), Bending moments M

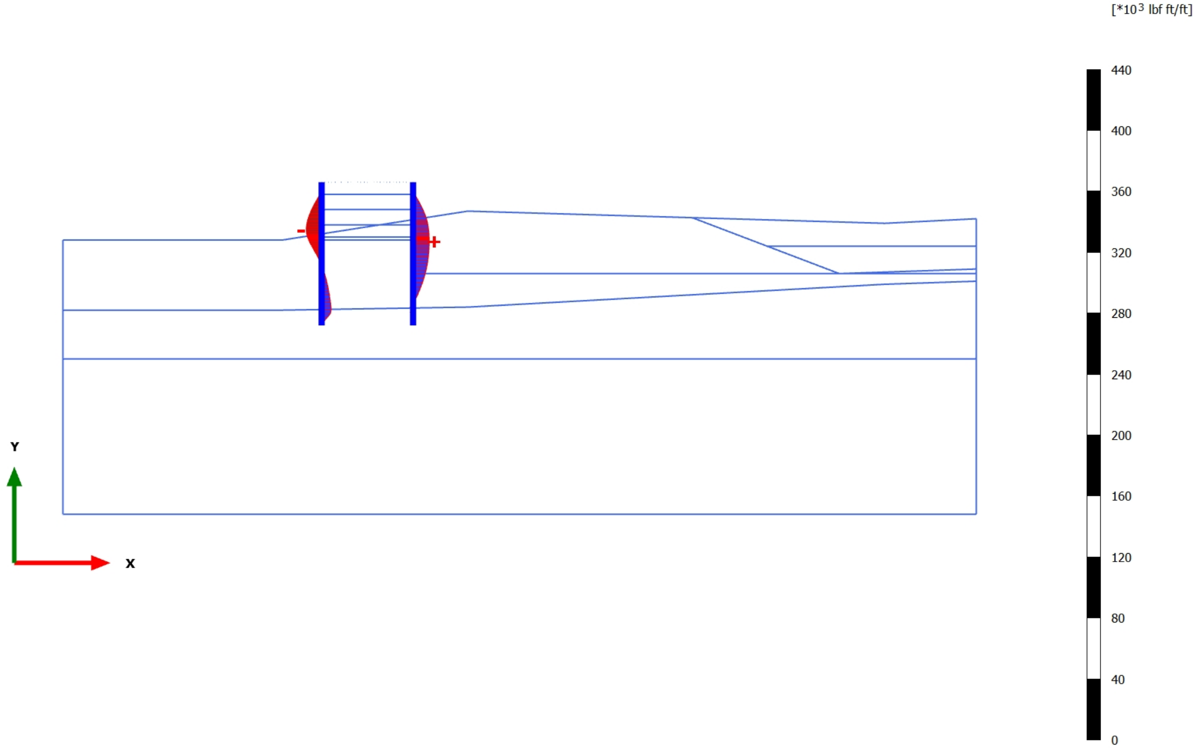


Bending moments M (scaled up 0.0100 times)

Maximum value = 1479 lbf ft/ft (Element 26 at Node 14663)

Minimum value = $-1.416*10^{-12}$ lbf ft/ft (Element 33 at Node 13303)

3.1.2.2.2 Calculation results, Plate, Backfill 3 [Phase_5] (5/38), Bending moments M

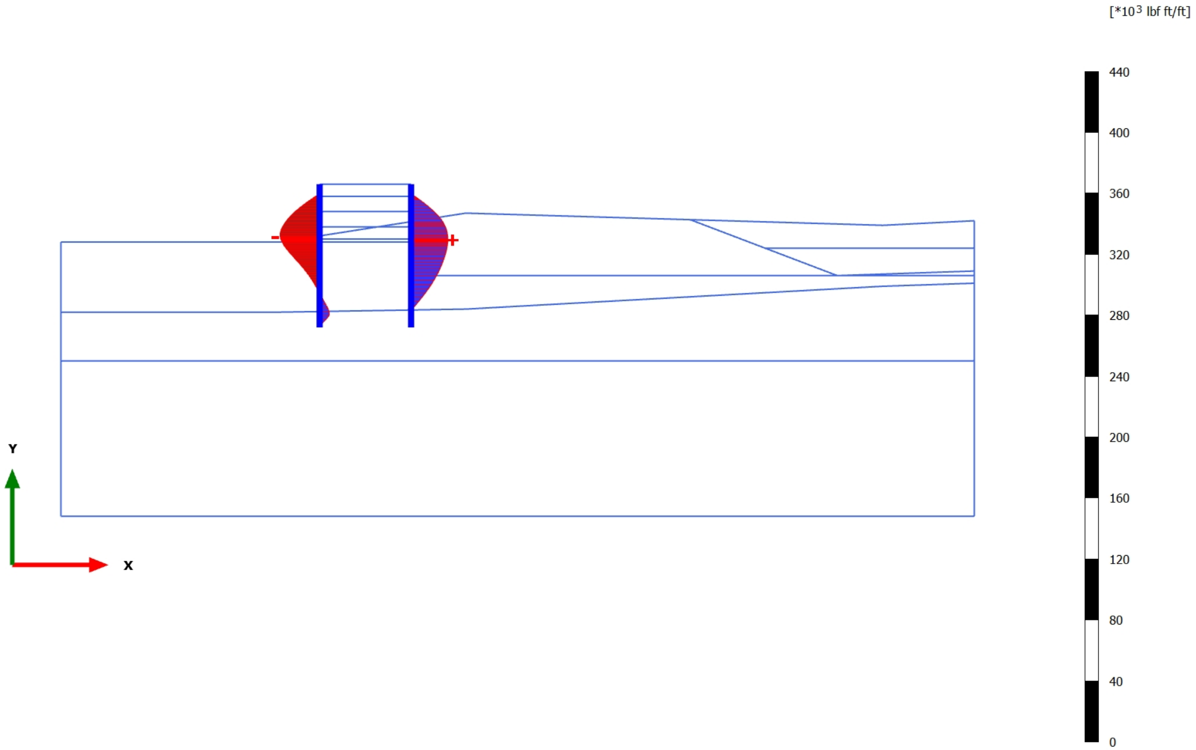


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.67*10^3$ lbf ft/ft (Element 18 at Node 14132)

Minimum value = $-10.19*10^3$ lbf ft/ft (Element 12 at Node 16402)

3.1.2.2.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/52), Bending moments M

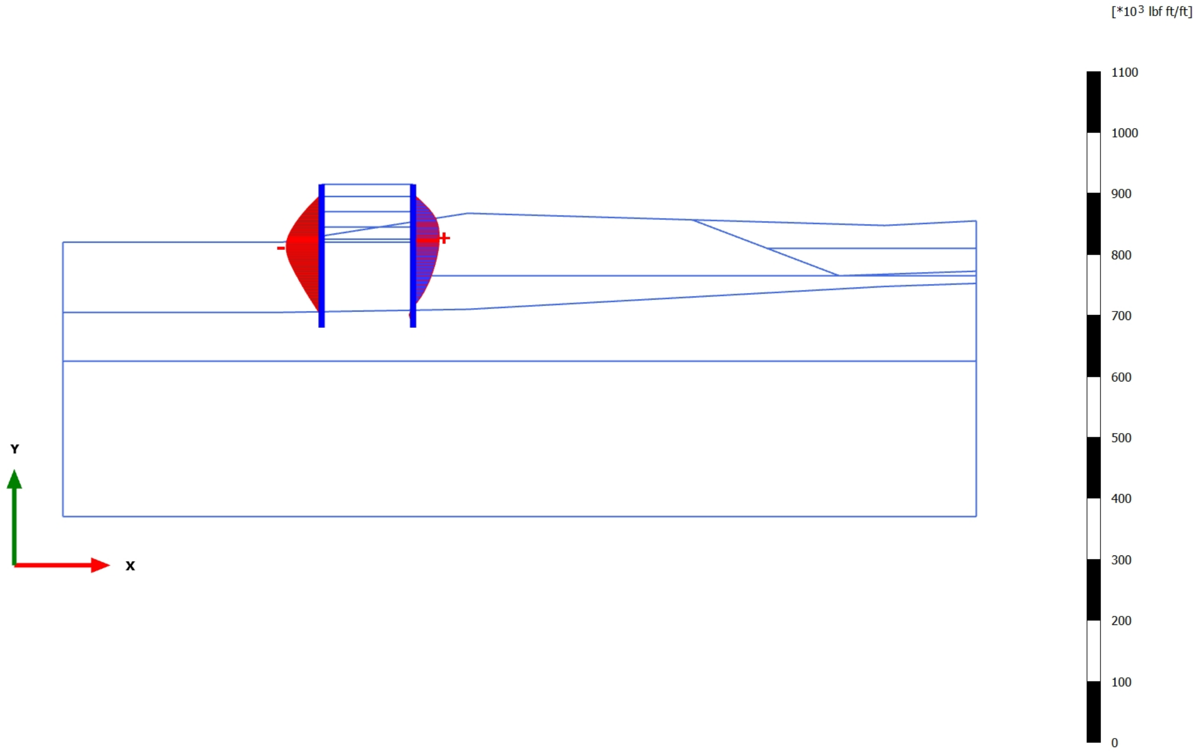


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $24.21*10^3$ lbf ft/ft (Element 17 at Node 14573)

Minimum value = $-26.03*10^3$ lbf ft/ft (Element 12 at Node 16400)

3.1.2.2.4 Calculation results, Plate, Dewater [Phase_7] (7/84), Bending moments M

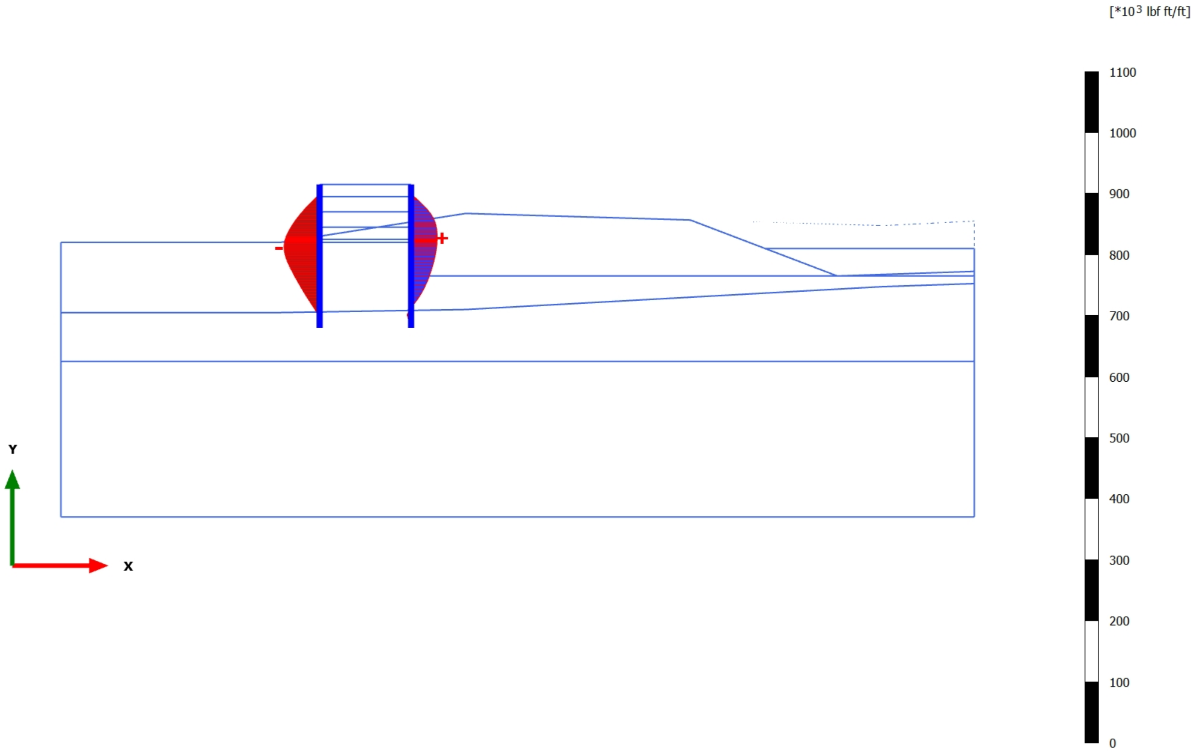


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 43.15*10^{3} lbf ft/ft (Element 14 at Node 14575)

Minimum value = -58.37*10^{3} lbf ft/ft (Element 23 at Node 16159)

3.1.2.2.5 Calculation results, Plate, Excavate 1 [Phase_8] (8/92), Bending moments M

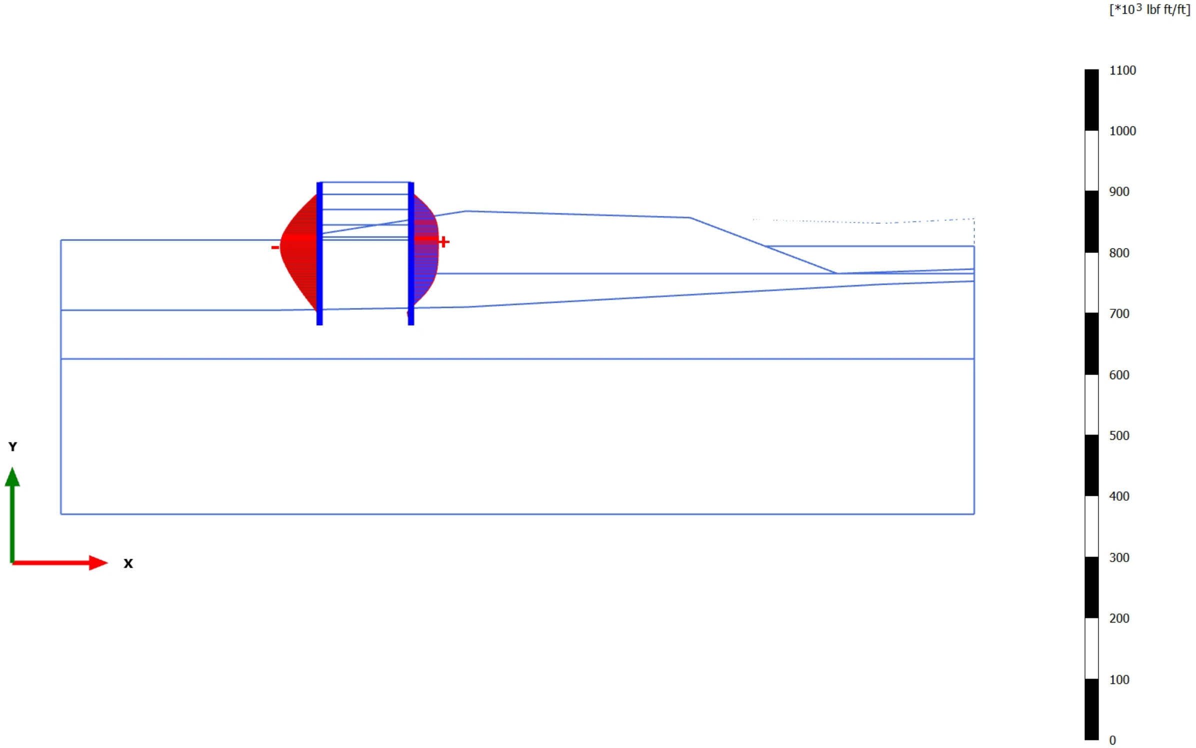


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $42.99*10^3$ lbf ft/ft (Element 14 at Node 14575)

Minimum value = $-58.50*10^3$ lbf ft/ft (Element 23 at Node 16159)

3.1.2.2.6 Calculation results, Plate, Dewater [Phase_9] (9/104), Bending moments M

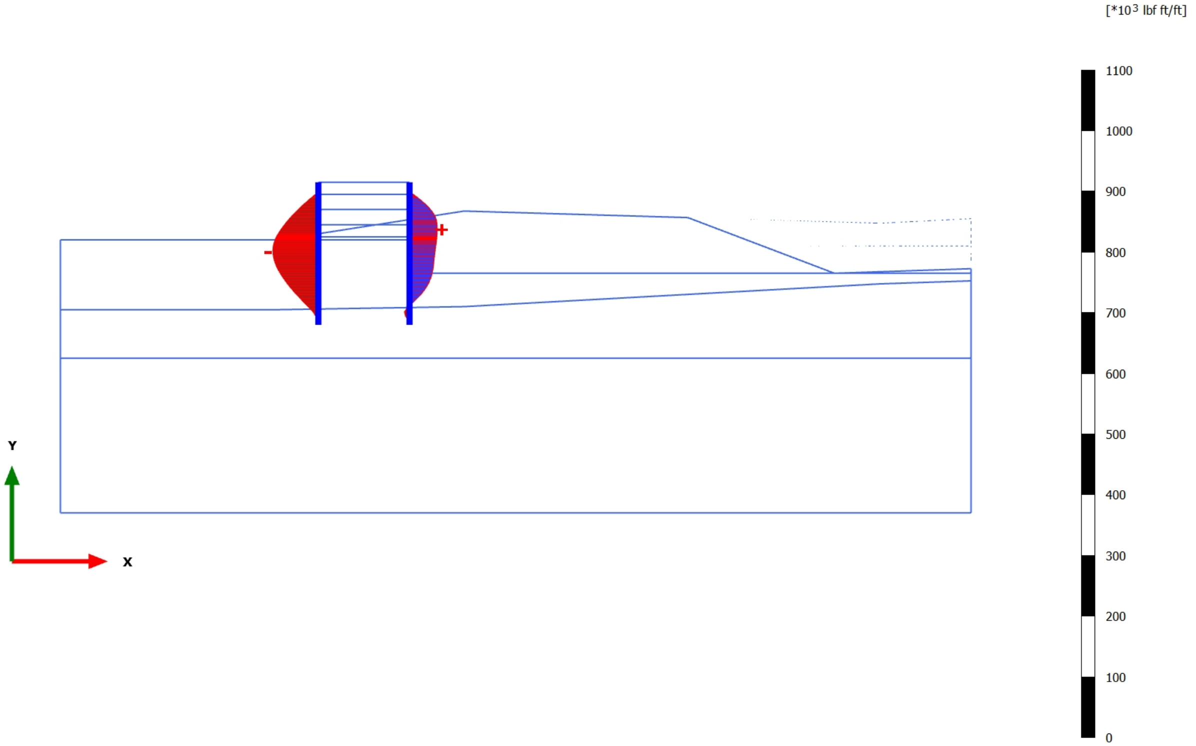


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $45.10*10^3$ lbf ft/ft (Element 18 at Node 14132)

Minimum value = $-64.75*10^3$ lbf ft/ft (Element 23 at Node 15810)

3.1.2.2.7 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/129), Bending moments M

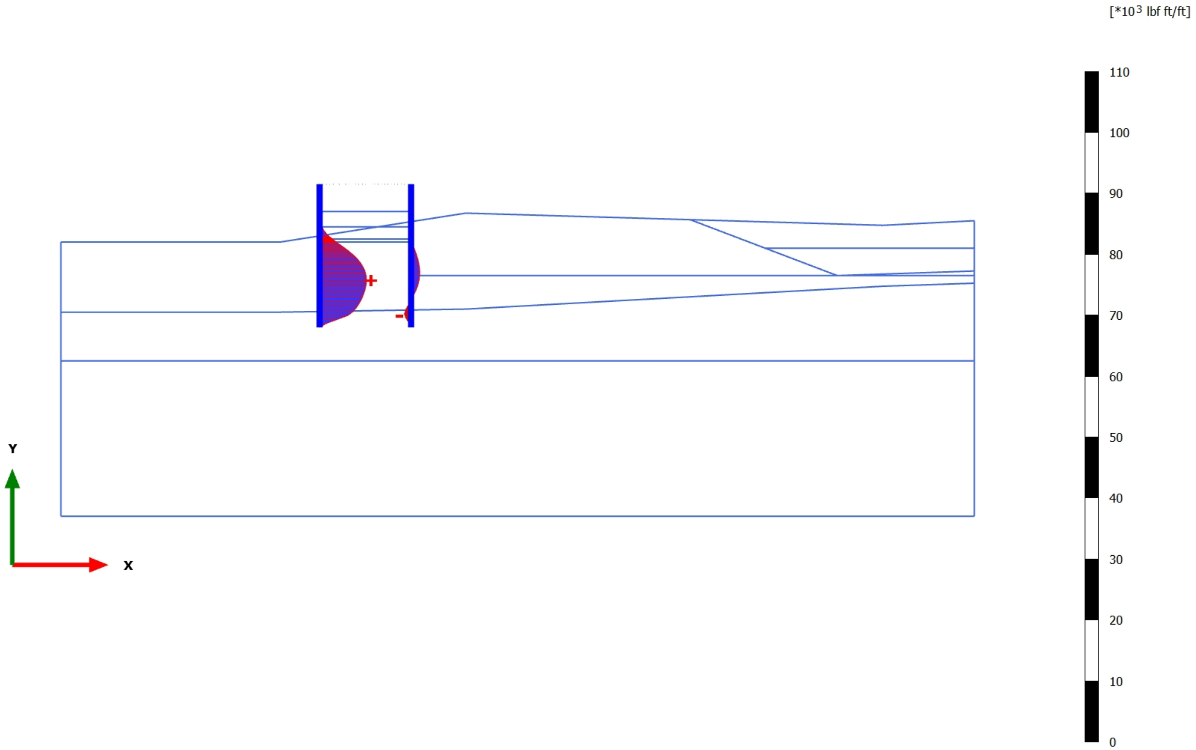


Bending moments M (scaled up 0.200*10⁻³ times)

Maximum value = 45.88*10³ lbf ft/ft (Element 13 at Node 14725)

Minimum value = -75.08*10³ lbf ft/ft (Element 24 at Node 15450)

3.1.2.2.8 Calculation results, Plate, Backfill 2 [Phase_3] (3/462), Bending moments M

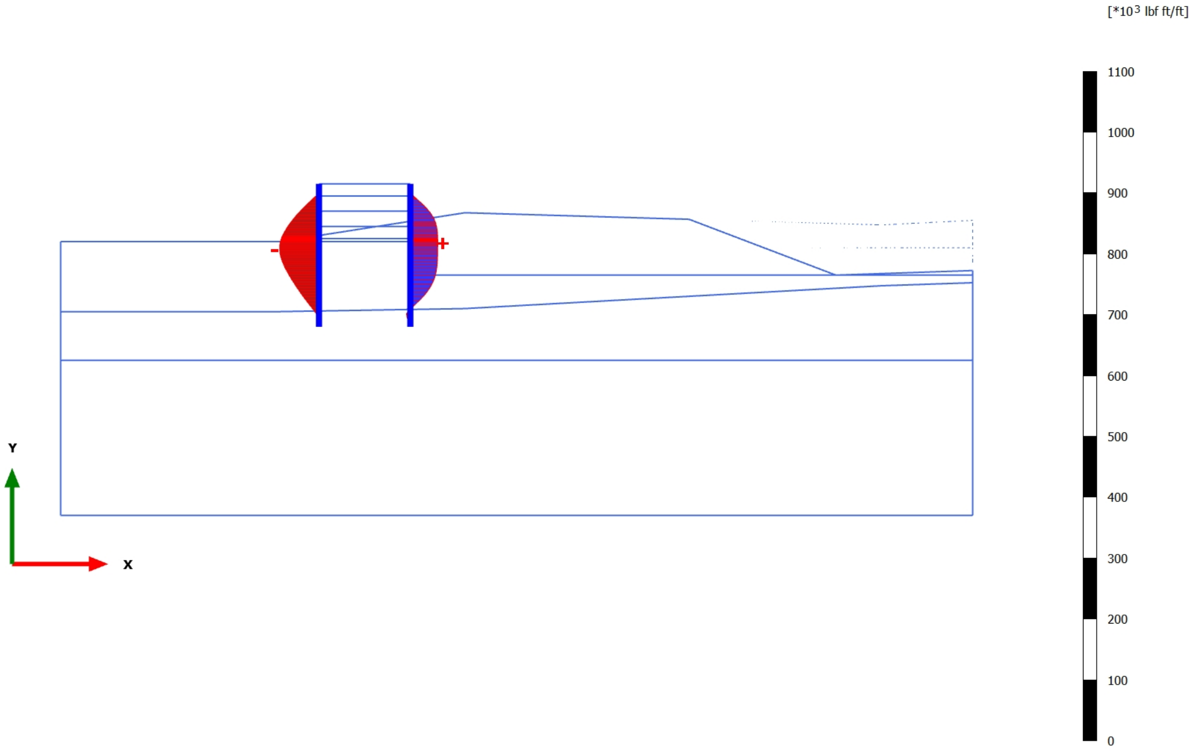


Bending moments M (scaled up 2.00*10^{-3} times)

Maximum value = 7676 lbf ft/ft (Element 27 at Node 14201)

Minimum value = -1086 lbf ft/ft (Element 32 at Node 11949)

3.1.2.2.9 Calculation results, Plate, Excavate 2 [Phase_10] (10/471), Bending moments M



Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 45.30*10^3 lbf ft/ft (Element 18 at Node 14132)

Minimum value = -64.90*10^3 lbf ft/ft (Element 23 at Node 15809)

3.2.1.1.2 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/38), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	11.764	0.000	11.764
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	11.764	0.000	11.764

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/52), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	32.565	0.000	32.565
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	32.565	0.000	32.565

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater [Phase_7] (7/84), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	59.425	0.000	59.425
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	59.425	0.000	59.425

3.2.1.1.5 Calculation results, Node-to-node anchor, Excavate 1 [Phase_8] (8/92), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	59.601	0.000	59.601
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	59.601	0.000	59.601

3.2.1.1.6 Calculation results, Node-to-node anchor, Dewater [Phase_9] (9/104), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	61.621	0.000	61.621
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	61.621	0.000	61.621

3.2.1.1.7 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/129), Table of node-to-node anchors

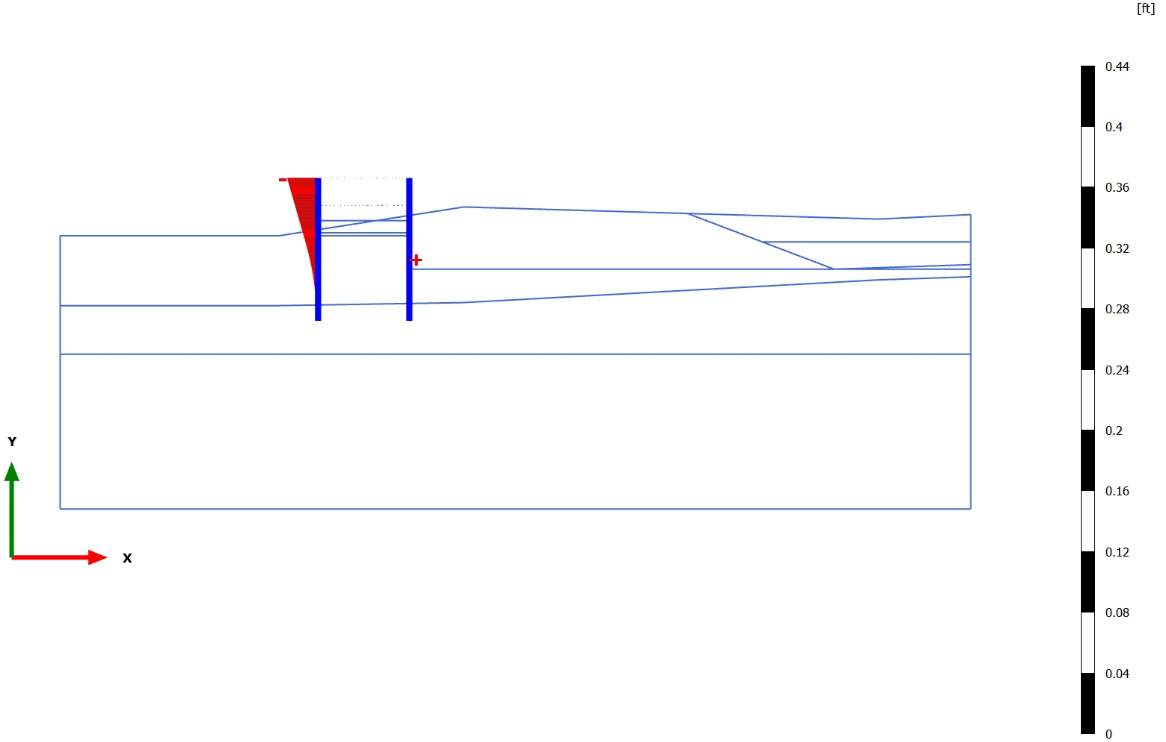
Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	76.687	0.000	76.687
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	76.687	0.000	76.687

3.2.1.1.9 Calculation results, Node-to-node anchor, Excavate 2 [Phase_10] (10/471), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	61.790	0.000	61.790
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	61.790	0.000	61.790

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/14), Total displacements u_x

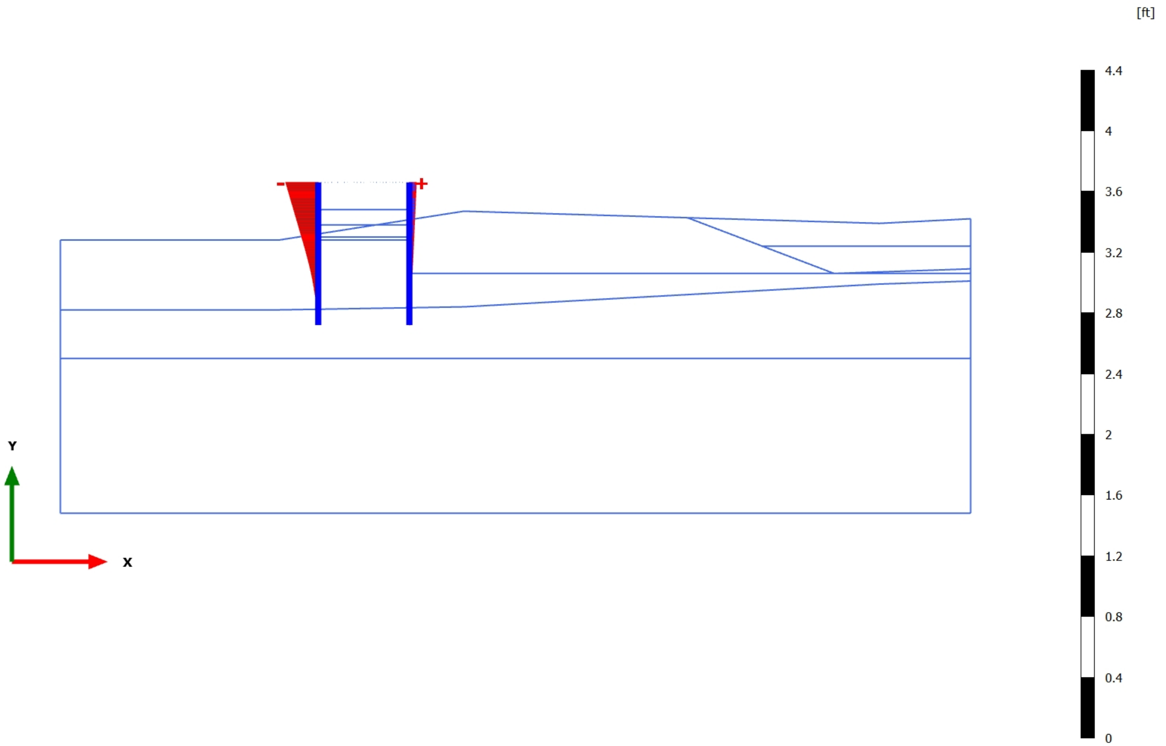


Total displacements u_x (scaled up 500 times)

Maximum value = $1.665*10^{-3}$ ft (Element 21 at Node 12927)

Minimum value = -0.02018 ft (Element 1 at Node 17341)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/32), Total displacements u_x

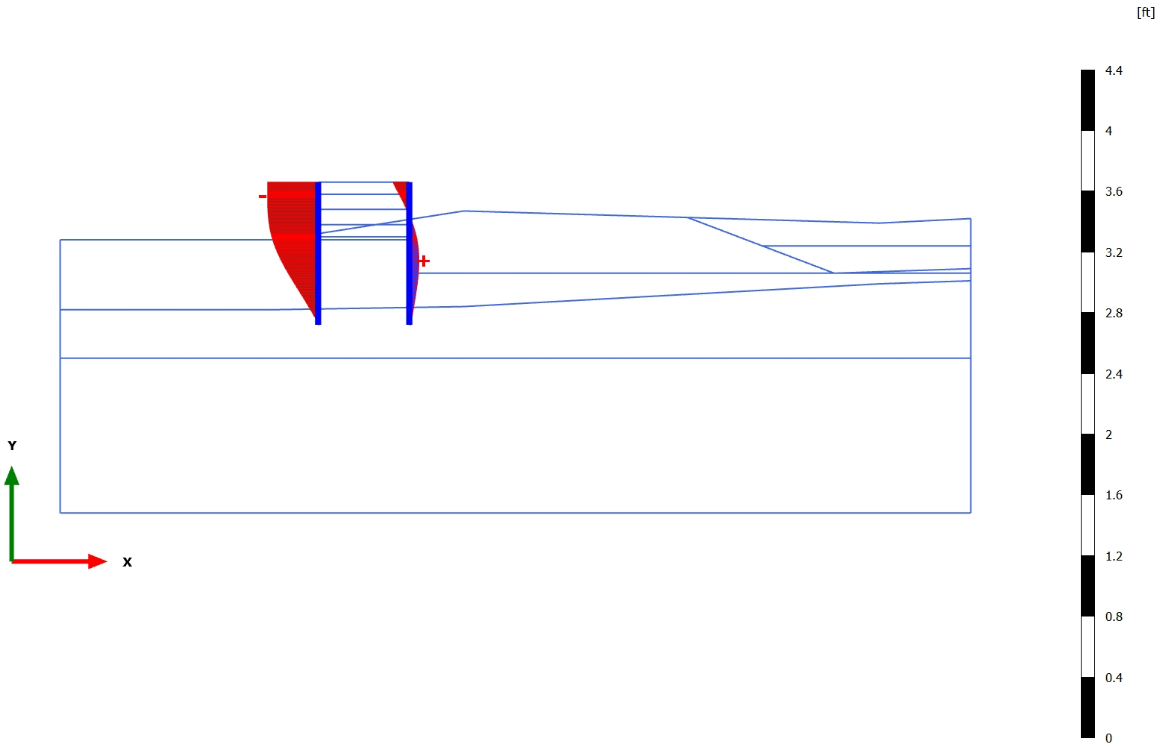


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.04680 ft (Element 2 at Node 14763)

Minimum value = -0.2144 ft (Element 1 at Node 17341)

3.1.1.1.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/60), Total displacements u_x

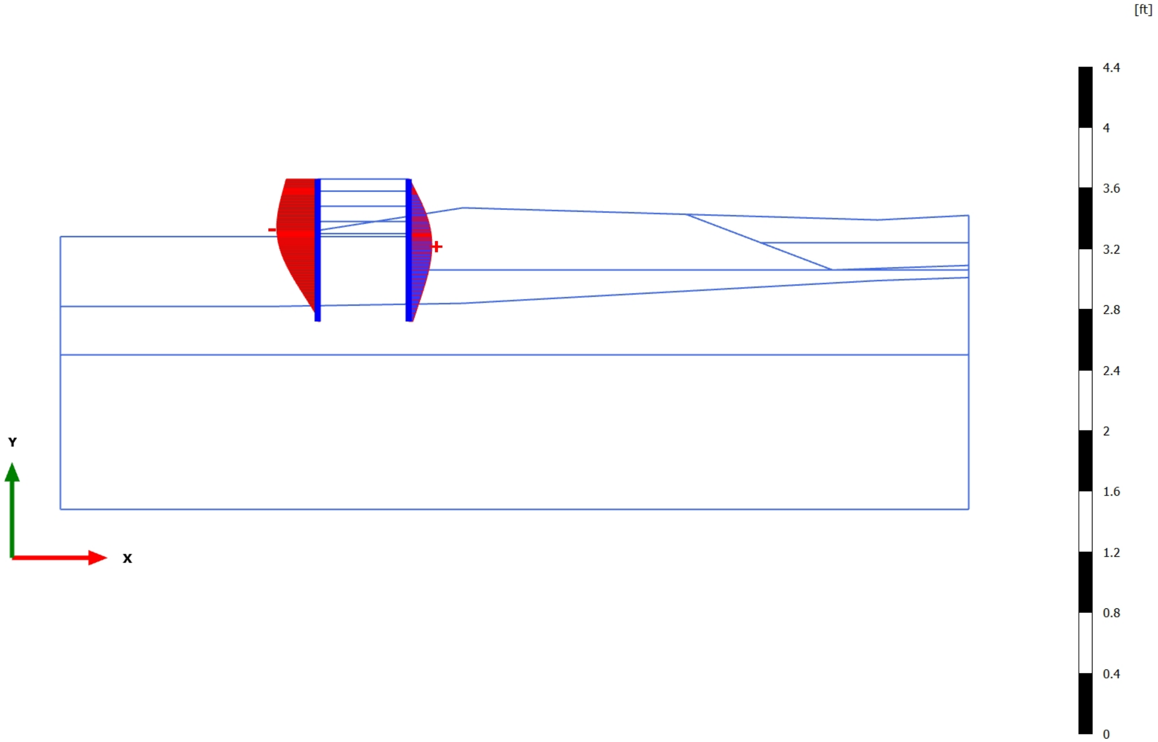


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.06381 ft (Element 20 at Node 13359)

Minimum value = -0.3333 ft (Element 5 at Node 16751)

3.1.1.1.1.4 Calculation results, Plate, Dewater-ss [Phase_16] (16/73), Total displacements u_x

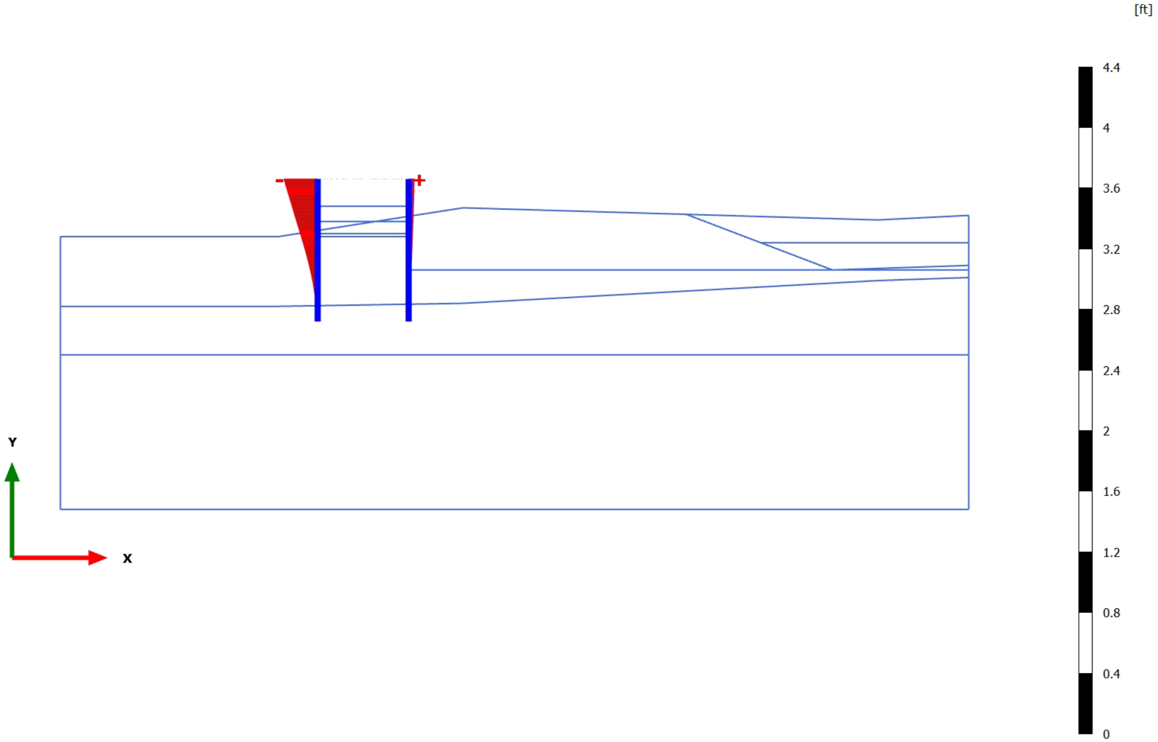


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1541 ft (Element 19 at Node 13656)

Minimum value = -0.2712 ft (Element 12 at Node 16401)

3.1.1.1.1.5 Calculation results, Plate, Consolidate [Phase_25] (25/96), Total displacements u_x

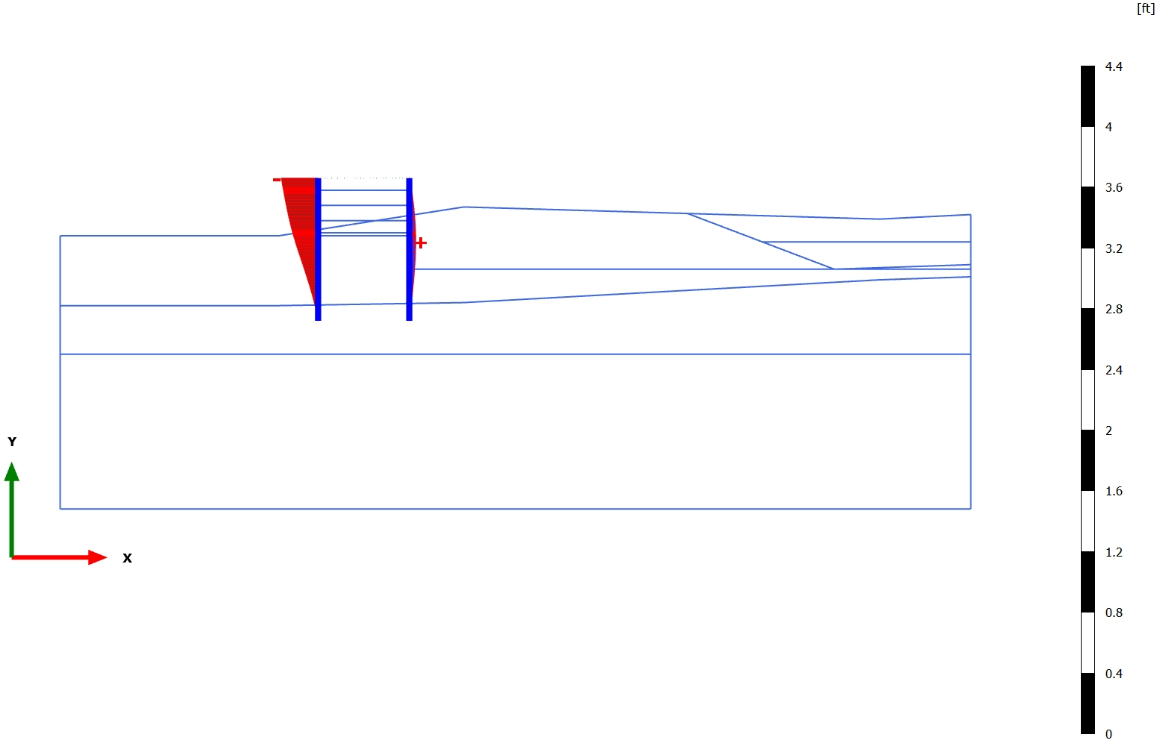


Total displacements u_x (scaled up 50.0 times) (Time 10.00 day)

Maximum value = 0.03766 ft (Element 2 at Node 14763)

Minimum value = -0.2232 ft (Element 1 at Node 17341)

3.1.1.1.1.6 Calculation results, Plate, Backfill 3 [Phase_5] (5/115), Total displacements u_x

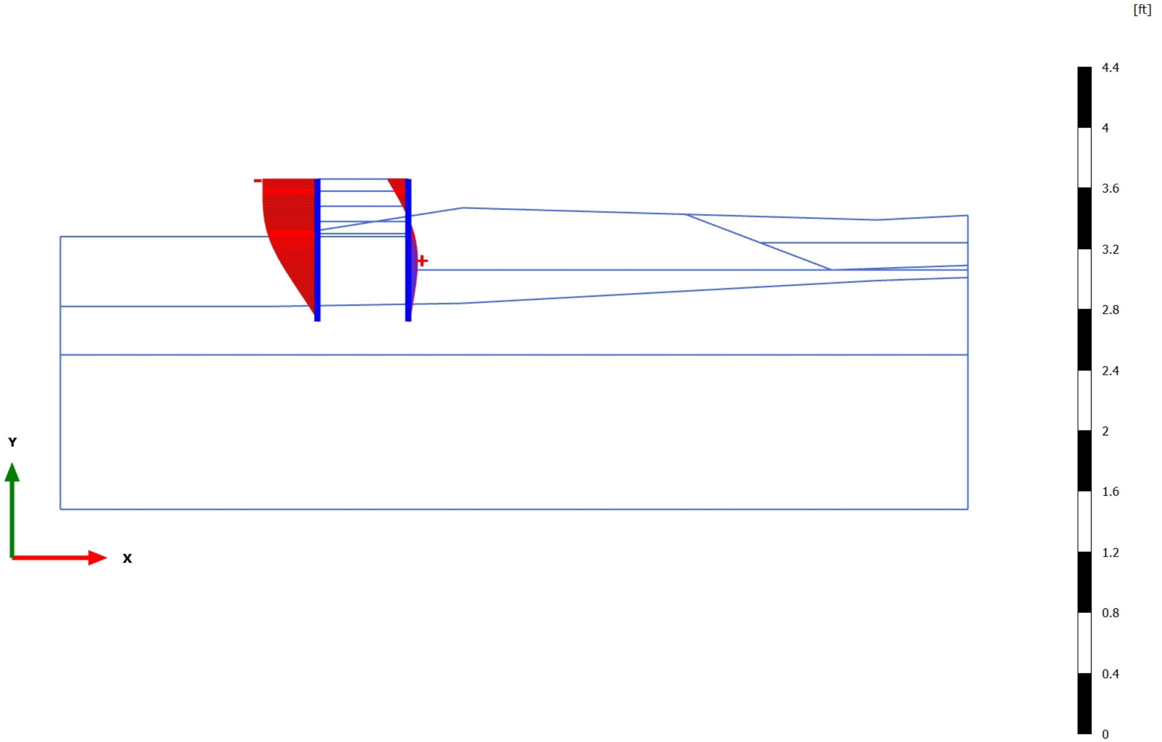


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.04274 ft (Element 19 at Node 13658)

Minimum value = -0.2428 ft (Element 1 at Node 17341)

3.1.1.1.1.7 Calculation results, Plate, Consolidate [Phase_7] (7/238), Total displacements u_x

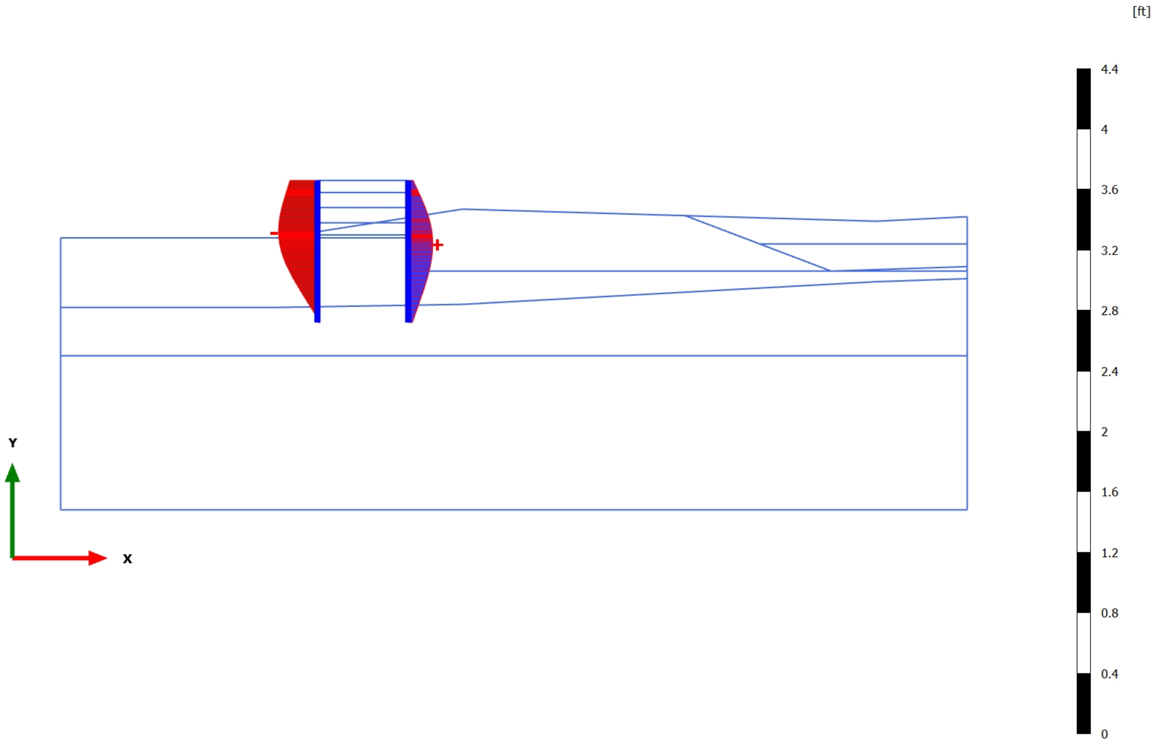


Total displacements u_x (scaled up 50.0 times) (Time 16.00 day)

Maximum value = 0.06111 ft (Element 21 at Node 12927)

Minimum value = -0.3617 ft (Element 1 at Node 17341)

3.1.1.1.1.8 Calculation results, Plate, Consolidation [Phase_17] (17/248), Total displacements u_x

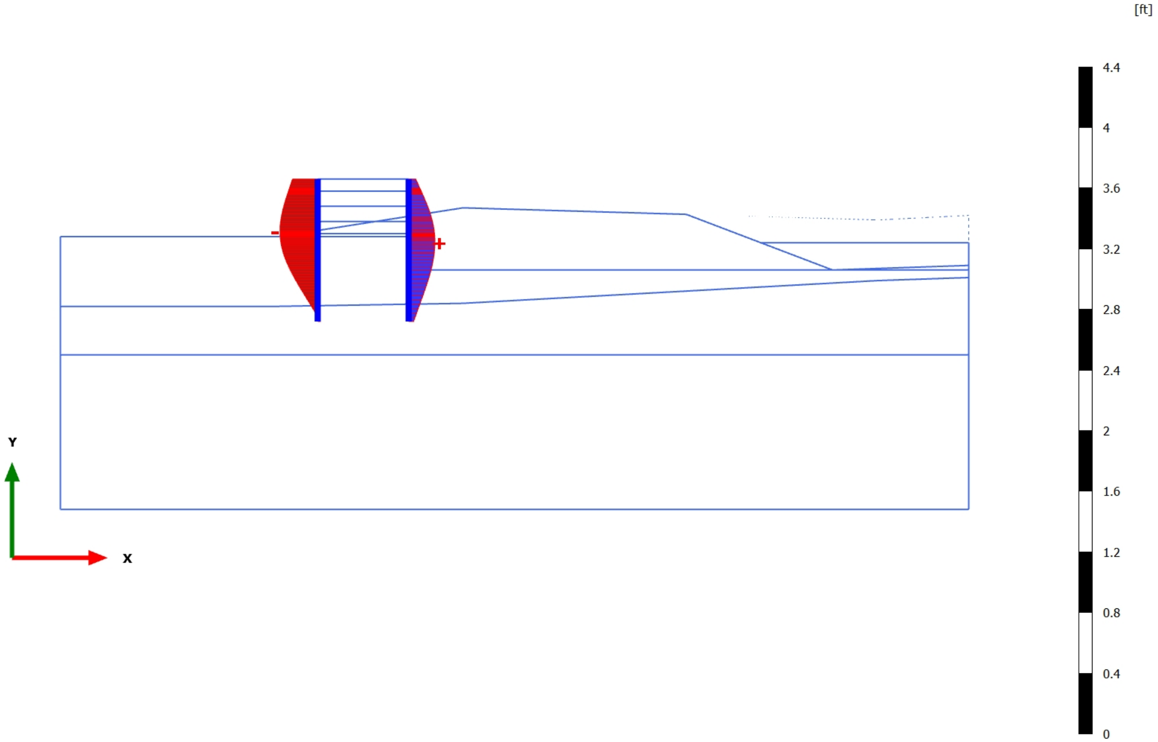


Total displacements u_x (scaled up 50.0 times) (Time 20.00 day)

Maximum value = 0.1631 ft (Element 19 at Node 13658)

Minimum value = -0.2576 ft (Element 12 at Node 16400)

3.1.1.1.1.9 Calculation results, Plate, Excavate 1 [Phase_18] (18/254), Total displacements u_x

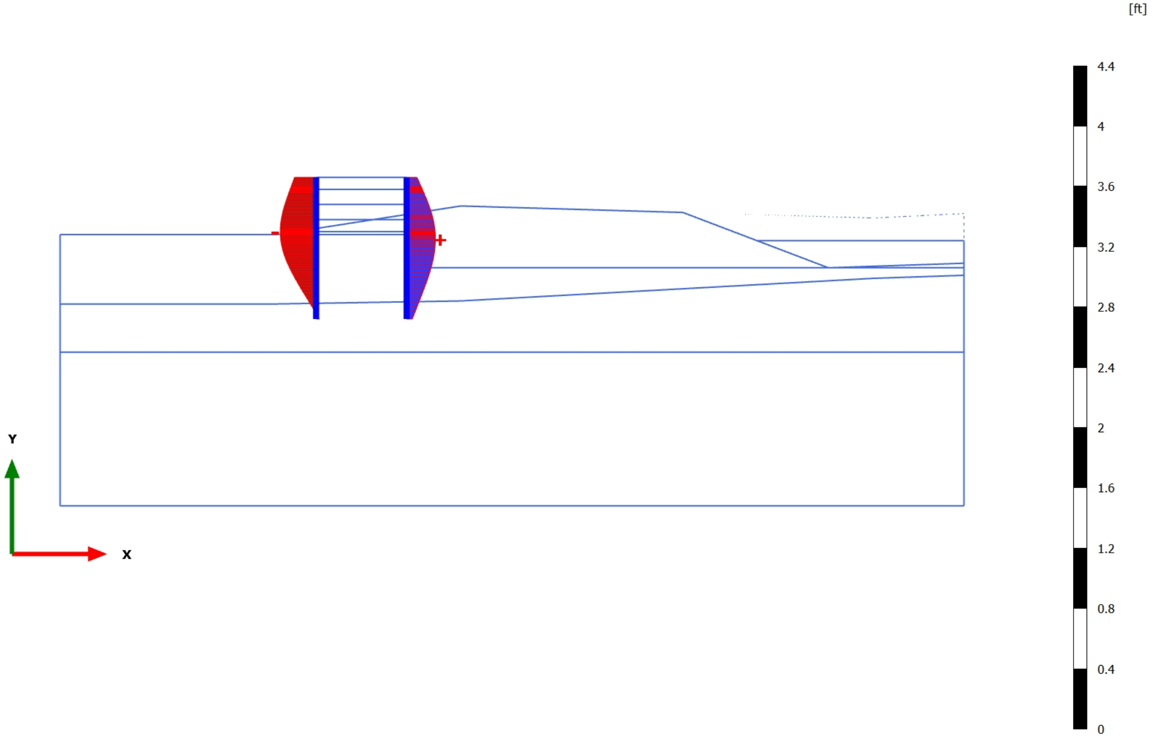


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1741 ft (Element 19 at Node 13658)

Minimum value = -0.2498 ft (Element 15 at Node 16397)

3.1.1.1.1.10 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/259), Total displacements u_x

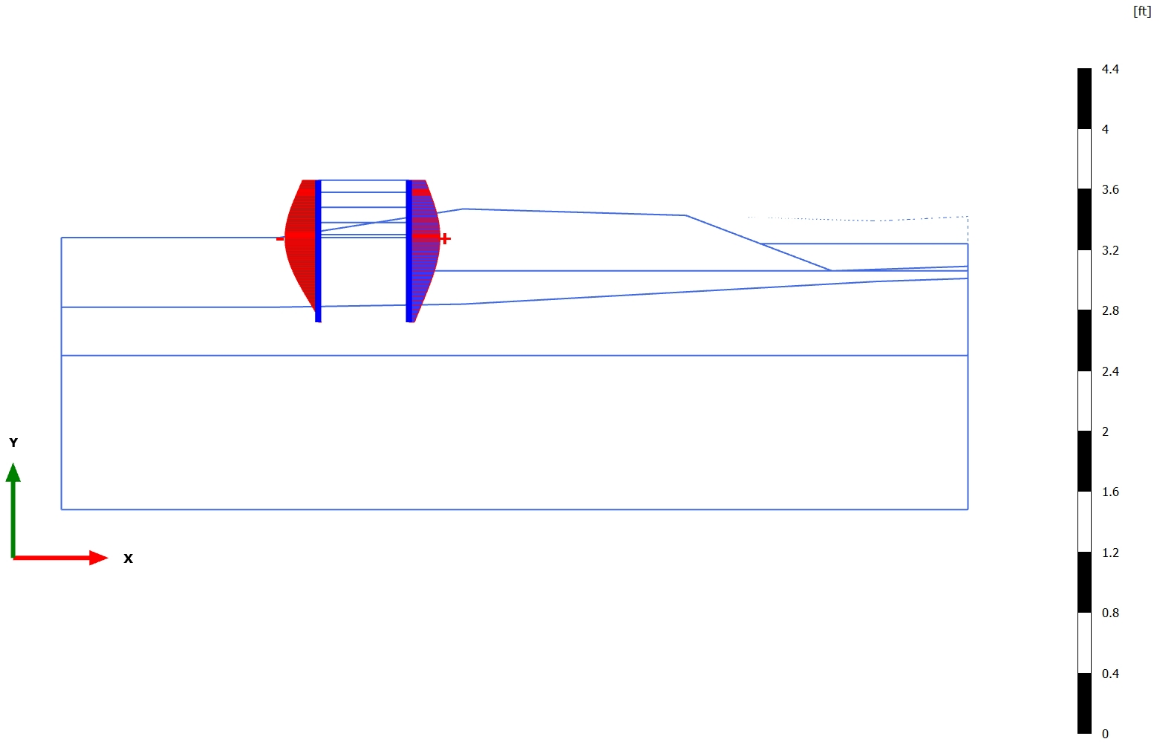


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1918 ft (Element 18 at Node 14129)

Minimum value = -0.2385 ft (Element 15 at Node 16396)

3.1.1.1.1.11 Calculation results, Plate, Consolidation [Phase_20] (20/276), Total displacements u_x

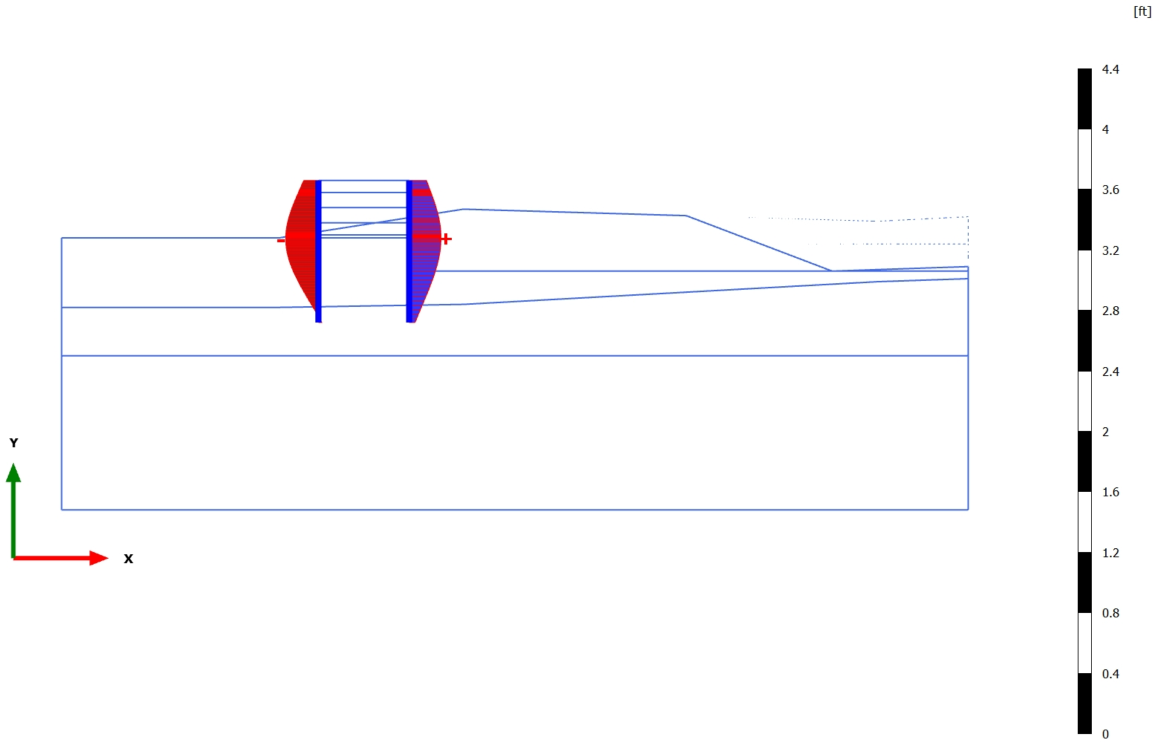


Total displacements u_x (scaled up 50.0 times) (Time 37.00 day)

Maximum value = 0.2063 ft (Element 17 at Node 14169)

Minimum value = -0.2203 ft (Element 16 at Node 16367)

3.1.1.1.1.12 Calculation results, Plate, Excavate 2 [Phase_21] (21/279), Total displacements u_x

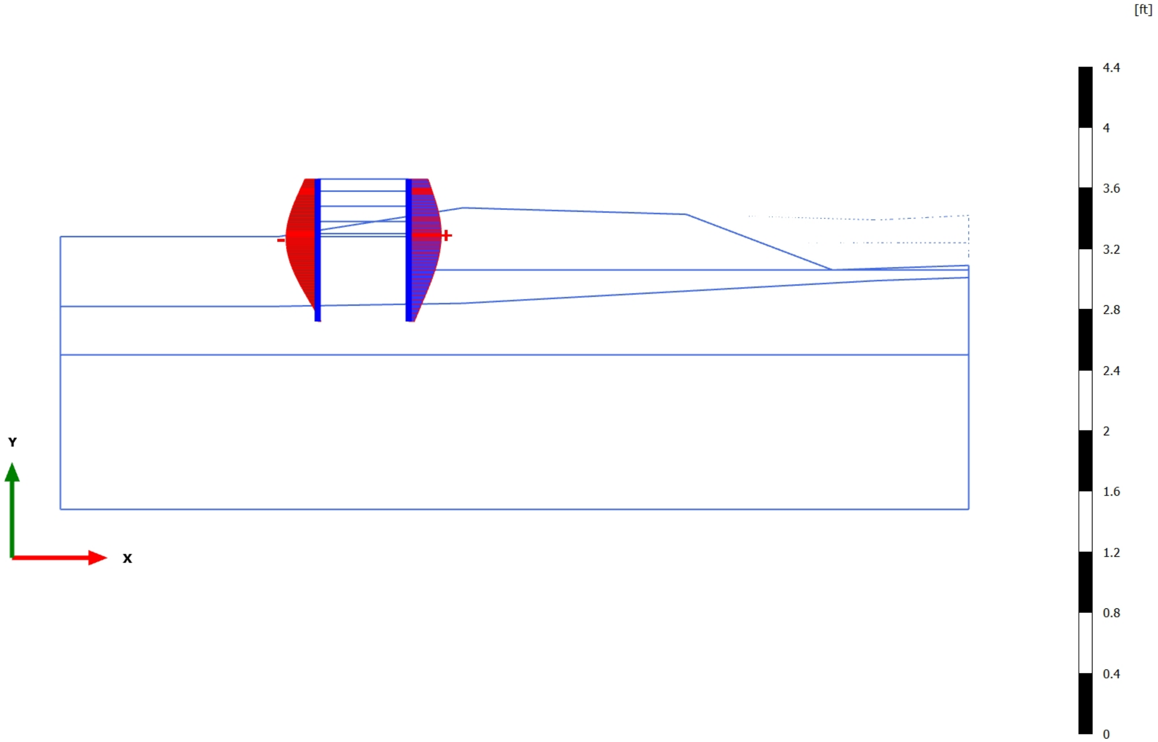


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.2112 ft (Element 17 at Node 14169)

Minimum value = -0.2172 ft (Element 22 at Node 16162)

3.1.1.1.1.13 Calculation results, Plate, Consolidate [Phase_8] (8/397), Total displacements u_x

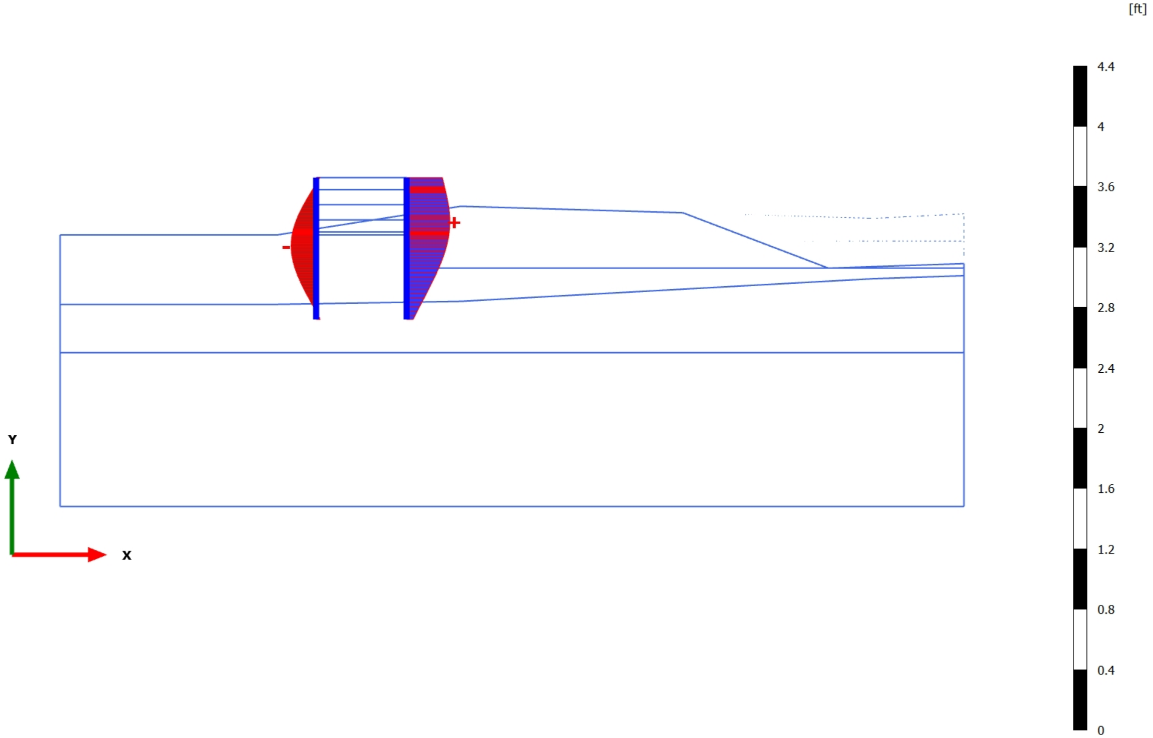


Total displacements u_x (scaled up 50.0 times) (Time 51.00 day)

Maximum value = 0.2161 ft (Element 17 at Node 14172)

Minimum value = -0.2100 ft (Element 22 at Node 16161)

3.1.1.1.1.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/403), Total displacements u_x

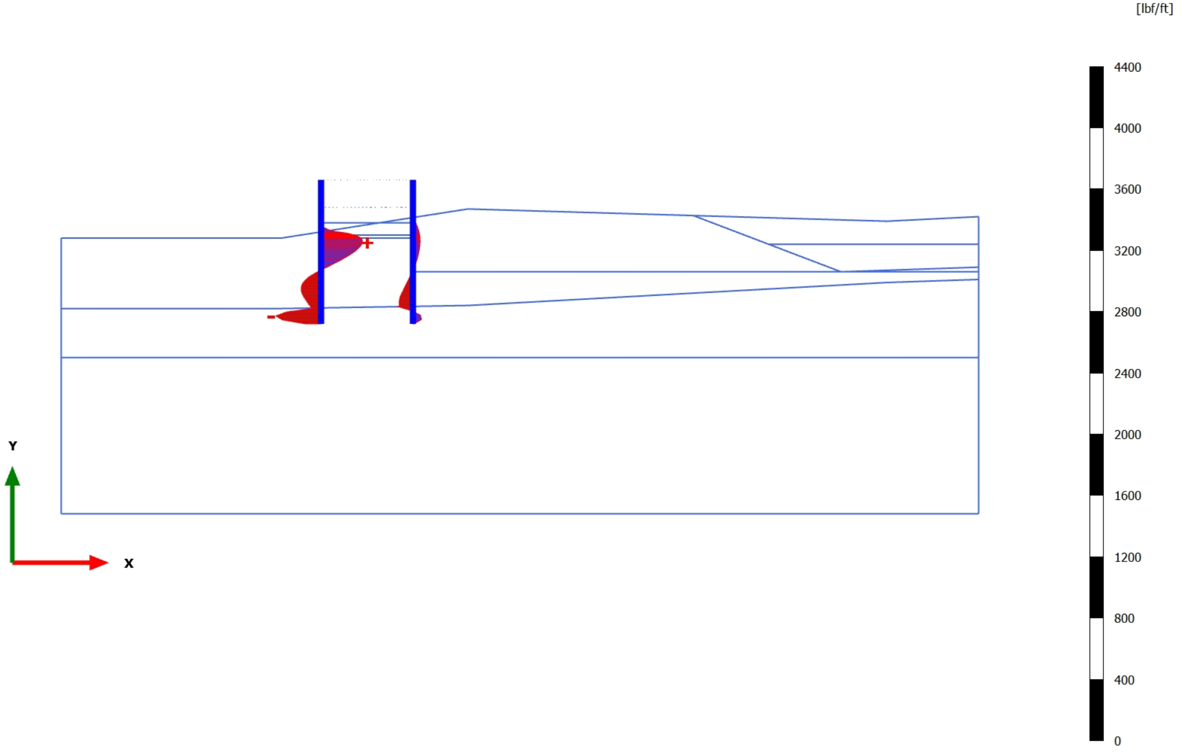


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.2872 ft (Element 13 at Node 14726)

Minimum value = -0.1663 ft (Element 24 at Node 15450)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/14), Shear forces Q

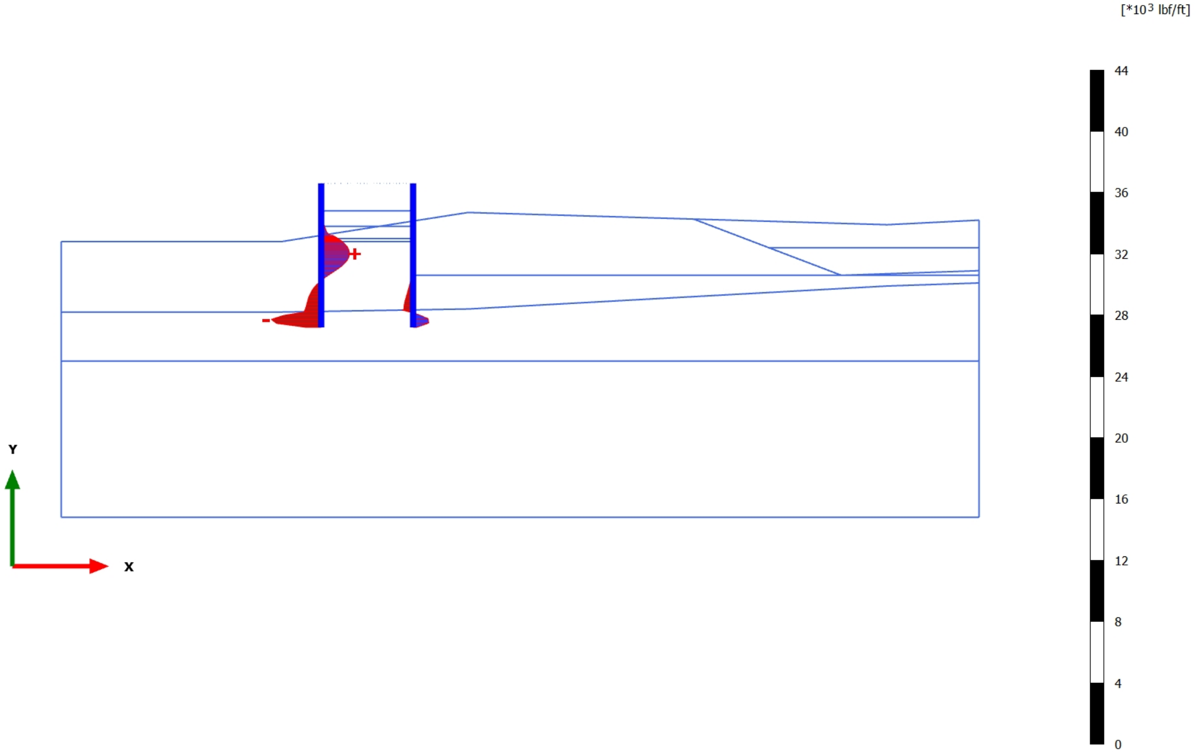


Shear forces Q (scaled up 0.0500 times)

Maximum value = 270.2 lbf/ft (Element 22 at Node 16160)

Minimum value = -296.5 lbf/ft (Element 33 at Node 13305)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/32), Shear forces Q

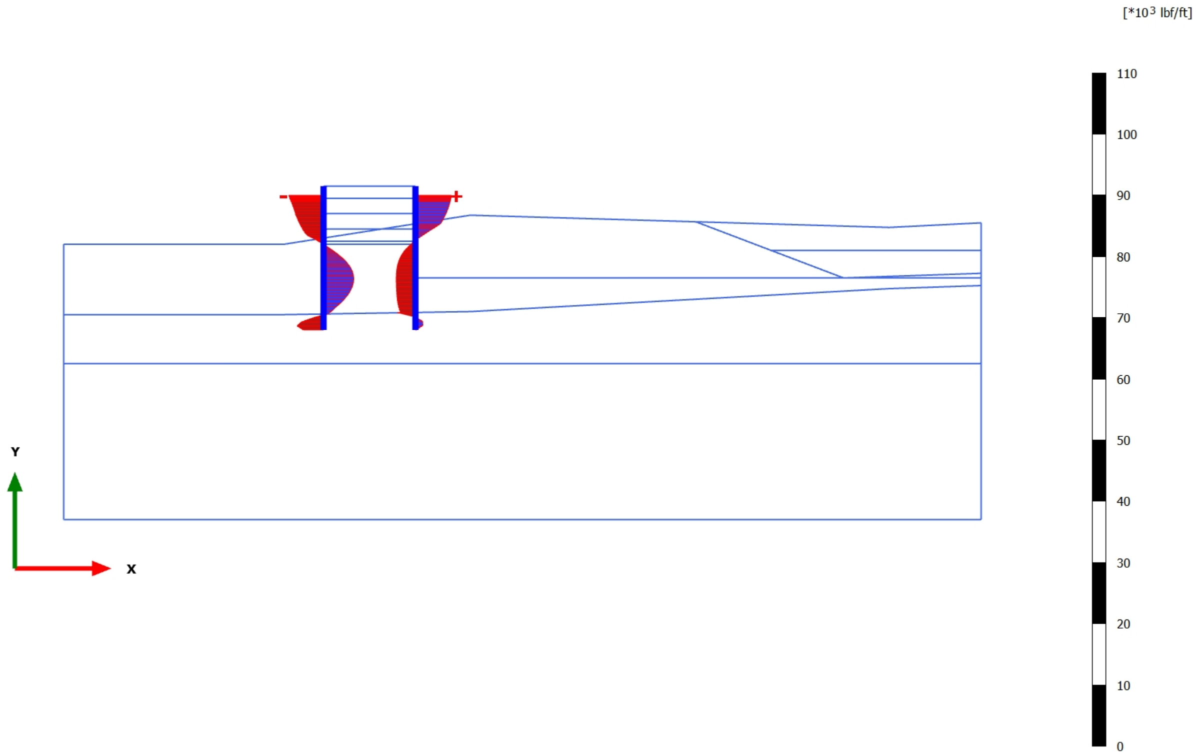


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 1846 lbf/ft (Element 24 at Node 15450)

Minimum value = -3277 lbf/ft (Element 33 at Node 13305)

3.1.2.1.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/60), Shear forces Q

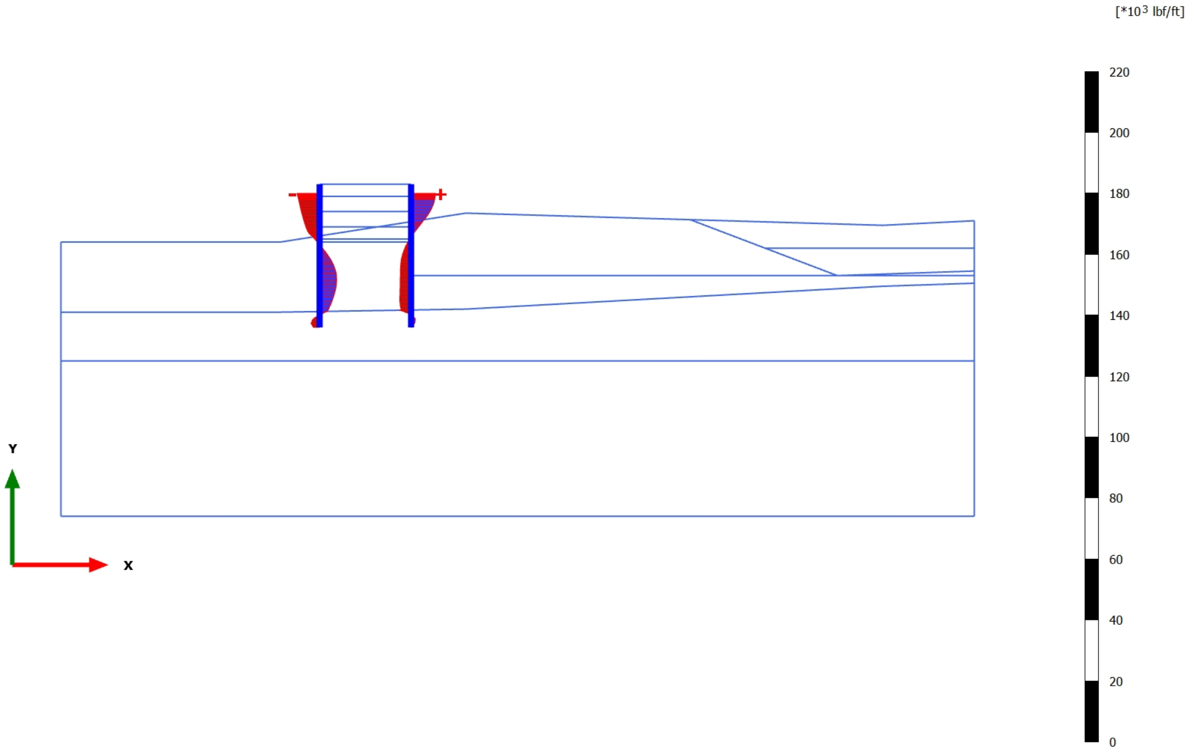


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 5912 lbf/ft (Element 4 at Node 14762)

Minimum value = -5709 lbf/ft (Element 3 at Node 17338)

3.1.2.1.4 Calculation results, Plate, Dewater-ss [Phase_16] (16/73), Shear forces Q

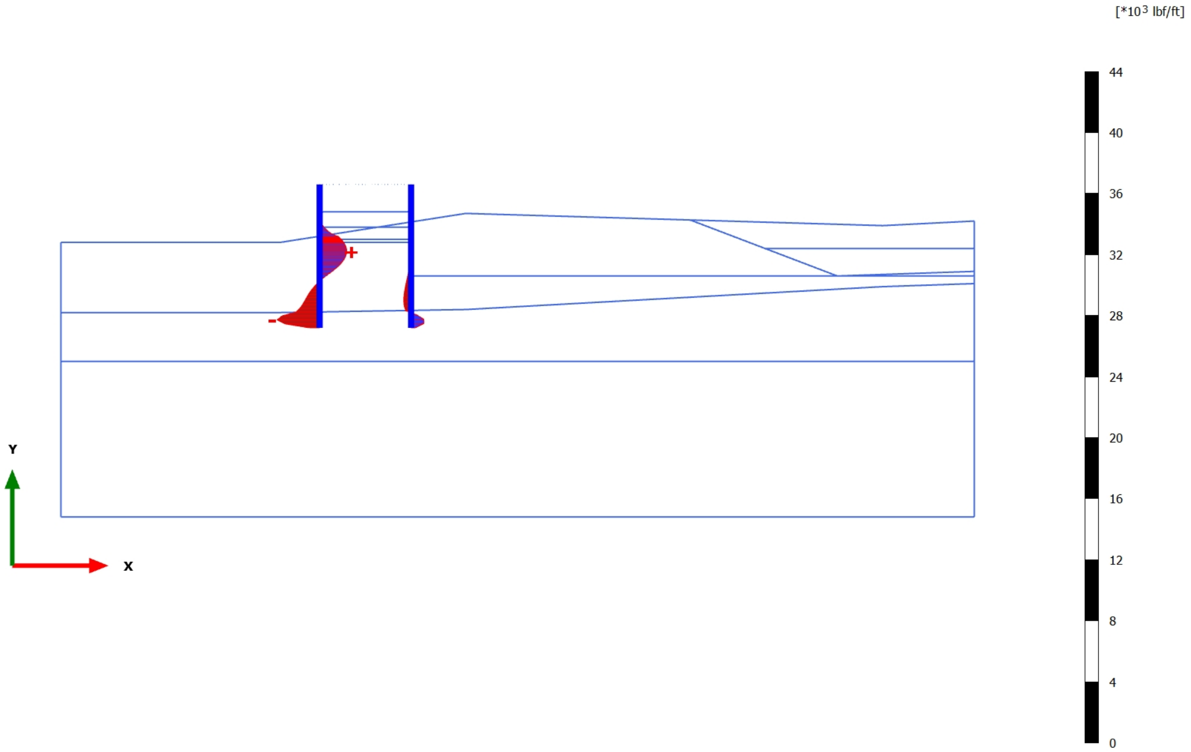


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8073 lbf/ft (Element 4 at Node 14762)

Minimum value = -7472 lbf/ft (Element 3 at Node 17338)

3.1.2.1.5 Calculation results, Plate, Consolidate [Phase_25] (25/96), Shear forces Q

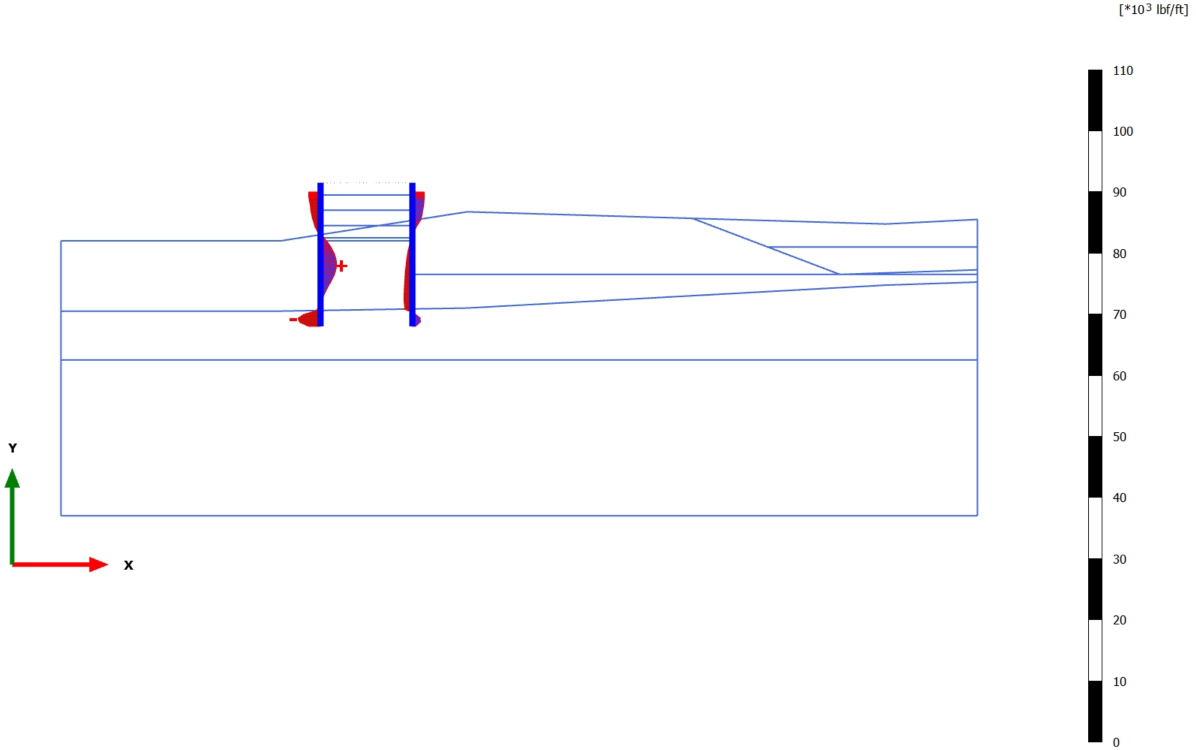


Shear forces Q (scaled up $5.00*10^{-3}$ times) (Time 10.00 day)

Maximum value = 1771 lbf/ft (Element 23 at Node 15808)

Minimum value = -2803 lbf/ft (Element 33 at Node 13305)

3.1.2.1.6 Calculation results, Plate, Backfill 3 [Phase_5] (5/115), Shear forces Q

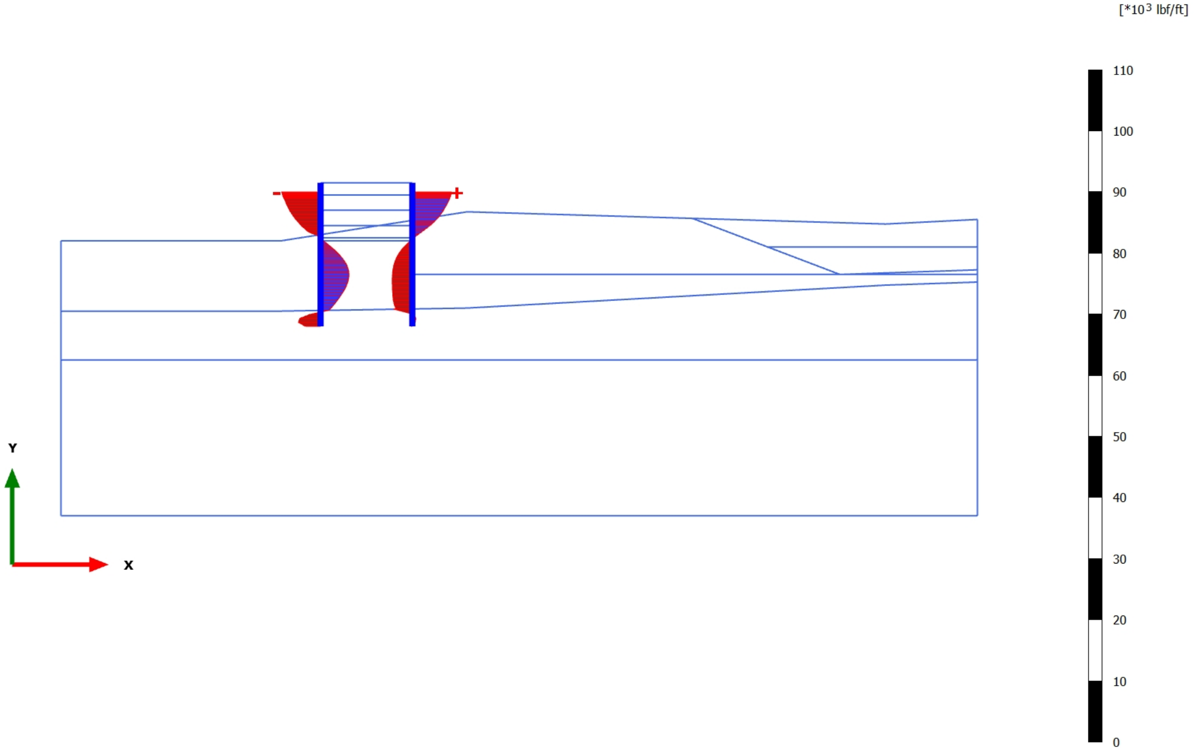


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 2596 lbf/ft (Element 26 at Node 14965)

Minimum value = -3736 lbf/ft (Element 33 at Node 13305)

3.1.2.1.7 Calculation results, Plate, Consolidate [Phase_7] (7/238), Shear forces Q

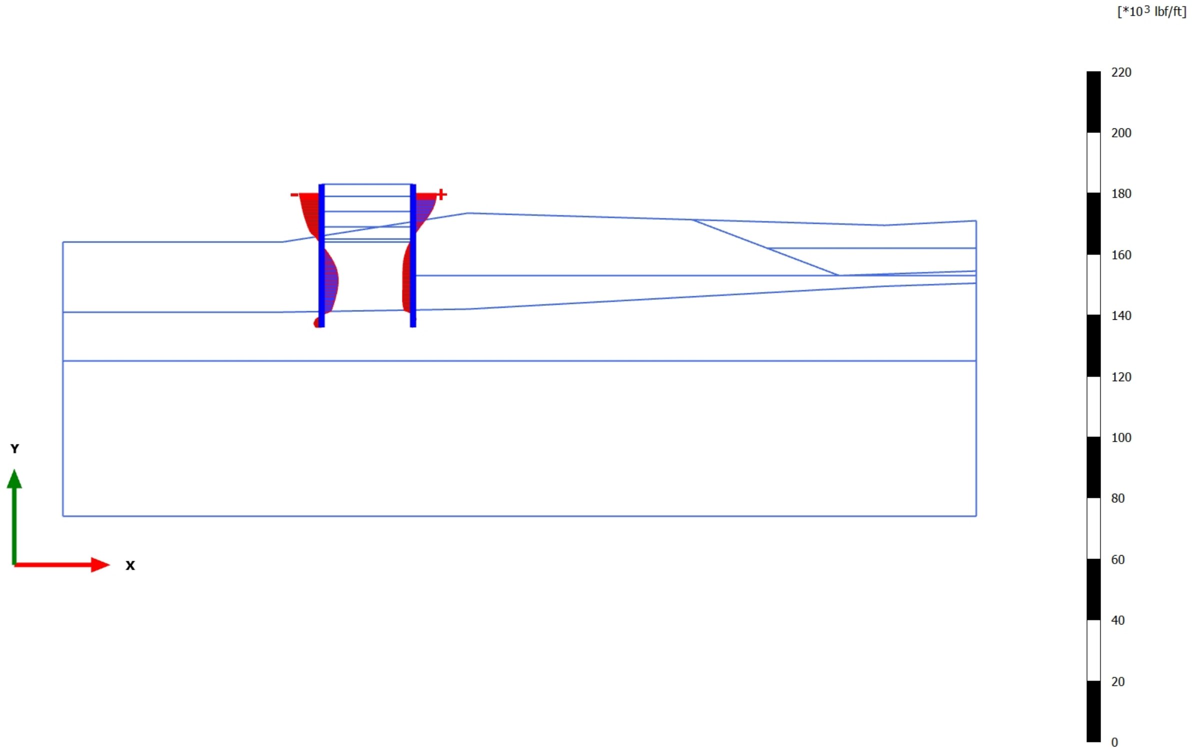


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 16.00 day)

Maximum value = 6481 lbf/ft (Element 4 at Node 14762)

Minimum value = -6400 lbf/ft (Element 3 at Node 17338)

3.1.2.1.8 Calculation results, Plate, Consolidation [Phase_17] (17/248), Shear forces Q

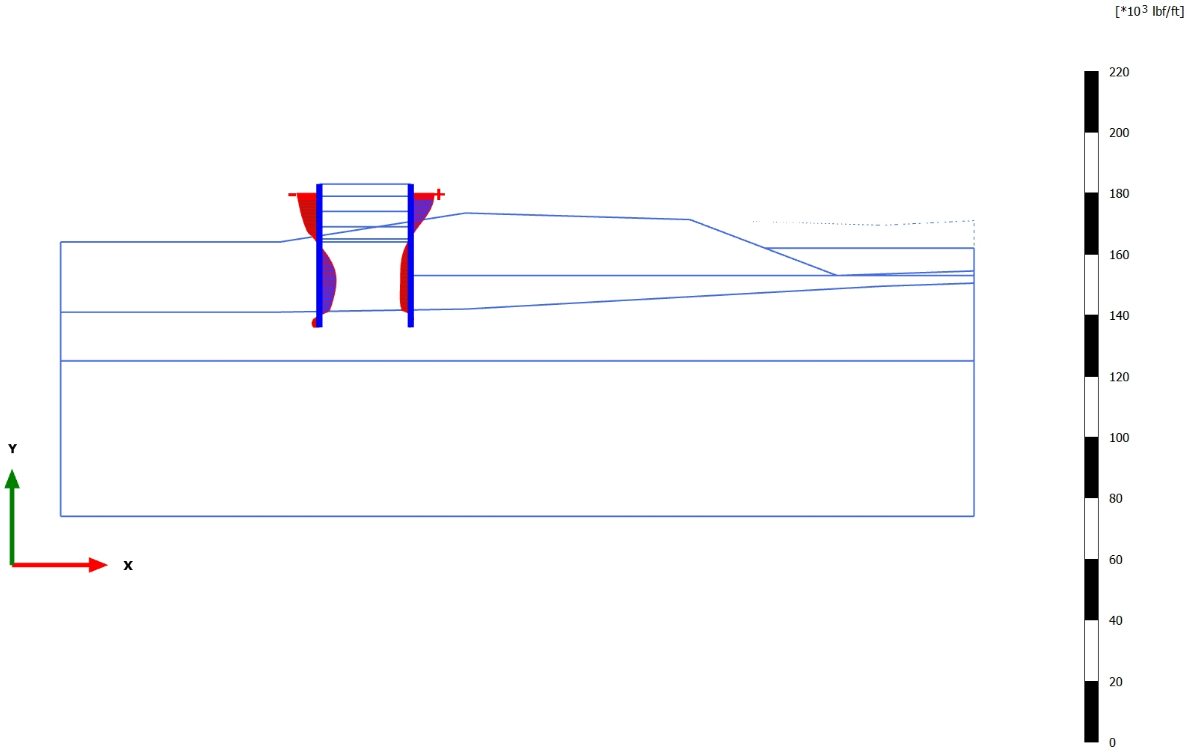


Shear forces Q (scaled up $1.00*10^{-3}$ times) (Time 20.00 day)

Maximum value = 7722 lbf/ft (Element 4 at Node 14762)

Minimum value = -7440 lbf/ft (Element 3 at Node 17338)

3.1.2.1.9 Calculation results, Plate, Excavate 1 [Phase_18] (18/254), Shear forces Q

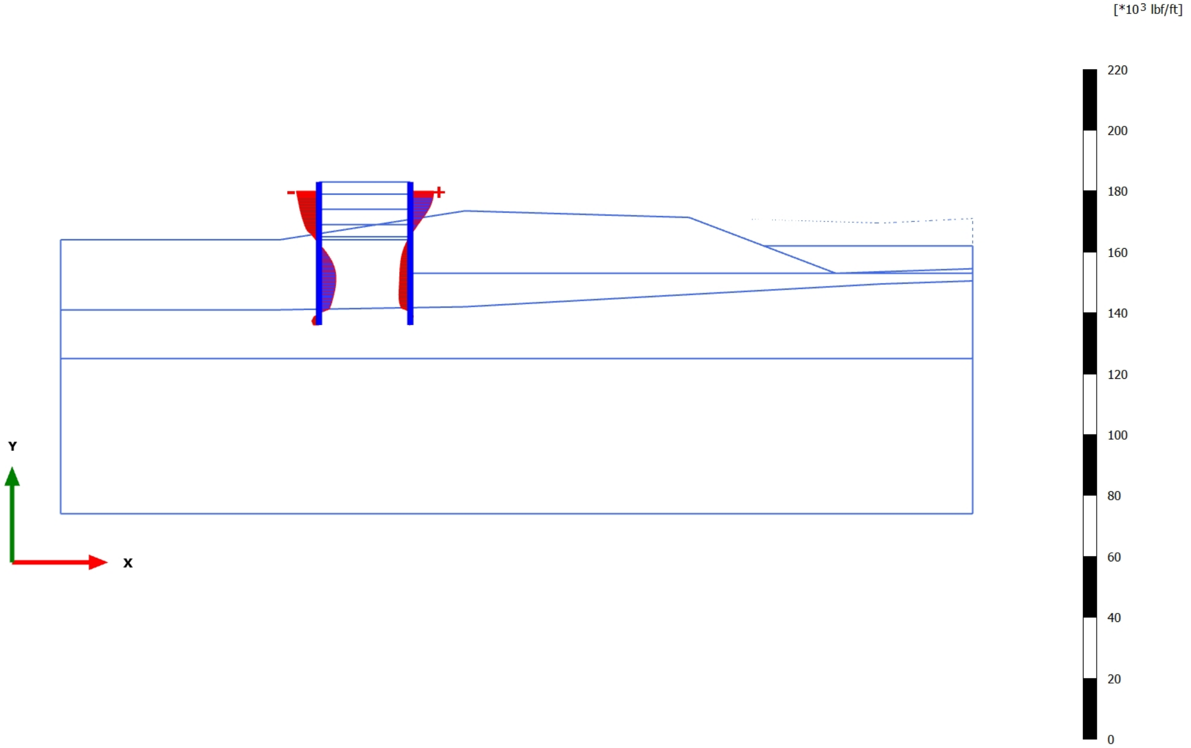


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 7720 lbf/ft (Element 4 at Node 14762)

Minimum value = -7457 lbf/ft (Element 3 at Node 17338)

3.1.2.1.10 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/259), Shear forces Q

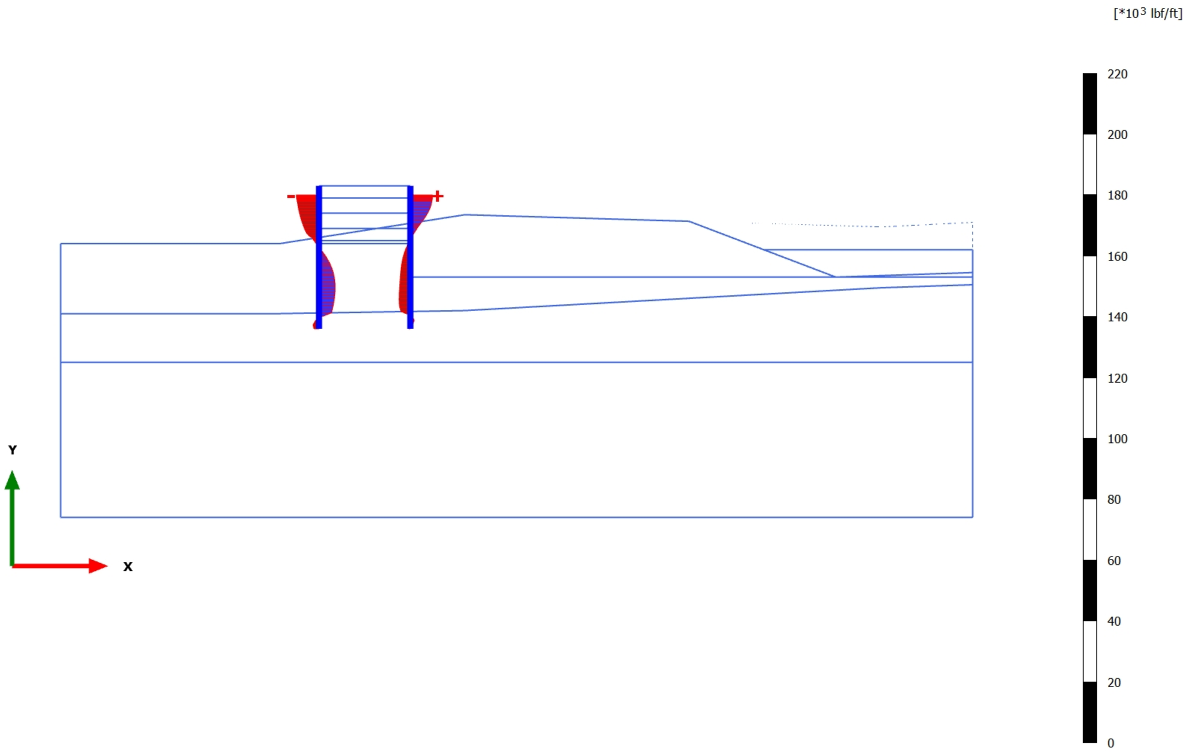


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 7744 lbf/ft (Element 4 at Node 14762)

Minimum value = -7501 lbf/ft (Element 3 at Node 17338)

3.1.2.1.11 Calculation results, Plate, Consolidation [Phase_20] (20/276), Shear forces Q

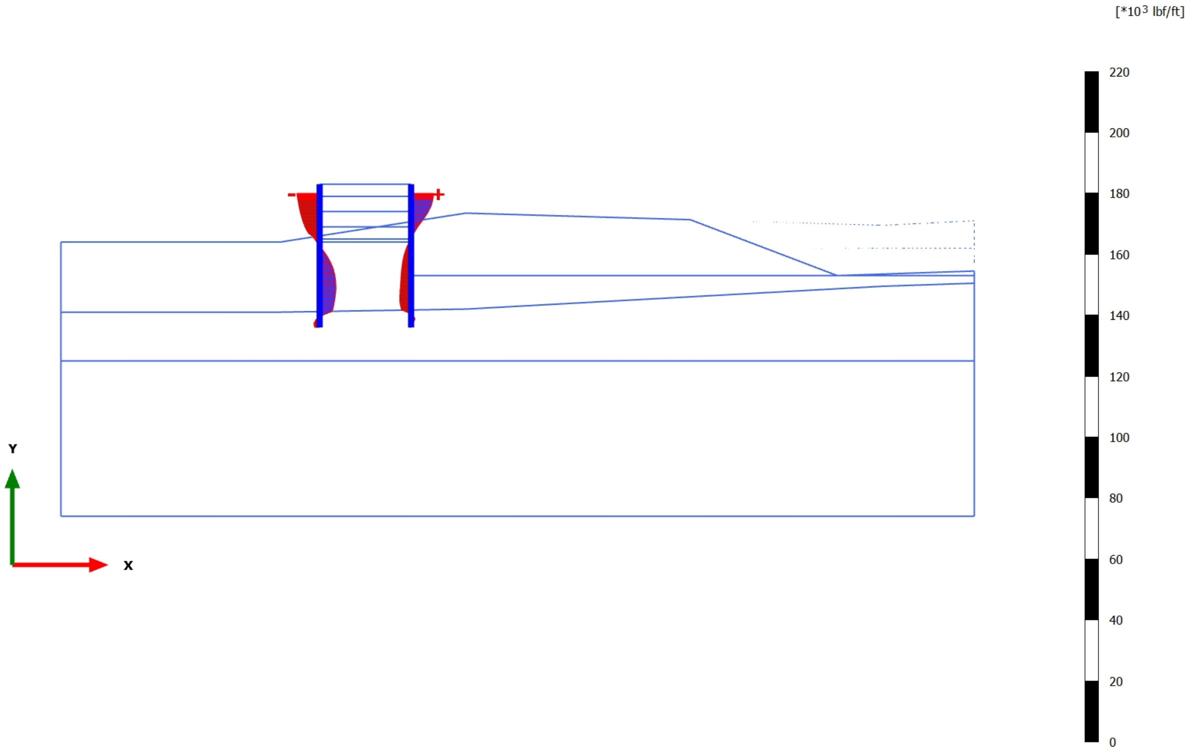


Shear forces Q (scaled up 1.00*10^{-3} times) (Time 37.00 day)

Maximum value = 7435 lbf/ft (Element 4 at Node 14762)

Minimum value = -7551 lbf/ft (Element 3 at Node 17338)

3.1.2.1.12 Calculation results, Plate, Excavate 2 [Phase_21] (21/279), Shear forces Q

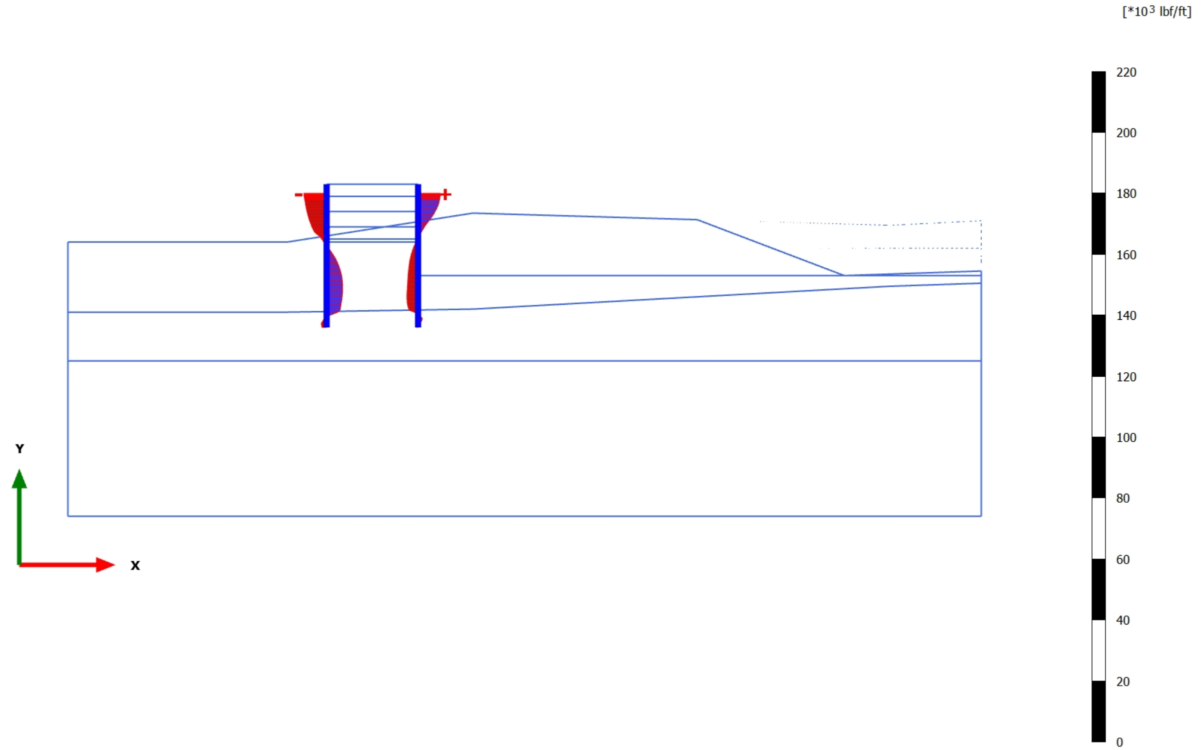


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 7435 lbf/ft (Element 4 at Node 14762)

Minimum value = -7551 lbf/ft (Element 3 at Node 17338)

3.1.2.1.13 Calculation results, Plate, Consolidate [Phase_8] (8/397), Shear forces Q

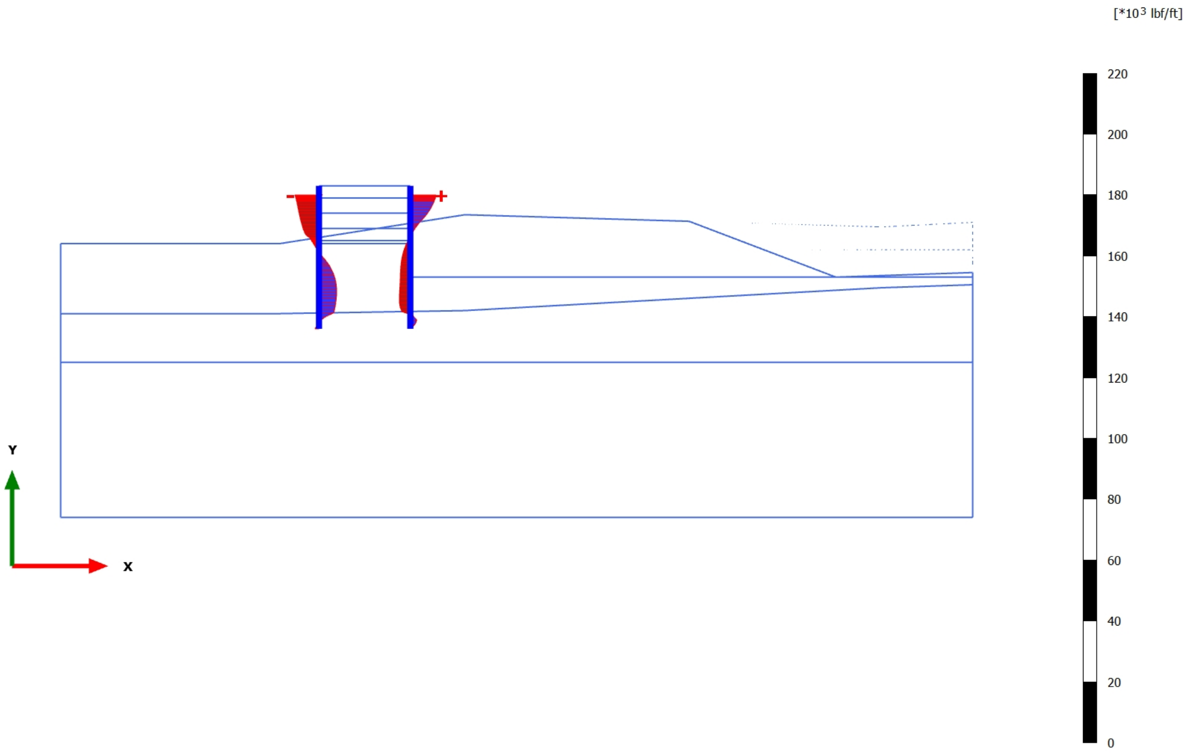


Shear forces Q (scaled up 1.00*10^{-3} times) (Time 51.00 day)

Maximum value = 7381 lbf/ft (Element 4 at Node 14762)

Minimum value = -7544 lbf/ft (Element 3 at Node 17338)

3.1.2.1.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/403), Shear forces Q

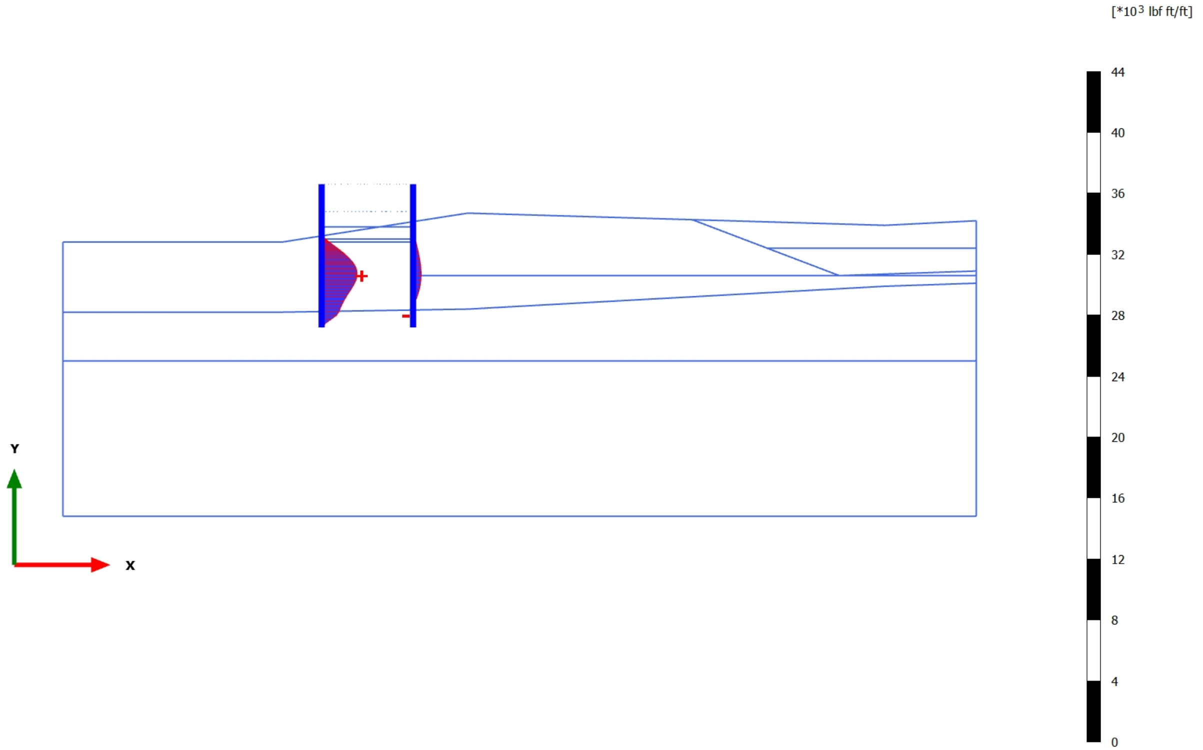


Shear forces Q (scaled up 1.00*10^{-3} times)

Maximum value = 8544 lbf/ft (Element 4 at Node 14762)

Minimum value = -7954 lbf/ft (Element 3 at Node 17338)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/14), Bending moments M

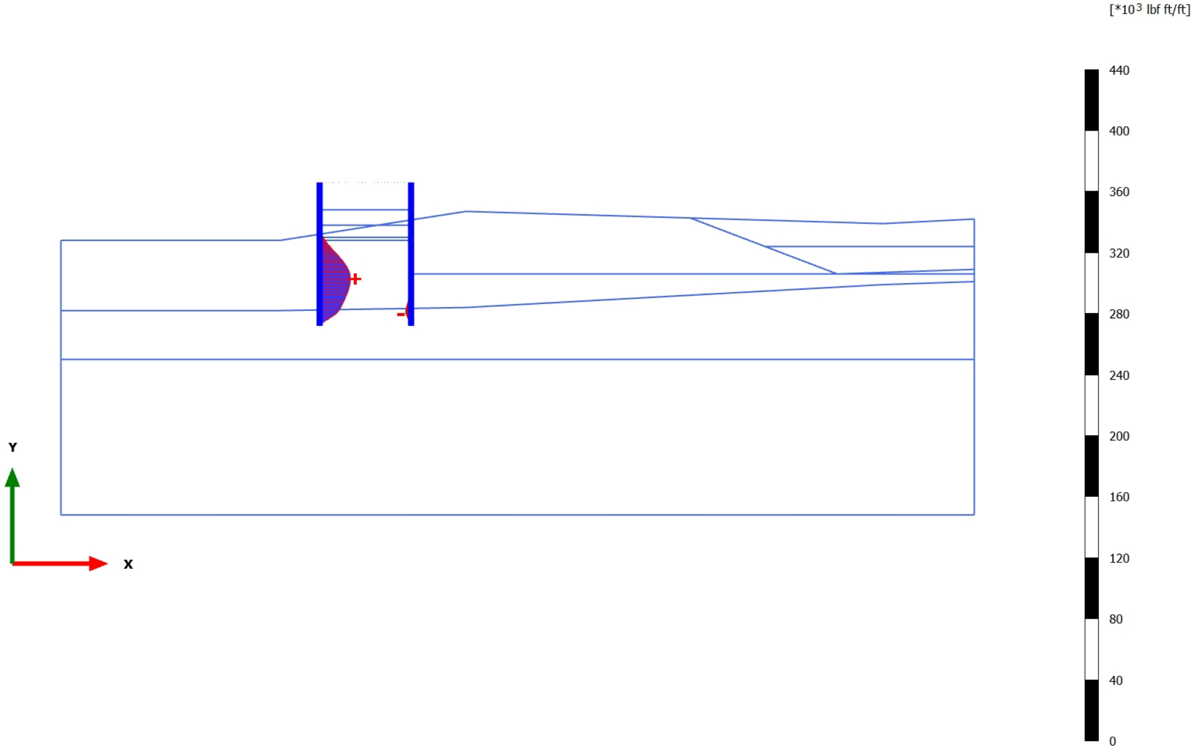


Bending moments M (scaled up $5.00*10^{-3}$ times)

Maximum value = 2331 lbf ft/ft (Element 27 at Node 14661)

Minimum value = -172.7 lbf ft/ft (Element 32 at Node 11949)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/32), Bending moments M

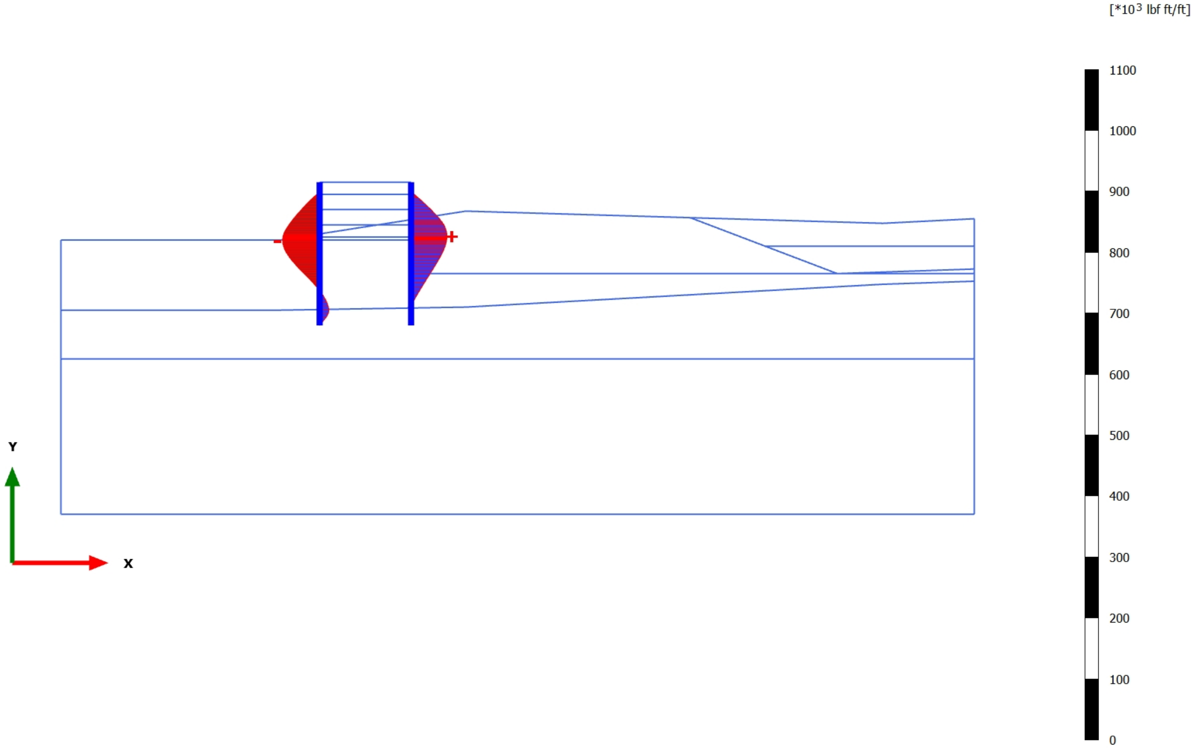


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $20.18*10^3$ lbf ft/ft (Element 27 at Node 14201)

Minimum value = -3548 lbf ft/ft (Element 32 at Node 11949)

3.1.2.2.3 Calculation results, Plate, Backfill 4 [Phase_6] (6/60), Bending moments M

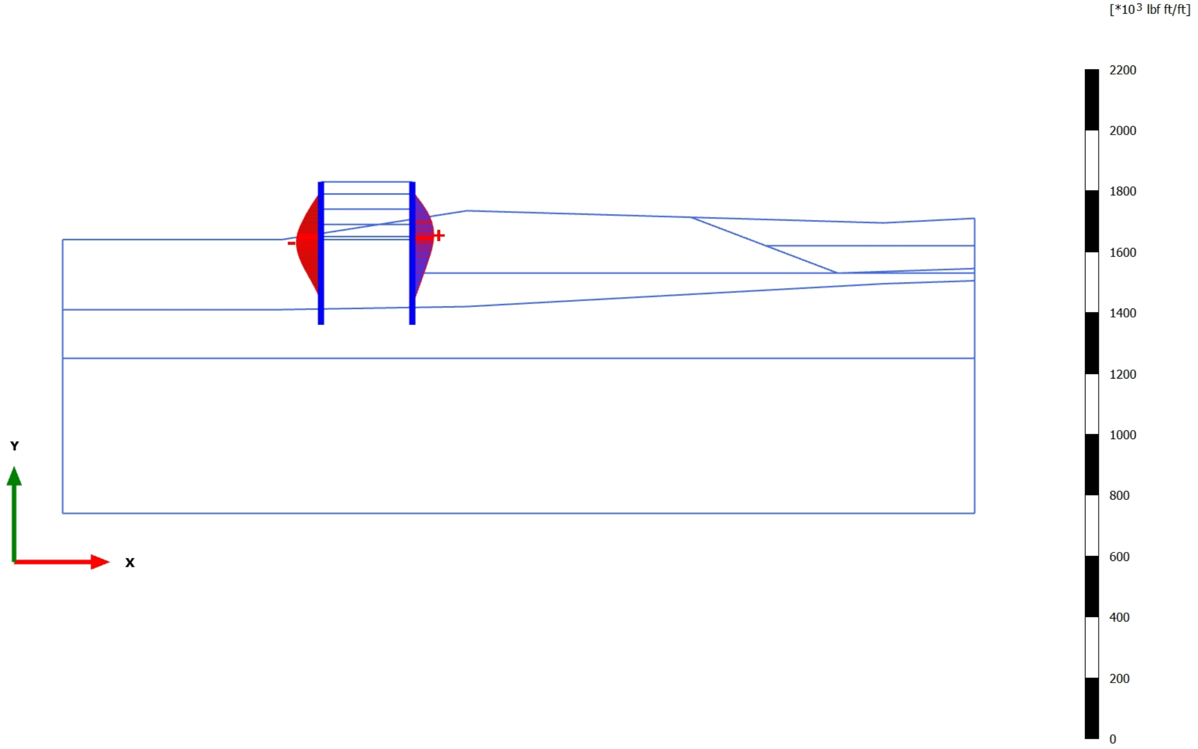


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 59.02*10^{3} lbf ft/ft (Element 14 at Node 14574)

Minimum value = -60.95*10^{3} lbf ft/ft (Element 22 at Node 16367)

3.1.2.2.4 Calculation results, Plate, Dewater-ss [Phase_16] (16/73), Bending moments M

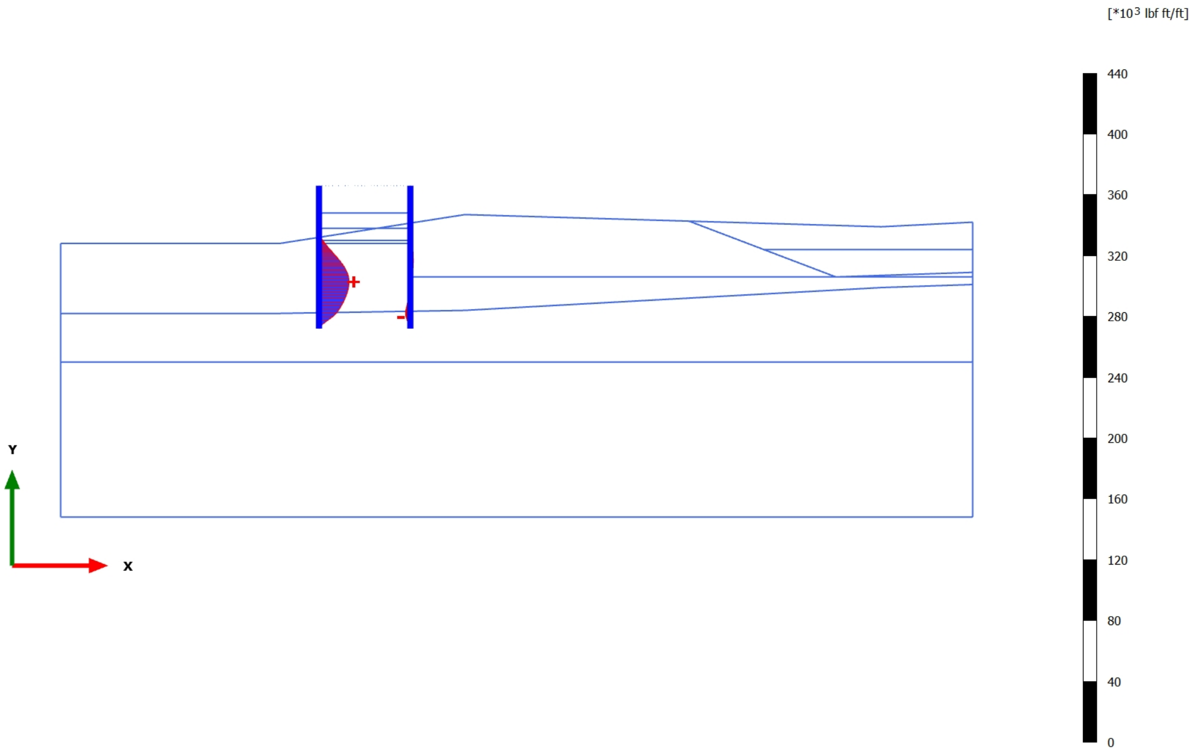


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 70.56*10^3 lbf ft/ft (Element 14 at Node 14575)

Minimum value = -81.01*10^3 lbf ft/ft (Element 22 at Node 16161)

3.1.2.2.5 Calculation results, Plate, Consolidate [Phase_25] (25/96), Bending moments M

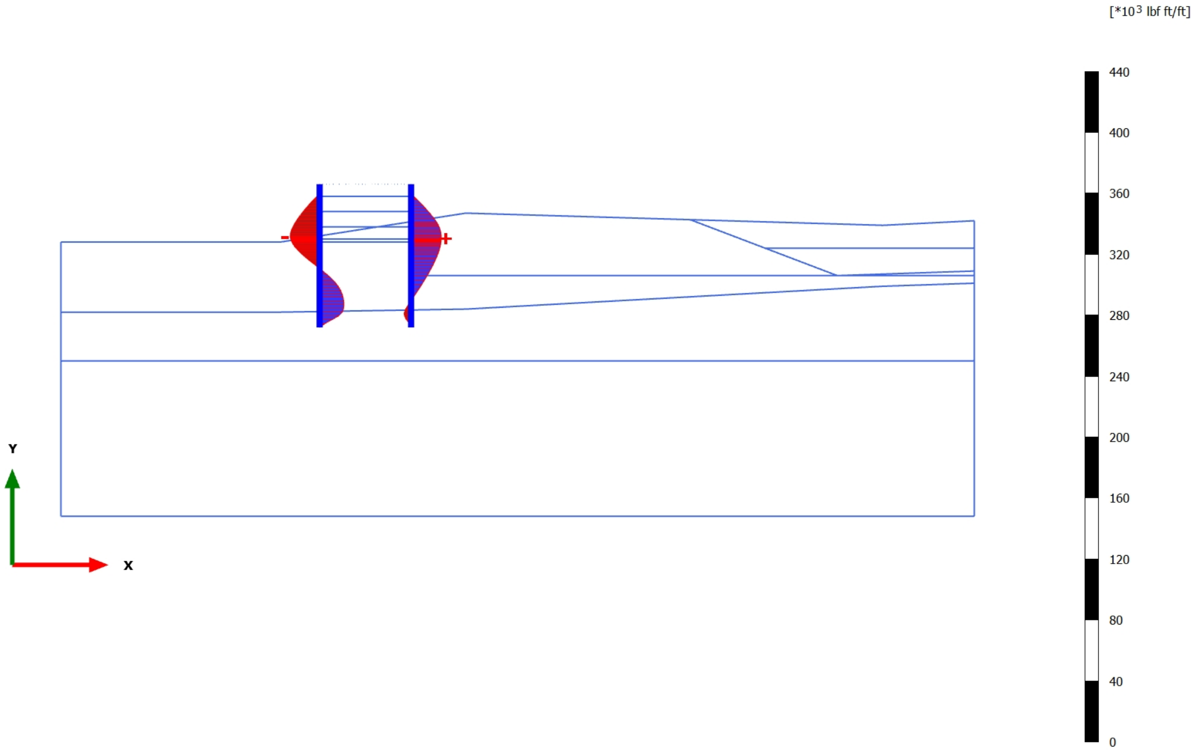


Bending moments M (scaled up 0.500×10^{-3} times) (Time 10.00 day)

Maximum value = 19.75×10^{3} lbf ft/ft (Element 27 at Node 14201)

Minimum value = -3054 lbf ft/ft (Element 32 at Node 11949)

3.1.2.2.6 Calculation results, Plate, Backfill 3 [Phase_5] (5/115), Bending moments M

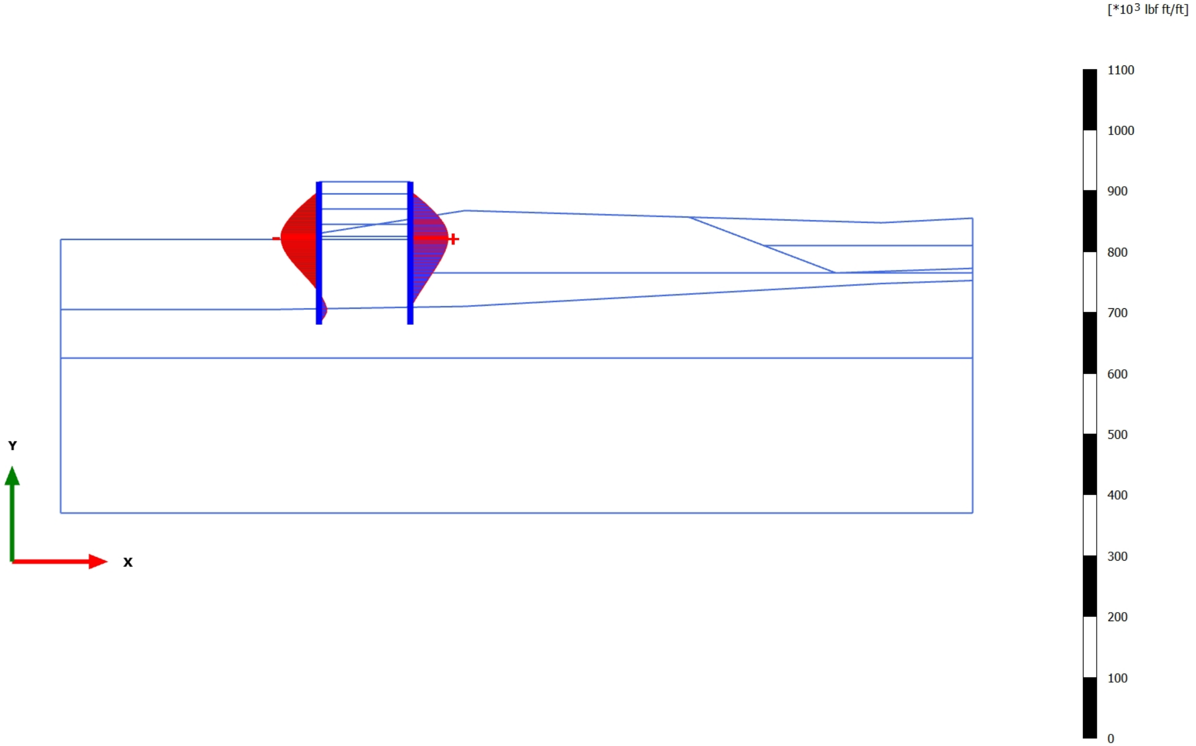


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 19.87*10^3 lbf ft/ft (Element 14 at Node 14574)

Minimum value = -19.40*10^3 lbf ft/ft (Element 12 at Node 16400)

3.1.2.2.7 Calculation results, Plate, Consolidate [Phase_7] (7/238), Bending moments M

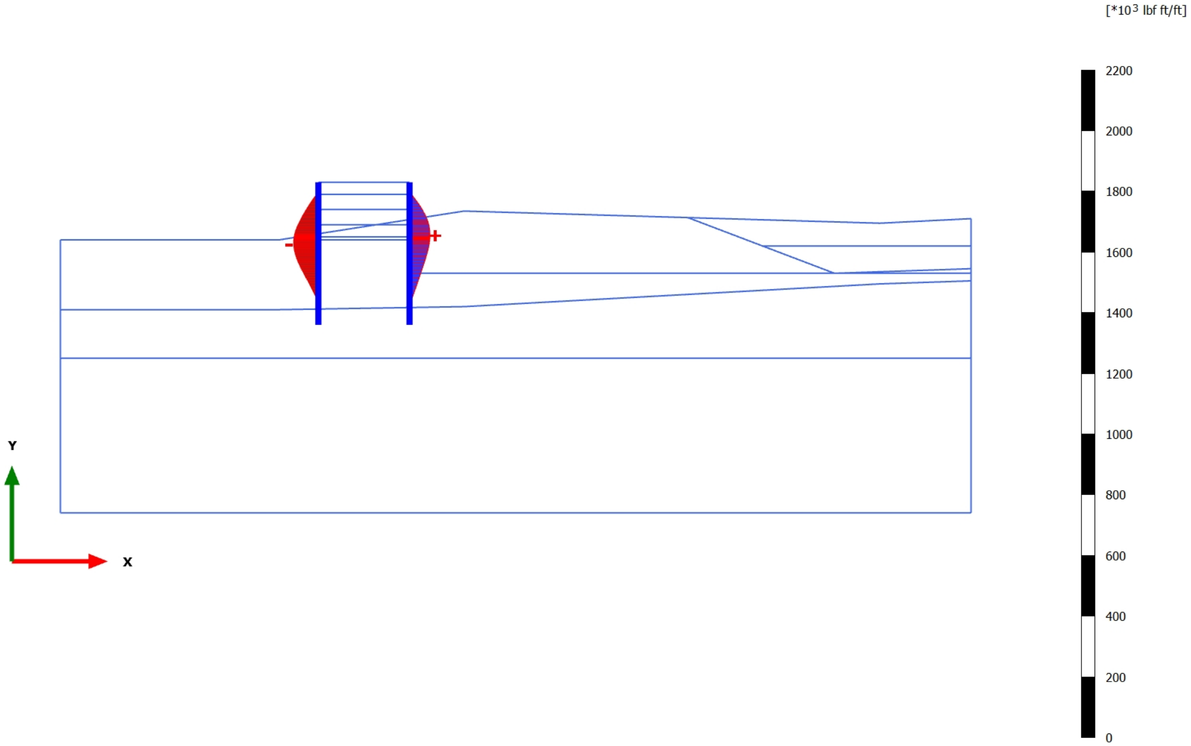


Bending moments M (scaled up 0.200×10^{-3} times) (Time 16.00 day)

Maximum value = 62.21×10^{3} lbf ft/ft (Element 17 at Node 14171)

Minimum value = -62.75×10^{3} lbf ft/ft (Element 16 at Node 16368)

3.1.2.2.8 Calculation results, Plate, Consolidation [Phase_17] (17/248), Bending moments M

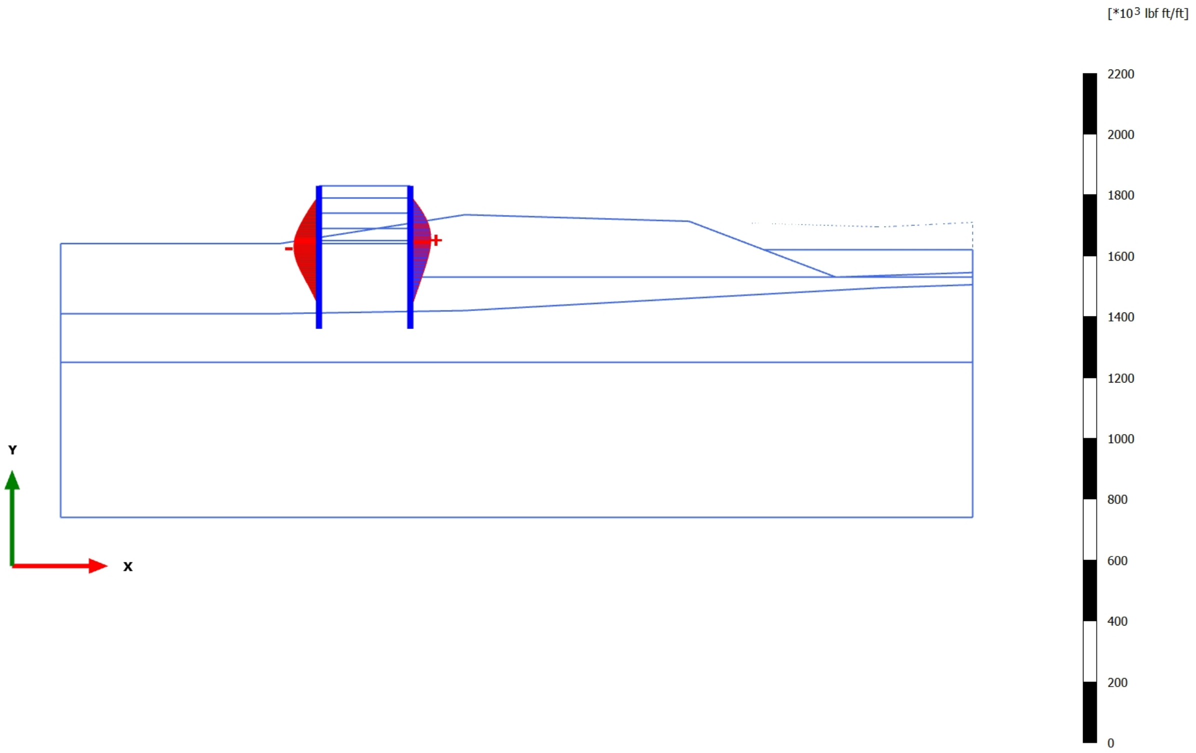


Bending moments M (scaled up $0.100*10^{-3}$ times) (Time 20.00 day)

Maximum value = $67.68*10^3$ lbf ft/ft (Element 14 at Node 14575)

Minimum value = $-81.60*10^3$ lbf ft/ft (Element 22 at Node 16160)

3.1.2.2.9 Calculation results, Plate, Excavate 1 [Phase_18] (18/254), Bending moments M

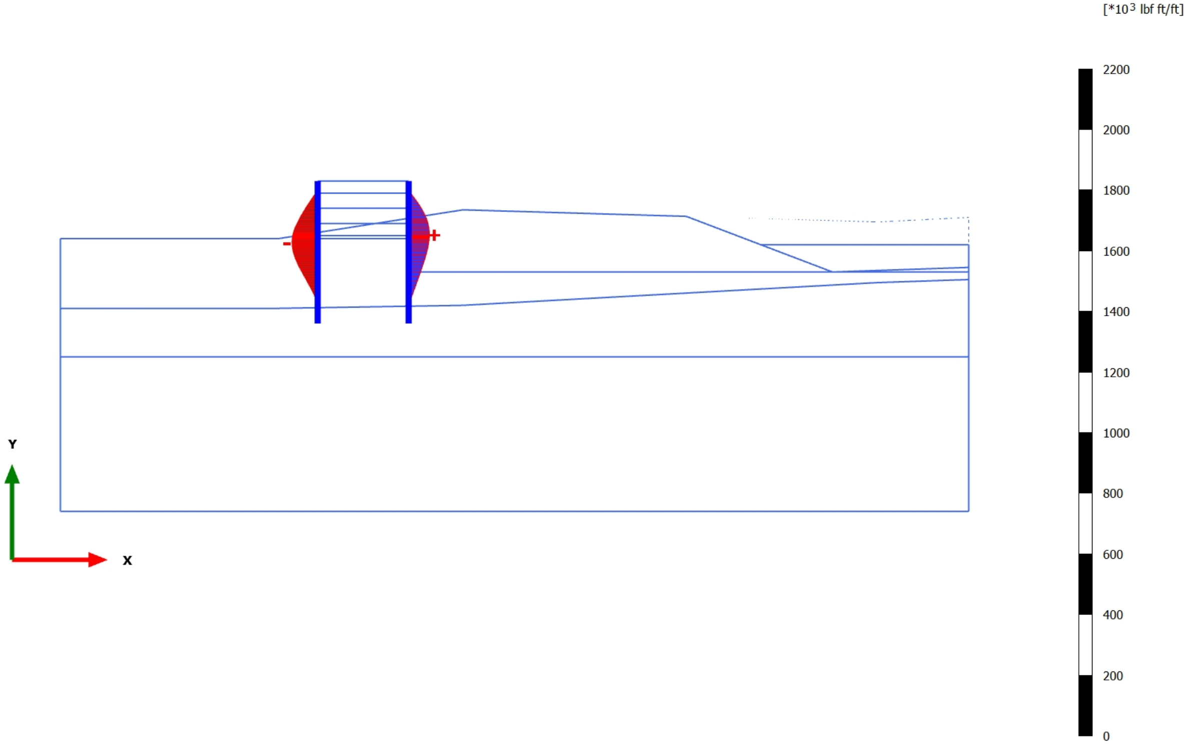


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 67.92*10^{3} lbf ft/ft (Element 14 at Node 14574)

Minimum value = -82.78*10^{3} lbf ft/ft (Element 22 at Node 16160)

3.1.2.2.10 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/259), Bending moments M

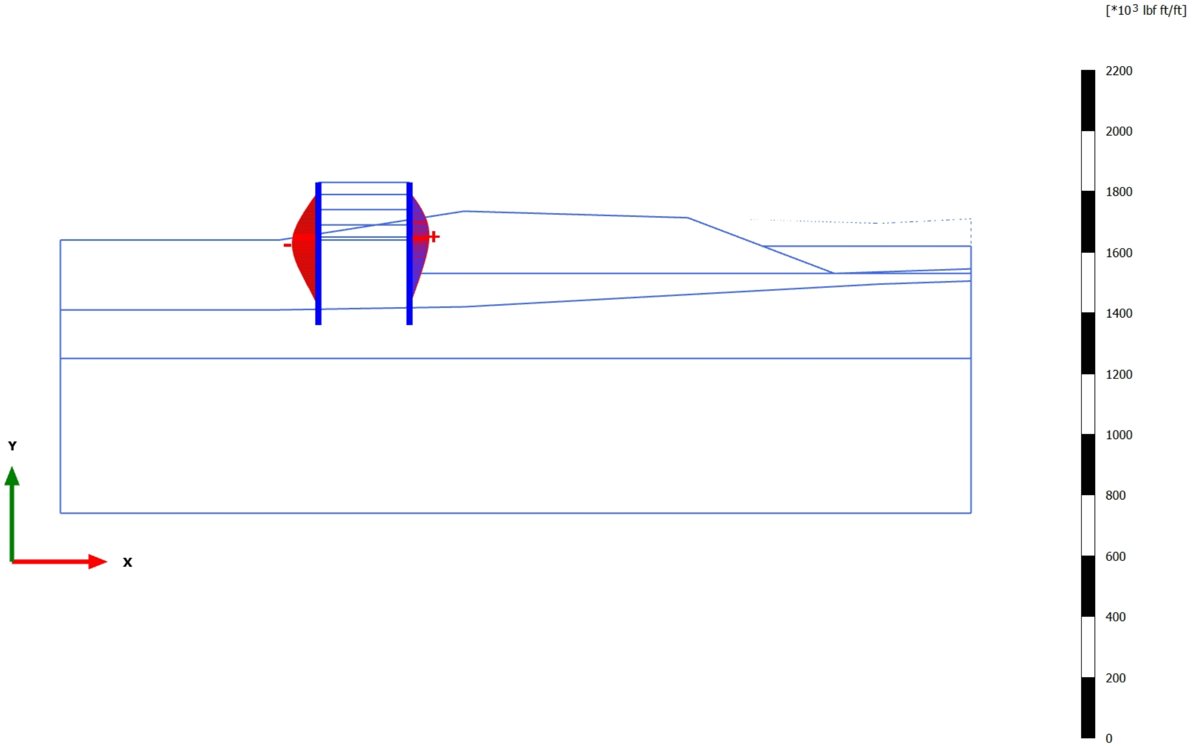


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 68.78*10^3 lbf ft/ft (Element 14 at Node 14574)

Minimum value = -85.06*10^3 lbf ft/ft (Element 22 at Node 16160)

3.1.2.2.11 Calculation results, Plate, Consolidation [Phase_20] (20/276), Bending moments M

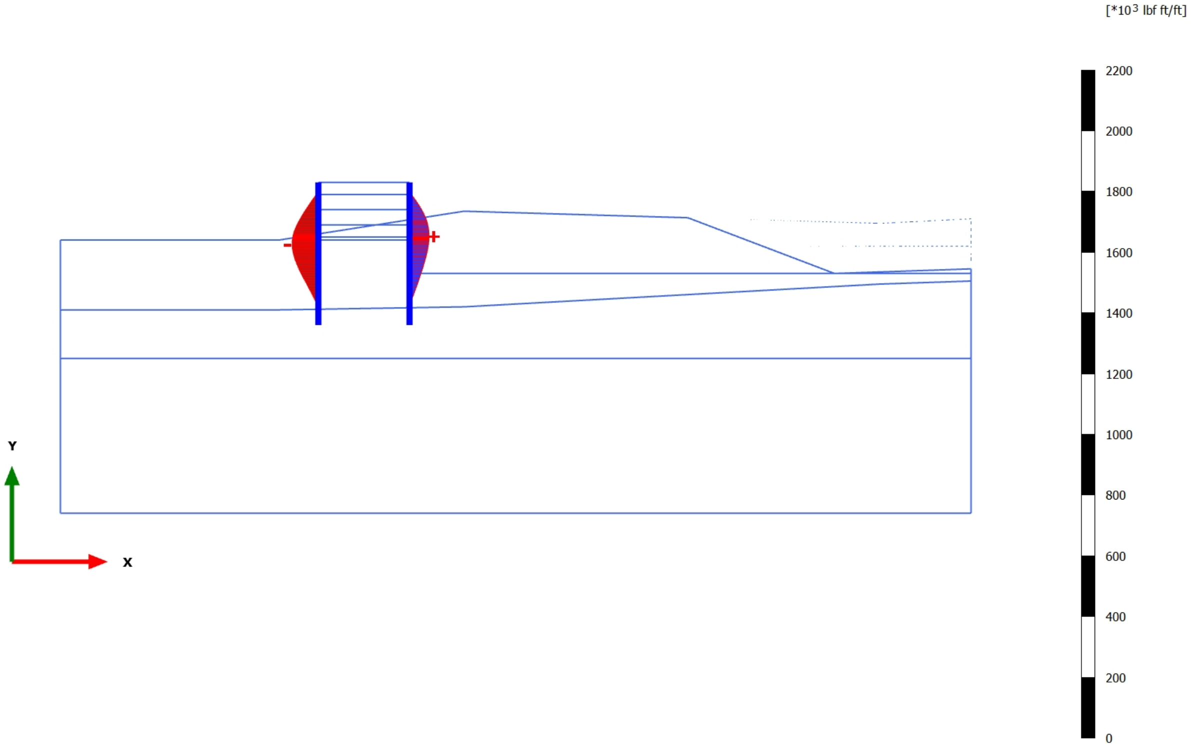


Bending moments M (scaled up 0.100*10^{-3} times) (Time 37.00 day)

Maximum value = 64.43*10^{3} lbf ft/ft (Element 14 at Node 14574)

Minimum value = -86.05*10^{3} lbf ft/ft (Element 22 at Node 16160)

3.1.2.2.12 Calculation results, Plate, Excavate 2 [Phase_21] (21/279), Bending moments M

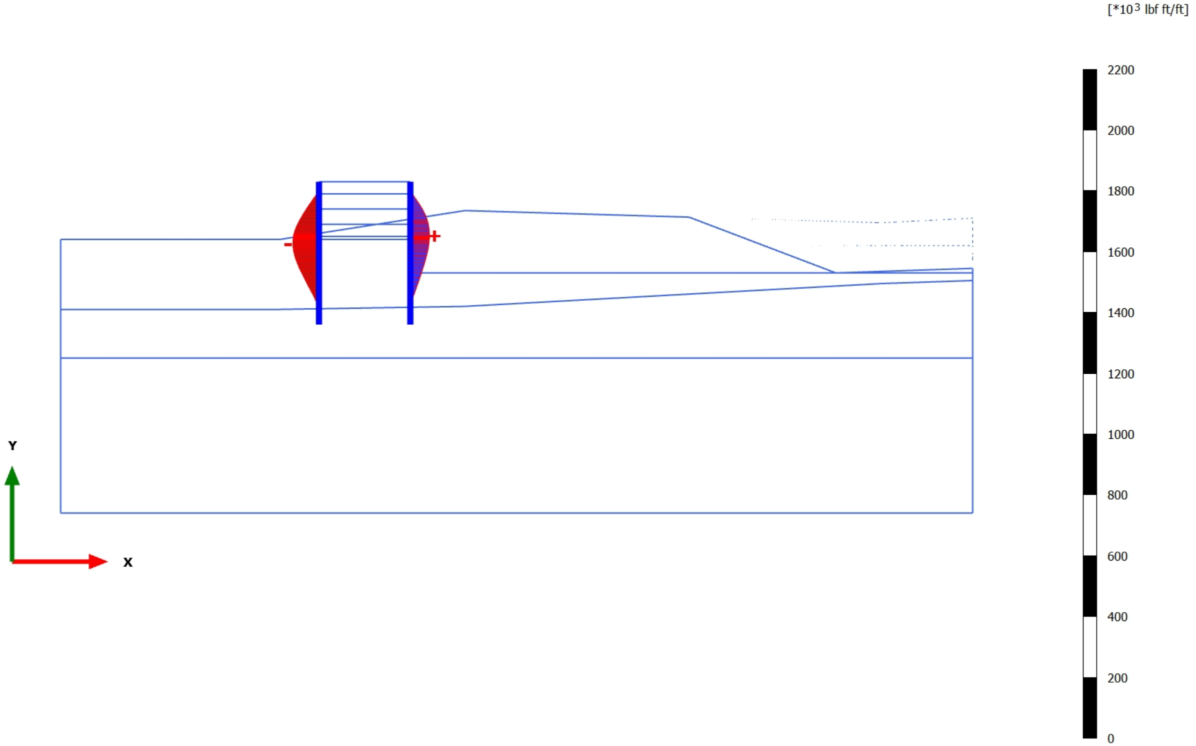


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 64.60*10^3 lbf ft/ft (Element 14 at Node 14574)

Minimum value = -86.48*10^3 lbf ft/ft (Element 22 at Node 16160)

3.1.2.2.13 Calculation results, Plate, Consolidate [Phase_8] (8/397), Bending moments M

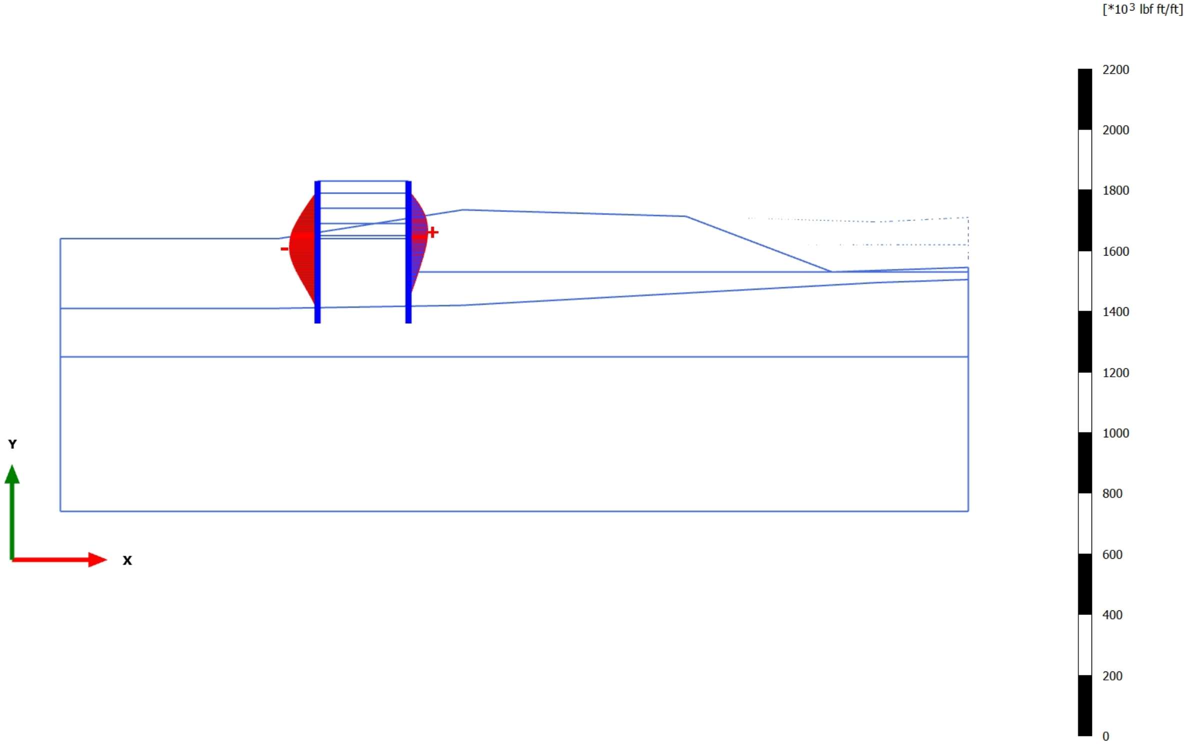


Bending moments M (scaled up 0.100*10⁻³ times) (Time 51.00 day)

Maximum value = 63.29*10³ lbf ft/ft (Element 14 at Node 14574)

Minimum value = -86.22*10³ lbf ft/ft (Element 22 at Node 16160)

3.1.2.2.14 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/403), Bending moments M



Bending moments M (scaled up $0.100*10^{-3}$ times)

Maximum value = $63.81*10^{3}$ lbf ft/ft (Element 13 at Node 14723)

Minimum value = $-93.09*10^{3}$ lbf ft/ft (Element 23 at Node 15808)

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/60), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	61.610	0.000	61.610
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	61.610	0.000	61.610

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater-ss [Phase_16] (16/73), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	83.845	0.000	83.845
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	83.845	0.000	83.845

3.2.1.1.5 Calculation results, Node-to-node anchor, Consolidate [Phase_25] (25/96), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	1219.793	0.000	1697.559
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	1219.793	0.000	1697.559

3.2.1.1.6 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/115), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	19.686	0.000	19.686
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	19.686	0.000	19.686

3.2.1.1.7 Calculation results, Node-to-node anchor, Consolidate [Phase_7] (7/238), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	67.536	0.000	72.202
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	67.536	0.000	72.202

3.2.1.1.8 Calculation results, Node-to-node anchor, Consolidation [Phase_17] (17/248), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	80.532	0.000	83.845
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	80.532	0.000	83.845

3.2.1.1.9 Calculation results, Node-to-node anchor, Excavate 1 [Phase_18] (18/254), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	80.732	0.000	83.845
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	80.732	0.000	83.845

3.2.1.1.10 Calculation results, Node-to-node anchor, Dewater 2 - ss [Phase_19] (19/259), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	81.223	0.000	83.845
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	81.223	0.000	83.845

3.2.1.1.11 Calculation results, Node-to-node anchor, Consolidation [Phase_20] (20/276), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	79.006	0.000	83.845
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	79.006	0.000	83.845

3.2.1.1.12 Calculation results, Node-to-node anchor, Excavate 2 [Phase_21] (21/279), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	79.065	0.000	83.845
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	79.065	0.000	83.845

3.2.1.1.13 Calculation results, Node-to-node anchor, Consolidate [Phase_8] (8/397), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	78.587	0.000	83.845
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	78.587	0.000	83.845

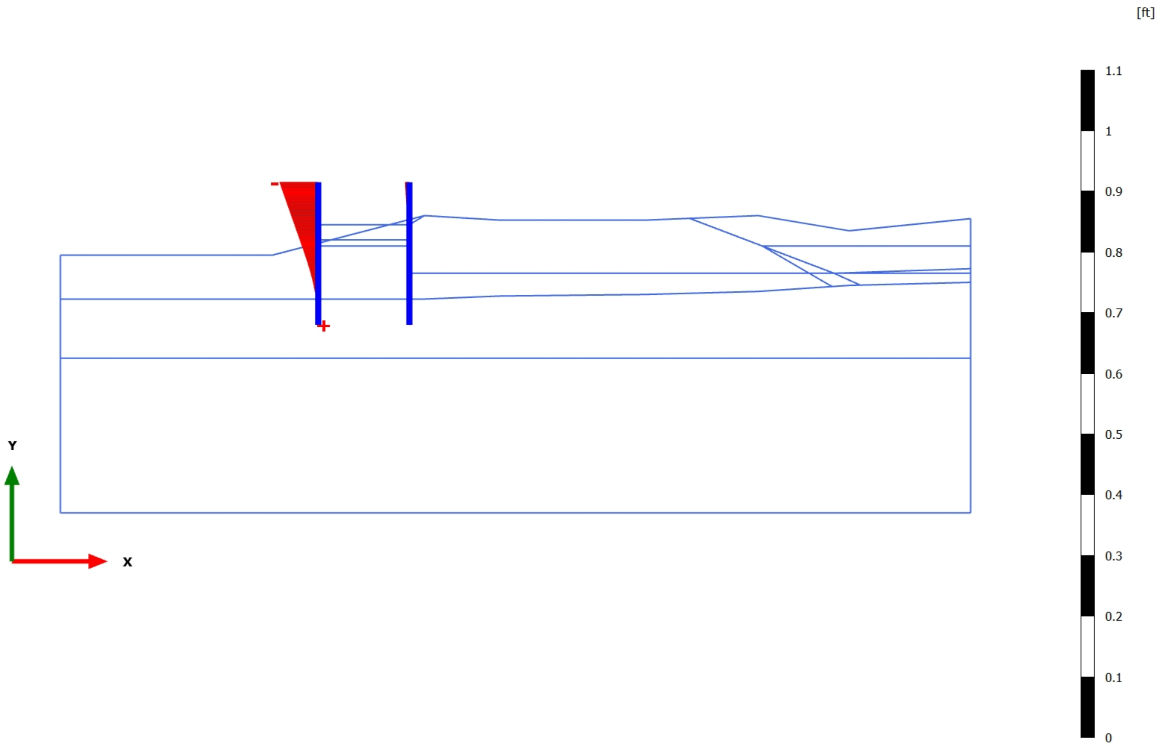
3.2.1.1.14 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_22] (22/403), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17338	1	-15.000	6.000	90.178	0.000	90.178
Element 1-1 (Node-to-node anchor)	14762	2	15.000	6.000	90.178	0.000	90.178

San Jacinto Section C4 - Drained Model

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/26), Total displacements u_x

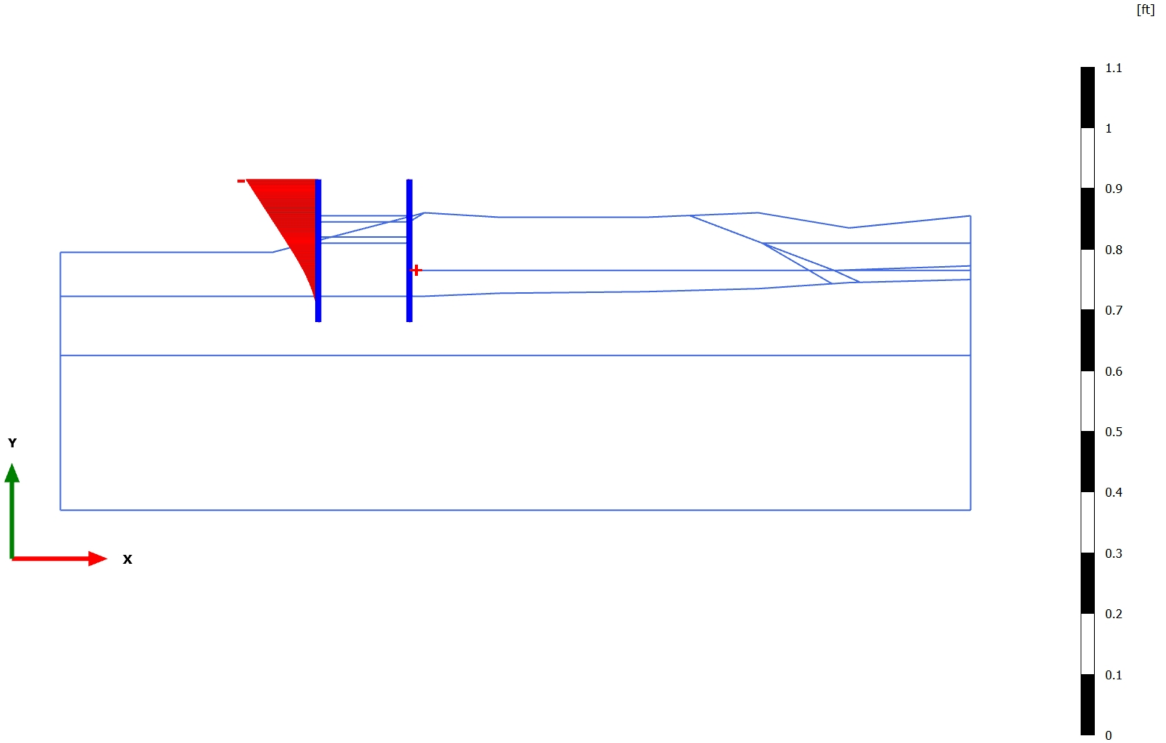


Total displacements u_x (scaled up 200 times)

Maximum value = $1.014*10^{-3}$ ft (Element 51 at Node 23843)

Minimum value = -0.06344 ft (Element 1 at Node 32637)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/45), Total displacements u_x

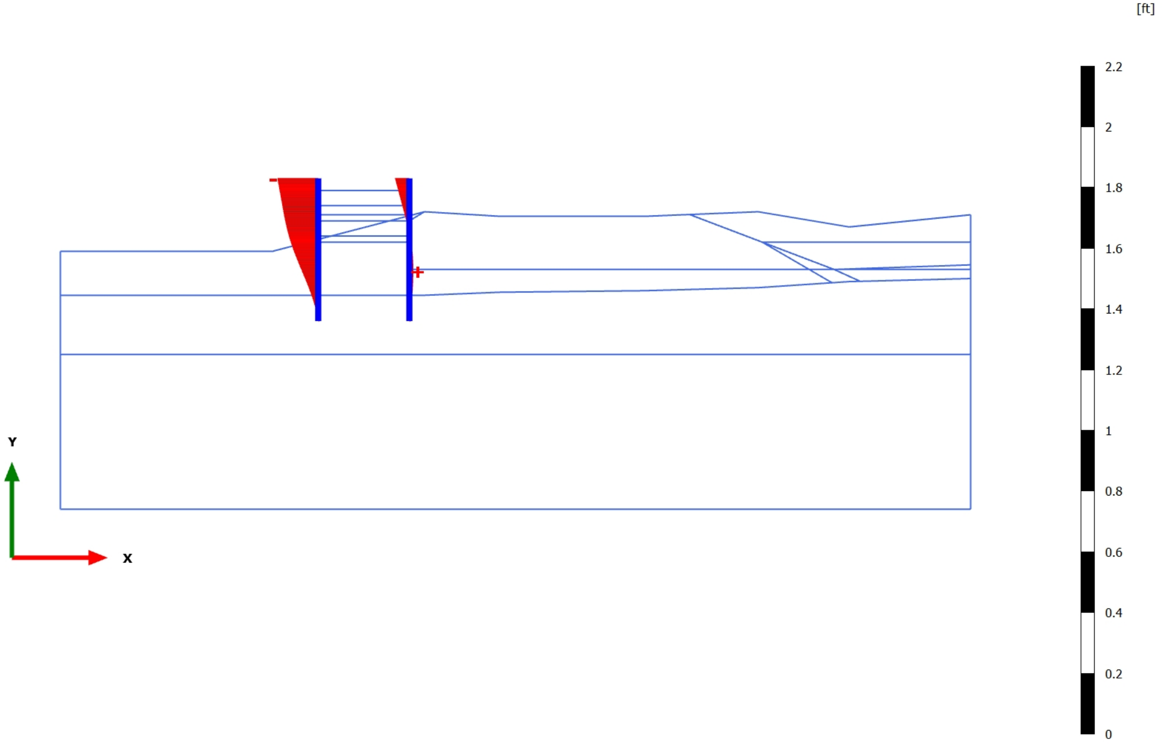


Total displacements u_x (scaled up 200 times)

Maximum value = 3.174×10^{-3} ft (Element 33 at Node 25458)

Minimum value = -0.1191 ft (Element 1 at Node 32637)

3.1.1.1.1.3 Calculation results, Plate, Backfill 3 [Phase_5] (5/89), Total displacements u_x

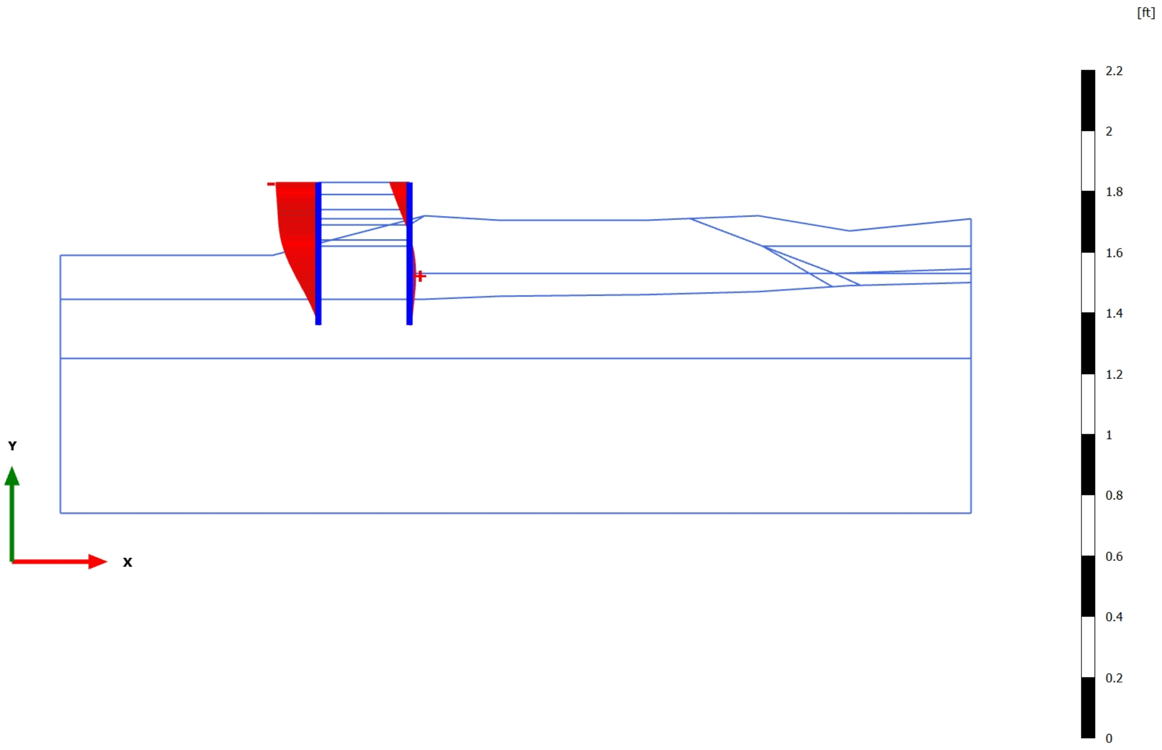


Total displacements u_x (scaled up 100 times)

Maximum value = 0.01219 ft (Element 44 at Node 25410)

Minimum value = -0.1335 ft (Element 1 at Node 32637)

3.1.1.1.1.4 Calculation results, Plate, Backfill 4 [Phase_6] (6/102), Total displacements u_x

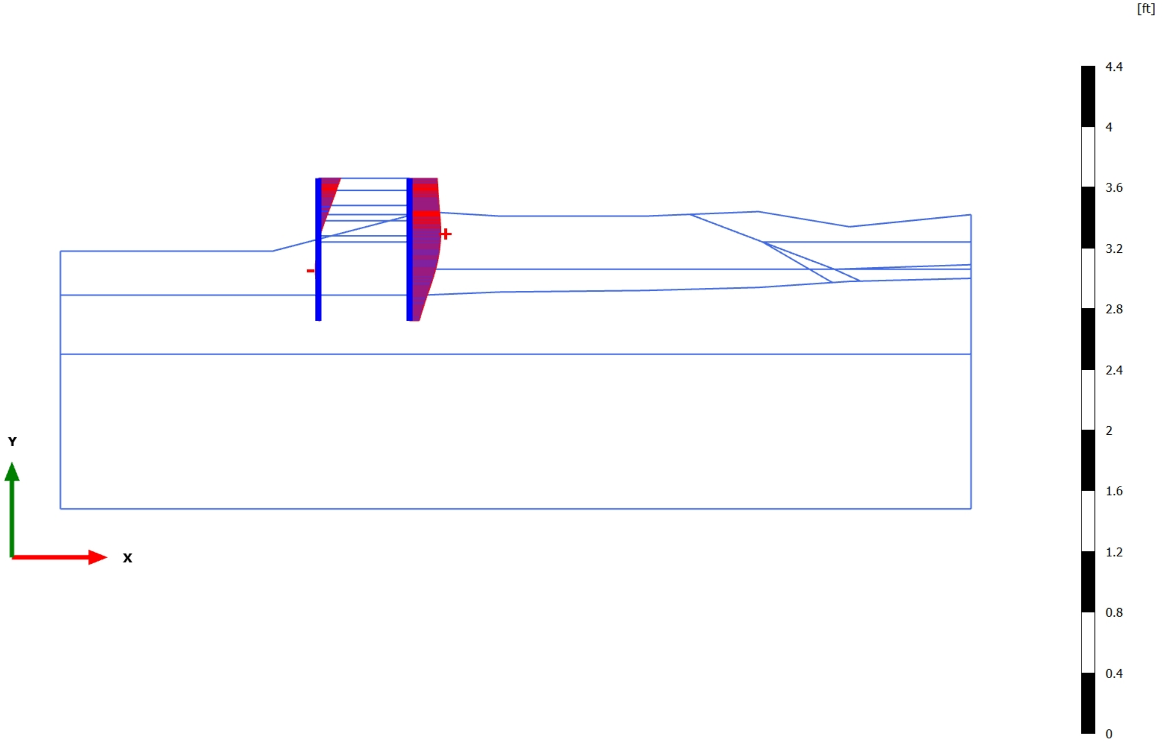


Total displacements u_x (scaled up 100 times)

Maximum value = 0.02061 ft (Element 44 at Node 25410)

Minimum value = -0.1405 ft (Element 1 at Node 32637)

3.1.1.1.1.5 Calculation results, Plate, Dewater [Phase_7] (7/163), Total displacements u_x

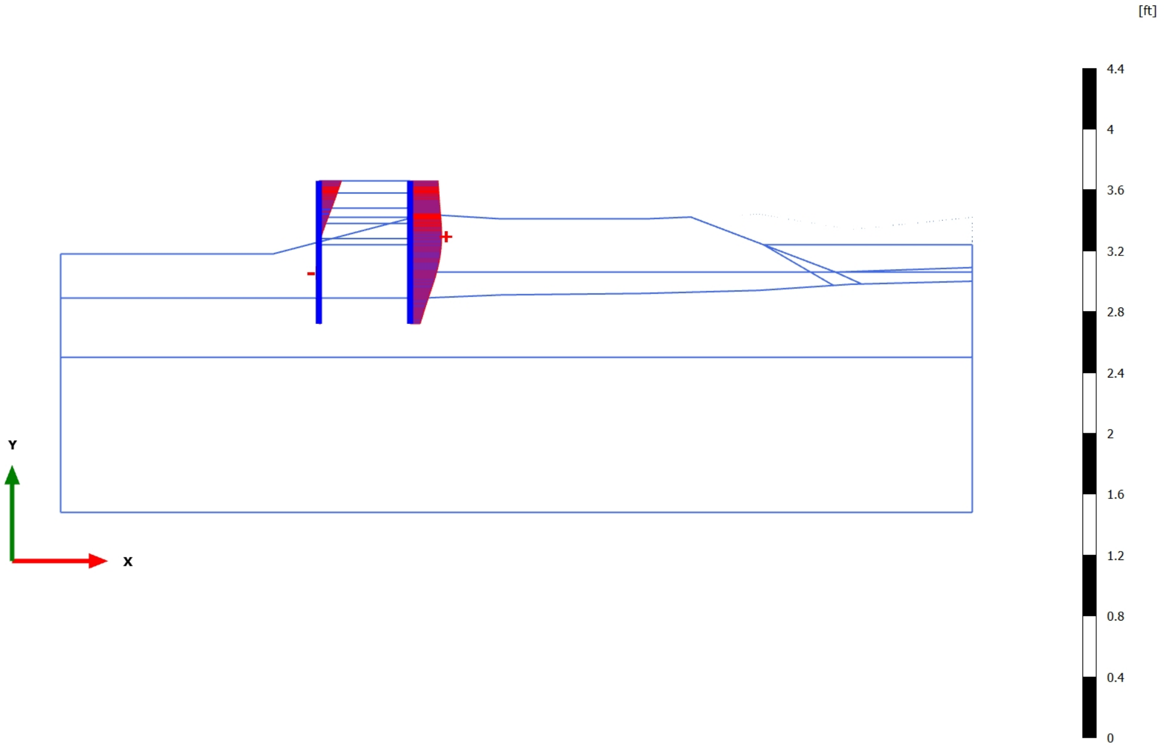


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.2063 ft (Element 26 at Node 25787)

Minimum value = -0.02092 ft (Element 39 at Node 27837)

3.1.1.1.1.6 Calculation results, Plate, Exc 1 [Phase_8] (8/168), Total displacements u_x

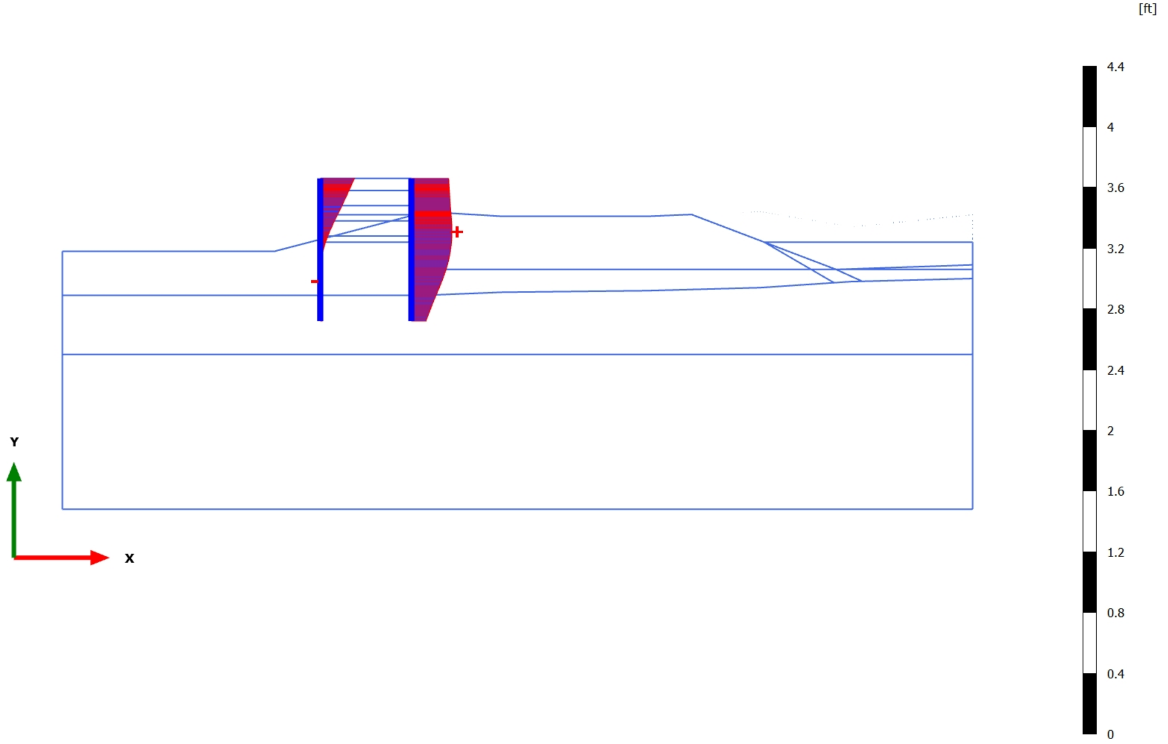


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.2084 ft (Element 26 at Node 25787)

Minimum value = -0.01990 ft (Element 39 at Node 27837)

3.1.1.1.1.7 Calculation results, Plate, Dewater 2 [Phase_9] (9/180), Total displacements u_x

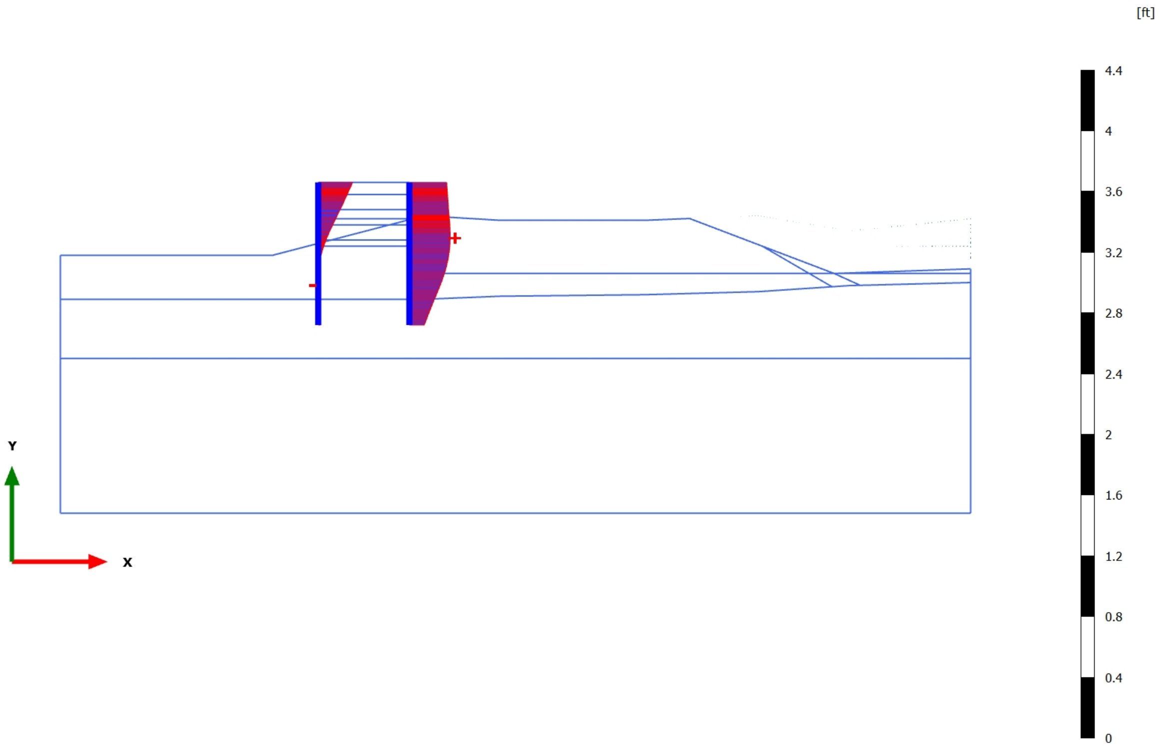


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.2680 ft (Element 26 at Node 25788)

Minimum value = -4.295×10^{-3} ft (Element 41 at Node 27099)

3.1.1.1.1.8 Calculation results, Plate, Exc 2 [Phase_10] (10/185), Total displacements u_x

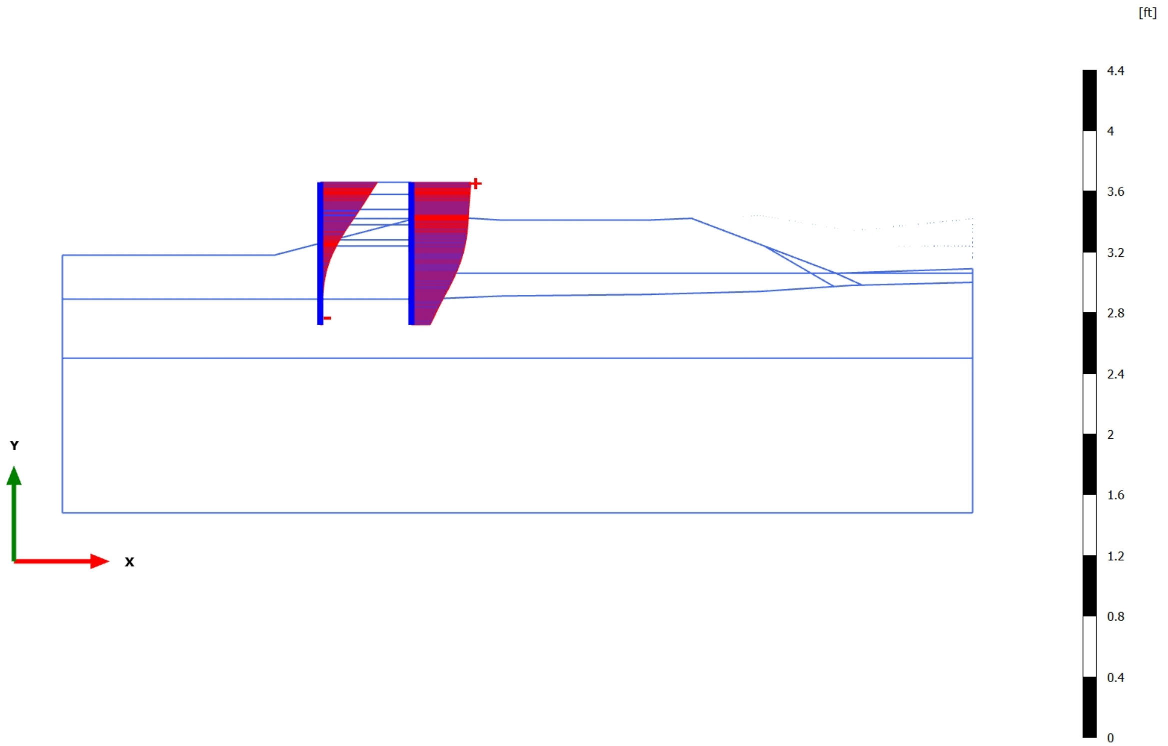


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.2699 ft (Element 26 at Node 25787)

Minimum value = -3.647×10^{-3} ft (Element 41 at Node 27099)

3.1.1.1.1.9 Calculation results, Plate, GW 9ft [Phase_11] (11/214), Total displacements u_x

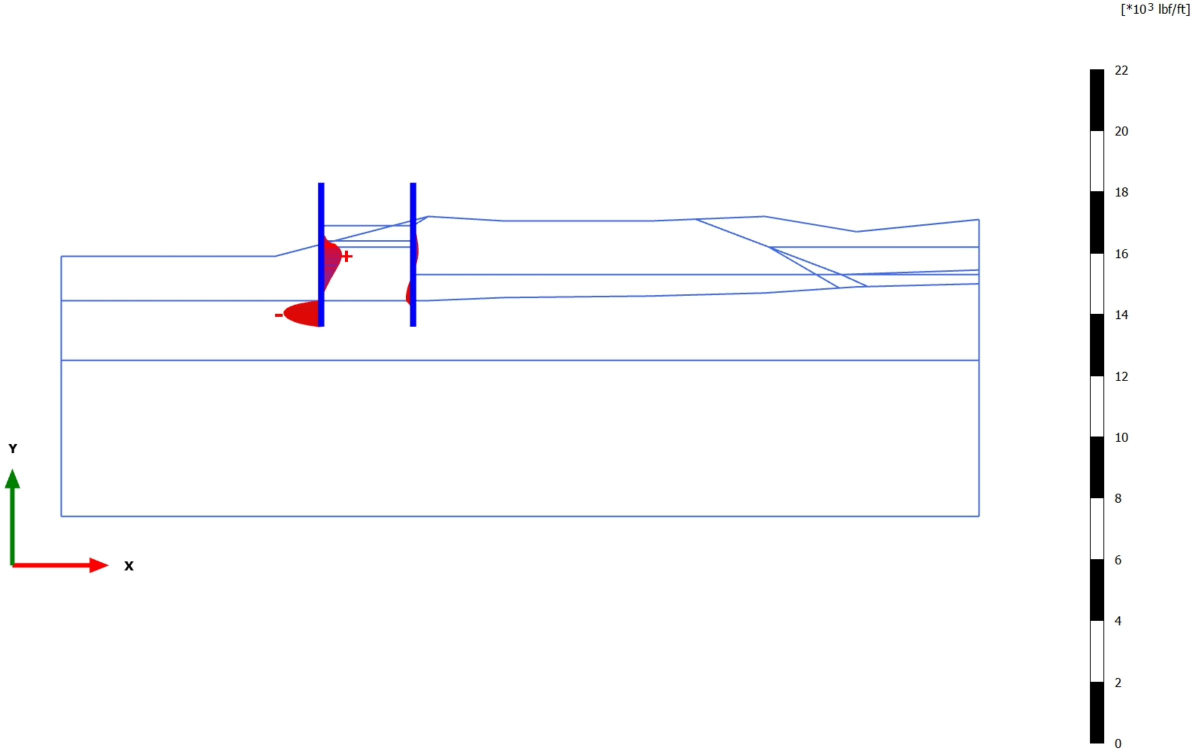


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3939 ft (Element 3 at Node 27321)

Minimum value = 0.01523 ft (Element 50 at Node 24516)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/26), Shear forces Q

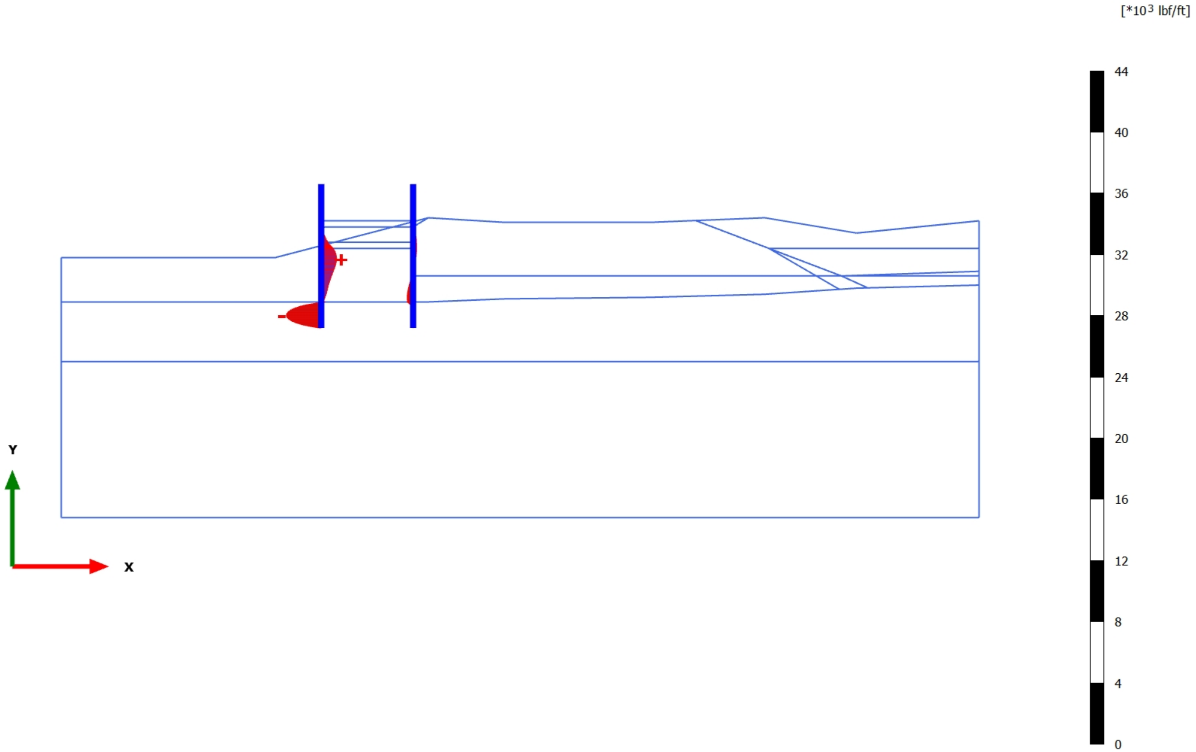


Shear forces Q (scaled up 0.0100 times)

Maximum value = 666.0 lbf/ft (Element 36 at Node 29601)

Minimum value = -1223 lbf/ft (Element 50 at Node 24987)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/45), Shear forces Q

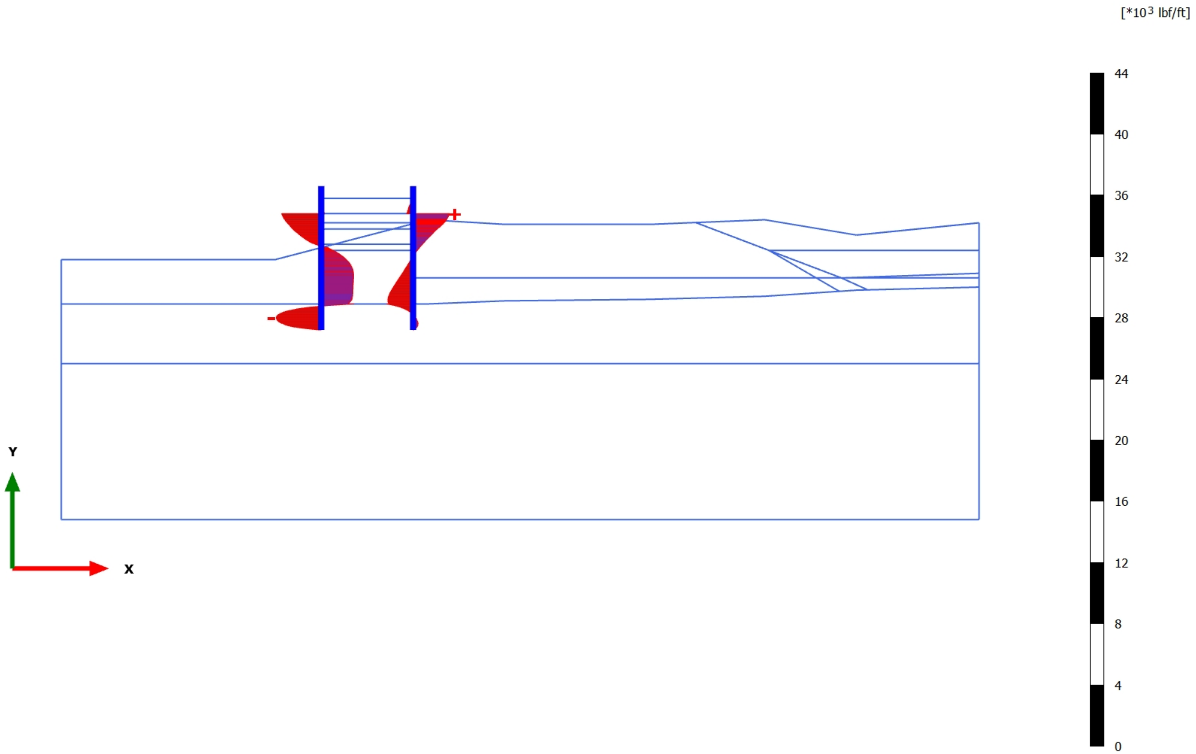


Shear forces Q (scaled up 5.00*10^{-3} times)

Maximum value = 993.9 lbf/ft (Element 36 at Node 29185)

Minimum value = -2282 lbf/ft (Element 50 at Node 24987)

3.1.2.1.3 Calculation results, Plate, Backfill 3 [Phase_5] (5/89), Shear forces Q

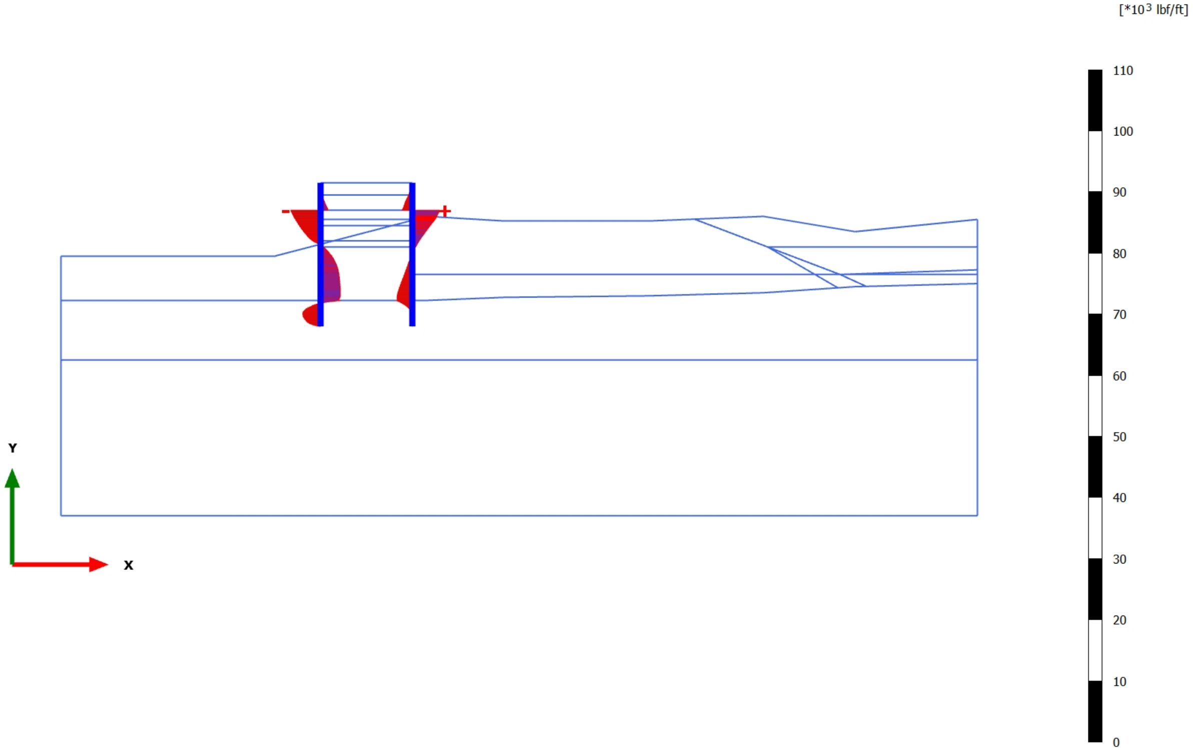


Shear forces Q (scaled up 5.00*10⁻³ times)

Maximum value = 2397 lbf/ft (Element 14 at Node 26818)

Minimum value = -2955 lbf/ft (Element 50 at Node 24987)

3.1.2.1.4 Calculation results, Plate, Backfill 4 [Phase_6] (6/102), Shear forces Q

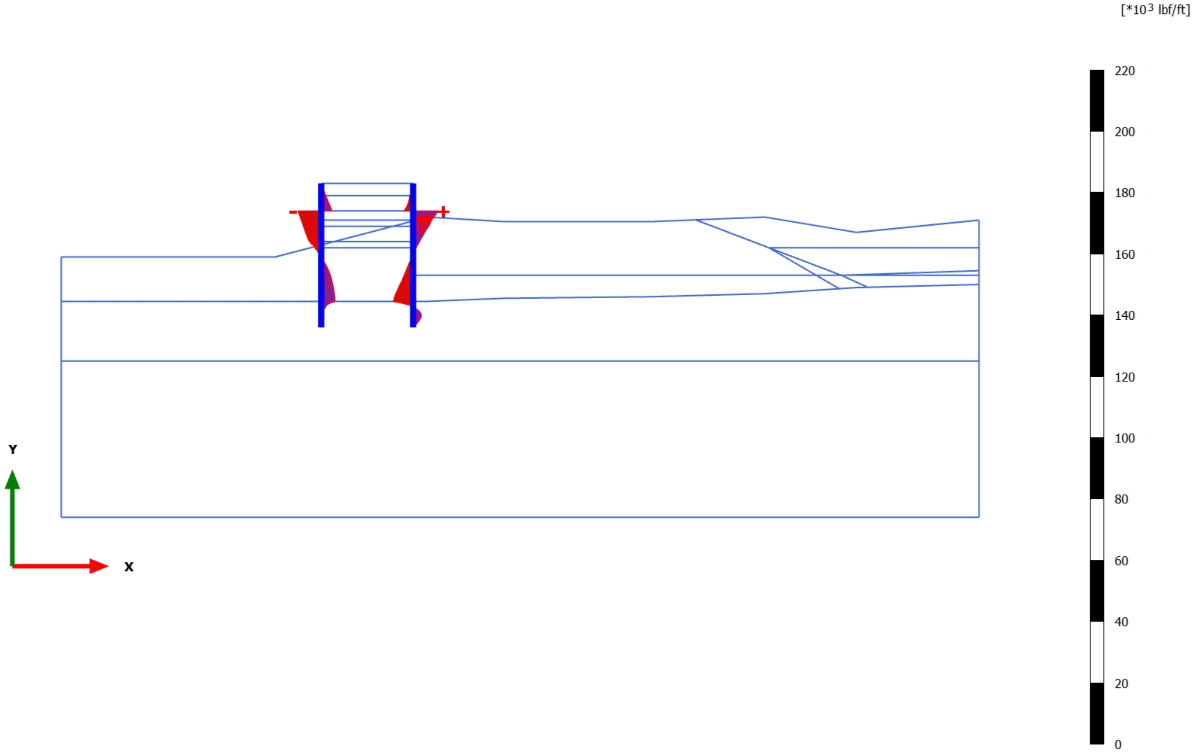


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 4489 lbf/ft (Element 14 at Node 26818)

Minimum value = -4922 lbf/ft (Element 13 at Node 31646)

3.1.2.1.5 Calculation results, Plate, Dewater [Phase_7] (7/163), Shear forces Q

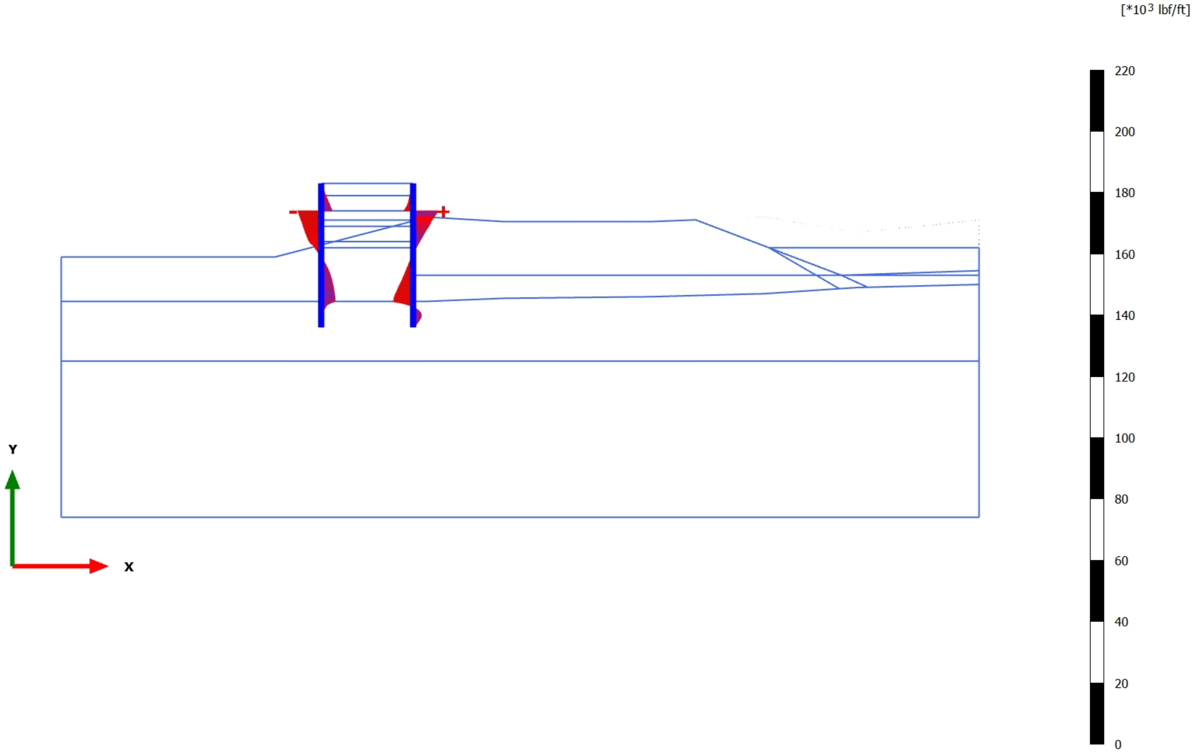


Shear forces Q (scaled up 1.00*10⁻³ times)

Maximum value = 8276 lbf/ft (Element 14 at Node 26818)

Minimum value = -7690 lbf/ft (Element 13 at Node 31646)

3.1.2.1.6 Calculation results, Plate, Exc 1 [Phase_8] (8/168), Shear forces Q

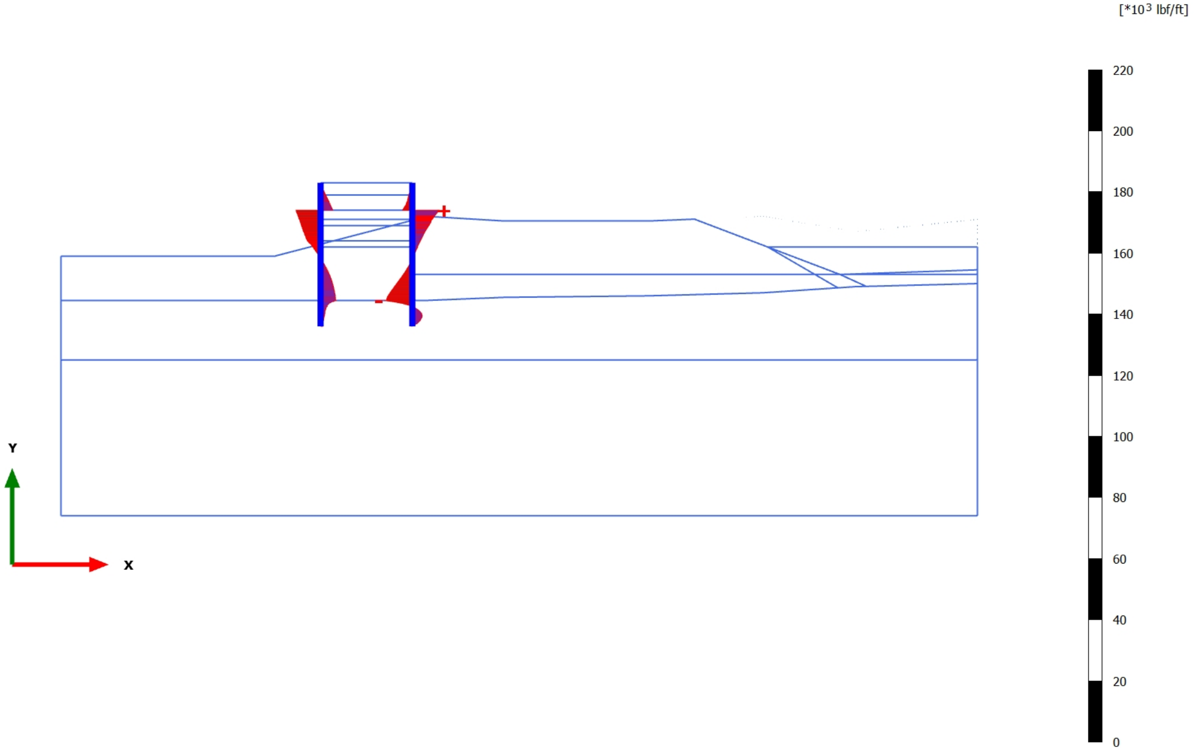


Shear forces Q (scaled up 1.00*10⁻³ times)

Maximum value = 8284 lbf/ft (Element 14 at Node 26818)

Minimum value = -7687 lbf/ft (Element 13 at Node 31646)

3.1.2.1.7 Calculation results, Plate, Dewater 2 [Phase_9] (9/180), Shear forces Q

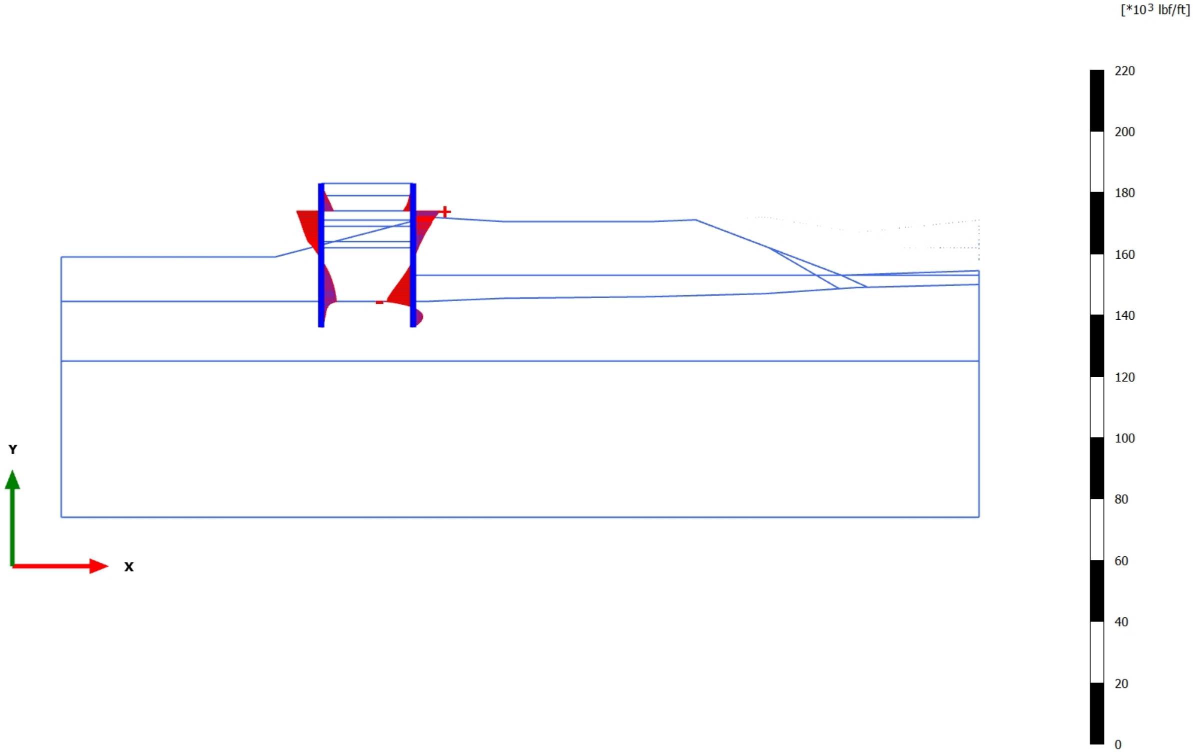


Shear forces Q (scaled up 1.00*10^{-3} times)

Maximum value = 8875 lbf/ft (Element 14 at Node 26818)

Minimum value = -9352 lbf/ft (Element 52 at Node 24317)

3.1.2.1.8 Calculation results, Plate, Exc 2 [Phase_10] (10/185), Shear forces Q

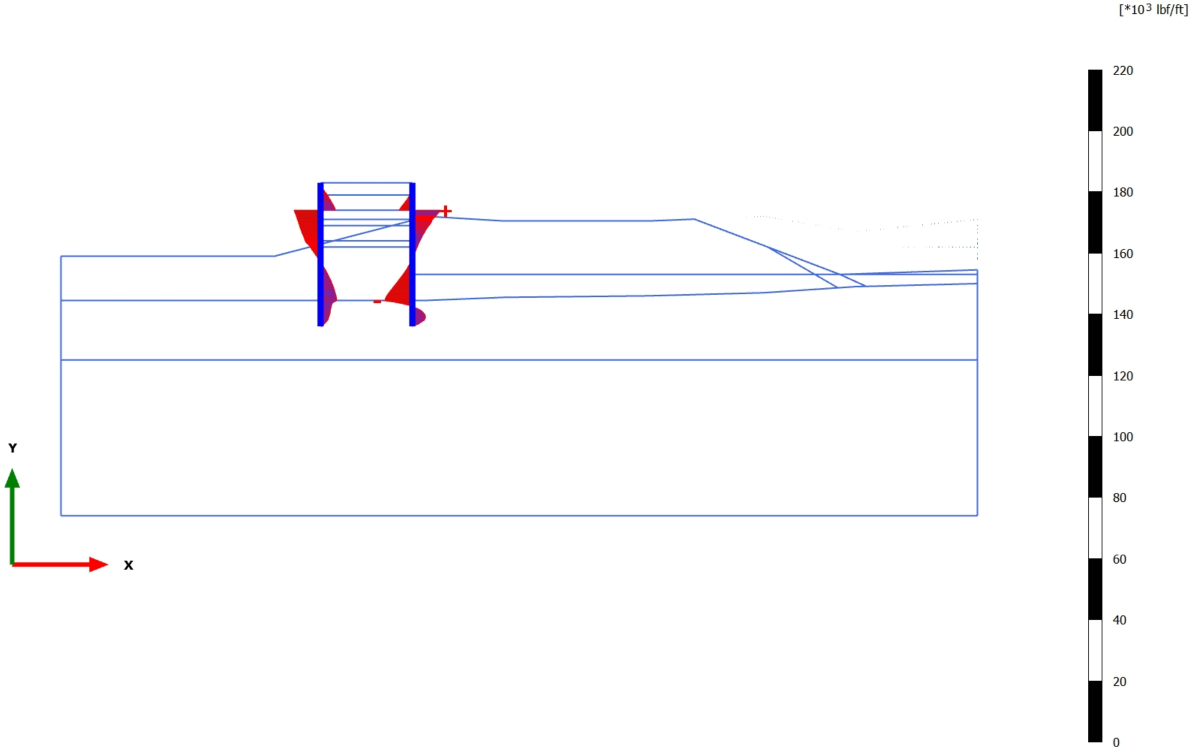


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8888 lbf/ft (Element 14 at Node 26818)

Minimum value = -9372 lbf/ft (Element 52 at Node 24317)

3.1.2.1.9 Calculation results, Plate, GW 9ft [Phase_11] (11/214), Shear forces Q

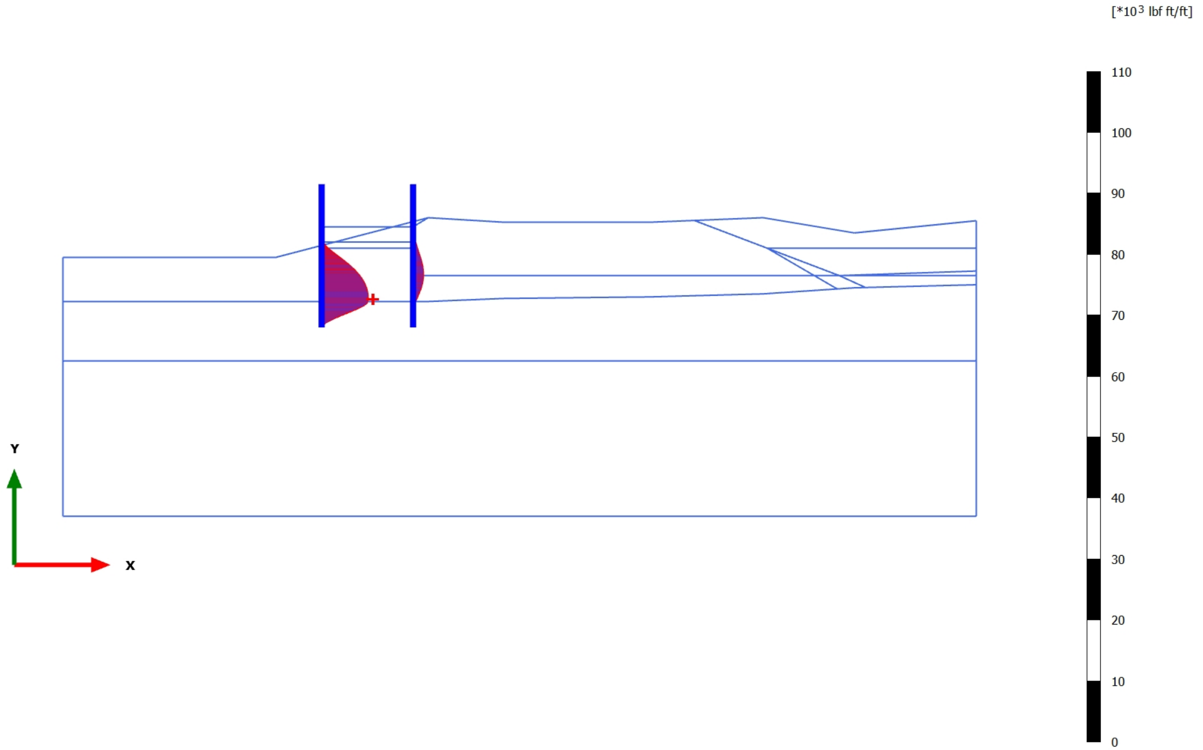


Shear forces Q (scaled up 1.00*10^{-3} times)

Maximum value = 9256 lbf/ft (Element 14 at Node 26818)

Minimum value = -9845 lbf/ft (Element 52 at Node 24317)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/26), Bending moments M

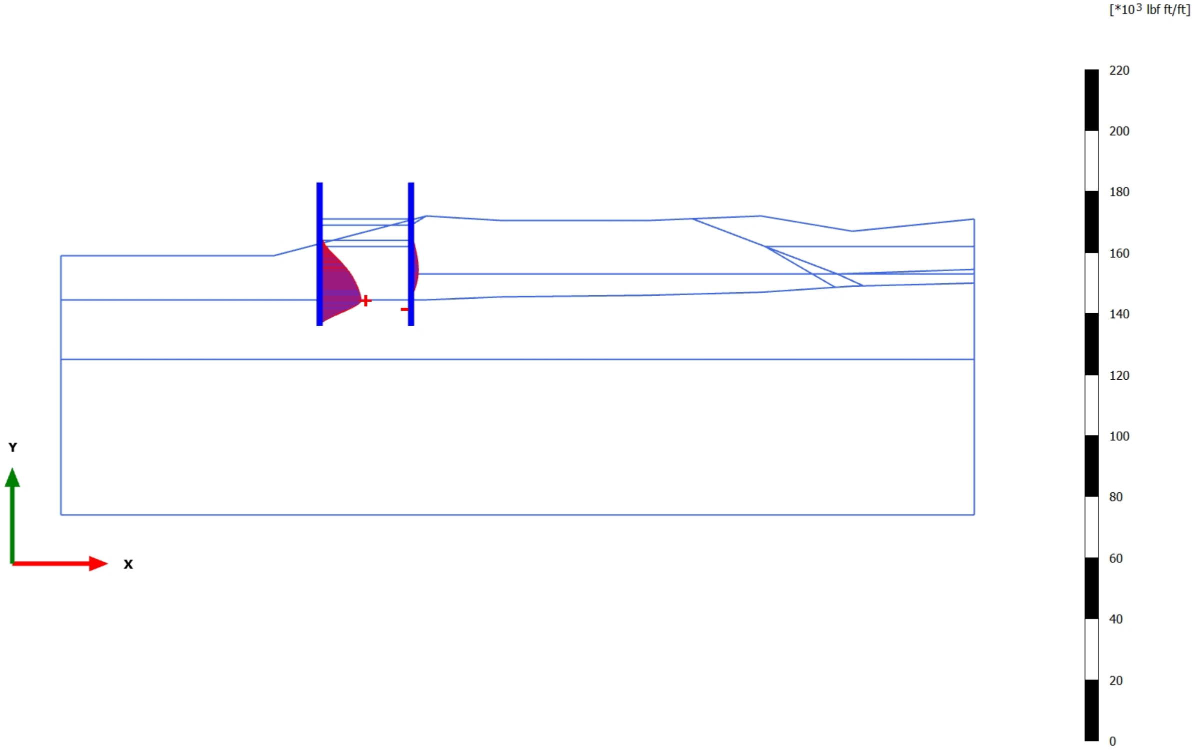


Bending moments M (scaled up 2.00*10^{-3} times)

Maximum value = 7672 lbf ft/ft (Element 43 at Node 26155)

Minimum value = -0.04837*10^{-9} lbf ft/ft (Element 1 at Node 32637)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/45), Bending moments M

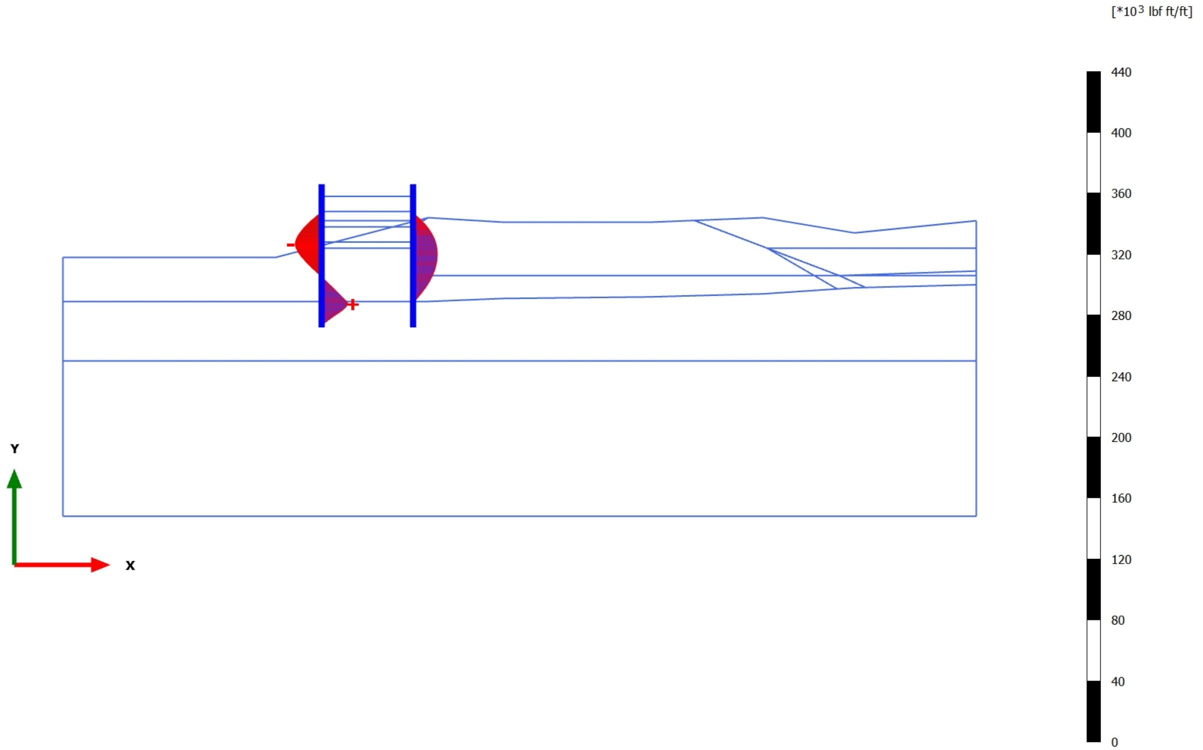


Bending moments M (scaled up $1.00*10^{-3}$ times)

Maximum value = $13.64*10^3$ lbf ft/ft (Element 43 at Node 26153)

Minimum value = -396.4 lbf ft/ft (Element 53 at Node 23215)

3.1.2.2.3 Calculation results, Plate, Backfill 3 [Phase_5] (5/89), Bending moments M

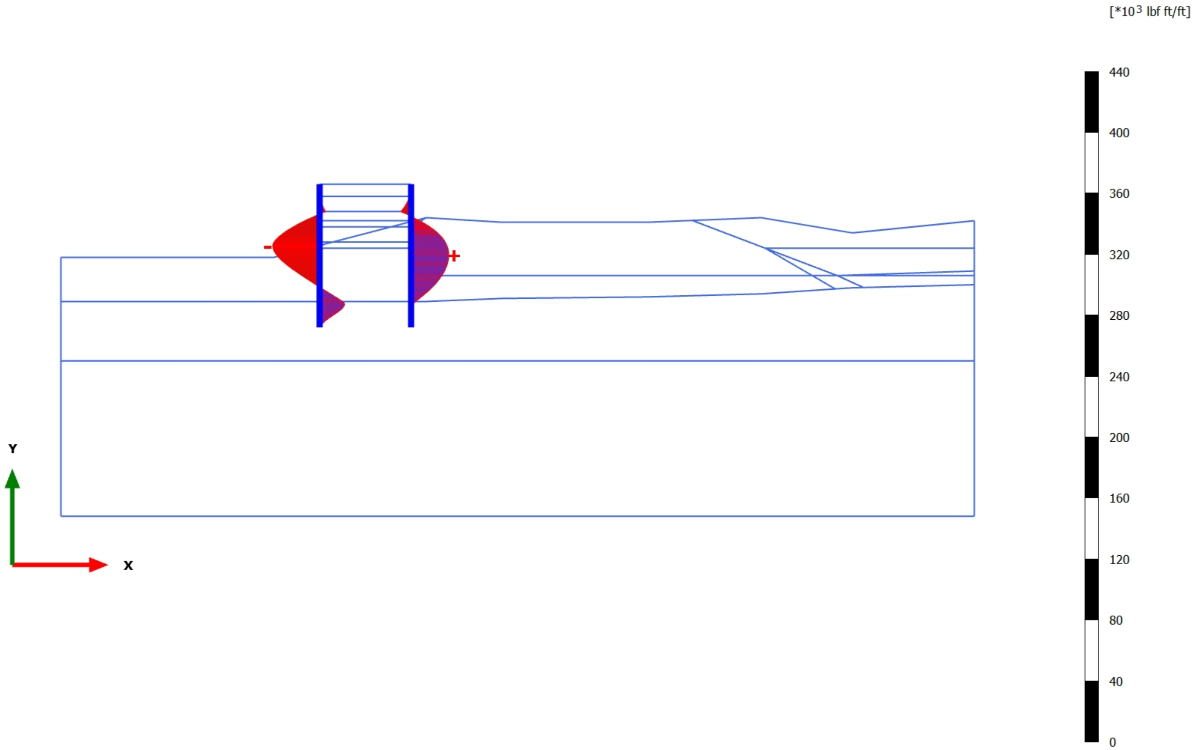


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 17.01*10^3 lbf ft/ft (Element 48 at Node 25716)

Minimum value = -17.37*10^3 lbf ft/ft (Element 27 at Node 30026)

3.1.2.2.4 Calculation results, Plate, Backfill 4 [Phase_6] (6/102), Bending moments M

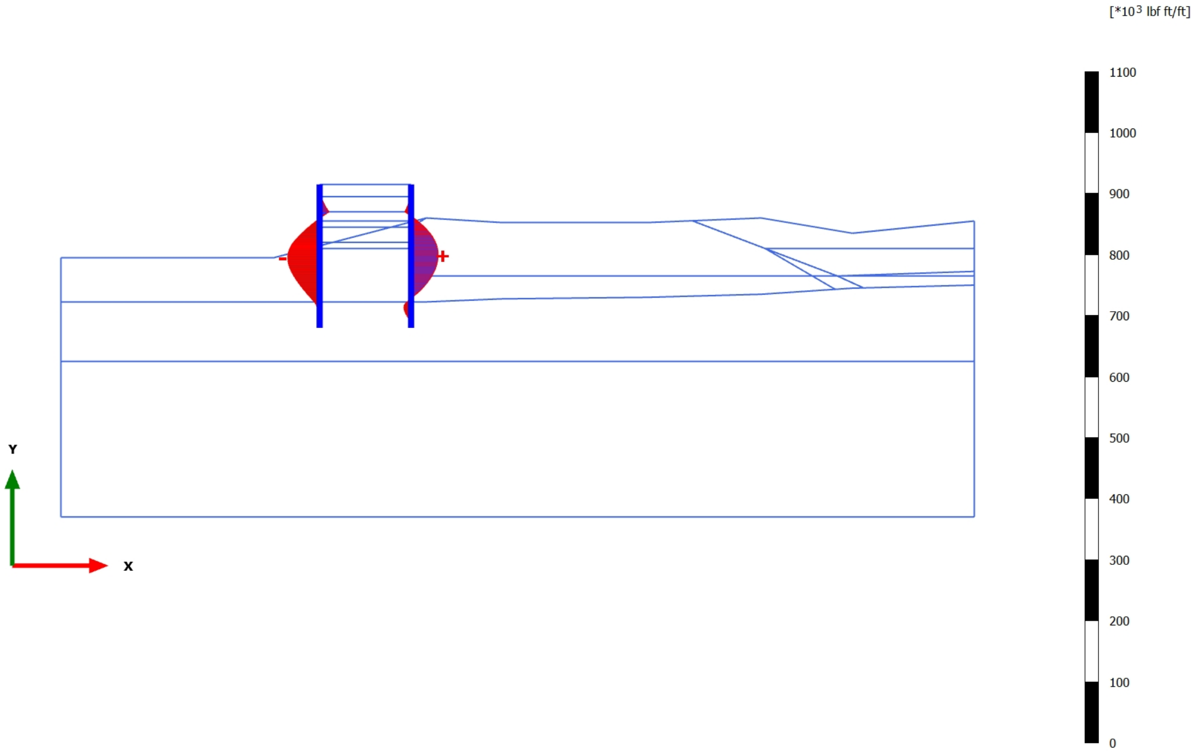


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 24.81*10^{3} lbf ft/ft (Element 30 at Node 25832)

Minimum value = -30.84*10^{3} lbf ft/ft (Element 29 at Node 30021)

3.1.2.2.5 Calculation results, Plate, Dewater [Phase_7] (7/163), Bending moments M

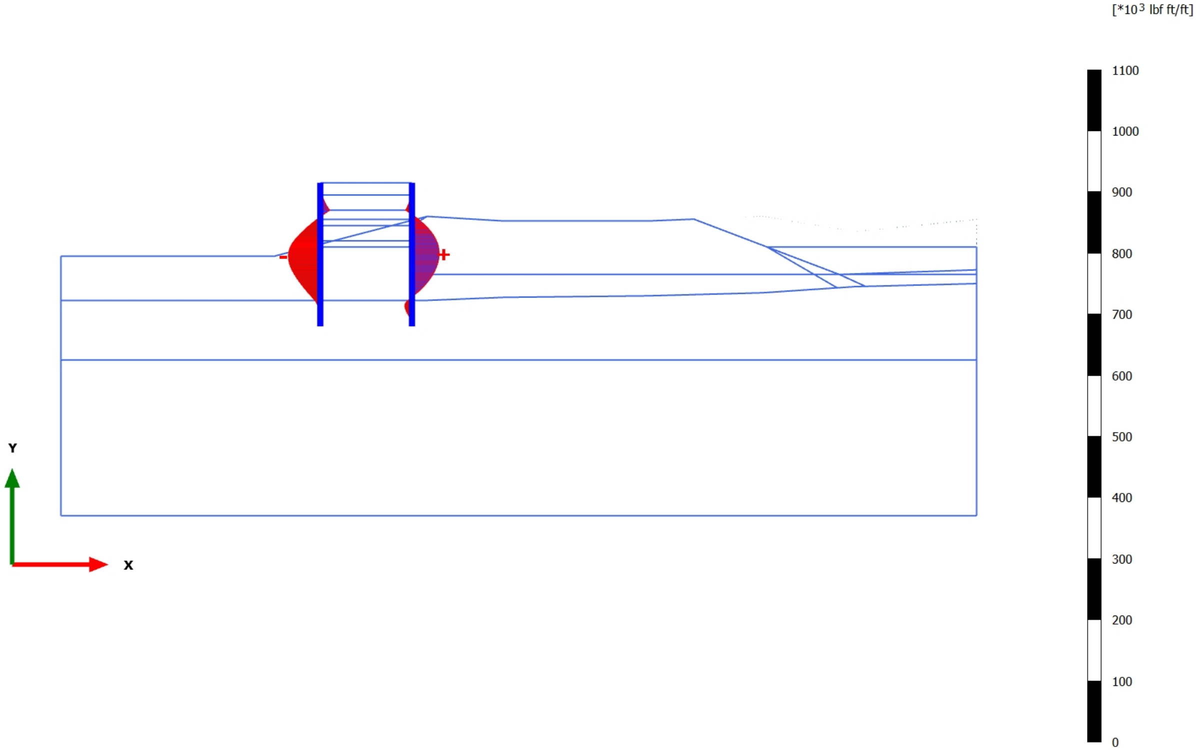


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $44.61*10^3$ lbf ft/ft (Element 31 at Node 25832)

Minimum value = $-52.48*10^3$ lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.6 Calculation results, Plate, Exc 1 [Phase_8] (8/168), Bending moments M

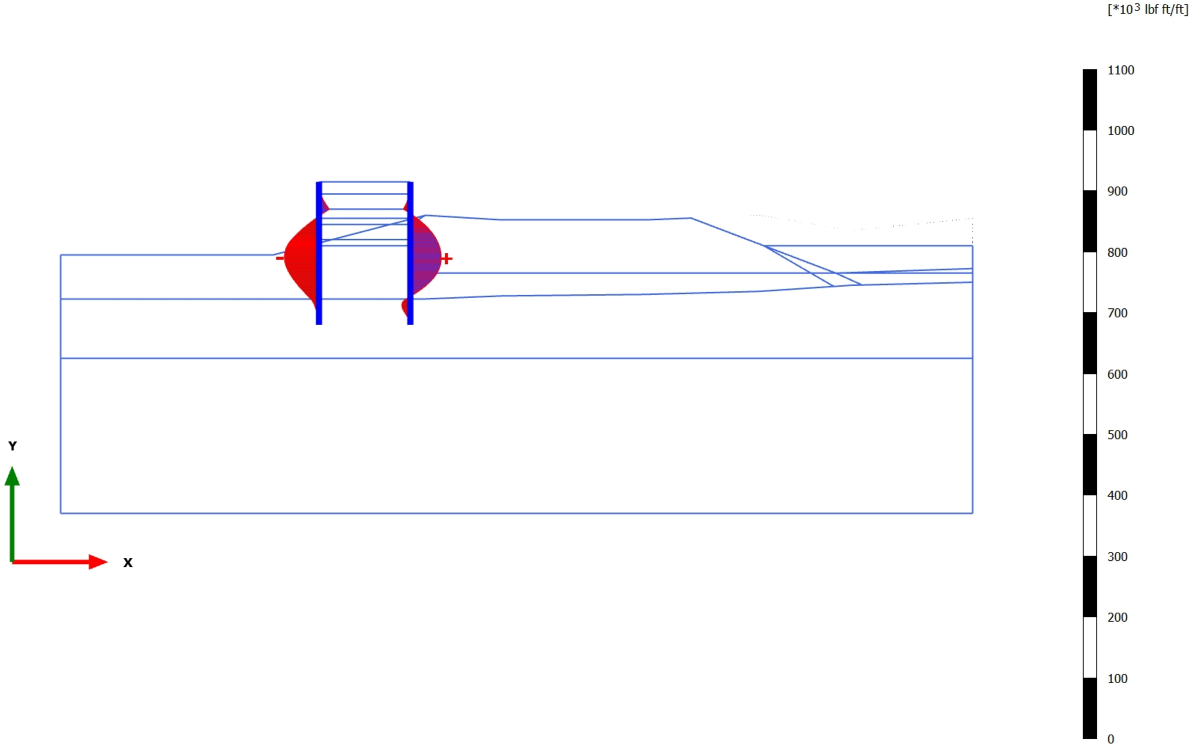


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $44.73*10^3$ lbf ft/ft (Element 30 at Node 25832)

Minimum value = $-52.38*10^3$ lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.7 Calculation results, Plate, Dewater 2 [Phase_9] (9/180), Bending moments M

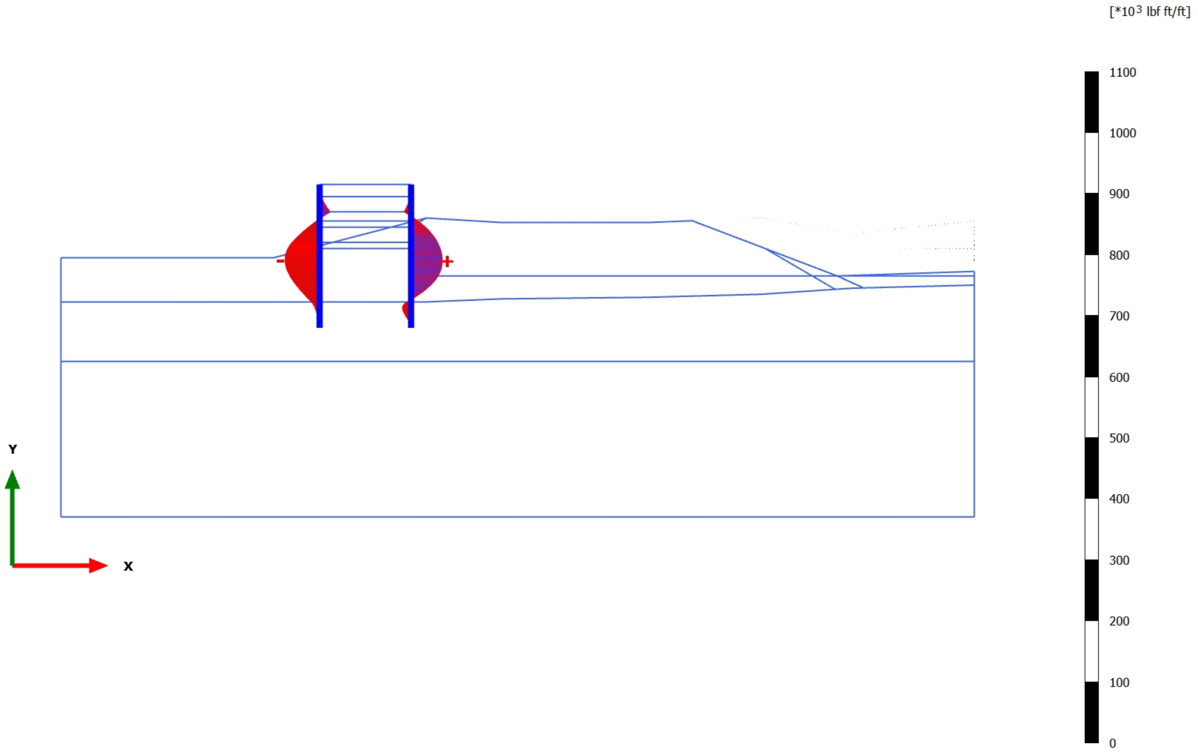


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $51.10*10^3$ lbf ft/ft (Element 31 at Node 25829)

Minimum value = $-57.03*10^3$ lbf ft/ft (Element 36 at Node 29186)

3.1.2.2.8 Calculation results, Plate, Exc 2 [Phase_10] (10/185), Bending moments M

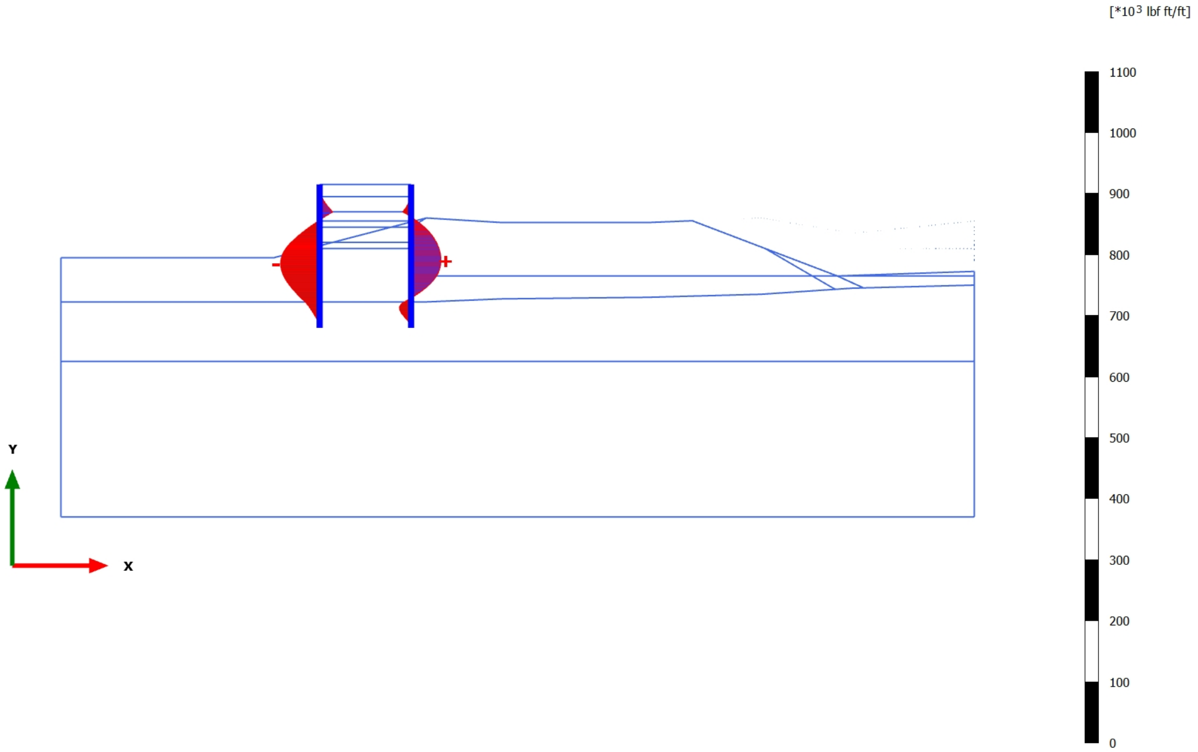


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 51.37*10^3 lbf ft/ft (Element 31 at Node 25829)

Minimum value = -56.92*10^3 lbf ft/ft (Element 36 at Node 29186)

3.1.2.2.9 Calculation results, Plate, GW 9ft [Phase_11] (11/214), Bending moments M



Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $49.26*10^{3}$ lbf ft/ft (Element 31 at Node 25829)

Minimum value = $-64.33*10^{3}$ lbf ft/ft (Element 37 at Node 28715)

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/89), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	22.606	0.000	22.606
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	22.606	0.000	22.606

3.2.1.1.4 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/102), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	49.371	0.000	49.371
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	49.371	0.000	49.371

3.2.1.1.5 Calculation results, Node-to-node anchor, Dewater [Phase_7] (7/163), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	89.975	0.000	89.975
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	89.975	0.000	89.975

3.2.1.1.6 Calculation results, Node-to-node anchor, Exc 1 [Phase_8] (8/168), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	90.064	0.000	90.064
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	90.064	0.000	90.064

3.2.1.1.7 Calculation results, Node-to-node anchor, Dewater 2 [Phase_9] (9/180), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	96.891	0.000	96.891
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	96.891	0.000	96.891

3.2.1.1.8 Calculation results, Node-to-node anchor, Exc 2 [Phase_10] (10/185), Table of node-to-node anchors

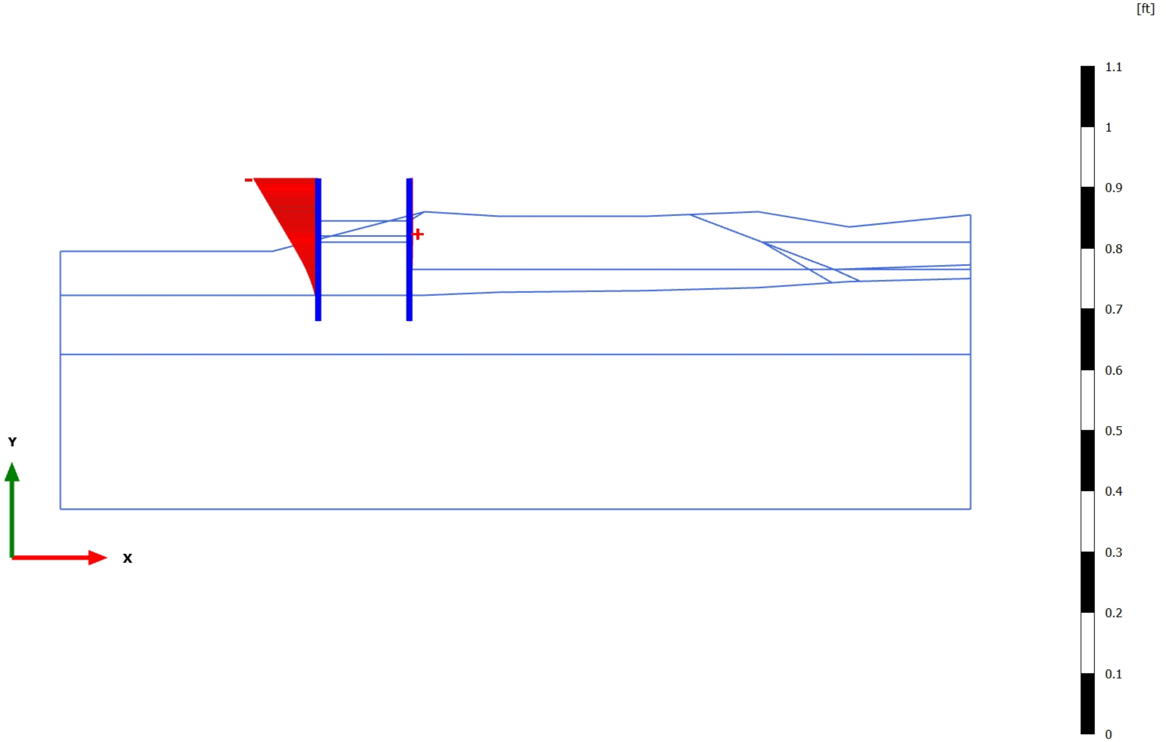
Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	96.968	0.000	96.968
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	96.968	0.000	96.968

3.2.1.1.9 Calculation results, Node-to-node anchor, GW 9ft [Phase_11] (11/214), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	109.451	0.000	109.451
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	109.451	0.000	109.451

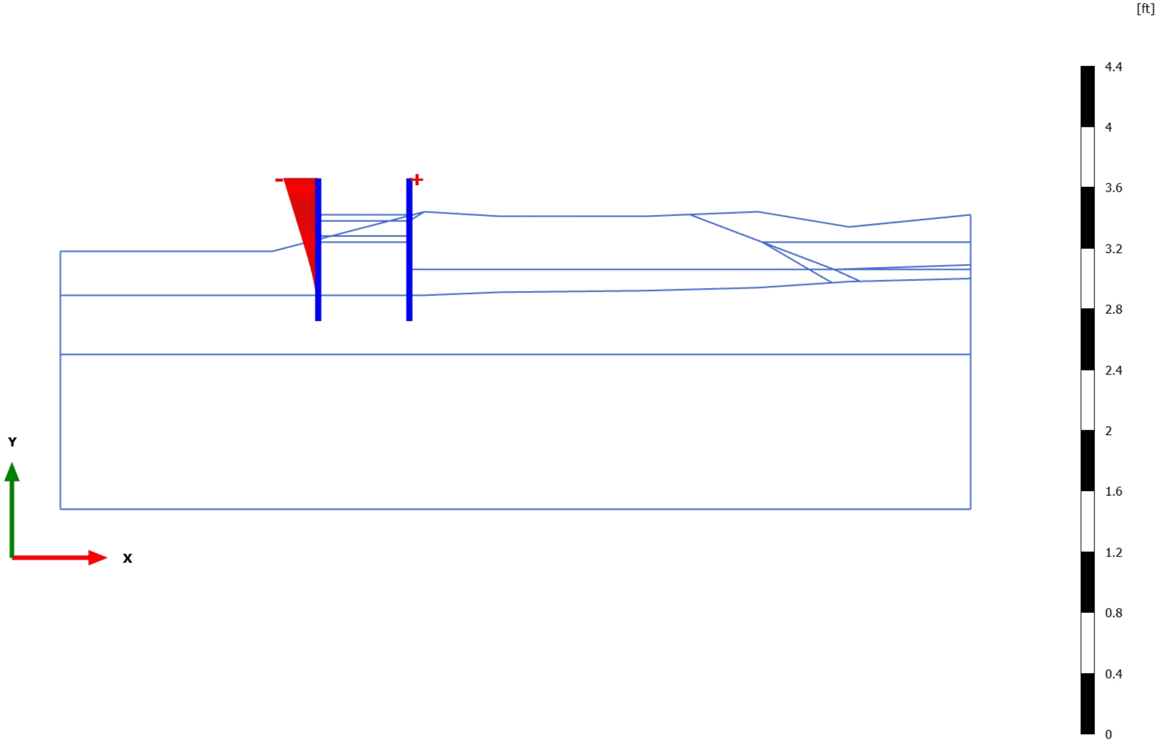
PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/29), Total displacements u_x



Total displacements u_x (scaled up 200 times)
Maximum value = $5.688*10^{-3}$ ft (Element 26 at Node 25787)
Minimum value = -0.1068 ft (Element 1 at Node 32637)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/47), Total displacements u_x

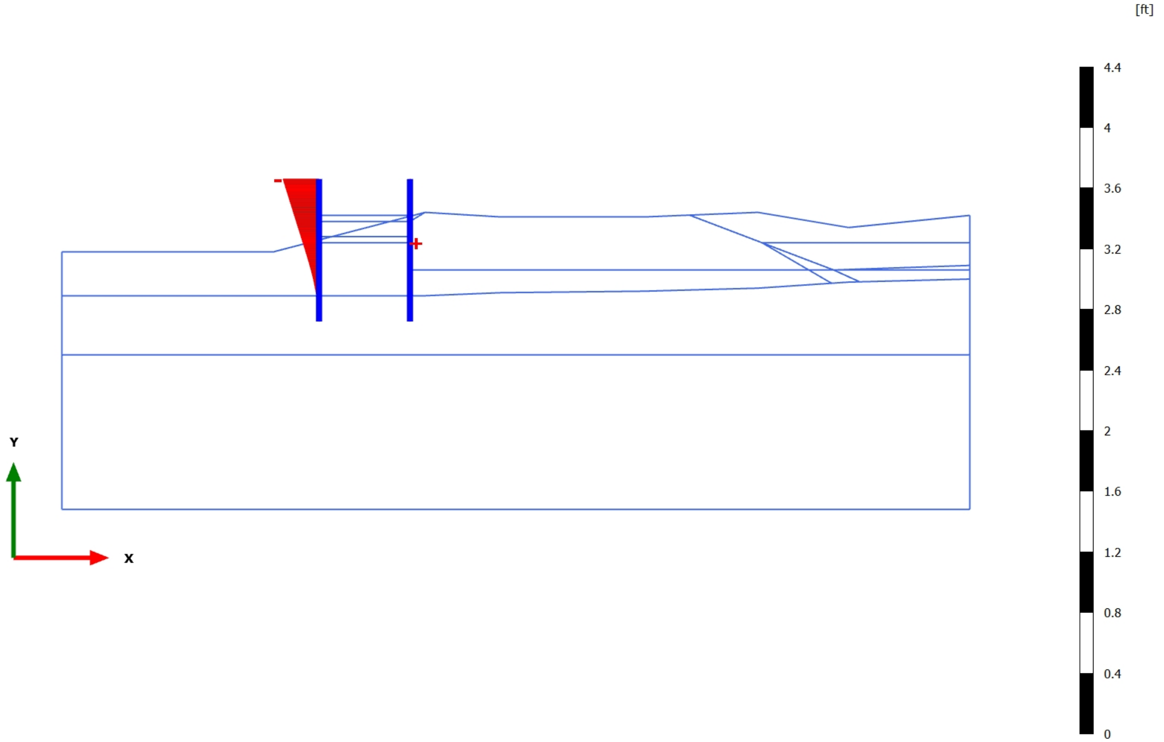


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.01794 ft (Element 3 at Node 27321)

Minimum value = -0.2277 ft (Element 1 at Node 32637)

3.1.1.1.1.3 Calculation results, Plate, Consolidate [Phase_25] (25/88), Total displacements u_x

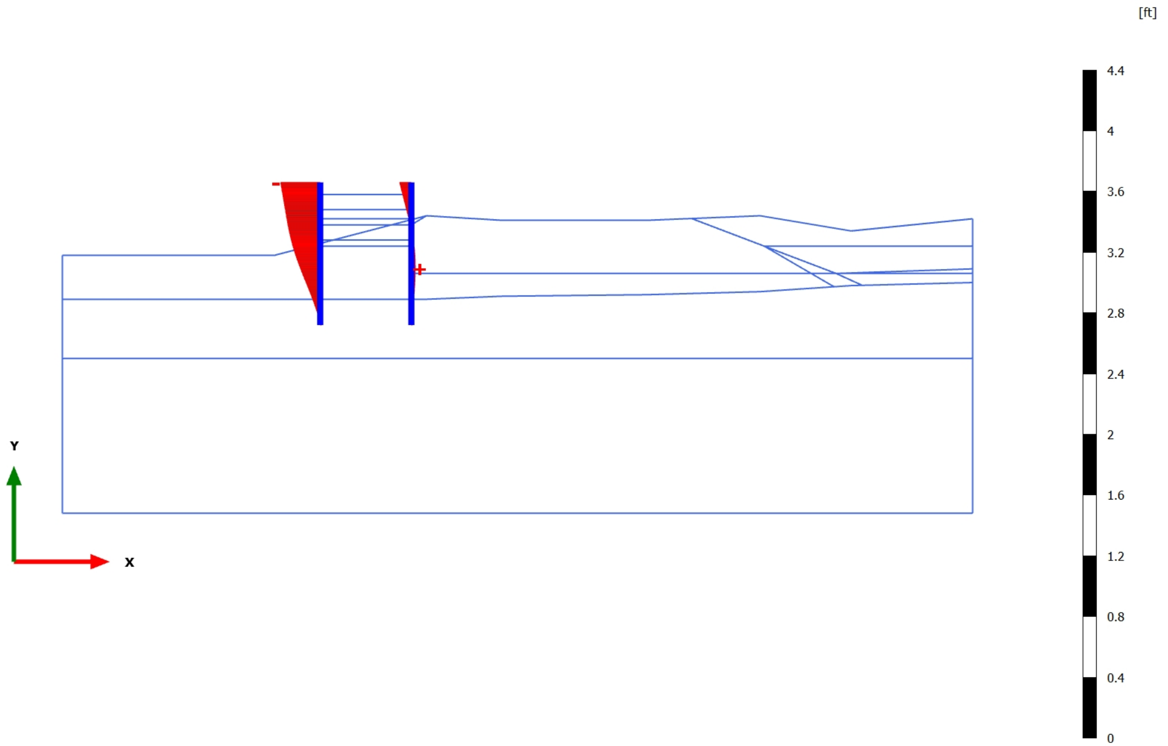


Total displacements u_x (scaled up 50.0 times) (Time 10.00 day)

Maximum value = $8.426*10^{-3}$ ft (Element 28 at Node 25774)

Minimum value = -0.2382 ft (Element 1 at Node 32637)

3.1.1.1.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/111), Total displacements u_x

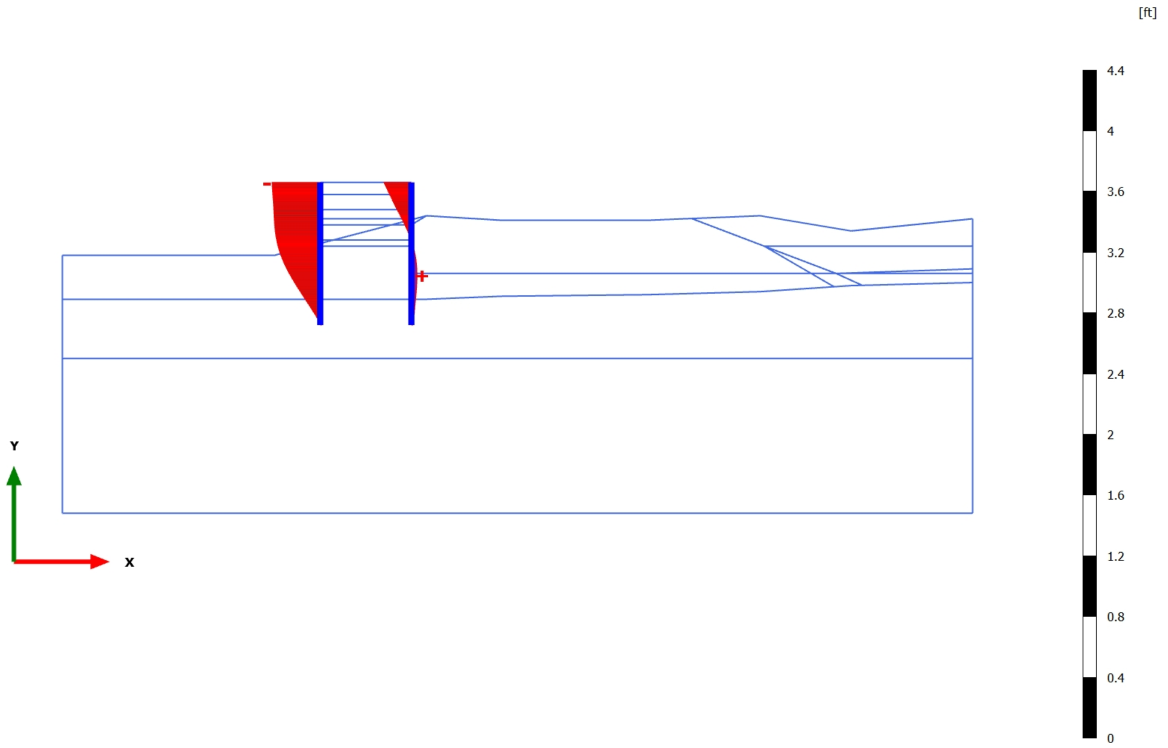


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.02628 ft (Element 33 at Node 25460)

Minimum value = -0.2610 ft (Element 1 at Node 32637)

3.1.1.1.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/125), Total displacements u_x

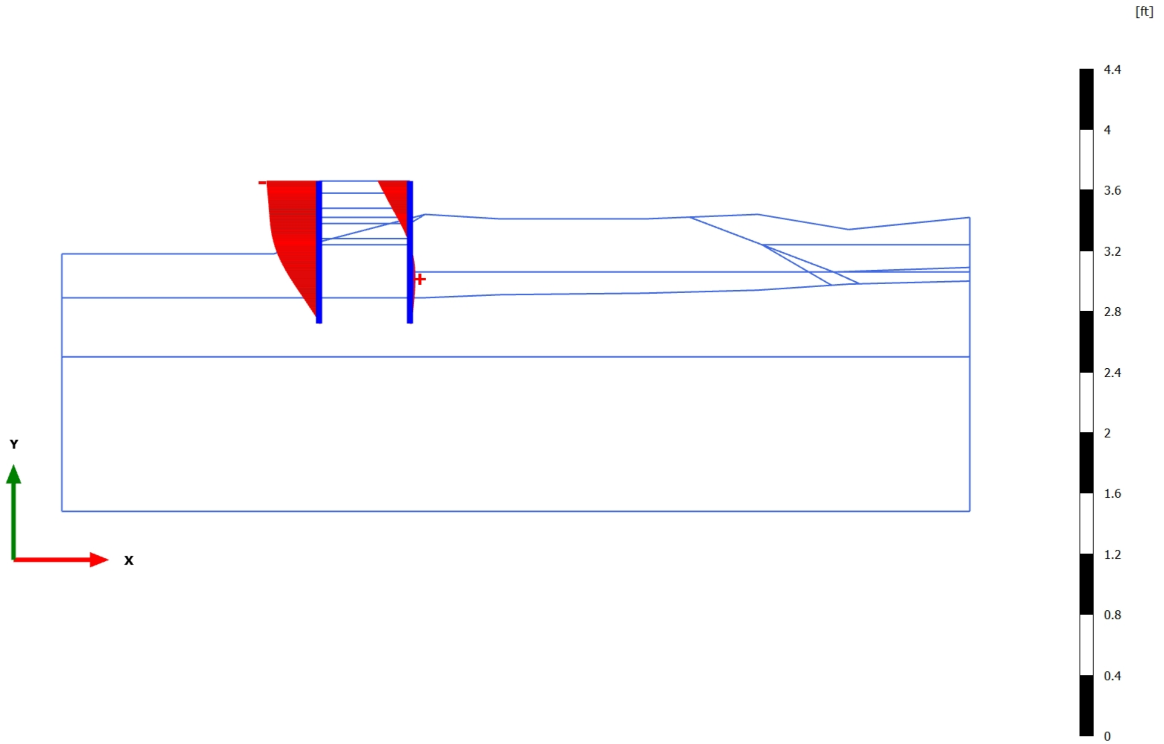


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.03768 ft (Element 44 at Node 25410)

Minimum value = -0.3180 ft (Element 1 at Node 32637)

3.1.1.1.1.6 Calculation results, Plate, Consolidate [Phase_7] (7/252), Total displacements u_x

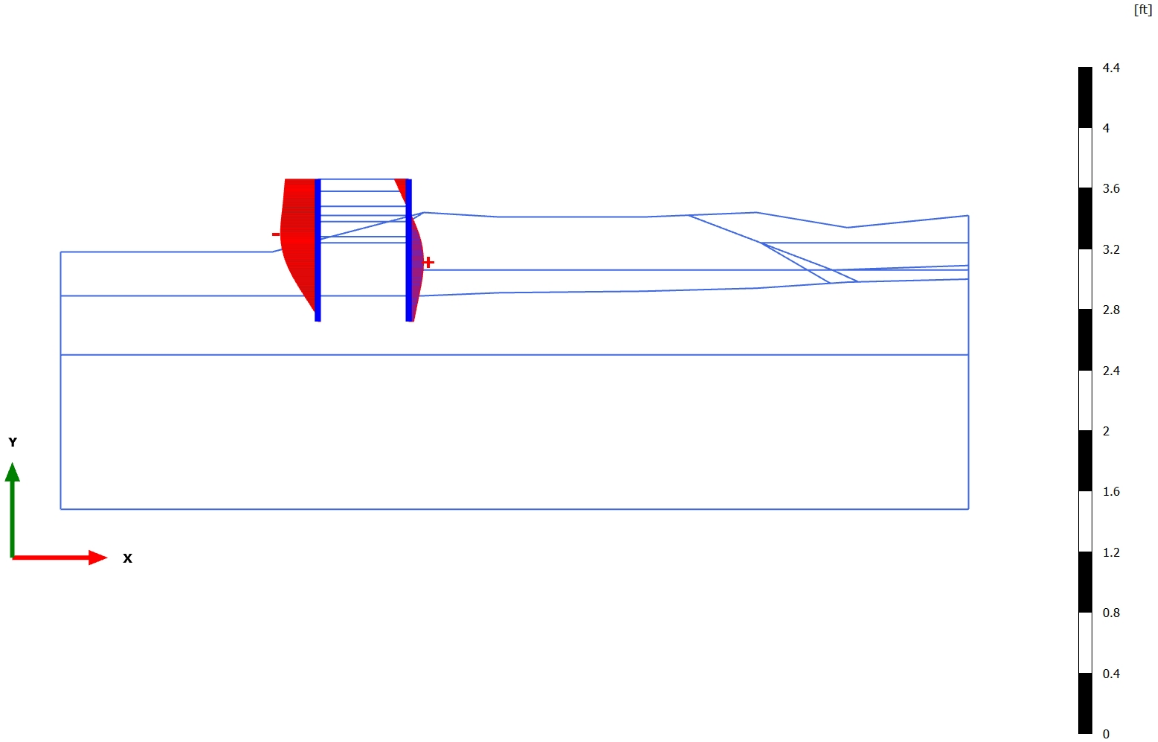


Total displacements u_x (scaled up 50.0 times) (Time 16.00 day)

Maximum value = 0.03412 ft (Element 44 at Node 25407)

Minimum value = -0.3461 ft (Element 1 at Node 32637)

3.1.1.1.1.7 Calculation results, Plate, Dewater-ss [Phase_16] (16/266), Total displacements u_x

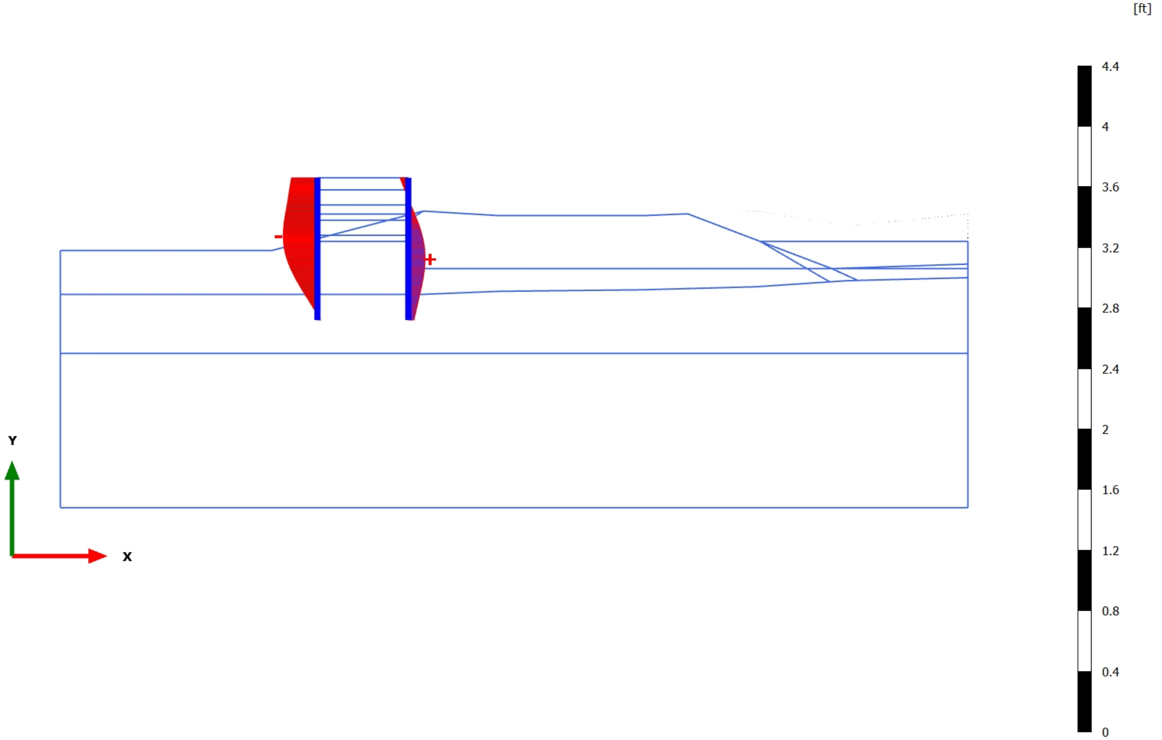


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.09802 ft (Element 32 at Node 25810)

Minimum value = -0.2466 ft (Element 22 at Node 30032)

3.1.1.1.1.8 Calculation results, Plate, Excavate 1 [Phase_18] (18/271), Total displacements u_x

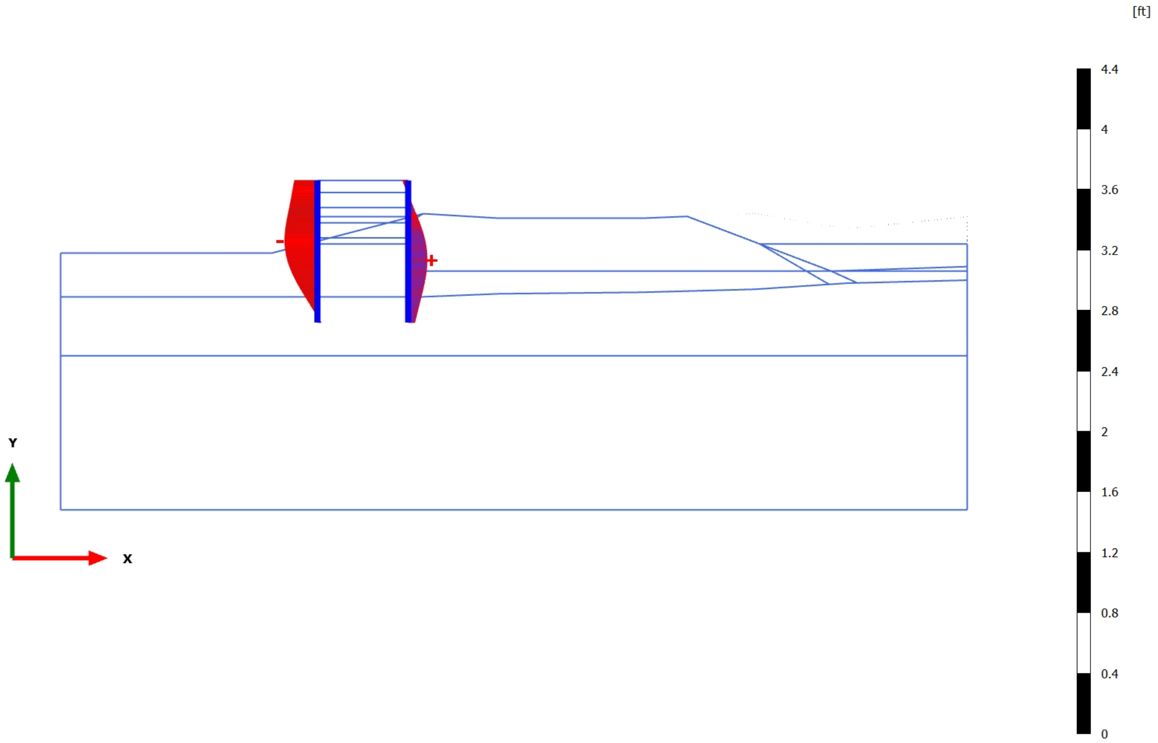


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1117 ft (Element 32 at Node 25811)

Minimum value = -0.2266 ft (Element 23 at Node 30028)

3.1.1.1.1.9 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/275), Total displacements u_x

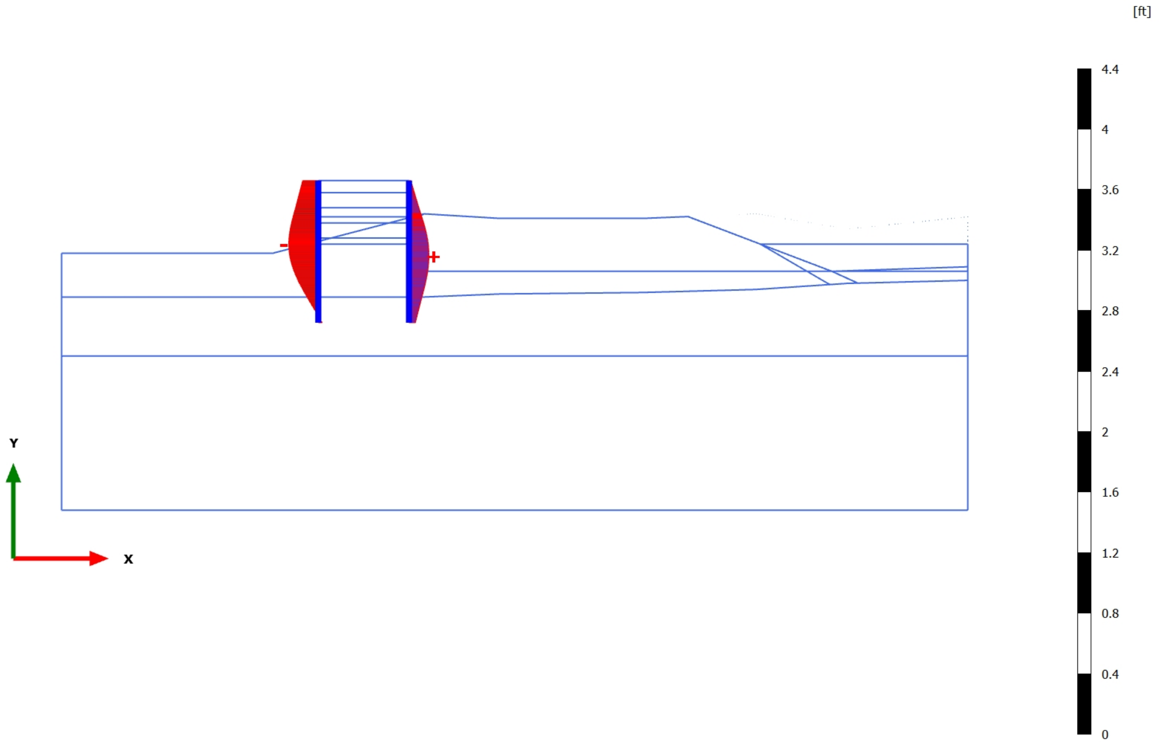


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1250 ft (Element 32 at Node 25812)

Minimum value = -0.2160 ft (Element 27 at Node 30025)

3.1.1.1.1.10 Calculation results, Plate, Consolidation [Phase_20] (20/296), Total displacements u_x

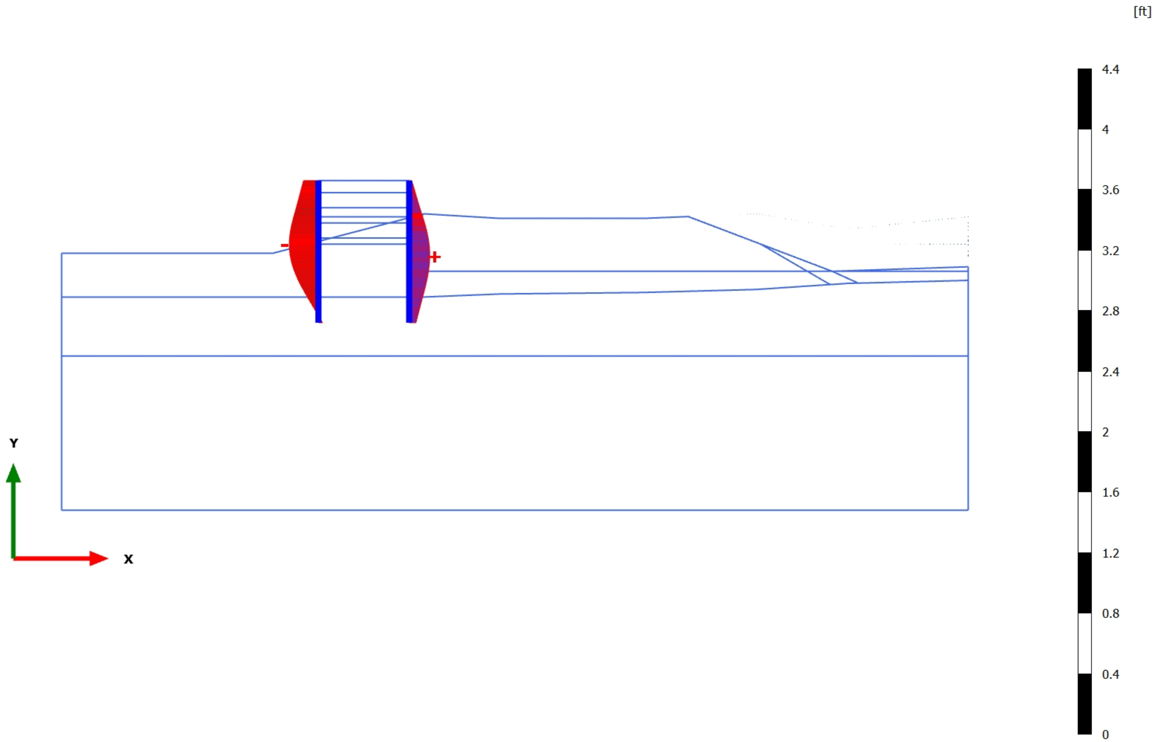


Total displacements u_x (scaled up 50.0 times) (Time 37.00 day)

Maximum value = 0.1326 ft (Element 31 at Node 25829)

Minimum value = -0.1961 ft (Element 29 at Node 30020)

3.1.1.1.1.11 Calculation results, Plate, Excavate 2 [Phase_21] (21/299), Total displacements u_x

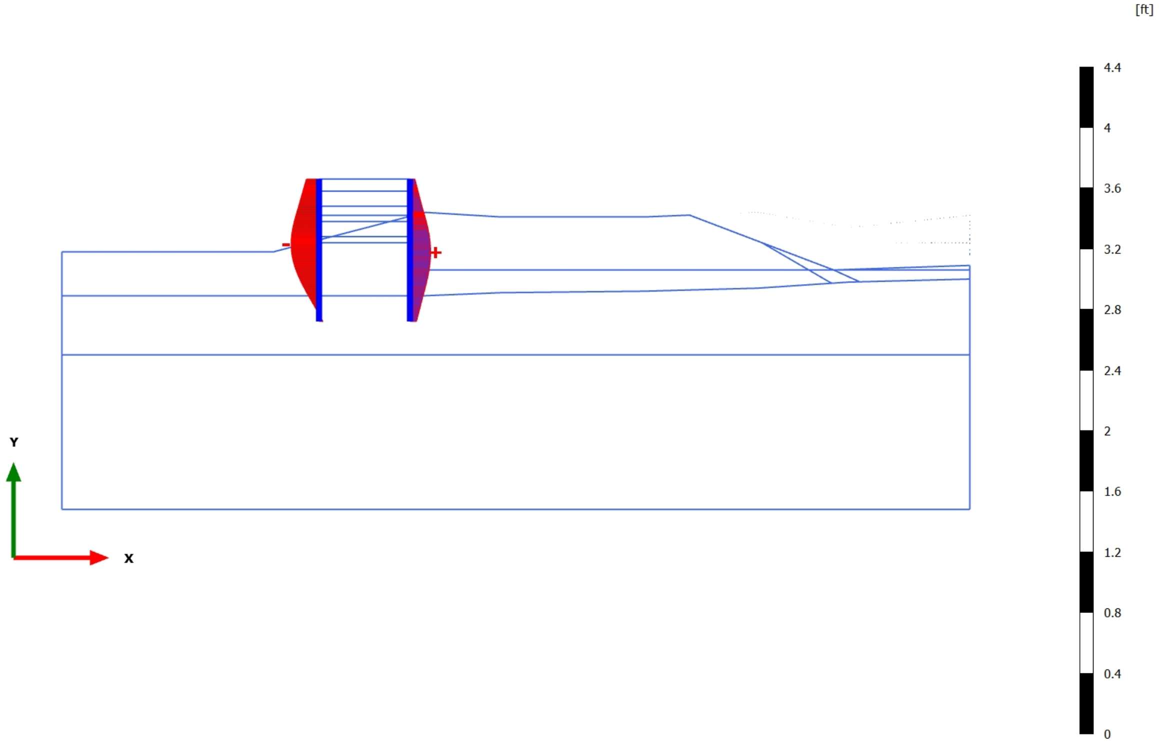


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1364 ft (Element 31 at Node 25829)

Minimum value = -0.1931 ft (Element 29 at Node 30020)

3.1.1.1.1.12 Calculation results, Plate, Consolidate [Phase_8] (8/309), Total displacements u_x

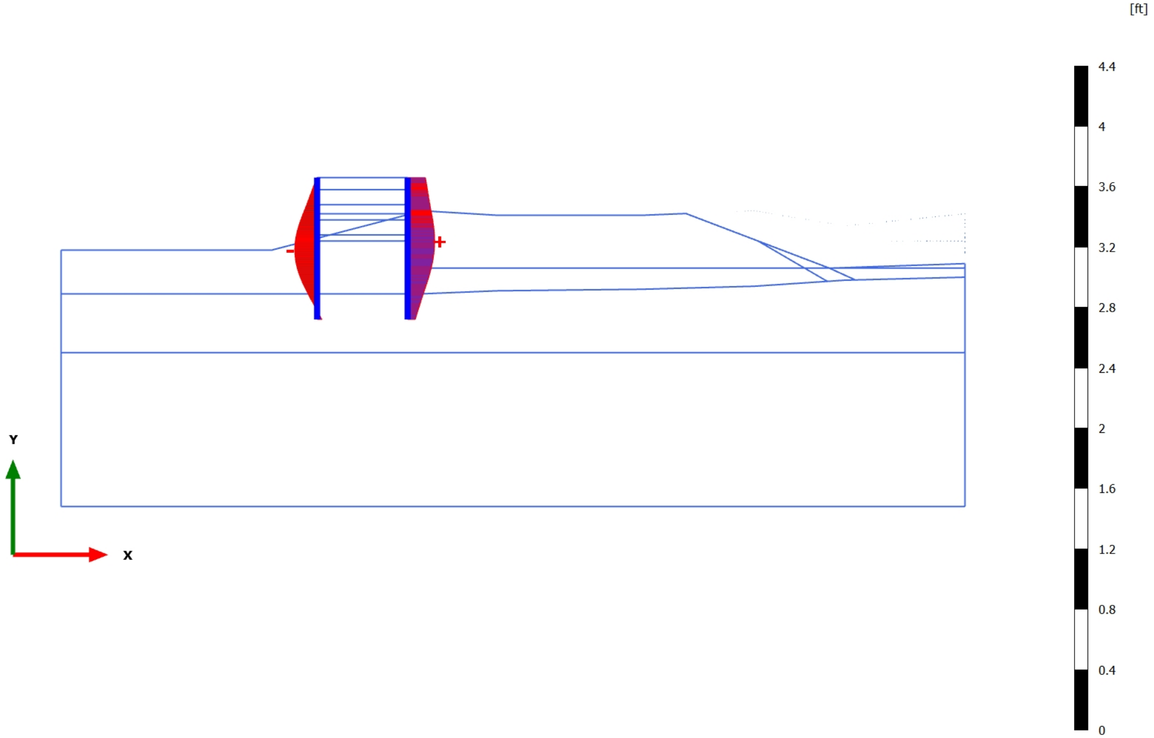


Total displacements u_x (scaled up 50.0 times) (Time 51.00 day)

Maximum value = 0.1374 ft (Element 31 at Node 25831)

Minimum value = -0.1856 ft (Element 34 at Node 30002)

3.1.1.1.1.13 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/379), Total displacements u_x

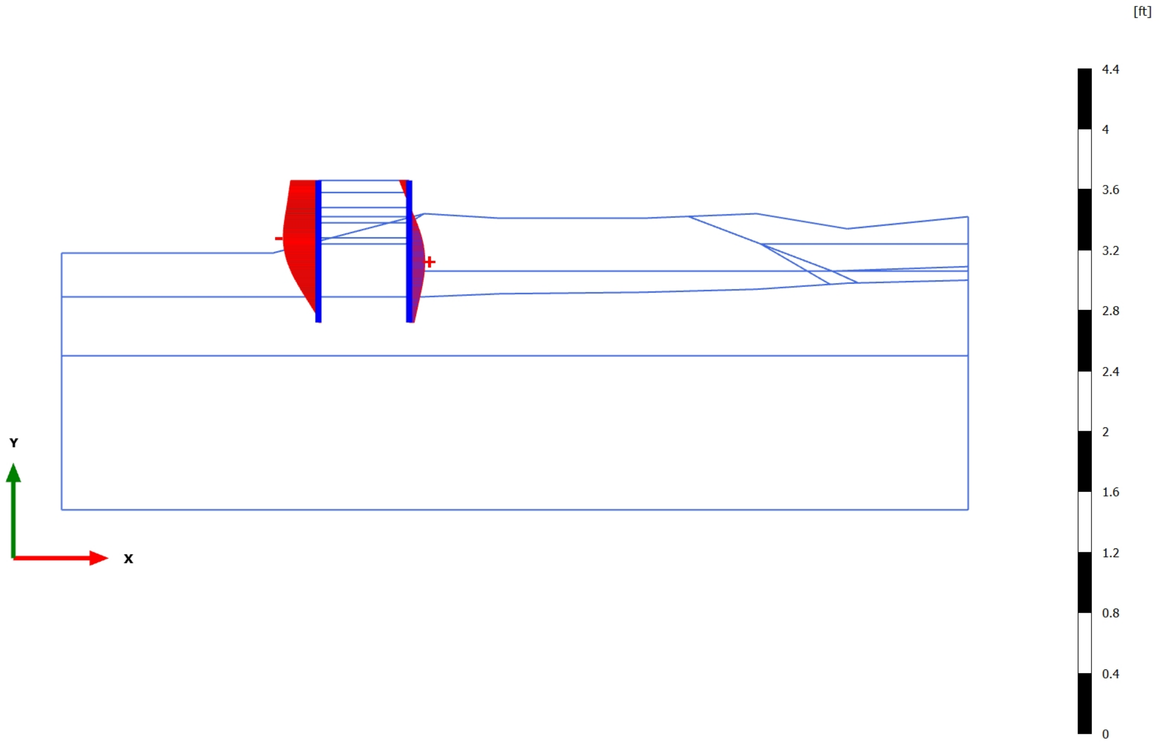


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.1799 ft (Element 28 at Node 25774)

Minimum value = -0.1493 ft (Element 36 at Node 29184)

3.1.1.1.1.14 Calculation results, Plate, Consolidation [Phase_17] (17/438), Total displacements u_x

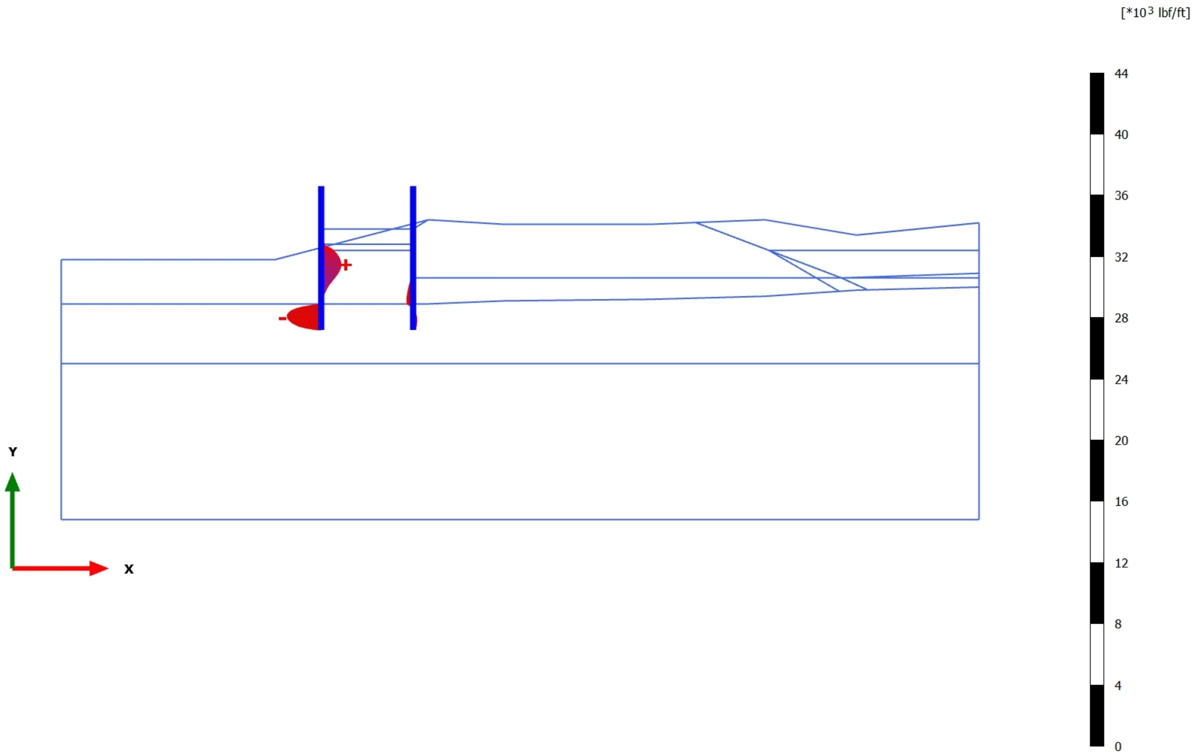


Total displacements u_x (scaled up 50.0 times) (Time 20.00 day)

Maximum value = 0.1039 ft (Element 32 at Node 25811)

Minimum value = -0.2332 ft (Element 23 at Node 30029)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/29), Shear forces Q

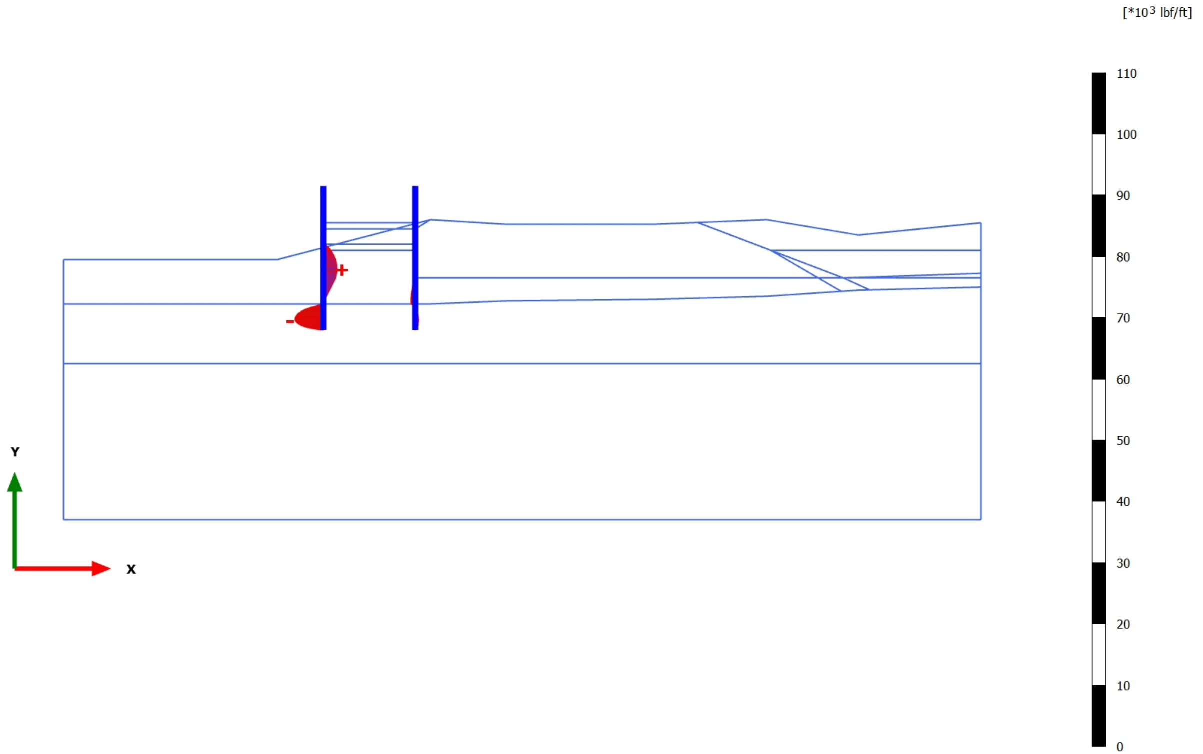


Shear forces Q (scaled up 5.00*10⁻³ times)

Maximum value = 1286 lbf/ft (Element 37 at Node 28714)

Minimum value = -2229 lbf/ft (Element 50 at Node 24987)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/47), Shear forces Q

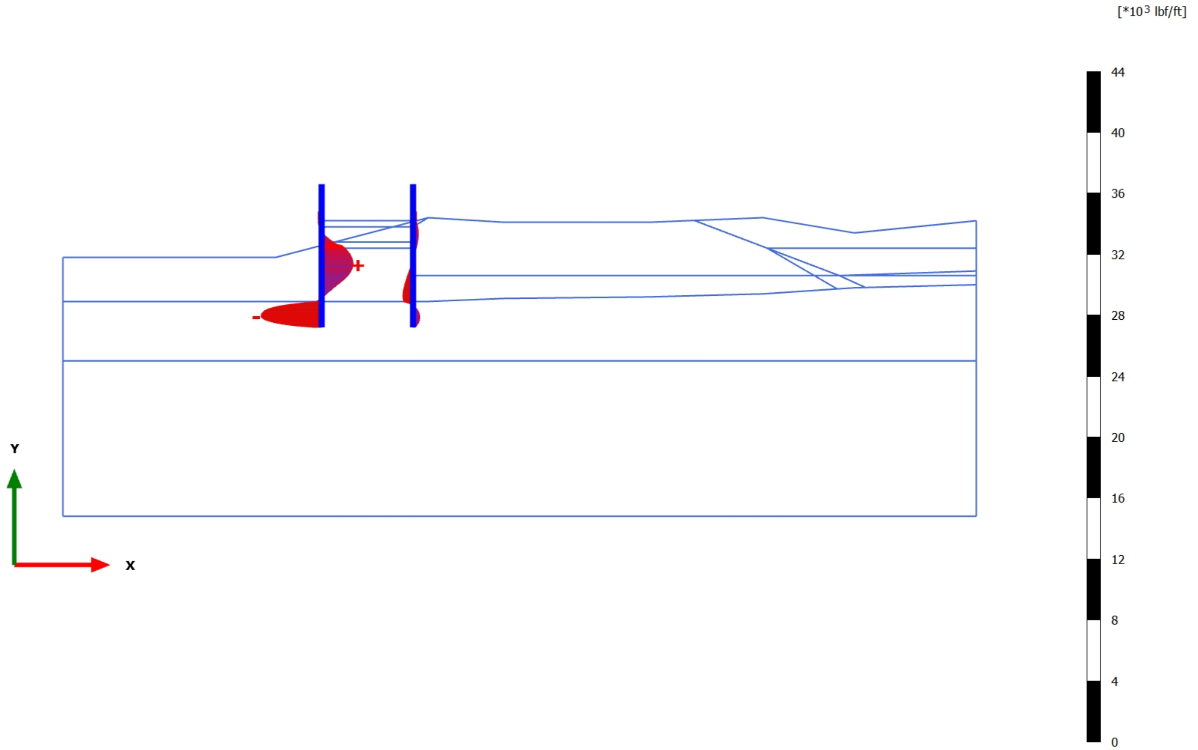


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 2247 lbf/ft (Element 38 at Node 28324)

Minimum value = -4675 lbf/ft (Element 50 at Node 24515)

3.1.2.1.3 Calculation results, Plate, Consolidate [Phase_25] (25/88), Shear forces Q

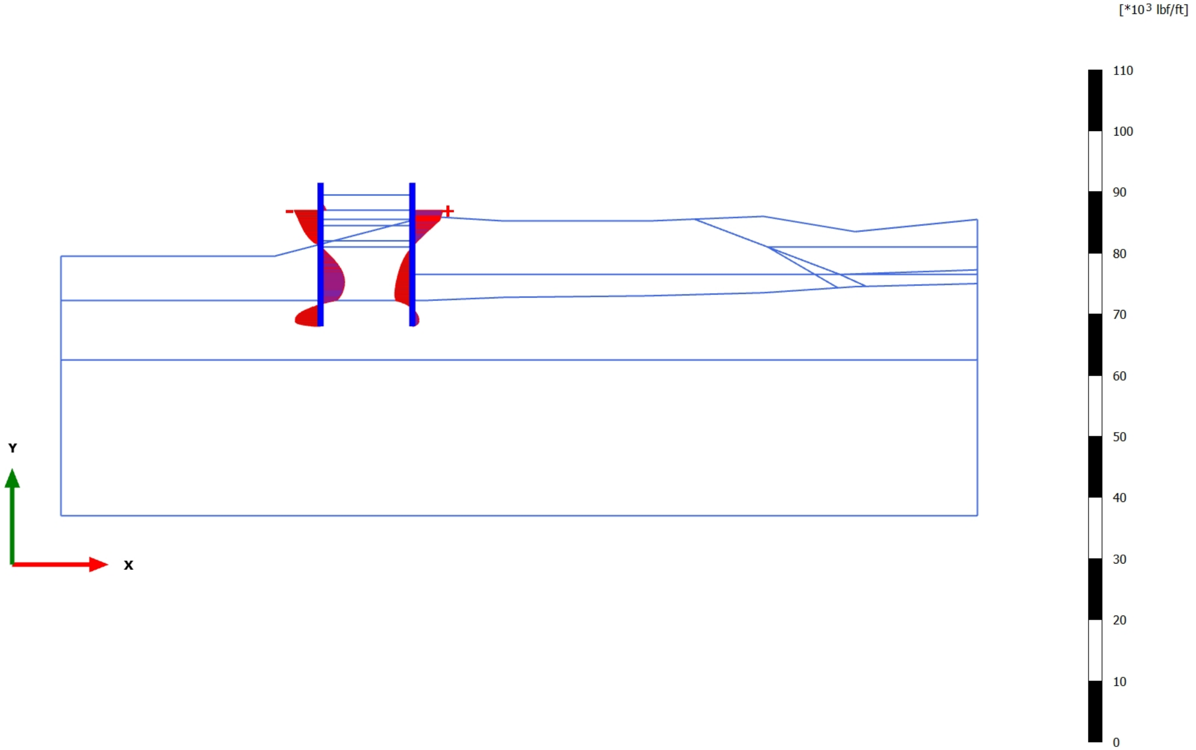


Shear forces Q (scaled up 5.00*10^{-3} times) (Time 10.00 day)

Maximum value = 2061 lbf/ft (Element 37 at Node 28716)

Minimum value = -3983 lbf/ft (Element 50 at Node 24514)

3.1.2.1.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/111), Shear forces Q

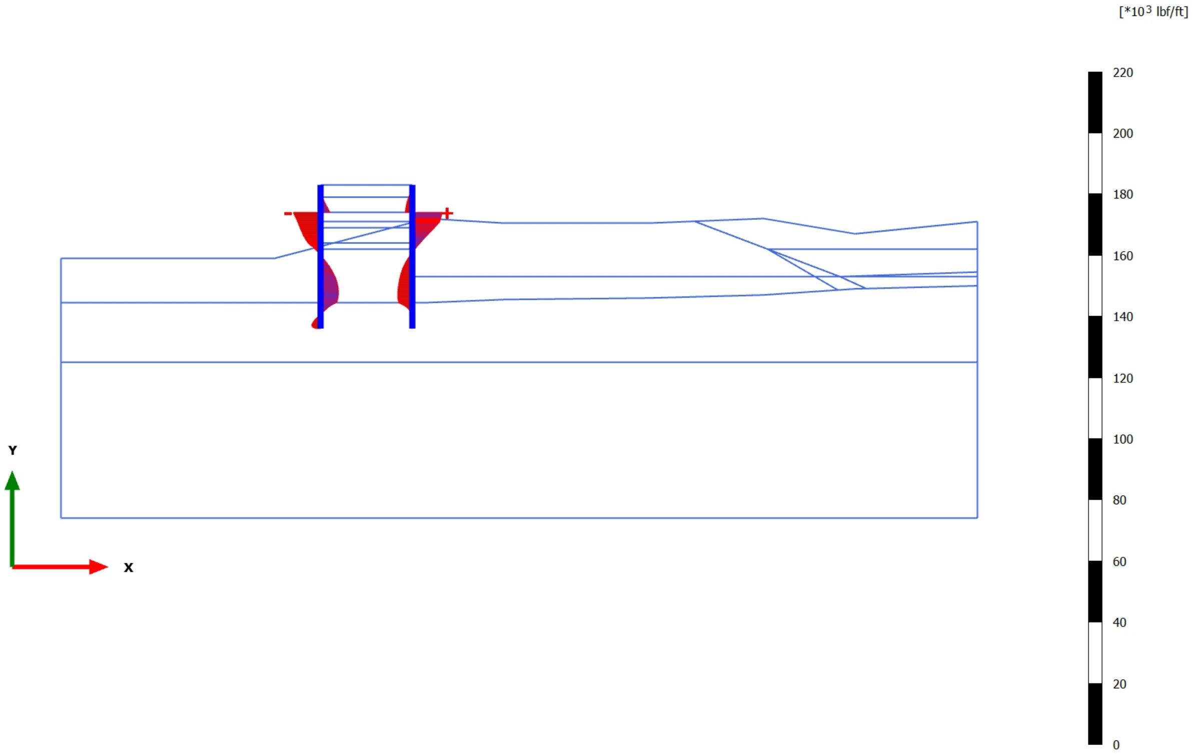


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 4987 lbf/ft (Element 14 at Node 26818)

Minimum value = -4338 lbf/ft (Element 13 at Node 31646)

3.1.2.1.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/125), Shear forces Q

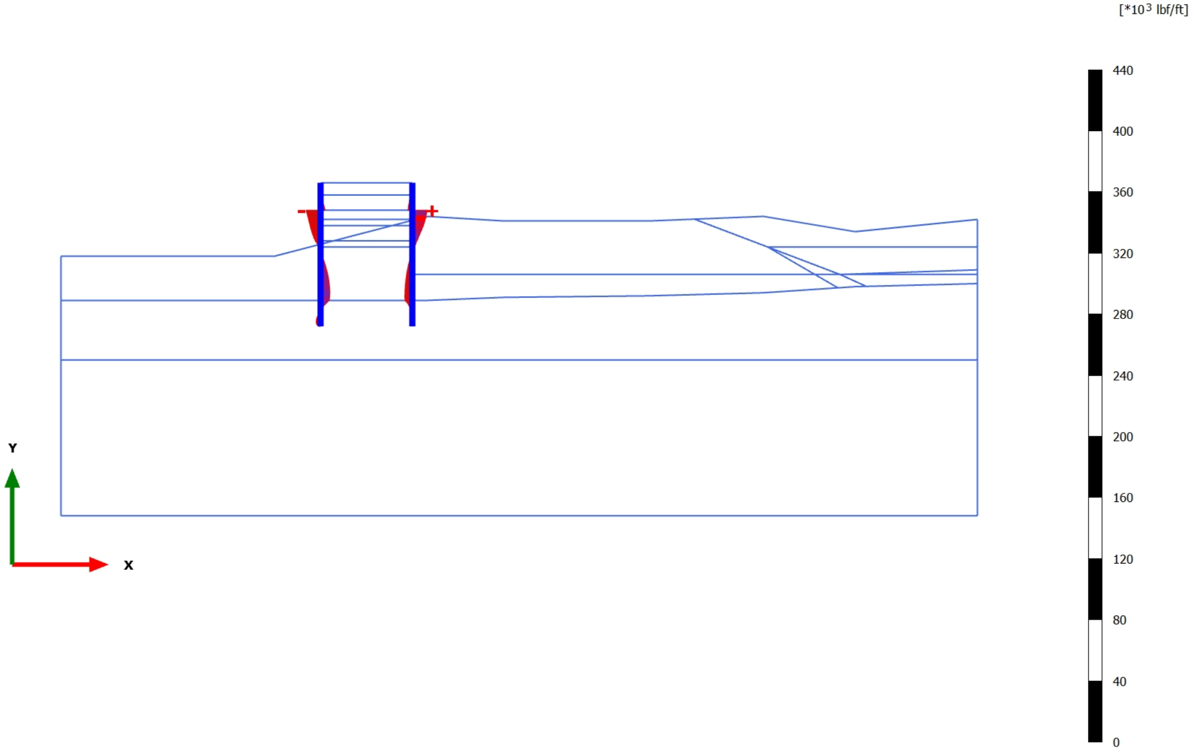


Shear forces Q (scaled up 1.00*10^{-3} times)

Maximum value = 9836 lbf/ft (Element 14 at Node 26818)

Minimum value = -9037 lbf/ft (Element 13 at Node 31646)

3.1.2.1.6 Calculation results, Plate, Consolidate [Phase_7] (7/252), Shear forces Q

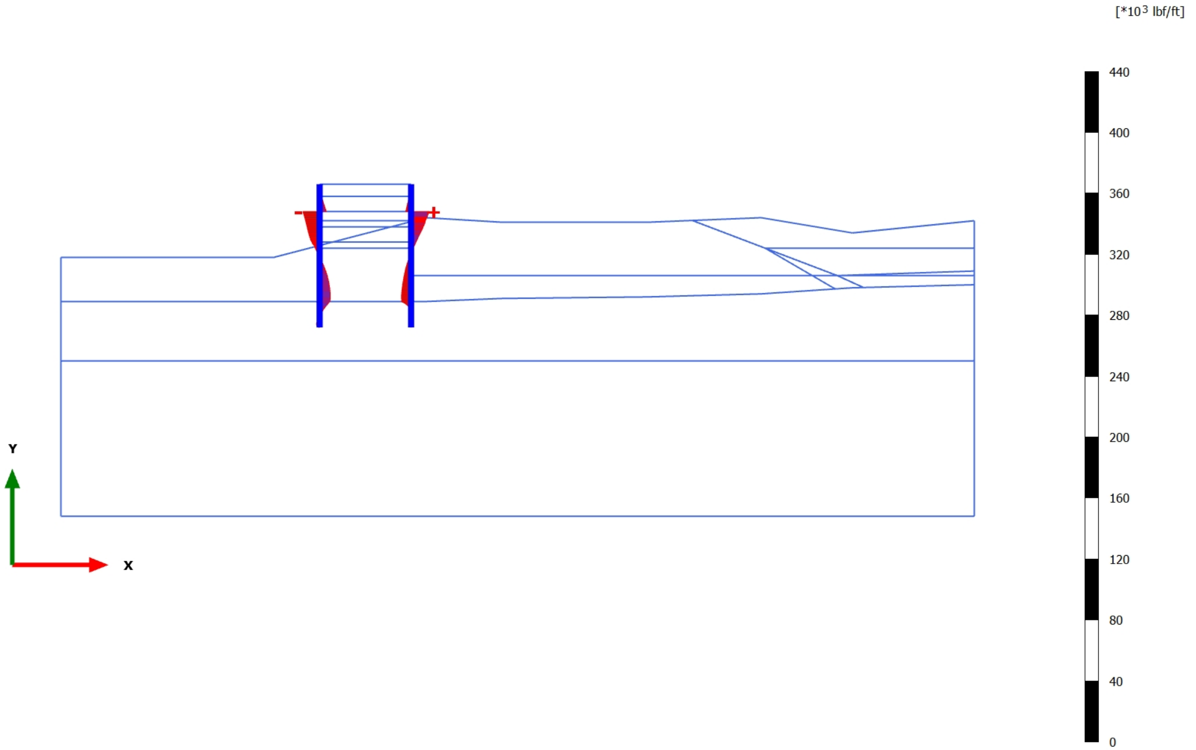


Shear forces Q (scaled up $0.500*10^{-3}$ times) (Time 16.00 day)

Maximum value = 9794 lbf/ft (Element 14 at Node 26818)

Minimum value = -9556 lbf/ft (Element 13 at Node 31646)

3.1.2.1.7 Calculation results, Plate, Dewater-ss [Phase_16] (16/266), Shear forces Q

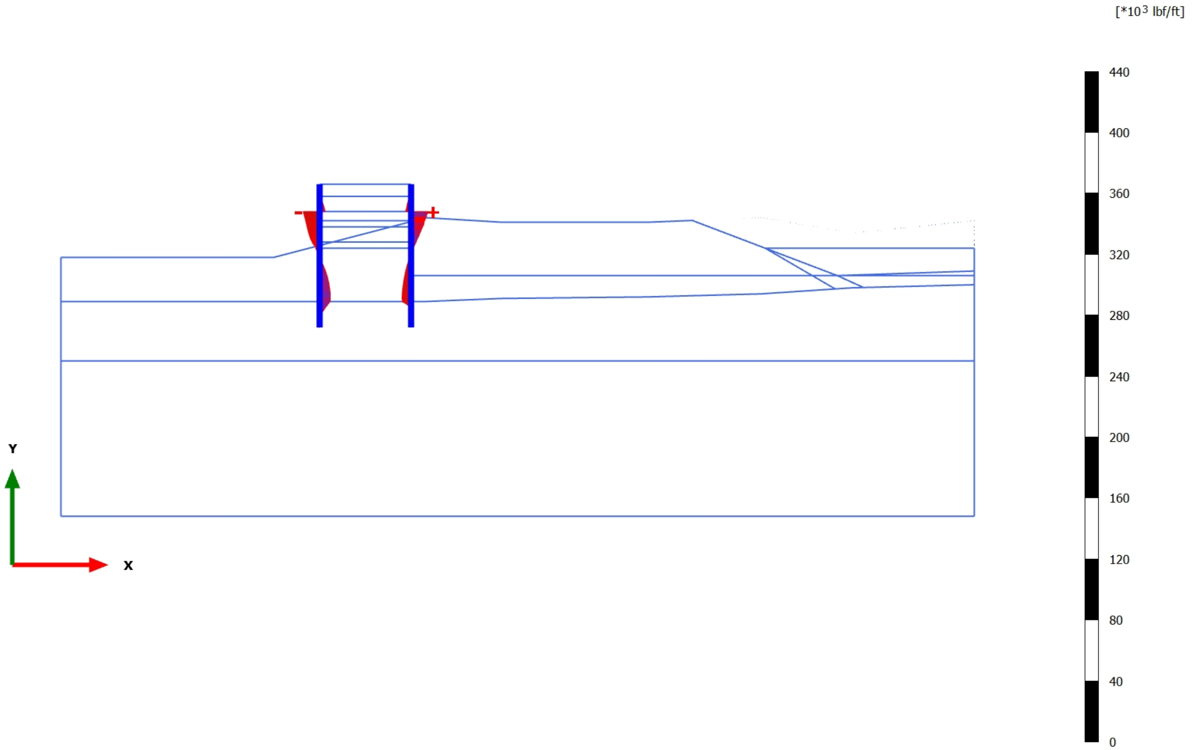


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.82*10^3$ lbf/ft (Element 14 at Node 26818)

Minimum value = $-11.03*10^3$ lbf/ft (Element 13 at Node 31646)

3.1.2.1.8 Calculation results, Plate, Excavate 1 [Phase_18] (18/271), Shear forces Q

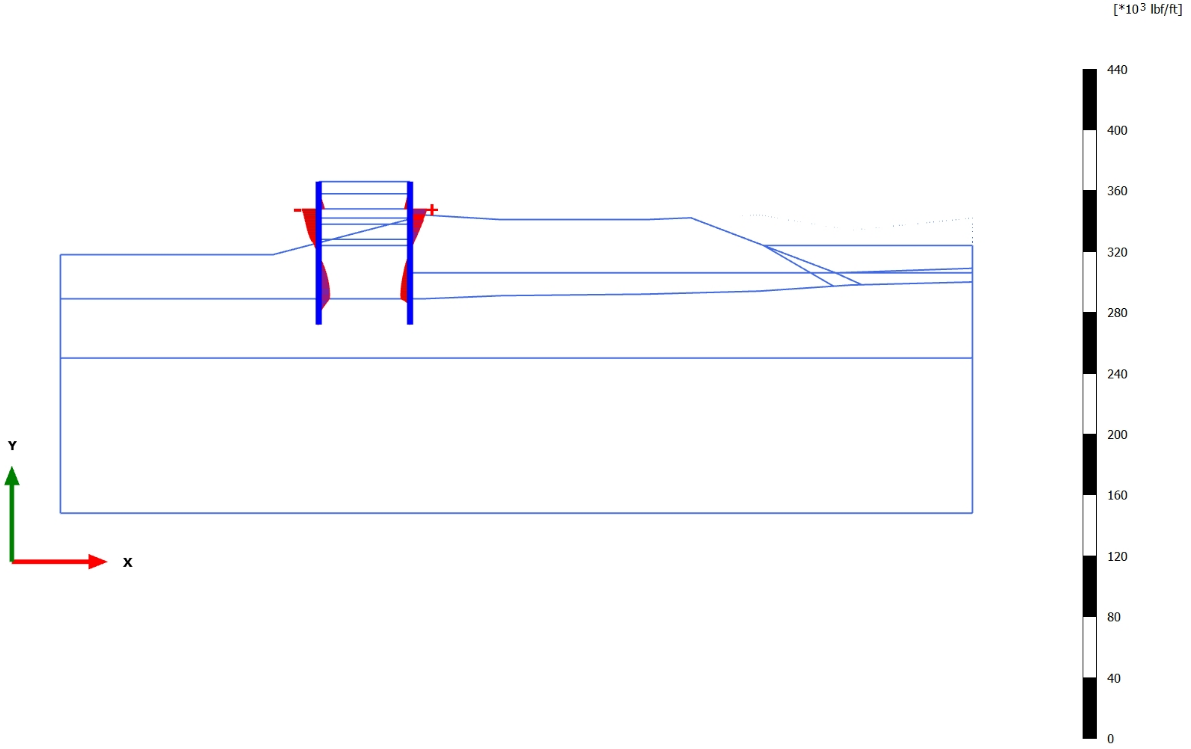


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 11.09*10^3 lbf/ft (Element 14 at Node 26818)

Minimum value = -10.93*10^3 lbf/ft (Element 13 at Node 31646)

3.1.2.1.9 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/275), Shear forces Q

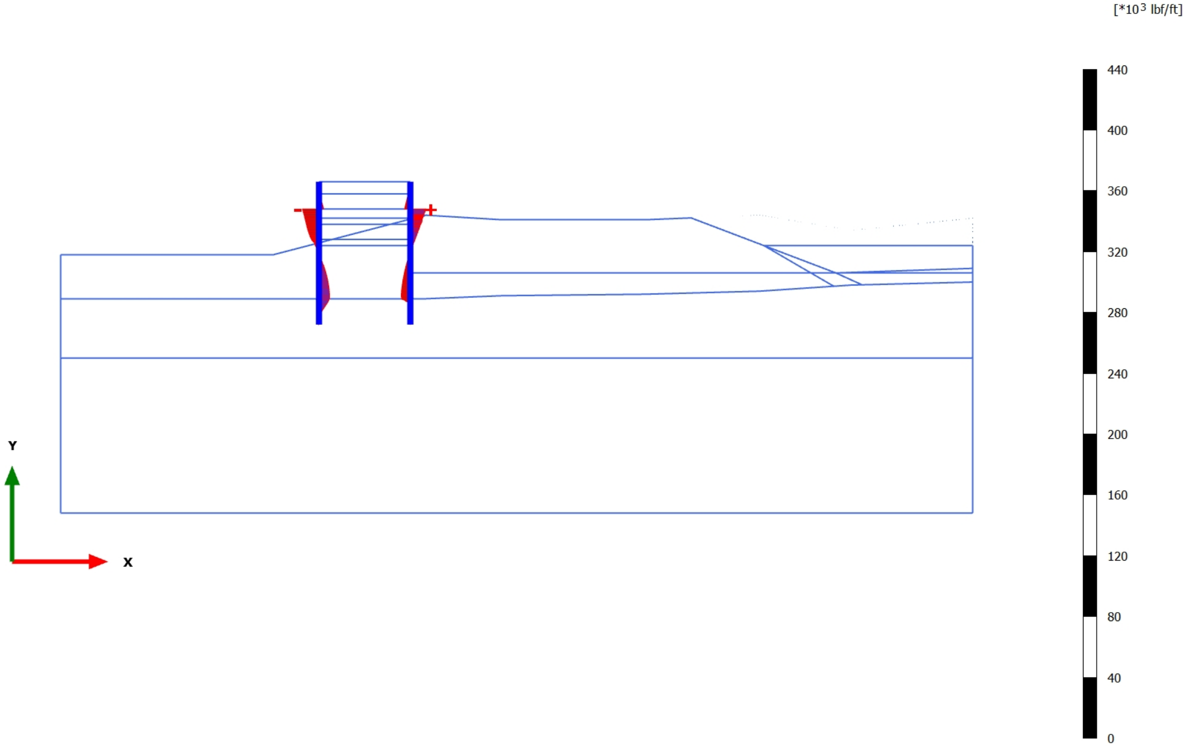


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.18*10^{3}$ lbf/ft (Element 14 at Node 26818)

Minimum value = $-11.02*10^{3}$ lbf/ft (Element 13 at Node 31646)

3.1.2.1.10 Calculation results, Plate, Consolidation [Phase_20] (20/296), Shear forces Q

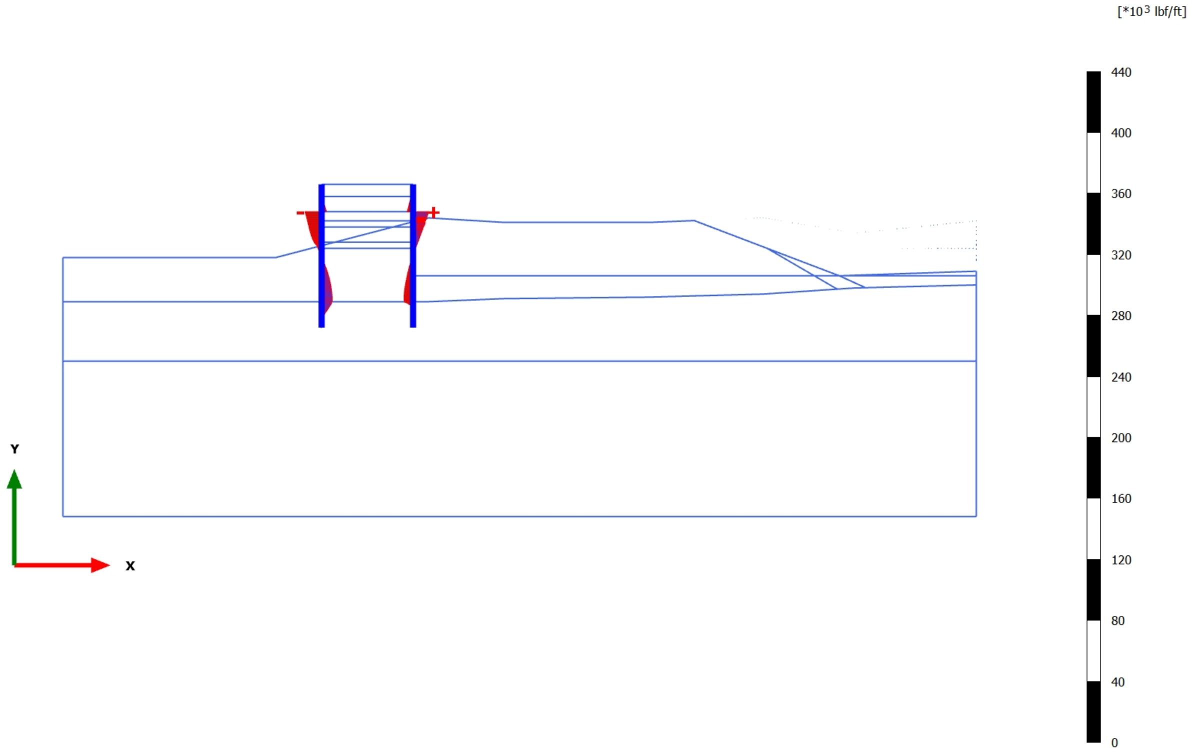


Shear forces Q (scaled up 0.500×10^{-3} times) (Time 37.00 day)

Maximum value = 10.30×10^3 lbf/ft (Element 14 at Node 26818)

Minimum value = -10.95×10^3 lbf/ft (Element 13 at Node 31646)

3.1.2.1.11 Calculation results, Plate, Excavate 2 [Phase_21] (21/299), Shear forces Q

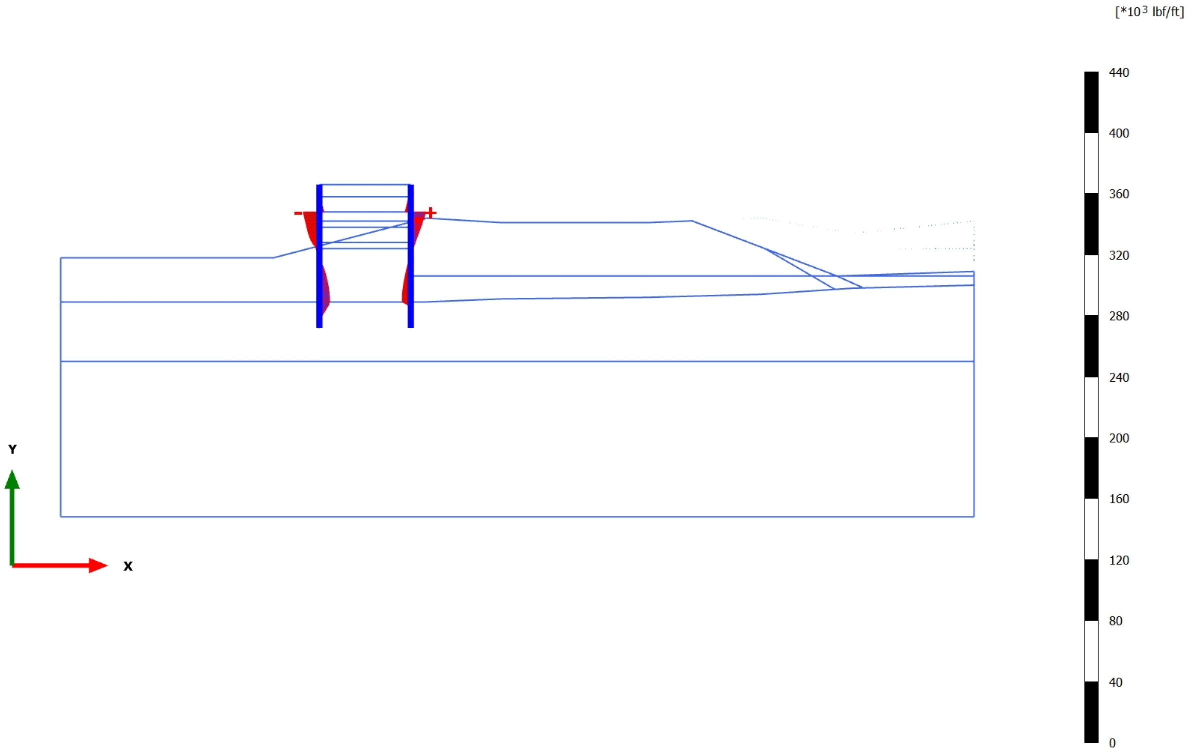


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 10.33*10^{3} lbf/ft (Element 14 at Node 26818)

Minimum value = -10.97*10^{3} lbf/ft (Element 13 at Node 31646)

3.1.2.1.12 Calculation results, Plate, Consolidate [Phase_8] (8/309), Shear forces Q

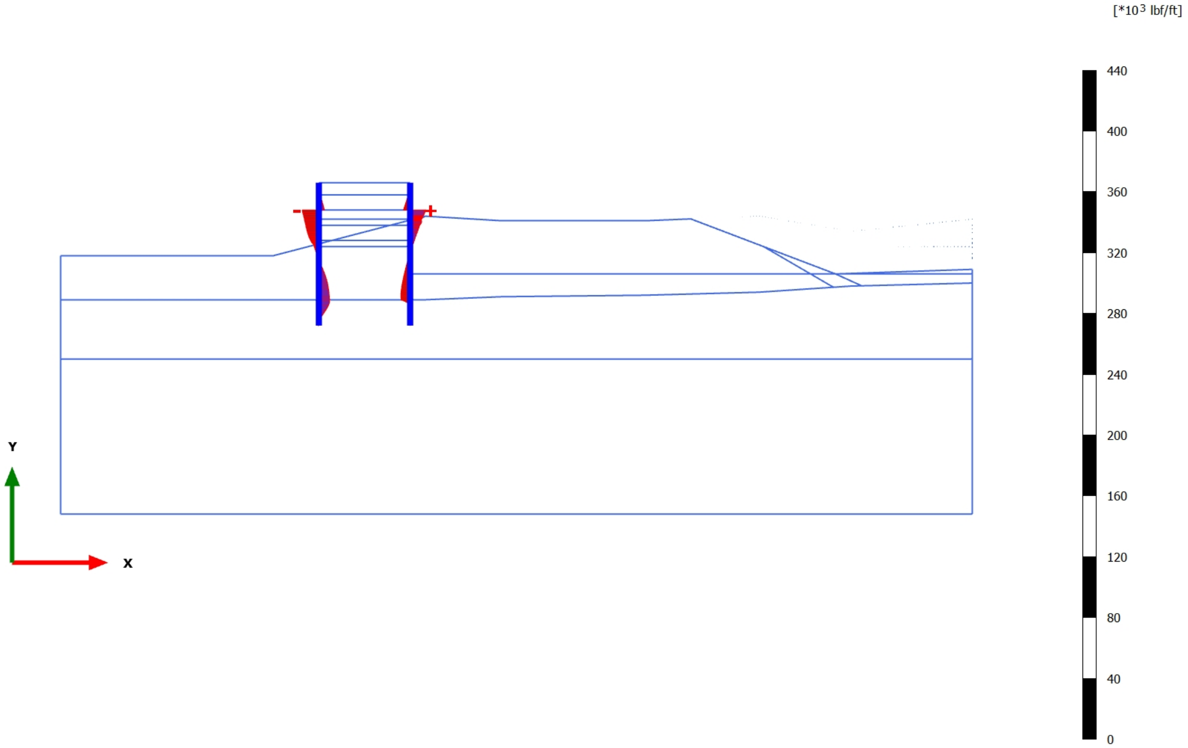


Shear forces Q (scaled up 0.500*10^{-3} times) (Time 51.00 day)

Maximum value = 10.05*10^3 lbf/ft (Element 14 at Node 26818)

Minimum value = -10.84*10^3 lbf/ft (Element 13 at Node 31646)

3.1.2.1.13 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/379), Shear forces Q

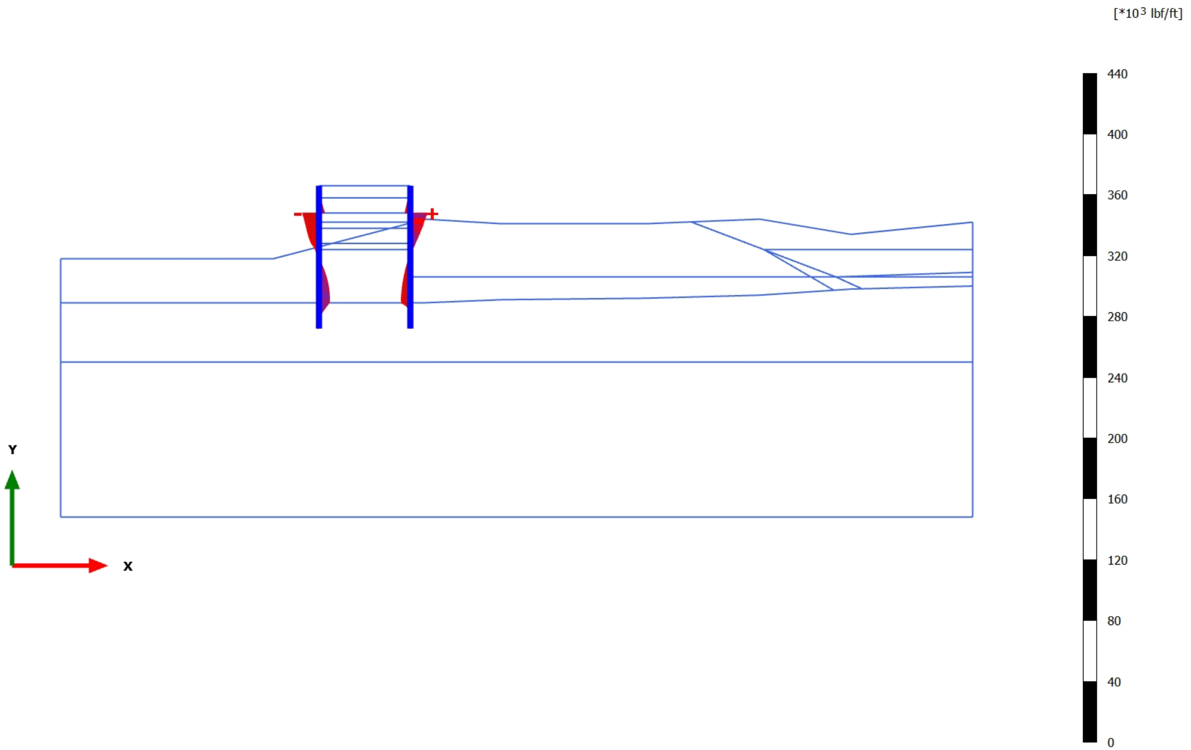


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.43*10^3$ lbf/ft (Element 14 at Node 26818)

Minimum value = $-11.13*10^3$ lbf/ft (Element 13 at Node 31646)

3.1.2.1.14 Calculation results, Plate, Consolidation [Phase_17] (17/438), Shear forces Q

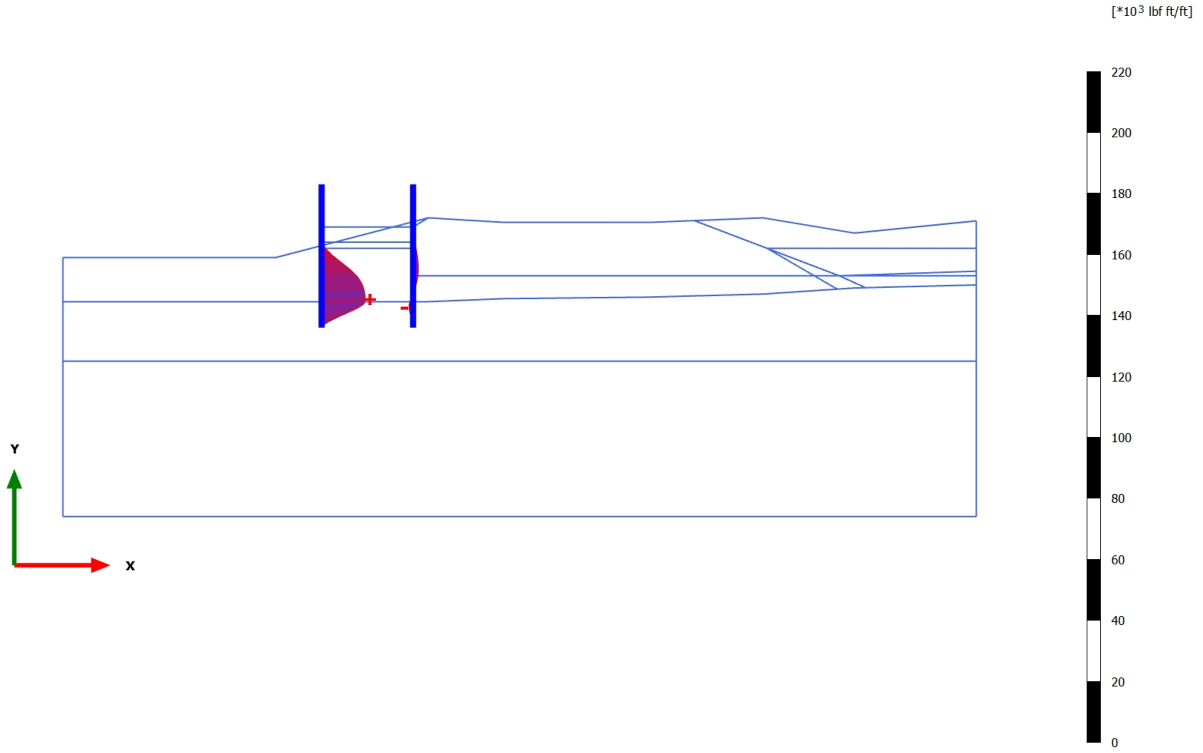


Shear forces Q (scaled up 0.500*10^{-3} times) (Time 20.00 day)

Maximum value = 11.05*10^{3} lbf/ft (Element 14 at Node 26818)

Minimum value = -10.88*10^{3} lbf/ft (Element 13 at Node 31646)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/29), Bending moments M

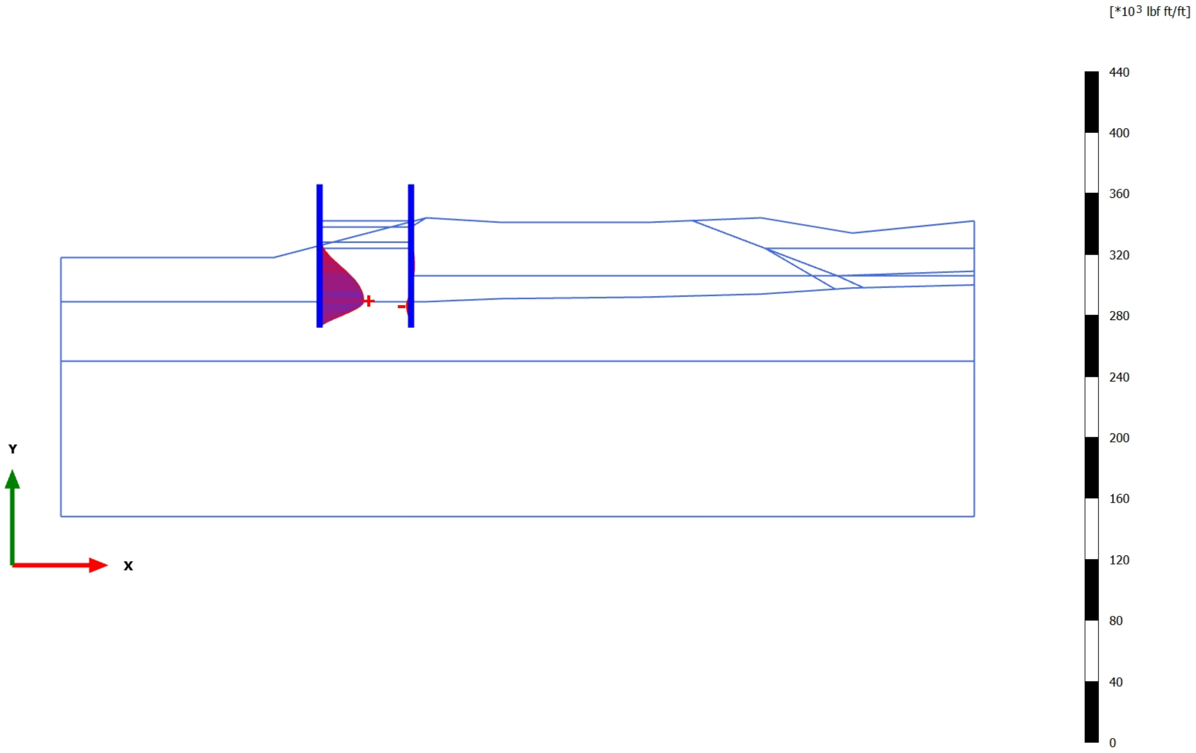


Bending moments M (scaled up 1.00×10^{-3} times)

Maximum value = 14.28×10^3 lbf ft/ft (Element 43 at Node 26155)

Minimum value = -1292 lbf ft/ft (Element 52 at Node 23789)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_3] (3/47), Bending moments M

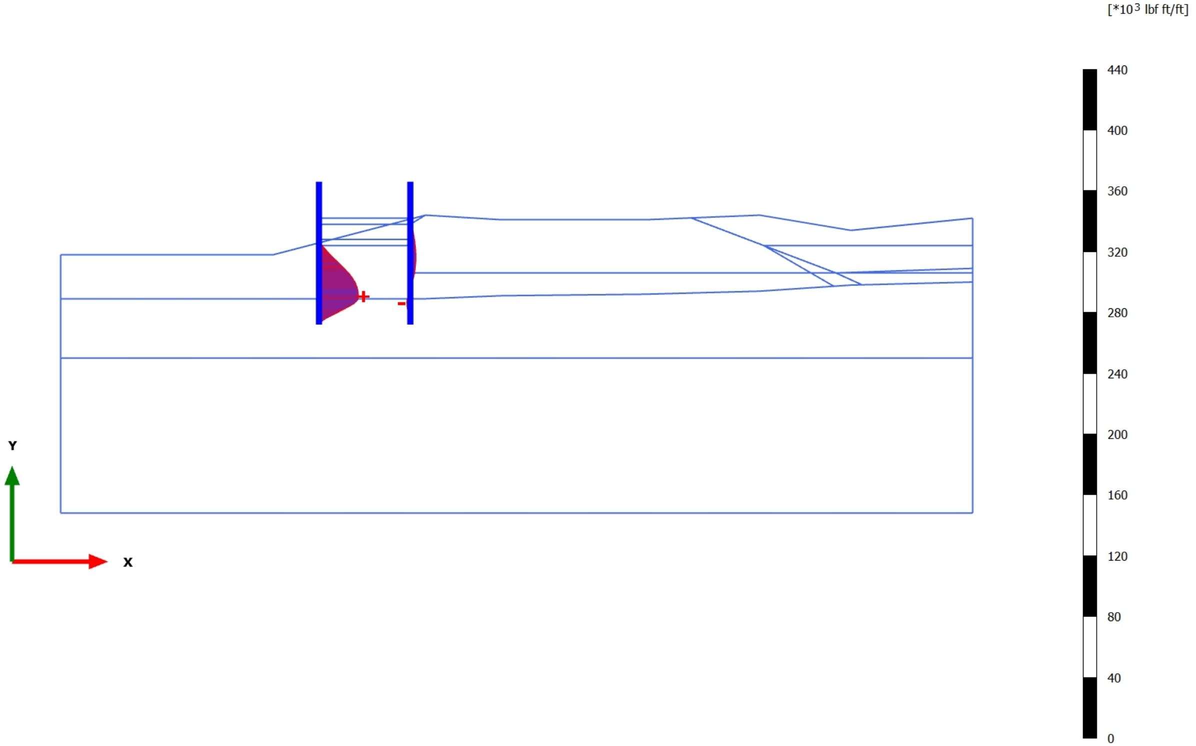


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 28.96*10^3 lbf ft/ft (Element 43 at Node 26154)

Minimum value = -3053 lbf ft/ft (Element 52 at Node 23790)

3.1.2.2.3 Calculation results, Plate, Consolidate [Phase_25] (25/88), Bending moments M

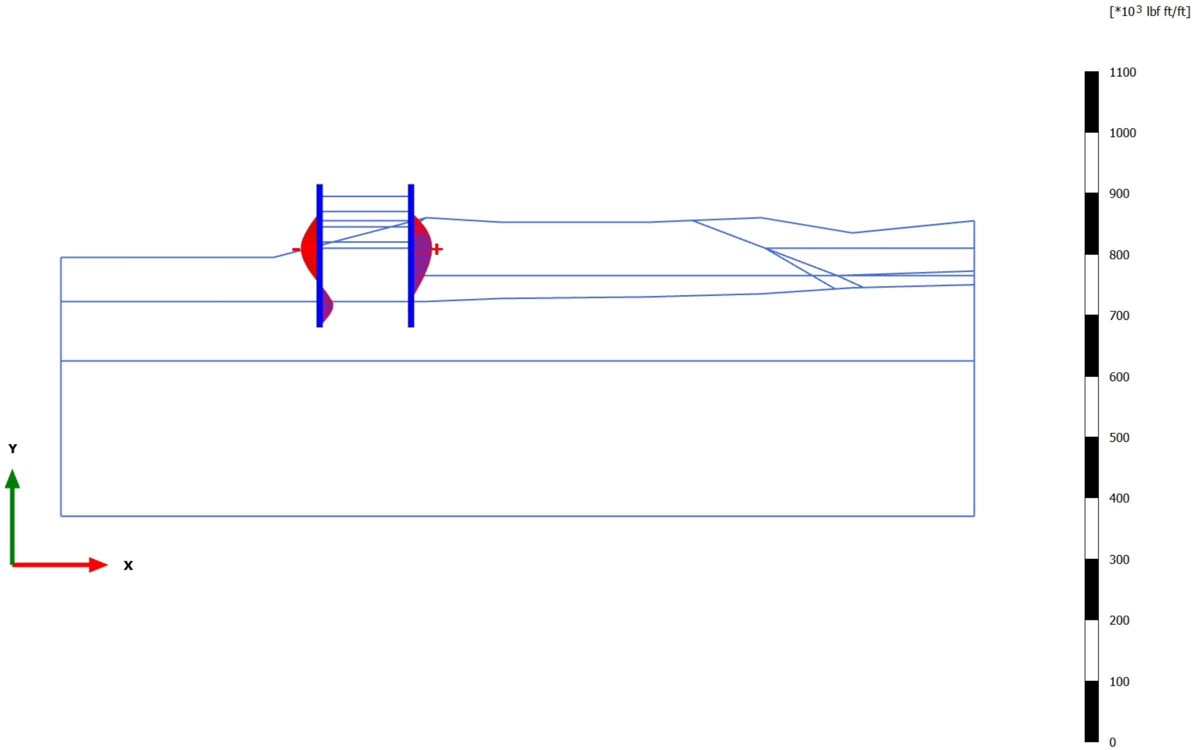


Bending moments M (scaled up 0.500×10^{-3} times) (Time 10.00 day)

Maximum value = 25.93×10^{3} lbf ft/ft (Element 43 at Node 26155)

Minimum value = -2315 lbf ft/ft (Element 52 at Node 23790)

3.1.2.2.4 Calculation results, Plate, Backfill 3 [Phase_5] (5/111), Bending moments M

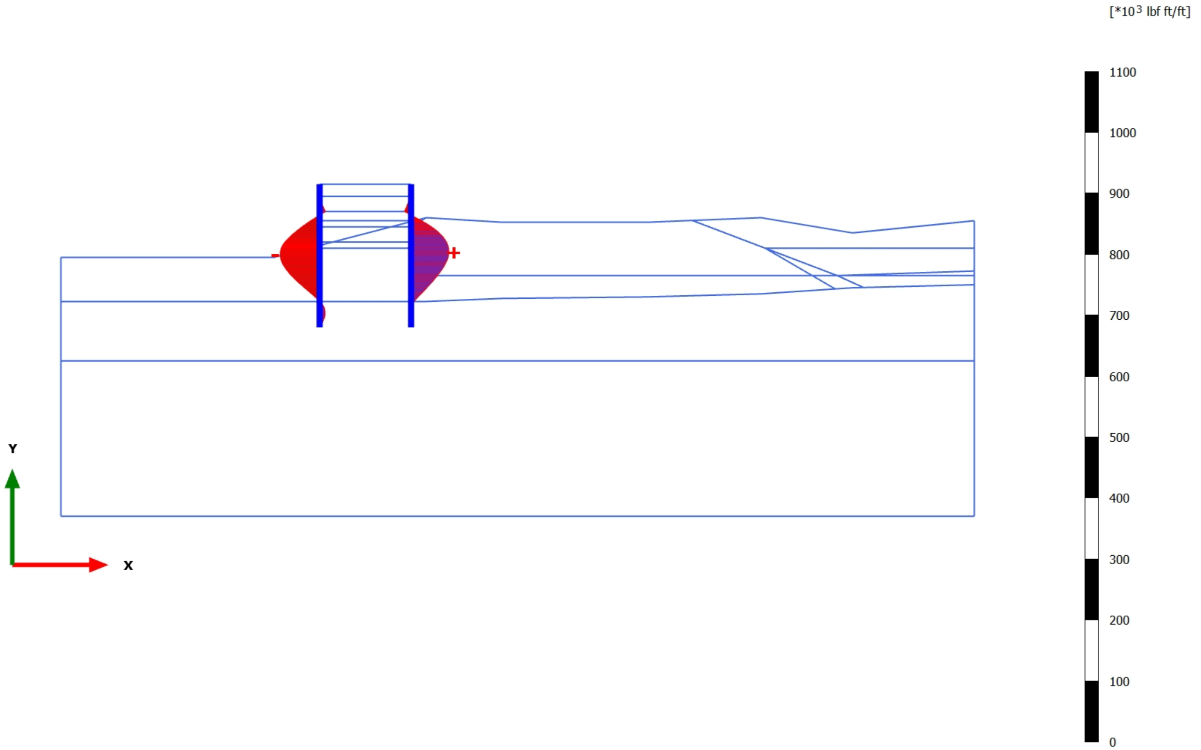


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $33.96*10^{3}$ lbf ft/ft (Element 28 at Node 25774)

Minimum value = $-30.38*10^{3}$ lbf ft/ft (Element 29 at Node 30020)

3.1.2.2.5 Calculation results, Plate, Backfill 4 [Phase_6] (6/125), Bending moments M

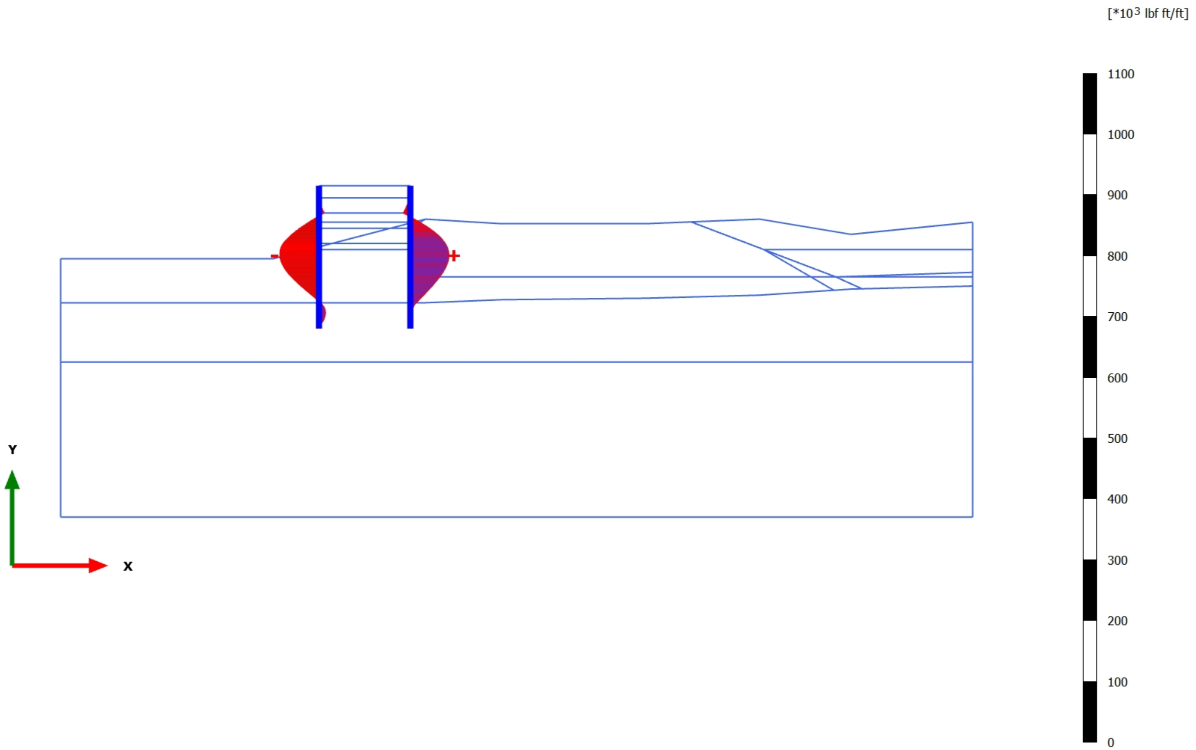


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $62.20*10^{3}$ lbf ft/ft (Element 30 at Node 25772)

Minimum value = $-64.91*10^{3}$ lbf ft/ft (Element 35 at Node 29603)

3.1.2.2.6 Calculation results, Plate, Consolidate [Phase_7] (7/252), Bending moments M

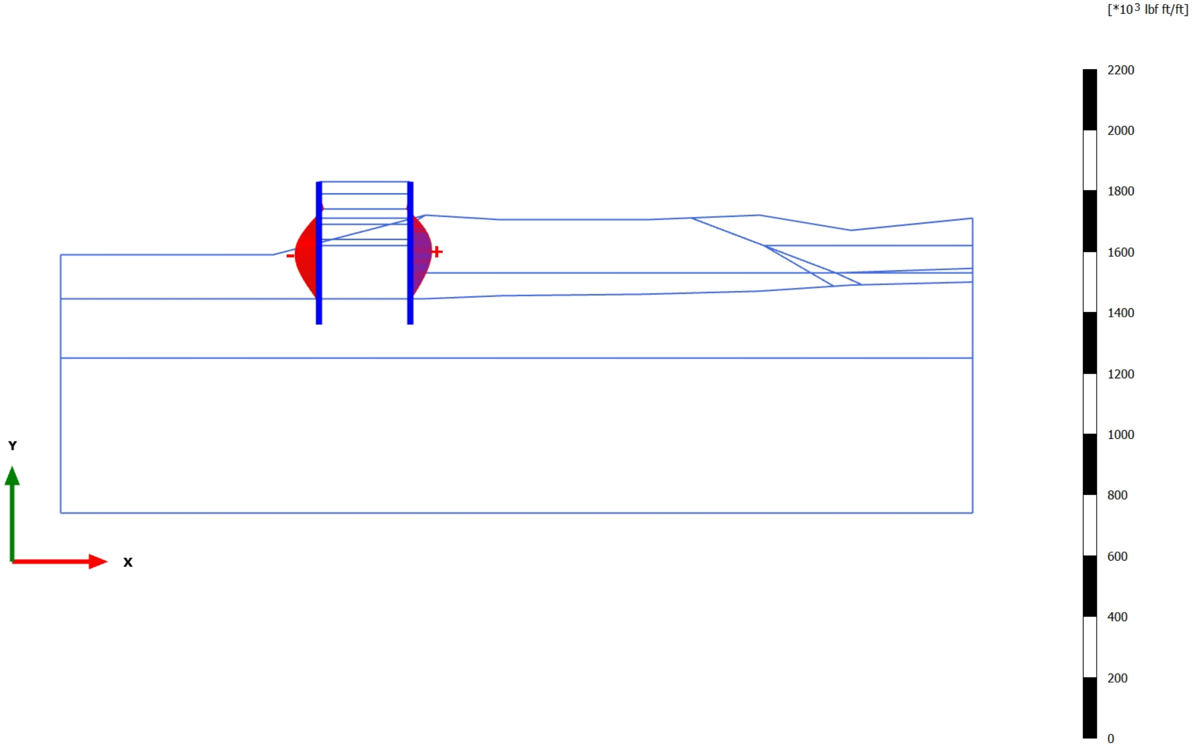


Bending moments M (scaled up 0.200*10^{-3} times) (Time 16.00 day)

Maximum value = 63.80*10^3 lbf ft/ft (Element 30 at Node 25771)

Minimum value = -64.58*10^3 lbf ft/ft (Element 35 at Node 29604)

3.1.2.2.7 Calculation results, Plate, Dewater-ss [Phase_16] (16/266), Bending moments M

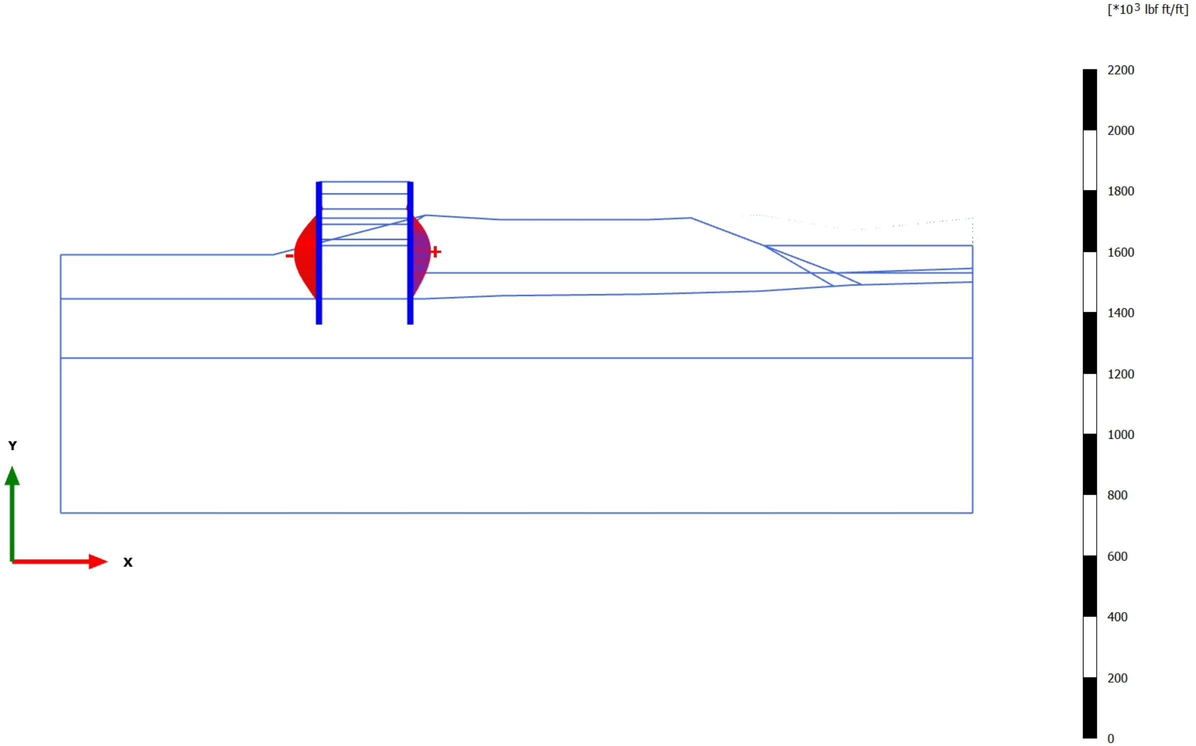


Bending moments M (scaled up 0.100×10^{-3} times)

Maximum value = 70.67×10^{3} lbf ft/ft (Element 30 at Node 25771)

Minimum value = -78.94×10^{3} lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.8 Calculation results, Plate, Excavate 1 [Phase_18] (18/271), Bending moments M

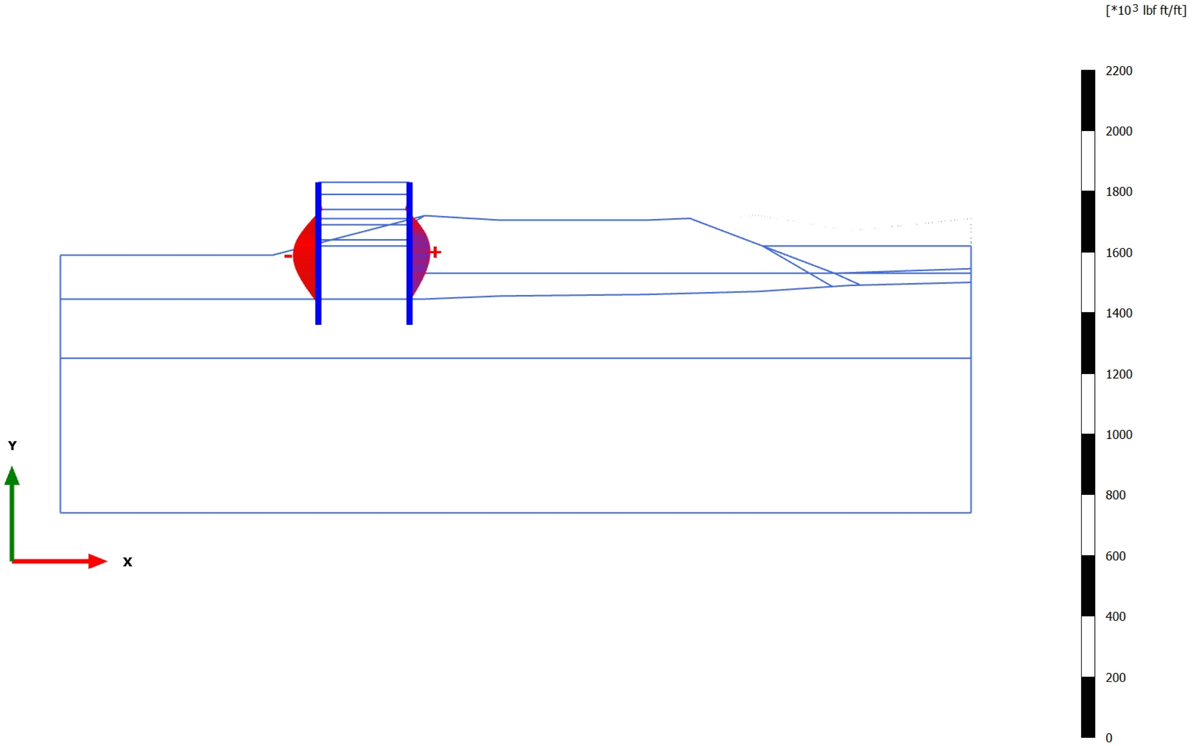


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 66.59*10^{3} lbf ft/ft (Element 30 at Node 25771)

Minimum value = -80.83*10^{3} lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.9 Calculation results, Plate, Dewater 2 - ss [Phase_19] (19/275), Bending moments M

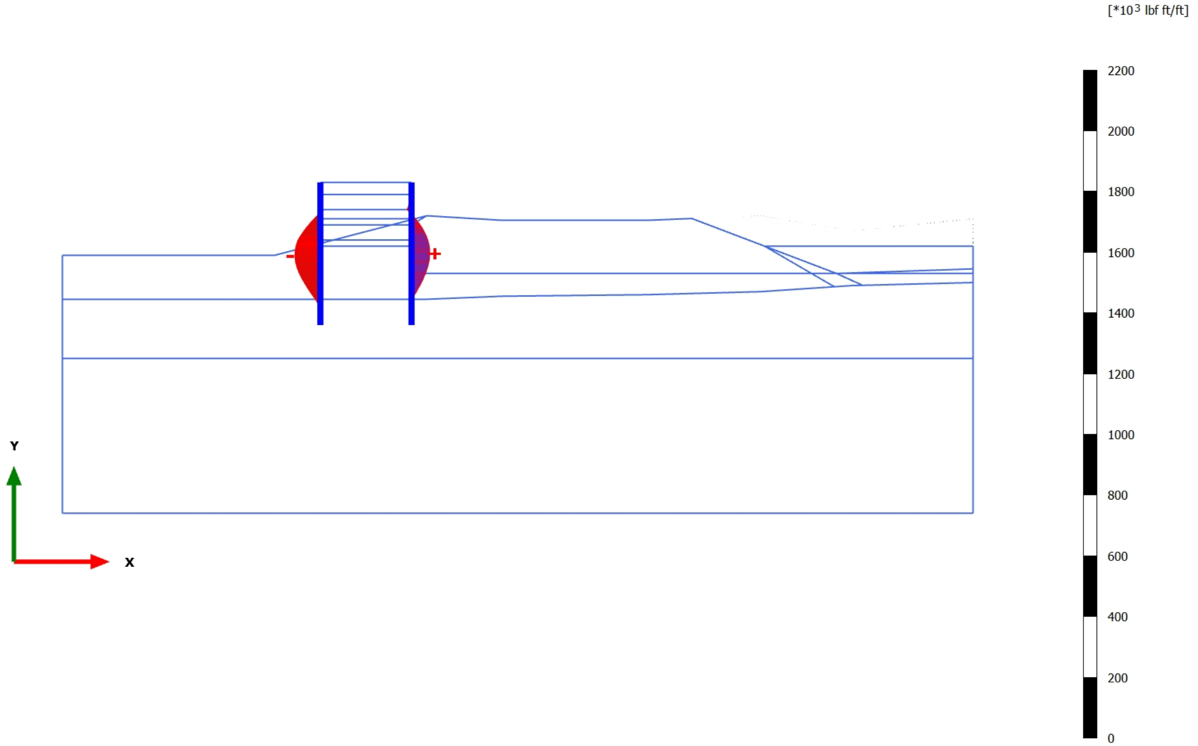


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 67.82*10^{3} lbf ft/ft (Element 30 at Node 25771)

Minimum value = -82.69*10^{3} lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.10 Calculation results, Plate, Consolidation [Phase_20] (20/296), Bending moments M

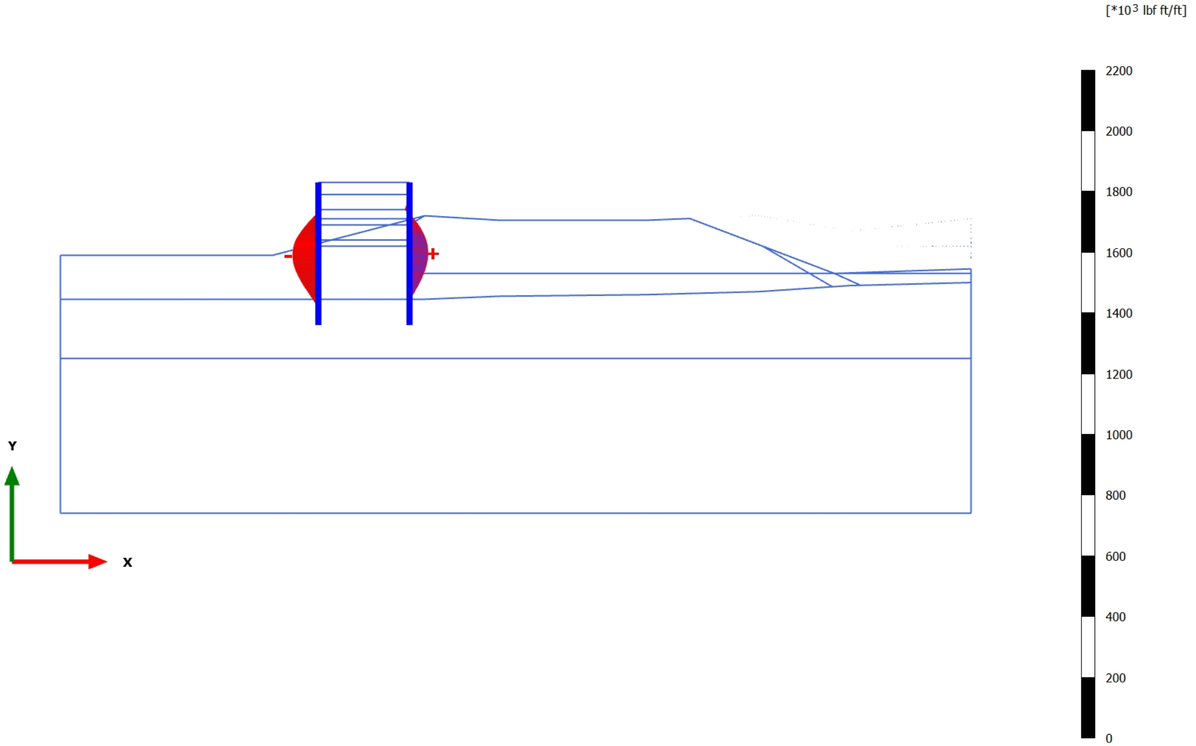


Bending moments M (scaled up 0.100*10^{-3} times) (Time 37.00 day)

Maximum value = 60.42*10^3 lbf ft/ft (Element 30 at Node 25832)

Minimum value = -84.00*10^3 lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.11 Calculation results, Plate, Excavate 2 [Phase_21] (21/299), Bending moments M

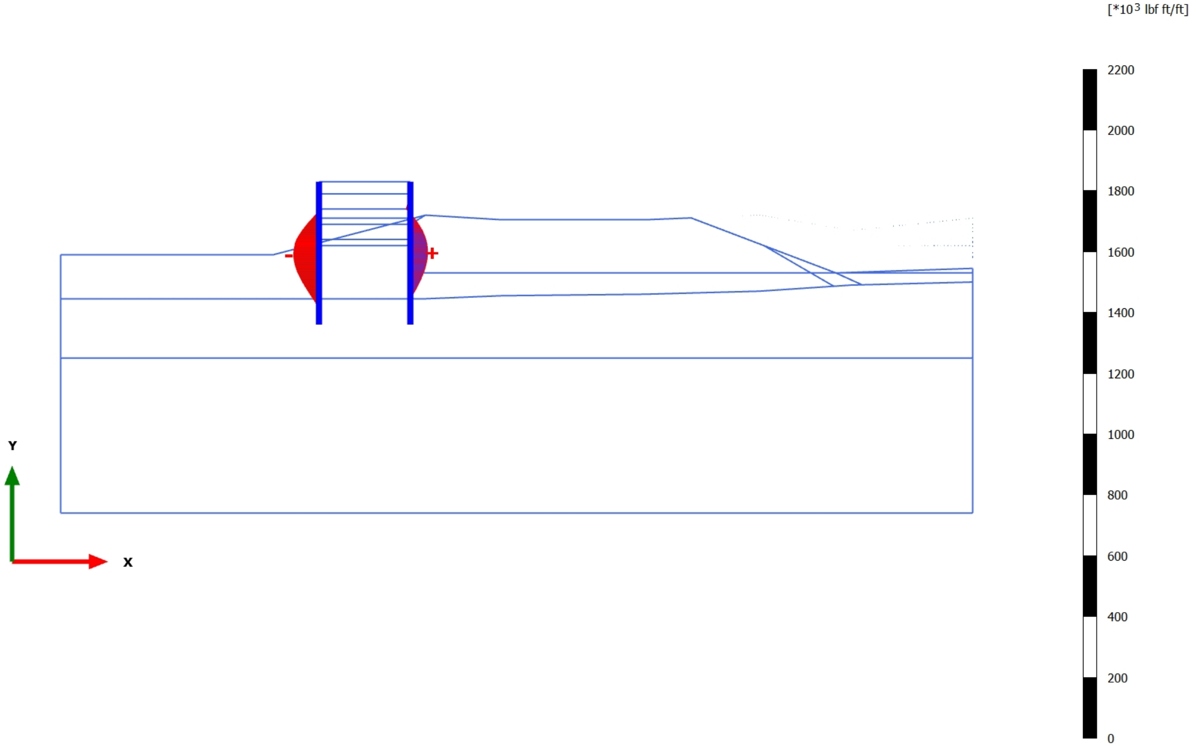


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 60.69*10^{3} lbf ft/ft (Element 30 at Node 25832)

Minimum value = -84.26*10^{3} lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.12 Calculation results, Plate, Consolidate [Phase_8] (8/309), Bending moments M

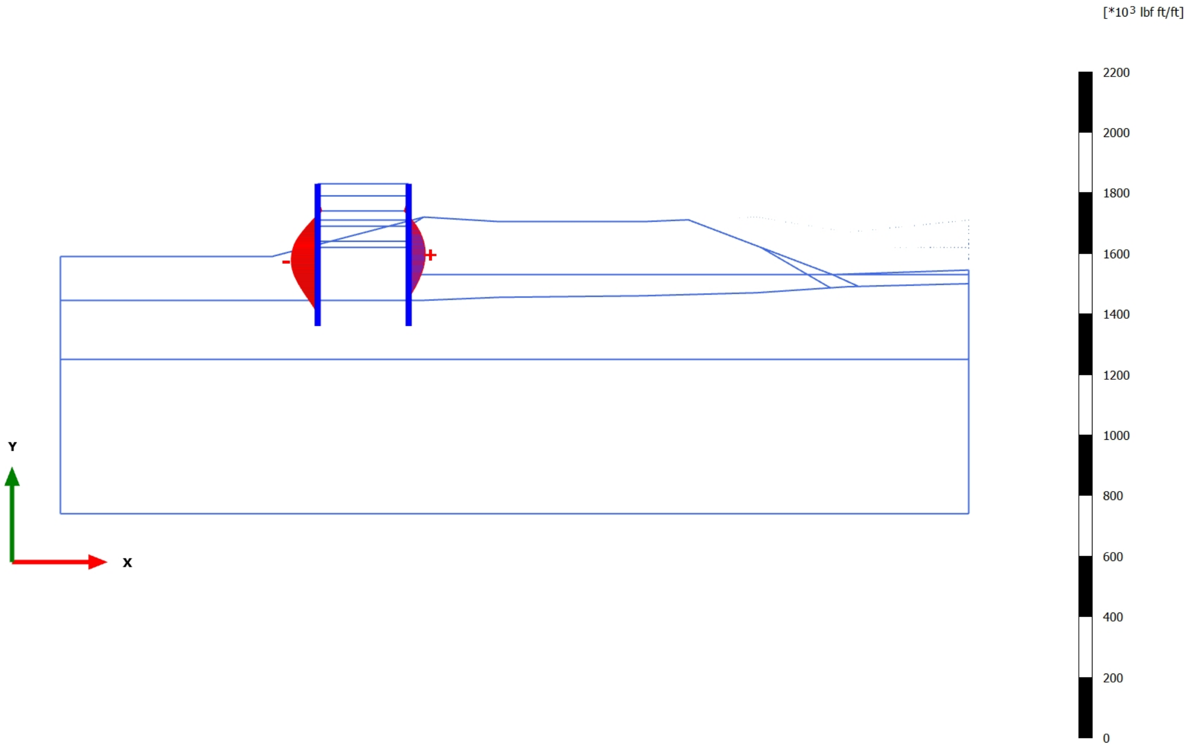


Bending moments M (scaled up 0.100*10^{-3} times) (Time 51.00 day)

Maximum value = 57.23*10^3 lbf ft/ft (Element 31 at Node 25832)

Minimum value = -83.33*10^3 lbf ft/ft (Element 36 at Node 29184)

3.1.2.2.13 Calculation results, Plate, Water rise 9 ft [Phase_22] (22/379), Bending moments M

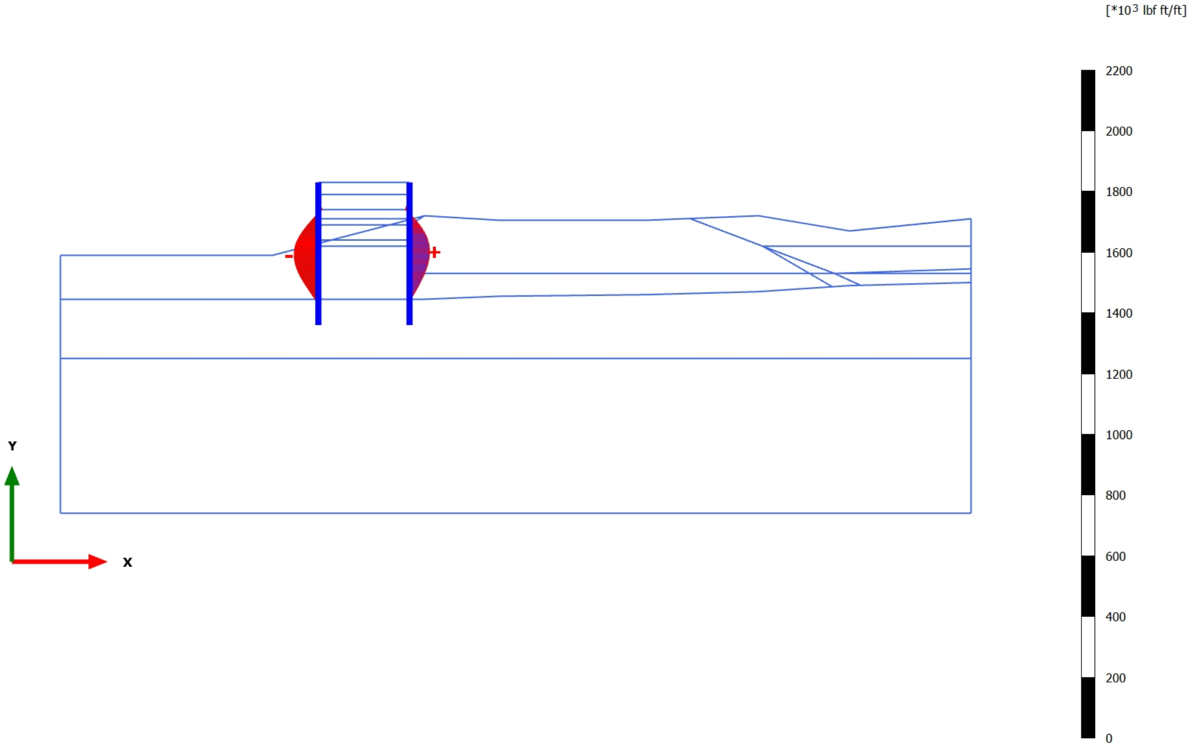


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 55.28*10^{3} lbf ft/ft (Element 30 at Node 25832)

Minimum value = -87.60*10^{3} lbf ft/ft (Element 37 at Node 28714)

3.1.2.2.14 Calculation results, Plate, Consolidation [Phase_17] (17/438), Bending moments M



Bending moments M (scaled up 0.100*10^{-3} times) (Time 20.00 day)

Maximum value = 66.23*10^{3} lbf ft/ft (Element 30 at Node 25771)

Minimum value = -79.94*10^{3} lbf ft/ft (Element 36 at Node 29184)

3.2.1.1.3 Calculation results, Node-to-node anchor, Consolidate [Phase_25] (25/88), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	1815.652	0.000	1973.295
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	1815.652	0.000	1973.295

3.2.1.1.4 Calculation results, Node-to-node anchor, Backfill 3 [Phase_5] (5/111), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	42.235	0.000	42.235
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	42.235	0.000	42.235

3.2.1.1.5 Calculation results, Node-to-node anchor, Backfill 4 [Phase_6] (6/125), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	97.231	0.000	97.231
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	97.231	0.000	97.231

3.2.1.1.6 Calculation results, Node-to-node anchor, Consolidate [Phase_7] (7/252), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	100.836	0.000	108.588
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	100.836	0.000	108.588

3.2.1.1.7 Calculation results, Node-to-node anchor, Dewater-ss [Phase_16] (16/266), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	122.974	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	122.974	0.000	122.974

3.2.1.1.8 Calculation results, Node-to-node anchor, Excavate 1 [Phase_18] (18/271), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	117.495	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	117.495	0.000	122.974

3.2.1.1.9 Calculation results, Node-to-node anchor, Dewater 2 - ss [Phase_19] (19/275), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	118.835	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	118.835	0.000	122.974

3.2.1.1.10 Calculation results, Node-to-node anchor, Consolidation [Phase_20] (20/296), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	112.645	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	112.645	0.000	122.974

3.2.1.1.11 Calculation results, Node-to-node anchor, Excavate 2 [Phase_21] (21/299), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	112.976	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	112.976	0.000	122.974

3.2.1.1.12 Calculation results, Node-to-node anchor, Consolidate [Phase_8] (8/309), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	110.345	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	110.345	0.000	122.974

3.2.1.1.13 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_22] (22/379), Table of node-to-node anchors

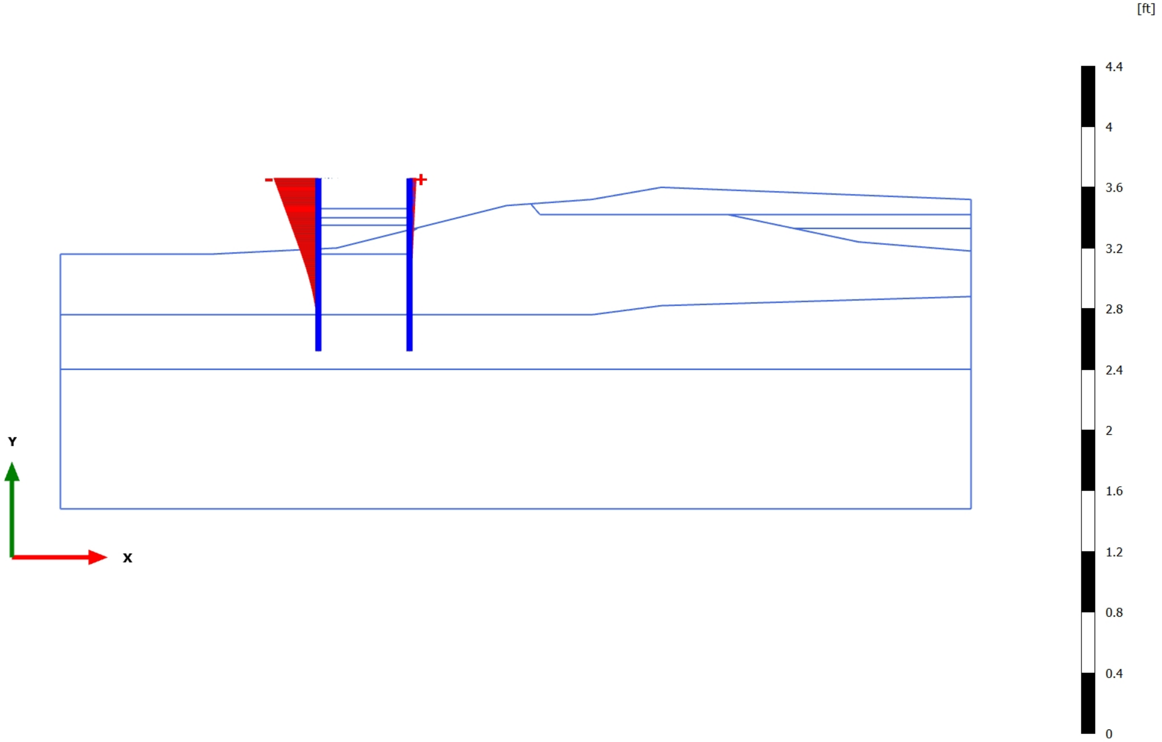
Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	118.728	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	118.728	0.000	122.974

3.2.1.1.14 Calculation results, Node-to-node anchor, Consolidation [Phase_17] (17/438), Table of node-to-node anchors

Structural element	Node [10^3]	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	31646	1	-15.000	0.000	116.833	0.000	122.974
Element 2-2 (Node-to-node anchor)	26818	2	15.000	0.000	116.833	0.000	122.974

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/155), Total displacements u_x

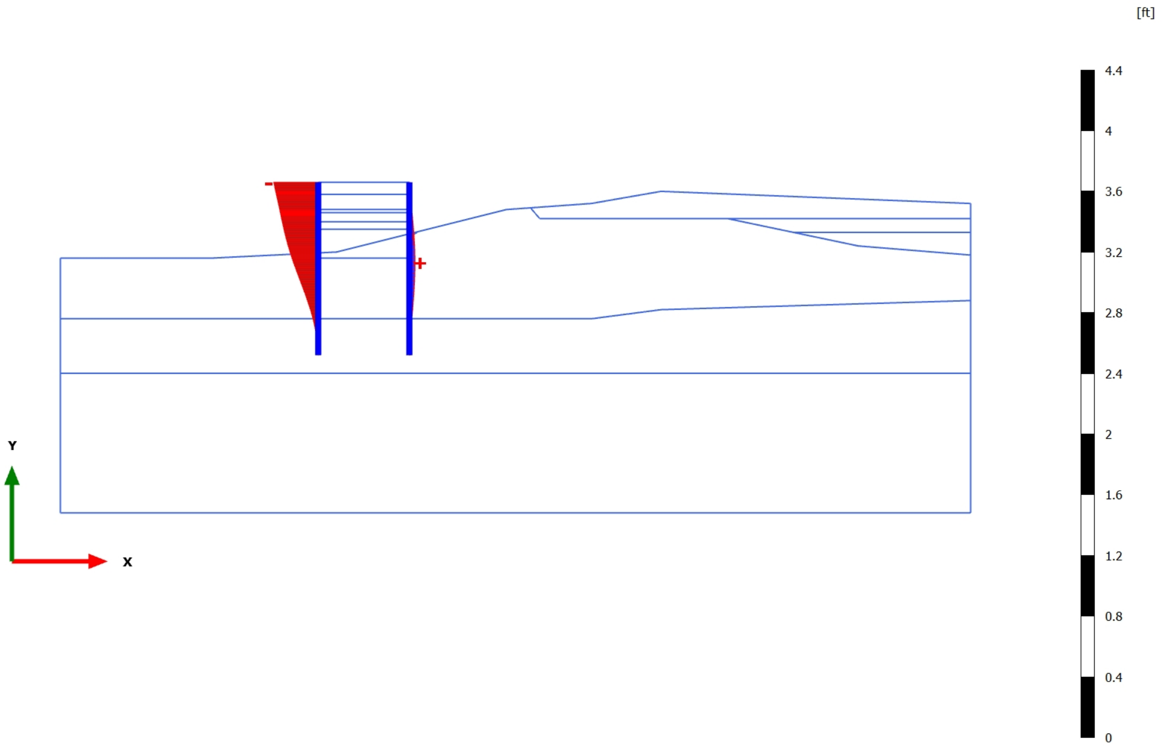


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.04378 ft (Element 2 at Node 1029)

Minimum value = -0.2928 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Backfill 2 [Phase_6] (6/184), Total displacements u_x

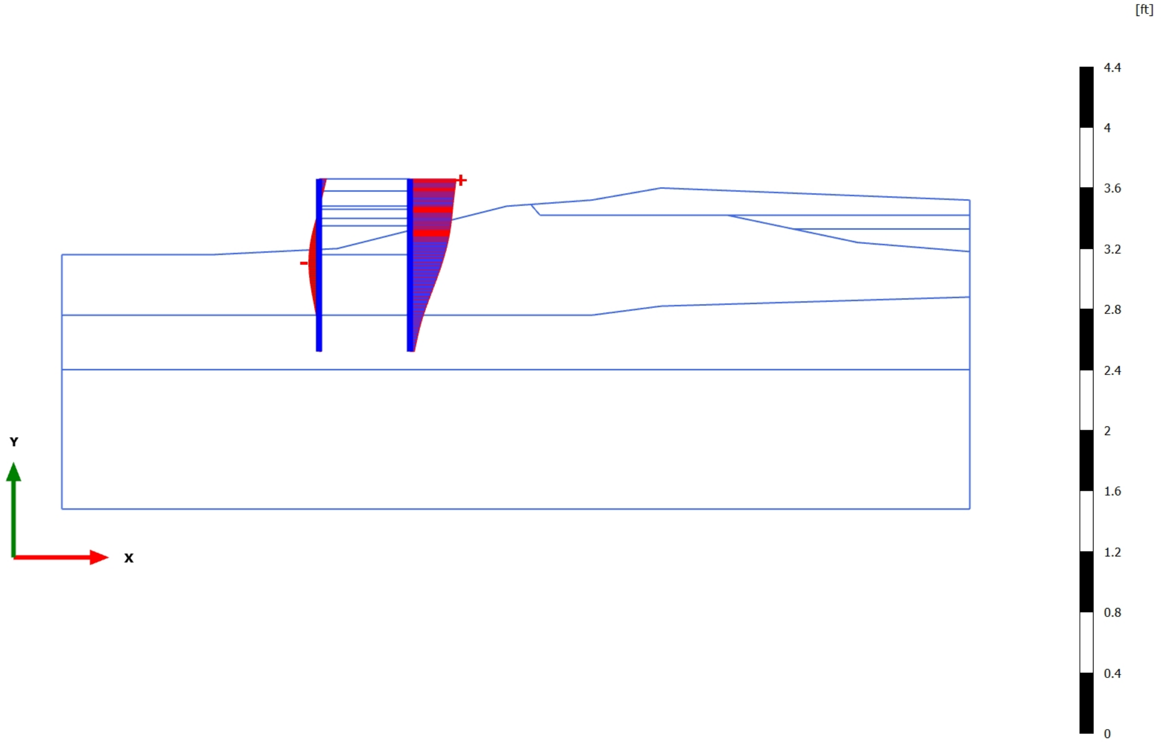


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.03779 ft (Element 33 at Node 5614)

Minimum value = -0.2940 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Dewater-ss [Phase_3] (3/204), Total displacements u_x

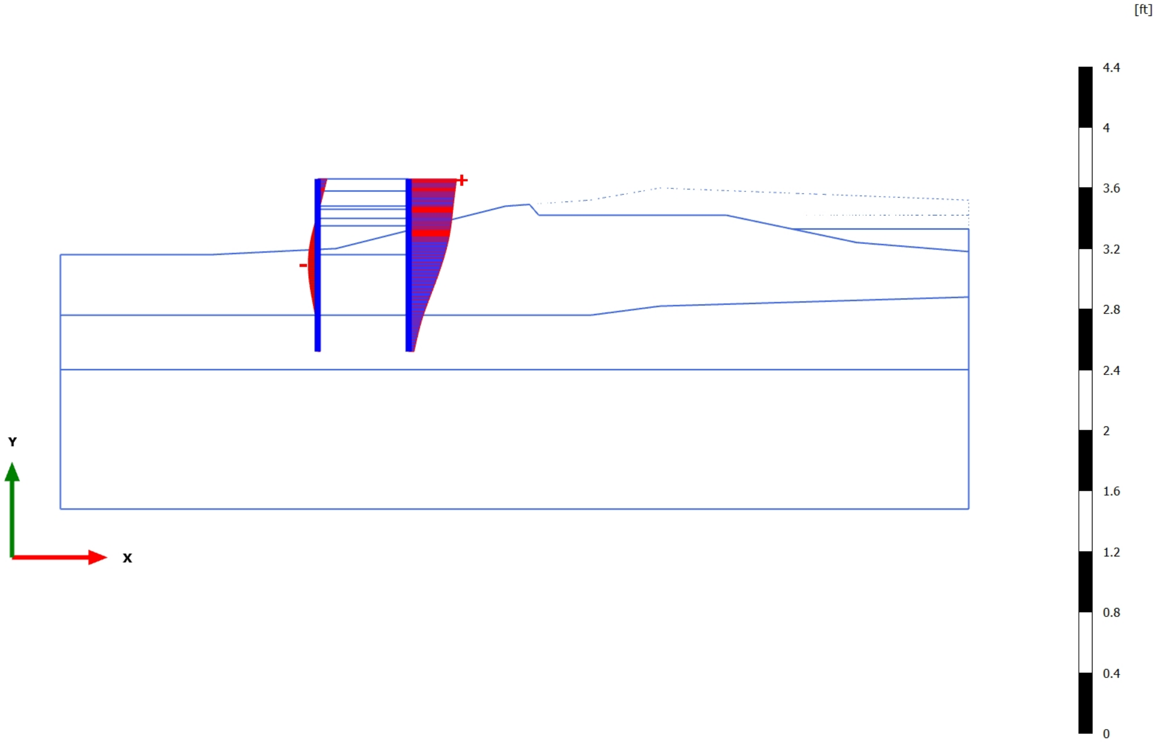


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3062 ft (Element 2 at Node 1029)

Minimum value = -0.06830 ft (Element 27 at Node 3817)

3.1.1.1.1.4 Calculation results, Plate, Excavate 1 [Phase_16] (16/208), Total displacements u_x

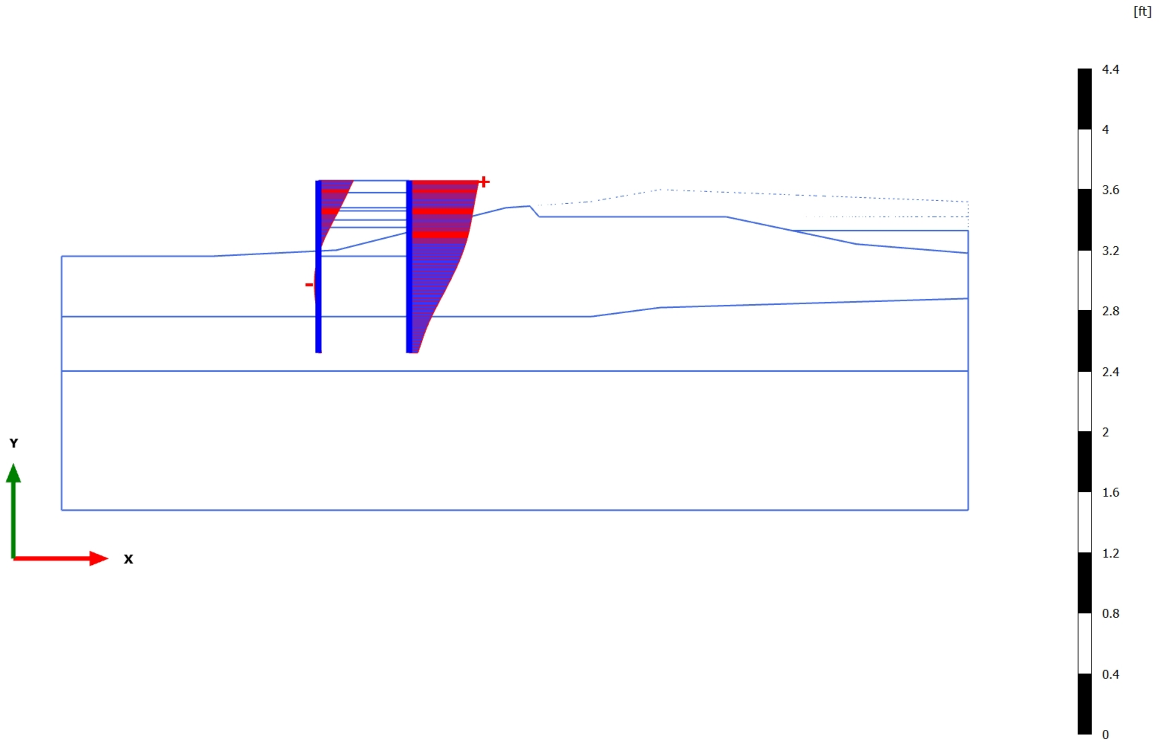


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.3174 ft (Element 2 at Node 1029)

Minimum value = -0.06292 ft (Element 28 at Node 3820)

3.1.1.1.1.5 Calculation results, Plate, Dewater 2-ss [Phase_17] (17/219), Total displacements u_x

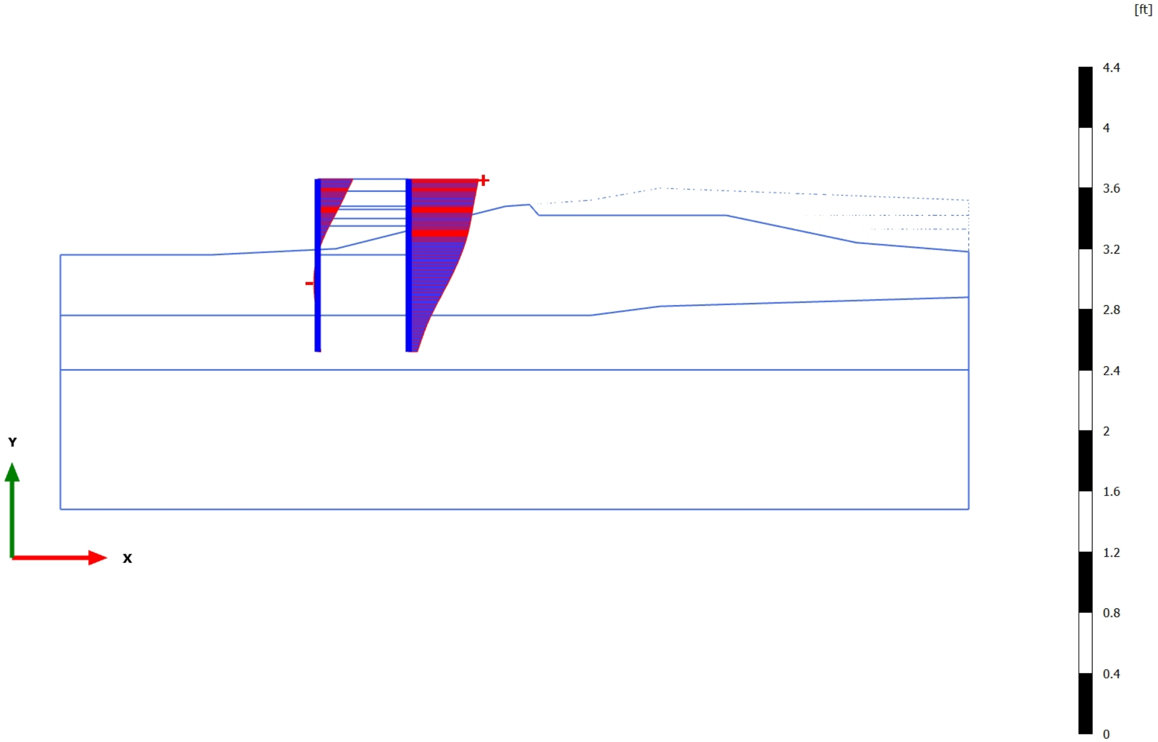


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4615 ft (Element 2 at Node 1029)

Minimum value = -0.02680 ft (Element 30 at Node 4604)

3.1.1.1.1.6 Calculation results, Plate, Excavate 2 [Phase_19] (19/222), Total displacements u_x

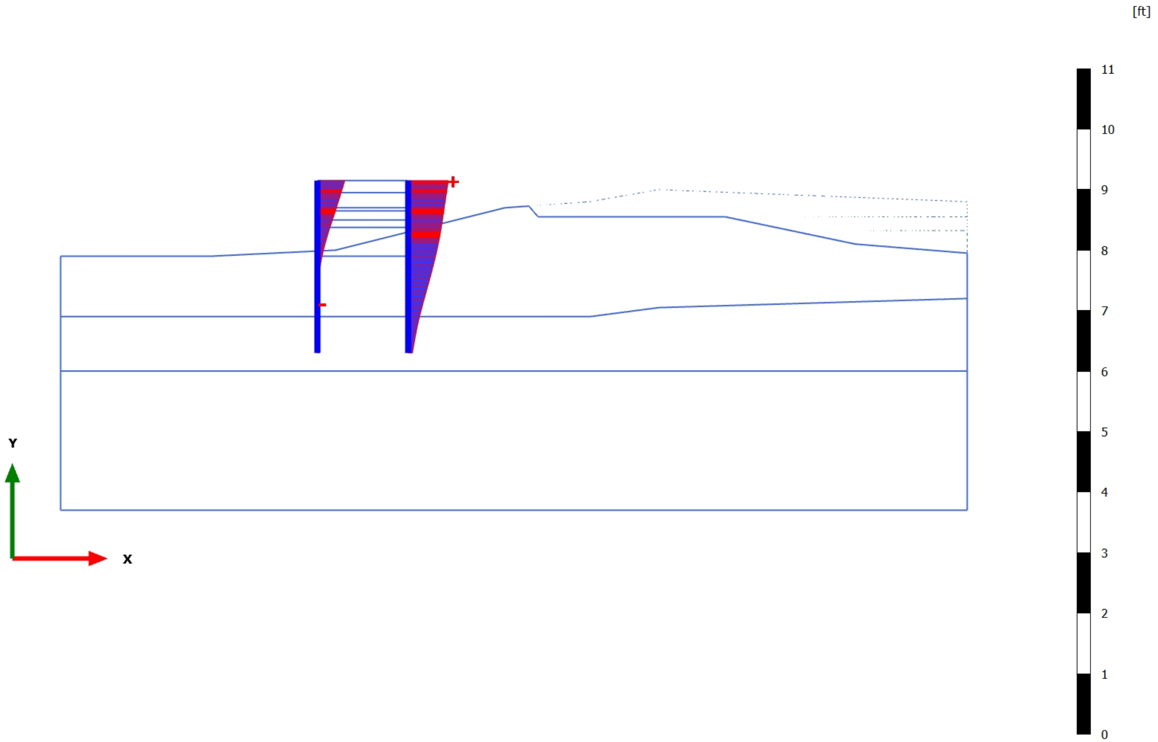


Total displacements u_x (scaled up 50.0 times)

Maximum value = 0.4626 ft (Element 2 at Node 1029)

Minimum value = -0.02622 ft (Element 30 at Node 4604)

3.1.1.1.1.7 Calculation results, Plate, Water rise 9 ft [Phase_20] (20/244), Total displacements u_x

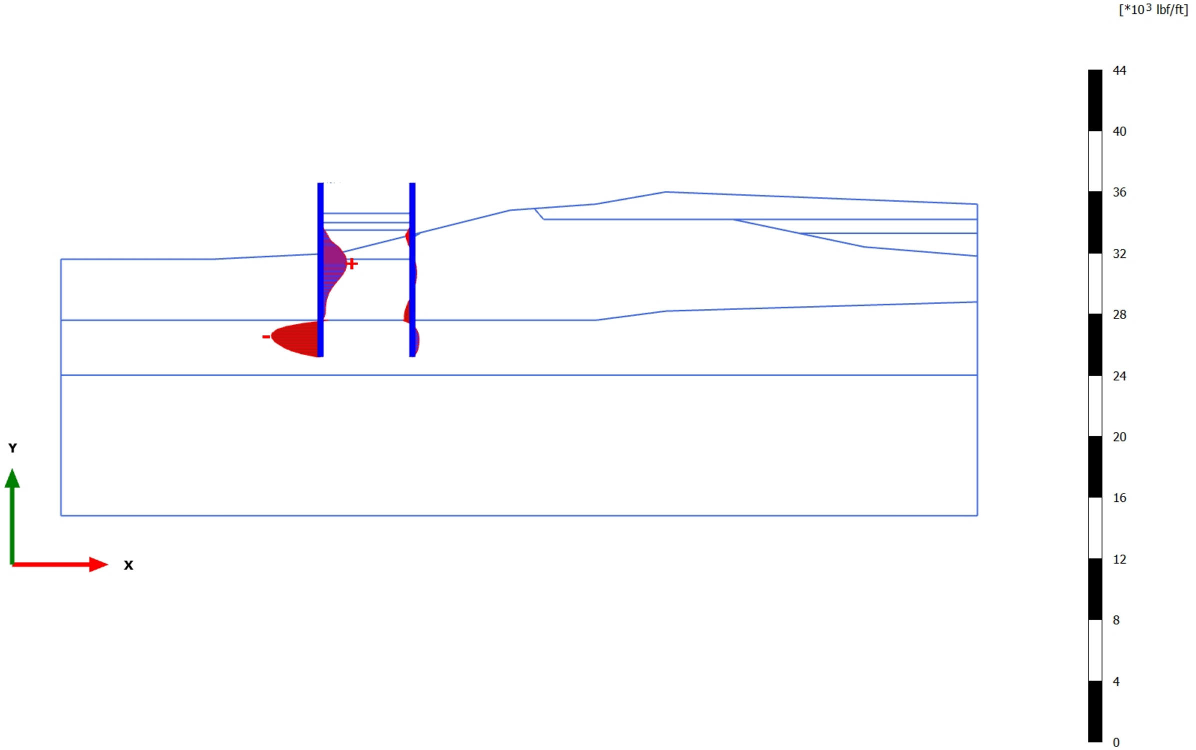


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.6671 ft (Element 2 at Node 1029)

Minimum value = 1.565×10^{-3} ft (Element 31 at Node 5649)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/155), Shear forces Q

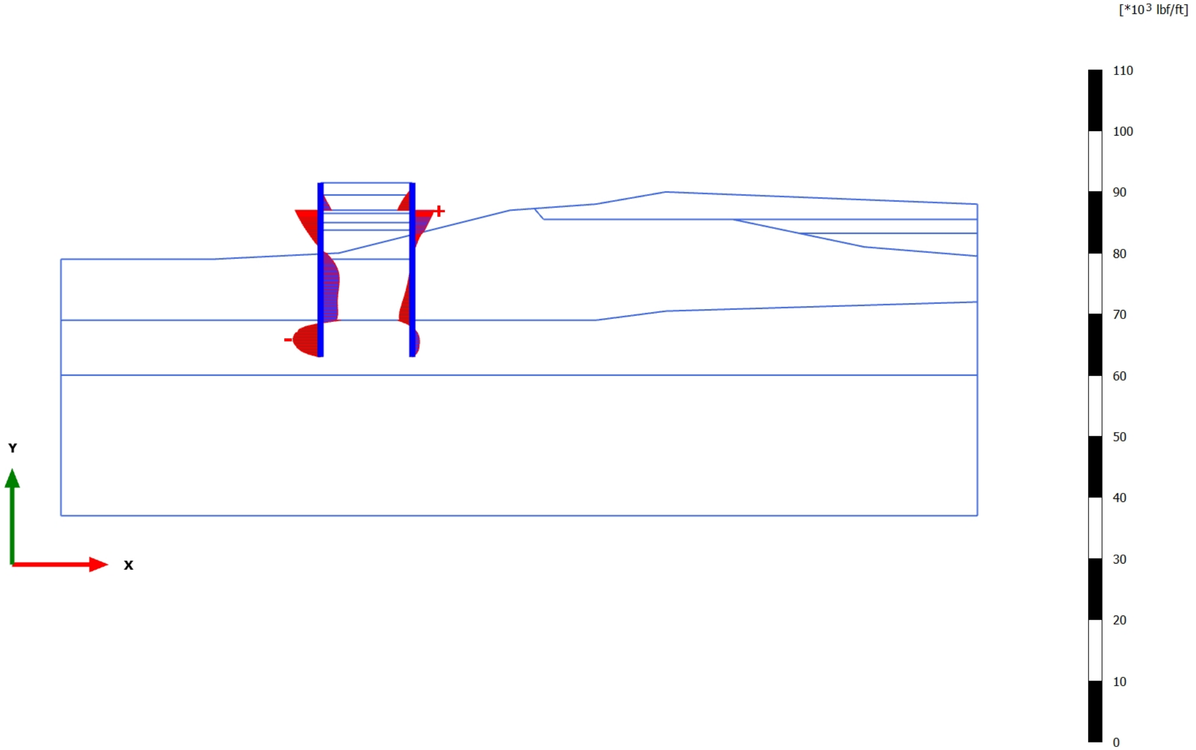


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 1715 lbf/ft (Element 27 at Node 2825)

Minimum value = -3231 lbf/ft (Element 38 at Node 6022)

3.1.2.1.2 Calculation results, Plate, Backfill 2 [Phase_6] (6/184), Shear forces Q

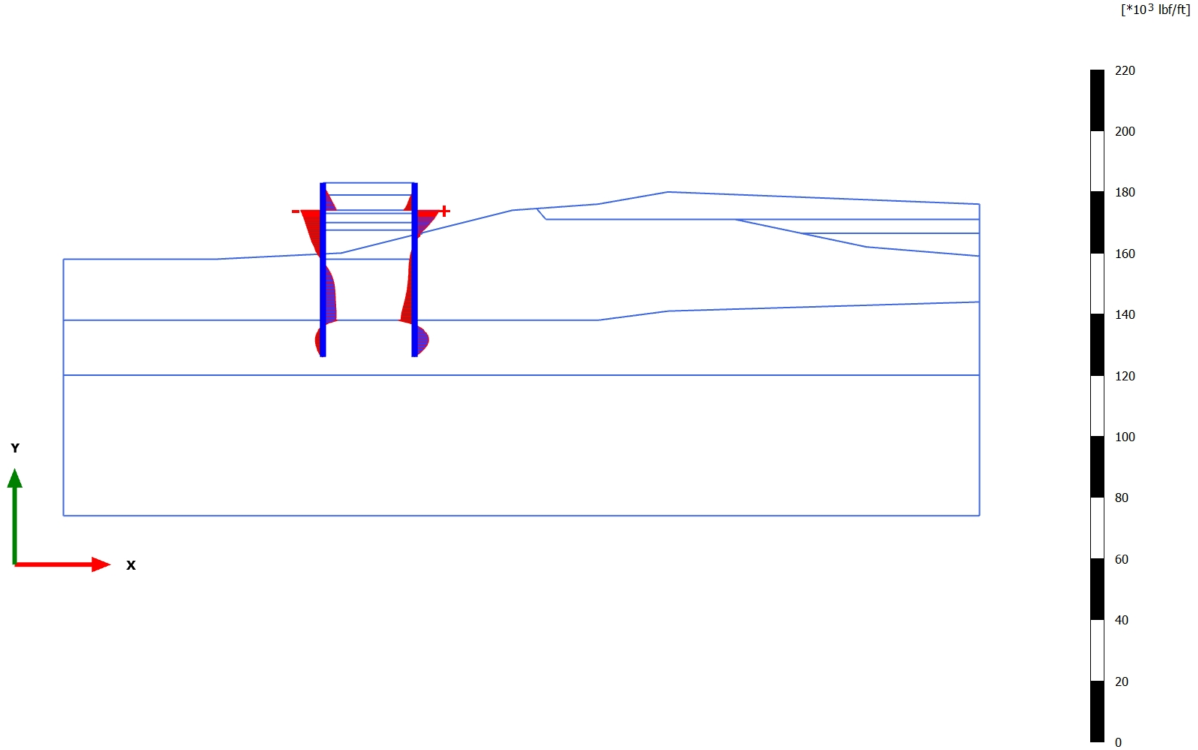


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 3584 lbf/ft (Element 11 at Node 1113)

Minimum value = -4535 lbf/ft (Element 38 at Node 6023)

3.1.2.1.3 Calculation results, Plate, Dewater-ss [Phase_3] (3/204), Shear forces Q

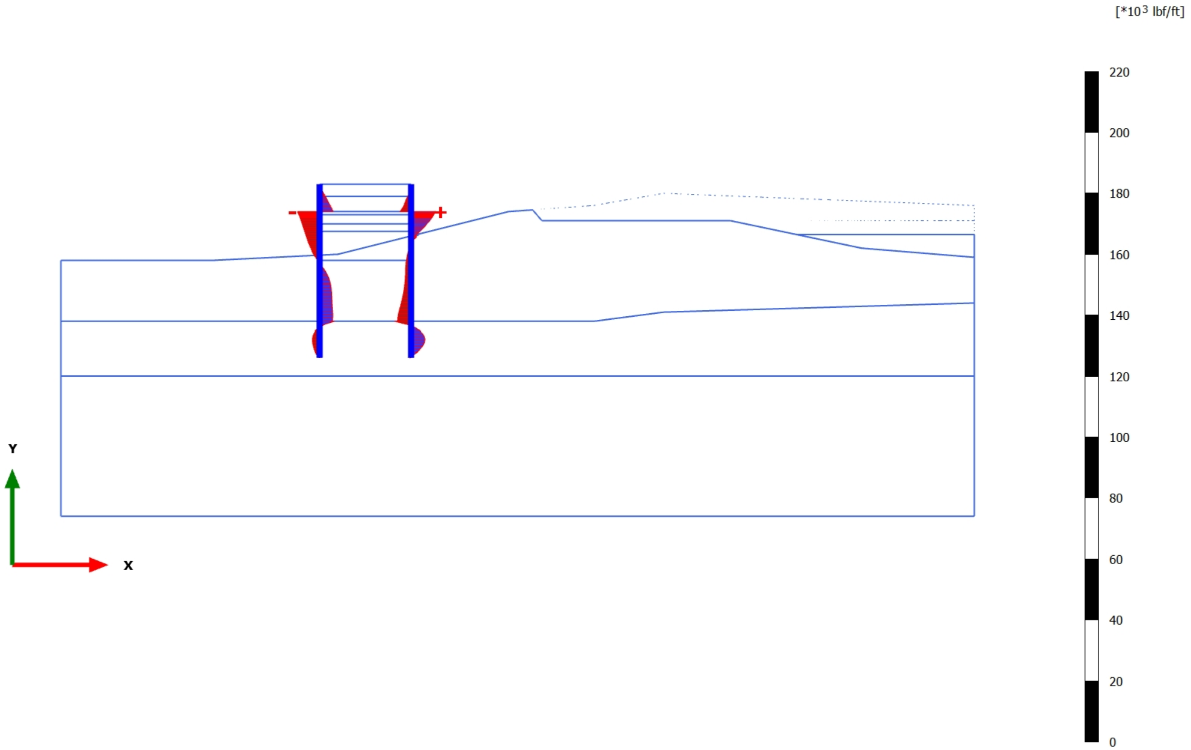


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8197 lbf/ft (Element 11 at Node 1113)

Minimum value = -7335 lbf/ft (Element 10 at Node 17)

3.1.2.1.4 Calculation results, Plate, Excavate 1 [Phase_16] (16/208), Shear forces Q

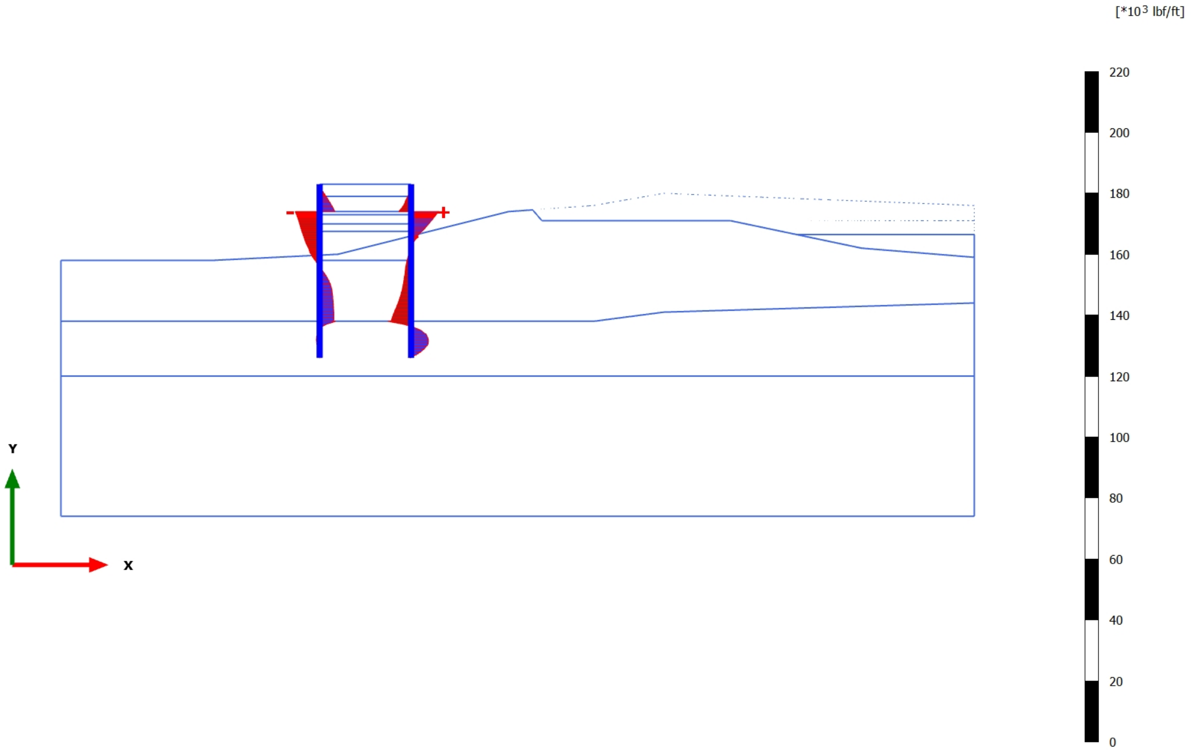


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 8141 lbf/ft (Element 11 at Node 1113)

Minimum value = -7315 lbf/ft (Element 10 at Node 17)

3.1.2.1.5 Calculation results, Plate, Dewater 2-ss [Phase_17] (17/219), Shear forces Q

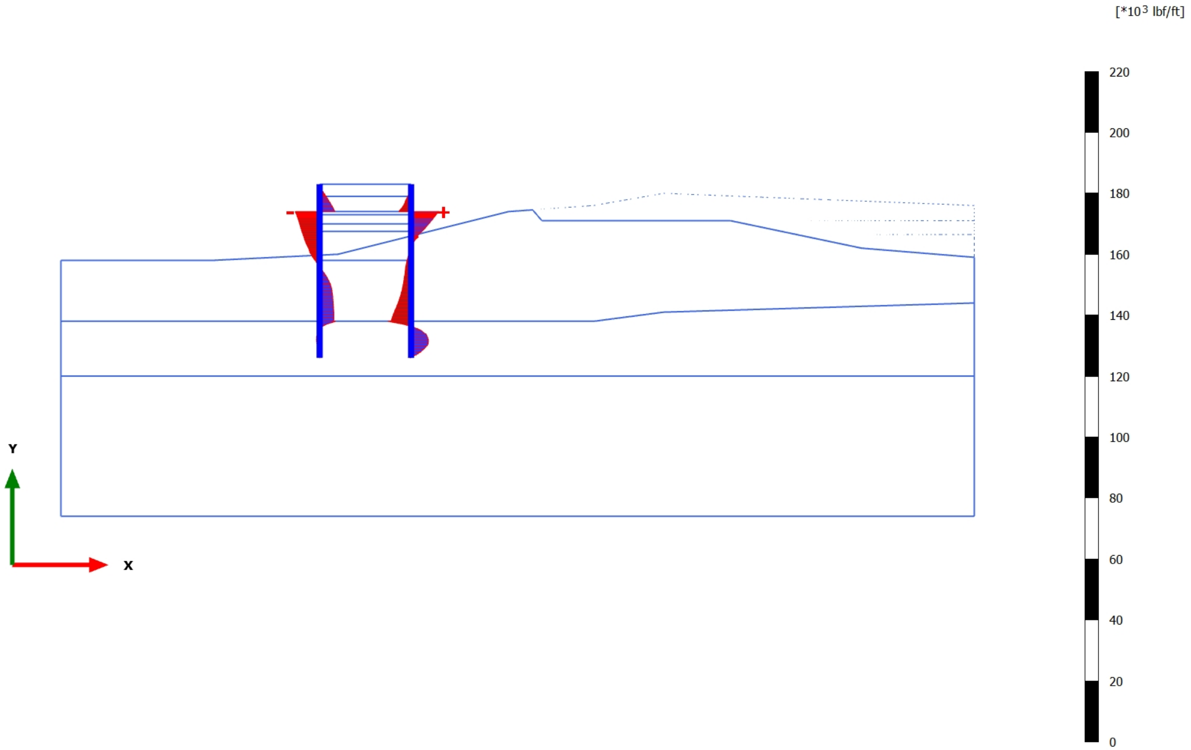


Shear forces Q (scaled up $1.00*10^{-3}$ times)

Maximum value = 9097 lbf/ft (Element 11 at Node 1113)

Minimum value = -8103 lbf/ft (Element 10 at Node 17)

3.1.2.1.6 Calculation results, Plate, Excavate 2 [Phase_19] (19/222), Shear forces Q

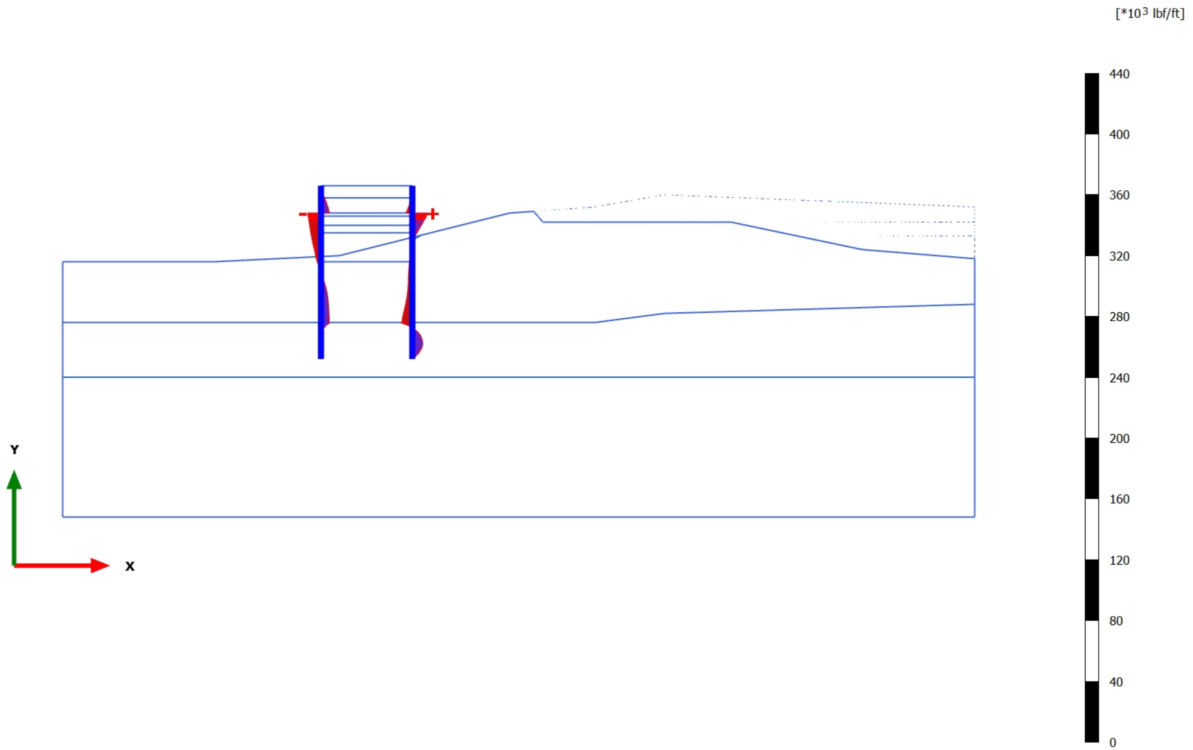


Shear forces Q (scaled up 1.00*10⁻³ times)

Maximum value = 9099 lbf/ft (Element 11 at Node 1113)

Minimum value = -8101 lbf/ft (Element 10 at Node 17)

3.1.2.1.7 Calculation results, Plate, Water rise 9 ft [Phase_20] (20/244), Shear forces Q

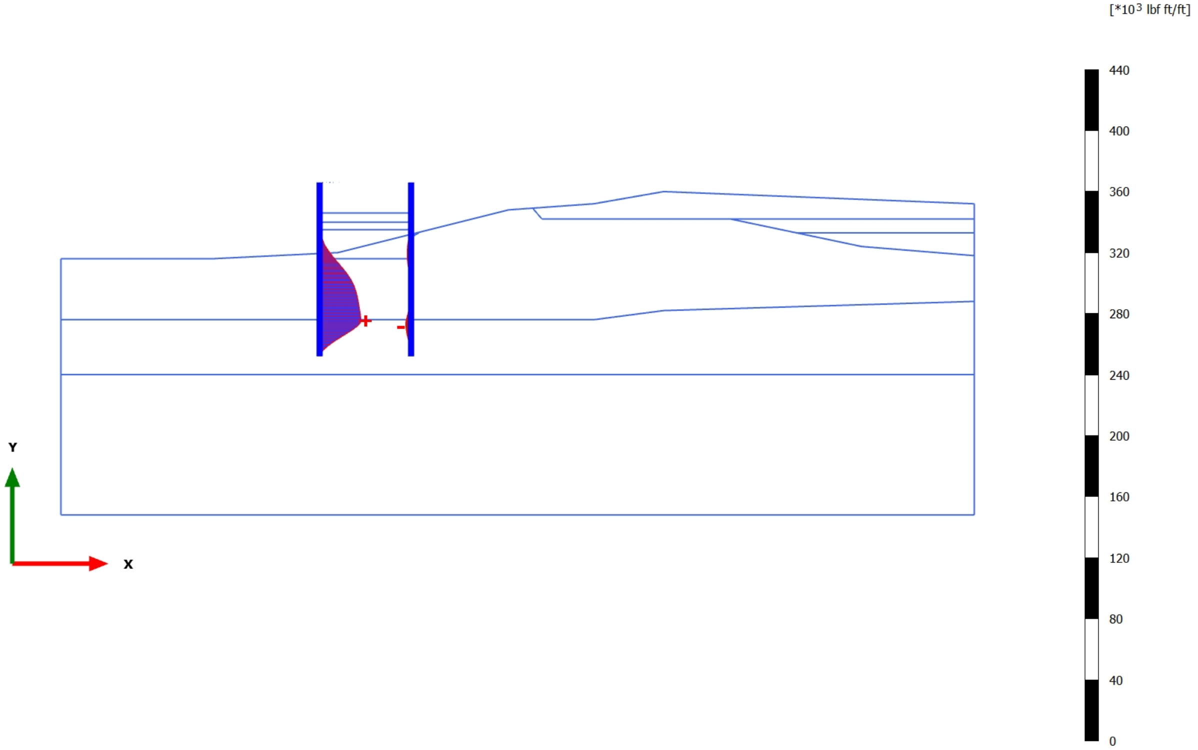


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 10.33*10^{3} lbf/ft (Element 11 at Node 1113)

Minimum value = -8895 lbf/ft (Element 10 at Node 17)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/155), Bending moments M

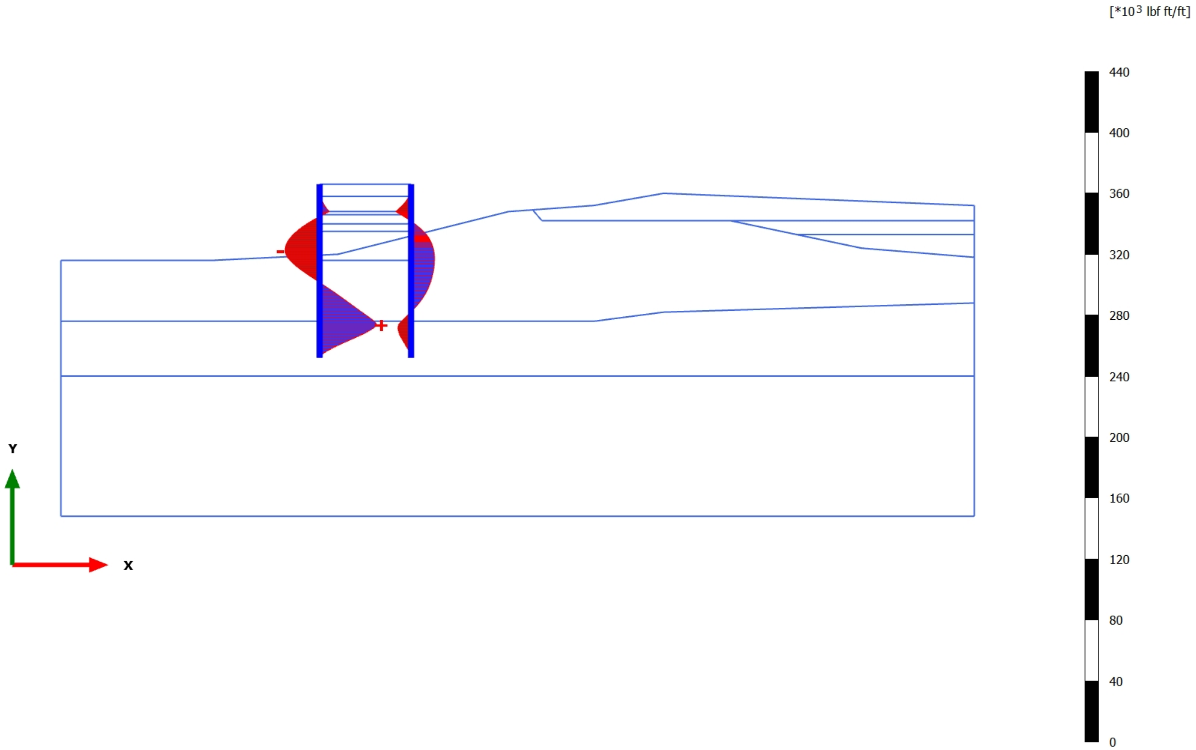


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 27.13*10^{3} lbf ft/ft (Element 32 at Node 5735)

Minimum value = -3516 lbf ft/ft (Element 40 at Node 6472)

3.1.2.2.2 Calculation results, Plate, Backfill 2 [Phase_6] (6/184), Bending moments M

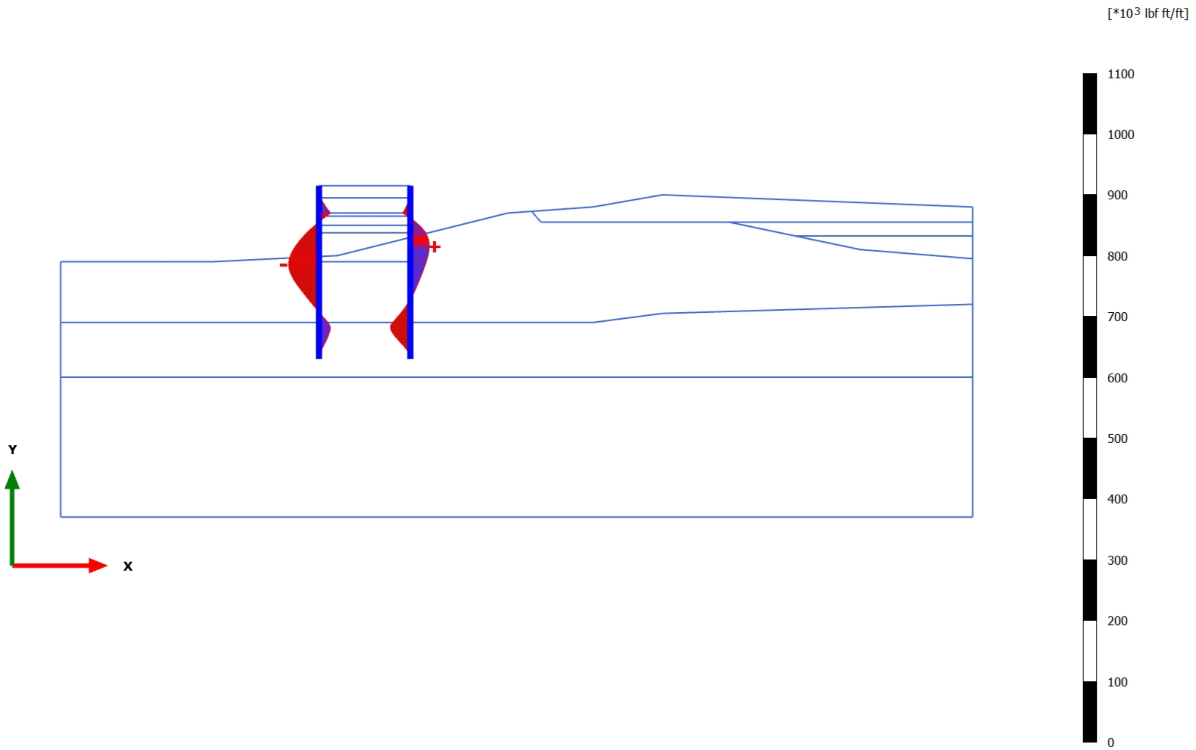


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 37.42*10^{3} lbf ft/ft (Element 37 at Node 5736)

Minimum value = -22.71*10^{3} lbf ft/ft (Element 22 at Node 1076)

3.1.2.2.3 Calculation results, Plate, Dewater-ss [Phase_3] (3/204), Bending moments M

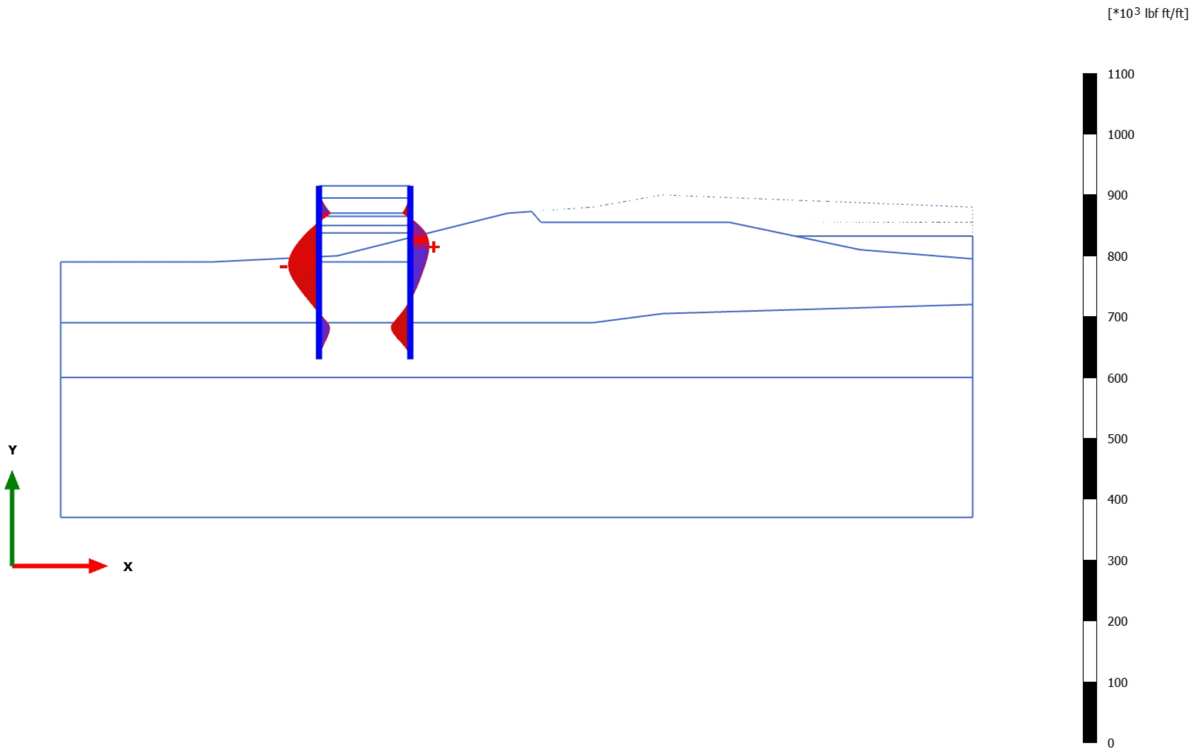


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 31.30*10^{3} lbf ft/ft (Element 24 at Node 5473)

Minimum value = -50.00*10^{3} lbf ft/ft (Element 27 at Node 2826)

3.1.2.2.4 Calculation results, Plate, Excavate 1 [Phase_16] (16/208), Bending moments M

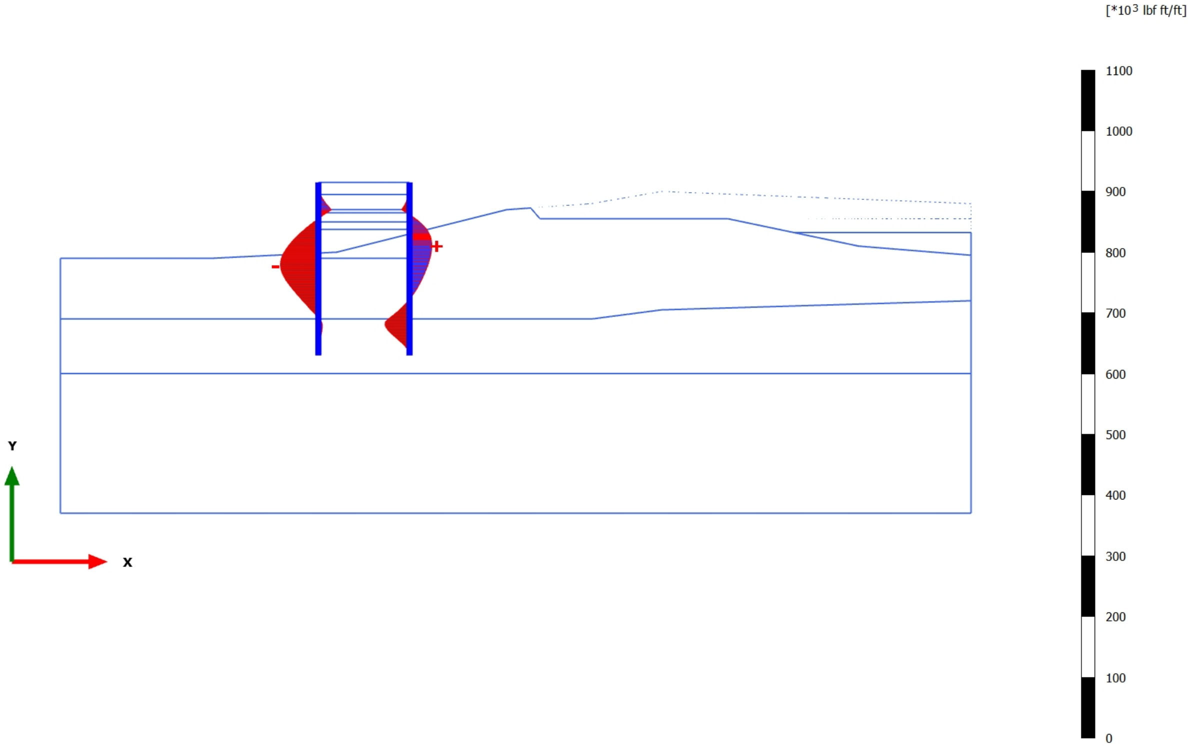


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $30.74*10^3$ lbf ft/ft (Element 24 at Node 5473)

Minimum value = $-50.29*10^3$ lbf ft/ft (Element 27 at Node 2825)

3.1.2.2.5 Calculation results, Plate, Dewater 2-ss [Phase_17] (17/219), Bending moments M

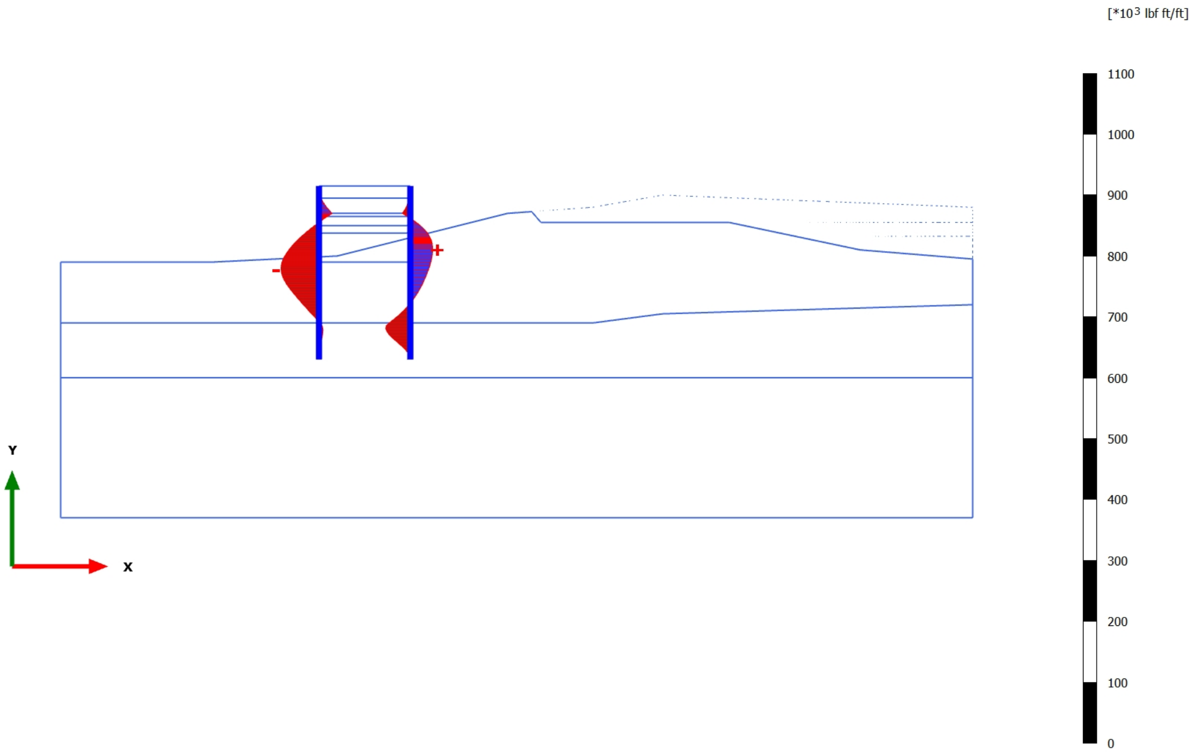


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 36.82*10^3 lbf ft/ft (Element 24 at Node 5489)

Minimum value = -62.53*10^3 lbf ft/ft (Element 27 at Node 3817)

3.1.2.2.6 Calculation results, Plate, Excavate 2 [Phase_19] (19/222), Bending moments M

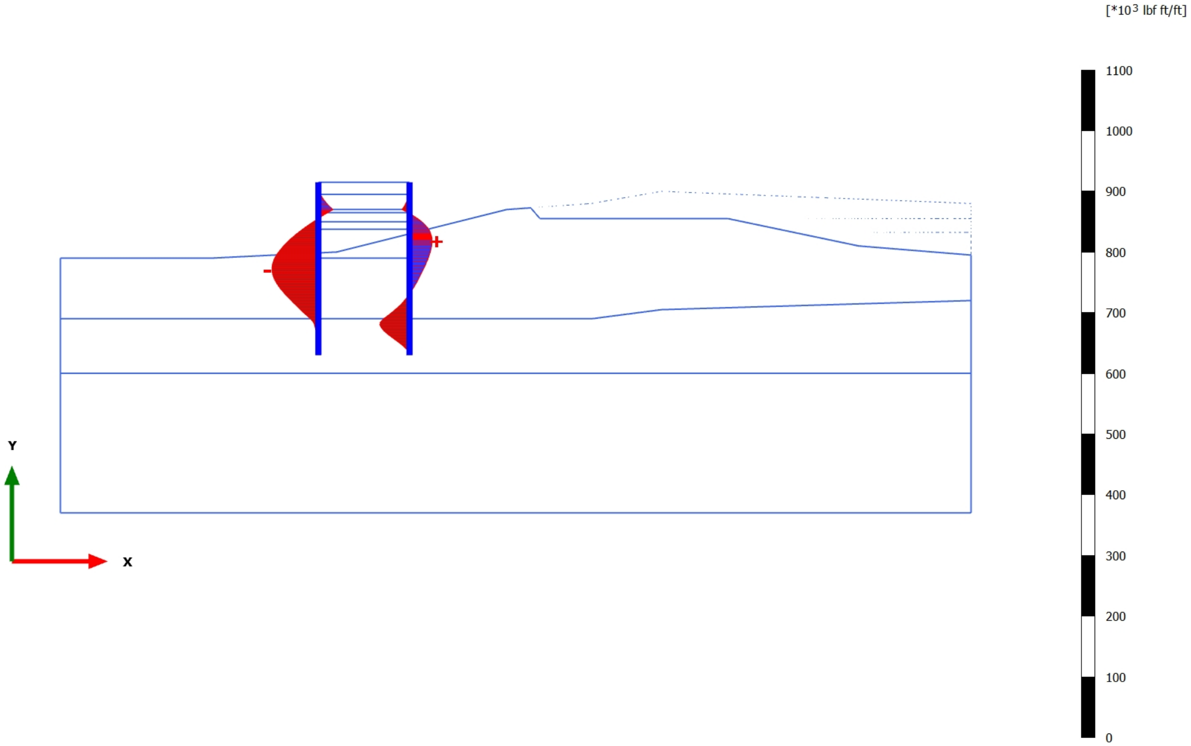


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = 36.88*10^3 lbf ft/ft (Element 24 at Node 5489)

Minimum value = -62.54*10^3 lbf ft/ft (Element 27 at Node 3817)

3.1.2.2.7 Calculation results, Plate, Water rise 9 ft [Phase_20] (20/244), Bending moments M



Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 37.28*10^3 lbf ft/ft (Element 24 at Node 5472)

Minimum value = -76.52*10^3 lbf ft/ft (Element 28 at Node 3819)

3.2.1.1.2 Calculation results, Node-to-node anchor, Backfill 2 [Phase_6] (6/184), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	36.061	0.000	36.061
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	36.061	0.000	36.061

3.2.1.1.3 Calculation results, Node-to-node anchor, Dewater-ss [Phase_3] (3/204), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	70.754	0.000	70.754
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	70.754	0.000	70.754

3.2.1.1.4 Calculation results, Node-to-node anchor, Excavate 1 [Phase_16] (16/208), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	70.656	0.000	70.754
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	70.656	0.000	70.754

3.2.1.1.5 Calculation results, Node-to-node anchor, Dewater 2-ss [Phase_17] (17/219), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	78.972	0.000	78.972
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	78.972	0.000	78.972

3.2.1.1.6 Calculation results, Node-to-node anchor, Excavate 2 [Phase_19] (19/222), Table of node-to-node anchors

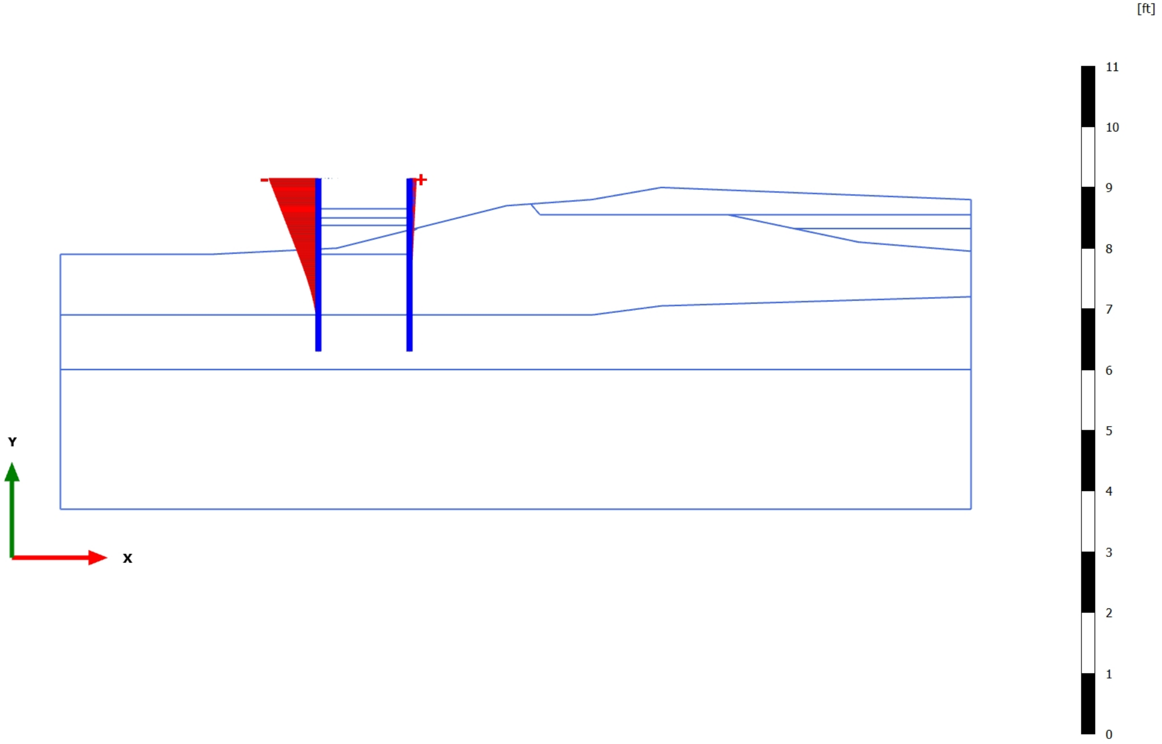
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	78.969	0.000	78.974
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	78.969	0.000	78.974

3.2.1.1.7 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_20] (20/244), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	87.008	0.000	87.008
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	87.008	0.000	87.008

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/356), Total displacements u_x

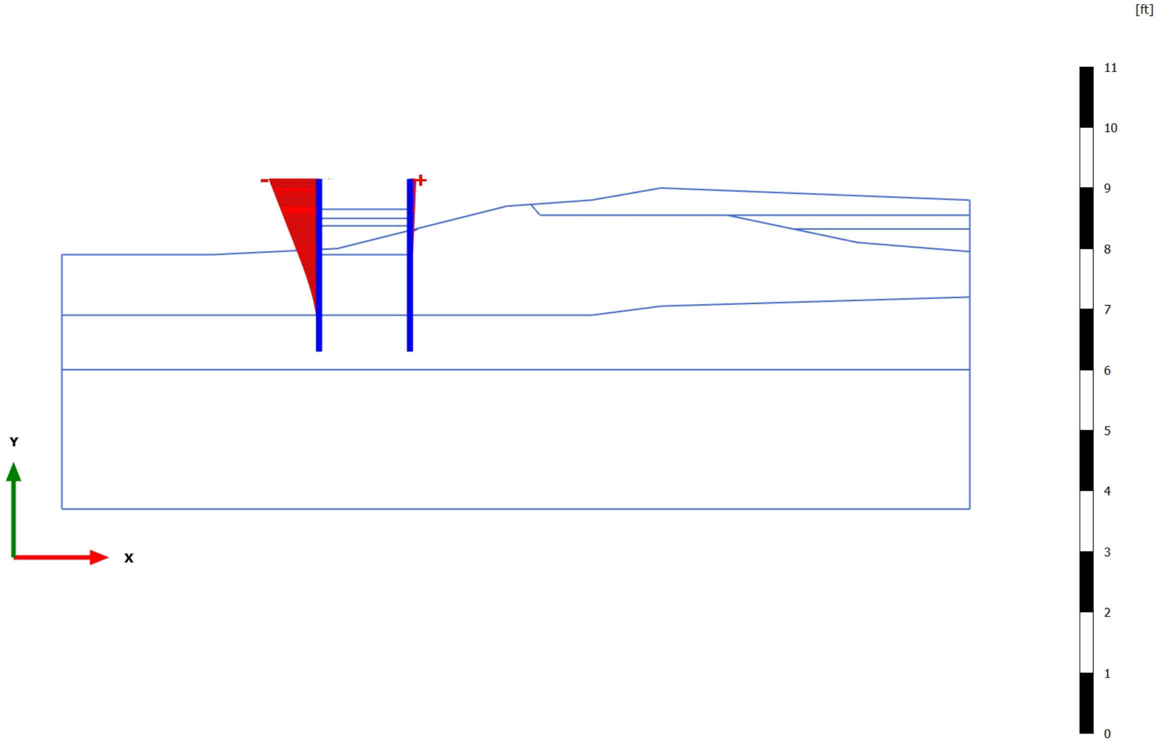


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.1141 ft (Element 2 at Node 1029)

Minimum value = -0.8157 ft (Element 1 at Node 4)

3.1.1.1.1.2 Calculation results, Plate, Consolidate [Phase_4] (7/448), Total displacements u_x

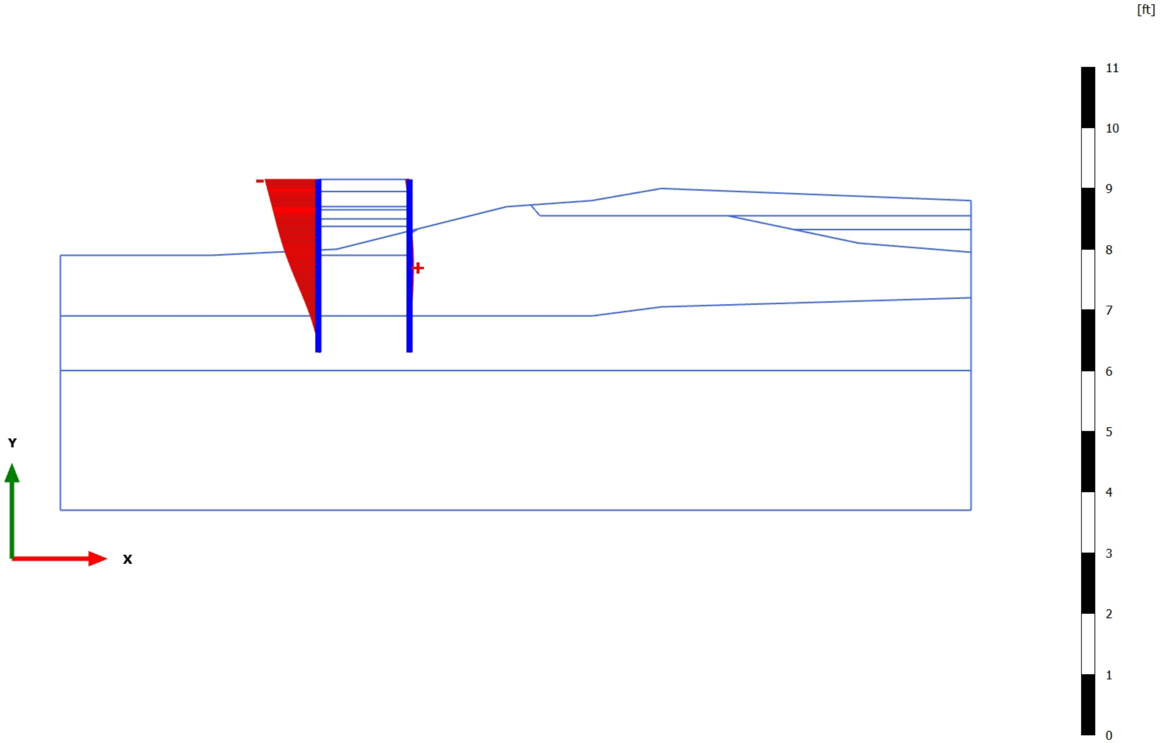


Total displacements u_x (scaled up 20.0 times) (Time 10.00 day)

Maximum value = 0.09945 ft (Element 2 at Node 1029)

Minimum value = -0.8279 ft (Element 1 at Node 4)

3.1.1.1.1.3 Calculation results, Plate, Backfill 2 [Phase_6] (6/475), Total displacements u_x

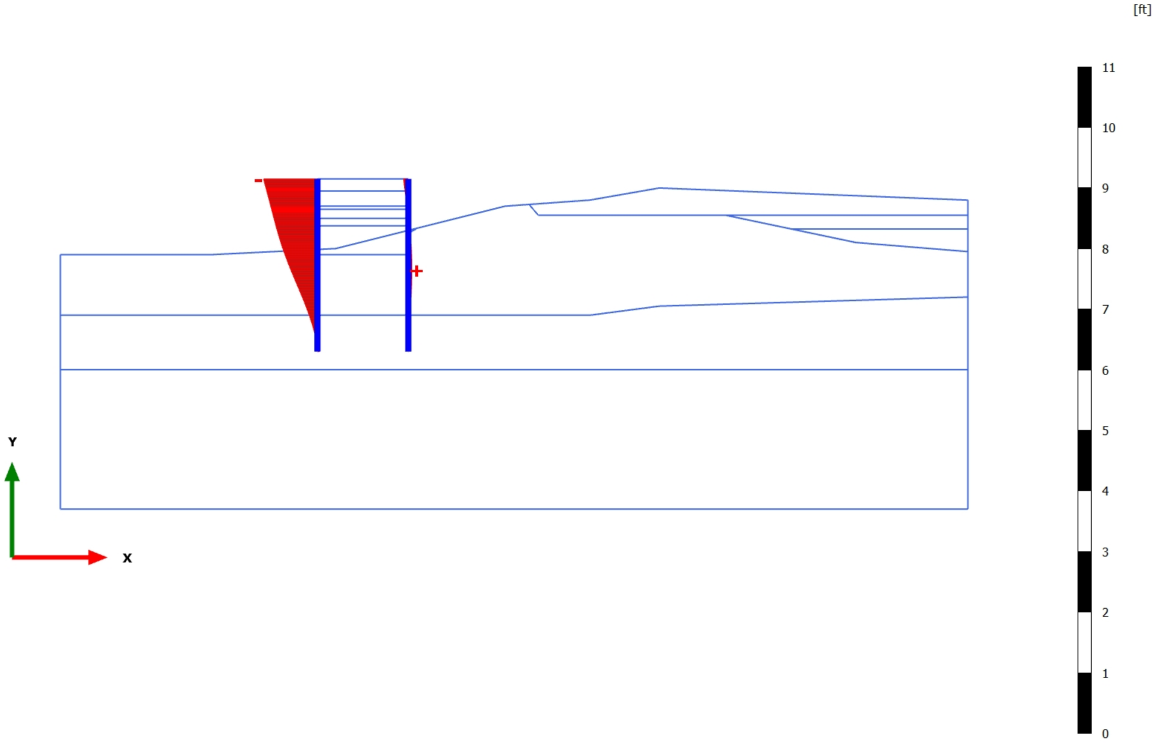


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.06709 ft (Element 33 at Node 5616)

Minimum value = -0.8799 ft (Element 1 at Node 4)

3.1.1.1.1.4 Calculation results, Plate, Consolidate [Phase_7] (8/492), Total displacements u_x

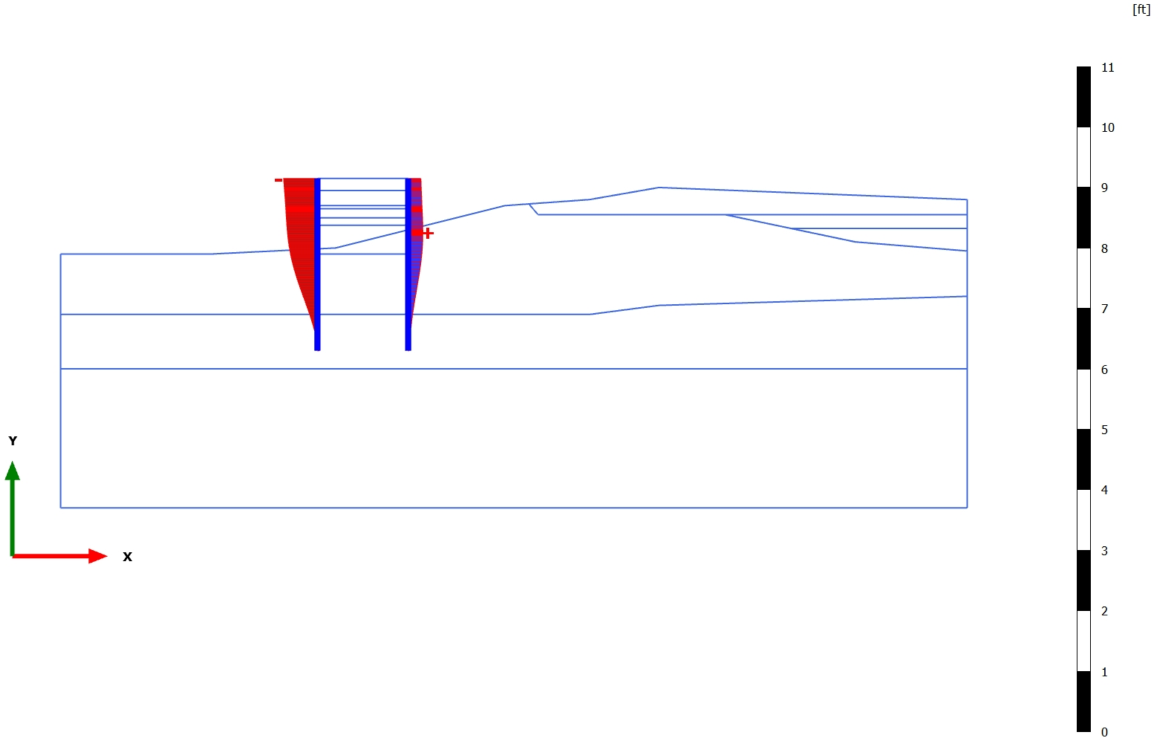


Total displacements u_x (scaled up 20.0 times) (Time 16.00 day)

Maximum value = 0.06161 ft (Element 33 at Node 5663)

Minimum value = -0.8916 ft (Element 1 at Node 4)

3.1.1.1.1.5 Calculation results, Plate, Consolidation [Phase_15] (15/518), Total displacements u_x

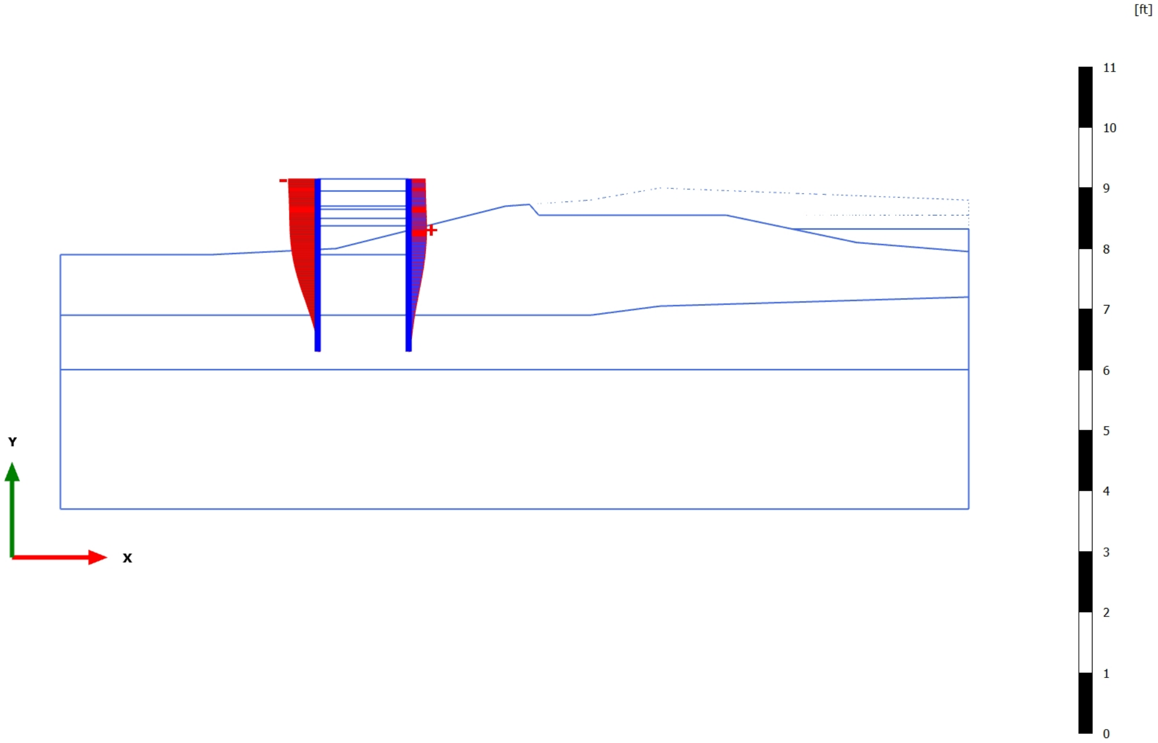


Total displacements u_x (scaled up 20.0 times) (Time 20.00 day)

Maximum value = 0.2439 ft (Element 19 at Node 5276)

Minimum value = -0.5610 ft (Element 1 at Node 4)

3.1.1.1.1.6 Calculation results, Plate, Excavate 1 [Phase_16] (16/526), Total displacements u_x

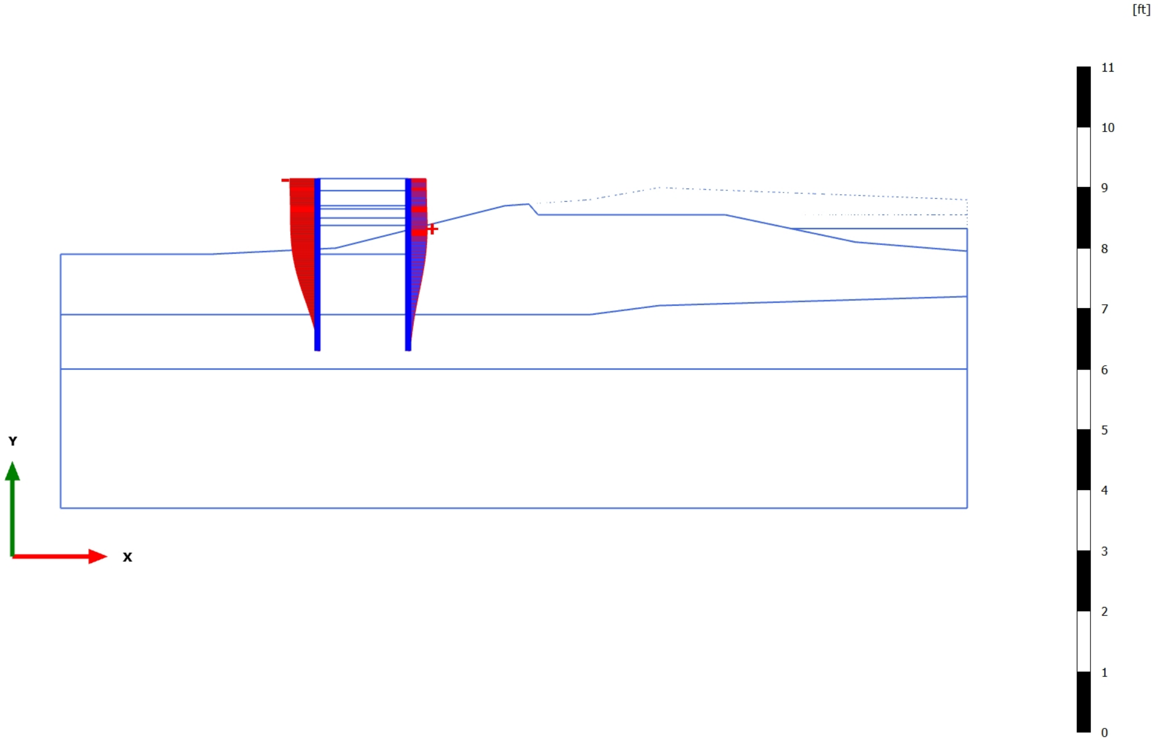


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.2970 ft (Element 18 at Node 2496)

Minimum value = -0.4862 ft (Element 1 at Node 4)

3.1.1.1.1.7 Calculation results, Plate, Dewater 2-ss [Phase_17] (17/530), Total displacements u_x

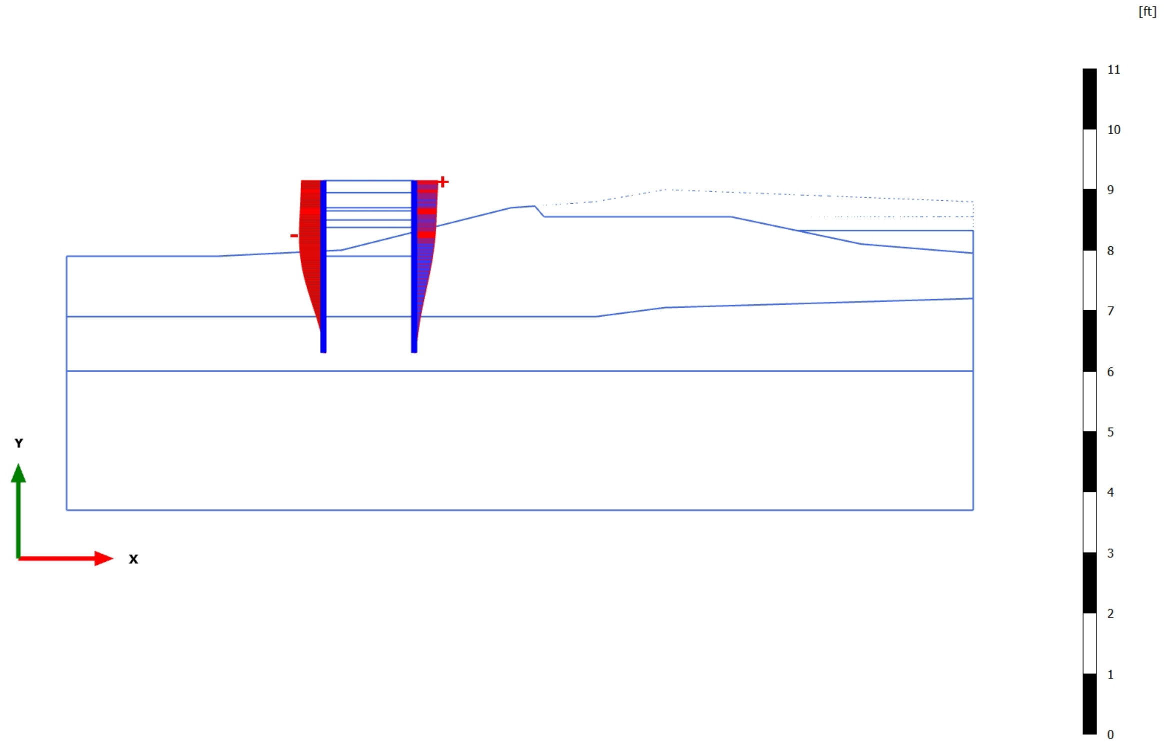


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.3157 ft (Element 18 at Node 2495)

Minimum value = -0.4598 ft (Element 1 at Node 4)

3.1.1.1.1.8 Calculation results, Plate, Consolidation [Phase_18] (18/549), Total displacements u_x

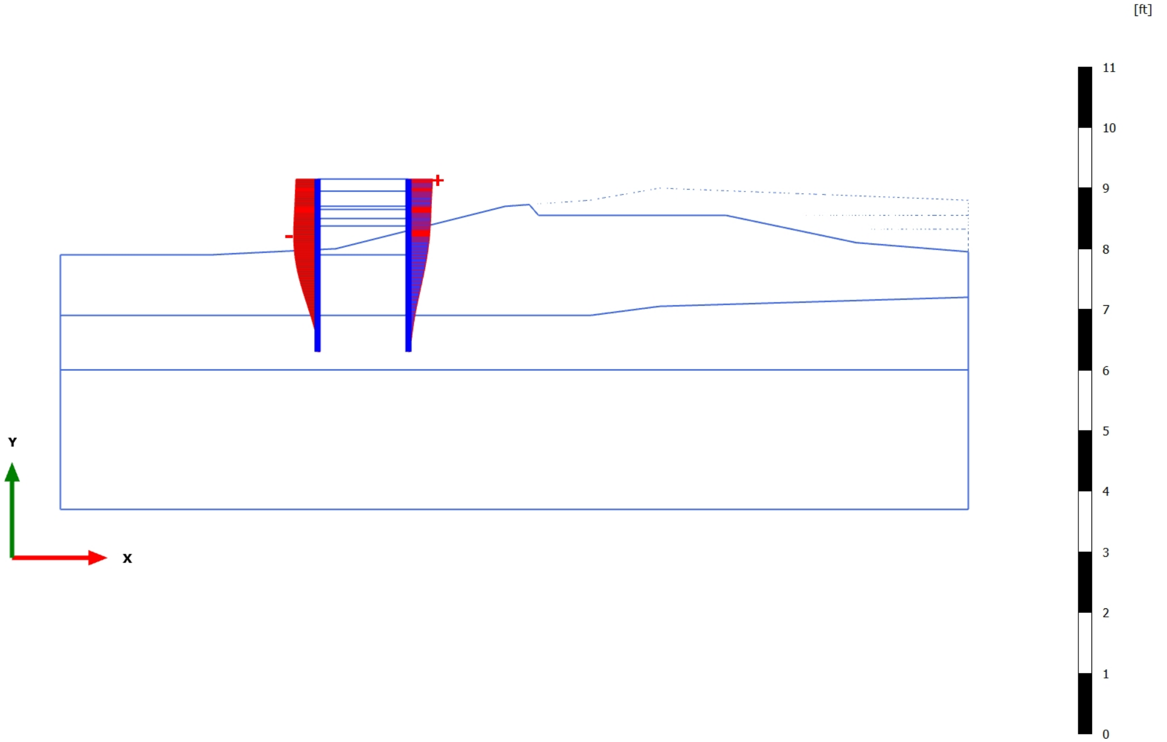


Total displacements u_x (scaled up 20.0 times) (Time 37.00 day)

Maximum value = 0.3951 ft (Element 2 at Node 1029)

Minimum value = -0.3995 ft (Element 20 at Node 320)

3.1.1.1.1.9 Calculation results, Plate, Excavate 2 [Phase_19] (19/551), Total displacements u_x

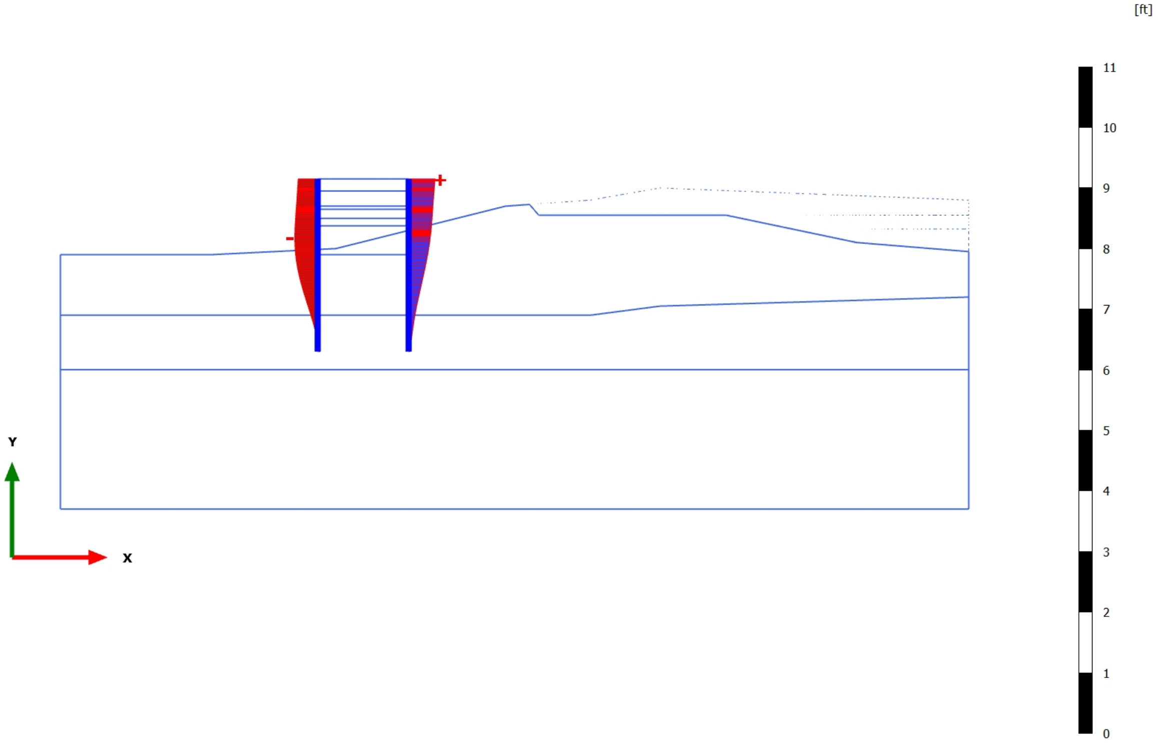


Total displacements u_x (scaled up 20.0 times)

Maximum value = 0.3997 ft (Element 2 at Node 1029)

Minimum value = -0.3963 ft (Element 20 at Node 649)

3.1.1.1.1.10 Calculation results, Plate, Consolidate [Phase_9] (10/562), Total displacements u_x

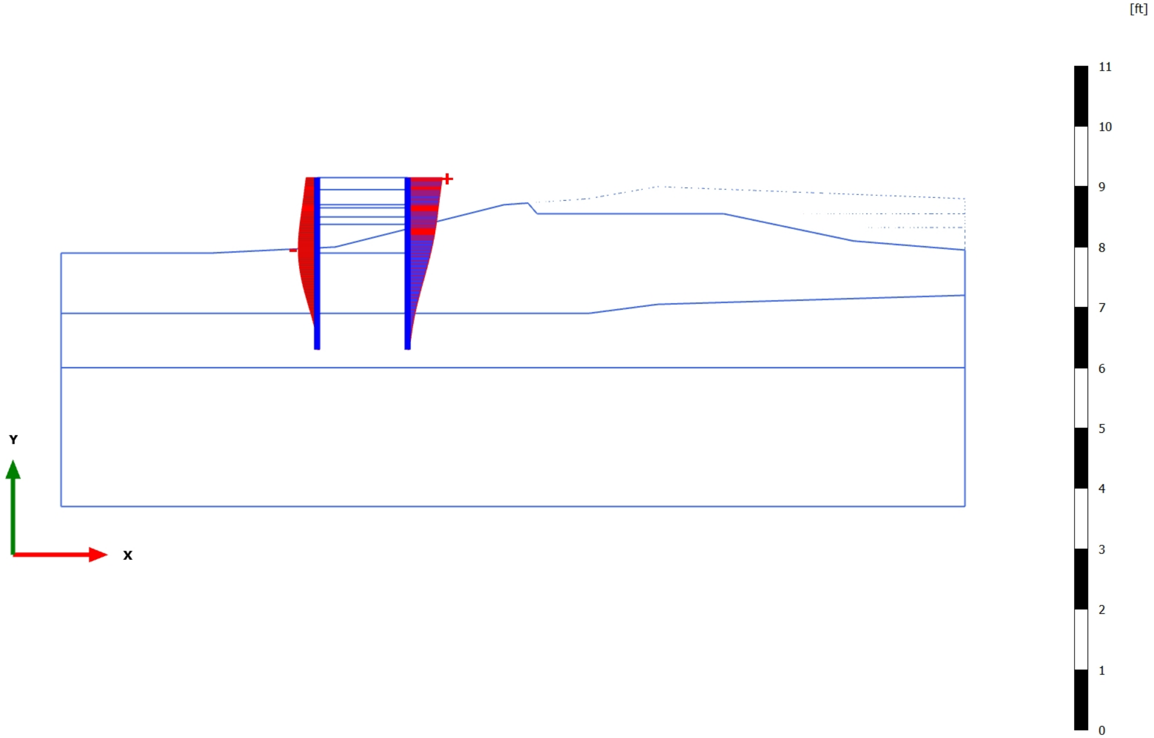


Total displacements u_x (scaled up 20.0 times) (Time 51.00 day)

Maximum value = 0.4377 ft (Element 2 at Node 1029)

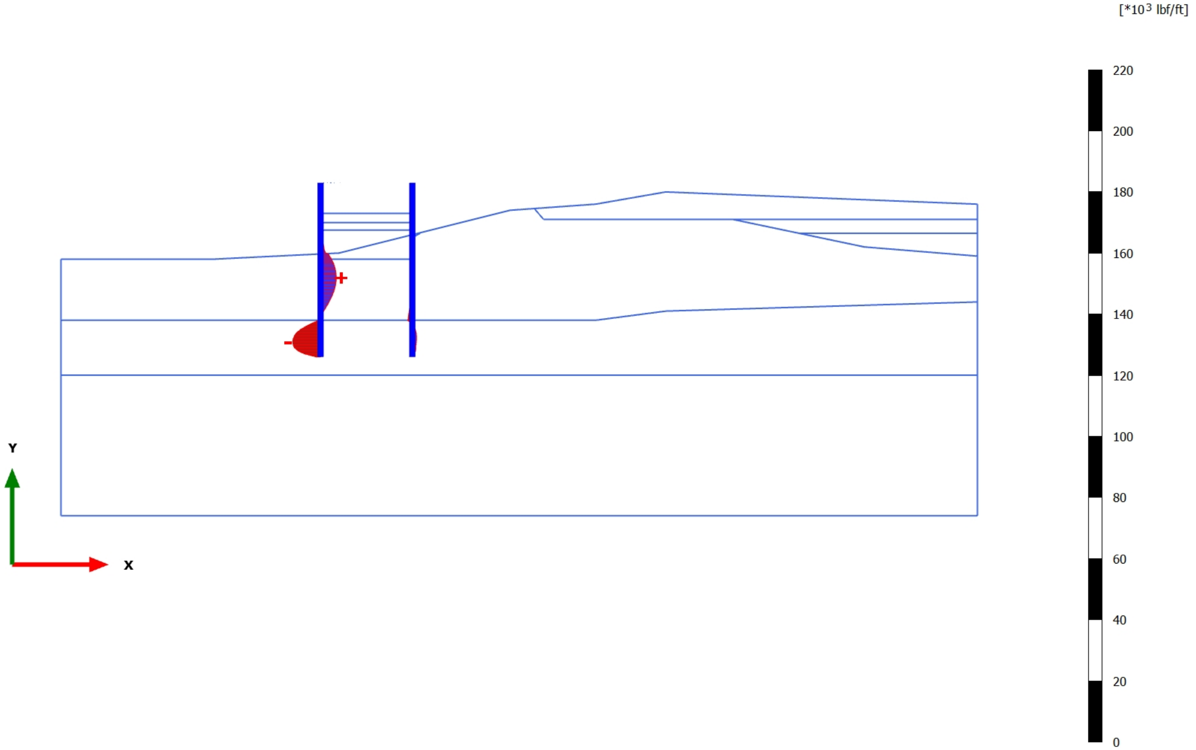
Minimum value = -0.3797 ft (Element 21 at Node 652)

3.1.1.1.1.11 Calculation results, Plate, Water rise 9 ft [Phase_20] (20/573), Total displacements u_x



Total displacements u_x (scaled up 20.0 times)
Maximum value = 0.5760 ft (Element 2 at Node 1029)
Minimum value = -0.3142 ft (Element 26 at Node 2802)

3.1.2.1.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/356), Shear forces Q

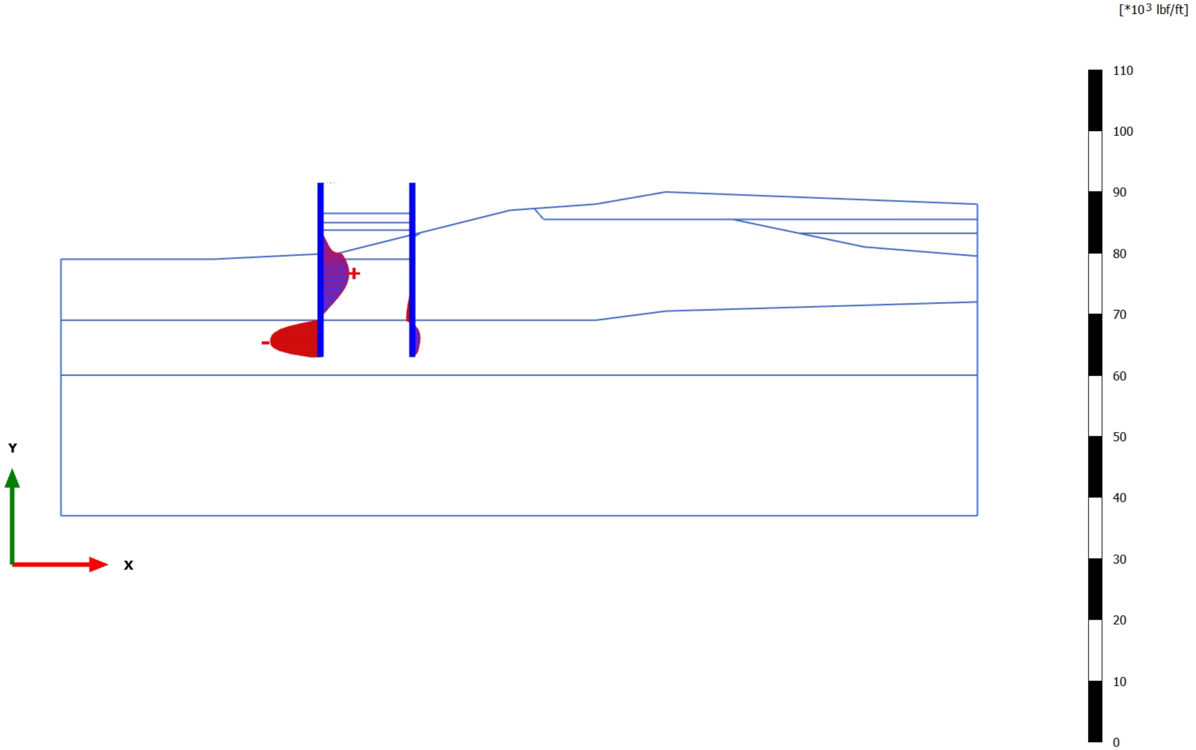


Shear forces Q (scaled up 1.00*10^{-3} times)

Maximum value = 5127 lbf/ft (Element 29 at Node 4254)

Minimum value = -9157 lbf/ft (Element 38 at Node 6024)

3.1.2.1.2 Calculation results, Plate, Consolidate [Phase_4] (7/448), Shear forces Q

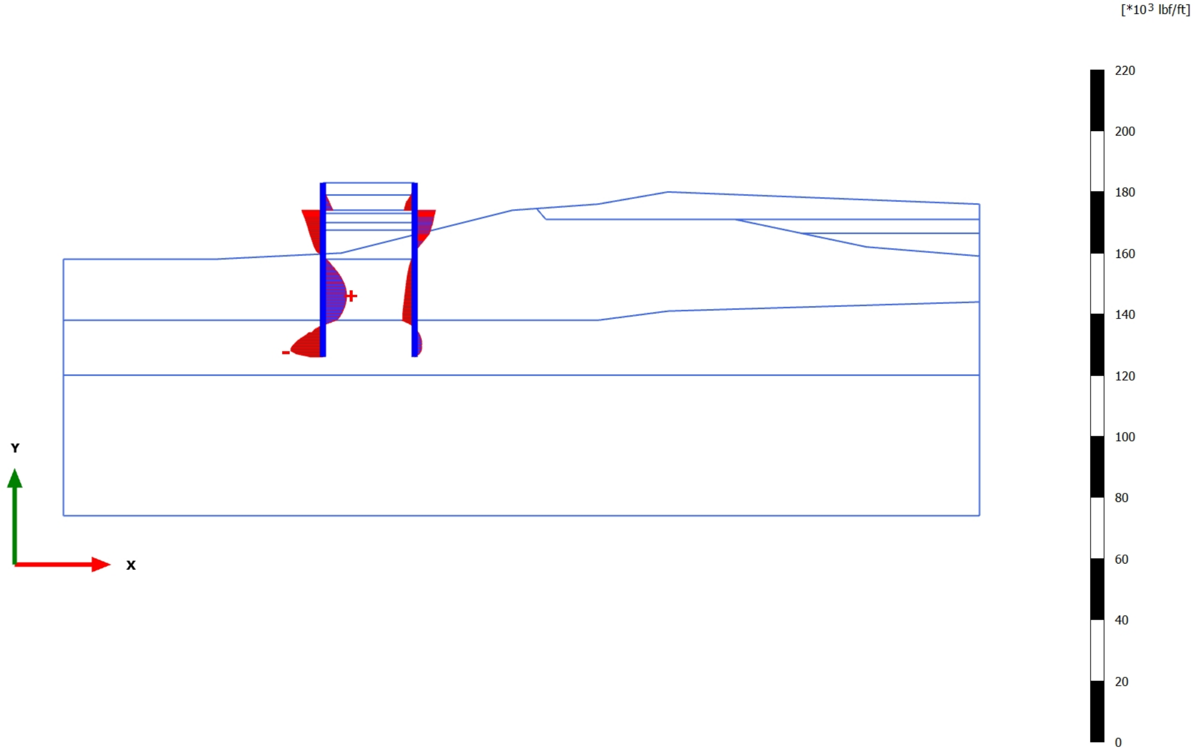


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 10.00 day)

Maximum value = 4629 lbf/ft (Element 28 at Node 3818)

Minimum value = -8214 lbf/ft (Element 38 at Node 6024)

3.1.2.1.3 Calculation results, Plate, Backfill 2 [Phase_6] (6/475), Shear forces Q

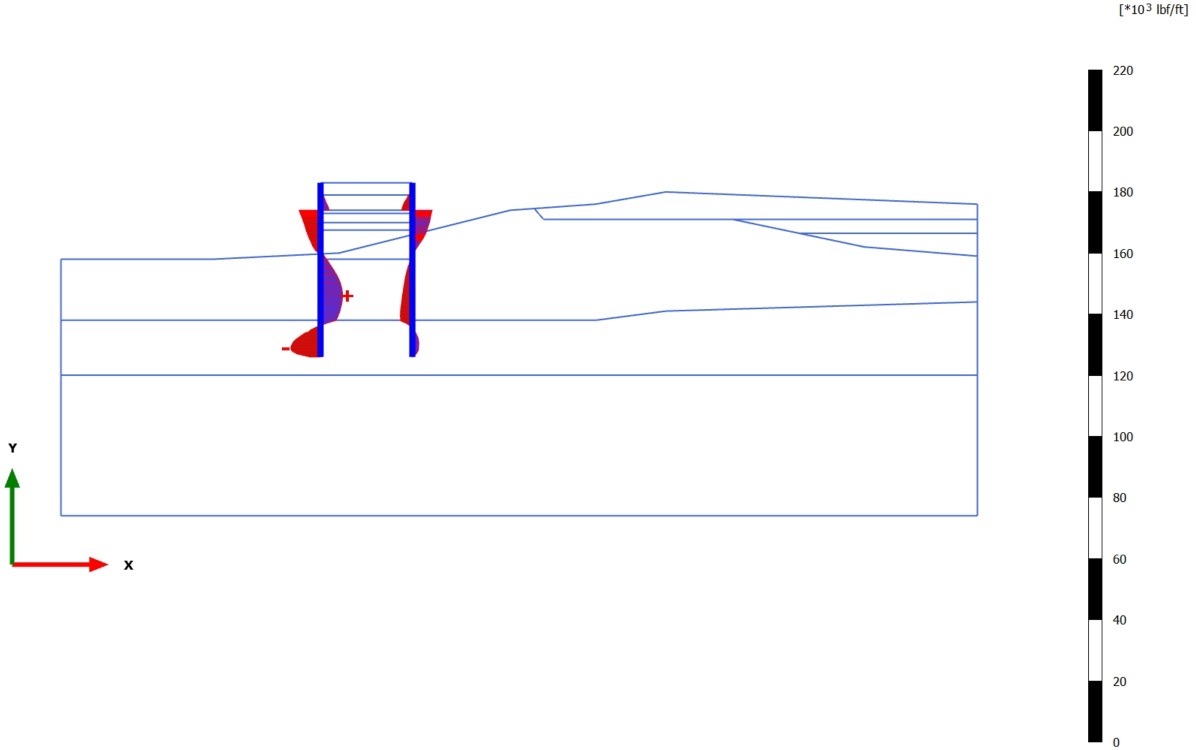


Shear forces Q (scaled up 1.00*10^{-3} times)

Maximum value = 7725 lbf/ft (Element 31 at Node 5209)

Minimum value = -10.53*10^3 lbf/ft (Element 39 at Node 6235)

3.1.2.1.4 Calculation results, Plate, Consolidate [Phase_7] (8/492), Shear forces Q

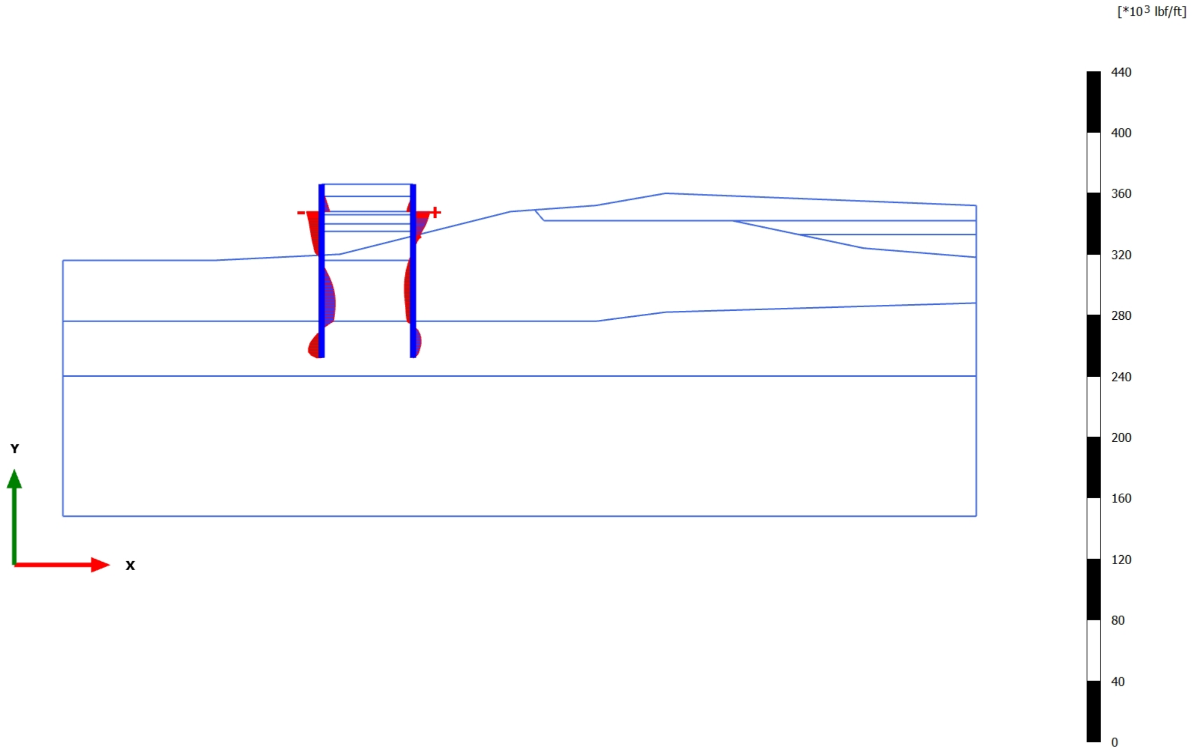


Shear forces Q (scaled up 1.00*10^{-3} times) (Time 16.00 day)

Maximum value = 7155 lbf/ft (Element 31 at Node 5209)

Minimum value = -9766 lbf/ft (Element 39 at Node 6234)

3.1.2.1.5 Calculation results, Plate, Consolidation [Phase_15] (15/518), Shear forces Q

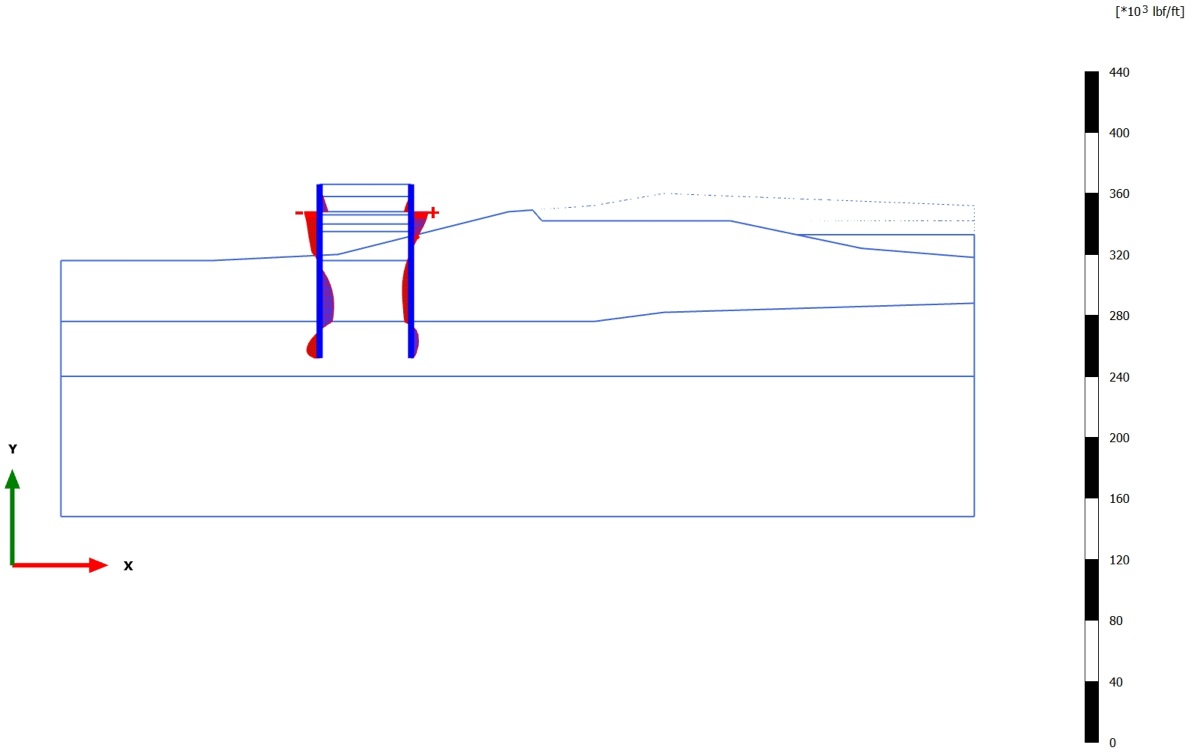


Shear forces Q (scaled up $0.500*10^{-3}$ times) (Time 20.00 day)

Maximum value = $11.14*10^{3}$ lbf/ft (Element 11 at Node 1113)

Minimum value = $-10.08*10^{3}$ lbf/ft (Element 10 at Node 17)

3.1.2.1.6 Calculation results, Plate, Excavate 1 [Phase_16] (16/526), Shear forces Q

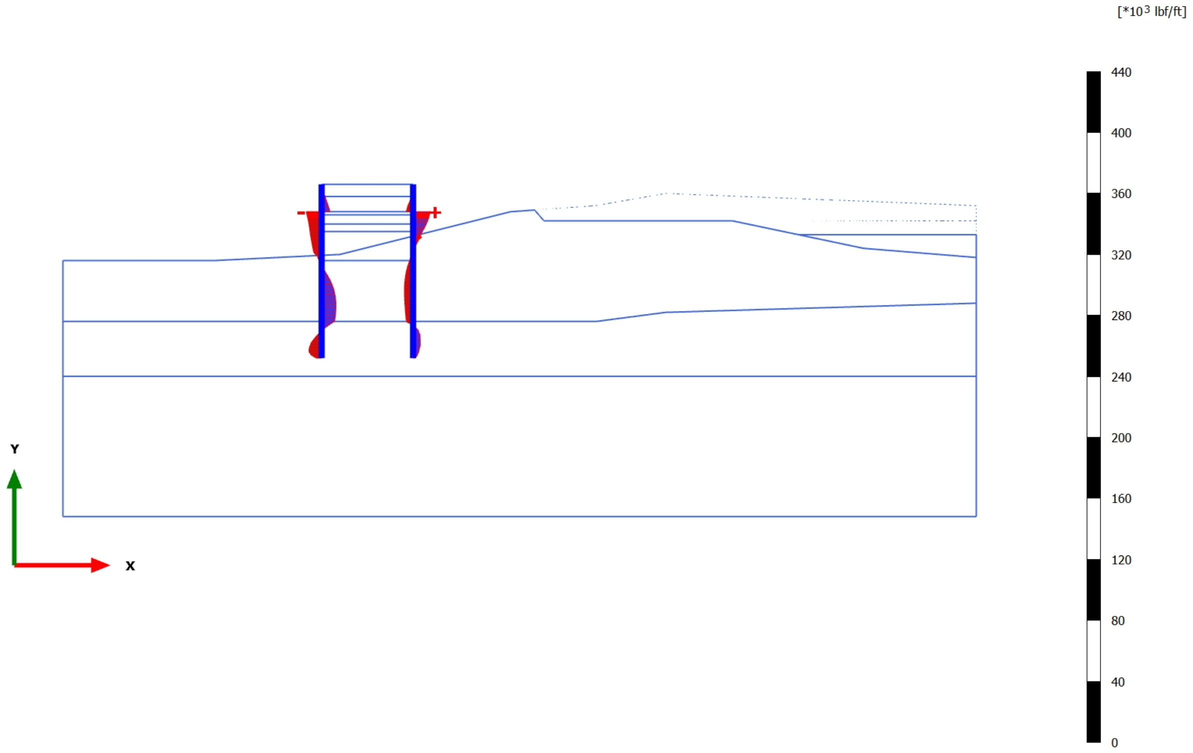


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.31*10^3$ lbf/ft (Element 11 at Node 1113)

Minimum value = $-10.23*10^3$ lbf/ft (Element 10 at Node 17)

3.1.2.1.7 Calculation results, Plate, Dewater 2-ss [Phase_17] (17/530), Shear forces Q

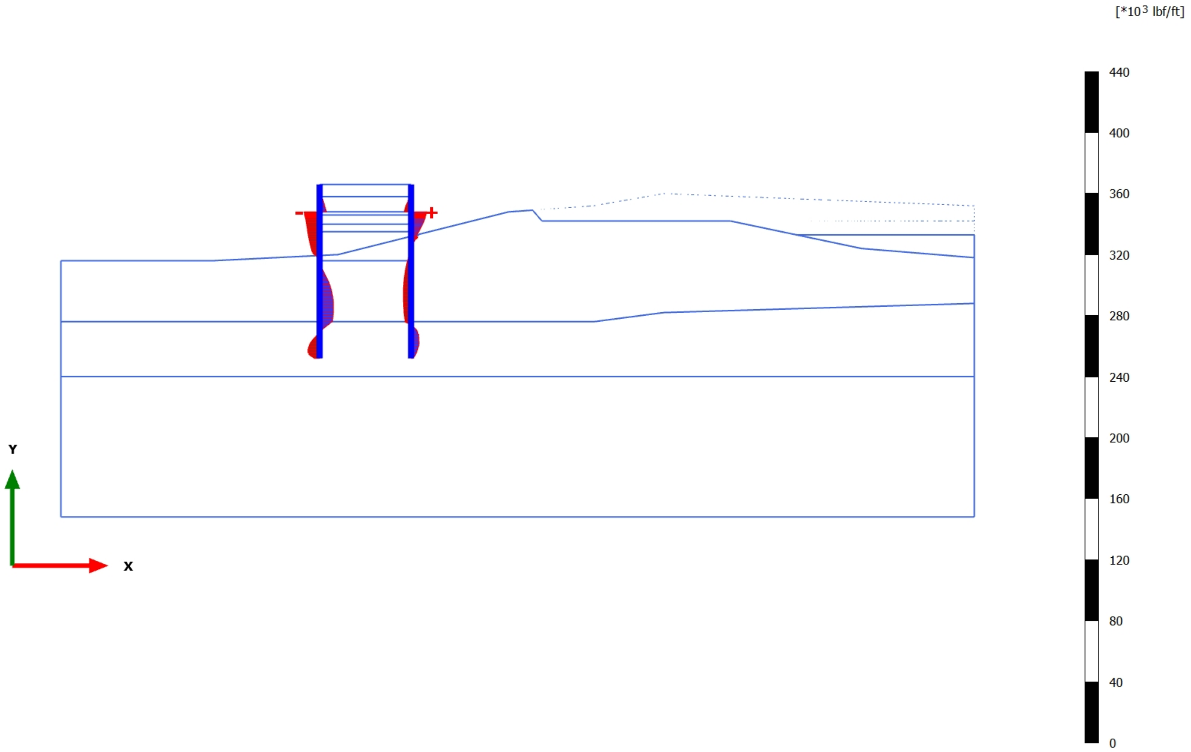


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $11.36*10^3$ lbf/ft (Element 11 at Node 1113)

Minimum value = $-10.28*10^3$ lbf/ft (Element 10 at Node 17)

3.1.2.1.8 Calculation results, Plate, Consolidation [Phase_18] (18/549), Shear forces Q

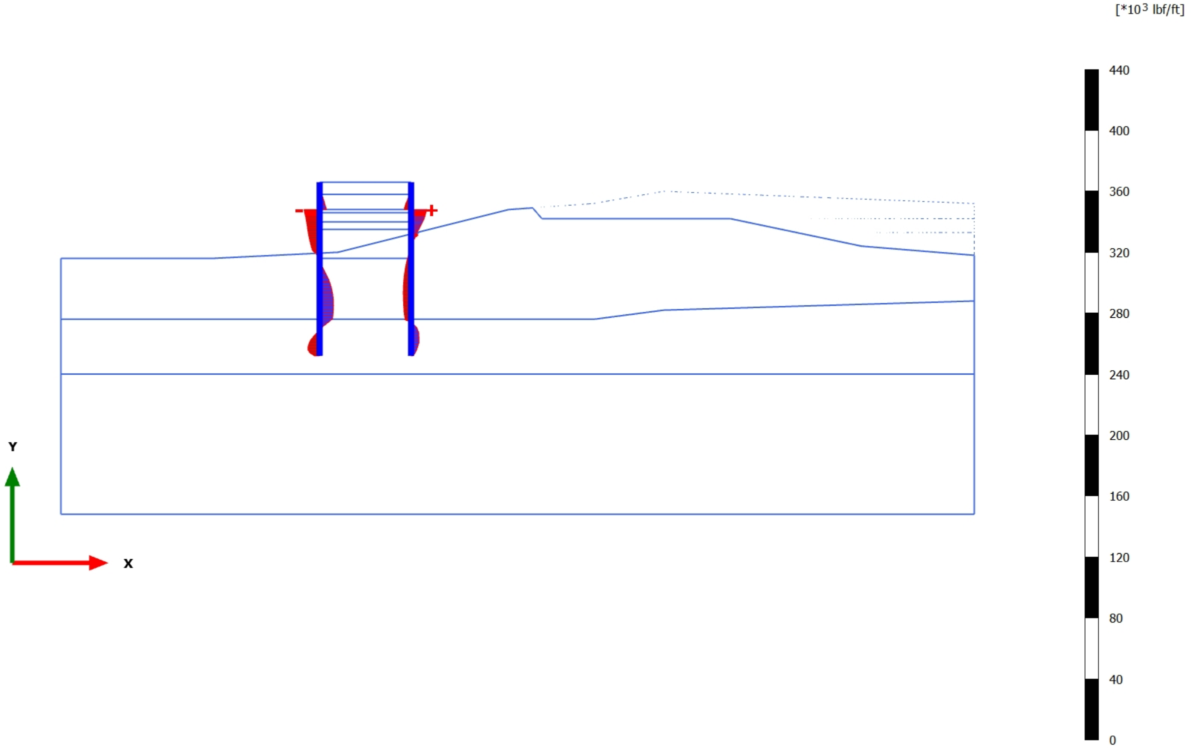


Shear forces Q (scaled up $0.500*10^{-3}$ times) (Time 37.00 day)

Maximum value = $10.35*10^3$ lbf/ft (Element 11 at Node 1113)

Minimum value = $-10.44*10^3$ lbf/ft (Element 10 at Node 17)

3.1.2.1.9 Calculation results, Plate, Excavate 2 [Phase_19] (19/551), Shear forces Q

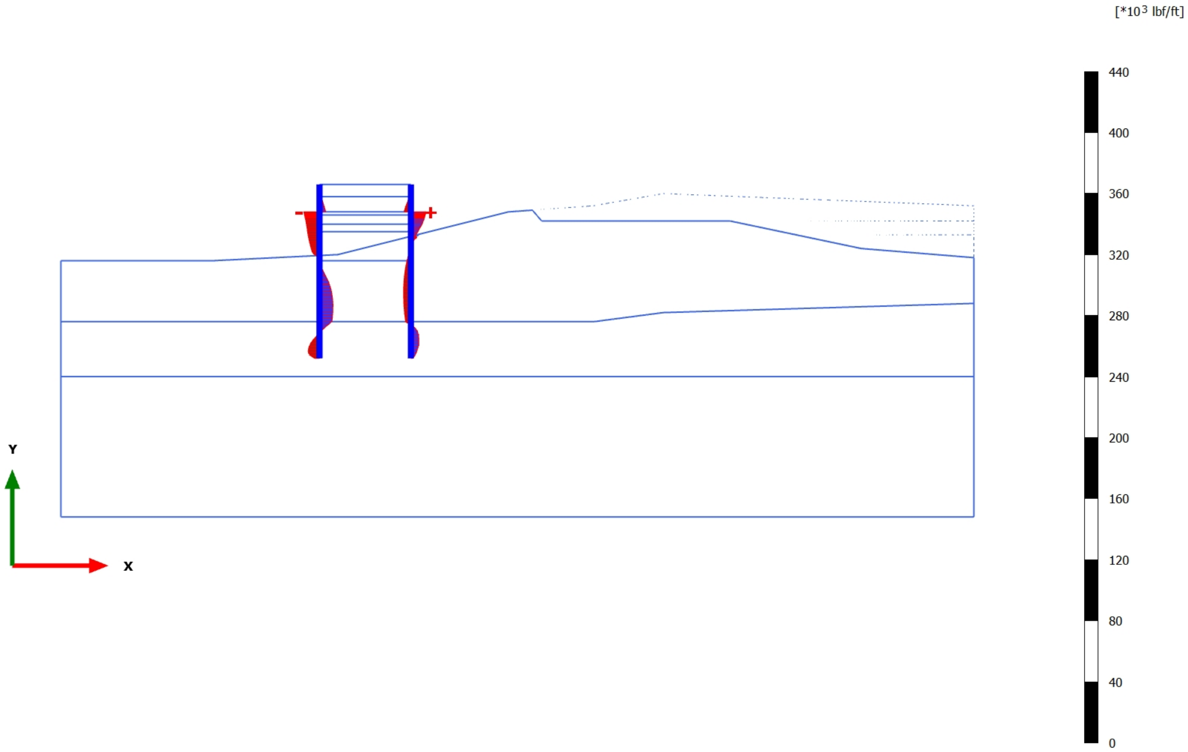


Shear forces Q (scaled up $0.500*10^{-3}$ times)

Maximum value = $10.36*10^3$ lbf/ft (Element 11 at Node 1113)

Minimum value = $-10.44*10^3$ lbf/ft (Element 10 at Node 17)

3.1.2.1.10 Calculation results, Plate, Consolidate [Phase_9] (10/562), Shear forces Q

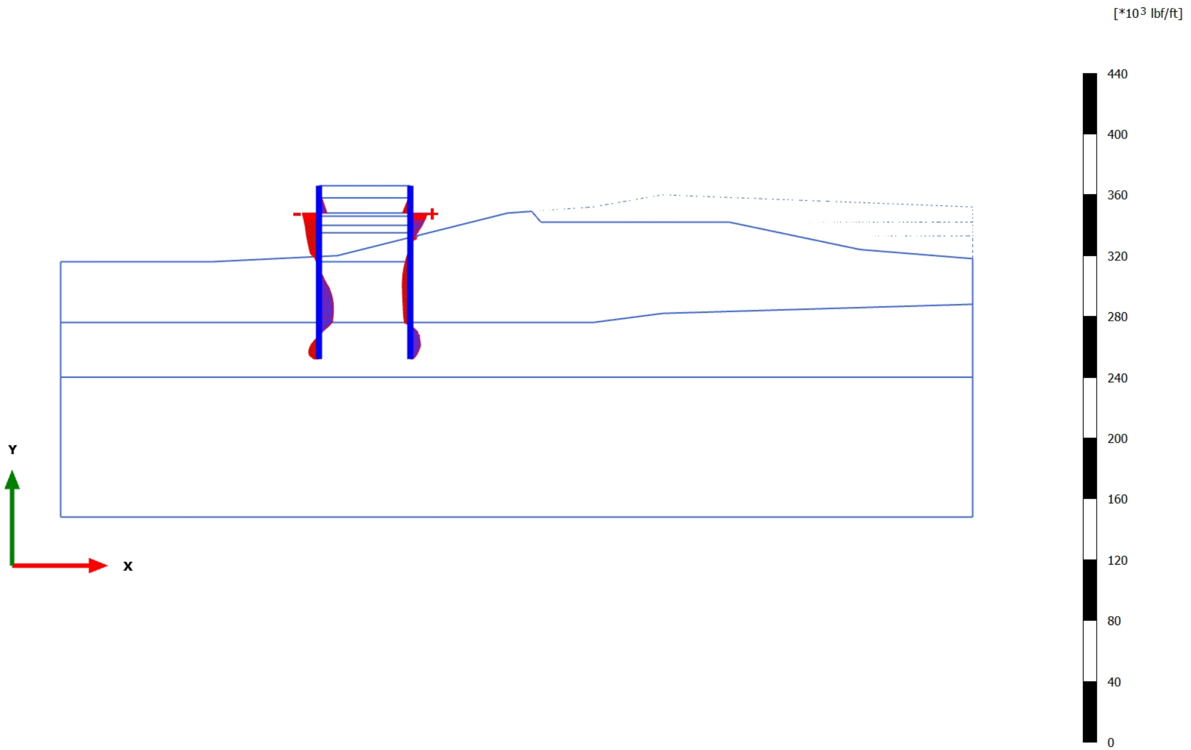


Shear forces Q (scaled up 0.500*10^{-3} times) (Time 51.00 day)

Maximum value = 10.05*10^3 lbf/ft (Element 11 at Node 1113)

Minimum value = -10.46*10^3 lbf/ft (Element 10 at Node 17)

3.1.2.1.11 Calculation results, Plate, Water rise 9 ft [Phase_20] (20/573), Shear forces Q

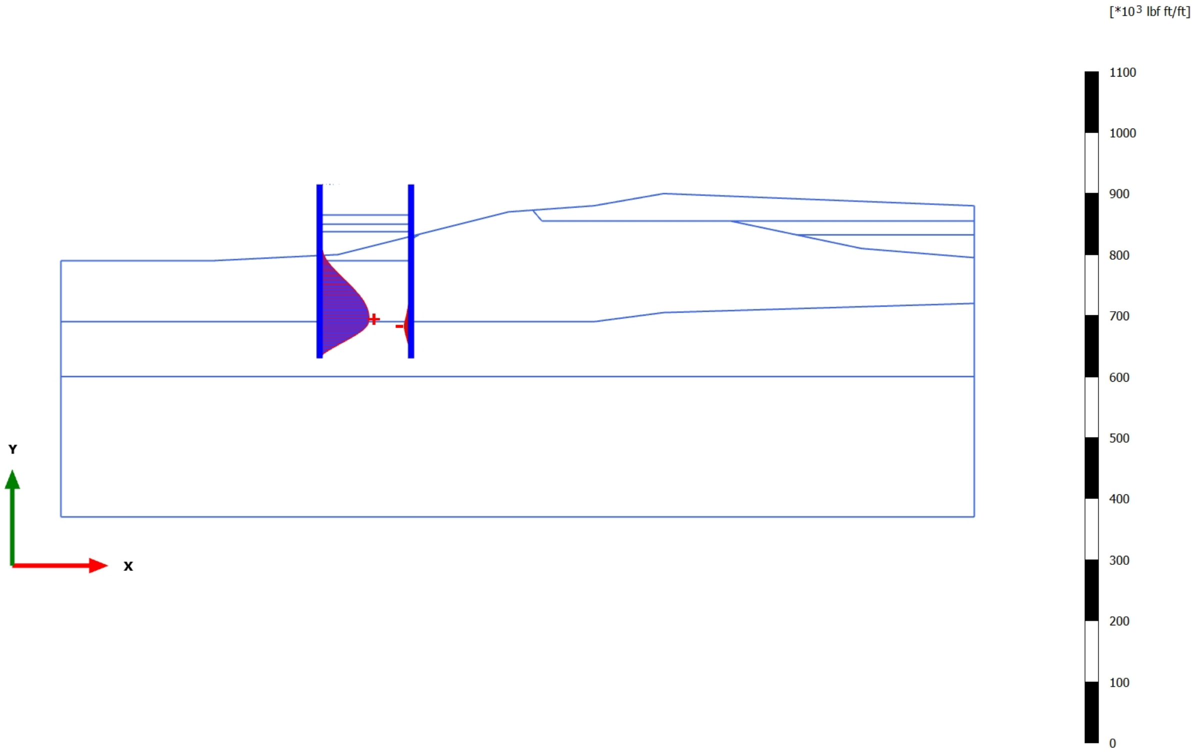


Shear forces Q (scaled up 0.500*10^{-3} times)

Maximum value = 11.40*10^{3} lbf/ft (Element 11 at Node 1113)

Minimum value = -11.19*10^{3} lbf/ft (Element 10 at Node 17)

3.1.2.2.1 Calculation results, Plate, Backfill 1 [Phase_2] (2/356), Bending moments M

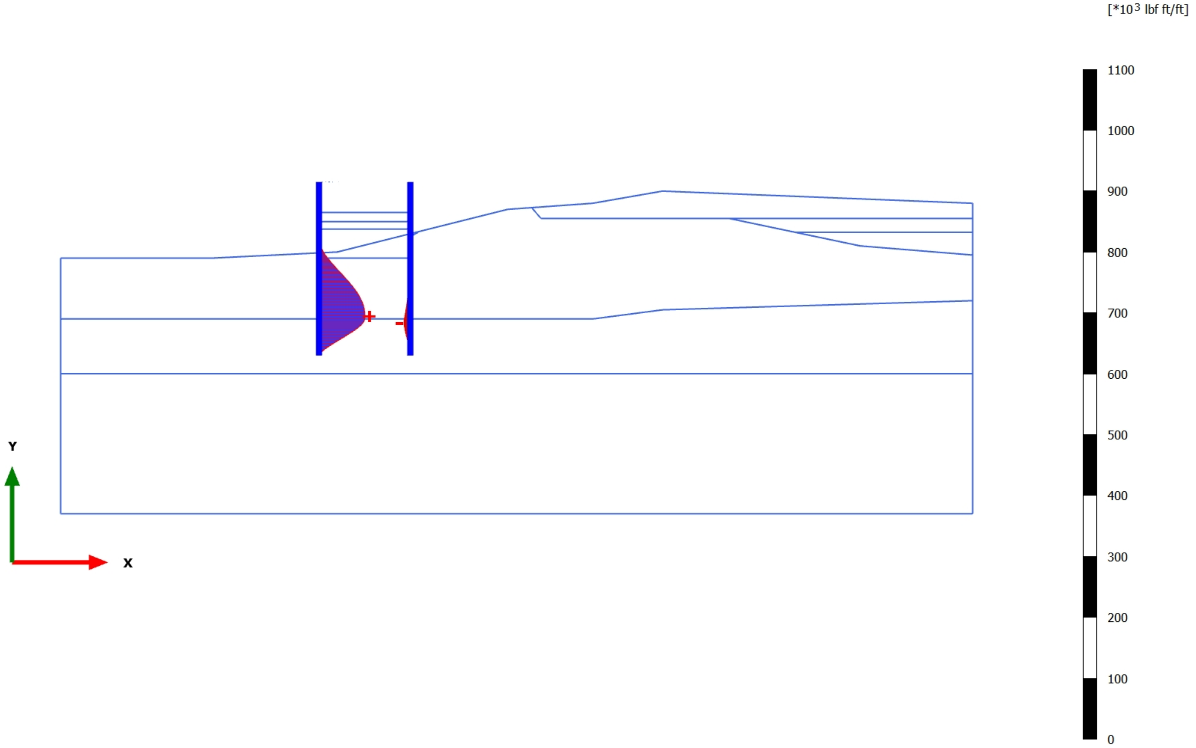


Bending moments M (scaled up $0.200*10^{-3}$ times)

Maximum value = $81.18*10^3$ lbf ft/ft (Element 32 at Node 5652)

Minimum value = $-11.16*10^3$ lbf ft/ft (Element 40 at Node 6471)

3.1.2.2.2 Calculation results, Plate, Consolidate [Phase_4] (7/448), Bending moments M

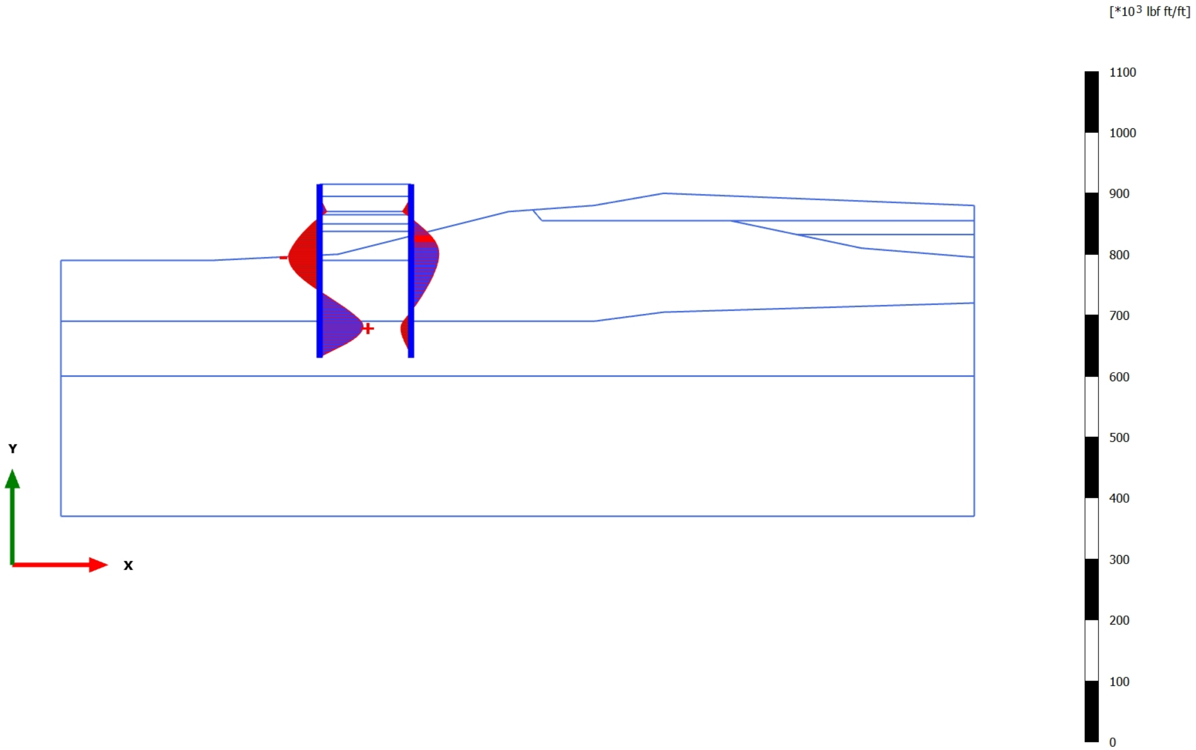


Bending moments M (scaled up 0.200*10^{-3} times) (Time 10.00 day)

Maximum value = 75.53*10^{3} lbf ft/ft (Element 32 at Node 5652)

Minimum value = -10.34*10^{3} lbf ft/ft (Element 40 at Node 6471)

3.1.2.2.3 Calculation results, Plate, Backfill 2 [Phase_6] (6/475), Bending moments M

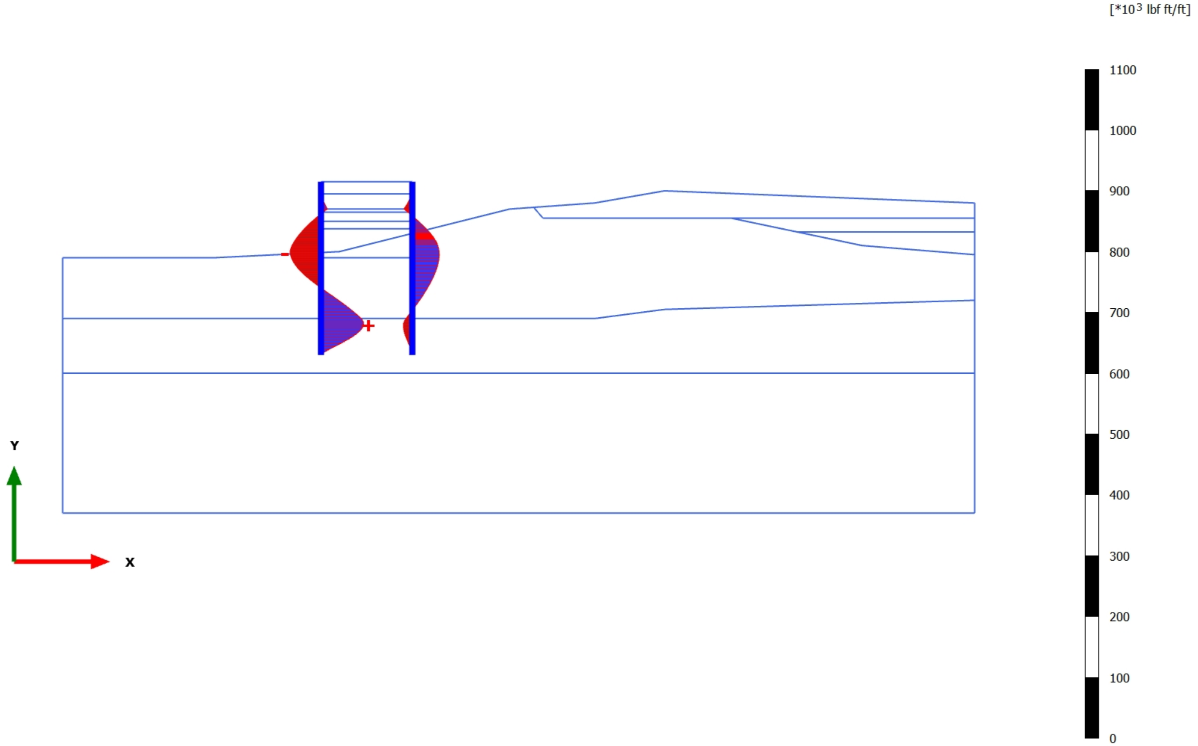


Bending moments M (scaled up 0.200×10^{-3} times)

Maximum value = 71.33×10^3 lbf ft/ft (Element 37 at Node 5737)

Minimum value = -51.13×10^3 lbf ft/ft (Element 26 at Node 2802)

3.1.2.2.4 Calculation results, Plate, Consolidate [Phase_7] (8/492), Bending moments M

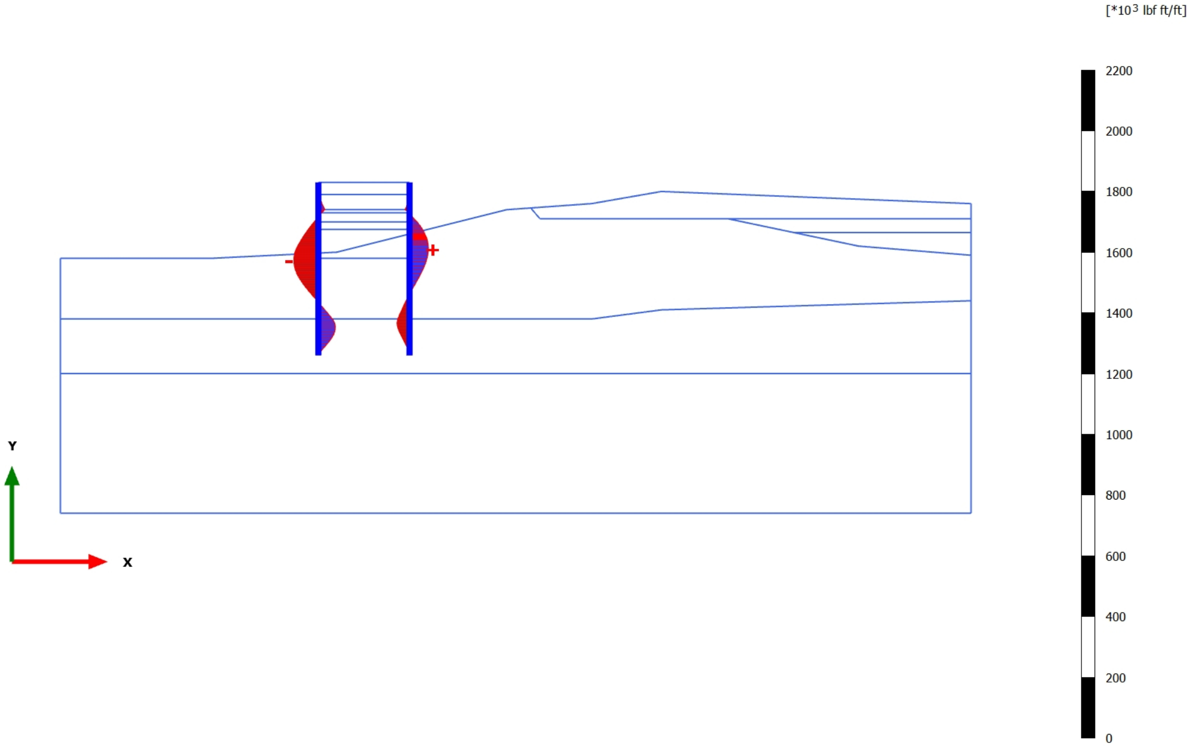


Bending moments M (scaled up 0.200×10^{-3} times) (Time 16.00 day)

Maximum value = 70.08×10^{3} lbf ft/ft (Element 37 at Node 5737)

Minimum value = -51.09×10^{3} lbf ft/ft (Element 22 at Node 2799)

3.1.2.2.5 Calculation results, Plate, Consolidation [Phase_15] (15/518), Bending moments M

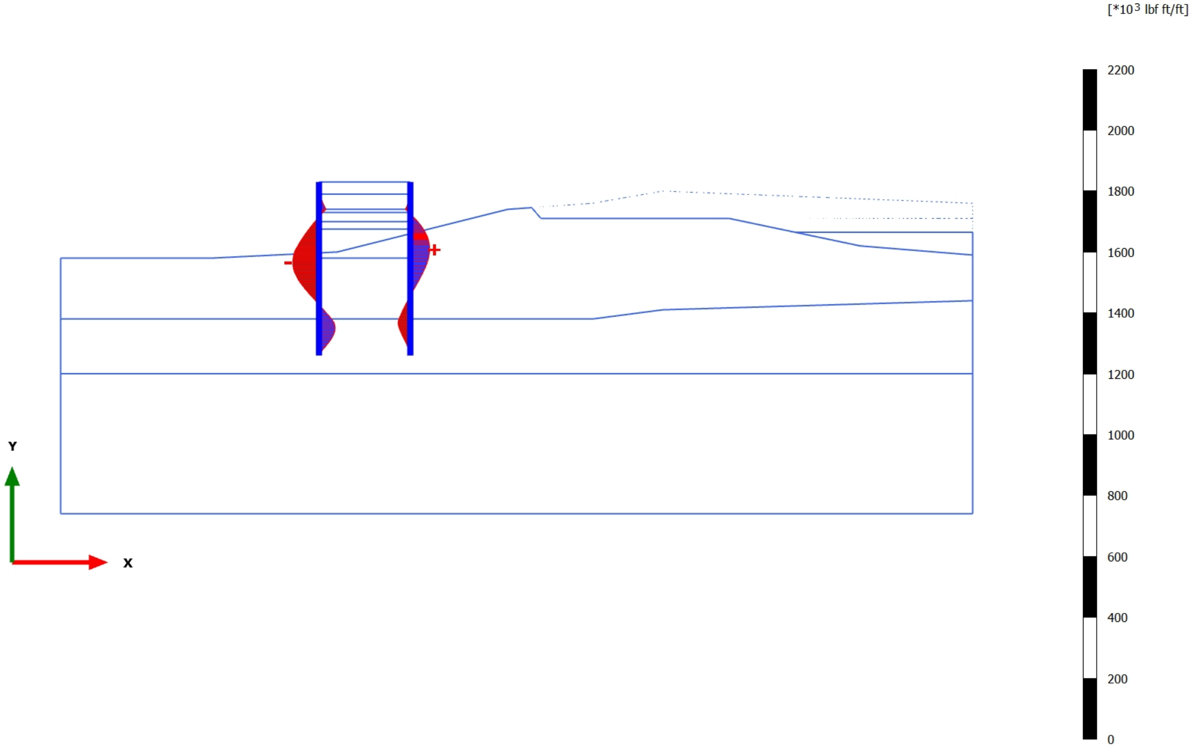


Bending moments M (scaled up 0.100*10^{-3} times) (Time 20.00 day)

Maximum value = 62.51*10^3 lbf ft/ft (Element 25 at Node 5490)

Minimum value = -81.22*10^3 lbf ft/ft (Element 27 at Node 2826)

3.1.2.2.6 Calculation results, Plate, Excavate 1 [Phase_16] (16/526), Bending moments M

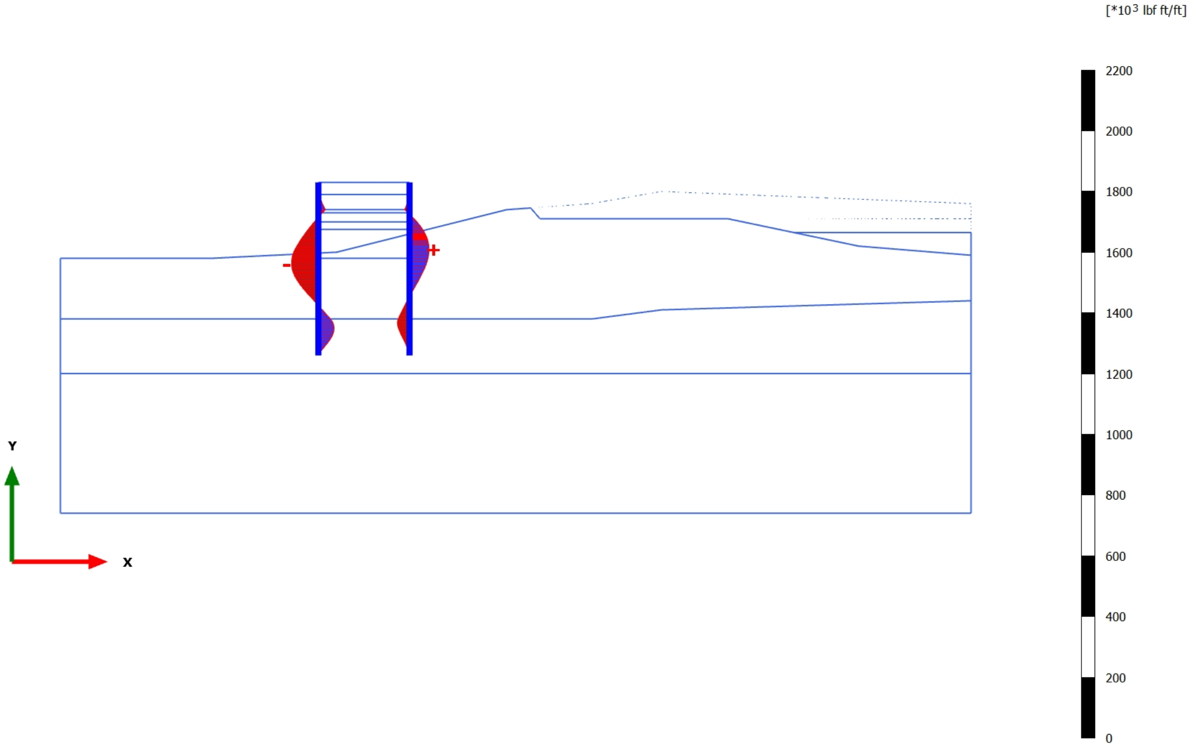


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 64.07*10^3 lbf ft/ft (Element 25 at Node 5490)

Minimum value = -86.57*10^3 lbf ft/ft (Element 27 at Node 2825)

3.1.2.2.7 Calculation results, Plate, Dewater 2-ss [Phase_17] (17/530), Bending moments M

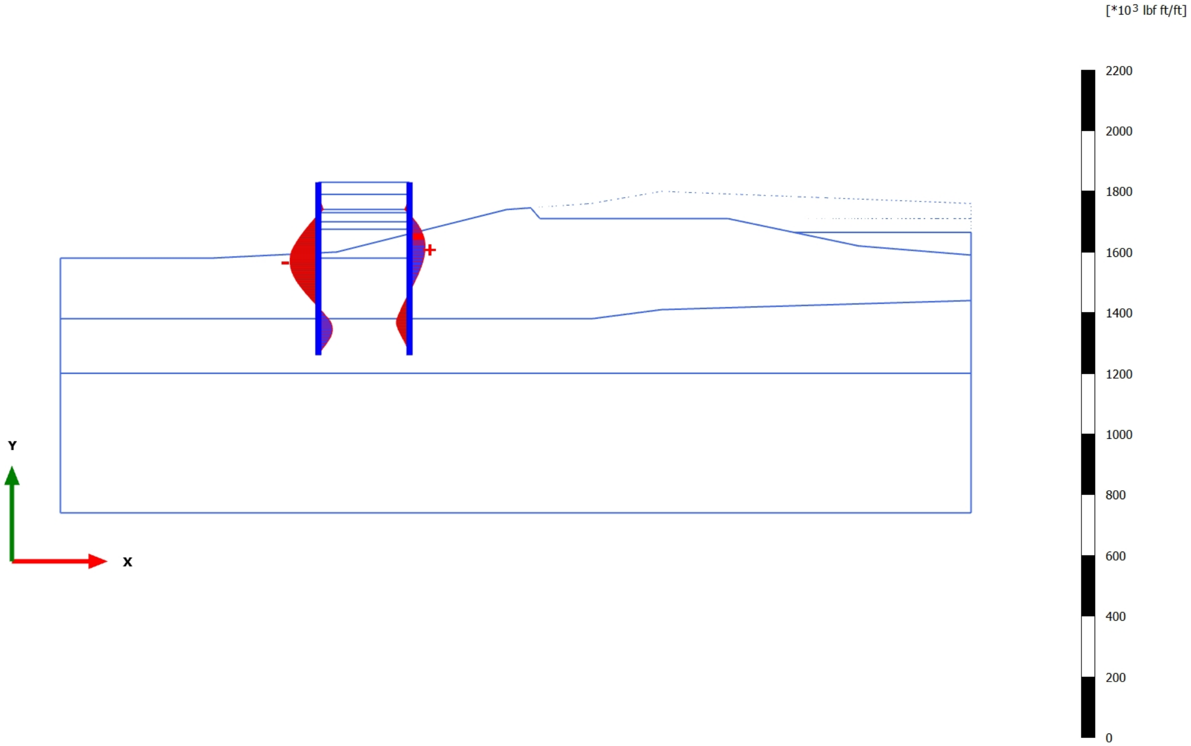


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 64.52*10^3 lbf ft/ft (Element 25 at Node 5490)

Minimum value = -88.58*10^3 lbf ft/ft (Element 27 at Node 2824)

3.1.2.2.8 Calculation results, Plate, Consolidation [Phase_18] (18/549), Bending moments M

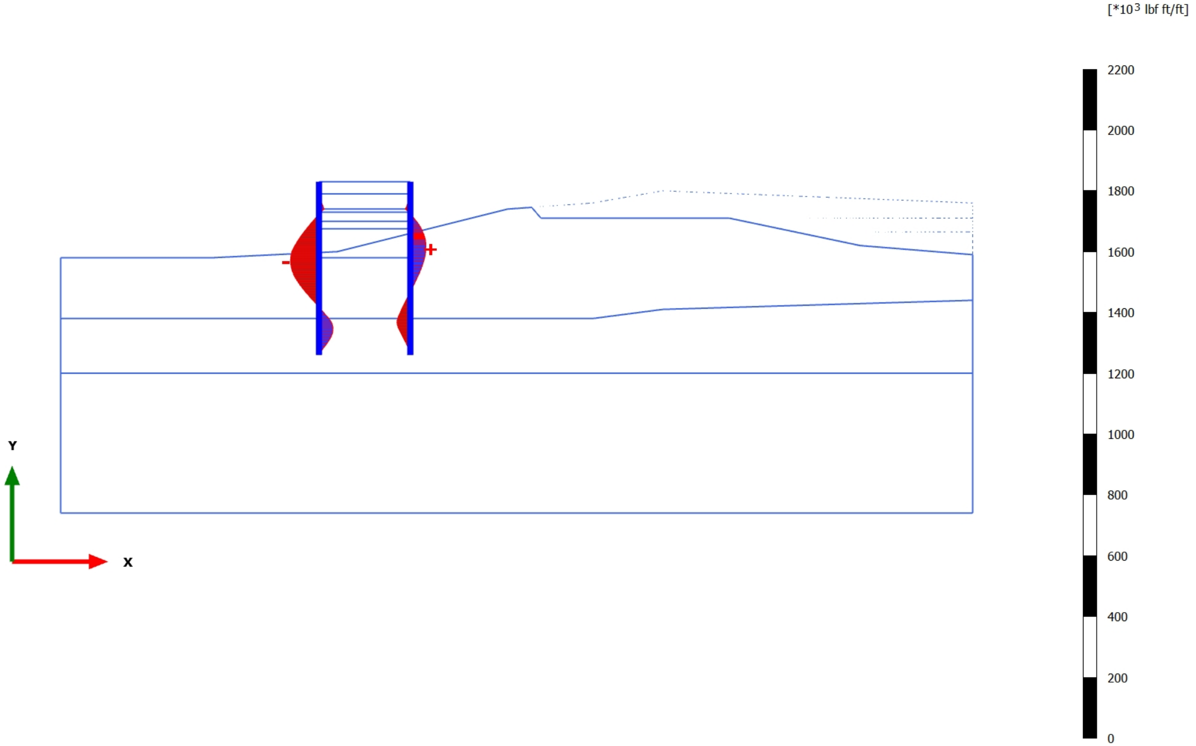


Bending moments M (scaled up 0.100*10^{-3} times) (Time 37.00 day)

Maximum value = 51.60*10^{3} lbf ft/ft (Element 25 at Node 5490)

Minimum value = -93.53*10^{3} lbf ft/ft (Element 27 at Node 2825)

3.1.2.2.9 Calculation results, Plate, Excavate 2 [Phase_19] (19/551), Bending moments M

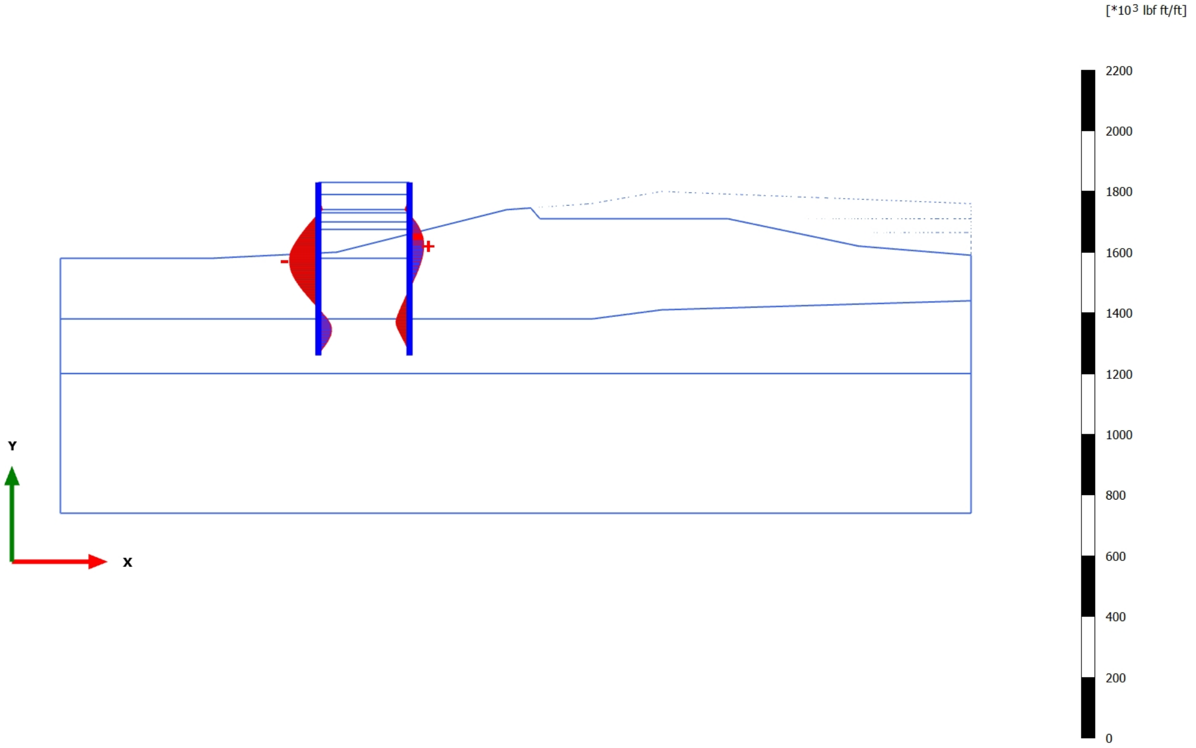


Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 51.81*10^3 lbf ft/ft (Element 25 at Node 5490)

Minimum value = -93.73*10^3 lbf ft/ft (Element 27 at Node 2825)

3.1.2.2.10 Calculation results, Plate, Consolidate [Phase_9] (10/562), Bending moments M

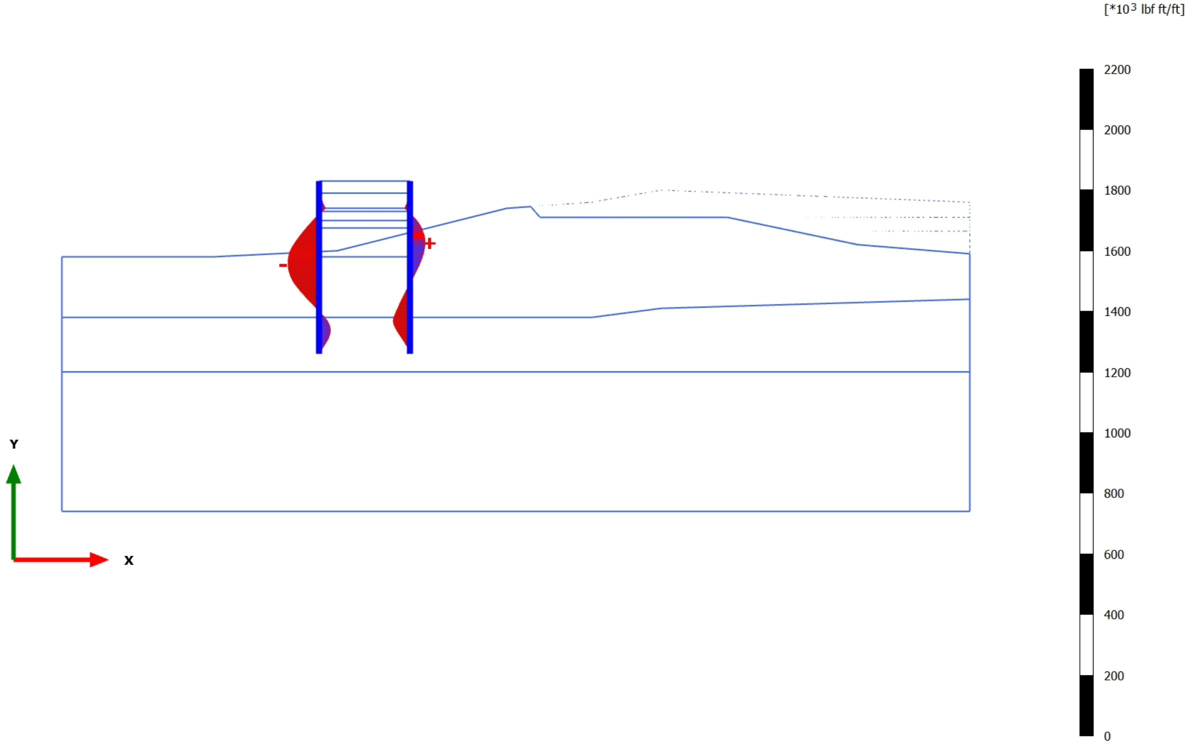


Bending moments M (scaled up 0.100*10^{-3} times) (Time 51.00 day)

Maximum value = 47.16*10^{3} lbf ft/ft (Element 25 at Node 5489)

Minimum value = -95.24*10^{3} lbf ft/ft (Element 27 at Node 2826)

3.1.2.2.11 Calculation results, Plate, Water rise 9 ft [Phase_20] (20/573), Bending moments M



Bending moments M (scaled up 0.100*10^{-3} times)

Maximum value = 49.67*10^3 lbf ft/ft (Element 24 at Node 5474)

Minimum value = -102.6*10^3 lbf ft/ft (Element 28 at Node 3817)

3.2.1.1.2 Calculation results, Node-to-node anchor, Consolidate [Phase_4] (7/448), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	1002.085	0.000	1017.717
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	1002.085	0.000	1017.717

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 2 [Phase_6] (6/475), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	61.820	0.000	61.820
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	61.820	0.000	61.820

3.2.1.1.4 Calculation results, Node-to-node anchor, Consolidate [Phase_7] (8/492), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	60.187	0.000	62.288
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	60.187	0.000	62.288

3.2.1.1.5 Calculation results, Node-to-node anchor, Consolidation [Phase_15] (15/518), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	92.222	0.000	94.012
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	92.222	0.000	94.012

3.2.1.1.6 Calculation results, Node-to-node anchor, Excavate 1 [Phase_16] (16/526), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	94.533	0.000	94.533
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	94.533	0.000	94.533

3.2.1.1.7 Calculation results, Node-to-node anchor, Dewater 2-ss [Phase_17] (17/530), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	95.112	0.000	95.112
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	95.112	0.000	95.112

3.2.1.1.8 Calculation results, Node-to-node anchor, Consolidation [Phase_18] (18/549), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	89.456	0.000	95.112
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	89.456	0.000	95.112

3.2.1.1.9 Calculation results, Node-to-node anchor, Excavate 2 [Phase_19] (19/551), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	89.562	0.000	95.112
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	89.562	0.000	95.112

3.2.1.1.10 Calculation results, Node-to-node anchor, Consolidate [Phase_9] (10/562), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	87.265	0.000	95.112
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	87.265	0.000	95.112

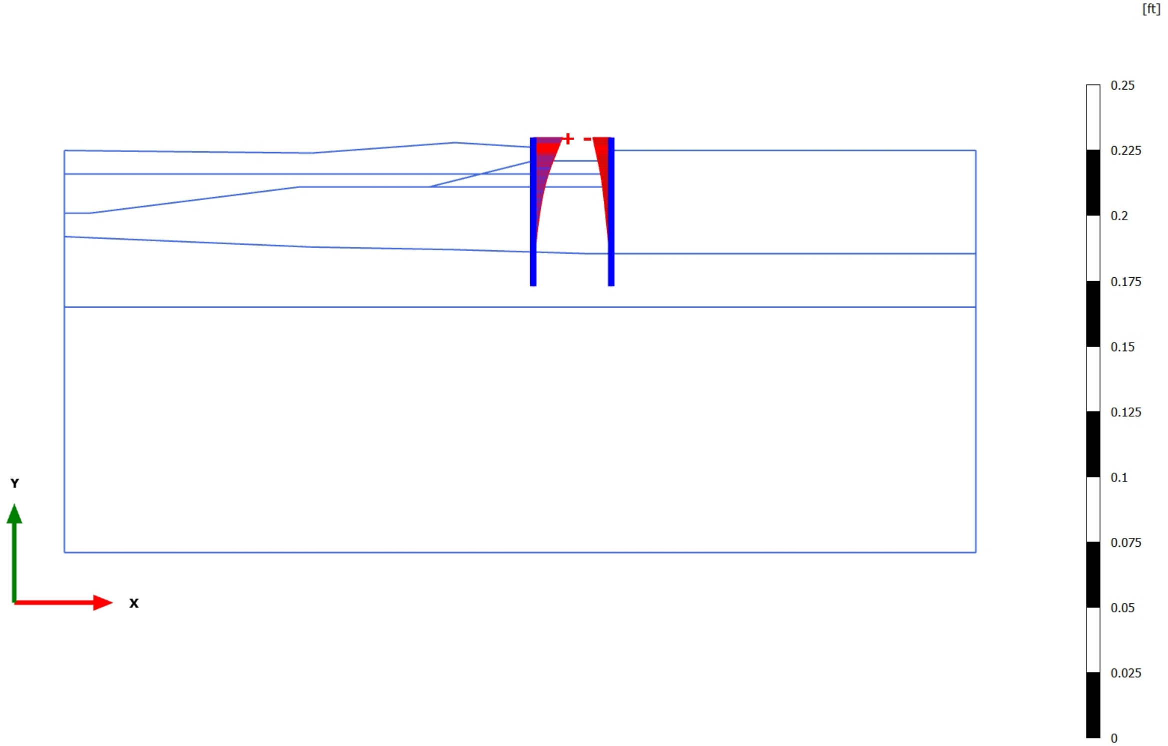
3.2.1.1.11 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_20] (20/573), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	17	1	-15.000	0.000	98.678	0.000	98.678
Element 3-3 (Node-to-node anchor)	1113	2	15.000	0.000	98.678	0.000	98.678

San Jacinto Section C6 - Drained Model

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Exc [Phase_2] (2/8), Total displacements u_x

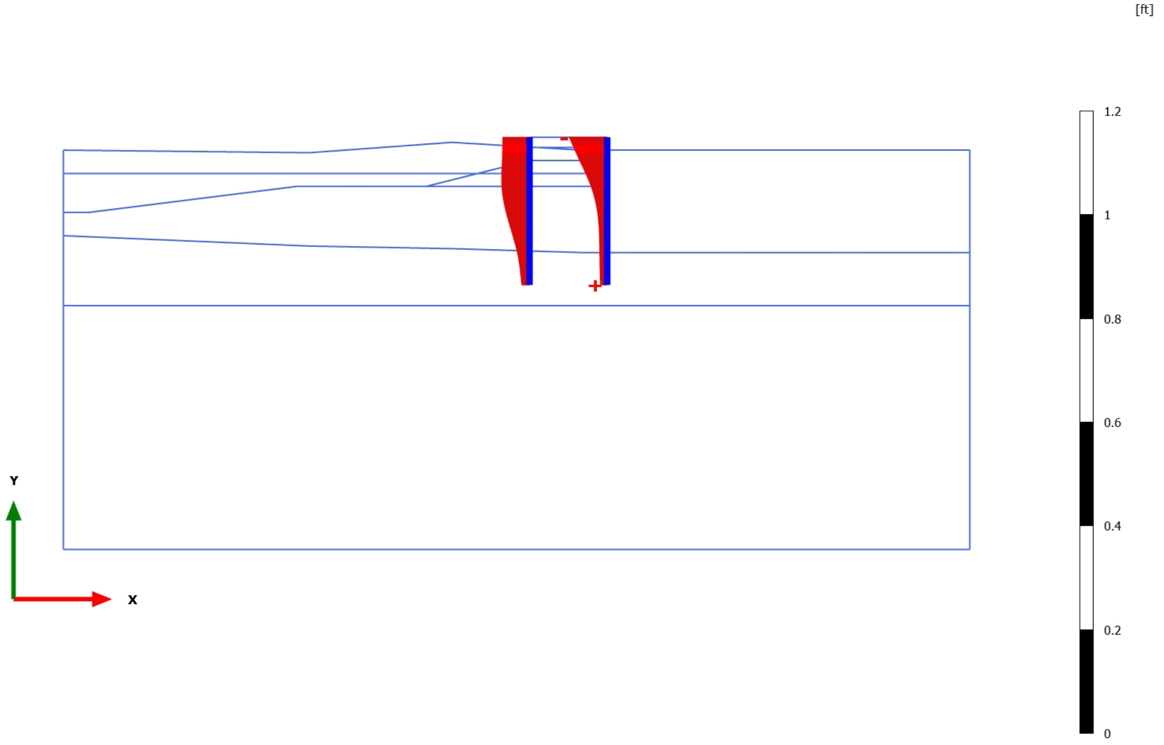


Total displacements u_x (scaled up $1.00*10^3$ times)

Maximum value = 0.01137 ft (Element 1 at Node 54)

Minimum value = $-7.144*10^{-3}$ ft (Element 4 at Node 361)

3.1.1.1.1.2 Calculation results, Plate, Dewater-SS [Phase_7] (7/18), Total displacements u_x

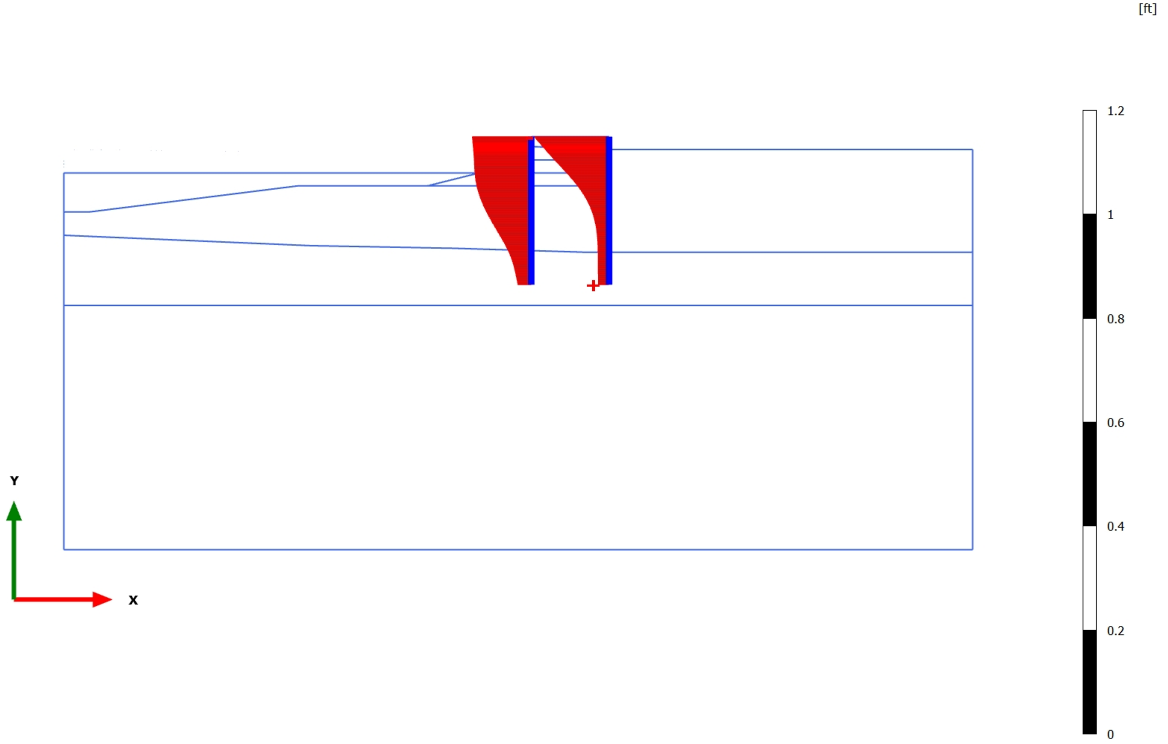


Total displacements u_x (scaled up 200 times)

Maximum value = -0.01299 ft (Element 48 at Node 18484)

Minimum value = -0.07329 ft (Element 4 at Node 361)

3.1.1.1.1.3 Calculation results, Plate, Excavate 1 [Phase_8] (8/33), Total displacements u_x

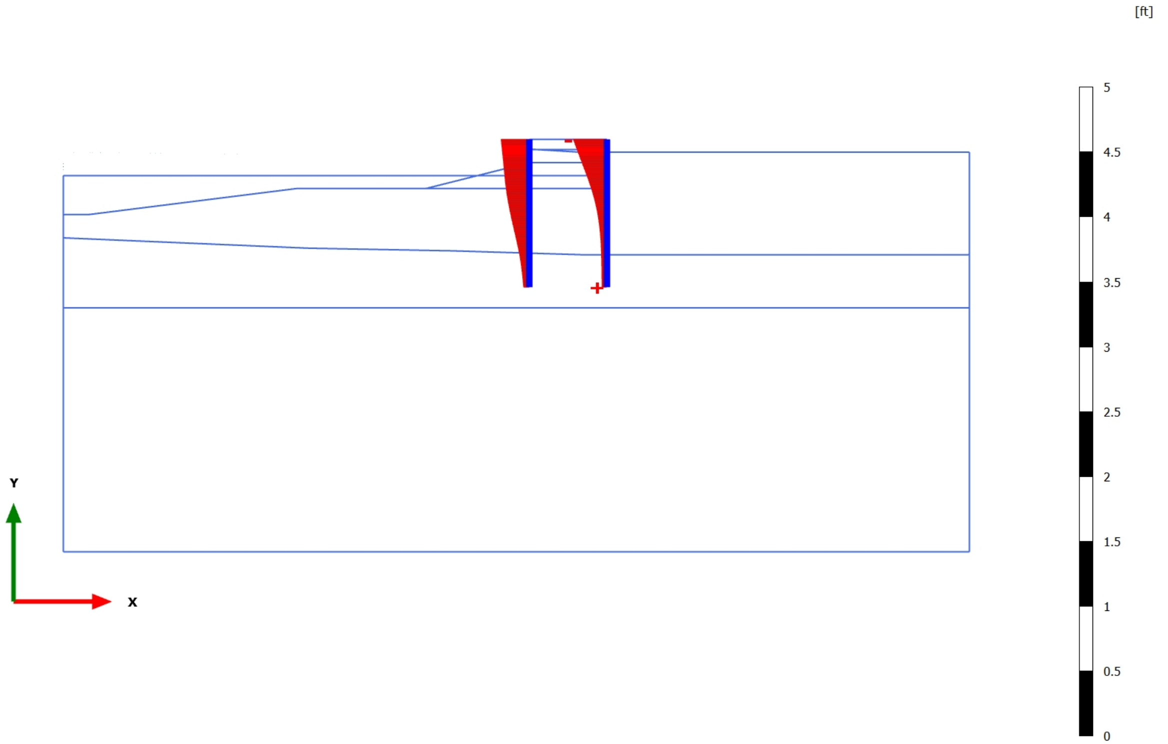


Total displacements u_x (scaled up 200 times)

Maximum value = -0.02060 ft (Element 48 at Node 18484)

Minimum value = -0.1444 ft (Element 4 at Node 361)

3.1.1.1.1.4 Calculation results, Plate, Dewater -SS [Phase_9] (9/43), Total displacements u_x

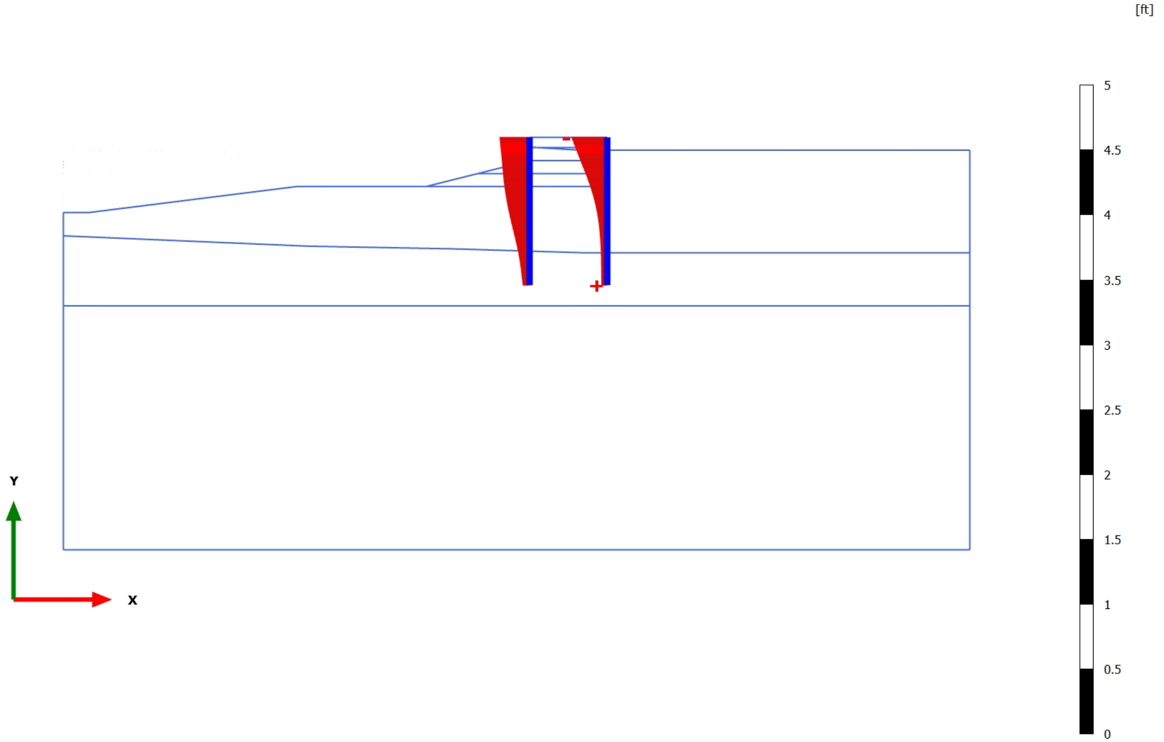


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.03761 ft (Element 48 at Node 18484)

Minimum value = -0.2595 ft (Element 4 at Node 361)

3.1.1.1.1.5 Calculation results, Plate, Excavate 2 [Phase_10] (10/49), Total displacements u_x

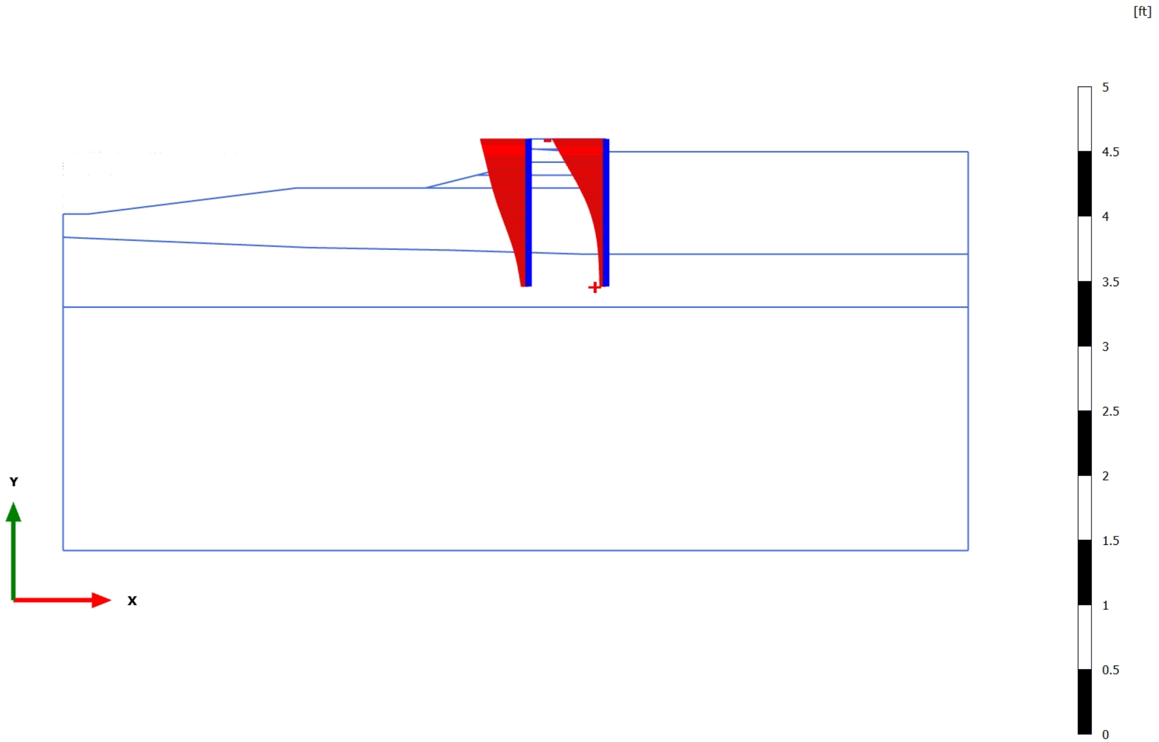


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.04226 ft (Element 48 at Node 18484)

Minimum value = -0.2738 ft (Element 4 at Node 361)

3.1.1.1.1.6 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/58), Total displacements u_x

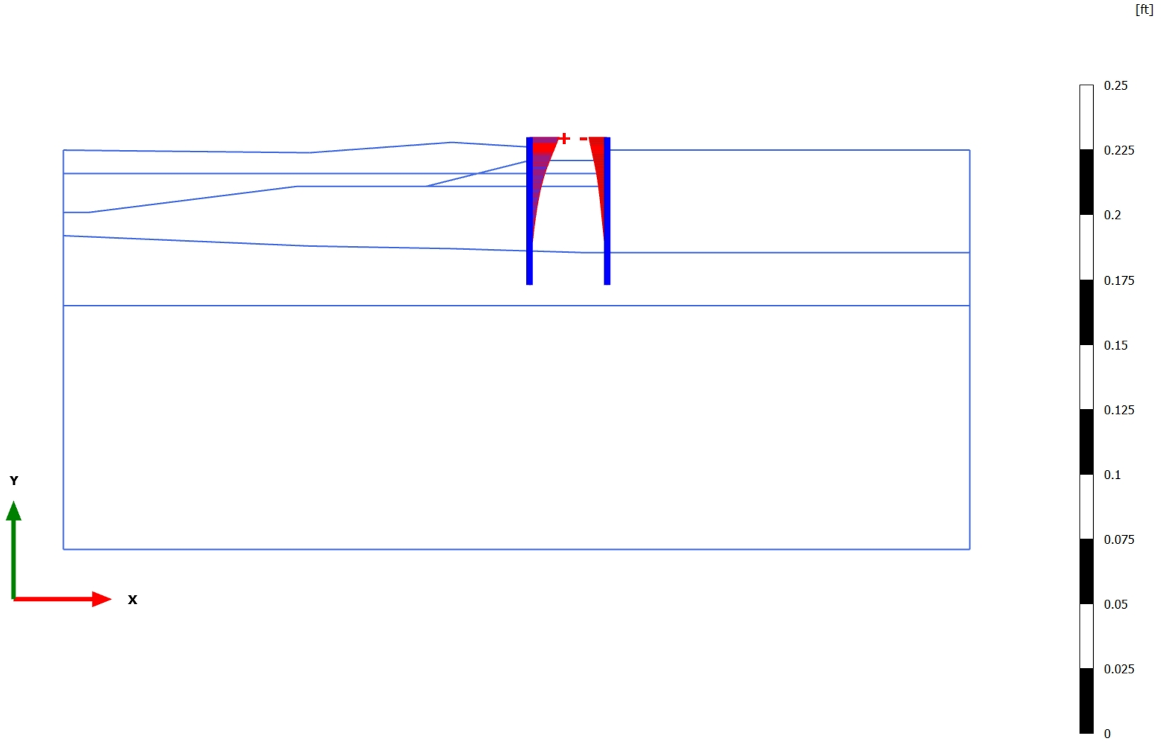


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.04901 ft (Element 48 at Node 18484)

Minimum value = -0.4171 ft (Element 4 at Node 361)

3.1.1.1.1.7 Calculation results, Plate, Install Rod [Phase_12] (4/138), Total displacements u_x

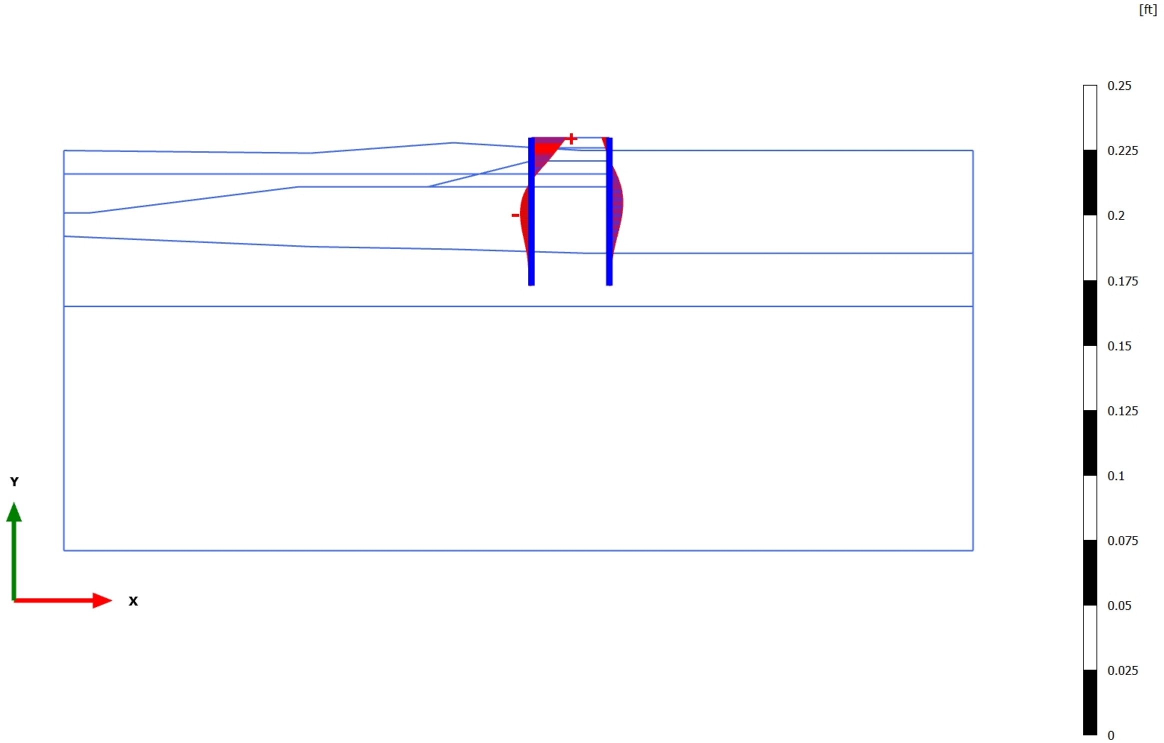


Total displacements u_x (scaled up $1.00*10^3$ times)

Maximum value = 0.01143 ft (Element 1 at Node 54)

Minimum value = $-7.117*10^{-3}$ ft (Element 4 at Node 361)

3.1.1.1.1.8 Calculation results, Plate, Backfill 1 [Phase_6] (6/190), Total displacements u_x

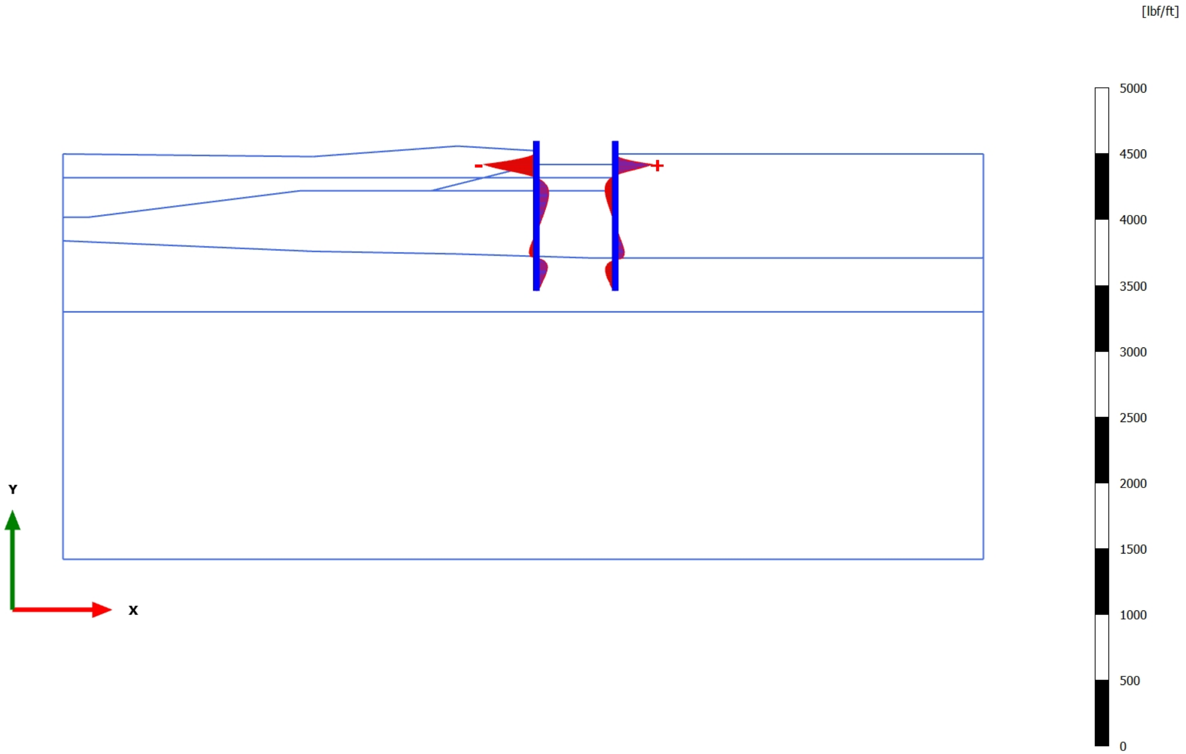


Total displacements u_x (scaled up $1.00*10^3$ times)

Maximum value = 0.01350 ft (Element 1 at Node 54)

Minimum value = $-4.255*10^{-3}$ ft (Element 25 at Node 15218)

3.1.2.1.1 Calculation results, Plate, Exc [Phase_2] (2/8), Shear forces Q

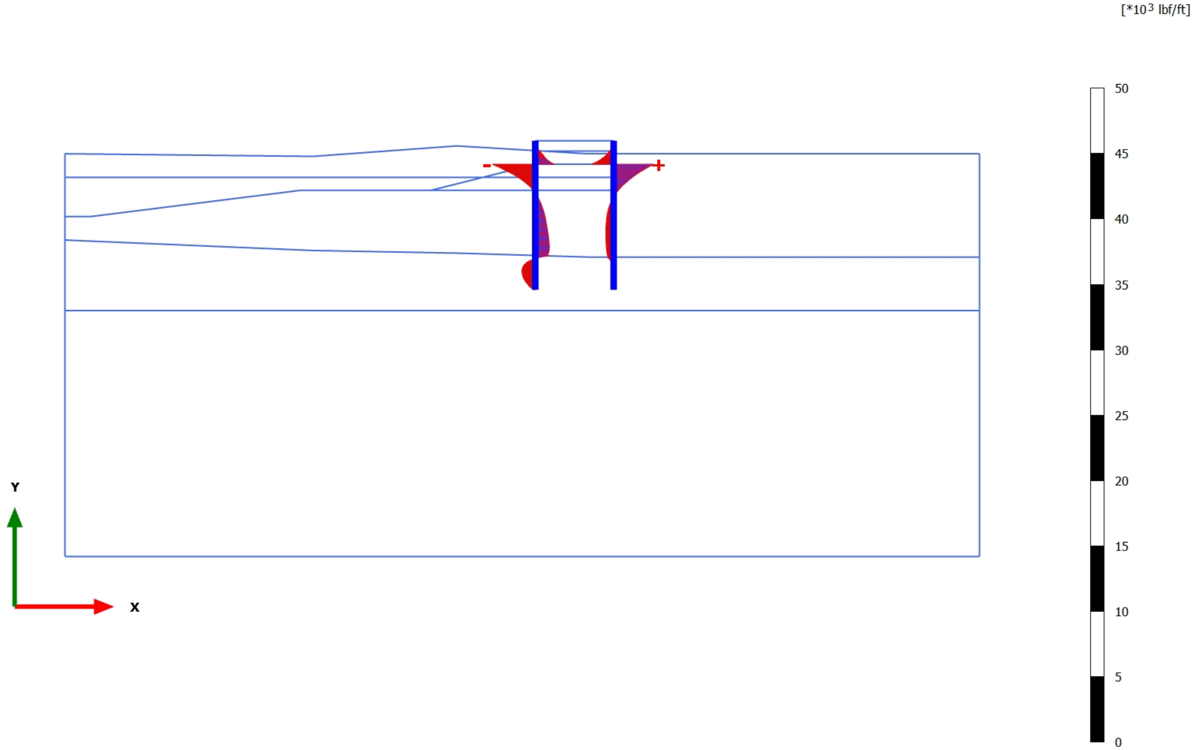


Shear forces Q (scaled up 0.0500 times)

Maximum value = 286.0 lbf/ft (Element 13 at Node 5729)

Minimum value = -403.0 lbf/ft (Element 11 at Node 7709)

3.1.2.1.2 Calculation results, Plate, Dewater-SS [Phase_7] (7/18), Shear forces Q

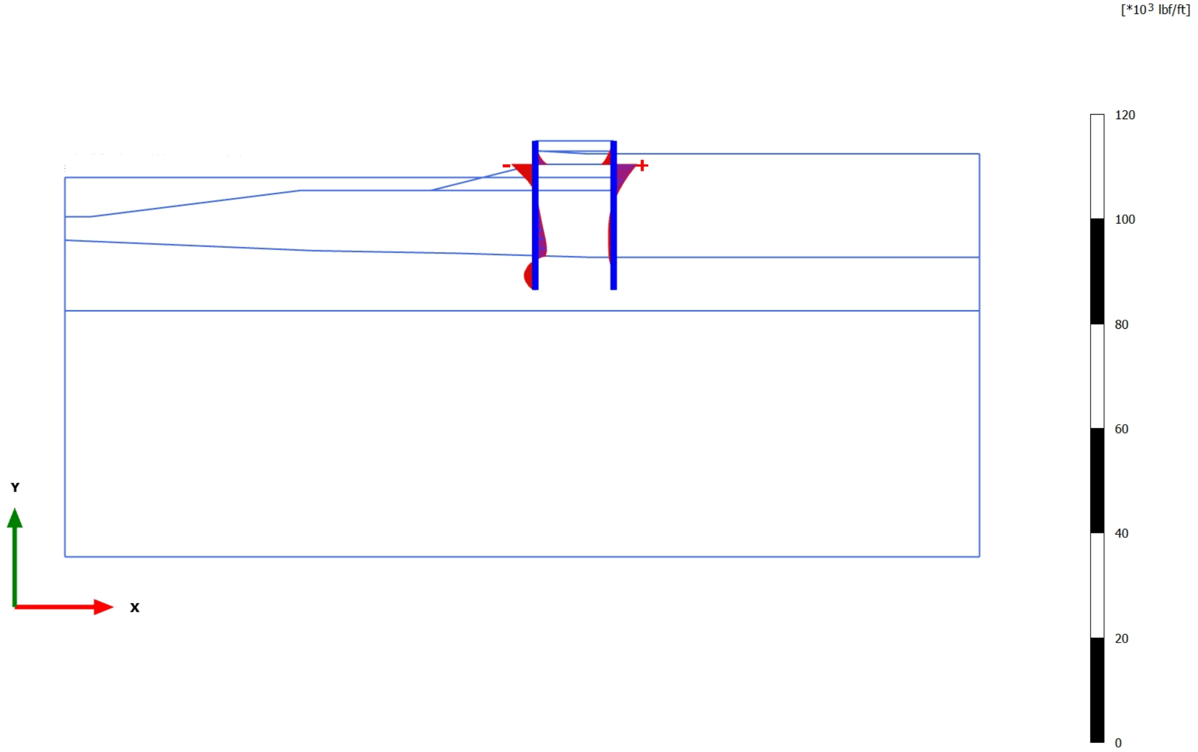


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 3059 lbf/ft (Element 16 at Node 5729)

Minimum value = -3291 lbf/ft (Element 14 at Node 7709)

3.1.2.1.3 Calculation results, Plate, Excavate 1 [Phase_8] (8/33), Shear forces Q

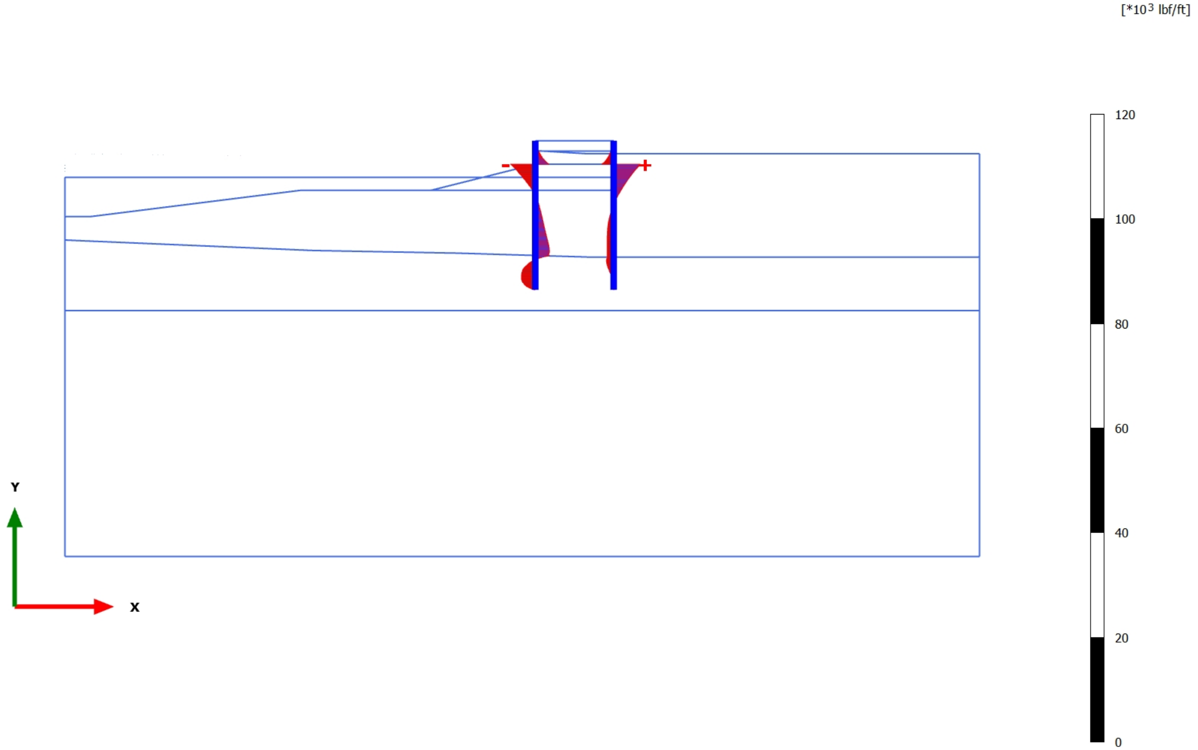


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 4467 lbf/ft (Element 16 at Node 5729)

Minimum value = -4525 lbf/ft (Element 14 at Node 7709)

3.1.2.1.4 Calculation results, Plate, Dewater -SS [Phase_9] (9/43), Shear forces Q

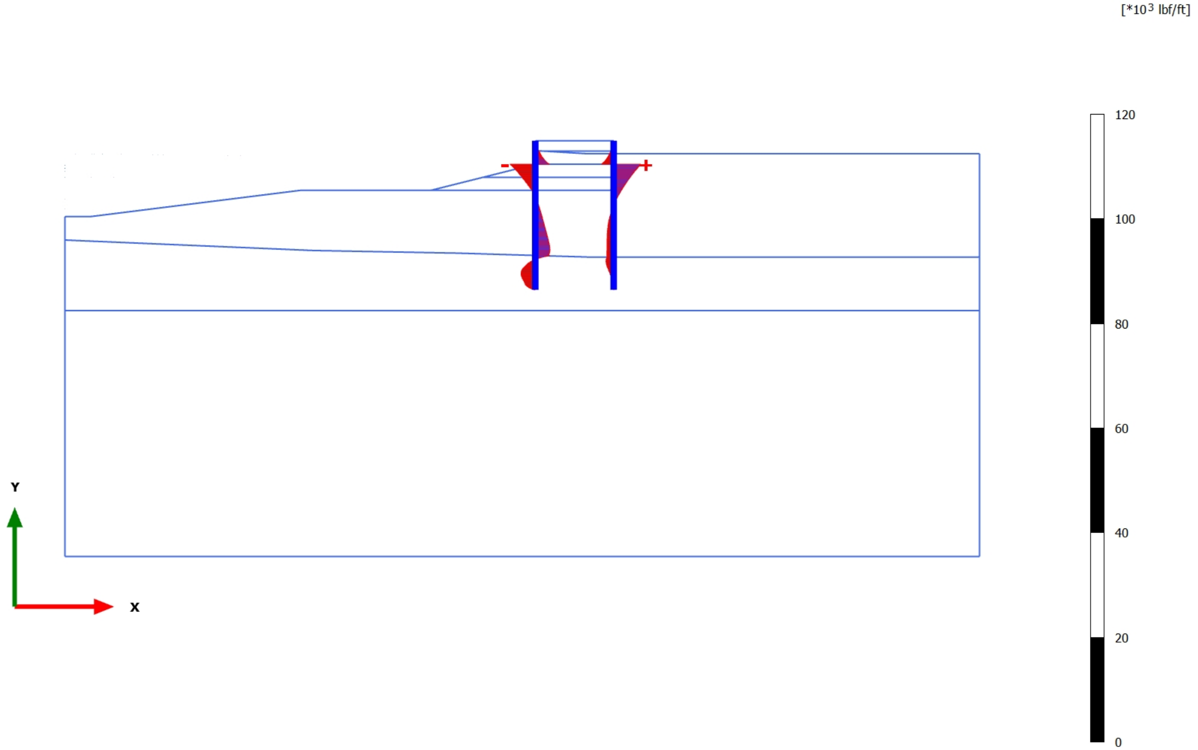


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 5140 lbf/ft (Element 16 at Node 5729)

Minimum value = -4763 lbf/ft (Element 14 at Node 7709)

3.1.2.1.5 Calculation results, Plate, Excavate 2 [Phase_10] (10/49), Shear forces Q

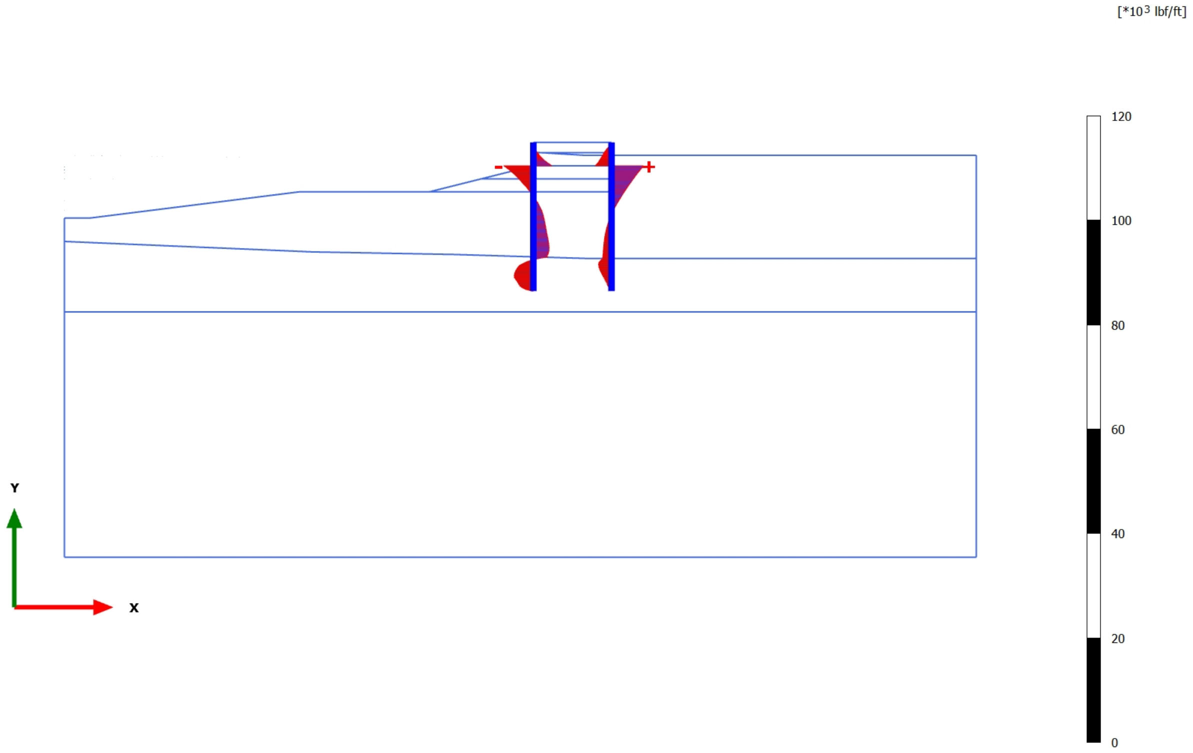


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 5236 lbf/ft (Element 16 at Node 5729)

Minimum value = -4849 lbf/ft (Element 14 at Node 7709)

3.1.2.1.6 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/58), Shear forces Q

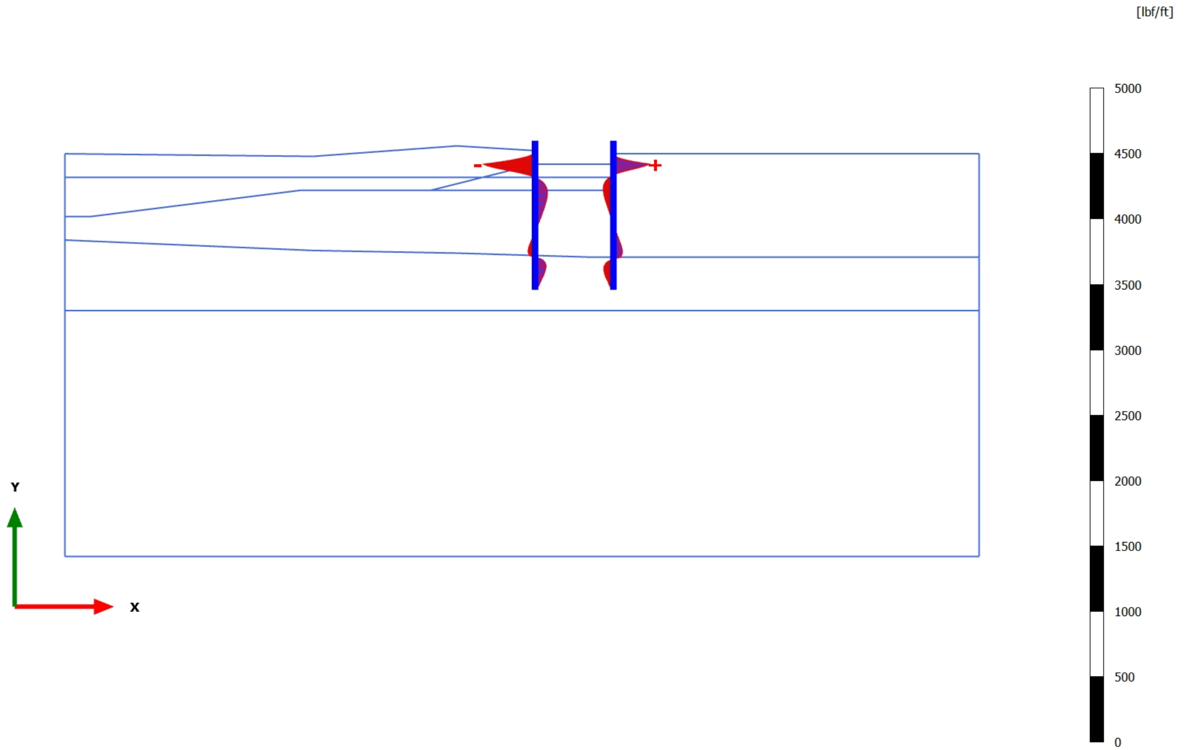


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 6167 lbf/ft (Element 16 at Node 5729)

Minimum value = -5689 lbf/ft (Element 14 at Node 7709)

3.1.2.1.7 Calculation results, Plate, Install Rod [Phase_12] (4/138), Shear forces Q

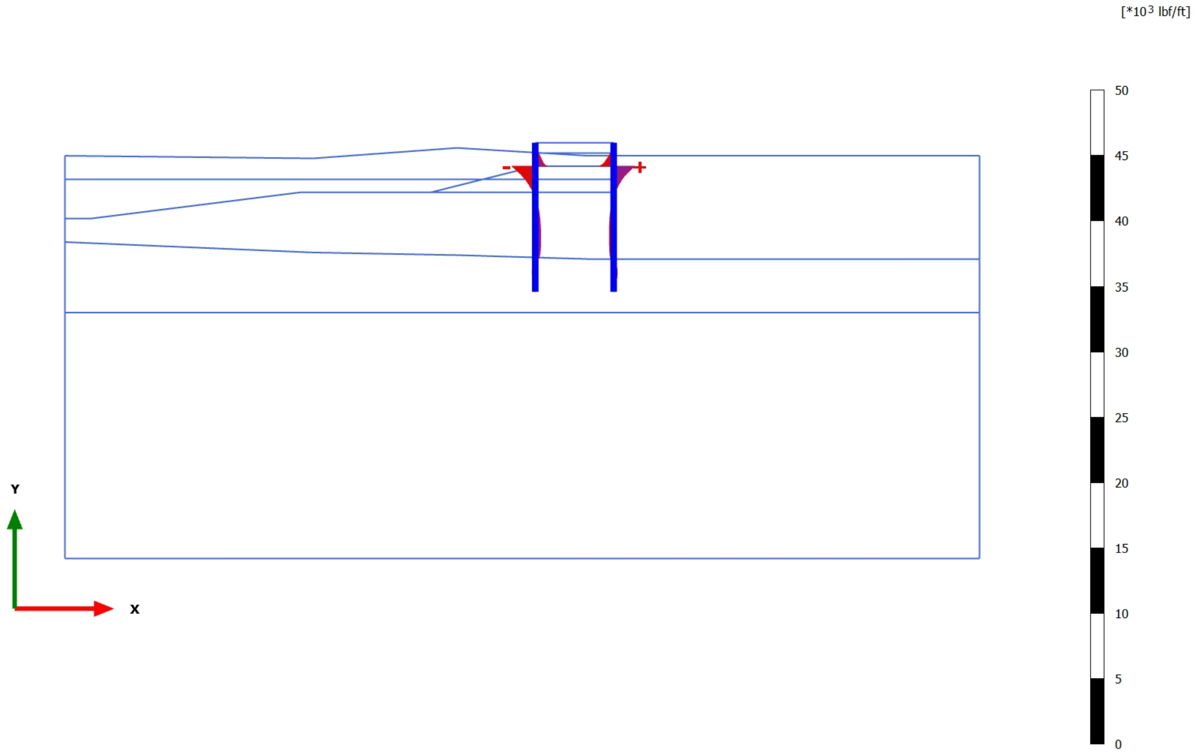


Shear forces Q (scaled up 0.0500 times)

Maximum value = 286.3 lbf/ft (Element 13 at Node 5729)

Minimum value = -403.1 lbf/ft (Element 11 at Node 7709)

3.1.2.1.8 Calculation results, Plate, Backfill 1 [Phase_6] (6/190), Shear forces Q

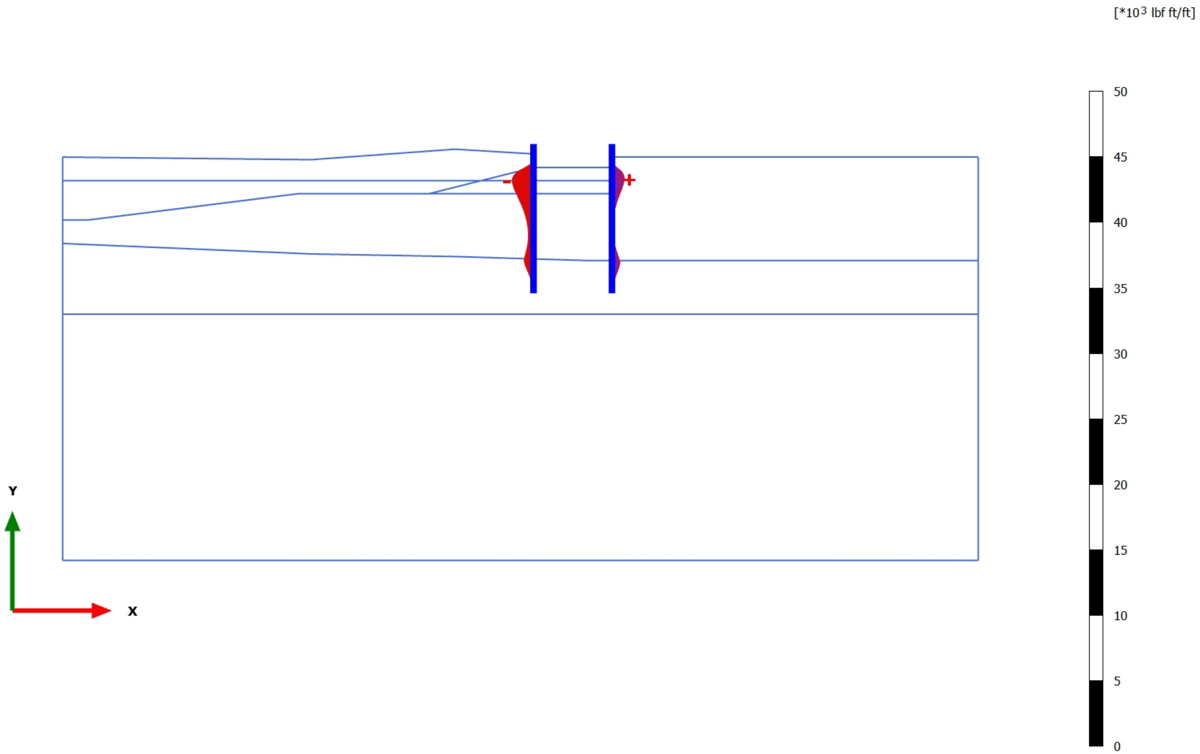


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 1614 lbf/ft (Element 16 at Node 5729)

Minimum value = -1792 lbf/ft (Element 14 at Node 7709)

3.1.2.2.1 Calculation results, Plate, Exc [Phase_2] (2/8), Bending moments M

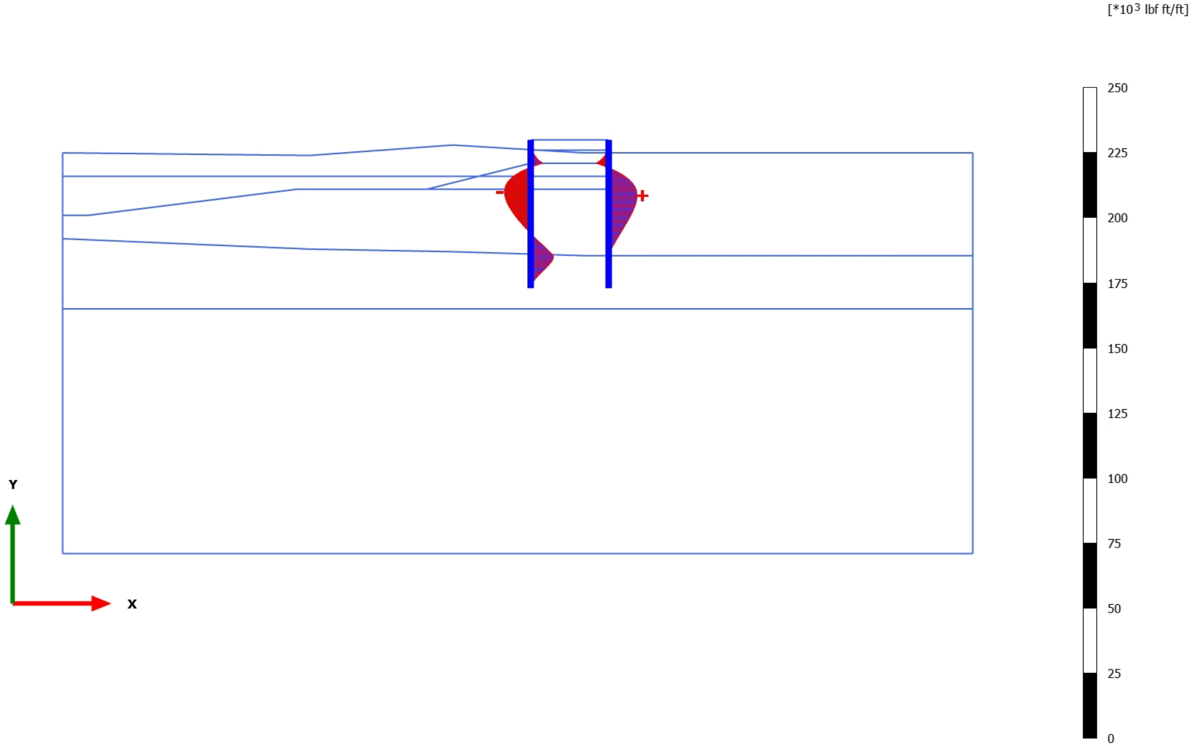


Bending moments M (scaled up 5.00*10^{-3} times)

Maximum value = 938.0 lbf ft/ft (Element 17 at Node 6792)

Minimum value = -1621 lbf ft/ft (Element 18 at Node 10471)

3.1.2.2.2 Calculation results, Plate, Dewater-SS [Phase_7] (7/18), Bending moments M

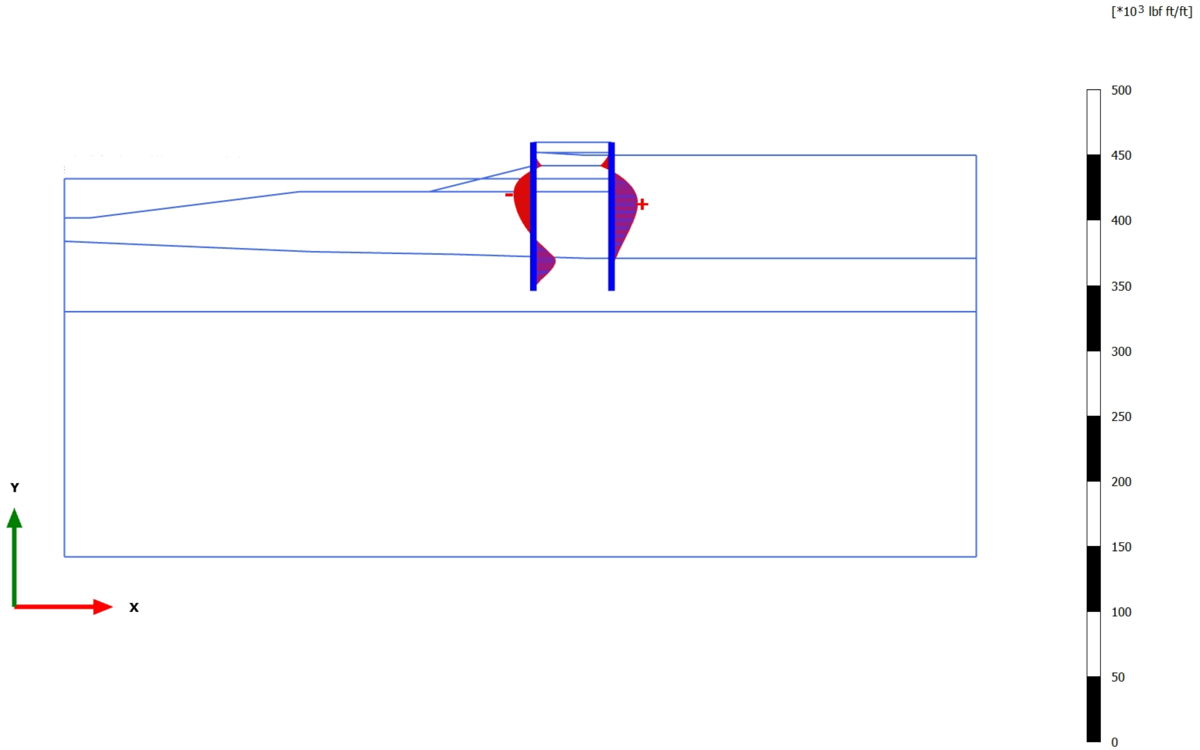


Bending moments M (scaled up $1.00*10^{-3}$ times)

Maximum value = $10.92*10^3$ lbf ft/ft (Element 31 at Node 9676)

Minimum value = $-10.07*10^3$ lbf ft/ft (Element 22 at Node 12992)

3.1.2.2.3 Calculation results, Plate, Excavate 1 [Phase_8] (8/33), Bending moments M

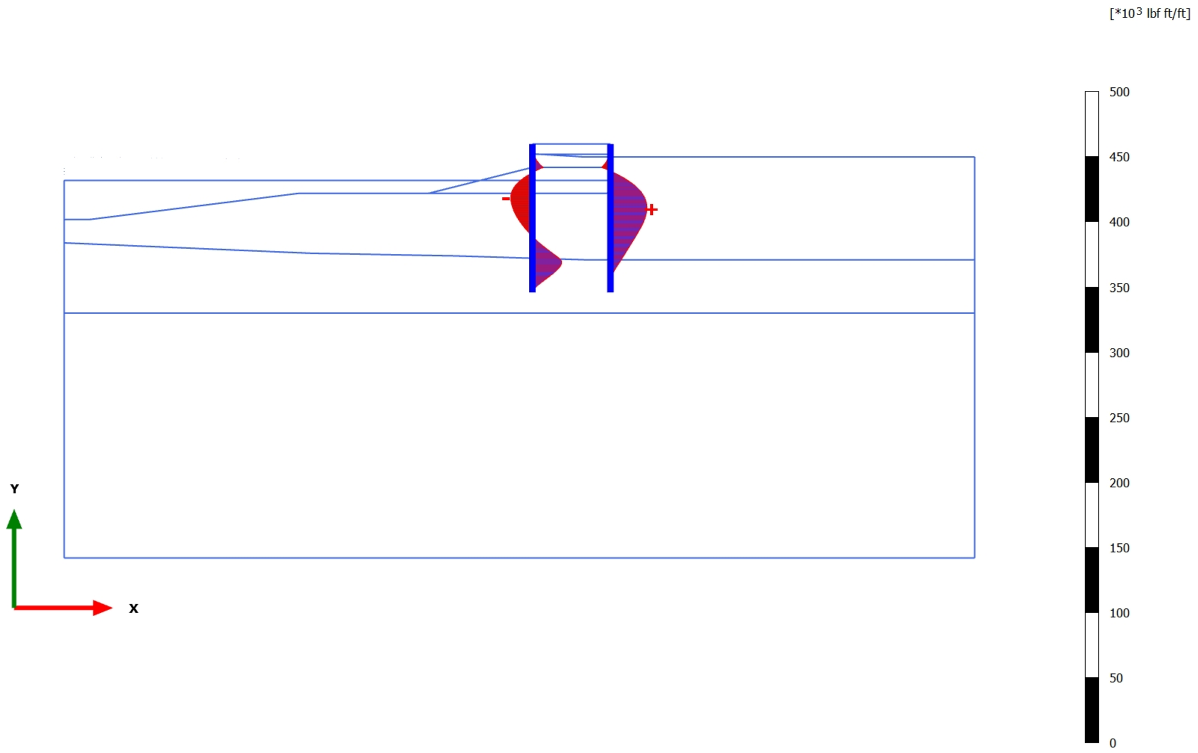


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $19.96*10^3$ lbf ft/ft (Element 32 at Node 10645)

Minimum value = $-14.94*10^3$ lbf ft/ft (Element 22 at Node 12992)

3.1.2.2.4 Calculation results, Plate, Dewater -SS [Phase_9] (9/43), Bending moments M

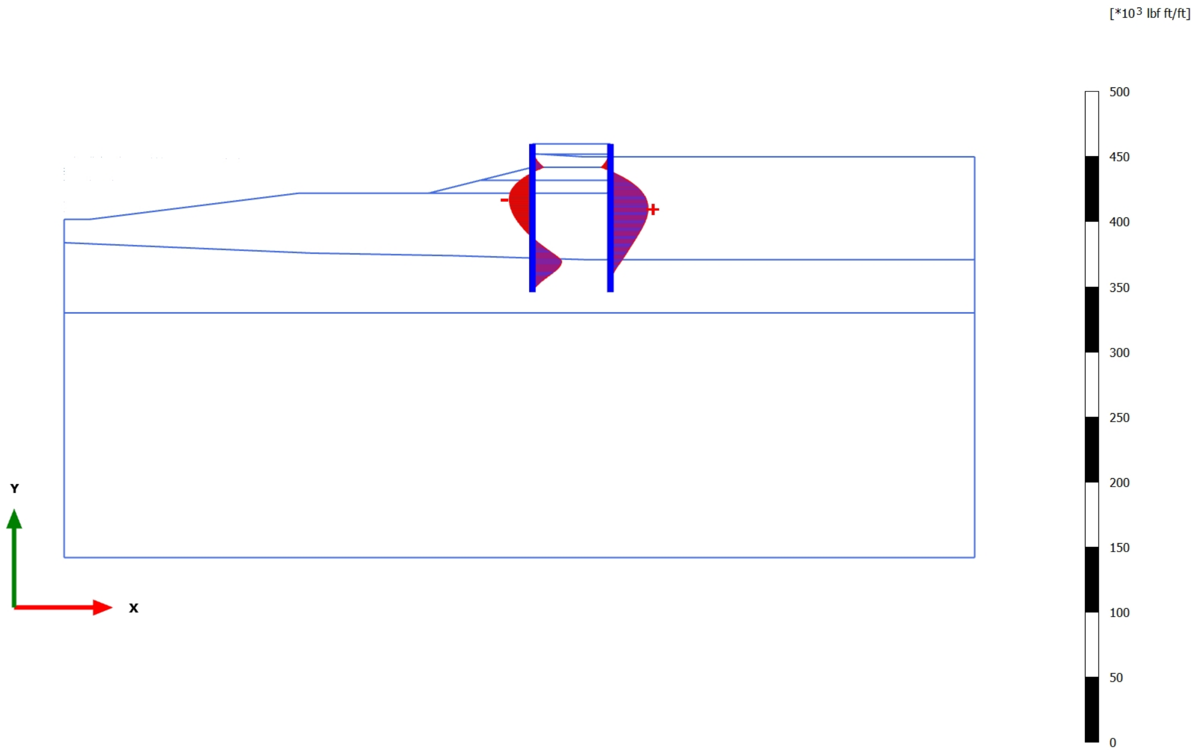


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $28.06*10^3$ lbf ft/ft (Element 32 at Node 11393)

Minimum value = $-16.64*10^3$ lbf ft/ft (Element 22 at Node 12991)

3.1.2.2.5 Calculation results, Plate, Excavate 2 [Phase_10] (10/49), Bending moments M

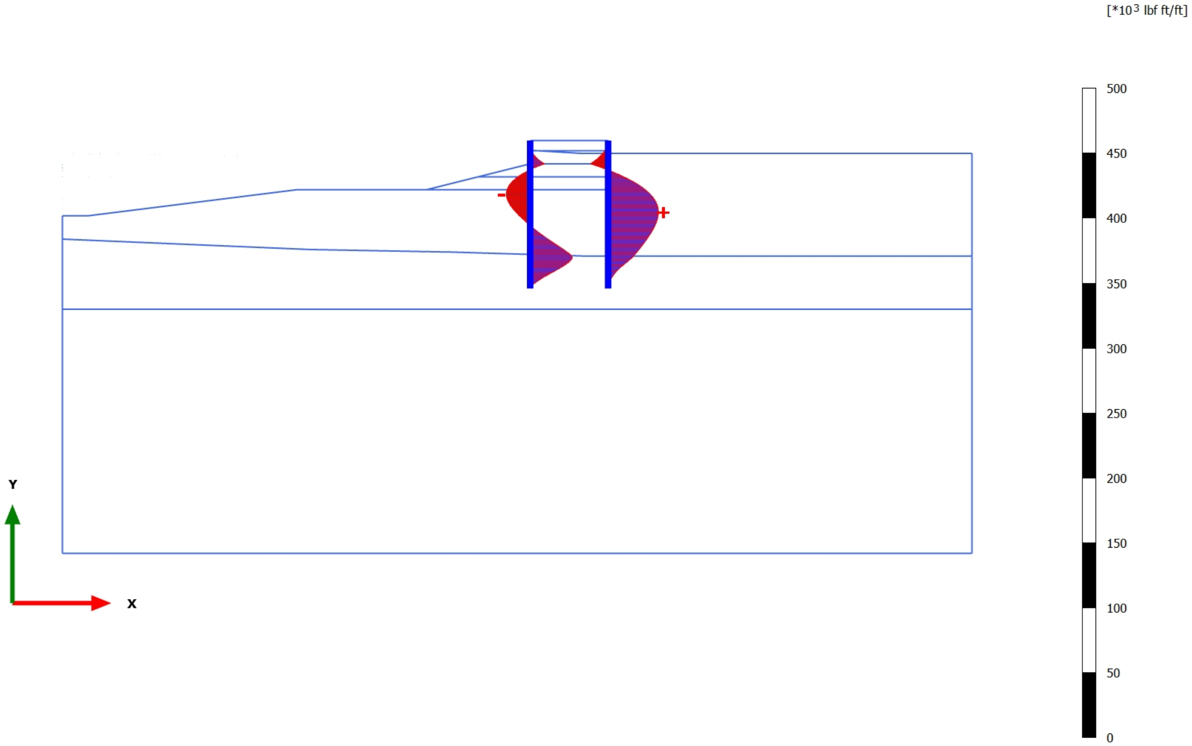


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 29.00*10^{3} lbf ft/ft (Element 32 at Node 11393)

Minimum value = -17.84*10^{3} lbf ft/ft (Element 22 at Node 12990)

3.1.2.2.6 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/58), Bending moments M

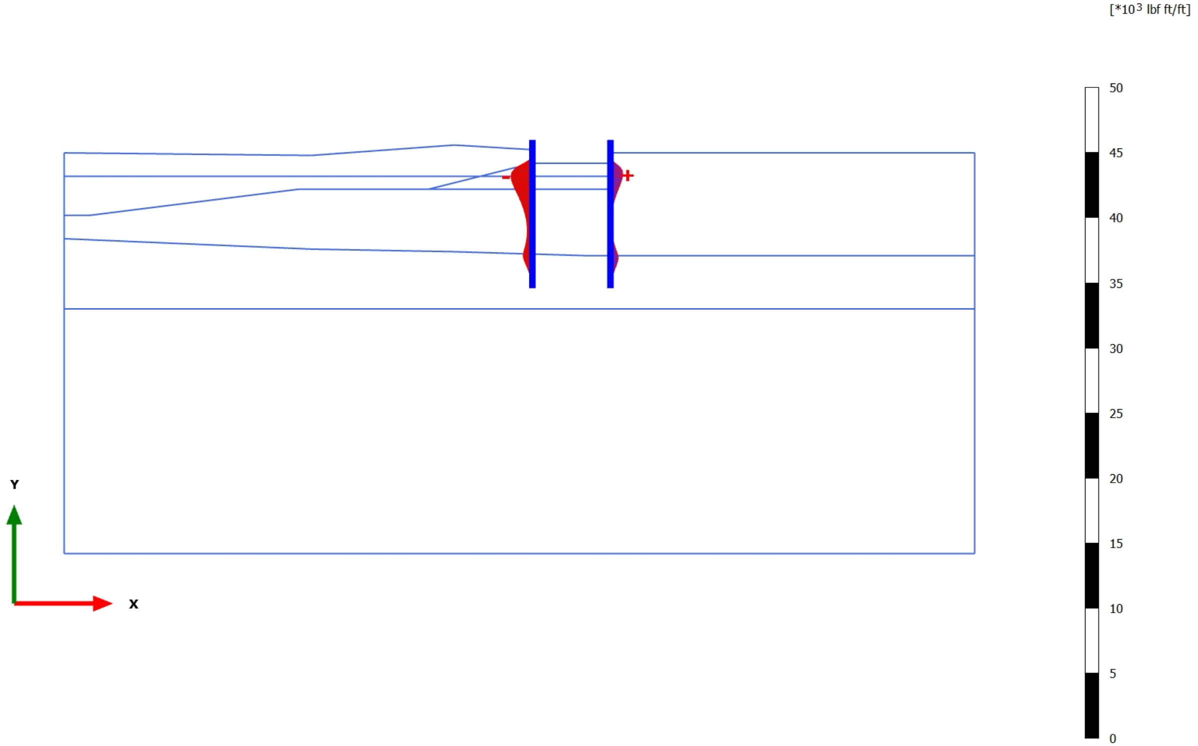


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 38.72*10^3 lbf ft/ft (Element 34 at Node 11881)

Minimum value = -18.37*10^3 lbf ft/ft (Element 22 at Node 12991)

3.1.2.2.7 Calculation results, Plate, Install Rod [Phase_12] (4/138), Bending moments M

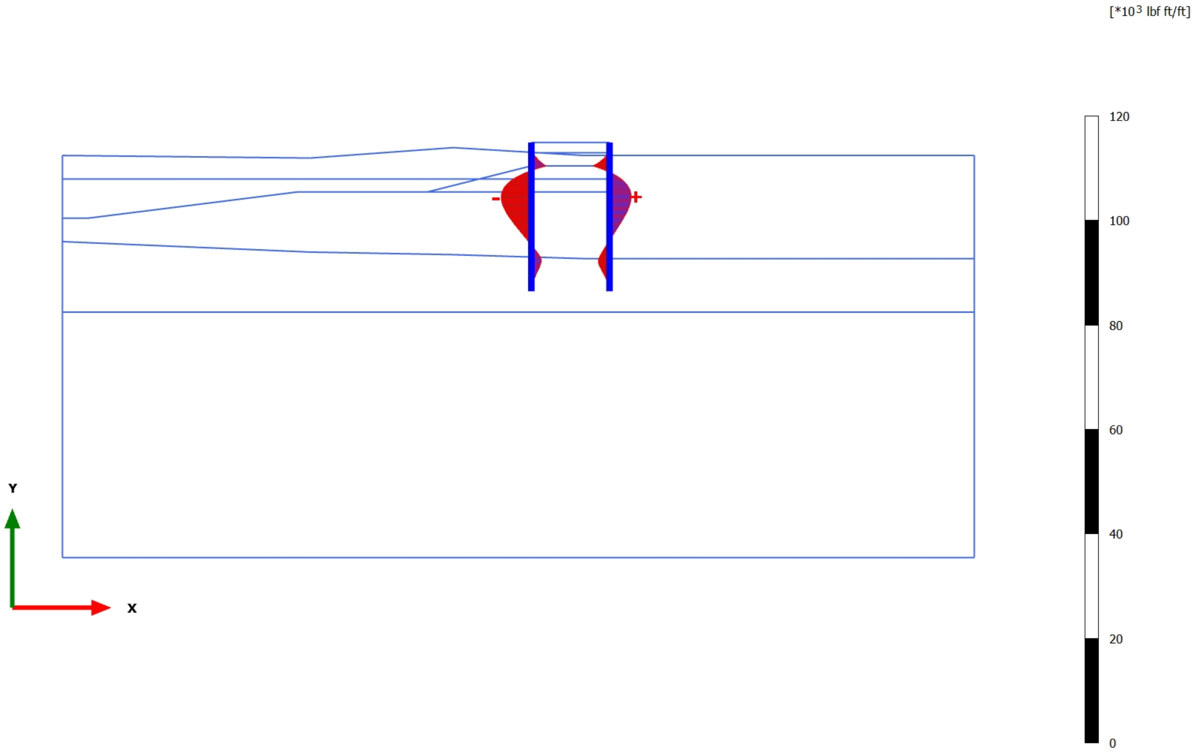


Bending moments M (scaled up 5.00*10^{-3} times)

Maximum value = 942.4 lbf ft/ft (Element 17 at Node 6792)

Minimum value = -1644 lbf ft/ft (Element 15 at Node 10471)

3.1.2.2.8 Calculation results, Plate, Backfill 1 [Phase_6] (6/190), Bending moments M



Bending moments M (scaled up $2.00*10^{-3}$ times)

Maximum value = 4148 lbf ft/ft (Element 31 at Node 9677)

Minimum value = -5777 lbf ft/ft (Element 22 at Node 12990)

3.2.1.1.2 Calculation results, Node-to-node anchor, Dewater-SS [Phase_7] (7/18), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	47.168	-53.811	47.168
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	47.168	-53.811	47.168

3.2.1.1.3 Calculation results, Node-to-node anchor, Excavate 1 [Phase_8] (8/33), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	67.699	-53.811	67.699
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	67.699	-53.811	67.699

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater -SS [Phase_9] (9/43), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	73.769	-53.811	73.769
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	73.769	-53.811	73.769

3.2.1.1.5 Calculation results, Node-to-node anchor, Excavate 2 [Phase_10] (10/49), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	75.459	-53.811	75.459
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	75.459	-53.811	75.459

3.2.1.1.6 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/58), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	92.571	-53.811	92.571
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	92.571	-53.811	92.571

3.2.1.1.7 Calculation results, Node-to-node anchor, Install Rod [Phase_12] (4/138), Table of node-to-node anchors

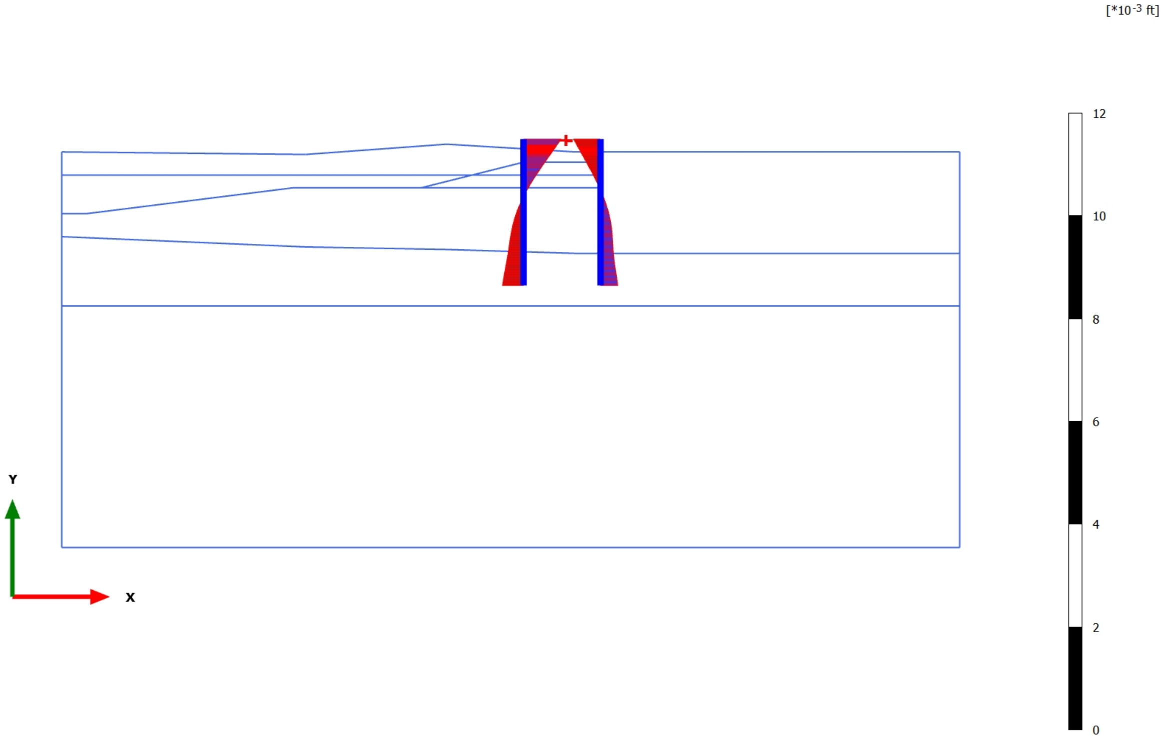
Structural element	Node	Local number	X [ft]	Y [ft]	N [lbf]	N_{min} [lbf]	N_{max} [lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	-53.811	-53.811	0.000
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	-53.811	-53.811	0.000

3.2.1.1.8 Calculation results, Node-to-node anchor, Backfill 1 [Phase_6] (6/190), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	26.567	-53.811	26.567
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	26.567	-53.811	26.567

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Install sheet pilen and tie rod [Phase_1] (1/5), Total displacements u_x

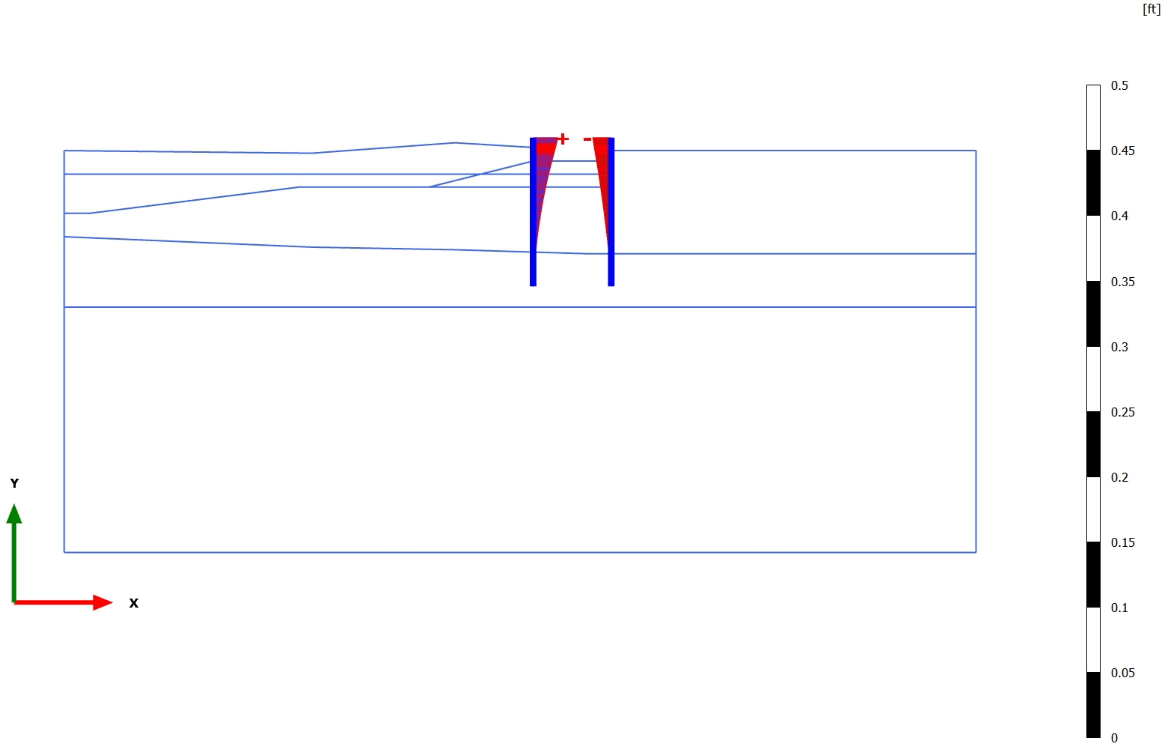


Total displacements u_x (scaled up $20.0*10^3$ times)

Maximum value = $0.7340*10^{-3}$ ft (Element 1 at Node 54)

Minimum value = $-0.5259*10^{-3}$ ft (Element 4 at Node 361)

3.1.1.1.1.2 Calculation results, Plate, Exc [Phase_2] (2/8), Total displacements u_x

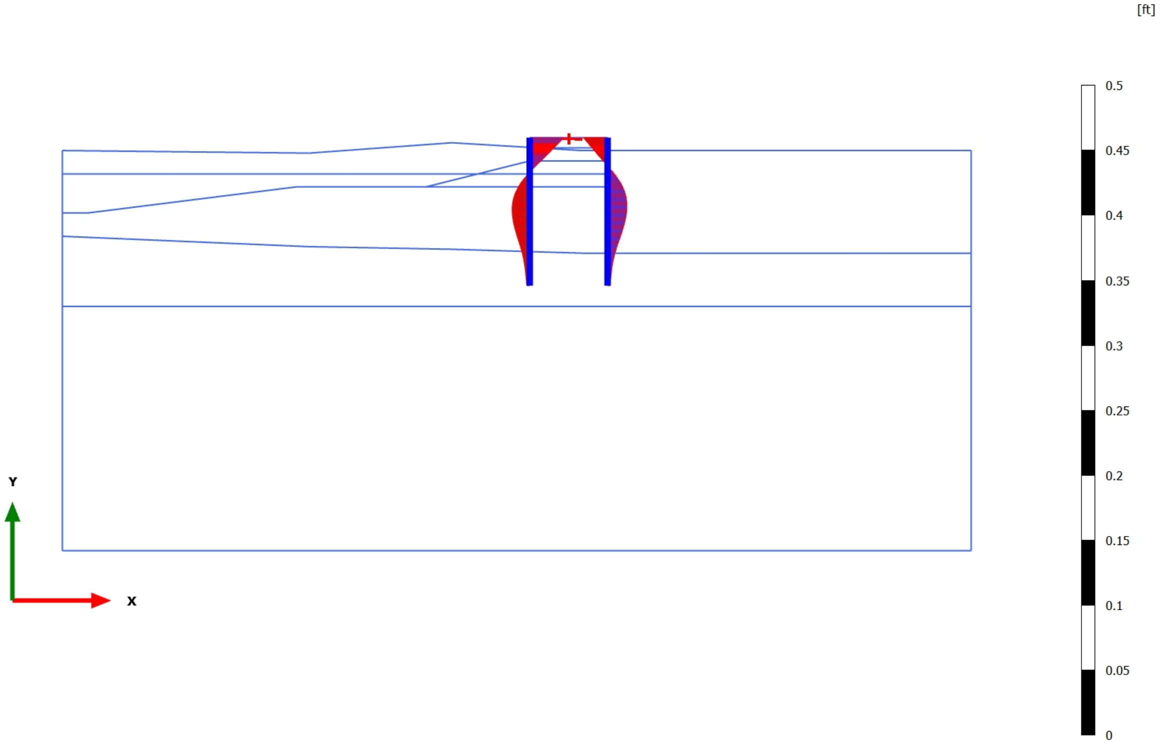


Total displacements u_x (scaled up 500 times)

Maximum value = 0.01919 ft (Element 1 at Node 54)

Minimum value = -0.01425 ft (Element 4 at Node 361)

3.1.1.1.1.3 Calculation results, Plate, Backfill 1 [Phase_6] (6/27), Total displacements u_x

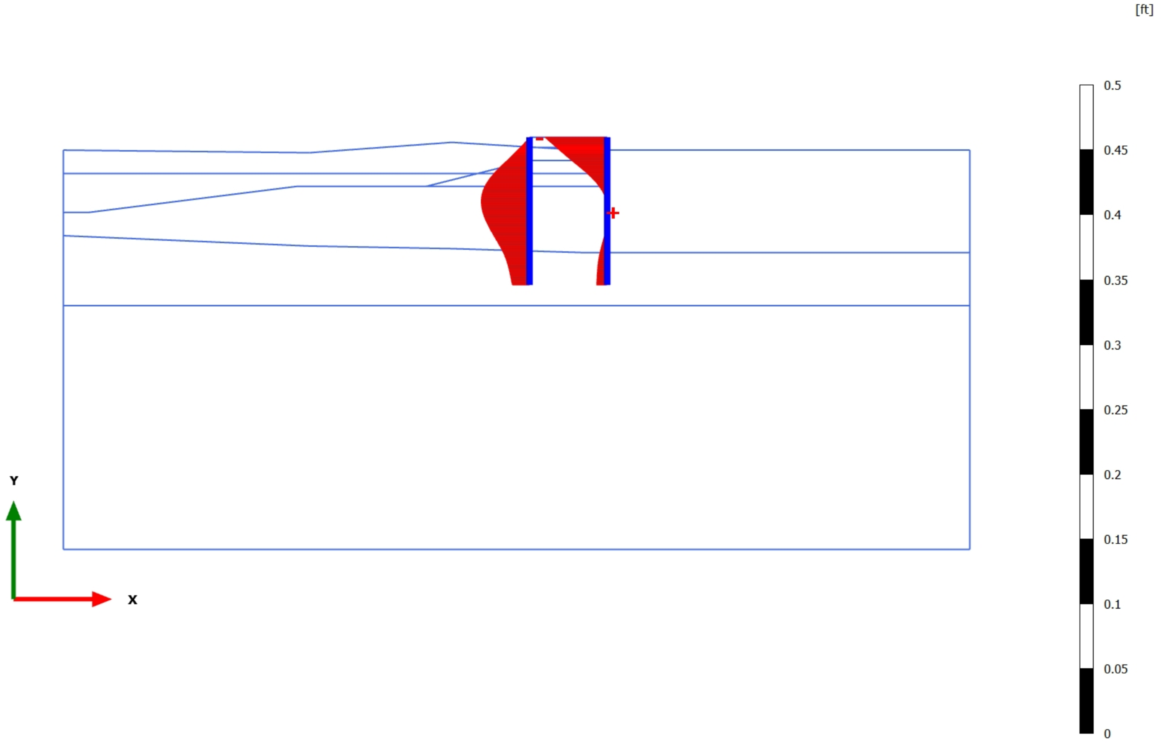


Total displacements u_x (scaled up 500 times)

Maximum value = 0.02650 ft (Element 1 at Node 54)

Minimum value = -0.01872 ft (Element 4 at Node 361)

3.1.1.1.1.4 Calculation results, Plate, Dewater-SS [Phase_7] (7/33), Total displacements u_x

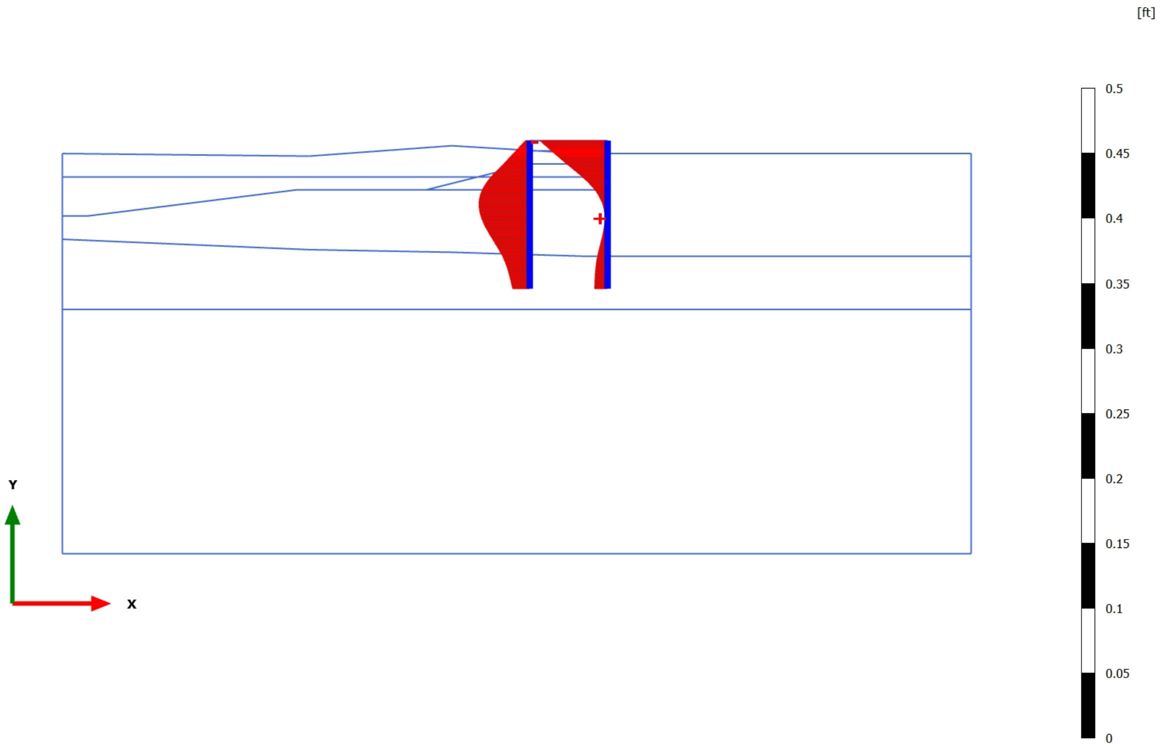


Total displacements u_x (scaled up 500 times)

Maximum value = 0.7291×10^{-3} ft (Element 34 at Node 11883)

Minimum value = -0.04828 ft (Element 4 at Node 361)

3.1.1.1.1.5 Calculation results, Plate, Consolidate [Phase_3] (3/47), Total displacements u_x

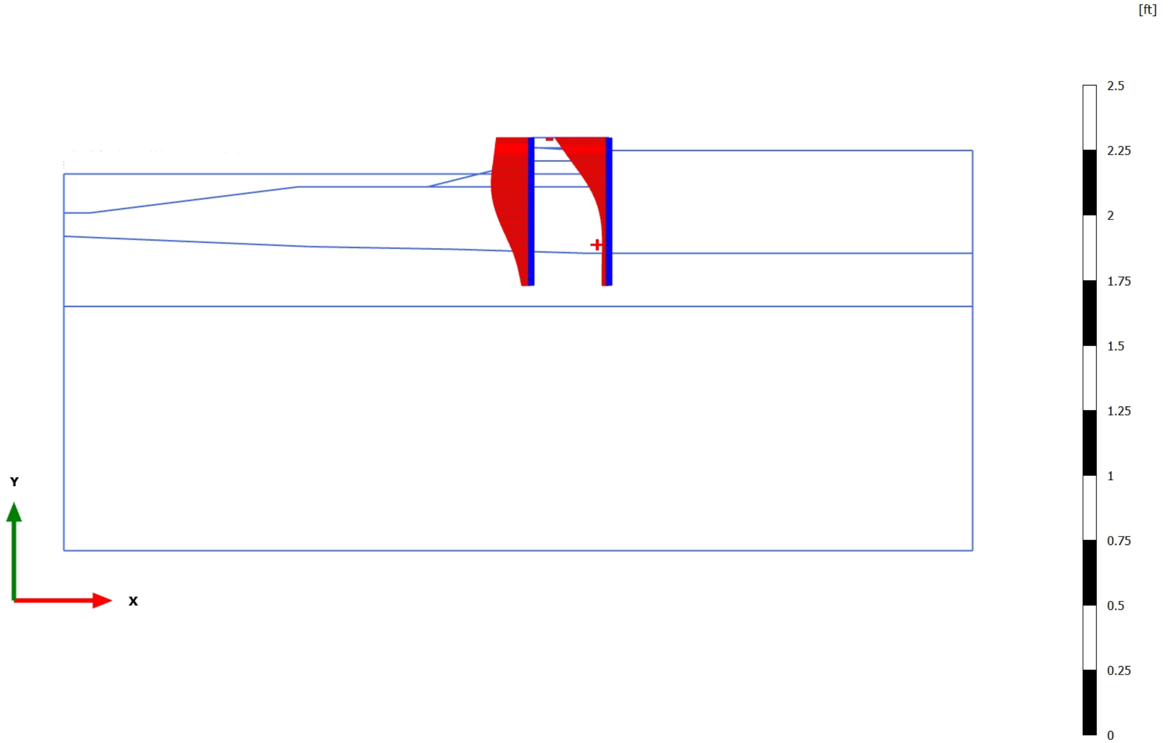


Total displacements u_x (scaled up 500 times) (Time 4.000 day)

Maximum value = -2.057×10^{-3} ft (Element 34 at Node 11882)

Minimum value = -0.05225 ft (Element 4 at Node 361)

3.1.1.1.1.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/63), Total displacements u_x

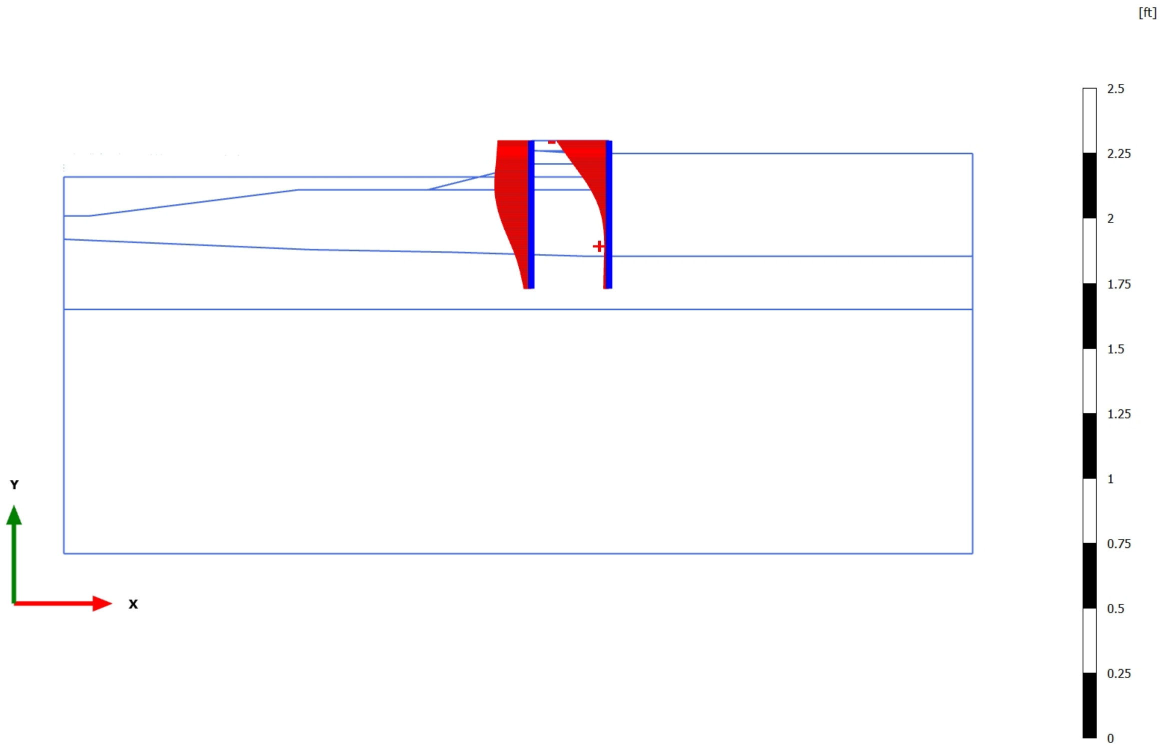


Total displacements u_x (scaled up 100 times)

Maximum value = -0.02601 ft (Element 38 at Node 15102)

Minimum value = -0.2092 ft (Element 4 at Node 361)

3.1.1.1.1.7 Calculation results, Plate, Consolidate [Phase_5] (5/79), Total displacements u_x

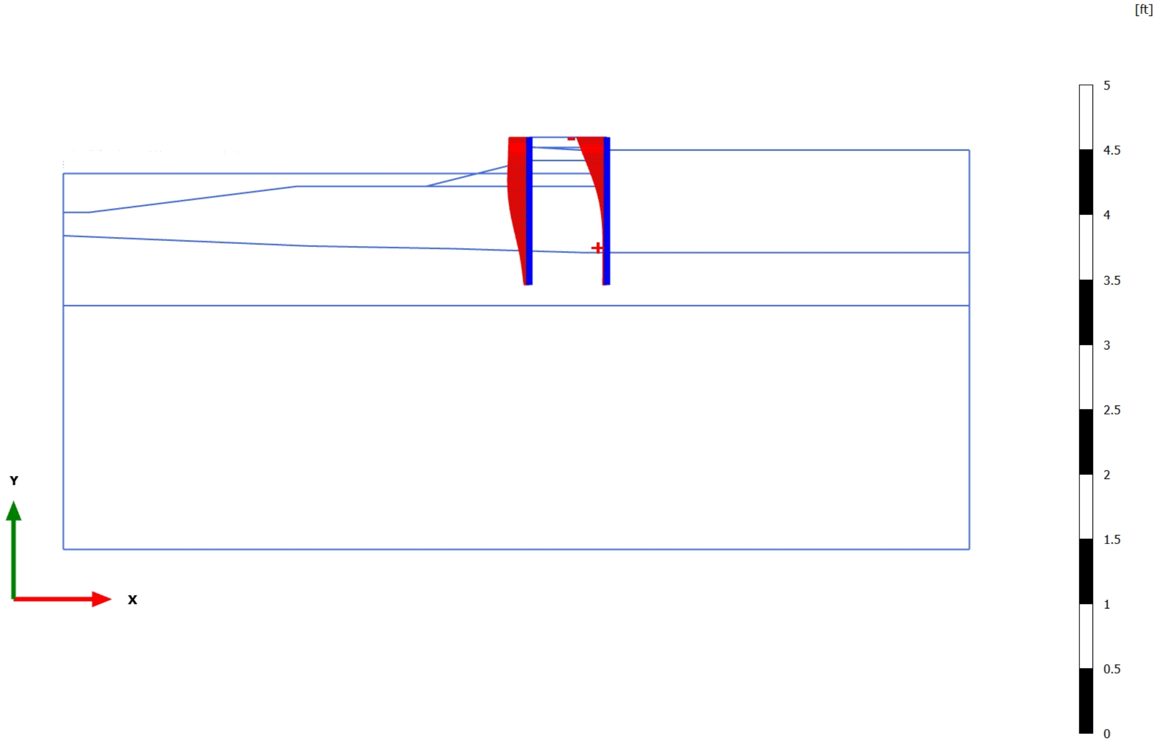


Total displacements u_x (scaled up 100 times) (Time 18.00 day)

Maximum value = -0.01766 ft (Element 38 at Node 15103)

Minimum value = -0.2028 ft (Element 4 at Node 361)

3.1.1.1.1.8 Calculation results, Plate, Dewater -SS [Phase_9] (9/85), Total displacements u_x

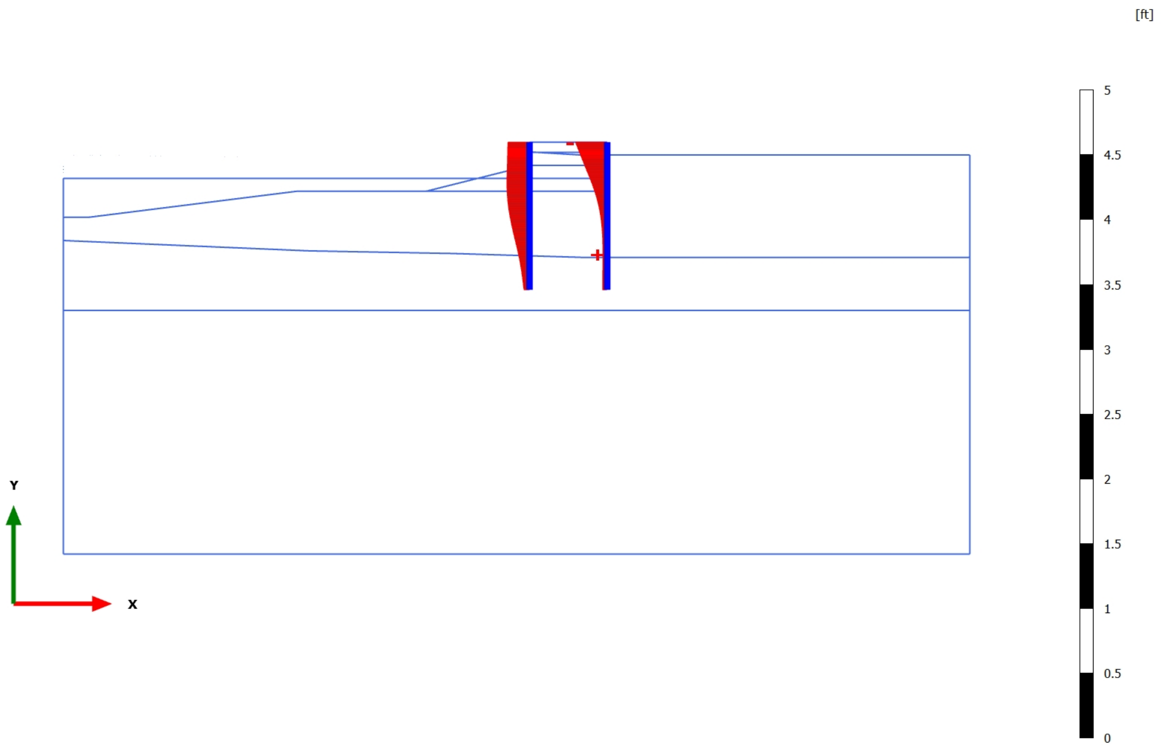


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.03150 ft (Element 39 at Node 16292)

Minimum value = -0.2355 ft (Element 4 at Node 361)

3.1.1.1.1.9 Calculation results, Plate, Consolidate [Phase_13] (13/91), Total displacements u_x

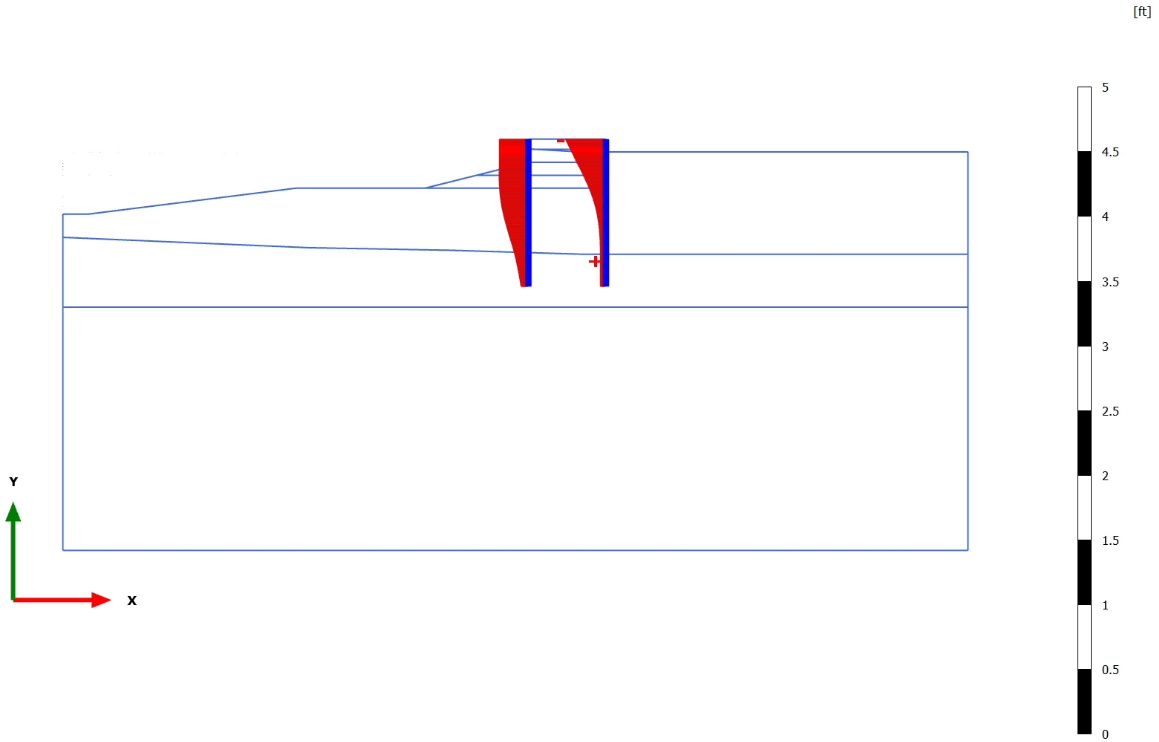


Total displacements u_x (scaled up 50.0 times) (Time 21.00 day)

Maximum value = -0.03373 ft (Element 39 at Node 16291)

Minimum value = -0.2456 ft (Element 4 at Node 361)

3.1.1.1.1.10 Calculation results, Plate, Excavate 2 [Phase_10] (10/100), Total displacements u_x

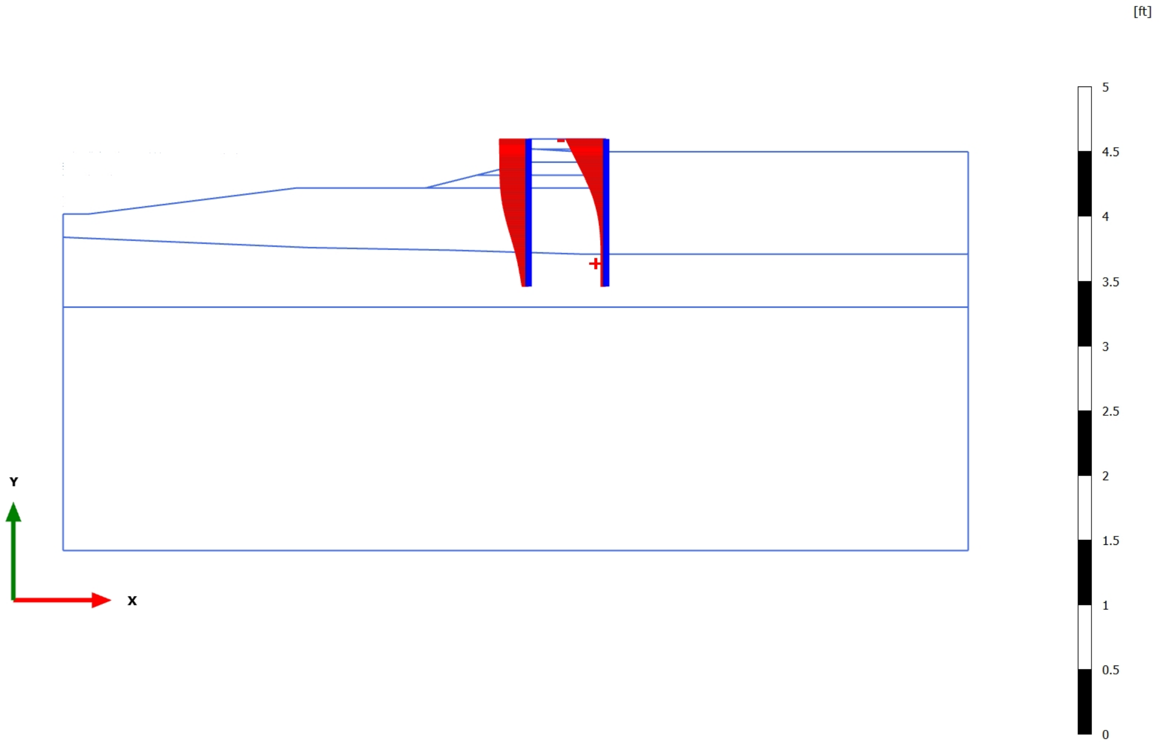


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.04338 ft (Element 45 at Node 17098)

Minimum value = -0.3136 ft (Element 4 at Node 361)

3.1.1.1.1.11 Calculation results, Plate, Consolidate [Phase_14] (14/110), Total displacements u_x

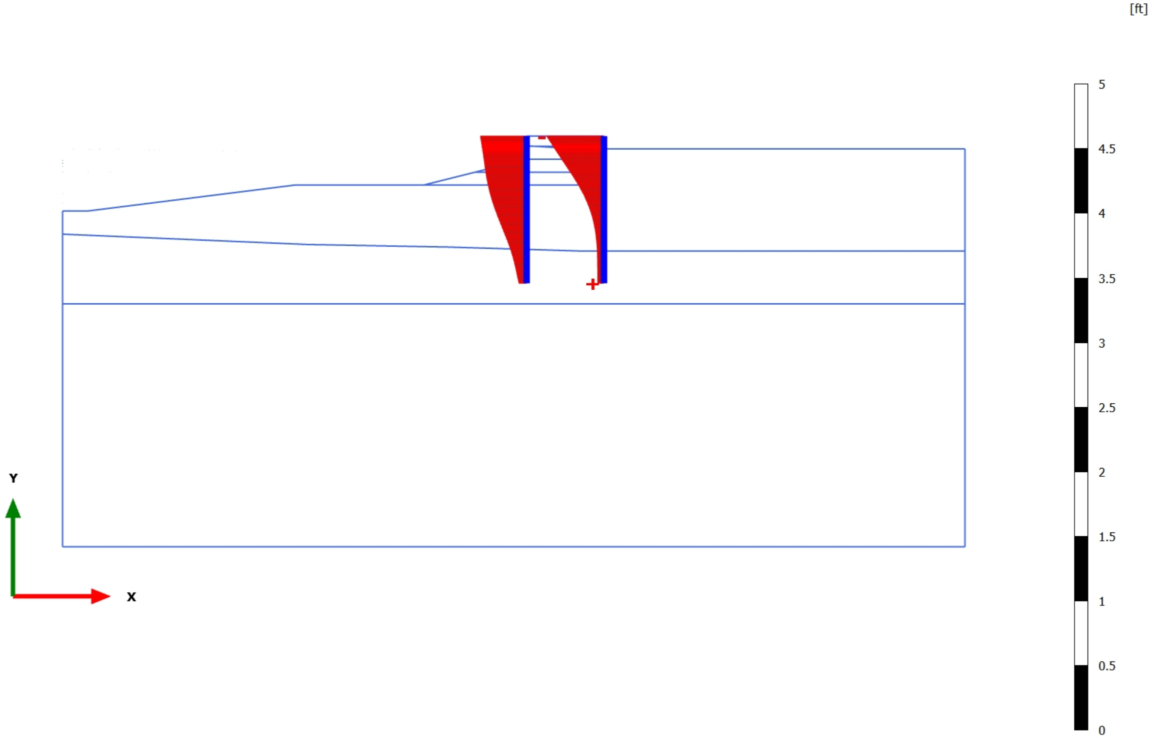


Total displacements u_x (scaled up 50.0 times) (Time 35.00 day)

Maximum value = -0.04016 ft (Element 45 at Node 17451)

Minimum value = -0.3132 ft (Element 4 at Node 361)

3.1.1.1.1.12 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/121), Total displacements u_x

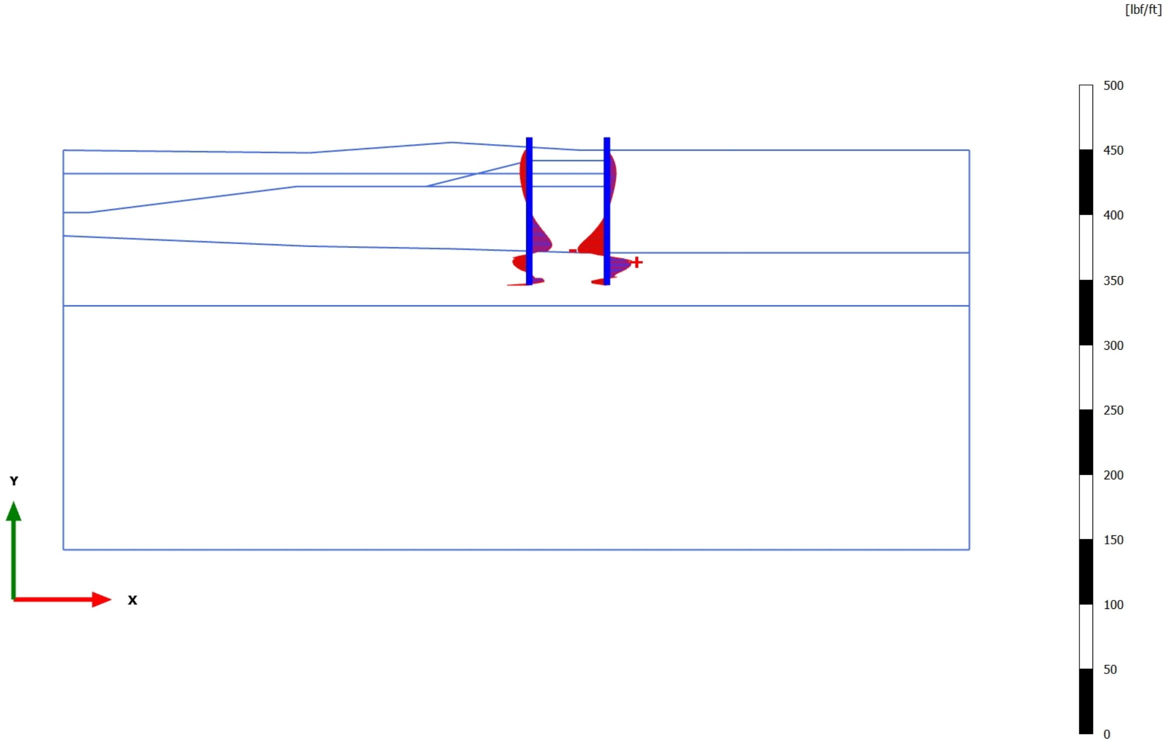


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.04737 ft (Element 48 at Node 18484)

Minimum value = -0.4441 ft (Element 4 at Node 361)

3.1.2.1.1 Calculation results, Plate, Install sheet pilen and tie rod [Phase_1] (1/5), Shear forces Q

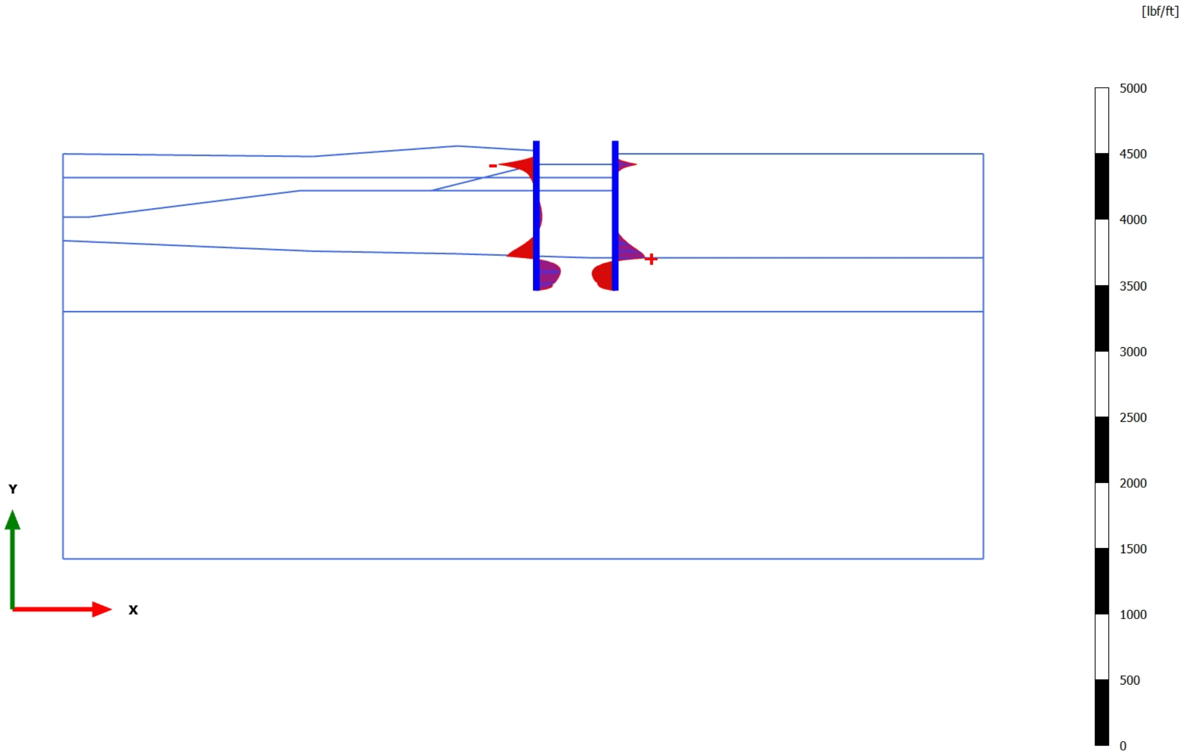


Shear forces Q (scaled up 0.500 times)

Maximum value = 19.11 lbf/ft (Element 45 at Node 17451)

Minimum value = -22.45 lbf/ft (Element 39 at Node 16291)

3.1.2.1.2 Calculation results, Plate, Exc [Phase_2] (2/8), Shear forces Q

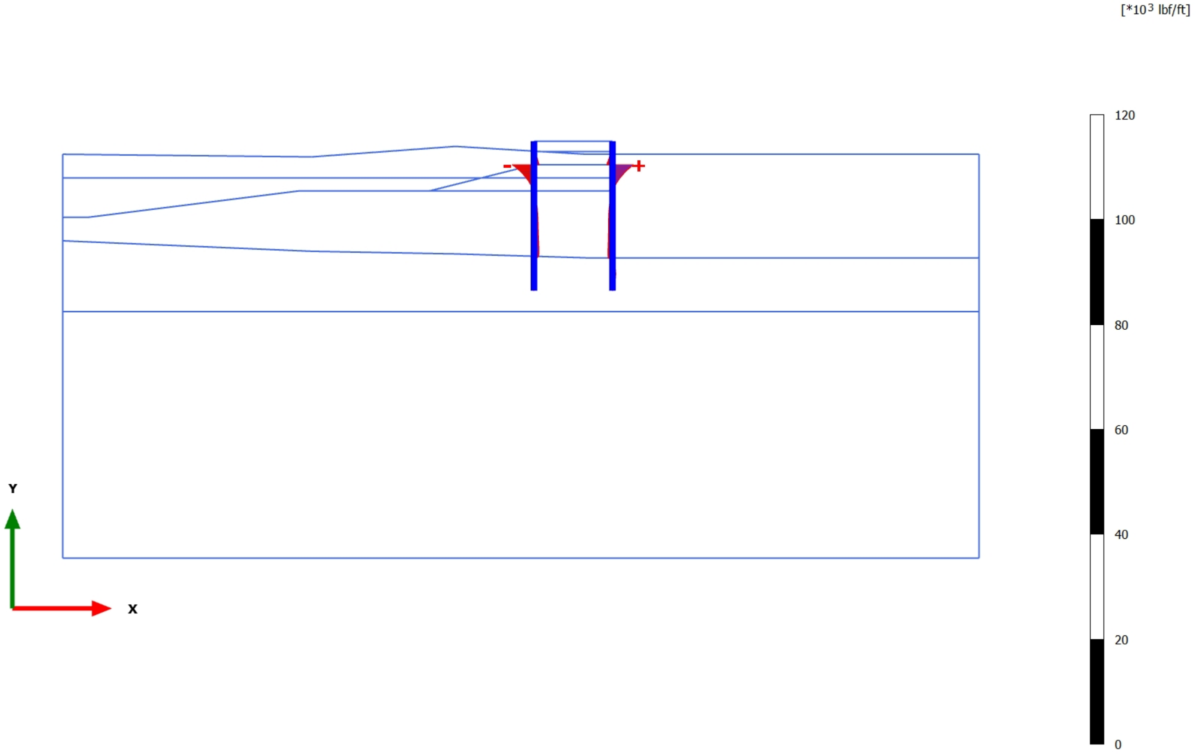


Shear forces Q (scaled up 0.0500 times)

Maximum value = 237.6 lbf/ft (Element 45 at Node 17097)

Minimum value = -290.5 lbf/ft (Element 11 at Node 7709)

3.1.2.1.3 Calculation results, Plate, Backfill 1 [Phase_6] (6/27), Shear forces Q

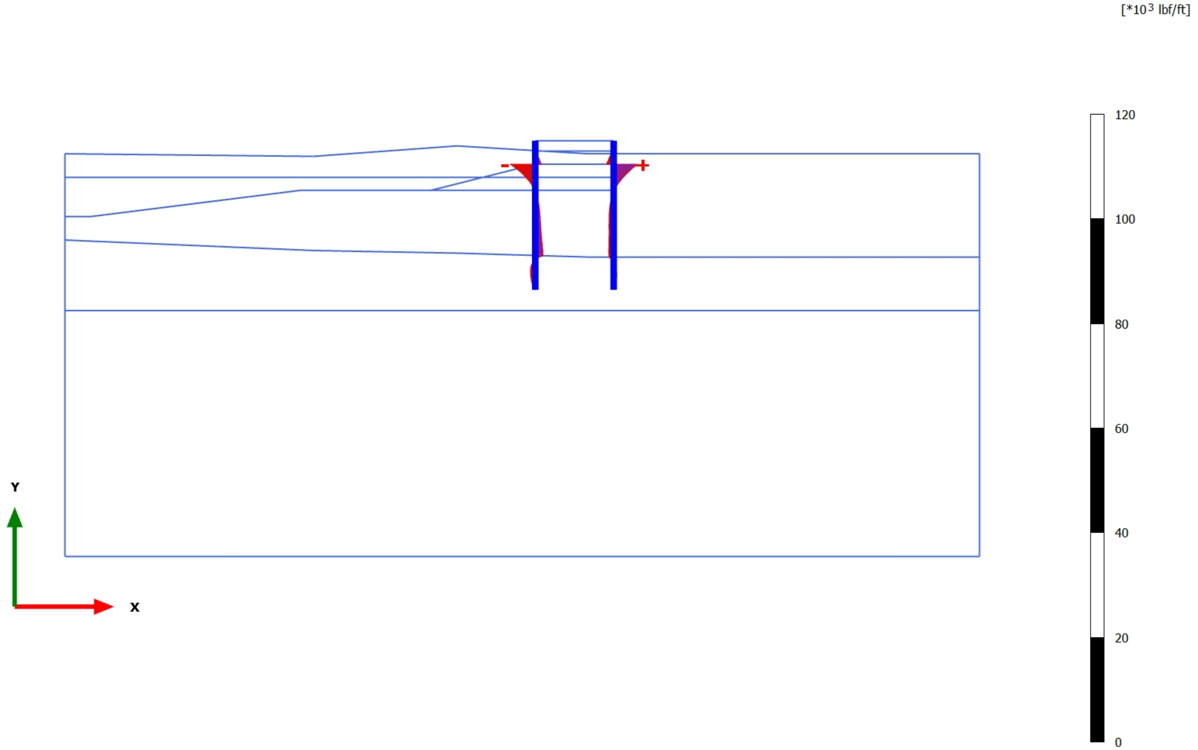


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 4056 lbf/ft (Element 16 at Node 5729)

Minimum value = -4169 lbf/ft (Element 14 at Node 7709)

3.1.2.1.4 Calculation results, Plate, Dewater-SS [Phase_7] (7/33), Shear forces Q

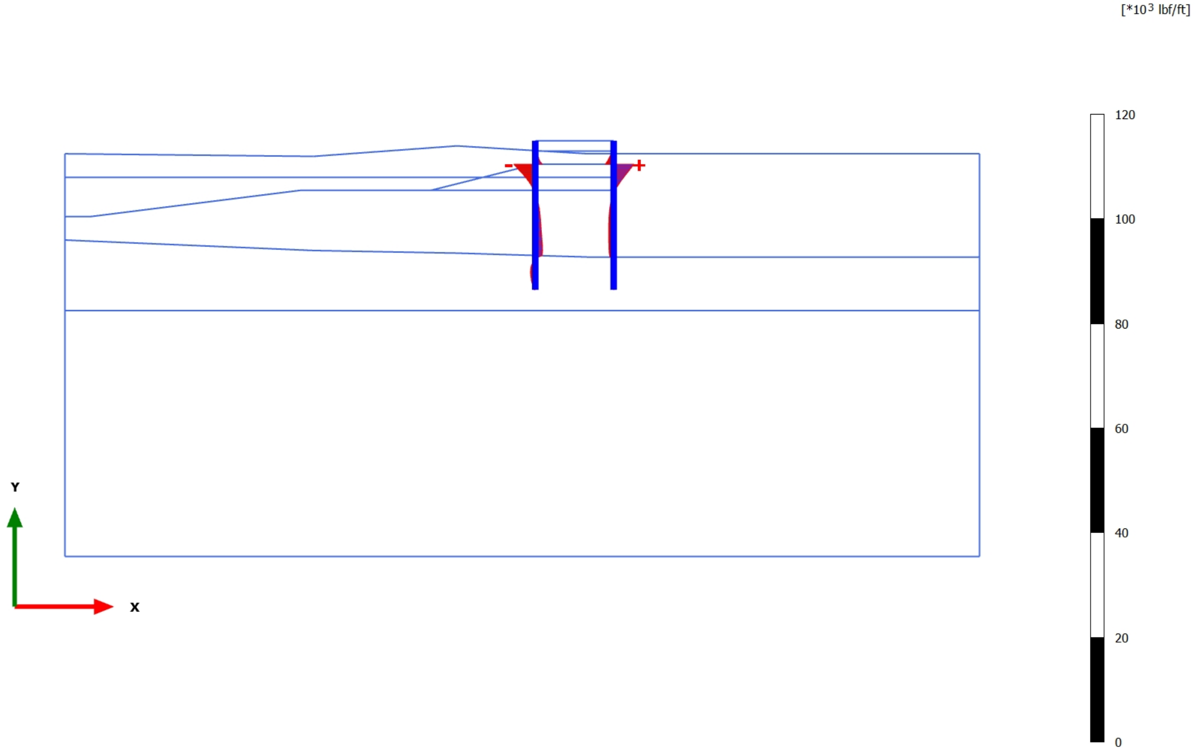


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 4628 lbf/ft (Element 16 at Node 5729)

Minimum value = -4811 lbf/ft (Element 14 at Node 7709)

3.1.2.1.5 Calculation results, Plate, Consolidate [Phase_3] (3/47), Shear forces Q

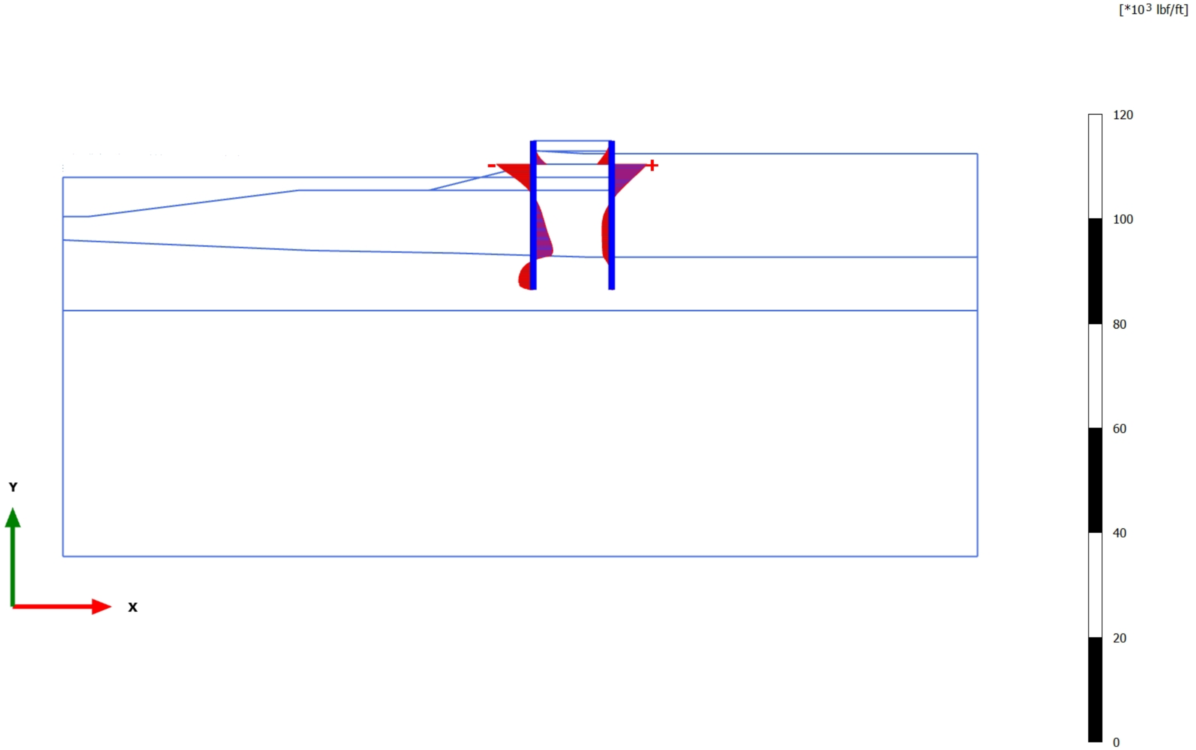


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 4.000 day)

Maximum value = 3889 lbf/ft (Element 16 at Node 5729)

Minimum value = -4158 lbf/ft (Element 14 at Node 7709)

3.1.2.1.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/63), Shear forces Q

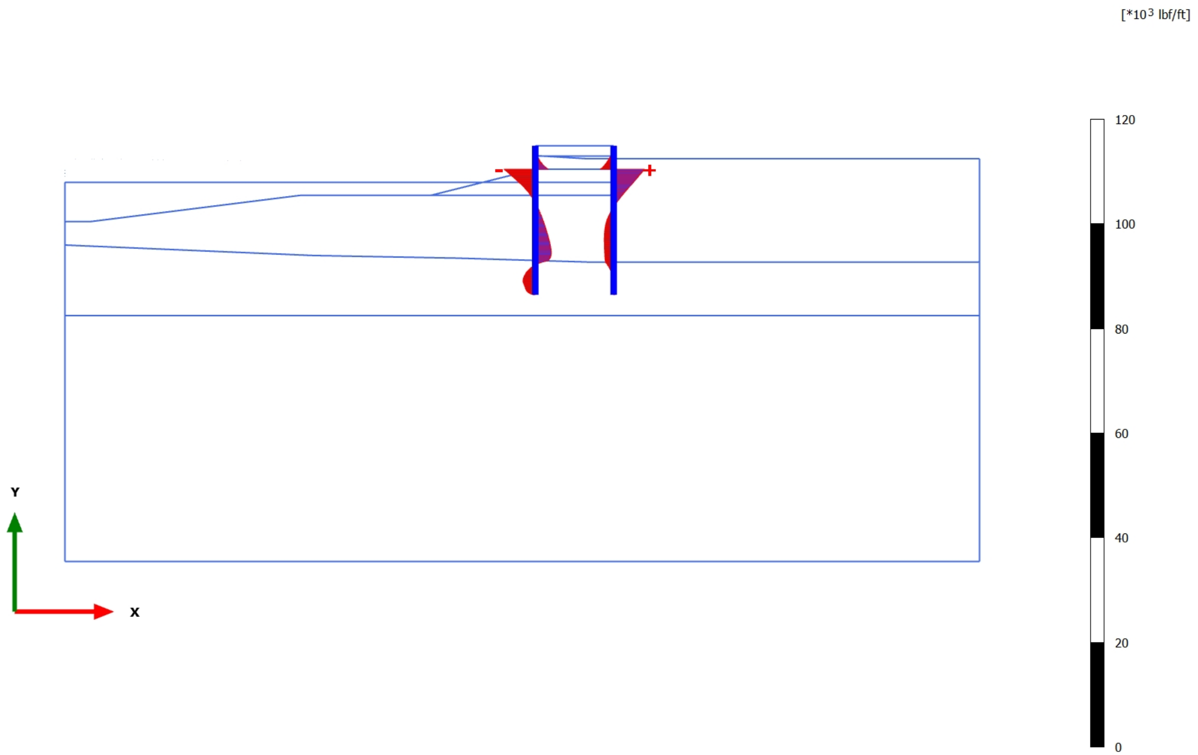


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 6780 lbf/ft (Element 16 at Node 5729)

Minimum value = -7059 lbf/ft (Element 14 at Node 7709)

3.1.2.1.7 Calculation results, Plate, Consolidate [Phase_5] (5/79), Shear forces Q

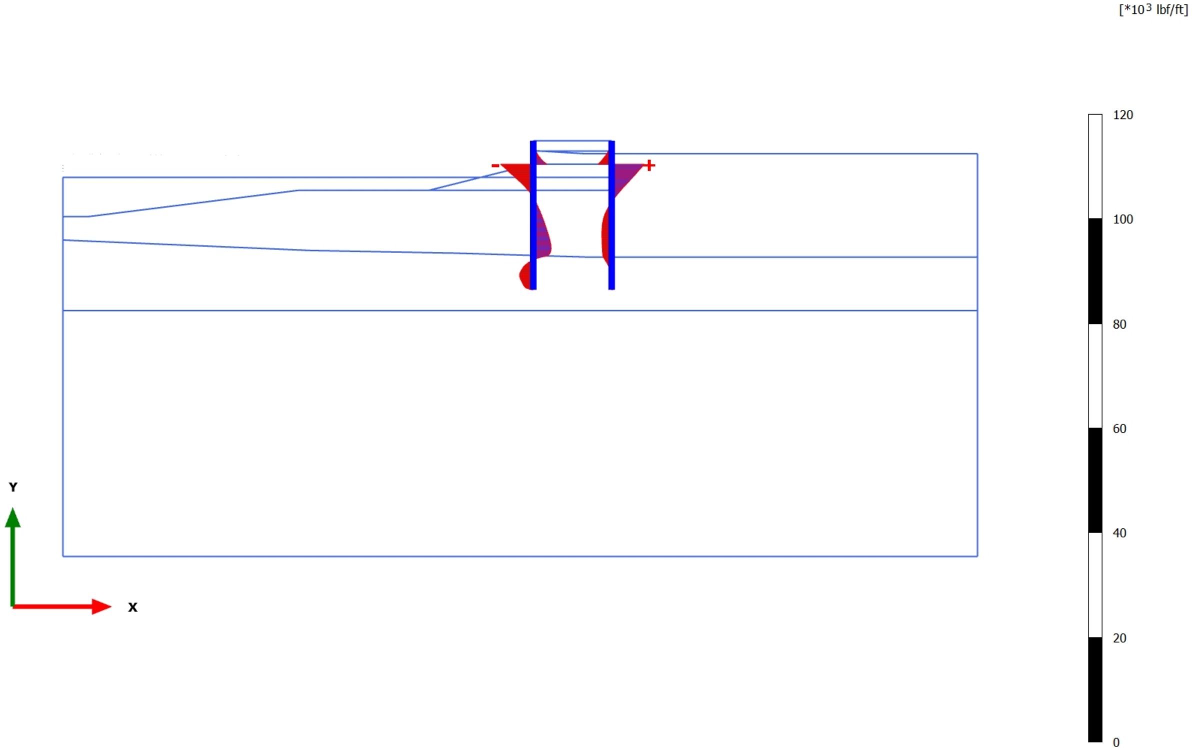


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 18.00 day)

Maximum value = 5959 lbf/ft (Element 16 at Node 5729)

Minimum value = -6009 lbf/ft (Element 14 at Node 7709)

3.1.2.1.8 Calculation results, Plate, Dewater -SS [Phase_9] (9/85), Shear forces Q

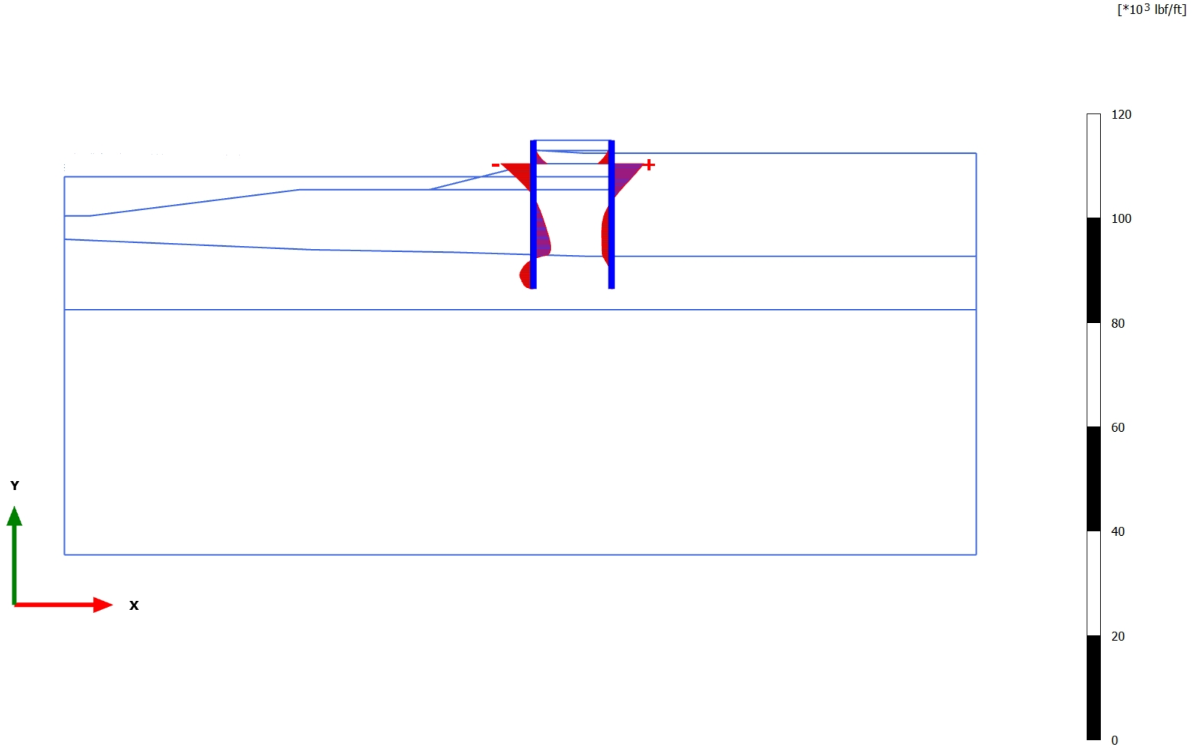


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 6275 lbf/ft (Element 16 at Node 5729)

Minimum value = -6303 lbf/ft (Element 14 at Node 7709)

3.1.2.1.9 Calculation results, Plate, Consolidate [Phase_13] (13/91), Shear forces Q

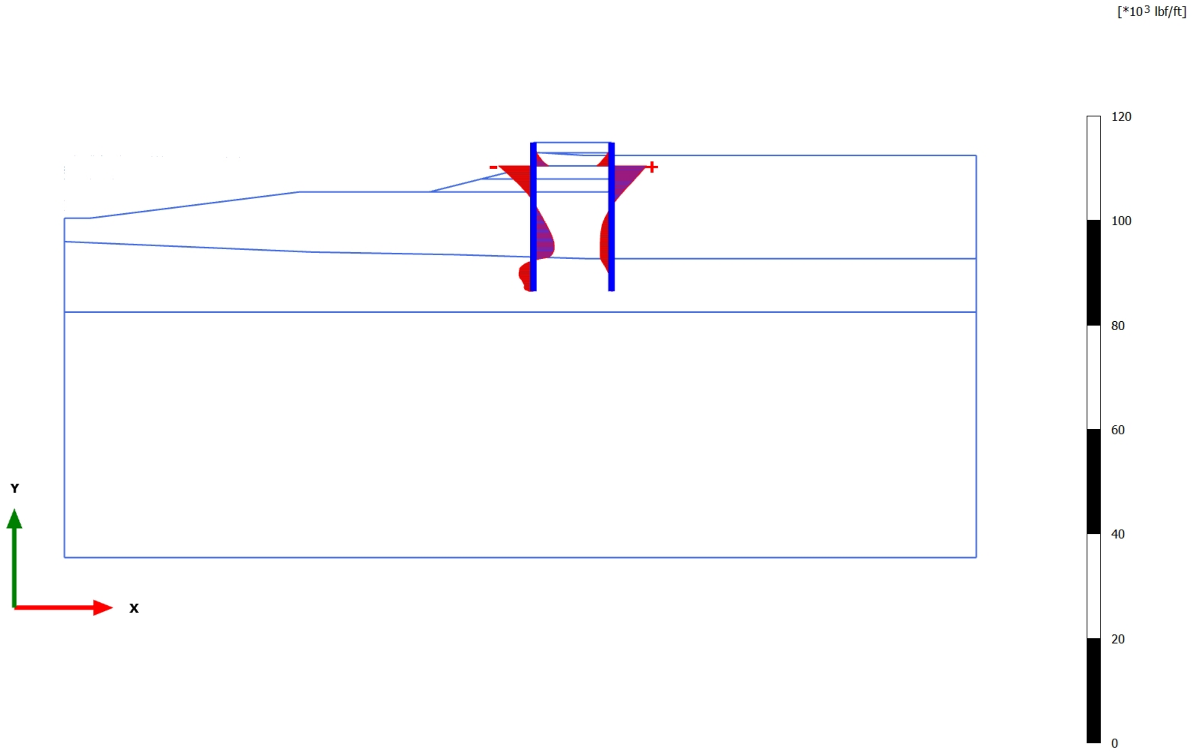


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 21.00 day)

Maximum value = 6262 lbf/ft (Element 16 at Node 5729)

Minimum value = -6251 lbf/ft (Element 14 at Node 7709)

3.1.2.1.10 Calculation results, Plate, Excavate 2 [Phase_10] (10/100), Shear forces Q

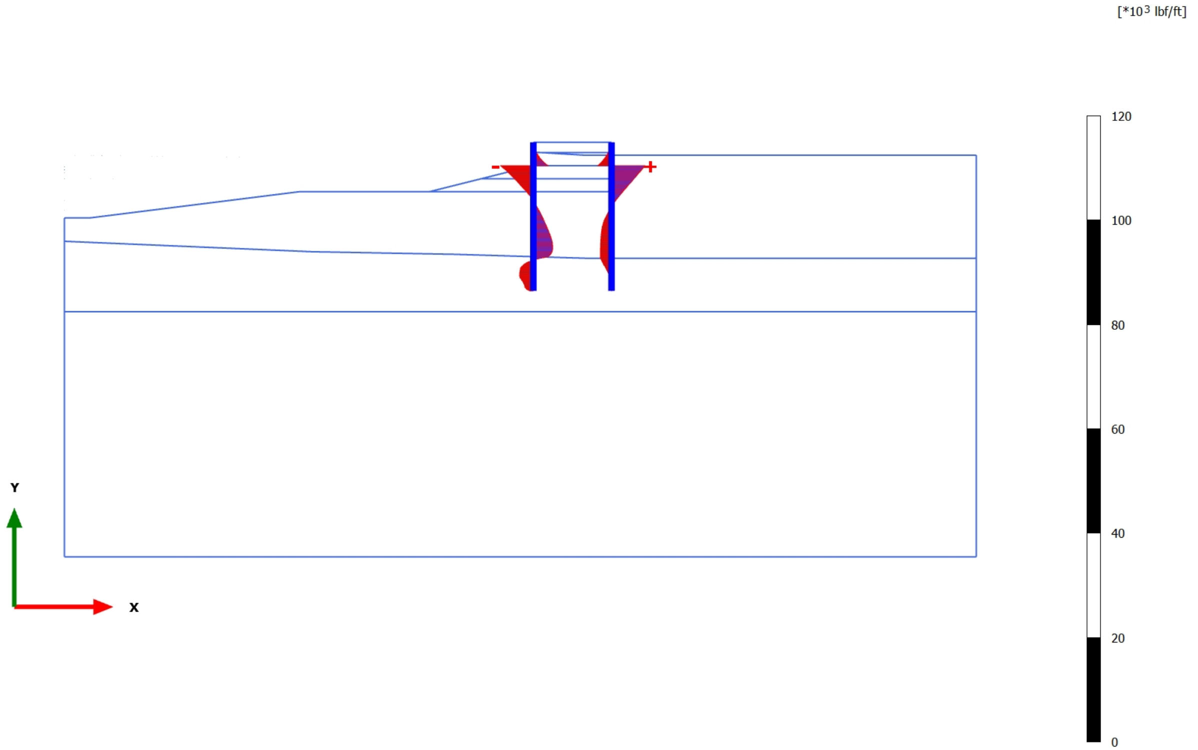


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 6766 lbf/ft (Element 16 at Node 5729)

Minimum value = -6698 lbf/ft (Element 14 at Node 7709)

3.1.2.1.11 Calculation results, Plate, Consolidate [Phase_14] (14/110), Shear forces Q

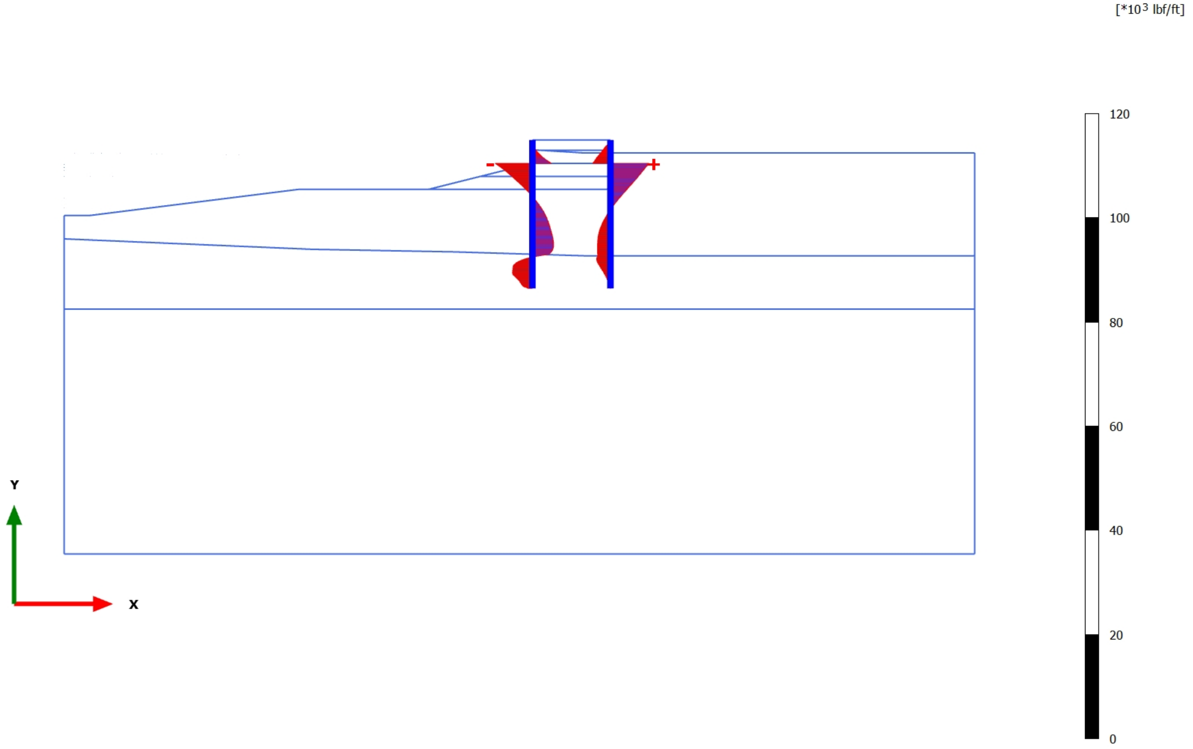


Shear forces Q (scaled up 2.00*10^{-3} times) (Time 35.00 day)

Maximum value = 6508 lbf/ft (Element 16 at Node 5729)

Minimum value = -6337 lbf/ft (Element 14 at Node 7709)

3.1.2.1.12 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/121), Shear forces Q

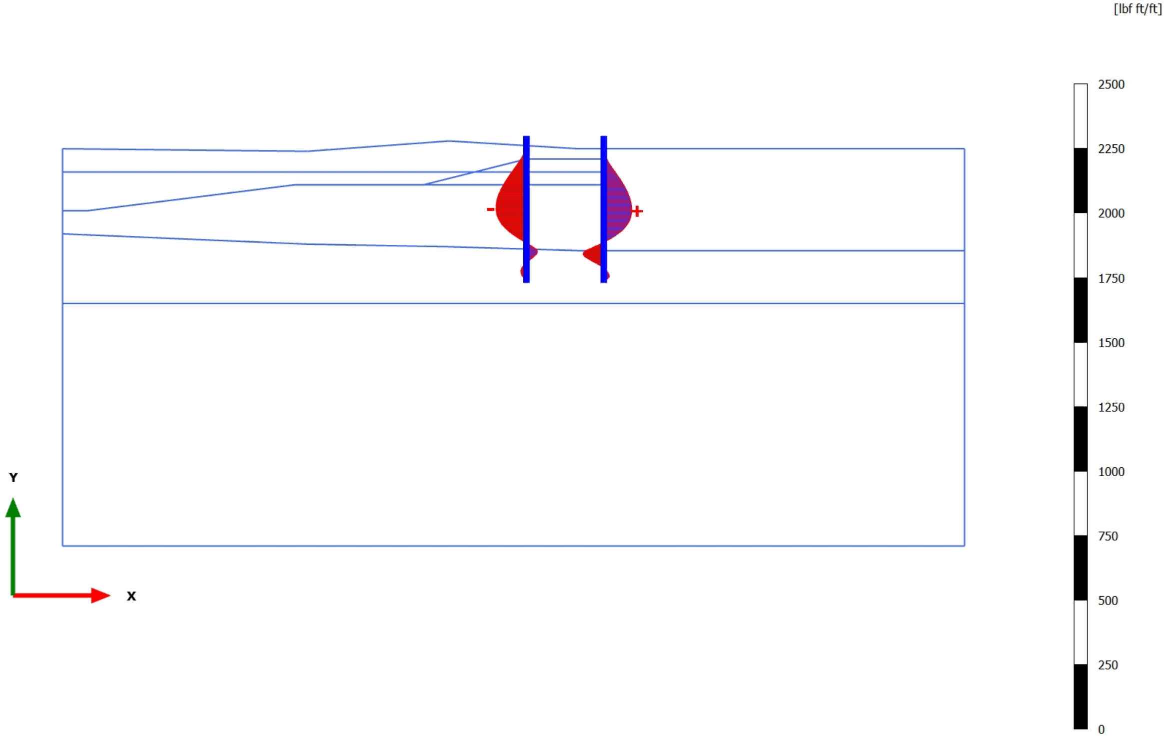


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 7430 lbf/ft (Element 16 at Node 5729)

Minimum value = -7174 lbf/ft (Element 14 at Node 7709)

3.1.2.2.1 Calculation results, Plate, Install sheet pilen and tie rod [Phase_1] (1/5), Bending moments M

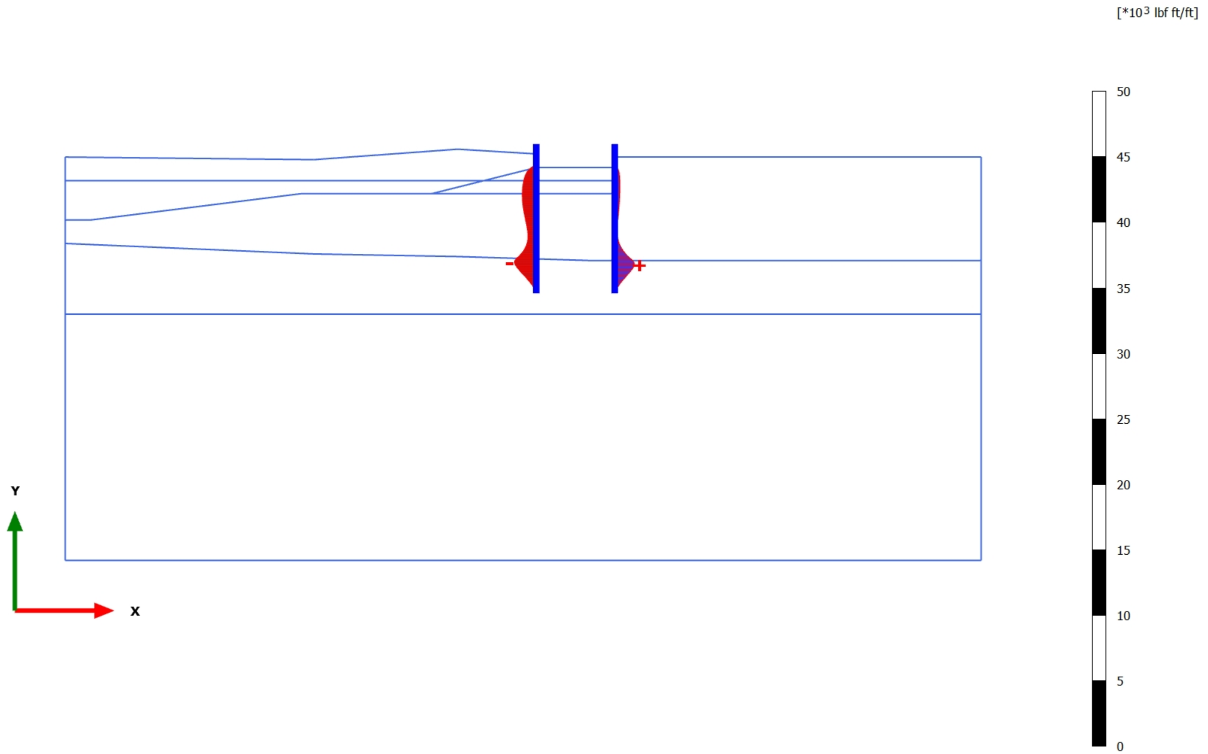


Bending moments M (scaled up 0.100 times)

Maximum value = 109.1 lbf ft/ft (Element 34 at Node 11883)

Minimum value = -118.5 lbf ft/ft (Element 25 at Node 15220)

3.1.2.2.2 Calculation results, Plate, Exc [Phase_2] (2/8), Bending moments M

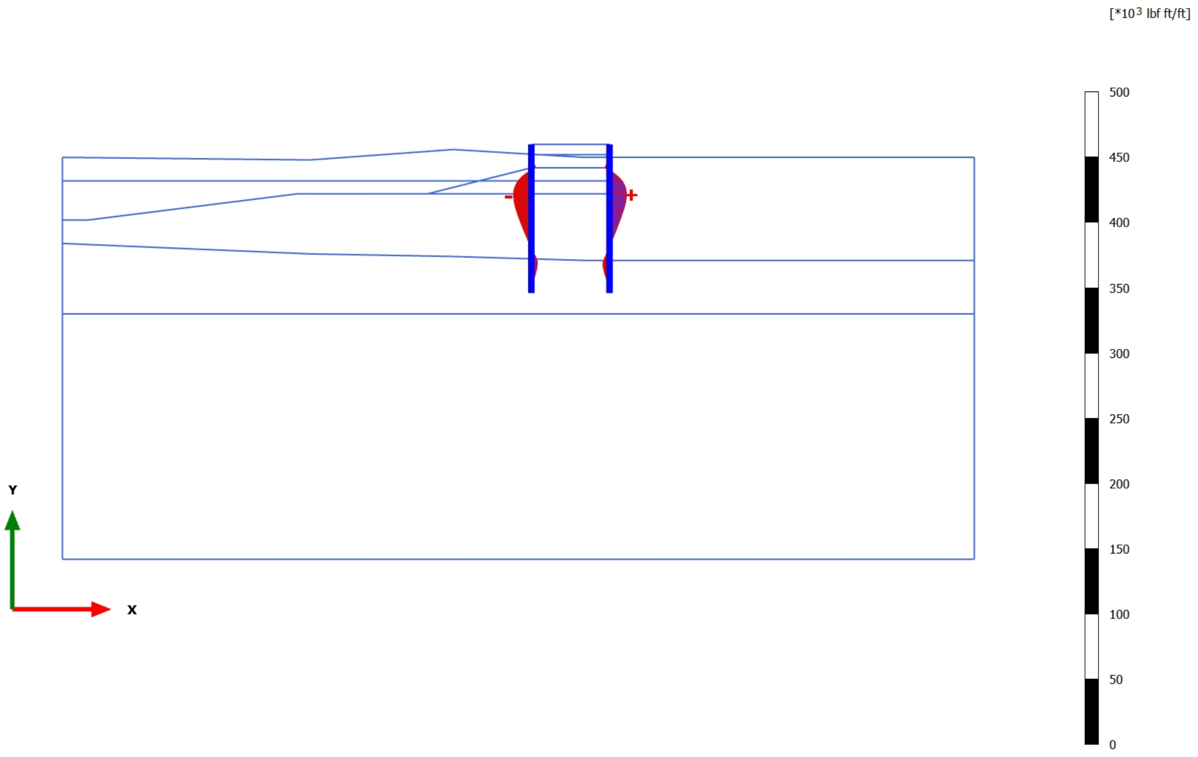


Bending moments M (scaled up $5.00*10^{-3}$ times)

Maximum value = 1501 lbf ft/ft (Element 45 at Node 17099)

Minimum value = -1665 lbf ft/ft (Element 40 at Node 18461)

3.1.2.2.3 Calculation results, Plate, Backfill 1 [Phase_6] (6/27), Bending moments M

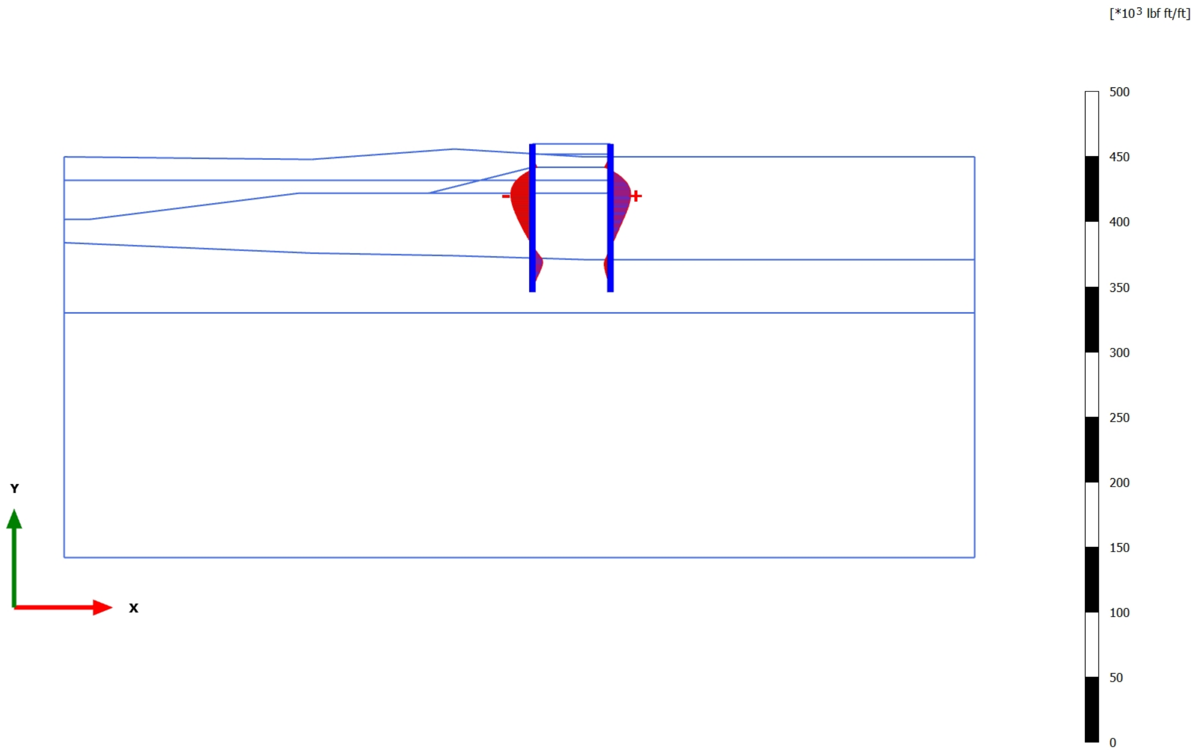


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $13.00*10^{3}$ lbf ft/ft (Element 31 at Node 9675)

Minimum value = $-13.67*10^{3}$ lbf ft/ft (Element 22 at Node 12992)

3.1.2.2.4 Calculation results, Plate, Dewater-SS [Phase_7] (7/33), Bending moments M

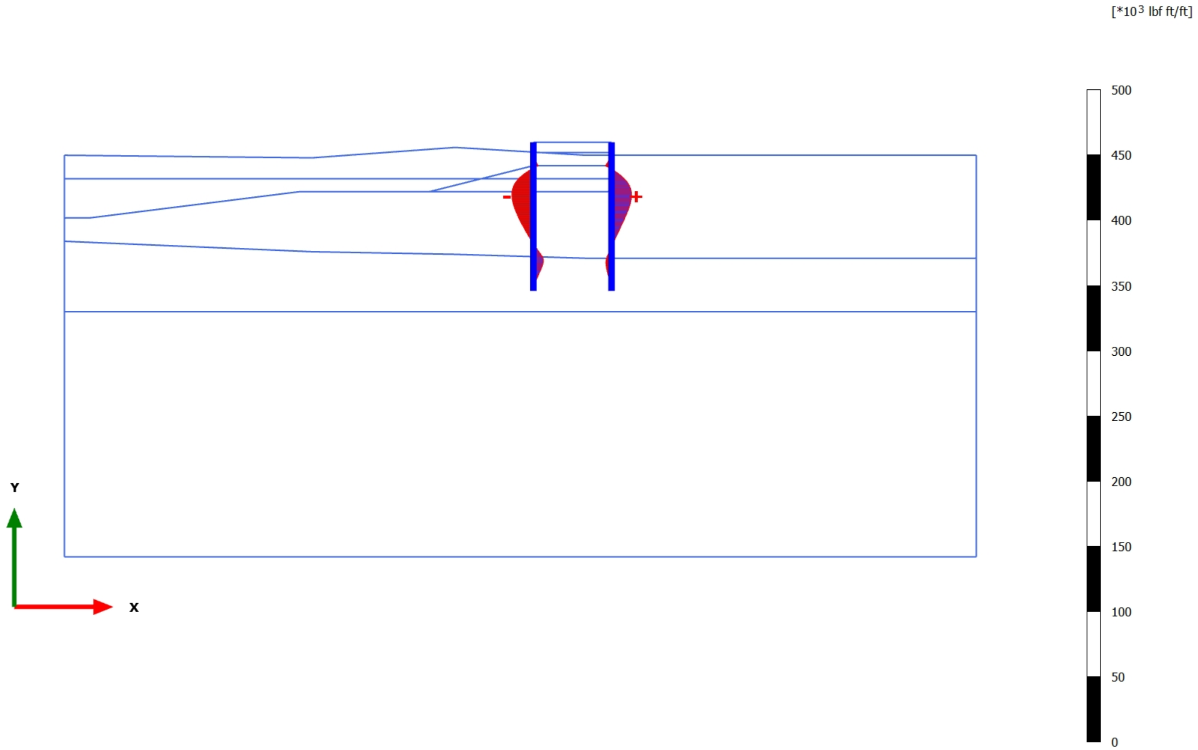


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $15.58*10^3$ lbf ft/ft (Element 31 at Node 9678)

Minimum value = $-16.64*10^3$ lbf ft/ft (Element 22 at Node 12992)

3.1.2.2.5 Calculation results, Plate, Consolidate [Phase_3] (3/47), Bending moments M

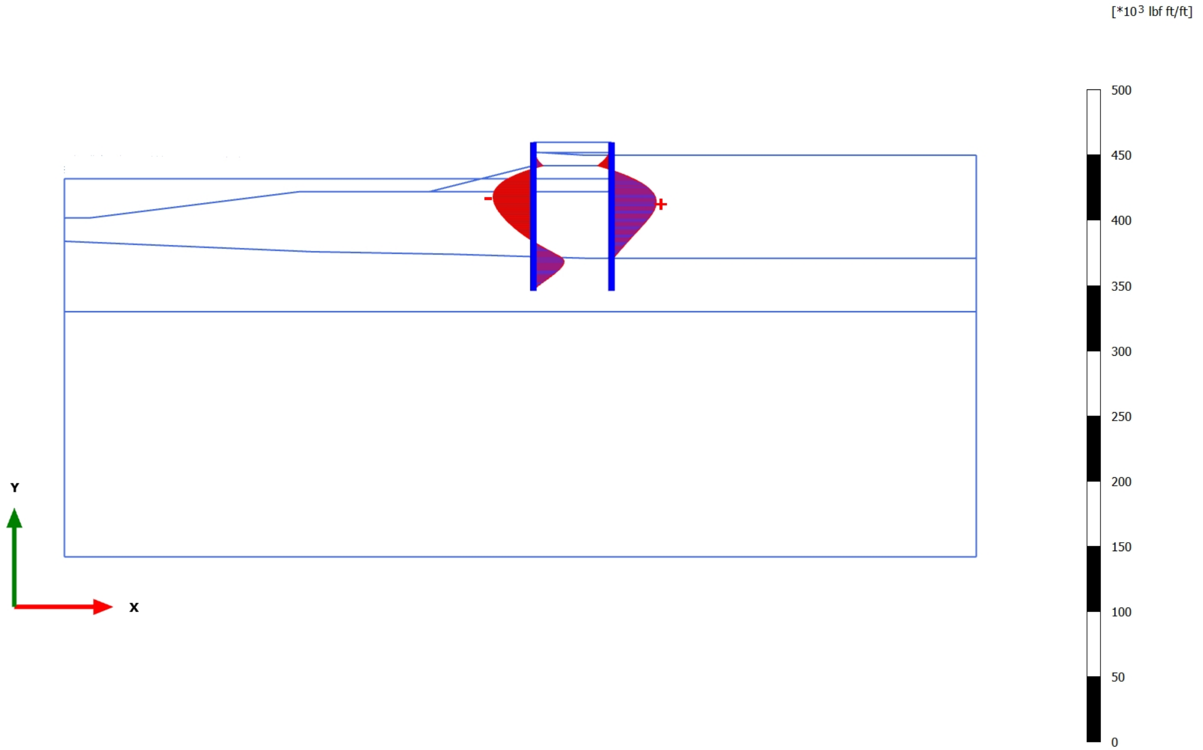


Bending moments M (scaled up 0.500*10⁻³ times) (Time 4.000 day)

Maximum value = 15.38*10³ lbf ft/ft (Element 31 at Node 9677)

Minimum value = -16.48*10³ lbf ft/ft (Element 22 at Node 12991)

3.1.2.2.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/63), Bending moments M

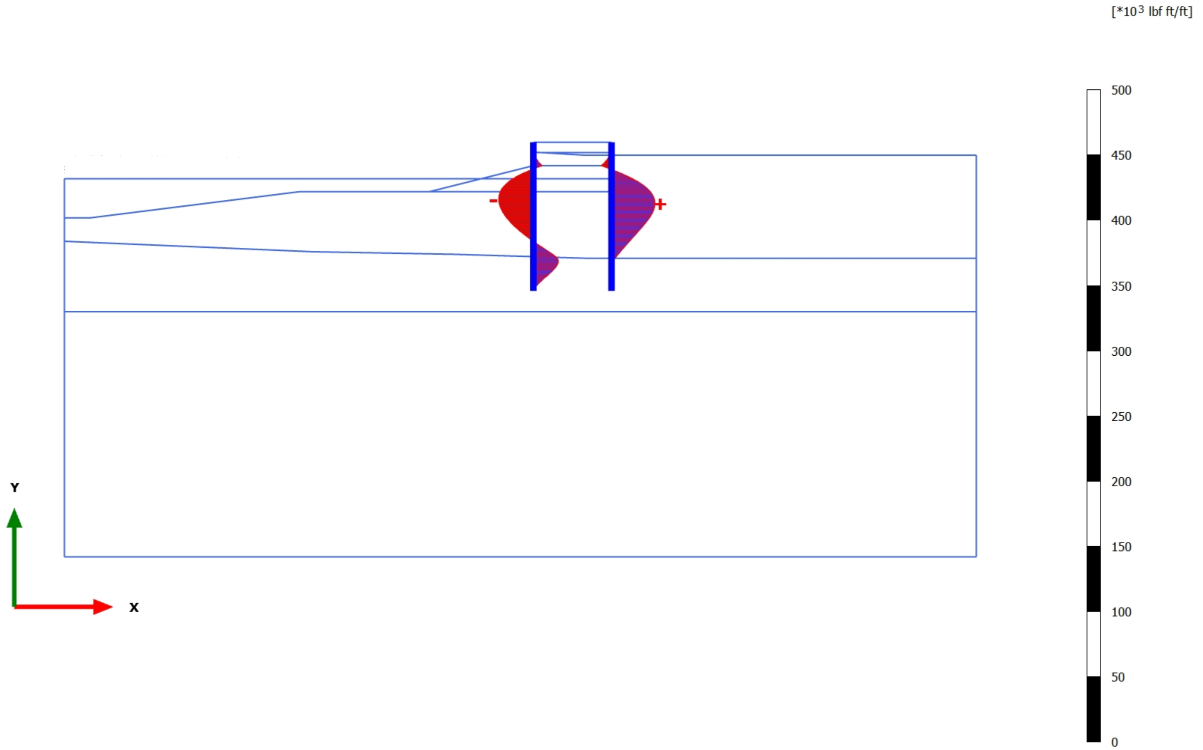


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $34.42*10^3$ lbf ft/ft (Element 32 at Node 10645)

Minimum value = $-30.92*10^3$ lbf ft/ft (Element 22 at Node 12990)

3.1.2.2.7 Calculation results, Plate, Consolidate [Phase_5] (5/79), Bending moments M

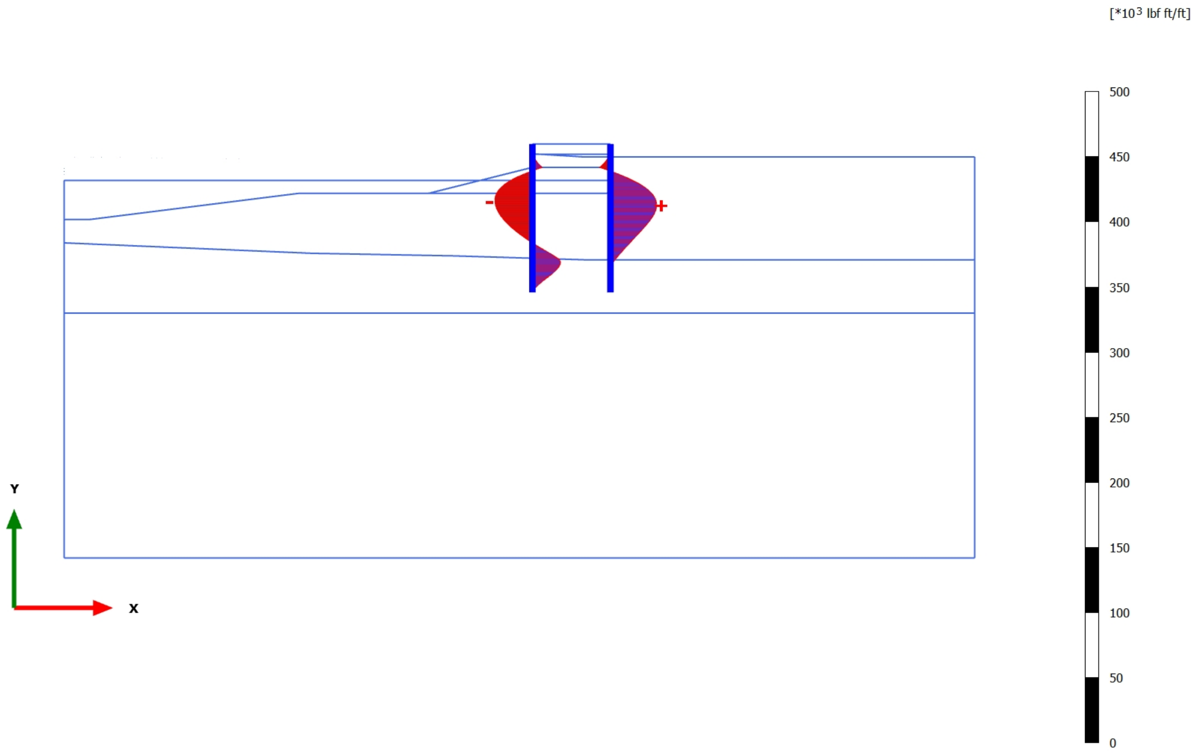


Bending moments M (scaled up 0.500*10^{-3} times) (Time 18.00 day)

Maximum value = 33.45*10^{3} lbf ft/ft (Element 32 at Node 10645)

Minimum value = -26.66*10^{3} lbf ft/ft (Element 23 at Node 13985)

3.1.2.2.8 Calculation results, Plate, Dewater -SS [Phase_9] (9/85), Bending moments M

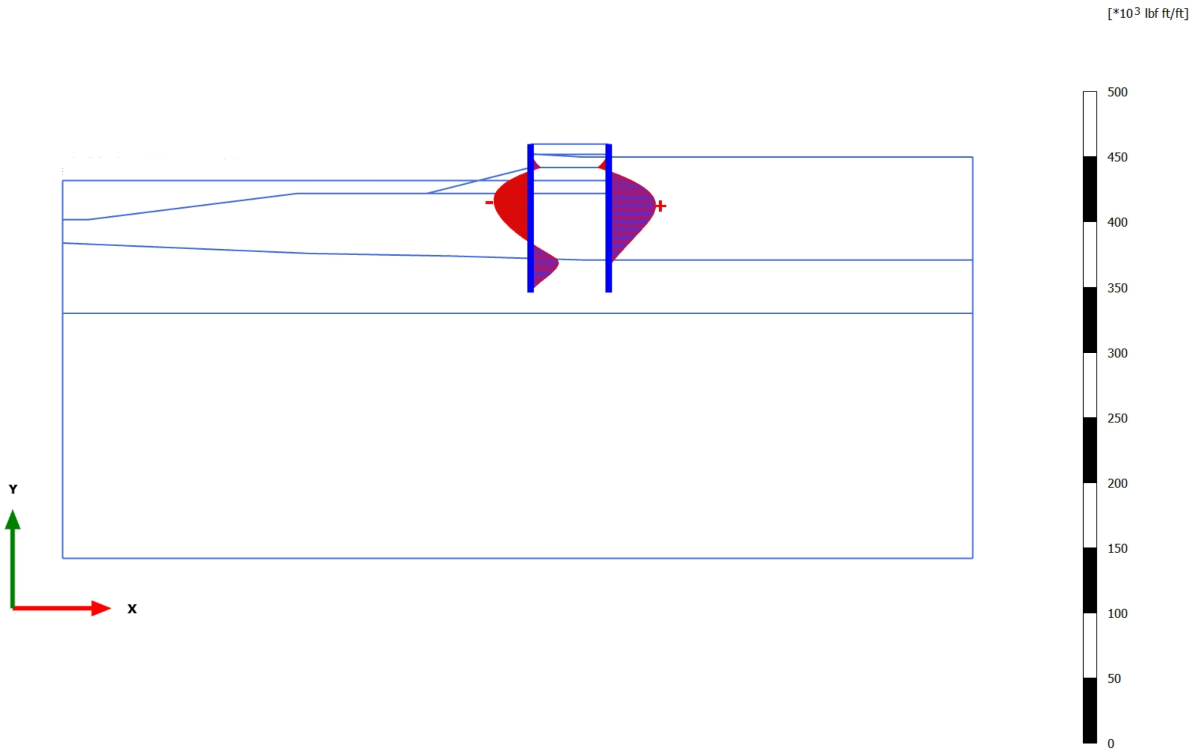


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $35.55*10^3$ lbf ft/ft (Element 32 at Node 10645)

Minimum value = $-28.85*10^3$ lbf ft/ft (Element 22 at Node 13985)

3.1.2.2.9 Calculation results, Plate, Consolidate [Phase_13] (13/91), Bending moments M

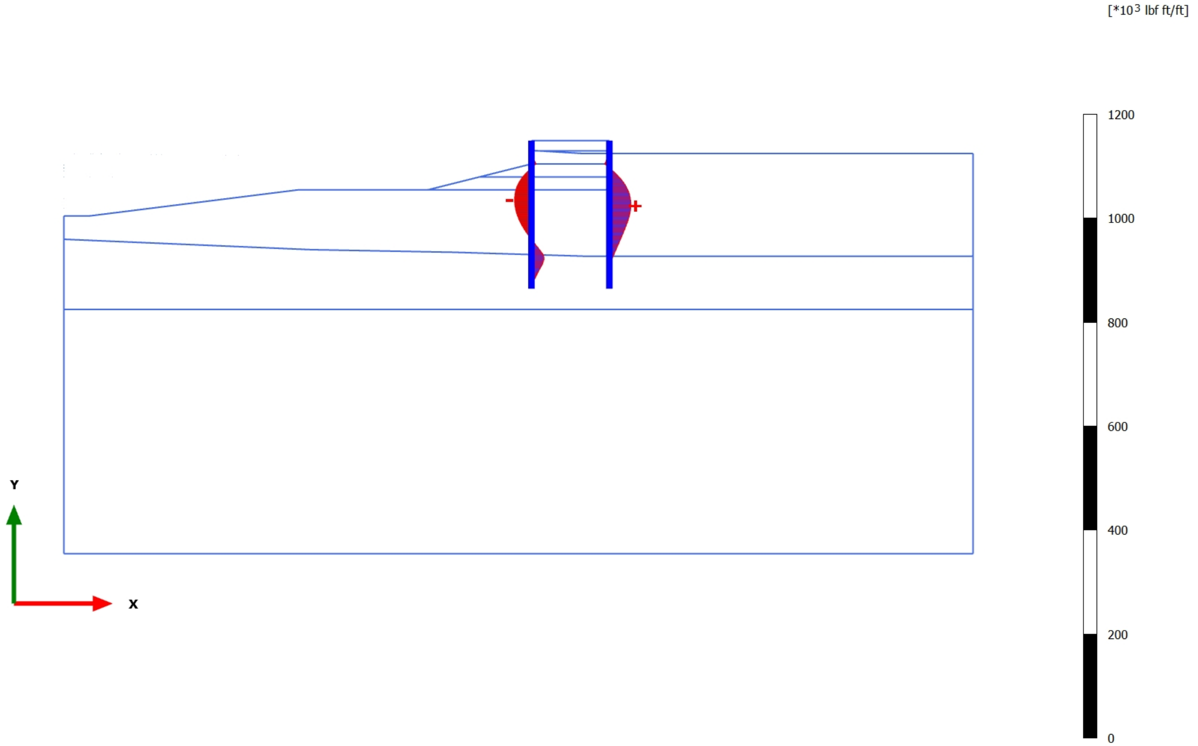


Bending moments M (scaled up 0.500*10^{-3} times) (Time 21.00 day)

Maximum value = 36.07*10^3 lbf ft/ft (Element 32 at Node 10645)

Minimum value = -28.24*10^3 lbf ft/ft (Element 23 at Node 13985)

3.1.2.2.10 Calculation results, Plate, Excavate 2 [Phase_10] (10/100), Bending moments M

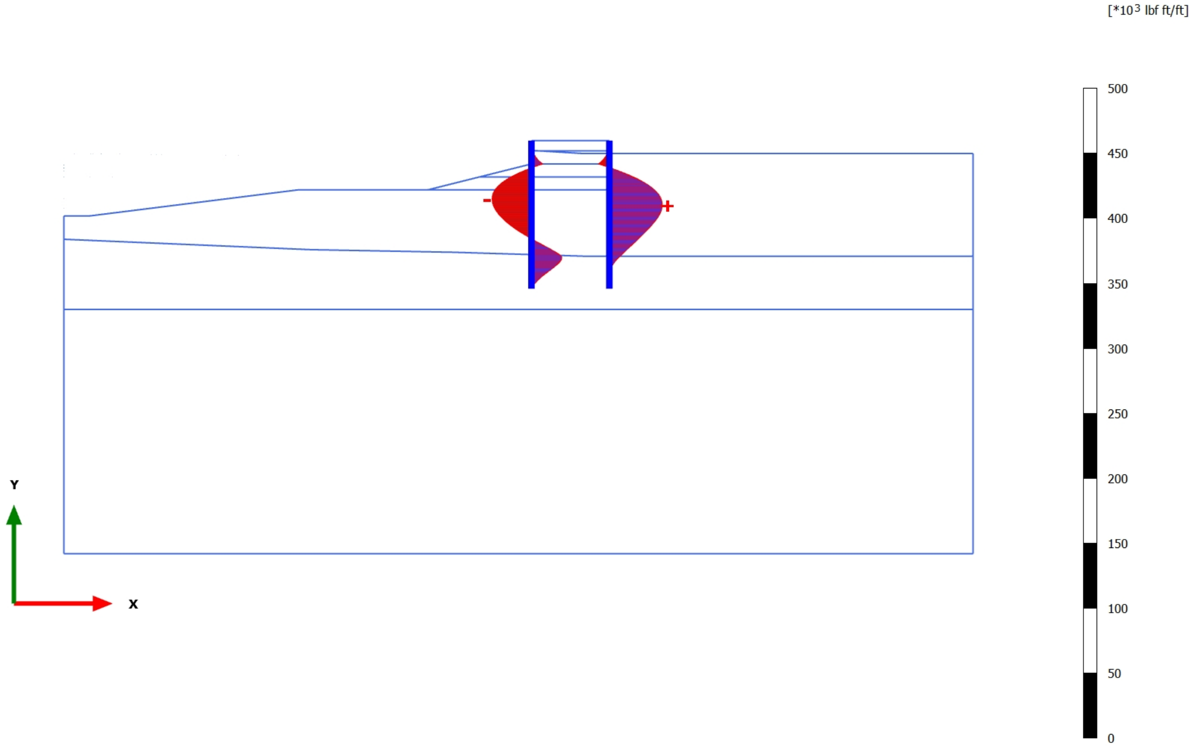


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 41.49*10^{3} lbf ft/ft (Element 33 at Node 11393)

Minimum value = -32.51*10^{3} lbf ft/ft (Element 23 at Node 13988)

3.1.2.2.11 Calculation results, Plate, Consolidate [Phase_14] (14/110), Bending moments M

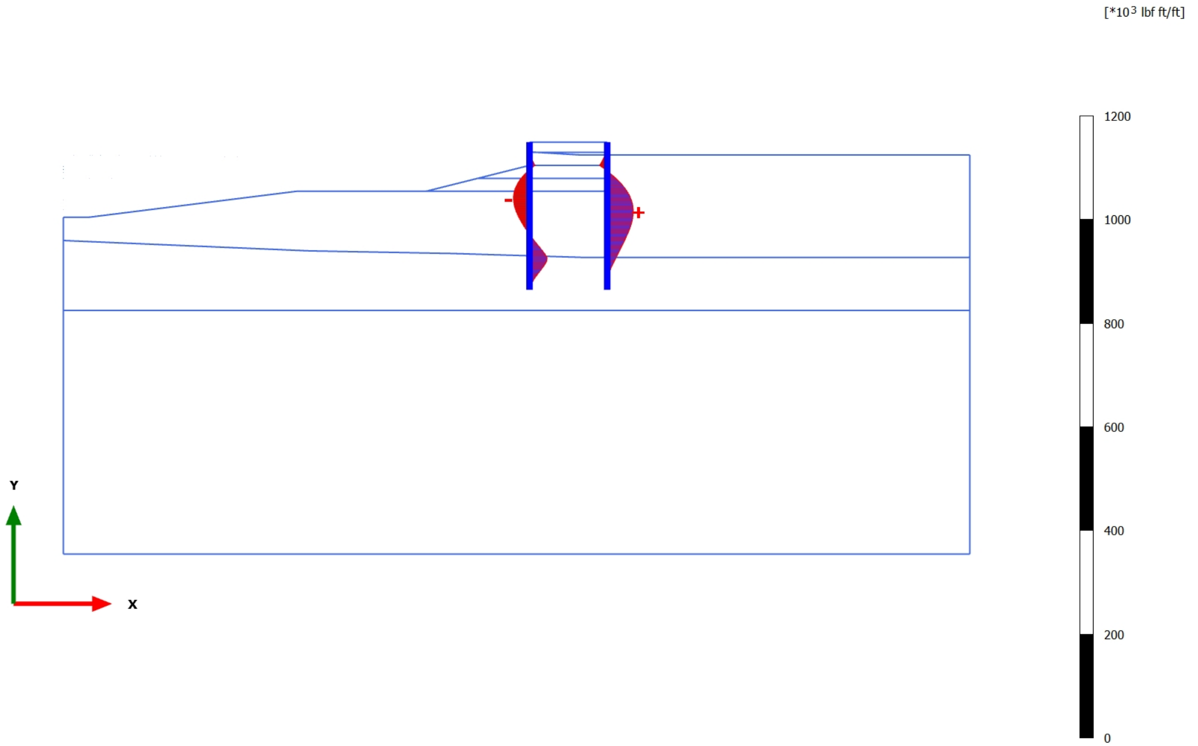


Bending moments M (scaled up 0.500*10^{-3} times) (Time 35.00 day)

Maximum value = 40.77*10^{3} lbf ft/ft (Element 32 at Node 11393)

Minimum value = -30.32*10^{3} lbf ft/ft (Element 23 at Node 13988)

3.1.2.2.12 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/121), Bending moments M



Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 50.37*10^3 lbf ft/ft (Element 33 at Node 11394)

Minimum value = -31.04*10^3 lbf ft/ft (Element 22 at Node 13985)

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill 1 [Phase_6] (6/27), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	51.957	-19.784	51.957
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	51.957	-19.784	51.957

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater-SS [Phase_7] (7/33), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	60.359	-19.784	60.359
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	60.359	-19.784	60.359

3.2.1.1.5 Calculation results, Node-to-node anchor, Consolidate [Phase_3] (3/47), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	55.586	-19.784	60.359
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	55.586	-19.784	60.359

3.2.1.1.6 Calculation results, Node-to-node anchor, Excavate 1 [Phase_8] (8/63), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	96.340	-19.784	96.340
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	96.340	-19.784	96.340

3.2.1.1.7 Calculation results, Node-to-node anchor, Consolidate [Phase_5] (5/79), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	85.586	-19.784	96.340
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	85.586	-19.784	96.340

3.2.1.1.8 Calculation results, Node-to-node anchor, Dewater -SS [Phase_9] (9/85), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	89.912	-19.784	96.340
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	89.912	-19.784	96.340

3.2.1.1.9 Calculation results, Node-to-node anchor, Consolidate [Phase_13] (13/91), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	89.432	-19.784	96.340
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	89.432	-19.784	96.340

3.2.1.1.10 Calculation results, Node-to-node anchor, Excavate 2 [Phase_10] (10/100), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	96.701	-19.784	96.701
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	96.701	-19.784	96.701

3.2.1.1.11 Calculation results, Node-to-node anchor, Consolidate [Phase_14] (14/110), Table of node-to-node anchors

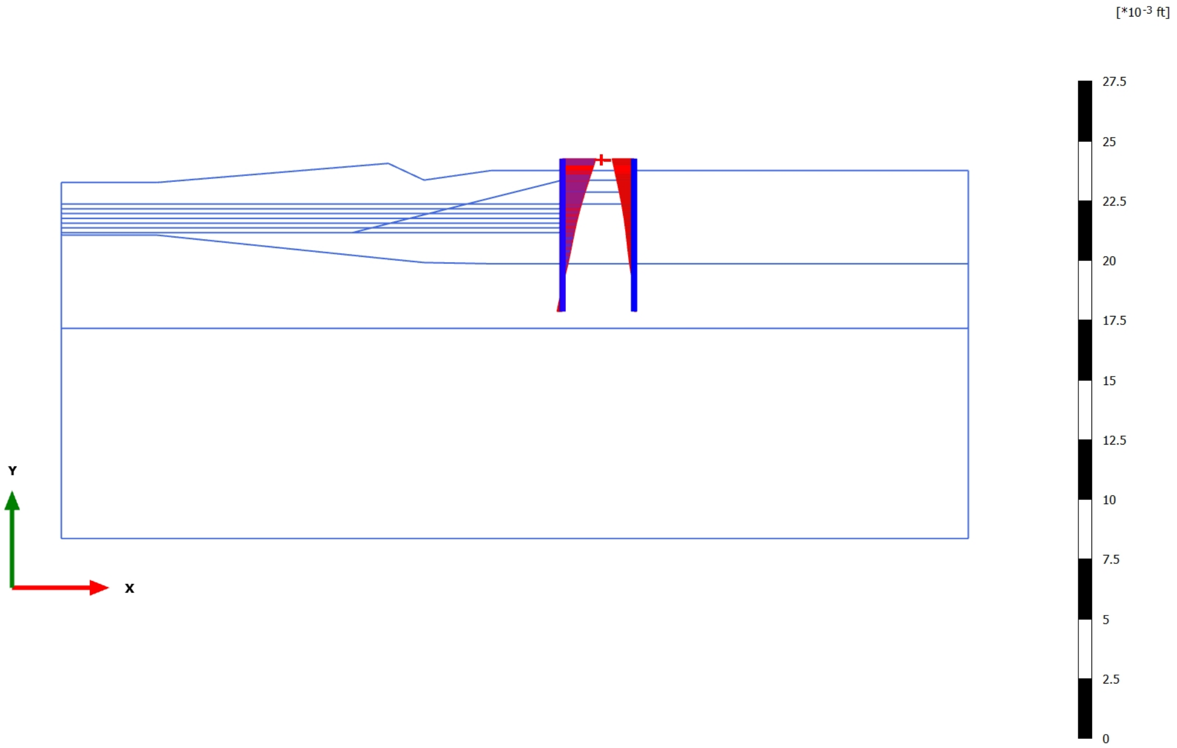
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	92.250	-19.784	96.701
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	92.250	-19.784	96.701

3.2.1.1.12 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/121), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_1_1	7709	1	30.000	0.000	108.719	-19.784	108.719
Element 1-1 (Node-to-node anchor)	5729	2	60.000	0.000	108.719	-19.784	108.719

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Install sheet pile [Phase_1] (1/5), Total displacements u_x

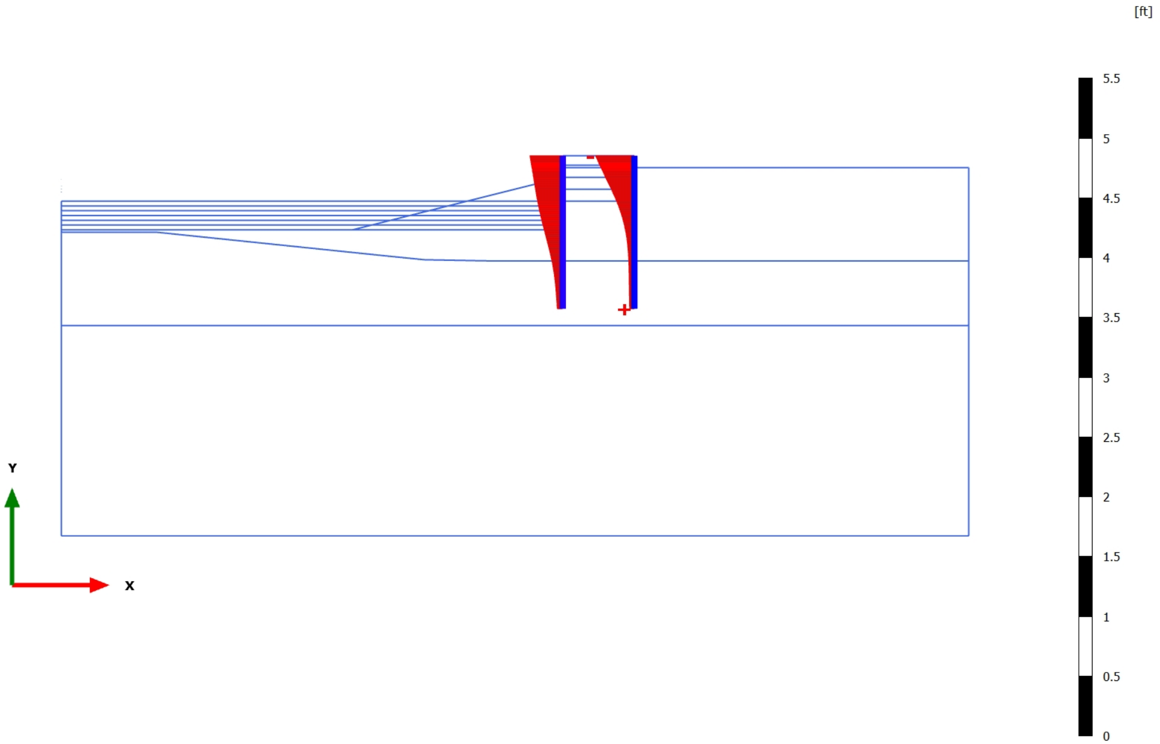


Total displacements u_x (scaled up $10.0*10^3$ times)

Maximum value = $1.412*10^{-3}$ ft (Element 1 at Node 4564)

Minimum value = $-0.9275*10^{-3}$ ft (Element 3 at Node 4397)

3.1.1.1.1.2 Calculation results, Plate, Dewater2- SS [Phase_9] (9/23), Total displacements u_x

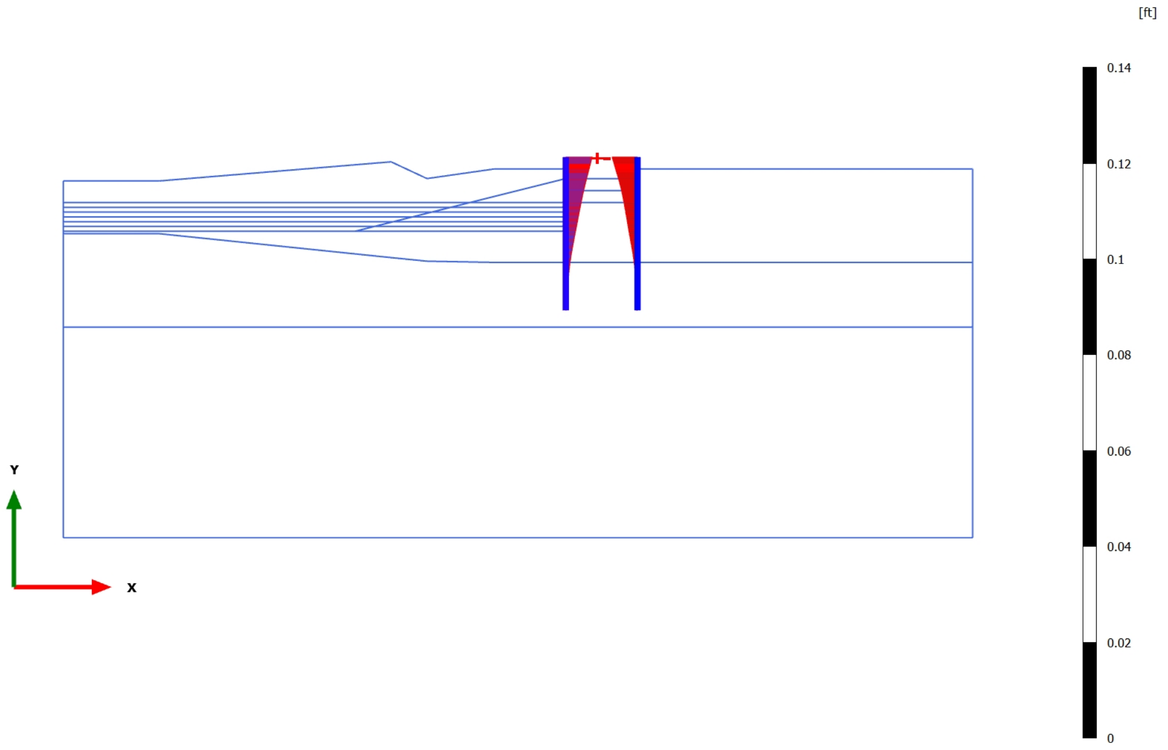


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.03957 ft (Element 48 at Node 22618)

Minimum value = -0.3261 ft (Element 3 at Node 4397)

3.1.1.1.1.3 Calculation results, Plate, Excavate [Phase_25] (25/30), Total displacements u_x

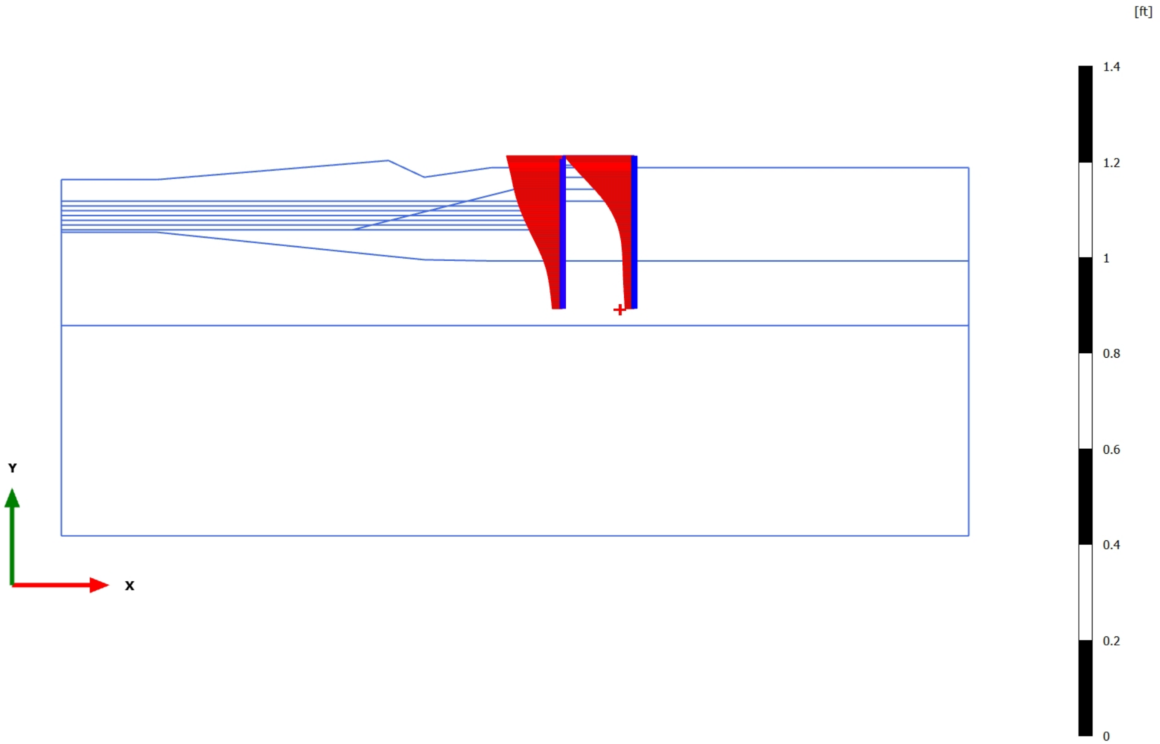


Total displacements u_x (scaled up $2.00*10^3$ times)

Maximum value = $5.525*10^{-3}$ ft (Element 1 at Node 4564)

Minimum value = $-5.325*10^{-3}$ ft (Element 3 at Node 4397)

3.1.1.1.1.4 Calculation results, Plate, Dewater -SS [Phase_7] (7/43), Total displacements u_x

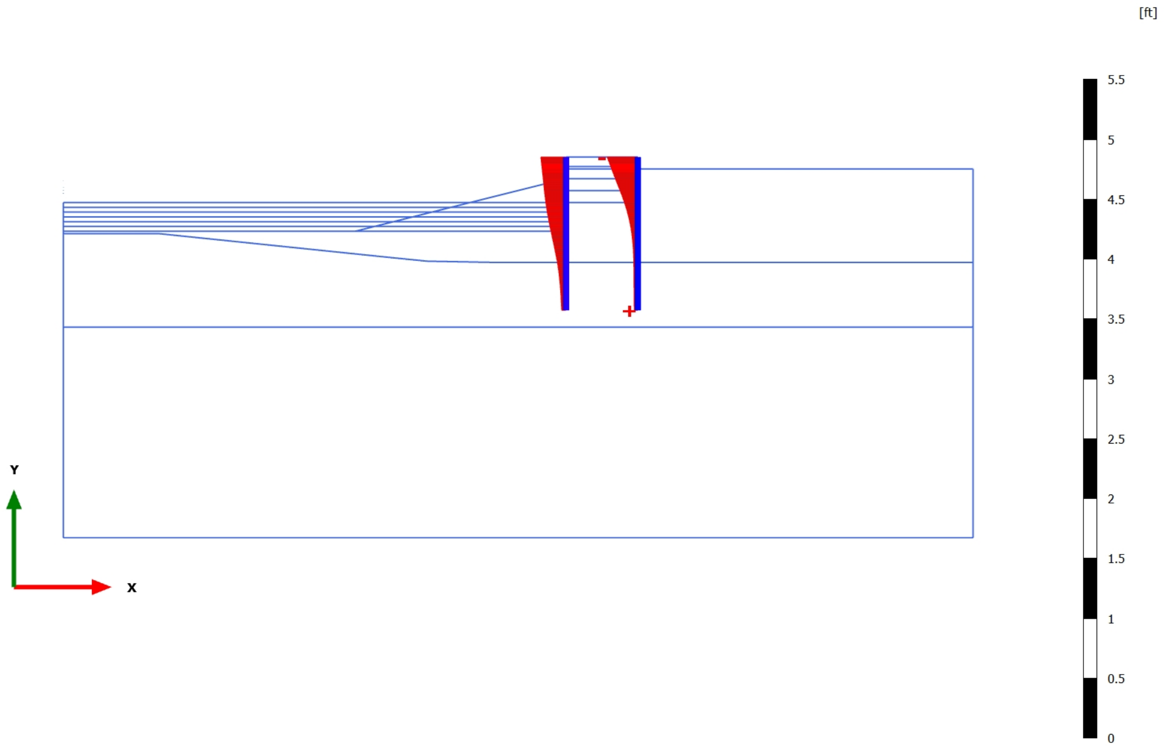


Total displacements u_x (scaled up 200 times)

Maximum value = -0.01945 ft (Element 48 at Node 22618)

Minimum value = -0.1484 ft (Element 3 at Node 4397)

3.1.1.1.1.5 Calculation results, Plate, Excavate 1 [Phase_8] (8/59), Total displacements u_x

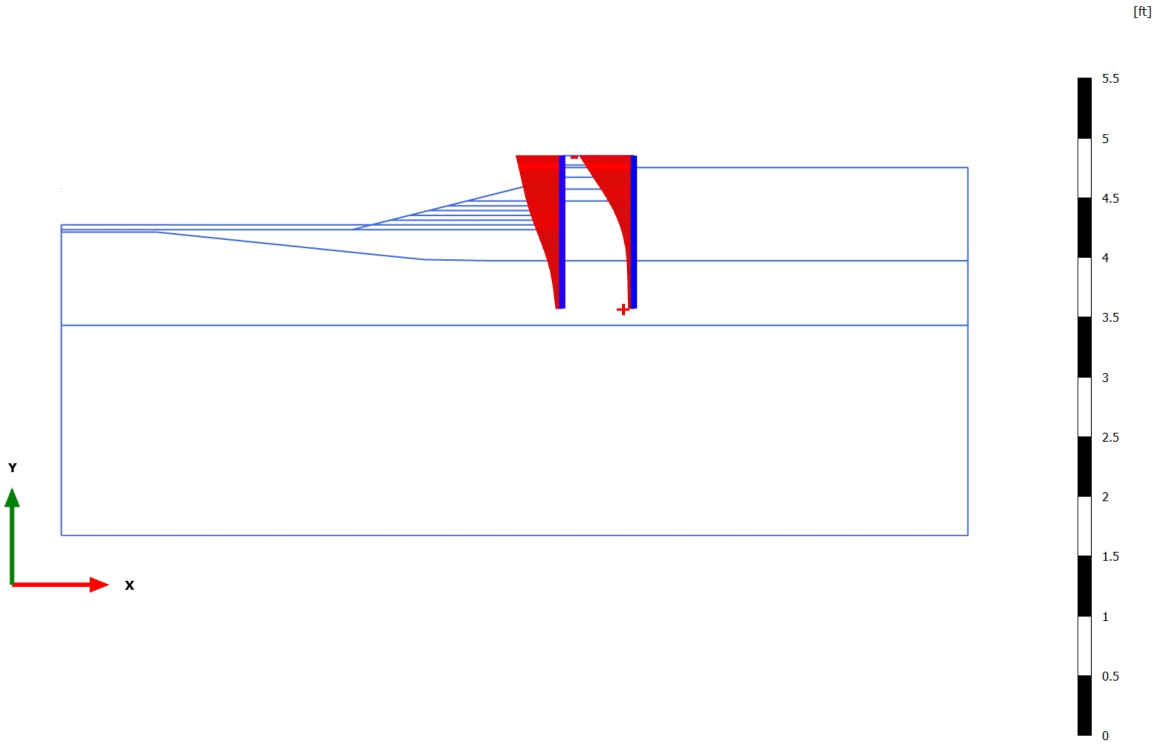


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.03020 ft (Element 48 at Node 22618)

Minimum value = -0.2563 ft (Element 3 at Node 4397)

3.1.1.1.1.6 Calculation results, Plate, Excavate 2 [Phase_10] (10/67), Total displacements u_x

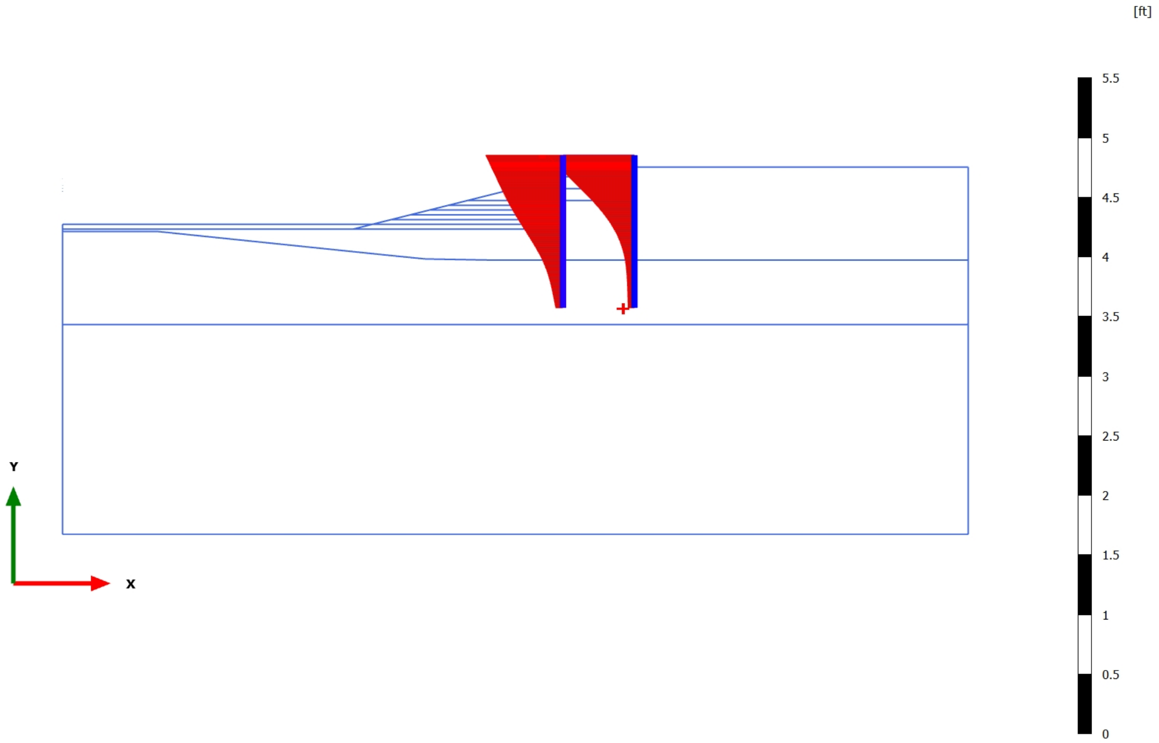


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.04637 ft (Element 48 at Node 22618)

Minimum value = -0.4552 ft (Element 3 at Node 4397)

3.1.1.1.1.7 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/81), Total displacements u_x

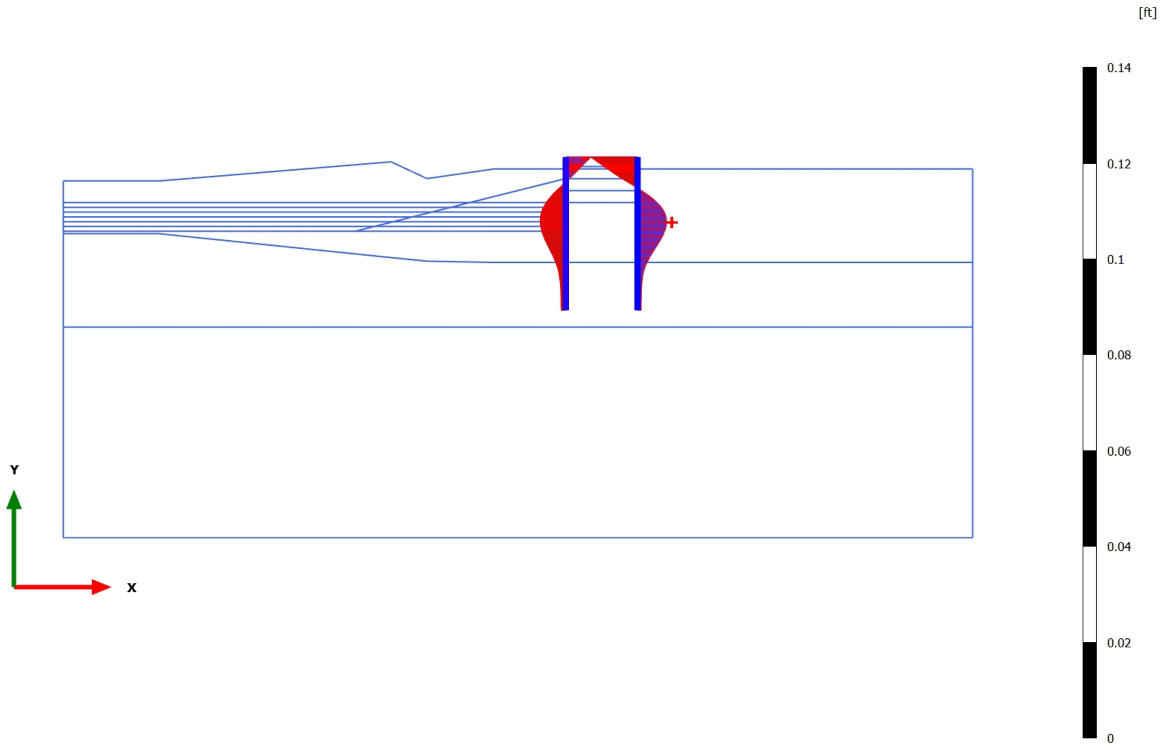


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.05267 ft (Element 48 at Node 22618)

Minimum value = -0.7299 ft (Element 3 at Node 4397)

3.1.1.1.1.8 Calculation results, Plate, Backfill [Phase_6] (6/120), Total displacements u_x

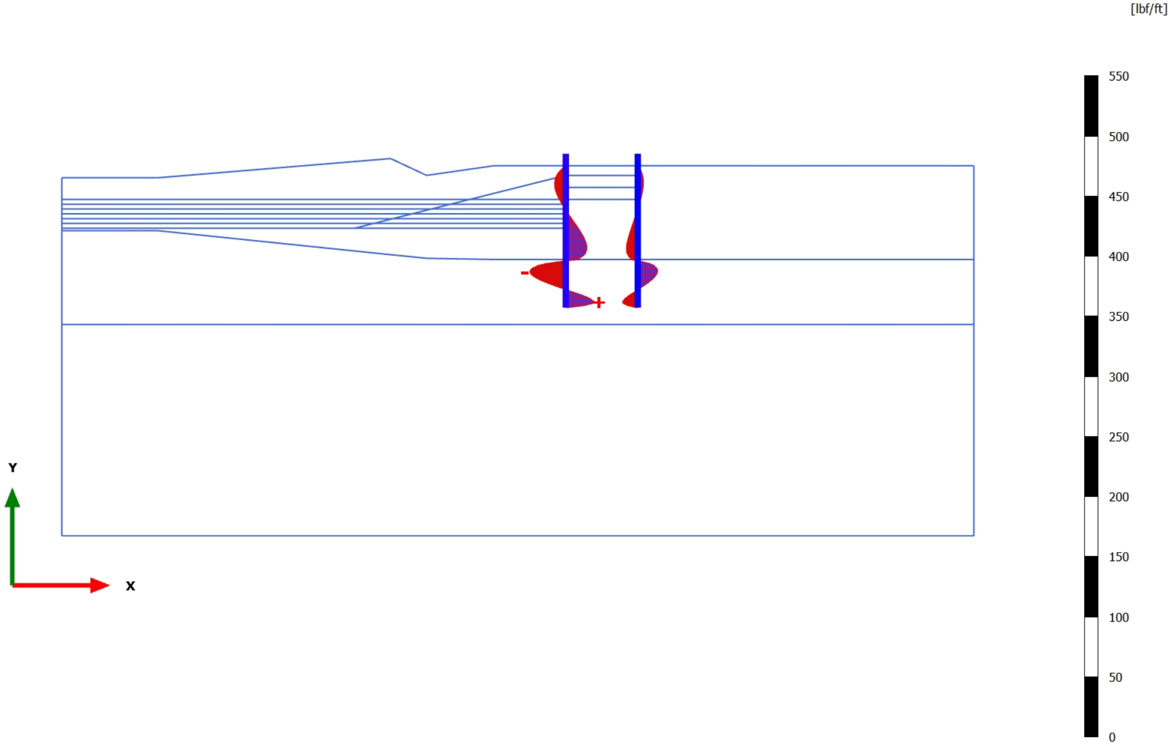


Total displacements u_x (scaled up $2.00*10^3$ times)

Maximum value = $6.053*10^{-3}$ ft (Element 27 at Node 11581)

Minimum value = $-9.841*10^{-3}$ ft (Element 3 at Node 4397)

3.1.2.1.1 Calculation results, Plate, Install sheet pile [Phase_1] (1/5), Shear forces Q

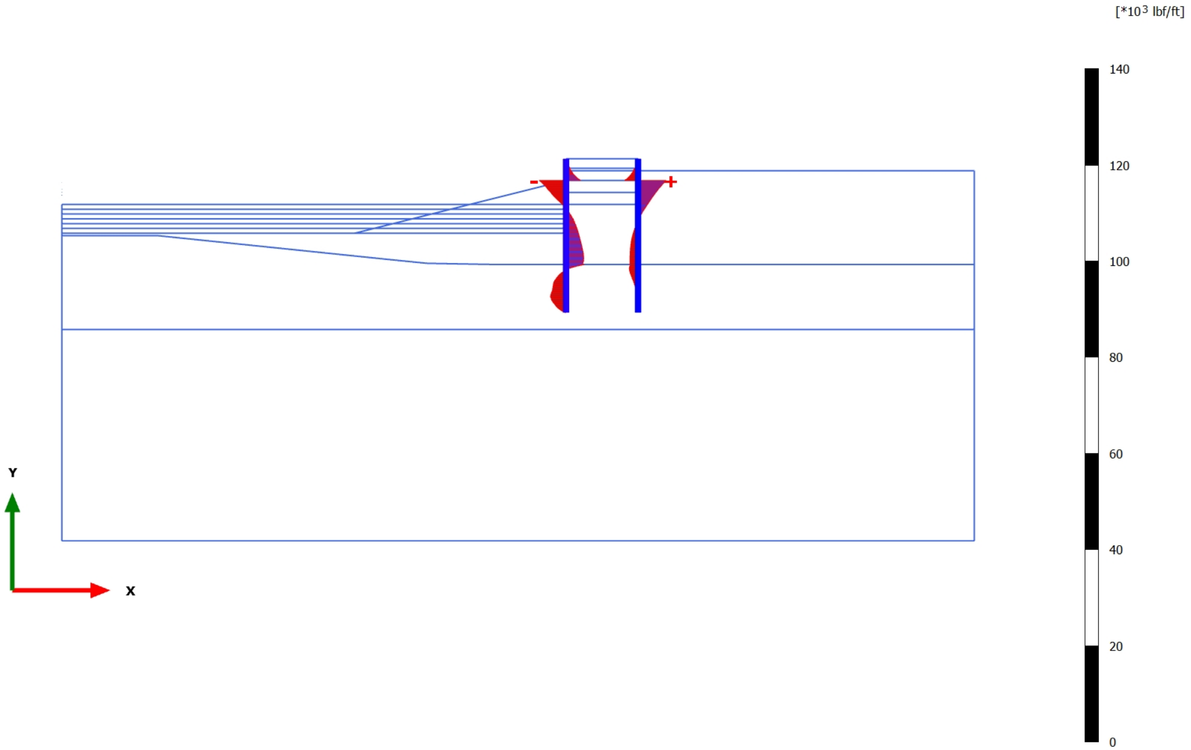


Shear forces Q (scaled up 0.500 times)

Maximum value = 23.76 lbf/ft (Element 42 at Node 26632)

Minimum value = -30.01 lbf/ft (Element 38 at Node 22509)

3.1.2.1.2 Calculation results, Plate, Dewater2- SS [Phase_9] (9/23), Shear forces Q

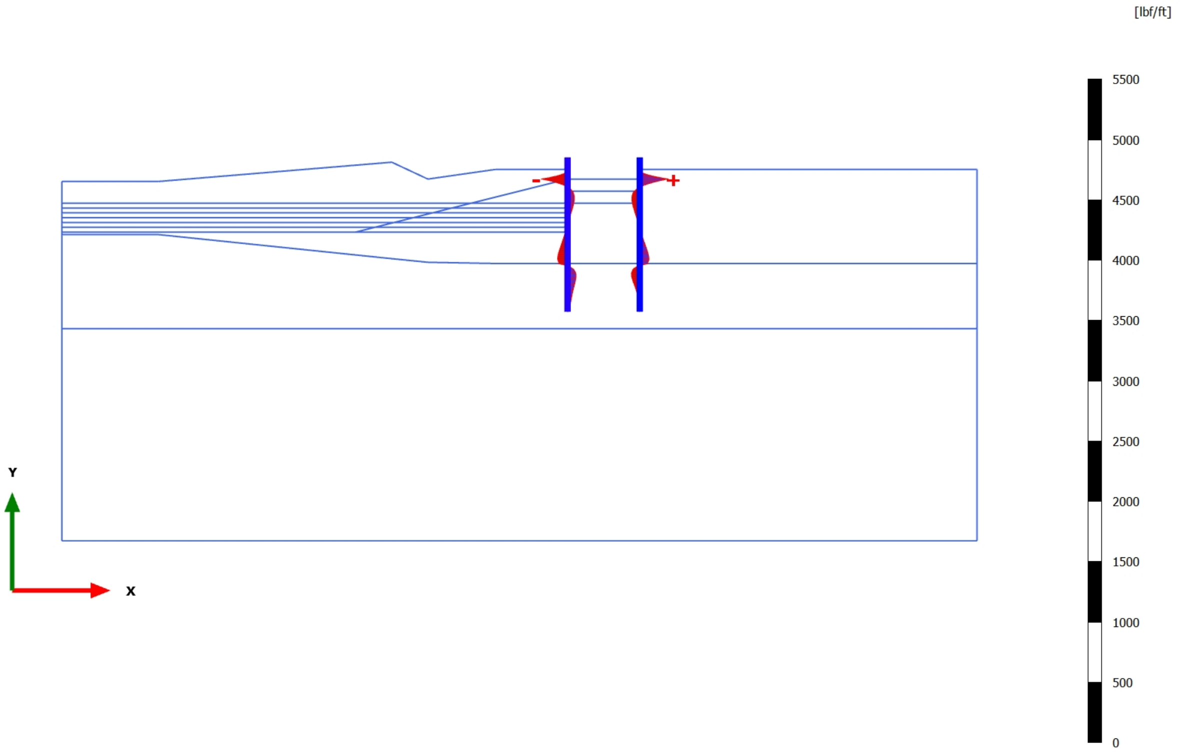


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 5892 lbf/ft (Element 13 at Node 6499)

Minimum value = -5621 lbf/ft (Element 11 at Node 8339)

3.1.2.1.3 Calculation results, Plate, Excavate [Phase_25] (25/30), Shear forces Q

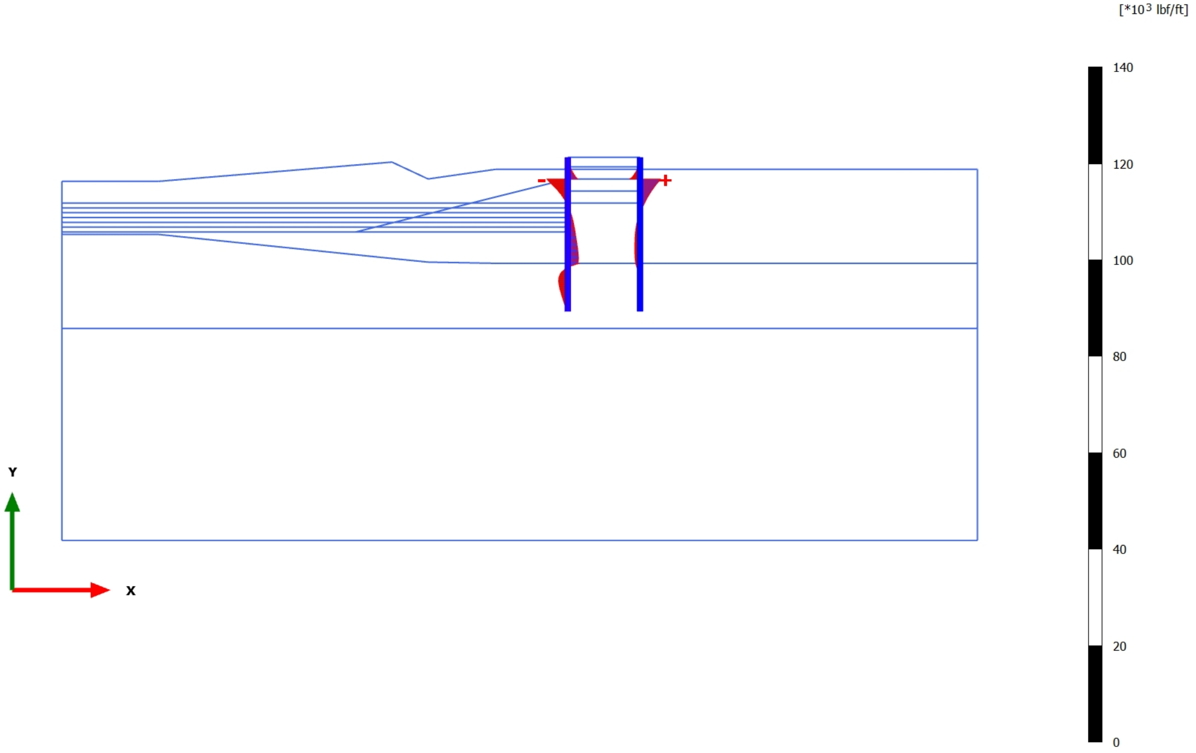


Shear forces Q (scaled up 0.0500 times)

Maximum value = 239.5 lbf/ft (Element 10 at Node 6499)

Minimum value = -219.5 lbf/ft (Element 8 at Node 8339)

3.1.2.1.4 Calculation results, Plate, Dewater -SS [Phase_7] (7/43), Shear forces Q

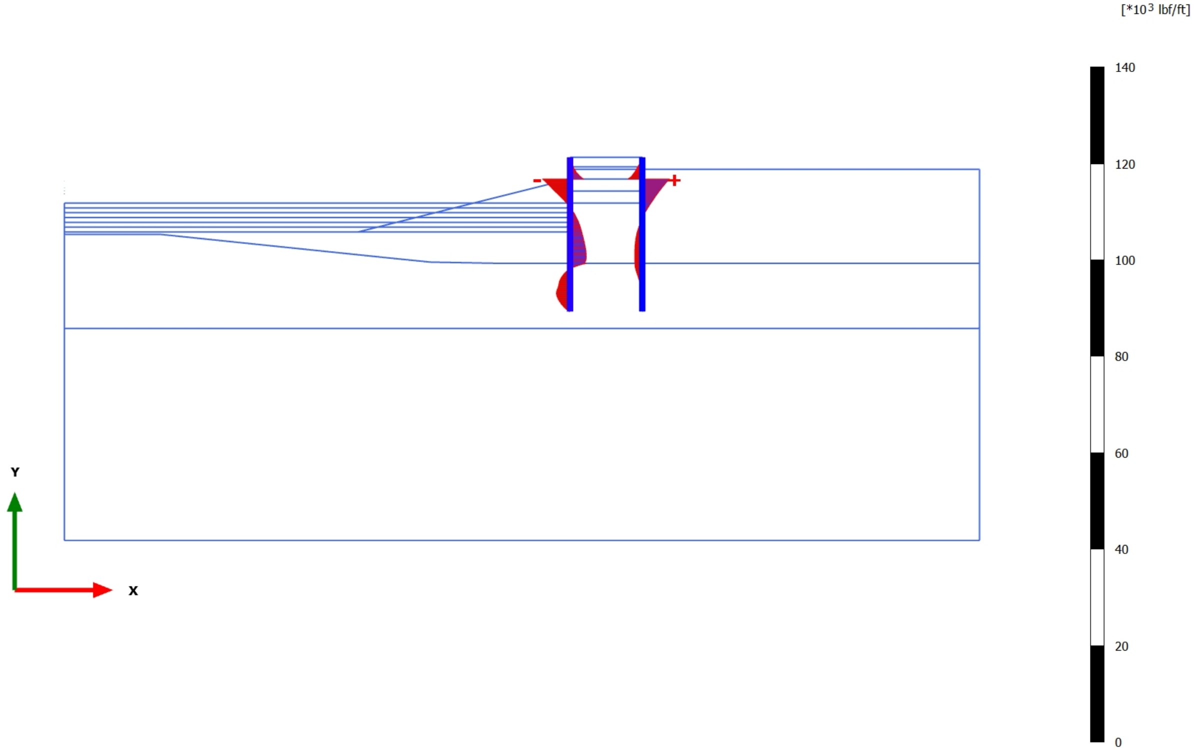


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 4326 lbf/ft (Element 13 at Node 6499)

Minimum value = -4387 lbf/ft (Element 11 at Node 8339)

3.1.2.1.5 Calculation results, Plate, Excavate 1 [Phase_8] (8/59), Shear forces Q

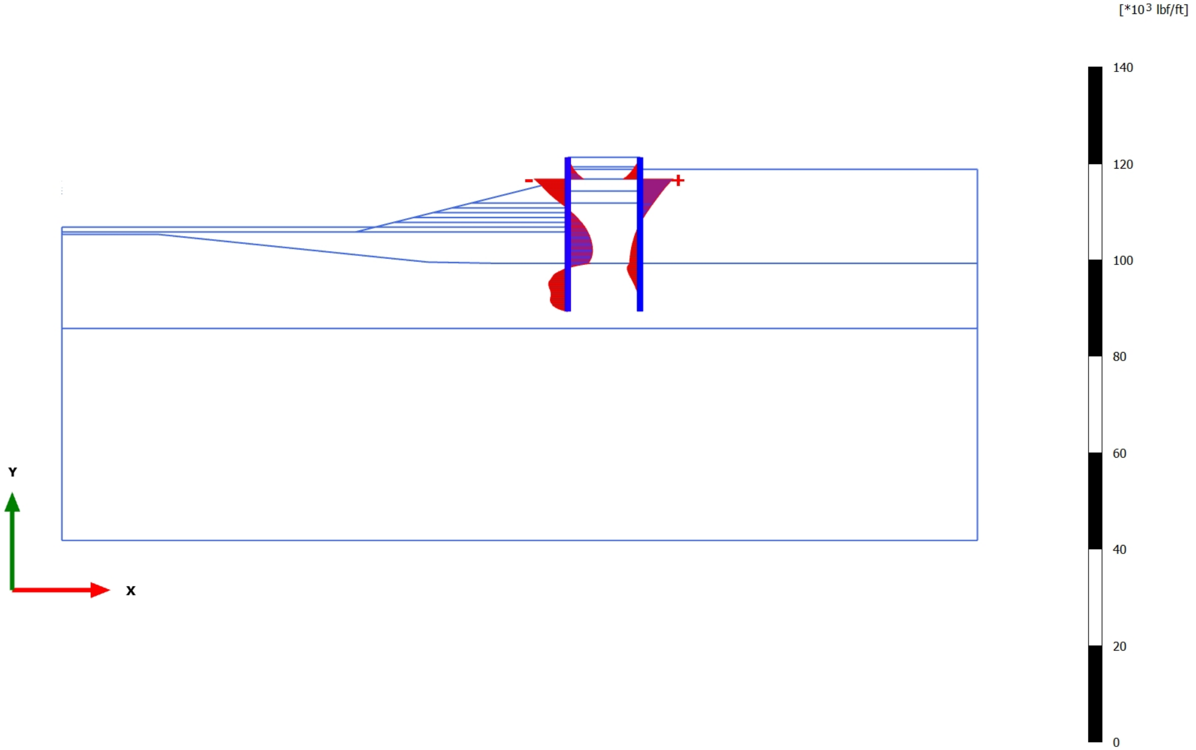


Shear forces Q (scaled up 2.00×10^{-3} times)

Maximum value = 5679 lbf/ft (Element 13 at Node 6499)

Minimum value = -5760 lbf/ft (Element 11 at Node 8339)

3.1.2.1.6 Calculation results, Plate, Excavate 2 [Phase_10] (10/67), Shear forces Q

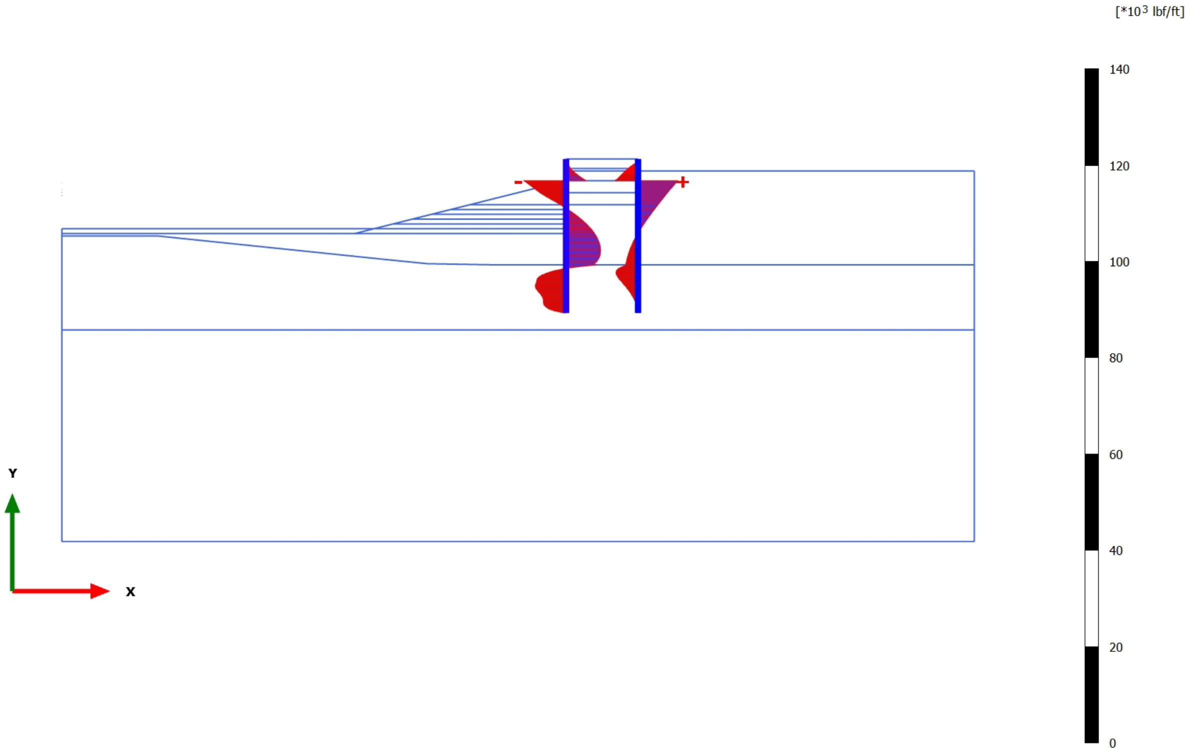


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 6873 lbf/ft (Element 13 at Node 6499)

Minimum value = -7012 lbf/ft (Element 11 at Node 8339)

3.1.2.1.7 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/81), Shear forces Q

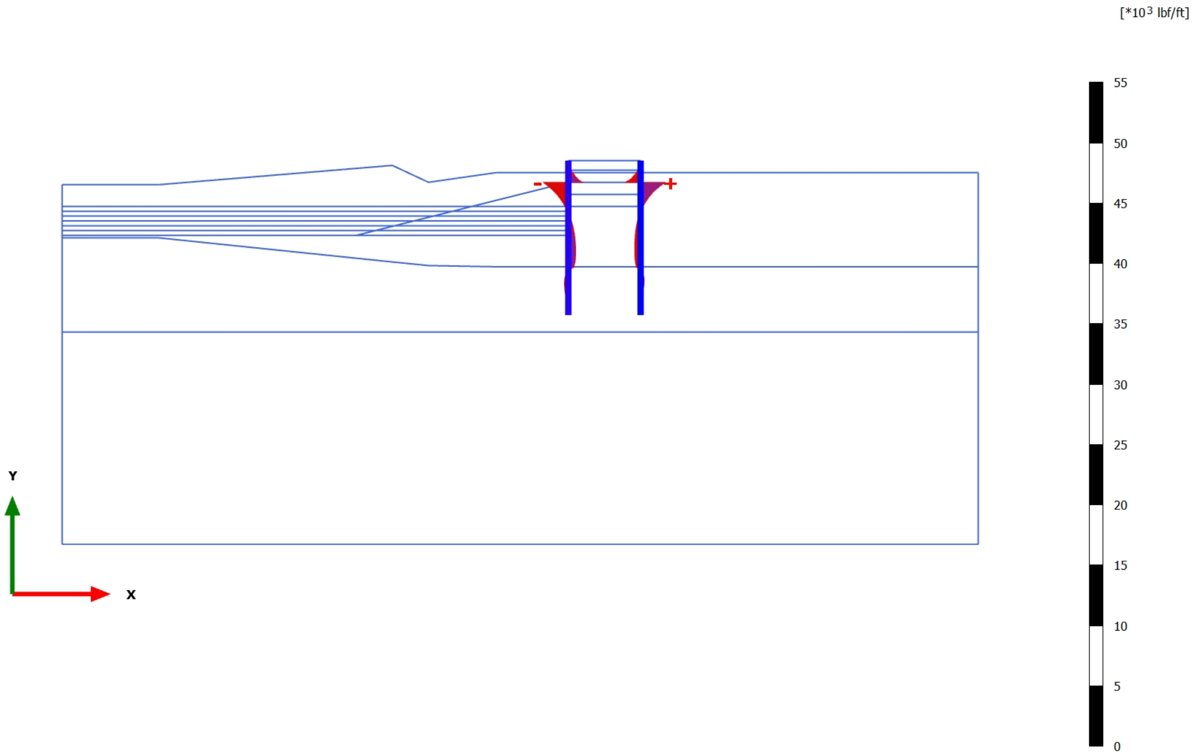


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 8329 lbf/ft (Element 13 at Node 6499)

Minimum value = -8868 lbf/ft (Element 11 at Node 8339)

3.1.2.1.8 Calculation results, Plate, Backfill [Phase_6] (6/120), Shear forces Q

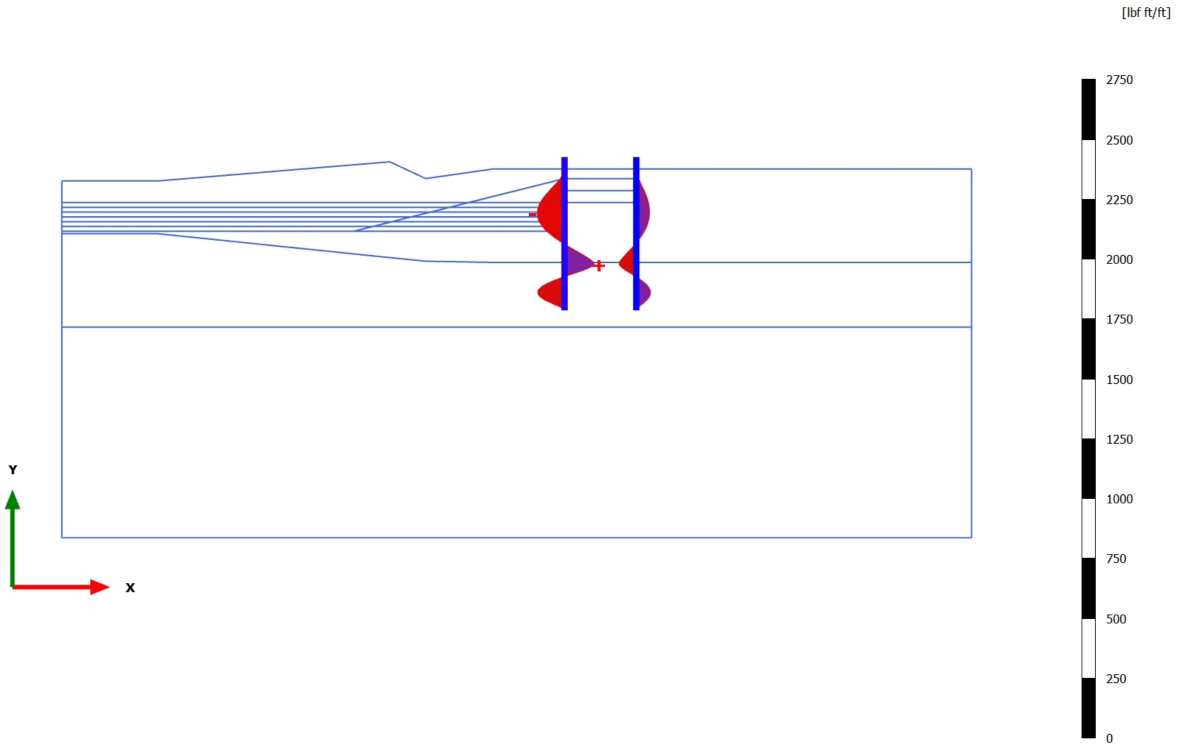


Shear forces Q (scaled up $5.00*10^{-3}$ times)

Maximum value = 2052 lbf/ft (Element 13 at Node 6499)

Minimum value = -2105 lbf/ft (Element 11 at Node 8339)

3.1.2.2.1 Calculation results, Plate, Install sheet pile [Phase_1] (1/5), Bending moments M

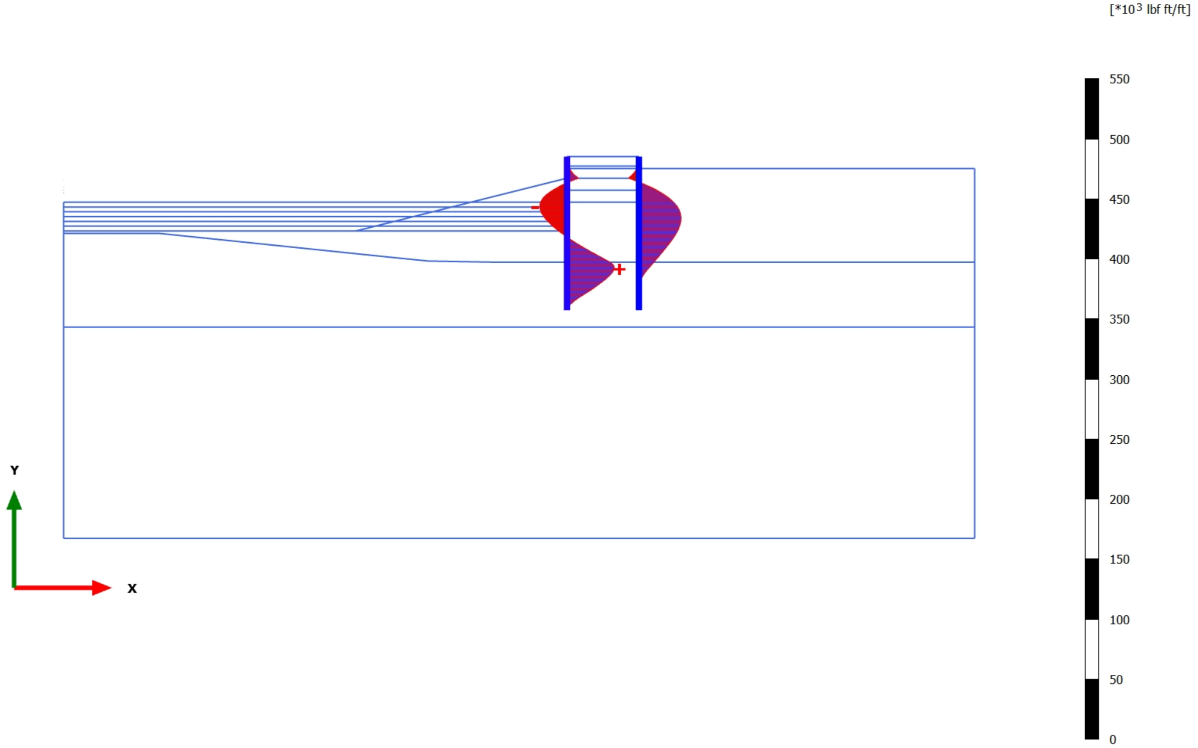


Bending moments M (scaled up 0.100 times)

Maximum value = 124.3 lbf ft/ft (Element 37 at Node 22236)

Minimum value = -113.5 lbf ft/ft (Element 21 at Node 14628)

3.1.2.2.2 Calculation results, Plate, Dewater2- SS [Phase_9] (9/23), Bending moments M

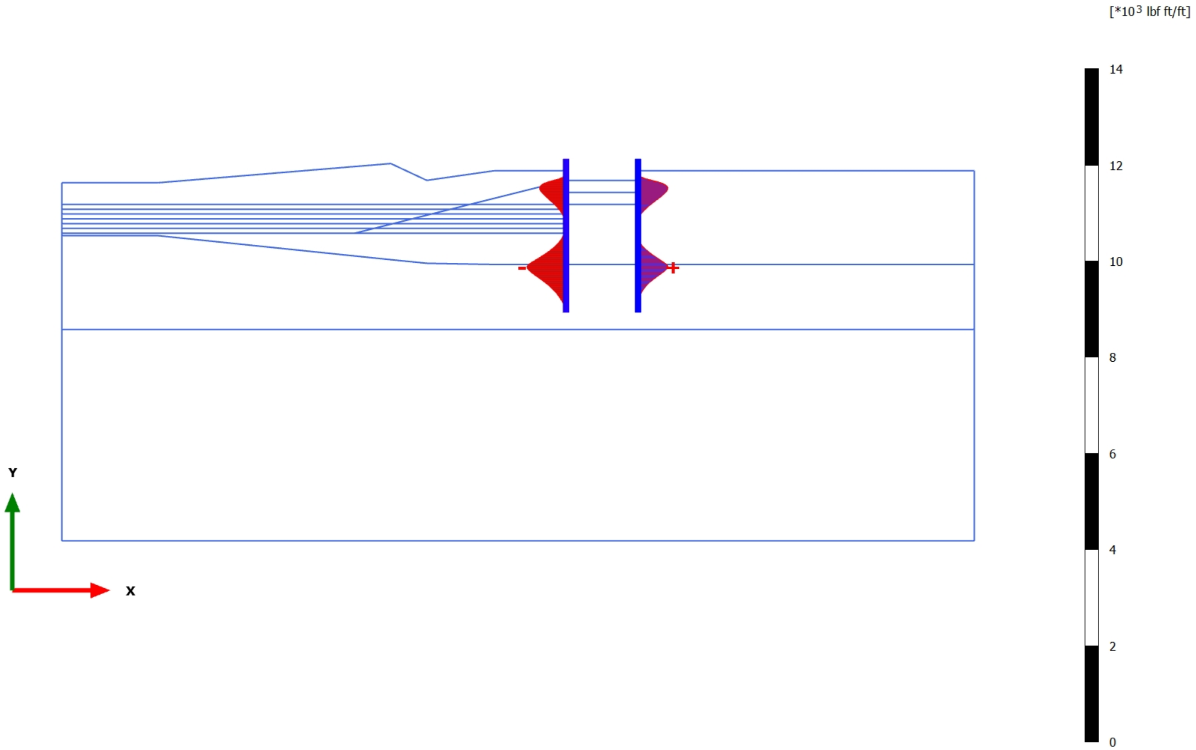


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $39.40*10^{3}$ lbf ft/ft (Element 37 at Node 22234)

Minimum value = $-22.77*10^{3}$ lbf ft/ft (Element 19 at Node 12346)

3.1.2.2.3 Calculation results, Plate, Excavate [Phase_25] (25/30), Bending moments M

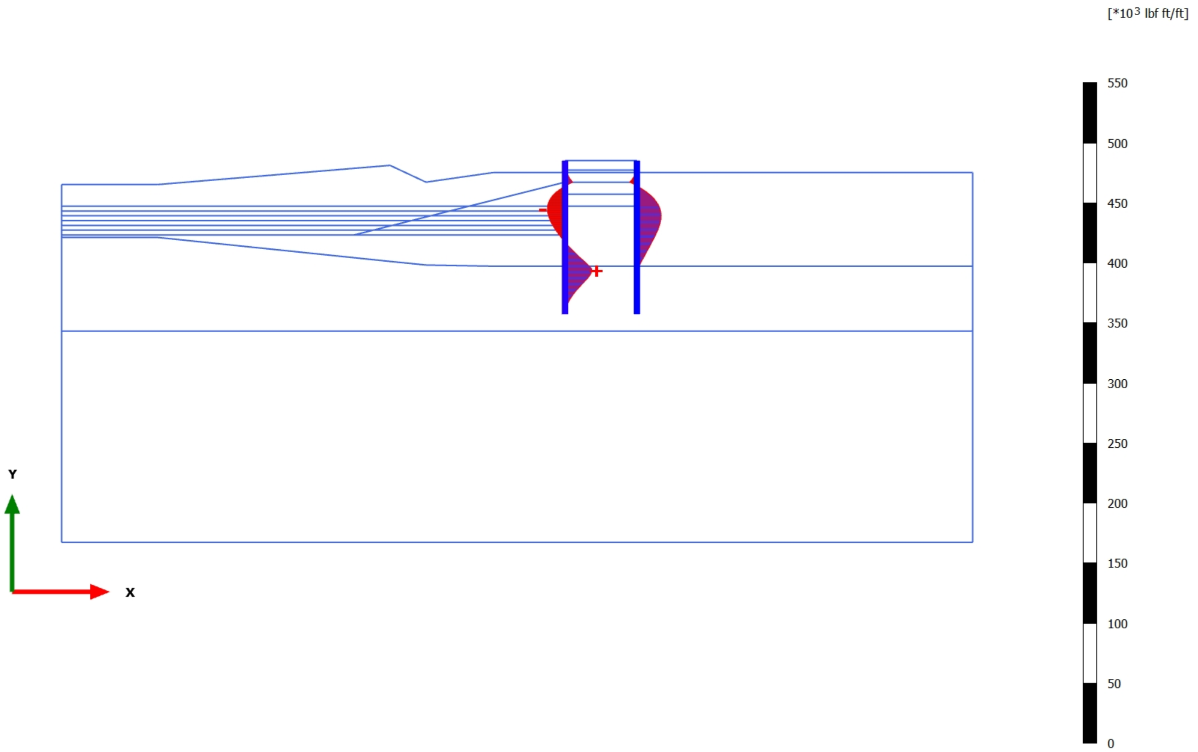


Bending moments M (scaled up 0.0200 times)

Maximum value = 625.3 lbf ft/ft (Element 43 at Node 17606)

Minimum value = -816.1 lbf ft/ft (Element 37 at Node 22236)

3.1.2.2.4 Calculation results, Plate, Dewater -SS [Phase_7] (7/43), Bending moments M

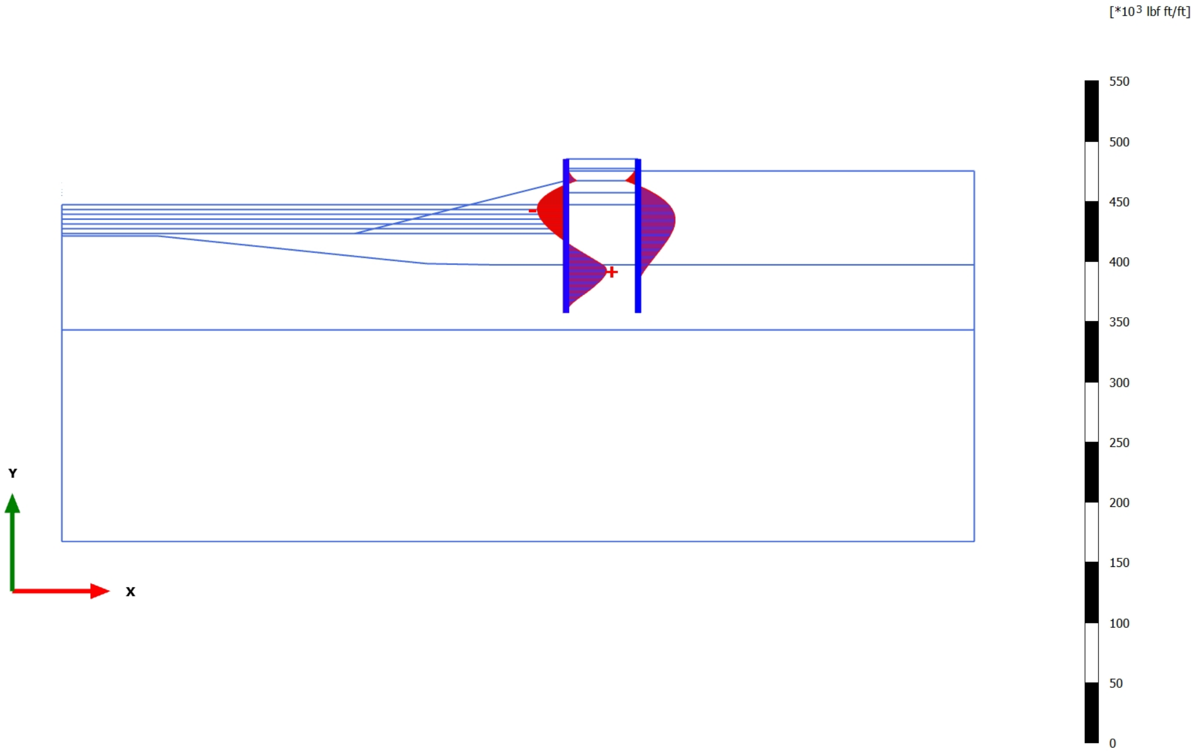


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 22.41*10^3 lbf ft/ft (Element 37 at Node 22235)

Minimum value = -14.71*10^3 lbf ft/ft (Element 19 at Node 12347)

3.1.2.2.5 Calculation results, Plate, Excavate 1 [Phase_8] (8/59), Bending moments M

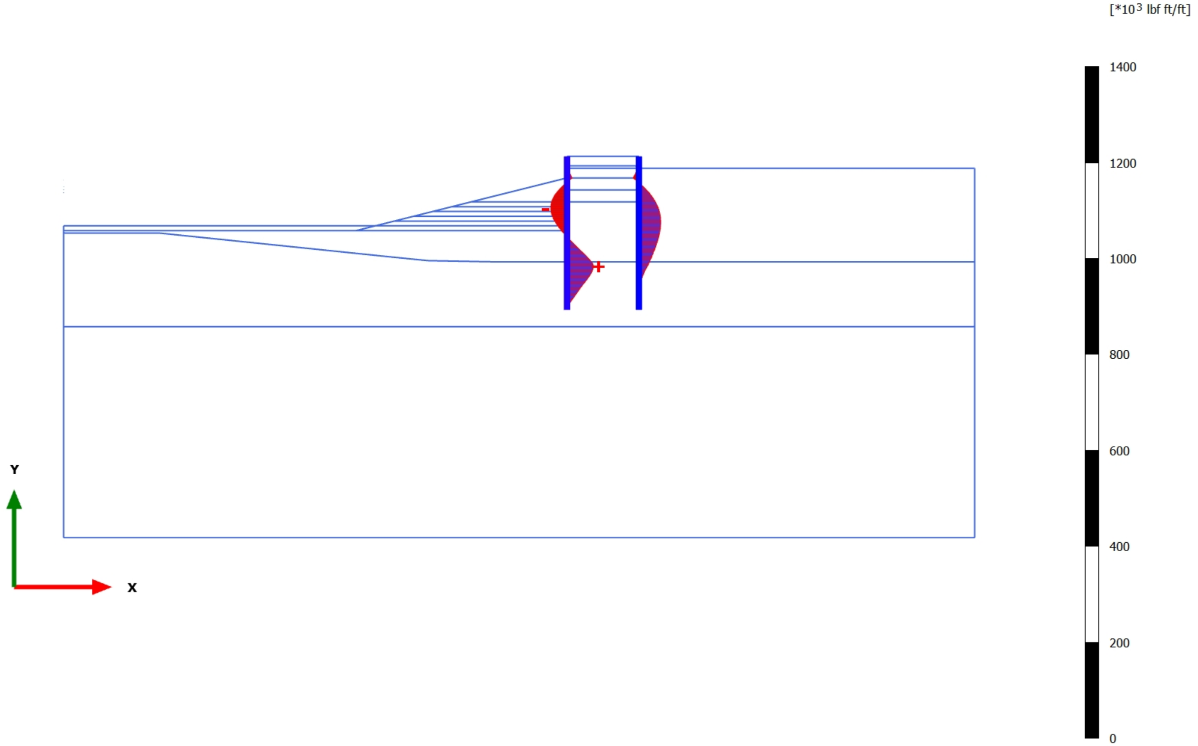


Bending moments M (scaled up $0.500*10^{-3}$ times)

Maximum value = $33.79*10^{3}$ lbf ft/ft (Element 37 at Node 22234)

Minimum value = $-23.93*10^{3}$ lbf ft/ft (Element 19 at Node 13641)

3.1.2.2.6 Calculation results, Plate, Excavate 2 [Phase_10] (10/67), Bending moments M

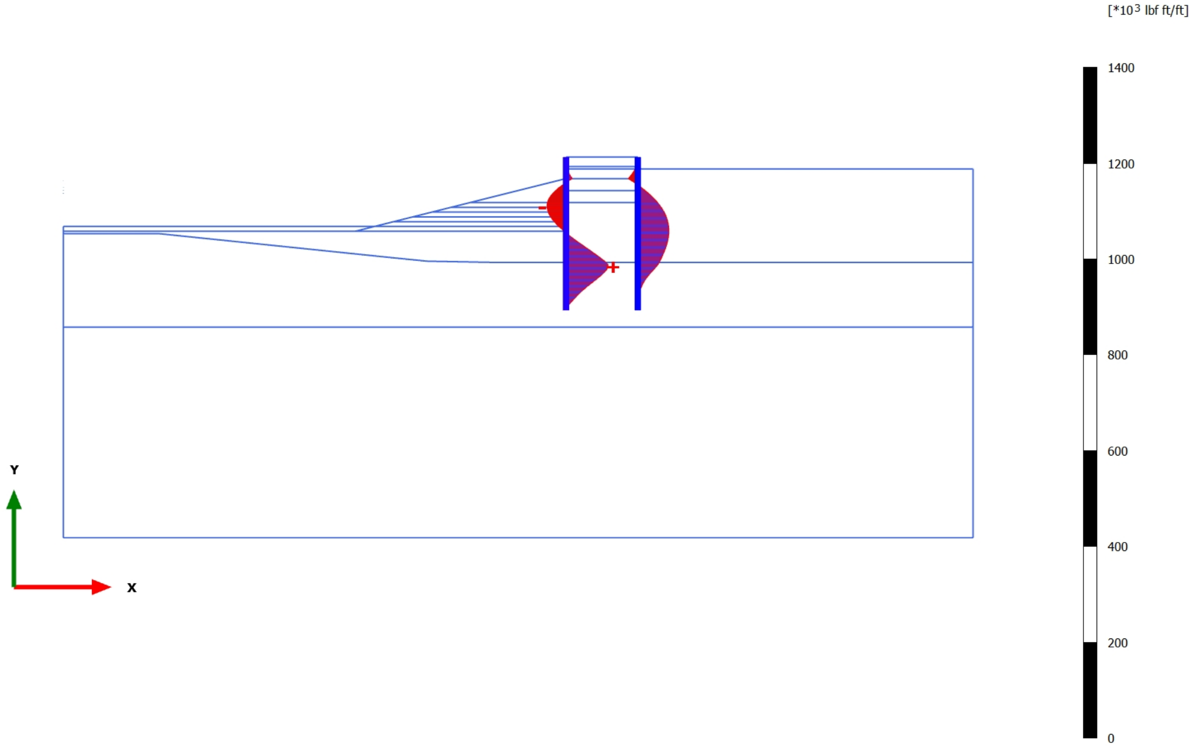


Bending moments M (scaled up 0.200×10^{-3} times)

Maximum value = 54.95×10^{3} lbf ft/ft (Element 37 at Node 22235)

Minimum value = -33.95×10^{3} lbf ft/ft (Element 20 at Node 13642)

3.1.2.2.7 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/81), Bending moments M

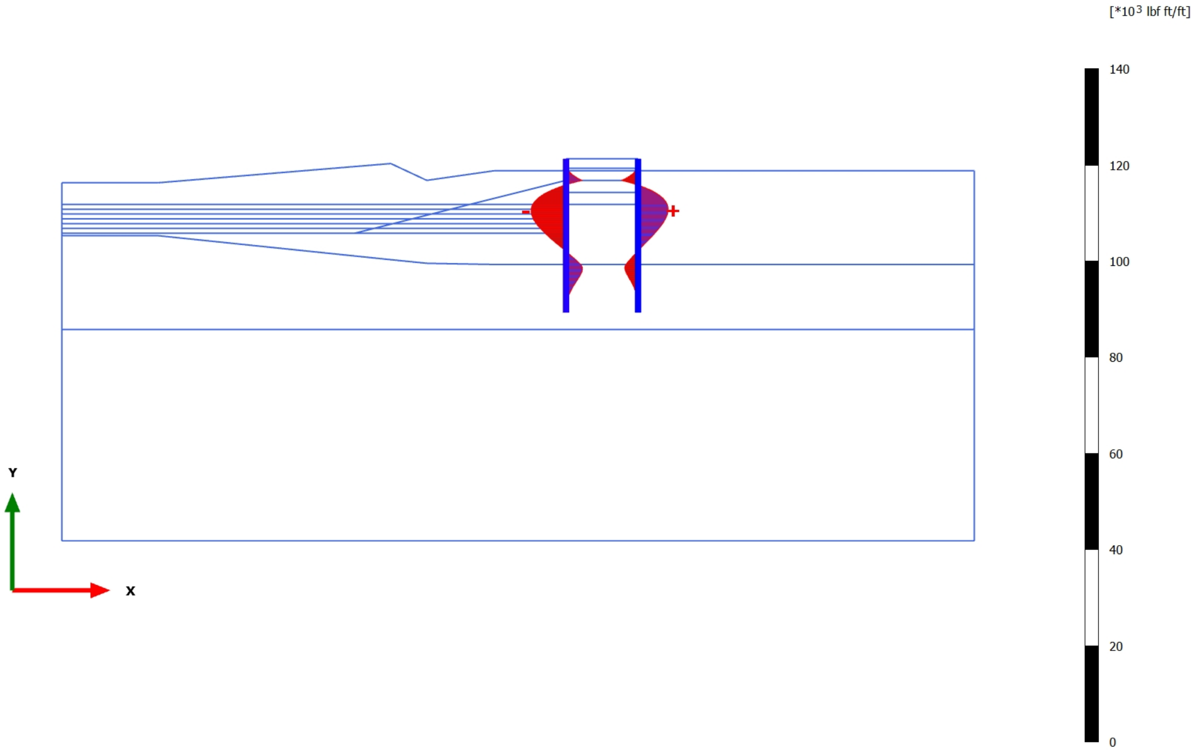


Bending moments M (scaled up 0.200*10⁻³ times)

Maximum value = 88.13*10³ lbf ft/ft (Element 37 at Node 22235)

Minimum value = -39.65*10³ lbf ft/ft (Element 19 at Node 12346)

3.1.2.2.8 Calculation results, Plate, Backfill [Phase_6] (6/120), Bending moments M



Bending moments M (scaled up $2.00*10^{-3}$ times)

Maximum value = 6268 lbf ft/ft (Element 25 at Node 9166)

Minimum value = -7280 lbf ft/ft (Element 20 at Node 13642)

3.2.1.1.2 Calculation results, Node-to-node anchor, Dewater2- SS [Phase_9] (9/23), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	43.178	-68.047	43.178
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	43.178	-68.047	43.178

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater -SS [Phase_7] (7/43), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	32.012	-68.047	32.012
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	32.012	-68.047	32.012

3.2.1.1.5 Calculation results, Node-to-node anchor, Excavate 1 [Phase_8] (8/59), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	42.880	-68.047	42.880
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	42.880	-68.047	42.880

3.2.1.1.6 Calculation results, Node-to-node anchor, Excavate 2 [Phase_10] (10/67), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	51.494	-68.047	51.494
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	51.494	-68.047	51.494

3.2.1.1.7 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/81), Table of node-to-node anchors

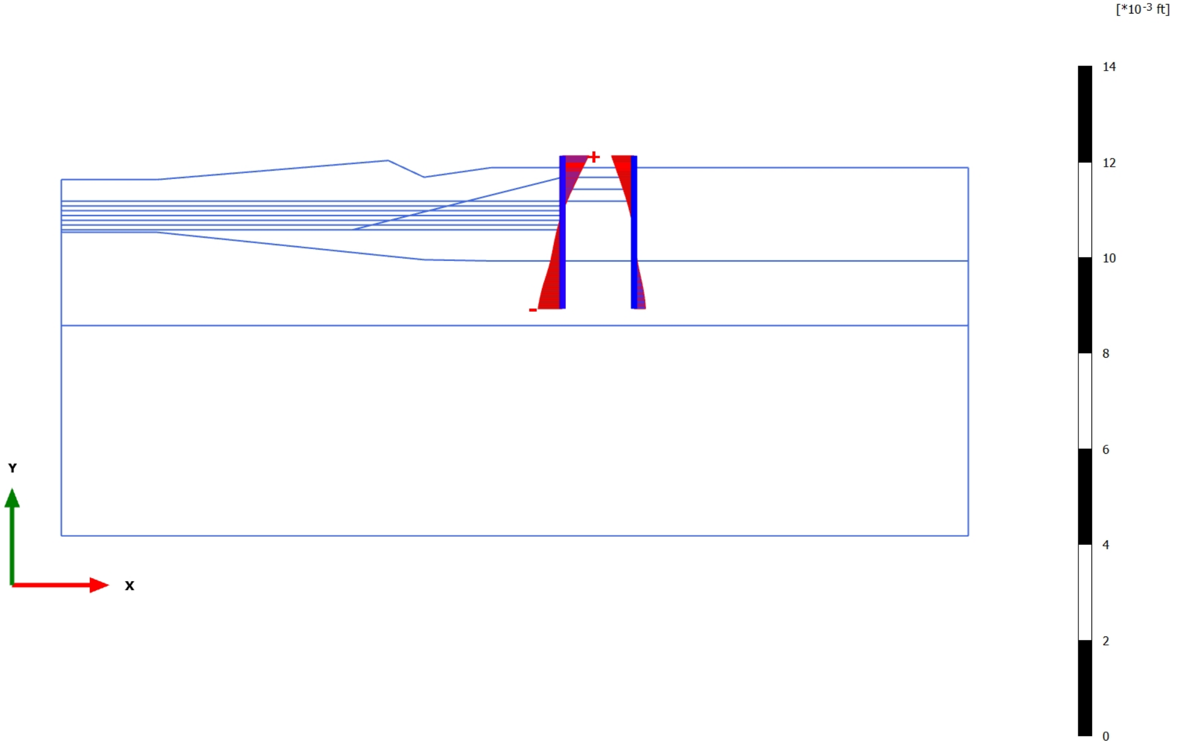
Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	65.370	-68.047	65.370
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	65.370	-68.047	65.370

3.2.1.1.8 Calculation results, Node-to-node anchor, Backfill [Phase_6] (6/120), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	16.415	-68.047	16.415
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	16.415	-68.047	16.415

PLAXIS Report

3.1.1.1.1.1 Calculation results, Plate, Install sheet pile [Phase_1] (1/5), Total displacements u_x

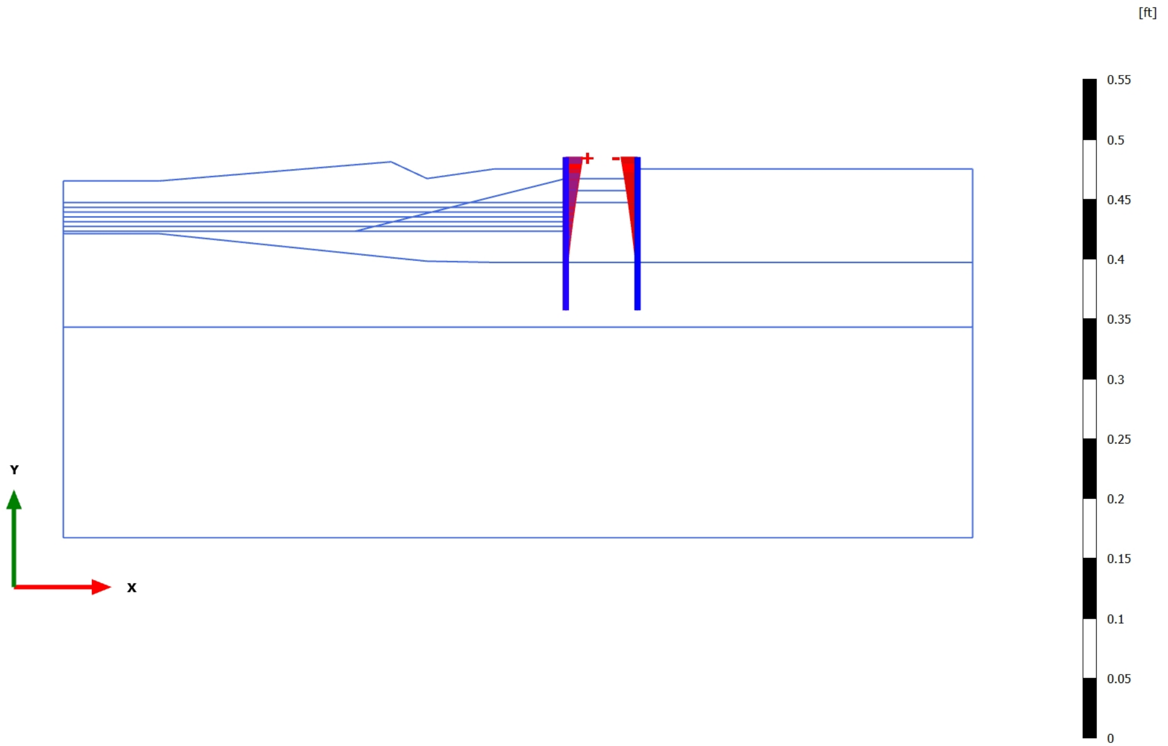


Total displacements u_x (scaled up $20.0*10^3$ times)

Maximum value = $0.5516*10^{-3}$ ft (Element 1 at Node 4564)

Minimum value = $-0.5126*10^{-3}$ ft (Element 42 at Node 26629)

3.1.1.1.1.2 Calculation results, Plate, Excavate [Phase_25] (25/7), Total displacements u_x

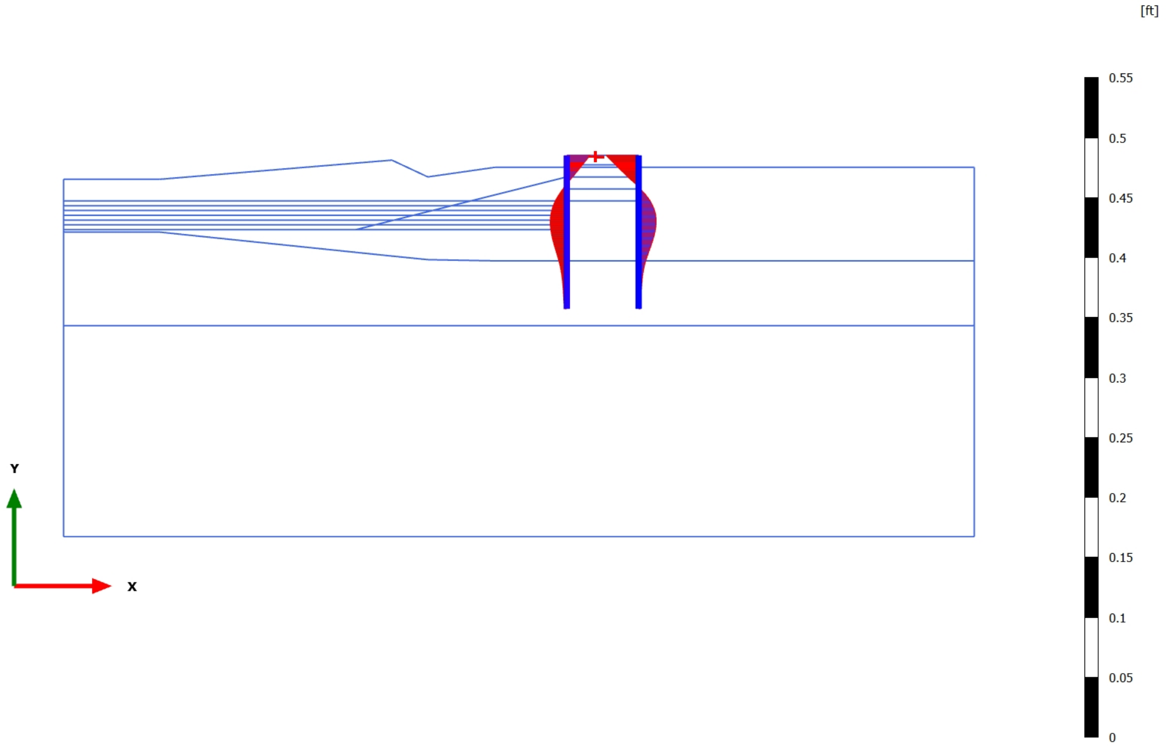


Total displacements u_x (scaled up 500 times)

Maximum value = 0.01425 ft (Element 1 at Node 4564)

Minimum value = -0.01393 ft (Element 3 at Node 4397)

3.1.1.1.1.3 Calculation results, Plate, Backfill [Phase_6] (6/27), Total displacements u_x

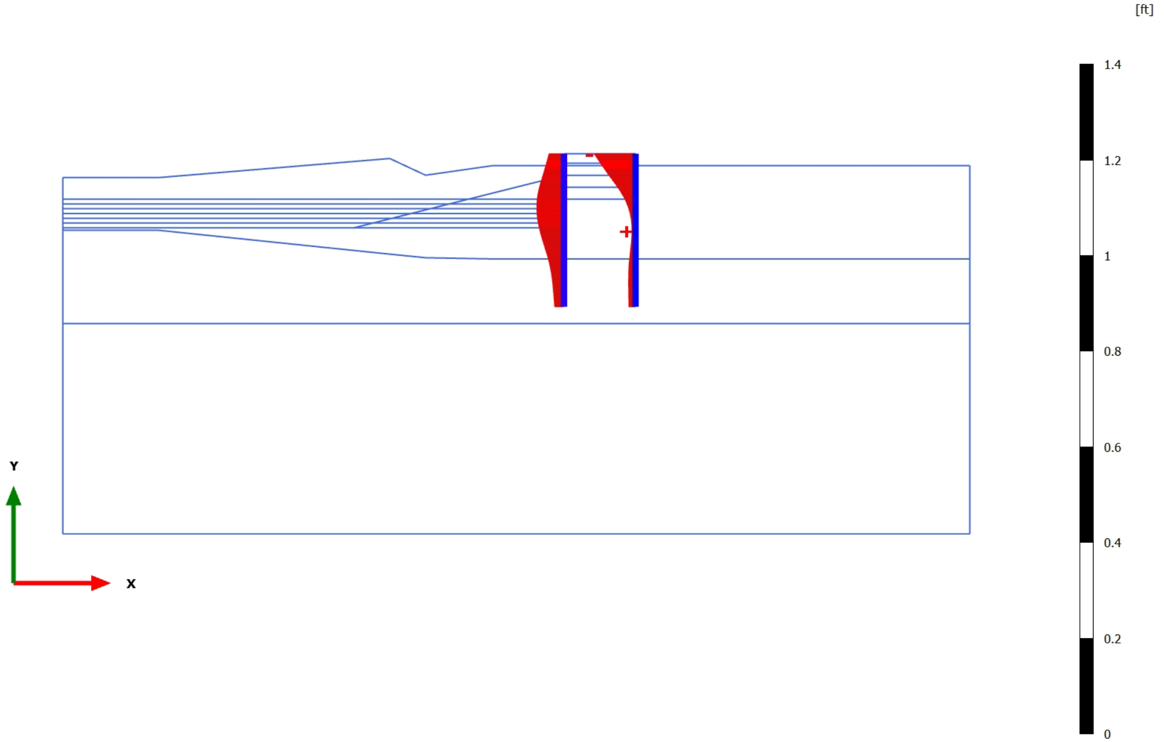


Total displacements u_x (scaled up 500 times)

Maximum value = 0.01955 ft (Element 1 at Node 4564)

Minimum value = -0.02740 ft (Element 3 at Node 4397)

3.1.1.1.1.4 Calculation results, Plate, Dewater -SS [Phase_7] (7/34), Total displacements u_x

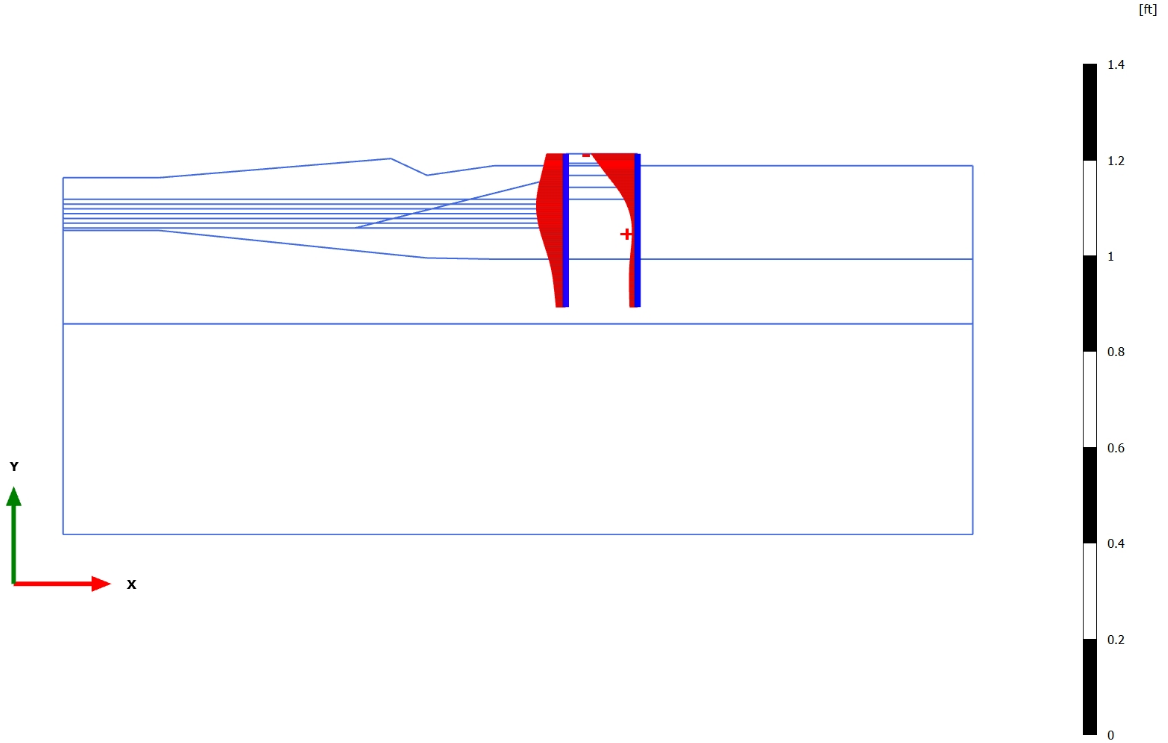


Total displacements u_x (scaled up 200 times)

Maximum value = -7.699×10^{-3} ft (Element 29 at Node 13814)

Minimum value = -0.08688 ft (Element 3 at Node 4397)

3.1.1.1.1.5 Calculation results, Plate, Consolidate [Phase_3] (4/47), Total displacements u_x

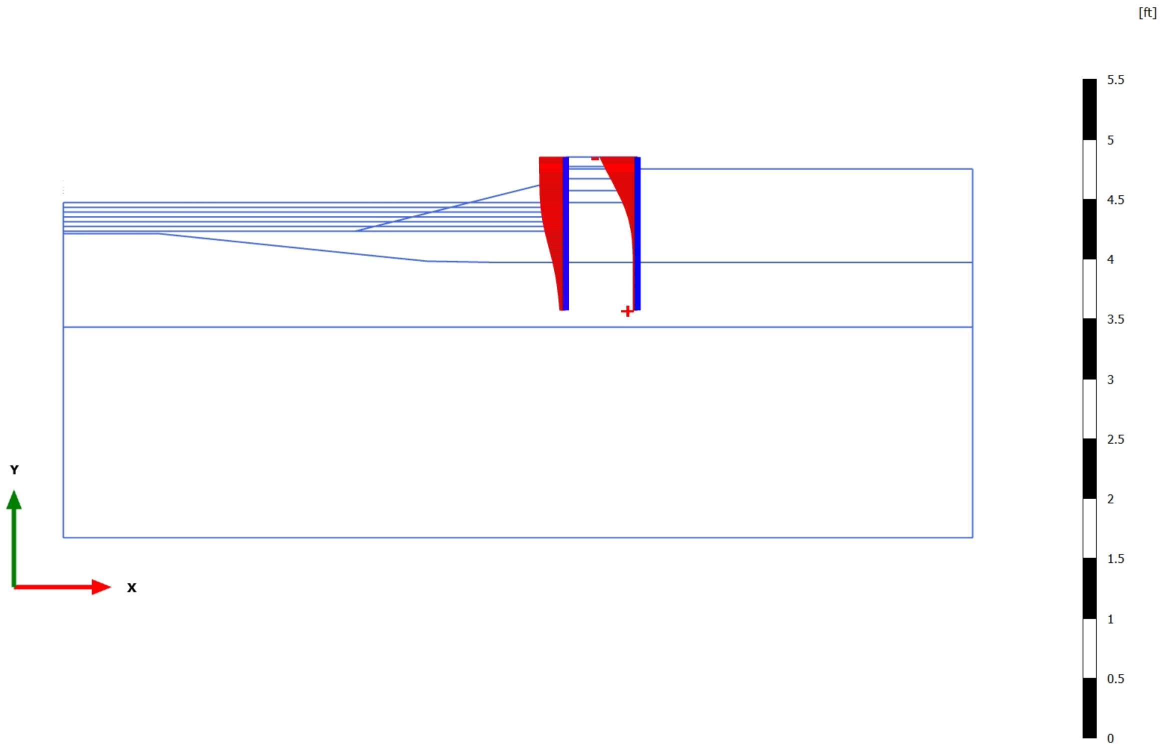


Total displacements u_x (scaled up 200 times) (Time 4.000 day)

Maximum value = -0.01120 ft (Element 29 at Node 13813)

Minimum value = -0.09692 ft (Element 3 at Node 4397)

3.1.1.1.1.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/58), Total displacements u_x

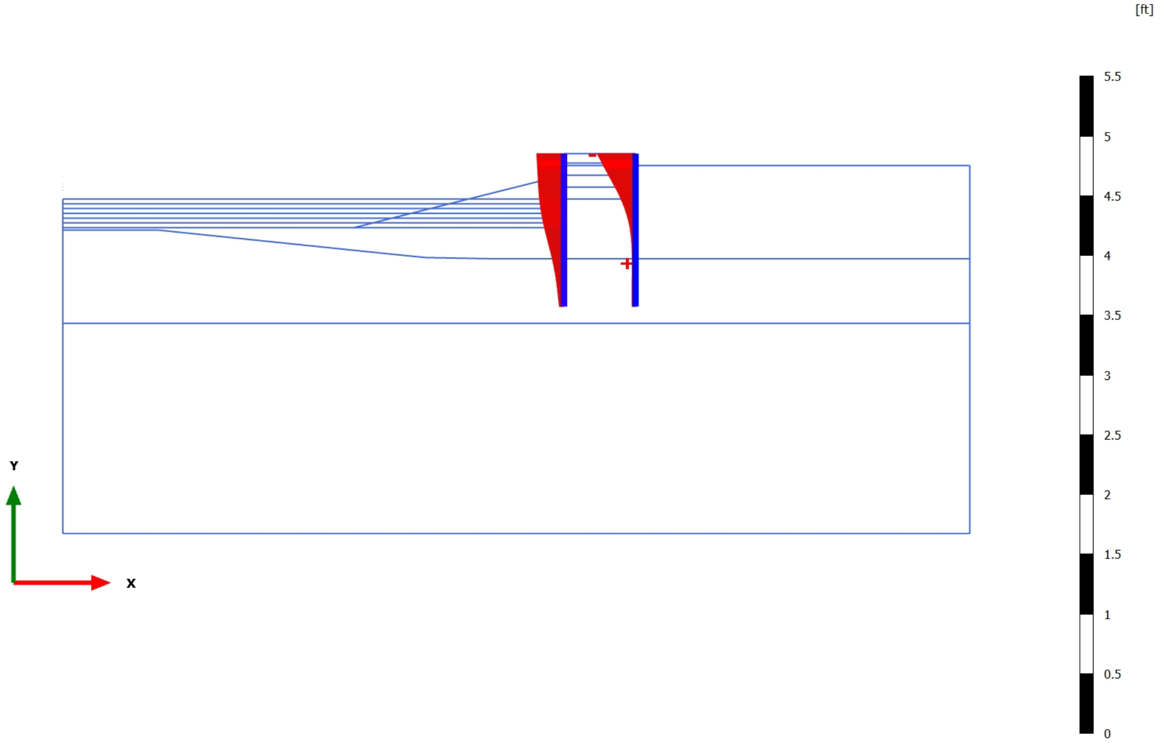


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.03737 ft (Element 48 at Node 22618)

Minimum value = -0.3159 ft (Element 3 at Node 4397)

3.1.1.1.1.7 Calculation results, Plate, Consolidation [Phase_5] (5/76), Total displacements u_x

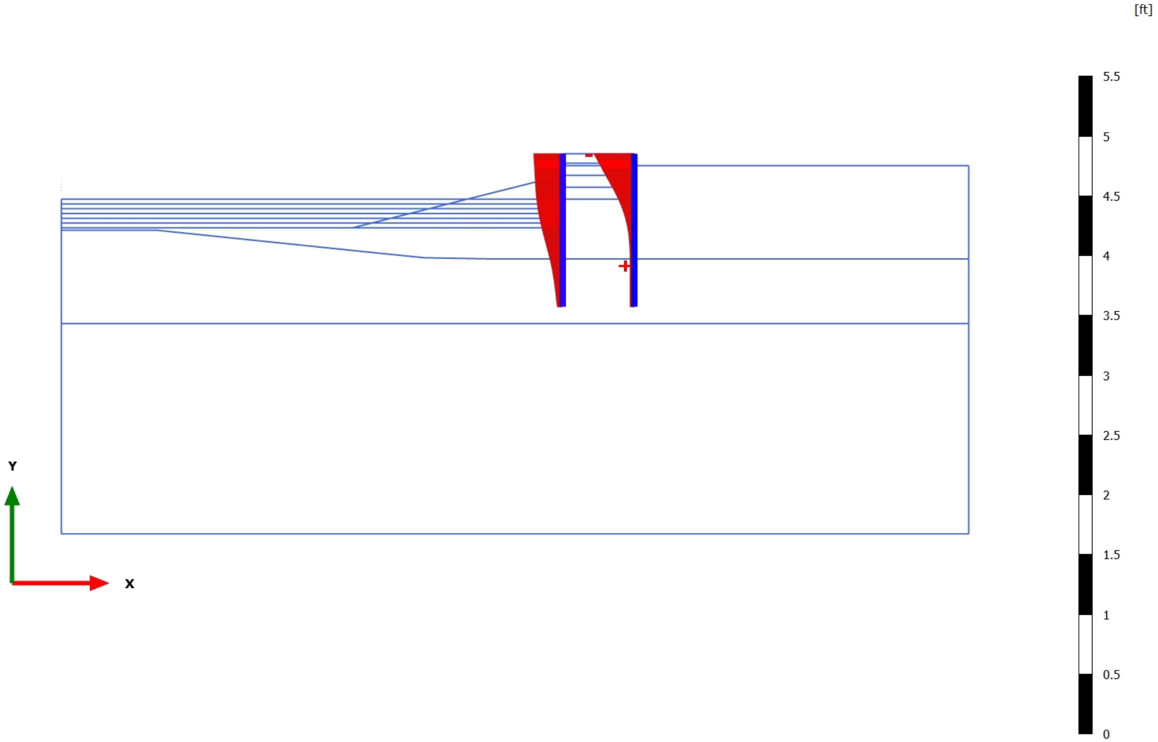


Total displacements u_x (scaled up 50.0 times) (Time 18.00 day)

Maximum value = -0.02849 ft (Element 43 at Node 17605)

Minimum value = -0.3223 ft (Element 3 at Node 4397)

3.1.1.1.1.8 Calculation results, Plate, Dewater2- SS [Phase_9] (9/80), Total displacements u_x

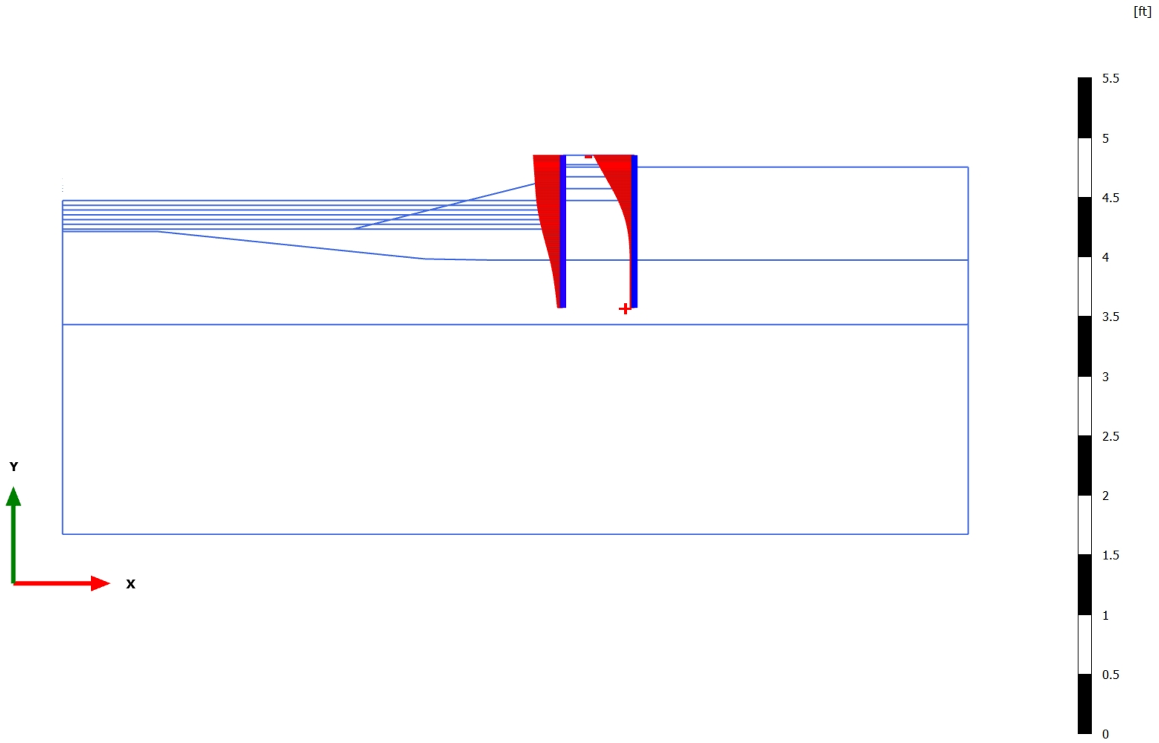


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.03566 ft (Element 43 at Node 17604)

Minimum value = -0.3382 ft (Element 3 at Node 4397)

3.1.1.1.1.9 Calculation results, Plate, Consolidation [Phase_12] (15/85), Total displacements u_x

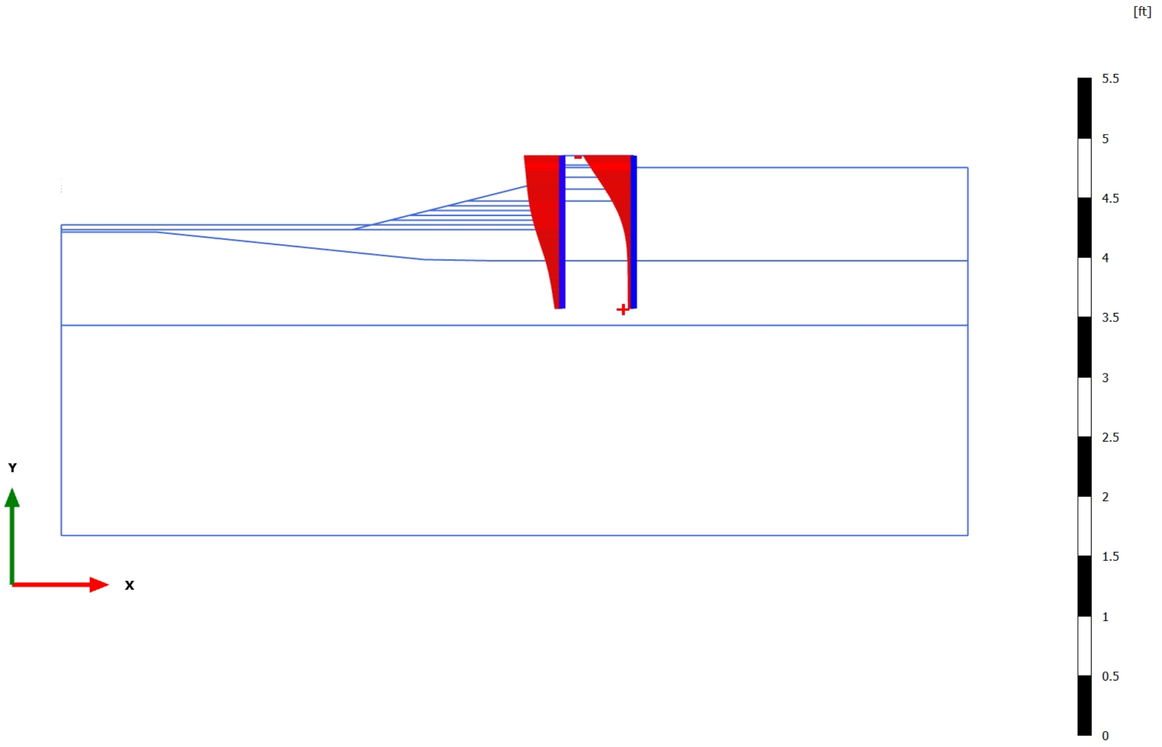


Total displacements u_x (scaled up 50.0 times) (Time 21.00 day)

Maximum value = -0.03689 ft (Element 48 at Node 22618)

Minimum value = -0.3440 ft (Element 3 at Node 4397)

3.1.1.1.1.10 Calculation results, Plate, Excavate 2 [Phase_10] (10/91), Total displacements u_x

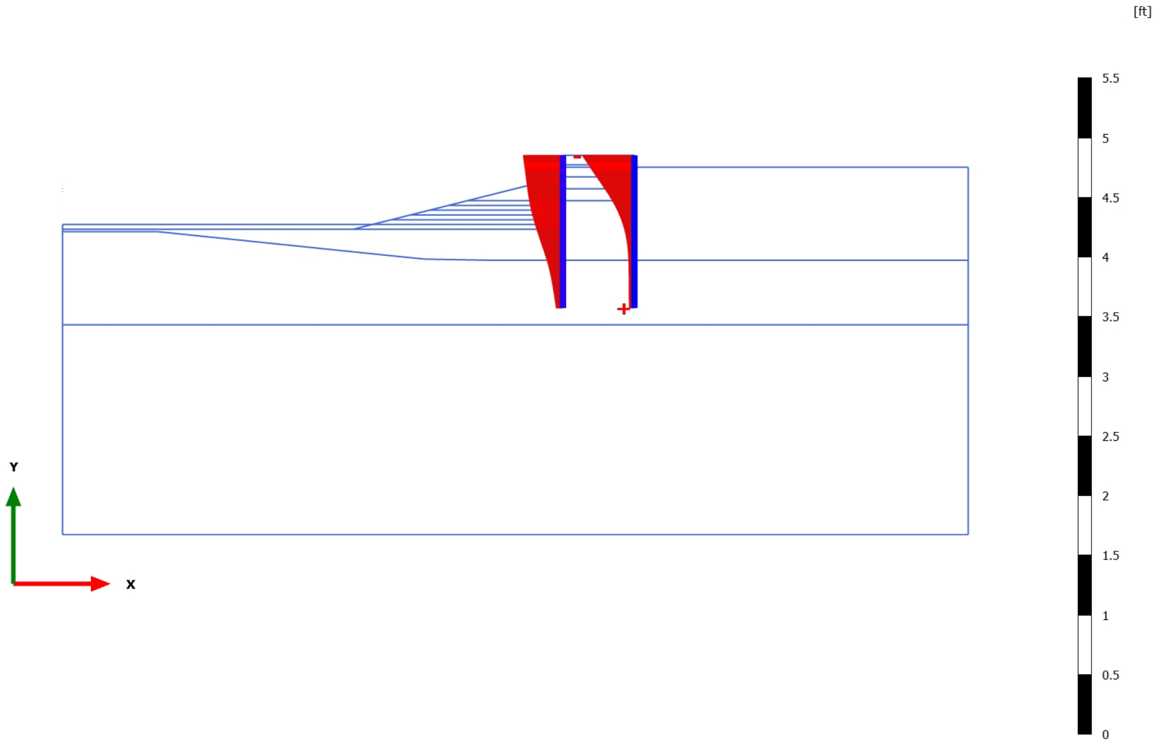


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.04727 ft (Element 48 at Node 22618)

Minimum value = -0.4241 ft (Element 3 at Node 4397)

3.1.1.1.1.11 Calculation results, Plate, Consolidation [Phase_16] (16/99), Total displacements u_x

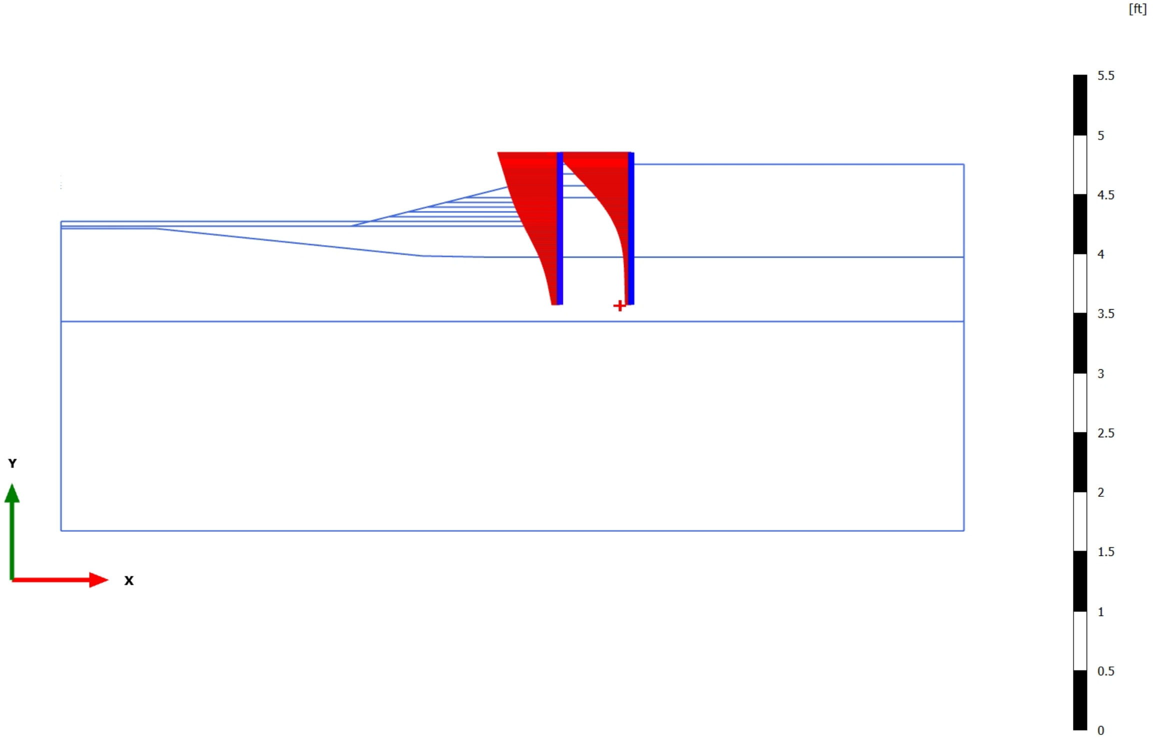


Total displacements u_x (scaled up 50.0 times) (Time 35.00 day)

Maximum value = -0.04397 ft (Element 48 at Node 22618)

Minimum value = -0.4379 ft (Element 3 at Node 4397)

3.1.1.1.1.12 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/111), Total displacements u_x

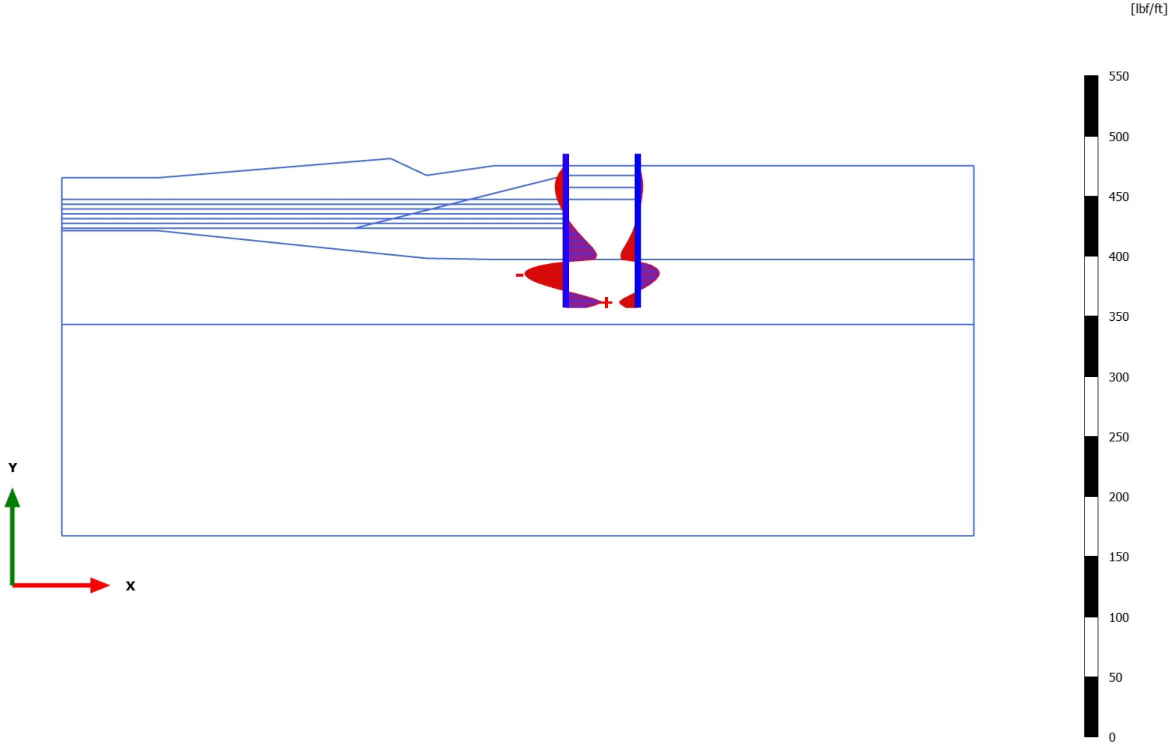


Total displacements u_x (scaled up 50.0 times)

Maximum value = -0.05055 ft (Element 48 at Node 22618)

Minimum value = -0.6402 ft (Element 3 at Node 4397)

3.1.2.1.1 Calculation results, Plate, Install sheet pile [Phase_1] (1/5), Shear forces Q

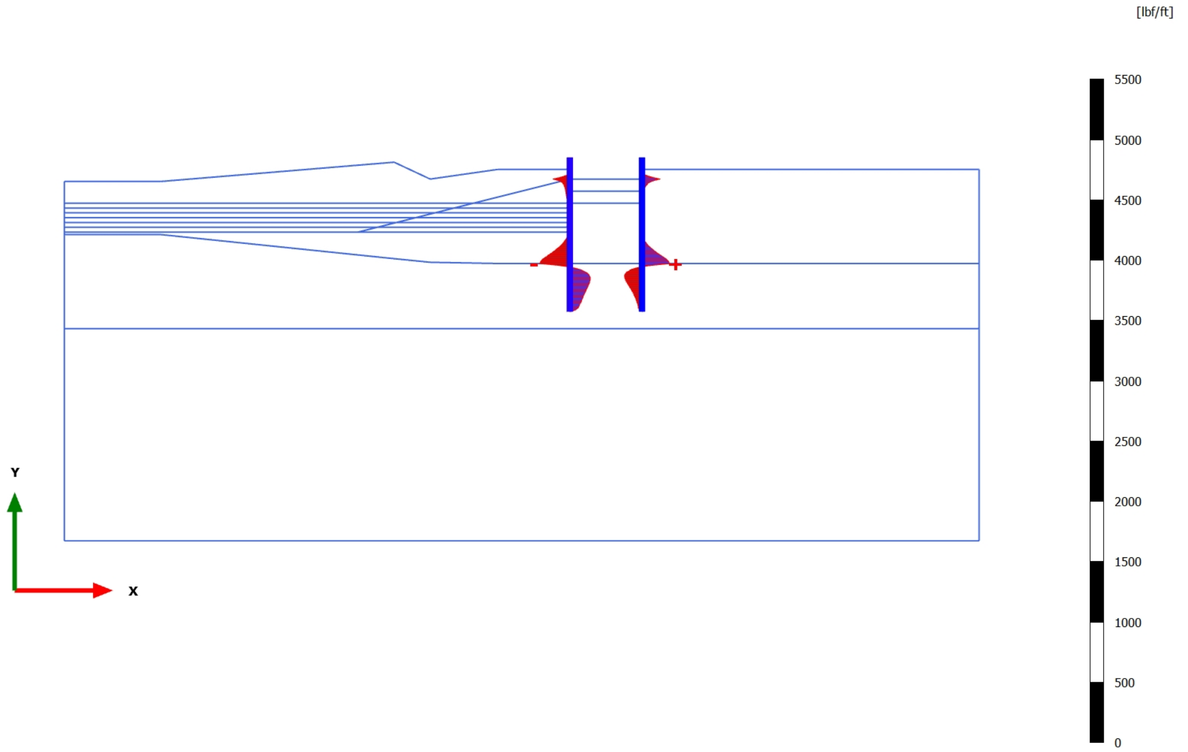


Shear forces Q (scaled up 0.500 times)

Maximum value = 29.39 lbf/ft (Element 42 at Node 26632)

Minimum value = -34.28 lbf/ft (Element 38 at Node 22508)

3.1.2.1.2 Calculation results, Plate, Excavate [Phase_25] (25/7), Shear forces Q

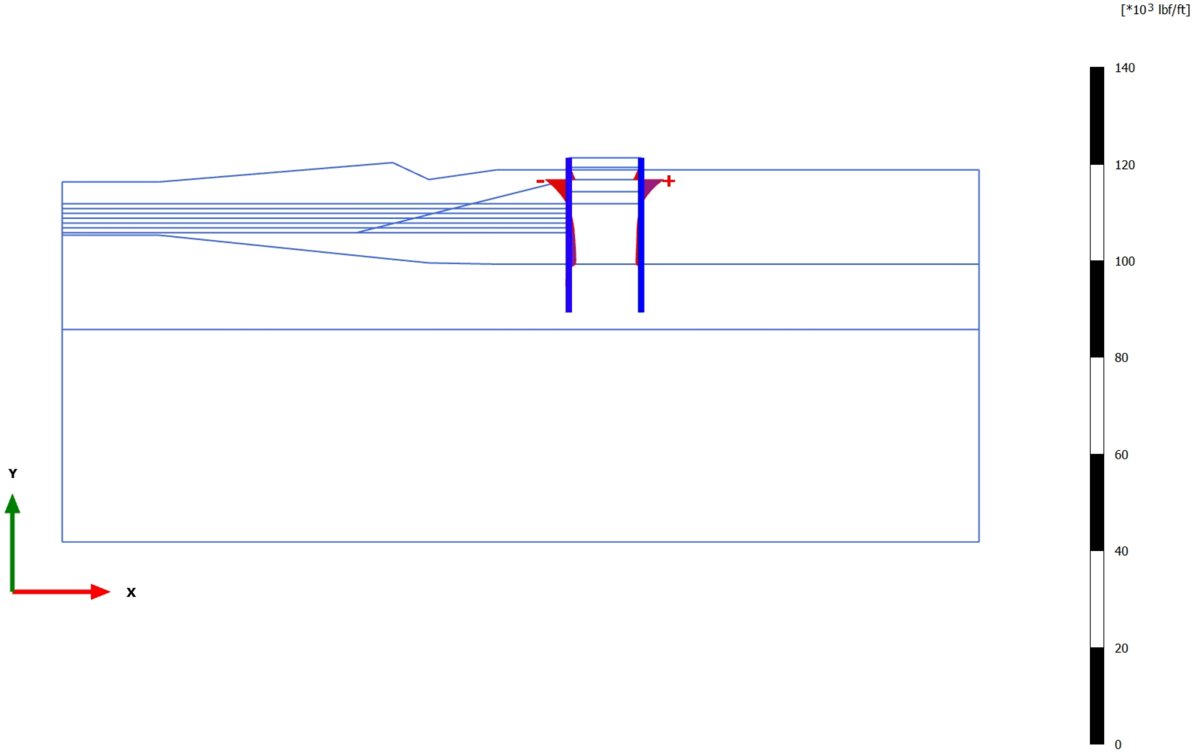


Shear forces Q (scaled up 0.0500 times)

Maximum value = 236.9 lbf/ft (Element 43 at Node 17603)

Minimum value = -256.4 lbf/ft (Element 37 at Node 22233)

3.1.2.1.3 Calculation results, Plate, Backfill [Phase_6] (6/27), Shear forces Q

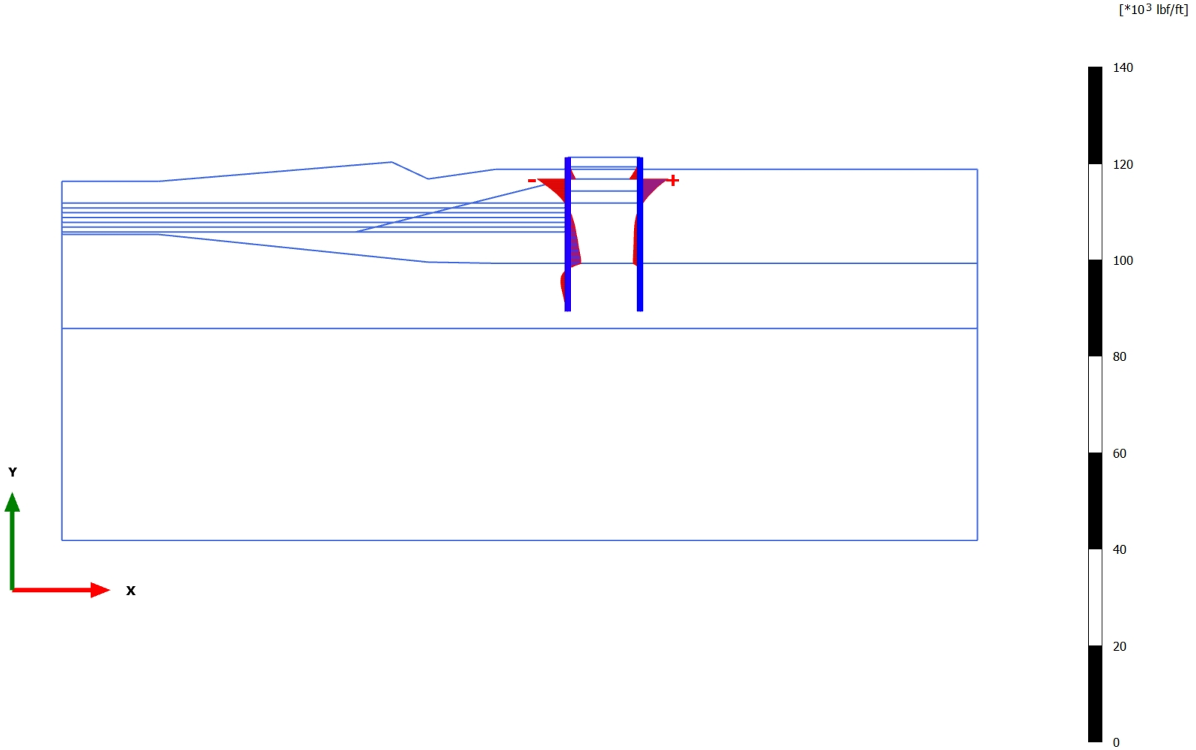


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 4658 lbf/ft (Element 13 at Node 6499)

Minimum value = -4919 lbf/ft (Element 11 at Node 8339)

3.1.2.1.4 Calculation results, Plate, Dewater -SS [Phase_7] (7/34), Shear forces Q

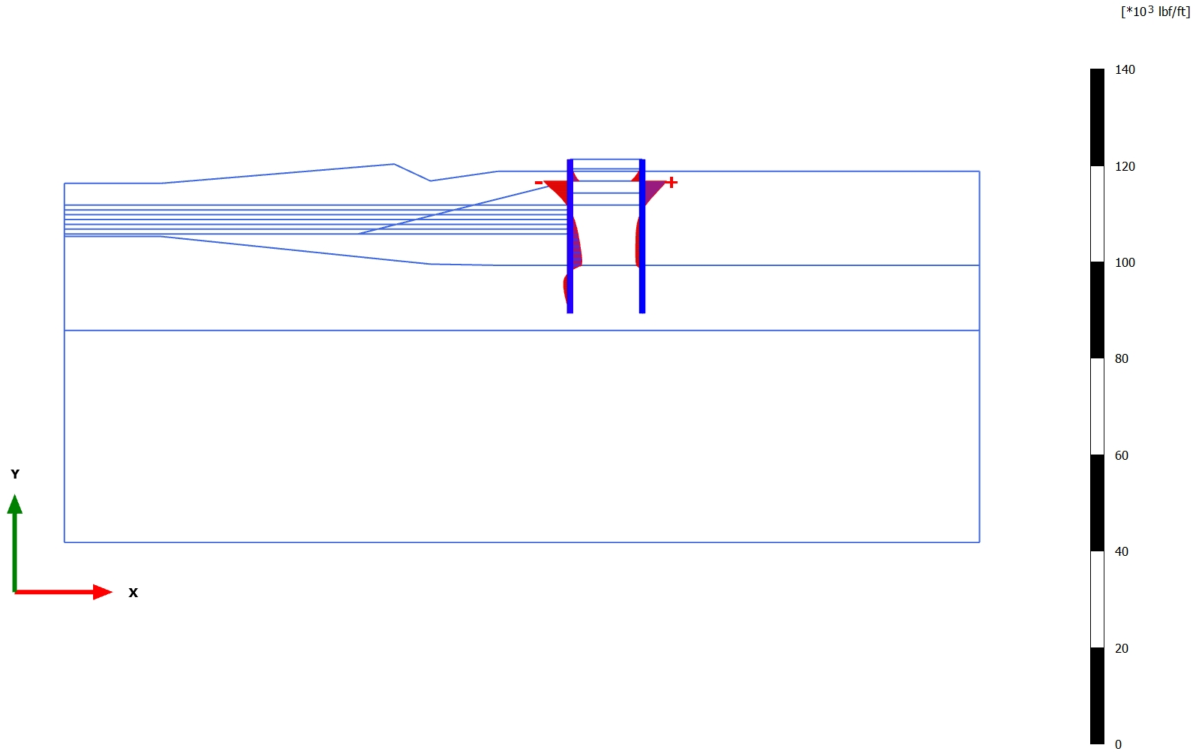


Shear forces Q (scaled up 2.00*10⁻³ times)

Maximum value = 5818 lbf/ft (Element 13 at Node 6499)

Minimum value = -6356 lbf/ft (Element 11 at Node 8339)

3.1.2.1.5 Calculation results, Plate, Consolidate [Phase_3] (4/47), Shear forces Q

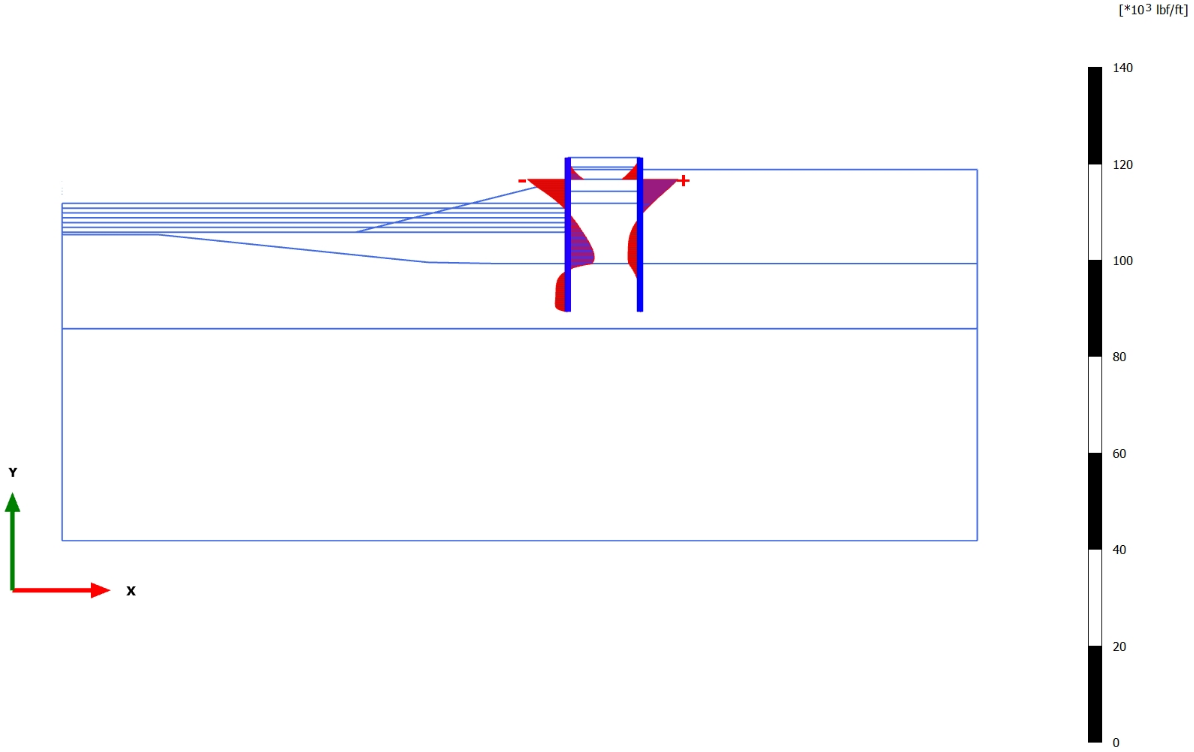


Shear forces Q (scaled up 2.00*10⁻³ times) (Time 4.000 day)

Maximum value = 5050 lbf/ft (Element 13 at Node 6499)

Minimum value = -5490 lbf/ft (Element 11 at Node 8339)

3.1.2.1.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/58), Shear forces Q

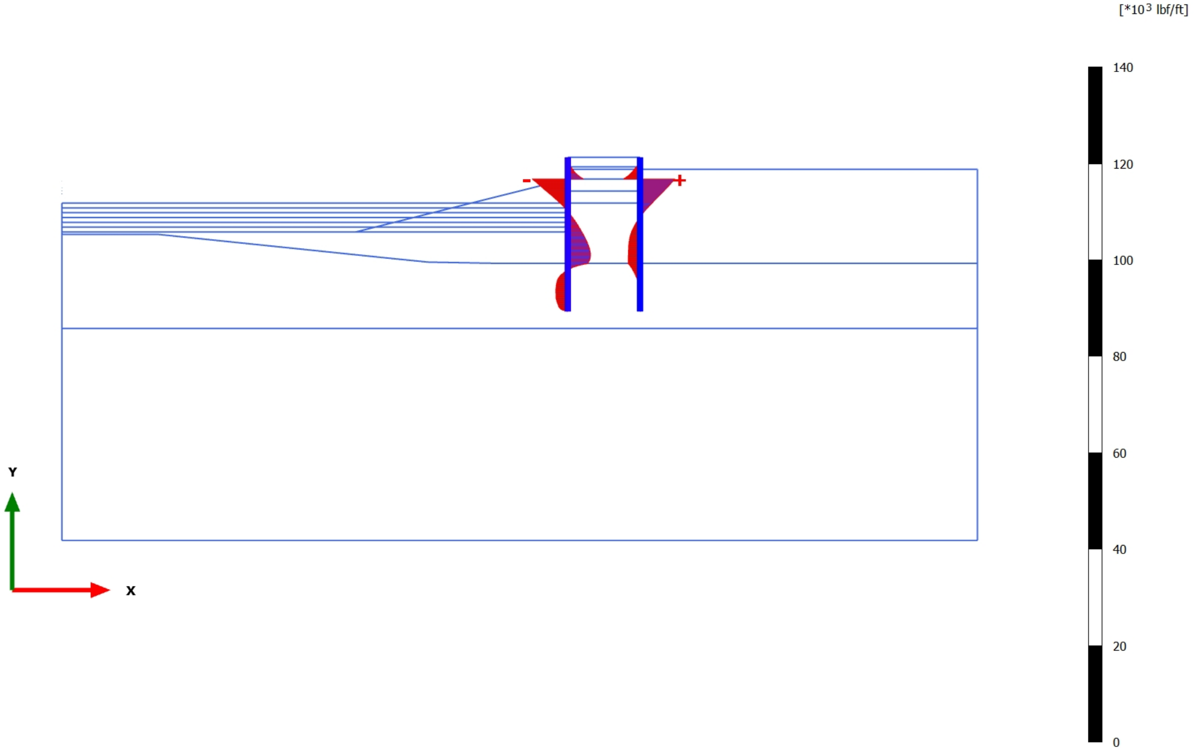


Shear forces Q (scaled up 2.00*10^{-3} times)

Maximum value = 7955 lbf/ft (Element 13 at Node 6499)

Minimum value = -8413 lbf/ft (Element 11 at Node 8339)

3.1.2.1.7 Calculation results, Plate, Consolidation [Phase_5] (5/76), Shear forces Q

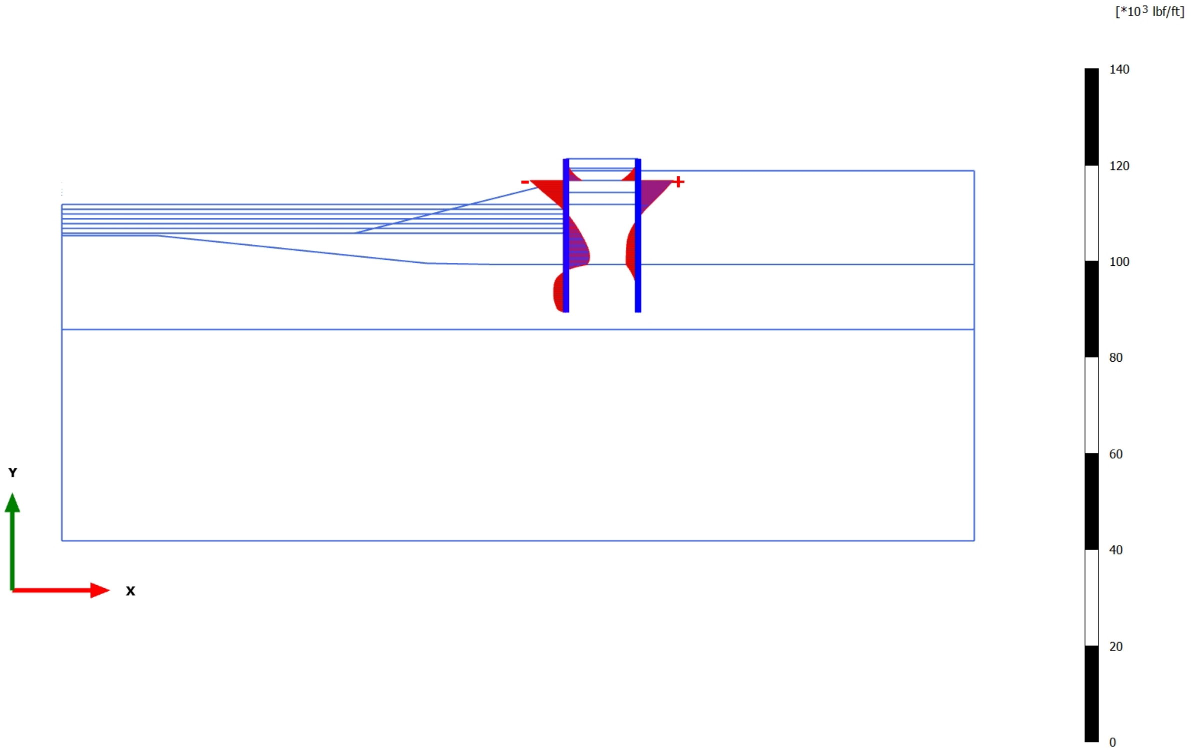


Shear forces Q (scaled up $2.00*10^{-3}$ times) (Time 18.00 day)

Maximum value = 7266 lbf/ft (Element 13 at Node 6499)

Minimum value = -7422 lbf/ft (Element 11 at Node 8339)

3.1.2.1.8 Calculation results, Plate, Dewater2- SS [Phase_9] (9/80), Shear forces Q

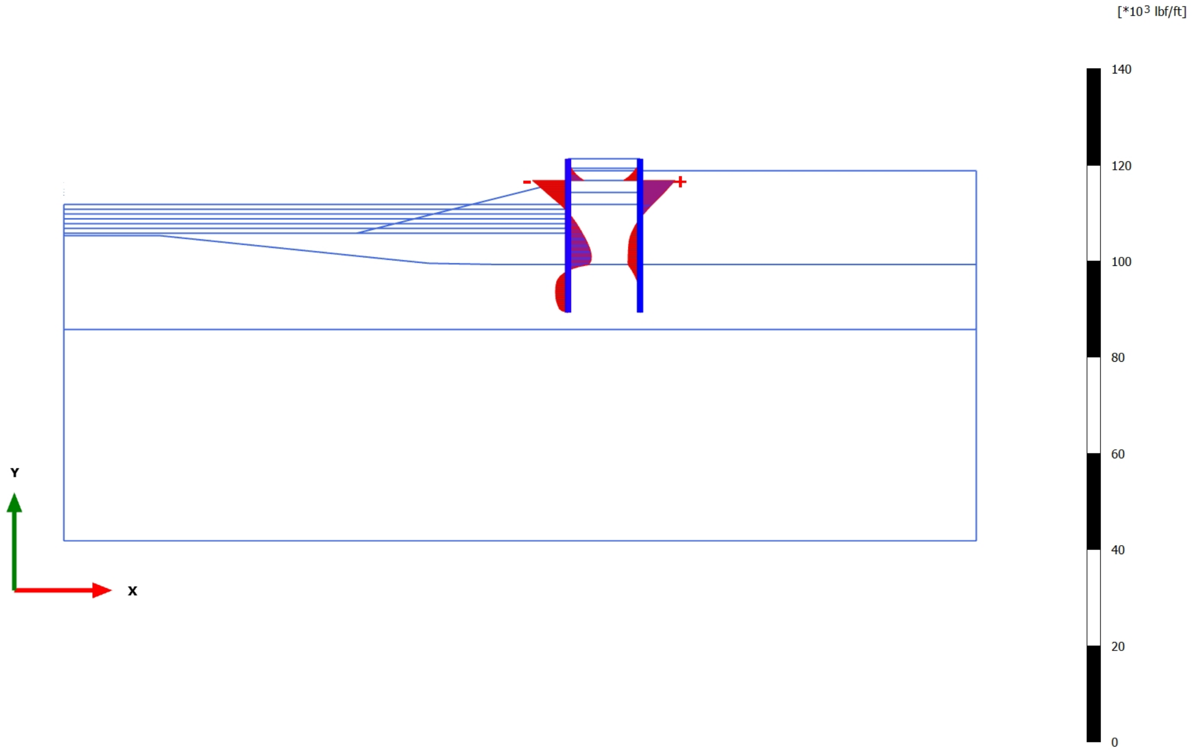


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 7383 lbf/ft (Element 13 at Node 6499)

Minimum value = -7556 lbf/ft (Element 11 at Node 8339)

3.1.2.1.9 Calculation results, Plate, Consolidation [Phase_12] (15/85), Shear forces Q

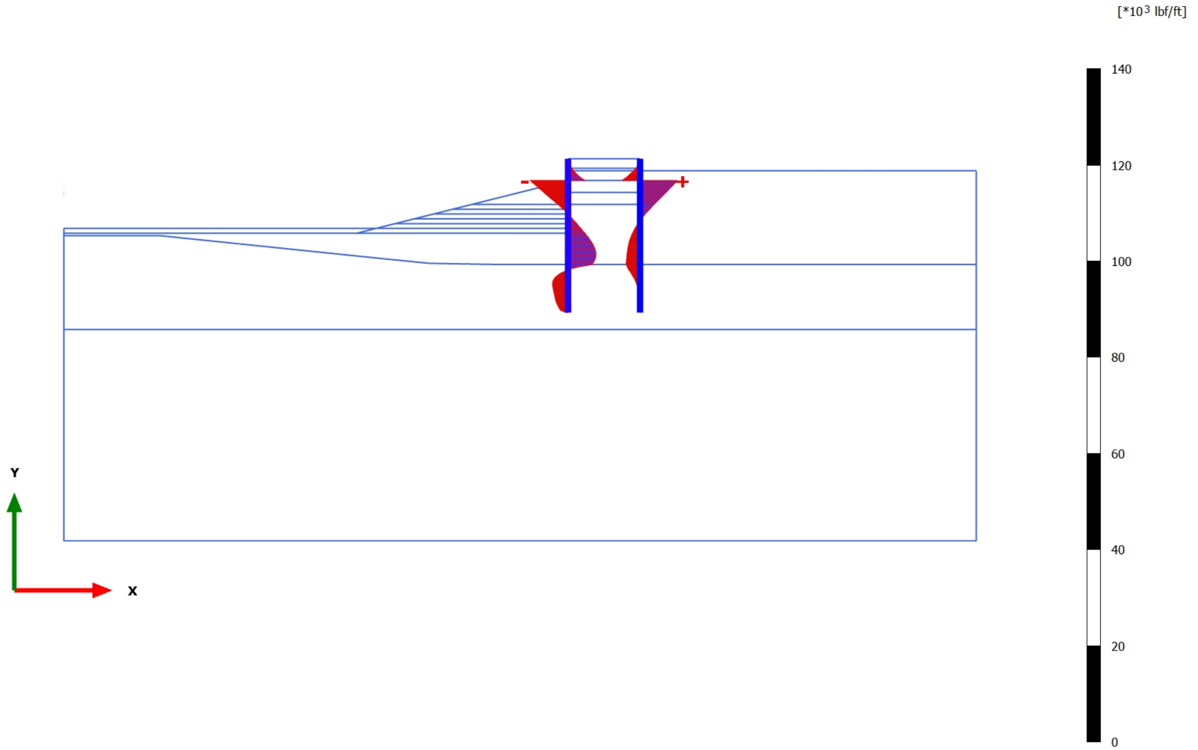


Shear forces Q (scaled up $2.00*10^{-3}$ times) (Time 21.00 day)

Maximum value = 7331 lbf/ft (Element 13 at Node 6499)

Minimum value = -7451 lbf/ft (Element 11 at Node 8339)

3.1.2.1.10 Calculation results, Plate, Excavate 2 [Phase_10] (10/91), Shear forces Q

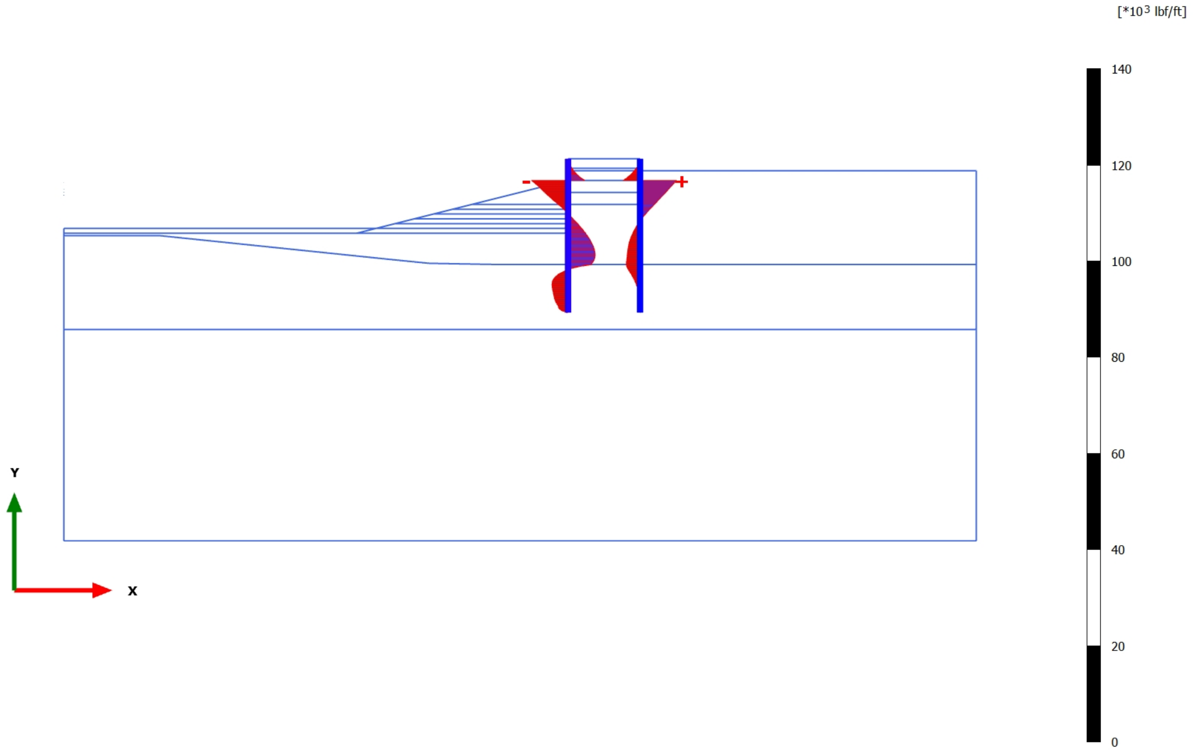


Shear forces Q (scaled up 2.00×10^{-3} times)

Maximum value = 7799 lbf/ft (Element 13 at Node 6499)

Minimum value = -7962 lbf/ft (Element 11 at Node 8339)

3.1.2.1.11 Calculation results, Plate, Consolidation [Phase_16] (16/99), Shear forces Q

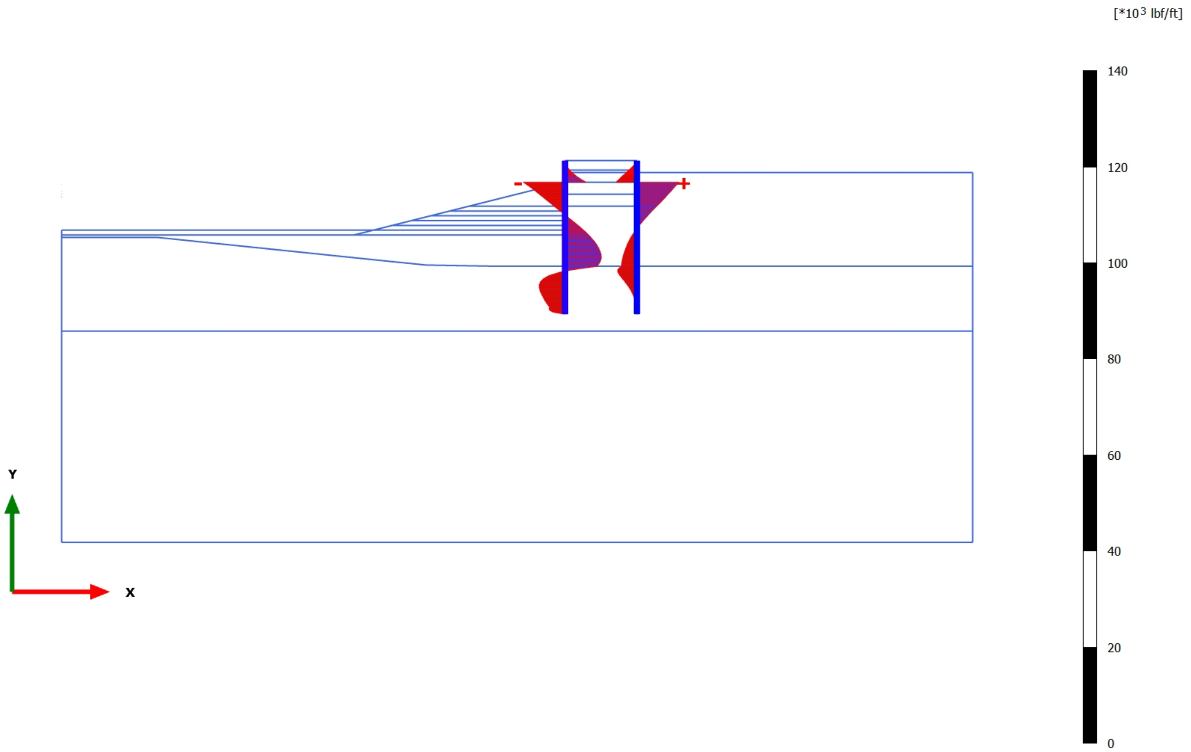


Shear forces Q (scaled up $2.00*10^{-3}$ times) (Time 35.00 day)

Maximum value = 7631 lbf/ft (Element 13 at Node 6499)

Minimum value = -7650 lbf/ft (Element 11 at Node 8339)

3.1.2.1.12 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/111), Shear forces Q

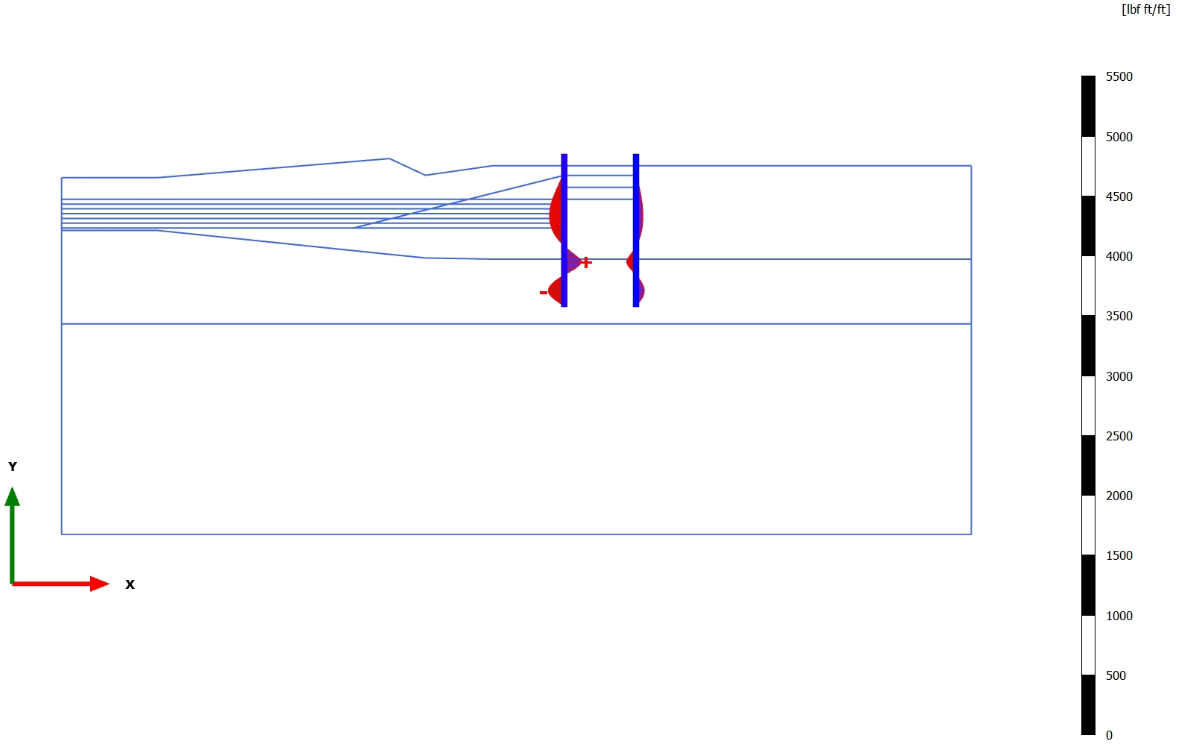


Shear forces Q (scaled up $2.00*10^{-3}$ times)

Maximum value = 8740 lbf/ft (Element 13 at Node 6499)

Minimum value = -8718 lbf/ft (Element 11 at Node 8339)

3.1.2.2.1 Calculation results, Plate, Install sheet pile [Phase_1] (1/5), Bending moments M

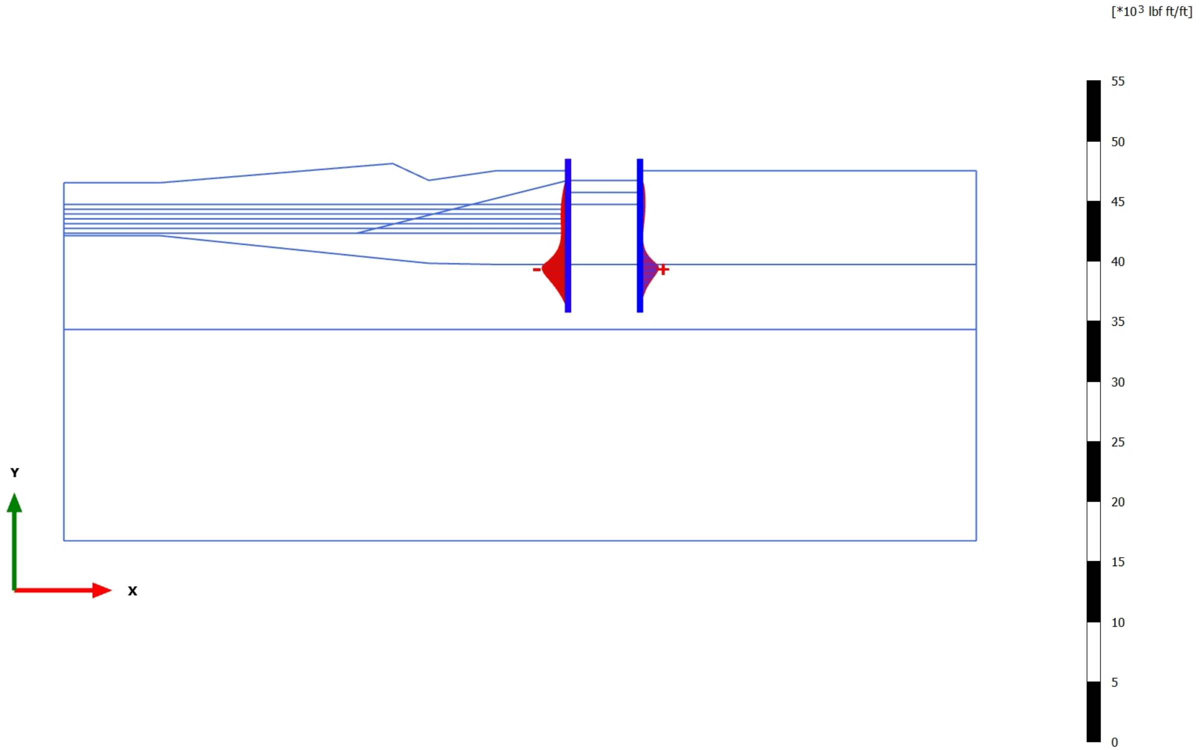


Bending moments M (scaled up 0.0500 times)

Maximum value = 143.9 lbf ft/ft (Element 37 at Node 22236)

Minimum value = -132.4 lbf ft/ft (Element 41 at Node 25310)

3.1.2.2.2 Calculation results, Plate, Excavate [Phase_25] (25/7), Bending moments M

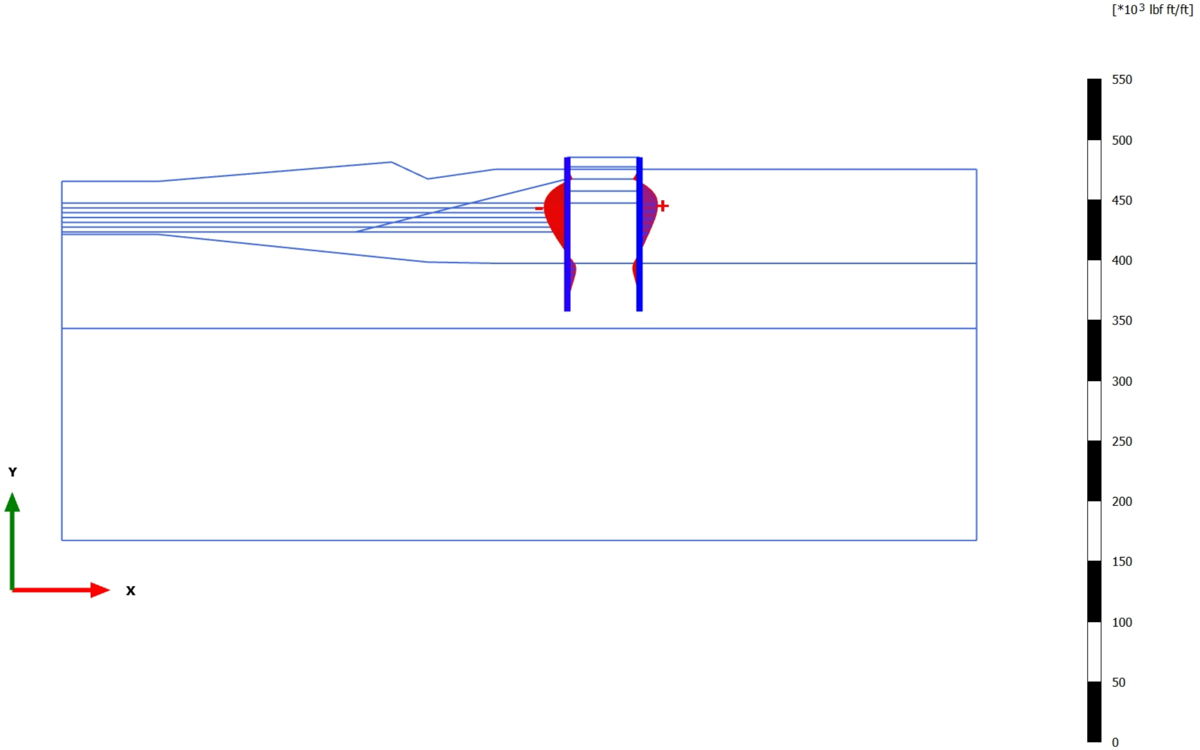


Bending moments M (scaled up $5.00*10^{-3}$ times)

Maximum value = 1537 lbf ft/ft (Element 43 at Node 17605)

Minimum value = -2174 lbf ft/ft (Element 37 at Node 22235)

3.1.2.2.3 Calculation results, Plate, Backfill [Phase_6] (6/27), Bending moments M

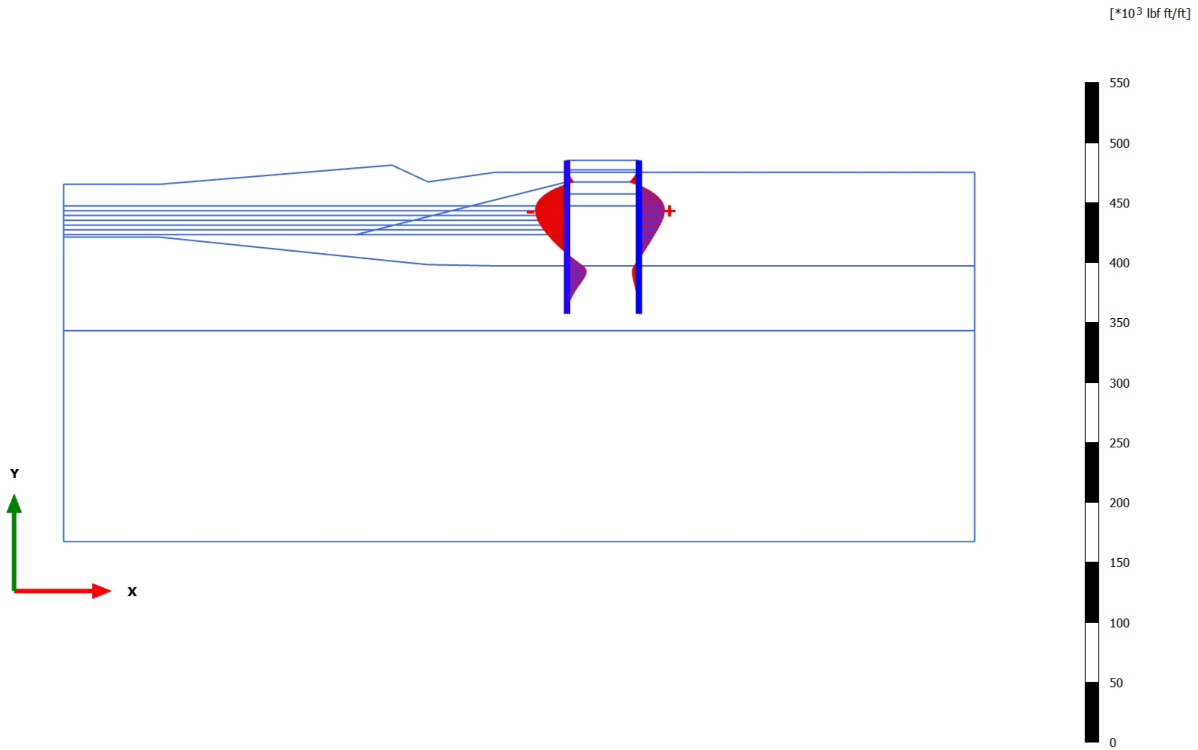


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 15.04*10^{3} lbf ft/ft (Element 25 at Node 9168)

Minimum value = -19.25*10^{3} lbf ft/ft (Element 19 at Node 12346)

3.1.2.2.4 Calculation results, Plate, Dewater -SS [Phase_7] (7/34), Bending moments M

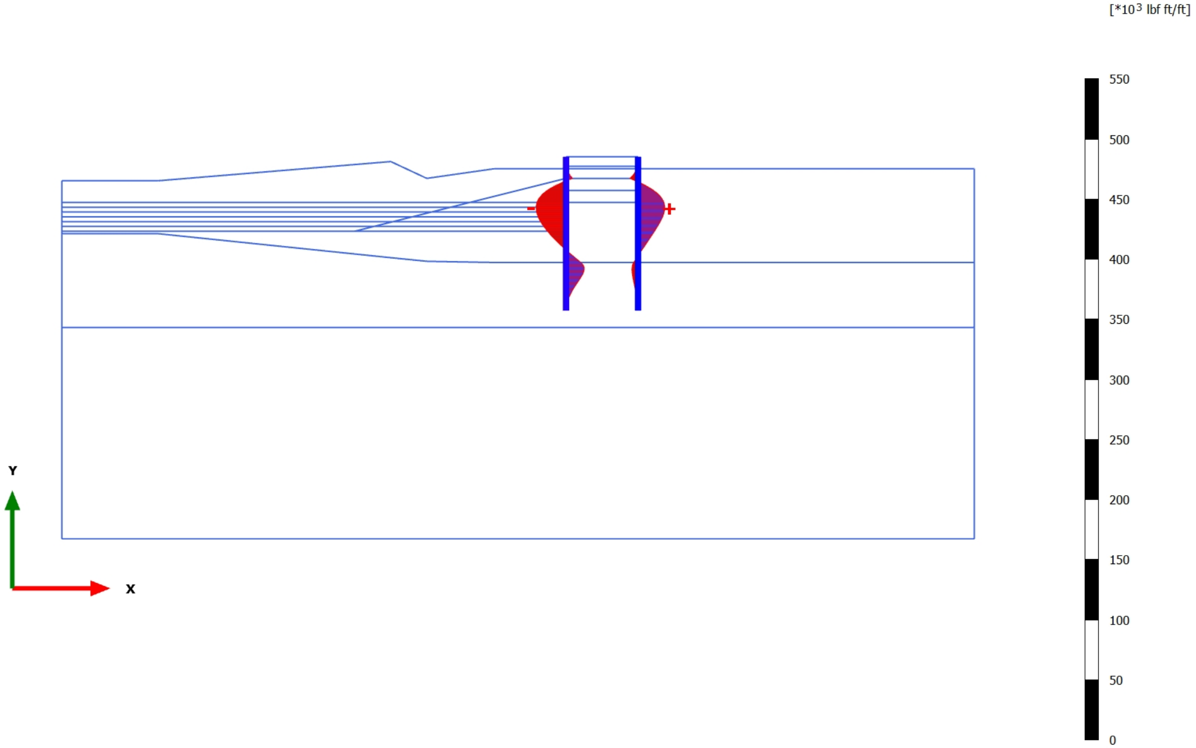


Bending moments M (scaled up 0.500*10^{-3} times)

Maximum value = 21.34*10^3 lbf ft/ft (Element 25 at Node 9167)

Minimum value = -26.33*10^3 lbf ft/ft (Element 19 at Node 13641)

3.1.2.2.5 Calculation results, Plate, Consolidate [Phase_3] (4/47), Bending moments M

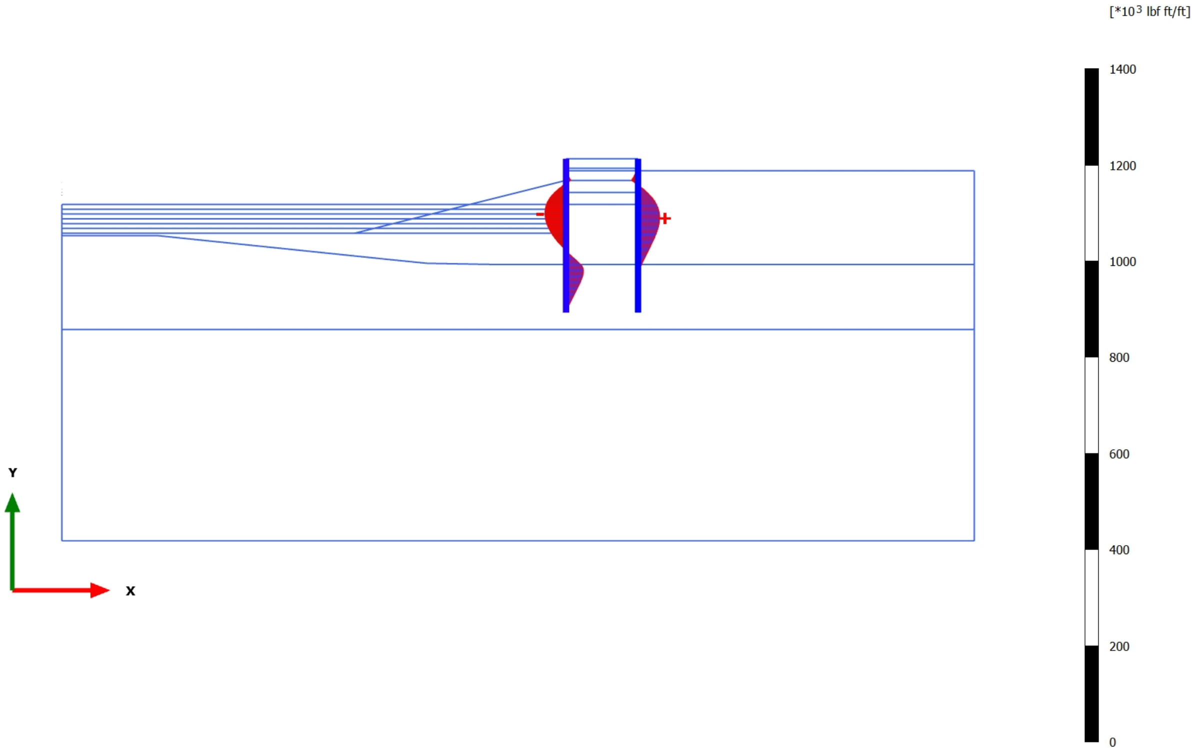


Bending moments M (scaled up $0.500*10^{-3}$ times) (Time 4.000 day)

Maximum value = $22.24*10^{3}$ lbf ft/ft (Element 25 at Node 9166)

Minimum value = $-24.90*10^{3}$ lbf ft/ft (Element 19 at Node 13641)

3.1.2.2.6 Calculation results, Plate, Excavate 1 [Phase_8] (8/58), Bending moments M

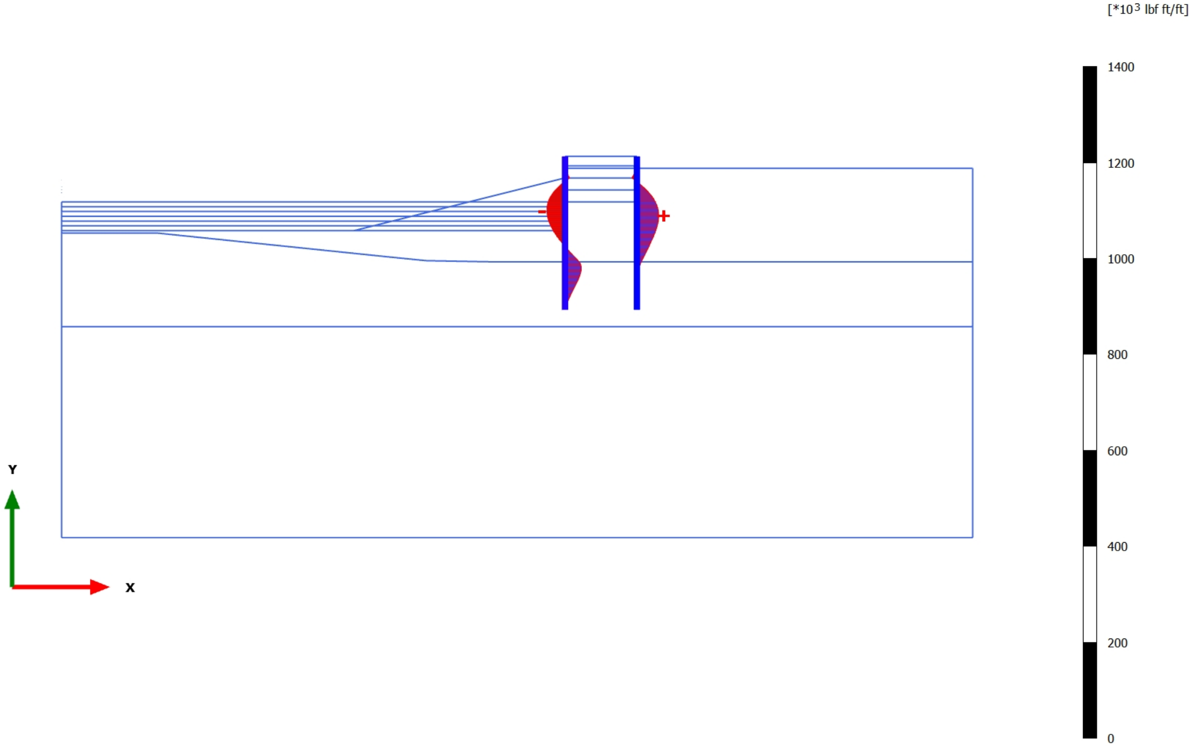


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 45.13*10^3 lbf ft/ft (Element 26 at Node 10442)

Minimum value = -44.03*10^3 lbf ft/ft (Element 20 at Node 13644)

3.1.2.2.7 Calculation results, Plate, Consolidation [Phase_5] (5/76), Bending moments M

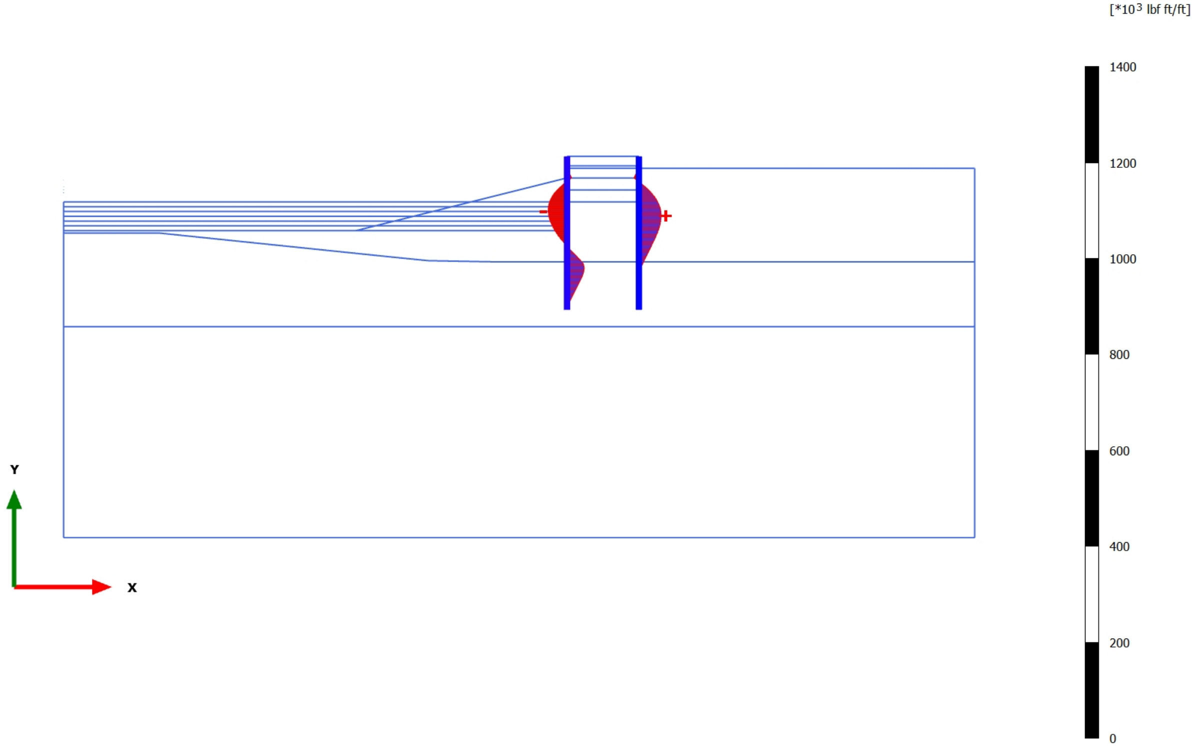


Bending moments M (scaled up 0.200*10⁻³ times) (Time 18.00 day)

Maximum value = 45.41*10³ lbf ft/ft (Element 26 at Node 10442)

Minimum value = -37.94*10³ lbf ft/ft (Element 20 at Node 13644)

3.1.2.2.8 Calculation results, Plate, Dewater2- SS [Phase_9] (9/80), Bending moments M

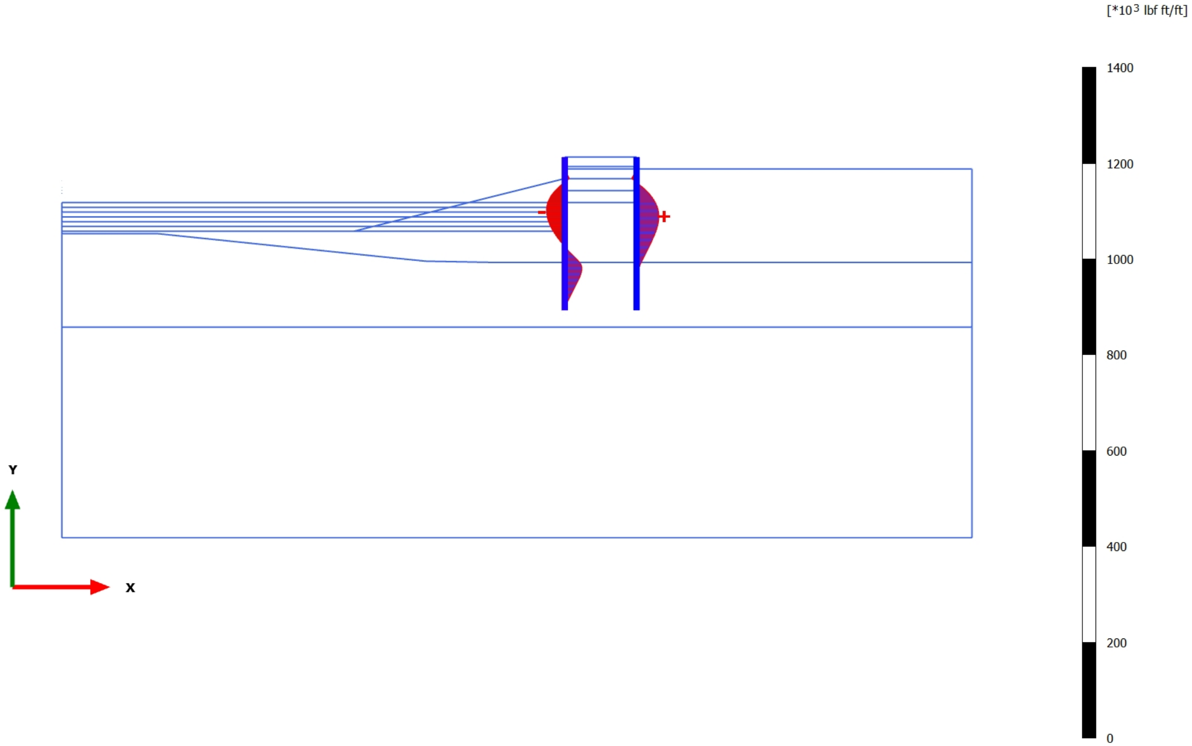


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 46.34*10^{3} lbf ft/ft (Element 26 at Node 10442)

Minimum value = -39.30*10^{3} lbf ft/ft (Element 20 at Node 13644)

3.1.2.2.9 Calculation results, Plate, Consolidation [Phase_12] (15/85), Bending moments M

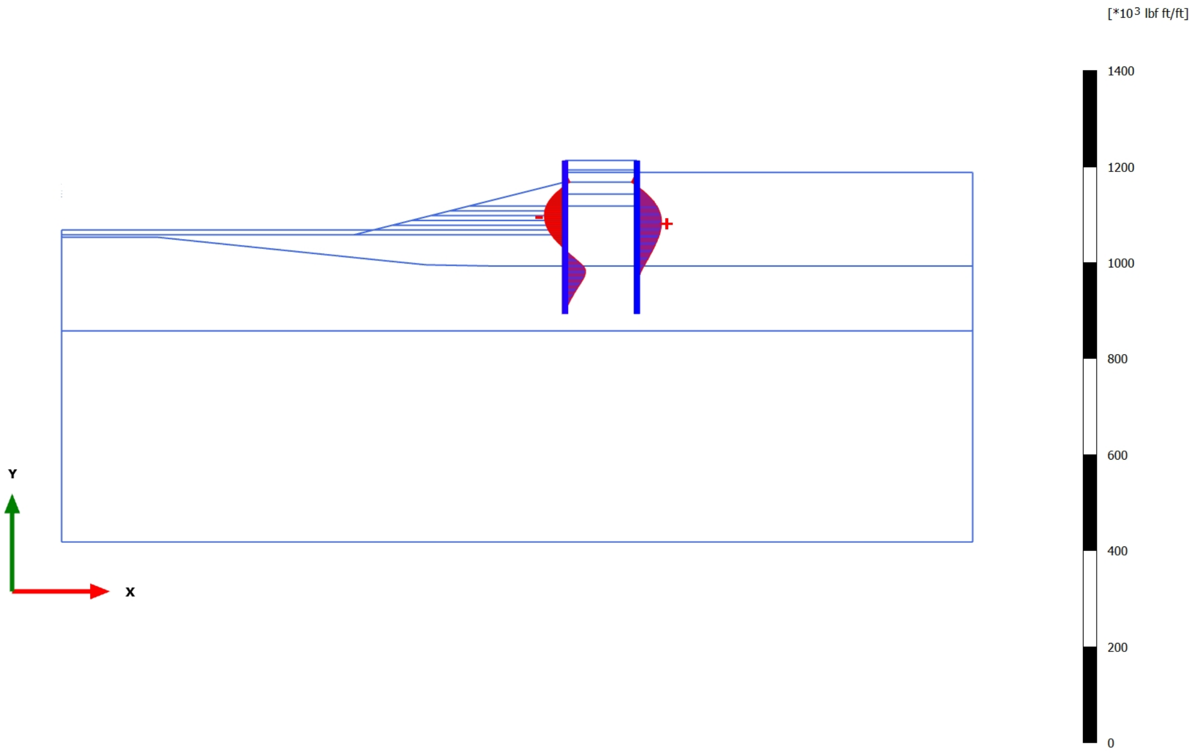


Bending moments M (scaled up 0.200*10^{-3} times) (Time 21.00 day)

Maximum value = 46.58*10^3 lbf ft/ft (Element 26 at Node 10442)

Minimum value = -38.25*10^3 lbf ft/ft (Element 20 at Node 13644)

3.1.2.2.10 Calculation results, Plate, Excavate 2 [Phase_10] (10/91), Bending moments M

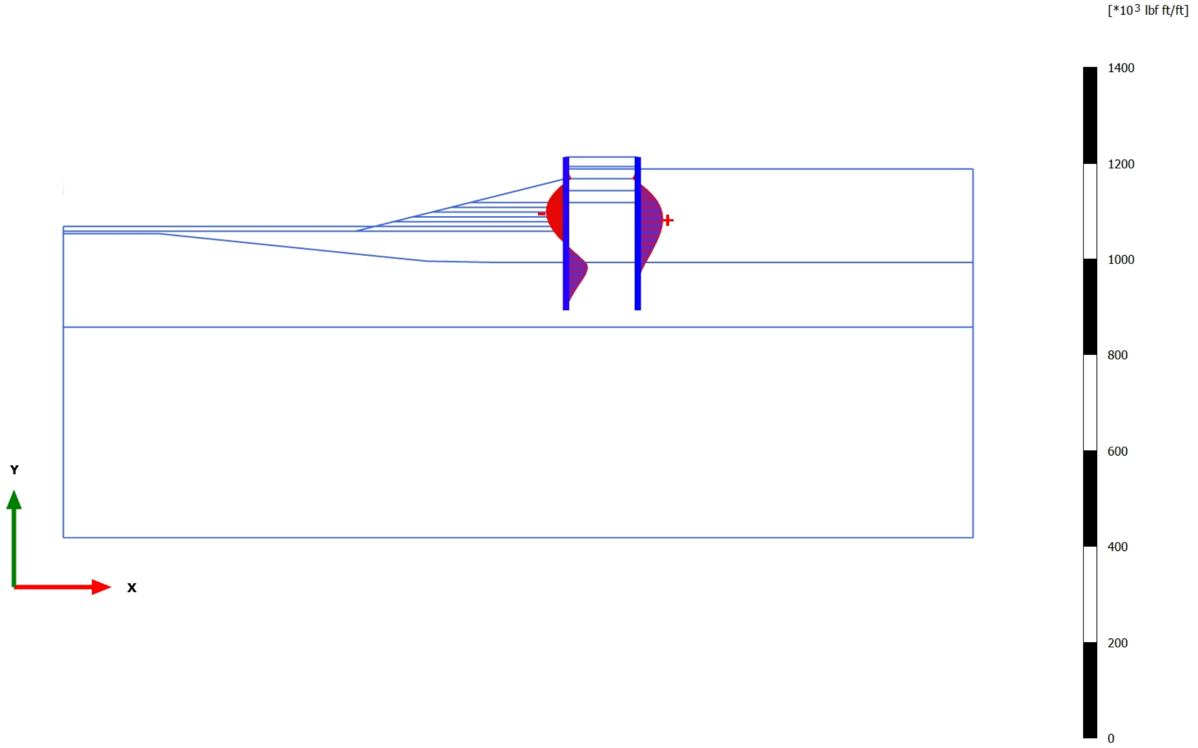


Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 51.33*10^{3} lbf ft/ft (Element 27 at Node 11582)

Minimum value = -43.29*10^{3} lbf ft/ft (Element 21 at Node 14627)

3.1.2.2.11 Calculation results, Plate, Consolidation [Phase_16] (16/99), Bending moments M

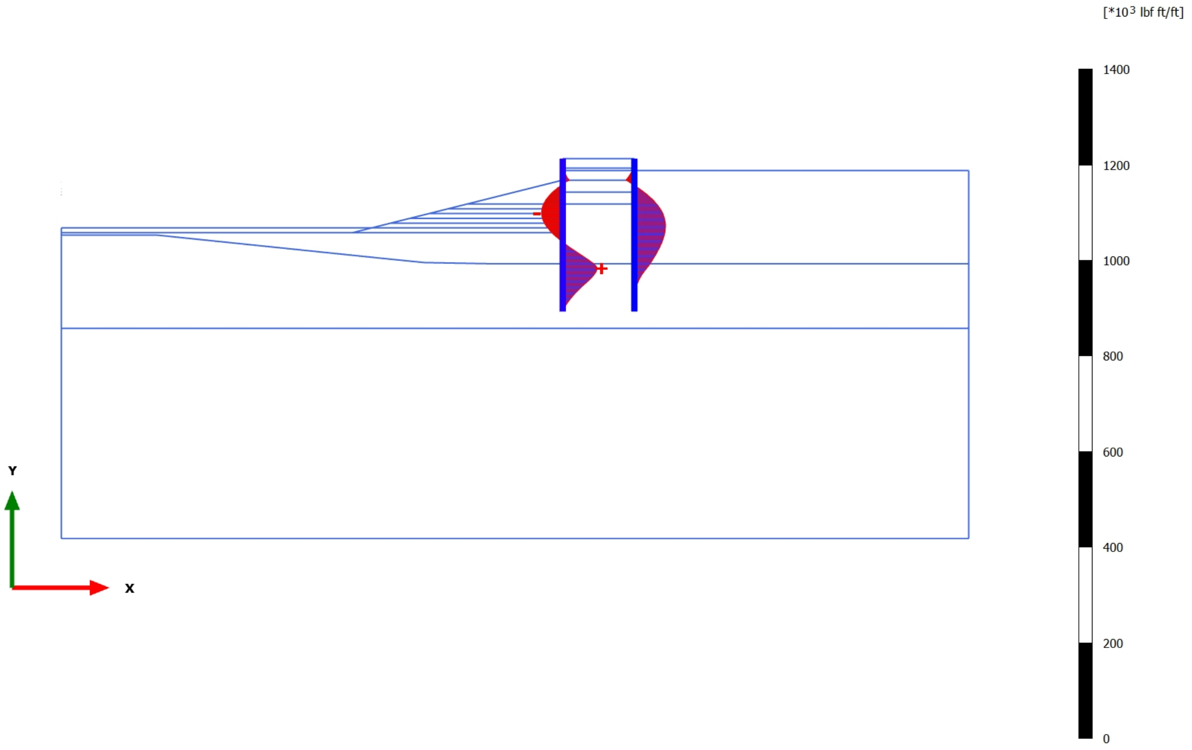


Bending moments M (scaled up 0.200*10⁻³ times) (Time 35.00 day)

Maximum value = 52.10*10³ lbf ft/ft (Element 27 at Node 11582)

Minimum value = -41.10*10³ lbf ft/ft (Element 21 at Node 14627)

3.1.2.2.12 Calculation results, Plate, Water rise 9 ft [Phase_11] (11/111), Bending moments M



Bending moments M (scaled up 0.200*10^{-3} times)

Maximum value = 71.64*10^{3} lbf ft/ft (Element 37 at Node 22235)

Minimum value = -44.30*10^{3} lbf ft/ft (Element 20 at Node 13644)

3.2.1.1.3 Calculation results, Node-to-node anchor, Backfill [Phase_6] (6/27), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	31.346	0.000	31.346
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	31.346	0.000	31.346

3.2.1.1.4 Calculation results, Node-to-node anchor, Dewater -SS [Phase_7] (7/34), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	40.121	0.000	40.121
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	40.121	0.000	40.121

3.2.1.1.5 Calculation results, Node-to-node anchor, Consolidate [Phase_3] (4/47), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	37.023	0.000	40.121
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	37.023	0.000	40.121

3.2.1.1.6 Calculation results, Node-to-node anchor, Excavate 1 [Phase_8] (8/58), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	58.660	0.000	58.660
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	58.660	0.000	58.660

3.2.1.1.7 Calculation results, Node-to-node anchor, Consolidation [Phase_5] (5/76), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	53.490	0.000	58.660
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	53.490	0.000	58.660

3.2.1.1.8 Calculation results, Node-to-node anchor, Dewater2- SS [Phase_9] (9/80), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	54.435	0.000	58.660
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	54.435	0.000	58.660

3.2.1.1.9 Calculation results, Node-to-node anchor, Consolidation [Phase_12] (15/85), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	53.878	0.000	58.660
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	53.878	0.000	58.660

3.2.1.1.10 Calculation results, Node-to-node anchor, Excavate 2 [Phase_10] (10/91), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	57.699	0.000	58.660
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	57.699	0.000	58.660

3.2.1.1.11 Calculation results, Node-to-node anchor, Consolidation [Phase_16] (16/99), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	55.925	0.000	58.660
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	55.925	0.000	58.660

3.2.1.1.12 Calculation results, Node-to-node anchor, Water rise 9 ft [Phase_11] (11/111), Table of node-to-node anchors

Structural element	Node	Local number	X [ft]	Y [ft]	N [10^3 lbf]	N_{min} [lbf]	N_{max} [10^3 lbf]
NodeToNodeAnchor_2_1	6499	1	110.000	0.000	65.557	0.000	65.557
Element 2-2 (Node-to-node anchor)	8339	2	80.000	0.000	65.557	0.000	65.557

Attachment 3

Structural Calculations

ATTACHMENT 3.1

GHD

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 1
Project San Jacinto River Waste Pits Site
Sheets By I.Goel
Date 06/08/2022
Subject BMP Design Summary
Checked By S.Chilka
Date 06/08/2022

Elevations (ft)	Usual	Unusual
Top of Wall	+9	+9
Top of Water Outside	+5	+9

Steel Sheet Pile, Fy 60 ksi

Loading Condition	Allowable Stress Factor	
	Moment & Axial Load	Shear
Usual, U	0.50	0.33
Unusual, UNU	0.67	0.44
Extreme, EXT	0.88	0.58

Sacrificial thickness (tc) - for accounting corrosion	0.0175	in
Corroded flange thickness (trf) - two exposed faces	tf-(2tc)	in
Corroded web thickness (trw) - two exposed faces	tw-(2tc)	in
Corroded section modulus Sr	(trf/tf)*S	in^3/ft
Corroded section area Avr	(trw/tw)*Av	in^2/ft

Corroded Section Capacities

Nucor Section	S (in^3/ft)	tf(in)	trf(in)	Sr (in^3/ft)	Moment (kip.ft / LF)		
					U	UNU	EXT
AZ 18-700	33.50	0.35	0.32	30.19	75	100	132
AZ 26-700	48.40	0.48	0.45	44.87	112	149	196
AZ 40-700N	74.30	0.67	0.63	70.41	176	234	308
AZ 52-700	95.90	0.95	0.91	92.35	231	307	404

Nucor Section	A_v (in^2/ft)	tw(in)	trw(in)	A_{vr} (in^2/ft)	Shear (kip / LF)		
					U	UNU	EXT
AZ 18-700	5.86	0.35	0.32	5.28	104	139	183
AZ 26-700	8.69	0.48	0.45	8.06	160	212	279
AZ 40-700N	10.25	0.52	0.49	9.56	189	252	331
AZ 52-700	13.30	0.67	0.63	12.60	250	332	437

Sheet Pile Design Summary

Section	Sheet Pile Section	Moment (kip.ft / LF)		Shear (kip / LF)		Governing DCR
		U	UNU	U	UNU	
C1	AZ26-700	101.9	114.9	9.5	10.9	0.91
C2	AZ40-700	154.3	172.2	18.0	18.8	0.88
C3	AZ26-700	96.1	111.2	12.5	13.1	0.86
C3A	AZ26-700	98.1	112.3	10.0	11.5	0.87
C4	AZ26-700	78.9	87.6	11.8	11.1	0.70
C4A	AZ26-700	86.5	93.0	7.6	8.6	0.77
C5	AZ26-700	93.7	102.6	10.4	11.2	0.84
C6	AZ26-700	41.5	50.4	6.8	7.4	0.37
C7	AZ26-700	55.0	88.1	8.0	8.9	0.59

Client International Paper Company & McGinnes Industrial Maintenance Corporation

Job Number 11215702

Sheet 2

Project San Jacinto River Waste Pits Site

Sheets By I.Goel

Date 06/08/2022

Subject BMP Design Summary

Checked By S.Chilka

Date 06/08/2022

Tie Rod - Waler Design Summary

Section	Tie Rod - Analysis Output			Demand Load (kips)	Design = 150% Demand	DCR
	Dia (in)	Spacing (ft)	Tension Load (kips)			
C1	2.25	10	131	66	98	0.45
C3A	2.25	10	131			
C4A	2.25	10	90			
C6	2.25	10	109			
C2	3	6	178	149	223	0.57
C3	2.25	6	105	88	131	0.61
C5	2.25	6	99			
C4	2.25	8	123	77	115	0.53
C7	2.25	5	66	66	98	0.45

Note: Demand Load factored for 5 ft spacing

Section	Waler Section	Waler Section DCR	Splice Connection Detail				Splice Connection DCR
			Plate Size (in X in)	Plate Thk. (in)	No of Bolts	Bolt Dia (in)	
C1	MC 12X35	0.64	24X8	0.75	12	1.25	0.59
C2	MC 18X45.8	0.76	24X8	1.25	12	1.375	0.82
C3	MC 12X35	0.85	24X8	0.75	12	1.25	0.79
C3A	MC 12X35	0.64	24X8	0.75	12	1.25	0.59
C4	MC 12X35	0.74	24X8	0.75	12	1.25	0.69
C4A	MC 12X35	0.64	24X8	0.75	12	1.25	0.59
C5	MC 12X35	0.85	24X8	0.75	12	1.25	0.79
C6	MC 12X35	0.64	24X8	0.75	12	1.25	0.59
C7	MC 12X35	0.64	24X8	0.75	12	1.25	0.59

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	3
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel	Date	06/03/2022
Subject	Check for revised tie rod spacing for design	Checked By	S.Chilka	Date	06/03/2022

<u>Check for revised tie rod spacing for design</u>

Modulus of Elasticity, E 29000 ksi

Section	Tie Rod Section		Tie Rod Spacing , S		EA/S (kip/ft)	
	Dia (in)	Area, A (in^2)	Design (ft)	Analysis (ft)	Design	Analysis
C1	2.25	4	5	10	23200.0	11600.0
C2	3	7.06	5	6	40948.0	34123.3
C3	2.25	4	5	6	23200.0	19333.3
C3A	2.25	4	5	10	23200.0	11600.0
C4	2.25	4	5	8	23200.0	14500.0
C4A	2.25	4	5	10	23200.0	11600.0
C5	2.25	4	5	6	23200.0	19333.3
C6	2.25	4	5	10	23200.0	11600.0
C7	2.25	4	5	5	23200.0	23200.0

Higher EA/S values from design when compared to analysis case confirms that the revised tie rod spacing is conservative.

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 4
Project San Jacinto River Waste Pits Site
Sheets By I.Goel
Date 06/03/2022
Subject Tie Rod Design Calculation
Checked By S.Chilka
Date 06/03/2022

DESIGN OF TIE ROD SECTION, AISC 360-16

Tie Rod Design - Sec C1, C3A, C4A, C6

MATERIAL PROPERTIES

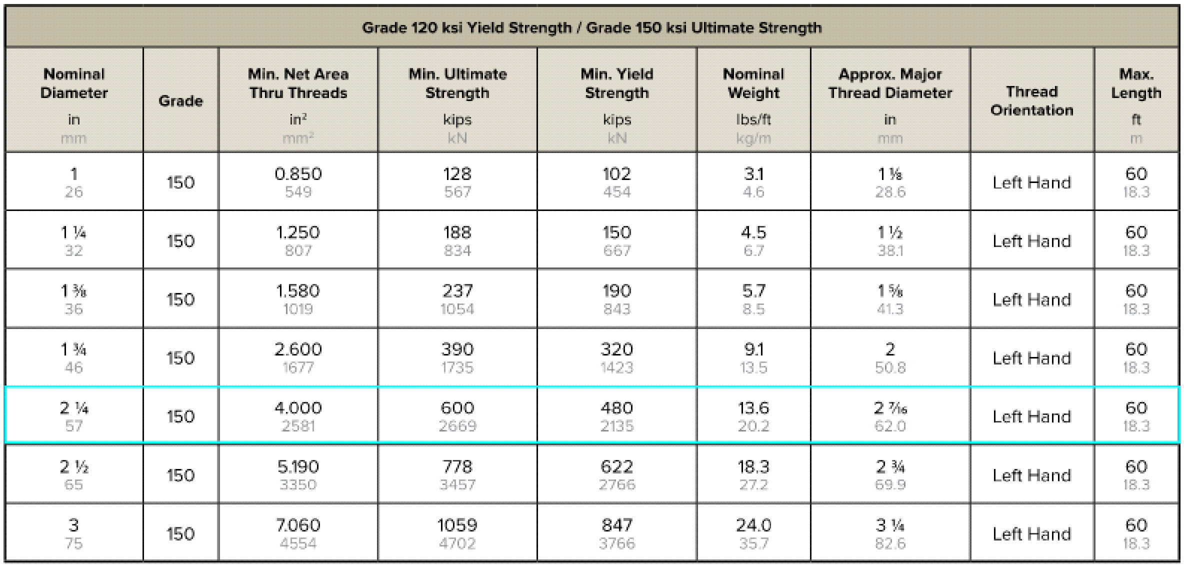
Steel Yield Stress $F_{ybar} := 120\text{ksi}$

Steel Tensile Stress $F_{ubar} := 150\text{ksi}$

Tie Rod with 2.25in nominal diameter

Tie rod nominal Diameter $d_{bar} := 2.25\text{in}$ Refer table below from Nucor Skyline Manual

Tie rod approx. major Thread Diameter $d_{bthr} := 2.44\text{in}$ Refer table below from Nucor Skyline Manual



Grade 120 ksi Yield Strength / Grade 150 ksi Ultimate Strength								
Nominal Diameter in mm	Grade	Min. Net Area Thru Threads in² mm²	Min. Ultimate Strength kips kN	Min. Yield Strength kips kN	Nominal Weight lbs/ft kg/m	Approx. Major Thread Diameter in mm	Thread Orientation	Max. Length ft m
1 26	150	0.850 549	128 567	102 454	3.1 4.6	1 ⅛ 28.6	Left Hand	60 18.3
1 ¼ 32	150	1.250 807	188 834	150 667	4.5 6.7	1 ½ 38.1	Left Hand	60 18.3
1 ⅜ 36	150	1.580 1019	237 1054	190 843	5.7 8.5	1 ⅝ 41.3	Left Hand	60 18.3
1 ¾ 46	150	2.600 1677	390 1735	320 1423	9.1 13.5	2 50.8	Left Hand	60 18.3
2 ¼ 57	150	4.000 2581	600 2669	480 2135	13.6 20.2	2 7/16 62.0	Left Hand	60 18.3
2 ½ 65	150	5.190 3350	778 3457	622 2766	18.3 27.2	2 ¾ 69.9	Left Hand	60 18.3
3 75	150	7.060 4554	1059 4702	847 3766	24.0 35.7	3 ¼ 82.6	Left Hand	60 18.3

Nucor Skyline's high strength threaded bar is cold rolled, threaded, quenched and tempered 4140 grade smooth rounds.

Sacrificial thickness - for accounting corrosion $t_c := 0.0175\text{in}$ Refer Basis of Design report

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 5
Project San Jacinto River Waste Pits Site
Sheets By I.Goel
Date 06/03/2022
Subject Tie Rod Design Calculation
Checked By S.Chilka
Date 06/03/2022

Bar Area - Unthreaded Portion (net area) $A_{barn} := \frac{\pi}{4} \cdot \left(d_{bar} - 2t_c\right)^2 = 3.85 \cdot in^2$

Bar Area - Threaded Portion (gross area) $A_{barg} := \frac{\pi}{4} \cdot \left(d_{bthr} - 2t_c\right)^2 = 4.54 \cdot in^2$

Length of Tie Rod $L_{bar} := 30ft$

ANALYSIS DEMAND LOADS

Tie rod Spacing $S_{bara} := 10ft$

Tie rod Tension Demand $F_{barda} := 131.3kip$

REVISED DEMAND LOADS FROM WALER ANALYSIS

Revised tie rod spacing $S_{bar} := 5ft$

Revised tie rod tension demand $F_{bard} := \frac{F_{barda} \cdot S_{bar}}{S_{bara}} = 65.65 \cdot kip$

Tie Rod Demand Load to safeguard against Progressive Failure

In certain situations, progressive collapse of the structure may be a consequence of an extreme condition, i.e failure of a tie rod. The load from the failed tie rod is redistributed to adjacent tie rods which normally accounts for an increase in the demand load on the tie rod by 50% in the typical design situation.

Tie rod Tension Demand - considering Progressive failure $F_{pbard} := 1.5 \cdot F_{bard} = 98.48 \cdot kip$

GHD

Client: International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number: 11215702
Sheet: 6
Project: San Jacinto River Waste Pits Site
Sheets By: I.Goel
Date: 06/03/2022
Subject: Tie Rod Design Calculation
Checked By: S.Chilka
Date: 06/03/2022

ALLOWABLE STRESS DESIGN CAPACITY - AISC 360-16

D2 Tensile Strength of the Tie Rod

Overstrength Factors $\Omega_{ty} := 1.67$ TensileYielding

$\Omega_{tr} := 2.0$ Tensile Rupture

Allowable tensile strength based on limit state of tensile yielding of gross section, Eq D2-1

$$P_{ny} := \frac{F_{ybar} \cdot A_{barg}}{\Omega_{ty}} = 326.4 \cdot kip$$

Shear Lag Factor, Table D3.1- Case1 $U := 1$

Allowable tensile strength based on limit state of tensile rupture in net section, Eq D2-2

$$P_{nr} := \frac{F_{ubar} \cdot A_{barn} \cdot U}{\Omega_{tr}} = 289 \cdot kip$$

J3.6 Tensile Strength of Threaded Parts

Overstrength Factors $\Omega_{thr} := 2.0$

Nominal Tensile Stress, Table J3.2 - Case 8 $F_{nt} := 0.75 \cdot F_{ubar} = 112.5 \cdot ksi$

Allowable Tensile Strength of threaded parts based on limit state of tension rupture, Eq J3-1

$$R_{nt} := \frac{F_{nt} \cdot A_{barn}}{\Omega_{thr}} = 216.8 \cdot kip$$

Allowable Tensile Strength $F_{barc} := \min\left(P_{ny}, P_{nr}, R_{nt}\right) = 216.8 \cdot kip$

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Capacity Check

$$DCR_2 := \left| \begin{array}{ll} \dfrac{F_{pbard}}{F_{barc}} & \text{if } \; F_{barc} \geq F_{pbard} \\ \text{"Increase Bar Size"} & \text{otherwise} \end{array} \right. = 0.45$$

GHD

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DESIGN OF TIE ROD SECTION, AISC 360-16

Tie Rod Design - Sec C2

MATERIAL PROPERTIES

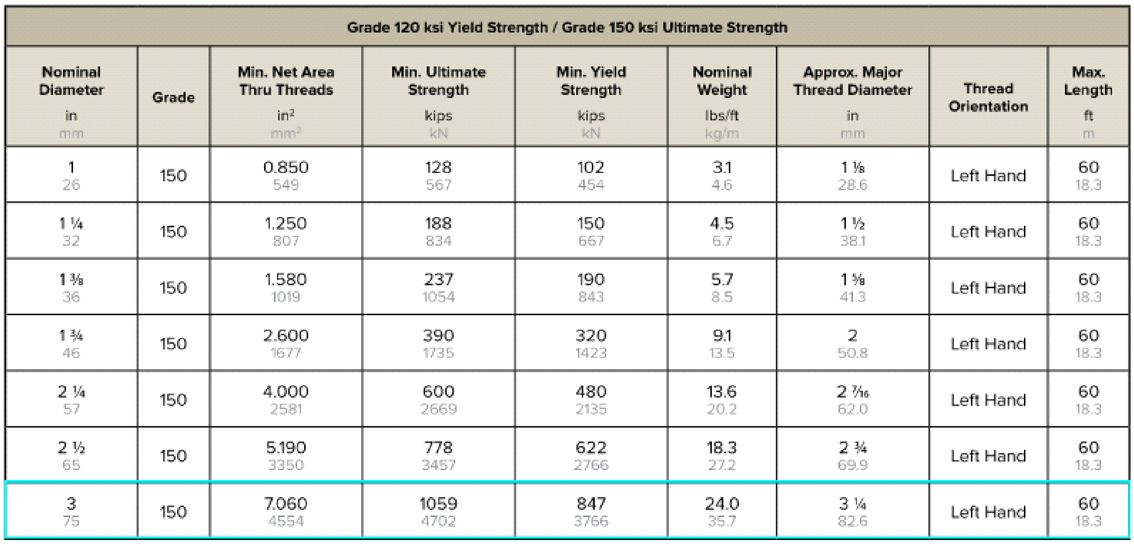
Steel Yield Stress $F_{ybar} := 120 ksi$

Steel Tensile Stress $F_{ubar} := 150 ksi$

Tie Rod with 3in nominal diameter

Tie rod nominal Diameter $d_{bar} := 3 in$ Refer table below from Nucor Skyline Manual

Tie rod approx. major Thread Diameter $d_{bthr} := 3.25 in$ Refer table below from Nucor Skyline Manual



Grade 120 ksi Yield Strength / Grade 150 ksi Ultimate Strength

Nominal Diameter in mm	Grade	Min. Net Area Thru Threads in² mm²	Min. Ultimate Strength kips kN	Min. Yield Strength kips kN	Nominal Weight lbs/ft kg/m	Approx. Major Thread Diameter in mm	Thread Orientation	Max. Length ft m
1 26	150	0.850 549	128 567	102 454	3.1 4.6	1 ⅛ 28.6	Left Hand	60 18.3
1 ¼ 32	150	1.250 807	188 834	150 667	4.5 6.7	1 ½ 38.1	Left Hand	60 18.3
1 ⅜ 36	150	1.580 1019	237 1054	190 843	5.7 8.5	1 ⅝ 41.3	Left Hand	60 18.3
1 ¾ 46	150	2.600 1677	390 1735	320 1423	9.1 13.5	2 50.8	Left Hand	60 18.3
2 ¼ 57	150	4.000 2581	600 2669	480 2135	13.6 20.2	2 7⁄16 62.0	Left Hand	60 18.3
2 ½ 65	150	5.190 3350	778 3457	622 2766	18.3 27.2	2 ¾ 69.9	Left Hand	60 18.3
3 75	150	7.060 4554	1059 4702	847 3766	24.0 35.7	3 ¼ 82.6	Left Hand	60 18.3

Nucor Skyline's high strength threaded bar is cold rolled, threaded, quenched and tempered 4140 grade smooth rounds.

Sacrificial thickness - for accounting corrosion $t_c := 0.0175 in$ Refer Basis of Design report

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Bar Area - Unthreaded Portion (net area) $A_{barn} := \frac{\pi}{4} \cdot \left(d_{bar} - 2t_c\right)^2 = 6.9 \cdot in^2$

Bar Area - Threaded Portion (gross area) $A_{barg} := \frac{\pi}{4} \cdot \left(d_{bthr} - 2t_c\right)^2 = 8.12 \cdot in^2$

Length of Tie Rod $L_{bar} := 30ft$

ANALYSIS DEMAND LOADS

Tie rod Spacing $S_{bara} := 6ft$

Tie rod Tension Demand $F_{barda} := 178.4kip$

REVISED DEMAND LOADS FROM WALER ANALYSIS

Revised tie rod spacing $S_{bar} := 5ft$

Revised tie rod tension demand $F_{bard} := \frac{F_{barda} \cdot S_{bar}}{S_{bara}} = 148.67 \cdot kip$

Tie Rod Demand Load to safeguard against Progressive Failure

In certain situations, progressive collapse of the structure may be a consequence of an extreme condition, i.e failure of a tie rod. The load from the failed tie rod is redistributed to adjacent tie rods which normally accounts for an increase in the demand load on the tie rod by 50% in the typical design situation.

Tie rod Tension Demand - considering Progressive failure $F_{pbard} := 1.5 \cdot F_{bard} = 223 \cdot kip$

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ALLOWABLE STRESS DESIGN CAPACITY - AISC 360-16

D2 Tensile Strength of the Tie Rod

Overstrength Factors $\Omega_{ty} := 1.67$ TensileYielding

$\Omega_{tr} := 2.0$ Tensile Rupture

Allowable tensile strength based on limit state of tensile yielding of gross section, Eq D2-1

$$P_{ny} := \frac{F_{ybar} \cdot A_{barg}}{\Omega_{ty}} = 583.3 \cdot kip$$

Shear Lag Factor, Table D3.1- Case1 $U := 1$

Allowable tensile strength based on limit state of tensile rupture in net section, Eq D2-2

$$P_{nr} := \frac{F_{ubar} \cdot A_{barn} \cdot U}{\Omega_{tr}} = 517.8 \cdot kip$$

J3.6 Tensile Strength of Threaded Parts

Overstrength Factors $\Omega_{thr} := 2.0$

Nominal Tensile Stress, Table J3.2 - Case 8

$$F_{nt} := 0.75 \cdot F_{ubar} = 112.5 \cdot ksi$$

Allowable Tensile Strength of threaded parts based on limit state of tension rupture, Eq J3-1

$$R_{nt} := \frac{F_{nt} \cdot A_{barn}}{\Omega_{thr}} = 388.4 \cdot kip$$

Allowable Tensile Strength

$$F_{barc} := \min\left(P_{ny}, P_{nr}, R_{nt}\right) = 388.4 \cdot kip$$

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Capacity Check

$$DCR_2 := \begin{cases} \dfrac{F_{pbard}}{F_{barc}} & \text{if } F_{barc} \geq F_{pbard} \\ \text{"Increase Bar Size"} & \text{otherwise} \end{cases} = 0.57$$

DESIGN OF TIE ROD SECTION, AISC 360-16

Tie Rod Design - Sec C5, C3

MATERIAL PROPERTIES

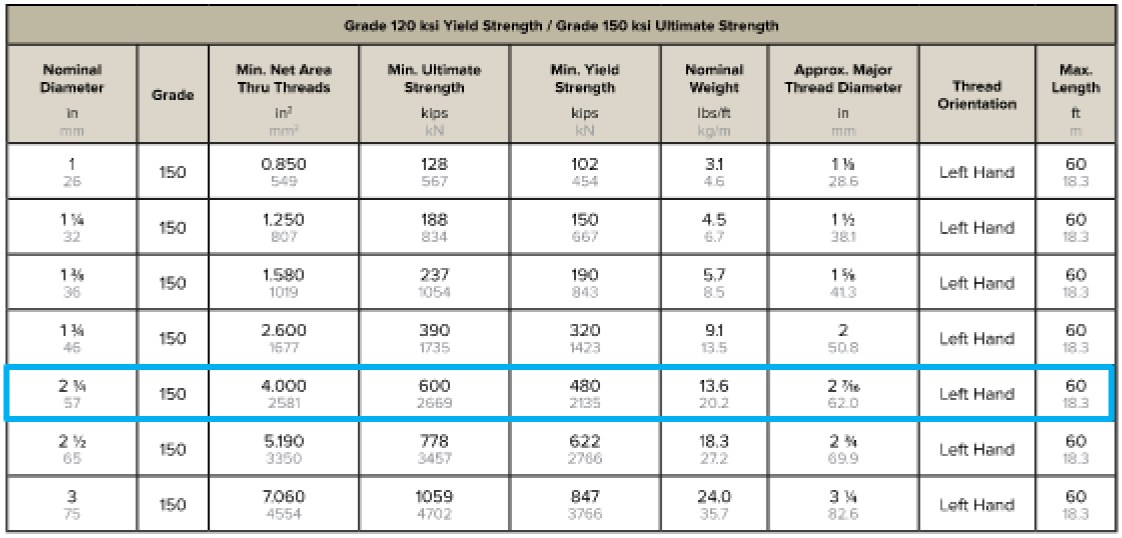
Steel Yield Stress $F_{ybar} := 120 ksi$

Steel Tensile Stress $F_{ubar} := 150 ksi$

Tie Rod with 2.25in nominal diameter

Tie rod nominal Diameter $d_{bar} := 2.25 in$ Refer table below from Nucor Skyline Manual

Tie rod approx. major Thread Diameter $d_{bthr} := 2.44 in$ Refer table below from Nucor Skyline Manual



Grade 120 ksi Yield Strength / Grade 150 ksi Ultimate Strength								
Nominal Diameter in mm	Grade	Min. Net Area Thru Threads in² mm²	Min. Ultimate Strength kips kN	Min. Yield Strength kips kN	Nominal Weight lbs/ft kg/m	Approx. Major Thread Diameter in mm	Thread Orientation	Max. Length ft m
1 26	150	0.850 549	128 567	102 454	3.1 4.6	1 ⅛ 28.6	Left Hand	60 18.3
1 ¼ 32	150	1.250 807	188 834	150 667	4.5 6.7	1 ½ 38.1	Left Hand	60 18.3
1 ⅜ 36	150	1.580 1019	237 1054	190 843	5.7 8.5	1 ⅝ 41.3	Left Hand	60 18.3
1 ¾ 46	150	2.600 1677	390 1735	320 1423	9.1 13.5	2 50.8	Left Hand	60 18.3
2 ¼ 57	150	4.000 2581	600 2669	480 2135	13.6 20.2	2 7/16 62.0	Left Hand	60 18.3
2 ½ 65	150	5.190 3350	778 3457	622 2766	18.3 27.2	2 ¾ 69.9	Left Hand	60 18.3
3 75	150	7.060 4554	1059 4702	847 3766	24.0 35.7	3 ¼ 82.6	Left Hand	60 18.3

Nucor Skyline's high strength threaded bar is cold rolled, threaded, quenched and tempered 4140 grade smooth rounds.

Sacrificial thickness - for accounting corrosion $t_c := 0.0175 in$ Refer Basis of Design report

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Bar Area - Unthreaded Portion (net area) $A_{barn} := \frac{\pi}{4} \cdot \left(d_{bar} - 2t_c\right)^2 = 3.85 \cdot in^2$

Bar Area - Threaded Portion (gross area) $A_{barg} := \frac{\pi}{4} \cdot \left(d_{bthr} - 2t_c\right)^2 = 4.54 \cdot in^2$

Length of Tie Rod $L_{bar} := 30ft$

ANALYSIS DEMAND LOADS

Tie rod Spacing $S_{bara} := 6ft$

Tie rod Tension Demand $F_{barda} := 105.2kip$

REVISED DEMAND LOADS FROM WALER ANALYSIS

Revised tie rod spacing $S_{bar} := 5ft$

Revised tie rod tension demand $F_{bard} := \frac{F_{barda} \cdot S_{bar}}{S_{bara}} = 87.67 \cdot kip$

Tie Rod Demand Load to safeguard against Progressive Failure

In certain situations, progressive collapse of the structure may be a consequence of an extreme condition, i.e failure of a tie rod. The load from the failed tie rod is redistributed to adjacent tie rods which normally accounts for an increase in the demand load on the tie rod by 50% in the typical design situation.

Tie rod Tension Demand - considering Progressive failure $F_{pbard} := 1.5 \cdot F_{bard} = 131.5 \cdot kip$

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ALLOWABLE STRESS DESIGN CAPACITY - AISC 360-16

D2 Tensile Strength of the Tie Rod

Overstrength Factors

$\Omega_{ty} := 1.67$ TensileYielding

$\Omega_{tr} := 2.0$ Tensile Rupture

Allowable tensile strength based on limit state of tensile yielding of gross section, Eq D2-1

$$P_{ny} := \frac{F_{ybar} \cdot A_{barg}}{\Omega_{ty}} = 326.4 \cdot kip$$

Shear Lag Factor, Table D3.1- Case1

$U := 1$

Allowable tensile strength based on limit state of tensile rupture in net section, Eq D2-2

$$P_{nr} := \frac{F_{ubar} \cdot A_{barn} \cdot U}{\Omega_{tr}} = 289 \cdot kip$$

J3.6 Tensile Strength of Threaded Parts

Overstrength Factors

$\Omega_{thr} := 2.0$

Nominal Tensile Stress, Table J3.2 - Case 8

$F_{nt} := 0.75 \cdot F_{ubar} = 112.5 \cdot ksi$

Allowable Tensile Strength of threaded parts based on limit state of tension rupture, Eq J3-1

$$R_{nt} := \frac{F_{nt} \cdot A_{barn}}{\Omega_{thr}} = 216.8 \cdot kip$$

Allowable Tensile Strength

$F_{barc} := \min\left(P_{ny}, P_{nr}, R_{nt}\right) = 216.8 \cdot kip$

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Capacity Check

$$DCR_2 := \begin{cases} \dfrac{F_{pbard}}{F_{barc}} & \text{if} \quad F_{barc} \geq F_{pbard} \\ \text{"Increase Bar Size"} & \text{otherwise} \end{cases} = 0.61$$

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DESIGN OF TIE ROD SECTION, AISC 360-16

Tie Rod Design - Sec C4

MATERIAL PROPERTIES

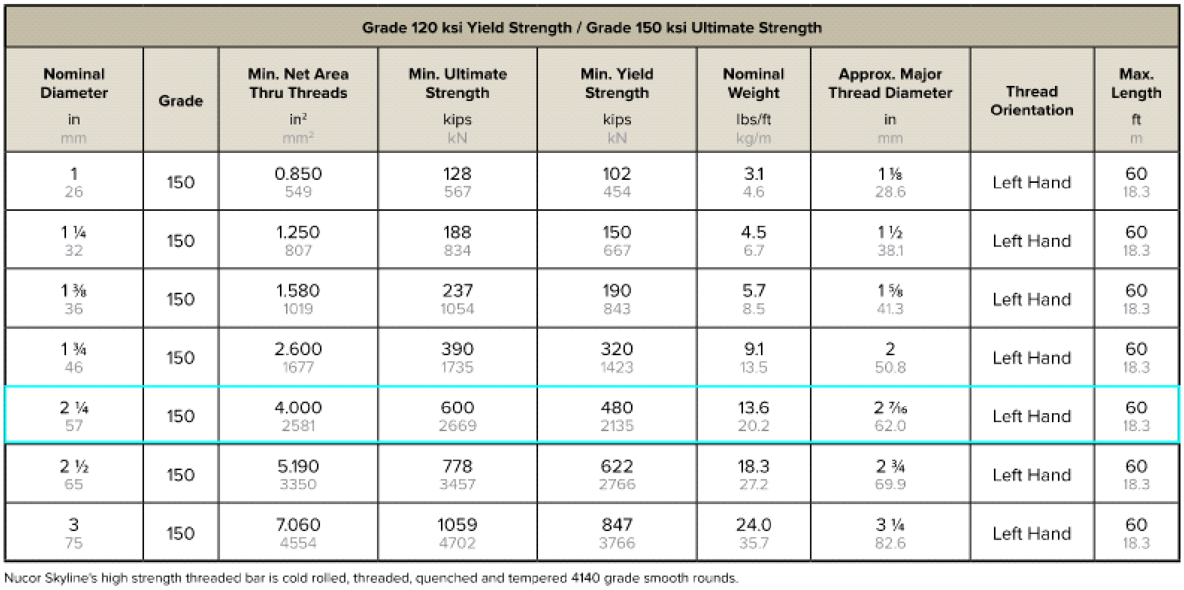
Steel Yield Stress $F_{ybar} := 120ksi$

Steel Tensile Stress $F_{ubar} := 150ksi$

Tie Rod with 2.25in nominal diameter

Tie rod nominal Diameter $d_{bar} := 2.25in$ Refer table below from Nucor Skyline Manual

Tie rod approx. major Thread Diameter $d_{bthr} := 2.44in$ Refer table below from Nucor Skyline Manual



Grade 120 ksi Yield Strength / Grade 150 ksi Ultimate Strength

Nominal Diameter in mm	Grade	Min. Net Area Thru Threads in² mm²	Min. Ultimate Strength kips kN	Min. Yield Strength kips kN	Nominal Weight lbs/ft kg/m	Approx. Major Thread Diameter in mm	Thread Orientation	Max. Length ft m
1 26	150	0.850 549	128 567	102 454	3.1 4.6	1 ⅛ 28.6	Left Hand	60 18.3
1 ¼ 32	150	1.250 807	188 834	150 667	4.5 6.7	1 ½ 38.1	Left Hand	60 18.3
1 ⅜ 36	150	1.580 1019	237 1054	190 843	5.7 8.5	1 ⅝ 41.3	Left Hand	60 18.3
1 ¾ 46	150	2.600 1677	390 1735	320 1423	9.1 13.5	2 50.8	Left Hand	60 18.3
2 ¼ 57	150	4.000 2581	600 2669	480 2135	13.6 20.2	2 7/16 62.0	Left Hand	60 18.3
2 ½ 65	150	5.190 3350	778 3457	622 2766	18.3 27.2	2 ¾ 69.9	Left Hand	60 18.3
3 75	150	7.060 4554	1059 4702	847 3766	24.0 35.7	3 ¼ 82.6	Left Hand	60 18.3

Nucor Skyline's high strength threaded bar is cold rolled, threaded, quenched and tempered 4140 grade smooth rounds.

Sacrificial thickness - for accounting corrosion $t_c := 0.0175in$ Refer Basis of Design report

Bar Area - Unthreaded Portion (net area) $A_{barn} := \frac{\pi}{4} \cdot \left(d_{bar} - 2t_c\right)^2 = 3.85 \cdot in^2$

Bar Area - Threaded Portion (gross area) $A_{barg} := \frac{\pi}{4} \cdot \left(d_{bthr} - 2t_c\right)^2 = 4.54 \cdot in^2$

Length of Tie Rod $L_{bar} := 30ft$

ANALYSIS DEMAND LOADS

Tie rod Spacing $S_{bara} := 8ft$

Tie rod Tension Demand $F_{barda} := 122.98kip$

REVISED DEMAND LOADS FROM WALER ANALYSIS

Revised tie rod spacing $S_{bar} := 5ft$

Revised tie rod tension demand $F_{bard} := \frac{F_{barda} \cdot S_{bar}}{S_{bara}} = 76.86 \cdot kip$

Tie Rod Demand Load to safeguard against Progressive Failure

In certain situations, progressive collapse of the structure may be a consequence of an extreme condition, i.e failure of a tie rod. The load from the failed tie rod is redistributed to adjacent tie rods which normally accounts for an increase in the demand load on the tie rod by 50% in the typical design situation.

Tie rod Tension Demand - considering Progressive failure $F_{pbard} := 1.5 \cdot F_{bard} = 115.29 \cdot kip$

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ALLOWABLE STRESS DESIGN CAPACITY - AISC 360-16

D2 Tensile Strength of the Tie Rod

Overstrength Factors $\Omega_{ty} := 1.67$ TensileYielding

$\Omega_{tr} := 2.0$ Tensile Rupture

Allowable tensile strength based on limit state of tensile yielding of gross section, Eq D2-1

$$P_{ny} := \frac{F_{ybar} \cdot A_{barg}}{\Omega_{ty}} = 326.4 \cdot kip$$

Shear Lag Factor, Table D3.1- Case1 $U := 1$

Allowable tensile strength based on limit state of tensile rupture in net section, Eq D2-2

$$P_{nr} := \frac{F_{ubar} \cdot A_{barn} \cdot U}{\Omega_{tr}} = 289 \cdot kip$$

J3.6 Tensile Strength of Threaded Parts

Overstrength Factors $\Omega_{thr} := 2.0$

Nominal Tensile Stress, Table J3.2 - Case 8 $F_{nt} := 0.75 \cdot F_{ubar} = 112.5 \cdot ksi$

Allowable Tensile Strength of threaded parts based on limit state of tension rupture, Eq J3-1

$$R_{nt} := \frac{F_{nt} \cdot A_{barn}}{\Omega_{thr}} = 216.8 \cdot kip$$

Allowable Tensile Strength $F_{barc} := \min\left(P_{ny}, P_{nr}, R_{nt}\right) = 216.8 \cdot kip$

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Capacity Check

$$DCR_2 := \begin{cases} \dfrac{F_{pbard}}{F_{barc}} & \text{if } F_{barc} \geq F_{pbard} \\ \text{"Increase Bar Size"} & \text{otherwise} \end{cases} = 0.53$$

DESIGN OF TIE ROD SECTION, AISC 360-16

Tie Rod Design - Sec C7

MATERIAL PROPERTIES

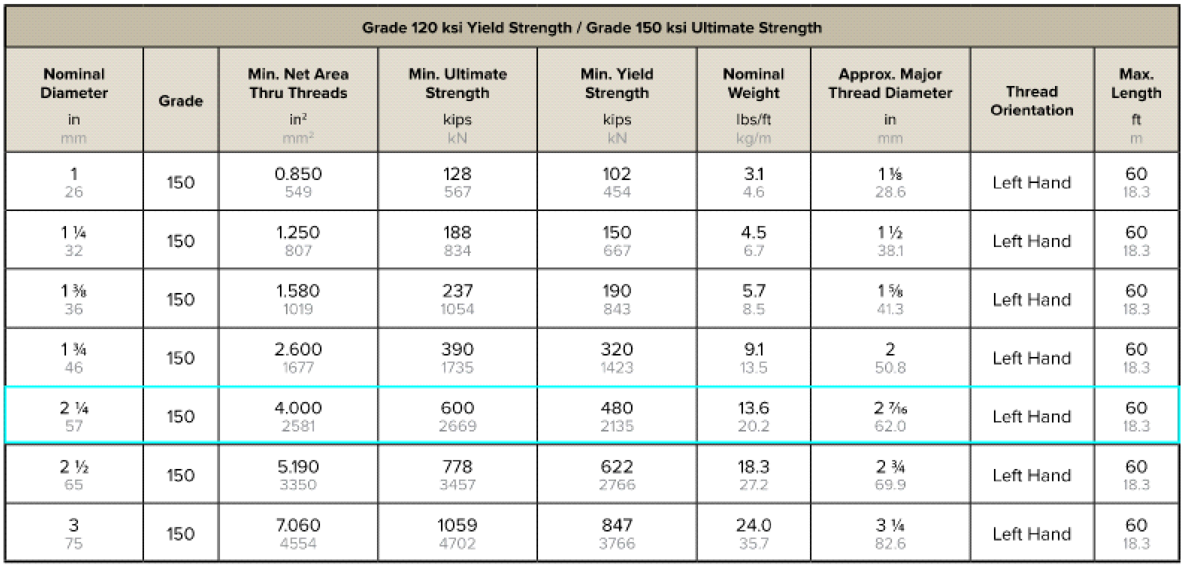
Steel Yield Stress $F_{ybar} := 120\text{ksi}$

Steel Tensile Stress $F_{ubar} := 150\text{ksi}$

Tie Rod with 2.25in nominal diameter

Tie rod nominal Diameter $d_{bar} := 2.25\text{in}$ Refer table below from Nucor Skyline Manual

Tie rod approx. major Thread Diameter $d_{bthr} := 2.44\text{in}$ Refer table below from Nucor Skyline Manual



Grade 120 ksi Yield Strength / Grade 150 ksi Ultimate Strength								
Nominal Diameter in mm	Grade	Min. Net Area Thru Threads in² mm²	Min. Ultimate Strength kips kN	Min. Yield Strength kips kN	Nominal Weight lbs/ft kg/m	Approx. Major Thread Diameter in mm	Thread Orientation	Max. Length ft m
1 26	150	0.850 549	128 567	102 454	3.1 4.6	1 ⅛ 28.6	Left Hand	60 18.3
1 ¼ 32	150	1.250 807	188 834	150 667	4.5 6.7	1 ½ 38.1	Left Hand	60 18.3
1 ⅜ 36	150	1.580 1019	237 1054	190 843	5.7 8.5	1 ⅝ 41.3	Left Hand	60 18.3
1 ¾ 46	150	2.600 1677	390 1735	320 1423	9.1 13.5	2 50.8	Left Hand	60 18.3
2 ¼ 57	150	4.000 2581	600 2669	480 2135	13.6 20.2	2 7⁄16 62.0	Left Hand	60 18.3
2 ½ 65	150	5.190 3350	778 3457	622 2766	18.3 27.2	2 ¾ 69.9	Left Hand	60 18.3
3 75	150	7.060 4554	1059 4702	847 3766	24.0 35.7	3 ¼ 82.6	Left Hand	60 18.3

Nucor Skyline's high strength threaded bar is cold rolled, threaded, quenched and tempered 4140 grade smooth rounds.

Sacrificial thickness - for accounting corrosion $t_c := 0.0175\text{in}$ Refer Basis of Design report

Bar Area - Unthreaded Portion (net area) $A_{barn} := \frac{\pi}{4} \cdot (d_{bar} - 2t_c)^2 = 3.85 \cdot in^2$

Bar Area - Threaded Portion (gross area) $A_{barg} := \frac{\pi}{4} \cdot (d_{bthr} - 2t_c)^2 = 4.54 \cdot in^2$

Length of Tie Rod $L_{bar} := 30ft$

ANALYSIS DEMAND LOADS

Tie rod Spacing $S_{bara} := 5ft$

Tie rod Tension Demand $F_{barda} := 65.6kip$

REVISED DEMAND LOADS FROM WALER ANALYSIS

Revised tie rod spacing $S_{bar} := 5ft$

Revised tie rod tension demand $F_{bard} := \frac{F_{barda} \cdot S_{bar}}{S_{bara}} = 65.6 \cdot kip$

Tie Rod Demand Load to safeguard against Progressive Failure

In certain situations, progressive collapse of the structure may be a consequence of an extreme condition, i.e failure of a tie rod. The load from the failed tie rod is redistributed to adjacent tie rods which normally accounts for an increase in the demand load on the tie rod by 50% in the typical design situation.

Tie rod Tension Demand - considering Progressive failure $F_{pbard} := 1.5 \cdot F_{bard} = 98.4 \cdot kip$

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Checked By: S.Chilka
Date: 06/03/2022

ALLOWABLE STRESS DESIGN CAPACITY - AISC 360-16

D2 Tensile Strength of the Tie Rod

Overstrength Factors $\Omega_{ty} := 1.67$ TensileYielding

$\Omega_{tr} := 2.0$ Tensile Rupture

Allowable tensile strength based on limit state of tensile yielding of gross section, Eq D2-1

$$P_{ny} := \frac{F_{ybar} \cdot A_{barg}}{\Omega_{ty}} = 326.4 \cdot kip$$

Shear Lag Factor, Table D3.1- Case1 $U := 1$

Allowable tensile strength based on limit state of tensile rupture in net section, Eq D2-2

$$P_{nr} := \frac{F_{ubar} \cdot A_{barn} \cdot U}{\Omega_{tr}} = 289 \cdot kip$$

J3.6 Tensile Strength of Threaded Parts

Overstrength Factors $\Omega_{thr} := 2.0$

Nominal Tensile Stress, Table J3.2 - Case 8

$$F_{nt} := 0.75 \cdot F_{ubar} = 112.5 \cdot ksi$$

Allowable Tensile Strength of threaded parts based on limit state of tension rupture, Eq J3-1

$$R_{nt} := \frac{F_{nt} \cdot A_{barn}}{\Omega_{thr}} = 216.8 \cdot kip$$

Allowable Tensile Strength

$$F_{barc} := \min\left(P_{ny}, P_{nr}, R_{nt}\right) = 216.8 \cdot kip$$

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Capacity Check

$$DCR_2 := \begin{cases} \dfrac{F_{pbard}}{F_{barc}} & \text{if } F_{barc} \geq F_{pbard} \\ \text{"Increase Bar Size"} & \text{otherwise} \end{cases} = 0.45$$

Analysis Demand Load on Waler - Sec C1, C3A, C4A, C6

Tie Rod Tension Demand Load from Analysis $T_{roda} := 131.3\text{kip}$

Tie Rod Spacing $S_{roda} := 10\text{ft}$

The tie rod spacing assumed in analysis results in large demand loads and section size for waler. To optimize section selection, tie rods will be closely spaced. Closely spaced tie rods will result in lower demand loads.

Revised Tie Rod Spacing $S_{rod} := 5\text{ft}$

Revised Tie Rod Tension Demand $T_{rod} := T_{roda} \cdot \frac{S_{rod}}{S_{roda}} = 65.65 \cdot \text{kip}$

Demand Load on waler $w_{dl} := \frac{T_{rod}}{S_{rod}} = 13.13 \cdot \frac{\text{kip}}{\text{ft}}$

Demand Load on Waler to safeguard against progressive failure

In certain situations, progressive collapse of the structure may be a conseequence of an extreme condition ie. failure of a tie rod. The wailing to the main wall will need to be checked to ensure that it will not collapse if the span between tie rods doubles following the loss of a tie rod.

SAP2000 analysis is used to calculate the bending moment and shear force demand on the waler for both the cases. Case 1 - without failure of a tie rod and, Case 2 - with failure of a tie rod.

For Case 1 - Continuous beam with four equal spans of length Srod is anaylzed
For Case 2 - Continuous beam with three spans of length Srod - 2Srod - Srod is analyzed

Waler Design is governed by the demands from Case 2

GHD

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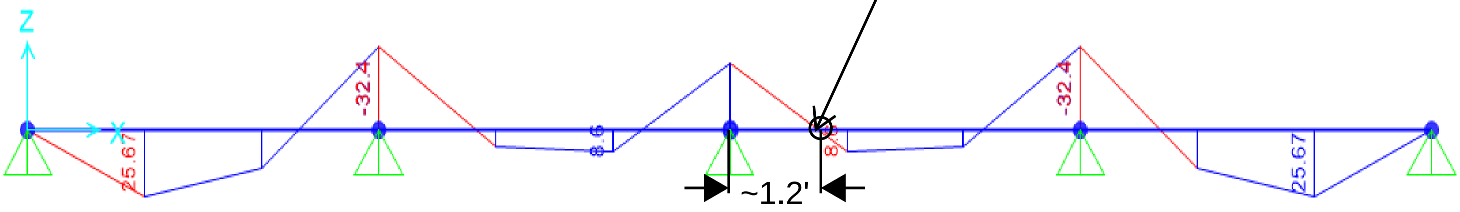
Bending Moment Diagram - Case 1

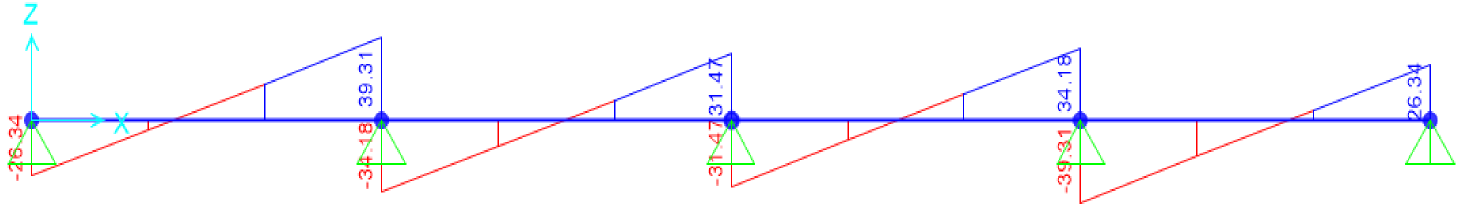


Point of zero moment

~1.2'

Bending Moment demand from SAP2000 - Mdsap = 32.5Kip-ft

Shear Force Diagram - Case 1



Shear Force demand from SAP2000 - Vdsap = 39.5Kip

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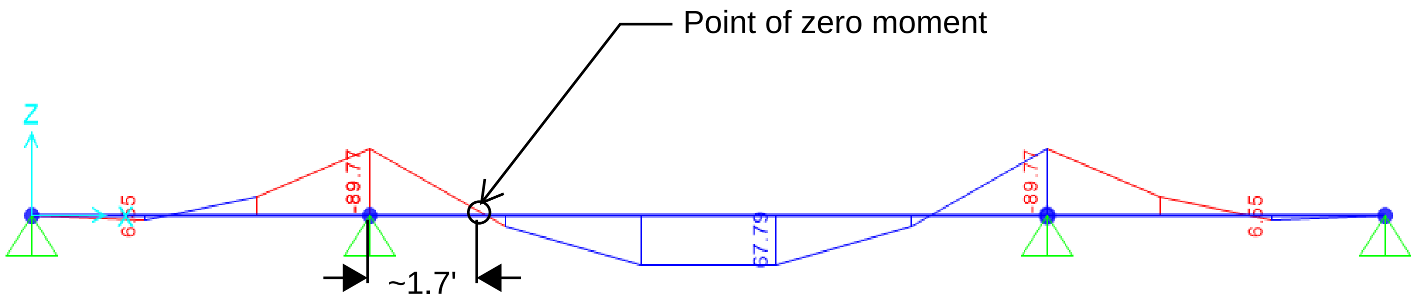
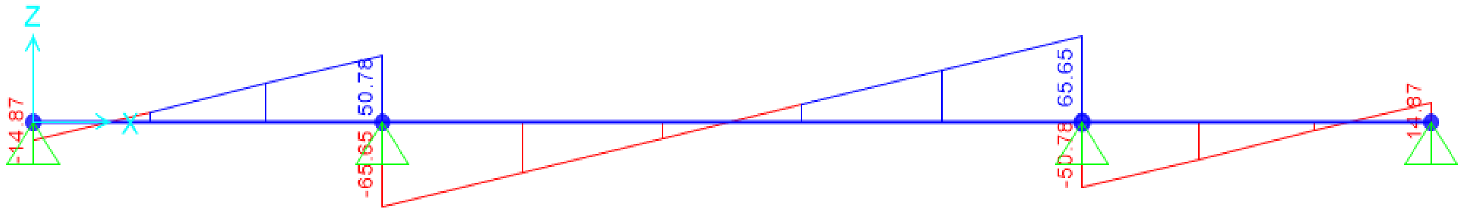
Bending Moment Diagram - Case 2



Bending Moment demand from SAP2000 - Mdsap = 90Kip-ft

Shear Force Diagram - Case 2



Shear Force demand from SAP2000 - Vdsap = 66Kip

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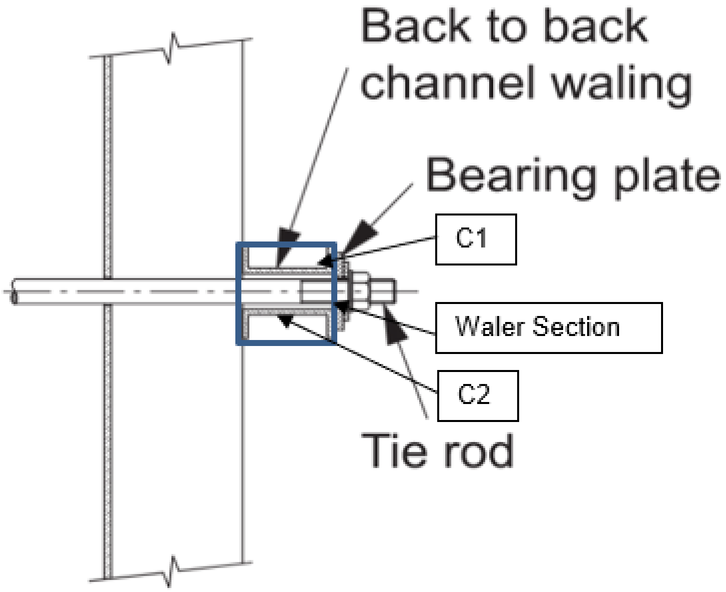
Waler Cross-Section



Waler is made of two channel sections C1 and C2

Design of corroded waler section, AISC 360-16

Bending moment demand on waler from SAP2000 $M_{dsap} := 90 kip \cdot ft$

Shear force demand on waler from SAP2000 $V_{dsap} := 66 \cdot kip$

Bending moment demand on C1 or C2 $Md := \frac{M_{dsap}}{2} = 45 \cdot kip \cdot ft$

Shear force demand on C1 or C2 $Vd := \frac{V_{dsap}}{2} = 33 \cdot kip$

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Steel yield stress	$Fy := 36ksi$	
Steel tensile stress	$Fu := 58ksi$	
Modulus of Elasticity of steel	$E := 29000ksi$	
Sacrificial thickness - for accounting corrosion	$tc := 0.0175in$	Refer Basis of Design report

Channel Section Dimensional Parameters (MC12X35)

Depth	$d := 12in$
Web thickness	$tw := 0.4375in$
Flange thickness	$tf := 0.6875in$
Flange width	$bf := 3.75in$
Distance	$k := 1.3125in$

Corroded Channel Section Dimensional Parameters (MC12X35)

Web thickness	$twc := tw - 2tc = 0.4 \cdot in$
Flange thickness	$tfc := tf - 2tc = 0.65 \cdot in$

Sectional Properties of Corroded Section

Plastic modulus about x axis

$$Zx := \left[(bf)\cdot\frac{(d)^2}{4}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^2}{4}\right] = 39.28\cdot in^3$$

Elastic modulus about x axis

$$Sx := \frac{\left[\left[(bf)\cdot\frac{(d)^3}{12}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^3}{12}\right]\right]}{(d)\cdot 0.5} = 33.12\cdot in^3$$

Torsion constant

$$J := \frac{\left[\left[2\cdot(bf)\cdot(tfc)^3\right] + \left[[(d) - (tfc)]\cdot(twc)^3\right]\right]}{3} = 0.94\cdot in^4$$

Moment of Inertia about external edge
of web parallel to y axis

$$Iyo := \left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^3}{3}\right] + \left[(bf)^3\cdot(tfc)\cdot\frac{2}{3}\right] = 23.17\cdot in^4$$

Cross sectional area

$$Ac := [2\cdot(bf)\cdot(tfc)] + [[(d) - [2\cdot(tfc)]]\cdot(twc)] = 9.2\cdot in^2$$

Distance of centroid from external edge of web

$$xc := \frac{\left[\left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^2}{2}\right] + \left[(bf)^2\cdot(tfc)\right]\right]}{Ac} = 1.09\cdot in$$

Moment of inertia about y axis

$$Iy := Iyo - \left(Ac\cdot xc^2\right) = 12.21\cdot in^4$$

Distance between flange centroids

$$ho := (d) - (tfc) = 11.35\cdot in$$

Warping torsional constant

$$Cw := \frac{\left[(tfc)\cdot(bf)^3\cdot[(d) - (tfc)]^2\right]\cdot[[3\cdot(bf)\cdot(tfc)] + [2\cdot(twc)\cdot[(d) - (tfc)]]]}{12\cdot[[6\cdot(bf)\cdot(tfc)] + [(twc)\cdot[(d) - (tfc)]]]}$$

$$Cw = 316.03\cdot in^6$$

radius of gyration about y axis

$$ry := \sqrt{\frac{Iy}{Ac}} = 1.15\cdot in$$

Overstrength factor for flexure

$$\Omega f := 1.67$$

Overstrength factor for shear

$$\Omega v := 1.67$$

Classification of sections for local buckling - Section B4.1

Classification of flanges in flexure - Table B4.1b (case 10)

Width - to - Thickness Ratio for flange

$$a_f := \frac{bf}{tfc} = 5.75$$

Limiting width to thickness ratio for compact flange section about major/minor axis

$$\lambda_{cf} := 0.38 \cdot \sqrt{\frac{E}{Fy}} = 10.79$$

Limiting width to thickness ratio for non compact flange section about major/minor axis

$$\lambda_{nf} := 1 \sqrt{\frac{E}{Fy}} = 28.38$$

Classification of web in flexure - Table B4.1b (case 15)

Width - to - Thickness Ratio for web

$$a_w := \frac{(d) - [2 \cdot (k - 2tc)]}{twc} = 23.47$$

Limiting width to thickness ratio for compact web section about major/minor axis

$$\lambda_{cw} := 3.76 \cdot \sqrt{\frac{E}{Fy}} = 106.72$$

Limiting width to thickness ratio for non compact web section about major/minor axis

$$\lambda_{nw} := 5.7 \sqrt{\frac{E}{Fy}} = 161.78$$

$$cn_{ff} := \left| \begin{array}{l} \text{"Compact flange"} \quad \text{if } a_f \le \lambda_{cf} \\ \text{"Non compact flange"} \quad \text{if } \lambda_{cf} \le a_f \le \lambda_{nf} \\ \text{"Slender flange"} \quad \text{otherwise} \end{array} \right. = \text{"Compact flange"}$$

$$cn_{wf} := \left| \begin{array}{l} \text{"Compact web"} \quad \text{if } a_w \le \lambda_{cw} \\ \text{"Non compact web"} \quad \text{if } \lambda_{cw} \le a_w \le \lambda_{nw} \\ \text{"Slender flange web"} \quad \text{otherwise} \end{array} \right. = \text{"Compact web"}$$

Allowable Stress Shear Design - Chapter G

Web area

$$Aw := (d) \cdot (twc) = 4.83 \cdot in^2$$

Web plate buckling coefficient

$$Kv := 5.34$$

$$r := 1.1 \cdot \left(Kv \cdot \frac{E}{Fy} \right)^{\frac{1}{2}} = 72.15$$

$$r1 := \frac{(d) - [2 \cdot (tfc)]}{twc} = 26.57$$

Web shear coefficient, Eq G2-3 and Eq G2-4

$$Cv1 := \begin{vmatrix} 1 \quad \text{if } r \geq r1 \\ \dfrac{r}{r1} \quad \text{if } r < r1 \end{vmatrix}$$

$$Cv1 = 1$$

Nominal shear strength, Eq G2-1

$$Vn := 0.6 \cdot Cv1 \cdot Aw \cdot Fy = 104.33 \cdot kip$$

Allowable shear strength

$$vc := \frac{Vn}{\Omega v} = 62.47 \cdot kip$$

Check for shear strength

$$Checkvc := \begin{vmatrix} \dfrac{Vd}{vc} \quad \text{if } vc \geq Vd \\ \text{"Revise waler section"} \quad \text{if } vc < Vd \end{vmatrix}$$

$$Checkvc = 0.53$$

Allowable Stress Flexure design about major axis - Chapter F

Yielding - Section F2.1

Nominal flexural strength for yielding, Eq F2-1

$$Mnyld := Fy \cdot Zx = 117.83 \cdot kip \cdot ft$$

Lateral Torsional Buckling - Section F2.2

Unbraced length $Lb := S_{rod}\cdot 2 = 120\cdot in$

Limiting unbraced length for yielding Eq F2-5 $Lp := 1.76\cdot ry\cdot\sqrt{\frac{E}{Fy}} = 57.55\cdot in$

Eq F2-8b $cf := \left(\frac{ho}{2}\right)\cdot\sqrt{\frac{Iy}{Cw}} = 1.12$

Eq F2-7 $rts := \sqrt{\frac{\sqrt{Iy\cdot Cw}}{Sx}} = 1.37\cdot in$

Eq F2-6

$$Lr := 1.95\cdot rts\cdot\frac{E\cdot\sqrt{\left(J\cdot\frac{cf}{Sx\cdot ho}\right)+\sqrt{\left(J\cdot\frac{cf}{Sx\cdot ho}\right)^2+\left[6.76\cdot\left(0.7\cdot\frac{Fy}{E}\right)^2\right]}}}{(0.7\cdot Fy)} = 245.54\cdot in$$

From SAP2000 analysis, for calculation of Cb (Lp<Lb<=Lr)

Moment at quarter point of unbraced segment $Ma := 28.4kip\cdot ft$

Moment at center line of unbraced segment $Mb := 67.8kip\cdot ft$

Moment at three quarter point of unbraced segment $Mc := 28.4kip\cdot ft$

Maximum moment in unbraced segment $Mabs := 89.8kip\cdot ft$

Plastic moment capacity

$$Mp := Mnyld$$

Lateral torsional buckling modification factor, Eq F1-1

$$Cb := 12.5\cdot\frac{Mabs}{[(2.5\cdot Mabs) + (3\cdot Ma) + (4\cdot Mb) + (3\cdot Mc)]} = 1.69$$

Nominal flexural strength for lateral torsional buckling - Eq F2-2

$$Mnltb := Cb\cdot\left[Mp - (Mp - 0.7\cdot Fy\cdot Sx)\cdot\frac{(Lb - Lp)}{(Lr - Lp)}\right]$$

$$Mnltb = 171.54\cdot kip\cdot ft$$

Nominal flexural strength

$$Mn := \min(Mnyld, Mnltb) = 117.83\cdot kip\cdot ft$$

Design flexure strength

$$mc := \frac{Mn}{\Omega f} = 70.56\cdot kip\cdot ft$$

Check for flexural strength

$$Checkmc := \left| \begin{array}{ll} \frac{Md}{mc} & \text{if } mc \geq Md \\ \text{"Revise waler section"} & \text{if } mc < Md \end{array} \right.$$

$$Checkmc = 0.64$$

Deflection Check

Limiting Deflection

$$L_{ld} := \frac{Lb}{360} = 0.33\cdot in$$

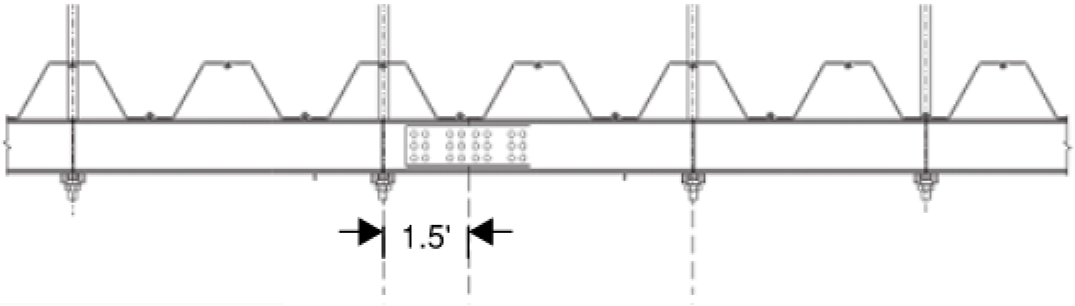
Maximum deflection from SAP2000 analysis $L_{md} := 0.18in$

Demand to Capacity Ratio

$$Check_d := \left| \begin{array}{ll} \dfrac{L_{md}}{L_{ld}} & \text{if } L_{ld} \geq L_{md} \\ \text{"Revise unbraced length"} & \text{if } L_{ld} < L_{md} \end{array} \right.$$

$$Check_d = 0.54$$

Bolted Splice Plate Connection Design for Waler, Allowable Stress Design - AISC 360-16



From SAP2000 analysis, point of zero moment in typical span for case 1 is ~1.2' and for case 2 is ~1.7' from tie rod anchorage. Point of splice connection for design is 1.5' from tie rod anchorage.

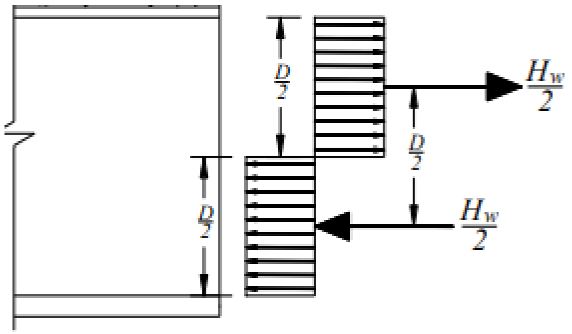
Resultant Web Force at Point of Splice Connection

Bending moment demand at point of splice, from SAP2000 analysis $Msd := 11kip \cdot ft$

Horizontal force in web due to moment at point of splice

$$H_w := \frac{Msd \cdot 4}{[d - [2 \cdot (k - 2tc)]]} = 55.9 \cdot kip$$

Resultant web force at point of splice connection $V_r := \sqrt{Vd^2 + H_w^2} = 64.92 \cdot kip$

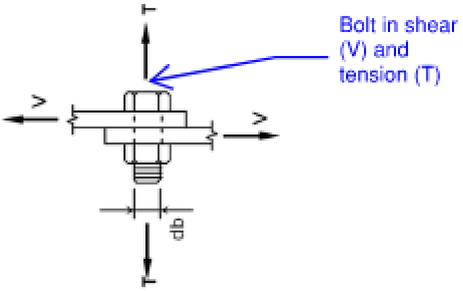


$$Web\ Moment = \frac{H_w}{2}\left(\frac{D}{2}\right)$$

$$H_w = \frac{Web\ Moment}{D/4}$$

Factored shear resistance of bolts in shear

No of shear planes $Ns := 1$



Bolt in shear (V) and tension (T)

Section J3, Table J3.2

Using HDG Group A, A325 bolts

Nominal shear stress when threads are not excluded from shear planes $Fnv := 54ksi$

Taking 1.25" nominal diameter bolt

Bolt nominal diameter $db := 1.25in$

Nominal unthreaded body area of bolt $Ab := 3.14 \cdot (db)^2 \cdot 0.25 = 1.23 \cdot in^2$

Nominal shear strength of bolt $\quad Rn := Fnv \cdot Ab \cdot Ns = 66.23 \cdot kip$

Overstrength factor $\quad \Omega b := 2$

Allowable shear strength of bolt $\quad Rr := \dfrac{Rn}{\Omega b} = 33.12 \cdot kip$

No of bolts required on each side of the web splice $\quad Nb := \dfrac{V_r}{Rr} = 1.96$

No of bolts provided on each side of the web splice $\quad Nf := 6$

No of bolt columns in connection pattern along the length of splice plate $\quad Nr := 3$

Bolt Connection Pattern

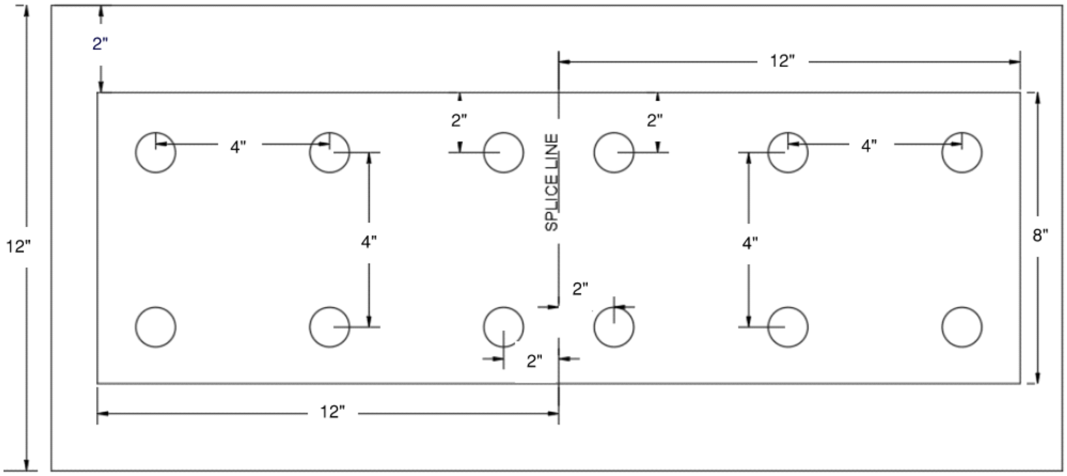


Table J3.3, for 1.25" bolt dia, standard hole dia is 1.375"

Hole diameter $\quad dbh := 1.375in$

Minimum center to center spacing allowed b/w holes, Sec J3.3

$$\mathrm{Smin} := \frac{8\cdot(\mathrm{db})}{3} = 3.33\cdot\mathrm{in}$$

Minimum clear spacing allowed b/w holes, Sec J3.3

$$\mathrm{Scmin} := \mathrm{db} = 1.25\cdot\mathrm{in}$$

Table J3.4, minimum edge distance allowed for 1.25" bolt dia

$$\mathrm{Semin} := 1.625\mathrm{in}$$

Providing a splice plate of 24"X8", 0.75" thickness for the connection

No of splice plates in the connection

$$\mathrm{Nsp} := 1$$

Eq. J4-3 and J4-4, strength of elements in shear

Depth of splice plate

$$\mathrm{dsp} := 8\mathrm{in}$$

Thickness of splice plate

$$\mathrm{Twsp} := 0.75\mathrm{in}$$

Reduced thickness of splice plate - for accounting corrosion

$$\mathrm{twsp} := \mathrm{Twsp} - \mathrm{tc} = 0.73\cdot\mathrm{in}$$

Gross area subject to shear

$$\mathrm{Agv} := \mathrm{dsp}\cdot\mathrm{twsp} = 5.86\cdot\mathrm{in}^2$$

Nominal shear yielding strength

$$\mathrm{Rnsy} := 0.6\cdot\mathrm{Fy}\cdot\mathrm{Agv}\cdot\mathrm{Nsp} = 126.58\cdot\mathrm{kip}$$

Overstrength factor

$$\Omega\mathrm{spsy} := 1.5$$

Allowable shear yielding strength

$$Rrsy := \frac{Rnsy}{\Omega spsy} = 84.38 \cdot kip$$

Demand to Capacity Ratio

$$Checksy := \left| \begin{array}{ll} \frac{Vd}{Rrsy} & \text{if } Rrsy \geq Vd \\ \text{"Revise splice plate"} & \text{if } Rrsy < Vd \end{array} \right.$$

$$Checksy = 0.39$$

Net area subject to shear

$$Anv := \left[dsp - \left(Nf \cdot \frac{dbh}{Nr} \right) \right] \cdot twsp = 3.85 \cdot in^2$$

Nominal shear rupture strength

$$Rnsr := 0.6 \cdot Fu \cdot Anv \cdot Nsp = 133.83 \cdot kip$$

Overstrength factor

$$\Omega spsr := 2$$

Allowable shear rupture strength

$$Rrsr := \frac{Rnsr}{\Omega spsr} = 66.91 \cdot kip$$

Demand to Capacity ratio

$$Checksr := \left| \begin{array}{ll} \frac{Vd}{Rrsr} & \text{if } Rrsr \geq Vd \\ \text{"Revise splice plate"} & \text{if } Rrsr < Vd \end{array} \right.$$

$$Checksr = 0.49$$

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Maximum spacing and edge distance - Section J3-5

Maximum edge distance

$$\mathrm{Semax} := \begin{cases} 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) & \text{if } 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 6\mathrm{in} \\ 6\mathrm{in} & \text{if } 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 6\mathrm{in} \end{cases} = 5.25\cdot\mathrm{in}$$

Maximum center to center longitudinal spacing allowed b/w holes

$$\mathrm{Smax} := \begin{cases} 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) & \text{if } 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 12\mathrm{in} \\ 12\mathrm{in} & \text{if } 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 12\mathrm{in} \end{cases} = 10.5\cdot\mathrm{in}$$

Distance of bolt from splice plate edge $\mathrm{Seprov} := 2\mathrm{in}$

Distance of bolt from channel section flange inner edge

$$\mathrm{Sepprov} := \mathrm{Seprov} + [(\mathrm{d} - \mathrm{dsp})\cdot 0.5 - \mathrm{k}] = 2.69\cdot\mathrm{in}$$

Spacing provided between bolts $\mathrm{Sprov} := 4\mathrm{in}$

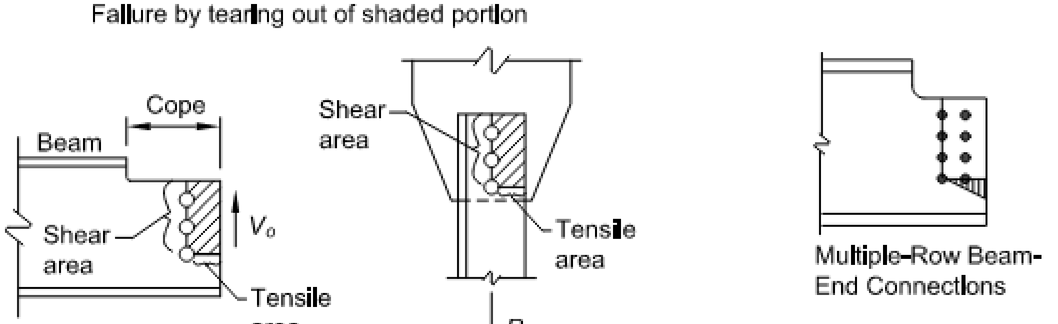
Check for bolt edge distance provided

$$\mathrm{Secheck} := \begin{cases} \text{"Okay"} & \text{if } \mathrm{Semin} \le \max(\mathrm{Sepprov},\mathrm{Seprov}) \le \mathrm{Semax} \\ \text{"Not Okay"} & \text{otherwise} \end{cases} = \text{"Okay"}$$

Check for spacing provided between bolts

$$\mathrm{Scheck} := \begin{cases} \text{"Okay"} & \text{if } (\max(\mathrm{Smin},\mathrm{Scmin} + \mathrm{dbh}) \le \mathrm{Sprov} \le \mathrm{Smax}) \\ \text{"Not Okay"} & \text{otherwise} \end{cases} = \text{"Okay"}$$

Block Shear Rupture Check, Eq. J4-5



(b) Cases for which $U_{bs} = 0.5$

Fig. C-J4.1. Failure surface for block shear rupture limit state.

No of bolts in the outermost edge of the connection pattern which is in tension

$$\text{Nbr} := 3$$

Net Area resisting the tensile stress

$$\text{Ant} := \text{Nsp}\cdot[\text{Seprov} + (\text{Nbr} - 1)\text{Sprov} - [\text{dbh}\cdot(\text{Nbr} - 0.5)]]\cdot\text{twsp} = 4.81\cdot\text{in}^2$$

Net Area resisting the shear stress

$$\text{Avn} := \text{Nsp}\cdot\left[\text{dsp} - \text{Seprov} - \left[\left[\left(\frac{\text{Nf}}{\text{Nr}}\right) - 0.5\right]\cdot\text{dbh}\right]\right]\cdot\text{twsp} = 2.88\cdot\text{in}^2$$

Gross area resisting the shear stress

$$\text{Avg} := \text{Nsp}\cdot(\text{dsp} - \text{Seprov})\cdot\text{twsp} = 4.39\cdot\text{in}^2$$

Nominal block shear strength

$$\text{Ubs} := 0.5$$

$$\text{Rbs} := [(0.6\cdot\text{Fu}\cdot\text{Avn}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})] = 239.77\cdot\text{kip}$$

$$\text{Rnbs} := \left|\begin{array}{l}\text{Rbs} \ \text{ if } \ \text{Rbs} \le [(0.6\cdot\text{Fy}\cdot\text{Avg}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})] \\ [(0.6\cdot\text{Fy}\cdot\text{Avg}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})] \ \text{ if } \ \text{Rbs} > [(0.6\cdot\text{Fy}\cdot\text{Avg}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})]\end{array}\right. = 234.34\cdot\text{kip}$$

Overstrength Factor $\Omega bs := 2$

Allowable block shear strength $Rrbs := \frac{Rnbs}{\Omega bs} = 117.17 \cdot kip$

Demand to Capacity Ratio

$$Checkbs := \left| \begin{array}{ll} \frac{Vd}{Rrbs} & \text{if } Rrbs \geq Vd \\ \text{"Revise splice plate"} & \text{if } Rrbs < Vd \end{array} \right.$$

$Checkbs = 0.28$

Bearing Resistance Check, Eq. J3-6a

Nominal bearing strength at bolt holes $Rnb := 2.4 \cdot (db) \cdot twsp \cdot Fu \cdot Nf = 764.73 \cdot kip$

Overstrength Factor $\Omega bh := 2$

Allowable bearing strength at bolt holes $Rrb := \frac{Rnb}{\Omega bh} = 382.36 \cdot kip$

Demand to Capacity Ratio

$$Checkbh := \left| \begin{array}{ll} \frac{V_r}{Rrb} & \text{if } Rrb \geq V_r \\ \text{"Revise splice plate or bolts"} & \text{if } Rrb < V_r \end{array} \right. = 0.17$$

Tearout Resistance Check, Eq. J3-6c

lc for edge bolts $lco := Seprov - \left(\frac{dbh}{2}\right) = 1.31 \cdot in$

lc for inner bolts

$$lci := Sprov - dbh = 2.63 \cdot in$$

Inner bolts on each side of splice

$$Ni := 0$$

For edge bolts, nominal tearout strength at bolt holes

$$Rnto := 1.2 \cdot twsp \cdot Fu \cdot lco \cdot (Nf - Ni) = 401.48 \cdot kip$$

For inner bolts. nominal tearout strength at bolt holes

$$Rnti := 1.2 \cdot twsp \cdot Fu \cdot lci \cdot Ni = 0 \cdot kip$$

Total nominal tearout strength at bolt holes

$$Rnt := Rnto + Rnti = 401.48 \cdot kip$$

Overstrength factor

$$\Omega bt := 2$$

Allowable tearout strength at bolt holes

$$Rrt := \frac{Rnt}{\Omega bt} = 200.74 \cdot kip$$

Demand to Capacity Ratio

$$Checkth := \begin{cases} \dfrac{V_r}{Rrt} & \text{if } Rrt \ge V_r \\ \text{"Revise splice plate or bolts"} & \text{if } Rrt < V_r \end{cases} = 0.32$$

Slip Resistance Check, Eq. J3-4

For class A surfaces

$$\mu := 0.3$$

$$Du := 1.13$$

Minimum bolt pretension, Table J3.1 for Group A, A325 bolts

$$Tb := 81kip$$

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$hf := 1$

Nominal slip resistance of bolts $Rsr := Nf \cdot Ns \cdot \mu \cdot Du \cdot Tb \cdot hf = 164.75 \cdot kip$

Overstrength Factor $\Omega sr := 1.5$

Allowable slip resistance of bolts $Rrslr := \frac{Rsr}{\Omega sr} = 109.84 \cdot kip$

Demand to Capacity Ratio

$$Checkslr := \left| \begin{array}{ll} \frac{V_r}{Rrslr} & \text{if } Rrslr \geq V_r \\ \text{"Revise bolts size"} & \text{if } Rrslr < V_r \end{array} \right. = 0.59$$

Design Summary

Provide rectangular splice plate of 24"X8",0.75" thickness. On each side of web splice bolted plate connection, provide 6 - 1.25" dia HDG Group A - A325 bolts.

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Analysis Demand Load on Waler - Sec C2

Tie Rod Tension Demand Load from Analysis $T_{roda} := 178.4\text{kip}$

Tie Rod Spacing $S_{roda} := 6\text{ft}$

The tie rod spacing assumed in analysis results in large demand loads and section size for waler. To optimize section selection, tie rods will be closely spaced. Closely spaced tie rods will result in lower demand loads.

Revised Tie Rod Spacing $S_{rod} := 5\text{ft}$

Revised Tie Rod Tension Demand $T_{rod} := T_{roda} \cdot \frac{S_{rod}}{S_{roda}} = 148.67 \cdot \text{kip}$

Demand Load on waler $w_{dl} := \frac{T_{rod}}{S_{rod}} = 29.73 \cdot \frac{\text{kip}}{\text{ft}}$

Demand Load on Waler to safeguard against progressive failure

In certain situations, progressive collapse of the structure may be a conseequence of an extreme condition ie. failure of a tie rod. The wailing to the main wall will need to be checked to ensure that it will not collapse if the span between tie rods doubles following the loss of a tie rod.

SAP2000 analysis is used to calculate the bending moment and shear force demand on the waler for both the cases. Case 1 - without failure of a tie rod and, Case 2 - with failure of a tie rod.

For Case 1 - Continuous beam with four equal spans of length Srod is anaylzed
For Case 2 - Continuous beam with three spans of length Srod - 2Srod - Srod is analyzed

Waler Design is governed by the demands from Case 2

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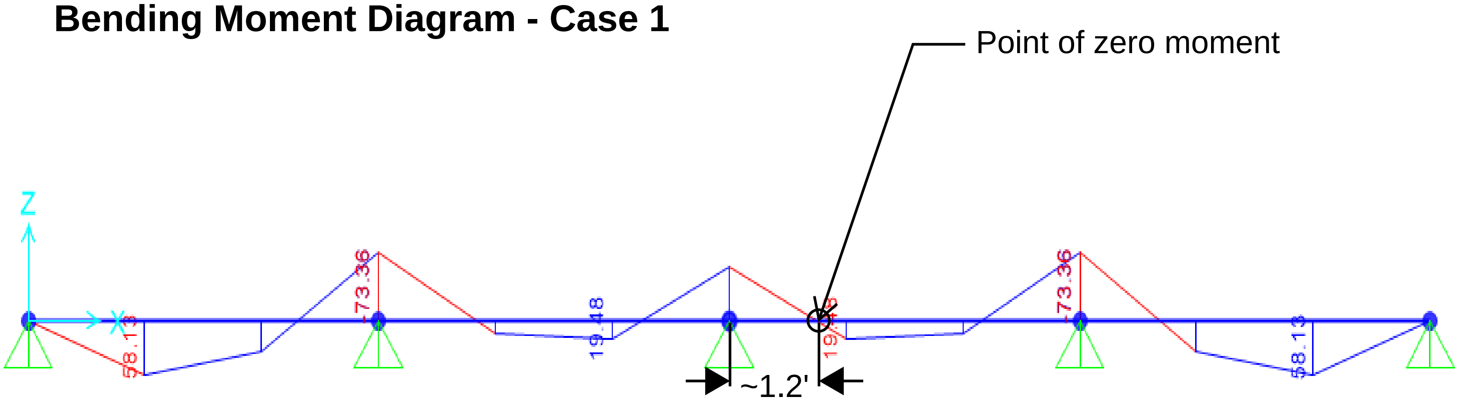
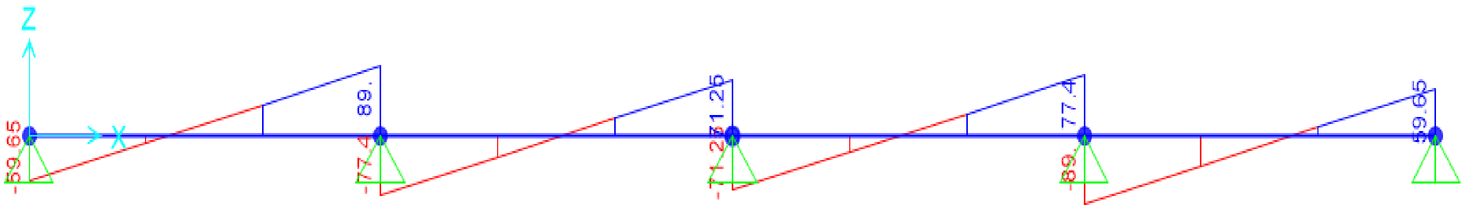
Bending Moment Diagram - Case 1



Bending Moment demand from SAP2000 - Mdsap = 73.4Kip-ft

Shear Force Diagram - Case 1



Shear Force demand from SAP2000 - Vdsap = 89Kip

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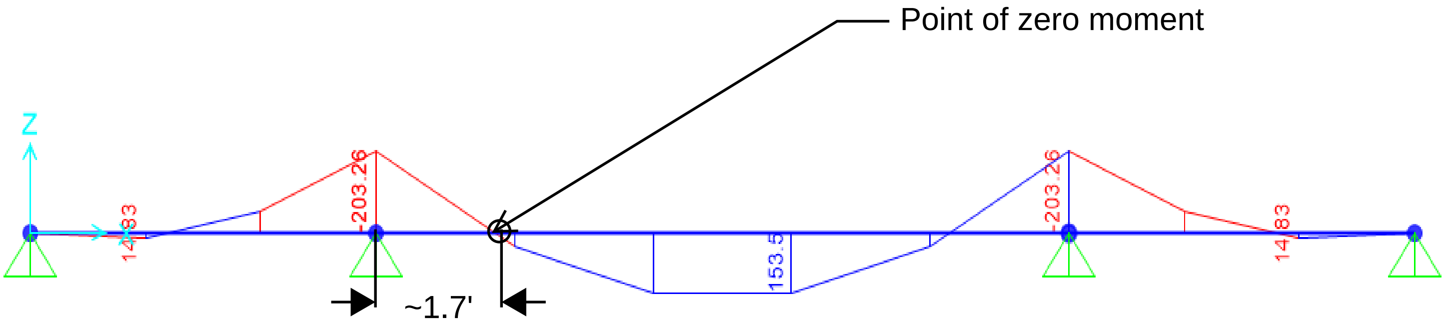
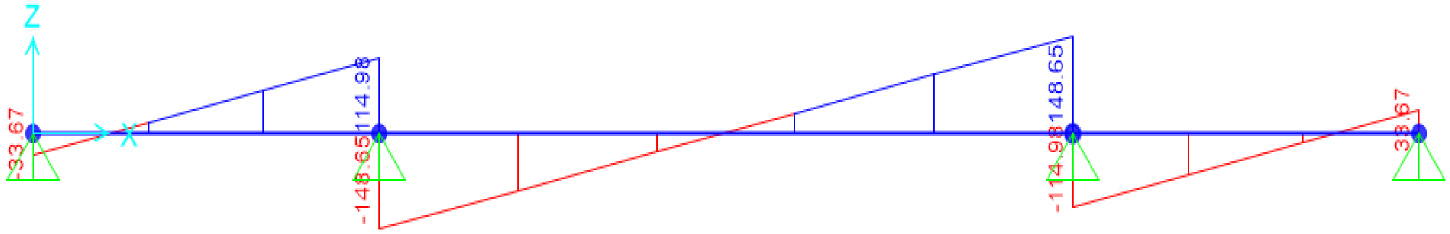
Bending Moment Diagram - Case 2



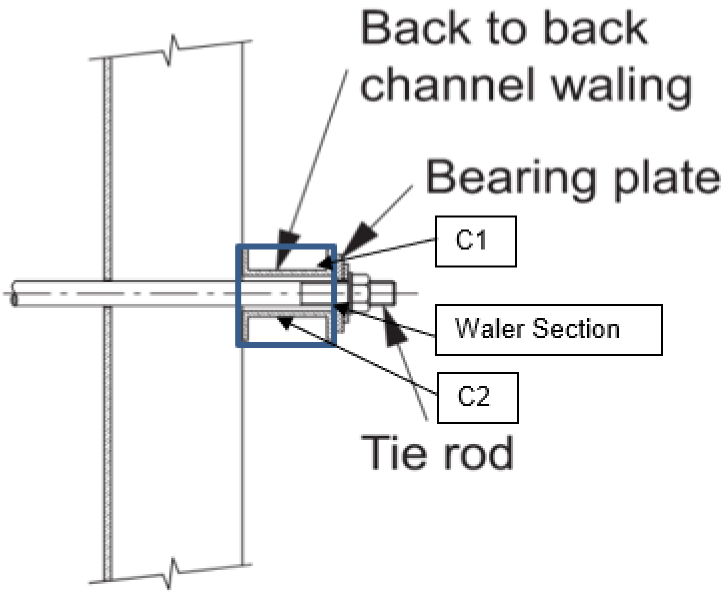
Bending Moment demand from SAP2000 - Mdsap = 203.3Kip-ft

Shear Force Diagram - Case 2



Shear Force demand from SAP2000 - Vdsap = 148.7Kip

Waler Cross-Section



Waler is made of two channel sections C1 and C2

Design of corroded waler section, AISC 360-16

Bending moment demand on waler from SAP2000 $M_{dsap} := 203.26\text{kip}\cdot\text{ft}$

Shear force demand on waler from SAP2000 $V_{dsap} := 149\cdot\text{kip}$

Bending moment demand on C1 or C2 $Md := \frac{M_{dsap}}{2} = 101.63\cdot\text{kip}\cdot\text{ft}$

Shear force demand on C1 or C2 $Vd := \frac{V_{dsap}}{2} = 74.5\cdot\text{kip}$

Steel yield stress $Fy := 36\text{ksi}$

Steel tensile stress $Fu := 58ksi$

Modulus of Elasticity of steel $E := 29000ksi$

Sacrificial thickness - for accounting corrosion $tc := 0.0175in$ Refer Basis of Design report

Channel Section Dimensional Parameters (MC18X45.8)

Depth $d := 18in$

Web thickness $tw := 0.5in$

Flange thickness $tf := 0.625in$

Flange width $bf := 4in$

Distance $k := 1.4375in$

Corroded Channel Section Dimensional Parameters (MC18X45.8)

Web thickness $twc := tw - 2tc = 0.47 \cdot in$

Flange thickness $tfc := tf - 2tc = 0.59 \cdot in$

Sectional Properties of Corroded Section

Plastic modulus about x axis

$$Zx := \left[(bf)\cdot\frac{(d)^2}{4}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^2}{4}\right] = 73.98 \cdot in^3$$

Elastic modulus about x axis

$$Sx := \frac{\left[\left[(bf)\cdot\frac{(d)^3}{12}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^3}{12}\right]\right]}{(d)\cdot 0.5} = 60.24\cdot in^3$$

Torsion constant

$$J := \frac{\left[\left[2\cdot(bf)\cdot(tfc)^3\right] + \left[[(d) - (tfc)]\cdot(twc)^3\right]\right]}{3} = 1.13\cdot in^4$$

Moment of Inertia about external edge
of web parallel to y axis

$$Iyo := \left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^3}{3}\right] + \left[(bf)^3\cdot(tfc)\cdot\frac{2}{3}\right] = 25.74\cdot in^4$$

Cross sectional area

$$Ac := [2\cdot(bf)\cdot(tfc)] + [[(d) - [2\cdot(tfc)]]\cdot(twc)] = 12.54\cdot in^2$$

Distance of centroid from external edge
of web

$$xc := \frac{\left[\left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^2}{2}\right] + \left[(bf)^2\cdot(tfc)\right]\right]}{Ac} = 0.9\cdot in$$

Moment of inertia about y axis

$$Iy := Iyo - \left(Ac\cdot xc^2\right) = 15.63\cdot in^4$$

Distance between flange centroids $ho := (d) - (tfc) = 17.41 \cdot in$

Warping torsional constant

$$Cw := \frac{\left[(tfc)\cdot(bf)^3\cdot[(d)-(tfc)]^2\right]\cdot[[3\cdot(bf)\cdot(tfc)]+[2\cdot(twc)\cdot[(d)-(tfc)]]]}{12\cdot[[6\cdot(bf)\cdot(tfc)]+[(twc)\cdot[(d)-(tfc)]]]}$$

$$Cw = 997.31 \cdot in^6$$

radius of gyration about y axis $ry := \sqrt{\frac{Iy}{Ac}} = 1.12 \cdot in$

Overstrength factor for flexure $\Omega f := 1.67$

Overstrength factor for shear $\Omega v := 1.67$

Classification of sections for local buckling - Section B4.1

Classification of flanges in flexure - Table B4.1b (case 10)

Width - to - Thickness Ratio for flange $a_f := \frac{bf}{tfc} = 6.78$

Limiting width to thickness ratio for compact flange section about major/minor axis $\lambda_{cf} := 0.38 \cdot \sqrt{\frac{E}{Fy}} = 10.79$

Limiting width to thickness ratio for non compact flange section about major/minor axis $\lambda_{nf} := 1 \sqrt{\frac{E}{Fy}} = 28.38$

Classification of web in flexure - Table B4.1b (case 15)

Width - to - Thickness Ratio for web $a_w := \frac{(d) - [2\cdot(k - 2tc)]}{twc} = 32.68$

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Limiting width to thickness ratio for compact web section about major/minor axis

$$\lambda_{cw} := 3.76 \cdot \sqrt{\frac{E}{Fy}} = 106.72$$

Limiting width to thickness ratio for non compact web section about major/minor axis

$$\lambda_{nw} := 5.7\sqrt{\frac{E}{Fy}} = 161.78$$

$$cn_{ff} := \left| \begin{array}{l} \text{"Compact flange"} \quad \text{if } a_f \le \lambda_{cf} \\ \text{"Non compact flange"} \quad \text{if } \lambda_{cf} \le a_f \le \lambda_{nf} \\ \text{"Slender flange"} \quad \text{otherwise} \end{array} \right. = \text{"Compact flange"}$$

$$cn_{wf} := \left| \begin{array}{l} \text{"Compact web"} \quad \text{if } a_w \le \lambda_{cw} \\ \text{"Non compact web"} \quad \text{if } \lambda_{cw} \le a_w \le \lambda_{nw} \\ \text{"Slender flange web"} \quad \text{otherwise} \end{array} \right. = \text{"Compact web"}$$

Allowable Stress Shear Design - Chapter G

Web area

$$Aw := (d) \cdot (twc) = 8.37 \cdot in^2$$

Web plate buckling coefficient

$$Kv := 5.34$$

$$r := 1.1 \cdot \left(Kv \cdot \frac{E}{Fy} \right)^{\frac{1}{2}} = 72.15$$

$$r1 := \frac{(d) - [2 \cdot (tfc)]}{twc} = 36.17$$

Web shear coefficient, Eq G2-3 and Eq G2-4

$$Cv1 := \left| \begin{array}{l} 1 \quad \text{if } r \ge r1 \\ \frac{r}{r1} \quad \text{if } r < r1 \end{array} \right.$$

$Cv1 = 1$

Nominal shear strength, Eq G2-1 $Vn := 0.6 \cdot Cv1 \cdot Aw \cdot Fy = 180.79 \cdot kip$

Allowable shear strength $vc := \frac{Vn}{\Omega v} = 108.26 \cdot kip$

Check for shear strength

$$Checkvc := \begin{cases} \frac{Vd}{vc} & \text{if } vc \ge Vd \\ \text{"Revise waler section"} & \text{if } vc < Vd \end{cases}$$

$Checkvc = 0.69$

Allowable Stress Flexure design about major axis - Chapter F

Yielding - Section F2.1

Nominal flexural strength for yielding, Eq F2-1 $Mnyld := Fy \cdot Zx = 221.93 \cdot kip \cdot ft$

Lateral Torsional Buckling - Section F2.2

Unbraced length $Lb := S_{rod} \cdot 2 = 120 \cdot in$

Limiting unbraced length for yielding Eq F2-5 $Lp := 1.76 \cdot ry \cdot \sqrt{\frac{E}{Fy}} = 55.77 \cdot in$

Eq F2-8b $cf := \left(\frac{ho}{2}\right) \cdot \sqrt{\frac{Iy}{Cw}} = 1.09$

Eq F2-7 $rts := \sqrt{\frac{\sqrt{Iy \cdot Cw}}{Sx}} = 1.44 \cdot in$

Eq F2-6

$$Lr := 1.95 \cdot rts \cdot \frac{E \cdot \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right) + \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right)^2 + \left[6.76 \cdot \left(0.7 \cdot \frac{Fy}{E}\right)^2\right]}}}{(0.7 \cdot Fy)} = 197.09 \cdot in$$

From SAP2000 analysis, for calculation of Cb (Lp<Lb<=Lr)

Moment at quarter point of unbraced segment $Ma := 64.3 kip \cdot ft$

Moment at center line of unbraced segment $Mb := 153.5 kip \cdot ft$

Moment at three quarter point of unbraced segment $Mc := 64.3 kip \cdot ft$

Maximum moment in unbraced segment $Mabs := 203.3 kip \cdot ft$

Plastic moment capacity $Mp := Mnyld$

Lateral torsional buckling modification factor, Eq F1-1

$$Cb := 12.5 \cdot \frac{Mabs}{[(2.5 \cdot Mabs) + (3 \cdot Ma) + (4 \cdot Mb) + (3 \cdot Mc)]} = 1.69$$

Nominal flexural strength for lateral torsional buckling - Eq F2-2

$$Mnltb := Cb \cdot \left[Mp - (Mp - 0.7 \cdot Fy \cdot Sx) \cdot \frac{(Lb - Lp)}{(Lr - Lp)}\right]$$

$$Mnltb = 300.9 \cdot kip \cdot ft$$

Nominal flexural strength

$$Mn := \min(Mnyld, Mnltb) = 221.93 \cdot kip \cdot ft$$

Design flexure strength

$$mc := \frac{Mn}{\Omega f} = 132.89 \cdot kip \cdot ft$$

Check for flexural strength

$$Checkmc := \left| \begin{array}{ll} \frac{Md}{mc} & \text{if } mc \geq Md \\ \text{"Revise waler section"} & \text{if } mc < Md \end{array} \right.$$

$$Checkmc = 0.76$$

Deflection Check

Limiting Deflection

$$L_{ld} := \frac{Lb}{360} = 0.33 \cdot in$$

Maximum deflection from SAP2000 analysis

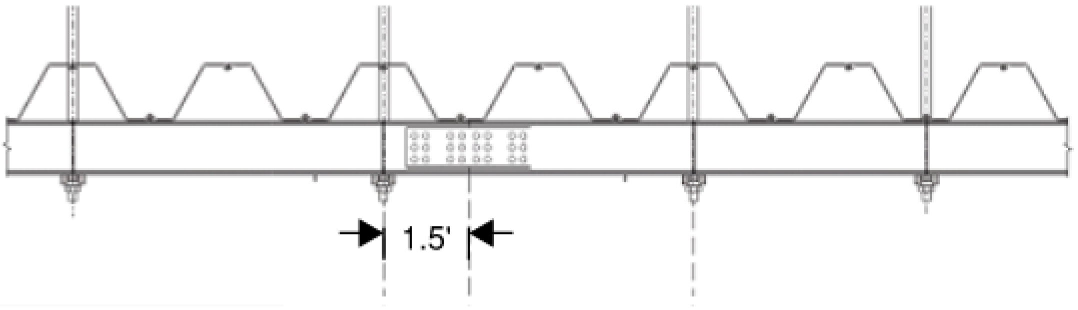
$$L_{md} := 0.25in$$

Demand to Capacity Ratio

$$Check_d := \left| \begin{array}{ll} \frac{L_{md}}{L_{ld}} & \text{if } L_{ld} \geq L_{md} \\ \text{"Revise unbraced length"} & \text{if } L_{ld} < L_{md} \end{array} \right.$$

$$Check_d = 0.75$$

Bolted Splice Plate Connection Design for Waler, Allowable Stress Design - AISC 360-16



From SAP2000 analysis, point of zero moment in typical span for case 1 is ~1.2' and for case 2 is ~1.7' from tie rod anchorage. Point of splice connection for design is 1.5' from tie rod anchorage.

Resultant Web Force at Point of Splice Connection

Bending moment demand at point of splice, from SAP2000 analysis

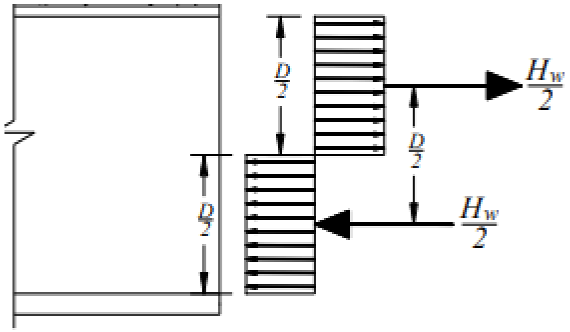
$$\mathrm{Msd} := 24.88\mathrm{kip}\cdot\mathrm{ft}$$

Horizontal force in web due to moment at point of splice

$$\mathrm{H_w} := \frac{\mathrm{Msd}\cdot 4}{[\mathrm{d} - [2\cdot(\mathrm{k} - 2\mathrm{tc})]]} = 78.59\cdot\mathrm{kip}$$

Resultant web force at point of splice connection

$$\mathrm{V_r} := \sqrt{\mathrm{Vd}^2 + \mathrm{H_w}^2} = 108.29\cdot\mathrm{kip}$$



$$Web\ Moment = \frac{H_w}{2}\left(\frac{D}{2}\right)$$

$$H_w = \frac{Web\ Moment}{D/4}$$

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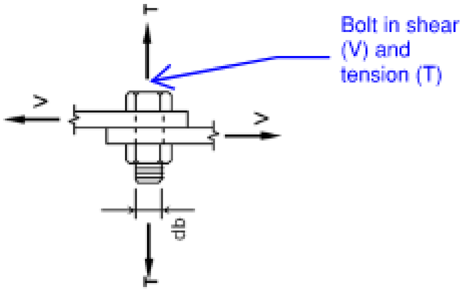
Factored shear resistance of bolts in shear

No of shear planes $Ns := 1$



Bolt in shear (V) and tension (T)

Section J3, Table J3.2

Using HDG Group A, A325 bolts

Nominal shear stress when threads are not excluded from shear planes $Fnv := 54\text{ksi}$

Taking 1.375" nominal diameter bolt

Bolt nominal diameter $db := 1.375\text{in}$

Nominal unthreaded body area of bolt $Ab := 3.14\cdot(db)^2\cdot 0.25 = 1.48\cdot\text{in}^2$

Nominal shear strength of bolt $Rn := Fnv\cdot Ab\cdot Ns = 80.14\cdot\text{kip}$

Overstrength factor $\Omega b := 2$

Allowable shear strength of bolt $Rr := \dfrac{Rn}{\Omega b} = 40.07\cdot\text{kip}$

No of bolts required on each side of the web splice $Nb := \dfrac{V_r}{Rr} = 2.7$

No of bolts provided on each side of the web splice $Nf := 6$

No of bolt columns in connection pattern along the length of splice plate $Nr := 3$

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Bolt Connection Pattern

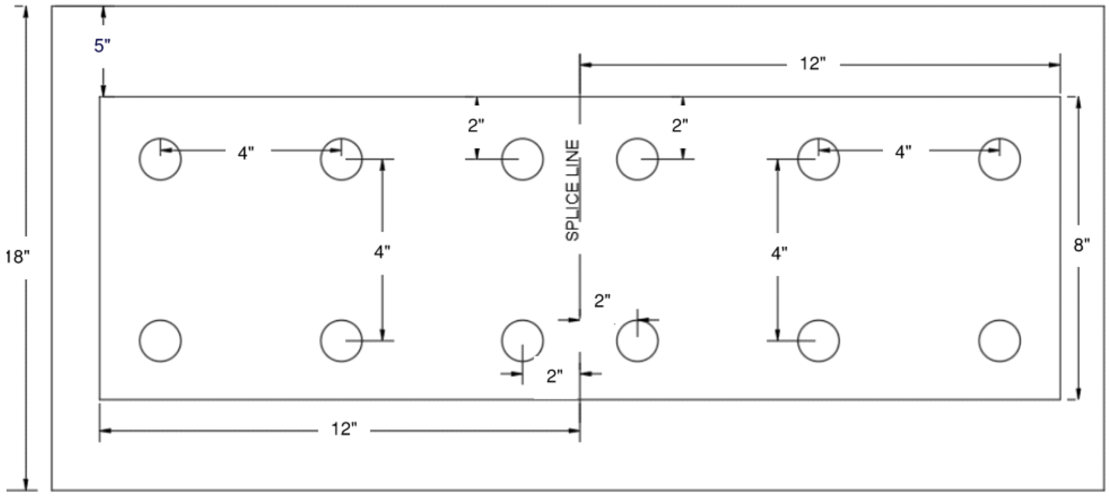

Table J3.3, for 1.375" bolt dia, standard hole dia is 1.5"

Hole diameter $dbh := 1.5in$

Minimum center to center spacing allowed b/w holes, Sec J3.3 $Smin := \frac{8\cdot(db)}{3} = 3.67\cdot in$

Minimum clear spacing allowed b/w holes, Sec J3.3 $Scmin := db = 1.38\cdot in$

Table J3.4, minimum edge distance allowed for 1.375" bolt dia $Semin := 1.72in$

Providing a splice plate of 24"X8", 1.25" thickness for the connection

No of splice plates in the connection $Nsp := 1$

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Eq. J4-3 and J4-4, strength of elements in shear

Depth of splice plate

$$\mathrm{dsp} := 8\mathrm{in}$$

Thickness of splice plate

$$\mathrm{Twsp} := 1.25\mathrm{in}$$

Reduced thickness of splice plate - for accounting corrosion

$$\mathrm{twsp} := \mathrm{Twsp} - \mathrm{tc} = 1.23\cdot\mathrm{in}$$

Gross area subject to shear

$$\mathrm{Agv} := \mathrm{dsp}\cdot\mathrm{twsp} = 9.86\cdot\mathrm{in}^{2}$$

Nominal shear yielding strength

$$\mathrm{Rnsy} := 0.6\cdot\mathrm{Fy}\cdot\mathrm{Agv}\cdot\mathrm{Nsp} = 212.98\cdot\mathrm{kip}$$

Overstrength factor

$$\Omega\mathrm{spsy} := 1.5$$

Allowable shear yielding strength

$$\mathrm{Rrsy} := \frac{\mathrm{Rnsy}}{\Omega\mathrm{spsy}} = 141.98\cdot\mathrm{kip}$$

Demand to Capacity Ratio

$$\mathrm{Checksy} := \left|\begin{array}{ll} \dfrac{\mathrm{Vd}}{\mathrm{Rrsy}} & \text{if } \mathrm{Rrsy} \ge \mathrm{Vd} \\ \text{"Revise splice plate"} & \text{if } \mathrm{Rrsy} < \mathrm{Vd} \end{array}\right.$$

$$\mathrm{Checksy} = 0.52$$

Net area subject to shear

$$\mathrm{Anv} := \left[\mathrm{dsp} - \left(\mathrm{Nf}\cdot\frac{\mathrm{dbh}}{\mathrm{Nr}}\right)\right]\cdot\mathrm{twsp} = 6.16\cdot\mathrm{in}^{2}$$

Nominal shear rupture strength $Rnsr := 0.6 \cdot Fu \cdot Anv \cdot Nsp = 214.45 \cdot kip$

Overstrength factor $\Omega spsr := 2$

Allowable shear rupture strength $Rrsr := \dfrac{Rnsr}{\Omega spsr} = 107.23 \cdot kip$

Demand to Capacity ratio

$$Checksr := \begin{vmatrix} \dfrac{Vd}{Rrsr} \quad \text{if } Rrsr \ge Vd \\ \text{"Revise splice plate"} \quad \text{if } Rrsr < Vd \end{vmatrix}$$

$Checksr = 0.69$

Maximum spacing and edge distance - Section J3-5

Maximum edge distance

$$Semax := \begin{vmatrix} 12 \cdot \min(tw, Twsp) \quad \text{if } 12 \cdot \min(tw, Twsp) \le 6in \\ 6in \quad \text{if } 12 \cdot \min(tw, Twsp) > 6in \end{vmatrix} = 6 \cdot in$$

Maximum center to center longitudinal spacing
allowed b/w holes

$$Smax := \begin{vmatrix} 24 \cdot \min(tw, Twsp) \quad \text{if } 24 \cdot \min(tw, Twsp) \le 12in \\ 12in \quad \text{if } 24 \cdot \min(tw, Twsp) > 12in \end{vmatrix} = 12 \cdot in$$

Distance of bolt from splice plate edge $Seprov := 2in$

Distance of bolt from channel section flange inner edge

$$\text{Sepprov} := \text{Seprov} + [(\text{d} - \text{dsp})\cdot 0.5 - \text{k}] = 5.56\cdot\text{in}$$

Spacing provided between bolts $\text{Sprov} := 4\text{in}$

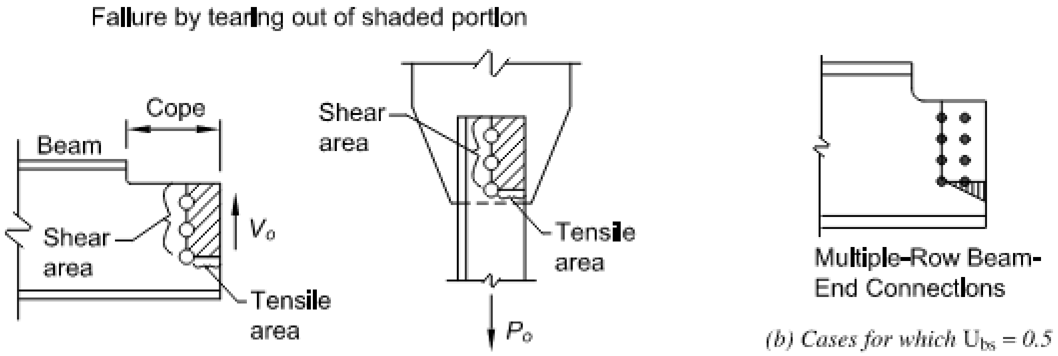
Check for bolt edge distance provided

$$\text{Secheck} := \left|\begin{array}{l}\text{"Okay" if Semin} \le \max(\text{Sepprov}, \text{Seprov}) \le \text{Semax} \\ \text{"Not Okay" otherwise}\end{array}\right. = \text{"Okay"}$$

Check for spacing provided between bolts

$$\text{Scheck} := \left|\begin{array}{l}\text{"Okay" if } (\max(\text{Smin}, \text{Scmin} + \text{dbh}) \le \text{Sprov} \le \text{Smax}) \\ \text{"Not Okay" otherwise}\end{array}\right. = \text{"Okay"}$$

Block Shear Rupture Check, Eq. J4-5



(b) Cases for which $U_{bs} = 0.5$

Fig. C-J4.1. Failure surface for block shear rupture limit state.

No of bolts in the outermost edge of the connection pattern which is in tension $\text{Nbr} := 3$

Net Area resisting the tensile stress

$$\text{Ant} := \text{Nsp}\cdot[\text{Seprov} + (\text{Nbr} - 1)\text{Sprov} - [\text{dbh}\cdot(\text{Nbr} - 0.5)]]\cdot\text{twsp} = 7.7\cdot\text{in}^2$$

Net Area resisting the shear stress

$$\text{Avn} := \text{Nsp}\cdot\left[\text{dsp} - \text{Seprov} - \left[\left[\left(\frac{\text{Nf}}{\text{Nr}}\right) - 0.5\right]\cdot\text{dbh}\right]\right]\cdot\text{twsp} = 4.62\cdot\text{in}^2$$

Gross area resisting the shear stress $\text{Avg} := \text{Nsp}\cdot(\text{dsp} - \text{Seprov})\cdot\text{twsp} = 7.39\cdot\text{in}^2$

Nominal block shear strength $\text{Ubs} := 0.5$

$$\text{Rbs} := [(0.6\cdot\text{Fu}\cdot\text{Avn}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})] = 384.23\cdot\text{kip}$$

$$\text{Rnbs} := \left|\begin{array}{l}\text{Rbs} \ \text{ if } \ \text{Rbs} \le [(0.6\cdot\text{Fy}\cdot\text{Avg}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})] \\ [(0.6\cdot\text{Fy}\cdot\text{Avg}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})] \ \text{ if } \ \text{Rbs} > [(0.6\cdot\text{Fy}\cdot\text{Avg}) + (\text{Ubs}\cdot\text{Fu}\cdot\text{Ant})]\end{array}\right. = 383.12\cdot\text{kip}$$

Overstrength Factor $\Omega\text{bs} := 2$

Allowable block shear strength $\text{Rrbs} := \dfrac{\text{Rnbs}}{\Omega\text{bs}} = 191.56\cdot\text{kip}$

Demand to Capacity Ratio

$$\text{Checkbs} := \left|\begin{array}{l}\dfrac{\text{Vd}}{\text{Rrbs}} \ \text{ if } \ \text{Rrbs} \ge \text{Vd} \\ \text{"Revise splice plate"} \ \text{ if } \ \text{Rrbs} < \text{Vd}\end{array}\right.$$

$$\text{Checkbs} = 0.39$$

Bearing Resistance Check, Eq. J3-6a

Nominal bearing strength at bolt holes $Rnb := 2.4 \cdot (db) \cdot twsp \cdot Fu \cdot Nf = 1.42 \times 10^{3} \cdot kip$

Overstrength Factor $\Omega bh := 2$

Allowable bearing strength at bolt holes $Rrb := \frac{Rnb}{\Omega bh} = 707.7 \cdot kip$

Demand to Capacity Ratio

$$Checkbh := \begin{vmatrix} \frac{V_r}{Rrb} \text{ if } Rrb \geq V_r \\ \text{"Revise splice plate or bolts" if } Rrb < V_r \end{vmatrix} = 0.15$$

Tearout Resistance Check, Eq. J3-6c

lc for edge bolts $lco := Seprov - \left(\frac{dbh}{2}\right) = 1.25 \cdot in$

lc for inner bolts $lci := Sprov - dbh = 2.5 \cdot in$

Inner bolts on each side of splice $Ni := 0$

For edge bolts, nominal tearout strength at bolt holes $Rnto := 1.2 \cdot twsp \cdot Fu \cdot lco \cdot (Nf - Ni) = 643.37 \cdot kip$

For inner bolts. nominal tearout strength at bolt holes $Rnti := 1.2 \cdot twsp \cdot Fu \cdot lci \cdot Ni = 0 \cdot kip$

Total nominal tearout strength at bolt holes $Rnt := Rnto + Rnti = 643.37 \cdot kip$

Overstrength factor $\Omega bt := 2$

Allowable tearout strength at bolt holes $Rrt := \frac{Rnt}{\Omega bt} = 321.68 \cdot kip$

Demand to Capacity Ratio

$$Checkth := \left| \begin{array}{ll} \frac{V_r}{Rrt} & \text{if } Rrt \geq V_r \\ \text{"Revise splice plate or bolts"} & \text{if } Rrt < V_r \end{array} \right. = 0.34$$

Slip Resistance Check, Eq. J3-4

For class A surfaces $\mu := 0.3$

$Du := 1.13$

Minimum bolt pretension, Table J3.1 for Group A, A325 bolts $Tb := 97kip$

$hf := 1$

Nominal slip resistance of bolts $Rsr := Nf \cdot Ns \cdot \mu \cdot Du \cdot Tb \cdot hf = 197.3 \cdot kip$

Overstrength Factor $\Omega sr := 1.5$

Allowable slip resistance of bolts $Rrslr := \frac{Rsr}{\Omega sr} = 131.53 \cdot kip$

GHD

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Demand to Capacity Ratio

$$\text{Checkslr} := \begin{vmatrix} \dfrac{V_r}{\text{Rrslr}} \ \text{ if } \ \text{Rrslr} \geq V_r \\ \text{"Revise bolts size"} \ \text{ if } \ \text{Rrslr} < V_r \end{vmatrix} = 0.82$$

Design Summary

Provide rectangular splice plate of 24"X8",1.25" thickness. On each side of web splice bolted plate connection, provide 6 - 1.375" dia HDG Group A - A325 bolts.

Analysis Demand Load on Waler - Sec C5, C3

Tie Rod Tension Demand Load from Analysis $T_{roda} := 105.2\text{kip}$

Tie Rod Spacing $S_{roda} := 6\text{ft}$

The tie rod spacing assumed in analysis results in large demand loads and section size for waler. To optimize section selection, tie rods will be closely spaced. Closely spaced tie rods will result in lower demand loads.

Revised Tie Rod Spacing $S_{rod} := 5\text{ft}$

Revised Tie Rod Tension Demand $T_{rod} := T_{roda} \cdot \frac{S_{rod}}{S_{roda}} = 87.67 \cdot \text{kip}$

Demand Load on waler $w_{dl} := \frac{T_{rod}}{S_{rod}} = 17.53 \cdot \frac{\text{kip}}{\text{ft}}$

Demand Load on Waler to safeguard against progressive failure

In certain situations, progressive collapse of the structure may be a conseequence of an extreme condition ie. failure of a tie rod. The wailing to the main wall will need to be checked to ensure that it will not collapse if the span between tie rods doubles following the loss of a tie rod.

SAP2000 analysis is used to calculate the bending moment and shear force demand on the waler for both the cases. Case 1 - without failure of a tie rod and, Case 2 - with failure of a tie rod.

For Case 1 - Continuous beam with four equal spans of length Srod is anaylzed
For Case 2 - Continuous beam with three spans of length Srod - 2Srod - Srod is analyzed

Waler Design is governed by the demands from Case 2

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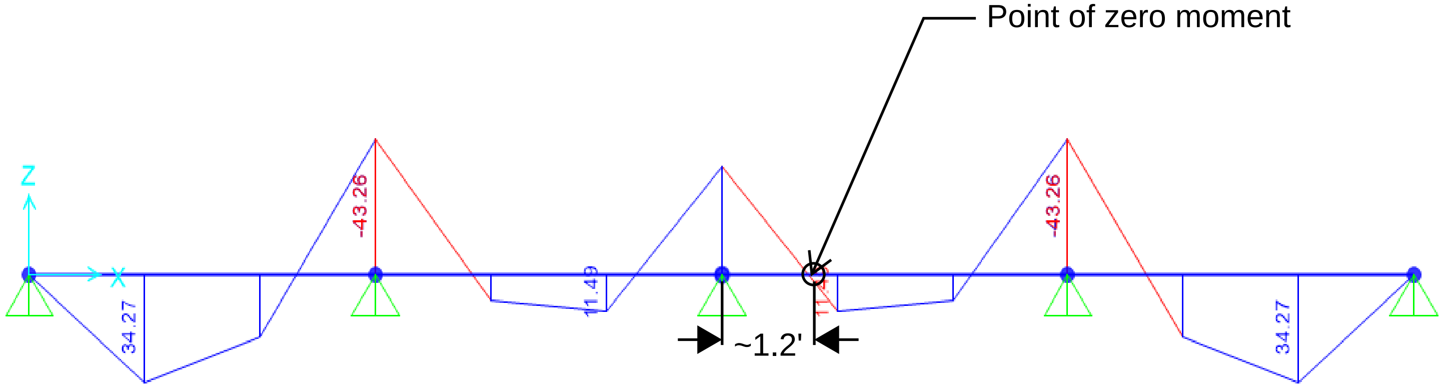
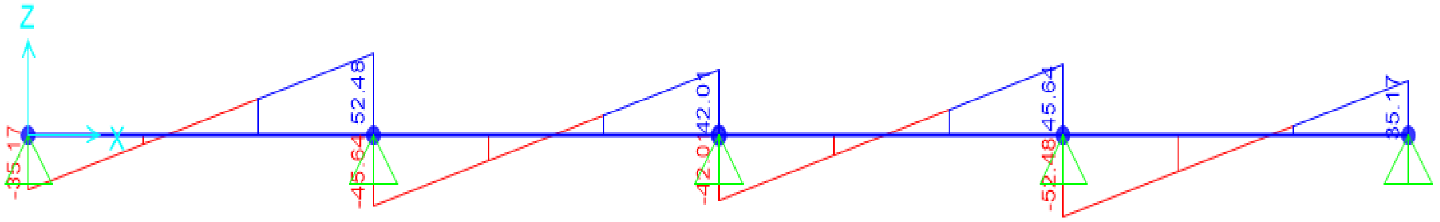
Bending Moment Diagram - Case 1



Bending Moment demand from SAP2000 - Mdsap = 43.26Kip-ft

Shear Force Diagram - Case 1



Shear Force demand from SAP2000 - Vdsap = 52.5Kip

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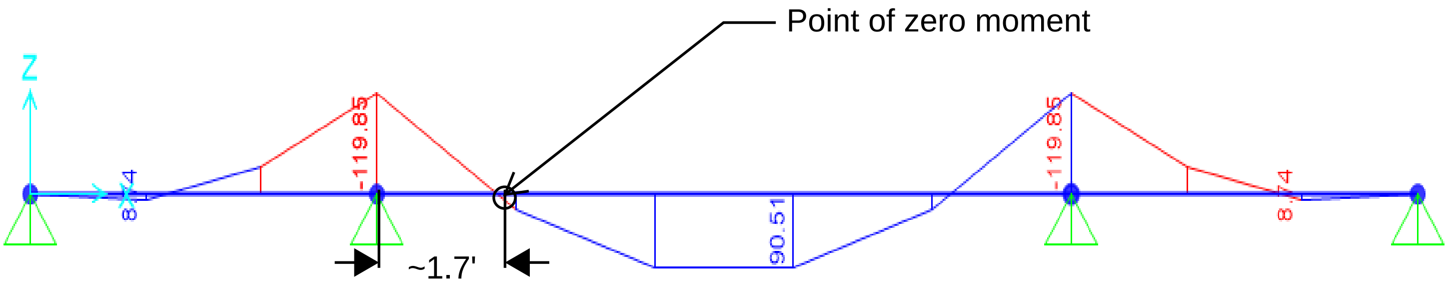
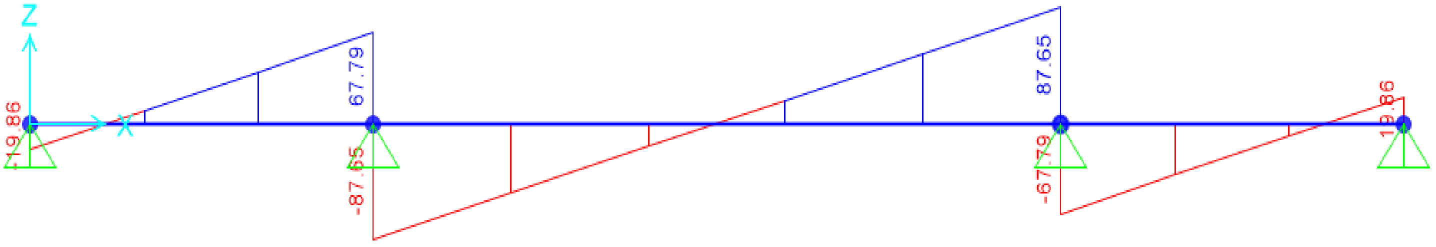
Bending Moment Diagram - Case 2



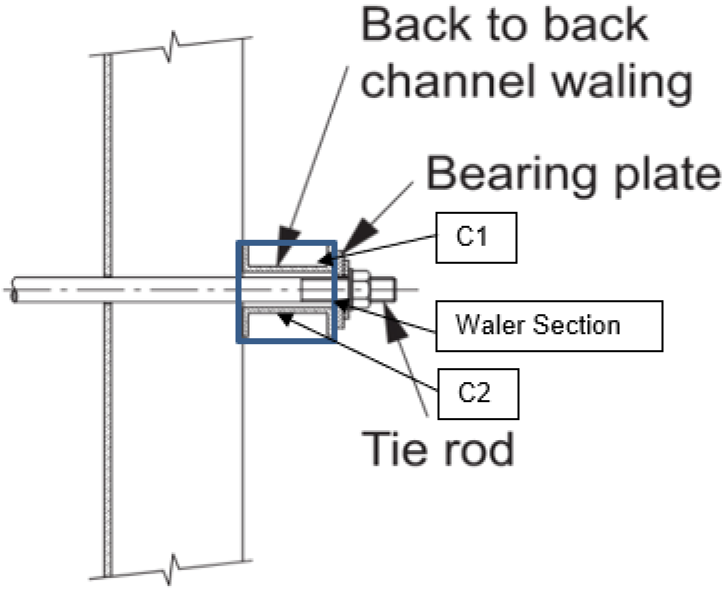
Bending Moment demand from SAP2000 - Mdsap = 119.85Kip-ft

Shear Force Diagram - Case 2



Shear Force demand from SAP2000 - Vdsap = 87.7Kip

Waler Cross-Section



Waler is made of two channel sections C1 and C2

Design of corroded waler section, AISC 360-16

Bending moment demand on waler from SAP2000 $M_{dsap} := 119.85\text{kip}\cdot\text{ft}$

Shear force demand on waler from SAP2000 $V_{dsap} := 87.7\cdot\text{kip}$

Bending moment demand on C1 or C2 $Md := \dfrac{M_{dsap}}{2} = 59.92\cdot\text{kip}\cdot\text{ft}$

Shear force demand on C1 or C2 $Vd := \dfrac{V_{dsap}}{2} = 43.85\cdot\text{kip}$

Steel yield stress	$Fy := 36ksi$	
Steel tensile stress	$Fu := 58ksi$	
Modulus of Elasticity of steel	$E := 29000ksi$	
Sacrificial thickness - for accounting corrosion	$tc := 0.0175in$	Refer Basis of Design report

Channel Section Dimensional Parameters (MC12X35)

Depth	$d := 12in$
Web thickness	$tw := 0.4375in$
Flange thickness	$tf := 0.6875in$
Flange width	$bf := 3.75in$
Distance	$k := 1.3125in$

Corroded Channel Section Dimensional Parameters (MC12X35)

Web thickness	$twc := tw - 2tc = 0.4 \cdot in$
Flange thickness	$tfc := tf - 2tc = 0.65 \cdot in$

Sectional Properties of Corroded Section

Plastic modulus about x axis

$$Zx := \left[(bf)\cdot\frac{(d)^2}{4}\right] - \left[[(bf)-(twc)]\cdot\frac{[(d)-[2\cdot(tfc)]]^2}{4}\right] = 39.28\cdot in^3$$

Elastic modulus about x axis

$$Sx := \frac{\left[\left[(bf)\cdot\frac{(d)^3}{12}\right] - \left[[(bf)-(twc)]\cdot\frac{[(d)-[2\cdot(tfc)]]^3}{12}\right]\right]}{(d)\cdot 0.5} = 33.12\cdot in^3$$

Torsion constant

$$J := \frac{\left[\left[2\cdot(bf)\cdot(tfc)^3\right] + \left[[(d)-(tfc)]\cdot(twc)^3\right]\right]}{3} = 0.94\cdot in^4$$

Moment of Inertia about external edge
of web parallel to y axis

$$Iyo := \left[[(d)-[2\cdot(tfc)]]\cdot\frac{(twc)^3}{3}\right] + \left[(bf)^3\cdot(tfc)\cdot\frac{2}{3}\right] = 23.17\cdot in^4$$

Cross sectional area

$$Ac := [2\cdot(bf)\cdot(tfc)] + [[(d)-[2\cdot(tfc)]]\cdot(twc)] = 9.2\cdot in^2$$

Distance of centroid from external edge of web

$$xc := \frac{\left[\left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^2}{2}\right] + \left[(bf)^2\cdot(tfc)\right]\right]}{Ac} = 1.09\cdot in$$

Moment of inertia about y axis $$Iy := Iyo - \left(Ac\cdot xc^2\right) = 12.21\cdot in^4$$

Distance between flange centroids $$ho := (d) - (tfc) = 11.35\cdot in$$

Warping torsional constant

$$Cw := \frac{\left[(tfc)\cdot(bf)^3\cdot[(d) - (tfc)]^2\right]\cdot[[3\cdot(bf)\cdot(tfc)] + [2\cdot(twc)\cdot[(d) - (tfc)]]]}{12\cdot[[6\cdot(bf)\cdot(tfc)] + [(twc)\cdot[(d) - (tfc)]]]}$$

$$Cw = 316.03\cdot in^6$$

radius of gyration about y axis $$ry := \sqrt{\frac{Iy}{Ac}} = 1.15\cdot in$$

Overstrength factor for flexure $$\Omega f := 1.67$$

Overstrength factor for shear $$\Omega v := 1.67$$

Classification of sections for local buckling - Section B4.1

Classification of flanges in flexure - Table B4.1b (case 10)

Width - to - Thickness Ratio for flange $$a_f := \frac{bf}{tfc} = 5.75$$

Limiting width to thickness ratio for compact flange section about major/minor axis

$$\lambda_{cf} := 0.38\cdot\sqrt{\frac{E}{Fy}} = 10.79$$

Limiting width to thickness ratio for non compact flange section about major/minor axis

$$\lambda_{nf} := 1\sqrt{\frac{E}{Fy}} = 28.38$$

Classification of web in flexure - Table B4.1b (case 15)

Width - to - Thickness Ratio for web

$$a_w := \frac{(d) - [2\cdot(k - 2tc)]}{twc} = 23.47$$

Limiting width to thickness ratio for compact web section about major/minor axis

$$\lambda_{cw} := 3.76\cdot\sqrt{\frac{E}{Fy}} = 106.72$$

Limiting width to thickness ratio for non compact web section about major/minor axis

$$\lambda_{nw} := 5.7\sqrt{\frac{E}{Fy}} = 161.78$$

$$cn_{ff} := \left|\begin{array}{l}\text{"Compact flange"} \quad \text{if } a_f \le \lambda_{cf} \\ \text{"Non compact flange"} \quad \text{if } \lambda_{cf} \le a_f \le \lambda_{nf} \\ \text{"Slender flange"} \quad \text{otherwise}\end{array}\right. = \text{"Compact flange"}$$

$$cn_{wf} := \left|\begin{array}{l}\text{"Compact web"} \quad \text{if } a_w \le \lambda_{cw} \\ \text{"Non compact web"} \quad \text{if } \lambda_{cw} \le a_w \le \lambda_{nw} \\ \text{"Slender flange web"} \quad \text{otherwise}\end{array}\right. = \text{"Compact web"}$$

Allowable Stress Shear Design - Chapter G

Web area

$$Aw := (d)\cdot(twc) = 4.83\cdot in^2$$

Web plate buckling coefficient

$$Kv := 5.34$$

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$$r := 1.1 \cdot \left(Kv \cdot \frac{E}{Fy}\right)^{\frac{1}{2}} = 72.15$$

$$r1 := \frac{(d) - [2 \cdot (tfc)]}{twc} = 26.57$$

Web shear coefficient, Eq G2-3 and Eq G2-4

$$Cv1 := \left| \begin{array}{ll} 1 & \text{if } r \geq r1 \\ \frac{r}{r1} & \text{if } r < r1 \end{array} \right.$$

$$Cv1 = 1$$

Nominal shear strength, Eq G2-1

$$Vn := 0.6 \cdot Cv1 \cdot Aw \cdot Fy = 104.33 \cdot kip$$

Allowable shear strength

$$vc := \frac{Vn}{\Omega v} = 62.47 \cdot kip$$

Check for shear strength

$$Checkvc := \left| \begin{array}{ll} \frac{Vd}{vc} & \text{if } vc \geq Vd \\ \text{"Revise waler section"} & \text{if } vc < Vd \end{array} \right.$$

$$Checkvc = 0.7$$

Allowable Stress Flexure design about major axis - Chapter F

Yielding - Section F2.1

Nominal flexural strength for yielding, Eq F2-1

$$Mnyld := Fy \cdot Zx = 117.83 \cdot kip \cdot ft$$

Lateral Torsional Buckling - Section F2.2

Unbraced length $Lb := S_{rod} \cdot 2 = 120 \cdot in$

Limiting unbraced length for yielding Eq F2-5 $Lp := 1.76 \cdot ry \cdot \sqrt{\frac{E}{Fy}} = 57.55 \cdot in$

Eq F2-8b $cf := \left(\frac{ho}{2}\right) \cdot \sqrt{\frac{Iy}{Cw}} = 1.12$

Eq F2-7 $rts := \sqrt{\frac{\sqrt{Iy \cdot Cw}}{Sx}} = 1.37 \cdot in$

Eq F2-6

$$Lr := 1.95 \cdot rts \cdot \frac{E \cdot \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right) + \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right)^2 + \left[6.76 \cdot \left(0.7 \cdot \frac{Fy}{E}\right)^2\right]}}}{(0.7 \cdot Fy)} = 245.54 \cdot in$$

From SAP2000 analysis, for calculation of Cb (Lp<Lb<=Lr)

Moment at quarter point of unbraced segment $Ma := 37.9 kip \cdot ft$

Moment at center line of unbraced segment $Mb := 90.5 kip \cdot ft$

Moment at three quarter point of unbraced segment $Mc := 37.9 kip \cdot ft$

Maximum moment in unbraced segment $Mabs := 119.85 kip \cdot ft$

Plastic moment capacity $Mp := Mnyld$

Lateral torsional buckling modification factor, Eq F1-1

$$Cb := 12.5 \cdot \frac{Mabs}{[(2.5 \cdot Mabs) + (3 \cdot Ma) + (4 \cdot Mb) + (3 \cdot Mc)]} = 1.69$$

Nominal flexural strength for lateral torsional buckling - Eq F2-2

$$Mnltb := Cb \cdot \left[Mp - (Mp - 0.7 \cdot Fy \cdot Sx) \cdot \frac{(Lb - Lp)}{(Lr - Lp)}\right]$$

$$Mnltb = 171.53 \cdot kip \cdot ft$$

Nominal flexural strength $Mn := \min(Mnyld, Mnltb) = 117.83 \cdot kip \cdot ft$

Design flexure strength $mc := \frac{Mn}{\Omega f} = 70.56 \cdot kip \cdot ft$

Check for flexural strength

$$Checkmc := \begin{cases} \frac{Md}{mc} & \text{if } mc \ge Md \\ \text{"Revise waler section"} & \text{if } mc < Md \end{cases}$$

$$Checkmc = 0.85$$

Deflection Check

Limiting Deflection $L_{ld} := \frac{Lb}{360} = 0.33 \cdot in$

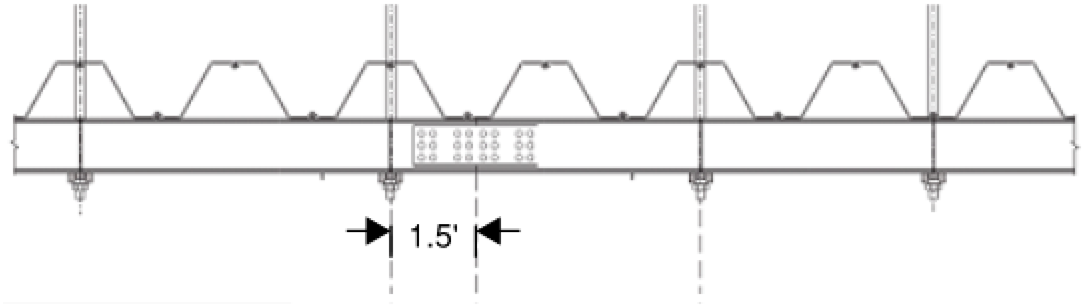
Maximum deflection from SAP2000 analysis $L_{md} := 0.21in$

Demand to Capacity Ratio

$$\mathrm{Check_d} := \left|\begin{array}{l} \dfrac{L_{md}}{L_{ld}} \quad \text{if } L_{ld} \ge L_{md} \\ \text{"Revise unbraced length"} \quad \text{if } L_{ld} < L_{md} \end{array}\right.$$

$$\mathrm{Check_d} = 0.63$$

Bolted Splice Plate Connection Design for Waler, Allowable Stress Design - AISC 360-16



From SAP2000 analysis, point of zero moment in typical span for case 1 is ~1.2' and for case 2 is ~1.7' from tie rod anchorage. Point of splice connection for design is 1.5' from tie rod anchorage.

Resultant Web Force at Point of Splice Connection

Bending moment demand at point of splice, from SAP2000 analysis

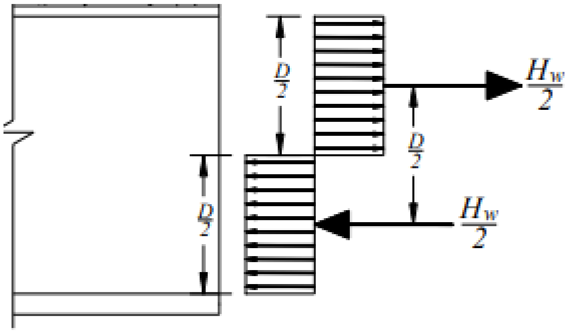
$$\mathrm{Msd} := 14.7\mathrm{kip}\cdot\mathrm{ft}$$

Horizontal force in web due to moment at point of splice

$$H_w := \frac{\mathrm{Msd}\cdot 4}{[d - [2\cdot(k - 2tc)]]} = 74.71\cdot\mathrm{kip}$$

Resultant web force at point of splice connection

$$V_r := \sqrt{Vd^2 + H_w^{\ 2}} = 86.62\cdot\mathrm{kip}$$

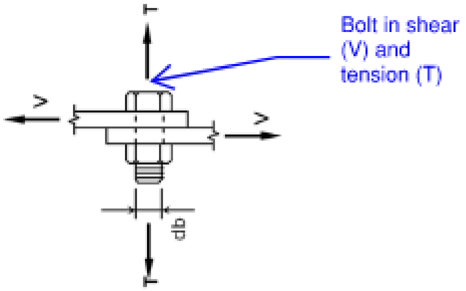


$$Web\ Moment = \frac{Hw}{2}\left(\frac{D}{2}\right)$$

$$H_w = \frac{Web\ Moment}{D/4}$$

Factored shear resistance of bolts in shear

No of shear planes $Ns := 1$



Section J3, Table J3.2

Using HDG Group A, A325 bolts

Nominal shear stress when threads are not excluded from shear planes $Fnv := 54ksi$

Taking 1.25" nominal diameter bolt

Bolt nominal diameter $db := 1.25in$

Nominal unthreaded body area of bolt $Ab := 3.14 \cdot (db)^2 \cdot 0.25 = 1.23 \cdot in^2$

Nominal shear strength of bolt $Rn := Fnv \cdot Ab \cdot Ns = 66.23 \cdot kip$

Overstrength factor $\Omega b := 2$

Allowable shear strength of bolt $Rr := \frac{Rn}{\Omega b} = 33.12 \cdot kip$

No of bolts required on each side of the web splice $Nb := \frac{V_r}{Rr} = 2.62$

No of bolts provided on each side of the web splice $Nf := 6$

No of bolt columns in connection pattern along the length of splice plate $Nr := 3$

Bolt Connection Pattern

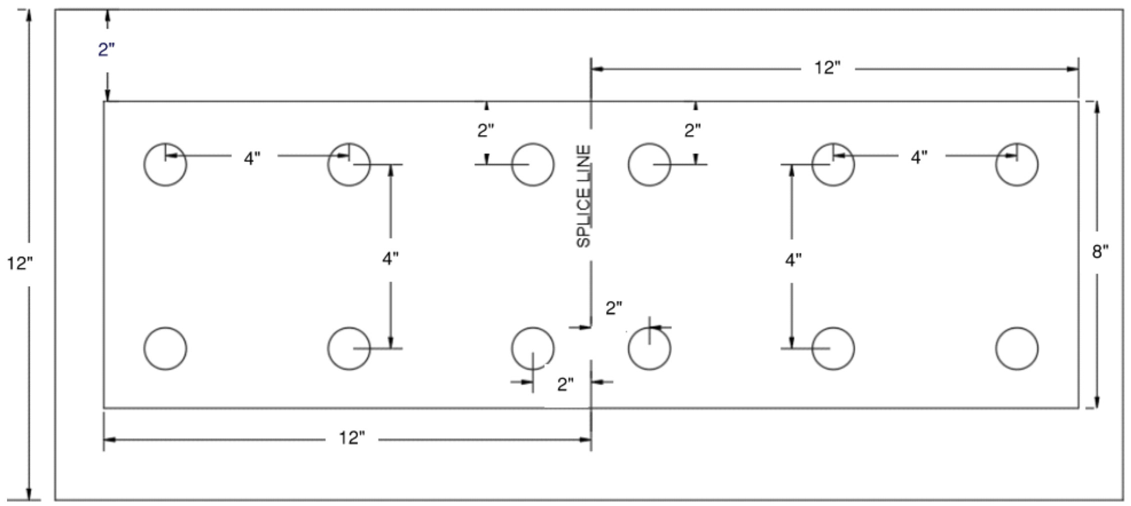


Table J3.3, for 1.25" bolt dia, standard hole dia is 1.375"

Hole diameter $dbh := 1.375in$

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Minimum center to center spacing allowed b/w holes, Sec J3.3

$$Smin := \frac{8\cdot(db)}{3} = 3.33\cdot in$$

Minimum clear spacing allowed b/w holes, Sec J3.3

$$Scmin := db = 1.25\cdot in$$

Table J3.4, minimum edge distance allowed for 1.25" bolt dia

$$Semin := 1.625in$$

Providing a splice plate of 24"X8", 0.75" thickness for the connection

No of splice plates in the connection

$$Nsp := 1$$

Eq. J4-3 and J4-4, strength of elements in shear

Depth of splice plate

$$dsp := 8in$$

Thickness of splice plate

$$Twsp := 0.75in$$

Reduced thickness of splice plate - for accounting corrosion

$$twsp := Twsp - tc = 0.73\cdot in$$

Gross area subject to shear

$$Agv := dsp\cdot twsp = 5.86\cdot in^2$$

Nominal shear yielding strength

$$Rnsy := 0.6\cdot Fy\cdot Agv\cdot Nsp = 126.58\cdot kip$$

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Overstrength factor

$$\Omega spsy := 1.5$$

Allowable shear yielding strength

$$Rrsy := \frac{Rnsy}{\Omega spsy} = 84.38 \cdot kip$$

Demand to Capacity Ratio

$$Checksy := \left| \begin{array}{ll} \frac{Vd}{Rrsy} & \text{if } Rrsy \geq Vd \\ \text{"Revise splice plate"} & \text{if } Rrsy < Vd \end{array} \right.$$

$$Checksy = 0.52$$

Net area subject to shear

$$Anv := \left[dsp - \left(Nf \cdot \frac{dbh}{Nr} \right) \right] \cdot twsp = 3.85 \cdot in^2$$

Nominal shear rupture strength

$$Rnsr := 0.6 \cdot Fu \cdot Anv \cdot Nsp = 133.83 \cdot kip$$

Overstrength factor

$$\Omega spsr := 2$$

Allowable shear rupture strength

$$Rrsr := \frac{Rnsr}{\Omega spsr} = 66.91 \cdot kip$$

Demand to Capacity ratio

$$Checksr := \left| \begin{array}{ll} \frac{Vd}{Rrsr} & \text{if } Rrsr \geq Vd \\ \text{"Revise splice plate"} & \text{if } Rrsr < Vd \end{array} \right.$$

$$Checksr = 0.66$$

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Maximum spacing and edge distance - Section J3-5

Maximum edge distance

$$\mathrm{Semax} := \begin{vmatrix} 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) \ \text{ if } \ 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 6\mathrm{in} \\ 6\mathrm{in} \ \text{ if } \ 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 6\mathrm{in} \end{vmatrix} = 5.25\cdot\mathrm{in}$$

Maximum center to center longitudinal spacing allowed b/w holes

$$\mathrm{Smax} := \begin{vmatrix} 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) \ \text{ if } \ 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 12\mathrm{in} \\ 12\mathrm{in} \ \text{ if } \ 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 12\mathrm{in} \end{vmatrix} = 10.5\cdot\mathrm{in}$$

Distance of bolt from splice plate edge $\mathrm{Seprov} := 2\mathrm{in}$

Distance of bolt from channel section flange inner edge

$$\mathrm{Sepprov} := \mathrm{Seprov} + [(\mathrm{d} - \mathrm{dsp})\cdot 0.5 - \mathrm{k}] = 2.69\cdot\mathrm{in}$$

Spacing provided between bolts $\mathrm{Sprov} := 4\mathrm{in}$

Check for bolt edge distance provided

$$\mathrm{Secheck} := \begin{vmatrix} \text{"Okay"} \ \text{ if } \ \mathrm{Semin} \le \max(\mathrm{Sepprov},\mathrm{Seprov}) \le \mathrm{Semax} \\ \text{"Not Okay"} \ \text{ otherwise} \end{vmatrix} = \text{"Okay"}$$

Check for spacing provided between bolts

$$\mathrm{Scheck} := \begin{vmatrix} \text{"Okay"} \ \text{ if } \ (\max(\mathrm{Smin},\mathrm{Scmin} + \mathrm{dbh}) \le \mathrm{Sprov} \le \mathrm{Smax}) \\ \text{"Not Okay"} \ \text{ otherwise} \end{vmatrix} = \text{"Okay"}$$

Block Shear Rupture Check, Eq. J4-5

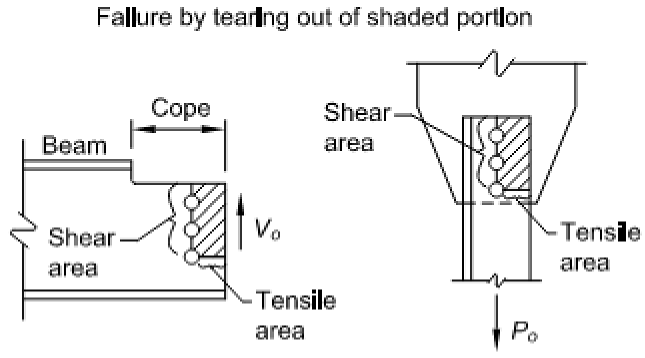
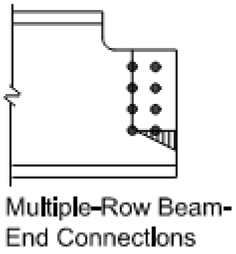


Fig. C-J4.1. Failure surface for block shear rupture limit state.



(b) Cases for which $U_{bs} = 0.5$

No of bolts in the outermost edge of the connection pattern which is in tension

$$Nbr := 3$$

Net Area resisting the tensile stress

$$Ant := Nsp \cdot [Seprov + (Nbr - 1)Sprov - [dbh \cdot (Nbr - 0.5)]] \cdot twsp = 4.81 \cdot in^2$$

Net Area resisting the shear stress

$$Avn := Nsp \cdot \left[dsp - Seprov - \left[\left[\left(\frac{Nf}{Nr} \right) - 0.5 \right] \cdot dbh \right] \right] \cdot twsp = 2.88 \cdot in^2$$

Gross area resisting the shear stress

$$Avg := Nsp \cdot (dsp - Seprov) \cdot twsp = 4.39 \cdot in^2$$

Nominal block shear strength

$$Ubs := 0.5$$

$$Rbs := [(0.6 \cdot Fu \cdot Avn) + (Ubs \cdot Fu \cdot Ant)] = 239.77 \cdot kip$$

$$Rnbs := \begin{cases} Rbs & \text{if } Rbs \le [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] \\ [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] & \text{if } Rbs > [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] \end{cases} = 234.34 \cdot kip$$

Overstrength Factor $\Omega bs := 2$

Allowable block shear strength $Rrbs := \frac{Rnbs}{\Omega bs} = 117.17 \cdot kip$

Demand to Capacity Ratio

$$Checkbs := \begin{cases} \frac{Vd}{Rrbs} & \text{if } Rrbs \ge Vd \\ \text{"Revise splice plate"} & \text{if } Rrbs < Vd \end{cases}$$

$Checkbs = 0.37$

Bearing Resistance Check, Eq. J3-6a

Nominal bearing strength at bolt holes $Rnb := 2.4 \cdot (db) \cdot twsp \cdot Fu \cdot Nf = 764.73 \cdot kip$

Overstrength Factor $\Omega bh := 2$

Allowable bearing strength at bolt holes $Rrb := \frac{Rnb}{\Omega bh} = 382.36 \cdot kip$

Demand to Capacity Ratio

$$Checkbh := \begin{cases} \frac{V_r}{Rrb} & \text{if } Rrb \ge V_r \\ \text{"Revise splice plate or bolts"} & \text{if } Rrb < V_r \end{cases} = 0.23$$

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Tearout Resistance Check, Eq. J3-6c

lc for edge bolts

$$\mathrm{lco} := \mathrm{Seprov} - \left(\frac{\mathrm{dbh}}{2}\right) = 1.31\cdot\mathrm{in}$$

lc for inner bolts

$$\mathrm{lci} := \mathrm{Sprov} - \mathrm{dbh} = 2.63\cdot\mathrm{in}$$

Inner bolts on each side of splice

$$\mathrm{Ni} := 0$$

For edge bolts, nominal tearout strength at bolt holes

$$\mathrm{Rnto} := 1.2\cdot\mathrm{twsp}\cdot\mathrm{Fu}\cdot\mathrm{lco}\cdot(\mathrm{Nf} - \mathrm{Ni}) = 401.48\cdot\mathrm{kip}$$

For inner bolts. nominal tearout strength at bolt holes

$$\mathrm{Rnti} := 1.2\cdot\mathrm{twsp}\cdot\mathrm{Fu}\cdot\mathrm{lci}\cdot\mathrm{Ni} = 0\cdot\mathrm{kip}$$

Total nominal tearout strength at bolt holes

$$\mathrm{Rnt} := \mathrm{Rnto} + \mathrm{Rnti} = 401.48\cdot\mathrm{kip}$$

Overstrength factor

$$\Omega\mathrm{bt} := 2$$

Allowable tearout strength at bolt holes

$$\mathrm{Rrt} := \frac{\mathrm{Rnt}}{\Omega\mathrm{bt}} = 200.74\cdot\mathrm{kip}$$

Demand to Capacity Ratio

$$\mathrm{Checkth} := \left|\begin{array}{ll} \dfrac{V_r}{\mathrm{Rrt}} & \text{if } \mathrm{Rrt} \ge V_r \\ \text{"Revise splice plate or bolts"} & \text{if } \mathrm{Rrt} < V_r \end{array}\right. = 0.43$$

GHD

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Slip Resistance Check, Eq. J3-4

For class A surfaces $\mu := 0.3$

$Du := 1.13$

Minimum bolt pretension, Table J3.1 for Group A, A325 bolts $Tb := 81\text{kip}$

$hf := 1$

Nominal slip resistance of bolts $Rsr := Nf \cdot Ns \cdot \mu \cdot Du \cdot Tb \cdot hf = 164.75 \cdot \text{kip}$

Overstrength Factor $\Omega sr := 1.5$

Allowable slip resistance of bolts $Rrslr := \dfrac{Rsr}{\Omega sr} = 109.84 \cdot \text{kip}$

Demand to Capacity Ratio

$$Checkslr := \begin{vmatrix} \dfrac{V_r}{Rrslr} \text{ if } Rrslr \ge V_r \\ \text{"Revise bolts size"} \text{ if } Rrslr < V_r \end{vmatrix} = 0.79$$

Design Summary

Provide rectangular splice plate of 24"X8",0.75" thickness. On each side of web splice bolted plate connection, provide 6 - 1.25" dia HDG Group A - A325 bolts.

Analysis Demand Load on Waler - Sec C4

Tie Rod Tension Demand Load from Analysis $T_{roda} := 122.98\text{kip}$

Tie Rod Spacing $S_{roda} := 8\text{ft}$

The tie rod spacing assumed in analysis results in large demand loads and section size for waler. To optimize section selection, tie rods will be closely spaced. Closely spaced tie rods will result in lower demand loads.

Revised Tie Rod Spacing $S_{rod} := 5\text{ft}$

Revised Tie Rod Tension Demand $T_{rod} := T_{roda} \cdot \frac{S_{rod}}{S_{roda}} = 76.86 \cdot \text{kip}$

Demand Load on waler $w_{dl} := \frac{T_{rod}}{S_{rod}} = 15.37 \cdot \frac{\text{kip}}{\text{ft}}$

Demand Load on Waler to safeguard against progressive failure

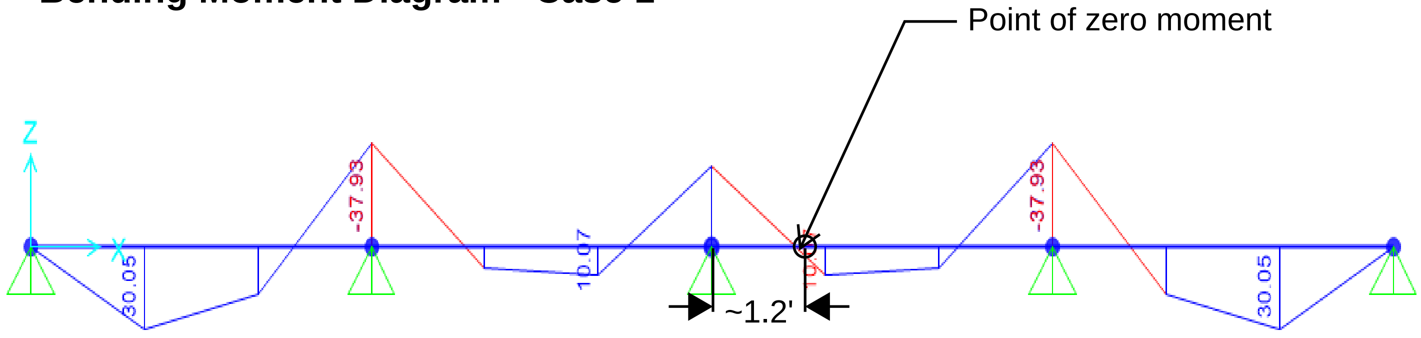
In certain situations, progressive collapse of the structure may be a conseequence of an extreme condition ie. failure of a tie rod. The wailing to the main wall will need to be checked to ensure that it will not collapse if the span between tie rods doubles following the loss of a tie rod.

SAP2000 analysis is used to calculate the bending moment and shear force demand on the waler for both the cases. Case 1 - without failure of a tie rod and, Case 2 - with failure of a tie rod.

For Case 1 - Continuous beam with four equal spans of length Srod is anaylzed
For Case 2 - Continuous beam with three spans of length Srod - 2Srod - Srod is analyzed

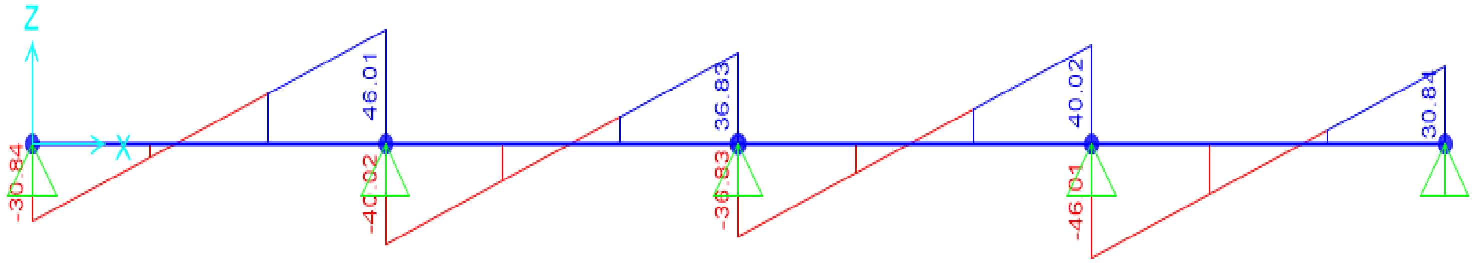
Waler Design is governed by the demands from Case 2

Bending Moment Diagram - Case 1



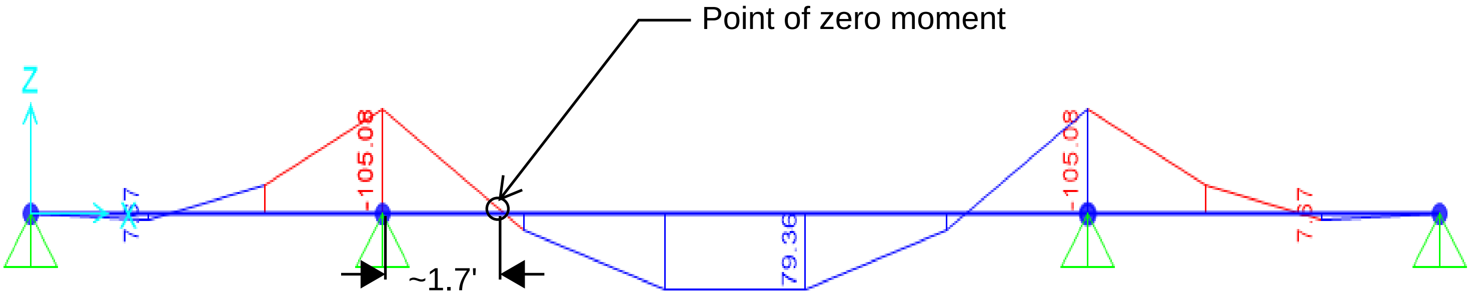
Bending Moment demand from SAP2000 - Mdsap = 37.93Kip-ft

Shear Force Diagram - Case 1



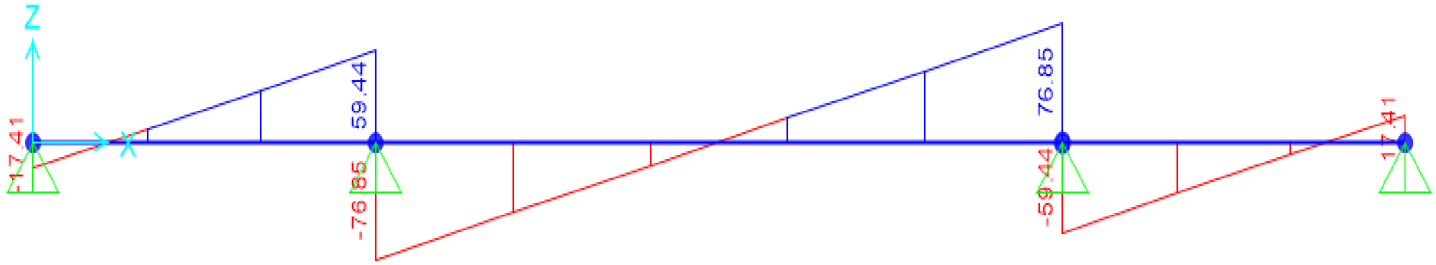
Shear Force demand from SAP2000 - Vdsap = 46.01Kip

Bending Moment Diagram - Case 2



Bending Moment demand from SAP2000 - Mdsap = 105.1Kip-ft

Shear Force Diagram - Case 2



Shear Force demand from SAP2000 - Vdsap = 76.9Kip

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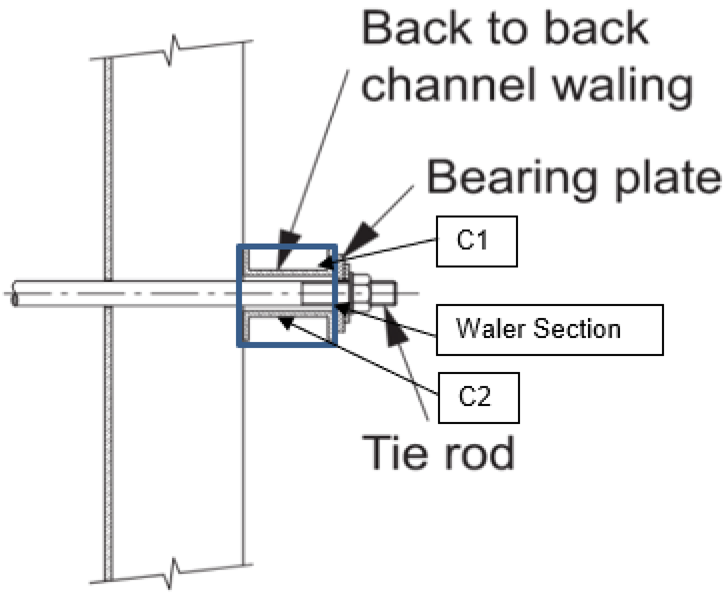
Waler Cross-Section



Waler is made of two channel sections C1 and C2

Design of corroded waler section, AISC 360-16

Bending moment demand on waler from SAP2000 $M_{dsap} := 105.1 kip \cdot ft$

Shear force demand on waler from SAP2000 $V_{dsap} := 76.9 \cdot kip$

Bending moment demand on C1 or C2 $Md := \dfrac{M_{dsap}}{2} = 52.55 \cdot kip \cdot ft$

Shear force demand on C1 or C2 $Vd := \dfrac{V_{dsap}}{2} = 38.45 \cdot kip$

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Steel yield stress	$Fy := 36\mathrm{ksi}$	
Steel tensile stress	$Fu := 58\mathrm{ksi}$	
Modulus of Elasticity of steel	$E := 29000\mathrm{ksi}$	
Sacrificial thickness - for accounting corrosion	$tc := 0.0175\mathrm{in}$	Refer Basis of Design report

Channel Section Dimensional Parameters (MC12X35)

Depth	$d := 12\mathrm{in}$
Web thickness	$tw := 0.4375\mathrm{in}$
Flange thickness	$tf := 0.6875\mathrm{in}$
Flange width	$bf := 3.75\mathrm{in}$
Distance	$k := 1.3125\mathrm{in}$

Corroded Channel Section Dimensional Parameters (MC12X35)

Web thickness	$twc := tw - 2tc = 0.4\cdot\mathrm{in}$
Flange thickness	$tfc := tf - 2tc = 0.65\cdot\mathrm{in}$

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Sectional Properties of Corroded Section

Plastic modulus about x axis

$$Zx := \left[(bf)\cdot\frac{(d)^2}{4}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^2}{4}\right] = 39.28\cdot in^3$$

Elastic modulus about x axis

$$Sx := \frac{\left[\left[(bf)\cdot\frac{(d)^3}{12}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^3}{12}\right]\right]}{(d)\cdot 0.5} = 33.12\cdot in^3$$

Torsion constant

$$J := \frac{\left[\left[2\cdot(bf)\cdot(tfc)^3\right] + \left[[(d) - (tfc)]\cdot(twc)^3\right]\right]}{3} = 0.94\cdot in^4$$

Moment of Inertia about external edge
of web parallel to y axis

$$Iyo := \left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^3}{3}\right] + \left[(bf)^3\cdot(tfc)\cdot\frac{2}{3}\right] = 23.17\cdot in^4$$

Cross sectional area

$$Ac := [2\cdot(bf)\cdot(tfc)] + [[(d) - [2\cdot(tfc)]]\cdot(twc)] = 9.2\cdot in^2$$

Distance of centroid from external edge of web

$$xc := \frac{\left[\left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^2}{2}\right] + \left[(bf)^2\cdot(tfc)\right]\right]}{Ac} = 1.09\cdot in$$

Moment of inertia about y axis

$$Iy := Iyo - \left(Ac\cdot xc^2\right) = 12.21\cdot in^4$$

Distance between flange centroids

$$ho := (d) - (tfc) = 11.35\cdot in$$

Warping torsional constant

$$Cw := \frac{\left[(tfc)\cdot(bf)^3\cdot[(d) - (tfc)]^2\right]\cdot[[3\cdot(bf)\cdot(tfc)] + [2\cdot(twc)\cdot[(d) - (tfc)]]]}{12\cdot[[6\cdot(bf)\cdot(tfc)] + [(twc)\cdot[(d) - (tfc)]]]}$$

$$Cw = 316.03\cdot in^6$$

radius of gyration about y axis

$$ry := \sqrt{\frac{Iy}{Ac}} = 1.15\cdot in$$

Overstrength factor for flexure

$$\Omega f := 1.67$$

Overstrength factor for shear

$$\Omega v := 1.67$$

Classification of sections for local buckling - Section B4.1

Classification of flanges in flexure - Table B4.1b (case 10)

Width - to - Thickness Ratio for flange

$$a_f := \frac{bf}{tfc} = 5.75$$

Limiting width to thickness ratio for compact flange section about major/minor axis

$$\lambda_{cf} := 0.38 \cdot \sqrt{\frac{E}{Fy}} = 10.79$$

Limiting width to thickness ratio for non compact flange section about major/minor axis

$$\lambda_{nf} := 1 \sqrt{\frac{E}{Fy}} = 28.38$$

Classification of web in flexure - Table B4.1b (case 15)

Width - to - Thickness Ratio for web

$$a_w := \frac{(d) - [2 \cdot (k - 2tc)]}{twc} = 23.47$$

Limiting width to thickness ratio for compact web section about major/minor axis

$$\lambda_{cw} := 3.76 \cdot \sqrt{\frac{E}{Fy}} = 106.72$$

Limiting width to thickness ratio for non compact web section about major/minor axis

$$\lambda_{nw} := 5.7 \sqrt{\frac{E}{Fy}} = 161.78$$

$$cn_{ff} := \left| \begin{array}{l} \text{"Compact flange"} \quad \text{if } a_f \le \lambda_{cf} \\ \text{"Non compact flange"} \quad \text{if } \lambda_{cf} \le a_f \le \lambda_{nf} \\ \text{"Slender flange"} \quad \text{otherwise} \end{array} \right. = \text{"Compact flange"}$$

$$cn_{wf} := \left| \begin{array}{l} \text{"Compact web"} \quad \text{if } a_w \le \lambda_{cw} \\ \text{"Non compact web"} \quad \text{if } \lambda_{cw} \le a_w \le \lambda_{nw} \\ \text{"Slender flange web"} \quad \text{otherwise} \end{array} \right. = \text{"Compact web"}$$

Allowable Stress Shear Design - Chapter G

Web area

$$Aw := (d) \cdot (twc) = 4.83 \cdot in^2$$

Web plate buckling coefficient

$$Kv := 5.34$$

$$r := 1.1\cdot\left(Kv\cdot\frac{E}{Fy}\right)^{\frac{1}{2}} = 72.15$$

$$r1 := \frac{(d) - [2\cdot(tfc)]}{twc} = 26.57$$

Web shear coefficient, Eq G2-3 and Eq G2-4

$$Cv1 := \left| \begin{array}{ll} 1 & \text{if } r \geq r1 \\ \frac{r}{r1} & \text{if } r < r1 \end{array} \right.$$

$$Cv1 = 1$$

Nominal shear strength, Eq G2-1

$$Vn := 0.6\cdot Cv1\cdot Aw\cdot Fy = 104.33\cdot kip$$

Allowable shear strength

$$vc := \frac{Vn}{\Omega v} = 62.47\cdot kip$$

Check for shear strength

$$Checkvc := \left| \begin{array}{ll} \frac{Vd}{vc} & \text{if } vc \geq Vd \\ \text{"Revise waler section"} & \text{if } vc < Vd \end{array} \right.$$

$$Checkvc = 0.62$$

Allowable Stress Flexure design about major axis - Chapter F

Yielding - Section F2.1

Nominal flexural strength for yielding, Eq F2-1

$$Mnyld := Fy\cdot Zx = 117.83\cdot kip\cdot ft$$

Lateral Torsional Buckling - Section F2.2

Unbraced length $Lb := S_{rod} \cdot 2 = 120 \cdot in$

Limiting unbraced length for yielding Eq F2-5 $Lp := 1.76 \cdot ry \cdot \sqrt{\frac{E}{Fy}} = 57.55 \cdot in$

Eq F2-8b $cf := \left(\frac{ho}{2}\right) \cdot \sqrt{\frac{Iy}{Cw}} = 1.12$

Eq F2-7 $rts := \sqrt{\frac{\sqrt{Iy \cdot Cw}}{Sx}} = 1.37 \cdot in$

Eq F2-6

$$Lr := 1.95 \cdot rts \cdot \frac{E \cdot \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right) + \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right)^2 + \left[6.76 \cdot \left(0.7 \cdot \frac{Fy}{E}\right)^2\right]}}}{(0.7 \cdot Fy)} = 245.54 \cdot in$$

From SAP2000 analysis, for calculation of Cb (Lp<Lb<=Lr)

Moment at quarter point of unbraced segment $Ma := 33.3 kip \cdot ft$

Moment at center line of unbraced segment $Mb := 79.4 kip \cdot ft$

Moment at three quarter point of unbraced segment $Mc := 33.3 kip \cdot ft$

Maximum moment in unbraced segment $Mabs := 105.1 kip \cdot ft$

Plastic moment capacity $\mathrm{Mp} := \mathrm{Mnyld}$

Lateral torsional buckling modification factor, Eq F1-1

$$\mathrm{Cb} := 12.5 \cdot \frac{\mathrm{Mabs}}{[(2.5 \cdot \mathrm{Mabs}) + (3 \cdot \mathrm{Ma}) + (4 \cdot \mathrm{Mb}) + (3 \cdot \mathrm{Mc})]} = 1.68$$

Nominal flexural strength for lateral torsional buckling - Eq F2-2

$$\mathrm{Mnltb} := \mathrm{Cb} \cdot \left[\mathrm{Mp} - (\mathrm{Mp} - 0.7 \cdot \mathrm{Fy} \cdot \mathrm{Sx}) \cdot \frac{(\mathrm{Lb} - \mathrm{Lp})}{(\mathrm{Lr} - \mathrm{Lp})}\right]$$

$$\mathrm{Mnltb} = 171.42 \cdot \mathrm{kip} \cdot \mathrm{ft}$$

Nominal flexural strength $\mathrm{Mn} := \min(\mathrm{Mnyld}, \mathrm{Mnltb}) = 117.83 \cdot \mathrm{kip} \cdot \mathrm{ft}$

Design flexure strength $\mathrm{mc} := \frac{\mathrm{Mn}}{\Omega \mathrm{f}} = 70.56 \cdot \mathrm{kip} \cdot \mathrm{ft}$

Check for flexural strength

$$\mathrm{Checkmc} := \left| \begin{array}{ll} \frac{\mathrm{Md}}{\mathrm{mc}} & \text{if } \mathrm{mc} \geq \mathrm{Md} \\ \text{"Revise waler section"} & \text{if } \mathrm{mc} < \mathrm{Md} \end{array} \right.$$

$$\mathrm{Checkmc} = 0.74$$

Deflection Check

Limiting Deflection $L_{ld} := \frac{\mathrm{Lb}}{360} = 0.33 \cdot \mathrm{in}$

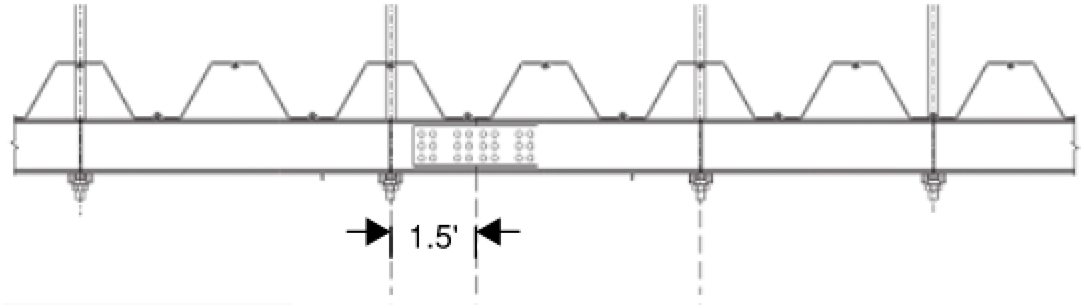
Maximum deflection from SAP2000 analysis $L_{md} := 0.19\text{in}$

Demand to Capacity Ratio

$$\text{Check}_d := \begin{cases} \dfrac{L_{md}}{L_{ld}} & \text{if } L_{ld} \geq L_{md} \\ \text{"Revise unbraced length"} & \text{if } L_{ld} < L_{md} \end{cases}$$

$$\text{Check}_d = 0.57$$

Bolted Splice Plate Connection Design for Waler, Allowable Stress Design - AISC 360-16



From SAP2000 analysis, point of zero moment in typical span for case 1 is ~1.2' and for case 2 is ~1.7' from tie rod anchorage. Point of splice connection for design is 1.5' from tie rod anchorage.

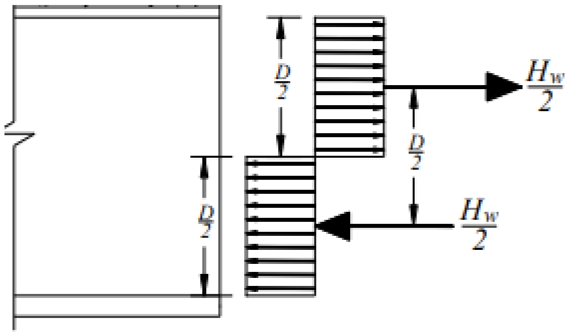
Resultant Web Force at Point of Splice Connection

Bending moment demand at point of splice, from SAP2000 analysis $\text{Msd} := 12.9\text{kip}\cdot\text{ft}$

Horizontal force in web due to moment at point of splice

$$H_w := \frac{\text{Msd}\cdot 4}{[d - [2\cdot(k - 2tc)]]} = 65.56\cdot\text{kip}$$

Resultant web force at point of splice connection $V_r := \sqrt{Vd^2 + H_w^2} = 76 \cdot kip$

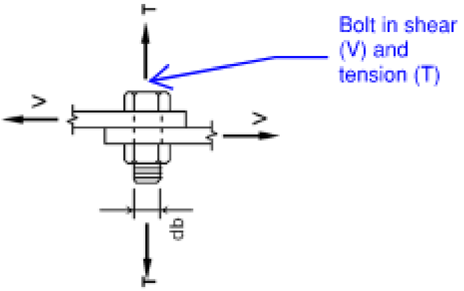


$$Web\ Moment = \frac{Hw}{2}\left(\frac{D}{2}\right)$$

$$H_w = \frac{Web\ Moment}{D/4}$$

Factored shear resistance of bolts in shear

No of shear planes $Ns := 1$



Bolt in shear (V) and tension (T)

Section J3, Table J3.2

Using HDG Group A, A325 bolts

Nominal shear stress when threads are not excluded from shear planes $Fnv := 54ksi$

Taking 1.25" nominal diameter bolt

Bolt nominal diameter $db := 1.25in$

Nominal unthreaded body area of bolt $Ab := 3.14 \cdot (db)^2 \cdot 0.25 = 1.23 \cdot in^2$

Nominal shear strength of bolt

$$Rn := Fnv \cdot Ab \cdot Ns = 66.23 \cdot kip$$

Overstrength factor

$$\Omega b := 2$$

Allowable shear strength of bolt

$$Rr := \frac{Rn}{\Omega b} = 33.12 \cdot kip$$

No of bolts required on each side of the web splice

$$Nb := \frac{V_r}{Rr} = 2.29$$

No of bolts provided on each side of the web splice

$$Nf := 6$$

No of bolt columns in connection pattern along the length of splice plate

$$Nr := 3$$

Bolt Connection Pattern

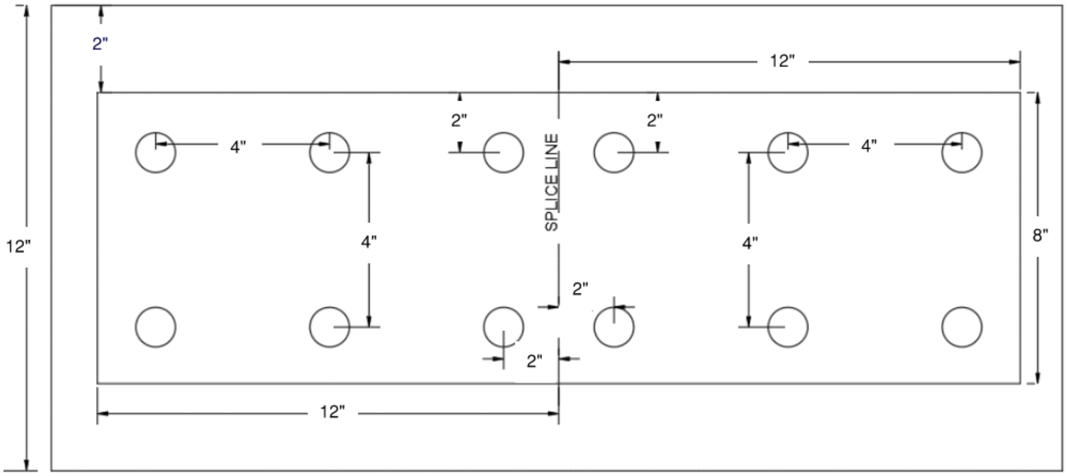


Table J3.3, for 1.25" bolt dia, standard hole dia is 1.375"

Hole diameter

$$dbh := 1.375in$$

Minimum center to center spacing allowed b/w holes, Sec J3.3

$$Smin := \frac{8\cdot(db)}{3} = 3.33\cdot in$$

Minimum clear spacing allowed b/w holes, Sec J3.3

$$Scmin := db = 1.25\cdot in$$

Table J3.4, minimum edge distance allowed for 1.25" bolt dia

$$Semin := 1.625in$$

Providing a splice plate of 24"X8", 0.75" thickness for the connection

No of splice plates in the connection

$$Nsp := 1$$

Eq. J4-3 and J4-4, strength of elements in shear

Depth of splice plate

$$dsp := 8in$$

Thickness of splice plate

$$Twsp := 0.75in$$

Reduced thickness of splice plate - for accounting corrosion

$$twsp := Twsp - tc = 0.73\cdot in$$

Gross area subject to shear

$$Agv := dsp\cdot twsp = 5.86\cdot in^2$$

Nominal shear yielding strength

$$Rnsy := 0.6\cdot Fy\cdot Agv\cdot Nsp = 126.58\cdot kip$$

Overstrength factor

$$\Omega spsy := 1.5$$

Allowable shear yielding strength

$$\text{Rrsy} := \frac{\text{Rnsy}}{\Omega\text{spsy}} = 84.38\cdot\text{kip}$$

Demand to Capacity Ratio

$$\text{Checksy} := \left| \begin{array}{ll} \dfrac{\text{Vd}}{\text{Rrsy}} & \text{if Rrsy} \geq \text{Vd} \\ \text{"Revise splice plate"} & \text{if Rrsy} < \text{Vd} \end{array} \right.$$

$$\text{Checksy} = 0.46$$

Net area subject to shear

$$\text{Anv} := \left[\text{dsp} - \left(\text{Nf}\cdot\frac{\text{dbh}}{\text{Nr}}\right)\right]\cdot\text{twsp} = 3.85\cdot\text{in}^2$$

Nominal shear rupture strength

$$\text{Rnsr} := 0.6\cdot\text{Fu}\cdot\text{Anv}\cdot\text{Nsp} = 133.83\cdot\text{kip}$$

Overstrength factor

$$\Omega\text{spsr} := 2$$

Allowable shear rupture strength

$$\text{Rrsr} := \frac{\text{Rnsr}}{\Omega\text{spsr}} = 66.91\cdot\text{kip}$$

Demand to Capacity ratio

$$\text{Checksr} := \left| \begin{array}{ll} \dfrac{\text{Vd}}{\text{Rrsr}} & \text{if Rrsr} \geq \text{Vd} \\ \text{"Revise splice plate"} & \text{if Rrsr} < \text{Vd} \end{array} \right.$$

$$\text{Checksr} = 0.57$$

Maximum spacing and edge distance - Section J3-5

Maximum edge distance

$$\mathrm{Semax} := \left| \begin{array}{l} 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) \quad \text{if } \; 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 6\mathrm{in} \\ 6\mathrm{in} \quad \text{if } \; 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 6\mathrm{in} \end{array} \right. = 5.25\cdot\mathrm{in}$$

Maximum center to center longitudinal spacing allowed b/w holes

$$\mathrm{Smax} := \left| \begin{array}{l} 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) \quad \text{if } \; 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 12\mathrm{in} \\ 12\mathrm{in} \quad \text{if } \; 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 12\mathrm{in} \end{array} \right. = 10.5\cdot\mathrm{in}$$

Distance of bolt from splice plate edge $\mathrm{Seprov} := 2\mathrm{in}$

Distance of bolt from channel section flange inner edge

$$\mathrm{Sepprov} := \mathrm{Seprov} + [(\mathrm{d} - \mathrm{dsp})\cdot 0.5 - \mathrm{k}] = 2.69\cdot\mathrm{in}$$

Spacing provided between bolts $\mathrm{Sprov} := 4\mathrm{in}$

Check for bolt edge distance provided

$$\mathrm{Secheck} := \left| \begin{array}{l} \text{"Okay"} \quad \text{if } \; \mathrm{Semin} \le \max(\mathrm{Sepprov},\mathrm{Seprov}) \le \mathrm{Semax} \\ \text{"Not Okay"} \quad \text{otherwise} \end{array} \right. = \text{"Okay"}$$

Check for spacing provided between bolts

$$\mathrm{Scheck} := \left| \begin{array}{l} \text{"Okay"} \quad \text{if } \; (\max(\mathrm{Smin},\mathrm{Scmin} + \mathrm{dbh}) \le \mathrm{Sprov} \le \mathrm{Smax}) \\ \text{"Not Okay"} \quad \text{otherwise} \end{array} \right. = \text{"Okay"}$$

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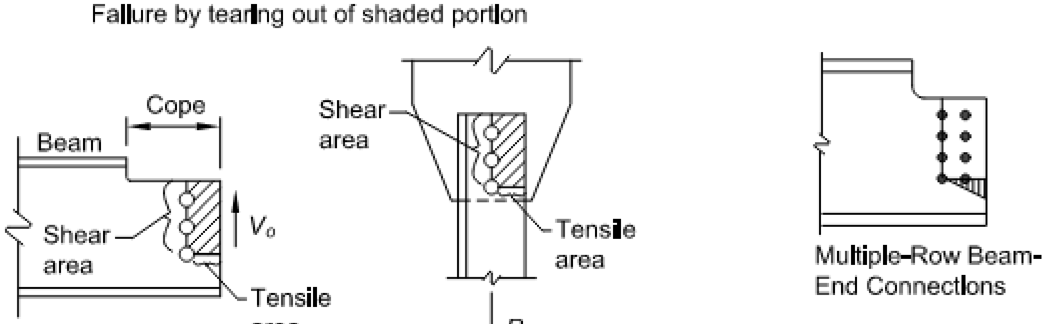
Block Shear Rupture Check, Eq. J4-5



(b) Cases for which $U_{bs} = 0.5$

Fig. C-J4.1. Failure surface for block shear rupture limit state.

No of bolts in the outermost edge of the connection pattern which is in tension

$$Nbr := 3$$

Net Area resisting the tensile stress

$$Ant := Nsp \cdot [Seprov + (Nbr - 1)Sprov - [dbh \cdot (Nbr - 0.5)]] \cdot twsp = 4.81 \cdot in^2$$

Net Area resisting the shear stress

$$Avn := Nsp \cdot \left[dsp - Seprov - \left[\left[\left(\frac{Nf}{Nr}\right) - 0.5\right] \cdot dbh\right]\right] \cdot twsp = 2.88 \cdot in^2$$

Gross area resisting the shear stress

$$Avg := Nsp \cdot (dsp - Seprov) \cdot twsp = 4.39 \cdot in^2$$

Nominal block shear strength

$$Ubs := 0.5$$

$$Rbs := [(0.6 \cdot Fu \cdot Avn) + (Ubs \cdot Fu \cdot Ant)] = 239.77 \cdot kip$$

$$Rnbs := \left| \begin{array}{l} Rbs \ \text{ if } \ Rbs \le [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] \\ {[(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)]} \ \text{ if } \ Rbs > [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] \end{array} \right. = 234.34 \cdot kip$$

Overstrength Factor $\Omega bs := 2$

Allowable block shear strength $Rrbs := \frac{Rnbs}{\Omega bs} = 117.17 \cdot kip$

Demand to Capacity Ratio $Checkbs := \begin{vmatrix} \frac{Vd}{Rrbs} \quad \text{if } Rrbs \geq Vd \\ \text{"Revise splice plate"} \quad \text{if } Rrbs < Vd \end{vmatrix}$

$Checkbs = 0.33$

Bearing Resistance Check, Eq. J3-6a

Nominal bearing strength at bolt holes $Rnb := 2.4 \cdot (db) \cdot twsp \cdot Fu \cdot Nf = 764.73 \cdot kip$

Overstrength Factor $\Omega bh := 2$

Allowable bearing strength at bolt holes $Rrb := \frac{Rnb}{\Omega bh} = 382.36 \cdot kip$

Demand to Capacity Ratio

$$Checkbh := \begin{vmatrix} \frac{V_r}{Rrb} \quad \text{if } Rrb \geq V_r \\ \text{"Revise splice plate or bolts"} \quad \text{if } Rrb < V_r \end{vmatrix} = 0.2$$

Tearout Resistance Check, Eq. J3-6c

lc for edge bolts $lco := Seprov - \left(\frac{dbh}{2}\right) = 1.31 \cdot in$

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lc for inner bolts

$$lci := Sprov - dbh = 2.63 \cdot in$$

Inner bolts on each side of splice

$$Ni := 0$$

For edge bolts, nominal tearout strength at bolt holes

$$Rnto := 1.2 \cdot twsp \cdot Fu \cdot lco \cdot (Nf - Ni) = 401.48 \cdot kip$$

For inner bolts. nominal tearout strength at bolt holes

$$Rnti := 1.2 \cdot twsp \cdot Fu \cdot lci \cdot Ni = 0 \cdot kip$$

Total nominal tearout strength at bolt holes

$$Rnt := Rnto + Rnti = 401.48 \cdot kip$$

Overstrength factor

$$\Omega bt := 2$$

Allowable tearout strength at bolt holes

$$Rrt := \frac{Rnt}{\Omega bt} = 200.74 \cdot kip$$

Demand to Capacity Ratio

$$Checkth := \left| \begin{array}{ll} \frac{V_r}{Rrt} & \text{if } Rrt \geq V_r \\ \text{"Revise splice plate or bolts"} & \text{if } Rrt < V_r \end{array} \right. = 0.38$$

Slip Resistance Check, Eq. J3-4

For class A surfaces

$$\mu := 0.3$$

$$Du := 1.13$$

Minimum bolt pretension, Table J3.1 for Group A, A325 bolts

$$Tb := 81kip$$

$hf := 1$

Nominal slip resistance of bolts $Rsr := Nf \cdot Ns \cdot \mu \cdot Du \cdot Tb \cdot hf = 164.75 \cdot kip$

Overstrength Factor $\Omega sr := 1.5$

Allowable slip resistance of bolts $Rrslr := \frac{Rsr}{\Omega sr} = 109.84 \cdot kip$

Demand to Capacity Ratio

$$Checkslr := \left| \begin{array}{ll} \frac{V_r}{Rrslr} & \text{if } Rrslr \geq V_r \\ \text{"Revise bolts size"} & \text{if } Rrslr < V_r \end{array} \right. = 0.69$$

Design Summary

Provide rectangular splice plate of 24"X8",0.75" thickness. On each side of web splice bolted plate connection, provide 6 - 1.25" dia HDG Group A - A325 bolts.

Analysis Demand Load on Waler - Sec C7

Tie Rod Tension Demand Load from Analysis $T_{roda} := 65.6\text{kip}$

Tie Rod Spacing $S_{roda} := 5\text{ft}$

The tie rod spacing assumed in analysis results in large demand loads and section size for waler. To optimize section selection, tie rods will be closely spaced. Closely spaced tie rods will result in lower demand loads.

Revised Tie Rod Spacing $S_{rod} := 5\text{ft}$

Revised Tie Rod Tension Demand $T_{rod} := T_{roda} \cdot \dfrac{S_{rod}}{S_{roda}} = 65.6 \cdot \text{kip}$

Demand Load on waler $w_{dl} := \dfrac{T_{rod}}{S_{rod}} = 13.12 \cdot \dfrac{\text{kip}}{\text{ft}}$

Demand Load on Waler to safeguard against progressive failure

In certain situations, progressive collapse of the structure may be a conseequence of an extreme condition ie. failure of a tie rod. The wailing to the main wall will need to be checked to ensure that it will not collapse if the span between tie rods doubles following the loss of a tie rod.

SAP2000 analysis is used to calculate the bending moment and shear force demand on the waler for both the cases. Case 1 - without failure of a tie rod and, Case 2 - with failure of a tie rod.

For Case 1 - Continuous beam with four equal spans of length Srod is anaylzed
For Case 2 - Continuous beam with three spans of length Srod - 2Srod - Srod is analyzed

Waler Design is governed by the demands from Case 2

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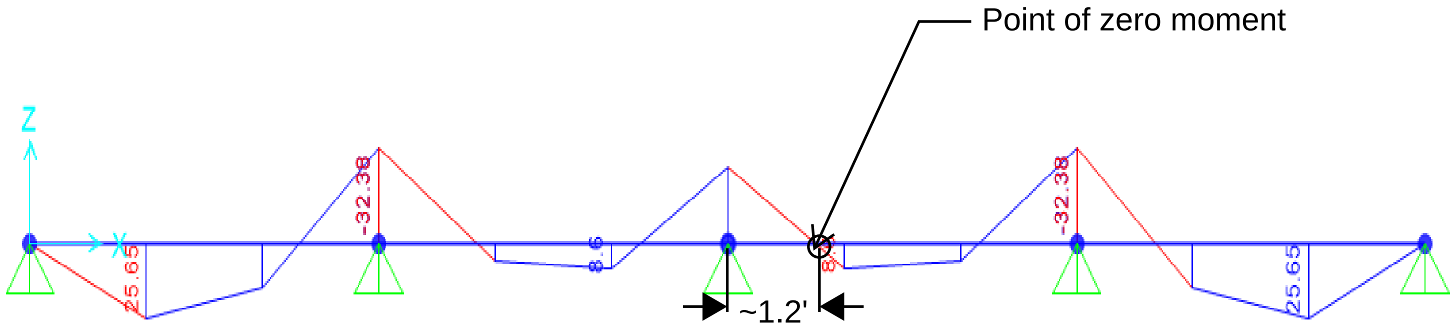
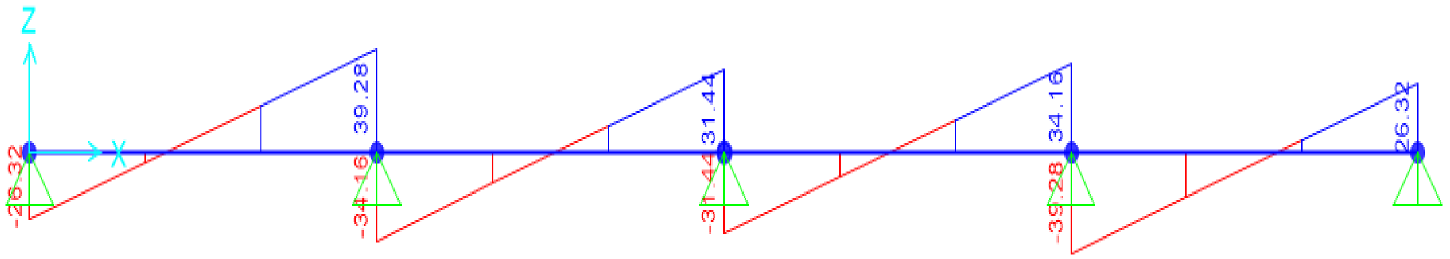
Bending Moment Diagram - Case 1



Bending Moment demand from SAP2000 - Mdsap = 32.4Kip-ft

Shear Force Diagram - Case 1



Shear Force demand from SAP2000 - Vdsap = 39.3Kip

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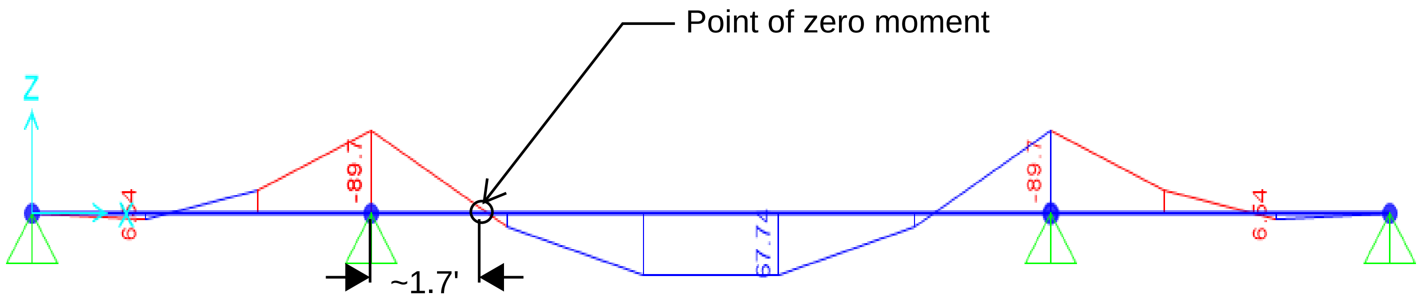
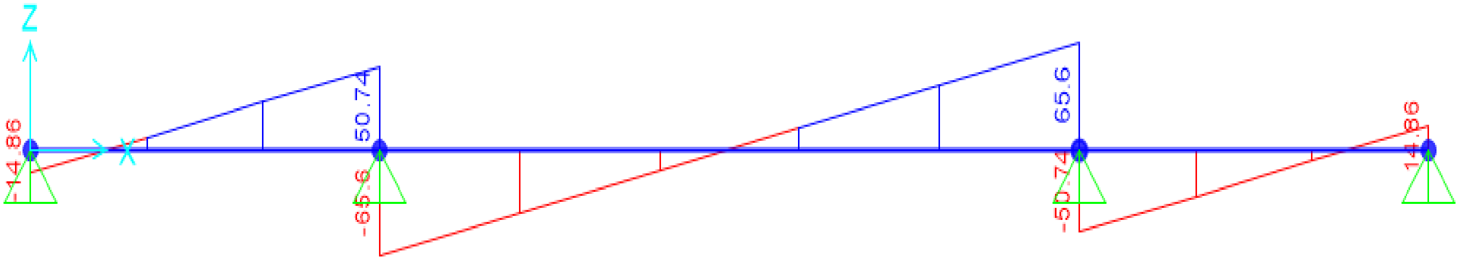
Bending Moment Diagram - Case 2


Point of zero moment

~1.7'

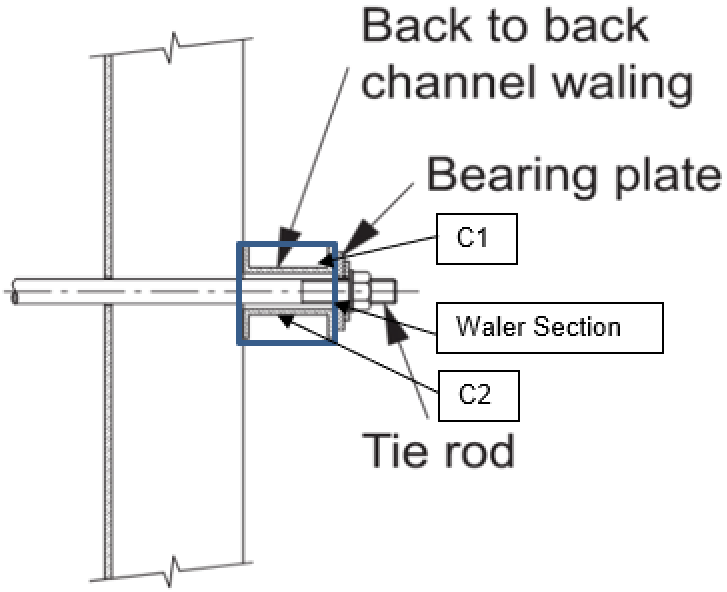
Bending Moment demand from SAP2000 - Mdsap = 89.7Kip-ft

Shear Force Diagram - Case 2



Shear Force demand from SAP2000 - Vdsap = 65.6Kip

Waler Cross-Section



Waler is made of two channel sections C1 and C2

Design of corroded waler section, AISC 360-16

Bending moment demand on waler from SAP2000 $M_{dsap} := 90kip \cdot ft$

Shear force demand on waler from SAP2000 $V_{dsap} := 66 \cdot kip$

Bending moment demand on C1 or C2 $Md := \frac{M_{dsap}}{2} = 45 \cdot kip \cdot ft$

Shear force demand on C1 or C2 $Vd := \frac{V_{dsap}}{2} = 33 \cdot kip$

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Steel yield stress	$Fy := 36\text{ksi}$	
Steel tensile stress	$Fu := 58\text{ksi}$	
Modulus of Elasticity of steel	$E := 29000\text{ksi}$	
Sacrificial thickness - for accounting corrosion	$tc := 0.0175\text{in}$	Refer Basis of Design report

Channel Section Dimensional Parameters (MC12X35)

Depth	$d := 12\text{in}$
Web thickness	$tw := 0.4375\text{in}$
Flange thickness	$tf := 0.6875\text{in}$
Flange width	$bf := 3.75\text{in}$
Distance	$k := 1.3125\text{in}$

Corroded Channel Section Dimensional Parameters (MC12X35)

Web thickness	$twc := tw - 2tc = 0.4 \cdot \text{in}$
Flange thickness	$tfc := tf - 2tc = 0.65 \cdot \text{in}$

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Sectional Properties of Corroded Section

Plastic modulus about x axis

$$Zx := \left[(bf)\cdot\frac{(d)^2}{4}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^2}{4}\right] = 39.28\cdot in^3$$

Elastic modulus about x axis

$$Sx := \frac{\left[\left[(bf)\cdot\frac{(d)^3}{12}\right] - \left[[(bf) - (twc)]\cdot\frac{[(d) - [2\cdot(tfc)]]^3}{12}\right]\right]}{(d)\cdot 0.5} = 33.12\cdot in^3$$

Torsion constant

$$J := \frac{\left[\left[2\cdot(bf)\cdot(tfc)^3\right] + \left[[(d) - (tfc)]\cdot(twc)^3\right]\right]}{3} = 0.94\cdot in^4$$

Moment of Inertia about external edge of web parallel to y axis

$$Iyo := \left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^3}{3}\right] + \left[(bf)^3\cdot(tfc)\cdot\frac{2}{3}\right] = 23.17\cdot in^4$$

Cross sectional area

$$Ac := [2\cdot(bf)\cdot(tfc)] + [[(d) - [2\cdot(tfc)]]\cdot(twc)] = 9.2\cdot in^2$$

Distance of centroid from external edge of web

$$xc := \frac{\left[\left[[(d) - [2\cdot(tfc)]]\cdot\frac{(twc)^2}{2}\right] + \left[(bf)^2\cdot(tfc)\right]\right]}{Ac} = 1.09\cdot in$$

Moment of inertia about y axis $Iy := Iyo - \left(Ac\cdot xc^2\right) = 12.21\cdot in^4$

Distance between flange centroids $ho := (d) - (tfc) = 11.35\cdot in$

Warping torsional constant

$$Cw := \frac{\left[(tfc)\cdot(bf)^3\cdot[(d) - (tfc)]^2\right]\cdot[[3\cdot(bf)\cdot(tfc)] + [2\cdot(twc)\cdot[(d) - (tfc)]]]}{12\cdot[[6\cdot(bf)\cdot(tfc)] + [(twc)\cdot[(d) - (tfc)]]]}$$

$$Cw = 316.03\cdot in^6$$

radius of gyration about y axis $ry := \sqrt{\frac{Iy}{Ac}} = 1.15\cdot in$

Overstrength factor for flexure $\Omega f := 1.67$

Overstrength factor for shear $\Omega v := 1.67$

Classification of sections for local buckling - Section B4.1

Classification of flanges in flexure - Table B4.1b (case 10)

Width - to - Thickness Ratio for flange $a_f := \frac{bf}{tfc} = 5.75$

Limiting width to thickness ratio for compact flange section about major/minor axis

$$\lambda_{cf} := 0.38 \cdot \sqrt{\frac{E}{Fy}} = 10.79$$

Limiting width to thickness ratio for non compact flange section about major/minor axis

$$\lambda_{nf} := 1 \sqrt{\frac{E}{Fy}} = 28.38$$

Classification of web in flexure - Table B4.1b (case 15)

Width - to - Thickness Ratio for web

$$a_w := \frac{(d) - [2 \cdot (k - 2tc)]}{twc} = 23.47$$

Limiting width to thickness ratio for compact web section about major/minor axis

$$\lambda_{cw} := 3.76 \cdot \sqrt{\frac{E}{Fy}} = 106.72$$

Limiting width to thickness ratio for non compact web section about major/minor axis

$$\lambda_{nw} := 5.7 \sqrt{\frac{E}{Fy}} = 161.78$$

$$cn_{ff} := \left| \begin{array}{l} \text{"Compact flange"} \quad \text{if } a_f \le \lambda_{cf} \\ \text{"Non compact flange"} \quad \text{if } \lambda_{cf} \le a_f \le \lambda_{nf} \\ \text{"Slender flange"} \quad \text{otherwise} \end{array} \right. = \text{"Compact flange"}$$

$$cn_{wf} := \left| \begin{array}{l} \text{"Compact web"} \quad \text{if } a_w \le \lambda_{cw} \\ \text{"Non compact web"} \quad \text{if } \lambda_{cw} \le a_w \le \lambda_{nw} \\ \text{"Slender flange web"} \quad \text{otherwise} \end{array} \right. = \text{"Compact web"}$$

Allowable Stress Shear Design - Chapter G

Web area

$$Aw := (d) \cdot (twc) = 4.83 \cdot in^2$$

Web plate buckling coefficient

$$Kv := 5.34$$

$$r := 1.1 \cdot \left(Kv \cdot \frac{E}{Fy} \right)^{\frac{1}{2}} = 72.15$$

$$r1 := \frac{(d) - [2 \cdot (tfc)]}{twc} = 26.57$$

Web shear coefficient, Eq G2-3 and Eq G2-4

$$Cv1 := \begin{vmatrix} 1 \quad \text{if } r \geq r1 \\ \dfrac{r}{r1} \quad \text{if } r < r1 \end{vmatrix}$$

$$Cv1 = 1$$

Nominal shear strength, Eq G2-1

$$Vn := 0.6 \cdot Cv1 \cdot Aw \cdot Fy = 104.33 \cdot kip$$

Allowable shear strength

$$vc := \frac{Vn}{\Omega v} = 62.47 \cdot kip$$

Check for shear strength

$$Checkvc := \begin{vmatrix} \dfrac{Vd}{vc} \quad \text{if } vc \geq Vd \\ \text{"Revise waler section"} \quad \text{if } vc < Vd \end{vmatrix}$$

$$Checkvc = 0.53$$

Allowable Stress Flexure design about major axis - Chapter F

Yielding - Section F2.1

Nominal flexural strength for yielding, Eq F2-1

$$Mnyld := Fy \cdot Zx = 117.83 \cdot kip \cdot ft$$

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Lateral Torsional Buckling - Section F2.2

Unbraced length $Lb := S_{rod} \cdot 2 = 120 \cdot in$

Limiting unbraced length for yielding Eq F2-5 $Lp := 1.76 \cdot ry \cdot \sqrt{\frac{E}{Fy}} = 57.55 \cdot in$

Eq F2-8b $cf := \left(\frac{ho}{2}\right) \cdot \sqrt{\frac{Iy}{Cw}} = 1.12$

Eq F2-7 $rts := \sqrt{\frac{\sqrt{Iy \cdot Cw}}{Sx}} = 1.37 \cdot in$

Eq F2-6

$$Lr := 1.95 \cdot rts \cdot \frac{E \cdot \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right) + \sqrt{\left(J \cdot \frac{cf}{Sx \cdot ho}\right)^2 + \left[6.76 \cdot \left(0.7 \cdot \frac{Fy}{E}\right)^2\right]}}}{(0.7 \cdot Fy)} = 245.54 \cdot in$$

From SAP2000 analysis, for calculation of Cb (Lp<Lb<=Lr)

Moment at quarter point of unbraced segment $Ma := 28.4 kip \cdot ft$

Moment at center line of unbraced segment $Mb := 67.7 kip \cdot ft$

Moment at three quarter point of unbraced segment $Mc := 28.4 kip \cdot ft$

Maximum moment in unbraced segment $Mabs := 89.7 kip \cdot ft$

Plastic moment capacity $Mp := Mnyld$

Lateral torsional buckling modification factor, Eq F1-1

$$Cb := 12.5 \cdot \frac{Mabs}{[(2.5 \cdot Mabs) + (3 \cdot Ma) + (4 \cdot Mb) + (3 \cdot Mc)]} = 1.68$$

Nominal flexural strength for lateral torsional buckling - Eq F2-2

$$Mnltb := Cb \cdot \left[Mp - (Mp - 0.7 \cdot Fy \cdot Sx) \cdot \frac{(Lb - Lp)}{(Lr - Lp)} \right]$$

$$Mnltb = 171.52 \cdot kip \cdot ft$$

Nominal flexural strength $Mn := \min(Mnyld, Mnltb) = 117.83 \cdot kip \cdot ft$

Design flexure strength $mc := \frac{Mn}{\Omega f} = 70.56 \cdot kip \cdot ft$

Check for flexural strength

$$Checkmc := \begin{cases} \frac{Md}{mc} & \text{if } mc \geq Md \\ \text{"Revise waler section"} & \text{if } mc < Md \end{cases}$$

$$Checkmc = 0.64$$

Deflection Check

Limiting Deflection $L_{ld} := \frac{Lb}{360} = 0.33 \cdot in$

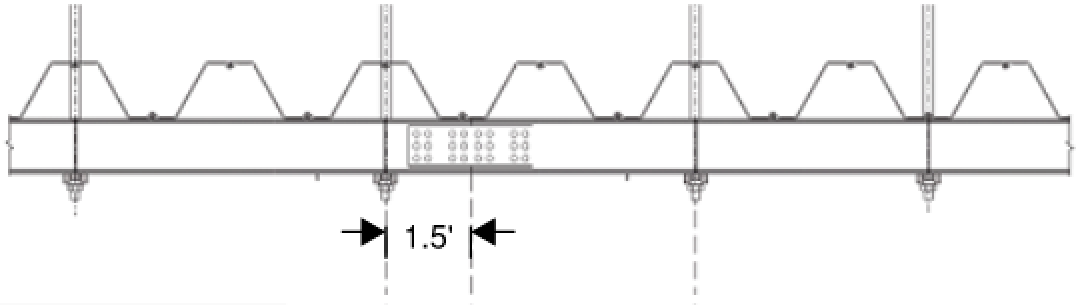
Maximum deflection from SAP2000 analysis $L_{md} := 0.18in$

Demand to Capacity Ratio

$$Check_d := \begin{cases} \dfrac{L_{md}}{L_{ld}} & \text{if } L_{ld} \geq L_{md} \\ \text{"Revise unbraced length"} & \text{if } L_{ld} < L_{md} \end{cases}$$

$$Check_d = 0.54$$

Bolted Splice Plate Connection Design for Waler, Allowable Stress Design - AISC 360-16



From SAP2000 analysis, point of zero moment in typical span for case 1 is ~1.2' and for case 2 is ~1.7' from tie rod anchorage. Point of splice connection for design is 1.5' from tie rod anchorage.

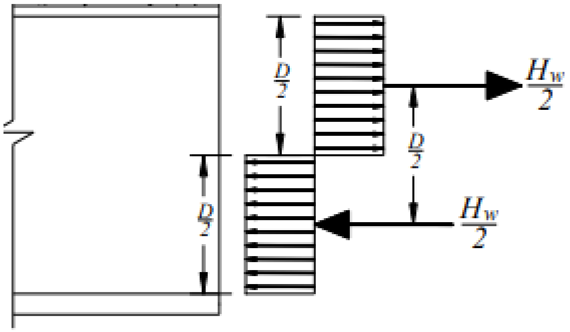
Resultant Web Force at Point of Splice Connection

Bending moment demand at point of splice, from SAP2000 analysis $Msd := 11kip \cdot ft$

Horizontal force in web due to moment at point of splice

$$H_w := \frac{Msd \cdot 4}{[d - [2 \cdot (k - 2tc)]]} = 55.9 \cdot kip$$

Resultant web force at point of splice connection $V_r := \sqrt{Vd^2 + H_w^2} = 64.92 \cdot kip$

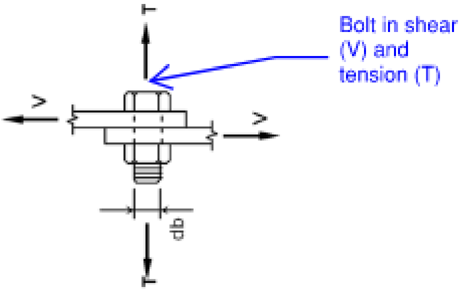


$$Web\ Moment = \frac{H_w}{2}\left(\frac{D}{2}\right)$$

$$H_w = \frac{Web\ Moment}{D/4}$$

Factored shear resistance of bolts in shear

No of shear planes $Ns := 1$



Bolt in shear (V) and tension (T)

Section J3, Table J3.2

Using HDG Group A, A325 bolts

Nominal shear stress when threads are not excluded from shear planes $Fnv := 54ksi$

Taking 1.25" nominal diameter bolt

Bolt nominal diameter $db := 1.25in$

Nominal unthreaded body area of bolt $Ab := 3.14 \cdot (db)^2 \cdot 0.25 = 1.23 \cdot in^2$

Nominal shear strength of bolt $Rn := Fnv \cdot Ab \cdot Ns = 66.23 \cdot kip$

Overstrength factor $\Omega b := 2$

Allowable shear strength of bolt $Rr := \frac{Rn}{\Omega b} = 33.12 \cdot kip$

No of bolts required on each side of the web splice $Nb := \frac{V_r}{Rr} = 1.96$

No of bolts provided on each side of the web splice $Nf := 6$

No of bolt columns in connection pattern along the length of splice plate $Nr := 3$

Bolt Connection Pattern

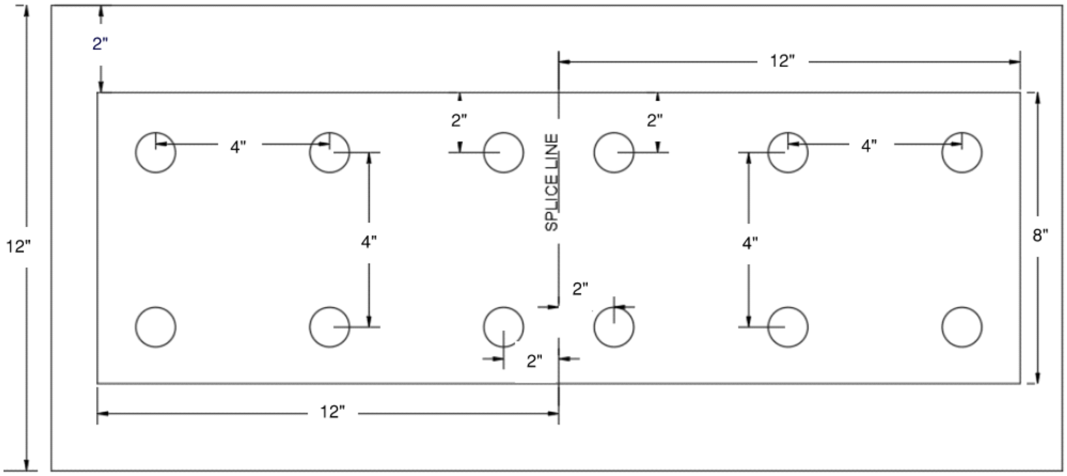


Table J3.3, for 1.25" bolt dia, standard hole dia is 1.375"

Hole diameter $dbh := 1.375in$

Minimum center to center spacing allowed b/w holes, Sec J3.3

$$\text{Smin} := \frac{8\cdot(\text{db})}{3} = 3.33\cdot\text{in}$$

Minimum clear spacing allowed b/w holes, Sec J3.3

$$\text{Scmin} := \text{db} = 1.25\cdot\text{in}$$

Table J3.4, minimum edge distance allowed for 1.25" bolt dia

$$\text{Semin} := 1.625\text{in}$$

Providing a splice plate of 24"X8", 0.75" thickness for the connection

No of splice plates in the connection

$$\text{Nsp} := 1$$

Eq. J4-3 and J4-4, strength of elements in shear

Depth of splice plate

$$\text{dsp} := 8\text{in}$$

Thickness of splice plate

$$\text{Twsp} := 0.75\text{in}$$

Reduced thickness of splice plate - for accounting corrosion

$$\text{twsp} := \text{Twsp} - \text{tc} = 0.73\cdot\text{in}$$

Gross area subject to shear

$$\text{Agv} := \text{dsp}\cdot\text{twsp} = 5.86\cdot\text{in}^2$$

Nominal shear yielding strength

$$\text{Rnsy} := 0.6\cdot\text{Fy}\cdot\text{Agv}\cdot\text{Nsp} = 126.58\cdot\text{kip}$$

Overstrength factor

$$\Omega\text{spsy} := 1.5$$

Allowable shear yielding strength

$$\mathrm{Rrsy} := \frac{\mathrm{Rnsy}}{\Omega\mathrm{spsy}} = 84.38\cdot\mathrm{kip}$$

Demand to Capacity Ratio

$$\mathrm{Checksy} := \begin{vmatrix} \dfrac{\mathrm{Vd}}{\mathrm{Rrsy}} \quad \text{if } \mathrm{Rrsy} \geq \mathrm{Vd} \\ \text{"Revise splice plate"} \quad \text{if } \mathrm{Rrsy} < \mathrm{Vd} \end{vmatrix}$$

$$\mathrm{Checksy} = 0.39$$

Net area subject to shear

$$\mathrm{Anv} := \left[\mathrm{dsp} - \left(\mathrm{Nf}\cdot\frac{\mathrm{dbh}}{\mathrm{Nr}}\right)\right]\cdot\mathrm{twsp} = 3.85\cdot\mathrm{in}^2$$

Nominal shear rupture strength

$$\mathrm{Rnsr} := 0.6\cdot\mathrm{Fu}\cdot\mathrm{Anv}\cdot\mathrm{Nsp} = 133.83\cdot\mathrm{kip}$$

Overstrength factor

$$\Omega\mathrm{spsr} := 2$$

Allowable shear rupture strength

$$\mathrm{Rrsr} := \frac{\mathrm{Rnsr}}{\Omega\mathrm{spsr}} = 66.91\cdot\mathrm{kip}$$

Demand to Capacity ratio

$$\mathrm{Checksr} := \begin{vmatrix} \dfrac{\mathrm{Vd}}{\mathrm{Rrsr}} \quad \text{if } \mathrm{Rrsr} \geq \mathrm{Vd} \\ \text{"Revise splice plate"} \quad \text{if } \mathrm{Rrsr} < \mathrm{Vd} \end{vmatrix}$$

$$\mathrm{Checksr} = 0.49$$

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Maximum spacing and edge distance - Section J3-5

Maximum edge distance

$$\mathrm{Semax} := \left|\begin{array}{l} 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) \ \text{ if } \ 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 6\mathrm{in} \\ 6\mathrm{in} \ \text{ if } \ 12\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 6\mathrm{in} \end{array}\right. = 5.25\cdot\mathrm{in}$$

Maximum center to center longitudinal spacing allowed b/w holes

$$\mathrm{Smax} := \left|\begin{array}{l} 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) \ \text{ if } \ 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) \le 12\mathrm{in} \\ 12\mathrm{in} \ \text{ if } \ 24\cdot\min(\mathrm{tw},\mathrm{Twsp}) > 12\mathrm{in} \end{array}\right. = 10.5\cdot\mathrm{in}$$

Distance of bolt from splice plate edge $\mathrm{Seprov} := 2\mathrm{in}$

Distance of bolt from channel section flange inner edge

$$\mathrm{Sepprov} := \mathrm{Seprov} + [(\mathrm{d} - \mathrm{dsp})\cdot 0.5 - \mathrm{k}] = 2.69\cdot\mathrm{in}$$

Spacing provided between bolts $\mathrm{Sprov} := 4\mathrm{in}$

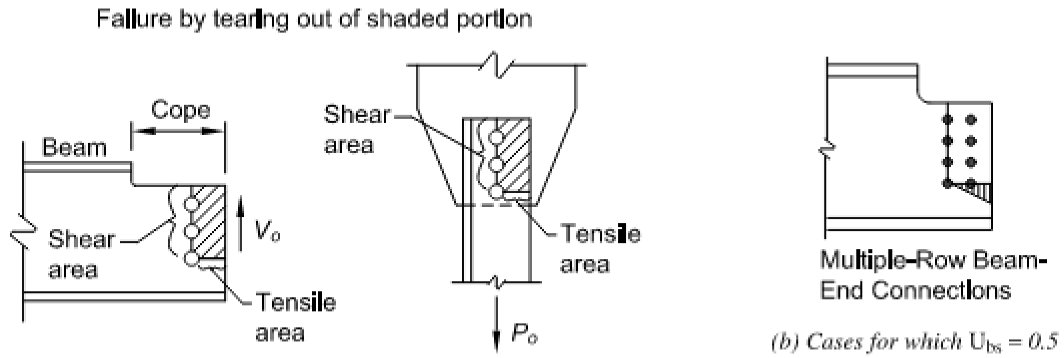
Check for bolt edge distance provided

$$\mathrm{Secheck} := \left|\begin{array}{l} \text{"Okay"} \ \text{ if } \ \mathrm{Semin} \le \max(\mathrm{Sepprov},\mathrm{Seprov}) \le \mathrm{Semax} \\ \text{"Not Okay"} \ \text{ otherwise} \end{array}\right. = \text{"Okay"}$$

Check for spacing provided between bolts

$$\mathrm{Scheck} := \left|\begin{array}{l} \text{"Okay"} \ \text{ if } \ (\max(\mathrm{Smin},\mathrm{Scmin} + \mathrm{dbh}) \le \mathrm{Sprov} \le \mathrm{Smax}) \\ \text{"Not Okay"} \ \text{ otherwise} \end{array}\right. = \text{"Okay"}$$

Block Shear Rupture Check, Eq. J4-5



(b) Cases for which $U_{bs} = 0.5$

Fig. C-J4.1. Failure surface for block shear rupture limit state.

No of bolts in the outermost edge of the connection pattern which is in tension

$$Nbr := 3$$

Net Area resisting the tensile stress

$$Ant := Nsp \cdot [Seprov + (Nbr - 1)Sprov - [dbh \cdot (Nbr - 0.5)]] \cdot twsp = 4.81 \cdot in^2$$

Net Area resisting the shear stress

$$Avn := Nsp \cdot \left[dsp - Seprov - \left[\left[\left(\frac{Nf}{Nr} \right) - 0.5 \right] \cdot dbh \right] \right] \cdot twsp = 2.88 \cdot in^2$$

Gross area resisting the shear stress

$$Avg := Nsp \cdot (dsp - Seprov) \cdot twsp = 4.39 \cdot in^2$$

Nominal block shear strength

$$Ubs := 0.5$$

$$Rbs := [(0.6 \cdot Fu \cdot Avn) + (Ubs \cdot Fu \cdot Ant)] = 239.77 \cdot kip$$

$$Rnbs := \begin{cases} Rbs & \text{if } Rbs \le [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] \\ [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] & \text{if } Rbs > [(0.6 \cdot Fy \cdot Avg) + (Ubs \cdot Fu \cdot Ant)] \end{cases} = 234.34 \cdot kip$$

Overstrength Factor $\Omega bs := 2$

Allowable block shear strength $Rrbs := \frac{Rnbs}{\Omega bs} = 117.17 \cdot kip$

Demand to Capacity Ratio

$$Checkbs := \left| \begin{array}{ll} \frac{Vd}{Rrbs} & \text{if } Rrbs \ge Vd \\ \text{"Revise splice plate"} & \text{if } Rrbs < Vd \end{array} \right.$$

$Checkbs = 0.28$

Bearing Resistance Check, Eq. J3-6a

Nominal bearing strength at bolt holes $Rnb := 2.4 \cdot (db) \cdot twsp \cdot Fu \cdot Nf = 764.73 \cdot kip$

Overstrength Factor $\Omega bh := 2$

Allowable bearing strength at bolt holes $Rrb := \frac{Rnb}{\Omega bh} = 382.36 \cdot kip$

Demand to Capacity Ratio

$$Checkbh := \left| \begin{array}{ll} \frac{V_r}{Rrb} & \text{if } Rrb \ge V_r \\ \text{"Revise splice plate or bolts"} & \text{if } Rrb < V_r \end{array} \right. = 0.17$$

Tearout Resistance Check, Eq. J3-6c

lc for edge bolts $lco := Seprov - \left(\frac{dbh}{2}\right) = 1.31 \cdot in$

lc for inner bolts $lci := Sprov - dbh = 2.63 \cdot in$

Inner bolts on each side of splice $Ni := 0$

For edge bolts, nominal tearout strength at bolt holes $Rnto := 1.2 \cdot twsp \cdot Fu \cdot lco \cdot (Nf - Ni) = 401.48 \cdot kip$

For inner bolts. nominal tearout strength at bolt holes $Rnti := 1.2 \cdot twsp \cdot Fu \cdot lci \cdot Ni = 0 \cdot kip$

Total nominal tearout strength at bolt holes $Rnt := Rnto + Rnti = 401.48 \cdot kip$

Overstrength factor $\Omega bt := 2$

Allowable tearout strength at bolt holes $Rrt := \frac{Rnt}{\Omega bt} = 200.74 \cdot kip$

Demand to Capacity Ratio

$$Checkth := \begin{cases} \frac{V_r}{Rrt} & \text{if } Rrt \geq V_r \\ \text{"Revise splice plate or bolts"} & \text{if } Rrt < V_r \end{cases} = 0.32$$

Slip Resistance Check, Eq. J3-4

For class A surfaces $\mu := 0.3$

$Du := 1.13$

Minimum bolt pretension, Table J3.1 for Group A, A325 bolts $Tb := 81kip$

$hf := 1$

Nominal slip resistance of bolts $Rsr := Nf \cdot Ns \cdot \mu \cdot Du \cdot Tb \cdot hf = 164.75 \cdot kip$

Overstrength Factor $\Omega sr := 1.5$

Allowable slip resistance of bolts $Rrslr := \frac{Rsr}{\Omega sr} = 109.84 \cdot kip$

Demand to Capacity Ratio

$$Checkslr := \left| \begin{array}{ll} \frac{V_r}{Rrslr} & \text{if } Rrslr \geq V_r \\ \text{"Revise bolts size"} & \text{if } Rrslr < V_r \end{array} \right. = 0.59$$

Design Summary

Provide rectangular splice plate of 24"X8",0.75" thickness. On each side of web splice bolted plate connection, provide 6 - 1.25" dia HDG Group A - A325 bolts.

ATTACHMENT 3.2

Client: International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number: 11215702
Sheet: 1
Project: San Jacinto River Waste Pits Site
Sheets By: I.Goel
Date: 06/02/2022
Subject: BMP Design - Wind Load Parametric Study
Checked By: S.Chilka
Date: 06/02/2022

BMP Design - Wind Load Parametric Study Summary

BMP structural analysis is performed for hydrostatic load from flood stage water level at El. +9ft. Analysis doesn't include wind loads. Hence, this parametric study evaluates the effect of wind loads on the BMP. The net load combining wind and hystrostatic load, without a reduction factor (0.6) on wind, is compared to the design case hydrostatic load. As the net load is lower than the design case hydrostatic load, further analytical evaluation of wind loads is not required.

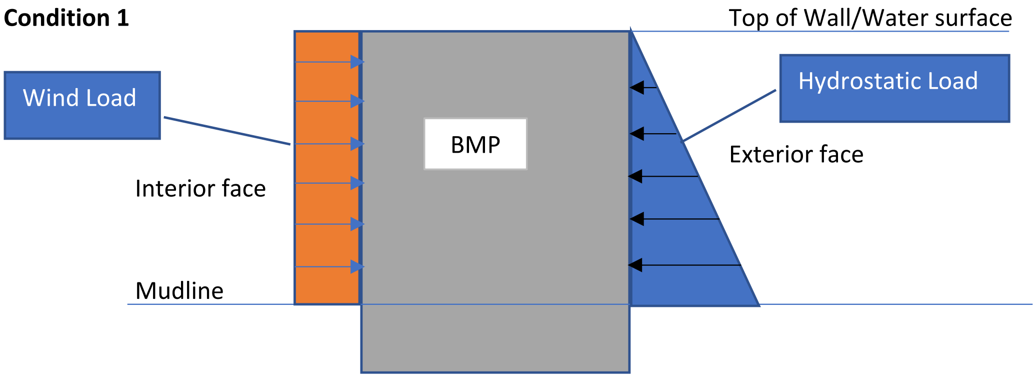
Evaluation results of extreme and unusual wind load cases for different mudline elevations are presented on the following pages.

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	2
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel	Date	06/02/2022
Subject	BMP Design - Wind Load Parametric Study	Checked By	S.Chilka	Date	06/02/2022

Mudline Elevation = 0ft

Wind Load - Extreme Case (EX)

Condition 1



Top of Wall elevation	9	ft
Mudline elevation	0	ft
Water Surface elevation	9	ft

Hydrostatic Load on Exterior face (Design case hydrostatic load)

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LEX1}	2.53	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1EX1}	3	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX1i}	0.39	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2EX1}	4.5	ft	from mudline elevation

Net Load on BMP	N_{LEX1}	2.13	kip/L.F	H_{LEX1}-W_{LEX1i}
Acting at height	H_{nlEX1}	2.7	ft	from mudline elevation

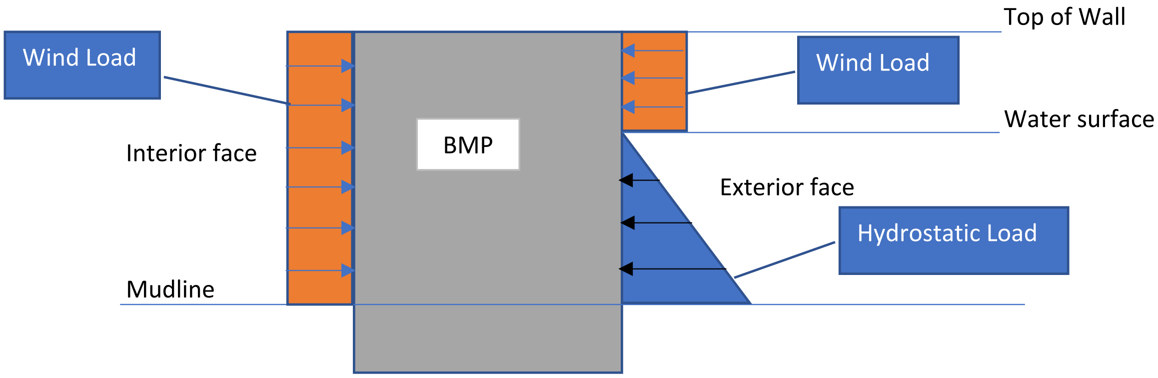
Load Govern Check Design case hydrostatic load governs

H_{LEX1}>=N_{LEX1} and H_{1EX1}>=H_{nlEX1}

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702
Sheet	3		
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel
Date	06/02/2022		
Subject	BMP Design - Wind Load Parametric Study	Checked By	S.Chilka
Date	06/02/2022		

Wind Load - Extreme Case (EX)

Condition 2



Top of Wall elevation	9	ft
Mudline elevation	0	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LEX2}	0.78	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1EX2}	1.67	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX2i}	0.39	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2EX2}	4.5	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX2e}	0.18	kip/ L.F	per unit ft length of BMP
Acting at height	H_{3EX2}	7	ft	from mudline elevation

Net Load on BMP	N_{LEX2}	0.56	kip/L.F	$(H_{LEX2}+W_{LEX2e}-W_{LEX2i})$
Acting at height	H_{nlEX2}	1.3	ft	from mudline elevation

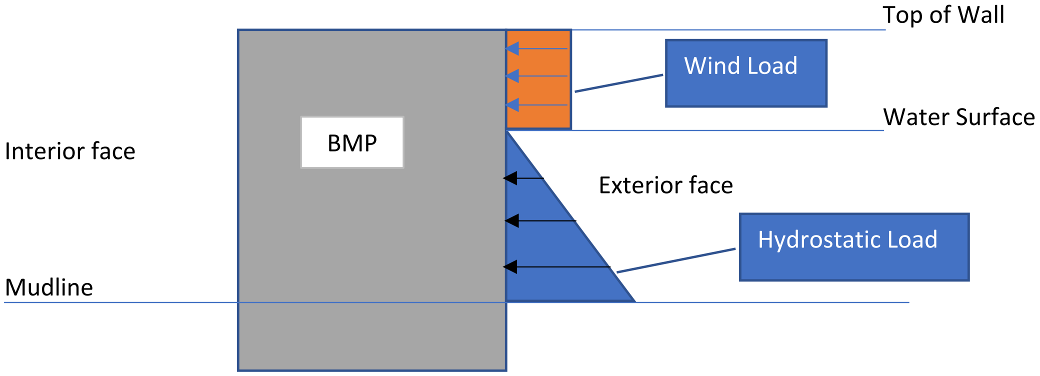
Load Govern Check Design case hydrostatic load governs

$H_{LEX1}>=N_{LEX2}$ and $H_{1EX1}>=H_{nlEX2}$

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	4
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel	Date	06/02/2022
Subject	BMP Design - Wind Load Parametric Study	Checked By	S.Chilka	Date	06/02/2022

Wind Load - Unusual Case (UN)

Condition 1



Top of Wall elevation	9	ft
Mudline elevation	0	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LUN1}	0.78	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1UN1}	1.67	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN1e}	0.10	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2UN1}	7	ft	from mudline elevation

Net Load on BMP	N_{LUN1}	0.88	kip/L.F	$(H_{LUN1}+W_{LUN1e})$
Acting at height	H_{nlUN1}	2.3	ft	from mudline elevation

Load Govern Check Design case hydrostatic load governs

$H_{LEX1}>=N_{LUN1}$ and $H_{1EX1}>=H_{nlLUN1}$

Client International Paper Company & McGinnes Industrial Maintenance Corporation

Job Number 11215702

Sheet 5

Project San Jacinto River Waste Pits Site

Sheets By I.Goel

Date 06/02/2022

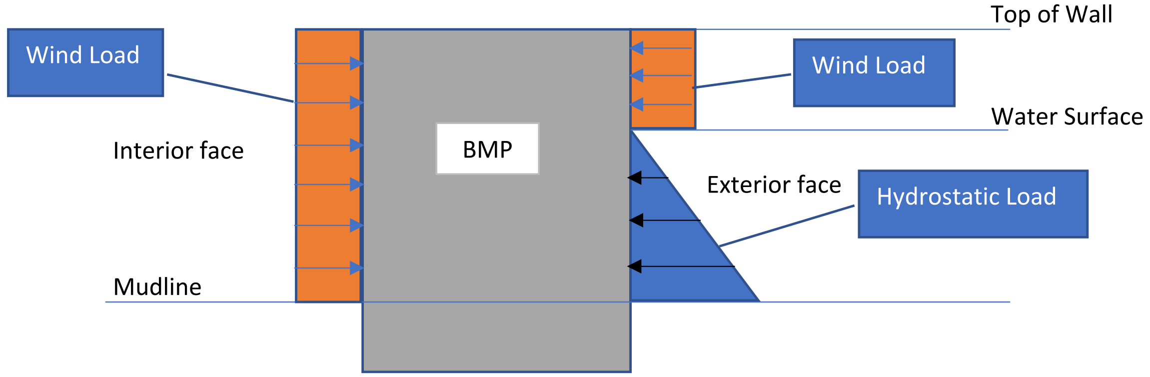
Subject BMP Design - Wind Load Parametric Study

Checked By S.Chilka

Date 06/02/2022

Wind Load - Unusual Case (UN)

Condition 2



Top of Wall elevation	9	ft
Mudline elevation	0	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LUN2}	0.78	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1UN2}	1.67	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN2i}	0.22	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2UN2}	4.5	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN2e}	0.10	kip/ L.F	per unit ft length of BMP
Acting at height	H_{3UN2}	7	ft	from mudline elevation

Net Load on BMP	N_{LUN2}	0.66	kip/L.F	$(H_{LUN2}+W_{LUN2e}-W_{LUN2i})$
Acting at height	H_{nlUN2}	1.5	ft	from mudline elevation

Load Govern Check Design case hydrostatic load governs

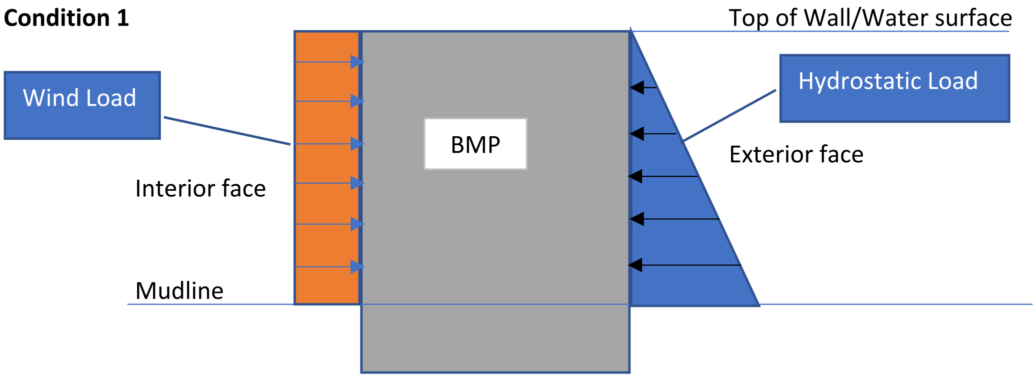
$H_{LEX1}>=N_{LUN2}$ and $H_{1EX1}>=H_{nlUN2}$

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 6
Project San Jacinto River Waste Pits Site
Sheets By I.Goel
Date 06/02/2022
Subject BMP Design - Wind Load Parametric Study
Checked By S.Chilka
Date 06/02/2022

Mudline Elevation = -10ft

Wind Load - Extreme Case (EX)

Condition 1



Top of Wall elevation	9	ft
Mudline elevation	-10	ft
Water Surface elevation	9	ft

Hydrostatic Load on Exterior face (Design case hydrostatic load)

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LEX1}	11.26	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1EX1}	6.33	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX1i}	0.83	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2EX1}	9.5	ft	from mudline elevation

Net Load on BMP	N_{LEX1}	10.43	kip/L.F	H_{LEX1}-W_{LEX1i}
Acting at height	H_{nlEX1}	6.1	ft	from mudline elevation

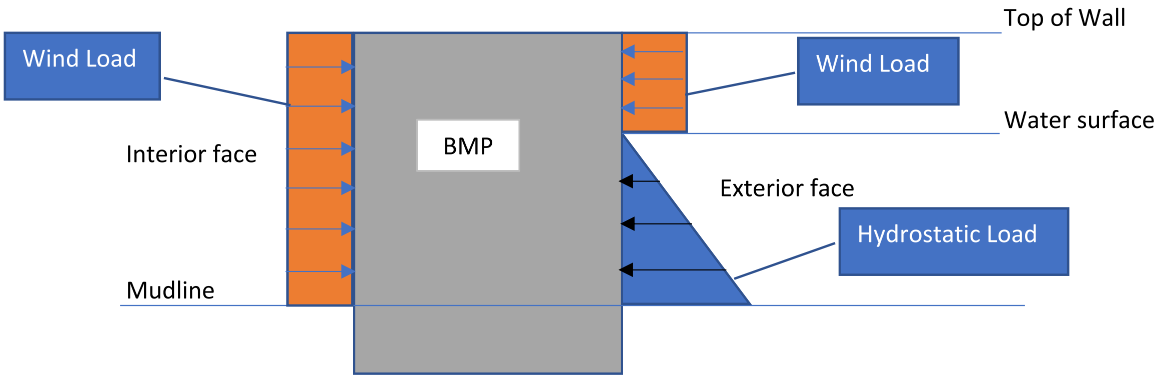
Load Govern Check Design case hydrostatic load governs

$H_{LEX1}>=N_{LEX1}$ and $H_{1EX1}>=H_{nlEX1}$

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 7
Project San Jacinto River Waste Pits Site
Sheets By I.Goel
Date 06/02/2022
Subject BMP Design - Wind Load Parametric Study
Checked By S.Chilka
Date 06/02/2022

Wind Load - Extreme Case (EX)

Condition 2



Top of Wall elevation	9	ft
Mudline elevation	-10	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LEX2}	7.02	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1EX2}	5.00	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX2i}	0.83	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2EX2}	9.5	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX2e}	0.18	kip/ L.F	per unit ft length of BMP
Acting at height	H_{3EX2}	17	ft	from mudline elevation

Net Load on BMP	N_{LEX2}	6.36	kip/L.F	$(H_{LEX2}+W_{LEX2e}-W_{LEX2i})$
Acting at height	H_{nlEX2}	4.7	ft	from mudline elevation

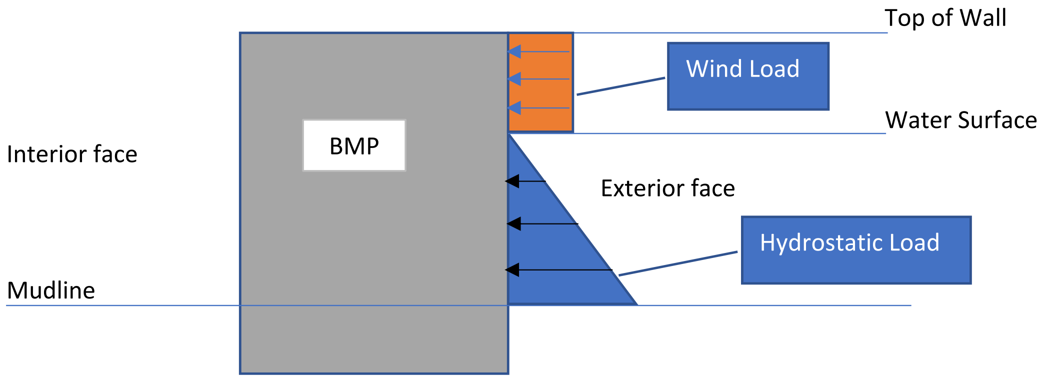
Load Govern Check Design case hydrostatic load governs

$H_{LEX1}>=N_{LEX2}$ and $H_{1EX1}>=H_{nlEX2}$

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	8
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel	Date	06/02/2022
Subject	BMP Design - Wind Load Parametric Study	Checked By	S.Chilka	Date	06/02/2022

Wind Load - Unusual Case (UN)

Condition 1



Top of Wall elevation	9	ft
Mudline elevation	-10	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LUN1}	7.02	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1UN1}	5.00	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN1e}	0.10	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2UN1}	17	ft	from mudline elevation

Net Load on BMP	N_{LUN1}	7.12	kip/L.F	$(H_{LUN1}+W_{LUN1e})$
Acting at height	H_{nlUN1}	5.2	ft	from mudline elevation

Load Govern Check

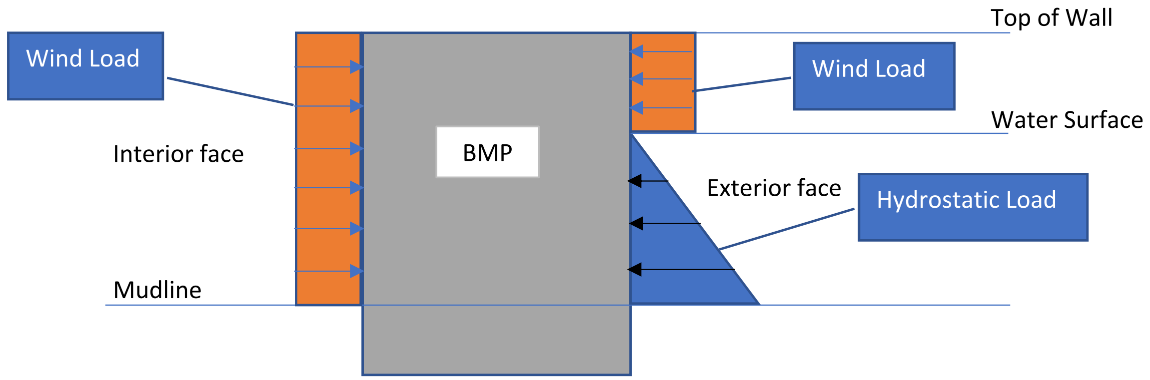
Design case hydrostatic load governs

$H_{LEX1}>=N_{LUN1}$ and $H_{1EX1}>=H_{nlLUN1}$

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 9
Project San Jacinto River Waste Pits Site
Sheets By I.Goel
Date 06/02/2022
Subject BMP Design - Wind Load Parametric Study
Checked By S.Chilka
Date 06/02/2022

Wind Load - Unusual Case (UN)

Condition 2



Top of Wall elevation	9	ft
Mudline elevation	-10	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LUN2}	7.02	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1UN2}	5.00	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN2i}	0.47	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2UN2}	9.5	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN2e}	0.10	kip/ L.F	per unit ft length of BMP
Acting at height	H_{3UN2}	17	ft	from mudline elevation

Net Load on BMP	N_{LUN2}	6.65	kip/L.F	$(H_{LUN2}+W_{LUN2e}-W_{LUN2i})$
Acting at height	H_{nlUN2}	4.9	ft	from mudline elevation

Load Govern Check Design case hydrostatic load governs

$H_{LEX1}>=N_{LUN2}$ and $H_{1EX1}>=H_{nlUN2}$

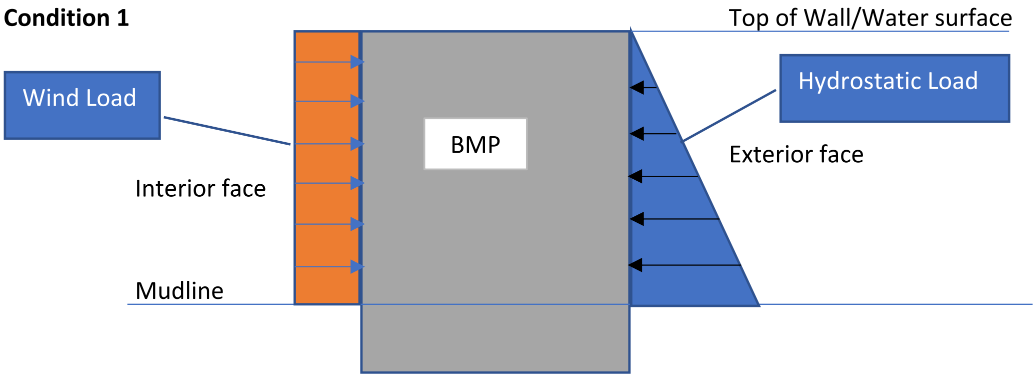
GHD

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 10
Project San Jacinto River Waste Pits Site
Sheets By I.Goel
Date 06/02/2022
Subject BMP Design - Wind Load Parametric Study
Checked By S.Chilka
Date 06/02/2022

Mudline Elevation = -20ft

Wind Load - Extreme Case (EX)

Condition 1



Top of Wall elevation	9	ft
Mudline elevation	-20	ft
Water Surface elevation	9	ft

Hydrostatic Load on Exterior face (Design case hydrostatic load)

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LEX1}	26.24	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1EX1}	9.67	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX1i}	1.27	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2EX1}	14.5	ft	from mudline elevation

Net Load on BMP	N_{LEX1}	24.97	kip/L.F	H_{LEX1}-W_{LEX1i}
Acting at height	H_{nlEX1}	9.4	ft	from mudline elevation

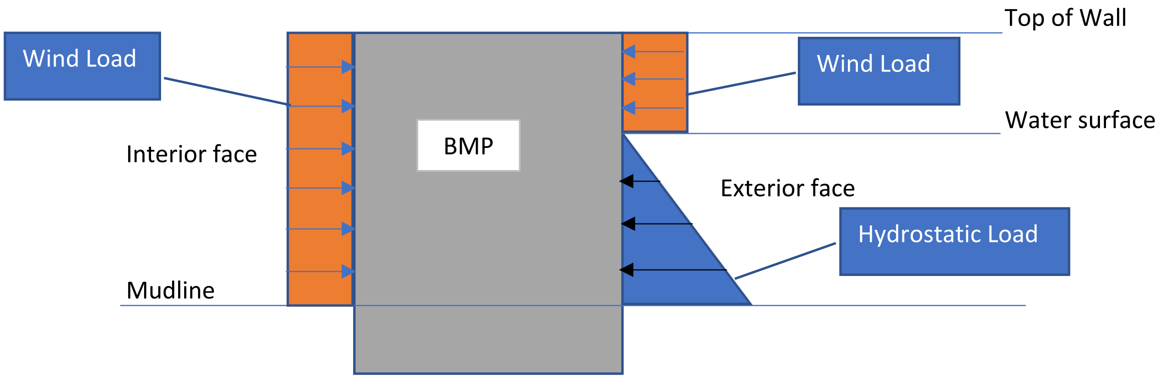
Load Govern Check Design case hydrostatic load governs
$H_{LEX1}>=N_{LEX1}$ and $H_{1EX1}>=H_{nlEX1}$

GHD

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	11
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel	Date	06/02/2022
Subject	BMP Design - Wind Load Parametric Study	Checked By	S.Chilka	Date	06/02/2022

Wind Load - Extreme Case (EX)

Condition 2



Top of Wall elevation	9	ft
Mudline elevation	-20	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LEX2}	19.50	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1EX2}	8.33	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX2i}	1.27	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2EX2}	14.5	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	43.87	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LEX2e}	0.18	kip/ L.F	per unit ft length of BMP
Acting at height	H_{3EX2}	27	ft	from mudline elevation

Net Load on BMP	N_{LEX2}	18.40	kip/L.F	$(H_{LEX2}+W_{LEX2e}-W_{LEX2i})$
Acting at height	H_{nlEX2}	8.1	ft	from mudline elevation

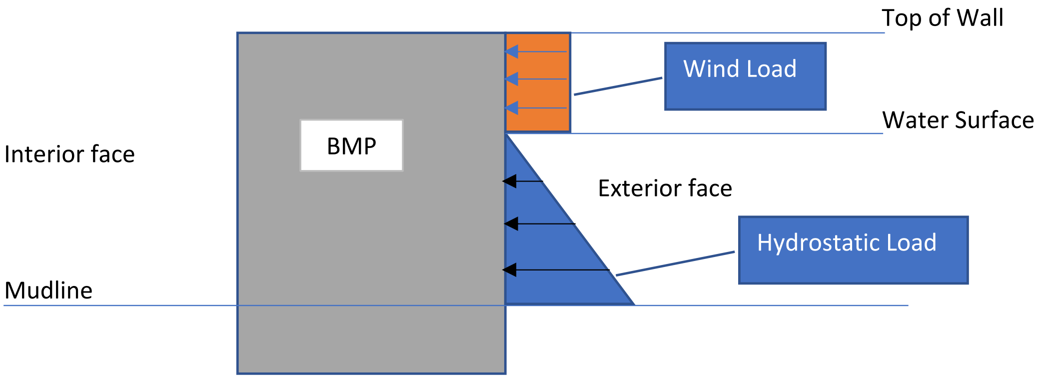
Load Govern Check Design case hydrostatic load governs

$H_{LEX1}>=N_{LEX2}$ and $H_{1EX1}>=H_{nlEX2}$

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	12
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel	Date	06/02/2022
Subject	BMP Design - Wind Load Parametric Study	Checked By	S.Chilka	Date	06/02/2022

Wind Load - Unusual Case (UN)

Condition 1



Top of Wall elevation	9	ft
Mudline elevation	-20	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LUN1}	19.50	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1UN1}	8.33	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN1e}	0.10	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2UN1}	27	ft	from mudline elevation

Net Load on BMP	N_{LUN1}	19.60	kip/L.F	$(H_{LUN1}+W_{LUN1e})$
Acting at height	H_{nlUN1}	8.4	ft	from mudline elevation

Load Govern Check

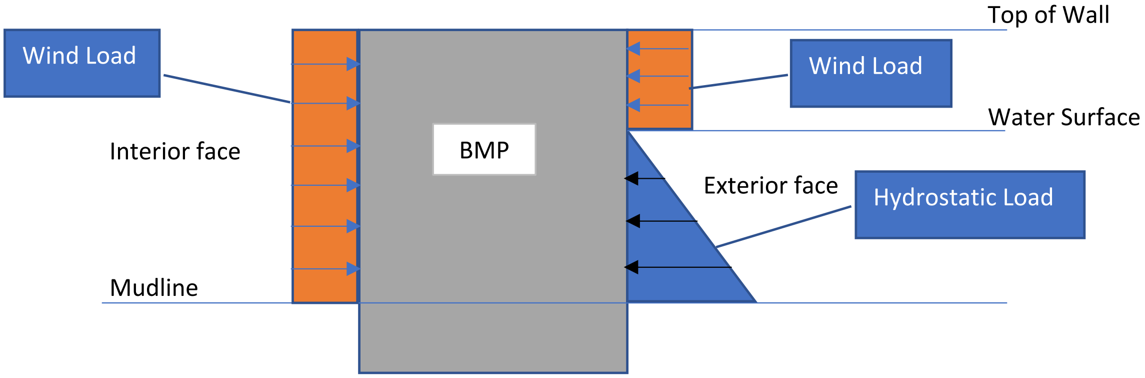
Design case hydrostatic load governs

H_{LEX1}>=N_{LUN1} and H_{1EX1}>=H_{nlLUN1}

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	13
Project	San Jacinto River Waste Pits Site	Sheets By	I.Goel	Date	06/02/2022
Subject	BMP Design - Wind Load Parametric Study	Checked By	S.Chilka	Date	06/02/2022

Wind Load - Unusual Case (UN)

Condition 2



Top of Wall elevation	9	ft
Mudline elevation	-20	ft
Water Surface elevation	5	ft

Hydrostatic Load on Exterior face

Density of water	ρ_w	62.4	lb/ft^3	
Total load on BMP	H_{LUN2}	19.50	kip/ L.F	per unit ft length of BMP
Acting at height	H_{1UN2}	8.33	ft	from mudline elevation

Wind Load on Interior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN2i}	0.72	kip/ L.F	per unit ft length of BMP
Acting at height	H_{2UN2}	14.5	ft	from mudline elevation

Wind Load on Exterior face

Wind pressure	q_{z3000}	24.89	lb/ft^2	Refer Basis of Design report
Total load on BMP	W_{LUN2e}	0.10	kip/ L.F	per unit ft length of BMP
Acting at height	H_{3UN2}	27	ft	from mudline elevation

Net Load on BMP	N_{LUN2}	18.88	kip/L.F	$(H_{LUN2}+W_{LUN2e}-W_{LUN2i})$
Acting at height	H_{nlUN2}	8.2	ft	from mudline elevation

Load Govern Check Design case hydrostatic load governs

$H_{LEX1}>=N_{LUN2}$ and $H_{1EX1}>=H_{nlUN2}$

ATTACHMENT 3.3

Client International Paper Company & McGinnes Industrial Maintenance Corporation
Job Number 11215702
Sheet 1
Project San Jacinto River Waste Pits Site
Sheets By S. Chilka
Date 06/05/2022
Subject Sheet Pile Seepage Evaluation
Checked By
Date

Section	H (ft)	h (ft)	H (m)	h (m)	L (ft)	n
C1	19	22	5.8	6.7	370.0	161
C2, C5	24	20	7.3	6.1	910.0	396
C3, C3A	14	25	4.3	7.6	450.0	196
C4	22	18	6.7	5.5	310.0	135
C4A	17	27	5.2	8.2	650.0	283
C6, C7	9	35	2.7	10.7	950.0	414

H = Height of Water Column above Sediment
h = Thickness of Sediment Layers
L = Approximate length of each analysis sections
n = number of interlocks per lineal feet of BMP
Sheet Pile Width, b 27.56 in, half pair
n = L / b

Arcelor Mittal, Impervious Steel Sheet Piles, Design & Practical Approach
Q1 = Discharge per interlock, cubic feet per second
Q = Total Discharge, cubic feet per second
Q1 = $\rho H (0.5 H + h)$ m3/s per interlock
Q = n Q1 m3/s, total
Q = (22.83E6) n Q1 gal/day or GPD

Inverse Resistivity (ρ) of Interlocks for various seal conditions
Materials by Arcelor Mittal. Other comparable but proprietary products available.

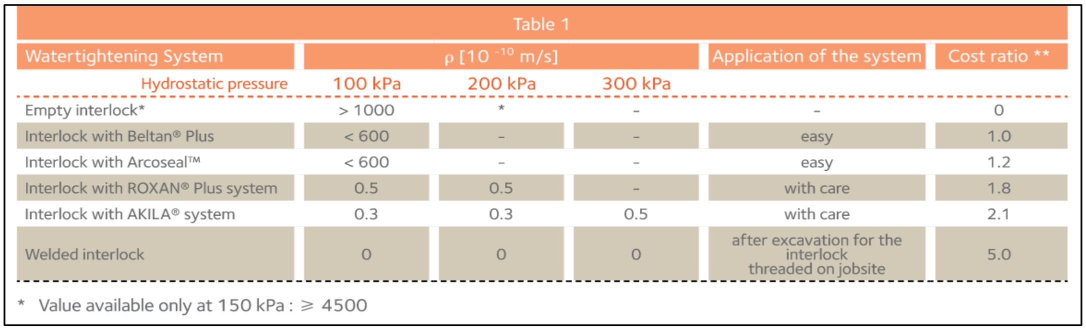


Table 1

Watertightening System	ρ [10^{-10} m/s]			Application of the system	Cost ratio **
Hydrostatic pressure	100 kPa	200 kPa	300 kPa		
Empty interlock*	> 1000	*	-	-	0
Interlock with Beltan® Plus	< 600	-	-	easy	1.0
Interlock with Arcoseal™	< 600	-	-	easy	1.2
Interlock with ROXAN® Plus system	0.5	0.5	-	with care	1.8
Interlock with AKILA® system	0.3	0.3	0.5	with care	2.1
Welded interlock	0	0	0	after excavation for the interlock threaded on jobsite	5.0

* Value available only at 150 kPa : ≥ 4500

Assume ρ 1.00E-07 m/s, minimum inverse resistivity for standard interlocks
Use SF 1.5 Safety factor for test parameters
ρ, design 1.50E-07

Section	Q1 (m3/s)	Q (GPD)
C1	8.3E-06	30676
C2, C5	1.1E-05	96815
C3, C3A	6.2E-06	27927
C4	8.9E-06	27398
C4A	8.4E-06	54341
C6, C7	5.0E-06	46785

Client	International Paper Company & McGinnes Industrial Maintenance Corporation	Job Number	11215702	Sheet	2
Project	San Jacinto River Waste Pits Site	Sheets By	S. Chilka	Date	06/05/2022
Subject	Sheet Pile Seepage Evaluation	Checked By		Date	

Assume	ρ	6.00E-08	m/s, maximum inverse resistivity for Beltan Plus or Arcoseal Seal
Use	SF	1.5	Safety factor for test parameters
	ρ, design	9.00E-08	

Section	Q1 (m3/s)	Q (GPD)
C1	5.00E-06	18406
C2, C5	6.42E-06	58089
C3, C3A	3.75E-06	16756
C4	5.33E-06	16439
C4A	5.05E-06	32605
C6, C7	2.97E-06	28071

Assume	ρ	5.00E-11	m/s, maximum inverse resistivity for ROXAN Plus System
Use	SF	1.5	Safety factor for test parameters
	ρ, design	7.50E-11	

Section	Q1 (m3/s)	Q (GPD)
C1	4.17E-09	15
C2, C5	5.35E-09	48
C3, C3A	3.12E-09	14
C4	4.45E-09	14
C4A	4.21E-09	27
C6, C7	2.48E-09	23

Assume	ρ	3.00E-11	m/s, maximum inverse resistivity for AKILA Seal
Use	SF	1.5	Safety factor for test parameters
	ρ, design	4.50E-11	

Section	Q1 (m3/s)	Q (GPD)
C1	2.50E-09	9
C2, C5	3.21E-09	29
C3, C3A	1.87E-09	8
C4	2.67E-09	8
C4A	2.52E-09	16
C6, C7	1.49E-09	14

ATTACHMENT 3.4

Client	IP & MIMC	Job Number	11215702	Sheet	1
Project	San Jacinto River Waste Pits Site	Sheets by	S. Chilka	Date	6/10/2022
Subject	Barge Impact - Northern Impoundment	Checked by		Date	

Summary of Impact Force for different impact velocities (V)

Design Barge	30,000 BBL		
Width	54 ft		
Contact Length	50 ft		
Load Case 1	20 kip/LF =	1000 kip	
Load Case 2	28 kip/LF =	1400 kip	

	V (ft/s)	**1.00**	**1.60**	**2.20**	**3.80**	**5.30**	
	V (knots)	**0.59**	**0.95**	**1.30**	**2.25**	**3.14**	
30,000 BBL Barge, Ballast	KE of Impact	30	76	144	430	837	kip.ft
	Barge Damage Length	0.02	0.04	0.08	0.25	0.47	ft
	Head-On Impact Force	71	182	344	1013	1401	kips
	30-deg Impact Force	54	137	258	760	1051	kips

	V (ft/s)	**1.00**	**1.60**	**2.20**	**3.80**	**5.30**	
	V (knots)	**0.59**	**0.95**	**1.30**	**2.25**	**3.14**	
30,000 BBL Barge, Laden	KE of Impact	172	440	832	2484	4831	kip.ft
	Barge Damage Length	0.10	0.25	0.47	1.32	2.39	ft
	Head-On Impact Force	409	1035	1401	1494	1611	kips
	30-deg Impact Force	307	777	1050	1120	1209	kips

Notes

🟧	Equivalent to Load Case 1
🟦	Equivalent to Load Case 2

Client	IP & MIMC	Job Number	11215702	Sheet	2
Project	San Jacinto River Waste Pits Site	Sheets by	S. Chilka	Date	6/10/2022
Subject	Barge Impact - Northern Impoundment	Checked by		Date	

Summary of Impact Force for different impact velocities (V)

Design Barge parameters from TXDOT Bridge Pier Design Criteria

Length	300	ft	
Width / Beam	54	ft	
Depth	12	ft	Hull Height
Water Unit Weight	63	pcf	Brackish water
Water Depth	20	ft	Flood Level to mudline

Two conditions of the barge - empty (ballast) and fully loaded (laden) are considered to determine the impact force for a head-on collision with the BMP

Ballast Draft	1.8	ft	Unloaded / Empty Barge
UKC Ratio, Ballast	10		Underkeel clearance to water depth ratio
Laden Draft	10.3	ft	Loaded Barge
UKC Ratio, Laden	1		Underkeel clearance to water depth ratio

Ballast Displacement	1820	kips	Lightship condition	
Alternate Units	910	ST	813	LT
Laden Displacement	10500	kips	Total Weight of the Barge + Cargo	
Alternate Units	5250	ST	4688	LT
Deadweight, DWT	9400	kips	Cargo Capacity	
Alternate Units	4700	ST	4196	LT

Impact Force - AASHTO Section 3.14

ft/s 0.00 2.2 ft/s 0.67 m/s

Kinetic Energy, $KE = \frac{C_H W V^2}{29.2}$ kip.ft (Eq. 3.14.7-1)

Where, W = Total or Laden Displacement (tonne) Note: 1 tonne = 0.98 LT

V = Impact Velocity

C_H = Hydrodynamic Mass Coefficient

C_H, Ballast	1.05	UKC Ratio > 0.5		
KE, Ballast	143	kip.ft	194	kN.m
C_H, Laden	1.05	UKC Ratio > 0.5		
KE, Laden	823	kip.ft	1117	kN.m

The total impact force on the barge pile is directly proportional to the horizontal damage length for a barge

Damage Length $a_B = 10.2\left(\sqrt{1+\frac{KE}{5,672}}-1\right)$ (Eq. 3.14.12-1)

a_B, Ballast	0.08	ft	The 10.2 factor is for 35ft wide barge. It should be
a_B, Laden	0.46	ft	modified by (10.2 / (Barge Width /35 ft)) for others.

Impact Force, Ballast	340	kip	(Eq. 3.14.11-1)
Impact Force, Laden	1400	kip	(Eq. 3.14.11-2)

Client	**IPC and MIMC**	Job Number	11215702	Sheet	3
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

Elevations (ft)	**NAVD88**
Top of Wall	+9
Top of Water Outside	+9

Steel Sheet Pile, Fy = 60 ksi

Loading Condition	**Allowable Stress Factor**	
	Moment & Axial Load	**Shear**
Usual, U	0.50	0.33
Unusual, UNU	0.67	0.44
Extreme, EXT	0.88	0.58

Sacrificial thickness (tc) - for accounting corrosion	0.0175	in
Corroded flange thickness (trf) - two exposed faces	tf-(2tc)	in
Corroded web thickness (trw) - two exposed faces	tw-(2tc)	in
Corroded section modulus Sr	(trf/tf)*S	in^3/ft
Corroded section area Avr	(trw/tw)*Av	in^2/ft

Corroded Section Capacities

Sheet Pile Section	**S (in^3/ft)**	**tf(in)**	**trf(in)**	**Sr (in^3/ft)**	**Moment (kip.ft / LF)**		
					U	**UNU**	**EXT**
AZ 26-700	48.40	0.48	0.45	44.87	112	149	196
AZ 40-700N	74.30	0.67	0.63	70.41	176	234	308
AZ 36-700N	66.80	0.59	0.56	62.84	157	209	275
AZ 52-700	95.90	0.95	0.91	92.35	231	307	404

Sheet Pile Section	**A_v (in^2/ft)**	**tw(in)**	**trw(in)**	**A_{vr} (in^2/ft)**	**Shear (kip / LF)**		
					U	**UNU**	**EXT**
AZ 26-700	8.69	0.48	0.45	8.06	160	212	279
AZ 40-700N	10.25	0.52	0.49	9.56	189	252	331
AZ 36-700N	8.67	0.44	0.41	7.98	158	210	276
AZ 52-700	13.30	0.67	0.63	12.60	250	332	437

Sheet Pile Design Summary - Barge Impact Study

Analysis Sections	**Design Load (kip/ft)**	**Total Applied Force (kip)**	**Analysis Demands per LF**			**DCR - Moment**	**DCR - Shear**
			Moment (kip-ft)	**Shear (kip)**	**Deflection (ft)**		
C2, AZ 40-700N	20	1000	342.4	64.5	1.4	1.11	0.19
	28	1400	465.9	68.5	2.8	1.51	0.21
C4, AZ 26-700	20	1000	159.6	39.6	0.8	0.81	0.14
	28	1400	251.2	39.6	1.6	1.28	0.14

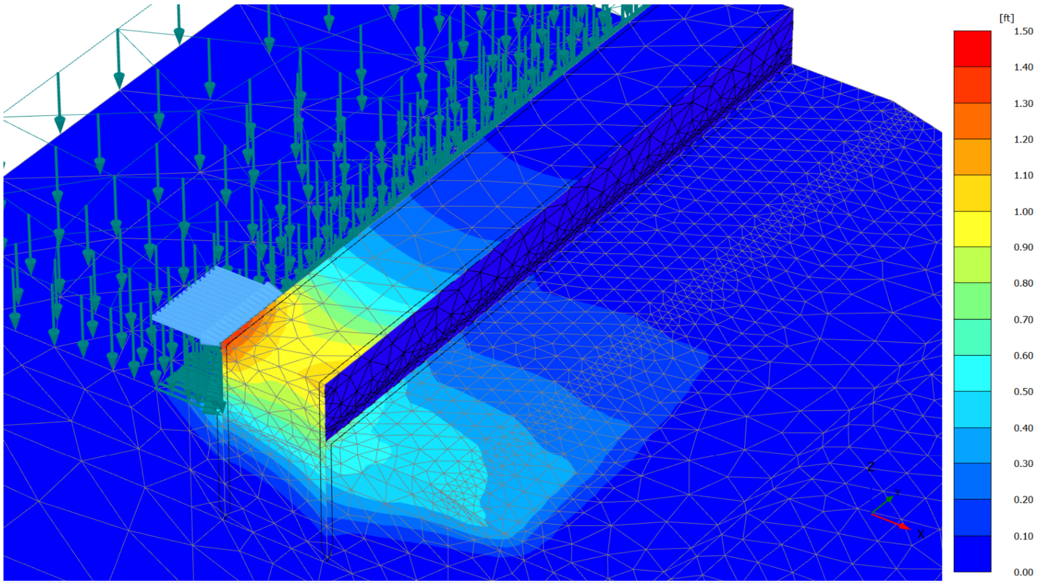
Total Force = Design Load x Contact Area (50 ft x 1 ft)

Alternative Sections	**Design Load (kip/ft)**	**DCR - Moment**	**DCR - Shear**
C4, AZ 36-700N	20	0.58	0.14
	28	0.91	0.14

Client	**IPC and MIMC**	Job Number	11215702	Sheet	4
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

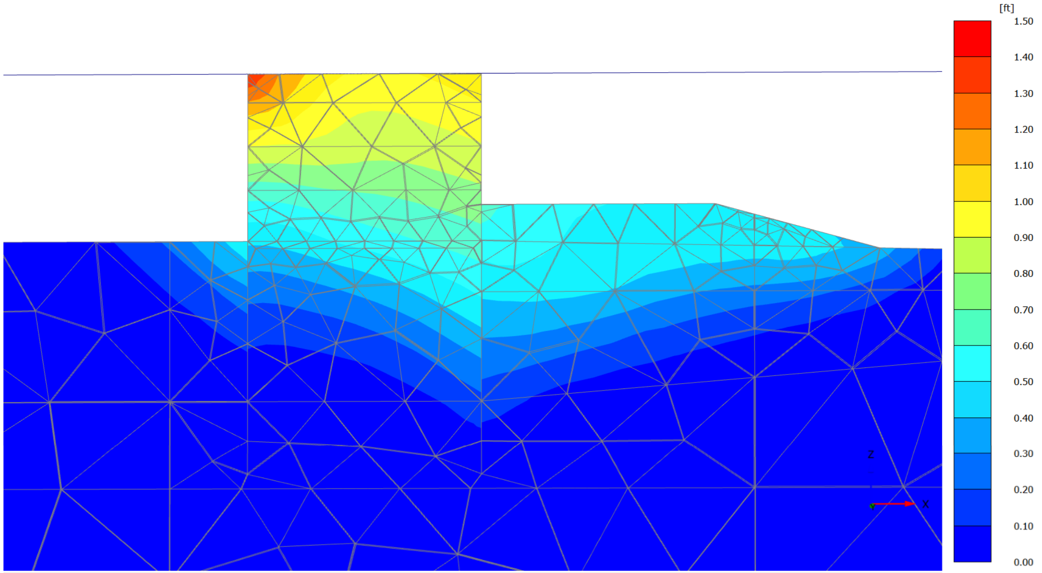
Analysis Output Results - Section C2 - 20kip/ft design load

Deflection Output



Phase displacements |Pu| (scaled up 5.00 times)

Maximum value = 1.410 ft (Element 11 at Node 174)

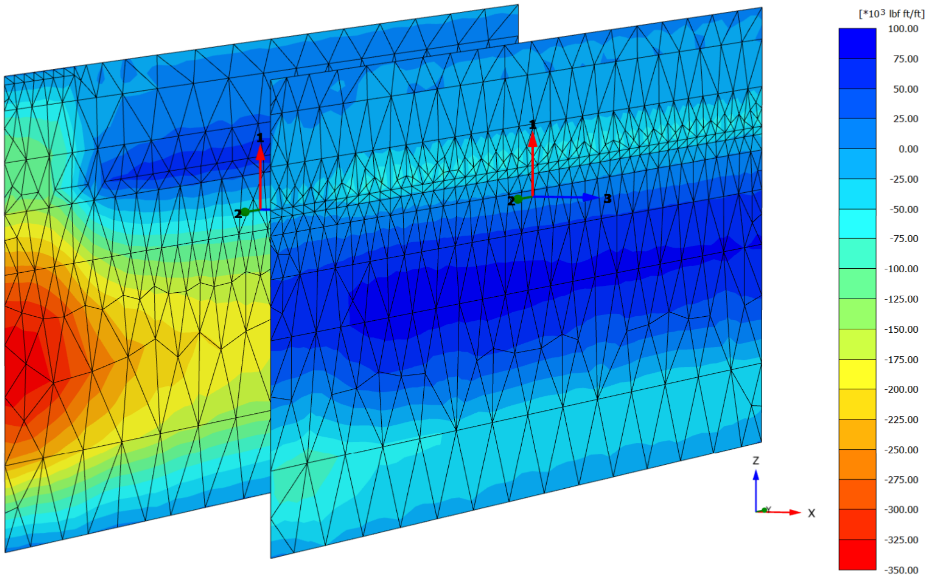


Phase displacements |Pu| (scaled up 5.00 times)

Maximum value = 1.409 ft

Client	**IPC and MIMC**	Job Number	11215702	Sheet	5
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

Bending Moment Output

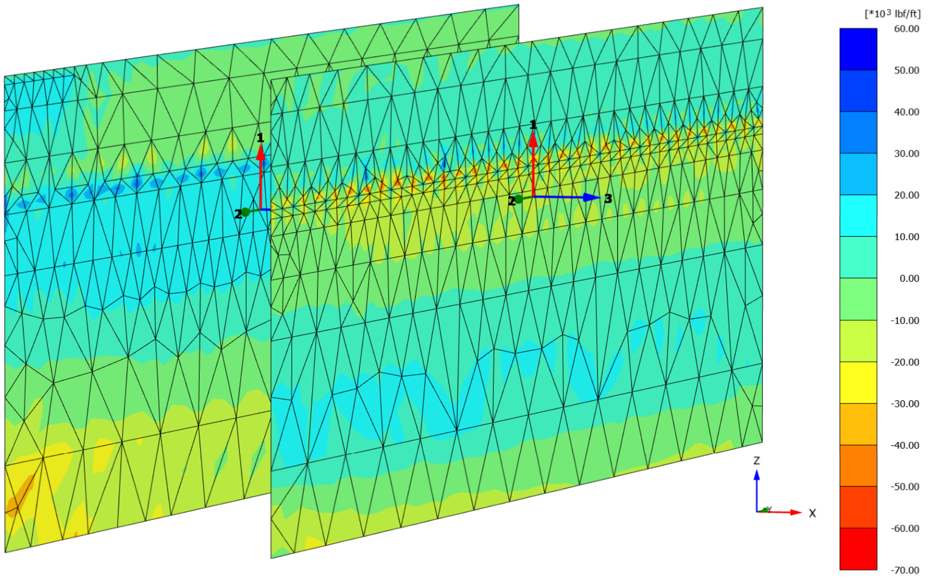


Bending moments M_{11} (scaled up 0.0200×10^{-3} times)

Maximum value = 93.60×10^3 lbf ft/ft (Element 877 at Node 1499)

Minimum value = -342.4×10^3 lbf ft/ft (Element 960 at Node 8087)

Shear Force Output



Shear forces Q_{13} (scaled up 0.100×10^{-3} times)

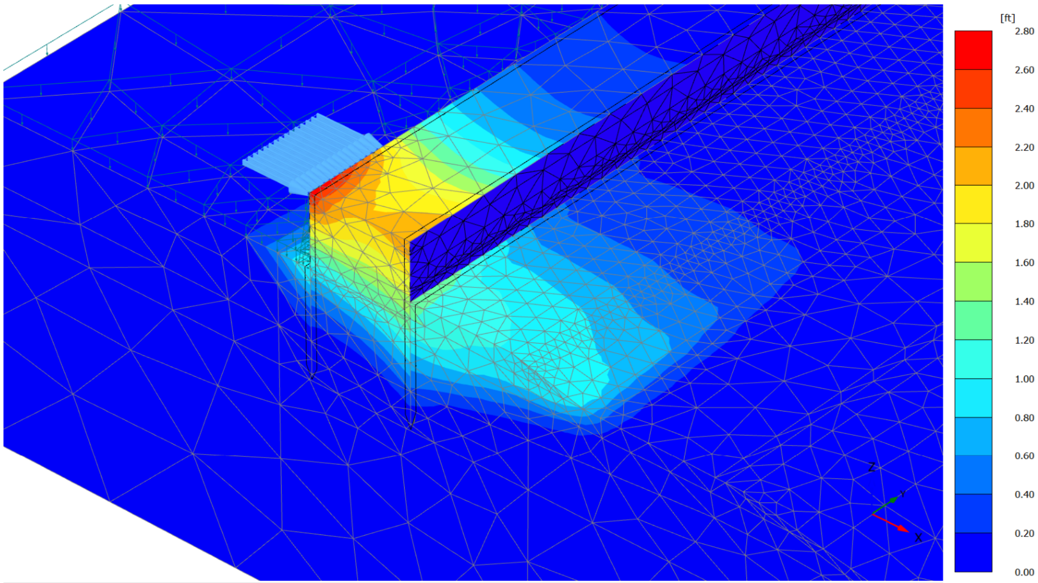
Maximum value = 51.30×10^3 lbf/ft (Element 419 at Node 2228)

Minimum value = -64.47×10^3 lbf/ft (Element 262 at Node 13546)

Client	**IPC and MIMC**	Job Number	11215702	Sheet	6
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

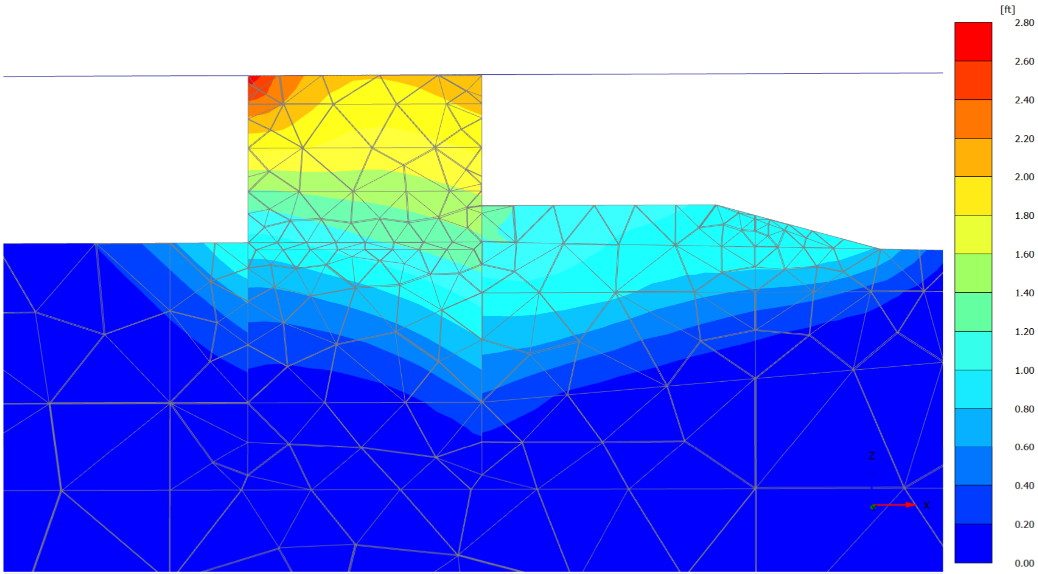
Analysis Output Results - Section C2 - 28kip/ft design load

Deflection Output



Phase displacements |Pu| (scaled up 5.00 times)

Maximum value = 2.750 ft (Element 11 at Node 174)

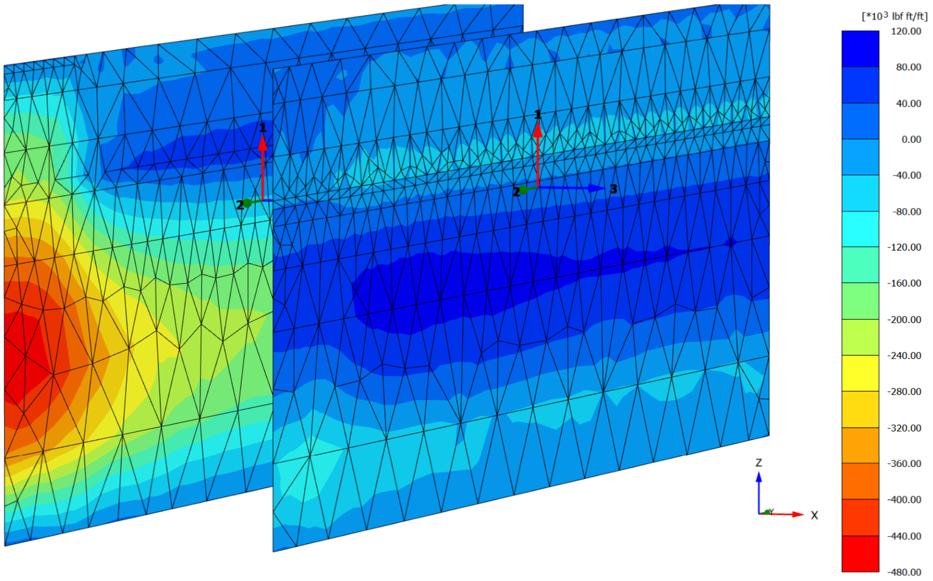


Phase displacements |Pu| (scaled up 5.00 times)

Maximum value = 2.748 ft

Client	**IPC and MIMC**	Job Number	11215702	Sheet	7
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

Bending Moment Output

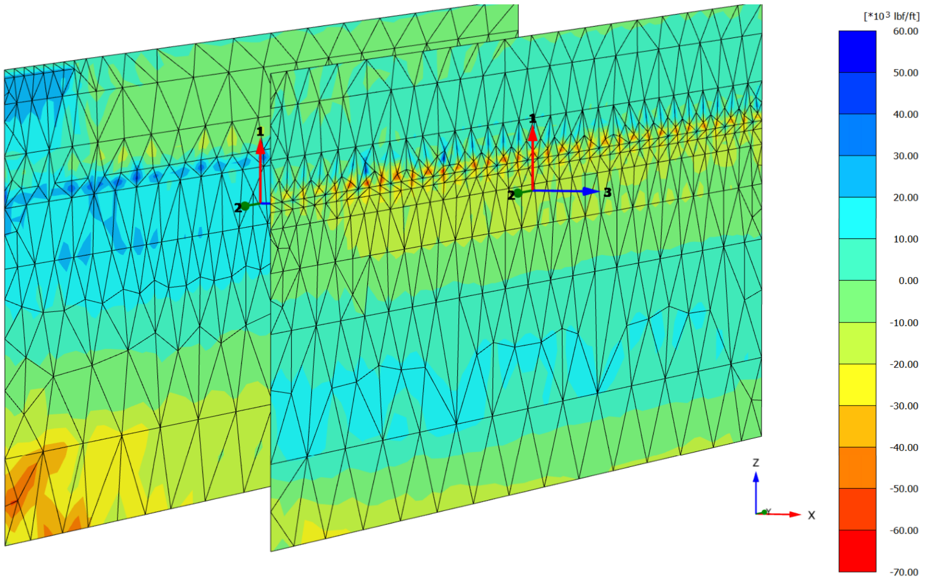


Bending moments M_{11} (scaled up 0.0200*10^{-3} times)

Maximum value = 102.8*10^3 lbf ft/ft (Element 880 at Node 1503)

Minimum value = -465.9*10^3 lbf ft/ft (Element 960 at Node 8087)

Shear Force Output



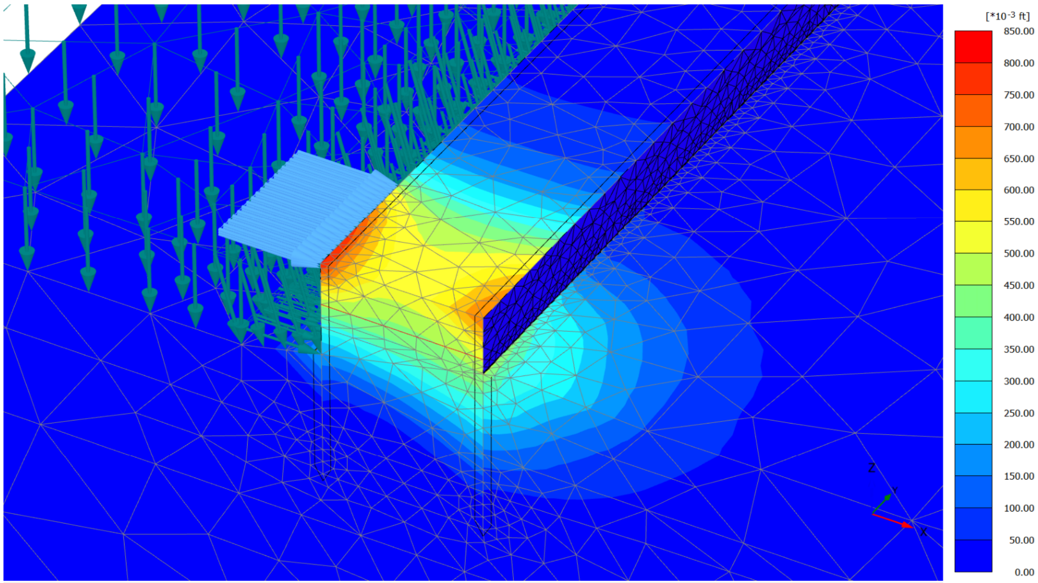
Shear forces Q_{13} (scaled up 0.0500*10^{-3} times)

Maximum value = 53.45*10^3 lbf/ft (Element 265 at Node 13558)

Minimum value = -68.54*10^3 lbf/ft (Element 262 at Node 13546)

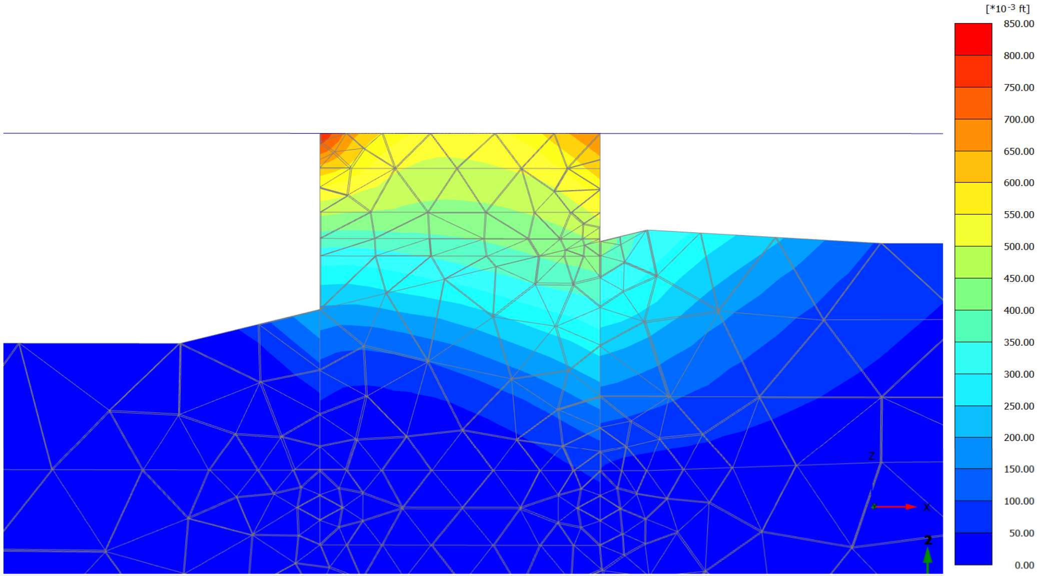
Analysis Output Results - Section C4 - 20kip/ft design load

Deflection Output



Phase displacements |Pu| (scaled up 10.0 times)

Maximum value = 0.8106 ft (Element 116 at Node 243)

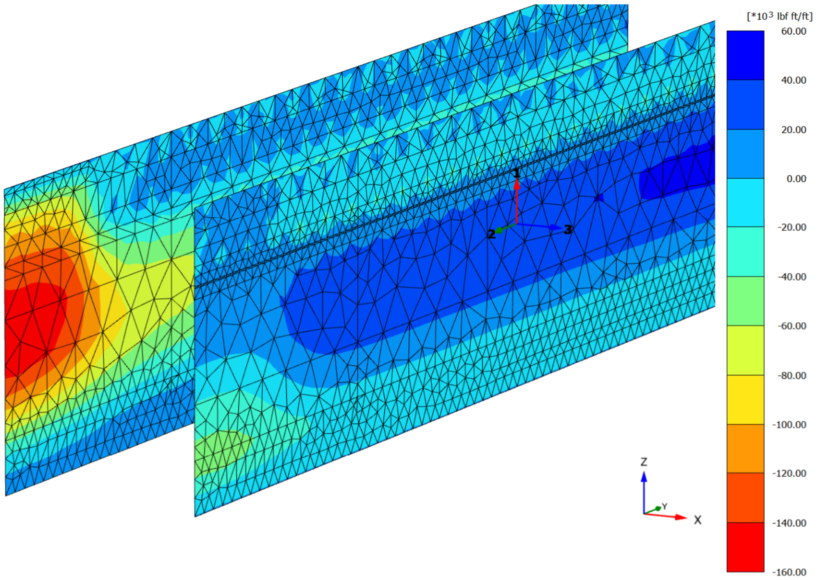


Phase displacements |Pu| (scaled up 10.0 times)

Maximum value = 0.8104 ft

Client	**IPC and MIMC**	Job Number	11215702	Sheet	9
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

Bending Moment Output

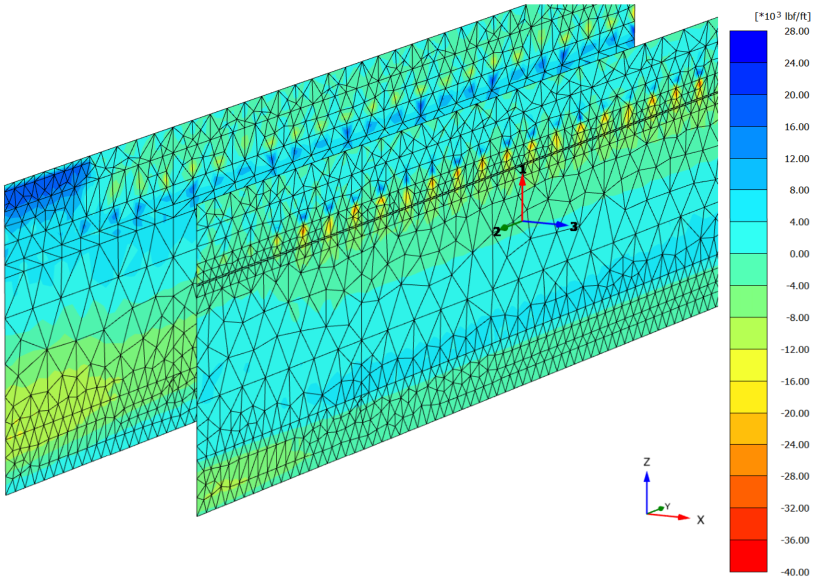


Bending moments M_{11} (scaled up 0.0500*10^{-3} times)

Maximum value = 53.20*10^3 lbf ft/ft (Element 1887 at Node 3739)

Minimum value = -159.6*10^3 lbf ft/ft (Element 2121 at Node 20066)

Shear Force Output



Shear forces Q_{13} (scaled up 0.200*10^{-3} times)

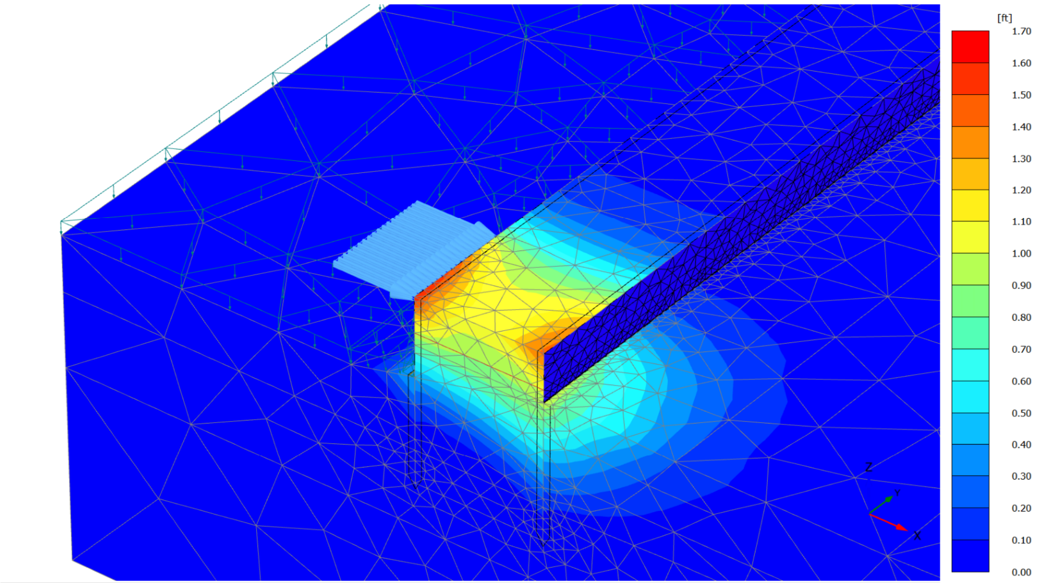
Maximum value = 25.79*10^3 lbf/ft (Element 971 at Node 7942)

Minimum value = -39.55*10^3 lbf/ft (Element 1036 at Node 7940)

Client	**IPC and MIMC**	Job Number	11215702	Sheet	10
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

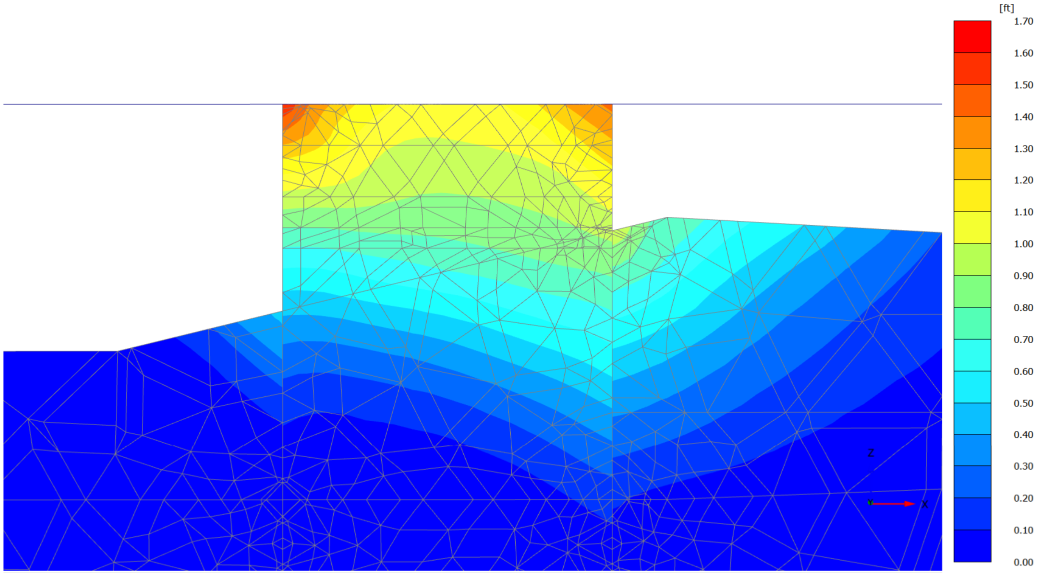
Analysis Output Results - Section C4 - 28kip/ft design load

Deflection Output



Phase displacements |Pu| (scaled up 5.00 times)

Maximum value = 1.617 ft (Element 116 at Node 243)

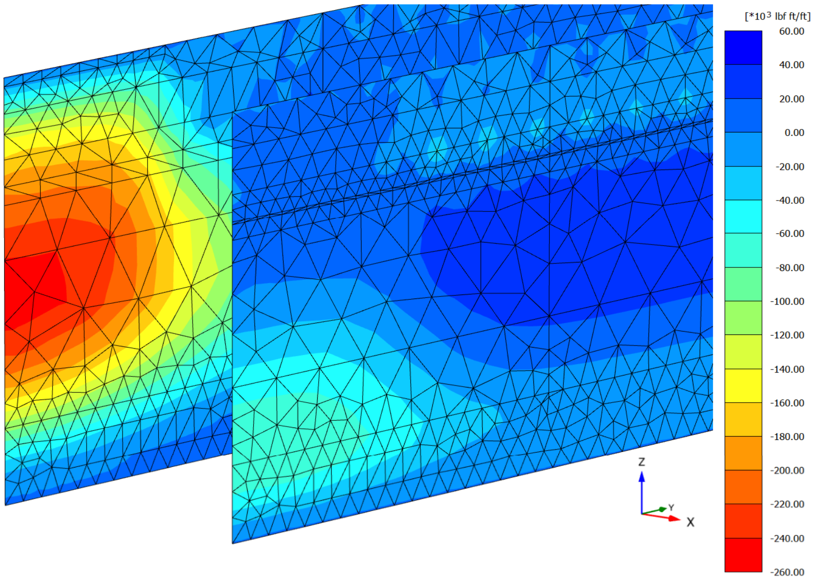


Phase displacements |Pu| (scaled up 5.00 times)

Maximum value = 1.608 ft

Client	**IPC and MIMC**	Job Number	11215702	Sheet	11
Project	San Jacinto River Waste Pits Site	Sheets by	I. Goel	Date	6/10/2022
Subject	San Jacinto Barge Impact Study Summary	Checked by	S. Chilka	Date	6/10/2022

Bending Moment Output

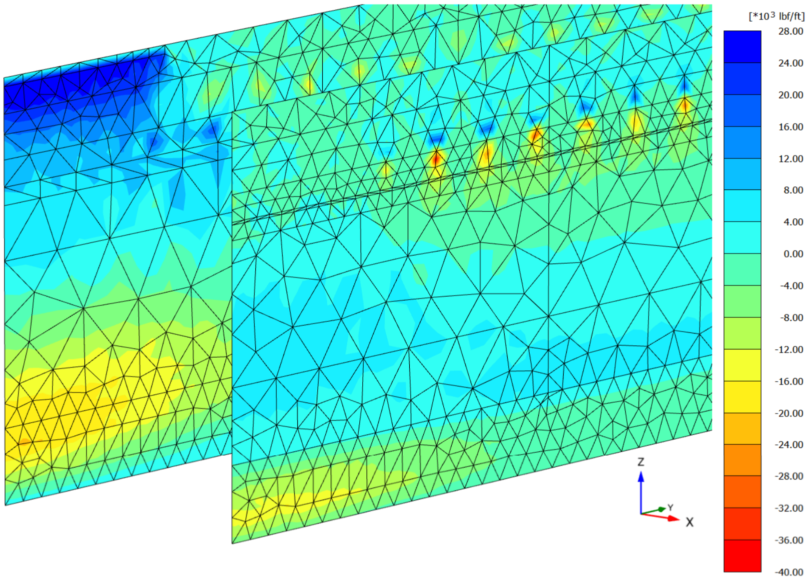


Bending moments M_{11} (scaled up 0.0500*10^{-3} times)

Maximum value = 53.24*10^3 lbf ft/ft (Element 1887 at Node 3739)

Minimum value = -251.2*10^3 lbf ft/ft (Element 2121 at Node 20066)

Shear Force Output



Shear forces Q_{13} (scaled up 0.200*10^{-3} times)

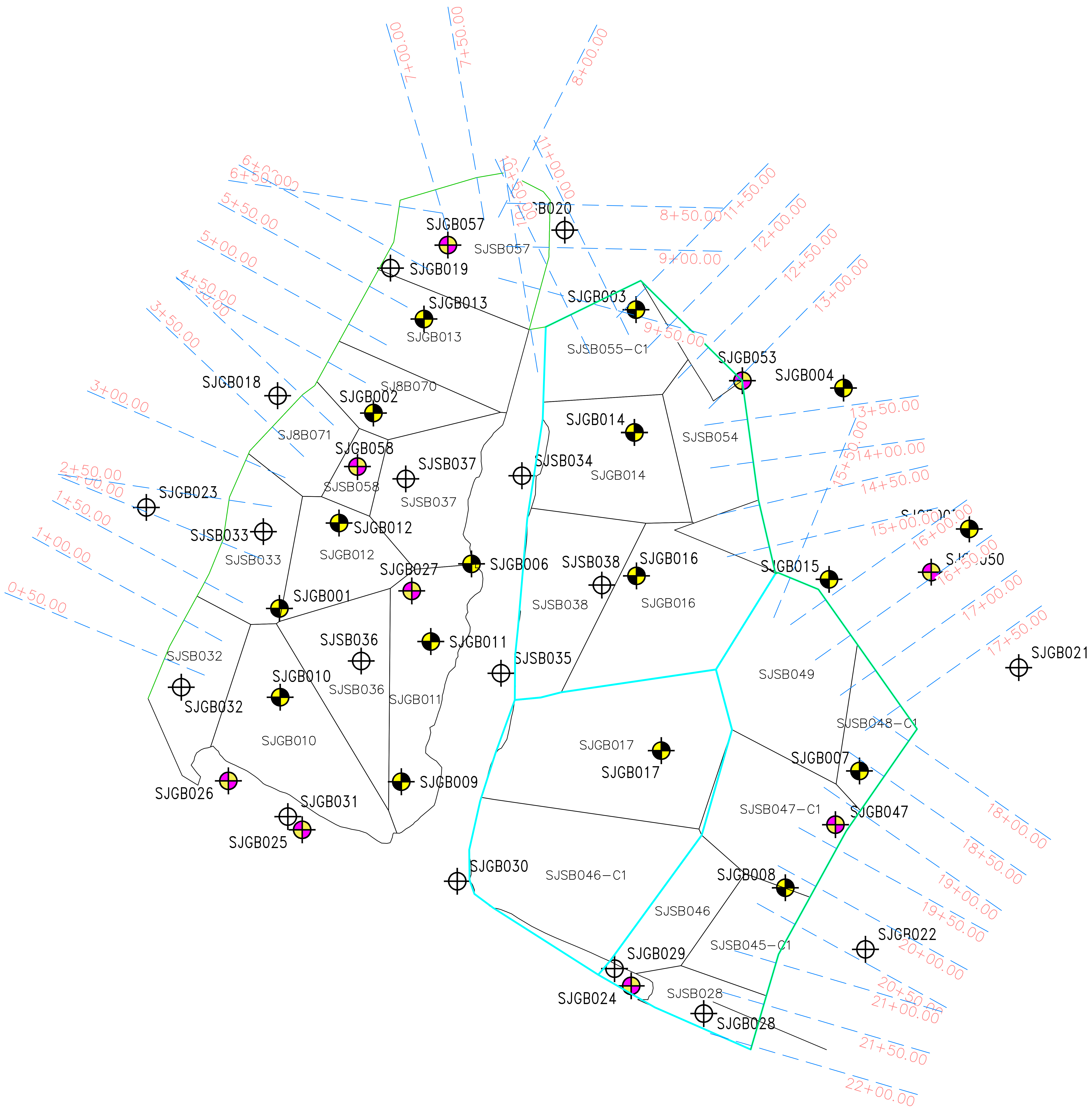
Maximum value = 27.83*10^3 lbf/ft (Element 10 at Node 5960)

Minimum value = -39.62*10^3 lbf/ft (Element 1036 at Node 7940)

Attachment 4

Northern Impoundment Preliminary Vibration Analysis

ENCLOSURE 4.1



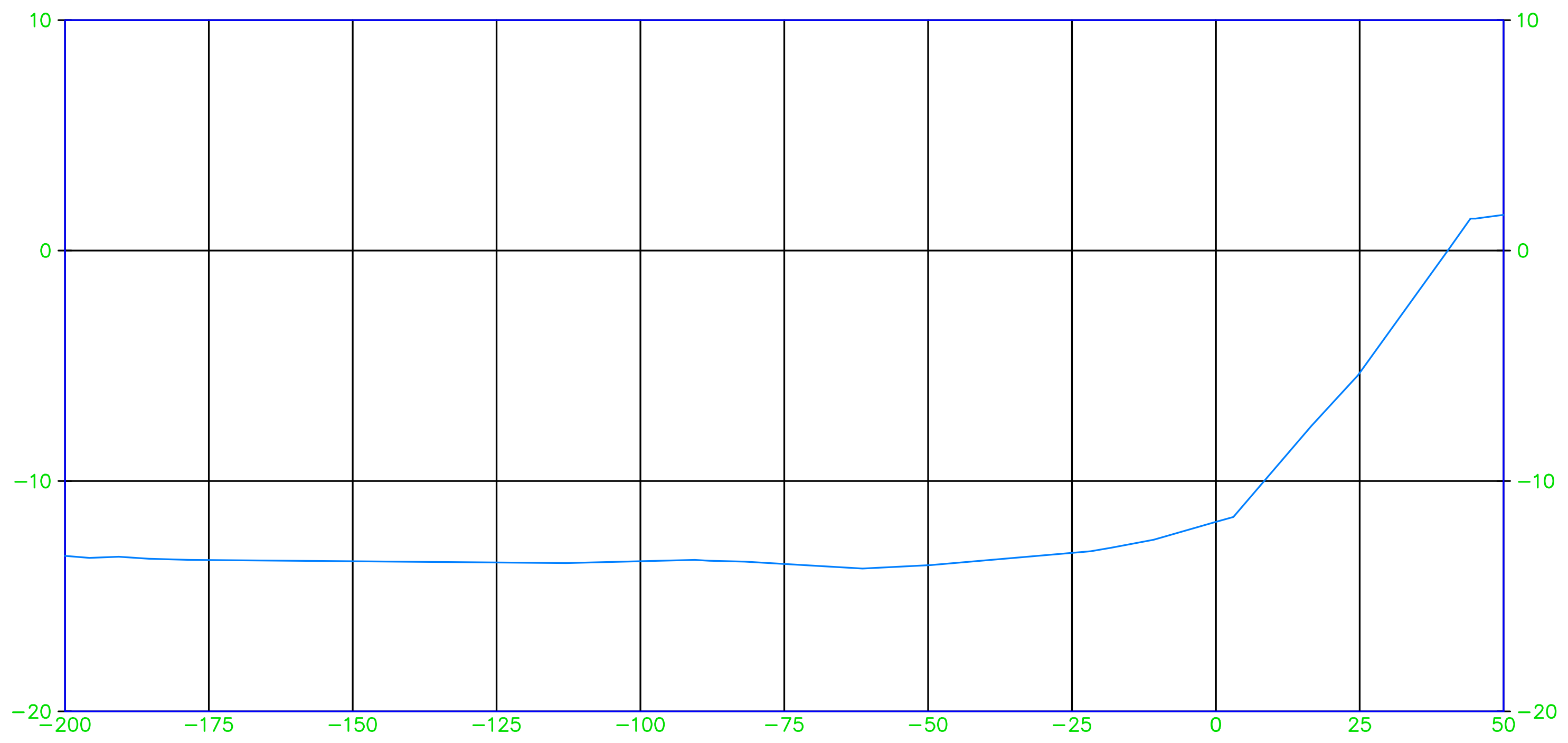
San Jacinto River Waste Pits

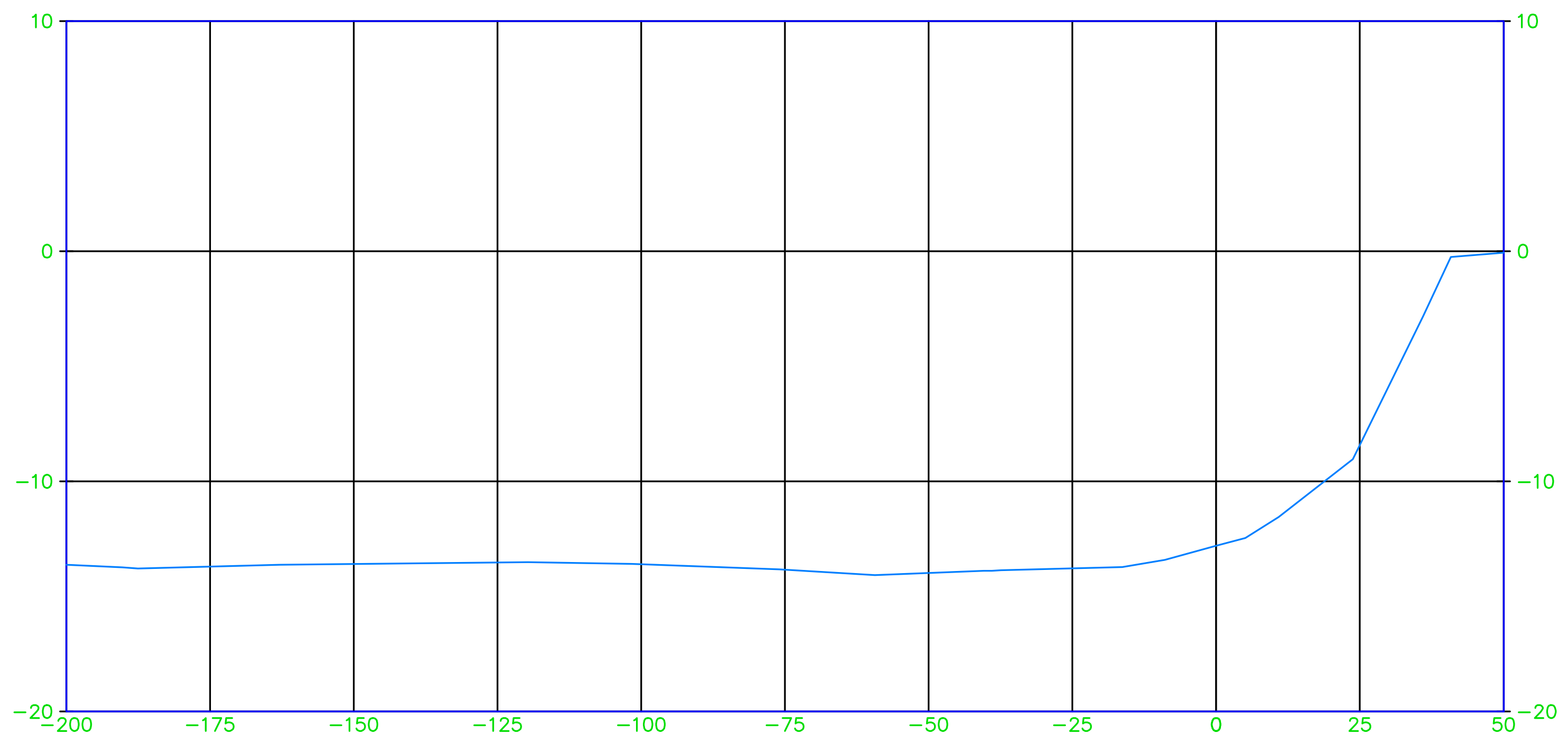
Harris County, Texas

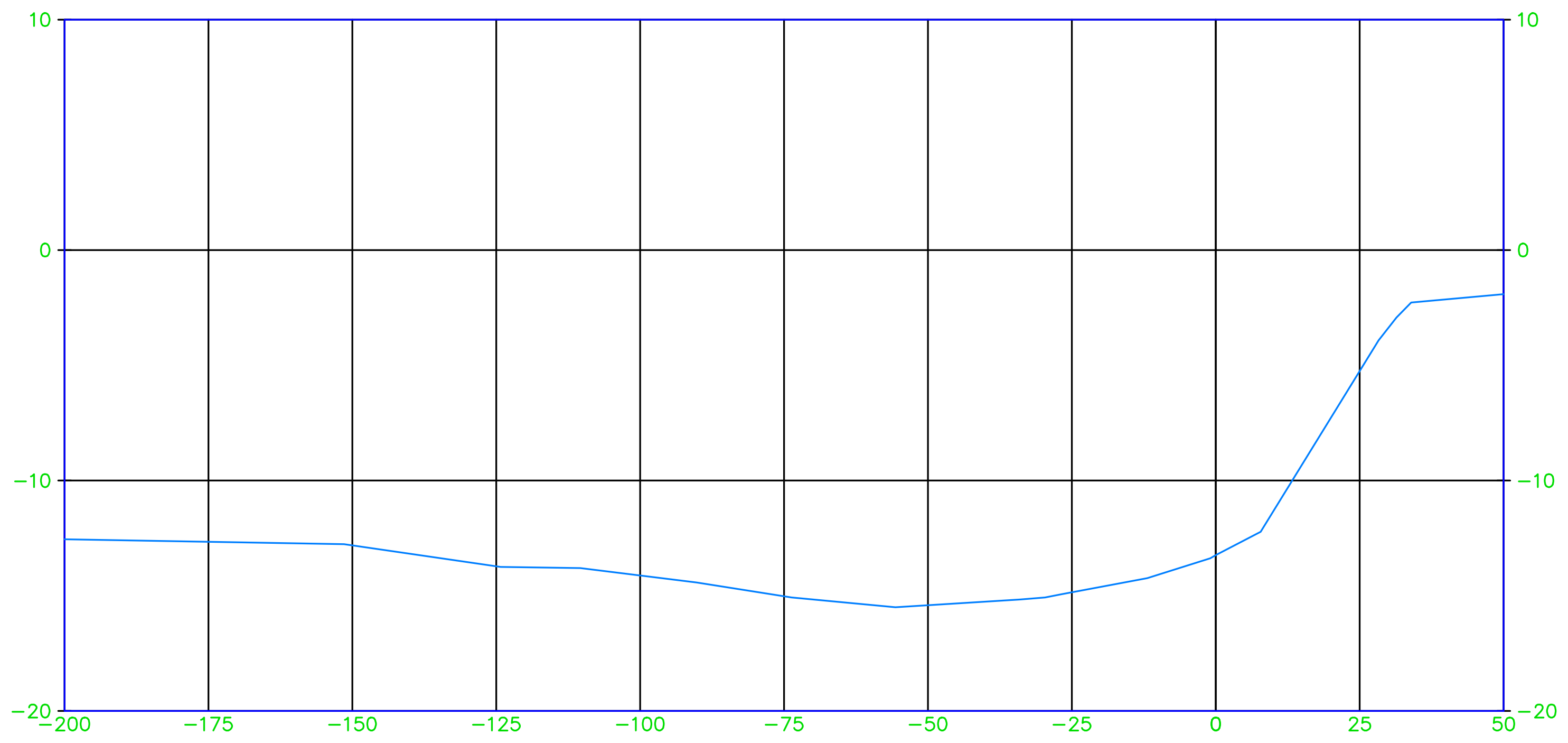
Ardaman & Associates, Inc.
Geotechnical, Environmental and
Materials Consultants

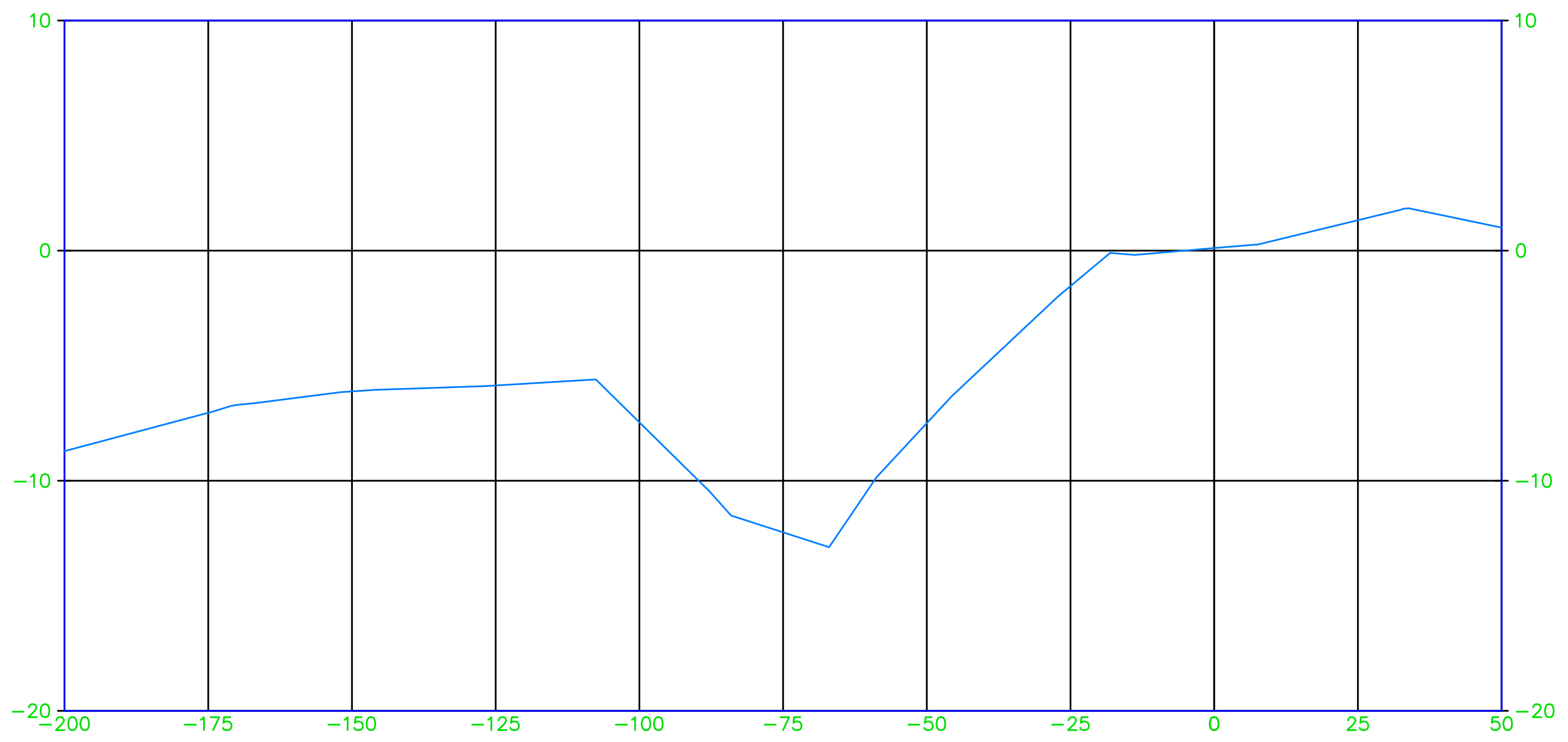
ENG	Drawn by:	Checked by:
GFS	AC	MLW
File No.: 18-2876	Date: 05/18/20	FIG No. 11

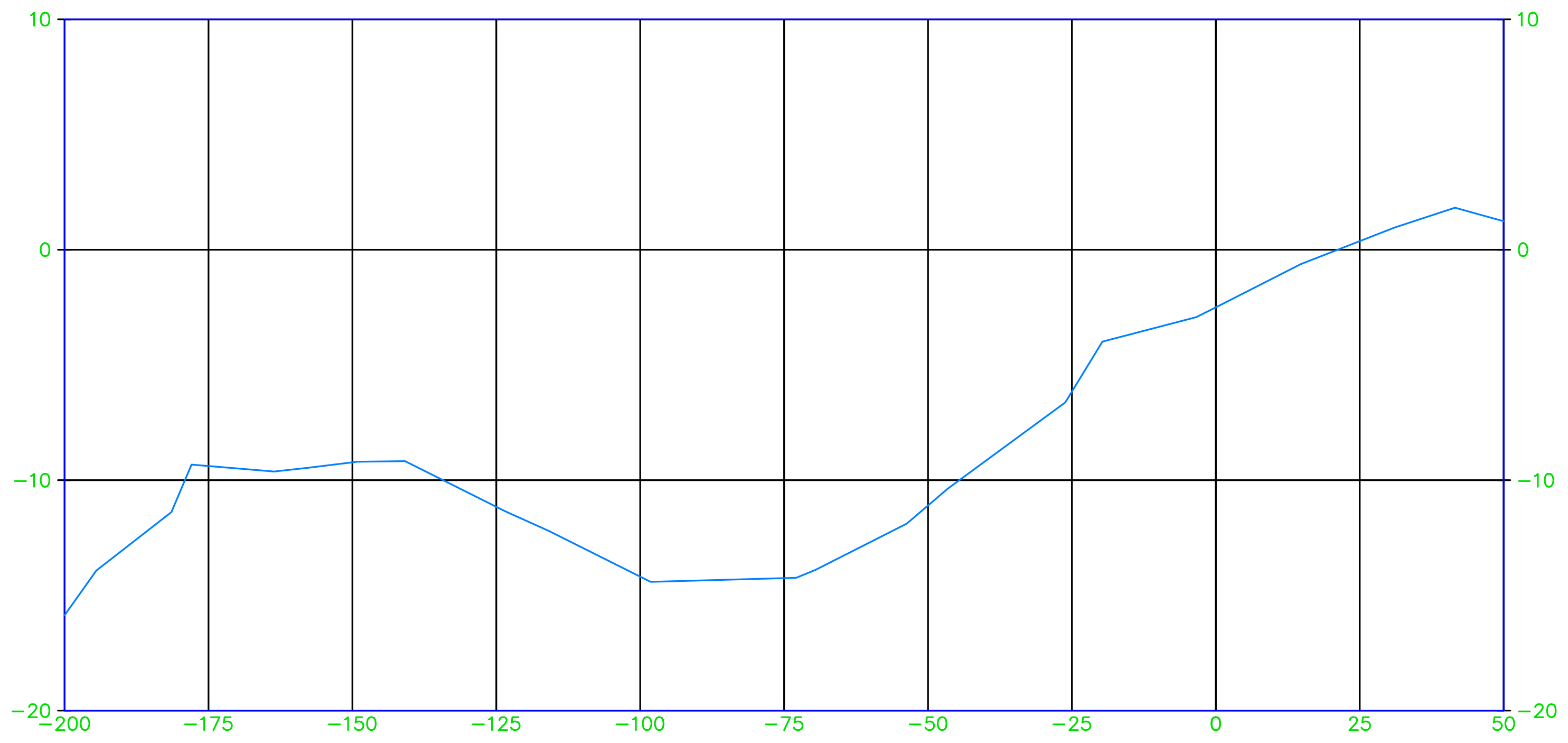
Title: **N.I. Vibration Analysis Stationing**


3+50.00


4+00.00


5+00.00


21+50.00


22+00.00

San Jacinto River Waste Pits

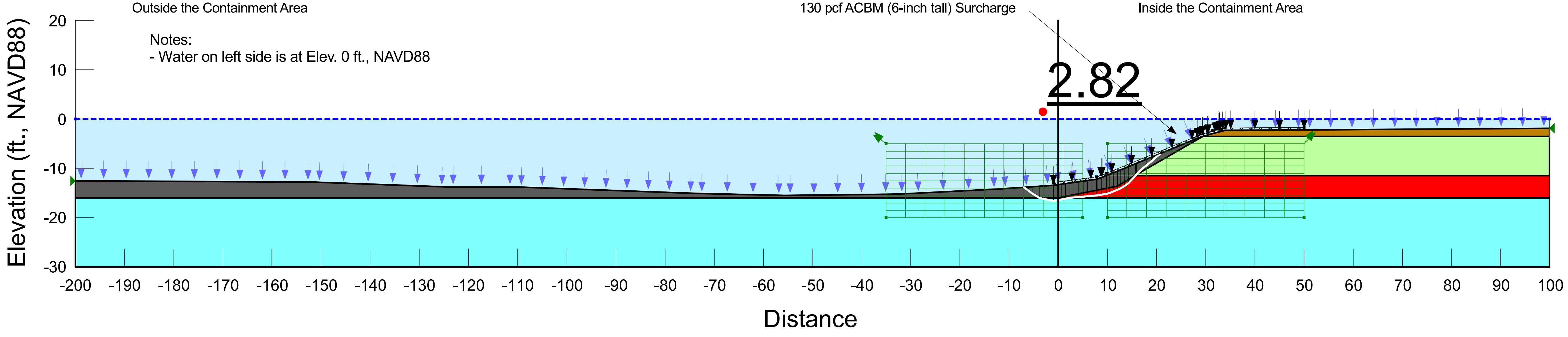
Harris County, Texas

Ardaman & Associates, Inc.
Geotechnical, Environmental and
Materials Consultants

ENG **GFS**	Drawn by: **AC**	Checked by: **MLW**
File No.: **18-2876**	Date: **05/18/20**	FIG **No. 12**

Title:
N.I. Vibration Analysis X-Sections

Method: Spencer
Slip Surface Option: Block
Factor of Safety: 2.82
Horz Seismic Coef.:



Northern Impoundment - Sta 5+00 (Vibration Analysis)

Horizontal Seismic Coef.: 0g

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟫	2- CLs (-1.6 to -3.4)	Mohr-Coulomb	117	200	0	0	1
🟩	3- CL (-3.4 to -11.5)	Mohr-Coulomb	95	900	0	0	1
🟥	4- SM (-11.5 to -16)	Mohr-Coulomb	120	0	25	0	1
🟦	4- SM (-16 to -???)	Mohr-Coulomb	120	0	33	0	1
⬛	Soft Soil	Mohr-Coulomb	90	100	0	0	1

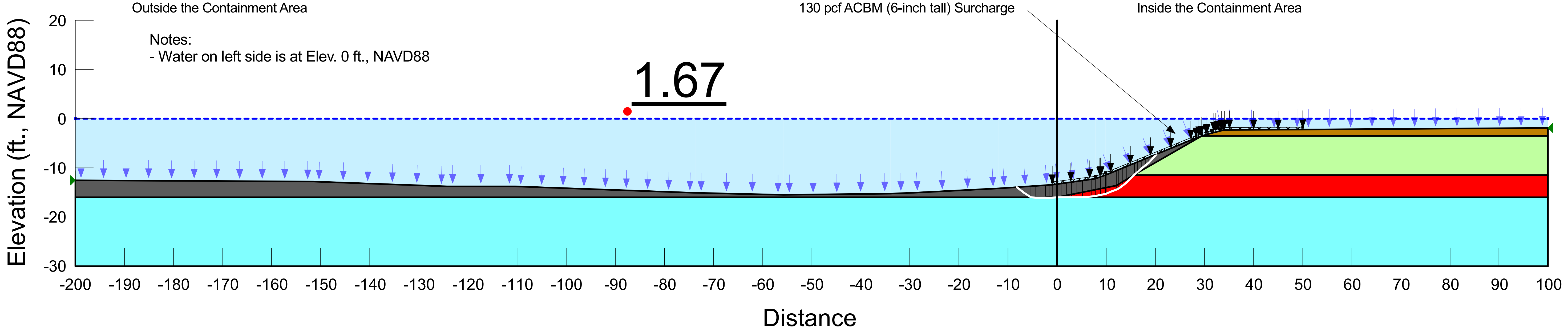
Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman & Associates, Inc.

Analysis Name: Deep - Spencer Block	
File Name: 18-2876 North Sta 5+00 Vibration (B058) - Soft Soil ACBM.gsz	
Date: 04/21/2020	Scale: 1:250

Figure No. 13

Method: Spencer
Slip Surface Option: Critical Slip Surfaces from Other
Factor of Safety: 1.67
Horz Seismic Coef.: 0.1



Northern Impoundment - Sta 5+00 (Vibration Analysis)

Horizontal Seismic Coef.: 00.1g

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟫	2- CLs (-1.6 to -3.4)	Mohr-Coulomb	117	200	0	0	1
🟩	3- CL (-3.4 to -11.5)	Mohr-Coulomb	95	900	0	0	1
🟥	4- SM (-11.5 to -16)	Mohr-Coulomb	120	0	25	0	1
🟦	4- SM (-16 to -???)	Mohr-Coulomb	120	0	33	0	1
⬛	Soft Soil	Mohr-Coulomb	90	100	0	0	1

Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman & Associates, Inc.

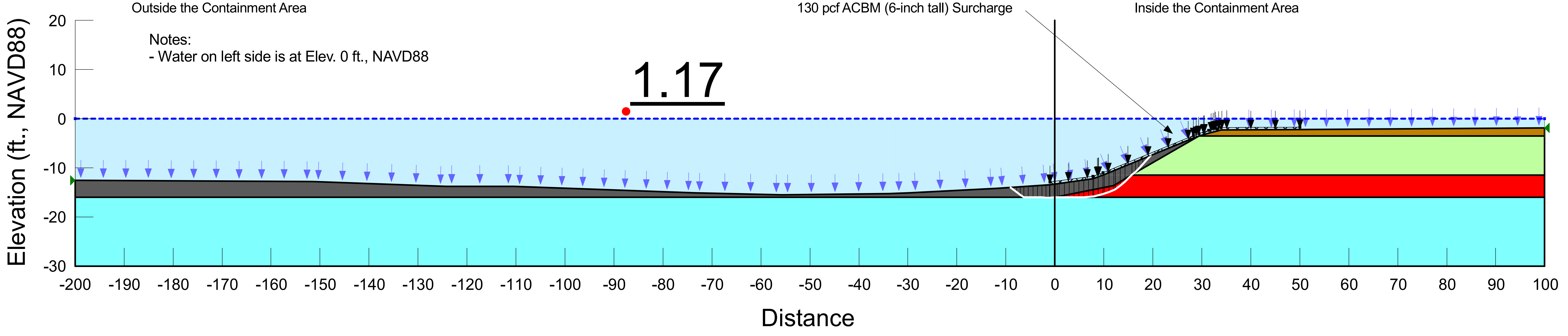
Analysis Name: Deep - Spencer Block (EQ=0.10)

File Name: 18-2876 North Sta 5+00 Vibration (B058) - Soft Soil ACBM.gsz

Date: 04/21/2020 Scale: 1:250

Figure No. 14

Method: Spencer
Slip Surface Option: Critical Slip Surfaces from Other
Factor of Safety: 1.17
Horz Seismic Coef.: 0.2



Northern Impoundment - Sta 5+00 (Vibration Analysis)

Horizontal Seismic Coef.: 00.2g

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟫	2- CLs (-1.6 to -3.4)	Mohr-Coulomb	117	200	0	0	1
🟩	3- CL (-3.4 to -11.5)	Mohr-Coulomb	95	900	0	0	1
🟥	4- SM (-11.5 to -16)	Mohr-Coulomb	120	0	25	0	1
🟦	4- SM (-16 to -???)	Mohr-Coulomb	120	0	33	0	1
⬛	Soft Soil	Mohr-Coulomb	90	100	0	0	1

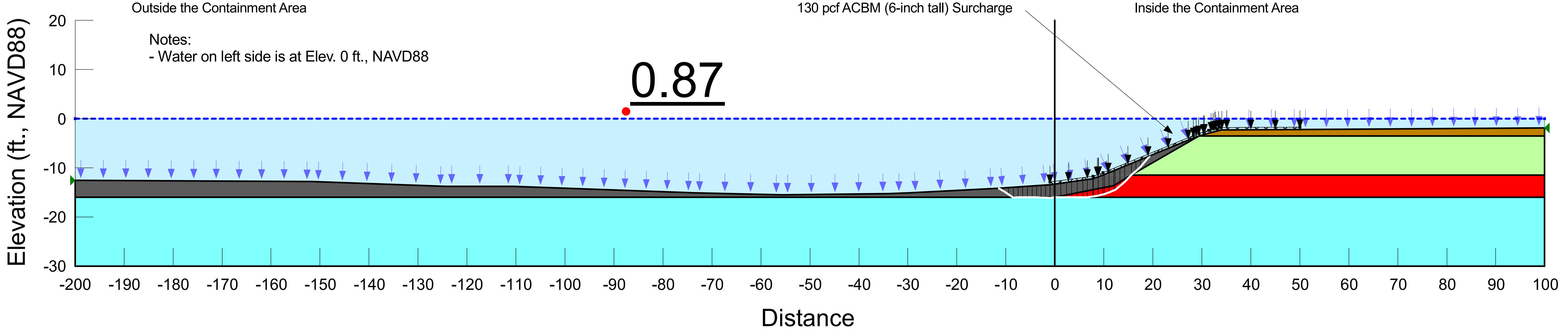
Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman & Associates, Inc.

Analysis Name: Deep - Spencer Block (EQ=0.20)
File Name: 18-2876 North Sta 5+00 Vibration (B058) - Soft Soil ACBM.gsz
Date: 04/21/2020 Scale: 1:250

Figure No. 15

Method: Spencer
Slip Surface Option: Critical Slip Surfaces from Other
Factor of Safety: 0.87
Horz Seismic Coef.: 0.3



Northern Impoundment - Sta 5+00 (Vibration Analysis)

Horizontal Seismic Coef.: 00.3g

Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟫	2- CLs (-1.6 to -3.4)	Mohr-Coulomb	117	200	0	0	1
🟩	3- CL (-3.4 to -11.5)	Mohr-Coulomb	95	900	0	0	1
🟥	4- SM (-11.5 to -16)	Mohr-Coulomb	120	0	25	0	1
🟦	4- SM (-16 to -???)	Mohr-Coulomb	120	0	33	0	1
⬛	Soft Soil	Mohr-Coulomb	90	100	0	0	1

Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman
& Associates, Inc.

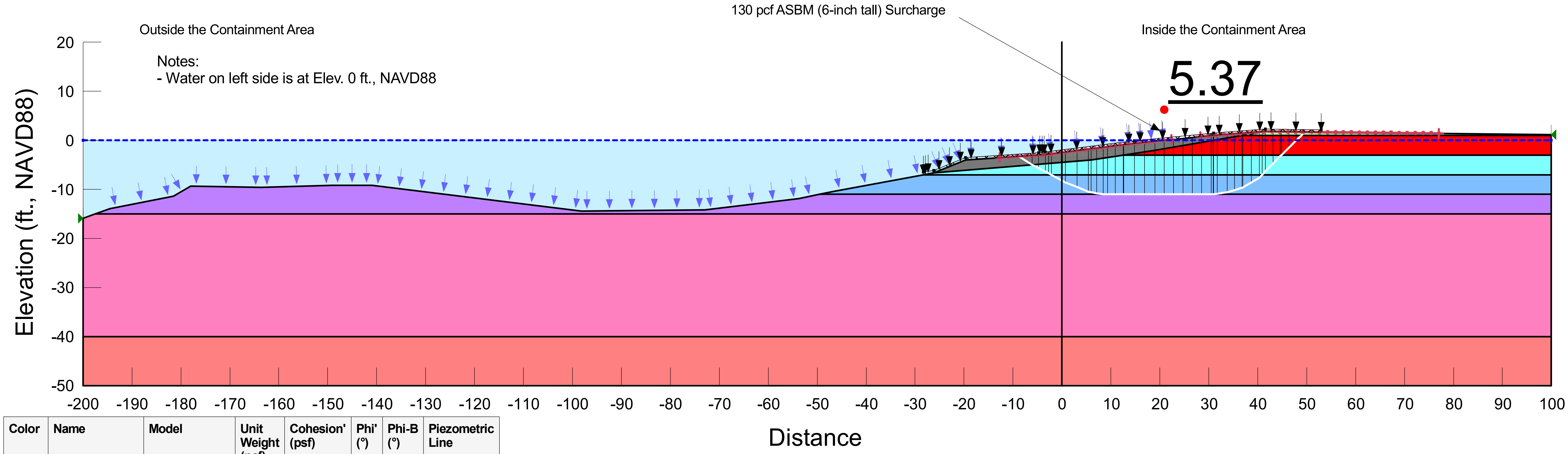
Analysis Name: Deep - Spencer Block (EQ=0.30)

File Name: 18-2876 North Sta 5+00 Vibration (B058) - Soft Soil ACBM.gsz

Date: 04/21/2020 Scale: 1:250

Figure No. 16

Method: Spencer
Slip Surface Option: Entry and Exit
Factor of Safety: 5.37
Horz Seismic Coef.:



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟩	3- CL (+3.3 to +1)	Mohr-Coulomb	131	800	0	0	1
🟥	4- OH (+1 to -3)	Mohr-Coulomb	95	600	0	0	1
🟦	5- SC (-3 to -7)	Mohr-Coulomb	115	0	28	0	1
🟦	6- CL (-7 to -11)	Mohr-Coulomb	115	200	0	0	1
🟪	7- CLs (-11 to -15)	Mohr-Coulomb	121	700	0	0	1
🟪	8- SM/SP-SC (-15 to -40)	Mohr-Coulomb	130	0	30	0	1
🟥	9- CH (-40 to -50)	Mohr-Coulomb	122	1,500	0	0	1
⬛	Soft Soil	Mohr-Coulomb	95	100	0	0	1

Northern Impoundment - Sta 22+00 (Vibration Analysis)

Horizontal Seismic Coef.: 0g

Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman
& Associates, Inc.

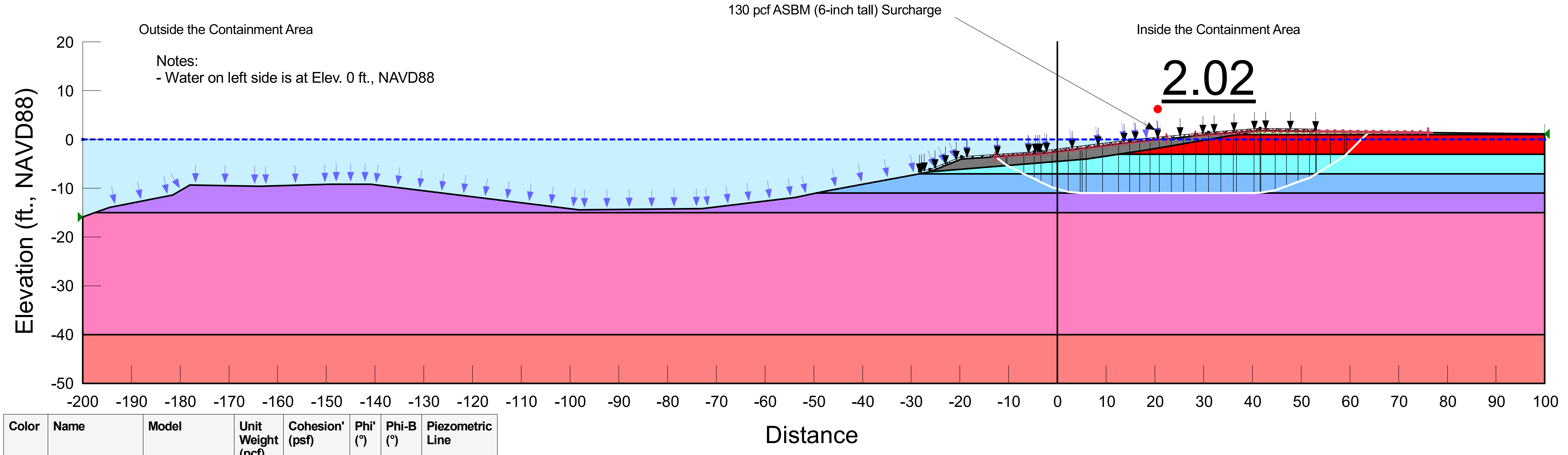
Analysis Name: Shallow - Spencer EE

File Name: 18-2876 North Sta 22+00 Vibration (B028) - Soft Soil ACBM.gsz

Date: 04/21/2020 Scale: 1:250

Figure No. 17

Method: Spencer
Slip Surface Option: Entry and Exit
Factor of Safety: 2.02
Horz Seismic Coef.: 0.1



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟩	3- CL (+3.3 to +1)	Mohr-Coulomb	131	800	0	0	1
🟥	4- OH (+1 to -3)	Mohr-Coulomb	95	600	0	0	1
🟦	5- SC (-3 to -7)	Mohr-Coulomb	115	0	28	0	1
🟦	6- CL (-7 to -11)	Mohr-Coulomb	115	200	0	0	1
🟪	7- CLs (-11 to -15)	Mohr-Coulomb	121	700	0	0	1
🟪	8- SM/SP-SC (-15 to -40)	Mohr-Coulomb	130	0	30	0	1
🟧	9- CH (-40 to -50)	Mohr-Coulomb	122	1,500	0	0	1
⬛	Soft Soil	Mohr-Coulomb	95	100	0	0	1

Northern Impoundment - Sta 22+00 (Vibration Analysis)

Horizontal Seismic Coef.: 00.1g

Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman
& Associates, Inc.

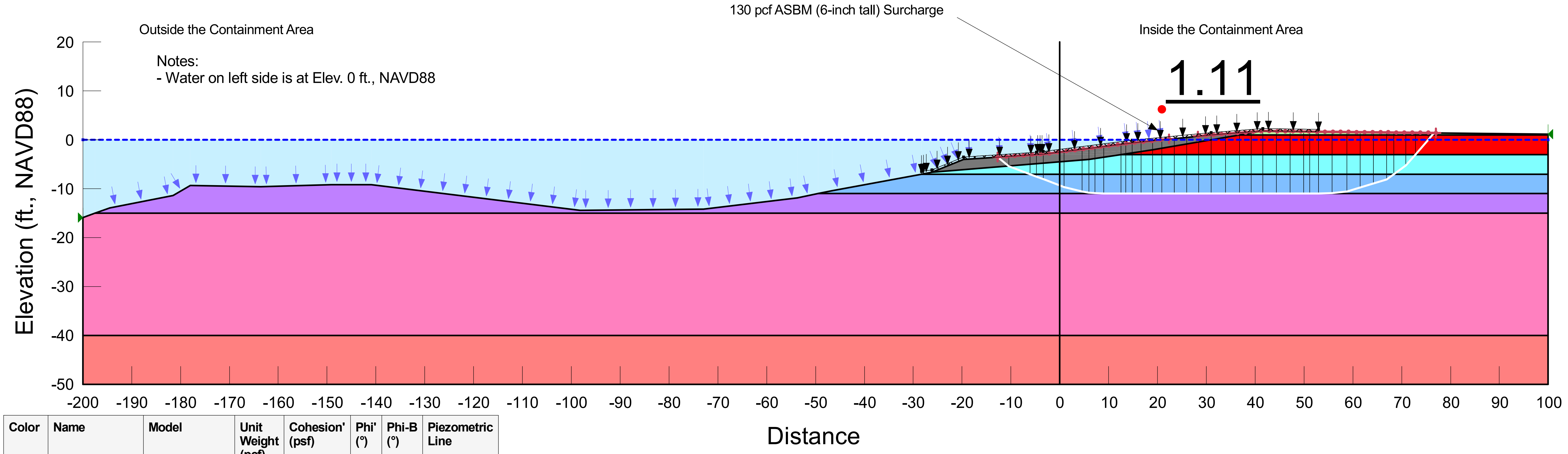
Analysis Name: Shallow - Spencer EE (EQ=0.10)

File Name: 18-2876 North Sta 22+00 Vibration (B028) - Soft Soil ACBM.gsz

Date: 04/21/2020 Scale: 1:250

Figure No. 18

Method: Spencer
Slip Surface Option: Entry and Exit
Factor of Safety: 1.11
Horz Seismic Coef.: 0.2



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟩	3- CL (+3.3 to +1)	Mohr-Coulomb	131	800	0	0	1
🟥	4- OH (+1 to -3)	Mohr-Coulomb	95	600	0	0	1
🟦	5- SC (-3 to -7)	Mohr-Coulomb	115	0	28	0	1
🟦	6- CL (-7 to -11)	Mohr-Coulomb	115	200	0	0	1
🟪	7- CLs (-11 to -15)	Mohr-Coulomb	121	700	0	0	1
🟪	8- SM/SP-SC (-15 to -40)	Mohr-Coulomb	130	0	30	0	1
🟧	9- CH (-40 to -50)	Mohr-Coulomb	122	1,500	0	0	1
⬛	Soft Soil	Mohr-Coulomb	95	100	0	0	1

Northern Impoundment - Sta 22+00 (Vibration Analysis)

Horizontal Seismic Coef.: 00.2g

Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman
& Associates, Inc.

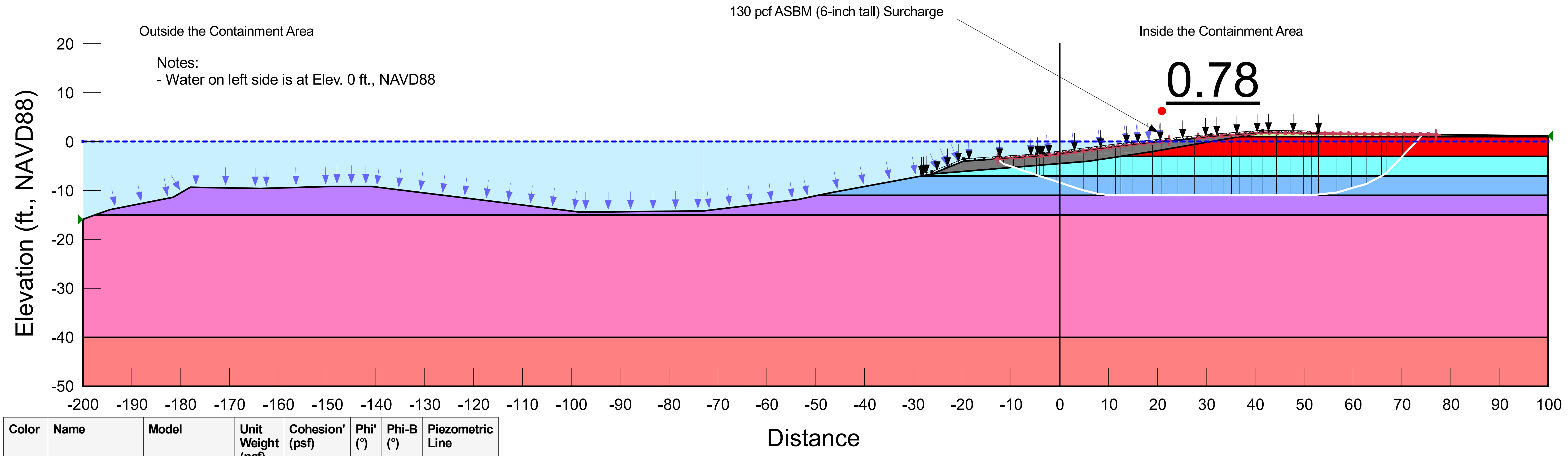
Analysis Name: Shallow - Spencer EE (EQ=0.20)

File Name: 18-2876 North Sta 22+00 Vibration (B028) - Soft Soil ACBM.gsz

Date: 04/21/2020 Scale: 1:250

Figure No. 19

Method: Spencer
Slip Surface Option: Entry and Exit
Factor of Safety: 0.78
Horz Seismic Coef.: 0.3



Color	Name	Model	Unit Weight (pcf)	Cohesion' (psf)	Phi' (°)	Phi-B (°)	Piezometric Line
🟩	3- CL (+3.3 to +1)	Mohr-Coulomb	131	800	0	0	1
🟥	4- OH (+1 to -3)	Mohr-Coulomb	95	600	0	0	1
🟦	5- SC (-3 to -7)	Mohr-Coulomb	115	0	28	0	1
🟦	6- CL (-7 to -11)	Mohr-Coulomb	115	200	0	0	1
🟪	7- CLs (-11 to -15)	Mohr-Coulomb	121	700	0	0	1
🟪	8- SM/SP-SC (-15 to -40)	Mohr-Coulomb	130	0	30	0	1
🟥	9- CH (-40 to -50)	Mohr-Coulomb	122	1,500	0	0	1
⬛	Soft Soil	Mohr-Coulomb	95	100	0	0	1

Northern Impoundment - Sta 22+00 (Vibration Analysis)

Horizontal Seismic Coef.: 00.3g

Directory: G:\Projects\2018\18-2876 (San Jacinto Waste Pits)\Analyses\SlopeW\Northern Impoundment\

Ardaman
& Associates, Inc.

Analysis Name: Shallow - Spencer EE (EQ=0.30)

File Name: 18-2876 North Sta 22+00 Vibration (B028) - Soft Soil ACBM.gsz

Date: 04/21/2020 Scale: 1:250

Figure No. 20

ENCLOSURE 4.2

Appendix D
Northern Impoundment
Preliminary Vibration Analysis

Appendix D - Northern Impoundment Preliminary Vibration Analysis

San Jacinto River Waste Pits Site
Harris County, Texas

Table of Contents

1. Introduction

The remedy for the Northern Impoundment at the San Jacinto River Waste Pits Site in Harris County, Texas selected by the EPA in the October 2017 Record of Decision (ROD), provides for the use of a Best Management Practice (BMP). The ROD describes the BMP as being implementable (based on information available at that time) and effective preventing or minimizing the release of waste material during removal activities to ensure compliance with Applicable or Relevant and Appropriate Requirements (ARARs). The 30% Preliminary Remedial Design (30% RD) presents a phased construction approach utilizing a cantilever retaining wall as the BMP to segregate the Northern Impoundment into five cells. The preliminary geotechnical engineering analysis performed by Ardaman & Associates, Inc. (Ardaman) indicates that a cantilever wall that consists of a tubular pipe pile with a pair of intermediary sheet pile (PAZ66/AZ38-700N) combination-wall system (combi-wall) and/or double H-Beam wall to be driven in excess of elevation -80 feet North American Vertical Datum 1988 (NAVD88) would be required to implement this approach.

The installation of the combi-wall system using a conventional diesel impact hammer was analyzed by Ardaman and the initial results based on wave equation analysis using GRLWEAP, a one-dimensional wave analysis equation program, indicates that a large diesel impact hammer is required to drive the piles to the specified depth. The GRLWEAP analysis is provided in the Ardaman *Geotechnical Engineering Report* (Appendix B). As discussed in Appendix B, further analysis performed by Ardaman, indicates that the vibration caused by pile driving could decrease the stability of the slope in the vicinity of the pile installation and result in the potential for a release of waste to the San Jacinto River.

This report expands on the vibration impact analysis performed by Ardaman. It includes a preliminary evaluation of the potential effects of vibrations during pile driving due to the following:

- The potential release of waste from the Northern Impoundment to surface water from a slope failure caused by the acceleration force from vibrations acting on the slope.
- The potential release of waste from the Northern Impoundment to surface water from a slope failure due to the development of excess pore water pressure caused by the ground motion from the vibrations.
- The potential release of waste from the Northern Impoundment from densification and settlement caused by the vibrations, from the pore water that potentially could contain waste constituents due to the shifting of the waste material from the area in which settlement occurred.
- The potential impact of vibrations on surrounding structures.

Figure 1 is a map of the Northern Impoundment showing the boring locations and the cross Section location evaluated for purposes of slope stability analysis.

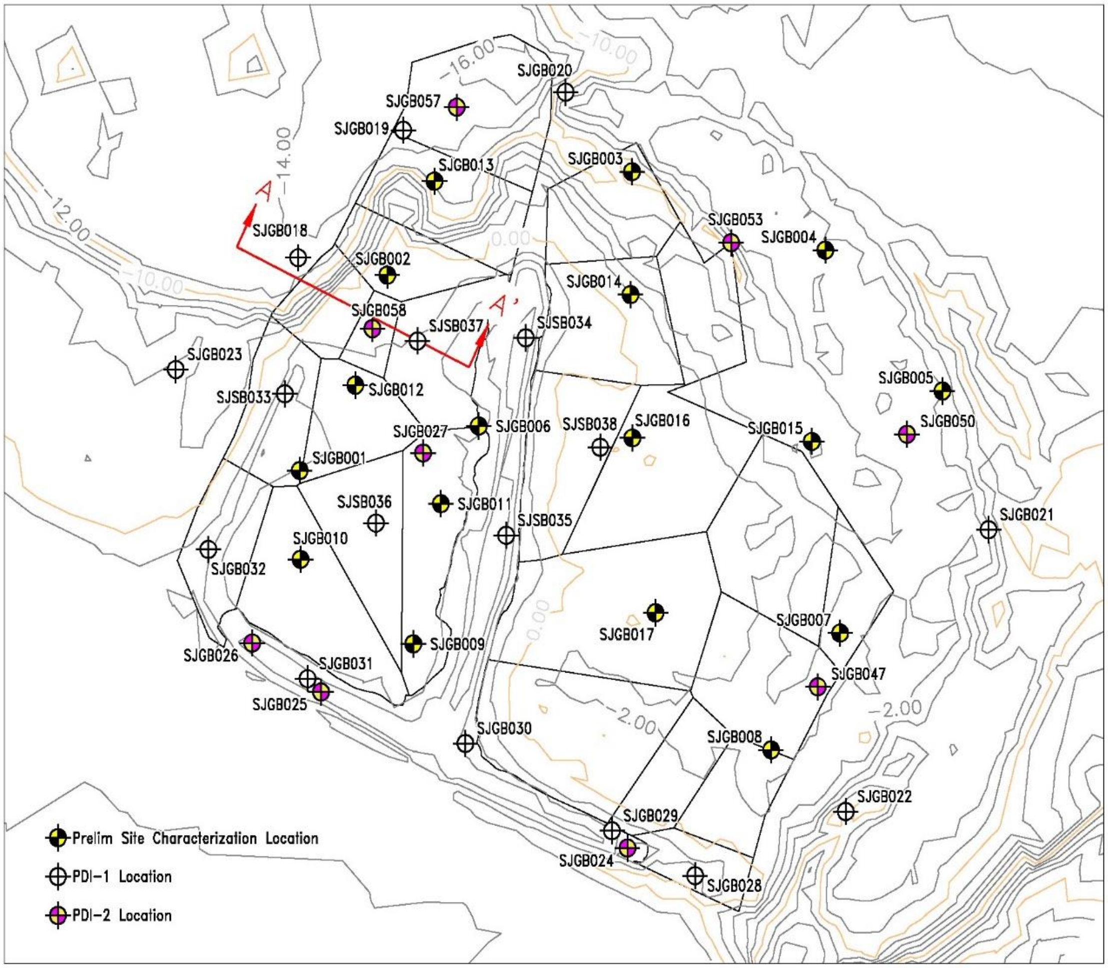


Figure 1 - Northern Impoundment Boring Locations, Topography, and Cross Section A-A' Location

2. Drivability and Hammer Types

Pile drivability and the equipment requirements are important aspects of a vibration impact analysis, as vibrations are directly related to the site conditions and the equipment necessary to drive the piles to the specified depths. The preliminary evaluation of initial inputs (such as peak particle velocity (PPV), ground acceleration, frequencies, etc.) required for the vibration analyses is largely related to the type of equipment used to advance the piles.

GHD Services Inc. (GHD) performed an additional evaluation using GRLWEAP based on data from borings SJGB053 and SJGB057 (see Figure 1 for boring locations) to predict the drivability of 66-inch and 84-inch diameter open-ended tubular steel pipe piles to a target depth of at least 100 feet. For this evaluation, Mohr-Coulomb parameters were inferred for the various soil layers interpreted from the boring logs. The GHD assessment also assumed the use of a pile toe inside friction reducer, which effectively prevents the development of significant internal friction during driving.

The GHD analysis showed that it may be possible to achieve the target depth with the 66-inch diameter pipe pile using an American Pile Driving Equipment (APE) D100-42 and D80-42 impact hammer. However, the results also indicated that a significant risk of driving refusal could occur at elevation -70 feet NAVD88 where a dense sand layer is encountered. The risk of premature refusal is greater if driving is temporarily interrupted, resulting in “setup” (i.e., significantly increased shaft resistance due to radial consolidation of cohesive soils in contact with the pile shaft). Premature driving refusal is predicted with the 84-inch diameter pipe pile for both hammers (D100-42 and D80-42) which indicates that driving the 84-inch diameter piles to a target depth of -100 feet NAVD88 is likely impracticable without a larger hammer.

The inputs for the vibration analysis presented herein (PPV, ground acceleration, frequencies, etc.) are based on the evaluations performed by Ardaman and GHD using a D100-42 hammer to advance the piles through the dense sand. These evaluations assume a maximum 66-inch diameter pipe pile. The 84-inch diameter pile would require an even larger hammer that would produce higher vibrations than are considered in this report.

The drivability analyses would require updating during future phases of the remedial design to incorporate information on the impact of specific pile driving equipment anticipated to be used.

3. Estimation of Vibration Velocity and Acceleration

During pile driving, ground vibrations are generated as a result of elastic deformation of the soil. The vibrations are then propagated through the soil as elastic waves. However, the wave motions generated by pile driving are complex due to the effect of soil damping and geometric damping. For this study, the CalTrans (2013) method was selected, as it uses the wave propagation theory and incorporates the pile driving equipment and soil type to predict the PPV, which is the best indicator of damage potential during pile driving. The PPV values are used to calculate peak particle acceleration, a value that is then used in the slope stability analyses.

3.1 Peak Particle Velocity (PPV)

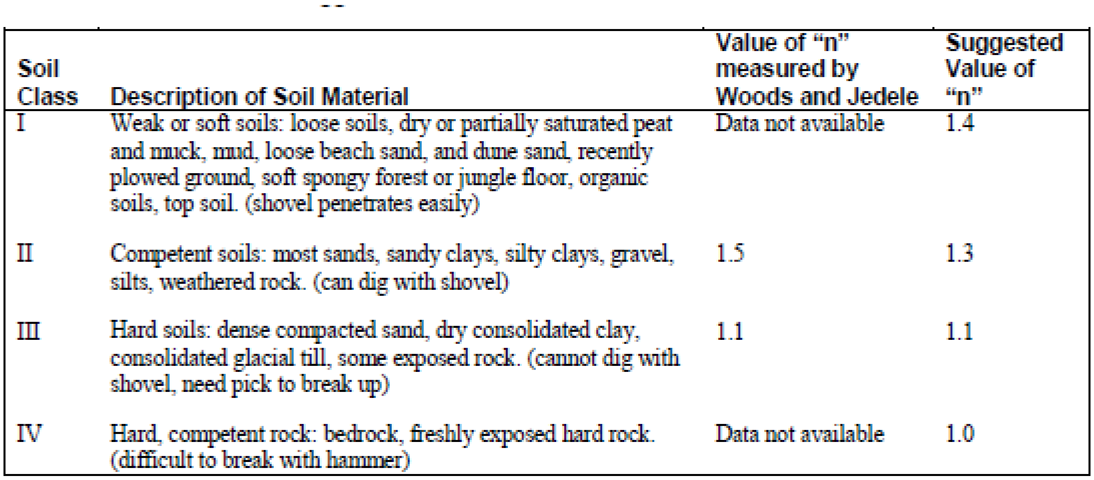
CalTrans (2013) published a method for predicting vibration amplitudes, in terms of PPV, for pile driving using a propagation model. Based on the CalTrans document, the estimated PPV from an impact hammer can be represented by:

$$PPV_{Impact\ Hammer} = PPV_{Ref}(25/D)^{n} \times (E_{equip}/E_{Ref})^{0.5}$$

Where:

$$PPV_{Ref} = 0.65\ in/\sec for\ a\ reference\ pile\ driver\ at\ 25\ ft$$
$$D = distance\ from\ pile\ hammer\ to\ the\ receiver\ in\ ft$$
$$n\ is\ the\ vibration\ attenuation\ rate\ through\ ground\ and\ is\ between\ 1.1\ and\ 1.5$$
$$(see\ table\ extracted\ from\ the\ Caltran's\ doucment\ below)$$
$$E_{Ref} = 36{,}000\ ft - lb\ (rated\ energy\ of\ reference\ pile\ driver$$
$$E_{equip} = rated\ energy\ of\ impact\ hammer\ in\ ft - lbs$$

The calculated PPV values based on the maximum rated energy of the APE D100-42 hammer ranges from 17.5 inches per second (in/sec) at a distance of 5 feet from the pile to 0.26 in/sec at a distance of 100 feet from the pile for a Class I soil type (n=1.4). The soil classes from the CalTrans document are listed below.



Soil Class	Description of Soil Material	Value of "n" measured by Woods and Jedele	Suggested Value of "n"
I	Weak or soft soils: loose soils, dry or partially saturated peat and muck, mud, loose beach sand, and dune sand, recently plowed ground, soft spongy forest or jungle floor, organic soils, top soil. (shovel penetrates easily)	Data not available	1.4
II	Competent soils: most sands, sandy clays, silty clays, gravel, silts, weathered rock. (can dig with shovel)	1.5	1.3
III	Hard soils: dense compacted sand, dry consolidated clay, consolidated glacial till, some exposed rock. (cannot dig with shovel, need pick to break up)	1.1	1.1
IV	Hard, competent rock: bedrock, freshly exposed hard rock. (difficult to break with hammer)	Data not available	1.0

This range of PPVs is used as input to estimate the peak particle acceleration (g force) as discussed in the following section.

3.2 Peak Particle Acceleration (g force)

Wiss (1967) presented a range of observed soil frequencies (f) during pile driving and a typical soil frequencies range for three soil types. For alluvial fill, the soil frequency is typically between 5 and 10 cycles per second (cps). For clay soil, the frequency is between 13 and 25 cps; and for sandy soil, the frequency is between 30 and 40 cps. The peak acceleration (A) as a function of PPV and soil frequency (CalTrans 2013) is:

$$A = 2\pi f V \quad where\ V = \ PPV\ and\ A\ is\ in\ the\ same\ unit\ as\ PPV$$

$$or\ \ A_g = 0.0163 f V \ \text{ where } A_g\ is\ the\ peak\ acceleration\ in\ term\ of\ g{-}force$$

Using the range of PPVs calculated from the previous Section and a soil frequency of 7.5 cps for alluvial fill, which is the predominant soil type for the upper 30 feet, the peak particle acceleration (g-force) ranges from 2.1g at a distance of 5 feet from the pile to 0.03g at a distance of 100 feet from the pile. At a distance of 20 feet from the pile, the peak particle acceleration is approximately 0.3g. These peak particle acceleration values will be used to evaluate the effects of pile driving vibrations on slope stability. As depicted in the *Preliminary 30% Remedial Design - Northern Impoundment*, the pile locations are anticipated to be closer than 20 feet from the slope; therefore, the peak particle acceleration values at the slope would be even greater.

4. Slope Stability

According to Lamens (2020): "the stability of a slope may be negatively affected by pile driving in two ways: (a) through dynamic or inertia-related effects and (b) through excess pore pressure development, diminishing the effective stress and, correspondingly, the mobilizable shear strength in the soil".

4.1 Analysis Approach

In order to properly assess the influence of pile driving on the slope stability (i.e. to analyze the reduction of factor of safety due to the vibrations), it is first required to evaluate the pre-pile driving stability of the slope. Accordingly, it is critical to establish a representative soil model with appropriate geometrical and geotechnical properties. This is typically done by collecting geotechnical information at the top and at the bottom of the slope, so that the soil profile along the slope is properly captured in the analysis.

The northwestern part of the Northern Impoundment is one area where piles would be driven onto and/or near the toe of a relatively steep slope and the slope stability evaluation focuses on this area. Figure 1 shows the cross Section (A-A') location where the evaluation was performed. The surrounding boring logs (SJGB018 and 019) show very soft surficial material in areas near the toe of the slope and the geotechnical data are limited because of poor recovery of this soft material during the sampling. There is also uncertainty because there are not any borings directly on the slope and the slope soil profile had to be developed from adjacent borings located more than 100 feet apart.

Due to the uncertainties in the soil conditions on the slope and the potential for these conditions to be different than those observed in the limited number of borings, a parametric study was performed to evaluate how changes in material thicknesses and strength would affect slope stability (under static conditions). Thus, the slope stability of these two soil types was evaluated for these same conditions considering the vibration impacts.

This preliminary evaluation focused on both cohesive (clay) and cohesionless (sand) material on the slope. The 6-inch thick articulated concrete block mat (ACBM) that is currently present on the northwest slope was not included in the preliminary evaluation as a cap material. It is expected that the ACBM would behave similarly to the underlying soil type under conditions in which there are vibrations from pile driving. The weight of the ACBM will increase the horizontal force and potential for failure caused by the vibrations. The impact of vibrations on slopes on which ACBM is present would need to be further evaluated as the design progresses.

4.1.1 Effects of Material Thickness and Strength (Cohesive Material) on Stability

The following figures show how the factors of safety vary under static conditions (without vibrations) with different material thickness and strength, considering a very soft (low strength) cohesive material at the surface. The left side of Figure 2 shows the calculated factors of safety for cohesive material with undrained shear strength of 100 pounds per square foot (psf) and thickness of 5, 10 and 15 feet on the slope. The right side of Figure 2 shows the factors of safety for cohesive material with undrained shear strength of 150 psf and the same thicknesses.

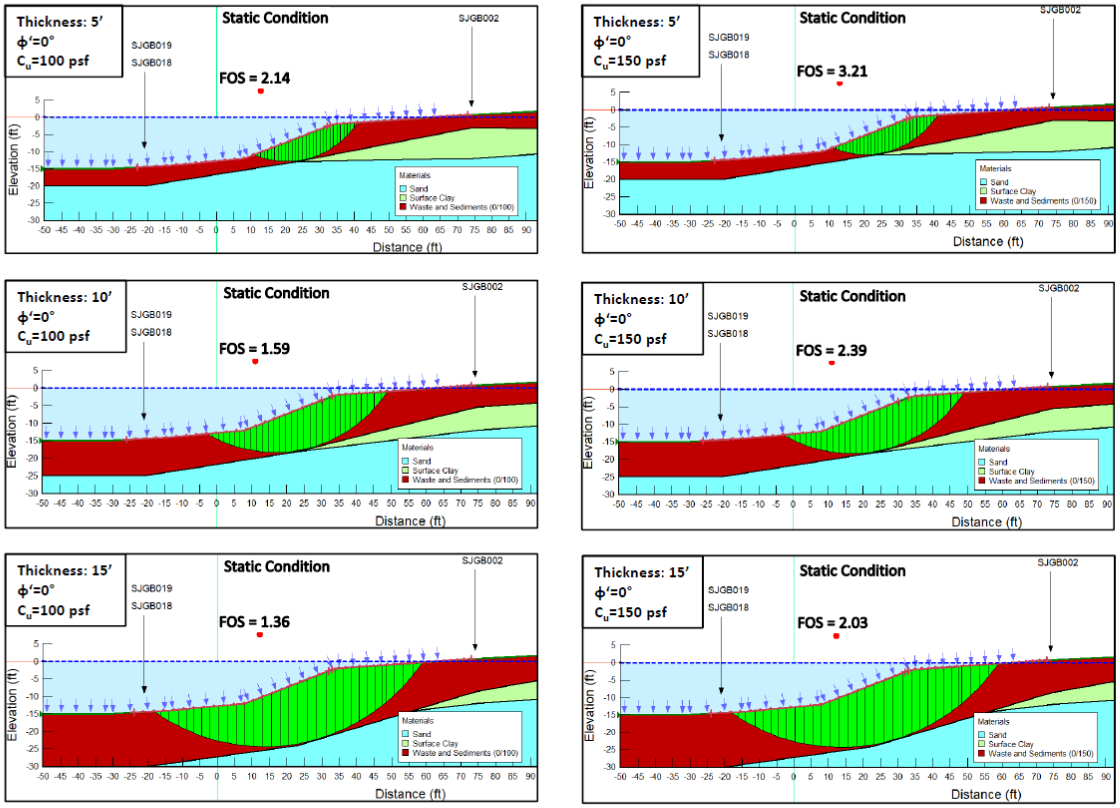


Figure 2 - Effects of Sediments Properties and Layer Thickness (Cohesive Material) on Factors of Safety in a Slope Stability Analysis

These figures show that both the thickness and the strength affect the static slope stability. Based on the boring logs (SJGB018, 019, and 002), there is a potential for any of the conditions depicted on the above figures to exist somewhere along the slope.

4.1.2 Effects of Friction Angle (Cohesionless Material) on Stability

A cohesionless material on a slope similar to the slope at the northwest corner of the Northern Impoundment has the potential for a shallow slip surface failure. This type of failure is dependent on the slope geometry and the friction angle of the material. The material thickness does not influence the result. The following figures show how the factors of safety vary with the friction angles under static conditions for the geometry on northwestern slope.

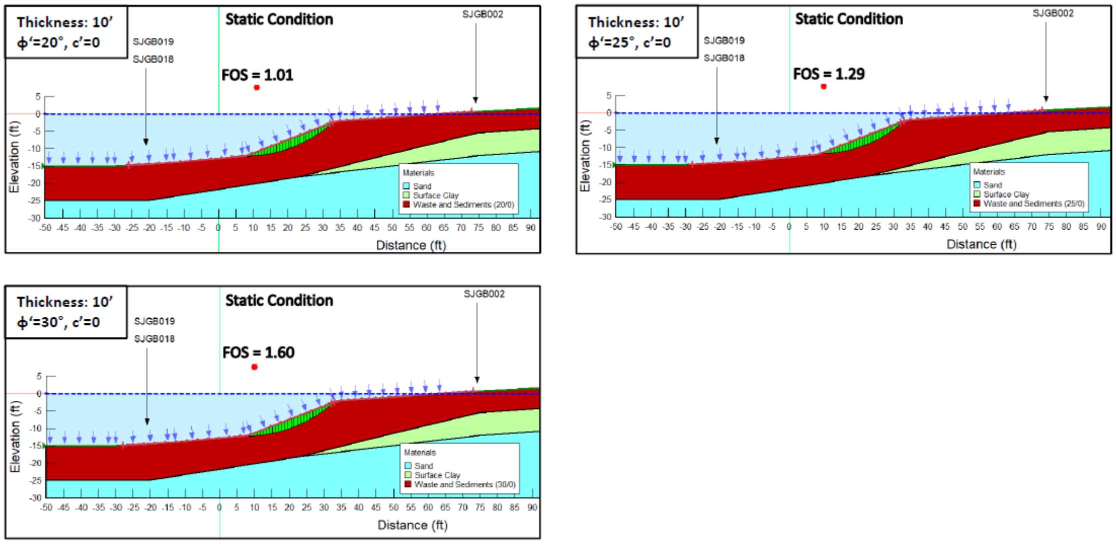


Figure 3 - Effects of Sediments Properties (Cohesionless Material) on Factors of Safety in a Slope Stability Analysis

These figures show that if a low friction angle cohesionless material is on the slope in the northwest portion of the Northern Impoundment (at any thickness), the slope would be marginally stable for a shallow slip surface failure under static conditions. The higher friction angle material is more stable and likely more representative of the Northern Impoundment soils, but may still be susceptible to failure with vibrations as discussed below.

4.2 Impact of Vibrations from Pile Driving on Slope Stability

Two methods were considered for the initial and preliminary evaluation of vibrations due to pile driving on slope stability. The first method is a pseudostatic or seismic approach that is commonly used to evaluate seismic impacts on slope stability. The second method is the evaluation of failure due to the development of excess pore pressures (EPP) from vibrations during pile driving.

4.2.1 Pseudostatic Approach

In this method, the effect of the vibrations is represented by simulated accelerations that produce inertial forces that act on the centroid of the soil mass. This effect is incorporated in the limit equilibrium method model (Slope/W) through the use of a horizontal pseudostatic coefficient (k_h), which is often considered to be equal to k_h =k*Amax/g, where Amax is the peak horizontal acceleration and k is a magnification factor. The k factor is usually determined from response analysis depending on the mode of vibration and soil damping. Based on published research on one-dimensional response during blasting and seismic events on a slope, the k factor ranges from 0.1 to 0.8 (Wong, et. al., 2000). Since the mechanisms involved during blasting and seismic events and those related to vibrations from pile driving are different, the use of the pseudostatic method is considered a preliminary assessment of influence of pile driving generated inertial forces on slope stability. For this study, the k factor is assumed to be 0.5 resulting in k_h=0.5*Amax/g. The acceleration values evaluated in Section 3.2 were considered initially as Amax to estimate the range of kₕ. These coefficient values ranging from 0.02 to 0.15 were considered in the analysis based on the vibration from the impact hammer as described in Section 3.1. This is considered to represent a range of Amax that could occur from approximately 20 feet to 100 feet of the pile driving location. It is important to note that the use of the kₕ in this study is based on the similar use of response peak ground acceleration (PGA) coefficient by Wong, et. al. (2000) in the analysis of slope stability due to vibrations from blasting. To our knowledge, no publication exists that provides direct correlation between the kₕ and peak particle acceleration; thus, the results presented below should be considered qualitative. These results, however, can be used to compare with Ardaman's slope stability analysis results using different soil conditions and similar kₕ values to highlight the influence of vibration on differing soil profiles and properties.

4.2.1.1 Cohesive Material

Results of the analyses showing the estimated impact of vibrations using different seismic coefficients for cohesive soils are provided below. The results are shown for a 10-foot thick material with undrained shear strength of 100 psf and 150 psf.

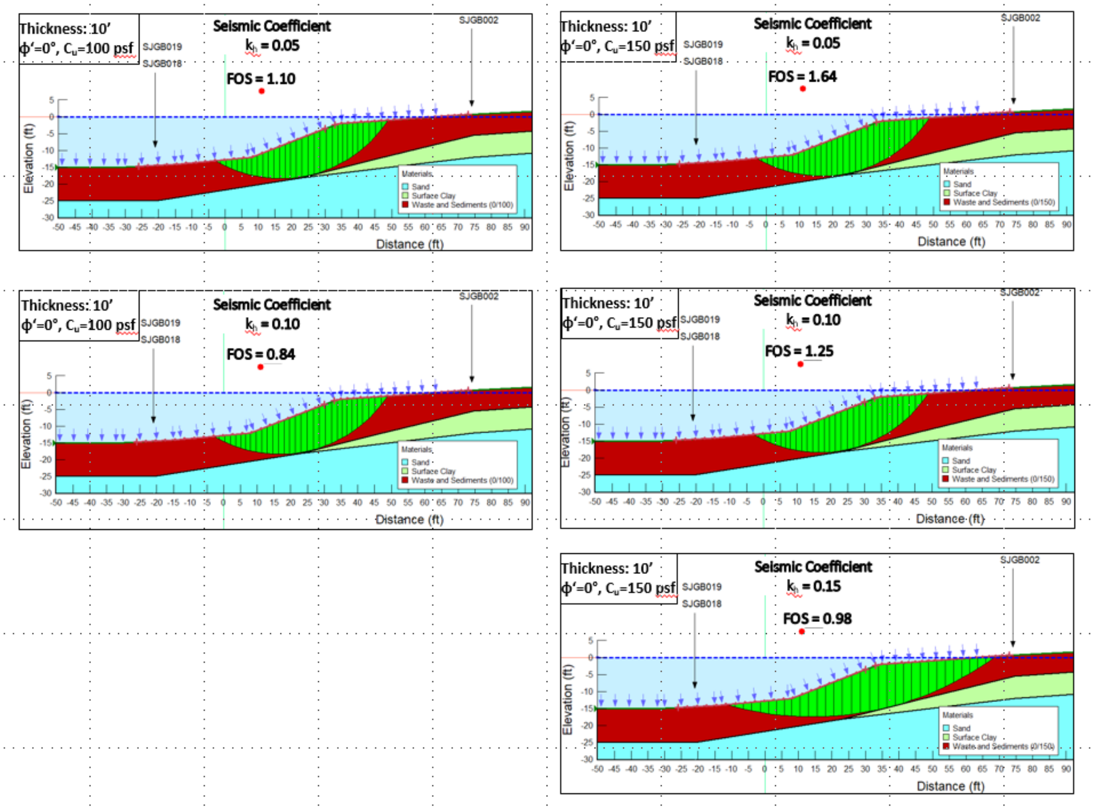


Figure 4 - Slope Stability Analysis with Varying kₕ for Cohesive Material

For the material with undrained shear strength of 100 psf, using the lower end seismic coefficient of 0.05 results in a slope that is marginally stable at a factor of safety of 1.10. The slope is unstable with a factor of safety of 0.84 when a seismic coefficient of 0.10 is applied. For the material with undrained shear strength of 150 psf, the slope is more stable, but the factor of safety is below 1.0 when a seismic coefficient of 0.15 is considered. The results shown in Figure 4 are for 10 feet of the cohesive material on top of the slope. The slopes would be less stable if the material is thicker than 10 feet and more stable if the material is below 10 feet in thickness.

4.2.1.2 Cohesionless Material

Results of the analyses showing the estimated impact of vibrations using different seismic coefficients for shallow slip surface failures of cohesionless soils are below. The results are shown for both the 25-degree friction angle and the 30-degree friction angle. The 20-degree friction angle presented in Figure 3 was marginally stable under static conditions. Therefore, it was assumed the slope would not be stable under conditions in which there are vibrations and further evaluation was not conducted.

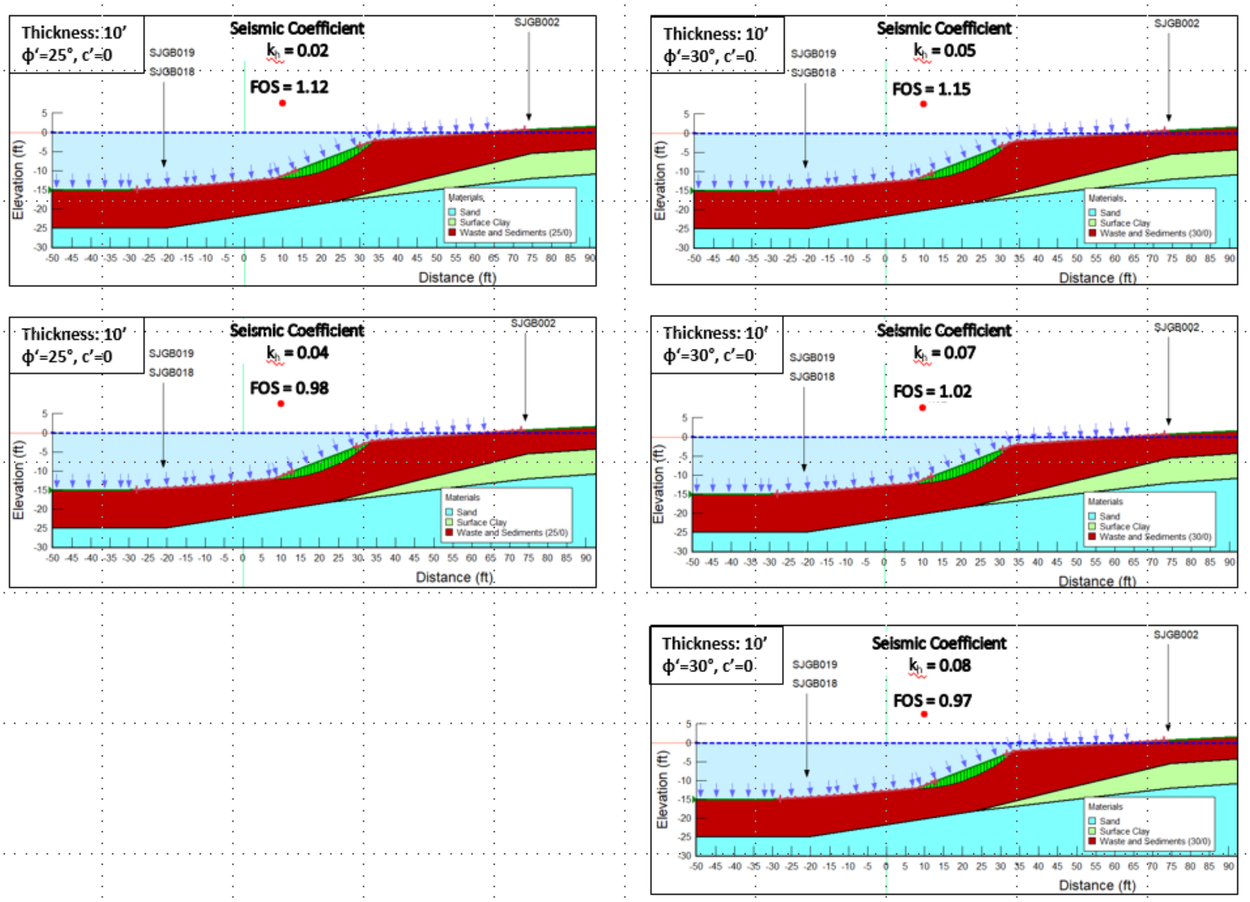


Figure 5 - Slope Stability Analysis with Varying k_h for Cohesionless Material

For the 25-degree friction angle material, a low seismic coefficient (of 0.02) results in a slope that is marginally stable, and a seismic coefficient of only 0.04 produces a factor of safety below 1.0. The higher friction angle material (30 degrees) is more stable, but when a 0.08 seismic coefficient is applied, the factor of safety on the slope falls below 1.0. The stability against a shallow slip surface failure for the cohesionless material is not affected by the thickness of the material on the slope. The risk of a shallow slip surface failure during construction under this condition could result in a release of waste material from the Northern Impoundment to the San Jacinto River.

4.2.2 Excess Pore Pressure Approach

During both impact and vibratory pile driving, the formation of various stress waves will create ground motion, which can develop EPPs. These EPPs can affect the stability of the slope. It is of particular concern for cohesionless soils with the potential for liquefaction.

The correlation between ground motion and the generation of EPP is a function of site conditions and equipment used and typically is determined during a test pile program. Without test pile data, the preliminary evaluation presented below was performed based on available literature values for the EPP as a function of distance from the pile driving. The EPP values were estimated based on a study by Lamens (2020) correlating the measured EPP versus radial distance from a test pile program during the installation of tubular and steel sheet piles on a submerged sandy slope. Lamens (2020) compared the data from the test pile program with data from the literature and plotted the maximum EPP normalized with effective stress (referred to as relative excess pore water, ru,max) versus the normalized horizontal distance (x/D) where x is the radial distance from the pile and D is the diameter of the pile and curve fit all the data with an exponential function. The exponential function proposed by Lamens is:

$$r_{u,max} = 2.6e^{-0.22(x/D)}$$

Comparison of the calculated values from this function to measured values from Lamens' test pile program indicates that the function typically overestimates the EPP. The measured ru,max values from the Lamens' test piles are in the order of 40% of the predicted values. Therefore, two EPP profiles within 40% of the predicted values from the exponential function were developed for the parametric slope stability evaluation. The first EPP profile assumed the EPP distribution is 0.33 times of ru,max and the second EPP profile assumed the EPP distribution is 0.38 times of ru,max. These EPP profiles are then incorporated in the Slope/W model to evaluate the slope stability due to pile driving.

Results of the slope stability analysis of the two simulated EPP profiles from pile driving for 10 feet of cohesionless material on the slope with an angle of internal friction of 30 degrees are presented in Figure 6 below.

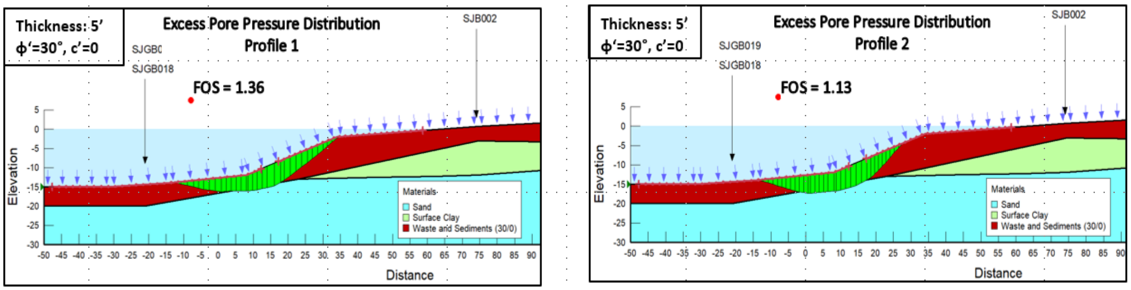


Figure 6 - Slope Stability Analysis for Two Normalized Excess Pore Pressure Profiles

The factors of safety for the two profiles are 1.36 and 1.13. This is compared to the static factor of safety shown on Figure 3 of 1.6. The result of this parametric study indicates the generation of EPP due to pile driving on a sandy slope reduces the margin of safety of the slope. Accordingly, there is a potential that the generation of EPP could cause slope failure.

5. Other Potential Vibration Impacts

The potential for settlement to occur from the vibrations and the potential impact of the vibrations to surrounding structures are evaluated in the following section.

5.1 Settlement

Settlement from vibrations due to pile driving may become problematic in loose, granular soils, especially close to the pile. For the Northern Impoundment, the concern is whether settlement could cause the release of pore water from locations beneath existing armored cap installed during the Time Critical Removal Action (TCRA), or whether shifting of the soils from settlement could cause the release of waste material into the surface water.

Several simplified methods for assessing densification or ground settlement during vibratory pile installation have been proposed by researchers during the last two decades. Models range from using acceleration amplitude and cone penetration test (CPT) tip resistance, PPV and shear wave velocity, soil compression factor, to a seven factors model that includes PPV and depth of soil layer. For this analysis, the seven factors empirical model proposed by Kim, et. al (1994) and the method proposed by Massarsch (2004) were used to provide settlement estimation for near field and far field conditions.

The Kim, et. al. (1994) method can be represented as:

$$lnY = 2.27 + 1.19x_1 - 0.71{x_1}^2 + 0.49x_2 - 0.68{x_2}^2 - 0.80x_3 + 1.09{x_3}^2 - 0.46x_4 + 0.06{x_4}^2 + 0.45x_5 - 0.38{x_5}^2 - 0.19x_6 - 0.1x_7$$

Where:

Factor Name	Range	Factor
velocity amplitude (v)	0.1 - 0.7 in/s	x_1 = -1+(v-0.1)/0.3
deviatoric stress (q)	2 - 15 psi	x_2 = -1+(q-2)/6.5
confining pressure (p)	10 - 30 psi	x_3 = -1+(p-10)/10
sand mixture	coarse, medium, fine	x_4 is resp. -1, 0, 1
number of vibrations	N = 60 - 500,000	x_5 = -1+(N-60)/269970
moisture content	dry, saturated	x_6 is resp. -1 and 2
initial relative density	loose, medium dense	x_7 is resp. -1 and 2

This is an empirical prediction model for estimating vibration induced settlement for small to intermediate vibration levels, which is recorded at an estimated distance of 50 feet and beyond the pile for the APE D100-42 hammer type. The seven factors include vibration amplitude, deviatoric stress, confining pressure, soil gradation, duration of vibration, relative density, and moisture content of the soil. This model may not simulate the exact loading condition of driving piles, but is a reasonable method to estimate the settlement within the range of expected vibrations from the pile driving. A parametric study was performed using the soil profile from boring SJSB027-G (see Figure 1) and varying the thickness of loose and fine sand layer at a depth of 15 feet below ground surface. The estimated settlement ranges from 0 for a 5-foot thick layer to 0.8 inch for a 25-foot thick layer at a horizontal distance of 50 feet from the wall,

The Massarsch (2004) method provides settlement estimation for a sand deposit adjacent to the pile within a zone of three times the pile diameter. The settlement is modeled as a function of a compression factor and the thickness of the compressible layer. The compression factor (α) is an empirical constant based on the driving energy and the density state of the sand deposit. The model is represented by the following equation:

$$S_{avg} = \frac{\propto (L + 6D)}{3} \quad where\ L\ is\ the\ thickness\ of\ layer\ and\ D\ is\ pile\ diameter$$

An estimated 15-foot thick sand deposit using the Massarsch model yielded a range of settlement estimation of 0.6 inches for a very dense sand deposit to more than 3 inches for a very loose sand deposit.

Based on these equations, settlement likely would only be a potential issue from pile driving at the Northern Impoundment within close proximity to the pile where up to more than 3 inches of settlement was estimated within a zone that is within a distance of three times the pile diameter. This volumetric change could potentially release pore water from the material within this localized area to the San Jacinto River.

5.2 Impact to Structures

Ground vibrations due to pile driving could potentially impact surrounding structures and underground utilities. Vibration amplitudes are closely related to the type of hammer used to drive the piles. Vibration amplitudes estimated in this Section should be considered preliminary estimates.

The closest structures to the Northern Impoundment are the piles that support the I-10 Bridge. There are approximately 80 feet between the bridge piles and the nearest BMP Section where the potential combi-wall would be installed. The maximum calculated PPV based on the APE D100-42 hammer at this distance is estimated at 0.5 in/sec for a Class III soil type and the minimum PPV is approximately 0.24 in/sec for a Class I soil type using the CalTrans' equation discussed in Section 3. These calculated values are within the threshold values provided in the CalTrans' guideline. However, as discussed in Section 3 above, the soil type and the hammer type in the vibratory hammer equation presents an uncertainty in the estimation of the PPV. A larger hammer may be required due to the presence of the dense clayey silty sand layer. Therefore, before completing the RD an evaluation would have to be conducted after the hammer type and pile depths are known to determine the potential impact on structures.

The nearest known underground utility is the Exxon Pipeline with varying depths of approximately 100 to 150 feet below ground surface and vibrations from the pile driving are not expected to affect this line. However, the owner of the Exxon Pipeline will need to be contacted to confirm the location of the pipeline, and an evaluation of the potential effect from vibrations should be conducted after the hammer type and pile depths are determined.

6. Conclusions

A preliminary evaluation was performed to assess the potential effects of vibrations due to construction of the BMP proposed for the Northern Impoundment. This will continue to be evaluated as the design progresses to account for changes to the BMP and to evaluate impacts on areas containing ACBM.

The results indicated that the impact hammer required to drive the piles that are included in the 30% RD has the potential to produce vibrations and an acceleration force that could adversely impact the stability of the slope of the Northern Impoundment. A failure of this slope could cause a release of waste material to the San Jacinto River. A major uncertainty in this evaluation is the condition of the soil material on the slope. Area boring logs indicate that the near surface material is very heterogeneous and therefore a preliminary parametric study was performed to show the factor of safety on slope stability for a range of conditions that could be present at the Northern Impoundment. The parametric study shows that under certain conditions (material strength and thickness that may be present on the slope), the slope could potentially fail from the vibrations caused by pile driving. Any slope failure (even a shallow slip surface failure) has the potential to cause a release of waste material to the San Jacinto River. It is important to note that the impact hammer used in the evaluation may not be sufficient to drive some of the pile types that are in the 30% RD. If a larger hammer is required, the vibrations and potential for failure would be greater.

Another mechanism that was considered is the development of EPP caused by the ground motion from the vibrations. Again, a parametric analysis was performed under different geotechnical conditions, and the results indicate that the generated EPP from pile driving can reduce the effective stress, which may cause the slope to become unstable with a potential for failure.

Both of these mechanisms indicate that there is a risk of slope failure from vibrations caused by pile driving, and the potential for failure is greatly dependent on the geotechnical properties on the slope. Due to this uncertainty, whether piles of the size and type required can be installed without causing a slope failure due to vibrations cannot be determined until an investigation is conducted along areas of the slope where the geometry indicates that under certain conditions of material type and thickness, there is a potential for instability. A more detailed slope stability evaluation is required.

There appears to be a lower risk of a potential release due to densification and settlement. The preliminary evaluation indicated that any appreciable settlement would be localized within close proximity to the pile.

The preliminary evaluation of the potential impacts to surrounding structures indicates that the PPV from the vibrations should be within the threshold values considered acceptable, but may not be if a large hammed needs to be used. A further evaluation will need to be conducted as part of the RD after the hammer type and pile depths are known to determine whether vibrations are within threshold values considered acceptable and to determine whether monitoring of vibrations and the potential impact on structures are required.

7. References

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