CALCULATIONS
FOR
PIPE PILE WALLS

STRUCTURE

UNION STREET BRIDGE
B.I.N. 2-24027-0

PREPARED FOR

GOWANUS ENVIRONMENTAL REMEDIATION TRUST

RTA1 BRIDGE STABILITY FINAL DESIGN

PREPARED BY

Greenman-Pedersen, Inc.

FEB 2020

DESIGN SUMMARY

Design Criteria:

Manuals & Specifications

1. NYSDOT Geotechnical Design Procedure for Flexible Wall Systems - Aug 2015
2. NYSDOT Bridge Manual, 2017 Edition, updated August 2017
3. AASHTO Standard Specifications for Highway Bridges, 17th Edition - 2002
4. USS Sheet Piling Design Manual – 1984
5. AASHTO LRFD Bridge Design Specifications – Seventh Edition with 2016 Interim Revisions
6. NYSDOT Standard Specifications
7. NYCDOT Seismic Design Guidelines for Bridges in Downstate Region - May 2016
8. United Facilities Criteria (UFC) Engineering and Design of Military Ports, January 2004

References:

- Hsieh, Pio-Go and Ou, Chang-Yu. "Shape of Ground Surface Settlement Profiles Caused by Excavation." Canadian Geotechnical Journal 35(6):1004-1017 (1998)

Software Used:

- CivilTech Shoring Suite – Version 8
- Microsoft Excel
- Midas Civil 2019 (v1.1)

Design Approach:

The dredging of the Gowanus Canal for RTA 1 proposed by Geosyntec will impact the substructures of the Union Street bridge. The east and west abutment pile caps are located at elevation -2.95 ft (NAVD 88), which is 13.5 feet higher than the proposed dredging elevation in the area. This is not acceptable even in a temporary condition. Interlocking pipe pile walls will be installed along the existing bulkhead and bridge abutments to protect them during dredging. This will isolate the sediment between the pier and the abutments, maintaining the abutment pile soil interaction. The design of the pipe pile walls was done in ASD following the procedure in the NYSDOT Geotechnical Design Procedure for Flexible Wall Systems (GDP-11). The design of the walls is split into four locations notated as follows:

- USDL01 – UA 0+00 TO UA 0+22 (Northwest corner of the bridge)
- USDL02 – UB 0+00 TO UB 0+32 (Northeast corner of the bridge)
- USDL03 – UC 0+00 TO UC 0+34 (Southeast corner of the bridge)
- USDL04 – UD 0+00 TO UD 0+26 (Southwest corner of the bridge)

Three design cases were evaluated for the previously mentioned design locations (USDL01-USDL04).

Design Case I:

This design case represents a temporary condition during the dredging of the canal. Since the bridge will be maintained throughout construction, surcharge loading from the dead and live load of the bridge abutment will be included in the wall design. This will be applied as an area surcharge. Since the Union Street Bridge has no approach slabs, an infinite surcharge of 250psf will be applied to the wall as per Ref. 3 Section 3.20.4. For further information regarding surcharge, see design assumptions. All design locations (USDL01-USDL04) are evaluated for this design case.

Design Case II:

Design Case II represents the final condition after the environmental cap has been installed. Surcharge loading from the dead and live load of the bridge will be included in the wall design as in Design Case I, as well as the surcharge due to the lack of approach slabs. A surcharge is also included for the future possibility of a 6" concrete environmental cap behind the wall. Since this is a final design condition, seismic analysis will be included in this design. Seismic design was completed for the controlling design location – USDL01.

Design Case III:

Design Case III represents a temporary condition during the in-situ stabilization (ISS) of soil adjacent to the Union Street Bridge. During ISS, there is a temporary loss of soil strength during soil mixing. ISS will occur between phase II and III dredging operations. Since phase II dredge operations will not impact the area around the Union Street Bridge, the minimum existing bathymetry elevation is used to compute the wall height. The extent of the temporary soil strength loss is assumed to be 5 feet below the bottom of soft sediment as directed by Geosyntec Consultants. Seismic is not considered for this condition.

Ground Settlements:

Settlement of substructures are limited to 0.25" as per NYCDOT - Division of Bridges Review Procedure for Private Development Project near Bridge Structure (see Appendix D). Due to the unknown depth and condition of timber piles, ground settlements adjacent to bridge substructures will be limited to 0.25". This is a conservative design criterion being that the substructures are located on piles. Settlements caused by the installation of walls have been minimized through the DTH drilling method with spiral flush technology. Ground settlements induced by lateral wall deflection have been estimated using the procedure found in "Shape of Ground Surface Settlement Profiles Caused by Excavation" by Hsieh and Ou (1998). For more on the calculation of ground settlement, see *Attachment C – Procedure for Estimating Ground Settlement*.

Seismic Design:

Seismic design of the pipe pile walls is completed in CivilTech Shoring Suite. The additional earthquake forces are applied using the wedge analysis described in Ref. 5 Section A11.3.2. Seismic loading is only considered for the final design condition. Ground acceleration coefficients have been calculated using the procedure found in the NYCDOT Seismic Design Guidelines for Bridges in Downstate Region, summarized below:

Calculation of PGA (Reference – NYCDOT Seismic Design Guidelines for Bridges in Downstate Region):

Since the rock surface is greater than 10 ft below the surface, the site is classified as a soil site as per Section 6. The soil information provided by GZA GeoEnvironmental, shows that average undrained shear strength (s_u) of the canal soils is less than 1000 psf. Using Table 11, soil class E has been chosen for this site. The PGA has been selected using table 13. Since the rock level and classification in this region is unknown, soil on top of rock class B has been conservativity assumed. For more on the seismic classification and calculation of PGA, see *Attachment D – Seismic Design Parameters.*

Analysis Methods and Design Assumptions:

All Design Cases:

Soils and Subsurface information:

- All soil information including soil design properties and soil layer thicknesses were obtained from the RTA 1 Bridge Soil Design Parameters prepared by GZA GeoEnvironmental, Inc. dated July 11, 2018 (*Appendix A*). Soil layer thicknesses have been modified for certain design locations per the Summary of Geotechnical Design Parameters prepared by Geosyntec Consultants (*Appendix C*).
- All upland (non-canal) soils are assumed to be retained by the existing bulkhead and/or bridge abutments.
- As per NYSDOT GDP-11 Section II.A.7, cohesive soils are modeled as cohesiveless soils using the internal angle of friction specified in the RTA 1 Bridge Soil Design Parameters.
- Soil in front and behind the proposed pipe pile wall is assumed to be in the fully submerged condition throughout construction.
- The effect of tidal lag will be one-half the mean tidal range, as per UFC 4-159-02 Engineering and Design of Military Ports – 2004. This will be applied to the active side of the wall.
- Dredge depths were obtained from the bottom of soft sediment surface provided by Geosyntec Consultants. An over dredge allowance of six inches was included during the calculation of final dredge depths.

Wall Design:

- Rankine Theory was used for the development of earth pressures on the pipe pile wall as per NYSDOT GDP-11 Section II.A.1.
- Pipe pile wall design was performed using the program CivilTech Shoring Suite – Version 8. Verification of the program shows that it conforms to the guidelines, theories, and design methods found in NYSDOT GDP-11.
- For loading control movement combined with the rigidity of the pipe pile wall, the at-rest earth pressure coefficient, k_o will be used when calculating the earth pressures on the active side of the wall.
- Settlements behind the wall due to lateral wall deflections were calculated using the procedure described in “Shape of Ground Surface Settlement Profiles Caused by Excavation” by Hsieh and Ou (1998).

Seismic Analysis:

- Union Street Bridge has a seismic classification of “Other” based on the performance criteria defined in the NYCDOT Seismic Design Guidelines for Bridges in Downstate Region.
- Pipe pile walls will be analyzed for a single earthquake hazard level having 7% probability of being exceeded in 75 years (1000 years Return Period) as per NYCDOT Seismic Design Guidelines for Bridges in Downstate Region Section 2.
- The vertical seismic acceleration cofficient (kv) is equal to zero as per AASHTO LRFD Bridge Design Specifications Section A11.3.2.

Bridge Modeling and Surcharge Loading

- Approach Span 3 of the Union Street Bridge was modeled in Midas Civil to determine the bridge superstructure reactions at the abutments. Span 3 was modeled because it includes the control house platform, which is an added dead load to USDL02 that the remaining three corners of the bridge do not have.

- Two reaction conditions apply: Reactions with the control house platform are applied to USDL02. Reactions without the control house platform are applied to USDL01, USDL03 and USDL04.
- HS-20 vehicular live load is applied to two lanes on the structure as per Ref. 3 Section 3.6.2, Section 3.6.3 and Figure 3.7.7A.
- Reduction in load intensity is applied as per Ref. 3 Section 3.12.1
- Pedestrian live load of 85 psf is applied simultaneously to the sidewalks as per Ref. 3 Section 3.14.1.
- Both bascules spans, main girders, and their repetitive counterweights bear on the rest piers and do not contribute any loading affects to the abutments.
- Superstructure information was obtained through as-built plans to create a model of the approach span for load calculation at the abutment.
- The self-weight of the bridge abutment was calculated by hand and added to the combined load of the structure on the proposed wall.
- Load from the abutment is distributed through the abutment piles and applied as a surcharge to the wall as an area load surcharge with an equivalent footing for the pile group after Hannigan et al. (2006) (see Figure 10.7.2.3.1-1 of AASHTO LRFD Bridge Design Specifications for application)
- The timber piles supporting the bridge abutments are of an unknown length and are assumed to be 20ft long.
- A surcharge of 250 psf is applied to the wall design due to the lack of approach slabs at the bridge approaches as per Ref. 3 Section 3.20.4. This value was obtained from Section II.A.2 of the NYSDOT Geotechnical Design Procedure for Flexible Wall Systems.

Design Case I:

- A factor of Safety of 1.25 for a temporary condition is applied to the coefficient of passive earth pressure as per NYSDOT GDP-11 Section II.B.1.

Design Case II:

- A factor of Safety of 1.5 for a final condition is be applied to the coefficient of passive earth pressure as per NYSDOT GDP-11 Section II.B.2.
- A 75 psf infinite surcharge was applied to the wall to account for a future environmental cap behind the wall.

Design Case III:

- A factor of Safety of 1.25 for a temporary condition is applied to the coefficient of passive earth pressure as per NYSDOT GDP-11 Section II.B.1.

<u>In Situ Stabilization (ISS):</u>

- The loss of soil strength during ISS is assumed to occur 5 ft below the bottom of soft sediment surface as per Geosyntec Consultants.
- ISS will occur between phase II and phase III dredging operations by Geosyntec Consultants. Phase II dredging will not affect the canal surface 40’ in either direction of the bridge limits.
- ISSed material and overlaying soft sediment will lose soil strength during ISS. Friction angle is assumed to be zero for this material.
- A unit weight of 80 pcf is conservatively assumed considering some of the ISS material will be native alluvial/glacial deposits.

- Wall heights are computed from the minimum elevation in the canal prior to phase II dredging, which is El. -11.0 ft.

Summary of Results:

Design Checks					
Design Location	Moment Capacity				Controlling Design Case
	Z_{req} (in^3)	Z (in^3)	D/C	Check	
USDL01	52.09	167.53	0.31	OK	Design Case III
USDL02	43.43	167.53	0.26	OK	Design Case III
USDL03	38.52	167.53	0.23	OK	Design Case III
USDL04	46.08	167.53	0.28	OK	Design Case III

Design Checks					
Design Location	Settlement (in)				Controlling Design Case
	δ_v	$\delta_{v,\ allow}$	D/C	Check	
USDL01	0.20	0.25	0.80	OK	Design Case I
USDL02	0.20	0.25	0.79	OK	Design Case I
USDL03	0.19	0.25	0.74	OK	Design Case II
USDL04	0.16	0.25	0.65	OK	Design Case III

Pipe Pile Information						
Design Location	Elevations (ft)			Section	Wall Height (ft)	Pile Length (ft)
	Top	Min. Tip	Dredge			
USDL01	3.00	-53.00	-16.50	O-Pile 28"_0.748"	9.00	56.00
USDL02	3.00	-55.00	-16.00	O-Pile 28"_0.748"	9.00	58.00
USDL03	3.00	-53.00	-15.50	O-Pile 28"_0.748"	9.00	56.00
USDL04	3.00	-54.00	-15.00	O-Pile 28"_0.748"	10.00	57.00

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ATTACHMENTS:

APPENDICES:

DESIGN CASE I

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - Summary of Results

References:

1. NYSDOT Geotechnical Design Procedure for Flexible Wall Systems - Aug 2015
2. NYSDOT Bridge Manual - 2017
3. AASHTO Standard Specifications for Highway Bridges, 17th Edition - 2002
4. USS Sheet Piling Design Manual - 1984
5. AASHTO LRFD Bridge Design Specifications - Seventh Edition with 2016 Iterim Revisions
6. NYSDOT Standard Specifications
7. AASHTO Manual for Bridge Evaluation, 3rd Edition - 2018

Appendices:

Appendix A - RTA 1 Bridge Soil Design Parameters by GZA GeoEnvironmental, Inc.
Appendix B - O-Pile Datasheet
Appendix C - Summary of Geotechnical Design Parameters by Geosyntec Consultants

Assumptions:

See design summary for assumptions.

Summary of Results:

The results of the verification are summarized in the table below:

Design Checks								
Design Location	Moment Capacity				Settlement (in)			
	Z_{req} (in^3)	Z (in^3)	D/C	Check	δ_v	$\delta_{v,allow}$	D/C	Check
USDL01	43.61	167.53	0.26	OK	0.20	0.25	0.80	OK
USDL02	35.46	167.53	0.21	OK	0.20	0.25	0.79	OK
USDL03	26.79	167.53	0.16	OK	0.14	0.25	0.56	OK
USDL04	30.03	167.53	0.18	OK	0.16	0.25	0.63	OK

Pipe Pile Information						
Design Location	Elevations (ft)			Section	Wall Height	Pile Length
	Top	Min. Tip	Dredge			
USDL01	3.00	-49.00	-16.50	O-Pile 28"_0.748"	14.50	52.00
USDL02	3.00	-46.00	-16.00	O-Pile 28"_0.748"	14.00	49.00
USDL03	3.00	-42.00	-15.50	O-Pile 28"_0.748"	13.50	45.00
USDL04	3.00	-42.00	-15.00	O-Pile 28"_0.748"	14.00	45.00

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - Inputs

Pipe Pile Wall Material:

ASTM A 572 Grade 50 Steel:

F_y = 50 *ksi*

E = 29000 *ksi* — *Ref. 5 Section 6.4.1*

Soil Parameters:

Constants:

γ_w = 62.4 *pcf* (Unit weight of water)

Soil Layer 1 - Soft Sediment:

γ = 80 *pcf* (Total unit weight) — *Appendix A - Page AP-1*

φ' = 28 *deg* (Effective Friction Angle) — *Appendix A - Page AP-1*

γ' = $\gamma - \gamma_w$ (Effective unit weight)

γ' = 17.6 *pcf*

$K_o = 1 - \sin\emptyset'$ (At-rest pressure coefficient) — *Ref. 5 Eq. 3.11.5.2-1*

k_o = 0.53

$K_p = \frac{1 + \sin\emptyset'}{1 - \sin\emptyset'}$ (Passive pressure coefficient) — *Ref. 1 Appendix A - Page A-1*

k_p = 2.77

F.S. = 1.25 (Factor of Safety) — *Ref. 1 Section II.B.1*

$K_p' = K_p/F.S.$ (Effective Passive Pressure Coefficient)

K_p' = 2.22

Soil Layer 2 - Native Alluvial Sediment:

γ = 115 *pcf* (Total unit weight) — *Appendix A - Page AP-1*

φ' = 28 *deg* (Effective Friction Angle) — *Appendix A - Page AP-1*

γ' = $\gamma - \gamma_w$ (Effective unit weight)

γ' = 52.6 *pcf*

$K_o = 1 - \sin\emptyset'$ (At-rest pressure coefficient) — *Ref. 5 Eq. 3.11.5.2-1*

k_o = 0.53

$K_p = \frac{1 + \sin\emptyset'}{1 - \sin\emptyset'}$ (Passive pressure coefficient) — *Ref. 1 Appendix A - Page A-1*

k_p = 2.77

F.S. = 1.25 (Factor of Safety) — *Ref. 1 Section II.B.1*

$K_p' = K_p/F.S.$ (Effective Passive Pressure Coefficient)

K_p' = 2.22

GPI

PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

Soil Layer 3 - Glacial Deposit:

γ =	125 *pcf*	(Total unit weight)		*Appendix A - Page AP-1*
φ' =	34 *deg*	(Effective Friction Angle)		*Appendix A - Page AP-1*
γ' =	$\gamma - \gamma_w$	(Effective unit weight)		
			γ' = 62.6 *pcf*	
$K_o = 1 - \sin \emptyset'$		(At-rest pressure coefficient)		*Ref. 5 Eq. 3.11.5.2-1*
			k_o = 0.44	
$K_p = \frac{1 + \sin \emptyset'}{1 - \sin \emptyset'}$		(Passive pressure coefficient)		*Ref. 1 Appendix A - Page A-1*
			k_p = 3.54	
F.S. =	1.25	(Factor of Safety)		*Ref. 1 Section II.B.1*
K_p' =	$K_p/F.S.$	(Effective Passive Pressure Coefficient)		
			K_p' = 2.83	

Ref. 7 Table 6A.6.2.1-1

Midas Model

Midas finite element model created to determine bridge superstructure loading on abutment footing.

Material Inputs:

Steel Construction Prior to 1905:

F_y = 26 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

F_u = 52 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

E = 29000 *ksi*

wt_s = 490 *pcf* — *Ref. 3 Section 3.3.6*

Steel Construction from 1936 to 1963:

F_y = 33 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

F_u = 66 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

E = 29000 *ksi*

wt_s = 490 *pcf* — *Ref. 3 Section 3.3.6*

Concrete Construction 1959 and Later:

f'_c = 3 *ksi* — *Ref. 7 Table 6A.5.2.1-1*

wt_c = 150 *pcf* — *Ref. 3 Section 3.3.6*

Reinforcing Steel Construction 1954 and Later:

f_y = 40 *ksi* — *Ref. 7 Table 6A.5.2.2-1*

Section Inputs:

Rolled Sections:

Member	Section	H	bf	tf	tw
Roadway Stringer	15I42.9	15	5.5	0.622	0.41
Roadway End Dia.	12SH30.9	12	3.45	0.6	0.45
Roadway Int. Dia.	10SH41.1	10	4.319	0.575	0.794
Sidewalk Stringer	12C25	12	3.047	0.501	0.387
Sidewalk Girder	18I54.7	18	6	0.691	0.46
Sidewalk Girder	18C42.7	18	3.95	0.625	0.45

Built-up Sections:

Member	Top Flange	Bottom Flange	Web Plate	Cov. Pl.
Floor Beam 6	2-L7x4x5/8	2-L6x4x5/8	65 1/4x3/8	12x3/8
Approach Girder*	2-L7x4x5/8	2-L7x4x5/8	48x1/2	14x1
Bumping Girder	2L6x4x5/8	2L6x4x5/8	LATTICE	12x1/2

**Approach Girder section information is assumed based on site visits and inspection reports due to lack of as-built information.*

Loads:

Dead Load (D):

Self Weight:

Self weight will be increased by 25% to account for connections and assumptions.

Curb:

b_c =	11	*in*	(width of curb)
h_c =	18	*in*	(Total height of curb)
Section:	18C 42.7		(Curb facing rolled section)
w_c =	0.249	*k/ft*	(Wt. curb per ft.)

Railing:

Post:

Section:	6WF 25		(Railing post section)
Min. Spa:	4.29	*ft*	(Railing post minimum spacing)

Top Rail:

b_{tr} =	7.5	*in*	(Width of top rail plate)
t_{tr} =	0.75	*in*	(Thickness of top rail plate)

Bottom Three Rails:

b_{br} =	5	*in*	(Width of bottom rails plate)
t_{br} =	0.5	*in*	(Thickness of bottom rails plate)
w_r =	0.050	*k/ft*	(Wt. railing per ft.)

Live Load (L):

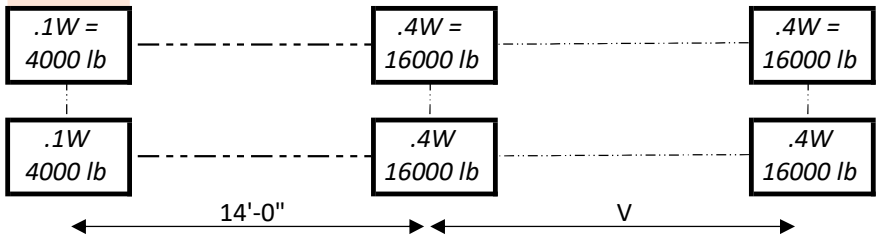
Vehicular Live Load:

Number of Lanes:

RW Width =	35	*ft*	(Width of roadway)	
No. Lanes =	2	*lanes*	(Number of travel lanes)	*Ref. 3 Section 3.6.2 & 3.6.3*

Standard HS-20 Truck:

W_{HS-20} = 40000 *lb* Stand H Truck: *Ref. 3 Figure 3.7.7A*



Standard HS-20 Lane Loading: *Ref. 3 Figure 3.7.6B*

w_{LL} =	0.64	*klf*	(Uniform lane load per linear foot of lane load
$P_{LL,S}$ =	26	kip	(Concentrated load for shear)
$P_{LL,m}$ =	18	kip	(Concentrated load for moment)

Impact:

No impact applied to the design of abutments or retaining walls *Ref. 3 Section 3.8.1.2*

Reduction in Load Intensity: *Ref. 3 Section 3.12.1*

# Lanes	Percent
1-2	100
3	90
>3	75

Sidewalk Live Loading:

$w_{LL,sw}$ = 85 *ksf* *Ref. 3 Section 3.14.1.1*

Abutment Dimensions:

Location	Component	Stem		Footing	
		L_{AS}	A_{AS}	L_{AF}	b_{AF}
East Abutment	North Footing	40	64.77	22.33	18
	South Footing	40		16.17	18
West Abutment	North Footing	30	64.77	12.33	18
	South Footing	30		12.33	18

Where:

A_{AS} = *Cross-sectional area of abutment stem (ft^2)*

L_{AS} = *Length of Abutment Stem, (ft)*

L_{AF} = *Length of Abutment Footing, (ft)*

b_{AF} = *Width of Abutment Footing, (ft)*

Calculation of Surcharge due to Bridge DL & LL:

Surcharge from bridge loading and control house is assumed to be distrubted through the foundation piles

$Q_{area} = P_{vT}/(bL)$

Q_{area} = *Area load input into CivilTech Shoring Suite*

$P_{vT} = P_{vAD} + P_{vSSD} + P_{vSSL} + P_{vCH}$

P_{vT} = Total vertical load applied to isloated footing

P_{vAD} = *Vertical load from dead load of abutment (kips)*

P_{vSSD} = *Vertical load from superstructure dead load (kips)*

P_{vSSL} = *Vertical load from superstructure live load (kips)*

P_{vCH} = *Vertical load from control house (kips)*

$P_{vAD} = A_{AS}\, wt_c\, L_{AS}$

Control House Surcharge:

Building load appiled to abutment footing is assumed to be 500 psf

Surcharge = 500 *psf*

Building Footprint:

L_{CH} = 22.5 *ft* (Length of Building)

b_{CH} = 14.5 *ft* (Width of Building)

P_{vCH} = 81.56 *kips* (Vertical load of control house)

Combinations of Loads: *Ref. 3 Table 3.22.1A*

AASHTO Loading	
Group	Factors Used
I	$\gamma\ (D + LL + \beta_E E)$

**No impact included for substructures or retaining walls* Ref. 3 Section 3.8.1.2

γ = *1.0* *Ref. 3 Table 3.22.1A*

β_E = *1.0* *for vertical and lateral earth pressure on retaining walls*

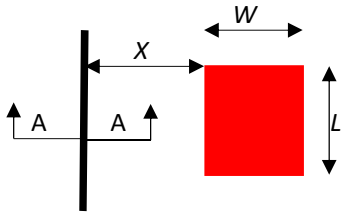
Calculation of Surcharge Loading:

Design Location	P_{vAD}	P_{vSSD}	P_{vSSL}	P_{vBS}	P_{vT}	Q_{area}
USDL02 - NE Ftg.	388.62	51.98813	81.88391	81.56	604.05454	1.50
USDL03 - SE Ftg.	388.62	44.22683	75.40961	N/A	508.25644	1.75
USDL01 - NW Ftg.	291.465	44.22683	75.40961	N/A	411.10144	1.85
USDL02 - SW Ftg.	291.465	44.22683	75.40961	N/A	411.10144	1.85

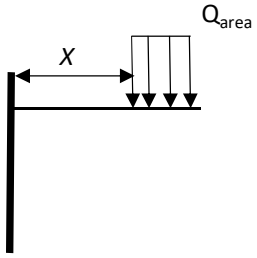
Area Load input into CivilTech:

Design Location	*L (ft)*	*W (ft)*	*X (ft)*	*Q_{area} (ksf)*
USDL01	*12.33*	*18.00*	*5*	*1.85*
USDL02	*22.33*	*18.00*	*5*	*1.50*
USDL03	*16.17*	*18.00*	*5*	*1.75*
USDL04	*12.33*	*18.00*	*5*	*1.85*

**See diagram for definition of L, W, X and Q_{area}*



Wall Plan View



Section A-A

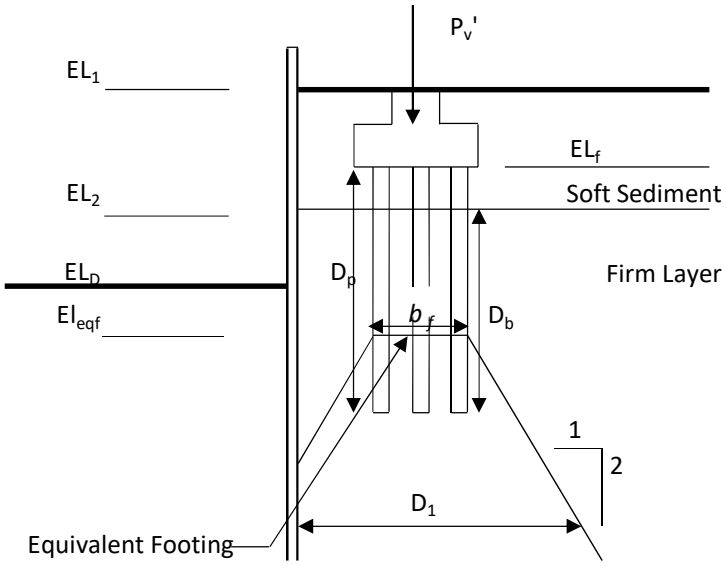
Calculation of Depth of Applied Surcharge Loading:

Calculate Location of Equivalent Footing: *Ref. 5 Figure 10.7.2.3.1-1*

$D_b = D_p-(EL_f-EL_2)$ (Total depth of pile in firm soil layer)

$EL_{eqf} = EL_f-D_p+1/3D_b$ (Elevation of equivalent footing) *Ref. 5 Figure 10.7.2.3.1-1*

Design Location	*EL_f*	*EL_1*	*EL_2*	*D_p*	*D_b*	*El_{eqf}*
USDL01	*-2.9*	*-2.00*	*-14.53*	*20.00*	8.37	-20.11
USDL02	*-2.9*	*-2.00*	*-14.55*	*20.00*	8.35	-20.12
USDL03	*-2.9*	*-2.00*	*-14.89*	*20.00*	8.01	-20.23
USDL04	*-2.9*	*-1.00*	*-12.79*	*20.00*	10.11	-19.53



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

Calculation of Surcharge due to Approach Roadway:

Since there are no approach slabs at the Union Street Bridge, a vehicular surcharge must be applied as per reference 3 Section 3.20.4

Ref. 1 Section II.A.2

$q_{infinite}$ = 0.25 ksf (Infinite surcharge applied behind the wall)

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL01

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.53	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-26.33	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-16.50	*ft*	(Dredge elevation)	
H =	14.50	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-49.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	52.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	-2.57	*ft*	(Active side water elevation)	
EL_{PW} =	-4.835	*ft*	(Passive side water elevation)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.85	*ksf*	(Area Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipeing Section:

M_{max} =	109.02	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-1*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 43.61 in^3

D/C = **0.26** ***OK***

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL01

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.34 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-1*

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.34

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *6 ft* (Distance behind the wall)

H_e = 14.50 *ft* (Height of excavation)

δ_v = *0.20 in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.80** ***OK***

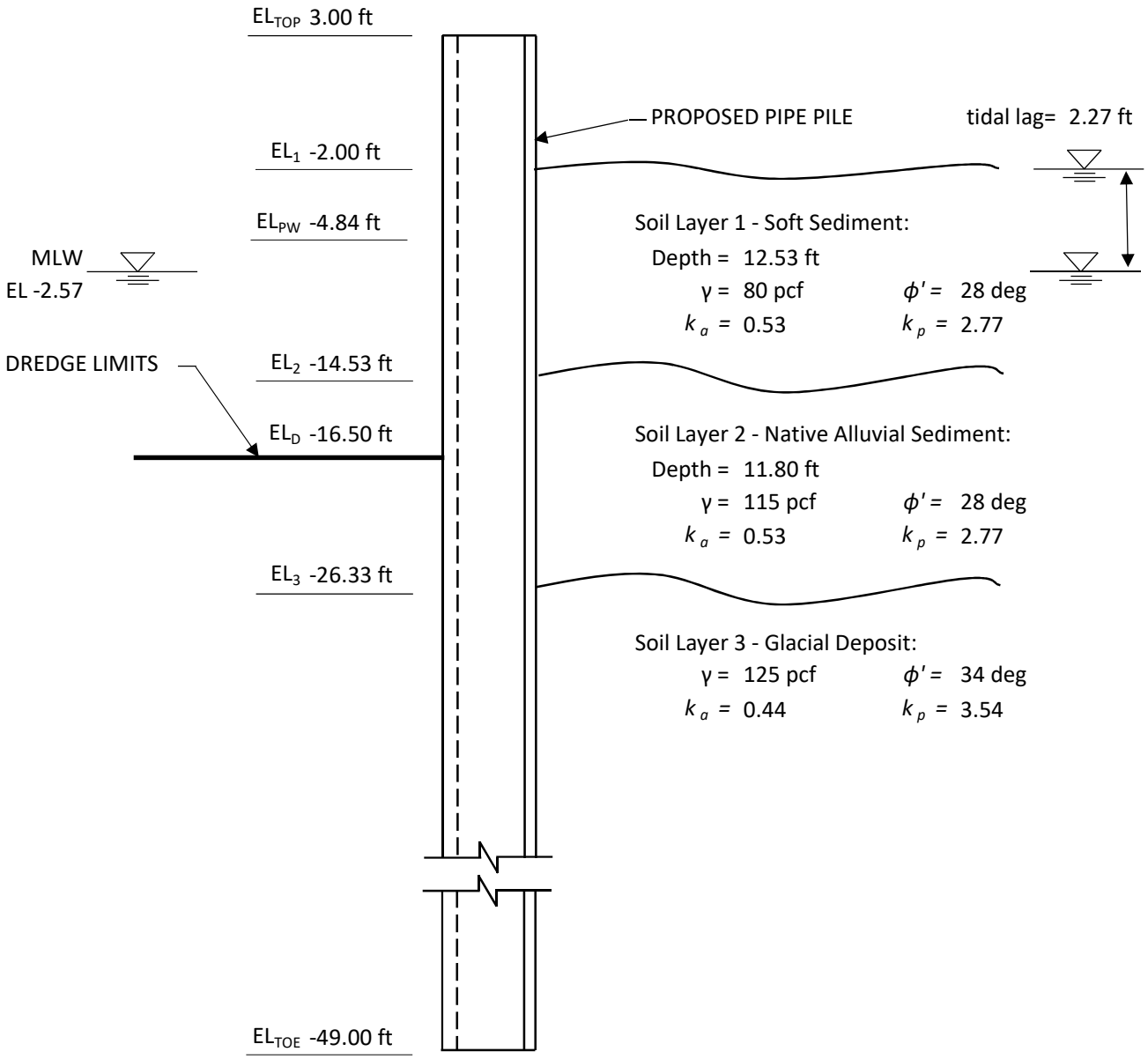
Depth of Pipe Pile Wall:

Embed = 31.86 *ft* (Minimum Embedment) *Attachment A - Page A-1*

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL01

Pipe Pile Cross-Section (Not to Scale):



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL02

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.55	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-21.30	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-16.00	*ft*	(Dredge elevation)	
H =	14.00	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-46.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	49.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	1.96	*ft*	(Active side water elevation)	
EL_{PW} =	-0.305	*ft*	(Passive side water elevation)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.50	*ksf*	(Applied Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipe Pile section:

M_{max} =	88.64	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-7*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 35.46 in^3

D/C = **0.21** ***OK***

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL02

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.27 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-7*

δ_{vm} = $R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.27

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *2.5 ft* (Distance behind the wall)

H_e = 14.00 *ft* (Height of excavation)

δ_v = *0.20 in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.79** ***OK***

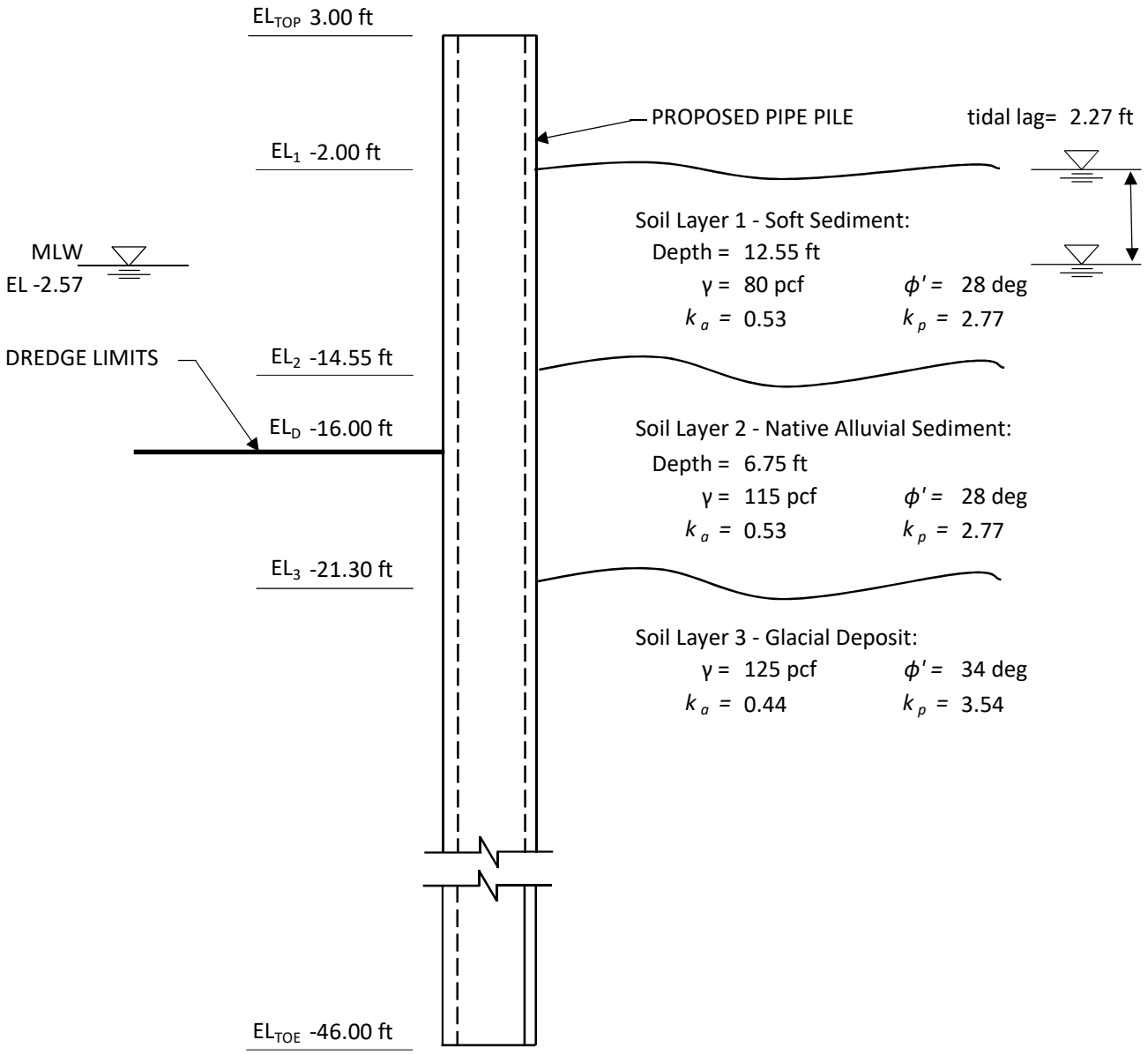
Depth of Pipe Pile Wall:

Embed = 29.17 *ft* (Minimum Embedment) *Attachment A - Page A-7*

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL02

Pipe Pile Cross-Section (Not to Scale):



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL03

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.89	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-15.39	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-15.50	*ft*	(Dredge elevation)	
H =	13.50	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-42.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	45.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	1.96	*ft*	(Active side water elevation)	
EL_{PW} =	-0.305	*ft*	(Passive side water elevation)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.75	*ksf*	(Applied Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipe Pile Section:

M_{max} =	66.98	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-12*
σ_{allow} =	$0.6f_y$		(Allowable stress in Pipe pile)	σ_{allow} = 30 *ksi*
Z_{min} =	M_{max}/σ_{allow}		(Minimum section modulus)	Z_{min} = 26.79 in^3
				D/C = **0.16** ***OK***

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL03

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement" *Attachment A - Page A-12*

δ_{hm} = 0.2 *in* (Calc. Deflection @ top of soil lay δ_{vm} = 0.20

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement)

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *3* *ft* (Distance behind the wall)

H_e = 13.50 *ft* (Height of excavation)

δ_v = *0.14* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.56** ***OK***

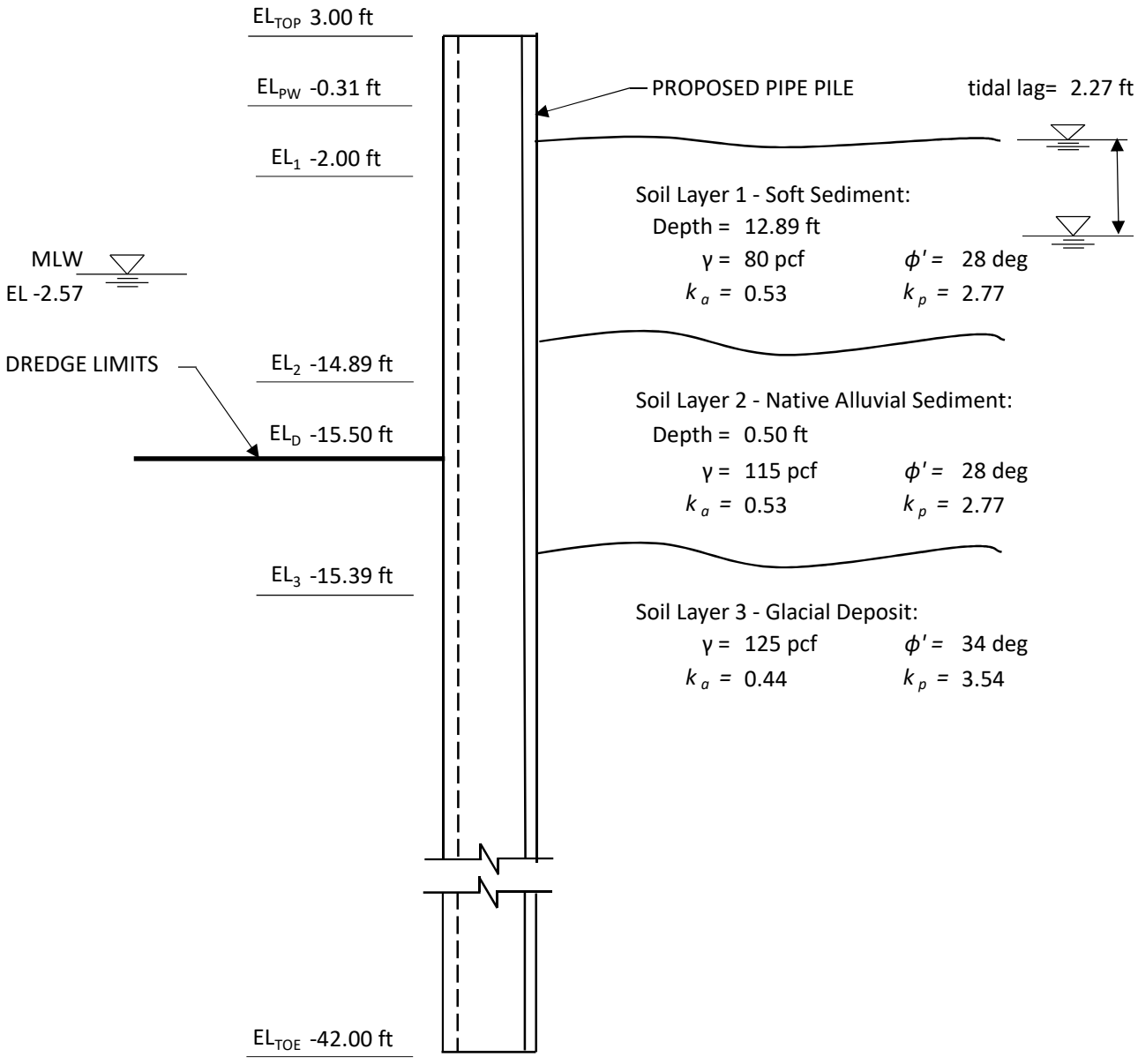
Depth of Pipe Pile Wall: *Attachment A - Page A-12*

Embed = 25.61 *ft* (Minimum Embedment)

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL03

Pipe Pile Cross-Section (Not to Scale):



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL04

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-1.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-12.79	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-15.00	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-15.00	*ft*	(Dredge elevation)	
H =	14.00	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-42.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	45.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	-2.57	*ft*	(Active side water elevation)	
EL_{PW} =	-4.835	*ft*	(Passive side water elevation)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.85	*ksf*	(Applied Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipe Pile Section:

M_{max} =	75.07	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-17*
σ_{allow} =	$0.6f_y$		(Allowable stress in Pipe pile)	σ_{allow} = 30 *ksi*
Z_{min} =	M_{max}/σ_{allow}		(Minimum section modulus)	Z_{min} = 30.03 in^3
				D/C = **0.18** ***OK***

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL04

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement" *Attachment A - Page A-17*

δ_{hm} = 0.23 *in* (Calc. Deflection @ top of soil lay δ_{vm} = 0.23

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement)

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *3.5* *ft* (Distance behind the wall)

H_e = 14.00 *ft* (Height of excavation)

δ_v = *0.16* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.63** ***OK***

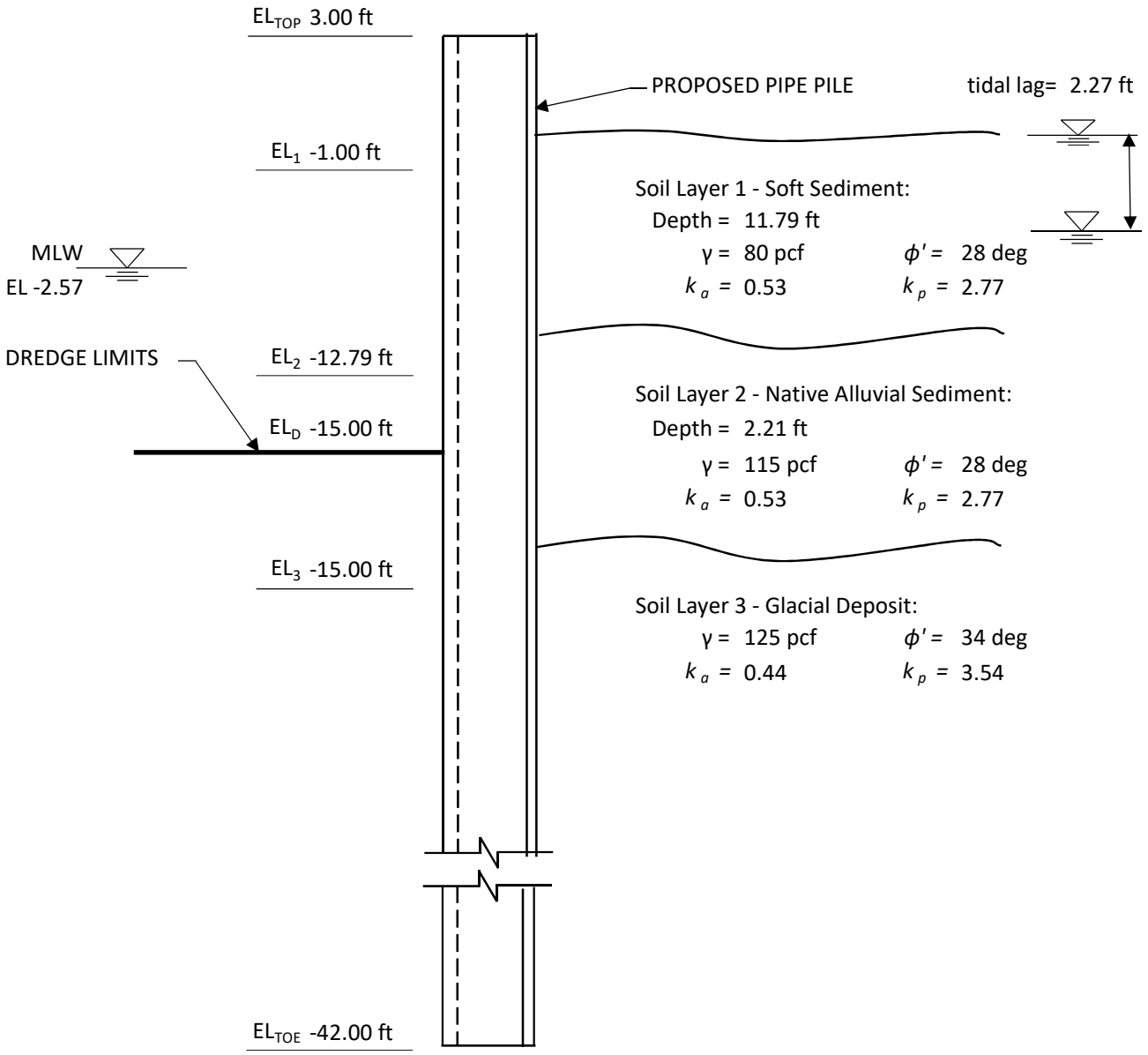
Depth of Pipe Pile Wall: *Attachment A - Page A-17*

Embed = 26.5 *ft* (Minimum Embedment)

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case I	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case I - USDL04

Pipe Pile Cross-Section (Not to Scale):



DESIGN CASE II

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case II	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case II - Summary of Results

References:

1. NYSDOT Geotechnical Design Procedure for Flexible Wall Systems - Aug 2015
2. NYSDOT Bridge Manual - 2017
3. AASHTO Standard Specifications for Highway Bridges, 17th Edition - 2002
4. USS Sheet Piling Design Manual - 1984
5. AASHTO LRFD Bridge Design Specifications - Seventh Edition with 2016 Iterim Revisions
6. NYSDOT Standard Specifications
7. AASHTO Manual for Bridge Evaluation, 3rd Edition - 2018

Appendices:

Appendix A - RTA 1 Bridge Soil Design Parameters by GZA GeoEnvironmental, Inc.
Appendix B - O-Pile Datasheet
Appendix C - Summary of Geotechnical Design Parameters by Geosyntec Consultants

Assumptions:

See design summary for assumptions.

Summary of Results:

The results of the verification are summarized in the table below:

Design Checks									
Design Location	Group	Moment Capacity				Settlement (in)			
		Z_{req} (in^3)	Z (in^3)	D/C	Check	δ_v	$\delta_{v,allow}$	D/C	Check
USDL01	I	43.23	167.53	0.26	OK	0.18	0.25	0.72	OK
USDL01	VII	43.07	167.53	0.26	OK	0.13	0.25	0.52	OK
USDL02	I	37.30	167.53	0.22	OK	0.19	0.25	0.74	OK
USDL03	I	27.26	167.53	0.16	OK	0.12	0.25	0.49	OK
USDL04	I	30.78	167.53	0.18	OK	0.14	0.25	0.58	OK

Pipe Pile Information						
Design Location	Elevations (ft)			Section	Wall Height	Pile Length
	Top	Min. Tip	Dredge			
USDL01	3.00	-52.00	-16.50	O-Pile 28"_0.748"	12.67	55.00
USDL02	3.00	-50.00	-16.00	O-Pile 28"_0.748"	12.17	53.00
USDL03	3.00	-45.00	-15.50	O-Pile 28"_0.748"	11.67	48.00
USDL04	3.00	-45.00	-15.00	O-Pile 28"_0.748"	12.17	48.00

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case II	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case II - Inputs

Pipe Pile Wall Material:

ASTM A 572 Grade 50 Steel:

F_y = 50 *ksi*

E = 29000 *ksi* — *Ref. 5 Section 6.4.1*

Soil Parameters:

Constants:

γ_w = 62.4 *pcf* (Unit weight of water)

Soil Layer 1 - Soft Sediment:

γ = 80 *pcf* (Total unit weight) — *Appendix A - Page AP-1*

φ' = 28 *deg* (Effective Friction Angle) — *Appendix A - Page AP-1*

γ' = $\gamma - \gamma_w$ (Effective unit weight)

γ' = 17.6 *pcf*

$K_o = 1 - \sin\emptyset'$ (At-rest pressure coefficient) — *Ref. 5 Eq. 3.11.5.2-1*

k_o = 0.53

$K_p = \frac{1+\sin\emptyset'}{1-\sin\emptyset'}$ (Passive pressure coefficient) — *Ref. 1 Appendix A - Page A-1*

k_p = 2.77

F.S. = 1.5 (Factor of Safety) — *Ref. 1 Section II.B.2*

K_p' = K_p/*F.S.* (Effective Passive Pressure Coefficient)

K_p' = 1.85

Soil Layer 2 - Native Alluvial Sediment:

γ = 115 *pcf* (Total unit weight) — *Appendix A - Page AP-1*

φ' = 28 *deg* (Effective Friction Angle) — *Appendix A - Page AP-1*

γ' = $\gamma - \gamma_w$ (Effective unit weight)

γ' = 52.6 *pcf*

$K_o = 1 - \sin\emptyset'$ (At-rest pressure coefficient) — *Ref. 5 Eq. 3.11.5.2-1*

k_o = 0.53

$K_p = \frac{1+\sin\emptyset'}{1-\sin\emptyset'}$ (Passive pressure coefficient) — *Ref. 1 Appendix A - Page A-1*

k_p = 2.77

F.S. = 1.5 (Factor of Safety) — *Ref. 1 Section II.B.2*

K_p' = K_p/*F.S.* (Effective Passive Pressure Coefficient)

K_p' = 1.85

Soil Layer 3 - Glacial Deposit:

γ =	125 *pcf*	(Total unit weight)		*Appendix A - Page AP-1*
φ' =	34 *deg*	(Effective Friction Angle)		*Appendix A - Page AP-1*
γ' =	$\gamma - \gamma_w$	(Effective unit weight)		
			γ' = 62.6 *pcf*	
$K_o = 1 - \sin\emptyset'$		(At-rest pressure coefficient)		*Ref. 5 Eq. 3.11.5.2-1*
			k_o = 0.44	
$K_p = \frac{1+\sin\emptyset'}{1-\sin\emptyset'}$		(Passive pressure coefficient)		*Ref. 1 Appendix A - Page A-1*
			k_p = 3.54	
F.S. =	1.5	(Factor of Safety)		*Ref. 1 Section II.B.2*
K_p' =	$K_p/F.S.$	(Effective Passive Pressure Coefficient)		
			K_p' = 2.36	

Soil Layer 4 - Sand Backfill/Cap:

γ =	115 *pcf*	(Total unit weight)		
φ' =	30 *deg*	(Effective Friction Angle)		
γ' =	$\gamma - \gamma_w$	(Effective unit weight)		
			γ' = 115 *pcf*	
$K_o = 1 - \sin\emptyset'$		(At-rest pressure coefficient)		*Ref. 5 Eq. 3.11.5.2-1*
			k_o = 0.50	
$K_p = \frac{1+\sin\emptyset'}{1-\sin\emptyset'}$		(Passive pressure coefficient)		*Ref. 1 Appendix A - Page A-1*
			k_p = 3.00	
F.S. =	1.5	(Factor of Safety)		*Ref. 1 Section II.B.2*
K_p' =	$K_p/F.S.$	(Effective Passive Pressure Coefficient)		
			K_p' = 2.00	

RTA 1 - Union Street Pipe Pile Wall Design Case II - Surcharge

Midas Model

Midas finite element model created to determine bridge superstructure loading on abutment footing.

Material Inputs:

Steel Construction Prior to 1905:

F_y =	26	*ksi*	*Ref. 7 Table 6A.6.2.1-1*
F_u =	52	*ksi*	*Ref. 7 Table 6A.6.2.1-1*
E =	29000	*ksi*	
wt_s =	490	*pcf*	*Ref. 3 Section 3.3.6*

Steel Construction from 1936 to 1963:

F_y =	33	*ksi*	*Ref. 7 Table 6A.6.2.1-1*
F_u =	66	*ksi*	*Ref. 7 Table 6A.6.2.1-1*
E =	29000	*ksi*	
wt_s =	490	*pcf*	*Ref. 3 Section 3.3.6*

Concrete Construction 1959 and Later:

f'_c =	3	*ksi*	*Ref. 7 Table 6A.5.2.1-1*
wt_c =	150	*pcf*	*Ref. 3 Section 3.3.6*

Reinforcing Steel Construction 1954 and Later:

f_y =	40	*ksi*	*Ref. 7 Table 6A.5.2.2-1*

Section Inputs:

Rolled Sections:

Member	Section	H	bf	tf	tw
Roadway Stringer	15I42.9	15	5.5	0.622	0.41
Roadway End Dia.	12SH30.9	12	3.45	0.6	0.45
Roadway Int. Dia.	10SH41.1	10	4.319	0.575	0.794
Sidewalk Stringer	12C25	12	3.047	0.501	0.387
Sidewalk Girder	18I54.7	18	6	0.691	0.46
Sidewalk Girder	18C42.7	18	3.95	0.625	0.45

Built-up Sections:

Member	Top Flange	Bottom Flange	Web Plate	Cov. Pl.
Floor Beam 6	2-L7x4x5/8	2-L6x4x5/8	65 1/4x3/8	12x3/8
Approach Girder*	2-L7x4x5/8	2-L7x4x5/8	48x1/2	14x1
Bumping Girder	2L6x4x5/8	2L6x4x5/8	LATTICE	12x1/2

**Approach Girder section information is assumed based on site visits and inspection reports due to lack of as-built information.*

Loads:

Dead Load (D):

Self Weight:

Self weight will be increased by 25% to account for connections and assumptions.

Curb:

b_c =	11 *in*	(width of curb)	
h_c =	18 *in*	(Total height of curb)	
Section:	18C 42.7	(Curb facing rolled section)	
w_c =	0.249 *k/ft*	(Wt. curb per ft.)	

Railing:

Post:

Section:	6WF 25	(Railing post section)	
Min. Spa:	4.29 *ft*	(Railing post minimum spacing)	

Top Rail:

b_{tr} =	7.5 *in*	(Width of top rail plate)	
t_{tr} =	0.75 *in*	(Thickness of top rail plate)	

Bottom Three Rails:

b_{br} =	5 *in*	(Width of bottom rails plate)	
t_{br} =	0.5 *in*	(Thickness of bottom rails plate)	
w_r =	0.050 *k/ft*	(Wt. railing per ft.)	

Live Load (L):

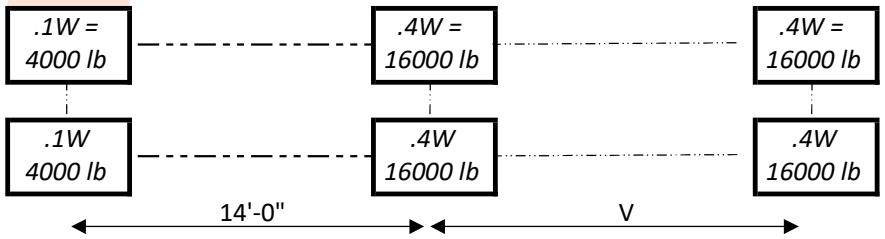
Vehicular Live Load:

Number of Lanes:

RW Width =	35 *ft*	(Width of roadway)	
No. Lanes =	2 *lanes*	(Number of travel lanes)	*Ref. 3 Section 3.6.2 & 3.6.3*

Standard HS-20 Truck:

W_{HS-20} = 40000 *lb* Stand H Truck: *Ref. 3 Figure 3.7.7A*



Standard HS-20 Lane Loading: *Ref. 3 Figure 3.7.6B*

w_{LL} =	0.64 *klf*	(Uniform lane load per linear foot of lane load
$P_{LL,S}$ =	26 kip	(Concentrated load for shear)
$P_{LL,m}$ =	18 kip	(Concentrated load for moment)

Impact:

No impact applied to the design of abutments or retaining walls *Ref. 3 Section 3.8.1.2*

Reduction in Load Intensity: *Ref. 3 Section 3.12.1*

# Lanes	Percent
1-2	100
3	90
>3	75

Sidewalk Live Loading:

$w_{LL,sw}$ = 85 *ksf* *Ref. 3 Section 3.14.1.1*

Abutment Dimensions:

Location	Component	Stem		Footing	
		L_{AS}	A_{AS}	L_{AF}	b_{AF}
East Abutment	North Footing	40	64.77	22.33	18
	South Footing	40		16.17	18
West Abutment	North Footing	30	64.77	12.33	18
	South Footing	30		12.33	18

Where:

A_{AS} = *Cross-sectional area of abutment stem (ft^2)*

L_{AS} = *Length of Abutment Stem, (ft)*

L_{AF} = *Length of Abutment Footing, (ft)*

b_{AF} = *Width of Abutment Footing, (ft)*

Calculation of Surcharge due to Bridge DL & LL:

Surcharge from bridge loading and control house is assumed to be distrubted through the foundation piles

$Q_{area} = P_{vT}/(bL)$

Q_{area} = *Area load input into CivilTech Shoring Suite*

$P_{vT} = P_{vAD} + P_{vSSD} + P_{vSSL} + P_{vCH}$

P_{vT} = Total vertical load applied to isloated footing

P_{vAD} = *Vertical load from dead load of abutment (kips)*

P_{vSSD} = *Vertical load from superstructure dead load (kips)*

P_{vSSL} = *Vertical load from superstructure live load (kips)*

P_{vCH} = *Vertical load from control house (kips)*

$P_{vAD} = A_{AS}\, wt_c\, L_{AS}$

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Control House Surcharge:

Building load appiled to abutment footing is assumed to be 500 psf

Surcharge = 500 *psf*

Building Footprint:

L_{CH} = 22.5 *ft* (Length of Building)

b_{CH} = 14.5 *ft* (Width of Building)

P_{vCH} = 81.56 *kips* (Vertical load of control house)

Combinations of Loads: *Ref. 3 Table 3.22.1A*

AASHTO Loading	
Group	Factors Used
I	$\gamma\ (D + LL + \beta_E E)$
VII	$\gamma\ (D + \beta_E E)$

**No impact included for substructures or retaining walls* Ref. 3 Section 3.8.1.2

γ = *1.0* *Ref. 3 Table 3.22.1A*

β_E = *1.0* *for vertical and lateral earth pressure on retaining walls*

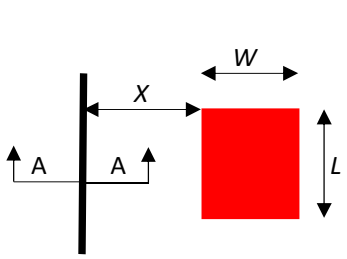
Calculation of Surcharge Loading:

	Appiled Loading				Group I		Group VII	
Design Location	P_{vAD}	P_{vSSD}	P_{vSSL}	P_{vBS}	P_{vT}	Q_{area}	P_{vT}	Q_{area}
USDL02 - NE Ftg.	388.62	51.98813	81.88391	81.56	604.0545	1.50	522.17	1.30
USDL03 - SE Ftg.	388.62	44.22683	75.40961	N/A	508.2564	1.75	432.85	1.49
USDL01 - NW Ftg.	291.465	44.22683	75.40961	N/A	411.1014	1.85	335.69	1.51
USDL02 - SW Ftg.	291.465	44.22683	75.40961	N/A	411.1014	1.85	335.69	1.51

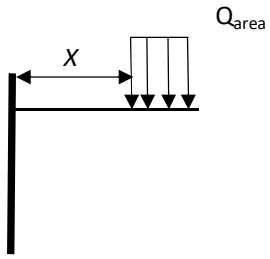
Area Load input into CivilTech:

				Group I	Group VII
Design Location	*L (ft)*	*W (ft)*	*X (ft)*	*Q_{area} (ksf)*	*Q_{area} (ksf)*
USDL01	*12.33*	*18.00*	*5*	*1.85*	1.30
USDL02	*22.33*	*18.00*	*5*	*1.50*	1.49
USDL03	*16.17*	*18.00*	*5*	*1.75*	1.51
USDL04	*12.33*	*18.00*	*5*	*1.85*	1.51

**See diagram for definition of L, W, X and Q_{area}*



Wall Plan View



Section A-A

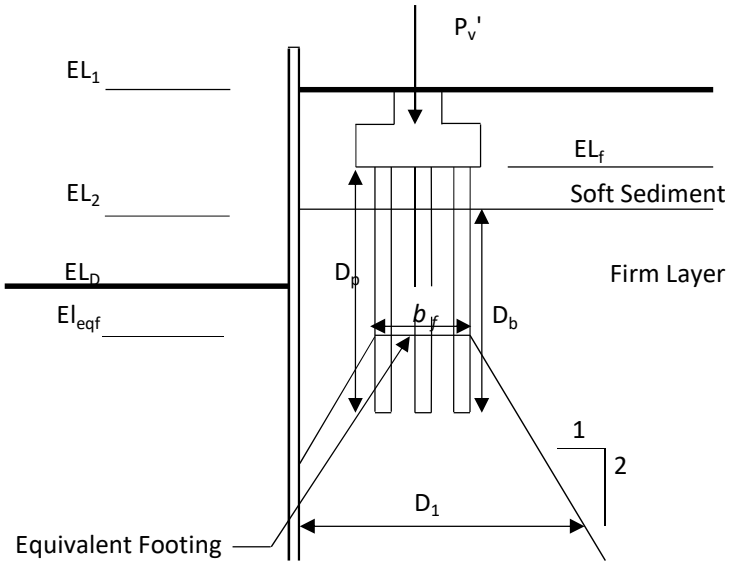
Calculation of Depth of Applied Surcharge Loading:

Calculate Location of Equivalent Footing: *Ref. 5 Figure 10.7.2.3.1-1*

$D_b = D_p-(EL_f-EL_2)$ (Total depth of pile in firm soil layer)

$EL_{eqf} = EL_f-D_p+1/3D_b$ (Elevation of equivalent footing) *Ref. 5 Figure 10.7.2.3.1-1*

Design Location	*EL_f*	*EL_1*	*EL_2*	*D_p*	*D_b*	*El_{eqf}*
USDL01	*-2.9*	*-2.00*	*-14.53*	*20.00*	8.37	-20.11
USDL02	*-2.9*	*-2.00*	*-14.55*	*20.00*	8.35	-20.12
USDL03	*-2.9*	*-2.00*	*-14.89*	*20.00*	8.01	-20.23
USDL04	*-2.9*	*-1.00*	*-12.79*	*20.00*	10.11	-19.53



Calculation of Surcharge due to Approach Roadway:

Since there are no approach slabs at the Union Street Bridge, a vehicular surcharge must be applied as per reference 3 Section 3.20.4

Ref. 1 Section II.A.2

q_{LL} = 0.25 *ksf* (Infinite surcharge applied behind the wall)

Calculation of Surcharge due to Environmental Cap Behind Wall

For design, there is an assumed 6" concrete cap behind the wall

t_{cap} = *6 in* *(Thickness of concrete cap)*

q_{cap} = 0.075 *ksf* (Infinite surcharge applied behind the wall)

Total Infinite surcharge behind wall

Group I:

$q_{infinite} = q_{LL} + q_{cap}$

$q_{infinite}$ = 0.325 *ksf* (Total Infinite surcharge applied behind the wall)

Group VII:

$q_{infinite} = q_{cap}$

$q_{infinite}$ = 0.075 *ksf* (Total Infinite surcharge applied behind the wall)

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RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL01

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.53	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-26.33	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-16.50	*ft*	(Dredge elevation)	
EL_{CAP} =	-14.67	*ft*	(Environmental Cap Elevation)	
H =	12.67	*ft*	(Wall height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-52.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	55.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL01

Load Combination Group I:

Surcharge Loading:

Q_{area} = 1.85 *ksf* (Area Surcharge)

$q_{infinite}$ = 0.33 *ksf* (Infinite Surcharge)

Check Pipeing Section:

M_{max} = 108.07 *k-ft* (Maximum moment on wall) *Attachment A - Page A-22*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 43.23 in^3

D/C = **0.26** ***OK***

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.32 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-22*

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.32

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = 6 *ft* (Distance behind the wall)

H_e = 12.67 *ft* (Height of excavation)

δ_v = *0.18* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.72** ***OK***

Depth of Pipe Pile Wall:

Embed = 35.21 *ft* (Minimum Embedment) *Attachment A - Page A-22*

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL01

Load Combination Group VII:

Surcharge Loading:

Q_{area} = 1.30 *ksf* (Area Surcharge)

$q_{infinite}$ = 0.075 *ksf* (Infinite Surcharge)

Seismic Coefficients:

k_h = 0.29 (Horizontal acceleration coefficient) *Attachment D - Page D-2*

k_v = 0 (Vertical acceleration coefficient) *Attachment D - Page D-2*

Check Pipeing Section:

M_{max} = 73.22 *k-ft* (Maximum moment on wall) *Attachment A - Page A-28*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 20.4 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 43.07 in^3

D/C = **0.26** ***OK***

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.23 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-28*

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.23

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = 6 *ft* (Distance behind the wall)

H_e = 12.67 *ft* (Height of excavation)

δ_v = 0.13 *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.52** ***OK***

Depth of Pipe Pile Wall:

E = 34 *ft* (Minimum Embedment) *Attachment A - Page A-28*

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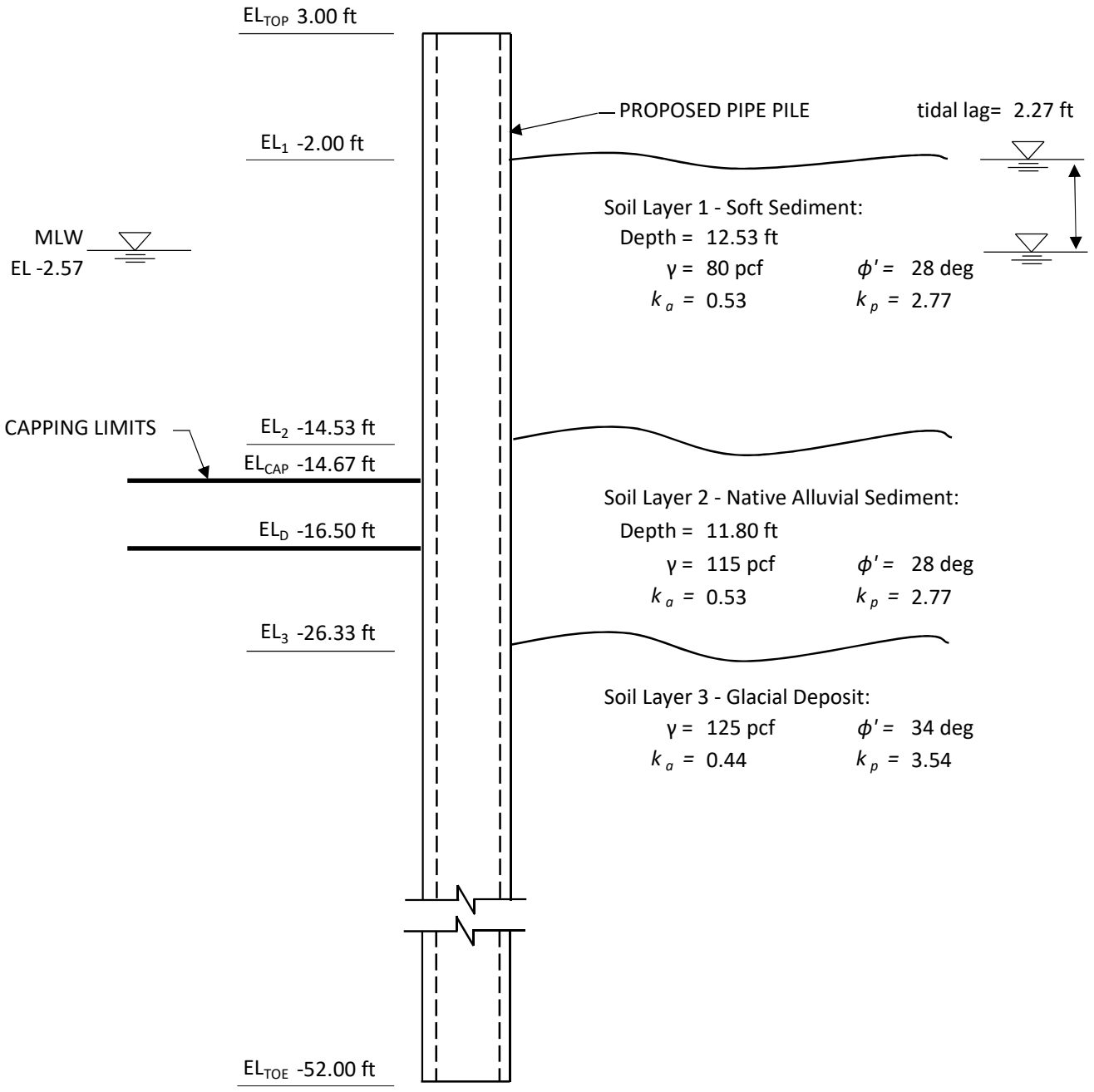
RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL01

Pipe Pile Cross-Section (Not to Scale):



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RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL02

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.55	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-21.30	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-16.00	*ft*	(Dredge elevation)	
EL_{CAP} =	-14.17	*ft*	(Environmental Cap Elevation)	
H =	12.17	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-50.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	53.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	1.96	*ft*	(Active side water elevation)	
EL_{PW} =	-0.305	*ft*	(Passive side water elevation)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.50	*ksf*	(Applied Surcharge)
$q_{infinite}$ =	0.33	*ksf*	(Infinite Surcharge)

Check Pipe Pile section:

M_{max} = 93.26 *k-ft* (Maximum moment on wall) *Attachment A - Page A-35*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 37.30 in^3

D/C = **0.22** ***OK***

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RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL02

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.26 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-35*

δ_{vm} = $R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.26

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *2.5 ft* (Distance behind the wall)

H_e = 12.17 *ft* (Height of excavation)

δ_v = *0.19 in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.74** ***OK***

Depth of Pipe Pile Wall:

Embed = 33.12 *ft* (Minimum Embedment) *Attachment A - Page A-35*

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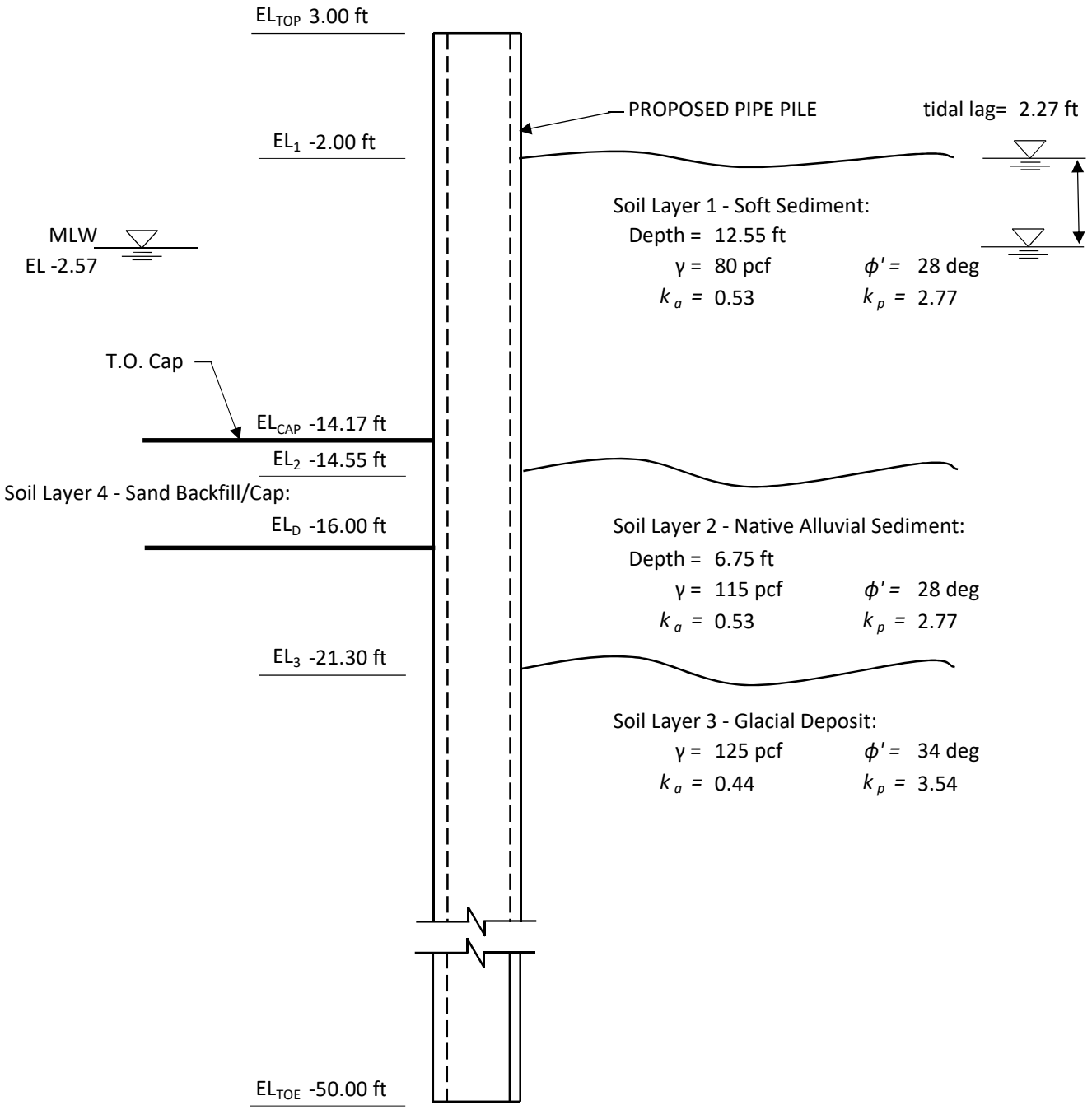
RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL02

Pipe Pile Cross-Section (Not to Scale):



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RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL03

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.89	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-15.39	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-15.50	*ft*	(Dredge elevation)	
EL_{CAP} =	-13.67	*ft*	(Environmental Cap Elevation)	
H =	11.67	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-45.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	48.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	1.96	*ft*	(Active side water elevation)	
EL_{PW} =	-0.305	*ft*	(Passive side water elevation)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.75	*ksf*	(Applied Surcharge)
$q_{infinite}$ =	0.33	*ksf*	(Infinite Surcharge)

Check Pipe Pile Section:

M_{max} = 68.14 *k-ft* (Maximum moment on wall) *Attachment A - Page A-41*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 27.26 in^3

D/C = **0.16** ***OK***

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case II	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL03

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.18 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-41*

δ_{vm} = $R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.18

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = 3 *ft* (Distance behind the wall)

H_e = 11.67 *ft* (Height of excavation)

δ_v = *0.12 in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

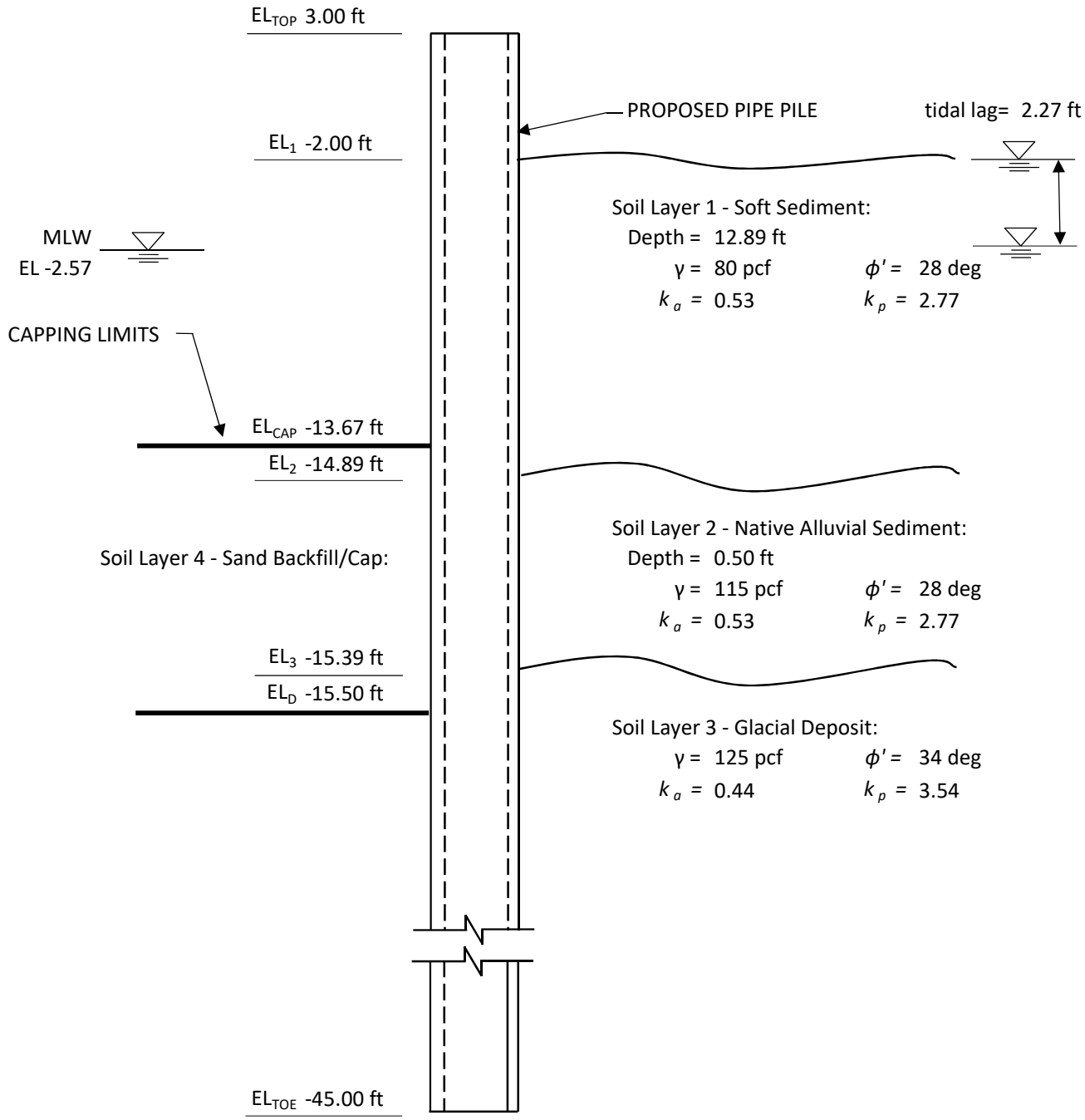
D/C = **0.49** ***OK***

Depth of Pipe Pile Wall:

Embed = 28.68 *ft* (Minimum Embedment) *Attachment A - Page A-41*

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL03

Pipe Pile Cross-Section (Not to Scale):



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case II	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL04

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-1.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-12.79	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-15.00	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-15.00	*ft*	(Dredge elevation)	
EL_{CAP} =	-13.17	*ft*	(Environmental Cap Elevation)	
H =	12.17	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-45.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	48.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	-2.57	*ft*	(Active side water elevation)	
EL_{PW} =	-4.835	*ft*	(Passive side water elevation)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.85	*ksf*	(Applied Surcharge)
$q_{infinite}$ =	0.33	*ksf*	(Infinite Surcharge)

Check Pipe Pile Section:

M_{max} = 76.95 *k-ft* (Maximum moment on wall) *Attachment A - Page A-46*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 30.78 in^3

D/C = **0.18** ***OK***

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL04

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.22 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-46*

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.22

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *3.5* *ft* (Distance behind the wall)

H_e = 12.17 *ft* (Height of excavation)

δ_v = *0.14* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.58** ***OK***

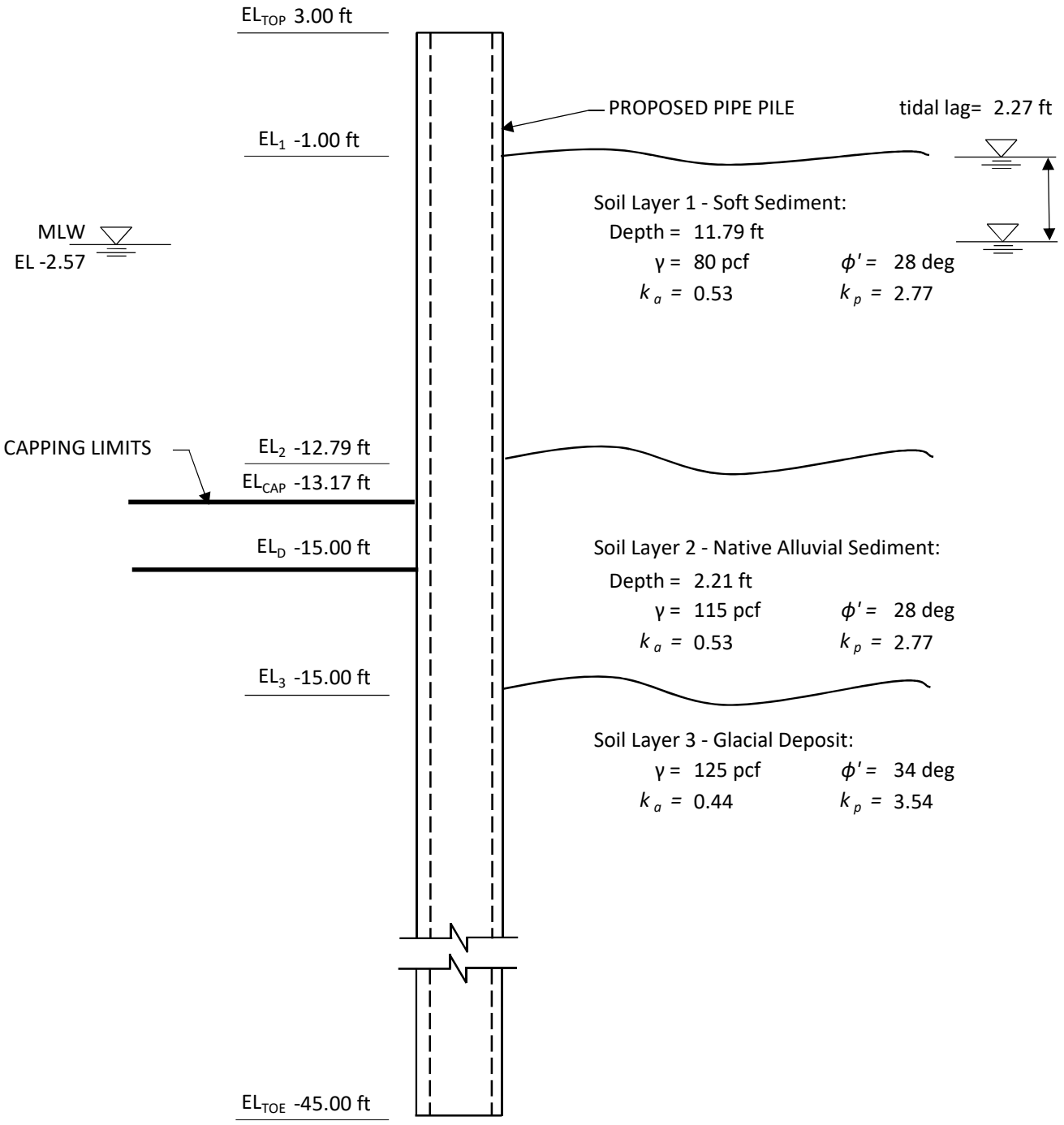
Depth of Pipe Pile Wall:

Embed = 29.87 *ft* (Minimum Embedment) *Attachment A - Page A-46*

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case II	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL04

Pipe Pile Cross-Section (Not to Scale):



DESIGN CASE III

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - Summary of Results

References:

1. NYSDOT Geotechnical Design Procedure for Flexible Wall Systems - Aug 2015
2. NYSDOT Bridge Manual - 2017
3. AASHTO Standard Specifications for Highway Bridges, 17th Edition - 2002
4. USS Sheet Piling Design Manual - 1984
5. AASHTO LRFD Bridge Design Specifications - Seventh Edition with 2016 Iterim Revisions
6. NYSDOT Standard Specifications
7. AASHTO Manual for Bridge Evaluation, 3rd Edition - 2018

Appendices:

Appendix A - RTA 1 Bridge Soil Design Parameters by GZA GeoEnvironmental, Inc.
Appendix B - O-Pile Datasheet
Appendix C - Summary of Geotechnical Design Parameters by Geosyntec Consultants

Assumptions:

See design summary for assumptions.

Summary of Results:

The results of the verification are summarized in the table below:

Design Checks									
Design Location	Load Group	Moment Capacity				Settlement (in)			
		Z_{req} (in^3)	Z (in^3)	D/C	Check	δ_v	$\delta_{v,allow}$	D/C	Check
USDL01	I	52.09	167.53	0.31	OK	0.13	0.25	0.52	OK
USDL02	I	43.43	167.53	0.26	OK	0.15	0.25	0.61	OK
USDL03	I	38.52	167.53	0.23	OK	0.13	0.25	0.53	OK
USDL04	I	46.08	167.53	0.28	OK	0.16	0.25	0.65	OK

Pipe Pile Information						
Design Location	Elevations (ft)			Section	Wall Height	Pile Length
	Top	Min. Tip	Dredge			
USDL01	3.00	-53.00	-16.50	O-Pile 28"_0.748"	9.00	56.00
USDL02	3.00	-55.00	-16.00	O-Pile 28"_0.748"	9.00	58.00
USDL03	3.00	-53.00	-15.50	O-Pile 28"_0.748"	9.00	56.00
USDL04	3.00	-54.00	-15.00	O-Pile 28"_0.748"	10.00	57.00

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - Inputs

Pipe Pile Wall Material:

ASTM A 572 Grade 50 Steel:

F_y = 50 *ksi*

E = 29000 *ksi* — *Ref. 5 Section 6.4.1*

Soil Parameters:

Constants:

γ_w = 62.4 *pcf* (Unit weight of water)

Soil Layer 1 - Soft Sediment:

γ = 80 *pcf* (Total unit weight) — *Appendix A - Page AP-1*

φ' = 28 *deg* (Effective Friction Angle) — *Appendix A - Page AP-1*

γ' = $\gamma - \gamma_w$ (Effective unit weight)

γ' = 17.6 *pcf*

$K_o = 1 - \sin\emptyset'$ (At-rest pressure coefficient) — *Ref. 5 Eq. 3.11.5.2-1*

k_o = 0.53

$K_p = \frac{1 + \sin\emptyset'}{1 - \sin\emptyset'}$ (Passive pressure coefficient) — *Ref. 1 Appendix A - Page A-1*

k_p = 2.77

F.S. = 1.25 (Factor of Safety) — *Ref. 1 Section II.B.1*

$K_p' = K_p/F.S.$ (Effective Passive Pressure Coefficient)

K_p' = 2.22

Soil Layer 2 - Native Alluvial Sediment:

γ = 115 *pcf* (Total unit weight) — *Appendix A - Page AP-1*

φ' = 28 *deg* (Effective Friction Angle) — *Appendix A - Page AP-1*

γ' = $\gamma - \gamma_w$ (Effective unit weight)

γ' = 52.6 *pcf*

$K_o = 1 - \sin\emptyset'$ (At-rest pressure coefficient) — *Ref. 5 Eq. 3.11.5.2-1*

k_o = 0.53

$K_p = \frac{1 + \sin\emptyset'}{1 - \sin\emptyset'}$ (Passive pressure coefficient) — *Ref. 1 Appendix A - Page A-1*

k_p = 2.77

F.S. = 1.25 (Factor of Safety) — *Ref. 1 Section II.B.1*

$K_p' = K_p/F.S.$ (Effective Passive Pressure Coefficient)

K_p' = 2.22

Soil Layer 3 - Glacial Deposit:

γ =	125 *pcf*	(Total unit weight)		*Appendix A - Page AP-1*
φ' =	34 *deg*	(Effective Friction Angle)		*Appendix A - Page AP-1*
γ' =	$\gamma - \gamma_w$	(Effective unit weight)		
			γ' = 62.6 *pcf*	
$K_o = 1 - \sin\emptyset'$		(At-rest pressure coefficient)		*Ref. 5 Eq. 3.11.5.2-1*
			k_o = 0.44	
$K_p = \frac{1+\sin\emptyset'}{1-\sin\emptyset'}$		(Passive pressure coefficient)		*Ref. 1 Appendix A - Page A-1*
			k_p = 3.54	
F.S. =	1.25	(Factor of Safety)		*Ref. 1 Section II.B.1*
K_p' =	$K_p/F.S.$	(Effective Passive Pressure Coefficient)		
			K_p' = 2.83	

Soil Layer 4 - ISS Material:

γ =	80 *pcf*	(Total unit weight)		
φ' =	0 *deg*	(Effective Friction Angle)		
γ' =	$\gamma - \gamma_w$	(Effective unit weight)		
			γ' = 80 *pcf*	
$K_o = 1 - \sin\emptyset'$		(At-rest pressure coefficient)		*Ref. 5 Eq. 3.11.5.2-1*
			k_o = 1.00	
$K_p = \frac{1+\sin\emptyset'}{1-\sin\emptyset'}$		(Passive pressure coefficient)		*Ref. 1 Appendix A - Page A-1*
			k_p = 1.00	
F.S. =	1.25	(Factor of Safety)		*Ref. 1 Section II.B.1*
K_p' =	$K_p/F.S.$	(Effective Passive Pressure Coefficient)		
			K_p' = 0.80	

RTA 1 - Union Street Pipe Pile Wall Design Case III - Surcharge

Midas Model

Midas finite element model created to determine bridge superstructure loading on abutment footing.

Material Inputs:

Steel Construction Prior to 1905:

F_y = 26 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

F_u = 52 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

E = 29000 *ksi*

wt_s = 490 *pcf* — *Ref. 3 Section 3.3.6*

Steel Construction from 1936 to 1963:

F_y = 33 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

F_u = 66 *ksi* — *Ref. 7 Table 6A.6.2.1-1*

E = 29000 *ksi*

wt_s = 490 *pcf* — *Ref. 3 Section 3.3.6*

Concrete Construction 1959 and Later:

f'_c = 3 *ksi* — *Ref. 7 Table 6A.5.2.1-1*

wt_c = 150 *pcf* — *Ref. 3 Section 3.3.6*

Reinforcing Steel Construction 1954 and Later:

f_y = 40 *ksi* — *Ref. 7 Table 6A.5.2.2-1*

Section Inputs:

Rolled Sections:

Member	Section	H	bf	tf	tw
Roadway Stringer	15I42.9	15	5.5	0.622	0.41
Roadway End Dia.	12SH30.9	12	3.45	0.6	0.45
Roadway Int. Dia.	10SH41.1	10	4.319	0.575	0.794
Sidewalk Stringer	12C25	12	3.047	0.501	0.387
Sidewalk Girder	18I54.7	18	6	0.691	0.46
Sidewalk Girder	18C42.7	18	3.95	0.625	0.45

Built-up Sections:

Member	Top Flange	Bottom Flange	Web Plate	Cov. Pl.
Floor Beam 6	2-L7x4x5/8	2-L6x4x5/8	65 1/4x3/8	12x3/8
Approach Girder*	2-L7x4x5/8	2-L7x4x5/8	48x1/2	14x1
Bumping Girder	2L6x4x5/8	2L6x4x5/8	LATTICE	12x1/2

**Approach Girder section information is assumed based on site visits and inspection reports due to lack of as-built information.*

Loads:

Dead Load (D):

Self Weight:

Self weight will be increased by 25% to account for connections and assumptions.

Curb:

b_c =	11	*in*	(width of curb)
h_c =	18	*in*	(Total height of curb)
Section:	18C 42.7		(Curb facing rolled section)
w_c =	0.249	*k/ft*	(Wt. curb per ft.)

Railing:

Post:

Section:	6WF 25		(Railing post section)
Min. Spa:	4.29	*ft*	(Railing post minimum spacing)

Top Rail:

b_{tr} =	7.5	*in*	(Width of top rail plate)
t_{tr} =	0.75	*in*	(Thickness of top rail plate)

Bottom Three Rails:

b_{br} =	5	*in*	(Width of bottom rails plate)
t_{br} =	0.5	*in*	(Thickness of bottom rails plate)
w_r =	0.050	*k/ft*	(Wt. railing per ft.)

Live Load (L):

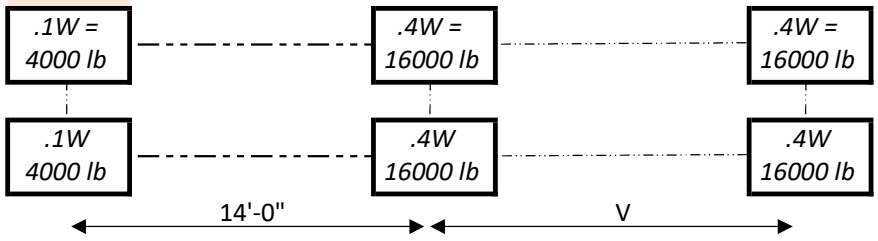
Vehicular Live Load:

Number of Lanes:

RW Width =	35	*ft*	(Width of roadway)	
No. Lanes =	2	*lanes*	(Number of travel lanes)	*Ref. 3 Section 3.6.2 & 3.6.3*

Standard HS-20 Truck:

W_{HS-20} = 40000 *lb* Stand H Truck: *Ref. 3 Figure 3.7.7A*



Standard HS-20 Lane Loading: *Ref. 3 Figure 3.7.6B*

w_{LL} =	0.64	*klf*	(Uniform lane load per linear foot of lane load
$P_{LL,S}$ =	26	kip	(Concentrated load for shear)
$P_{LL,m}$ =	18	kip	(Concentrated load for moment)

Impact:

No impact applied to the design of abutments or retaining walls *Ref. 3 Section 3.8.1.2*

Reduction in Load Intensity: *Ref. 3 Section 3.12.1*

# Lanes	Percent
1-2	100
3	90
>3	75

Sidewalk Live Loading:

$w_{LL,sw}$ = 85 *ksf* *Ref. 3 Section 3.14.1.1*

Abutment Dimensions:

Location	Component	Stem		Footing	
		L_{AS}	A_{AS}	L_{AF}	b_{AF}
East Abutment	North Footing	40	64.77	22.33	18
	South Footing	40		16.17	18
West Abutment	North Footing	30	64.77	12.33	18
	South Footing	30		12.33	18

Where:

A_{AS} = *Cross-sectional area of abutment stem (ft^2)*

L_{AS} = *Length of Abutment Stem, (ft)*

L_{AF} = *Length of Abutment Footing, (ft)*

b_{AF} = *Width of Abutment Footing, (ft)*

Calculation of Surcharge due to Bridge DL & LL:

Surcharge from bridge loading and control house is assumed to be distrubted through the foundation piles

$Q_{area} = P_{vT}/(bL)$

Q_{area} = *Area load input into CivilTech Shoring Suite*

$P_{vT} = P_{vAD} + P_{vSSD} + P_{vSSL} + P_{vCH}$

P_{vT} = Total vertical load applied to isloated footing

P_{vAD} = *Vertical load from dead load of abutment (kips)*

P_{vSSD} = *Vertical load from superstructure dead load (kips)*

P_{vSSL} = *Vertical load from superstructure live load (kips)*

P_{vCH} = *Vertical load from control house (kips)*

$P_{vAD} = A_{AS}\, wt_c\, L_{AS}$

Control House Surcharge:

Building load appiled to abutment footing is assumed to be 500 psf

Surcharge = 500 *psf*

Building Footprint:

L_{CH} = 22.5 *ft* (Length of Building)

b_{CH} = 14.5 *ft* (Width of Building)

P_{vCH} = 81.56 *kips* (Vertical load of control house)

Combinations of Loads: *Ref. 3 Table 3.22.1A*

AASHTO Loading	
Group	Factors Used
I	$\gamma\ (D + LL + \beta_E E)$

**No impact included for substructures or retaining walls* Ref. 3 Section 3.8.1.2

γ = *1.0* *Ref. 3 Table 3.22.1A*

β_E = *1.0* *for vertical and lateral earth pressure on retaining walls*

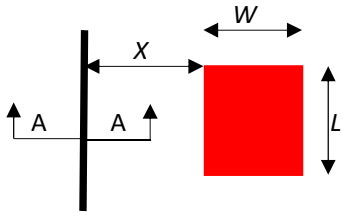
Calculation of Surcharge Loading:

	Appiled Loading				Group I	
Design Location	P_{vAD}	P_{vSSD}	P_{vSSL}	P_{vBS}	P_{vT}	Q_{area}
USDL02 - NE Ftg.	388.62	51.98813	81.88391	81.56	604.0545	1.50
USDL03 - SE Ftg.	388.62	44.22683	75.40961	N/A	508.2564	1.75
USDL01 - NW Ftg.	291.465	44.22683	75.40961	N/A	411.1014	1.85
USDL02 - SW Ftg.	291.465	44.22683	75.40961	N/A	411.1014	1.85

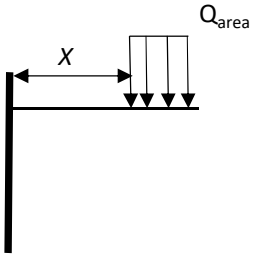
Area Load input into CivilTech:

				Group I
Design Location	*L (ft)*	*W (ft)*	*X (ft)*	*Q_{area} (ksf)*
USDL01	*12.33*	*18.00*	*5*	*1.85*
USDL02	*22.33*	*18.00*	*5*	*1.50*
USDL03	*16.17*	*18.00*	*5*	*1.75*
USDL04	*12.33*	*18.00*	*5*	*1.85*

**See diagram for definition of L, W, X and Q_{area}*



Wall Plan View



Section A-A

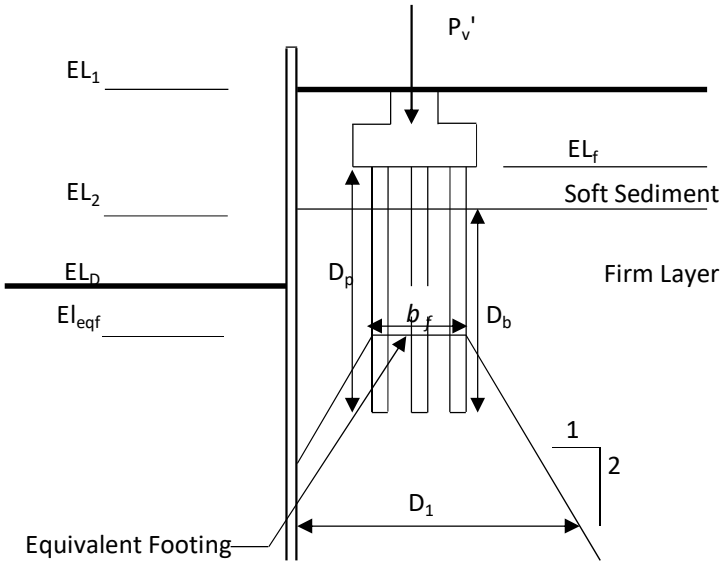
Calculation of Depth of Applied Surcharge Loading:

Calculate Location of Equivalent Footing: *Ref. 5 Figure 10.7.2.3.1-1*

$D_b = D_p-(EL_f-EL_2)$ (Total depth of pile in firm soil layer)

$EL_{eqf} = EL_f-D_p+1/3D_b$ (Elevation of equivalent footing) *Ref. 5 Figure 10.7.2.3.1-1*

Design Location	*EL_f*	*EL_1*	*EL_2*	*D_p*	*D_b*	*El_{eqf}*
USDL01	*-2.9*	*-2.00*	*-14.53*	*20.00*	8.37	-20.11
USDL02	*-2.9*	*-2.00*	*-14.55*	*20.00*	8.35	-20.12
USDL03	*-2.9*	*-2.00*	*-14.89*	*20.00*	8.01	-20.23
USDL04	*-2.9*	*-1.00*	*-12.79*	*20.00*	10.11	-19.53



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

Calculation of Surcharge due to Approach Roadway:

Since there are no approach slabs at the Union Street Bridge, a vehicular surcharge must be applied as per reference 3 Section 3.20.4

Ref. 1 Section II.A.2

q_{LL} = 0.25 *ksf* (Infinite surcharge applied behind the wall)

Total Infinite surcharge behind wall

Group I:

$q_{infinite} = q_{LL}$

$q_{infinite}$ = 0.25 *ksf* (Total Infinite surcharge applied behind the wall)

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL01

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.53	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-26.33	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_{DII} =	-11.00	*ft*	(Phase II Dredge elevation)	
El_D =	-16.50	*ft*	(Phase III Dredge elevation)	
EL_{ISS} =	-21.50	*ft*	(Bottom of ISS Elevation)	
H =	9.00	*ft*	(Wall height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-53.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	56.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.85	*ksf*	(Area Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipeing Section:

M_{max} =	130.22	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-51*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 52.09 in^3

D/C = **0.31** ***OK***

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL01

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.27 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-51*

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.27

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = 6 *ft* (Distance behind the wall)

H_e = 9.00 *ft* (Height of excavation)

δ_v = *0.13* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.52** ***OK***

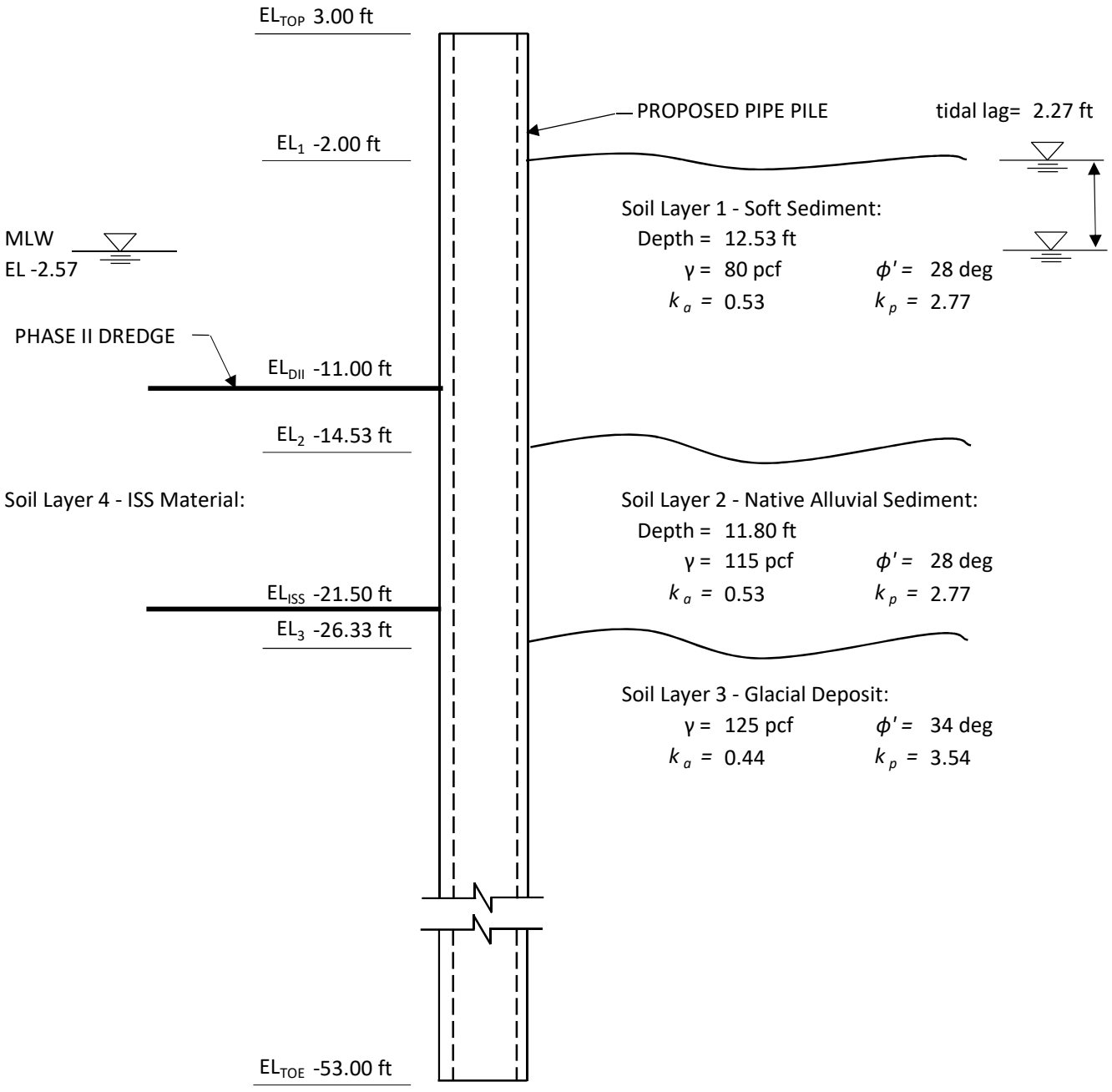
Depth of Pipe Pile Wall:

Embed = 41.39 *ft* (Minimum Embedment) *Attachment A - Page A-51*

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL01

Pipe Pile Cross-Section (Not to Scale):



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL02

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.55	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-21.30	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_{DII} =	-11.00	*ft*	(Phase II Dredge elevation)	
El_D =	-16.00	*ft*	(Phase III Dredge elevation)	
EL_{ISS} =	-21.00	*ft*	(Bottom of ISS Elevation)	
H =	9.00	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-55.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	58.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.50	*ksf*	(Applied Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipe Pile section:

M_{max} =	108.58	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-57*
σ_{allow} =	$0.6f_y$		(Allowable stress in Pipe pile)	
			σ_{allow} =	30 *ksi*
Z_{min} =	M_{max}/σ_{allow}		(Minimum section modulus)	
			Z_{min} =	43.43 in^3
			D/C =	**0.26** ***OK***

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL02

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.23 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-57*

δ_{vm} = $R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.23

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *2.5* *ft* (Distance behind the wall)

H_e = 9.00 *ft* (Height of excavation)

δ_v = *0.15* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

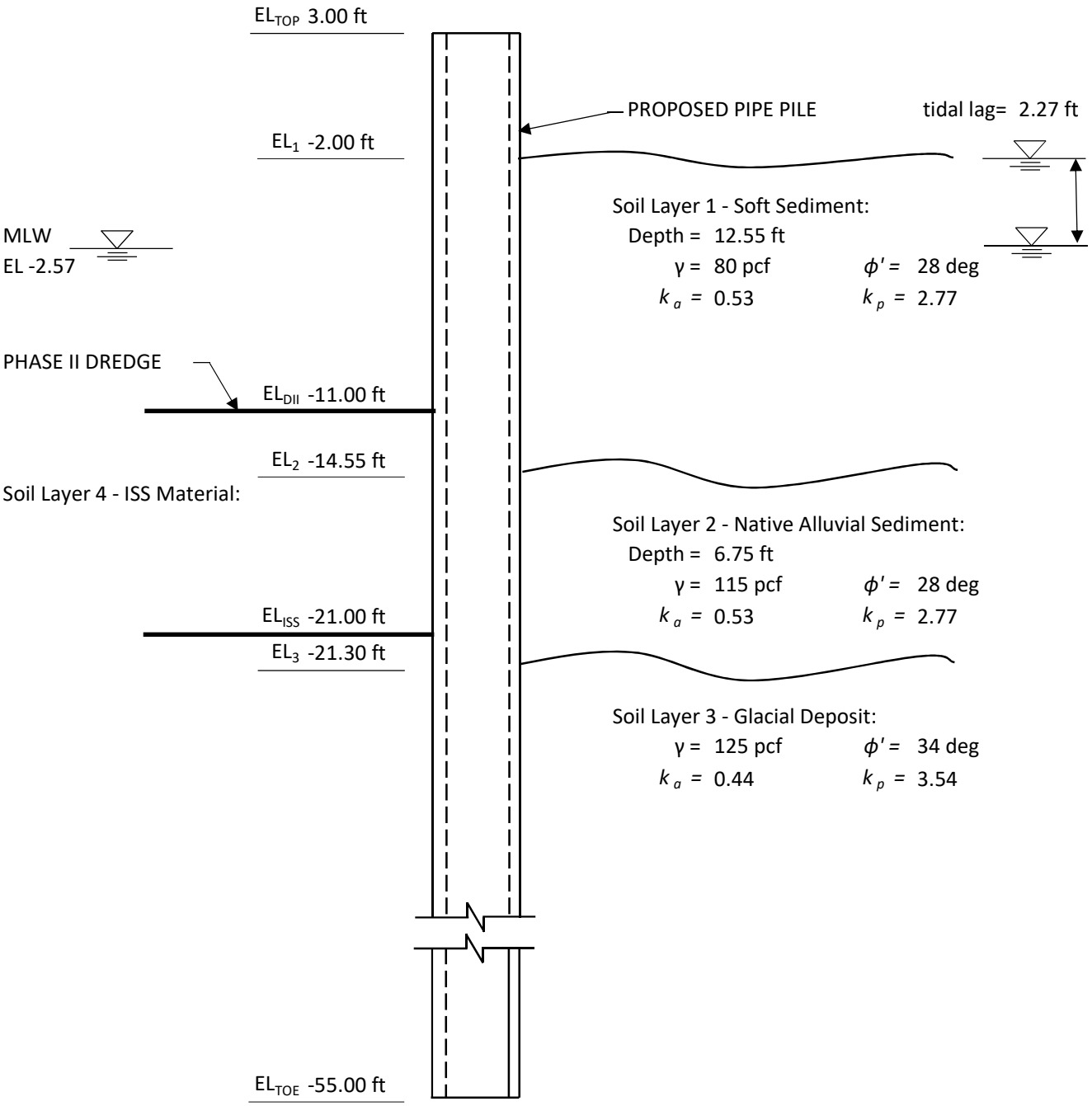
D/C = **0.61** ***OK***

Depth of Pipe Pile Wall:

Embed = 38.78 *ft* (Minimum Embedment) *Attachment A - Page A-57*

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL02

Pipe Pile Cross-Section (Not to Scale):



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL03

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.89	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-15.39	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_{DII} =	-11.00	*ft*	(Phase II Dredge elevation)	
El_D =	-15.50	*ft*	(Phase III Dredge elevation)	
EL_{ISS} =	-20.50	*ft*	(Bottom of ISS Elevation)	
H =	9.00	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-53.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	56.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.75	*ksf*	(Applied Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipe Pile Section:

M_{max} =	96.29	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-62*
σ_{allow} =	$0.6f_y$		(Allowable stress in Pipe pile)	
			σ_{allow} =	30 *ksi*
Z_{min} =	M_{max}/σ_{allow}		(Minimum section modulus)	
			Z_{min} =	38.52 in^3
			D/C =	**0.23** ***OK***

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL03

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.21 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-62*

δ_{vm} = $R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.21

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *3* *ft* (Distance behind the wall)

H_e = 9.00 *ft* (Height of excavation)

δ_v = *0.13* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.53** ***OK***

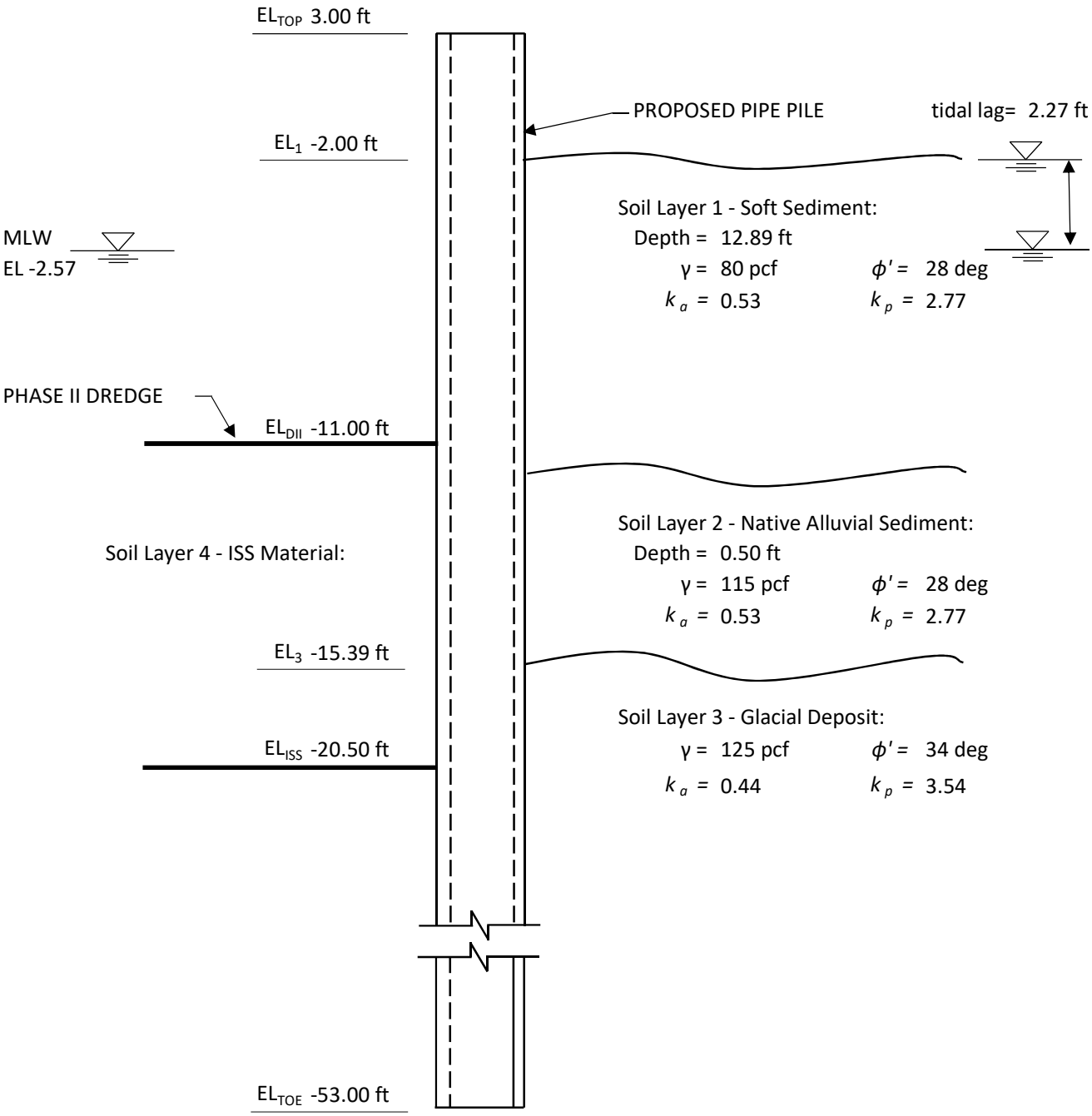
Depth of Pipe Pile Wall:

Embed = 36.97 *ft* (Minimum Embedment) *Attachment A - Page A-62*

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL03

Pipe Pile Cross-Section (Not to Scale):



GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL04

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-1.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-12.79	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-15.00	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_{DII} =	-11.00	*ft*	(Phase II Dredge elevation)	
El_D =	-15.00	*ft*	(Phase III Dredge elevation)	
EL_{ISS} =	-20.00	*ft*	(Bottom of ISS Elevation)	
H =	10.00	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-54.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	57.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	

Design of Pipe Pile Walls (using CivilTech Shoring Suite):

Pipe Pile Section Properties: *Appendix B*

Pipe:	O-Pile 28"_0.748"		
Wt =	87.46	lb/ft	(Wt of pipe pile)
b =	30.44	*in*	(Width of pipe pile)
I =	2345.44	in^4/ft	(Moment of inertia of pipe pile)
Z =	167.53	in^3/ft	(Plastic section modulus of pipe pile)

Surcharge Loading:

Q_{area} =	1.85	*ksf*	(Applied Surcharge)	
$q_{infinite}$ =	0.25	*ksf*	(Infinite Surcharge)	*Ref. 1 Section II.A.2*

Check Pipe Pile Section:

M_{max} =	115.21	*k-ft*	(Maximum moment on wall)	*Attachment A - Page A-67*

$\sigma_{allow} = 0.6 f_y$ (Allowable stress in Pipe pile)

σ_{allow} = 30 *ksi*

$Z_{min} = M_{max} / \sigma_{allow}$ (Minimum section modulus)

Z_{min} = 46.08 in^3

D/C = **0.28** ***OK***

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL04

Calculate Settlement Behind Wall:

See "Attachment C - Procedure for Estimating Ground Settlement"

δ_{hm} = 0.26 *in* (Calc. Deflection @ top of soil layer 1) *Attachment A - Page A-67*

$\delta_{vm} = R\delta_{hm}$ (Maximum ground settlement) δ_{vm} = 0.26

R = 1.0 (Ratio between ground settlement and wall deflection)

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

d = *3.5* *ft* (Distance behind the wall)

H_e = 10.00 *ft* (Height of excavation)

δ_v = *0.16* *in* (Ground Settlement at distance d behind the wall)

$\delta_{v,\,allow}$ = 0.25 *in* (Allowable ground settlement)

D/C = **0.65** ***OK***

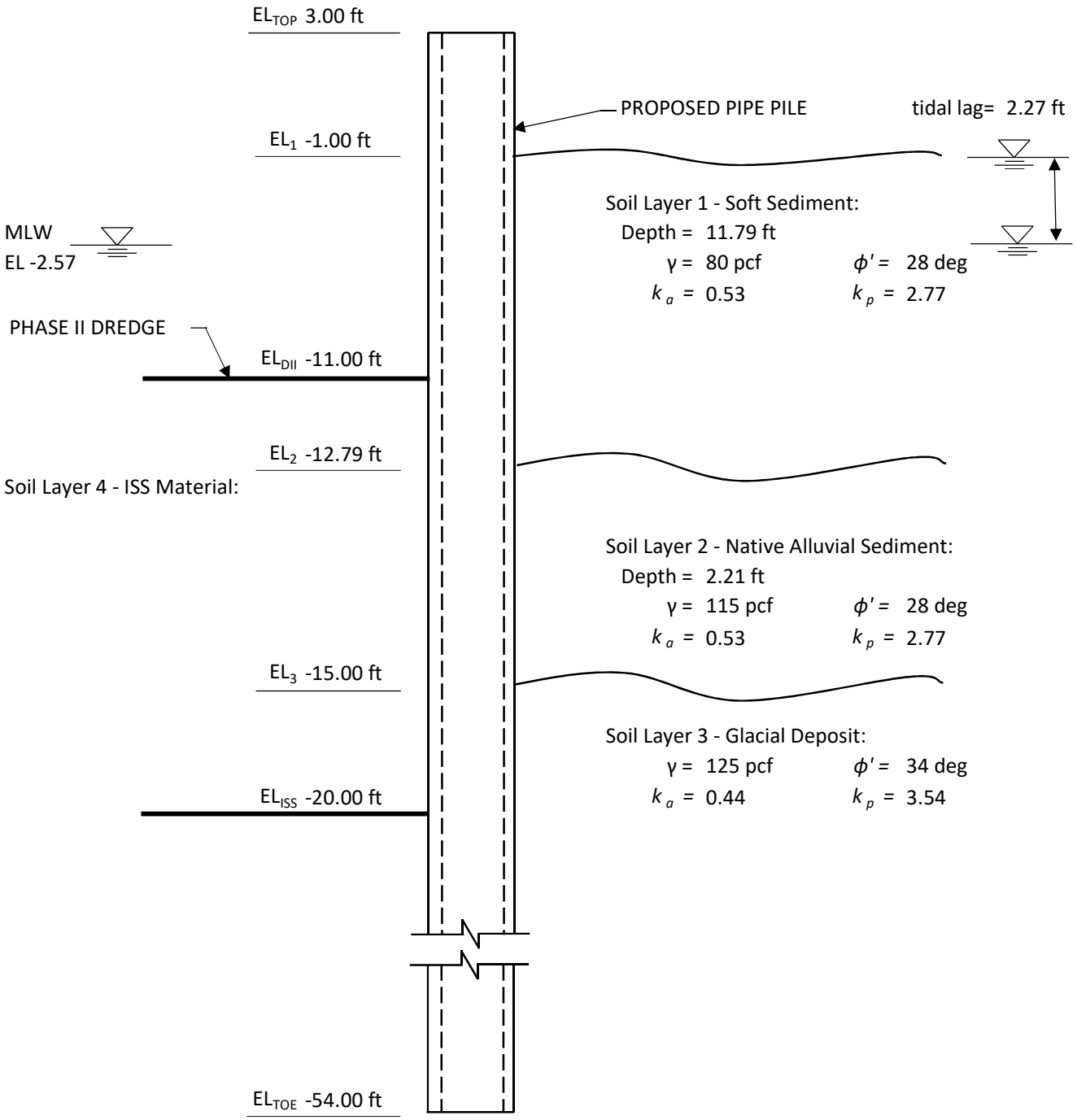
Depth of Pipe Pile Wall:

Embed = 38.58 *ft* (Minimum Embedment) *Attachment A - Page A-67*

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/18
SUBJECT:	RTA 1 - Union Street Sheet Pile Design Case III	CHECKED BY:	JRA	DATE:	6/14/19

RTA 1 - Union Street Pipe Pile Wall Design Case III - USDL04

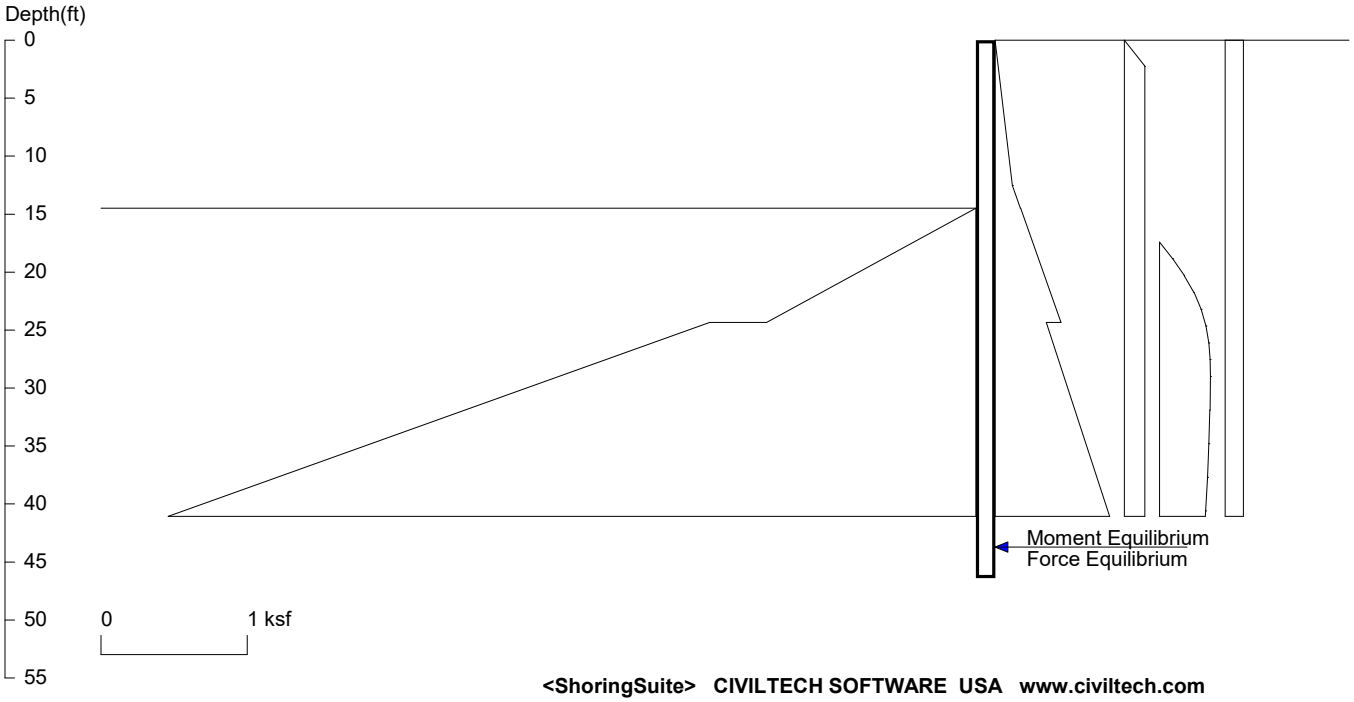
Pipe Pile Cross-Section (Not to Scale):



ATTACHMENT A – CIVILTECH SHORING SUITE OUTPUT

Union Street Case I_USDL01

Case I_USDL01_Design



<ShoringSuite> CIVILTECH SOFTWARE USA www.civiltech.com

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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Cas

Wall Height=14.5 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=31.86 Min. Pile Length=46.36
MOMENT IN PILE: Max. Moment=109.02 per Pile Spacing=1.0 at Depth=30.55

PILE SELECTION:
Request Min. Section Modulus = 43.6 in3/ft=2344.46 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.34(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	12.530	0.118	0.009434
12.530	0.117	14.500	0.172	0.027906
*	Below	Base		
14.500	0.174	24.330	0.451	0.028196
24.330	0.349	130.500	3.111	0.026016
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	130.500	0.141	0.000000
*	Sur-	charge		
17.400	0.000	18.850	0.089	0.061476
18.850	0.089	20.300	0.169	0.055408
20.300	0.169	21.750	0.235	0.045230
21.750	0.235	23.200	0.284	0.033621
23.200	0.284	24.650	0.317	0.022705
24.650	0.317	26.100	0.336	0.013576
26.100	0.336	27.550	0.346	0.006491
27.550	0.346	29.000	0.348	0.001255

29.000	0.348	31.900	0.344	-0.001242
31.900	0.344	34.800	0.337	-0.002540
34.800	0.337	37.700	0.327	-0.003415
37.700	0.327	40.600	0.315	-0.003982
40.600	0.315	43.500	0.303	-0.004327
43.500	0.303	46.400	0.290	-0.004512
*	Sur-	charge		
0.000	0.125	0.725	0.125	0.000000
0.725	0.125	1.450	0.125	0.000000
1.450	0.125	2.175	0.125	0.000000
2.175	0.125	2.900	0.125	0.000000
2.900	0.125	3.625	0.125	0.000000
3.625	0.125	4.350	0.125	0.000000
4.350	0.125	5.075	0.125	0.000000
5.075	0.125	5.800	0.125	0.000000
5.800	0.125	6.525	0.125	0.000000
6.525	0.125	7.250	0.125	0.000000
7.250	0.125	7.975	0.125	0.000000
7.975	0.125	8.700	0.125	0.000000
8.700	0.125	9.425	0.125	0.000000
9.425	0.125	10.150	0.125	0.000000
10.150	0.125	10.875	0.125	0.000000
10.875	0.125	11.600	0.125	0.000000
11.600	0.125	12.325	0.125	0.000000
12.325	0.125	13.050	0.125	0.000000
13.050	0.125	13.775	0.125	0.000000
13.775	0.125	14.500	0.125	0.000000
14.500	0.125	15.950	0.125	0.000000
15.950	0.125	17.400	0.125	0.000000
17.400	0.125	18.850	0.125	0.000000
18.850	0.125	20.300	0.125	0.000000
20.300	0.125	21.750	0.125	0.000000
21.750	0.125	23.200	0.125	0.000000
23.200	0.125	24.650	0.125	0.000000
24.650	0.125	26.100	0.125	0.000000
26.100	0.125	27.550	0.125	0.000000
27.550	0.125	29.000	0.125	0.000000
29.000	0.125	31.900	0.125	0.000000
31.900	0.125	34.800	0.125	0.000000
34.800	0.125	37.700	0.125	0.000000
37.700	0.125	40.600	0.125	0.000000
40.600	0.125	43.500	0.125	0.000000
43.500	0.125	46.400	0.125	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
14.500	0.000	24.330	1.432	0.145693
24.330	1.821	130.500	25.340	0.221527

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	14.50	1.00

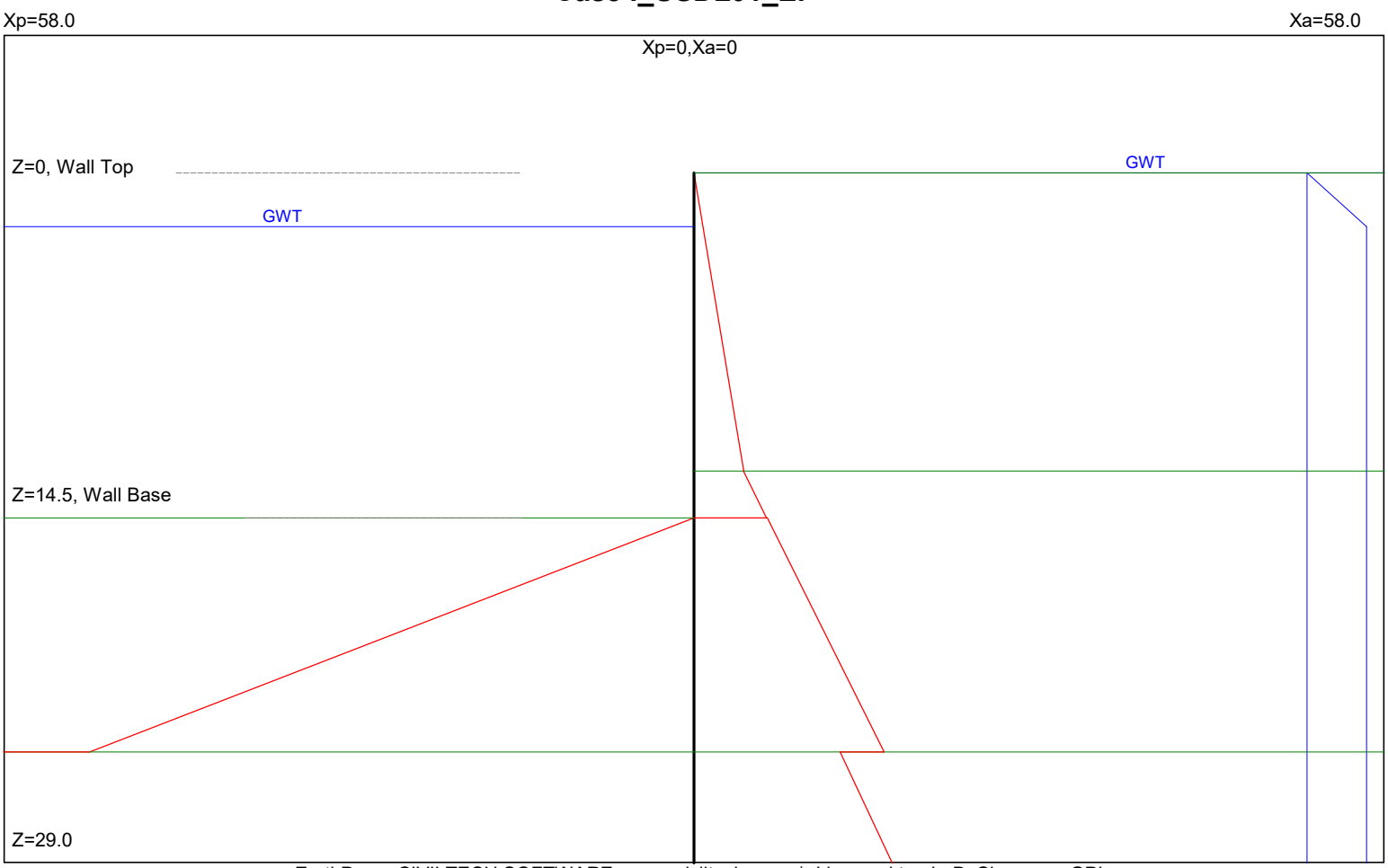
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case I_USDL01

Case I_USDL01_EP



* INPUT DATA *

Wall Height=14.5 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.5	0.0	12.5	800.0	2	Native Alluv
3	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	14.5	0.0	14.5	800.0	2	Native Alluv
2	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 1.03 per one linear foot (or meter) width along wall height
Total Static Force above Base= 1.03

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	12.53	0.12	0.0094	0.5360
12.53	0.12	14.50	0.17	0.0279	0.5305

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
14.50	0.17	24.33	0.45	0.0282	0.5360
24.33	0.35	29.00	0.47	0.0264	0.4225

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

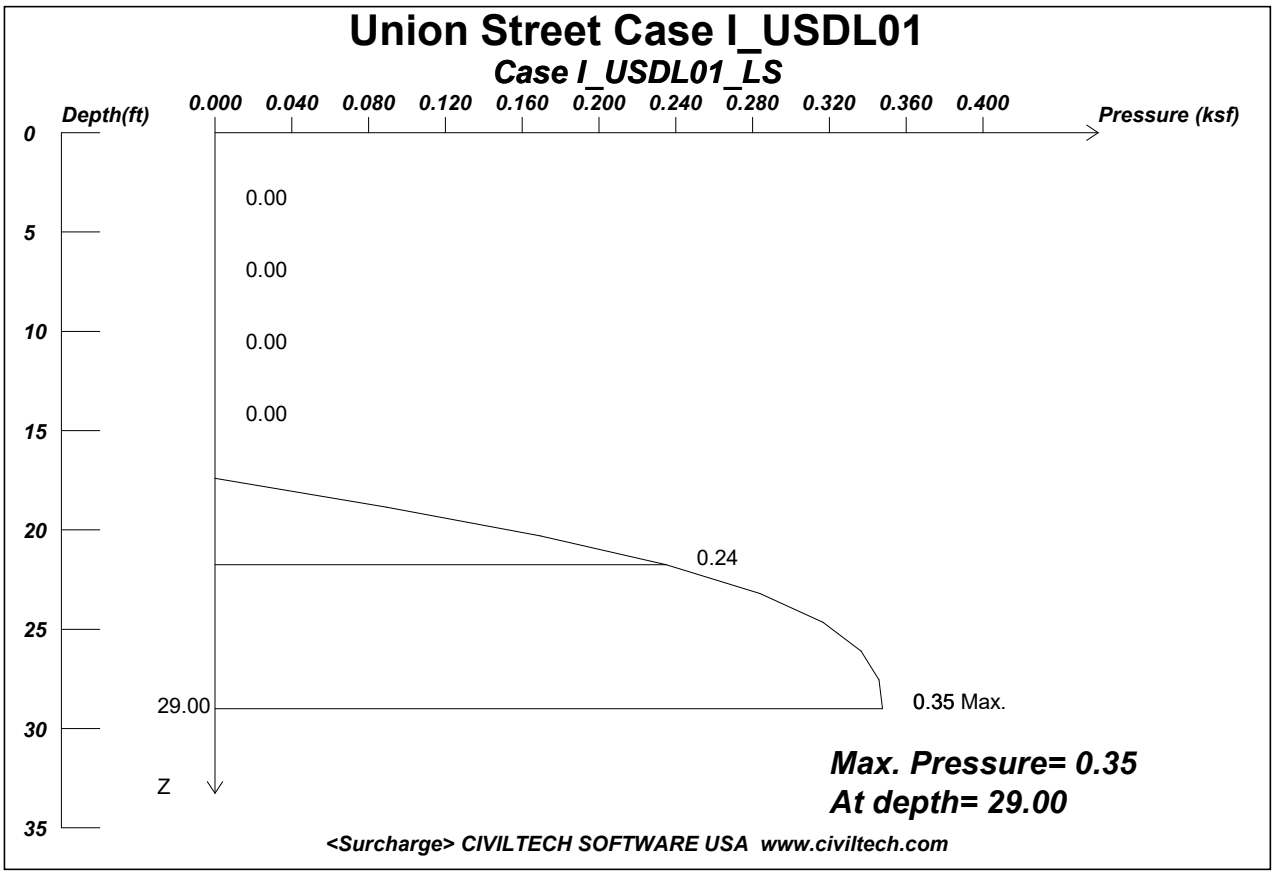
Z1	Pp1	Z2	Pp2	Slope	Kp
14.50	0.00	24.33	1.43	0.146	2.7698
24.33	1.78	29.00	2.85	0.230	3.6693

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	29.00	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/11/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case I\



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Wall Height, H= 14.50 Load Depth, D= 18.11

Load Factor of Surcharge Loading = 1

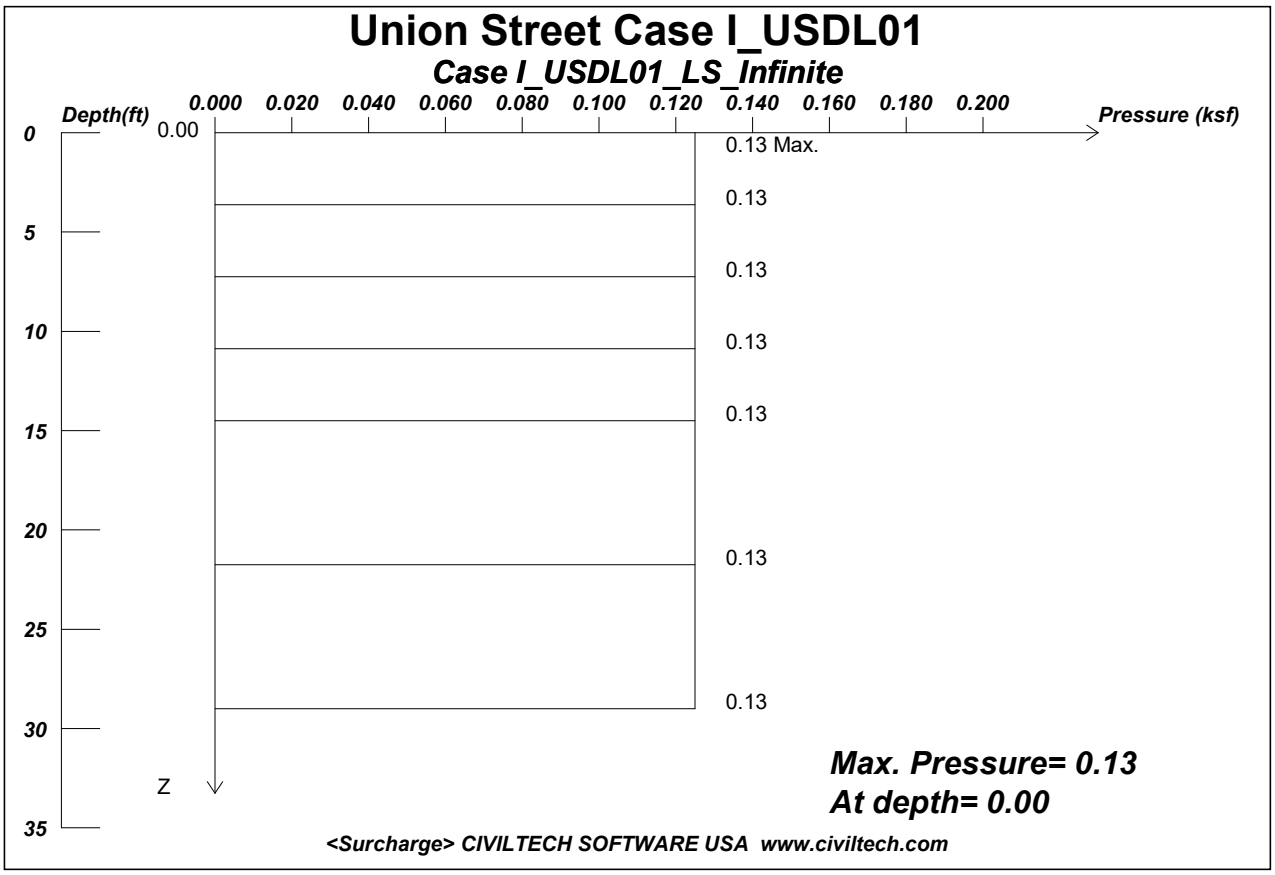
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.348 at depth = 29.00

X	Width	Length	Area Load
5.0	18.0	12.3	1.85

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf



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Wall Height, H= 14.50 Load Depth, D= 0

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

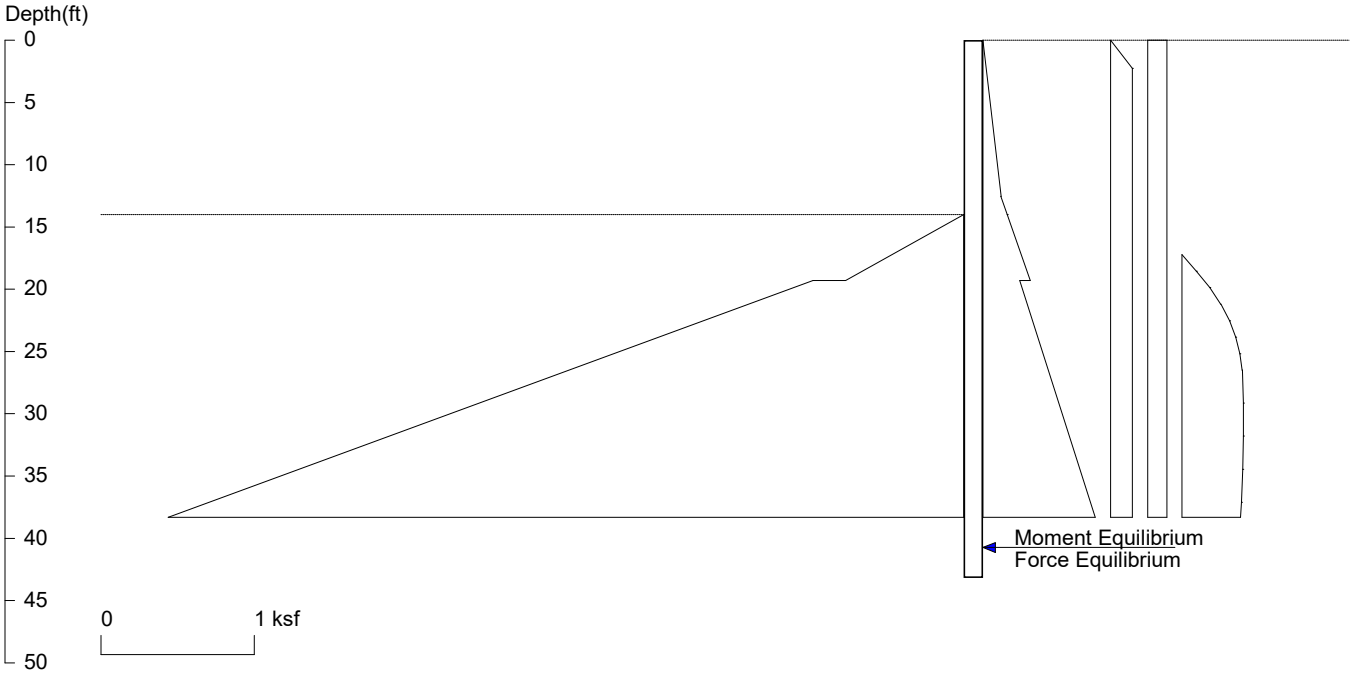
Max. Pressure = 0.125 at depth = 0.00

Infinite Surcharge, Q=0.250 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case I_USDL02

Case I_USDL02_Design



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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case

Wall Height=14.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=29.17 Min. Pile Length=43.17
MOMENT IN PILE: Max. Moment=88.64 per Pile Spacing=1.0 at Depth=28.21

PILE SELECTION:
Request Min. Section Modulus = 35.5 in3/ft=1906.09 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.27(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	12.550	0.118	0.009434
12.550	0.117	14.000	0.158	0.027906
*	Below	Base		
14.000	0.159	19.300	0.309	0.028196
19.300	0.239	126.000	3.014	0.026012
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	126.000	0.141	0.000000
*	Sur-	charge		
0.000	0.125	0.700	0.125	0.000000
0.700	0.125	1.400	0.125	0.000000
1.400	0.125	2.100	0.125	0.000000
2.100	0.125	2.800	0.125	0.000000
2.800	0.125	3.500	0.125	0.000000
3.500	0.125	4.200	0.125	0.000000
4.200	0.125	4.900	0.125	0.000000
4.900	0.125	5.600	0.125	0.000000

5.600	0.125	6.300	0.125	0.000000
6.300	0.125	7.000	0.125	0.000000
7.000	0.125	7.700	0.125	0.000000
7.700	0.125	8.400	0.125	0.000000
8.400	0.125	9.100	0.125	0.000000
9.100	0.125	9.800	0.125	0.000000
9.800	0.125	10.500	0.125	0.000000
10.500	0.125	11.200	0.125	0.000000
11.200	0.125	11.900	0.125	0.000000
11.900	0.125	12.600	0.125	0.000000
12.600	0.125	13.300	0.125	0.000000
13.300	0.125	14.000	0.125	0.000000
14.000	0.125	15.400	0.125	0.000000
15.400	0.125	16.800	0.125	0.000000
16.800	0.125	18.200	0.125	0.000000
18.200	0.125	19.600	0.125	0.000000
19.600	0.125	21.000	0.125	0.000000
21.000	0.125	22.400	0.125	0.000000
22.400	0.125	23.800	0.125	0.000000
23.800	0.125	25.200	0.125	0.000000
25.200	0.125	26.600	0.125	0.000000
26.600	0.125	28.000	0.125	0.000000
28.000	0.125	30.800	0.125	0.000000
30.800	0.125	33.600	0.125	0.000000
33.600	0.125	36.400	0.125	0.000000
36.400	0.125	39.200	0.125	0.000000
39.200	0.125	42.000	0.125	0.000000
42.000	0.125	44.800	0.125	0.000000
*	Sur-	charge		
17.225	0.000	18.550	0.094	0.070990
18.550	0.094	19.875	0.180	0.065069
19.875	0.180	21.200	0.253	0.054864
21.200	0.253	22.525	0.310	0.042750
22.525	0.310	23.850	0.350	0.030807
23.850	0.350	25.175	0.377	0.020307
25.175	0.377	26.500	0.393	0.011745
26.500	0.393	29.150	0.400	0.002553
29.150	0.400	31.800	0.400	0.000066
31.800	0.400	34.450	0.395	-0.001748
34.450	0.395	37.100	0.387	-0.003042
37.100	0.387	39.750	0.377	-0.003942
39.750	0.377	42.400	0.365	-0.004547
42.400	0.365	45.050	0.352	-0.004933

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
14.000	0.000	19.300	0.772	0.145693
19.300	0.984	126.000	24.613	0.221455

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	14.00	1.00

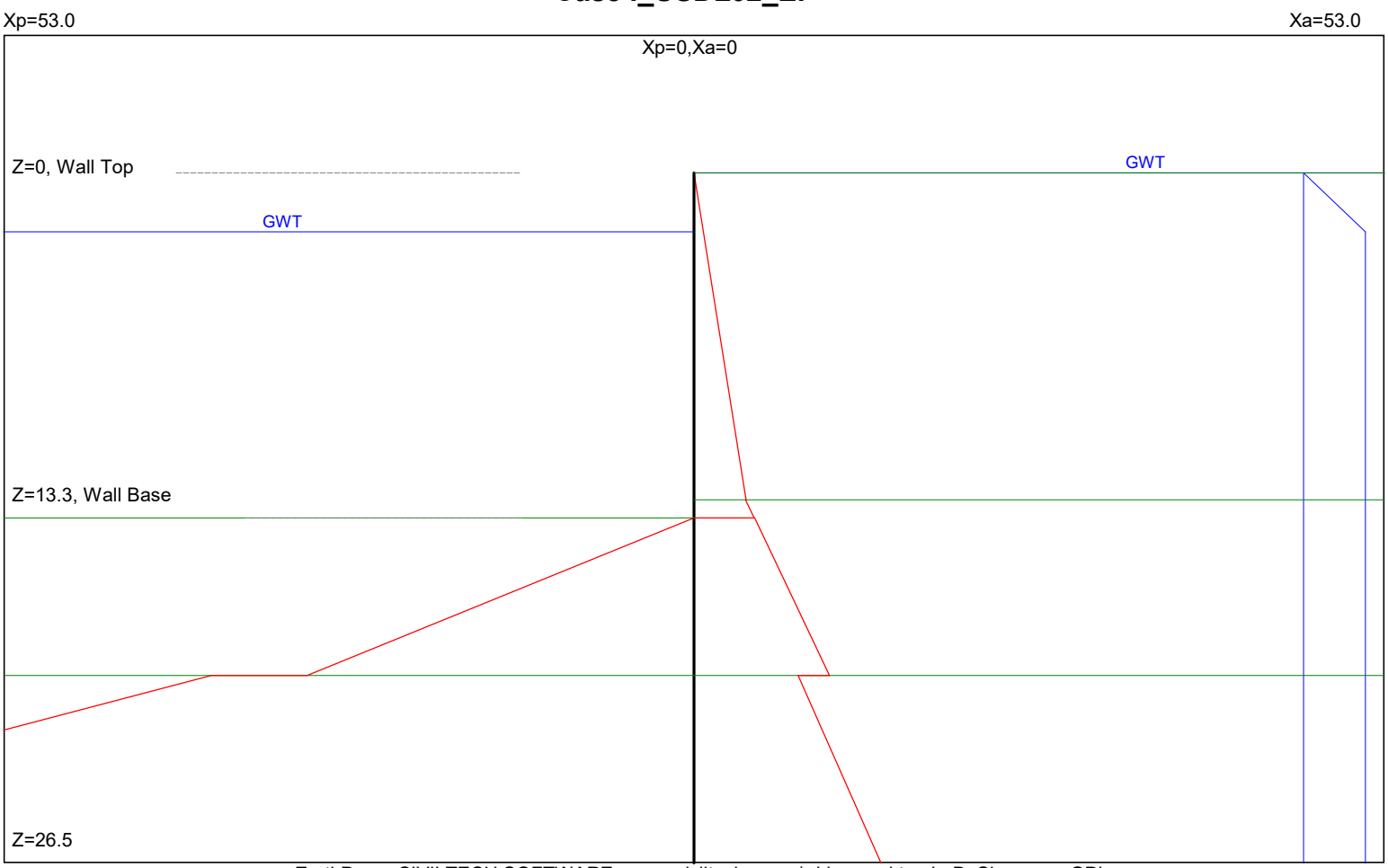
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case I_USDL02

Case I_USDL02_EP



* INPUT DATA *

Wall Height=13.3 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.6	0.0	12.6	800.0	2	Native Alluv
3	19.3	0.0	19.3	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	13.3	0.0	13.3	800.0	2	Native Alluv
2	19.3	0.0	19.3	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.83 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.83

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	12.55	0.12	0.0094	0.5360
12.55	0.12	13.25	0.14	0.0279	0.5305

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
13.25	0.14	19.30	0.31	0.0282	0.5360
19.30	0.24	26.50	0.43	0.0262	0.4187

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
13.25	0.00	19.30	0.88	0.146	2.7698
19.30	1.10	26.50	2.72	0.225	3.5973

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	26.50	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

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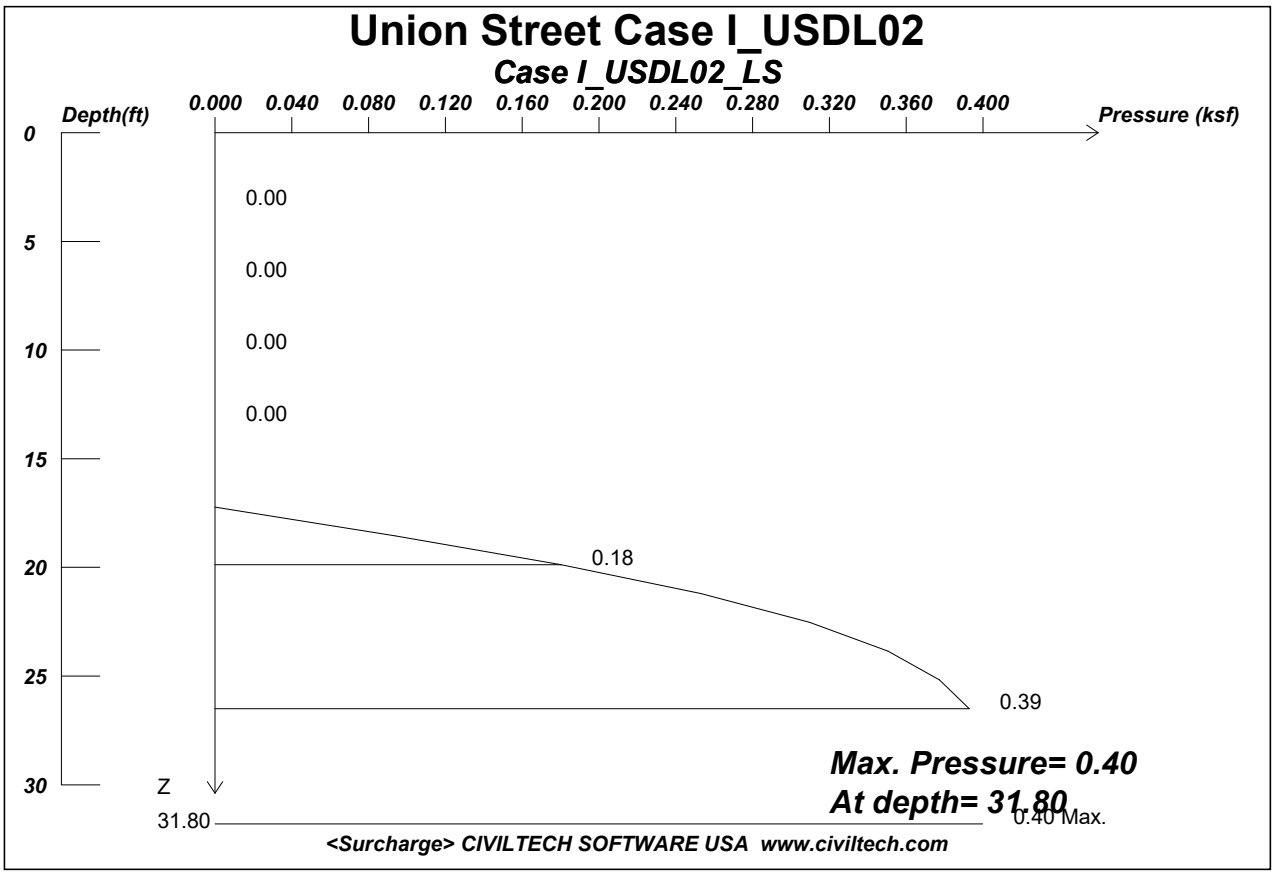

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Wall Height, H= 13.25 Load Depth, D= 18.12

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.400 at depth = 31.80

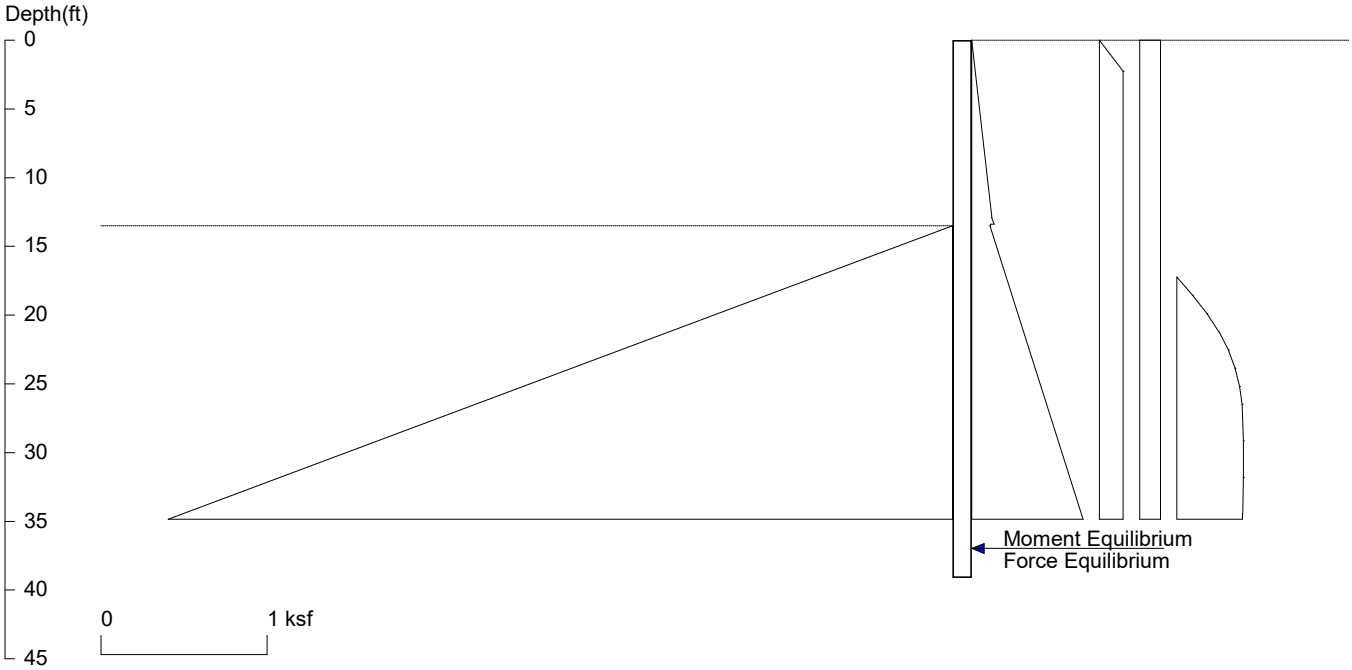
X	Width	Length	Area Load
5.0	18.0	22.3	1.50

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case I_USDL03

Case I_USDL03_Design



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Wall Height=13.5 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=25.61 Min. Pile Length=39.11
MOMENT IN PILE: Max. Moment=66.98 per Pile Spacing=1.0 at Depth=25.39

PILE SELECTION:
Request Min. Section Modulus = 22.3 in3/ft=1200.29 cm3/m, Fy= 60 ksi = 414 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.20(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	12.890	0.122	0.009434
12.890	0.120	13.390	0.134	0.027906
13.390	0.111	13.500	0.114	0.027348
*	Below	Base		
13.500	0.109	121.500	2.947	0.026279
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	121.500	0.141	0.000000
*	Sur-	charge		
0.000	0.125	0.675	0.125	0.000000
0.675	0.125	1.350	0.125	0.000000
1.350	0.125	2.025	0.125	0.000000
2.025	0.125	2.700	0.125	0.000000
2.700	0.125	3.375	0.125	0.000000
3.375	0.125	4.050	0.125	0.000000
4.050	0.125	4.725	0.125	0.000000
4.725	0.125	5.400	0.125	0.000000

5.400	0.125	6.075	0.125	0.000000
6.075	0.125	6.750	0.125	0.000000
6.750	0.125	7.425	0.125	0.000000
7.425	0.125	8.100	0.125	0.000000
8.100	0.125	8.775	0.125	0.000000
8.775	0.125	9.450	0.125	0.000000
9.450	0.125	10.125	0.125	0.000000
10.125	0.125	10.800	0.125	0.000000
10.800	0.125	11.475	0.125	0.000000
11.475	0.125	12.150	0.125	0.000000
12.150	0.125	12.825	0.125	0.000000
12.825	0.125	13.500	0.125	0.000000
13.500	0.125	14.850	0.125	0.000000
14.850	0.125	16.200	0.125	0.000000
16.200	0.125	17.550	0.125	0.000000
17.550	0.125	18.900	0.125	0.000000
18.900	0.125	20.250	0.125	0.000000
20.250	0.125	21.600	0.125	0.000000
21.600	0.125	22.950	0.125	0.000000
22.950	0.125	24.300	0.125	0.000000
24.300	0.125	25.650	0.125	0.000000
25.650	0.125	27.000	0.125	0.000000
27.000	0.125	29.700	0.125	0.000000
29.700	0.125	32.400	0.125	0.000000
32.400	0.125	35.100	0.125	0.000000
35.100	0.125	37.800	0.125	0.000000
37.800	0.125	40.500	0.125	0.000000
*	Sur-	charge		
17.225	0.000	18.550	0.094	0.070990
18.550	0.094	19.875	0.180	0.065069
19.875	0.180	21.200	0.253	0.054864
21.200	0.253	22.525	0.310	0.042750
22.525	0.310	23.850	0.350	0.030807
23.850	0.350	25.175	0.377	0.020307
25.175	0.377	26.500	0.393	0.011745
26.500	0.393	29.150	0.400	0.002553
29.150	0.400	31.800	0.400	0.000066
31.800	0.400	34.450	0.395	-0.001748
34.450	0.395	37.100	0.387	-0.003042
37.100	0.387	39.750	0.377	-0.003942

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
13.500	0.000	121.500	23.914	0.221424

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	13.50	1.00

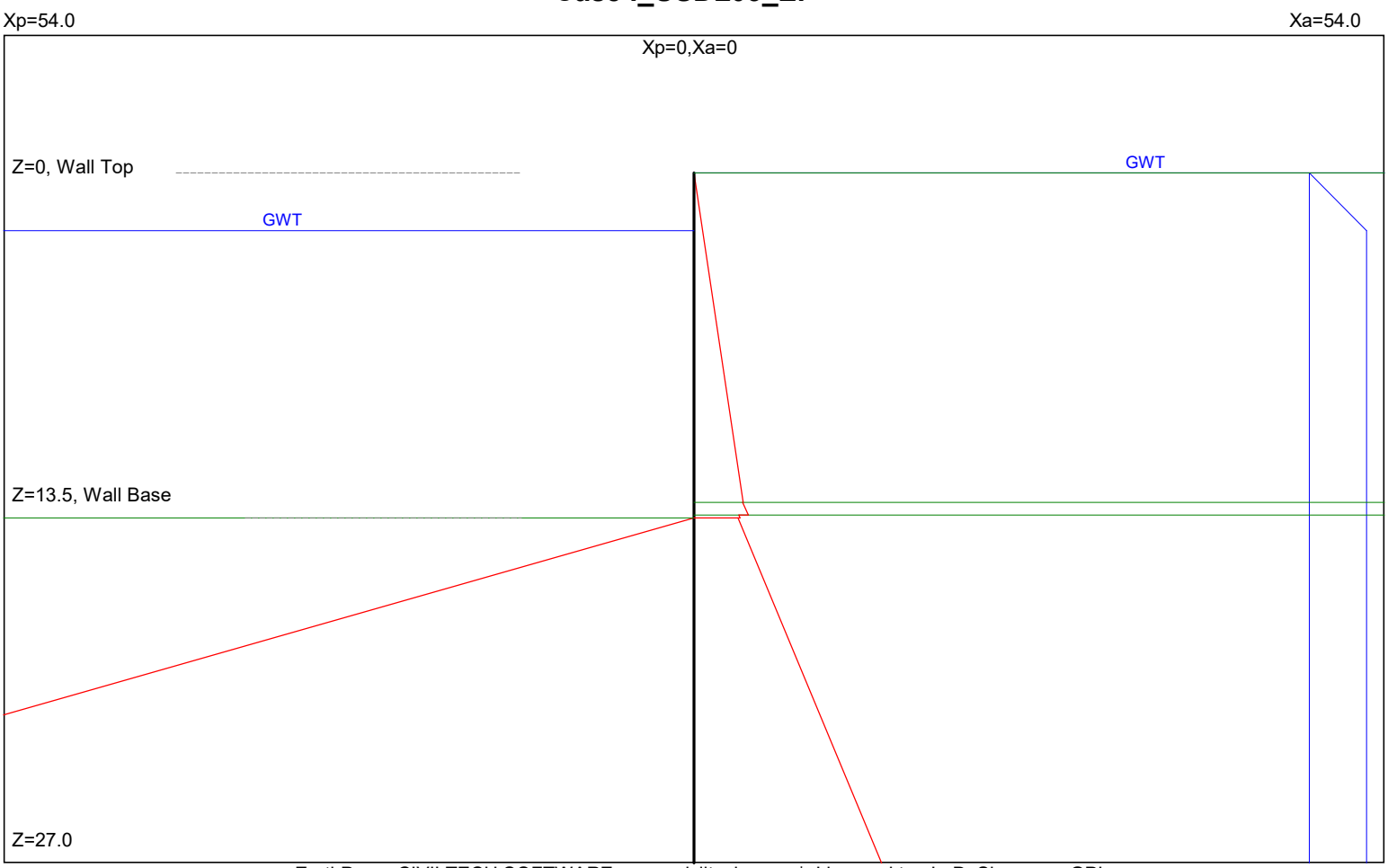
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case I_USDL03

Case I_USDL03_EP



* INPUT DATA *

Wall Height=13.5 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.9	0.0	12.9	800.0	2	Native Alluv
3	13.4	0.0	13.4	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	13.5	0.0	13.5	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.86 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.86

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	12.89	0.12	0.0094	0.5360
12.89	0.12	13.39	0.13	0.0279	0.5305
13.39	0.11	13.50	0.11	0.0273	0.4369

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
13.50	0.11	27.00	0.46	0.0263	0.4204

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

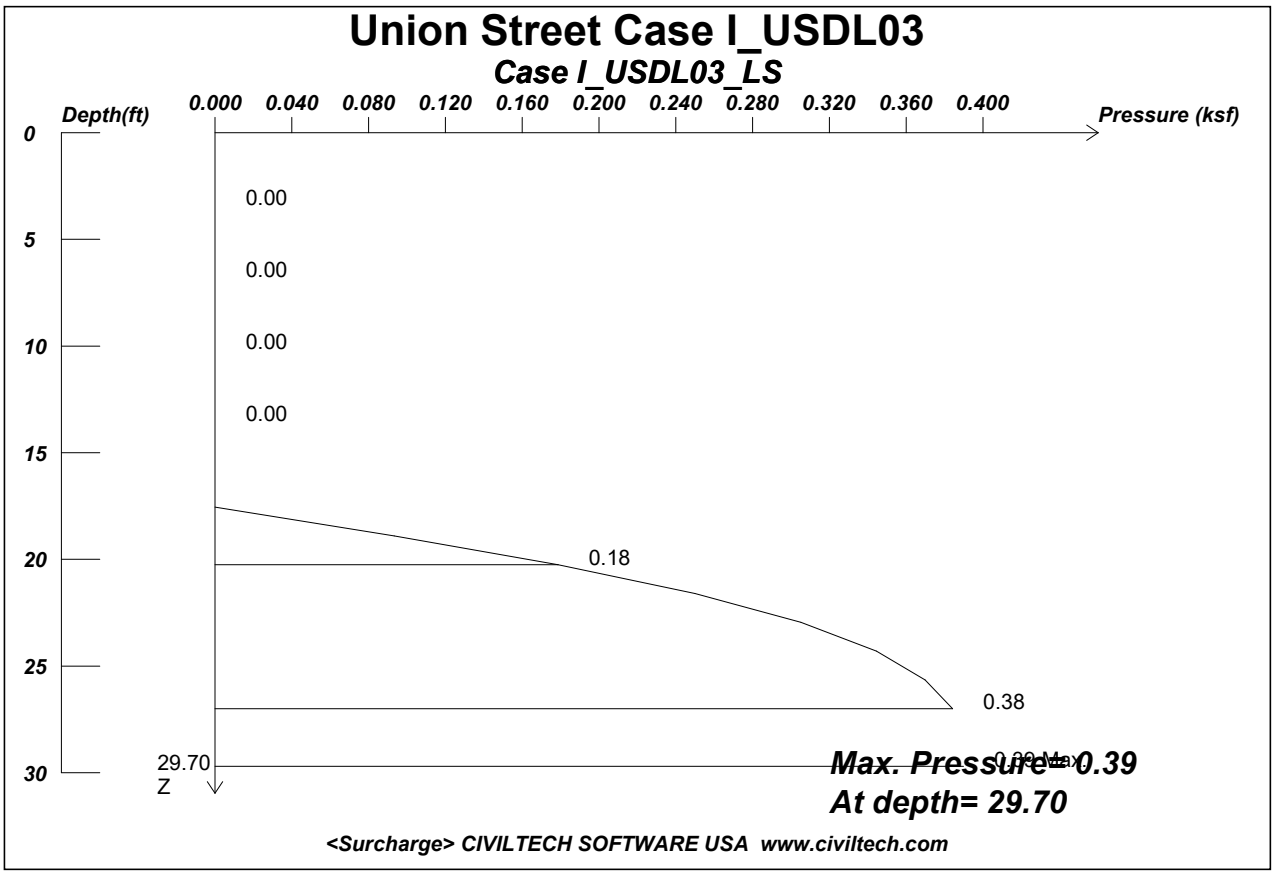
Z1	Pp1	Z2	Pp2	Slope	Kp
13.50	0.00	27.00	2.99	0.221	3.5371

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	27.00	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/9/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case I\U



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Wall Height, H= 13.50 Load Depth, D= 18.23

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.390 at depth = 29.70

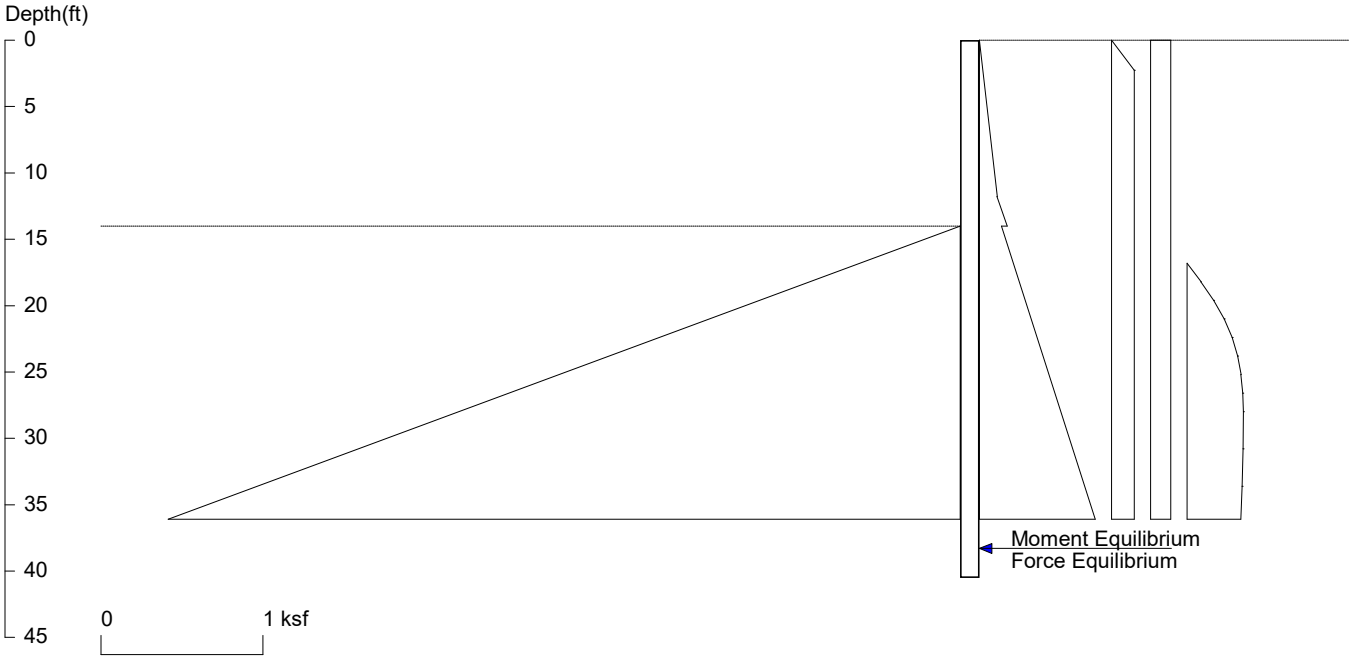
X	Width	Length	Area Load
5.0	18.0	16.2	1.75

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case I_USDL04

Case I_USDL04_Design



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Wall Height=14.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=26.50 Min. Pile Length=40.50
MOMENT IN PILE: Max. Moment=75.07 per Pile Spacing=1.0 at Depth=26.46

PILE SELECTION:
Request Min. Section Modulus = 30.0 in3/ft=1614.23 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.23(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	11.790	0.111	0.009434
11.790	0.110	14.000	0.172	0.027906
*	Below	Base		
14.000	0.136	126.000	3.079	0.026279
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	126.000	0.141	0.000000
*	Sur-	charge		
0.000	0.125	0.700	0.125	0.000000
0.700	0.125	1.400	0.125	0.000000
1.400	0.125	2.100	0.125	0.000000
2.100	0.125	2.800	0.125	0.000000
2.800	0.125	3.500	0.125	0.000000
3.500	0.125	4.200	0.125	0.000000
4.200	0.125	4.900	0.125	0.000000
4.900	0.125	5.600	0.125	0.000000
5.600	0.125	6.300	0.125	0.000000

6.300	0.125	7.000	0.125	0.000000
7.000	0.125	7.700	0.125	0.000000
7.700	0.125	8.400	0.125	0.000000
8.400	0.125	9.100	0.125	0.000000
9.100	0.125	9.800	0.125	0.000000
9.800	0.125	10.500	0.125	0.000000
10.500	0.125	11.200	0.125	0.000000
11.200	0.125	11.900	0.125	0.000000
11.900	0.125	12.600	0.125	0.000000
12.600	0.125	13.300	0.125	0.000000
13.300	0.125	14.000	0.125	0.000000
14.000	0.125	15.400	0.125	0.000000
15.400	0.125	16.800	0.125	0.000000
16.800	0.125	18.200	0.125	0.000000
18.200	0.125	19.600	0.125	0.000000
19.600	0.125	21.000	0.125	0.000000
21.000	0.125	22.400	0.125	0.000000
22.400	0.125	23.800	0.125	0.000000
23.800	0.125	25.200	0.125	0.000000
25.200	0.125	26.600	0.125	0.000000
26.600	0.125	28.000	0.125	0.000000
28.000	0.125	30.800	0.125	0.000000
30.800	0.125	33.600	0.125	0.000000
33.600	0.125	36.400	0.125	0.000000
36.400	0.125	39.200	0.125	0.000000
39.200	0.125	42.000	0.125	0.000000
*	Sur-	charge		
16.800	0.000	18.200	0.086	0.061548
18.200	0.086	19.600	0.164	0.055857
19.600	0.164	21.000	0.229	0.046206
21.000	0.229	22.400	0.278	0.035017
22.400	0.278	23.800	0.312	0.024293
23.800	0.312	25.200	0.333	0.015144
25.200	0.333	26.600	0.344	0.007902
26.600	0.344	28.000	0.348	0.002446
28.000	0.348	30.800	0.346	-0.000762
30.800	0.346	33.600	0.340	-0.002169
33.600	0.340	36.400	0.331	-0.003140
36.400	0.331	39.200	0.320	-0.003789
39.200	0.320	42.000	0.308	-0.004202

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
14.000	0.000	126.000	24.800	0.221424

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	14.00	1.00

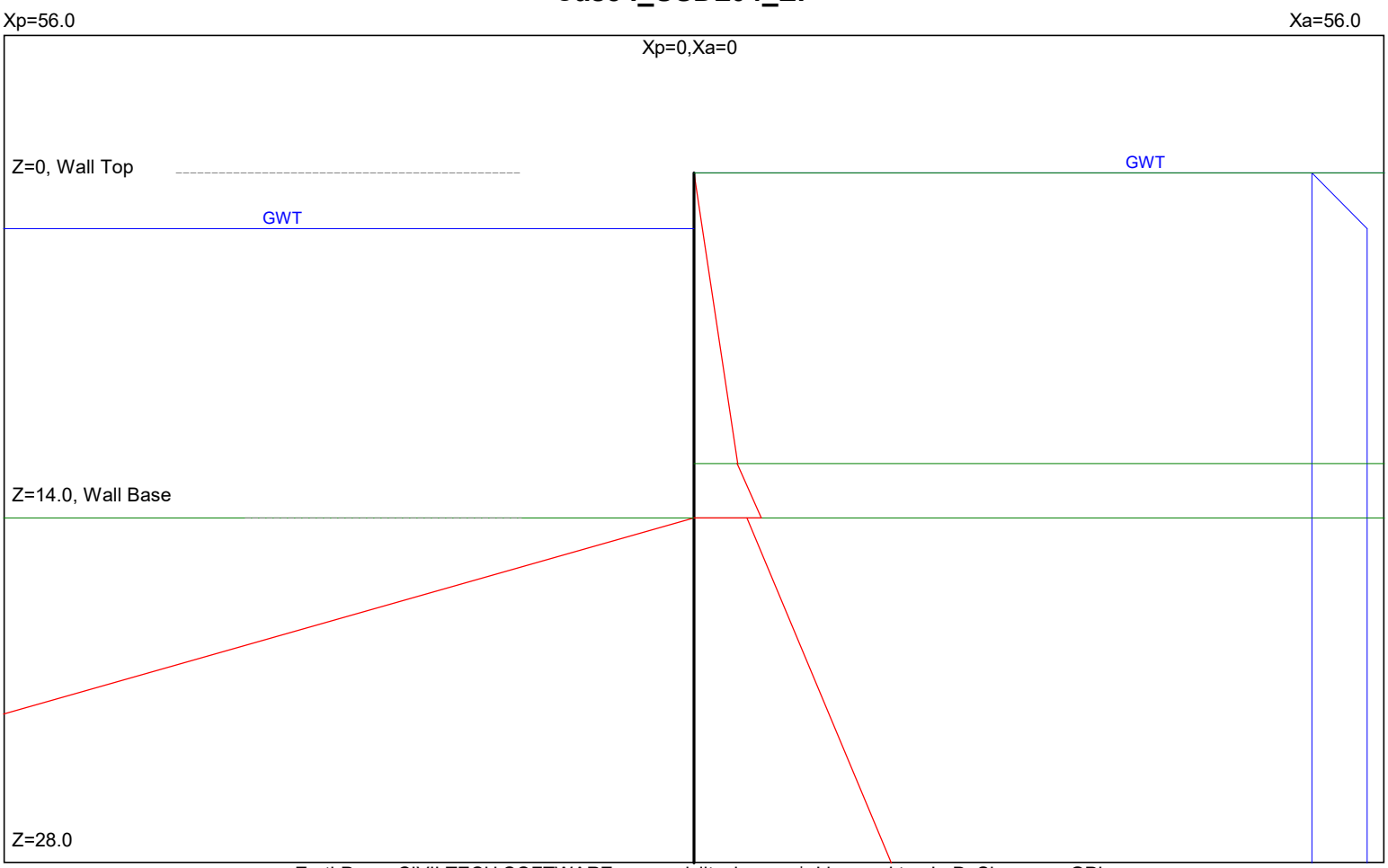
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case I_USDL04

Case I_USDL04_EP



* INPUT DATA *

Wall Height=14.0 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	11.8	0.0	11.8	800.0	2	Native Alluv
3	14.0	0.0	14.0	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	14.0	0.0	14.0	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 1.00 per one linear foot (or meter) width along wall height
Total Static Force above Base= 1.00

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	11.79	0.11	0.0094	0.5360
11.79	0.11	14.00	0.17	0.0279	0.5305

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
14.00	0.14	28.00	0.50	0.0263	0.4206

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

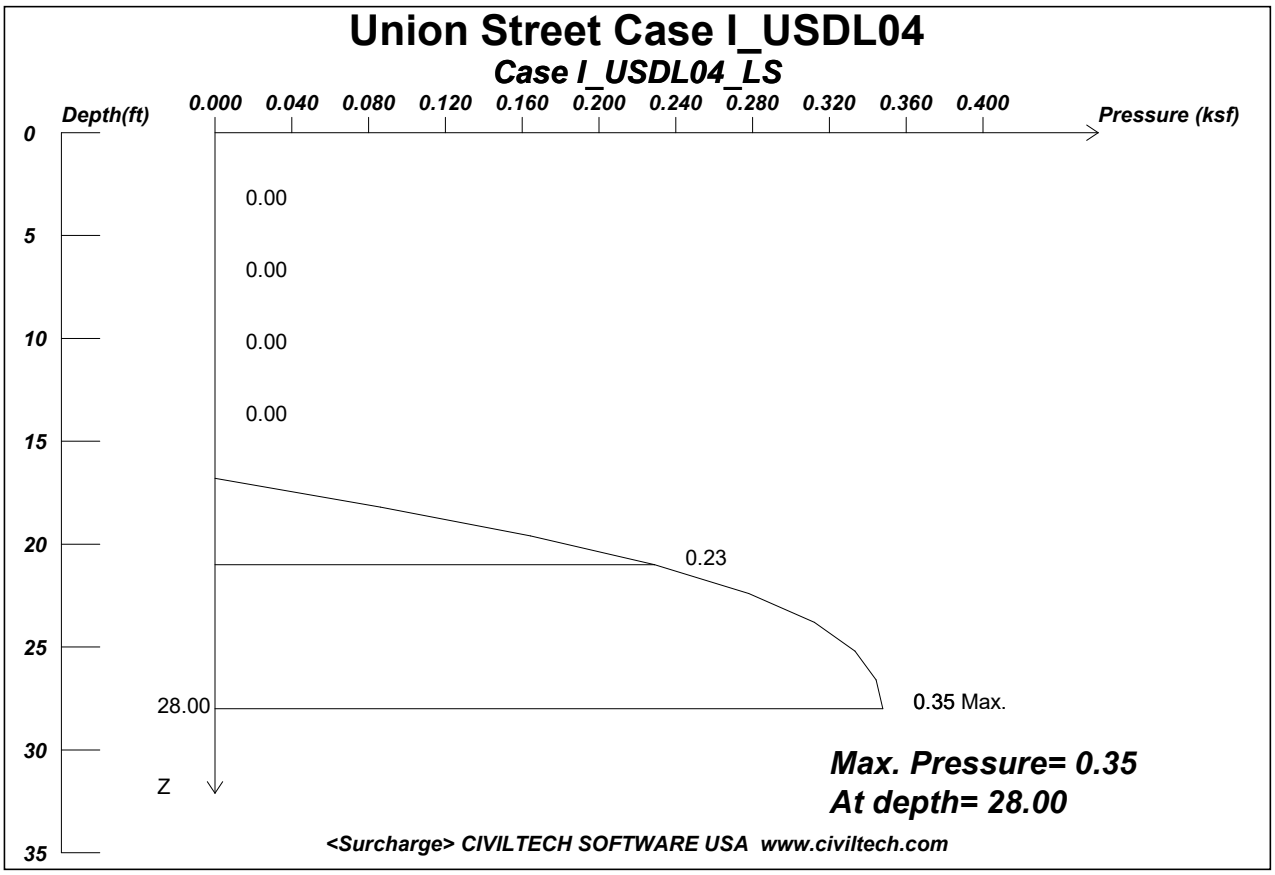
Z1	Pp1	Z2	Pp2	Slope	Kp
14.00	0.00	28.00	3.10	0.221	3.5371

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	28.00	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/9/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case I\U



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Wall Height, H= 14 Load Depth, D= 17.53

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.348 at depth = 28.00

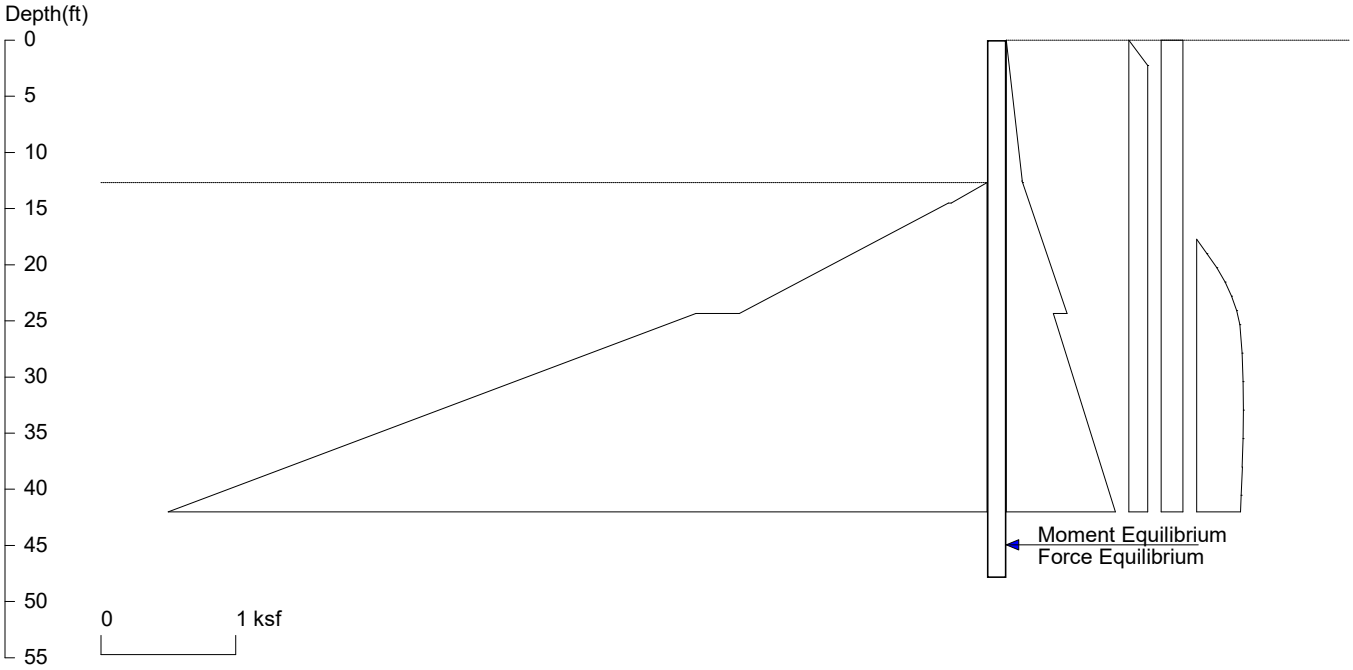
X	Width	Length	Area Load
5.0	18.0	12.3	1.85

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case II_USDL01

Case II_USDL01_Design



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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case

Wall Height=12.7 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=35.21 Min. Pile Length=47.88
MOMENT IN PILE: Max. Moment=108.07 per Pile Spacing=1.0 at Depth=30.66

PILE SELECTION:
Request Min. Section Modulus = 43.2 in3/ft=2323.88 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.32(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	12.530	0.118	0.009434
12.530	0.117	12.670	0.121	0.027906
*	Below	Base		
12.670	0.122	24.330	0.451	0.028196
24.330	0.349	114.030	2.683	0.026020
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	114.030	0.141	0.000000
*	Sur-	charge		
0.000	0.162	0.633	0.162	0.000000
0.633	0.162	1.267	0.162	0.000000
1.267	0.162	1.900	0.162	0.000000
1.900	0.162	2.534	0.162	0.000000
2.534	0.162	3.168	0.162	0.000000
3.168	0.162	3.801	0.162	0.000000
3.801	0.162	4.435	0.162	0.000000
4.435	0.162	5.068	0.162	0.000000

5.068	0.162	5.702	0.162	0.000000
5.702	0.162	6.335	0.162	0.000000
6.335	0.162	6.969	0.162	0.000000
6.969	0.162	7.602	0.162	0.000000
7.602	0.162	8.236	0.162	0.000000
8.236	0.162	8.869	0.162	0.000000
8.869	0.162	9.503	0.162	0.000000
9.503	0.162	10.136	0.162	0.000000
10.136	0.162	10.770	0.162	0.000000
10.770	0.162	11.403	0.162	0.000000
11.403	0.162	12.037	0.162	0.000000
12.037	0.162	12.670	0.162	0.000000
12.670	0.162	13.937	0.162	0.000000
13.937	0.162	15.204	0.162	0.000000
15.204	0.162	16.471	0.162	0.000000
16.471	0.162	17.738	0.162	0.000000
17.738	0.162	19.005	0.162	0.000000
19.005	0.162	20.272	0.162	0.000000
20.272	0.162	21.539	0.162	0.000000
21.539	0.162	22.806	0.162	0.000000
22.806	0.162	24.073	0.162	0.000000
24.073	0.162	25.340	0.162	0.000000
25.340	0.162	27.874	0.162	0.000000
27.874	0.162	30.408	0.162	0.000000
30.408	0.162	32.942	0.162	0.000000
32.942	0.162	35.476	0.162	0.000000
35.476	0.162	38.010	0.162	0.000000
38.010	0.162	40.544	0.162	0.000000
40.544	0.162	43.078	0.162	0.000000
43.078	0.162	45.612	0.162	0.000000
45.612	0.162	48.146	0.162	0.000000
*	Sur-	charge		
17.738	0.000	19.005	0.078	0.061729
19.005	0.078	20.272	0.150	0.056997
20.272	0.150	21.539	0.212	0.048743
21.539	0.212	22.806	0.261	0.038767
22.806	0.261	24.073	0.298	0.028718
24.073	0.298	25.340	0.323	0.019679
25.340	0.323	27.874	0.338	0.006067
27.874	0.338	30.408	0.346	0.003074
30.408	0.346	32.942	0.348	0.000783
32.942	0.348	35.476	0.345	-0.000927
35.476	0.345	38.010	0.340	-0.002175
38.010	0.340	40.544	0.332	-0.003068
40.544	0.332	43.078	0.323	-0.003689
43.078	0.323	45.612	0.312	-0.004107
45.612	0.312	48.146	0.301	-0.004370

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
*	Below	Base		
12.670	0.000	14.500	0.267	0.145693
14.500	0.288	24.330	1.840	0.157836
24.330	2.163	114.030	22.033	0.221516

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	12.67	1.00

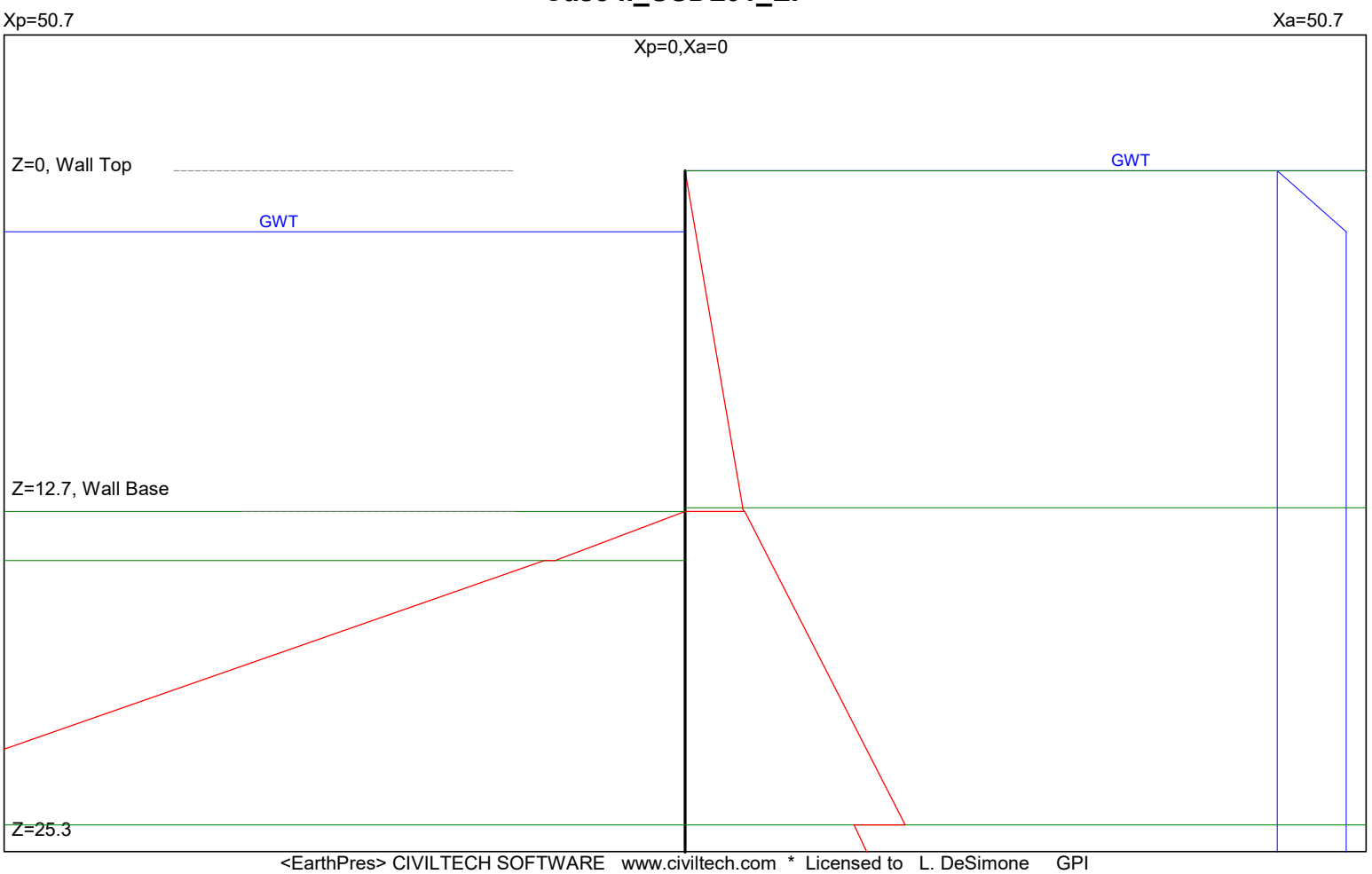
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case II_USDL01

Case II_USDL01_EP



* INPUT DATA *

Wall Height=12.7 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.5	0.0	12.5	800.0	2	Native Alluv
3	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	12.7	0.0	12.7	800.0	2	Native Alluv
2	14.5	0.0	14.5	800.0	4	Sand Backfil

3	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.76 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.76

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	12.53	0.12	0.0094	0.5360
12.53	0.12	12.67	0.12	0.0279	0.5305

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
12.67	0.12	24.33	0.45	0.0282	0.5360
24.33	0.35	25.34	0.37	0.0258	0.4117

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
12.67	0.00	14.50	0.27	0.146	2.7698
14.50	0.29	24.33	1.84	0.158	3.0007
24.33	2.14	25.34	2.37	0.230	3.6702

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	25.34	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

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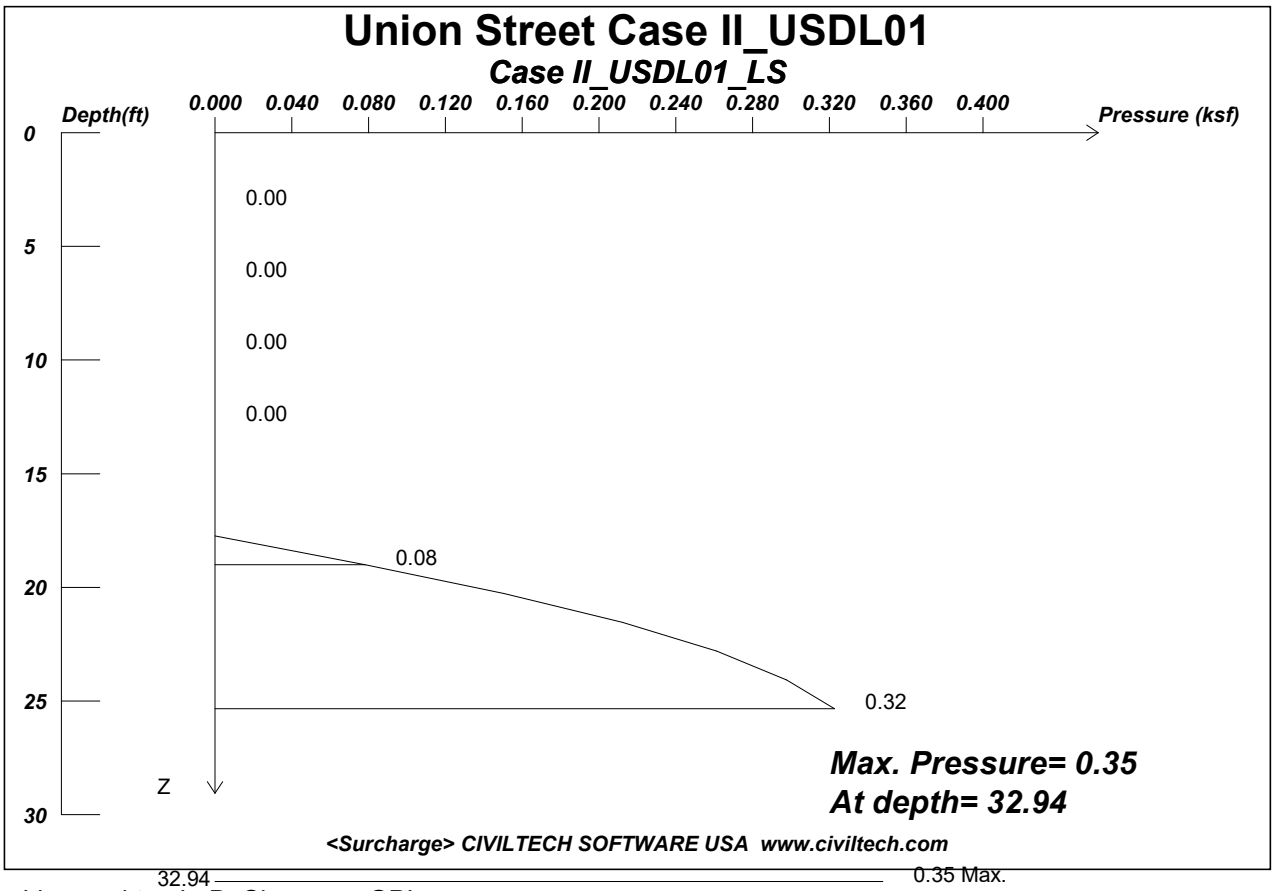

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Date: 6/12/2019 File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Stree

Wall Height, H= 12.67 Load Depth, D= 18.11

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

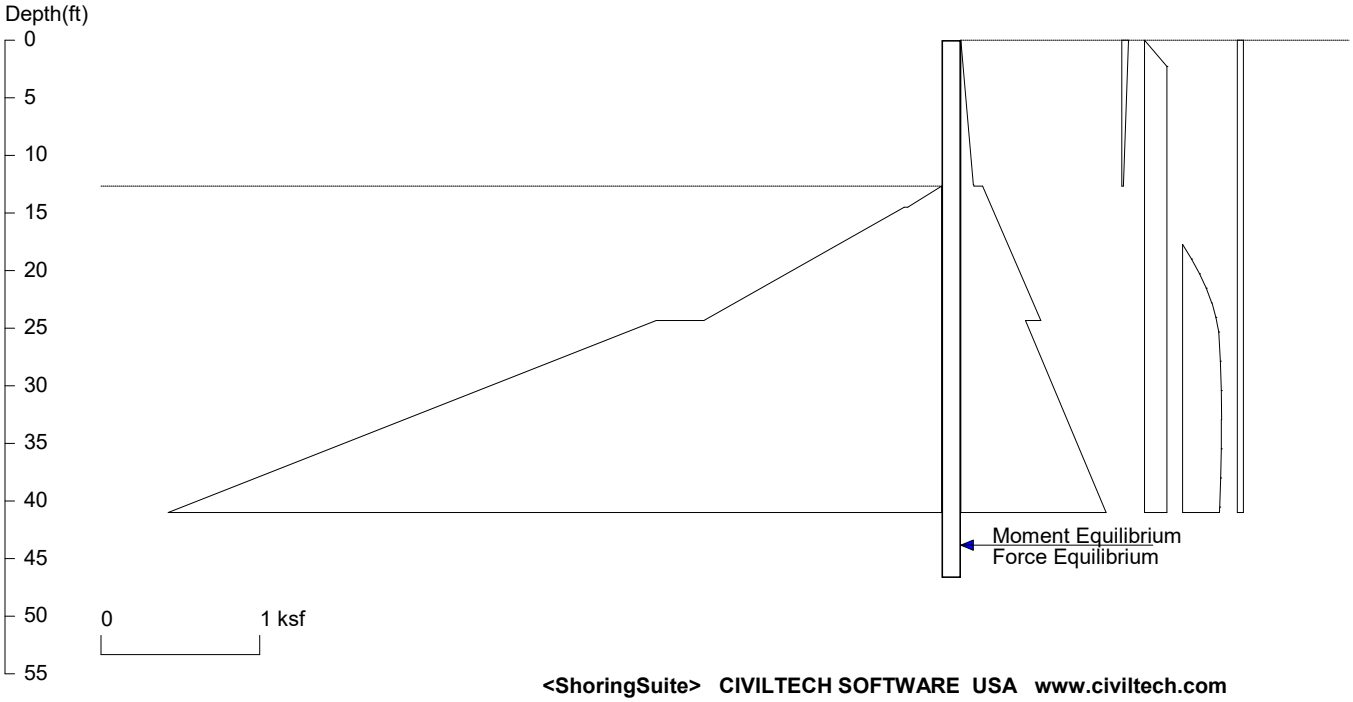
Max. Pressure = 0.348 at depth = 32.94

X	Width	Length	Area Load
5.0	18.0	12.3	1.85

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case II_USDL01_Seismic
Case II_USDL01_EP



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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case

Wall Height=12.7 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=34.00 Min. Pile Length=46.67
MOMENT IN PILE: Max. Moment=73.22 per Pile Spacing=1.0 at Depth=30.15

PILE SELECTION:
Request Min. Section Modulus = 29.3 in3/ft=1574.50 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.23(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	12.530	0.080	0.006354
12.530	0.080	12.670	0.082	0.018990
*	Below	Base		
12.670	0.137	24.330	0.504	0.031517
24.330	0.407	114.030	3.137	0.030435
*	Earth	Queck		
0.000	0.042	12.670	0.011	-0.002516
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	114.030	0.141	0.000000
*	Sur-	charge		
17.738	0.000	19.005	0.055	0.043377
19.005	0.055	20.272	0.106	0.040052
20.272	0.106	21.539	0.149	0.034252
21.539	0.149	22.806	0.184	0.027242
22.806	0.184	24.073	0.209	0.020180
24.073	0.209	25.340	0.227	0.013828

25.340	0.227	27.874	0.238	0.004263
27.874	0.238	30.408	0.243	0.002160
30.408	0.243	32.942	0.244	0.000550
32.942	0.244	35.476	0.243	-0.000651
35.476	0.243	38.010	0.239	-0.001528
38.010	0.239	40.544	0.233	-0.002156
40.544	0.233	43.078	0.227	-0.002592
43.078	0.227	45.612	0.220	-0.002886
45.612	0.220	48.146	0.212	-0.003071
*	Sur-	charge		
0.000	0.038	0.633	0.038	0.000000
0.633	0.038	1.267	0.038	0.000000
1.267	0.038	1.900	0.038	0.000000
1.900	0.038	2.534	0.038	0.000000
2.534	0.038	3.168	0.038	0.000000
3.168	0.038	3.801	0.038	0.000000
3.801	0.038	4.435	0.038	0.000000
4.435	0.038	5.068	0.038	0.000000
5.068	0.038	5.702	0.038	0.000000
5.702	0.038	6.335	0.038	0.000000
6.335	0.038	6.969	0.038	0.000000
6.969	0.038	7.602	0.038	0.000000
7.602	0.038	8.236	0.038	0.000000
8.236	0.038	8.869	0.038	0.000000
8.869	0.038	9.503	0.038	0.000000
9.503	0.038	10.136	0.038	0.000000
10.136	0.038	10.770	0.038	0.000000
10.770	0.038	11.403	0.038	0.000000
11.403	0.038	12.037	0.038	0.000000
12.037	0.038	12.670	0.038	0.000000
12.670	0.038	13.937	0.038	0.000000
13.937	0.038	15.204	0.038	0.000000
15.204	0.038	16.471	0.038	0.000000
16.471	0.038	17.738	0.038	0.000000
17.738	0.038	19.005	0.038	0.000000
19.005	0.038	20.272	0.038	0.000000
20.272	0.038	21.539	0.038	0.000000
21.539	0.038	22.806	0.038	0.000000
22.806	0.038	24.073	0.038	0.000000
24.073	0.038	25.340	0.038	0.000000
25.340	0.038	27.874	0.038	0.000000
27.874	0.038	30.408	0.038	0.000000
30.408	0.038	32.942	0.038	0.000000
32.942	0.038	35.476	0.038	0.000000
35.476	0.038	38.010	0.038	0.000000
38.010	0.038	40.544	0.038	0.000000
40.544	0.038	43.078	0.038	0.000000
43.078	0.038	45.612	0.038	0.000000
45.612	0.038	48.146	0.038	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
*	Below	Base		
12.670	0.000	14.500	0.214	0.116953
14.500	0.235	24.330	1.497	0.128377
24.330	1.799	114.030	18.333	0.184319

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	12.67	1.00

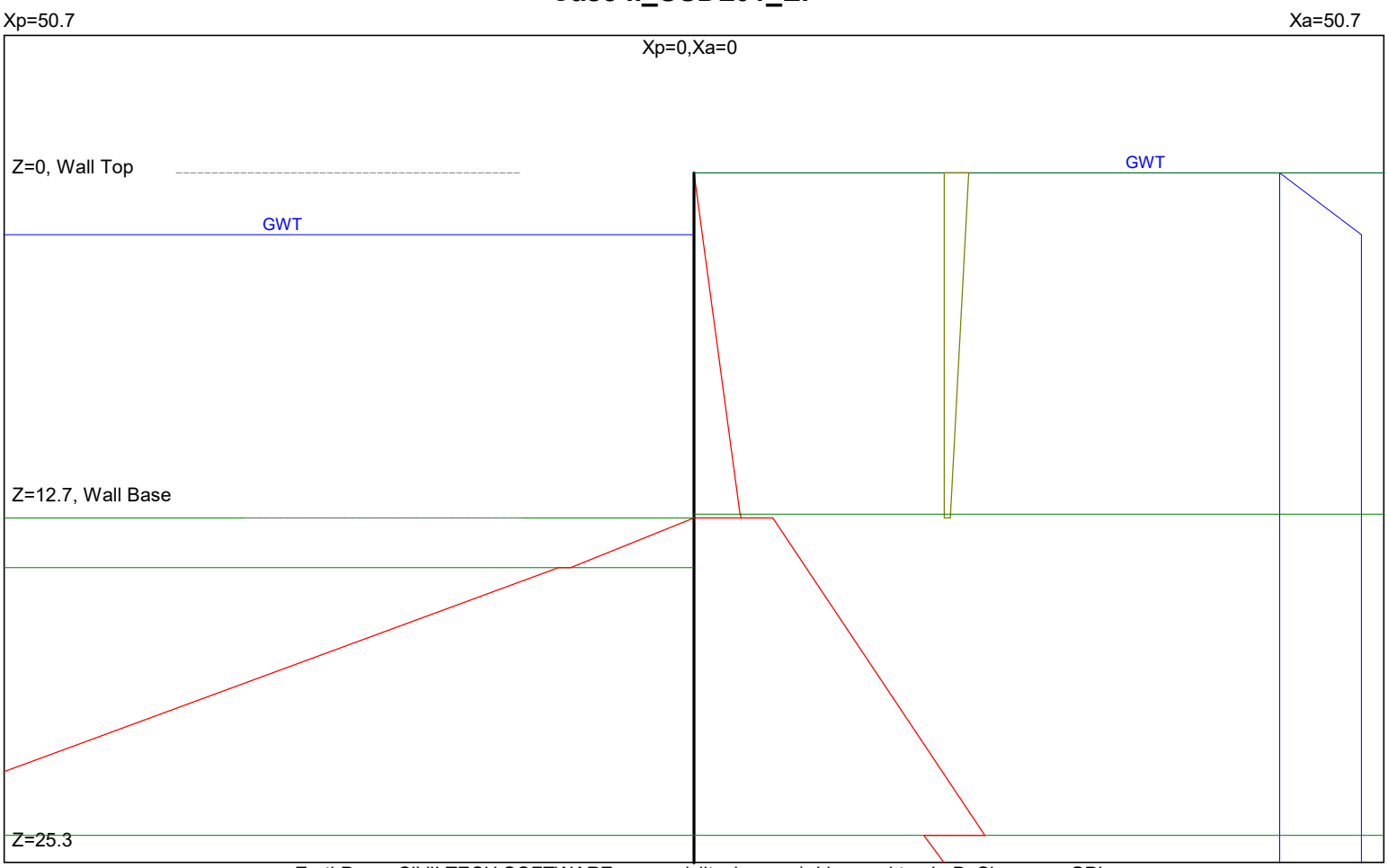
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case II_USDL01_Seismic

Case II_USDL01_EP



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UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

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* INPUT DATA *

Wall Height=12.7 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.5	0.0	12.5	800.0	2	Native Alluv
3	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	12.7	0.0	12.7	800.0	2	Native Alluv
2	14.5	0.0	14.5	800.0	4	Sand Backfil

3	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.85 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.51
Total Earthquake Force above Base= 0.34. Distributed in trapezoid. Total earthquake force acting at 0.4H below wall top.

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	12.53	0.08	0.0064	0.3610
12.53	0.08	12.67	0.08	0.0190	0.3610

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
12.67	0.14	24.33	0.50	0.0315	0.5992
24.33	0.40	25.34	0.43	0.0350	0.5590

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
12.67	0.00	14.50	0.21	0.117	2.2234
14.50	0.23	24.33	1.50	0.128	2.4406
24.33	1.78	25.34	1.97	0.189	3.0270

Output Earthquake Pressure above Base - Output to Shoring - Multiplier of Pressure = 1
Total Earthq. Force, Ee = 0.34

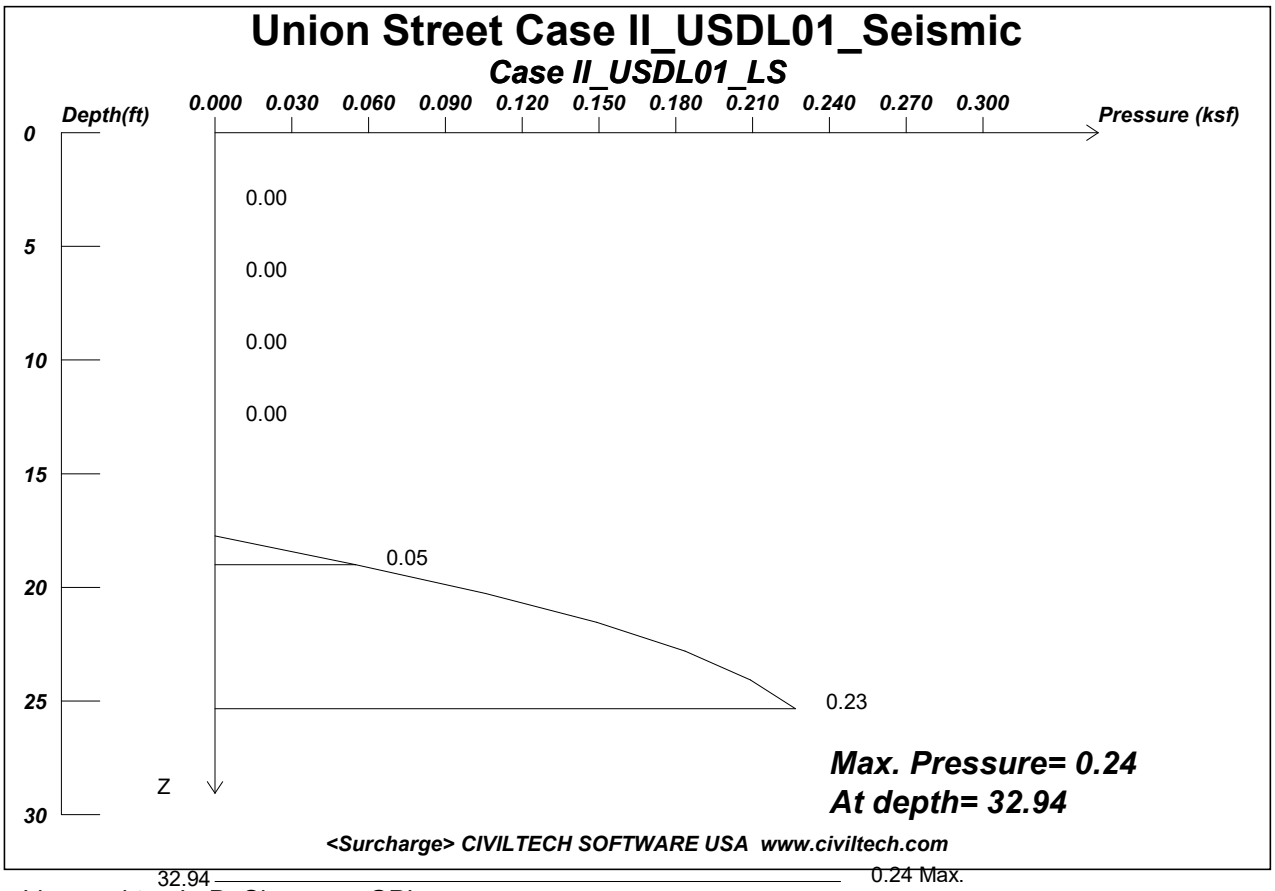
No	Zq1	Pq1	Zq2	Pq2	Slope
0	0.00	0.042	12.67	0.011	-0.003

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	25.34	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/12/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case II\



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Wall Height, H= 12.67 Load Depth, D= 18.11

Load Factor of Surcharge Loading = 1

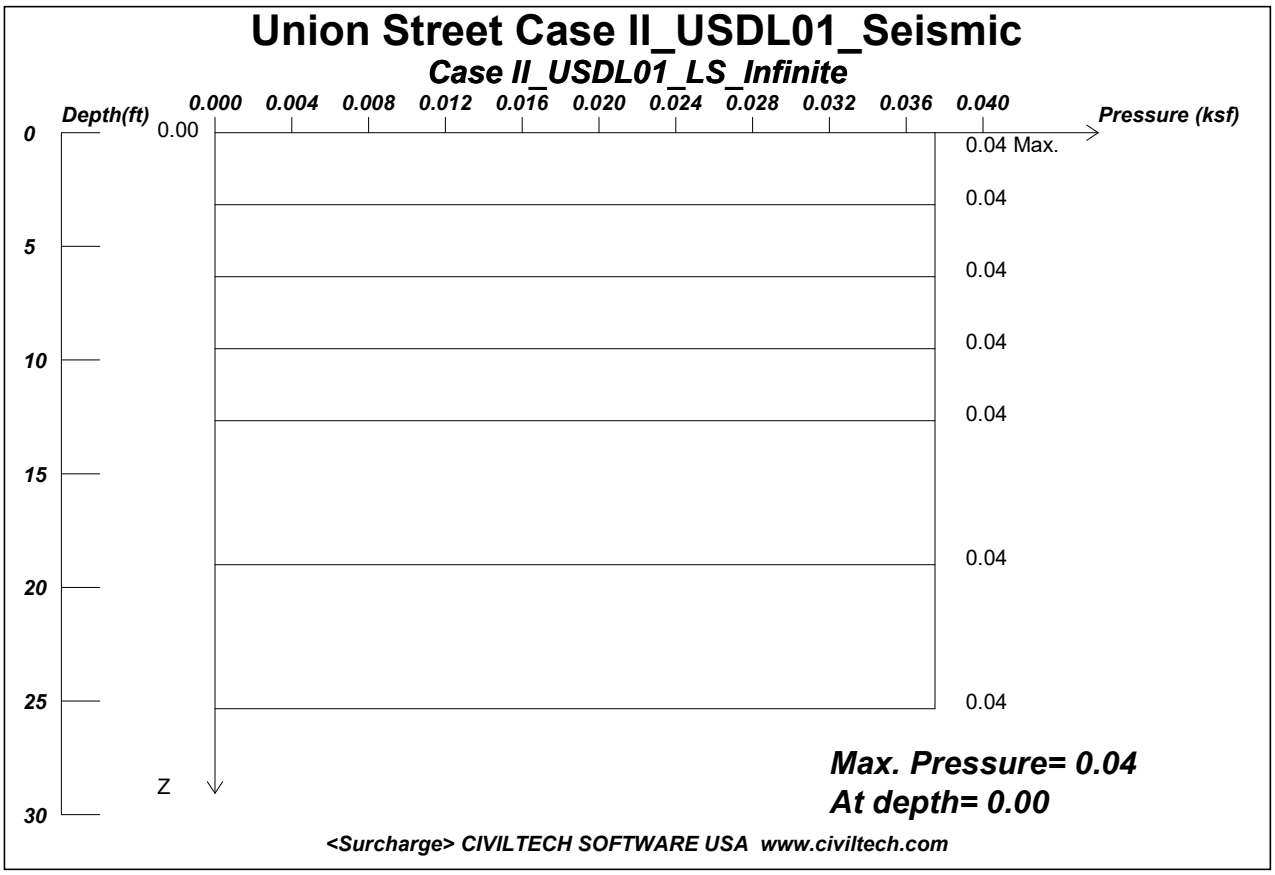
Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.244 at depth = 32.94

X	Width	Length	Area Load
5.0	18.0	12.3	1.30

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf



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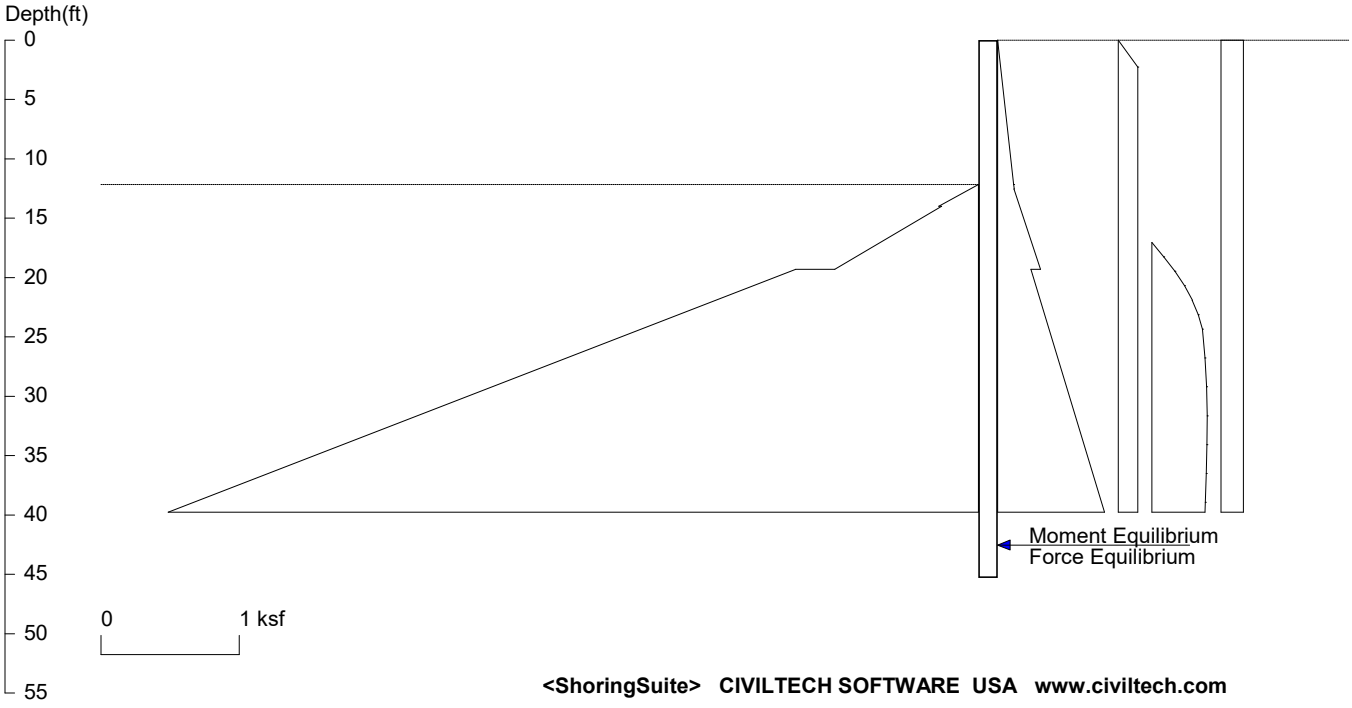
Wall Height, H= 12.67 Load Depth, D= 0
Load Factor of Surcharge Loading = 1
Rigid Wall Condition -- No movement or deflection of the wall are allowed.
Max. Pressure = 0.038 at depth = 0.00

Infinite Surcharge, Q=0.075 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case II_USDL02
Case II_USDL02_Design



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Wall Height=12.2 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=33.12 Min. Pile Length=45.29
MOMENT IN PILE: Max. Moment=93.26 per Pile Spacing=1.0 at Depth=28.76

PILE SELECTION:
Request Min. Section Modulus = 37.3 in3/ft=2005.48 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.26(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	12.170	0.115	0.009434
*	Below	Base		
12.170	0.115	12.550	0.118	0.009434
12.550	0.118	19.300	0.309	0.028196
19.300	0.239	109.530	2.586	0.026014
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	109.530	0.141	0.000000
*	Sur-	charge		
17.038	0.000	18.255	0.087	0.071152
18.255	0.087	19.472	0.167	0.066098
19.472	0.167	20.689	0.237	0.057193
20.689	0.237	21.906	0.293	0.046268
21.906	0.293	23.123	0.336	0.035060
23.123	0.336	24.340	0.366	0.024777
24.340	0.366	26.774	0.385	0.008010
26.774	0.385	29.208	0.396	0.004468

29.208	0.396	31.642	0.400	0.001703
31.642	0.400	34.076	0.399	-0.000400
34.076	0.399	36.510	0.395	-0.001966
36.510	0.395	38.944	0.387	-0.003111
38.944	0.387	41.378	0.377	-0.003929
41.378	0.377	43.812	0.366	-0.004499
43.812	0.366	46.246	0.355	-0.004878
*	Sur-	charge		
0.000	0.162	0.609	0.162	0.000000
0.609	0.162	1.217	0.162	0.000000
1.217	0.162	1.826	0.162	0.000000
1.826	0.162	2.434	0.162	0.000000
2.434	0.162	3.043	0.162	0.000000
3.043	0.162	3.651	0.162	0.000000
3.651	0.162	4.260	0.162	0.000000
4.260	0.162	4.868	0.162	0.000000
4.868	0.162	5.477	0.162	0.000000
5.477	0.162	6.085	0.162	0.000000
6.085	0.162	6.694	0.162	0.000000
6.694	0.162	7.302	0.162	0.000000
7.302	0.162	7.911	0.162	0.000000
7.911	0.162	8.519	0.162	0.000000
8.519	0.162	9.128	0.162	0.000000
9.128	0.162	9.736	0.162	0.000000
9.736	0.162	10.344	0.162	0.000000
10.344	0.162	10.953	0.162	0.000000
10.953	0.162	11.561	0.162	0.000000
11.561	0.162	12.170	0.162	0.000000
12.170	0.162	13.387	0.162	0.000000
13.387	0.162	14.604	0.162	0.000000
14.604	0.162	15.821	0.162	0.000000
15.821	0.162	17.038	0.162	0.000000
17.038	0.162	18.255	0.162	0.000000
18.255	0.162	19.472	0.162	0.000000
19.472	0.162	20.689	0.162	0.000000
20.689	0.162	21.906	0.162	0.000000
21.906	0.162	23.123	0.162	0.000000
23.123	0.162	24.340	0.162	0.000000
24.340	0.162	26.774	0.162	0.000000
26.774	0.162	29.208	0.162	0.000000
29.208	0.162	31.642	0.162	0.000000
31.642	0.162	34.076	0.162	0.000000
34.076	0.162	36.510	0.162	0.000000
36.510	0.162	38.944	0.162	0.000000
38.944	0.162	41.378	0.162	0.000000
41.378	0.162	43.812	0.162	0.000000
43.812	0.162	46.246	0.162	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
*	Below	Base		
12.170	0.000	14.000	0.289	0.157800
14.000	0.266	19.300	1.039	0.145792
19.300	1.322	109.530	21.307	0.221497

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	12.17	1.00

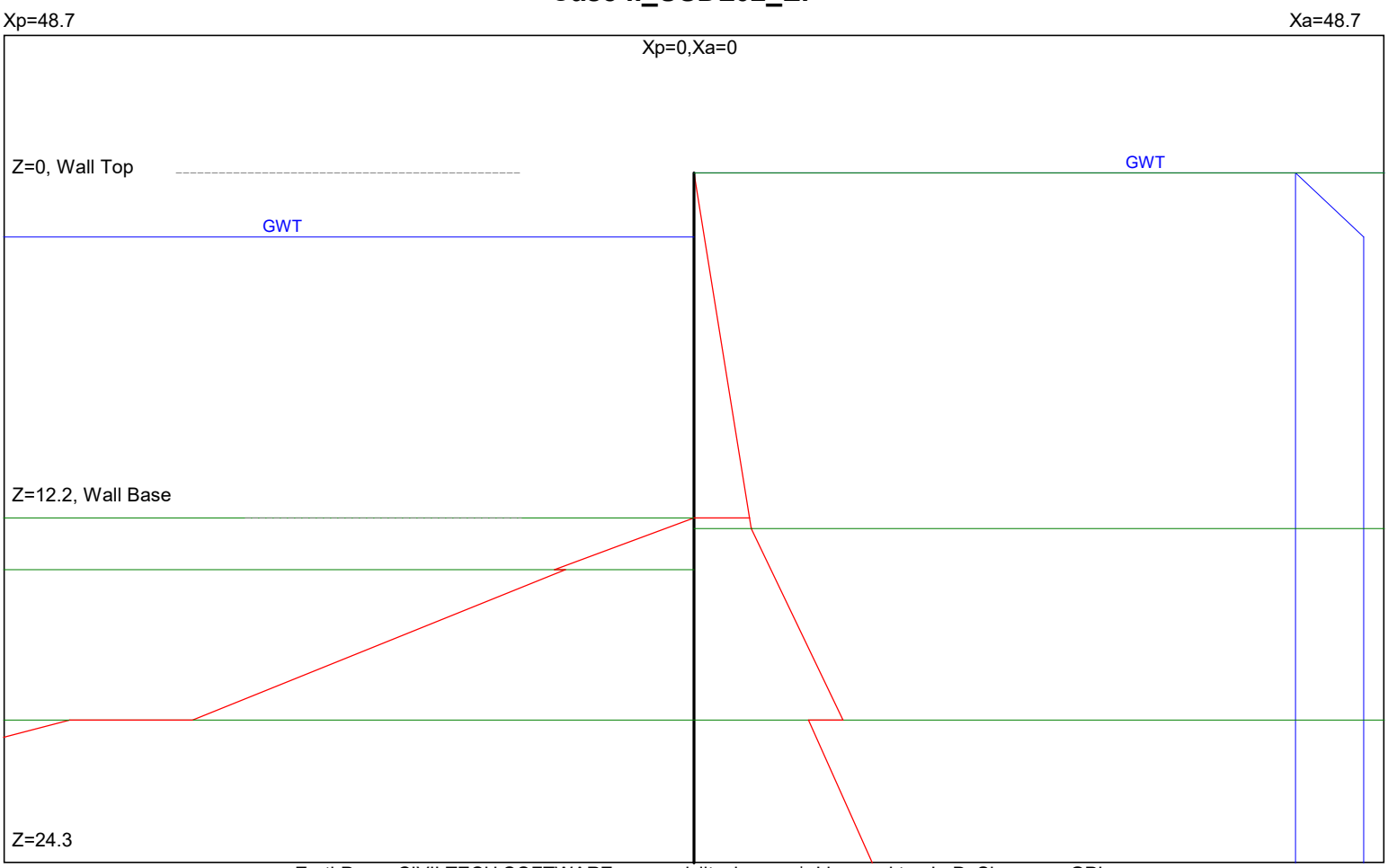
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case II_USDL02

Case II_USDL02_EP



* INPUT DATA *

Wall Height=12.2 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.6	0.0	12.6	800.0	2	Native Alluv
3	19.3	0.0	19.3	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	12.2	0.0	12.2	800.0	4	Sand Backfil
2	14.0	0.0	14.0	800.0	2	Native Alluv

3	19.3	0.0	19.3	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.70 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.70

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	12.17	0.11	0.0094	0.5360

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
12.17	0.11	12.55	0.12	0.0094	0.5360
12.55	0.12	19.30	0.31	0.0282	0.5360
19.30	0.24	24.34	0.37	0.0262	0.4178

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
12.17	0.00	14.00	0.29	0.158	3.0000
14.00	0.27	19.30	1.04	0.146	2.7717
19.30	1.29	24.34	2.44	0.227	3.6242

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	24.34	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

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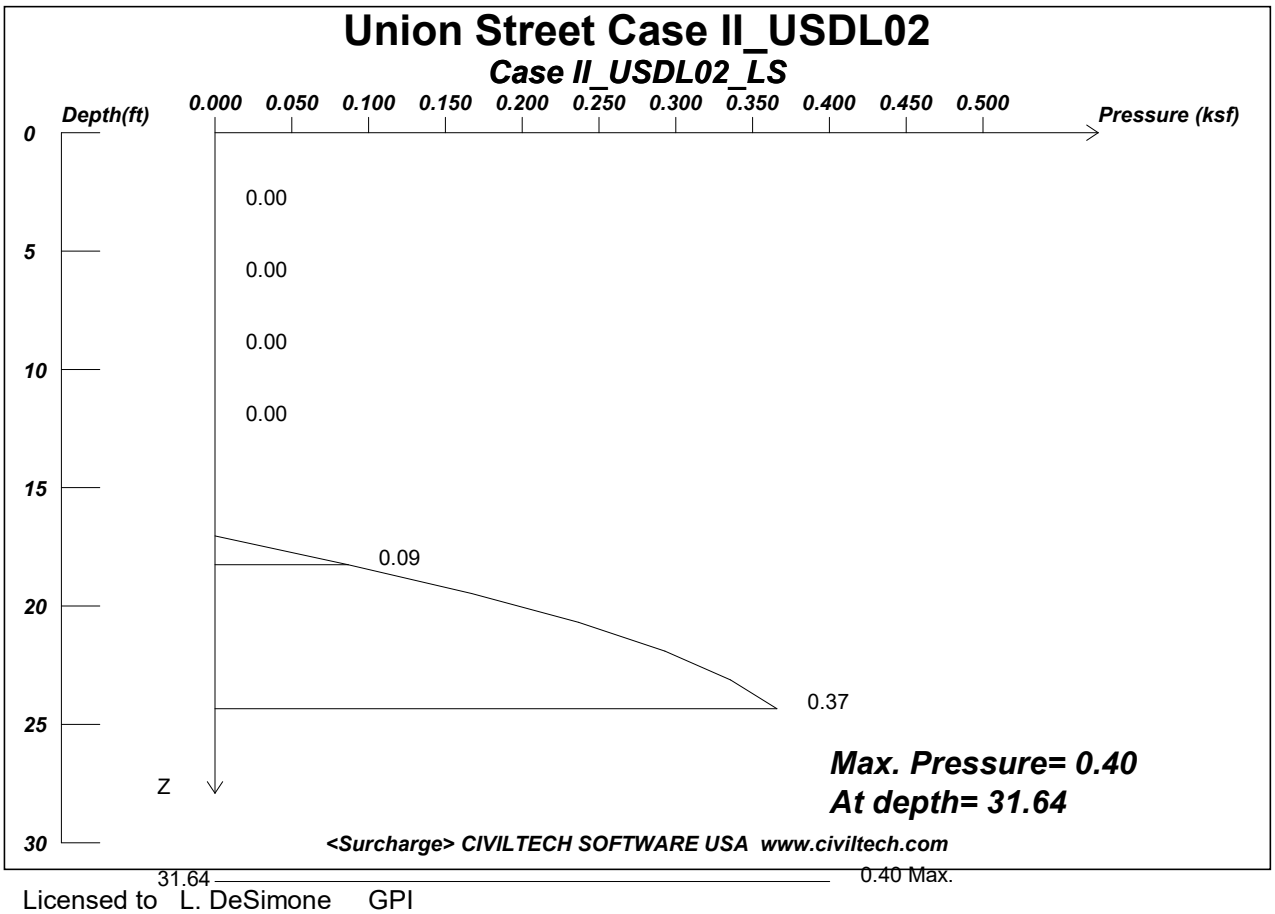

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Wall Height, H= 12.17 Load Depth, D= 18.12

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

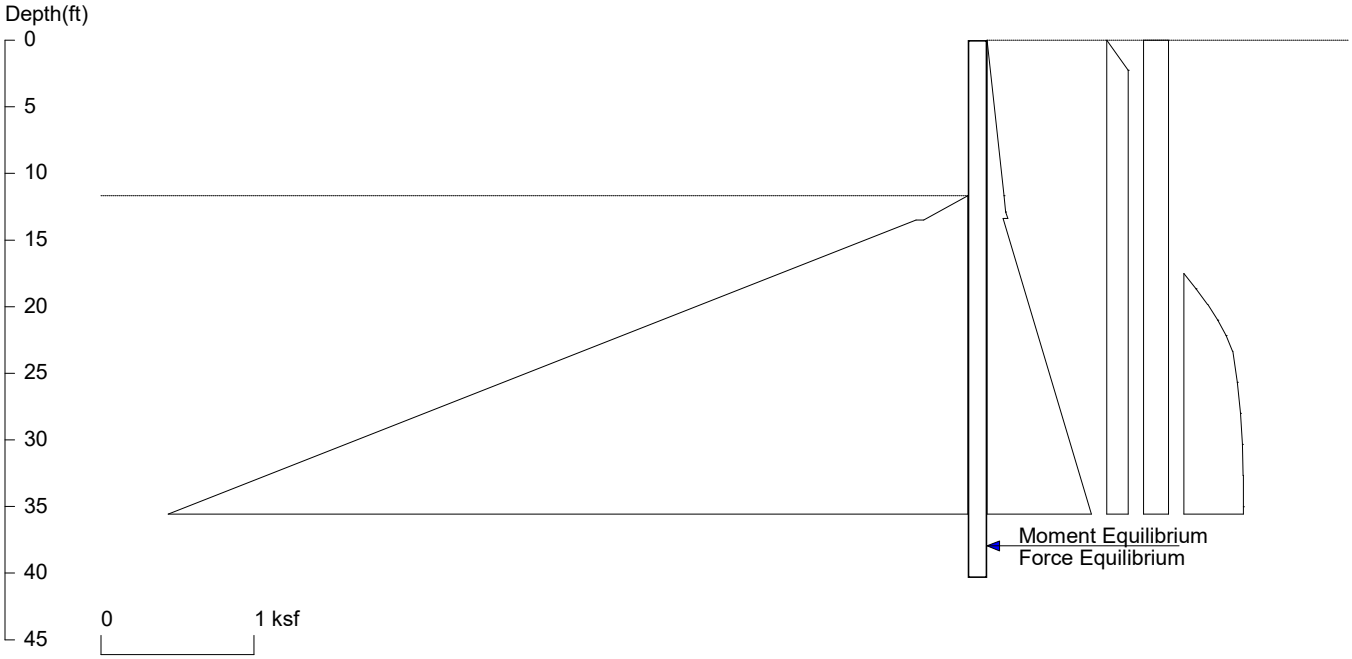
Max. Pressure = 0.400 at depth = 31.64

X	Width	Length	Area Load
5.0	18.0	22.3	1.50

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case II_USDL03
Case II_USDL03_EP



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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case

Wall Height=11.7 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=28.68 Min. Pile Length=40.35
MOMENT IN PILE: Max. Moment=68.14 per Pile Spacing=1.0 at Depth=25.33

PILE SELECTION:
Request Min. Section Modulus = 22.7 in3/ft=1221.15 cm3/m, Fy= 60 ksi = 414 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.18(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	11.670	0.110	0.009434
*	Below	Base		
11.670	0.110	12.890	0.122	0.009434
12.890	0.122	13.390	0.136	0.028196
13.390	0.105	105.030	2.488	0.026009
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	105.030	0.141	0.000000
*	Sur-	charge		
0.000	0.162	0.584	0.162	0.000000
0.584	0.162	1.167	0.162	0.000000
1.167	0.162	1.751	0.162	0.000000
1.751	0.162	2.334	0.162	0.000000
2.334	0.162	2.918	0.162	0.000000
2.918	0.162	3.501	0.162	0.000000
3.501	0.162	4.084	0.162	0.000000
4.084	0.162	4.668	0.162	0.000000

4.668	0.162	5.251	0.162	0.000000
5.251	0.162	5.835	0.162	0.000000
5.835	0.162	6.418	0.162	0.000000
6.418	0.162	7.002	0.162	0.000000
7.002	0.162	7.585	0.162	0.000000
7.585	0.162	8.169	0.162	0.000000
8.169	0.162	8.752	0.162	0.000000
8.752	0.162	9.336	0.162	0.000000
9.336	0.162	9.919	0.162	0.000000
9.919	0.162	10.503	0.162	0.000000
10.503	0.162	11.086	0.162	0.000000
11.086	0.162	11.670	0.162	0.000000
11.670	0.162	12.837	0.162	0.000000
12.837	0.162	14.004	0.162	0.000000
14.004	0.162	15.171	0.162	0.000000
15.171	0.162	16.338	0.162	0.000000
16.338	0.162	17.505	0.162	0.000000
17.505	0.162	18.672	0.162	0.000000
18.672	0.162	19.839	0.162	0.000000
19.839	0.162	21.006	0.162	0.000000
21.006	0.162	22.173	0.162	0.000000
22.173	0.162	23.340	0.162	0.000000
23.340	0.162	25.674	0.162	0.000000
25.674	0.162	28.008	0.162	0.000000
28.008	0.162	30.342	0.162	0.000000
30.342	0.162	32.676	0.162	0.000000
32.676	0.162	35.010	0.162	0.000000
35.010	0.162	37.344	0.162	0.000000
37.344	0.162	39.678	0.162	0.000000
39.678	0.162	42.012	0.162	0.000000
*	Sur-	charge		
17.505	0.000	18.672	0.081	0.069398
18.672	0.081	19.839	0.157	0.064846
19.839	0.157	21.006	0.223	0.056748
21.006	0.223	22.173	0.277	0.046667
22.173	0.277	23.340	0.320	0.036137
23.340	0.320	25.674	0.350	0.013142
25.674	0.350	28.008	0.371	0.008861
28.008	0.371	30.342	0.383	0.005329
30.342	0.383	32.676	0.389	0.002518
32.676	0.389	35.010	0.390	0.000339
35.010	0.390	37.344	0.387	-0.001316
37.344	0.387	39.678	0.381	-0.002550
39.678	0.381	42.012	0.373	-0.003455

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
*	Below	Base		
11.670	0.000	13.500	0.289	0.157800
13.500	0.340	105.030	20.608	0.221427

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	11.67	1.00

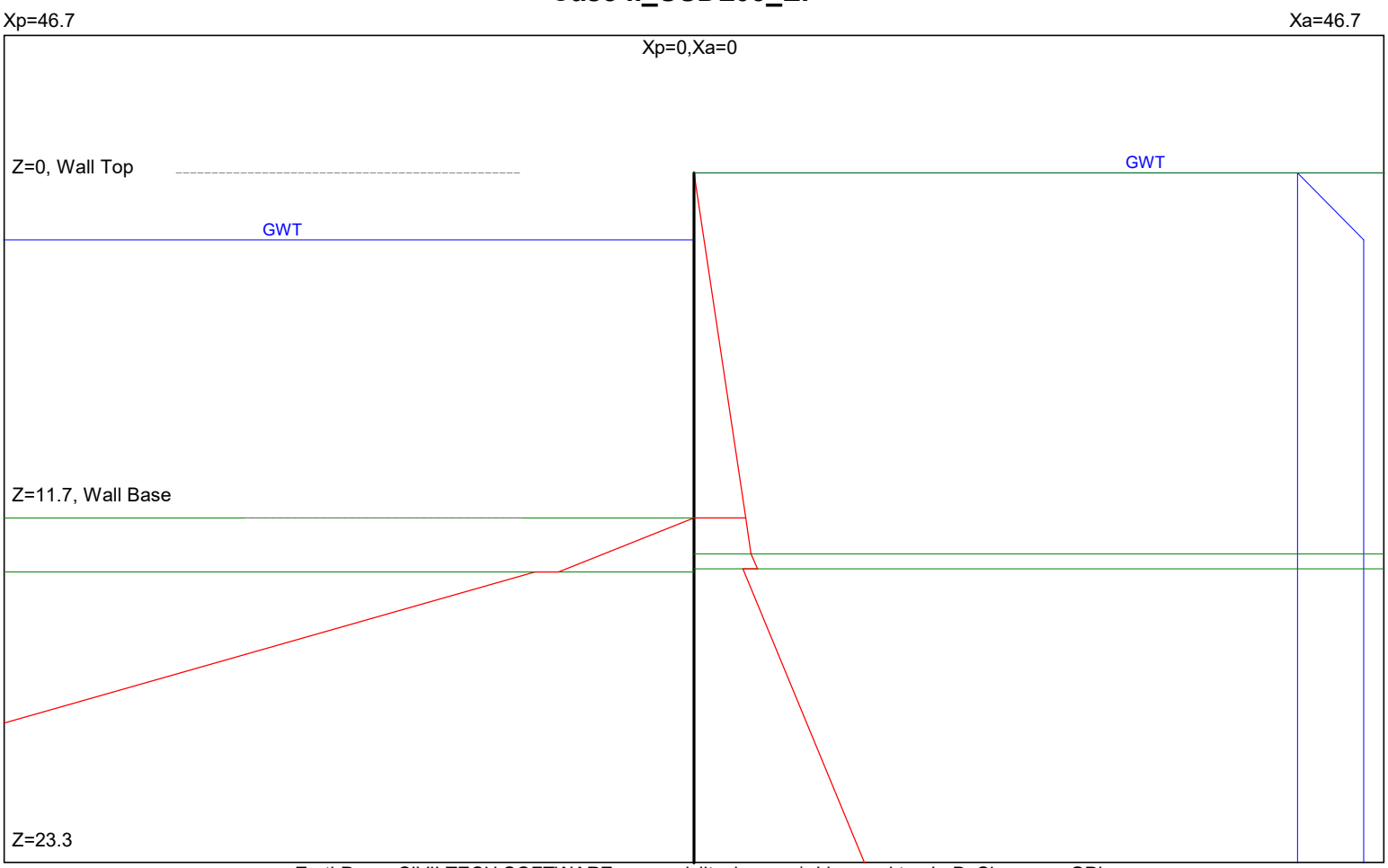
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case II_USDL03

Case II_USDL03_EP



* INPUT DATA *

Wall Height=11.7 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.9	0.0	12.9	800.0	2	Native Alluv
3	13.4	0.0	13.4	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	11.7	0.0	11.7	800.0	4	Sand Backfil
2	13.5	0.0	13.5	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.64 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.64

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	11.67	0.11	0.0094	0.5360

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
11.67	0.11	12.89	0.12	0.0094	0.5360
12.89	0.12	13.39	0.14	0.0282	0.5360
13.39	0.10	23.34	0.36	0.0261	0.4166

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

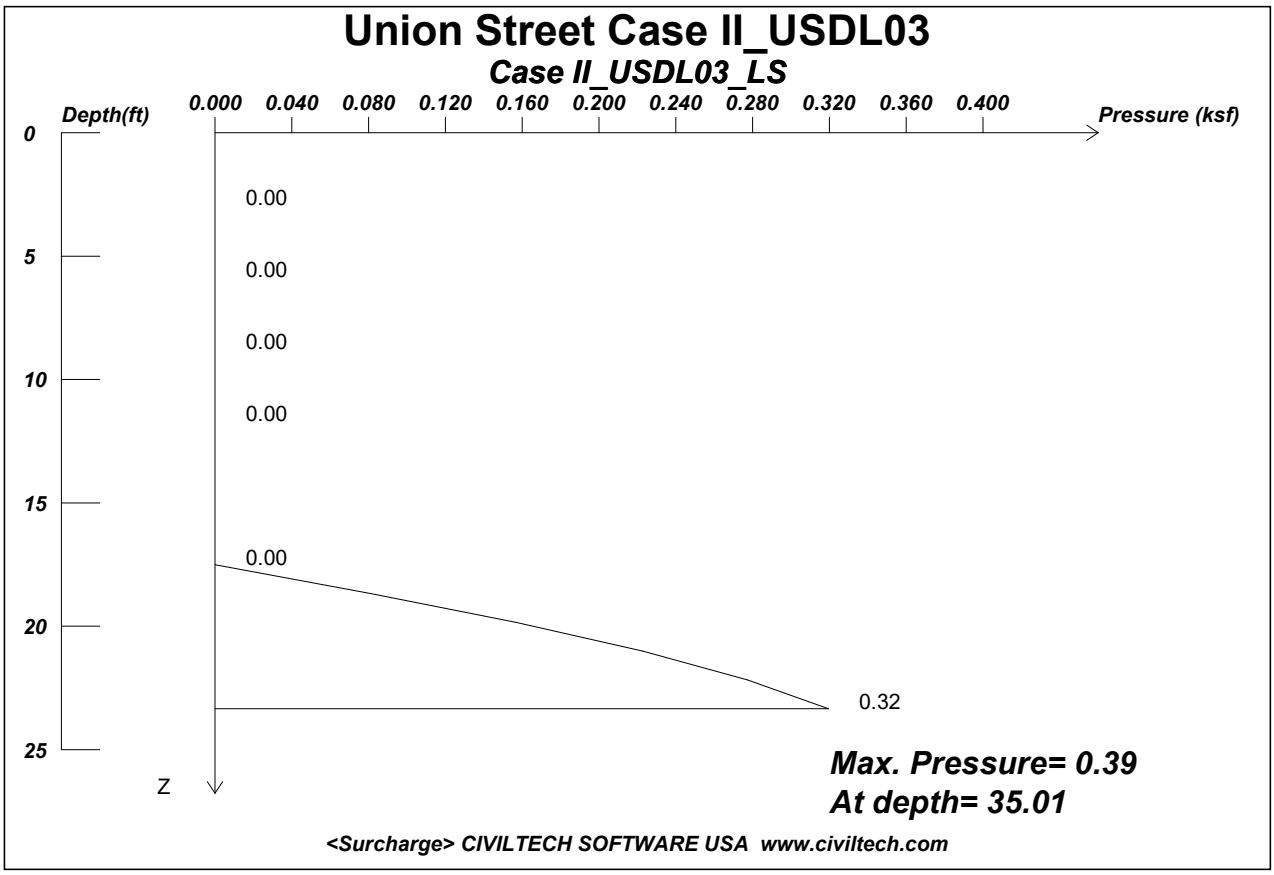
Z1	Pp1	Z2	Pp2	Slope	Kp
11.67	0.00	13.50	0.29	0.158	3.0000
13.50	0.34	23.34	2.52	0.222	3.5399

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	23.34	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/12/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case II\



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35.01 0.39 Max.

Wall Height, H= 11.67 Load Depth, D= 18.23

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

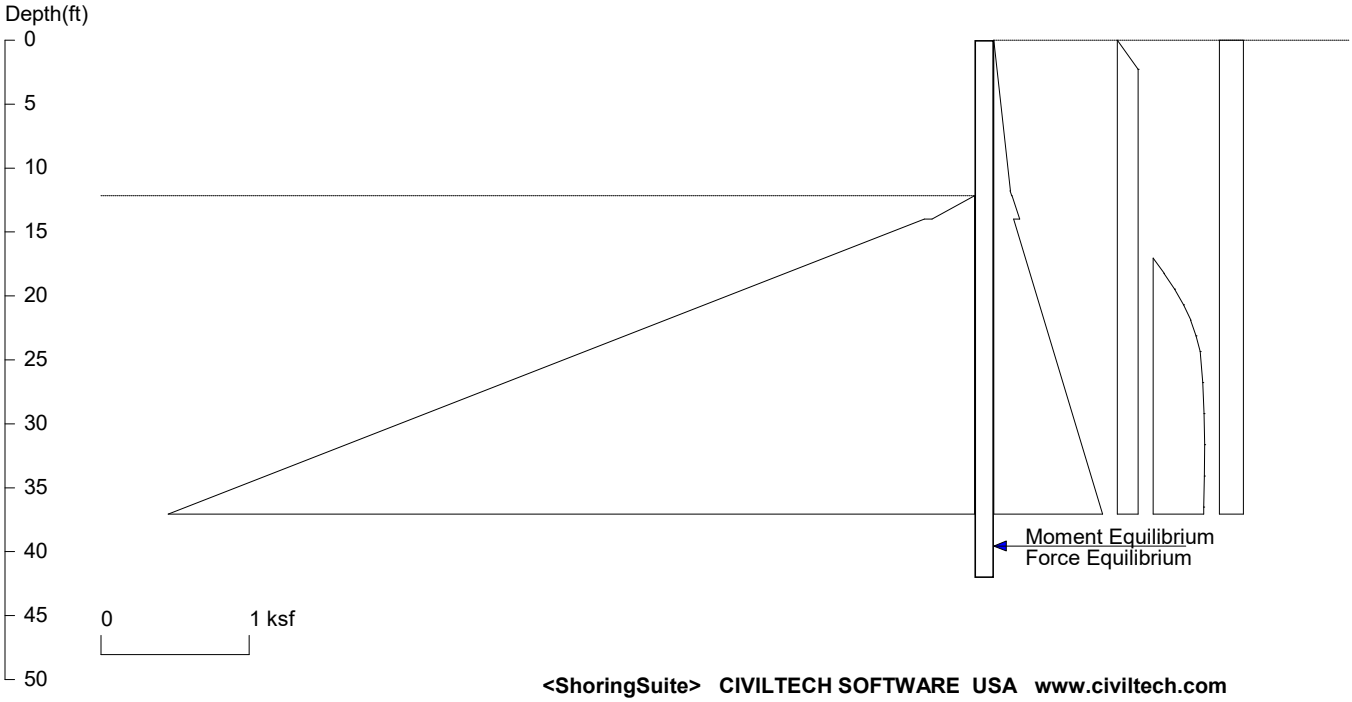
Max. Pressure = 0.390 at depth = 35.01

X	Width	Length	Area Load
5.0	18.0	16.2	1.75

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case II_USDL04
Case II_USDL04_EP



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Wall Height=12.2 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=29.87 Min. Pile Length=42.04
MOMENT IN PILE: Max. Moment=76.95 per Pile Spacing=1.0 at Depth=26.59

PILE SELECTION:
Request Min. Section Modulus = 30.8 in3/ft=1654.63 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.22(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	11.790	0.111	0.009434
11.790	0.110	12.170	0.121	0.027906
*	Below	Base		
12.170	0.122	14.000	0.174	0.028196
14.000	0.134	109.530	2.619	0.026009
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	109.530	0.141	0.000000
*	Sur-	charge		
17.038	0.000	18.255	0.075	0.061793
18.255	0.075	19.472	0.145	0.057404
19.472	0.145	20.689	0.206	0.049670
20.689	0.206	21.906	0.254	0.040182
21.906	0.254	23.123	0.291	0.030449
23.123	0.291	24.340	0.318	0.021518
24.340	0.318	26.774	0.335	0.006956
26.774	0.335	29.208	0.344	0.003880

29.208	0.344	31.642	0.348	0.001479
31.642	0.348	34.076	0.347	-0.000348
34.076	0.347	36.510	0.343	-0.001708
36.510	0.343	38.944	0.336	-0.002702
38.944	0.336	41.378	0.328	-0.003413
41.378	0.328	43.812	0.318	-0.003907
*	Sur-	charge		
0.000	0.162	0.609	0.162	0.000000
0.609	0.162	1.217	0.162	0.000000
1.217	0.162	1.826	0.162	0.000000
1.826	0.162	2.434	0.162	0.000000
2.434	0.162	3.043	0.162	0.000000
3.043	0.162	3.651	0.162	0.000000
3.651	0.162	4.260	0.162	0.000000
4.260	0.162	4.868	0.162	0.000000
4.868	0.162	5.477	0.162	0.000000
5.477	0.162	6.085	0.162	0.000000
6.085	0.162	6.694	0.162	0.000000
6.694	0.162	7.302	0.162	0.000000
7.302	0.162	7.911	0.162	0.000000
7.911	0.162	8.519	0.162	0.000000
8.519	0.162	9.128	0.162	0.000000
9.128	0.162	9.736	0.162	0.000000
9.736	0.162	10.344	0.162	0.000000
10.344	0.162	10.953	0.162	0.000000
10.953	0.162	11.561	0.162	0.000000
11.561	0.162	12.170	0.162	0.000000
12.170	0.162	13.387	0.162	0.000000
13.387	0.162	14.604	0.162	0.000000
14.604	0.162	15.821	0.162	0.000000
15.821	0.162	17.038	0.162	0.000000
17.038	0.162	18.255	0.162	0.000000
18.255	0.162	19.472	0.162	0.000000
19.472	0.162	20.689	0.162	0.000000
20.689	0.162	21.906	0.162	0.000000
21.906	0.162	23.123	0.162	0.000000
23.123	0.162	24.340	0.162	0.000000
24.340	0.162	26.774	0.162	0.000000
26.774	0.162	29.208	0.162	0.000000
29.208	0.162	31.642	0.162	0.000000
31.642	0.162	34.076	0.162	0.000000
34.076	0.162	36.510	0.162	0.000000
36.510	0.162	38.944	0.162	0.000000
38.944	0.162	41.378	0.162	0.000000
41.378	0.162	43.812	0.162	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.5

Z1	P1	Z2	P2	Slope
*	Below	Base		
12.170	0.000	14.000	0.289	0.157800
14.000	0.340	109.530	21.493	0.221427

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	12.17	1.00

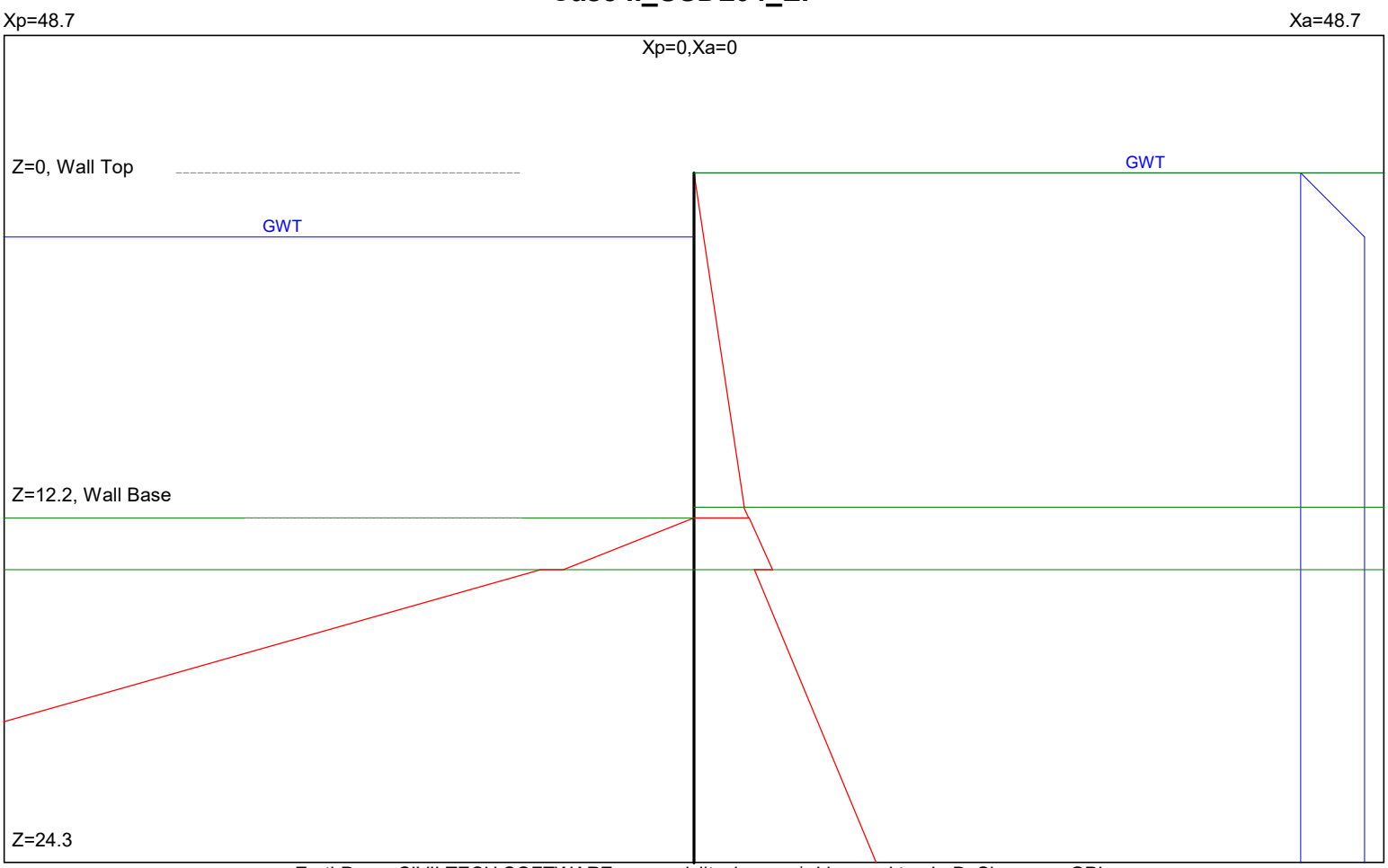
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case II_USDL04

Case II_USDL04_EP



* INPUT DATA *

Wall Height=12.2 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	11.8	0.0	11.8	800.0	2	Native Alluv
3	14.0	0.0	14.0	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	12.2	0.0	12.2	800.0	4	Sand Backfil
2	14.0	0.0	14.0	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.70 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.70

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	11.79	0.11	0.0094	0.5360
11.79	0.11	12.17	0.12	0.0279	0.5305

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
12.17	0.12	14.00	0.17	0.0282	0.5360
14.00	0.13	24.34	0.40	0.0261	0.4167

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
12.17	0.00	14.00	0.29	0.158	3.0000
14.00	0.34	24.34	2.63	0.222	3.5396

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	24.34	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

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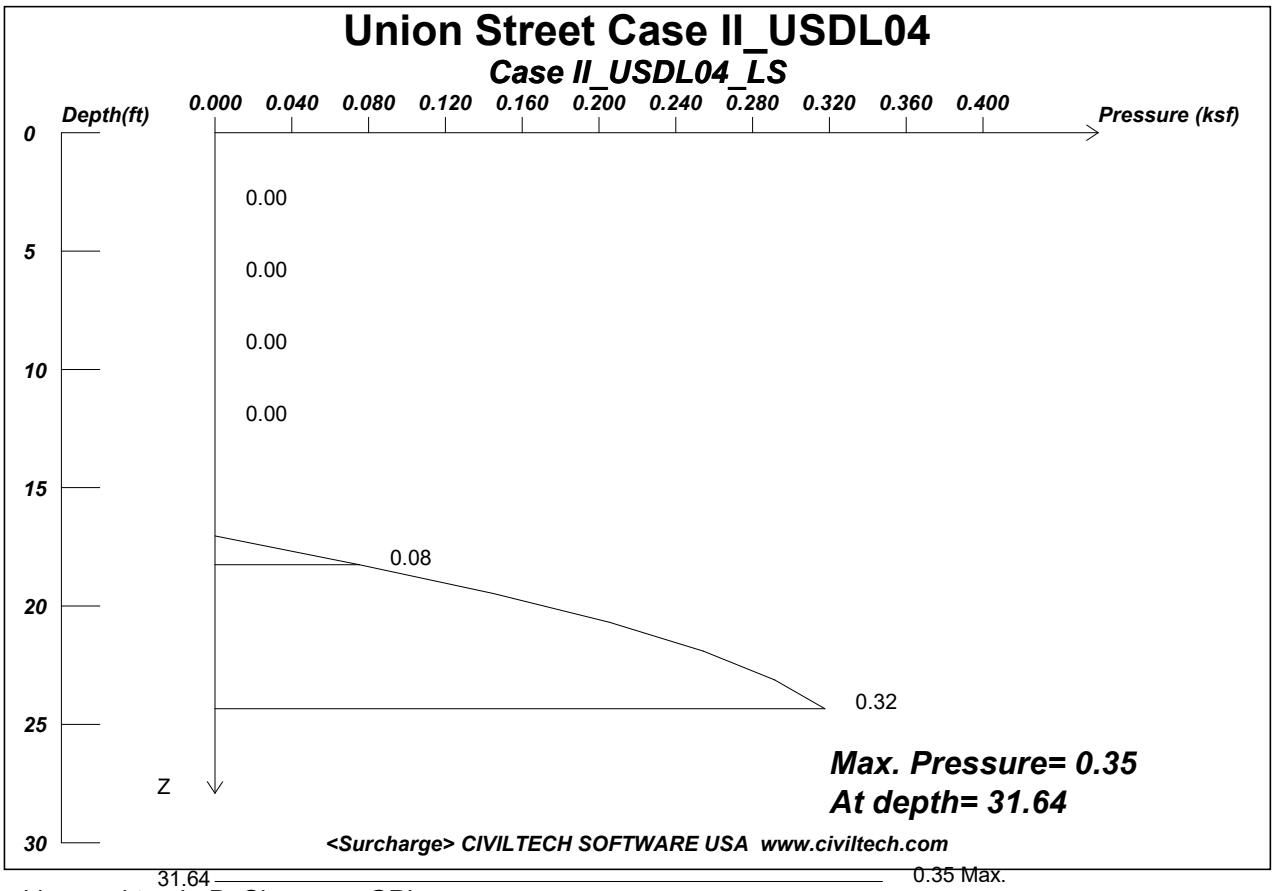

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Wall Height, H= 12.17 Load Depth, D= 17.53

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

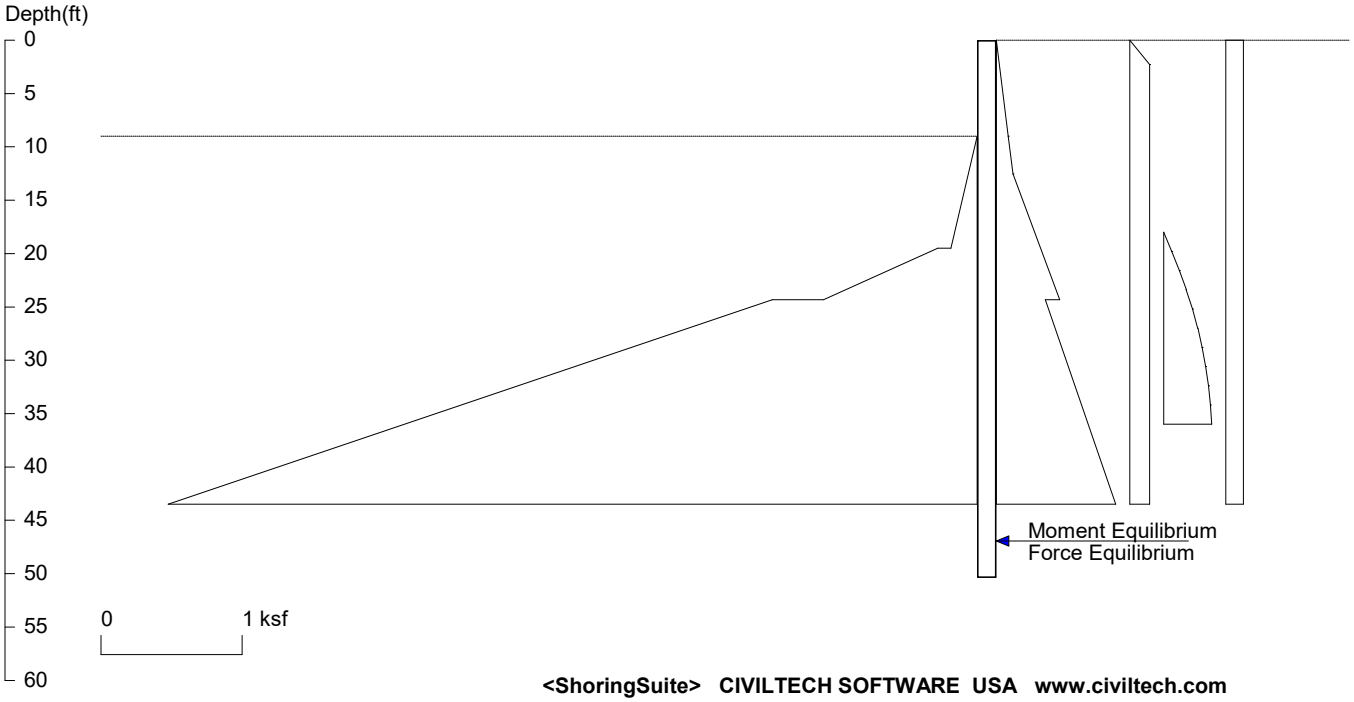
Max. Pressure = 0.348 at depth = 31.64

X	Width	Length	Area Load
5.0	18.0	12.3	1.85

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case III_USDL01
Case III_USDL01_EP



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Wall Height=9.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=41.39 Min. Pile Length=50.39
MOMENT IN PILE: Max. Moment=130.22 per Pile Spacing=1.0 at Depth=32.61

PILE SELECTION:
Request Min. Section Modulus = 52.1 in3/ft=2800.23 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.27(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	9.000	0.085	0.009434
*	Below	Base		
9.000	0.085	12.530	0.118	0.009434
12.530	0.118	24.330	0.451	0.028196
24.330	0.348	81.000	1.824	0.026040
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	81.000	0.141	0.000000
*	Sur-	charge		
18.000	0.000	19.800	0.056	0.031070
19.800	0.056	21.600	0.110	0.029834
21.600	0.110	23.400	0.159	0.027532
23.400	0.159	25.200	0.203	0.024454
25.200	0.203	27.000	0.241	0.020939
27.000	0.241	28.800	0.272	0.017300
28.800	0.272	30.600	0.297	0.013784
30.600	0.297	32.400	0.316	0.010554

32.400	0.316	34.200	0.330	0.007695
34.200	0.330	36.000	0.339	0.005237
*	Sur-	charge		
0.000	0.125	0.725	0.125	0.000000
0.725	0.125	1.450	0.125	0.000000
1.450	0.125	2.175	0.125	0.000000
2.175	0.125	2.900	0.125	0.000000
2.900	0.125	3.625	0.125	0.000000
3.625	0.125	4.350	0.125	0.000000
4.350	0.125	5.075	0.125	0.000000
5.075	0.125	5.800	0.125	0.000000
5.800	0.125	6.525	0.125	0.000000
6.525	0.125	7.250	0.125	0.000000
7.250	0.125	7.975	0.125	0.000000
7.975	0.125	8.700	0.125	0.000000
8.700	0.125	9.425	0.125	0.000000
9.425	0.125	10.150	0.125	0.000000
10.150	0.125	10.875	0.125	0.000000
10.875	0.125	11.600	0.125	0.000000
11.600	0.125	12.325	0.125	0.000000
12.325	0.125	13.050	0.125	0.000000
13.050	0.125	13.775	0.125	0.000000
13.775	0.125	14.500	0.125	0.000000
14.500	0.125	15.950	0.125	0.000000
15.950	0.125	17.400	0.125	0.000000
17.400	0.125	18.850	0.125	0.000000
18.850	0.125	20.300	0.125	0.000000
20.300	0.125	21.750	0.125	0.000000
21.750	0.125	23.200	0.125	0.000000
23.200	0.125	24.650	0.125	0.000000
24.650	0.125	26.100	0.125	0.000000
26.100	0.125	27.550	0.125	0.000000
27.550	0.125	29.000	0.125	0.000000
29.000	0.125	31.900	0.125	0.000000
31.900	0.125	34.800	0.125	0.000000
34.800	0.125	37.700	0.125	0.000000
37.700	0.125	40.600	0.125	0.000000
40.600	0.125	43.500	0.125	0.000000
43.500	0.125	46.400	0.125	0.000000
46.400	0.125	49.300	0.125	0.000000
49.300	0.125	52.200	0.125	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
9.000	0.000	19.500	0.185	0.017600
19.500	0.279	24.330	1.089	0.167676
24.330	1.452	81.000	14.130	0.223716

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	9.00	1.00

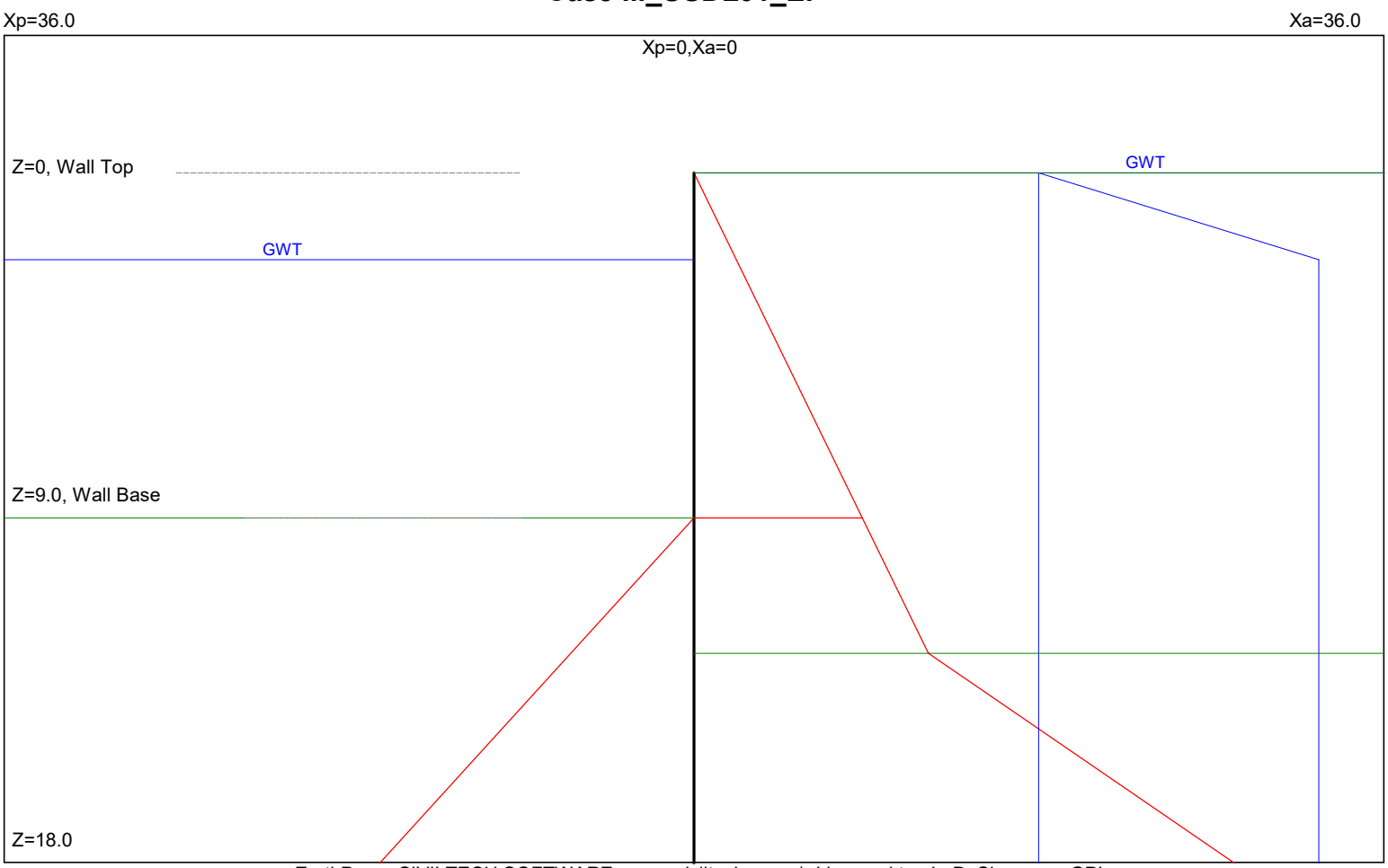
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case III_USDL01

Case III_USDL01_EP



* INPUT DATA *

Wall Height=9.0 Total Soil Types= 4

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	80.0	80.0	0.00	0.0	0	4	ISS

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.5	0.0	12.5	800.0	2	Native Alluv
3	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	9.0	0.0	9.0	800.0	4	ISS
2	19.5	0.0	19.5	800.0	2	Native Alluv

3	24.3	0.0	24.3	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.38 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.38

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	9.00	0.08	0.0094	0.5360

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
9.00	0.08	12.53	0.12	0.0094	0.5360
12.53	0.12	18.00	0.27	0.0282	0.5360

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pp1	Z2	Pp2	Slope	Kp
9.00	0.00	18.00	0.16	0.018	1.0000

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	18.00	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

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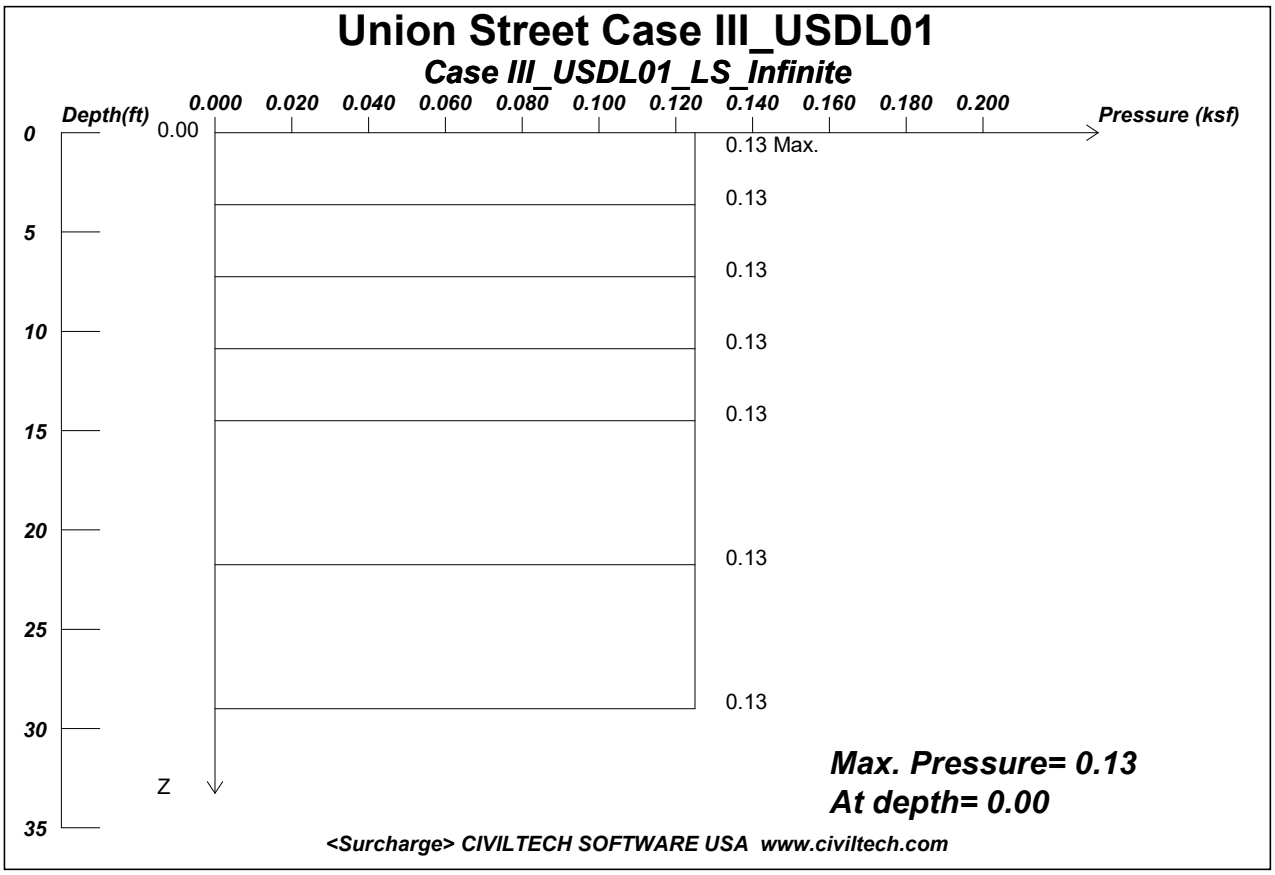

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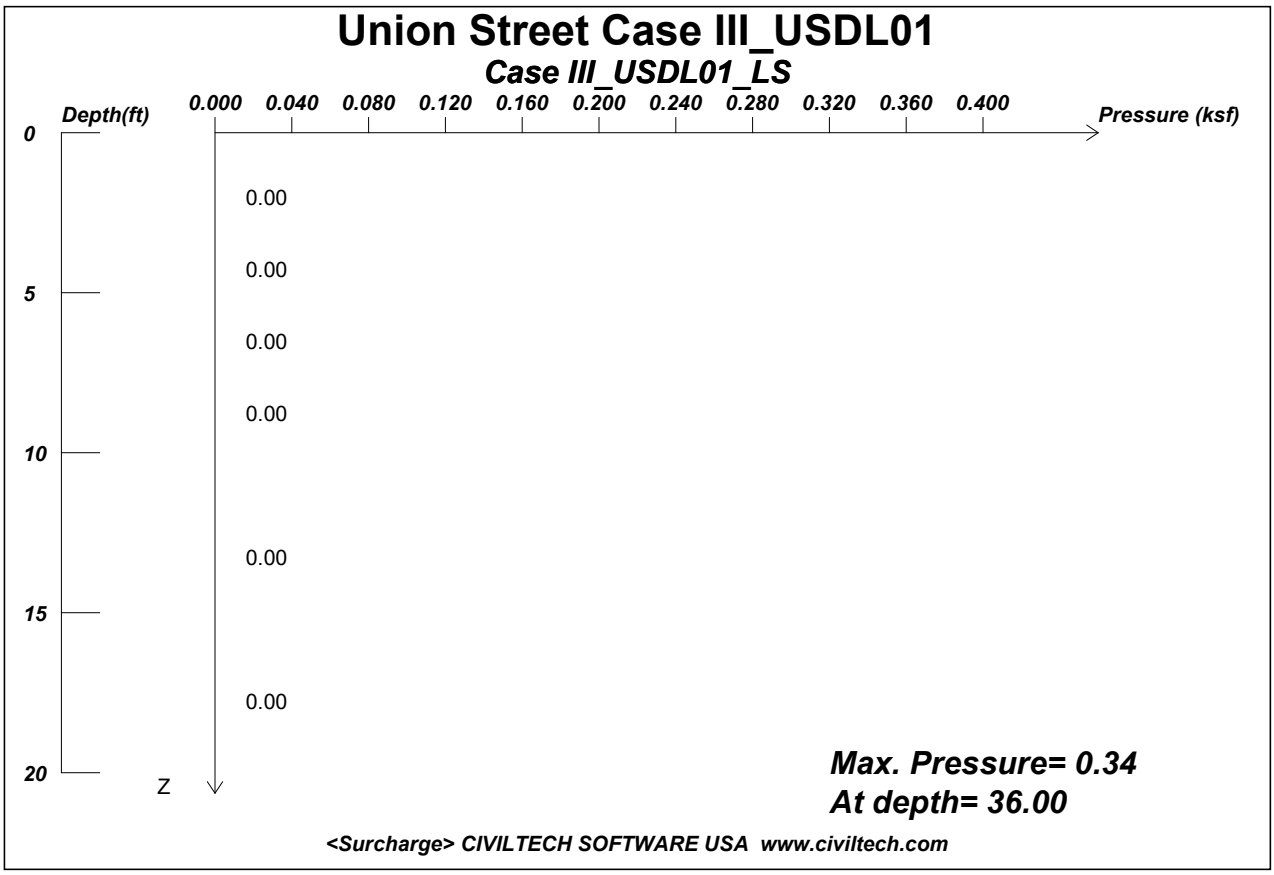
Wall Height, H= 14.50 Load Depth, D= 0
Load Factor of Surcharge Loading = 1
Rigid Wall Condition -- No movement or deflection of the wall are allowed.
Max. Pressure = 0.125 at depth = 0.00

Infinite Surcharge, Q=0.250 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf



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Wall Height, H= 9 Load Depth, D= 18.11

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

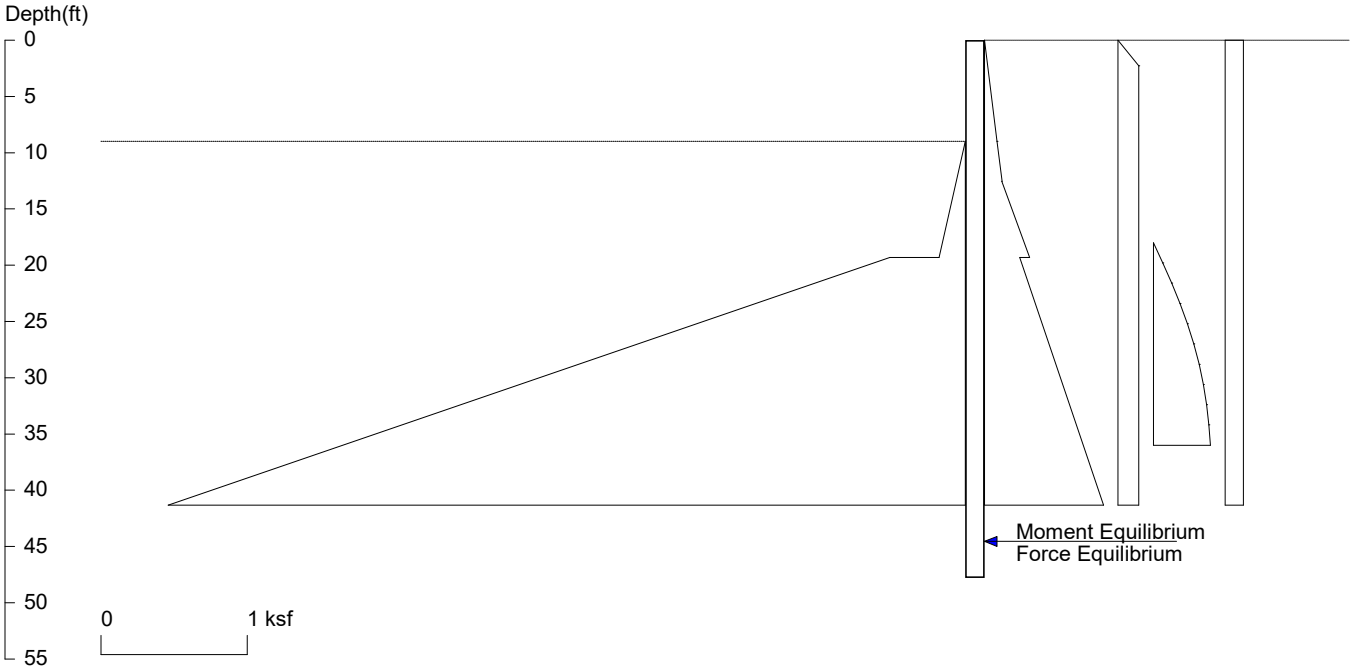
Max. Pressure = 0.339 at depth = 36.00

X	Width	Length	Area Load
36.00			0.34 Max.
5.0	18.0	12.3	1.85

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case III_USDL02
Case III_USDL02_EP



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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case

Wall Height=9.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=38.78 Min. Pile Length=47.78
MOMENT IN PILE: Max. Moment=108.58 per Pile Spacing=1.0 at Depth=30.71

PILE SELECTION:
Request Min. Section Modulus = 43.4 in3/ft=2334.95 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.23(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	9.000	0.085	0.009434
*	Below	Base		
9.000	0.085	12.550	0.118	0.009434
12.550	0.118	19.300	0.309	0.028196
19.300	0.239	81.000	1.844	0.026022
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	81.000	0.141	0.000000
*	Sur-	charge		
18.000	0.000	19.800	0.064	0.035776
19.800	0.064	21.600	0.126	0.034352
21.600	0.126	23.400	0.183	0.031702
23.400	0.183	25.200	0.234	0.028158
25.200	0.234	27.000	0.277	0.024111
27.000	0.277	28.800	0.313	0.019921
28.800	0.313	30.600	0.342	0.015872
30.600	0.342	32.400	0.364	0.012152

32.400	0.364	34.200	0.380	0.008861
34.200	0.380	36.000	0.390	0.006030
*	Sur-	charge		
0.000	0.125	0.700	0.125	0.000000
0.700	0.125	1.400	0.125	0.000000
1.400	0.125	2.100	0.125	0.000000
2.100	0.125	2.800	0.125	0.000000
2.800	0.125	3.500	0.125	0.000000
3.500	0.125	4.200	0.125	0.000000
4.200	0.125	4.900	0.125	0.000000
4.900	0.125	5.600	0.125	0.000000
5.600	0.125	6.300	0.125	0.000000
6.300	0.125	7.000	0.125	0.000000
7.000	0.125	7.700	0.125	0.000000
7.700	0.125	8.400	0.125	0.000000
8.400	0.125	9.100	0.125	0.000000
9.100	0.125	9.800	0.125	0.000000
9.800	0.125	10.500	0.125	0.000000
10.500	0.125	11.200	0.125	0.000000
11.200	0.125	11.900	0.125	0.000000
11.900	0.125	12.600	0.125	0.000000
12.600	0.125	13.300	0.125	0.000000
13.300	0.125	14.000	0.125	0.000000
14.000	0.125	15.400	0.125	0.000000
15.400	0.125	16.800	0.125	0.000000
16.800	0.125	18.200	0.125	0.000000
18.200	0.125	19.600	0.125	0.000000
19.600	0.125	21.000	0.125	0.000000
21.000	0.125	22.400	0.125	0.000000
22.400	0.125	23.800	0.125	0.000000
23.800	0.125	25.200	0.125	0.000000
25.200	0.125	26.600	0.125	0.000000
26.600	0.125	28.000	0.125	0.000000
28.000	0.125	30.800	0.125	0.000000
30.800	0.125	33.600	0.125	0.000000
33.600	0.125	36.400	0.125	0.000000
36.400	0.125	39.200	0.125	0.000000
39.200	0.125	42.000	0.125	0.000000
42.000	0.125	44.800	0.125	0.000000
44.800	0.125	47.600	0.125	0.000000
47.600	0.125	50.400	0.125	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
9.000	0.000	19.300	0.181	0.017600
19.300	0.518	81.000	14.342	0.224049

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	9.00	1.00

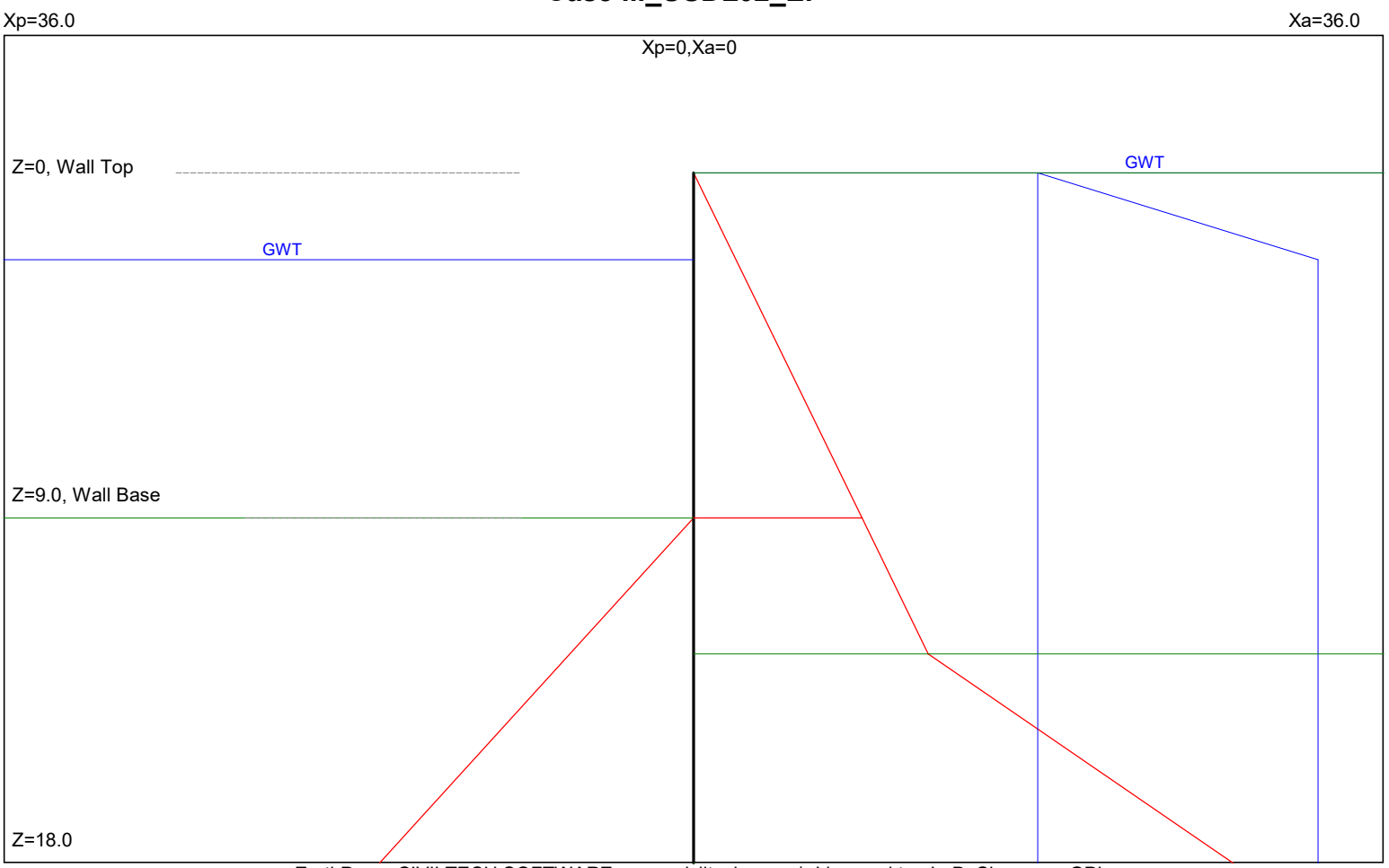
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case III_USDL02

Case III_USDL02_EP



* INPUT DATA *

Wall Height=9.0 Total Soil Types= 5

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil
5	80.0	80.0	0.00	0.0	0	4	ISS

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.6	0.0	12.6	800.0	2	Native Alluv
3	19.3	0.0	19.3	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	9.0	0.0	9.0	800.0	5	ISS

2	19.3	0.0	19.3	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.38 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.38

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	9.00	0.08	0.0094	0.5360

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
9.00	0.08	12.55	0.12	0.0094	0.5360
12.55	0.12	18.00	0.27	0.0282	0.5360

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

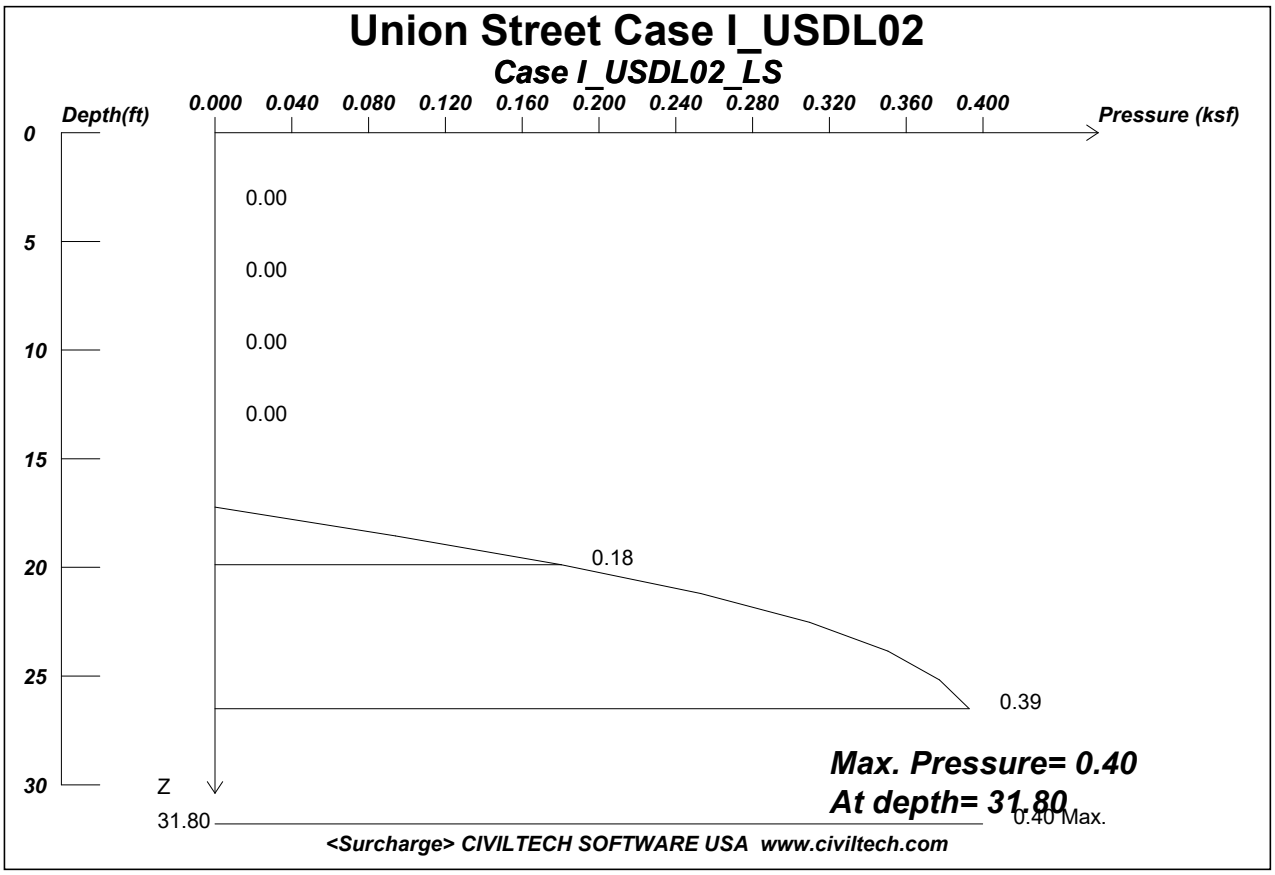
Z1	Pp1	Z2	Pp2	Slope	Kp
9.00	0.00	18.00	0.16	0.018	1.0000

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	18.00	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/18/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case II



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Date: 6/18/2019 File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Stree

Wall Height, H= 13.25 Load Depth, D= 18.12

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

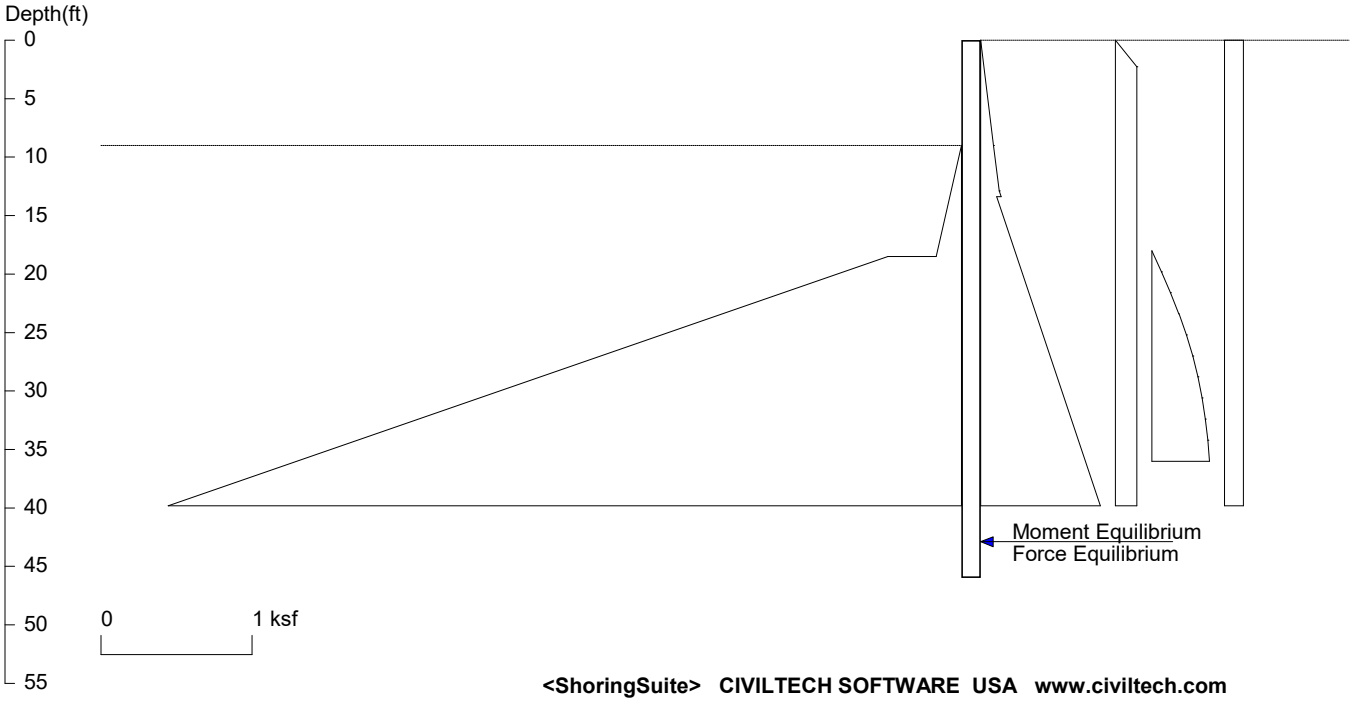
Max. Pressure = 0.400 at depth = 31.80

X	Width	Length	Area Load
5.0	18.0	22.3	1.50

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case III_USDL03
Case III_USDL03_EP



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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case

Wall Height=9.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=36.97 Min. Pile Length=45.97
MOMENT IN PILE: Max. Moment=96.29 per Pile Spacing=1.0 at Depth=29.41

PILE SELECTION:
Request Min. Section Modulus = 32.1 in3/ft=1725.56 cm3/m, Fy= 60 ksi = 414 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.21(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	9.000	0.085	0.009434
*	Below	Base		
9.000	0.085	12.890	0.122	0.009434
12.890	0.122	13.390	0.136	0.028196
13.390	0.105	81.000	1.864	0.026012
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	81.000	0.141	0.000000
*	Sur-	charge		
18.000	0.000	19.800	0.063	0.034859
19.800	0.063	21.600	0.123	0.033472
21.600	0.123	23.400	0.179	0.030889
23.400	0.179	25.200	0.228	0.027437
25.200	0.228	27.000	0.270	0.023493
27.000	0.270	28.800	0.305	0.019410
28.800	0.305	30.600	0.333	0.015465
30.600	0.333	32.400	0.354	0.011841

32.400	0.354	34.200	0.370	0.008634
34.200	0.370	36.000	0.380	0.005876
*	Sur-	charge		
0.000	0.125	0.675	0.125	0.000000
0.675	0.125	1.350	0.125	0.000000
1.350	0.125	2.025	0.125	0.000000
2.025	0.125	2.700	0.125	0.000000
2.700	0.125	3.375	0.125	0.000000
3.375	0.125	4.050	0.125	0.000000
4.050	0.125	4.725	0.125	0.000000
4.725	0.125	5.400	0.125	0.000000
5.400	0.125	6.075	0.125	0.000000
6.075	0.125	6.750	0.125	0.000000
6.750	0.125	7.425	0.125	0.000000
7.425	0.125	8.100	0.125	0.000000
8.100	0.125	8.775	0.125	0.000000
8.775	0.125	9.450	0.125	0.000000
9.450	0.125	10.125	0.125	0.000000
10.125	0.125	10.800	0.125	0.000000
10.800	0.125	11.475	0.125	0.000000
11.475	0.125	12.150	0.125	0.000000
12.150	0.125	12.825	0.125	0.000000
12.825	0.125	13.500	0.125	0.000000
13.500	0.125	14.850	0.125	0.000000
14.850	0.125	16.200	0.125	0.000000
16.200	0.125	17.550	0.125	0.000000
17.550	0.125	18.900	0.125	0.000000
18.900	0.125	20.250	0.125	0.000000
20.250	0.125	21.600	0.125	0.000000
21.600	0.125	22.950	0.125	0.000000
22.950	0.125	24.300	0.125	0.000000
24.300	0.125	25.650	0.125	0.000000
25.650	0.125	27.000	0.125	0.000000
27.000	0.125	29.700	0.125	0.000000
29.700	0.125	32.400	0.125	0.000000
32.400	0.125	35.100	0.125	0.000000
35.100	0.125	37.800	0.125	0.000000
37.800	0.125	40.500	0.125	0.000000
40.500	0.125	43.200	0.125	0.000000
43.200	0.125	45.900	0.125	0.000000
45.900	0.125	48.600	0.125	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
9.000	0.000	18.500	0.167	0.017600
18.500	0.488	81.000	14.463	0.223595

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	9.00	1.00

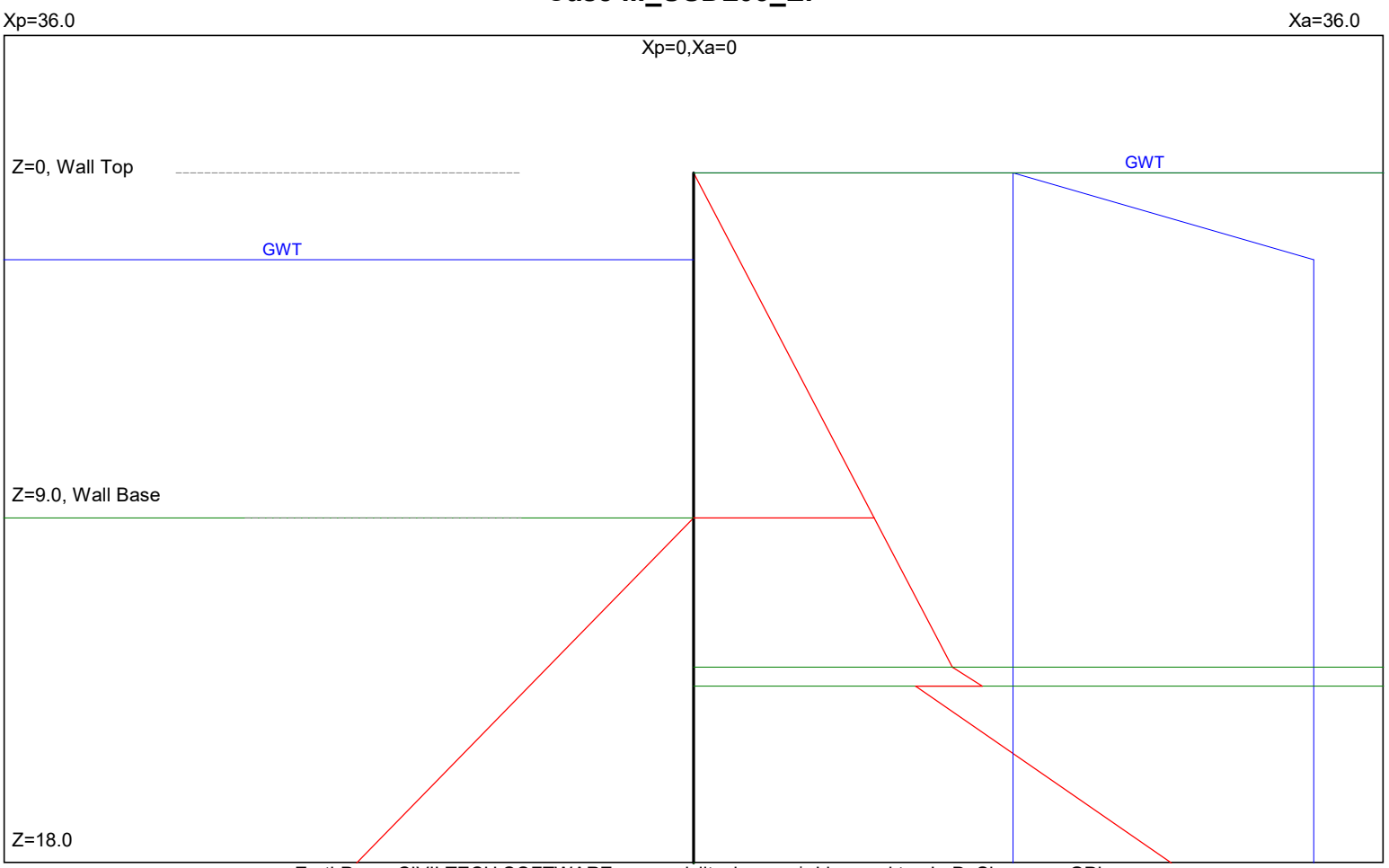
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case III_USDL03

Case III_USDL03_EP



* INPUT DATA *

Wall Height=9.0 Total Soil Types= 5

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil
5	80.0	80.0	0.00	0.0	0	4	ISS

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	12.9	0.0	12.9	800.0	2	Native Alluv
3	13.4	0.0	13.4	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	9.0	0.0	9.0	800.0	5	ISS

2	18.5	0.0	18.5	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.38 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.38

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	9.00	0.08	0.0094	0.5360

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
9.00	0.08	12.89	0.12	0.0094	0.5360
12.89	0.12	13.39	0.14	0.0282	0.5360
13.39	0.10	18.00	0.22	0.0261	0.4169

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

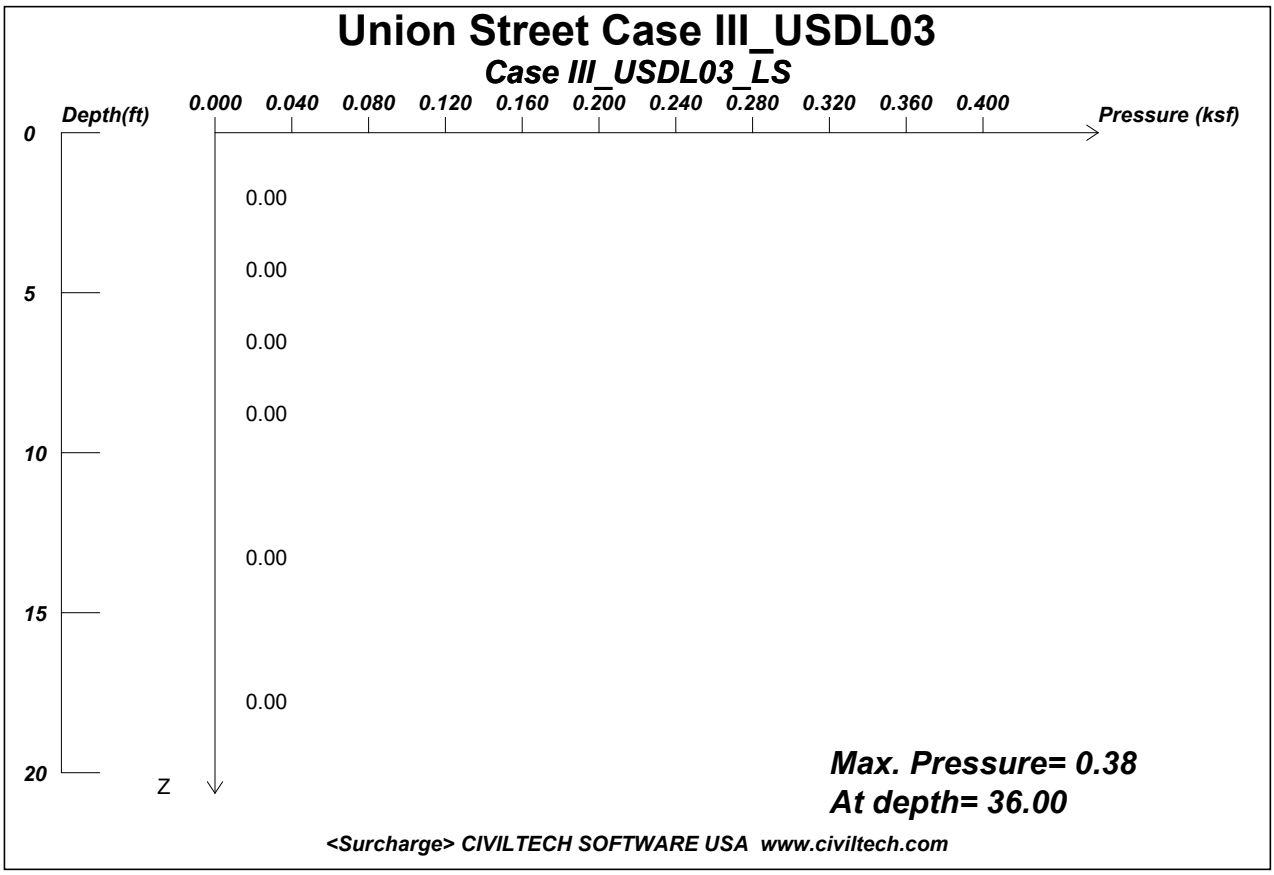
Z1	Pp1	Z2	Pp2	Slope	Kp
9.00	0.00	18.00	0.16	0.018	1.0000

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	18.00	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/18/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case II



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Wall Height, H= 9 Load Depth, D= 18.23

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

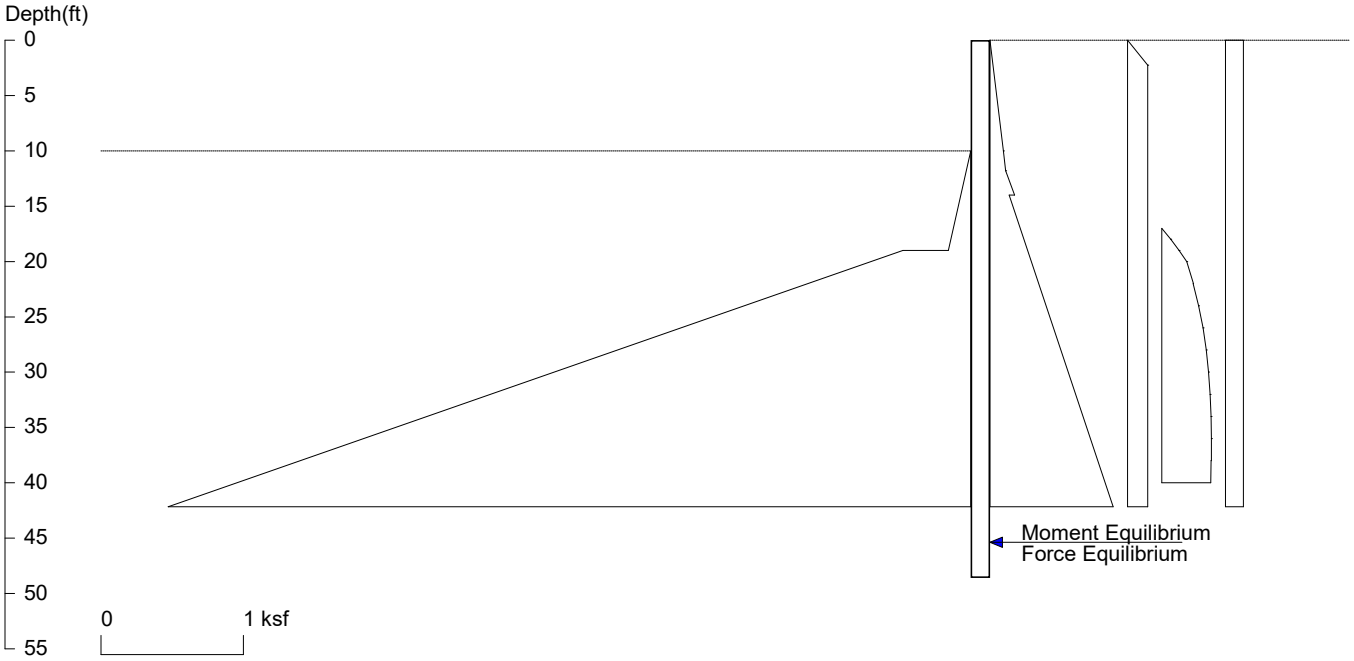
Max. Pressure = 0.380 at depth = 36.00

X	Width	Length	Area Load
36.00			0.38 Max.
5.0	18.0	16.2	1.75

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

Union Street Case III_USDL04
Case III_USDL04_EP



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File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case

Wall Height=10.0 Pile Diameter=1.0 Pile Spacing=1.0 Wall Type: 1. Sheet Pile

PILE LENGTH: Min. Embedment=38.58 Min. Pile Length=48.58
MOMENT IN PILE: Max. Moment=115.21 per Pile Spacing=1.0 at Depth=31.28

PILE SELECTION:
Request Min. Section Modulus = 46.1 in3/ft=2477.54 cm3/m, Fy= 50 ksi = 345 MPa, Fb/Fy=0.60
User Input I (Moment of Inertia):
Top Deflection = 0.26(in) based on E (ksi)=29000.00 and I (in4)/foot=2345.4

DRIVING PRESSURES (ACTIVE, WATER, & SURCHARGE):

Z1	P1	Z2	P2	Slope
*	Above	Base		
0.000	0.000	10.000	0.094	0.009434
*	Below	Base		
10.000	0.094	11.790	0.111	0.009434
11.790	0.111	14.000	0.174	0.028196
14.000	0.134	90.000	2.111	0.026011
*	Water	Pres.		
0.000	0.000	2.265	0.141	0.062400
2.265	0.141	90.000	0.141	0.000000
*	Sur-	charge		
17.000	0.000	18.000	0.062	0.062041
18.000	0.062	19.000	0.121	0.059015
19.000	0.121	20.000	0.175	0.053467
20.000	0.175	22.000	0.221	0.023118
22.000	0.221	24.000	0.259	0.019118
24.000	0.259	26.000	0.289	0.015127
26.000	0.289	28.000	0.312	0.011420
28.000	0.312	30.000	0.328	0.008148

30.000	0.328	32.000	0.339	0.005367
32.000	0.339	34.000	0.345	0.003069
34.000	0.345	36.000	0.348	0.001208
36.000	0.348	38.000	0.347	-0.000274
38.000	0.347	40.000	0.344	-0.001437
*	Sur-	charge		
0.000	0.125	0.700	0.125	0.000000
0.700	0.125	1.400	0.125	0.000000
1.400	0.125	2.100	0.125	0.000000
2.100	0.125	2.800	0.125	0.000000
2.800	0.125	3.500	0.125	0.000000
3.500	0.125	4.200	0.125	0.000000
4.200	0.125	4.900	0.125	0.000000
4.900	0.125	5.600	0.125	0.000000
5.600	0.125	6.300	0.125	0.000000
6.300	0.125	7.000	0.125	0.000000
7.000	0.125	7.700	0.125	0.000000
7.700	0.125	8.400	0.125	0.000000
8.400	0.125	9.100	0.125	0.000000
9.100	0.125	9.800	0.125	0.000000
9.800	0.125	10.500	0.125	0.000000
10.500	0.125	11.200	0.125	0.000000
11.200	0.125	11.900	0.125	0.000000
11.900	0.125	12.600	0.125	0.000000
12.600	0.125	13.300	0.125	0.000000
13.300	0.125	14.000	0.125	0.000000
14.000	0.125	15.400	0.125	0.000000
15.400	0.125	16.800	0.125	0.000000
16.800	0.125	18.200	0.125	0.000000
18.200	0.125	19.600	0.125	0.000000
19.600	0.125	21.000	0.125	0.000000
21.000	0.125	22.400	0.125	0.000000
22.400	0.125	23.800	0.125	0.000000
23.800	0.125	25.200	0.125	0.000000
25.200	0.125	26.600	0.125	0.000000
26.600	0.125	28.000	0.125	0.000000
28.000	0.125	30.800	0.125	0.000000
30.800	0.125	33.600	0.125	0.000000
33.600	0.125	36.400	0.125	0.000000
36.400	0.125	39.200	0.125	0.000000
39.200	0.125	42.000	0.125	0.000000
42.000	0.125	44.800	0.125	0.000000
44.800	0.125	47.600	0.125	0.000000
47.600	0.125	50.400	0.125	0.000000

PASSIVE PRESSURES: Pressures below will be divided by a Factor of Safety =1.25

Z1	P1	Z2	P2	Slope
*	Below	Base		
10.000	0.000	19.000	0.158	0.017600
19.000	0.478	90.000	16.307	0.222940

ACTIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00
2	10.00	1.00

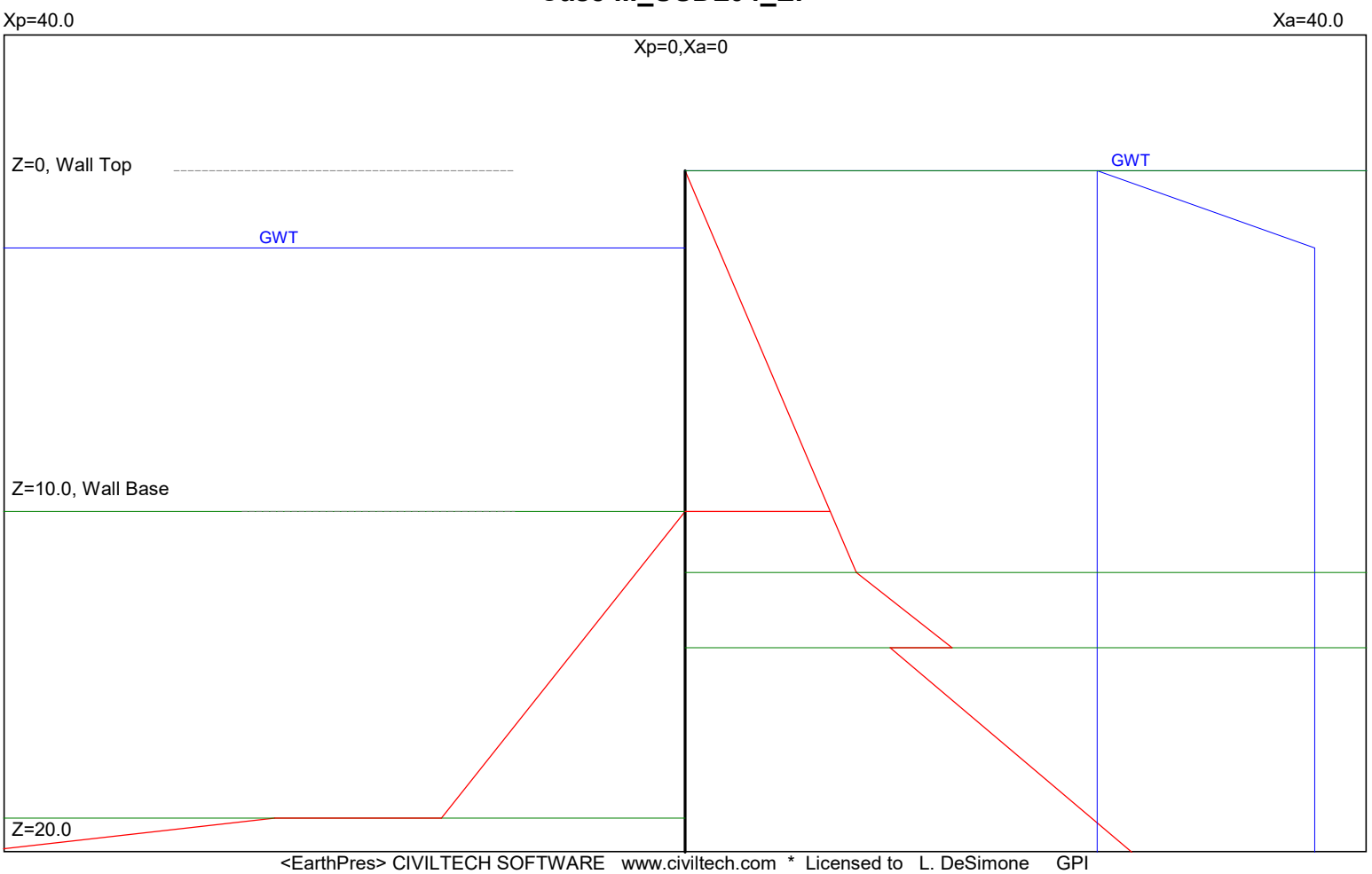
PASSIVE SPACING:

No.	Z depth	Spacing
1	0.00	1.00

UNITS: Width,Spacing,Diameter,Length,and Depth - ft; Force - kip; Moment - kip-ft
Friction,Bearing,and Pressure - ksf; Pres. Slope - kip/ft3; Deflection - in

Union Street Case III_USDL04

Case III_USDL04_EP



* INPUT DATA *

Wall Height=10.0 Total Soil Types= 5

Soil No.	Weight	Saturate	Phi	Cohesion	Nspt	Type	Description
1	80.0	80.0	28.00	0.0	0	3	Soft Sedimen
2	115.0	115.0	28	0.0	0	4	Native Alluv
3	125.0	125.0	34	0.0	0	4	Glacial Depo
4	115.0	115.0	30	0.0	0	4	Sand Backfil
5	80.0	80.0	0.00	0.0	0	4	ISS

Ground Surface at Active Side:

Line	Z1	Xa1	Z2	Xa2	Soil No.	Description
1	0.0	0.0	0.0	800.0	1	Soft Sedimen
2	11.8	0.0	11.8	800.0	2	Native Alluv
3	14.0	0.0	14.0	800.0	3	Glacial Depo

Water Table at Active Side:

Point	Z-water	X-water
1	0.0	0.0
2	0.0	800.0

Ground Surface at Passive Side:

Line	Z1	Xp1	Z2	Xp2	Soil No.	Description
1	10.0	0.0	10.0	800.0	5	ISS

2	19.0	0.0	19.0	800.0	3	Glacial Depo

Water Table at Passive Side:

Point	Z-water	X-water
1	2.3	0.0
2	2.3	800.0

Wall Friction Options: 1.* No wall friction
Wall Batter Angle = 0
Apparent Pressure Conversion: 1.* Default (Terzaghi and Peck)*
Water Density = 62.4
Water Pressure: 1.* No seepage at wall tip

* OUTPUT RESULTS *

Total Force above Base= 0.47 per one linear foot (or meter) width along wall height
Total Static Force above Base= 0.47

Driving Pressure above Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Coef.
0.00	0.00	10.00	0.09	0.0094	0.5360

Driving Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

Z1	Pa1	Z2	Pa2	Slope	Ka or Ko
10.00	0.09	11.79	0.11	0.0094	0.5360
11.79	0.11	14.00	0.17	0.0282	0.5360
14.00	0.13	20.00	0.29	0.0262	0.4180

Passive Pressure below Base - Output to Shoring - Multiplier of Pressure = 1

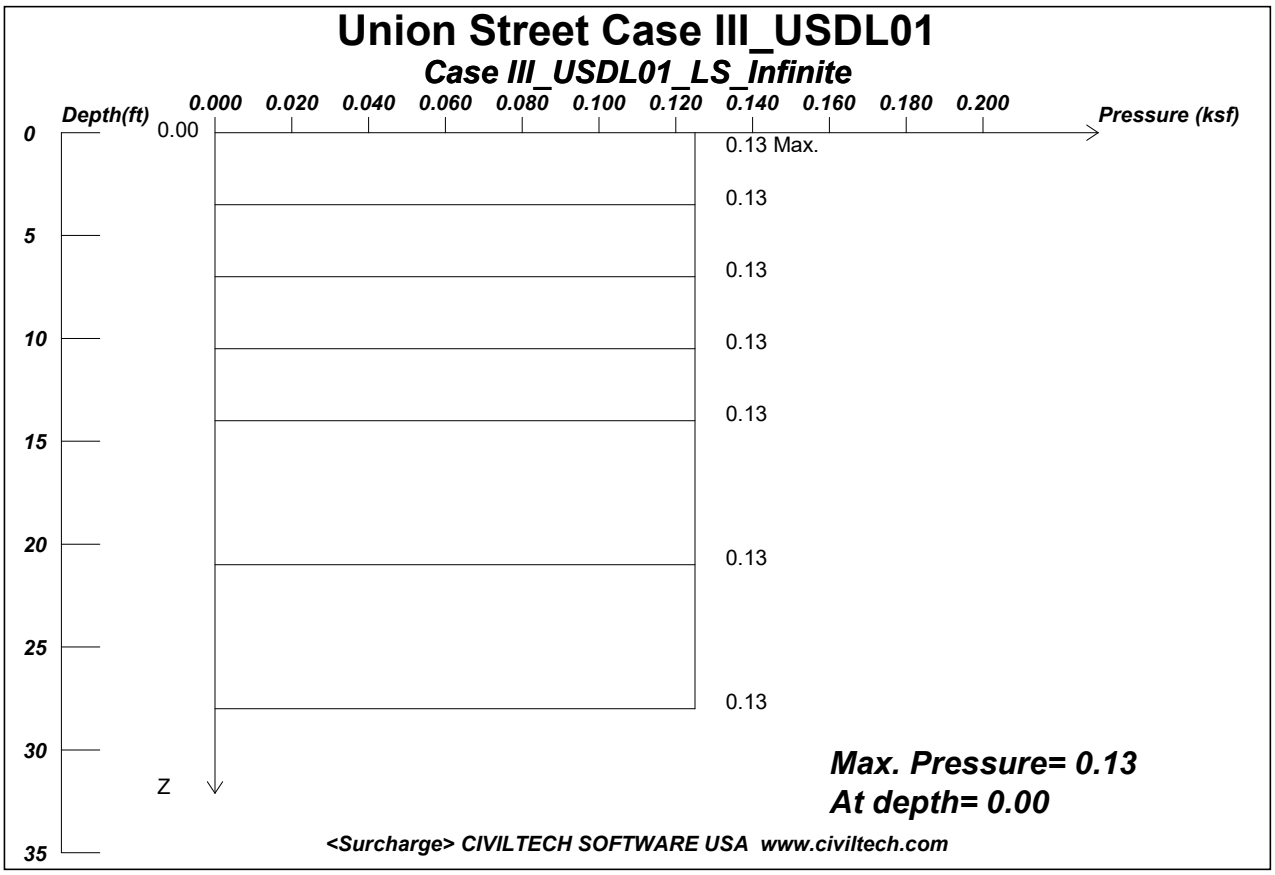
Z1	Pp1	Z2	Pp2	Slope	Kp
10.00	0.00	19.00	0.16	0.018	1.0000
19.00	0.27	20.00	0.46	0.195	3.1184

Water Pressure - Output to Shoring - Multiplier of Pressure = 1

No	Z1	Pw1	Z2	Pw2	kw1
0	0.00	0.00	2.27	0.14	0.06
1	2.27	0.14	20.00	0.14	0.00

UNITS: DEPTH/DISTANCE: ft, UNIT WEIGHT: pcf, FORCE: kip/ft, PRESSURE: ksf, SLOPE: kcf

Date: 6/18/2019 File Name: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Street\Pipe Pile Wall\Case II



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Date: 6/18/2019 File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Stree

Wall Height, H= 14 Load Depth, D= 0

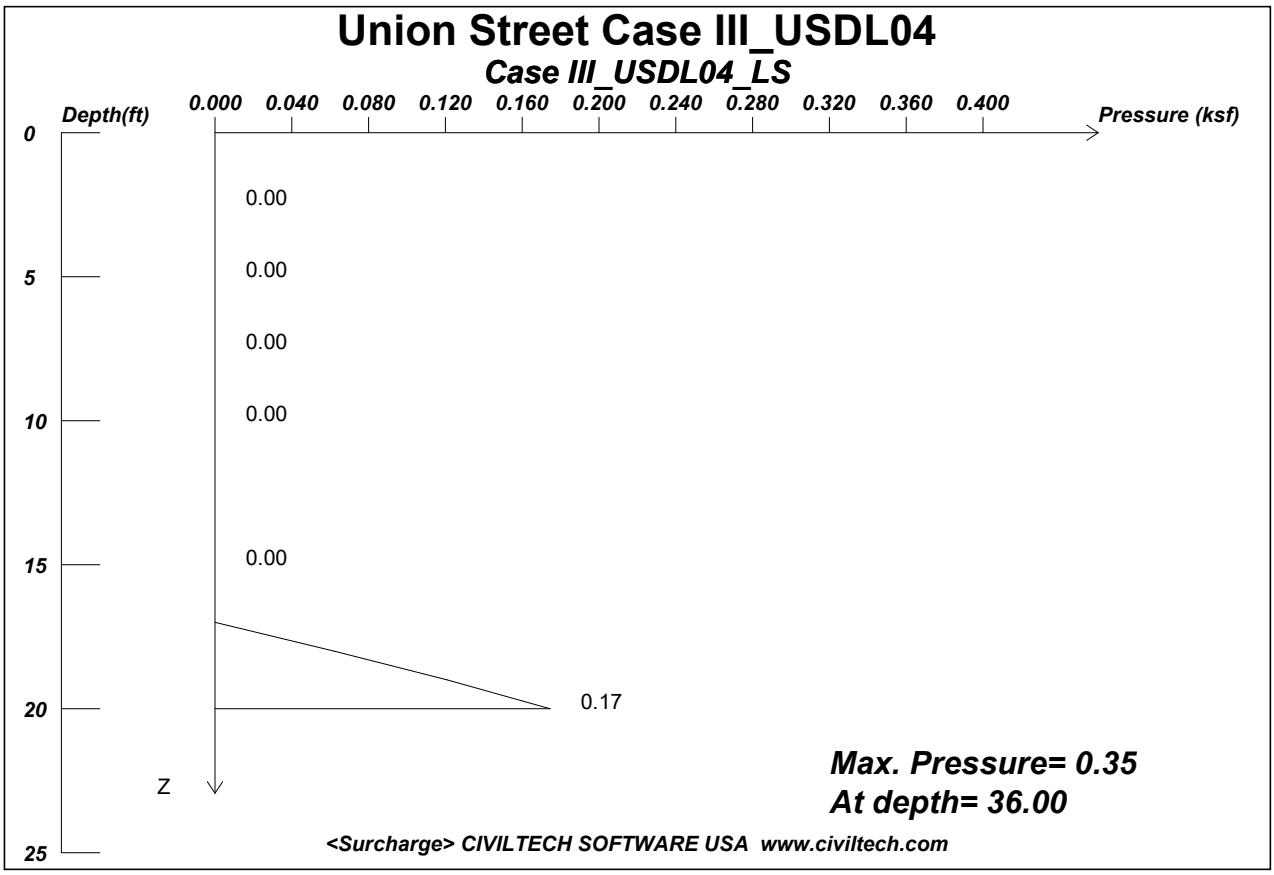
Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.125 at depth = 0.00

Infinite Surcharge, Q=0.250 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf



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Date: 6/18/2019 File: O:\2017\BAB-2017020.00 GOWANUS CANAL SUPERFUND SITE\Design\Structures\Union Stree

Wall Height, H= 10 Load Depth, D= 17.53

Load Factor of Surcharge Loading = 1

Rigid Wall Condition -- No movement or deflection of the wall are allowed.

Max. Pressure = 0.348 at depth = 36.00

36.00 ——— 0.35 Max.

X	Width	Length	Area Load
5.0	18.0	12.3	1.85

Infinite Surcharge, Q=0 Active Wedge Approach * (recommend)

UNITS: LENGTH/DEPTH: ft, Qpoint: kip, Qline: kip/ft, Qstrip/Qarea/PRESSURE: ksf

ATTACHMENT B – MIDAS CIVIL OUTPUT

Attachment B – Midas Civil Output

Midas Model created to determine the reactions from the Union Street Bridge superstructure. Reactions are combined with abutment loading to determine the surcharge on the proposed wall structure. Approach span 3 is modeled to account for the control house platform on the north fascia. Wind, temperature and other horizontal loadings are not included in this model.

Inputs:

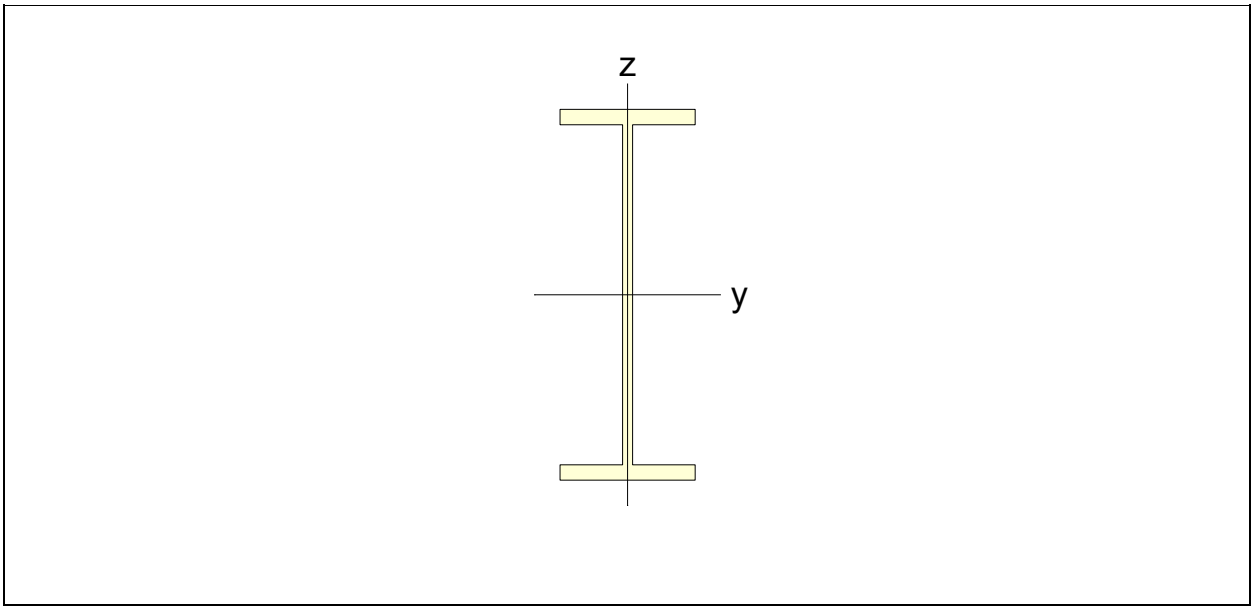
Materials:

Table 1 Matl

ID	Name	Type	Elasticity (kips/ft^2)	Poisson	Thermal (1/[F])	Density (kips/ft^3)	Mass Density (kips/ft^3/g)	Material Type
1	A572-50	Steel	4.1760e+006	0.3	6.5000e-006	4.9075e-001	1.5253e-002	Isotropic
2	Grade C3000	Concrete	4.5445e+005	0.2	6.0000e-006	1.5000e-001	4.6621e-003	Isotropic
3	Dummy	Concrete	4.5445e+005	0.2	6.0000e-006	0.0000e+000	4.6621e-003	Isotropic
4	Steel 1905	Steel	4.1760e+006	0.3	6.5000e-006	4.9075e-001	1.5253e-002	Isotropic
5	Steel 1936-1963	Steel	4.1760e+006	0.3	6.5000e-006	4.9075e-001	1.5253e-002	Isotropic

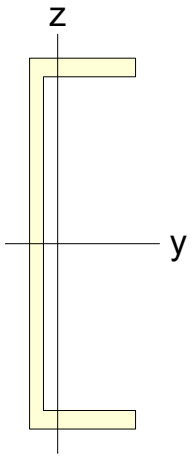
Sections:

Table 2 2 : 15I42.9



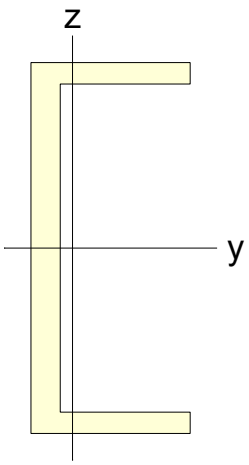
A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.087	0.040	0.043	0.625	0.625
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.021	0.001	0.229	0.229

Table 3 3 : 12SHC30.9



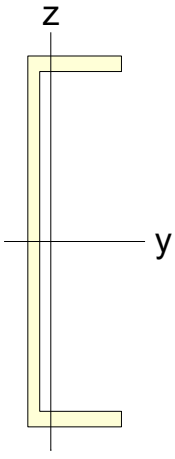
A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.062	0.024	0.037	0.500	0.500
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.009	0.000	0.211	0.076

Table 4 4 : 10SHC41.1



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.083	0.029	0.055	0.417	0.417
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.008	0.001	0.266	0.094

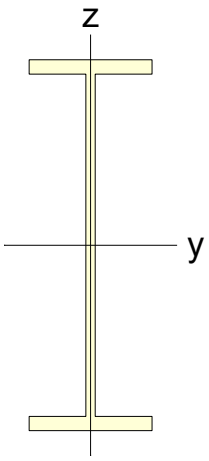
Table 5 5 : 12C25



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)

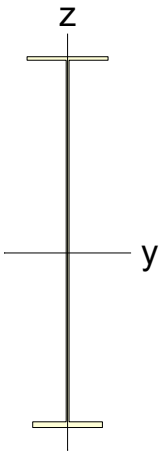
0.051	0.018	0.032	0.500	0.500
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.007	0.000	0.191	0.062

Table 6 6 : 18I54.7



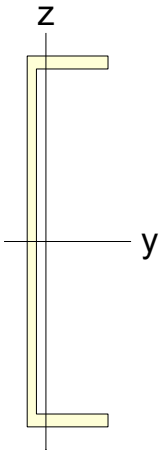
A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.111	0.048	0.058	0.750	0.750
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.038	0.001	0.250	0.250

Table 7 7 : FB-6



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.370	0.124	0.227	2.883	2.565
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	1.584	0.015	0.599	0.599

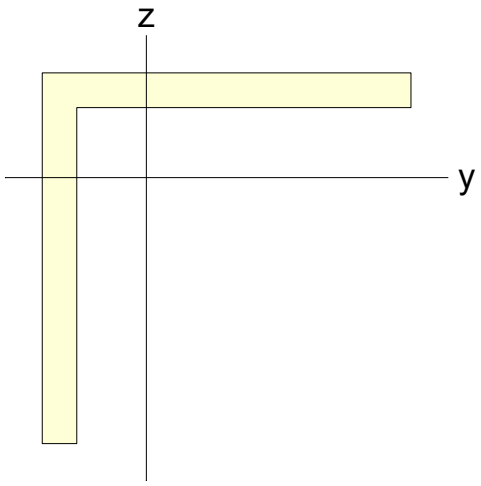
Table 8 9 : 18C42.7



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)

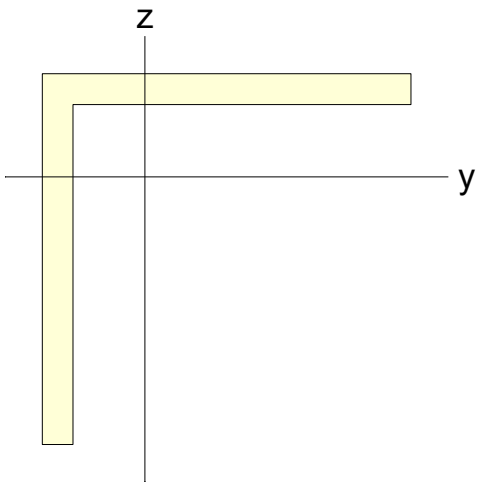
0.087	0.029	0.056	0.750	0.750
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.026	0.001	0.253	0.076

Table 9 10 : L4X4X3/8



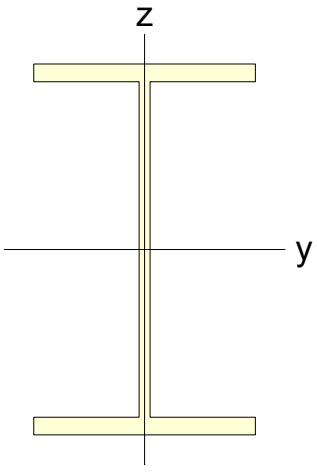
A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.020	0.009	0.009	0.094	0.239
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.000	0.000	0.239	0.094

Table 10 11 : L6X6X1/2



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.040	0.017	0.017	0.139	0.361
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.001	0.001	0.361	0.139

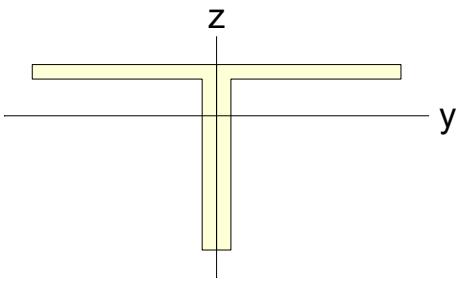
Table 11 12 : Bumping Girder



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)

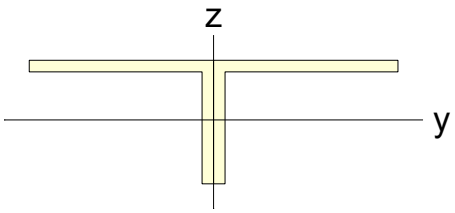
0.258	0.146	0.091	0.875	0.875
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.139	0.016	0.526	0.526

Table 12 13 : 2L8X8X5/8



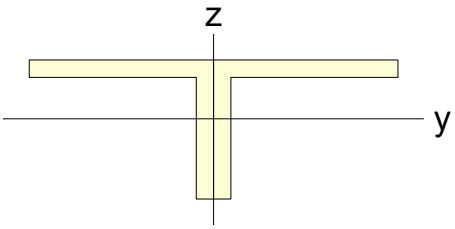
A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.135	0.058	0.058	0.184	0.482
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.006	0.010	0.667	0.667

Table 13 14 : 2L6X4X3/8X3/8LLBB



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.050	0.026	0.017	0.161	0.172
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.001	0.003	0.500	0.500

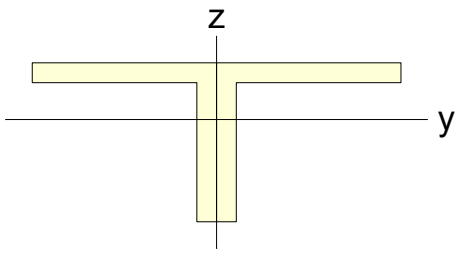
Table 14 15 : 2L4X3X3/8LLBB



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)

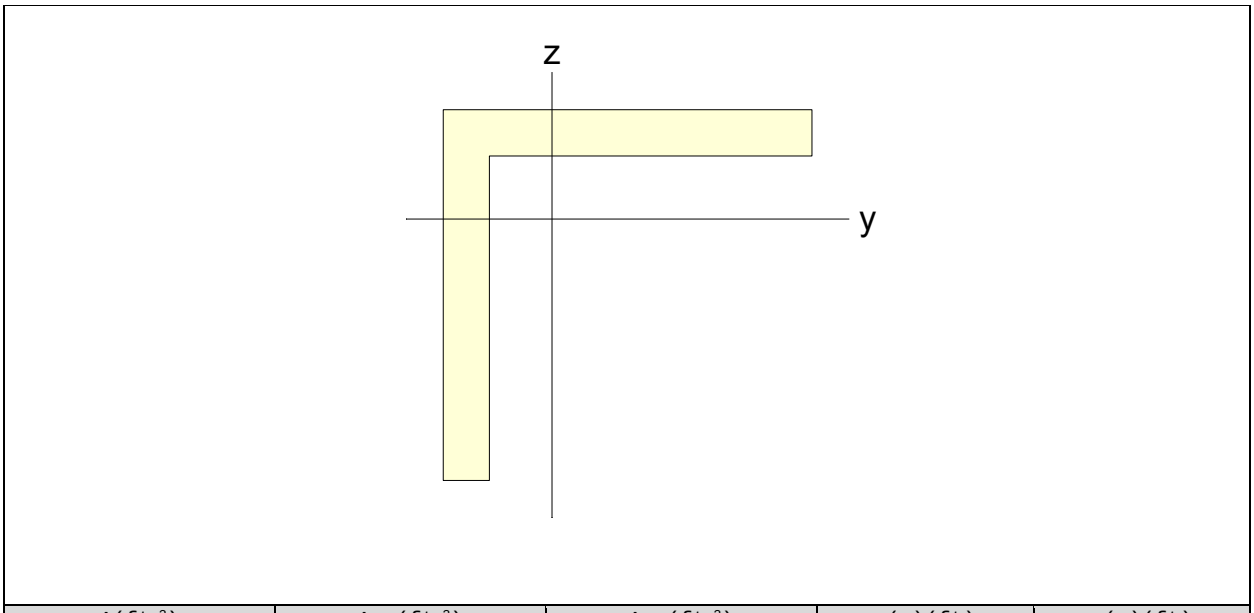
0.035	0.017	0.013	0.106	0.144
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.000	0.001	0.333	0.333

Table 15 16 : 2L3-1/2X3X3/8LLBB



A(ft ^{2})	Asy(ft ^{2})	Asz(ft ^{2})	z(+)(ft)	z(-)(ft)
0.032	0.015	0.013	0.089	0.161
Ixx(ft ^{4})	Iyy(ft ^{4})	Izz(ft ^{4})	y(+)(ft)	y(-)(ft)
0.000	0.000	0.001	0.292	0.292

Table 16 17 : L4X4X1/2



A(ft ²)	Asy(ft ²)	Asz(ft ²)	z(+)(ft)	z(-)(ft)
0.026	0.012	0.012	0.098	0.235
Ixx(ft ⁴)	Iyy(ft ⁴)	Izz(ft ⁴)	y(+)(ft)	y(-)(ft)
0.000	0.000	0.000	0.235	0.098

Loads:

Railing (D):

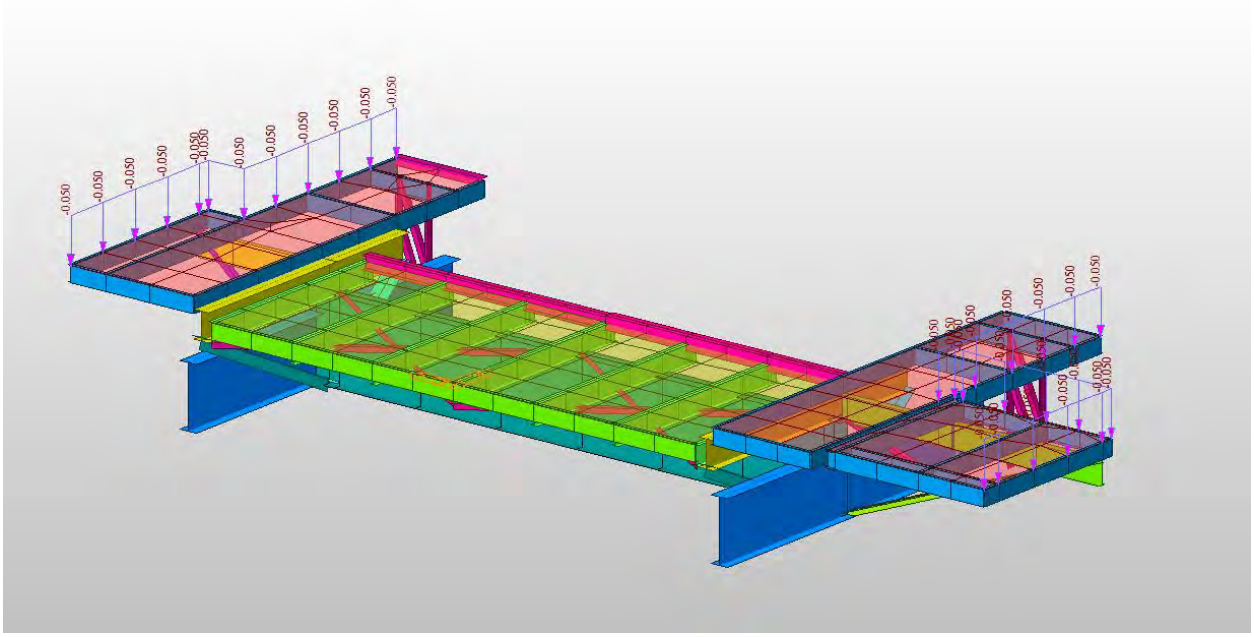


Figure 1 Railing Load

Sidewalk (LL):

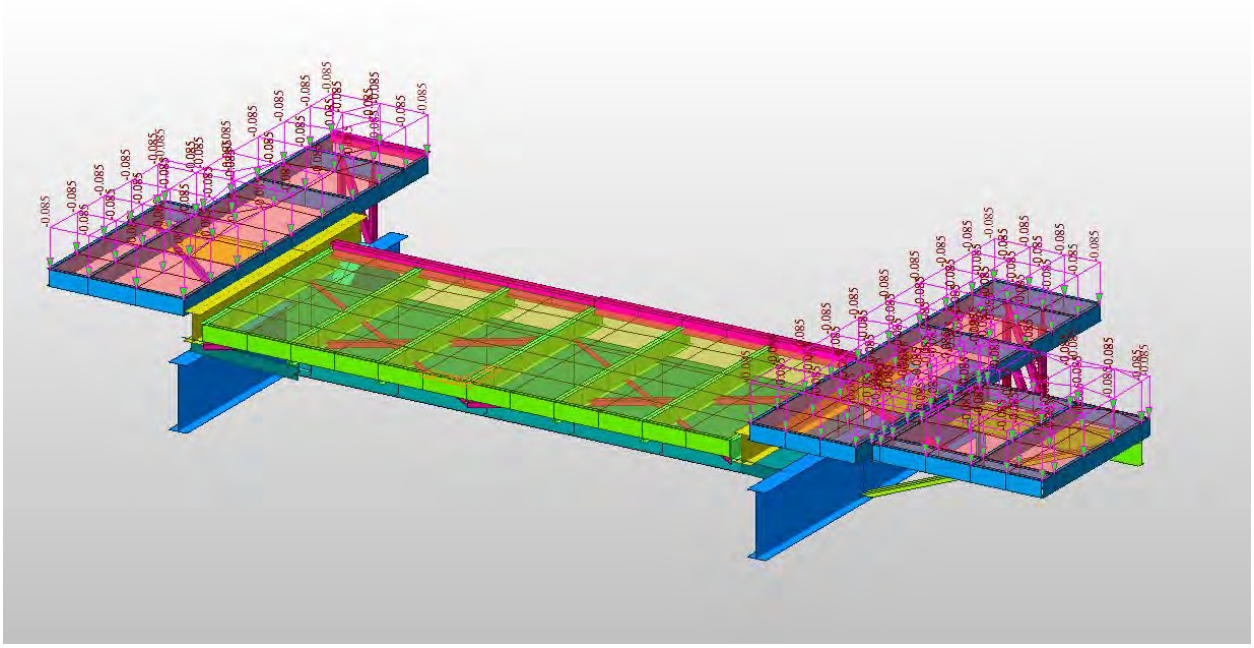


Figure 2 Sidewalk LL

Moving Load Traffic Surface Lanes:

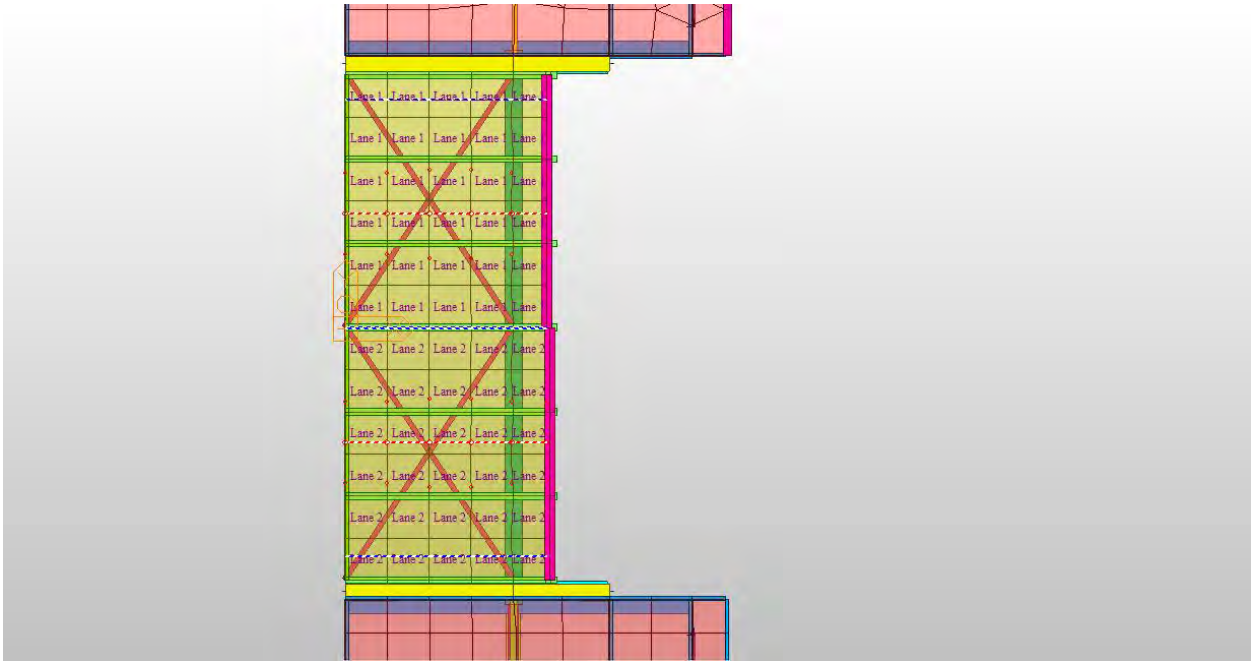


Figure 3 Traffic Surface Lanes

Results:

Support Node Locations:

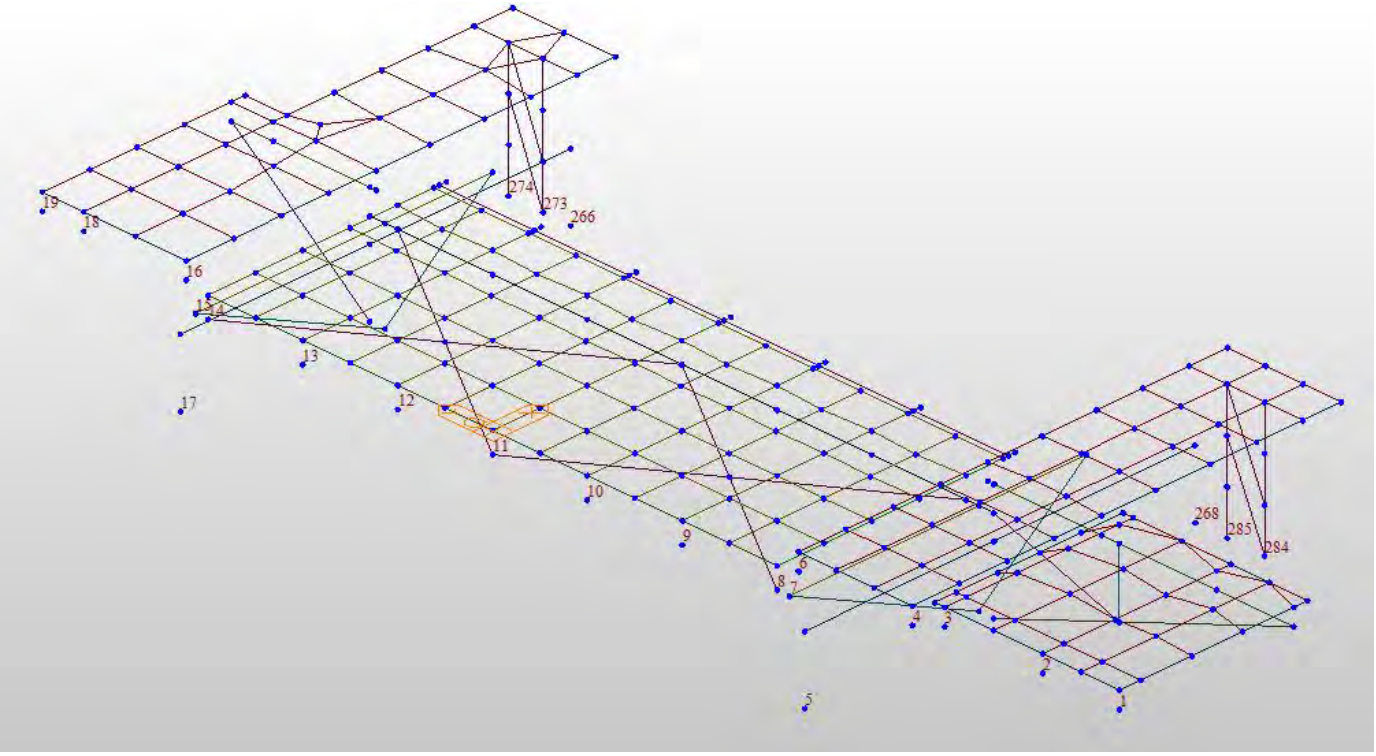


Figure 4 Support Node Locations

Control House Reactions:

Reactions from the superstructure with the control house platform.

Table 17 Abut Rxn Control House

Node	Load	FX (kips)	FY (kips)	FZ (kips)	MX (ft*kips)	MY (ft*kips)
1	D	0	0.737906	2.49737	0	0
2	D	0	1.257239	2.298187	0	0
3	D	0	0.223835	0.569433	0	0
4	D	0	3.677603	5.413461	0	0
5	D	0.072143	-5.223827	26.750572	9.70552	-146.394991
6	D	0	2.43715	-0.016631	0	0
7	D	0	-0.116074	1.939721	0	0
8	D	0	1.405292	2.276139	0	0
9	D	0	1.161107	4.057344	0	0
10	D	0	0.580422	3.986541	0	0

11	D	0	-0.239483	4.431985	0	0
1	L(max)	0	0.612796	1.922632	0	0
2	L(max)	0	0.993991	2.21579	0	0
3	L(max)	0	0.226398	0.828977	0	0
4	L(max)	0	3.110397	4.448415	0	0
5	L(max)	0.069371	-3.725341	26.669188	8.11522	-30.503539
6	L(max)	0	1.737556	0.611833	0	0
7	L(max)	0	-0.054082	0.001995	0	0
8	L(max)	0	2.92814	2.950561	0	0
9	L(max)	0	6.087756	17.106027	0	0
10	L(max)	0	1.48741	17.35077	0	0
11	L(max)	0	5.65743	15.555447	0	0

Sum of D reactions = 51.99 kips

Sum of L reactions = 81.88 kips

No Control House Reactions:

*Reactions from the superstructure **without** the control house platform.*

Table 18 Abut Rxn No Control House

Node	Load	FX (kips)	FY (kips)	FZ (kips)	MX (ft*kips)	MY (ft*kips)
11	D	0	-0.239483	4.431985	0	0
12	D	0	-0.936039	3.987767	0	0
13	D	0	-1.554526	4.047057	0	0
14	D	0	-1.698298	2.34279	0	0
15	D	0	-0.013147	2.068499	0	0
16	D	0	-0.175519	0.975529	0	0
17	D	0.084817	1.378534	24.226711	-2.483219	-131.892533
18	D	0	-1.743008	2.304929	0	0
19	D	0	-0.791805	2.057559	0	0
11	L(max)	0	5.65743	15.555447	0	0
12	L(max)	0	3.440204	17.351557	0	0
13	L(max)	0	0.221518	17.098536	0	0

14	L(max)	0	0.965022	3.001602	0	0
15	L(max)	0	0.038353	-0.00375	0	0
16	L(max)	0	0.098596	1.267053	0	0
17	L(max)	0.074561	1.57816	24.972046	-1.726822	-20.862598
18	L(max)	0	-1.217579	2.411164	0	0
19	L(max)	0	-0.514611	1.533678	0	0

Sum of D reactions = 44.23 kips

Sum of L reactions = 75.41 kips

ATTACHMENT C – PROCEDURE FOR ESTIMATING GROUND SETTLEMENT

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	8/24/19
SUBJECT:	RTA 1 - Pipe Pile Design	CHECKED BY:	JRA	DATE:	6/4/19

RTA 1 - Pipe Pile Design - Procedure for Estimating Ground Settlement

The analysis of excavation-induced ground settlements follows the following procedure found in "Shape of Ground Surface Settlement Profiles Caused by Excavation" by Hsieh and Ou (1998) (pages 1009-1010):

1. Predict the maximum lateral wall deflection (δ_{hm}).
2. Determine the type of settlement profile.
3. Estimate the maximum ground surface settlement (δ_{hm}) using the relationship shown by Hsieh and Ou (1998).
4. Calculate the surface settlement at various distances behind the wall using the relationship shown by Hsieh and Ou (1998).

Results of the procedure by Hsieh and Ou (1998):

1. The maximum lateral wall deflection has been calculated for each design case and location using the design software CivilTech Shoring Suite and the method found in the USS Steel Sheet Piling Design Manual.
2. The settlement profile is spandrel due to the free head condition of the cantilever wall.
3. Hsieh and Ou (1998) developed a relationship between maximum lateral wall deflection (δ_{hm}) and maximum ground settlement (δ_{vm}) using excavation case-history data. "In most cases δ_{vm} is equal to (0.5-0.75)δ_{hm}, and the upper limit is $\delta_{vm} = \delta_{hm}$." Conservatively, the relationship between δ_{hm} and δ_{vm} will be considered equal.
4. The ground settlement is predicted using the following equations by Hsieh and Ou (1998):

$$\delta_v = \left(-0.636\sqrt{\frac{d}{H_e}} + 1\right)\delta_{vm} \; if \; \frac{d}{H_e} \leq 2; and$$

$$\delta_v = \left(-0.171\sqrt{\frac{d}{H_e}} + 0.342\right)\delta_{vm} \; if \; 2 < \frac{d}{H_e} \leq 4$$

Where:

δ_v = *Ground surface settlement*

d = *Distance behind the wall*

H_e = *Wall height*

ATTACHMENT D – SEISMIC DESIGN PARAMETERS

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	5/28/19
SUBJECT:	RTA1 - Bridge Support Design	CHECKED BY:	JRA	DATE:	6/4/19

Attachment D - Seismic Design Parameters

References:

1. NYSDOT Geotechnical Design Procedure for Flexible Wall Systems - Aug 2015
2. NYSDOT Bridge Manual - 2017
3. AASHTO Standard Specifications for Highway Bridges, 17th Edition - 2002
4. USS Sheet Piling Design Manual - 1984
5. AASHTO LRFD Bridge Design Specifications - Seventh Edition with 2016 Iterim Revisions
6. NYSDOT Standard Specifications
7. Hsieh, Pio-Go and Ou, Chang-Yu. "Shape of Ground Surface Settlement Profiles Caused by Excavation." *Canadian Geotechnical Journal 35(6):1004-1017* (1998)
8. NYCDOT Seismic Design Guidelines for Bridges in Downstate Region - May 2016

Appendices:

Appendix A - RTA 1 Bridge Soil Design Parameters by GZA GeoEnvironmental, Inc.
Appendix B - Skyline Steel AZ Sheet Pile Datasheet
Appendix C - Summary of Geotechnical Design Parameters by Geosyntec Consultants

Seismic Design of Pipe Pile Walls:

Seismic design of the pipe pile walls is completed in CivilTech Shoring Suite. The additional earthquake forces are applied using the wedge analysis described in Ref. 5 Section A11.3.2. Seismic loading is only considered for the final design condition. Since 1.0 to 2.0 in of permanent ground deformation is not strictly permitted, the reduction of the horizontal seismic acceleration cofficient (k_h) can not be used. Instead, the peak ground acceleration coefficient will be used as per Ref. 5 Section A11.3.2. The vertical seismic acceleration cofficient (k_v) = 0 as per Ref. 5 Section A11.3.2.

Calculation of Horizontal Seismic Acceleration Coefficient, k_h:

Bridge Classification & Preformance Criteria:

Union Street bridge classification is assumed to be Other based on Ref. 8 Table 1.
Wall designs will be analyzed for a single earthquake hazard level having 7% probability of being exceeded in 75 years (1000 years Return Period).

Site Classification:

As per Ref. 8 Section 6.3.1, since rock is greater than 10 feet below the surface, this is a soil site.

Soil Site Classification:

As per Ref. 8 Section 6.3.1, for non-critical bridges, soil site classes shall be characterized on the basis of average soil properties. For cohsionless soils, the SPT resistance N may be used. For cohesive soils, the undrained shear strength (s_u) may be used. Since there are muliple soil types at this location, both soil parameters will be considered.

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design		SHEET:	OF	
JOB NO.:	BAB-2017020.01		MADE BY:	PLT	DATE: 5/28/19
SUBJECT:	RTA1 - Bridge Support Design		CHECKED BY:	JRA	DATE: 6/4/19

Cohesive Soils Layers:

Soft Sediment:

$s_u = 0.3\sigma'_v$ *Appendix A*

$s_u = 73.92$ *pcf*

Max. depth = 14 *ft* (Maximum soft sediment layer depth)

$\gamma =$ 80 *pcf* (Total unit weight)

$\sigma'_v =$ 246.4 *psf* (Effective vertical stress)

Native Alluvial:

$s_u =$ *250 if > EL. -20 ft* *Appendix A*

$s_u =$ *500 if < EL. -20 ft*

Ref. 8 Table 11:

$s_u <$ *1000* *pcf for Soil Class E*

Cohesionless Soil Layers:

Glacial Deposits:

$N_{60} =$ 16 *bpf* (SPT for Glacial Deposits) *Appendix C Table 6*

Ref. 8 Table 11:

N < *15* *pcf for Soil Class E*

Since the soft sediment and Native Alluvial Sediments are within the limits of soil class E and the Glacial Deposits are on the very low end of Soil Class D, Soil Class E has been selected for this site.

Soil Class = E (based on undrained shear strength) *Ref. 8 Table 11*

Calculation of Seismic Design Spectra and PGA:

As per Ref. 8 Section 7.2, soil on top of rock class B will be assumed when determining the PGA.

PGA = 0.29 *Ref. 8 Table 13*

Calculation of k_h:

$k_h =$ PGA *Ref. 5 Section A11.3.2*

$k_h =$ 0.29

ATTACHMENT E – CORROSION DURABILITY

GPI					
PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	JRA	DATE:	6/20/19
SUBJECT:	RTA1 - Bridge Support Design	CHECKED BY:	PLT	DATE:	6/21/19

Attachment E - Pipe Pile Corrosion Durability

References:

1. Arcelor Mittal Piling Handbook 8th Edition, Reprint 2008
2. AISC Steel Construction Manual 14th Edition

Corrosion Durability Pipe Pile Walls:

Corrosion Durability of the pipe pile walls is completed in accordance with the procedure set forth in the Arcelor Mittal Piling Handbook. The corrosion durability is checked for a 50 year timeline. To be conservative, the maximum moment determined for all design cases and locations shall be used, which is Union Street Design Case II Location USDL02, maximum moment = 93.26 kip-ft.

Assumptions:

Polluted Natural Soils and industrial grounds below elevation of clean backfill and concrete cap.
Seawater

RTA 1 - Union Street Pipe Pile Wall Design Case II - USDL02

Design Elevations:

(All elevations are based on the North American Vertical Datum of 1988 (NAVD88)

EL_1 =	-2.00	*ft*	(Minimum existing bathymetry elevation)	
EL_2 =	-14.55	*ft*	(Minimum el. of soft-native interface)	*Appendix C Table 1d*
EL_3 =	-21.30	*ft*	(Minimum el. of native-glacial interface)	*Appendix C Table 1d*
El_D =	-16.00	*ft*	(Dredge elevation)	
EL_{CAP} =	-14.17	*ft*	(Environmental Cap Elevation)	
H =	12.17	*ft*	(Dredge height)	
EL_{TOP} =	3.00	*ft*	(Top of wall elevation)	
EL_{TOE} =	-50.00	*ft*	(Toe of wall elevation, add additional 20%)	
H_w =	53.00	*ft*	(Height of wall)	
MHW EL =	1.96	*ft*	(Mean high water elevation)	
MLW EL =	-2.57	*ft*	(Mean low water elevation)	
Tidal Lag =	2.265	*ft*	(Tidal lag)	
EL_{AW} =	1.96	*ft*	(Active side water elevation)	
EL_{PW} =	-0.305	*ft*	(Passive side water elevation)	

Corrosion Loss Rates:

Soil and Water Corrosion thicknesses below taken from Ref 1. Table 3.3.1 and 3.3.2 for 50 year timeline

Step 1:

Depth	Inshore Face Thickness Loss (mm)	Outshore Face Thickness Loss (mm)	Total Thickness Loss Over 50 Year Life
0 - 1 ft	Splash Zone (3.75)	Splash Zone (3.75)	15 mm (0.591 in)
1 - 5 ft	Tidal (3.75)	Tidal (3.75)	15 mm (0.591 in)
5 - 17 ft	Contam. Soil (1.5)	Immersed (1.75)	6.5 mm (0.256 in)
17 - 19 ft	Contam. Soil (1.5)	Clean Soil (1.2)	5.4 mm (0.213 in)
19 - 53 ft	Contam. Soil (1.5)	Contam. Soil (1.5)	6.0 mm (0.236 in)

Note:

1. Depth of zero feet is equivalent to the top of pile at EL. 3.00
2. Corrosion accounted for on exterior face of pile inshore and outshore, as well as interior face of pile.

Step 2:

Depth	Maximum Bending Moment (k-ft)
0 - 1 ft	0.1
1 - 5 ft	3.3
5 - 17 ft	47.5
17 - 19 ft	58.4
19 - 53 ft	93.3

Note:
Bending Moments taken from Civil Tech Shoring Suite Output for Case II USDL02.

Step 3:

Depth	Min. Section Modulus (in^3)
0 - 1 ft	0.04
1 - 5 ft	1.44
5 - 17 ft	20.74
17 - 19 ft	25.49
19 - 53 ft	40.70

Section modulus = M_{max} / (.55*F_y)

F_y = 50 ksi

Step 4:

Section Modulus of Hollow Circle S= .098175(D^4-d^4)/D (Ref. 2. Table 17-27)

D= Outside Diameter

d= Inside Diameter

O-Pile Manufacturer's Cutsheet 28" dia. Pile S= 167.53 in^3/ft

Adjusted Section Modulus After Corrosion Loss

Depth	Pile Dia. (in)	Pile Thickness (in)	Corrosion Loss (in)	Adjusted S_x (in^3)	Check
0 - 1 ft	28	0.748	0.591	107.0	OK
1 - 5 ft	28	0.748	0.591	107.0	OK
5 - 17 ft	28	0.748	0.256	149.3	OK
17 - 19 ft	28	0.748	0.213	154.8	OK
19 - 53 ft	28	0.748	0.236	151.8	OK

ATTACHMENT F – VIBRATION ANALYSIS

GPI

PROJECT:	RTA 1 Bridge Stability Final Design	SHEET:		OF	
JOB NO.:	BAB-2017020.01	MADE BY:	PLT	DATE:	11/15/19
SUBJECT:	RTA 1 - Carroll Street Design Case I	CHECKED BY:	JRA	DATE:	12/16/19

RTA 1 - Vibration Assesment due to Pile Removal

References:

1. Ground Vibrations From Pile and Sheet Pile Driving Part 1 - Building Damage - Massarsch and Fellenius, 2014
2. Guidelines for Estimation of Shear Wave Velocity Profiles - Wair, DeJong and Shantz, 2012
3. Summary of Geotechnical Design Parameters prepared by Geosyntec Consultants

Purpose:

This calculation evaluates the potential for soil to experience shakedown settlement due to the removal of timber dolphin piles. The shear strain amplitude in the area surrounding the pile is estimated using the procedure found in "Ground Vibrations From Pile and Sheet Pile Driving Part 1 - Building Damage" by Massarsch and Fellenius, 2014. This shear strain is compared with a widely accepted threshold strain to determine the potential for impacts. The calculations are based on several factors that contribute to the risk of impacts to nearby structures:

- *Depth and type of pile*
- *Ground stratification*
- *Location, depth, and type of nearby structure foundation*
- *Ground Properties*

Since these dolphin piles are in close proximity to the existing pier foundations, these foundations may be susceptible to settlements due to vibrations.

Assumptions:

1. Due to the threshold limits for vibration prescribed in the NYCDOT - Division of Bridges Review Procedure for Private Development Project near Bridge Structure, Peak Particle Velocity (PPV) will be 0.5 in/sec.
2. Union Street pier foundation is located 5 ft to the nearest dolphin pile.
3. The pier foundation has a bottom of cap elevation of -15.55' and is founded on primarily Glacial Deposits. Therefore, vibration effects to this structure will be established within this layer.
4. Shear wave speed and total shear strain will be calculated at the center of the layer.
5. N_{60} blow counts were obtained from "Summary of Geotechnical Design Parameters" by Geosyntec.

Inputs:

Mudline EL:	-9	*ft*	
Water Elevation:	-1.96	*ft*	
γ_w =	62.4	*pcf*	(Unit weight of water)
g =	32.2	*ft/sec²*	(Acceleration due to Gravity)
Pile Embedment:	20	*ft*	(Assumed)

Soil Properties:

Layer No.	Layer Discription	Layer Thickness	Bottom of Layer Elevation	N_{60}	γ	γ'	ϕ'	σ_v'
		(ft)	(ft)		(pcf)	(pcf)	(deg)	(psf)
1	Soft Sediment	5	-14	2	80	17.6	28	44
2	Native Alluvial	5	-19	3.5	115	52.6	28	175.5
3	Glacial Deposits	15	-34	19	125	62.6	34	645

Peak Particle Velocity in Soil at Pile-Soil Interface:

v_s = 0.5 *in/sec* (NYCDOT)

Calculation of Shear Wave Speed, c_s:

$c_s = 30N_{60}^{0.215}\sigma'_v{}^{0.275}$ (all soils) (Ref. 2 Table 4.11)

Where:

c_s = Shear wave speed (m/s)

N_{60} = Corrected Blow Counts

σ'_v = Overburden stress (kPa)

c_s = 145.12 *m/s*

c_s = 476.11 *ft/s*

Calculation of Shearing Strain at Points in Soil Mass:

$\gamma = v_s/c_s$ (Shear strain) (Ref. 1 Eq. 2)

γ = 0.009%

γ_t = 0.010% (Threshold Strain Level) (Ref. 2 pg. 135)

$\gamma \leq \gamma_t$ **OK**

Soil disturbance should not occur since shear strain value is below the threshold value.