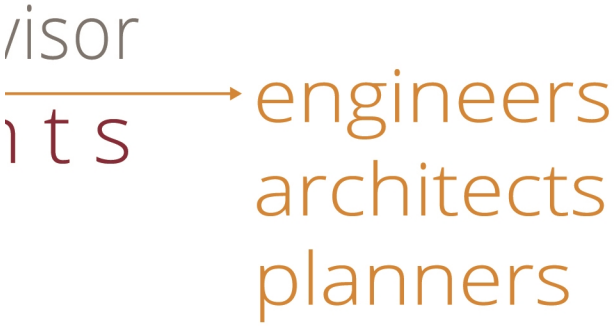
DeepEX 2022: Report Output

A program for the evaluation of deep excavations Deep Excavation LLC,
New York, New York, www.deepexcavation.com

Project: ODOT PID No. 108665; LAK-20-19.59 - WEST

Company: CT Consult
Prepared by engineer:
File number: CT PRO
Time: 7/6/2022 11:57:

File: H:\2018\180743\ODOT\ProjectData\108665_LAK_20_WEST\Design\Structures\EngData\SHORING DESIGN\DeepEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP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engineers
architects
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ANALYSIS AND CHECKING SUMMARY

The following tables summarize critical resuls for all design sections. These results may include wall moments, shears, displacements, stress checks, wall embedment safety factors, basal & slope stability safety factors, etc.

Summary vs Design Section

Culvert at STA. 253	Wall Moment	Wall Shear	Wall Displace	Max Support	Critical Support	Embedment	Comments
0: AASHTO LRFD (201	(k-ft/ft)	(k/ft)	(in)	Reaction (k/ft)	Check	Wall FS	
Culvert at STA. 253	115.11	33.78	0	No supports	No supports	1.807	Calculation successful
0: AASHTO LRFD (201	115.11	33.78	0	No supports	No supports	1.807	Calculation successful
0: AASHTO LRFD (201	225.77	44.93	0	No supports	No supports	1.242	Calculation successful
0: AASHTO LRFD (201	225.77	44.93	0	No supports	No supports	1.242	Calculation successful
0: AASHTO LRFD (201	215.98	43.57	0	No supports	No supports	1.259	Calculation successful

Extended Summary

Table: Extended summary for all design sections.

Design Section	Calculation Result	Wall Displacement	Settlement
Name		(in)	(in)
Culvert at STA. 253+86 Shoring (Se	Calculation successful	2.24	2.34
0: AASHTO LRFD (2010): Service I	Calculation successful	2.24	2.34
0: AASHTO LRFD (2010): Strength Ia	Calculation successful	5.64	2.39
0: AASHTO LRFD (2010): Strength Ib	Calculation successful	5.64	2.39
0: AASHTO LRFD (2010): Strength II	Calculation successful	5.29	2.36

Table: Extended summary for wall moments and shears for all design sections.

Design Section	Wall Moment	Wall Moment	Wall Shear	Wall Shear
Name	(k-ft/ft)	(k-ft)	(k/ft)	(k)
Culvert at STA. 253+86 Shoring (Serv	115.11	115.11	33.78	33.78
0: AASHTO LRFD (2010): Service I	115.11	115.11	33.78	33.78
0: AASHTO LRFD (2010): Strength Ia	225.77	225.77	44.93	44.93
0: AASHTO LRFD (2010): Strength Ib	225.77	225.77	44.93	44.93
0: AASHTO LRFD (2010): Strength II	215.98	215.98	43.57	43.57

Table: Extended summary for wall stress checks for all design sections.

Design Section	STR Combined	STR Moment	STR Shear	Wall Concrete Service
Name	Wall Ratio	Wall Ratio	Wall Ratio	Stress Ratio FIC
Culvert at STA. 253+86 Shoring (Serv	0.501	0.501	0.207	N/A
0: AASHTO LRFD (2010): Service I	0.501	0.501	0.207	N/A
0: AASHTO LRFD (2010): Strength Ia	0.982	0.982	0.275	N/A
0: AASHTO LRFD (2010): Strength Ib	0.982	0.982	0.275	N/A
0: AASHTO LRFD (2010): Strength II	0.94	0.94	0.267	N/A

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

Table: Extended summary for support results for all design sections

Design Section	Max Support	Max Support	Critical	STR Support	Support Geotech
Name	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull
Culvert at STA. 253+86 Shoring (Se	No supports	No supports	No supports	No supports	No supports
0: AASHTO LRFD (2010): Service I	No supports	No supports	No supports	No supports	No supports
0: AASHTO LRFD (2010): Strength Ia	No supports	No supports	No supports	No supports	No supports
0: AASHTO LRFD (2010): Strength Ib	No supports	No supports	No supports	No supports	No supports
0: AASHTO LRFD (2010): Strength II	No supports	No supports	No supports	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).

Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

Table: Summary for basal stability and wall embedment safety factors from conventional analyses.

Design Section	FS	Toe FS	Toe FS	Toe FS
Name	Basal	Passive	Rotation	Length
Culvert at STA. 253+86 Shoring (Serv	1000	21.622	2.535	1.807
0: AASHTO LRFD (2010): Service I	1000	21.622	2.535	1.807
0: AASHTO LRFD (2010): Strength Ia	1000	10.838	1.362	1.242
0: AASHTO LRFD (2010): Strength Ib	1000	10.838	1.362	1.242
0: AASHTO LRFD (2010): Strength II	1000	10.838	1.387	1.259

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
TOE FS Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
TOE FS Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
TOE FS Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0

Table: Summary for wall embedment safety factors from elastoplastic analyses.

Design Section	FS Mobilized	FS
Name	Passive	True/Active
Culvert at STA. 253+86 Shoring (Servi	N/A	N/A
0: AASHTO LRFD (2010): Service I	N/A	N/A
0: AASHTO LRFD (2010): Strength Ia	N/A	N/A
0: AASHTO LRFD (2010): Strength Ib	N/A	N/A
0: AASHTO LRFD (2010): Strength II	N/A	N/A

Table notes:

FS Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.
FS True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Table: Summary for hydraulic safety factors, water flow, and slope stability

Design Section	Hydraulic	Qflow	FSslope
Name	Heave FS	(ft3/hr)	
Culvert at STA. 253+86 Shoring (Servi	1.821	N/A	3.282
0: AASHTO LRFD (2010): Service I	1.821	N/A	3.282
0: AASHTO LRFD (2010): Strength Ia	1.821	N/A	3.243
0: AASHTO LRFD (2010): Strength Ib	1.821	N/A	3.243
0: AASHTO LRFD (2010): Strength II	1.821	N/A	3.266

Critical Items

	Critical Value	Critical Design Sectio	Critical Stage	Critical Wall	Critical Item Index
Wall Moment Check	0.982	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	92
Wall Moment (k-ft/ft)	225.773	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	0
Wall Moment (k-ft)	225.773	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	0
Wall Moment Capacity (k-ft/ft)	229.875	4: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	91
Wall Shear (k/ft)	44.926	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	123
Wall Shear (k)	44.926	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	123
Wall Shear Check	0.275	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	123
Wall Shear Capacity (k/ft)	163.267	4: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	122
Wall Displacements (in)	5.639	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	N/A
Surface Settlements (in)	2.386	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	0
Toe FS Passive (Classic)	10.838	4: 0: AASHTO LRFD (	0: Stage 0	1: Wall 1	0
Toe FS Rotation (Classic)	1.362	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	1
Toe FS Length (Classic)	1.242	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	1
FS 1.0 Req. Embed (Classic) (ft)	25.37	3: 0: AASHTO LRFD (	1: Stage 1	1: Wall 1	1
Basal FS (Classic)	1000	4: 0: AASHTO LRFD (	0: Stage 0	1: Wall 1	0

Support Results

	Critical Value	Critical Design Sectio	Critical Stage	Critical Wall	Critical Item Index
Results not available	Results not available	Results not available	Results not available	Results not available	Results not available

Wall Results

	Critical Value	Critical Design Sectio	Critical Stage	Critical Wall	Critical Item Index
Wall Moment ABS (k-ft)	225.773	3: 0: AASHTO LRFD (2	1: Stage 1	1: Wall 1	0
Wall Moment +M (k-ft)	0	4: 0: AASHTO LRFD (2	0: Stage 0	1: Wall 1	0
Wall Moment -M (k-ft)	-225.773	3: 0: AASHTO LRFD (2	1: Stage 1	1: Wall 1	0
Wall Moment Check	0.982	3: 0: AASHTO LRFD (2	1: Stage 1	1: Wall 1	92
Wall Moment Capacity (k-ft/ft)	229.875	4: 0: AASHTO LRFD (2	1: Stage 1	1: Wall 1	91
Wall Shear (k)	44.926	3: 0: AASHTO LRFD (2	1: Stage 1	1: Wall 1	123
Wall Shear Check	0.275	3: 0: AASHTO LRFD (2	1: Stage 1	1: Wall 1	123
Wall Shear Capacity (k/ft)	163.267	4: 0: AASHTO LRFD (2	1: Stage 1	1: Wall 1	122

Max. Moment vs Stage

	Base Model	DS: 1	DS: 2	DS: 3	DS: 4
M stg0 (k-ft/ft)	DS: 0	DS: 1	DS: 2	DS: 3	DS: 4
M stg1 (k-ft/ft)	-115.11	-115.11	-225.77	-225.77	-215.98

Max. Shear vs Stage

	Base Model	DS: 1	DS: 2	DS: 3	DS: 4
V stg0 (k/ft)	DS: 0	DS: 1	DS: 2	DS: 3	DS: 4
V stg1 (k/ft)	-33.78	-33.78	-44.93	-44.93	-43.57

Max. Support F vs Stage

	Base Model	DS: 1	DS: 2	DS: 3	DS: 4
Rmax Stage 0 (k/ft)	DS: 0	DS: 1	DS: 2	DS: 3	DS: 4
Rmax Stage 1 (k/ft)					

STRUCTURAL MATERIALS DATA

Steel

Name	Strength Fy	Fu	Elastic E	Density g
	(ksi)	(ksi)	(ksi)	(kcf)
Fe360	34.1	52.2	29855.1	0.49
Fe510	51.5	73.9	29855.1	0.49
A36	36	58	29000	0.49
A50	50	72.5	29000	0.49
New steel 4	35	60	29855.1	0.49

Concrete

Name	Strength Fc'	Elastic E	Density g	Tension Strength Ft
	(ksi)	(ksi)	(kcf)	(% of Fc')
C20/25	2.9	4342.3	0.1591	10
C25/30	3.6	4561.7	0.1591	10
Fc 3ksi	3	3122	0.15	10

Steel rebar

Name	Strength Fy	Elastic E
	(ksi)	(ksi)

Grade 60	60	29000
Grade 75	75	29000
Grade 80	80	29000
Grade 150	150	29000
Strands 270 ksi	270	29000
S410	59.4	30434.8
S500	72.5	30434.8
B450C	65.2	30434.8

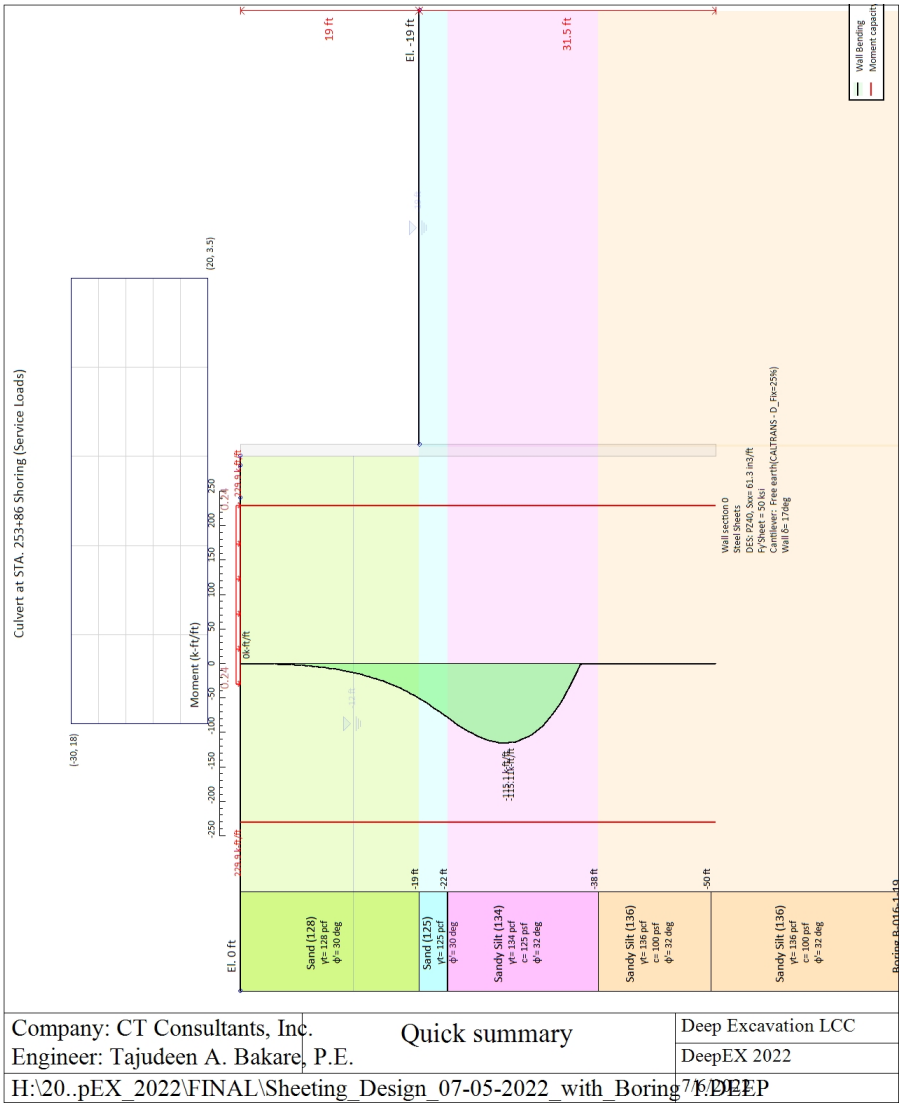
Wood

Name	Ultimate Bending Srtength Fbu	Ultimate Tensile Strength Ftu	Ultimate Shear Strength Fvu	Density g	Elastic E
	(ksi)	(ksi)	(ksi)	(kcf)	(ksi)
Construction Timb	1.6	1.4	0.8	0.05	1000
Regular grade	1	1	0.6	0.05	800

STEEL
Name=material name
fy=fyk= characteristc resistance for steel (for all the codes)
Fu=fuk= ultimate resistence for steel (for all the codes)
Elastic E= Elastic modulus
Density g= specific weight
CONCRETE
Name=material name
f'c=fck= cylindrical resistance for concrete (for all the codes)
Elastic E= Elastic modulus
Density g= specific weight
Tension strength=ft=fctk= characteristic tension resistance for concrete
STEEL REBARS
Name=material name
fy=fyk= characteristic resistance for steel (for all the codes)
Fu=fuk= ultimate resistence for steel (for all the codes)
Elastic E= Elastic modulus
Density g= specific weight
WOOD
Name=material name
Fb=fbk= Ultimate bending strength
Ftu=ftuk= Ultimate tensile strength
Fvu=fvuk= Ultimate shear strength
Density g= specific weight
Elastic E= Elastic modulus

Project: ODOT PID No. 108665; LAK-20-19.59 - WEST
Results for Design Section 0: Culvert at STA. 253+86
Shoring (Service Loads)

ANALYSIS AND CHECKING SUMMARY



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	Quick summary	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring_1.DEEP		7/6/2022

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
0	Wall section	50.5	19	0/229.88	115.11/229.88	21.622	2.535	1.807	-36.43	3.282

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

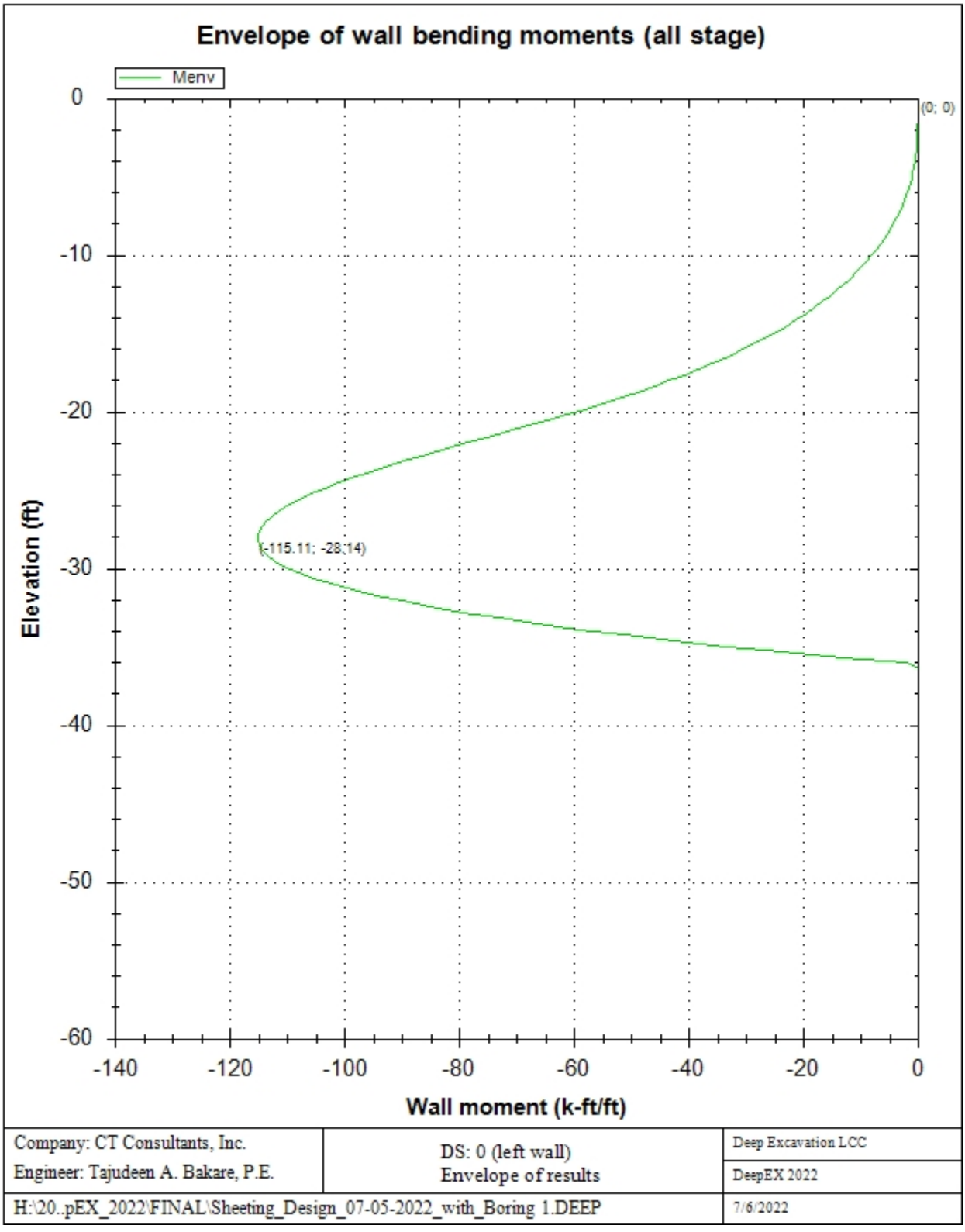
1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.849	12.4	3.282	0.373	12.449	3.282

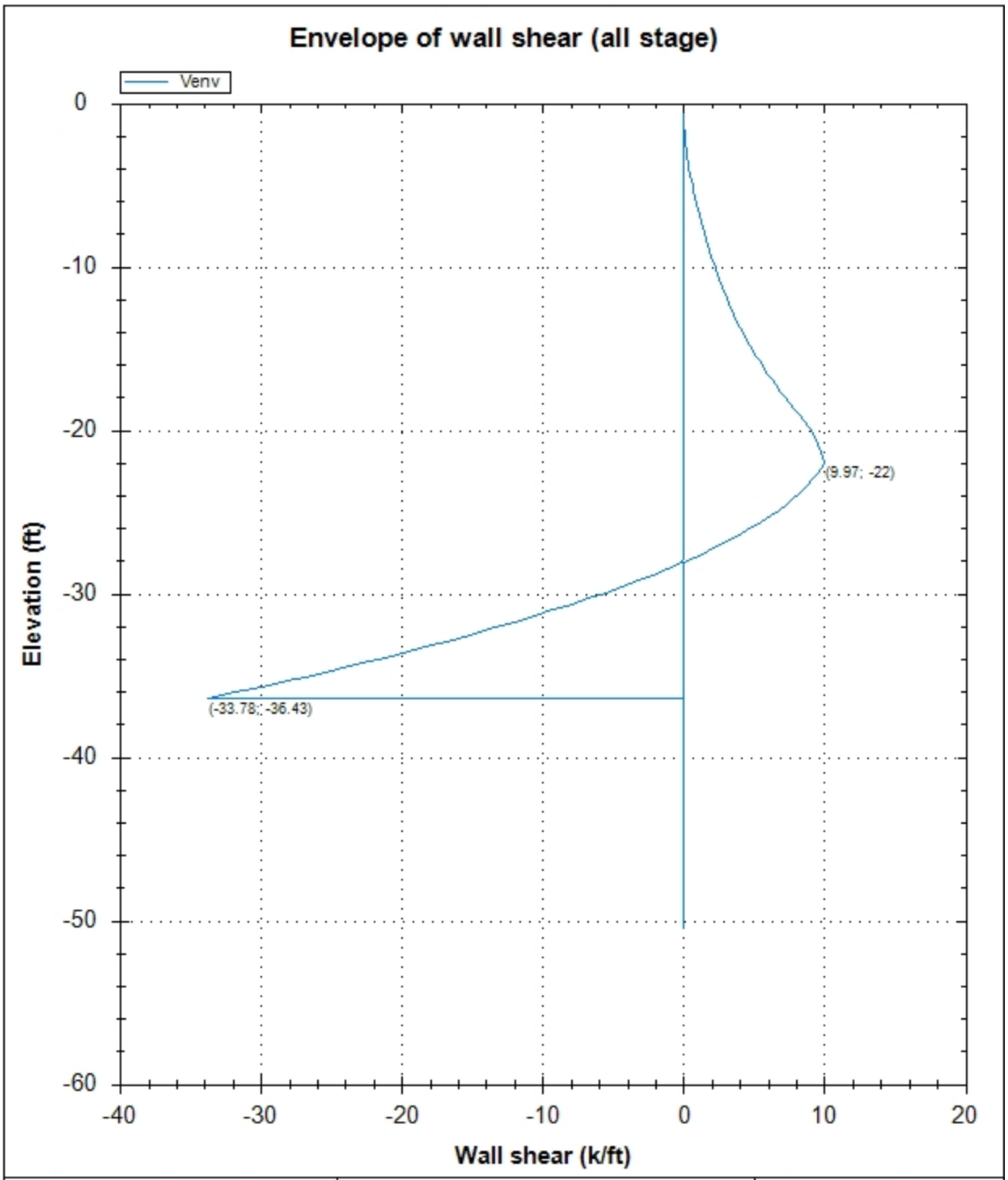
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
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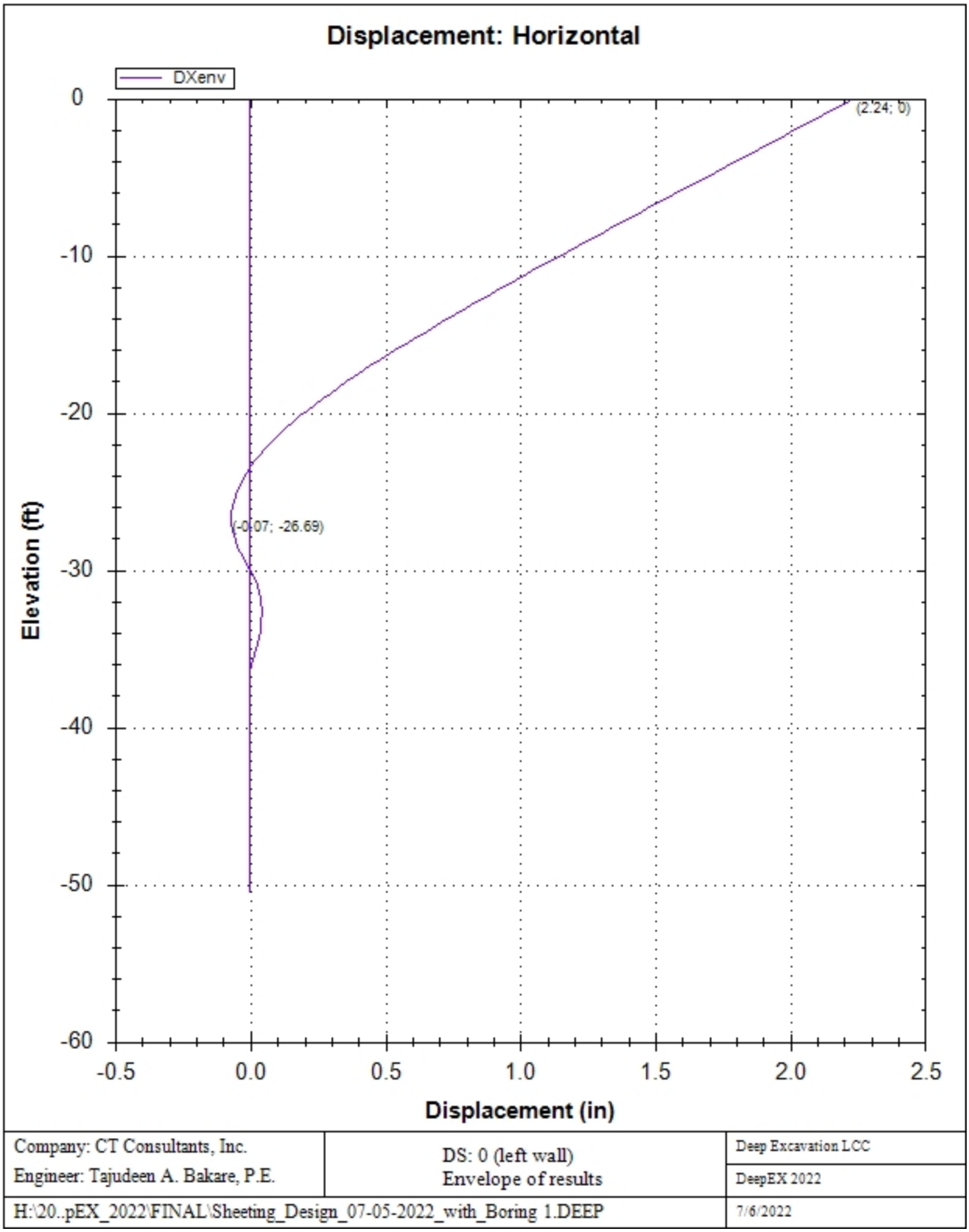


Extended vs Stage

	Calculation Result	Wall Displaceme	Settlement	Wall Moment	Wall Moment
		(in)	(in)	(k-ft/ft)	(k-ft)
Stage 0	Calculated	0	N/A	0	0
Stage 1	Calculated	2.24	2.34	115.11	115.11

	Wall Shear	Wall Shear	STR Combined	STR Moment	STR Shear
	(k/ft)	(k)	Wall Ratio	Wall Ratio	Wall Ratio
Stage 0	0	0	0	0	0
Stage 1	33.78	33.78	0.501	0.501	0.207

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

	Max Support	Max Support	Critical	STR Support	Support Geotech
	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull out
Stage 0	0	0	N/A	No supports	No supports
Stage 1	0	0	N/A	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).
Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

	FS	Toe FS	Toe FS	Toe FS	Zcut	FS Mobilized	FS
	Basal	Passive	Rotation	Length	(nonlinear)	Passive	True/Active
Stage 0	1000	21.622	20.213	140.278	N/A	N/A	N/A
Stage 1	N/A	N/A	2.535	1.807	N/A	N/A	N/A

	Hydraulic	Qflow	FSslope
	Heave FS	(ft3/hr)	
Stage 0	2.729	N/A	N/C
Stage 1	1.821	N/A	3.282

Support Force/S vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Support Force vs Stage

Support Force vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	20.213	21.622	20.213	140.278	N/A	N/A
0:Stage 0	1.807	N/A	2.535	1.807	N/A	N/A

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
Wall embedment safety factors from conventional analysis (limit-equilibrium):
FS1 Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
FS2 Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
FS3 Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0
Wall embedment safety factors from non-linear analysis:
FS4 Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.

FS5 True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Tables for stress checks follow: Support force/Design capacity

Support Check vs Stage

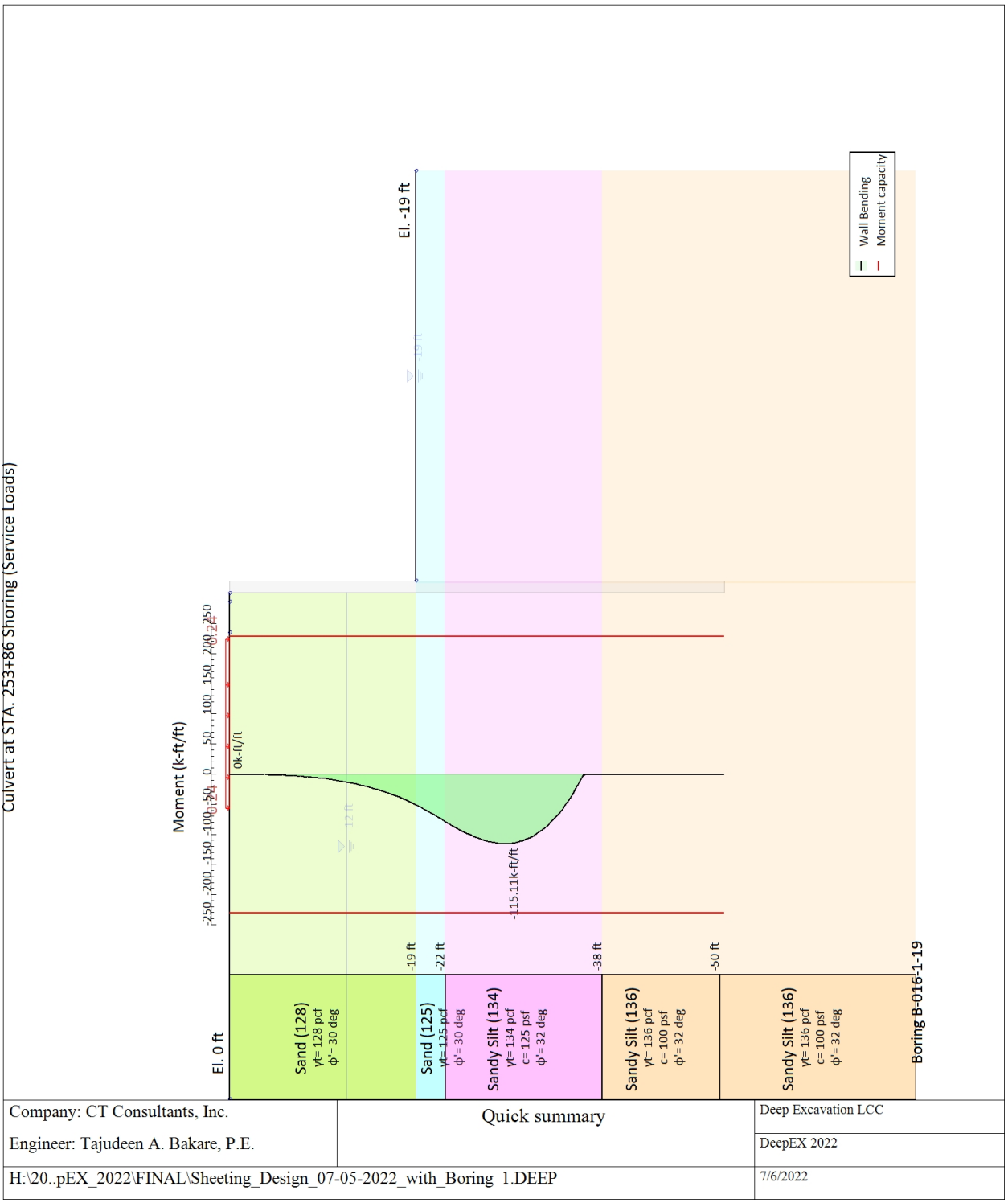
	No Supports
0:Stage 0	No support
1:Stage 1	

Forces (Res. F, M/Drive F, M)

	FS1 Passive	FS2 Rotation	FS3 Length	FS4 Mobilized Passive	FS5 Actual Drive	Fh EQ Soil	Fh EQ Water
	(FxResist/FxDrive)	(Mresist/Mdrive)	(Embedment/ToeFS=1)	(FxPassive/FxPas_Mobili	/ Theory Active		
Stage 0	594.114/27.477	10534.52/521.19	50.5/0.36	N/A	N/A	N/A	N/A
Stage 1	N/A	1930.96/453.04	31.5/17.43	N/A	N/A	N/A	N/A

Reinforcement Requirements

	Parameter Description
Note:	Wall does not use steel reinforcement. Section does not apply.



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(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
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Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

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@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.849	12.4	3.282	0.373	12.449	3.282

General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

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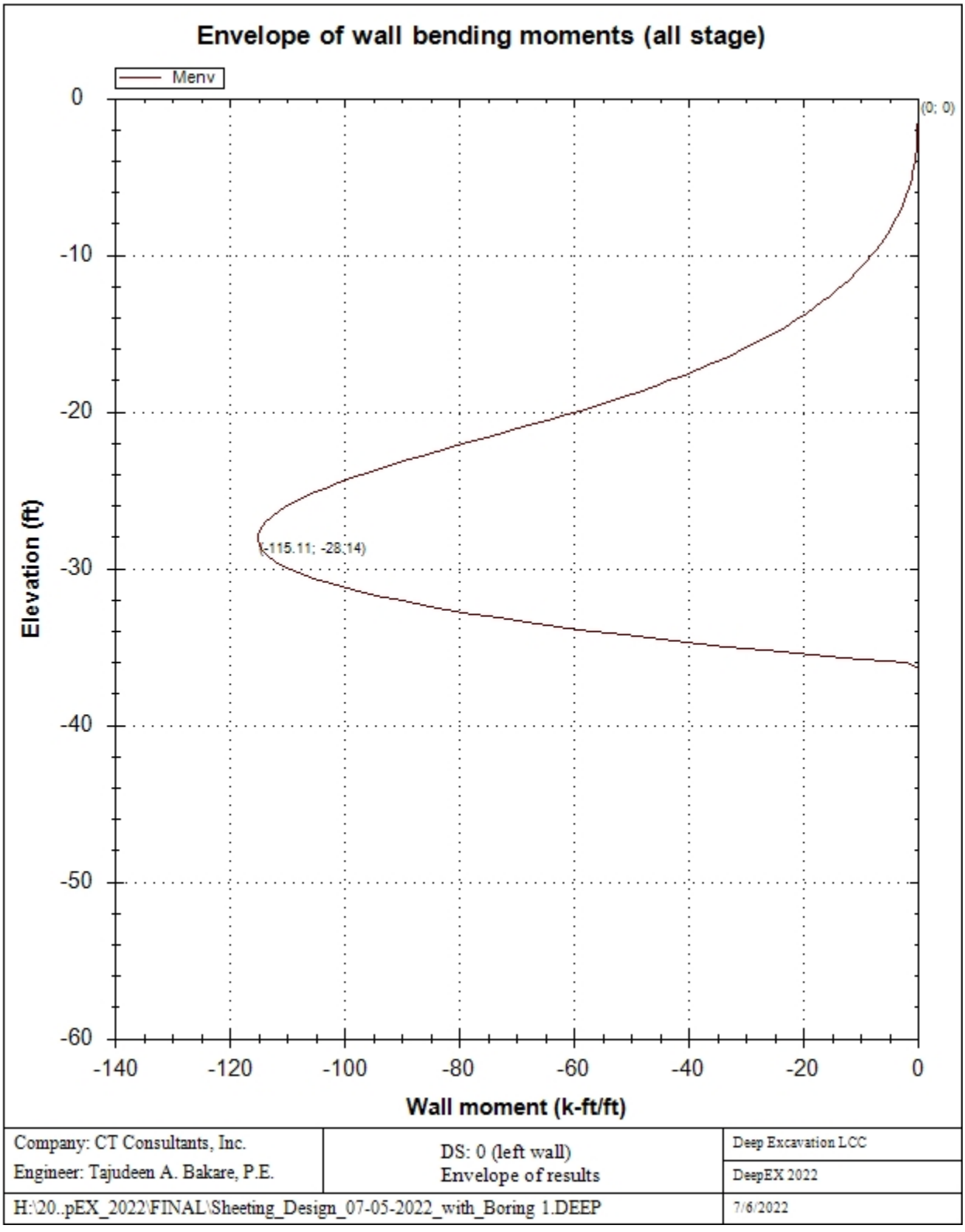
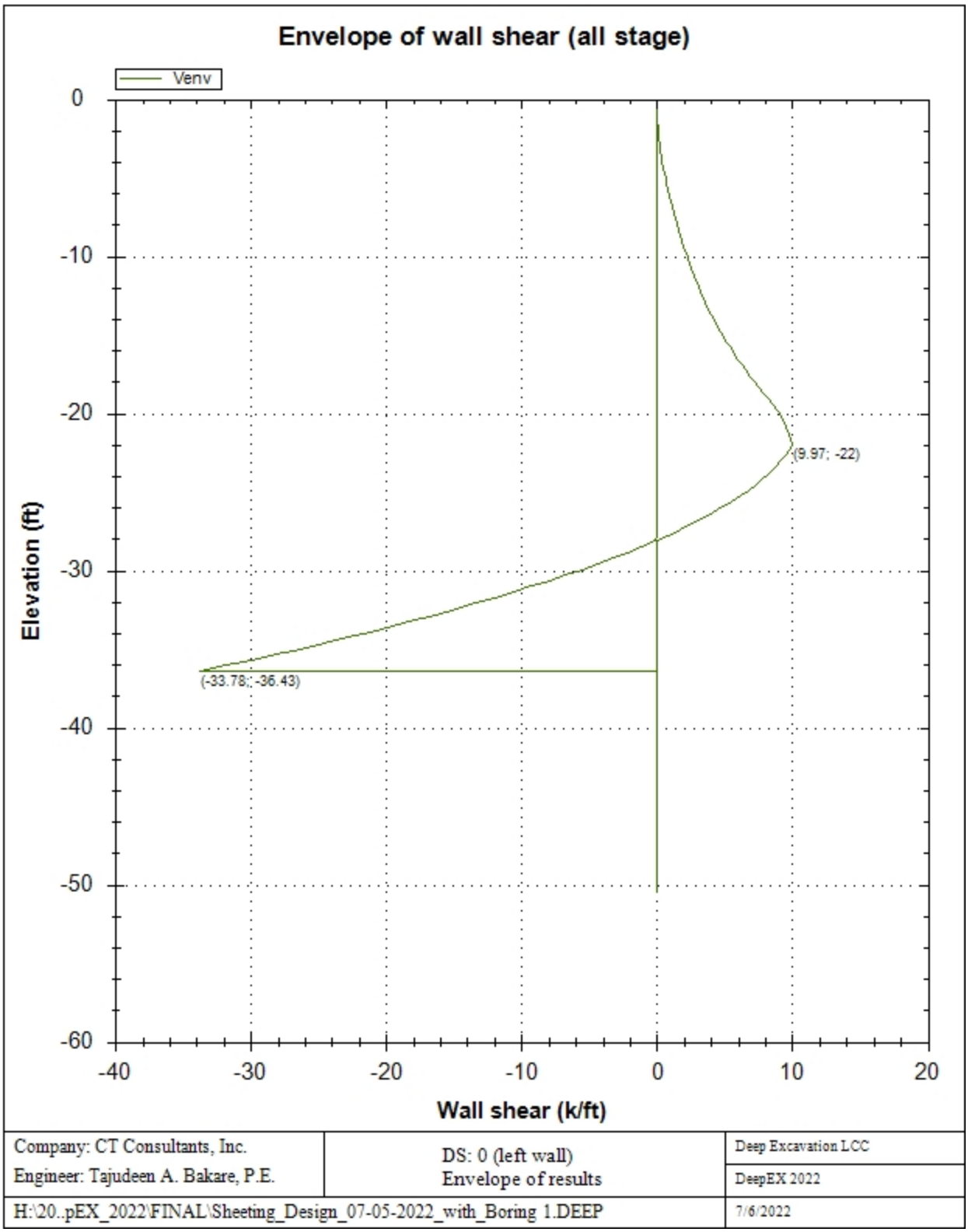
A sequence of result diagrams for each excavation stage is reported





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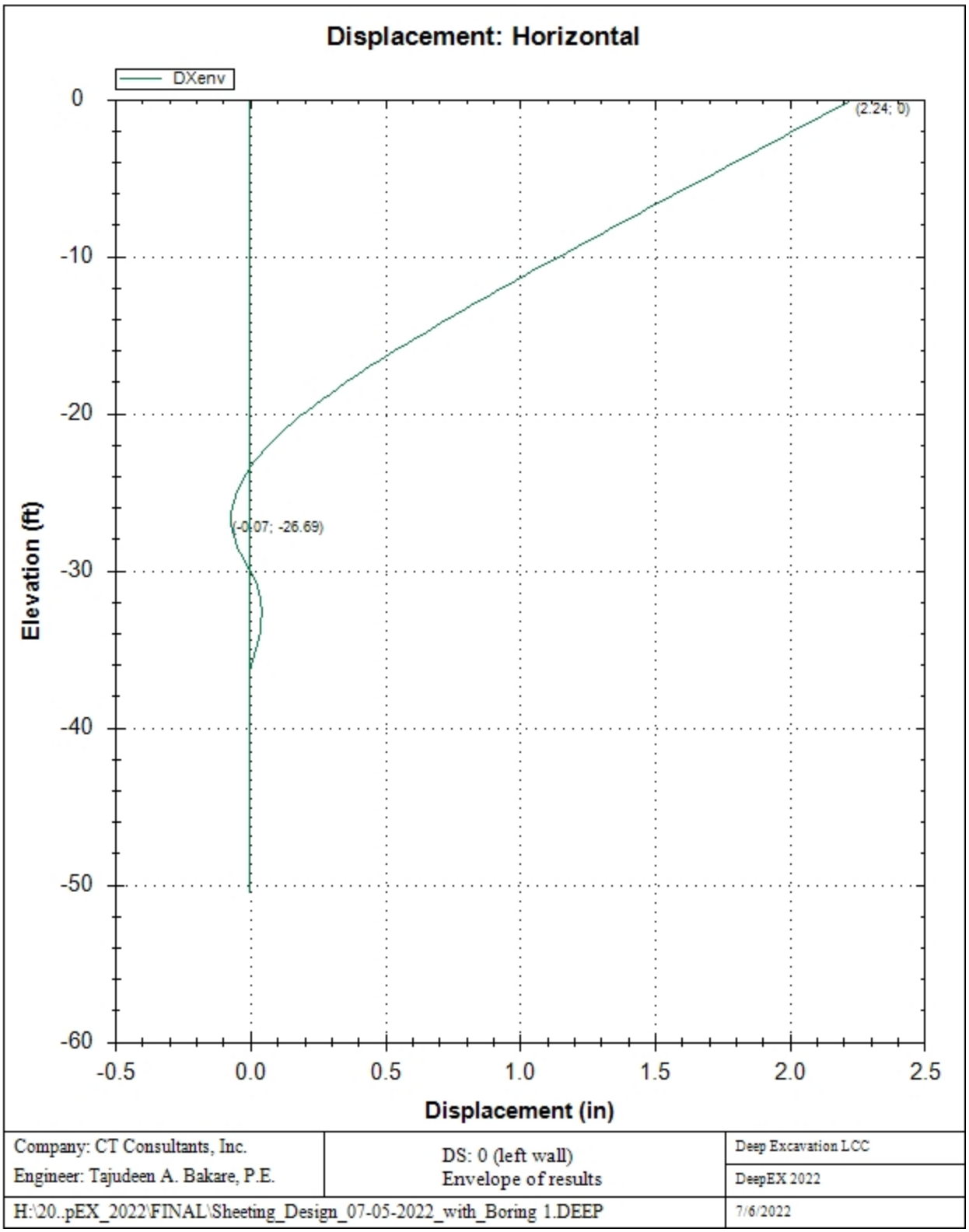


DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:

Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)
F Su'= safety factof for undrained shear strength (Eurocode 7 methods)
F EQ= Load factor for seismic loads
F perm load= Load factor for permanent loads (dead load, etc)
F temp load= Load factor on live loads and other temporary loads
F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks
F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks
F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:
Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)
F Su'= safety factof for undrained shear strength (Eurocode 7 methods)
F EQ= Load factor for seismic loads
F perm load= Load factor for permanent loads (dead load, etc)
F temp load= Load factor on live loads and other temporary loads
F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks
F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks
F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1
1	Default	Service Factors	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1	1

SOIL DATA

Name	g tot	g dry	Frict	C'	Su	FRp	FRcv	Eload	rEur	kAp	kPp	kAcv	kPcv	Vary	Spring	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(deg)	(deg)	(ksf)	(-)	NL	NL	NL	NL		Model	
Sand (128)	128	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sand (125)	125	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sandy Silt (13	134	134	32	125	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	
Sandy Silt (13	136	136	32	100	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	

Name	Poisson	Min Ka	Min sh	ko.NC	nOCR	aH.EXP	aV.EXP	qSkin	qNails	kS.nails	PL
	v	(clays)	(clays)	-	-	(0 to 1)	(0 to 1)	(psi)	(psi)	(k/ft3)	(ksi)
Sand (128)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sand (125)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-

gtot = total soil specific weight
gdry = dry weigth of the soil
Frict = friction angle
C' = effective cohesion
Su = Undrained shear strength (only for CLAY soils in undrained conditions, used as a cutoff strength in NL analysis)
Evc = Virgin compression elastic modulus
Eur = unloading/reloading elastic modulus
Kap = Peak active thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kpp = Peak passive thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kacv = Constant volume active thrust coeff (only for clays, initial value)
Kpcv = Constant volume passive thrust coeff (only for clays, initial value).
Spring models= spring model (LIN= constant E over the soil layer height , EXP=exponential , SIMC=simplified winkler)
LIN= Linear-Elastic-Perfectly Plastic,
EXP: Exponential, SUB: Modulus of Subgrade Reaction
SIMC= Simplified Clay mode

SOIL BORINGS

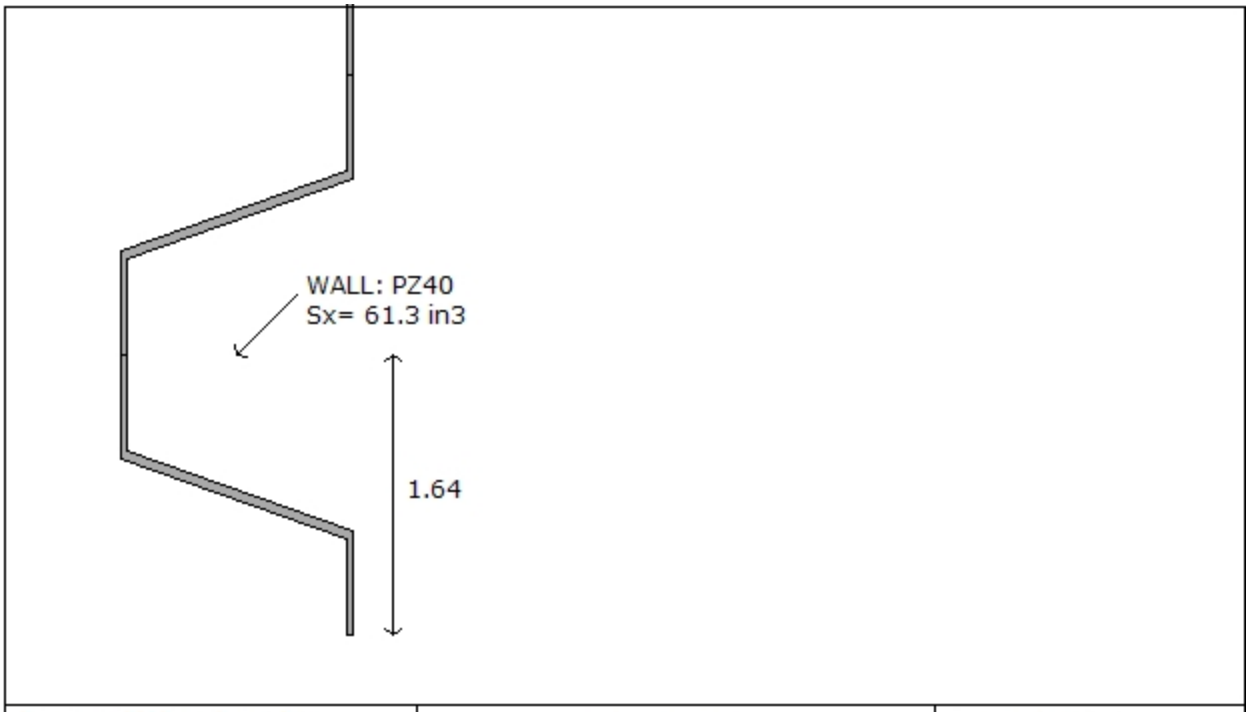
Top Elev= superior SOil level
Soil type= type of the soil (sand , clay , etc)
OCR= overconsolidation ratio
K0= at rest coefficient

Name: Boring B-016-1-19, pos: (0, 0)

Top elev.	Soil type	OCR	Ko
0	Sand (128)	1	0.5
-19	Sand (125)	1	0.5
-22	Sandy Silt (134	1	0.47
-38	Sandy Silt (136	1	0.47
-50	Sandy Silt (136	1	0.47

WALL DATA

Wall section 0: Wall section 0



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	Wall sketch	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Wall type: Steel sheet piling
Top wall El: 0 ft Bottom wall El: -50.5 ft
Hor. wall spacing: 1 ft Wall thickness = 1.37 ft
Passive width below exc: 1 ft Active width below exc: 1 ft Swater= 1 ft
Steel members fy = 50 ksi Esteel = 29000 ksi
Wall friction: Constant value = 17 degrees
Steel wall capacities are calculated with ANSI/AISC 360-10
Concrete capacities are calculated with ACI 318-19
Note: With ultimate capacities you may have to use a structural safety factor.
Steel sheet pile properties

Table: Steel Sheet Pile Cross Sectional Properties

DES	Shape	W	A	h	t	b	s	Ixx	Sxx
		(plf)	(in^2/ft)	(in)	(in)	(in)	(in)	(in^4/ft)	(in^3/ft)
PZ40	Z	65.6	11.75	16.4	0.5	19.69	0.605	503	61.3

GENERAL WALL DATA
Hor wall spacing= Wall horizontal spacing
Passive width below exc= spacing for passive thrust pressure for classic analysis
f'c=fck= cylindrical concrete resistance
fyk=fy= steel rebar characteristic resistance
Econc= Concrete Elastic modulus
fctk= characteristic Concrete tension
Esteel= steel elastic modulus
TABULAR DATA (principal parameters)
1) Diaphragm wall (rectangular cross section)
N/A= data not available
Fy=fyk

F'c=fck
D=wall thickness
B=wall width
2)Steel sheet pile
DES=shape (Z or U)
W=width per unit of length
A=area
h=height
t=horizontal part thickness
b=width of the single sheet pile part
s=inclined part thickness
Ixx=strong axis inertia (per unit of length)
Sxx=strong axis section modulus (per unit of length)
3)Secant piles wall, Tangent piles wall, soldier piles, soldier piles and timber lagging
W=weight per unit of length
A=area
D=diameter
tw=web thickness
tp= pipe thickness
bf=flange width
tf= flange thickness
k= flange thickness+stem base height
Ixx= strong axis inertia modulus (per unit of length)
Sxx= strong axis section modulus (per unit of length)
rx=radius of gyration about X axis
ry=radius of gyration about Y axis
Iyy=weak axis inertia modulus (per unit of length)
Syy=weak axis section modulus (per unit of length)
rT=radius of gyration for torsion
Cw= warping constant

GENERAL ANALYSIS CRITERIA

Summary of stage assumptions

Name	Analysis	Drive	ka-Mult	Htr T/B	Resist	Res	Contle
	Method	Press		(%)	Press	Mult	Method
Stage 0	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth
Stage 1	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth

Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1	20.213	20.213	21.622
Stage 1		N/A	1	1.807	2.535	N/A

Name=excavation stage name

Analysis method

springs = Elastoplastic spring analysis used

DR = Drained condition for CLAY model

U = Undrained condition for CLAY model for all the soils

Up = Undrained condition just for selected soil

Limit equilibrium analysis settings

Drive press:

Ka (Active pressure diagram), Ka-Trap = Trapezoid apparent diagram from active pressures x multiplier,

FHWA= Federal Highway Administration apparent pressure diagrams.

Ko = At-rest lateral earth pressures.

Peck = Peck 1969 Apparent earth pressure diagrams.

2 Step rect = Two step rectangular apparent earth pressure diagram.

User def. = User defined apparent earth pressure diagram.

Ka+d (and so on) indicates that wall friction is applied

ka mult = multiplication factor for Ka when Ka-Trap is selected

Htr T/B (%) = trapezoidal pressure scheme, top and bottom triangular percentage of excavation depth H

Resit press = Kp (passive earth pressures)

Res Mult = Safety factor applied directly on resisting pressures (

COntle Method = cantilever analysis method for limit equilibrium analysis.

Support Model: Method for calculating support reactions in limit-equlibrium analysis.

Beam= support reactions beam analysis (uses Blum's method).

Trib= support reactions from tributary height calculations (Can be applied with apparent diagrams).

Axial Incl = Axial loads included for structural design

Used FS wall = Safety factor for axial+bending wall resistance to divide ultimate wall capacities.

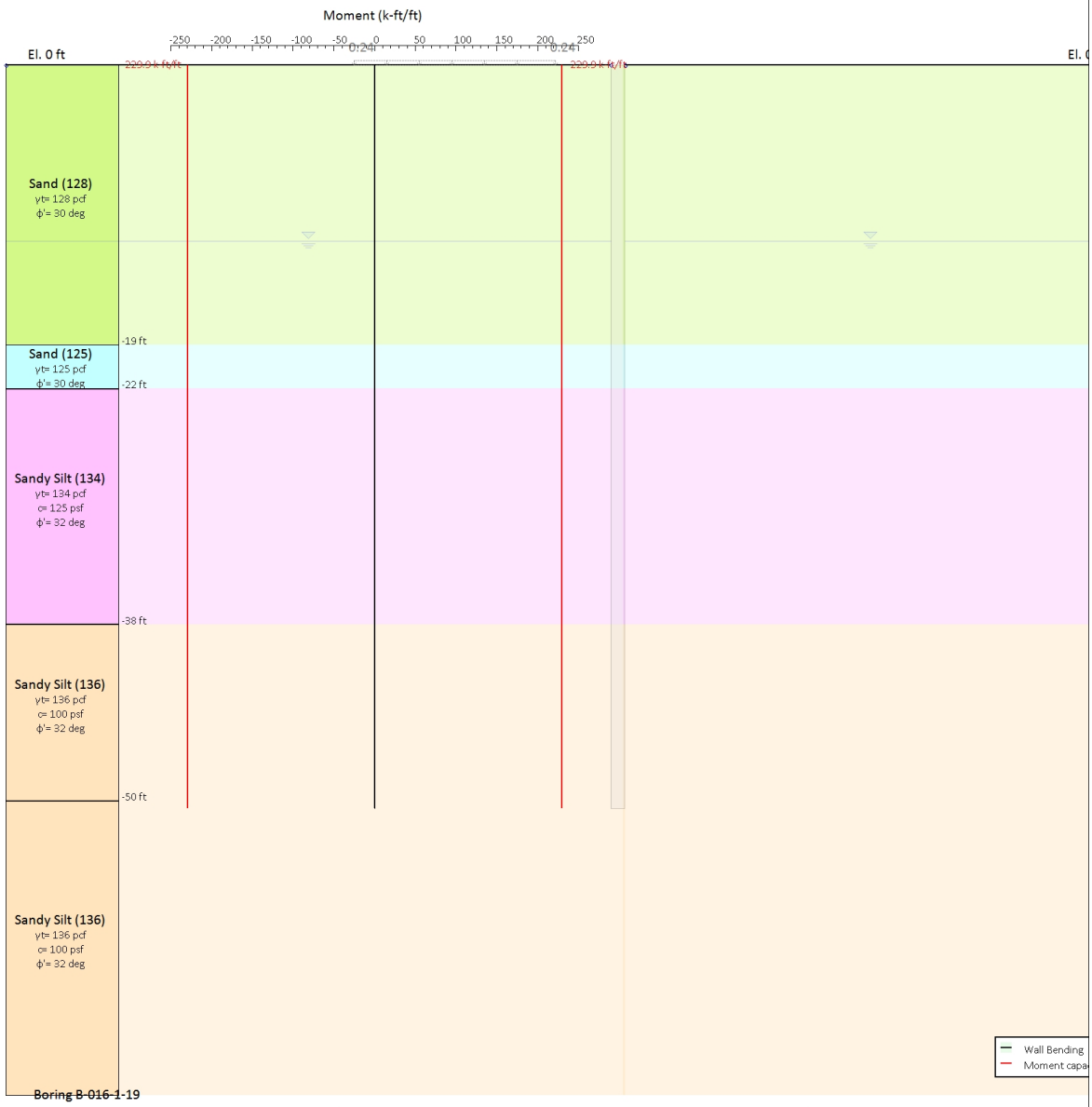
Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)

Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)

Toe FSpas= driving/resisting pressure safety factor (for limit equilibrium analysis)

EXCAVATION STAGES SKETCHES

A sequence of figures for each excavation stage is reported



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0, Stage 0	Deep Excavation LCC DeepEX 2022
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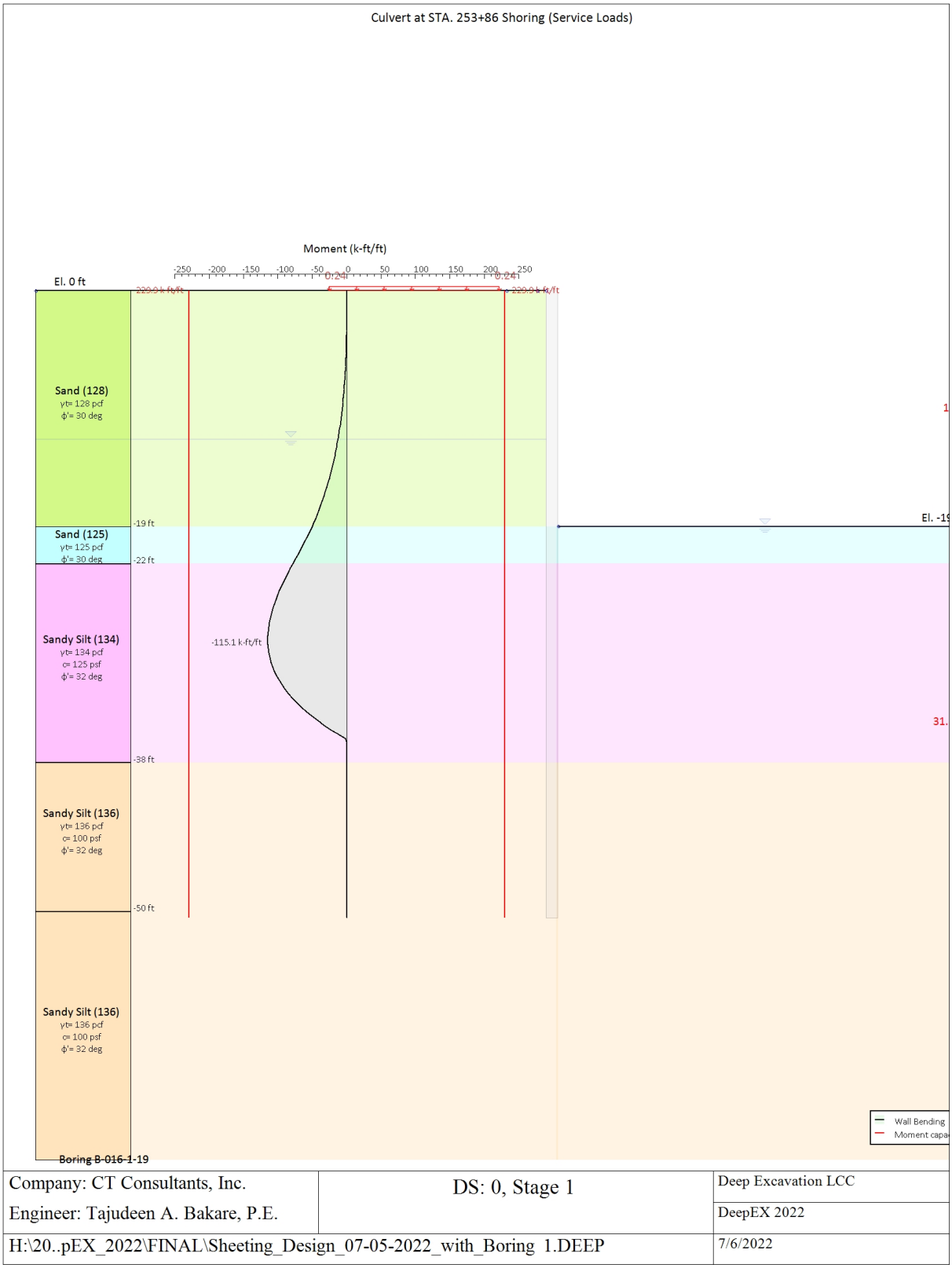


Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0, Stage 1	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring_1.DEEP		7/6/2022

Toe stability

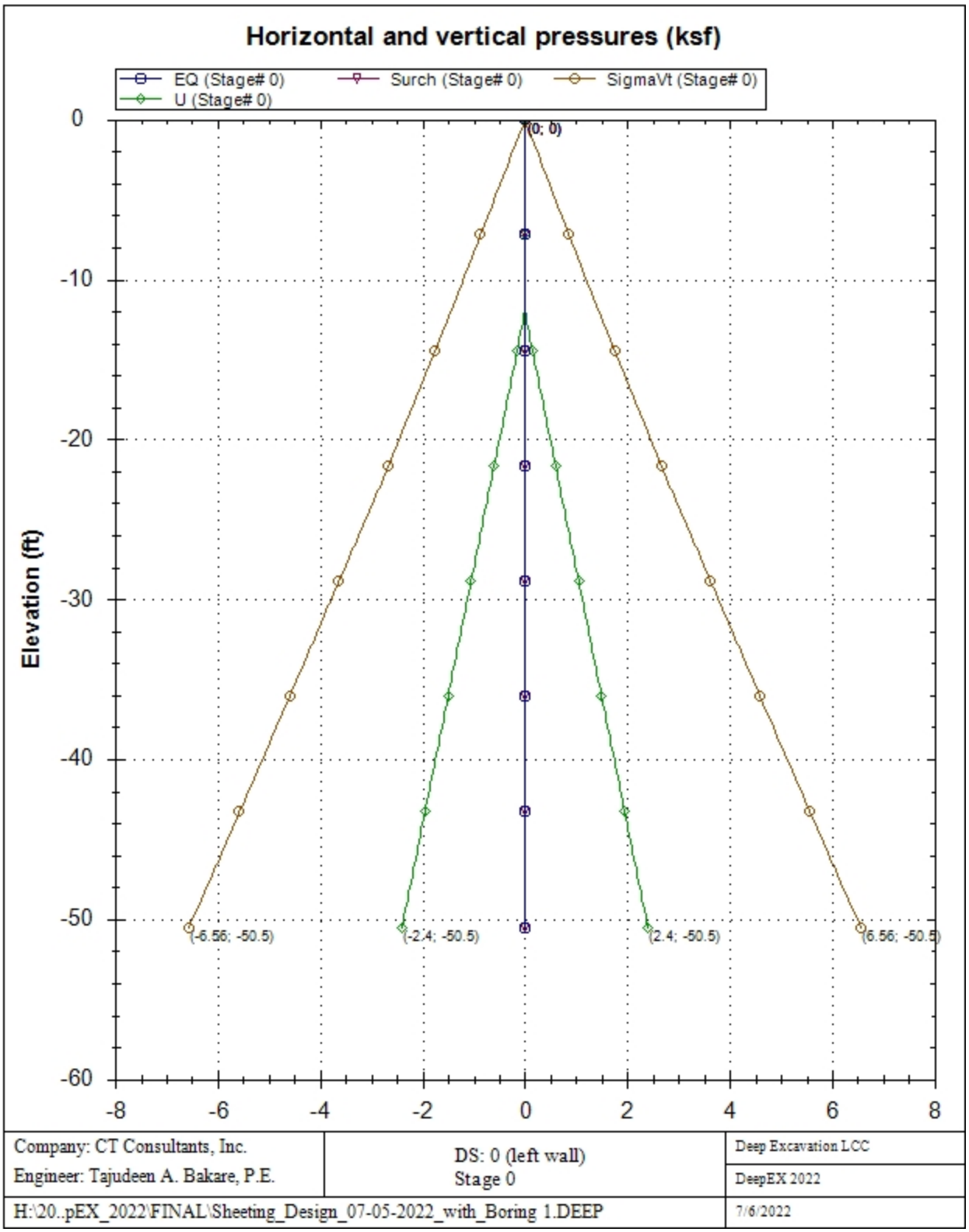
Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	20.213	21.622	20.213	140.278	N/A	N/A
Stage 1	1.807	N/A	2.535	1.807	N/A	N/A

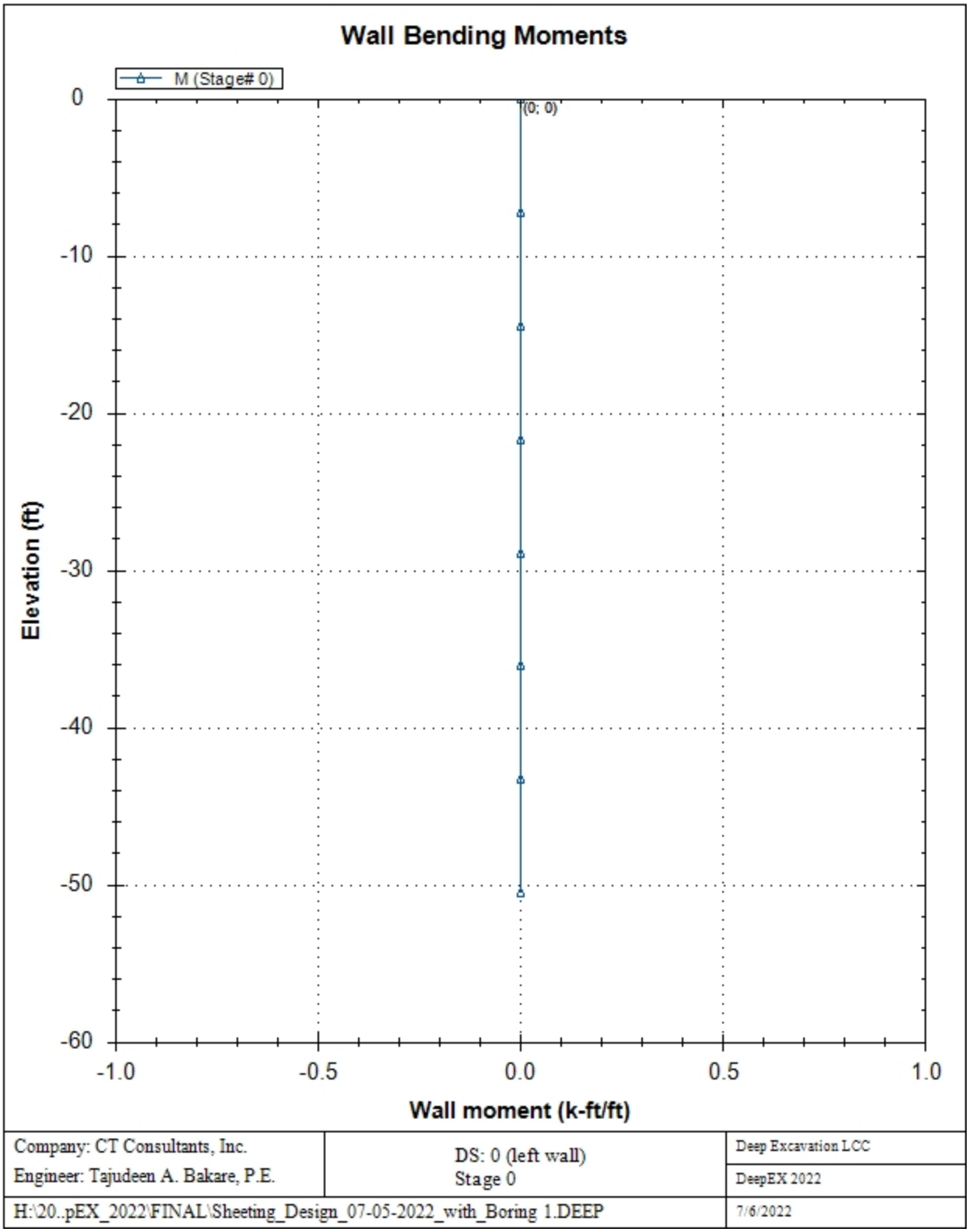
Legend: Wall embedment safety factors (toe)
Min Toe FS= Minimum wall embedment safety factor (from all analysis methods)
Limit-equilibrium analysis methods: The following safety factors may not be applicable for all stages.
FS1 Passive: Horizontal force safety factor, FS1= Resisting/Driving force
FS2 Rotation: Rotational safety factor about lowest support, FS2= Resisting moment/Driving moment
FS3 Length (from FS1, FS2): Program determines maximum required wall embedment for safety factor of 1 for methods FS1 and FS2 (say length LFS1). Then FS length= Provided wall embedment/LFS1.
Non-linear elastoplastic analysis safety factors:
FS4 Mobilized Passive: Safety factor on mobilized passive resistance, FS4= Available passive soil resistance/Mobilized passive soil force on excavation side.
FS5 Active Drive Thrust/Theory Active: Ratio of soil thrust on retained side/ Active condition theoretical minimum thrust. This factor is not as critical, and indicates how close to active conditions the model is.
General recommendations on wall embedment (excluding FS5):
When then excavation is designed with allowable standards, engineers generally use minimum safety factors from 1.2 to 1.5 depending on the level of confidence. A minimum safety factor of 1.2 is generally applied on FS3.
With ultimate limit state designs (such as Eurocode 7, and LRFD) the required safety factor must generally be greater than 1.0. In non-linear solutions it might be impossible to achieve exactly 1 on FS4 as this would likely trigger overall failure.

Result diagrams (for walls)

A sequence of result diagrams for each excavation stage is reported



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Stage 0	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Stage 0	Deep Excavation LCC DeepEX 2022
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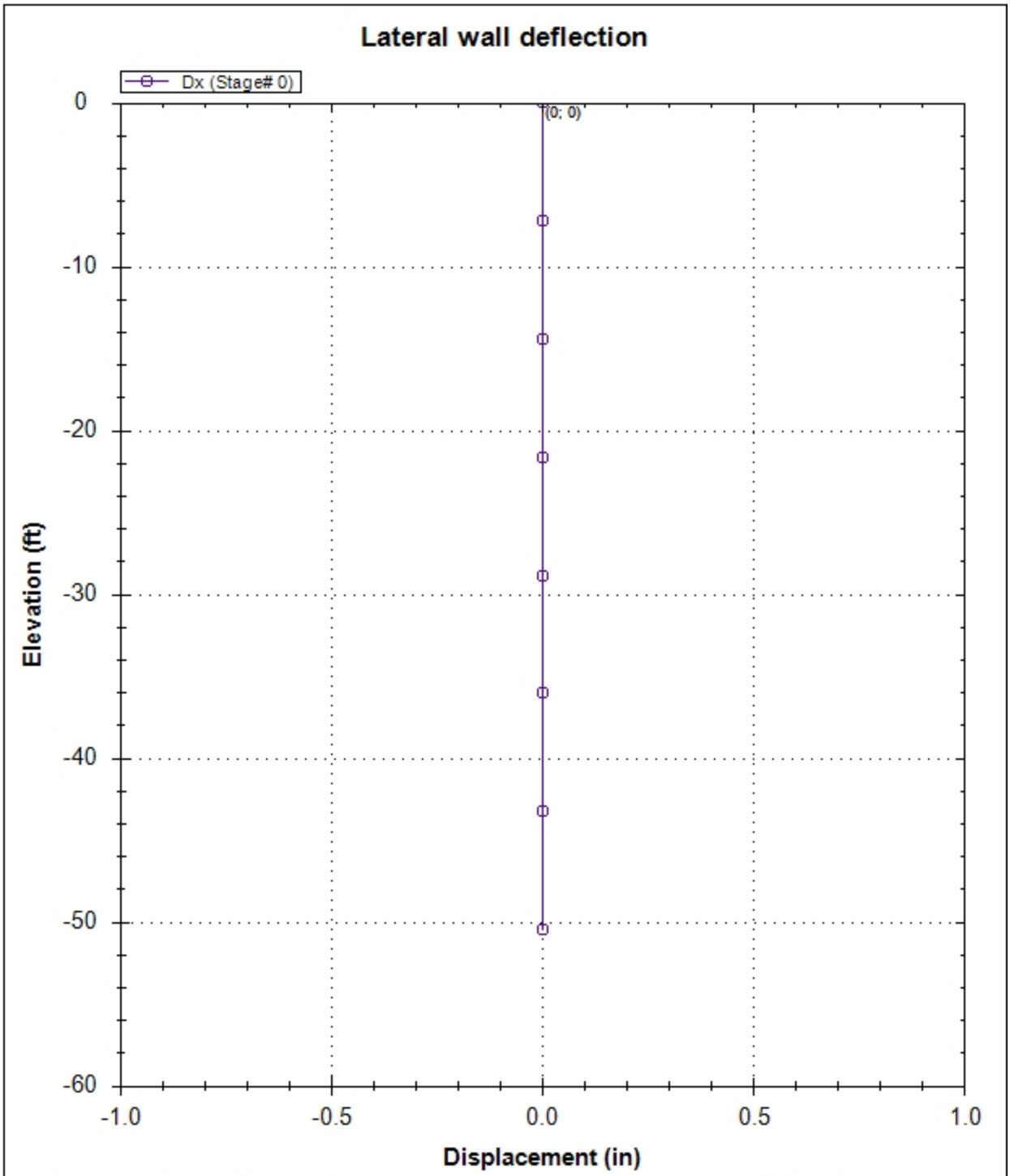

Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Stage 0	Deep Excavation LCC DeepEX 2022
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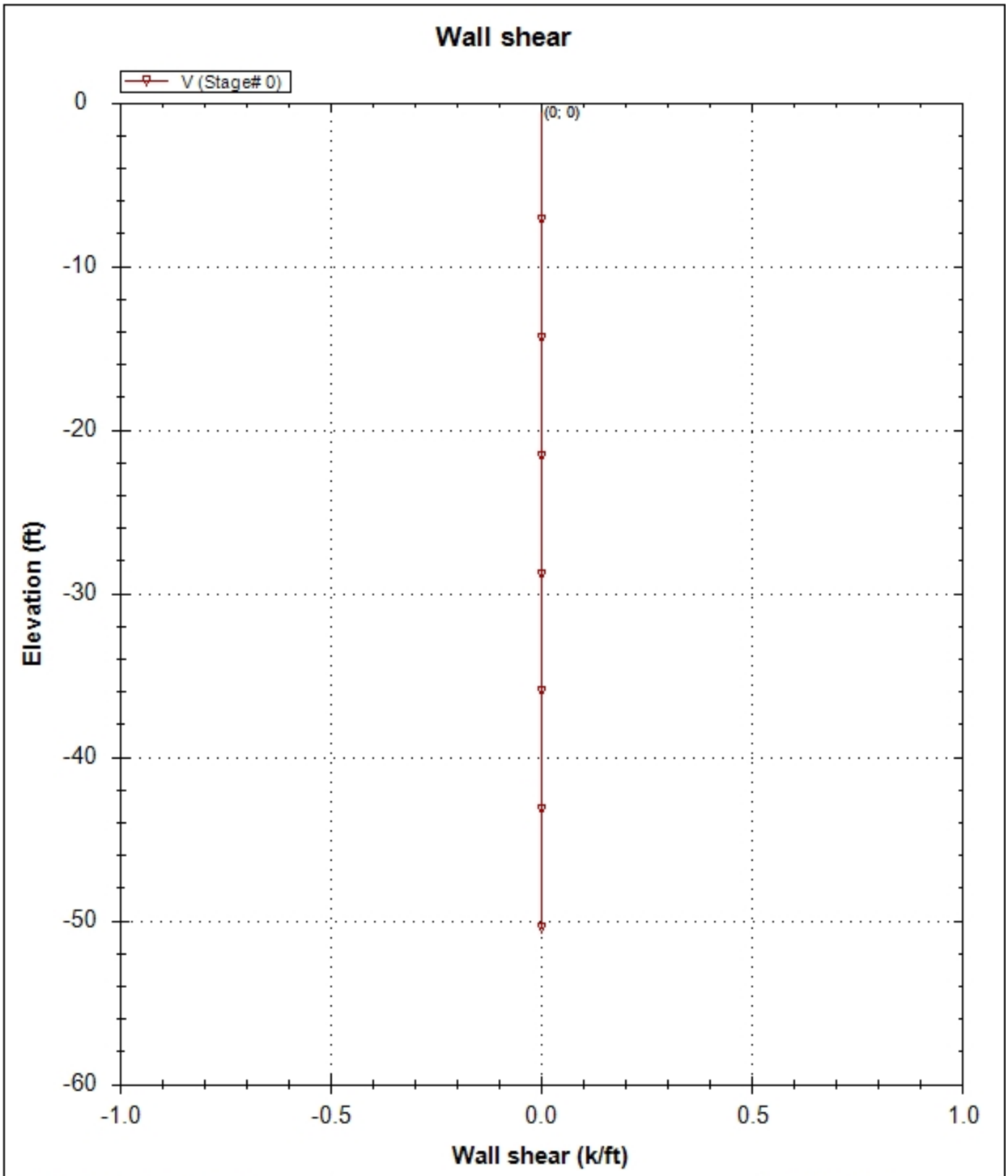

Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Stage 0	Deep Excavation LCC DeepEX 2022
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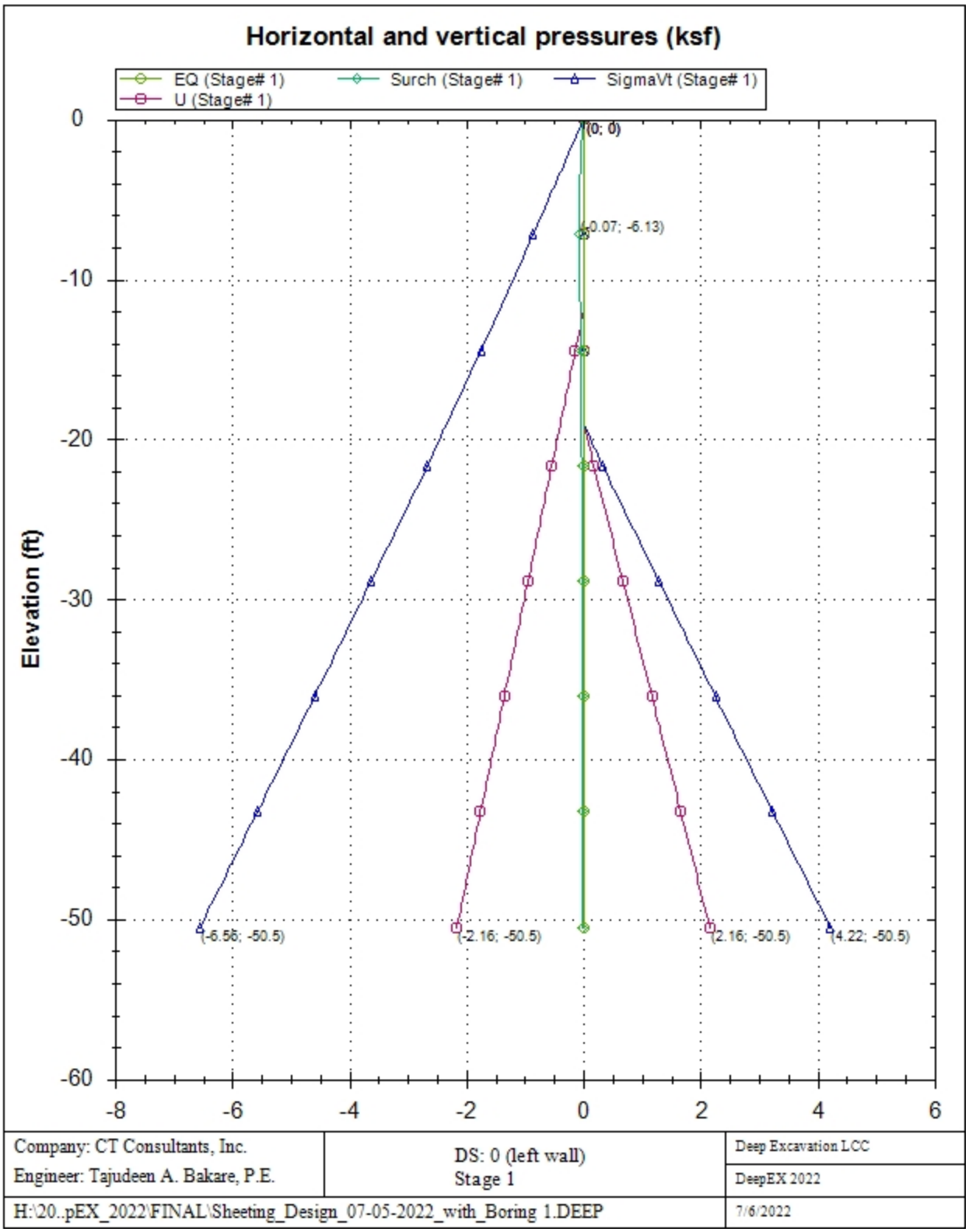

Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Stage 1	Deep Excavation LCC DeepEX 2022
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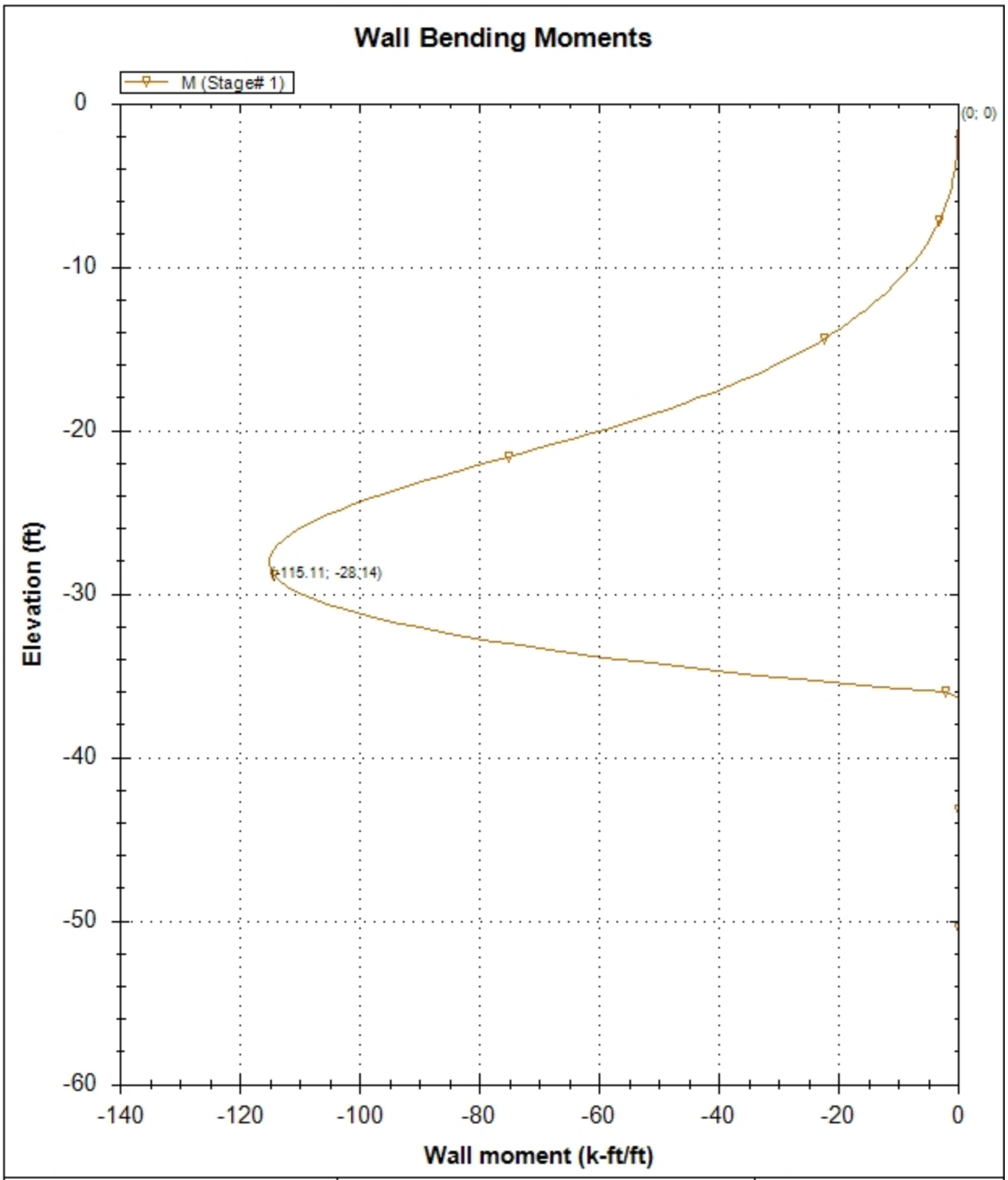

Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Stage 1	Deep Excavation LCC DeepEX 2022
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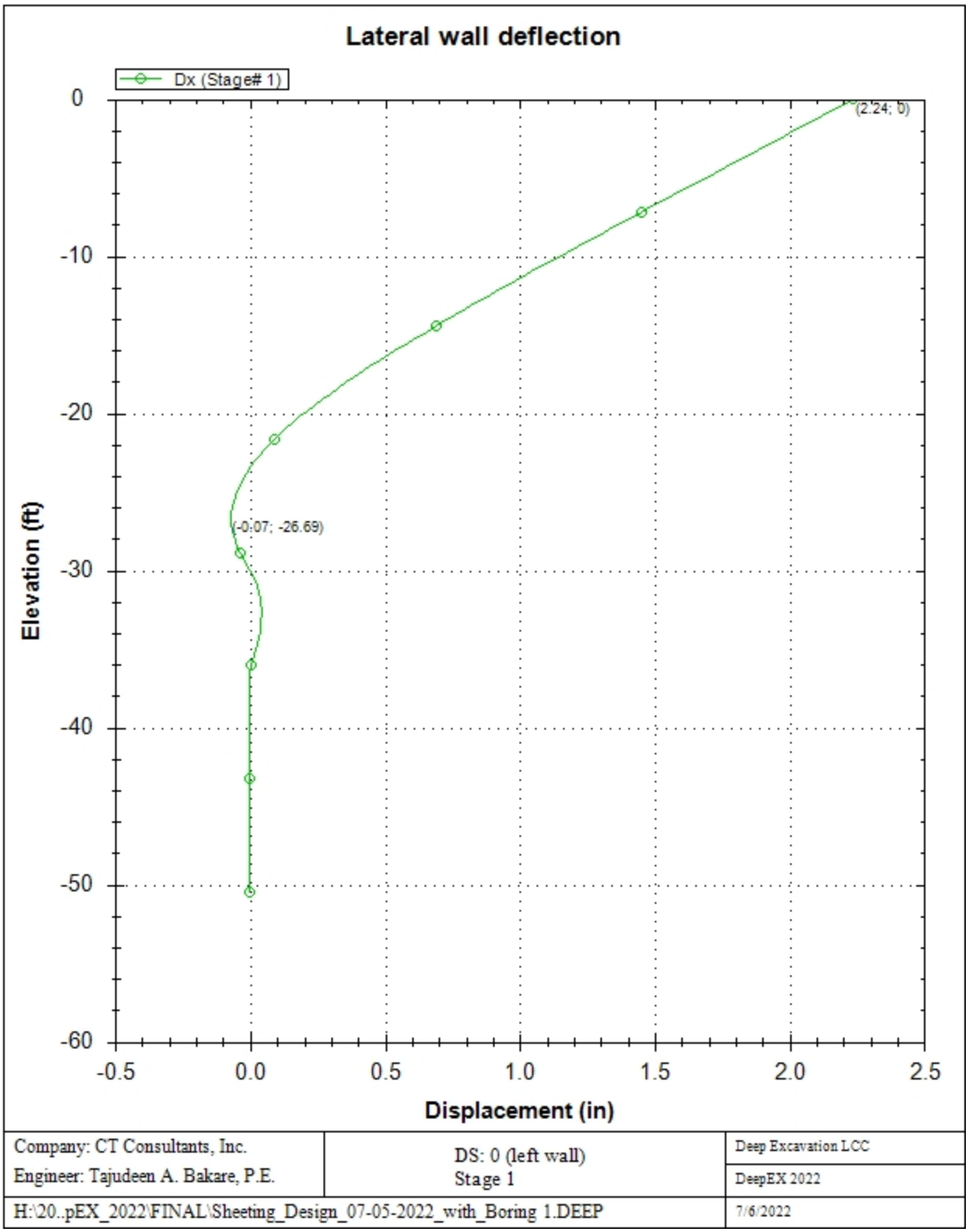

Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 0 (left wall) Stage 1	Deep Excavation LCC DeepEX 2022
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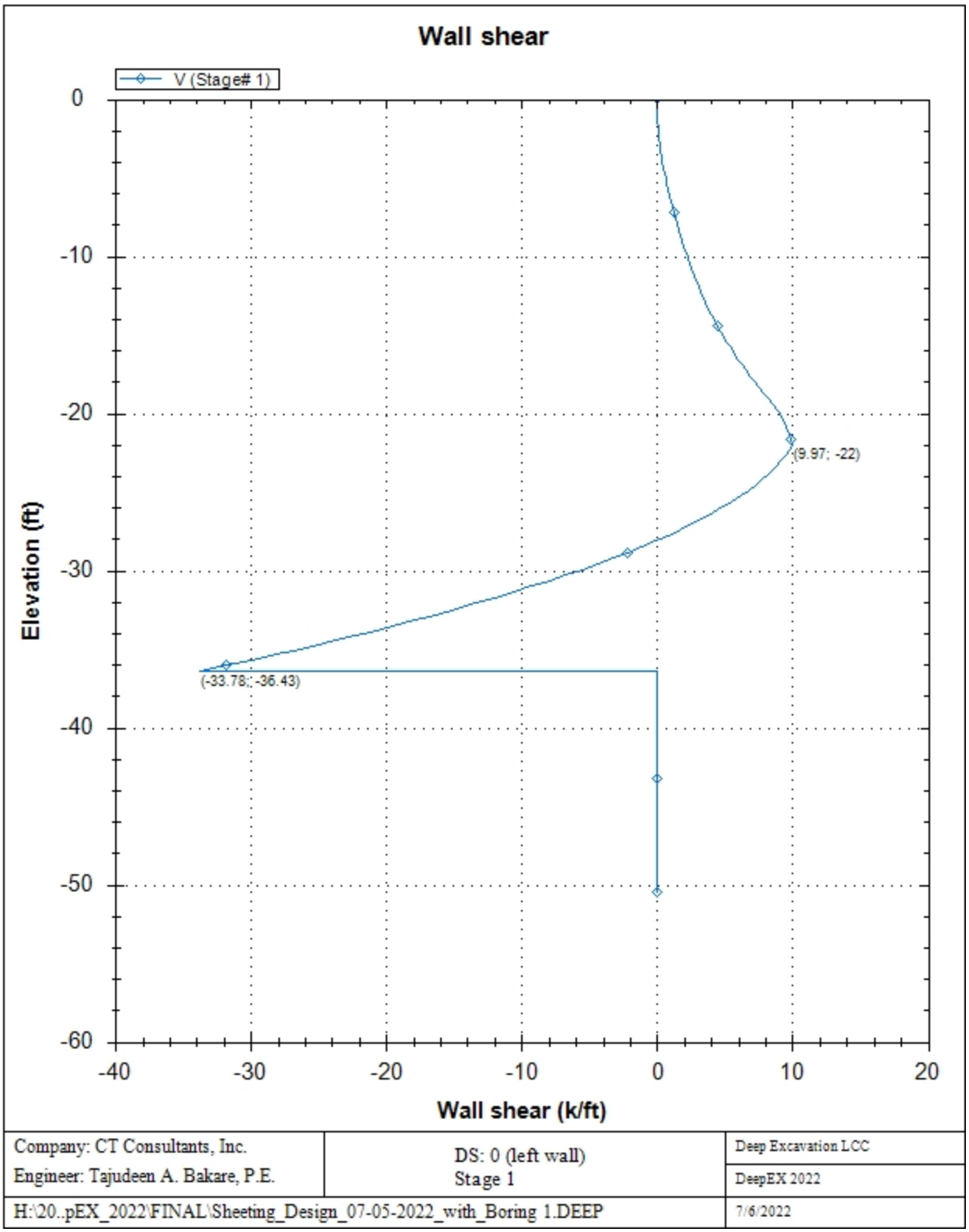


WALL RESULTS TABLE

Wall 1 Stage: 0

Wall	EL	Sht L	Sht R	Shs L	Shs R	q	U L	U R	M	V	dx	Mcap L	Mcap R	VcapL	VcapR
Node	(ft)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(k-ft/ft)	(klf)	(in)	(k-ft/ft)	(k-ft/ft)	(klf)	(klf)
0	0	0	0	0	0	0	0	0	0	0	0	229.88	229.88	163.27	163.27
2	-0.72	0.025	0.405	0.025	0.405	0	0	0	0	0	0	229.88	229.88	163.27	163.27
4	-1.44	0.05	0.809	0.05	0.809	0	0	0	0	0	0	229.88	229.88	163.27	163.27
6	-2.16	0.074	1.214	0.074	1.214	0	0	0	0	0	0	229.88	229.88	163.27	163.27
8	-2.89	0.099	1.618	0.099	1.618	0	0	0	0	0	0	229.88	229.88	163.27	163.27
10	-3.61	0.124	2.023	0.124	2.023	0	0	0	0	0	0	229.88	229.88	163.27	163.27
12	-4.33	0.149	2.427	0.149	2.427	0	0	0	0	0	0	229.88	229.88	163.27	163.27
14	-5.05	0.174	2.832	0.174	2.832	0	0	0	0	0	0	229.88	229.88	163.27	163.27
16	-5.77	0.198	3.236	0.198	3.236	0	0	0	0	0	0	229.88	229.88	163.27	163.27
18	-6.49	0.223	3.641	0.223	3.641	0	0	0	0	0	0	229.88	229.88	163.27	163.27
20	-7.21	0.248	4.046	0.248	4.046	0	0	0	0	0	0	229.88	229.88	163.27	163.27
22	-7.94	0.273	4.45	0.273	4.45	0	0	0	0	0	0	229.88	229.88	163.27	163.27
24	-8.66	0.297	4.855	0.297	4.855	0	0	0	0	0	0	229.88	229.88	163.27	163.27
26	-9.38	0.322	5.259	0.322	5.259	0	0	0	0	0	0	229.88	229.88	163.27	163.27
28	-10.1	0.347	5.664	0.347	5.664	0	0	0	0	0	0	229.88	229.88	163.27	163.27
30	-10.82	0.372	6.068	0.372	6.068	0	0	0	0	0	0	229.88	229.88	163.27	163.27
32	-11.54	0.397	6.473	0.397	6.473	0	0	0	0	0	0	229.88	229.88	163.27	163.27
34	-12.26	0.434	6.83	0.418	6.814	0	0.016	0.016	0	0	0	229.88	229.88	163.27	163.27
36	-12.99	0.493	7.097	0.431	7.035	0	0.062	0.062	0	0	0	229.88	229.88	163.27	163.27
38	-13.71	0.551	7.363	0.445	7.256	0	0.107	0.107	0	0	0	229.88	229.88	163.27	163.27
40	-14.43	0.61	7.629	0.458	7.477	0	0.152	0.152	0	0	0	229.88	229.88	163.27	163.27
42	-15.15	0.668	7.895	0.472	7.699	0	0.197	0.197	0	0	0	229.88	229.88	163.27	163.27
44	-15.87	0.727	8.161	0.485	7.92	0	0.242	0.242	0	0	0	229.88	229.88	163.27	163.27
46	-16.59	0.785	8.428	0.499	8.141	0	0.287	0.287	0	0	0	229.88	229.88	163.27	163.27
48	-17.31	0.844	8.694	0.512	8.362	0	0.332	0.332	0	0	0	229.88	229.88	163.27	163.27
50	-18.04	0.903	8.96	0.526	8.583	0	0.377	0.377	0	0	0	229.88	229.88	163.27	163.27
52	-18.76	0.961	9.226	0.54	8.804	0	0.422	0.422	0	0	0	229.88	229.88	163.27	163.27
54	-19.48	1.019	9.486	0.553	9.019	0	0.467	0.467	0	0	0	229.88	229.88	163.27	163.27
56	-20.2	1.077	9.742	0.566	9.23	0	0.512	0.512	0	0	0	229.88	229.88	163.27	163.27
58	-20.92	1.135	9.998	0.579	9.441	0	0.557	0.557	0	0	0	229.88	229.88	163.27	163.27
60	-21.64	1.193	10.254	0.591	9.652	0	0.602	0.602	0	0	0	229.88	229.88	163.27	163.27
62	-22.36	1.079	12.219	0.432	11.573	0	0.647	0.647	0	0	0	229.88	229.88	163.27	163.27
64	-23.09	1.137	12.533	0.446	11.841	0	0.692	0.692	0	0	0	229.88	229.88	163.27	163.27
66	-23.81	1.196	12.847	0.459	12.11	0	0.737	0.737	0	0	0	229.88	229.88	163.27	163.27
68	-24.53	1.255	13.161	0.473	12.379	0	0.782	0.782	0	0	0	229.88	229.88	163.27	163.27
70	-25.25	1.314	13.475	0.487	12.648	0	0.827	0.827	0	0	0	229.88	229.88	163.27	163.27
72	-25.97	1.372	13.789	0.5	12.917	0	0.872	0.872	0	0	0	229.88	229.88	163.27	163.27
74	-26.69	1.431	14.103	0.514	13.186	0	0.917	0.917	0	0	0	229.88	229.88	163.27	163.27
76	-27.41	1.49	14.416	0.528	13.455	0	0.962	0.962	0	0	0	229.88	229.88	163.27	163.27
78	-28.14	1.548	14.73	0.542	13.723	0	1.007	1.007	0	0	0	229.88	229.88	163.27	163.27
80	-28.86	1.607	15.044	0.555	13.992	0	1.052	1.052	0	0	0	229.88	229.88	163.27	163.27
82	-29.58	1.666	15.358	0.569	14.261	0	1.097	1.097	0	0	0	229.88	229.88	163.27	163.27
84	-30.3	1.725	15.672	0.583	14.53	0	1.142	1.142	0	0	0	229.88	229.88	163.27	163.27
86	-31.02	1.783	15.986	0.596	14.799	0	1.187	1.187	0	0	0	229.88	229.88	163.27	163.27
88	-31.74	1.842	16.3	0.61	15.068	0	1.232	1.232	0	0	0	229.88	229.88	163.27	163.27
90	-32.46	1.901	16.613	0.624	15.336	0	1.277	1.277	0	0	0	229.88	229.88	163.27	163.27
92	-33.19	1.959	16.927	0.637	15.605	0	1.322	1.322	0	0	0	229.88	229.88	163.27	163.27
94	-33.91	2.018	17.241	0.651	15.874	0	1.367	1.367	0	0	0	229.88	229.88	163.27	163.27

96	-34.63	2.077	17.555	0.665	16.143	0	1.412	1.412	0	0	0	229.88	229.88	163.27	163.27
98	-35.35	2.136	17.869	0.679	16.412	0	1.457	1.457	0	0	0	229.88	229.88	163.27	163.27
100	-36.07	2.194	18.183	0.692	16.681	0	1.502	1.502	0	0	0	229.88	229.88	163.27	163.27
102	-36.79	2.253	18.497	0.706	16.95	0	1.547	1.547	0	0	0	229.88	229.88	163.27	163.27
104	-37.51	2.312	18.811	0.72	17.218	0	1.592	1.592	0	0	0	229.88	229.88	163.27	163.27
106	-38.24	2.396	19.013	0.759	17.376	0	1.637	1.637	0	0	0	229.88	229.88	163.27	163.27
108	-38.96	2.455	19.334	0.773	17.652	0	1.682	1.682	0	0	0	229.88	229.88	163.27	163.27
110	-39.68	2.514	19.656	0.787	17.928	0	1.727	1.727	0	0	0	229.88	229.88	163.27	163.27
112	-40.4	2.574	19.977	0.801	18.205	0	1.772	1.772	0	0	0	229.88	229.88	163.27	163.27
114	-41.12	2.633	20.298	0.816	18.481	0	1.817	1.817	0	0	0	229.88	229.88	163.27	163.27
116	-41.84	2.692	20.62	0.83	18.758	0	1.862	1.862	0	0	0	229.88	229.88	163.27	163.27
118	-42.56	2.751	20.941	0.844	19.034	0	1.907	1.907	0	0	0	229.88	229.88	163.27	163.27
120	-43.29	2.81	21.262	0.858	19.31	0	1.952	1.952	0	0	0	229.88	229.88	163.27	163.27
122	-44.01	2.869	21.584	0.872	19.587	0	1.997	1.997	0	0	0	229.88	229.88	163.27	163.27
124	-44.73	2.928	21.905	0.886	19.863	0	2.042	2.042	0	0	0	229.88	229.88	163.27	163.27
126	-45.45	2.987	22.227	0.9	20.139	0	2.087	2.087	0	0	0	229.88	229.88	163.27	163.27
128	-46.17	3.046	22.548	0.914	20.416	0	2.132	2.132	0	0	0	229.88	229.88	163.27	163.27
130	-46.89	3.105	22.869	0.928	20.692	0	2.177	2.177	0	0	0	229.88	229.88	163.27	163.27
132	-47.61	3.165	23.191	0.942	20.968	0	2.222	2.222	0	0	0	229.88	229.88	163.27	163.27
134	-48.34	3.224	23.512	0.956	21.245	0	2.267	2.267	0	0	0	229.88	229.88	163.27	163.27
136	-49.06	3.283	23.834	0.97	21.521	0	2.312	2.312	0	0	0	229.88	229.88	163.27	163.27
138	-49.78	3.342	24.155	0.985	21.798	0	2.357	2.357	0	0	0	229.88	229.88	163.27	163.27
140	-50.5	3.401	24.476	0.999	22.074	0	2.402	2.402	0	0	0	229.88	229.88	163.27	163.27

Wall 1 Stage: 1

Wall	EL	Sht L	Sht R	Shs L	Shs R	q	U L	U R	M	V	dx	Mcap L	Mcap R	VcapL	VcapR
Node	(ft)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(ksf)	(k-ft/ft)	(klf)	(in)	(k-ft/ft)	(k-ft/ft)	(klf)	(klf)
0	0	0	0	0	0	0	0	0	0	0	2.24	229.88	229.88	163.27	163.27
2	-0.72	0.025	0	0.025	0	0.015	0	0	0	0.01	2.16	229.88	229.88	163.27	163.27
4	-1.44	0.05	0	0.05	0	0.03	0	0	0.03	0.06	2.08	229.88	229.88	163.27	163.27
6	-2.16	0.074	0	0.074	0	0.042	0	0	0.09	0.13	2	229.88	229.88	163.27	163.27
8	-2.89	0.099	0	0.099	0	0.051	0	0	0.22	0.22	1.92	229.88	229.88	163.27	163.27
10	-3.61	0.124	0	0.124	0	0.058	0	0	0.42	0.34	1.84	229.88	229.88	163.27	163.27
12	-4.33	0.149	0	0.149	0	0.063	0	0	0.72	0.49	1.76	229.88	229.88	163.27	163.27
14	-5.05	0.174	0	0.174	0	0.065	0	0	1.13	0.65	1.69	229.88	229.88	163.27	163.27
16	-5.77	0.198	0	0.198	0	0.067	0	0	1.66	0.83	1.61	229.88	229.88	163.27	163.27
18	-6.49	0.223	0	0.223	0	0.067	0	0	2.33	1.03	1.53	229.88	229.88	163.27	163.27
20	-7.21	0.248	0	0.248	0	0.066	0	0	3.15	1.25	1.45	229.88	229.88	163.27	163.27
22	-7.94	0.273	0	0.273	0	0.065	0	0	4.14	1.48	1.37	229.88	229.88	163.27	163.27
24	-8.66	0.297	0	0.297	0	0.063	0	0	5.3	1.74	1.29	229.88	229.88	163.27	163.27
26	-9.38	0.322	0	0.322	0	0.061	0	0	6.65	2	1.22	229.88	229.88	163.27	163.27
28	-10.1	0.347	0	0.347	0	0.059	0	0	8.19	2.29	1.14	229.88	229.88	163.27	163.27
30	-10.82	0.372	0	0.372	0	0.057	0	0	9.95	2.59	1.06	229.88	229.88	163.27	163.27
32	-11.54	0.397	0	0.397	0	0.055	0	0	11.94	2.91	0.98	229.88	229.88	163.27	163.27
34	-12.26	0.433	0	0.418	0	0.052	0.015	0	14.15	3.24	0.91	229.88	229.88	163.27	163.27
36	-12.99	0.488	0	0.433	0	0.05	0.055	0	16.62	3.61	0.84	229.88	229.88	163.27	163.27
38	-13.71	0.544	0	0.448	0	0.048	0.096	0	19.37	4.02	0.76	229.88	229.88	163.27	163.27
40	-14.43	0.599	0	0.463	0	0.046	0.136	0	22.43	4.47	0.69	229.88	229.88	163.27	163.27
42	-15.15	0.654	0	0.477	0	0.043	0.177	0	25.82	4.95	0.62	229.88	229.88	163.27	163.27
44	-15.87	0.71	0	0.492	0	0.041	0.217	0	29.58	5.47	0.55	229.88	229.88	163.27	163.27
46	-16.59	0.765	0	0.507	0	0.039	0.258	0	33.73	6.03	0.48	229.88	229.88	163.27	163.27
48	-17.31	0.82	0	0.522	0	0.037	0.298	0	38.29	6.63	0.42	229.88	229.88	163.27	163.27

50	-18.04	0.876	0	0.537	0	0.036	0.339	0	43.31	7.27	0.36	229.88	229.88	163.27	163.27
52	-18.76	0.931	0	0.552	0	0.034	0.379	0	48.79	7.95	0.3	229.88	229.88	163.27	163.27
54	-19.48	0.986	0.159	0.566	0.126	0.032	0.42	0.033	54.78	8.62	0.24	229.88	229.88	163.27	163.27
56	-20.2	1.041	0.398	0.58	0.316	0.031	0.461	0.082	61.21	9.18	0.19	229.88	229.88	163.27	163.27
58	-20.92	1.095	0.638	0.594	0.506	0.029	0.501	0.132	67.99	9.6	0.14	229.88	229.88	163.27	163.27
60	-21.64	1.15	0.877	0.609	0.696	0.028	0.542	0.181	75.02	9.88	0.09	229.88	229.88	163.27	163.27
62	-22.36	1.031	1.805	0.449	1.574	0.026	0.582	0.231	82.15	9.72	0.05	229.88	229.88	163.27	163.27
64	-23.09	1.087	2.1	0.464	1.82	0.025	0.623	0.28	88.95	9.09	0.02	229.88	229.88	163.27	163.27
66	-23.81	1.142	2.395	0.479	2.065	0.024	0.663	0.33	95.23	8.29	-0.01	229.88	229.88	163.27	163.27
68	-24.53	1.197	2.69	0.494	2.311	0.023	0.704	0.379	100.88	7.32	-0.04	229.88	229.88	163.27	163.27
70	-25.25	1.253	2.985	0.509	2.556	0.022	0.744	0.429	105.75	6.17	-0.05	229.88	229.88	163.27	163.27
72	-25.97	1.308	3.28	0.524	2.801	0.021	0.785	0.479	109.74	4.85	-0.07	229.88	229.88	163.27	163.27
74	-26.69	1.364	3.575	0.538	3.047	0.02	0.825	0.528	112.71	3.36	-0.07	229.88	229.88	163.27	163.27
76	-27.41	1.419	3.87	0.553	3.292	0.019	0.866	0.578	114.55	1.69	-0.07	229.88	229.88	163.27	163.27
78	-28.14	1.474	4.165	0.568	3.538	0.018	0.906	0.627	115.11	-0.15	-0.06	229.88	229.88	163.27	163.27
80	-28.86	1.53	4.46	0.583	3.783	0.017	0.947	0.677	114.29	-2.17	-0.04	229.88	229.88	163.27	163.27
82	-29.58	1.585	4.755	0.598	4.028	0.016	0.987	0.726	111.95	-4.35	-0.01	229.88	229.88	163.27	163.27
84	-30.3	1.641	5.05	0.613	4.274	0.016	1.028	0.776	107.96	-6.71	0.01	229.88	229.88	163.27	163.27
86	-31.02	1.696	5.344	0.628	4.519	0.015	1.068	0.825	102.22	-9.25	0.03	229.88	229.88	163.27	163.27
88	-31.74	1.751	5.639	0.643	4.765	0.014	1.109	0.875	94.58	-11.96	0.04	229.88	229.88	163.27	163.27
90	-32.46	1.807	5.934	0.658	5.01	0.014	1.149	0.924	84.92	-14.84	0.04	229.88	229.88	163.27	163.27
92	-33.19	1.862	6.229	0.672	5.256	0.013	1.19	0.974	73.12	-17.89	0.04	229.88	229.88	163.27	163.27
94	-33.91	1.918	6.524	0.687	5.501	0.012	1.23	1.023	59.06	-21.12	0.04	229.88	229.88	163.27	163.27
96	-34.63	1.973	6.819	0.702	5.746	0.012	1.271	1.073	42.61	-24.52	0.03	229.88	229.88	163.27	163.27
98	-35.35	2.028	7.114	0.717	5.992	0.011	1.311	1.122	23.64	-28.1	0.02	229.88	229.88	163.27	163.27
100	-36.07	2.084	7.409	0.732	6.237	0.011	1.352	1.172	2.03	-31.84	0.01	229.88	229.88	163.27	163.27
102	-36.79	2.139	7.704	0.747	6.483	0.01	1.392	1.221	0	0	0	229.88	229.88	163.27	163.27
104	-37.51	2.195	7.999	0.762	6.728	0.01	1.433	1.271	0	0	0	229.88	229.88	163.27	163.27
106	-38.24	2.276	8.182	0.803	6.862	0.01	1.473	1.32	0	0	0	229.88	229.88	163.27	163.27
108	-38.96	2.332	8.485	0.818	7.115	0.009	1.514	1.37	0	0	0	229.88	229.88	163.27	163.27
110	-39.68	2.388	8.787	0.833	7.368	0.009	1.554	1.419	0	0	0	229.88	229.88	163.27	163.27
112	-40.4	2.443	9.09	0.848	7.621	0.008	1.595	1.469	0	0	0	229.88	229.88	163.27	163.27
114	-41.12	2.499	9.392	0.864	7.874	0.008	1.635	1.518	0	0	0	229.88	229.88	163.27	163.27
116	-41.84	2.555	9.695	0.879	8.127	0.008	1.676	1.568	0	0	0	229.88	229.88	163.27	163.27
118	-42.56	2.611	9.997	0.894	8.38	0.007	1.716	1.617	0	0	0	229.88	229.88	163.27	163.27
120	-43.29	2.667	10.299	0.91	8.632	0.007	1.757	1.667	0	0	0	229.88	229.88	163.27	163.27
122	-44.01	2.722	10.602	0.925	8.885	0.007	1.798	1.716	0	0	0	229.88	229.88	163.27	163.27
124	-44.73	2.778	10.904	0.94	9.138	0.007	1.838	1.766	0	0	0	229.88	229.88	163.27	163.27
126	-45.45	2.834	11.207	0.955	9.391	0.006	1.879	1.816	0	0	0	229.88	229.88	163.27	163.27
128	-46.17	2.89	11.509	0.971	9.644	0.006	1.919	1.865	0	0	0	229.88	229.88	163.27	163.27
130	-46.89	2.946	11.812	0.986	9.897	0.006	1.96	1.915	0	0	0	229.88	229.88	163.27	163.27
132	-47.61	3.001	12.114	1.001	10.15	0.006	2	1.964	0	0	0	229.88	229.88	163.27	163.27
134	-48.34	3.057	12.417	1.016	10.403	0.005	2.041	2.014	0	0	0	229.88	229.88	163.27	163.27
136	-49.06	3.113	12.719	1.032	10.656	0.005	2.081	2.063	0	0	0	229.88	229.88	163.27	163.27
138	-49.78	3.169	13.021	1.047	10.909	0.005	2.122	2.113	0	0	0	229.88	229.88	163.27	163.27
140	-50.5	3.224	13.324	1.062	11.162	0.005	2.162	2.162	0	0	0	229.88	229.88	163.27	163.27

LEGEND

Wall node=number of the node (0 at top)

EL= Node elevation

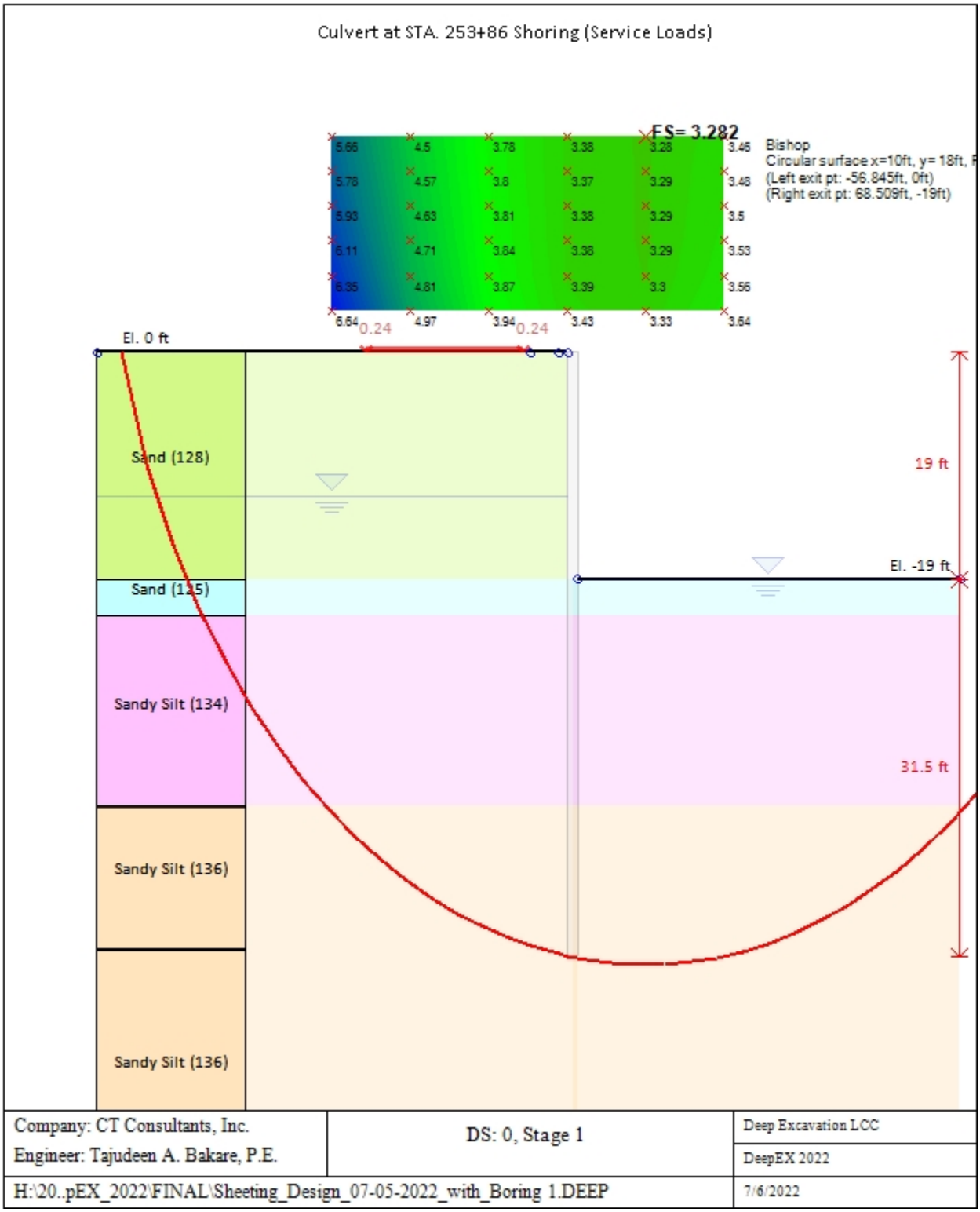
Sht L=Total horizontal soil pressure (on the left side of the wall)

Sht R=Total horizontal soil pressure (on the right side of the wall)

Shs L=Effective horizontal soil pressure (on the left side of the wall)
Shs R=Effective horizontal soil pressure (on the right side of the wall)
q=pressure given by the surcharge
U L= Water pressure (on the left side of the wall)
U R= Water pressure (on the right side of the wall)
M=bending moment (per unit length)
V=shear (per unit length)
dx=wall deflection
McapL=Ultimate bending moment (on the left side of the wall)
McapR=Ultimate bending moment (on the right side of the wall)
VcapL=Ultimate resistance shear (on the left side of the wall)
VcapR=Ultimate resistance shear (on the right side of the wall)

EXCAVATION STAGES AND SLOPE STABILITY

Reports a sequence of figures for each stage with slope stability results.



SLOPE STABILITY ANALYSIS: SLICE RESULTS ALL STAGES

Slope stability analysis design section: Culvert at STA. 253+86 Shoring (Service Loads)

Slope stability analysis Stage: 0

Slope stability not analyzed for this stage.

Slope stability analysis Stage: 1

Slope stability calculated for this stage.

Critical point at x= 10 z= 18 FS= 3.282

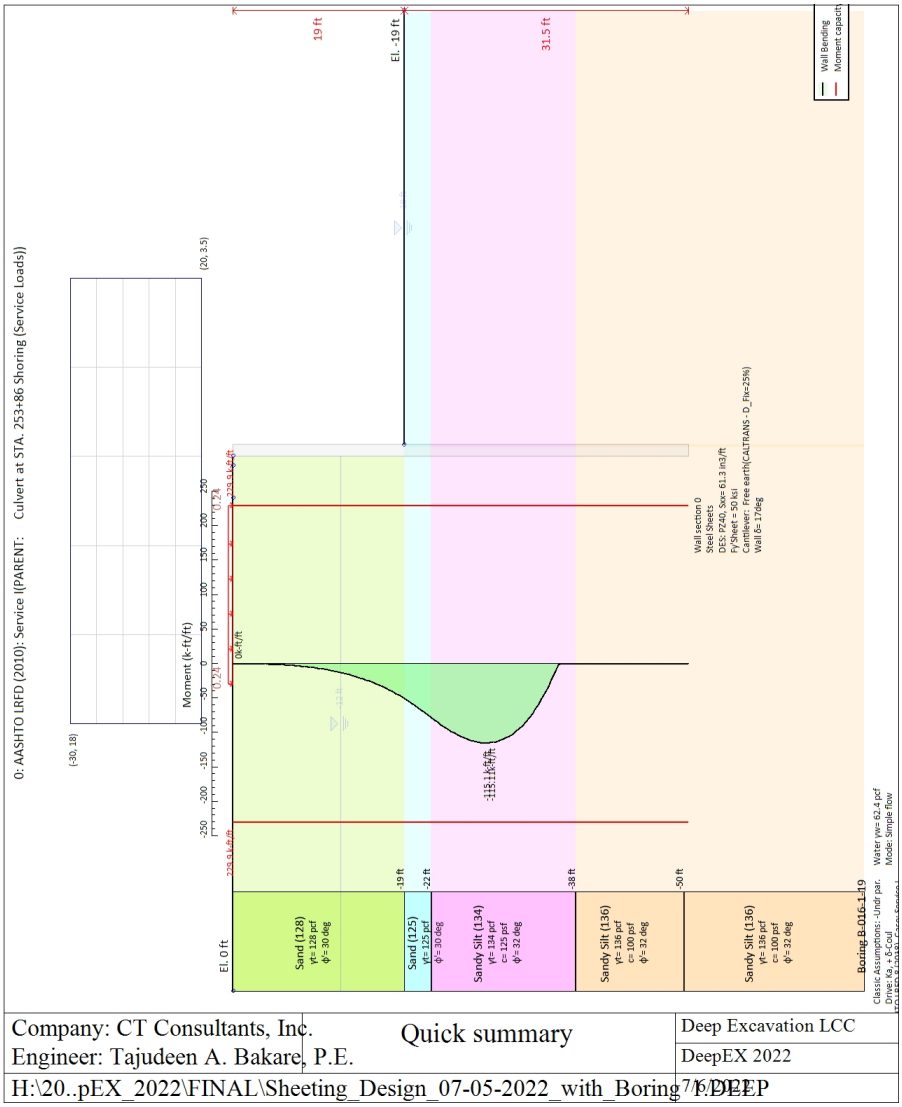
Slice	x1	ZsL	ZtL	x2	ZsR	ZtR	DL	an	Fr	c	Wn	ubL	ubR	tBase	Nr	EiL	EiR	TL	TR	UbF
No.	ft	ft	ft	ft	ft	ft	ft	deg	deg	ksf	k/ft	ksf	ksf	k/ft	k/ft	k/ft	k/ft	k/ft	k/ft	k/ft
0	-56.84	0	0	-53.55	-9.46	0	10.02	70.78	30	0	1.9	0	0	0.7	3.8	0	0	0	0	0
1	-53.55	-9.46	0	-50.25	-16.1	0	7.41	63.56	30	0	5.1	0	0.3	1.4	8	0	0	0	0	0.6
2	-50.25	-16.1	0	-46.95	-21.36	0	6.21	57.92	30	0	7.6	0.3	0.6	1.6	9.1	0	0	0	0	2.6
3	-46.95	-21.36	0	-43.65	-25.75	0	5.49	53.08	31	0.06	9.6	0.6	0.9	1.9	9.6	0	0	0	0	4
4	-43.65	-25.75	0	-40.35	-29.51	0	5	48.73	32	0.12	11.4	0.9	1.1	2.1	10.1	0	0	0	0	4.9
5	-40.35	-29.51	0	-37.05	-32.78	0	4.64	44.74	32	0.12	13	1.1	1.3	2.2	10.6	0	0	0	0	5.5
6	-37.05	-32.78	0	-33.75	-35.65	0	4.37	41.01	32	0.12	14.3	1.3	1.5	2.3	11	0	0	0	0	6.1
7	-33.75	-35.65	0	-30.45	-38.18	0	4.16	37.48	32	0.11	15.5	1.5	1.6	2.3	11.3	0	0	0	0	6.5
8	-30.45	-38.18	0	-27.16	-40.41	0	3.98	34.11	32	0.1	16.6	1.6	1.8	2.3	11.7	0	0	0	0	6.8
9	-27.16	-40.41	0	-23.86	-42.38	0	3.84	30.87	32	0.1	17.5	1.8	1.9	2.5	12.4	0	0	0	0	7
10	-23.86	-42.38	0	-20.56	-44.12	0	3.73	27.74	32	0.1	18.4	1.9	2	2.6	13	0	0	0	0	7.3
11	-20.56	-44.12	0	-17.26	-45.63	0	3.63	24.69	32	0.1	19.1	2	2.1	2.6	13.2	0	0	0	0	7.4
12	-17.26	-45.63	0	-13.96	-46.95	0	3.55	21.72	32	0.1	19.7	2.1	2.2	2.7	13.4	0	0	0	0	7.6
13	-13.96	-46.95	0	-10.66	-48.07	0	3.48	18.81	32	0.1	20.3	2.2	2.3	2.7	13.6	0	0	0	0	7.7
14	-10.66	-48.07	0	-7.36	-49.01	0	3.43	15.95	32	0.1	20.7	2.3	2.3	2.7	13.8	0	0	0	0	7.8
15	-7.36	-49.01	0	-4.66	-49.66	0	2.78	13.38	32	0.1	17.3	2.3	2.3	2.2	11.2	0	0	0	0	6.5
16	-4.66	-49.66	0	-1	-50.35	0	3.72	10.68	32	0.1	23.7	2.3	2.4	2.9	14.8	0	0	0	0	8.8
17	-1	-50.35	0	0	-50.5	0	1.01	8.72	32	0.1	6.5	2.4	2.4	0.8	4.1	0	0	0	0	2.4
18	0	-50.5	0	1.37	-50.69	0	1.38	7.73	32	0.1	9	2.4	2	1.2	5.9	0	0	0	0	3
19	1.37	-50.69	-19	2.53	-50.82	-19	1.17	6.68	32	0.1	4.9	2	2	0.5	2.6	0	0	0	0	2.3
20	2.53	-50.82	-19	5.83	-51.1	-19	3.31	4.82	32	0.1	14.1	2	2	1.5	7.4	0	0	0	0	6.6
21	5.83	-51.1	-19	9.13	-51.22	-19	3.3	2.09	32	0.1	14.2	2	2	1.5	7.5	0	0	0	0	6.6
22	9.13	-51.22	-19	12.43	-51.18	-19	3.3	-0.65	32	0.1	14.2	2	2	1.6	7.6	0	0	0	0	6.6
23	12.43	-51.18	-19	15.73	-50.99	-19	3.3	-3.38	32	0.1	14.2	2	2	1.6	7.7	0	0	0	0	6.6
24	15.73	-50.99	-19	19.03	-50.64	-19	3.32	-6.12	32	0.1	14.1	2	2	1.6	7.7	0	0	0	0	6.6
25	19.03	-50.64	-19	22.33	-50.12	-19	3.34	-8.87	32	0.1	13.9	2	1.9	1.6	7.7	0	0	0	0	6.5
26	22.33	-50.12	-19	25.62	-49.44	-19	3.37	-11.65	32	0.1	13.6	1.9	1.9	1.6	7.7	0	0	0	0	6.5
27	25.62	-49.44	-19	28.92	-48.59	-19	3.41	-14.45	32	0.1	13.3	1.9	1.8	1.6	7.7	0	0	0	0	6.4
28	28.92	-48.59	-19	32.22	-47.56	-19	3.45	-17.29	32	0.1	12.8	1.8	1.8	1.6	7.7	0	0	0	0	6.3
29	32.22	-47.56	-19	35.52	-46.35	-19	3.51	-20.18	32	0.1	12.3	1.8	1.7	1.5	7.6	0	0	0	0	6.1
30	35.52	-46.35	-19	38.82	-44.94	-19	3.59	-23.12	32	0.1	11.7	1.7	1.6	1.5	7.5	0	0	0	0	6
31	38.82	-44.94	-19	42.12	-43.32	-19	3.67	-26.12	32	0.1	11.1	1.6	1.5	1.5	7.3	0	0	0	0	5.8
32	42.12	-43.32	-19	45.42	-41.48	-19	3.78	-29.21	32	0.1	10.3	1.5	1.4	1.5	7.1	0	0	0	0	5.5
33	45.42	-41.48	-19	48.72	-39.39	-19	3.91	-32.39	32	0.1	9.4	1.4	1.3	1.4	6.8	0	0	0	0	5.2
34	48.72	-39.39	-19	52.01	-37.02	-19	4.06	-35.69	32	0.11	8.4	1.3	1.1	1.4	6.5	0	0	0	0	4.9
35	52.01	-37.02	-19	55.31	-34.33	-19	4.25	-39.13	32	0.12	7.3	1.1	1	1.3	6	0	0	0	0	4.4
36	55.31	-34.33	-19	58.61	-31.29	-19	4.49	-42.75	32	0.12	6	1	0.8	1.2	5.4	0	0	0	0	3.9
37	58.61	-31.29	-19	61.91	-27.8	-19	4.8	-46.59	32	0.12	4.6	0.8	0.5	1.1	4.6	0	0	0	0	3.2
38	61.91	-27.8	-19	65.21	-23.76	-19	5.21	-50.74	32	0.12	2.9	0.5	0.3	0.9	3.4	0	0	0	0	2.2
39	65.21	-23.76	-19	68.51	-19	-19	5.79	-55.29	31	0.06	1	0.3	0	0.4	1.5	0	0	0	0	0.9

LEGEND

x1 = Left x coordinate
ZsL= Left slice bottom elevation
ZtL= Left top elevation
x2 = Right x coordinate
ZsR= Right slice bottom elevation
ZtR= Right top eleevation
DL = Slice base width
an = Base angle
Fr = Average friction angle at base
c = Average cohesion at base (may include undrained clay strengths)
Wn = Total slice weight
ubL= Water pressure at left bottom point
ubR= Water pressure at right bottom point
tBase= Base shear resistance
Nr = Effective normal reaction at bottom of slice
EiL= Lateral interslice force on left face
EiR= Lateral interslice force on right face
TL = Vertical interslice shear on left vertical face
TR = Vertical interslice shear on right vertical face
UbF= Normal water force at slice base

Project: ODOT PID No. 108665; LAK-20-19.59 - WEST
Results for Design Section 1: 0: AASHTO LRFD (2010): Service I

ANALYSIS AND CHECKING SUMMARY



Company: CT Consultants, Inc.	Quick summary	Deep Excavation LCC
Engineer: Tajudeen A. Bakare, P.E.		DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
0	Wall section	50.5	19	0/229.88	115.11/229.88	21.622	2.535	1.807	-36.43	3.282

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

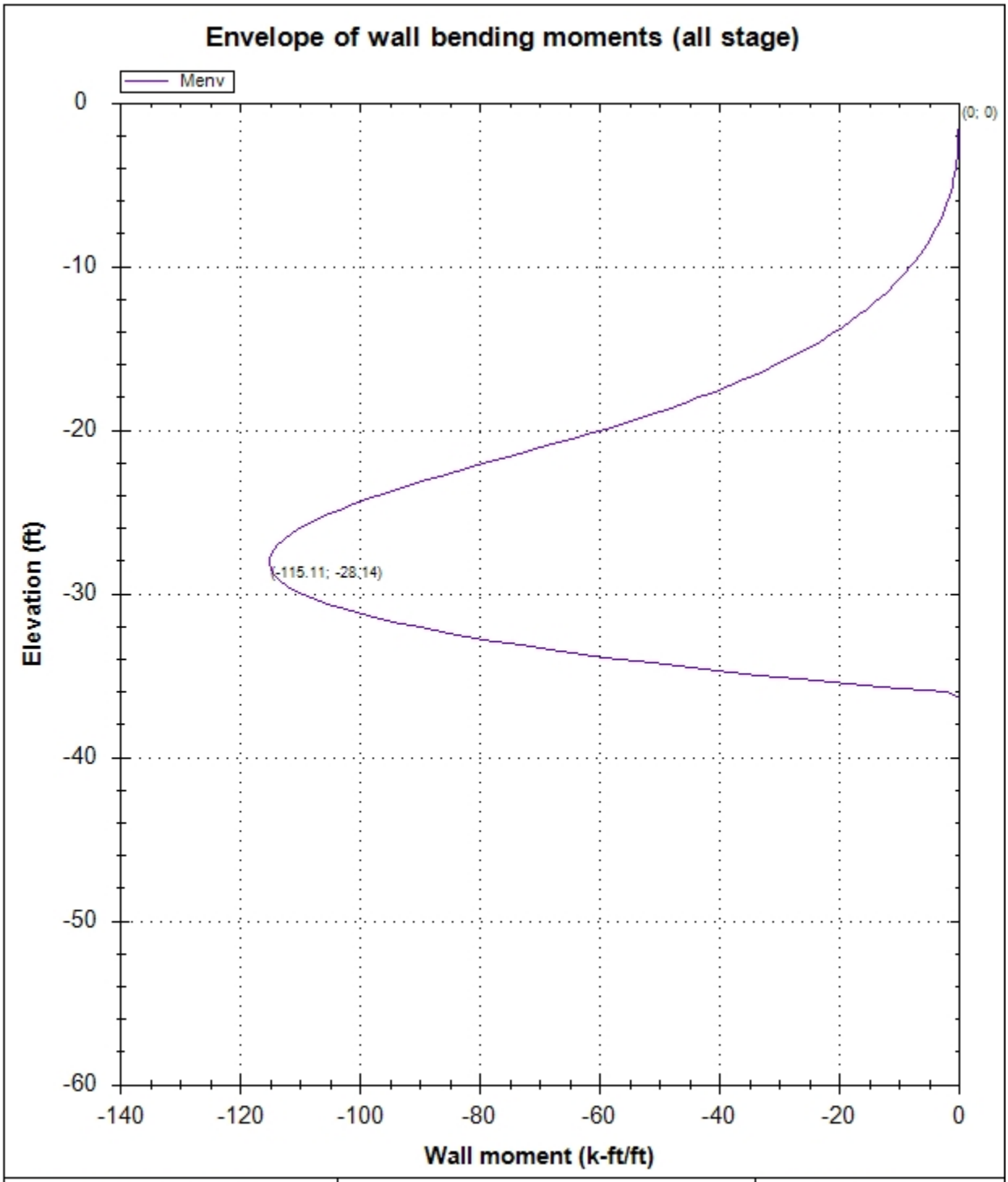
1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.849	12.4	3.282	0.373	12.449	3.282

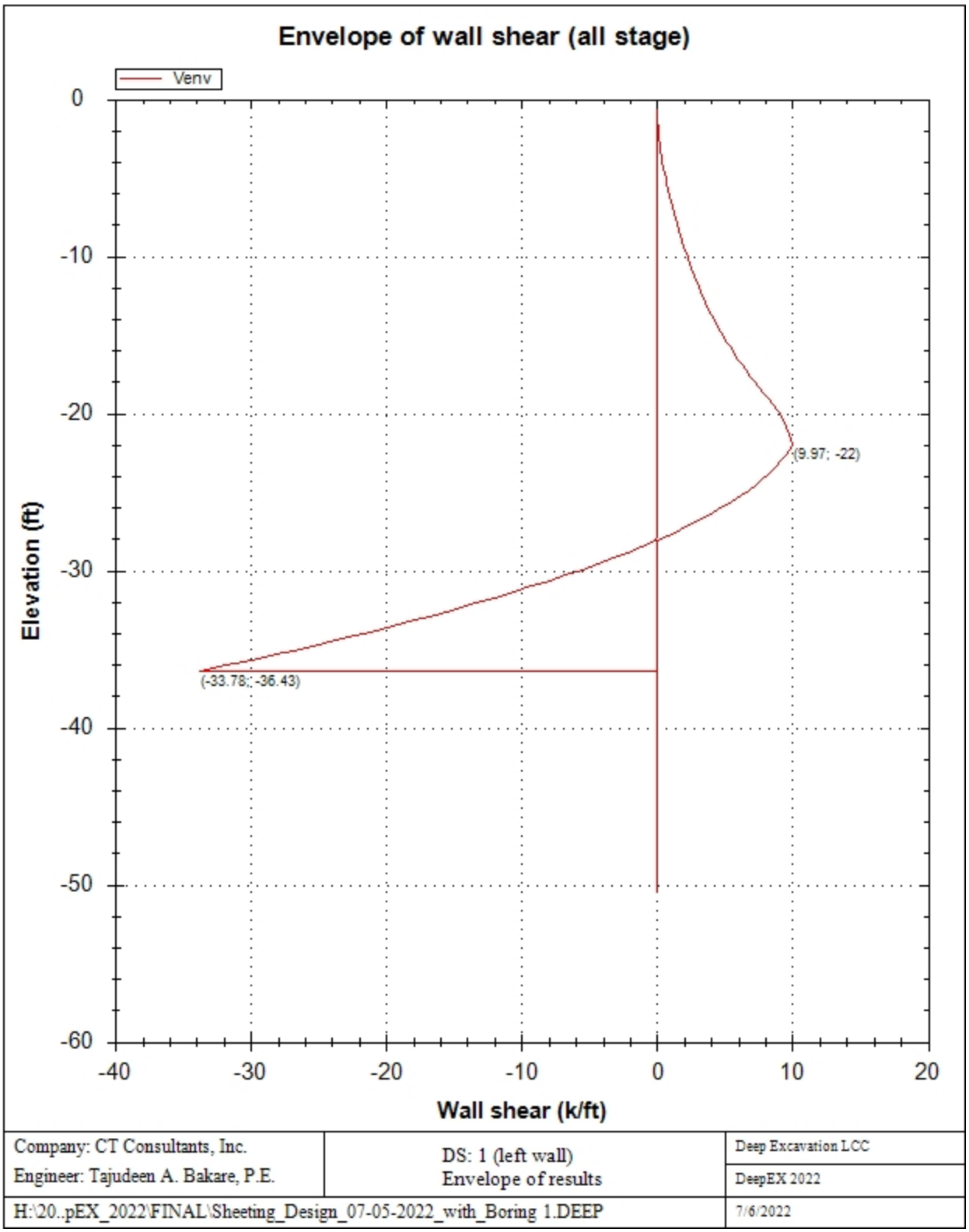
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

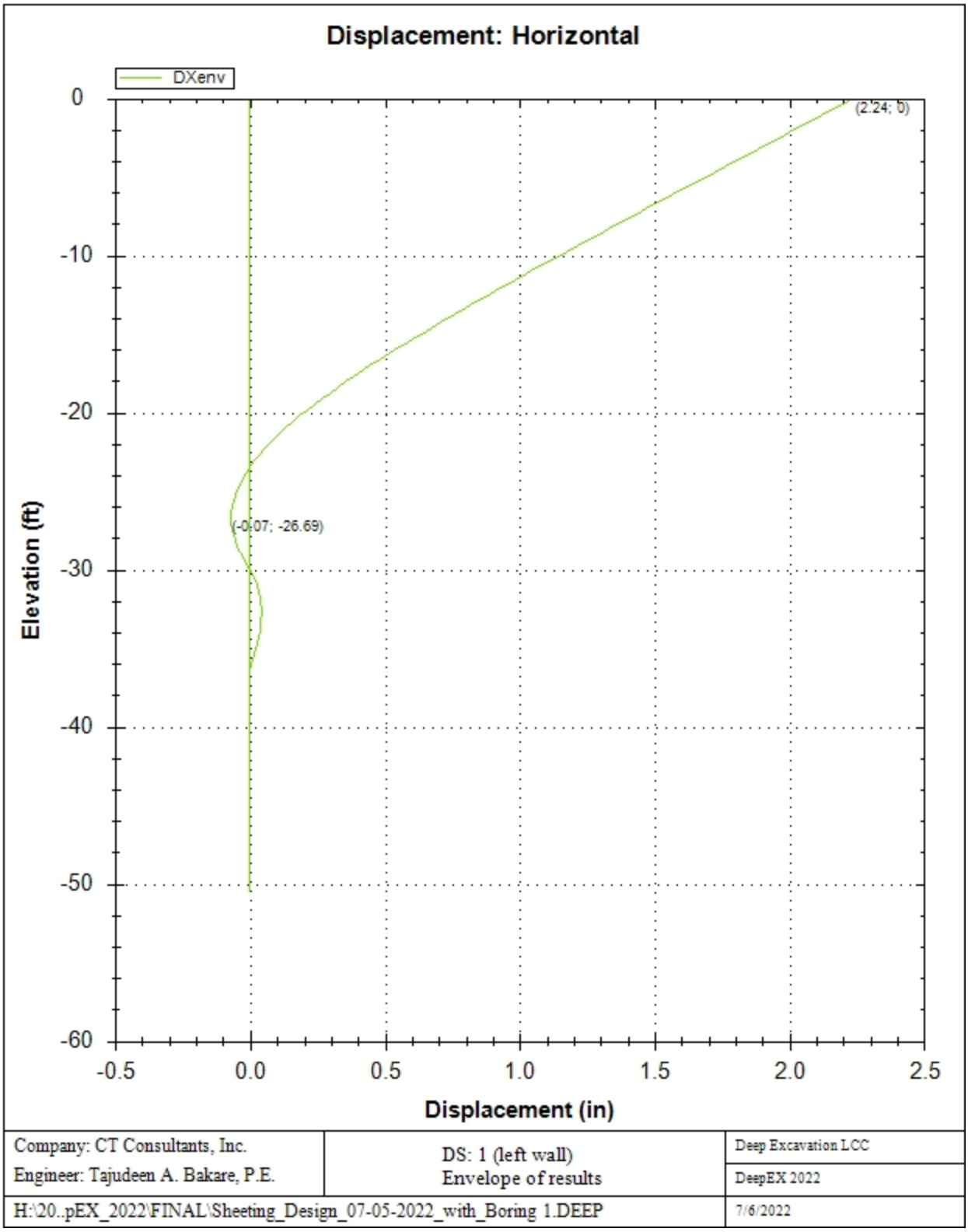
Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 1 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022



Extended vs Stage

	Calculation Result	Wall Displaceme	Settlement	Wall Moment	Wall Moment
		(in)	(in)	(k-ft/ft)	(k-ft)
Stage 0	Calculated	0	N/A	0	0
Stage 1	Calculated	2.24	2.34	115.11	115.11

	Wall Shear	Wall Shear	STR Combined	STR Moment	STR Shear
	(k/ft)	(k)	Wall Ratio	Wall Ratio	Wall Ratio
Stage 0	0	0	0	0	0
Stage 1	33.78	33.78	0.501	0.501	0.207

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

	Max Support	Max Support	Critical	STR Support	Support Geotech
	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull out
Stage 0	0	0	N/A	No supports	No supports
Stage 1	0	0	N/A	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).
Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

	FS	Toe FS	Toe FS	Toe FS	Zcut	FS Mobilized	FS
	Basal	Passive	Rotation	Length	(nonlinear)	Passive	True/Active
Stage 0	1000	21.622	20.213	140.278	N/A	N/A	N/A
Stage 1	N/A	N/A	2.535	1.807	N/A	N/A	N/A

	Hydraulic	Qflow	FSslope
	Heave FS	(ft3/hr)	
Stage 0	2.729	N/A	N/C
Stage 1	1.821	N/A	3.282

Support Force/S vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Support Force vs Stage

Support Force vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	20.213	21.622	20.213	140.278	N/A	N/A
0:Stage 0	1.807	N/A	2.535	1.807	N/A	N/A

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
Wall embedment safety factors from conventional analysis (limit-equilibrium):
FS1 Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
FS2 Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
FS3 Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0
Wall embedment safety factors from non-linear analysis:
FS4 Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.

FS5 True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Tables for stress checks follow: Support force/Design capacity

Support Check vs Stage

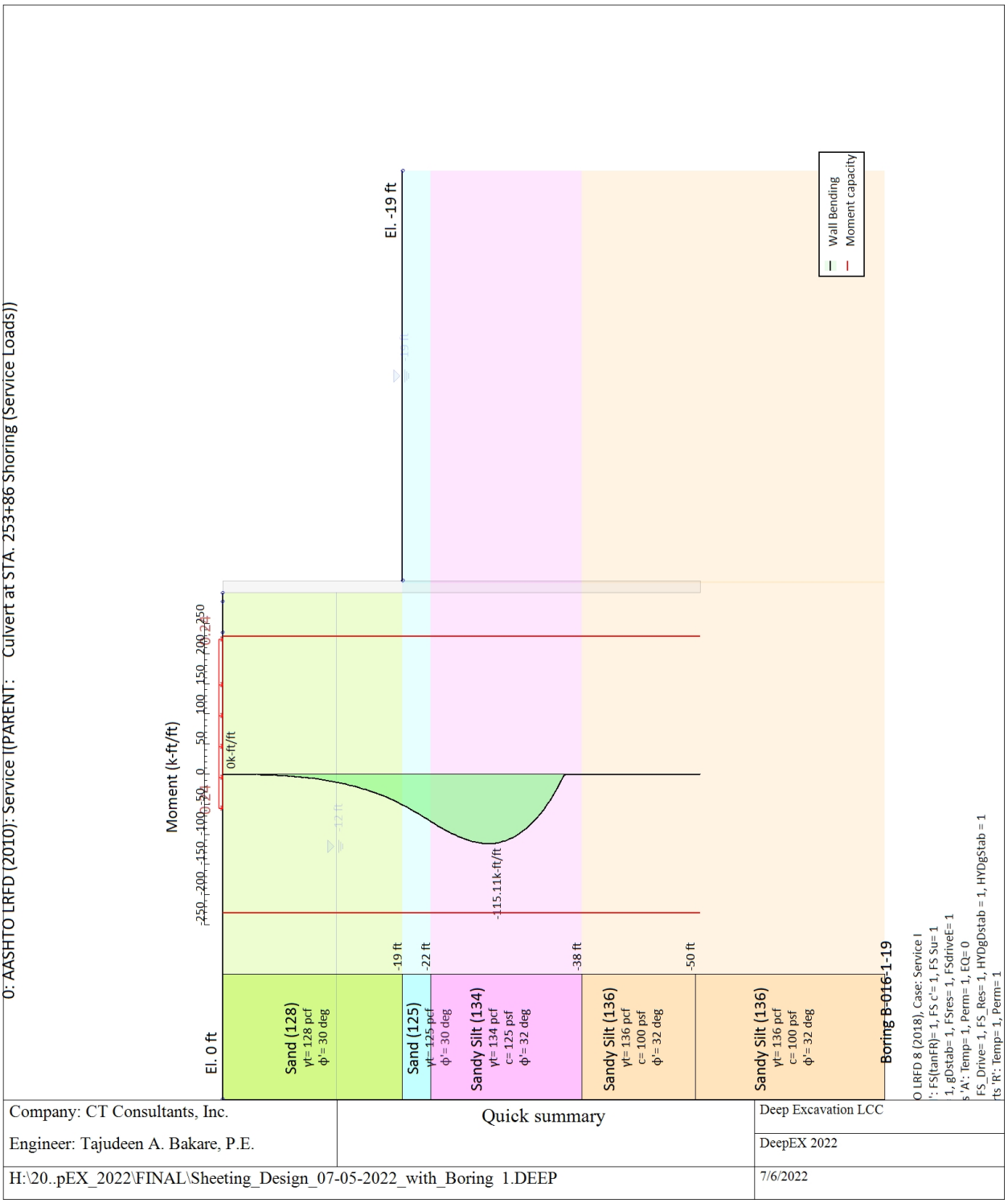
	No Supports
0:Stage 0	No support
1:Stage 1	

Forces (Res. F, M/Drive F, M)

	FS1 Passive	FS2 Rotation	FS3 Length	FS4 Mobilized Passive	FS5 Actual Drive	Fh EQ Soil	Fh EQ Water
	(FxResist/FxDrive)	(Mresist/Mdrive)	(Embedment/ToeFS=1)	(FxPassive/FxPas_Mobili	/ Theory Active		
Stage 0	594.114/27.477	10534.52/521.19	50.5/0.36	N/A	N/A	N/A	N/A
Stage 1	N/A	1930.96/453.04	31.5/17.43	N/A	N/A	N/A	N/A

Reinforcement Requirements

	Parameter Description
Note:	Wall does not use steel reinforcement. Section does not apply.


0: AASHTO LRFD (2010): Service I(PARENT: Culvert at STA. 253+86 Shoring (Service Loads))
El. -19 ft
Wall Bending
Moment capacity
Moment (k-ft/ft)
-250 -200 -150 -100 -50 0 50 100 150 200 250
0k-ft/ft
-115.11k-ft/ft
El. 0 ft
-19 ft
-22 ft
-38 ft
-50 ft
Sand (128)
γt= 128 pcf
ϕ'= 30 deg
Sand (125)
γt= 125 pcf
ϕ'= 30 deg
Sandy Silt (134)
γt= 134 pcf
c= 125 psf
ϕ'= 32 deg
Sandy Silt (136)
γt= 136 pcf
c= 100 psf
ϕ'= 32 deg
Sandy Silt (136)
γt= 136 pcf
c= 100 psf
ϕ'= 32 deg
Boring B-016-1-19
O LRFD 8 (2018), Case: Service I
': FS(tanFR)= 1, FS c'= 1, FS Su= 1
1, gDstab= 1, FSres= 1, FSdriveE= 1
s 'A': Temp= 1, Perm= 1, EQ= 0
FS_Drive= 1, FS_Res= 1, HYDgDstab = 1, HYDgStab = 1
ts 'R': Temp= 1, Perm= 1
Company: CT Consultants, Inc.
Engineer: Tajudeen A. Bakare, P.E.
Quick summary
Deep Excavation LCC
DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP
7/6/2022

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
0	Wall section	50.5	19	0/229.88	115.11/229.88	21.622	2.535	1.807	-36.43	3.282

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

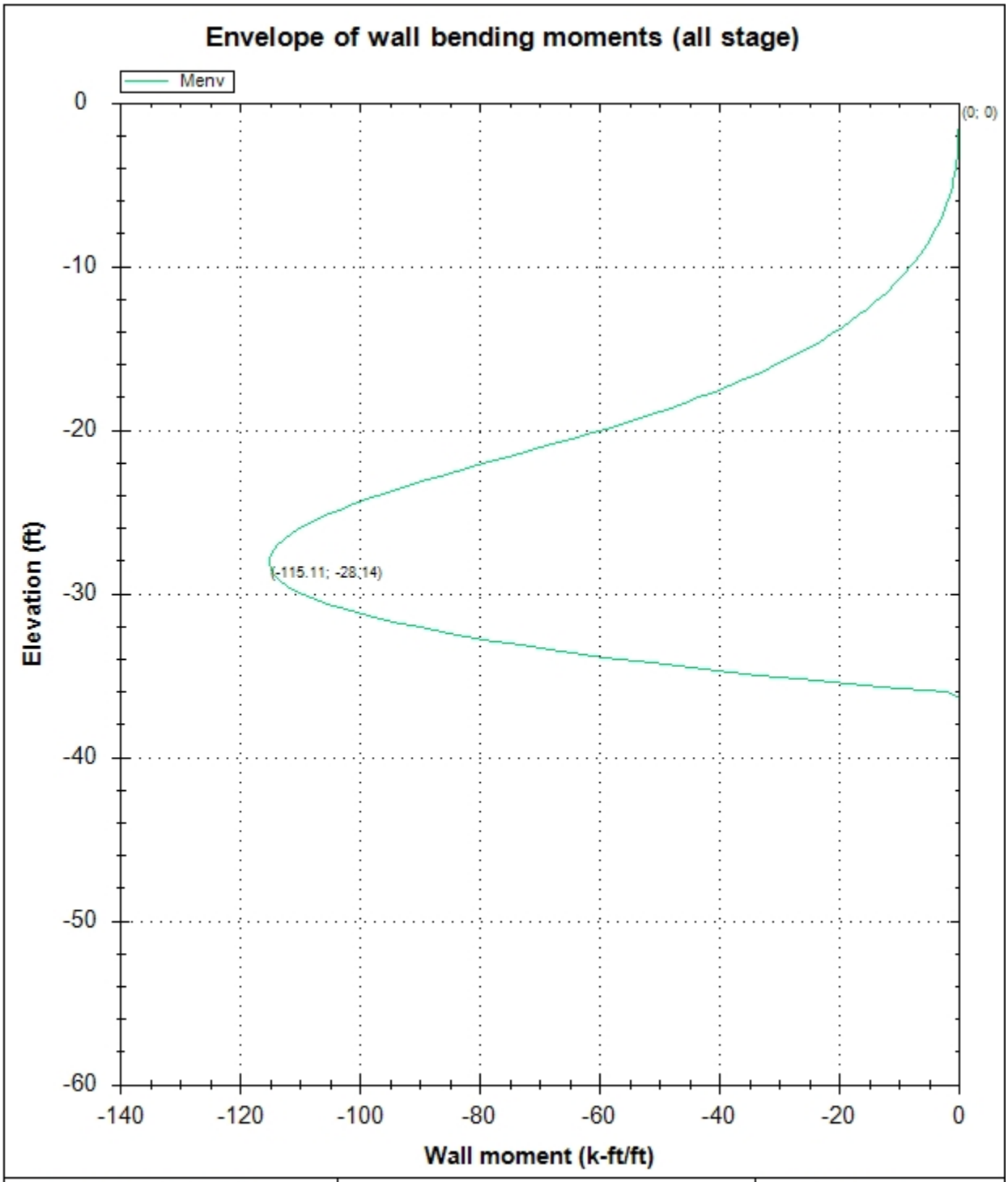
1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.849	12.4	3.282	0.373	12.449	3.282

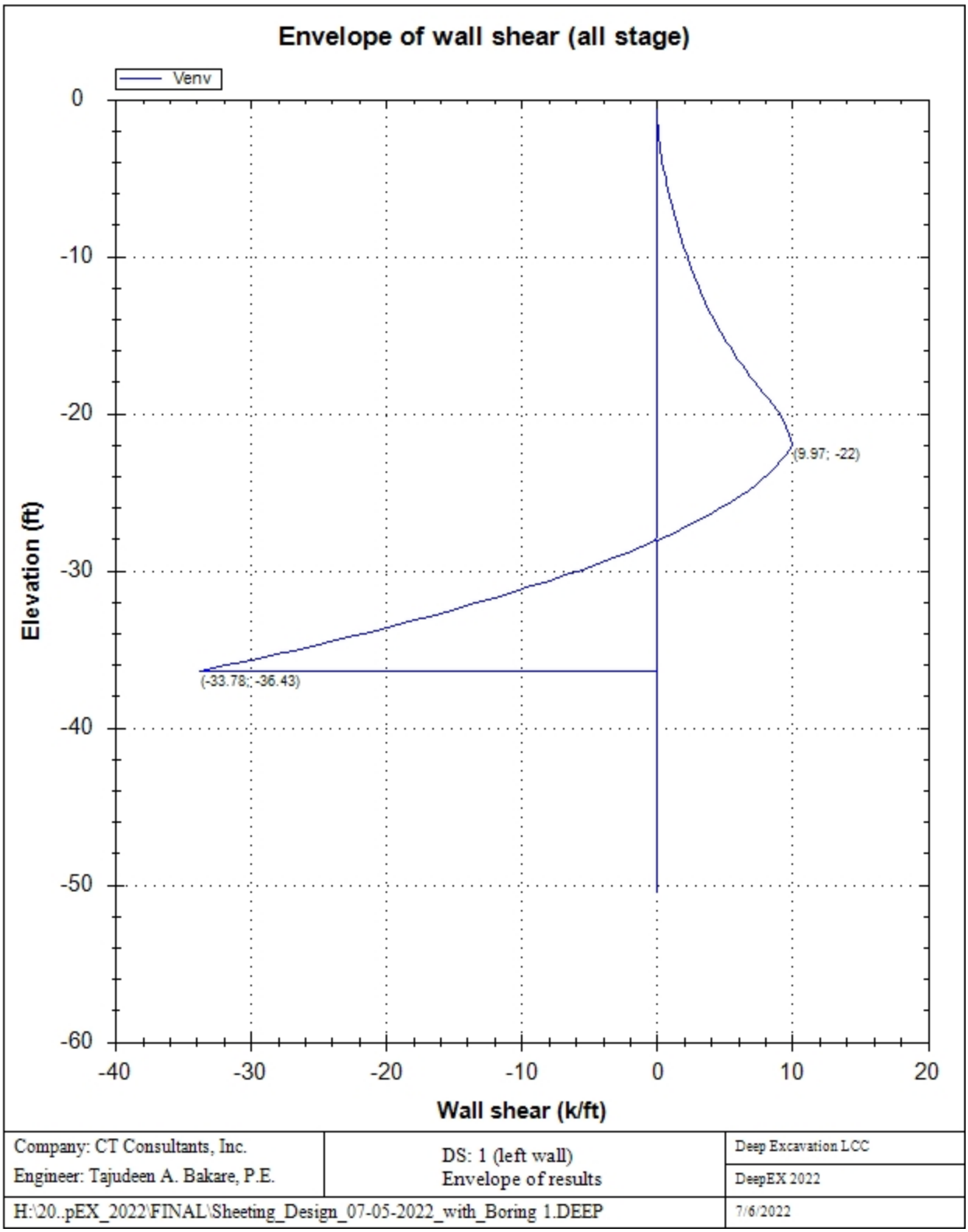
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

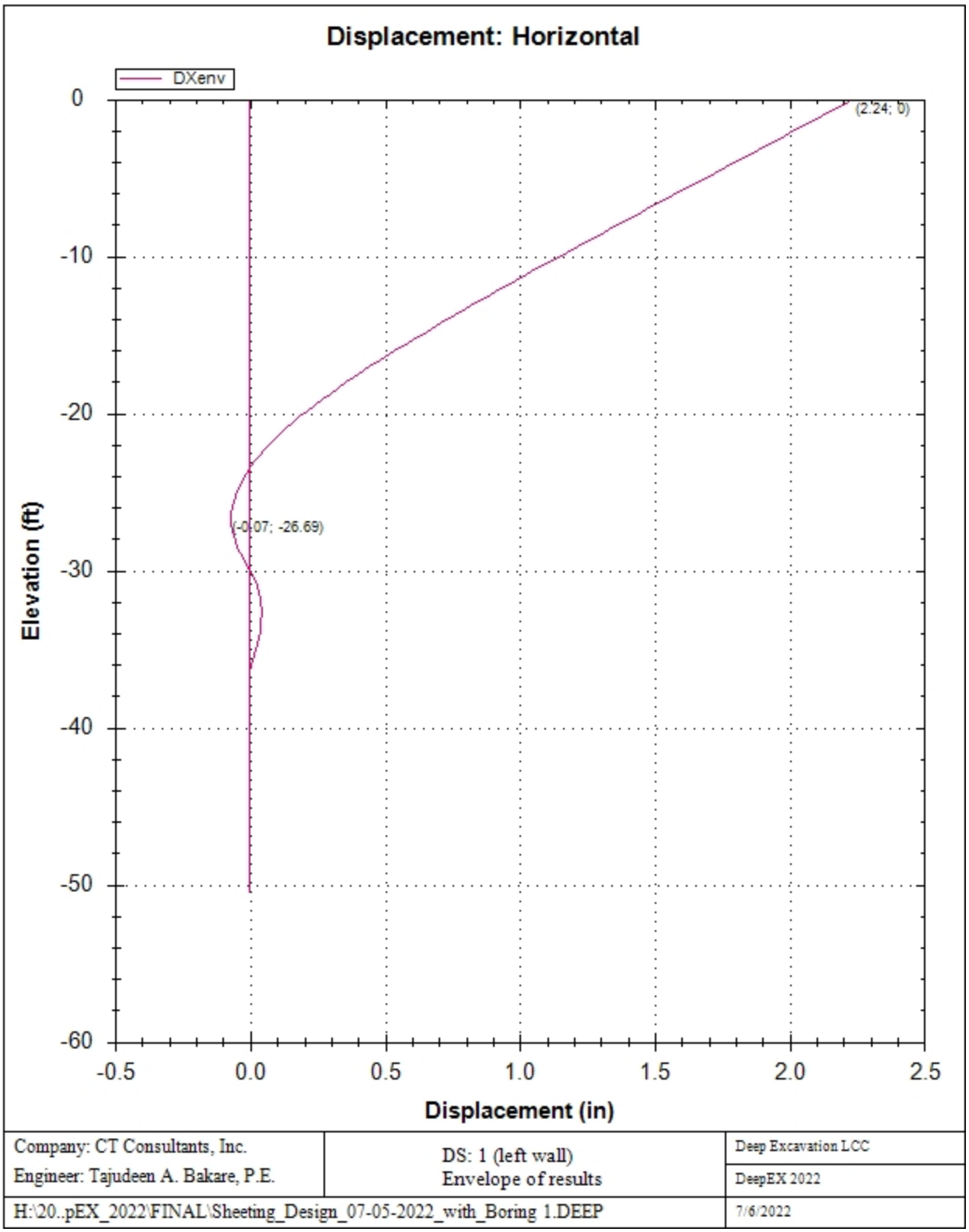
Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 1 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022



DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:

Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)
F Su'= safety factof for undrained shear strength (Eurocode 7 methods)
F EQ= Load factor for seismic loads
F perm load= Load factor for permanent loads (dead load, etc)
F temp load= Load factor on live loads and other temporary loads
F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks
F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks
F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Service I	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
1	AASHTO LRFD	Service I	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:
Ftan fr=mult factor for friction angle
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F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Service I	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1
1	AASHTO LRFD	Service I	1	1	1	0	1	1	1	1	1	1	1	1	1	1	1	1

SOIL DATA

Name	g tot	g dry	Frict	C'	Su	FRp	FRcv	Eload	rEur	kAp	kPp	kAcv	kPcv	Vary	Spring	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(deg)	(deg)	(ksf)	(-)	NL	NL	NL	NL		Model	
Sand (128)	128	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sand (125)	125	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sandy Silt (13	134	134	32	125	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	
Sandy Silt (13	136	136	32	100	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	

Name	Poisson	Min Ka	Min sh	ko.NC	nOCR	aH.EXP	aV.EXP	qSkin	qNails	kS.nails	PL
	v	(clays)	(clays)	-	-	(0 to 1)	(0 to 1)	(psi)	(psi)	(k/ft3)	(ksi)
Sand (128)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sand (125)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-

gtot = total soil specific weight
gdry = dry weigth of the soil
Frict = friction angle
C' = effective cohesion
Su = Undrained shear strength (only for CLAY soils in undrained conditions, used as a cutoff strength in NL analysis)
Evc = Virgin compression elastic modulus
Eur = unloading/reloading elastic modulus
Kap = Peak active thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kpp = Peak passive thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kacv = Constant volume active thrust coeff (only for clays, initial value)
Kpcv = Constant volume passive thrust coeff (only for clays, initial value).
Spring models= spring model (LIN= constant E over the soil layer height , EXP=exponential , SIMC=simplified winkler)
LIN= Linear-Elastic-Perfectly Plastic,
EXP: Exponential, SUB: Modulus of Subgrade Reaction
SIMC= Simplified Clay mode

SOIL BORINGS

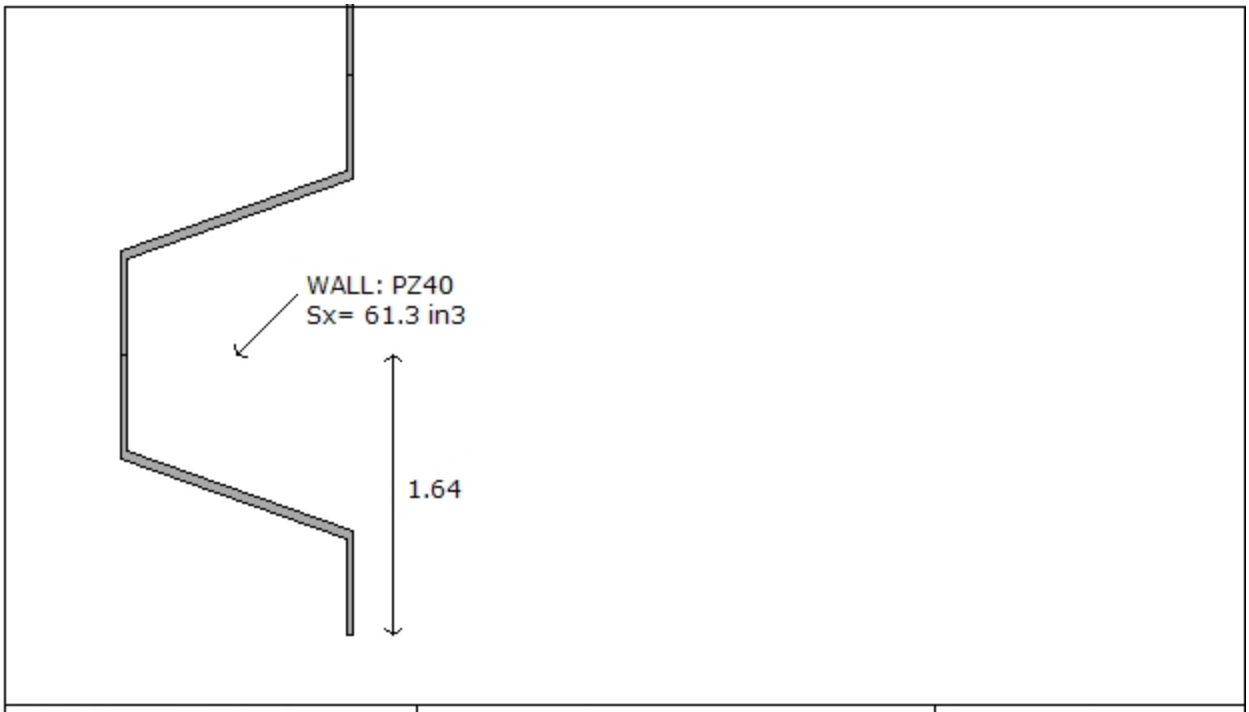
Top Elev= superior SOil level
Soil type= type of the soil (sand , clay , etc)
OCR= overconsolidation ratio
K0= at rest coefficient

Name: Boring B-016-1-19, pos: (0, 0)

Top elev.	Soil type	OCR	Ko
0	Sand (128)	1	0.5
-19	Sand (125)	1	0.5
-22	Sandy Silt (134	1	0.47
-38	Sandy Silt (136	1	0.47
-50	Sandy Silt (136	1	0.47

WALL DATA

Wall section 0: Wall section 0



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	Wall sketch	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Wall type: Steel sheet piling
Top wall El: 0 ft Bottom wall El: -50.5 ft
Hor. wall spacing: 1 ft Wall thickness = 1.37 ft
Passive width below exc: 1 ft Active width below exc: 1 ft Swater= 1 ft
Steel members fy = 50 ksi Esteel = 29000 ksi
Wall friction: Constant value = 17 degrees
Steel wall capacities are calculated with ANSI/AISC 360-10
Concrete capacities are calculated with ACI 318-19
Note: With ultimate capacities you may have to use a structural safety factor.
Steel sheet pile properties

Table: Steel Sheet Pile Cross Sectional Properties

DES	Shape	W	A	h	t	b	s	Ixx	Sxx
		(plf)	(in^2/ft)	(in)	(in)	(in)	(in)	(in^4/ft)	(in^3/ft)
PZ40	Z	65.6	11.75	16.4	0.5	19.69	0.605	503	61.3

GENERAL WALL DATA
Hor wall spacing= Wall horizontal spacing
Passive width below exc= spacing for passive thrust pressure for classic analysis
f'c=fck= cylindrical concrete resistance
fyk=fy= steel rebar characteristic resistance
Econc= Concrete Elastic modulus
fctk= characteristic Concrete tension
Esteel= steel elastic modulus
TABULAR DATA (principal parameters)
1) Diaphragm wall (rectangular cross section)
N/A= data not available
Fy=fyk

F'c=fck
D=wall thickness
B=wall width
2)Steel sheet pile
DES=shape (Z or U)
W=width per unit of length
A=area
h=height
t=horizontal part thickness
b=width of the single sheet pile part
s=inclined part thickness
Ixx=strong axis inertia (per unit of length)
Sxx=strong axis section modulus (per unit of length)
3)Secant piles wall, Tangent piles wall, soldier piles, soldier piles and timber lagging
W=weight per unit of length
A=area
D=diameter
tw=web thickness
tp= pipe thickness
bf=flange width
tf= flange thickness
k= flange thickness+stem base height
Ixx= strong axis inertia modulus (per unit of length)
Sxx= strong axis section modulus (per unit of length)
rx=radius of gyration about X axis
ry=radius of gyration about Y axis
Iyy=weak axis inertia modulus (per unit of length)
Syy=weak axis section modulus (per unit of length)
rT=radius of gyration for torsion
Cw= warping constant

GENERAL ANALYSIS CRITERIA

Summary of stage assumptions

Name	Analysis	Drive	ka-Mult	Htr T/B	Resist	Res	Contle
	Method	Press		(%)	Press	Mult	Method
Stage 0	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth
Stage 1	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth

Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1	20.213	20.213	21.622
Stage 1		N/A	1	1.807	2.535	N/A

Name=excavation stage name
Analysis method
springs = Elastoplastic spring analysis used
DR = Drained condition for CLAY model
U = Undrained condition for CLAY model for all the soils
Up = Undrained condition just for selected soil
Limit equilibrium analysis settings
Drive press:
Ka (Active pressure diagram), Ka-Trap = Trapezoid apparent diagram from active pressures x multiplier,
FHWA= Federal Highway Administration apparent pressure diagrams.
Ko = At-rest lateral earth pressures.
Peck = Peck 1969 Apparent earth pressure diagrams.
2 Step rect = Two step rectangular apparent earth pressure diagram.
User def. = User defined apparent earth pressure diagram.
Ka+d (and so on) indicates that wall friction is applied
ka mult = multiplication factor for Ka when Ka-Trap is selected
Htr T/B (%) = trapezoidal pressure scheme, top and bottom triangular percentage of excavation depth H
Resit press = Kp (passive earth pressures)
Res Mult = Safety factor applied directly on resisting pressures (
COntle Method = cantilever analysis method for limit equilibrium analysis.
Support Model: Method for calculating support reactions in limit-equlibrium analysis.
Beam= support reactions beam analysis (uses Blum's method).
Trib= support reactions from tributary height calculations (Can be applied with apparent diagrams).
Axial Incl = Axial loads included for structural design
Used FS wall = Safety factor for axial+bending wall resistance to divide ultimate wall capacities.
Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)
Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)
Toe FSpas= driving/resisting pressure safety factor (for limit equilibrium analysis)

EXCAVATION STAGES SKETCHES

A sequence of figures for each excavation stage is reported

Toe stability

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	20.213	21.622	20.213	140.278	N/A	N/A
Stage 1	1.807	N/A	2.535	1.807	N/A	N/A

Legend: Wall embedment safety factors (toe)
Min Toe FS= Minimum wall embedment safety factor (from all analysis methods)
Limit-equilibrium analysis methods: The following safety factors may not be applicable for all stages.
FS1 Passive: Horizontal force safety factor, FS1= Resisting/Driving force
FS2 Rotation: Rotational safety factor about lowest support, FS2= Resisting moment/Driving moment
FS3 Length (from FS1, FS2): Program determines maximum required wall embedment for safety factor of 1 for methods FS1 and FS2 (say length LFS1). Then FS length= Provided wall embedment/LFS1.
Non-linear elastoplastic analysis safety factors:
FS4 Mobilized Passive: Safety factor on mobilized passive resistance, FS4= Available passive soil resistance/Mobilized passive soil force on excavation side.
FS5 Active Drive Thrust/Theory Active: Ratio of soil thrust on retained side/ Active condition theoretical minimum thrust. This factor is not as critical, and indicates how close to active conditions the model is.
General recommendations on wall embedment (excluding FS5):
When then excavation is designed with allowable standards, engineers generally use minimum safety factors from 1.2 to 1.5 depending on the level of confidence. A minimum safety factor of 1.2 is generally applied on FS3.
With ultimate limit state designs (such as Eurocode 7, and LRFD) the required safety factor must generally be greater than 1.0. In non-linear solutions it might be impossible to achieve exactly 1 on FS4 as this would likely trigger overall failure.

Result diagrams (for walls)

A sequence of result diagrams for each excavation stage is reported

WALL RESULTS TABLE

LEGEND
Wall node=number of the node (0 at top)
EL= Node elevation
Sht L=Total horizontal soil pressure (on the left side of the wall)
Sht R=Total horizontal soil pressure (on the right side of the wall)
Shs L=Effective horizontal soil pressure (on the left side of the wall)
Shs R=Effective horizontal soil pressure (on the right side of the wall)
q=pressure given by the surcharge
U L= Water pressure (on the left side of the wall)
U R= Water pressure (on the right side of the wall)
M=bending moment (per unit length)
V=shear (per unit length)
dx=wall deflection
McapL=Ultimate bending moment (on the left side of the wall)
McapR=Ultimate bending moment (on the right side of the wall)
VcapL=Ultimate resistance shear (on the left side of the wall)
VcapR=Ultimate resistance shear (on the right side of the wall)

EXCAVATION STAGES AND SLOPE STABILITY

Reports a sequence of figures for each stage with slope stability results.

SLOPE STABILITY ANALYSIS: SLICE RESULTS ALL STAGES

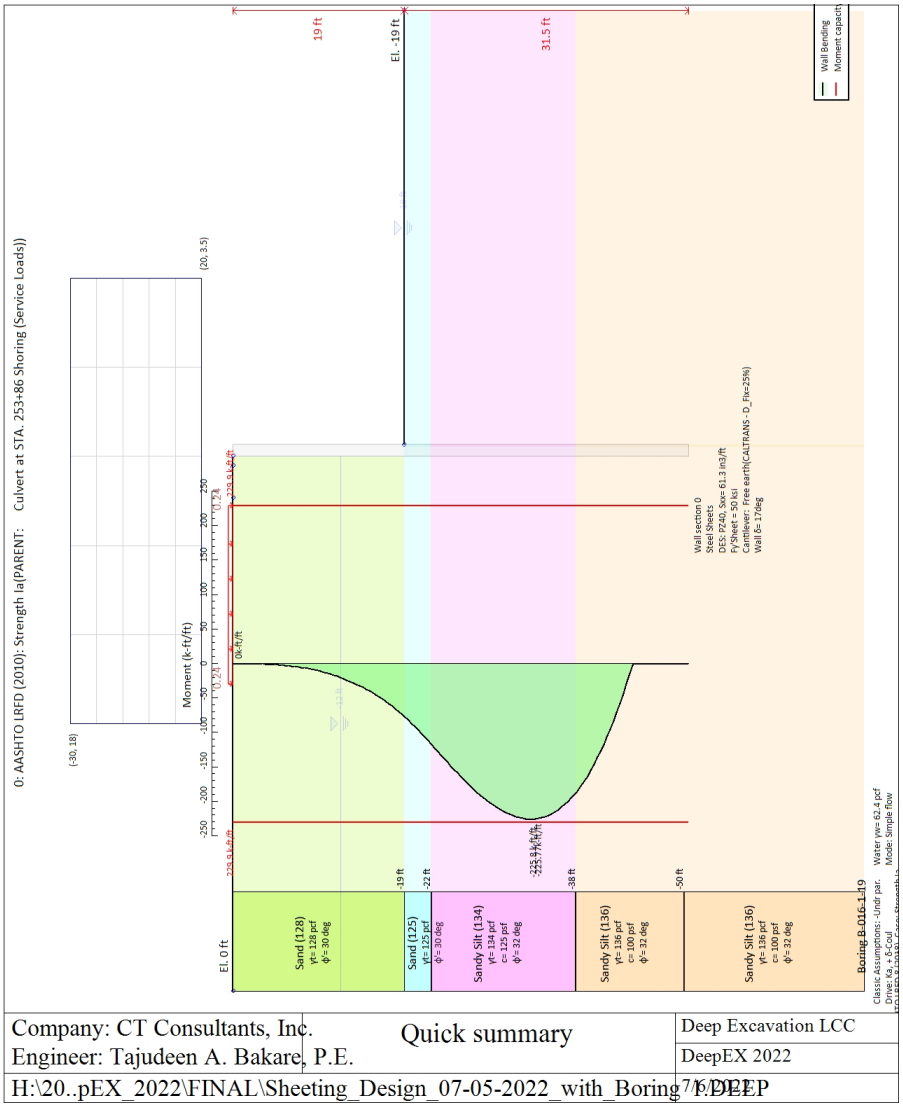
Slope stability analysis design section: 0: AASHTO LRFD (2010): Service I

LEGEND

x1 = Left x coordinate
ZsL= Left slice bottom elevation
ZtL= Left top elevation
x2 = Right x coordinate
ZsR= Right slice bottom elevation
ZtR= Right top eleevation
DL = Slice base width
an = Base angle
Fr = Average friction angle at base
c = Average cohesion at base (may include undrained clay strengths)
Wn = Total slice weight
ubL= Water pressure at left bottom point
ubR= Water pressure at right bottom point
tBase= Base shear resistance
Nr = Effective normal reaction at bottom of slice
EiL= Lateral interslice force on left face
EiR= Lateral interslice force on right face
TL = Vertical interslice shear on left vertical face
TR = Vertical interslice shear on right vertical face
UbF= Normal water force at slice base

Project: ODOT PID No. 108665; LAK-20-19.59 - WEST
Results for Design Section 2: 0: AASHTO LRFD (2010): Strength Ia

ANALYSIS AND CHECKING SUMMARY



Company: CT Consultants, Inc.	Quick summary	Deep Excavation LCC
Engineer: Tajudeen A. Bakare, P.E.		DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
0	Wall section	50.5	19	0/229.88	225.77/229.88	10.838	1.362	1.242	-44.37	3.243

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

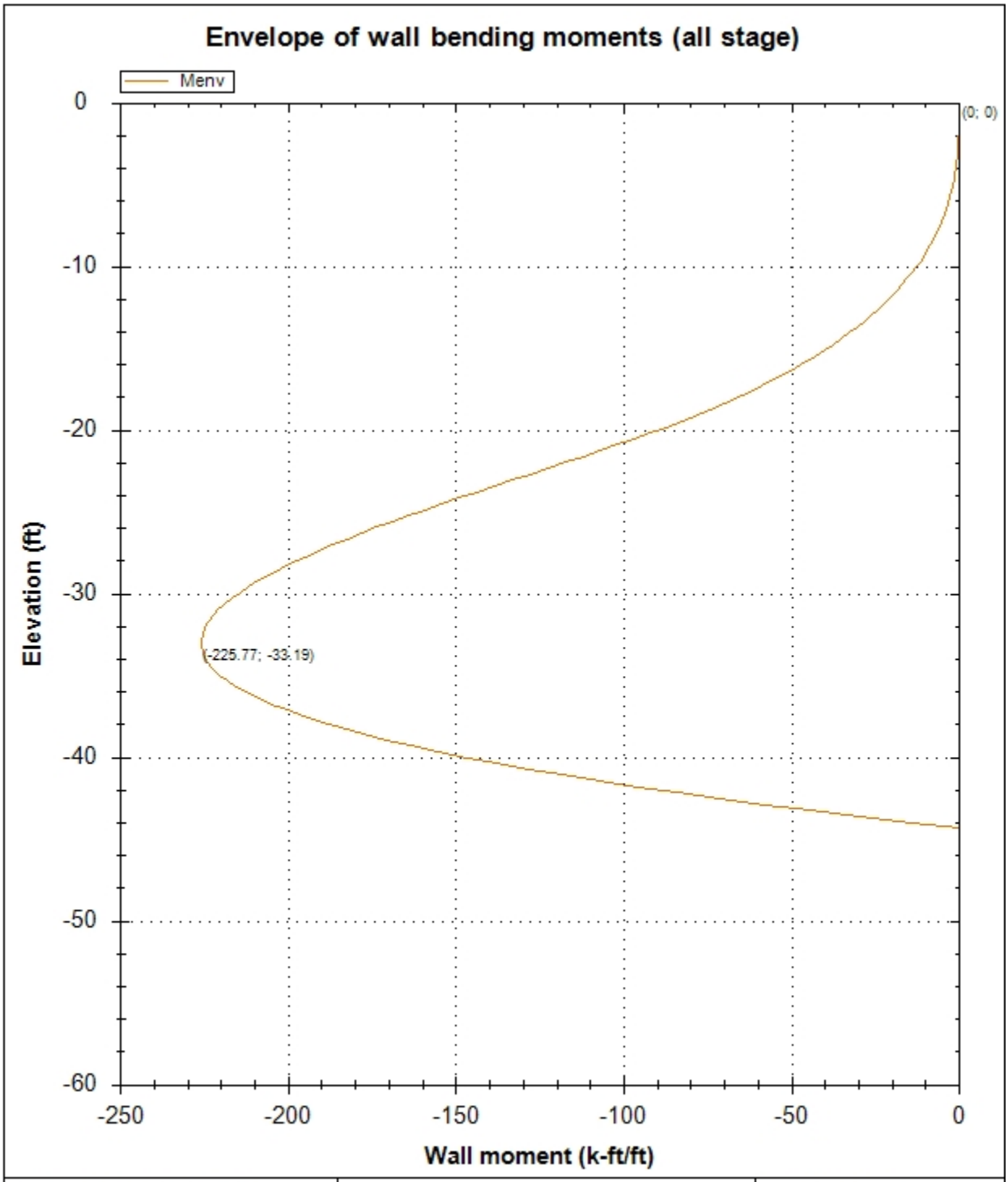
1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.867	12.4	3.243	0.38	12.449	3.243

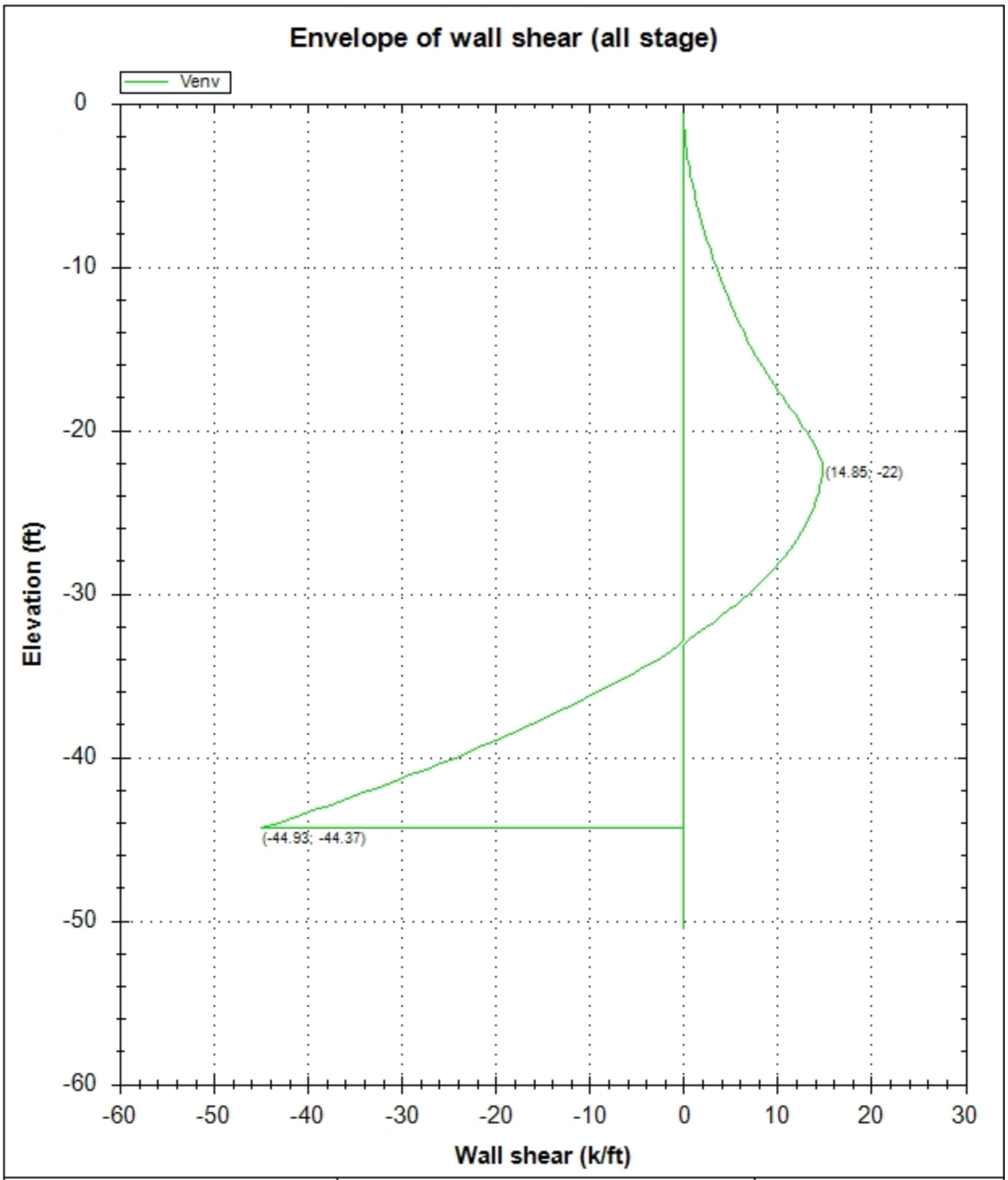
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

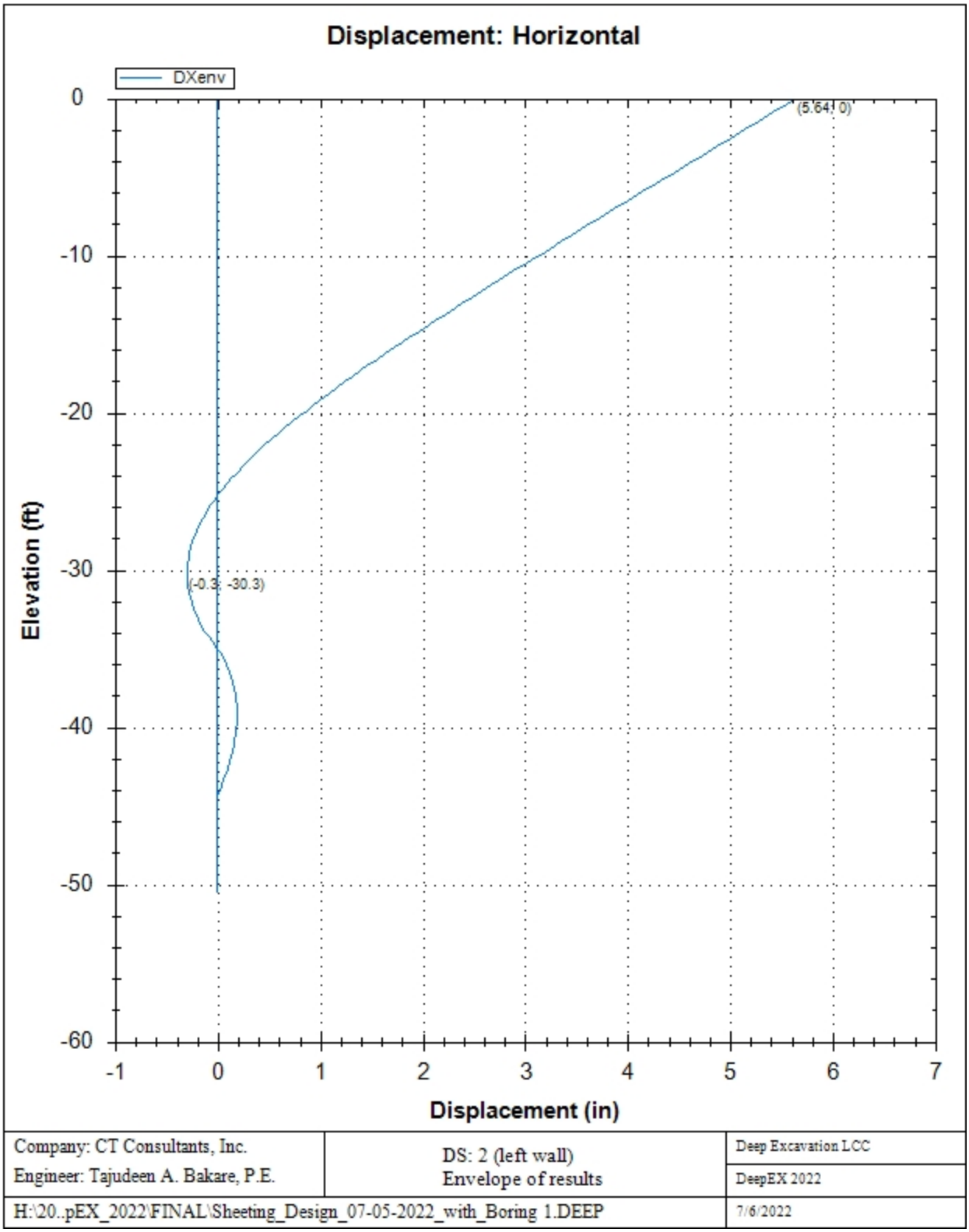
Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 2 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022



Extended vs Stage

	Calculation Result	Wall Displaceme	Settlement	Wall Moment	Wall Moment
		(in)	(in)	(k-ft/ft)	(k-ft)
Stage 0	Calculated	0	N/A	0	0
Stage 1	Calculated	5.64	2.39	225.77	225.77

	Wall Shear	Wall Shear	STR Combined	STR Moment	STR Shear
	(k/ft)	(k)	Wall Ratio	Wall Ratio	Wall Ratio
Stage 0	0	0	0	0	0
Stage 1	44.93	44.93	0.982	0.982	0.275

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

	Max Support	Max Support	Critical	STR Support	Support Geotech
	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull out
Stage 0	0	0	N/A	No supports	No supports
Stage 1	0	0	N/A	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).
Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

	FS	Toe FS	Toe FS	Toe FS	Zcut	FS Mobilized	FS
	Basal	Passive	Rotation	Length	(nonlinear)	Passive	True/Active
Stage 0	1000	10.838	10.132	140.278	N/A	N/A	N/A
Stage 1	N/A	N/A	1.362	1.242	N/A	N/A	N/A

	Hydraulic	Qflow	FSslope
	Heave FS	(ft3/hr)	
Stage 0	2.729	N/A	N/C
Stage 1	1.821	N/A	3.243

Support Force/S vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Support Force vs Stage

Support Force vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	10.132	10.838	10.132	140.278	N/A	N/A
0:Stage 0	1.242	N/A	1.362	1.242	N/A	N/A

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
Wall embedment safety factors from conventional analysis (limit-equilibrium):
FS1 Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
FS2 Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
FS3 Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0
Wall embedment safety factors from non-linear analysis:
FS4 Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.

FS5 True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Tables for stress checks follow: Support force/Design capacity

Support Check vs Stage

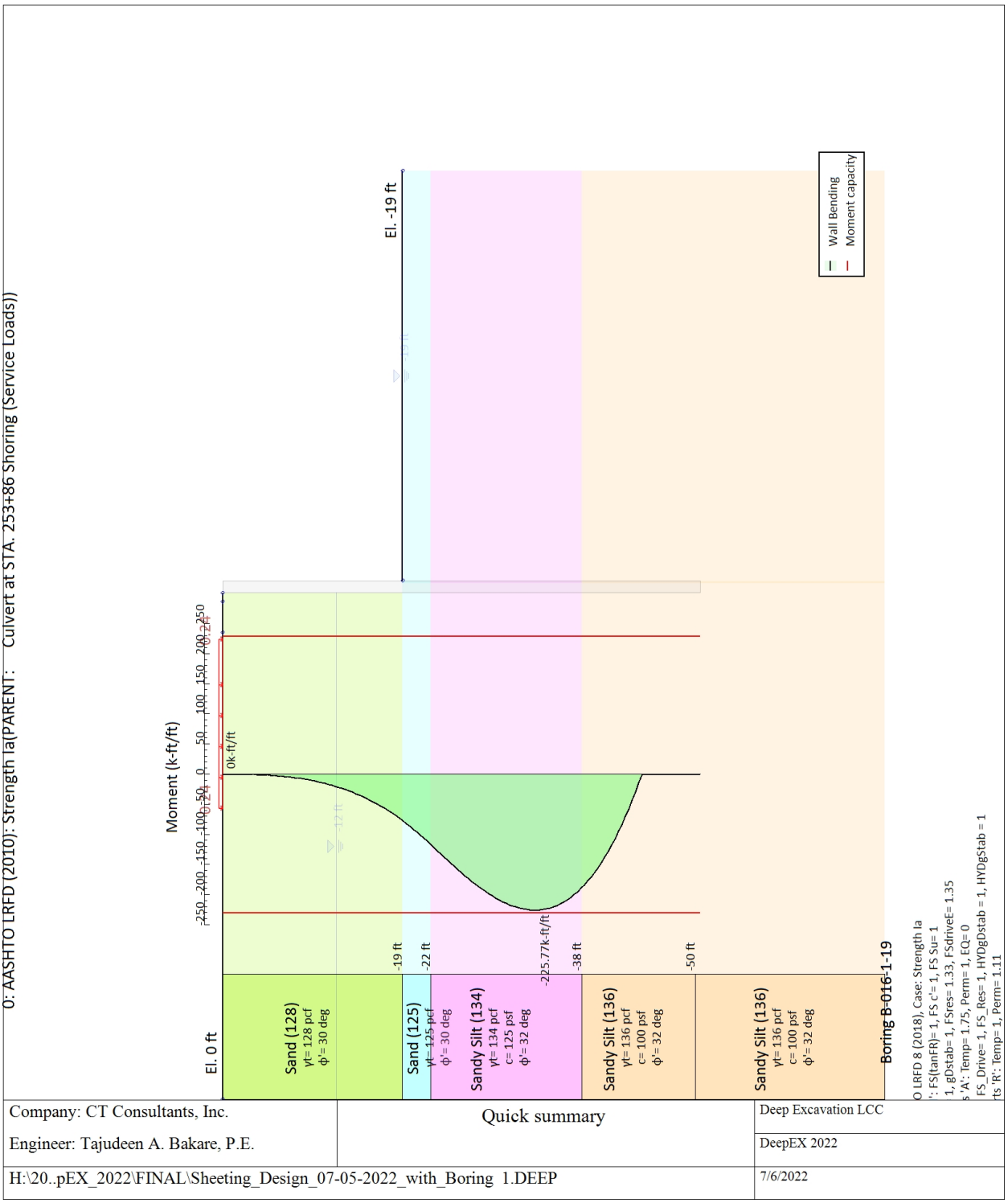
	No Supports
0:Stage 0	No support
1:Stage 1	

Forces (Res. F, M/Drive F, M)

	FS1 Passive	FS2 Rotation	FS3 Length	FS4 Mobilized Passive	FS5 Actual Drive	Fh EQ Soil	Fh EQ Water
	(FxResist/FxDrive)	(Mresist/Mdrive)	(Embedment/ToeFS=1)	(FxPassive/FxPas_Mobili	/ Theory Active		
Stage 0	446.702/41.215	7920.69/781.78	50.5/0.36	N/A	N/A	N/A	N/A
Stage 1	N/A	1451.85/616.83	31.5/25.37	N/A	N/A	N/A	N/A

Reinforcement Requirements

	Parameter Description
Note:	Wall does not use steel reinforcement. Section does not apply.



Company: CT Consultants, Inc.	Quick summary	Deep Excavation LCC
Engineer: Tajudeen A. Bakare, P.E.		DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Summary of Wall Moments and Toe Requirements

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(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
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Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

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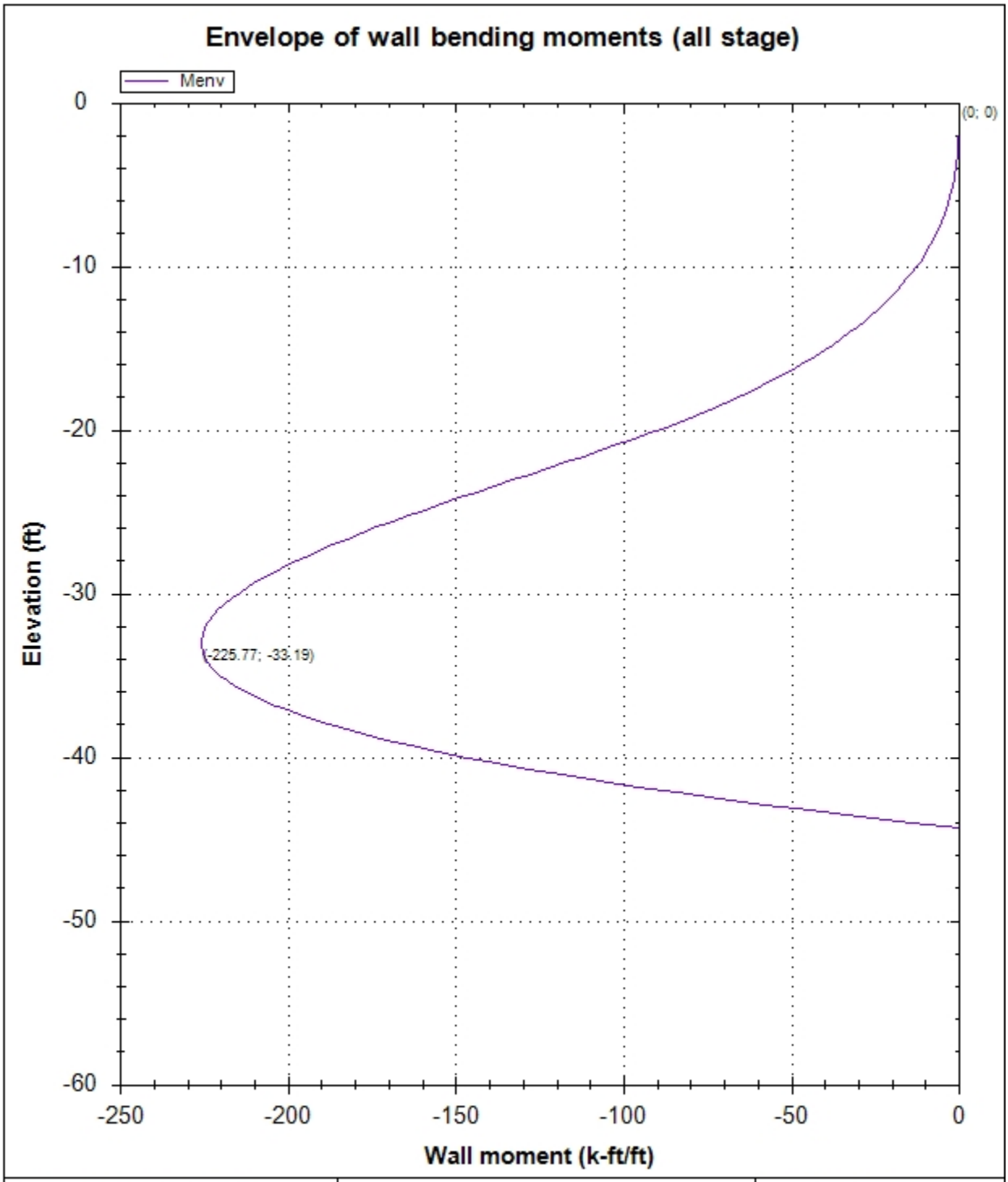
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.867	12.4	3.243	0.38	12.449	3.243

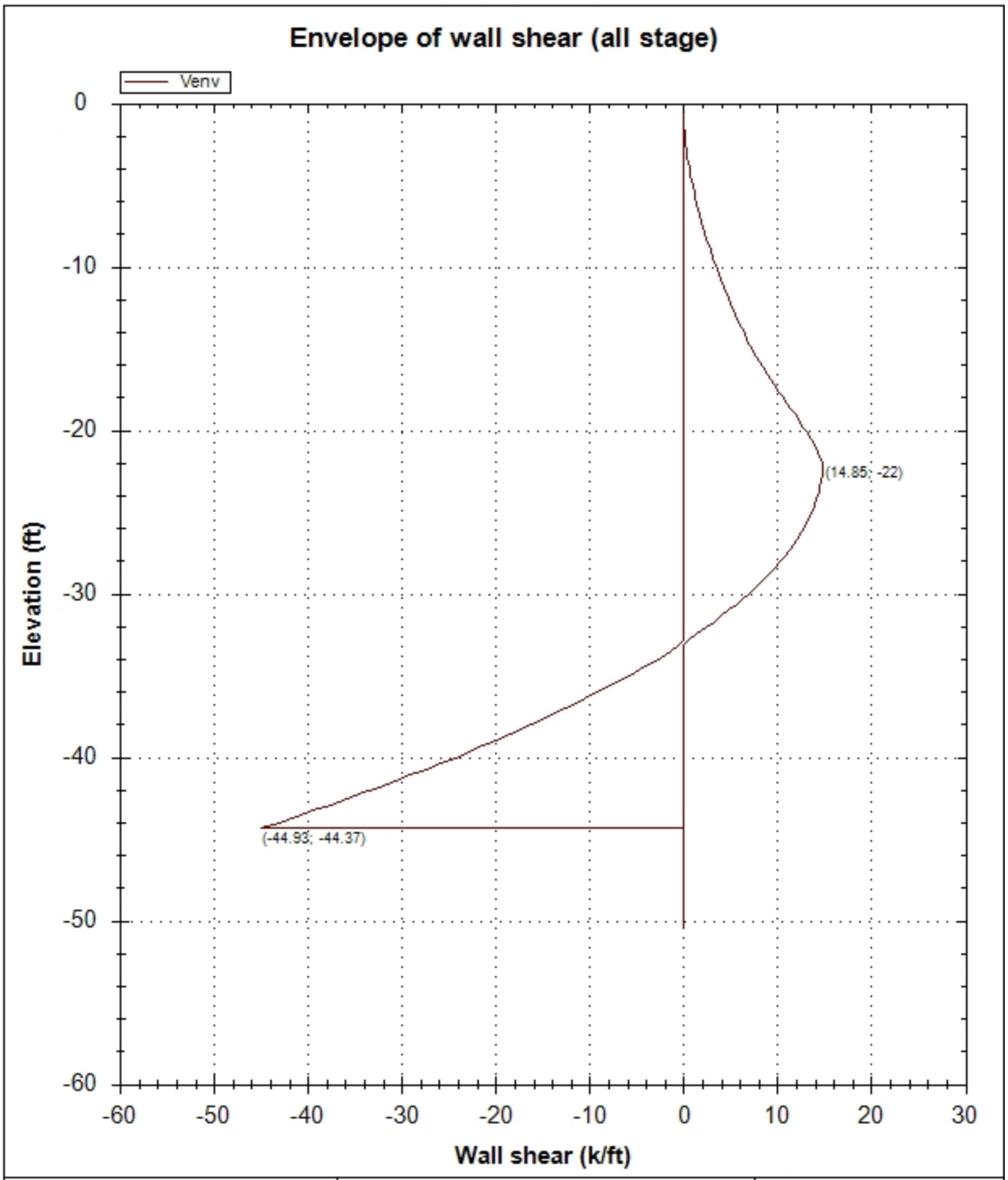
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 2 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
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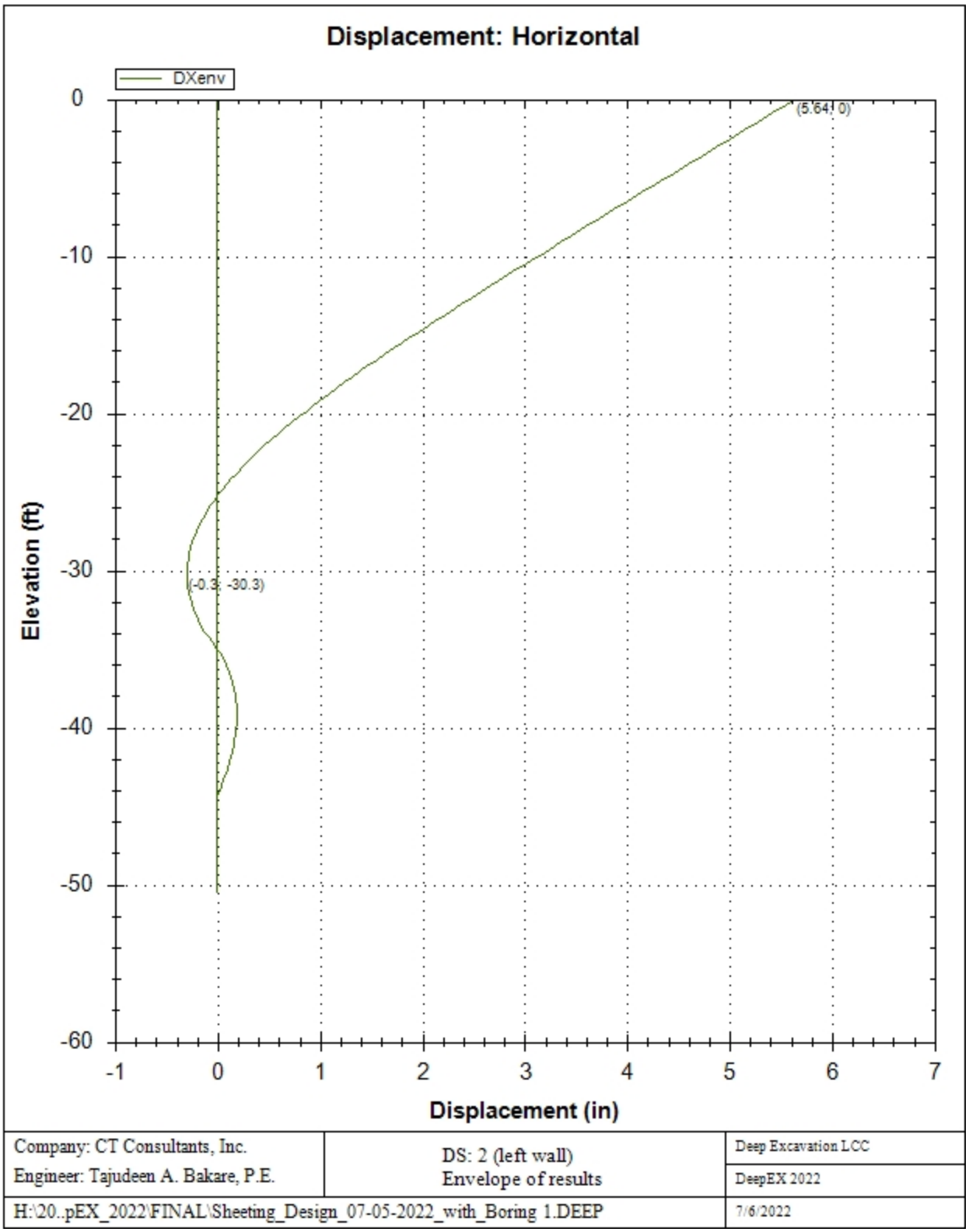

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:

Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)
F Su'= safety factof for undrained shear strength (Eurocode 7 methods)
F EQ= Load factor for seismic loads
F perm load= Load factor for permanent loads (dead load, etc)
F temp load= Load factor on live loads and other temporary loads
F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks
F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks
F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Strength Ia	1	1	1	0	1	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1
1	AASHTO LRFD	Strength Ia	1	1	1	0	1	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:
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F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Strength Ia	1	1	1	0	1	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1
1	AASHTO LRFD	Strength Ia	1	1	1	0	1	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1

SOIL DATA

Name	g tot	g dry	Frict	C'	Su	FRp	FRcv	Eload	rEur	kAp	kPp	kAcv	kPcv	Vary	Spring	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(deg)	(deg)	(ksf)	(-)	NL	NL	NL	NL		Model	
Sand (128)	128	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sand (125)	125	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sandy Silt (13	134	134	32	125	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	
Sandy Silt (13	136	136	32	100	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	

Name	Poisson	Min Ka	Min sh	ko.NC	nOCR	aH.EXP	aV.EXP	qSkin	qNails	kS.nails	PL
	v	(clays)	(clays)	-	-	(0 to 1)	(0 to 1)	(psi)	(psi)	(k/ft3)	(ksi)
Sand (128)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sand (125)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-

gtot = total soil specific weight
gdry = dry weigth of the soil
Frict = friction angle
C' = effective cohesion
Su = Undrained shear strength (only for CLAY soils in undrained conditions, used as a cutoff strength in NL analysis)
Evc = Virgin compression elastic modulus
Eur = unloading/reloading elastic modulus
Kap = Peak active thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kpp = Peak passive thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kacv = Constant volume active thrust coeff (only for clays, initial value)
Kpcv = Constant volume passive thrust coeff (only for clays, initial value).
Spring models= spring model (LIN= constant E over the soil layer height , EXP=exponential , SIMC=simplified winkler)
LIN= Linear-Elastic-Perfectly Plastic,
EXP: Exponential, SUB: Modulus of Subgrade Reaction
SIMC= Simplified Clay mode

SOIL BORINGS

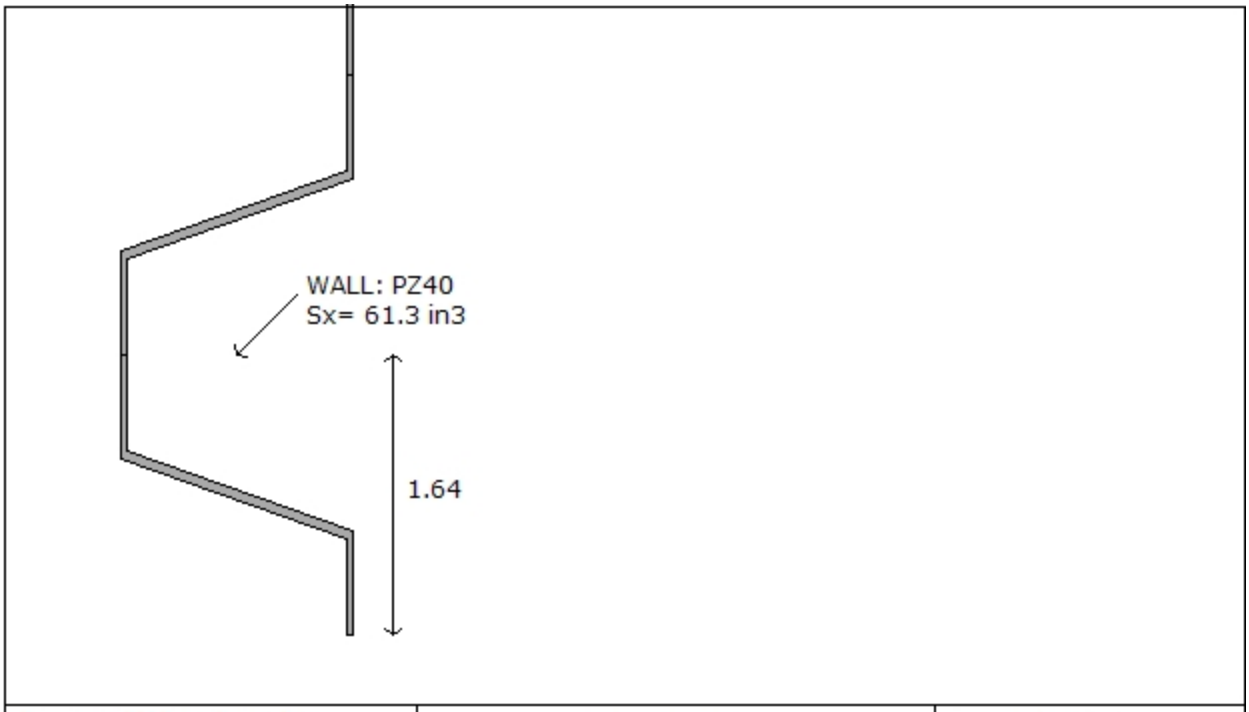
Top Elev= superior SOil level
Soil type= type of the soil (sand , clay , etc)
OCR= overconsolidation ratio
K0= at rest coefficient

Name: Boring B-016-1-19, pos: (0, 0)

Top elev.	Soil type	OCR	Ko
0	Sand (128)	1	0.5
-19	Sand (125)	1	0.5
-22	Sandy Silt (134	1	0.47
-38	Sandy Silt (136	1	0.47
-50	Sandy Silt (136	1	0.47

WALL DATA

Wall section 0: Wall section 0



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	Wall sketch	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Wall type: Steel sheet piling
Top wall El: 0 ft Bottom wall El: -50.5 ft
Hor. wall spacing: 1 ft Wall thickness = 1.37 ft
Passive width below exc: 1 ft Active width below exc: 1 ft Swater= 1 ft
Steel members fy = 50 ksi Esteel = 29000 ksi
Wall friction: Constant value = 17 degrees
Steel wall capacities are calculated with ANSI/AISC 360-10
Concrete capacities are calculated with ACI 318-19
Note: With ultimate capacities you may have to use a structural safety factor.
Steel sheet pile properties

Table: Steel Sheet Pile Cross Sectional Properties

DES	Shape	W	A	h	t	b	s	Ixx	Sxx
		(plf)	(in^2/ft)	(in)	(in)	(in)	(in)	(in^4/ft)	(in^3/ft)
PZ40	Z	65.6	11.75	16.4	0.5	19.69	0.605	503	61.3

GENERAL WALL DATA
Hor wall spacing= Wall horizontal spacing
Passive width below exc= spacing for passive thrust pressure for classic analysis
f'c=fck= cylindrical concrete resistance
fyk=fy= steel rebar characteristic resistance
Econc= Concrete Elastic modulus
fctk= characteristic Concrete tension
Esteel= steel elastic modulus
TABULAR DATA (principal parameters)
1) Diaphragm wall (rectangular cross section)
N/A= data not available
Fy=fyk

F'c=fck
D=wall thickness
B=wall width
2)Steel sheet pile
DES=shape (Z or U)
W=width per unit of length
A=area
h=height
t=horizontal part thickness
b=width of the single sheet pile part
s=inclined part thickness
Ixx=strong axis inertia (per unit of length)
Sxx=strong axis section modulus (per unit of length)
3)Secant piles wall, Tangent piles wall, soldier piles, soldier piles and timber lagging
W=weight per unit of length
A=area
D=diameter
tw=web thickness
tp= pipe thickness
bf=flange width
tf= flange thickness
k= flange thickness+stem base height
Ixx= strong axis inertia modulus (per unit of length)
Sxx= strong axis section modulus (per unit of length)
rx=radius of gyration about X axis
ry=radius of gyration about Y axis
Iyy=weak axis inertia modulus (per unit of length)
Syy=weak axis section modulus (per unit of length)
rT=radius of gyration for torsion
Cw= warping constant

GENERAL ANALYSIS CRITERIA

Summary of stage assumptions

Name	Analysis	Drive	ka-Mult	Htr T/B	Resist	Res	Contle
	Method	Press		(%)	Press	Mult	Method
Stage 0	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth
Stage 1	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth

Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1	10.132	10.132	10.838
Stage 1		N/A	1	1.242	1.362	N/A

Name=excavation stage name
Analysis method
springs = Elastoplastic spring analysis used
DR = Drained condition for CLAY model
U = Undrained condition for CLAY model for all the soils
Up = Undrained condition just for selected soil
Limit equilibrium analysis settings
Drive press:
Ka (Active pressure diagram), Ka-Trap = Trapezoid apparent diagram from active pressures x multiplier,
FHWA= Federal Highway Administration apparent pressure diagrams.
Ko = At-rest lateral earth pressures.
Peck = Peck 1969 Apparent earth pressure diagrams.
2 Step rect = Two step rectangular apparent earth pressure diagram.
User def. = User defined apparent earth pressure diagram.
Ka+d (and so on) indicates that wall friction is applied
ka mult = multiplication factor for Ka when Ka-Trap is selected
Htr T/B (%) = trapezoidal pressure scheme, top and bottom triangular percentage of excavation depth H
Resit press = Kp (passive earth pressures)
Res Mult = Safety factor applied directly on resisting pressures (
COntle Method = cantilever analysis method for limit equilibrium analysis.
Support Model: Method for calculating support reactions in limit-equlibrium analysis.
Beam= support reactions beam analysis (uses Blum's method).
Trib= support reactions from tributary height calculations (Can be applied with apparent diagrams).
Axial Incl = Axial loads included for structural design
Used FS wall = Safety factor for axial+bending wall resistance to divide ultimate wall capacities.
Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)
Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)
Toe FSpas= driving/resisting pressure safety factor (for limit equilibrium analysis)

EXCAVATION STAGES SKETCHES

A sequence of figures for each excavation stage is reported

Toe stability

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	10.132	10.838	10.132	140.278	N/A	N/A
Stage 1	1.242	N/A	1.362	1.242	N/A	N/A

Legend: Wall embedment safety factors (toe)
Min Toe FS= Minimum wall embedment safety factor (from all analysis methods)
Limit-equilibrium analysis methods: The following safety factors may not be applicable for all stages.
FS1 Passive: Horizontal force safety factor, FS1= Resisting/Driving force
FS2 Rotation: Rotational safety factor about lowest support, FS2= Resisting moment/Driving moment
FS3 Length (from FS1, FS2): Program determines maximum required wall embedment for safety factor of 1 for methods FS1 and FS2 (say length LFS1). Then FS length= Provided wall embedment/LFS1.
Non-linear elastoplastic analysis safety factors:
FS4 Mobilized Passive: Safety factor on mobilized passive resistance, FS4= Available passive soil resistance/Mobilized passive soil force on excavation side.
FS5 Active Drive Thrust/Theory Active: Ratio of soil thrust on retained side/ Active condition theoretical minimum thrust. This factor is not as critical, and indicates how close to active conditions the model is.
General recommendations on wall embedment (excluding FS5):
When then excavation is designed with allowable standards, engineers generally use minimum safety factors from 1.2 to 1.5 depending on the level of confidence. A minimum safety factor of 1.2 is generally applied on FS3.
With ultimate limit state designs (such as Eurocode 7, and LRFD) the required safety factor must generally be greater than 1.0. In non-linear solutions it might be impossible to achieve exactly 1 on FS4 as this would likely trigger overall failure.

Result diagrams (for walls)

A sequence of result diagrams for each excavation stage is reported

WALL RESULTS TABLE

LEGEND
Wall node=number of the node (0 at top)
EL= Node elevation
Sht L=Total horizontal soil pressure (on the left side of the wall)
Sht R=Total horizontal soil pressure (on the right side of the wall)
Shs L=Effective horizontal soil pressure (on the left side of the wall)
Shs R=Effective horizontal soil pressure (on the right side of the wall)
q=pressure given by the surcharge
U L= Water pressure (on the left side of the wall)
U R= Water pressure (on the right side of the wall)
M=bending moment (per unit length)
V=shear (per unit length)
dx=wall deflection
McapL=Ultimate bending moment (on the left side of the wall)
McapR=Ultimate bending moment (on the right side of the wall)
VcapL=Ultimate resistance shear (on the left side of the wall)
VcapR=Ultimate resistance shear (on the right side of the wall)

EXCAVATION STAGES AND SLOPE STABILITY

Reports a sequence of figures for each stage with slope stability results.

SLOPE STABILITY ANALYSIS: SLICE RESULTS ALL STAGES

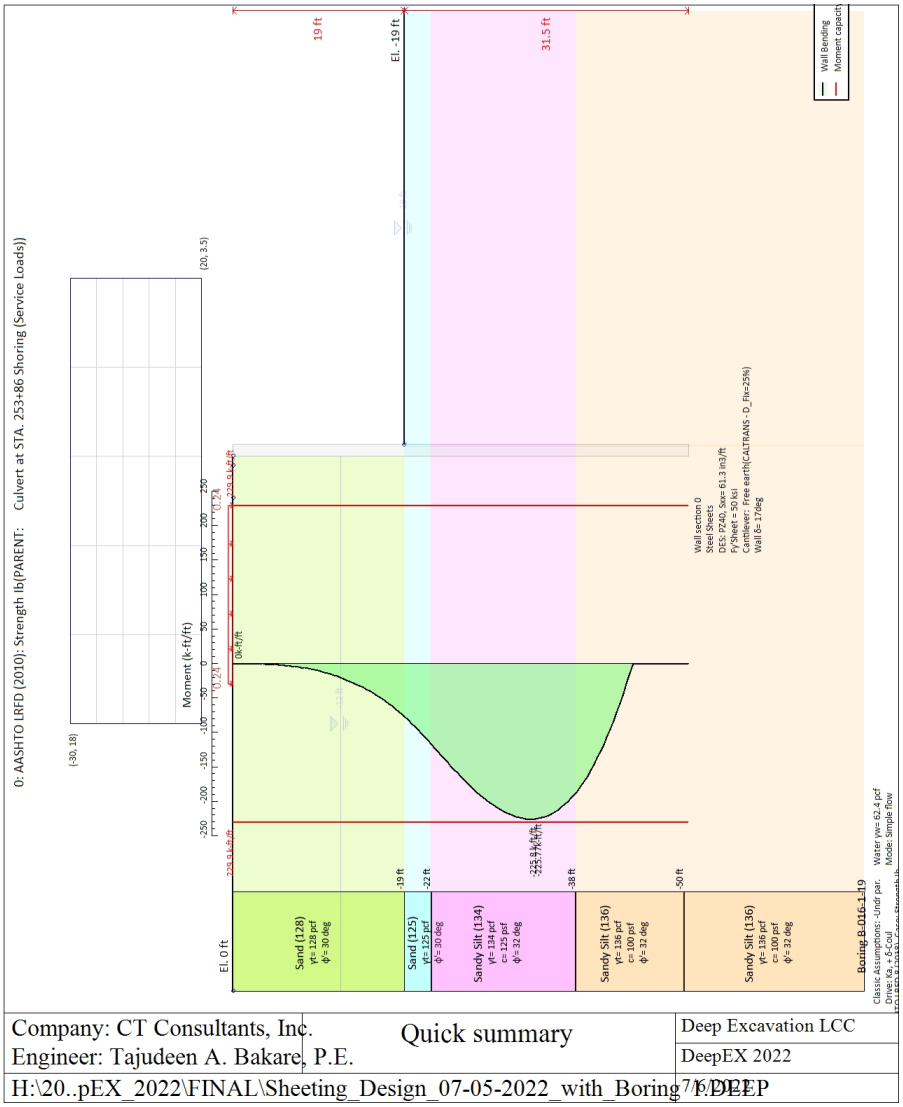
Slope stability analysis design section: 0: AASHTO LRFD (2010): Strength Ia

LEGEND

x1 = Left x coordinate
ZsL= Left slice bottom elevation
ZtL= Left top elevation
x2 = Right x coordinate
ZsR= Right slice bottom elevation
ZtR= Right top eleevation
DL = Slice base width
an = Base angle
Fr = Average friction angle at base
c = Average cohesion at base (may include undrained clay strengths)
Wn = Total slice weight
ubL= Water pressure at left bottom point
ubR= Water pressure at right bottom point
tBase= Base shear resistance
Nr = Effective normal reaction at bottom of slice
EiL= Lateral interslice force on left face
EiR= Lateral interslice force on right face
TL = Vertical interslice shear on left vertical face
TR = Vertical interslice shear on right vertical face
UbF= Normal water force at slice base

Project: ODOT PID No. 108665; LAK-20-19.59 - WEST
Results for Design Section 3: 0: AASHTO LRFD (2010): Strength Ib

ANALYSIS AND CHECKING SUMMARY



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	Quick summary	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
0	Wall section	50.5	19	0/229.88	225.77/229.88	10.838	1.362	1.242	-44.37	3.243

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

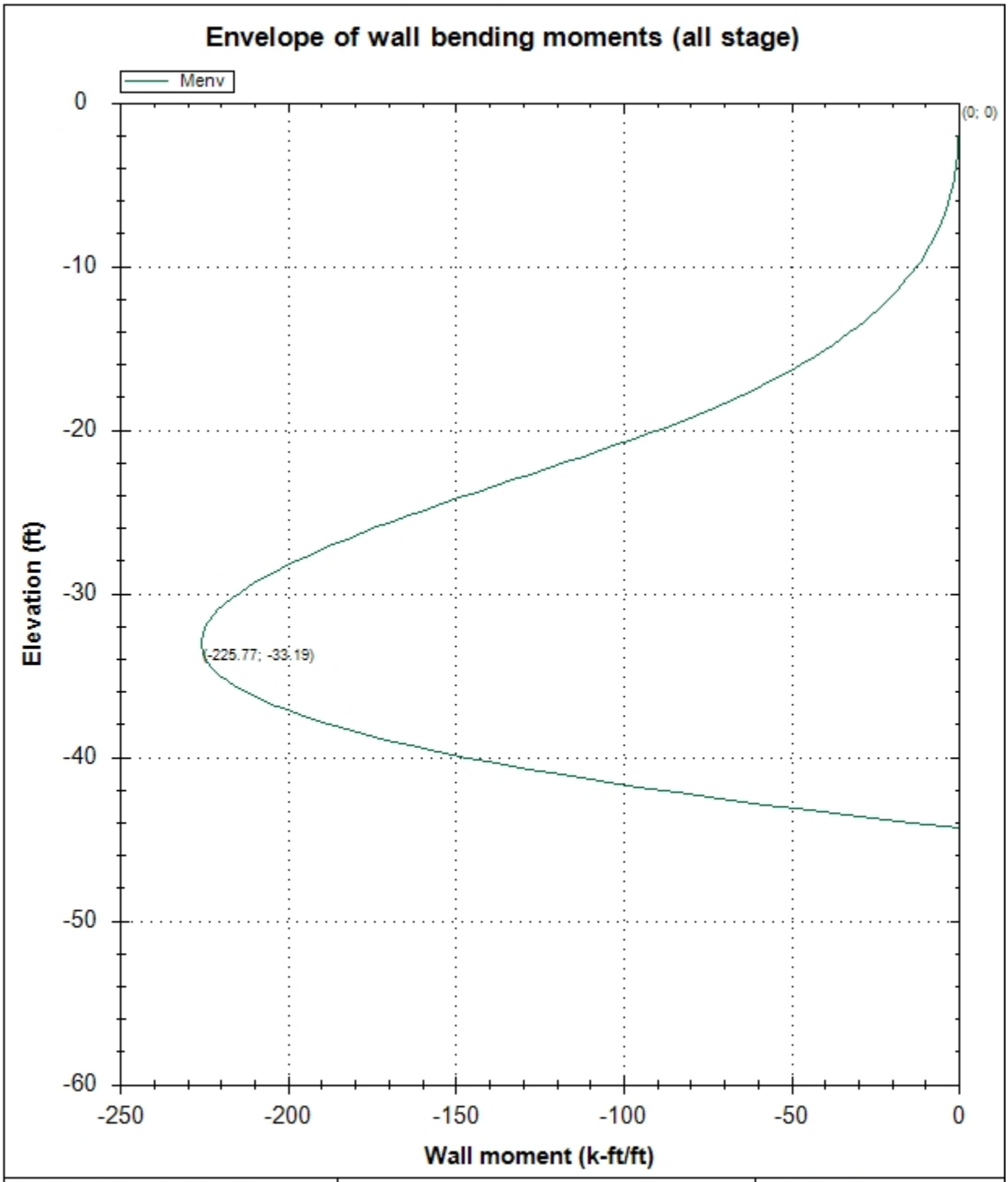
1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.867	12.4	3.243	0.38	12.449	3.243

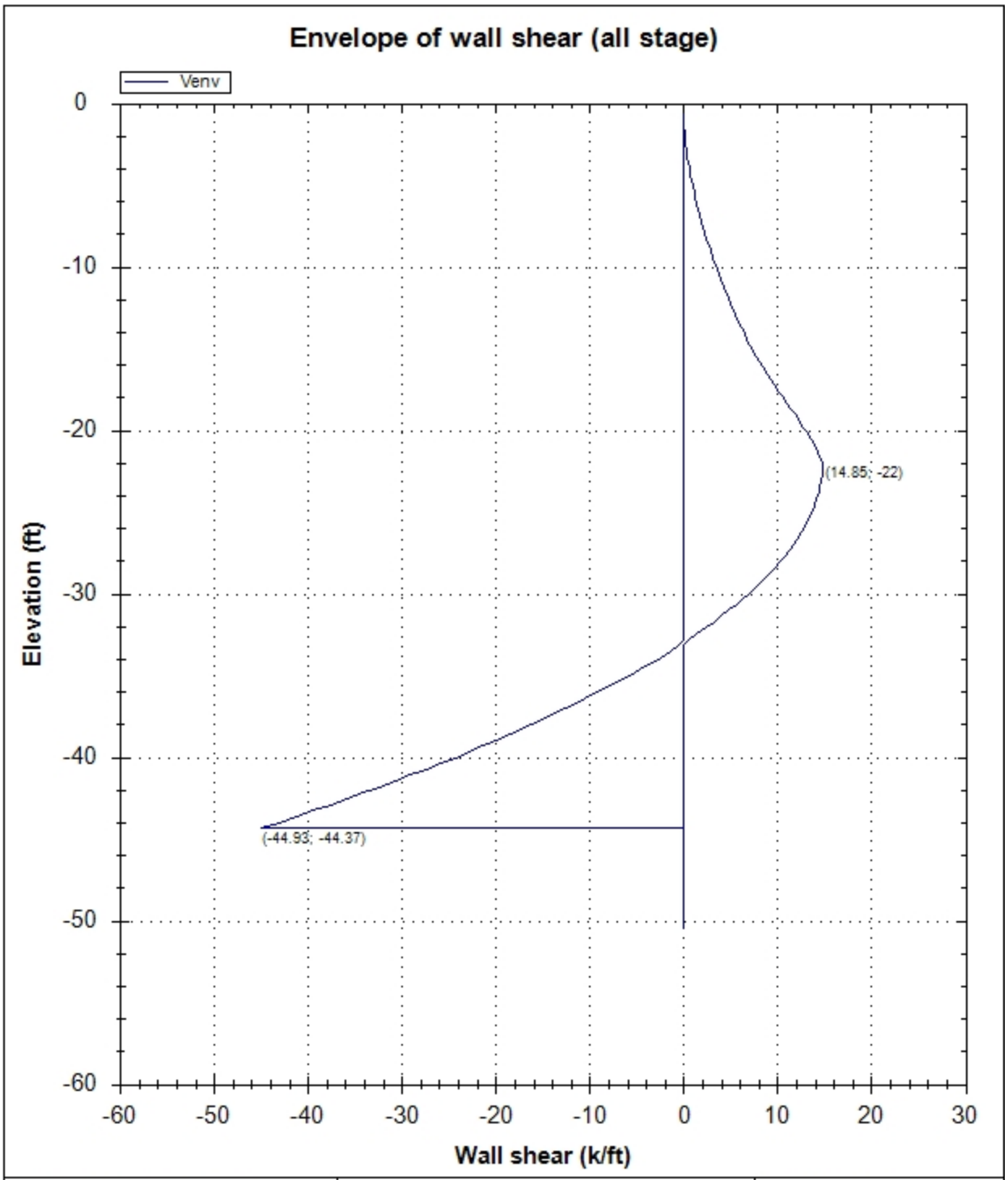
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 3 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
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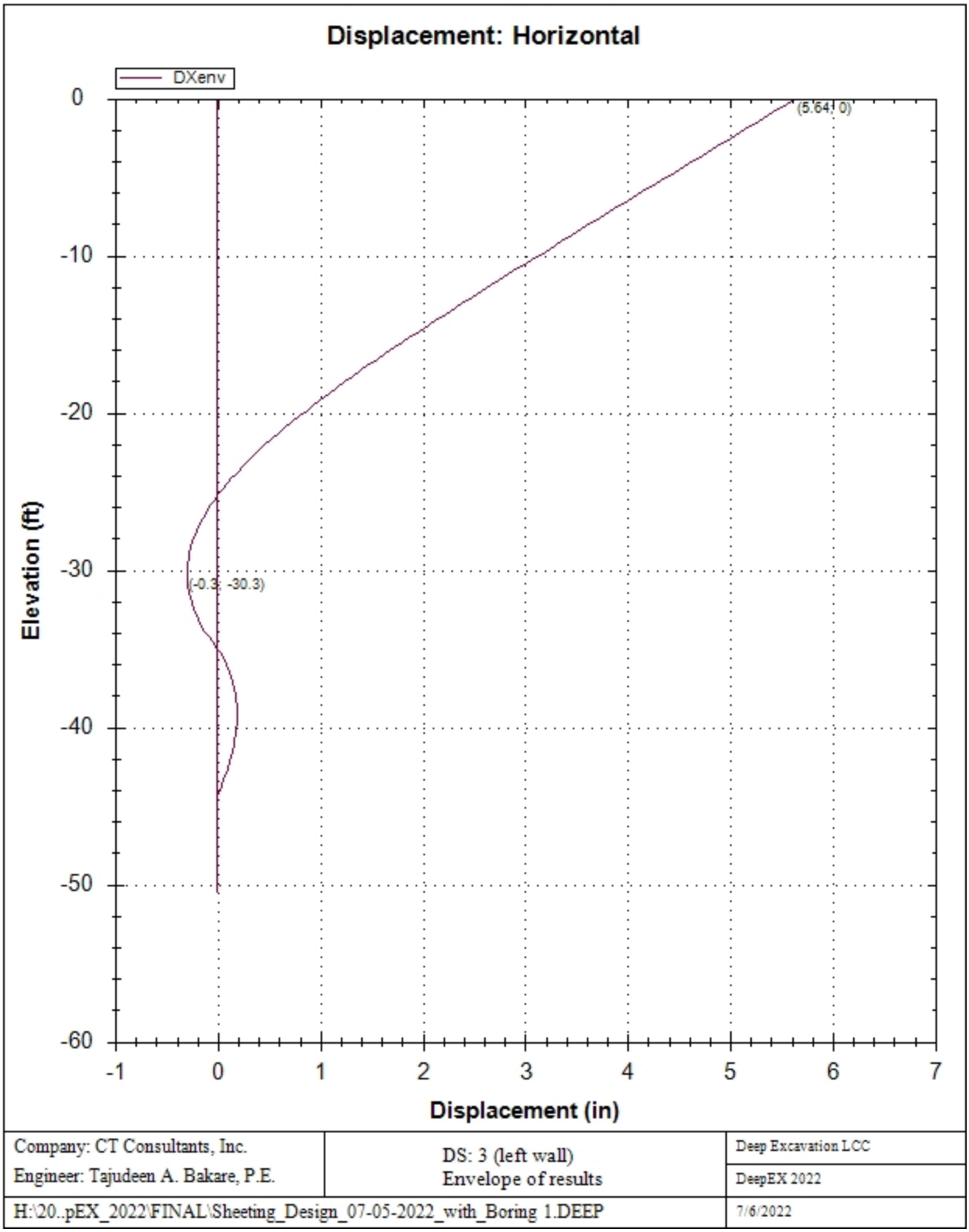


Extended vs Stage

	Calculation Result	Wall Displaceme	Settlement	Wall Moment	Wall Moment
		(in)	(in)	(k-ft/ft)	(k-ft)
Stage 0	Calculated	0	N/A	0	0
Stage 1	Calculated	5.64	2.39	225.77	225.77

	Wall Shear	Wall Shear	STR Combined	STR Moment	STR Shear
	(k/ft)	(k)	Wall Ratio	Wall Ratio	Wall Ratio
Stage 0	0	0	0	0	0
Stage 1	44.93	44.93	0.982	0.982	0.275

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

	Max Support	Max Support	Critical	STR Support	Support Geotech
	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull out
Stage 0	0	0	N/A	No supports	No supports
Stage 1	0	0	N/A	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).
Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

	FS	Toe FS	Toe FS	Toe FS	Zcut	FS Mobilized	FS
	Basal	Passive	Rotation	Length	(nonlinear)	Passive	True/Active
Stage 0	1000	10.838	10.132	140.278	N/A	N/A	N/A
Stage 1	N/A	N/A	1.362	1.242	N/A	N/A	N/A

	Hydraulic	Qflow	FSslope
	Heave FS	(ft3/hr)	
Stage 0	2.729	N/A	N/C
Stage 1	1.821	N/A	3.243

Support Force/S vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Support Force vs Stage

Support Force vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	10.132	10.838	10.132	140.278	N/A	N/A
0:Stage 0	1.242	N/A	1.362	1.242	N/A	N/A

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
Wall embedment safety factors from conventional analysis (limit-equilibrium):
FS1 Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
FS2 Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
FS3 Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0
Wall embedment safety factors from non-linear analysis:
FS4 Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.

FS5 True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Tables for stress checks follow: Support force/Design capacity

Support Check vs Stage

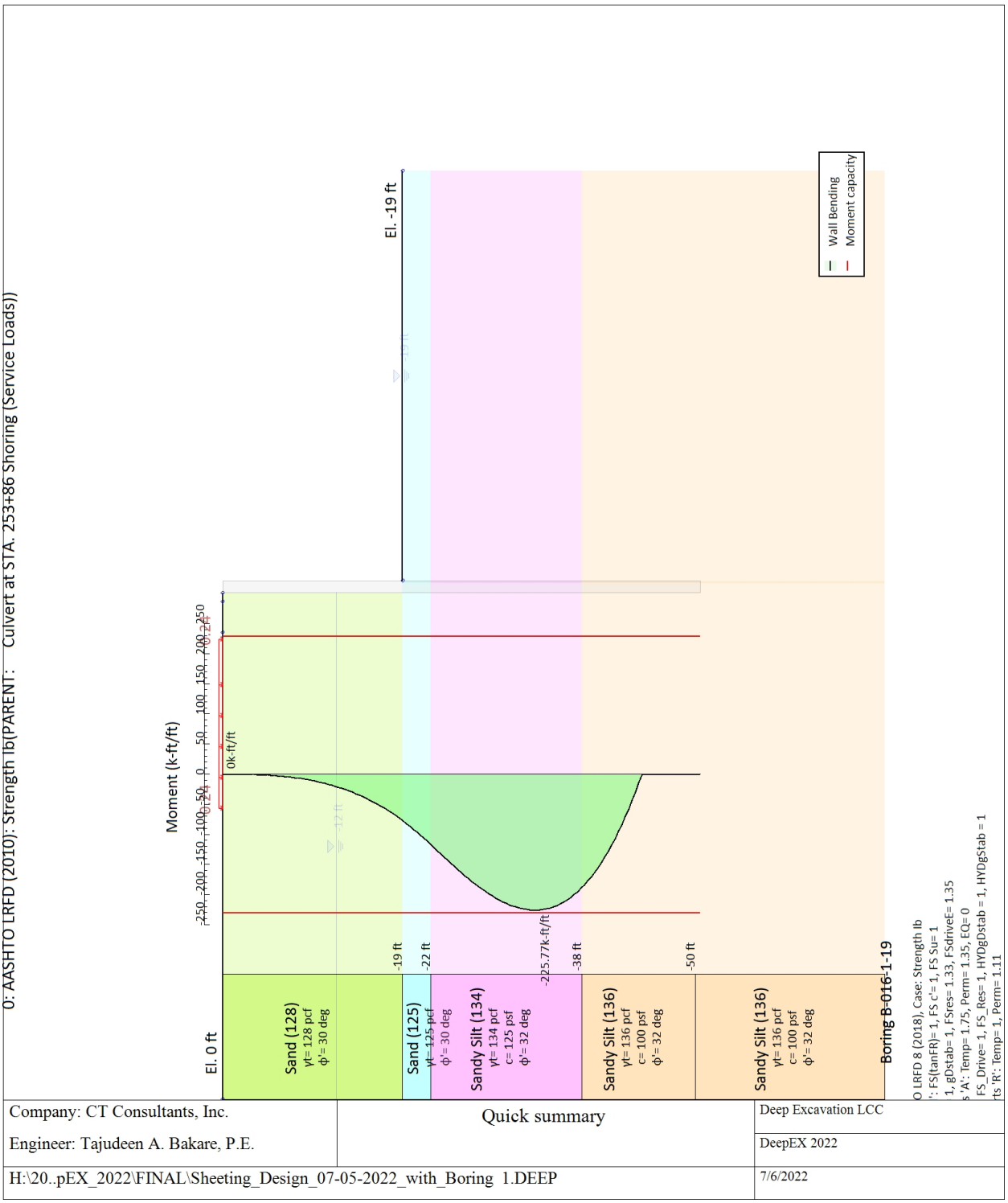
	No Supports
0:Stage 0	No support
1:Stage 1	

Forces (Res. F, M/Drive F, M)

	FS1 Passive	FS2 Rotation	FS3 Length	FS4 Mobilized Passive	FS5 Actual Drive	Fh EQ Soil	Fh EQ Water
	(FxResist/FxDrive)	(Mresist/Mdrive)	(Embedment/ToeFS=1)	(FxPassive/FxPas_Mobili	/ Theory Active		
Stage 0	446.702/41.215	7920.69/781.78	50.5/0.36	N/A	N/A	N/A	N/A
Stage 1	N/A	1451.85/616.83	31.5/25.37	N/A	N/A	N/A	N/A

Reinforcement Requirements

	Parameter Description
Note:	Wall does not use steel reinforcement. Section does not apply.



Company: CT Consultants, Inc.	Quick summary	Deep Excavation LCC
Engineer: Tajudeen A. Bakare, P.E.		DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Summary of Wall Moments and Toe Requirements

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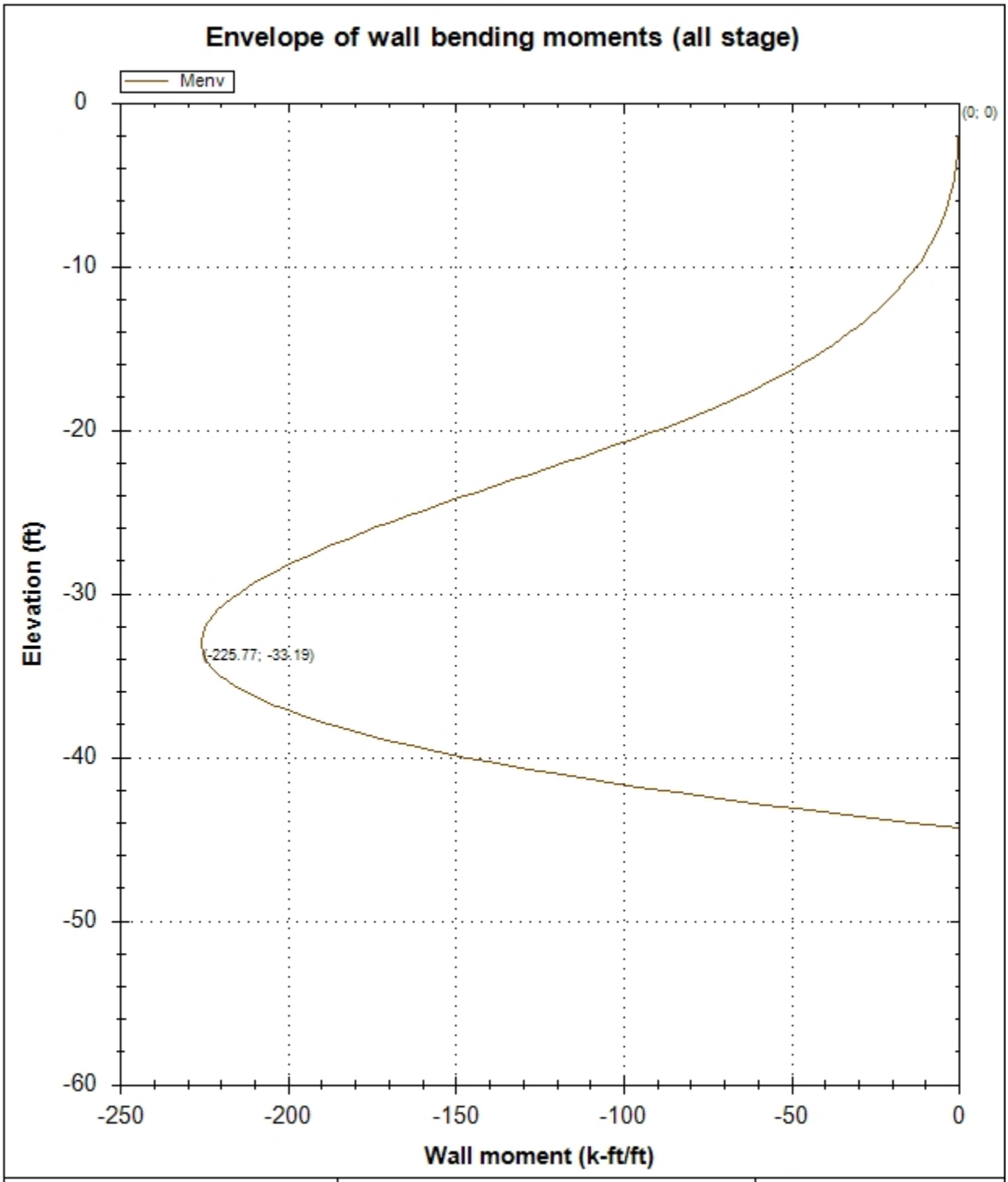
1000	0.867	12.4	3.243	0.38	12.449	3.243

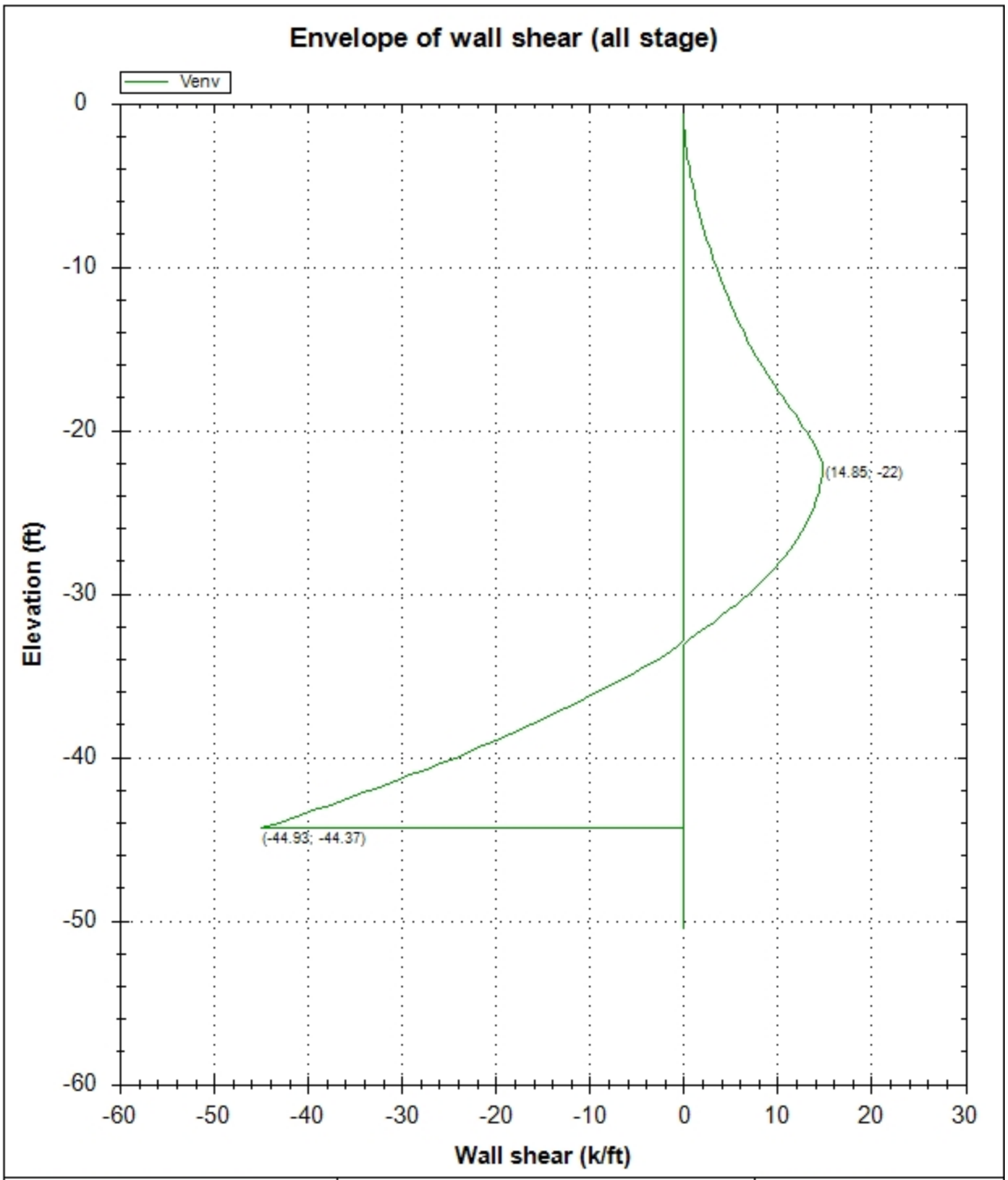
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 3 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
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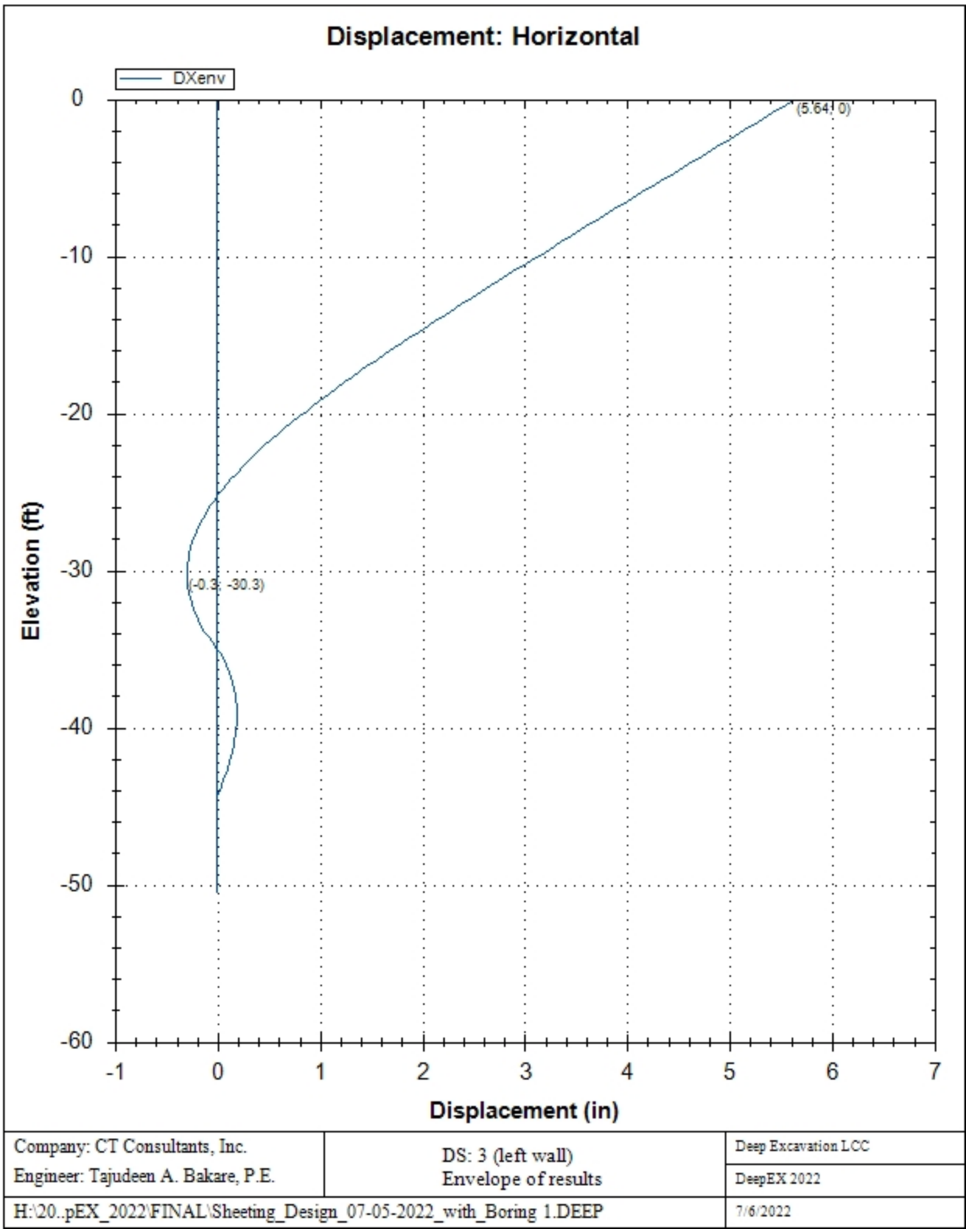

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:

Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)
F Su'= safety factof for undrained shear strength (Eurocode 7 methods)
F EQ= Load factor for seismic loads
F perm load= Load factor for permanent loads (dead load, etc)
F temp load= Load factor on live loads and other temporary loads
F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks
F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks
F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Strength Ib	1	1	1	0	1.35	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1
1	AASHTO LRFD	Strength Ib	1	1	1	0	1.35	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:
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F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Strength Ib	1	1	1	0	1.35	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1
1	AASHTO LRFD	Strength Ib	1	1	1	0	1.35	1.75	1.11	1	1.35	1.33	1	1	1	1	1	1

SOIL DATA

Name	g tot	g dry	Frict	C'	Su	FRp	FRcv	Eload	rEur	kAp	kPp	kAcv	kPcv	Vary	Spring	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(deg)	(deg)	(ksf)	(-)	NL	NL	NL	NL		Model	
Sand (128)	128	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sand (125)	125	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sandy Silt (13	134	134	32	125	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	
Sandy Silt (13	136	136	32	100	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	

Name	Poisson	Min Ka	Min sh	ko.NC	nOCR	aH.EXP	aV.EXP	qSkin	qNails	kS.nails	PL
	v	(clays)	(clays)	-	-	(0 to 1)	(0 to 1)	(psi)	(psi)	(k/ft3)	(ksi)
Sand (128)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sand (125)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-

gtot = total soil specific weight
gdry = dry weigth of the soil
Frict = friction angle
C' = effective cohesion
Su = Undrained shear strength (only for CLAY soils in undrained conditions, used as a cutoff strength in NL analysis)
Evc = Virgin compression elastic modulus
Eur = unloading/reloading elastic modulus
Kap = Peak active thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kpp = Peak passive thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kacv = Constant volume active thrust coeff (only for clays, initial value)
Kpcv = Constant volume passive thrust coeff (only for clays, initial value).
Spring models= spring model (LIN= constant E over the soil layer height , EXP=exponential , SIMC=simplified winkler)
LIN= Linear-Elastic-Perfectly Plastic,
EXP: Exponential, SUB: Modulus of Subgrade Reaction
SIMC= Simplified Clay mode

SOIL BORINGS

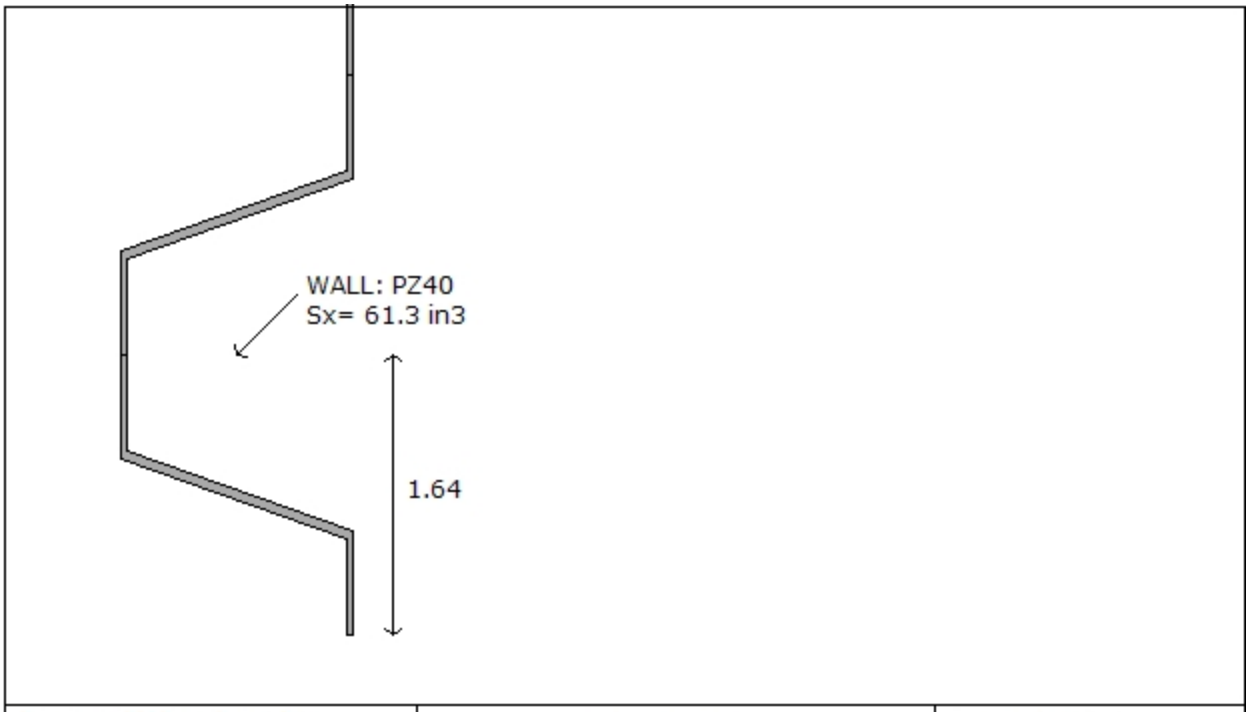
Top Elev= superior SOil level
Soil type= type of the soil (sand , clay , etc)
OCR= overconsolidation ratio
K0= at rest coefficient

Name: Boring B-016-1-19, pos: (0, 0)

Top elev.	Soil type	OCR	Ko
0	Sand (128)	1	0.5
-19	Sand (125)	1	0.5
-22	Sandy Silt (134	1	0.47
-38	Sandy Silt (136	1	0.47
-50	Sandy Silt (136	1	0.47

WALL DATA

Wall section 0: Wall section 0



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	Wall sketch	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Wall type: Steel sheet piling
Top wall El: 0 ft Bottom wall El: -50.5 ft
Hor. wall spacing: 1 ft Wall thickness = 1.37 ft
Passive width below exc: 1 ft Active width below exc: 1 ft Swater= 1 ft
Steel members fy = 50 ksi Esteel = 29000 ksi
Wall friction: Constant value = 17 degrees
Steel wall capacities are calculated with ANSI/AISC 360-10
Concrete capacities are calculated with ACI 318-19
Note: With ultimate capacities you may have to use a structural safety factor.
Steel sheet pile properties

Table: Steel Sheet Pile Cross Sectional Properties

DES	Shape	W	A	h	t	b	s	Ixx	Sxx
		(plf)	(in^2/ft)	(in)	(in)	(in)	(in)	(in^4/ft)	(in^3/ft)
PZ40	Z	65.6	11.75	16.4	0.5	19.69	0.605	503	61.3

GENERAL WALL DATA
Hor wall spacing= Wall horizontal spacing
Passive width below exc= spacing for passive thrust pressure for classic analysis
f'c=fck= cylindrical concrete resistance
fyk=fy= steel rebar characteristic resistance
Econc= Concrete Elastic modulus
fctk= characteristic Concrete tension
Esteel= steel elastic modulus
TABULAR DATA (principal parameters)
1) Diaphragm wall (rectangular cross section)
N/A= data not available
Fy=fyk

F'c=fck
D=wall thickness
B=wall width
2)Steel sheet pile
DES=shape (Z or U)
W=width per unit of length
A=area
h=height
t=horizontal part thickness
b=width of the single sheet pile part
s=inclined part thickness
Ixx=strong axis inertia (per unit of length)
Sxx=strong axis section modulus (per unit of length)
3)Secant piles wall, Tangent piles wall, soldier piles, soldier piles and timber lagging
W=weight per unit of length
A=area
D=diameter
tw=web thickness
tp= pipe thickness
bf=flange width
tf= flange thickness
k= flange thickness+stem base height
Ixx= strong axis inertia modulus (per unit of length)
Sxx= strong axis section modulus (per unit of length)
rx=radius of gyration about X axis
ry=radius of gyration about Y axis
Iyy=weak axis inertia modulus (per unit of length)
Syy=weak axis section modulus (per unit of length)
rT=radius of gyration for torsion
Cw= warping constant

GENERAL ANALYSIS CRITERIA

Summary of stage assumptions

Name	Analysis	Drive	ka-Mult	Htr T/B	Resist	Res	Contle
	Method	Press		(%)	Press	Mult	Method
Stage 0	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth
Stage 1	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth

Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1	10.132	10.132	10.838
Stage 1		N/A	1	1.242	1.362	N/A

Name=excavation stage name
Analysis method
springs = Elastoplastic spring analysis used
DR = Drained condition for CLAY model
U = Undrained condition for CLAY model for all the soils
Up = Undrained condition just for selected soil
Limit equilibrium analysis settings
Drive press:
Ka (Active pressure diagram), Ka-Trap = Trapezoid apparent diagram from active pressures x multiplier,
FHWA= Federal Highway Administration apparent pressure diagrams.
Ko = At-rest lateral earth pressures.
Peck = Peck 1969 Apparent earth pressure diagrams.
2 Step rect = Two step rectangular apparent earth pressure diagram.
User def. = User defined apparent earth pressure diagram.
Ka+d (and so on) indicates that wall friction is applied
ka mult = multiplication factor for Ka when Ka-Trap is selected
Htr T/B (%) = trapezoidal pressure scheme, top and bottom triangular percentage of excavation depth H
Resit press = Kp (passive earth pressures)
Res Mult = Safety factor applied directly on resisting pressures (
COntle Method = cantilever analysis method for limit equilibrium analysis.
Support Model: Method for calculating support reactions in limit-equlibrium analysis.
Beam= support reactions beam analysis (uses Blum's method).
Trib= support reactions from tributary height calculations (Can be applied with apparent diagrams).
Axial Incl = Axial loads included for structural design
Used FS wall = Safety factor for axial+bending wall resistance to divide ultimate wall capacities.
Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)
Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)
Toe FSpas= driving/resisting pressure safety factor (for limit equilibrium analysis)

EXCAVATION STAGES SKETCHES

A sequence of figures for each excavation stage is reported

Toe stability

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	10.132	10.838	10.132	140.278	N/A	N/A
Stage 1	1.242	N/A	1.362	1.242	N/A	N/A

Legend: Wall embedment safety factors (toe)
Min Toe FS= Minimum wall embedment safety factor (from all analysis methods)
Limit-equilibrium analysis methods: The following safety factors may not be applicable for all stages.
FS1 Passive: Horizontal force safety factor, FS1= Resisting/Driving force
FS2 Rotation: Rotational safety factor about lowest support, FS2= Resisting moment/Driving moment
FS3 Length (from FS1, FS2): Program determines maximum required wall embedment for safety factor of 1 for methods FS1 and FS2 (say length LFS1). Then FS length= Provided wall embedment/LFS1.
Non-linear elastoplastic analysis safety factors:
FS4 Mobilized Passive: Safety factor on mobilized passive resistance, FS4= Available passive soil resistance/Mobilized passive soil force on excavation side.
FS5 Active Drive Thrust/Theory Active: Ratio of soil thrust on retained side/ Active condition theoretical minimum thrust. This factor is not as critical, and indicates how close to active conditions the model is.
General recommendations on wall embedment (excluding FS5):
When then excavation is designed with allowable standards, engineers generally use minimum safety factors from 1.2 to 1.5 depending on the level of confidence. A minimum safety factor of 1.2 is generally applied on FS3.
With ultimate limit state designs (such as Eurocode 7, and LRFD) the required safety factor must generally be greater than 1.0. In non-linear solutions it might be impossible to achieve exactly 1 on FS4 as this would likely trigger overall failure.

Result diagrams (for walls)

A sequence of result diagrams for each excavation stage is reported

WALL RESULTS TABLE

LEGEND
Wall node=number of the node (0 at top)
EL= Node elevation
Sht L=Total horizontal soil pressure (on the left side of the wall)
Sht R=Total horizontal soil pressure (on the right side of the wall)
Shs L=Effective horizontal soil pressure (on the left side of the wall)
Shs R=Effective horizontal soil pressure (on the right side of the wall)
q=pressure given by the surcharge
U L= Water pressure (on the left side of the wall)
U R= Water pressure (on the right side of the wall)
M=bending moment (per unit length)
V=shear (per unit length)
dx=wall deflection
McapL=Ultimate bending moment (on the left side of the wall)
McapR=Ultimate bending moment (on the right side of the wall)
VcapL=Ultimate resistance shear (on the left side of the wall)
VcapR=Ultimate resistance shear (on the right side of the wall)

EXCAVATION STAGES AND SLOPE STABILITY

Reports a sequence of figures for each stage with slope stability results.

SLOPE STABILITY ANALYSIS: SLICE RESULTS ALL STAGES

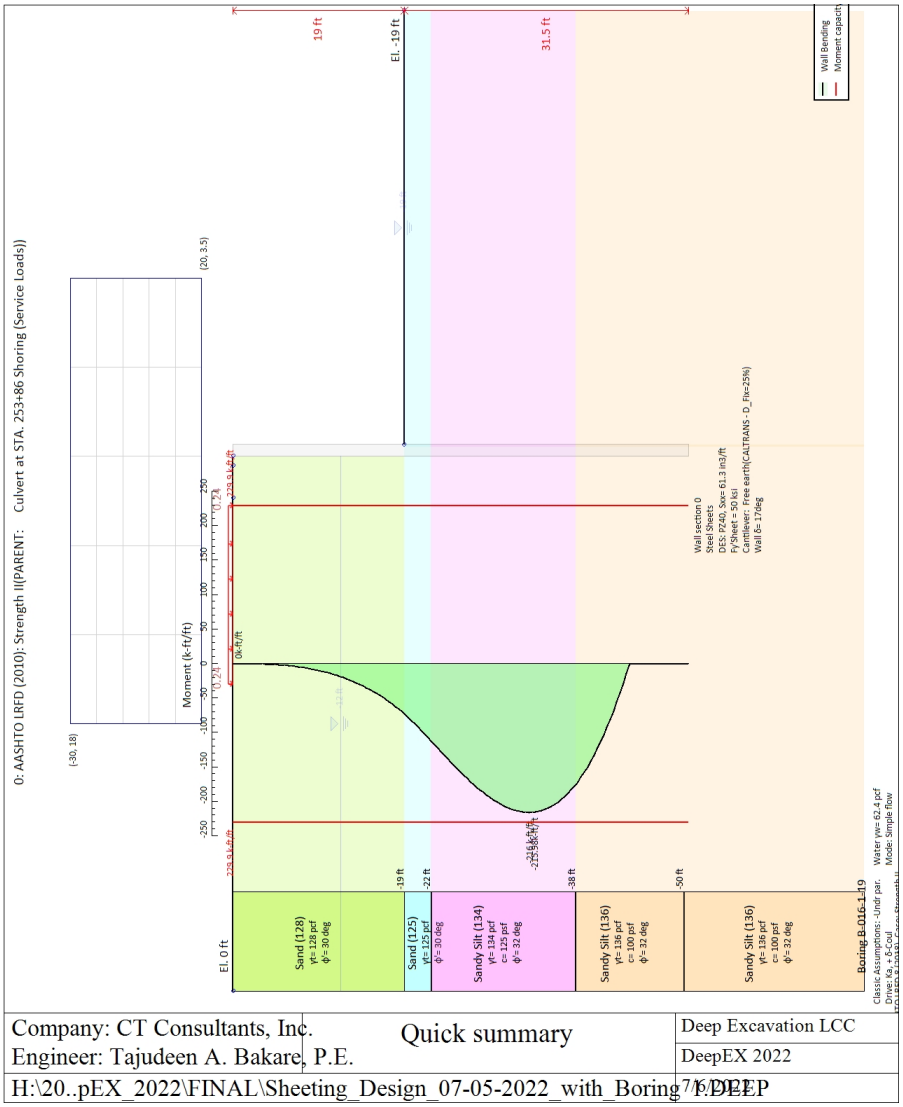
Slope stability analysis design section: 0: AASHTO LRFD (2010): Strength Ib

LEGEND

x1 = Left x coordinate
ZsL= Left slice bottom elevation
ZtL= Left top elevation
x2 = Right x coordinate
ZsR= Right slice bottom elevation
ZtR= Right top eleevation
DL = Slice base width
an = Base angle
Fr = Average friction angle at base
c = Average cohesion at base (may include undrained clay strengths)
Wn = Total slice weight
ubL= Water pressure at left bottom point
ubR= Water pressure at right bottom point
tBase= Base shear resistance
Nr = Effective normal reaction at bottom of slice
EiL= Lateral interslice force on left face
EiR= Lateral interslice force on right face
TL = Vertical interslice shear on left vertical face
TR = Vertical interslice shear on right vertical face
UbF= Normal water force at slice base

Project: ODOT PID No. 108665; LAK-20-19.59 - WEST
Results for Design Section 4: 0: AASHTO LRFD (2010): Strength II

ANALYSIS AND CHECKING SUMMARY



Company: CT Consultants, Inc.	Quick summary	Deep Excavation LCC
Engineer: Tajudeen A. Bakare, P.E.		DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Summary of Wall Moments and Toe Requirements

Top Wall	Wall	L-Wall	H-Exc.	Max+M/Cap	Max-M/Cap	FS Toe	FS Toe	FS Toe	FS 1 Toe EL.	Slope
(ft)	Section	(ft)	(ft)	(k-ft/ft)	(k-ft/ft)	Passive	Rotation	Embedment	(ft)	Stab. FS
0	Wall section	50.5	19	0/229.88	215.98/229.88	10.838	1.387	1.259	-44.01	3.266

Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

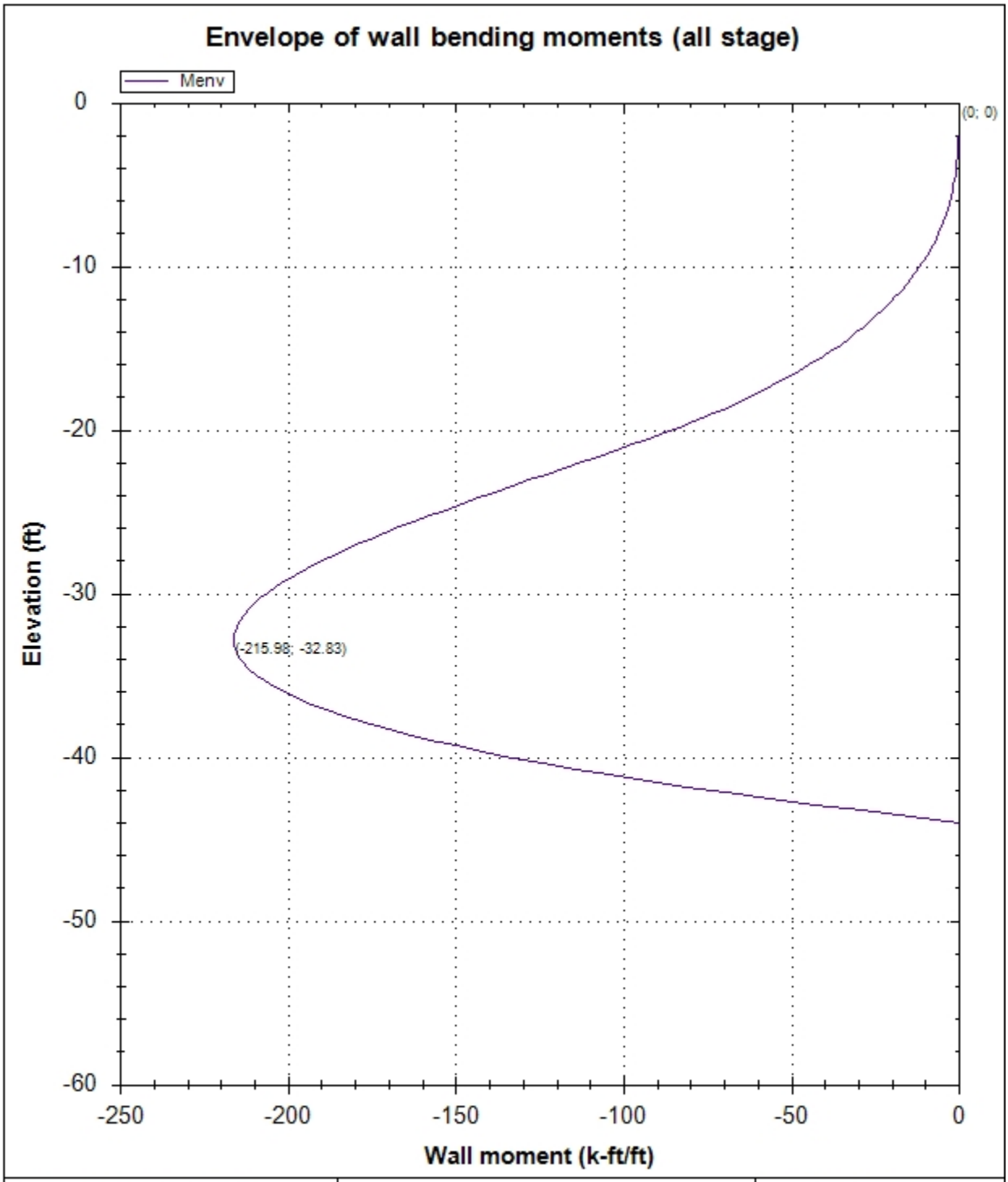
1. FSmin	2. DxMax (in)	2. Stiffness	2. FSbasal	3. Dx/H (%)	3. Stiffness	3. FSbasal
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.857	12.4	3.266	0.376	12.449	3.266

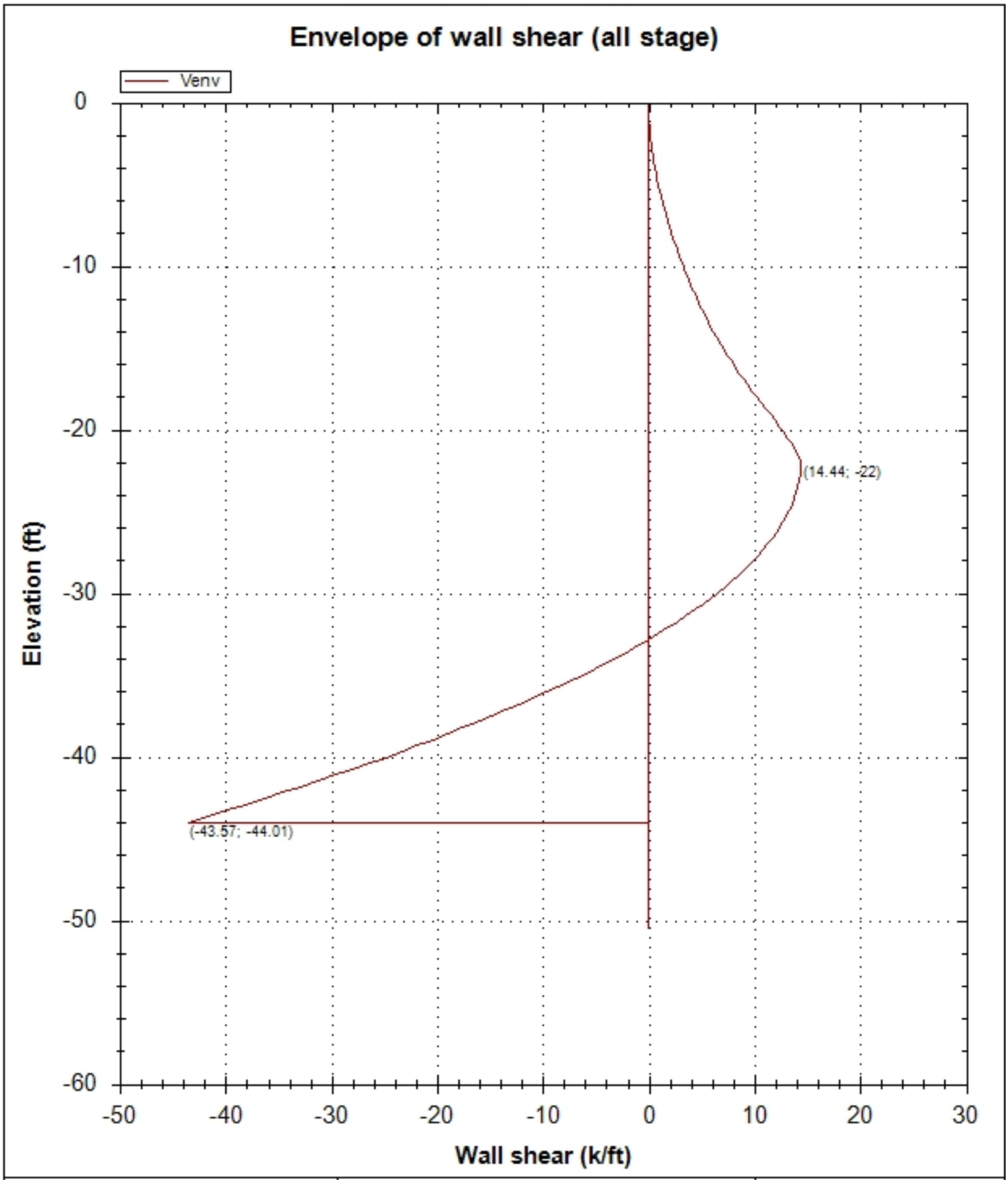
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

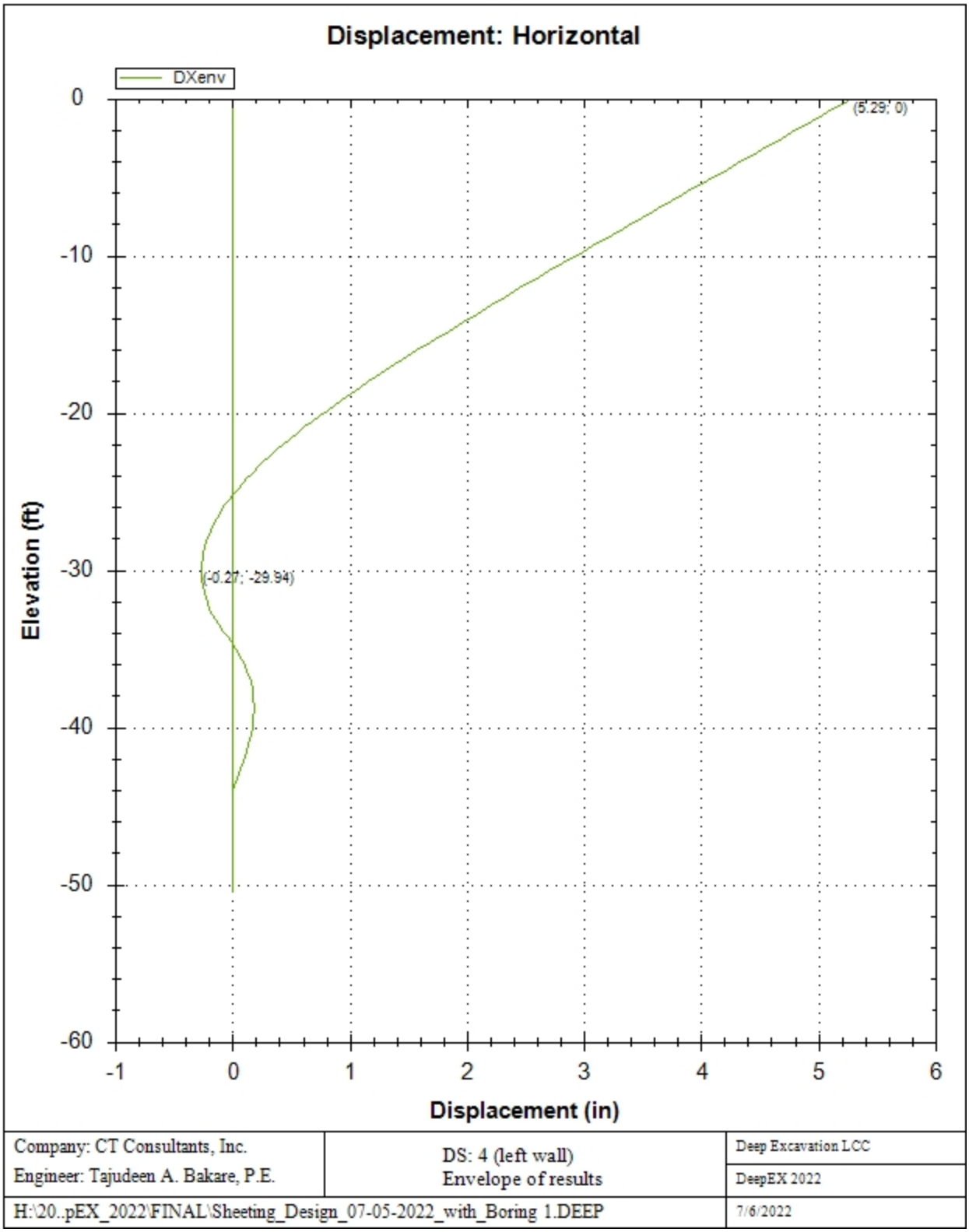
Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 4 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022



Extended vs Stage

	Calculation Result	Wall Displaceme	Settlement	Wall Moment	Wall Moment
		(in)	(in)	(k-ft/ft)	(k-ft)
Stage 0	Calculated	0	N/A	0	0
Stage 1	Calculated	5.29	2.36	215.98	215.98

	Wall Shear	Wall Shear	STR Combined	STR Moment	STR Shear
	(k/ft)	(k)	Wall Ratio	Wall Ratio	Wall Ratio
Stage 0	0	0	0	0	0
Stage 1	43.57	43.57	0.94	0.94	0.267

Table notes:

STR Combined: Combined stress check, along eccentricity line considering axial load and moment (demand/capacity).
STR Moment : Moment stress check, assuming constant axial load on wall (demand/capacity).
STR Shear : Shear stress check (shear force demand/wall shear capacity).

	Max Support	Max Support	Critical	STR Support	Support Geotech
	Reaction (k/ft)	Reaction (k)	Support Check	Ratio	Capacity Ratio (pull out
Stage 0	0	0	N/A	No supports	No supports
Stage 1	0	0	N/A	No supports	No supports

Table notes:

STR Support ratio: Critical structural stress check for support (force demand/structural capacity).
Support geotech capacity ratio: Critical geotechnical capacity stress check (demand/geotechnical capacity).
Critical support check: Critical demand/design capacity ratio (structural or geotechnical).

	FS	Toe FS	Toe FS	Toe FS	Zcut	FS Mobilized	FS
	Basal	Passive	Rotation	Length	(nonlinear)	Passive	True/Active
Stage 0	1000	10.838	10.132	140.278	N/A	N/A	N/A
Stage 1	N/A	N/A	1.387	1.259	N/A	N/A	N/A

	Hydraulic	Qflow	FSslope
	Heave FS	(ft3/hr)	
Stage 0	2.729	N/A	N/C
Stage 1	1.821	N/A	3.266

Support Force/S vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Support Force vs Stage

Support Force vs Stage

	No Supports
0:Stage 0	No support
1:Stage 1	

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	10.132	10.838	10.132	140.278	N/A	N/A
0:Stage 0	1.259	N/A	1.387	1.259	N/A	N/A

Table notes:

FSbasal : Critical basal stability safety factor (relevant only when soft clays are present beneath the excavation).
Wall embedment safety factors from conventional analysis (limit-equilibrium):
FS1 Passive : Safety factor for wall embedment based on FS= Available horizontal thrust resistance/Driving hor. thrust.
FS2 Rotation: Safety factor for wall embedment based on FS= Available resisting moment/Driving moment.
FS3 Length : Safety factor for wall embedment based on FS= Available wall embedment/Required embedment for FS=1.0
Wall embedment safety factors from non-linear analysis:
FS4 Mobilized Passive : Safety factor= Available horizontal passive resistance/Mobilized passive thrust.

FS5 True/Active : Soil thrust on retained wall side/Minimum theoretically horizontal active force thrust.

Tables for stress checks follow: Support force/Design capacity

Support Check vs Stage

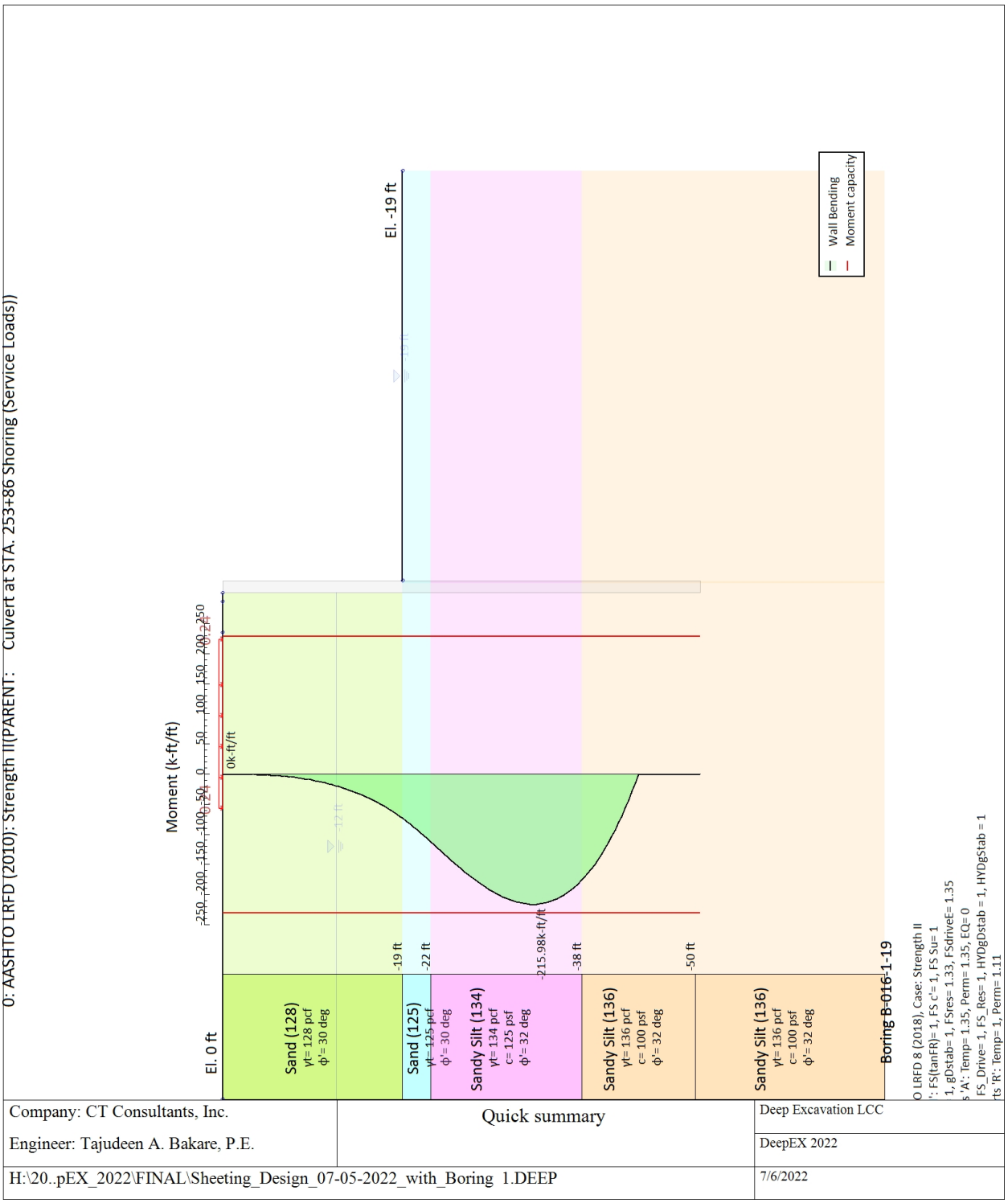
	No Supports
0:Stage 0	No support
1:Stage 1	

Forces (Res. F, M/Drive F, M)

	FS1 Passive	FS2 Rotation	FS3 Length	FS4 Mobilized Passive	FS5 Actual Drive	Fh EQ Soil	Fh EQ Water
	(FxResist/FxDrive)	(Mresist/Mdrive)	(Embedment/ToeFS=1)	(FxPassive/FxPas_Mobili	/ Theory Active		
Stage 0	446.702/41.215	7920.69/781.78	50.5/0.36	N/A	N/A	N/A	N/A
Stage 1	N/A	1451.85/613.17	31.5/25.01	N/A	N/A	N/A	N/A

Reinforcement Requirements

	Parameter Description
Note:	Wall does not use steel reinforcement. Section does not apply.



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Summary of Basal Stability and Predicted Wall Movements According to Clough 1989 Method Wall: W

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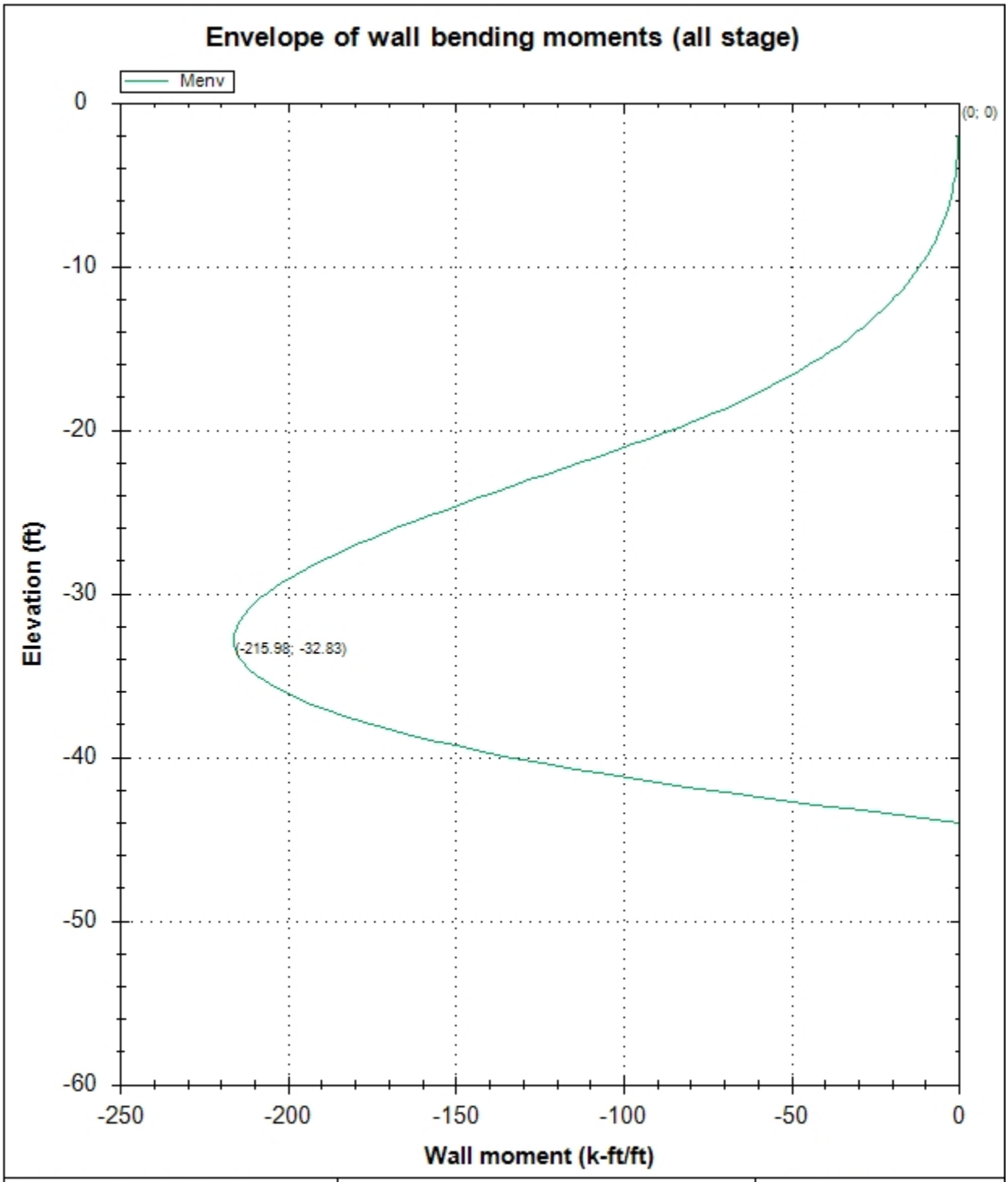
@ stage 0	@ stage 1	@ DxMax	@ DxMax	@ stage 1	@ Dx/H max	@ Dx/H max
1000	0.857	12.4	3.266	0.376	12.449	3.266

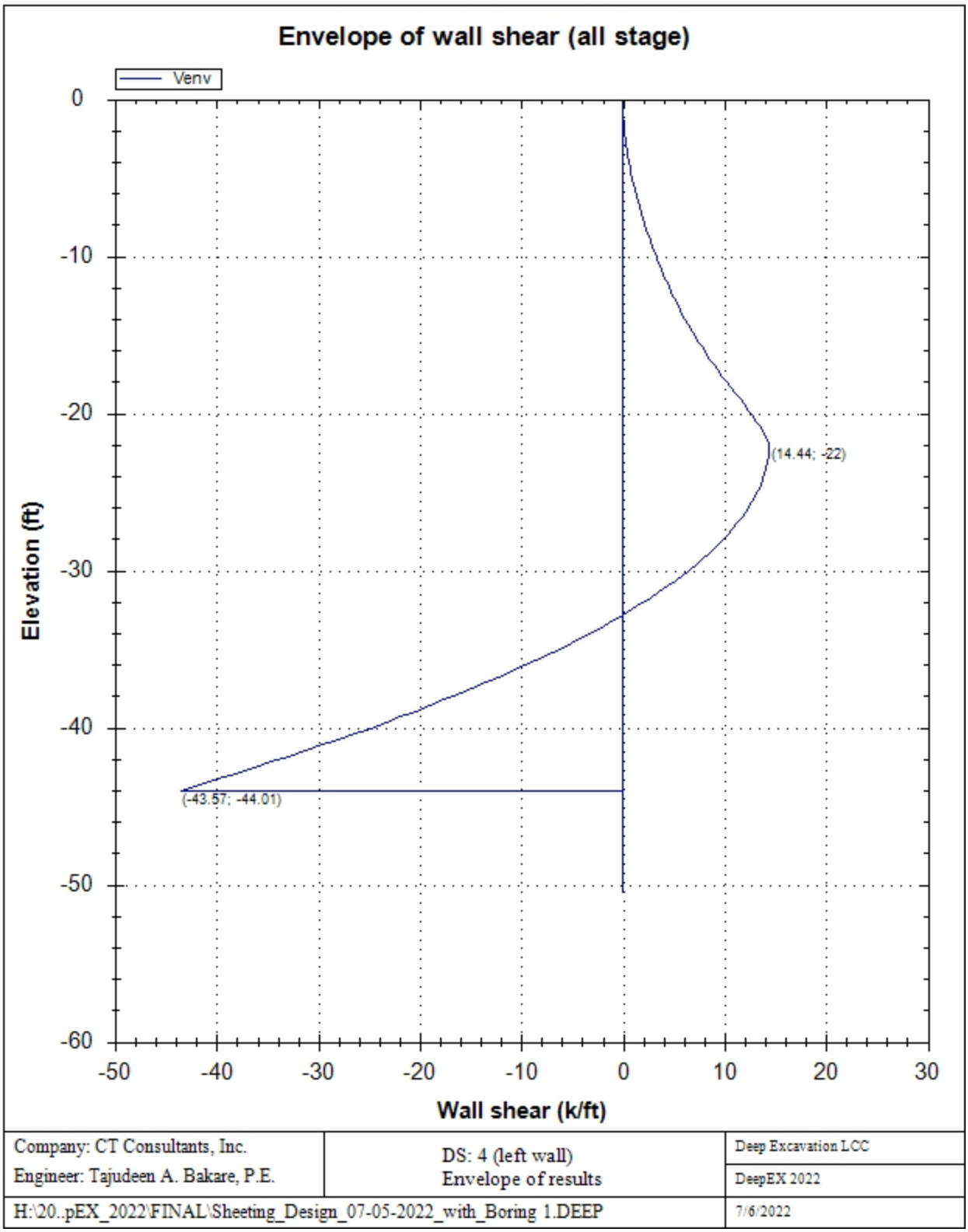
General assumptions for last stage: Stage 1

Concrete Code:	ACI 318-19
Steel Code:	ANSI/AISC 360-10
1st Wall Limit Equilibrium	California Shoring Manual-11
Negative moment	20%:
Drain State Clays	Default
Water γ= 62.4 pcf	Simple flow
Drive	Ka, + δ-Coul
Resist	Kp,+ δ-Caquot

Envelope of results

A sequence of result diagrams for each excavation stage is reported





Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	DS: 4 (left wall) Envelope of results	Deep Excavation LCC DeepEX 2022
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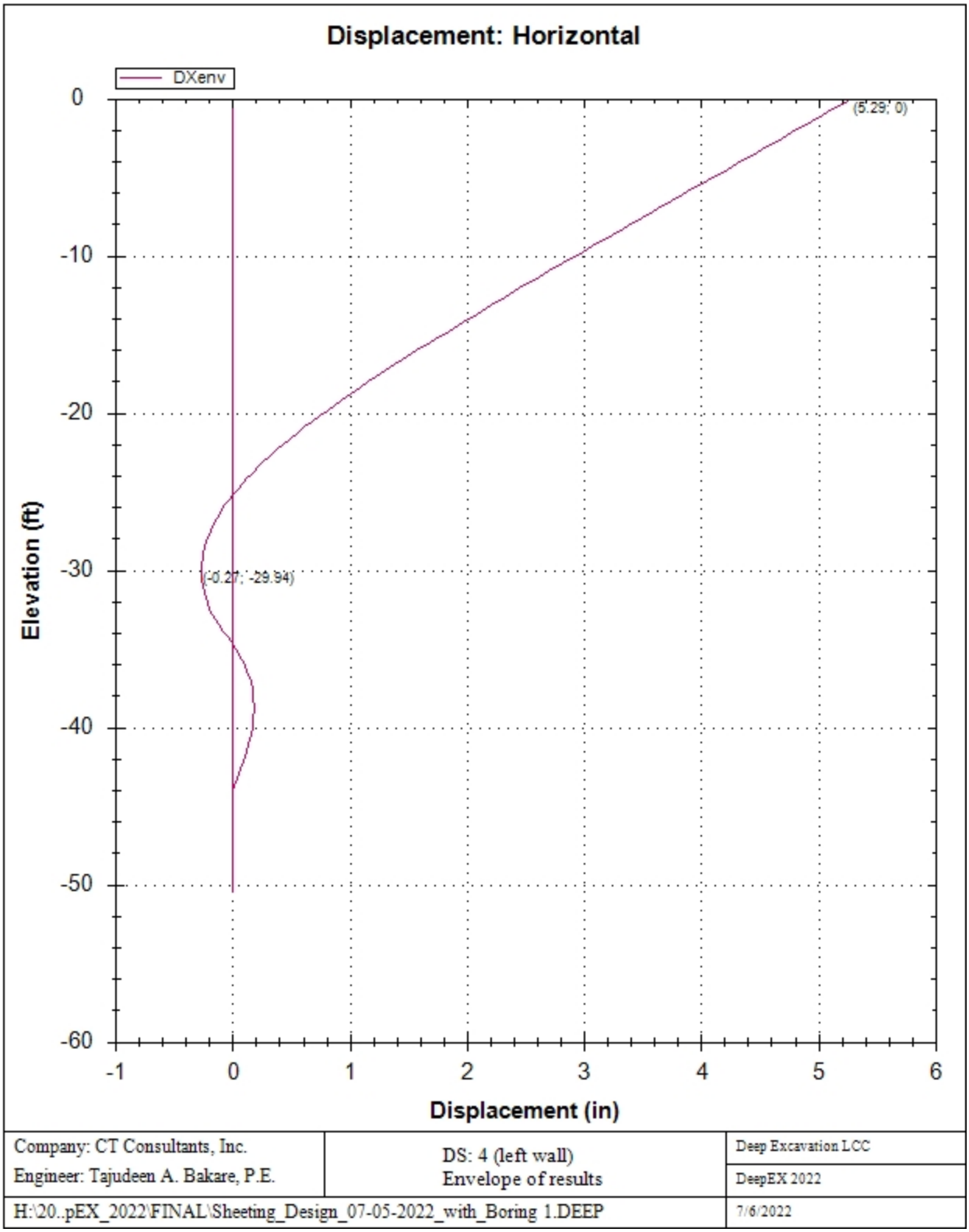

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:

Ftan fr=mult factor for friction angle
F C'= safety factor on effective cohesion (Eurocode 7 methods)
F Su'= safety factof for undrained shear strength (Eurocode 7 methods)
F EQ= Load factor for seismic loads
F perm load= Load factor for permanent loads (dead load, etc)
F temp load= Load factor on live loads and other temporary loads
F perm supp= Reduction factor for resistance for pull out checking of permanent tiebacks
F temp supp= Reduction factor for resistance for pull out checking of temporary tiebacks
F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Strength II	1	1	1	0	1.35	1.35	1.11	1	1.35	1.33	1	1	1	1	1	1
1	AASHTO LRFD	Strength II	1	1	1	0	1.35	1.35	1.11	1	1.35	1.33	1	1	1	1	1	1

DESIGN APPROACHES AND COMBINATION FACTORS

The Design Approaches (from Codes or Customized by the user) and related safety factors are the following:
Ftan fr=mult factor for friction angle
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F temp load= Load factor on live loads and other temporary loads
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F earth Dstab= Load factor for driving earth pressures, unfavorable (on retained side)
F earth stab= Safety factor for passive pressures, favorable (on excavation side)
F GWT Dstab (ground water)= Load factor for driving water pressures, unfavorable
F GWT stab (ground water)= Load factor for resisting water pressure, favorable
F HYD Dstab= Load factor for hydraulic heave, unfavorable (hydraulic checking)
F HYD stab= Resistance factor for hydraulic heave, favorable (hydraulic checking)
F UPL Dstab= Load factor for uplift check, unfavorable
F UPL stab= Resistance factor for uplift check, favorable

Stage	Design Code	Design Case	F(tan	F	F	F	F(perm	F(temp	F(perm	F(temp	F Earth	F Earth	F GWT	F GWT	F HYD	F HYD	F UPL	F UPL
	Name		fr)	(c')	(Su)	(EQ)	load)	load)	sup)	sup)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)	(Dstab)	(stab)
0	AASHTO LRFD	Strength II	1	1	1	0	1.35	1.35	1.11	1	1.35	1.33	1	1	1	1	1	1
1	AASHTO LRFD	Strength II	1	1	1	0	1.35	1.35	1.11	1	1.35	1.33	1	1	1	1	1	1

SOIL DATA

Name	g tot	g dry	Frict	C'	Su	FRp	FRcv	Eload	rEur	kAp	kPp	kAcv	kPcv	Vary	Spring	Color
	(pcf)	(pcf)	(deg)	(psf)	(psf)	(deg)	(deg)	(ksf)	(-)	NL	NL	NL	NL		Model	
Sand (128)	128	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sand (125)	125	120	30	0	N/A	N/A	N/A	300	3	0.33	3	N/A	N/A	True	Linear	
Sandy Silt (13	134	134	32	125	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	
Sandy Silt (13	136	136	32	100	N/A	N/A	N/A	400	3	0.31	3.26	N/A	N/A	True	Linear	

Name	Poisson	Min Ka	Min sh	ko.NC	nOCR	aH.EXP	aV.EXP	qSkin	qNails	kS.nails	PL
	v	(clays)	(clays)	-	-	(0 to 1)	(0 to 1)	(psi)	(psi)	(k/ft3)	(ksi)
Sand (128)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sand (125)	0.35	-	-	0.5	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-
Sandy Silt (13	0.4	-	-	0.47	0.8	-	-	0	0	0	-

gtot = total soil specific weight
gdry = dry weigth of the soil
Frict = friction angle
C' = effective cohesion
Su = Undrained shear strength (only for CLAY soils in undrained conditions, used as a cutoff strength in NL analysis)
Evc = Virgin compression elastic modulus
Eur = unloading/reloading elastic modulus
Kap = Peak active thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kpp = Peak passive thrust coefficient (initial value, may be modified on each stage according to analysis settings).
Kacv = Constant volume active thrust coeff (only for clays, initial value)
Kpcv = Constant volume passive thrust coeff (only for clays, initial value).
Spring models= spring model (LIN= constant E over the soil layer height , EXP=exponential , SIMC=simplified winkler)
LIN= Linear-Elastic-Perfectly Plastic,
EXP: Exponential, SUB: Modulus of Subgrade Reaction
SIMC= Simplified Clay mode

SOIL BORINGS

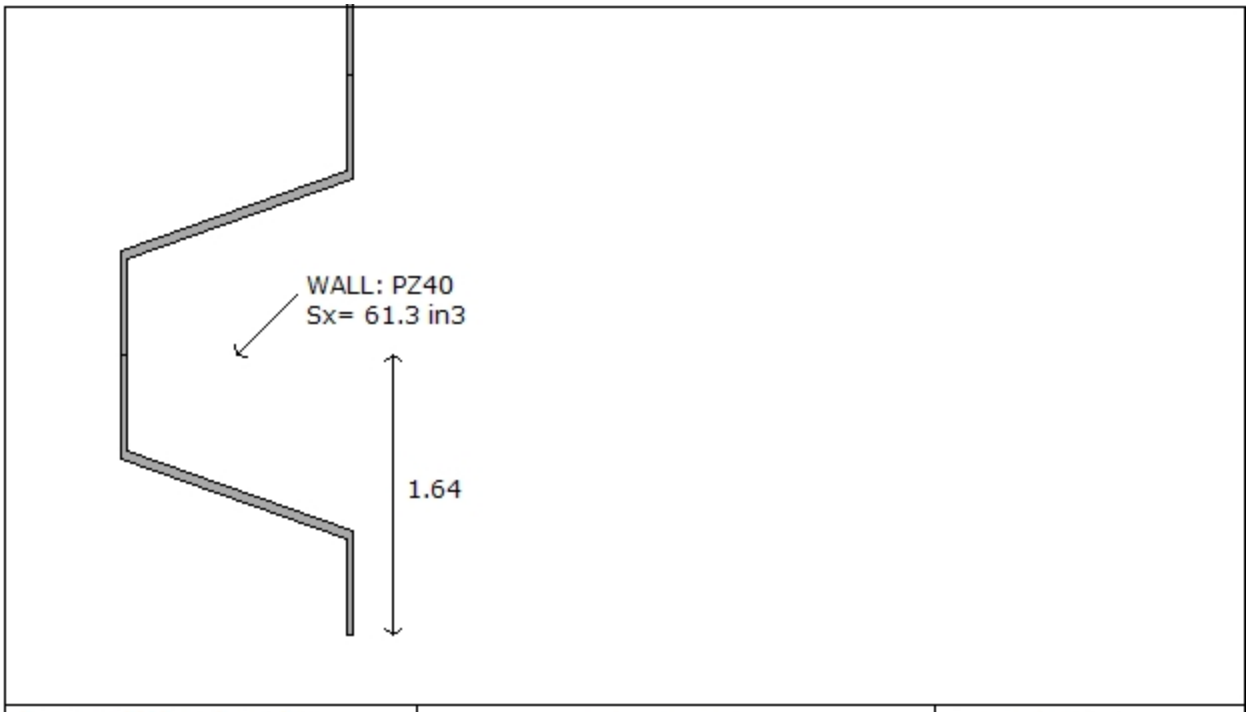
Top Elev= superior SOil level
Soil type= type of the soil (sand , clay , etc)
OCR= overconsolidation ratio
K0= at rest coefficient

Name: Boring B-016-1-19, pos: (0, 0)

Top elev.	Soil type	OCR	Ko
0	Sand (128)	1	0.5
-19	Sand (125)	1	0.5
-22	Sandy Silt (134	1	0.47
-38	Sandy Silt (136	1	0.47
-50	Sandy Silt (136	1	0.47

WALL DATA

Wall section 0: Wall section 0



Company: CT Consultants, Inc. Engineer: Tajudeen A. Bakare, P.E.	Wall sketch	Deep Excavation LCC DeepEX 2022
H:\20..pEX_2022\FINAL\Sheeting_Design_07-05-2022_with_Boring 1.DEEP		7/6/2022

Wall type: Steel sheet piling
Top wall El: 0 ft Bottom wall El: -50.5 ft
Hor. wall spacing: 1 ft Wall thickness = 1.37 ft
Passive width below exc: 1 ft Active width below exc: 1 ft Swater= 1 ft
Steel members fy = 50 ksi Esteel = 29000 ksi
Wall friction: Constant value = 17 degrees
Steel wall capacities are calculated with ANSI/AISC 360-10
Concrete capacities are calculated with ACI 318-19
Note: With ultimate capacities you may have to use a structural safety factor.
Steel sheet pile properties

Table: Steel Sheet Pile Cross Sectional Properties

DES	Shape	W	A	h	t	b	s	Ixx	Sxx
		(plf)	(in^2/ft)	(in)	(in)	(in)	(in)	(in^4/ft)	(in^3/ft)
PZ40	Z	65.6	11.75	16.4	0.5	19.69	0.605	503	61.3

GENERAL WALL DATA
Hor wall spacing= Wall horizontal spacing
Passive width below exc= spacing for passive thrust pressure for classic analysis
f'c=fck= cylindrical concrete resistance
fyk=fy= steel rebar characteristic resistance
Econc= Concrete Elastic modulus
fctk= characteristic Concrete tension
Esteel= steel elastic modulus
TABULAR DATA (principal parameters)
1) Diaphragm wall (rectangular cross section)
N/A= data not available
Fy=fyk

F'c=fck
D=wall thickness
B=wall width
2)Steel sheet pile
DES=shape (Z or U)
W=width per unit of length
A=area
h=height
t=horizontal part thickness
b=width of the single sheet pile part
s=inclined part thickness
Ixx=strong axis inertia (per unit of length)
Sxx=strong axis section modulus (per unit of length)
3)Secant piles wall, Tangent piles wall, soldier piles, soldier piles and timber lagging
W=weight per unit of length
A=area
D=diameter
tw=web thickness
tp= pipe thickness
bf=flange width
tf= flange thickness
k= flange thickness+stem base height
Ixx= strong axis inertia modulus (per unit of length)
Sxx= strong axis section modulus (per unit of length)
rx=radius of gyration about X axis
ry=radius of gyration about Y axis
Iyy=weak axis inertia modulus (per unit of length)
Syy=weak axis section modulus (per unit of length)
rT=radius of gyration for torsion
Cw= warping constant

GENERAL ANALYSIS CRITERIA

Summary of stage assumptions

Name	Analysis	Drive	ka-Mult	Htr T/B	Resist	Res	Contle
	Method	Press		(%)	Press	Mult	Method
Stage 0	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth
Stage 1	Conventional	Ka+ δ	N/A	N/A	Kp+ d	N/A	Free Earth

Name	Support	Axial	Used	Min Toe	Toe	Toe
	Model	Incl	FSwall	FDtoe	FSrot	FSpas
Stage 0		N/A	1	10.132	10.132	10.838
Stage 1		N/A	1	1.259	1.387	N/A

Name=excavation stage name
Analysis method
springs = Elastoplastic spring analysis used
DR = Drained condition for CLAY model
U = Undrained condition for CLAY model for all the soils
Up = Undrained condition just for selected soil
Limit equilibrium analysis settings
Drive press:
Ka (Active pressure diagram), Ka-Trap = Trapezoid apparent diagram from active pressures x multiplier,
FHWA= Federal Highway Administration apparent pressure diagrams.
Ko = At-rest lateral earth pressures.
Peck = Peck 1969 Apparent earth pressure diagrams.
2 Step rect = Two step rectangular apparent earth pressure diagram.
User def. = User defined apparent earth pressure diagram.
Ka+d (and so on) indicates that wall friction is applied
ka mult = multiplication factor for Ka when Ka-Trap is selected
Htr T/B (%) = trapezoidal pressure scheme, top and bottom triangular percentage of excavation depth H
Resit press = Kp (passive earth pressures)
Res Mult = Safety factor applied directly on resisting pressures (
COntle Method = cantilever analysis method for limit equilibrium analysis.
Support Model: Method for calculating support reactions in limit-equlibrium analysis.
Beam= support reactions beam analysis (uses Blum's method).
Trib= support reactions from tributary height calculations (Can be applied with apparent diagrams).
Axial Incl = Axial loads included for structural design
Used FS wall = Safety factor for axial+bending wall resistance to divide ultimate wall capacities.
Min FD Toe= embedded minimum safety factor (for limit equilibrium analysis)
Toe FS rot= rotation safety factor (classic for limit equilibrium analysis)
Toe FSpas= driving/resisting pressure safety factor (for limit equilibrium analysis)

EXCAVATION STAGES SKETCHES

A sequence of figures for each excavation stage is reported

Toe stability

Embedment FS vs Stage

	Min Toe FS	FS1 Passive	FS2 Rotation	FS3 Length (from FS1, FS2)	FS4 Mobilized Passive	FS5 Actual Drive Thrust / Theory
Stage 0	10.132	10.838	10.132	140.278	N/A	N/A
Stage 1	1.259	N/A	1.387	1.259	N/A	N/A

Legend: Wall embedment safety factors (toe)
Min Toe FS= Minimum wall embedment safety factor (from all analysis methods)
Limit-equilibrium analysis methods: The following safety factors may not be applicable for all stages.
FS1 Passive: Horizontal force safety factor, FS1= Resisting/Driving force
FS2 Rotation: Rotational safety factor about lowest support, FS2= Resisting moment/Driving moment
FS3 Length (from FS1, FS2): Program determines maximum required wall embedment for safety factor of 1 for methods FS1 and FS2 (say length LFS1). Then FS length= Provided wall embedment/LFS1.
Non-linear elastoplastic analysis safety factors:
FS4 Mobilized Passive: Safety factor on mobilized passive resistance, FS4= Available passive soil resistance/Mobilized passive soil force on excavation side.
FS5 Active Drive Thrust/Theory Active: Ratio of soil thrust on retained side/ Active condition theoretical minimum thrust. This factor is not as critical, and indicates how close to active conditions the model is.
General recommendations on wall embedment (excluding FS5):
When then excavation is designed with allowable standards, engineers generally use minimum safety factors from 1.2 to 1.5 depending on the level of confidence. A minimum safety factor of 1.2 is generally applied on FS3.
With ultimate limit state designs (such as Eurocode 7, and LRFD) the required safety factor must generally be greater than 1.0. In non-linear solutions it might be impossible to achieve exactly 1 on FS4 as this would likely trigger overall failure.

Result diagrams (for walls)

A sequence of result diagrams for each excavation stage is reported

WALL RESULTS TABLE

LEGEND
Wall node=number of the node (0 at top)
EL= Node elevation
Sht L=Total horizontal soil pressure (on the left side of the wall)
Sht R=Total horizontal soil pressure (on the right side of the wall)
Shs L=Effective horizontal soil pressure (on the left side of the wall)
Shs R=Effective horizontal soil pressure (on the right side of the wall)
q=pressure given by the surcharge
U L= Water pressure (on the left side of the wall)
U R= Water pressure (on the right side of the wall)
M=bending moment (per unit length)
V=shear (per unit length)
dx=wall deflection
McapL=Ultimate bending moment (on the left side of the wall)
McapR=Ultimate bending moment (on the right side of the wall)
VcapL=Ultimate resistance shear (on the left side of the wall)
VcapR=Ultimate resistance shear (on the right side of the wall)

EXCAVATION STAGES AND SLOPE STABILITY

Reports a sequence of figures for each stage with slope stability results.

SLOPE STABILITY ANALYSIS: SLICE RESULTS ALL STAGES

Slope stability analysis design section: 0: AASHTO LRFD (2010): Strength II

LEGEND

x1 = Left x coordinate
ZsL= Left slice bottom elevation
ZtL= Left top elevation
x2 = Right x coordinate
ZsR= Right slice bottom elevation
ZtR= Right top eleevation
DL = Slice base width
an = Base angle
Fr = Average friction angle at base
c = Average cohesion at base (may include undrained clay strengths)
Wn = Total slice weight
ubL= Water pressure at left bottom point
ubR= Water pressure at right bottom point
tBase= Base shear resistance
Nr = Effective normal reaction at bottom of slice
EiL= Lateral interslice force on left face
EiR= Lateral interslice force on right face
TL = Vertical interslice shear on left vertical face
TR = Vertical interslice shear on right vertical face
UbF= Normal water force at slice base