BP6.R017

HARNETT COUNTY BRIDGE 54

FOUNDATION RECOMMENDATIONS

FOUNDATION RECOMMENDATIONS

WBS # BP6.R017

T.I.P. NO. N/A

COUNTY HARNETT

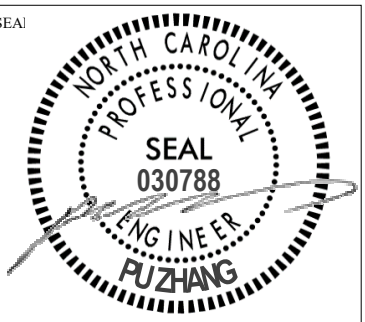
STATION 18+84.00 -L-

BRIDGE NO. 420054

DESCRIPTION BRIDGE ON SR 1130 (NORRINGTON ROAD) OVER BIG GULLY CREEK BETWEEN SR 1129 AND SR 1128

	INITIALS	DATE
DESIGN	PZ	02/24/23
CHECK	KRB	2/24/23
APPROVAL		

SEAL



SIGNATURE

	STATION	FOUNDATION TYPE	FACTORED RESISTANCE	MISCELLANEOUS DETAILS
END BENT 1	18+37.81 -L-	Cap on HP 12x53 Steel Pile w/ Steel Pile Points	65 tons/pile	Bottom of Cap El. = 159.5 ft ± Est. Avg. Length of Pile = 20 ft LT = 15 ft RT Number of Piles = 7
BENT 1	18+84.00 -L-	36 inch Dia. Drilled Pier	360 tons/pier	Bottom of Cap El. = 159.5 ft ± Top of Drilled Pier El. = 159.5 ft Point of Fixity El. = 137 ft Tip El. No Higher Than = 130 ft Number of Piers = 3
END BENT 2	19+30.19 -L-	Cap on HP 12x53 Steel Pile w/ Steel Pile Points	65 tons/pile	Bottom of Cap El. = 160.4 ft ± Est. Avg. Length of Pile = 20 ft Number of Piles = 7

NOTES ON PLANS & COMMENTS (See following page)

TIP # N/A **County** HARNETT

FOUNDATION RECOMMENDATION NOTES ON PLANS

1. For piles, see piles provision and section 450 of the standard specifications.
2. For drilled piers, see section 411 of the standard specifications.
3. Install permanent steel casings at Bent No. 1 by vibrating, screwing or driving permanent casings before excavating or disturbing any material below elevation 144.7 ft.
4. Do not dewater drilled pier excavtions at Bent No. 1. Clean the bottom of excavations with a submersible pump or an airlift. Wet placement of concrete is required.
5. Do note use slurry construction for drilled piers at Bent No. 1.
6. It has been estimated that a hammer with an equivalent rated energy in the range of 20 to 30 ft-kips per blow will be required to drive piles at End Bents No. 1 and 2. This estimated energy range does not release the Contractor from providing driving equipment in accordance with Subarticle 450-3(D) (2) of the Standard Specifications.

SPECIAL NOTE ON PLANS

1. Soft alluvium within limits of embankment at End Bents No. 1 and 2 shall be undercut prior to pile driving. See Roadway Plans for undercut at End Bent No. 1 and 2.

FOUNDATION RECOMMENDATION COMMENTS

1. The required driving resistances at End Bents No.1 and 2 were estimated using a resistance factor of 0.6 assuming WEAP analysis with limited quantity of PDAs.
2. A D12 or similar hammer should be sufficient to drive the piles at the end bents to the required resistance without overstress.
3. Use type II modified bridge approach fill (2018 Roadway Standard Drawing No. 422.02) at End Bents No. 1 and 2.
4. 1.5:1 (H:V) end bent slopes with proper slope protection are ok.
5. Waiting periods are not required at End Bents.
6. Permanent casing tip is set at 1 foot within WR. The risk for WR to cave during construction is low.
7. Pile Redrives are not included due to driving end bent piles to rock.
8. Design scour elevation is 144.7 ft at Bent No. 1.

SUMMARY OF PILE INFORMATION/INSTALLATION

(Blank entries indicate item is not applicable to structure)

End Bent/ Bent No, Pile(s) #-# (e.g., "Bent 1, Piles 1-5")	Factored Resistance per Pile TONS	Pile Cut-Off (Top of Pile) Elevation FT	Estimated Pile Lenth per Pile FT	Scour Critical Elevation FT	Driven Piles			Predrilling for Piles*			Drilled-In Piles		
					Min Pile Tip (Tip No Higher Than) Elev FT	Required Driving Resistance (RDR)** per Pile TONS	Total Pile Redrives Quantity EACH	Predrilling Length per Pile Lin FT	Predrilling Elevation (Elev Not To Predrill Below) FT	Maximum Predrilling Dia INCHES	Pile Excavation (Bottom of Hole) Elev FT	Pile Exc Not In Soil per Pile Lin FT	Pile Exc In Soil per Pile Lin FT
End Bent 1, Piles 1-3	65	See Substructure Plans	20			110							
End Bent 1, Piles 4-7	65		15			110							
End Bent 2, Piles 1-7	65		20			110							

*Predrilling for Piles is required for end bents/bents with a predrilling length and at the Contractor's option for end bents/bents with predrilling information but no predrilling length.

$$^{**}RDR = \frac{Factored\ Resistance + Factored\ Downdrag\ Load + Factored\ Dead\ Load}{Dynamic\ Resistance\ Factor} + Nominal\ Downdrag\ Resistance + \frac{Nominal\ Scour\ Resistance}{Scour\ Resistance\ Factor}$$

SUMMARY OF PDA/PILE ORDER LENGTHS

(Blank entries indicate item is not applicable to structure)

Pile Driving Analyzer (PDA)				Pile Order Lengths	
End Bent/ Bent No	PDA Testing Required? YES or MAYBE	PDA Test Pile Length FT	Total PDA Testing Quantity EACH	End Bent/ Bent No(s)	Pile Order Length Basis* EST or PDA
End Bent 1	MAYBE	20	1		
End Bent 2	MAYBE	20			

*EST = Pile order lengths from estimated pile lengths; PDA = Pile order lengths based on PDA testing. For groups of end bents/bents with pile order lengths based on PDA testing, the first end bent/bent no. listed for each group is the representative end bent/bent with the PDA.

PILE DESIGN INFORMATION

(Blank entries indicate item is not applicable to structure)

End Bent/ Bent No, Pile(s) #-# (e.g., "Bent 1, Piles 1-5")	Factored Axial Load per Pile TONS	Factored Downdrag Load per Pile TONS	Factored Dead Load* per Pile TONS	Dynamic Resistance Factor	Nominal Downdrag Resistance per Pile TONS	Nominal Scour Resistance per Pile TONS	Scour Resistance Factor (Default = 1.00)
End Bent 1, Piles 1-7	61			0.60			
End Bent 2, Piles 1-7	61			0.60			

*Factored Dead Load is factored weight of pile above the ground line.

SUMMARY OF PILE ACCESSORIES

(Blank entries indicate item is not applicable to structure)

End Bent/ Bent No, Pile(s) #-# (e.g., "Bent 1, Piles 1-5")	Pipe Pile Plates Required? YES or MAYBE	Steel Pile Points			Steel Pile Tips Required? YES
		Pipe Pile Cutting Shoes Required? YES	Pipe Pile Conical Points Required? YES	H-Pile Points Required? YES	
End Bent 1, Piles 1-7				YES	
End Bent 2, Piles 1-7				YES	
TOTAL QTY:				14	

SUMMARY OF DRILLED PIER INFORMATION/INSTALLATION

(Blank entries indicate item is not applicable to structure)

End Bent/ Bent No, Pier(s) #-# (e.g., "Bent 1, Piers 1-3")	Factored Resistance per Pier TONS	Minimum Pier Tip (Tip No Higher Than) Elevation FT	Required Tip Resistance per Pier TSF	Scour Critical Elevation FT	Minimum Drilled Pier Penetration Into Rock per Pier Lin FT	Drilled Pier Length per Pier Lin FT	Drilled Pier Length Not In Soil per Pier Lin FT	Drilled Pier Length In Soil per Pier Lin FT	Permanent Steel Casing Required? YES or MAYBE	Permanent Steel Casing Tip Elevation (Elev Not To Extend Casing Below) FT	Permanent Steel Casing Length* per Pier Lin FT
Bent 1, Piers 1-3	360	130.0	25	143			14.0	15.8	YES	144.7	14.8

*Permanent Steel Casing Length equals the difference between the ground line or top of drilled pier elevation, whichever is higher, and the permanent casing tip elevation.

SUMMARY OF DRILLED PIER TESTING

(Blank entries indicate item is not applicable to structure)

End Bent/ Bent No, Pier(s) #-# (e.g., "Bent 1, Piers 1-3")	Standard Penetration Test (SPT) Required? YES or MAYBE	Crosshole Sonic Logging (CSL) Required?* YES or MAYBE	Total CSL Tube Length (For All Tubes) per Pier Lin FT	Shaft Inspection Device (SID) Required? YES or MAYBE	Pile Integrity Test (PIT) Required? MAYBE
Bent 1, Pier 1	MAYBE	MAYBE	124	MAYBE	
Bent 1, Pier 2	MAYBE	MAYBE	124	MAYBE	
Bent 1, Pier 3	MAYBE	MAYBE	124	MAYBE	
TOTAL QTY:	3	1	372	1	

*CSL Tubes are required if CSL Testing is or may be required. The number of CSL Tubes per drilled pier is equal to one tube per foot of design pier diameter with at least 4 tubes per pier. The length of each CSL Tube is equal to the drilled pier length plus 1.5 ft.

PROJECT NO. BP6.R017

HARNETT COUNTY

STATION: 18+84.00 -L-

NOTES:

1. The Pile and Drilled Pier Foundation Tables are based on the bridge substructure design and foundation recommendations sealed by a North Carolina Professional Engineer (Pu Zhang, #030788) on 2-24-2023.
2. Total Pile Driving Equipment Setup quantity (not shown in Pile Foundation Tables) equals the number of driven piles, i.e., the number of piles with a Required Driving Resistance.
3. The Engineer will determine the need for PDA Testing, Permanent Steel Casing, SPTs, CSL Testing, SID Inspections when these items may be required.

SIGNATURE DATE

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

PILE, DRILLED PIER, AND SPREAD FOOTING FOUNDATION TABLES

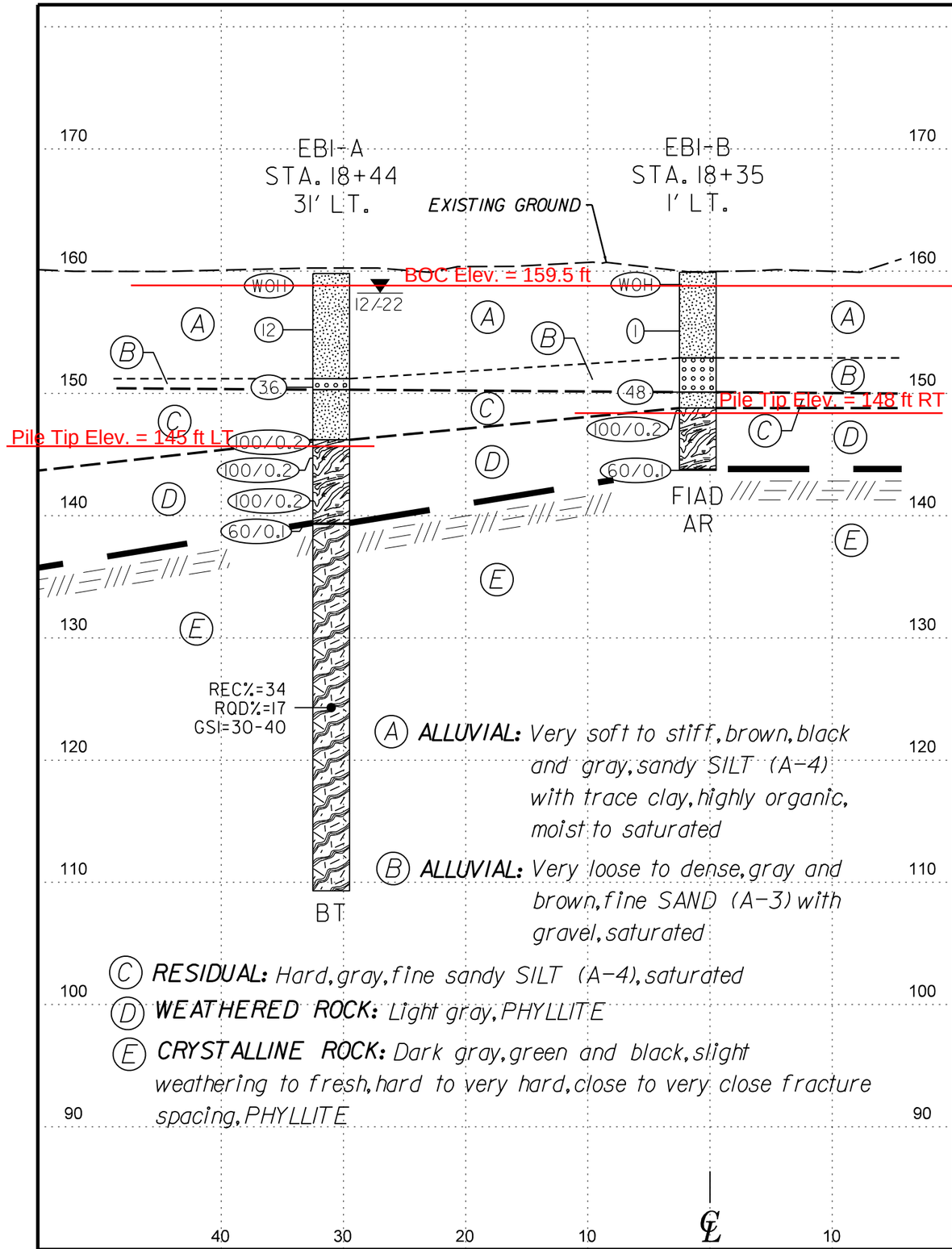
REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	TOTAL SHEETS
1			3			
2			4			

PROJECT REFERENCE NO.	SHEET NO.
BP6.R017	5

NOTES:

GROUNDLINE OBTAINED USING 420054_ls_tin.tin FILE DATED 02-17-2022

INFERRED STRATIGRAPHY IS DRAWN AT THE CROSS SECTIONS WITH THE BORINGS PROJECTED ONTO THE CROSS SECTIONS



(A) **ALLUVIAL:** *Very soft to stiff, brown, black and gray, sandy SILT (A-4) with trace clay, highly organic, moist to saturated*

(B) **ALLUVIAL:** *Very loose to dense, gray and brown, fine SAND (A-3) with gravel, saturated*

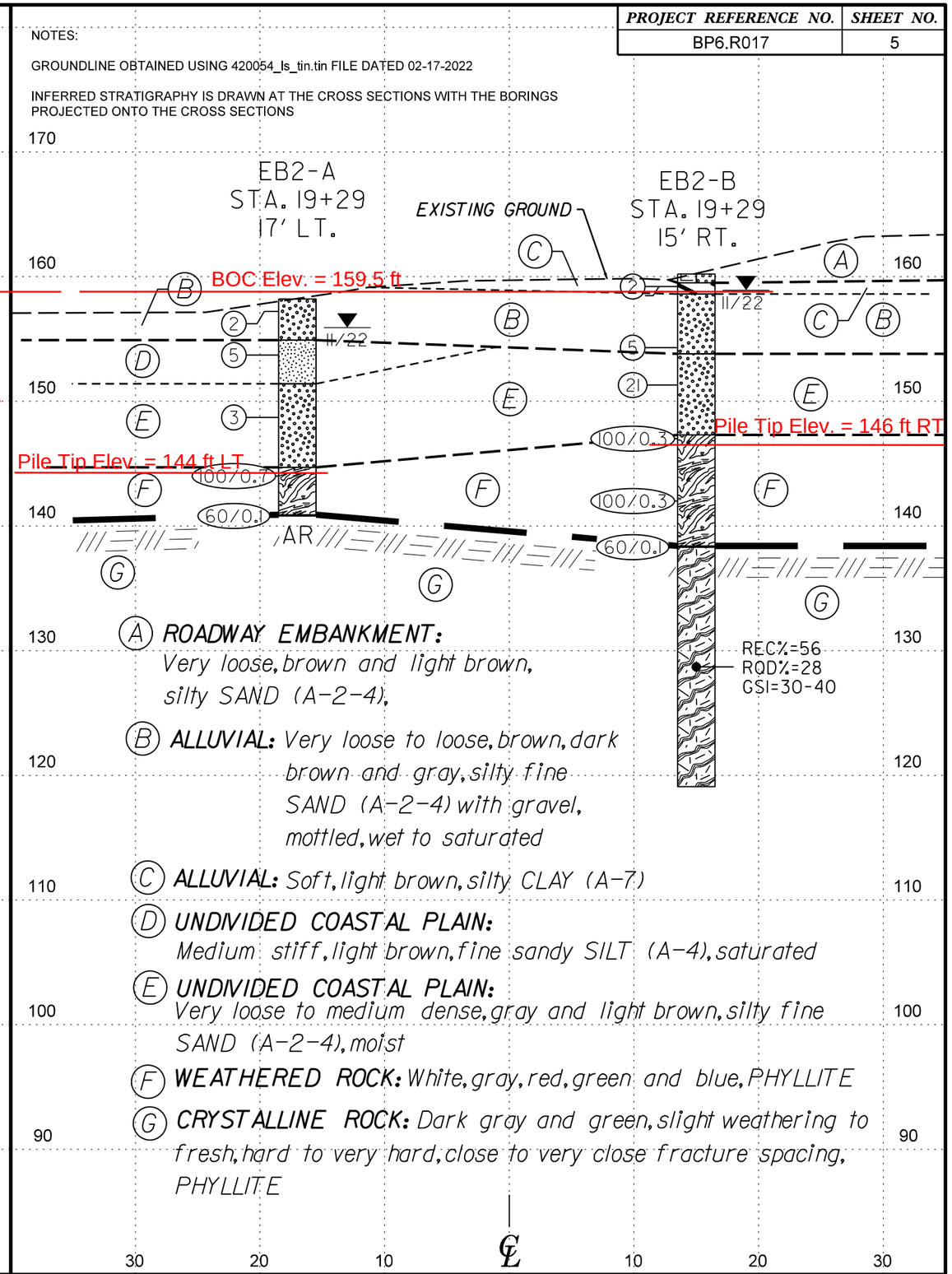
(C) **RESIDUAL:** *Hard, gray, fine sandy SILT (A-4), saturated*

(D) **WEATHERED ROCK:** *Light gray, PHYLLITE*

(E) **CRYSTALLINE ROCK:** *Dark gray, green and black, slight weathering to fresh, hard to very hard, close to very close fracture spacing, PHYLLITE*

HORIZ. SCALE (FEET) 0 10 20 — VE = 1:1

BRIDGE NO. 54 – END BENT 1 –L– STA. 18+39 – 90° SKEW



(A) **ROADWAY EMBANKMENT:** *Very loose, brown and light brown, silty SAND (A-2-4),*

(B) **ALLUVIAL:** *Very loose to loose, brown, dark brown and gray, silty fine SAND (A-2-4) with gravel, mottled, wet to saturated*

(C) **ALLUVIAL:** *Soft, light brown, silty CLAY (A-7)*

(D) **UNDIVIDED COASTAL PLAIN:** *Medium stiff, light brown, fine sandy SILT (A-4), saturated*

(E) **UNDIVIDED COASTAL PLAIN:** *Very loose to medium dense, gray and light brown, silty fine SAND (A-2-4), moist*

(F) **WEATHERED ROCK:** *White, gray, red, green and blue, PHYLLITE*

(G) **CRYSTALLINE ROCK:** *Dark gray and green, slight weathering to fresh, hard to very hard, close to very close fracture spacing, PHYLLITE*

HORIZ. SCALE (FEET) 0 10 20 — VE = 1:1

BRIDGE NO. 54 – END BENT 2 –L– STA. 19+29 – 90° SKEW

HDR Engineering, Inc., of the Carolinas
555 Fayetteville Street, Suite 900
Raleigh, NC 27601

SUBJECT: BRIDGE ON SR 1130		WBS Element: BP6.R017
(NORRINGTON ROAD) OVER BIG GULLY CREEK		HARNETT County
PREPARED BY:	PZ	N/A
DATE:	01/04/23	
CHECKED BY:	KRB	SHEET:
DATE:	01/5/23	

END BENTS SUMMARY

END BENT 1

GEOTECHNICAL INFORMATION

BORING ID	GROUND ELEV. (ft)	CONFIRMED TOP OF WR ELEV. (ft)*	CONFIRMED TOP OF ROCK ELEV. (ft)*	GROUNDWATER ELEV. (ft)	
EB1-A	159.8	146.2	139.4	158.2	(24 hr)
EB1-B	159.9	148.8	143.9	N/A	

*: Top of 100 over material for WR or 60 over <0.1' for Rock, unless hard drilling noted on the log.

Factored Load: **61** tons/pile (PROVIDED BY STRUCTURAL ENGINEER)

Maximum factored Structure Resistance for pile = 160 tons for HP12x53, and 220 tons for HP14x73 - NCDOT Structures

Use 12x53 HP Piles with a factored resistance of 65 tons/pile.

Q_r = 65 tons/pile

Approx. Elevation	(Left Side)	(Right Side)	
Bottom Of Cap =	159.5 ft.	159.5 ft.	
Top of MSE Leveling Pad =	- ft.	- ft.	
Top of WR =	146 ft.	149 ft.	
Anticipated Pile Tip = -	145 ft.	148 ft.	: Assume 1 ft penetration into WR.
Cal. Pile Length =	16.3 ft.	13.7 ft.	: Assume 2 ft embedment in pile cap.
Recommended Length =	20 ft.	15 ft.	

ESTIMATED AVG. PILE LENGTH = 20 ft.

END BENT 2

GEOTECHNICAL INFORMATION

BORING ID	GROUND ELEV. (ft)	CONFIRMED TOP OF WR ELEV. (ft)*	CONFIRMED TOP OF ROCK ELEV. (ft)*	GROUNDWATER ELEV. (ft)	
EB2-A	158.2	144.7	140.9	155.9	(24 hr)
EB2-B	160.2	147.3	138.4	158.9	(24 hr)

*: Top of 100 over material for WR or 60 over <0.1' for Rock, unless hard drilling noted on the log.

Factored Load: **61** tons/pile (PROVIDED BY STRUCTURAL ENGINEER)

Maximum factored Structure Resistance for pile = 160 tons for HP12x53, and 220 tons for HP14x73 - NCDOT Structures

Use 12x53 HP Piles with a factored resistance of 65 tons/pile.

Q_r = 65 tons/pile

Approx. Elevation	(Left Side)	(Right Side)	
Bottom Of Cap =	160.4 ft.	160.4 ft.	
Top of MSE Leveling Pad =	- ft.	- ft.	
Top of WR =	145 ft.	147 ft.	
Anticipated Pile Tip = -	144 ft.	146 ft.	: Assume 1 ft penetration into WR.
Cal. Pile Length =	19 ft.	16.1 ft.	: Assume 2 ft embedment in pile cap.
Recommended Length =	20 ft.	20 ft.	

ESTIMATED AVG. PILE LENGTH = 20 ft LT, 15 ft RT.

DOWNDRAG

1) Piles will be driven to refusal in/on Weathered rock at End Bents. No movement is anticipated at the pile tip after refusal. Approximately 5 feet of RDWY EMB fill will be placed. Alluvial materials consisting of very soft sandy silt with high organics and soft silty clay are present at both End Bents. These soils shall be undercut and replaced with Class III Select materials. Drag load is anticipated to be minimum.

OTHER END BENT ITEMS

1) 1.5:1 (H:V) end bent slopes with proper slope protection are ok.

WEAP ANALYSIS

Dynamic resistance factor is 0.60 for WEAP w/o or w/ limited PDA, and 0.75 for 2 PDAs per site conditions.

Limit of driving Stress is 0.9 x (50 ksi) = 45 ksi - AASHTO

Based on experience with similar loads, subsurface conditions, and piles, a typical D12 or similar hammer should be sufficient to drive the piles to the required resistance without overstress.

	Required Driving Resistance (kip)	Hammer	Max Comp. Stress (ksi)	Max. Tension Stress (ksi)	Stroke (ft)	Blow Counts (bpf)
EB1	220	D12	28	0.7	7	45
EB2	220	D12	28	0.7	7	45

HDR Engineering, Inc. of the Carolinas
555 Fayetteville St, Suite 900 Raleigh, N.C. 27601
N.C.B.E.L.S. License Number: F-0116

0 50 100
FEET
VE = 5:1

PROJECT REFERENCE NO.	SHEET NO.
BP6.R017	4

BRIDGE NO. 54
PROFILE AT CL OF –L–

NOTES:

GROUNDLINE OBTAINED FROM VHB ENGINEERING SURVEY

INFERRED STRATIGRAPHY IS DRAWN AT THE PROFILE WITH THE BORINGS PROJECTED ONTO THE PROFILE

WS=159.2'
DATE OF SURVEY
3/17/2022

L_1600
STA. 16+00
CL

EB1-A
STA. 18+44
31' LT.

EB2-A
STA. 19+29
17' LT.

L_2100
STA. 21+00
CL

EXISTING GROUND

BOC Elev. = 159.5 ft

Design Scour Elev. = 144.7 ft

POF Elev. = 137 ft

Tip Elev. = 130 ft

FIAD
BT

FIAD
BT

AR

BT

1.5:1

12/22

11/22

WOH
12
36
100/0.2
100/0.2
100/0.2
60/0.1
2
5
3
100/0.7
60/0.1

REC%=34
RQD%=17
GSI=30-40

180
170
160
150
140
130
120
110
100

16+00 17+00 18+00 19+00 20+00 21+00 22+00

(A) **ALLUVIAL:** *Very soft to stiff, brown, black, tan and gray, sandy SILT (A-4) with trace clay, highly organic, moist to saturated*

(B) **ALLUVIAL:** *Very loose to dense, gray, brown, tan and black, fine SAND with little gravel and silty fine SAND (A-3, A-2-4), saturated*

(C) **UNDIVIDED COASTAL PLAIN:** *Tan and orange, sandy CLAY (A-6), mottled, moist*

(D) **UNDIVIDED COASTAL PLAIN:** *Medium stiff, light brown, tan, and gray, fine sandy SILT (A-4), mottled, moist to saturated*

(E) **UNDIVIDED COASTAL PLAIN:** *Very loose, gray and light brown, silty fine SAND (A-2-4)*

(F) **RESIDUAL:** *Hard, gray, fine sandy SILT (A-4), saturated*

(G) **WEATHERED ROCK:** *Gray, white and red, PHYLLITE*

(H) **CRYSTALLINE ROCK:** *Dark gray, green and black, slight weathering to fresh, hard to very hard, close to very close fracture spacing, PHYLLITE*

HDR Engineering, Inc., of the Carolinas
555 Fayetteville Street, Suite 900
Raleigh, NC 27601

SUBJECT: BRIDGE ON SR 1130		WBS Element: BP6.R017
(NORRINGTON ROAD) OVER BIG GULLY CREEK		HARNETT County
PREPARED BY:	PZ	N/A
DATE:	12/19/22	
CHECKED BY:	KRB	SHEET:
DATE:	12/27/22	

INTERIOR BENTS SUMMARY

BENT 1

HYDRAULIC INFORMATION

THEORETICAL 100 YEAR SCOUR ELEV.	=	139.9	ft
THEORETICAL 500 YEAR SCOUR ELEV.	=	N/A	ft
GEOTECH ADJUSTED SCOUR ELEV.	=	N/A	ft
DESIGN SCOUR ELEV.	=	144.7	ft
NORMAL WATER SURFACE ELEV.	=	157.8	ft
WATER SURFACE ELEV. DURING DRILLING:	=	159.2	ft

GEOTECHNICAL INFORMATION

BORING ID	GROUND ELEV. (ft)	TOP OF WR ELEV. (ft)	TOP OF ROCK ELEV. (ft)	GROUNDWATER ELEV. (ft)	
EB1-A	159.8	146.2	139.4	158.2	(24 hr)
EB1-B	159.9	148.8	143.9	N/A	
EB2-A	158.2	144.7	140.9	155.9	(24 hr)
EB2-B	160.2	147.3	138.4	158.9	(24 hr)
	Average:	146.8	140.7		

FOUNDATION TYPE:	**36 inch Diameter Drilled Pier**		
FACTORED LOAD:	**360**	tons	
BOC ELEV.	159.5	ft	(PROVIDED BY STRUCTURAL ENGINEER)
EXISTING GROUND:	155.5	ft	
POINT OF FIXITY EL.	137	ft	(BASED ON LPILE RUN)
TIP NO HIGHER THAN	130	ft	(BASED ON AXIAL RESISTANCE)
TIP NO HIGHER THAN	134	ft	(BASED ON LATERAL RESISTANCE)
TIP NO HIGHER THAN	**130**	**ft**	
RECOMMENDED MIN TIP	**130**	**ft**	
REQUIRED TIP RESIST.	**25**	**tsf**	**USE 25 tsf**
			For quantity calc, considering half of WR as "Not in Soil"
DRILLED PIER IN SOIL	8.8	ft	=(8.8+6.1/2)=12ft in soil per pier
DRILLED PIER IN WR	6.1	ft	=6.1/2+10.7=14ft not in soil per pier
DRILLED PIER IN ROCK	10.7	ft	
CSL TUBE	31.0	ft	=31*4=124ft per pier

HDR Engineering, Inc., of the Carolinas
555 Fayetteville Street, Suite 900
Raleigh, NC 27601

SUBJECT: BRIDGE ON SR 1130 (NORRINGTON ROAD) OVER BIG GULLY C		WBS Element: BP6.R017
		HARNETT County
PREPARED BY:	PZ	N/A
DATE:	12/19/22	
CHECKED BY:	KRB	SHEET:
DATE:	12/27/22	

DRILLED PIER LOADS

Bent 1

Maximum Axial Load with Longitudinal Shear & Moment

Axial Load	720	(kips)
Moment	80	(kips-ft)
Shear Load	6	(kips)

Maximum Longitudinal Shear with Axial Load & Longitudinal Moment

Axial Load	420	(kips)
Moment	10	(kips-ft)
Shear Load	10	(kips)

Maximum Transverse Shear with Axial Load & Transverse Moment

Axial Load	390	(kips)
Moment	345	(kips-ft)
Shear Load	15	(kips)

LPILE2019 INPUT SHEET (ENGLISH)

Designer: PZ Checker: KRB

Sheet #:

Project Title

TIP # **N/A** Bent # 1

COUNTY: **HARNETT** Boring # B1-A

Pile Properties

Total Pile Length	26	(ft)
Increments (recommend 50 to 100)	100	
Distance from Top of Pile to Ground Surface	14.80	(ft)
Combined Ground Slope & Batter Angles	0	(degrees)

Pile Sections

Section #	Depth (ft)	Diameter (inches)	Mom. of Inertia (in^4)	Area (in^2)	Modulus of Elasticity (lbs/in^2)
1	0	30	39761	707	3800000
2	0.0	30	39761	707	3800000
3	0.0	36	82448	1018	3800000
4	100	36	82448	1018	3800000

Pile-Head Boundary Conditions & Loading

Pile-Head Fixity Conditions	V=Shear (lbs)	M=Moment (lbs-in)	P=Axial load (lbs)
Shear & Moment	6000	960000	720000
Shear & Moment	10000	120000	420000
Shear & Slope	15000	4140000	390000
Shear & Slope (convert M to S)	31829	-	390000

Soil Layers

Layer #	Soil Type	Layer Top (ft)	Layer Bottom (ft)
1	3	14.80	39.50
2	3	39.50	39.50
3			
4			
5		-	
6		-	-
7		-	-
8		-	-

WR

#1 = Soft Clay Criteria (Matlock)
#2 = Stiff Clay with Free Water
#3 = Stiff Clay without Free Water
#4 = Sand (Reese, 1974)
#5 = Linear Interp. p-y curves
#6 = Strong Rock (Vuggy Limestone)
#7 = Silt (Cemented c-phi soil)
#8 = API Sand (O'Neill)
#9 = Weak Rock (Reese, 1977)
#10 = Piedmont Residual

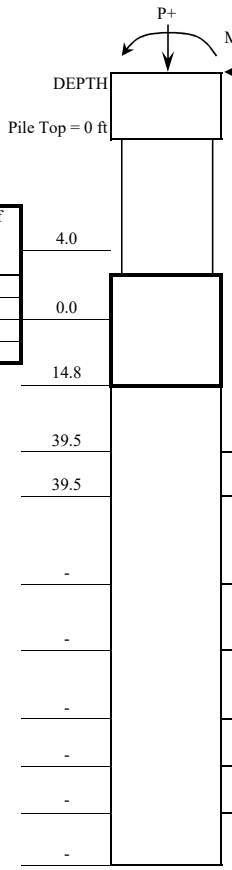
SOIL and ROCK PROPERTIES DATA

Non-rock Soil Types	Eff. Unit Wt. γ' (lbs/ft^3)	p-y Modulus k, (lbs/in^3)	Cohesive Str. c, (lbs/ft^2)	Friction Angle ϕ (degrees)	Soil Strain ε_{50}
3	72.6	2000	8000		0.004
3	72.6	2000	8000		0.004
0					
0					
0					
0					
0					
0					

Weak Rock	Eff. Unit Wt. γ' (lbs/ft^3)	Young's Mod.* Er, (lbs/in^2)	Uniax. Comp. Str. (lbs/in^2)	RQD (%)	k rm (.0005 to .00005)

Strong Rock Properties (Vuggy Limestone)	Eff. Unit Wt. γ' (lbs/ft^3)	Uniax. Comp. Str. C_m (lbs/in^2)	RQD (%)	C_0 (lbs/in^2)
0		0		

* Young's Modulus of Rock = 200 to 500 X Comp. Strength of Rock (RULE OF THUMB)



Input Elevation

BOC Elev. =	159.5	ft
Existing Ground Ele. =	155.5	ft
Finished Ground Ele. =	155.5	ft
TOS Elev. =	159.5	ft
Design Scour	144.7	ft
	120	ft
	120	ft
	-	ft
	-	ft
	-	ft
	-	ft
	-	ft
	-	ft

DEFLECTION @ PILE TOP = Δ_{TOP}

	Δ_{TOP}	(in)	First Neg.	(ft)	Pile Length	
Strength:	0.16	(in)	20.5	(ft)	26	(ft)
		(in)				
Strength:	Max. Neg.	@	22.6	(ft)		

COMMENTS:

When POF is above bedrock, the POF is at the maximum negative deflection.

PT. OF FIXITY ELEV. =	**137**	ft
TIP NO HIGHER THAN EL. =	**134**	ft

$C_m = \alpha_E \cdot C_0$

$\alpha_E = 0.0231 \cdot RQD - 1.32 \geq 0.15$

C_m= Uniaxial comp strength of rock mass

C_0= Uniaxial comp strength of intact rock

SCOUR MEMO

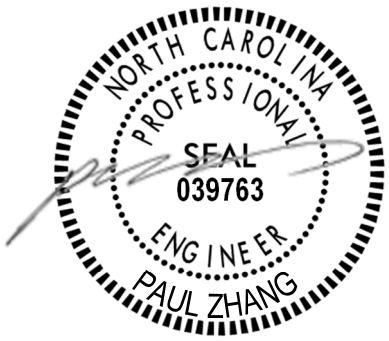
February 24, 2023

Memorandum to:	Matthew Alexander, P.E. Assistant State Geotechnical Engineer
WBS Element:	BP6.R017
TIP:	N/A
County:	HARNETT
Description:	BRIDGE ON SR 1130 (NORRINGTON ROAD) OVER BIG GULLY CREEK BETWEEN SR 1129 AND SR 1128
Subject:	Design Scour Elevation

After a review of site flooding history, historical scour depth, and geologic conditions encountered at the site, HDR Engineering, Inc. of the Carolinas, has determined the design scour elevation(s) (DSE), and presents the following:

Location	Theoretical Scour Elevation	Historical Scour Elevation	Design Scour Elevation	Does DSE impact end bents?
Bent 1	139.9 feet	144.7 feet	144.7 feet	No

The Theoretical Scour Elevation is from the Bridge Survey and Hydraulic Design Report dated 6/14/2022. The Design Scour Elevation is higher than the Theoretical Scour Elevation. The subsurface investigation revealed the top of weathered rock is above the theoretical scour elevations listed. These materials are resistant to scour. Evidence of historical scour via the presence of alluvial soils was noted during the subsurface investigation. It should be noted that the proposed end bent slopes and creek banks will be lined with Class II Rip Rap.



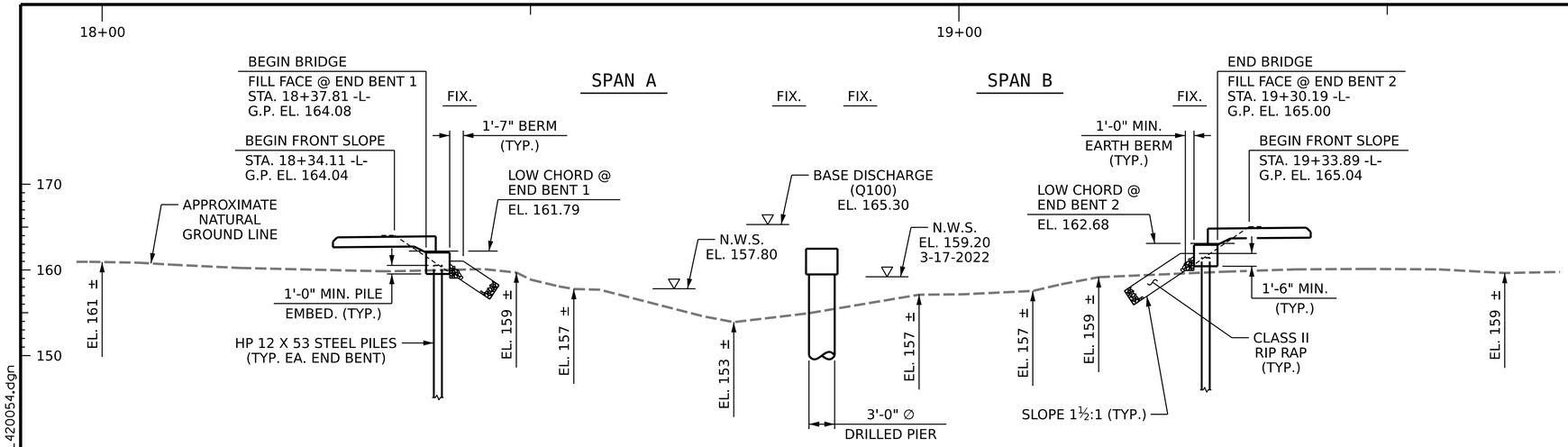
Paul Zhang, Ph.D., P.E.
Senior Geotechnical Project Manager

hdrinc.com 555 Fayetteville Street, Suite 900, Raleigh, NC 27601-3034
(919) 232-6600

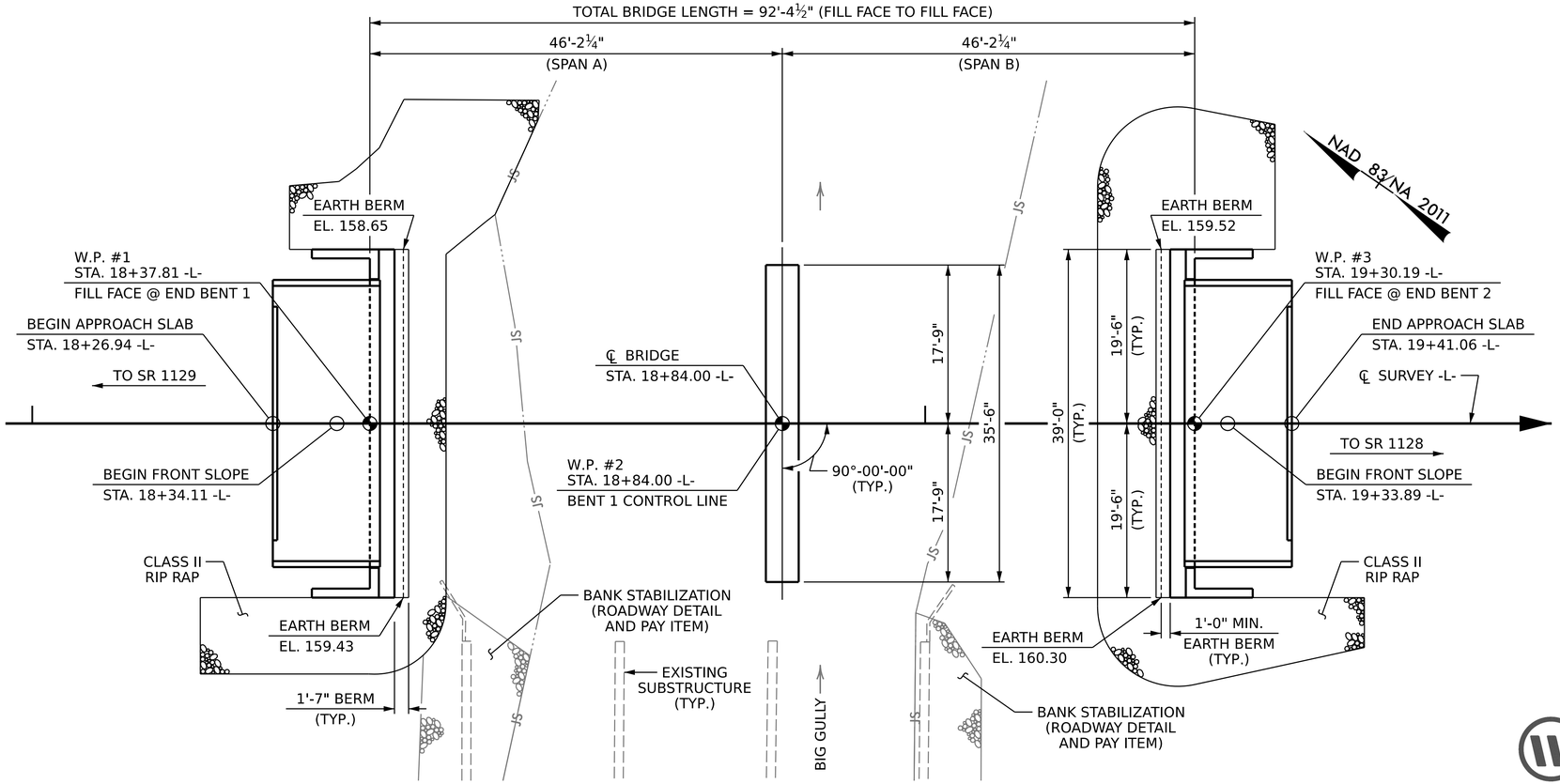
STRUCTURES INFORMATION

GENERAL DRAWING

LOADING INFORMATION



SECTION ALONG ℄ SURVEY -L-



PLAN

(PILES AND DRILLED PIERS NOT SHOWN IN PLAN VIEW)

(+) 1.0000% △ (-) 1.1739%

PVI STA. 20+50.00
EL. = 166.20
VC = 250'

GRADE DATA -L-

HYDRAULIC DATA:

DESIGN DISCHARGE	= 9000 CFS
FREQUENCY OF DESIGN FLOOD	= 25 YEAR
DESIGN HIGH WATER ELEVATION	= 164.8
DRAINAGE AREA	= 156 SQ. MI.
BASE DISCHARGE (Q 100)	= 12000 CFS
BASE HIGH WATER ELEVATION	= 165.3

OVERTOPPING FLOOD DATA:

OVERTOPPING DISCHARGE	= 3403 CFS
FREQUENCY OF OVERTOPPING FLOOD	= <10 YEAR
OVERTOPPING FLOOD ELEVATION	= 162.8 * *

* * OVERTOPPING OCCURS AT LEFT EDGE OF PAVEMENT AT STA. 14+50.00 -L-

I HEREBY CERTIFY THESE PLANS ARE THE AS-BUILT PLANS

PROJECT NO. BP6.R017

HARNETT COUNTY

STATION: 18+84.00 -L-

SHEET 1 OF 2 REPLACES BRIDGE #420054

DRAWN BY : T. BANKOVICH DATE : 8-22
CHECKED BY : J.Z. BLINSON DATE : 8-22
DESIGN ENGINEER OF RECORD: D.A. SEALEY DATE : 8-22

WGI
5640 Dillard Drive, Suite 200
Cary, NC 27518
LICENSURE NO. C-4434

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

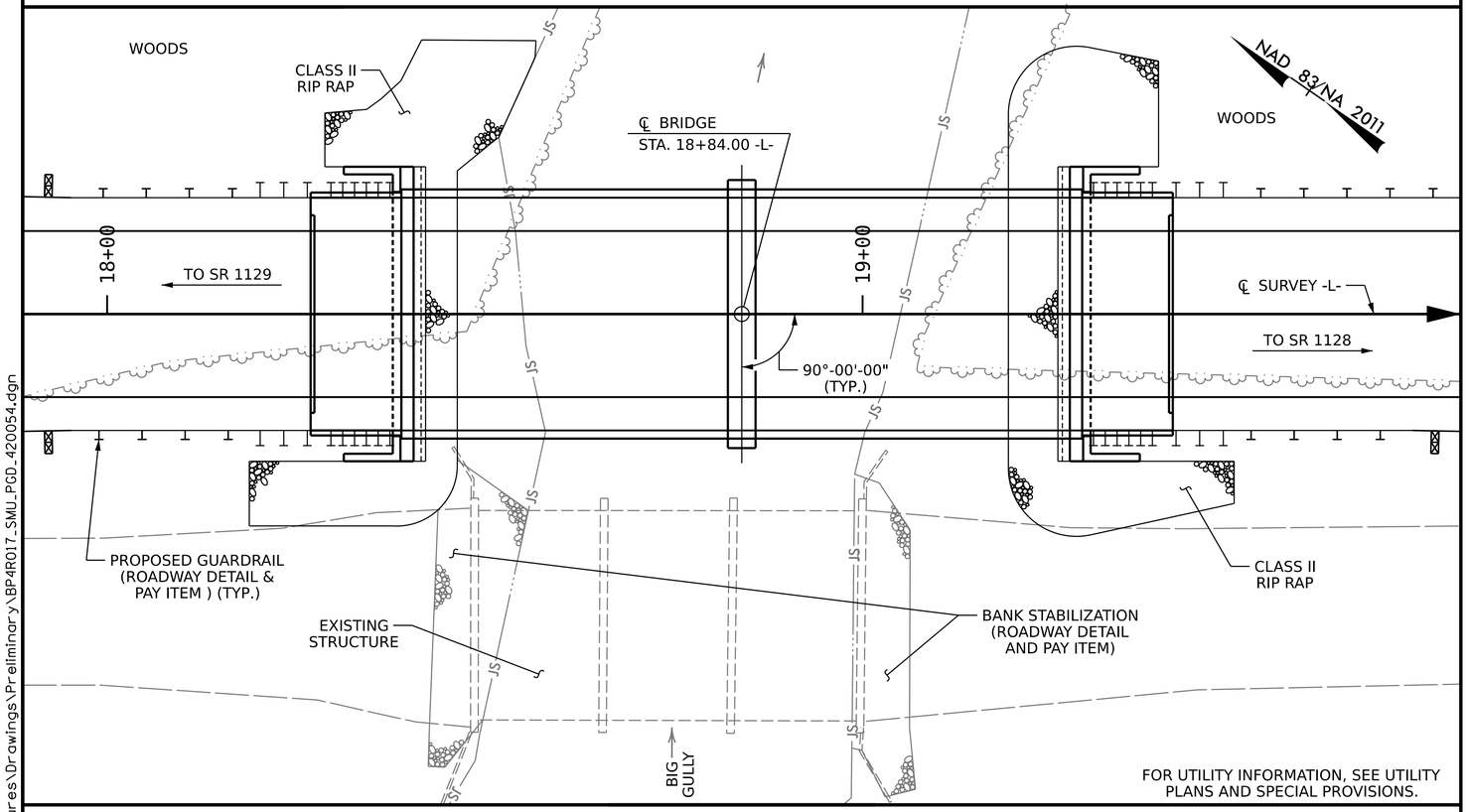
STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH
PRELIMINARY

GENERAL DRAWING

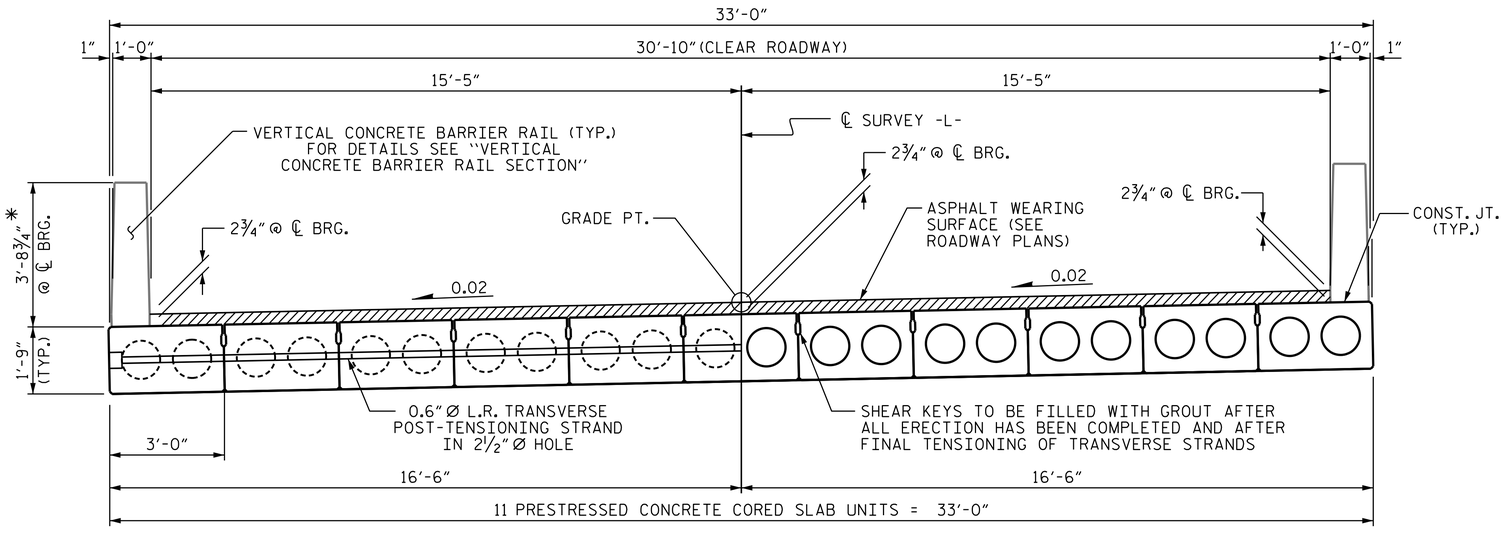
FOR BRIDGE ON SR 1130
(NORRINGTON ROAD)
OVER BIG GULLY CREEK
BETWEEN SR 1129 AND SR 1128

REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	S-1
1			3			TOTAL SHEETS
2			4			2

BM #1 RAIL ROAD SPIKE IN THE BASE OF A 16" BIRCH TREE, STA. 20+41.05 -L-, 5.17' RT., EL. 160.50



LOCATION SKETCH



HALF SECTION
AT INTERMEDIATE DIAPHRAGMS

HALF SECTION
THROUGH VOIDS

TYPICAL SECTION

* - THE MAXIMUM BARRIER RAIL HEIGHT AND ASPHALT THICKNESS IS SHOWN. THE HEIGHT OF THE BARRIER RAIL AND ASPHALT THICKNESS VARIES WHILE THE TOP OF THE BARRIER RAIL FOLLOWS THE PROFILE OF THE GUTTERLINE.

NOTES:

ASSUMED LIVE LOAD = HL-93 OR ALTERNATE LOADING.

THIS BRIDGE HAS BEEN DESIGNED IN ACCORDANCE WITH THE AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS.

THIS BRIDGE IS LOCATED IN SEISMIC ZONE 1.

DRAWN BY :	T. BANKOVICH	DATE :	8-22
CHECKED BY :	J.Z. BLINSON	DATE :	8-22
DESIGN ENGINEER OF RECORD:	D.A. SEALEY	DATE :	8-22

WGI
5640 Dillard Drive, Suite 200
Cary, NC 27518
LICENSURE NO. C-4434

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

PROJECT NO. BP6.R017
HARNETT COUNTY
STATION: 18+84.00 -L-

SHEET 2 OF 2

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH
PRELIMINARY

GENERAL DRAWING

FOR BRIDGE ON SR 1130 (NORRINGTON ROAD) OVER BIG GULLY CREEK BETWEEN SR 1129 AND SR 1128

REVISIONS						SHEET NO.
NO.	BY:	DATE:	NO.	BY:	DATE:	S-2
1			3			TOTAL SHEETS
2			4			2

8/10/2022 6:38:50 AM P:\Raleigh\Projects\2021\Div 6 (SEA)\BP6.R017 (Harnett 54)\Structures\Drawings\Preliminary\BP4R017_SMU_PGD_420054.dgn

Column on Drilled Pier
Controlling Column Factored Loads

JM 6/14/2022

For bridge width 27' and 30'

Average CS Unit Length on Cap	Max. Axial Load F_Y = Kips	Long. Shear F_Z = Kips	Long. Mom. M_X = Kips-ft.	Max. Long. Shear F_Z = Kips	Axial Load F_Y = Kips	Long. Mom. M_X = Kips-ft.	Max. Trans. Shear F_X = Kips	Axial Load F_Y = Kips	Trans. Moment M_Z = Kips-ft.
≤ 40'	-520	6	70	-8	-270	-10	9	-230	315
>40' and ≤ 55'	-680	6	80	-10	-400	-10	13	-330	405
>55' and ≤ 70'	-800	7	85	-12	-490	-15	15	-410	485

For bridge width 33'

Average CS Unit Length on Cap	Max. Axial Load F_Y = Kips	Long. Shear F_Z = Kips	Long. Mom. M_X = Kips-ft.	Max. Long. Shear F_Z = Kips	Axial Load F_Y = Kips	Long. Mom. M_X = Kips-ft.	Max. Trans. Shear F_X = Kips	Axial Load F_Y = Kips	Trans. Moment M_Z = Kips-ft.
≤ 40'	-550	-6	-70	-8	-280	-10	-11	-260	-265
>40' and ≤ 55'	-720	-6	-80	-10	-420	-10	-15	-390	-345
>55' and ≤ 70'	-850	-7	-85	-12	-520	-15	-17	-410	-430

45'

Bent 1

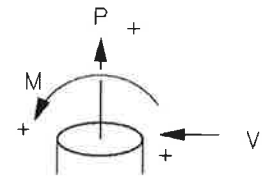
For bridge width 36' and 39'

Average CS Unit Length on Cap	Max. Axial Load F_Y = Kips	Long. Shear F_Z = Kips	Long. Mom. M_X = Kips-ft.	Max. Long. Shear F_Z = Kips	Axial Load F_Y = Kips	Long. Mom. M_X = Kips-ft.	Max. Trans. Shear F_X = Kips	Axial Load F_Y = Kips	Trans. Moment M_Z = Kips-ft.
≤ 40'	-600	6	70	-9	-350	-50	10	-330	360
>40' and ≤ 55'	-790	6	80	-11	-480	-60	13	-490	445
>55' and ≤ 70'	-940	7	85	-12	-560	-65	16	-610	515

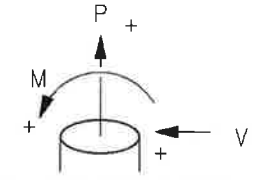
$$\text{Average CS Unit Length on Cap} = \frac{\text{CS Unit Length Before Cap} + \text{CS Unit Length After Cap}}{2}$$

Table 1 - Use this table when total height from BOC to POF ≤ 50' and column length ≤ 25'

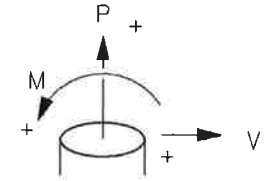
Bridge Width	Skew	Cap Length	Column Dia.	Drilled Pier Dia.	No. of Cols 'X'	Cols Spa. 'Y'
27'	60/120	35'-10"	2'-6"	3'-0"	3	13'-0"
	75/105	31'-6"	2'-6"	3'-0"	3	12'-0"
	90	29'-6"	2'-6"	3'-0"	3	11'-0"
30'	60/120	39'-4"	2'-6"	3'-0"	3	14'-0"
	75/105	34'-6"	2'-6"	3'-0"	3	13'-0"
	90	32'-6"	2'-6"	3'-0"	3	12'-0"
33'	60/120	42'-10"	2'-6"	3'-0"	3	15'-0"
	75/105	37'-8"	2'-6"	3'-0"	3	14'-0"
	90	35'-6"	2'-6"	3'-0"	3	13'-0"
36'	60/120	46'-2"	2'-6"	3'-0"	3	16'-0"
	75/105	40'-10"	2'-6"	3'-0"	3	15'-0"
	90	38'-6"	2'-6"	3'-0"	3	14'-0"
39'	60/120	49'-8"	2'-6"	3'-0"	3	17'-0"
	75/105	43'-10"	2'-6"	3'-0"	3	16'-0"
	90	41'-6"	2'-6"	3'-0"	3	15'-0"



MAX AXIAL CASE



MAX LONG. SHEAR CASE



MAX TRANS. SHEAR CASE

Table 2 - Use this table when Table 1 limit(s) is exceeded, total height from BOC to POF ≤ 60' and column length ≤ 30'

Bridge Width	Skew	Cap Length	Column Dia.	Drilled Pier Dia.	No. of Cols 'X'	Cols Spa. 'Y'
27'	60/120	35'-10"	3'-0"	3'-6"	3	13'-0"
	75/105	31'-6"	3'-0"	3'-6"	3	12'-0"
	90	29'-6"	3'-0"	3'-6"	3	11'-0"
30'	60/120	39'-4"	3'-0"	3'-6"	3	14'-0"
	75/105	34'-6"	3'-0"	3'-6"	3	13'-0"
	90	32'-6"	3'-0"	3'-6"	3	12'-0"
33'	60/120	42'-10"	3'-0"	3'-6"	3	15'-0"
	75/105	37'-8"	3'-0"	3'-6"	3	14'-0"
	90	35'-6"	3'-0"	3'-6"	3	13'-0"
36'	60/120	46'-2"	3'-0"	3'-6"	3	16'-0"
	75/105	40'-10"	3'-0"	3'-6"	3	15'-0"
	90	38'-6"	3'-0"	3'-6"	3	14'-0"
39'	60/120	49'-8"	3'-0"	3'-6"	3	17'-0"
	75/105	43'-10"	3'-0"	3'-6"	3	16'-0"
	90	41'-6"	3'-0"	3'-6"	3	15'-0"

End Bent Geometry and Loads (Cored Slabs)

✓ JAG 6/16/2022

Bridge Width	CS Unit Length	Factored Pile Reaction (kips)	Factored Pile Reaction (tons)
27'	25'-0"	106	53
	30'-0"	118	59
	35'-0"	126	63
	40'-0"	132	66
	45'-0"	140	70
	50'-0"	154	77
	55'-0"	162	81
	60'-0"	170	85
	65'-0"	178	89
	70'-0"	184	92
30'	25'-0"	110	55
	30'-0"	122	61
	35'-0"	132	66
	40'-0"	140	70
	45'-0"	148	74
	50'-0"	162	81
	55'-0"	170	85
	60'-0"	180	90
	65'-0"	188	94
	70'-0"	194	97
✓ 33'	25'-0"	92	46
	30'-0"	102	51
	35'-0"	110	55
	40'-0"	118	59
	✓ 45'-0"	✓ 122	✓ 61
	50'-0"	134	67
	55'-0"	142	71
	60'-0"	148	74
	65'-0"	156	78
	70'-0"	162	81
36'	25'-0"	96	48
	30'-0"	108	54
	35'-0"	116	58
	40'-0"	122	61
	45'-0"	130	65
	50'-0"	142	71
	55'-0"	148	74
	60'-0"	156	78
	65'-0"	164	82
	70'-0"	170	85
39'	25'-0"	100	50
	30'-0"	112	56
	35'-0"	120	60
	40'-0"	126	63
	45'-0"	136	68
	50'-0"	146	73
	55'-0"	154	77
	60'-0"	162	81
	65'-0"	170	85
	70'-0"	176	88

✓ End Bents 1 & 2

Bridge Width	Skew	Cap Length	No. of Vertical Piles	Pile Spacing
27'	60/120	38'-2"	5	8'-6"
	75/105	34'-3"	5	7'-6"
	90	33'-0"	5	7'-6"
30'	60/120	41'-8"	5	9'-6"
	75/105	37'-4"	5	8'-3"
	90	36'-0"	5	8'-3"
33'	60/120	45'-2"	7	7'-0"
	75/105	40'-6"	7	6'-0"
	90	39'-0"	7	6'-0"
36'	60/120	48'-7"	7	7'-6"
	75/105	43'-7"	7	6'-6"
	90	42'-0"	7	6'-6"
39'	60/120	52'-0"	7	8'-0"
	75/105	46'-8"	7	7'-0"
	90	45'-0"	7	7'-0"

SUPPORTING CALCULATIONS

END BENT NO. 1

```
=============================================================================

                 APILE for Windows, Version 2019.9.3

                  Serial Number :  226375647

                  A Program for Analyzing the Axial Capacity
                  and Short-term Settlement of Driven Piles
                            under Axial Loading.
                (c) Copyright ENSOFT, Inc., 1987-2015
                      All Rights Reserved

=============================================================================

This program is licensed to :

HDR, Inc.
APILE Global, Global License

Path to file locations      : C:\Users\puzhang\Documents\ZP\Harnett 54 (10340043)\EB\
Name of input data file     : 420054 EB1.ap9d
Name of output file         : 420054 EB1.ap9o
Name of plot output file    : 420054 EB1.ap9p

-----------------------------------------------------------------------------
                     Time and Date of Analysis
-----------------------------------------------------------------------------

          Date:  December 16, 2022     Time:  14:38:26
```



```
     **********************
     * INPUT INFORMATION *
     **********************



     Harnett County Bridge 54 EB1-B

     DESIGNER   : PZ

     JOB NUMBER :


     METHOD FOR UNIT LOAD TRANSFERS :

     - API RP 2A (American Petroleum Institute)
       Unfactored Unit Side Friction and Unit Side Resistance are used.



     COMPUTATION METHOD(S) FOR PILE CAPACITY :

     - FHWA (Federal Highway Administration)
     - API RP 2A (American Petroleum Institute)


     TYPE OF LOADING :
     - COMPRESSION


     PILE TYPE :

     H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 15.50 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 20.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 8.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 48.00 IN.
- TIP AREA OF PILE = 15.50 IN2
- INCREMENT OF PILE LENGTH USED IN COMPUTATION = 1.00 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/FT^3	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	SAND	0.80*	52.60	24.00	11.20**
10.00	SAND	0.80*	52.60	24.00	11.20**
10.00	SAND	0.80*	62.60	38.00	46.00**
11.00	SAND	0.80*	62.60	38.00	46.00**
11.00	SAND	0.80*	72.60	42.00	50.00**
20.00	SAND	0.80*	72.60	42.00	50.00**

* VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
10.00	1.000	1.000
10.00	1.000	1.000
11.00	1.000	1.000
11.00	1.000	1.000
20.00	1.000	1.000

1

****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.0	0.1
2.00	0.1	0.1	0.2
3.00	0.2	0.1	0.3
4.00	0.3	0.1	0.5
5.00	0.5	0.2	0.7
6.00	0.8	0.2	1.0
7.00	1.1	0.2	1.3
8.00	1.4	0.3	1.7
9.00	1.7	1.4	3.1
10.00	2.1	4.4	6.6
11.00	3.1	8.0	11.1
12.00	4.8	11.9	16.7

BOC = 159.5 ft

4.8/220=2%

****
* API RP-2A (2010) *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
1.00	0.0	0.1	0.1
2.00	0.1	0.1	0.2
3.00	0.3	0.2	0.5
4.00	0.5	0.3	0.7
5.00	0.7	0.3	1.0
6.00	1.0	0.4	1.4
7.00	1.4	0.4	1.9
8.00	1.9	0.5	2.4
9.00	2.3	1.1	3.4
10.00	2.9	1.8	4.7
11.00	3.8	2.6	6.4
12.00	5.2	3.5	8.7

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

****
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *
****

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		

```
                                0.0000E+00      0.0000E+00
                                0.0000E+00      0.2445E-01
                                0.0000E+00      0.4736E-01
                                0.0000E+00      0.8709E-01
                                0.0000E+00      0.1222E+00
                                0.0000E+00      0.1528E+00
                                0.0000E+00      0.3056E+00
                                0.0000E+00      0.4584E+00
                                0.0000E+00      0.7639E+00
                                0.0000E+00      0.3056E+01
2          10      0.5025E+01
                                0.0000E+00      0.0000E+00
                                0.1517E+00      0.2445E-01
                                0.2528E+00      0.4736E-01
                                0.3792E+00      0.8709E-01
                                0.4551E+00      0.1222E+00
                                0.5056E+00      0.1528E+00
                                0.5056E+00      0.3056E+00
                                0.5056E+00      0.4584E+00
                                0.5056E+00      0.7639E+00
                                0.5056E+00      0.3056E+01
3          10      0.9958E+01
                                0.0000E+00      0.0000E+00
                                0.3006E+00      0.2445E-01
                                0.5010E+00      0.4736E-01
                                0.7515E+00      0.8709E-01
                                0.9018E+00      0.1222E+00
                                0.1002E+01      0.1528E+00
                                0.1002E+01      0.3056E+00
                                0.1002E+01      0.4584E+00
                                0.1002E+01      0.7639E+00
                                0.1002E+01      0.3056E+01
4          10      0.1000E+02
                                0.0000E+00      0.0000E+00
                                0.3019E+00      0.2445E-01
                                0.5031E+00      0.4736E-01
                                0.7547E+00      0.8709E-01
                                0.9056E+00      0.1222E+00
                                0.1006E+01      0.1528E+00
                                0.1006E+01      0.3056E+00
                                0.1006E+01      0.4584E+00
                                0.1006E+01      0.7639E+00
                                0.1006E+01      0.3056E+01
5          10      0.1053E+02
                                0.0000E+00      0.0000E+00
                                0.4778E+00      0.2445E-01
                                0.7964E+00      0.4736E-01
                                0.1195E+01      0.8709E-01
                                0.1434E+01      0.1222E+00
                                0.1593E+01      0.1528E+00
                                0.1593E+01      0.3056E+00
                                0.1593E+01      0.4584E+00
                                0.1593E+01      0.7639E+00
                                0.1593E+01      0.3056E+01
6          10      0.1096E+02
                                0.0000E+00      0.0000E+00
                                0.6231E+00      0.2445E-01
                                0.1039E+01      0.4736E-01
                                0.1558E+01      0.8709E-01
                                0.1869E+01      0.1222E+00
                                0.2077E+01      0.1528E+00
                                0.2077E+01      0.3056E+00
                                0.2077E+01      0.4584E+00
                                0.2077E+01      0.7639E+00
                                0.2077E+01      0.3056E+01
7          10      0.1100E+02
                                0.0000E+00      0.0000E+00
                                0.6371E+00      0.2445E-01
                                0.1062E+01      0.4736E-01
```

			0.1593E+01	0.8709E-01
			0.1911E+01	0.1222E+00
			0.2124E+01	0.1528E+00
			0.2124E+01	0.3056E+00
			0.2124E+01	0.4584E+00
			0.2124E+01	0.7639E+00
			0.2124E+01	0.3056E+01
8	10	0.1553E+02		
			0.0000E+00	0.0000E+00
			0.8304E+00	0.2445E-01
			0.1384E+01	0.4736E-01
			0.2076E+01	0.8709E-01
			0.2491E+01	0.1222E+00
			0.2768E+01	0.1528E+00
			0.2768E+01	0.3056E+00
			0.2768E+01	0.4584E+00
			0.2768E+01	0.7639E+00
			0.2768E+01	0.3056E+01
9	10	0.1996E+02		
			0.0000E+00	0.0000E+00
			0.8304E+00	0.2445E-01
			0.1384E+01	0.4736E-01
			0.2076E+01	0.8709E-01
			0.2491E+01	0.1222E+00
			0.2768E+01	0.1528E+00
			0.2768E+01	0.3056E+00
			0.2768E+01	0.4584E+00
			0.2768E+01	0.7639E+00
			0.2768E+01	0.3056E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.2192E+00	0.7639E-02
0.4384E+00	0.1528E-01
0.8767E+00	0.3056E-01
0.1753E+01	0.1986E+00
0.2630E+01	0.6417E+00
0.3156E+01	0.1115E+01
0.3507E+01	0.1528E+01
0.3507E+01	0.2292E+01
0.3507E+01	0.3056E+01

LOAD VERSUS SETTLEMENT CURVE

****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.5543E-02	0.1026E-03	0.2869E-02	0.1000E-03
0.5543E-01	0.1026E-02	0.2869E-01	0.1000E-02
0.2772E+00	0.5129E-02	0.1435E+00	0.5000E-02
0.5543E+00	0.1026E-01	0.2869E+00	0.1000E-01
0.1109E+01	0.2052E-01	0.5738E+00	0.2000E-01
0.2101E+01	0.5097E-01	0.9782E+00	0.5000E-01
0.2668E+01	0.8121E-01	0.1135E+01	0.8000E-01
0.2988E+01	0.1014E+00	0.1239E+01	0.1000E+00
0.3926E+01	0.2018E+00	0.1756E+01	0.2000E+00
0.4519E+01	0.5021E+00	0.2350E+01	0.5000E+00
0.4976E+01	0.8024E+00	0.2806E+01	0.8000E+00
0.5198E+01	0.1002E+01	0.3028E+01	0.1000E+01
0.5677E+01	0.2003E+01	0.3507E+01	0.2000E+01

GRLWEAP 14-[Professional version] - [420054 EB1.gww]

File Input Output Options View Windows Help

English | Inspector's Chart

Hammer Information [9/7/2021]

Source: ALL ID: 1 Type: ALL Manufacturer: ALL

ID	Make	Model	Type	Ram Wt/Ecc. M.	Energy/Power	Stroke/Freq.
3	DELMAG	D 12	OED	2.75	22.605	8.22
4	DELMAG	D 15	OED	3.3	27.093	8.21
5	DELMAG	D 16-32	OED	3.52	40.198	11.42
6	DELMAG	D 22	OED	4.91	40.606	8.27
7	DELMAG	D 22-02	OED	4.85	48.5	10

Hammer Parameter

Efficiency 0.80

Pressure 1380.0 psi Fixed 100 %

Stroke 5.00 ft Stroke Incr. 0.50 ft

Pile Material

○ Concrete ◉ Steel ○ Timber

Cushion Information

	Hammer	Pile	
Area	415.000	0	in²
E. Modulus	530.0	0	ksi
Thickness	2.0	0	in
C.O.R	0.80	0.50	
Stiffness	109976.03	0	kips/in
Helmet Weight	2.700		kips

Pile Information

Length	20.00 ft		
Penetration	12.00 ft		
Inclination	0 deg	Ratio: x 1 : z 0	
Section Area	15.500 in²	Segments	Auto
E. Modulus	29000.0 ksi	S-Length	Auto.
Spec. Weight	492.000 lb/ft³	S-St. Wt	Auto.
End Bg. Area	141.890 in²	Splices	0
Perimeter	3.970 ft	Pile Type	
Pile Size	12.04 in	H Pile	

Ultimate Capacities

kips

1	220.0	6	240.0
2	80.0	7	280.0
3	120.0	8	320.0
4	160.0	9	360.0
5	200.0	10	400.0
Incr.	0		Reset

Soil Parameters

2nd Toe - No

Quake

Shaft 0.100 in Const.

Toe 0.060 in

Damping

Shaft 0.100 s/ft Const.

Toe 0.150 s/ft Smith

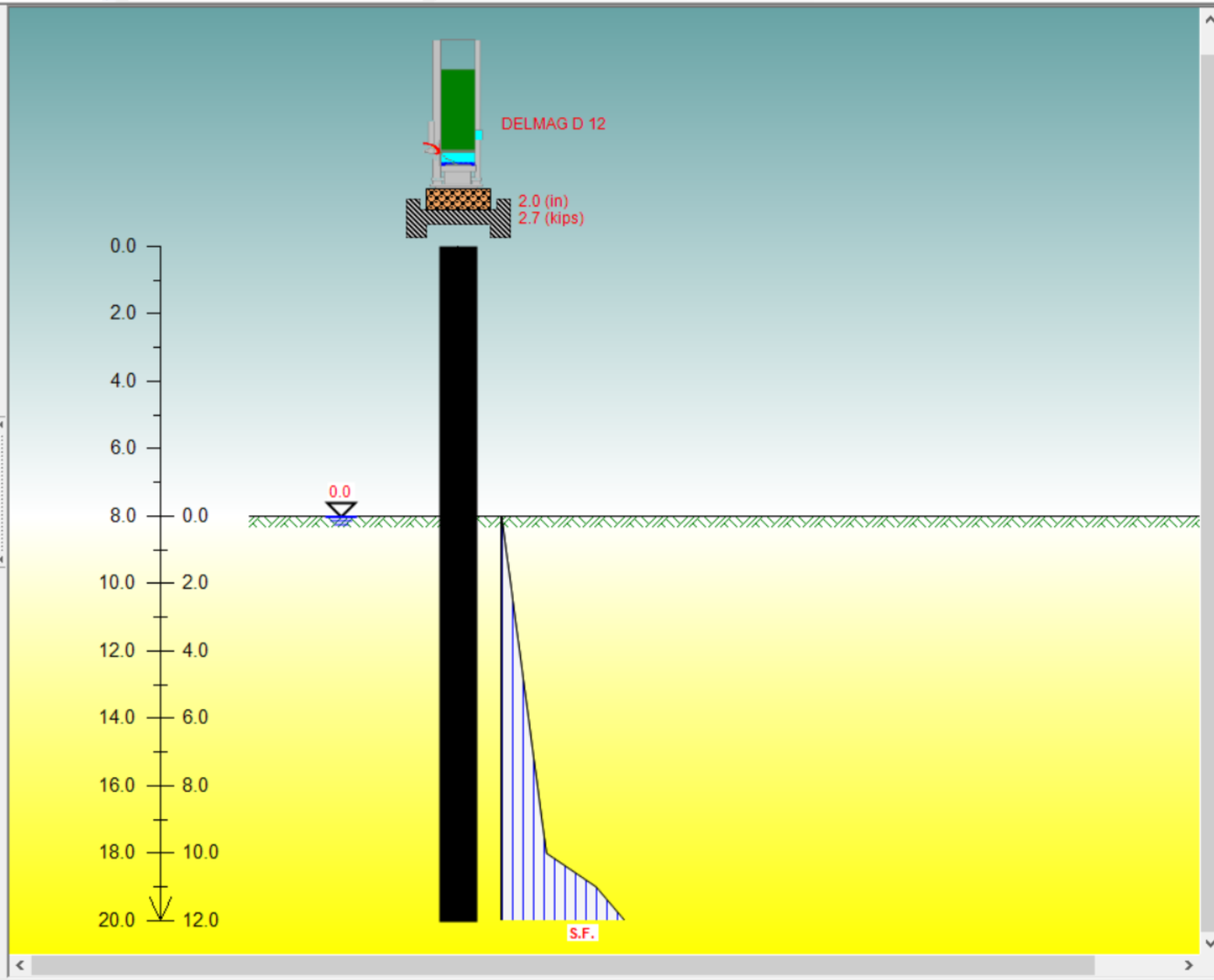
Shaft Resistance

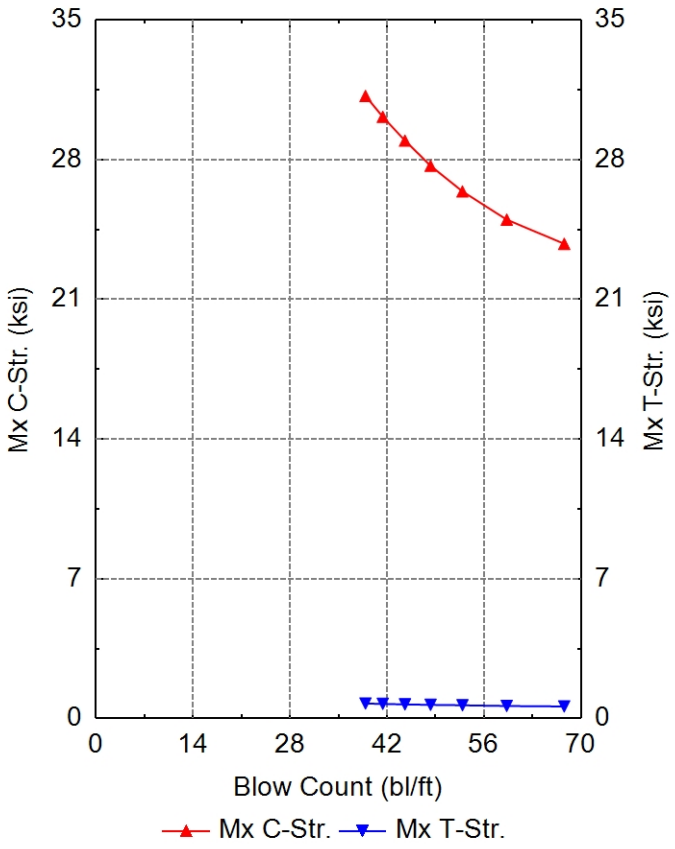
Percentage 2 %

Residual Stress Analysis No

Two Pile Model - Off

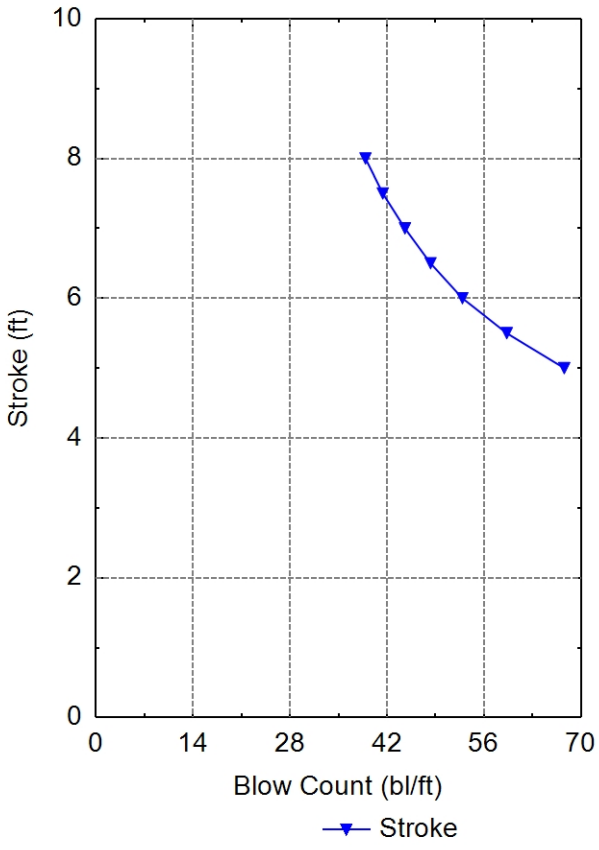
Fix Stroke and Pressure

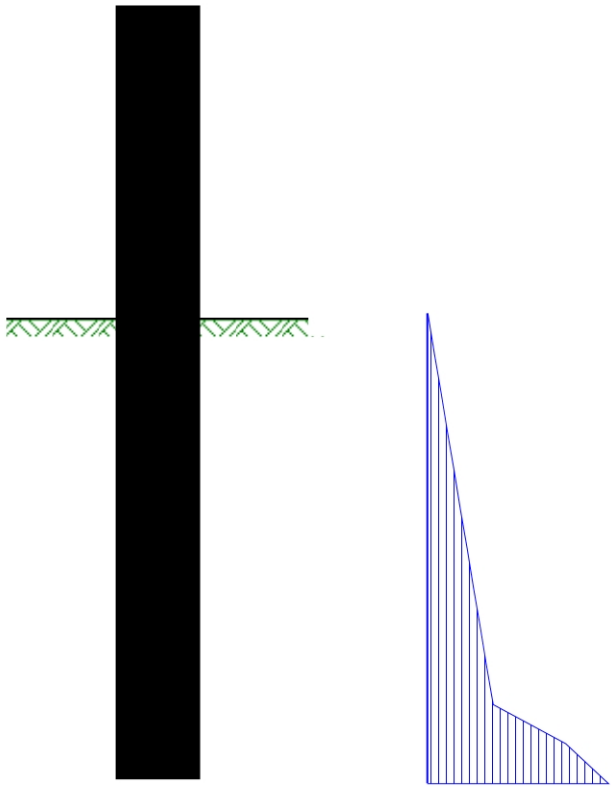




DELMAG D 12

Capacity	220.0	kips
Ram Weight	2.75	kips
Efficiency	0.800	
Pressure	1380.0 (100%)	psi
Helmet Weight	2.700	kips
Hammer Cushion	109976.0	kips/in
COR of H.C.	0.800	
Skin Quake	0.098	in
Toe Quake	0.060	in
Skin Damping	0.100	s/ft
Toe Damping	0.152	s/ft
Pile Length	20.00	ft
Pile Penetration	12.00	ft
Pile Top Area	15.50	in²
RSA	No	





Pile Model

Shaft=2%
(Prop.)

Bearing Graph Summary — DELMAG D 12

Rut	Mx C-Str.	Top Str.	Mx T-Str.	Blow Ct	Stroke	ENTHRU	Hammer	Trans. Ratio
kips	ksi	ksi	ksi	bl/ft	ft	kip-ft	DELMAG	%
220.0	23.78	23.78	0.61	67.6	5.00	6.61	D 12	29.2
220.0	24.99	24.87	0.63	59.3	5.50	7.54	D 12	33.4
220.0	26.40	25.95	0.66	52.9	6.00	8.53	D 12	37.7
220.0	27.69	26.84	0.69	48.3	6.50	9.44	D 12	41.8
220.0	28.95	27.75	0.71	44.6	7.00	10.33	D 12	45.7
220.0	30.14	28.65	0.74	41.4	7.50	11.28	D 12	49.9
220.0	31.18	29.47	0.75	38.9	8.00	12.19	D 12	53.9

BENT NO. 1

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
Drilled Pier Axial Resistance Worksheet

PROJECT: BP6.R017 COUNTY: Harnett
DESCRIPTION: Bridge No. 420054, Bent 1
DESIGNED BY: PZ DATE: 12/15/22 STATION: 18+84 -L-
CHECKED BY: KRB DATE: 12/20/22 STR. NO.: PAGE: 1 OF 6

Elevations

Bottom of Cap (BOC) Elevation =	159.50	ft
Top of Pier/Bottom of Column Elevation =	159.50	ft
Natural Ground / Finished Grade Elevation =	155.50	ft
Groundwater Table (GWT) Elevation =	157.80	ft
Design Scour (DSE) Elevation =	144.70	ft
Amount of Contraction Scour (from BSR) =	12.30	ft
Is Permanent Casing Required?	◉ Yes / Maybe ○ No	
Bottom of Permanent Casing Elevation =	144.00	ft
Drilled Pier Tip Elevation =	130.00	ft

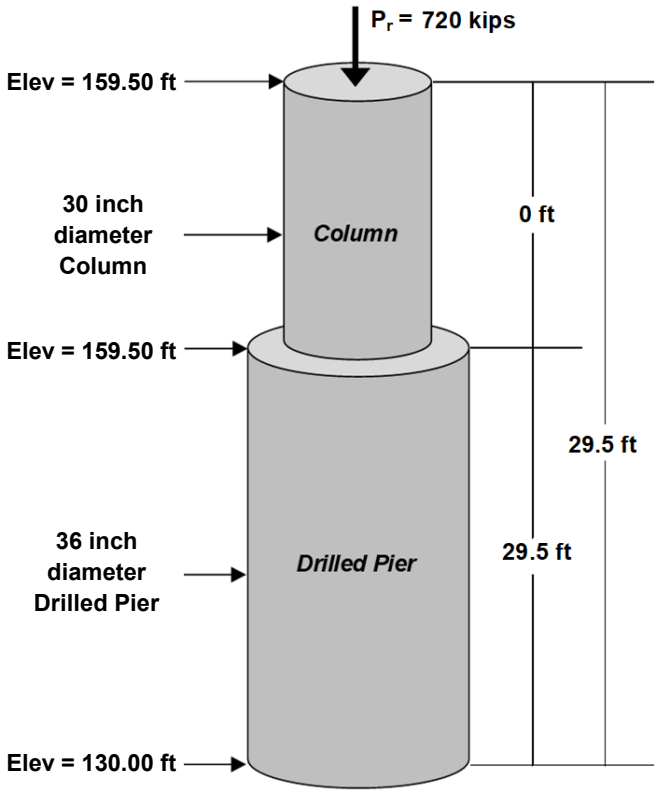


Figure shows typical drilled pier

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	720.0	kips
Number of Drilled Piers per Bent =	3	
Diameter of Column (d_{Column}) =	30	in
Diameter of Drilled Pier (d_{DP}) =	36	in
Unit Weight of Concrete (γ_c) =	0.150	kcf
Compressive Strength of Concrete (f'_c) =	4.500	ksi

Subsurface Information and Soil/Rock Layer Properties

internally calculate $N1_{60}$ values at midpoint of each layer : ☑

Subsurface Boring Name / ID No. =	EB2A	
SPT Hammer Energy Efficiency Rating (ER) =	88	%
Top of Boring (Collar) Elevation =	159.80	ft
Depth to Groundwater Table (for actual boring) =	1.60	ft

Calculate GSI using RQD values : ☐
(Use if GSI is not shown on boring)

Layer No.	Material Description	Layer Elevations Top[1] (ft)	Layer Elevations Bottom (ft)	Total γ (kcf)	N (bpf)	N_{60} (bpf)	$N1_{60}$ (bpf)	RQD (%)	[2] GSI	q_u (ksf)	E_i (ksi)	v
1	Weathered Rock	144.70	139.40	0.135	500	733	865					
2	Weathered Rock	139.40	130.00	0.140	600	880	924					
3												
4												
5												
6												
7												
8												
TIP [3]	Weathered Rock	130.00	124.00	0.140	600	880	836					

Notes

1. Resistance from subsurface layers above the Bottom of Column Elevation, Drilled Pier Design Scour Elevation, and Permanent Casing Elevation will be ignored.
2. Hard rock layers with poor or very poor quality rock mass (GSI < 30) will be modeled as weathered rock.
3. Input the subsurface information for the soil / rock at the base of the drilled pier to a distance of 2 pier diameters below the base of the drilled pier.

Side Resistance in Weathered and Hard Rock

$R_s = (A_s)(q_s)$ *AASHTO Eqn. 10.8.3.5-3*

q_s = unit side resistance for weathered or hard rock layer (ksf)

For weathered rock layers or hard rock layers with a GSI < 30

= 8 ksf *NCDOT Policy*

For drilled piers socketed into hard rock

$$= \left(C \sqrt{\frac{q_u}{p_a}} \right) p_a$$ *AASHTO Eqn. 10.8.3.5.4b-1*

C = regression coefficent taken as 1.0 for normal rock sockets (see AASHTO C10.8.3.5.4b-1 for details)

For fractured rock that caves and cannot be drilled without artificial support

$$= \left(0.65 \alpha_E \sqrt{\frac{q_u}{p_a}} \right) p_a$$ *AASHTO Eqn. 10.8.3.5.4b-2*

a_E = reduction factor to account for jointing in rock (from AASHTO Table 10.8.3.5.4b-1)

RQD (%)	Joint Modificaiton Factor, α_E	
	Closed Joints	Open or Gouge-Filled Joints
100	1.00	0.85
70	0.85	0.55
50	0.60	0.55
30	0.50	0.50
20	0.45	0.45

q_u = Uniaxial Compressive Strength of Intact Rock (ksf) $\leq f'_c$

f'_c = 28 day Compressive Strength of Concrete (4.5 ksi = 648 ksf)

p_a = atmospheric pressure (2.12 ksf)

A_s = area of drilled pier side resistance (ft^2)

= $(\pi)(B)(\Delta z)$

B = diameter of drilled pier (subtract 2 inches to account for possible reduction of drilled pier in rock)

= (36 inches - 2 inches) / 12 inches per ft = 2.83 ft

Δz = effective thickness of the soil layer (ft)

Layer No.	Rock Type	Layer Elevations		AASHTO Equation and Rock Joint Condition to use	RQD (%)	α_E	q_u (ksf)	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
		Top (ft)	Bottom (ft)								
1	Weathered Rock	144.00	139.40	N/A	N/A	N/A	N/A	8.000	4.60	40.95	328
2	Weathered Rock	139.40	130.00	N/A	N/A	N/A	N/A	8.000	9.40	83.67	669

Total Side Resistance in Weathered and Hard Rock = 997

Note: *Hard Rock Layers with a poor surface quality (GSI < 30) will be modeled as weathered rock with an N_{60} = 600 blows/ft.*

Tip Resistance in Weathered Rock

$R_p = (q_p)(A_p)$ *AASHTO Eqn. 10.8.3.5-2*

q_p = unit tip resistance (ksf)

$= (N_C)(S_U)$ *AASHTO Eqn. 10.8.3.5.1c-1*

N_C = cohesion bearing capacity factor *N_c = 9 for Weathered Rock per NCDOT Policy*

S_U = undrained shear strength of material below drilled pier tip (ksf)

$= 0.23(OCR)^{0.8}(\sigma'_{vo})$ *Mayne and Harris, 1993 (after Jamiolkowski, et al., 1985)*

$OCR = (\sigma'_p)/(\sigma'_{vo})$

$\sigma'_p = 0.47(N_{60})^{0.8}(\rho_a)$ *AASHTO Eqn. 10.8.3.5.2b-4*

N_{60} = SPT-N value corrected for hammer efficiency *N_{60} limited to 600 blows/ft*

ρ_a = atmospheric pressure (2.12 ksf)

σ'_{vo} = effective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46

A_p = area of drilled pier tip resistance (ft^2)

$= (\pi)(B^2)/4$

B = diameter of drilled pier (subtract 2 inches to account for possible reduction of drilled pier in rock)
(36 inches - 2 inches) / 12 inches per ft = 2.83 ft

Tip Elevation (ft)	N_C	N_{60}	σ'_p (ksf)	σ'_{vo} (ksf)	OCR	S_U (ksf)	q_p (ksf)	A_p (ft^2)	R_p (kips)
130.00	9	600	166	1.114	149.274	14.057	126.513	6.31	798

Summary of Nominal and Factored Side Resistance

Material Type	Nominal Side Resistance (kips)	Resistance Factor from AASHTO Table 10.5.5.2.4-1	Factored Side Resistance (kips)	Percentage of Side Resistance produced by Material Type
Cohesive Soil	0	0.45	0	0.0%
Cohesionless Soil	0	0.55	0	0.0%
CohesiveIGM	0	0.60	0	0.0%
Weathered Rock	997	0.60	598	100.0%
Hard Rock	0	0.55	0	0.0%
Total	**997**		**598**	**100%**

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance = 798 kips
Tip Resistance Factor = 0.55
Total Factored Tip Resistance = 439 kips

the drilled pier is bearing on Weathered Rock
for Weathered Rock (use IGM), see AASHTO Table 10.5.5.2.4-1.

Required Factored Resistance

$R_{req} = P_r + \gamma_{DC}(W_{Column} + W_{Pier}) - \gamma_{WA}W_{Water} - \gamma_{DC}W_{Soil/Rock} \geq P_r$ *Required Factored Resistance*

P_r = 720 kips *Maximum Factored Axial Load Reported by Structure Design*
γ_{DC} = 1.25 *Factor for Permanent Dead Loads, from AASHTO Table 3.4.1-2*
γ_{WA} = 1.00 *Factor for Water Loads, from AASHTO Table 3.4.1-1*

$W_{Column} = (A_{Column})(L_{Column})(\gamma_c)$ *Unfactored Weight of Column*

A_{Column} = 4.91 ft^2 *Area of Column*
L_{Column} = 0 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*
= 0 kips

$W_{Pier} = (A_{Pier})(L_{Pier})(\gamma_c)$ *Unfactored Weight of Drilled Pier*

A_{Pier} = 7.07 ft^2 *Area of Drilled Pier*
L_{Pier} = 29.5 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*
= 31 kips

$W_{Water} = (A_{Pier})(z_w)(\gamma_w)$ *Unfactored Weight of Water Displaced by Drilled Pier*

A_{Pier} = 7.07 ft^2 *Area of Drilled Pier*
z_w = 28 ft *Depth from water surface to the drilled pier tip*
γ_w = 0.0624 kcf *Unit Weight of Water*
= 12 kips

$W_{Soil/Rock} = (A_{Pier})(\sigma'_{vo})$ *Unfactored Effective Weight of Soil / Rock that will be displaced*

A_{Pier} = 7.07 ft^2 *Area of Drilled Pier*
σ'_{vo} = 1.114 ksf *effective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46*

$W_{Soil/Rock}$ = 8 kips

R_{req} = 720 kips + 1.25(0 kips + 31 kips) -1.00(12 kips) -1.25(8 kips) = 737 kips

Load Transfer of Side and Tip Resistance

The majority of the side resistance is produced by Weathered Rock , which is treated as a cohesive material for Load transfer. Use AASHTO Figure 10.8.2.2.2.1 to predict the normalized load transfer for side resistance.

The drilled pier tip is bearing on Weathered Rock, which is treated as a cohesive material for load transfer. Use AASHTO Figure 10.8.2.2.2.2 to predict the normalized load transfer for tip resistance.

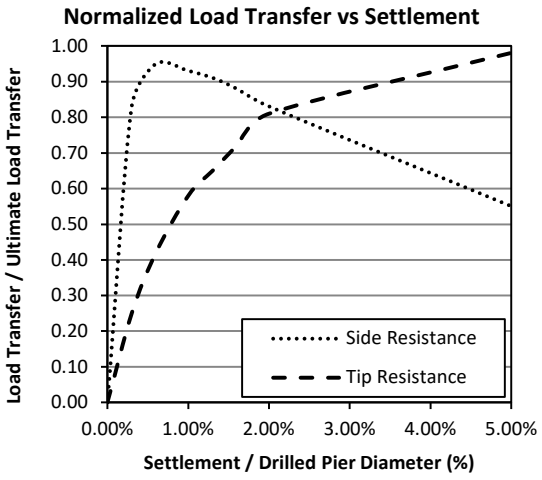
Load Transfer of Side and Tip Resistance (continued)

$\Delta z / D$ (%)	Normalized Side Transfer R_{sd} / R_s AASHTO Figure 10.8.2.2.2.1	Normalized Tip Transfer R_{pd} / R_p AASHTO Figure 10.8.2.2.2.2
0.0	0.00	0.00
0.3	0.83	0.25
0.6	0.95	0.42
1.0	0.93	0.58
1.3	0.91	0.65
1.6	0.88	0.72
2.0	0.83	0.81
5.0	0.55	0.98

$\Delta z / D$ = total settlement / drilled pier diameter

R_{sd} / R_s = developed side resistance / total nominal side resistance

R_{pd} / R_p = developed tip resistance / total nominal tip resistance



Developed Factored Resistance, (R_{rd})

Use the normalized load transfer values along with the total factored side and tip resistance values to calculate the developed side and tip resistance at different vertical displacements. The developed factored resistance must be greater than or equal to the required axial resistance, ($R_{rd} \geq R_{req}$).

$\frac{\Delta z}{D}$	D (in)	Δz (in)	$\varphi_{qs}R_s$ (kips)	$\frac{R_{sd}}{R_s}$	$\varphi_{qs}R_{sd}$ (kips)	$\varphi_{qp}R_p$ (kips)	$\frac{R_{pd}}{R_p}$	$\varphi_{qp}R_{pd}$ (kips)	R_{rd} (kips)	R_{req} (kips)	Axial Resistance Requirement Satisfied
0.3%	36	0.11	598	0.83	496	439	0.25	110	606	737	NO
0.6%	**36**	**0.22**	**598**	**0.95**	**568**	**439**	**0.42**	**184**	**752**	**737**	**YES**
1.0%	36	0.36	598	0.93	556	439	0.58	255	811	737	YES
1.3%	36	0.47	598	0.91	544	439	0.65	285	829	737	YES
1.6%	36	0.58	598	0.88	526	439	0.72	316	842	737	YES
2.0%	36	0.72	598	0.83	496	439	0.81	355	851	737	YES
5.0%	36	1.80	598	0.55	329	439	0.98	430	759	737	YES

$\varphi_{qs}R_s$ = total factored side resistance

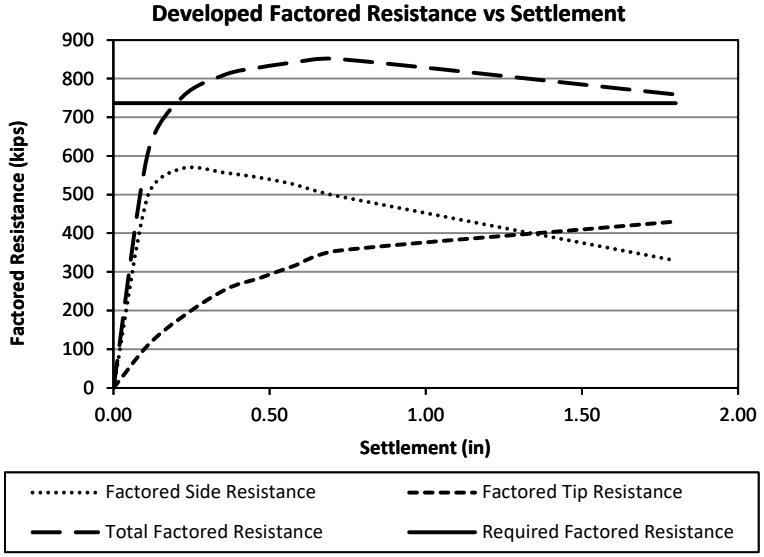
$\varphi_{qp}R_p$ = total factored tip resistance

$\varphi_{qs}R_{sd}$ = developed factored side resistance
= $(R_{sd}/R_s)(\varphi_{qs}R_s)$

$\varphi_{qp}R_{pd}$ = developed factored tip resistance
= $(R_{pd}/R_p)(\varphi_{qp}R_p)$

The axial resistance requirement is satisfied at an estimated vertical displacement of 0.22 inches.

Developed Factored Side Resistance = 568 kips
Developed Factored Tip Resistance = 184 kips
Developed Factored Total Resistance = 752 kips



Required Tip Resistance

q_{req} = required tip resistance (rounded up to the nearest 10 ksf or 5 tsf)

$$= \frac{\frac{R_{req} - \varphi_{qs} R_{sd}}{A_T}}{\varphi_{qp}} \leq q_p$$

NCDOT policy

R_r = required factored geotechnical resistance (kips)

$\varphi_{qs}R_{sd}$ = factored developed side resistance (kips)

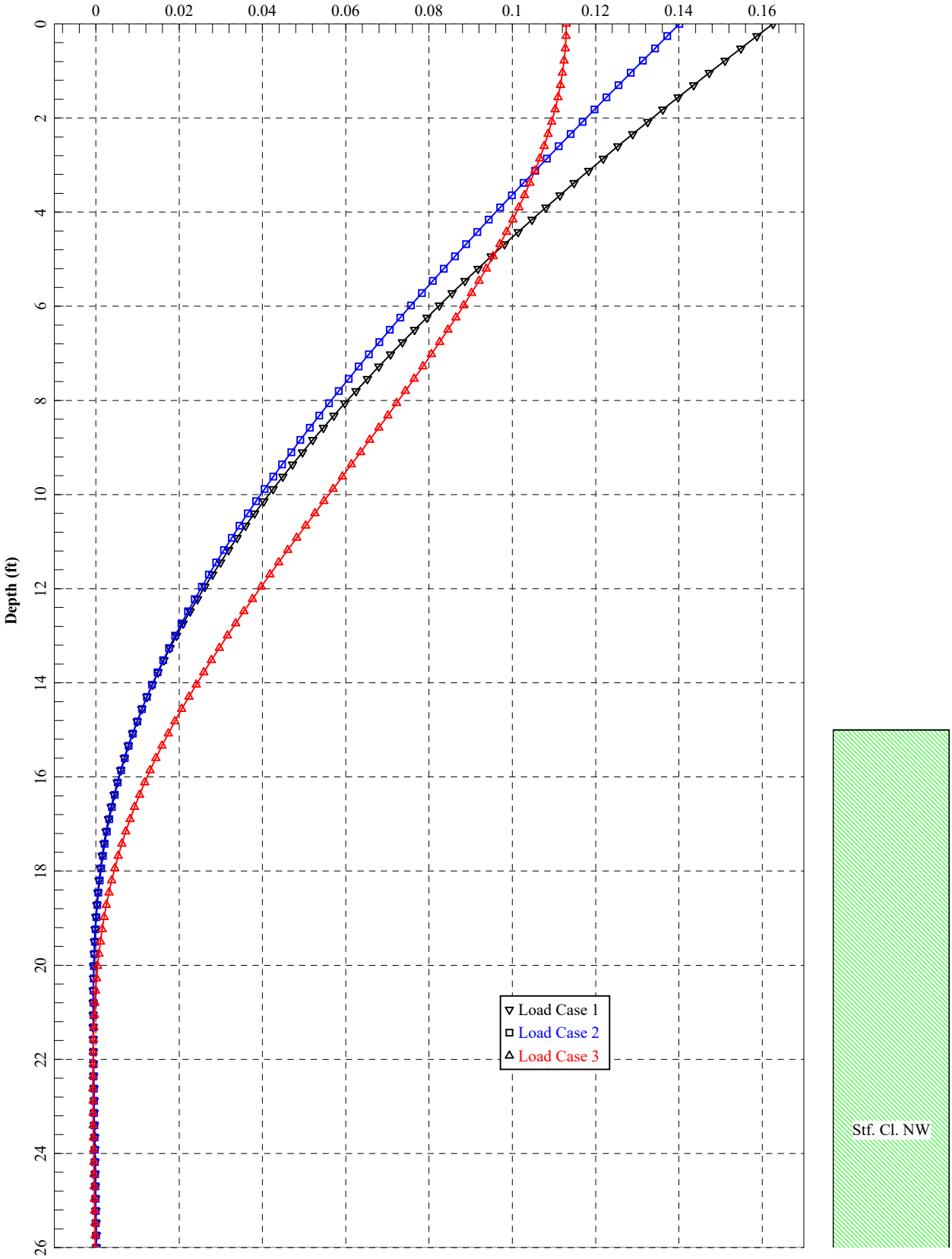
A_T = area of drilled pier tip (ft^2)

φ_{qp} = tip resistance factor

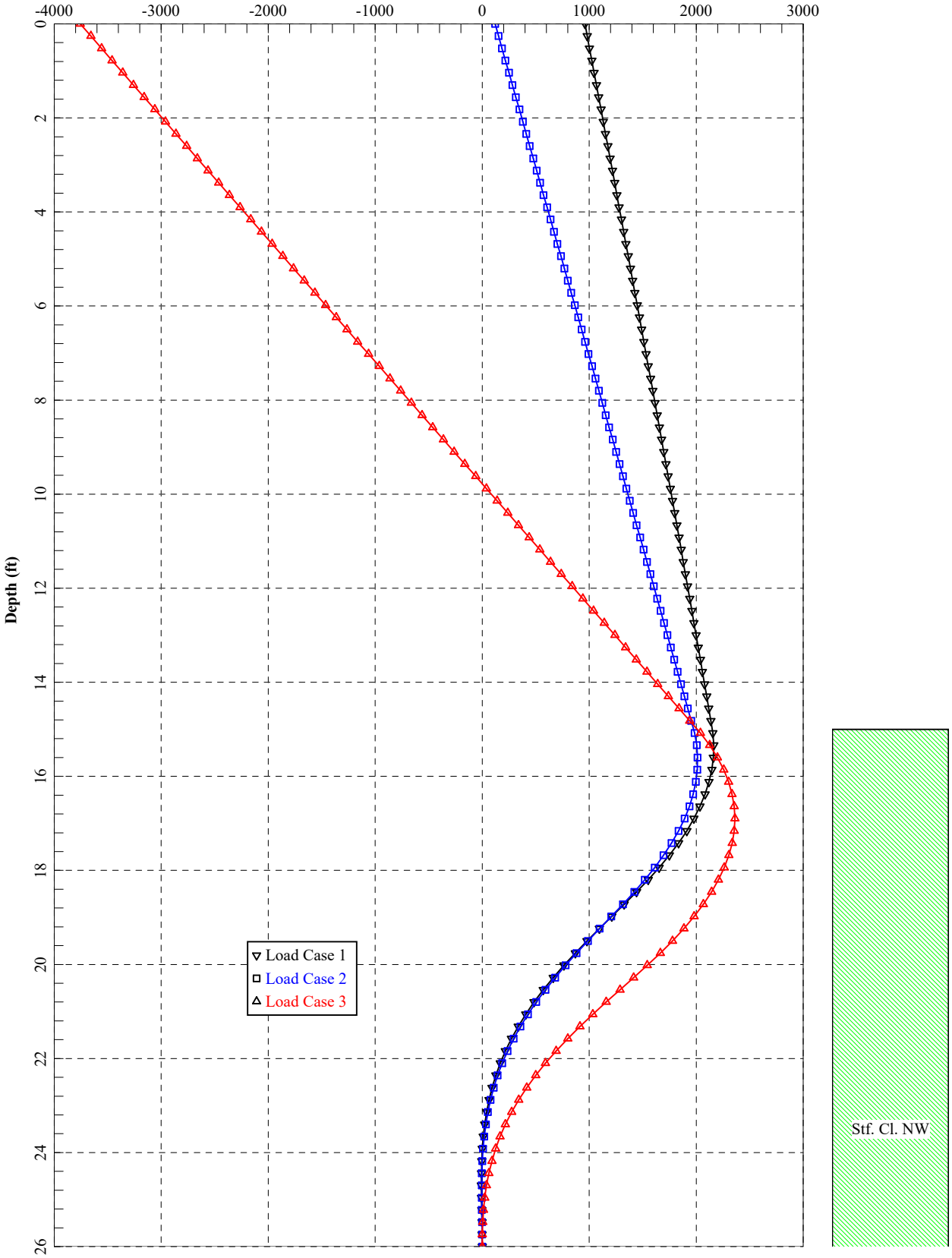
q_p = unit tip resistance (ksf)

R_{req} (kips)	$\varphi_{qs}R_{sd}$ (kips)	A_{Tip} (ft^2)	φ_{qp}	q_p (ksf)	q_{req} (ksf)
737	568	6.31	0.55	127	50

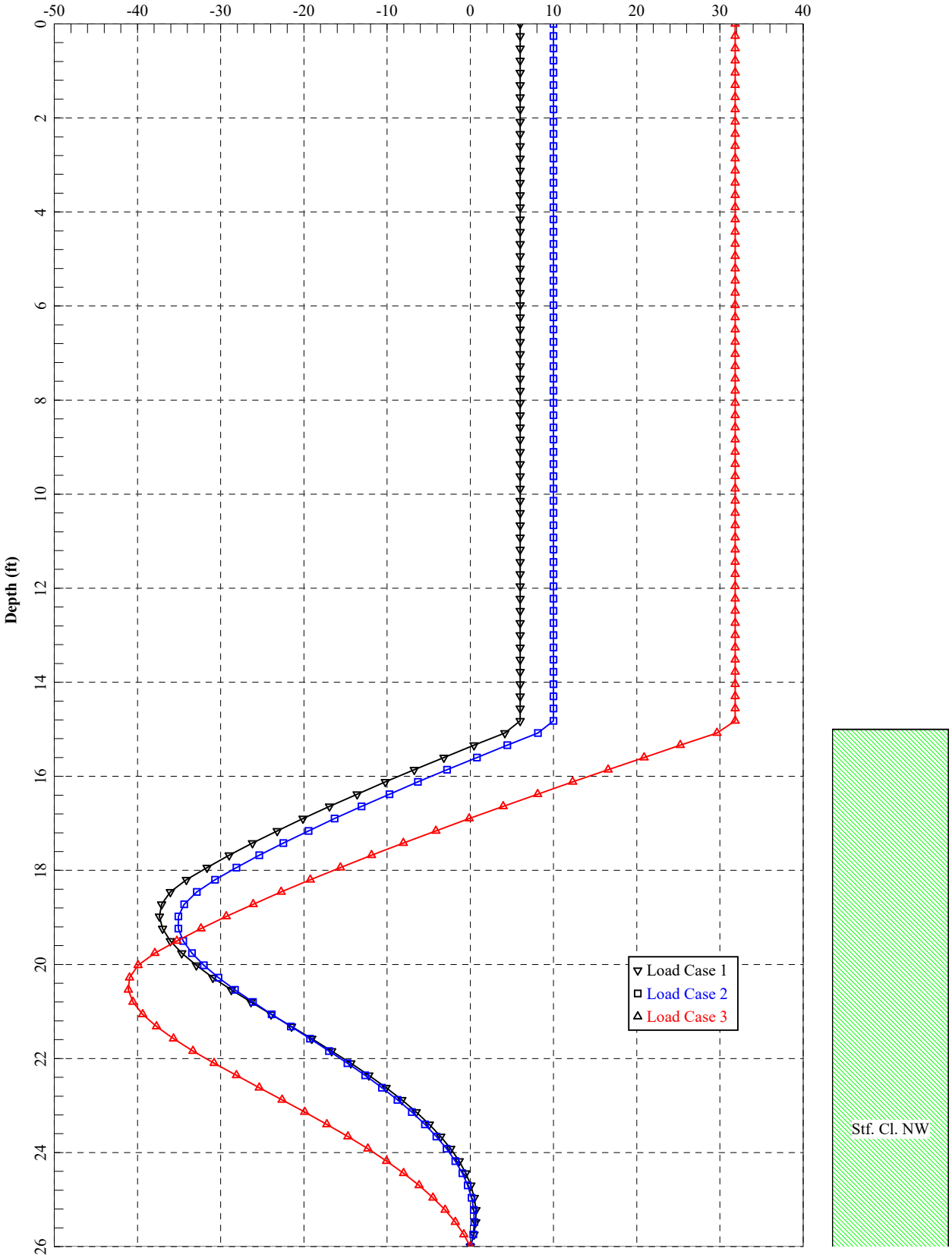
Hanett County Bridge 54 Bent 1
Lateral Pile Deflection (inches)



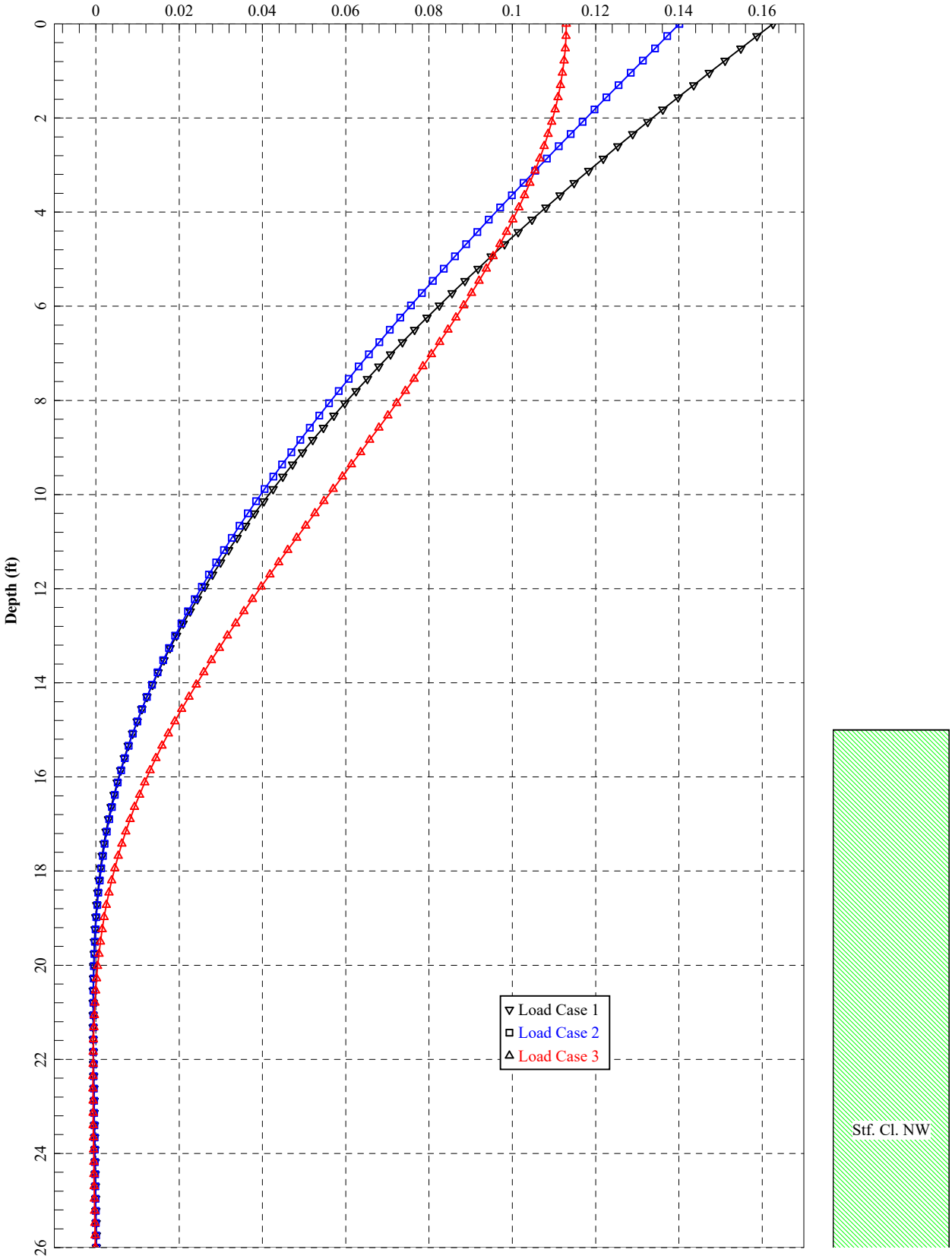
Johnston County Bridge 173 B1A
Bending Moment (in-kips)



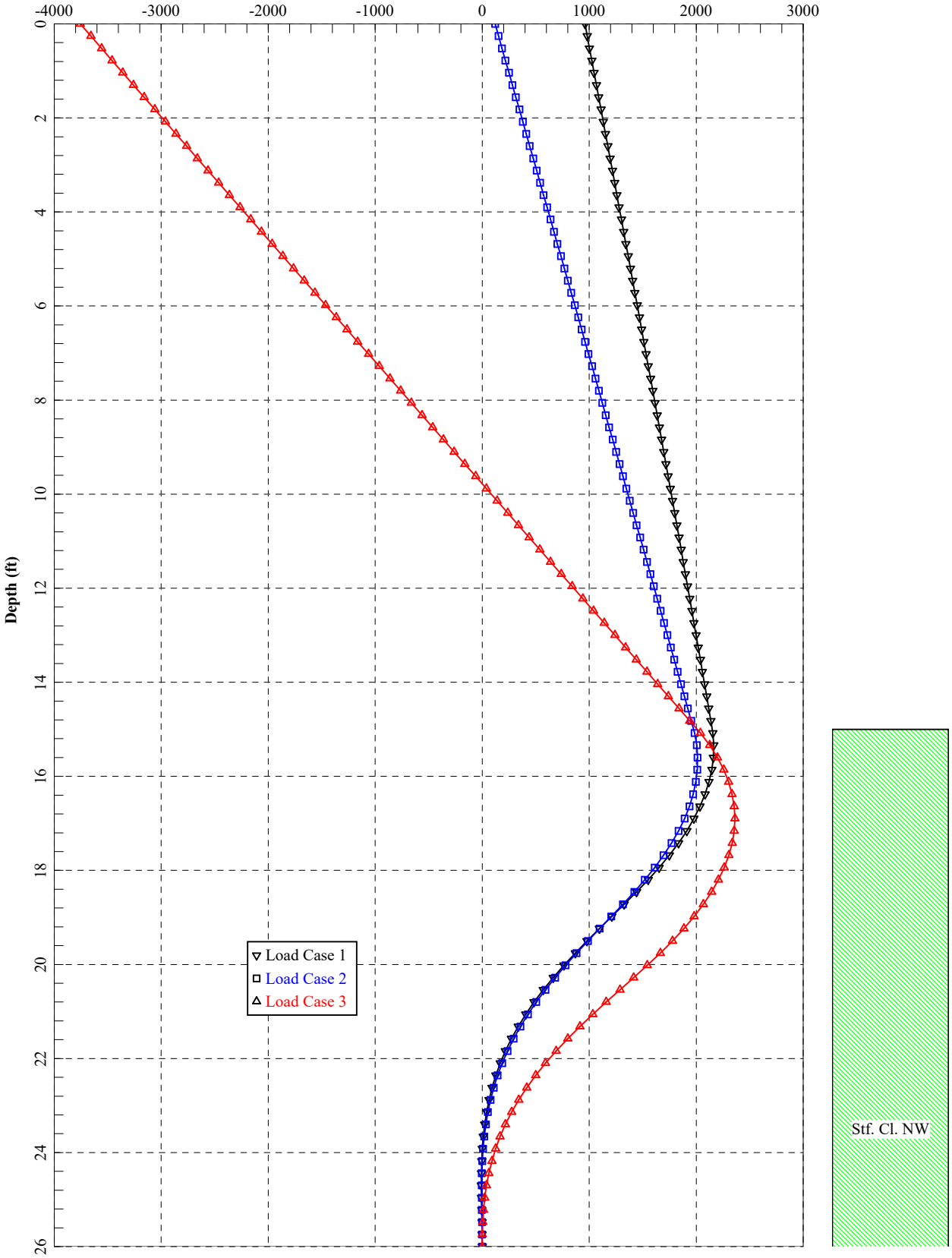
Johnston County Bridge 173 B1A
Shear Force (kips)



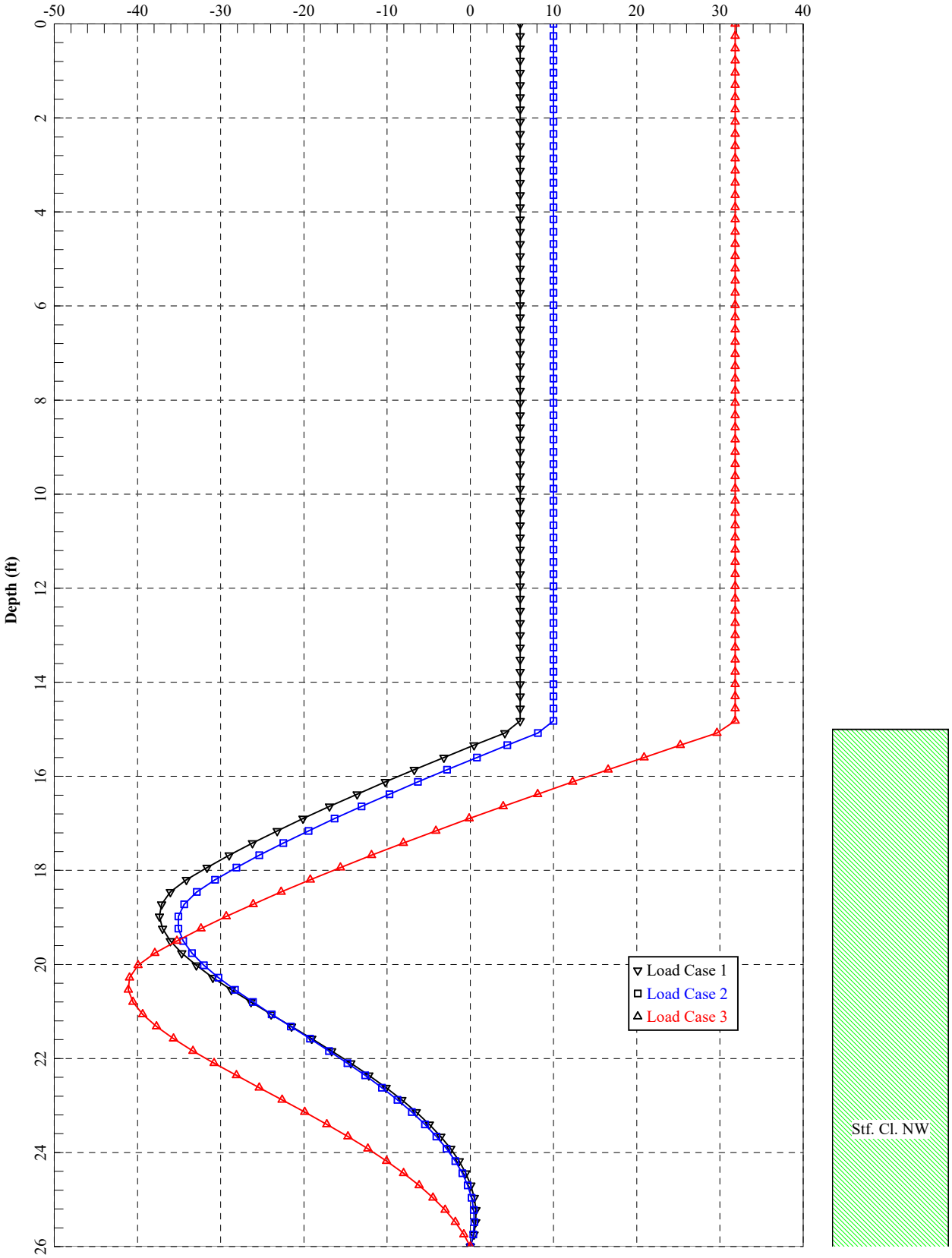
Hanett County Bridge 54 Bent 1
Lateral Pile Deflection (inches)



Johnston County Bridge 173 B1A
Bending Moment (in-kips)



Johnston County Bridge 173 B1A
Shear Force (kips)



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================================================================================

                     LPile for Windows, Version 2019-11.002

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
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--------------------------------------------------------------------------------
                             Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Users\puzhang\Documents\ZP\Harnett 54 (10340043)\IB\

Name of input data file:
Bent B1A.lp11

Name of output report file:
Bent B1A.lp11

Name of plot output file:
Bent B1A.lp11

Name of runtime message file:
Bent B1A.lp11



--------------------------------------------------------------------------------
                           Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  December 15, 2022           Time:  13:21:19



--------------------------------------------------------------------------------
                                  Problem Title
--------------------------------------------------------------------------------

Project Name: BP6.R017 Bridge 420054


Job Number:


Client: NCDOT


Engineer: PZ
```

Description: Bent 1

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:
 - Maximum number of iterations allowed = 500
 - Deflection tolerance for convergence = 1.0000E-05 in
 - Maximum allowable deflection = 100.0000 in
 - Number of pile increments = 100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - No distributed lateral loads are entered
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
Total length of pile = 26.000 ft
Depth of ground surface below top of pile = 15.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	26.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile		
Cross-sectional Shape	=	Circular Pile
Length of section	=	26.000000 ft
Width of top of section	=	36.000000 in
Width of bottom of section	=	36.000000 in
Top Area	=	1018. sq. in
Bottom Area	=	1018. sq. in
Moment of Inertia at Top	=	82448. in^4
Moment of Inertia at Bottom	=	82448. in^4
Elastic Modulus	=	3800000. psi

Ground Slope and Pile Batter Angles

Ground Slope Angle	=	0.000 degrees
	=	0.000 radians
Pile Batter Angle	=	0.000 degrees
	=	0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	15.000000 ft
Distance from top of pile to bottom of layer	=	43.000000 ft
Effective unit weight at top of layer	=	72.600000 pcf
Effective unit weight at bottom of layer	=	72.600000 pcf
Undrained cohesion at top of layer	=	8000. psf
Undrained cohesion at bottom of layer	=	8000. psf
Epsilon-50 at top of layer	=	0.004000
Epsilon-50 at bottom of layer	=	0.004000

(Depth of the lowest soil layer extends 17.000 ft below the pile tip)

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	E50 or krm
1	Stiff Clay w/o Free Water	15.0000 43.0000	72.6000 72.6000	8000. 8000.	0.00400 0.00400

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 3

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 6000. lbs	M = 960000. in-lbs	720000.	No	Yes
2	1	V = 10000. lbs	M = 120000. in-lbs	420000.	No	Yes
3	2	V = 31829. lbs	S = 0.0000 in/in	390000.	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

---

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 6000.0 lbs
Applied moment at pile head = 960000.0 in-lbs
Axial thrust load on pile head = 720000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1626	960000.	6000.	-0.00125	916.8558	3.13E+11	0.00	0.00	0.00
0.2600	0.1587	981506.	6000.	-0.00124	921.5510	3.13E+11	0.00	0.00	0.00
0.5200	0.1549	1002990.	6000.	-0.00123	926.2414	3.13E+11	0.00	0.00	0.00
0.7800	0.1511	1024452.	6000.	-0.00122	930.9269	3.13E+11	0.00	0.00	0.00
1.0400	0.1473	1045891.	6000.	-0.00121	935.6074	3.13E+11	0.00	0.00	0.00
1.3000	0.1436	1067306.	6000.	-0.00119	940.2828	3.13E+11	0.00	0.00	0.00
1.5600	0.1398	1088698.	6000.	-0.00118	944.9530	3.13E+11	0.00	0.00	0.00
1.8200	0.1362	1110065.	6000.	-0.00117	949.6179	3.13E+11	0.00	0.00	0.00
2.0800	0.1325	1131407.	6000.	-0.00116	954.2773	3.13E+11	0.00	0.00	0.00
2.3400	0.1289	1152724.	6000.	-0.00115	958.9312	3.13E+11	0.00	0.00	0.00
2.6000	0.1253	1174015.	6000.	-0.00114	963.5795	3.13E+11	0.00	0.00	0.00
2.8600	0.1218	1195280.	6000.	-0.00113	968.2221	3.13E+11	0.00	0.00	0.00
3.1200	0.1183	1216518.	6000.	-0.00111	972.8588	3.13E+11	0.00	0.00	0.00
3.3800	0.1149	1237729.	6000.	-0.00110	977.4895	3.13E+11	0.00	0.00	0.00

3.6400	0.1114	1258913.	6000.	-0.00109	982.1143	3.13E+11	0.00	0.00	0.00
3.9000	0.1080	1280068.	6000.	-0.00108	986.7329	3.13E+11	0.00	0.00	0.00
4.1600	0.1047	1301194.	6000.	-0.00106	991.3452	3.13E+11	0.00	0.00	0.00
4.4200	0.1014	1322292.	6000.	-0.00105	995.9512	3.13E+11	0.00	0.00	0.00
4.6800	0.09814	1343360.	6000.	-0.00104	1001.	3.13E+11	0.00	0.00	0.00
4.9400	0.09493	1364397.	6000.	-0.00102	1005.	3.13E+11	0.00	0.00	0.00
5.2000	0.09175	1385405.	6000.	-0.00101	1010.	3.13E+11	0.00	0.00	0.00
5.4600	0.08862	1406381.	6000.	-9.97E-04	1014.	3.13E+11	0.00	0.00	0.00
5.7200	0.08553	1427326.	6000.	-9.83E-04	1019.	3.13E+11	0.00	0.00	0.00
5.9800	0.08248	1448239.	6000.	-9.69E-04	1023.	3.13E+11	0.00	0.00	0.00
6.2400	0.07948	1469119.	6000.	-9.54E-04	1028.	3.13E+11	0.00	0.00	0.00
6.5000	0.07652	1489967.	6000.	-9.40E-04	1033.	3.13E+11	0.00	0.00	0.00
6.7600	0.07362	1510781.	6000.	-9.25E-04	1037.	3.13E+11	0.00	0.00	0.00
7.0200	0.07075	1531562.	6000.	-9.10E-04	1042.	3.13E+11	0.00	0.00	0.00
7.2800	0.06794	1552308.	6000.	-8.94E-04	1046.	3.13E+11	0.00	0.00	0.00
7.5400	0.06517	1573019.	6000.	-8.79E-04	1051.	3.13E+11	0.00	0.00	0.00
7.8000	0.06246	1593696.	6000.	-8.63E-04	1055.	3.13E+11	0.00	0.00	0.00
8.0600	0.05979	1614336.	6000.	-8.47E-04	1060.	3.13E+11	0.00	0.00	0.00
8.3200	0.05717	1634941.	6000.	-8.31E-04	1064.	3.13E+11	0.00	0.00	0.00
8.5800	0.05460	1655509.	6000.	-8.14E-04	1069.	3.13E+11	0.00	0.00	0.00
8.8400	0.05209	1676040.	6000.	-7.98E-04	1073.	3.13E+11	0.00	0.00	0.00
9.1000	0.04963	1696533.	6000.	-7.81E-04	1078.	3.13E+11	0.00	0.00	0.00
9.3600	0.04722	1716989.	6000.	-7.64E-04	1082.	3.13E+11	0.00	0.00	0.00
9.6200	0.04486	1737406.	6000.	-7.47E-04	1087.	3.13E+11	0.00	0.00	0.00
9.8800	0.04256	1757784.	6000.	-7.29E-04	1091.	3.13E+11	0.00	0.00	0.00
10.1400	0.04031	1778123.	6000.	-7.12E-04	1095.	3.13E+11	0.00	0.00	0.00
10.4000	0.03811	1798422.	6000.	-6.94E-04	1100.	3.13E+11	0.00	0.00	0.00
10.6600	0.03598	1818681.	6000.	-6.76E-04	1104.	3.13E+11	0.00	0.00	0.00
10.9200	0.03390	1838899.	6000.	-6.58E-04	1109.	3.13E+11	0.00	0.00	0.00
11.1800	0.03187	1859076.	6000.	-6.39E-04	1113.	3.13E+11	0.00	0.00	0.00
11.4400	0.02991	1879211.	6000.	-6.21E-04	1118.	3.13E+11	0.00	0.00	0.00
11.7000	0.02800	1899305.	6000.	-6.02E-04	1122.	3.13E+11	0.00	0.00	0.00
11.9600	0.02615	1919356.	6000.	-5.83E-04	1126.	3.13E+11	0.00	0.00	0.00
12.2200	0.02436	1939364.	6000.	-5.64E-04	1131.	3.13E+11	0.00	0.00	0.00
12.4800	0.02263	1959328.	6000.	-5.44E-04	1135.	3.13E+11	0.00	0.00	0.00
12.7400	0.02096	1979249.	6000.	-5.25E-04	1139.	3.13E+11	0.00	0.00	0.00
13.0000	0.01936	1999126.	6000.	-5.05E-04	1144.	3.13E+11	0.00	0.00	0.00
13.2600	0.01781	2018957.	6000.	-4.85E-04	1148.	3.13E+11	0.00	0.00	0.00
13.5200	0.01633	2038744.	6000.	-4.65E-04	1152.	3.13E+11	0.00	0.00	0.00
13.7800	0.01492	2058485.	6000.	-4.44E-04	1157.	3.13E+11	0.00	0.00	0.00
14.0400	0.01356	2078180.	6000.	-4.24E-04	1161.	3.13E+11	0.00	0.00	0.00
14.3000	0.01227	2097828.	6000.	-4.03E-04	1165.	3.13E+11	0.00	0.00	0.00
14.5600	0.01105	2117430.	6000.	-3.82E-04	1170.	3.13E+11	0.00	0.00	0.00
14.8200	0.00989	2136984.	6000.	-3.61E-04	1174.	3.13E+11	0.00	0.00	0.00
15.0800	0.00880	2156490.	4141.	-3.39E-04	1178.	3.13E+11	-1192.	422722.	0.00
15.3400	0.00777	2164347.	451.7464	-3.18E-04	1180.	3.13E+11	-1173.	470928.	0.00
15.6000	0.00681	2160737.	-3175.	-2.96E-04	1179.	3.13E+11	-1152.	527528.	0.00
15.8600	0.00592	2145865.	-6733.	-2.75E-04	1176.	3.13E+11	-1129.	594610.	0.00
16.1200	0.00510	2119958.	-10215.	-2.54E-04	1170.	3.13E+11	-1103.	674986.	0.00
16.3800	0.00434	2083266.	-13612.	-2.33E-04	1162.	3.13E+11	-1075.	772524.	0.00
16.6400	0.00365	2036066.	-16916.	-2.12E-04	1152.	3.13E+11	-1043.	892703.	0.00
16.9000	0.00302	1978665.	-20117.	-1.92E-04	1139.	3.13E+11	-1009.	1043556.	0.00
17.1600	0.00245	1911398.	-23205.	-1.73E-04	1125.	3.13E+11	-970.6875	1237370.	0.00
17.4200	0.00194	1834640.	-26167.	-1.54E-04	1108.	3.13E+11	-928.0946	1494013.	0.00
17.6800	0.00149	1748806.	-28988.	-1.36E-04	1089.	3.13E+11	-880.0552	1848030.	0.00
17.9400	0.00109	1654366.	-31648.	-1.19E-04	1068.	3.13E+11	-824.8280	2365904.	0.00
18.2000	7.41E-04	1551860.	-34119.	-1.03E-04	1046.	3.13E+11	-759.2050	3196319.	0.00
18.4600	4.43E-04	1441929.	-36035.	-8.85E-05	1022.	3.13E+11	-469.0853	3306390.	0.00
18.7200	1.89E-04	1327399.	-37083.	-7.47E-05	997.0661	3.13E+11	-202.8354	3348262.	0.00
18.9800	-2.34E-05	1210865.	-37360.	-6.20E-05	971.6245	3.13E+11	25.4088	3390135.	0.00
19.2400	-1.98E-04	1094551.	-36980.	-5.06E-05	946.2309	3.13E+11	217.9697	3432007.	0.00
19.5000	-3.39E-04	980335.	-36052.	-4.02E-05	921.2953	3.13E+11	377.3563	3473880.	0.00
19.7600	-4.49E-04	869770.	-34673.	-3.10E-05	897.1568	3.13E+11	506.1983	3515752.	0.00
20.0200	-5.32E-04	764113.	-32936.	-2.29E-05	874.0899	3.13E+11	607.1864	3557624.	0.00
20.2800	-5.92E-04	664350.	-30924.	-1.58E-05	852.3096	3.13E+11	683.0199	3599497.	0.00
20.5400	-6.31E-04	571220.	-28709.	-9.62E-06	831.9776	3.13E+11	736.3606	3641369.	0.00
20.8000	-6.52E-04	485246.	-26360.	-4.36E-06	813.2078	3.13E+11	769.7934	3683242.	0.00
21.0600	-6.58E-04	406754.	-23933.	7.95E-08	796.0715	3.13E+11	785.7929	3725114.	0.00
21.3200	-6.52E-04	335903.	-21480.	3.78E-06	780.6033	3.13E+11	786.6968	3766986.	0.00

21.5800	-6.35E-04	272702.	-19044.	6.81E-06	766.8053	3.13E+11	774.6834	3808859.	0.00
21.8400	-6.09E-04	217036.	-16663.	9.25E-06	754.6523	3.13E+11	751.7564	3850731.	0.00
22.1000	-5.77E-04	168683.	-14368.	1.12E-05	744.0959	3.13E+11	719.7322	3892603.	0.00
22.3600	-5.39E-04	127333.	-12184.	1.26E-05	735.0683	3.13E+11	680.2340	3934476.	0.00
22.6200	-4.98E-04	92601.	-10132.	1.37E-05	727.4857	3.13E+11	634.6882	3976348.	0.00
22.8800	-4.54E-04	64045.	-8231.	1.45E-05	721.2515	3.13E+11	584.3253	4018221.	0.00
23.1400	-4.07E-04	41176.	-6492.	1.50E-05	716.2588	3.13E+11	530.1839	4060093.	0.00
23.4000	-3.60E-04	23468.	-4927.	1.54E-05	712.3926	3.13E+11	473.1182	4101965.	0.00
23.6600	-3.12E-04	10364.	-3543.	1.55E-05	709.5318	3.13E+11	413.8074	4143838.	0.00
23.9200	-2.63E-04	1288.	-2347.	1.56E-05	707.5504	3.13E+11	352.7684	4185710.	0.00
24.1800	-2.14E-04	-4354.	-1344.	1.56E-05	708.2197	3.13E+11	290.3702	4227583.	0.00
24.4400	-1.66E-04	-7169.	-537.2200	1.55E-05	708.8343	3.13E+11	226.8512	4269455.	0.00
24.7000	-1.17E-04	-7776.	69.9147	1.54E-05	708.9668	3.13E+11	162.3377	4311327.	0.00
24.9600	-6.94E-05	-6802.	474.2707	1.54E-05	708.7542	3.13E+11	96.8649	4353200.	0.00
25.2200	-2.16E-05	-4885.	672.8039	1.53E-05	708.3357	3.13E+11	30.3999	4395072.	0.00
25.4800	2.61E-05	-2673.	662.2997	1.53E-05	707.8526	3.13E+11	-37.1333	4436944.	0.00
25.7400	7.37E-05	-821.2119	439.2807	1.53E-05	707.4484	3.13E+11	-105.8275	4478817.	0.00
26.0000	1.21E-04	0.00	0.00	1.53E-05	707.2692	3.13E+11	-175.7627	2260345.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

Pile-head deflection = 0.16258869 inches
Computed slope at pile head = -0.00124503 radians
Maximum bending moment = 2164347. inch-lbs
Maximum shear force = -37360. lbs
Depth of maximum bending moment = 15.34000000 feet below pile head
Depth of maximum shear force = 18.98000000 feet below pile head
Number of iterations = 13
Number of zero deflection points = 2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 10000.0 lbs
Applied moment at pile head = 120000.0 in-lbs
Axial thrust load on pile head = 420000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1401	120000.	10000.	-9.40E-04	438.7720	3.13E+11	0.00	0.00	0.00
0.2600	0.1372	152431.	10000.	-9.39E-04	445.8524	3.13E+11	0.00	0.00	0.00
0.5200	0.1343	184861.	10000.	-9.37E-04	452.9324	3.13E+11	0.00	0.00	0.00
0.7800	0.1313	217288.	10000.	-9.35E-04	460.0119	3.13E+11	0.00	0.00	0.00
1.0400	0.1284	249712.	10000.	-9.33E-04	467.0907	3.13E+11	0.00	0.00	0.00
1.3000	0.1255	282133.	10000.	-9.30E-04	474.1688	3.13E+11	0.00	0.00	0.00
1.5600	0.1226	314550.	10000.	-9.27E-04	481.2462	3.13E+11	0.00	0.00	0.00
1.8200	0.1197	346964.	10000.	-9.24E-04	488.3226	3.13E+11	0.00	0.00	0.00
2.0800	0.1169	379372.	10000.	-9.20E-04	495.3980	3.13E+11	0.00	0.00	0.00
2.3400	0.1140	411776.	10000.	-9.17E-04	502.4724	3.13E+11	0.00	0.00	0.00
2.6000	0.1111	444174.	10000.	-9.12E-04	509.5456	3.13E+11	0.00	0.00	0.00
2.8600	0.1083	476567.	10000.	-9.08E-04	516.6175	3.13E+11	0.00	0.00	0.00
3.1200	0.1055	508953.	10000.	-9.03E-04	523.6880	3.13E+11	0.00	0.00	0.00
3.3800	0.1027	541333.	10000.	-8.98E-04	530.7571	3.13E+11	0.00	0.00	0.00
3.6400	0.09987	573705.	10000.	-8.92E-04	537.8247	3.13E+11	0.00	0.00	0.00
3.9000	0.09709	606071.	10000.	-8.86E-04	544.8906	3.13E+11	0.00	0.00	0.00
4.1600	0.09434	638428.	10000.	-8.80E-04	551.9549	3.13E+11	0.00	0.00	0.00
4.4200	0.09160	670777.	10000.	-8.73E-04	559.0172	3.13E+11	0.00	0.00	0.00
4.6800	0.08889	703117.	10000.	-8.67E-04	566.0777	3.13E+11	0.00	0.00	0.00

4.9400	0.08620	735448.	10000.	-8.59E-04	573.1362	3.13E+11	0.00	0.00	0.00
5.2000	0.08353	767769.	10000.	-8.52E-04	580.1926	3.13E+11	0.00	0.00	0.00
5.4600	0.08088	800080.	10000.	-8.44E-04	587.2468	3.13E+11	0.00	0.00	0.00
5.7200	0.07826	832381.	10000.	-8.36E-04	594.2987	3.13E+11	0.00	0.00	0.00
5.9800	0.07566	864671.	10000.	-8.28E-04	601.3482	3.13E+11	0.00	0.00	0.00
6.2400	0.07309	896950.	10000.	-8.19E-04	608.3953	3.13E+11	0.00	0.00	0.00
6.5000	0.07055	929217.	10000.	-8.10E-04	615.4398	3.13E+11	0.00	0.00	0.00
6.7600	0.06804	961472.	10000.	-8.00E-04	622.4817	3.13E+11	0.00	0.00	0.00
7.0200	0.06556	993714.	10000.	-7.91E-04	629.5208	3.13E+11	0.00	0.00	0.00
7.2800	0.06311	1025944.	10000.	-7.80E-04	636.5571	3.13E+11	0.00	0.00	0.00
7.5400	0.06069	1058160.	10000.	-7.70E-04	643.5905	3.13E+11	0.00	0.00	0.00
7.8000	0.05830	1090362.	10000.	-7.59E-04	650.6209	3.13E+11	0.00	0.00	0.00
8.0600	0.05595	1122550.	10000.	-7.48E-04	657.6481	3.13E+11	0.00	0.00	0.00
8.3200	0.05363	1154723.	10000.	-7.37E-04	664.6722	3.13E+11	0.00	0.00	0.00
8.5800	0.05135	1186882.	10000.	-7.25E-04	671.6930	3.13E+11	0.00	0.00	0.00
8.8400	0.04911	1219024.	10000.	-7.13E-04	678.7104	3.13E+11	0.00	0.00	0.00
9.1000	0.04690	1251151.	10000.	-7.01E-04	685.7243	3.13E+11	0.00	0.00	0.00
9.3600	0.04473	1283262.	10000.	-6.88E-04	692.7346	3.13E+11	0.00	0.00	0.00
9.6200	0.04261	1315356.	10000.	-6.76E-04	699.7413	3.13E+11	0.00	0.00	0.00
9.8800	0.04052	1347432.	10000.	-6.62E-04	706.7443	3.13E+11	0.00	0.00	0.00
10.1400	0.03847	1379491.	10000.	-6.49E-04	713.7434	3.13E+11	0.00	0.00	0.00
10.4000	0.03647	1411532.	10000.	-6.35E-04	720.7386	3.13E+11	0.00	0.00	0.00
10.6600	0.03451	1443555.	10000.	-6.21E-04	727.7298	3.13E+11	0.00	0.00	0.00
10.9200	0.03260	1475559.	10000.	-6.06E-04	734.7168	3.13E+11	0.00	0.00	0.00
11.1800	0.03073	1507543.	10000.	-5.91E-04	741.6996	3.13E+11	0.00	0.00	0.00
11.4400	0.02891	1539508.	10000.	-5.76E-04	748.6782	3.13E+11	0.00	0.00	0.00
11.7000	0.02714	1571453.	10000.	-5.61E-04	755.6524	3.13E+11	0.00	0.00	0.00
11.9600	0.02541	1603377.	10000.	-5.45E-04	762.6220	3.13E+11	0.00	0.00	0.00
12.2200	0.02374	1635280.	10000.	-5.29E-04	769.5872	3.13E+11	0.00	0.00	0.00
12.4800	0.02211	1667162.	10000.	-5.12E-04	776.5476	3.13E+11	0.00	0.00	0.00
12.7400	0.02054	1699023.	10000.	-4.95E-04	783.5033	3.13E+11	0.00	0.00	0.00
13.0000	0.01902	1730861.	10000.	-4.78E-04	790.4542	3.13E+11	0.00	0.00	0.00
13.2600	0.01756	1762676.	10000.	-4.61E-04	797.4001	3.13E+11	0.00	0.00	0.00
13.5200	0.01615	1794469.	10000.	-4.43E-04	804.3411	3.13E+11	0.00	0.00	0.00
13.7800	0.01479	1826238.	10000.	-4.25E-04	811.2769	3.13E+11	0.00	0.00	0.00
14.0400	0.01349	1857983.	10000.	-4.07E-04	818.2075	3.13E+11	0.00	0.00	0.00
14.3000	0.01225	1889704.	10000.	-3.88E-04	825.1328	3.13E+11	0.00	0.00	0.00
14.5600	0.01107	1921400.	10000.	-3.69E-04	832.0527	3.13E+11	0.00	0.00	0.00
14.8200	0.00995	1953072.	10000.	-3.50E-04	838.9671	3.13E+11	0.00	0.00	0.00
15.0800	0.00889	1984717.	8136.	-3.30E-04	845.8760	3.13E+11	-1195.	419492.	0.00
15.3400	0.00789	2004706.	4435.	-3.10E-04	850.2399	3.13E+11	-1177.	465727.	0.00
15.6000	0.00695	2013207.	792.5091	-2.90E-04	852.0959	3.13E+11	-1158.	519739.	0.00
15.8600	0.00608	2010412.	-2786.	-2.70E-04	851.4857	3.13E+11	-1136.	583384.	0.00
16.1200	0.00526	1996533.	-6292.	-2.50E-04	848.4557	3.13E+11	-1112.	659129.	0.00
16.3800	0.00451	1971806.	-9719.	-2.31E-04	843.0571	3.13E+11	-1085.	750317.	0.00
16.6400	0.00382	1936489.	-13059.	-2.11E-04	835.3468	3.13E+11	-1056.	861600.	0.00
16.9000	0.00319	1890869.	-16303.	-1.92E-04	825.3871	3.13E+11	-1023.	999648.	0.00
17.1600	0.00262	1835261.	-19441.	-1.74E-04	813.2469	3.13E+11	-987.7770	1174387.	0.00
17.4200	0.00211	1770014.	-22461.	-1.56E-04	799.0022	3.13E+11	-948.1628	1401301.	0.00
17.6800	0.00165	1695514.	-25350.	-1.38E-04	782.7374	3.13E+11	-903.8499	1706060.	0.00
17.9400	0.00125	1612194.	-28091.	-1.22E-04	764.5469	3.13E+11	-853.5883	2134879.	0.00
18.2000	8.92E-04	1520543.	-30664.	-1.06E-04	744.5378	3.13E+11	-795.2330	2781248.	0.00
18.4600	5.84E-04	1421132.	-32870.	-9.17E-05	722.8343	3.13E+11	-618.8431	3306390.	0.00
18.7200	3.20E-04	1315678.	-34371.	-7.81E-05	699.8116	3.13E+11	-343.3882	3348262.	0.00
18.9800	9.69E-05	1206863.	-35071.	-6.55E-05	676.0554	3.13E+11	-105.2655	3390135.	0.00
19.2400	-8.87E-05	1097009.	-35083.	-5.40E-05	652.0720	3.13E+11	97.5979	3432007.	0.00
19.5000	-2.40E-04	988090.	-34513.	-4.36E-05	628.2930	3.13E+11	267.4929	3473880.	0.00
19.7600	-3.61E-04	881762.	-33461.	-3.43E-05	605.0796	3.13E+11	406.8603	3515752.	0.00
20.0200	-4.54E-04	779384.	-32018.	-2.61E-05	582.7283	3.13E+11	518.2313	3557624.	0.00
20.2800	-5.24E-04	682040.	-30267.	-1.88E-05	561.4762	3.13E+11	604.1726	3599497.	0.00
20.5400	-5.72E-04	590568.	-28283.	-1.24E-05	541.5061	3.13E+11	667.2392	3641369.	0.00
20.8000	-6.01E-04	505583.	-26135.	-6.99E-06	522.9523	3.13E+11	709.9329	3683242.	0.00
21.0600	-6.15E-04	427503.	-23882.	-2.34E-06	505.9059	3.13E+11	734.6676	3725114.	0.00
21.3200	-6.16E-04	356569.	-21575.	1.56E-06	490.4196	3.13E+11	743.7398	3766986.	0.00
21.5800	-6.06E-04	292870.	-19262.	4.79E-06	476.5128	3.13E+11	739.3055	3808859.	0.00
21.8400	-5.86E-04	236364.	-16980.	7.43E-06	464.1764	3.13E+11	723.3611	3850731.	0.00
22.1000	-5.59E-04	186896.	-14763.	9.54E-06	453.3766	3.13E+11	697.7308	3892603.	0.00
22.3600	-5.27E-04	144218.	-12639.	1.12E-05	444.0592	3.13E+11	664.0570	3934476.	0.00
22.6200	-4.89E-04	108002.	-10630.	1.24E-05	436.1525	3.13E+11	623.7961	3976348.	0.00

22.8800	-4.49E-04	77857.	-8754.	1.34E-05	429.5713	3.13E+11	578.2166	4018221.	0.00
23.1400	-4.06E-04	53339.	-7028.	1.40E-05	424.2186	3.13E+11	528.4024	4060093.	0.00
23.4000	-3.61E-04	33965.	-5462.	1.45E-05	419.9888	3.13E+11	475.2576	4101965.	0.00
23.6600	-3.16E-04	19216.	-4067.	1.47E-05	416.7689	3.13E+11	419.5149	4143838.	0.00
23.9200	-2.70E-04	8551.	-2848.	1.49E-05	414.4405	3.13E+11	361.7467	4185710.	0.00
24.1800	-2.23E-04	1407.	-1812.	1.49E-05	412.8809	3.13E+11	302.3779	4227583.	0.00
24.4400	-1.77E-04	-2793.	-962.9574	1.49E-05	413.1835	3.13E+11	241.7015	4269455.	0.00
24.7000	-1.30E-04	-4641.	-305.2650	1.49E-05	413.5869	3.13E+11	179.8962	4311327.	0.00
24.9600	-8.39E-05	-4737.	157.9639	1.48E-05	413.6079	3.13E+11	117.0454	4353200.	0.00
25.2200	-3.77E-05	-3694.	423.4834	1.48E-05	413.3801	3.13E+11	53.1593	4395072.	0.00
25.4800	8.30E-06	-2133.	488.0004	1.47E-05	413.0394	3.13E+11	-11.8023	4436944.	0.00
25.7400	5.43E-05	-687.4655	348.0579	1.47E-05	412.7238	3.13E+11	-77.9045	4478817.	0.00
26.0000	1.00E-04	0.00	0.00	1.47E-05	412.5737	3.13E+11	-145.2096	2260345.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 2:

Pile-head deflection = 0.14011880 inches
Computed slope at pile head = -0.00094036 radians
Maximum bending moment = 2013207. inch-lbs
Maximum shear force = -35083. lbs
Depth of maximum bending moment = 15.60000000 feet below pile head
Depth of maximum shear force = 19.24000000 feet below pile head
Number of iterations = 13
Number of zero deflection points = 2

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

Pile-head conditions are Shear and Pile-head Rotation (Loading Type 2)

Shear force at pile head = 31829.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 390000.0 lbs

(Zero slope for this load indicates fixed-head conditions)

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness in-lb^2	Soil Res. p lb/inch	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1130	-3756853.	31829.	0.00	1203.	3.13E+11	0.00	0.00	0.00
0.2600	0.1129	-3657523.	31829.	-3.69E-05	1182.	3.13E+11	0.00	0.00	0.00
0.5200	0.1127	-3558150.	31829.	-7.28E-05	1160.	3.13E+11	0.00	0.00	0.00
0.7800	0.1124	-3458733.	31829.	-1.08E-04	1138.	3.13E+11	0.00	0.00	0.00
1.0400	0.1121	-3359275.	31829.	-1.42E-04	1116.	3.13E+11	0.00	0.00	0.00
1.3000	0.1116	-3259775.	31829.	-1.75E-04	1095.	3.13E+11	0.00	0.00	0.00
1.5600	0.1110	-3160237.	31829.	-2.07E-04	1073.	3.13E+11	0.00	0.00	0.00
1.8200	0.1103	-3060659.	31829.	-2.38E-04	1051.	3.13E+11	0.00	0.00	0.00
2.0800	0.1095	-2961045.	31829.	-2.68E-04	1030.	3.13E+11	0.00	0.00	0.00
2.3400	0.1086	-2861395.	31829.	-2.97E-04	1008.	3.13E+11	0.00	0.00	0.00
2.6000	0.1076	-2761711.	31829.	-3.25E-04	986.0392	3.13E+11	0.00	0.00	0.00
2.8600	0.1066	-2661992.	31829.	-3.52E-04	964.2688	3.13E+11	0.00	0.00	0.00
3.1200	0.1054	-2562242.	31829.	-3.78E-04	942.4913	3.13E+11	0.00	0.00	0.00
3.3800	0.1042	-2462460.	31829.	-4.03E-04	920.7071	3.13E+11	0.00	0.00	0.00
3.6400	0.1029	-2362649.	31829.	-4.27E-04	898.9163	3.13E+11	0.00	0.00	0.00
3.9000	0.1016	-2262809.	31829.	-4.50E-04	877.1193	3.13E+11	0.00	0.00	0.00
4.1600	0.1001	-2162942.	31829.	-4.72E-04	855.3163	3.13E+11	0.00	0.00	0.00
4.4200	0.09861	-2063048.	31829.	-4.93E-04	833.5076	3.13E+11	0.00	0.00	0.00
4.6800	0.09704	-1963130.	31829.	-5.13E-04	811.6934	3.13E+11	0.00	0.00	0.00
4.9400	0.09541	-1863187.	31829.	-5.32E-04	789.8741	3.13E+11	0.00	0.00	0.00
5.2000	0.09372	-1763222.	31829.	-5.50E-04	768.0498	3.13E+11	0.00	0.00	0.00
5.4600	0.09198	-1663236.	31829.	-5.67E-04	746.2208	3.13E+11	0.00	0.00	0.00

5.7200	0.09018	-1563229.	31829.	-5.83E-04	724.3875	3.13E+11	0.00	0.00	0.00
5.9800	0.08834	-1463204.	31829.	-5.98E-04	702.5500	3.13E+11	0.00	0.00	0.00
6.2400	0.08645	-1363161.	31829.	-6.12E-04	680.7086	3.13E+11	0.00	0.00	0.00
6.5000	0.08452	-1263101.	31829.	-6.25E-04	658.8636	3.13E+11	0.00	0.00	0.00
6.7600	0.08255	-1163026.	31829.	-6.37E-04	637.0153	3.13E+11	0.00	0.00	0.00
7.0200	0.08054	-1062937.	31829.	-6.48E-04	615.1639	3.13E+11	0.00	0.00	0.00
7.2800	0.07850	-962835.	31829.	-6.59E-04	593.3097	3.13E+11	0.00	0.00	0.00
7.5400	0.07643	-862722.	31829.	-6.68E-04	571.4530	3.13E+11	0.00	0.00	0.00
7.8000	0.07434	-762597.	31829.	-6.76E-04	549.5940	3.13E+11	0.00	0.00	0.00
8.0600	0.07222	-662464.	31829.	-6.83E-04	527.7329	3.13E+11	0.00	0.00	0.00
8.3200	0.07008	-562323.	31829.	-6.89E-04	505.8701	3.13E+11	0.00	0.00	0.00
8.5800	0.06792	-462175.	31829.	-6.94E-04	484.0058	3.13E+11	0.00	0.00	0.00
8.8400	0.06574	-362021.	31829.	-6.98E-04	462.1403	3.13E+11	0.00	0.00	0.00
9.1000	0.06356	-261863.	31829.	-7.01E-04	440.2739	3.13E+11	0.00	0.00	0.00
9.3600	0.06137	-161701.	31829.	-7.03E-04	418.4067	3.13E+11	0.00	0.00	0.00
9.6200	0.05917	-61538.	31829.	-7.04E-04	396.5391	3.13E+11	0.00	0.00	0.00
9.8800	0.05697	38626.	31829.	-7.05E-04	391.5369	3.13E+11	0.00	0.00	0.00
10.1400	0.05478	138789.	31829.	-7.04E-04	413.4045	3.13E+11	0.00	0.00	0.00
10.4000	0.05258	238951.	31829.	-7.02E-04	435.2718	3.13E+11	0.00	0.00	0.00
10.6600	0.05040	339110.	31829.	-6.99E-04	457.1385	3.13E+11	0.00	0.00	0.00
10.9200	0.04822	439265.	31829.	-6.95E-04	479.0042	3.13E+11	0.00	0.00	0.00
11.1800	0.04606	539415.	31829.	-6.90E-04	500.8688	3.13E+11	0.00	0.00	0.00
11.4400	0.04391	639558.	31829.	-6.84E-04	522.7320	3.13E+11	0.00	0.00	0.00
11.7000	0.04179	739693.	31829.	-6.77E-04	544.5934	3.13E+11	0.00	0.00	0.00
11.9600	0.03969	839819.	31829.	-6.70E-04	566.4530	3.13E+11	0.00	0.00	0.00
12.2200	0.03761	939935.	31829.	-6.61E-04	588.3102	3.13E+11	0.00	0.00	0.00
12.4800	0.03556	1040040.	31829.	-6.51E-04	610.1651	3.13E+11	0.00	0.00	0.00
12.7400	0.03355	1140132.	31829.	-6.40E-04	632.0171	3.13E+11	0.00	0.00	0.00
13.0000	0.03157	1240210.	31829.	-6.28E-04	653.8661	3.13E+11	0.00	0.00	0.00
13.2600	0.02963	1340274.	31829.	-6.15E-04	675.7119	3.13E+11	0.00	0.00	0.00
13.5200	0.02773	1440321.	31829.	-6.01E-04	697.5541	3.13E+11	0.00	0.00	0.00
13.7800	0.02588	1540350.	31829.	-5.87E-04	719.3925	3.13E+11	0.00	0.00	0.00
14.0400	0.02407	1640361.	31829.	-5.71E-04	741.2268	3.13E+11	0.00	0.00	0.00
14.3000	0.02232	1740352.	31829.	-5.54E-04	763.0568	3.13E+11	0.00	0.00	0.00
14.5600	0.02062	1840322.	31829.	-5.36E-04	784.8822	3.13E+11	0.00	0.00	0.00
14.8200	0.01897	1940270.	31829.	-5.17E-04	806.7027	3.13E+11	0.00	0.00	0.00
15.0800	0.01739	2040194.	29624.	-4.97E-04	828.5181	3.13E+11	-1413.	253590.	0.00
15.3400	0.01587	2126336.	25232.	-4.77E-04	847.3247	3.13E+11	-1402.	275725.	0.00
15.6000	0.01441	2198803.	20877.	-4.55E-04	863.1456	3.13E+11	-1389.	300767.	0.00
15.8600	0.01303	2257719.	16565.	-4.33E-04	876.0080	3.13E+11	-1375.	329239.	0.00
16.1200	0.01171	2303226.	12303.	-4.10E-04	885.9431	3.13E+11	-1358.	361787.	0.00
16.3800	0.01047	2335486.	8095.	-3.87E-04	892.9860	3.13E+11	-1339.	399218.	0.00
16.6400	0.00929	2354680.	3949.	-3.64E-04	897.1766	3.13E+11	-1318.	442553.	0.00
16.9000	0.00820	2361013.	-128.6257	-3.40E-04	898.5590	3.13E+11	-1295.	493099.	0.00
17.1600	0.00717	2354706.	-4131.	-3.17E-04	897.1822	3.13E+11	-1270.	552559.	0.00
17.4200	0.00622	2336008.	-8050.	-2.94E-04	893.1001	3.13E+11	-1242.	623183.	0.00
17.6800	0.00534	2305189.	-11878.	-2.70E-04	886.3718	3.13E+11	-1212.	708015.	0.00
17.9400	0.00453	2262547.	-15607.	-2.48E-04	877.0622	3.13E+11	-1178.	811270.	0.00
18.2000	0.00379	2208407.	-19226.	-2.25E-04	865.2422	3.13E+11	-1142.	938952.	0.00
18.4600	0.00313	2143123.	-22727.	-2.04E-04	850.9896	3.13E+11	-1102.	1099938.	0.00
18.7200	0.00252	2067088.	-26096.	-1.83E-04	834.3895	3.13E+11	-1058.	1307942.	0.00
18.9800	0.00199	1980730.	-29320.	-1.63E-04	815.5360	3.13E+11	-1009.	1585431.	0.00
19.2400	0.00151	1884529.	-32381.	-1.43E-04	794.5335	3.13E+11	-953.5923	1972173.	0.00
19.5000	0.00109	1779023.	-35257.	-1.25E-04	771.4994	3.13E+11	-890.1870	2546657.	0.00
19.7600	7.28E-04	1664829.	-37917.	-1.08E-04	746.5687	3.13E+11	-814.5504	3491503.	0.00
20.0200	4.17E-04	1542687.	-39929.	-9.20E-05	719.9026	3.13E+11	-475.3628	3557624.	0.00
20.2800	1.54E-04	1415898.	-40947.	-7.73E-05	692.2221	3.13E+11	-177.4686	3599497.	0.00
20.5400	-6.52E-05	1287364.	-41105.	-6.38E-05	664.1608	3.13E+11	76.1427	3641369.	0.00
20.8000	-2.44E-04	1159556.	-40537.	-5.16E-05	636.2578	3.13E+11	288.4145	3683242.	0.00
21.0600	-3.87E-04	1034542.	-39365.	-4.07E-05	608.9647	3.13E+11	462.4775	3725114.	0.00
21.3200	-4.98E-04	914017.	-37705.	-3.10E-05	582.6518	3.13E+11	601.5708	3766986.	0.00
21.5800	-5.81E-04	799337.	-35661.	-2.25E-05	557.6148	3.13E+11	708.9719	3808859.	0.00
21.8400	-6.38E-04	691548.	-33326.	-1.50E-05	534.0825	3.13E+11	787.9351	3850731.	0.00
22.1000	-6.75E-04	591421.	-30783.	-8.65E-06	512.2229	3.13E+11	841.6387	3892603.	0.00
22.3600	-6.92E-04	499480.	-28108.	-3.22E-06	492.1504	3.13E+11	873.1407	3934476.	0.00
22.6200	-6.95E-04	416033.	-25365.	1.34E-06	473.9321	3.13E+11	885.3421	3976348.	0.00
22.8800	-6.84E-04	341198.	-22610.	5.11E-06	457.5943	3.13E+11	880.9571	4018221.	0.00
23.1400	-6.63E-04	274935.	-19890.	8.18E-06	443.1278	3.13E+11	862.4910	4060093.	0.00
23.4000	-6.33E-04	217065.	-17246.	1.06E-05	430.4936	3.13E+11	832.2238	4101965.	0.00

23.6600	-5.96E-04	167293.	-14712.	1.25E-05	419.6274	3.13E+11	792.1997	4143838.	0.00
23.9200	-5.55E-04	125231.	-12315.	1.40E-05	410.4444	3.13E+11	744.2217	4185710.	0.00
24.1800	-5.09E-04	90411.	-10078.	1.51E-05	402.8427	3.13E+11	689.8514	4227583.	0.00
24.4400	-4.61E-04	62306.	-8019.	1.58E-05	396.7068	3.13E+11	630.4126	4269455.	0.00
24.7000	-4.10E-04	40337.	-6151.	1.63E-05	391.9105	3.13E+11	566.9988	4311327.	0.00
24.9600	-3.59E-04	23887.	-4485.	1.67E-05	388.3191	3.13E+11	500.4846	4353200.	0.00
25.2200	-3.06E-04	12308.	-3031.	1.68E-05	385.7912	3.13E+11	431.5393	4395072.	0.00
25.4800	-2.54E-04	4930.	-1796.	1.69E-05	384.1805	3.13E+11	360.6448	4436944.	0.00
25.7400	-2.01E-04	1063.	-783.4811	1.70E-05	383.3362	3.13E+11	288.1146	4478817.	0.00
26.0000	-1.48E-04	0.00	0.00	1.70E-05	383.1041	3.13E+11	214.1169	2260345.	0.00

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 3:

Pile-head deflection = 0.11295363 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = -3756853. inch-lbs
Maximum shear force = -41105. lbs
Depth of maximum bending moment = 0.000000 feet below pile head
Depth of maximum shear force = 20.54000000 feet below pile head
Number of iterations = 14
Number of zero deflection points = 1

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	6000.	M, in-lb	960000.	720000.	0.1626	-0.00125	-37360.	2164347.
2	V, lb	10000.	M, in-lb	120000.	420000.	0.1401	-9.40E-04	-35083.	2013207.
3	V, lb	31829.	S, rad	0.00	390000.	0.1130	0.00	-41105.	-3756853.

Maximum pile-head deflection = 0.1625886939 inches
Maximum pile-head rotation = -0.0012450280 radians = -0.071335 deg.

The analysis ended normally.

END BENT NO. 2

```
=============================================================================

                 APILE for Windows, Version 2019.9.3

                  Serial Number :  226375647

                  A Program for Analyzing the Axial Capacity
                  and Short-term Settlement of Driven Piles
                            under Axial Loading.
                (c) Copyright ENSOFT, Inc., 1987-2015
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=============================================================================

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Path to file locations      : C:\Users\puzhang\Documents\ZP\Harnett 54 (10340043)\EB\
Name of input data file     : 420054 EB2.ap9d
Name of output file         : 420054 EB2.ap9o
Name of plot output file    : 420054 EB2.ap9p

-----------------------------------------------------------------------------
                     Time and Date of Analysis
-----------------------------------------------------------------------------

          Date:  December 16, 2022     Time:  15:06:02



1
          **********************
          * INPUT INFORMATION *
          **********************



          Harnett County Bridge 54 EB2-A

          DESIGNER   : PZ

          JOB NUMBER :


          METHOD FOR UNIT LOAD TRANSFERS :

          - API RP 2A (American Petroleum Institute)
            Unfactored Unit Side Friction and Unit Side Resistance are used.



          COMPUTATION METHOD(S) FOR PILE CAPACITY :

          - FHWA (Federal Highway Administration)
          - API RP 2A (American Petroleum Institute)


          TYPE OF LOADING :
          - COMPRESSION


          PILE TYPE :

          H-Pile/Steel Pile
```

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI
- CROSS SECTION AREA = 15.50 IN2

NONCIRCULAR PILE PROPERTIES :

- TOTAL PILE LENGTH, TL = 20.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 5.50 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 48.00 IN.
- TIP AREA OF PILE = 15.50 IN2
- INCREMENT OF PILE LENGTH
  USED IN COMPUTATION = 0.50 FT.

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/FT^3	FRICTION ANGLE DEGREES	BEARING CAPACITY FACTOR
0.00	SAND	0.80*	52.60	26.00	13.60**
13.50	SAND	0.80*	52.60	26.00	13.60**
13.50	SAND	0.80*	72.60	42.00	50.00**
20.00	SAND	0.80*	72.60	42.00	50.00**

* VALUE ASSUMED BY THE PROGRAM
** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDISTURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING
  WERE SET TO BE 0.10E+08 BECAUSE THE USER DOES NOT
  PLAN TO LIMIT THE COMPUTED DATA.

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
13.50	1.000	1.000
13.50	1.000	1.000
20.00	1.000	1.000

****
* COMPUTATION RESULT *
****

****
* FED. HWY. METHOD *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
0.50	0.0	0.0	0.0
1.00	0.0	0.1	0.1
1.50	0.1	0.1	0.1
2.00	0.1	0.1	0.2
2.50	0.1	0.1	0.3
3.00	0.2	0.1	0.4
3.50	0.3	0.2	0.5
4.00	0.4	0.2	0.6
4.50	0.5	0.2	0.7
5.00	0.6	0.2	0.8
5.50	0.7	0.3	1.0
6.00	0.9	0.3	1.2
6.50	1.0	0.3	1.3
7.00	1.2	0.3	1.5
7.50	1.3	0.4	1.7
8.00	1.5	0.4	1.9
8.50	1.7	0.4	2.1
9.00	1.9	0.4	2.4
9.50	2.2	0.5	2.6
10.00	2.4	0.5	2.9
10.50	2.6	0.5	3.1
11.00	2.9	0.5	3.4
11.50	3.2	0.6	3.7
12.00	3.4	2.1	5.5
12.50	3.7	4.0	7.8
13.00	4.0	6.1	10.1
13.50	4.4	8.2	12.6
14.00	5.1	10.5	15.5
14.50	6.2	12.8	19.0

BOC = 159.5 ft

6.2/220=3%

****
* API RP-2A (2010) *
****

PILE PENETRATION FT.	TOTAL SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.0	0.0
0.50	0.0	0.1	0.1
1.00	0.0	0.1	0.1
1.50	0.1	0.1	0.2
2.00	0.1	0.2	0.3
2.50	0.2	0.2	0.4
3.00	0.3	0.2	0.5
3.50	0.4	0.3	0.7
4.00	0.5	0.3	0.8
4.50	0.7	0.3	1.0
5.00	0.8	0.4	1.2
5.50	1.0	0.4	1.4
6.00	1.2	0.5	1.6
6.50	1.4	0.5	1.9
7.00	1.6	0.5	2.1
7.50	1.8	0.6	2.4
8.00	2.1	0.6	2.7
8.50	2.3	0.7	3.0
9.00	2.6	0.7	3.3
9.50	2.9	0.7	3.6
10.00	3.2	0.8	4.0

10.50	3.6	0.8	4.4
11.00	3.9	0.8	4.8
11.50	4.3	0.9	5.2
12.00	4.7	1.2	5.9
12.50	5.0	1.7	6.7
13.00	5.5	2.1	7.6
13.50	5.9	2.6	8.5
14.00	6.6	3.1	9.6
14.50	7.5	3.6	11.1

NOTES:
- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN
  IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION
  OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

****
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *
****

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.0000E+00		
			0.0000E+00	0.0000E+00
			0.0000E+00	0.2445E-01
			0.0000E+00	0.4736E-01
			0.0000E+00	0.8709E-01
			0.0000E+00	0.1222E+00
			0.0000E+00	0.1528E+00
			0.0000E+00	0.3056E+00
			0.0000E+00	0.4584E+00
			0.0000E+00	0.7639E+00
			0.0000E+00	0.3056E+01
2	10	0.6775E+01		
			0.0000E+00	0.0000E+00
			0.2280E+00	0.2445E-01
			0.3800E+00	0.4736E-01
			0.5700E+00	0.8709E-01
			0.6840E+00	0.1222E+00
			0.7600E+00	0.1528E+00
			0.7600E+00	0.3056E+00
			0.7600E+00	0.4584E+00
			0.7600E+00	0.7639E+00
			0.7600E+00	0.3056E+01
3	10	0.1346E+02		
			0.0000E+00	0.0000E+00
			0.4529E+00	0.2445E-01
			0.7548E+00	0.4736E-01
			0.1132E+01	0.8709E-01
			0.1359E+01	0.1222E+00
			0.1510E+01	0.1528E+00
			0.1510E+01	0.3056E+00
			0.1510E+01	0.4584E+00
			0.1510E+01	0.7639E+00
			0.1510E+01	0.3056E+01
4	10	0.1350E+02		
			0.0000E+00	0.0000E+00
			0.4543E+00	0.2445E-01
			0.7572E+00	0.4736E-01
			0.1136E+01	0.8709E-01
			0.1363E+01	0.1222E+00
			0.1514E+01	0.1528E+00
			0.1514E+01	0.3056E+00
			0.1514E+01	0.4584E+00

			0.1514E+01	0.7639E+00
			0.1514E+01	0.3056E+01
5	10	0.1678E+02		
			0.0000E+00	0.0000E+00
			0.9830E+00	0.2445E-01
			0.1638E+01	0.4736E-01
			0.2458E+01	0.8709E-01
			0.2949E+01	0.1222E+00
			0.3277E+01	0.1528E+00
			0.3277E+01	0.3056E+00
			0.3277E+01	0.4584E+00
			0.3277E+01	0.7639E+00
			0.3277E+01	0.3056E+01
6	10	0.1996E+02		
			0.0000E+00	0.0000E+00
			0.9830E+00	0.2445E-01
			0.1638E+01	0.4736E-01
			0.2458E+01	0.8709E-01
			0.2949E+01	0.1222E+00
			0.3277E+01	0.1528E+00
			0.3277E+01	0.3056E+00
			0.3277E+01	0.4584E+00
			0.3277E+01	0.7639E+00
			0.3277E+01	0.3056E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.2240E+00	0.7639E-02
0.4480E+00	0.1528E-01
0.8959E+00	0.3056E-01
0.1792E+01	0.1986E+00
0.2688E+01	0.6417E+00
0.3225E+01	0.1115E+01
0.3584E+01	0.1528E+01
0.3584E+01	0.2292E+01
0.3584E+01	0.3056E+01

LOAD VERSUS SETTLEMENT CURVE

****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.9980E-02	0.1043E-03	0.2932E-02	0.1000E-03
0.9980E-01	0.1043E-02	0.2932E-01	0.1000E-02
0.4990E+00	0.5216E-02	0.1466E+00	0.5000E-02
0.9980E+00	0.1043E-01	0.2932E+00	0.1000E-01
0.1996E+01	0.2086E-01	0.5864E+00	0.2000E-01
0.3955E+01	0.5169E-01	0.9996E+00	0.5000E-01
0.5194E+01	0.8219E-01	0.1159E+01	0.8000E-01
0.5866E+01	0.1025E+00	0.1266E+01	0.1000E+00
0.7497E+01	0.2032E+00	0.1795E+01	0.2000E+00
0.8103E+01	0.5035E+00	0.2401E+01	0.5000E+00
0.8569E+01	0.8038E+00	0.2867E+01	0.8000E+00
0.8796E+01	0.1004E+01	0.3094E+01	0.1000E+01
0.9286E+01	0.2004E+01	0.3584E+01	0.2000E+01

GRLWEAP 14-[Professional version] - [420054 EB2.gwwx]

File Input Output Options View Windows Help

English | Inspector's Chart

Source: ALL ID: 1 Type: ALL Manufacturer: ALL

ID	Make	Model	Type	Ram Wt/Ecc. M.	Energy/Power	Stroke/Freq.
3	DELMAG	D 12	OED	2.75	22.605	8.22
4	DELMAG	D 15	OED	3.3	27.093	8.21
5	DELMAG	D 16-32	OED	3.52	40.198	11.42
6	DELMAG	D 22	OED	4.91	40.606	8.27
7	DELMAG	D 22-02	OED	4.85	48.5	10

Hammer Parameter

Efficiency 0.80

Pressure 1380.0 psi Fixed 100 %

Stroke 5.00 ft Stroke Incr. 0.50 ft

Pile Material

○ Concrete ◉ Steel ○ Timber

Cushion Information

	Hammer	Pile	
Area	415.000	0	in²
E. Modulus	530.0	0	ksi
Thickness	2.0	0	in
C.O.R	0.80	0.50	
Stiffness	109976.03	0	kips/in
Helmet Weight	2.700		kips

Pile Information

Length	20.00 ft		
Penetration	14.50 ft		
Inclination	0 deg	Ratio: x 1 : z 0	
Section Area	15.500 in²	Segments	Auto
E. Modulus	29000.0 ksi	S-Length	Auto.
Spec. Weight	492.000 lb/ft³	S-St. Wt	Auto.
End Bg. Area	141.890 in²	Splices	0
Perimeter	3.970 ft	Pile Type	
Pile Size	12.04 in	H Pile	

Ultimate Capacities

kips

1	220.0	6	240.0
2	80.0	7	280.0
3	120.0	8	320.0
4	160.0	9	360.0
5	200.0	10	400.0
Incr.	0		Reset

Soil Parameters

2nd Toe - No

Quake

Shaft 0.100 in Const.

Toe 0.060 in

Damping

Shaft 0.100 s/ft Const.

Toe 0.150 s/ft Smith

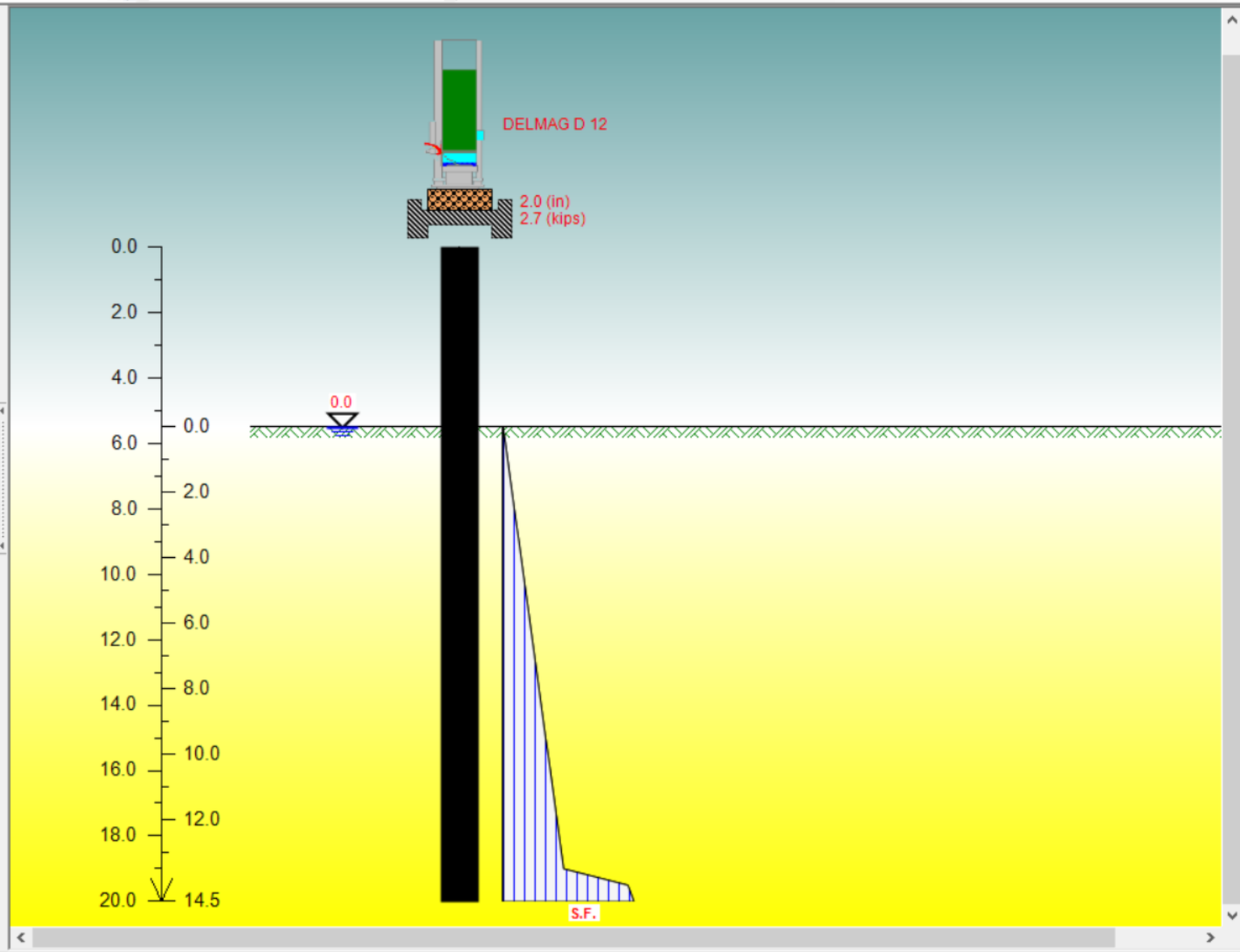
Shaft Resistance

Percentage 3 %

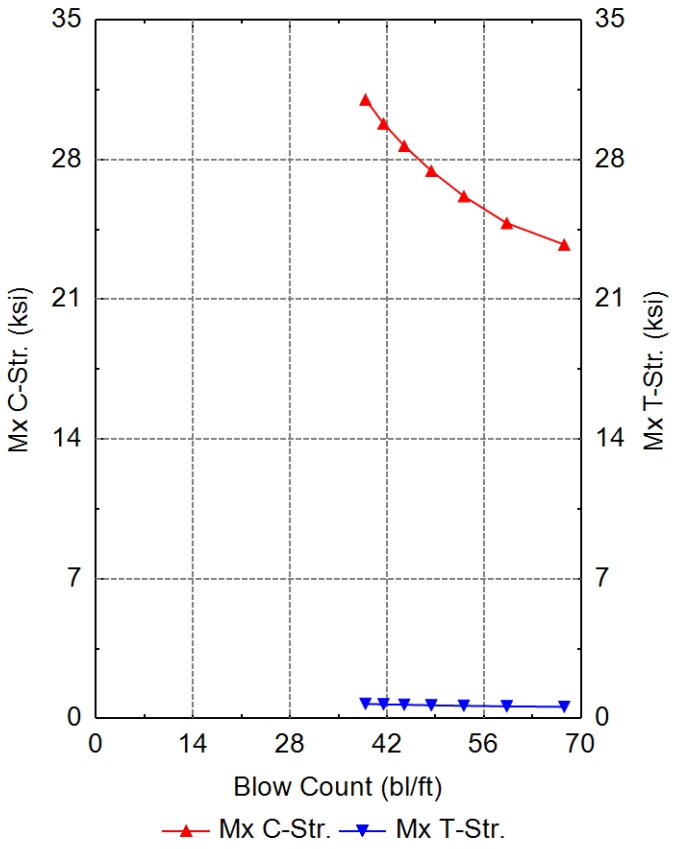
Residual Stress Analysis No

Two Pile Model - Off

Fix Stroke and Pressure

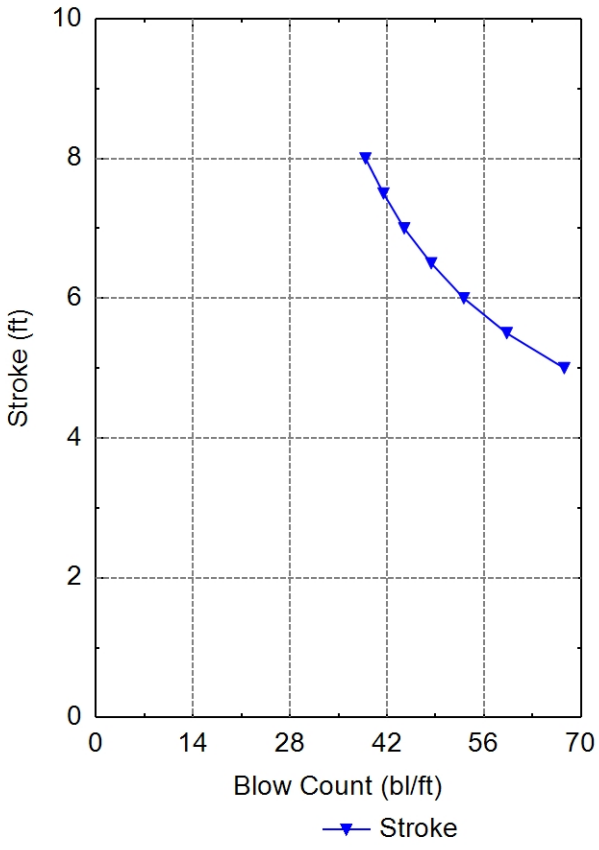


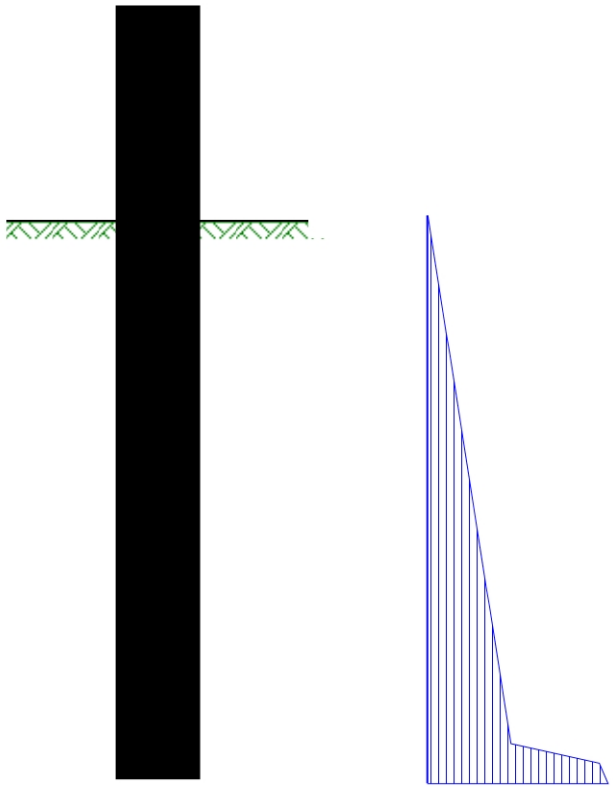
Press F1 for General Help Topics or F3 for Specific Help on Current Parameters



DELMAG D 12

Capacity	220.0	kips
Ram Weight	2.75	kips
Efficiency	0.800	
Pressure	1380.0 (100%)	psi
Helmet Weight	2.700	kips
Hammer Cushion	109976.0	kips/in
COR of H.C.	0.800	
Skin Quake	0.098	in
Toe Quake	0.060	in
Skin Damping	0.100	s/ft
Toe Damping	0.152	s/ft
Pile Length	20.00	ft
Pile Penetration	14.50	ft
Pile Top Area	15.50	in²
RSA	No	





Pile Model

Shaft=3%
(Prop.)

Bearing Graph Summary — DELMAG D 12

Rut	Mx C-Str.	Top Str.	Mx T-Str.	Blow Ct	Stroke	ENTHRU	Hammer	Trans. Ratio
kips	ksi	ksi	ksi	bl/ft	ft	kip-ft	DELMAG	%
220.0	23.74	23.74	0.58	67.6	5.00	6.60	D 12	29.2
220.0	24.82	24.82	0.61	59.3	5.50	7.55	D 12	33.4
220.0	26.16	25.80	0.64	53.1	6.00	8.49	D 12	37.6
220.0	27.44	26.72	0.66	48.4	6.50	9.41	D 12	41.6
220.0	28.69	27.66	0.69	44.5	7.00	10.36	D 12	45.8
220.0	29.80	28.52	0.71	41.5	7.50	11.26	D 12	49.8
220.0	31.01	29.36	0.74	38.9	8.00	12.18	D 12	53.9