ECS Southeast, LLP

Bridge Foundation Design Recommendations

Bridge No. 063 on NC-88 over Cranberry Creek

Project No: BP.11.R003.1
Project ID: SF-040063
Ashe County, North Carolina

ECS Project No. 09:29662

September 10, 2022

September 10, 2022

Ms. Nikki Honeycutt, P.E.
STV Engineers, Inc.
900 W. Trade Street, Suite 715
Charlotte, North Carolina 28202

ECS Project No.:09:29662

Reference: Bridge Foundation Design Recommendations
Bridge No. 063 on NC-88 over Cranberry Creek
Project No: BP.11.R003.1
Project ID: SF-040063
County: Ashe

Dear MS. Honeycutt:

ECS Southeast, LLP (ECS) is pleased to submit the Bridge Foundation Design Recommendations Report associated with design and construction of Bridge No. 063 on NC-88 over Cranberry Creek in Ashe County, North Carolina. This work was performed in general accordance with our Proposal No. 09-28281P dated July 15, 2021.

Our design is based on project information and structure loads provided to us by STV. This report contains the foundation recommendations, the Structure Subsurface Investigation report prepared by ECS, and supporting calculations.

ECS Southeast, LLP appreciates the opportunity to assist you during this phase of the project. If you have questions concerning this report, please contact our office at 704-525-5152.

Respectfully,

ECS SOUTHEAST, LLP

NORTH CAROLINA PROFESSIONAL SEAL 045542 ENGINEER KELLY N. DE MONTBRUN
9/9/2022

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FOUNDATION RECOMMENDATIONS

WBS NO. BP11.R003.1

DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek

T.I.P. NO. N/A

COUNTY Ashe

STATION 16+85.00 -L-

	INITIALS	DATE
DESIGN	KND	09/09/22
CHECK	MJW	09/10/22
REVISED		

SEAL

NORTH CAROLINA PROFESSIONAL SEAL 045542 ENGINEER KELLY NICOLE MONTBRUN

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SIGNATURE

	STATION	FOUNDATION TYPE	FACTORED LOAD	MISCELLANEOUS DETAILS
END BENT NO. 1	16+08.56 -L-	Cap on HP 12X53 Steel Piles	65 Tons/Pile	Average Bottom of Cap Elevation = 2,722.0 ft +/- Average Pile Length = 45 ft (LT), 40 ft (RT) 7 Vertical Piles @ 7'-6" Spacing
BENT NO. 1	16+49.93 -L-	36" Diameter Drilled Pier	420 Tons/Pier	Average Bottom of Cap Elevation = 2,722.8 ft +/- Point of Fixity Elevation = 2,685 ft (LT), 2,691 ft (RT) Tip No Higher Than Elevation = 2,656 ft Number of Piers/Cap = 3
BENT NO. 2	17+20.07 -L-	36" Diameter Drilled Pier	415 Tons/Pier	Average Bottom of Cap Elevation = 2,722.5 ft +/- Point of Fixity Elevation = 2,696 ft Tip No Higher Than Elevation = 2,689 ft Number of Piers/Cap = 3
END BENT NO. 2	17+61.44 -L-	Cap on HP 12X53 Steel Piles	65 Tons/Pile	Average Bottom of Cap Elevation = 2,721.3 ft +/- Average Pile Length = 20 ft 7 Vertical Piles @ 7'-6" Spacing

(SEE NOTES ON PLANS AND COMMENTS ON FOLLOWING PAGES)

WBS No: BP11.R003.1 **County:** Ashe

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 (LT) BY VIBRATING, SCREWING OR DRIVING PERMANENT CASINGS BEFORE EXCAVATING OR DISTURBING ANY MATERIAL BELOW ELEVATION 2,694 FT.

4) INSTALL PERMANENT STEEL CASINGS AT BENT NO. 1 (RT) BY VIBRATING, SCREWING OR DRIVING PERMANENT CASINGS BEFORE EXCAVATING OR DISTURBING ANY MATERIAL BELOW ELEVATION 2,700 FT.

5) INSTALL PERMANENT STEEL CASINGS AT BENT NO. 2 BY VIBRATING, SCREWING OR DRIVING PERMANENT CASINGS BEFORE

WBS No: BP11.R003.1 **County:** Ashe

FOUNDATION RECOMMENDATION COMMENTS

1) CLASS II RIP RAP WILL BE USED FOR SCOUR PROTECTION AT END BENT NO. 1 AND END BENT NO. 2.

2) TYPE II BRIDGE APPROACH FILL (STANDARD DETAIL 422.02) SHOULD BE USED AT END BENT NO. 1 AND END BENT NO. 2.

3) NO WAITING PERIOD IS REQUIRED AT EITHER END BENT PRIOR TO CONSTRUCTION.

4) AVERAGE PILE LENGTHS ARE BASED ON PLUMB PILES FROM THE BOTTOM OF CAP ELEVATION TO THE ANTICIPATED TIP ELEVATION, ROUNDED UP TO THE NEAREST 5 FEET.

5) BASED ON THE BSR, THE DESIGN SCOUR ELEVATION AT BENT NO. 1 AND BENT NO. 2 IS 2,698 FT. FOR OUR ANALYSIS, THE SCOUR DEPTHS WERE ADJUSTED BASED ON THE TOP OF ROCK ELEVATION ENCOUNTERED AT BENT NO. 1 RT AND BENT NO. 2 RT BORING LOCATIONS.

6) PDA WILL NOT BE USED TO MONITOR DRIVING STRESSES AT END BENT NO. 1 AND END BENT NO. 2.

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION	SUBJECT: Bridge 063 on NC-88 over Cranberry Creek		WBS No. BP11.R003.1
DIVISION OF HIGHWAYS	PREPARED BY:	KND	COUNTY: Ashe
HIGHWAY BUILDING	DATE:	Sep-22	TIP No. N/A
1589 MAIL SERVICE CENTER	CHECKED BY:	MJW	**Bridge Structure No. 040063**
RALEIGH, NORTH CAROLINA 27699-1589	DATE:	Sep-22	

SCOUR DETERMINATION

HYDRAULICS SCOUR ELEVATIONS

(100-year scour elevation provided in the Bridge Survey & Hydraulic Design Report provided by STV dated 14/15/2022)

Bent No. 1	**2698.0**	ft
Bent No. 2	**2698.0**	ft

DESIGN SCOUR ELEVATIONS

(Used the 100-year scour elevation, unless "non-scourable" rock or WR was encountered at a higher elevation)

Bent No. 1	**2698.0**	ft (LT)	**2700.4**	ft (RT)
Bent No. 2	**2698.0**	ft (LT)	**2698.4**	ft (RT)

SCOUR CRITICAL ELEVATIONS

(Use 2 to 3 feet below the design scour elevation or ~ 1 foot into non-scourable rock)

Bent No. 1	**2695.0**	ft (LT)	**2698.0**	ft (RT)
Bent No. 2	**2697.0**	ft (LT)	**2697.0**	ft (RT)

SUBSURFACE INVENTORY REPORT

STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	BP.11.R003.1	1	20

REFERENCE: BP11.R003.1

PROJECT: N/A

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

STRUCTURE SUBSURFACE INVESTIGATION

COUNTY *ASHE*

PROJECT DESCRIPTION *BRIDGE ON NC-88 OVER CRANBERRY CREEK BETWEEN SR 1614 AND SR 1609*

SITE DESCRIPTION *-L- STATION 16+85*

CONTENTS

PERSONNEL

A. BLACKMORE

HPC

INVESTIGATED BY *ECS SOUTHEAST, LLP*

DRAWN BY *K. DE MONTBRUN, P.E.*

CHECKED BY *M. WALKO, P.E.*

SUBMITTED BY *ECS SOUTHEAST, LLP*

DATE *SEPTEMBER 2022*

CAUTION NOTICE

THE SUBSURFACE INFORMATION AND THE SUBSURFACE INVESTIGATION ON WHICH IT IS BASED WERE MADE FOR THE PURPOSE OF STUDY, PLANNING AND DESIGN, AND NOT FOR CONSTRUCTION OR PAY PURPOSES. THE VARIOUS FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA AVAILABLE MAY BE REVIEWED OR INSPECTED IN RALEIGH BY CONTACTING THE N. C. DEPARTMENT OF TRANSPORTATION, GEOTECHNICAL ENGINEERING UNIT AT (919) 707-6850. THE SUBSURFACE PLANS AND REPORTS, FIELD BORING LOGS, ROCK CORES AND SOIL TEST DATA ARE NOT PART OF THE CONTRACT.

GENERAL SOIL AND ROCK STRATA DESCRIPTIONS AND INDICATED BOUNDARIES ARE BASED ON A GEOTECHNICAL INTERPRETATION OF ALL AVAILABLE SUBSURFACE DATA AND MAY NOT NECESSARILY REFLECT THE ACTUAL SUBSURFACE CONDITIONS BETWEEN BORINGS OR BETWEEN SAMPLED STRATA WITHIN THE BOREHOLE. THE LABORATORY SAMPLE DATA AND THE IN SITU (IN-PLACE) TEST DATA CAN BE RELIED ON ONLY TO THE DEGREE OF RELIABILITY INHERENT IN THE STANDARD TEST METHOD. THE OBSERVED WATER LEVELS OR SOIL MOISTURE CONDITIONS INDICATED IN THE SUBSURFACE INVESTIGATIONS ARE AS RECORDED AT THE TIME OF THE INVESTIGATION. THESE WATER LEVELS OR SOIL MOISTURE CONDITIONS MAY VARY CONSIDERABLY WITH TIME ACCORDING TO CLIMATIC CONDITIONS INCLUDING TEMPERATURES, PRECIPITATION AND WIND, AS WELL AS OTHER NON-CLIMATIC FACTORS.

THE BIDDER OR CONTRACTOR IS CAUTIONED THAT DETAILS SHOWN ON THE SUBSURFACE PLANS ARE PRELIMINARY ONLY AND IN MANY CASES THE FINAL DESIGN DETAILS ARE DIFFERENT. FOR BIDDING AND CONSTRUCTION PURPOSES, REFER TO THE CONSTRUCTION PLANS AND DOCUMENTS FOR FINAL DESIGN INFORMATION ON THIS PROJECT. THE DEPARTMENT DOES NOT WARRANT OR GUARANTEE THE SUFFICIENCY OR ACCURACY OF THE INVESTIGATION MADE, NOR THE INTERPRETATIONS MADE, OR OPINION OF THE DEPARTMENT AS TO THE TYPE OF MATERIALS AND CONDITIONS TO BE ENCOUNTERED. THE BIDDER OR CONTRACTOR IS CAUTIONED TO MAKE SUCH INDEPENDENT SUBSURFACE INVESTIGATIONS AS HE DEEMS NECESSARY TO SATISFY HIMSELF AS TO CONDITIONS TO BE ENCOUNTERED ON THE PROJECT. THE CONTRACTOR SHALL HAVE NO CLAIM FOR ADDITIONAL COMPENSATION OR FOR AN EXTENSION OF TIME FOR ANY REASON RESULTING FROM THE ACTUAL CONDITIONS ENCOUNTERED AT THE SITE DIFFERING FROM THOSE INDICATED IN THE SUBSURFACE INFORMATION.

NOTES:

1. THE INFORMATION CONTAINED HEREIN IS NOT IMPLIED OR GUARANTEED BY THE N. C. DEPARTMENT OF TRANSPORTATION AS ACCURATE NOR IS IT CONSIDERED PART OF THE PLANS, SPECIFICATIONS OR CONTRACT FOR THE PROJECT.
2. BY HAVING REQUESTED THIS INFORMATION, THE CONTRACTOR SPECIFICALLY WAIVES ANY CLAIMS FOR INCREASED COMPENSATION OR EXTENSION OF TIME BASED ON DIFFERENCES BETWEEN THE CONDITIONS INDICATED HEREIN AND THE ACTUAL CONDITIONS AT THE PROJECT SITE.

Prepared in the Office of:

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NORTH CAROLINA PROFESSIONAL SEAL 045442 ENGINEER KELLY N. DE MONTBRUN

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SIGNATURE DATE

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

PROJECT REFERENCE NO.	SHEET NO.
BP.11.R003.1	2

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS
(PAGE 1 OF 2)

SOIL DESCRIPTION

SOIL IS CONSIDERED UNCONSOLIDATED, SEMI-CONSOLIDATED, OR WEATHERED EARTH MATERIALS THAT CAN BE PENETRATED WITH A CONTINUOUS FLIGHT POWER AUGER AND YIELD LESS THAN 100 BLOWS PER FOOT ACCORDING TO THE STANDARD PENETRATION TEST (AASHTO T 206, ASTM D1586). SOIL CLASSIFICATION IS BASED ON THE AASHTO SYSTEM. BASIC DESCRIPTIONS GENERALLY INCLUDE THE FOLLOWING: CONSISTENCY, COLOR, TEXTURE, MOISTURE, AASHTO CLASSIFICATION, AND OTHER PERTINENT FACTORS SUCH AS MINERALOGICAL COMPOSITION, ANGULARITY, STRUCTURE, PLASTICITY, ETC. FOR EXAMPLE,
VERY STIFF, GRAY, SILTY CLAY, MOIST WITH INTERBEDDED FINE SAND LAYERS, HIGHLY PLASTIC, A-7-6

SOIL LEGEND AND AASHTO CLASSIFICATION

GENERAL CLASS.	GRANULAR MATERIALS (≤ 35% PASSING #200)							SILT-CLAY MATERIALS (> 35% PASSING #200)				ORGANIC MATERIALS		
GROUP CLASS.	A-1		A-3	A-2				A-4	A-5	A-6	A-7	A-1, A-2 A-3	A-4, A-5 A-6, A-7	
	A-1-a	A-1-b		A-2-4	A-2-5	A-2-6	A-2-7				A-7-5, A-7-6			
SYMBOL														
% PASSING #10 #40 #200	50 MX 30 MX 15 MX	50 MX 25 MX	51 MN 10 MX	35 MX	35 MX	35 MX	35 MX	36 MN	36 MN	36 MN	36 MN	GRANULAR SOILS	SILT-CLAY SOILS	MUCK, PEAT
MATERIAL PASSING #40 LL PI	6 MX		NP	40 MX 10 MX	41 MN 10 MX	40 MX 11 MN	41 MN 11 MN	40 MX 10 MX	41 MN 10 MX	40 MX 11 MN	41 MN 11 MN	SOILS WITH LITTLE OR MODERATE AMOUNTS OF ORGANIC MATTER		HIGHLY ORGANIC SOILS
GROUP INDEX	0		0	0		4 MX		8 MX	12 MX	16 MX	NO MX			
USUAL TYPES OF MAJOR MATERIALS	STONE FRAGS. GRAVEL, AND SAND		FINE SAND	SILTY OR CLAYEY GRAVEL AND SAND				SILTY SOILS		CLAYEY SOILS				
GEN. RATING AS SUBGRADE	EXCELLENT TO GOOD							FAIR TO POOR				FAIR TO POOR	POOR	UNSUITABLE

PI OF A-7-5 SUBGROUP IS ≤ LL - 30 ; PI OF A-7-6 SUBGROUP IS > LL - 30

CONSISTENCY OR DENSENESS

PRIMARY SOIL TYPE	COMPACTNESS OR CONSISTENCY	RANGE OF STANDARD PENETRATION RESISTANCE (N-VALUE)	RANGE OF UNCONFINED COMPRESSIVE STRENGTH ($TONS/FT^2$)
GENERALLY GRANULAR MATERIAL (NON-COHESIVE)	VERY LOOSE LOOSE MEDIUM DENSE DENSE VERY DENSE	< 4 4 TO 10 10 TO 30 30 TO 50 > 50	N/A
GENERALLY SILT-CLAY MATERIAL (COHESIVE)	VERY SOFT SOFT MEDIUM STIFF STIFF VERY STIFF HARD	< 2 2 TO 4 4 TO 8 8 TO 15 15 TO 30 > 30	< 0.25 0.25 TO 0.5 0.5 TO 1.0 1 TO 2 2 TO 4 > 4

TEXTURE OR GRAIN SIZE

U.S. STD. SIEVE SIZE	4	10	40	60	200	270
OPENING (MM)	4.76	2.00	0.42	0.25	0.075	0.053

BOULDER (BLDR.)	COBBLE (COB.)	GRAVEL (GR.)	COARSE SAND (CSE. SD.)	FINE SAND (F SD.)	SILT (SL.)	CLAY (CL.)

GRAIN SIZE	MM	305	75	2.0	0.25	0.05	0.005
	IN.	12	3				

SOIL MOISTURE - CORRELATION OF TERMS

SOIL MOISTURE SCALE (ATTERBERG LIMITS)	FIELD MOISTURE DESCRIPTION	GUIDE FOR FIELD MOISTURE DESCRIPTION
	- SATURATED - (SAT.)	USUALLY LIQUID; VERY WET, USUALLY FROM BELOW THE GROUND WATER TABLE
LL — LIQUID LIMIT PLASTIC RANGE (PI) PL — PLASTIC LIMIT	- WET - (W)	SEMISOLID; REQUIRES DRYING TO ATTAIN OPTIMUM MOISTURE
OM — OPTIMUM MOISTURE SL — SHRINKAGE LIMIT	- MOIST - (M)	SOLID; AT OR NEAR OPTIMUM MOISTURE
	- DRY - (D)	REQUIRES ADDITIONAL WATER TO ATTAIN OPTIMUM MOISTURE

PLASTICITY

	PLASTICITY INDEX (PI)	DRY STRENGTH
NON PLASTIC	0-5	VERY LOW
SLIGHTLY PLASTIC	6-15	SLIGHT
MODERATELY PLASTIC	16-25	MEDIUM
HIGHLY PLASTIC	26 OR MORE	HIGH

COLOR

DESCRIPTIONS MAY INCLUDE COLOR OR COLOR COMBINATIONS (TAN, RED, YELLOW-BROWN, BLUE-GRAY). MODIFIERS SUCH AS LIGHT, DARK, STREAKED, ETC. ARE USED TO DESCRIBE APPEARANCE.

GRADATION

WELL GRADED - INDICATES A GOOD REPRESENTATION OF PARTICLE SIZES FROM FINE TO COARSE.
UNIFORMLY GRADED - INDICATES THAT SOIL PARTICLES ARE ALL APPROXIMATELY THE SAME SIZE.
GAP-GRADED - INDICATES A MIXTURE OF UNIFORM PARTICLE SIZES OF TWO OR MORE SIZES.

ANGULARITY OF GRAINS

THE ANGULARITY OR ROUNDNESS OF SOIL GRAINS IS DESIGNATED BY THE TERMS: ANGULAR, SUBANGULAR, SUBROUNDED, OR ROUNDED.

MINERALOGICAL COMPOSITION

MINERAL NAMES SUCH AS QUARTZ, FELDSPAR, MICA, TALC, KAOLIN, ETC. ARE USED IN DESCRIPTIONS WHEN THEY ARE CONSIDERED OF SIGNIFICANCE.

COMPRESSIBILITY

SLIGHTLY COMPRESSIBLE	LL < 31
MODERATELY COMPRESSIBLE	LL = 31 - 50
HIGHLY COMPRESSIBLE	LL > 50

PERCENTAGE OF MATERIAL

ORGANIC MATERIAL	GRANULAR SOILS	SILT - CLAY SOILS	OTHER MATERIAL	
TRACE OF ORGANIC MATTER	2 - 3%	3 - 5%	TRACE	1 - 10%
LITTLE ORGANIC MATTER	3 - 5%	5 - 12%	LITTLE	10 - 20%
MODERATELY ORGANIC	5 - 10%	12 - 20%	SOME	20 - 35%
HIGHLY ORGANIC	> 10%	> 20%	HIGHLY	35% AND ABOVE

GROUND WATER

- WATER LEVEL IN BORE HOLE IMMEDIATELY AFTER DRILLING
- STATIC WATER LEVEL AFTER 24 HOURS
- PW — PERCHED WATER, SATURATED ZONE, OR WATER BEARING STRATA
- SPRING OR SEEP

MISCELLANEOUS SYMBOLS

- ROADWAY EMBANKMENT (RE) WITH SOIL DESCRIPTION
- SOIL SYMBOL
- ARTIFICIAL FILL (AF) OTHER THAN ROADWAY EMBANKMENT
- INFERRED SOIL BOUNDARY
- INFERRED ROCK LINE
- ALLUVIAL SOIL BOUNDARY
- 25/025 — DIP & DIP DIRECTION OF ROCK STRUCTURES
- SPT, DPT, DMT, VST, PMT — TEST BORING
- AUGER BORING
- CORE BORING
- MW — MONITORING WELL
- PIEZOMETER INSTALLATION
- SLOPE INDICATOR INSTALLATION
- CONE PENETROMETER TEST
- SOUNDING ROD
- TEST BORING WITH CORE
- SPT N-VALUE

RECOMMENDATION SYMBOLS

- UNDERCUT
- SHALLOW UNDERCUT
- UNCLASSIFIED EXCAVATION - UNSUITABLE WASTE
- UNCLASSIFIED EXCAVATION - ACCEPTABLE DEGRADABLE ROCK
- UNCLASSIFIED EXCAVATION - ACCEPTABLE, BUT NOT TO BE USED IN THE TOP 3 FEET OF EMBANKMENT OR BACKFILL

ABBREVIATIONS

AR - AUGER REFUSAL
BT - BORING TERMINATED
CL. - CLAY
CPT - CONE PENETRATION TEST
CSE. - COARSE
DMT - DILATOMETER TEST
DPT - DYNAMIC PENETRATION TEST
e - VOID RATIO
F - FINE
FOSS. - FOSSILIFEROUS
FRAC. - FRACTURED, FRACTURES
FRAGS. - FRAGMENTS
HI. - HIGHLY
MED. - MEDIUM
MICA. - MICACEOUS
MOD. - MODERATELY
NP - NON PLASTIC
ORG. - ORGANIC
PMT - PRESSUREMETER TEST
SAP. - SAPROLITIC
SD. - SAND, SANDY
SL. - SILT, SILTY
SLI. - SLIGHTLY
TCR - TRICONE REFUSAL
ω - MOISTURE CONTENT
V - VERY
VST - VANE SHEAR TEST
WEA. - WEATHERED
γ - UNIT WEIGHT
γ_d - DRY UNIT WEIGHT

SAMPLE ABBREVIATIONS

S - BULK
SS - SPLIT SPOON
ST - SHELBY TUBE
RS - ROCK
RT - RECOMPACTED TRIAXIAL
CBR - CALIFORNIA BEARING RATIO

EQUIPMENT USED ON SUBJECT PROJECT

DRILL UNITS:
- [ ] CME-45C
- [ ] CME-55
- [X] CME-550
- [ ] VANE SHEAR TEST
- [ ] PORTABLE HOIST
- [ ] _____
- [ ] _____

ADVANCING TOOLS:
- [ ] CLAY BITS
- [ ] 6" CONTINUOUS FLIGHT AUGER
- [X] 8" HOLLOW AUGERS
- [ ] HARD FACED FINGER BITS
- [ ] TUNG.-CARBIDE INSERTS
- [X] CASING [ ] W/ ADVANCER
- [ ] TRICONE _____" STEEL TEETH
- [ ] TRICONE _____" TUNG.-CARB.
- [X] CORE BIT
- [ ] _____

HAMMER TYPE:
- [X] AUTOMATIC [ ] MANUAL

CORE SIZE:
- [ ] -B _____ [ ] -H _____
- [X] -N Q2

HAND TOOLS:
- [ ] POST HOLE DIGGER
- [ ] HAND AUGER
- [ ] SOUNDING ROD
- [ ] VANE SHEAR TEST
- [ ] _____

PROJECT REFERENCE NO.	SHEET NO.
BP.11.R003.1	2A

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS
(PAGE 2 OF 2)

ROCK DESCRIPTION

HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT REFUSAL IF TESTED. AN INFERRED ROCK LINE INDICATES THE LEVEL AT WHICH NON-COASTAL PLAIN MATERIAL WOULD YIELD SPT REFUSAL. SPT REFUSAL IS PENETRATION BY A SPLIT SPOON SAMPLER EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS IN NON-COASTAL PLAIN MATERIAL. THE TRANSITION BETWEEN SOIL AND ROCK IS OFTEN REPRESENTED BY A ZONE OF WEATHERED ROCK.
ROCK MATERIALS ARE TYPICALLY DIVIDED AS FOLLOWS:

WEATHERED ROCK (WR)		NON-COASTAL PLAIN MATERIAL THAT WOULD YIELD SPT N VALUES > 100 BLOWS PER FOOT IF TESTED.
CRYSTALLINE ROCK (CR)		FINE TO COARSE GRAIN IGNEOUS AND METAMORPHIC ROCK THAT WOULD YIELD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES GRANITE, GNEISS, GABBRO, SCHIST, ETC.
NON-CRYSTALLINE ROCK (NCR)		FINE TO COARSE GRAIN METAMORPHIC AND NON-COASTAL PLAIN SEDIMENTARY ROCK THAT WOULD YEILD SPT REFUSAL IF TESTED. ROCK TYPE INCLUDES PHYLLITE, SLATE, SANDSTONE, ETC.
COASTAL PLAIN SEDIMENTARY ROCK (CP)		COASTAL PLAIN SEDIMENTS CEMENTED INTO ROCK, BUT MAY NOT YIELD SPT REFUSAL. ROCK TYPE INCLUDES LIMESTONE, SANDSTONE, CEMENTED SHELL BEDS, ETC.

WEATHERING

FRESH	ROCK FRESH, CRYSTALS BRIGHT, FEW JOINTS MAY SHOW SLIGHT STAINING. ROCK RINGS UNDER HAMMER IF CRYSTALLINE.
VERY SLIGHT (V SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED, SOME JOINTS MAY SHOW THIN CLAY COATINGS IF OPEN, CRYSTALS ON A BROKEN SPECIMEN FACE SHINE BRIGHTLY. ROCK RINGS UNDER HAMMER BLOWS IF OF A CRYSTALLINE NATURE.
SLIGHT (SLI.)	ROCK GENERALLY FRESH, JOINTS STAINED AND DISCOLORATION EXTENDS INTO ROCK UP TO 1 INCH. OPEN JOINTS MAY CONTAIN CLAY. IN GRANITOID ROCKS SOME OCCASIONAL FELDSPAR CRYSTALS ARE DULL AND DISCOLORED. CRYSTALLINE ROCKS RING UNDER HAMMER BLOWS.
MODERATE (MOD.)	SIGNIFICANT PORTIONS OF ROCK SHOW DISCOLORATION AND WEATHERING EFFECTS. IN GRANITOID ROCKS, MOST FELDSPARS ARE DULL AND DISCOLORED, SOME SHOW CLAY. ROCK HAS DULL SOUND UNDER HAMMER BLOWS AND SHOWS SIGNIFICANT LOSS OF STRENGTH AS COMPARED WITH FRESH ROCK.
MODERATELY SEVERE (MOD. SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. IN GRANITOID ROCKS, ALL FELDSPARS DULL AND DISCOLORED AND A MAJORITY SHOW KAOLINIZATION. ROCK SHOWS SEVERE LOSS OF STRENGTH AND CAN BE EXCAVATED WITH A GEOLOGIST'S PICK. ROCK GIVES "CLUNK" SOUND WHEN STRUCK. *IF TESTED, WOULD YIELD SPT REFUSAL*
SEVERE (SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC CLEAR AND EVIDENT BUT REDUCED IN STRENGTH TO STRONG SOIL. IN GRANITOID ROCKS ALL FELDSPARS ARE KAOLINIZED TO SOME EXTENT. SOME FRAGMENTS OF STRONG ROCK USUALLY REMAIN. *IF TESTED, WOULD YIELD SPT N VALUES > 100 BPF*
VERY SEVERE (V SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC ELEMENTS ARE DISCERNIBLE BUT MASS IS EFFECTIVELY REDUCED TO SOIL STATUS, WITH ONLY FRAGMENTS OF STRONG ROCK REMAINING. SAPROLITE IS AN EXAMPLE OF ROCK WEATHERED TO A DEGREE THAT ONLY MINOR VESTIGES OF ORIGINAL ROCK FABRIC REMAIN. *IF TESTED, WOULD YIELD SPT N VALUES < 100 BPF*
COMPLETE	ROCK REDUCED TO SOIL. ROCK FABRIC NOT DISCERNIBLE, OR DISCERNIBLE ONLY IN SMALL AND SCATTERED CONCENTRATIONS. QUARTZ MAY BE PRESENT AS DIKES OR STRINGERS. SAPROLITE IS ALSO AN EXAMPLE.

ROCK HARDNESS

VERY HARD	CANNOT BE SCRATCHED BY KNIFE OR SHARP PICK. BREAKING OF HAND SPECIMENS REQUIRES SEVERAL HARD BLOWS OF THE GEOLOGIST'S PICK.
HARD	CAN BE SCRATCHED BY KNIFE OR PICK ONLY WITH DIFFICULTY. HARD HAMMER BLOWS REQUIRED TO DETACH HAND SPECIMEN.
MODERATELY HARD	CAN BE SCRATCHED BY KNIFE OR PICK. GOUGES OR GROOVES TO 0.25 INCHES DEEP CAN BE EXCAVATED BY HARD BLOW OF A GEOLOGIST'S PICK. HAND SPECIMENS CAN BE DETACHED BY MODERATE BLOWS.
MEDIUM HARD	CAN BE GROOVED OR GOUGED 0.05 INCHES DEEP BY FIRM PRESSURE OF KNIFE OR PICK POINT. CAN BE EXCAVATED IN SMALL CHIPS TO PEICES 1 INCH MAXIMUM SIZE BY HARD BLOWS OF THE POINT OF A GEOLOGIST'S PICK.
SOFT	CAN BE GROVED OR GOUGED READILY BY KNIFE OR PICK. CAN BE EXCAVATED IN FRAGMENTS FROM CHIPS TO SEVERAL INCHES IN SIZE BY MODERATE BLOWS OF A PICK POINT. SMALL, THIN PIECES CAN BE BROKEN BY FINGER PRESSURE.
VERY SOFT	CAN BE CARVED WITH KNIFE. CAN BE EXCAVATED READILY WITH POINT OF PICK. PIECES 1 INCH OR MORE IN THICKNESS CAN BE BROKEN BY FINGER PRESSURE. CAN BE SCRATCHED READILY BY FINGERNAIL.

FRACTURE SPACING

TERM	SPACING
VERY WIDE	MORE THAN 10 FEET
WIDE	3 TO 10 FEET
MODERATELY CLOSE	1 TO 3 FEET
CLOSE	0.16 TO 1 FOOT
VERY CLOSE	LESS THAN 0.16 FEET

BEDDING

TERM	THICKNESS
VERY THICKLY BEDDED	4 FEET
THICKLY BEDDED	1.5 - 4 FEET
THINLY BEDDED	0.16 - 1.5 FEET
VERY THINLY BEDDED	0.03 - 0.16 FEET
THICKLY LAMINATED	0.008 - 0.03 FEET
THINLY LAMINATED	< 0.008 FEET

INDURATION

FOR SEDIMENTARY ROCKS, INDURATION IS THE HARDENING OF MATERIAL BY CEMENTING, HEAT, PRESSURE, ETC.

FRIABLE	RUBBING WITH FINGER FREES NUMEROUS GRAINS; GENTLE BLOW BY HAMMER DISINTEGRATES SAMPLE.
MODERATELY INDURATED	GRAINS CAN BE SEPARATED FROM SAMPLE WITH STEEL PROBE; BREAKS EASILY WHEN HIT WITH HAMMER.
INDURATED	GRAINS ARE DIFFICULT TO SEPARATE WITH STEEL PROBE; DIFFICULT TO BREAK WITH HAMMER.
EXTREMELY INDURATED	SHARP HAMMER BLOWS REQUIRED TO BREAK SAMPLE; SAMPLE BREAKS ACROSS GRAINS.

TERMS AND DEFINITIONS

ALLUVIUM (ALLUV.) - SOILS THAT HAVE BEEN TRANSPORTED BY WATER.

AQUIFER - A WATER BEARING FORMATION OR STRATA.

ARENACEOUS - APPLIED TO ROCKS THAT HAVE BEEN DERIVED FROM SAND OR THAT CONTAIN SAND.

ARGILLACEOUS - APPLIED TO ALL ROCKS OR SUBSTANCES COMPOSED OF CLAY MINERALS, OR HAVING A NOTABLE PROPORTION OF CLAY IN THEIR COMPOSITION, SUCH AS SHALE, SLATE, ETC.

ARTESIAN - GROUND WATER THAT IS UNDER SUFFICIENT PRESSURE TO RISE ABOVE THE LEVEL AT WHICH IT IS ENCOUNTERED, BUT WHICH DOES NOT NECESSARILY RISE TO OR ABOVE THE GROUND SURFACE.

CALCAREOUS (CALC.) - SOILS THAT CONTAIN APPRECIABLE AMOUNTS OF CALCIUM CARBONATE.

COLLUVIUM - ROCK FRAGMENTS MIXED WITH SOIL DEPOSITED BY GRAVITY ON SLOPE OR AT BOTTOM OF SLOPE.

CORE RECOVERY (REC.) - TOTAL LENGTH OF ALL MATERIAL RECOVERED IN THE CORE BARREL DIVIDED BY TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.

DIKE - A TABULAR BODY OF IGNEOUS ROCK THAT CUTS ACROSS THE STRUCTURE OF ADJACENT ROCKS OR CUTS MASSIVE ROCK.

DIP - THE ANGLE AT WHICH A STRATUM OR ANY PLANAR FEATURE IS INCLINED FROM THE HORIZONTAL.

DIP DIRECTION (DIP AZIMUTH) - THE DIRECTION OR BEARING OF THE HORIZONTAL TRACE OF THE LINE OF DIP, MEASURED CLOCKWISE FROM NORTH.

FAULT - A FRACTURE OR FRACTURE ZONE ALONG WHICH THERE HAS BEEN DISPLACEMENT OF THE SIDES RELATIVE TO ONE ANOTHER PARALLEL TO THE FRACTURE.

FISSILE - A PROPERTY OF SPLITTING ALONG CLOSELY SPACED PARALLEL PLANES.

FLOAT - ROCK FRAGMENTS ON SURFACE NEAR THEIR ORIGINAL POSITION AND DISLODGED FROM PARENT MATERIAL.

FLOOD PLAIN (FP) - LAND BORDERING A STREAM, BUILT OF SEDIMENTS DEPOSITED BY THE STREAM.

FORMATION (FM.) - A MAPPABLE GEOLOGIC UNIT THAT CAN BE RECOGNIZED AND TRACED IN THE FIELD.

JOINT - FRACTURE IN ROCK ALONG WHICH NO APPRECIABLE MOVEMENT HAS OCCURRED.

LEDGE - A SHELF-LIKE RIDGE OR PROJECTION OF ROCK WHOSE THICKNESS IS SMALL COMPARED TO ITS LATERAL EXTENT.

LENS - A BODY OF SOIL OR ROCK THAT THINS OUT IN ONE OR MORE DIRECTIONS.

MOTTLED (MOT.) - IRREGULARLY MARKED WITH SPOTS OF DIFFERENT COLORS. MOTTLING IN SOILS USUALLY INDICATES POOR AERATION AND LACK OF GOOD DRAINAGE.

PERCHED WATER - WATER MAINTAINED ABOVE THE NORMAL GROUND WATER LEVEL BY THE PRESENCE OF AN INTERVENING IMPERVIOUS STRATUM.

RESIDUAL (RES.) SOIL - SOIL FORMED IN PLACE BY THE WEATHERING OF ROCK.

ROCK QUALITY DESIGNATION (RQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF CORE RUN AND EXPRESSED AS A PERCENTAGE.

SAPROLITE (SAP.) - RESIDUAL SOIL THAT RETAINS THE RELIC STRUCTURE OR FABRIC OF THE PARENT ROCK.

SILL - AN INTRUSIVE BODY OF IGNEOUS ROCK OF APPROXIMATELY UNIFORM THICKNESS AND RELATIVELY THIN COMPARED WITH ITS LATERAL EXTENT, THAT HAS BEEN EMPLACED PARALLEL TO THE BEDDING OR SCHISTOSITY OF THE INTRUDED ROCKS.

SLICKENSIDE - POLISHED AND STRIATED SURFACE THAT RESULTS FROM FRICTION ALONG A FAULT OR SLIP PLANE.

STANDARD PENETRATION TEST (PENETRATION RESISTANCE) (SPT) - NUMBER OF BLOWS (N OR BPF) OF A 140 LB. HAMMER FALLING 30 INCHES REQUIRED TO PRODUCE A PENETRATION OF 1 FOOT INTO SOIL WITH A 2 INCH OUTSIDE DIAMETER SPLIT SPOON SAMPLER. SPT REFUSAL IS PENETRATION EQUAL TO OR LESS THAN 0.1 FOOT PER 60 BLOWS.

STRATA CORE RECOVERY (SREC.) - TOTAL LENGTH OF STRATA MATERIAL RECOVERED DIVIDED BY TOTAL LENGTH OF STRATUM AND EXPRESSED AS A PERCENTAGE.

STRATA ROCK QUALITY DESIGNATION (SRQD) - A MEASURE OF ROCK QUALITY DESCRIBED BY TOTAL LENGTH OF ROCK SEGMENTS WITHIN A STRATUM EQUAL TO OR GREATER THAN 4 INCHES DIVIDED BY THE TOTAL LENGTH OF STRATA AND EXPRESSED AS A PERCENTAGE.

TOPSOIL (TS.) - SURFACE SOILS USUALLY CONTAINING ORGANIC MATTER.

BENCH MARK:

ELEVATION: FEET

NOTES:

FIAD = FILLED IN AFTER DRILLING

DESIGN FILES, .TIN AND .GPK FILE PROVIDED BY STV.

DATE: 8-15-14

PROJECT REFERENCE NO.	SHEET NO.
BP.11.R003.1	2B

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

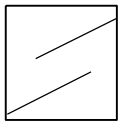
SUPPLEMENTAL LEGEND, GEOLOGICAL STRENGTH INDEX (GSI) TABLES FROM AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (PAGE 1 OF 2)

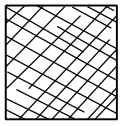
AASHTO LRFD Figure 10.4.6.4-1 — Determination of GSI for Jointed Rock Mass (Marinos and Hoek, 2000)

GEOLOGICAL STRENGTH INDEX (GSI) FOR JOINTED ROCKS (Hoek and Marinos, 2000)

From the lithology, structure and surface conditions of the discontinuities, estimate the average value of GSI. Do not try to be too precise. Quoting a range from 33 to 37 is more realistic than stating that GSI = 35. Note that the table does not apply to structurally controlled failures. Where weak planar structural planes are present in an unfavorable orientation with respect to the excavation face, these will dominate the rock mass behaviour. The shear strength of surfaces in rocks that are prone to deterioration as a result of changes in moisture content will be reduced if water is present. When working with rocks in the fair to very poor categories, a shift to the right may be made for wet conditions. Water pressure is dealt with by effective stress analysis.

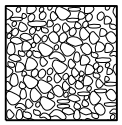
STRUCTURE


INTACT OR MASSIVE - intact rock specimens or massive in situ rock with few widely spaced discontinuities

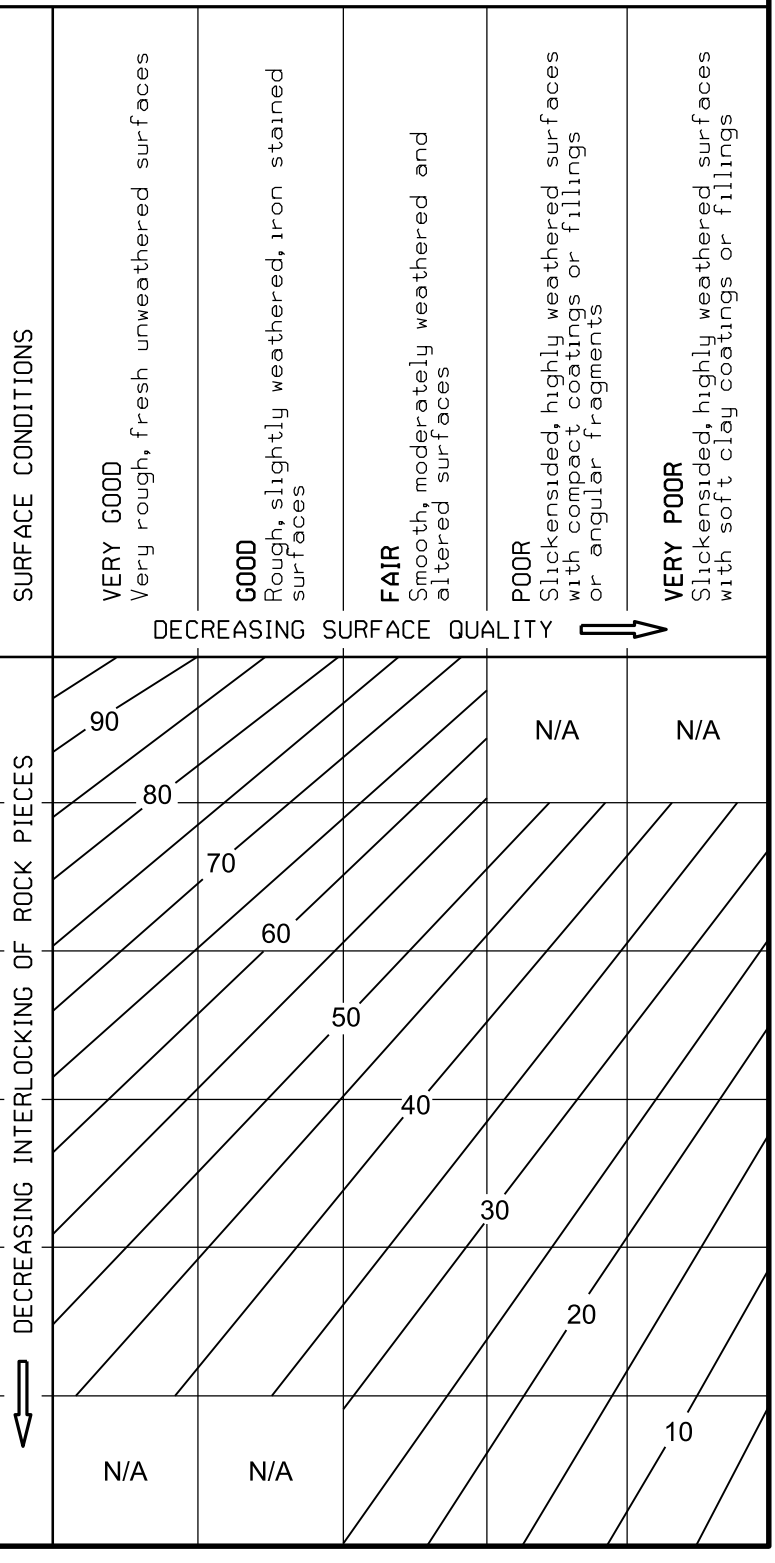

BLOCKY - well interlocked undisturbed rock mass consisting of cubical blocks formed by three intersecting discontinuity sets


VERY BLOCKY - interlocked, partially disturbed mass with multi-faceted angular blocks formed by 4 or more joint sets


BLOCKY/DISTURBED/SEAMY - folded with angular blocks formed by many intersecting discontinuity sets. Persistence of bedding planes or schistosity


DISINTEGRATED - poorly interlocked, heavily broken rock mass with mixture of angular and rounded rock pieces


LAMINATED/SHEARED - Lack of blockiness due to close spacing of weak schistosity or shear planes



PROJECT REFERENCE NO.	SHEET NO.
BP.11.R003.1	2C

NORTH CAROLINA DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

SUPPLEMENTAL LEGEND, GEOLOGICAL STRENGTH INDEX (GSI) TABLES FROM AASHTO LRFD BRIDGE DESIGN SPECIFICATIONS (PAGE 2 OF 2)

AASHTO LRFD Figure 10.4.6.4-2 — Determination of GSI for Tectonically Deformed Heterogeneous Rock Masses (Marinos and Hoek, 2000)

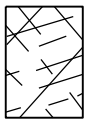
GSI FOR HETEROGENEOUS ROCK MASSES SUCH AS FLYSCH (Marinos. P and Hoek E., 2000)

From a description of the lithology, structure and surface conditions (particularly of the bedding planes), choose a box in the chart. Locate the position in the box that corresponds to the condition of the discontinuities and estimate the average value of GSI from the contours. Do not attempt to be too precise. Quoting a range from 33 to 37 is more realistic than giving GSI = 35. Note that the Hoek-Brown criterion does not apply to structurally controlled failures. Where unfavourably oriented continuous weak planar discontinuities are present, these will dominate the behaviour of the rock mass. The strength of some rock masses is reduced by the presence of groundwater and this can be allowed for by a slight shift to the right in the columns for fair, poor and very poor conditions. Water pressure does not change the value of GSI and it is dealt with by using effective stress analysis.

COMPOSITION AND STRUCTURE

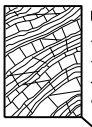
SURFACE CONDITIONS OF DISCONTINUITIES (Predominantly bedding planes)

VERY GOOD - Very Rough, fresh unweathered surfaces	GOOD - Rough, slightly weathered surfaces	FAIR - Smooth, moderately weathered and altered surfaces	POOR - Very smooth, occasionally slickensided surfaces with compact coatings or fillings with angular fragments	VERY POOR - Very smooth, slickensided or highly weathered surfaces with soft clay coatings or fillings



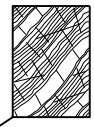
A. *Thick bedded, very blocky sandstone The effect of pelitic coatings on the bedding planes is minimized by the confinement of the rock mass. In shallow tunnels or slopes these bedding planes may cause structurally controlled instability.*

B. *Sandstone with thin interlayers of siltstone*



C. *Sandstone and siltstone in similar amounts*

D. *Siltstone or silty shale with sandstone layers*



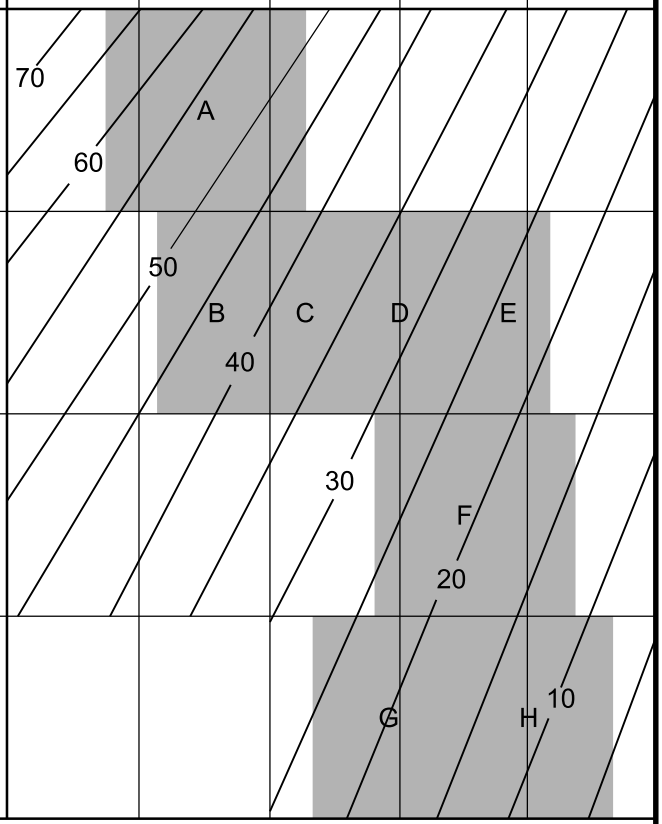
E. *Weak siltstone or clayey shale with sandstone layers*

C, D, E, and **G** - may be more or less folded than illustrated but this does not change the strength. Tectonic deformation, faulting and loss of continuity moves these categories to **F** and **H.**

F. *Tectonically deformed, intensively folded/faulted, sheared clayey shale or siltstone with broken and deformed sandstone layers forming an almost chaotic structure*

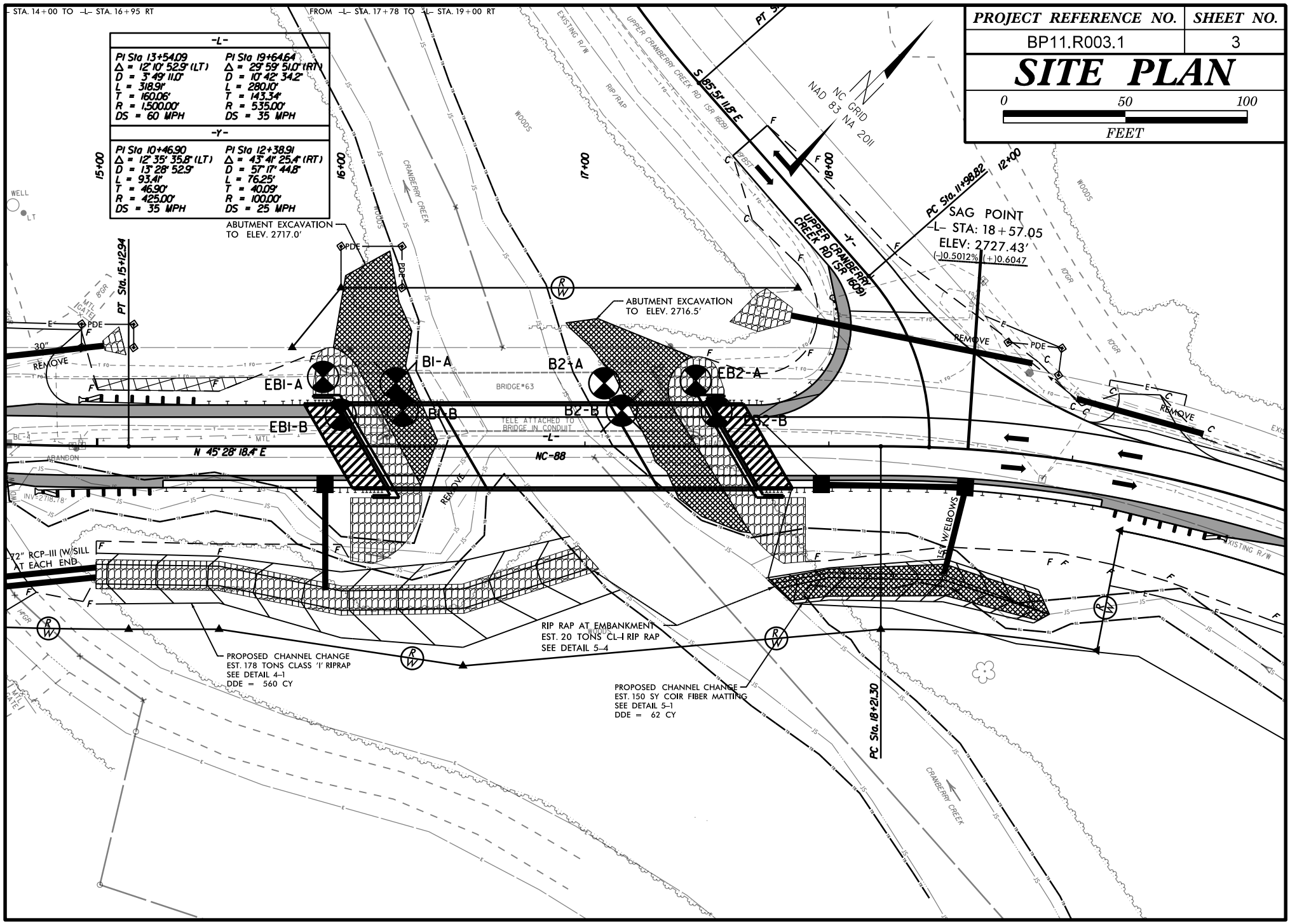
G. *Undisturbed silty or clayey shale with or without a few very thin sandstone layers*

H. ***Tectonically deformed silty or clayey shale forming a chaotic structure with pockets of clay. Thin layers of sandstone are transformed into small rock pieces.***



→ Means deformation after tectonic disturbance

DATE: 8-19-16



GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB1-A	**STATION** 15+93	**OFFSET** 28 ft LT	**ALIGNMENT** -L-	**0 HR.** 17.3
COLLAR ELEV. 2,727.3 ft	**TOTAL DEPTH** 55.2 ft	**NORTHING** 977,654	**EASTING** 1,328,007	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER J. Cain	**START DATE** 07/12/22	**COMP. DATE** 07/12/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2730											
										2,727.3 GROUND SURFACE	0.0
	2,726.6	0.7								2,726.6 **ROADWAY EMBANKMENT**	0.7
2725			3	6	5	11		M		Asphalt 0.5' Stone 0.2'	
	2,723.8	3.5	8	6	5	11		M		Medium Stiff to Very Stiff, Brown-Tan, Fine to Coarse Sandy SILT, with trace mica and rock fragments	
2720	2,721.3	6.0	2	2	3	5		M			
	2,718.8	8.5	4	16	4	20		W			
2715											
	2,713.8	13.5	1	1	7	8		W		2,713.3 **ALLUVIAL**	14.0
2710								▽		Medium Stiff, Black, Fine to Coarse Sandy SILT (A-4), with trace roots and mica	
	2,708.8	18.5	3	4	3	7		W		2,709.8 **RESIDUAL**	17.5
2705										Medium Stiff to Hard, Brown-Orange-Gray-Tan, Fine to Coarse Sandy SILT (A-4), with trace to some mica	
	2,703.8	23.5	1	4	6	10		W			
2700											
	2,698.8	28.5	8	10	12	22		W			
2695											
	2,693.8	33.5	39	47	48	95		W			
2690											
	2,688.8	38.5	17	18	39	57		W			
2685											
	2,683.8	43.5	17	44	56/0.4	100/0.9				2,683.3 **WEATHERED ROCK**	44.0
2680										(BIOTITE/HORNBLENDE GNEISS) Brown-Gray	
	2,678.8	48.5	30	38	37	75		M		2,679.8 **RESIDUAL**	47.5
2675										Hard, Brown-Gray, Fine to Coarse Sandy SILT (A-4)	
	2,673.8	53.5	100/0.2			100/0.2				2,673.8	53.5
	2,672.2	55.1	60/0.1			60/0.1				2,672.2 **WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Brown-Gray	55.1
	2,672.1	55.2								**CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS)	

Boring Terminated with Standard Penetration Test Refusal at Elevation 2,672.1 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

Notes:
Shot rock encountered at 4 ft. Boring offset 4 ft and continued.

GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 16+00	**OFFSET** 13 ft LT	**ALIGNMENT** -L-	**0 HR.** 14.0
COLLAR ELEV. 2,727.4 ft	**TOTAL DEPTH** 53.5 ft	**NORTHING** 977,648	**EASTING** 1,328,023	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/12/22	**COMP. DATE** 07/12/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	ELEV. (ft)	DEPTH (ft)
2730												
										GROUND SURFACE	2,727.4	0.0
	2,726.4	1.0								**ROADWAY EMBANKMENT**	2,726.4	1.0
2725			9	7	13	20		M		Asphalt 0.8' Stone 0.2' Medium Dense, Brown-Tan, Silty Fine to Coarse SAND (A-2-4), with trace rock fragments		
	2,723.9	3.5	10	9	6	15		M			2,721.4	6.0
2720	2,721.4	6.0	3	8	9	17		M		Very Stiff, Brown, Fine to Coarse Sandy SILT (A-4), with trace rock fragments	2,718.9	8.5
	2,718.9	8.5	3	5	3	8		M		Loose, Brown-Gray, Silty Fine to Coarse Silty SAND (A-2-4), with trace rock fragments		
2715												
	2,713.9	13.5	2	3	4	7		W		**ALLUVIAL** Loose, Black, Silty Fine to Coarse SAND (A-2-4), with trace roots and mica	2,713.4	14.0
2710											2,709.9	17.5
	2,708.9	18.5	5	5	10	15		Sat.		Medium Dense, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)		
2705											2,704.9	22.5
	2,703.9	23.5	5	8	20	28		W		**RESIDUAL** Very Stiff to Hard, Brown-Gray, Fine to Coarse Sandy SILT (A-4), with trace to some mica		
2700	2,698.9	28.5	20	30	19	49		W				
2695	2,693.9	33.5	12	15	15	30		W				
2690												
	2,688.9	38.5	25	75/0.4		100/0.9				**WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Gray	2,688.9	38.5
2685	2,683.9	43.5	35	44	55	99		W		**RESIDUAL** Hard, Gray-White, Fine to Coarse Sandy SILT (A-4), with trace mica	2,684.9	42.5
2680												
	2,678.9	48.5	59	41/0.1		100/0.6				**WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Gray-White-Tan	2,678.9	48.5
2675												
	2,674.0	53.4	60/0.1			60/0.1					2,674.0	53.4
										CRYSTALLINE ROCK (BIOTITE/HORNBLENDE GNEISS)	2,673.9	53.5
										Boring Terminated with Standard Penetration Test Refusal at Elevation 2,673.9 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)		

Notes:
Cobbles encountered while drilling between 15 and 21 ft.

GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609			**GROUND WTR (ft)**
BORING NO. B1-A	**STATION** 16+22	**OFFSET** 26 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,718.3 ft	**TOTAL DEPTH** 74.9 ft	**NORTHING** 977,673	**EASTING** 1,328,030	**24 HR.** 2.4
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** Core Boring	**HAMMER TYPE** Automatic
DRILLER J. Cain	**START DATE** 07/13/22	**COMP. DATE** 07/13/22	**SURFACE WATER DEPTH** N/A

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
										ELEV. (ft) DEPTH (ft)
2720	2,718.3	0.0								2,718.3 GROUND SURFACE 0.0
			2	3	3	6		W		**ALLUVIAL** Medium Stiff, Brown-Black, Fine to Coarse Sandy SILT (A-4), with trace mica
2715	2,714.8	3.5								2,715.3 3.0
			3	6	9	15		Sat.		Loose to Medium Dense, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)
	2,712.3	6.0								
			3	3	4	7		Sat.		
2710	2,709.8	8.5								
			2	3	4	7		Sat.		
2705	2,704.8	13.5								2,705.8 12.5
			16	19	25	44		W		**RESIDUAL** Very Stiff to Hard, Gray-Tan, Fine to Coarse Sandy SILT (A-4), with trace mica
2700	2,699.8	18.5								
			10	10	7	17		W		
2695	2,694.8	23.5								2,694.8 23.5
			23	77/0.2		100/0.7				**WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Tan-Brown
2690	2,689.8	28.5	100/0.2			100/0.2				
2685	2,684.8	33.5								2,685.3 33.0
			9	12	18	30		W		**RESIDUAL** Hard, Brown, Fine to Coarse Sandy SILT (A-4), with trace rock fragments
2680	2,679.8	38.5								
			19	30	43	73		W		
2675	2,674.8	43.5								2,676.8 41.5
			5	6	7	13		Sat.		Medium Dense, Brown, Silty Fine to Coarse SAND (A-2-4), with little rock fragments
2670	2,669.8	48.5								2,669.8 48.5
			100/0.2			100/0.2				**WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Gray
2665	2,665.5	52.8	60/0.1			60/0.1				2,665.5 52.8
										2,665.4 52.9 **CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS)
							RS-1			**CRYSTALLINE ROCK** Fresh, Hard, White-Green BIOTITE/HORNBLENDE GNEISS with Wide Fracture Spacing
2660										REC = 100%, RQD = 100%, GSI = 85 - 90
2655										
2650										
							RS-2			
2645										2,643.4 74.9
										Boring Terminated at Elevation 2,643.4 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

NCDOT BORE SINGLE BRIDGE063_GEO_GTM.GPJ NC_DOT.GDT 9/6/22

GEOTECHNICAL BORING REPORT
CORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609			**GROUND WTR (ft)**
BORING NO. B1-A	**STATION** 16+22	**OFFSET** 26 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,718.3 ft	**TOTAL DEPTH** 74.9 ft	**NORTHING** 977,673	**EASTING** 1,328,030	**24 HR.** 2.4
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** Core Boring	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/13/22	**COMP. DATE** 07/13/22	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ-2	**TOTAL RUN** 22.0 ft			

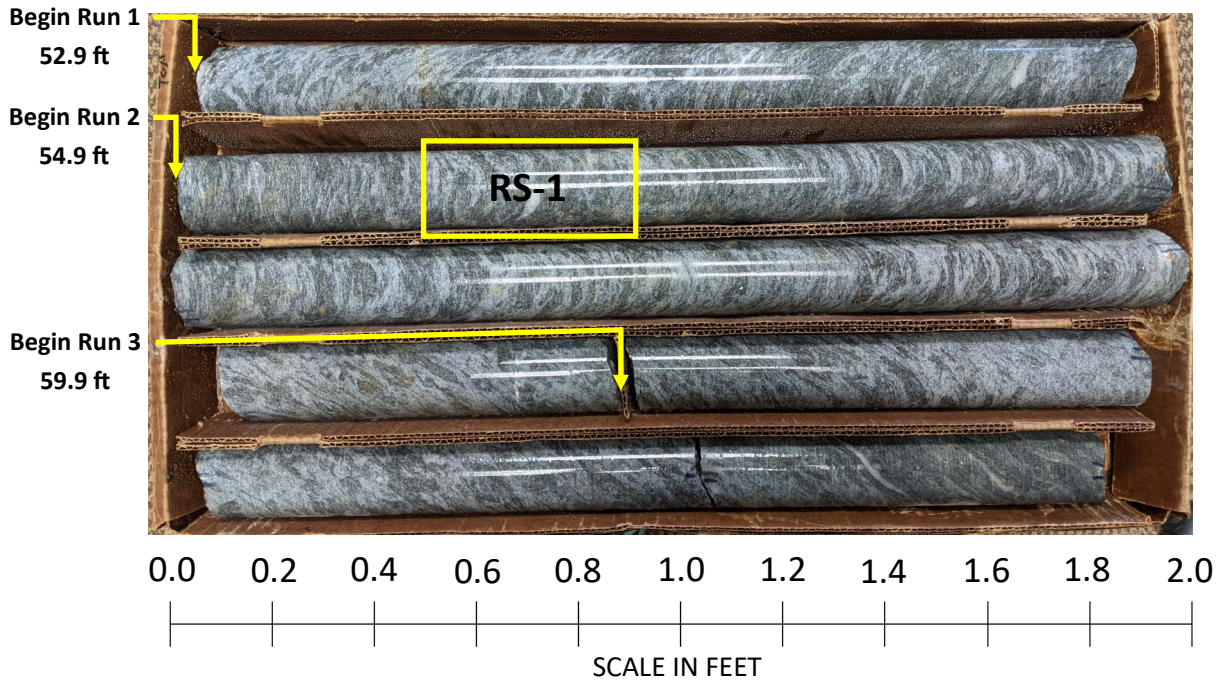
ELEV (ft)	RUN ELEV (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
2665.4											ELEV. (ft)
2665											DEPTH (ft)
											Begin Coring @ 52.9 ft
	2,665.4	52.9	2.0	2:07/1.0	(2.0)	(2.0)		(22.0)	(22.0)		2,665.4 **CRYSTALLINE ROCK** 52.9
	2,663.4	54.9		1:37/1.0	100%	100%		100%	100%		Fresh, Hard, White-Green BIOTITE/HORNBLENDE GNEISS with Wide Fracture Spacing
			5.0	1:44/1.0	(5.0)	(5.0)	RS-1				
				1:47/1.0	100%	100%					REC = 100%, RQD = 100%, GSI = 85 - 90
2660				1:49/1.0							
	2,658.4	59.9		1:52/1.0							RS-1: 55.4' - 55.8'
			5.0	1:50/1.0	(5.0)	(5.0)					Unit Weight = 173.2 pcf
				1:35/1.0							Unconfined Compressive Strength = 10,248 psi / 1,476 ksf
				1:43/1.0	100%	100%					
2655				1:52/1.0							RS-2: 68.8' - 69.2'
				1:59/1.0							Unit Weight = 173.8 pcf
	2,653.4	64.9		2:02/1.0							Unconfined Compressive Strength = 8,845 psi / 1,274 ksf
			5.0	1:59/1.0	(5.0)	(5.0)					
				1:48/1.0	100%	100%					
2650				1:56/1.0							
				1:42/1.0							
	2,648.4	69.9		1:50/1.0			RS-2				
			5.0	1:44/1.0	(5.0)	(5.0)					
				1:53/1.0	100%	100%					
2645				1:36/1.0							
				1:40/1.0							
	2,643.4	74.9		1:44/1.0							2,643.4 74.9
											Boring Terminated at Elevation 2,643.4 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

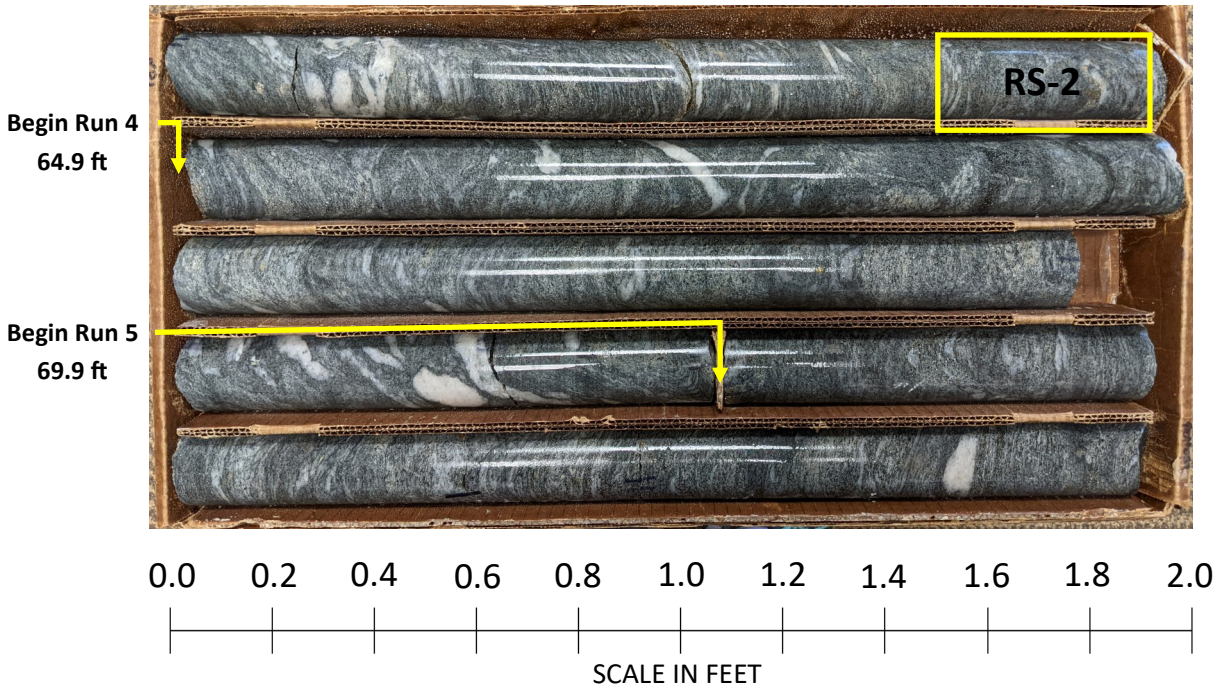
Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609

Project ID: BP11.R003.1

Rock Core Photographs: Boring - B1-A

Station: 16+22 Offset: 26 ft LT



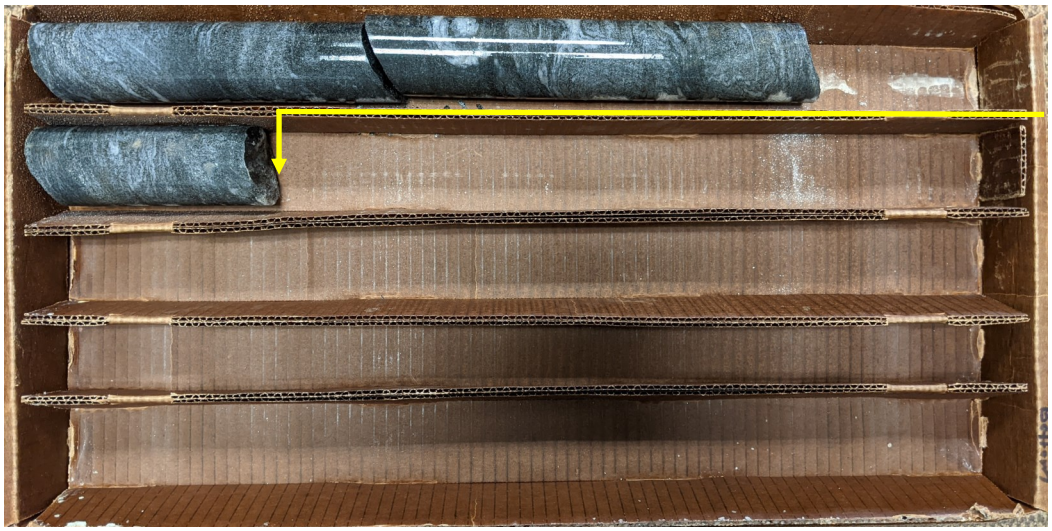


Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609

Project ID: BP11.R003.1

Rock Core Photographs: Boring - B1-A

Station: 16+22 Offset: 26 ft LT



GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609			**GROUND WTR (ft)**
BORING NO. B1-B	**STATION** 16+25	**OFFSET** 15 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,718.9 ft	**TOTAL DEPTH** 28.8 ft	**NORTHING** 977,667	**EASTING** 1,328,040	**24 HR.** 0.5
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/14/22	**COMP. DATE** 07/14/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2720											
	2,718.9	0.0	1	0	1	1		W		2,718.9 GROUND SURFACE	0.0
										ALLUVIAL Very Loose, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)	
2715	2,715.4	3.5	2	1	2	3		Sat.		2,713.4	5.5
	2,712.9	6.0	1	1	1	2		Sat.		Very Soft to Soft, Brown-Black, Fine to Coarse Sandy SILT (A-4), with trace mica	
2710	2,710.4	8.5	3	0	1	1		Sat.		2,706.9	12.0
2705	2,705.4	13.5	9	15	16	31		W		**RESIDUAL** Hard, Gray-Black, Fine to Coarse SandySILT (A-4), with some mica	
2700	2,700.4	18.5	100/0.3			100/0.3				2,700.4 **WEATHERED ROCK** Gray-Brown (BIOTITE/HORNBLENDE GNEISS)	18.5
2695	2,695.4	23.5	100/0.2			100/0.2					
	2,690.4	28.5	100/0.3			100/0.3				2,690.1 Boring Terminated at Elevation 2,690.1 ft In Weathered Rock (BIOTITE/HORNBLENDE GNEISS)	28.8

NCDOT BORE SINGLE BRIDGE063_GEO_GTM.GPJ NC_DOT.GDT 9/6/22

GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. B2-A	**STATION** 17+08	**OFFSET** 26 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,715.9 ft	**TOTAL DEPTH** 18.1 ft	**NORTHING** 977,733	**EASTING** 1,328,091	**24 HR.** 2.3
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER J. Cain	**START DATE** 07/13/22	**COMP. DATE** 07/13/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
2720										
	2,715.9	0.0								2,715.9 GROUND SURFACE 0.0
2715			3	2	3	5		M		**ALLUVIAL** Medium Stiff, Brown, Fine to Coarse Sandy SILT (A-4), with trace cobbles
	2,712.4	3.5	4	7	6	13		Sat.		2,712.9 3.0 Medium Dense, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)
2710	2,709.9	6.0	6	3	4	7		Sat.		2,710.4 5.5 Loose, Gray-Brown, Silty Fine to Coarse SAND (A-2-4), with some cobbles
	2,707.4	8.5	3	4	11	15		W		2,707.4 8.5 **RESIDUAL** Very Stiff to Hard, Brown-Tan-Gray, Fine to Coarse Sandy SILT (A-4), with trace mica
2705										
	2,702.4	13.5	11	22	26	48		W		
2700										
	2,697.9	18.0	60/0.1			60/0.1				2,697.9 18.0 2,697.8 18.1 **CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS) Boring Terminated with Standard Penetration Test Refusal at Elevation 2,697.8 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609			**GROUND WTR (ft)**
BORING NO. B2-B	**STATION** 17+15	**OFFSET** 15 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,715.6 ft	**TOTAL DEPTH** 39.2 ft	**NORTHING** 977,730	**EASTING** 1,328,104	**24 HR.** 1.1
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** Core Boring	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/12/22	**COMP. DATE** 07/12/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
										ELEV. (ft) DEPTH (ft)
2720										
2715	2,715.6	0.0								2,715.6 GROUND SURFACE 0.0
			1	4	6	10		Sat.		**ALLUVIAL** Loose to Medium Dense, Brown-White-Tan, Silty Fine to Coarse SAND (A-2-4), with some cobbles
	2,712.1	3.5	7	10	10	20				
2710	2,709.6	6.0	6	8	4	12		Sat.		
	2,707.1	8.5	2	3	4	7		Sat.		
2705										2,703.1 12.5
	2,702.1	13.5	4	7	7	14		W		**RESIDUAL** Medium Dense, Brown-Tan, Fine to Coarse Sandy SILT (A-4), with trace mica
2700	2,698.4	17.2	60/0.0			60/0.0				2,698.4 17.2
2695							RS-3			**CRYSTALLINE ROCK** Fresh, Hard, White-Green BIOTITE/HORNBLENDE GNEISS with Wide Fracture Spacing
2690										REC = 100%, RQD = 100%, GSI = 85 - 90
2685							RS-4			
2680										2,676.4 39.2
										Boring Terminated at Elevation 2,676.4 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

GEOTECHNICAL BORING REPORT
CORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609			**GROUND WTR (ft)**
BORING NO. B2-B	**STATION** 17+15	**OFFSET** 15 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,715.6 ft	**TOTAL DEPTH** 39.2 ft	**NORTHING** 977,730	**EASTING** 1,328,104	**24 HR.** 1.1
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** Core Boring	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/12/22	**COMP. DATE** 07/12/22	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ-2	**TOTAL RUN** 22.0 ft			

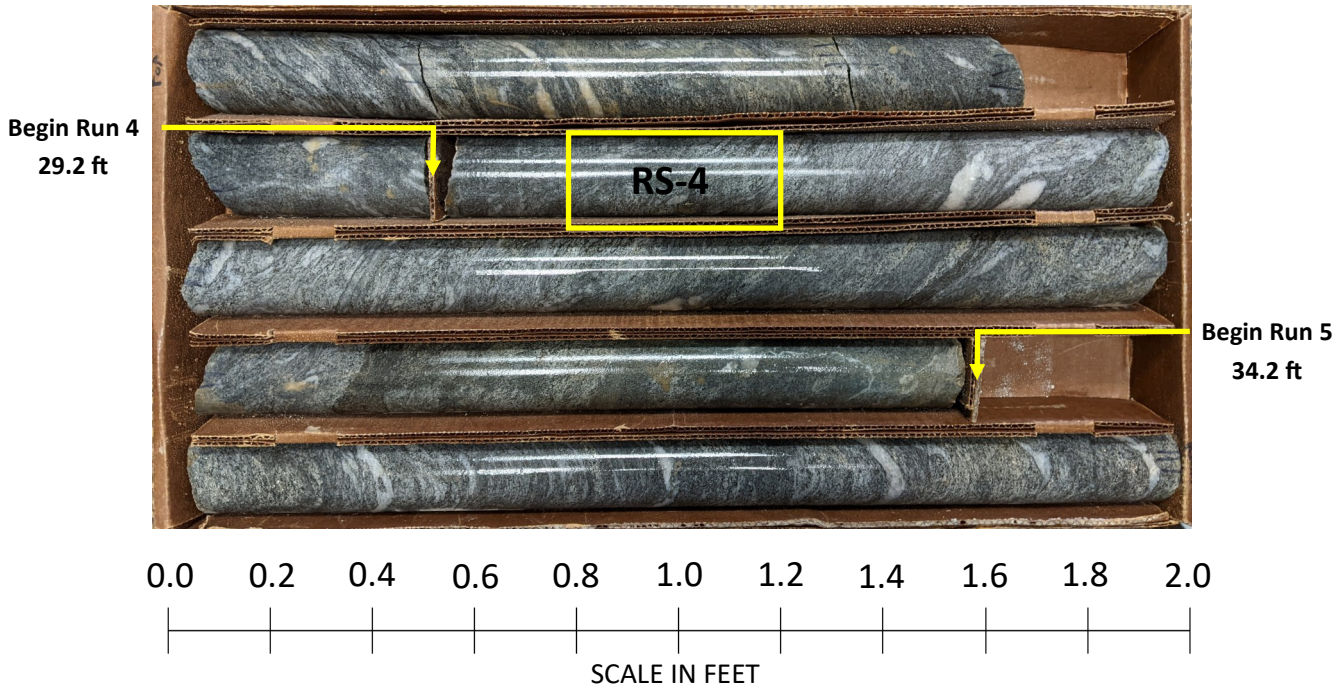
ELEV (ft)	RUN ELEV (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
2698.4											Begin Coring @ 17.2 ft
	2,698.4	17.2	2.0	4:07/1.0	(2.0) 100%	(2.0) 100%		(22.0) 100%	(22.0) 100%		2,698.4 **CRYSTALLINE ROCK** 17.2
	2,696.4	19.2		*N=60/0.0*							Fresh, Hard, White-Green BIOTITE/HORNBLENDE GNEISS with Wide Fracture Spacing
2695			5.0	4:07/1.0							
				3:21/1.0	(5.0) 100%	(5.0) 100%	RS-3				REC = 100%, RQD = 100%, GSI = 85 - 90
				2:18/1.0							
				2:05/1.0							RS-3: 20.0' - 20.4'
				2:15/1.0							Unit Weight = 174.3 pcf
				1:55/1.0							Unconfined Compressive Strength = 10,724 psi / 1,544 ksf
	2,691.4	24.2		2:24/1.0							
2690			5.0	1:26/1.0	(5.0) 100%	(5.0) 100%					RS-4: 29.6' - 30.0'
				1:26/1.0							Unit Weight = 174.3 pcf
				1:19/1.0							Unconfined Compressive Strength = 7,257 psi / 1,045 ksf
				1:31/1.0							
	2,686.4	29.2		1:22/1.0							
2685			5.0	1:21/1.0	(5.0) 100%	(5.0) 100%	RS-4				
				1:28/1.0							
				1:34/1.0							
				1:25/1.0							
	2,681.4	34.2		1:07/1.0							
2680			5.0	1:29/1.0	(5.0) 100%	(5.0) 100%					
				1:18/1.0							
				1:52/1.0							
				1:43/1.0							
	2,676.4	39.2		1:38/1.0							2,676.4 39.2
											Boring Terminated at Elevation 2,676.4 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609

Project ID: BP11.R003.1

Rock Core Photographs: Boring - B2-B

Station: 17+15 Offset: 15 ft LT

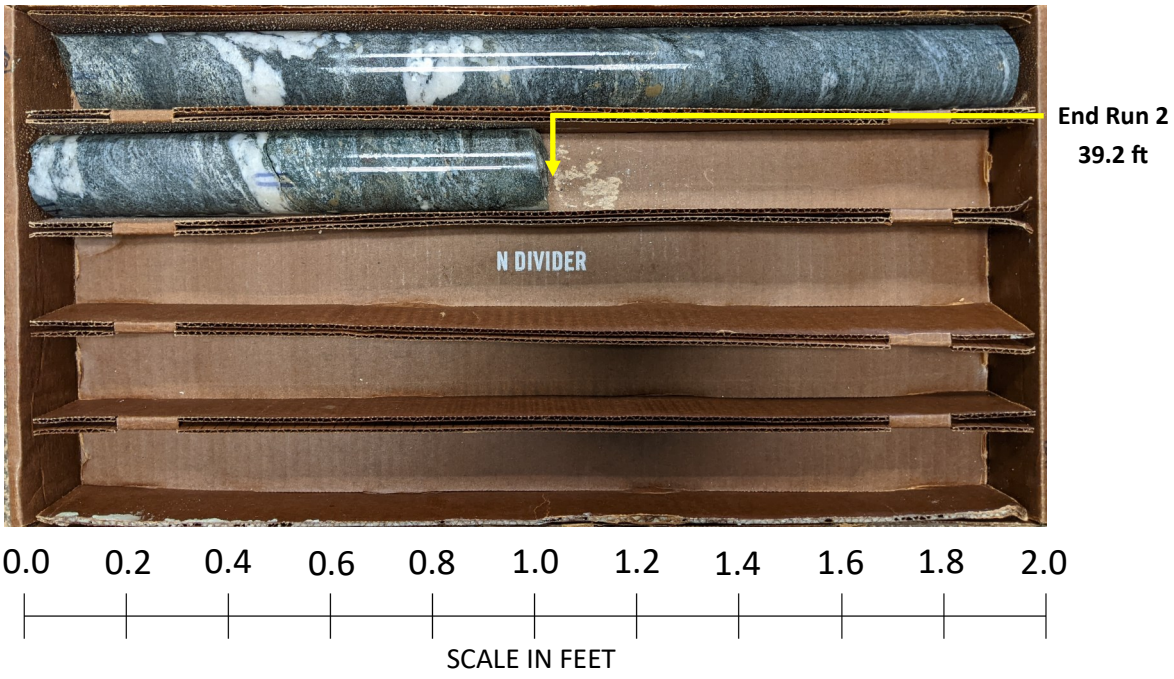


Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609

Project ID: BP11.R003.1

Rock Core Photographs: Boring - B2-B

Station: 17+15 Offset: 15 ft LT



GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 17+45	**OFFSET** 27 ft LT	**ALIGNMENT** -L-	**0 HR.** 16.2
COLLAR ELEV. 2,727.6 ft	**TOTAL DEPTH** 23.6 ft	**NORTHING** 977,760	**EASTING** 1,328,117	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/11/22	**COMP. DATE** 07/11/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2730											
										2,727.6 GROUND SURFACE	0.0
	2,726.6	1.0								2,726.6 **ROADWAY EMBANKMENT** Asphalt 1.0'	1.0
2725			9	5	3	8		M		Soft to Stiff, Brown-Tan-Gray, Fine to Coarse Sandy SILT (A-4), with trace rock fragments and trace mica	
	2,724.1	3.5	2	1	2	3		W			
	2,721.6	6.0									
2720			2	2	1	3		M			
	2,719.1	8.5	3	3	6	9		W			
2715											
	2,714.1	13.5	1	0	1	1		W		2,714.1 **ALLUVIAL** Very Soft, Black, Fine to Coarse Sandy SILT (A-4), with trace mica	13.5
2710											
	2,709.1	18.5	6	17	42	59		M		2,709.6 **RESIDUAL** Hard, Gray-White, Fine to Coarse Sandy SILT (A-4), with trace mica and trace rock fragments	18.0
2705											
	2,704.1	23.5	60/0.1			60/0.1				2,704.1	23.5
										2,704.0 **CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS)	23.6
										Boring Terminated with Standard Penetration Test Refusal at Elevation 2,704.0 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)	
										Notes: Cobbles layer encountered while drilling at 17 ft.	

GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB2-B	**STATION** 17+54	**OFFSET** 14 ft LT	**ALIGNMENT** -L-	**0 HR.** 15.1
COLLAR ELEV. 2,727.6 ft	**TOTAL DEPTH** 19.8 ft	**NORTHING** 977,757	**EASTING** 1,328,132	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/11/22	**COMP. DATE** 07/11/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2730											
										2,727.6 GROUND SURFACE	0.0
	2,726.5	1.1								2,726.5 **ROADWAY EMBANKMENT**	1.1
2725			3	2	4	6		M		Asphalt 0.7'	
	2,724.1	3.5								2,724.6 Stone 0.4'	3.0
			3	5	2	7		M		Loose, Brown, Silty Fine to Coarse SAND (A-2-4), with trace rock fragments	
	2,721.6	6.0									
2720			2	2	3	5		M		Soft to Medium Stiff, Brown, Fine to Coarse Sandy SILT (A-4), with trace rock fragments	
	2,719.1	8.5									
			2	2	2	4		W			
2715										2,715.1	12.5
	2,714.1	13.5								**ALLUVIAL**	
			1	1	2	3		W		Soft, Black, Fine to Coarse Sandy SILT (A-4), with trace mica and wood	
2710											
	2,709.1	18.5								2,709.1	18.5
	2,707.8	19.8	47	53/0.4		100/0.9				2,707.8 **WEATHERED ROCK**	19.8
			60/0.0			60/0.0				(BIOTITE/HORNBLENDE GNEISS) Gray	
										Boring Terminated with Standard Penetration Test Refusal at Elevation 2,707.8 ft On Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)	

SUPPORTING DOCUMENTATION

From: Melvin, Laura E
To: Kelly N. de Montbrun, P.E.
Cc: Saucier, Stephen L.; Honeycutt, Nikki T.; Griscom, Jason
Subject: [EXTERNAL] RE: BP11.R003.1 Approved BSR for Geotech Recs
Date: Wednesday, July 20, 2022 5:33:04 PM
Attachments: image001.jpg
401_001_BP11.R003.1_SMU_PGD1_001_040063.pdf
Drilled Pier Loads.pdf
End Bent Loads_CSSP.pdf

Kelly,

I have attached the PGD as well as the standard NCDOT pier and pile loads that I've marked up to increase to account for the extra weight due to the concrete overlay and the 24" cored slabs on the 40' end spans instead of the standard 21" cored slabs.
See below for bottom of cap elevations. Note that because the bridge is superelevated, bottom of cap elevations are an average. Also note that I have top of drilled pier elevations on the PGD, which make all the columns at Bent 1 11'-0" tall and all the columns at Bent 2 8'-3" tall.
End Bent 1: 2722.0
Bent 1: 2722.8
Bent 2: 2722.5
End Bent 2: 2721.3

Please let us know if there's anything else you need. Thank you!

Laura Melvin, PE
STV Engineers, Inc.
Direct: (704) 319-5094
Office: (704) 372-1885
900 W Trade St, Suite 715
Charlotte, NC 28202

From: Kelly N. de Montbrun, P.E. <KdeMontbrun@ecslimited.com>
Sent: Monday, July 18, 2022 2:49 PM
To: Honeycutt, Nikki T. <Nikki.Honeycutt@stvinc.com>
Cc: Saucier, Stephen L. <Stephen.Saucier@stvinc.com>; 4021458 <4021458@stvinc.com>; Michael Walko <mwalko@ecslimited.com>
Subject: RE: BP11.R003.1 Approved BSR for Geotech Recs

Thanks Nikki. We finished the drilling for this bridge last week. We'll do a couple rock breaks this week/next week. We'll just need cap elevations, loads, and PGD to prepare the geotechnical recommendations.

Thanks,
Kelly

KELLY N. DE MONTBRUN, P.E. | Senior Project Engineer

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KdeMontbrun@ecslimited.com | www.ecslimited.com

CHARLOTTE'S BEST AND BRIGHTEST COMPANIES TO WORK FOR 2022 WINNER

Instagram | LinkedIn | Facebook | Twitter

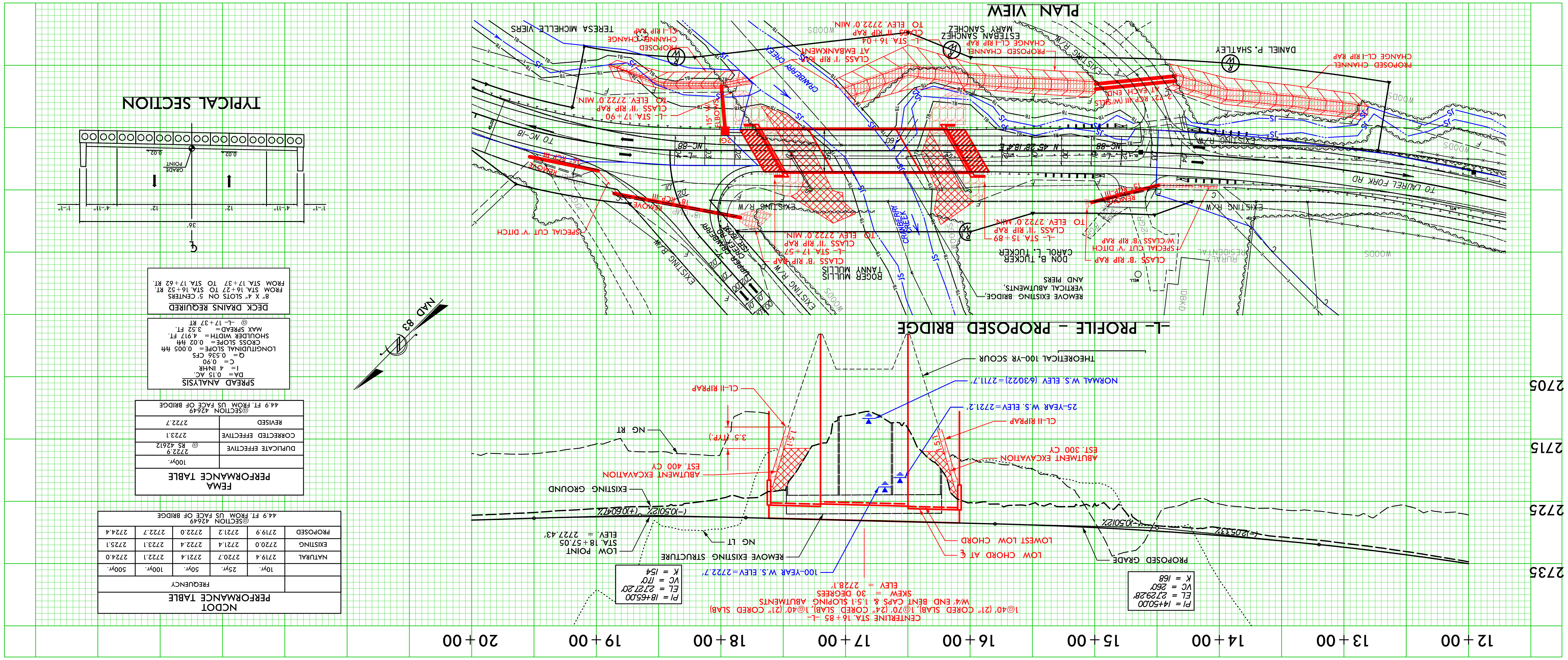
From: Honeycutt, Nikki T. <Nikki.Honeycutt@stvinc.com>
Sent: Monday, July 18, 2022 2:45 PM
To: Michael J Walko, P.E. <MWalko@ecslimited.com>; Kelly N. de Montbrun, P.E. <KdeMontbrun@ecslimited.com>
Cc: Saucier, Stephen L. <Stephen.Saucier@stvinc.com>; 4021458 <4021458@stvinc.com>
Subject: [EXTERNAL] BP11.R003.1 Approved BSR for Geotech Recs

Mike and Kelly,

We have an approved BSR for BP11.R003, so you can proceed with the geotechnical recommendations. Stephen can send you the electronic files for the project for your use. Let us know if you have any questions.

Thank you,

Nikki Honeycutt, PE
Senior Associate | Engineering Director – Highways
STV Engineers, Inc.
Office: (704) 372-1885
Direct: (704) 816-2512
Cell: (704) 604-2374



INFORMATION TO BE SHOWN ON PLANS

WS EL. Taken @ River Station 42649

	Discharge		Frequency		Elev.	
Design:	4000	c.f.s.	25	yr.	2721.2	ft.
Base Flood:	5588	c.f.s.	100	yr.	2722.7	ft.
Overtopping:	11500	c.f.s.	500+	yr.	2727.3	ft.

OVERTOPPING OCCURS @ -L- STA. 18+57.05 PROPOSED ROADWAY

ADDITIONAL INFORMATION AND COMPUTATIONS

BED MATERIAL IS SAND, GRAVEL & COBBLE, BANKS ARE STEEP, WELL VEGETATED AND STABLE

RURAL BLUE RIDGE SIR 2009-5158 — FIS /FEMA FLOWS

$Q_{10} = 288\ (24.6)^{0.756} = 3042$ SAY 3000 CFS

$Q_{25} = 398\ (24.6)^{0.724} = 4045$ SAY 4000 CFS

$Q_{50} = 479\ (24.6)^{0.718} = 4776$ SAY 4800 CFS

$Q_{100} = 575\ (24.6)^{0.713} = 5642$ SAY 5600 CFS — FEMA Q_{100} = 5588 CFS

$Q_{500} = 794\ (24.6)^{0.704} = 7569$ SAY 7600 CFS

NOTE: USE USGS FLOWS FOR DESIGN AND FEMA FLOWS FOR COMPLIANCE

(100-YEAR) CONTRACTION SCOUR:

$Y_2 = Y_1 [Q_2/Q_1]^{6/7} [W_1/W_2]^{K1}$ — $Y_2 = 11.89\ [4584.08/3138.13]^{6/7}\ [37.20/37.20]^{0.69}$

$Ys = Y_2 - Yo$ — $Ys = 16.45 - 9.69 = 6.76'$ SAY 6.8'

(100-YEAR) LOCAL SCOUR: (CSU EQUATION)

$Ys = 2.0(K_1)(K_2)(K_3)(a)^{0.65} (Y_1)^{0.35} (Fr_1)^{0.43}$ — $Ys = 2.0(1.0)(1.0)(1.1)(2.5)^{0.65} (11.59)^{0.35} (0.303)^{0.43}$

Ys= ? — Ys= 5.63' SAY 5.6'

NO STRUCTURES UPSTREAM OR DOWNSTREAM THAT WERE IN PLACE AT THE TIME THIS PROJECT WAS DESIGNED WILL BE ADVERSELY IMPACTED

*ACCORDING TO INFORMATION PROVIDED BY CHAD COX, NCDOT BRIDGE MAINTENANCE ENGINEER, THERE ARE NO INCIDENTS WITH OVERTOPPING OR DEBRIS.

SITE DATA

Drainage Area 24.6 SQ. MILES — Source USGS STREAMSTATS

River Basin NEW — Character RURAL REGION 2

Stream Classification (Such as Trout, High Quality Water, etc.) B, Tr, +

Data on Existing Structure RC DECK GIRDERS (1@41'-1", 1@42'-6", 1@41'-1") W/VERT. CONCRETE ABUTMENTS

OAL = 125' — Total Waterway Opening 945 s.f.

Waterway Opening Below 100yr. WS EL. 824 s.f.

Debris Potential: Low X Moderate .... High ....

Data on Structures Up and Down Stream

US: TIMBER FLOOR ON I-BEAMS W/VERTICAL ABUTMENTS (040114) (1@30'-9") OAL=31'

DS: TIMBER FLOOR ON I-BEAMS W/CONCRETE PIER AND VERTICAL ABUTMENTS (040183) (2@24'-11") OAL=50'

Design Control Elev. 2723.1 ft.(CORRECTED EFFECTIVE 100-YR WSEL @ RS 42649)

Gage Station No. N/A — Period of Records N/A yrs.

Max. Discharge N/A c.f.s. Date N/A Frequency N/A

Historical Flood Information: CHAD COX ASHE COUNTY BRIDGE MAINTENANCE SUPERVISOR

Date N/A Elev. N/A ft. Est. Freq. N/A yr. Source CHAD COX ASHE COUNTY BRIDGE MAINTENANCE SUPERVISOR Period of Knowledge .... yrs.

Date .... Elev. .... ft. Est. Freq. .... yr. Source .... Period of Knowledge .... yrs.

Date .... Elev. .... ft. Est. Freq. .... yr. Source .... Period of Knowledge .... yrs.

Historical Scour Info. : General N/A ft. Contraction N/A ft. Local N/A ft.

Channel Slope 0.0028 ft/ft Source LiDAR — Normal Water Surface Elev. 2711.7 (6/30/2021) ft.

Manning's n: Left O.B. 0.08-0.15 Channel .04 Right O.B. 0.08 Source FIS/FIELD VERIFIED

Flood Study /Status LIMITED (ASHE CO. FIS 11/4/2009 PANEL: 3927) — Non-Encroachment Established? NO

Flood Study 100yr. Discharge 5588 c.f.s. WS Elev.: With Non-Encroachment 2722.9 ft. Non-Encroachment Without 2722.9 ft. @ River Station 42612

DESIGN DATA

Hydrological Method USE SIR 2009-5158 FOR DESIGN, USE FEMA FOR COMPLIANCE

Hydraulic Design Method HEC-RAS 6.0.0 (SF-040063 CRANBERRY CREEK NC-88)

Floods Evaluated: @ River Station 42649

Freq. (yr.)	Q (c.f.s.)	Elev. (ft.)	Backwater (ft.)	Bridge Opening Velocity (f.p.s.)
10	3000	2719.9	0.5	6.1
25	4000	2721.2	0.5	6.4
50	4800	2722.0	0.6	6.8
100	5588	2722.7	0.6	7.3
500	7600	2724.4	0.4	8.0

Waterway Opening Provided Below Design W.S. Elev. 727 s.f., 100yr W.S. Elev. 886 s.f., Total 1268 s.f.

Average Channel Velocity (Design) 4.8 f.p.s. Average Overbank Velocity (Design) 1.6 f.p.s.

Computed Scour : General N/A ft. Contraction 6.8 ft. Local 5.3 ft.

Is a Floodway Revision Required? NO (MOA TYPE A, DECREASE OF 0.2' @ RS 42649)

BRIDGE SURVEY & HYDRAULIC DESIGN REPORT

N. C. DEPARTMENT OF TRANSPORTATION
DIVISION OF HIGHWAYS
HYDRAULICS UNIT
RALEIGH, N. C.

I.D. No. SF-040063 — Project No. BP11.R003.1 — Proj. Station -L- 16+85

County ASHE — Bridge Over CRANBERRY CREEK — Bridge Inv. No. 063

On Highway NC-88 — Between SR 1614 (LAUREL FORK RD) and SR 1609 (UPPER CRANBERRY CREEK RD)

Recommended Structure 1@40' (21" CORED SLAB), 1@70' (24" CORED SLAB), 1@40' (21" CORED SLAB) W/ CONC. OVERLAY, 4' END BENT CAPS, AND 1.5:1 SLOPING ABUTMENTS AND 3.5' VERTICAL CONCRETE BARRIER RAIL

Recommended Width of Roadway 33'-10" CLEAR ROADWAY — Skew 60 DEGREES

Recommended Location is (Up) At, Down) Stream from Existing Crossing, 18' UPSTREAM OF EXISITNG BRIDGE

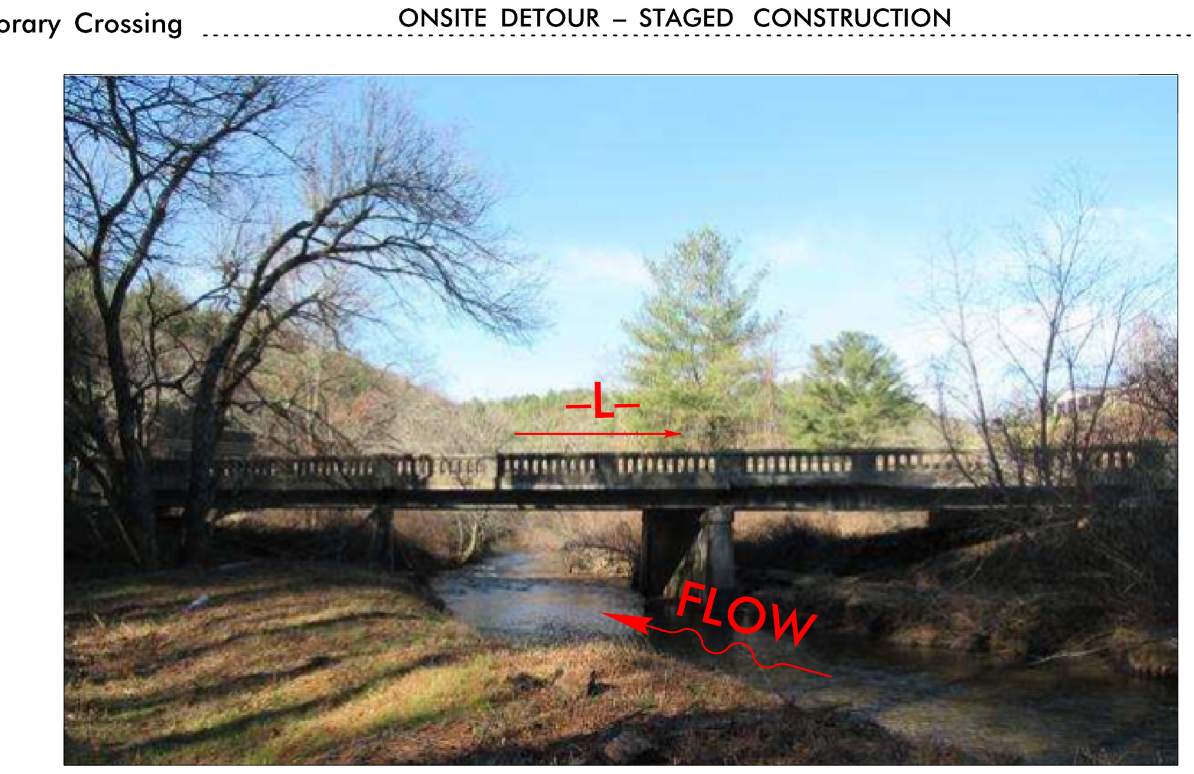
Latitude 36.41497 — Longitude -81.28344

Statewide Tier ☐ — Regional Tier ☒ — Sub-Regional Tier ☐

Bench Mark is BM-1, -L- STA. 24+96.11, 28.3' RT, RAILROAD SPIKE SET IN 15" CHERRY TREE

Northing 977872 — Easting 1328813 — Elev. 2722.76 ft. Datum: NAVD 88

Temporary Crossing ONSITE DETOUR - STAGED CONSTRUCTION



Designed by: PETER WALDRON, PE STV ENGINEERS, INC. (LICENSE NO. F-0991)

Assisted by: EDWARD VANCE, PE — Date 4/15/2022

Project Engineer : NIKKI HONEYCUTT, P.E.

Reviewed by:

SEAL 049956 — ENGINEER — PETER B. WALDRON

Stream CRANBERRY CREEK Struc. Inv. No. 063 I.D. No. SF-040063 Project No. BP11.R003.1 PDF File 040063_2022_SF-040063_CRANBERRYCREEK_NC88.PDF

16+00 16+50 17+00 17+50 18+00 18+50

VERTICAL CURVE DATA -L-

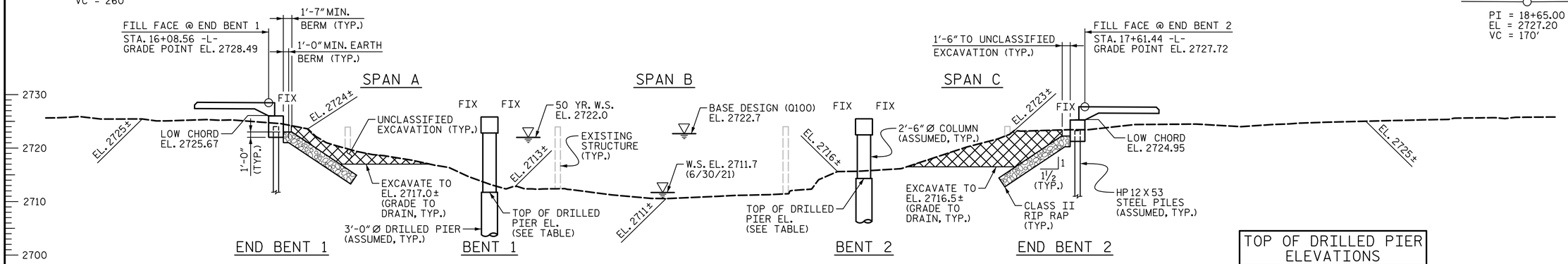
(-)2.0533% (-)0.5012%

PI = 14+50.00
EL = 2729.28
VC = 260'

VERTICAL CURVE DATA -L-

(-)0.5012% (+)0.6047%

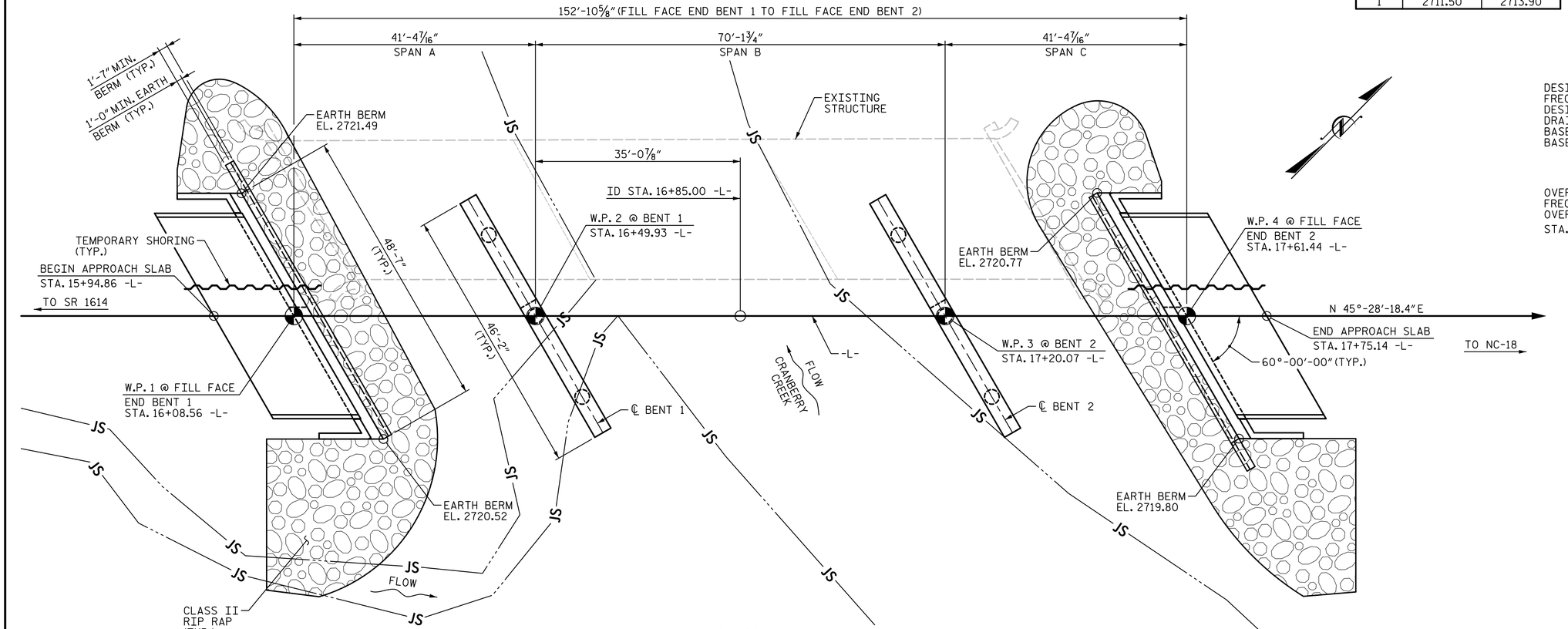
PI = 18+65.00
EL = 2727.20
VC = 170'



SECTION ALONG -L-

BENTS ON SECTION AT RIGHT ANGLES TO BENTS

TOP OF DRILLED PIER ELEVATIONS		
NO.	BENT 1	BENT 2
1	2712.14	2714.54
1	2711.82	2714.22
1	2711.50	2713.90



PLAN

(STEEL PILES NOT SHOWN FOR CLARITY)

HYDRAULIC DATA

DESIGN DISCHARGE: 4,800 CFS
FREQUENCY OF DESIGN FLOOD: 50 YRS.
DESIGN HIGH WATER ELEVATION: 2722.0
DRAINAGE AREA: 24.6 SQ. MI.
BASE DISCHARGE (Q100): 5588 CFS
BASE HIGH WATER ELEVATION: 2722.7

OVERTOPPING DATA

OVERTOPPING DISCHARGE: 11,500 CFS
FREQUENCY OF OVERTOPPING: 500 + YRS.
OVERTOPPING FLOOD ELEVATION: 2727.3
STA. 18+57.05 -L- PROPOSED ROADWAY APPROACH

PROJECT NO. BP11.R003.1
ASHE COUNTY
STATION: 16+85.00 -L-

SHEET 1 OF 2 REPLACES BRIDGE NO. 063

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
RALEIGH

PRELIMINARY GENERAL DRAWING

FOR BRIDGE ON NC-88
OVER CRANBERRY CREEK
BETWEEN SR 1614 AND SR 1609

STV 100 Years
STV ENGINEERS, INC.
900 West Trade St., Suite 715
Charlotte, NC 28202
NC License Number F-0991

DOCUMENT NOT CONSIDERED FINAL UNLESS ALL SIGNATURES COMPLETED

REVISIONS					
NO.	BY:	DATE:	NO.	BY:	DATE:
1			3		
2			4		

SHEET NO. S-1
TOTAL SHEETS 4

DRAWN BY : LEM DATE : 4-22
CHECKED BY : MLO DATE : 7-22
DESIGN ENGINEER OF RECORD : JTG DATE : 11-22

melvinle 7/20/2022 4:20:53 PM R:\Structures\Ustation\Preliminary Plans\40I_001_BP11R003.1_SMU_PGDI_001_040063.dgn

End Bent Geometry and Loads (Cored Slabs)

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 + 8 = 130	61 + 4 = 65
	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

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"

Column on Drilled Pier
Controlling Column Factored Loads

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

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

+20 kips = -810 k

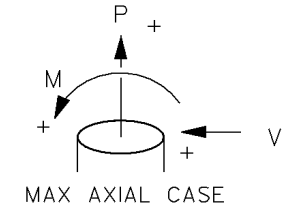
+20 kips = 500 k

+20 kips = -510 k

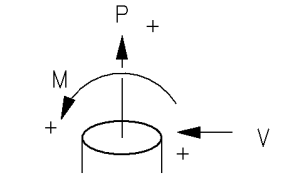
$$\text{Average CS Unit Length on Cap} = \frac{\text{CS Unit Length Before Cap} + \text{CS Unit Length After Cap}}{2}$$

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

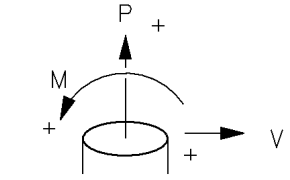
Bridge Width	Skew	Cap Length	Column Dia.	Drilled Pier Dia.	No. of Cols `X'	Cols Spa. `Y'
27'	60/120	35'-10"	2'-6"	3'-0"	3	13'-0"
	75/105	31'-6"	2'-6"	3'-0"	3	12'-0"
	90	29'-6"	2'-6"	3'-0"	3	11'-0"
30'	60/120	39'-4"	2'-6"	3'-0"	3	14'-0"
	75/105	34'-6"	2'-6"	3'-0"	3	13'-0"
	90	32'-6"	2'-6"	3'-0"	3	12'-0"
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"

GEOTECHNICAL BORING REPORT
BORE LOG

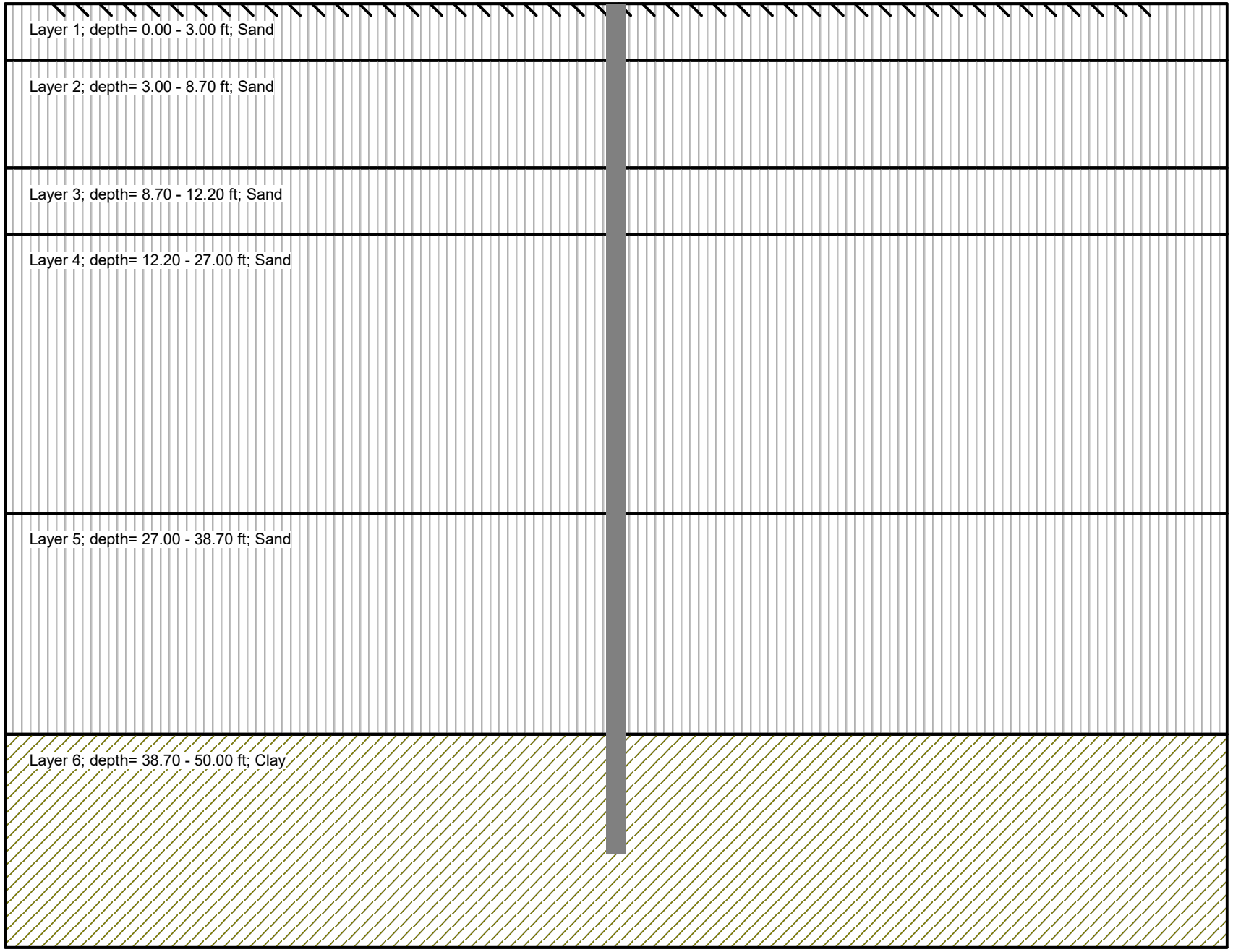
WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB1-A	**STATION** 15+93	**OFFSET** 28 ft LT	**ALIGNMENT** -L-	**0 HR.** 17.3
COLLAR ELEV. 2,727.3 ft	**TOTAL DEPTH** 55.2 ft	**NORTHING** 977,654	**EASTING** 1,328,007	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER J. Cain	**START DATE** 07/12/22	**COMP. DATE** 07/12/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
									Avg BOC = 2722.0
	2,727.3	0.0							GROUND SURFACE
	2,726.6	0.7	3	6	5		M		ROADWAY EMBANKMENT Asphalt 0.5' Stone 0.2'
2725	2,723.8	3.5	8	6	5		M		Medium Stiff to Very Stiff, Brown-Tan, Fine to Coarse Sandy SILT, with trace mica and rock fragments
	2,721.3	6.0	2	2	3		M		BOC γ=120 ϕ=28
2720	2,718.8	8.5	4	16	4	3	W		2719
									γ=120 ϕ=32
2715	2,713.8	13.5	1	1	7	87	W		2,713.3 14.0
									ALLUVIAL Medium Stiff, Black, Fine to Coarse Sandy SILT (A-4), with trace roots and mica
2710	2,708.8	18.5	3	4	3	12.2	W		2,709.8 17.5 RESIDUAL Medium Stiff to Hard, Brown-Orange-Gray-Tan, Fine to Coarse Sandy SILT (A-4), with trace to some mica
									γ=120 ϕ=30
2705	2,703.8	23.5	1	4	6		W		
2700	2,698.8	28.5	8	10	12		W		
									2695
2695	2,693.8	33.5	39	47	48	27	W		
2690	2,688.8	38.5	17	18	39		W		
									γ=120 ϕ=34
2685	2,683.8	43.5	17	44	56/0.4	38.7			2,683.3 44.0
									WEATHERED ROCK (BIOTITE/HORNBLENDE GNEISS) Brown-Gray
2680	2,678.8	48.5	30	38	37		M		2,679.8 47.5 RESIDUAL Hard, Brown-Gray, Fine to Coarse Sandy SILT (A-4)
2675	2,673.8	53.5	100/0.2						2,673.8 53.5 100/0.2
	2,672.2	55.1	60/0.1						60/0.1 2,672.2 55.1 WEATHERED ROCK (BIOTITE/HORNBLENDE GNEISS) Brown-Gray
	2,672.1	55.2							CRYSTALLINE ROCK (BIOTITE/HORNBLENDE GNEISS) Boring Terminated with Standard Penetration Test Refusal at Elevation 2,672.1 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

Avg Pile Length = 45 ft

Notes:
Shot rock encountered at 4 ft. Boring offset 4 ft and continued.

End Bent No. 1 - L I



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APILE for Windows, Version 2019.9.10

Serial Number : 562476398

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

==========

This program is licensed to :

ECS Carolinas, LLP
Charlotte, NC, USA

Path to file locations : C:\Users\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500-29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\APile\
Name of input data file : EB1- LT.ap9d
Name of output file : EB1- LT.ap9o
Name of plot output file : EB1- LT.ap9p

Time and Date of Analysis

Date: September 08, 2022 Time: 08:26:05

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****
* INPUT INFORMATION *
****

Bridge No. 063 over Cranberry Creek

DESIGNER : KND

JOB NUMBER : 09:29662

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

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 = 45.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 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	Nq FACTOR FHWA
0.00	SAND	0.80*	120.00	28.00	22.80**
3.00	SAND	0.80*	120.00	28.00	22.80**
3.00	SAND	0.80*	120.00	32.00	40.40**
8.70	SAND	0.80*	120.00	32.00	40.40**
8.70	SAND	0.80*	120.00	30.00	30.00**
12.20	SAND	0.80*	120.00	30.00	30.00**
12.20	SAND	0.80*	57.60	30.00	30.00**
27.00	SAND	0.80*	57.60	30.00	30.00**
27.00	SAND	0.80*	57.60	34.00	55.60**
38.70	SAND	0.80*	57.60	34.00	55.60**

38.70	CLAY	0.80*	100.00	0.00	4.80**
50.00	CLAY	0.80*	100.00	0.00	4.80**

* 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
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*	200.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	200.00	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
3.00	1.000	1.000
3.00	1.000	1.000
8.70	1.000	1.000
8.70	1.000	1.000
12.20	1.000	1.000
12.20	1.000	1.000
27.00	1.000	1.000
27.00	1.000	1.000
38.70	1.000	1.000
38.70	1.000	1.000
50.00	1.000	1.000

1

****
* COMPUTATION RESULT *

****

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

PILE PENETRATION FT.	SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.1	0.1
1.00	0.1	0.2	0.2
2.00	0.2	0.5	0.7
3.00	0.6	0.8	1.4
4.00	1.1	1.2	2.3
5.00	1.9	1.6	3.5
6.00	2.8	2.0	4.7
7.00	3.9	2.3	6.2
8.00	5.2	2.2	7.4
9.00	6.6	2.0	8.7
10.00	8.1	1.8	9.9
11.00	9.6	1.4	11.0
12.00	11.2	1.4	12.7
13.00	13.0	1.4	14.4
14.00	14.9	1.4	16.3
15.00	16.8	1.4	18.3
16.00	18.9	1.4	20.3
17.00	21.0	1.4	22.4
18.00	23.1	1.4	24.5
19.00	25.3	1.4	26.8
20.00	27.6	1.4	29.1
21.00	30.0	1.4	31.4
22.00	32.4	1.4	33.9
23.00	34.9	1.4	36.4
24.00	37.5	1.4	38.9
25.00	40.1	1.4	41.6
26.00	42.8	3.0	45.8
27.00	45.6	4.7	50.3
28.00	49.0	6.4	55.4
29.00	53.1	7.9	61.0
30.00	57.3	7.9	65.2
31.00	61.5	7.9	69.5
32.00	65.9	7.9	73.8
33.00	70.4	7.9	78.3
34.00	74.9	7.9	82.8
35.00	79.6	7.9	87.5
36.00	84.3	7.9	92.2
37.00	89.2	7.9	97.1
38.00	94.1	51.8	145.9
39.00	99.1	100.8	200.0
40.00	498.8	149.8	648.6
41.00	1292.9	193.8	1486.7

Factored Load = 65 tons/pile

By Inspection, pile should refuse 1 ft into weathered rock. Tip = 2,682.3 ft.

Pile Penetration = 39.7 ft.

L = 41.7 ft, Say average Pile Length = 45 ft.

Drive Piled to 65 tons/0.6 = 110 ton (220 kips)

For WEAP: 99k/220k = 45% skin

42.00	2087.1	193.8	2280.8
43.00	2881.2	193.8	3075.0
44.00	3675.4	193.8	3869.2
45.00	4469.6	193.8	4663.3

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	0.4167E-01		
			0.0000E+00	0.0000E+00
			0.2729E-02	0.2427E-01
			0.4548E-02	0.4702E-01
			0.6821E-02	0.8645E-01
			0.8186E-02	0.1213E+00
			0.9095E-02	0.1517E+00
			0.9095E-02	0.3033E+00
			0.9095E-02	0.4550E+00
			0.9095E-02	0.7584E+00
			0.9095E-02	0.3033E+01
2	10	0.1500E+01		
			0.0000E+00	0.0000E+00
			0.9823E-01	0.2427E-01
			0.1637E+00	0.4702E-01
			0.2456E+00	0.8645E-01
			0.2947E+00	0.1213E+00
			0.3274E+00	0.1517E+00
			0.3274E+00	0.3033E+00
			0.3274E+00	0.4550E+00
			0.3274E+00	0.7584E+00
			0.3274E+00	0.3033E+01
3	10	0.2958E+01		
			0.0000E+00	0.0000E+00
			0.1937E+00	0.2427E-01
			0.3229E+00	0.4702E-01
			0.4843E+00	0.8645E-01
			0.5812E+00	0.1213E+00
			0.6458E+00	0.1517E+00
			0.6458E+00	0.3033E+00
			0.6458E+00	0.4550E+00

		0.6458E+00	0.7584E+00
		0.6458E+00	0.3033E+01
4	10	0.3042E+01	
		0.0000E+00	0.0000E+00
		0.2032E+00	0.2427E-01
		0.3386E+00	0.4702E-01
		0.5079E+00	0.8645E-01
		0.6095E+00	0.1213E+00
		0.6772E+00	0.1517E+00
		0.6772E+00	0.3033E+00
		0.6772E+00	0.4550E+00
		0.6772E+00	0.7584E+00
		0.6772E+00	0.3033E+01
5	10	0.5850E+01	
		0.0000E+00	0.0000E+00
		0.5223E+00	0.2427E-01
		0.8705E+00	0.4702E-01
		0.1306E+01	0.8645E-01
		0.1567E+01	0.1213E+00
		0.1741E+01	0.1517E+00
		0.1741E+01	0.3033E+00
		0.1741E+01	0.4550E+00
		0.1741E+01	0.7584E+00
		0.1741E+01	0.3033E+01
6	10	0.8658E+01	
		0.0000E+00	0.0000E+00
		0.7730E+00	0.2427E-01
		0.1288E+01	0.4702E-01
		0.1933E+01	0.8645E-01
		0.2319E+01	0.1213E+00
		0.2577E+01	0.1517E+00
		0.2577E+01	0.3033E+00
		0.2577E+01	0.4550E+00
		0.2577E+01	0.7584E+00
		0.2577E+01	0.3033E+01
7	10	0.8742E+01	
		0.0000E+00	0.0000E+00
		0.7805E+00	0.2427E-01
		0.1301E+01	0.4702E-01
		0.1951E+01	0.8645E-01
		0.2341E+01	0.1213E+00
		0.2602E+01	0.1517E+00
		0.2602E+01	0.3033E+00
		0.2602E+01	0.4550E+00
		0.2602E+01	0.7584E+00
		0.2602E+01	0.3033E+01
8	10	0.1045E+02	
		0.0000E+00	0.0000E+00
		0.7803E+00	0.2427E-01
		0.1300E+01	0.4702E-01
		0.1951E+01	0.8645E-01
		0.2341E+01	0.1213E+00
		0.2601E+01	0.1517E+00

		0.2601E+01	0.3033E+00
		0.2601E+01	0.4550E+00
		0.2601E+01	0.7584E+00
		0.2601E+01	0.3033E+01
9	10	0.1216E+02	
		0.0000E+00	0.0000E+00
		0.9078E+00	0.2427E-01
		0.1513E+01	0.4702E-01
		0.2270E+01	0.8645E-01
		0.2724E+01	0.1213E+00
		0.3026E+01	0.1517E+00
		0.3026E+01	0.3033E+00
		0.3026E+01	0.4550E+00
		0.3026E+01	0.7584E+00
		0.3026E+01	0.3033E+01
10	10	0.1224E+02	
		0.0000E+00	0.0000E+00
		0.9141E+00	0.2427E-01
		0.1523E+01	0.4702E-01
		0.2285E+01	0.8645E-01
		0.2742E+01	0.1213E+00
		0.3047E+01	0.1517E+00
		0.3047E+01	0.3033E+00
		0.3047E+01	0.4550E+00
		0.3047E+01	0.7584E+00
		0.3047E+01	0.3033E+01
11	10	0.1960E+02	
		0.0000E+00	0.0000E+00
		0.1207E+01	0.2427E-01
		0.2012E+01	0.4702E-01
		0.3018E+01	0.8645E-01
		0.3622E+01	0.1213E+00
		0.4024E+01	0.1517E+00
		0.4024E+01	0.3033E+00
		0.4024E+01	0.4550E+00
		0.4024E+01	0.7584E+00
		0.4024E+01	0.3033E+01
12	10	0.2696E+02	
		0.0000E+00	0.0000E+00
		0.1471E+01	0.2427E-01
		0.2452E+01	0.4702E-01
		0.3677E+01	0.8645E-01
		0.4413E+01	0.1213E+00
		0.4903E+01	0.1517E+00
		0.4903E+01	0.3033E+00
		0.4903E+01	0.4550E+00
		0.4903E+01	0.7584E+00
		0.4903E+01	0.3033E+01
13	10	0.2704E+02	
		0.0000E+00	0.0000E+00
		0.1499E+01	0.2427E-01
		0.2499E+01	0.4702E-01
		0.3748E+01	0.8645E-01

		0.4498E+01	0.1213E+00
		0.4997E+01	0.1517E+00
		0.4997E+01	0.3033E+00
		0.4997E+01	0.4550E+00
		0.4997E+01	0.7584E+00
		0.4997E+01	0.3033E+01
14	10	0.3285E+02	
		0.0000E+00	0.0000E+00
		0.2357E+01	0.2427E-01
		0.3929E+01	0.4702E-01
		0.5894E+01	0.8645E-01
		0.7072E+01	0.1213E+00
		0.7858E+01	0.1517E+00
		0.7858E+01	0.3033E+00
		0.7858E+01	0.4550E+00
		0.7858E+01	0.7584E+00
		0.7858E+01	0.3033E+01
15	10	0.3866E+02	
		0.0000E+00	0.0000E+00
		0.2649E+01	0.2427E-01
		0.4415E+01	0.4702E-01
		0.6623E+01	0.8645E-01
		0.7947E+01	0.1213E+00
		0.8831E+01	0.1517E+00
		0.8831E+01	0.3033E+00
		0.8831E+01	0.4550E+00
		0.8831E+01	0.7584E+00
		0.8831E+01	0.3033E+01
16	10	0.3874E+02	
		0.0000E+00	0.0000E+00
		0.2653E+01	0.2427E-01
		0.4422E+01	0.4702E-01
		0.6633E+01	0.8645E-01
		0.7960E+01	0.1213E+00
		0.8844E+01	0.1517E+00
		0.7960E+01	0.3033E+00
		0.7960E+01	0.4550E+00
		0.7960E+01	0.7584E+00
		0.7960E+01	0.3033E+01
17	10	0.4435E+02	
		0.0000E+00	0.0000E+00
		0.4167E+03	0.2427E-01
		0.6944E+03	0.4702E-01
		0.1042E+04	0.8645E-01
		0.1250E+04	0.1213E+00
		0.1389E+04	0.1517E+00
		0.1250E+04	0.3033E+00
		0.1250E+04	0.4550E+00
		0.1250E+04	0.7584E+00
		0.1250E+04	0.3033E+01
18	10	0.4996E+02	
		0.0000E+00	0.0000E+00
		0.4167E+03	0.2427E-01

0.6944E+03	0.4702E-01
0.1042E+04	0.8645E-01
0.1250E+04	0.1213E+00
0.1389E+04	0.1517E+00
0.1250E+04	0.3033E+00
0.1250E+04	0.4550E+00
0.1250E+04	0.7584E+00
0.1250E+04	0.3033E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1211E+02	0.7584E-02
0.2422E+02	0.1517E-01
0.4844E+02	0.3033E-01
0.9688E+02	0.1972E+00
0.1453E+03	0.6370E+00
0.1744E+03	0.1107E+01
0.1938E+03	0.1517E+01
0.1938E+03	0.2275E+01
0.1938E+03	0.3033E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.2172E+02	0.1943E-01	0.1597E+00	0.1000E-03
0.2343E+03	0.2268E+00	0.1597E+01	0.1000E-02
0.9411E+03	0.1001E+01	0.7984E+01	0.5000E-02
0.1589E+04	0.1725E+01	0.1597E+02	0.1000E-01
0.2487E+04	0.2739E+01	0.3194E+02	0.2000E-01
0.3559E+04	0.3993E+01	0.5415E+02	0.5000E-01
0.3998E+04	0.4535E+01	0.6286E+02	0.8000E-01
0.4163E+04	0.4751E+01	0.6866E+02	0.1000E+00
0.4237E+04	0.4945E+01	0.9719E+02	0.2000E+00
0.4161E+04	0.5157E+01	0.1302E+03	0.5000E+00
0.4186E+04	0.5487E+01	0.1554E+03	0.8000E+00
0.4198E+04	0.5702E+01	0.1677E+03	0.1000E+01
0.4224E+04	0.6733E+01	0.1938E+03	0.2000E+01

WEAP Parameter Calculation

Bent #: **EB-1 LT**

		Toe Quake	Shaft Quake
Pile Type:	HP 12X53	**0.10**	**0.10**

Subsurface Conditions: Loose/Soft or Submerged

Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping	
1	2722.0	2719.0	7	Sand	0.20	
2	2719.0	2713.3	28	Sand	0.15	
3	2713.3	2709.8	11	Sand	0.18	
4	2709.8	2695.0	18	Sand	0.18	
5	2695.0	2683.3	100	Sand	0.10	
6	2683.3	2682.3	100	WR	0.10	
7						
8						
9						
10						
11						
12						
13						**Toe Damping**
					0.15	**0.10**

Length of Pile	39.7

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Bridge No. 063

09-Sep-2022
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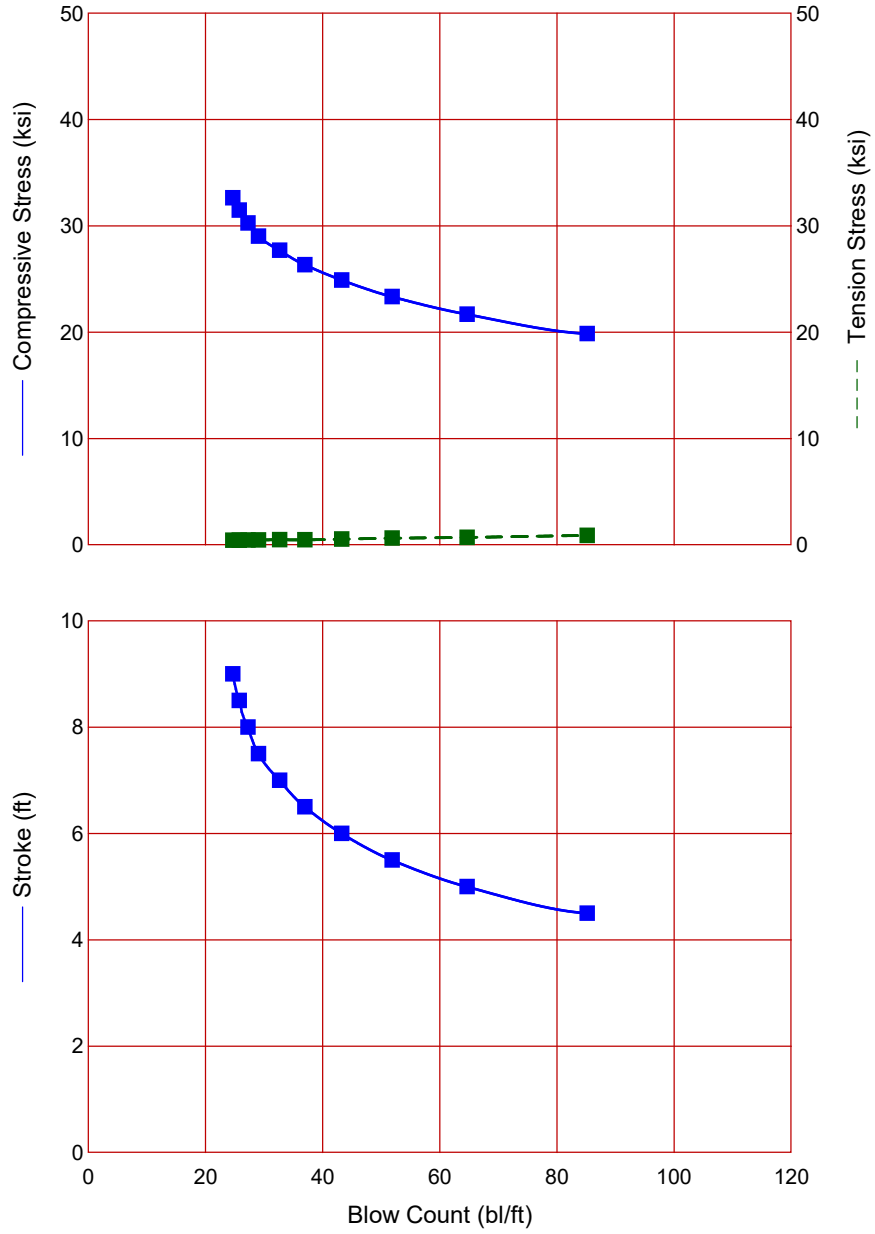
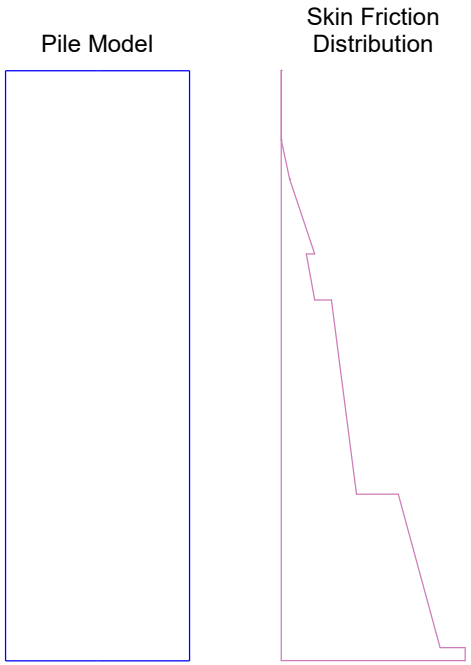


DELMAG D 19-32

Capacity	220.0	kips
Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1580 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.150	s/ft
Toe Damping	0.100	s/ft
Pile Length	45.00	ft
Pile Penetration	39.70	ft
Pile Top Area	15.50	in2



Res. Shaft = 45 %
(Proportional)

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Bridge No. 063

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
220.0	19.86	0.89	85.2	4.50	7.26
220.0	21.68	0.71	64.7	5.00	8.86
220.0	23.34	0.64	51.9	5.50	10.55
220.0	24.90	0.55	43.3	6.00	12.28
220.0	26.34	0.48	37.0	6.50	14.09
220.0	27.69	0.49	32.7	7.00	15.82
220.0	29.02	0.47	29.1	7.50	17.76
220.0	30.26	0.45	27.3	8.00	19.17
220.0	31.47	0.44	25.8	8.50	20.55
220.0	32.63	0.43	24.7	9.00	21.78

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09-Sep-2022
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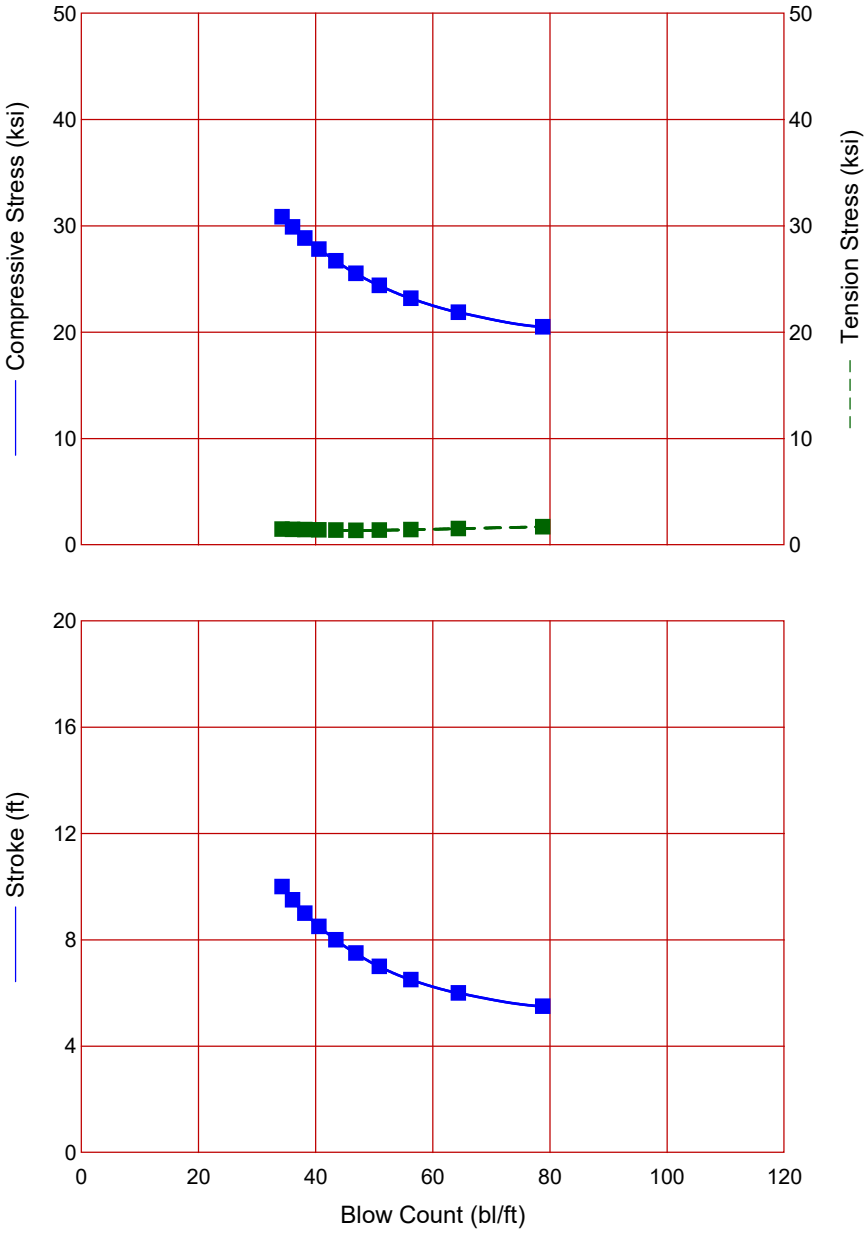
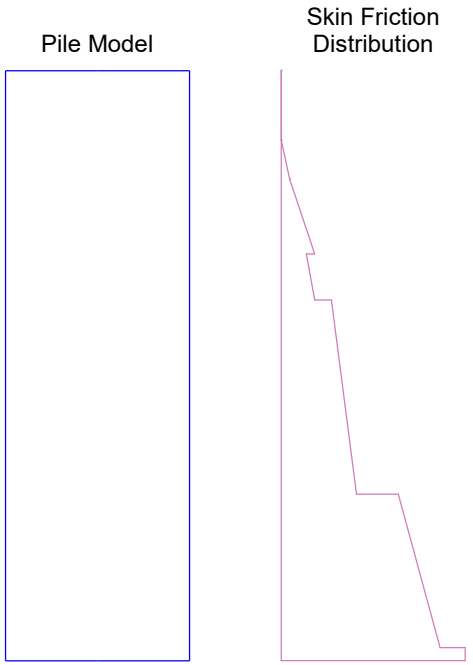


DELMAG D 12

Capacity	220.0	kips
Ram Weight	2.75	kips
Efficiency	0.800	
Pressure	1380 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.150	s/ft
Toe Damping	0.100	s/ft
Pile Length	45.00	ft
Pile Penetration	39.70	ft
Pile Top Area	15.50	in2



Res. Shaft = 45 %
(Proportional)

ECS Carolinas LLP
Bridge No. 063

09-Sep-2022
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
220.0	20.50	1.71	78.8	5.50	7.74
220.0	21.88	1.53	64.4	6.00	8.95
220.0	23.19	1.43	56.3	6.50	9.95
220.0	24.40	1.39	50.9	7.00	10.89
220.0	25.54	1.37	46.9	7.50	11.76
220.0	26.70	1.39	43.5	8.00	12.67
220.0	27.80	1.41	40.6	8.50	13.58
220.0	28.85	1.43	38.2	9.00	14.48
220.0	29.89	1.45	36.1	9.50	15.40
220.0	30.85	1.48	34.3	10.00	16.27

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins
and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

Input File: C:\USERS\KDEMONTBRUN\ONEDRIVE - ECS CORPORATE SERVICES\09 PROJECTS 27500 - 29999\29500-29999\09-29662 BRIDGE 063 ON NC 88 OVER CRANBERRY CREEK \ANALYSIS\WEAP\EB1 - LT_D12.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (12/4/2018)

Input File Contents

Bridge No. 063

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
6	0	3	-2	1	0	0	0	0	0	45	1	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.185	32.185	141.890	12.040	H Pile

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
45.000	15.50	30457.9	493.356	3.970	0	0.850	0.010

FFatigue	F0	0-Bottom
0	0.000	0.000

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 12	1	4

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
2.75	104.41	11.81	10.80	8.22	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.81	21.27	11.81	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
11.07	109.60	97.00	0.0020	0.0020	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1380.00	0.00	0.00	0.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
5.5000	0.8000	1380.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.150	0.100	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug

0.000	0.000	0.000	0.000	0.000	0.000

Research Toe Plug: RD plug toe: m, d

0.000	0.000

Research Toe Plug: New Toe Plug Model is NOT applied

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	39.70	39.70	0.00	0.00	0.00	0.00	0.00	0.000
3.00	0.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
3.00	0.10	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
8.70	0.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
8.70	0.24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
12.20	0.33	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
12.20	0.42	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
27.00	0.69	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
27.00	1.07	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
38.70	1.44	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
38.70	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
39.70	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
39.70	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000
45.00	1.61	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.000

Rult									
220.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Bridge No. 063

Hammer Model: D 12 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.688				
2	0.688	121704.2	1.000	0.0000	
3	0.688	121704.2	1.000	0.0000	
4	0.688	121704.2	1.000	0.0000	
Imp Block	0.810	67059.7	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0098	5.2
Combined Pile Top		12239.6			

HAMMER OPTIONS:

Hammer File ID No.	3	Hammer Type	OE Diesel
Stroke Option	Var.P-IC	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight (kips)	2.75	Ram Length (inch)	104.41
Maximum Stroke (ft)	10.80		
Rated Stroke (ft)	8.22	Efficiency	0.800
Maximum Pressure (psi)	1380.00	Actual Pressure (psi)	1380.00
Compression Exponent	1.350	Expansion Exponent	1.250
Ram Diameter (inch)	11.81		
Combustion Delay (s)	0.00200	Ignition Duration (s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		0.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area	(in2)	141.890	Pile Type		H Pile
Pile Size	(inch)	12.040			

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	30458.	493.4	4.0	0	16911.	27.9
45.0	15.50	30458.	493.4	4.0	0	16911.	27.9

Wave Travel Time 2L/c (ms) 5.322

Pile and Soil Model — Total Capacity Rut (kips) 220.0

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.171	12240	0.010	0.000	0.85	0.0	0.150	0.100	3.21	4.0	15.5
2	0.171	12240	0.000	0.000	1.00	0.1	0.150	0.100	6.43	4.0	15.5
3	0.171	12240	0.000	0.000	1.00	1.0	0.150	0.100	9.64	4.0	15.5
4	0.171	12240	0.000	0.000	1.00	2.5	0.150	0.100	12.86	4.0	15.5
5	0.171	12240	0.000	0.000	1.00	3.3	0.150	0.100	16.07	4.0	15.5
6	0.171	12240	0.000	0.000	1.00	4.5	0.150	0.100	19.29	4.0	15.5
7	0.171	12240	0.000	0.000	1.00	5.8	0.150	0.100	22.50	4.0	15.5
8	0.171	12240	0.000	0.000	1.00	6.5	0.150	0.100	25.71	4.0	15.5
9	0.171	12240	0.000	0.000	1.00	7.2	0.150	0.100	28.93	4.0	15.5
10	0.171	12240	0.000	0.000	1.00	7.9	0.150	0.100	32.14	4.0	15.5
11	0.171	12240	0.000	0.000	1.00	13.0	0.150	0.100	35.36	4.0	15.5
12	0.171	12240	0.000	0.000	1.00	14.4	0.150	0.100	38.57	4.0	15.5
13	0.171	12240	0.000	0.000	1.00	15.6	0.150	0.100	41.79	4.0	15.5
14	0.171	12240	0.000	0.000	1.00	17.4	0.150	0.100	45.00	4.0	15.5
Toe						121.0	0.100	0.100			

2.390 kips total unreduced pile weight (g= 32.17 ft/s2)
2.391 kips total reduced pile weight (g= 32.19 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	39.70	Pile Damping Fact.(k/ft/s)	0.558
% Shaft Resistance	45		
Inspection Chart			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.185 32.185	
Output Segment Generation: Automatic			

Bridge No. 063 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	310.4	0.00	20.02	10.14	0.445	7.74
2	-9.2	313.1	-0.60	20.20	10.15	0.428	7.61
3	-17.0	315.8	-1.10	20.38	10.08	0.412	7.45
4	-21.9	317.8	-1.41	20.50	9.98	0.396	7.23
5	-23.5	316.9	-1.52	20.44	9.83	0.379	6.95
6	-25.5	314.5	-1.64	20.29	9.63	0.363	6.63
7	-26.4	310.8	-1.71	20.05	9.41	0.347	6.27
8	-24.5	304.7	-1.58	19.66	9.16	0.331	5.89
9	-21.4	298.0	-1.38	19.23	8.91	0.317	5.51
10	-18.1	291.4	-1.17	18.80	8.61	0.302	5.12
11	-14.6	284.7	-0.94	18.36	8.33	0.287	4.65
12	-9.2	264.1	-0.59	17.04	8.47	0.274	4.12
13	-4.7	228.2	-0.30	14.72	9.05	0.263	3.60
14	-1.5	202.2	-0.10	13.05	8.72	0.252	3.31

(Eq) Return Strokes and Stroke Analyzed (ft):
6.26 5.42 5.50 5.50

Max. Combustion Pressure 1205.8 psi

Bridge No. 063 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	331.3	0.00	21.37	10.95	0.481	8.95
2	-8.2	333.6	-0.53	21.52	10.93	0.464	8.82
3	-14.6	337.3	-0.94	21.76	10.89	0.448	8.65
4	-18.3	339.1	-1.18	21.88	10.77	0.432	8.42
5	-20.5	337.6	-1.32	21.78	10.61	0.415	8.11
6	-23.4	335.9	-1.51	21.67	10.42	0.399	7.76
7	-23.7	331.5	-1.53	21.39	10.16	0.383	7.37
8	-21.5	325.1	-1.39	20.98	9.92	0.368	6.95
9	-18.7	318.3	-1.21	20.53	9.62	0.353	6.53
10	-15.9	310.8	-1.03	20.05	9.32	0.338	6.09
11	-13.1	304.2	-0.85	19.63	8.98	0.323	5.56
12	-8.5	282.3	-0.55	18.21	9.12	0.309	4.93
13	-4.5	243.5	-0.29	15.71	9.73	0.297	4.31
14	-1.5	215.2	-0.10	13.89	9.36	0.286	3.98

(Eq) Return Strokes and Stroke Analyzed (ft):
6.20 6.01 6.00

Max. Combustion Pressure 1334.5 psi

Bridge No. 063 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	350.9	0.00	22.64	11.68	0.507	9.95
2	-7.3	353.7	-0.47	22.82	11.70	0.491	9.83
3	-13.9	356.9	-0.90	23.03	11.62	0.474	9.66
4	-18.6	359.4	-1.20	23.19	11.53	0.458	9.41
5	-20.1	358.1	-1.30	23.10	11.36	0.441	9.09
6	-22.1	355.5	-1.43	22.93	11.15	0.425	8.72
7	-22.2	351.5	-1.43	22.68	10.90	0.410	8.30
8	-19.9	344.6	-1.28	22.23	10.62	0.394	7.85
9	-17.2	337.4	-1.11	21.77	10.32	0.380	7.39
10	-14.4	329.9	-0.93	21.28	9.97	0.365	6.91
11	-11.5	322.5	-0.74	20.81	9.63	0.350	6.32
12	-7.1	299.6	-0.46	19.33	9.75	0.336	5.62
13	-3.8	258.9	-0.24	16.70	10.40	0.324	4.93
14	-1.3	228.0	-0.08	14.71	9.96	0.313	4.55

(Eq) Return Strokes and Stroke Analyzed (ft):
6.14 6.50

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	369.0	0.00	23.80	12.37	0.528	10.89
2	-7.6	372.4	-0.49	24.03	12.41	0.512	10.76
3	-14.7	375.6	-0.95	24.23	12.35	0.496	10.60
4	-19.3	378.2	-1.25	24.40	12.23	0.480	10.34
5	-20.6	377.3	-1.33	24.34	12.07	0.464	10.00
6	-21.5	374.6	-1.39	24.17	11.82	0.448	9.61
7	-21.4	370.2	-1.38	23.88	11.58	0.432	9.17
8	-19.1	363.4	-1.23	23.45	11.26	0.417	8.69
9	-16.5	355.1	-1.06	22.91	10.97	0.402	8.19
10	-13.7	347.8	-0.88	22.44	10.58	0.387	7.67
11	-10.8	339.8	-0.70	21.92	10.22	0.373	7.03
12	-6.6	315.4	-0.42	20.35	10.33	0.359	6.27
13	-3.4	273.0	-0.22	17.61	11.01	0.347	5.50
14	-1.2	240.9	-0.08	15.54	10.54	0.336	5.09

(Eq) Return Strokes and Stroke Analyzed (ft):
6.08 7.00

Max. Combustion Pressure 1380.0 psi

Bridge No. 063 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	386.1	0.00	24.91	13.05	0.548	11.76
2	-8.2	390.2	-0.53	25.18	13.08	0.532	11.64
3	-15.6	393.9	-1.00	25.41	13.04	0.516	11.47
4	-20.1	395.8	-1.30	25.54	12.89	0.499	11.20
5	-21.2	395.3	-1.36	25.50	12.75	0.483	10.85
6	-20.7	392.9	-1.34	25.35	12.50	0.467	10.44
7	-20.5	387.5	-1.32	25.00	12.22	0.452	9.97
8	-18.1	381.1	-1.17	24.59	11.91	0.437	9.46
9	-15.5	372.8	-1.00	24.05	11.57	0.422	8.93
10	-12.8	364.6	-0.82	23.52	11.19	0.407	8.38
11	-9.9	357.0	-0.64	23.03	10.77	0.393	7.69
12	-5.8	331.5	-0.38	21.39	10.87	0.379	6.87
13	-2.9	286.1	-0.19	18.46	11.57	0.367	6.03
14	-1.0	253.2	-0.07	16.34	11.07	0.356	5.58

(Eq) Return Strokes and Stroke Analyzed (ft):
6.03 7.50

Max. Combustion Pressure 1380.0 psi

Bridge No. 063 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	403.5	0.00	26.03	13.69	0.567	12.67
2	-8.5	407.3	-0.55	26.27	13.74	0.551	12.55
3	-16.1	410.7	-1.04	26.50	13.68	0.535	12.38
4	-20.5	413.9	-1.33	26.71	13.57	0.519	12.10
5	-21.5	412.8	-1.39	26.63	13.40	0.503	11.74
6	-20.5	409.8	-1.32	26.44	13.12	0.487	11.31
7	-19.8	405.4	-1.28	26.15	12.86	0.472	10.81
8	-17.4	398.1	-1.12	25.68	12.51	0.457	10.27
9	-14.8	389.0	-0.96	25.10	12.18	0.442	9.70
10	-12.0	381.1	-0.78	24.59	11.75	0.428	9.11
11	-9.3	372.8	-0.60	24.05	11.33	0.413	8.38
12	-5.3	346.2	-0.34	22.34	11.42	0.399	7.49
13	-2.5	299.5	-0.16	19.32	12.14	0.387	6.58
14	-0.8	264.6	-0.05	17.07	11.56	0.376	6.10

(Eq) Return Strokes and Stroke Analyzed (ft):
5.97 8.00

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	419.9	0.00	27.09	14.32	0.586	13.58
2	-8.9	423.5	-0.57	27.32	14.37	0.570	13.46
3	-16.5	427.9	-1.06	27.61	14.30	0.554	13.28
4	-20.9	431.0	-1.35	27.80	14.21	0.538	13.00
5	-21.8	429.5	-1.41	27.71	14.02	0.522	12.62
6	-20.9	426.5	-1.35	27.51	13.75	0.506	12.17
7	-19.2	422.2	-1.24	27.24	13.46	0.491	11.65
8	-16.8	414.4	-1.09	26.73	13.09	0.477	11.08
9	-14.2	405.4	-0.92	26.15	12.76	0.462	10.48
10	-11.4	397.0	-0.74	25.61	12.30	0.447	9.85
11	-8.7	388.3	-0.56	25.05	11.86	0.432	9.07
12	-4.9	360.6	-0.31	23.27	11.94	0.419	8.11
13	-2.2	312.1	-0.14	20.13	12.69	0.407	7.13
14	-0.6	276.1	-0.04	17.81	12.04	0.396	6.61

(Eq) Return Strokes and Stroke Analyzed (ft):
5.92 8.50

Max. Combustion Pressure 1380.0 psi

Bridge No. 063 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	435.5	0.00	28.10	14.93	0.603	14.48
2	-9.2	440.3	-0.59	28.41	14.96	0.588	14.36
3	-16.9	444.9	-1.09	28.71	14.95	0.572	14.18
4	-21.3	447.1	-1.37	28.85	14.82	0.556	13.89
5	-22.2	445.8	-1.43	28.76	14.62	0.540	13.50
6	-21.3	443.8	-1.37	28.63	14.38	0.525	13.03
7	-19.0	438.4	-1.23	28.28	14.03	0.510	12.48
8	-16.2	430.1	-1.05	27.75	13.71	0.495	11.88
9	-13.5	421.8	-0.87	27.21	13.31	0.480	11.25
10	-10.7	412.1	-0.69	26.59	12.87	0.466	10.58
11	-8.4	404.0	-0.54	26.06	12.36	0.451	9.75
12	-4.4	375.7	-0.28	24.24	12.46	0.437	8.73
13	-1.8	324.3	-0.12	20.92	13.24	0.425	7.68
14	-0.4	287.8	-0.03	18.56	12.48	0.414	7.12

(Eq) Return Strokes and Stroke Analyzed (ft):
5.88 9.00

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	450.9	0.00	29.09	15.51	0.621	15.40
2	-9.4	455.1	-0.60	29.36	15.55	0.606	15.28
3	-17.2	460.5	-1.11	29.71	15.52	0.590	15.10
4	-21.5	463.3	-1.39	29.89	15.41	0.575	14.80
5	-22.5	461.4	-1.45	29.76	15.19	0.559	14.39
6	-21.7	459.2	-1.40	29.62	14.94	0.543	13.90
7	-19.6	454.2	-1.26	29.30	14.61	0.528	13.33
8	-16.4	445.4	-1.06	28.74	14.23	0.513	12.70
9	-13.7	436.5	-0.88	28.16	13.86	0.499	12.03
10	-11.5	427.2	-0.74	27.56	13.36	0.484	11.33
11	-9.2	417.9	-0.59	26.96	12.86	0.470	10.44
12	-4.6	388.5	-0.30	25.06	12.94	0.456	9.36
13	-1.5	336.0	-0.10	21.68	13.73	0.444	8.24
14	-0.3	298.8	-0.02	19.28	12.92	0.433	7.64

(Eq) Return Strokes and Stroke Analyzed (ft):
5.84 9.50

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 121.0 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	465.5	0.00	30.03	16.03	0.637	16.27
2	-9.6	470.6	-0.62	30.36	16.13	0.622	16.15
3	-17.6	474.8	-1.13	30.63	16.10	0.607	15.97
4	-22.0	478.2	-1.42	30.85	15.94	0.591	15.66
5	-23.0	477.4	-1.48	30.80	15.78	0.575	15.24
6	-22.3	474.5	-1.44	30.61	15.49	0.560	14.73
7	-20.5	468.5	-1.33	30.23	15.15	0.545	14.13
8	-17.7	460.9	-1.14	29.74	14.78	0.530	13.47
9	-15.2	451.1	-0.98	29.10	14.35	0.516	12.77
10	-12.9	441.1	-0.83	28.46	13.89	0.501	12.04
11	-10.4	432.9	-0.67	27.93	13.31	0.486	11.11
12	-5.5	402.6	-0.35	25.98	13.42	0.473	9.96
13	-1.2	346.5	-0.08	22.36	14.22	0.461	8.77
14	-0.1	309.2	0.00	19.95	13.38	0.449	8.14

(Eq) Return Strokes and Stroke Analyzed (ft):
5.81 10.00

Max. Combustion Pressure 1380.0 psi

Bridge No. 063 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
220.0	78.8	5.50	5.50	-1.71	7	19	20.50	4	2	7.7	50.4
220.0	64.4	6.00	6.01	-1.53	7	19	21.88	4	2	8.9	48.3
220.0	56.3	6.50	6.14	-1.43	7	19	23.19	4	2	10.0	47.1
220.0	50.9	7.00	6.08	-1.39	6	19	24.40	4	2	10.9	46.3
220.0	46.9	7.50	6.03	-1.36	5	49	25.54	4	2	11.8	45.6
220.0	43.5	8.00	5.97	-1.39	5	49	26.71	4	2	12.7	44.9
220.0	40.6	8.50	5.92	-1.41	5	49	27.80	4	2	13.6	44.3
220.0	38.2	9.00	5.88	-1.43	5	48	28.85	4	2	14.5	43.7
220.0	36.1	9.50	5.84	-1.45	5	48	29.89	4	2	15.4	43.1
220.0	34.3	10.00	5.81	-1.48	5	48	30.85	4	2	16.3	42.6

GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 16+00	**OFFSET** 13 ft LT	**ALIGNMENT** -L-	**0 HR.** 14.0
COLLAR ELEV. 2,727.4 ft	**TOTAL DEPTH** 53.5 ft	**NORTHING** 977,648	**EASTING** 1,328,023	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/12/22	**COMP. DATE** 07/12/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
									BOC = 2,722.0
	2,727.4	0.0							GROUND SURFACE
	2,726.4	1.0	9	7	13		M		**ROADWAY EMBANKMENT** Asphalt 0.8' Stone 0.2'
	2,723.9	3.5	10	9	6		M		Medium Dense, Brown-Tan, Silty Fine to Coarse SAND (A-2-4), with trace rock fragments
	2,721.4	6.0	3	8	9		M		Very Stiff, Brown, Fine to Coarse Sandy SILT (A-4), with trace rock fragments
	2,718.9	8.5	3	5	3		M		Loose, Brown-Gray, Silty Fine to Coarse Silty SAND (A-2-4), with trace rock fragments
	2,713.9	13.5	2	3	4	8.6	W		**ALLUVIAL** Loose, Black, Silty Fine to Coarse SAND (A-2-4), with trace roots and mica
	2,709.9	17.5	5	5	10		Sat.		Medium Dense, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)
	2,704.9	22.5	5	8	20	17.1	W		**RESIDUAL** Very Stiff to Hard, Brown-Gray, Fine to Coarse Sandy SILT (A-4), with trace to some mica
	2,688.9	38.5	20	30	19		W		
	2,684.9	42.5	12	15	15		W		**RESIDUAL** Hard, Gray-White, Fine to Coarse Sandy SILT (A-4), with trace mica
	2,678.9	48.5	25	75/0.4		33.1	W		**WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Gray
	2,674.0	53.4	35	44	55		W		**WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Gray-White-Tan
	2,673.9	53.5	59	41/0.1			W		**CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS)
			60/0.1						Boring Terminated with Standard Penetration Test Refusal at Elevation 2,673.9 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

BLOWS PER FOOT: 0 25 50 75 100

BOC
γ=120 Φ=30
γ=120 Φ=32
γ=120 Φ=32
100/0.9
100/0.6
60/0.1

L = 2722.0 - 2687.9 + 2.0
= 36.1 ft
Avg Pile Length = 40 ft

Notes
Cobbles encountered while drilling between 15 and 21 ft.

NCDOT BORE SINGLE BRIDGE063_GEO_GTM.GPJ NC_DOT.GDT 8/29/22

End Bent No. 1 - RT

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

            APILE for Windows, Version 2019.9.10

            Serial Number :  562476398

            A Program for Analyzing the Axial Capacity
            and Short-term Settlement of Driven Piles
                  under Axial Loading.
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=============================================================================

 This program is licensed to :

 ECS Carolinas, LLP
 Charlotte, NC, USA

 Path to file locations      : C:\Users\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500-
29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\APile\
 Name of input data file     : EB1- RT.ap9d
 Name of output file         : EB1- RT.ap9o
 Name of plot output file    : EB1- RT.ap9p

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

          Date:  September 08, 2022     Time:  08:33:29


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


      Bridge No. 063 over Cranberry Creek

      DESIGNER   : KND

      JOB NUMBER : 09:29662


      METHOD FOR UNIT LOAD TRANSFERS :

      - FHWA (Federal Highway Administration)
        Unfactored Unit Side Friction and Unit Side Resistance are used.
```

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

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 = 40.00 FT.
- BATTER ANGLE = 0.00 DEG
- PILE STICKUP LENGTH, PSL = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 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	Nq FACTOR FHWA
0.00	SAND	0.80*	120.00	30.00	30.00**
8.60	SAND	0.80*	120.00	30.00	30.00**
8.60	SAND	0.80*	57.60	32.00	40.40**
17.10	SAND	0.80*	57.60	32.00	40.40**
17.10	SAND	0.80*	57.60	32.00	40.40**
33.10	SAND	0.80*	57.60	32.00	40.40**
33.10	CLAY	0.80*	100.00	0.00	4.80**
50.00	CLAY	0.80*	100.00	0.00	4.80**

* 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
0.10E+08*	0.10E+08*	200.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	200.00	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
8.60	1.000	1.000
8.60	1.000	1.000
17.10	1.000	1.000
17.10	1.000	1.000
33.10	1.000	1.000
33.10	1.000	1.000
50.00	1.000	1.000

1

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

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

PILE PENETRATION FT.	SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.1	0.1

1.00	0.1	0.2	0.3
2.00	0.3	0.4	0.7
3.00	0.6	0.7	1.3
4.00	1.1	0.9	2.0
5.00	1.8	1.1	2.9
6.00	2.6	1.3	3.8
7.00	3.5	1.4	4.9
8.00	4.6	1.8	6.4
9.00	5.8	2.3	8.0
10.00	7.2	2.8	10.0
11.00	8.9	3.3	12.1
12.00	10.6	3.4	14.0
13.00	12.4	3.5	15.9
14.00	14.3	3.5	17.9
15.00	16.3	3.6	19.8
16.00	18.4	3.6	21.9
17.00	20.5	3.6	24.1
18.00	22.7	3.6	26.3
19.00	25.0	3.6	28.6
20.00	27.4	3.6	31.0
21.00	29.9	3.6	33.4
22.00	32.5	3.6	36.0
23.00	35.1	3.6	38.6
24.00	37.8	3.6	41.4
25.00	40.6	3.6	44.1
26.00	43.5	3.6	47.0
27.00	46.4	3.6	50.0
28.00	49.5	3.6	53.0
29.00	52.6	3.6	56.2
30.00	55.8	3.6	59.4
31.00	59.1	3.6	62.7
32.00	62.5	3.6	66.0
33.00	65.9	48.5	114.4
34.00	69.5	98.7	168.1
35.00	468.3	148.8	617.1
36.00	1262.5	193.8	1456.2
37.00	2056.6	193.8	2250.4
38.00	2850.8	193.8	3044.6
39.00	3645.0	193.8	3838.7
40.00	4439.1	193.8	4632.9

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 *
****

Factored Load = 65 tons/pile

By Inspection, pile should refuse 1 ft into weathered rock. Tip Elevation = 2,687.9 ft.

Pile Penetration = 34.1 ft.

L = 36.1 ft., Say average Pile Length = 40 ft.

Drive Piles to 65 tons/0.6 = 110 ton (220 kips)

For WEAP: 70k/220k = 32% skin

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.4167E-01		
			0.0000E+00	0.0000E+00
			0.3111E-02	0.2427E-01
			0.5185E-02	0.4702E-01
			0.7778E-02	0.8645E-01
			0.9333E-02	0.1213E+00
			0.1037E-01	0.1517E+00
			0.1037E-01	0.3033E+00
			0.1037E-01	0.4550E+00
			0.1037E-01	0.7584E+00
			0.1037E-01	0.3033E+01
2	10	0.4300E+01		
			0.0000E+00	0.0000E+00
			0.3211E+00	0.2427E-01
			0.5351E+00	0.4702E-01
			0.8027E+00	0.8645E-01
			0.9632E+00	0.1213E+00
			0.1070E+01	0.1517E+00
			0.1070E+01	0.3033E+00
			0.1070E+01	0.4550E+00
			0.1070E+01	0.7584E+00
			0.1070E+01	0.3033E+01
3	10	0.8558E+01		
			0.0000E+00	0.0000E+00
			0.6390E+00	0.2427E-01
			0.1065E+01	0.4702E-01
			0.1598E+01	0.8645E-01
			0.1917E+01	0.1213E+00
			0.2130E+01	0.1517E+00
			0.2130E+01	0.3033E+00
			0.2130E+01	0.4550E+00
			0.2130E+01	0.7584E+00
			0.2130E+01	0.3033E+01
4	10	0.8642E+01		
			0.0000E+00	0.0000E+00
			0.6453E+00	0.2427E-01
			0.1075E+01	0.4702E-01
			0.1613E+01	0.8645E-01
			0.1936E+01	0.1213E+00
			0.2151E+01	0.1517E+00
			0.2151E+01	0.3033E+00
			0.2151E+01	0.4550E+00
			0.2151E+01	0.7584E+00
			0.2151E+01	0.3033E+01
5	10	0.1285E+02		
			0.0000E+00	0.0000E+00
			0.9685E+00	0.2427E-01
			0.1614E+01	0.4702E-01

		0.2421E+01	0.8645E-01
		0.2906E+01	0.1213E+00
		0.3228E+01	0.1517E+00
		0.3228E+01	0.3033E+00
		0.3228E+01	0.4550E+00
		0.3228E+01	0.7584E+00
		0.3228E+01	0.3033E+01
6	10	0.1706E+02	
		0.0000E+00	0.0000E+00
		0.1149E+01	0.2427E-01
		0.1915E+01	0.4702E-01
		0.2872E+01	0.8645E-01
		0.3447E+01	0.1213E+00
		0.3830E+01	0.1517E+00
		0.3830E+01	0.3033E+00
		0.3830E+01	0.4550E+00
		0.3830E+01	0.7584E+00
		0.3830E+01	0.3033E+01
7	10	0.1714E+02	
		0.0000E+00	0.0000E+00
		0.1152E+01	0.2427E-01
		0.1921E+01	0.4702E-01
		0.2881E+01	0.8645E-01
		0.3457E+01	0.1213E+00
		0.3841E+01	0.1517E+00
		0.3841E+01	0.3033E+00
		0.3841E+01	0.4550E+00
		0.3841E+01	0.7584E+00
		0.3841E+01	0.3033E+01
8	10	0.2510E+02	
		0.0000E+00	0.0000E+00
		0.1493E+01	0.2427E-01
		0.2489E+01	0.4702E-01
		0.3734E+01	0.8645E-01
		0.4480E+01	0.1213E+00
		0.4978E+01	0.1517E+00
		0.4978E+01	0.3033E+00
		0.4978E+01	0.4550E+00
		0.4978E+01	0.7584E+00
		0.4978E+01	0.3033E+01
9	10	0.3306E+02	
		0.0000E+00	0.0000E+00
		0.1835E+01	0.2427E-01
		0.3058E+01	0.4702E-01
		0.4586E+01	0.8645E-01
		0.5504E+01	0.1213E+00
		0.6115E+01	0.1517E+00
		0.6115E+01	0.3033E+00
		0.6115E+01	0.4550E+00
		0.6115E+01	0.7584E+00
		0.6115E+01	0.3033E+01
10	10	0.3314E+02	
		0.0000E+00	0.0000E+00

		0.1838E+01	0.2427E-01
		0.3063E+01	0.4702E-01
		0.4595E+01	0.8645E-01
		0.5514E+01	0.1213E+00
		0.6127E+01	0.1517E+00
		0.5514E+01	0.3033E+00
		0.5514E+01	0.4550E+00
		0.5514E+01	0.7584E+00
		0.5514E+01	0.3033E+01
11	10	0.4155E+02	
		0.0000E+00	0.0000E+00
		0.4167E+03	0.2427E-01
		0.6944E+03	0.4702E-01
		0.1042E+04	0.8645E-01
		0.1250E+04	0.1213E+00
		0.1389E+04	0.1517E+00
		0.1250E+04	0.3033E+00
		0.1250E+04	0.4550E+00
		0.1250E+04	0.7584E+00
		0.1250E+04	0.3033E+01
12	10	0.4996E+02	
		0.0000E+00	0.0000E+00
		0.4167E+03	0.2427E-01
		0.6944E+03	0.4702E-01
		0.1042E+04	0.8645E-01
		0.1250E+04	0.1213E+00
		0.1389E+04	0.1517E+00
		0.1250E+04	0.3033E+00
		0.1250E+04	0.4550E+00
		0.1250E+04	0.7584E+00
		0.1250E+04	0.3033E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1211E+02	0.7584E-02
0.2422E+02	0.1517E-01
0.4844E+02	0.3033E-01
0.9688E+02	0.1972E+00
0.1453E+03	0.6370E+00
0.1744E+03	0.1107E+01
0.1938E+03	0.1517E+01
0.1938E+03	0.2275E+01
0.1938E+03	0.3033E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.1886E+02	0.1576E-01	0.1597E+00	0.1000E-03
0.2144E+03	0.1883E+00	0.1597E+01	0.1000E-02
0.9117E+03	0.8607E+00	0.7984E+01	0.5000E-02
0.1559E+04	0.1497E+01	0.1597E+02	0.1000E-01
0.2456E+04	0.2390E+01	0.3194E+02	0.2000E-01
0.3529E+04	0.3503E+01	0.5415E+02	0.5000E-01
0.3967E+04	0.3986E+01	0.6286E+02	0.8000E-01
0.4133E+04	0.4180E+01	0.6866E+02	0.1000E+00
0.4206E+04	0.4364E+01	0.9719E+02	0.2000E+00
0.4130E+04	0.4586E+01	0.1302E+03	0.5000E+00
0.4155E+04	0.4913E+01	0.1554E+03	0.8000E+00
0.4167E+04	0.5126E+01	0.1677E+03	0.1000E+01
0.4193E+04	0.6154E+01	0.1938E+03	0.2000E+01

WEAP Parameter Calculation

Bent #: **EB-1 RT**

		Toe Quake	Shaft Quake
Pile Type:	HP 12X53	**0.10**	**0.10**

Subsurface Conditions: Loose/Soft or Submerged

Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping
1	2722.0	2713.4	18	Sand	0.18
2	2713.4	2704.9	16	Sand	0.18
3	2704.9	2688.9	50	Sand	0.12
4	2688.9	2687.9	100	WR	0.10
5					
6					
7					
8					
9					
10					
11					
12					
13					

	Toe Damping
0.15	**0.10**

Length of Pile	34.1

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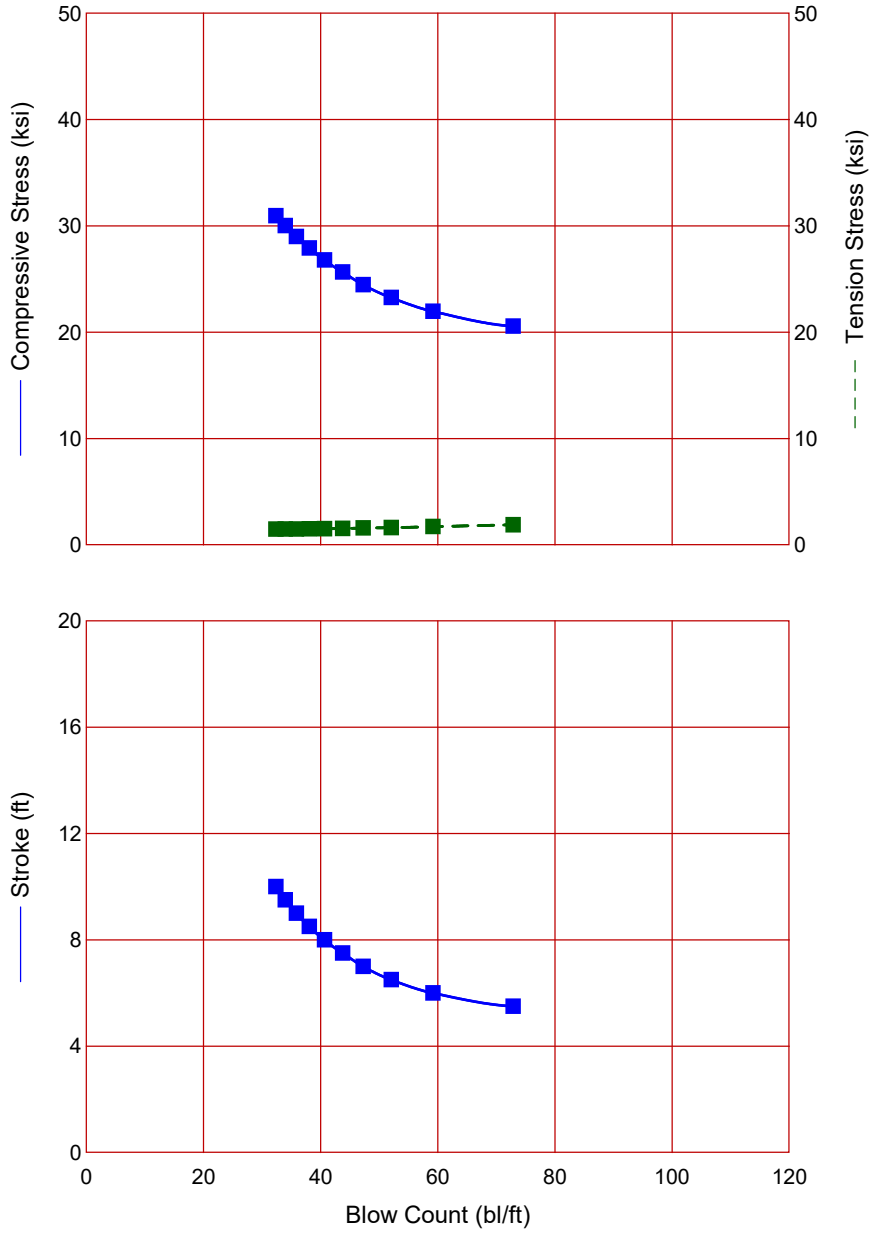
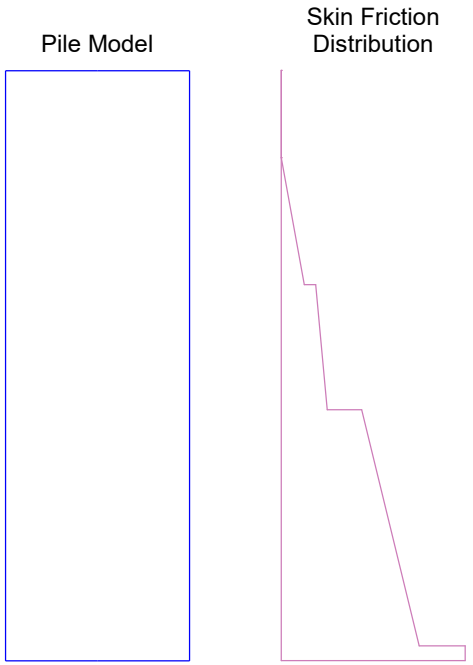
Bridge No. 063 - EB1 - RT

06-Sep-2022
GRLWEAP Version 2010



DELMAG D 12

Capacity	220.0	kips
Ram Weight	2.75	kips
Efficiency	0.800	
Pressure	1380 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.150	s/ft
Toe Damping	0.100	s/ft
Pile Length	40.00	ft
Pile Penetration	34.10	ft
Pile Top Area	15.50	in2



Res. Shaft = 32 %
(Proportional)

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Bridge No. 063 - EB1 - RT

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
220.0	20.56	1.89	72.9	5.50	7.74
220.0	21.96	1.72	59.2	6.00	8.96
220.0	23.26	1.63	52.1	6.50	9.97
220.0	24.46	1.59	47.3	7.00	10.92
220.0	25.65	1.55	43.8	7.50	11.79
220.0	26.79	1.52	40.7	8.00	12.71
220.0	27.91	1.50	38.1	8.50	13.62
220.0	28.99	1.49	35.9	9.00	14.53
220.0	30.02	1.49	34.0	9.50	15.45
220.0	30.95	1.48	32.4	10.00	16.33

Delmag D12 or similar hammer is suitable for driving piles at End Bent No. 1 RT

GEOTECHNICAL BORING REPORT
BORE LOG

Bent No. 1 - LT

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. B1-A	**STATION** 16+22	**OFFSET** 26 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,718.3 ft	**TOTAL DEPTH** 74.9 ft	**NORTHING** 977,673	**EASTING** 1,328,030	**24 HR.** 2.4
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** Core Boring		**HAMMER TYPE** Automatic
DRILLER J. Cain	**START DATE** 07/13/22	**COMP. DATE** 07/13/22	**SURFACE WATER DEPTH** N/A	

BOC = 2722.8'

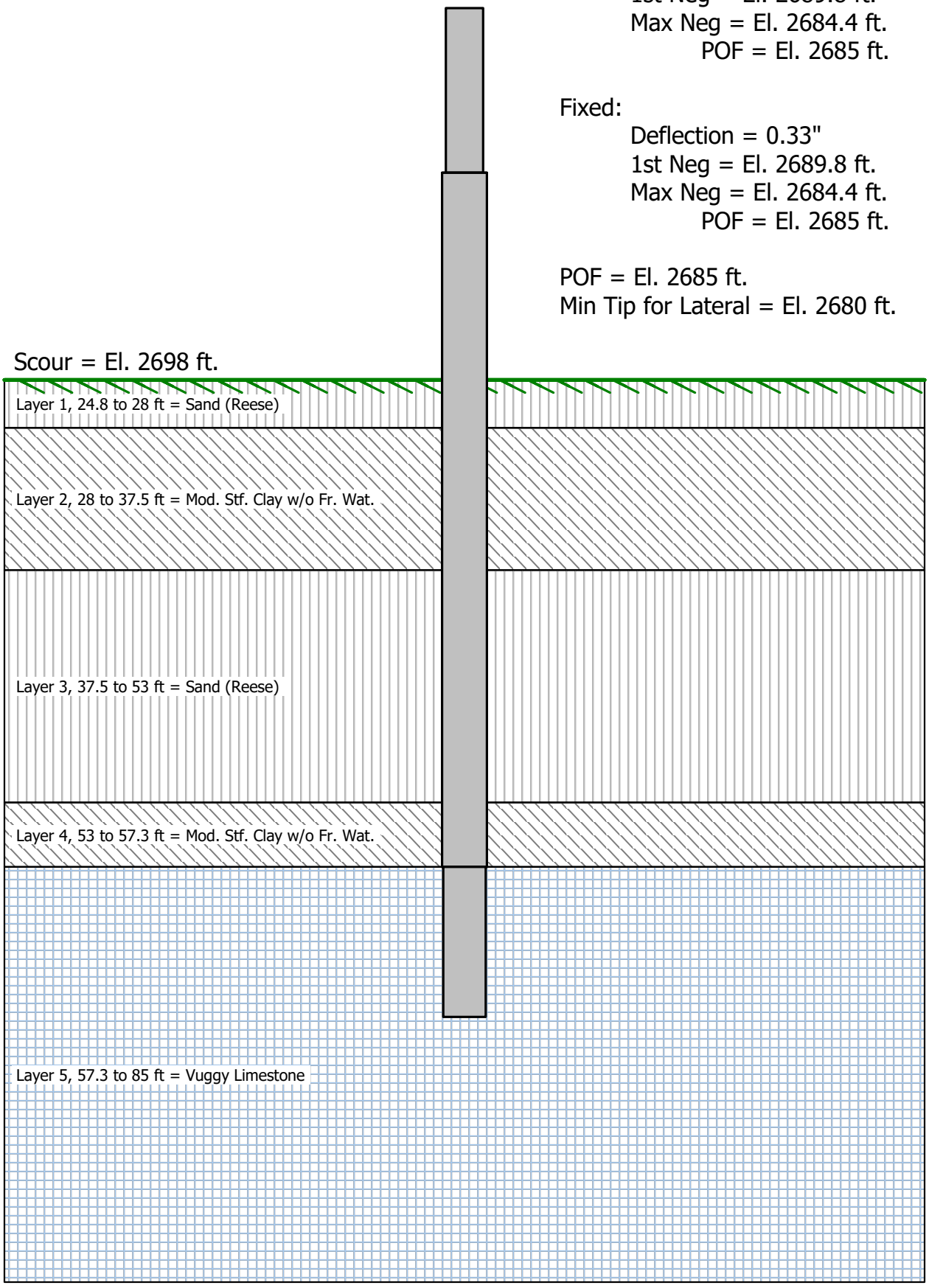
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
2720										ELEV. (ft) DEPTH (ft)
	2,718.3	0.0								2,718.3 GROUND SURFACE 0.0
			2	3	3	6		W		**ALLUVIAL** Medium Stiff, Brown-Black, Fine to Coarse Sandy SILT (A-4), with trace mica
2715	2,714.8	3.5								2,715.3 3.0
			3	6	9	15		Sat.		Loose to Medium Dense, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)
	2,712.3	6.0								TOP OF PIER = 2711.82'
			3	3	4	7 (10)		Sat.		
2710	2,709.8	8.5								
			2	3	4	7 (10)		Sat.		
2705	2,704.8	13.5								2,705.8 12.5
			16	19	25	44 (62)		W		**RESIDUAL** Very Stiff to Hard, Gray-Tan, Fine to Coarse Sandy SILT (A-4), with trace mica
2700	2,699.8	18.5								
			10	10	7	17 (24)		W		BSR Scour 2698'
2695	2,694.8	23.5								2694' Perm Case
			23	77/0.2		100/0.7				2,694.8 23.5 **WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Tan-Brown
2690	2,689.8	28.5	100/0.2			100/0.2				
2685	2,684.8	33.5								2,685.3 33.0
			9	12	18	30 (42)		W		**RESIDUAL** Hard, Brown, Fine to Coarse Sandy SILT (A-4), with trace rock fragments
2680	2,679.8	38.5								
			19	30	43	73 (100)		W		
2675	2,674.8	43.5								2,676.8 41.5 Medium Dense, Brown, Silty Fine to Coarse SAND (A-2-4), with little rock fragments
			5	6	7	13 (18)		Sat.		
2670	2,669.8	48.5								2,669.8 48.5 **WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Gray
			100/0.2			100/0.2				
2665	2,665.5	52.8								2,665.5 52.8
			60/0.1			60/0.1				2,665.4 52.9 **CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS)
							RS-1			**CRYSTALLINE ROCK** Fresh, Hard, White-Green BIOTITE/HORNBLENDE GNEISS with Wide Fracture Spacing
2660										REC = 100%, RQD = 100%, GSI = 85 - 90
2655										
2650										
							RS-2			
2645										2,643.4 74.9 Boring Terminated at Elevation 2,643.4 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

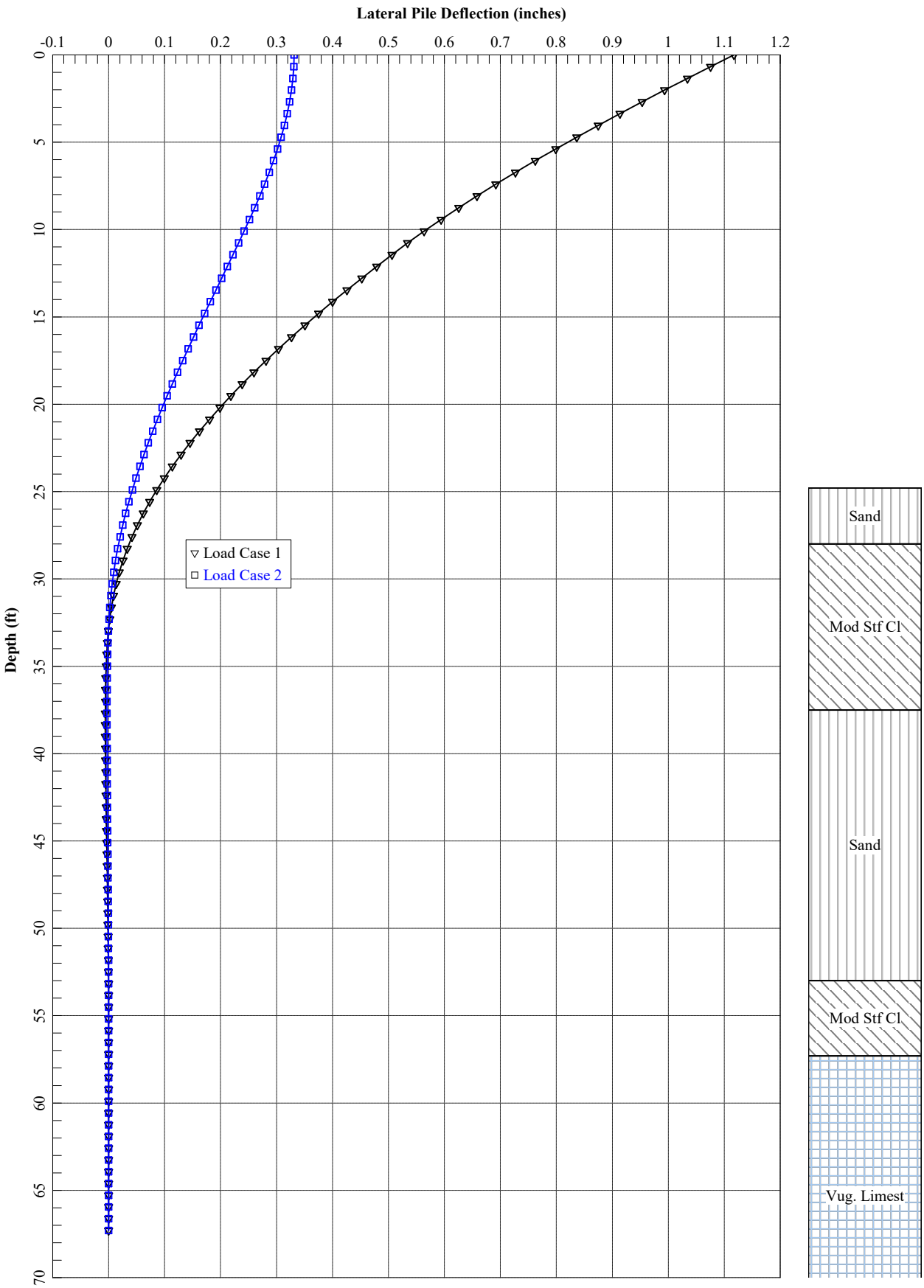
Bent No. 1 - LT

Free:
Deflection = 1.11"
1st Neg = El. 2689.8 ft.
Max Neg = El. 2684.4 ft.
POF = El. 2685 ft.

Fixed:
Deflection = 0.33"
1st Neg = El. 2689.8 ft.
Max Neg = El. 2684.4 ft.
POF = El. 2685 ft.

POF = El. 2685 ft.
Min Tip for Lateral = El. 2680 ft.





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LPile for Windows, Version 2019-11.009

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

==========

This copy of LPile is being used by:

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Files Used for Analysis

Path to file locations:
\Users\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500- 29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\LPile\

Name of input data file:
Bridge 063- Bent 1 (B1-A).lp11d

Name of output report file:
Bridge 063- Bent 1 (B1-A).lp11o

Name of plot output file:
Bridge 063- Bent 1 (B1-A).lp11p

Name of runtime message file:
Bridge 063- Bent 1 (B1-A).lp11r

Date and Time of Analysis

Date: September 9, 2022 Time: 8:44:05

Problem Title

Project Name: Bridge 063

Job Number: 09-29662

Client: STV

Engineer: ECS Southeast

Description: Bent 1 (LT) Lateral Analysis

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
- Input of side resistance moment along pile 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 = 3
Total length of pile = 67.300 ft
Depth of ground surface below top of pile = 24.8000 ft

Pile diameters used for p-y curve computations are defined using 6 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	30.0000
2	10.980	30.0000
3	10.980	36.0000
4	57.300	36.0000
5	57.300	34.0000
6	67.300	34.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 10.980000 ft
Width of top of section = 30.000000 in
Width of bottom of section = 30.000000 in
Top Area = 706.858347 sq. in
Bottom Area = 706.858347 sq. in
Moment of Inertia at Top = 39761. in^4
Moment of Inertia at Bottom = 39761. in^4
Elastic Modulus = 3122019. psi

Pile Section No. 2:

Section 2 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 46.320000 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 = 3823676. psi

Pile Section No. 3:

Section 3 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 10.000000 ft
Width of top of section = 34.000000 in
Width of bottom of section = 34.000000 in
Top Area = 907.920277 sq. in
Bottom Area = 907.920277 sq. in
Moment of Inertia at Top = 65597. in^4
Moment of Inertia at Bottom = 65597. in^4
Elastic Modulus = 3823676. 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 5 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 24.800000 ft
Distance from top of pile to bottom of layer = 28.000000 ft
Effective unit weight at top of layer = 57.600000 pcf
Effective unit weight at bottom of layer = 57.600000 pcf
Friction angle at top of layer = 32.000000 deg.
Friction angle at bottom of layer = 32.000000 deg.
Subgrade k at top of layer = 60.000000 pci
Subgrade k at bottom of layer = 60.000000 pci

Layer 2 is stiff clay with user-defined k-value

Distance from top of pile to top of layer = 28.000000 ft
Distance from top of pile to bottom of layer = 37.500000 ft
Effective unit weight at top of layer = 100.000000 pcf
Effective unit weight at bottom of layer = 100.000000 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
Subgrade k at top of layer = 2000. pci
Subgrade k at bottom of layer = 2000. pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 37.500000 ft
Distance from top of pile to bottom of layer = 53.000000 ft
Effective unit weight at top of layer = 57.600000 pcf
Effective unit weight at bottom of layer = 57.600000 pcf
Friction angle at top of layer = 32.000000 deg.
Friction angle at bottom of layer = 32.000000 deg.
Subgrade k at top of layer = 60.000000 pci
Subgrade k at bottom of layer = 60.000000 pci

Layer 4 is stiff clay with user-defined k-value

Distance from top of pile to top of layer = 53.000000 ft
Distance from top of pile to bottom of layer = 57.300000 ft
Effective unit weight at top of layer = 100.000000 pcf
Effective unit weight at bottom of layer = 100.000000 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
Subgrade k at top of layer = 2000. pci
Subgrade k at bottom of layer = 2000. pci

Layer 5 is strong rock (vuggy limestone)

Distance from top of pile to top of layer = 57.300000 ft
Distance from top of pile to bottom of layer = 85.000000 ft
Effective unit weight at top of layer = 173.000000 pcf
Effective unit weight at bottom of layer = 173.000000 pcf
Uniaxial compressive strength at top of layer = 10248. psi
Uniaxial compressive strength at bottom of layer = 10248. psi

(Depth of the lowest soil layer extends 17.700 ft below the pile tip)

**** Warning- Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 173.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	E50 or krm	kpy pci
1	Sand	24.8000	57.6000	--	32.0000	--	--	60.0000
	(Reese, et al.)	28.0000	57.6000	--	32.0000	--	--	60.0000
2	Stiff Clay w/o	28.0000	100.0000	8000.	--	--	0.00400	2000.
	Free Water, using k	37.5000	100.0000	8000.	--	--	0.00400	2000.
3	Sand	37.5000	57.6000	--	32.0000	--	--	60.0000
	(Reese, et al.)	53.0000	57.6000	--	32.0000	--	--	60.0000
4	Stiff Clay w/o	53.0000	100.0000	8000.	--	--	0.00400	2000.
	Free Water, using k	57.3000	100.0000	8000.	--	--	0.00400	2000.
5	Strong Rock	57.3000	173.0000	--	--	10248.	--	--
	(Vuggy Limestone)	85.0000	173.0000	--	--	10248.	--	--

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 = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 11000. lbs	M = 720000. in-lbs	500000.	No	Yes
2	2	V = 13000. lbs	S = 0.0000 in/in	510000.	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 = 3

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 3:

Moment-curvature properties were derived from elastic section properties

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Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	24.8000	0.00	N.A.	No	0.00	9161.
2	28.0000	0.1268	No	No	9161.	881073.
3	37.5000	22.3501	No	No	890234.	2364122.
4	53.0000	25.7652	No	No	3254357.	1070512.
5	57.3000	32.5000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals
for Layer n. Layering correction equivalent depths are computed only
for soil types with both shallow-depth and deep-depth expressions for
peak lateral load transfer. These soil types are soft and stiff clays,
non-liquefied sands, and cemented c-phi soil.

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 = 11000.0 lbs
Applied moment at pile head = 720000.0 in-lbs
Axial thrust load on pile head = 500000.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	1.1173	720000.	11000.	-0.00519	978.9797	1.24E+11	0.00	0.00	0.00
0.6730	1.0756	829684.	11000.	-0.00514	1020.	1.24E+11	0.00	0.00	0.00
1.3460	1.0343	939150.	11000.	-0.00508	1062.	1.24E+11	0.00	0.00	0.00
2.0190	0.9935	1048369.	11000.	-0.00501	1103.	1.24E+11	0.00	0.00	0.00
2.6920	0.9533	1157312.	11000.	-0.00494	1144.	1.24E+11	0.00	0.00	0.00
3.3650	0.9137	1265952.	11000.	-0.00486	1185.	1.24E+11	0.00	0.00	0.00
4.0380	0.8748	1374259.	11000.	-0.00478	1226.	1.24E+11	0.00	0.00	0.00
4.7110	0.8366	1482205.	11000.	-0.00468	1267.	1.24E+11	0.00	0.00	0.00
5.3840	0.7991	1589762.	11000.	-0.00458	1307.	1.24E+11	0.00	0.00	0.00
6.0570	0.7625	1696901.	11000.	-0.00448	1348.	1.24E+11	0.00	0.00	0.00
6.7300	0.7268	1803594.	11000.	-0.00436	1388.	1.24E+11	0.00	0.00	0.00
7.4030	0.6920	1909814.	11000.	-0.00424	1428.	1.24E+11	0.00	0.00	0.00
8.0760	0.6583	2015531.	11000.	-0.00412	1468.	1.24E+11	0.00	0.00	0.00
8.7490	0.6256	2120719.	11000.	-0.00398	1507.	1.24E+11	0.00	0.00	0.00
9.4220	0.5940	2225351.	11000.	-0.00384	1547.	1.24E+11	0.00	0.00	0.00
10.0950	0.5635	2329397.	11000.	-0.00369	1586.	1.24E+11	0.00	0.00	0.00
10.7680	0.5343	2432832.	11000.	-0.00354	1625.	1.24E+11	0.00	0.00	0.00
11.4410	0.5064	2535627.	11000.	-0.00342	1045.	3.15E+11	0.00	0.00	0.00
12.1140	0.4790	2638160.	11000.	-0.00336	1067.	3.15E+11	0.00	0.00	0.00
12.7870	0.4522	2740420.	11000.	-0.00329	1090.	3.15E+11	0.00	0.00	0.00
13.4600	0.4259	2842397.	11000.	-0.00322	1112.	3.15E+11	0.00	0.00	0.00
14.1330	0.4002	2944080.	11000.	-0.00314	1134.	3.15E+11	0.00	0.00	0.00
14.8060	0.3751	3045458.	11000.	-0.00307	1156.	3.15E+11	0.00	0.00	0.00
15.4790	0.3507	3146521.	11000.	-0.00299	1178.	3.15E+11	0.00	0.00	0.00
16.1520	0.3269	3247259.	11000.	-0.00291	1200.	3.15E+11	0.00	0.00	0.00
16.8250	0.3037	3347660.	11000.	-0.00282	1222.	3.15E+11	0.00	0.00	0.00
17.4980	0.2813	3447716.	11000.	-0.00273	1244.	3.15E+11	0.00	0.00	0.00
18.1710	0.2596	3547414.	11000.	-0.00264	1266.	3.15E+11	0.00	0.00	0.00
18.8440	0.2386	3646746.	11000.	-0.00255	1287.	3.15E+11	0.00	0.00	0.00
19.5170	0.2183	3745701.	11000.	-0.00246	1309.	3.15E+11	0.00	0.00	0.00
20.1900	0.1989	3844268.	11000.	-0.00236	1330.	3.15E+11	0.00	0.00	0.00
20.8630	0.1802	3942438.	11000.	-0.00226	1352.	3.15E+11	0.00	0.00	0.00
21.5360	0.1624	4040199.	11000.	-0.00216	1373.	3.15E+11	0.00	0.00	0.00
22.2090	0.1453	4137543.	11000.	-0.00205	1395.	3.15E+11	0.00	0.00	0.00

22.8820	0.1292	4234459.	11000.	-0.00195	1416.	3.15E+11	0.00	0.00	0.00	
23.5550	0.1139	4330936.	11000.	-0.00184	1437.	3.15E+11	0.00	0.00	0.00	
24.2280	0.09952	4426966.	11000.	-0.00172	1458.	3.15E+11	0.00	0.00	0.00	
24.9010	0.08605	4522538.	10977.	-0.00161	1479.	3.15E+11	-5.6312	528.5361	0.00	
25.5740	0.07351	4617274.	10789.	-0.00149	1499.	3.15E+11	-40.9652	4501.	0.00	
26.2470	0.06193	4708862.	10363.	-0.00137	1519.	3.15E+11	-64.5198	8414.	0.00	
26.9200	0.05132	4795754.	9786.	-0.00125	1538.	3.15E+11	-78.3383	12327.	0.00	
27.5930	0.04171	4877040.	9131.	-0.00113	1556.	3.15E+11	-83.8732	16241.	0.00	
28.2660	0.03310	4952352.	1969.	-0.00100	1572.	3.15E+11	-1690.	412238.	0.00	
28.9390	0.02552	4916944.	-11493.	-8.76E-04	1565.	3.15E+11	-1644.	520315.	0.00	
29.6120	0.01896	4773783.	-24527.	-7.52E-04	1533.	3.15E+11	-1583.	674524.	0.00	
30.2850	0.01338	4526850.	-36994.	-6.32E-04	1480.	3.15E+11	-1504.	907474.	0.00	
30.9580	0.00874	4181370.	-48284.	-5.21E-04	1404.	3.15E+11	-1292.	1193568.	0.00	
31.6310	0.00497	3751174.	-56792.	-4.19E-04	1310.	3.15E+11	-814.7221	1324012.	0.00	
32.3040	0.00197	3267452.	-61515.	-3.29E-04	1205.	3.15E+11	-355.0427	1454455.	0.00	
32.9770	-3.51E-04	2760236.	-62671.	-2.52E-04	1094.	3.15E+11	68.8257	1584899.	0.00	
33.6500	-0.00210	2257223.	-60591.	-1.88E-04	984.0149	3.15E+11	446.4157	1715342.	0.00	
34.3230	-0.00339	1783093.	-55663.	-1.36E-04	880.5030	3.15E+11	773.8409	1845786.	0.00	
34.9960	-0.00430	1359250.	-48289.	-9.59E-05	787.9697	3.15E+11	1052.	1976230.	0.00	
35.6690	-0.00493	1003910.	-38841.	-6.56E-05	710.3921	3.15E+11	1287.	2106673.	0.00	
36.3420	-0.00536	732428.	-27645.	-4.34E-05	651.1223	3.15E+11	1485.	2237117.	0.00	
37.0150	-0.00564	557731.	-15042.	-2.69E-05	612.9826	3.15E+11	1636.	2344388.	0.00	
37.6880	-0.00580	489685.	-8218.	-1.35E-05	598.1268	3.15E+11	53.7771	74940.	0.00	
38.3610	-0.00585	425095.	-7771.	-1.74E-06	584.0256	3.15E+11	57.1520	78853.	0.00	
39.0340	-0.00582	364189.	-7299.	8.37E-06	570.7286	3.15E+11	59.6819	82767.	0.00	
39.7070	-0.00572	307138.	-6810.	1.70E-05	558.2733	3.15E+11	61.3741	86680.	0.00	
40.3800	-0.00555	254058.	-6311.	2.42E-05	546.6849	3.15E+11	62.2515	90593.	0.00	
41.0530	-0.00533	205012.	-5808.	3.00E-05	535.9771	3.15E+11	62.3503	94507.	0.00	
41.7260	-0.00506	160012.	-5307.	3.47E-05	526.1526	3.15E+11	61.7176	98420.	0.00	
42.3990	-0.00477	119020.	-4813.	3.83E-05	517.2033	3.15E+11	60.4099	102333.	0.00	
43.0720	-0.00445	81955.	-4333.	4.09E-05	509.1114	3.15E+11	58.4905	106247.	0.00	
43.7450	-0.00411	48698.	-3871.	4.25E-05	501.8506	3.15E+11	56.0282	110160.	0.00	
44.4180	-0.00376	19089.	-3430.	4.34E-05	495.3865	3.15E+11	53.0957	114073.	0.00	
45.0910	-0.00341	-7058.	-3015.	4.36E-05	492.7600	3.15E+11	49.7677	117986.	0.00	
45.7640	-0.00306	-29959.	-2628.	4.31E-05	497.7597	3.15E+11	46.1201	121900.	0.00	
46.4370	-0.00271	-49849.	-2271.	4.21E-05	502.1020	3.15E+11	42.2290	125813.	0.00	
47.1100	-0.00238	-66979.	-1946.	4.06E-05	505.8419	3.15E+11	38.1693	129726.	0.00	
47.7830	-0.00206	-81613.	-1655.	3.87E-05	509.0368	3.15E+11	34.0148	133640.	0.00	
48.4560	-0.00175	-94020.	-1397.	3.64E-05	511.7455	3.15E+11	29.8371	137553.	0.00	
49.1290	-0.00147	-104472.	-1173.	3.39E-05	514.0272	3.15E+11	25.7058	141466.	0.00	
49.8020	-0.00120	-113236.	-981.3348	3.11E-05	515.9405	3.15E+11	21.6880	145380.	0.00	
50.4750	-9.66E-04	-120573.	-821.6859	2.81E-05	517.5424	3.15E+11	17.8487	149293.	0.00	
51.1480	-7.51E-04	-126734.	-692.0688	2.49E-05	518.8875	3.15E+11	14.2507	153206.	0.00	
51.8210	-5.63E-04	-131953.	-590.2877	2.16E-05	520.0268	3.15E+11	10.9551	157120.	0.00	
52.4940	-4.02E-04	-136443.	-513.6596	1.82E-05	521.0071	3.15E+11	8.0216	161033.	0.00	
53.1670	-2.70E-04	-140396.	260.2147	1.46E-05	521.8702	3.15E+11	183.6263	5498205.	0.00	
53.8400	-1.66E-04	-132358.	1469.	1.11E-05	520.1153	3.15E+11	115.8269	5628649.	0.00	
54.5130	-9.00E-05	-116752.	2196.	7.93E-06	516.7082	3.15E+11	64.2102	5759093.	0.00	
55.1860	-3.81E-05	-96946.	2568.	5.20E-06	512.3842	3.15E+11	27.7486	5889536.	0.00	
55.8590	-6.11E-06	-75320.	2698.	2.99E-06	507.6628	3.15E+11	4.5581	6019980.	0.00	
56.5320	1.02E-05	-53389.	2685.	1.34E-06	502.8748	3.15E+11	-7.7967	6150423.	0.00	
57.2050	1.55E-05	-31961.	2605.	2.48E-07	498.1967	3.15E+11	-12.0896	6280867.	0.00	
57.8780	1.42E-05	-11318.	1967.	-3.44E-07	553.6424	2.51E+11	-145.9284	8.28E+07	0.00	

58.5510	9.99E-06	-191.7530	964.0081	-5.29E-07	550.7588	2.51E+11	-102.3920	8.28E+07	0.00
59.2240	5.69E-06	4257.	314.9537	-4.64E-07	551.8123	2.51E+11	-58.3446	8.28E+07	0.00
59.8970	2.50E-06	4899.	-24.1774	-3.16E-07	551.9788	2.51E+11	-25.6403	8.28E+07	0.00
60.5700	5.85E-07	3869.	-151.9054	-1.75E-07	551.7117	2.51E+11	-5.9912	8.28E+07	0.00
61.2430	-3.27E-07	2447.	-162.5758	-7.35E-08	551.3433	2.51E+11	3.3487	8.28E+07	0.00
61.9160	-6.02E-07	1243.	-124.1480	-1.40E-08	551.0314	2.51E+11	6.1679	8.28E+07	0.00
62.5890	-5.54E-07	441.8377	-76.3313	1.31E-08	550.8237	2.51E+11	5.6738	8.28E+07	0.00
63.2620	-3.91E-07	10.3321	-37.2591	2.04E-08	550.7118	2.51E+11	4.0023	8.28E+07	0.00
63.9350	-2.25E-07	-160.1361	-11.7970	1.80E-08	550.7506	2.51E+11	2.3033	8.28E+07	0.00
64.6080	-1.01E-07	-180.3573	1.6671	1.25E-08	550.7559	2.51E+11	1.0310	8.28E+07	0.00
65.2810	-2.34E-08	-133.3094	6.7970	7.42E-09	550.7437	2.51E+11	0.2394	8.28E+07	0.00
65.9540	1.92E-08	-70.6319	6.9679	4.14E-09	550.7275	2.51E+11	-0.1971	8.28E+07	0.00
66.6270	4.34E-08	-20.7973	4.3743	2.66E-09	550.7145	2.51E+11	-0.4453	8.28E+07	0.00
67.3000	6.23E-08	0.00	0.00	2.33E-09	550.7091	2.51E+11	-0.6380	4.14E+07	0.00

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

Output Summary for Load Case No. 1:

Pile-head deflection = 1.11725661 inches
Computed slope at pile head = -0.00518632 radians
Maximum bending moment = 4952352. inch-lbs
Maximum shear force = -62671. lbs
Depth of maximum bending moment = 28.26600000 feet below pile head
Depth of maximum shear force = 32.97700000 feet below pile head
Number of iterations = 11
Number of zero deflection points = 4

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

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

Shear force at pile head = 13000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 510000.0 lbs

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

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. p	Soil Spr. Es*H	Distrib. Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	0.3314	-2044561.	13000.	0.00	1493.	1.24E+11	0.00	0.00	0.00
0.6730	0.3309	-1939299.	13000.	-1.30E-04	1453.	1.24E+11	0.00	0.00	0.00
1.3460	0.3293	-1833517.	13000.	-2.52E-04	1413.	1.24E+11	0.00	0.00	0.00
2.0190	0.3268	-1727244.	13000.	-3.68E-04	1373.	1.24E+11	0.00	0.00	0.00
2.6920	0.3234	-1620508.	13000.	-4.77E-04	1333.	1.24E+11	0.00	0.00	0.00

3.3650	0.3191	-1513338.	13000.	-5.79E-04	1292.	1.24E+11	0.00	0.00	0.00
4.0380	0.3140	-1405763.	13000.	-6.74E-04	1252.	1.24E+11	0.00	0.00	0.00
4.7110	0.3082	-1297811.	13000.	-7.62E-04	1211.	1.24E+11	0.00	0.00	0.00
5.3840	0.3017	-1189511.	13000.	-8.43E-04	1170.	1.24E+11	0.00	0.00	0.00
6.0570	0.2946	-1080892.	13000.	-9.17E-04	1129.	1.24E+11	0.00	0.00	0.00
6.7300	0.2869	-971984.	13000.	-9.83E-04	1088.	1.24E+11	0.00	0.00	0.00
7.4030	0.2787	-862815.	13000.	-0.00104	1047.	1.24E+11	0.00	0.00	0.00
8.0760	0.2701	-753415.	13000.	-0.00110	1006.	1.24E+11	0.00	0.00	0.00
8.7490	0.2610	-643813.	13000.	-0.00114	964.3849	1.24E+11	0.00	0.00	0.00
9.4220	0.2516	-534039.	13000.	-0.00118	922.9718	1.24E+11	0.00	0.00	0.00
10.0950	0.2420	-424121.	13000.	-0.00121	881.5048	1.24E+11	0.00	0.00	0.00
10.7680	0.2321	-314090.	13000.	-0.00123	839.9949	1.24E+11	0.00	0.00	0.00
11.4410	0.2220	-203975.	13000.	-0.00125	545.5750	3.15E+11	0.00	0.00	0.00
12.1140	0.2119	-93838.	13000.	-0.00125	521.5300	3.15E+11	0.00	0.00	0.00
12.7870	0.2018	16309.	13000.	-0.00125	504.6038	3.15E+11	0.00	0.00	0.00
13.4600	0.1917	126454.	13000.	-0.00125	528.6506	3.15E+11	0.00	0.00	0.00
14.1330	0.1816	236585.	13000.	-0.00125	552.6945	3.15E+11	0.00	0.00	0.00
14.8060	0.1716	346692.	13000.	-0.00124	576.7330	3.15E+11	0.00	0.00	0.00
15.4790	0.1616	456762.	13000.	-0.00123	600.7634	3.15E+11	0.00	0.00	0.00
16.1520	0.1518	566784.	13000.	-0.00121	624.7834	3.15E+11	0.00	0.00	0.00
16.8250	0.1420	676746.	13000.	-0.00120	648.7902	3.15E+11	0.00	0.00	0.00
17.4980	0.1324	786637.	13000.	-0.00118	672.7815	3.15E+11	0.00	0.00	0.00
18.1710	0.1229	896445.	13000.	-0.00116	696.7547	3.15E+11	0.00	0.00	0.00
18.8440	0.1137	1006158.	13000.	-0.00113	720.7072	3.15E+11	0.00	0.00	0.00
19.5170	0.1046	1115765.	13000.	-0.00111	744.6366	3.15E+11	0.00	0.00	0.00
20.1900	0.09579	1225254.	13000.	-0.00108	768.5402	3.15E+11	0.00	0.00	0.00
20.8630	0.08722	1334614.	13000.	-0.00104	792.4156	3.15E+11	0.00	0.00	0.00
21.5360	0.07892	1443833.	13000.	-0.00101	816.2603	3.15E+11	0.00	0.00	0.00
22.2090	0.07092	1552900.	13000.	-9.70E-04	840.0717	3.15E+11	0.00	0.00	0.00
22.8820	0.06325	1661803.	13000.	-9.29E-04	863.8473	3.15E+11	0.00	0.00	0.00
23.5550	0.05591	1770530.	13000.	-8.85E-04	887.5847	3.15E+11	0.00	0.00	0.00
24.2280	0.04895	1879071.	13000.	-8.39E-04	911.2813	3.15E+11	0.00	0.00	0.00
24.9010	0.04237	1987414.	12988.	-7.89E-04	934.9346	3.15E+11	-3.0812	587.2867	0.00
25.5740	0.03620	2095345.	12894.	-7.37E-04	958.4982	3.15E+11	-20.1762	4501.	0.00
26.2470	0.03047	2201740.	12684.	-6.82E-04	981.7263	3.15E+11	-31.7468	8414.	0.00
26.9200	0.02519	2305832.	12400.	-6.24E-04	1004.	3.15E+11	-38.4569	12327.	0.00
27.5930	0.02039	2407173.	12080.	-5.64E-04	1027.	3.15E+11	-41.0120	16241.	0.00
28.2660	0.01609	2505584.	6509.	-5.01E-04	1048.	3.15E+11	-1339.	671794.	0.00
28.9390	0.01231	2516426.	-3833.	-4.36E-04	1050.	3.15E+11	-1223.	802238.	0.00
29.6120	0.00904	2447260.	-12988.	-3.73E-04	1035.	3.15E+11	-1045.	932681.	0.00
30.2850	0.00629	2309707.	-20549.	-3.12E-04	1005.	3.15E+11	-827.7235	1063125.	0.00
30.9580	0.00401	2117926.	-26283.	-2.55E-04	963.4279	3.15E+11	-592.4449	1193568.	0.00
31.6310	0.00217	1887280.	-30111.	-2.04E-04	913.0734	3.15E+11	-355.3761	1324012.	0.00
32.3040	7.17E-04	1633257.	-32067.	-1.59E-04	857.6152	3.15E+11	-129.1556	1454455.	0.00
32.9770	-3.95E-04	1370638.	-32275.	-1.20E-04	800.2803	3.15E+11	77.6107	1584899.	0.00
33.6500	-0.00122	1112936.	-30912.	-8.84E-05	744.0190	3.15E+11	260.0897	1715342.	0.00
34.3230	-0.00182	872080.	-28179.	-6.30E-05	691.4355	3.15E+11	416.7260	1845786.	0.00
34.9960	-0.00224	658312.	-24281.	-4.34E-05	644.7657	3.15E+11	548.5563	1976230.	0.00
35.6690	-0.00252	480252.	-19407.	-2.88E-05	605.8918	3.15E+11	658.3746	2106673.	0.00
36.3420	-0.00271	345082.	-13721.	-1.82E-05	576.3815	3.15E+11	749.7857	2237117.	0.00
37.0150	-0.00282	258778.	-7357.	-1.05E-05	557.5397	3.15E+11	826.1735	2367560.	0.00
37.6880	-0.00288	226331.	-3914.	-4.27E-06	550.4559	3.15E+11	26.6880	74940.	0.00
38.3610	-0.00289	195601.	-3692.	1.13E-06	543.7469	3.15E+11	28.1898	78853.	0.00

39.0340	-0.00286	166689.	-3460.	5.77E-06	537.4348	3.15E+11	29.2875	82767.	0.00
39.7070	-0.00279	139669.	-3221.	9.70E-06	531.5358	3.15E+11	29.9867	86680.	0.00
40.3800	-0.00270	114591.	-2977.	1.30E-05	526.0607	3.15E+11	30.2998	90593.	0.00
41.0530	-0.00258	91476.	-2733.	1.56E-05	521.0144	3.15E+11	30.2455	94507.	0.00
41.7260	-0.00245	70325.	-2490.	1.77E-05	516.3966	3.15E+11	29.8477	98420.	0.00
42.3990	-0.00230	51112.	-2252.	1.92E-05	512.2022	3.15E+11	29.1344	102333.	0.00
43.0720	-0.00214	33795.	-2021.	2.03E-05	508.4215	3.15E+11	28.1366	106247.	0.00
43.7450	-0.00197	18309.	-1798.	2.10E-05	505.0406	3.15E+11	26.8879	110160.	0.00
44.4180	-0.00180	4575.	-1587.	2.13E-05	502.0422	3.15E+11	25.4233	114073.	0.00
45.0910	-0.00163	-7501.	-1388.	2.12E-05	502.6810	3.15E+11	23.7788	117986.	0.00
45.7640	-0.00146	-18026.	-1204.	2.09E-05	504.9787	3.15E+11	21.9909	121900.	0.00
46.4370	-0.00129	-27114.	-1034.	2.03E-05	506.9629	3.15E+11	20.0956	125813.	0.00
47.1100	-0.00113	-34889.	-879.3323	1.95E-05	508.6603	3.15E+11	18.1286	129726.	0.00
47.7830	-9.74E-04	-41478.	-741.0176	1.86E-05	510.0988	3.15E+11	16.1247	133640.	0.00
48.4560	-8.29E-04	-47011.	-618.8998	1.74E-05	511.3068	3.15E+11	14.1175	137553.	0.00
49.1290	-6.93E-04	-51618.	-512.8735	1.62E-05	512.3126	3.15E+11	12.1396	141466.	0.00
49.8020	-5.68E-04	-55428.	-422.5759	1.48E-05	513.1444	3.15E+11	10.2223	145380.	0.00
50.4750	-4.54E-04	-58565.	-347.3960	1.33E-05	513.8293	3.15E+11	8.3958	149293.	0.00
51.1480	-3.53E-04	-61149.	-286.4845	1.18E-05	514.3934	3.15E+11	6.6888	153206.	0.00
51.8210	-2.64E-04	-63290.	-238.7617	1.02E-05	514.8608	3.15E+11	5.1296	157120.	0.00
52.4940	-1.88E-04	-65090.	-202.9250	8.56E-06	515.2537	3.15E+11	3.7453	161033.	0.00
53.1670	-1.25E-04	-66638.	157.1077	6.87E-06	515.5917	3.15E+11	85.4159	5498205.	0.00
53.8400	-7.69E-05	-62609.	718.3873	5.21E-06	514.7120	3.15E+11	53.5835	5628649.	0.00
54.5130	-4.13E-05	-55078.	1054.	3.71E-06	513.0678	3.15E+11	29.4187	5759093.	0.00
55.1860	-1.70E-05	-45622.	1222.	2.42E-06	511.0035	3.15E+11	12.4127	5889536.	0.00
55.8590	-2.23E-06	-35352.	1279.	1.38E-06	508.7614	3.15E+11	1.6596	6019980.	0.00
56.5320	5.25E-06	-24970.	1270.	6.06E-07	506.4949	3.15E+11	-4.0015	6150423.	0.00
57.2050	7.57E-06	-14847.	1230.	9.64E-08	504.2847	3.15E+11	-5.8864	6280867.	0.00
57.8780	6.81E-06	-5106.	924.2535	-1.76E-07	563.0465	2.51E+11	-69.8073	8.28E+07	0.00
58.5510	4.73E-06	83.1114	446.7570	-2.57E-07	561.7449	2.51E+11	-48.4434	8.28E+07	0.00
59.2240	2.66E-06	2112.	140.9011	-2.21E-07	562.2708	2.51E+11	-27.3010	8.28E+07	0.00
59.8970	1.15E-06	2361.	-16.9388	-1.49E-07	562.3351	2.51E+11	-11.7877	8.28E+07	0.00
60.5700	2.50E-07	1840.	-74.8961	-8.18E-08	562.2002	2.51E+11	-2.5653	8.28E+07	0.00
61.2430	-1.71E-07	1152.	-78.1734	-3.36E-08	562.0218	2.51E+11	1.7537	8.28E+07	0.00
61.9160	-2.93E-07	577.6461	-58.9633	-5.80E-09	561.8730	2.51E+11	3.0036	8.28E+07	0.00
62.5890	-2.65E-07	199.3948	-35.8746	6.71E-09	561.7750	2.51E+11	2.7142	8.28E+07	0.00
63.2620	-1.85E-07	-1.8563	-17.2687	9.89E-09	561.7238	2.51E+11	1.8935	8.28E+07	0.00
63.9350	-1.05E-07	-79.6108	-5.2711	8.58E-09	561.7440	2.51E+11	1.0777	8.28E+07	0.00
64.6080	-4.63E-08	-87.0663	0.9947	5.89E-09	561.7459	2.51E+11	0.4740	8.28E+07	0.00
65.2810	-9.99E-09	-63.5929	3.3223	3.47E-09	561.7398	2.51E+11	0.1024	8.28E+07	0.00
65.9540	9.74E-09	-33.4326	3.3329	1.90E-09	561.7320	2.51E+11	-0.09978	8.28E+07	0.00
66.6270	2.08E-08	-9.7754	2.0705	1.21E-09	561.7259	2.51E+11	-0.2129	8.28E+07	0.00
67.3000	2.93E-08	0.00	0.00	1.05E-09	561.7233	2.51E+11	-0.2999	4.14E+07	0.00

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

Output Summary for Load Case No. 2:

Pile-head deflection = 0.33142621 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 2516426. inch-lbs
Maximum shear force = -32275. lbs

Depth of maximum bending moment = 28.93900000 feet below pile head
Depth of maximum shear force = 32.97700000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 4

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	Load 1	Load Type	Load 2	Axial Pile-head Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	11000.	M, in-lb	720000.	500000.	1.1173	-0.00519	-62671.	4952352.
2	V, lb	13000.	S, rad	0.00	510000.	0.3314	0.00	-32275.	2516426.

Maximum pile-head deflection = 1.1172566122 inches
Maximum pile-head rotation =-0.0051863219 radians =-0.297154 deg.

Summary of Warning Messages

The following warning was reported 1605 times

**** Warning ****

This warning is for an input value for uniaxial compressive strength that
has been specified for a soil defined using the vuggy limestone criteria.
The input value is outside of the range of 1,000 to 2,500 psi
(6,895 to 17,237 kPa) which were used in actual field tests
on which this theory is based. Higher or lower values may be applicable
but the user is warned about the theoretical and testing limitations.

The analysis ended normally.

Elevations

Bottom of Cap (BOC) Elevation =	2,722.80	ft
Top of Pier/Bottom of Column Elevation =	2,711.82	ft
Natural Ground / Finished Grade Elevation =	2,712.00	ft
Groundwater Table (GWT) Elevation =	2,716.00	ft
Design Scour (DSE) Elevation =	2,698.00	ft
Amount of Contraction Scour (from BSR) =	6.80	ft
Is Permanent Casing Required?	◉ Yes / Maybe ○ No	
Bottom of Permanent Casing Elevation =	2,694.00	ft
Drilled Pier Tip Elevation =	2,656.00	ft

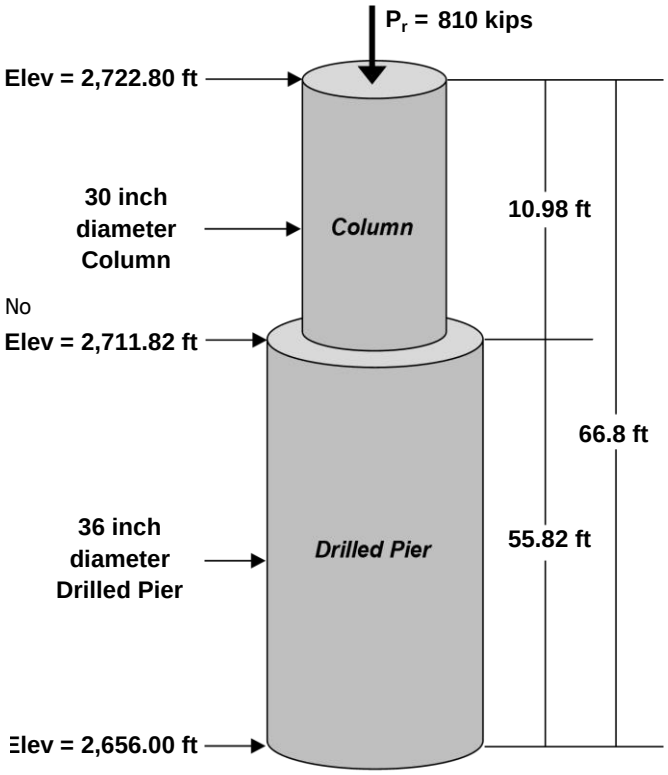


Figure shows typical drilled pier

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	810.0	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. =	B1-A	
SPT Hammer Energy Efficiency Rating (ER) =	84	%
Top of Boring (Collar) Elevation =	2718.30	ft
Depth to Groundwater Table (for actual boring) =	2.40	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	2,698.00	2,685.30	0.135	100	140	146					
2	Cohesionless Soil (Sand)	2,685.30	2,669.80	0.120	35	49	44					
3	Weathered Rock	2,669.80	2,665.50	0.135	100	140	118					
4	Hard Rock	2,665.50	2,656.00	0.173			N/A	100	85	1,476		
5												
6												
7												
8												
TIP [3]	Hard Rock	2,656.00	2,650.00	0.174			N/A	100	85	1,274	8,860	0.220

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.

Correcting SPT Values for Hammer Efficiency and Overburden Pressure

SPT-N Value Corrected for Hammer Efficiency, (N_{60})

$N_{60} = (ER/60\%)(N)$ *AASHTO Eqn. 10.4.6.2.4-2*

N_{60} = SPT blow count corrected for hammer efficiency (blows/ft)
ER = hammer efficiency expressed as percent of theoretical free fall energy delivered by the hammer system actually used. If ER is not known, use 80% for automatic hammers and 60% for drop hammers.
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for Overburden Pressure, (N1)

$N1 = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-1*

N1 = SPT blow count corrected for overburden pressure (blows/ft)
C_N = correction factor = $[0.77\log_{10}(40/\sigma'_v) < 2.0$
$\sigma'_v = \sigma_v - \mu$ = effective vertical stress at the depth of the SPT-N value (ksf)
σ_v = total vertical stress at the depth of the SPT-N value (ksf)
μ = total pore water pressure at the depth of the SPT-N value (ksf)
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for both Overburden Pressure and Hammer Efficiency, ($N1_{60}$)

$N1_{60} = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-3*

Summary of Corrected N Values for Boring

Top of Boring (Collar) Elevation = 2,718.3 ft
Depth to Groundwater Table = 2.4 ft
Hammer Efficiency (ER) = 84 %
Unit Weight of Water = 0.0624 kcf

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	σ_v at top (ksf)	Δz (ft)	Total γ (kcf)	σ_v at bottom (ksf)	σ_v at midpoint (ksf)	z_{water} (ft)	μ at midpoint (ksf)	σ'_{vo} at midpoint (ksf)	N (bpf)	N_{60} (bpf)	C_N	$N1_{60}$ (bpf)
1	2698.00	2685.30	2.436	12.70	0.135	4.151	3.293	24.25	1.513	1.78	100	140	1.04	146
2	2685.30	2669.80	4.151	15.50	0.120	6.011	5.081	38.35	2.393	2.687	35	49	0.9	44
3	2669.80	2665.50	6.011	4.30	0.135	6.591	6.301	48.25	3.011	3.29	100	140	0.84	118
4	2665.50	2656.00	6.591	9.50	0.173	8.235	7.413	55.15	3.441	3.971	N/A			N/A
5														
6														
7														
8														
TIP	2656.00	2650.00	8.235	6.00	0.174	9.279	8.757	62.90	3.925	4.832	N/A			N/A

Selecting Design Properties for Hard Rock

1. q_u values for rock should be based on AASHTO Table 10.4.6.4-1 (which uses Point Load Index Testing) or actual values from Uniaxial Compressive Strength Testing. If neither of these options is available, the NCDOT Rock Core Database may be used to estimate compressive strength.
2. E_i and v values for rock should be based on AASHTO Tables C10.4.6.5-1, and 2 if lab test data is not available

Unconfined Compressive Strength from Point Load Strength Index for Hard Rock AASHTO Table C10.4.6.4-1

Parameter			Ranges of Values						
1	Strength of intact rock material	Point load strength index	>175 ksf	85–175 ksf	45–85 ksf	20–45 ksf	For this low range, uniaxial compressive test is preferred		
		Uniaxial compressive strength	>4320 ksf	2160–4320 ksf	1080–2160 ksf	520–1080 ksf	215–520 ksf	70–215 ksf	20–70 ksf
	Relative Rating		15	12	7	4	2	1	0

Summary of Elastic Moduli for Intact Rock, E_i (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-1

Rock Type	No. of Values	No. of Rock Types	Elastic Modulus, E_i (ksi $\times 10^3$)			Standard Deviation (ksi $\times 10^3$)
			Maximum	Minimum	Mean	
Granite	26	26	14.5	0.93	7.64	3.55
Diorite	3	3	16.2	2.48	7.45	6.19
Gabbro	3	3	12.2	9.8	11.0	0.97
Diabase	7	7	15.1	10.0	12.8	1.78
Basalt	12	12	12.2	4.20	8.14	2.60
Quartzite	7	7	12.8	5.29	9.59	2.32
Marble	14	13	10.7	0.58	6.18	2.49
Gneiss	13	13	11.9	4.13	8.86	2.31
Slate	11	2	3.79	0.35	1.39	0.96
Schist	13	12	10.0	0.86	4.97	3.18
Phyllite	3	3	2.51	1.25	1.71	0.57
Sandstone	27	19	5.68	0.09	2.13	1.19
Siltstone	5	5	4.76	0.38	2.39	1.65
Shale	30	14	5.60	0.001	1.42	1.45
Limestone	30	30	13.0	0.65	5.7	3.73
Dolostone	17	16	11.4	0.83	4.22	3.44

Summary of Poisson's Ratio for Intact Rock, v (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-2

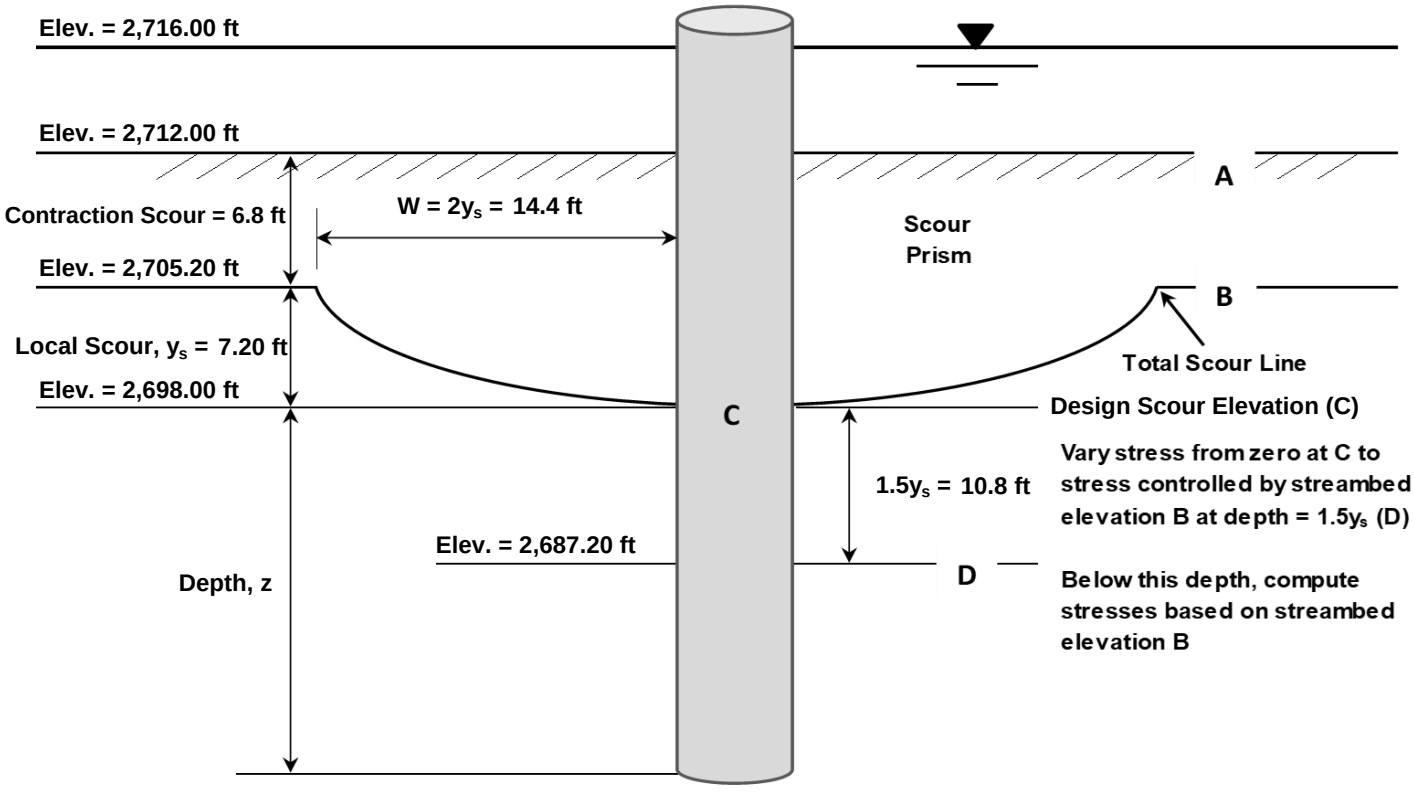
Rock Type	No. of Values	No. of Rock Types	Poisson's Ratio, v			Standard Deviation
			Maximum	Minimum	Mean	
Granite	22	22	0.39	0.09	0.20	0.08
Gabbro	3	3	0.20	0.16	0.18	0.02
Diabase	6	6	0.38	0.20	0.29	0.06
Basalt	11	11	0.32	0.16	0.23	0.05
Quartzite	6	6	0.22	0.08	0.14	0.05
Marble	5	5	0.40	0.17	0.28	0.08
Gneiss	11	11	0.40	0.09	0.22	0.09
Schist	12	11	0.31	0.02	0.12	0.08
Sandstone	12	9	0.46	0.08	0.20	0.11
Siltstone	3	3	0.23	0.09	0.18	0.06
Shale	3	3	0.18	0.03	0.09	0.06
Limestone	19	19	0.33	0.12	0.23	0.06
Dolostone	5	5	0.35	0.14	0.29	0.08

Calculating Design Stresses for Drilled Piers based on Scour Prism used in FHWA GEC 010

For analysis purposes, lower ground line to the contraction scour elevation (CSE) to account for contraction scour reported in the bridge survey report.

- If the CSE is lower than or equal to the design scour elevation (DSE), consider all scour as contraction scour and lower th ground line to the design scour elevation (DSE).
- If the CSE is higher than the DSE, consider the difference between the CSE and the DSE as local scour.

Groundwater Elevation =	2716.00	ft	
Original Pre-Scour Streambed Elevation (Point A) =	2712.00	ft	*= Natural Ground / Finished Grade Elevation*
Amount of Contraction Scour =	6.80	ft	
Streambed Elevation after General Scour (Point B) =	2705.20	ft	*= Point A - Contraction Scour ≥ Design Scour Elevation*
Amount of Local Scour (y_s) =	7.20	ft	
p of the embedded length of the drilled pier (Point C) =	2698.00	ft	*= Design Scour Elevation*
$1.5(y_s)$ =	10.80	ft	
evation corresponding to a depth of $1.5(y_s)$, (Point D) =	2687.20	ft	*= Point C - 1.5y $_s$*



Adapted from FHWA GEC 010 Figure 13.18: Illustration of Scour Prism and Effects on Drilled Pier

Per FHWA GEC 010 page 13-46, vertical stress along any depth of the drilled pier can be estimated as follows;

1) At the top of the embedded drilled pier (Point C) the vertical stress is equal to zero.
2) At a depth of 1.5ys (Point D) or greater, assume the vertical stress is controlled by the streambed elevation (Point B).
3) Assume a linear variation in vertical stress from 0 at Point C to the vertical stress value controlled by the streambed at Point I

Soil Layer Profile and Effective Vertical Stress controlled by the streambed elevation (Point B)

- Assume the streambed elevation is equal to the contraction scour elevation (Elevation 2,705.20 ft).

Layer No.	Top (ft)	Midpoint (ft)	Bottom (ft)	σ_{v_top} (ksf)	$\mu_{\_top}$ (ksf)	σ'_{v_top} (ksf)	Δz (ft)	γ (kcf)	σ_{v_bottom} (ksf)	$\mu_{\_bottom}$ (ksf)	σ'_{v_bottom} (ksf)
0	2705.20	2701.60	2698.00	0.000	0.000	0.000	7.20	0.120	0.864	0.449	0.415
1	2698.00	2691.65	2685.30	0.864	0.449	0.415	12.70	0.135	2.578	1.242	1.337
2	2685.30	2677.55	2669.80	2.578	1.242	1.337	15.50	0.120	4.438	2.209	2.230
3	2669.80	2667.65	2665.50	4.438	2.209	2.230	4.30	0.135	5.019	2.477	2.542
4	2665.50	2660.75	2656.00	5.019	2.477	2.542	9.50	0.173	6.662	3.070	3.592
5											
6											
7											
8											

Variation in Vertical Stress from Point C to Point D

- Assume the top of the embedded drilled pier is equal to the design scour elevation.
- Vertical stress at elevation 2698 ft (Point C) = 0 ksf
- Assume a linear variation in vertical stress from 0 ksf at elevation 2,698.00 ft (Point C) to a stress value controlled by the elevation 2,705.20 ft (Point B) at the depth Point D, elevation 2,687.20 ft.
- PointD lies within Soil Layer No.1

Point D Elevation (ft)	Top of Layer 1 (ft)	σ_v at 2,698.00 ft	Depth below Layer 1 (ft)	γ for Layer 2	μ at Point D (ksf)	σ'_v at Point D (ksf)
2687.20	2698.00	0.864	10.80	0.135	1.123	1.199

Point	Elevation (ft)	z (ft)	σ'_v (ksf)	Equation for linear variation over a depth of $1.5y_s$
C	2,698.00	0.00	0.000	σ'_v (for z = 0 to 10.8 ft) = (0.1110)z
D	2,687.20	10.80	1.199	

- All stress calculations below elevation 2,687.20 ft (Point D) will be based on elevation 2,705.20 ft (Point B).

Summary of Design Stress at the Midpoint of each Soil Layer and at Tip of Drilled Pier

Layer	Top (ft)	Bottom (ft)	Midpoint (ft)	z (ft)	Is z < $1.5y_s$?	$\sigma_{v\_midpoint}$ (ksf)	μ (ksf)	$\sigma'_{v\_midpoint}$ (ksf)
1	2698.00	2685.30	2691.65	6.35	yes	----	----	0.705
2	2685.30	2669.80	2677.55	20.45	no	3.508	1.725	1.783
3	2669.80	2665.50	2667.65	30.35	no	4.729	2.343	2.386
4	2665.50	2656.00	2660.75	37.25	no	5.841	2.774	3.067

Tip Elev. (ft)	z (ft)	σ_{v_bottom} (ksf)	μ (ksf)	σ'_{v_bottom} (ksf)
2656.00	42.00	6.662	3.070	3.592

Side Resistance in Cohesionless Soil (Sand / Gravel with $N1_{60} \leq 100$)

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

q_s = unit side resistance for soil layer (ksf)

$= (\beta)(\sigma'_v)$ *AASHTO Eqn. 10.8.3.5.2b-1*

β = load transfer coefficient

$$= \left(1 - \sin \phi'_f\right)\left(\frac{\sigma'_p}{\sigma'_v}\right)^{\sin \phi'_f} \tan \phi'_f$$ *AASHTO Eqn. 10.8.3.5.2b-2*

ϕ'_f = effective friction angle

$= 27.5 + 9.2 \log(N1_{60}), \quad N1_{60} \leq 100$ *AASHTO Eqn. 10.8.3.5.2b-3*

$N1_{60}$ = SPT - N value corrected for hammer efficiency and overburden (limited to 100 bpf)

σ'_p = effective vertical preconsolidation stress

For Sands: $\frac{\sigma'_p}{\rho_a} \approx 0.47(N_{60})^m$ *AASHTO Eqn. 10.8.3.5.2b-4*

For Gravels: $\frac{\sigma'_p}{\rho_a} = 0.15(N_{60})$ *AASHTO Eqn. 10.8.3.5.2b-5*

m = 0.6 for clean sands; 0.8 for silty sands and sandy silts

N_{60} = SPT - N value corrected for hammer efficiency (limited to 100 bpf)

ρ_a = atmospheric pressure (2.12 ksf)

σ'_v = effective vertical stress at soil layer mid-depth as defined in FHWA GEC 010 pages 13-46

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

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

B = diameter of drilled pier (3 ft)

Δz = effective thickness of the soil layer (ft)

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	Material Type	$N1_{60}$	ϕ' (deg)	m	N_{60}	σ'_p/ρ_a	σ'_v (ksf)	β	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
2	2,685.30	2,669.80	Sand	44	43	0.6	49	4.860	1.783	0.981	1.749	15.50	146.08	255

Total Side Resistance in Cohesionless Soil = 255

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 Top (ft)	Layer Elevations Bottom (ft)	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)
1	Weathered Rock	2,694.00	2,685.30	N/A	N/A	N/A	N/A	8.000	8.70	77.44	620
3	Weathered Rock	2,669.80	2,665.50	N/A	N/A	N/A	N/A	8.000	4.30	38.28	306
4	Hard Rock	2,665.50	2,656.00	10.8.3.5.4b-2 (open joints)	100	0.85	648	20.478	9.50	84.56	1732

Total Side Resistance in Weathered and Hard Rock = 2,658

Tip Resistance in Hard Rock

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

q_p = unit tip resistance (ksf)

If rock to a depth of 2B below drilled pier tip is intact or tightly jointed and the depth of socket > 1.5 D

$= 2.5q_u$ *AASHTO Eqn. 10.8.3.5.4c-1*

If the rock to a depth of 2D below the drilled pier tip is jointed with random orientation

$$= A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-2*

q_u = Uniaxial Compressive Strength of Intact Rock (ksf)

σ'_{vb} = vertical effective stress at the socket bearing elevation

$$A = \sigma'_{vb} + q_u\left[m_b\left(\frac{\sigma'_{vb}}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-3*

$$s = exp\left(\frac{GSI - 100}{9}\right)$$ *AASHTO Eqn. 10.4.6.4-2*

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{\frac{-GSI}{15}} - e^{\frac{-20}{3}}\right)$$ *AASHTO Eqn. 10.4.6.4-3*

$$m_b = exp\left(\frac{GSI - 100}{28}\right) m_i$$ *AASHTO Eqn. 10.4.6.4-4*

m_i = constant for intact rock *AASHTO Table 10.4.6.4-1*

GSI = Global Strength Index

***Hard Rock Layers with an GSI less than 30 will be modeled as weathered rock.**

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

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

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

Tip Elevation (ft)	AASHTO Equation used to calculate q_u	q_u (ksf)	GSI	m	m_b	s	a	A	q_p (ksf)	A_p (ft^2)	R_p (kips)
2656.00	10.8.3.5.4c-1	1,274	85	28	N/A	N/A	N/A	N/A	3,185	6.31	20,097

Tip Resistance in Hard Rock (continued)

Table 10.4.6.4-1—Values of the Constant mi by Rock Group

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (21 ± 3) Breccia (19 ± 5)	Sandstone 17 ± 4	Siltstone 7 ± 2 Greywacke (18 ± 3)	Claystone 4 ± 2 Shale (6 ± 2) Marl (7 ± 2)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestone (10 ± 5)	Micritic Limestone (8 ± 3)	Dolomite (9 ± 3)
		Evaporites		Gypsum 10 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4)) Metasandstone (19 ± 3)	Quartzite 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolite 26 ± 6	Gneiss 28 ± 5	
	Foliated*			Schist (10 ± 3)	Phyllite (7 ± 3)	Slate 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3)) Basalt (25 ± 5)	
		Pyroclastic	Agglomerate (19 ± 3)	Volcanic breccia (19 ± 5)	Tuff (13 ± 5)	

Summary of Nominal and Factored Side Resistance

Cohesionless IGM	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	255	0.55	140	8.8%
CohesiveIGM	0	0.60	0	0.0%
Weathered Rock	926	0.60	556	31.8%
Hard Rock	1,732	0.55	953	59.5%
Total	**2,913**		**1,649**	**100%**

Note: *When drilled piers are socketed in hard rock, the side resistance above the hard rock will be ignored. For the purpose of this spreadsheet, a drilled pier will be considered socketed in hard rock if either of these conditions are met;*

1. *The pier is embedded the greater of 3 feet or 1 pier diameter into hard rock.*
2. *At least 50% of the total nominal side resistance is produced by the hard rock layer(s).*

Summary of Nominal and Factored Side Resistance (continued)

Total Nominal Side Resistance =	1,732	kips	
Side Resistance Factor =	0.55		*for Hard Rock, see AASHTO Table 10.5.5.2.4-1.*
Total Factored Side Resistance =	953	kips	

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance =	20,097	kips	*the drilled pier is bearing on Hard Rock*
Tip Resistance Factor =	0.50		*for Hard Rock, see AASHTO Table 10.5.5.2.4-1.*
Total Factored Tip Resistance =	10,049	kips	

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 = 810 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} = 10.98 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 8 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} = 55.82 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 59 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 = 60 ft *Depth from water surface to the drilled pier tip*
γ_w = 0.0624 kcf *Unit Weight of Water*

= 26 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} = 3.592 ksf *ffective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46*

$W_{Soil/Rock}$ = 25 kips

R_{req} = 810 kips + 1.25(8 kips + 59 kips) -1.00(26 kips) -1.25(25 kips) = 837 kips

Load Transfer of Side and Tip Resistance for Drilled Piers in Hard Rock with no Rock Socket

Per AASHTO Section 10.8.3.5.4a, The Factored Geotechnical Resistance for Drilled Piers socketed in hard rock will be based on side resistance, tip resistance, or a combination of both. Using a combination of both side and tip resistance requires a displacement based analysis and falls outside the limitations of this spreadsheet. For details on displacement based analysis, see *FHWA GEC 010 Appendix D.3.1* .

Developed Factored Resistance, (R_{rd})

Select which value to use for the Factored Developed Resistance

(●) Use the Factored Side Resistance of the rock socket.

( ) Use the Factored Tip Resistance of the rock socket.

953 kips ≥ 837 kips

The axial resistance requirement is satisfied.

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)
837	953	6.31	0.50	3185	0

GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. B1-B	**STATION** 16+25	**OFFSET** 15 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,718.9 ft	**TOTAL DEPTH** 28.8 ft	**NORTHING** 977,667	**EASTING** 1,328,040	**24 HR.** 0.5
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER J. Cain	**START DATE** 07/14/22	**COMP. DATE** 07/14/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
2720						BOC = 2722.8 Top of Pier = 2711.82'				
	2718.9	0.0						W		2718.9 GROUND SURFACE 0.0
2715	2715.4	3.5	1	0	1	1				**ALLUVIAL** Very Loose, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)
	2712.9	6.0	2	1	2	3		Sat.		2713.4 5.5
2710	2710.4	8.5	1	1	1	2		Sat.		Very Soft to Soft, Brown-Black, Fine to Coarse Sandy SILT (A-4), with trace mica
			3	0	1	1		Sat.		
2705	2705.4	13.5	9	15	16	31		W		2706.9 12.0 **RESIDUAL** Hard, Gray-Black, Fine to Coarse SandySILT (A-4), with some mica
2700	2700.4	18.5	100/0.3			100/0.3	Designation			2700.4 18.5 **WEATHERED ROCK** Gray-Brown (BIOTITE/HORNBLENDE GNEISS)
2695	2695.4	23.5	100/0.2			100/0.2				
	2690.4	28.5	100/0.3			100/0.3				2690.1 28.8 Boring Terminated at Elevation 2,690.1 ft In Weathered Rock (BIOTITE/HORNBLENDE GNEISS)

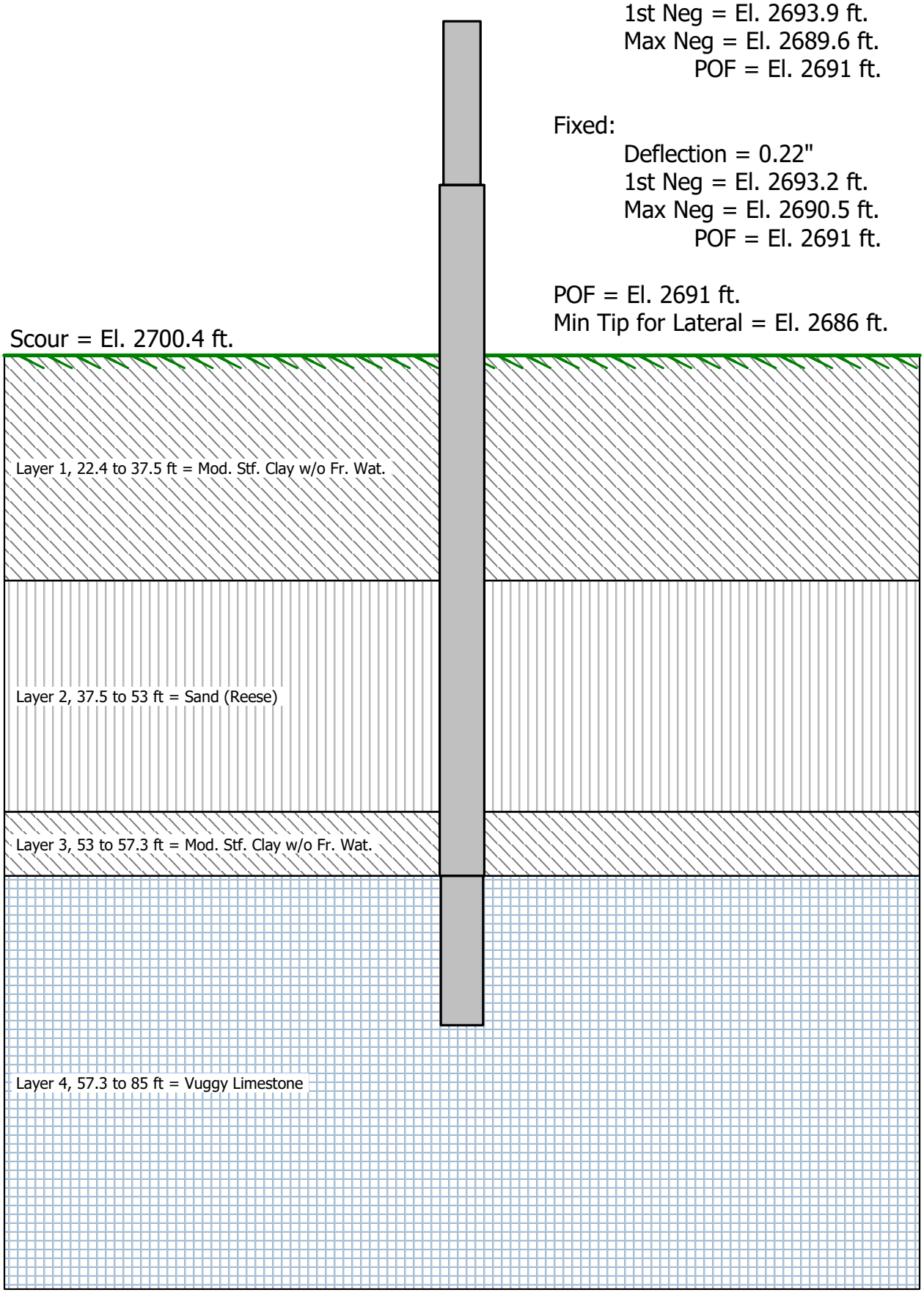
Assumed Soil/Rock Parameters below Elev. 2690ft. that are consistent with Boring B1-A.

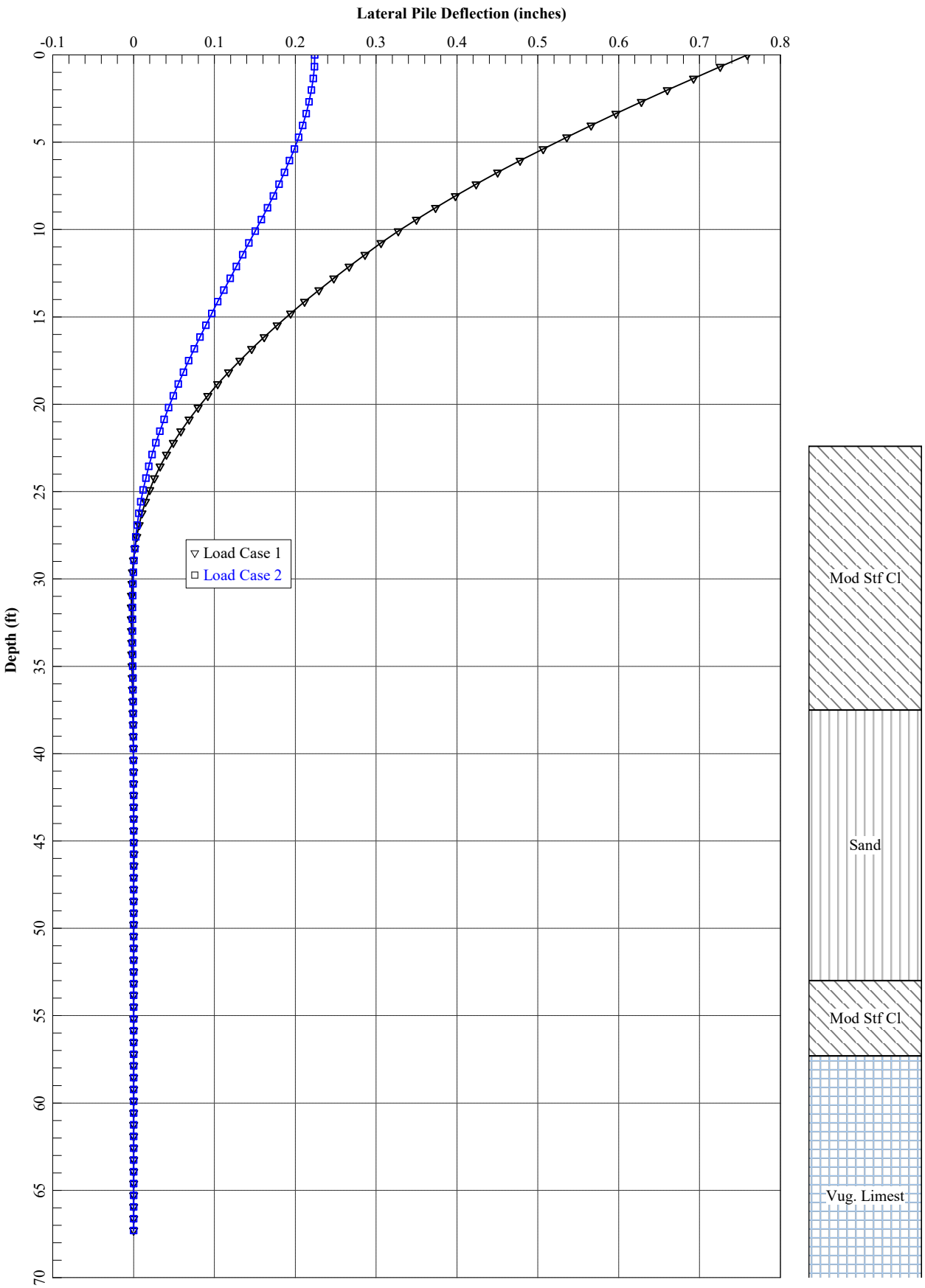
Bent No. 1 - RT

Free:
Deflection = 0.76"
1st Neg = El. 2693.9 ft.
Max Neg = El. 2689.6 ft.
POF = El. 2691 ft.

Fixed:
Deflection = 0.22"
1st Neg = El. 2693.2 ft.
Max Neg = El. 2690.5 ft.
POF = El. 2691 ft.

POF = El. 2691 ft.
Min Tip for Lateral = El. 2686 ft.





==========

LPile for Windows, Version 2019-11.009

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

==========

This copy of LPile is being used by:

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Files Used for Analysis

Path to file locations:
\Users\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500- 29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\LPile\

Name of input data file:
Bridge 063- Bent 1 (B1-B).lp11d

Name of output report file:
Bridge 063- Bent 1 (B1-B).lp11o

Name of plot output file:
Bridge 063- Bent 1 (B1-B).lp11p

Name of runtime message file:
Bridge 063- Bent 1 (B1-B).lp11r

Date and Time of Analysis

Date: September 9, 2022 Time: 7:57:48

Problem Title

Project Name: Bridge 063

Job Number: 09-29662

Client: STV

Engineer: ECS Southeast

Description: Bent 1 (RT) Lateral Analysis

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
- Input of side resistance moment along pile 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 = 3
Total length of pile = 67.300 ft
Depth of ground surface below top of pile = 22.4000 ft

Pile diameters used for p-y curve computations are defined using 6 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	30.0000
2	10.980	30.0000
3	10.980	36.0000
4	57.300	36.0000
5	57.300	34.0000
6	67.300	34.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 10.980000 ft
Width of top of section = 30.000000 in
Width of bottom of section = 30.000000 in
Top Area = 706.858347 sq. in
Bottom Area = 706.858347 sq. in
Moment of Inertia at Top = 39761. in^4
Moment of Inertia at Bottom = 39761. in^4
Elastic Modulus = 3122019. psi

Pile Section No. 2:

Section 2 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 46.320000 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 = 3823676. psi

Pile Section No. 3:

Section 3 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 10.000000 ft
Width of top of section = 34.000000 in
Width of bottom of section = 34.000000 in
Top Area = 907.920277 sq. in
Bottom Area = 907.920277 sq. in
Moment of Inertia at Top = 65597. in^4
Moment of Inertia at Bottom = 65597. in^4
Elastic Modulus = 3823676. 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 4 layers

Layer 1 is stiff clay with user-defined k-value

Distance from top of pile to top of layer = 22.400000 ft
Distance from top of pile to bottom of layer = 37.500000 ft
Effective unit weight at top of layer = 100.000000 pcf
Effective unit weight at bottom of layer = 100.000000 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
Subgrade k at top of layer = 2000. pci
Subgrade k at bottom of layer = 2000. pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 37.500000 ft
Distance from top of pile to bottom of layer = 53.000000 ft
Effective unit weight at top of layer = 57.600000 pcf
Effective unit weight at bottom of layer = 57.600000 pcf
Friction angle at top of layer = 32.000000 deg.
Friction angle at bottom of layer = 32.000000 deg.
Subgrade k at top of layer = 60.000000 pci
Subgrade k at bottom of layer = 60.000000 pci

Layer 3 is stiff clay with user-defined k-value

Distance from top of pile to top of layer = 53.000000 ft
Distance from top of pile to bottom of layer = 57.300000 ft
Effective unit weight at top of layer = 100.000000 pcf
Effective unit weight at bottom of layer = 100.000000 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
Subgrade k at top of layer = 2000. pci
Subgrade k at bottom of layer = 2000. pci

Layer 4 is strong rock (vuggy limestone)

Distance from top of pile to top of layer = 57.300000 ft
Distance from top of pile to bottom of layer = 85.000000 ft
Effective unit weight at top of layer = 173.000000 pcf
Effective unit weight at bottom of layer = 173.000000 pcf
Uniaxial compressive strength at top of layer = 10248. psi
Uniaxial compressive strength at bottom of layer = 10248. psi

(Depth of the lowest soil layer extends 17.700 ft below the pile tip)

**** Warning- Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer 1, for effective unit weight = 173.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.	Uniaxial qu psi	E50 or krm	kpy pci
1	Stiff Clay w/o Free Water, using k	22.4000 37.5000	100.0000 100.0000	8000. 8000.	-- --	-- --	0.00400 0.00400	2000. 2000.
2	Sand (Reese, et al.)	37.5000 53.0000	57.6000 57.6000	-- --	32.0000 32.0000	-- --	-- --	60.0000 60.0000
3	Stiff Clay w/o Free Water, using k	53.0000 57.3000	100.0000 100.0000	8000. 8000.	-- --	-- --	0.00400 0.00400	2000. 2000.
4	Strong Rock (Vuggy Limestone)	57.3000 85.0000	173.0000 173.0000	-- --	-- --	10248. 10248.	-- --	-- --

---

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 = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 11000. lbs	M = 720000. in-lbs	500000.	No	Yes
2	2	V = 13000. lbs	S = 0.0000 in/in	510000.	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 = 3

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 3:

Moment-curvature properties were derived from elastic section properties

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Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	22.4000	0.00	N.A.	No	0.00	1577422.
2	37.5000	26.5223	No	No	1577422.	2947177.
3	53.0000	32.2499	No	No	4524599.	1207982.
4	57.3000	34.9000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

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 = 11000.0 lbs
Applied moment at pile head = 720000.0 in-lbs
Axial thrust load on pile head = 500000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. p	Soil Spr. Es*H	Distrib. Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	0.7592	720000.	11000.	-0.00417	978.9797	1.24E+11	0.00	0.00	0.00
0.6730	0.7257	825581.	11000.	-0.00412	1019.	1.24E+11	0.00	0.00	0.00
1.3460	0.6926	930944.	11000.	-0.00406	1059.	1.24E+11	0.00	0.00	0.00
2.0190	0.6601	1036063.	11000.	-0.00400	1098.	1.24E+11	0.00	0.00	0.00
2.6920	0.6280	1140910.	11000.	-0.00393	1138.	1.24E+11	0.00	0.00	0.00
3.3650	0.5966	1245457.	11000.	-0.00385	1177.	1.24E+11	0.00	0.00	0.00
4.0380	0.5658	1349677.	11000.	-0.00377	1217.	1.24E+11	0.00	0.00	0.00
4.7110	0.5358	1453543.	11000.	-0.00367	1256.	1.24E+11	0.00	0.00	0.00
5.3840	0.5065	1557026.	11000.	-0.00358	1295.	1.24E+11	0.00	0.00	0.00
6.0570	0.4780	1660101.	11000.	-0.00347	1334.	1.24E+11	0.00	0.00	0.00
6.7300	0.4504	1762739.	11000.	-0.00336	1372.	1.24E+11	0.00	0.00	0.00
7.4030	0.4237	1864914.	11000.	-0.00324	1411.	1.24E+11	0.00	0.00	0.00
8.0760	0.3980	1966600.	11000.	-0.00312	1449.	1.24E+11	0.00	0.00	0.00
8.7490	0.3734	2067768.	11000.	-0.00299	1487.	1.24E+11	0.00	0.00	0.00
9.4220	0.3498	2168394.	11000.	-0.00285	1525.	1.24E+11	0.00	0.00	0.00
10.0950	0.3273	2268450.	11000.	-0.00270	1563.	1.24E+11	0.00	0.00	0.00
10.7680	0.3061	2367910.	11000.	-0.00255	1601.	1.24E+11	0.00	0.00	0.00
11.4410	0.2861	2466747.	11000.	-0.00245	1030.	3.15E+11	0.00	0.00	0.00
12.1140	0.2666	2565330.	11000.	-0.00238	1051.	3.15E+11	0.00	0.00	0.00
12.7870	0.2476	2663647.	11000.	-0.00231	1073.	3.15E+11	0.00	0.00	0.00
13.4600	0.2292	2761689.	11000.	-0.00224	1094.	3.15E+11	0.00	0.00	0.00
14.1330	0.2114	2859445.	11000.	-0.00217	1115.	3.15E+11	0.00	0.00	0.00
14.8060	0.1941	2956905.	11000.	-0.00210	1137.	3.15E+11	0.00	0.00	0.00
15.4790	0.1775	3054060.	11000.	-0.00202	1158.	3.15E+11	0.00	0.00	0.00
16.1520	0.1615	3150898.	11000.	-0.00194	1179.	3.15E+11	0.00	0.00	0.00
16.8250	0.1461	3247411.	11000.	-0.00186	1200.	3.15E+11	0.00	0.00	0.00
17.4980	0.1315	3343588.	11000.	-0.00178	1221.	3.15E+11	0.00	0.00	0.00
18.1710	0.1175	3439418.	11000.	-0.00169	1242.	3.15E+11	0.00	0.00	0.00
18.8440	0.1042	3534893.	11000.	-0.00160	1263.	3.15E+11	0.00	0.00	0.00
19.5170	0.09165	3630003.	11000.	-0.00151	1284.	3.15E+11	0.00	0.00	0.00
20.1900	0.07985	3724737.	11000.	-0.00141	1304.	3.15E+11	0.00	0.00	0.00
20.8630	0.06883	3819085.	11000.	-0.00132	1325.	3.15E+11	0.00	0.00	0.00
21.5360	0.05859	3913039.	11000.	-0.00122	1346.	3.15E+11	0.00	0.00	0.00
22.2090	0.04917	4006587.	11000.	-0.00112	1366.	3.15E+11	0.00	0.00	0.00
22.8820	0.04057	4099722.	9105.	-0.00101	1386.	3.15E+11	-469.3279	93423.	0.00
23.5550	0.03282	4161821.	3536.	-9.06E-04	1400.	3.15E+11	-909.8510	223867.	0.00
24.2280	0.02594	4164148.	-4733.	-7.99E-04	1400.	3.15E+11	-1138.	354310.	0.00
24.9010	0.01991	4091832.	-14153.	-6.94E-04	1385.	3.15E+11	-1195.	484754.	0.00
25.5740	0.01473	3941149.	-23510.	-5.91E-04	1352.	3.15E+11	-1122.	615197.	0.00
26.2470	0.01037	3716871.	-31906.	-4.93E-04	1303.	3.15E+11	-957.1383	745641.	0.00
26.9200	0.00677	3429782.	-38737.	-4.01E-04	1240.	3.15E+11	-734.6064	876084.	0.00
27.5930	0.00389	3094426.	-43660.	-3.18E-04	1167.	3.15E+11	-484.3806	1006528.	0.00
28.2660	0.00164	2727158.	-46549.	-2.43E-04	1087.	3.15E+11	-231.0762	1136972.	0.00
28.9390	-3.96E-05	2344537.	-47457.	-1.78E-04	1003.	3.15E+11	6.2099	1267415.	0.00
29.6120	-0.00124	1962078.	-46568.	-1.23E-04	919.5789	3.15E+11	213.8398	1397859.	0.00
30.2850	-0.00203	1593363.	-44157.	-7.74E-05	839.0813	3.15E+11	383.2834	1528302.	0.00
30.9580	-0.00249	1249482.	-40548.	-4.10E-05	764.0053	3.15E+11	510.5389	1658746.	0.00
31.6310	-0.00269	938770.	-36082.	-1.30E-05	696.1708	3.15E+11	595.3946	1789189.	0.00
32.3040	-0.00270	666793.	-31091.	7.60E-06	636.7929	3.15E+11	640.6041	1919633.	0.00

32.9770	-0.00256	436529.	-25875.	2.17E-05	586.5218	3.15E+11	651.0401	2050076.	0.00
33.6500	-0.00234	248682.	-20691.	3.05E-05	545.5110	3.15E+11	632.8804	2180520.	0.00
34.3230	-0.00207	102086.	-15741.	3.50E-05	513.5063	3.15E+11	592.8695	2310964.	0.00
34.9960	-0.00178	-5852.	-11176.	3.62E-05	492.4966	3.15E+11	537.6829	2441407.	0.00
35.6690	-0.00149	-78721.	-7093.	3.52E-05	508.4053	3.15E+11	473.4087	2571851.	0.00
36.3420	-0.00121	-120705.	-3546.	3.26E-05	517.5713	3.15E+11	405.1499	2702294.	0.00
37.0150	-9.60E-04	-136252.	-549.8064	2.93E-05	520.9655	3.15E+11	336.7424	2832738.	0.00
37.6880	-7.37E-04	-129822.	842.7369	2.59E-05	519.5617	3.15E+11	8.1173	88895.	0.00
38.3610	-5.42E-04	-122850.	900.6521	2.27E-05	518.0394	3.15E+11	6.2252	92809.	0.00
39.0340	-3.71E-04	-115458.	943.7502	1.96E-05	516.4257	3.15E+11	4.4479	96722.	0.00
39.7070	-2.25E-04	-107765.	973.0299	1.68E-05	514.7461	3.15E+11	2.8031	100635.	0.00
40.3800	-1.01E-04	-99877.	989.6190	1.41E-05	513.0241	3.15E+11	1.3051	104549.	0.00
41.0530	2.66E-06	-91894.	994.7447	1.16E-05	511.2812	3.15E+11	-0.03574	108462.	0.00
41.7260	8.71E-05	-83904.	989.7050	9.38E-06	509.5368	3.15E+11	-1.2123	112375.	0.00
42.3990	1.54E-04	-75984.	975.8421	7.34E-06	507.8078	3.15E+11	-2.2208	116289.	0.00
43.0720	2.06E-04	-68201.	954.5169	5.49E-06	506.1086	3.15E+11	-3.0603	120202.	0.00
43.7450	2.43E-04	-60611.	927.0861	3.84E-06	504.4515	3.15E+11	-3.7328	124115.	0.00
44.4180	2.68E-04	-53258.	894.8812	2.38E-06	502.8462	3.15E+11	-4.2427	128029.	0.00
45.0910	2.81E-04	-46176.	859.1889	1.11E-06	501.3001	3.15E+11	-4.5964	131942.	0.00
45.7640	2.86E-04	-39389.	821.2348	1.11E-08	499.8184	3.15E+11	-4.8028	135855.	0.00
46.4370	2.82E-04	-32912.	782.1671	-9.15E-07	498.4042	3.15E+11	-4.8722	139768.	0.00
47.1100	2.71E-04	-26748.	743.0440	-1.68E-06	497.0586	3.15E+11	-4.8166	143682.	0.00
47.7830	2.54E-04	-20896.	704.8207	-2.29E-06	495.7811	3.15E+11	-4.6493	147595.	0.00
48.4560	2.34E-04	-15346.	668.3393	-2.75E-06	494.5692	3.15E+11	-4.3852	151508.	0.00
49.1290	2.10E-04	-10079.	634.3187	-3.08E-06	493.4194	3.15E+11	-4.0399	155422.	0.00
49.8020	1.84E-04	-5075.	603.3459	-3.27E-06	492.3270	3.15E+11	-3.6304	159335.	0.00
50.4750	1.57E-04	-307.5083	575.8672	-3.34E-06	491.2861	3.15E+11	-3.1746	163248.	0.00
51.1480	1.30E-04	4253.	552.1806	-3.29E-06	492.1475	3.15E+11	-2.6913	167162.	0.00
51.8210	1.04E-04	8638.	532.4275	-3.13E-06	493.1048	3.15E+11	-2.2005	171075.	0.00
52.4940	7.95E-05	12878.	516.5842	-2.85E-06	494.0305	3.15E+11	-1.7231	174988.	0.00
53.1670	5.78E-05	17005.	337.2005	-2.47E-06	494.9314	3.15E+11	-42.7008	5963383.	0.00
53.8400	3.97E-05	18345.	43.9560	-2.02E-06	495.2239	3.15E+11	-29.9204	6093827.	0.00
54.5130	2.53E-05	17731.	-155.5141	-1.55E-06	495.0900	3.15E+11	-19.4779	6224270.	0.00
55.1860	1.46E-05	15845.	-280.4300	-1.12E-06	494.6783	3.15E+11	-11.4572	6354714.	0.00
55.8590	7.13E-06	13211.	-349.8037	-7.51E-07	494.1031	3.15E+11	-5.7230	6485157.	0.00
56.5320	2.43E-06	10201.	-380.9386	-4.51E-07	493.4461	3.15E+11	-1.9875	6615601.	0.00
57.2050	-1.64E-07	7061.	-388.4111	-2.30E-07	492.7606	3.15E+11	0.1369	6746044.	0.00
57.8780	-1.29E-06	3930.	-334.3452	-7.66E-08	551.7275	2.51E+11	13.2524	8.28E+07	0.00
58.5510	-1.40E-06	1662.	-222.8731	1.34E-08	551.1398	2.51E+11	14.3534	8.28E+07	0.00
59.2240	-1.08E-06	329.6068	-120.3890	4.55E-08	550.7946	2.51E+11	11.0265	8.28E+07	0.00
59.8970	-6.66E-07	-283.2757	-48.3195	4.62E-08	550.7826	2.51E+11	6.8213	8.28E+07	0.00
60.5700	-3.29E-07	-451.2232	-7.1630	3.44E-08	550.8261	2.51E+11	3.3710	8.28E+07	0.00
61.2430	-1.10E-07	-399.2504	10.9840	2.07E-08	550.8126	2.51E+11	1.1231	8.28E+07	0.00
61.9160	5.94E-09	-273.9769	15.2730	9.90E-09	550.7801	2.51E+11	-0.06091	8.28E+07	0.00
62.5890	5.02E-08	-152.6404	12.9483	3.03E-09	550.7487	2.51E+11	-0.5148	8.28E+07	0.00
63.2620	5.48E-08	-64.8604	8.6004	-4.75E-10	550.7260	2.51E+11	-0.5619	8.28E+07	0.00
63.9350	4.26E-08	-13.7226	4.5698	-1.74E-09	550.7127	2.51E+11	-0.4362	8.28E+07	0.00
64.6080	2.67E-08	8.9652	1.7021	-1.82E-09	550.7115	2.51E+11	-0.2740	8.28E+07	0.00
65.2810	1.32E-08	13.7838	0.04837	-1.45E-09	550.7127	2.51E+11	-0.1356	8.28E+07	0.00
65.9540	3.31E-09	9.7581	-0.6361	-1.07E-09	550.7117	2.51E+11	-0.03392	8.28E+07	0.00
66.6270	-4.07E-09	3.5186	-0.6046	-8.57E-10	550.7101	2.51E+11	0.04172	8.28E+07	0.00
67.3000	-1.05E-08	0.00	0.00	-8.01E-10	550.7091	2.51E+11	0.1080	4.14E+07	0.00

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.75916629 inches
Computed slope at pile head = -0.00417015 radians
Maximum bending moment = 4164148. inch-lbs
Maximum shear force = -47457. lbs
Depth of maximum bending moment = 24.22800000 feet below pile head
Depth of maximum shear force = 28.93900000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 5

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

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

Shear force at pile head = 13000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 510000.0 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 lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.2241	-1776787.	13000.	0.00	1392.	1.24E+11	0.00	0.00	0.00
0.6730	0.2236	-1671561.	13000.	-1.12E-04	1352.	1.24E+11	0.00	0.00	0.00
1.3460	0.2223	-1565887.	13000.	-2.17E-04	1312.	1.24E+11	0.00	0.00	0.00
2.0190	0.2201	-1459793.	13000.	-3.16E-04	1272.	1.24E+11	0.00	0.00	0.00
2.6920	0.2172	-1353309.	13000.	-4.07E-04	1232.	1.24E+11	0.00	0.00	0.00
3.3650	0.2135	-1246461.	13000.	-4.92E-04	1192.	1.24E+11	0.00	0.00	0.00
4.0380	0.2092	-1139280.	13000.	-5.70E-04	1151.	1.24E+11	0.00	0.00	0.00
4.7110	0.2043	-1031793.	13000.	-6.40E-04	1111.	1.24E+11	0.00	0.00	0.00
5.3840	0.1989	-924030.	13000.	-7.04E-04	1070.	1.24E+11	0.00	0.00	0.00
6.0570	0.1929	-816019.	13000.	-7.60E-04	1029.	1.24E+11	0.00	0.00	0.00
6.7300	0.1866	-707790.	13000.	-8.10E-04	988.5205	1.24E+11	0.00	0.00	0.00
7.4030	0.1799	-599371.	13000.	-8.53E-04	947.6188	1.24E+11	0.00	0.00	0.00
8.0760	0.1728	-490791.	13000.	-8.88E-04	906.6564	1.24E+11	0.00	0.00	0.00
8.7490	0.1655	-382080.	13000.	-9.16E-04	865.6445	1.24E+11	0.00	0.00	0.00
9.4220	0.1580	-273266.	13000.	-9.38E-04	824.5939	1.24E+11	0.00	0.00	0.00
10.0950	0.1504	-164380.	13000.	-9.52E-04	783.5157	1.24E+11	0.00	0.00	0.00
10.7680	0.1426	-55449.	13000.	-9.59E-04	742.4208	1.24E+11	0.00	0.00	0.00
11.4410	0.1349	53497.	13000.	-9.60E-04	512.7227	3.15E+11	0.00	0.00	0.00
12.1140	0.1271	162437.	13000.	-9.57E-04	536.5065	3.15E+11	0.00	0.00	0.00
12.7870	0.1194	271360.	13000.	-9.52E-04	560.2865	3.15E+11	0.00	0.00	0.00

13.4600	0.1118	380254.	13000.	-9.44E-04	584.0602	3.15E+11	0.00	0.00	0.00
14.1330	0.1042	489108.	13000.	-9.32E-04	607.8252	3.15E+11	0.00	0.00	0.00
14.8060	0.09670	597911.	13000.	-9.18E-04	631.5790	3.15E+11	0.00	0.00	0.00
15.4790	0.08934	706650.	13000.	-9.02E-04	655.3189	3.15E+11	0.00	0.00	0.00
16.1520	0.08213	815315.	13000.	-8.82E-04	679.0426	3.15E+11	0.00	0.00	0.00
16.8250	0.07509	923894.	13000.	-8.60E-04	702.7475	3.15E+11	0.00	0.00	0.00
17.4980	0.06824	1032375.	13000.	-8.35E-04	726.4311	3.15E+11	0.00	0.00	0.00
18.1710	0.06160	1140748.	13000.	-8.07E-04	750.0909	3.15E+11	0.00	0.00	0.00
18.8440	0.05520	1249000.	13000.	-7.77E-04	773.7245	3.15E+11	0.00	0.00	0.00
19.5170	0.04906	1357120.	13000.	-7.43E-04	797.3292	3.15E+11	0.00	0.00	0.00
20.1900	0.04320	1465098.	13000.	-7.07E-04	820.9028	3.15E+11	0.00	0.00	0.00
20.8630	0.03764	1572920.	13000.	-6.68E-04	844.4425	3.15E+11	0.00	0.00	0.00
21.5360	0.03241	1680577.	13000.	-6.26E-04	867.9461	3.15E+11	0.00	0.00	0.00
22.2090	0.02753	1788056.	13000.	-5.82E-04	891.4109	3.15E+11	0.00	0.00	0.00
22.8820	0.02301	1895347.	11925.	-5.35E-04	914.8345	3.15E+11	-266.1863	93423.	0.00
23.5550	0.01889	1985076.	8736.	-4.85E-04	934.4242	3.15E+11	-523.5695	223867.	0.00
24.2280	0.01518	2040448.	3933.	-4.34E-04	946.5130	3.15E+11	-665.7877	354310.	0.00
24.9010	0.01189	2052181.	-1636.	-3.81E-04	949.0745	3.15E+11	-713.4286	484754.	0.00
25.5740	0.00902	2017166.	-7291.	-3.29E-04	941.4300	3.15E+11	-687.1326	615197.	0.00
26.2470	0.00657	1937122.	-12516.	-2.78E-04	923.9549	3.15E+11	-606.8036	745641.	0.00
26.9200	0.00452	1817297.	-16949.	-2.30E-04	897.7948	3.15E+11	-490.8669	876084.	0.00
27.5930	0.00285	1665265.	-20367.	-1.86E-04	864.6033	3.15E+11	-355.6525	1006528.	0.00
28.2660	0.00153	1489861.	-22671.	-1.45E-04	826.3092	3.15E+11	-214.9503	1136972.	0.00
28.9390	5.08E-04	1300281.	-23861.	-1.09E-04	784.9201	3.15E+11	-79.7595	1267415.	0.00
29.6120	-2.41E-04	1105361.	-24014.	-7.87E-05	742.3653	3.15E+11	41.7731	1397859.	0.00
30.2850	-7.62E-04	913049.	-23263.	-5.28E-05	700.3798	3.15E+11	144.2436	1528302.	0.00
30.9580	-0.00109	730049.	-21773.	-3.18E-05	660.4273	3.15E+11	224.7428	1658746.	0.00
31.6310	-0.00128	561630.	-19725.	-1.52E-05	623.6581	3.15E+11	282.5051	1789189.	0.00
32.3040	-0.00134	411577.	-17298.	-2.75E-06	590.8986	3.15E+11	318.4942	1919633.	0.00
32.9770	-0.00132	282253.	-14659.	6.14E-06	562.6647	3.15E+11	334.9602	2050076.	0.00
33.6500	-0.00124	174746.	-11954.	1.20E-05	539.1938	3.15E+11	335.0010	2180520.	0.00
34.3230	-0.00113	89070.	-9301.	1.54E-05	520.4891	3.15E+11	322.1516	2310964.	0.00
34.9960	-9.92E-04	24396.	-6788.	1.68E-05	506.3695	3.15E+11	300.0185	2441407.	0.00
35.6690	-8.54E-04	-20713.	-4479.	1.69E-05	505.5653	3.15E+11	271.9699	2571851.	0.00
36.3420	-7.20E-04	-48081.	-2408.	1.60E-05	511.5403	3.15E+11	240.8837	2702294.	0.00
37.0150	-5.96E-04	-59733.	-591.2366	1.46E-05	514.0843	3.15E+11	208.9539	2832738.	0.00
37.6880	-4.84E-04	-57751.	274.0270	1.31E-05	513.6515	3.15E+11	5.3264	88895.	0.00
38.3610	-3.84E-04	-55415.	313.3552	1.17E-05	513.1415	3.15E+11	4.4131	92809.	0.00
39.0340	-2.96E-04	-52786.	345.4714	1.03E-05	512.5675	3.15E+11	3.5404	96722.	0.00
39.7070	-2.18E-04	-49920.	370.7426	8.96E-06	511.9418	3.15E+11	2.7180	100635.	0.00
40.3800	-1.51E-04	-46871.	389.6090	7.72E-06	511.2762	3.15E+11	1.9542	104549.	0.00
41.0530	-9.35E-05	-43690.	402.5704	6.56E-06	510.5818	3.15E+11	1.2556	108462.	0.00
41.7260	-4.51E-05	-40423.	410.1726	5.48E-06	509.8684	3.15E+11	0.6271	112375.	0.00
42.3990	-5.00E-06	-37110.	412.9956	4.49E-06	509.1452	3.15E+11	0.07203	116289.	0.00
43.0720	2.74E-05	-33789.	411.6407	3.58E-06	508.4202	3.15E+11	-0.4076	120202.	0.00
43.7450	5.28E-05	-30491.	406.7197	2.75E-06	507.7001	3.15E+11	-0.8111	124115.	0.00
44.4180	7.19E-05	-27242.	398.8439	2.01E-06	506.9909	3.15E+11	-1.1393	128029.	0.00
45.0910	8.53E-05	-24065.	388.6151	1.36E-06	506.2973	3.15E+11	-1.3939	131942.	0.00
45.7640	9.38E-05	-20977.	376.6159	7.80E-07	505.6230	3.15E+11	-1.5777	135855.	0.00
46.4370	9.79E-05	-17989.	363.4019	2.81E-07	504.9706	3.15E+11	-1.6947	139768.	0.00
47.1100	9.83E-05	-15109.	349.4945	-1.43E-07	504.3420	3.15E+11	-1.7494	143682.	0.00
47.7830	9.56E-05	-12342.	335.3739	-4.94E-07	503.7379	3.15E+11	-1.7475	147595.	0.00
48.4560	9.03E-05	-9688.	321.4734	-7.76E-07	503.1585	3.15E+11	-1.6950	151508.	0.00

49.1290	8.31E-05	-7144.	308.1733	-9.92E-07	502.6029	3.15E+11	-1.5988	155422.	0.00
49.8020	7.43E-05	-4703.	295.7962	-1.14E-06	502.0700	3.15E+11	-1.4664	159335.	0.00
50.4750	6.46E-05	-2357.	284.6020	-1.23E-06	501.5578	3.15E+11	-1.3058	163248.	0.00
51.1480	5.44E-05	-95.4573	274.7832	-1.27E-06	501.0642	3.15E+11	-1.1258	167162.	0.00
51.8210	4.42E-05	2092.	266.4601	-1.24E-06	501.5001	3.15E+11	-0.9354	171075.	0.00
52.4940	3.44E-05	4219.	259.6767	-1.16E-06	501.9643	3.15E+11	-0.7445	174988.	0.00
53.1670	2.54E-05	6296.	180.8329	-1.02E-06	502.4179	3.15E+11	-18.7810	5963383.	0.00
53.8400	1.78E-05	7148.	50.7253	-8.52E-07	502.6039	3.15E+11	-13.4398	6093827.	0.00
54.5130	1.17E-05	7122.	-39.8553	-6.70E-07	502.5983	3.15E+11	-8.9922	6224270.	0.00
55.1860	7.00E-06	6510.	-98.3972	-4.95E-07	502.4645	3.15E+11	-5.5055	6354714.	0.00
55.8590	3.67E-06	5537.	-132.5385	-3.41E-07	502.2522	3.15E+11	-2.9495	6485157.	0.00
56.5320	1.49E-06	4372.	-149.3928	-2.14E-07	501.9978	3.15E+11	-1.2244	6615601.	0.00
57.2050	2.21E-07	3126.	-155.0823	-1.18E-07	501.7258	3.15E+11	-0.1845	6746044.	0.00
57.8780	-4.06E-07	1868.	-139.0188	-4.76E-08	562.2074	2.51E+11	4.1626	8.28E+07	0.00
58.5510	-5.48E-07	880.8743	-99.5491	-3.33E-09	561.9516	2.51E+11	5.6120	8.28E+07	0.00
59.2240	-4.60E-07	259.8824	-57.8529	1.50E-08	561.7907	2.51E+11	4.7140	8.28E+07	0.00
59.8970	-3.05E-07	-53.6902	-26.2054	1.84E-08	561.7372	2.51E+11	3.1234	8.28E+07	0.00
60.5700	-1.64E-07	-163.5389	-6.8253	1.49E-08	561.7657	2.51E+11	1.6760	8.28E+07	0.00
61.2430	-6.48E-08	-164.0549	2.6249	9.58E-09	561.7658	2.51E+11	0.6643	8.28E+07	0.00
61.9160	-8.77E-09	-121.2200	5.6703	4.99E-09	561.7547	2.51E+11	0.08985	8.28E+07	0.00
62.5890	1.58E-08	-72.5088	5.3806	1.87E-09	561.7421	2.51E+11	-0.1616	8.28E+07	0.00
63.2620	2.15E-08	-34.3281	3.8403	1.51E-10	561.7322	2.51E+11	-0.2198	8.28E+07	0.00
63.9350	1.82E-08	-10.4810	2.1992	-5.70E-10	561.7260	2.51E+11	-0.1866	8.28E+07	0.00
64.6080	1.22E-08	1.1975	0.9393	-7.20E-10	561.7236	2.51E+11	-0.1254	8.28E+07	0.00
65.2810	6.58E-09	4.6958	0.1605	-6.25E-10	561.7245	2.51E+11	-0.06744	8.28E+07	0.00
65.9540	2.14E-09	3.7951	-0.2005	-4.88E-10	561.7243	2.51E+11	-0.02197	8.28E+07	0.00
66.6270	-1.31E-09	1.4610	-0.2352	-4.04E-10	561.7237	2.51E+11	0.01339	8.28E+07	0.00
67.3000	-4.38E-09	0.00	0.00	-3.80E-10	561.7233	2.51E+11	0.04485	4.14E+07	0.00

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

Output Summary for Load Case No. 2:

Pile-head deflection = 0.22407232 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 2052181. inch-lbs
Maximum shear force = -24014. lbs
Depth of maximum bending moment = 24.90100000 feet below pile head
Depth of maximum shear force = 29.61200000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 5

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	11000.	M, in-lb	720000.	500000.	0.7592	-0.00417	-47457.	4164148.
2	V, lb	13000.	S, rad	0.00	510000.	0.2241	0.00	-24014.	2052181.

Maximum pile-head deflection = 0.7591662877 inches
Maximum pile-head rotation =-0.0041701533 radians =-0.238932 deg.

Summary of Warning Messages

The following warning was reported 1605 times

**** Warning ****

This warning is for an input value for uniaxial compressive strength that
has been specified for a soil defined using the vuggy limestone criteria.
The input value is outside of the range of 1,000 to 2,500 psi
(6,895 to 17,237 kPa) which were used in actual field tests
on which this theory is based. Higher or lower values may be applicable
but the user is warned about the theoretical and testing limitations.

The analysis ended normally.

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

PROJECT: BP11.R003.1 COUNTY: Ashe
DESCRIPTION: Bridge No. 063 on NC88 over Cranberry Creek - B1 - RT
DESIGNED BY: KND DATE: 09/08/22 STATION: 16+50
CHECKED BY: DATE: STR. NO.: 63 PAGE: 1 OF 7

Elevations

Bottom of Cap (BOC) Elevation =	2,722.80	ft
Top of Pier/Bottom of Column Elevation =	2,711.82	ft
Natural Ground / Finished Grade Elevation =	2,712.00	ft
Groundwater Table (GWT) Elevation =	2,718.00	ft
Design Scour (DSE) Elevation =	2,700.40	ft
Amount of Contraction Scour (from BSR) =	6.80	ft
Is Permanent Casing Required?	◉ Yes / Maybe ○ No	
Bottom of Permanent Casing Elevation =	2,700.00	ft
Drilled Pier Tip Elevation =	2,656.00	ft

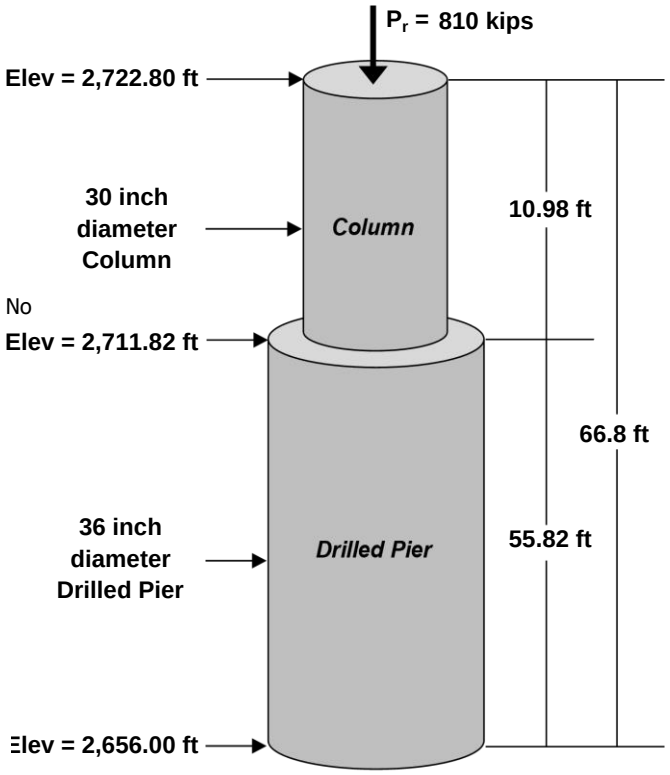


Figure shows typical drilled pier

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	810.0	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. =	B1-B	
SPT Hammer Energy Efficiency Rating (ER) =	84	%
Top of Boring (Collar) Elevation =	2718.90	ft
Depth to Groundwater Table (for actual boring) =	0.50	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	2,700.40	2,685.30	0.135	100	140	150					
2	Cohesionless Soil (Sand)	2,685.30	2,669.80	0.120	35	49	45					
3	Weathered Rock	2,669.80	2,665.50	0.135	100	140	118					
4	Hard Rock	2,665.50	2,656.00	0.173			N/A	100	85	1,476		
5												
6												
7												
8												
TIP [3]	Hard Rock	2,656.00	2,650.00	0.174			N/A	100	85	1,274	8,860	0.220

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.

Correcting SPT Values for Hammer Efficiency and Overburden Pressure

SPT-N Value Corrected for Hammer Efficiency, (N_{60})

$N_{60} = (ER/60\%)(N)$ *AASHTO Eqn. 10.4.6.2.4-2*

N_{60} = SPT blow count corrected for hammer efficiency (blows/ft)
ER = hammer efficiency expressed as percent of theoretical free fall energy delivered by the hammer system actually used. If ER is not known, use 80% for automatic hammers and 60% for drop hammers.
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for Overburden Pressure, (N1)

$N1 = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-1*

N1 = SPT blow count corrected for overburden pressure (blows/ft)
C_N = correction factor = $[0.77\log_{10}(40/\sigma'_v) < 2.0$
$\sigma'_v = \sigma_v - \mu$ = effective vertical stress at the depth of the SPT-N value (ksf)
σ_v = total vertical stress at the depth of the SPT-N value (ksf)
μ = total pore water pressure at the depth of the SPT-N value (ksf)
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for both Overburden Pressure and Hammer Efficiency, ($N1_{60}$)

$N1_{60} = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-3*

Summary of Corrected N Values for Boring

Top of Boring (Collar) Elevation = 2,718.9 ft
Depth to Groundwater Table = 0.5 ft
Hammer Efficiency (ER) = 84 %
Unit Weight of Water = 0.0624 kcf

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	σ_v at top (ksf)	Δz (ft)	Total γ (kcf)	σ_v at bottom (ksf)	σ_v at midpoint (ksf)	z_{water} (ft)	μ at midpoint (ksf)	σ'_{vo} at midpoint (ksf)	N (bpf)	N_{60} (bpf)	C_N	$N1_{60}$ (bpf)
1	2700.40	2685.30	2.220	15.10	0.135	4.258	3.239	25.55	1.594	1.645	100	140	1.07	150
2	2685.30	2669.80	4.258	15.50	0.120	6.118	5.188	40.85	2.549	2.639	35	49	0.91	45
3	2669.80	2665.50	6.118	4.30	0.135	6.699	6.409	50.75	3.167	3.242	100	140	0.84	118
4	2665.50	2656.00	6.699	9.50	0.173	8.343	7.521	57.65	3.597	3.923	N/A			N/A
5														
6														
7														
8														
TIP	2656.00	2650.00	8.343	6.00	0.174	9.387	8.865	65.40	4.081	4.784	N/A			N/A

Selecting Design Properties for Hard Rock

1. q_u values for rock should be based on AASHTO Table 10.4.6.4-1 (which uses Point Load Index Testing) or actual values from Uniaxial Compressive Strength Testing. If neither of these options is available, the NCDOT Rock Core Database may be used to estimate compressive strength.

2. E_i and v values for rock should be based on AASHTO Tables C10.4.6.5-1, and 2 if lab test data is not available

Unconfined Compressive Strength from Point Load Strength Index for Hard Rock AASHTO Table C10.4.6.4-1

Parameter			Ranges of Values						
1	Strength of intact rock material	Point load strength index	>175 ksf	85–175 ksf	45–85 ksf	20–45 ksf	For this low range, uniaxial compressive test is preferred		
		Uniaxial compressive strength	>4320 ksf	2160–4320 ksf	1080–2160 ksf	520–1080 ksf	215–520 ksf	70–215 ksf	20–70 ksf
	Relative Rating		15	12	7	4	2	1	0

Summary of Elastic Moduli for Intact Rock, E_i (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-1

Rock Type	No. of Values	No. of Rock Types	Elastic Modulus, E_i (ksi $\times 10^3$)			Standard Deviation (ksi $\times 10^3$)
			Maximum	Minimum	Mean	
Granite	26	26	14.5	0.93	7.64	3.55
Diorite	3	3	16.2	2.48	7.45	6.19
Gabbro	3	3	12.2	9.8	11.0	0.97
Diabase	7	7	15.1	10.0	12.8	1.78
Basalt	12	12	12.2	4.20	8.14	2.60
Quartzite	7	7	12.8	5.29	9.59	2.32
Marble	14	13	10.7	0.58	6.18	2.49
Gneiss	13	13	11.9	4.13	8.86	2.31
Slate	11	2	3.79	0.35	1.39	0.96
Schist	13	12	10.0	0.86	4.97	3.18
Phyllite	3	3	2.51	1.25	1.71	0.57
Sandstone	27	19	5.68	0.09	2.13	1.19
Siltstone	5	5	4.76	0.38	2.39	1.65
Shale	30	14	5.60	0.001	1.42	1.45
Limestone	30	30	13.0	0.65	5.7	3.73
Dolostone	17	16	11.4	0.83	4.22	3.44

Summary of Poisson's Ratio for Intact Rock, v (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-2

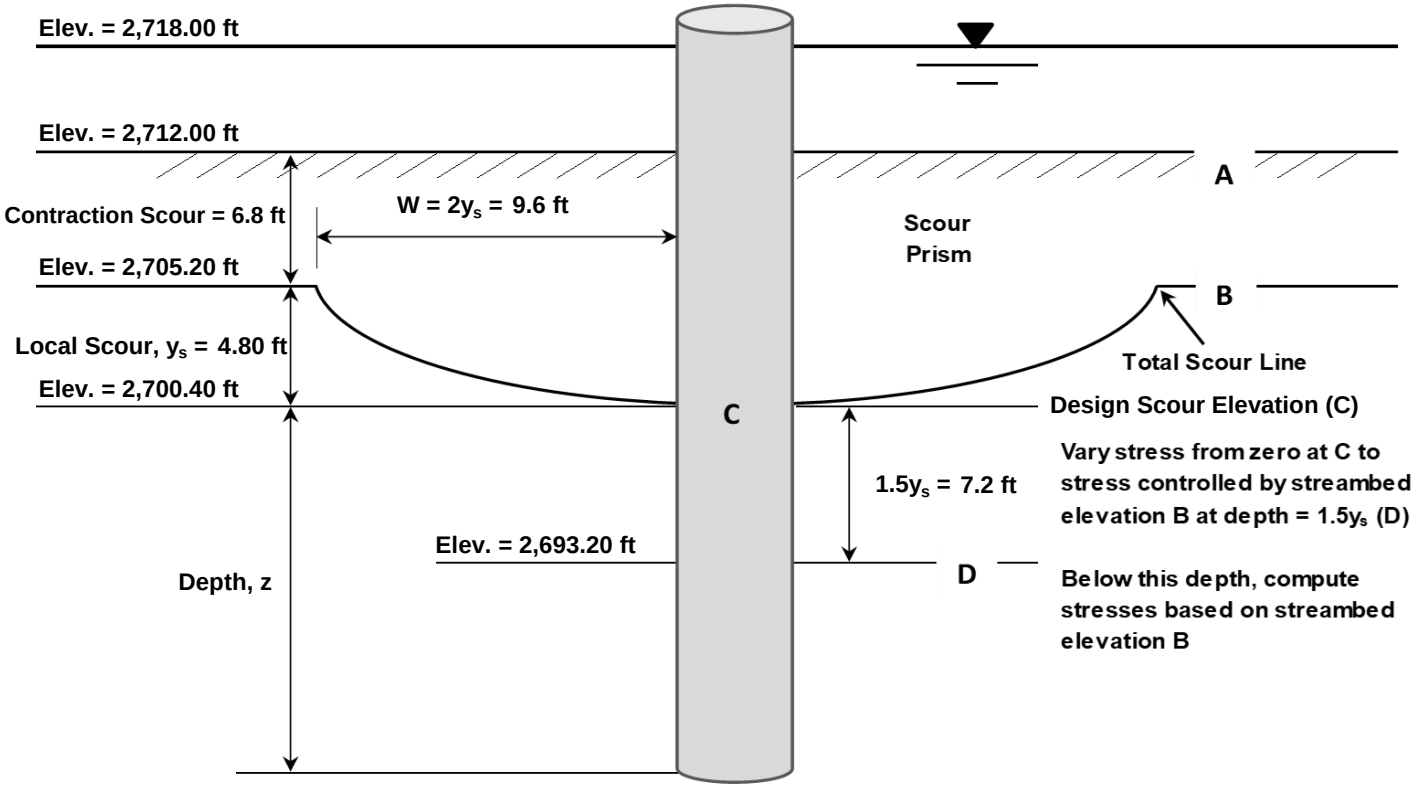
Rock Type	No. of Values	No. of Rock Types	Poisson's Ratio, v			Standard Deviation
			Maximum	Minimum	Mean	
Granite	22	22	0.39	0.09	0.20	0.08
Gabbro	3	3	0.20	0.16	0.18	0.02
Diabase	6	6	0.38	0.20	0.29	0.06
Basalt	11	11	0.32	0.16	0.23	0.05
Quartzite	6	6	0.22	0.08	0.14	0.05
Marble	5	5	0.40	0.17	0.28	0.08
Gneiss	11	11	0.40	0.09	0.22	0.09
Schist	12	11	0.31	0.02	0.12	0.08
Sandstone	12	9	0.46	0.08	0.20	0.11
Siltstone	3	3	0.23	0.09	0.18	0.06
Shale	3	3	0.18	0.03	0.09	0.06
Limestone	19	19	0.33	0.12	0.23	0.06
Dolostone	5	5	0.35	0.14	0.29	0.08

Calculating Design Stresses for Drilled Piers based on Scour Prism used in FHWA GEC 010

For analysis purposes, lower ground line to the contraction scour elevation (CSE) to account for contraction scour reported in the bridge survey report.

- If the CSE is lower than or equal to the design scour elevation (DSE), consider all scour as contraction scour and lower th ground line to the design scour elevation (DSE).
- If the CSE is higher than the DSE, consider the difference between the CSE and the DSE as local scour.

Groundwater Elevation =	2718.00	ft	
Original Pre-Scour Streambed Elevation (Point A) =	2712.00	ft	*= Natural Ground / Finished Grade Elevation*
Amount of Contraction Scour =	6.80	ft	
Streambed Elevation after General Scour (Point B) =	2705.20	ft	*= Point A - Contraction Scour ≥ Design Scour Elevation*
Amount of Local Scour (y_s) =	4.80	ft	
p of the embedded length of the drilled pier (Point C) =	2700.40	ft	*= Design Scour Elevation*
$1.5(y_s)$ =	7.20	ft	
evation corresponding to a depth of $1.5(y_s)$, (Point D) =	2693.20	ft	*= Point C - 1.5y $_s$*



Adapted from FHWA GEC 010 Figure 13.18: Illustration of Scour Prism and Effects on Drilled Pier

Per FHWA GEC 010 page 13-46, vertical stress along any depth of the drilled pier can be estimated as follows;

1) At the top of the embedded drilled pier (Point C) the vertical stress is equal to zero.
2) At a depth of 1.5ys (Point D) or greater, assume the vertical stress is controlled by the streambed elevation (Point B).
3) Assume a linear variation in vertical stress from 0 at Point C to the vertical stress value controlled by the streambed at Point I

Soil Layer Profile and Effective Vertical Stress controlled by the streambed elevation (Point B)

- Assume the streambed elevation is equal to the contraction scour elevation (Elevation 2,705.20 ft).

Layer No.	Top (ft)	Midpoint (ft)	Bottom (ft)	σ_{v_top} (ksf)	$\mu_{\_top}$ (ksf)	σ'_{v_top} (ksf)	Δz (ft)	γ (kcf)	σ_{v_bottom} (ksf)	$\mu_{\_bottom}$ (ksf)	σ'_{v_bottom} (ksf)
0	2705.20	2702.80	2700.40	0.000	0.000	0.000	4.80	0.120	0.576	0.300	0.276
1	2700.40	2692.85	2685.30	0.576	0.300	0.276	15.10	0.135	2.614	1.242	1.373
2	2685.30	2677.55	2669.80	2.614	1.242	1.373	15.50	0.120	4.474	2.209	2.266
3	2669.80	2667.65	2665.50	4.474	2.209	2.266	4.30	0.135	5.055	2.477	2.578
4	2665.50	2660.75	2656.00	5.055	2.477	2.578	9.50	0.173	6.698	3.070	3.628
5											
6											
7											
8											

Variation in Vertical Stress from Point C to Point D

- Assume the top of the embedded drilled pier is equal to the design scour elevation.
- Vertical stress at elevation 2700.4 ft (Point C) = 0 ksf
- Assume a linear variation in vertical stress from 0 ksf at elevation 2,700.40 ft (Point C) to a stress value controlled by the elevation 2,705.20 ft (Point B) at the depth Point D, elevation 2,693.20 ft.
- PointD lies within Soil Layer No.1

Point D Elevation (ft)	Top of Layer 1 (ft)	σ_v at 2,700.40 ft	Depth below Layer 1 (ft)	γ for Layer 2	μ at Point D (ksf)	σ'_v at Point D (ksf)
2693.20	2700.40	0.576	7.20	0.135	0.749	0.799

Point	Elevation (ft)	z (ft)	σ'_v (ksf)	Equation for linear variation over a depth of $1.5y_s$
C	2,700.40	0.00	0.000	σ'_v (for z = 0 to 7.2 ft) = (0.1110)z
D	2,693.20	7.20	0.799	

- All stress calculations below elevation 2,693.20 ft (Point D) will be based on elevation 2,705.20 ft (Point B).

Summary of Design Stress at the Midpoint of each Soil Layer and at Tip of Drilled Pier

Layer	Top (ft)	Bottom (ft)	Midpoint (ft)	z (ft)	Is z < $1.5y_s$?	$\sigma_{v\_midpoint}$ (ksf)	μ (ksf)	$\sigma'_{v\_midpoint}$ (ksf)
1	2700.40	2685.30	2692.85	7.55	no	1.595	0.771	0.825
2	2685.30	2669.80	2677.55	22.85	no	3.544	1.725	1.819
3	2669.80	2665.50	2667.65	32.75	no	4.765	2.343	2.422
4	2665.50	2656.00	2660.75	39.65	no	5.877	2.774	3.103

Tip Elev. (ft)	z (ft)	σ_{v_bottom} (ksf)	μ (ksf)	σ'_{v_bottom} (ksf)
2656.00	44.40	6.698	3.070	3.628

Side Resistance in Cohesionless Soil (Sand / Gravel with $N1_{60} \leq 100$)

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

q_s = unit side resistance for soil layer (ksf)

$= (\beta)(\sigma'_v)$ *AASHTO Eqn. 10.8.3.5.2b-1*

β = load transfer coefficient

$$= \left(1 - \sin \phi'_f\right)\left(\frac{\sigma'_p}{\sigma'_v}\right)^{\sin \phi'_f} \tan \phi'_f$$ *AASHTO Eqn. 10.8.3.5.2b-2*

ϕ'_f = effective friction angle

$= 27.5 + 9.2 \log(N1_{60}), \quad N1_{60} \leq 100$ *AASHTO Eqn. 10.8.3.5.2b-3*

$N1_{60}$ = SPT - N value corrected for hammer efficiency and overburden (limited to 100 bpf)

σ'_p = effective vertical preconsolidation stress

For Sands: $\frac{\sigma'_p}{\rho_a} \approx 0.47(N_{60})^m$ *AASHTO Eqn. 10.8.3.5.2b-4*

For Gravels: $\frac{\sigma'_p}{\rho_a} = 0.15(N_{60})$ *AASHTO Eqn. 10.8.3.5.2b-5*

m = 0.6 for clean sands; 0.8 for silty sands and sandy silts

N_{60} = SPT - N value corrected for hammer efficiency (limited to 100 bpf)

ρ_a = atmospheric pressure (2.12 ksf)

σ'_v = effective vertical stress at soil layer mid-depth as defined in FHWA GEC 010 pages 13-46

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

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

B = diameter of drilled pier (3 ft)

Δz = effective thickness of the soil layer (ft)

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	Material Type	$N1_{60}$	ϕ' (deg)	m	N_{60}	σ'_p/ρ_a	σ'_v (ksf)	β	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
2	2,685.30	2,669.80	Sand	45	43	0.6	49	4.860	1.819	0.968	1.761	15.50	146.08	257

Total Side Resistance in Cohesionless Soil = 257

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 Top (ft)	Layer Elevations Bottom (ft)	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)
1	Weathered Rock	2,700.00	2,685.30	N/A	N/A	N/A	N/A	8.000	14.70	130.85	1047
3	Weathered Rock	2,669.80	2,665.50	N/A	N/A	N/A	N/A	8.000	4.30	38.28	306
4	Hard Rock	2,665.50	2,656.00	10.8.3.5.4b-2 (open joints)	100	0.85	648	20.478	9.50	84.56	1732

Total Side Resistance in Weathered and Hard Rock = 3,085

Tip Resistance in Hard Rock

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

q_p = unit tip resistance (ksf)

If rock to a depth of 2B below drilled pier tip is intact or tightly jointed and the depth of socket > 1.5 D

$= 2.5q_u$ *AASHTO Eqn. 10.8.3.5.4c-1*

If the rock to a depth of 2D below the drilled pier tip is jointed with random orientation

$$= A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-2*

q_u = Uniaxial Compressive Strength of Intact Rock (ksf)
σ'_{vb} = vertical effective stress at the socket bearing elevation

$$A = \sigma'_{vb} + q_u\left[m_b\left(\frac{\sigma'_{vb}}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-3*

$$s = exp\left(\frac{GSI - 100}{9}\right)$$ *AASHTO Eqn. 10.4.6.4-2*

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{\frac{-GSI}{15}} - e^{\frac{-20}{3}}\right)$$ *AASHTO Eqn. 10.4.6.4-3*

$$m_b = exp\left(\frac{GSI - 100}{28}\right) m_i$$ *AASHTO Eqn. 10.4.6.4-4*

m_i = constant for intact rock *AASHTO Table 10.4.6.4-1*

GSI = Global Strength Index

***Hard Rock Layers with an GSI less than 30 will be modeled as weathered rock.**

A_p = area of drilled pier tip resistance (ft^2)
$= (\pi)(B^2)/4$

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

Tip Elevation (ft)	AASHTO Equation used to calculate q_u	q_u (ksf)	GSI	m	m_b	s	a	A	q_p (ksf)	A_p (ft^2)	R_p (kips)
2656.00	10.8.3.5.4c-1	1,274	85	28	N/A	N/A	N/A	N/A	3,185	6.31	20,097

Tip Resistance in Hard Rock (continued)

Table 10.4.6.4-1—Values of the Constant mi by Rock Group

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (21 ± 3) Breccia (19 ± 5)	Sandstone 17 ± 4	Siltstone 7 ± 2 Greywacke (18 ± 3)	Claystone 4 ± 2 Shale (6 ± 2) Marl (7 ± 2)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestone (10 ± 5)	Micritic Limestone (8 ± 3)	Dolomite (9 ± 3)
		Evaporites		Gypsum 10 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4)) Metasandstone (19 ± 3)	Quartzite 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolite 26 ± 6	Gneiss 28 ± 5	
	Foliated*			Schist (10 ± 3)	Phyllite (7 ± 3)	Slate 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3)) Basalt (25 ± 5)	
		Pyroclastic	Agglomerate (19 ± 3)	Volcanic breccia (19 ± 5)	Tuff (13 ± 5)	

Summary of Nominal and Factored Side Resistance

Cohesionless IGM	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	257	0.55	141	7.7%
CohesiveIGM	0	0.60	0	0.0%
Weathered Rock	1,353	0.60	812	40.5%
Hard Rock	1,732	0.55	953	51.8%
Total	**3,342**		**1,906**	**100%**

Note: *When drilled piers are socketed in hard rock, the side resistance above the hard rock will be ignored. For the purpose of this spreadsheet, a drilled pier will be considered socketed in hard rock if either of these conditions are met;*

1. *The pier is embedded the greater of 3 feet or 1 pier diameter into hard rock.*
2. *At least 50% of the total nominal side resistance is produced by the hard rock layer(s).*

Summary of Nominal and Factored Side Resistance (continued)

Total Nominal Side Resistance =	1,732	kips	
Side Resistance Factor =	0.55		*for Hard Rock, see AASHTO Table 10.5.5.2.4-1.*
Total Factored Side Resistance =	953	kips	

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance =	20,097	kips	*the drilled pier is bearing on Hard Rock*
Tip Resistance Factor =	0.50		*for Hard Rock, see AASHTO Table 10.5.5.2.4-1.*
Total Factored Tip Resistance =	10,049	kips	

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 = 810 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} = 10.98 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 8 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} = 55.82 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 59 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 = 62 ft *Depth from water surface to the drilled pier tip*
γ_w = 0.0624 kcf *Unit Weight of Water*

= 27 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} = 3.628 ksf *ffective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46*

$W_{Soil/Rock}$ = 26 kips

R_{req} = 810 kips + 1.25(8 kips + 59 kips) -1.00(27 kips) -1.25(26 kips) = 834 kips

Load Transfer of Side and Tip Resistance for Drilled Piers in Hard Rock with no Rock Socket

Per AASHTO Section 10.8.3.5.4a, The Factored Geotechnical Resistance for Drilled Piers socketed in hard rock will be based on side resistance, tip resistance, or a combination of both. Using a combination of both side and tip resistance requires a displacement based analysis and falls outside the limitations of this spreadsheet. For details on displacement based analysis, see *FHWA GEC 010 Appendix D.3.1* .

Developed Factored Resistance, (R_{rd})

Select which value to use for the Factored Developed Resistance

(●) Use the Factored Side Resistance of the rock socket.

( ) Use the Factored Tip Resistance of the rock socket.

953 kips ≥ 834 kips

The axial resistance requirement is satisfied.

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)
834	953	6.31	0.50	3185	0

GEOTECHNICAL BORING REPORT
BORE LOG

Bent No. 2 - LT

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. B2-A	**STATION** 17+08	**OFFSET** 26 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,715.9 ft	**TOTAL DEPTH** 18.1 ft	**NORTHING** 977,733	**EASTING** 1,328,091	**24 HR.** 2.3
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers		**HAMMER TYPE** Automatic
DRILLER J. Cain	**START DATE** 07/13/22	**COMP. DATE** 07/13/22	**SURFACE WATER DEPTH** N/A	

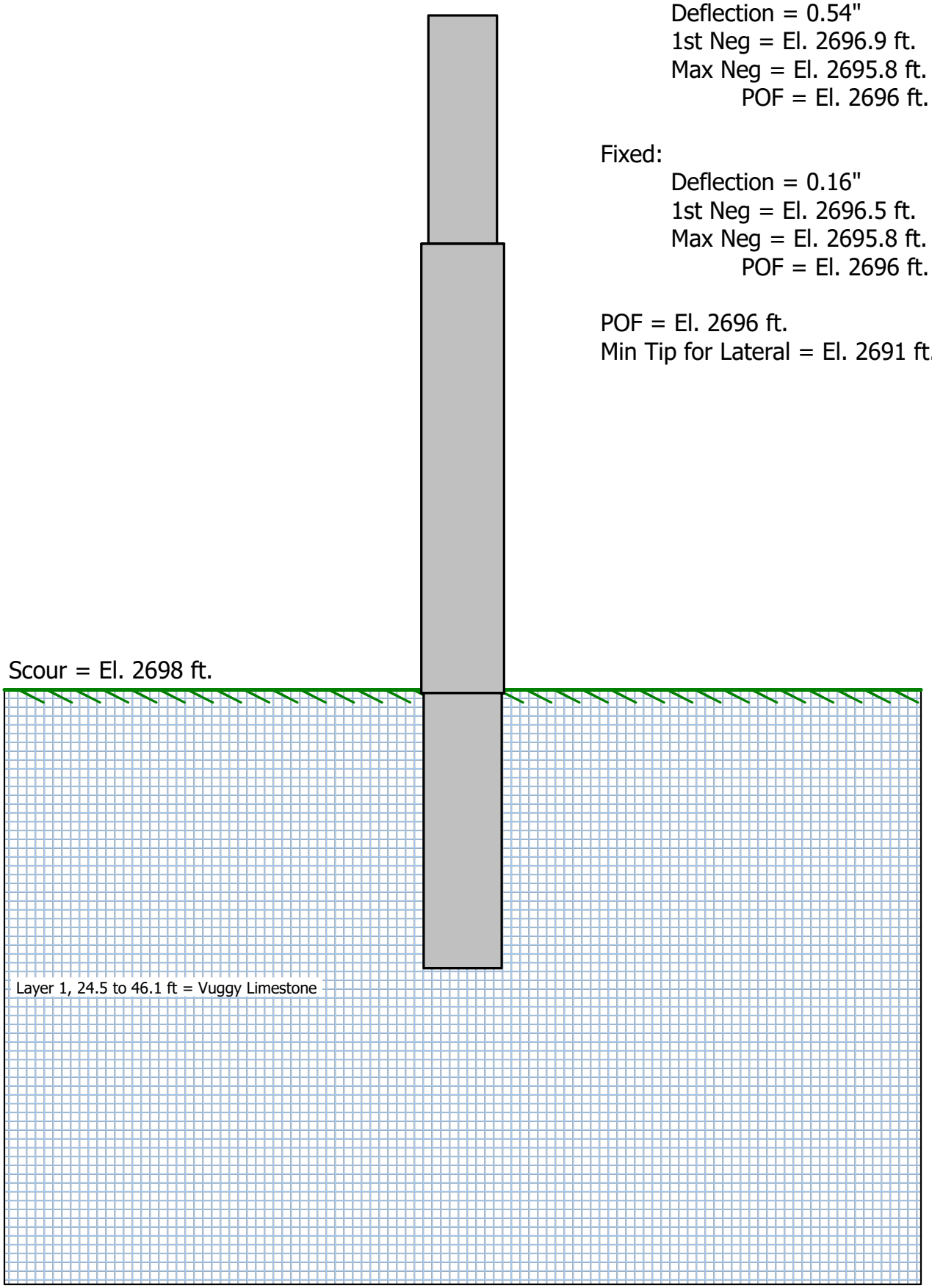
ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION ELEV. (ft)	DEPTH (ft)
2720						BOC = 2722.5'					
2715	2715.9	0.0	3	2	3	5 TOP OF PIER El. 27 14.2'		M		2715.9 GROUND SURFACE	0.0
	2712.4	3.5	4	7	6	13		Sat.		2712.9 **ALLUVIAL** Medium Stiff, Brown, Fine to Coarse Sandy SILT (A-4), with trace cobbles	3.0
2710	2709.9	6.0	6	3	4	7		Sat.		2710.4 Medium Dense, Brown, Fine to Coarse Sandy GRAVEL (A-1-a)	5.5
	2707.4	8.5	3	4	11	15		W		2707.4 Loose, Gray-Brown, Silty Fine to Coarse SAND (A-2-4), with some cobbles	8.5
2705										**RESIDUAL** Very Stiff to Hard, Brown-Tan-Gray, Fine to Coarse Sandy SILT (A-4), with trace mica	
	2702.4	13.5	11	22	26	48		W		BSR Scour El 2698' Perm Case El. 288'	
2700	2697.9	18.0	50/0.1			50/0.1				2697.9 **CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS)	18.0
										2697.8 Boring Terminated with Standard Penetration Test Refusal at Elevation 2,697.8 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)	18.1

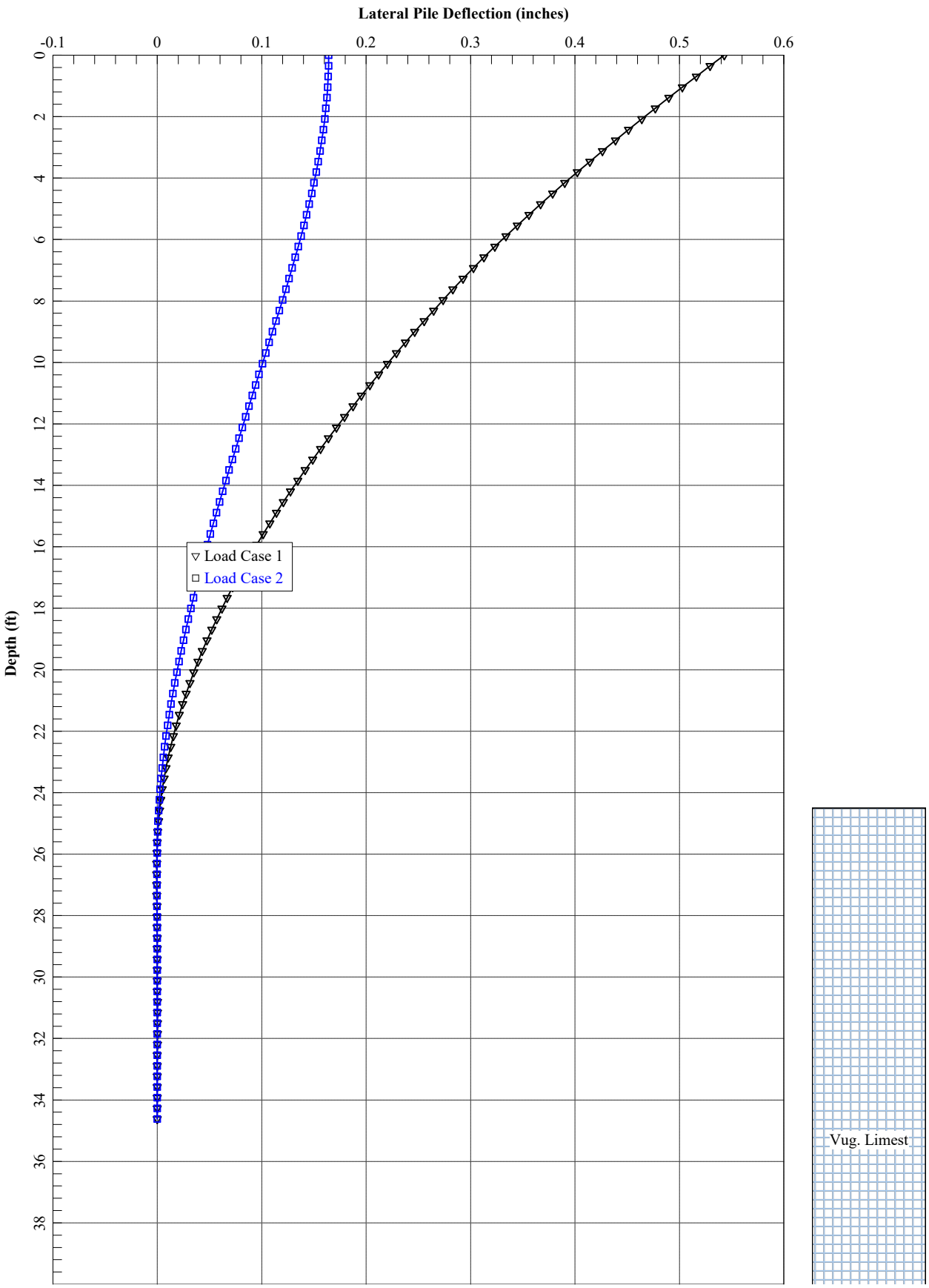
Bent No. 2 – E1

Free:
Deflection = 0.54"
1st Neg = El. 2696.9 ft.
Max Neg = El. 2695.8 ft.
POF = El. 2696 ft.

Fixed:
Deflection = 0.16"
1st Neg = El. 2696.5 ft.
Max Neg = El. 2695.8 ft.
POF = El. 2696 ft.

POF = El. 2696 ft.
Min Tip for Lateral = El. 2691 ft.





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LPile for Windows, Version 2019-11.009

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\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500- 29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\LPile\

Name of input data file:
Bridge 063- Bent 2 (B2-A).lp11d

Name of output report file:
Bridge 063- Bent 2 (B2-A).lp11o

Name of plot output file:
Bridge 063- Bent 2 (B2-A).lp11p

Name of runtime message file:
Bridge 063- Bent 2 (B2-A).lp11r

Date and Time of Analysis

Date: September 8, 2022 Time: 10:22:18

Problem Title

Project Name: Bridge 063

Job Number: 09-29662

Client: STV

Engineer: ECS Southeast

Description: Bent 2 (LT) Lateral Analysis

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
- Input of side resistance moment along pile 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 = 3
Total length of pile = 34.620 ft
Depth of ground surface below top of pile = 24.5000 ft

Pile diameters used for p-y curve computations are defined using 6 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	30.0000
2	8.300	30.0000
3	8.300	36.0000
4	24.620	36.0000
5	24.620	34.0000
6	34.620	34.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 8.300000 ft
Width of top of section = 30.000000 in
Width of bottom of section = 30.000000 in
Top Area = 706.858347 sq. in
Bottom Area = 706.858347 sq. in
Moment of Inertia at Top = 39761. in^4
Moment of Inertia at Bottom = 39761. in^4
Elastic Modulus = 3122019. psi

Pile Section No. 2:

Section 2 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 16.320000 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 = 3823676. psi

Pile Section No. 3:

Section 3 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 10.000000 ft
Width of top of section = 34.000000 in
Width of bottom of section = 34.000000 in
Top Area = 907.920277 sq. in
Bottom Area = 907.920277 sq. in
Moment of Inertia at Top = 65597. in^4
Moment of Inertia at Bottom = 65597. in^4
Elastic Modulus = 3823676. 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 strong rock (vuggy limestone)

Distance from top of pile to top of layer = 24.500000 ft
Distance from top of pile to bottom of layer = 46.100000 ft
Effective unit weight at top of layer = 174.000000 pcf
Effective unit weight at bottom of layer = 174.000000 pcf
Uniaxial compressive strength at top of layer = 10724. psi
Uniaxial compressive strength at bottom of layer = 10724. psi

(Depth of the lowest soil layer extends 11.480 ft below the pile tip)

**** Warning- Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer 0, for effective unit weight = 174.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi
1	Strong Rock	24.5000	174.0000	10724.
	(Vuggy Limestone)	46.1000	174.0000	10724.

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 = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 11000. lbs	M = 720000. in-lbs	500000.	No	Yes
2	2	V = 13000. lbs	S = 0.0000 in/in	510000.	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 = 3

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 3:

Moment-curvature properties were derived from elastic section properties

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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 = 11000.0 lbs
Applied moment at pile head = 720000.0 in-lbs
Axial thrust load on pile head = 500000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. p	Soil Spr. Es*H	Distrib. Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	0.5429	720000.	11000.	-0.00325	978.9797	1.24E+11	0.00	0.00	0.00
0.3462	0.5295	772420.	11000.	-0.00322	998.7555	1.24E+11	0.00	0.00	0.00
0.6924	0.5161	824786.	11000.	-0.00320	1019.	1.24E+11	0.00	0.00	0.00
1.0386	0.5029	877095.	11000.	-0.00317	1038.	1.24E+11	0.00	0.00	0.00
1.3848	0.4898	929343.	11000.	-0.00314	1058.	1.24E+11	0.00	0.00	0.00
1.7310	0.4768	981527.	11000.	-0.00311	1078.	1.24E+11	0.00	0.00	0.00
2.0772	0.4640	1033642.	11000.	-0.00307	1097.	1.24E+11	0.00	0.00	0.00
2.4234	0.4513	1085685.	11000.	-0.00304	1117.	1.24E+11	0.00	0.00	0.00
2.7696	0.4388	1137653.	11000.	-0.00300	1137.	1.24E+11	0.00	0.00	0.00
3.1158	0.4264	1189541.	11000.	-0.00296	1156.	1.24E+11	0.00	0.00	0.00
3.4620	0.4142	1241347.	11000.	-0.00292	1176.	1.24E+11	0.00	0.00	0.00
3.8082	0.4021	1293067.	11000.	-0.00288	1195.	1.24E+11	0.00	0.00	0.00

4.1544	0.3903	1344697.	11000.	-0.00283	1215.	1.24E+11	0.00	0.00	0.00
4.5006	0.3786	1396233.	11000.	-0.00279	1234.	1.24E+11	0.00	0.00	0.00
4.8468	0.3671	1447673.	11000.	-0.00274	1253.	1.24E+11	0.00	0.00	0.00
5.1930	0.3558	1499011.	11000.	-0.00269	1273.	1.24E+11	0.00	0.00	0.00
5.5392	0.3448	1550246.	11000.	-0.00264	1292.	1.24E+11	0.00	0.00	0.00
5.8854	0.3339	1601372.	11000.	-0.00259	1311.	1.24E+11	0.00	0.00	0.00
6.2316	0.3233	1652388.	11000.	-0.00253	1331.	1.24E+11	0.00	0.00	0.00
6.5778	0.3129	1703288.	11000.	-0.00248	1350.	1.24E+11	0.00	0.00	0.00
6.9240	0.3027	1754070.	11000.	-0.00242	1369.	1.24E+11	0.00	0.00	0.00
7.2702	0.2928	1804730.	11000.	-0.00236	1388.	1.24E+11	0.00	0.00	0.00
7.6164	0.2831	1855265.	11000.	-0.00230	1407.	1.24E+11	0.00	0.00	0.00
7.9626	0.2737	1905671.	11000.	-0.00223	1426.	1.24E+11	0.00	0.00	0.00
8.3088	0.2645	1955944.	11000.	-0.00219	918.2398	3.15E+11	0.00	0.00	0.00
8.6550	0.2555	2006164.	11000.	-0.00216	929.2037	3.15E+11	0.00	0.00	0.00
9.0012	0.2466	2056328.	11000.	-0.00214	940.1556	3.15E+11	0.00	0.00	0.00
9.3474	0.2377	2106437.	11000.	-0.00211	951.0953	3.15E+11	0.00	0.00	0.00
9.6936	0.2290	2156488.	11000.	-0.00208	962.0224	3.15E+11	0.00	0.00	0.00
10.0398	0.2204	2206480.	11000.	-0.00205	972.9366	3.15E+11	0.00	0.00	0.00
10.3860	0.2120	2256411.	11000.	-0.00202	983.8375	3.15E+11	0.00	0.00	0.00
10.7322	0.2036	2306281.	11000.	-0.00199	994.7251	3.15E+11	0.00	0.00	0.00
11.0784	0.1954	2356087.	11000.	-0.00196	1006.	3.15E+11	0.00	0.00	0.00
11.4246	0.1873	2405829.	11000.	-0.00193	1016.	3.15E+11	0.00	0.00	0.00
11.7708	0.1794	2455505.	11000.	-0.00190	1027.	3.15E+11	0.00	0.00	0.00
12.1170	0.1716	2505114.	11000.	-0.00187	1038.	3.15E+11	0.00	0.00	0.00
12.4632	0.1639	2554654.	11000.	-0.00183	1049.	3.15E+11	0.00	0.00	0.00
12.8094	0.1563	2604125.	11000.	-0.00180	1060.	3.15E+11	0.00	0.00	0.00
13.1556	0.1489	2653524.	11000.	-0.00176	1071.	3.15E+11	0.00	0.00	0.00
13.5018	0.1417	2702850.	11000.	-0.00173	1081.	3.15E+11	0.00	0.00	0.00
13.8480	0.1346	2752103.	11000.	-0.00169	1092.	3.15E+11	0.00	0.00	0.00
14.1942	0.1276	2801280.	11000.	-0.00166	1103.	3.15E+11	0.00	0.00	0.00
14.5404	0.1208	2850381.	11000.	-0.00162	1114.	3.15E+11	0.00	0.00	0.00
14.8866	0.1142	2899403.	11000.	-0.00158	1124.	3.15E+11	0.00	0.00	0.00
15.2328	0.1077	2948346.	11000.	-0.00154	1135.	3.15E+11	0.00	0.00	0.00
15.5790	0.1013	2997209.	11000.	-0.00150	1146.	3.15E+11	0.00	0.00	0.00
15.9252	0.09517	3045989.	11000.	-0.00146	1156.	3.15E+11	0.00	0.00	0.00
16.2714	0.08918	3094686.	11000.	-0.00142	1167.	3.15E+11	0.00	0.00	0.00
16.6176	0.08335	3143298.	11000.	-0.00138	1177.	3.15E+11	0.00	0.00	0.00
16.9638	0.07769	3191825.	11000.	-0.00134	1188.	3.15E+11	0.00	0.00	0.00
17.3100	0.07221	3240263.	11000.	-0.00130	1199.	3.15E+11	0.00	0.00	0.00
17.6562	0.06691	3288614.	11000.	-0.00125	1209.	3.15E+11	0.00	0.00	0.00
18.0024	0.06178	3336874.	11000.	-0.00121	1220.	3.15E+11	0.00	0.00	0.00
18.3486	0.05684	3385043.	11000.	-0.00117	1230.	3.15E+11	0.00	0.00	0.00
18.6948	0.05209	3433119.	11000.	-0.00112	1241.	3.15E+11	0.00	0.00	0.00
19.0410	0.04752	3481101.	11000.	-0.00108	1251.	3.15E+11	0.00	0.00	0.00
19.3872	0.04314	3528988.	11000.	-0.00103	1262.	3.15E+11	0.00	0.00	0.00
19.7334	0.03896	3576778.	11000.	-9.84E-04	1272.	3.15E+11	0.00	0.00	0.00
20.0796	0.03497	3624470.	11000.	-9.36E-04	1283.	3.15E+11	0.00	0.00	0.00
20.4258	0.03118	3672064.	11000.	-8.88E-04	1293.	3.15E+11	0.00	0.00	0.00
20.7720	0.02759	3719556.	11000.	-8.39E-04	1303.	3.15E+11	0.00	0.00	0.00
21.1182	0.02421	3766947.	11000.	-7.90E-04	1314.	3.15E+11	0.00	0.00	0.00
21.4644	0.02103	3814235.	11000.	-7.40E-04	1324.	3.15E+11	0.00	0.00	0.00
21.8106	0.01806	3861418.	11000.	-6.89E-04	1334.	3.15E+11	0.00	0.00	0.00
22.1568	0.01530	3908496.	11000.	-6.38E-04	1345.	3.15E+11	0.00	0.00	0.00

22.5030	0.01276	3955466.	11000.	-5.86E-04	1355.	3.15E+11	0.00	0.00	0.00
22.8492	0.01043	4002329.	11000.	-5.34E-04	1365.	3.15E+11	0.00	0.00	0.00
23.1954	0.00832	4049081.	11000.	-4.81E-04	1375.	3.15E+11	0.00	0.00	0.00
23.5416	0.00643	4095723.	11000.	-4.27E-04	1385.	3.15E+11	0.00	0.00	0.00
23.8878	0.00477	4142253.	11000.	-3.73E-04	1396.	3.15E+11	0.00	0.00	0.00
24.2340	0.00334	4188670.	11000.	-3.18E-04	1406.	3.15E+11	0.00	0.00	0.00
24.5802	0.00213	4234971.	-36408.	-2.63E-04	1416.	3.15E+11	-22823.	4.46E+07	0.00
24.9264	0.00115	3887251.	-109507.	-2.02E-04	1558.	2.51E+11	-12368.	4.46E+07	0.00
25.2726	4.46E-04	3325938.	-145129.	-1.43E-04	1413.	2.51E+11	-4781.	4.46E+07	0.00
25.6188	-3.28E-05	2681994.	-154331.	-9.30E-05	1246.	2.51E+11	351.4371	4.46E+07	0.00
25.9650	-3.27E-04	2044023.	-146320.	-5.39E-05	1080.	2.51E+11	3505.	4.46E+07	0.00
26.3112	-4.80E-04	1466472.	-128342.	-2.48E-05	930.7560	2.51E+11	5150.	4.46E+07	0.00
26.6574	-5.33E-04	977756.	-105777.	-4.54E-06	804.1017	2.51E+11	5713.	4.46E+07	0.00
27.0036	-5.18E-04	587608.	-82372.	8.42E-06	702.9921	2.51E+11	5555.	4.46E+07	0.00
27.3498	-4.63E-04	293307.	-60526.	1.57E-05	626.7217	2.51E+11	4962.	4.46E+07	0.00
27.6960	-3.87E-04	84643.	-41590.	1.88E-05	572.6449	2.51E+11	4154.	4.46E+07	0.00
28.0422	-3.06E-04	-52331.	-26142.	1.91E-05	564.2712	2.51E+11	3283.	4.46E+07	0.00
28.3884	-2.29E-04	-132643.	-14232.	1.76E-05	585.0845	2.51E+11	2451.	4.46E+07	0.00
28.7346	-1.60E-04	-170655.	-5577.	1.51E-05	594.9357	2.51E+11	1716.	4.46E+07	0.00
29.0808	-1.03E-04	-179044.	288.1401	1.22E-05	597.1097	2.51E+11	1108.	4.46E+07	0.00
29.4270	-5.88E-05	-168312.	3900.	9.30E-06	594.3284	2.51E+11	631.0722	4.46E+07	0.00
29.7732	-2.60E-05	-146682.	5790.	6.69E-06	588.7229	2.51E+11	278.8267	4.46E+07	0.00
30.1194	-3.25E-06	-120235.	6441.	4.48E-06	581.8690	2.51E+11	34.8204	4.46E+07	0.00
30.4656	1.12E-05	-93183.	6263.	2.71E-06	574.8582	2.51E+11	-120.4624	4.46E+07	0.00
30.8118	1.93E-05	-68207.	5583.	1.38E-06	568.3855	2.51E+11	-206.9838	4.46E+07	0.00
31.1580	2.27E-05	-46801.	4648.	4.25E-07	562.8379	2.51E+11	-243.1743	4.46E+07	0.00
31.5042	2.28E-05	-29590.	3634.	-2.08E-07	558.3776	2.51E+11	-244.8298	4.46E+07	0.00
31.8504	2.09E-05	-16603.	2659.	-5.90E-07	555.0120	2.51E+11	-224.6505	4.46E+07	0.00
32.1966	1.79E-05	-7494.	1793.	-7.90E-07	552.6512	2.51E+11	-192.2193	4.46E+07	0.00
32.5428	1.44E-05	-1701.	1073.	-8.66E-07	551.1500	2.51E+11	-154.2584	4.46E+07	0.00
32.8890	1.07E-05	1429.	514.0517	-8.68E-07	551.0795	2.51E+11	-115.0421	4.46E+07	0.00
33.2352	7.17E-06	2574.	115.3906	-8.35E-07	551.3761	2.51E+11	-76.8803	4.46E+07	0.00
33.5814	3.79E-06	2391.	-128.6758	-7.94E-07	551.3288	2.51E+11	-40.6175	4.46E+07	0.00
33.9276	5.71E-07	1508.	-225.7573	-7.62E-07	551.0999	2.51E+11	-6.1192	4.46E+07	0.00
34.2738	-2.54E-06	518.5591	-181.8301	-7.45E-07	550.8435	2.51E+11	27.2665	4.46E+07	0.00
34.6200	-5.62E-06	0.00	0.00	-7.41E-07	550.7091	2.51E+11	60.2696	2.23E+07	0.00

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.54289831 inches
Computed slope at pile head = -0.00324793 radians
Maximum bending moment = 4234971. inch-lbs
Maximum shear force = -154331. lbs
Depth of maximum bending moment = 24.58020000 feet below pile head
Depth of maximum shear force = 25.61880000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 3

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

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

Shear force at pile head = 13000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 510000.0 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 lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1641	-1618108.	13000.	0.00	1332.	1.24E+11	0.00	0.00	0.00
0.3462	0.1640	-1564044.	13000.	-5.32E-05	1312.	1.24E+11	0.00	0.00	0.00
0.6924	0.1637	-1509868.	13000.	-1.05E-04	1291.	1.24E+11	0.00	0.00	0.00
1.0386	0.1631	-1455586.	13000.	-1.54E-04	1271.	1.24E+11	0.00	0.00	0.00
1.3848	0.1624	-1401200.	13000.	-2.02E-04	1250.	1.24E+11	0.00	0.00	0.00
1.7310	0.1614	-1346715.	13000.	-2.48E-04	1230.	1.24E+11	0.00	0.00	0.00
2.0772	0.1603	-1292134.	13000.	-2.92E-04	1209.	1.24E+11	0.00	0.00	0.00
2.4234	0.1590	-1237462.	13000.	-3.35E-04	1188.	1.24E+11	0.00	0.00	0.00
2.7696	0.1575	-1182702.	13000.	-3.75E-04	1168.	1.24E+11	0.00	0.00	0.00
3.1158	0.1559	-1127858.	13000.	-4.14E-04	1147.	1.24E+11	0.00	0.00	0.00
3.4620	0.1541	-1072935.	13000.	-4.51E-04	1126.	1.24E+11	0.00	0.00	0.00
3.8082	0.1522	-1017935.	13000.	-4.86E-04	1106.	1.24E+11	0.00	0.00	0.00
4.1544	0.1501	-962863.	13000.	-5.19E-04	1085.	1.24E+11	0.00	0.00	0.00
4.5006	0.1478	-907722.	13000.	-5.50E-04	1064.	1.24E+11	0.00	0.00	0.00
4.8468	0.1455	-852518.	13000.	-5.79E-04	1043.	1.24E+11	0.00	0.00	0.00
5.1930	0.1430	-797252.	13000.	-6.07E-04	1022.	1.24E+11	0.00	0.00	0.00
5.5392	0.1405	-741931.	13000.	-6.33E-04	1001.	1.24E+11	0.00	0.00	0.00
5.8854	0.1378	-686556.	13000.	-6.57E-04	980.5101	1.24E+11	0.00	0.00	0.00
6.2316	0.1350	-631133.	13000.	-6.79E-04	959.6014	1.24E+11	0.00	0.00	0.00
6.5778	0.1321	-575666.	13000.	-6.99E-04	938.6759	1.24E+11	0.00	0.00	0.00
6.9240	0.1292	-520157.	13000.	-7.17E-04	917.7349	1.24E+11	0.00	0.00	0.00
7.2702	0.1262	-464612.	13000.	-7.34E-04	896.7801	1.24E+11	0.00	0.00	0.00
7.6164	0.1231	-409033.	13000.	-7.48E-04	875.8128	1.24E+11	0.00	0.00	0.00
7.9626	0.1200	-353426.	13000.	-7.61E-04	854.8346	1.24E+11	0.00	0.00	0.00
8.3088	0.1168	-297794.	13000.	-7.69E-04	566.0575	3.15E+11	0.00	0.00	0.00
8.6550	0.1136	-242153.	13000.	-7.73E-04	553.9100	3.15E+11	0.00	0.00	0.00
9.0012	0.1104	-186505.	13000.	-7.75E-04	541.7611	3.15E+11	0.00	0.00	0.00
9.3474	0.1071	-130853.	13000.	-7.78E-04	529.6110	3.15E+11	0.00	0.00	0.00
9.6936	0.1039	-75196.	13000.	-7.79E-04	517.4601	3.15E+11	0.00	0.00	0.00
10.0398	0.1007	-19538.	13000.	-7.79E-04	505.3088	3.15E+11	0.00	0.00	0.00
10.3860	0.09741	36121.	13000.	-7.79E-04	508.9293	3.15E+11	0.00	0.00	0.00
10.7322	0.09418	91779.	13000.	-7.79E-04	521.0806	3.15E+11	0.00	0.00	0.00
11.0784	0.09095	147435.	13000.	-7.77E-04	533.2312	3.15E+11	0.00	0.00	0.00
11.4246	0.08772	203086.	13000.	-7.75E-04	545.3810	3.15E+11	0.00	0.00	0.00
11.7708	0.08451	258732.	13000.	-7.72E-04	557.5295	3.15E+11	0.00	0.00	0.00
12.1170	0.08131	314370.	13000.	-7.68E-04	569.6765	3.15E+11	0.00	0.00	0.00

12.4632	0.07813	370000.	13000.	-7.63E-04	581.8215	3.15E+11	0.00	0.00	0.00
12.8094	0.07497	425619.	13000.	-7.58E-04	593.9643	3.15E+11	0.00	0.00	0.00
13.1556	0.07183	481227.	13000.	-7.52E-04	606.1045	3.15E+11	0.00	0.00	0.00
13.5018	0.06872	536821.	13000.	-7.45E-04	618.2418	3.15E+11	0.00	0.00	0.00
13.8480	0.06564	592400.	13000.	-7.38E-04	630.3758	3.15E+11	0.00	0.00	0.00
14.1942	0.06259	647962.	13000.	-7.30E-04	642.5061	3.15E+11	0.00	0.00	0.00
14.5404	0.05957	703507.	13000.	-7.21E-04	654.6326	3.15E+11	0.00	0.00	0.00
14.8866	0.05660	759031.	13000.	-7.11E-04	666.7547	3.15E+11	0.00	0.00	0.00
15.2328	0.05366	814535.	13000.	-7.01E-04	678.8722	3.15E+11	0.00	0.00	0.00
15.5790	0.05077	870016.	13000.	-6.90E-04	690.9848	3.15E+11	0.00	0.00	0.00
15.9252	0.04793	925472.	13000.	-6.78E-04	703.0920	3.15E+11	0.00	0.00	0.00
16.2714	0.04514	980903.	13000.	-6.65E-04	715.1936	3.15E+11	0.00	0.00	0.00
16.6176	0.04240	1036306.	13000.	-6.52E-04	727.2892	3.15E+11	0.00	0.00	0.00
16.9638	0.03972	1091681.	13000.	-6.38E-04	739.3785	3.15E+11	0.00	0.00	0.00
17.3100	0.03710	1147024.	13000.	-6.23E-04	751.4612	3.15E+11	0.00	0.00	0.00
17.6562	0.03454	1202336.	13000.	-6.08E-04	763.5368	3.15E+11	0.00	0.00	0.00
18.0024	0.03205	1257615.	13000.	-5.92E-04	775.6052	3.15E+11	0.00	0.00	0.00
18.3486	0.02963	1312858.	13000.	-5.75E-04	787.6658	3.15E+11	0.00	0.00	0.00
18.6948	0.02728	1368064.	13000.	-5.57E-04	799.7185	3.15E+11	0.00	0.00	0.00
19.0410	0.02500	1423233.	13000.	-5.39E-04	811.7628	3.15E+11	0.00	0.00	0.00
19.3872	0.02280	1478361.	13000.	-5.20E-04	823.7985	3.15E+11	0.00	0.00	0.00
19.7334	0.02068	1533448.	13000.	-5.00E-04	835.8251	3.15E+11	0.00	0.00	0.00
20.0796	0.01865	1588493.	13000.	-4.79E-04	847.8424	3.15E+11	0.00	0.00	0.00
20.4258	0.01670	1643493.	13000.	-4.58E-04	859.8500	3.15E+11	0.00	0.00	0.00
20.7720	0.01485	1698447.	13000.	-4.36E-04	871.8476	3.15E+11	0.00	0.00	0.00
21.1182	0.01308	1753354.	13000.	-4.13E-04	883.8348	3.15E+11	0.00	0.00	0.00
21.4644	0.01141	1808212.	13000.	-3.90E-04	895.8114	3.15E+11	0.00	0.00	0.00
21.8106	0.00984	1863019.	13000.	-3.65E-04	907.7769	3.15E+11	0.00	0.00	0.00
22.1568	0.00838	1917775.	13000.	-3.40E-04	919.7311	3.15E+11	0.00	0.00	0.00
22.5030	0.00702	1972477.	13000.	-3.15E-04	931.6735	3.15E+11	0.00	0.00	0.00
22.8492	0.00576	2027123.	13000.	-2.88E-04	943.6040	3.15E+11	0.00	0.00	0.00
23.1954	0.00462	2081714.	13000.	-2.61E-04	955.5221	3.15E+11	0.00	0.00	0.00
23.5416	0.00359	2136246.	13000.	-2.34E-04	967.4275	3.15E+11	0.00	0.00	0.00
23.8878	0.00268	2190718.	13000.	-2.05E-04	979.3199	3.15E+11	0.00	0.00	0.00
24.2340	0.00188	2245129.	13000.	-1.76E-04	991.1989	3.15E+11	0.00	0.00	0.00
24.5802	0.00122	2299478.	-14075.	-1.46E-04	1003.	3.15E+11	-13035.	4.46E+07	0.00
24.9264	6.72E-04	2128798.	-56122.	-1.13E-04	1113.	2.51E+11	-7207.	4.46E+07	0.00
25.2726	2.75E-04	1833654.	-77222.	-8.04E-05	1037.	2.51E+11	-2951.	4.46E+07	0.00
25.6188	4.41E-06	1487519.	-83449.	-5.29E-05	947.2247	2.51E+11	-47.2990	4.46E+07	0.00
25.9650	-1.64E-04	1140516.	-79895.	-3.11E-05	857.2962	2.51E+11	1758.	4.46E+07	0.00
26.3112	-2.54E-04	823822.	-70587.	-1.48E-05	775.2227	2.51E+11	2723.	4.46E+07	0.00
26.6574	-2.87E-04	554088.	-58536.	-3.41E-06	705.3192	2.51E+11	3079.	4.46E+07	0.00
27.0036	-2.82E-04	337472.	-45855.	3.98E-06	649.1817	2.51E+11	3026.	4.46E+07	0.00
27.3498	-2.54E-04	173074.	-33909.	8.20E-06	606.5766	2.51E+11	2725.	4.46E+07	0.00
27.6960	-2.14E-04	55692.	-23482.	1.01E-05	576.1563	2.51E+11	2295.	4.46E+07	0.00
28.0422	-1.70E-04	-22080.	-14925.	1.04E-05	567.4454	2.51E+11	1825.	4.46E+07	0.00
28.3884	-1.28E-04	-68358.	-8288.	9.63E-06	579.4389	2.51E+11	1370.	4.46E+07	0.00
28.7346	-9.01E-05	-90981.	-3433.	8.31E-06	585.3018	2.51E+11	966.7570	4.46E+07	0.00
29.0808	-5.88E-05	-96916.	-115.6659	6.75E-06	586.8398	2.51E+11	630.1562	4.46E+07	0.00
29.4270	-3.40E-05	-91971.	1952.	5.19E-06	585.5583	2.51E+11	365.0712	4.46E+07	0.00
29.7732	-1.57E-05	-80722.	3059.	3.76E-06	582.6431	2.51E+11	167.8532	4.46E+07	0.00
30.1194	-2.82E-06	-66574.	3470.	2.54E-06	578.9764	2.51E+11	30.2014	4.46E+07	0.00
30.4656	5.44E-06	-51901.	3412.	1.56E-06	575.1740	2.51E+11	-58.3246	4.46E+07	0.00

30.8118	1.01E-05	-38234.	3065.	8.11E-07	571.6319	2.51E+11	-108.5518	4.46E+07	0.00
31.1580	1.22E-05	-26439.	2568.	2.75E-07	568.5751	2.51E+11	-130.5655	4.46E+07	0.00
31.5042	1.24E-05	-16896.	2021.	-8.37E-08	566.1020	2.51E+11	-133.0696	4.46E+07	0.00
31.8504	1.15E-05	-9649.	1489.	-3.04E-07	564.2240	2.51E+11	-123.1059	4.46E+07	0.00
32.1966	9.89E-06	-4527.	1013.	-4.21E-07	562.8965	2.51E+11	-106.0219	4.46E+07	0.00
32.5428	7.98E-06	-1234.	614.5363	-4.69E-07	562.0432	2.51E+11	-85.5973	4.46E+07	0.00
32.8890	5.99E-06	581.0891	303.2487	-4.74E-07	561.8739	2.51E+11	-64.2619	4.46E+07	0.00
33.2352	4.04E-06	1287.	79.7060	-4.59E-07	562.0570	2.51E+11	-43.3554	4.46E+07	0.00
33.5814	2.18E-06	1245.	-58.9556	-4.38E-07	562.0461	2.51E+11	-23.3987	4.46E+07	0.00
33.9276	4.07E-07	799.3546	-116.6182	-4.21E-07	561.9305	2.51E+11	-4.3610	4.46E+07	0.00
34.2738	-1.31E-06	278.1198	-96.4158	-4.12E-07	561.7954	2.51E+11	14.0868	4.46E+07	0.00
34.6200	-3.01E-06	0.00	0.00	-4.09E-07	561.7233	2.51E+11	32.3294	2.23E+07	0.00

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

Output Summary for Load Case No. 2:

Pile-head deflection = 0.16410752 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 2299478. inch-lbs
Maximum shear force = -83449. lbs
Depth of maximum bending moment = 24.58020000 feet below pile head
Depth of maximum shear force = 25.61880000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 3

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	Load 1	Pile-head 2	Load Type	Load 2	Axial Pile-head Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	11000.	M, in-lb	720000.	500000.	0.5429	-0.00325	-154331.	4234971.	
2	V, lb	13000.	S, rad	0.00	510000.	0.1641	0.00	-83449.	2299478.	

Maximum pile-head deflection = 0.5428983141 inches
Maximum pile-head rotation =-0.0032479322 radians =-0.186093 deg.

Summary of Warning Messages

The following warning was reported 3210 times

**** Warning ****

This warning is for an input value for uniaxial compressive strength that has been specified for a soil defined using the vuggy limestone criteria. The input value is outside of the range of 1,000 to 2,500 psi (6,895 to 17,237 kPa) which were used in actual field tests on which this theory is based. Higher or lower values may be applicable but the user is warned about the theoretical and testing limitations.

The analysis ended normally.

Elevations

Bottom of Cap (BOC) Elevation =	2,722.50	ft
Top of Pier/Bottom of Column Elevation =	2,714.22	ft
Natural Ground / Finished Grade Elevation =	2,715.00	ft
Groundwater Table (GWT) Elevation =	2,713.00	ft
Design Scour (DSE) Elevation =	2,698.00	ft
Amount of Contraction Scour (from BSR) =	6.80	ft
Is Permanent Casing Required?	◉ Yes / Maybe ○ No	
Bottom of Permanent Casing Elevation =	2,698.00	ft
Drilled Pier Tip Elevation =	2,689.00	ft

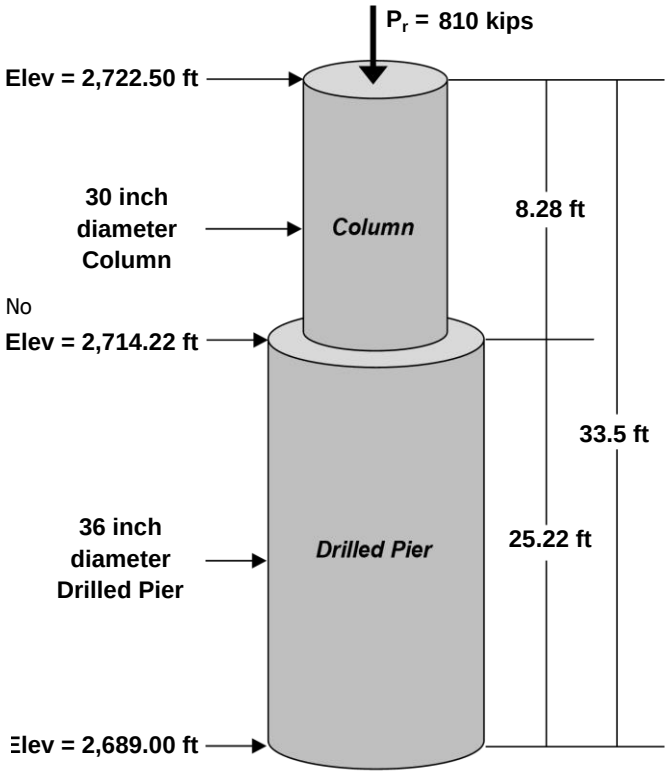


Figure shows typical drilled pier

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	810.0	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. =	B2-A	
SPT Hammer Energy Efficiency Rating (ER) =	84	%
Top of Boring (Collar) Elevation =	2715.90	ft
Depth to Groundwater Table (for actual boring) =	2.30	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	Hard Rock	2,698.00	2,689.00	0.174			N/A	100	85	1,544		
2												
3												
4												
5												
6												
7												
8												
TIP [3]	Hard Rock	2,689.00	2,683.00	0.174			N/A	100	85	1,045	8,860	0.220

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.

Correcting SPT Values for Hammer Efficiency and Overburden Pressure

SPT-N Value Corrected for Hammer Efficiency, (N_{60})

$N_{60} = (ER/60\%)(N)$ *AASHTO Eqn. 10.4.6.2.4-2*

N_{60} = SPT blow count corrected for hammer efficiency (blows/ft)
ER = hammer efficiency expressed as percent of theoretical free fall energy delivered by the hammer system actually used. If ER is not known, use 80% for automatic hammers and 60% for drop hammers.
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for Overburden Pressure, (N1)

$N1 = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-1*

N1 = SPT blow count corrected for overburden pressure (blows/ft)
C_N = correction factor = $[0.77\log_{10}(40/\sigma'_v) < 2.0$
$\sigma'_v = \sigma_v - \mu$ = effective vertical stress at the depth of the SPT-N value (ksf)
σ_v = total vertical stress at the depth of the SPT-N value (ksf)
μ = total pore water pressure at the depth of the SPT-N value (ksf)
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for both Overburden Pressure and Hammer Efficiency, ($N1_{60}$)

$N1_{60} = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-3*

Summary of Corrected N Values for Boring

Top of Boring (Collar) Elevation = 2,715.9 ft
Depth to Groundwater Table = 2.3 ft
Hammer Efficiency (ER) = 84 %
Unit Weight of Water = 0.0624 kcf

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	σ_v at top (ksf)	Δz (ft)	Total γ (kcf)	σ_v at bottom (ksf)	σ_v at midpoint (ksf)	z_{water} (ft)	μ at midpoint (ksf)	σ'_{vo} at midpoint (ksf)	N (bpf)	N_{60} (bpf)	C_N	$N1_{60}$ (bpf)
1	2698.00	2689.00	2.148	9.00	0.174	3.714	2.931	20.10	1.254	1.677	N/A			N/A
2														
3														
4														
5														
6														
7														
8														
TIP	2689.00	2683.00	3.714	6.00	0.174	4.758	4.236	27.60	1.722	2.514	N/A			N/A

Selecting Design Properties for Hard Rock

1. q_u values for rock should be based on AASHTO Table 10.4.6.4-1 (which uses Point Load Index Testing) or actual values from Uniaxial Compressive Strength Testing. If neither of these options is available, the NCDOT Rock Core Database may be used to estimate compressive strength.

2. E_i and v values for rock should be based on AASHTO Tables C10.4.6.5-1, and 2 if lab test data is not available

Unconfined Compressive Strength from Point Load Strength Index for Hard Rock AASHTO Table C10.4.6.4-1

Parameter			Ranges of Values						
1	Strength of intact rock material	Point load strength index	>175 ksf	85–175 ksf	45–85 ksf	20–45 ksf	For this low range, uniaxial compressive test is preferred		
		Uniaxial compressive strength	>4320 ksf	2160–4320 ksf	1080–2160 ksf	520–1080 ksf	215–520 ksf	70–215 ksf	20–70 ksf
	Relative Rating		15	12	7	4	2	1	0

Summary of Elastic Moduli for Intact Rock, E_i (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-1

Rock Type	No. of Values	No. of Rock Types	Elastic Modulus, E_i (ksi $\times 10^3$)			Standard Deviation (ksi $\times 10^3$)
			Maximum	Minimum	Mean	
Granite	26	26	14.5	0.93	7.64	3.55
Diorite	3	3	16.2	2.48	7.45	6.19
Gabbro	3	3	12.2	9.8	11.0	0.97
Diabase	7	7	15.1	10.0	12.8	1.78
Basalt	12	12	12.2	4.20	8.14	2.60
Quartzite	7	7	12.8	5.29	9.59	2.32
Marble	14	13	10.7	0.58	6.18	2.49
Gneiss	13	13	11.9	4.13	8.86	2.31
Slate	11	2	3.79	0.35	1.39	0.96
Schist	13	12	10.0	0.86	4.97	3.18
Phyllite	3	3	2.51	1.25	1.71	0.57
Sandstone	27	19	5.68	0.09	2.13	1.19
Siltstone	5	5	4.76	0.38	2.39	1.65
Shale	30	14	5.60	0.001	1.42	1.45
Limestone	30	30	13.0	0.65	5.7	3.73
Dolostone	17	16	11.4	0.83	4.22	3.44

Summary of Poisson's Ratio for Intact Rock, v (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-2

Rock Type	No. of Values	No. of Rock Types	Poisson's Ratio, v			Standard Deviation
			Maximum	Minimum	Mean	
Granite	22	22	0.39	0.09	0.20	0.08
Gabbro	3	3	0.20	0.16	0.18	0.02
Diabase	6	6	0.38	0.20	0.29	0.06
Basalt	11	11	0.32	0.16	0.23	0.05
Quartzite	6	6	0.22	0.08	0.14	0.05
Marble	5	5	0.40	0.17	0.28	0.08
Gneiss	11	11	0.40	0.09	0.22	0.09
Schist	12	11	0.31	0.02	0.12	0.08
Sandstone	12	9	0.46	0.08	0.20	0.11
Siltstone	3	3	0.23	0.09	0.18	0.06
Shale	3	3	0.18	0.03	0.09	0.06
Limestone	19	19	0.33	0.12	0.23	0.06
Dolostone	5	5	0.35	0.14	0.29	0.08

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 Top (ft)	Layer Elevations Bottom (ft)	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)
1	Hard Rock	2,698.00	2,689.00	10.8.3.5.4b-2 (open joints)	100	0.85	648	20.478	9.00	80.11	1640

Total Side Resistance in Weathered and Hard Rock = 1,640

Tip Resistance in Hard Rock

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

q_p = unit tip resistance (ksf)

If rock to a depth of 2B below drilled pier tip is intact or tightly jointed and the depth of socket > 1.5 D

$= 2.5q_u$ *AASHTO Eqn. 10.8.3.5.4c-1*

If the rock to a depth of 2D below the drilled pier tip is jointed with random orientation

$$= A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-2*

q_u = Uniaxial Compressive Strength of Intact Rock (ksf)
σ'_{vb} = vertical effective stress at the socket bearing elevation

$$A = \sigma'_{vb} + q_u\left[m_b\left(\frac{\sigma'_{vb}}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-3*

$$s = exp\left(\frac{GSI - 100}{9}\right)$$ *AASHTO Eqn. 10.4.6.4-2*

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{\frac{-GSI}{15}} - e^{\frac{-20}{3}}\right)$$ *AASHTO Eqn. 10.4.6.4-3*

$$m_b = exp\left(\frac{GSI - 100}{28}\right) m_i$$ *AASHTO Eqn. 10.4.6.4-4*

m_i = constant for intact rock *AASHTO Table 10.4.6.4-1*

GSI = Global Strength Index

***Hard Rock Layers with an GSI less than 30 will be modeled as weathered rock.**

A_p = area of drilled pier tip resistance (ft^2)
$= (\pi)(B^2)/4$

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

Tip Elevation (ft)	AASHTO Equation used to calculate q_u	q_u (ksf)	GSI	m	m_b	s	a	A	q_p (ksf)	A_p (ft^2)	R_p (kips)
2689.00	10.8.3.5.4c-1	1,045	85	28	N/A	N/A	N/A	N/A	2,613	6.31	16,488

Tip Resistance in Hard Rock (continued)

Table 10.4.6.4-1—Values of the Constant mi by Rock Group

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (21 ± 3) Breccia (19 ± 5)	Sandstone 17 ± 4	Siltstone 7 ± 2 Greywacke (18 ± 3)	Claystone 4 ± 2 Shale (6 ± 2) Marl (7 ± 2)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestone (10 ± 5)	Micritic Limestone (8 ± 3)	Dolomite (9 ± 3)
		Evaporites		Gypsum 10 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4)) Metasandstone (19 ± 3)	Quartzite 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolite 26 ± 6	Gneiss 28 ± 5	
	Foliated*			Schist (10 ± 3)	Phyllite (7 ± 3)	Slate 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3)) Basalt (25 ± 5)	
		Pyroclastic	Agglomerate (19 ± 3)	Volcanic breccia (19 ± 5)	Tuff (13 ± 5)	

Summary of Nominal and Factored Side Resistance

Cohesionless IGM	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	0	0.60	0	0.0%
Hard Rock	1,640	0.55	902	100.0%
Total	**1,640**		**902**	**100%**

Note: *When drilled piers are socketed in hard rock, the side resistance above the hard rock will be ignored. For the purpose of this spreadsheet, a drilled pier will be considered socketed in hard rock if either of these conditions are met;*

1. *The pier is embedded the greater of 3 feet or 1 pier diameter into hard rock.*
2. *At least 50% of the total nominal side resistance is produced by the hard rock layer(s).*

Summary of Nominal and Factored Side Resistance (continued)

Total Nominal Side Resistance =	1,640	kips
Side Resistance Factor =	0.55	
Total Factored Side Resistance =	902	kips

for Hard Rock, see AASHTO Table 10.5.5.2.4-1.

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance =	16,488	kips
Tip Resistance Factor =	0.50	
Total Factored Tip Resistance =	8,244	kips

the drilled pier is bearing on Hard Rock
for Hard Rock, 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 = 810 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} = 8.28 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 6 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} = 25.22 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 27 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 = 24 ft *Depth from water surface to the drilled pier tip*
γ_w = 0.0624 kcf *Unit Weight of Water*

= 11 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} = 1.350 ksf *ffective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46*

$W_{Soil/Rock}$ = 10 kips

R_{req} = 810 kips + 1.25(6 kips + 27 kips) -1.00(11 kips) -1.25(10 kips) = 828 kips

Load Transfer of Side and Tip Resistance for Drilled Piers in Hard Rock with no Rock Socket

Per AASHTO Section 10.8.3.5.4a, The Factored Geotechnical Resistance for Drilled Piers socketed in hard rock will be based on side resistance, tip resistance, or a combination of both. Using a combination of both side and tip resistance requires a displacement based analysis and falls outside the limitations of this spreadsheet. For details on displacement based analysis, see *FHWA GEC 010 Appendix D.3.1* .

Developed Factored Resistance, (R_{rd})

Select which value to use for the Factored Developed Resistance

(●) Use the Factored Side Resistance of the rock socket.

( ) Use the Factored Tip Resistance of the rock socket.

902 kips ≥ 828 kips

The axial resistance requirement is satisfied.

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)
828	902	6.31	0.50	2613	0

GEOTECHNICAL BORING REPORT
BORE LOG

Bent No. 2 - RT

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. B2-B	**STATION** 17+15	**OFFSET** 15 ft LT	**ALIGNMENT** -L-	**0 HR.** N/A
COLLAR ELEV. 2,715.6 ft	**TOTAL DEPTH** 39.2 ft	**NORTHING** 977,730	**EASTING** 1,328,104	**24 HR.** 1.1
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** Core Boring	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/12/22	**COMP. DATE** 07/12/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
						BOC = 2722.5'				ELEV. (ft) DEPTH (ft)
2720										
2715	2,715.6	0.0	1	4	6	10		Sat.		2,715.6 GROUND SURFACE 0.0
						TOP OF PIER EL. 2714.22'				**ALLUVIAL**
	2,712.1	3.5	7	10	10	20		Sat.		Loose to Medium Dense, Brown-White-Tan, Silty Fine to Coarse SAND (A-2-4), with some cobbles
2710	2,709.6	6.0	6	8	4	12		Sat.		
	2,707.1	8.5	2	3	4	7		Sat.		
2705										2,703.1 12.5
	2,702.1	13.5	4	7	7	14		W		**RESIDUAL** Medium Dense, Brown-Tan, Fine to Coarse Sandy SILT (A-4), with trace mica
2700	2,698.4	17.2	50/0.0			50/0.0				2,698.4 17.2
2695							RS-3			**CRYSTALLINE ROCK** Fresh, Hard, White-Green BIOTITE/HORNBLENDE GNEISS with Wide Fracture Spacing
2690										REC = 100%, RQD = 100%, GSI = 85 - 90
2685							RS-4			
2680										2,676.4 39.2
										Boring Terminated at Elevation 2,676.4 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

Perm Case EL 2698'

BSR Scour El. 2698

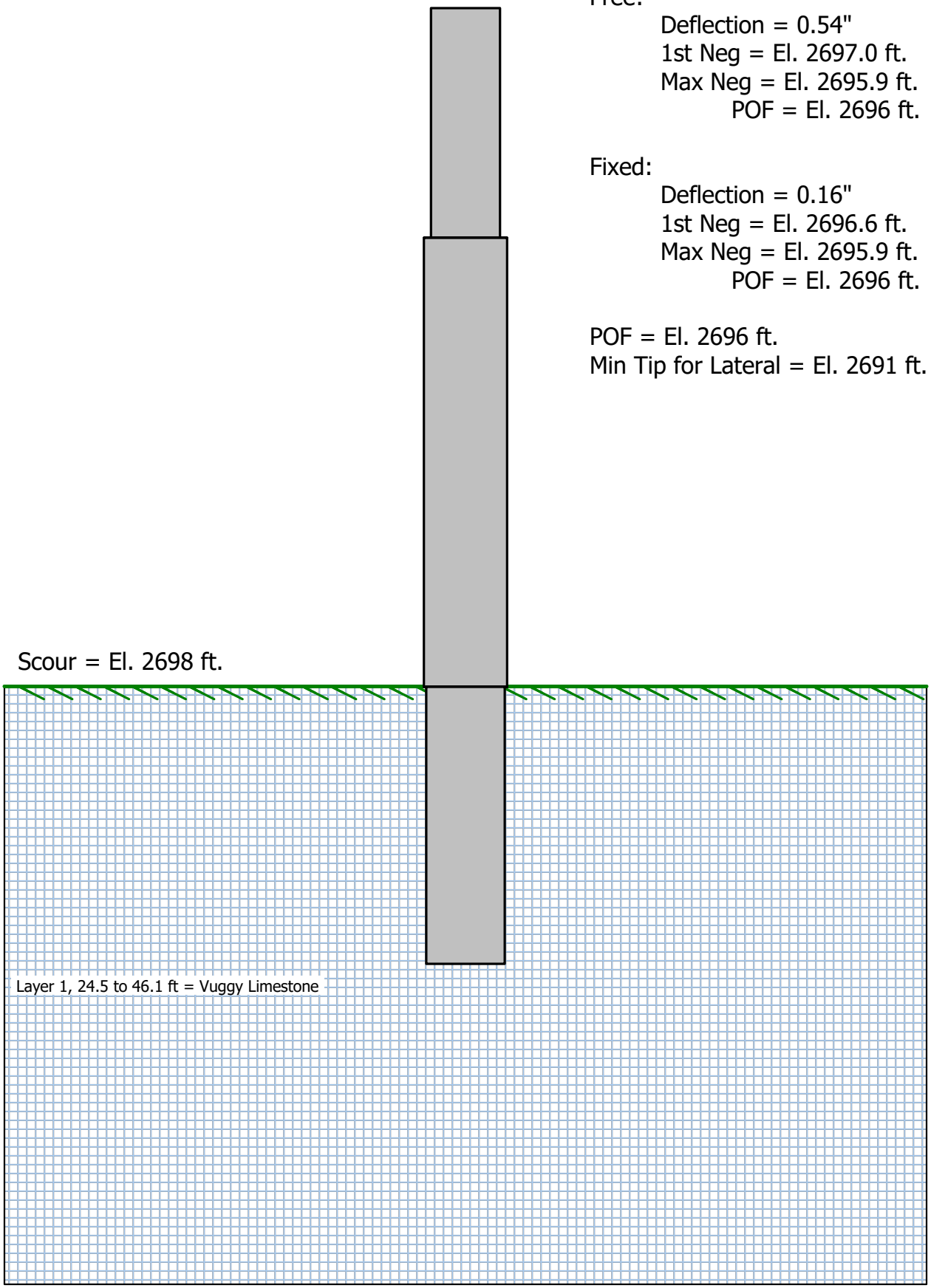
NCDOT BORE SINGLE BRIDGE663_GEO_GTM.GPJ NC_DOT.GDT 9/6/22

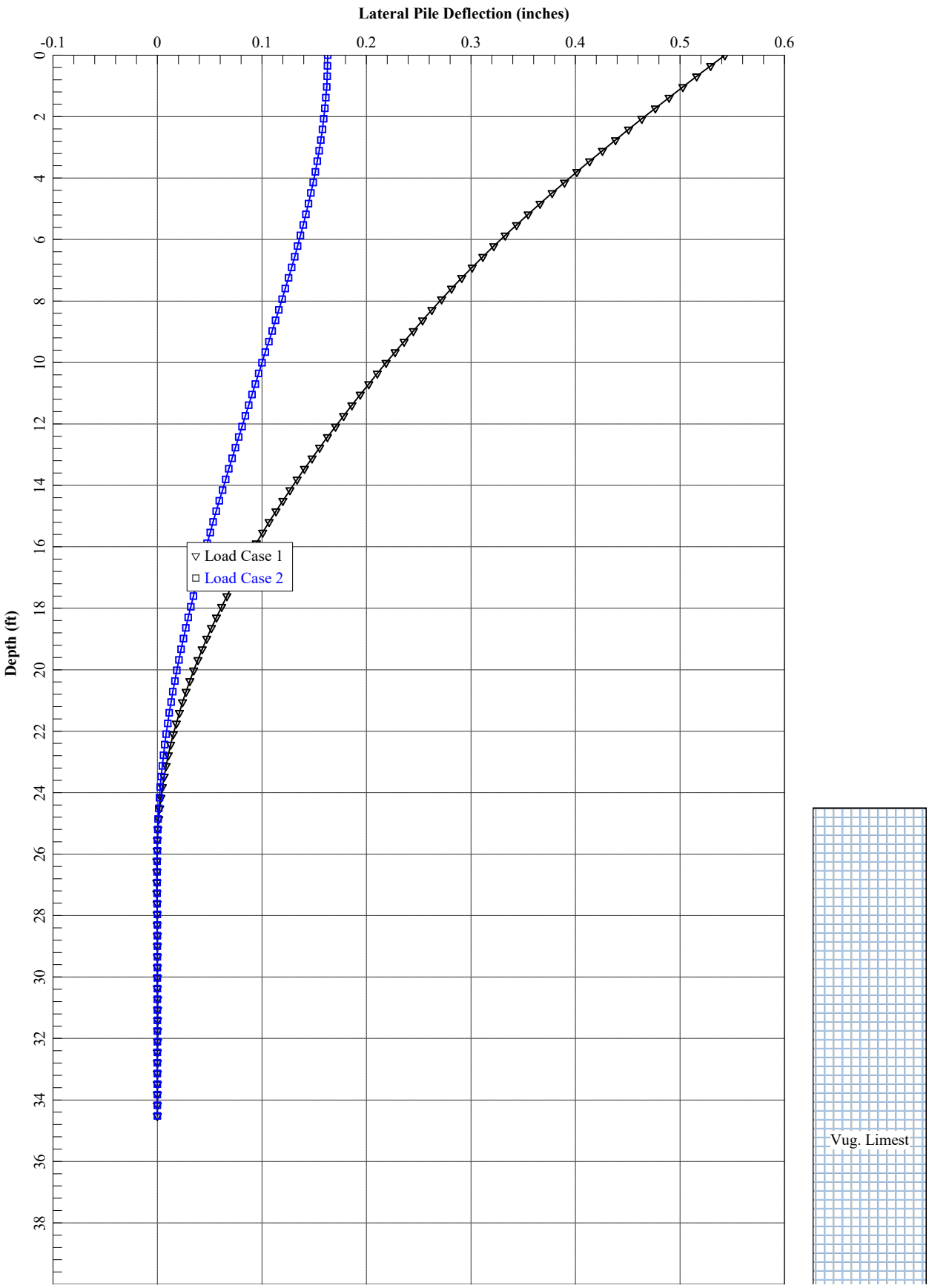
Bent No. 2 - RT

Free:
Deflection = 0.54"
1st Neg = El. 2697.0 ft.
Max Neg = El. 2695.9 ft.
POF = El. 2696 ft.

Fixed:
Deflection = 0.16"
1st Neg = El. 2696.6 ft.
Max Neg = El. 2695.9 ft.
POF = El. 2696 ft.

POF = El. 2696 ft.
Min Tip for Lateral = El. 2691 ft.





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LPile for Windows, Version 2019-11.009

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\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500- 29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\LPile\

Name of input data file:
Bridge 063- Bent 2 (B2-B).lp11d

Name of output report file:
Bridge 063- Bent 2 (B2-B).lp11o

Name of plot output file:
Bridge 063- Bent 2 (B2-B).lp11p

Name of runtime message file:
Bridge 063- Bent 2 (B2-B).lp11r

Date and Time of Analysis

Date: September 8, 2022 Time: 10:37:22

Problem Title

Project Name: Bridge 063

Job Number: 09-29662

Client: STV

Engineer: ECS Southeast

Description: Bent 2 (RT) Lateral Analysis

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
- Input of side resistance moment along pile 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 = 3
Total length of pile = 34.520 ft
Depth of ground surface below top of pile = 24.5000 ft

Pile diameters used for p-y curve computations are defined using 6 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	30.0000
2	8.300	30.0000
3	8.300	36.0000
4	24.520	36.0000
5	24.520	34.0000
6	34.520	34.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 8.300000 ft
Width of top of section = 30.000000 in
Width of bottom of section = 30.000000 in
Top Area = 706.858347 sq. in
Bottom Area = 706.858347 sq. in
Moment of Inertia at Top = 39761. in^4
Moment of Inertia at Bottom = 39761. in^4
Elastic Modulus = 3122019. psi

Pile Section No. 2:

Section 2 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 16.220000 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 = 3823676. psi

Pile Section No. 3:

Section 3 is an elastic pile
Cross-sectional Shape = Circular Pile
Length of section = 10.000000 ft
Width of top of section = 34.000000 in
Width of bottom of section = 34.000000 in
Top Area = 907.920277 sq. in
Bottom Area = 907.920277 sq. in
Moment of Inertia at Top = 65597. in^4
Moment of Inertia at Bottom = 65597. in^4
Elastic Modulus = 3823676. 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 strong rock (vuggy limestone)

Distance from top of pile to top of layer = 24.500000 ft
Distance from top of pile to bottom of layer = 46.100000 ft
Effective unit weight at top of layer = 174.000000 pcf
Effective unit weight at bottom of layer = 174.000000 pcf
Uniaxial compressive strength at top of layer = 10724. psi
Uniaxial compressive strength at bottom of layer = 10724. psi

(Depth of the lowest soil layer extends 11.580 ft below the pile tip)

**** Warning- Possible Input Data Error ****

Values entered for effective unit weight of rock were outside the limits of
50 pcf to 150 pcf.

The maximum input value, in layer 0, for effective unit weight = 174.00 pcf

This data may be erroneous. Please check your data.

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Uniaxial qu psi
1	Strong Rock	24.5000	174.0000	10724.
	(Vuggy Limestone)	46.1000	174.0000	10724.

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 = 2

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length	Run Analysis
1	1	V = 11000. lbs	M = 720000. in-lbs	500000.	No	Yes
2	2	V = 13000. lbs	S = 0.0000 in/in	510000.	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 = 3

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 3:

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 = 11000.0 lbs
Applied moment at pile head = 720000.0 in-lbs
Axial thrust load on pile head = 500000.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. p	Soil Spr. Es*H	Distrib. Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	0.5429	720000.	11000.	-0.00327	978.9797	1.24E+11	0.00	0.00	0.00
0.3452	0.5294	772322.	11000.	-0.00325	998.7187	1.24E+11	0.00	0.00	0.00
0.6904	0.5160	824591.	11000.	-0.00322	1018.	1.24E+11	0.00	0.00	0.00
1.0356	0.5027	876803.	11000.	-0.00319	1038.	1.24E+11	0.00	0.00	0.00
1.3808	0.4896	928954.	11000.	-0.00316	1058.	1.24E+11	0.00	0.00	0.00
1.7260	0.4765	981042.	11000.	-0.00313	1077.	1.24E+11	0.00	0.00	0.00
2.0712	0.4636	1033061.	11000.	-0.00310	1097.	1.24E+11	0.00	0.00	0.00
2.4164	0.4509	1085009.	11000.	-0.00306	1117.	1.24E+11	0.00	0.00	0.00
2.7616	0.4382	1136882.	11000.	-0.00303	1136.	1.24E+11	0.00	0.00	0.00
3.1068	0.4258	1188676.	11000.	-0.00299	1156.	1.24E+11	0.00	0.00	0.00
3.4520	0.4135	1240388.	11000.	-0.00295	1175.	1.24E+11	0.00	0.00	0.00
3.7972	0.4014	1292015.	11000.	-0.00290	1195.	1.24E+11	0.00	0.00	0.00

4.1424	0.3894	1343552.	11000.	-0.00286	1214.	1.24E+11	0.00	0.00	0.00
4.4876	0.3777	1394996.	11000.	-0.00281	1234.	1.24E+11	0.00	0.00	0.00
4.8328	0.3661	1446344.	11000.	-0.00277	1253.	1.24E+11	0.00	0.00	0.00
5.1780	0.3548	1497592.	11000.	-0.00272	1272.	1.24E+11	0.00	0.00	0.00
5.5232	0.3436	1548736.	11000.	-0.00267	1292.	1.24E+11	0.00	0.00	0.00
5.8684	0.3327	1599774.	11000.	-0.00261	1311.	1.24E+11	0.00	0.00	0.00
6.2136	0.3219	1650701.	11000.	-0.00256	1330.	1.24E+11	0.00	0.00	0.00
6.5588	0.3114	1701513.	11000.	-0.00250	1349.	1.24E+11	0.00	0.00	0.00
6.9040	0.3012	1752208.	11000.	-0.00245	1368.	1.24E+11	0.00	0.00	0.00
7.2492	0.2912	1802782.	11000.	-0.00239	1387.	1.24E+11	0.00	0.00	0.00
7.5944	0.2814	1853232.	11000.	-0.00233	1406.	1.24E+11	0.00	0.00	0.00
7.9396	0.2719	1903553.	11000.	-0.00226	1425.	1.24E+11	0.00	0.00	0.00
8.2848	0.2626	1953743.	11000.	-0.00220	1444.	1.24E+11	0.00	0.00	0.00
8.6300	0.2537	2003797.	11000.	-0.00215	928.6871	3.15E+11	0.00	0.00	0.00
8.9752	0.2448	2053798.	11000.	-0.00213	939.6031	3.15E+11	0.00	0.00	0.00
9.3204	0.2360	2103742.	11000.	-0.00210	950.5069	3.15E+11	0.00	0.00	0.00
9.6656	0.2274	2153629.	11000.	-0.00207	961.3982	3.15E+11	0.00	0.00	0.00
10.0108	0.2189	2203457.	11000.	-0.00204	972.2767	3.15E+11	0.00	0.00	0.00
10.3560	0.2105	2253226.	11000.	-0.00201	983.1421	3.15E+11	0.00	0.00	0.00
10.7012	0.2022	2302933.	11000.	-0.00198	993.9942	3.15E+11	0.00	0.00	0.00
11.0464	0.1940	2352577.	11000.	-0.00195	1005.	3.15E+11	0.00	0.00	0.00
11.3916	0.1860	2402158.	11000.	-0.00192	1016.	3.15E+11	0.00	0.00	0.00
11.7368	0.1781	2451673.	11000.	-0.00189	1026.	3.15E+11	0.00	0.00	0.00
12.0820	0.1704	2501121.	11000.	-0.00186	1037.	3.15E+11	0.00	0.00	0.00
12.4272	0.1627	2550501.	11000.	-0.00182	1048.	3.15E+11	0.00	0.00	0.00
12.7724	0.1552	2599812.	11000.	-0.00179	1059.	3.15E+11	0.00	0.00	0.00
13.1176	0.1479	2649052.	11000.	-0.00176	1070.	3.15E+11	0.00	0.00	0.00
13.4628	0.1407	2698220.	11000.	-0.00172	1080.	3.15E+11	0.00	0.00	0.00
13.8080	0.1336	2747315.	11000.	-0.00169	1091.	3.15E+11	0.00	0.00	0.00
14.1532	0.1267	2796334.	11000.	-0.00165	1102.	3.15E+11	0.00	0.00	0.00
14.4984	0.1200	2845278.	11000.	-0.00161	1112.	3.15E+11	0.00	0.00	0.00
14.8436	0.1134	2894144.	11000.	-0.00157	1123.	3.15E+11	0.00	0.00	0.00
15.1888	0.1069	2942932.	11000.	-0.00154	1134.	3.15E+11	0.00	0.00	0.00
15.5340	0.1006	2991639.	11000.	-0.00150	1144.	3.15E+11	0.00	0.00	0.00
15.8792	0.09452	3040265.	11000.	-0.00146	1155.	3.15E+11	0.00	0.00	0.00
16.2244	0.08857	3088808.	11000.	-0.00142	1166.	3.15E+11	0.00	0.00	0.00
16.5696	0.08279	3137267.	11000.	-0.00138	1176.	3.15E+11	0.00	0.00	0.00
16.9148	0.07717	3185641.	11000.	-0.00133	1187.	3.15E+11	0.00	0.00	0.00
17.2600	0.07173	3233928.	11000.	-0.00129	1197.	3.15E+11	0.00	0.00	0.00
17.6052	0.06646	3282127.	11000.	-0.00125	1208.	3.15E+11	0.00	0.00	0.00
17.9504	0.06138	3330237.	11000.	-0.00121	1218.	3.15E+11	0.00	0.00	0.00
18.2956	0.05647	3378256.	11000.	-0.00116	1229.	3.15E+11	0.00	0.00	0.00
18.6408	0.05175	3426183.	11000.	-0.00112	1239.	3.15E+11	0.00	0.00	0.00
18.9860	0.04722	3474017.	11000.	-0.00107	1250.	3.15E+11	0.00	0.00	0.00
19.3312	0.04287	3521757.	11000.	-0.00103	1260.	3.15E+11	0.00	0.00	0.00
19.6764	0.03871	3569400.	11000.	-9.79E-04	1270.	3.15E+11	0.00	0.00	0.00
20.0216	0.03475	3616946.	11000.	-9.32E-04	1281.	3.15E+11	0.00	0.00	0.00
20.3668	0.03099	3664394.	11000.	-8.84E-04	1291.	3.15E+11	0.00	0.00	0.00
20.7120	0.02743	3711743.	11000.	-8.36E-04	1302.	3.15E+11	0.00	0.00	0.00
21.0572	0.02407	3758990.	11000.	-7.87E-04	1312.	3.15E+11	0.00	0.00	0.00
21.4024	0.02091	3806135.	11000.	-7.37E-04	1322.	3.15E+11	0.00	0.00	0.00
21.7476	0.01796	3853176.	11000.	-6.87E-04	1332.	3.15E+11	0.00	0.00	0.00
22.0928	0.01522	3900113.	11000.	-6.36E-04	1343.	3.15E+11	0.00	0.00	0.00

22.4380	0.01269	3946943.	11000.	-5.84E-04	1353.	3.15E+11	0.00	0.00	0.00	
22.7832	0.01038	3993666.	11000.	-5.32E-04	1363.	3.15E+11	0.00	0.00	0.00	
23.1284	0.00828	4040280.	11000.	-4.79E-04	1373.	3.15E+11	0.00	0.00	0.00	
23.4736	0.00641	4086784.	11000.	-4.26E-04	1383.	3.15E+11	0.00	0.00	0.00	
23.8188	0.00475	4133177.	11000.	-3.72E-04	1394.	3.15E+11	0.00	0.00	0.00	
24.1640	0.00333	4179458.	11000.	-3.17E-04	1404.	3.15E+11	0.00	0.00	0.00	
24.5092	0.00213	4225625.	-36204.	-2.62E-04	1414.	3.15E+11	-22791.	4.44E+07	0.00	
24.8544	0.00115	3880598.	-109050.	-2.02E-04	1556.	2.51E+11	-12380.	4.44E+07	0.00	
25.1996	4.49E-04	3323002.	-144668.	-1.43E-04	1412.	2.51E+11	-4817.	4.44E+07	0.00	
25.5448	-2.88E-05	2682642.	-154004.	-9.32E-05	1246.	2.51E+11	309.1232	4.44E+07	0.00	
25.8900	-3.23E-04	2047496.	-146184.	-5.42E-05	1081.	2.51E+11	3467.	4.44E+07	0.00	
26.2352	-4.78E-04	1471765.	-128395.	-2.51E-05	932.1277	2.51E+11	5122.	4.44E+07	0.00	
26.5804	-5.31E-04	983875.	-105985.	-4.83E-06	805.6874	2.51E+11	5698.	4.44E+07	0.00	
26.9256	-5.18E-04	593718.	-82687.	8.19E-06	704.5755	2.51E+11	5551.	4.44E+07	0.00	
27.2708	-4.63E-04	298799.	-60896.	1.56E-05	628.1451	2.51E+11	4970.	4.44E+07	0.00	
27.6160	-3.89E-04	89144.	-41969.	1.88E-05	573.8115	2.51E+11	4168.	4.44E+07	0.00	
27.9612	-3.08E-04	-48985.	-26496.	1.91E-05	563.4041	2.51E+11	3302.	4.44E+07	0.00	
28.3064	-2.30E-04	-130453.	-14538.	1.76E-05	584.5169	2.51E+11	2471.	4.44E+07	0.00	
28.6516	-1.62E-04	-169506.	-5822.	1.51E-05	594.6378	2.51E+11	1737.	4.44E+07	0.00	
28.9968	-1.05E-04	-178753.	107.3174	1.23E-05	597.0342	2.51E+11	1126.	4.44E+07	0.00	
29.3420	-6.03E-05	-168667.	3780.	9.40E-06	594.4205	2.51E+11	646.9411	4.44E+07	0.00	
29.6872	-2.72E-05	-147475.	5723.	6.79E-06	588.9285	2.51E+11	291.3840	4.44E+07	0.00	
30.0324	-4.11E-06	-121278.	6418.	4.57E-06	582.1393	2.51E+11	44.0236	4.44E+07	0.00	
30.3776	1.07E-05	-94322.	6272.	2.79E-06	575.1533	2.51E+11	-114.3599	4.44E+07	0.00	
30.7228	1.90E-05	-69324.	5614.	1.44E-06	568.6750	2.51E+11	-203.5433	4.44E+07	0.00	
31.0680	2.26E-05	-47817.	4691.	4.68E-07	563.1013	2.51E+11	-241.8663	4.44E+07	0.00	
31.4132	2.29E-05	-30459.	3683.	-1.79E-07	558.6027	2.51E+11	-245.1079	4.44E+07	0.00	
31.7584	2.11E-05	-17305.	2707.	-5.73E-07	555.1939	2.51E+11	-226.0032	4.44E+07	0.00	
32.1036	1.81E-05	-8029.	1837.	-7.82E-07	552.7899	2.51E+11	-194.2026	4.44E+07	0.00	
32.4488	1.46E-05	-2085.	1110.	-8.66E-07	551.2495	2.51E+11	-156.5116	4.44E+07	0.00	
32.7940	1.09E-05	1174.	543.2211	-8.73E-07	551.0133	2.51E+11	-117.2909	4.44E+07	0.00	
33.1392	7.36E-06	2419.	136.8058	-8.44E-07	551.3361	2.51E+11	-78.9312	4.44E+07	0.00	
33.4844	3.95E-06	2310.	-114.3843	-8.04E-07	551.3079	2.51E+11	-42.3464	4.44E+07	0.00	
33.8296	6.95E-07	1475.	-217.5363	-7.73E-07	551.0914	2.51E+11	-7.4566	4.44E+07	0.00	
34.1748	-2.46E-06	511.3689	-178.4021	-7.57E-07	550.8417	2.51E+11	26.3511	4.44E+07	0.00	
34.5200	-5.57E-06	0.00	0.00	-7.53E-07	550.7091	2.51E+11	59.7836	2.22E+07	0.00	

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.54294551 inches
Computed slope at pile head = -0.00327384 radians
Maximum bending moment = 4225625. inch-lbs
Maximum shear force = -154004. lbs
Depth of maximum bending moment = 24.50920000 feet below pile head
Depth of maximum shear force = 25.54480000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 3

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

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

Shear force at pile head = 13000.0 lbs
Rotation of pile head = 0.000E+00 radians
Axial load at pile head = 510000.0 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 lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1629	-1609548.	13000.	0.00	1329.	1.24E+11	0.00	0.00	0.00
0.3452	0.1628	-1555640.	13000.	-5.28E-05	1308.	1.24E+11	0.00	0.00	0.00
0.6904	0.1625	-1501622.	13000.	-1.04E-04	1288.	1.24E+11	0.00	0.00	0.00
1.0356	0.1619	-1447499.	13000.	-1.53E-04	1268.	1.24E+11	0.00	0.00	0.00
1.3808	0.1612	-1393273.	13000.	-2.00E-04	1247.	1.24E+11	0.00	0.00	0.00
1.7260	0.1603	-1338950.	13000.	-2.46E-04	1227.	1.24E+11	0.00	0.00	0.00
2.0712	0.1592	-1284532.	13000.	-2.90E-04	1206.	1.24E+11	0.00	0.00	0.00
2.4164	0.1579	-1230023.	13000.	-3.32E-04	1186.	1.24E+11	0.00	0.00	0.00
2.7616	0.1564	-1175427.	13000.	-3.72E-04	1165.	1.24E+11	0.00	0.00	0.00
3.1068	0.1548	-1120749.	13000.	-4.10E-04	1144.	1.24E+11	0.00	0.00	0.00
3.4520	0.1530	-1065992.	13000.	-4.47E-04	1124.	1.24E+11	0.00	0.00	0.00
3.7972	0.1511	-1011159.	13000.	-4.81E-04	1103.	1.24E+11	0.00	0.00	0.00
4.1424	0.1490	-956256.	13000.	-5.14E-04	1082.	1.24E+11	0.00	0.00	0.00
4.4876	0.1468	-901285.	13000.	-5.45E-04	1062.	1.24E+11	0.00	0.00	0.00
4.8328	0.1445	-846250.	13000.	-5.74E-04	1041.	1.24E+11	0.00	0.00	0.00
5.1780	0.1421	-791156.	13000.	-6.02E-04	1020.	1.24E+11	0.00	0.00	0.00
5.5232	0.1395	-736005.	13000.	-6.27E-04	999.1650	1.24E+11	0.00	0.00	0.00
5.8684	0.1369	-680803.	13000.	-6.51E-04	978.3397	1.24E+11	0.00	0.00	0.00
6.2136	0.1341	-625553.	13000.	-6.73E-04	957.4963	1.24E+11	0.00	0.00	0.00
6.5588	0.1313	-570259.	13000.	-6.93E-04	936.6362	1.24E+11	0.00	0.00	0.00
6.9040	0.1284	-514925.	13000.	-7.11E-04	915.7610	1.24E+11	0.00	0.00	0.00
7.2492	0.1254	-459554.	13000.	-7.27E-04	894.8721	1.24E+11	0.00	0.00	0.00
7.5944	0.1224	-404151.	13000.	-7.41E-04	873.9710	1.24E+11	0.00	0.00	0.00
7.9396	0.1193	-348720.	13000.	-7.54E-04	853.0591	1.24E+11	0.00	0.00	0.00
8.2848	0.1161	-293264.	13000.	-7.65E-04	832.1380	1.24E+11	0.00	0.00	0.00
8.6300	0.1129	-237787.	13000.	-7.71E-04	552.9569	3.15E+11	0.00	0.00	0.00
8.9752	0.1097	-182304.	13000.	-7.74E-04	540.8438	3.15E+11	0.00	0.00	0.00
9.3204	0.1065	-126815.	13000.	-7.76E-04	528.7296	3.15E+11	0.00	0.00	0.00
9.6656	0.1033	-71323.	13000.	-7.77E-04	516.6146	3.15E+11	0.00	0.00	0.00
10.0108	0.1001	-15829.	13000.	-7.78E-04	504.4992	3.15E+11	0.00	0.00	0.00
10.3560	0.09686	39665.	13000.	-7.78E-04	509.7030	3.15E+11	0.00	0.00	0.00
10.7012	0.09364	95158.	13000.	-7.77E-04	521.8182	3.15E+11	0.00	0.00	0.00
11.0464	0.09043	150649.	13000.	-7.75E-04	533.9329	3.15E+11	0.00	0.00	0.00
11.3916	0.08722	206135.	13000.	-7.73E-04	546.0467	3.15E+11	0.00	0.00	0.00
11.7368	0.08403	261616.	13000.	-7.70E-04	558.1592	3.15E+11	0.00	0.00	0.00
12.0820	0.08085	317089.	13000.	-7.66E-04	570.2702	3.15E+11	0.00	0.00	0.00

12.4272	0.07768	372554.	13000.	-7.61E-04	582.3792	3.15E+11	0.00	0.00	0.00
12.7724	0.07454	428008.	13000.	-7.56E-04	594.4859	3.15E+11	0.00	0.00	0.00
13.1176	0.07142	483451.	13000.	-7.50E-04	606.5901	3.15E+11	0.00	0.00	0.00
13.4628	0.06833	538880.	13000.	-7.43E-04	618.6913	3.15E+11	0.00	0.00	0.00
13.8080	0.06526	594294.	13000.	-7.36E-04	630.7893	3.15E+11	0.00	0.00	0.00
14.1532	0.06223	649691.	13000.	-7.28E-04	642.8837	3.15E+11	0.00	0.00	0.00
14.4984	0.05923	705071.	13000.	-7.19E-04	654.9741	3.15E+11	0.00	0.00	0.00
14.8436	0.05628	760431.	13000.	-7.09E-04	667.0602	3.15E+11	0.00	0.00	0.00
15.1888	0.05336	815770.	13000.	-6.99E-04	679.1418	3.15E+11	0.00	0.00	0.00
15.5340	0.05049	871086.	13000.	-6.88E-04	691.2184	3.15E+11	0.00	0.00	0.00
15.8792	0.04766	926378.	13000.	-6.76E-04	703.2897	3.15E+11	0.00	0.00	0.00
16.2244	0.04489	981644.	13000.	-6.63E-04	715.3554	3.15E+11	0.00	0.00	0.00
16.5696	0.04217	1036883.	13000.	-6.50E-04	727.4152	3.15E+11	0.00	0.00	0.00
16.9148	0.03950	1092093.	13000.	-6.36E-04	739.4687	3.15E+11	0.00	0.00	0.00
17.2600	0.03690	1147273.	13000.	-6.21E-04	751.5155	3.15E+11	0.00	0.00	0.00
17.6052	0.03435	1202421.	13000.	-6.06E-04	763.5554	3.15E+11	0.00	0.00	0.00
17.9504	0.03187	1257536.	13000.	-5.90E-04	775.5881	3.15E+11	0.00	0.00	0.00
18.2956	0.02947	1312616.	13000.	-5.73E-04	787.6130	3.15E+11	0.00	0.00	0.00
18.6408	0.02713	1367659.	13000.	-5.55E-04	799.6301	3.15E+11	0.00	0.00	0.00
18.9860	0.02486	1422665.	13000.	-5.37E-04	811.6388	3.15E+11	0.00	0.00	0.00
19.3312	0.02268	1477631.	13000.	-5.18E-04	823.6390	3.15E+11	0.00	0.00	0.00
19.6764	0.02057	1532556.	13000.	-4.98E-04	835.6301	3.15E+11	0.00	0.00	0.00
20.0216	0.01855	1587438.	13000.	-4.78E-04	847.6120	3.15E+11	0.00	0.00	0.00
20.3668	0.01662	1642276.	13000.	-4.56E-04	859.5843	3.15E+11	0.00	0.00	0.00
20.7120	0.01477	1697069.	13000.	-4.34E-04	871.5466	3.15E+11	0.00	0.00	0.00
21.0572	0.01302	1751814.	13000.	-4.12E-04	883.4986	3.15E+11	0.00	0.00	0.00
21.4024	0.01136	1806511.	13000.	-3.88E-04	895.4401	3.15E+11	0.00	0.00	0.00
21.7476	0.00980	1861158.	13000.	-3.64E-04	907.3705	3.15E+11	0.00	0.00	0.00
22.0928	0.00834	1915753.	13000.	-3.40E-04	919.2897	3.15E+11	0.00	0.00	0.00
22.4380	0.00699	1970295.	13000.	-3.14E-04	931.1973	3.15E+11	0.00	0.00	0.00
22.7832	0.00574	2024783.	13000.	-2.88E-04	943.0929	3.15E+11	0.00	0.00	0.00
23.1284	0.00460	2079214.	13000.	-2.61E-04	954.9763	3.15E+11	0.00	0.00	0.00
23.4736	0.00358	2133587.	13000.	-2.33E-04	966.8470	3.15E+11	0.00	0.00	0.00
23.8188	0.00267	2187901.	13000.	-2.05E-04	978.7049	3.15E+11	0.00	0.00	0.00
24.1640	0.00188	2242154.	13000.	-1.76E-04	990.5494	3.15E+11	0.00	0.00	0.00
24.5092	0.00121	2296346.	-13982.	-1.46E-04	1002.	3.15E+11	-13027.	4.44E+07	0.00
24.8544	6.73E-04	2126930.	-55919.	-1.13E-04	1113.	2.51E+11	-7220.	4.44E+07	0.00
25.1996	2.77E-04	1833549.	-77030.	-8.05E-05	1037.	2.51E+11	-2973.	4.44E+07	0.00
25.5448	6.62E-06	1489093.	-83334.	-5.30E-05	947.6325	2.51E+11	-71.0197	4.44E+07	0.00
25.8900	-1.62E-04	1143365.	-79881.	-3.13E-05	858.0347	2.51E+11	1738.	4.44E+07	0.00
26.2352	-2.53E-04	827427.	-70670.	-1.50E-05	776.1570	2.51E+11	2709.	4.44E+07	0.00
26.5804	-2.86E-04	557942.	-58696.	-3.57E-06	706.3181	2.51E+11	3072.	4.44E+07	0.00
26.9256	-2.82E-04	341158.	-46064.	3.85E-06	650.1368	2.51E+11	3026.	4.44E+07	0.00
27.2708	-2.55E-04	176294.	-34141.	8.12E-06	607.4111	2.51E+11	2730.	4.44E+07	0.00
27.6160	-2.15E-04	58274.	-23712.	1.01E-05	576.8255	2.51E+11	2305.	4.44E+07	0.00
27.9612	-1.71E-04	-20198.	-15134.	1.04E-05	566.9578	2.51E+11	1837.	4.44E+07	0.00
28.3064	-1.29E-04	-67156.	-8466.	9.65E-06	579.1272	2.51E+11	1383.	4.44E+07	0.00
28.6516	-9.13E-05	-90378.	-3574.	8.35E-06	585.1453	2.51E+11	978.9419	4.44E+07	0.00
28.9968	-5.98E-05	-96798.	-218.2614	6.81E-06	586.8092	2.51E+11	641.0816	4.44E+07	0.00
29.3420	-3.49E-05	-92215.	1885.	5.25E-06	585.6214	2.51E+11	374.2380	4.44E+07	0.00
29.6872	-1.63E-05	-81206.	3022.	3.81E-06	582.7685	2.51E+11	175.0486	4.44E+07	0.00
30.0324	-3.30E-06	-67191.	3458.	2.59E-06	579.1364	2.51E+11	35.4367	4.44E+07	0.00
30.3776	5.12E-06	-52566.	3418.	1.60E-06	575.3461	2.51E+11	-54.8798	4.44E+07	0.00

30.7228	9.94E-06	-38880.	3084.	8.44E-07	571.7994	2.51E+11	-106.6311	4.44E+07	0.00
31.0680	1.21E-05	-27023.	2594.	3.00E-07	568.7265	2.51E+11	-129.8576	4.44E+07	0.00
31.4132	1.24E-05	-17393.	2049.	-6.71E-08	566.2309	2.51E+11	-133.2585	4.44E+07	0.00
31.7584	1.16E-05	-10049.	1516.	-2.94E-07	564.3277	2.51E+11	-123.8988	4.44E+07	0.00
32.1036	9.99E-06	-4831.	1038.	-4.17E-07	562.9754	2.51E+11	-107.1664	4.44E+07	0.00
32.4488	8.10E-06	-1452.	635.5994	-4.68E-07	562.0996	2.51E+11	-86.8895	4.44E+07	0.00
32.7940	6.11E-06	436.6193	319.8719	-4.77E-07	561.8365	2.51E+11	-65.5475	4.44E+07	0.00
33.1392	4.15E-06	1200.	91.8880	-4.63E-07	562.0344	2.51E+11	-44.5258	4.44E+07	0.00
33.4844	2.27E-06	1200.	-50.8395	-4.43E-07	562.0343	2.51E+11	-24.3847	4.44E+07	0.00
33.8296	4.78E-07	780.9546	-111.9578	-4.27E-07	561.9257	2.51E+11	-5.1239	4.44E+07	0.00
34.1748	-1.26E-06	274.1072	-94.4769	-4.18E-07	561.7944	2.51E+11	13.5639	4.44E+07	0.00
34.5200	-2.99E-06	0.00	0.00	-4.16E-07	561.7233	2.51E+11	32.0507	2.22E+07	0.00

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

Output Summary for Load Case No. 2:

Pile-head deflection = 0.16289763 inches
Computed slope at pile head = 0.000000 radians
Maximum bending moment = 2296346. inch-lbs
Maximum shear force = -83334. lbs
Depth of maximum bending moment = 24.50920000 feet below pile head
Depth of maximum shear force = 25.54480000 feet below pile head
Number of iterations = 6
Number of zero deflection points = 3

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	Load 1	Pile-head 1	Load Type 2	Axial Load 2	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	11000.	M, in-lb	720000.	500000.	0.5429	-0.00327	-154004.	4225625.
2	V, lb	13000.	S, rad	0.00	510000.	0.1629	0.00	-83334.	2296346.

Maximum pile-head deflection = 0.5429455054 inches
Maximum pile-head rotation =-0.0032738445 radians =-0.187577 deg.

Summary of Warning Messages

The following warning was reported 3210 times

**** Warning ****

This warning is for an input value for uniaxial compressive strength that has been specified for a soil defined using the vuggy limestone criteria. The input value is outside of the range of 1,000 to 2,500 psi (6,895 to 17,237 kPa) which were used in actual field tests on which this theory is based. Higher or lower values may be applicable but the user is warned about the theoretical and testing limitations.

The analysis ended normally.

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

PROJECT: BP11.R003.1 COUNTY: Ashe
DESCRIPTION: Bridge No. 063 on NC88 over Cranberry Creek - B2 - RT
DESIGNED BY: KND DATE: 09/08/22 STATION: 17+20
CHECKED BY: DATE: STR. NO.: 63 PAGE: 1 OF 6

Elevations

Bottom of Cap (BOC) Elevation =	2,722.50	ft
Top of Pier/Bottom of Column Elevation =	2,714.22	ft
Natural Ground / Finished Grade Elevation =	2,715.00	ft
Groundwater Table (GWT) Elevation =	2,714.00	ft
Design Scour (DSE) Elevation =	2,698.00	ft
Amount of Contraction Scour (from BSR) =	6.80	ft
Is Permanent Casing Required?	◉ Yes / Maybe ○ No	
Bottom of Permanent Casing Elevation =	2,698.00	ft
Drilled Pier Tip Elevation =	2,689.00	ft

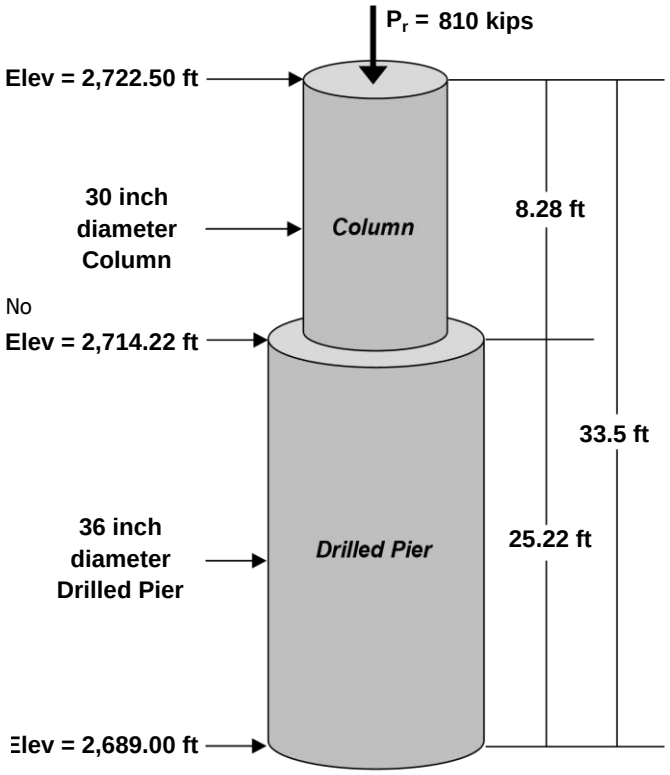


Figure shows typical drilled pier

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	810.0	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. =	B2-B	
SPT Hammer Energy Efficiency Rating (ER) =	84	%
Top of Boring (Collar) Elevation =	2715.60	ft
Depth to Groundwater Table (for actual boring) =	1.10	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	Hard Rock	2,698.00	2,689.00	0.174			N/A	100	85	1,544		
2												
3												
4												
5												
6												
7												
8												
TIP [3]	Hard Rock	2,689.00	2,683.00	0.174			N/A	100	85	1,045	8,860	0.220

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.

Correcting SPT Values for Hammer Efficiency and Overburden Pressure

SPT-N Value Corrected for Hammer Efficiency, (N_{60})

$N_{60} = (ER/60\%)(N)$ *AASHTO Eqn. 10.4.6.2.4-2*

N_{60} = SPT blow count corrected for hammer efficiency (blows/ft)
ER = hammer efficiency expressed as percent of theoretical free fall energy delivered by the hammer system actually used. If ER is not known, use 80% for automatic hammers and 60% for drop hammers.
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for Overburden Pressure, (N1)

$N1 = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-1*

N1 = SPT blow count corrected for overburden pressure (blows/ft)
C_N = correction factor = $[0.77\log_{10}(40/\sigma'_v) < 2.0$
$\sigma'_v = \sigma_v - \mu$ = effective vertical stress at the depth of the SPT-N value (ksf)
σ_v = total vertical stress at the depth of the SPT-N value (ksf)
μ = total pore water pressure at the depth of the SPT-N value (ksf)
N = uncorrected SPT blow count (blows/ft)

SPT-N Value Corrected for both Overburden Pressure and Hammer Efficiency, ($N1_{60}$)

$N1_{60} = (C_N)(N)$ *AASHTO Eqn. 10.4.6.2.4-3*

Summary of Corrected N Values for Boring

Top of Boring (Collar) Elevation = 2,715.6 ft
Depth to Groundwater Table = 1.1 ft
Hammer Efficiency (ER) = 84 %
Unit Weight of Water = 0.0624 kcf

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	σ_v at top (ksf)	Δz (ft)	Total γ (kcf)	σ_v at bottom (ksf)	σ_v at midpoint (ksf)	z_{water} (ft)	μ at midpoint (ksf)	σ'_{vo} at midpoint (ksf)	N (bpf)	N_{60} (bpf)	C_N	$N1_{60}$ (bpf)
1	2698.00	2689.00	2.112	9.00	0.174	3.678	2.895	21.00	1.310	1.585	N/A			N/A
2														
3														
4														
5														
6														
7														
8														
TIP	2689.00	2683.00	3.678	6.00	0.174	4.722	4.200	28.50	1.778	2.422	N/A			N/A

Selecting Design Properties for Hard Rock

1. q_u values for rock should be based on AASHTO Table 10.4.6.4-1 (which uses Point Load Index Testing) or actual values from Uniaxial Compressive Strength Testing. If neither of these options is available, the NCDOT Rock Core Database may be used to estimate compressive strength.

2. E_i and v values for rock should be based on AASHTO Tables C10.4.6.5-1, and 2 if lab test data is not available

Unconfined Compressive Strength from Point Load Strength Index for Hard Rock AASHTO Table C10.4.6.4-1

Parameter			Ranges of Values						
1	Strength of intact rock material	Point load strength index	>175 ksf	85–175 ksf	45–85 ksf	20–45 ksf	For this low range, uniaxial compressive test is preferred		
		Uniaxial compressive strength	>4320 ksf	2160–4320 ksf	1080–2160 ksf	520–1080 ksf	215–520 ksf	70–215 ksf	20–70 ksf
	Relative Rating		15	12	7	4	2	1	0

Summary of Elastic Moduli for Intact Rock, E_i (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-1

Rock Type	No. of Values	No. of Rock Types	Elastic Modulus, E_i (ksi $\times 10^3$)			Standard Deviation (ksi $\times 10^3$)
			Maximum	Minimum	Mean	
Granite	26	26	14.5	0.93	7.64	3.55
Diorite	3	3	16.2	2.48	7.45	6.19
Gabbro	3	3	12.2	9.8	11.0	0.97
Diabase	7	7	15.1	10.0	12.8	1.78
Basalt	12	12	12.2	4.20	8.14	2.60
Quartzite	7	7	12.8	5.29	9.59	2.32
Marble	14	13	10.7	0.58	6.18	2.49
Gneiss	13	13	11.9	4.13	8.86	2.31
Slate	11	2	3.79	0.35	1.39	0.96
Schist	13	12	10.0	0.86	4.97	3.18
Phyllite	3	3	2.51	1.25	1.71	0.57
Sandstone	27	19	5.68	0.09	2.13	1.19
Siltstone	5	5	4.76	0.38	2.39	1.65
Shale	30	14	5.60	0.001	1.42	1.45
Limestone	30	30	13.0	0.65	5.7	3.73
Dolostone	17	16	11.4	0.83	4.22	3.44

Summary of Poisson's Ratio for Intact Rock, v (modified by Kulhawy, 1978) AASHTO Table C10.4.6.5-2

Rock Type	No. of Values	No. of Rock Types	Poisson's Ratio, v			Standard Deviation
			Maximum	Minimum	Mean	
Granite	22	22	0.39	0.09	0.20	0.08
Gabbro	3	3	0.20	0.16	0.18	0.02
Diabase	6	6	0.38	0.20	0.29	0.06
Basalt	11	11	0.32	0.16	0.23	0.05
Quartzite	6	6	0.22	0.08	0.14	0.05
Marble	5	5	0.40	0.17	0.28	0.08
Gneiss	11	11	0.40	0.09	0.22	0.09
Schist	12	11	0.31	0.02	0.12	0.08
Sandstone	12	9	0.46	0.08	0.20	0.11
Siltstone	3	3	0.23	0.09	0.18	0.06
Shale	3	3	0.18	0.03	0.09	0.06
Limestone	19	19	0.33	0.12	0.23	0.06
Dolostone	5	5	0.35	0.14	0.29	0.08

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 Top (ft)	Layer Elevations Bottom (ft)	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)
1	Hard Rock	2,698.00	2,689.00	10.8.3.5.4b-2 (open joints)	100	0.85	648	20.478	9.00	80.11	1640

Total Side Resistance in Weathered and Hard Rock = 1,640

Tip Resistance in Hard Rock

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

q_p = unit tip resistance (ksf)

If rock to a depth of 2B below drilled pier tip is intact or tightly jointed and the depth of socket > 1.5 D

$= 2.5q_u$ *AASHTO Eqn. 10.8.3.5.4c-1*

If the rock to a depth of 2D below the drilled pier tip is jointed with random orientation

$$= A + q_u\left[m_b\left(\frac{A}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-2*

q_u = Uniaxial Compressive Strength of Intact Rock (ksf)
σ'_{vb} = vertical effective stress at the socket bearing elevation

$$A = \sigma'_{vb} + q_u\left[m_b\left(\frac{\sigma'_{vb}}{q_u}\right) + s\right]^a$$ *AASHTO Eqn. 10.8.3.5.4c-3*

$$s = exp\left(\frac{GSI - 100}{9}\right)$$ *AASHTO Eqn. 10.4.6.4-2*

$$a = \frac{1}{2} + \frac{1}{6}\left(e^{\frac{-GSI}{15}} - e^{\frac{-20}{3}}\right)$$ *AASHTO Eqn. 10.4.6.4-3*

$$m_b = exp\left(\frac{GSI - 100}{28}\right) m_i$$ *AASHTO Eqn. 10.4.6.4-4*

m_i = constant for intact rock *AASHTO Table 10.4.6.4-1*

GSI = Global Strength Index

***Hard Rock Layers with an GSI less than 30 will be modeled as weathered rock.**

A_p = area of drilled pier tip resistance (ft^2)
$= (\pi)(B^2)/4$

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

Tip Elevation (ft)	AASHTO Equation used to calculate q_u	q_u (ksf)	GSI	m	m_b	s	a	A	q_p (ksf)	A_p (ft^2)	R_p (kips)
2689.00	10.8.3.5.4c-1	1,045	85	28	N/A	N/A	N/A	N/A	2,613	6.31	16,488

Tip Resistance in Hard Rock (continued)

Table 10.4.6.4-1—Values of the Constant mi by Rock Group

Rock type	Class	Group	Texture			
			Coarse	Medium	Fine	Very fine
SEDIMENTARY	Clastic		Conglomerate (21 ± 3) Breccia (19 ± 5)	Sandstone 17 ± 4	Siltstone 7 ± 2 Greywacke (18 ± 3)	Claystone 4 ± 2 Shale (6 ± 2) Marl (7 ± 2)
	Non-Clastic	Carbonates	Crystalline Limestone (12 ± 3)	Sparitic Limestone (10 ± 5)	Micritic Limestone (8 ± 3)	Dolomite (9 ± 3)
		Evaporites		Gypsum 10 ± 2	Anhydrite 12 ± 2	
		Organic				Chalk 7 ± 2
METAMORPHIC	Non Foliated		Marble 9 ± 3	Hornfels (19 ± 4)) Metasandstone (19 ± 3)	Quartzite 20 ± 3	
	Slightly foliated		Migmatite (29 ± 3)	Amphibolite 26 ± 6	Gneiss 28 ± 5	
	Foliated*			Schist (10 ± 3)	Phyllite (7 ± 3)	Slate 7 ± 4
IGNEOUS	Plutonic	Light	Granite 32 ± 3 Granodiorite (29 ± 3)	Diorite 25 ± 5		
		Dark	Gabbro 27 ± 3 Norite 20 ± 5	Dolerite (16 ± 5)		
	Hypabyssal		Porphyries (20 ± 5)		Diabase (15 ± 5)	Peridotite (25 ± 5)
	Volcanic	Lava		Rhyolite (25 ± 5) Andesite 25 ± 5	Dacite (25 ± 3)) Basalt (25 ± 5)	
		Pyroclastic	Agglomerate (19 ± 3)	Volcanic breccia (19 ± 5)	Tuff (13 ± 5)	

Summary of Nominal and Factored Side Resistance

Cohesionless IGM	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	0	0.60	0	0.0%
Hard Rock	1,640	0.55	902	100.0%
Total	**1,640**		**902**	**100%**

Note: *When drilled piers are socketed in hard rock, the side resistance above the hard rock will be ignored. For the purpose of this spreadsheet, a drilled pier will be considered socketed in hard rock if either of these conditions are met;*

1. *The pier is embedded the greater of 3 feet or 1 pier diameter into hard rock.*
2. *At least 50% of the total nominal side resistance is produced by the hard rock layer(s).*

Summary of Nominal and Factored Side Resistance (continued)

Total Nominal Side Resistance =	1,640	kips
Side Resistance Factor =	0.55	
Total Factored Side Resistance =	902	kips

for Hard Rock, see AASHTO Table 10.5.5.2.4-1.

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance =	16,488	kips
Tip Resistance Factor =	0.50	
Total Factored Tip Resistance =	8,244	kips

the drilled pier is bearing on Hard Rock
for Hard Rock, 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 = 810 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} = 8.28 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 6 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} = 25.22 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 27 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 = 25 ft *Depth from water surface to the drilled pier tip*
γ_w = 0.0624 kcf *Unit Weight of Water*

= 11 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} = 1.350 ksf *ffective vertical stress at drilled pier tip as defined in FHWA GEC 010 pages 13-46*

$W_{Soil/Rock}$ = 10 kips

R_{req} = 810 kips + 1.25(6 kips + 27 kips) -1.00(11 kips) -1.25(10 kips) = 828 kips

Load Transfer of Side and Tip Resistance for Drilled Piers in Hard Rock with no Rock Socket

Per AASHTO Section 10.8.3.5.4a, The Factored Geotechnical Resistance for Drilled Piers socketed in hard rock will be based on side resistance, tip resistance, or a combination of both. Using a combination of both side and tip resistance requires a displacement based analysis and falls outside the limitations of this spreadsheet. For details on displacement based analysis, see *FHWA GEC 010 Appendix D.3.1* .

Developed Factored Resistance, (R_{rd})

Select which value to use for the Factored Developed Resistance

(●) Use the Factored Side Resistance of the rock socket.

( ) Use the Factored Tip Resistance of the rock socket.

902 kips ≥ 828 kips

The axial resistance requirement is satisfied.

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)
828	902	6.31	0.50	2613	0

GEOTECHNICAL BORING REPORT
BORE LOG

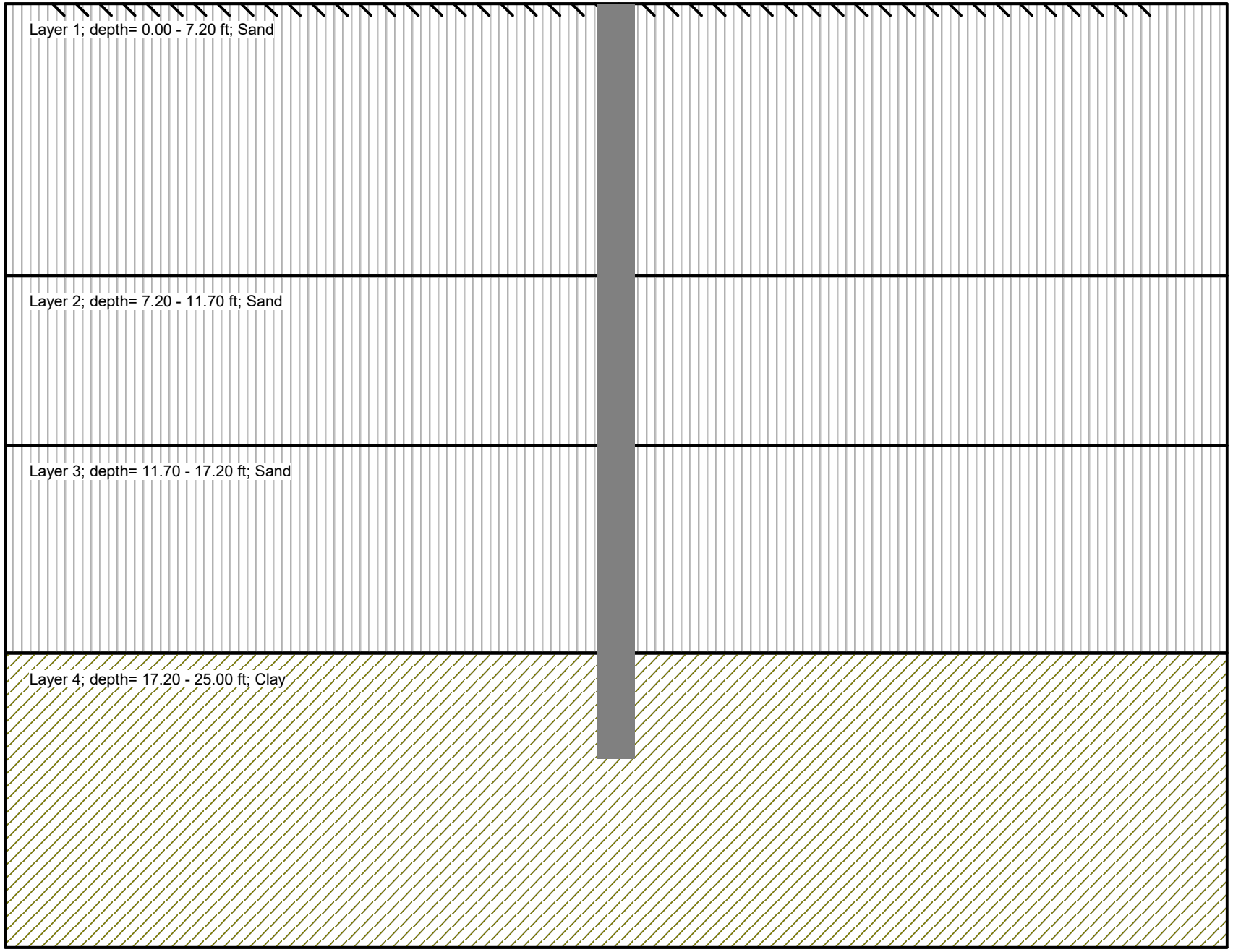
WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 17+45	**OFFSET** 27 ft LT	**ALIGNMENT** -L-	**0 HR.** 16.2
COLLAR ELEV. 2,727.6 ft	**TOTAL DEPTH** 23.6 ft	**NORTHING** 977,760	**EASTING** 1,328,117	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/11/22	**COMP. DATE** 07/11/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION
						Avg BOC = 2721.3'				
2730										
	2,727.6									2,727.6 GROUND SURFACE 0.0
	2,726.6	1.0	9	5	3	8		M		2,726.6 **ROADWAY EMBANKMENT** 1.0 Asphalt 1.0'
2725	2,724.1	3.5	2	1	2	3		W		Soft to Stiff, Brown-Tan-Gray, Fine to Coarse Sandy SILT (A-4), with trace rock fragments and trace mica
	2,721.6	6.0	2	2	1	3 (4)		M		
2720	2,719.1	8.5	3	3	6	9 (13) γ=120 φ=28		W		
2715	2,714.1	13.5	1	0	1	1 (1) γ=110 φ=26	7.2	W		2,714.1 13.5 **ALLUVIAL** Very Soft, Black, Fine to Coarse Sandy SILT (A-4), with trace mica
2710	2,709.1	18.5	6	17	42	γ=120 φ=34 59 (83)	11.7	M		2,709.6 18.0 **RESIDUAL** Hard, Gray-White, Fine to Coarse Sandy SILT (A-4), with trace mica and trace rock fragments
2705	2,704.1	23.5	60/0.1			60/0.1	17.2			2,704.1 23.5 2,704.0 23.6 **CRYSTALLINE ROCK** (BIOTITE/HORNBLENDE GNEISS) Boring Terminated with Standard Penetration Test Refusal at Elevation 2,704.0 ft In Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)

L=20 Ft

Notes:
Cobbles layer encountered while drilling at 17 ft.

End Bent No. 2 - LT



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APILE for Windows, Version 2019.9.10

Serial Number : 562476398

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

==========

This program is licensed to :

ECS Carolinas, LLP
Charlotte, NC, USA

Path to file locations : C:\Users\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500-29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\APile\
Name of input data file : EB2- LT.ap9d
Name of output file : EB2- LT.ap9o
Name of plot output file : EB2- LT.ap9p

Time and Date of Analysis

Date: September 08, 2022 Time: 08:40:37

1

****
* INPUT INFORMATION *
****

Bridge No. 063 over Cranberry Creek

DESIGNER : KND

JOB NUMBER : 09:29662

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

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 = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 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	Nq FACTOR FHWA
0.00	SAND	0.80*	120.00	28.00	22.80**
7.20	SAND	0.80*	120.00	28.00	22.80**
7.20	SAND	0.80*	47.60	26.00	17.40**
11.70	SAND	0.80*	47.60	26.00	17.40**
11.70	SAND	0.80*	57.60	34.00	55.60**
17.20	SAND	0.80*	57.60	34.00	55.60**
17.20	CLAY	0.80*	174.00	0.00	4.80**
25.00	CLAY	0.80*	174.00	0.00	4.80**

* 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
0.10E+08*	0.10E+08*	1500.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1500.00	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
7.20	1.000	1.000
7.20	1.000	1.000
11.70	1.000	1.000
11.70	1.000	1.000
17.20	1.000	1.000
17.20	1.000	1.000
25.00	1.000	1.000

1

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

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

PILE PENETRATION FT.	SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.1	0.1

1.00	0.1	0.2	0.2
2.00	0.2	0.3	0.6
3.00	0.6	0.5	1.0
4.00	1.0	0.6	1.6
5.00	1.6	0.8	2.3
6.00	2.2	0.9	3.2
7.00	3.1	1.0	4.1
8.00	4.0	1.0	5.0
9.00	4.9	1.0	6.0
10.00	5.9	1.0	6.9
11.00	6.9	1.9	8.7
12.00	7.9	2.9	10.8
13.00	9.4	4.0	13.4
14.00	11.4	5.0	16.5
15.00	13.6	5.2	18.8
16.00	15.8	5.5	21.3
17.00	18.2	347.6	365.8
18.00	20.6	729.4	750.0
19.00	3000.0	1111.2	4111.1
20.00	8956.2	1453.1	10409.3

Factored Load = 65 tons/pile

By Inspection, pile should refuse on Crystalline rock. Tip Elevation = 2,704 ft.

Pile Penetration = 17.3 ft

L = 19.3 ft, say average Pile Length = 20 ft.

Drive Piles to 65 tons/0.6 = 110 ton (220 kips)

For WEAP: 19k/220k = 9% skin

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	0.4167E-01		
			0.0000E+00	0.0000E+00
			0.2729E-02	0.2427E-01
			0.4548E-02	0.4702E-01
			0.6821E-02	0.8645E-01
			0.8186E-02	0.1213E+00
			0.9095E-02	0.1517E+00
			0.9095E-02	0.3033E+00
			0.9095E-02	0.4550E+00
			0.9095E-02	0.7584E+00
			0.9095E-02	0.3033E+01
2	10	0.3600E+01		
			0.0000E+00	0.0000E+00
			0.2357E+00	0.2427E-01
			0.3929E+00	0.4702E-01

		0.5894E+00	0.8645E-01
		0.7072E+00	0.1213E+00
		0.7858E+00	0.1517E+00
		0.7858E+00	0.3033E+00
		0.7858E+00	0.4550E+00
		0.7858E+00	0.7584E+00
		0.7858E+00	0.3033E+01
3	10	0.7158E+01	
		0.0000E+00	0.0000E+00
		0.4688E+00	0.2427E-01
		0.7813E+00	0.4702E-01
		0.1172E+01	0.8645E-01
		0.1406E+01	0.1213E+00
		0.1563E+01	0.1517E+00
		0.1563E+01	0.3033E+00
		0.1563E+01	0.4550E+00
		0.1563E+01	0.7584E+00
		0.1563E+01	0.3033E+01
4	10	0.7242E+01	
		0.0000E+00	0.0000E+00
		0.4742E+00	0.2427E-01
		0.7904E+00	0.4702E-01
		0.1186E+01	0.8645E-01
		0.1423E+01	0.1213E+00
		0.1581E+01	0.1517E+00
		0.1581E+01	0.3033E+00
		0.1581E+01	0.4550E+00
		0.1581E+01	0.7584E+00
		0.1581E+01	0.3033E+01
5	10	0.9450E+01	
		0.0000E+00	0.0000E+00
		0.4870E+00	0.2427E-01
		0.8116E+00	0.4702E-01
		0.1217E+01	0.8645E-01
		0.1461E+01	0.1213E+00
		0.1623E+01	0.1517E+00
		0.1623E+01	0.3033E+00
		0.1623E+01	0.4550E+00
		0.1623E+01	0.7584E+00
		0.1623E+01	0.3033E+01
6	10	0.1166E+02	
		0.0000E+00	0.0000E+00
		0.5367E+00	0.2427E-01
		0.8945E+00	0.4702E-01
		0.1342E+01	0.8645E-01
		0.1610E+01	0.1213E+00
		0.1789E+01	0.1517E+00
		0.1789E+01	0.3033E+00
		0.1789E+01	0.4550E+00
		0.1789E+01	0.7584E+00
		0.1789E+01	0.3033E+01
7	10	0.1174E+02	
		0.0000E+00	0.0000E+00

		0.5386E+00	0.2427E-01
		0.8977E+00	0.4702E-01
		0.1346E+01	0.8645E-01
		0.1616E+01	0.1213E+00
		0.1795E+01	0.1517E+00
		0.1795E+01	0.3033E+00
		0.1795E+01	0.4550E+00
		0.1795E+01	0.7584E+00
		0.1795E+01	0.3033E+01
8	10	0.1445E+02	
		0.0000E+00	0.0000E+00
		0.1126E+01	0.2427E-01
		0.1877E+01	0.4702E-01
		0.2816E+01	0.8645E-01
		0.3379E+01	0.1213E+00
		0.3754E+01	0.1517E+00
		0.3754E+01	0.3033E+00
		0.3754E+01	0.4550E+00
		0.3754E+01	0.7584E+00
		0.3754E+01	0.3033E+01
9	10	0.1716E+02	
		0.0000E+00	0.0000E+00
		0.1262E+01	0.2427E-01
		0.2104E+01	0.4702E-01
		0.3156E+01	0.8645E-01
		0.3787E+01	0.1213E+00
		0.4208E+01	0.1517E+00
		0.4208E+01	0.3033E+00
		0.4208E+01	0.4550E+00
		0.4208E+01	0.7584E+00
		0.4208E+01	0.3033E+01
10	10	0.1724E+02	
		0.0000E+00	0.0000E+00
		0.1266E+01	0.2427E-01
		0.2111E+01	0.4702E-01
		0.3166E+01	0.8645E-01
		0.3799E+01	0.1213E+00
		0.4222E+01	0.1517E+00
		0.3799E+01	0.3033E+00
		0.3799E+01	0.4550E+00
		0.3799E+01	0.7584E+00
		0.3799E+01	0.3033E+01
11	10	0.2110E+02	
		0.0000E+00	0.0000E+00
		0.3125E+04	0.2427E-01
		0.5208E+04	0.4702E-01
		0.7812E+04	0.8645E-01
		0.9375E+04	0.1213E+00
		0.1042E+05	0.1517E+00
		0.9375E+04	0.3033E+00
		0.9375E+04	0.4550E+00
		0.9375E+04	0.7584E+00
		0.9375E+04	0.3033E+01

12 10 0.2496E+02

0.0000E+00	0.0000E+00
0.3125E+04	0.2427E-01
0.5208E+04	0.4702E-01
0.7812E+04	0.8645E-01
0.9375E+04	0.1213E+00
0.1042E+05	0.1517E+00
0.9375E+04	0.3033E+00
0.9375E+04	0.4550E+00
0.9375E+04	0.7584E+00
0.9375E+04	0.3033E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.9082E+02	0.7584E-02
0.1816E+03	0.1517E-01
0.3633E+03	0.3033E-01
0.7266E+03	0.1972E+00
0.1090E+04	0.6370E+00
0.1308E+04	0.1107E+01
0.1453E+04	0.1517E+01
0.1453E+04	0.2275E+01
0.1453E+04	0.3033E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.2336E+02	0.1166E-01	0.1198E+01	0.1000E-03
0.2968E+03	0.1488E+00	0.1198E+02	0.1000E-02
0.1522E+04	0.7713E+00	0.5988E+02	0.5000E-02
0.2767E+04	0.1409E+01	0.1198E+03	0.1000E-01
0.4638E+04	0.2375E+01	0.2395E+03	0.2000E-01
0.7172E+04	0.3708E+01	0.4061E+03	0.5000E-01
0.8178E+04	0.4266E+01	0.4714E+03	0.8000E-01
0.8681E+04	0.4551E+01	0.5150E+03	0.1000E+00
0.9061E+04	0.4854E+01	0.7289E+03	0.2000E+00
0.9021E+04	0.5136E+01	0.9767E+03	0.5000E+00
0.9210E+04	0.5537E+01	0.1165E+04	0.8000E+00
0.9302E+04	0.5786E+01	0.1258E+04	0.1000E+01
0.9497E+04	0.6891E+01	0.1453E+04	0.2000E+01

WEAP Parameter Calculation

Bent #: **EB2 - LT**

		Toe Quake	Shaft Quake
Pile Type:	HP 12X53	**0.10**	**0.10**

Subsurface Conditions: Loose/Soft or Submerged

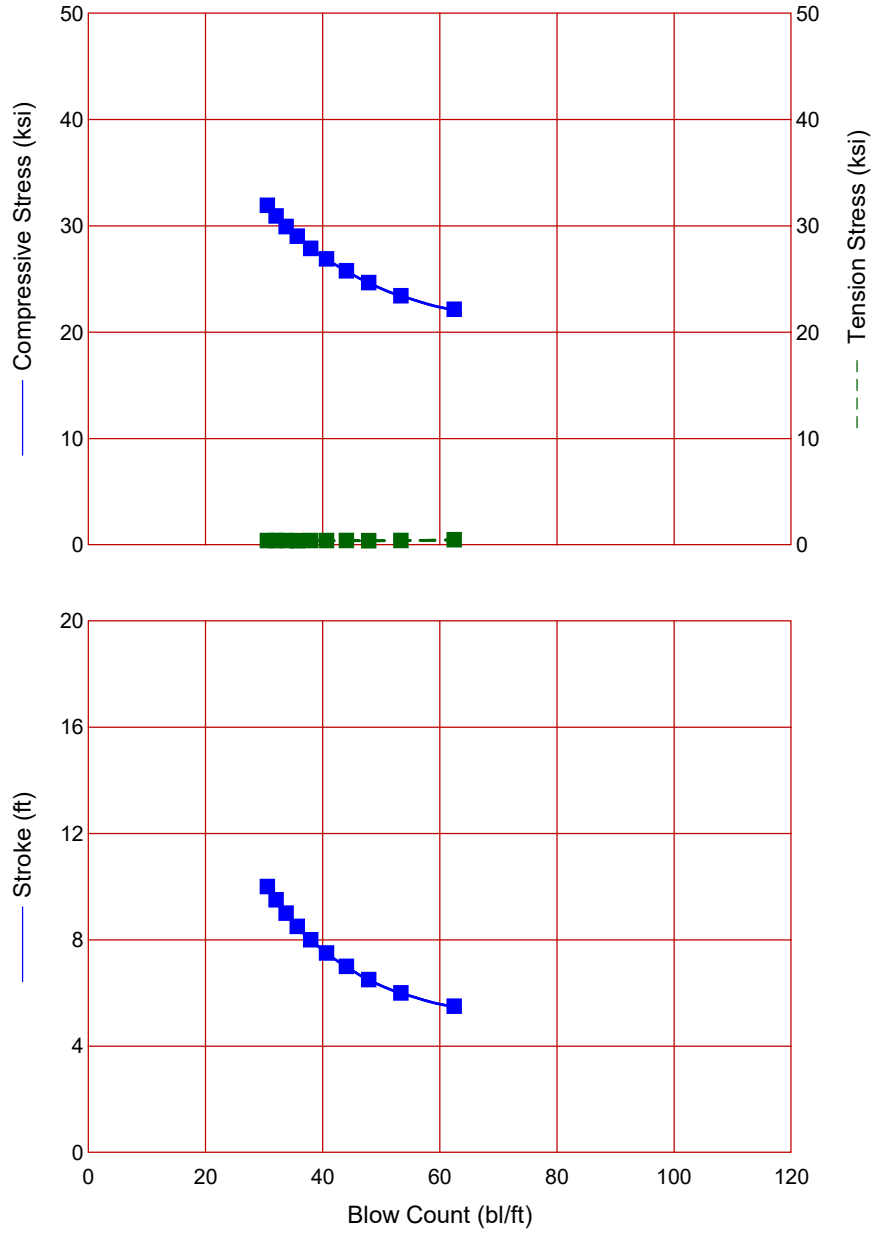
Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping
1	2721.3	2714.1	9	Sand	0.20
2	2714.1	2709.6	1	Sand	0.20
3	2709.6	2704.1	83	Sand	0.10
4	2704.1	2704.0	100	Rock	0.10
5					
6					
7					
8					
9					
10					
11					
12					
13					

Shaft Damping	Toe Damping
0.17	**0.10**

Length of Pile	17.3

ECS Carolinas LLP
Bridge No. 063 - EB2 - LT

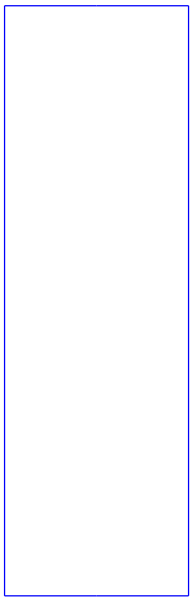
06-Sep-2022
GRLWEAP Version 2010



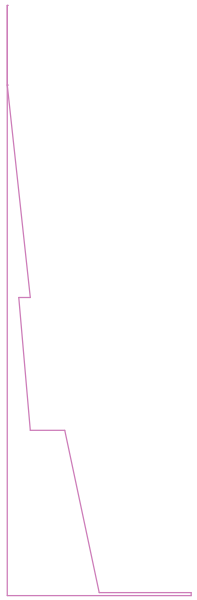
DELMAG D 12

Capacity	220.0	kips
Ram Weight	2.75	kips
Efficiency	0.800	
Pressure	1380 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.170	s/ft
Toe Damping	0.100	s/ft
Pile Length	20.00	ft
Pile Penetration	17.30	ft
Pile Top Area	15.50	in2

Pile Model



Skin Friction Distribution



Res. Shaft = 9 %
(Proportional)

ECS Carolinas LLP
Bridge No. 063 - EB2 - LT

06-Sep-2022
GRLWEAP Version 2010

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
220.0	22.14	0.48	62.5	5.50	7.32
220.0	23.42	0.41	53.4	6.00	8.46
220.0	24.65	0.39	47.9	6.50	9.44
220.0	25.77	0.41	44.1	7.00	10.33
220.0	26.88	0.40	40.7	7.50	11.28
220.0	27.87	0.40	38.0	8.00	12.20
220.0	29.02	0.39	35.7	8.50	13.12
220.0	29.93	0.40	33.8	9.00	14.02
220.0	30.92	0.40	32.1	9.50	14.91
220.0	31.92	0.40	30.6	10.00	15.85

Delmag D12 or similar hammer is suitable for driving piles at End Bent No. 2 LT

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins
and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity - blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They MUST be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of building and other factors.

```
 Input  File: C:\USERS\KDEMONTBRUN\ONEDRIVE - ECS CORPORATE SERVICES\09 PROJECTS
27500 - 29999\29500-29999\09-29662 BRIDGE 063 ON NC 88 OVER CRANBERRY CREEK
\ANALYSIS\WEAP\EB2 - LT_D12.GWW
 Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
 Hammer File Version:  2003 (12/4/2018)

                      Input File Contents
    Bridge No. 063 - EB2 - LT
 OUT OSG HAM STR FUL PEL  N SPL N-U P-D %SK ISM  0 PHI RSA ITR H-D MXT     DEx
   6   0   3  -2   1   0  0   0   0   0   9   1  0   0   0   0   0   0   0.000
    Pile g  Hammer g  Toe Area Pile Size           Pile Type
    32.185    32.185   141.890    12.040              H Pile
      W Cp       A Cp       E Cp       T Cp       CoR       ROut       StCp
     1.900    227.000      530.0      2.000     0.800      0.010        0.0
      A Cu       E Cu       T Cu        CoR       ROut       StCu
     0.000        0.0      0.000      0.000      0.000        0.0
      LPle       APle       EPle       WPle       Peri         CI        CoR       ROut
    20.000      15.50    30457.9    493.356      3.970          0      0.850      0.010
 FFatigue         F0  0-Bottom
         0     0.000      0.000
 Manufac  Hmr Name  HmrType No Seg-s
 DELMAG   D 12            1        4
    Ram Wt     Ram L    Ram Dia    MaxStrk    RtdStrk     Efficy
      2.75    104.41      11.81      10.80       8.22       0.80
    IB. Wt     IB. L     IB.Dia     IB CoR      IB RO
      0.81     21.27      11.81      0.900      0.010
 CompStrk A Chamber V Chamber    C Delay  C Duratn Exp Coeff VolCStart  Vol CEnd
    11.07    109.60      97.00     0.0020    0.0020     1.250       0.00       0.00
     P atm        P1         P2         P3         P4         P5
    14.70   1380.00       0.00       0.00       0.00       0.00
    Stroke     Effic.  Pressure  R-Weight   T-Delay Exp-Coeff   Eps-Str  Total-AW
    5.5000     0.8000 1380.0000     0.0000     0.0000     0.0000     0.0100     0.0000
        Qs         Qt         Js         Jt         Qx         Jx       Rati       Dept
     0.100      0.100      0.170      0.100      0.000      0.000      0.000      0.000
 Research Soil Model: Atoe, Plug,  Gap, Q-fac
     0.000      0.000      0.000      0.000
 Research Soil Model: RD-skn: m, d, toe: m, d
     0.000      0.000      0.000      0.000
 Research Toe Plug: Res-int, Q-int, D-int, Res-plug, Q-plug, D-plug
     0.000      0.000      0.000      0.000      0.000      0.000
 Research Toe Plug: RD plug toe: m, d
     0.000      0.000
 Research Toe Plug: New Toe Plug Model is NOT applied
 Res. Distribution
    Dpth     Rskn       Dpth     Dpth
    0.00     0.00      17.30    17.30     0.00     0.00     0.00    0.00    0.00    0.000
    7.20     0.18       0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.000
    7.20     0.15       0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.000
   11.70     0.17       0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.000
   11.70     0.54       0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.000
   17.20     0.80       0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.000
   17.20     1.61       0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.000
   20.00     1.61       0.00     0.00     0.00     0.00     0.00    0.00    0.00    0.000
 Rult
  220.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0      0.0
```

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

Bridge No. 063 - EB2 - LT

Hammer Model: D 12 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.688				
2	0.688	121704.2	1.000	0.0000	
3	0.688	121704.2	1.000	0.0000	
4	0.688	121704.2	1.000	0.0000	
Imp Block	0.810	67059.7	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0098	5.2
Combined Pile Top		11802.4			

HAMMER OPTIONS:

Hammer File ID No.	3	Hammer Type	OE Diesel
Stroke Option	Var.P-IC	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	2.75	Ram Length	(inch)	104.41
Maximum Stroke	(ft)	10.80			
Rated Stroke	(ft)	8.22	Efficiency		0.800
Maximum Pressure	(psi)	1380.00	Actual Pressure	(psi)	1380.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	11.81			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		0.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

PILE PROFILE:

Toe Area	(in2)	141.890	Pile Type		H Pile
Pile Size	(inch)	12.040			

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	C Index	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	30458.	493.4	4.0	0	16911.	27.9
20.0	15.50	30458.	493.4	4.0	0	16911.	27.9

Wave Travel Time 2L/c (ms) 2.365

Pile and Soil Model — Total Capacity Rut (kips) 220.0

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.177	11802	0.010	0.000	0.85	0.0	0.170	0.100	3.33	4.0	15.5
2	0.177	11802	0.000	0.000	1.00	0.7	0.170	0.100	6.67	4.0	15.5
3	0.177	11802	0.000	0.000	1.00	1.7	0.170	0.100	10.00	4.0	15.5
4	0.177	11802	0.000	0.000	1.00	2.0	0.170	0.100	13.33	4.0	15.5
5	0.177	11802	0.000	0.000	1.00	5.8	0.170	0.100	16.67	4.0	15.5
6	0.177	11802	0.000	0.000	1.00	9.5	0.170	0.100	20.00	4.0	15.5
Toe						200.2	0.100	0.100			

1.062 kips total unreduced pile weight (g= 32.17 ft/s2)
1.063 kips total reduced pile weight (g= 32.19 ft/s2)

PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	17.30	Pile Damping Fact.(k/ft/s)	0.558
% Shaft Resistance	9		
Inspection Chart			
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.185	32.185
Output Segment Generation: Automatic			

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	316.6	0.00	20.42	10.12	0.379	7.32
2	-3.8	319.7	-0.25	20.63	10.06	0.362	7.16
3	-6.6	322.4	-0.42	20.80	10.01	0.344	6.96
4	-7.1	318.9	-0.46	20.57	10.26	0.327	6.73
5	-7.4	315.8	-0.48	20.38	10.65	0.309	6.42
6	-4.6	343.2	-0.30	22.14	9.43	0.292	6.16

(Eq) Return Strokes and Stroke Analyzed (ft):
6.26 5.42 5.50 5.50

Max. Combustion Pressure 1207.5 psi

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	337.1	0.00	21.75	10.90	0.411	8.46
2	-3.2	341.1	-0.20	22.00	10.88	0.394	8.30
3	-5.2	343.2	-0.34	22.14	10.83	0.376	8.08
4	-5.7	340.4	-0.37	21.96	11.07	0.359	7.84
5	-6.3	331.3	-0.41	21.38	11.54	0.342	7.51
6	-3.9	363.0	-0.25	23.42	10.12	0.325	7.22

(Eq) Return Strokes and Stroke Analyzed (ft):
6.20 6.00 6.00

Max. Combustion Pressure 1334.5 psi

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	356.4	0.00	22.99	11.65	0.437	9.44
2	-3.0	360.0	-0.19	23.22	11.61	0.420	9.28
3	-4.9	363.2	-0.32	23.43	11.55	0.402	9.06
4	-5.6	360.0	-0.36	23.23	11.81	0.385	8.80
5	-6.1	345.7	-0.39	22.30	12.32	0.368	8.44
6	-3.8	382.1	-0.24	24.65	10.80	0.350	8.14

(Eq) Return Strokes and Stroke Analyzed (ft):
6.15 6.50

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	375.1	0.00	24.20	12.37	0.458	10.33
2	-3.0	378.9	-0.19	24.45	12.34	0.441	10.17
3	-5.0	382.2	-0.32	24.66	12.27	0.424	9.94
4	-5.8	379.4	-0.38	24.48	12.54	0.407	9.67
5	-6.3	361.3	-0.40	23.31	13.09	0.390	9.29
6	-3.9	399.5	-0.25	25.77	11.42	0.372	8.97

(Eq) Return Strokes and Stroke Analyzed (ft):
6.11 7.00

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	393.0	0.00	25.35	13.04	0.481	11.28
2	-3.0	397.5	-0.19	25.65	13.04	0.464	11.11
3	-5.0	400.0	-0.32	25.80	12.97	0.447	10.88
4	-5.7	397.9	-0.37	25.67	13.23	0.430	10.60
5	-6.2	378.3	-0.40	24.41	13.82	0.412	10.19
6	-3.9	416.6	-0.25	26.88	12.00	0.395	9.85

(Eq) Return Strokes and Stroke Analyzed (ft):
6.05 7.50

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	409.8	0.00	26.44	13.70	0.502	12.20
2	-3.0	414.2	-0.20	26.73	13.68	0.485	12.03
3	-5.0	418.1	-0.32	26.97	13.61	0.468	11.79
4	-5.7	415.4	-0.37	26.80	13.88	0.450	11.49
5	-6.1	395.7	-0.40	25.53	14.52	0.433	11.06
6	-3.9	432.0	-0.25	27.87	12.57	0.416	10.71

(Eq) Return Strokes and Stroke Analyzed (ft):
6.01 8.00

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	426.0	0.00	27.48	14.32	0.522	13.12
2	-3.1	431.0	-0.20	27.80	14.30	0.505	12.95
3	-5.0	435.0	-0.32	28.06	14.23	0.488	12.69
4	-5.6	432.2	-0.36	27.88	14.51	0.471	12.39
5	-6.1	412.0	-0.39	26.58	15.18	0.453	11.93
6	-3.9	449.8	-0.25	29.02	13.11	0.436	11.56

(Eq) Return Strokes and Stroke Analyzed (ft):
5.97 8.50

Max. Combustion Pressure 1380.0 psi

Bridge No. 063 - EB2 - LT 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	441.4	0.00	28.48	14.89	0.542	14.02
2	-3.1	447.6	-0.20	28.88	14.91	0.525	13.84
3	-5.1	451.2	-0.33	29.11	14.87	0.507	13.58
4	-5.7	447.2	-0.37	28.85	15.11	0.490	13.26
5	-6.1	427.6	-0.40	27.59	15.77	0.473	12.78
6	-3.9	463.9	-0.25	29.93	13.65	0.455	12.39

(Eq) Return Strokes and Stroke Analyzed (ft):
5.93 9.00

Max. Combustion Pressure 1380.0 psi

Bridge No. 063 - EB2 - LT 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	456.3	0.00	29.44	15.49	0.560	14.91
2	-3.1	462.9	-0.20	29.87	15.48	0.543	14.73
3	-5.1	467.1	-0.33	30.13	15.44	0.526	14.46
4	-5.7	464.0	-0.37	29.94	15.69	0.508	14.12
5	-6.2	443.0	-0.40	28.58	16.43	0.491	13.61
6	-4.0	479.2	-0.26	30.92	14.13	0.473	13.21

(Eq) Return Strokes and Stroke Analyzed (ft):
5.90 9.50

Max. Combustion Pressure 1380.0 psi

Rut= 220.0, Rtoe = 200.2 kips, Time Inc. =0.076 ms

No	mxTForce kips	mxCForce kips	mxTStrss ksi	mxCStrss ksi	max V ft/s	max D inch	max Et kip-ft
1	0.0	471.7	0.00	30.43	16.05	0.580	15.85
2	-3.2	477.8	-0.20	30.82	16.08	0.563	15.67
3	-5.1	481.1	-0.33	31.04	16.02	0.545	15.38
4	-5.6	479.2	-0.36	30.91	16.28	0.528	15.03
5	-6.1	456.5	-0.40	29.45	17.02	0.510	14.50
6	-3.9	494.8	-0.25	31.92	14.59	0.492	14.07

(Eq) Return Strokes and Stroke Analyzed (ft):
5.86 10.00

Max. Combustion Pressure 1380.0 psi

Bridge No. 063 - EB2 - LT 09/09/2022
ECS Carolinas LLP GRLWEAP Version 2010

Rut kips	Bl Ct b/ft	Stroke (ft) down	Stroke (ft) up	Ten Str ksi	i	t	Comp Str ksi	i	t	ENTHRU kip-ft	Bl Rt b/min
220.0	62.5	5.50	5.50	-0.48	5	17	22.14	6	3	7.3	50.4
220.0	53.4	6.00	6.00	-0.41	5	17	23.42	6	3	8.5	48.3
220.0	47.9	6.50	6.15	-0.39	5	36	24.65	6	3	9.4	47.1
220.0	44.1	7.00	6.11	-0.40	5	36	25.77	6	3	10.3	46.3
220.0	40.7	7.50	6.05	-0.40	5	36	26.88	6	3	11.3	45.6
220.0	38.0	8.00	6.01	-0.40	5	36	27.87	6	3	12.2	44.9
220.0	35.7	8.50	5.97	-0.39	5	36	29.02	6	3	13.1	44.2
220.0	33.8	9.00	5.93	-0.40	5	36	29.93	6	3	14.0	43.6
220.0	32.1	9.50	5.90	-0.40	5	36	30.92	6	3	14.9	43.0
220.0	30.6	10.00	5.86	-0.40	5	18	31.92	6	3	15.9	42.5

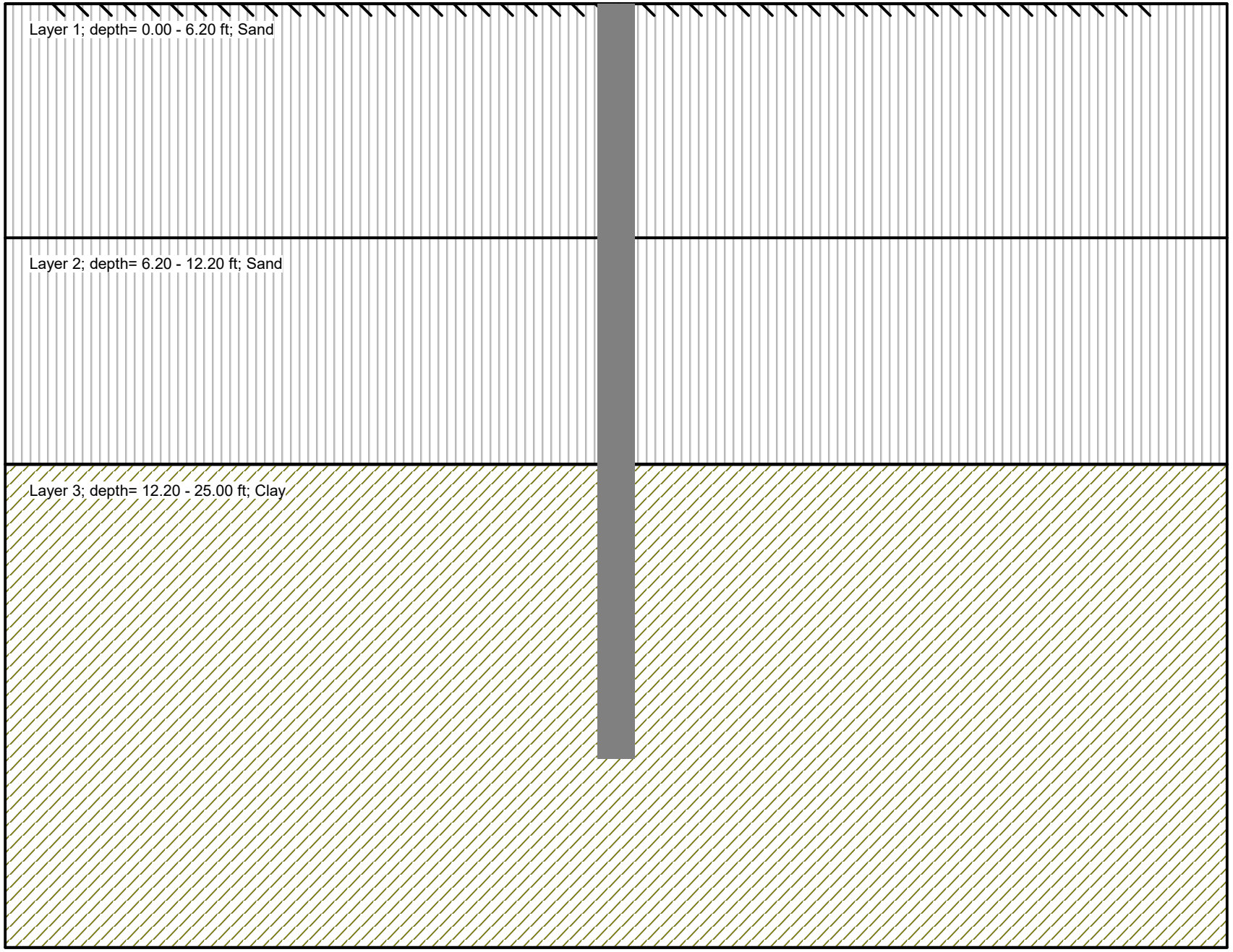
GEOTECHNICAL BORING REPORT
BORE LOG

WBS BP11.R003.1	**TIP** N/A	**COUNTY** ASHE	**GEOLOGIST** A. Blackmore	
SITE DESCRIPTION Bridge No. 063 on NC-88 over Cranberry Creek between SR 1614 and SR 1609				**GROUND WTR (ft)**
BORING NO. EB2-B	**STATION** 17+54	**OFFSET** 14 ft LT	**ALIGNMENT** -L-	**0 HR.** 15.1
COLLAR ELEV. 2,727.6 ft	**TOTAL DEPTH** 19.8 ft	**NORTHING** 977,757	**EASTING** 1,328,132	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE HPC2473 CME-550X 84% 04/19/2022		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER J. Cain	**START DATE** 07/11/22	**COMP. DATE** 07/11/22	**SURFACE WATER DEPTH** N/A	

ELEV (ft)	DRIVE ELEV (ft)	DEPTH (ft)	BLOW COUNT 0.5ft	0.5ft	0.5ft	BLOWS PER FOOT 0 25 50 75 100	SAMP. NO.	MOI	LOG	SOIL AND ROCK DESCRIPTION	ELEV. (ft)	DEPTH (ft)
2730						Avg BOC = 2721.3'						
										GROUND SURFACE	2,727.6	0.0
	2,726.5	1.1								**ROADWAY EMBANKMENT**	2,726.5	1.1
2725			3	2	4	6		M		Asphalt 0.7' Stone 0.4'	2,724.6	3.0
	2,724.1	3.5	3	5	2	7		M		Loose, Brown, Silty Fine to Coarse SAND (A-2-4), with trace rock fragments		
	2,721.6	6.0					BOC			~~Soft to Medium Stiff, Brown, Fine to Coarse~~		
2720			2	2	3	5 (7)		M		Sandy SILT (A-4), with trace rock fragments		
	2,719.1	8.5	2	2	2	4 (5) γ=120 φ=28		W				
2715							16.2					
	2,714.1	13.5	1	1	2	3 (4) γ=110 φ=26		W		**ALLUVIAL** Soft, Black, Fine to Coarse Sandy SILT (A-4), with trace mica and wood	2,715.1	12.5
2710							12.2					
	2,709.1	18.5									2,709.1	18.5
	2,707.8	19.8	47 60/0.0	53/0.4		100/0.9 60/0.0				**WEATHERED ROCK** (BIOTITE/HORNBLENDE GNEISS) Gray	2,707.8	19.8
										Boring Terminated with Standard Penetration Test Refusal at Elevation 2,707.8 ft On Crystalline Rock (BIOTITE/HORNBLENDE GNEISS)		

L = 20 Ft

End Bent No. 2 - RT



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APILE for Windows, Version 2019.9.10

Serial Number : 562476398

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.

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This program is licensed to :

ECS Carolinas, LLP
Charlotte, NC, USA

Path to file locations : C:\Users\kdemontbrun\OneDrive- ECS Corporate Services\09 Projects 27500-29999\29500-29999\09-29662 Bridge 063 on NC 88 over Cranberry Creek\Analysis\APile\
Name of input data file : EB2- RT.ap9d
Name of output file : EB2- RT.ap9o
Name of plot output file : EB2- RT.ap9p

Time and Date of Analysis

Date: September 08, 2022 Time: 08:42:40

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****
* INPUT INFORMATION *
****

Bridge No. 063 over Cranberry Creek

DESIGNER : KND

JOB NUMBER : 09:29662

METHOD FOR UNIT LOAD TRANSFERS :

- FHWA (Federal Highway Administration)
Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :

- FHWA (Federal Highway Administration)

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 = 0.00 FT.
- ZERO FRICTION LENGTH, ZFL = 0.00 FT.
- PERIMETER OF PILE = 47.65 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	Nq FACTOR FHWA
0.00	SAND	0.80*	120.00	28.00	22.80**
6.20	SAND	0.80*	120.00	28.00	22.80**
6.20	SAND	0.80*	47.60	26.00	17.40**
12.20	SAND	0.80*	47.60	26.00	17.40**
12.20	CLAY	0.80*	100.00	0.00	4.80**
25.00	CLAY	0.80*	100.00	0.00	4.80**

* 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*	200.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	200.00	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
6.20	1.000	1.000
6.20	1.000	1.000
12.20	1.000	1.000
12.20	1.000	1.000
25.00	1.000	1.000

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

****
* FED. HWY. METHOD *
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PILE PENETRATION FT.	SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	0.1	0.1
1.00	0.1	0.2	0.2
2.00	0.2	0.3	0.6
3.00	0.6	0.5	1.0
4.00	1.0	0.6	1.6
5.00	1.6	0.8	2.3
6.00	2.2	0.9	3.1

7.00	3.1	0.9	3.9
8.00	3.9	0.9	4.8
9.00	4.7	0.9	5.6
10.00	5.6	0.9	6.5
11.00	6.5	0.9	7.4
12.00	7.4	46.5	54.0
13.00	8.4	97.4	105.8
14.00	406.0	148.2	554.2
15.00	1200.2	193.7	1393.9
16.00	1994.4	193.7	2188.1
17.00	2788.5	193.8	2982.3
18.00	3582.7	193.7	3776.4
19.00	4376.8	193.7	4570.6
20.00	5171.0	193.7	5364.8

Factored Load = 65 tons/pile

By Inspection, pile should refuse 1 ft into weathered rock. Tip Elevation = 2,708.1 ft.

Pile Penetration = 13.2 ft

L = 15.2 ft, say average Pile Length = 20 ft.

Drive Piles to 65 tons/0.6 = 110 ton (220 kips)

For WEAP: 9k/220k = 4% skin

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.

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**********************************************
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING                      *
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T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.4167E-01		
			0.0000E+00	0.0000E+00
			0.2729E-02	0.2427E-01
			0.4548E-02	0.4702E-01
			0.6821E-02	0.8645E-01
			0.8186E-02	0.1213E+00
			0.9095E-02	0.1517E+00
			0.9095E-02	0.3033E+00
			0.9095E-02	0.4550E+00
			0.9095E-02	0.7584E+00
			0.9095E-02	0.3033E+01
2	10	0.3100E+01		
			0.0000E+00	0.0000E+00
			0.2030E+00	0.2427E-01
			0.3383E+00	0.4702E-01
			0.5075E+00	0.8645E-01
			0.6090E+00	0.1213E+00
			0.6767E+00	0.1517E+00
			0.6767E+00	0.3033E+00
			0.6767E+00	0.4550E+00
			0.6767E+00	0.7584E+00

		0.6767E+00	0.3033E+01
3	10	0.6158E+01	
		0.0000E+00	0.0000E+00
		0.4033E+00	0.2427E-01
		0.6721E+00	0.4702E-01
		0.1008E+01	0.8645E-01
		0.1210E+01	0.1213E+00
		0.1344E+01	0.1517E+00
		0.1344E+01	0.3033E+00
		0.1344E+01	0.4550E+00
		0.1344E+01	0.7584E+00
		0.1344E+01	0.3033E+01
4	10	0.6242E+01	
		0.0000E+00	0.0000E+00
		0.4087E+00	0.2427E-01
		0.6812E+00	0.4702E-01
		0.1022E+01	0.8645E-01
		0.1226E+01	0.1213E+00
		0.1362E+01	0.1517E+00
		0.1362E+01	0.3033E+00
		0.1362E+01	0.4550E+00
		0.1362E+01	0.7584E+00
		0.1362E+01	0.3033E+01
5	10	0.9200E+01	
		0.0000E+00	0.0000E+00
		0.4471E+00	0.2427E-01
		0.7451E+00	0.4702E-01
		0.1118E+01	0.8645E-01
		0.1341E+01	0.1213E+00
		0.1490E+01	0.1517E+00
		0.1490E+01	0.3033E+00
		0.1490E+01	0.4550E+00
		0.1490E+01	0.7584E+00
		0.1490E+01	0.3033E+01
6	10	0.1216E+02	
		0.0000E+00	0.0000E+00
		0.5137E+00	0.2427E-01
		0.8562E+00	0.4702E-01
		0.1284E+01	0.8645E-01
		0.1541E+01	0.1213E+00
		0.1712E+01	0.1517E+00
		0.1712E+01	0.3033E+00
		0.1712E+01	0.4550E+00
		0.1712E+01	0.7584E+00
		0.1712E+01	0.3033E+01
7	10	0.1224E+02	
		0.0000E+00	0.0000E+00
		0.5156E+00	0.2427E-01
		0.8593E+00	0.4702E-01
		0.1289E+01	0.8645E-01
		0.1547E+01	0.1213E+00
		0.1719E+01	0.1517E+00
		0.1547E+01	0.3033E+00

		0.1547E+01	0.4550E+00
		0.1547E+01	0.7584E+00
		0.1547E+01	0.3033E+01
8	10	0.1860E+02	
		0.0000E+00	0.0000E+00
		0.4167E+03	0.2427E-01
		0.6944E+03	0.4702E-01
		0.1042E+04	0.8645E-01
		0.1250E+04	0.1213E+00
		0.1389E+04	0.1517E+00
		0.1250E+04	0.3033E+00
		0.1250E+04	0.4550E+00
		0.1250E+04	0.7584E+00
		0.1250E+04	0.3033E+01
9	10	0.2496E+02	
		0.0000E+00	0.0000E+00
		0.4167E+03	0.2427E-01
		0.6944E+03	0.4702E-01
		0.1042E+04	0.8645E-01
		0.1250E+04	0.1213E+00
		0.1389E+04	0.1517E+00
		0.1250E+04	0.3033E+00
		0.1250E+04	0.4550E+00
		0.1250E+04	0.7584E+00
		0.1250E+04	0.3033E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0.0000E+00	0.0000E+00
0.1211E+02	0.7584E-02
0.2422E+02	0.1517E-01
0.4844E+02	0.3033E-01
0.9687E+02	0.1972E+00
0.1453E+03	0.6370E+00
0.1744E+03	0.1107E+01
0.1937E+03	0.1517E+01
0.1937E+03	0.2275E+01
0.1937E+03	0.3033E+01

LOAD VERSUS SETTLEMENT CURVE
****

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0.2400E+02	0.9807E-02	0.1597E+00	0.1000E-03
0.2890E+03	0.1182E+00	0.1597E+01	0.1000E-02

0.1296E+04	0.5386E+00	0.7984E+01	0.5000E-02
0.2155E+04	0.9092E+00	0.1597E+02	0.1000E-01
0.3149E+04	0.1361E+01	0.3194E+02	0.2000E-01
0.4182E+04	0.1885E+01	0.5415E+02	0.5000E-01
0.4611E+04	0.2131E+01	0.6286E+02	0.8000E-01
0.4781E+04	0.2238E+01	0.6866E+02	0.1000E+00
0.4850E+04	0.2381E+01	0.9719E+02	0.2000E+00
0.4774E+04	0.2644E+01	0.1302E+03	0.5000E+00
0.4800E+04	0.2957E+01	0.1554E+03	0.8000E+00
0.4812E+04	0.3164E+01	0.1677E+03	0.1000E+01
0.4838E+04	0.4178E+01	0.1937E+03	0.2000E+01

WEAP Parameter Calculation

Bent #: **EB2 - RT**

		Toe Quake	Shaft Quake
Pile Type:	HP 12X53	**0.10**	**0.10**

Subsurface Conditions: Loose/Soft or Submerged

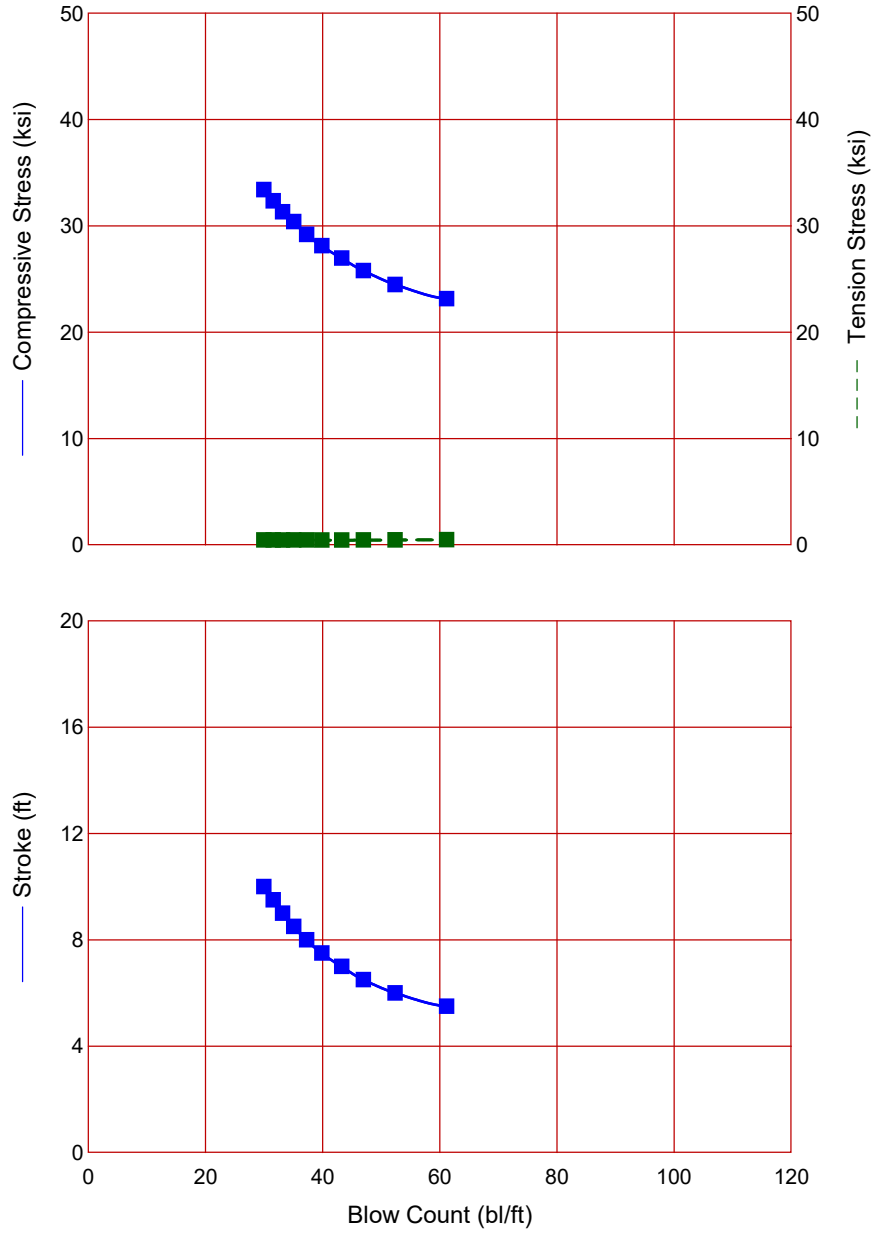
Layer #	Top	Bottom	Navg	Soil Type	Shaft Damping
1	2721.3	2715.1	6	Sand	0.20
2	2715.1	2709.1	4	Sand	0.20
3	2709.1	2708.1	100	WR	0.10
4					
5					
6					
7					
8					
9					
10					
11					
12					
13					
					0.19

Toe Damping
0.10

Length of Pile	13.2

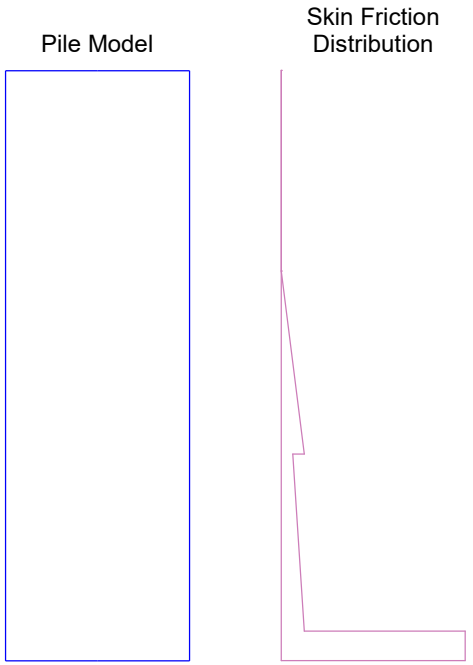
ECS Carolinas LLP
Bridge No. 063 - EB2 - RT

09-Sep-2022
GRLWEAP Version 2010



DELMAG D 12

Capacity	220.0	kips
Ram Weight	2.75	kips
Efficiency	0.800	
Pressure	1380 (100%)	psi
Helmet Weight	1.90	kips
Hammer Cushion	60155	kips/in
COR of H.C.	0.800	
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.190	s/ft
Toe Damping	0.100	s/ft
Pile Length	20.00	ft
Pile Penetration	13.20	ft
Pile Top Area	15.50	in2



Res. Shaft = 4 %
(Proportional)

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
220.0	23.14	0.49	61.2	5.50	7.36
220.0	24.48	0.47	52.4	6.00	8.50
220.0	25.79	0.46	47.0	6.50	9.49
220.0	26.96	0.46	43.3	7.00	10.38
220.0	28.12	0.46	39.9	7.50	11.33
220.0	29.19	0.46	37.3	8.00	12.25
220.0	30.39	0.46	35.1	8.50	13.18
220.0	31.32	0.46	33.2	9.00	14.09
220.0	32.35	0.46	31.6	9.50	14.98
220.0	33.40	0.46	30.0	10.00	15.92