STATE	STATE PROJECT REFERENCE NO.	SHEET NO.	TOTAL SHEETS
N.C.	17BP.12.R.35	1	13

PROJECT: 17BP.12.R.35 REFERENCE: N/A

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

STRUCTURE SUBSURFACE INVESTIGATION

COUNTY *Cleveland*

PROJECT DESCRIPTION *DIVISION 12 LOW IMPACT BRIDGE REPLACEMENT*

SITE DESCRIPTION *BRIDGE NO. 022135 ON SR 1330 (CRAWLEY GIN ROAD) OVER MAYNE CREEK*

CONTENTS

PERSONNEL

P. Weaver

E. Rogers

E. Estep

INVESTIGATED BY *ESP Associates, P.A.*

DRAWN BY *P. Petrucci*

CHECKED BY *P. Weaver*

SUBMITTED BY *ESP Associates, P.A.*

DATE *May, 2015*

CAUTION NOTICE

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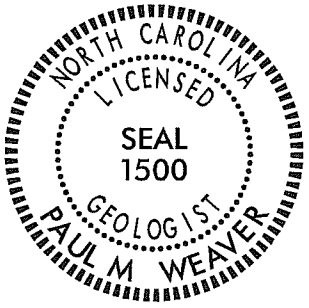

SIGNATURE 5/21/2015 DATE

PROJECT REFERENCE NO.	SHEET NO.
17BP.12.R.35	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 EXCAVATION
- 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
w - 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
- [X] CME-55
- [ ] 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 [X] W/ ADVANCER
- [X] TRICONE 2 7/8" STEEL TEETH
- [ ] TRICONE _____ TUNG.-CARB.
- [ ] CORE BIT
- [ ] _____

HAMMER TYPE:
- [X] AUTOMATIC [ ] MANUAL

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

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

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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: BM #1: RR SPIKE IN SW ROOT OF 14" OAK
-L- STA. 16+94.50, 28.65' RT
ELEVATION: 800.43 FEET

NOTES:

F.I.A.D. = FILLED IMMEDIATELY AFTER DRILLING

DATE: 8-15-14

PROJECT REFERENCE NO.	SHEET NO.
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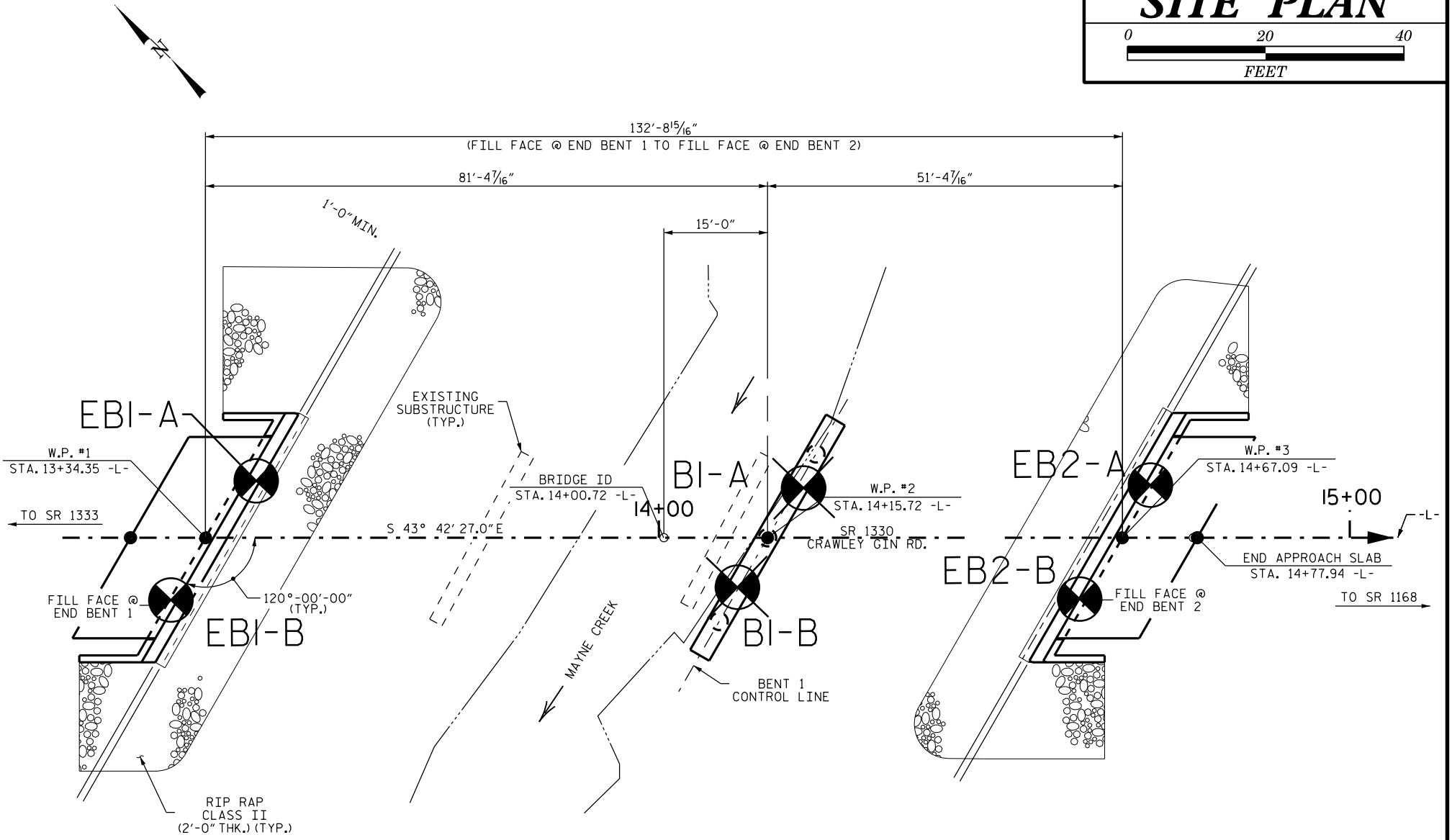
SITE PLAN

0 20 40

FEET



PLAN

PILES NOT SHOWN IN PLAN VIEW FOR CLARITY

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. EB1-A	**STATION** 13+42	**OFFSET** 8 ft LT	**ALIGNMENT** -L-	**0 HR.** 17.1
COLLAR ELEV. 788.1 ft	**TOTAL DEPTH** 30.8 ft	**NORTHING** 582,605	**EASTING** 1,198,142	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER Estep, E.	**START DATE** 05/15/15	**COMP. DATE** 05/15/15	**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)
790										
	788.1	0.0								GROUND SURFACE
	787.8	0.3								Asphalt
	787.2	0.9								Gravel Base
785	784.6	3.5	3	3	3	6		M		**ROADWAY EMBANKMENT** Red, Tan, and Brown; Medium Stiff; Coarse to Fine Sandy; Clayey SILT (A-5) with Gravel, Some Mica, and Trace Organics
780	779.1	9.0	3	3	3	6		M		**ALLUVIAL** Brown and Red, Loose, Silty, Fine SAND (A-3) with Trace Clay
775	774.6	13.5	1	2	2	4		W		
770	769.1	19.0	5	6	10	16		W		**RESIDUAL** Brown, Red, and White; Medium Dense; Coarse to Find SAND and Rock Fragments (A-1-b), Highly Micaceous with Trace Silt
765	765.1	23.0	100/0.3			100/0.3				**WEATHERED ROCK** Tan, Orange, and White; QUARTZ SCHIST
760	759.6	28.5	100/0.5			100/0.5				
	757.3	30.8	60/0.0			60/0.0				Boring Terminated with Standard Penetration Test Refusal at Elevation 757.3 ft On CRYSTALLINE ROCK: QUARTZ SCHIST

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. EB1-B	**STATION** 13+29	**OFFSET** 9 ft RT	**ALIGNMENT** -L-	**0 HR.** 19.0
COLLAR ELEV. 788.2 ft	**TOTAL DEPTH** 42.6 ft	**NORTHING** 582,602	**EASTING** 1,198,121	**24 HR.** 17.0
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER Estep, E.	**START DATE** 05/13/15	**COMP. DATE** 05/13/15	**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)
790										788.2 GROUND SURFACE	0.0
										787.8	0.4
										787.4 Asphalt / Sand Base	0.8
785	784.7	3.5	2	3	4	7		M		Red to Tan Brown, Medium Stiff, Coarse to Fine Sandy, Clayey SILT (A-5) with Some Gravel and Mica and with Trace Organics	
780	779.7	8.5	2	2	3	5		W		779.2 **ALLUVIAL** Reddish Brown, Loose, Silty, Fine SAND (A-3) with Trace Organics and Clay	9.0
775	774.7	13.5	4	6	9	15		W		774.2 **RESIDUAL** Tan, Red, and Brown; Medium Dense; Silty; Fine SAND (A-3) with Little Mica	14.0
770	769.7	18.5	20	11	5	16		W		769.2 Brown, Red, Black, and White; Medium Dense; Coarse to Fine SAND and Rock Fragment (A-1-b); Highly Micaceous	19.0
765	764.7	23.5	15	16	29	45		M			
760	759.7	28.5	100/0.4			100/0.4				760.2 **WEATHERED ROCK** White, Gray, Red, and Brown; MICA SCHIST	28.0
755	754.6	33.6	100/0.2			100/0.2					
750	749.7	38.5	100/0.2			100/0.2					
	745.6	42.6	60/0.0			60/0.0				745.6 Boring Terminated with Standard Penetration Test Refusal at Elevation 745.6 ft On CRYSTALLINE ROCK: MICA SCHIST	42.6

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. B1-A	**STATION** 14+21	**OFFSET** 7 ft LT	**ALIGNMENT** -L-	**0 HR.** 0.4
COLLAR ELEV. 768.5 ft	**TOTAL DEPTH** 21.0 ft	**NORTHING** 582,547	**EASTING** 1,198,196	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER Estep, E.	**START DATE** 05/14/15	**COMP. DATE** 05/14/15	**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)
790											
785											
780											
775											
770											
										768.5 GROUND SURFACE	0.0
765	765.0	3.5	8	100/0.3		100/0.3				**ALLUVIAL** Tan, Brown, and Orange; Fine to Coarse SAND and Gravel (A-1-b) - Saturated	
										764.5	4.0
										764.0 **CRYSTALLINE ROCK** White and Black, BIOTITE GNEISS	4.5
760	760.0	8.5	60/0.0			60/0.0				White and Black, BIOTITE GNEISS	
										760.0	8.5
										758.4 Black with White, Moderately to Slightly Weathered, Moderately Hard to Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing	10.1
755										Black with White, Very Slightly Weathered to Fresh, Hard, BIOTITE GNEISS with Moderately Close to Wide Fracture Spacing	
750											
										747.5	21.0
										Boring Terminated at Elevation 747.5 ft In CRYSTALLINE ROCK: BIOTITE GNEISS	

NCDOT GEOTECHNICAL ENGINEERING UNIT
CORE BORING REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. B1-A	**STATION** 14+21	**OFFSET** 7 ft LT	**ALIGNMENT** -L-	**0 HR.** 0.4
COLLAR ELEV. 768.5 ft	**TOTAL DEPTH** 21.0 ft	**NORTHING** 582,547	**EASTING** 1,198,196	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER Estep, E.	**START DATE** 05/14/15	**COMP. DATE** 05/14/15	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 12.5 ft			

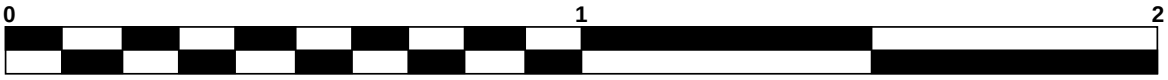
ELEV (ft)	RUN ELEV (ft)	DEPTH (ft)	RUN (ft)	DRILL RATE (Min/ft)	RUN REC. (ft) %	RUN RQD (ft) %	SAMP. NO.	STRATA REC. (ft) %	STRATA RQD (ft) %	LOG	DESCRIPTION AND REMARKS
											ELEV. (ft) / DEPTH (ft)
760											Begin Coring @ 8.5 ft
	760.0	8.5	2.5	*N=60/0.0*	(2.0)	(0.8)		(1.1)	(0.0)		760.0 / 8.5 Black with White, Moderately to Slightly Weathered, Moderately Hard to
	757.5	11.0		5:22 5:36	80%	32%		69%	0%		758.4 / 10.1 Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing
			5.0	2:05/0.5	(5.0)	(4.4)		(10.6)	(9.9)		Black with White, Very Slightly Weathered to Fresh, Hard, BIOTITE GNEISS
755				2:52 3:54 4:23 5:05	100%	88%		97%	91%		with Moderately Close to Close Fracture Spacing Note: 3 Joints @ 10 degrees to 20 degrees 5 Joints @ 0 degrees to 10 degrees
	752.5	16.0		3:58							
			5.0	3:44	(4.7)	(4.7)					
750				3:58 4:08 4:19	94%	94%					
	747.5	21.0		4:30							747.5 / 21.0 Boring Terminated at Elevation 747.5 ft In CRYSTALLINE ROCK: BIOTITE GNEISS

CORE PHOTOGRAPH

WBS No. 17BP.12.R.35

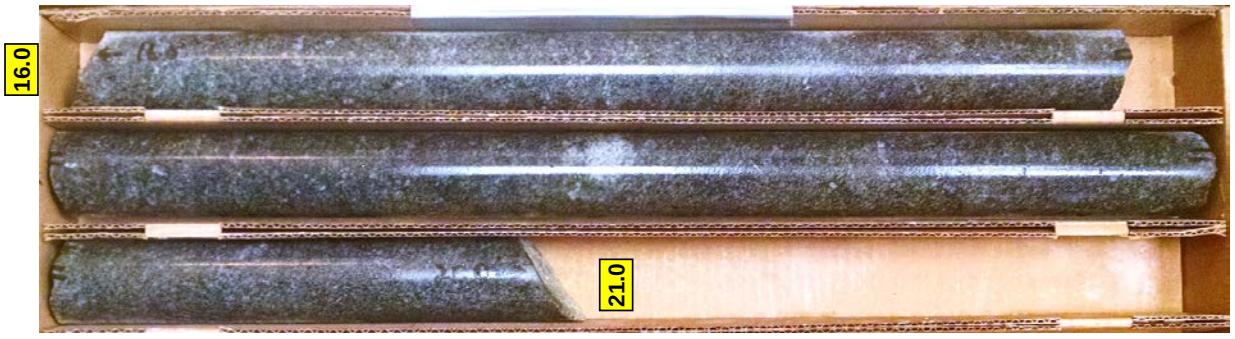
Project Description: Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek
Cleveland County, North Carolina

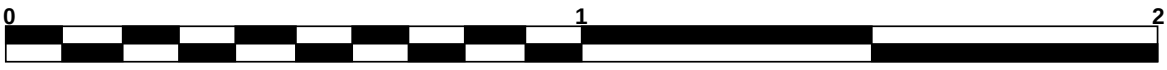
B1- A
8.5 Feet to 16.0 Feet



FEET

B1- A
16.0 Feet to 21.0 Feet





FEET

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. B1-B	**STATION** 14+11	**OFFSET** 7 ft RT	**ALIGNMENT** -L-	**0 HR.** 0.3
COLLAR ELEV. 768.4 ft	**TOTAL DEPTH** 36.5 ft	**NORTHING** 582,544	**EASTING** 1,198,179	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** Mud Rotary	**HAMMER TYPE** Automatic	
DRILLER Estep, E.	**START DATE** 05/12/15	**COMP. DATE** 05/27/01	**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)
790											
785											
780											
775											
770											
										768.4 GROUND SURFACE	0.0
765	764.9	3.5	9	13	14	27		Sat.		**ALLUVIAL** Tan and Brown to Orange, Fine to Coarse SAND and Gravel (A-1-b) 764.4	4.0
760	759.9	8.5	100/0.2			100/0.2				**RESIDUAL** Red Brown, Very Stiff, Coarse to Fine Sandy SILT (A-4) with Rock Fragments and Some Mica 760.1	8.3
755	754.9	13.5	60/0.1			60/0.1		Lost All Circulation at Top of Crystalline Rock		**WEATHERED ROCK** Dark Gray with White, PHYLLITE with Amphibolite Inclusions 757.4	11.0
750	749.9	18.5	60/0.0			60/0.0				**CRYSTALLINE ROCK** Dark Gray with White, PHYLLITE with Amphilolite Inclusions 749.9	18.5
745										Dark Gray with White, Moderately to Slightly Weathered, Moderately Hard to Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing and with Isolated Garnet 743.2	25.2
740										White and Dark Gray, Slightly Weathered, Moderately Hard to Hard, Schistosic BIOTITE MICA GNEISS with Close to Moderately Close Fracture Spacing 736.9	31.5
735										White and Dark Gray, Very Slightly Weathered to Fresh, Hard to Very Hard, BIOTITE GNEISS with Moderately Close Fracture Spacing 731.9	36.5
										Boring Terminated at Elevation 731.9 ft In CRYSTALLINE ROCK: BIOTITE GNEISS	

NCDOT GEOTECHNICAL ENGINEERING UNIT
CORE BORING REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. B1-B	**STATION** 14+11	**OFFSET** 7 ft RT	**ALIGNMENT** -L-	**0 HR.** 0.3
COLLAR ELEV. 768.4 ft	**TOTAL DEPTH** 36.5 ft	**NORTHING** 582,544	**EASTING** 1,198,179	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** Mud Rotary		**HAMMER TYPE** Automatic
DRILLER Estep, E.	**START DATE** 05/12/15	**COMP. DATE** 05/27/01	**SURFACE WATER DEPTH** N/A	
CORE SIZE NQ	**TOTAL RUN** 18.0 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
											ELEV. (ft) DEPTH (ft)
749.9											Begin Coring @ 18.5 ft
	749.9	18.5	3.0	*N=60/0.0* 1:29 2:21 2:28	(2.8) 93%	(1.4) 47%		(5.7) 85%	(2.0) 30%		749.9 Dark Gray with White, Moderately to Slightly Weathered, Moderately Hard to Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing and with Isolated Garnet 18.5 Note: Some High Angle to Near Vertical Fractures
	746.9	21.5									
745			5.0	2:51 2:54 5:51 5:29	(4.2) 84%	(1.0) 20%					743.2 25.2
	741.9	26.5		4:07				(6.3) 100%	(4.9) 78%		White and Dark Gray, Slightly Weathered, Moderately Hard to Hard, Schistosic BIOTITE MICA GNEISS with Close to Moderately Close Fracture Spacing Note: 3 Joints @ 30 degrees to 40 degrees 10 Joines @ 0 degrees to 10 degrees
740			5.0	4:15 3:57 2:24 2:31	(5.0) 100%	(4.5) 90%					
	736.9	31.5		1:51							736.9 31.5
735			5.0	3:05 2:31 3:97 7:52	(5.0) 100%	(4.7) 94%		(5.0) 100%	(4.7) 94%		White and Dark Gray, Very Slightly Weathered to Fresh, Hard to Very Hard, BIOTITE GNEISS with Moderately Close Fracture Spacing Note: Bottom 2 Feet is Well Foliated with Foliation Angles Near 0 Degrees
	731.9	36.5		7:53							731.9 36.5 Boring Terminated at Elevation 731.9 ft In CRYSTALLINE ROCK: BIOTITE GNEISS

CORE PHOTOGRAPH

WBS No. 17BP.12.R.35

Project Description: Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek

Cleveland County, North Carolina

B1- B

18.5 Feet to 26.5 Feet

B1- B

26.5 Feet to 36.5 Feet

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. EB2-A	**STATION** 14+71	**OFFSET** 8 ft LT	**ALIGNMENT** -L-	**0 HR.** Dry
COLLAR ELEV. 788.6 ft	**TOTAL DEPTH** 16.5 ft	**NORTHING** 582,511	**EASTING** 1,198,231	**24 HR.** FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER Estep, E.	**START DATE** 05/15/15	**COMP. DATE** 05/15/15	**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)
790											
										788.6 GROUND SURFACE	0.0
										788.3	0.3
										787.9 Asphalt / Sand Base	0.7
785	785.1	3.5	3	4	4	8		M		**ROADWAY EMBANKMENT** Red, Tan, and Brown; Medium Stiff to Stiff; Coarse to Fine Sandy; Clayey SILT (A-5) with Gravel and Some Mica	
780	780.1	8.5	2	4	4	8		M		779.6	9.0
										ALLUVIAL Brown and Red, Loose, Silty, Fine SAND (A-3) with Trace Organics	
775	775.1	13.5								775.6	13.0
	774.4	14.2	100/0.3			100/0.3				**WEATHERED ROCK** White, Gray, and Brown; MICA SCHIST	
	772.1	16.5	100/0.2			100/0.2				772.1	16.5
			60/0.0			60/0.0				Boring Terminated with Standard Penetration Test Refusal at Elevation 772.1 ft On CRYSTALLINE ROCK: MICA SCHIST	

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	**TIP** N/A	**COUNTY** CLEVELAND	**GEOLOGIST** Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				**GROUND WTR (ft)**
BORING NO. EB2-B	**STATION** 14+61	**OFFSET** 9 ft RT	**ALIGNMENT** -L-	**0 HR.** 19.0
COLLAR ELEV. 788.4 ft	**TOTAL DEPTH** 19.5 ft	**NORTHING** 582,507	**EASTING** 1,198,212	**24 HR.** 17.0
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		**DRILL METHOD** H.S. Augers	**HAMMER TYPE** Automatic	
DRILLER Estep, E.	**START DATE** 05/13/15	**COMP. DATE** 05/13/15	**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)
790											
										788.4 GROUND SURFACE	0.0
										788.1 Asphalt	0.3
										787.7 Sand Base	0.7
785	784.9	3.5	3	2	1	3		M		**ROADWAY EMBANKMENT** Red to Tan Brown, Soft , Coarse to Fine Sandy, Clayey SILT (A-5) with Gravel and Some Mica	
780	779.9	8.5	3	3	3	6		M		780.4 **ALLUVIAL** Brown and Red, Loose, Silty, Fine SAND (A-3) with Trace Organics	8.0
775	774.9	13.5	30	47	15	62		M		775.4 **RESIDUAL** White, Brown, and Red; Very Dense; Coarse to Fine SAND and Rock Fragments (A-1-b) with Little Mica	13.0
770	769.9	18.5								770.4	18.0
	768.9	19.5	100/0.5			100/0.5				768.9 **WEATHERED ROCK** Red, Brown, and Black; MICA SCHIST	19.5
			60/0.0			60/0.0				Boring Terminated with Standard Penetration Test Refusal at Elevation 768.9 ft On CRYSTALLINE ROCK: MICA SCHIST	

ESP Associates, P.A.	Job No.:	17BP.12.R.35	Sheet		of
	Task:	Foundation Recs		Phase	
	Job Name:	Bridge # 135 over Mayne Creek on SR 1330			
	By:	grt	Date:	5/19/2015	
	Checked By:	ab	Date:	6/4/2015	

CALCULATIONS

ESP Associates, P.A.	Job No.:	17BP.12.R.35	Sheet		of
	Task:	Foundation Recs	Phase		
	Job Name:	Bridge # 135 over Mayne Creek on SR 1330			
	By:	grt	Date:	5/19/2015	
	Checked By:	ab	Date:	6/4/2015	

End Bent 1

Reference AASHTO LRFD and NCDOT LRFD Driven Pile Foundation Policy (6th Update)

Bottom of Cap Elev = 785.46

No. of Piles = 3 Vertical, 2 Brace

Pile Type = HP 12x53

Factored axial load = 236 k = 118 t, Use 118 tons

Axial Capacity

Piles will attain most of axial resistance from end bearing on weathered rock

Top of weathered rock elev: EB1-A = 765.1', EB1-B = 760.2'

Pile length to top of weathered rock: EB1-A = 20.5', EB1-B = 25.5'

Assume piles will be driven 1' into weathered rock

Pile length left = 20.5 + 1 +1 = 22.5', Say 25', length includes 1 foot embedment into cap

Pile length right = 25.5 + 1 +1 = 27.5', Say 30', length includes 1 foot embedment into cap

Weap Analysis

Required driving resistance = 236/0.6 = 393 k, Say 400 kips = 200 tons

Driving resistance factor = 0.6, (NCDOT Driven Pile Policy Article 3.2.1)

Min blow count = 30 bpf, Max blow count = 180 bpf, Max comp. stress = 0.9 Fy = 0.9 x 50 = 45 ksi

Average pile penetration = 24'

Assume 10% skin resistance

Results:

Delmag D 19-32 (42.4 ft-kip): Max comp stress = 38.1 ksi, Blow counts = 87 bpf, OK

Since D 19-32 hammer works, no hammer energy range note required.

Miscellaneous

End slopes of 1.5:1 are ok by inspection

No downdrag due to minimal added embankment and immediate settlement

No waiting periods before driving piles

Pile points are required due to rock fragments and shallow weathered rock

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

DRAFT

WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek			GROUND WTR (ft)
BORING NO. EB1-A	STATION 13+42	OFFSET 8 ft LT	ALIGNMENT -L-	0 HR. 17.1
COLLAR ELEV. 788.1 ft	TOTAL DEPTH 30.8 ft	NORTHING N/A	EASTING N/A	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD H.S. Augers	HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/15/15	COMP. DATE 05/15/15	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
						EG 792.88'				ELEV. (ft) DEPTH (ft)
790										
	788.1	0.0								GROUND SURFACE 0.0
	787.7	0.4								Asphalt 0.4
	787.2	0.9								Gravel Base
785	784.6	3.5	3	3	3	6		M		**ROADWAY EMBANKMENT** Red, Tan, and Brown; Medium Stiff; Coarse to Fine Sandy; Clayey SILT (A-5) with Gravel, Some Mica, and Trace Organics
780	779.5	8.6	3	3	3	6		M		
	779.1	9.0								**ALLUVIAL** Brown and Red, Loose, Silty, Fine SAND (A-3) with Trace Clay
775	774.6	13.5	1	2	2	4		W		
770	769.6	18.5	5	6	10	16		W		
	769.1	19.0								**RESIDUAL** Brown, Red, and White; Medium Dense; Coarse to Find SAND and Rock Fragments (A-1-b), Highly Micaceous with Trace Silt
765	765.1	23.0	100/0.3			100/0.3				**WEATHERED ROCK** Tan, Orange, and White; QUARTZ SCHIST
760	759.6	28.5	100/0.5			100/0.5				
	757.3	30.8	60/0.0			60/0.0				Boring Terminated with Standard Penetration Test Refusal at Elevation 757.3 ft On CRYSTALLINE ROCK: QUARTZ SCHIST

BOC 785.44'

20.5'

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

SHEET

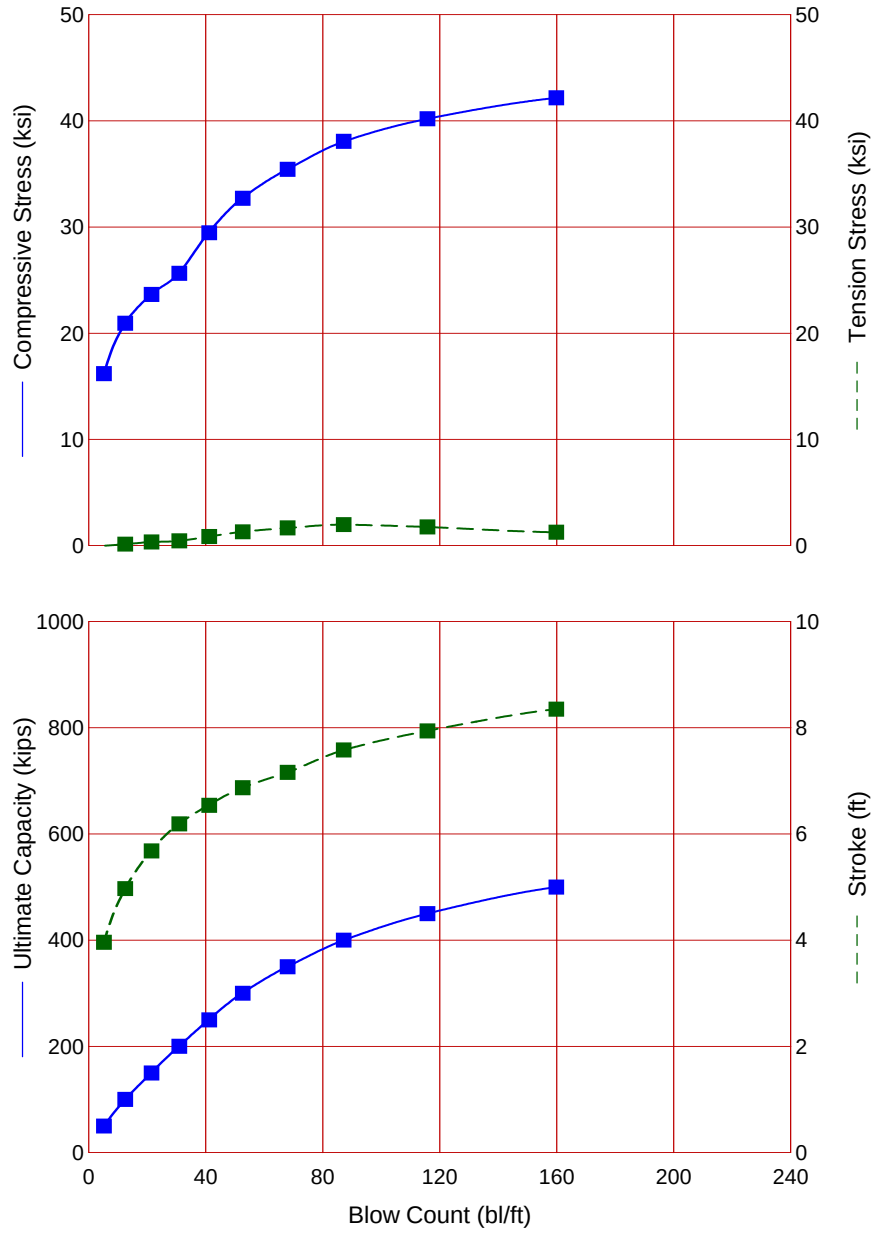
WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				GROUND WTR (ft)
BORING NO. EB1-B	STATION 13+29	OFFSET 9 ft RT	ALIGNMENT -L-	0 HR. 19.0
COLLAR ELEV. 788.2 ft	TOTAL DEPTH 42.6 ft	NORTHING N/A	EASTING N/A	24 HR. 17.0
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD H.S. Augers		HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/13/15	COMP. DATE 05/13/15	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)
790						FG 792.88'				
										788.2 GROUND SURFACE 0.0
										787.8 0.4
										787.4 Asphalt 0.8
785						BOC 785.46'				Sand Base
	784.7	3.5	2	3	4	7		M		Red to Tan Brown, Medium Stiff, Coarse to Fine Sandy, Clayey SILT (A-5) with Some Gravel and Mica and with Trace Organics
780	779.7	8.5	2	2	3	5 10.5'		W		779.2 9.0
										ALLUVIAL
775	774.7	13.5								Reddish Brown, Loose, Silty, Fine SAND (A-3) with Trace Organics and Clay
			4	6	9	15		W		774.2 14.0
								W		RESIDUAL
770	769.7	18.5								Tan, Red, and Brown; Medium Dense; Silty; Fine SAND (A-3) with Little Mica
			20	11	5	16 15'		W		769.2 19.0
765	764.7	23.5								Brown, Red, Black, and White; Medium Dense; Coarse to Fine SAND and Rock Fragment (A-1-b); Highly Micaceous
			15	16	29	45		M		
760	759.7	28.5								760.2 28.0
			100/0.4			100/0.4				WEATHERED ROCK
755	754.6	33.6								White, Gray, Red, and Brown; MICA SCHIST
			100/0.2			100/0.2				
750	749.7	38.5								
			100/0.2			100/0.2				
	745.6	42.6								745.6 42.6
			60/0.0			60/0.0				Boring Terminated with Standard Penetration Test Refusal at Elevation 745.6 ft On CRYSTALLINE ROCK: MICA SCHIST

NCDOT BORE SINGLE BRIDGE 022135 GINT LOGS.GPJ NC_DOT.GDT 5/14/15

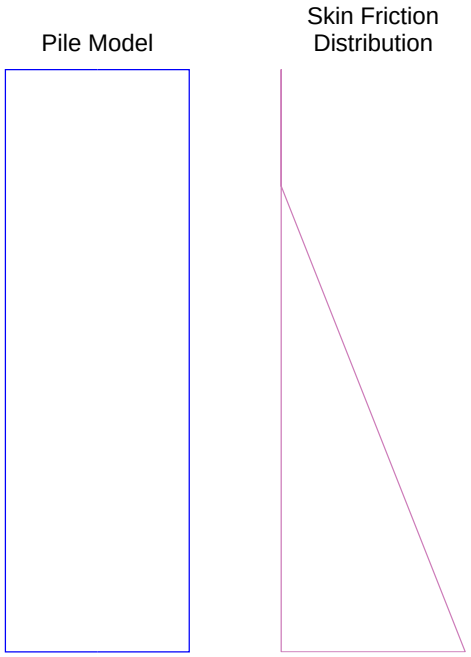
ESP Associates, P.A.
BR 135 EB1, D19-32

19-May-2015
GRLWEAP Version 2010



DELMAG D 19-32

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1275 (85%)	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	sec/ft
Toe Damping	0.100	sec/ft
Pile Length	30.00	ft
Pile Penetration	24.00	ft
Pile Top Area	15.60	in2



Res. Shaft = 10 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
50.0	16.20	0.00	5.2	3.96	16.60
100.0	20.93	0.14	12.5	4.97	14.35
150.0	23.65	0.35	21.5	5.68	13.46
200.0	25.64	0.45	31.0	6.19	13.33
250.0	29.46	0.86	41.2	6.54	13.37
300.0	32.69	1.30	52.7	6.87	13.75
350.0	35.43	1.67	68.0	7.16	14.14
400.0	38.05	1.98	87.2	7.58	14.79
450.0	40.18	1.76	115.8	7.94	15.39
500.0	42.16	1.27	159.9	8.35	16.09

ESP Associates, P.A.	Job No.:	17BP.12.R.35	Sheet		of
	Task:	Foundation Recs	Phase		
	Job Name:	Bridge # 135 over Mayne Creek on SR 1330			
	By:	grt	Date:	6/3/2015	
	Checked By:	ab	Date:	6/4/2015	

Bent 1

Reference AASHTO LRFD

Bottom of Cap Elev = 786.22'

No. of Columns = 3, Column Spacing = 11'

Column dia. = 30", Shaft dia. = 36"

Top of shaft elevation = 771' per Structure Design

Design Scour elevation = 764' (theoretical scour elev = 764.5')

Factored axial load = 689.4 kips = 344.7 tons, Use 345 tons/pier

Lateral Analysis

Use Lpile software, Check B1-B and B1-A

Model hard rock as stiff clay. C = 4000-8000 psf, E50 = 0.004, k = 2000 pci

Lpile results:

B1-A, Max top of col deflection = 0.7", Point of fixity elev = 756', Tip elev = 754' (2' below POF)

B1-B, Max top of col deflection = 0.9", Point of fixity elev = 751.5', Tip elev = 748'

Axial Analysis

Use NCDOT Drilled Pier Axial Resistance Spreadsheet, See attached.

Use rock strength from NCDOT's rock core database

Results

B1-A: Neglect side resistance. Required tip resistance = 230 ksf = 115 tsf left

B1-B: Required resistance = 715 k, Factored side resistance = 612 k < 715 k NG at tip elev = 746'

Remaining capacity will be derived from tip bearing on rock.

Reqd tip bearing = 716 - 612 = 104 k, 104k/6.31 = 17 ksf = 8.5 tsf, Say 30 tsf center and right

Summary

Minimum number of CSL tests = 1

Minimum rock socket = 10', left and 14' center and right

Min tip elev = 754' left, 746' center and right, Point of Fixity Elev = 756 left, 751.5 right'

Scour critical elevation = 762' , Assume 2' below design scour elev.

Permanent casing may be require. Minimum tip on weathered rock.

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				GROUND WTR (ft)
BORING NO. B1-A	STATION 14+21	OFFSET 7 ft LT	ALIGNMENT -L-	0 HR. 0.4
COLLAR ELEV. 768.5 ft	TOTAL DEPTH 21.0 ft	NORTHING 582,547	EASTING 1,198,196	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD Mud Rotary		HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/14/15	COMP. DATE 05/14/15	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)
790											
785						BOC 786.22'					
780						15'					
775											
770						TOS 771'					
										768.5 GROUND SURFACE	0.0
765	765.0	3.5	8	100/0.3		Des Scour				ALLUVIAL Tan, Brown, and Orange; Fine to Coarse SAND and Gravel (A-1-b) - Saturated	
						100/0.3				764.5	4.0
										764.0 CRYSTALLINE ROCK White and Black, BIOTITE GNEISS	4.5
760	760.0	8.5	60/0.0			60/0.0				White and Black, BIOTITE GNEISS 760.0	8.5
										758.4 Black with White, Moderately to Slightly Weathered, Moderately Hard to Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing	10.1
755						TIP				Black with White, Very Slightly Weathered to Fresh, Hard, BIOTITE GNEISS with Moderately Close to Wide Fracture Spacing	
750											
										747.5	21.0
										Boring Terminated at Elevation 747.5 ft In CRYSTALLINE ROCK: BIOTITE GNEISS	

NCDOT GEOTECHNICAL ENGINEERING UNIT
CORE BORING REPORT

WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				GROUND WTR (ft)
BORING NO. B1-A	STATION 14+21	OFFSET 7 ft LT	ALIGNMENT -L-	0 HR. 0.4
COLLAR ELEV. 768.5 ft	TOTAL DEPTH 21.0 ft	NORTHING 582,547	EASTING 1,198,196	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD Mud Rotary		HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/14/15	COMP. DATE 05/14/15	SURFACE WATER DEPTH N/A	
CORE SIZE NQ	TOTAL RUN 12.5 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
											ELEV. (ft) / DEPTH (ft)
760											Begin Coring @ 8.5 ft
	760.0	8.5	2.5	N=60/0.0 5:22 5:36	(2.0) 80%	(0.8) 32%		(1.1) 69%	(0.0) 0%		760.0 / 8.5 Black with White, Moderately to Slightly Weathered, Moderately Hard to Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing
	757.5	11.0	5.0	2:05/0.5 2:52 3:54 4:23 5:05 3:58	(5.0) 100%	(4.4) 88%		(10.6) 97%	(9.9) 91%		758.4 / 10.1 Black with White, Very Slightly Weathered to Fresh, Hard, BIOTITE GNEISS with Moderately Close to Close Fracture Spacing Note: 3 Joints @ 10 degrees to 20 degrees 5 Joints @ 0 degrees to 10 degrees
755											
	752.5	16.0	5.0	3:44 3:58 4:08 4:19	(4.7) 94%	(4.7) 94%					
750											
	747.5	21.0		4:30							747.5 / 21.0 Boring Terminated at Elevation 747.5 ft In CRYSTALLINE ROCK: BIOTITE GNEISS

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				GROUND WTR (ft)
BORING NO. B1-B	STATION 14+11	OFFSET 7 ft RT	ALIGNMENT -L-	0 HR. 0.3
COLLAR ELEV. 768.4 ft	TOTAL DEPTH 36.5 ft	NORTHING 582,544	EASTING 1,198,179	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD Mud Rotary		HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/12/15	COMP. DATE 05/27/01	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)
790												
785						BOC 786.22'						
780						15'						
775						TOS 771'						
770						7'					768.4	0.0
										GROUND SURFACE		
										ALLUVIAL: Tan and Brown to Orange, Fine to Coarse SAND and Gravel (A-1-b)	764.4	4.0
765	764.9	3.5	9	13	14	Design Scour 27		Sat.		RESIDUAL: Red Brown, Very Stiff, Coarse to Fine Sandy SILT (A-4) with Rock Fragments and Some Mica	760.1	8.3
760	759.9	8.5	100/0.2			4' 3' 100/0.2				WEATHERED ROCK: Dark Gray with White, PHYLLITE with Amphibolite Inclusions	757.4	11.0
755	754.9	13.5	60/0.1			4.5' 60/0.1		Lost All Circulation at Top of Crystalline Rock		CRYSTALLINE ROCK: Dark Gray with White, PHYLLITE with Amphilolite Inclusions	749.9	18.5
750	749.9	18.5	60/0.0			TIP 60/0.0				Dark Gray with White, Moderately to Slightly Weathered, Moderately Hard to Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing and with Isolated Garnet	743.2	25.2
745										White and Dark Gray, Slightly Weathered, Moderately Hard to Hard, Schistosic BIOTITE MICA GNEISS with Close to Moderately Close Fracture Spacing	736.9	31.5
740										White and Dark Gray, Very Slightly Weathered to Fresh, Hard to Very Hard, BIOTITE GNEISS with Moderately Close Fracture Spacing	731.9	36.5
735										Boring Terminated at Elevation 731.9 ft In CRYSTALLINE ROCK: BIOTITE GNEISS		

NCDOT GEOTECHNICAL ENGINEERING UNIT
CORE BORING REPORT

WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.	
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek				GROUND WTR (ft)
BORING NO. B1-B	STATION 14+11	OFFSET 7 ft RT	ALIGNMENT -L-	0 HR. 0.3
COLLAR ELEV. 768.4 ft	TOTAL DEPTH 36.5 ft	NORTHING 582,544	EASTING 1,198,179	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD Mud Rotary		HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/12/15	COMP. DATE 05/27/01	SURFACE WATER DEPTH N/A	
CORE SIZE NQ	TOTAL RUN 18.0 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
749.9											Begin Coring @ 18.5 ft
	749.9	18.5	3.0	N=60/0.0 1:29 2:21 2:28	(2.8) 93%	(1.4) 47%		(5.7) 85%	(2.0) 30%		749.9 Dark Gray with White, Moderately to Slightly Weathered, Moderately Hard to Hard, BIOTITE GNEISS with Very Close to Close Fracture Spacing and with Isolated Garnet 18.5 Note: Some High Angle to Near Vertical Fractures
	746.9	21.5	5.0	2:51 2:54 5:51 5:29 4:07	(4.2) 84%	(1.0) 20%					743.2 25.2
745	741.9	26.5						(6.3) 100%	(4.9) 78%		White and Dark Gray, Slightly Weathered, Moderately Hard to Hard, Schistosic BIOTITE MICA GNEISS with Close to Moderately Close Fracture Spacing Note: 3 Joints @ 30 degrees to 40 degrees 10 Joines @ 0 degrees to 10 degrees
			5.0	4:15 3:57 2:24 2:31 1:51	(5.0) 100%	(4.5) 90%					736.9 31.5
740	736.9	31.5									White and Dark Gray, Very Slightly Weathered to Fresh, Hard to Very Hard, BIOTITE GNEISS with Moderately Close Fracture Spacing Note: Bottom 2 Feet is Well Foliated with Foliation Angles Near 0 Degrees
			5.0	3:05 2:31 3:97 7:52 7:53	(5.0) 100%	(4.7) 94%		(5.0) 100%	(4.7) 94%		731.9 36.5
735	731.9	36.5									Boring Terminated at Elevation 731.9 ft In CRYSTALLINE ROCK: BIOTITE GNEISS

LPile Plus for Windows, Version 2012-06.037

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

This copy of LPile is licensed to:

ESP
Raleigh

Serial Number of Security Device: 162969677
Company Name Stored in Security Device: ESP Associates, PA

Files Used for Analysis

Path to file locations: G:\Projects\2013\BW17.300 (Div. 12 Low Impact Bridges)\17BP.12.R.35 (Bridge 022135)\Foundation Recommendations\Calculations\Lpile\
Name of input data file: Br 135 B1A.lp6d
Name of output report file: Br 135 B1A.lp6o
Name of plot output file: Br 135 B1A.lp6p
Name of runtime messeage file: Br 135 B1A.lp6r

Date and Time of Analysis

Date: June 5, 2015 Time: 14:02:20

Problem Title

Project Name: Div 12 LIBR

Job Number: 17BP.12.R.35

Client: Baker

Engineer: GRT

Description: BR 135 B1-B

Program Options

Engineering units are US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes pile response to lateral loading and will compute nonlinear moment-curvature and nominal moment capacity for section types with nonlinear properties.

Computation Options:
- Analysis does not use p-y multipliers (individual pile or shaft only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix values
- Report pile response for full length of pile
- Analysis assumes no loading by soil movements acting on pile
- No p-y curves to be computed and reported for user-specified depths

Solution Control Parameters:

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

Pile Response Output Options:
- 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

Pile Structural Properties and Geometry

Total number of pile sections	=	2
Total length of pile	=	34.00 ft
Depth of ground surface below top of pile	=	22.00 ft

Pile diameter values used for p-y curve computations are defined using 4 points.

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

Point	Depth X ft	Pile Diameter in
1	0.00000	30.0000000
2	15.000000	30.0000000
3	15.000000	36.0000000
4	34.000000	36.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	15.00000000 ft
Top Width	=	30.00000000 in
Bottom Width	=	30.00000000 in
Top Area	=	706.85834706 Sq. in
Bottom Area	=	706.85834706 Sq. in
Moment of Inertia at Top	=	39761. in^4
Moment of Inertia at Bottom	=	39761. in^4
Elastic Modulus	=	3800000. lbs/in^2

Pile Section No. 2:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	19.00000000 ft
Top Width	=	36.00000000 in
Bottom Width	=	36.00000000 in
Top Area	=	706.85834706 Sq. in
Bottom Area	=	706.85834706 Sq. in
Moment of Inertia at Top	=	39761. in^4
Moment of Inertia at Bottom	=	39761. in^4
Elastic Modulus	=	3800000. lbs/in^2

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 2 layers

Layer 1 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	22.00000 ft
Distance from top of pile to bottom of layer	=	28.00000 ft
Effective unit weight at top of layer	=	70.00000 pcf
Effective unit weight at bottom of layer	=	70.00000 pcf
Undrained cohesion at top of layer	=	6000.00000 psf
Undrained cohesion at bottom of layer	=	6000.00000 psf
Epsilon-50 at top of layer	=	0.00400
Epsilon-50 at bottom of layer	=	0.00400
Subgrade k at top of layer	=	2000.00000 pci
Subgrade k at bottom of layer	=	2000.00000 pci

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	28.00000 ft
Distance from top of pile to bottom of layer	=	45.00000 ft
Effective unit weight at top of layer	=	70.00000 pcf
Effective unit weight at bottom of layer	=	70.00000 pcf
Undrained cohesion at top of layer	=	8000.00000 psf
Undrained cohesion at bottom of layer	=	8000.00000 psf
Epsilon-50 at top of layer	=	0.00400
Epsilon-50 at bottom of layer	=	0.00400
Subgrade k at top of layer	=	2000.00000 pci
Subgrade k at bottom of layer	=	2000.00000 pci

(Depth of lowest soil layer extends 11.00 ft below pile tip)

Summary of Soil Properties

Layer Num.	Layer Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Strain Factor Epsilon 50	kpy pci
1	Stiff Clay with Free Water	22.000	70.000	6000.000	0.00400	2000.000
		28.000	70.000	6000.000	0.00400	2000.000
2	Stiff Clay with Free Water	28.000	70.000	8000.000	0.00400	2000.000
		45.000	70.000	8000.000	0.00400	2000.000

Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 3

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 5100.00000 lbs	M = 1554000. in-lbs	689400.	No
2	1	V = 10300. lbs	M = -544800. in-lbs	429400.	No
3	1	V = 15500. lbs	M = -2961600. in-lbs	336100.	No

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust 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 = 2

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

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 = 5100.000 lbs
Applied moment at pile head = 1554000.000 in-lbs
Axial thrust load on pile head = 689400.000 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/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	1.2180	1554000.	5100.0000	-0.006423	1561.5576	1.511E+11	0.000	0.000	0.000
0.340	1.1918	1592816.	5100.0000	-0.006381	1576.2013	1.511E+11	0.000	0.000	0.000
0.680	1.1659	1631512.	5100.0000	-0.006337	1590.7994	1.511E+11	0.000	0.000	0.000
1.020	1.1401	1670084.	5100.0000	-0.006293	1605.3508	1.511E+11	0.000	0.000	0.000
1.360	1.1145	1708528.	5100.0000	-0.006247	1619.8543	1.511E+11	0.000	0.000	0.000
1.700	1.0892	1746843.	5100.0000	-0.006201	1634.3089	1.511E+11	0.000	0.000	0.000
2.040	1.0640	1785026.	5100.0000	-0.006153	1648.7134	1.511E+11	0.000	0.000	0.000
2.380	1.0389	1823072.	5100.0000	-0.006104	1663.0667	1.511E+11	0.000	0.000	0.000
2.720	1.0141	1860980.	5100.0000	-0.006054	1677.3678	1.511E+11	0.000	0.000	0.000
3.060	0.9895	1898747.	5100.0000	-0.006004	1691.6156	1.511E+11	0.000	0.000	0.000
3.400	0.9652	1936370.	5100.0000	-0.005952	1705.8090	1.511E+11	0.000	0.000	0.000
3.740	0.9410	1973846.	5100.0000	-0.005899	1719.9469	1.511E+11	0.000	0.000	0.000
4.080	0.9170	2011171.	5100.0000	-0.005845	1734.0282	1.511E+11	0.000	0.000	0.000
4.420	0.8933	2048344.	5100.0000	-0.005790	1748.0519	1.511E+11	0.000	0.000	0.000
4.760	0.8698	2085361.	5100.0000	-0.005735	1762.0169	1.511E+11	0.000	0.000	0.000
5.100	0.8465	2122220.	5100.0000	-0.005678	1775.9222	1.511E+11	0.000	0.000	0.000
5.440	0.8234	2158918.	5100.0000	-0.005620	1789.7666	1.511E+11	0.000	0.000	0.000
5.780	0.8006	2195452.	5100.0000	-0.005561	1803.5492	1.511E+11	0.000	0.000	0.000

6.120	0.7781	2231819.	5100.0000	-0.005501	1817.2689	1.511E+11	0.000	0.000	0.000
6.460	0.7557	2268016.	5100.0000	-0.005441	1830.9246	1.511E+11	0.000	0.000	0.000
6.800	0.7337	2304042.	5100.0000	-0.005379	1844.5154	1.511E+11	0.000	0.000	0.000
7.140	0.7118	2339892.	5100.0000	-0.005316	1858.0401	1.511E+11	0.000	0.000	0.000
7.480	0.6903	2375564.	5100.0000	-0.005253	1871.4978	1.511E+11	0.000	0.000	0.000
7.820	0.6690	2411056.	5100.0000	-0.005188	1884.8874	1.511E+11	0.000	0.000	0.000
8.160	0.6479	2446365.	5100.0000	-0.005122	1898.2079	1.511E+11	0.000	0.000	0.000
8.500	0.6272	2481488.	5100.0000	-0.005056	1911.4583	1.511E+11	0.000	0.000	0.000
8.840	0.6067	2516423.	5100.0000	-0.004988	1924.6376	1.511E+11	0.000	0.000	0.000
9.180	0.5865	2551167.	5100.0000	-0.004920	1937.7448	1.511E+11	0.000	0.000	0.000
9.520	0.5665	2585716.	5100.0000	-0.004851	1950.7789	1.511E+11	0.000	0.000	0.000
9.860	0.5469	2620070.	5100.0000	-0.004780	1963.7389	1.511E+11	0.000	0.000	0.000
10.200	0.5275	2654224.	5100.0000	-0.004709	1976.6238	1.511E+11	0.000	0.000	0.000
10.540	0.5085	2688177.	5100.0000	-0.004637	1989.4327	1.511E+11	0.000	0.000	0.000
10.880	0.4897	2721925.	5100.0000	-0.004564	2002.1645	1.511E+11	0.000	0.000	0.000
11.220	0.4712	2755467.	5100.0000	-0.004490	2014.8184	1.511E+11	0.000	0.000	0.000
11.560	0.4531	2788800.	5100.0000	-0.004415	2027.3933	1.511E+11	0.000	0.000	0.000
11.900	0.4352	2821920.	5100.0000	-0.004339	2039.8883	1.511E+11	0.000	0.000	0.000
12.240	0.4176	2854827.	5100.0000	-0.004263	2052.3024	1.511E+11	0.000	0.000	0.000
12.580	0.4004	2887516.	5100.0000	-0.004185	2064.6347	1.511E+11	0.000	0.000	0.000
12.920	0.3835	2919986.	5100.0000	-0.004107	2076.8843	1.511E+11	0.000	0.000	0.000
13.260	0.3669	2952235.	5100.0000	-0.004027	2089.0502	1.511E+11	0.000	0.000	0.000
13.600	0.3506	2984259.	5100.0000	-0.003947	2101.1315	1.511E+11	0.000	0.000	0.000
13.940	0.3347	3016056.	5100.0000	-0.003866	2113.1274	1.511E+11	0.000	0.000	0.000
14.280	0.3191	3047625.	5100.0000	-0.003784	2125.0367	1.511E+11	0.000	0.000	0.000
14.620	0.3038	3078962.	5100.0000	-0.003702	2136.8588	1.511E+11	0.000	0.000	0.000
14.960	0.2889	3110065.	5100.0000	-0.003618	2148.5926	1.511E+11	0.000	0.000	0.000
15.300	0.2743	3140932.	5100.0000	-0.003534	2397.2245	1.511E+11	0.000	0.000	0.000
15.640	0.2600	3171560.	5100.0000	-0.003449	2411.0902	1.511E+11	0.000	0.000	0.000
15.980	0.2461	3201947.	5100.0000	-0.003362	2424.8468	1.511E+11	0.000	0.000	0.000
16.320	0.2326	3232092.	5100.0000	-0.003276	2438.4933	1.511E+11	0.000	0.000	0.000
16.660	0.2194	3261990.	5100.0000	-0.003188	2452.0286	1.511E+11	0.000	0.000	0.000
17.000	0.2066	3291641.	5100.0000	-0.003099	2465.4518	1.511E+11	0.000	0.000	0.000
17.340	0.1941	3321042.	5100.0000	-0.003010	2478.7619	1.511E+11	0.000	0.000	0.000
17.680	0.1820	3350191.	5100.0000	-0.002920	2491.9577	1.511E+11	0.000	0.000	0.000
18.020	0.1703	3379085.	5100.0000	-0.002829	2505.0383	1.511E+11	0.000	0.000	0.000
18.360	0.1589	3407723.	5100.0000	-0.002738	2518.0028	1.511E+11	0.000	0.000	0.000
18.700	0.1480	3436101.	5100.0000	-0.002645	2530.8500	1.511E+11	0.000	0.000	0.000
19.040	0.1374	3464219.	5100.0000	-0.002552	2543.5791	1.511E+11	0.000	0.000	0.000
19.380	0.1271	3492074.	5100.0000	-0.002458	2556.1891	1.511E+11	0.000	0.000	0.000
19.720	0.1173	3519663.	5100.0000	-0.002363	2568.6790	1.511E+11	0.000	0.000	0.000
20.060	0.1079	3546985.	5100.0000	-0.002268	2581.0479	1.511E+11	0.000	0.000	0.000
20.400	0.0988	3574038.	5100.0000	-0.002172	2593.2949	1.511E+11	0.000	0.000	0.000
20.740	0.0901	3600819.	5100.0000	-0.002075	2605.4189	1.511E+11	0.000	0.000	0.000
21.080	0.0819	3627327.	5100.0000	-0.001977	2617.4191	1.511E+11	0.000	0.000	0.000
21.420	0.0740	3653559.	5100.0000	-0.001879	2629.2946	1.511E+11	0.000	0.000	0.000
21.760	0.0665	3679514.	5100.0000	-0.001780	2641.0445	1.511E+11	0.000	0.000	0.000
22.100	0.0595	3705189.	4808.8448	-0.001680	2652.6678	1.511E+11	-142.7231	9792.0000	0.000
22.440	0.0528	3728207.	3379.9031	-0.001580	2663.0882	1.511E+11	-557.7385	43085.	0.000
22.780	0.0466	3741657.	463.4701	-0.001479	2669.1773	1.511E+11	-871.8855	76378.	0.000
23.120	0.0407	3740310.	-3549.5052	-0.001378	2668.5673	1.511E+11	-1095.2592	109670.	0.000
23.460	0.0353	3720446.	-8309.2438	-0.001277	2659.5748	1.511E+11	-1237.9460	142963.	0.000
23.800	0.0303	3679692.	-13446.	-0.001177	2641.1254	1.511E+11	-1279.9411	172220.	0.000
24.140	0.0257	3617353.	-18672.	-0.001079	2612.9038	1.511E+11	-1281.7547	203317.	0.000
24.480	0.0215	3533402.	-23870.	-0.000982	2574.8986	1.511E+11	-1266.5049	240137.	0.000
24.820	0.0177	3428100.	-28898.	-0.000888	2527.2276	1.511E+11	-1198.2565	276134.	0.000
25.160	0.0143	3302591.	-33550.	-0.000798	2470.4087	1.511E+11	-1082.1475	309427.	0.000
25.500	0.0112	3158817.	-37676.	-0.000710	2405.3212	1.511E+11	-940.5288	342720.	0.000
25.840	0.008473	2999147.	-41188.	-0.000627	2333.0373	1.511E+11	-780.8480	376013.	0.000
26.180	0.006079	2826250.	-44025.	-0.000549	2254.7659	1.511E+11	-609.8597	409306.	0.000
26.520	0.003997	2642988.	-46154.	-0.000475	2171.8015	1.511E+11	-433.5866	442598.	0.000
26.860	0.002206	2452306.	-47563.	-0.000406	2085.4787	1.511E+11	-257.2960	475891.	0.000
27.200	0.000685	2257156.	-48262.	-0.000342	1997.1325	1.511E+11	-85.4947	509184.	0.000
27.540	-0.000587	2060410.	-48278.	-0.000284	1908.0645	1.511E+11	78.0622	542477.	0.000
27.880	-0.001632	1864808.	-47648.	-0.000231	1819.5139	1.511E+11	230.3458	575770.	0.000
28.220	-0.002472	1672899.	-46539.	-0.000183	1732.6351	1.511E+11	313.3870	517246.	0.000
28.560	-0.003127	1486079.	-45039.	-0.000141	1648.0604	1.511E+11	421.9944	550539.	0.000
28.900	-0.003619	1306171.	-43122.	-0.000103	1566.6147	1.511E+11	517.8690	583832.	0.000
29.240	-0.003967	1134784.	-40841.	-6.991E-05	1489.0268	1.511E+11	600.0008	617125.	0.000
29.580	-0.004190	973300.	-38255.	-4.145E-05	1415.9214	1.511E+11	667.8771	650417.	0.000
29.920	-0.004305	822859.	-35421.	-1.720E-05	1347.8156	1.511E+11	721.4187	683710.	0.000
30.260	-0.004330	684364.	-32397.	3.151E-06	1285.1182	1.511E+11	760.9133	717003.	0.000
30.600	-0.004279	558484.	-29239.	1.993E-05	1228.1313	1.511E+11	786.9477	750296.	0.000
30.940	-0.004167	445661.	-26001.	3.349E-05	1177.0557	1.511E+11	800.3397	783589.	0.000
31.280	-0.004006	346128.	-22732.	4.418E-05	1131.9961	1.511E+11	802.0716	816881.	0.000
31.620	-0.003807	259919.	-19478.	5.236E-05	1092.9689	1.511E+11	793.2267	850174.	0.000
31.960	-0.003579	186896.	-16279.	5.840E-05	1059.9106	1.511E+11	774.9279	883467.	0.000
32.300	-0.003330	126758.	-13171.	6.263E-05	1032.6856	1.511E+11	748.2820	916760.	0.000
32.640	-0.003068	79066.	-10188.	6.541E-05	1011.0952	1.511E+11	714.3279	950053.	0.000
32.980	-0.002796	43259.	-7355.3594	6.706E-05	994.8853	1.511E+11	673.9900	983345.	0.000
33.320	-0.002520	18669.	-4699.2221	6.790E-05	983.7531	1.511E+11	628.0381	1016638.	0.000
33.660	-0.002242	4531.7225	-2240.8370	6.821E-05	977.3530	1.511E+11	577.0526	1049931.	0.000
34.000	-0.001964	0.000	0.000	6.827E-05	975.3015	1.511E+11	521.3969	541612.	0.000

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

Output Summary for Load Case No. 1:

```
Pile-head deflection             =      1.2179663 inches
Computed slope at pile head      =     -0.0064234 radians
Maximum bending moment           =       3741657. inch-lbs
Maximum shear force              =         -48278. lbs
Depth of maximum bending moment  =    273.3600000 inches below pile head
Depth of maximum shear force     =    330.4800000 inches below pile head
Number of iterations             =              6
Number of zero deflection points =              1
```

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

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

Shear force at pile head = 10300.000 lbs
Applied moment at pile head = -544800.000 in-lbs
Axial thrust load on pile head = 429400.000 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/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.7146	-544800.	10300.	-0.002942	813.0059	1.511E+11	0.000	0.000	0.000
0.340	0.7026	-497609.	10300.	-0.002956	795.2029	1.511E+11	0.000	0.000	0.000
0.680	0.6905	-450395.	10300.	-0.002969	777.3911	1.511E+11	0.000	0.000	0.000
1.020	0.6783	-403160.	10300.	-0.002980	759.5712	1.511E+11	0.000	0.000	0.000
1.360	0.6662	-355905.	10300.	-0.002990	741.7441	1.511E+11	0.000	0.000	0.000
1.700	0.6539	-308634.	10300.	-0.002999	723.9106	1.511E+11	0.000	0.000	0.000
2.040	0.6417	-261347.	10300.	-0.003007	706.0717	1.511E+11	0.000	0.000	0.000
2.380	0.6294	-214049.	10300.	-0.003013	688.2281	1.511E+11	0.000	0.000	0.000
2.720	0.6171	-166741.	10300.	-0.003019	670.3806	1.511E+11	0.000	0.000	0.000
3.060	0.6048	-119424.	10300.	-0.003022	652.5302	1.511E+11	0.000	0.000	0.000
3.400	0.5924	-72102.	10300.	-0.003025	634.6777	1.511E+11	0.000	0.000	0.000
3.740	0.5801	-24777.	10300.	-0.003026	616.8238	1.511E+11	0.000	0.000	0.000
4.080	0.5677	22550.	10300.	-0.003026	615.9839	1.511E+11	0.000	0.000	0.000
4.420	0.5554	69876.	10300.	-0.003025	633.8378	1.511E+11	0.000	0.000	0.000
4.760	0.5430	117198.	10300.	-0.003023	651.6904	1.511E+11	0.000	0.000	0.000
5.100	0.5307	164515.	10300.	-0.003019	669.5409	1.511E+11	0.000	0.000	0.000
5.440	0.5184	211824.	10300.	-0.003014	687.3885	1.511E+11	0.000	0.000	0.000
5.780	0.5061	259123.	10300.	-0.003007	705.2323	1.511E+11	0.000	0.000	0.000
6.120	0.4939	306409.	10300.	-0.003000	723.0715	1.511E+11	0.000	0.000	0.000
6.460	0.4816	353681.	10300.	-0.002991	740.9052	1.511E+11	0.000	0.000	0.000
6.800	0.4695	400937.	10300.	-0.002981	758.7327	1.511E+11	0.000	0.000	0.000
7.140	0.4573	448173.	10300.	-0.002969	776.5529	1.511E+11	0.000	0.000	0.000
7.480	0.4452	495389.	10300.	-0.002956	794.3652	1.511E+11	0.000	0.000	0.000
7.820	0.4332	542581.	10300.	-0.002942	812.1686	1.511E+11	0.000	0.000	0.000
8.160	0.4212	589747.	10300.	-0.002927	829.9623	1.511E+11	0.000	0.000	0.000
8.500	0.4093	636885.	10300.	-0.002911	847.7455	1.511E+11	0.000	0.000	0.000
8.840	0.3975	683993.	10300.	-0.002893	865.5173	1.511E+11	0.000	0.000	0.000
9.180	0.3857	731069.	10300.	-0.002874	883.2770	1.511E+11	0.000	0.000	0.000
9.520	0.3740	778110.	10300.	-0.002853	901.0236	1.511E+11	0.000	0.000	0.000
9.860	0.3624	825114.	10300.	-0.002832	918.7562	1.511E+11	0.000	0.000	0.000
10.200	0.3509	872080.	10300.	-0.002809	936.4742	1.511E+11	0.000	0.000	0.000
10.540	0.3395	919004.	10300.	-0.002785	954.1766	1.511E+11	0.000	0.000	0.000
10.880	0.3282	965885.	10300.	-0.002759	971.8626	1.511E+11	0.000	0.000	0.000
11.220	0.3170	1012719.	10300.	-0.002732	989.5314	1.511E+11	0.000	0.000	0.000
11.560	0.3059	1059506.	10300.	-0.002704	1007.1821	1.511E+11	0.000	0.000	0.000
11.900	0.2949	1106243.	10300.	-0.002675	1024.8138	1.511E+11	0.000	0.000	0.000
12.240	0.2841	1152928.	10300.	-0.002645	1042.4259	1.511E+11	0.000	0.000	0.000
12.580	0.2733	1199558.	10300.	-0.002613	1060.0173	1.511E+11	0.000	0.000	0.000
12.920	0.2628	1246131.	10300.	-0.002580	1077.5874	1.511E+11	0.000	0.000	0.000
13.260	0.2523	1292645.	10300.	-0.002546	1095.1352	1.511E+11	0.000	0.000	0.000
13.600	0.2420	1339099.	10300.	-0.002510	1112.6599	1.511E+11	0.000	0.000	0.000
13.940	0.2318	1385488.	10300.	-0.002473	1130.1608	1.511E+11	0.000	0.000	0.000
14.280	0.2218	1431813.	10300.	-0.002435	1147.6369	1.511E+11	0.000	0.000	0.000
14.620	0.2119	1478069.	10300.	-0.002396	1165.0874	1.511E+11	0.000	0.000	0.000
14.960	0.2022	1524256.	10300.	-0.002355	1182.5116	1.511E+11	0.000	0.000	0.000
15.300	0.1927	1570370.	10300.	-0.002314	1318.3949	1.511E+11	0.000	0.000	0.000
15.640	0.1834	1616410.	10300.	-0.002271	1339.2377	1.511E+11	0.000	0.000	0.000
15.980	0.1742	1662374.	10300.	-0.002226	1360.0458	1.511E+11	0.000	0.000	0.000
16.320	0.1652	1708259.	10300.	-0.002181	1380.8183	1.511E+11	0.000	0.000	0.000
16.660	0.1564	1754063.	10300.	-0.002134	1401.5542	1.511E+11	0.000	0.000	0.000
17.000	0.1478	1799785.	10300.	-0.002086	1422.2526	1.511E+11	0.000	0.000	0.000
17.340	0.1394	1845421.	10300.	-0.002037	1442.9124	1.511E+11	0.000	0.000	0.000
17.680	0.1312	1890970.	10300.	-0.001986	1463.5327	1.511E+11	0.000	0.000	0.000
18.020	0.1232	1936429.	10300.	-0.001935	1484.1125	1.511E+11	0.000	0.000	0.000
18.360	0.1154	1981797.	10300.	-0.001882	1504.6508	1.511E+11	0.000	0.000	0.000
18.700	0.1078	2027071.	10300.	-0.001828	1525.1466	1.511E+11	0.000	0.000	0.000
19.040	0.1005	2072249.	10300.	-0.001772	1545.5991	1.511E+11	0.000	0.000	0.000
19.380	0.0933	2117329.	10300.	-0.001716	1566.0072	1.511E+11	0.000	0.000	0.000
19.720	0.0865	2162309.	10300.	-0.001658	1586.3699	1.511E+11	0.000	0.000	0.000
20.060	0.0798	2207186.	10300.	-0.001599	1606.6863	1.511E+11	0.000	0.000	0.000
20.400	0.0734	2251960.	10300.	-0.001539	1626.9555	1.511E+11	0.000	0.000	0.000
20.740	0.0673	2296626.	10300.	-0.001477	1647.1764	1.511E+11	0.000	0.000	0.000
21.080	0.0614	2341184.	10300.	-0.001415	1667.3481	1.511E+11	0.000	0.000	0.000
21.420	0.0557	2385631.	10300.	-0.001351	1687.4697	1.511E+11	0.000	0.000	0.000
21.760	0.0503	2429966.	10300.	-0.001286	1707.5402	1.511E+11	0.000	0.000	0.000
22.100	0.0452	2474185.	10079.	-0.001220	1727.5586	1.511E+11	-108.5424	9792.0000	0.000
22.440	0.0404	2516481.	8987.1377	-0.001152	1746.7061	1.511E+11	-426.4751	43085.	0.000
22.780	0.0358	2551558.	6749.0903	-0.001084	1762.5858	1.511E+11	-670.6070	76378.	0.000
23.120	0.0315	2575351.	3651.4802	-0.001015	1773.3572	1.511E+11	-847.8293	109670.	0.000
23.460	0.0275	2584909.	-46.9273	-0.000945	1777.6842	1.511E+11	-965.1156	142963.	0.000
23.800	0.0238	2578279.	-4115.8557	-0.000875	1774.6829	1.511E+11	-1029.4572	176256.	0.000
24.140	0.0204	2554391.	-8353.4365	-0.000806	1763.8683	1.511E+11	-1047.7883	209549.	0.000
24.480	0.0173	2512939.	-12586.	-0.000738	1745.1030	1.511E+11	-1026.9062	242842.	0.000
24.820	0.0144	2454275.	-16666.	-0.000671	1718.5451	1.511E+11	-973.3911	276134.	0.000
25.160	0.0118	2379291.	-20475.	-0.000605	1684.5993	1.511E+11	-893.5304	309427.	0.000
25.500	0.009443	2289320.	-23916.	-0.000542	1643.8689	1.511E+11	-793.2495	342720.	0.000
25.840	0.007357	2186036.	-26917.	-0.000482	1597.1116	1.511E+11	-678.0521	376013.	0.000
26.180	0.005512	2071362.	-29429.	-0.000424	1545.1977	1.511E+11	-552.9710	409306.	0.000
26.520	0.003895	1947385.	-31419.	-0.000370	1489.0722	1.511E+11	-422.5315	442598.	0.000

26.860	0.002493	1816282.	-32874.	-0.000319	1429.7209	1.511E+11	-290.7272	475891.	0.000
27.200	0.001290	1680253.	-33795.	-0.000272	1368.1398	1.511E+11	-161.0076	509184.	0.000
27.540	0.000273	1541465.	-34198.	-0.000229	1305.3094	1.511E+11	-36.2786	542477.	0.000
27.880	-0.000575	1402000.	-34106.	-0.000189	1242.1725	1.511E+11	81.0857	575770.	0.000
28.220	-0.001268	1263818.	-33613.	-0.000153	1179.6167	1.511E+11	160.6966	517246.	0.000
28.560	-0.001821	1128252.	-32784.	-0.000120	1118.2448	1.511E+11	245.7587	550539.	0.000
28.900	-0.002251	996723.	-31626.	-9.179E-05	1058.7008	1.511E+11	322.0702	583832.	0.000
29.240	-0.002570	870509.	-30175.	-6.658E-05	1001.5625	1.511E+11	388.7800	617125.	0.000
29.580	-0.002794	750725.	-28474.	-4.469E-05	947.3354	1.511E+11	445.4168	650417.	0.000
29.920	-0.002935	638320.	-26562.	-2.594E-05	896.4489	1.511E+11	491.8440	683710.	0.000
30.260	-0.003006	534072.	-24481.	-1.011E-05	849.2552	1.511E+11	528.2135	717003.	0.000
30.600	-0.003018	438592.	-22271.	3.022E-06	806.0306	1.511E+11	554.9156	750296.	0.000
30.940	-0.002981	352329.	-19971.	1.370E-05	766.9785	1.511E+11	572.5302	783589.	0.000
31.280	-0.002906	275579.	-17616.	2.218E-05	732.2334	1.511E+11	581.7774	816881.	0.000
31.620	-0.002800	208501.	-15239.	2.872E-05	701.8667	1.511E+11	583.4689	850174.	0.000
31.960	-0.002671	151126.	-12869.	3.357E-05	675.8924	1.511E+11	578.4616	883467.	0.000
32.300	-0.002526	103372.	-10531.	3.701E-05	654.2742	1.511E+11	567.6137	916760.	0.000
32.640	-0.002369	65063.	-8247.4999	3.928E-05	636.9313	1.511E+11	551.7425	950053.	0.000
32.980	-0.002206	35935.	-6037.5084	4.064E-05	623.7449	1.511E+11	531.5866	983345.	0.000
33.320	-0.002038	15655.	-3917.2205	4.134E-05	614.5637	1.511E+11	507.7702	1016638.	0.000
33.660	-0.001868	3825.8563	-1900.5961	4.160E-05	609.2087	1.511E+11	480.7712	1049931.	0.000
34.000	-0.001698	0.000	0.000	4.166E-05	607.4767	1.511E+11	450.8935	541612.	0.000

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

Output Summary for Load Case No. 2:

Pile-head deflection = 0.7145905 inches
Computed slope at pile head = -0.0029417 radians
Maximum bending moment = 2584909. inch-lbs
Maximum shear force = -34198. lbs
Depth of maximum bending moment = 281.5200000 inches below pile head
Depth of maximum shear force = 330.4800000 inches below pile head
Number of iterations = 6
Number of zero deflection points = 1

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

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

Shear force at pile head = 15500.000 lbs
Applied moment at pile head = -2961600.000 in-lbs
Axial thrust load on pile head = 336100.000 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/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1828	-2961600.	15500.	0.000820	1592.7661	1.511E+11	0.000	0.000	0.000
0.340	0.1860	-2899430.	15500.	0.000741	1569.3119	1.511E+11	0.000	0.000	0.000
0.680	0.1889	-2837152.	15500.	0.000663	1545.8173	1.511E+11	0.000	0.000	0.000
1.020	0.1914	-2774769.	15500.	0.000588	1522.2830	1.511E+11	0.000	0.000	0.000
1.360	0.1937	-2712284.	15500.	0.000514	1498.7099	1.511E+11	0.000	0.000	0.000
1.700	0.1956	-2649698.	15500.	0.000441	1475.0990	1.511E+11	0.000	0.000	0.000
2.040	0.1973	-2587014.	15500.	0.000370	1451.4511	1.511E+11	0.000	0.000	0.000
2.380	0.1987	-2524234.	15500.	0.000301	1427.7670	1.511E+11	0.000	0.000	0.000
2.720	0.1997	-2461360.	15500.	0.000234	1404.0476	1.511E+11	0.000	0.000	0.000
3.060	0.2006	-2398396.	15500.	0.000169	1380.2939	1.511E+11	0.000	0.000	0.000
3.400	0.2011	-2335343.	15500.	0.000105	1356.5066	1.511E+11	0.000	0.000	0.000
3.740	0.2014	-2272203.	15500.	4.241E-05	1332.6867	1.511E+11	0.000	0.000	0.000
4.080	0.2015	-2208979.	15500.	-1.810E-05	1308.8351	1.511E+11	0.000	0.000	0.000
4.420	0.2013	-2145673.	15500.	-7.689E-05	1284.9527	1.511E+11	0.000	0.000	0.000
4.760	0.2008	-2082288.	15500.	-0.000134	1261.0402	1.511E+11	0.000	0.000	0.000
5.100	0.2002	-2018826.	15500.	-0.000189	1237.0987	1.511E+11	0.000	0.000	0.000
5.440	0.1993	-1955289.	15500.	-0.000243	1213.1289	1.511E+11	0.000	0.000	0.000
5.780	0.1982	-1891679.	15500.	-0.000295	1189.1319	1.511E+11	0.000	0.000	0.000
6.120	0.1969	-1828000.	15500.	-0.000345	1165.1084	1.511E+11	0.000	0.000	0.000
6.460	0.1954	-1764253.	15500.	-0.000394	1141.0594	1.511E+11	0.000	0.000	0.000
6.800	0.1937	-1700440.	15500.	-0.000440	1116.9857	1.511E+11	0.000	0.000	0.000
7.140	0.1918	-1636565.	15500.	-0.000486	1092.8883	1.511E+11	0.000	0.000	0.000
7.480	0.1897	-1572629.	15500.	-0.000529	1068.7680	1.511E+11	0.000	0.000	0.000
7.820	0.1875	-1508634.	15500.	-0.000570	1044.6258	1.511E+11	0.000	0.000	0.000
8.160	0.1851	-1444584.	15500.	-0.000610	1020.4625	1.511E+11	0.000	0.000	0.000
8.500	0.1825	-1380480.	15500.	-0.000648	996.2790	1.511E+11	0.000	0.000	0.000
8.840	0.1798	-1316326.	15500.	-0.000685	972.0762	1.511E+11	0.000	0.000	0.000
9.180	0.1769	-1252122.	15500.	-0.000720	947.8550	1.511E+11	0.000	0.000	0.000
9.520	0.1739	-1187872.	15500.	-0.000752	923.6164	1.511E+11	0.000	0.000	0.000
9.860	0.1708	-1123578.	15500.	-0.000784	899.3611	1.511E+11	0.000	0.000	0.000
10.200	0.1675	-1059243.	15500.	-0.000813	875.0901	1.511E+11	0.000	0.000	0.000
10.540	0.1641	-994868.	15500.	-0.000841	850.8044	1.511E+11	0.000	0.000	0.000
10.880	0.1606	-930457.	15500.	-0.000867	826.5047	1.511E+11	0.000	0.000	0.000
11.220	0.1571	-866011.	15500.	-0.000891	802.1921	1.511E+11	0.000	0.000	0.000
11.560	0.1534	-801533.	15500.	-0.000914	777.8673	1.511E+11	0.000	0.000	0.000
11.900	0.1496	-737025.	15500.	-0.000934	753.5314	1.511E+11	0.000	0.000	0.000
12.240	0.1457	-672490.	15500.	-0.000953	729.1851	1.511E+11	0.000	0.000	0.000
12.580	0.1418	-607930.	15500.	-0.000971	704.8295	1.511E+11	0.000	0.000	0.000
12.920	0.1378	-543347.	15500.	-0.000986	680.4654	1.511E+11	0.000	0.000	0.000
13.260	0.1338	-478745.	15500.	-0.001000	656.0937	1.511E+11	0.000	0.000	0.000
13.600	0.1297	-414124.	15500.	-0.001012	631.7152	1.511E+11	0.000	0.000	0.000
13.940	0.1255	-349489.	15500.	-0.001022	607.3311	1.511E+11	0.000	0.000	0.000
14.280	0.1213	-284840.	15500.	-0.001031	582.9420	1.511E+11	0.000	0.000	0.000

14.620	0.1171	-220181.	15500.	-0.001038	558.5489	1.511E+11	0.000	0.000	0.000
14.960	0.1128	-155514.	15500.	-0.001043	534.1528	1.511E+11	0.000	0.000	0.000
15.300	0.1086	-90841.	15500.	-0.001046	516.6085	1.511E+11	0.000	0.000	0.000
15.640	0.1043	-26164.	15500.	-0.001048	487.3291	1.511E+11	0.000	0.000	0.000
15.980	0.1000	38513.	15500.	-0.001048	492.9193	1.511E+11	0.000	0.000	0.000
16.320	0.0958	103189.	15500.	-0.001046	522.1986	1.511E+11	0.000	0.000	0.000
16.660	0.0915	167861.	15500.	-0.001042	551.4762	1.511E+11	0.000	0.000	0.000
17.000	0.0873	232527.	15500.	-0.001037	580.7509	1.511E+11	0.000	0.000	0.000
17.340	0.0830	297184.	15500.	-0.001030	610.0217	1.511E+11	0.000	0.000	0.000
17.680	0.0789	361831.	15500.	-0.001021	639.2876	1.511E+11	0.000	0.000	0.000
18.020	0.0747	426463.	15500.	-0.001010	668.5474	1.511E+11	0.000	0.000	0.000
18.360	0.0706	491081.	15500.	-0.000998	697.8000	1.511E+11	0.000	0.000	0.000
18.700	0.0666	555679.	15500.	-0.000983	727.0444	1.511E+11	0.000	0.000	0.000
19.040	0.0626	620258.	15500.	-0.000968	756.2795	1.511E+11	0.000	0.000	0.000
19.380	0.0587	684813.	15500.	-0.000950	785.5042	1.511E+11	0.000	0.000	0.000
19.720	0.0548	749343.	15500.	-0.000931	814.7174	1.511E+11	0.000	0.000	0.000
20.060	0.0511	813845.	15500.	-0.000910	843.9181	1.511E+11	0.000	0.000	0.000
20.400	0.0474	878318.	15500.	-0.000887	873.1051	1.511E+11	0.000	0.000	0.000
20.740	0.0438	942757.	15500.	-0.000862	902.2774	1.511E+11	0.000	0.000	0.000
21.080	0.0404	1007162.	15500.	-0.000836	931.4339	1.511E+11	0.000	0.000	0.000
21.420	0.0370	1071529.	15500.	-0.000808	960.5735	1.511E+11	0.000	0.000	0.000
21.760	0.0338	1135857.	15500.	-0.000778	989.6951	1.511E+11	0.000	0.000	0.000
22.100	0.0307	1200143.	15350.	-0.000746	1018.7977	1.511E+11	-73.6353	9792.0000	0.000
22.440	0.0277	1263158.	14603.	-0.000713	1047.3252	1.511E+11	-292.5377	43085.	0.000
22.780	0.0249	1321257.	13057.	-0.000678	1073.6271	1.511E+11	-465.4291	76378.	0.000
23.120	0.0222	1371559.	10891.	-0.000642	1096.3993	1.511E+11	-595.8883	109670.	0.000
23.460	0.0196	1411892.	8272.9858	-0.000604	1114.6580	1.511E+11	-687.6731	142963.	0.000
23.800	0.0172	1440724.	5350.9968	-0.000566	1127.7107	1.511E+11	-744.6745	176256.	0.000
24.140	0.0150	1457107.	2259.2986	-0.000527	1135.1275	1.511E+11	-770.8638	209549.	0.000
24.480	0.0129	1460604.	-884.5412	-0.000487	1136.7106	1.511E+11	-770.2341	242842.	0.000
24.820	0.0110	1451226.	-3979.1715	-0.000448	1132.4648	1.511E+11	-746.7415	276134.	0.000
25.160	0.009286	1429363.	-6939.1877	-0.000409	1122.5673	1.511E+11	-704.2468	309427.	0.000
25.500	0.007696	1395724.	-9694.6337	-0.000371	1107.3386	1.511E+11	-646.4620	342720.	0.000
25.840	0.006260	1351272.	-12190.	-0.000334	1087.2148	1.511E+11	-576.9004	376013.	0.000
26.180	0.004972	1297166.	-14385.	-0.000298	1062.7209	1.511E+11	-498.8351	409306.	0.000
26.520	0.003828	1234709.	-16250.	-0.000264	1034.4461	1.511E+11	-415.2641	442598.	0.000
26.860	0.002820	1165293.	-17768.	-0.000231	1003.0211	1.511E+11	-328.8831	475891.	0.000
27.200	0.001940	1090360.	-18932.	-0.000201	969.0982	1.511E+11	-242.0679	509184.	0.000
27.540	0.001180	1011356.	-19746.	-0.000173	933.3328	1.511E+11	-156.8637	542477.	0.000
27.880	0.000531	929704.	-20219.	-0.000146	896.3683	1.511E+11	-74.9829	575770.	0.000
28.220	-1.467E-05	846770.	-20368.	-0.000122	858.8231	1.511E+11	1.8596	517246.	0.000
28.560	-0.000467	763835.	-20236.	-0.000101	821.2778	1.511E+11	63.0672	550539.	0.000
28.900	-0.000836	681921.	-19863.	-8.113E-05	784.1949	1.511E+11	119.6208	583832.	0.000
29.240	-0.001129	601974.	-19271.	-6.379E-05	748.0021	1.511E+11	170.8255	617125.	0.000
29.580	-0.001356	524847.	-18481.	-4.858E-05	713.0865	1.511E+11	216.2461	650417.	0.000
29.920	-0.001526	451301.	-17518.	-3.540E-05	679.7917	1.511E+11	255.6831	683710.	0.000
30.260	-0.001645	381995.	-16407.	-2.415E-05	648.4162	1.511E+11	289.1449	717003.	0.000
30.600	-0.001723	317488.	-15171.	-1.470E-05	619.2133	1.511E+11	316.8184	750296.	0.000
30.940	-0.001765	258242.	-13833.	-6.929E-06	592.3925	1.511E+11	339.0384	783589.	0.000
31.280	-0.001779	204631.	-12414.	-6.796E-07	568.1224	1.511E+11	356.2555	816881.	0.000
31.620	-0.001771	156943.	-10935.	4.202E-06	546.5336	1.511E+11	369.0039	850174.	0.000
31.960	-0.001745	115392.	-9411.1959	7.879E-06	527.7230	1.511E+11	377.8694	883467.	0.000
32.300	-0.001707	80126.	-7858.0891	1.052E-05	511.7580	1.511E+11	383.4574	916760.	0.000
32.640	-0.001659	51241.	-6287.6585	1.229E-05	498.6814	1.511E+11	386.3614	950053.	0.000
32.980	-0.001606	28785.	-4709.7313	1.337E-05	488.5156	1.511E+11	387.1323	983345.	0.000
33.320	-0.001550	12773.	-3132.0347	1.393E-05	481.2666	1.511E+11	386.2484	1016638.	0.000
33.660	-0.001493	3189.6937	-1560.5527	1.415E-05	476.9282	1.511E+11	384.0859	1049931.	0.000
34.000	-0.001435	0.000	0.000	1.419E-05	475.4842	1.511E+11	380.8909	541612.	0.000

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

Output Summary for Load Case No. 3:

```
Pile-head deflection             =      0.1828463 inches
Computed slope at pile head      =      0.0008200 radians
Maximum bending moment           =      -2961600. inch-lbs
Maximum shear force              =        -20368. lbs
Depth of maximum bending moment  =       0.000000 inches below pile head
Depth of maximum shear force     =    338.6400000 inches below pile head
Number of iterations             =              6
Number of zero deflection points =              1
```

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 5100.0000	M = 1554000.	689400.	1.21796632	3741657.	-48278.	-0.00642342
2	1	V = 10300.	M = -544800.	429400.	0.71459051	2584909.	-34198.	-0.00294174

```
  3     1   V =     15500.  M =  -2961600.        336100.     0.18284633      -2961600.        -20368.     0.00082002
```

The analysis ended normally.

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

                  LPile Plus for Windows, Version 2012-06.037

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

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

This copy of LPile is licensed to:

ESP
Raleigh

Serial Number of Security Device:        162969677
Company Name Stored in Security Device:  ESP Associates, PA


-----------------------------------------------------------------------------
                          Files Used for Analysis
-----------------------------------------------------------------------------

Path to file locations:        G:\Projects\2013\BW17.300 (Div. 12 Low Impact Bridges)\17BP.12.R.35 (Bridge 022135)\Foundation
Recommendations\Calculations\Lpile\
Name of input data file:       Br 135 B1B.lp6d
Name of output report file:    Br 135 B1B.lp6o
Name of plot output file:      Br 135 B1B.lp6p
Name of runtime messeage file: Br 135 B1B.lp6r


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

               Date:  June 2, 2015     Time:  15:04:48

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

Project Name: Div 12 LIBR

Job Number: 17BP.12.R.35

Client: Baker

Engineer: GRT

Description: BR 135 B1-B


-----------------------------------------------------------------------------
                            Program Options
-----------------------------------------------------------------------------

Engineering units are US Customary Units: pounds, inches, feet

Basic Program Options:

This analysis computes pile response to lateral loading and will compute nonlinear
moment-curvature and nominal moment capacity for section types with nonlinear properties.

Computation Options:
- Analysis does not use p-y multipliers (individual pile or shaft only)
- Analysis assumes no shear resistance at pile tip
- Analysis for fixed-length pile or shaft only
- No computation of foundation stiffness matrix values
- Report pile response for full length of pile
- Analysis assumes no loading by soil movements acting on pile
- No p-y curves to be computed and reported for user-specified depths

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

Pile Response Output Options:
- 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


-----------------------------------------------------------------------------
                  Pile Structural Properties and Geometry
-----------------------------------------------------------------------------

Total number of pile sections                     =          2

Total length of pile                              =      38.00 ft

Depth of ground surface below top of pile         =      22.00 ft

Pile diameter values used for p-y curve computations are defined using 4 points.
```

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

Point	Depth X ft	Pile Diameter in
1	0.00000	30.0000000
2	15.000000	30.0000000
3	15.000000	36.0000000
4	38.000000	36.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	15.00000000 ft
Top Width	=	30.00000000 in
Bottom Width	=	30.00000000 in
Top Area	=	706.85834706 Sq. in
Bottom Area	=	706.85834706 Sq. in
Moment of Inertia at Top	=	39761. in^4
Moment of Inertia at Bottom	=	39761. in^4
Elastic Modulus	=	3800000. lbs/in^2

Pile Section No. 2:

Section Type	=	Elastic Pile
Cross-sectional Shape	=	Circular
Section Length	=	23.00000000 ft
Top Width	=	36.00000000 in
Bottom Width	=	36.00000000 in
Top Area	=	1017.87601976 Sq. in
Bottom Area	=	1017.87601976 Sq. in
Moment of Inertia at Top	=	82448. in^4
Moment of Inertia at Bottom	=	82448. in^4
Elastic Modulus	=	3800000. lbs/in^2

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

Distance from top of pile to top of layer	=	22.00000 ft
Distance from top of pile to bottom of layer	=	26.00000 ft
Effective unit weight at top of layer	=	60.00000 pcf
Effective unit weight at bottom of layer	=	60.00000 pcf
Friction angle at top of layer	=	35.00000 deg.
Friction angle at bottom of layer	=	35.00000 deg.
Subgrade k at top of layer	=	125.00000 pci
Subgrade k at bottom of layer	=	125.00000 pci

Layer 2 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	26.00000 ft
Distance from top of pile to bottom of layer	=	29.00000 ft
Effective unit weight at top of layer	=	70.00000 pcf
Effective unit weight at bottom of layer	=	70.00000 pcf
Undrained cohesion at top of layer	=	3000.00000 psf
Undrained cohesion at bottom of layer	=	3000.00000 psf
Epsilon-50 at top of layer	=	0.00500
Epsilon-50 at bottom of layer	=	0.00500
Subgrade k at top of layer	=	1000.00000 pci
Subgrade k at bottom of layer	=	1000.00000 pci

Layer 3 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	=	29.00000 ft
Distance from top of pile to bottom of layer	=	36.00000 ft
Effective unit weight at top of layer	=	70.00000 pcf
Effective unit weight at bottom of layer	=	70.00000 pcf
Undrained cohesion at top of layer	=	4000.00000 psf
Undrained cohesion at bottom of layer	=	4000.00000 psf
Epsilon-50 at top of layer	=	0.00400
Epsilon-50 at bottom of layer	=	0.00400
Subgrade k at top of layer	=	2000.00000 pci

Subgrade k at bottom of layer = 2000.00000 pci

Layer 4 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 36.00000 ft
Distance from top of pile to bottom of layer = 51.00000 ft
Effective unit weight at top of layer = 70.00000 pcf
Effective unit weight at bottom of layer = 70.00000 pcf
Undrained cohesion at top of layer = 8000.00000 psf
Undrained cohesion at bottom of layer = 8000.00000 psf
Epsilon-50 at top of layer = 0.00400
Epsilon-50 at bottom of layer = 0.00400
Subgrade k at top of layer = 2000.00000 pci
Subgrade k at bottom of layer = 2000.00000 pci

(Depth of lowest soil layer extends 13.00 ft below pile tip)

Summary of Soil Properties

Layer Num.	Layer Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Strain Factor Epsilon 50	kpy pci
1	Sand (Reese, et al.)	22.000	60.000	--	35.000	--	125.000
		26.000	60.000	--	35.000	--	125.000
2	Stiff Clay with Free Water	26.000	70.000	3000.000	--	0.00500	1000.000
		29.000	70.000	3000.000	--	0.00500	1000.000
3	Stiff Clay with Free Water	29.000	70.000	4000.000	--	0.00400	2000.000
		36.000	70.000	4000.000	--	0.00400	2000.000
4	Stiff Clay with Free Water	36.000	70.000	8000.000	--	0.00400	2000.000
		51.000	70.000	8000.000	--	0.00400	2000.000

Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 3

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 5100.00000 lbs	M = 1554000. in-lbs	689400.	No
2	1	V = 10300. lbs	M = -544800. in-lbs	429400.	No
3	1	V = 15500. lbs	M = -2961600. in-lbs	336100.	No

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust 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 = 2

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

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 = 5100.000 lbs
Applied moment at pile head = 1554000.000 in-lbs
Axial thrust load on pile head = 689400.000 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/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.8743	1554000.	5100.0000	-0.004849	1561.5576	1.511E+11	0.000	0.000	0.000
0.380	0.8523	1592426.	5100.0000	-0.004802	1576.0540	1.511E+11	0.000	0.000	0.000
0.760	0.8305	1630701.	5100.0000	-0.004753	1590.4935	1.511E+11	0.000	0.000	0.000
1.140	0.8090	1668821.	5100.0000	-0.004703	1604.8746	1.511E+11	0.000	0.000	0.000
1.520	0.7877	1706783.	5100.0000	-0.004652	1619.1960	1.511E+11	0.000	0.000	0.000
1.900	0.7666	1744583.	5100.0000	-0.004600	1633.4563	1.511E+11	0.000	0.000	0.000
2.280	0.7457	1782218.	5100.0000	-0.004547	1647.6541	1.511E+11	0.000	0.000	0.000
2.660	0.7251	1819683.	5100.0000	-0.004493	1661.7882	1.511E+11	0.000	0.000	0.000
3.040	0.7047	1856976.	5100.0000	-0.004437	1675.8571	1.511E+11	0.000	0.000	0.000
3.420	0.6846	1894092.	5100.0000	-0.004380	1689.8595	1.511E+11	0.000	0.000	0.000
3.800	0.6648	1931029.	5100.0000	-0.004323	1703.7942	1.511E+11	0.000	0.000	0.000
4.180	0.6452	1967783.	5100.0000	-0.004264	1717.6597	1.511E+11	0.000	0.000	0.000
4.560	0.6259	2004350.	5100.0000	-0.004204	1731.4548	1.511E+11	0.000	0.000	0.000
4.940	0.6069	2040727.	5100.0000	-0.004143	1745.1782	1.511E+11	0.000	0.000	0.000
5.320	0.5881	2076910.	5100.0000	-0.004081	1758.8285	1.511E+11	0.000	0.000	0.000
5.700	0.5696	2112896.	5100.0000	-0.004018	1772.4045	1.511E+11	0.000	0.000	0.000
6.080	0.5515	2148682.	5100.0000	-0.003953	1785.9049	1.511E+11	0.000	0.000	0.000
6.460	0.5336	2184263.	5100.0000	-0.003888	1799.3283	1.511E+11	0.000	0.000	0.000
6.840	0.5160	2219638.	5100.0000	-0.003821	1812.6736	1.511E+11	0.000	0.000	0.000
7.220	0.4987	2254802.	5100.0000	-0.003754	1825.9394	1.511E+11	0.000	0.000	0.000
7.600	0.4818	2289752.	5100.0000	-0.003685	1839.1245	1.511E+11	0.000	0.000	0.000
7.980	0.4651	2324485.	5100.0000	-0.003616	1852.2276	1.511E+11	0.000	0.000	0.000
8.360	0.4488	2358997.	5100.0000	-0.003545	1865.2476	1.511E+11	0.000	0.000	0.000
8.740	0.4328	2393285.	5100.0000	-0.003473	1878.1831	1.511E+11	0.000	0.000	0.000
9.120	0.4171	2427347.	5100.0000	-0.003401	1891.0330	1.511E+11	0.000	0.000	0.000
9.500	0.4018	2461178.	5100.0000	-0.003327	1903.7959	1.511E+11	0.000	0.000	0.000
9.880	0.3868	2494775.	5100.0000	-0.003252	1916.4708	1.511E+11	0.000	0.000	0.000
10.260	0.3721	2528136.	5100.0000	-0.003176	1929.0564	1.511E+11	0.000	0.000	0.000
10.640	0.3578	2561257.	5100.0000	-0.003099	1941.5515	1.511E+11	0.000	0.000	0.000
11.020	0.3439	2594135.	5100.0000	-0.003022	1953.9549	1.511E+11	0.000	0.000	0.000
11.400	0.3303	2626767.	5100.0000	-0.002943	1966.2655	1.511E+11	0.000	0.000	0.000
11.780	0.3170	2659150.	5100.0000	-0.002863	1978.4820	1.511E+11	0.000	0.000	0.000
12.160	0.3041	2691280.	5100.0000	-0.002782	1990.6034	1.511E+11	0.000	0.000	0.000
12.540	0.2916	2723155.	5100.0000	-0.002701	2002.6284	1.511E+11	0.000	0.000	0.000
12.920	0.2795	2754771.	5100.0000	-0.002618	2014.5560	1.511E+11	0.000	0.000	0.000
13.300	0.2678	2786127.	5100.0000	-0.002534	2026.3850	1.511E+11	0.000	0.000	0.000
13.680	0.2564	2817218.	5100.0000	-0.002450	2038.1142	1.511E+11	0.000	0.000	0.000
14.060	0.2454	2848041.	5100.0000	-0.002364	2049.7426	1.511E+11	0.000	0.000	0.000
14.440	0.2348	2878595.	5100.0000	-0.002278	2061.2691	1.511E+11	0.000	0.000	0.000
14.820	0.2247	2908875.	5100.0000	-0.002191	2072.6925	1.511E+11	0.000	0.000	0.000
15.200	0.2149	2938879.	5100.0000	-0.002125	1318.9075	3.133E+11	0.000	0.000	0.000
15.580	0.2053	2968749.	5100.0000	-0.002082	1325.4286	3.133E+11	0.000	0.000	0.000
15.960	0.1959	2998483.	5100.0000	-0.002039	1331.9202	3.133E+11	0.000	0.000	0.000
16.340	0.1867	3028080.	5100.0000	-0.001995	1338.3817	3.133E+11	0.000	0.000	0.000
16.720	0.1777	3057538.	5100.0000	-0.001951	1344.8130	3.133E+11	0.000	0.000	0.000
17.100	0.1689	3086857.	5100.0000	-0.001906	1351.2138	3.133E+11	0.000	0.000	0.000
17.480	0.1603	3116034.	5100.0000	-0.001861	1357.5838	3.133E+11	0.000	0.000	0.000
17.860	0.1519	3145068.	5100.0000	-0.001815	1363.9226	3.133E+11	0.000	0.000	0.000
18.240	0.1437	3173959.	5100.0000	-0.001769	1370.2300	3.133E+11	0.000	0.000	0.000
18.620	0.1358	3202704.	5100.0000	-0.001723	1376.5057	3.133E+11	0.000	0.000	0.000
19.000	0.1280	3231303.	5100.0000	-0.001676	1382.7494	3.133E+11	0.000	0.000	0.000
19.380	0.1205	3259754.	5100.0000	-0.001629	1388.9608	3.133E+11	0.000	0.000	0.000
19.760	0.1132	3288056.	5100.0000	-0.001581	1395.1396	3.133E+11	0.000	0.000	0.000
20.140	0.1061	3316208.	5100.0000	-0.001533	1401.2856	3.133E+11	0.000	0.000	0.000
20.520	0.0992	3344207.	5100.0000	-0.001485	1407.3985	3.133E+11	0.000	0.000	0.000
20.900	0.0925	3372054.	5100.0000	-0.001436	1413.4780	3.133E+11	0.000	0.000	0.000
21.280	0.0861	3399747.	5100.0000	-0.001386	1419.5238	3.133E+11	0.000	0.000	0.000
21.660	0.0799	3427283.	5100.0000	-0.001337	1425.5356	3.133E+11	0.000	0.000	0.000
22.040	0.0739	3454663.	5094.1303	-0.001287	1431.5132	3.133E+11	-2.5744	158.8374	0.000
22.420	0.0682	3481832.	5024.6342	-0.001236	1437.4446	3.133E+11	-27.9063	1867.1050	0.000
22.800	0.0626	3508261.	4837.6437	-0.001185	1443.2146	3.133E+11	-54.1070	3939.2380	0.000
23.180	0.0573	3533404.	4531.4440	-0.001134	1448.7038	3.133E+11	-80.1911	6376.7365	0.000
23.560	0.0523	3556718.	4108.1122	-0.001083	1453.7938	3.133E+11	-105.4808	9198.5159	0.000
23.940	0.0475	3577676.	3569.2857	-0.001031	1458.3693	3.133E+11	-130.8466	12569.	0.000
24.320	0.0429	3595750.	2930.6407	-0.000978	1462.3152	3.133E+11	-149.2609	15869.	0.000
24.700	0.0385	3610555.	2234.3660	-0.000926	1465.5475	3.133E+11	-156.1228	18468.	0.000
25.080	0.0344	3621949.	1515.5631	-0.000873	1468.0350	3.133E+11	-159.1417	21067.	0.000
25.460	0.0306	3629868.	790.8128	-0.000821	1469.7638	3.133E+11	-158.7312	23666.	0.000
25.840	0.0270	3634320.	74.8090	-0.000768	1470.7359	3.133E+11	-155.3055	26266.	0.000
26.220	0.0236	3635377.	-2708.6586	-0.000715	1470.9666	3.133E+11	-1065.5136	206030.	0.000
26.600	0.0204	3614112.	-7505.9478	-0.000662	1466.3239	3.133E+11	-1038.5606	231651.	0.000
26.980	0.0175	3571085.	-12166.	-0.000610	1456.9304	3.133E+11	-1005.1696	261248.	0.000
27.360	0.0149	3506995.	-16659.	-0.000558	1442.9381	3.133E+11	-965.4322	295798.	0.000
27.740	0.0125	3422668.	-20956.	-0.000508	1424.5281	3.133E+11	-919.4028	336641.	0.000
28.120	0.0103	3319068.	-25029.	-0.000459	1401.9101	3.133E+11	-867.0716	385673.	0.000
28.500	0.008270	3197286.	-28849.	-0.000411	1375.3228	3.133E+11	-808.3194	445695.	0.000
28.880	0.006501	3058550.	-32245.	-0.000366	1345.0340	3.133E+11	-681.1072	477781.	0.000
29.260	0.004934	2905512.	-35776.	-0.000322	1311.6227	3.133E+11	-867.4274	801671.	0.000
29.640	0.003560	2734303.	-39324.	-0.000281	1274.2446	3.133E+11	-688.9997	882457.	0.000
30.020	0.002368	2548643.	-41989.	-0.000243	1233.7113	3.133E+11	-479.8758	924044.	0.000
30.400	0.001345	2352888.	-43733.	-0.000207	1190.9741	3.133E+11	-284.8254	965631.	0.000
30.780	0.000478	2151102.	-44623.	-0.000174	1146.9204	3.133E+11	-105.6068	1007219.	0.000
31.160	-0.000246	1947023.	-44735.	-0.000145	1102.3658	3.133E+11	56.5878	1048806.	0.000
31.540	-0.000841	1744030.	-44147.	-0.000118	1058.0486	3.133E+11	201.0911	1090393.	0.000
31.920	-0.001320	1545140.	-42942.	-9.384E-05	1014.6269	3.133E+11	327.7120	1131980.	0.000
32.300	-0.001697	1352993.	-41199.	-7.275E-05	972.6774	3.133E+11	436.6807	1173567.	0.000
32.680	-0.001984	1169864.	-38998.	-5.439E-05	932.6968	3.133E+11	528.5900	1215155.	0.000
33.060	-0.002193	997673.	-36415.	-3.861E-05	895.1042	3.133E+11	604.3325	1256742.	0.000
33.440	-0.002336	838002.	-33521.	-2.526E-05	860.2450	3.133E+11	665.0379	1298329.	0.000
33.820	-0.002423	692122.	-30381.	-1.412E-05	828.3965	3.133E+11	712.0084	1339916.	0.000
34.200	-0.002465	561015.	-27117.	-5.000E-06	799.7733	3.133E+11	719.5352	1331324.	0.000
34.580	-0.002469	444845.	-23835.	2.320E-06	774.4110	3.133E+11	720.1484	1330200.	0.000
34.960	-0.002443	343628.	-20559.	8.057E-06	752.3135	3.133E+11	716.4456	1337084.	0.000

35.340	-0.002395	257294.	-17308.	1.243E-05	733.4649	3.133E+11	709.3543	1350460.	0.000
35.720	-0.002330	185697.	-14096.	1.565E-05	717.8340	3.133E+11	699.6323	1369235.	0.000
36.100	-0.002252	128640.	-11351.	1.794E-05	705.3773	3.133E+11	504.4705	1021278.	0.000
36.480	-0.002166	82067.	-9049.1315	1.948E-05	695.2095	3.133E+11	504.9481	1062865.	0.000
36.860	-0.002075	45990.	-6752.0671	2.041E-05	687.3331	3.133E+11	502.5363	1104452.	0.000
37.240	-0.001980	20360.	-4471.5559	2.089E-05	681.7376	3.133E+11	497.6879	1146040.	0.000
37.620	-0.001884	5077.5868	-2217.8894	2.108E-05	678.4012	3.133E+11	490.7624	1187627.	0.000
38.000	-0.001788	0.000	0.000	2.111E-05	677.2927	3.133E+11	481.9961	614607.	0.000

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.8743366 inches
Computed slope at pile head = -0.0048491 radians
Maximum bending moment = 3635377. inch-lbs
Maximum shear force = -44735. lbs
Depth of maximum bending moment = 314.6400000 inches below pile head
Depth of maximum shear force = 373.9200000 inches below pile head
Number of iterations = 8
Number of zero deflection points = 1

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

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

Shear force at pile head = 10300.000 lbs
Applied moment at pile head = -544800.000 in-lbs
Axial thrust load on pile head = 429400.000 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/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.5272	-544800.	10300.	-0.002072	813.0059	1.511E+11	0.000	0.000	0.000
0.380	0.5177	-493760.	10300.	-0.002087	793.7506	1.511E+11	0.000	0.000	0.000
0.760	0.5082	-442690.	10300.	-0.002101	774.4843	1.511E+11	0.000	0.000	0.000
1.140	0.4986	-391595.	10300.	-0.002114	755.2082	1.511E+11	0.000	0.000	0.000
1.520	0.4889	-340476.	10300.	-0.002125	735.9233	1.511E+11	0.000	0.000	0.000
1.900	0.4792	-289337.	10300.	-0.002134	716.6308	1.511E+11	0.000	0.000	0.000
2.280	0.4694	-238181.	10300.	-0.002142	697.3319	1.511E+11	0.000	0.000	0.000
2.660	0.4596	-187011.	10300.	-0.002149	678.0277	1.511E+11	0.000	0.000	0.000
3.040	0.4498	-135830.	10300.	-0.002154	658.7193	1.511E+11	0.000	0.000	0.000
3.420	0.4400	-84640.	10300.	-0.002157	639.4079	1.511E+11	0.000	0.000	0.000
3.800	0.4301	-33446.	10300.	-0.002159	620.0946	1.511E+11	0.000	0.000	0.000
4.180	0.4203	17750.	10300.	-0.002159	614.1730	1.511E+11	0.000	0.000	0.000
4.560	0.4105	68945.	10300.	-0.002158	633.4866	1.511E+11	0.000	0.000	0.000
4.940	0.4006	120136.	10300.	-0.002155	652.7988	1.511E+11	0.000	0.000	0.000
5.320	0.3908	171320.	10300.	-0.002151	672.1082	1.511E+11	0.000	0.000	0.000
5.700	0.3810	222494.	10300.	-0.002145	691.4138	1.511E+11	0.000	0.000	0.000
6.080	0.3712	273654.	10300.	-0.002137	710.7145	1.511E+11	0.000	0.000	0.000
6.460	0.3615	324799.	10300.	-0.002128	730.0091	1.511E+11	0.000	0.000	0.000
6.840	0.3518	375924.	10300.	-0.002117	749.2964	1.511E+11	0.000	0.000	0.000
7.220	0.3422	427027.	10300.	-0.002105	768.5753	1.511E+11	0.000	0.000	0.000
7.600	0.3326	478105.	10300.	-0.002092	787.8448	1.511E+11	0.000	0.000	0.000
7.980	0.3231	529155.	10300.	-0.002077	807.1035	1.511E+11	0.000	0.000	0.000
8.360	0.3137	580173.	10300.	-0.002060	826.3505	1.511E+11	0.000	0.000	0.000
8.740	0.3043	631157.	10300.	-0.002041	845.5845	1.511E+11	0.000	0.000	0.000
9.120	0.2951	682104.	10300.	-0.002022	864.8045	1.511E+11	0.000	0.000	0.000
9.500	0.2859	733010.	10300.	-0.002000	884.0093	1.511E+11	0.000	0.000	0.000
9.880	0.2768	783873.	10300.	-0.001977	903.1977	1.511E+11	0.000	0.000	0.000
10.260	0.2679	834690.	10300.	-0.001953	922.3686	1.511E+11	0.000	0.000	0.000
10.640	0.2590	885457.	10300.	-0.001927	941.5209	1.511E+11	0.000	0.000	0.000
11.020	0.2503	936172.	10300.	-0.001900	960.6535	1.511E+11	0.000	0.000	0.000
11.400	0.2417	986832.	10300.	-0.001871	979.7653	1.511E+11	0.000	0.000	0.000
11.780	0.2332	1037434.	10300.	-0.001840	998.8550	1.511E+11	0.000	0.000	0.000
12.160	0.2249	1087974.	10300.	-0.001808	1017.9216	1.511E+11	0.000	0.000	0.000
12.540	0.2168	1138450.	10300.	-0.001774	1036.9639	1.511E+11	0.000	0.000	0.000
12.920	0.2087	1188858.	10300.	-0.001739	1055.9809	1.511E+11	0.000	0.000	0.000
13.300	0.2009	1239197.	10300.	-0.001703	1074.9713	1.511E+11	0.000	0.000	0.000
13.680	0.1932	1289462.	10300.	-0.001664	1093.9341	1.511E+11	0.000	0.000	0.000
14.060	0.1857	1339651.	10300.	-0.001625	1112.8682	1.511E+11	0.000	0.000	0.000
14.440	0.1784	1389760.	10300.	-0.001584	1131.7724	1.511E+11	0.000	0.000	0.000
14.820	0.1713	1439788.	10300.	-0.001541	1150.6456	1.511E+11	0.000	0.000	0.000
15.200	0.1643	1489731.	10300.	-0.001508	747.0961	3.133E+11	0.000	0.000	0.000
15.580	0.1575	1539631.	10300.	-0.001486	757.9903	3.133E+11	0.000	0.000	0.000
15.960	0.1508	1589487.	10300.	-0.001463	768.8749	3.133E+11	0.000	0.000	0.000
16.340	0.1442	1639298.	10300.	-0.001440	779.7496	3.133E+11	0.000	0.000	0.000
16.720	0.1377	1689062.	10300.	-0.001416	790.6141	3.133E+11	0.000	0.000	0.000
17.100	0.1313	1738778.	10300.	-0.001391	801.4680	3.133E+11	0.000	0.000	0.000
17.480	0.1250	1788444.	10300.	-0.001365	812.3112	3.133E+11	0.000	0.000	0.000
17.860	0.1188	1838060.	10300.	-0.001339	823.1432	3.133E+11	0.000	0.000	0.000
18.240	0.1128	1887623.	10300.	-0.001312	833.9638	3.133E+11	0.000	0.000	0.000
18.620	0.1068	1937132.	10300.	-0.001284	844.7727	3.133E+11	0.000	0.000	0.000
19.000	0.1011	1986587.	10300.	-0.001255	855.5695	3.133E+11	0.000	0.000	0.000
19.380	0.0954	2035984.	10300.	-0.001226	866.3540	3.133E+11	0.000	0.000	0.000
19.760	0.0899	2085324.	10300.	-0.001196	877.1257	3.133E+11	0.000	0.000	0.000
20.140	0.0845	2134604.	10300.	-0.001165	887.8845	3.133E+11	0.000	0.000	0.000
20.520	0.0792	2183823.	10300.	-0.001134	898.6300	3.133E+11	0.000	0.000	0.000
20.900	0.0741	2232980.	10300.	-0.001102	909.3620	3.133E+11	0.000	0.000	0.000
21.280	0.0692	2282073.	10300.	-0.001069	920.0800	3.133E+11	0.000	0.000	0.000
21.660	0.0644	2331102.	10300.	-0.001035	930.7839	3.133E+11	0.000	0.000	0.000

22.040	0.0598	2380063.	10294.	-0.001001	941.4732	3.133E+11	-2.4368	185.9448	0.000
22.420	0.0553	2428907.	10229.	-0.000966	952.1367	3.133E+11	-26.4021	2178.1679	0.000
22.800	0.0509	2477132.	10052.	-0.000930	962.6652	3.133E+11	-51.1636	4579.2485	0.000
23.180	0.0468	2524223.	9762.4011	-0.000894	972.9460	3.133E+11	-75.7841	7385.8804	0.000
23.560	0.0428	2569666.	9362.4451	-0.000857	982.8671	3.133E+11	-99.6352	10616.	0.000
23.940	0.0390	2612964.	8876.6885	-0.000819	992.3199	3.133E+11	-113.4159	13270.	0.000
24.320	0.0353	2653829.	8337.8081	-0.000781	1001.2415	3.133E+11	-122.9351	15869.	0.000
24.700	0.0319	2692062.	7763.3766	-0.000742	1009.5886	3.133E+11	-129.0085	18468.	0.000
25.080	0.0286	2727536.	7168.3935	-0.000702	1017.3332	3.133E+11	-131.9490	21067.	0.000
25.460	0.0254	2760189.	6566.4202	-0.000662	1024.4619	3.133E+11	-132.0744	23666.	0.000
25.840	0.0225	2790016.	5969.5596	-0.000622	1030.9739	3.133E+11	-129.7066	26266.	0.000
26.220	0.0198	2817067.	3449.2499	-0.000581	1036.8796	3.133E+11	-975.6924	224997.	0.000
26.600	0.0172	2823750.	-948.3543	-0.000540	1038.3386	3.133E+11	-953.0814	252426.	0.000
26.980	0.0148	2810534.	-5229.6281	-0.000499	1035.4533	3.133E+11	-924.6703	283990.	0.000
27.360	0.0127	2778011.	-9368.3477	-0.000459	1028.3528	3.133E+11	-890.5577	320667.	0.000
27.740	0.0107	2726890.	-13339.	-0.000419	1017.1923	3.133E+11	-850.8188	363776.	0.000
28.120	0.008847	2658001.	-17115.	-0.000379	1002.1523	3.133E+11	-805.4849	415159.	0.000
28.500	0.007206	2572286.	-20598.	-0.000341	983.4392	3.133E+11	-722.1358	456988.	0.000
28.880	0.005735	2471483.	-23615.	-0.000305	961.4319	3.133E+11	-600.8904	477781.	0.000
29.260	0.004428	2358115.	-26846.	-0.000269	936.6813	3.133E+11	-816.5685	840870.	0.000
29.640	0.003278	2227699.	-30154.	-0.000236	908.2092	3.133E+11	-634.3569	882457.	0.000
30.020	0.002276	2084030.	-32652.	-0.000205	876.8434	3.133E+11	-461.1253	924044.	0.000
30.400	0.001411	1930713.	-34385.	-0.000175	843.3713	3.133E+11	-298.9000	965631.	0.000
30.780	0.000676	1771126.	-35407.	-0.000149	808.5303	3.133E+11	-149.2175	1007219.	0.000
31.160	5.716E-05	1608386.	-35777.	-0.000124	773.0009	3.133E+11	-13.1477	1048806.	0.000
31.540	-0.000454	1445326.	-35559.	-0.000102	737.4017	3.133E+11	108.6761	1090393.	0.000
31.920	-0.000870	1284485.	-34819.	-8.182E-05	702.2870	3.133E+11	216.0197	1131980.	0.000
32.300	-0.001201	1128099.	-33622.	-6.426E-05	668.1449	3.133E+11	309.0060	1173567.	0.000
32.680	-0.001456	978106.	-32032.	-4.893E-05	635.3986	3.133E+11	388.0683	1215155.	0.000
33.060	-0.001647	836155.	-30113.	-3.573E-05	604.4078	3.133E+11	453.9017	1256742.	0.000
33.440	-0.001782	703618.	-27921.	-2.453E-05	575.4724	3.133E+11	507.4127	1298329.	0.000
33.820	-0.001871	581612.	-25511.	-1.517E-05	548.8362	3.133E+11	549.6675	1339916.	0.000
34.200	-0.001921	471019.	-22931.	-7.513E-06	524.6916	3.133E+11	581.8417	1381503.	0.000
34.580	-0.001939	372512.	-20225.	-1.374E-06	503.1854	3.133E+11	605.1698	1423091.	0.000
34.960	-0.001933	286577.	-17429.	3.422E-06	484.4242	3.133E+11	620.8966	1464678.	0.000
35.340	-0.001908	213545.	-14577.	7.062E-06	468.4798	3.133E+11	630.2294	1506265.	0.000
35.720	-0.001869	153611.	-11711.	9.734E-06	455.3951	3.133E+11	626.5434	1528940.	0.000
36.100	-0.001819	106701.	-9353.6581	1.163E-05	445.1538	3.133E+11	407.4261	1021278.	0.000
36.480	-0.001763	68260.	-7488.0292	1.290E-05	436.7614	3.133E+11	410.8322	1062865.	0.000
36.860	-0.001701	38360.	-5611.7228	1.368E-05	430.2335	3.133E+11	412.1092	1104452.	0.000
37.240	-0.001638	17028.	-3733.5930	1.408E-05	425.5763	3.133E+11	411.6320	1146040.	0.000
37.620	-0.001573	4254.3338	-1860.9570	1.424E-05	422.7876	3.133E+11	409.6996	1187627.	0.000
38.000	-0.001508	0.000	0.000	1.427E-05	421.8588	3.133E+11	406.5096	614607.	0.000

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

Output Summary for Load Case No. 2:

Pile-head deflection = 0.5272000 inches
Computed slope at pile head = -0.0020715 radians
Maximum bending moment = 2823750. inch-lbs
Maximum shear force = -35777. lbs
Depth of maximum bending moment = 319.2000000 inches below pile head
Depth of maximum shear force = 373.9200000 inches below pile head
Number of iterations = 7
Number of zero deflection points = 1

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

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

Shear force at pile head = 15500.000 lbs
Applied moment at pile head = -2961600.000 in-lbs
Axial thrust load on pile head = 336100.000 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/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.1366	-2961600.	15500.	0.001061	1592.7661	1.511E+11	0.000	0.000	0.000
0.380	0.1413	-2892478.	15500.	0.000973	1566.6892	1.511E+11	0.000	0.000	0.000
0.760	0.1455	-2823221.	15500.	0.000886	1540.5619	1.511E+11	0.000	0.000	0.000
1.140	0.1493	-2753834.	15500.	0.000802	1514.3853	1.511E+11	0.000	0.000	0.000
1.520	0.1528	-2684320.	15500.	0.000720	1488.1606	1.511E+11	0.000	0.000	0.000
1.900	0.1559	-2614682.	15500.	0.000640	1461.8891	1.511E+11	0.000	0.000	0.000
2.280	0.1586	-2544923.	15500.	0.000562	1435.5720	1.511E+11	0.000	0.000	0.000
2.660	0.1610	-2475046.	15500.	0.000487	1409.2104	1.511E+11	0.000	0.000	0.000
3.040	0.1631	-2405054.	15500.	0.000413	1382.8057	1.511E+11	0.000	0.000	0.000
3.420	0.1648	-2334951.	15500.	0.000341	1356.3590	1.511E+11	0.000	0.000	0.000
3.800	0.1662	-2264740.	15500.	0.000272	1329.8715	1.511E+11	0.000	0.000	0.000
4.180	0.1673	-2194425.	15500.	0.000205	1303.3446	1.511E+11	0.000	0.000	0.000
4.560	0.1681	-2124008.	15500.	0.000140	1276.7793	1.511E+11	0.000	0.000	0.000
4.940	0.1686	-2053493.	15500.	7.649E-05	1250.1770	1.511E+11	0.000	0.000	0.000
5.320	0.1688	-1982882.	15500.	1.558E-05	1223.5388	1.511E+11	0.000	0.000	0.000
5.700	0.1687	-1912180.	15500.	-4.319E-05	1196.8661	1.511E+11	0.000	0.000	0.000
6.080	0.1684	-1841390.	15500.	-9.984E-05	1170.1600	1.511E+11	0.000	0.000	0.000
6.460	0.1678	-1770514.	15500.	-0.000154	1143.4217	1.511E+11	0.000	0.000	0.000
6.840	0.1670	-1699557.	15500.	-0.000207	1116.6526	1.511E+11	0.000	0.000	0.000
7.220	0.1659	-1628521.	15500.	-0.000257	1089.8537	1.511E+11	0.000	0.000	0.000
7.600	0.1646	-1557409.	15500.	-0.000305	1063.0265	1.511E+11	0.000	0.000	0.000
7.980	0.1631	-1486226.	15500.	-0.000351	1036.1721	1.511E+11	0.000	0.000	0.000
8.360	0.1614	-1414974.	15500.	-0.000395	1009.2918	1.511E+11	0.000	0.000	0.000

8.740	0.1595	-1343656.	15500.	-0.000436	982.3868	1.511E+11	0.000	0.000	0.000
9.120	0.1574	-1272276.	15500.	-0.000476	955.4583	1.511E+11	0.000	0.000	0.000
9.500	0.1552	-1200838.	15500.	-0.000513	928.5076	1.511E+11	0.000	0.000	0.000
9.880	0.1528	-1129343.	15500.	-0.000548	901.5360	1.511E+11	0.000	0.000	0.000
10.260	0.1502	-1057797.	15500.	-0.000581	874.5446	1.511E+11	0.000	0.000	0.000
10.640	0.1475	-986202.	15500.	-0.000612	847.5348	1.511E+11	0.000	0.000	0.000
11.020	0.1446	-914561.	15500.	-0.000641	820.5078	1.511E+11	0.000	0.000	0.000
11.400	0.1416	-842877.	15500.	-0.000667	793.4649	1.511E+11	0.000	0.000	0.000
11.780	0.1385	-771155.	15500.	-0.000692	766.4072	1.511E+11	0.000	0.000	0.000
12.160	0.1353	-699397.	15500.	-0.000714	739.3361	1.511E+11	0.000	0.000	0.000
12.540	0.1320	-627607.	15500.	-0.000734	712.2527	1.511E+11	0.000	0.000	0.000
12.920	0.1286	-555787.	15500.	-0.000752	685.1584	1.511E+11	0.000	0.000	0.000
13.300	0.1251	-483942.	15500.	-0.000767	658.0544	1.511E+11	0.000	0.000	0.000
13.680	0.1216	-412075.	15500.	-0.000781	630.9420	1.511E+11	0.000	0.000	0.000
14.060	0.1180	-340188.	15500.	-0.000792	603.8224	1.511E+11	0.000	0.000	0.000
14.440	0.1144	-268286.	15500.	-0.000802	576.6968	1.511E+11	0.000	0.000	0.000
14.820	0.1107	-196372.	15500.	-0.000809	549.5666	1.511E+11	0.000	0.000	0.000
15.200	0.1070	-124448.	15500.	-0.000812	357.3668	3.133E+11	0.000	0.000	0.000
15.580	0.1033	-52521.	15500.	-0.000814	341.6638	3.133E+11	0.000	0.000	0.000
15.960	0.0996	19406.	15500.	-0.000814	334.4342	3.133E+11	0.000	0.000	0.000
16.340	0.0959	91334.	15500.	-0.000813	350.1373	3.133E+11	0.000	0.000	0.000
16.720	0.0922	163259.	15500.	-0.000811	365.8400	3.133E+11	0.000	0.000	0.000
17.100	0.0885	235180.	15500.	-0.000808	381.5418	3.133E+11	0.000	0.000	0.000
17.480	0.0848	307097.	15500.	-0.000804	397.2426	3.133E+11	0.000	0.000	0.000
17.860	0.0811	379006.	15500.	-0.000799	412.9418	3.133E+11	0.000	0.000	0.000
18.240	0.0775	450907.	15500.	-0.000793	428.6392	3.133E+11	0.000	0.000	0.000
18.620	0.0739	522798.	15500.	-0.000786	444.3344	3.133E+11	0.000	0.000	0.000
19.000	0.0703	594677.	15500.	-0.000778	460.0271	3.133E+11	0.000	0.000	0.000
19.380	0.0668	666543.	15500.	-0.000769	475.7168	3.133E+11	0.000	0.000	0.000
19.760	0.0633	738394.	15500.	-0.000759	491.4033	3.133E+11	0.000	0.000	0.000
20.140	0.0599	810229.	15500.	-0.000748	507.0862	3.133E+11	0.000	0.000	0.000
20.520	0.0565	882046.	15500.	-0.000735	522.7652	3.133E+11	0.000	0.000	0.000
20.900	0.0532	953843.	15500.	-0.000722	538.4399	3.133E+11	0.000	0.000	0.000
21.280	0.0499	1025618.	15500.	-0.000707	554.1099	3.133E+11	0.000	0.000	0.000
21.660	0.0467	1097371.	15500.	-0.000692	569.7749	3.133E+11	0.000	0.000	0.000
22.040	0.0436	1169099.	15495.	-0.000675	585.4346	3.133E+11	-2.2463	234.8481	0.000
22.420	0.0406	1240755.	15434.	-0.000658	601.0784	3.133E+11	-24.3294	2734.3057	0.000
22.800	0.0376	1311877.	15276.	-0.000639	616.6057	3.133E+11	-45.1382	5472.0000	0.000
23.180	0.0347	1382031.	15033.	-0.000620	631.9217	3.133E+11	-61.4954	8071.2000	0.000
23.560	0.0320	1450875.	14722.	-0.000599	646.9518	3.133E+11	-74.7932	10670.	0.000
23.940	0.0293	1518132.	14357.	-0.000578	661.6354	3.133E+11	-85.2017	13270.	0.000
24.320	0.0267	1583584.	13951.	-0.000555	675.9247	3.133E+11	-92.9011	15869.	0.000
24.700	0.0242	1647068.	13516.	-0.000531	689.7846	3.133E+11	-98.0813	18468.	0.000
25.080	0.0218	1708476.	13062.	-0.000507	703.1912	3.133E+11	-100.9415	21067.	0.000
25.460	0.0196	1767748.	12600.	-0.000482	716.1312	3.133E+11	-101.6897	23666.	0.000
25.840	0.0175	1824865.	12139.	-0.000456	728.6010	3.133E+11	-100.5426	26266.	0.000
26.220	0.0154	1879851.	9944.0088	-0.000429	740.6055	3.133E+11	-862.1177	254642.	0.000
26.600	0.0135	1916868.	6050.8698	-0.000401	748.6871	3.133E+11	-845.3994	284584.	0.000
26.980	0.0118	1936264.	2245.3562	-0.000373	752.9216	3.133E+11	-823.6855	318815.	0.000
27.360	0.0101	1938489.	-1449.9803	-0.000345	753.4074	3.133E+11	-797.0761	358283.	0.000
27.740	0.008637	1924097.	-5013.0209	-0.000317	750.2653	3.133E+11	-765.6610	404245.	0.000
28.120	0.007257	1893741.	-8341.4050	-0.000289	743.6380	3.133E+11	-694.1566	436194.	0.000
28.500	0.006002	1848909.	-11296.	-0.000262	733.8502	3.133E+11	-601.5325	456988.	0.000
28.880	0.004871	1791527.	-13831.	-0.000235	721.3228	3.133E+11	-510.3252	477781.	0.000
29.260	0.003858	1723494.	-16616.	-0.000210	706.4698	3.133E+11	-711.3800	840870.	0.000
29.640	0.002959	1640631.	-19544.	-0.000185	688.3791	3.133E+11	-572.6972	882457.	0.000
30.020	0.002170	1545822.	-21852.	-0.000162	667.6805	3.133E+11	-439.6921	924044.	0.000
30.400	0.001483	1441836.	-23570.	-0.000140	644.9784	3.133E+11	-314.0113	965631.	0.000
30.780	0.000892	1331289.	-24735.	-0.000120	620.8437	3.133E+11	-196.9375	1007219.	0.000
31.160	0.000389	1216617.	-25388.	-0.000101	595.8086	3.133E+11	-89.4012	1048806.	0.000
31.540	-3.346E-05	1100058.	-25574.	-8.457E-05	570.3616	3.133E+11	8.0000	1090393.	0.000
31.920	-0.000383	983642.	-25339.	-6.941E-05	544.9456	3.133E+11	94.9771	1131980.	0.000
32.300	-0.000666	869179.	-24731.	-5.592E-05	519.9560	3.133E+11	171.5213	1173567.	0.000
32.680	-0.000893	758262.	-23798.	-4.408E-05	495.7408	3.133E+11	237.8706	1215155.	0.000
33.060	-0.001068	652275.	-22584.	-3.382E-05	472.6018	3.133E+11	294.4756	1256742.	0.000
33.440	-0.001201	552397.	-21133.	-2.505E-05	450.7964	3.133E+11	341.9623	1298329.	0.000
33.820	-0.001297	459617.	-19485.	-1.769E-05	430.5407	3.133E+11	381.0941	1339916.	0.000
34.200	-0.001362	374751.	-17675.	-1.161E-05	412.0128	3.133E+11	412.7333	1381503.	0.000
34.580	-0.001403	298458.	-15736.	-6.714E-06	395.3567	3.133E+11	437.8032	1423091.	0.000
34.960	-0.001424	231263.	-13695.	-2.859E-06	380.6867	3.133E+11	457.2497	1464678.	0.000
35.340	-0.001429	173571.	-11576.	8.711E-08	368.0912	3.133E+11	472.0040	1506265.	0.000
35.720	-0.001423	125689.	-9398.8285	2.265E-06	357.6377	3.133E+11	482.9458	1547852.	0.000
36.100	-0.001408	87846.	-7578.5956	3.819E-06	349.3760	3.133E+11	315.4020	1021278.	0.000
36.480	-0.001388	56560.	-6121.8833	4.870E-06	342.5456	3.133E+11	323.5069	1062865.	0.000
36.860	-0.001364	32000.	-4631.1307	5.514E-06	337.1836	3.133E+11	330.3319	1104452.	0.000
37.240	-0.001338	14307.	-3111.4748	5.851E-06	333.3210	3.133E+11	336.1838	1146040.	0.000
37.620	-0.001310	3605.2239	-1566.7878	5.982E-06	330.9845	3.133E+11	341.3104	1187627.	0.000
38.000	-0.001283	0.000	0.000	6.008E-06	330.1974	3.133E+11	345.8772	614607.	0.000

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

Output Summary for Load Case No. 3:

```
Pile-head deflection             =      0.1366219 inches
Computed slope at pile head      =      0.0010610 radians
Maximum bending moment           =      -2961600. inch-lbs
Maximum shear force              =        -25574. lbs
Depth of maximum bending moment  =       0.000000 inches below pile head
Depth of maximum shear force     =    378.4800000 inches below pile head
Number of iterations             =              6
Number of zero deflection points =              1
```

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 5100.0000	M = 1554000.	689400.	0.87433658	3635377.	-44735.	-0.00484905
2	1	V = 10300.	M = -544800.	429400.	0.52719999	2823750.	-35777.	-0.00207154
3	1	V = 15500.	M = -2961600.	336100.	0.13662186	-2961600.	-25574.	0.00106096

The analysis ended normally.

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

PROJECT: 17BP.12.R.35 COUNTY Cleveland
SUBJECT: Drilled Pier Axial Resistance Calculations
Bridge # 135 over mayne Creek on SR 1330 B1-A
PREPARED BY: grt DATE: 06/03/15 STATION: 14+00.72
CHECKED BY: DATE: STR. NO.: PAGE: 1 OF 5

DISCLAIMER: *The application of this spreadsheet is the responsibility of the user. It is imperative that the user understands the potential accuracy limitations and examines the reasonableness of the results with engineering knowledge and experience. There are no expressed or implied warranties.*

Elevations

Bottom of Cap (BOC) Elevation =	786.00	ft
Top of Pier/Bottom of Column Elevation =	771.00	ft
Natural Ground / Finished Grade Elevation =	768.50	ft
Groundwater Table (GWT) Elevation =	768.50	ft
Design Scour (DSE) Elevation =	764.00	ft
Is Permanent Casing Required?	○ Yes / Maybe ◉ No	
Bottom of Permanent Casing Elevation =	N/A	ft
Drilled Pier Tip Elevation =	754.00	ft

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	690.0	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

Miscellaneous Properties

SPT Hammer Energy Efficiency Rating (ER) =	84	%
Unit Weight of Water (γ_w) =	0.0624	kcf

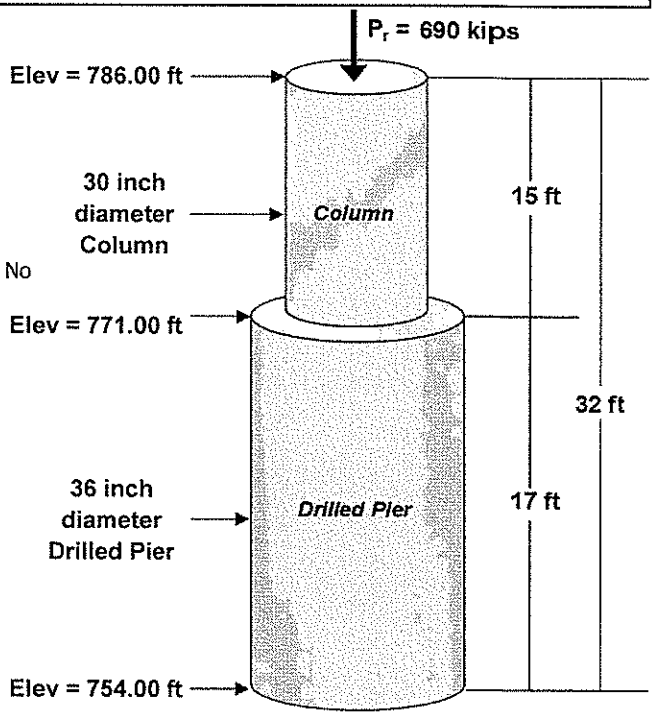


Figure shows typical drilled pier (not drawn to scale)

Soil and Rock Information

Layer No.	Material Description	Layer Elevations Top[1] (ft)	Layer Elevations Bottom (ft)	Total γ (kcf)	N (bpf)	(2) RQD (%)	(2) RMR	q_u (ksf)	E_i (ksi)	ν
1	Hard Rock	764.00	758.00	0.140			41	2,000	7,000	
2	Hard Rock	758.00	754.00	0.140			69	2,000	7,000	
3										
4										
5										
6										
7										
8										
TIP [3]	Hard Rock	754.00	748.00	0.140			69	2,000	7,000	

Tip Resistance Method for Hard Rock (if applicable)

◉ Based on RMR (AASHTO Section ○ Based on GSI (FHWA-NHI-10-016 Section 3 and

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 (RMR < 44 or GSI < 30) will be modeled as weathered rock.
3. Input the subsurface information for the soil / rock at the base of the drilled pier to a distance of 2 pier diameters below the base of the drilled pier.

Side Resistance in Weathered and Hard Rock

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

A_s = area of drilled pier side resistance (ft^2)
= $(\pi)(B)(\Delta z)$

B = diameter of drilled pier - 2 inches to account for possible reduction for drilled pier in rock (B = 2.83 ft)
Δz = effective thickness of the soil layer (ft)

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

= 8 ksf for Weathered Rock Layers or Hard Rock Layers with an RMR < 44 *NCDOT Policy*

= $0.65(a_E)(p_a)(q_u/p_a)^{0.5} < 7.8(p_a)(f'_c/p_a)^{0.5}$ for Hard Rock Layers *AASHTO Eqn. 10.8.3.5.4b-1*

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

E_m/E_i	α_E
1.0	1.0
0.5	0.8
0.3	0.7
0.1	0.55
0.05	0.45

E_m = Elastic modulus of rock mass (ksi) ≤ E_i

$$= 145\left[10^{\frac{RMR-10}{40}}\right]$$ *AASHTO Eqn. 10.4.6.5-1*

RMR = Rock Mass Rating
E_i = Elastic modulus of intact rock (ksi) taken from AASHTO Table C10.4.6.5-1 if lab test data is not available

q_u = Uniaxial Compressive Strength of Intact Rock (ksf) based on Point Load Index Value Correlation or Rock Core Uniaxial Compressive Strength Test Data
p_a = atmospheric pressure (2.12 ksf)
f'_c = 28 day Compressive Strength of Concrete (4.5 ksi)

****** Note that p_a and f'_c are in different units. This is not a typo. ******

$7.8(p_a)(f'_c/p_a)^{0.5}$ = the limiting value for nominal side resistance based on the strength of the concrete

Layer No.	Rock Type	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	RMR	E_m (ksi)	E_i (ksi)	E_m/E_i	α_E	q_u (ksf)	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
1	Hard Rock	764.00	758.00	41	N/A	N/A	N/A	N/A	N/A	8.000	6.00	53.41	427
2	Hard Rock	758.00	754.00	69	4,329	7,000	0.62	0.85	2,000	24.000	4.00	35.60	854

Total Side Resistance in Weathered and Hard Rock = 1,281

Tip Resistance in Hard Rock based on RMR

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

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)

q_p = unit tip resistance (ksf) *$q_p \geq 90$ ksf per NCDOT policy*

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

$$= \left[\sqrt{s} + \sqrt{m\sqrt{s} + s}\right] q_u$$ *AASHTO Eqn. 10.8.3.5.4c-2*

q_u = Uniaxial Compressive Strength of Intact Rock (ksf)

m,s = fractured rock mass parameters specified in Table 10.4.6.4-4 (shown below)

Rock Quality	Constants	Rock Type A = Carbonate rocks with well developed crystal cleavage—*dolomite, limestone and marble* B = Lithified argrillaceous rocks—*mudstone, siltstone, shale and slate (normal to cleavage)* C = Arenaceous rocks with strong crystals and poorly developed crystal cleavage—*sandstone and quartzite* D = Fine grained polyminerallic igneous crystalline rocks—*andesite, dolerite, diabase and rhyolite* E = Coarse grained polyminerallic igneous & metamorphic crystalline rocks—*amphibolite, gabbro gneiss, granite, norite, quartz-diorite*				
		A	B	C	D	E
INTACT ROCK SAMPLES Laboratory size specimens free from discontinuities. CSIR rating: *RMR* = 100	*m* *s*	7.00 1.00	10.00 1.00	15.00 1.00	17.00 1.00	25.00 1.00
VERY GOOD QUALITY ROCK MASS Tightly interlocking undisturbed rock with unweathered joints at 3–10 ft CSIR rating: *RMR* = 85	*m* *s*	2.40 0.082	3.43 0.082	5.14 0.082	5.82 0.082	8.567 0.082
GOOD QUALITY ROCK MASS Fresh to slightly weathered rock, slightly disturbed with joints at 3–10 ft CSIR rating: *RMR* = 65	*m* *s*	0.575 0.00293	0.821 0.00293	1.231 0.00293	1.395 0.00293	2.052 0.00293
FAIR QUALITY ROCK MASS Several sets of moderately weathered joints spaced at 1–3 ft CSIR rating: *RMR* = 44	*m* *s*	0.128 0.00009	0.183 0.00009	0.275 0.00009	0.311 0.00009	0.458 0.00009

Tip Elevation (ft)	AASHTO Equation used to calculate q_u	RMR	q_u (ksf)	Rock type	m	s	q_p (ksf)	A_p (ft^2)	R_p (kips)
754.00	10.8.3.5.4c-2	69	2000	E	2.731	0.006	1,088	6.31	6,865

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%
IGM	0	0.60	0	0.0%
Weathered Rock	427	0.60	256	33.3%
Hard Rock	854	0.55	470	66.7%
Total	**1,281**		**726**	**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).*

Total Nominal Side Resistance = 854 kips
Side Resistance Factor = 0.55 *for Hard Rock, see AASHTO Table 10.5.5.2.4-1.*
Total Factored Side Resistance = 470 kips

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance = 6,865 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 = 3,433 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 = 690 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} = 15 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 11 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} = 17 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 18 kips

Required Factored Resistance (continued)

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

A_{Pier} = 7.07 ft^2 *Area of Drilled Pier*

z_w = 15 ft *Depth from water surface to the drilled pier tip*

γ_w = 0.0624 kcf *Unit Weight of Water*

= 7 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} = 0.776 ksf *Vertical Effective Stress (taken from the DSE) at the Drilled Pier Tip*

$W_{Soil/Rock}$ = 5 kips

R_{req} = 690 kips + 1.25(11 kips + 18 kips) -1.00(7 kips) -1.25(5 kips) = 713 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.

3,433 kips ≥ 713 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)

$$= \frac{\frac{R_{req} - \varphi_{qs} R_{sd}}{A_T}}{\varphi_{tip}} \leq q_p$$ *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)
713	0	6.31	0.50	1088	230

STATE OF NORTH CAROLINA
DEPARTMENT OF TRANSPORTATION
GEOTECHNICAL ENGINEERING UNIT
1589 MAIL SERVICE CENTER
RALEIGH, NC 27699

PROJECT: 17BP.12.R.35 COUNTY Cleveland
SUBJECT: Drilled Pier Axial Resistance Calculations
Bridge # 135 over mayne Creek on SR 1330 B1-B
PREPARED BY: grt DATE: 06/03/15 STATION: 14+00.72
CHECKED BY: DATE: STR. NO.: PAGE: 1 OF 6

DISCLAIMER: *The application of this spreadsheet is the responsibility of the user. It is imperative that the user understands the potential accuracy limitations and examines the reasonableness of the results with engineering knowledge and experience. There are no expressed or implied warranties.*

Elevations

Bottom of Cap (BOC) Elevation =	786.00	ft
Top of Pier/Bottom of Column Elevation =	771.00	ft
Natural Ground / Finished Grade Elevation =	768.50	ft
Groundwater Table (GWT) Elevation =	768.50	ft
Design Scour (DSE) Elevation =	764.00	ft
Is Permanent Casing Required?	○ Yes / Maybe ◉ No	
Bottom of Permanent Casing Elevation =	N/A	ft
Drilled Pier Tip Elevation =	746.00	ft

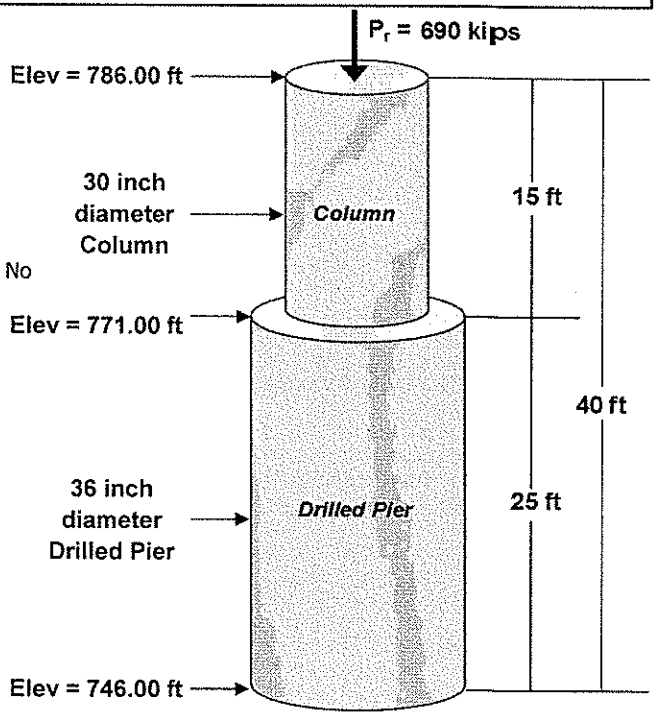


Figure shows typical drilled pier (not drawn to scale)

Drilled Pier Information

Maximum Factored Axial Load (P_r) =	690.0	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

Miscellaneous Properties

SPT Hammer Energy Efficiency Rating (ER) =	84	%
Unit Weight of Water (γ_w) =	0.0624	kcf

Soil and Rock Information

Layer No.	Material Description	Layer Elevations Top[1] (ft)	Layer Elevations Bottom (ft)	Total γ (kcf)	N (bpf)	[2] RQD (%)	[2] RMR	q_u (ksf)	E_i (ksi)	ν
1	Cohesionless Soil (Sand)	764.00	760.00	0.120	27					
2	Weathered Rock	760.00	757.00	0.130	500					
3	Hard Rock	757.00	752.50	0.140			34	2,000	7,000	
4	Hard Rock	752.50	746.00	0.140			41	2,000	7,000	
5										
6										
7										
8										
TIP [3]	Hard Rock	746.00	740.00	0.140			50	2,000	7,000	

Tip Resistance Method for Hard Rock (if applicable)

◉ Based on RMR (AASHTO Section ○ Based on GSI (FHWA-NHI-10-016 Section 3 and

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 (RMR < 44 or GSI < 30) will be modeled as weathered rock.
3. Input the subsurface information for the soil / rock at the base of the drilled pier to a distance of 2 pier diameters below the base of the drilled pier.

Side Resistance in Cohesionless IGM (Cohesionless Material with $N1_{60} > 50$)

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

A_s = area of drilled piers side resistance (ft^2)
$= (\pi)(B)(\Delta z)$

B = diameter of drilled piers (3 ft)
Δz = effective thickness of the soil layer (ft)

q_s = unit side resistance for soil layer (ksf)
$= f_{sn} = \sigma'_v \beta$ *FHWA GEC 010 Eqn. 13-7*

σ'_v = vertical effective stress at the mid point of the soil layer (ksf)

β = load transfer coefficient
$= K_o \tan \delta$ *FHWA GEC 010 Eqn. 13-6*

K_o = coefficient of at rest earth pressure for layer
$= (1 - \sin \phi') \, OCR^{\sin \phi'} \leq K_p$ *FHWA GEC 010 Eqn. 13-8*

ϕ' = effective friction angle = $27.5 + 9.2 \log(N1_{60})$, $N1_{60} \leq 100$ *FHWA GEC 010 Eqn. 3-8*

$$OCR = \frac{\sigma'_p}{\sigma'_v} = \frac{\text{effective vertical preconsolidation stress (ksf)}}{\text{average vertical effective stress of soil layer (ksf)}}$$ *FHWA GEC 010 Eqn. 13-9*

$$\text{For Sands: } \frac{\sigma'_p}{p_a} = 0.47(N_{60})^m$$ *FHWA GEC 010 Eqn. 13-11*

$$\text{For Gravels: } \frac{\sigma'_p}{p_a} = 0.15(N_{60})$$ *FHWA GEC 010 Eqn. 13-12*

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)
p_a = atmospheric pressure (2.12 ksf)

K_p = Coefficient of Passive Earth Pressure

$$= \tan^2\left(45 + \frac{\phi}{2}\right)$$ *FHWA GEC 010 Eqn. 3-10*

δ = Interface Friction Angle = ϕ' for Drilled Piers

Layer No.	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	σ'_v (ksf)	ϕ' (deg)	m	N_{60} (bpf)	σ'_p/p_a	σ'_p (ksf)	OCR	K_o	K_p	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
1	764.00	760.00	0.115	44	0.6	38	4.17	8.84	76.87	6.23	5.55	0.616	4.00	37.70	23

Total Side Resistance in Cohesionless IGM = 23

Side Resistance in Weathered and Hard Rock

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

A_s = area of drilled pier side resistance (ft^2)
$= (\pi)(B)(\Delta z)$

B = diameter of drilled pier - 2 inches to account for possible reduction for drilled pier in rock (B = 2.83 ft)
Δz = effective thickness of the soil layer (ft)

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

= 8 ksf for Weathered Rock Layers or Hard Rock Layers with an RMR < 44 *NCDOT Policy*

$= 0.65(a_E)(p_a)(q_u/p_a)^{0.5} < 7.8(p_a)(f'_c/p_a)^{0.5}$ for Hard Rock Layers *AASHTO Eqn. 10.8.3.5.4b-1*

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

E_m/E_i	α_E
1.0	1.0
0.5	0.8
0.3	0.7
0.1	0.55
0.05	0.45

E_m = Elastic modulus of rock mass (ksi) $\leq E_i$

$$= 145\left[10^{\frac{RMR-10}{40}}\right]$$ *AASHTO Eqn. 10.4.6.5-1*

RMR = Rock Mass Rating
E_i = Elastic modulus of intact rock (ksi) taken from AASHTO Table C10.4.6.5-1 if lab test data is not available

q_u = Uniaxial Compressive Strength of Intact Rock (ksf) based on Point Load Index Value Correlation or Rock Core Uniaxial Compressive Strength Test Data
p_a = atmospheric pressure (2.12 ksf)
f'_c = 28 day Compressive Strength of Concrete (4.5 ksi)

****** Note that p_a and f'_c are in different units. This is not a typo. ******

$7.8(p_a)(f'_c/p_a)^{0.5}$ = the limiting value for nominal side resistance based on the strength of the concrete

Layer No.	Rock Type	Layer Elevations Top (ft)	Layer Elevations Bottom (ft)	RMR	E_m (ksi)	E_i (ksi)	E_m/E_i	α_E	q_u (ksf)	q_s (ksf)	Δz (ft)	A_s (ft^2)	R_s (kips)
2	Weathered Rock	760.00	757.00	N/A	N/A	N/A	N/A	N/A	N/A	8.000	3.00	26.70	214
3	Hard Rock	757.00	752.50	34	N/A	N/A	N/A	N/A	N/A	8.000	4.50	40.06	320
4	Hard Rock	752.50	746.00	41	N/A	N/A	N/A	N/A	N/A	8.000	6.50	57.86	463
												Total Side Resistance in Weathered and Hard Rock =	**997**

Tip Resistance in Hard Rock based on RMR

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

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)

q_p = unit tip resistance (ksf) *$q_p \geq 90$ ksf per NCDOT policy*

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

$$= \left[\sqrt{s} + \sqrt{m\sqrt{s} + s}\right] q_u$$ *AASHTO Eqn. 10.8.3.5.4c-2*

q_u = Uniaxial Compressive Strength of Intact Rock (ksf)

m,s = fractured rock mass parameters specified in Table 10.4.6.4-4 (shown below)

Rock Quality	Constants	Rock Type A = Carbonate rocks with well developed crystal cleavage—*dolomite, limestone and marble* B = Lithified argrillaceous rocks—*mudstone, siltstone, shale and slate (normal to cleavage)* C = Arenaceous rocks with strong crystals and poorly developed crystal cleavage—*sandstone and quartzite* D = Fine grained polyminerallic igneous crystalline rocks—*andesite, dolerite, diabase and rhyolite* E = Coarse grained polyminerallic igneous & metamorphic crystalline rocks—*amphibolite, gabbro gneiss, granite, norite, quartz-diorite*				
		A	B	C	D	E
INTACT ROCK SAMPLES Laboratory size specimens free from discontinuities. CSIR rating: *RMR* = 100	*m* *s*	7.00 1.00	10.00 1.00	15.00 1.00	17.00 1.00	25.00 1.00
VERY GOOD QUALITY ROCK MASS Tightly interlocking undisturbed rock with unweathered joints at 3–10 ft CSIR rating: *RMR* = 85	*m* *s*	2.40 0.082	3.43 0.082	5.14 0.082	5.82 0.082	8.567 0.082
GOOD QUALITY ROCK MASS Fresh to slightly weathered rock, slightly disturbed with joints at 3–10 ft CSIR rating: *RMR* = 65	*m* *s*	0.575 0.00293	0.821 0.00293	1.231 0.00293	1.395 0.00293	2.052 0.00293
FAIR QUALITY ROCK MASS Several sets of moderately weathered joints spaced at 1–3 ft CSIR rating: *RMR* = 44	*m* *s*	0.128 0.00009	0.183 0.00009	0.275 0.00009	0.311 0.00009	0.458 0.00009

Tip Elevation (ft)	AASHTO Equation used to calculate q_u	RMR	q_u (ksf)	Rock type	m	s	q_p (ksf)	A_p (ft^2)	R_p (kips)
746.00	10.8.3.5.4c-2	50	2000	E	0.703	0.00024	242	6.31	1,527

Summary of Nominal and Factored Side Resistance

Weathered Rock	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%
IGM	23	0.60	14	2.3%
Weathered Rock	997	0.60	598	97.7%
Hard Rock	0	0.55	0	0.0%
Total	**1,020**		**612**	**100%**

Note: *Side resistance in soil and weathered rock develops at a much greater displacement than hard rock. If the pier does not have a true rock socket, the side resistance from the hard rock will be ignored and nominal side resistance will be based on the total side resistance in soil and weathered rock.*

Total Nominal Side Resistance = 1,020 kips
Total Factored Side Resistance = 612 kips

Summary of Total Nominal and Factored Tip Resistance

Total Nominal Tip Resistance = 1,527 kips
Tip Resistance Factor = 0.50
Total Factored Tip Resistance = 764 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 = 690 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} = 15 ft *Length of Column*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 11 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 ft *Length of Drilled Pier*
γ_c = 0.150 kcf *Unit Weight of Concrete*

= 27 kips

Required Factored Resistance (continued)

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

A_{Pier} = 7.07 ft^2 — *Area of Drilled Pier*

z_w = 23 ft — *Depth from water surface to the drilled pier tip*

γ_w = 0.0624 kcf — *Unit Weight of Water*

= 10 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} = 1.2868 ksf — *Vertical Effective Stress (taken from the DSE) at the Drilled Pier Tip*

$W_{Soil/Rock}$ = 9 kips

R_{req} = 690 kips + 1.25(11 kips + 27 kips) -1.00(10 kips) -1.25(9 kips) = 716 kips

Load Transfer and Developed Resistance for Drilled Piers in Hard Rock with no Rock Socket

For Load Transfer of a drilled pier that is bearing on hard rock with no rock socket, the total displacement of the pier will be controlled by the rock layer below the base of the pier. The total displacement, (w_c), will be calculated using FHWA GEC 10 Equation D-17 and assumes the entire load is carried by the tip. Use the normalized load transfer values along with the total factored side resistance to calculate the factored side resistance developed in the soil and weathered rock layers at this displacement. The remaining factored resistance that is carried by the drilled pier tip must be less than or equal to the total factored tip resistance.

Calculate the total displacement, w_c, at the drilled pier tip (assume entire load is carried by the tip)

$$w_c = F_3\left(\frac{Q_c}{\pi E_r B}\right) - F_4 B$$ — *FHWA-NHI-10-016 Eqn. D-17*

$Q_c = R_{req}$ = 716 kips — *Required Factored Resistance*

B = 36 inches — *Diameter of Drilled Pier*

L = 0.01 inches — *Length of Pier in Hard Rock (use 0.01 inch when assuming entire load carried by tip)*

E_c = 3,824 ksi — *Elastic Modulus of Concrete*

v_c = 0.25 — *Poisson's Ration for Concrete*

E_{i_r} = 7,000 ksi — *Elastic Modulus of Intact Rock around Drilled Pier Tip*
(Assume $E_{i\_r} = E_{i\_b}$ if the tip of the drilled pier is sitting on top of the hard rock layer)

E_r ($\leq E_{i\_r}$) = 706 ksi — *Elastic Modulus of Rock Mass around Drilled Pier Tip (AASHTO Eqn. 10.4.6.5-1)*
(Assume $E_r = E_b$ if the tip of the drilled pier is sitting on top of the hard rock layer)

v_r = 0.00 — *Poisson's Ration of Rock Mass around Drilled Pier Tip*
(Assume $v_r = v_b$ if the tip of the drilled pier is sitting on top of the hard rock layer)

E_{i_b} = 7,000 ksi — *Elastic Modulus of Intact Rock below Drilled Pier Tip*

E_b ($\leq E_{i\_b}$) = 1,450 ksi — *Elastic Modulus of Rock Mass below Drilled Pier Tip (FHWA-NHI-10-016 Table 3-9)*

v_b = 0.00 — *Poisson's Ration of Rock Mass below Drilled Pier Tip*

Load Transfer and Developed Resistance for Drilled Piers in Hard Rock with no Rock Socket (continued)

ζ = 0.01 $= ln[5(1 - v_b)L/B]$ *(must be > 0) FHWA-NHI-10-016 Eqn. D-11*

a_1 = 5.92781312 $= (1 + v_r)\zeta + a_2$ *FHWA-NHI-10-016 Eqn. D-25*

a_2 = 5.91781312 $= \left[(1 - v_c)\left(\frac{E_r}{E_C}\right) + (1 + v_r)\right]\left(\frac{1}{2\tan\phi\tan\psi}\right)$ *FHWA-NHI-10-016 Eqn. D-26*

a_3 = 0.263781934 $= \left(\frac{v_c}{2\tan\psi}\right)\left(\frac{E_r}{E_c}\right)$ *FHWA-NHI-10-016 Eqn. D-27*

β = 51.4352 $= a_3\left(\frac{E_c}{E_r}\right)B$ *FHWA-NHI-10-016 Eqn. D-24*

α = 10402.85862 $= a_1\left(\frac{E_c}{E_r}\right)\left(\frac{B^2}{4}\right)$ *FHWA-NHI-10-016 Eqn. D-23*

λ_1 = 0.007639165 $= \frac{-\beta + (\beta^2 + 4\alpha)^{1/2}}{2\alpha}$ *FHWA-NHI-10-016 Eqn. D-22*

λ_2 = -0.0125835 $= \frac{-\beta - (\beta^2 + 4\alpha)^{1/2}}{2\alpha}$ *FHWA-NHI-10-016 Eqn. D-22*

D_3 = -0.10056346 $= \left[\pi(1 - v_b{}^2)\left(\frac{E_r}{E_b}\right) + 4a_3 + a_1\lambda_2 B\right] exp[\lambda_2 D]$ *FHWA-NHI-10-016 Eqn. D-21*

D_4 = 4.215287897 $= \left[\pi(1 - v_b{}^2)\left(\frac{E_r}{E_b}\right) + 4a_3 + a_1\lambda_1 B\right] exp[\lambda_1 D]$ *FHWA-NHI-10-016 Eqn. D-21*

C_3 = -0.02330096 $= \frac{D_3}{D_4 - D_3}$ *FHWA-NHI-10-016 Eqn. D-20*

C_4 = 0.976699044 $= \frac{D_4}{D_4 - D_3}$ *FHWA-NHI-10-016 Eqn. D-20*

F_3 = 1.529650493 $= a_1(\lambda_1 BC_3 - \lambda_2 BC_4) - 4a_3$ *FHWA-NHI-10-016 Eqn. D-18*

F_4 = 8.50807E-08 $= \left[1 - a_1\left(\frac{\lambda_1 - \lambda_2}{D_4 - D_3}\right)B\right] a_2\left(\frac{c}{E_r}\right)$ *FHWA-NHI-10-016 Eqn. D-19*

w_c = 0.01 inches *Total Displacement at Drilled Pier Tip*

Calculate the developed side resistance in the soil / weathered rock layers at the displacement, w_c

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

Load Transfer and Developed Resistance for Drilled Piers in Hard Rock with no Rock Socket (continued)

Δz / D (%)	Normalized Side Transfer R_{sd} / R_s AASHTO Figure 10.8.2.2.2.1
0.0	0.00
0.3	0.83
0.6	0.95
1.0	0.93
1.3	0.91
1.6	0.88
2.0	0.83
5.0	0.55

Developed Side Resistance					
Δz / D	D (in)	Δz (in)	$\varphi_{qs}R_s$ (kips)	R_{sd} / R_s	$\varphi_{qs}R_{sd}$ (kips)
0.00%	36	0.00	612	0.00	
0.03%	**36**	**0.01**	**612**	**0.08**	**46**
0.30%	36	0.11	612	0.83	

Δz / D = total settlement / drilled pier diameter
R_{sd} / R_s = developed side resistance / total nominal side resistance
$\varphi_{qs}R_s$ = total factored side resistance
$\varphi_{qs}R_{sd}$ = developed factored side resistance
= $(R_{sd}/R_s)(\varphi_{qs}R_s)$

Calculate the remaining resistance that must be carried by the tip (must ≤ the total factored tip resistance)

Required Factored Resistance = 716 kips
Developed Factored Side Resistance = 46 kips
Required Factored Tip Resistance = 670 kips **≤ 764 kips OK**

Required Tip Resistance

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

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

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)
716	46	6.31	0.50	242	220

NCDOT Rock Core Database

B-2945	8.2801	Cleveland	7.59-7.73	15500	8240000	Biotite gneiss
B-2945	8.2801	Cleveland	9.95-10.10	9100	6950000	Biotite gneiss
B-2945	8.2801	Cleveland	11.08-11.20	14500	9250000	Biotite gneiss
B-2945	8.2801	Cleveland	6.26-6.38	10100	6710000	Biotite gneiss
B-2945	8.2801	Cleveland	8.51-8.65	20100	7020000	Biotite gneiss
B-2945	8.2801	Cleveland	10.07-10.20	3500		Biotite gneiss
B-2945	8.2801	Cleveland	11.05-11.20	22100	10780000	Biotite gneiss
B-2945	8.2801	Cleveland	13.13-13.25	17300	9580000	Biotite gneiss
B-2945	8.2801	Cleveland	6.72-6.87	14100	7200000	Biotite gneiss
B-2945	8.2801	Cleveland	8.45-8.55	19400	11520000	Biotite gneiss
B-2945	8.2801	Cleveland	5.89-6.00	9700	6220000	Biotite gneiss
B-2945	8.2801	Cleveland	7.41-7.57	8500	3670000	Biotite gneiss
B-2945	8.2801	Cleveland	8.01-8.15	26000	12180000	Biotite gneiss
B-2945	8.2801	Cleveland	9.54-9.67	14500	5640000	Biotite gneiss
B-2946	8.28011	Cleveland	21.5	4900	2964000	Biotite Gneiss
B-2946	8.28011	Cleveland	15.1	29100	8980000	Biotite Gneiss
B-2946	8.28011	Cleveland	1.1	9400	2516000	Biotite Gneiss
B-2946	8.28011	Cleveland	12.9	17400	6860000	Biotite Gneiss
B-2946	8.28011	Cleveland	0.9	9800	2092000	Biotite Gneiss
B-2946	8.28011	Cleveland	13.2	15100	5000000	Biotite Gneiss
N/A	5.8052	Cleveland	39.40-39.85	8480	6360000	Biotite Gneiss
N/A	5.8052	Cleveland	40.5-41.0	8140	3360000	Biotite Gneiss
			Average	**2443 ksf**	**7912 ksi**	
			(minus high and low)			

Rock Mass Rating (AASHTO)

Project:	**Div 12 Bridge 135**
Boring Location:	**B1-A**
Stratigraphic Depth Range:	**4.5' - 10.5, BIOTITE GNEISS**

A. CLASSIFICATION PARAMETERS AND THEIR VALUES

	Parameter		Range of Values								
1	Strength of Intact Rock Material	Point-load Strength Index	>1215psi	590 - 1215 psi	312 - 590 psi	139-312 psi	For this low range - Uniaxial Comp. Strength test is preferred			Strength Value	13.93
		Uniaxial Comp. Strength	>30 ksi	15 - 30 ksi	7.5 - 15 ksi	3.6 - 7.5 ksi	1.5 - 3.6 ksi	0.5 - 1.5 ksi	0.1 - 0.5 ksi		15.76
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**	**Rating**	**12**
2	Drill Core Quality - RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	<25%			Quality Value	81
	Rating		**20**	**17**	**13**	**8**	**3**			**Rating**	**8**
3	Spacing of Discontinuities		>10 ft	3 - 10 ft	1 - 3 ft	2in - 1ft	<2in			Disc. Spacing	2in - 1 ft.
	Rating		**30**	**25**	**20**	**10**	**5**			**Rating**	**5**
4	Condition of Discontinuities		Very Rough Surfaces	Slightly Rough Surface	Slightly Rough Surface	Slickensided Surfaces	Soft Gouge >0.2 in thick			Disc. Condition	
			Not Continuous	Separation <0.5 in	Separation <0.5 in	or Gouge <0.2 in thick	of Separation > 0.2 in				
			No Separation	Hard Joint Wall Rock	Soft Joint Wall Rock	or Separation 0.05 - 0.2in	Continuous Joints				
			Hard Joint Wall Rock			Continuous Joints					
	Rating		**25**	**20**	**12**	**6**	**0**			**Rating**	**20**
5	Inflow per 30 ft tunnel length		None	< 400 gal/hr	400 - 2000 gal/hr		>2000 gal/hr			Groundwater	
	(Joint Water Pressure)/ (Major Principle σ)		0	0.0 - 0.2	0.2 - 0.5		>0.5				
	General Conditions		Completely Dry	Moist only	Under Moderate Water Pressure		Severe Water Problems				
	Rating		**10**	**7**	**4**		**0**			**Rating**	**4**

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS

	Strike and Dip Orientations	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable			
6	Tunnels	0	-2	-5	-10	-12		**Adjust. to Rating**	-8
	Foundations	0	-2	-7	-15	-25			
	Slopes	0	-5	-25	-50	-60			

ROCK MASS CLASSIFICATION	**Class III: Fair Rock**	**ROCK MASS RATING**	**41**

Rock Mass Rating (AASHTO)

Project:	**Div 12 Bridge 135**
Boring Location:	**B1-A**
Stratigraphic Depth Range:	**10.5' - 16', BIOTITE GNEISS**

A. CLASSIFICATION PARAMETERS AND THEIR VALUES

	Parameter		Range of Values								
1	Strength of Intact Rock Material	Point-load Strength Index	>1215psi	590 - 1215 psi	312 - 590 psi	139-312 psi	For this low range - Uniaxial Comp. Strength test is preferred			Strength Value	13.93
		Uniaxial Comp. Strength	>30 ksi	15 - 30 ksi	7.5 - 15 ksi	3.6 - 7.5 ksi	1.5 - 3.6 ksi	0.5 - 1.5 ksi	0.1 - 0.5 ksi		15.76
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**	**Rating**	**12**
2	Drill Core Quality - RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	<25%			Quality Value	81
	Rating		**20**	**17**	**13**	**8**	**3**			**Rating**	**17**
3	Spacing of Discontinuities		>10 ft	3 - 10 ft	1 - 3 ft	2in - 1ft	<2in			Disc. Spacing	2in - 1 ft.
	Rating		**30**	**25**	**20**	**10**	**5**			**Rating**	**10**
4	Condition of Discontinuities		Very Rough Surfaces	Slightly Rough Surface	Slightly Rough Surface	Slickensided Surfaces	Soft Gouge >0.2 in thick			Disc. Condition	
			Not Continuous	Separation <0.5 in	Separation <0.5 in	or Gouge <0.2 in thick	of Separation > 0.2 in				
			No Separation	Hard Joint Wall Rock	Soft Joint Wall Rock	or Separation 0.05 - 0.2in	Continuous Joints				
			Hard Joint Wall Rock			Continuous Joints					
	Rating		**25**	**20**	**12**	**6**	**0**			**Rating**	**20**
5	Inflow per 30 ft tunnel length		None	< 400 gal/hr	400 - 2000 gal/hr		>2000 gal/hr			Groundwater	
	(Joint Water Pressure)/ (Major Principle σ)		0	0.0 - 0.2	0.2 - 0.5		>0.5				
	General Conditions		Completely Dry	Moist only	Under Moderate Water Pressure		Severe Water Problems				
	Rating		**10**	**7**	**4**		**0**			**Rating**	**10**

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS

	Strike and Dip Orientations	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable			
6	Tunnels	0	-2	-5	-10	-12		**Adjust. to Rating**	0
	Foundations	0	-2	-7	-15	-25			
	Slopes	0	-5	-25	-50	-60			

ROCK MASS CLASSIFICATION	**Class II; Good Rock**	**ROCK MASS RATING**	**69**

Rock Mass Rating (AASHTO)

Project:	**Div 12 Bridge 135**
Boring Location:	**B1-B**
Stratigraphic Depth Range:	**11.5' - 18.5', BIOTITE GNEISS**

A. CLASSIFICATION PARAMETERS AND THEIR VALUES

	Parameter		Range of Values								
1	Strength of Intact Rock Material	Point-load Strength Index	>1215psi	590 - 1215 psi	312 - 590 psi	139-312 psi	For this low range - Uniaxial Comp. Strength test is preferred			Strength Value	13.93
		Uniaxial Comp. Strength	>30 ksi	15 - 30 ksi	7.5 - 15 ksi	3.6 - 7.5 ksi	1.5 - 3.6 ksi	0.5 - 1.5 ksi	0.1 - 0.5 ksi		15.76
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**	**Rating**	**12**
2	Drill Core Quality - RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	<25%			Quality Value	81
	Rating		**20**	**17**	**13**	**8**	**3**			**Rating**	**3**
3	Spacing of Discontinuities		>10 ft	3 - 10 ft	1 - 3 ft	2in - 1ft	<2in			Disc. Spacing	2in - 1 ft.
	Rating		**30**	**25**	**20**	**10**	**5**			**Rating**	**7**
4	Condition of Discontinuities		Very Rough Surfaces	Slightly Rough Surface	Slightly Rough Surface	Slickensided Surfaces	Soft Gouge >0.2 in thick			Disc. Condition	
			Not Continuous	Separation <0.5 in	Separation <0.5 in	or Gouge <0.2 in thick	of Separation > 0.2 in				
			No Separation	Hard Joint Wall Rock	Soft Joint Wall Rock	or Separation 0.05 - 0.2in	Continuous Joints				
			Hard Joint Wall Rock			Continuous Joints					
	Rating		**25**	**20**	**12**	**6**	**0**			**Rating**	**20**
5	Inflow per 30 ft tunnel length		None	< 400 gal/hr	400 - 2000 gal/hr		>2000 gal/hr			Groundwater	
	(Joint Water Pressure)/ (Major Principle σ)		0	0.0 - 0.2	0.2 - 0.5		>0.5				
	General Conditions		Completely Dry	Moist only	Under Moderate Water Pressure		Severe Water Problems				
	Rating		**10**	**7**	**4**		**0**			**Rating**	**4**

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS

	Strike and Dip Orientations	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable			
6	Tunnels	0	-2	-5	-10	-12		**Adjust. to Rating**	-7
	Foundations	0	-2	-7	-15	-25			
	Slopes	0	-5	-25	-50	-60			

ROCK MASS CLASSIFICATION	**Class IV: Poor Rock**	**ROCK MASS RATING**	**39**

Rock Mass Rating (AASHTO)

Project: **Div 12 Bridge 135**

Boring Location: **B1-B**

Stratigraphic Depth Range: **18.5' - 26.5, BIOTITE GNEISS**

A. CLASSIFICATION PARAMETERS AND THEIR VALUES

	Parameter		Range of Values								
1	Strength of Intact Rock Material	Point-load Strength Index	>1215psi	590 - 1215 psi	312 - 590 psi	139-312 psi	For this low range - Uniaxial Comp. Strength test is preferred			Strength Value	13.93
		Uniaxial Comp. Strength	>30 ksi	15 - 30 ksi	7.5 - 15 ksi	3.6 - 7.5 ksi	1.5 - 3.6 ksi	0.5 - 1.5 ksi	0.1 - 0.5 ksi		15.76
	Rating		**15**	**12**	**7**	**4**	**2**	**1**	**0**	**Rating**	**12**
2	Drill Core Quality - RQD		90 - 100%	75 - 90%	50 - 75%	25 - 50%	<25%			Quality Value	81
	Rating		**20**	**17**	**13**	**8**	**3**			**Rating**	**13**
3	Spacing of Discontinuities		>10 ft	3 - 10 ft	1 - 3 ft	2in - 1ft	<2in			Disc. Spacing	2in - 1 ft.
	Rating		**30**	**25**	**20**	**10**	**5**			**Rating**	**5**
4	Condition of Discontinuities		Very Rough Surfaces	Slightly Rough Surface	Slightly Rough Surface	Slickensided Surfaces	Soft Gouge >0.2 in thick			Disc. Condition	
			Not Continuous	Separation <0.5 in	Separation <0.5 in	or Gouge <0.2 in thick	of Separation > 0.2 in				
			No Separation	Hard Joint Wall Rock	Soft Joint Wall Rock	or Separation 0.05 - 0.2in	Continuous Joints				
			Hard Joint Wall Rock			Continuous Joints					
	Rating		**25**	**20**	**12**	**6**	**0**			**Rating**	**20**
5	Inflow per 30 ft tunnel length		None	< 400 gal/hr	400 - 2000 gal/hr		>2000 gal/hr			Groundwater	
	(Joint Water Pressure)/ (Major Principle σ)		0	0.0 - 0.2	0.2 - 0.5		>0.5				
	General Conditions		Completely Dry	Moist only	Under Moderate Water Pressure		Severe Water Problems				
	Rating		**10**	**7**	**4**		**0**			**Rating**	**7**

B. RATING ADJUSTMENT FOR DISCONTINUITY ORIENTATIONS

	Strike and Dip Orientations	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable			
6	Tunnels	0	-2	-5	-10	-12		**Adjust. to Rating**	-7
	Foundations	0	-2	-7	-15	-25			
	Slopes	0	-5	-25	-50	-60			

ROCK MASS CLASSIFICATION	**Class III: Fair Rock**	**ROCK MASS RATING**	**50**

ESP Associates, P.A.	Job No.:	17BP.12.R.35	Sheet		of
	Task:	Foundation Recs	Phase		
	Job Name:	Bridge # 1354 over Mayne Creek on SR 1330			
	By:	grt	Date:	5/19/2015	
	Checked By:	ab	Date:	6/4/2015	

End Bent 2

Reference AASHTO LRFD and NCDOT LRFD Driven Pile Foundation Policy (6th Update)

Bottom of Cap Elev = 785.07

No. of Piles = 3 Vertical, 2 Brace

Pile Type = HP 12x53

Factored axial load = 170 k = 85 t, Use 85 tons

Axial Capacity

Piles will attain most of axial resistance from end bearing on weathered rock

Top of weathered rock elev: EB2-A = 775.6', EB2-B = 770.4'

Pile length to top of weathered rock: EB2-A = 9.5', EB1-B = 15'

Assume piles will be driven 1' into weathered rock

Pile length left = 9.5 + 1 +1 = 11.5', Say 15', length includes 1 foot embedment into cap

Pile length right = 15 + 1 +1 = 17', Say 20', length includes 1 foot embedment into cap

Weap Analysis

Required driving resistance = 170/0.6 = 283 k, Say 290 kips = 145 tons

Driving resistance factor = 0.6, (NCDOT Driven Pile Policy Article 3.2.1)

Min blow count = 30 bpf, Max blow count = 180 bpf, Max comp. stress = 0.9 Fy = 0.9 x 50 = 45 ksi

Average pile penetration = 14'

Assume 10% skin resistance

Results:

Delmag D 19-32 (42.4 ft-kip): Max comp stress = 33.1 ksi, Blow counts = 51 bpf, OK

Since D 19-32 hammer works, no hammer energy range note required.

Miscellaneous

End slopes of 1.5:1 are ok by inspection

No downdrag due to no added embankment

No waiting periods, before driving piles

Pile points are required due to shallow weathered rock

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

DRAFT

WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek			GROUND WTR (ft)
BORING NO. EB2-A	STATION 14+71	OFFSET 8 ft LT	ALIGNMENT -L-	0 HR. Dry
COLLAR ELEV. 788.6 ft	TOTAL DEPTH 16.5 ft	NORTHING N/A	EASTING N/A	24 HR. FIAD
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD H.S. Augers	HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/15/15	COMP. DATE 05/15/15	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
						EG 792.45'				
790										
	788.6	0.0								GROUND SURFACE
	788.3	0.3								Asphalt
	787.9	0.7								Sand Base
785	785.1	3.5	3	4	4	8 BOC 785.07'		M		**ROADWAY EMBANKMENT** Red, Tan, and Brown; Medium Stiff to Stiff; Coarse to Fine Sandy; Clayey SILT (A-5) with Gravel and Some Mica
780	780.1	8.5	2	4	4	8 9.5'		M		**ALLUVIAL** Brown and Red, Loose, Silty, Fine SAND (A-3) with Trace Organics
	779.6	9.0								
775	775.1	13.5								
	774.4	14.2	100/0.3			100/0.3				**WEATHERED ROCK** White, Gray, and Brown; MICA SCHIST
	772.1	16.5	100/0.2			100/0.2				
			60/0.0			60/0.0				Boring Terminated with Standard Penetration Test Refusal at Elevation 772.1 ft On CRYSTALLINE ROCK: MICA SCHIST

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

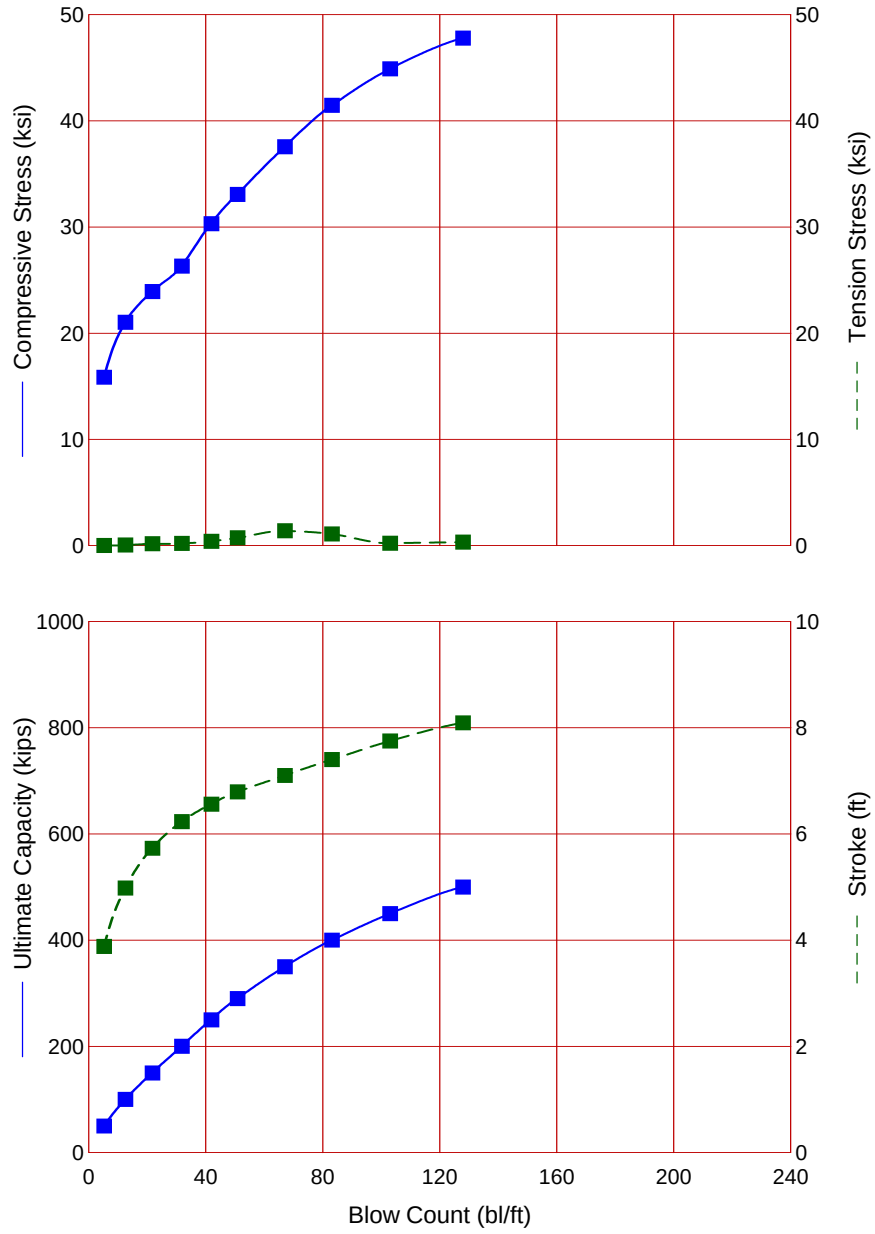
SHEET

WBS 17BP.12.R.35	TIP N/A	COUNTY CLEVELAND	GEOLOGIST Rogers, E.
SITE DESCRIPTION Bridge No. 022135 on SR 1330 (Crawley Gin Road) over Mayne Creek			GROUND WTR (ft)
BORING NO. EB2-B	STATION 14+61	OFFSET 9 ft RT	ALIGNMENT -L-	0 HR. 19.0
COLLAR ELEV. 788.4 ft	TOTAL DEPTH 19.5 ft	NORTHING N/A	EASTING N/A	24 HR. 17.0
DRILL RIG/HAMMER EFF./DATE TRI9435 CME-55 84% 02/20/2015		DRILL METHOD H.S. Augers	HAMMER TYPE Automatic
DRILLER Estep, E.	START DATE 05/13/15	COMP. DATE 05/13/15	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
						FG 792.45'				
790										
										788.4 GROUND SURFACE 0.0
										787.7 Asphalt 0.3
										Sand Base 0.7
785	784.9	3.5	3	2	1	3 BOC 785.07		M		ROADWAY EMBANKMENT Red to Tan Brown, Soft , Coarse to Fine Sandy, Clayey SILT (A-5) with Gravel and Some Mica
780	779.9	8.5	3	3	3	6 10'		M		780.4 8.0 ALLUVIAL Brown and Red, Loose, Silty, Fine SAND (A-3) with Trace Organics
775	774.9	13.5	30	47	15	62 5'		M		775.4 13.0 RESIDUAL White, Brown, and Red; Very Dense; Coarse to Fine SAND and Rock Fragments (A-1-b) with Little Mica
770	769.9	18.5								770.4 18.0
	768.9	19.5	100/0.5			100/0.5				768.9 WEATHERED ROCK 19.5 Red, Brown, and Black; MICA SCHIST
			60/0.0			60/0.0				Boring Terminated with Standard Penetration Test Refusal at Elevation 768.9 ft On CRYSTALLINE ROCK: MICA SCHIST

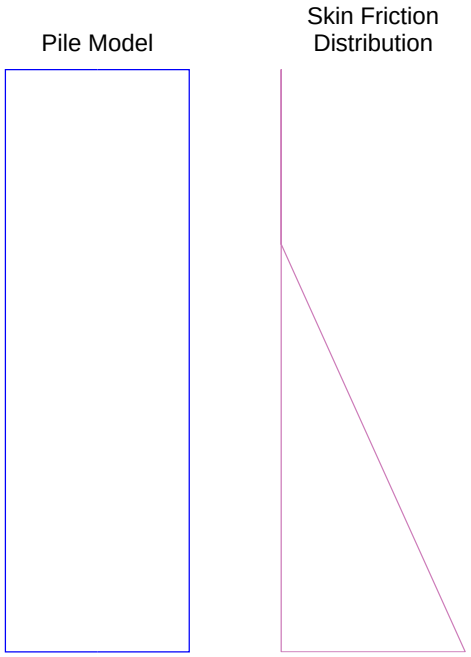
ESP Associates, P.A.
BR 135 EB1, D19-32

19-May-2015
GRLWEAP Version 2010



DELMAG D 19-32

Ram Weight	4.00	kips
Efficiency	0.800	
Pressure	1275 (85%)	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	0.200	sec/ft
Toe Damping	0.100	sec/ft
Pile Length	20.00	ft
Pile Penetration	14.00	ft
Pile Top Area	15.60	in2



Res. Shaft = 10 %
(Proportional)

Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
50.0	15.86	0.02	5.3	3.88	16.53
100.0	21.02	0.06	12.6	4.98	14.33
150.0	23.92	0.18	21.8	5.73	13.33
200.0	26.31	0.21	31.9	6.23	12.97
250.0	30.30	0.41	42.0	6.56	12.85
290.0	33.07	0.73	50.9	6.79	12.90
350.0	37.55	1.40	67.1	7.10	13.15
400.0	41.45	1.11	83.2	7.40	13.58
450.0	44.89	0.23	103.1	7.75	14.11
500.0	47.78	0.33	128.0	8.09	14.73