SUBSURFACE INVESTIGATION AND BRIDGE FOUNDATION DESIGN RECOMMENDATIONS

TIP B-4861
BRIDGE ON RIDGE STREET (-L-) OVER
WSSB RAILROAD (-RR-)

F&R PROJECT NO. 66L-0292

Prepared For:

TGS Engineers
804-C North Lafayette Street
Shelby, North Carolina 28150

Prepared By:

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July 9, 2010

SINCE 1881

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July 9, 2010

Mr. Ray D. Elliott, P.E.
TGS Engineers
804-C North Lafayette Street
Shelby, North Carolina 28150

WBS Element No.:	N/A
TIP No.:	B-4861
County:	Anson
Description:	Bridge on Ridge Street over WSSB Railroad
F&R Project No.	66L-0292

Re: **Subsurface Investigation and Bridge Foundation Design Recommendations for Bridge on Ridge Street (-L-) Over WSSB Railroad (-RR-)**

Dear Mr. Elliott:

Froehling & Robertson, Inc. (F&R) has completed the subsurface exploration and bridge foundation design recommendations for the bridge replacement proposed for Ridge Street (-L-) over WSSB Railroad (-RR-). The work was performed in general accordance with F&R's proposal No. 1066-0186G dated October 2, 2009. This report contains a description of the project information provided to F&R, a discussion of the general subsurface conditions encountered during the exploration, and engineering recommendations for the foundations of the proposed structure.

Please do not hesitate to contact us if you have any questions regarding this report or if you need additional services.

Sincerely,
FROEHLING & ROBERTSON, INC.

NORTH CAROLINA PROFESSIONAL SEAL 20175 ENGINEER ELIZABETH C. HOWEY

Elizabeth C. Howey, P.E., P.G.
Senior Project Engineer 7/9/10

Daniel K. Schaefer, P.E.
Raleigh Branch Manager

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1.0 PURPOSE AND SCOPE OF SERVICES

The purpose of the subsurface investigation and geotechnical engineering evaluation was to explore the subsurface conditions at the site and to provide geotechnical design recommendations for the design of the bridge foundations.

F&R's scope of services included the following:

- Advancing 4 soil test borings to depths ranging from 27.6 to 38.6 feet;
- Performing geotechnical laboratory testing on representative soil samples;
- Preparing typed Boring Logs;
- Performing a geotechnical engineering evaluation of the subsurface conditions with regard to their suitability to support the bridge foundations;
- Preparing this geotechnical report by Professional Engineers; and
- Preparing Foundation Recommendations.

This report is organized to discuss Project Information (Section 2.0), Exploration Procedures (Section 3.0), Regional Geology (Section 4.0), Subsurface Conditions (Section 5.0), and Engineering Evaluation & Recommendations (Section 6.0).

2.0 PROJECT INFORMATION

The project is located along Ridge Street over existing WSSB railroad, northwest of Ansonville in Anson County, North Carolina. The proposed bridge will replace an existing bridge at the same location with an off-site detour. The new bridge will consist of a single span of 85 feet. The proposed skew angle is 89°44'42" and the proposed bridge width is 41'-7" with 28'-0" feet of clear roadway width and 5'-6" sidewalks on both sides.

The existing grade on the underlying WSSB Railroad will be maintained with the opening widened for a potential future track. To facilitate the widening while maintaining a single span bridge, MSE walls are proposed at each end bent. While our scope does not include the MSE wall evaluation and design, it is our understanding that the walls will turn back at the ends to facilitate potential future track widening along the corridor.

3.0 EXPLORATION PROCEDURES

3.1 FIELD EXPLORATION

A subsurface exploration was conducted in October 2009. Two borings were advanced at End Bent 1 and two borings were advanced at End Bent 2. The borings are shown in plan view on Figure 1 in Appendix C. The borings were located in the field by F&R personnel making tape measurements from the existing bridge. After the completion of drilling, F&R performed a survey to obtain the boring collar elevations based on the elevation provided at baseline point BL-3.

A CME-55 track-mounted drill rig advanced the borings with 2.25 inch inside diameter hollow stem augers for borehole stabilization. The borings were advanced to depths ranging from 27.6 to 38.6 feet (elevation 319.3 to 308.5 feet). Standard Penetration Tests (SPT) were performed at frequent intervals with a 140-pound automatic hammer, in general accordance with ASTM D-1586, at all boring locations to aid in foundation analysis.

Representative portions of the soil samples obtained from each SPT interval were sealed in glass jars, labeled and transported to our laboratory for final classification by a geotechnical engineer. The soil samples were visually classified using visual-manual identification procedures using the representative tested samples for reference.

Groundwater levels were recorded in the borings immediately after completion of drilling activities and after a stabilization period of at least 24-hours.

3.2 LABORATORY TESTING

Eight representative soil samples were selected and tested for gradation and Atterberg Limits in accordance with AASHTO T-87, T-88, T-89, and T-90 as modified by the NCDOT Materials and Tests Unit. The natural soil moisture content was also determined for these eight samples in accordance with AASHTO T 265. The purpose of the index testing was to aid in our classification of the soil samples and development of engineering recommendations. The laboratory test results are

presented in Appendix D of this report.

4.0 REGIONAL GEOLOGY

Based on review of the *Geologic Map of North Carolina* (1985), the project site is situated very near a contact between metamorphic rock of the Carolina Slate Belt consisting of metamudstone and meta-argillite (non-crystalline rock, NCR) to the north and west and Triassic deposits of the Chatham Group consisting of conglomerate and fanglomerate to the south and east. The weathered rock (WR) and NCR encountered in our borings is described as tan to light gray metasiltstone.

The typical soil profile at this site consists of non-plastic to low plasticity residual silt near the surface, underlain by weathered rock and/or non-crystalline rock. The boundary between soil and rock is not sharply defined. A transitional zone termed "Weathered Rock" is typically found overlying the more competent bedrock. Weathered Rock (WR) is defined, for engineering purposes, as residual material exhibiting Standard Penetration Resistances in excess of 100 blows per foot (bpf). Weathering is facilitated by fractures, joints and by the presence of less resistant rock types. Consequently, the profile of residual soil, weathered rock, and rock can be irregular and erratic, even over short horizontal distances. Commonly, lenses and boulders of weathered rock or rock can be encountered within the soil mantle, well above the consistent WR or rock level.

5.0 SUBSURFACE CONDITIONS

Strata breaks designated on the Boring Logs represent approximate boundaries between soil types. The actual transition from one soil type to another may be gradual or occur between soil samples. The generalized subsurface conditions at the site are described below. For more detailed soil descriptions and stratifications at a particular boring location, the respective boring logs provided in Appendix C should be reviewed.

5.1 STRATIGRAPHY

The stratigraphy discussion below refers to the borings drilled in October 2009. Residual soil was encountered at the ground surface at all boring locations. The upper 2 to 3 feet of residual soil consists of firm to stiff clayey silt (A-4). Beneath the surficial layer, the borings generally encountered saprolitic, very stiff to very hard clayey silt (A-4). The residual soil extends to depths of 3.5 to 11.5 feet (elevation 343.6 to 338.2 feet). The residual soil is underlain by weathered rock (WR) and/or non-crystalline rock (NCR) at all boring locations. WR was defined previously as residual material exhibiting an SPT N-value of at least 100 blows per foot. In accordance with the NCDOT legend, rock is defined by Standard Penetration Test (SPT) refusal (60/0.1 or 60/0.0); rock coring was not performed. It is noted that residual soils were re-encountered below the weathered rock in boring EB1-A from a depth of 14.5 to 21.5 feet (elevation 332.4 to 325.4 feet) and consisted of saprolitic, hard (SPT N-value = 61) clayey silt (A-4). Non-crystalline rock was then encountered below the residual soil and continued to boring termination in boring EB1-A.

5.2 GROUNDWATER CONDITIONS

In the borings, water levels were measured both immediately after drilling and after a stabilization period of at least 24 hours. Borings EB1-A and EB2-B were dry immediately after drilling while water was encountered in borings EB1-B and EB2-A at elevations of 314.6 and 317.8 feet, respectively. After a stabilization period of at least 24 hours, boring EB1-A was dry while water was measured in borings EB1-B, EB2-A and EB2-B at elevations of 318.1, 317.6 and 312.7 feet, respectively.

It should be noted that even though the soil samples recovered were dry to moist at the time of drilling, soil moisture and groundwater elevations vary depending upon seasonal factors such as precipitation and temperature. As such, soil moisture and groundwater conditions at other times of the year may vary or be different from those observed at the time of this exploration and described in this report.

Due to the presence of fine-grained silt/clay soils, WR, and NCR, trapped or perched water conditions could develop during periods of inclement weather and during seasonally wet periods. Such conditions could cause a flow of water into excavations and deeper cuts. In addition, if site grading is performed during the seasonally wet months or after extended periods of inclement weather, wet and water softened near surface soil conditions should be expected.

6.0 ENGINEERING EVALUATION AND RECOMMENDATIONS

6.1 GENERAL DEVELOPMENT CONSIDERATIONS

The conclusions and recommendations contained in this section of the report are based upon the subsurface conditions encountered in the four soil test borings, site observations, information provided regarding the proposed structure, and our past experience on similar projects. It is our opinion that the subsurface conditions encountered at the project site are suitable for the proposed construction from a geotechnical standpoint provided the project is constructed in accordance with the recommendations included in this report and the NCDOT Standard Specifications for Roads and Structures, and with adequate construction oversight, observation, and testing. Applicable Project Special Provisions to be included with this project are attached in Appendix B: Pile Excavation (7-18-06) and Pile Driving Analyzer (11-17-06). It should be noted piles designed with AASHTO Standard Specifications (LFD) are installed in accordance with Section 450 of the NCDOT Standard Specifications for Roads and Structures and no Special Provision is provided. As design progresses, F&R should be afforded an opportunity to review project structural plans and specifications to confirm that the recommendations presented in this report have been properly interpreted and implemented, and to determine if additional geotechnical recommendations are needed.

6.2 FOUNDATIONS

This section presents a summary of F&R's foundation recommendations. Attached in Appendix A are the Foundation Recommendations Sheets that include notes to be placed on the plans. Computer output for the preliminary GRL WEAP analysis is also attached in Appendix E. Note

that F&R's scope of work does not include the proposed MSE abutments and it is our understanding that their design will be performed by others.

The majority of the excavation for the proposed MSE walls is expected to be in WR and NCR and this material is expected to be present at and below the base of the MSE walls. Since NCDOT generally does not allow the use of spread footings at MSE wall locations, the pile caps will be supported by HP 12X53 piles. In accordance with the NCDOT Special Provision for MSE walls, the piles will be installed after the excavation is performed for the MSE walls. By inspection, the 50 tons of design capacity per pile will be available primarily through tip resistance in/on the non-crystalline rock (NCR) anticipated at the pile tip elevations.

To comply with the NCDOT requirement to install at least 10 feet of pile length into natural ground (Section 450-8 of the Standard Specifications) and to embed enough pile length so that the piles stand in place while the MSE walls are constructed around them, pile excavation is required for the piles. It is expected that this excavation will be performed in rock (Pay Item: Pile Excavation Not in Soil) and the quantity will be 10 feet per pile.

After installing the piles in the excavated holes, the piles are driven to the required capacity. The specific hammer information is not known at this time but a Delmag D-12 (commonly utilized by local contractors) was utilized in the wave equation program GRL WEAP 2005 to determine if the piles could be driven to the required tonnage (100 tons with a FS = 2) without overstressing the pile by driving inside the excavation with no skin friction to provide damping. Based on the results, the piles can be driven to the required tonnage without overstressing. However, since we do not have specific hammer information, we recommend that a Pile Driving Analyzer (PDA) be utilized during installation of the first pile to monitor the stresses during driving to confirm that they are maintained below allowable limits since it is anticipated that each pile will be driven to refusal. The PDA testing should be conducted in accordance with the attached Special Provision (Pile Driving Analyzer) and F&R should observe the test and/or review the results. Monitoring of the production piles should be performed by the geotechnical engineer or personnel working directly under their supervision to verify that the piles are properly installed.

In addition, due to the fact that the piles will be driven in WR/NCR, we recommend that pile points be utilized to limit damage to the tips during driving.

6.3 SLOPE STABILITY AND EMBANKMENT SETTLEMENT

According to the Preliminary General Drawing provided by TGS, the existing grade on the underlying WSSB railroad will remain the same but the existing cut slopes will be excavated to construct the proposed MSE walls; therefore, no end slopes are proposed. Excavating the existing cut will involve residual soil, WR, and NCR. The MSE walls are expected to be founded on/in the NCR encountered in our borings. It is our understanding that the design and global stability analyses of the MSE walls will be performed by others, but based on our boring information, no significant stability or settlement problems are anticipated in the underlying NCR.

6.4 EXCAVATIONS

As mentioned previously, the excavation at the end bents to facilitate the abutment construction is anticipated to involve residual soil, weathered rock and non-crystalline rock. While we were able to auger through this material and rock coring was not performed, some of the material is shown as rock as defined by Standard Penetration Test (SPT) refusal (60/0.1 or 60/0.0). It is expected that blasting may be required to remove some of this material. While it is anticipated that neither the existing bridge nor proposed bridge will be in place at the time of the slope excavation, we recommend the contractor adhere to the requirements in Section 410-11 of the NCDOT Standard Specifications. In addition, the AREMA manual (American Railway Engineering and Maintenance- of-Way Association) has requirements for the controlled blasting of rock. See "Roadbed" Sections 1.3.5.8 and 1.3.5.9.

7.0 LIMITATIONS

This report has been prepared for the exclusive use of TGS Engineers and their agents for specific application to the referenced property in accordance with generally accepted soil and foundation engineering practices. No other warranty, expressed or implied, is made. These

FOUNDATION RECOMMENDATIONS

WBS # N/A

T.I.P. NO. B-4861

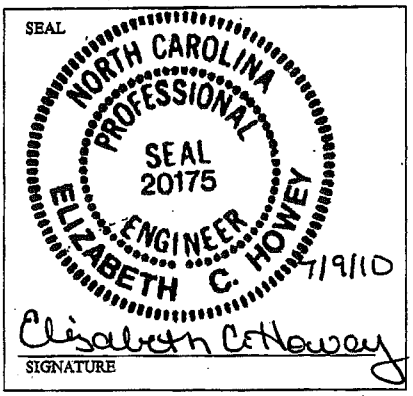
COUNTY Anson

STATION 12+66.683 -L- =

11+50.99 -RR-

DESCRIPTION Bridge on Ridge Street over WSSB Railroad between Old Plank Road and Highway 52

	INITIALS	DATE
DESIGN	ECH	Jul-10
CHECK	DKS	Jul-10
APPROVAL		



	STATION	FOUNDATION TYPE	ALLOWABLE LOAD	MISCELLANEOUS DETAILS
END BENT 1	12+27.214 -L-	Cap on HP 12x53 Steel Piles	50 Tons/Pile	Assumed BOC Elevation = 343± ft. Average pile length = 35± feet
END BENT 2	13+12.214 -L-	Cap on HP 12x53 Steel Piles	50 Tons/Pile	Assumed BOC Elevation = 344± ft. Average pile length = 35± feet

NOTES ON PLANS & COMMENTS (See following page)

TIP # B-4861 **County** Anson

FOUNDATION RECOMMENDATION NOTES ON PLANS

1) For Piles, see Section 450 of the NCDOT Standard Specifications for Roads and Structures.

2) Drive piles at End Bents 1 and 2 to a required bearing capacity of 100 tons per pile. The required bearing capacity is equal to the allowable bearing capacity with a minimum factor of safety of two.

3) Steel H-pile points are required for H piles at End Bents 1 and 2. For steel pile points, see Piles Special Provision.

4) Testing the first production pile with the pile driving analyzer (PDA) during driving, restriking, or redriving is required. For Pile Driving Analyzer, see Special Provisions.

5) Pile excavation is required to install piles at End Bents 1 and 2. Excavate holes to an elevation that provides 10 feet of pile penetration below the bottom the MSE walls. After placing piles in holes, drive piles to the required driving resistance. For Pile Excavation, see Special Provisions.

6) For blasting adjacent to highway structures, see Section 410-11 of the NCDOT Standard Specifications for Roads and Structures. In addition, the AREMA manual (American Railway Engineering and Maintenance of Way Association) has requirements for the controlled blasting of rock. See "Roadbed" Sections 1.3.5.8 and 1.3.5.9.

FOUNDATION RECOMMENDATION COMMENTS

1) The hammer type is not known at this time. Based on preliminary GRL WEAP analyses, the piles should be capable of bring driven to the required capacity withour overstress.

2) MSE walls are proposed at the end bents. It is anticipated that the excavation for the MSE walls will be performed prior to the pile excavation for the end bent piles. The design and global stability of the MSE walls is to be performed by others.

BEARING PILE PAY ITEM QUANTITIES

WBS ELEMENT 34480.3.GV1 DATE Jul-10

TIP NO. B-4861 DESIGNED BY ECH

COUNTY Anson CHECKED BY DKS

STATION 12+66.683 -L- =
11+50.99 -RR-

DESCRIPTION Bridge on Ridge Street over WSSB Railroad between Old Plank Road and Highway 52

NUMBER OF BENTS WITH PILES
NUMBER OF PILES PER BENT
NUMBER OF END BENTS WITH PILES 2
NUMBER OF PILES PER END BENT 20

Only required for "Pile Excavation" Pay Items.

BENT # OR END BENT #	BEARING PILE PAY ITEMS						
	PIPE PILE PLATES (yes/no/maybe)	STEEL PILE POINTS (yes/no)	PILE REDRIVES (per each)	PILE EXCAVATION (linear ft) IN SOIL	PILE EXCAVATION (linear ft) NOT IN SOIL	PDA TESTING* (per each)	PDA ASSISTANCE* (per each)
End Bent 1	no	yes	0	0	10'/Pile	*	*
End Bent 2	no	yes	0	0	10'/pile	*	*
TOTALS			0	0	0	1	0

* If PDA testing is required at a specific bent or end bent with a Note on Plans, show "PDA Testing" and "PDA Assistance" pay items per that specific bent or end bent. If PDA testing may be required or is required for multiple bents or end bents with a Note on Plans, show "PDA Testing" and "PDA Assistance" pay items as a total per structure only (do not show per bent or end bent).

Notes:
Blanks or "no" represent quantity of zero.

If pipe pile plates are required or may be required, Structure Design should determine the pay item quantity, "Pipe Pile Plates" equal to the number of pipe piles per bent or end bent.

If pile points are required, Structure Design should determine the pay item quantity, "Steel Pile Points" equal to the number of steel piles per bent or end bent.

STATE OF NORTH CAROLINA DEPARTMENT OF TRANSPORTATION DIVISION OF HIGHWAYS HIGHWAY BUILDING 1589 MAIL SERVICE CENTER RALEIGH, NORTH CAROLINA 27699-1589	SUBJECT: Ridge Road over WSSB Railroad		WBS Element N/A
			COUNTY Anson
	PREPARED BY:	ECH	TIP # B-4861
	DATE:	May-10	
	CHECKED BY:	DKS	SHEET: 3
	DATE:	May-10	

END BENTS SUMMARY

END BENT 1

Pile Type: HP 12X53 Steel Piles
Assumed Bottom of Cap Elevation: 343± feet (Scaled from PGD)
Approx. Top of Weathered Rock Elevation: 343± feet (Boring Logs)
Anticipated Pile Length: 35± feet (10 feet below MSE Wall Excavation)
Average Pile Length: 35± feet
Allowable Design Load: 50 Tons/Pile
Required Driving Resistance: 100 Tons/Pile FS = 2 (LFD, AASHTO Standard Specs.)

END BENT 2

Pile Type: HP 12X53 Steel Piles
Assumed Bottom of Cap Elevation: 344± feet (Scaled from PGD)
Approx. Top of Weathered Rock Elevation: 341± to 338± feet (Boring Logs)
Anticipated Pile Length: 35± feet (10 feet below MSE Wall Excavation)
Average Pile Length: 35± feet
Allowable Design Load: 50 Tons/Pile
Required Driving Resistance: 100 Tons/Pile FS = 2 (LFD, AASHTO Standard Specs.)

NOTES

1. For Piles, see Section 450 of the NCDOT Standard Specifications for Roads and Structures.

2. Drive piles at End Bents 1 and 2 to a required bearing capacity of 100 tons per pile. The required bearing capacity is equal to the allowable bearing capacity with a minimum factor of safety of two.

3. Steel H-pile points are required for H piles at End Bents 1 and 2. For steel pile points, see Piles Special Provision.

4. Testing the first production pile with the pile driving analyzer (PDA) during driving , restriking, or redriving is required. For Pile Driving Analyzer, see Special Provisions.

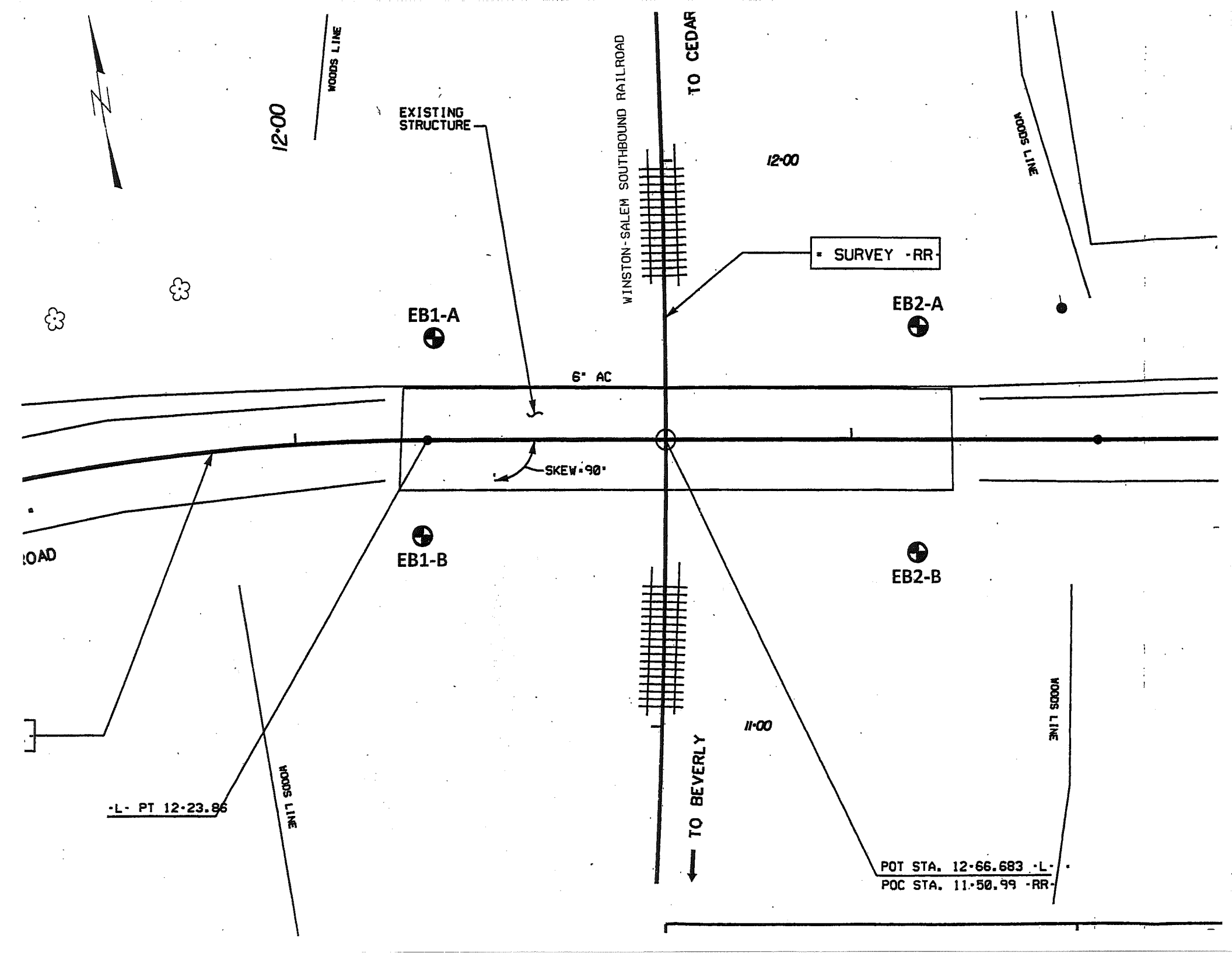
5. Pile excavation is required to install piles at End Bents 1 and 2. Excavate holes to an elevation that provides 10 feet of pile penetration below the bottom the MSE walls. After placing piles in holes, drive piles to the required driving resistance. For Pile Excavation, see Special Provisions.

COMMENTS

1. By inspection, adequate pile capacity is available in tip resistance in/on the NCR encountered in the borings near the anticipated pile tip elevations.

APPENDIX C

NCDOT LEGEND SHEET, PLAN VIEW, AND BORING LOGS


WOODS LINE
12-00
EXISTING STRUCTURE
WINSTON-SALEM SOUTHBOUND RAILROAD
TO CEDAR
12-00
WOODS LINE
SURVEY -RR-
EB1-A
EB2-A
6" AC
SKEW-90°
EB1-B
EB2-B
11-00
TO BEVERLY
WOODS LINE
-L- PT 12-23.86
WOODS LINE
POT STA. 12-66.683 -L-
POC STA. 11-50.99 -RR-

GEOTECHNICAL ENGINEERING UNIT

SUBSURFACE INVESTIGATION

SOIL AND ROCK LEGEND, TERMS, SYMBOLS, AND ABBREVIATIONS

OIL DESCRIPTION

DATED, SEMI-CONSOLIDATED, OR WEATHERED EARTH MATERIALS
OUS FLIGHT POWER AUGER, AND YIELD LESS THAN
ARD PENETRATION TEST (AASHTO T206, ASTM D-1586). SOIL
SYSTEM. BASIC DESCRIPTIONS GENERALLY SHALL INCLUDE:
SHTO CLASSIFICATION, AND OTHER PERTINENT FACTORS SUCH
, STRUCTURE, PLASTICITY, ETC. EXAMPLE:

SF WITH INTERBEDDED FINE SAND LAYERS,HIGHLY PLASTIC,A-7-6

AND AASHTO CLASSIFICATION

	SILT-CLAY MATERIALS (> 35% PASSING #200)				ORGANIC MATERIALS		
	A-4	A-5	A-6	A-7	A-1, A-2 A-3	A-4, A-5 A-6, A-7	
2				A-7-5 A-7-6			
A-2-6 A-2-7							
	GRANULAR SOILS		SILT-CLAY SOILS				MUCK, PEAT
35 MX 35 MX	36 MN	36 MN	36 MN	36 MN			
41 MN 41 MN	40 MX	41 MN	40 MX	41 MN	SOILS WITH LITTLE OR MODERATE AMOUNTS OF ORGANIC MATTER		HIGHLY ORGANIC SOILS
11 MN 11 MN	10 MX	10 MX	11 MN	11 MN			
4 MX	8 MX	12 MX	16 MX	No MX			
CLAYEY IO SAND	SILTY SOILS		CLAYEY SOILS				
	FAIR TO POOR				FAIR TO POOR	POOR	UNSUITABLE

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

TENCY OR DENSENESS

OR Y	RANGE OF STANDARD PENETRATION RESISTENCE (N-VALUE)	RANGE OF UNCONFINED COMPRESSIVE STRENGTH (TONS/FT²)
	<4 4 TO 10 10 TO 30 30 TO 50 >50	N/A
	<2 2 TO 4 4 TO 8 8 TO 15 15 TO 30 >30	<0.25 0.25 TO 0.50 0.5 TO 1.0 1 TO 2 2 TO 4 >4

URE OR GRAIN SIZE

10	40	60	200	270
2.00	0.42	0.25	0.075	0.053

COARSE SAND (CSE. SD.)	FINE SAND (F SD.)	SILT (SL.)	CLAY (CL.)
2.0	0.25	0.05	0.005

- CORRELATION OF TERMS

ELD MOISTURE DESCRIPTION	GUIDE FOR FIELD MOISTURE DESCRIPTION
SATURATED - (SAT.)	USUALLY LIQUID; VERY WET, USUALLY FROM BELOW THE GROUND WATER TABLE
- WET - (W)	SEMISOLID; REQUIRES DRYING TO ATTAIN OPTIMUM MOISTURE
- MOIST - (M)	SOLID; AT OR NEAR OPTIMUM MOISTURE
- DRY - (D)	REQUIRES ADDITIONAL WATER TO ATTAIN OPTIMUM MOISTURE

PLASTICITY

ASTICITY INDEX (PI)	DRY STRENGTH
	VERY LOW

GRADATION

WELL GRADED - INDICATES A GOOD REPRESENTATION OF PARTICLE SIZES FROM FINE TO COARSE.
UNIFORM - INDICATES THAT SOIL PARTICLES ARE ALL APPROXIMATELY THE SAME SIZE. (ALSO POORLY GRADED)
GAP-GRADED - INDICATES A MIXTURE OF UNIFORM PARTICLES 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 WHENEVER THEY ARE CONSIDERED OF SIGNIFICANCE.

COMPRESSIBILITY

SLIGHTLY COMPRESSIBLE	LIQUID LIMIT LESS THAN 31
MODERATELY COMPRESSIBLE	LIQUID LIMIT EQUAL TO 31-50
HIGHLY COMPRESSIBLE	LIQUID LIMIT GREATER THAN 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 W/ CORE
- SPT N-VALUE
- REF — SPT REFUSAL

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:
- [ ] MOBILE B-___
- [ ] BK-51
- [X] CME-55
- [ ] CME-850

ADVANCING TOOLS:
- [ ] CLAY BITS
- [ ] 6" CONTINUOUS FLIGHT AUGER
- [X] 8" HOLLOW AUGERS
- [ ] HARD FACED FINGER BITS
- [ ] TUNG.-CARBIDE INSERTS

HAMMER TYPE:
- [X] AUTOMATIC
- [ ] MANUAL

CORE SIZE:
- [ ] -B___
- [ ] -N___
- [ ] -H

ROCK DESCRIPTION

HARD ROCK IS NON-COASTAL PLAIN MATERIAL THAT IF TESTED, WOULD YIELD SPT REFUSAL. 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, YIELDS SPT N VALUES > 100 BPF*
VERY SEVERE (V SEV.)	ALL ROCK EXCEPT QUARTZ DISCOLORED OR STAINED. ROCK FABRIC ELEMENTS ARE DISCERNIBLE BUT THE MASS IS EFFECTIVELY REDUCED TO SOIL STATUS, WITH ONLY FRAGMENTS OF STRONG ROCK REMAINING. SAPROLITE IS AN EXAMPLE OF ROCK WEATHERED TO A DEGREE SUCH THAT ONLY MINOR VESTIGES OF THE ORIGINAL ROCK FABRIC REMAIN. *IF TESTED, YIELDS 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 FEET
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 THE MATERIAL BY CEMENTING, HEAT, PRESSURE, ETC.

RUBBING WITH FINGER FREES APPRECIABLE GRAINS

ALLUVIUM (ALLUV
AQUIFER - A WAT
ARENACEOUS - AP
ARGILLACEOUS - OR HAVING A NOT
ARTESIAN - GROU AT WHICH IT IS GROUND SURFACE.
CALCAREOUS (CAL
COLLUVIUM - ROC OF SLOPE.
CORE RECOVERY (R LENGTH OF CORE
DIKE - A TABULA ROCKS OR CUTS
DIP - THE ANGLE HORIZONTAL.
DIP DIRECTION (D THE LINE OF DIP.
FAULT - A FRACT SIDES RELATIVE
FISSILE - A PROP
FLOAT - ROCK FR PARENT MATERIAL
FLOOD PLAIN (FP) THE STREAM.
FORMATION (FM.) - THE FIELD.
JOINT - FRACTURE
LEDGE - A SHELF ITS LATERAL EXT
LENS - A BODY O
MOTTLED (MOT.) - SOILS USUALLY I
PERCHED WATER - INTERVENING IMPE
RESIDUAL (RES.) S
ROCK QUALITY DE ROCK SEGMENTS EXPRESSED AS A
SAPROLITE (SAP.) - PARENT ROCK.
SILL - AN INTRUS RELATIVELY THIN TO THE BEDDING
SLICKENSIDE - PO SLIP PLANE.
STANDARD PENETR A 140 LB. HAMMER A 2 INCH OUTSIDE THAN 0.1 FOOT PE
STRATA CORE REC OF STRATUM AND
STRATA ROCK QUAL TOTAL LENGTH OF TOTAL LENGTH OF
TOPSOIL (TS.) - S

BENCH MARK:

NOTES:

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

PROJECT NO. 66L-0292	ID. B-4861	COUNTY Anson	GEOLOGIST D. Racey
SITE DESCRIPTION Bridge on Ridge Street over WSSB RR			GROUND WTR (ft)
BORING NO. EB1-A	STATION 12+25	OFFSET 18ft LT	ALIGNMENT -L-	0 HR. Dry
COLLAR ELEV. 346.9 ft	TOTAL DEPTH 27.6 ft	NORTHING N/A	EASTING N/A	24 HR. Dry
DRILL MACHINE CME 55	DRILL METHOD 2.25" ID HSA		HAMMER TYPE Automatic
START DATE 10/22/09	COMP. DATE 10/22/09	SURFACE WATER DEPTH N/A	DEPTH TO ROCK 21.5 ft

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
	346.9	0.0								ELEV. (ft) DEPTH (ft)
350										346.9 GROUND SURFACE 0.0
	344.9	2.0	2	4	3	7	SS-30	5%		RESIDUAL
345			7	17	20	37		D		344.9 Tan-light gray, white & black, clayey SILT (A-4(3)), with little fine to coarse sand, trace rock fragments, trace roots, saprolitic. 2.0
	343.4	3.5	37	62	38/0.2'	100/0.7		D		342.9 Tan, light gray & red, clayey SILT (A-4), with quartz fragments, saprolitic. 4.0
340										WEATHERED ROCK
	338.4	8.5	100/0.3'			100/0.3		D		Tan, white, brown & black, METASILTSTONE.
335										
	333.4	13.5	93	7/0.0'		100/0.5		D		332.4 14.5
330										Tan, white, brown & black, clayey SILT (A-4(0)), with little fine to coarse sand, saprolitic.
	328.4	18.5	28	32	29	61	SS-35	10%		
325										325.4 21.5
	323.4	23.5	60/0.0'			60/0.0		D		NON-CRYSTALLINE ROCK Light gray with tan, METASILTSTONE.
320										
	319.4	27.5	60/0.1'			60/0.1		D		319.3 27.6
315										Boring Terminated at Elevation 319.3 ft in NON-CRYSTALLINE ROCK (METASILTSTONE)
310										
305										
300										
295										
290										
285										
280										
275										
270										

NOTES:

1) 0.0'-0.5' Surficial Organic Soils
2) Field Professional indicates strata break in split spoon at a depth of 4.0'.
3) Driller indicates softer drilling at a depth of 14.5'.
4) Driller indicates harder drilling at a depth of 21.5'.
5) Drill rig broke while augering to 28.5', unable to advance, performed SPT at a depth of 27.5' and terminated boring.

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

PROJECT NO. 66L-0292	ID. B-4861	COUNTY Anson	GEOLOGIST D. Racey
SITE DESCRIPTION Bridge on Ridge Street over WSSB RR			GROUND WTR (ft)
BORING NO. EB1-B	STATION 12+23	OFFSET 17ft RT	ALIGNMENT -L-	0 HR. 32.5
COLLAR ELEV. 347.1 ft	TOTAL DEPTH 38.6 ft	NORTHING N/A	EASTING N/A	24 HR. 29.0
DRILL MACHINE CME 55	DRILL METHOD 2.25" ID HSA		HAMMER TYPE Automatic
START DATE 10/22/09	COMP. DATE 10/22/09	SURFACE WATER DEPTH N/A		DEPTH TO ROCK 13.5 ft

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)
350										
	347.1	0.0								347.1 GROUND SURFACE 0.0
			2	3	2	5 98	SS-20	6%		**RESIDUAL**
345	345.1	2.0								345.1 Tan & light gray, clayey SILT (A-4(3)), with little fine to coarse sand, trace rock fragments, trace roots. 2.0
	343.6	3.5	18	37	61		SS-21	5%		343.6 3.5
			57	43/0.3'		100/0.8'		D		White, tan, brown & black, clayey SILT (A-4(0)), with little fine to coarse sand, some rock & quartz fragments, saprolitic.
340										**WEATHERED ROCK**
	338.6	8.5	100/0.3'			100/0.3'		D		Tan, white & light gray, METASILTSTONE.
335										
	333.6	13.5	60/0.0'			60/0.0'		D		333.6 13.5 **NON-CRYSTALLINE ROCK** Tan & brown, METASILTSTONE.
330										
	328.6	18.5	60/0.1'			60/0.1'		D		
325										
	323.6	23.5	100/0.2'			100/0.2'		M		323.6 23.5 **WEATHERED ROCK** Brown, METASILTSTONE.
320										
	318.6	28.5	60/0.0'			60/0.0'		D		318.6 28.5 **NON-CRYSTALLINE ROCK** Light gray & tan, METASILTSTONE.
315										
	313.6	33.5	60/0.1'			60/0.1'		D		
310										
	308.6	38.5	60/0.1'			60/0.1'		W		308.5 38.6 Boring Terminated at Elevation 308.5 ft in NON-CRYSTALLINE ROCK (METASILTSTONE)
305										
300										NOTES:
295										1) 0.0'-0.4' Surficial Organic Soils 2) Driller indicates difficult drilling from a depth of 13.5' to boring termination.
290										
285										
280										
275										
270										

NCDOT BORE SINGLE 66L-0292.GPJ NC_DOT.GDT 11/9/09

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

PROJECT NO. 66L-0292	ID. B-4861	COUNTY Anson	GEOLOGIST D. Racey
SITE DESCRIPTION Bridge on Ridge Street over WSSB RR			GROUND WTR (ft)
BORING NO. EB2-A	STATION 13+12	OFFSET 20ft LT	ALIGNMENT -L-	0 HR. 31.8
COLLAR ELEV. 349.6 ft	TOTAL DEPTH 38.6 ft	NORTHING N/A	EASTING N/A	24 HR. 32.0
DRILL MACHINE CME 55	DRILL METHOD 2.25" ID HSA		HAMMER TYPE Automatic
START DATE 10/22/09	COMP. DATE 10/22/09	SURFACE WATER DEPTH N/A	DEPTH TO ROCK 13.5 ft

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)
350	349.6	0.0								349.6 GROUND SURFACE 0.0
	347.6	2.0	2	4	3	7	SS-10	7%		**RESIDUAL**
	346.1	3.5	3	7	13	20		D		Tan & light gray with black, clayey SILT (A-4(4)), with some fine to coarse sand, trace roots. 346.6 3.0
345			14	16	23	39	SS-12	8%		Tan, light gray, white & black with red specks, clayey SILT (A-4(7)), with little fine to coarse sand, trace quartz fragments, saprolitic. 341.1 8.5
340	341.1	8.5	100/0.3'			100/0.3'		D		**WEATHERED ROCK** Brown, METASILTSTONE.
335	336.1	13.5	60/0.1'			60/0.1'		D		336.1 13.5 **NON-CRYSTALLINE ROCK** Tan, METASILTSTONE.
330	331.1	18.5	100/0.2'			100/0.2'		D/M		332.1 17.5 **WEATHERED ROCK** 330.6 Brown & tan, METASILTSTONE. 19.0
325	326.1	23.5	60/0.1'			60/0.1'		D		**NON-CRYSTALLINE ROCK** Tan to light gray, METASILTSTONE.
320	321.1	28.5	60/0.1'			60/0.1'		D		
315	316.1	33.5	60/0.1'			60/0.1'		D		
310	311.1	38.5	60/0.1'			60/0.1'		W		311.0 38.6 Boring Terminated at Elevation 311.0 ft in NON-CRYSTALLINE ROCK (METASILTSTONE)
305										
300										
295										
290										
285										
280										
275										
270										

NOTES:

1) 0.0'-0.4' Surficial Organic Soils
2) Field Professional indicates strata break in split spoon at a depth of 3.0'.
3) Driller indicates softer drilling at a depth of 17.5'.
4) Driller indicates harder drilling at a depth of 19.0'.
5) Driller indicates softer drilling from a depth of 31.0'-33.1'.

NCDOT BORE SINGLE 66L-0292.GPJ NC_DOT.GDT 11/9/09

NCDOT GEOTECHNICAL ENGINEERING UNIT
BORELOG REPORT

PROJECT NO. 66L-0292	ID. B-4861	COUNTY Anson	GEOLOGIST D. Racey
SITE DESCRIPTION Bridge on Ridge Street over WSSB RR			GROUND WTR (ft)
BORING NO. EB2-B	STATION 13+12	OFFSET 20ft RT	ALIGNMENT -L-	0 HR. Dry
COLLAR ELEV. 349.7 ft	TOTAL DEPTH 38.5 ft	NORTHING N/A	EASTING N/A	24 HR. 37.0
DRILL MACHINE CME 55	DRILL METHOD 2.25" ID HSA		HAMMER TYPE Automatic
START DATE 10/21/09	COMP. DATE 10/21/09	SURFACE WATER DEPTH N/A	DEPTH TO ROCK 11.5 ft

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)
350	349.7	0.0								349.7 GROUND SURFACE 0.0
	347.7	2.0	2	5	4	9	SS-1	8%		**RESIDUAL**
	346.2	3.5	6	10	14	24		D		347.7 Tan, clayey SILT (A-4(6)), with little fine to coarse sand, trace rock fragments, trace roots.. 2.0
345			23	29	32	61		D		Tan, light gray & white with red specks, clayey SILT (A-4(5)), with some fine to coarse sand, trace quartz fragments, saprolitic.
340	341.2	8.5	25	22	59	81	SS-4	12%		338.2 11.5
	336.2	13.5	60/0.0'			60/0.0'		D		**NON-CRYSTALLINE ROCK** Tan & brown to light gray, METASILTSTONE.
335										
	331.2	18.5	60/0.1'			60/0.1'		D		
330										
	326.2	23.5	60/0.1'			60/0.1'		D		
325										
	321.2	28.5	60/0.1'			60/0.1'		D		
320										
	316.2	33.5	60/0.0'			60/0.0'		W		
315										
310										311.2 38.5
305										Boring Terminated at Elevation 311.2 ft in NON-CRYSTALLINE ROCK (METASILTSTONE)
300										NOTES: 1) 0.0'-0.3' Surficial Organic Soils 2) Driller indicates harder drilling at a depth of 11.5'. 3) Augers plugged, unable to perform SPT at 38.5'.
295										
290										
285										
280										
275										
270										

NCDOT BORE SINGLE 66L-0292.GPJ NC_DOT.GDT 11/9/09

APPENDIX D

LABORATORY TEST RESULTS

Soils Laboratory

et over WSSB Railroad

FOR QUALITY

COUNTY: Anson
RECEIVED: 10/27/09
REPORTED: 11/4/09
BY: D. Jenks
Cert No. 101-02-0603

TEST RESULTS

1-A	EB1-A	EB1-B	EB1-B	EB2-A	EB2-A	EB2-B	EB2-B						
-30	SS-35	SS-20	SS-21	SS-10	SS-12	SS-1	SS-4						
.6	1.3	12.9	25.4	4.9	5.1	8.2	6.0						
.1	95.4	78.3	66.2	89.5	89.9	86.7	89.9						
.2	87.5	72.7	59.5	79.2	84.7	79.1	81.7						
.3	81.9	68.8	54.6	70.6	79.7	71.6	72.7						

MINUS #10 FRACTION

9	10.6	8.8	12.5	14.7	7.6	11.8	11.8						
9	4.4	4.2	6.2	7.8	4.7	6.8	9.0						
.5	49.3	38.3	27.7	35.4	36.3	31.3	33.9						
.7	35.7	48.7	53.6	42.1	51.4	50.1	45.3						
)	23	31	25	31	35	32	30						
6	NP	25	21	24	27	22	22						
	NP	6	4	7	8	10	8						
(3)	A-4(0)	A-4(3)	A-4(0)	A-4(4)	A-4(7)	A-4(6)	A-4(5)						
25	12+25	12+23	12+23	13+12	13+12	13+12	13+12						
LT	18 ft LT	17 ft RT	17 ft RT	20 ft LT	20 ft LT	20 ft RT	20 ft RT						
5	18.5	0.4	2.0	0.4	3.5	0.3	8.5						
5	20.0	1.5	3.5	1.5	5.0	1.5	10.0						
3	10.4	6.3	4.9	6.6	8.2	7.7	12.4						

APPENDIX E

COMPUTER OUTPUT

GRLWEAP - Version 2005
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

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

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local non-axial stresses and prestress effects must also be accounted for by the user.

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

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

Input File: G:\APPS\GRLWEAP 2005\BRANCH 66\B-4861 MSE DELMAG D 12.GWI
Hammer File: G:\apps\GRLWEAP 2005\HAMMER2003.GW
Hammer File Version: 2003 (10/24/2008)

Input File Contents

B-4861 MSE Delmag D 12

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

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	144.000	12.000	H Pile

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

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

LPle	APle	EPle	WPle	Peri	Strg	CoR	ROut
35.000	15.500	30000.000	492.000	4.000	36.000	0.850	0.010

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

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

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

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
11.07	109.60	97.00	0.002	0.002	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1275.00	0.00	0.00	0.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
8.2200	0.8000	1275.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.100	0.100	0.200	0.150	0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

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

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Dpth	Dpth						
0.00	0.00	1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00
0.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
1.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
35.00	1.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00

Rult

50.0	100.0	200.0	300.0	400.0	450.0	475.0	500.0	520.0	550.0

Diameter	COGHammer	WHammer	ABatter	Depth Sup	Flag
0.000	0.000	0.000	0.000	0.000	0

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2005
English Units

B-4861 MSE Delmag D 12

Hammer Model: D 12 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.688				
2	0.688	121704.2	1.000	0.0100	
3	0.688	121704.2	1.000	0.0100	
4	0.688	121704.2	1.000	0.0100	
Imp Block	0.810	67059.7	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.2
Combined Pile Top		12178.6			

HAMMER OPTIONS:

Hammer File ID No.	3	Hammer Type	OE Diesel
Stroke Option	VarP-FxdS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight	(kips)	2.75	Ram Length	(inch)	104.41
Maximum Stroke	(ft)	10.80	Actual Stroke	(ft)	8.22
Rated Stroke	(ft)	8.22	Efficiency		0.800
Maximum Pressure	(psi)	1275.00	Actual Pressure	(psi)	1275.00
Compression Exponent		1.350	Expansion Exponent		1.250
Ram Diameter	(inch)	11.81			
Combustion Delay	(s)	0.00200	Ignition Duration	(s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

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

B-4861 MSE Delmag D 12 — 05/18/2010
Froehling & Robertson, Inc. — GRLWEAP(TM) Version 2005

PILE PROFILE:

Toe Area	(in2)	144.000	Pile Type	H Pile
Pile Size	(inch)	12.000		

L b Top ft	Area in2	E-Mod ksi	Spec Wt lb/ft3	Perim ft	Strength ksi	Wave Sp ft/s	EA/c k/ft/s
0.0	15.50	30000.	492.0	4.0	36.000	16807.	27.7
35.0	15.50	30000.	492.0	4.0	36.000	16807.	27.7

Wave Travel Time 2L/c (ms) 4.165

Pile and Soil Model — Total Capacity Rut (kips) 50.0

No.	Weight kips	Stiffn k/in	C-Slk ft	T-Slk ft	CoR	Soil-S kips	Soil-D s/ft	Quake inch	LbTop ft	Perim ft	Area in2
1	0.169	12179.	0.010	0.000	0.85	0.0	0.200	0.100	3.18	4.0	15.5
2	0.169	12179.	0.000	0.000	1.00	0.0	0.200	0.100	6.36	4.0	15.5
11	0.169	12179.	0.000	0.000	1.00	0.5	0.200	0.100	35.00	4.0	15.5
Toe						49.5	0.150	0.100			

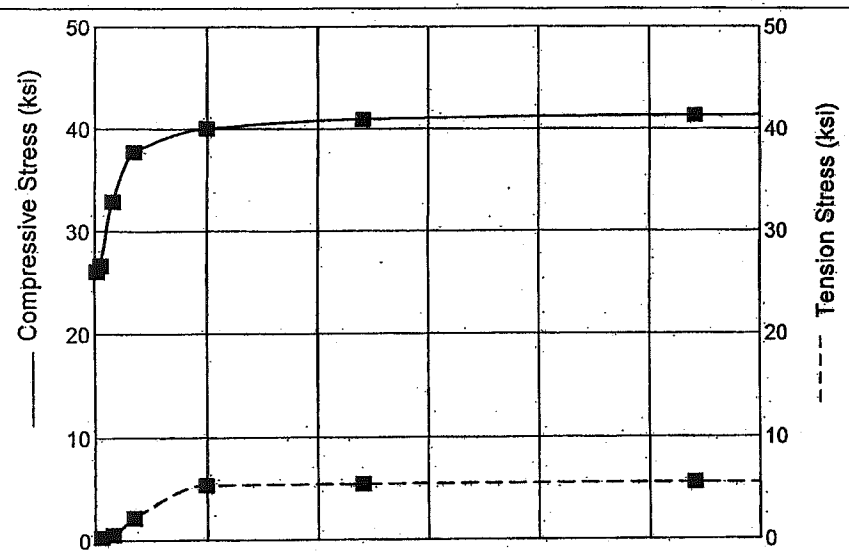
1.854 kips total unreduced pile weight (g= 32.17 ft/s2)
1.854 kips total reduced pile weight (g= 32.17 ft/s2)

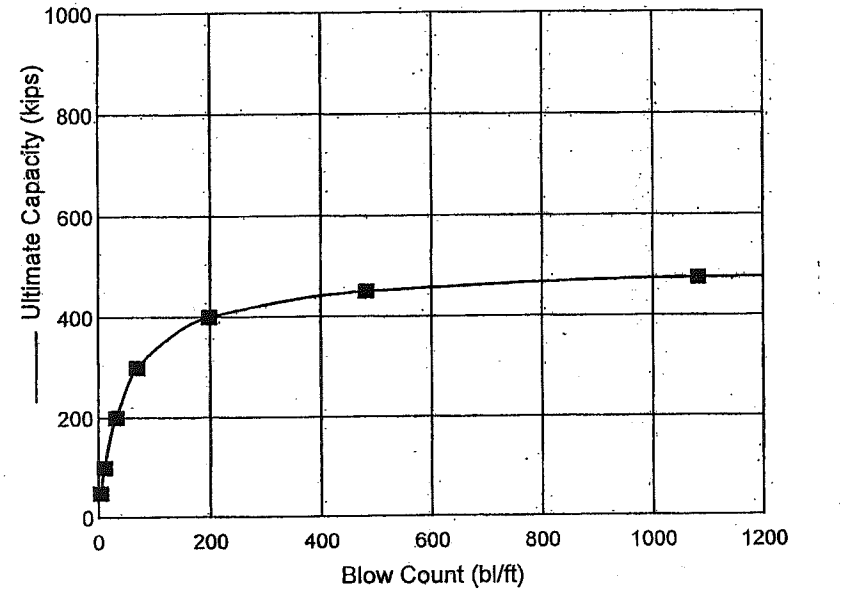
PILE, SOIL, ANALYSIS OPTIONS:

Uniform pile		Pile Segments: Automatic	
No. of Slacks/Splices	0	Pile Damping (%)	1
Pile Penetration (ft)	1.00	Pile Damping Fact.(k/ft/s)	0.553
% Shaft Resistance	1		
Soil Damping Option	Smith		
Max No Analysis Iterations	0	Time Increment/Critical	160
Output Time Interval	1	Analysis Time-Input (ms)	0
Output Level: Variable vs Time			
Gravity Mass, Pile, Hammer:	32.170	32.170	32.170
Output Segment Generation: Automatic			

Froehling & Robertson, Inc.
B-4861 MSE Delmag D 12

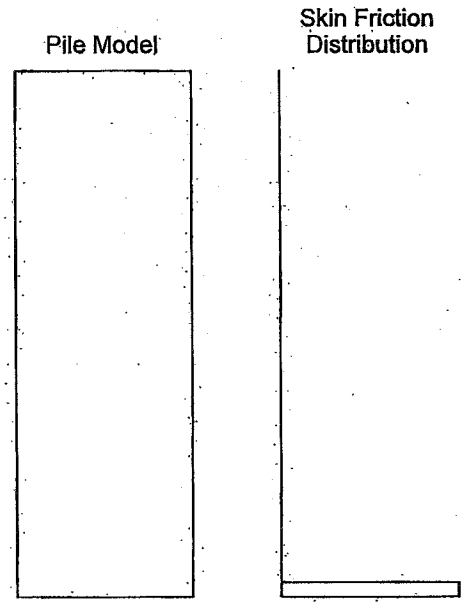
18-May-2010
GRLWEAP (TM) Version 2005





DELMAG D 12

Stroke	8.22	ft
Efficiency	0.800	
Helmet	1.90	kips
Hammer Cushion	60155	kips/in
Skin Quake	0.100	in
Toe Quake	0.100	in
Skin Damping	0.200	sec/ft
Toe Damping	0.150	sec/ft
Pile Length	35.00	ft
Pile Penetration	1.00	ft
Pile Top Area	15.50	in2



Res. Shaft = 1 %
(Proportional)

Froehling & Robertson, Inc.
B-4861 MSE Delmag D 12

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Ultimate Capacity kips	Maximum Compression Stress ksi	Maximum Tension Stress ksi	Blow Count bl/ft	Stroke ft	Energy kips-ft
50.0	26.12	0.00	4.2	8.22	29.46
100.0	26.71	0.32	11.3	8.22	20.46
FS=2 200.0	32.93 < 45 OK	0.60	32.0 > 30 OK	8.22	14.68
300.0	37.75	2.21	69.6	8.22	12.85
400.0	40.05	5.34	198.6	8.22	11.83
450.0	40.94	5.43	481.6	8.22	11.48
475.0	41.33	5.54	1082.2	8.22	11.36
500.0	41.69	5.48	5498.3	8.22	11.24
520.0	41.96	5.46	9999.0	8.22	11.20