# Geotechnical Baseline Report

S-29-765 (Hanging Rock Church Rd.) Bridge Replacement over Hanging Rock Creek

*Lancaster County, SC*

September 23, 2022

September 23, 2022

Mr. Trapp Harris, PE, DBIA
Geotechnical Engineer
Alternative Delivery
South Carolina Department of Transportation
955 Park Street
Columbia, SC 29201

Dear Mr. Harris,

We have completed the Geotechnical Baseline Report for the S-29-765 (Hanging Rock Church Rd.) Bridge Replacement over Hanging Rock Creek in Lancaster County, SC. Please call at your convenience if you have questions or comments. HDR appreciates the opportunity to provide geotechnical engineering services to the South Carolina Department of Transportation.

Sincerely,
HDR

Kiera Hughes, E.I.T.
*Engineer-in-Training*

Lila Leon, P.E., Ph.D.
*Senior Geotechnical Engineer*

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HDR ENGINEERING, INC. OF THE CAROLINAS
No. C0318
CERTIFICATE OF AUTHORIZATION

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# 1 Introduction

This Geotechnical Baseline Report (GBR) provides a characterization of the subsurface conditions to the South Carolina Department of Transportation (SCDOT) for the proposed S-29-765 Bridge Replacement over Hanging Rock Creek, in Lancaster County, South Carolina. The proposed bridge intends to replace the existing bridge over Hanging Rock Creek on Hanging Rock Church Road.

This Geotechnical Baseline Report was prepared in general accordance with the 2022 SCDOT Geotechnical Design Manual (GDM) and PCDM-11 Supplemental Design Criteria for Low Volume Bridge Replacement Projects. Geotechnical data including standard penetration testing (SPT), bulk sampling, rock cores, and a variety of laboratory tests are presented herein to provide geological features and site conditions for the design of the proposed bridge. Preliminary geotechnical considerations for construction are also included in this report.

## 1.1 Project Description

The project site is located approximately two miles southwest of the Town of Kershaw, approximately a quarter of a mile southwest of the intersection of S-29-765 with State Road S-29-766. It is bound to the north by U.S. Route S21 and to the east by U.S. Route 601. It is placed within an area experiencing a low volume of traffic. A Site Vicinity Map is included in Appendix A.

The existing bridge over Hanging Rock Creek is approximately 90 feet in length and 24 feet wide and will be removed and replaced with a new bridge along the existing alignment. The proposed multi span replacement bridge will be approximately 210 feet in length and will accommodate two 11-foot lanes with 4-foot shoulders. Construction is anticipated to be completed with a temporary detour of traffic.

# 2 Investigative Procedures

The geotechnical subsurface exploration at the project site was performed by F&ME Consultants in July 2022. The subsurface investigation consisted of standard penetration test (SPT) borings, rock core samples, and bulk sample soil collection.

A test location plan showing all testing locations is included in Appendix A. The boring logs and rock core photos from the subsurface investigation are included in Appendix B.

## 2.1 Drilling and Sampling

A total of two (2) SPT borings were performed during the subsurface investigation, B-13 and B-14. Auger refusal was encountered in both borings at depths of 88.5 feet and 22.5 feet, as well as 67.5 feet, respectively. Advancement of the bridge borings B-13 and B-14 below auger refusal was accomplished with NQ rock coring techniques. These were terminated at depths of 96.3 feet and 77.5 feet.

The boring logs from the subsurface investigations are included in Appendix B. The borings were advanced by a CME 45B using wash rotary and driven casing drilling techniques. Soil sampling and penetration testing was performed in general accordance with ASTM D-1586 and ASTM D-1587. SPT's were typically conducted continuously in the top 10 feet of each boring followed by 5-foot intervals thereafter until auger refusal was encountered. SPT's were carried out utilizing a standard 1.4-inch I.D., 2-inch O.D, split barrel, or split-spoon sampler. Blow counts recorded at these intervals were produced from SPT hammer with energy ratio of 81.4%. The hammer energy ratio is identified on each boring log. SPT hammer energy measurements on the CME 45B drill rig were performed with a pile driving analyzer (PDA) and the SPT Hammer Energy Calibration Report is included in Appendix D.

One (1) bulk sample was obtained at boring BS-2 collectively from 5 feet below the existing ground surface from auger cuttings. The collected rock core samples were evaluated in the field and the percentage of core recovery (REC) and Rock Quality Designation (RQD) were recorded.

Recovered SPT, bulk sample, and rock cores were sent to the F&ME laboratory for testing.

## 2.2 Groundwater Conditions

Stabilized groundwater levels recorded approximately 24 hours after completion of investigation operations indicated groundwater depths of 11.2 feet and 19.5 feet. These depths correspond to elevations of 376.5 feet and 377.1 feet.

These reported groundwater levels are interpreted to be dependent upon seasonal fluctuations, individual event intensity and/or level of Hanging Rock Creek.

## 2.3 Field Testing Summary

The field testing locations and other pertinent information are summarized in Table 2-1 below, and are also plotted on the test location plan included in Appendix A.

**Table 2-1. Field Soil Testing Summary**

| Test Hole No. | Station[a] | Offset (ft) | Latitude | Longitude | Top of Boring Elevation (ft) | Test Type | Total Depth (ft) |
|---|---|---|---|---|---|---|---|
| B-13 | 35+07 | 2 LT | 34.52676 | -80.61018 | 387.7 | SPT/RC | 96.3 |
| B-14 | 33+54 | 3 LT | 34.52648 | -80.61056 | 396.6 | SPT/RC | 77.5 |
| BS-2 | 33+51 | 3 LT | 34.52647 | -80.61057 | 396.8 | BULK | 5.0 |

[a] Stations based on latest S-29-765 alignment.

# 3 Laboratory Test Program

Laboratory testing was performed by F&ME Consultants on representative samples collected from the geotechnical borings to obtain index and engineering properties.

Geotechnical index property testing included natural moisture content, Atterberg limits, #200 wash, and sieve analysis. Engineering property tests included consolidated undrained (CU) triaxial compression, unconfined compression of rock, Standard Proctor, and corrosion series testing.

Laboratory testing was performed in general accordance with ASTM or AASHTO test procedures. Representative samples were classified in accordance with the AASHTO and Unified Soil Classification System (USCS). Table 3-1 summarizes the testing types and quantity of each test performed. For detailed laboratory information, refer to Appendix C.

**Table 3-1. Laboratory Testing Summary**

| Test Type | Quantity |
|---|---|
| Natural Moisture Content | 9 |
| Atterberg Limits | 9 |
| Grain Size Analysis with Hydrometer | 3 |
| Grain Size Analysis with #200 Wash | 3 |
| #200 Wash | 3 |
| CU Triaxial | 1 |
| Unconfined Compression of Rock | 3 |
| Standard Proctor | 1 |
| Corrosion Series | 1 |

## 3.1 Soil and Rock Properties

Soil samples from the preliminary geotechnical subsurface site exploration for this bridge site were grouped and classified into AASHTO and USCS soil classifications. According to the AASHTO Soil Classification System, the classifications of these samples ranged from A-4 to A-7-6. According to the Unified Soil Classification System, the classifications of these samples ranged from silty sand (SM) to clayey sand (SC). Tested samples yielded liquid limits ranging from 0 to 59 and plasticity indices ranging from 0 to 29.

Corrosion series test were performed on select split spoon samples. Standard proctor testing and remolded CU triaxial tests were performed on each of the collected bulk samples. Finally, three (3) unconfined compression tests were performed on recovered rock samples with unconfined strength results ranging from 13,430 psi and 30,820 psi. Results of laboratory testing are included in Appendix C.

# 4 Subsurface Conditions

## 4.1 Regional Geology

The bridge site is located on State Road S-29-765 roughly two miles southwest of the Town of Kershaw in Lancaster County, South Carolina and crosses over Hanging Rock Creek which is part of the PeeDee River watershed (DHEC, 2016). The bridge site lies

within the Piedmont Physiographic Province in close proximity to the Fall Line of South Carolina. The Piedmont Province is bounded by the Blue Ridge Physiographic Province to the west and the Coastal Upper Coastal Plain Province to the east. The Fall Line is an unconformity that delineates the boundary between coastal plain sediments and the crystalline bed rock of the Piedmont. The Piedmont Province is characterized by gently rolling topography, deeply weathered bedrock, few rock outcrops and complex geology with a multitude of rock types formed during the Paleozoic Era (250 to 570 MYA). The geology of this region is further complicated by the Alleghanian orogeny (325 to 260 MYA), the mountain building event which helped to form the present-day Appalachian Mountain chain, and subsequent deformation/metamorphism of the region (Butler, 1991). Soils overlying bedrock in the Piedmont are typically considered to be residual soil (soil weathered in place from bedrock). Published geological maps of the region show the site is in proximity to the Liberty Granite Pluton, Carolina Slate Belt, and Upper Cretaceous Sandhills formations.

## 4.2 Soil and Rock Stratification

In general, the soil profile is dominated by silty sands and elastic silts. These comprise the residual soils overlying the partially weathered rock (PWR) layer in boring B-14 and the granite bedrock in B-13. Bedrock was intercepted at an approximate depth of 85.5 feet from the existing ground.

Roadway fill consisting of clayey sand, fat clay, and sandy elastic silt was interpreted to range between 6 feet to 8 feet in thickness. Underlying roadway fill, alluvial soils were sampled as a very loose to loose clayey sand layer of an approximate 10-foot thickness. The thickness of the residual soils underlying alluvium ranged from 40 feet to 70 feet between borings B-13 and B-14. PWR is found underlying the residual soils in B-14 as rock fragments and weathered soil with a thickness of approximately 10.0 feet and represents the transitional zone between soil and rock. Granite makes up the bedrock underlying the project site. A layer of granite 5.0 feet thick, interpreted as a boulder, was also encountered at a depth of 22.5 feet between soil layers in boring B-14. Recovered rock core was in general fresh to completely weathered. Discontinuities were spaced close to very close, with irregular, slightly rough to rough join surfaces. Rock core recovery ranged from 0 to 97 percent, RQD ranged from 0 to 90 percent, and rock unconfined compression testing revealed strong to very strong rock with values ranging from 13,430 psi to 30,820 psi.

A summary of the main strata intercepted by the soil test borings is provided in Table 4-1 below. A subsurface profile developed based on the collected soil and rock information is included in Appendix A.

**Table 4-1. Soil and Rock Stratification**

| Geology | Top of Layer Elev. (ft) | USCS Soil Type | SPT-N (1) | Plasticity Index(1) | Fines Content(1) | REC / RQD |
|---|---|---|---|---|---|---|
| Roadway Fill | 396-388 | SC, CH, SM, MH | 5-9 (6) | 19-29 (25) | 48-85 (67) | - |
| Alluvium | 384-379 | SC | 2-6 (4) | 10-15 (12) | 40-49 (45) | |
| Residuum | 371-369 | SM, MH | 7-58 (34) | 0-14 (7) | 39-68 (54) | - |
| PWR | 329 | - | 100+ | - | - | - |
| Rock | 302 | - | - | - | - | 0-97% / 0-90% (59%) / (30%) |

(1) Values in parentheses indicate the average of the values in the range

# 5 Design and Construction Considerations

## 5.1 Foundations

Driven steel H-piles are anticipated to be the most feasible foundation type for the proposed bridge abutments. Based on Table 9-3 in SCDOT GDM 2022, assuming redundant piles, a resistance factor of 0.5 will be used for design if wave equation is applied for verification and a resistance factor of 0.65 will be used assuming Dynamic Monitoring (PDA) with wave equation analysis. It is anticipated that foundation piles will be installed following the approach embankment construction. If for any reason foundation piles will already be in-place when the approach embankment construction begins, foundation pile design must account for any downdrag loads subjected to the piles.

Due to the variability in the rock surface or thickness of weathered rock underlying the site, tip elevations are also anticipated to exhibit variability across the site. For piles driven to practical refusal in PWR or rock, their resistance will be limited by their structural resistance. Reinforced pile tips will be required to penetrate to PWR and rock. The wave equation analysis should be performed for predicting the drivability of piles along with estimating stresses during driving and, in general, verifying the ability of the Contractor's selected hammer to drive the piles to the desired penetration while preventing overstressing.

Due to the potential of encountering shallow rock or rock as boulders at the pile locations, pile pre-drilling may be required for the pile installation. The water table level may have an impact on the pre-drilled hole stability. If unstable soil conditions are encountered at these locations, temporary casing may be required to stabilize the pre-drilled holes.

For the bridge interior bents, drilled shafts appear to be the most appropriate foundation type due to the anticipated shallow rock (in the form of boulders as well) conditions. Drilled shaft diameters should be a minimum of 6 inches larger than the column and the rock

socket diameters. Installation of permanent casing will be required for the construction of the drilled shafts. Permanent casing will need to extend a few inches into rock to ensure sufficient support is provided while advancing the drilled shaft excavation through the overlying saturated soils. For the design of the drilled shafts with rock sockets, a resistance factor of 0.60 for both side friction and end bearing will be used in accordance with Table 9-4 of the SCDOT GDM 2022, assuming redundant drilled shafts are used. It must be noted that side resistance along the cased length of the drilled shaft, anticipated to extend to the top of rock, will not be considered int the calculated axial resistances.

## 5.2 Corrosion Potential Results

Corrosion testing of a representative split spoon sample was performed by F&ME Consultants and the results are included in Appendix C. The full corrosion and deterioration testing results included pH, resistivity, chlorides and sulfates content and are summarized in Table 5-1 below.

**Table 5-1. Corrosion Series Laboratory Testing Summary**

| Test Hole No. | Alignment | Station | Offset | Sample Depth (ft) | Chloride (ppm) | Sulfate (ppm) | pH | Resistivity (ohm·cm) |
|---|---|---|---|---|---|---|---|---|
| B-13 | S-29-765 | 35+07 | 2 LT | 18.5-30.0 | < 10 | 156 | 6.6 | 19,368 |

Based on the criteria set forth in section 7.18 in SCDOT GDM 2022, the environmental classification of the project site is non-aggressive. Interpretation of these data shall be communicated with the structural engineer for the project.

## 5.3 Embankment Construction

Some fill quantities may be required for construction of the embankments on this project. Assuming that the majority of embankment construction will utilize the available on-site materials, a bulk sample obtained from the top 5 ft of existing embankment material along the alignment was used to provide a better characterization of the material locally available. The bulk sample was tested for soil classification and was also remolded and compacted to 95% of the Standard Proctor prior to being tested under CU Triaxial Compression. Results are summarized in Table 5-2 below.

**Table 5-2. Bulk Sample Testing Summary**

| Sample No. | Station | Offset (ft) | Sample Depth (ft) | USCS Soil Type | Compaction | | Shear Strength | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | Optimum Moisture (%) | Max Dry Density (pcf) | c' (psf) | φ' (°) | c (psf) | φ (°) |
| BS-2 | 33+51 | 3 LT | 0.0-5.0 | SC | 15.2 | 113.1 | 423 | 20.3 | 576 | 15.0 |

# 6 Limitations to Report

This report has been prepared in general accordance with procedures in SCDOT GDM Chapter 21 and generally accepted soil and foundation engineering practices for specific

application to the proposed S-29-765 Bridge over Hanging Rock Creek in Lancaster County, South Carolina. No other warranty expressed or implied is made. The Geotechnical Engineer of Record for the project must review the data submitted in this report and develop their own interpretation of the testing results as they apply to design. The subsurface investigation logs included herein, do not reflect variations in subsurface conditions which could exist intermediate of the boring locations or in unexplored areas of the site. Should such variations become apparent during construction, it will be necessary to perform additional subsurface exploration based upon on-site observations of the conditions.

# 7 References


Butler, J.R. (1991). "Metamorphism". In Horton, J.W., Jr., and Zullo, V.A., Eds., the Geology of the Carolinas: Knoxville, University of Tennessee Press: 127.

DHEC, SC, et al. “DHEC S.C. Watershed Atlas” *Live Healthy S.C.*, 14 Apr. 2016, https://gis.dhec.sc.gov/watersheds/

Horton, J Wright, and Dicken, Connie L., 2001, Preliminary Geologic Map of the Appalachian Piedmont and Blue Ridge, South Carolina Segment; U.S. Geological Survey, Open-File Report 01-298, CD, scale 1:500,00.

SCDNR “Geologic Map of South Carolina”, March 2012 https://www.dnr.sc.gov/geology/

SCDOT (2022) “Geotechnical Design Manual”, Version 3.0; https://www.scdot.org/business/pdf/geotech/SCDOT-Geotechnical-Design-Manual-2022.pdf

# Appendix A. Site Vicinity Map, Test Location Plan, Subsurface Profile

HDR ENGINEERING INC.
OF THE CAROLINAS

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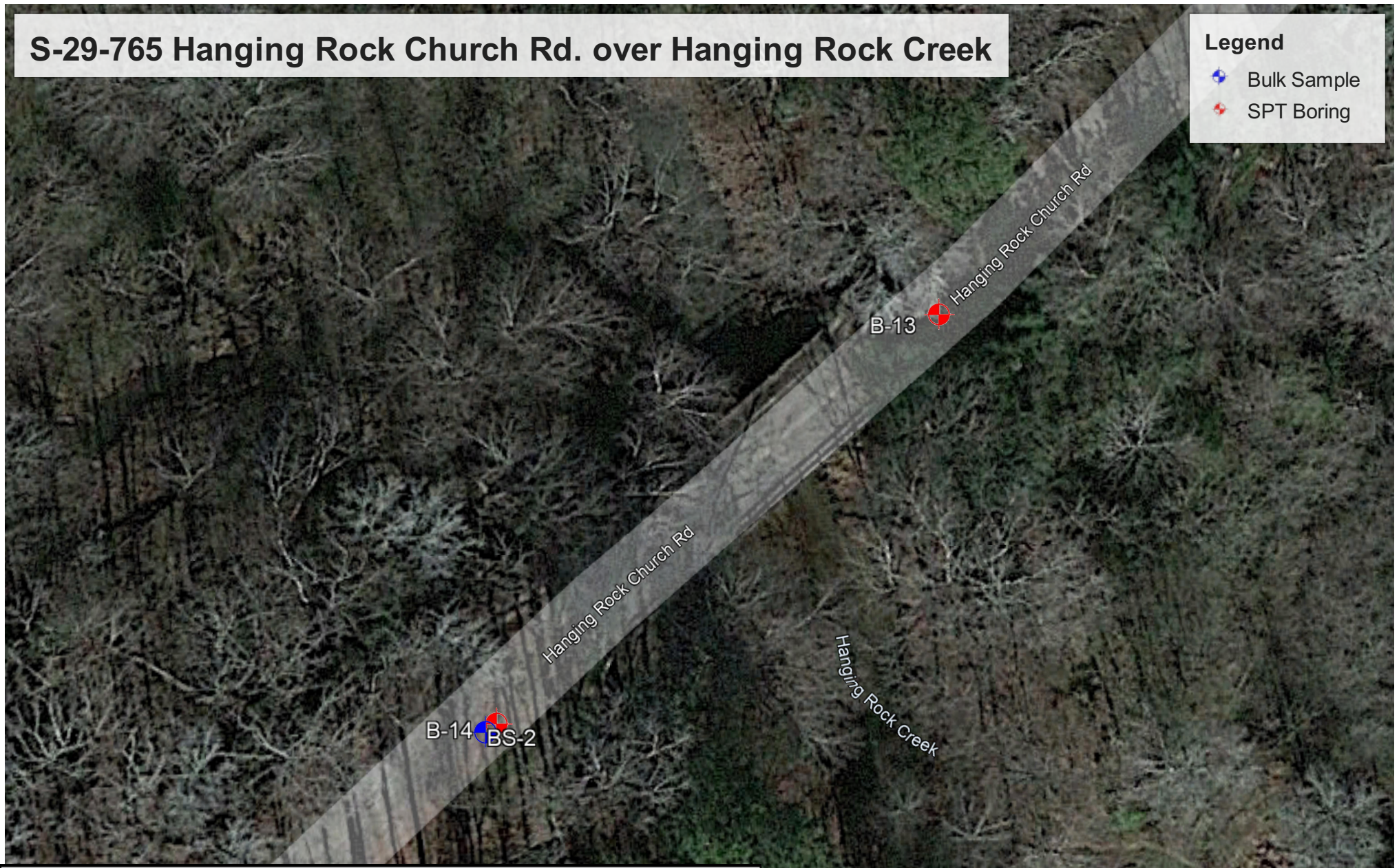
**S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek**

| COUNTY | SITE VICINITY MAP |
|---|---|
| LANCASTER | Source: Google Maps |

# S-29-765 Hanging Rock Church Rd. over Hanging Rock Creek

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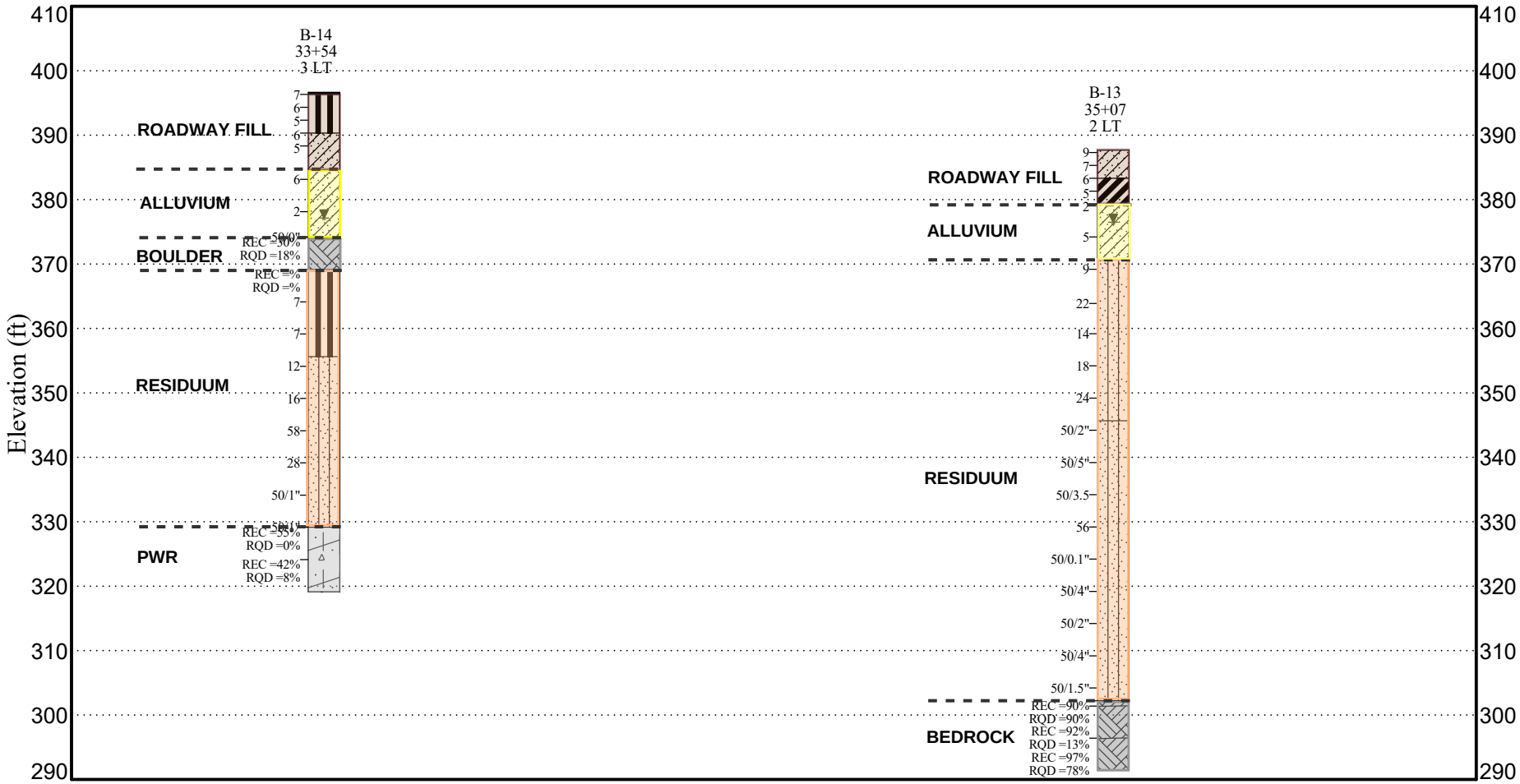
**S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek**

| COUNTY | FIELD TEST LOCATION PLAN |
|---|---|
| LANCASTER | Source: Google Earth |




| BORING | ELEVATION | STATION | OFFSET |
|---|---|---|---|
| B-13 | 387.7 | 35+07 | 2 LT |
| B-14 | 396.6 | 33+54 | 3 LT |
| | | | |
| | | | |
| | | | |
| | | | |

Roadway Fill - Clayey Sand, Fat Clay and Sandy Elastic Silt
(SC, CH, MH/A-7-6, A-7-5)

Alluvium - Clayey Sand
(SC/A-4, A-6)

Residuum - Silty Sand, Sandy Elastic Silt
(SM, MH/A-4,A-7-5)

PWR - Saprolite

BEDROCK - Granite

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# SUBSURFACE PROFILE

S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek
Lancaster, SC County, South Carolina

| PROJECT ID. | DATE | PLATE |
|---|---|---|
| P041154 | Sep 2022 | 1 |

HDR FENCE S-29-765 HANGING ROCK CREEK.GPJ SCDOT DATA TEMPLATE 01_30_2015.GDT 9/1/22

# Appendix B. Boring Logs, Rock Core Photos

# SOIL CLASSIFICATION CHART

| MAJOR DIVISIONS | | | SYMBOLS GRAPH | SYMBOLS LETTER | TYPICAL DESCRIPTIONS |
|---|---|---|---|---|---|
| COARSE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS LARGER THAN NO. 200 SIEVE SIZE | GRAVEL AND GRAVELLY SOILS<br>MORE THAN 50% OF COARSE FRACTION RETAINED ON NO. 4 SIEVE | CLEAN GRAVELS<br>(LITTLE OR NO FINES) | | GW | WELL-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES |
| | | | | GP | POORLY-GRADED GRAVELS, GRAVEL - SAND MIXTURES, LITTLE OR NO FINES |
| | | GRAVELS WITH FINES<br>(APPRECIABLE AMOUNT OF FINES) | | GM | SILTY GRAVELS, GRAVEL - SAND - SILT MIXTURES |
| | | | | GC | CLAYEY GRAVELS, GRAVEL - SAND - CLAY MIXTURES |
| | SAND AND SANDY SOILS<br>MORE THAN 50% OF COARSE FRACTION PASSING ON NO. 4 SIEVE | CLEAN SANDS<br>(LITTLE OR NO FINES) | | SW | WELL-GRADED SANDS, GRAVELLY SANDS, LITTLE OR NO FINES |
| | | | | SP | POORLY-GRADED SANDS, GRAVELLY SAND, LITTLE OR NO FINES |
| | | SANDS WITH FINES<br>(APPRECIABLE AMOUNT OF FINES) | | SM | SILTY SANDS, SAND - SILT MIXTURES |
| | | | | SC | CLAYEY SANDS, SAND - CLAY MIXTURES |
| FINE GRAINED SOILS<br>MORE THAN 50% OF MATERIAL IS SMALLER THAN NO. 200 SIEVE SIZE | SILTS AND CLAYS | LIQUID LIMIT LESS THAN 50 | | ML | INORGANIC SILTS AND VERY FINE SANDS, ROCK FLOUR, SILTY OR CLAYEY FINE SANDS OR CLAYEY SILTS WITH SLIGHT PLASTICITY |
| | | | | CL | INORGANIC CLAYS OF LOW TO MEDIUM PLASTICITY, GRAVELLY CLAYS, SANDY CLAYS, SILTY CLAYS, LEAN CLAYS |
| | | | | OL | ORGANIC SILTS AND ORGANIC SILTY CLAYS OF LOW PLASTICITY |
| | SILTS AND CLAYS | LIQUID LIMIT GREATER THAN 50 | | MH | INORGANIC SILTS, MICACEOUS OR DIATOMACEOUS FINE SAND OR SILTY SOILS |
| | | | | CH | INORGANIC CLAYS OF HIGH PLASTICITY |
| | | | | OH | ORGANIC CLAYS OF MEDIUM TO HIGH PLASTICITY, ORGANIC SILTS |
| HIGHLY ORGANIC SOILS | | | | PT | PEAT, HUMUS, SWAMP SOILS WITH HIGH ORGANIC CONTENTS |

NOTE: DUAL SYMBOLS ARE USED TO INDICATE BORDERLINE SOIL CLASSIFICATIONS

## SCDOT Soil Test Log Descriptors

**a** - **Relative Density / Consistency Terms**

Relative Density[1]

| Descriptive Term | Relative Density | SPT Blow Count |
|---|---|---|
| Very Loose | 0 to 15% | < 4 |
| Loose | 16 to 35% | 5 to 10 |
| Medium Dense | 36 to 65% | 11 to 30 |
| Dense | 66 to 85% | 31 to 50 |
| Very Dense | 86to 100% | >51 |

Consistency[2]

| Descriptive Term | Unconfined Compression Strength ($q_u$) (tsf) | SPT Blow Count |
|---|---|---|
| Very Soft | <0.25 | <2 |
| Soft | 0.26 to 0.50 | 3 to 4 |
| Firm | 0.51 to 1.00 | 5 to 8 |
| Stiff | 1.01 to 2.00 | 9 to 15 |
| Very Stiff | 2.01 to 4.00 | 16 to 30 |
| Hard | >4.01 | > 31 |

**b** **Moisture Condition**

| Descriptive Term | Criteria |
|---|---|
| Dry | Absence of moisture, dusty, dry to the touch |
| Moist | Damp but no visible water |
| Wet | Visible free water, usually in coarse-grained soils below the water table |

**c** **Color**

Describe the sample color while sample is still moist, using Munsell color chart.

**d** **Angularity**[1]

| Descriptive Term | Criteria |
|---|---|
| Angular | Particles have sharp edges and relatively plane sides with unpolished surfaces |
| Subangular | Particles are similar to angular description but have rounded edges |
| Subrounded | Particles have nearly plane sides but have well-rounded corners and edges |
| Rounded | Particles have smoothly curved sides and no edges |

**e** **HCl Reaction**[3]

| Descriptive Term | Criteria |
|---|---|
| None Reactive | No visible reaction |
| Weakly Reactive | Some reaction, with bubbles forming slowly |
| Strongly Reactive | Violent reaction, with bubbles forming immediately |

**f** **Cementation**[3]

| Descriptive Term | Criteria |
|---|---|
| Weakly Cemented | Crumbles or breaks with handling or little finger pressure |
| Moderately Cemented | Crumbles or breaks with considerable finger pressure |
| Strongly Cemented | Will not crumble or break with finger pressure |

**g** **Particle-Size Range**[1]

Gravel

| | mm | Sieve size |
|---|---|---|
| Fine | 4.76 to 19.1 | #4 to ¾ inch |
| Coarse | 19.1 to 76.2 | ¾ inch to 3 inch |

Sand

| | mm | Sieve size |
|---|---|---|
| Fine | 0.074 to 0.42 | #200 to #40 |
| Medium | 0.42 to 2.00 | #40 to #10 |
| Coarse | 4.00 to 4.76 | #10 to #4 |

**h** **Primary Soil Type**[1, 2]

The primary soil type will be shown in all capital letters

**i** **USCS Soil Designation**

Indicate USCS soil designation as defined in ASTM D-2487 and D-2488

**j** **AASHTO Soil Designation**

Indicate AASHTO soil designation as defined in AASHTO M-145 and ASTM D-3282

[1]Applies to coarse-grained soils (major portion retained on No. 200 sieve)
[2]Appiles to fine-grained soils (major portion passing No. 200 sieve)
[3]Use as required

**Figure 6-15, SCDOT Soil Test Log Descriptors – Soil**

SCDOT Soil Test Log Descriptors

k **Rock Type**
Indicate type of rock encountered (i.e. granite, limestone, shale, slate, etc.)

l **Color**
Describe the sample color while sample is still moist, using Munsell color chart.

m **Texture**
Describe the nonfracture structural features. Stratification is the layering of sedimentary rock and foliation is the layering of metaphoric rock

| Descriptive Term | Criteria |
|---|---|
| Very Thickly Bedded | > 1.0 m |
| Thickly Bedded | 0.5 to 1.0 m |
| Thinly Bedded | 50 to 500 mm |
| Very Thinly Bedded | 10 to 50 mm |
| Laminated | 2.5 to 10 mm |
| Thinly Laminated | < 2.5 mm |

n **Grain Size and Shape**
Describe the size and shape of all visible grains, typically used on sedimentary rock.

*Size*

| Descriptor | mm | Sieve size |
|---|---|---|
| Very coarse grained | > 4.75 | Grain sizes greater than popcorn kernels |
| Coarse grained | 2.00 – 4.75 | Individual grains easy to distinguish by eye |
| Medium grained | 0.425 – 2.00 | Individual grains distinguished by eye |
| Fine grained | 0.075 – 0.425 | Individual grains distinguished with difficulty |
| Very Fine grained | < 0.075 | Individual grains cannot be distinguished by unaided eye |

*Shape*

| Descriptive Term | Criteria |
|---|---|
| Angular | Shows little wear: edges and corners are sharp |
| Subangular | Shows definite effects of wear; edges and corners are slightly rounded off |
| Subrounded | Shows considerable wear; edges and corners are rounded to smooth curves |
| Rounded | Shows extreme wear; edges and corners are smoother to broad curves |
| Well-rounded | Completely worn; edges and corners are not present |

o **Weathering / Alteration**
Weathering is the physical disintegration of the minerals by atmospheric processes. Alteration is disintegration of the minerals by geothermal processes.

| Description | Recognition |
|---|---|
| Residual Soil | Original minerals of rock have been entirely decomposed to secondary minerals, and original rock fabric is not apparent; material can be easily broken by hand |
| Completely Weathered / Altered | Original minerals of rock have been almost entirely decomposed to secondary minerals, although the original fabric may be intact; material can be granulated by hand |
| Highly Weathered / Altered | More than half of the rock is decomposed; rock is weakened so that a minimum 1-7/8 inch diameter sample can be easily broken readily by hand across rock fabric |
| Moderately Weathered / Altered | Rock is discolored and noticeably weakened, but less than half is decomposed; a minimum 1-7/8 inch diameter sample cannot be broken readily by hand across rock fabric |
| Slightly Weathered / Altered | Rock is slightly discolored, but not noticeably lower in strength than fresh rock |
| Fresh | Rock shows no discoloration, loss of strength, or other effect of weathering / alteration |

**Figure 6-16, SCDOT Soil Test Log Descriptors – Rock**

SCDOT Soil Test Log Descriptors

p **Rock Strength**

Provide a qualitative assessment of the rock strength using either a geologic hammer or knife.

| Description | Recognition | Approximately Uniaxial Compressive Strength (psi) |
|---|---|---|
| Extremely Weak Rock | Can be indented by thumbnail | 35 – 150 |
| Very Weak Rock | Can be peeled by pocket knife | 150 –700 |
| Weak Rock | Can be peeled with difficulty by pocket knife | 700 – 3,500 |
| Medium Strong Rock | Can be indented 3/16 inch with sharp end of pick | 3,500 – 7,200 |
| Strong Rock | Requires one hammer blow to fracture | 7,200 – 14,500 |
| Very Strong Rock | Requires many hammer blows to fracture | 14,500 – 35,000 |
| Extremely Strong Rock | Can only be chipped with hammer blows | > 35,000 |

q **Strike and Dip**

Dip of fracture surface measured relative to horizontal with bearing and direction (i.e. N30°down, etc.)

r **Discontinuity Type**

F - Fault
J - Joint
Sh - Shear
Fo - Foliation
V - Vein
B - Bedding

s **Discontinuity Width (millimeters)**

W - Wide (12.5 – 50)
MW - Moderately Wide (2.5 – 12.5)
N - Narrow (1.25 – 2.5)
VN - Very Narrow (< 1.25)
T - Tight (0)

t **Amount of Infilling**

Su - Surface Stain
Sp - Spotty
Pa - Partially Filled
Fi - Filled
No - None

u **Type of Infilling**

Cl - Clay
Ca - Calcite
Ch - Chloride
Fe - Iron Oxide
Gy - Gypsum/Talc
H - Healed
No - None
Py - Pyrite
Qz - Quartz
Sd - Sand

v **Surface Shape of Joint**

Wa - Wavy
Pl - Planar
St - Stepped
Ir - Irregular

w **Discontinuity Spacing (feet)**

EW Extremely Wide (> 65)
W Wide (22 – 65)
M Moderate (7.5 – 22)
C Close (2 – 7.5)
VC Very Close (< 2)

x **Roughness of Surface**

Slk - Slickensided (surface has smooth, glassy finish with visual evidence of striations)
S - Smooth (surface appears smooth and feels so to the touch)
SR - Slightly Rough (asperities on the discontinuity surfaces are distinguishable and can be felt)
R - Rough (some ridges and side-angle steps are evident; asperities are clearly visible, and discontinuity surface feels very abrasive
VR - Very Rough (near-vertical steps and ridges occur on the discontinuity surface)

**Figure 6-17, SCDOT Soil Test Log Descriptors – Rock (con't)**

# Appendix B. Subsurface Investigation

Boring Logs

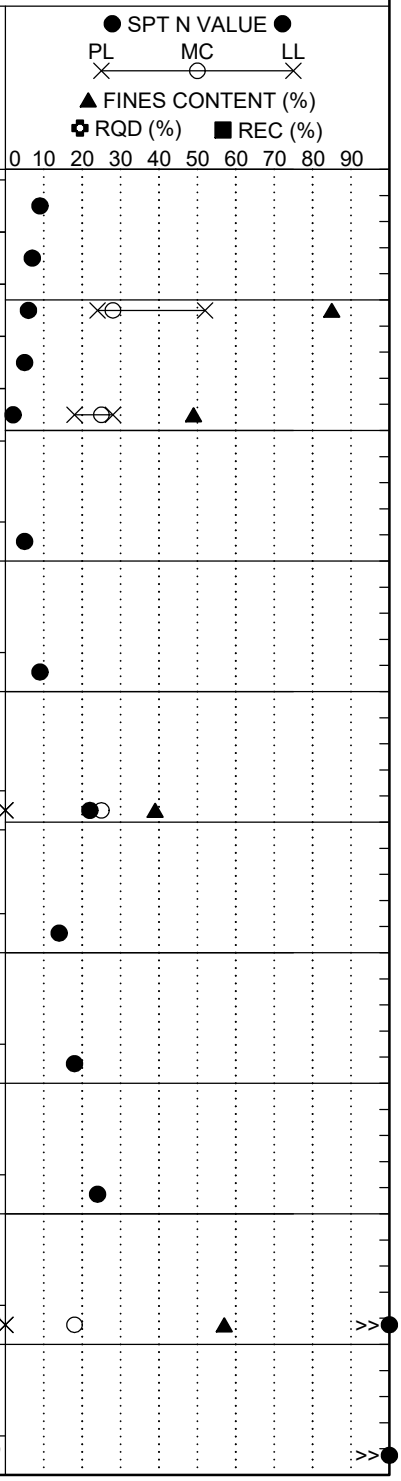
hdrinc.com

1201 Main Street, Suite 800 Columbia, SC 29201
**T** 803.254.5800

# SCDOT Soil Test Log

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project ID:** | P041154 | **County:** | Lancaster, SC | **Boring No.:** | B-13 | | |
| **Site Description:** | S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek | | | **Route:** | S-29-765 | | |
| **Eng./Geo.:** | N. Yacobi /HDR | **Boring Location:** | 35+07 | **Offset:** | 2 LT | **Alignment:** | S-29-765 |
| **Elev.:** | 387.7 ft | **Latitude:** | 34.52676 | **Longitude:** | -80.61018 | **Date Started:** | 7/20/2022 |
| **Total Depth:** | 96.3 ft | **Soil Depth:** | 85.5 ft | **Core Depth:** | 10.8 ft | **Date Completed:** | 7/21/2022 |
| **Bore Hole Diameter (in):** | 2.97" | **Sampler Configuration** | | **Liner Required:** | Y (N) | **Liner Used:** | Y (N) |
| **Drill Machine:** | CME 45B | **Drill Method:** | RW & RC | **Hammer Type:** | Automatic | **Energy Ratio:** | 81.4% |
| **Core Size:** | NQ | **Driller:** | D. Harris/ F&ME | **Groundwater:** | **TOB** N.M. | **24HR** | 11.2 ft |

| Elevation (ft) | Depth (ft) | MATERIAL DESCRIPTION | Sample Depth (ft) | Sample No./Type | 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | N Value |
|---|---|---|---|---|---|---|---|---|---|
| | 0.0 | **ROADWAY FILL** - Loose, wet, brown and orange subangular, fine to coarse grained, Clayey SAND (SC/A-7-6). 7.5YR5/6 5YR6/8 | 0.4 | SS-1 | 8 | 5 | 4 | 5 | 9 |
| | | | 2.4 | SS-2 | 2 | 3 | 4 | 3 | 7 |
| 382.7 | 4.4 | Firm, wet, dark red, FAT CLAY (CH/A-7-6) with sand. 10R3/6 LL=52, PL=24, PI=28, NMC=27.7, %200=85.0 (%Silt=44.2, %Clay=40.8) | 4.4 | SS-3 | 2 | 3 | 3 | 4 | 6 |
| | | | 6.4 | SS-4 | 2 | 2 | 3 | 4 | 5 |
| 377.7 | 8.4 | **ALLUVIUM** - Very loose to loose, wet, dark gray, fine to coarse grained, Clayey SAND (SC/A-4). 5YR4/1 LL=28, PL=18, PI=10, NMC=25.3, %200=49.3 (%Silt=29.9, %Clay=19.4) | 8.4 | SS-5 | WOH | WOH | 2 | 1 | 2 |
| | | | 13.5 | SS-6 | 2 | 2 | 3 | | 5 |
| 372.7 | 17.0 | **RESIDUUM** - Loose to medium dense, wet, gray, subrounded to subangular, weakly to strongly cemented, fine to coarse grained, Silty SAND (SM/A-4), micaceous. 5YR5/1 LL=NP, PL=NP, PI=NP, NMC=25.0, %200=39.2 | 18.5 | SS-7 | 2 | 3 | 6 | | 9 |
| 367.7 | | | 23.8 | SS-8 | 4 | 11 | 11 | | 22 |
| 362.7 | | | 28.5 | SS-9 | 4 | 6 | 8 | | 14 |
| 357.7 | | | 33.5 | SS-10 | 4 | 8 | 10 | | 18 |
| 352.7 | | | 38.5 | SS-11 | 9 | 11 | 13 | | 24 |
| 347.7 | | SS-11: no recovery | | | | | | | |
| | 42.0 | Very dense, moist, gray and brown, subangular to subrounded, moderately cemented, fine to coarse grained, Silty SAND (SM/A-4). 5YR6/1 7.5YR4/2 LL=NP, PL=NP, PI=NP, NMC=18.2, %200=56.7 | 43.5 | SS-12 | 24 | 47 | 50/2" | | 50/2" |
| 342.7 | | | 48.5 | SS-13 | 50/5" | | | | 50/5" |




LEGEND

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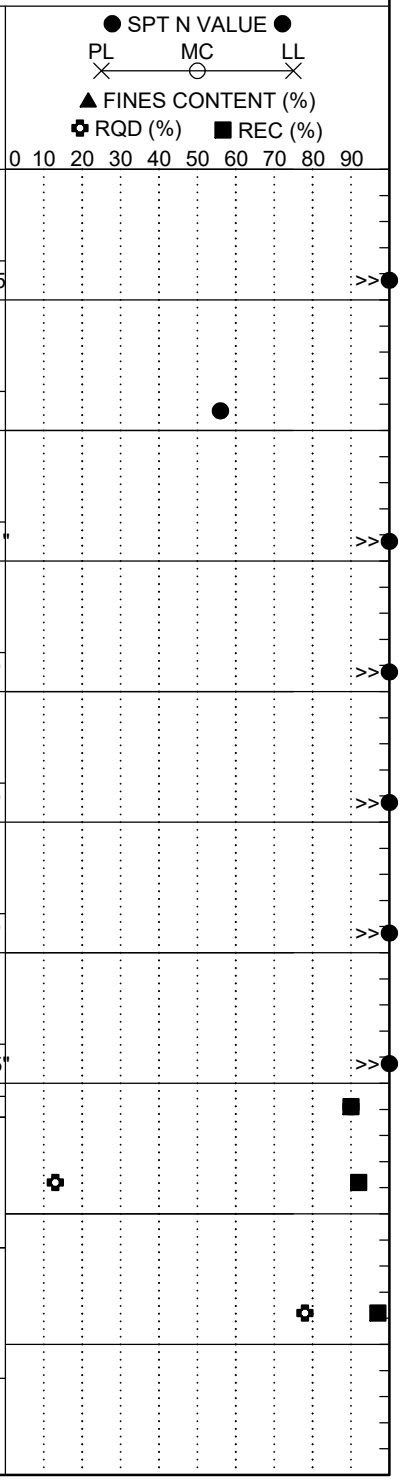
| SAMPLER TYPE | | DRILLING METHOD | |
|---|---|---|---|
| SS - Split Spoon | NQ - Rock Core, 1-7/8" | HSA - Hollow Stem Auger | RW - Rotary Wash |
| UD - Undisturbed Sample | CU - Cuttings | CFA - Continuous Flight Augers | RC - Rock Core |
| AWG - Rock Core, 1-1/8" | CT - Continuous Tube | DC - Driving Casing | |

# SCDOT Soil Test Log

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project ID:** | P041154 | **County:** | Lancaster, SC | **Boring No.:** | B-13 | | |
| **Site Description:** | S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek | | | **Route:** | S-29-765 | | |
| **Eng./Geo.:** | N. Yacobi /HDR | **Boring Location:** | 35+07 | **Offset:** | 2 LT | **Alignment:** | S-29-765 |
| **Elev.:** | 387.7 ft | **Latitude:** | 34.52676 | **Longitude:** | -80.61018 | **Date Started:** | 7/20/2022 |
| **Total Depth:** | 96.3 ft | **Soil Depth:** | 85.5 ft | **Core Depth:** | 10.8 ft | **Date Completed:** | 7/21/2022 |
| **Bore Hole Diameter (in):** | 2.97" | **Sampler Configuration** | | **Liner Required:** | Y (N) | **Liner Used:** | Y (N) |
| **Drill Machine:** | CME 45B | **Drill Method:** | RW & RC | **Hammer Type:** | Automatic | **Energy Ratio:** | 81.4% |
| **Core Size:** | NQ | **Driller:** | D. Harris/ F&ME | **Groundwater:** | **TOB** N.M. | **24HR** | 11.2 ft |

| Elevation (ft) | Depth (ft) | MATERIAL DESCRIPTION | Sample Depth (ft) | Sample No./Type | 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | N Value |
|---|---|---|---|---|---|---|---|---|---|
| | | | 53.5 | SS-14 | 50/3.5" | | | | 50/3.5 |
| 332.7 | | | | | | | | | |
| | | | 58.5 | SS-15 | 29 | 29 | 27 | | 56 |
| 327.7 | | | | | | | | | |
| | | | 63.5 | SS-16 | 50/0.1" | | | | 50/0.1" |
| 322.7 | | | | | | | | | |
| | | | 68.5 | SS-17 | 50/4" | | | | 50/4" |
| 317.7 | | | | | | | | | |
| | | | 73.5 | SS-18 | 50/2" | | | | 50/2" |
| 312.7 | | | | | | | | | |
| | | | 78.5 | SS-19 | 17 | 50/4" | | | 50/4" |
| 307.7 | | | | | | | | | |
| | | Auger and split-spoon refusal at 85.5'. Begin coring. | 83.5 | SS-20 | 50/1.5" | | | | 50/1.5" |
| 302.7 | 85.5 | | 85.5 | | | | | | |
| | 86.3 | **GRANITE** - Gray and black, very fine to fine grained, fresh to slightly weathered, very strong rock, very hard. Oxidation on surface of single joint. NQ-1: %REC=90, RQD=90 | 86.3 | NQ-1 | | | | | |
| | | | | NQ-2 | | | | | |
| 297.7 | 91.3 | | 91.3 | | | | | | |
| | | Gray and black with brown and orange oxidation throughout, prevalent on joint surfaces, very fine to fine grained, moderately to slightly weathered, medium strong to strong, moderately hard to hard. Very close joints, partly open to open, irregular surface, slightly rough, surface stain to spotty. | | NQ-3 | | | | | |
| 292.7 | 96.3 | | | | | | | | |




LEGEND

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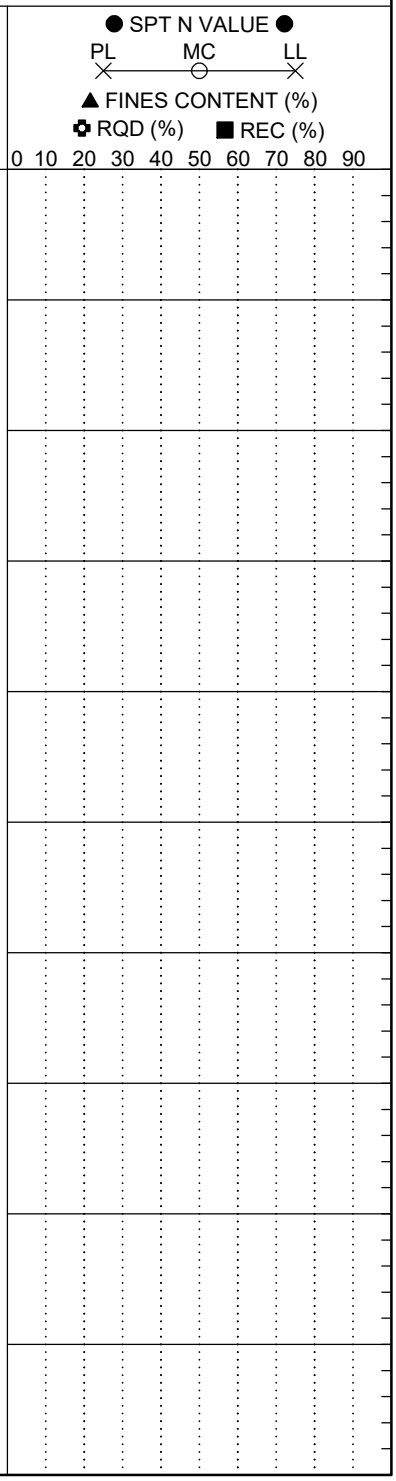
| SAMPLER TYPE | | DRILLING METHOD | |
|---|---|---|---|
| SS - Split Spoon | NQ - Rock Core, 1-7/8" | HSA - Hollow Stem Auger | RW - Rotary Wash |
| UD - Undisturbed Sample | CU - Cuttings | CFA - Continuous Flight Augers | RC - Rock Core |
| AWG - Rock Core, 1-1/8" | CT - Continuous Tube | DC - Driving Casing | |

# SCDOT Soil Test Log

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project ID:** | P041154 | | | **County:** | Lancaster, SC | **Boring No.:** | B-13 |
| **Site Description:** | S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek | | | | | **Route:** | S-29-765 |
| **Eng./Geo.:** | N. Yacobi /HDR | **Boring Location:** | 35+07 | **Offset:** | 2 LT | **Alignment:** | S-29-765 |
| **Elev.:** | 387.7 ft | **Latitude:** | 34.52676 | **Longitude:** | -80.61018 | **Date Started:** | 7/20/2022 |
| **Total Depth:** | 96.3 ft | **Soil Depth:** | 85.5 ft | **Core Depth:** | 10.8 ft | **Date Completed:** | 7/21/2022 |
| **Bore Hole Diameter (in):** | 2.97" | **Sampler Configuration** | | **Liner Required:** | Y (N) | **Liner Used:** | Y (N) |
| **Drill Machine:** | CME 45B | **Drill Method:** | RW & RC | **Hammer Type:** | Automatic | **Energy Ratio:** | 81.4% |
| **Core Size:** | NQ | **Driller:** | D. Harris/ F&ME | **Groundwater:** | **TOB** N.M. | **24HR** | 11.2 ft |

| Elevation (ft) | Depth (ft) | MATERIAL DESCRIPTION | Graphic Log | Sample Depth (ft) | Sample No./Type | 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | N Value |
|---|---|---|---|---|---|---|---|---|---|---|
| | | NQ-2: %REC=92, RQD=13, qu=13,430 psi, RMR=39 , GSI=55-60 | | | | | | | | |
| 282.7 | | Gray and black, very fine to fine, fresh to slight weathering, very strong rock, very hard. Close to very close joints, tight to partly open, irregular, rough, no infilling. | | | | | | | | |
| | | NQ-3: %REC=97, RQD=78, qu=19,650 psi, RMR=76 , GSI=80-85 | | | | | | | | |
| 277.7 | | 94.7': Heavy, white mineralization in joint. | | | | | | | | |
| | | Boring Terminated at 96.3' (Elev. 291.4') | | | | | | | | |
| 272.7 | | | | | | | | | | |
| 267.7 | | | | | | | | | | |
| 262.7 | | | | | | | | | | |
| 257.7 | | | | | | | | | | |
| 252.7 | | | | | | | | | | |
| 247.7 | | | | | | | | | | |
| 242.7 | | | | | | | | | | |




## LEGEND

| SAMPLER TYPE | | DRILLING METHOD | |
|---|---|---|---|
| SS - Split Spoon | NQ - Rock Core, 1-7/8" | HSA - Hollow Stem Auger | RW - Rotary Wash |
| UD - Undisturbed Sample | CU - Cuttings | CFA - Continuous Flight Augers | RC - Rock Core |
| AWG - Rock Core, 1-1/8" | CT - Continuous Tube | DC - Driving Casing | |

# Rock Core Photos

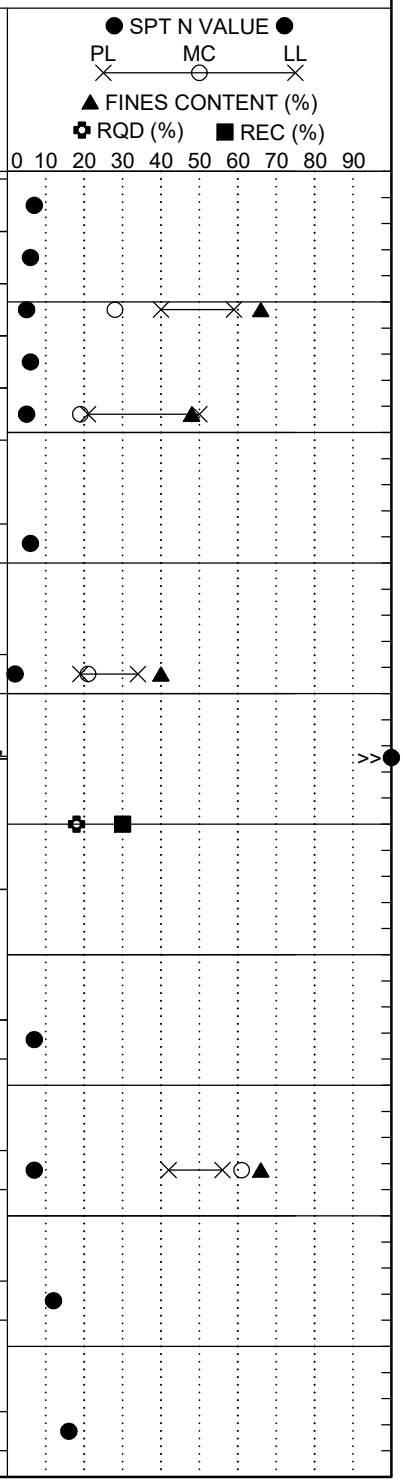
## B-13
## Box 1 of 1 (85.5’ to 96.3’)

# SCDOT Soil Test Log

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project ID:** | P041154 | **County:** | Lancaster, SC | **Boring No.:** | B-14 | | |
| **Site Description:** | S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek | | | **Route:** | S-29-765 | | |
| **Eng./Geo.:** | N. Yacobi /HDR | **Boring Location:** | 33+54 | **Offset:** | 3 LT | **Alignment:** | S-29-765 |
| **Elev.:** | 396.6 ft | **Latitude:** | 34.52648 | **Longitude:** | -80.61056 | **Date Started:** | 7/25/2022 |
| **Total Depth:** | 77.5 ft | **Soil Depth:** | 72.5 ft | **Core Depth:** | 5 ft | **Date Completed:** | 7/25/2022 |
| **Bore Hole Diameter (in):** | 2.97" | **Sampler Configuration** | | **Liner Required:** | Y (N) | **Liner Used:** | Y (N) |
| **Drill Machine:** | CME 45B | **Drill Method:** | RW & RC | **Hammer Type:** | Automatic | **Energy Ratio:** | 81.4% |
| **Core Size:** | NQ | **Driller:** | D. Harris/ F&ME | **Groundwater:** | **TOB** N.M. | **24HR** | 19.5 ft |

| Elevation (ft) | Depth (ft) | MATERIAL DESCRIPTION |
|---|---|---|
| | 0.0 | |
| | 0.3 | 0.3' ASPHALT |
| | | **ROADWAY FILL** - Soft, wet, orange, subrounded, fine to coarse grained, Sandy Elastic SILT (MH/A-7-5). 5YR6/8 |
| 391.6 | | LL=59, PL=40, PI=19, NMC=27.8, %200=66.2 |
| | 6.3 | |
| | | Loose, moist, red and brown, subangular, fine to coarse grained, Clayey SAND (SC/A-7-6). 10R4/6 2.5YR4/5 |
| 386.6 | | LL=50, PL=21, PI=29, NMC=18.6, %200=48.3 |
| | 12.0 | |
| | | **ALLUVIUM** - Loose to very loose, wet, light brown, fine to coarse grained, Clayey SAND (SC/A-6). 5YR4/4 |
| 381.6 | | LL=34, PL=19. PI=15, NMC=20.8, %200=39.7 (%Silt=24.3, %Clay=15.4) |
| 376.6 | | Auger and split-spoon refusal at 22.5'. |
| | 22.5 | Begin coring. |
| | | **GRANITE** - Poor recovery. Gray and black, very fine to fine, fresh, very strong, very hard, soil and clay in joints. (possible boulder) |
| 371.6 | | |
| | 27.5 | NQ-1: %REC=30%, RQD=18%, qu=30,820 psi, RMR=42 |
| 366.6 | | NQ-2: no recovery (possible soil) |
| | | **RESIDUUM** - Soft, wet, brown and yellow, subangular, weakly cemented, fine to coarse, Sandy Elastic SILT (MH/A-7-5) 10YR4/3 10YR6/6 |
| 361.6 | | LL=56, PL=42, PI=14, NMC=60.6, %200=65.7 |
| 356.6 | 41.0 | |
| | | Medium dense to very dense, wet, brown and yellow, subangular, weakly cemented, fine to coarse grained, Silty SAND (SM/A-4). 10YR4/3 10YR6/4 |
| 351.6 | | SS-11: no recovery |
| | | SS-12: encountered a single rock fragment |

| Sample Depth (ft) | Sample No./Type | 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | N Value |
|---|---|---|---|---|---|---|
| 0.3 | SS-1 | 4 | 3 | 4 | 4 | 7 |
| 2.3 | SS-2 | 2 | 2 | 4 | 3 | 6 |
| 4.3 | SS-3 | 2 | 2 | 3 | 3 | 5 |
| 6.3 | SS-4 | 2 | 3 | 3 | 2 | 6 |
| 8.3 | SS-5 | 2 | 2 | 3 | 4 | 5 |
| 13.5 | SS-6 | 3 | 3 | 3 | | 6 |
| 18.5 | SS-7 | 1 | 1 | 1 | | 2 |
| 22.4 | ~~SS-8~~ | ~~50/0"~~ | | | | ~~50/0"~~ |
| 22.5 | NQ-1 | | | | | |
| 27.5 | NQ-2 | | | | | |
| 32.5 | SS-9 | 3 | 3 | 4 | | 7 |
| 37.5 | SS-10 | 2 | 2 | 5 | | 7 |
| 42.5 | SS-11 | 4 | 4 | 8 | | 12 |
| 47.5 | SS-12 | 11 | 8 | 8 | | 16 |




LEGEND

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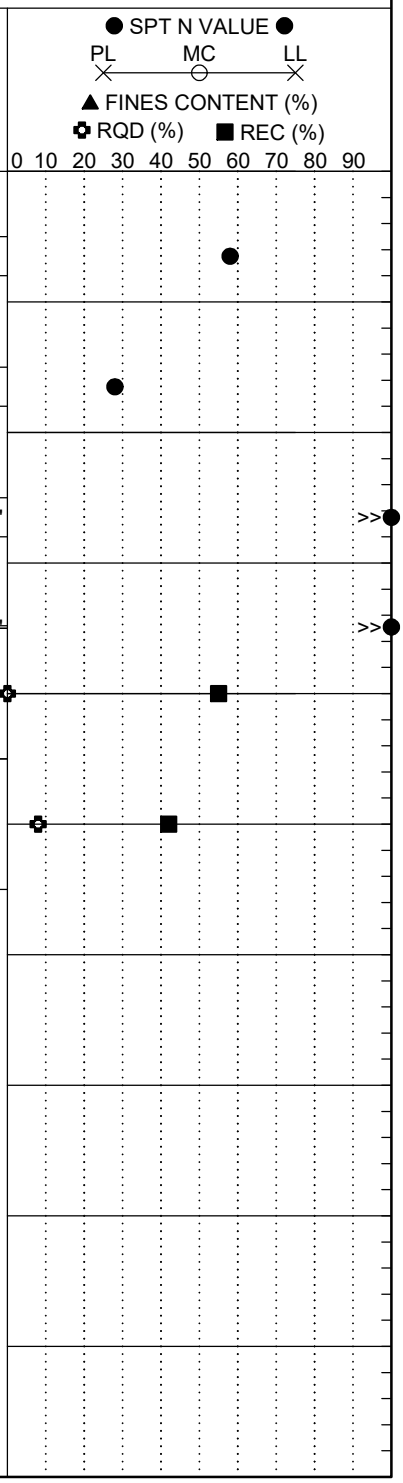
| SAMPLER TYPE | | DRILLING METHOD | |
|---|---|---|---|
| SS - Split Spoon | NQ - Rock Core, 1-7/8" | HSA - Hollow Stem Auger | RW - Rotary Wash |
| UD - Undisturbed Sample | CU - Cuttings | CFA - Continuous Flight Augers | RC - Rock Core |
| AWG - Rock Core, 1-1/8" | CT - Continuous Tube | DC - Driving Casing | |

# SCDOT Soil Test Log

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| **Project ID:** | P041154 | | | **County:** | Lancaster, SC | **Boring No.:** | B-14 |
| **Site Description:** | S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek | | | | | **Route:** | S-29-765 |
| **Eng./Geo.:** | N. Yacobi /HDR | **Boring Location:** | 33+54 | **Offset:** | 3 LT | **Alignment:** | S-29-765 |
| **Elev.:** | 396.6 ft | **Latitude:** | 34.52648 | **Longitude:** | -80.61056 | **Date Started:** | 7/25/2022 |
| **Total Depth:** | 77.5 ft | **Soil Depth:** | 72.5 ft | **Core Depth:** | 5 ft | **Date Completed:** | 7/25/2022 |
| **Bore Hole Diameter (in):** | 2.97" | **Sampler Configuration** | | **Liner Required:** | Y (N) | **Liner Used:** | Y (N) |
| **Drill Machine:** | CME 45B | **Drill Method:** | RW & RC | **Hammer Type:** | Automatic | **Energy Ratio:** | 81.4% |
| **Core Size:** | NQ | **Driller:** | D. Harris/ F&ME | **Groundwater:** | **TOB** N.M. | **24HR** | 19.5 ft |

| Elevation (ft) | Depth (ft) | MATERIAL DESCRIPTION | Sample Depth (ft) | Sample No./Type | 1st 6" | 2nd 6" | 3rd 6" | 4th 6" | N Value |
|---|---|---|---|---|---|---|---|---|---|
| | | | 52.5 | SS-13 | 12 | 23 | 35 | | 58 |
| 341.6 | | | | | | | | | |
| | | | 57.5 | SS-14 | 13 | 12 | 16 | | 28 |
| 336.6 | | | | | | | | | |
| | | | 62.5 | SS-15 | 37 | 50/1" | | | 50/1" |
| 331.6 | | Auger and split-spoon refusal at 67.5'. Begin coring. | | | | | | | |
| | 67.5 | **PARTIALLY WEATHERED ROCK (PWR)** Igneous protolith, moderately to completely weathered, yellow grayish color, fine to medium grained, weak (broken by hand), soft, significant portions of run weathered to soil. | 67.4 67.5 | SS-16 | 29 | 50/1" | | | 50/1" |
| 326.6 | | | | NQ-3 | | | | | |
| | | | 72.5 | | | | | | |
| | | NQ-3: %REC=55, RQD=0, GSI=20-25 | | | | | | | |
| 321.6 | | NQ-4: %REC=42, RQD=8, GSI=30-35 | | NQ-4 | | | | | |
| | 77.5 | NQ-4: Light gray and white, fine to very coarse grained, moderately to slightly weathered, strong, hard | | | | | | | |
| 316.6 | | Boring Terminated at 77.5' (Elev. 319.1') | | | | | | | |
| 311.6 | | | | | | | | | |
| 306.6 | | | | | | | | | |
| 301.6 | | | | | | | | | |




## LEGEND

| SAMPLER TYPE | | DRILLING METHOD | |
|---|---|---|---|
| SS - Split Spoon | NQ - Rock Core, 1-7/8" | HSA - Hollow Stem Auger | RW - Rotary Wash |
| UD - Undisturbed Sample | CU - Cuttings | CFA - Continuous Flight Augers | RC - Rock Core |
| AWG - Rock Core, 1-1/8" | CT - Continuous Tube | DC - Driving Casing | |

# Rock Core Photos

## B-14
## Box 1 of 1 (22.5’ to 77.5’)

# Appendix C. Laboratory Testing

# SUMMARY OF LABORATORY RESULTS



**PROJECT ID** P041154 **PROJECT NAME** S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC

| Borehole | Depth | Liquid Limit | Plastic Limit | Plasticity Index | Maximum Size (mm) | %<#200 Sieve | Class-ification | Water Content (%) | Dry Density (pcf) | Satur-ation (%) | Void Ratio |
|---|---|---|---|---|---|---|---|---|---|---|---|
| B-13 | 6.4 | 52 | 24 | 28 | 0.075 | 85 | CH | | | | |
| B-13 | 10.4 | 28 | 18 | 10 | 0.075 | 49 | SC | | | | |
| B-13 | 25.0 | NP | NP | NP | 0.075 | 39 | SM | | | | |
| B-13 | 45.0 | NP | NP | NP | 0.075 | 57 | ML | | | | |
| B-14 | 6.3 | 59 | 40 | 19 | 0.075 | 66 | MH | | | | |
| B-14 | 10.3 | 50 | 21 | 29 | 0.075 | 48 | SC | | | | |
| B-14 | 20.0 | 34 | 19 | 15 | 0.075 | 40 | SC | | | | |
| B-14 | 39.0 | 56 | 42 | 14 | 0.075 | 66 | MH | | | | |

# Rock Coring Summary



**PROJECT ID** P041154

**PROJECT NAME** S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC

| Borehole | Core Run Number | Core Run Top Depth | REC (%) | RQD (%) | $q_u$ (psi) | Poisson's Ratio | Secant Modulus (ksi) | Unit Weight (pcf) | RMR | GSI |
|---|---|---|---|---|---|---|---|---|---|---|
| B-13 | NQ-1 | 85.5 | 90 | 90 | | | | | | |
| B-13 | NQ-2 | 86.3 | 92 | 13 | 13430 | 0.20 | 5300 | 172 | 39 | 58 |
| B-13 | NQ-3 | 91.3 | 97 | 78 | 19650 | 0.18 | 3730 | 172 | 76 | 83 |
| B-14 | NQ-1 | 22.5 | 30 | 18 | 30820 | 0.30 | 1430 | 186 | 42 | |
| B-14 | NQ-3 | 67.5 | 55 | 0 | | | | | | 23 |
| B-14 | NQ-4 | 72.5 | 42 | 8 | | | | | | 33 |

# INDEX PROPERTIES VERSUS DEPTH

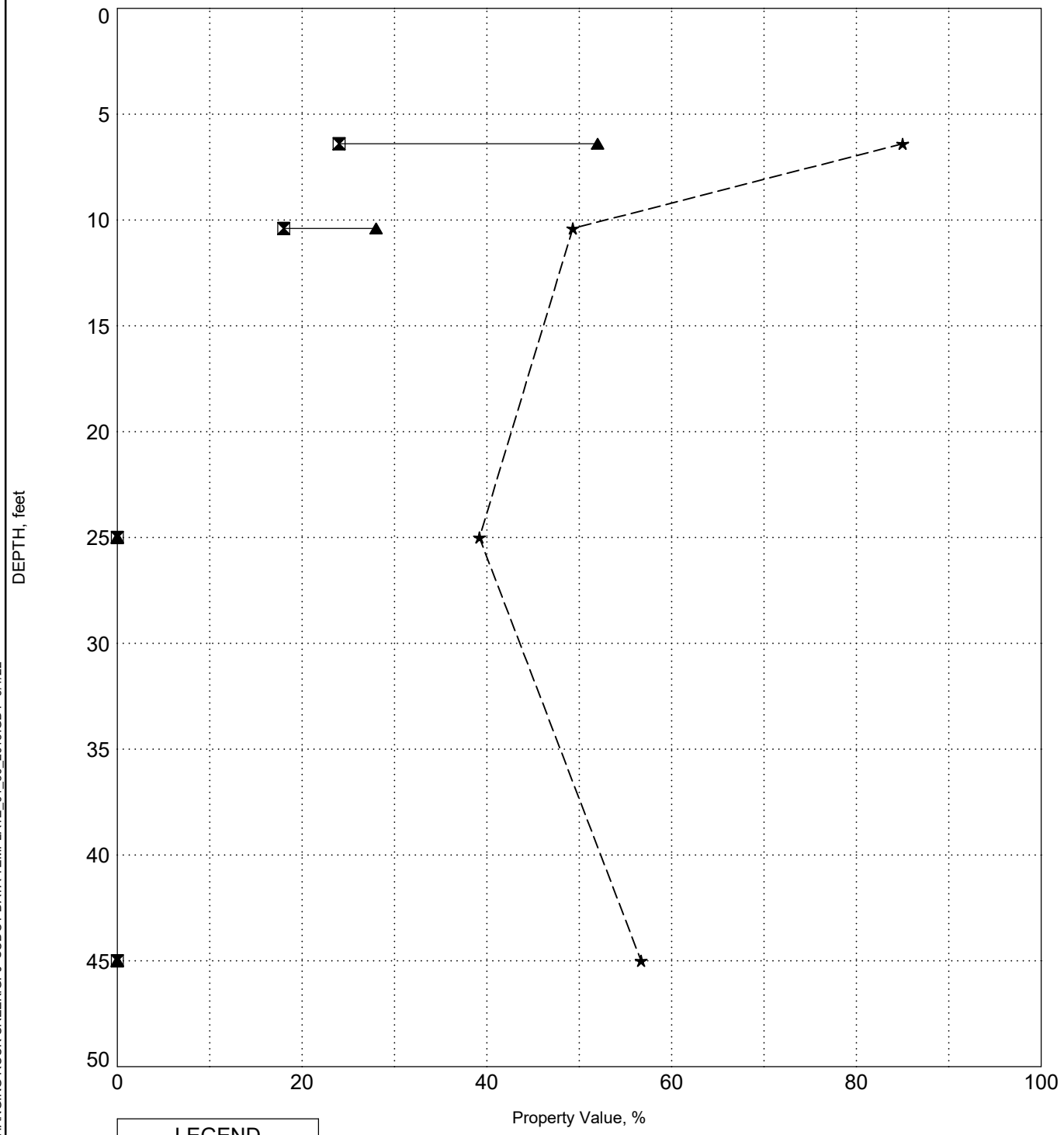
**PROJECT ID** P041154

**PROJECT NAME** S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC

## BORING B-13

SURFACE ELEVATION: 387.7




| LEGEND |
|---|
| ● Water Content |
| ⊠ Plastic Limit |
| ▲ Liquid Limit |
| ★ Fines |

# INDEX PROPERTIES VERSUS DEPTH

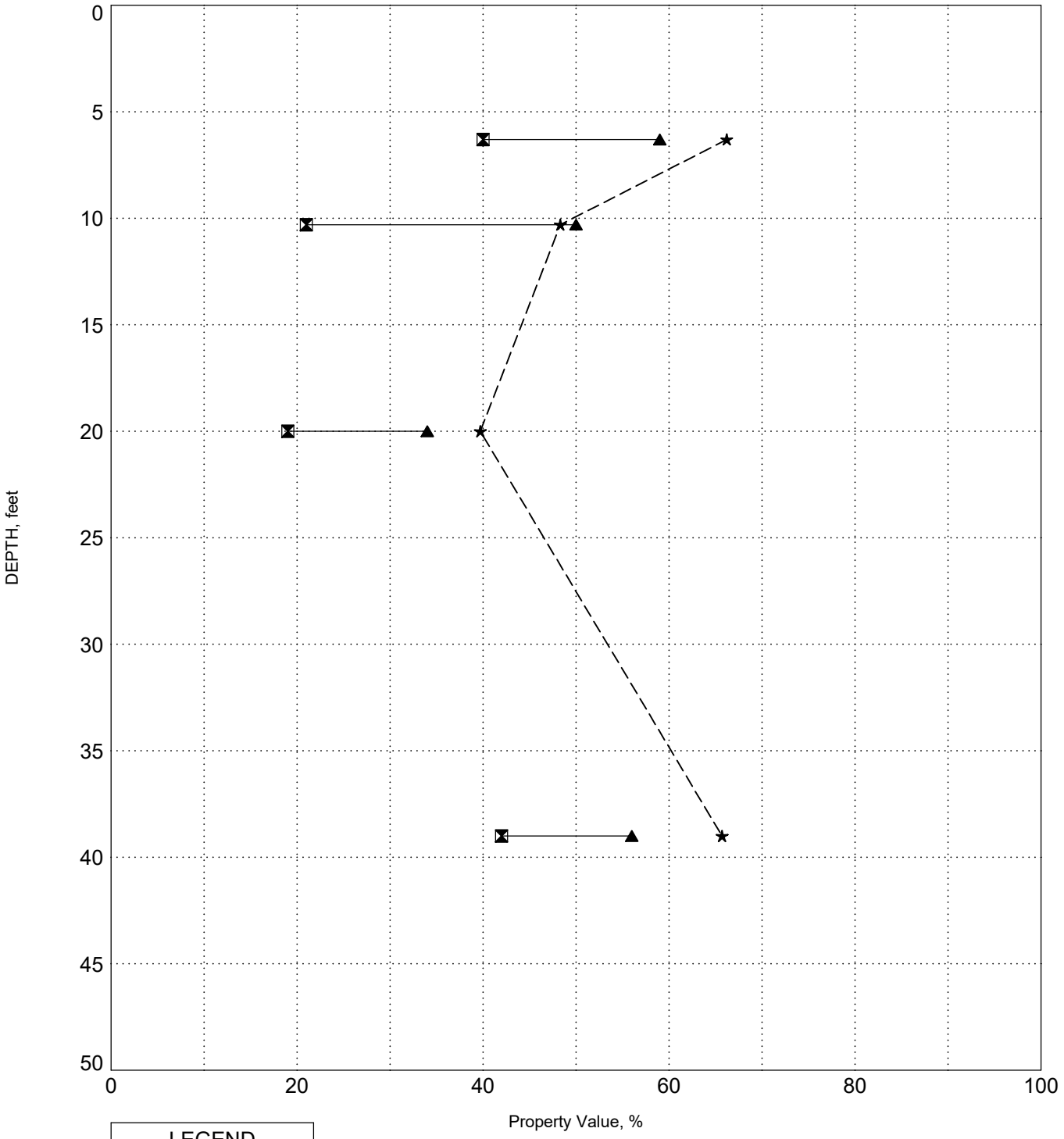
**PROJECT ID** P041154

**PROJECT NAME** S-29-765 (Hanging Rock Church Rd.) over Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC

## BORING B-14

SURFACE ELEVATION: 396.6




| LEGEND |
|---|
| ● Water Content |
| ⊠ Plastic Limit |
| ▲ Liquid Limit |
| ★ Fines |

# Laboratory Testing Procedures

## Grain Size Distribution

Wash #200 Testing has been conducted following ASTM D1140 Standard Test Methods for Determining the Amount of Material Finer that 75-µm (No. 200) Sieve in Soils by Washing. Full grain size analysis was conducted on select samples following ASTM D6913 Standard Test Method for Sieve Analysis of Fine and Coarse Aggregates.

## Hydrometer

Hydrometer grain size analysis for soils was conducted following ASTM D7928 Standard Test Method for Particle Size Analysis of Soils.

## Atterberg Limits

Atterberg limits testing have been conducted following ASTM D4318 Standard Test Method for Liquid Limit, Plastic Limit, and Plasticity Index of Soils.

## Moisture Content

Moisture content testing has been conducted following ASTM D2216 Standard Test Method for Laboratory Determination of Water (Moisture) Content of Soil and Rock.

## Standard Proctor

Standard Proctor testing has been conducted following ASTM D698 Standard Test Methods for Laboratory Compaction Characteristics of Soil Using Standard Effort (12,400 ft-lbf/ft 3 (600kN-m/m3)).

## Consolidated-Undrained Triaxial Test

CU testing allows the soil specimen to be consolidated under a confining pressure prior to shear and has been conducted following ASTM D4767 Standard Test Method for Consolidated-Undrained Triaxial Compression Test for Cohesive Soils. The soil specimens in this case were bulk samples that were remolded and compacted to 95% of the Standard Proctor.

**Corrosion Series**

Corrosion series testing has been conducted including pH, chloride content, sulfate content, and resistivity. PH testing was conducted AASHTO T289 Standard Method of Test for Determining pH of Soil for Use is Corrosion Testing. Chloride content testing was conducted following AASHTO T291 Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil. Sulfate content testing was conducted following AASHTO T290 Standard Method of Test for Determining Water-Soluble Sulfate Content in Soil. Resistivity testing was conducted following AASHTO T288 Standard Method of Test for Determining Minimum Laboratory Soil Resistivity.

**Compressive Strength of Rock Cores**

Compressive strength of rock cores has been conducted following ASTM D7012 Standard Test for Compressive Strength and Elastic Moduli of Intact Rock Core Specimens under Varying States of Stress and Temperatures.

# Appendix C. Laboratory Testing

Split Spoon Samples

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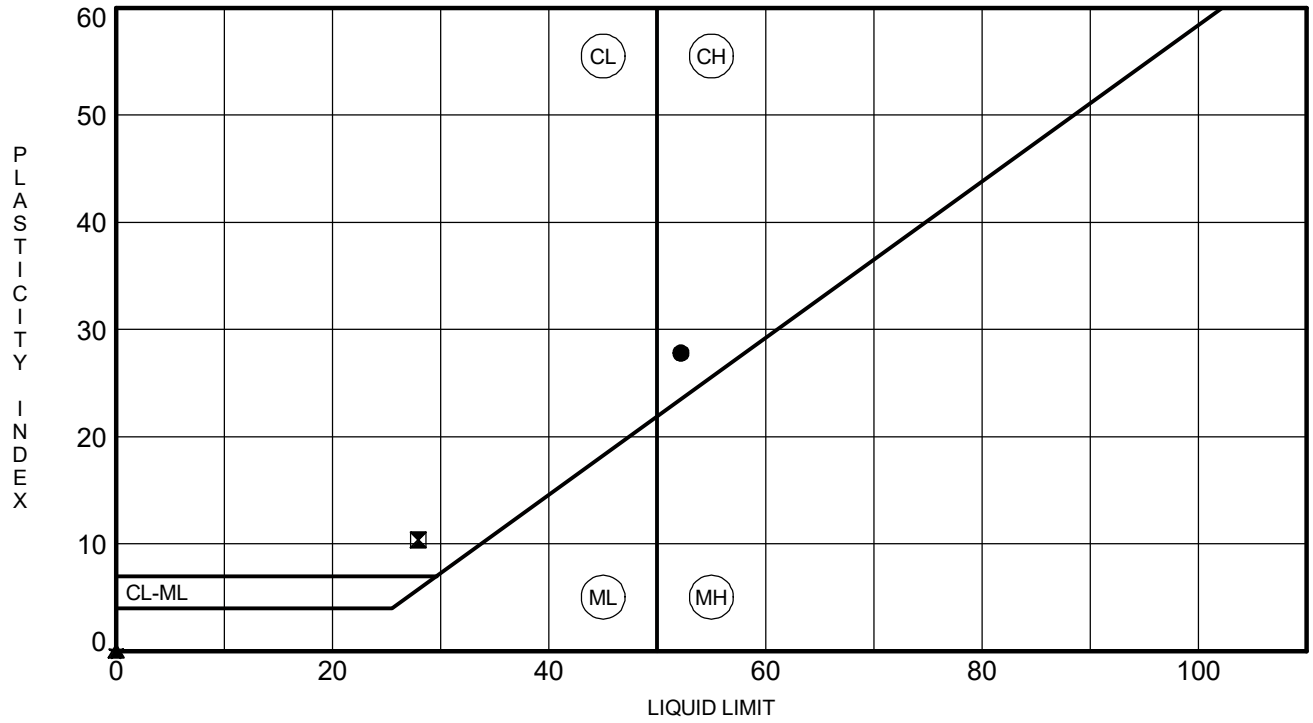
1201 Main Street, Suite 800 Columbia, SC 29201
**T** 803.254.5800

# ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041154 **PROJECT NAME** S-29-765 RBO Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC



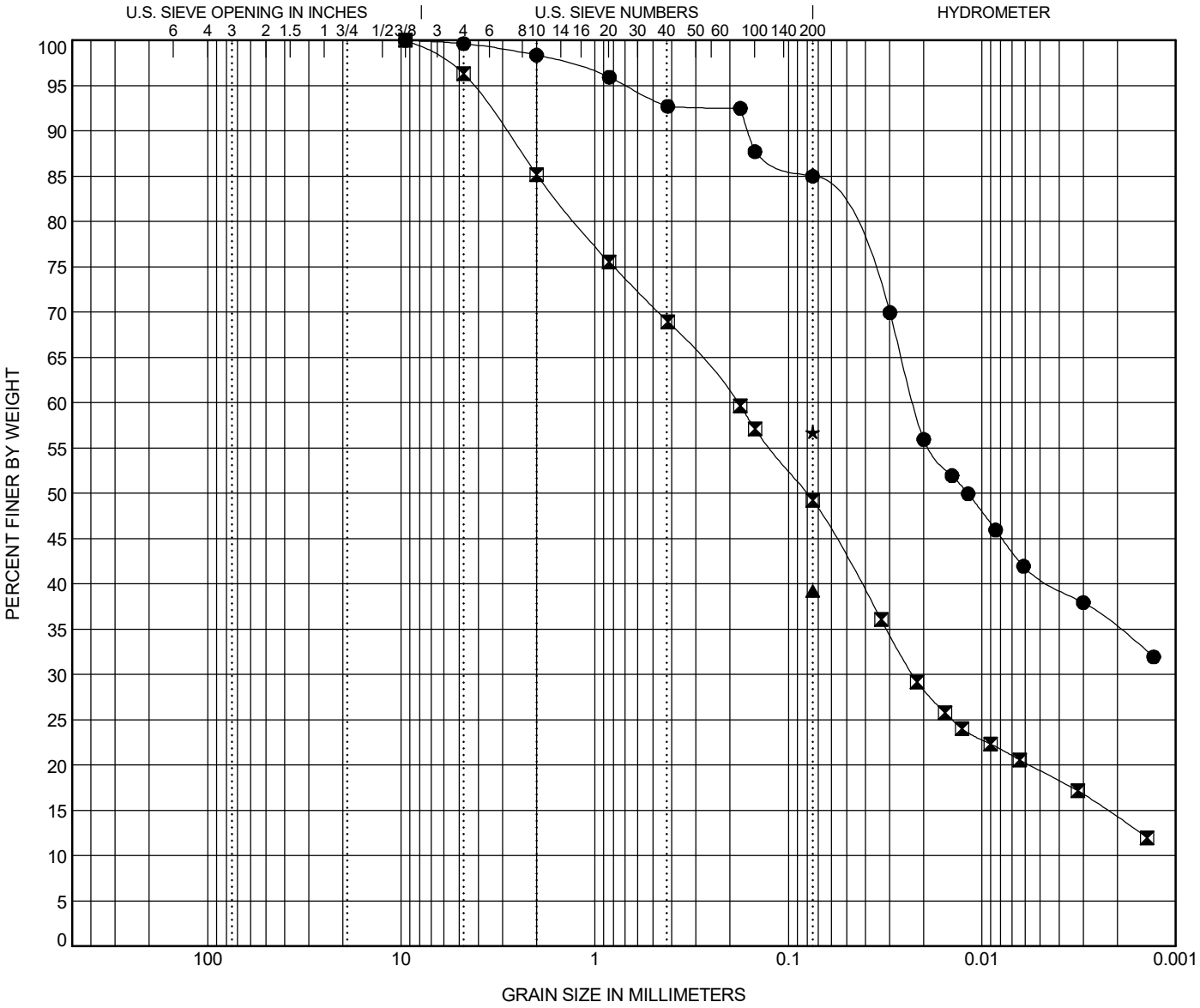

| | BOREHOLE | DEPTH | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ● | **B-13** | **6.4** | **52** | **24** | **28** | **85** | **FAT CLAY with SAND (CH/A-7-6)** |
| ⊠ | **B-13** | **10.4** | **28** | **18** | **10** | **49** | **CLAYEY SAND (SC/A-4)** |
| ▲ | **B-13** | **25.0** | **NP** | **NP** | **NP** | **39** | **SILTY SAND (SM/A-4)** |
| ★ | **B-13** | **45.0** | **NP** | **NP** | **NP** | **57** | **SANDY SILT (ML/A-4)** |

ATTERBERG LIMITS G6656.004 - S-765 RBO HANGING ROCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 8/9/22

# GRAIN SIZE DISTRIBUTION

**PROJECT ID** P041154 **PROJECT NAME** S-29-765 RBO Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | BOREHOLE | DEPTH | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **B-13** | **6.4** | **FAT CLAY with SAND (CH/A-7-6)** | **52** | **24** | **28** | | |
| ⊠ | **B-13** | **10.4** | **CLAYEY SAND (SC/A-4)** | **28** | **18** | **10** | | |
| ▲ | **B-13** | **25.0** | **SILTY SAND (SM/A-4)** | **NP** | **NP** | **NP** | | |
| ★ | **B-13** | **45.0** | **SANDY SILT (ML/A-4)** | **NP** | **NP** | **NP** | | |

| | BOREHOLE | DEPTH | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-13** | **6.4** | **9.51** | **0.022** | | | **0.4** | **14.6** | **44.2** | **40.8** |
| ⊠ | **B-13** | **10.4** | **9.51** | **0.182** | **0.023** | | **3.7** | **47.1** | **29.9** | **19.4** |
| ▲ | **B-13** | **25.0** | **0.075** | | | | | | **39.2** | |
| ★ | **B-13** | **45.0** | **0.075** | | | | | | **56.7** | |

# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION
## (AASHTO T265)

| | | | |
|---|---|---|---|
| **PROJECT:** | S-29-795 RBO Hanging Rock Creek | **SCDOT PROJECT ID:** | P041154 |
| **SAMPLE NUMBER:** | 22-2278 | **DATE SAMPLE RECEIVED:** | 7/28/2022 |
| **DESCRIPTION OF SOIL:** | Various | | |
| **TESTED BY:** | CM | **DATE SETUP:** | 7/28/2022 |
| **WEIGHED BY:** | LK | **DATE OF WEIGHING:** | 7/29/2022 |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | B-13 | B-13 | B-13 | B-13 | |
| **SAMPLE NO.** | SS-3 | SS-5 | SS-8 | SS-12 | |
| **SAMPLE DEPTH (FT.)** | 4.4 - 6.4 | 8.4 - 10.4 | 23.5 - 25.0 | 43.5 - 45.0 | |
| **WATER CONTENT, W%** | 27.7 | 25.3 | 25.0 | 18.2 | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

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3112 Devine St., Columbia, SC 29205

| | |
|---|---|
| Client: | F&ME Consultants |
| Project Name: | S-29-765 Bridge Repl. over Hanging Rock Creek |
| Project Location: | Lancaster, South Carolina |
| GTX #: | 316002 |
| Test Date: | 09/01/22 |
| Tested By: | mgh |
| Checked By: | mcm |

# pH by AASHTO T 289

| Boring ID | Sample ID | Depth, ft | Description | pH |
|---|---|---|---|---|
| B-13 | --- | 18.5 - 30.0 | Moist, brown silty sand | 6.6 |

Notes:

| | |
|---|---|
| Client: | F&ME Consultants |
| Project: | S-29-765 Bridge Repl. over Hanging Rock Creek |
| Location: | Lancaster County, SC |
| GTX#: | 316002 |
| Test Date: | 09/01/22 |
| Tested By: | mgh |
| Checked By: | |

# Minimum Laboratory Soil Resistivity by AASHTO T 288

| Boring ID | Sample ID | Depth, ft. | Sample Description | Minimum Soil Resistivity, ohm-cm |
|---|---|---|---|---|
| B-13 | --- | 18.5 - 30.0 | Moist, brown silty sand | 19,368 |

Notes: Test Equipment: Nilsson Model 400 Soil Resistance Meter, MC Miller Soil Box
Test conducted in standard laboratory atmosphere: 68-73 F

PO Box 572455 / Salt Lake City UT 84157-2455 / USA
TEL +1 801 262 2448 · FAX +1 801 262 9870 · www.TEi-TS.com

GEOTESTING EXPRESS INCORPORATED
2358 PERIMETER PARK DRIVE
SUITE 320
ATLANTA GA 30341-1315
USA

| | |
|---|---|
| Analysis No. | TS-A2210531 |
| Report Date | 01 September 2022 |
| Date Sampled | 26 August 2022 |
| Date Received | 30 August 2022 |
| Where Sampled | Atlanta, GA USA |
| Sampled By | Client |

This is to attest that we have examined: Soil: Project: S-29-765 Bridge Replacement over Hanging Rock Creek; Site Location: Lancaster County, SC; Job Number: GTX-316002

When examined to the applicable requirements of:

| | |
|---|---|
| AASHTO T-291-18 | "Standard Method of Test for Determining Water-Soluble Chloride Ion Content in Soil" Method B |
| AASHTO T 290-20 | "Standard Method of Test for Determining Water-Soluble Sulfate Ion Content in Soil" |

Results:

AASHTO T 291 - Chloride Method B

| Sample | | Results | | Detection Limit |
|---|---|---|---|---|
| | | ppm (mg/kg) | %[1] | |
| - — - | | < 10. | < 0.0010 | 10. |
| B-13 | 18.5 - 30.0 | | | |

NOTE: [1]Percent by weight after drying and prepared as per the Standard.

AASHTO T 290 – Sulfates (Soluble)

| Sample | | Results | | Detection Limit |
|---|---|---|---|---|
| | | ppm (mg/kg) | %[1] | |
| - — - | | 156. | 0.0156 | 10. |
| B-13 | 18.5 - 30.0 | | | |

NOTE: [1]Percent by weight after drying and prepared as per the Standard.

END OF ANALYSIS

USEPA Laboratory ID UT00930

Merrill Gee P.E. – Engineer in Charge

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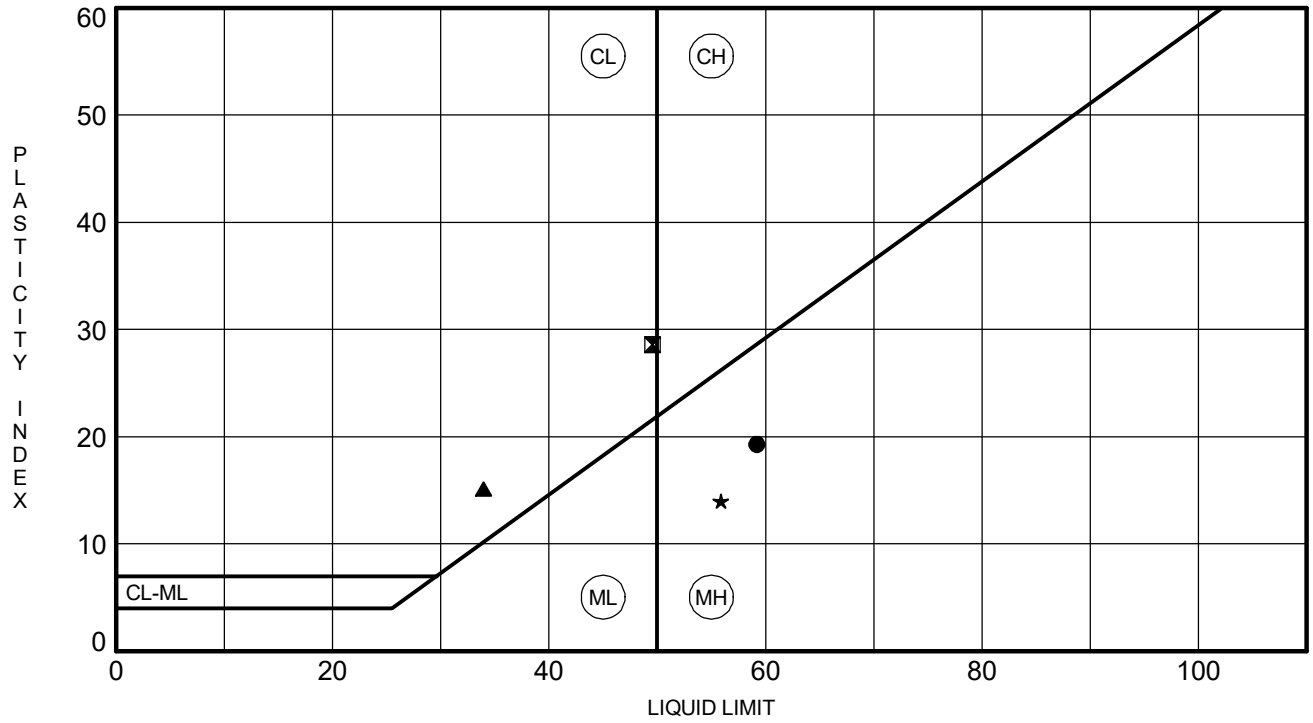
# ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041154 **PROJECT NAME** S-29-765 RBO Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC



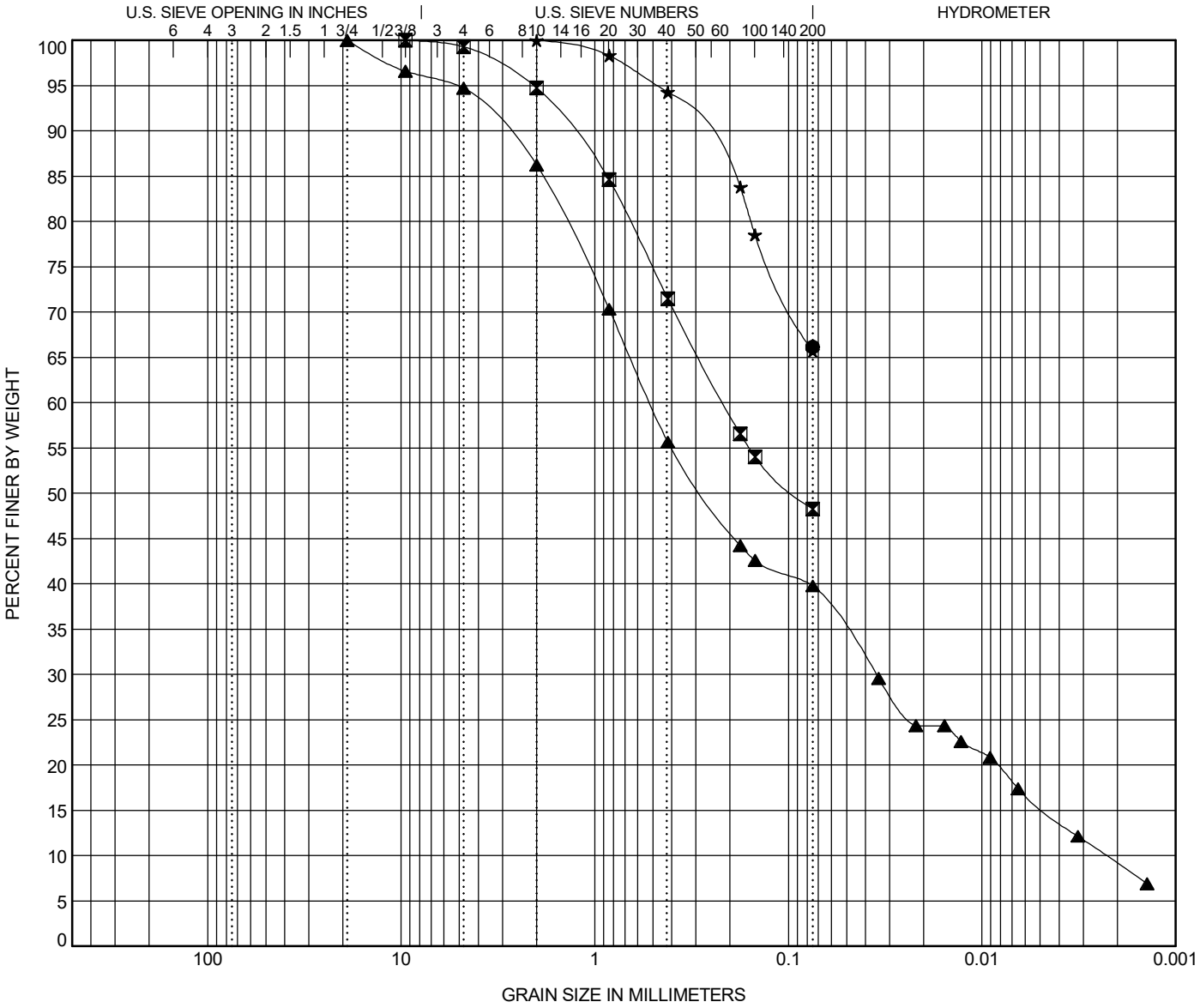

| | BOREHOLE | DEPTH | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ● | **B-14** | **6.3** | **59** | **40** | **19** | **66** | **SANDY ELASTIC SILT (MH/A-7-5)** |
| ⧗ | **B-14** | **10.3** | **50** | **21** | **29** | **48** | **CLAYEY SAND (SC/A-7-6)** |
| ▲ | **B-14** | **20.0** | **34** | **19** | **15** | **40** | **CLAYEY SAND (SC/A-6)** |
| ★ | **B-14** | **39.0** | **56** | **42** | **14** | **66** | **SANDY ELASTIC SILT (MH/A-7-5)** |

ATTERBERG LIMITS G6656.004 - S-765 RBO HANGING ROCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 8/9/22

# GRAIN SIZE DISTRIBUTION

**PROJECT ID** P041154 **PROJECT NAME** S-29-765 RBO Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | BOREHOLE | DEPTH | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **B-14** | **6.3** | **SANDY ELASTIC SILT (MH/A-7-5)** | **59** | **40** | **19** | | |
| ⊠ | **B-14** | **10.3** | **CLAYEY SAND (SC/A-7-6)** | **50** | **21** | **29** | | |
| ▲ | **B-14** | **20.0** | **CLAYEY SAND (SC/A-6)** | **34** | **19** | **15** | **1.06** | **226.47** |
| ★ | **B-14** | **39.0** | **SANDY ELASTIC SILT (MH/A-7-5)** | **56** | **42** | **14** | | |

| | BOREHOLE | DEPTH | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **B-14** | **6.3** | **0.075** | | | | | | **66.2** | |
| ⊠ | **B-14** | **10.3** | **9.51** | **0.216** | | | **0.7** | **51.0** | **48.3** | |
| ▲ | **B-14** | **20.0** | **19** | **0.516** | **0.035** | **0.002** | **5.3** | **54.9** | **24.3** | **15.4** |
| ★ | **B-14** | **39.0** | **2** | | | | **0.0** | **34.3** | **65.7** | |

GRAIN SIZE G6656.004 - S-765 RBO HANGING ROCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 8/9/22

# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION
## (AASHTO T265)

| | | | |
|---|---|---|---|
| **PROJECT:** | S-29-795 RBO Hanging Rock Creek | **SCDOT PROJECT ID:** | P041154 |
| **SAMPLE NUMBER:** | 22-2279 | **DATE SAMPLE RECEIVED:** | 7/28/2022 |
| **DESCRIPTION OF SOIL:** | Various | | |
| **TESTED BY:** | CM | **DATE SETUP:** | 7/28/2022 |
| **WEIGHED BY:** | LK | **DATE OF WEIGHING:** | 7/29/2022 |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | B-14 | B-14 | B-14 | B-14 | |
| **SAMPLE NO.** | SS-3 | SS-5 | SS-7 | SS-10 | |
| **SAMPLE DEPTH (FT.)** | 4.3 - 6.3 | 8.3 - 10.3 | 18.5 - 20.0 | 37.5 - 39.0 | |
| **WATER CONTENT, W%** | 27.8 | 18.6 | 20.8 | 60.6 | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

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# Appendix C. Laboratory Testing

Bulk Samples

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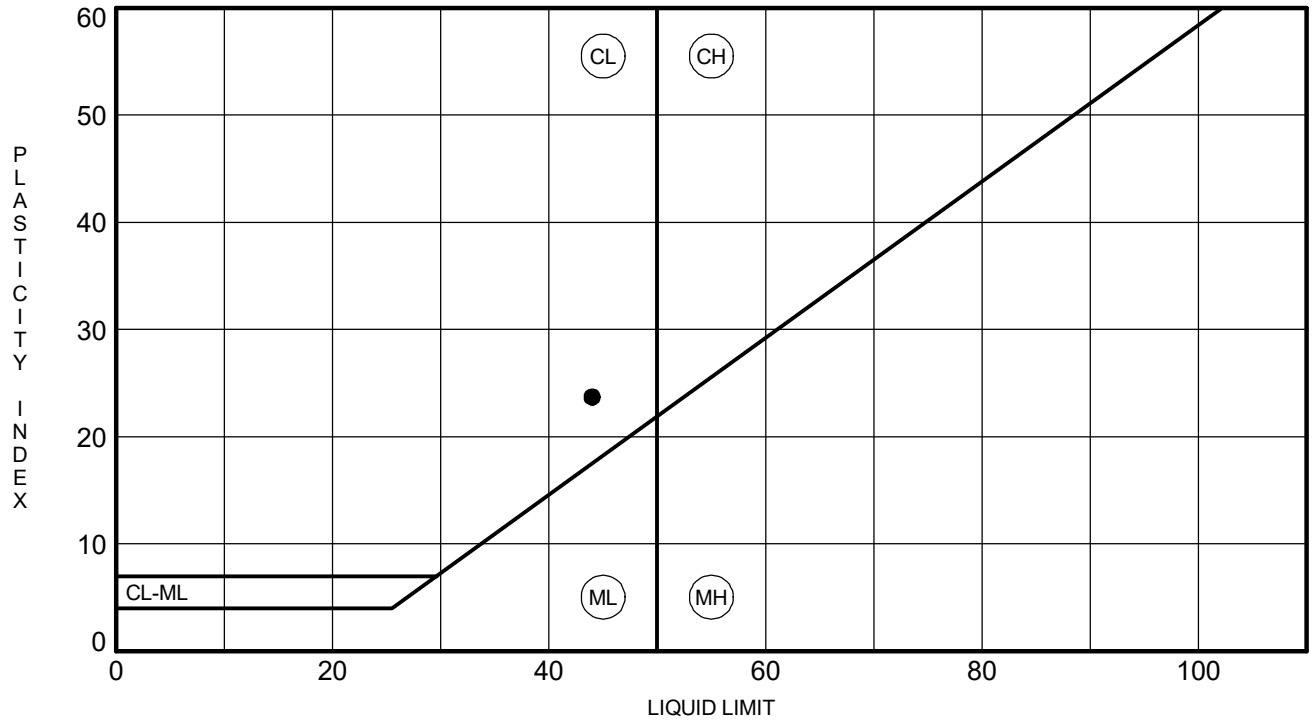
**T** 803.254.5800

# ATTERBERG LIMITS' RESULTS

**PROJECT ID** P041154 **PROJECT NAME** S-29-765 RBO Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC



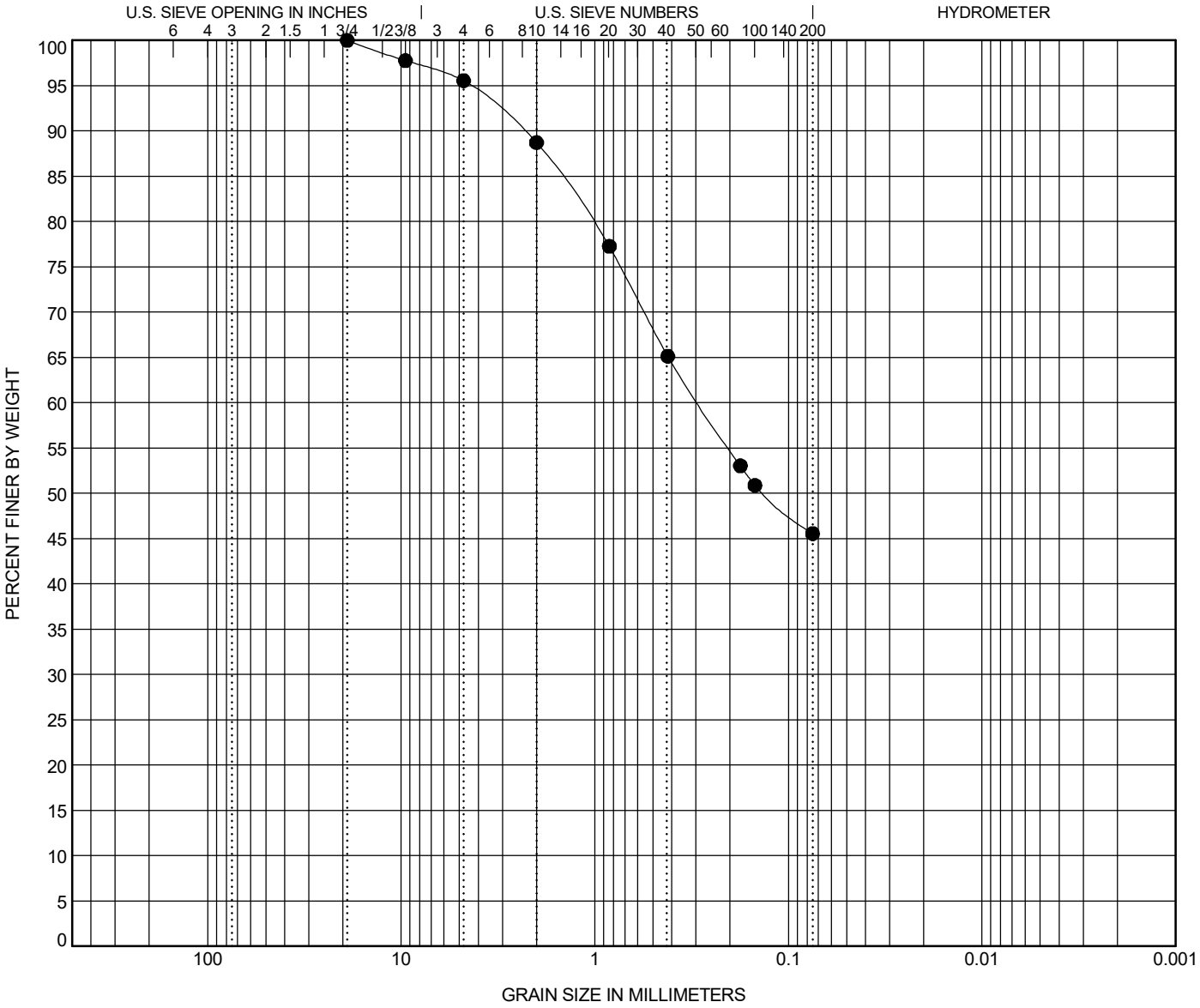

| | BOREHOLE | DEPTH | LL | PL | PI | Fines | Classification |
|---|---|---|---|---|---|---|---|
| ● | **BS-2** | **5.0** | **44** | **20** | **24** | **46** | **CLAYEY SAND (SC/A-7-6)** |

ATTERBERG LIMITS G6656.004 - S-765 RBO HANGING ROCK CREEK.GPJ SCDOT DATA TEMPLATE_01_30_2015.GDT 8/9/22

# GRAIN SIZE DISTRIBUTION

**PROJECT ID** P041154 **PROJECT NAME** S-29-765 RBO Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC




| COBBLES | GRAVEL | | SAND | | | SILT OR CLAY |
|---|---|---|---|---|---|---|
| | coarse | fine | coarse | medium | fine | |

| | BOREHOLE | DEPTH | Classification | LL | PL | PI | Cc | Cu |
|---|---|---|---|---|---|---|---|---|
| ● | **BS-2** | **5.0** | **CLAYEY SAND (SC/A-7-6)** | **44** | **20** | **24** | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |
| | | | | | | | | |

| | BOREHOLE | DEPTH | D100 | D60 | D30 | D10 | %Gravel | %Sand | %Silt | %Clay |
|---|---|---|---|---|---|---|---|---|---|---|
| ● | **BS-2** | **5.0** | **19** | **0.291** | | | **4.5** | **50.0** | **45.6** | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |
| | | | | | | | | | | |

# F&ME CONSULTANTS, INC.

## MOISTURE CONTENT DETERMINATION
## (AASHTO T265)

| | | | |
|---|---|---|---|
| **PROJECT:** | S-29-795 RBO Hanging Rock Creek | **SCDOT PROJECT ID:** | P041154 |
| **SAMPLE NUMBER:** | 22-2280 | **DATE SAMPLE RECEIVED:** | 7/28/2022 |
| **DESCRIPTION OF SOIL:** | Clayey SAND (SC/A-7-6) | | |
| **TESTED BY:** | CM | **DATE SETUP:** | 7/28/2022 |
| **WEIGHED BY:** | LK | **DATE OF WEIGHING:** | 7/29/2022 |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | BS-2 | | | | |
| **SAMPLE NO.** | -- | | | | |
| **SAMPLE DEPTH (FT.)** | 0.0 - 5.0 | | | | |
| **WATER CONTENT, W%** | 16.2 | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

| | | | | | |
|---|---|---|---|---|---|
| **BORING NO.** | | | | | |
| **SAMPLE NO.** | | | | | |
| **SAMPLE DEPTH (FT.)** | | | | | |
| **WATER CONTENT, W%** | | | | | |

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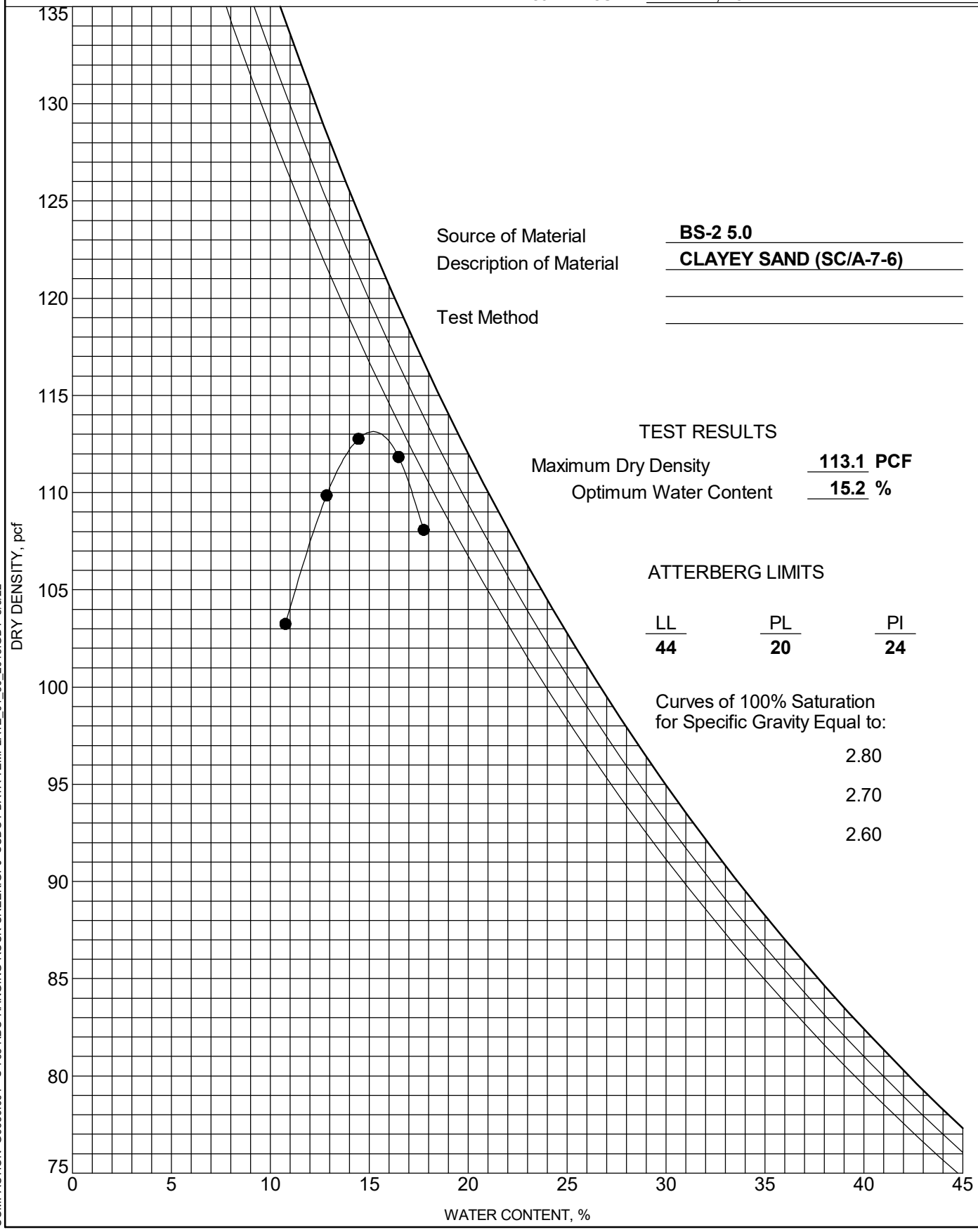
# MOISTURE-DENSITY RELATIONSHIP

**PROJECT ID** P041154

**PROJECT NAME** S-29-765 RBO Hanging Rock Creek

**PROJECT COUNTY** Lancaster, SC




Source of Material **BS-2 5.0**

Description of Material **CLAYEY SAND (SC/A-7-6)**

Test Method

TEST RESULTS

Maximum Dry Density **113.1** **PCF**

Optimum Water Content **15.2** **%**

ATTERBERG LIMITS

| LL | PL | PI |
|---|---|---|
| **44** | **20** | **24** |

Curves of 100% Saturation for Specific Gravity Equal to:

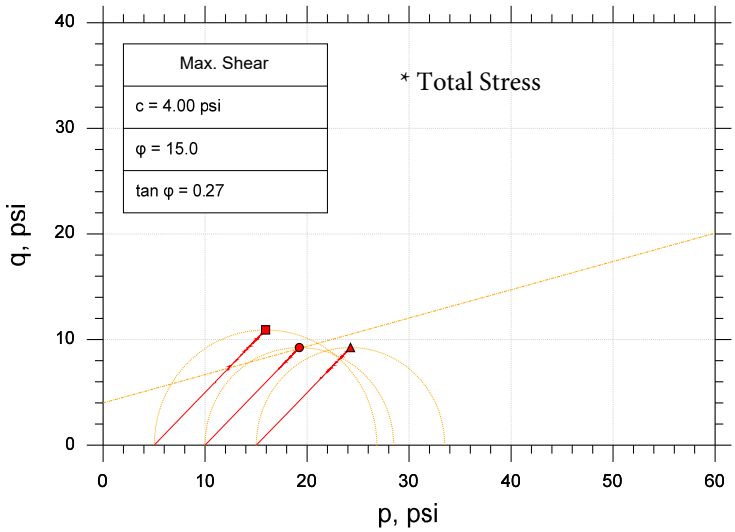
2.80

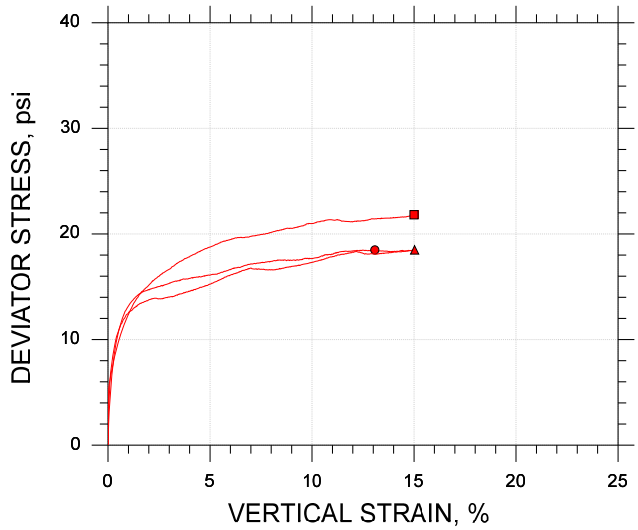
2.70

2.60

| | |
|---|---|
| Client: F&ME Consultants | |
| Project Name: S-29-765 RBO Hanging Rock Creek | |
| Project Location: Lancaster County, SC | |
| Project Number: GTX-316002 | |
| Tested By: jm | Checked By: mcm |
| Boring ID: BS-2 | |
| Preparation: reconstituted | |
| Description: Moist, yellowish red clayey sand | |
| Classification: | |
| Group Symbol: | |
| Liquid Limit: --- | Plastic Limit: --- |
| Plasticity Index: --- | Estimated Specific Gravity: 2.7 |

# CONSOLIDATED UNDRAINED TRIAXIAL TEST by AASHTO T297

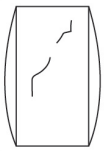



| | | | | |
|---|---|---|---|---|
| | Symbol | ■ | ● | ▲ |
| | Sample ID | --- | --- | --- |
| | Depth, ft | 0-5 ft | 0-5 ft | 0-5 ft |
| | Test Number | CU-1-1 | CU-1-2A | CU-1-3 |
| Initial | Height, in | 4.120 | 4.040 | 4.020 |
| Initial | Diameter, in | 2.030 | 2.030 | 2.020 |
| Initial | Moisture Content (from Cuttings), % | 16.6 | 16.7 | 17.1 |
| Initial | Dry Density, pcf | 107. | 107. | 107. |
| Initial | Saturation (Wet Method), % | 78.1 | 78.5 | 81.0 |
| Initial | Void Ratio | 0.573 | 0.575 | 0.569 |
| Before Shear | Moisture Content, % | 20.5 | 20.4 | 19.8 |
| Before Shear | Dry Density, pcf | 109. | 109. | 110. |
| Before Shear | Cross-sectional Area (Method A), in² | 3.217 | 3.201 | 3.163 |
| Before Shear | Saturation, % | 100.0 | 100.0 | 100.0 |
| Before Shear | Void Ratio | 0.552 | 0.550 | 0.536 |
| Before Shear | Back Pressure, psi | 134.8 | 119.0 | 128.8 |
| | Vertical Effective Consolidation Stress, psi | 5.022 | 9.991 | 15.04 |
| | Horizontal Effective Consolidation Stress, psi | 5.003 | 9.992 | 15.03 |
| | Vertical Strain after Consolidation, % | 0.2724 | 0.2061 | 0.2531 |
| | Volumetric Strain after Consolidation, % | -0.1248 | 0.7964 | 0.4657 |
| | Time to 50% Consolidation, min | --- | --- | 1.000 |
| | Shear Strength, psi | 10.91 | 9.242 | 9.245 |
| | Strain at Failure, % | 15.0 | 13.1 | 15.0 |
| | Strain Rate, %/min | 0.06000 | 0.06000 | 0.06000 |
| | Deviator Stress at Failure, psi | 21.82 | 18.48 | 18.49 |
| | Effective Minor Principal Stress at Failure, psi | 9.676 | 7.983 | 9.014 |
| | Effective Major Principal Stress at Failure, psi | 31.49 | 26.47 | 27.50 |
| | B-Value | 0.96 | 0.96 | 0.95 |

Notes:
- Before Shear Saturation set to 100% for phase calculation.
- Moisture Content determined by ASTM D2216.
- Deviator Stress includes membrane correction.
- Values for c and φ determined from best-fit straight line for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site conditions.

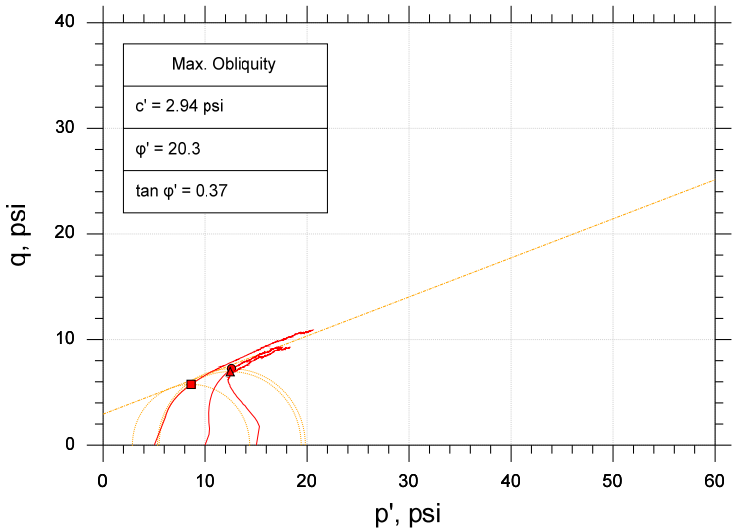
Remarks:

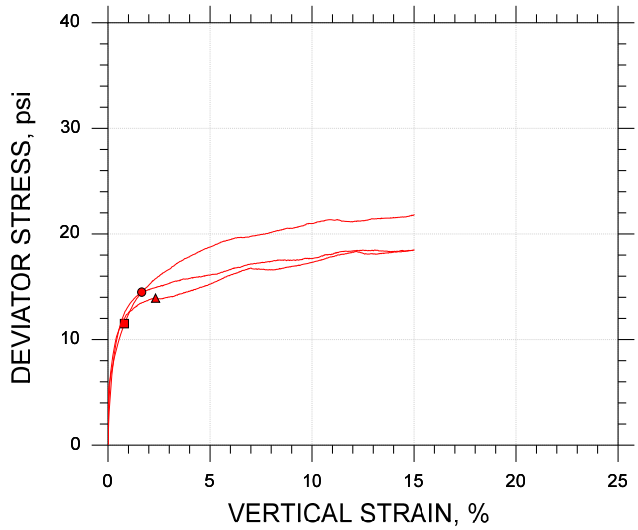


Target Compaction: 95% of (113.1 pcf) at Optimum Moisture Content (15.2%) +/- 2% - Values Provided by Client

| | |
|---|---|
| Client: F&ME Consultants | |
| Project Name: S-29-765 RBO Hanging Rock Creek | |
| Project Location: Lancaster County, SC | |
| Project Number: GTX-316002 | |
| Tested By: jm | Checked By: mcm |
| Boring ID: BS-2 | |
| Preparation: reconstituted | |
| Description: Moist, yellowish red clayey sand | |
| Classification: | |
| Group Symbol: | |
| Liquid Limit: --- | Plastic Limit: --- |
| Plasticity Index: --- | Estimated Specific Gravity: 2.7 |

# CONSOLIDATED UNDRAINED TRIAXIAL TEST by AASHTO T297

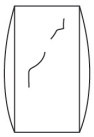



| | | | | |
|---|---|---|---|---|
| Symbol | | ■ | ● | ▲ |
| Sample ID | | --- | --- | --- |
| Depth, ft | | 0-5 ft | 0-5 ft | 0-5 ft |
| Test Number | | CU-1-1 | CU-1-2A | CU-1-3 |
| Initial | Height, in | 4.120 | 4.040 | 4.020 |
| | Diameter, in | 2.030 | 2.030 | 2.020 |
| | Moisture Content (from Cuttings), % | 16.6 | 16.7 | 17.1 |
| | Dry Density, pcf | 107. | 107. | 107. |
| | Saturation (Wet Method), % | 78.1 | 78.5 | 81.0 |
| | Void Ratio | 0.573 | 0.575 | 0.569 |
| Before Shear | Moisture Content, % | 20.5 | 20.4 | 19.8 |
| | Dry Density, pcf | 109. | 109. | 110. |
| | Cross-sectional Area (Method A), in² | 3.217 | 3.201 | 3.163 |
| | Saturation, % | 100.0 | 100.0 | 100.0 |
| | Void Ratio | 0.552 | 0.550 | 0.536 |
| | Back Pressure, psi | 134.8 | 119.0 | 128.8 |
| Vertical Effective Consolidation Stress, psi | | 5.022 | 9.991 | 15.04 |
| Horizontal Effective Consolidation Stress, psi | | 5.003 | 9.992 | 15.03 |
| Vertical Strain after Consolidation, % | | 0.2724 | 0.2061 | 0.2531 |
| Volumetric Strain after Consolidation, % | | -0.1248 | 0.7964 | 0.4657 |
| Time to 50% Consolidation, min | | --- | --- | 1.000 |
| Shear Strength, psi | | 5.755 | 7.244 | 6.961 |
| Strain at Failure, % | | 0.801 | 1.65 | 2.33 |
| Strain Rate, %/min | | 0.06000 | 0.06000 | 0.06000 |
| Deviator Stress at Failure, psi | | 11.51 | 14.49 | 13.92 |
| Effective Minor Principal Stress at Failure, psi | | 2.869 | 5.343 | 5.499 |
| Effective Major Principal Stress at Failure, psi | | 14.38 | 19.83 | 19.42 |
| B-Value | | 0.96 | 0.96 | 0.95 |

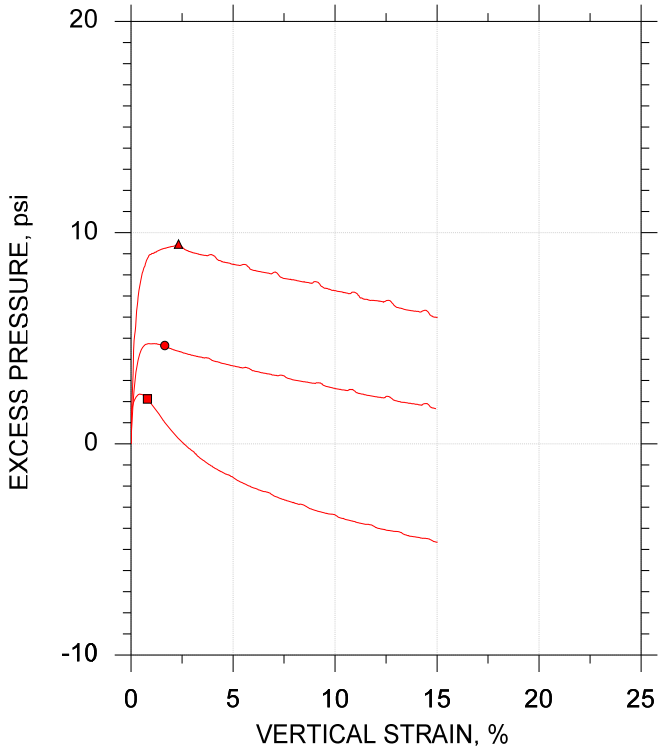
Notes:
- Before Shear Saturation set to 100% for phase calculation.
- Moisture Content determined by ASTM D2216.
- Deviator Stress includes membrane correction.
- Values for c and φ determined from best-fit straight line for the specific test conditions. Actual strength parameters may vary and should be determined by an engineer for site conditions.

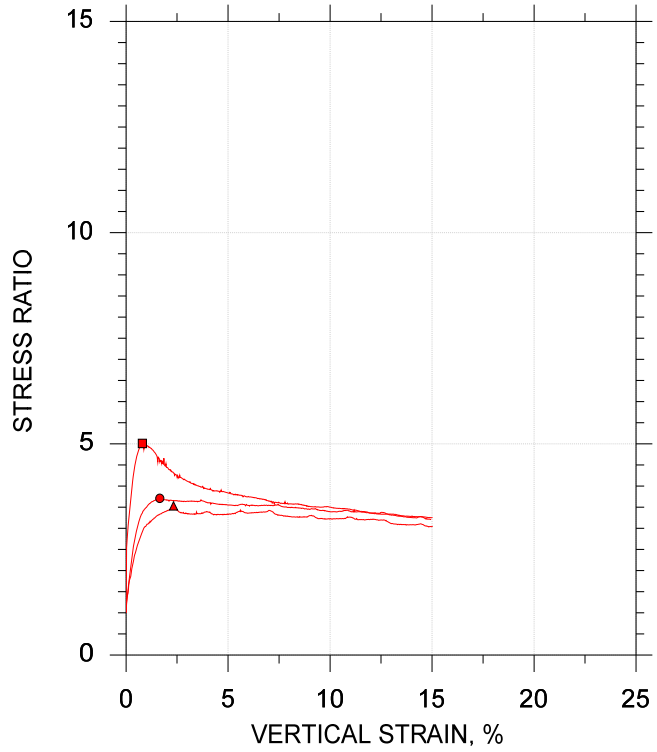
Remarks:

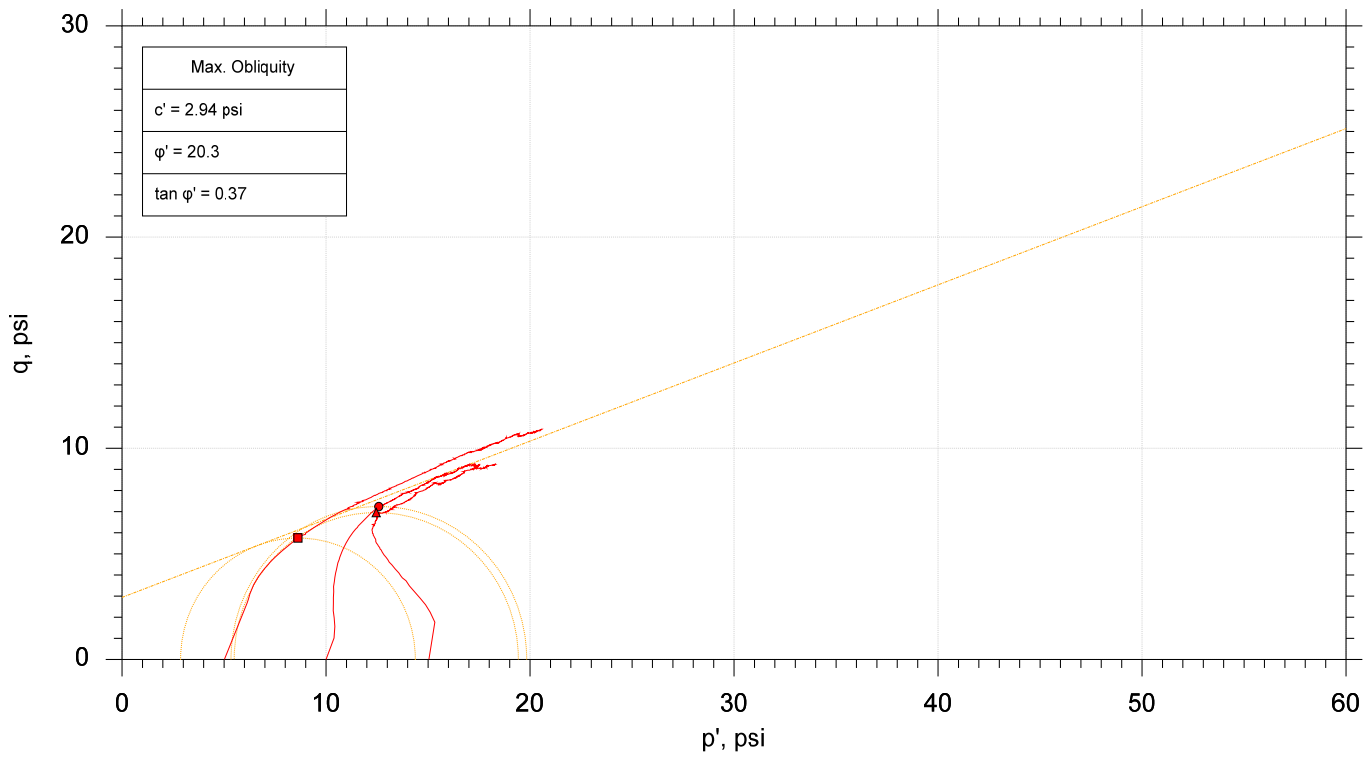


Target Compaction: 95% of (113.1 pcf) at Optimum Moisture Content (15.2%) +/- 2% - Values Provided by Client

# CONSOLIDATED UNDRAINED TRIAXIAL TEST by AASHTO T297




| | Sample No. | Test No. | Depth | Tested By | Test Date | Checked By | Check Date | Test File |
|---|---|---|---|---|---|---|---|---|
| ■ | --- | CU-1-1 | 0-5 ft | jm | 8/30/22 | mcm | 9/1/22 | 316002-CU-1-1m.dat |
| ● | --- | CU-1-2A | 0-5 ft | cag/jm | 9/1/22 | mcm | 9/4/22 | 316002-CU-1-2Am.dat |
| ▲ | --- | CU-1-3 | 0-5 ft | cag | 8/19/22 | mcm | 8/29/22 | 316002-CU-1-3m.dat |
| | | | | | | | | |

GeoTesting EXPRESS

| | | |
|---|---|---|
| Project: S-29-765 RBO Hanging Rock Creek | Location: Lancaster County, SC | Project No.: GTX-316002 |
| Boring No.: BS-2 | Sample Type: reconstituted | |
| Description: Moist, yellowish red clayey sand | | |
| Target Compaction: 95% of (113.1 pcf) at Optimum Moisture Content (15.2%) +/- 2% - Values Provided by Client | | |

# Appendix C. Laboratory Testing

Rock Cores

hdrinc.com

1201 Main Street, Suite 800 Columbia, SC 29201
**T** 803.254.5800

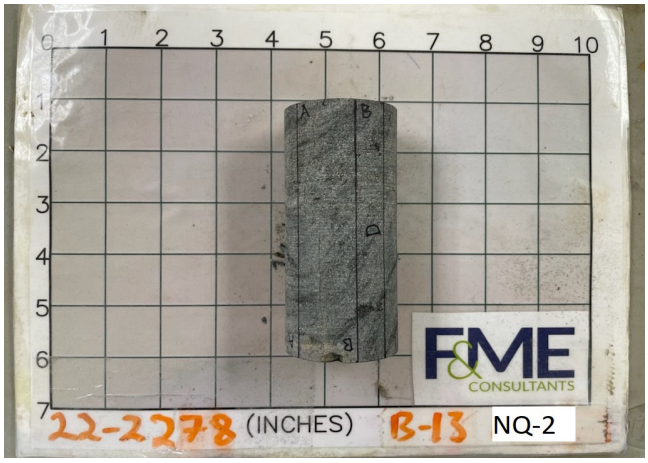
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

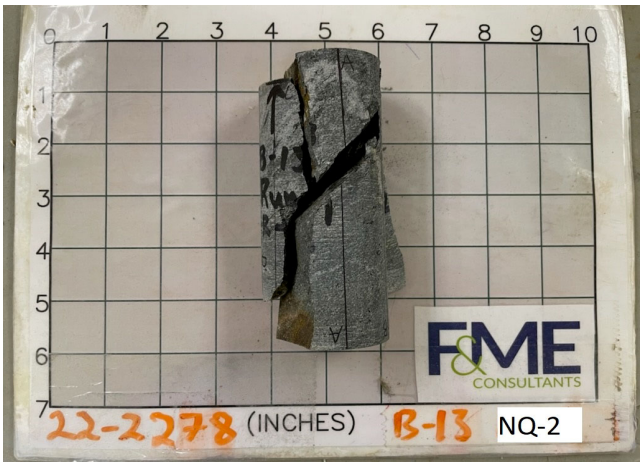
| | | | | | |
|---|---|---|---|---|---|
| Project | S-765 RBO Hanging Rock Creek | | | Date | 8/28/2022 |
| Project No. | G6656.004 | Sample Diameter (in.) | 1.864 | Tested By | WAP |
| SCDOT ID | P041154 | Sample Length (in.) | 4.077 | Reviewed By | WJG |
| Boring | B-13 | Unit Weight (pcf) | 172.1 | Core Size | NQ |
| Sample No. | NQ-2 / 22-2278A | L/D Ratio | 2.19 | Recovery | 92% |
| Depth | 89.5' - 89.8' | Load Rate (psi/sec) | 30 | RQD | 13% |
| Description | Gray/White/Black Granite | | | | |

Test Data

| Percent of Failure Load | Strain ($10^{-6}$) Axial | Strain ($10^{-6}$) Radial | Load (lbs) | Compressive Stress (psi) | Secant Modulus $x10^6$ (psi) | Poisson's Ratio |
|---|---|---|---|---|---|---|
| 10% | -600 | 131 | 3,668 | 1,344 | 4.48 | 0.22 |
| 20% | -1146 | 217 | 7,352 | 2,694 | 4.70 | 0.19 |
| 30% | -1601 | 308 | 10,879 | 3,987 | 4.98 | 0.19 |
| 40% | -2027 | 406 | 14,678 | 5,379 | 5.31 | 0.20 |
| 50% | -2429 | 514 | 18,360 | 6,728 | 5.54 | 0.21 |
| 60% | -2804 | 628 | 21,929 | 8,036 | 5.73 | 0.22 |
| 70% | -3194 | 761 | 25,650 | 9,399 | 5.89 | 0.24 |
| 80% | -3597 | 935 | 29,333 | 10,749 | 5.98 | 0.26 |
| 90% | -4049 | 1206 | 32,916 | 12,062 | 5.96 | 0.30 |
| 100% | -5187 | 3118 | 36,642 | 13,428 | | |

Sample Photos



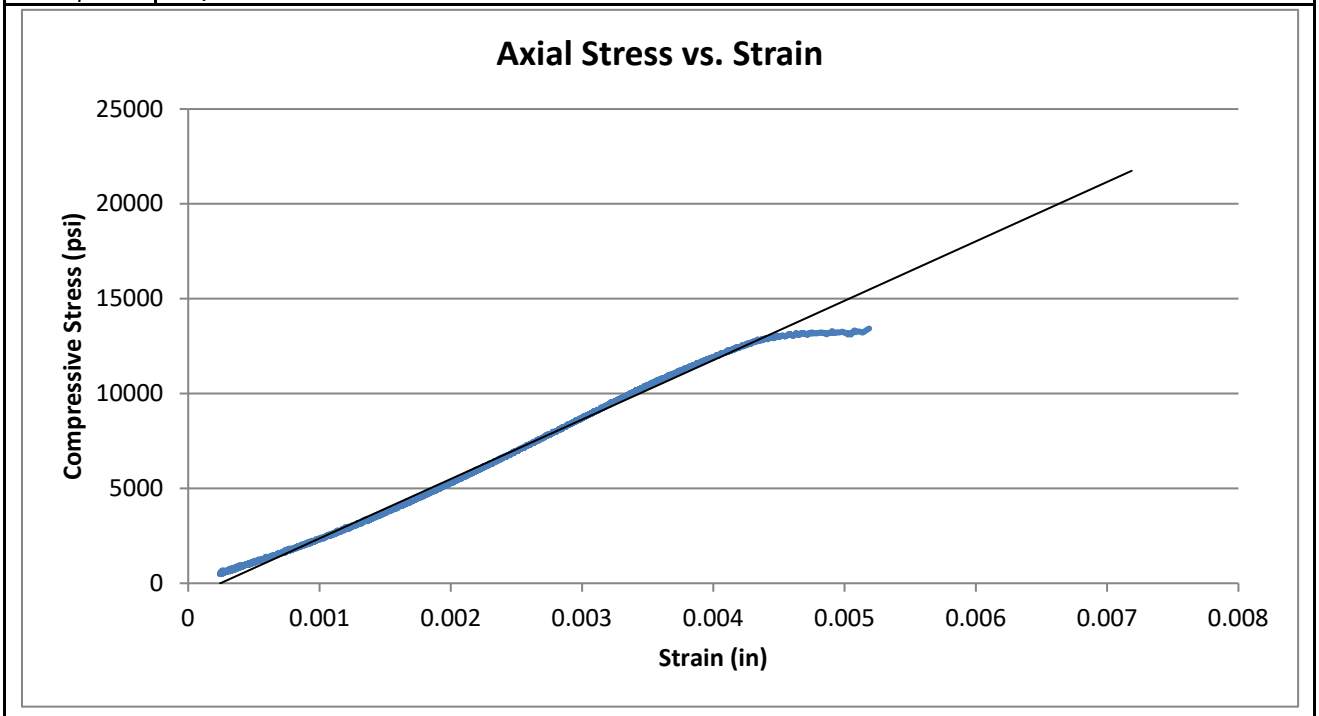



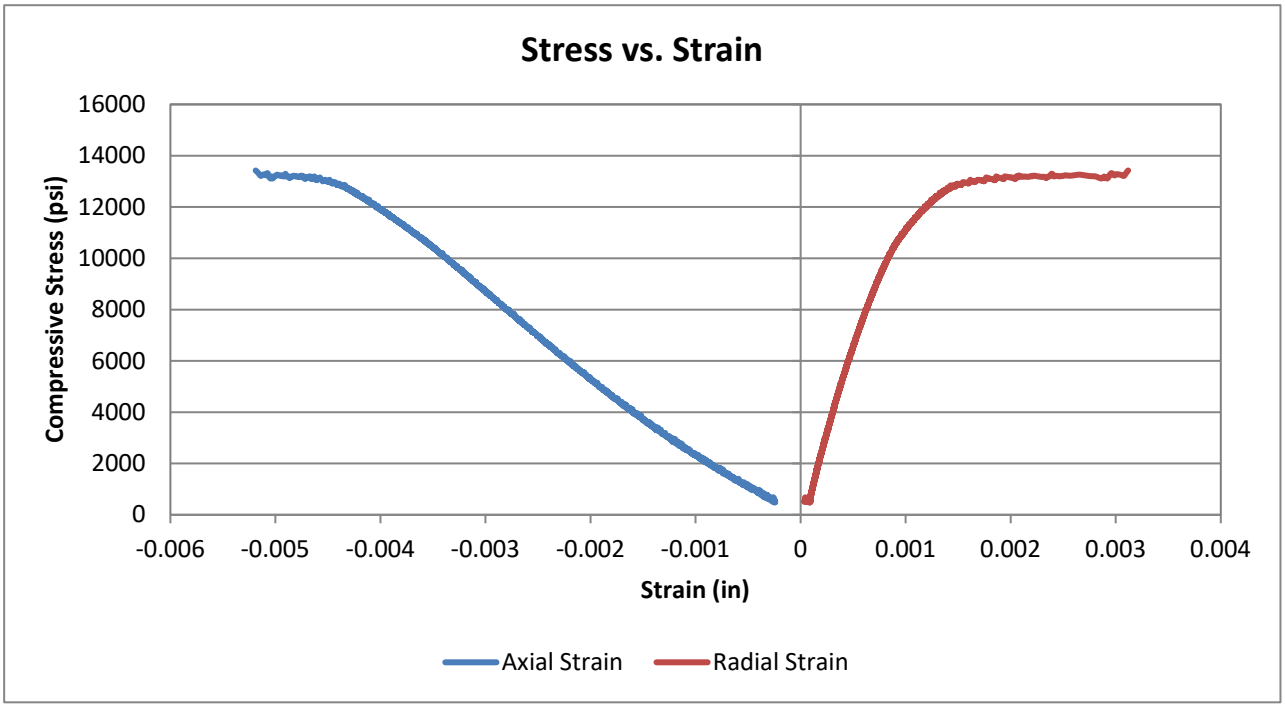

Test Results

| | | | |
|---|---|---|---|
| Unconfined Compressive Strength (psi) | **13,430** | Elastic Modulus (psi) | 5.30E+06 |
| | | Poisson's Ratio in Elastic Range | 0.20 |
| Comments | Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. | | |

Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

| | | | | | |
|---|---|---|---|---|---|
| Project | S-765 RBO Hanging Rock Creek | | | Date | 8/28/2022 |
| Project No. | G6656.004 | Sample Diameter (in.) | 1.864 | Tested By | WAP |
| SCDOT ID | P041154 | Sample Length (in.) | 4.077 | Reviewed By | WJG |
| Boring | B-13 | Unit Weight (pcf) | 172.1 | Core Size | NQ |
| Sample No. | NQ-2 / 22-2278A | L/D Ratio | 2.19 | Recovery | 92% |
| Depth | 89.5' - 89.8' | Load Rate (psi/sec) | 30 | RQD | 13% |
| Description | Gray/White/Black Granite | | | | |



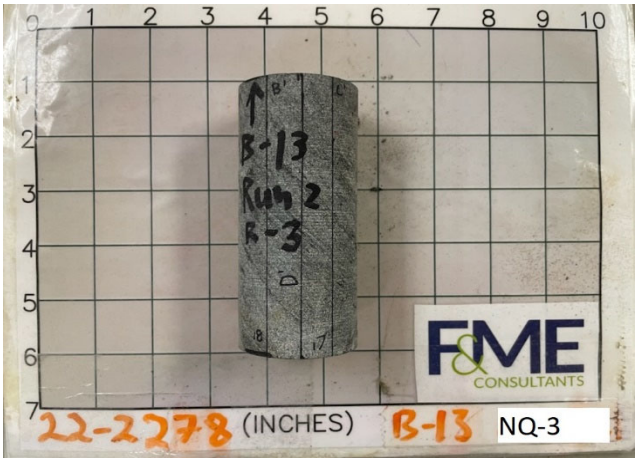
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

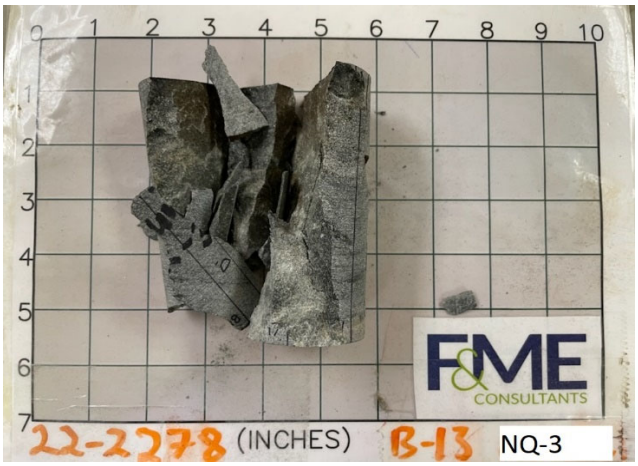
| | | | | | |
|---|---|---|---|---|---|
| Project | S-765 RBO Hanging Rock Creek | | | Date | 8/28/2022 |
| Project No. | G6656.004 | Sample Diameter (in.) | 1.862 | Tested By | WAP |
| SCDOT ID | P041154 | Sample Length (in.) | 4.137 | Reviewed By | WJG |
| Boring | B-13 | Unit Weight (pcf) | 172.2 | Core Size | NQ |
| Sample No. | NQ-3 / 22-2278B | L/D Ratio | 2.22 | Recovery | 97% |
| Depth | 91.8' - 92.1' | Load Rate (psi/sec) | 30 | RQD | 78% |
| Description | Gray/White/Black Granite | | | | |

Test Data

| Percent of Failure Load | Strain ($10^{-6}$) Axial | Strain ($10^{-6}$) Radial | Load (lbs) | Compressive Stress (psi) | Secant Modulus $x10^6$ (psi) | Poisson's Ratio |
|---|---|---|---|---|---|---|
| 10% | -1627 | 349 | 5,358 | 1,968 | 2.42 | 0.21 |
| 20% | -2480 | 474 | 10,738 | 3,943 | 3.18 | 0.19 |
| 30% | -3111 | 544 | 16,076 | 5,904 | 3.79 | 0.17 |
| 40% | -3681 | 638 | 21,409 | 7,862 | 4.27 | 0.17 |
| 50% | -4231 | 720 | 26,753 | 9,825 | 4.64 | 0.17 |
| 60% | -4767 | 791 | 32,122 | 11,797 | 4.95 | 0.17 |
| 70% | -5303 | 669 | 37,432 | 13,747 | 5.18 | 0.13 |
| 80% | -5881 | 635 | 42,898 | 15,754 | 5.36 | 0.11 |
| 90% | -6479 | 681 | 48,133 | 17,676 | 5.46 | 0.11 |
| 100% | -7894 | -296 | 53,503 | 19,648 | | |

Sample Photos



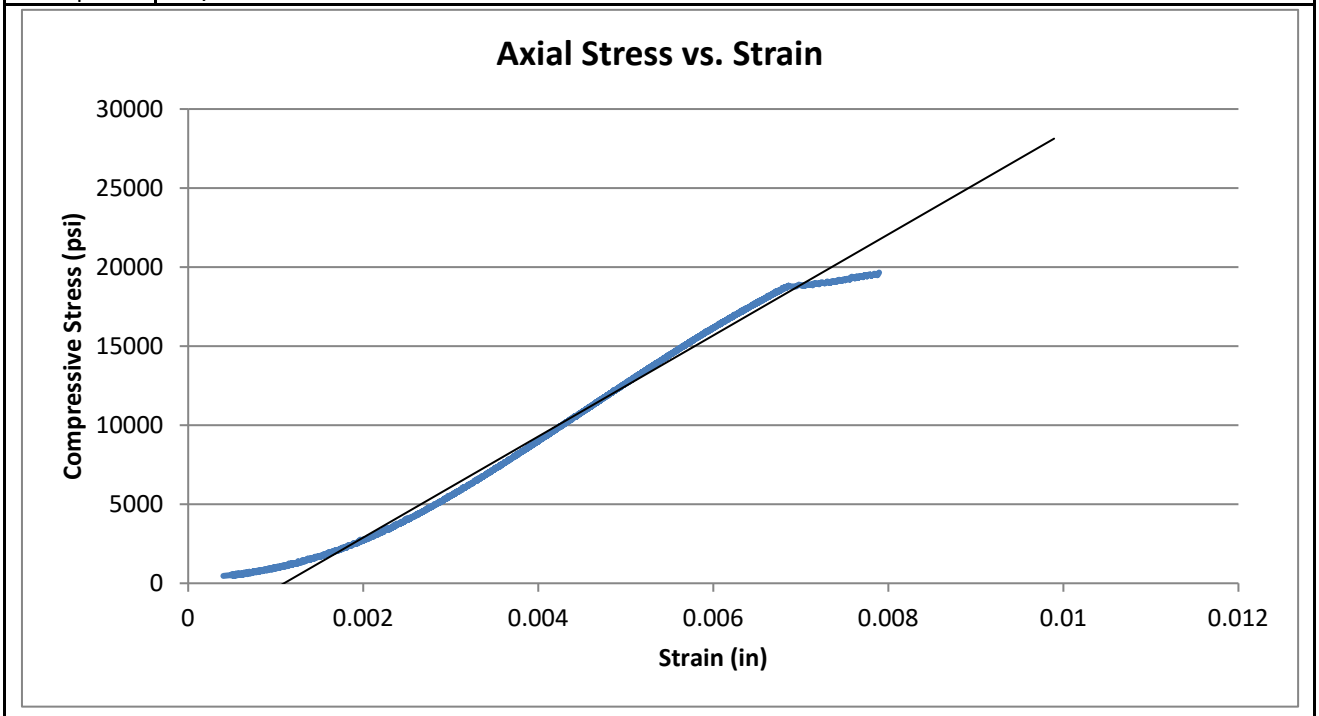

Test Results

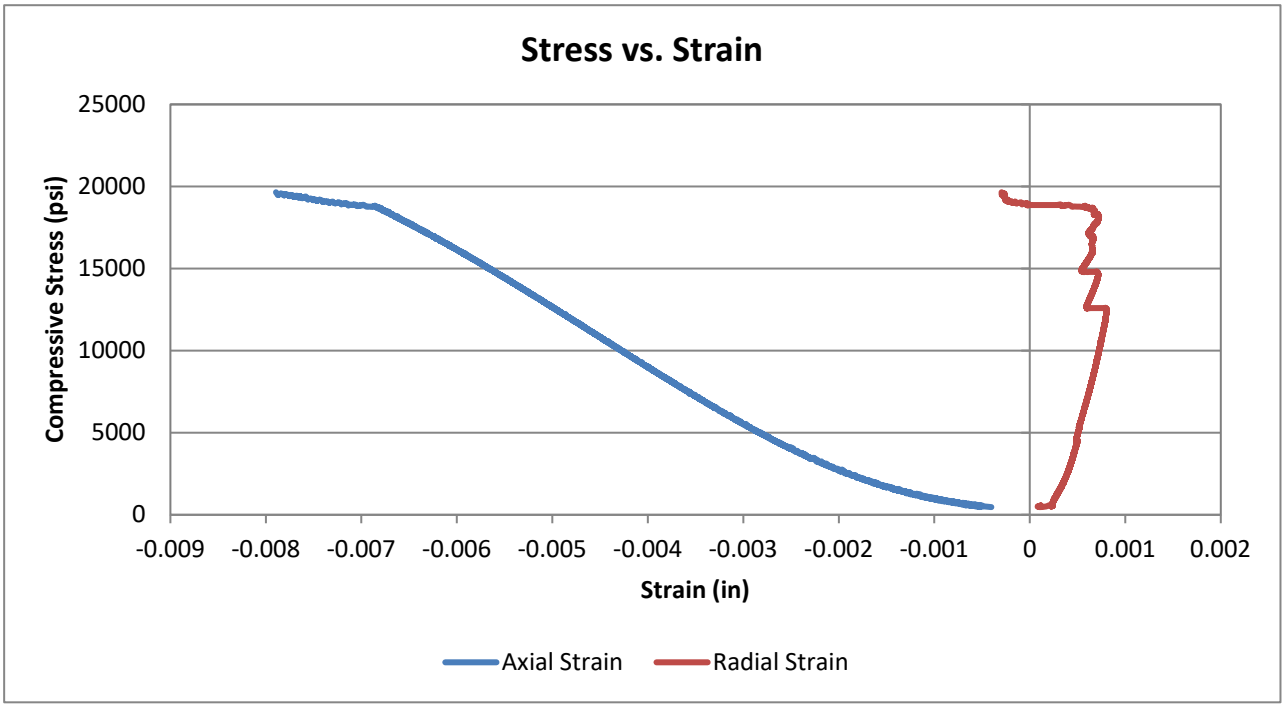
| | | | |
|---|---|---|---|
| Unconfined Compressive Strength (psi) | **19,650** | Elastic Modulus (psi) | 3.73E+06 |
| | | Poisson's Ratio in Elastic Range | 0.18 |

Comments: Elastic range was taken as between 0.002 and 0.004 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.

Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

| | | | | | |
|---|---|---|---|---|---|
| Project | S-765 RBO Hanging Rock Creek | | | Date | 8/28/2022 |
| Project No. | G6656.004 | Sample Diameter (in.) | 1.862 | Tested By | WAP |
| SCDOT ID | P041154 | Sample Length (in.) | 4.137 | Reviewed By | WJG |
| Boring | B-13 | Unit Weight (pcf) | 172.2 | Core Size | NQ |
| Sample No. | NQ-3 / 22-2278B | L/D Ratio | 2.22 | Recovery | 97% |
| Depth | 91.8' - 92.1' | Load Rate (psi/sec) | 30 | RQD | 78% |
| Description | Gray/White/Black Granite | | | | |



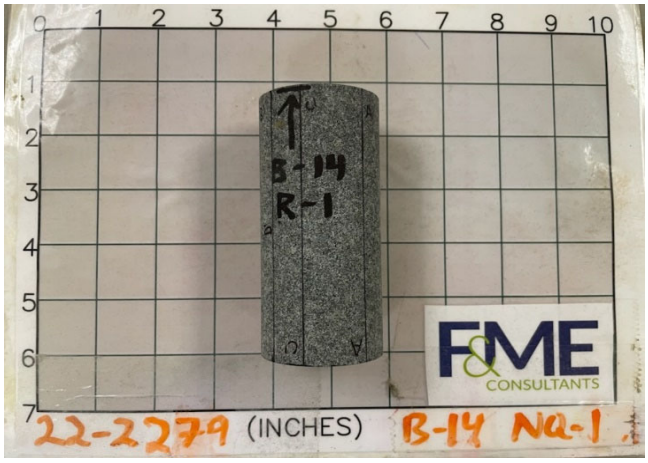
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

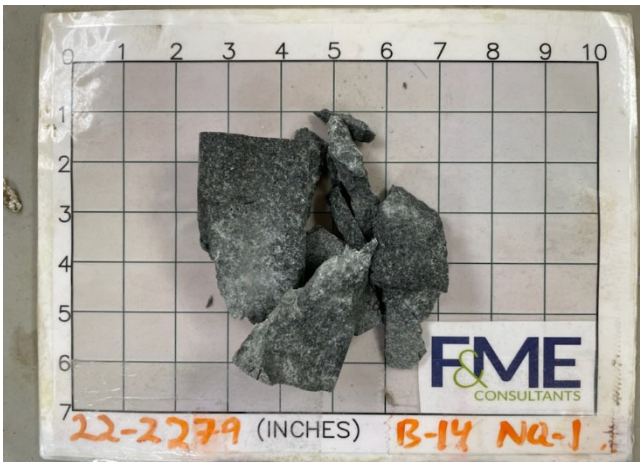
| | | | | | |
|---|---|---|---|---|---|
| Project | S-765 RBO Hanging Rock Creek | | | Date | 8/28/2022 |
| Project No. | G6656.004 | Sample Diameter (in.) | 1.868 | Tested By | WAP |
| SCDOT ID | P041154 | Sample Length (in.) | 4.095 | Reviewed By | WJG |
| Boring | B-14 | Unit Weight (pcf) | 185.8 | Core Size | NQ |
| Sample No. | NQ-1 / 22-2279A | L/D Ratio | 2.19 | Recovery | 30% |
| Depth | 26.7' - 27.0' | Load Rate (psi/sec) | 30 | RQD | 18% |
| Description | Gray/White/Black Granite | | | | |

Test Data

| Percent of Failure Load | Strain ($10^{-6}$) Axial | Strain ($10^{-6}$) Radial | Load (lbs) | Compressive Stress (psi) | Secant Modulus $x10^6$ (psi) | Poisson's Ratio |
|---|---|---|---|---|---|---|
| 10% | -447 | 160 | 8,444 | 3,081 | 13.78 | 0.36 |
| 20% | -871 | 279 | 16,866 | 6,154 | 14.13 | 0.32 |
| 30% | -1296 | 399 | 25,311 | 9,236 | 14.25 | 0.31 |
| 40% | -1720 | 518 | 33,769 | 12,322 | 14.33 | 0.30 |
| 50% | -2164 | 640 | 42,282 | 15,428 | 14.26 | 0.30 |
| 60% | -2603 | 763 | 50,704 | 18,501 | 14.22 | 0.29 |
| 70% | -3061 | 897 | 59,173 | 21,591 | 14.11 | 0.29 |
| 80% | -3542 | 1051 | 67,483 | 24,624 | 13.91 | 0.30 |
| 90% | -4086 | 1271 | 76,054 | 27,751 | 13.58 | 0.31 |
| 100% | -4809 | 1980 | 84,470 | 30,822 | | |

Sample Photos



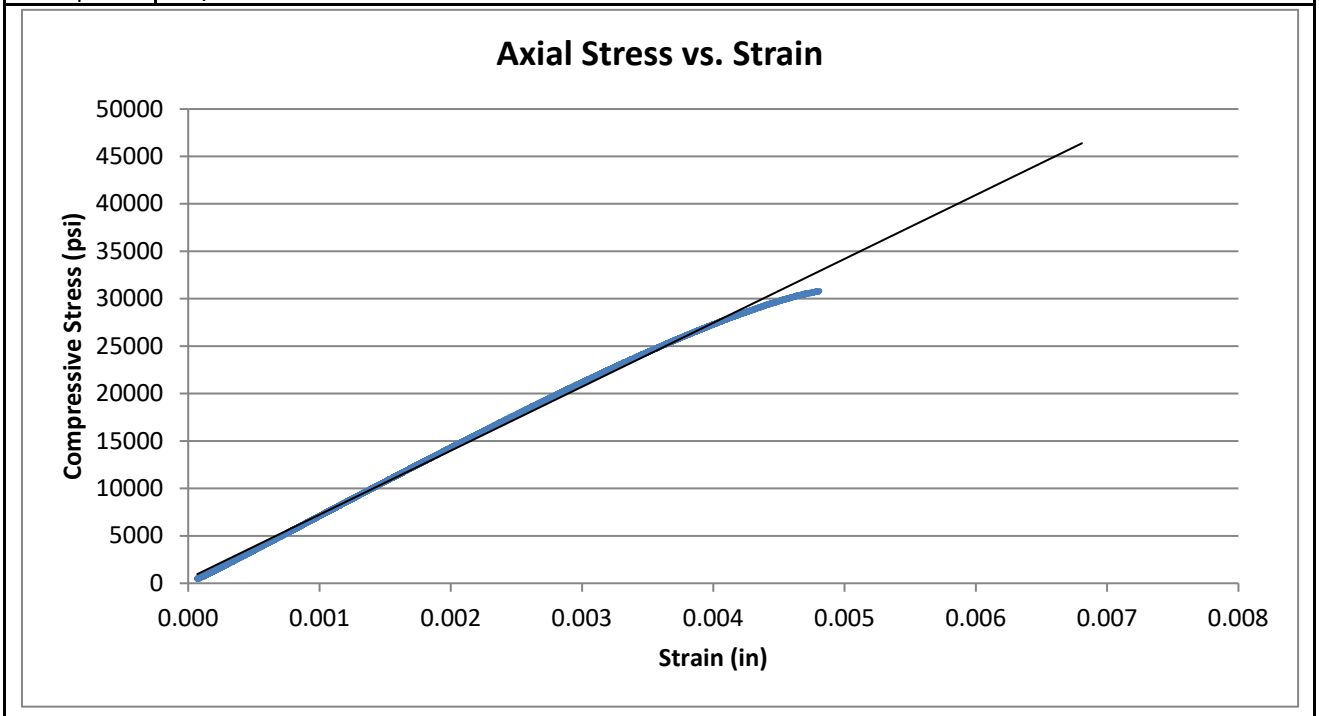



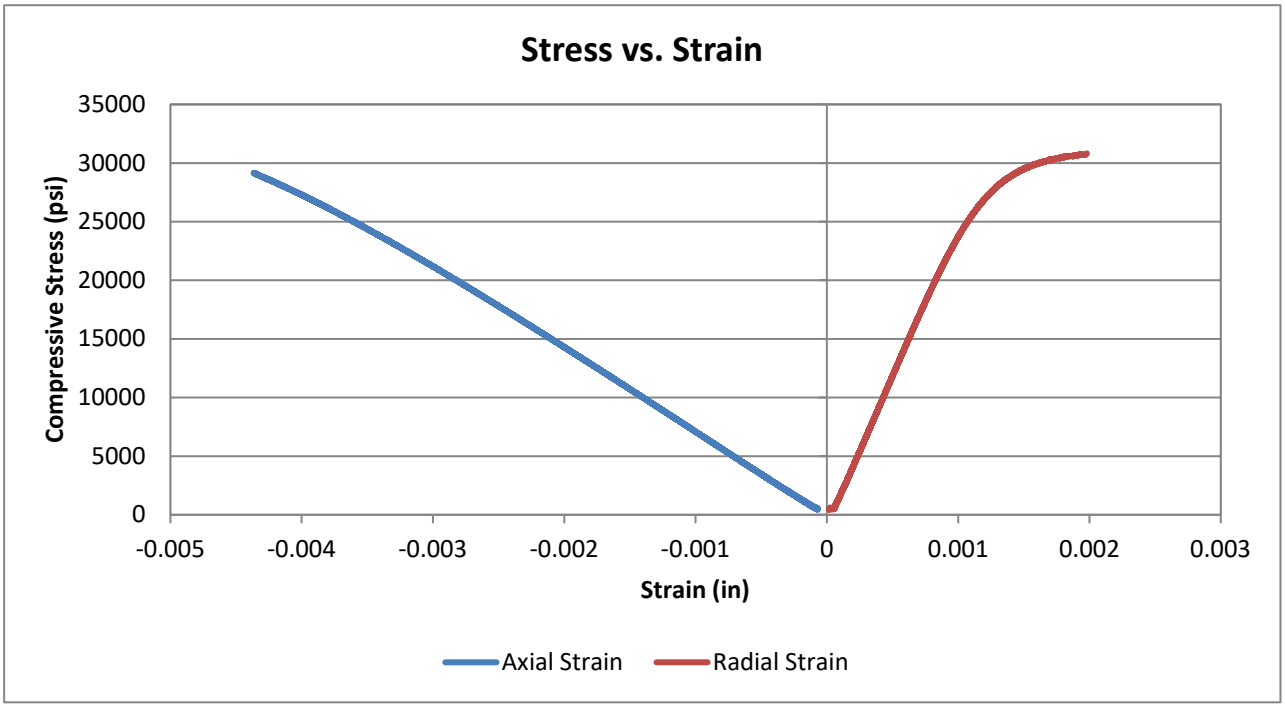

Test Results

| | | | |
|---|---|---|---|
| Unconfined Compressive Strength (psi) | **30,820** | Elastic Modulus (psi) | 1.43E+07 |
| | | Poisson's Ratio in Elastic Range | 0.30 |
| Comments | Elastic range was taken as between 0.001 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. | | |

Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

| | | | | | |
|---|---|---|---|---|---|
| Project | S-765 RBO Hanging Rock Creek | | | Date | 8/28/2022 |
| Project No. | G6656.004 | Sample Diameter (in.) | 1.868 | Tested By | WAP |
| SCDOT ID | P041154 | Sample Length (in.) | 4.095 | Reviewed By | WJG |
| Boring | B-14 | Unit Weight (pcf) | 185.8 | Core Size | NQ |
| Sample No. | NQ-1 / 22-2279A | L/D Ratio | 2.19 | Recovery | 30% |
| Depth | 26.7' - 27.0' | Load Rate (psi/sec) | 30 | RQD | 18% |
| Description | Gray/White/Black Granite | | | | |



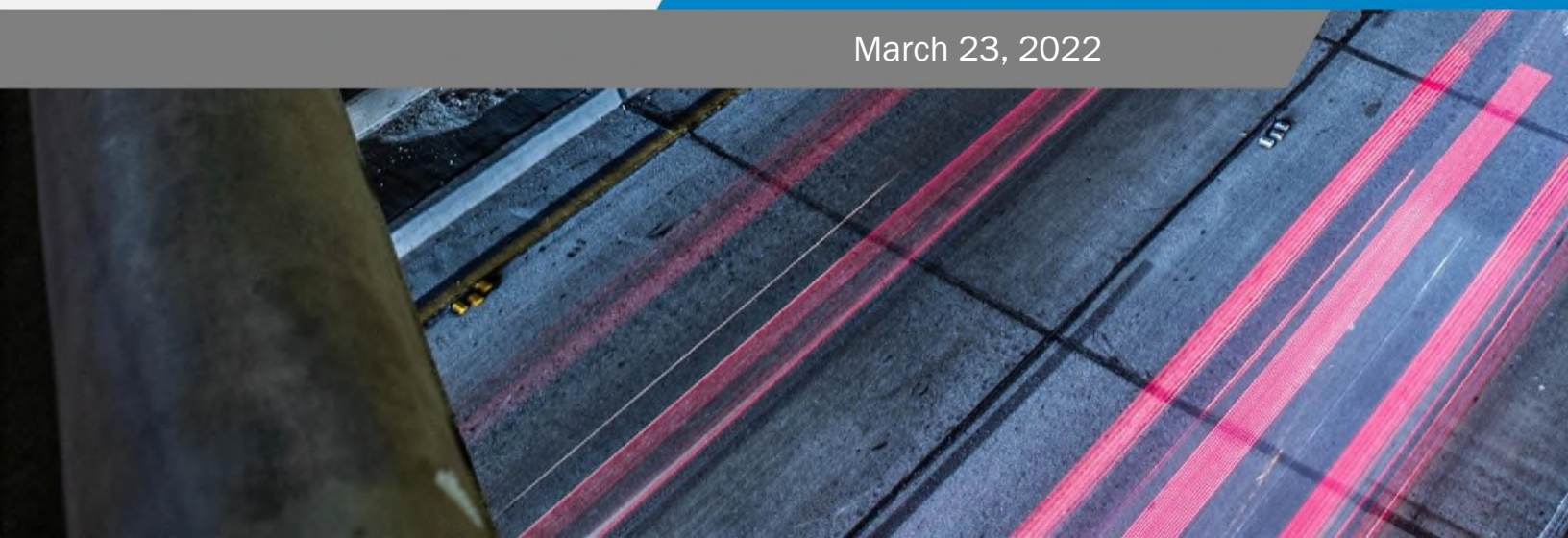
# Appendix D. SPT Hammer Energy Calibration Report

CAROLINAS GEOTECHNICAL GROUP

# Report of SPT Hammer Energy

**Prepared for:**
Breccia Construction, LLC
620-B Industrial Way
Chester, South Carolina 29706

March 23, 2022



CAROLINAS GEOTECHNICAL GROUP

N.C. Firm License: P-1904

2400 Crownpoint Executive Drive
Suite 800
Charlotte, NC 28227

(980) 339-8684
contact@carolinasgeotech.com
www.carolinasgeotech.com

March 23, 2022

Mr. Jarod S. Ford
Breccia Construction, LLC
620-B Industrial Way
Chester, South Carolina 29706

SUBJECT: **Report of SPT Hammer Energy**
Breccia Construction, LLC CME 45B Trailer Rig (SN 303304)
Chester, South Carolina
CG2 Project No.: 240021095

Dear Mr. Ford:

Carolinas Geotechnical Group, PLLC (CG2) has completed the Standard Penetration Test (SPT) energy measurements on the automatic hammer mounted on a Breccia Construction, LLC (Breccia) CME 45B trailer-mounted drill rig with a serial number of 303304, see attached Drill Rig Photo Log. This service was performed by Mr. Robert E. Kral, PE on March 11, 2022. SPT energy testing was performed in general accordance with ASTM D4633 and the most recent revision of the North Carolina Department of Transportation (NCDOT), Geotechnical Engineering Unit's requirements. The testing procedures, equipment used during testing, and detailed results are presented in this report.

CG2 recommends Breccia submit this Report of SPT Hammer Energy to the NCDOT Geotechnical Engineering Unit for review and approval no later than April 8, 2022.

## DYNAMIC TESTING METHODOLOGY

Testing was performed using a model SPT (Serial No. 4549 TB) Pile Driving Analyzer™ (PDA) manufactured by Pile Dynamics, Inc. The PDA was used to record and interpret data from two piezoresistive accelerometers (Serial Nos. K11957 and K10959) bolted to a 2-foot long AWJ drill rod (SN 528AWJ) internally instrumented with two strain transducers. The instrumented AWJ drill rod has a cross-sectional area of 1.19 square inches, an outside diameter of approximately 1.75 inches, and an inside diameter of 1.25 inches at the gauge location. The accelerometers and strain gauges, which are mounted on opposing axis near the middle of the instrumented rod, monitor acceleration and strain for each hammer blow. The analyzer converts the data to velocities and forces and computes the maximum transferred hammer energies with the "EFV" method described in ASTM D4633. Preliminary results are recorded and displayed in real-time for each blow. Calibration sheets for the PDA, accelerometers, and the instrumented rod are included in the Appendix III.

## TESTING AND OBSERVATIONS

CG2 personnel was on site March 11, 2022 to observe and perform high-strain dynamic testing during SPT sampling on the CME 45B trailer-mounted drill rig operated by D. Harris of Breccia. The measurements were taken during drilling operations at 1817 Lowrys Highway in Chester, South Carolina (Chester County). The approximate coordinates (not professionally surveyed) for the test location are 34.770585, -81.245517. No Soil Test Boring Log was maintained. SPT energy measurements were recorded during three intervals at depths of approximately 28½, 33½, and 38½ feet below the existing ground surface. The information presented in the table below summarizes the equipment tested and tooling used during the SPT energy measurements.

**Table 1: SPT Field Data**

| Drill Rig Information | |
|---|---|
| Manufacturer | CME |
| Model | 45B |
| Serial Number | 303304 |
| Operator | D. Harris |
| Carrier | Trailer |
| **Hammer Information** | |
| Model / Type | CME / Auto |
| Serial Number | N/A |
| Anvil Height (inches) | 11.5 |
| Anvil Diameter (inches) | 2.5 |
| Drop Height (inches) | 30 |
| Ram Weight (pounds) | 140 |
| Ram Serial Number | N/A |
| **Drilling and Instrumented Rod Information** | |
| Drill Rod Type | AWJ |
| OD (inches) | 1.75 |
| ID (inches) | 1.25 |
| Cross-Sectional Area ($in^2$) | 1.19 |
| Typical Lengths (feet) | 5 |
| Instrumented Rod Type | AWJ (SN 528) |
| OD (inches) | 1.75 |
| ID (inches) | 1.25 |
| Cross-Sectional Area ($in^2$) | 1.19 |
| Total Instrumented Rod Length (feet) | 2.00 |
| Length Below Gages (feet) | 0.70 |
| Split-Spoon Length (feet) | 2.85 |

## DYNAMIC TESTING RESULTS

The total rod length from the instrumentation to the tip of the split-spoon sampler was determined by adding 3.6 feet to the required drill rod length at each sample depth. Based on the test data, the automatic hammer on the CME 45B Trailer-mounted drill rig operated at a rate of about 53.2 to 61.4 blows per minute (BPM) during dynamic testing. The measured transferred hammer energy (EFV) ranged from 273.5 to 298.0 foot-pounds, which corresponds to Energy Transfer Ratio (ETR) values of 78.2 to 85.1%, respectively.

The SPT Energy Measurement Data Summary tables in the Appendix present the test data from every hammer blow at each sampling interval along with representative force and velocity traces for each test interval. The reported blow counts, obtained by the drill rig personnel, and a summary of the test data and average computed hammer energy and transfer ratio values are provided in Table 2. Plots and tables of the following are also included in the Appendix and present the test data with depth for each test interval:

- Penetration vs. BLC
- Penetration vs. FMX
- Penetration vs. EFV
- Penetration vs. CSX
- Penetration vs. VMX
- Penetration vs. ETR
- Average ETR vs. Rod Length
- ETR vs. Rod Length

Table 2: Summary of Dynamic Testing Results

| Data Set ID | Sample Depth (ft) | Drill Rod Length (ft) | Instrumentation to Sampler Tip Length (ft) | Blows per 6" Increment / N-value | Soil Sample Description (Piedmont Residual) | Avg. BPM | Avg. EFV (ft-lbs) | Avg. ETR (%) |
|---|---|---|---|---|---|---|---|---|
| 1 | 28½ - 30 | 30 | 33.6 | 4-6-7 / 13 | SA SILT | 53.4 | 277.5 | 79.3 |
| 2 | 33½ - 35 | 35 | 38.6 | 3-5-6 / 11 | SA SILT | 58.3 | 291.4 | 83.3 |
| 3 | 38½ - 40 | 40 | 43.6 | 4-6-9 / 15 | SA SILT | 55.5 | 286.8 | 81.9 |
| | | | | | Overall Average | 55.6 | 285.0 | 81.4 |

The average hammer rate, transferred energy, and transfer ratio were calculated for each depth interval. Per ASTM D4633, only the blows from the final foot of each sample interval (i.e., the blows that determine the N-value) were included when computing the average values shown in Table 2. The overall average transferred hammer energy for the automatic hammer on the CME 45B trailer-mounted drill rig (for all the depth intervals tested) was 285.0 foot-pounds, with an average ETR of 81.4%.

## LIMITATIONS OF REPORT

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The information contained in this report were based on the applicable standards of our profession in this geographic area at the time this report was prepared. No other warranty, express or implied, is made.

## CLOSING

CG2 is pleased to have the opportunity to provide these services to you. If you have questions concerning the content of this report, or if CG2 can be of further service, please contact CG2 at (980) 339-8684.

Sincerely,
**Carolinas Geotechnical Group, PLLC**

DocuSigned by:
D. Matthew Brewer
386129C0A4C1462...
D. Matthew Brewer, PE
Senior Project Engineer

DocuSigned by:
Robert E Kral
8AD703B2A8484F4...
Robert E. Kral, PE
Senior Project Engineer
NC Registration No. 042642

NORTH CAROLINA PROFESSIONAL SEAL 042642 ENGINEER ROBERT E. KRAL

**Appendices:**

- Appendix I - CME 45B Trailer Rig (SN 303304) SPT Energy Measurements Summary Plots and Tables
- Appendix II - SPT Hammer Energy Field Form (Field Log) and Drill Rig Photo Log
- Appendix III - Instrumented Rod and Accelerometer Calibration Sheets
- Appendix IV - Certificate of Proficiency

# APPENDIX I

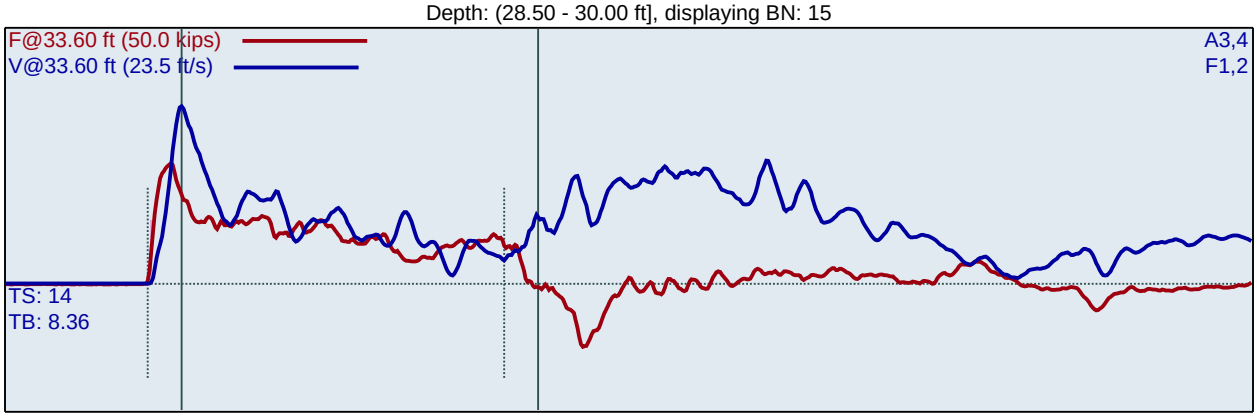
CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in^2
LE: 33.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (28.50 - 30.00 ft], displaying BN: 15




F1 : [528AWJ1] 205.26 PDICAL (1) FF1
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

BPM: Blows/Minute
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement

CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

| LP | BL# | BC | BPM | FMX | VMX | DMX | CSX | DFN | EFV | ETR |
|---|---|---|---|---|---|---|---|---|---|---|
| ft | | /6" | bpm | kips | ft/s | in | ksi | in | ft-lb | % |
| 28.63 | 1 | 4 | 1.9 | 23.8 | 15.1 | 2.0 | 20.0 | 1.5 | 258.9 | 74.0 |
| 28.75 | 2 | 4 | 52.7 | 25.1 | 15.4 | 1.6 | 21.1 | 1.5 | 269.5 | 77.0 |
| 28.88 | 3 | 4 | 53.1 | 25.1 | 15.7 | 1.6 | 21.1 | 1.5 | 272.5 | 77.8 |
| 29.00 | 4 | 4 | 53.5 | 24.6 | 15.4 | 1.5 | 20.7 | 1.5 | 269.5 | 77.0 |
| 29.08 | 5 | 6 | 53.4 | 25.0 | 15.6 | 1.2 | 21.0 | 1.0 | 273.5 | 78.2 |
| 29.17 | 6 | 6 | 53.3 | 24.8 | 15.7 | 1.1 | 20.8 | 1.0 | 274.5 | 78.4 |
| 29.25 | 7 | 6 | 53.4 | 24.6 | 15.7 | 1.1 | 20.7 | 1.0 | 277.2 | 79.2 |
| 29.33 | 8 | 6 | 53.3 | 24.7 | 16.0 | 1.1 | 20.8 | 1.0 | 274.8 | 78.5 |
| 29.42 | 9 | 6 | 53.4 | 24.6 | 16.0 | 1.1 | 20.6 | 1.0 | 275.4 | 78.7 |
| 29.50 | 10 | 6 | 53.7 | 24.3 | 15.9 | 1.1 | 20.4 | 1.0 | 276.7 | 79.1 |
| 29.57 | 11 | 7 | 53.3 | 24.6 | 16.3 | 1.0 | 20.7 | 0.9 | 281.6 | 80.4 |
| 29.64 | 12 | 7 | 53.3 | 24.1 | 16.2 | 1.1 | 20.2 | 0.9 | 279.6 | 79.9 |
| 29.71 | 13 | 7 | 53.5 | 23.8 | 16.1 | 1.1 | 20.0 | 0.9 | 280.2 | 80.0 |
| 29.79 | 14 | 7 | 53.7 | 23.7 | 16.5 | 1.0 | 19.9 | 0.9 | 278.2 | 79.5 |
| 29.86 | 15 | 7 | 53.2 | 23.6 | 16.3 | 1.0 | 19.8 | 0.9 | 277.1 | 79.2 |
| 29.93 | 16 | 7 | 53.4 | 23.3 | 15.7 | 0.9 | 19.6 | 0.9 | 278.7 | 79.6 |
| 30.00 | 17 | 7 | 53.5 | 23.2 | 17.1 | 0.9 | 19.5 | 0.9 | 280.6 | 80.2 |
| | | Average | 53.4 | 24.2 | 16.1 | 1.1 | 20.3 | 0.9 | 277.5 | 79.3 |
| | | Std Dev | 0.1 | 0.6 | 0.4 | 0.1 | 0.5 | 0.1 | 2.4 | 0.7 |
| | | Maximum | 53.7 | 25.0 | 17.1 | 1.2 | 21.0 | 1.0 | 281.6 | 80.4 |
| | | Minimum | 53.2 | 23.2 | 15.6 | 0.9 | 19.5 | 0.9 | 273.5 | 78.2 |

N-value: 13

Sample Interval Time: 17.92 seconds.

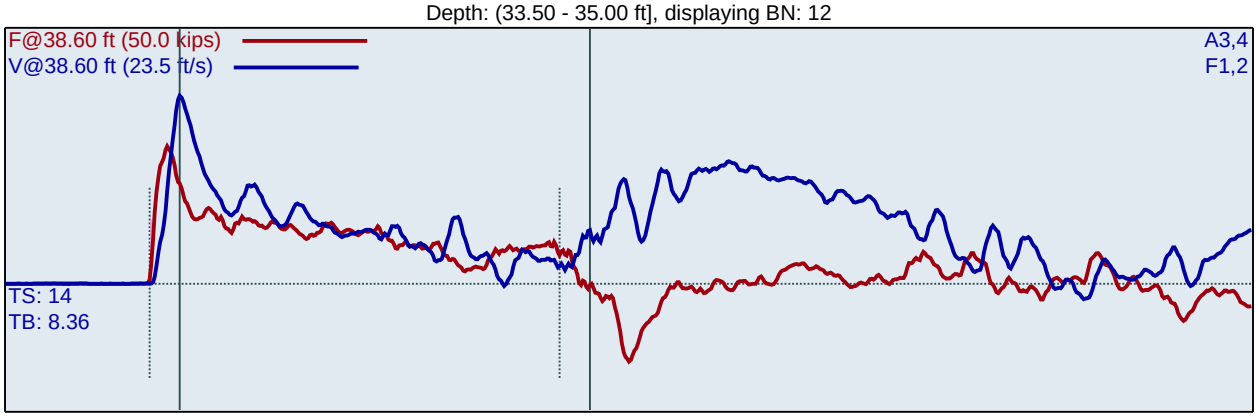
CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in^2
LE: 38.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (33.50 - 35.00 ft], displaying BN: 12




F1 : [528AWJ1] 205.26 PDICAL (1) FF1
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

| LP ft | BL# | BC /6" | BPM bpm | FMX kips | VMX ft/s | DMX in | CSX ksi | DFN in | EFV ft-lb | ETR % |
|---|---|---|---|---|---|---|---|---|---|---|
| 33.67 | 1 | 3 | 1.9 | 27.2 | 16.3 | 2.3 | 22.8 | 2.0 | 290.7 | 83.0 |
| 33.83 | 2 | 3 | 60.1 | 27.7 | 17.1 | 2.0 | 23.2 | 2.0 | 300.3 | 85.8 |
| 34.00 | 3 | 3 | 60.9 | 27.7 | 17.1 | 2.0 | 23.3 | 2.0 | 302.3 | 86.4 |
| 34.10 | 4 | 5 | 61.4 | 27.6 | 16.8 | 1.3 | 23.2 | 1.2 | 293.7 | 83.9 |
| 34.20 | 5 | 5 | 58.8 | 27.3 | 16.7 | 1.3 | 22.9 | 1.2 | 286.9 | 82.0 |
| 34.30 | 6 | 5 | 57.9 | 27.1 | 16.9 | 1.2 | 22.8 | 1.2 | 288.5 | 82.4 |
| 34.40 | 7 | 5 | 57.7 | 27.5 | 17.0 | 1.2 | 23.2 | 1.2 | 288.2 | 82.3 |
| 34.50 | 8 | 5 | 57.9 | 26.7 | 16.8 | 1.2 | 22.5 | 1.2 | 292.5 | 83.6 |
| 34.58 | 9 | 6 | 57.8 | 26.6 | 17.0 | 1.1 | 22.4 | 1.0 | 290.0 | 82.9 |
| 34.67 | 10 | 6 | 58.1 | 26.9 | 17.0 | 1.0 | 22.6 | 1.0 | 287.6 | 82.2 |
| 34.75 | 11 | 6 | 58.1 | 26.6 | 17.1 | 1.0 | 22.4 | 1.0 | 288.5 | 82.4 |
| 34.83 | 12 | 6 | 57.8 | 26.9 | 17.3 | 1.0 | 22.6 | 1.0 | 298.0 | 85.1 |
| 34.92 | 13 | 6 | 58.1 | 26.5 | 17.2 | 1.0 | 22.3 | 1.0 | 295.9 | 84.6 |
| 35.00 | 14 | 6 | 58.2 | 26.2 | 17.0 | 1.0 | 22.0 | 1.0 | 295.4 | 84.4 |
| | | Average | 58.3 | 26.9 | 17.0 | 1.1 | 22.6 | 1.1 | 291.4 | 83.3 |
| | | Std Dev | 1.0 | 0.4 | 0.2 | 0.1 | 0.4 | 0.1 | 3.7 | 1.1 |
| | | Maximum | 61.4 | 27.6 | 17.3 | 1.3 | 23.2 | 1.2 | 298.0 | 85.1 |
| | | Minimum | 57.7 | 26.2 | 16.7 | 1.0 | 22.0 | 1.0 | 286.9 | 82.0 |

N-value: 11

Sample Interval Time: 13.30 seconds.

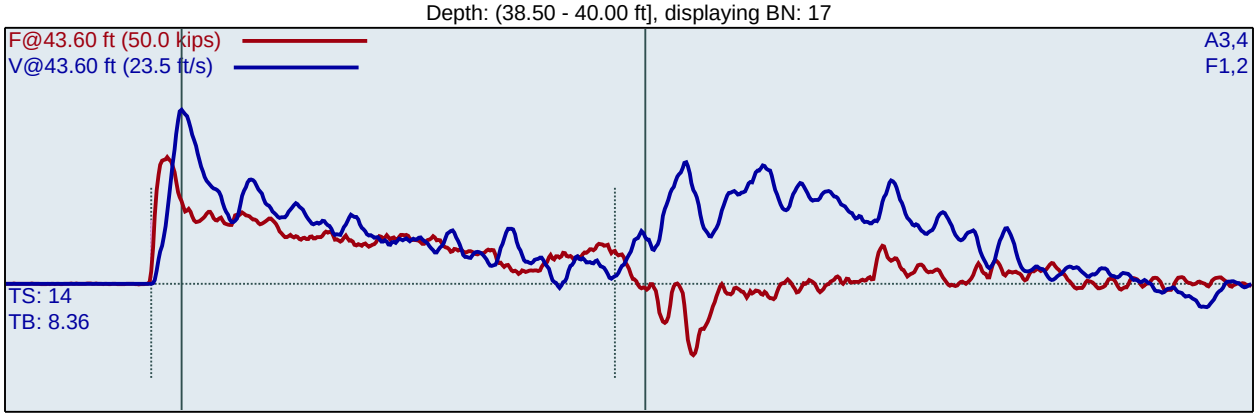
CME 45B (SN 303304)
REK
B-1

B-1
Interval start: 3/11/2022

AR: 1.19 in^2
LE: 43.60 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (38.50 - 40.00 ft], displaying BN: 17




F1 : [528AWJ1] 205.26 PDICAL (1) FF1
F2 : [528AWJ2] 205.86 PDICAL (1) FF1

A3 (PR): [K11957] 407.045 mv/6.4v/5000g (1) VF1
A4 (PR): [K10959] 417.27 mv/6.4v/5000g (1) VF1

| LP ft | BL# | BC /6" | BPM bpm | FMX kips | VMX ft/s | DMX in | CSX ksi | DFN in | EFV ft-lb | ETR % |
|---|---|---|---|---|---|---|---|---|---|---|
| 38.63 | 1 | 4 | 1.9 | 26.6 | 16.9 | 2.2 | 22.3 | 1.5 | 303.5 | 86.7 |
| 38.75 | 2 | 4 | 59.6 | 25.2 | 16.8 | 1.8 | 21.2 | 1.5 | 301.7 | 86.2 |
| 38.88 | 3 | 4 | 59.9 | 25.2 | 16.3 | 1.5 | 21.2 | 1.5 | 295.2 | 84.3 |
| 39.00 | 4 | 4 | 56.8 | 24.6 | 16.3 | 1.5 | 20.7 | 1.5 | 291.6 | 83.3 |
| 39.08 | 5 | 6 | 55.7 | 24.9 | 16.0 | 1.2 | 20.9 | 1.0 | 290.3 | 82.9 |
| 39.17 | 6 | 6 | 55.5 | 24.9 | 16.0 | 1.2 | 21.0 | 1.0 | 290.4 | 83.0 |
| 39.25 | 7 | 6 | 56.0 | 24.7 | 16.2 | 1.2 | 20.8 | 1.0 | 288.0 | 82.3 |
| 39.33 | 8 | 6 | 55.4 | 25.2 | 16.2 | 1.1 | 21.2 | 1.0 | 287.7 | 82.2 |
| 39.42 | 9 | 6 | 55.7 | 25.1 | 15.8 | 1.0 | 21.1 | 1.0 | 283.1 | 80.9 |
| 39.50 | 10 | 6 | 55.3 | 24.9 | 15.8 | 1.0 | 21.0 | 1.0 | 288.5 | 82.4 |
| 39.56 | 11 | 9 | 55.5 | 24.5 | 16.0 | 0.8 | 20.6 | 0.7 | 286.8 | 82.0 |
| 39.61 | 12 | 9 | 55.7 | 24.6 | 16.0 | 0.8 | 20.7 | 0.7 | 284.4 | 81.3 |
| 39.67 | 13 | 9 | 55.4 | 24.4 | 16.2 | 0.8 | 20.5 | 0.7 | 289.2 | 82.6 |
| 39.72 | 14 | 9 | 55.4 | 24.4 | 15.9 | 0.8 | 20.5 | 0.7 | 283.6 | 81.0 |
| 39.78 | 15 | 9 | 55.3 | 24.7 | 15.9 | 0.8 | 20.7 | 0.7 | 287.0 | 82.0 |
| 39.83 | 16 | 9 | 55.5 | 24.0 | 15.6 | 0.8 | 20.2 | 0.7 | 284.1 | 81.2 |
| 39.89 | 17 | 9 | 55.6 | 24.8 | 16.0 | 0.7 | 20.8 | 0.7 | 283.9 | 81.1 |
| 39.94 | 18 | 9 | 55.6 | 24.4 | 15.7 | 0.7 | 20.5 | 0.7 | 284.9 | 81.4 |
| 40.00 | 19 | 9 | 55.4 | 24.2 | 16.2 | 0.8 | 20.3 | 0.7 | 289.6 | 82.7 |
| | | Average | 55.5 | 24.7 | 16.0 | 0.9 | 20.7 | 0.8 | 286.8 | 81.9 |
| | | Std Dev | 0.2 | 0.3 | 0.2 | 0.2 | 0.3 | 0.2 | 2.5 | 0.7 |
| | | Maximum | 56.0 | 25.2 | 16.2 | 1.2 | 21.2 | 1.0 | 290.4 | 83.0 |
| | | Minimum | 55.3 | 24.0 | 15.6 | 0.7 | 20.2 | 0.7 | 283.1 | 80.9 |

N-value: 15

Sample Interval Time: 19.28 seconds.

**Summary of SPT Test Results**

Project: CME 45B (SN 303304), Test Date: 3/11/2022

BPM: Blows/Minute
FMX: Maximum Force
VMX: Maximum Velocity
DMX: Maximum Displacement
CSX: Compression Stress Maximum
DFN: Final Displacement
EFV: Maximum Energy
ETR: Energy Transfer Ratio - Rated

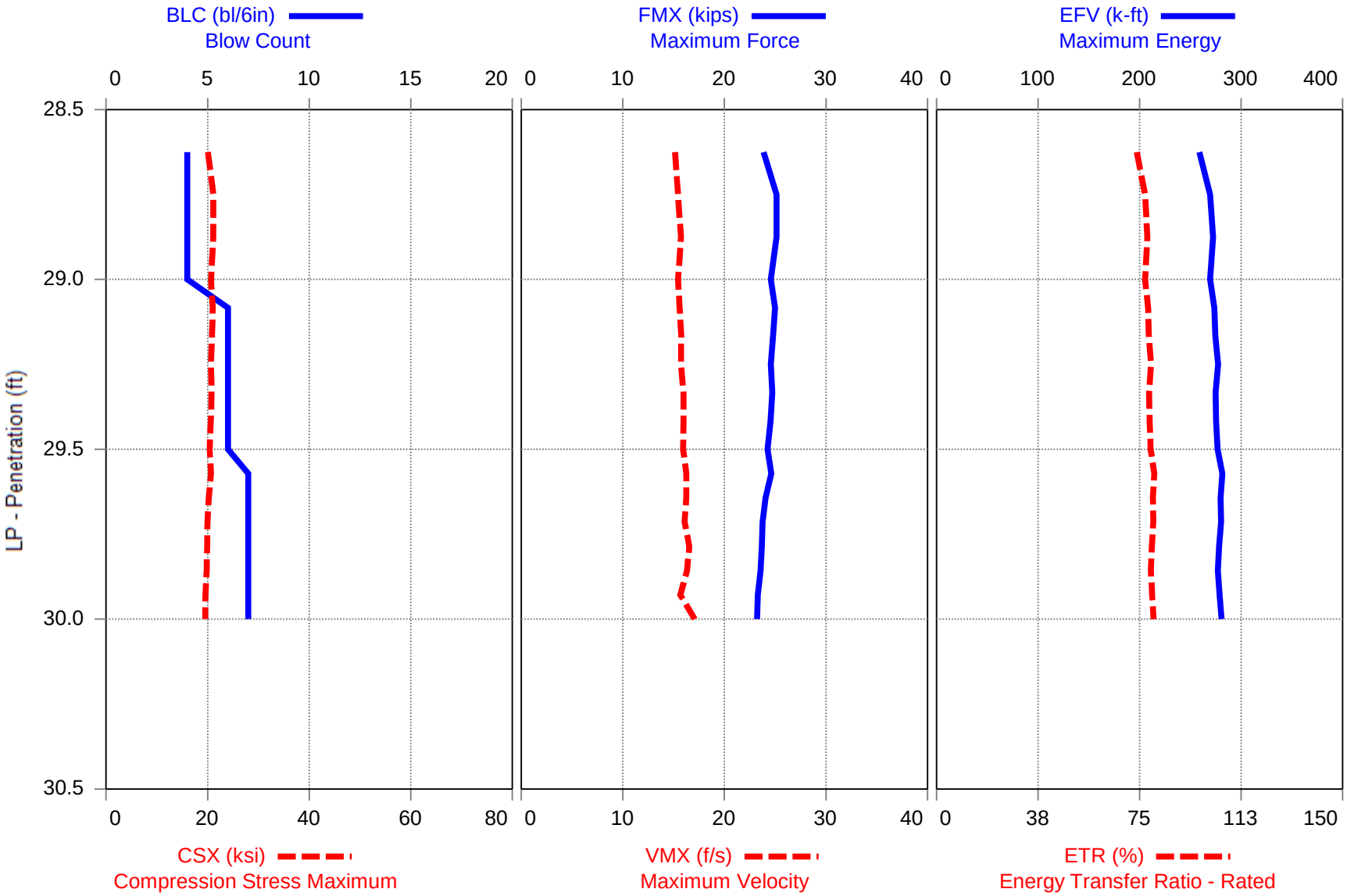
| Instr. Length ft | Start Depth ft | Final Depth ft | Blows Applied /6" | **N Value** | **N60 Value** | Average BPM bpm | Average FMX kips | Average VMX ft/s | Average DMX in | Average CSX ksi | Average DFN in | Average EFV ft-lb | Average ETR % |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 33.60 | 28.50 | 30.00 | **4-6-7** | **13** | **17** | 53.4 | 24.2 | 16.1 | 1.1 | 20.3 | 0.9 | 277.5 | 79.3 |
| 38.60 | 33.50 | 35.00 | **3-5-6** | **11** | **14** | 58.3 | 26.9 | 17.0 | 1.1 | 22.6 | 1.1 | 291.4 | 83.3 |
| 43.60 | 38.50 | 40.00 | **4-6-9** | **15** | **20** | 55.5 | 24.7 | 16.0 | 0.9 | 20.7 | 0.8 | 286.8 | 81.9 |
| | | | | | **Overall Average Values:** | 55.6 | 25.1 | 16.3 | 1.0 | 21.1 | 0.9 | 285.0 | 81.4 |
| | | | | | **Standard Deviation:** | 2.0 | 1.2 | 0.5 | 0.2 | 1.0 | 0.2 | 6.3 | 1.8 |
| | | | | | **Overall Maximum Value:** | 61.4 | 27.6 | 17.3 | 1.3 | 23.2 | 1.2 | 298.0 | 85.1 |
| | | | | | **Overall Minimum Value:** | 53.2 | 23.2 | 15.6 | 0.7 | 19.5 | 0.7 | 273.5 | 78.2 |

Pile Dynamics, Inc. - PDIPLOT2 Ver 2021.1.61.0 - Case Method & iCAP® Results

Printed: 23-March-2022

Test started: 11-March-2022

CME 45B (SN 303304) - 28.5 TO 30.0

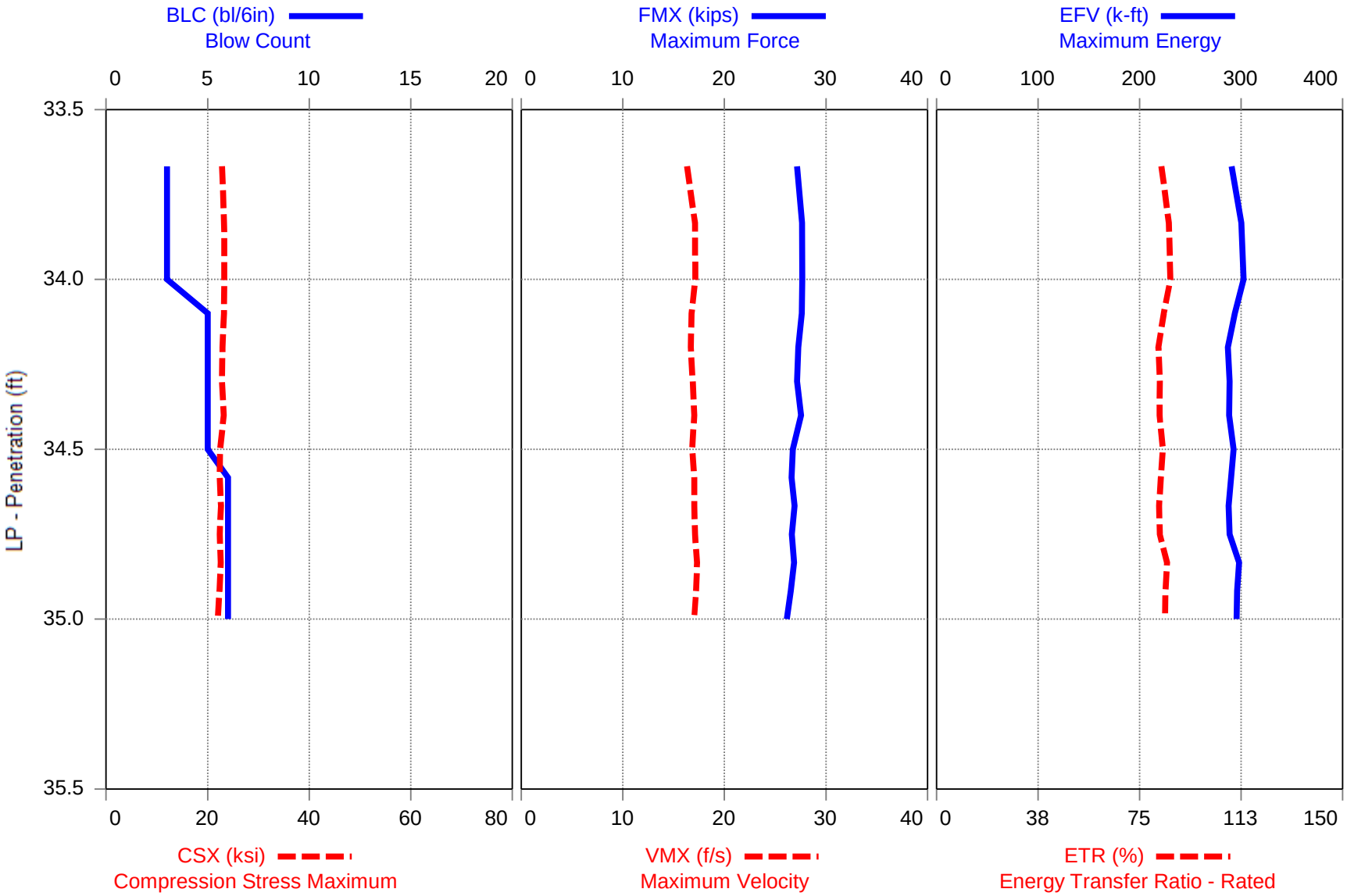


Pile Dynamics, Inc. - PDIPLOT2 Ver 2021.1.61.0 - Case Method & iCAP® Results

Printed: 23-March-2022

Test started: 11-March-2022

CME 45B (SN 303304) - 33.5 TO 35.0

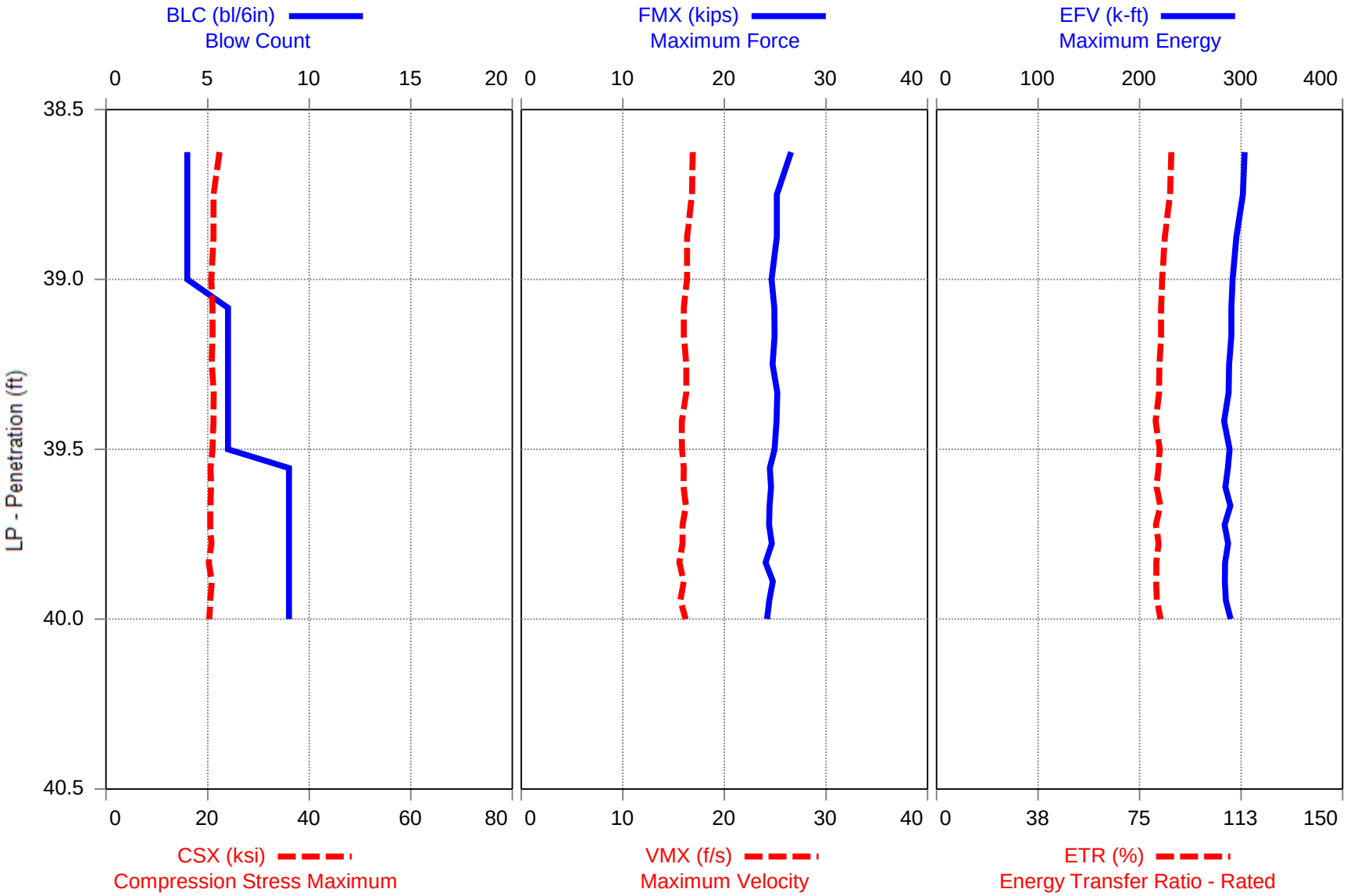


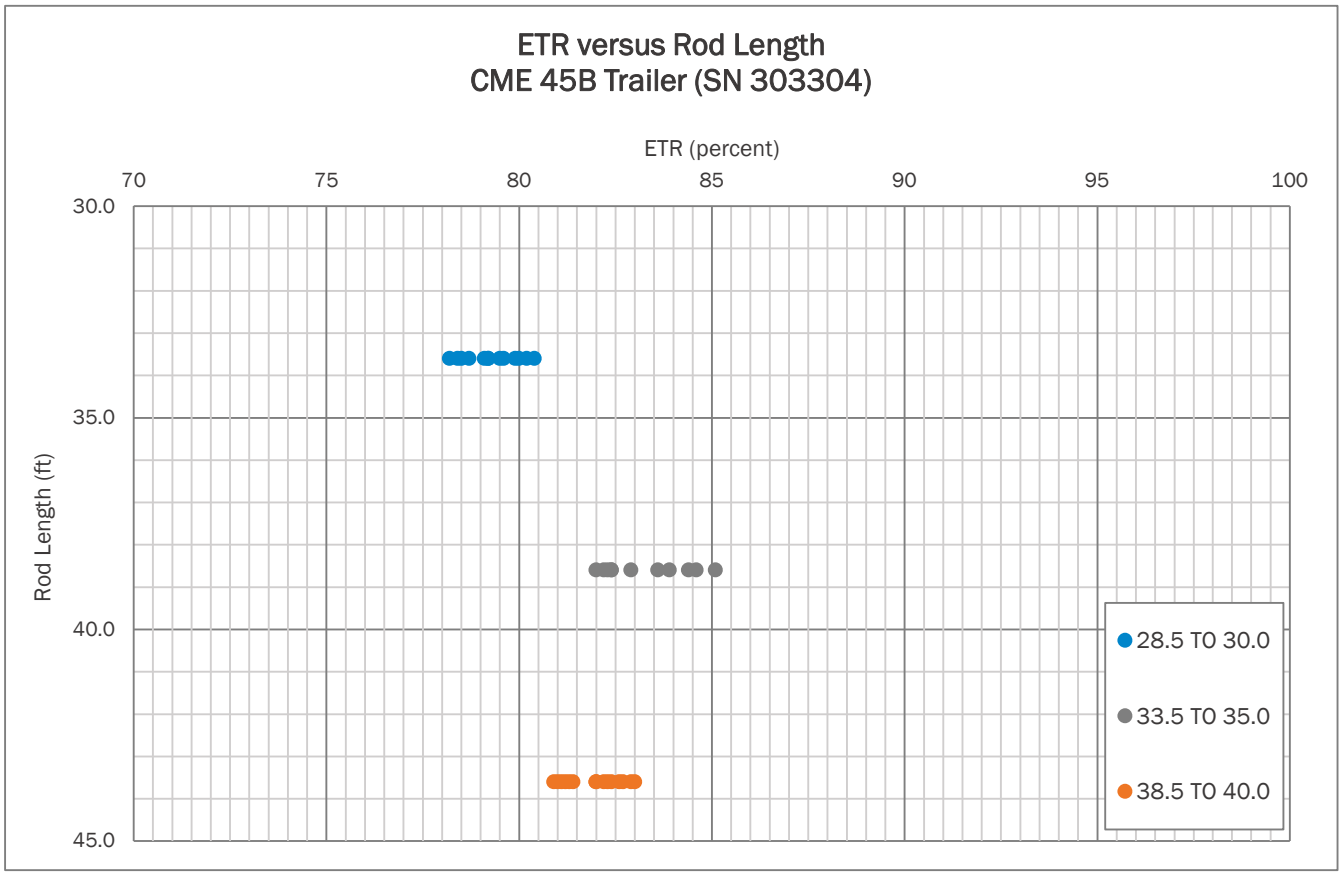
Pile Dynamics, Inc. - PDIPLOT2 Ver 2021.1.61.0 - Case Method & iCAP® Results

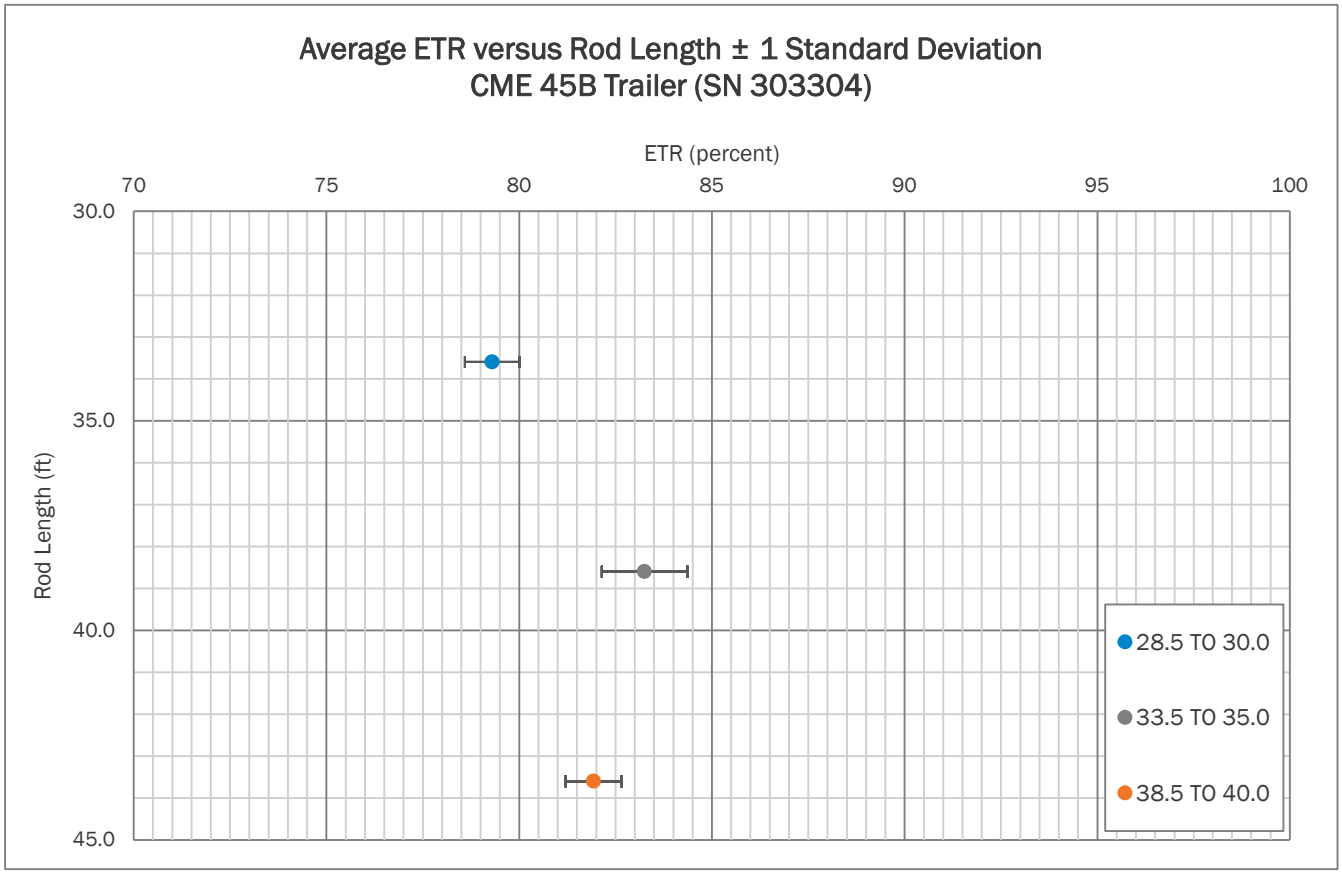
Printed: 23-March-2022

Test started: 11-March-2022

CME 45B (SN 303304) - 38.5 TO 40.0




ETR versus Rod Length
CME 45B Trailer (SN 303304)
ETR (percent)
70
75
80
85
90
95
100
Rod Length (ft)
30.0
35.0
40.0
45.0
28.5 TO 30.0
33.5 TO 35.0
38.5 TO 40.0


Average ETR versus Rod Length ± 1 Standard Deviation
CME 45B Trailer (SN 303304)
ETR (percent)
70
75
80
85
90
95
100
Rod Length (ft)
30.0
35.0
40.0
45.0
28.5 TO 30.0
33.5 TO 35.0
38.5 TO 40.0

# APPENDIX II

# SPT Hammer Energy Field Form

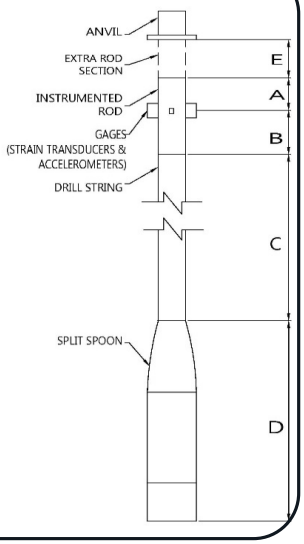
| | | | |
|---|---|---|---|
| **Project:** | SPT HAMMER ENERGY | **Date:** | 3/11/2022 |
| **Project No.:** | 240021095 | **Weather:** | 50's CLOUDY |
| **Boring No.:** | B-1 | **Drill Rod Type:** | AWJ |

### *On-site Personnel*

| | |
|---|---|
| Drilling Company: | BRECCIA CONSTRUCTION, LLC |
| Rig Operator: | D. HARRIS |
| Engr/Geologist: | N/A |
| Client Rep.: | N/A |
| Analyzer Oper.: | R. KRAL |

### *Rod Info*

| | | |
|---|---|---|
| ***(A + E)*** Impact Surface to Gages Length: | 1.36 | ft |
| ***(B)*** Instr. Rod Length below Gages: | 0.70 | ft |
| ***(A) + (B)*** Instr. Rod Length: | 2.00 | ft |
| ***(D)*** Spoon Length: | 2.85 | ft |
| ***(E)*** Rod Length Above Instr. Rod (if applicable): | 0.06 | ft |
| Instr. Rod S/N: | 528AWJ | |
| Instr. Rod Outside Dia.: | 1.75 | in. |
| Instr. Rod Area: | 1.19 | $in^2$ |
| PDA Make/Model: | SPT | |
| PDA Serial No.: | 4549 TB | |
| Calib. Pulse Test (y/n): | Y | |




### *Rig/Hammer Info*

| | |
|---|---|
| Drill Rig Make/Model: | CME 45B |
| Carrier Type: | TRAILER |
| Rig Serial No.: | 303304 (DR-1) |
| Hammer Type/Model: | CME |
| Hammer Serial No.: | N/A |
| Hammer Drop System: | AUTO |
| Lubrication Condition: | PER MANUFACTURER |
| Manufacturer Recommended Operation Rate (bpm): | 55 |
| Drop Height (in.): | 30 |
| Hammer Weight (lbs): | 140 |
| Anvil Dimension (in.): | 11.5 |
| Drilling Method: | 2.25 HSA |

### *Gage Info*

| Gage | | Serial No. | Calibration No. |
|---|---|---|---|
| Accel. | A3 | K11957 | 407.00 |
| | A4 | K10959 | 417.30 |
| Strain | F3 | 528AWJ-1 | 205.26 |
| | F4 | 528AWJ-2 | 205.86 |

| Date of Test | Test Depth Increment (ft to ft) | Test Time Start / Stop (military) | Length of Drill String (ft) *(C)* | (LE) Length below Gages (ft) *(B) + (C) + (D)* | Avg. Meas. Hammer Rate (BPM) | SPT Blow Counts 6" | 12" | 18" | N-Value | Drop Height in Tolerance (y/n) | Soil Class. |
|---|---|---|---|---|---|---|---|---|---|---|---|
| 11-Mar | 28.5 TO 30.0 | 0830/0830 | 30 | 33.6 | 53 | 4 | 6 | 7 | 13 | Y | SA SI |
| 11-Mar | 33.5 TO 35.0 | 0837/0837 | 35 | 38.6 | 57 | 3 | 5 | 6 | 11 | Y | SA SI |
| 11-Mar | 38.5 TO 40.0 | 0842/0843 | 40 | 43.6 | 56 | 4 | 6 | 9 | 15 | Y | SA SI |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |
| | | | | | | | | | | | |

*Notes:*
TESTING PERFORMED AT 1817 LOWRYS HIGHWAY IN CHESTER, SOUTH CAROLINA (CHESTER COUNTY). THE APPROXIMATE COORDINATES ARE 34.770585, -81.245517.

NOTE: (1) Note any unusual hammer operating conditions that affect the hammer performance, or changes in operating conditions (e.g. veritcality, weather, or lubrication between trials). (2) Note any changes in rod diameter along drill string and record locations of short rod sections.

Prepared By (print/signature) — Date: 3/11/2022

Figure No. 1: Rear View of Drill Rig

Figure No. 2: Side View of Drill Rig

Figure No. 3: Serial Number Plate

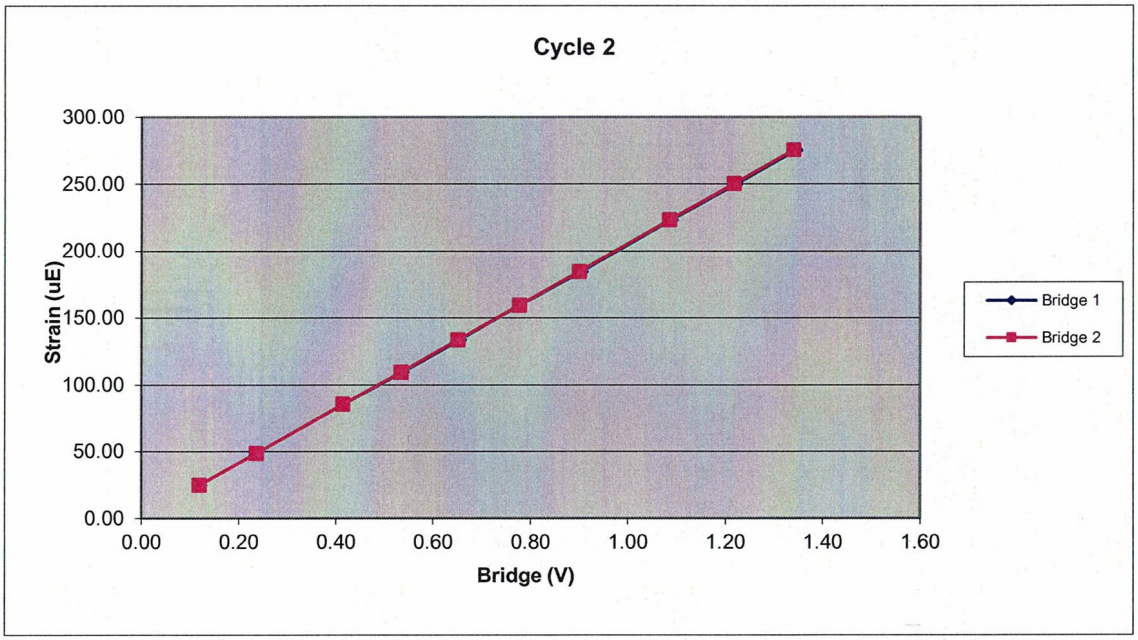
Figure No. 4: Automatic Hammer

# APPENDIX III

| 528AWJ | | Cycle 2 | | |
|---|---|---|---|---|
| **Sample** | **Force (lb)** | **Strain (µE)** | **Bridge 1 (V)** | **Bridge 2 (V)** |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 905.16 | 24.61 | 0.12 | 0.12 |
| 3 | 1753.20 | 48.18 | 0.24 | 0.24 |
| 4 | 3064.74 | 84.99 | 0.42 | 0.41 |
| 5 | 3947.87 | 108.99 | 0.54 | 0.53 |
| 6 | 4813.36 | 133.40 | 0.65 | 0.65 |
| 7 | 5727.49 | 159.02 | 0.78 | 0.78 |
| 8 | 6643.67 | 184.17 | 0.90 | 0.90 |
| 9 | 8004.82 | 222.89 | 1.09 | 1.09 |
| 10 | 8980.07 | 249.70 | 1.22 | 1.22 |
| 11 | 9885.91 | 275.04 | 1.35 | 1.34 |

| **Bridge 1** | | **Bridge 2** | |
|---|---|---|---|
| **Force Calibration (lb/V)** | **7340.27** | **Force Calibration (lb/V)** | **7362.32** |
| Offset | **12.98** | Offset | **13.21** |
| Correlation | **1.000000** | Correlation | **0.999999** |
| **Strain Calibration (µE/V)** | **204.74** | **Strain Calibration (µE/V)** | **205.35** |
| Offset | **-0.39** | Offset | **-0.39** |
| Correlation | **0.999993** | Correlation | **0.999995** |

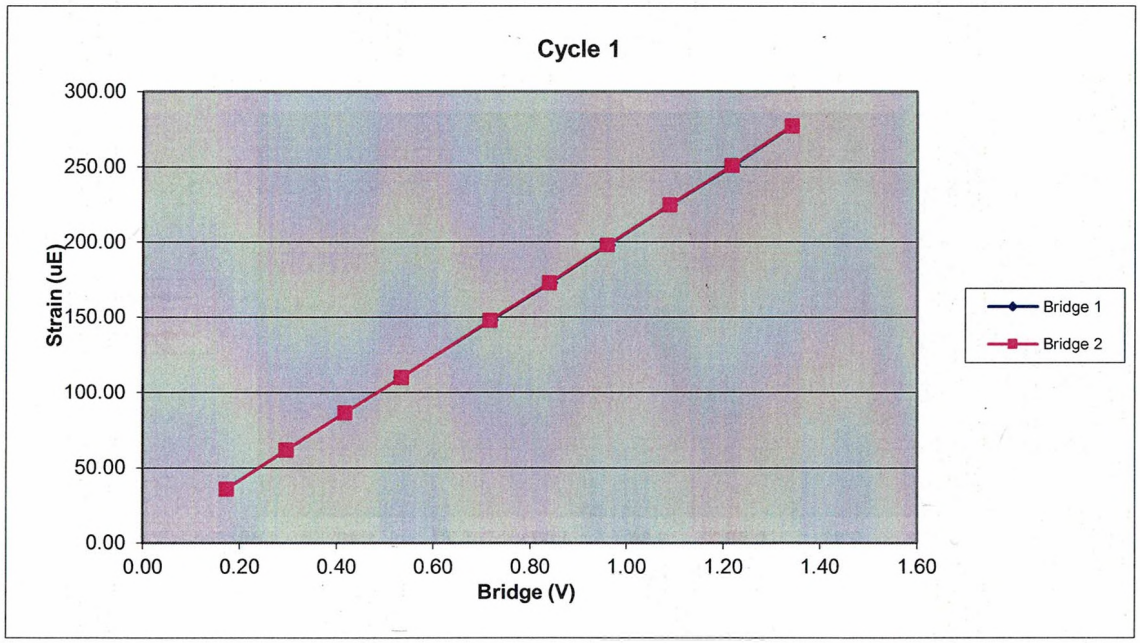
| **Force Strain Calibration** | |
|---|---|
| **EA (Kips)** | **35851.72** |
| Offset | **27.08** |
| Correlation | **0.999996** |



| 528AWJ | | Cycle 1 | | |
|---|---|---|---|---|
| **Sample** | **Force (lb)** | **Strain (μE)** | **Bridge 1 (V)** | **Bridge 2 (V)** |
| 1 | 0.00 | 0.00 | 0.00 | 0.00 |
| 2 | 1278.49 | 35.63 | 0.17 | 0.17 |
| 3 | 2188.92 | 61.59 | 0.30 | 0.30 |
| 4 | 3085.11 | 86.16 | 0.42 | 0.42 |
| 5 | 3944.56 | 110.01 | 0.53 | 0.54 |
| 6 | 5284.17 | 147.69 | 0.72 | 0.72 |
| 7 | 6199.57 | 172.59 | 0.84 | 0.84 |
| 8 | 7071.20 | 197.80 | 0.96 | 0.96 |
| 9 | 8023.54 | 224.47 | 1.09 | 1.09 |
| 10 | 8958.62 | 250.45 | 1.22 | 1.22 |
| 11 | 9876.55 | 276.81 | 1.34 | 1.34 |

| **Bridge 1** | | **Bridge 2** | |
|---|---|---|---|
| **Force Calibration (lb/V)** | **7346.16** | **Force Calibration (lb/V)** | **7359.87** |
| Offset | 9.71 | Offset | 6.72 |
| Correlation | 0.999998 | Correlation | 0.999999 |
| **Strain Calibration (μE/V)** | **205.65** | **Strain Calibration (μE/V)** | **206.03** |
| Offset | 0.08 | Offset | -0.01 |
| Correlation | 0.999990 | Correlation | 0.999993 |

| **Force Strain Calibration** | |
|---|---|
| **EA (Kips)** | **35721.25** |
| Offset | 7.11 |
| Correlation | 0.999990 |



Bridge Excitation (V) 5
Shunt Resitor (ohm) 60.4k

| Calibration Factors | 528AWJ | | |
|---|---|---|---|
| Bridge 1 (µE/V) | 205.26 | Bridge 2 (µE/V) | 205.86 |
| EA Factor (Kips) | 35777.05 | Area (in^2) | 1.19 |

Calibrated by: _____
Calibrated Date: 1/28/2021

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

Traceable to N.I.S.T.

# Accelerometer Calibration Certificate
# Pile Dynamics, Inc.

**Calibrated by Pile Dynamics, Inc.**
**Calibration performed on 19Apr2021**

| | | | |
|---|---|---|---|
| **Serial No:** | K10959 | **Temperature:** | 21.0 °C |
| **Model:** | PR | **Humidity:** | 38% |
| **Calibrated on:** | Channel 3 on 8G 5161 LE | | |

| | | | |
|---|---|---|---|
| **Ref Acc 1:** | 69096!<br>978 g's/volt | **Cal on:** | 27Jan2021 |
| **Ref Acc 2:** | 69132!<br>960 g's/volt | **Cal on:** | 09Feb2021 |

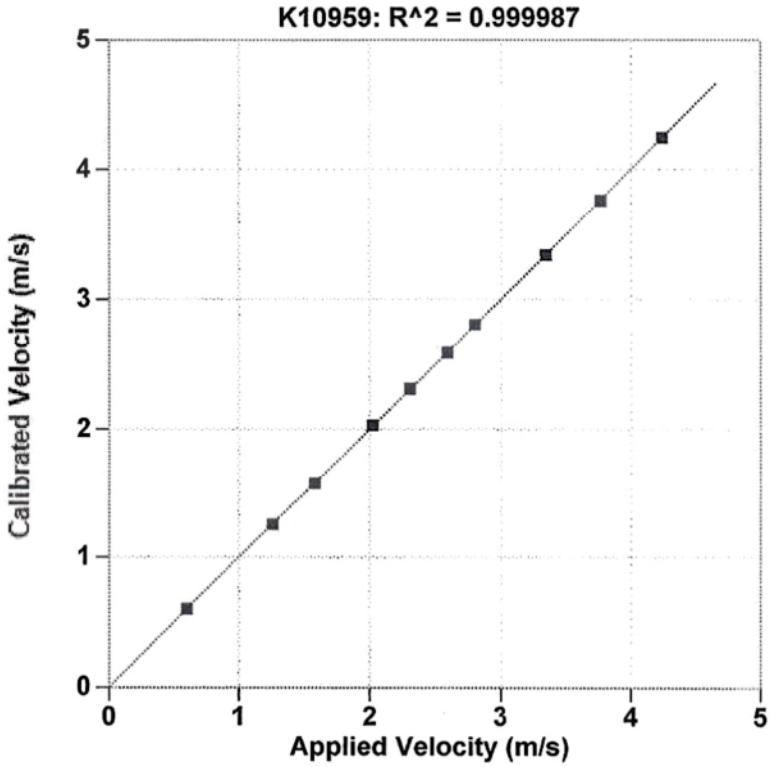
**Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).**

**PDA CALIBRATION FACTOR**

**417.3 mv/5000g**
(83.5 µv/g)
R^2: 0.999987 [Chip programmed]

Operator: William Johnson

Signed




| Reference Velocity | S/N K10959 Velocity |
|---|---|
| m/s | m/s |
| 0.600 | 0.600 |
| 1.260 | 1.255 |
| 1.578 | 1.577 |
| 2.021 | 2.028 |
| 2.306 | 2.311 |
| 2.590 | 2.590 |
| 2.801 | 2.806 |
| 3.346 | 3.344 |
| 3.767 | 3.762 |
| 4.241 | 4.241 |

Maximum Acceleration: 938 g's

# Accelerometer Calibration Certificate
# Pile Dynamics, Inc.

**Calibrated by Pile Dynamics, Inc.**
**Calibration performed on 22Jan2021**

| | | | |
|---|---|---|---|
| **Serial No:** | K10960 | **Temperature:** | 20.0 °C |
| **Model:** | PR | **Humidity:** | 28% |
| **Calibrated on:** | Channel 4 on 8G 5161 LE | | |

| | | | |
|---|---|---|---|
| **Ref Acc 1:** | 63479!<br>1080 g's/volt | **Cal on:** | 09Sep2020 |
| **Ref Acc 2:** | 65538!<br>1040 g's/volt | **Cal on:** | 27Jan2020 |

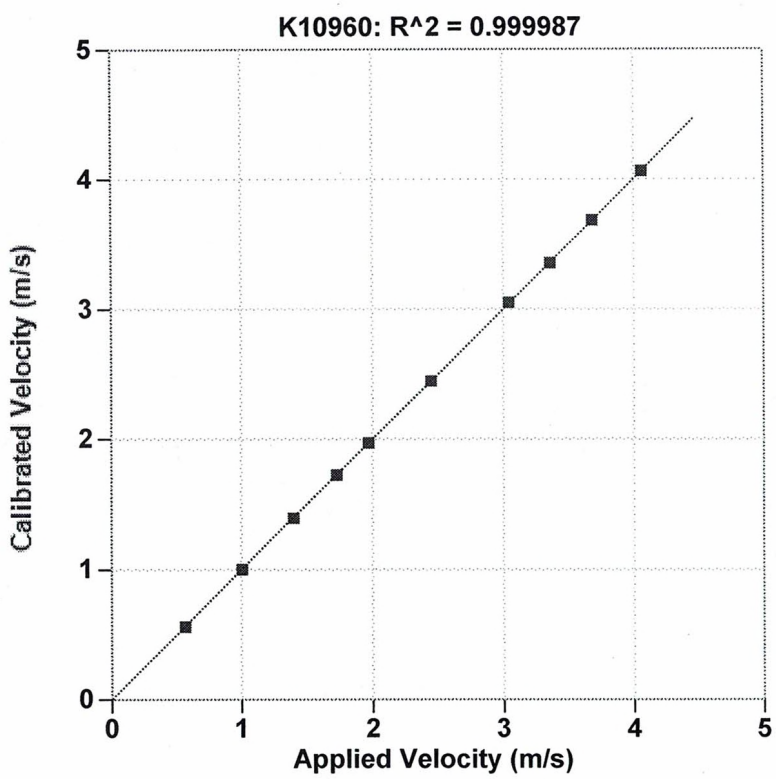
**Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).**

**PDA CALIBRATION FACTOR**

**425.7 mv/5000g**
(85.1 μv/g)
R^2: 0.999987 [Chip programmed]

Operator: William Johnson

Signed




| Reference Velocity | S/N K10960 Velocity |
|---|---|
| m/s | m/s |
| 0.568 | 0.564 |
| 1.006 | 1.001 |
| 1.400 | 1.393 |
| 1.728 | 1.726 |
| 1.969 | 1.970 |
| 2.447 | 2.448 |
| 3.043 | 3.051 |
| 3.359 | 3.356 |
| 3.683 | 3.684 |
| 4.063 | 4.062 |

Maximum Acceleration: 889 g's

# Accelerometer Calibration Certificate
# Pile Dynamics, Inc.

**Calibrated by Pile Dynamics, Inc.**
**Calibration performed on** MAR 2 2021

| | | | |
|---|---|---|---|
| **Serial No:** | K11957 | **Temperature:** | 20.0 °C |
| **Model:** | PR | **Humidity:** | 27% |
| **Calibrated on:** | Channel 4 on 8G 5161 LE | | |

| | | | |
|---|---|---|---|
| **Ref Acc 1:** | 63479!<br>1079 g's/volt | **Cal on:** | 22Jan2021 |
| **Ref Acc 2:** | 65538!<br>1043 g's/volt | **Cal on:** | 22Jan2021 |

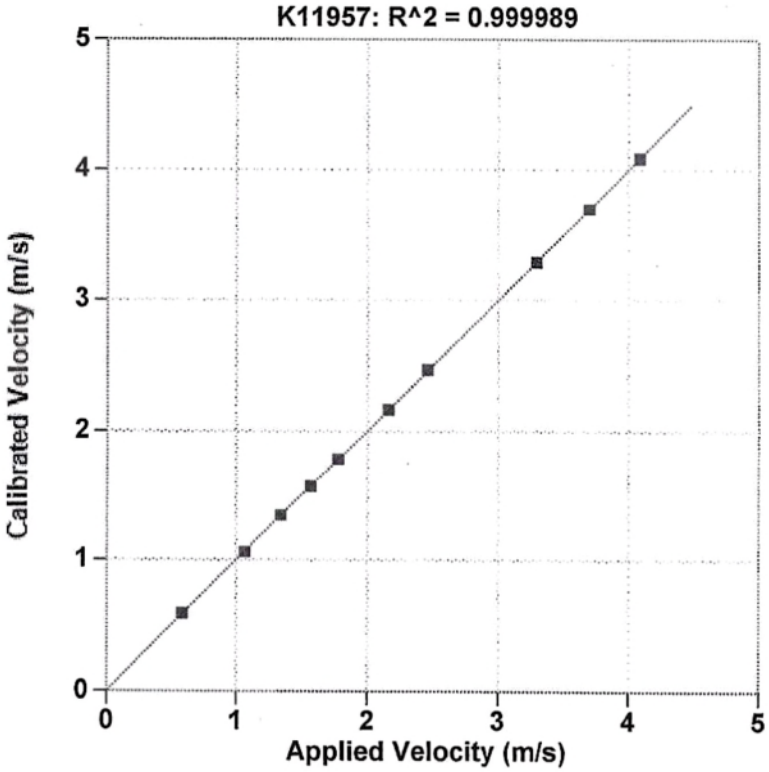
**Reference accelerometer calibrations are traceable to the United States National Institute of Standards and Technology (NIST).**

**PDA CALIBRATION FACTOR**

**407.0 mv/5000g**
(81.4 µv/g)
R^2: 0.999989 [Chip programmed]

Operator: William Johnson

Signed




| Reference Velocity | S/N K11957 Velocity |
|---|---|
| m/s | m/s |
| 0.588 | 0.589 |
| 1.066 | 1.061 |
| 1.344 | 1.345 |
| 1.571 | 1.570 |
| 1.779 | 1.783 |
| 2.161 | 2.164 |
| 2.458 | 2.465 |
| 3.294 | 3.291 |
| 3.701 | 3.700 |
| 4.089 | 4.086 |

Maximum Acceleration: 894 g's

# APPENDIX IV

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

# Robert E. Kral
# Carolinas Geotechnical Group

has on May 20, 2016 achieved the rank of

# ADVANCED

## on the **Dynamic Measurement and Analysis Proficiency Test.**

The individual identified on this document demonstrated to the degree granted above an understanding of theory, data quality evaluation, interpretation and signal matching for high strain dynamic testing of deep foundations. ***It is recommended* that Individuals at the Advanced level seek Master or Expert levels through additional study within six years of the date of this document.**

The ability of the individual named to provide appropriate knowledge and advice on a specific project is not implied or warranted by the Pile Driving Contractors Association or Pile Dynamics, Inc. **This certificate can be verified at www.PDAproficiencytest.com.** The Pile Driving Contractors Association or Pile Dynamics, Inc. assumes no liability for foundation testing and analysis work performed by the bearer of this certificate.

Steven A. Hall, Executive Director
Pile Driving Contractors Association

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2072