GEOTECHNICAL SUBSURFACE DATA REPORT

Carolina Crossroads - Phase 1 Additional Borings
Richland & Lexington County, South Carolina

PREPARED FOR
HDR, Inc.
1122 Lady Street, Suite 1100
Columbia, South Carolina 29201

PREPARED BY
F&ME Consultants, Inc.
1825 Blanding Street
Columbia, South Carolina 29201

SCDOT Project ID: P039718
F&ME Project #: G5662.01

NOVEMBER 23, 2020

November 23, 2020

Ms. Erin Slayton, P.E.
HDR, Inc.
1122 Lady Street, Suite 1100
Columbia, South Carolina 29201

Re.: Geotechnical Subsurface Data Report
Carolina Crossroads – Phase 1 Additional Borings
Richland & Lexington County, South Carolina
SCDOT Project ID: P039718
F&ME File No: G5662.01

Ms. Slayton:

Submitted herein is the Geotechnical Subsurface Data Report (GSDR) for the additional borings performed within the Phase 1 portion of the Carolina Crossroads project. This report includes field test data and laboratory test results from the performed geotechnical investigation.

Please notify us if there are any questions.

Respectfully Submitted,

F&ME CONSULTANTS

2020.11.23 12:27:22-05'00'

John F. Hamilton, P.E.
Geotechnical Design Manager

Attachments

JFH/jfh

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APPENDIX

1. INTRODUCTION

1.1. GENERAL

The site is within the Phase 1 portion of the Carolina Crossroads project. The site is generally located along I-26 Ramp C between the existing I-126 interstate and the Saluda River along the Richland County and Lexington County border in South Carolina. A site location plan is presented in Section 1 of the Appendix.

1.2. SCOPE

F&ME performed geotechnical soil test borings and laboratory testing for the project. The South Carolina Department of Transportation (SCDOT) developed the scope of services for the geotechnical subsurface investigation provided herein. The Scope of Services was submitted to F&ME by HDR via email on October 12, 2020. A copy of the Scope of Services is provided in Section 7 of the Appendix.

The field investigation consisted of Soil Test Borings (STB) with Standard Penetration Testing (SPT) and rock core sampling. Laboratory testing was performed on only rock core specimens collected from the soil test borings. The exploration methods and laboratory procedures were conducted in general accordance with the current American Association of State Highway and Transportation Officials (AASHTO), American Society of Testing and Materials (ASTM) Standards, and the SCDOT Geotechnical Design Manual (GDM). This report was prepared in general accordance with the 2019 SCDOT Geotechnical Design Manual (GDM), Version 2.0.

2. SUBSURFACE INVESTIGATION SUMMARY

From November 3-9, 2020, three (3) soil test borings (designated as B-60A-1, B-60A-2, & B-61A) were performed at the site. The general test boring locations were provided by the SCDOT.

The soil test borings were performed with a CME 550 ATV mounted drill rig. The borings utilized hollow stem auger drilling techniques to maintain a stable borehole. Standard Penetration Testing (SPT's) was continuously obtained in the top ten (10) feet of each boring or to an auger refusal condition. Following the continuous sampling, as necessary, SPT testing was performed on standard five (5) foot intervals. SPT samples were performed in general accordance with ASTM D-1586 to determine the relative densities and consistencies of the subsurface soils and to collect subsurface soil samples. An automatic hammer was used to perform the SPTs. The measured energy ratios for the CME 550 hammer is 86%.

The locations, depths, and elevations of the borings performed for the subsurface investigation are provided in the following table.

Field Investigation Summary Table

Test ID	Test Type	Test Depth (ft)	Station	Offset	Latitude	Longitude	Elevation (ft-MSL)
B-60A-1	STB	10	5414+50	0.3' RT	34.0238283	-81.098425	171.0
B-60A-2	STB w/ RC	28.7	5414+50	2.7' LT	34.0238341	-81.0984181	171.0
B-61A	STB w/ RC	55.3	5410+98	25.0' RT	34.0245688	-81.0991537	171.9

STB=Soil Test Boring
RC=Rock Coring

The collected soil samples were examined and logged in the field by F&ME personnel, sealed in plastic bags, and transported to our laboratory. The soils were visually classified in the field based upon the Unified Soil Classification System.

Rock cores collected from the test borings were also transported to our laboratory for visual inspection and determinations of rock recovery ratios (REC), rock-quality designations (RQD), Geologic Strength Indices (GSI), Rock Mass Ratings (RMR), and unconfined compressive (UC) rock strength testing. We have provided photos of the recovered rock core specimens in Section 4 of the Appendix.

We have provided a boring location plan displaying the locations of the borings performed during the subsurface investigation in Section 2 of the Appendix.

3. LABORATORY TESTING SUMMARY

Following completion of F&ME's field investigation, F&ME selected several rock core specimens for unconfined compressive (UC) rock strength laboratory testing. Laboratory testing of the soil material above rock was not performed and was not included in the provided scope of services.

F&ME acquired the rock cores collected from soil borings B-60 and B-61 previously performed by S&ME. S&ME previously performed three (3) UC rock strength tests on samples within soil boring B-60 and one (1) UC rock strength test on samples within soil boring B-61. Under the scope of services provided herein, F&ME attempted two (2) additional UC strength tests within B-61, but only one (1) test was completed. The other specimen broke along an existing fracture during the testing setup, and the testing was subsequently cancelled for that specimen.

The laboratory testing for the project was completed at F&ME's AASHTO accredited laboratory. The laboratory testing was performed in general accordance with procedures set forth in the most current AASHTO and ASTM standards.

The performed laboratory testing quantities are detailed in the following table.

Laboratory Testing Summary Table

Type of Test	Quantity	Procedure
Compressive Strength of Rock Cores	10	ASTM D7012 – Method C & D

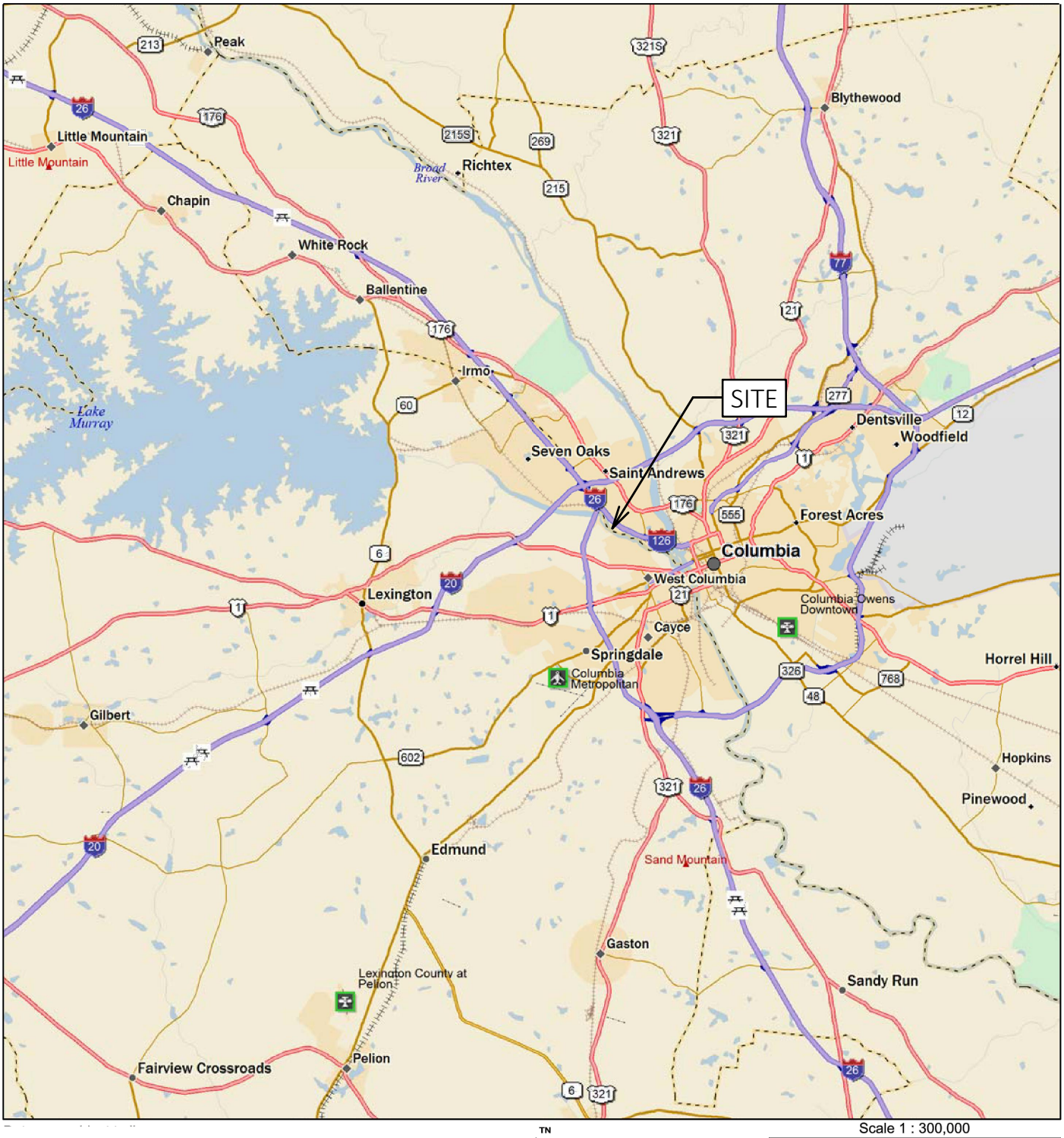
The data sheets containing the results from the indicated testing are provided in Section 5 of the Appendix. We note that the rock mass at soil boring B-61 and B-61A locations was fractured at several locations. The fractures may produce non-representative indications of the rock strength as determined from the laboratory UC rock strength testing. Additional field and/or laboratory testing may be necessary to further evaluate the rock strength at these locations.

In an effort to promote clarity in the immediate area surrounding the subsurface investigation performed under this scope of services, we have included the laboratory UC rock strength test results from soil borings B-60 and B-61 previously performed by S&ME in the laboratory test results summary sheet provided in Section 5 of the Appendix. Refer to the Geotechnical Base Line Report for the individual laboratory testing data sheets from soil borings B-60 and B-61.

APPENDIX TOC

APPENDIX

SECTION 1 SITE LOCATION PLAN



F&ME CONSULTANTS, INC.
COLUMBIA, SC

REV.	BY	DATE	DESCRIPTION OF REVISION
4			
3			
2			
1			

TOPO. _____ DATE _____
DWG. CTC DATE 11.17.20 GROUP ____ – _____
R/W _____ DATE _____

CAROLINA CROSSROADS PHASE 1
RICHLAND/LEXINGTON COUNTY, SOUTH CAROLINA

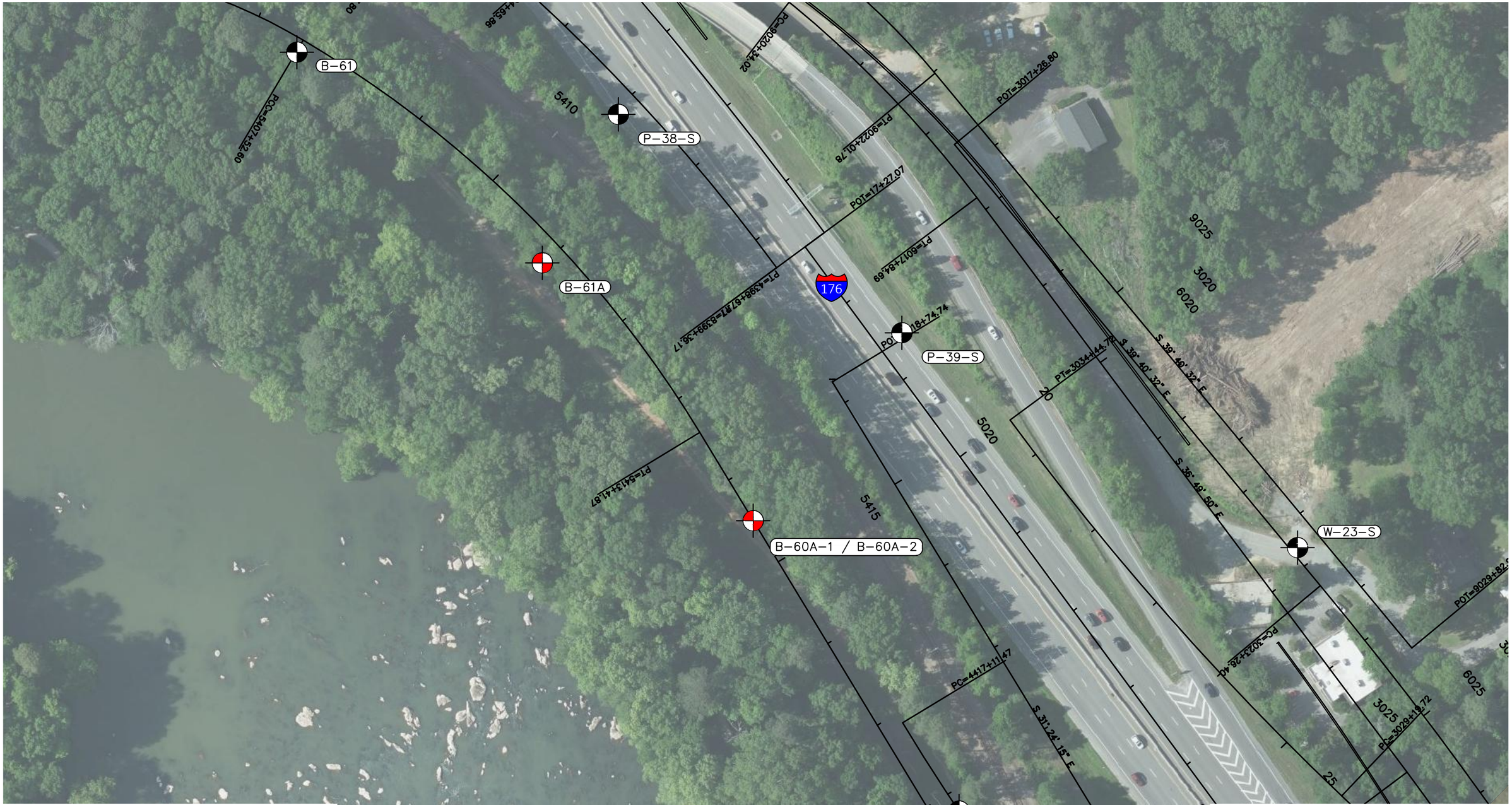
SITE LOCATION PLAN

F&ME JOB NO. G5662.010

SCALE: As Noted | FIGURE 1

APPENDIX

SECTION 2 BORING LOCATION PLAN



LEGEND:

- SOIL TEST BORING LOCATION
- SOIL TEST BORING LOCATION (PREVIOUSLY PERFORMED)

N

REV.	BY	DATE	DESCRIPTION OF REVISION
4			
3			
2			
1			

TOPO. ____ DATE ____
DWG. CTC DATE 11.17.20 GROUP ____ – ____
R/W ____ DATE ____

F&ME CONSULTANTS, INC.
COLUMBIA, SC

CAROLINA CROSSROADS PHASE 2
RICHLAND/LEXINGTON COUNTY, SOUTH CAROLINA

BORING LOCATION PLAN

F&ME JOB NO. G5662.010

SCALE: 1"=100' | FIGURE 2

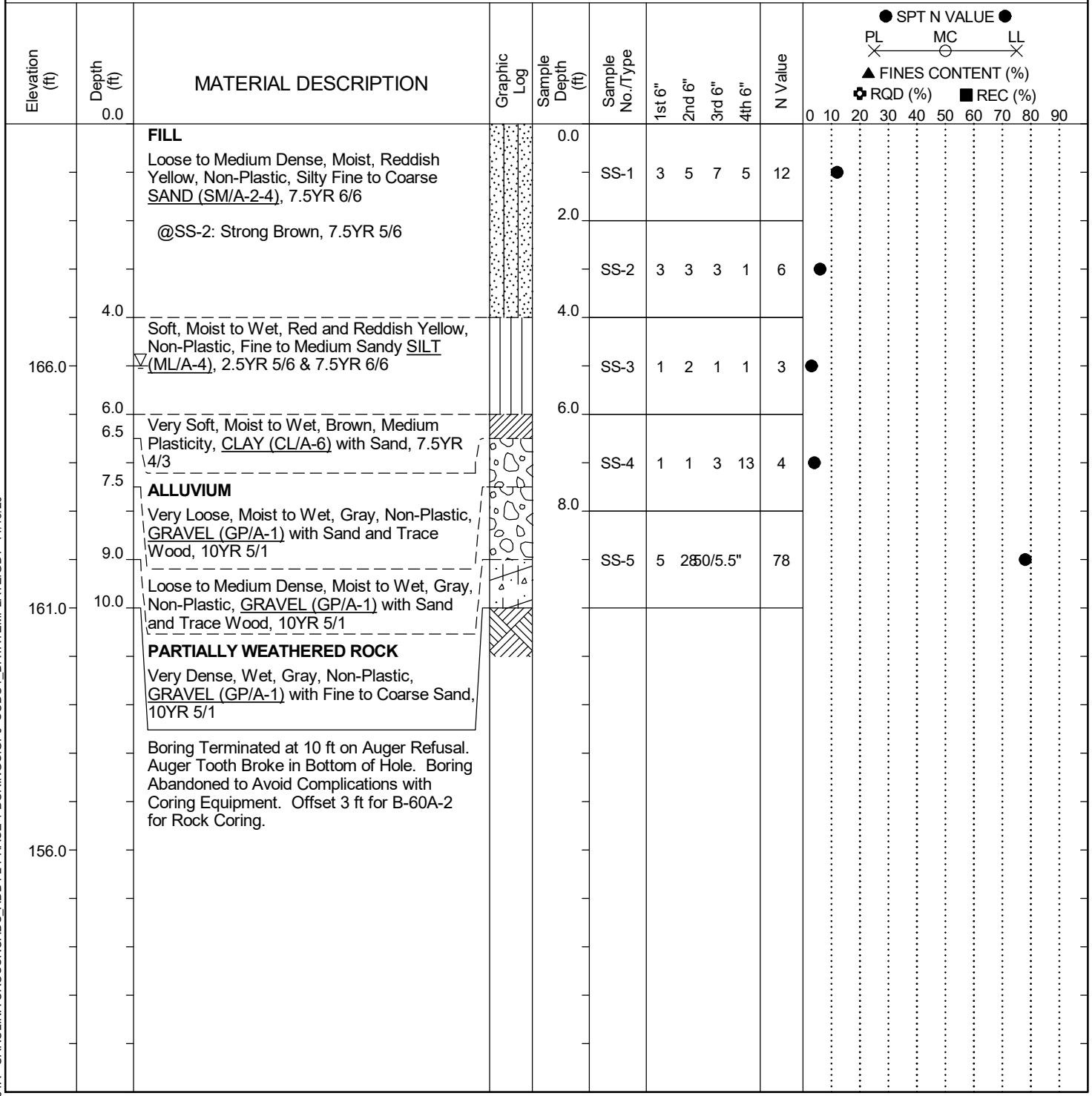
APPENDIX

SECTION 3 BORING LOGS

SCDOT Soil Test Log

Project ID:	P039718			**County:**	Richland	**Boring No.:**	B-60A-1
Site Description:	Carolina Crossroads - Phase 1 Additional Borings					**Route:**	I-26 Ramp C
Eng./Geo.:	C. Piercy	**Boring Location:**	5414+50	**Offset:**	0.3' RT	**Alignment:**	Mainline
Elev.:	171.0 ft	**Latitude:**	34.0238283	**Longitude:**	-81.098425	**Date Started:**	11/9/2020
Total Depth:	10 ft	**Soil Depth:**	10 ft	**Core Depth:**	0 ft	**Date Completed:**	11/9/2020
Bore Hole Diameter (in):	6	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	86%
Core Size:	NQ	**Driller:**	L. Guempel	**Groundwater:**	**TOB** 5 ft	**24HR**	Cave @ 6.0

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Sample Depth (ft)	Sample No./Type	1st 6"	2nd 6"	3rd 6"	4th 6"	N Value
	0.0	**FILL** Loose to Medium Dense, Moist, Reddish Yellow, Non-Plastic, Silty Fine to Coarse SAND (SM/A-2-4), 7.5YR 6/6	0.0	SS-1	3	5	7	5	12
		@SS-2: Strong Brown, 7.5YR 5/6	2.0	SS-2	3	3	3	1	6
	4.0	Soft, Moist to Wet, Red and Reddish Yellow, Non-Plastic, Fine to Medium Sandy SILT (ML/A-4), 2.5YR 5/6 & 7.5YR 6/6	4.0	SS-3	1	2	1	1	3
166.0									
	6.0		6.0	SS-4	1	1	3	13	4
	6.5	Very Soft, Moist to Wet, Brown, Medium Plasticity, CLAY (CL/A-6) with Sand, 7.5YR 4/3							
	7.5	**ALLUVIUM** Very Loose, Moist to Wet, Gray, Non-Plastic, GRAVEL (GP/A-1) with Sand and Trace Wood, 10YR 5/1	8.0	SS-5	5	28	50/5.5"		78
	9.0								
	10.0	Loose to Medium Dense, Moist to Wet, Gray, Non-Plastic, GRAVEL (GP/A-1) with Sand and Trace Wood, 10YR 5/1							
161.0		**PARTIALLY WEATHERED ROCK** Very Dense, Wet, Gray, Non-Plastic, GRAVEL (GP/A-1) with Fine to Coarse Sand, 10YR 5/1							
		Boring Terminated at 10 ft on Auger Refusal. Auger Tooth Broke in Bottom of Hole. Boring Abandoned to Avoid Complications with Coring Equipment. Offset 3 ft for B-60A-2 for Rock Coring.							
156.0									



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	

SCDOT Soil Test Log

Project ID:	P039718	**County:**	Richland	**Boring No.:**	B-60A-2		
Site Description:	Carolina Crossroads - Phase 1 Additional Borings			**Route:**	I-26 Ramp C		
Eng./Geo.:	C. Piercy	**Boring Location:**	5414+50	**Offset:**	2.7' LT	**Alignment:**	Mainline
Elev.:	171.0 ft	**Latitude:**	34.0238341	**Longitude:**	-81.0984181	**Date Started:**	11/9/2020
Total Depth:	28.7 ft	**Soil Depth:**	8.7 ft	**Core Depth:**	20 ft	**Date Completed:**	11/9/2020
Bore Hole Diameter (in):	6	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	86%
Core Size:	NQ	**Driller:**	L. Guempel	**Groundwater:**	**TOB** 4.2 ft	**24HR**	Caved @ 7.4

Elevation (ft)	Depth (ft)	MATERIAL DESCRIPTION	Graphic Log	Sample Depth (ft)	Sample No./Type	1st 6" / 2nd 6" / 3rd 6" / 4th 6"	N Value
	0.0	Auger to 8.7 ft and Commence Rock Coring.					
166.0							
	8.7	**GRANITE** Pink/White/Black, Feldspar/Quartz/Biotite @NQ-1: Slightly to Moderately Weathered, Joints Dip 10 to 40 Degrees, REC=93, RQD=34, GSI=45-55, RMR=26, J, VC, MW-N, Pl/Ir, SR/R, No, 7.7 min/ft		8.7	NQ-1		
161.0		@NQ-2: Slightly Weathered to Fresh, Joints Dip 10 to 50 Degrees, REC=94, RQD=75, GSI=55-65, RMR=40/43, J, VC, MW-VN, Pl/St/Ir, SR/R, Pa, 18.2 min/ft @10.0 ft: UC Strength=28730 psi		10.0	NQ-2		
156.0		@14.4 ft: UC Strength=34720 psi @NQ-3: Slightly Weathered to Fresh, Joints Dip 10 to 75 Degrees, REC=93, RQD=65, GSI=55-65, RMR=36, J, VC, MW-VN, Pl/Ir, SR/R, Fi, 9.4 min/ft @15.7 ft: UC Strength=28050 psi		15.0	NQ-3		
				20.0			

SPT N VALUE ● PL × MC ○ LL ×
▲ FINES CONTENT (%)
✿ RQD (%) ■ REC (%)
0 10 20 30 40 50 60 70 80 90

LEGEND

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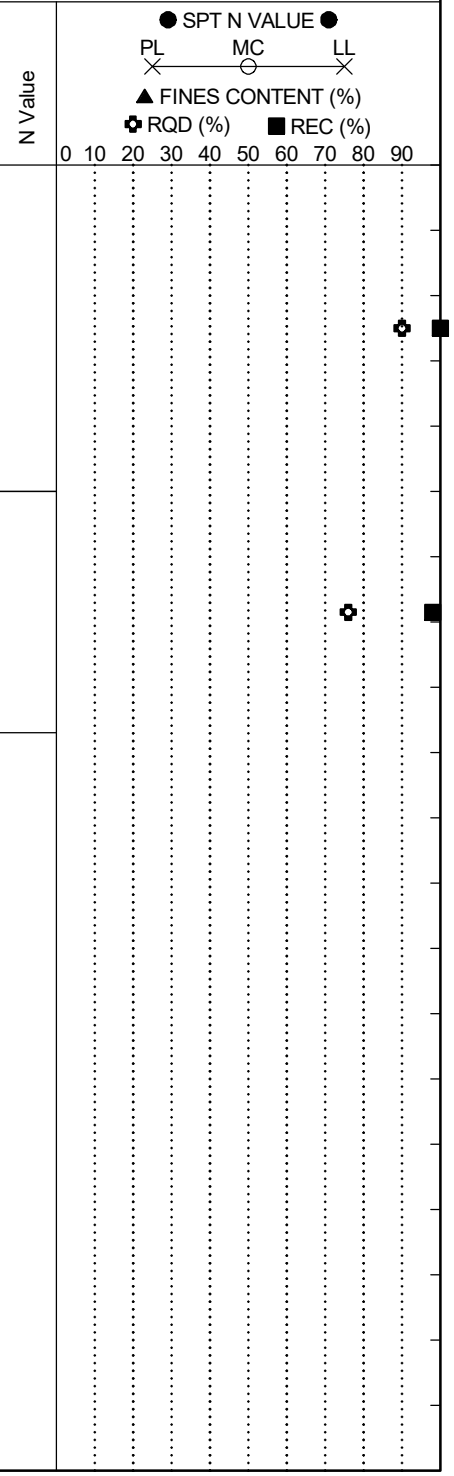
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

SCDOT Soil Test Log

Project ID:	P039718	**County:**	Richland	**Boring No.:**	B-60A-2		
Site Description:	Carolina Crossroads - Phase 1 Additional Borings			**Route:**	I-26 Ramp C		
Eng./Geo.:	C. Piercy	**Boring Location:**	5414+50	**Offset:**	2.7' LT	**Alignment:**	Mainline
Elev.:	171.0 ft	**Latitude:**	34.0238341	**Longitude:**	-81.0984181	**Date Started:**	11/9/2020
Total Depth:	28.7 ft	**Soil Depth:**	8.7 ft	**Core Depth:**	20 ft	**Date Completed:**	11/9/2020
Bore Hole Diameter (in):	6	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	86%
Core Size:	NQ	**Driller:**	L. Guempel	**Groundwater:**	**TOB** 4.2 ft	**24HR**	Caved @ 7.4

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-4: Slightly Weathered to Fresh, Joints Dip 10 to 80 Degrees, REC=100, RQD=90, GSI=45-55, RMR=40, J, VC, MW-VN, Pl/Ir, S/R, Fi, 10.6 min/ft					
		@22.3 ft: UC Strength=23121 psi			NQ-4		
146.0				25.0			
		@NQ-5: Slightly Weathered to Fresh, Joints Dip 10 to 50 Degrees, REC=98, RQD=76, GSI=45-55, RMR=40, J, VC, MW-VN, Pl/Ir, S/R, Fi, 11.9 min/ft			NQ-5		
	28.7	Boring Terminated at 28.7 ft.					
141.0							
136.0							



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	

SCDOT Soil Test Log

Project ID:	P039718			**County:**	Richland	**Boring No.:**	B-61A
Site Description:	Carolina Crossroads - Phase 1 Additional Borings					**Route:**	I-26 Ramp C
Eng./Geo.:	C. Piercy	**Boring Location:**	5410+98	**Offset:**	25.0' RT	**Alignment:**	Mainline
Elev.:	171.9 ft	**Latitude:**	34.0245688	**Longitude:**	-81.0991537	**Date Started:**	11/3/2020
Total Depth:	55.3 ft	**Soil Depth:**	25.25 ft	**Core Depth:**	30 ft	**Date Completed:**	11/3/2020
Bore Hole Diameter (in):	6	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	86%
Core Size:	NQ	**Driller:**	L. Guempel	**Groundwater:**	**TOB** 2 ft	**24HR**	0.5 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
	0.0	**ALLUVIUM**		0.0						
		Very Soft, Moist, Brown and Gray, Medium Plasticity, Fine to Coarse Sandy CLAY (CL/A-6) with Trace Organics, 10YR 5/3 & 10YR 5/1			SS-1	WOH/18"			1	0
	2.5	Very Loose, Wet, Olive, Low Plasticity, Silty Clayey Fine to Medium SAND (SC-SM/A-2-4) with Organics, 5Y 4/2		2.0	SS-2	2	2	2	3	4
	4.0	@SS-3: No Recovery		4.0	SS-3	2	3	3	3	6
166.9	6.0	Very Soft, Wet, Dark Gray, Medium Plasticity, Fine to Medium Sandy CLAY (CL/A-6), 2.5Y 4/1		6.0	SS-4	WOH/18"			1	0
	8.0	Loose, Wet, Gray, Low Plasticity, Clayey Fine to Medium SAND (SC/A-2-6), 2.5Y 5/1		8.0	SS-5	1	2	3	2	5
161.9	12.0	**RESIDUUM**								
		Very Dense, Wet, Yellowish Brown, Non-Plastic, Silty Fine to Coarse SAND (SM/A-2-4), 10YR 5/4		13.5						
	13.9	**WEATHERED PHYLLITE**			SS-6	38	50/5.5"			88+
156.9		Very Dense, Dry, Gray, Non-Plastic, GRAVEL (GP-A-1) with Sand, 10YR 6/1								
				18.5						
		@SS-7: Gray, 2.5Y 5/1			SS-7	14	34	50/5"		84+

SPT N VALUE ● PL MC LL ▲ FINES CONTENT (%) ✿ RQD (%) ■ REC (%)
0 10 20 30 40 50 60 70 80 90

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:	P039718			**County:**	Richland	**Boring No.:**	B-61A
Site Description:	Carolina Crossroads - Phase 1 Additional Borings					**Route:**	I-26 Ramp C
Eng./Geo.:	C. Piercy	**Boring Location:**	5410+98	**Offset:**	25.0' RT	**Alignment:**	Mainline
Elev.:	171.9 ft	**Latitude:**	34.0245688	**Longitude:**	-81.0991537	**Date Started:**	11/3/2020
Total Depth:	55.3 ft	**Soil Depth:**	25.25 ft	**Core Depth:**	30 ft	**Date Completed:**	11/3/2020
Bore Hole Diameter (in):	6	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	86%
Core Size:	NQ	**Driller:**	L. Guempel	**Groundwater:**	**TOB** 2 ft	**24HR**	0.5 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
	22.0	Very Dense, Dry, Gray, Non-Plastic, Silty Fine to Coarse SAND (SM/A-2-4) with Gravel, 2.5Y 5/1		23.5	SS-8	30 50/2"	100+
146.9	25.3	**PHYLLITE** Dark Gray, Quartz/Feldspar/Sericite @NQ-1: Completely to Highly Weathered, Joints Dip 5 to 85 Degrees, REC=68, RQD=7, GSI=10-20, RMR=9, J, VC, MW-VN, Pl/St/Ir, S/SR, Fi, 4.8 min/ft		25.3	NQ-1		
141.9		@NQ-2: Highly to Moderately Weathered, Joints Dip 10 to 80 Degrees, REC=86, RQD=25, GSI=10-20, RMR=14, J/V, VC, MW-VN, Wa/Pl/St/Ir, S/SR, Fi, 5 min/ft		30.0	NQ-2		
136.9		@NQ-3: Slightly to Moderately Weathered, Joints Dip 10 to 75 Degrees, REC=97, RQD=71, GSI=25-30, RMR=25/36, J/V, VC, MW-VN, Pl/St/Ir, S/SR, Fi, 3.6 min/ft @35.4 ft: UC Strength=1380 psi @37.5 ft: UC Strength=16260 psi		35.0	NQ-3		
				40.0			

SPT N VALUE ● PL MC LL ▲ FINES CONTENT (%) ✿ RQD (%) ■ REC (%)
0 10 20 30 40 50 60 70 80 90

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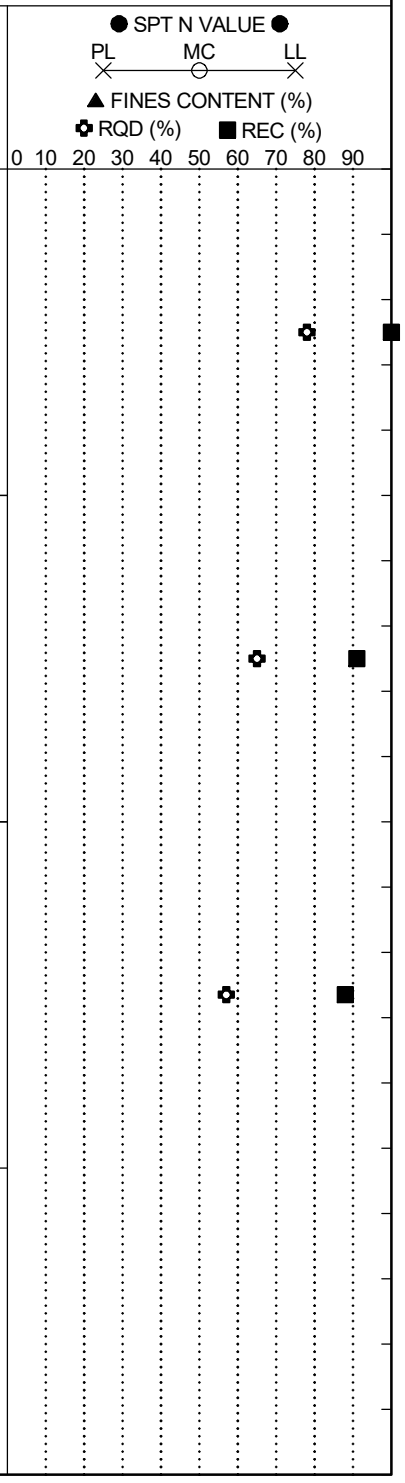
LEGEND

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	

SCDOT Soil Test Log

Project ID:	P039718	**County:**	Richland	**Boring No.:**	B-61A		
Site Description:	Carolina Crossroads - Phase 1 Additional Borings			**Route:**	I-26 Ramp C		
Eng./Geo.:	C. Piercy	**Boring Location:**	5410+98	**Offset:**	25.0' RT	**Alignment:**	Mainline
Elev.:	171.9 ft	**Latitude:**	34.0245688	**Longitude:**	-81.0991537	**Date Started:**	11/3/2020
Total Depth:	55.3 ft	**Soil Depth:**	25.25 ft	**Core Depth:**	30 ft	**Date Completed:**	11/3/2020
Bore Hole Diameter (in):	6	**Sampler Configuration**		**Liner Required:**	Y (N)	**Liner Used:**	Y (N)
Drill Machine:	CME 550	**Drill Method:**	HSA	**Hammer Type:**	Automatic	**Energy Ratio:**	86%
Core Size:	NQ	**Driller:**	L. Guempel	**Groundwater:**	**TOB** 2 ft	**24HR**	0.5 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-4: Highly to Slightly Weathered, Joints Dip 10 to 75 Degrees, REC=100, RQD=78, GSI=10-25, RMR=40, J/V, VC, MW-VN, Pl/St/Ir, S/SR, Pa/Fi, 4.8 min/ft @40.6 ft: UC Strength=15260 psi			NQ-4		
126.9		@NQ-5: Moderately Weathered, Joints Dip 5 to 80 Degrees, REC=91, RQD=65, GSI=15-25, RMR=31, J/V, VC, MW-VN, Pl/St/Ir, S/SR, Fi, 5.8 min/ft @45.1 ft: UC Strength=14800 psi		45.0	NQ-5		
121.9		@NQ-6: Highly to Moderately Weathered, Joints Dip 10 to 70 Degrees, REC=88, RQD=57, GSI=15-25, RMR=28, J/V, VC, MW-VN, Pl/St/Ir, S/SR, Fi, 5.5 min/ft @52.7 ft: UC Strength=5650 psi		50.0	NQ-6		
116.9	55.3	Boring Terminated at 55.3 ft.					



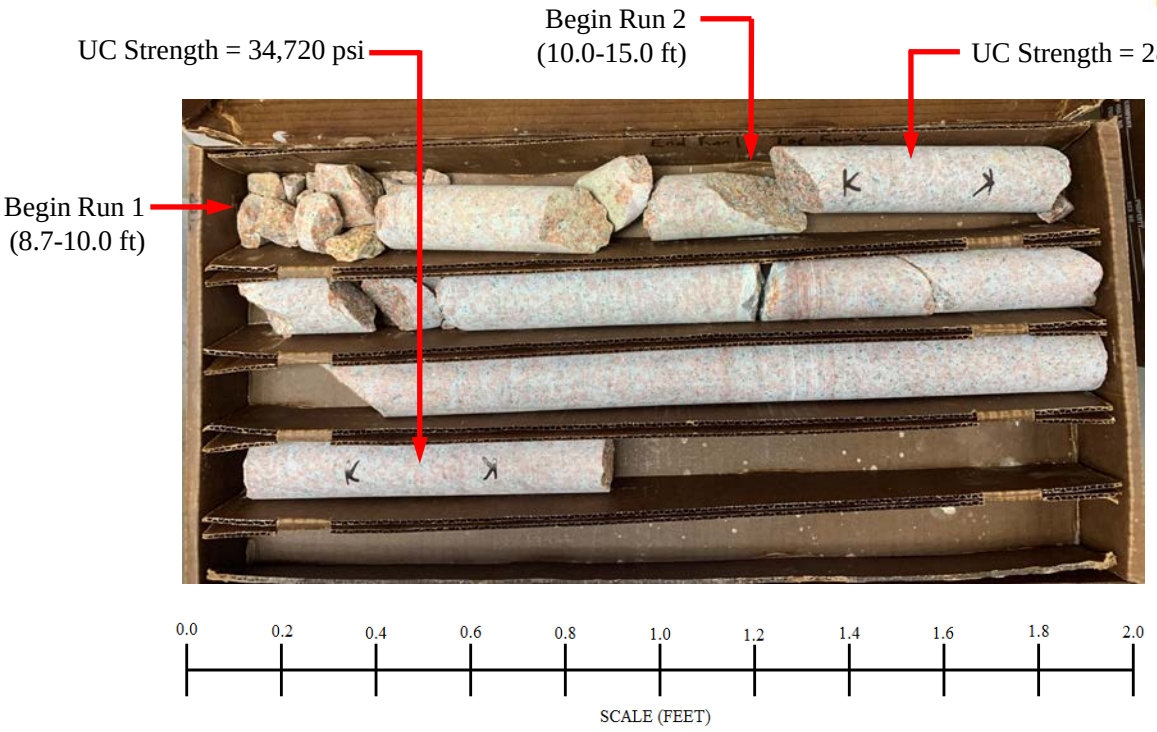
LEGEND

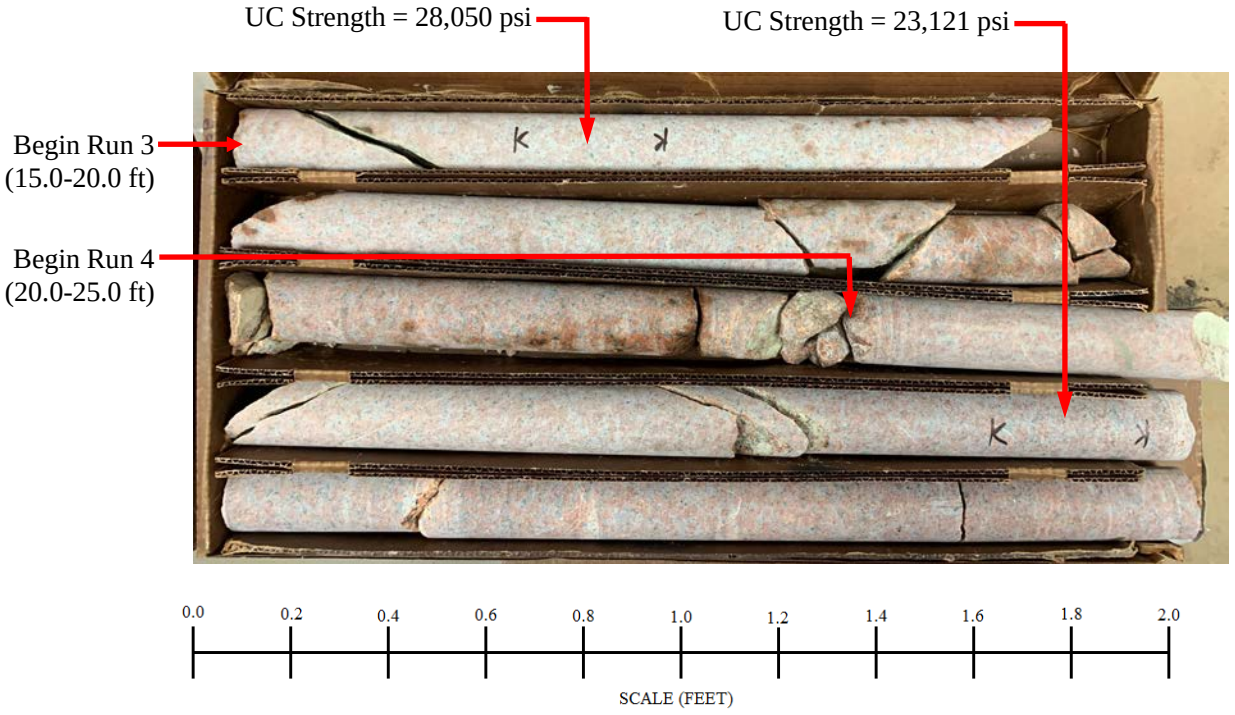
SAMPLER TYPE		DRILLING METHOD	
SS - Split Spoon	NQ - Rock Core, 1-7/8"	HSA - Hollow Stem Auger	RW - Rotary Wash
UD - Undisturbed Sample	CU - Cuttings	CFA - Continuous Flight Augers	RC - Rock Core
AWG - Rock Core, 1-1/8"	CT - Continuous Tube	DC - Driving Casing	

APPENDIX

SECTION 4 ROCK CORE PHOTOS

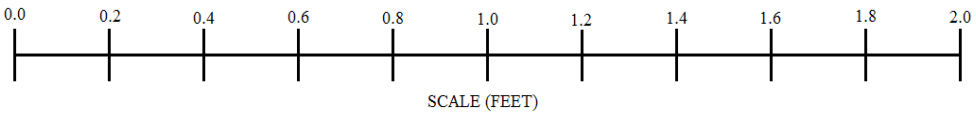
Carolina Crossroads – Phase 1
Boring B-60A-2



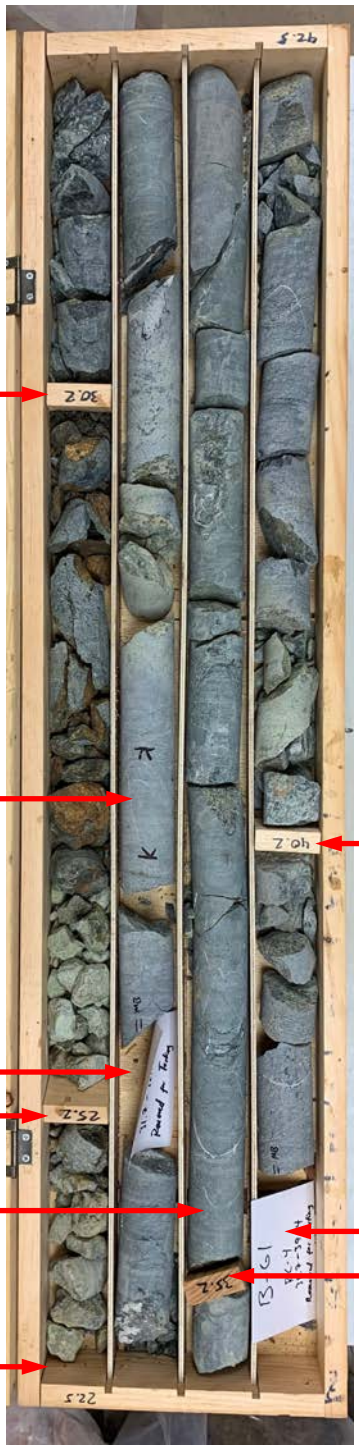


Carolina Crossroads – Phase 1
Boring B-60A-2

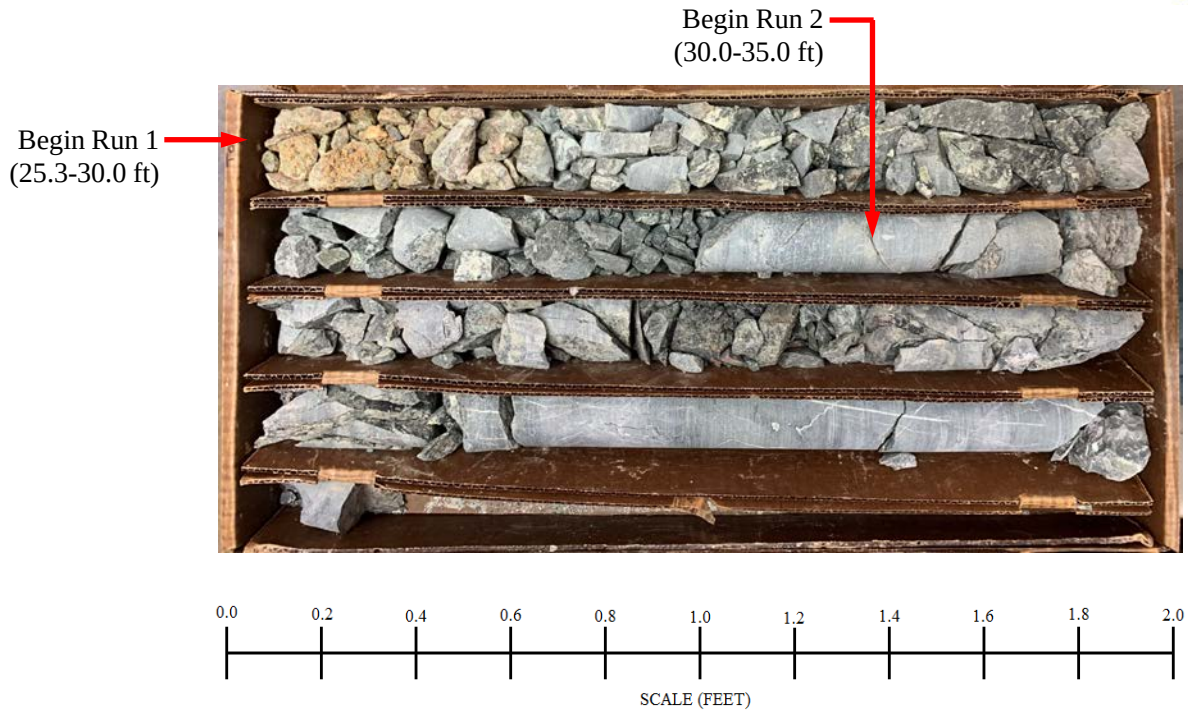
Begin Run 5
(25.0-28.7 ft)

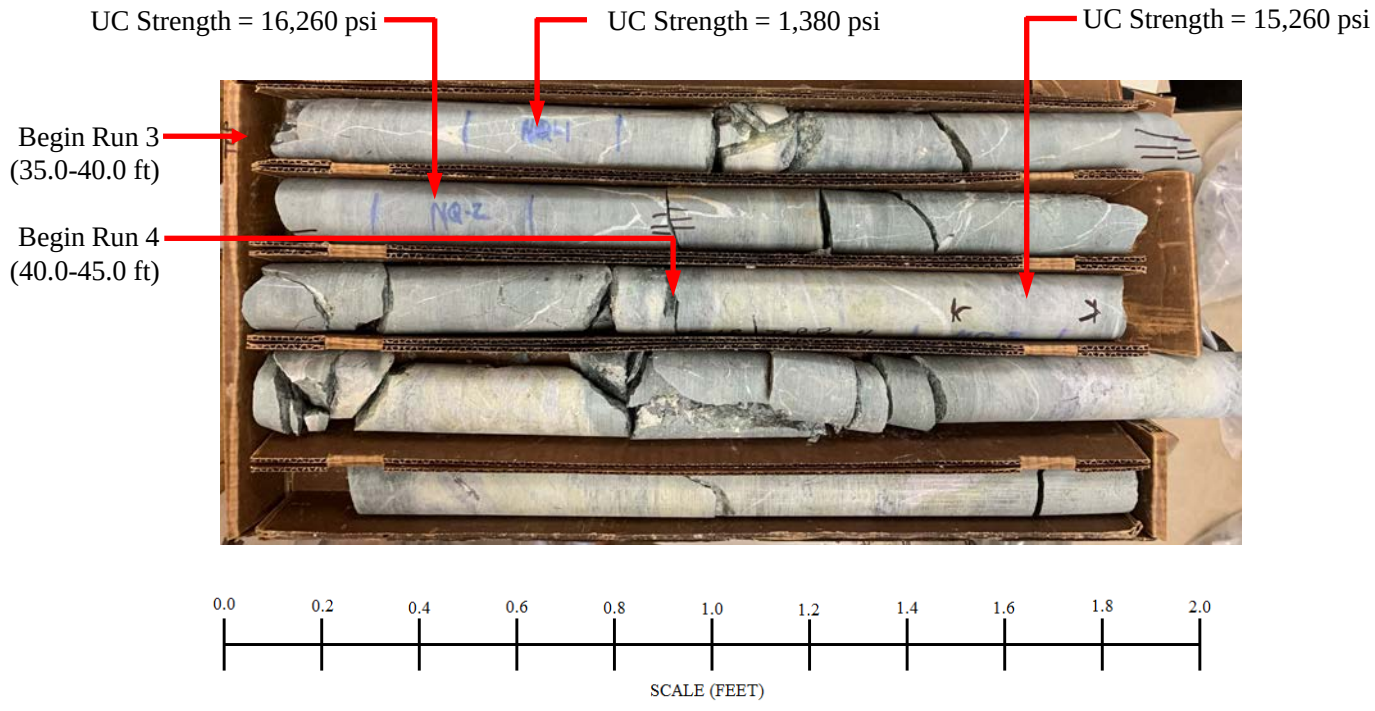


Carolina Crossroads – Phase 1
Boring B-61



Carolina Crossroads – Phase 1
Boring B-61A





Carolina Crossroads – Phase 1
Boring B-61A

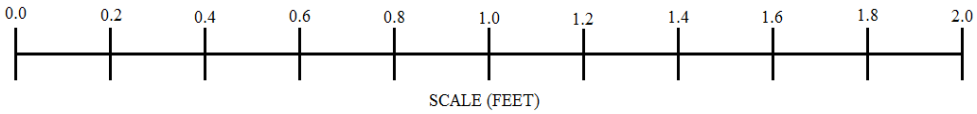
UC Strength = 14,800 psi

UC Strength test attempted but sample broke during test setup

UC Strength = 5,650 psi

Begin Run 5 (45.0-50.0 ft)

Begin Run 6 (50.0-55.3 ft)



APPENDIX

SECTION 5 LABORATORY TEST RESULTS

CAROLINA CROSSROADS PHASE 1
LEXINGTON/RICHLAND COUNTIES, SOUTH CAROLINA
F&ME PROJECT NO.: G5662.01; SCDOT PROJECT NO.: P039718

ROCK CORE LABORATORY RESULTS SUMMARY

Boring Number	Core Run Number	Sample Depth (ft)	Rock Type	REC (%)	RQD (%)	RMR	GSI	Unit Weight (lb/ft^3)	Elastic Modulus (ksi)	Poissons Ratio	UC Strength (psi)
B-60	RC-3	16.2-16.9	Granite	100	63	47	60-70	165.2	--	--	12540
B-60	RC-4	23.3-24.3	Granite	100	78	69	65-75	165.8	--	--	40627
B-60	RC-5	26.2-26.7	Granite	100	100	82	65-75	165.7	--	--	32094
B-60A-2	NQ-2	10.0 - 10.3	Granite	94	75	40	55-65	162.7	7270	--	28730
B-60A-2	NQ-2	14.4 - 14.7	Granite	94	75	43	55-65	163.6	9960	0.22	34720
B-60A-2	NQ-3	15.7 - 16.0	Granite	93	65	36	55-65	163.4	10000	0.19	28050
B-60A-2	NQ-4	22.3 - 22.6	Granite	100	90	40	45-55	163.4	9630	0.31	23121
B-61	RC-4	35.5-35.8	Schist	100	52	49	60-70	237.1	4440	1.14	7630
B-61	RC-4	38.7-39.4	Schist	100	52	49	60-70	176.3	--	--	15571
B-61A	NQ-3	35.4 - 35.7	Phyllite	97	71	25	25-30	173.5	9310	0.32	1380
B-61A	NQ-3	37.5 - 37.8	Phyllite	97	71	36	25-30	176.7	10800	0.38	16260
B-61A	NQ-4	40.6 - 40.9	Phyllite	100	78	40	10-25	193.8	13600	0.23	15260
B-61A	NQ-5	45.1 - 45.4	Phyllite	91	65	31	15-25	200.1	14400	0.21	14800
B-61A	NQ-6	52.7 - 53.0	Phyllite	88	57	28	15-25	175.1	2040	0.27	5650

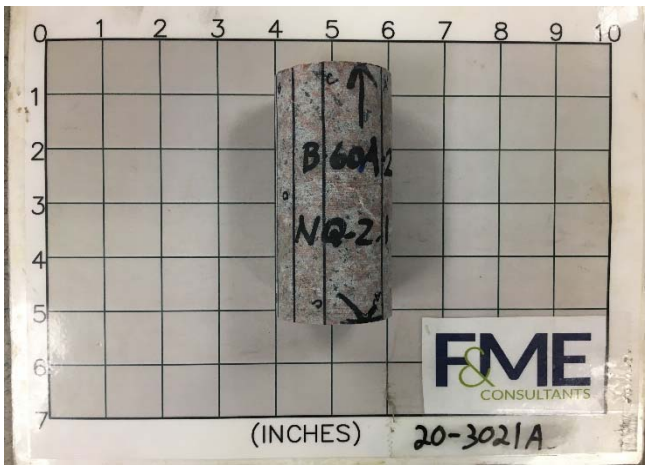
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

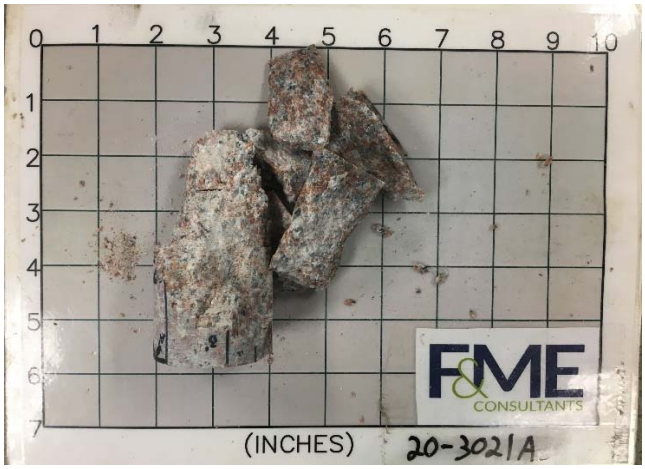
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.864	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.986	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	162.7	Core Size	NQ
Sample No.	NQ-2.1 / 20-3021A	L/D Ratio	2.14	Recovery	94%
Depth	10.0' - 10.3'	Load Rate (psi/sec)	35	RQD	75%
Description	Pink/Brown/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%	-1190	0	7,815	2,864	4.81	N/A
20%	-1922	0	15,595	5,715	5.95	N/A
30%	-2573	0	23,554	8,632	6.71	N/A
40%	-3191	0	31,312	11,475	7.19	N/A
50%	-3808	0	39,176	14,356	7.54	N/A
60%	-4433	0	47,121	17,268	7.79	N/A
70%	-5039	0	54,865	20,105	7.98	N/A
80%	-5672	0	62,738	22,990	8.11	N/A
90%	-6306	0	70,585	25,866	8.20	N/A
100%	-4893	0	78,409	28,733		

Sample Photos





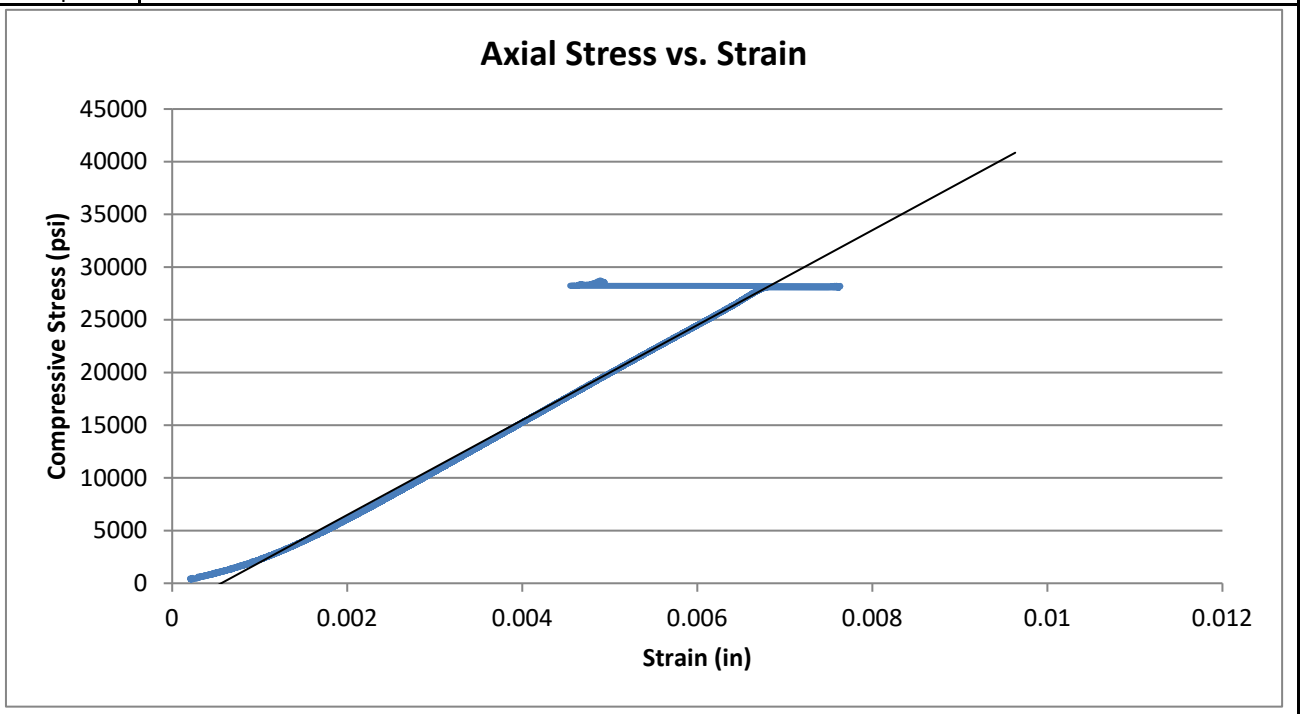
Test Results

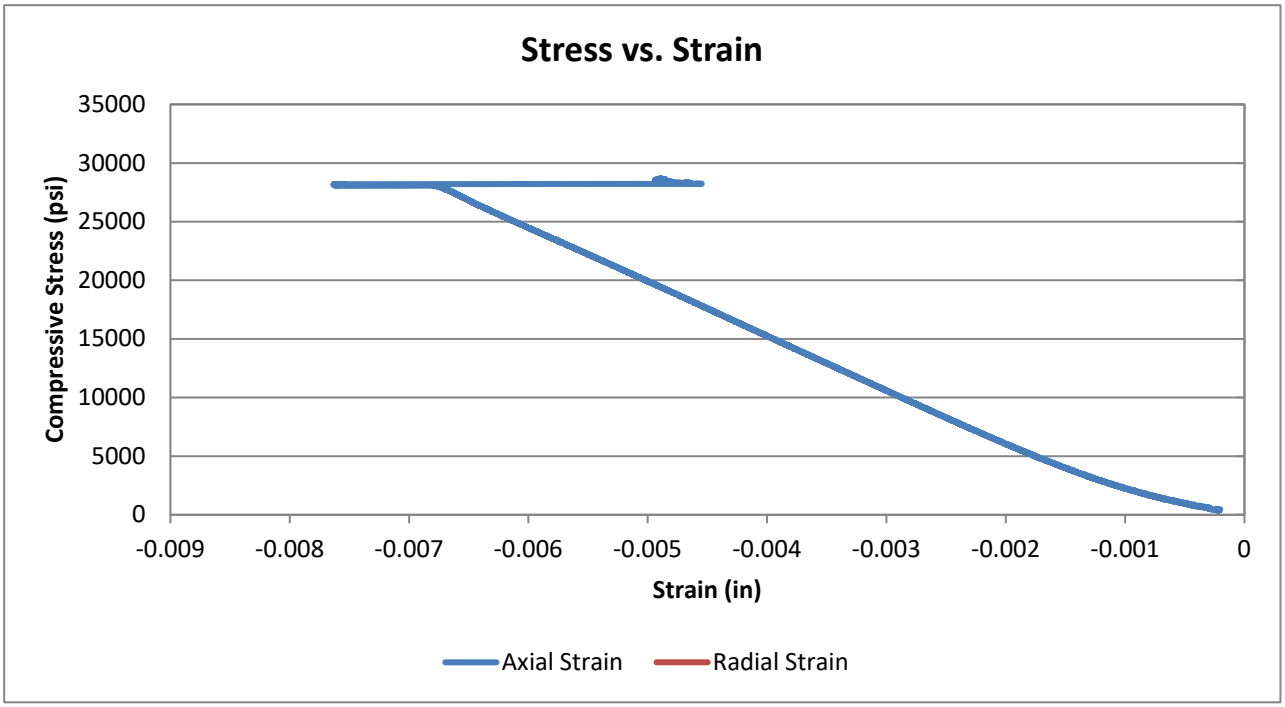
Unconfined Compressive Strength (psi)	**28,730**	Elastic Modulus (psi)	7.27E+06
		Poisson's Ratio in Elastic Range	N/A
Comments	Elastic range was taken as between 0.002 and 0.005 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. During testing, the radial strain gauge did not properly function. As such, no Poisson Ratio data is available.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.864	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.986	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	162.7	Core Size	NQ
Sample No.	NQ-2.1 / 20-3021A	L/D Ratio	2.14	Recovery	94%
Depth	10.0' - 10.3'	Load Rate (psi/sec)	35	RQD	75%
Description	Pink/Brown/Black Granite				





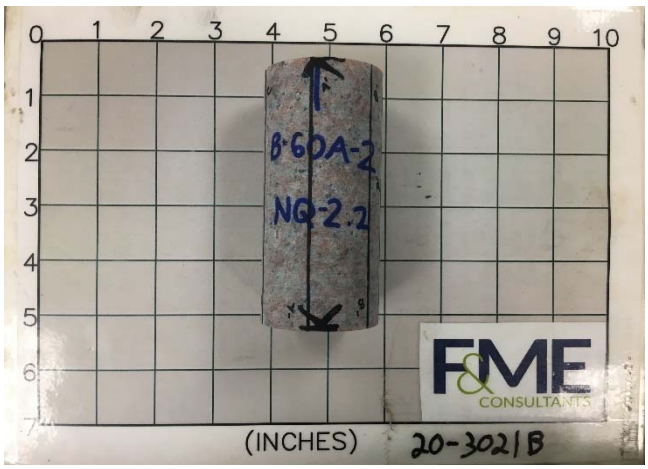
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.867	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.101	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	163.6	Core Size	NQ
Sample No.	NQ-2.2 / 20-3021B	L/D Ratio	2.20	Recovery	94%
Depth	14.7' - 15.0'	Load Rate (psi/sec)	50	RQD	75%
Description	Pink/Brown/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%	-759	132	9,586	3,502	9.23	0.17
20%	-1442	294	19,003	6,941	9.63	0.20
30%	-2117	454	28,541	10,425	9.85	0.21
40%	-2791	604	38,008	13,883	9.95	0.22
50%	-3478	741	47,505	17,352	9.98	0.21
60%	-4177	890	57,031	20,832	9.98	0.21
70%	-4851	1094	66,593	24,325	10.03	0.23
80%	-5593	1393	76,022	27,769	9.93	0.25
90%	-6396	1845	85,535	31,244	9.77	0.29
100%	-7387	1854	95,039	34,715		

Sample Photos



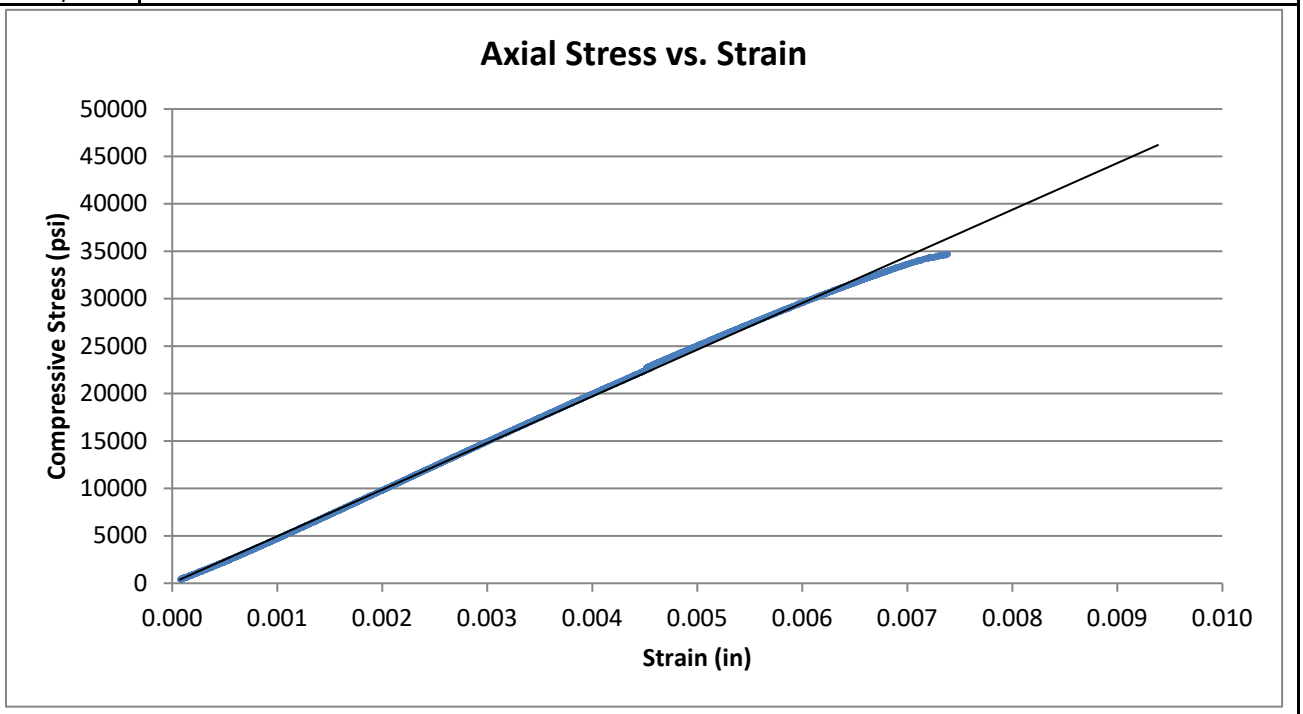
Test Results

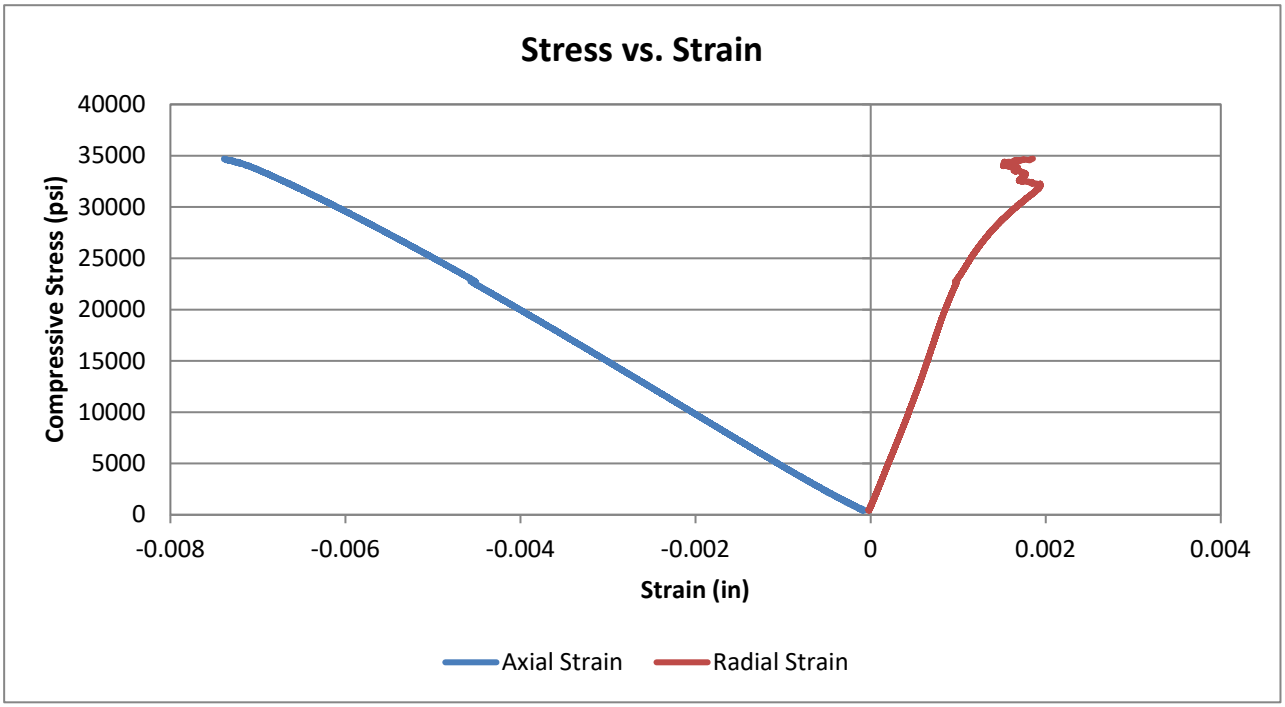
Unconfined Compressive Strength (psi)	**34,720**	Elastic Modulus (psi)	9.96E+06
		Poisson's Ratio in Elastic Range	0.22
Comments	Elastic range was taken as between 0.002 and 0.005 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.867	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.101	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	163.6	Core Size	NQ
Sample No.	NQ-2.2 / 20-3021B	L/D Ratio	2.20	Recovery	94%
Depth	14.7' - 15.0'	Load Rate (psi/sec)	50	RQD	75%
Description	Pink/Brown/Black Granite				





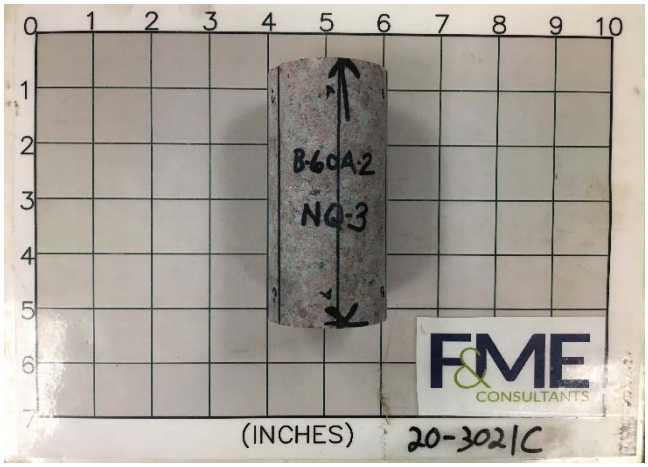
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

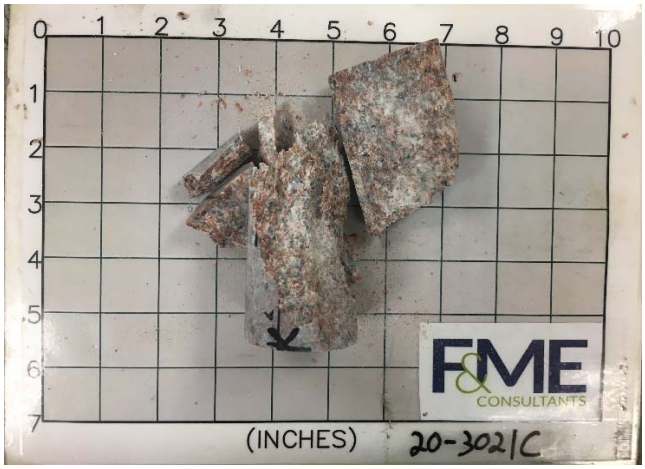
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.869	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.993	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	163.4	Core Size	NQ
Sample No.	NQ-3 / 20-3021C	L/D Ratio	2.14	Recovery	93%
Depth	15.7' - 16.0'	Load Rate (psi/sec)	70	RQD	65%
Description	Pink/Brown/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%	-670	132	7,618	2,777	8.29	0.20
20%	-1201	229	15,377	5,605	9.34	0.19
30%	-1709	323	23,082	8,413	9.85	0.19
40%	-2226	418	30,773	11,217	10.08	0.19
50%	-2748	511	38,478	14,025	10.21	0.19
60%	-3272	602	46,165	16,827	10.28	0.18
70%	-3810	690	53,710	19,577	10.28	0.18
80%	-4390	811	61,578	22,445	10.23	0.18
90%	-4827	1102	69,246	25,240	10.46	0.23
100%	-4804	397	76,946	28,047		

Sample Photos





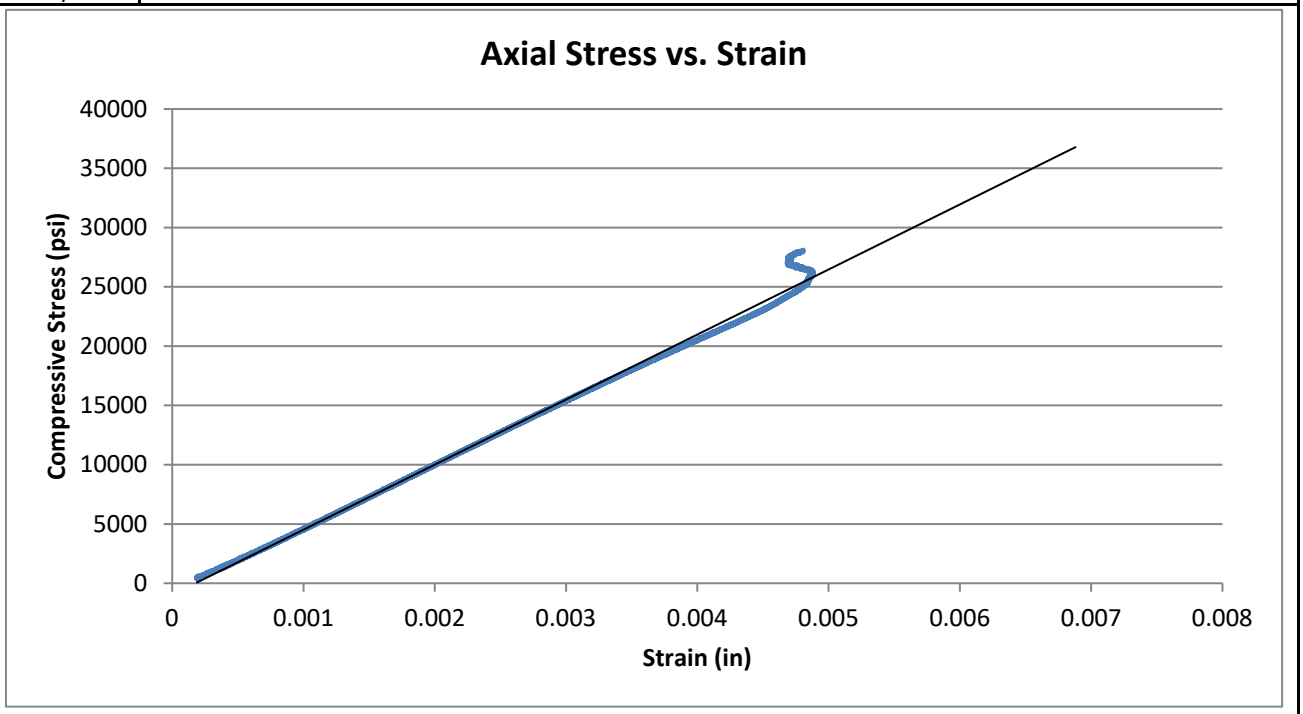
Test Results

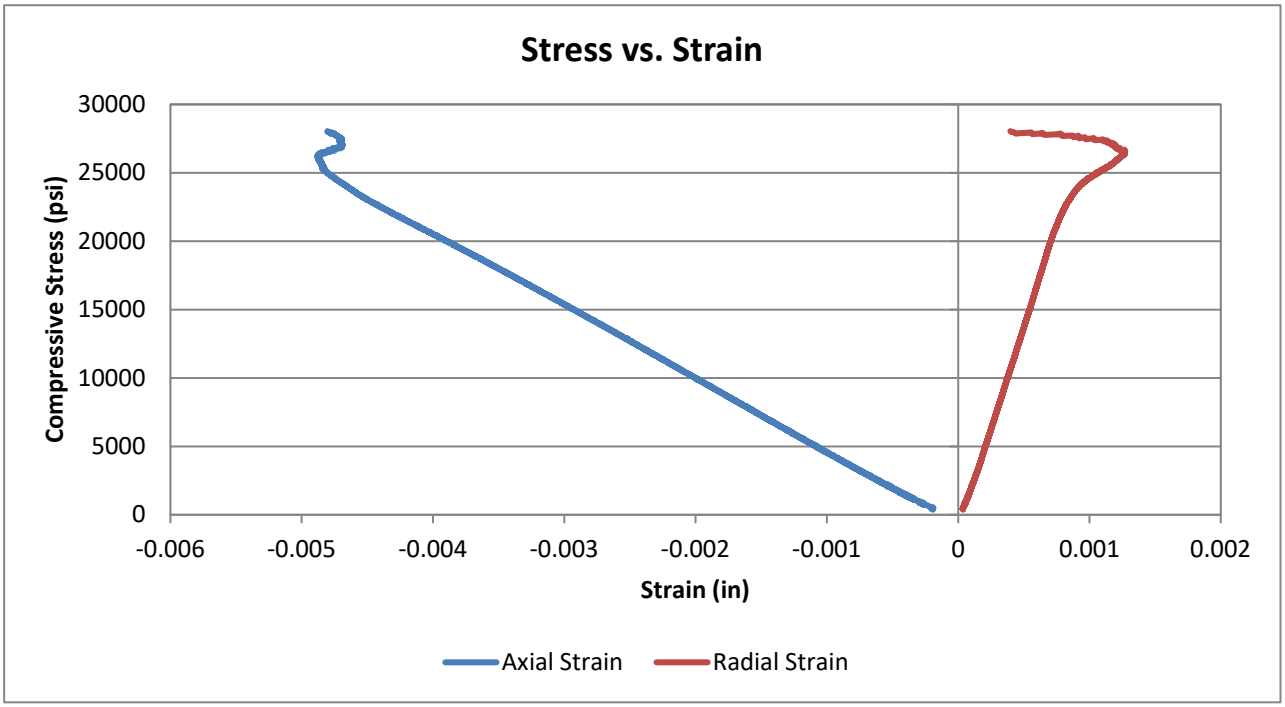
Unconfined Compressive Strength (psi)	**28,050**	Elastic Modulus (psi)	1.00E+07
		Poisson's Ratio in Elastic Range	0.19
Comments	Elastic range was taken as between 0.001 and 0.004 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.869	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.993	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	163.4	Core Size	NQ
Sample No.	NQ-3 / 20-3021C	L/D Ratio	2.14	Recovery	93%
Depth	15.7' - 16.0'	Load Rate (psi/sec)	70	RQD	65%
Description	Pink/Brown/Black Granite				





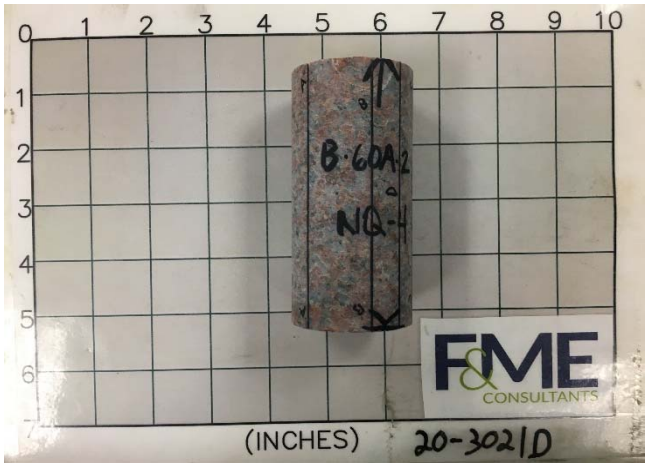
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

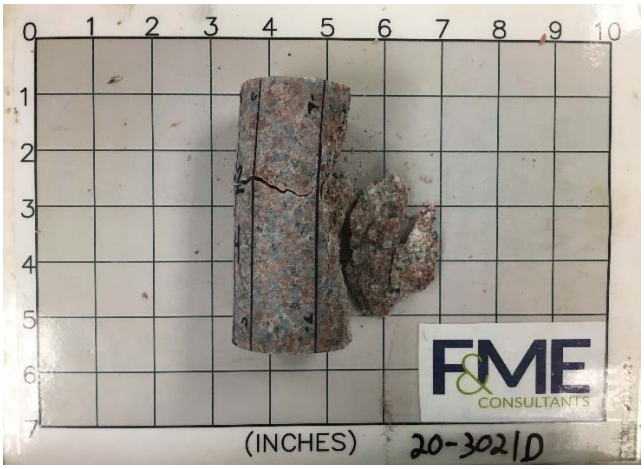
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.869	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.021	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	163.4	Core Size	NQ
Sample No.	NQ-4 / 20-3021D	L/D Ratio	2.15	Recovery	100%
Depth	22.3' - 22.6'	Load Rate (psi/sec)	50	RQD	90%
Description	Pink/Brown/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%	-527	228	6,365	2,320	8.81	0.43
20%	-967	333	12,686	4,624	9.56	0.34
30%	-1434	451	19,027	6,935	9.67	0.31
40%	-1924	579	25,367	9,246	9.61	0.30
50%	-2401	709	31,793	11,588	9.65	0.30
60%	-2869	845	38,007	13,854	9.66	0.29
70%	-3359	998	44,367	16,171	9.63	0.30
80%	-7292	1163	50,750	18,498	5.07	0.16
90%	-7819	1407	57,070	20,802	5.32	0.18
100%	-16004	1761	63,435	23,122		

Sample Photos



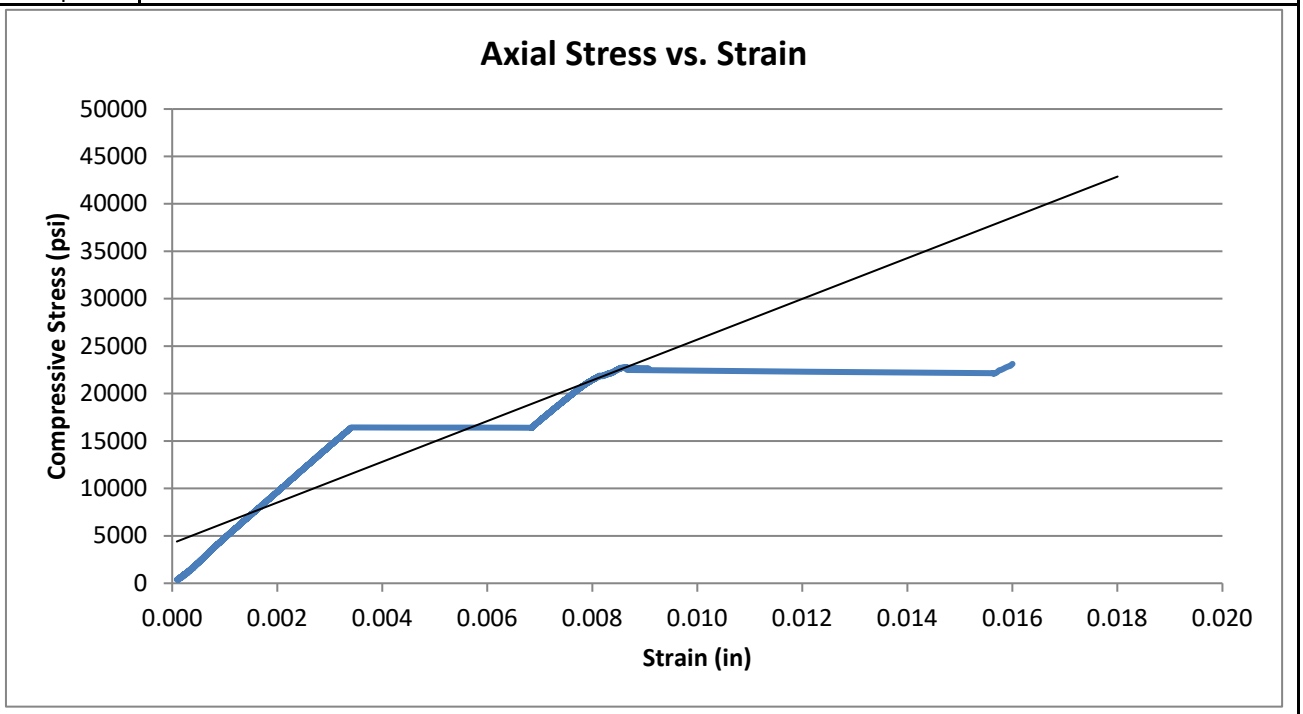


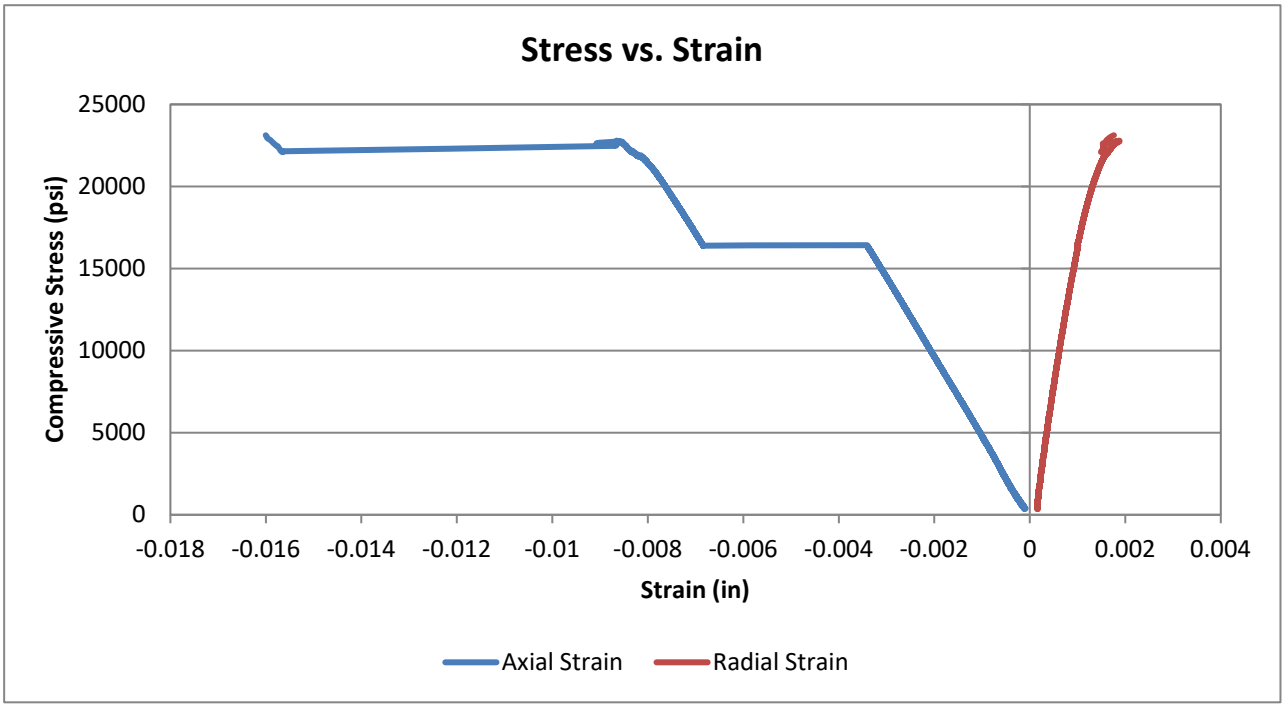
Test Results

Unconfined Compressive Strength (psi)	**23,121**	Elastic Modulus (psi)	9.63E+06
		Poisson's Ratio in Elastic Range	0.31
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. Sample exhibited a partial failure at 16,400 psi.		

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.869	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.021	Reviewed By	JSF
Boring	B-60A.2	Unit Weight (pcf)	163.4	Core Size	NQ
Sample No.	NQ-4 / 20-3021D	L/D Ratio	2.15	Recovery	100%
Depth	22.3' - 22.6'	Load Rate (psi/sec)	50	RQD	90%
Description	Pink/Brown/Black Granite				





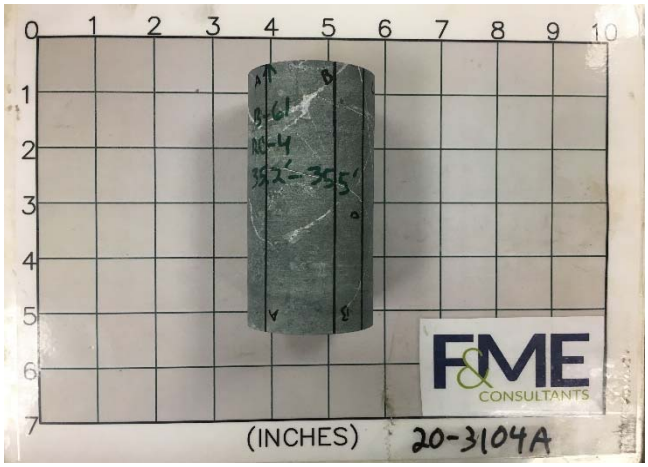
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

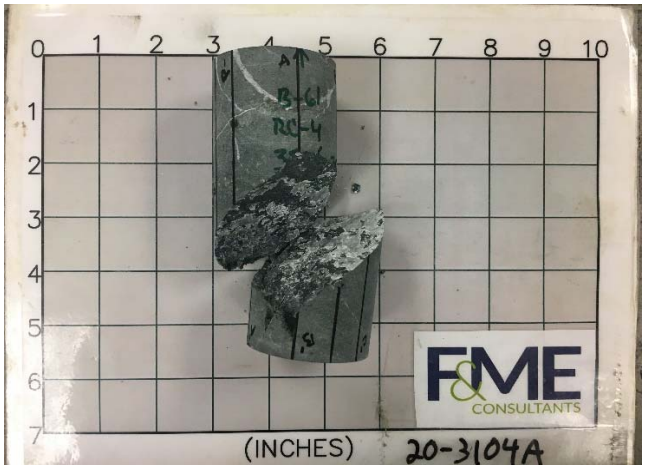
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.977	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.07	Reviewed By	JSF
Boring	B-61	Unit Weight (pcf)	237.1	Core Size	NQ
Sample No.	RC-4 / 20-3104A	L/D Ratio	1.55	Recovery	100%
Depth	35.2' - 35.5'	Load Rate (psi/sec)	20	RQD	14%
Description	Blue/Green/Grey Schist				

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%	-527	717	2,342	763	2.89	1.36
20%	-826	1216	4,672	1,522	3.69	1.47
30%	-1109	1465	7,025	2,288	4.13	1.32
40%	-1391	1640	9,369	3,052	4.39	1.18
50%	-1669	1770	11,718	3,817	4.57	1.06
60%	-1949	1887	14,044	4,575	4.69	0.97
70%	-2252	2024	16,374	5,334	4.74	0.90
80%	-2576	2195	18,794	6,122	4.75	0.85
90%	-2874	2439	21,060	6,860	4.77	0.85
100%	-3388	3534	23,429	7,632		

Sample Photos





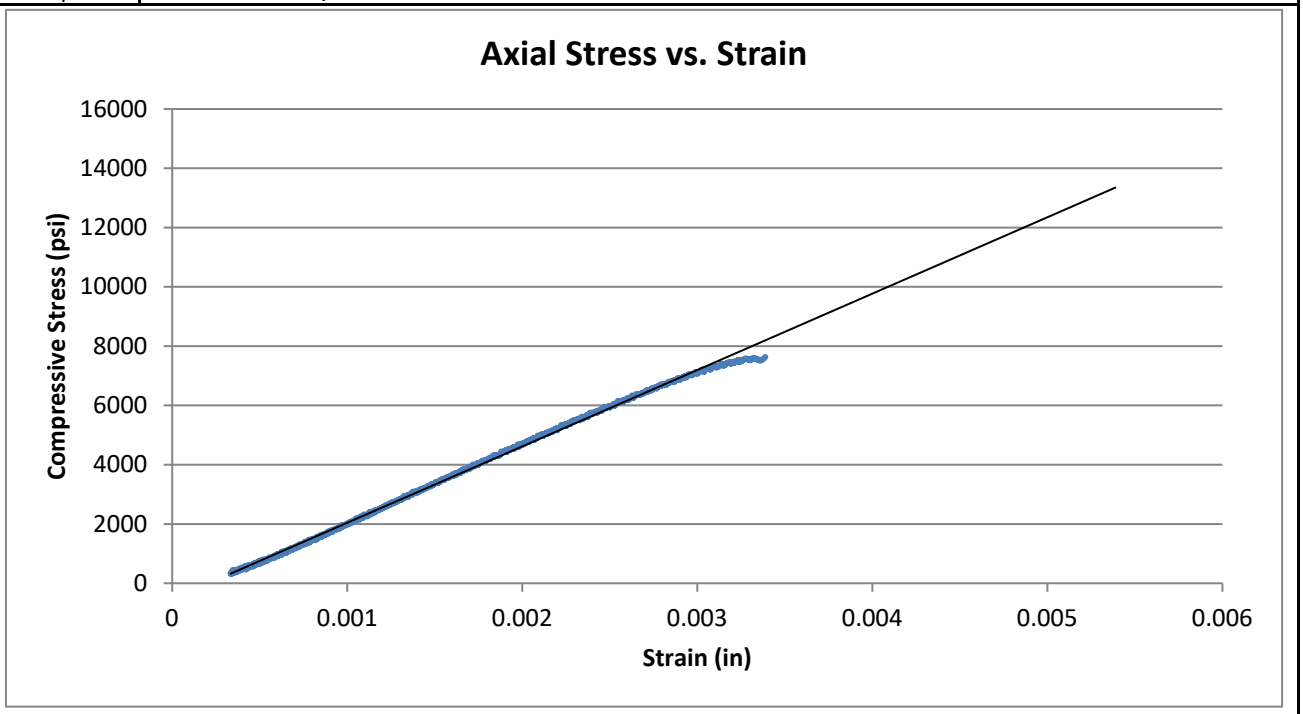
Test Results

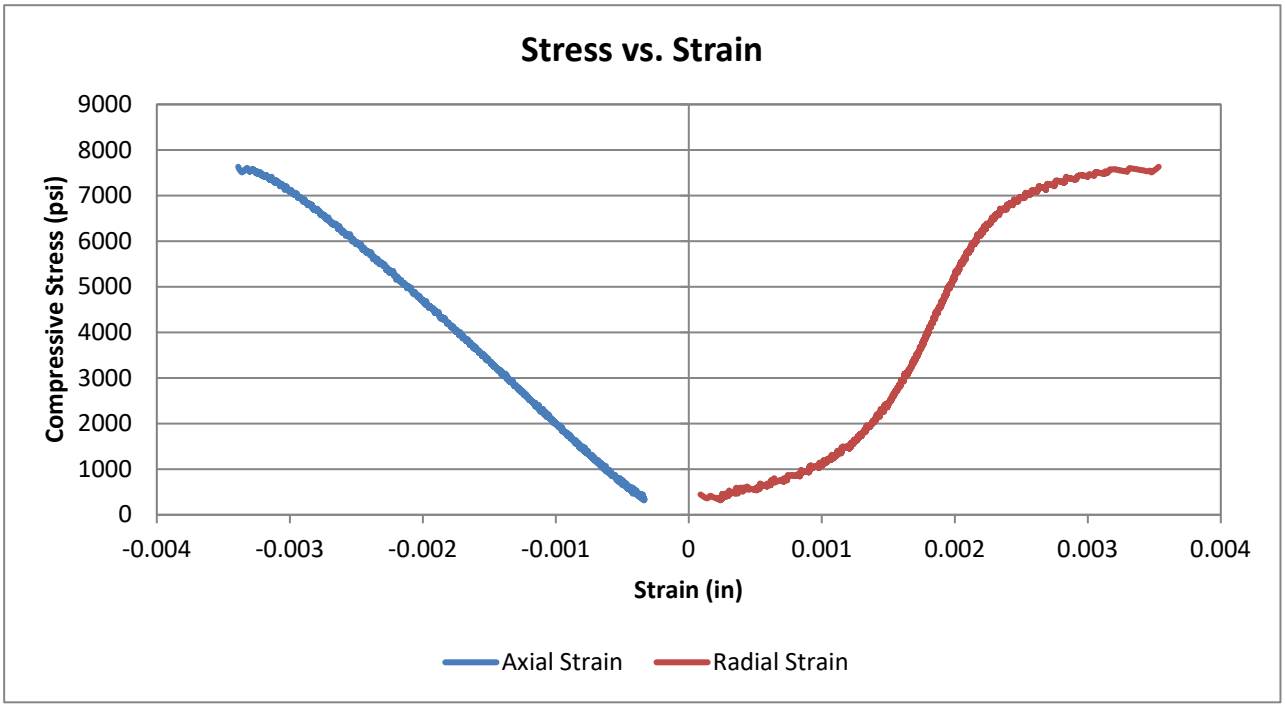
Unconfined Compressive Strength (psi)	**7,630**	Elastic Modulus (psi)	4.44E+06
		Poisson's Ratio in Elastic Range	1.14
Comments	Elastic range was taken as between 0.001 and 0.002 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. High Poisson Ratio is attributed to displacement of a healed fracture and does not necessarily represent the Poisson Ratio of the intact rock		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.977	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.07	Reviewed By	JSF
Boring	B-61	Unit Weight (pcf)	237.1	Core Size	NQ
Sample No.	RC-4 / 20-3104A	L/D Ratio	1.55	Recovery	100%
Depth	35.2' - 35.5'	Load Rate (psi/sec)	20	RQD	14%
Description	Blue/Green/Grey Schist				





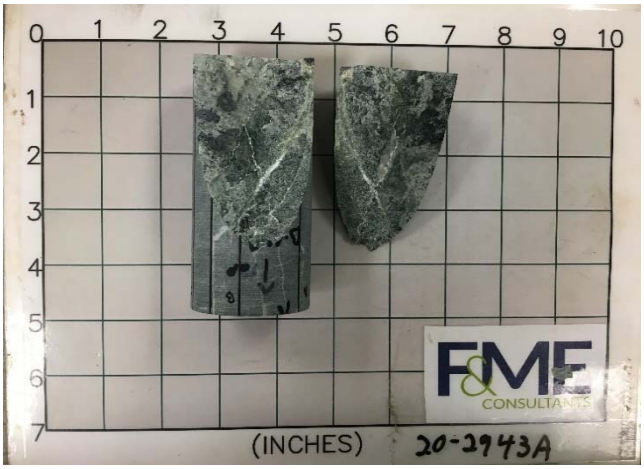
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.861	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.065	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	173.5	Core Size	NQ
Sample No.	NQ-3.1 / 20-2943A	L/D Ratio	2.18	Recovery	97%
Depth	35.4' - 35.7'	Load Rate (psi/sec)	20	RQD	71%
Description	Blue/Green/Grey Phyllite				

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%	Sample Preload Range					
20%						
30%	-77	-2	1,103	405	10.56	0.02
40%	-98	10	1,531	563	11.44	0.10
50%	-149	47	1,863	685	9.20	0.32
60%	-181	79	2,247	826	9.15	0.44
70%	-211	121	2,684	987	9.35	0.57
80%	-269	189	3,050	1,121	8.33	0.70
90%	-281	223	3,203	1,178	8.39	0.79
100%	-331	296	3,763	1,383		

Sample Photos



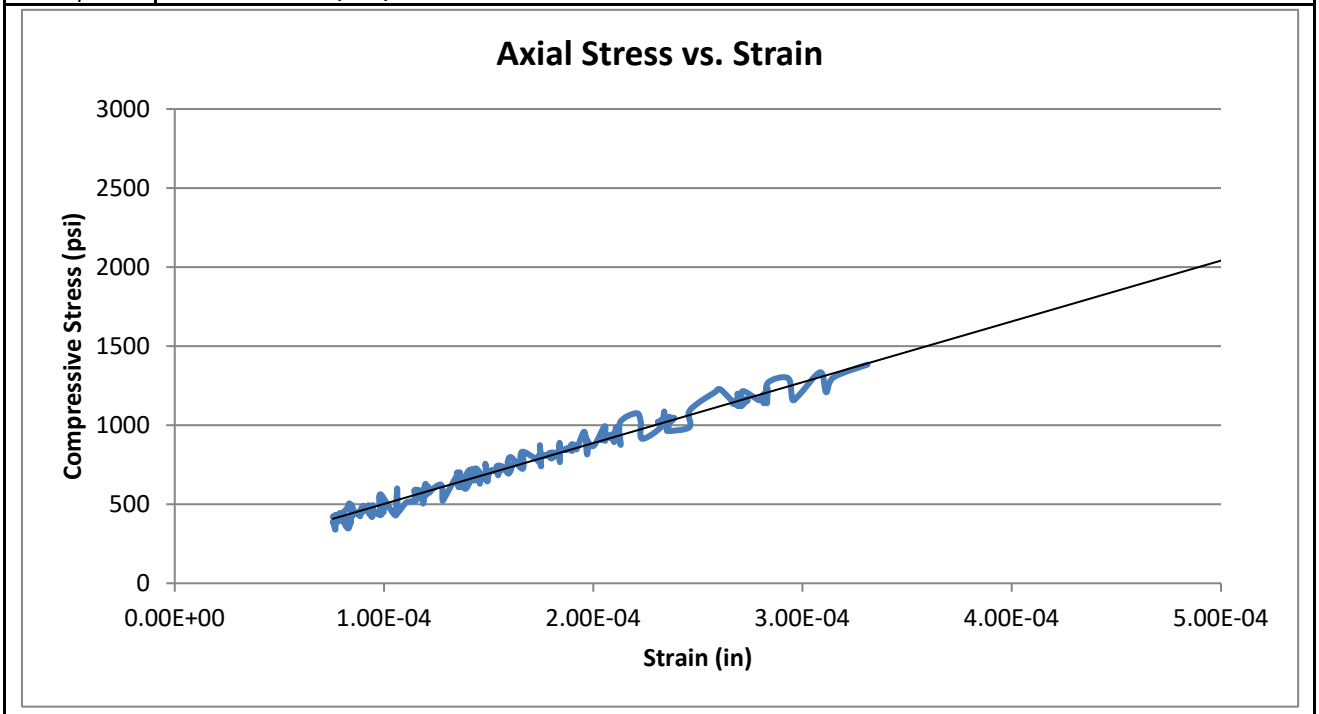
Test Results

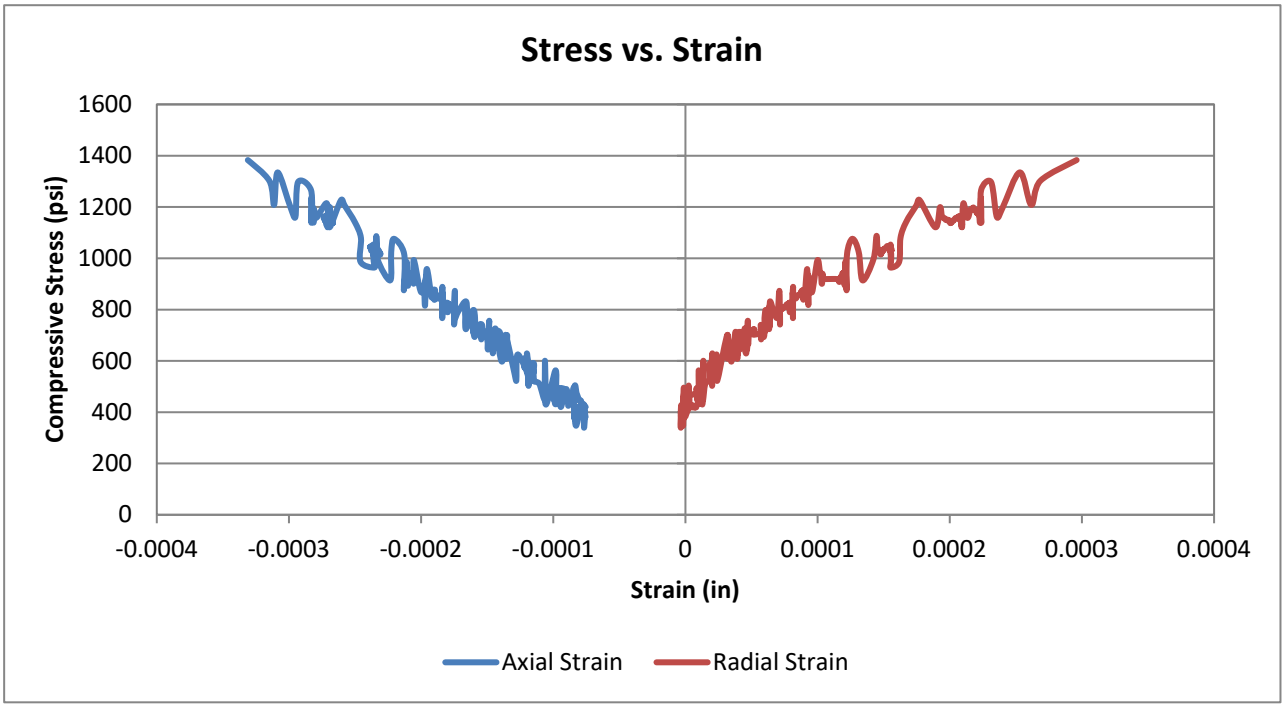
Unconfined Compressive Strength (psi)	**1,380**	Elastic Modulus (psi)	9.31E+06
		Poisson's Ratio in Elastic Range	0.32
Comments	Elastic range was taken as between 0.0001 and 0.0002 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. Rock sample failed along a healed joint.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.861	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.065	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	173.5	Core Size	NQ
Sample No.	NQ-3.1 / 20-2943A	L/D Ratio	2.18	Recovery	97%
Depth	35.4' - 35.7'	Load Rate (psi/sec)	20	RQD	71%
Description	Blue/Green/Grey Phyllite				





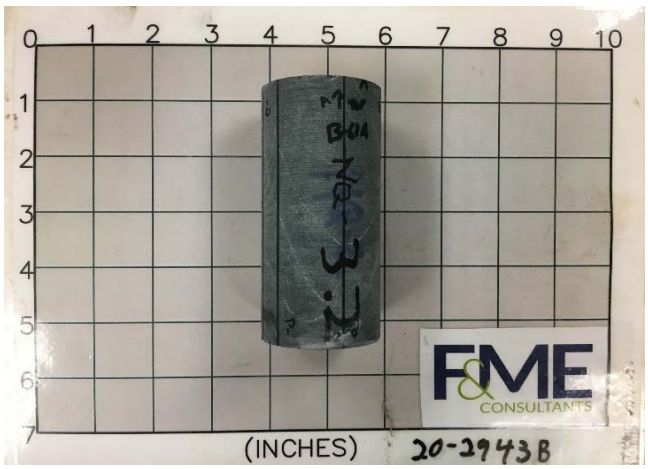
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

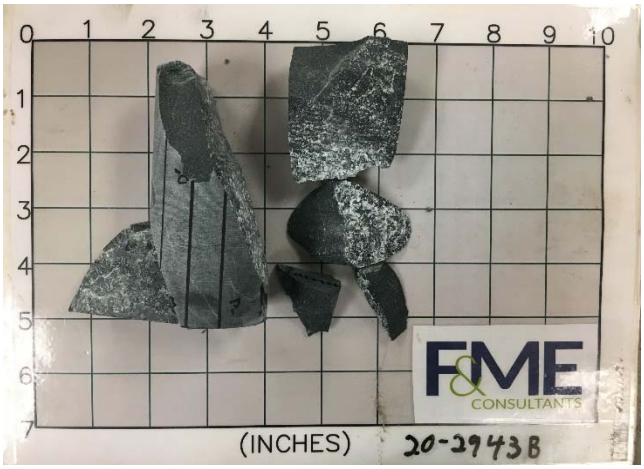
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.862	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.039	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	176.7	Core Size	NQ
Sample No.	NQ-3.2 / 20-2943B	L/D Ratio	2.17	Recovery	97%
Depth	37.5' - 37.8'	Load Rate (psi/sec)	20	RQD	71%
Description	Blue/Green/Grey Phyllite				

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%	-294	112	4,447	1,633	11.12	0.38
20%	-593	233	8,853	3,251	10.97	0.39
30%	-885	344	13,187	4,843	10.95	0.39
40%	-1197	457	17,699	6,500	10.86	0.38
50%	-1499	569	22,136	8,129	10.84	0.38
60%	-1810	680	26,571	9,758	10.78	0.38
70%	-2120	791	30,940	11,362	10.72	0.37
80%	-2449	906	35,479	13,029	10.64	0.37
90%	-2775	1017	39,843	14,632	10.55	0.37
100%	-3110	1132	44,270	16,258		

Sample Photos





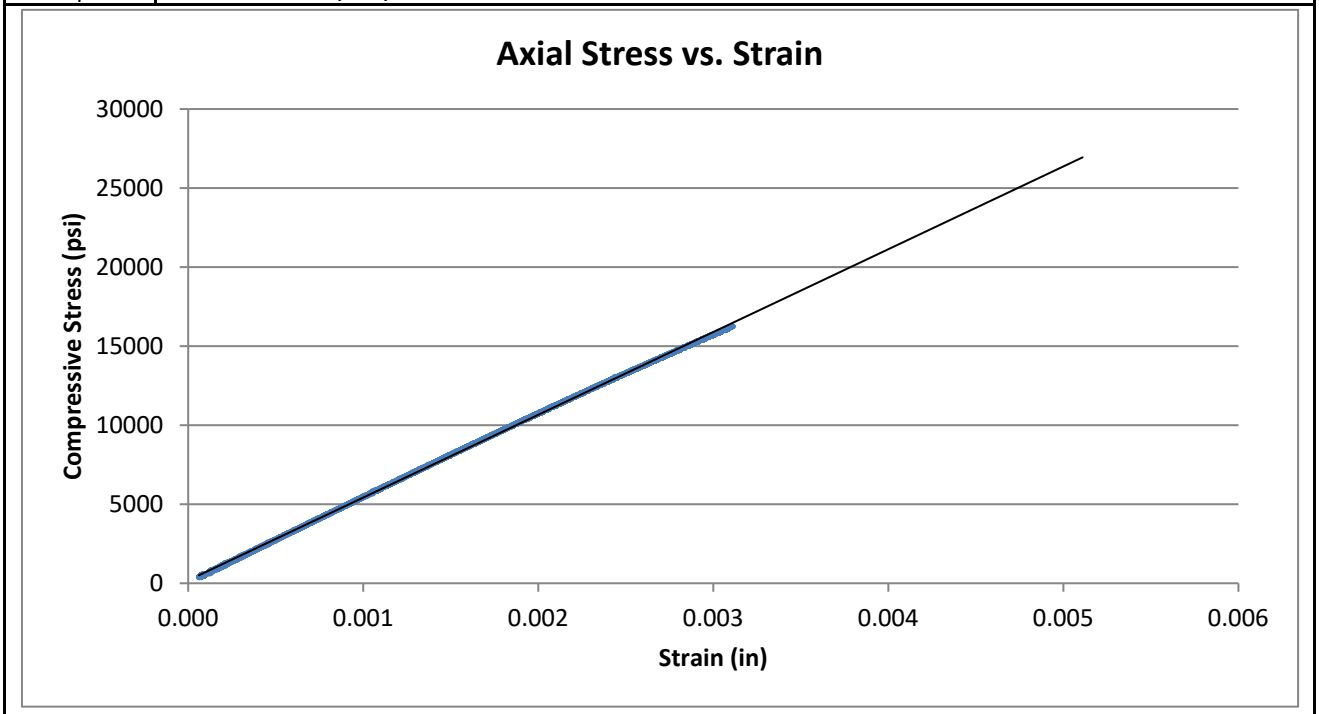
Test Results

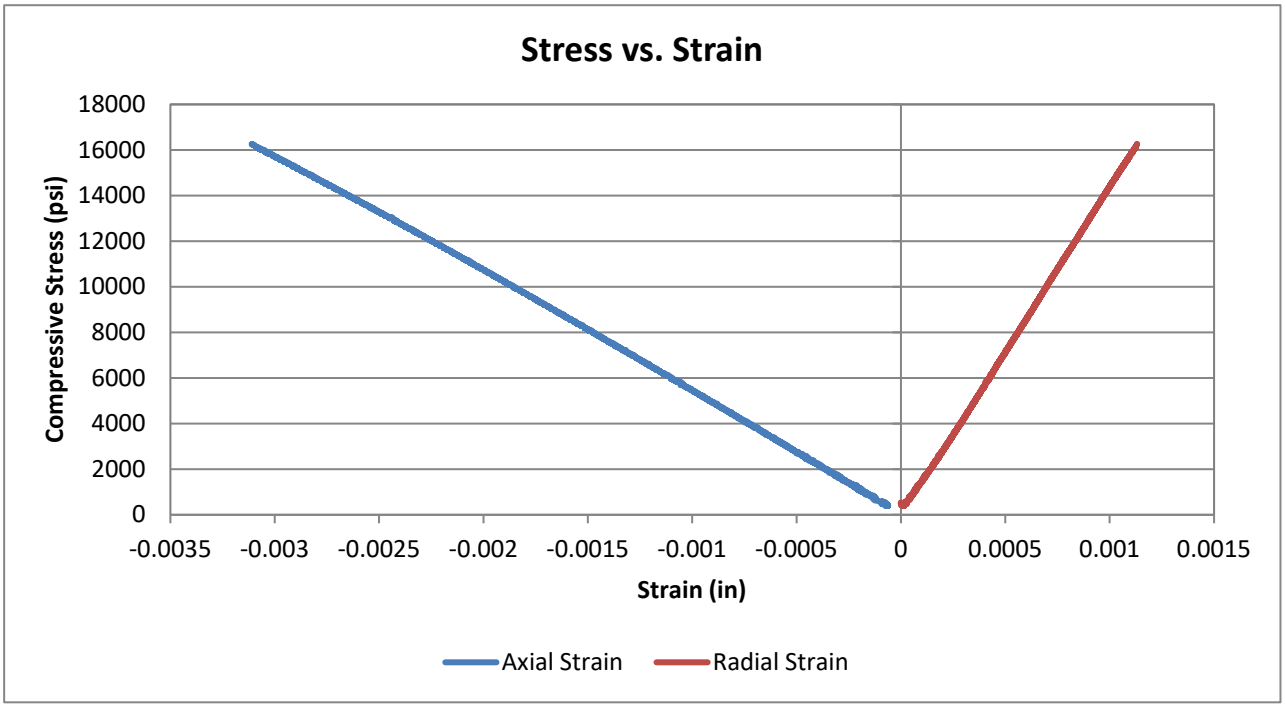
Unconfined Compressive Strength (psi)	**16,260**	Elastic Modulus (psi)	1.08E+07
		Poisson's Ratio in Elastic Range	0.38
Comments	Elastic range was taken as between 0.001 and 0.0025 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.862	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.039	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	176.7	Core Size	NQ
Sample No.	NQ-3.2 / 20-2943B	L/D Ratio	2.17	Recovery	97%
Depth	37.5' - 37.8'	Load Rate (psi/sec)	20	RQD	71%
Description	Blue/Green/Grey Phyllite				





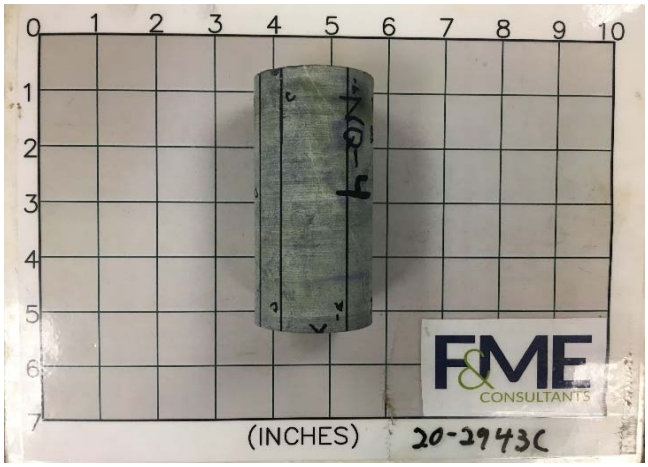
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

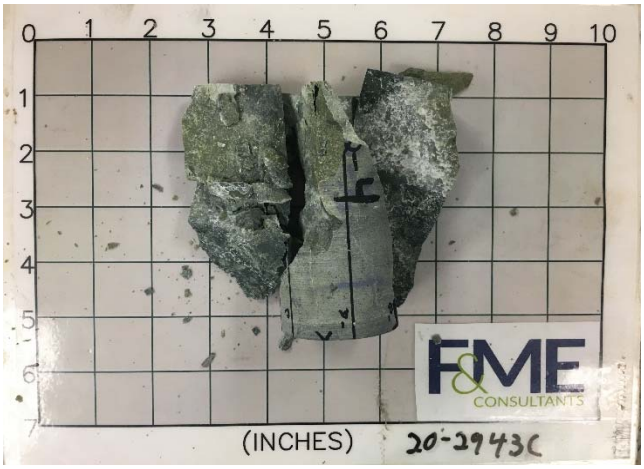
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/20
Project No.	G5662.01	Sample Diameter (in.)	1.862	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.978	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	193.8	Core Size	NQ
Sample No.	NQ-4 / 20-2943A	L/D Ratio	2.14	Recovery	100%
Depth	40.6' - 40.9'	Load Rate (psi/sec)	20	RQD	78%
Description	Blue/Green/Grey Phyllite				

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%	-266	39	4,157	1,527	11.46	0.15
20%	-473	100	8,360	3,070	12.98	0.21
30%	-678	156	12,504	4,592	13.55	0.23
40%	-884	211	16,637	6,110	13.82	0.24
50%	-1088	260	20,710	7,605	13.98	0.24
60%	-1303	310	24,975	9,172	14.07	0.24
70%	-1353	416	29,087	10,682	15.79	0.31
80%	-1271	259	33,290	12,225	19.23	0.20
90%	-1375	344	37,334	13,711	19.94	0.25
100%	-1219	-8031	41,544	15,257		

Sample Photos





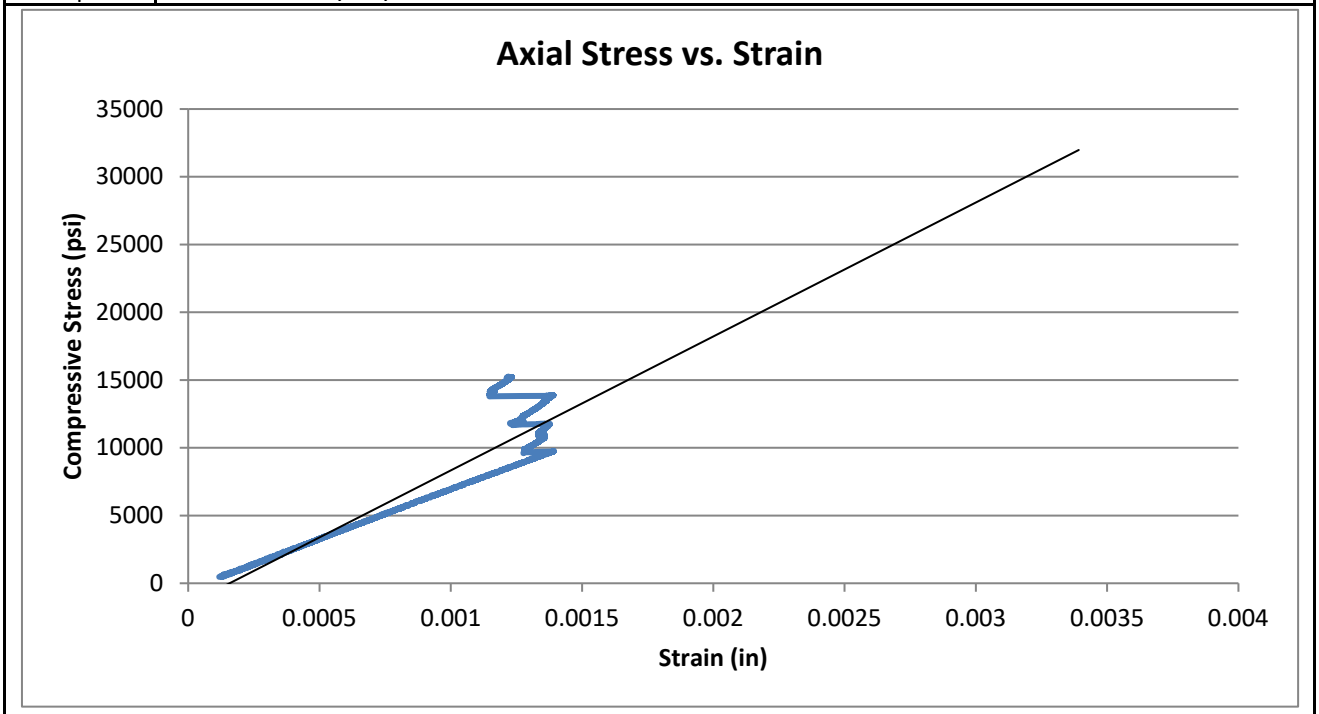
Test Results

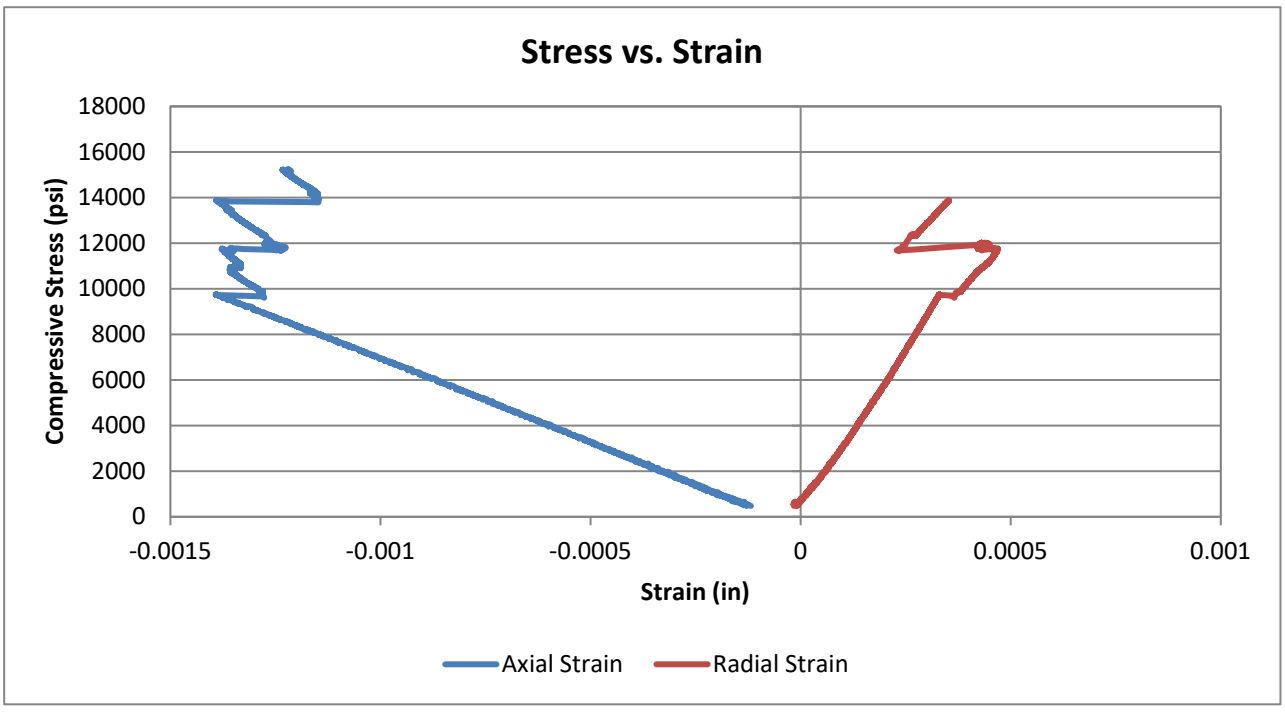
Unconfined Compressive Strength (psi)	**15,260**	Elastic Modulus (psi)	1.36E+07
		Poisson's Ratio in Elastic Range	0.23
Comments	Elastic range was taken as between 0.0005 and 0.001 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. Sample exhibited a partial failure at 9,600 psi. At 13,800 psi, a partial failure displaced the radial strain transducer.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.862	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.978	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	193.8	Core Size	NQ
Sample No.	NQ-4 / 20-2943A	L/D Ratio	2.14	Recovery	100%
Depth	40.6' - 40.9'	Load Rate (psi/sec)	20	RQD	78%
Description	Blue/Green/Grey Phyllite				





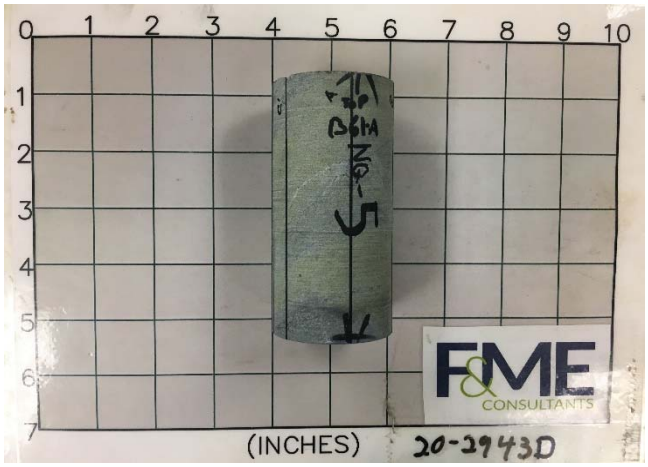
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

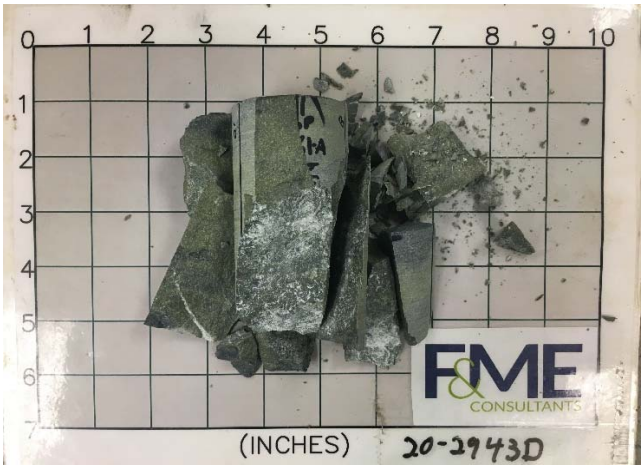
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.863	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.966	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	200.1	Core Size	NQ
Sample No.	NQ-5 / 20-2943D	L/D Ratio	2.13	Recovery	91%
Depth	45.1' - 45.4'	Load Rate (psi/sec)	20	RQD	65%
Description	Blue/Green/Grey Phyllite				

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%	-251	72	4,083	1,498	11.94	0.29
20%	-446	109	8,102	2,972	13.32	0.24
30%	-638	144	12,171	4,465	13.99	0.23
40%	-826	176	16,234	5,955	14.42	0.21
50%	-1023	208	20,284	7,441	14.55	0.20
60%	-1208	238	24,348	8,932	14.79	0.20
70%	-1397	269	28,333	10,394	14.89	0.19
80%	901	3077	32,449	11,904	26.42	3.41
90%	930	3741	36,531	13,401	28.81	4.02
100%	969	4400	40,569	14,883		

Sample Photos





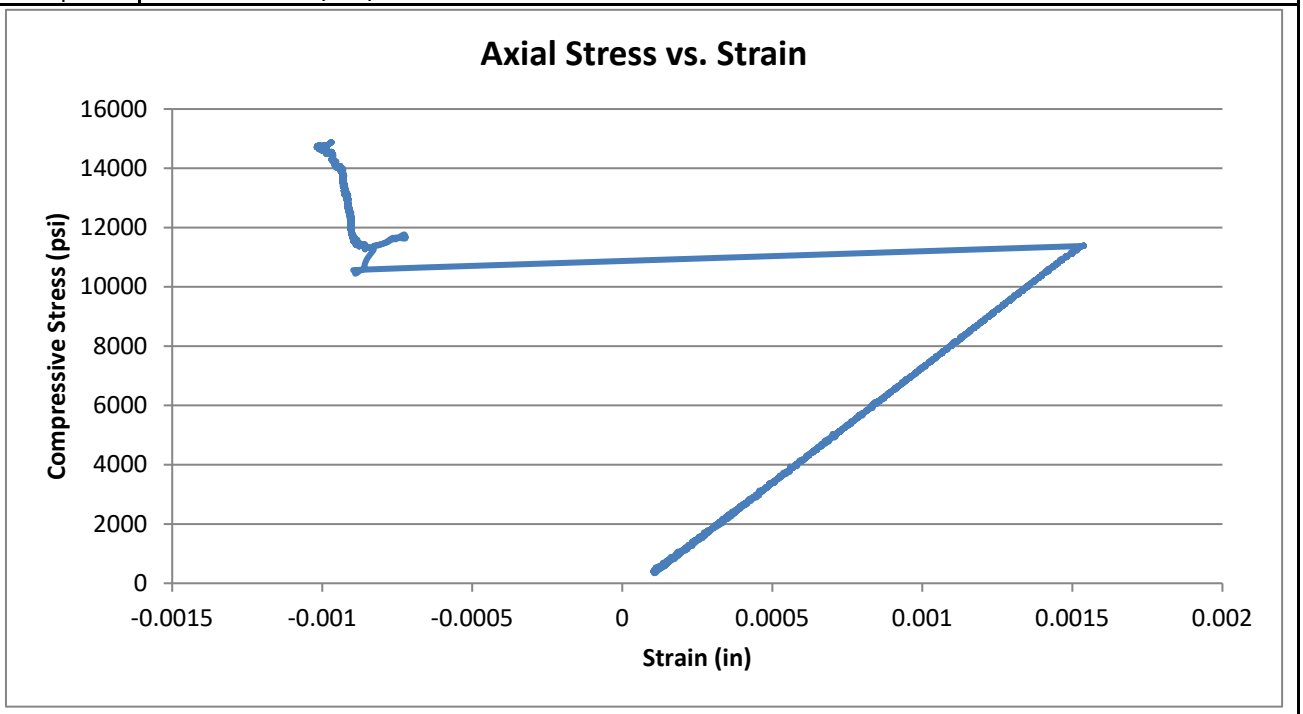
Test Results

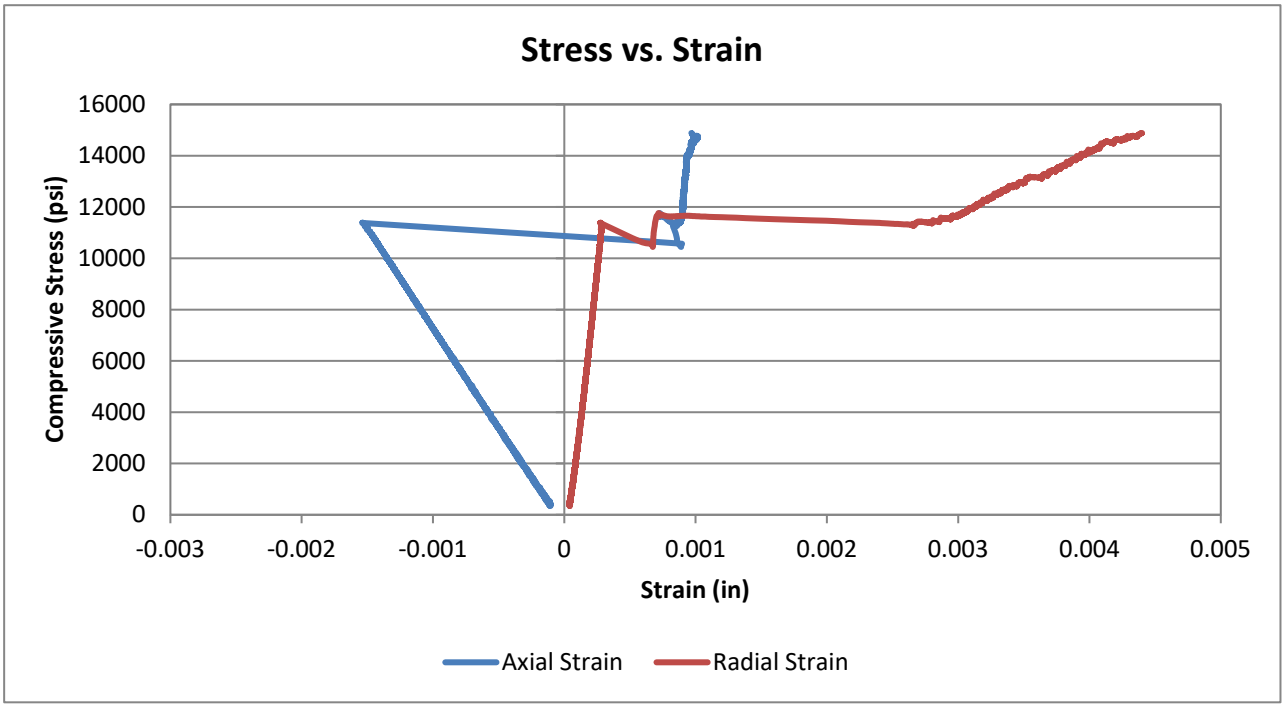
Unconfined Compressive Strength (psi)	**14,800**	Elastic Modulus (psi)	1.44E+07
		Poisson's Ratio in Elastic Range	0.21
Comments	Elastic range was taken as between 0.0005 and 0.0015 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range. Sample experienced a partial failure at 11,300 psi which displaced the axial strain gauge.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.863	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	3.966	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	200.1	Core Size	NQ
Sample No.	NQ-5 / 20-2943D	L/D Ratio	2.13	Recovery	91%
Depth	45.1' - 45.4'	Load Rate (psi/sec)	20	RQD	65%
Description	Blue/Green/Grey Phyllite				





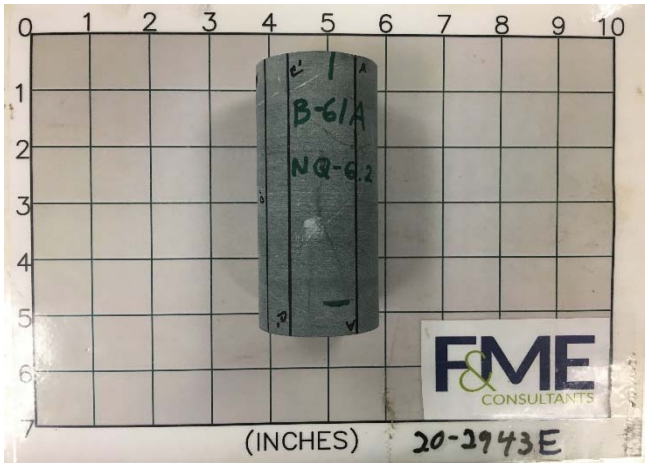
Compressive Strength and Elastic Moduli of Intact Rock Core Specimens
ASTM D7012 - Method D / SC-T-39

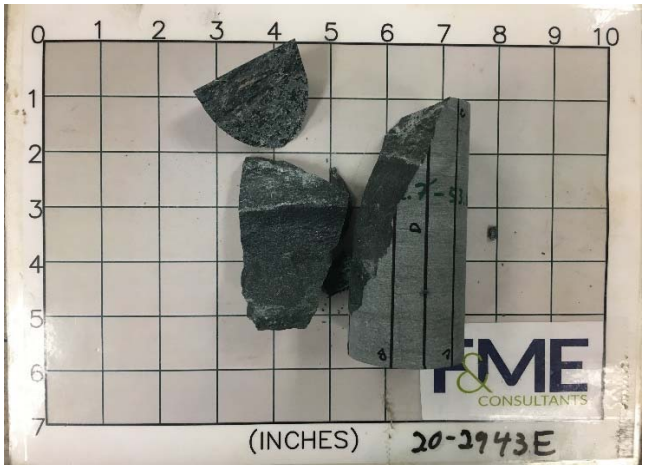
Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.861	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.139	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	175.1	Core Size	NQ
Sample No.	NQ-6 / 20-2943E	L/D Ratio	2.22	Recovery	88%
Depth	52.7 - 53.0'	Load Rate (psi/sec)	20	RQD	57%
Description	Blue/Green/Grey Phyllite				

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%	-172	181	1,535	564	6.56	1.05
20%	-1864	518	3,040	1,118	1.20	0.28
30%	-2112	590	4,632	1,703	1.61	0.28
40%	-2347	650	6,139	2,257	1.92	0.28
50%	-2572	687	7,623	2,802	2.18	0.27
60%	-2821	724	9,228	3,392	2.41	0.26
70%	-3080	726	10,724	3,942	2.56	0.24
80%	-3421	705	12,333	4,534	2.65	0.21
90%	-3713	675	13,877	5,102	2.75	0.18
100%	-4098	723	15,381	5,655		

Sample Photos





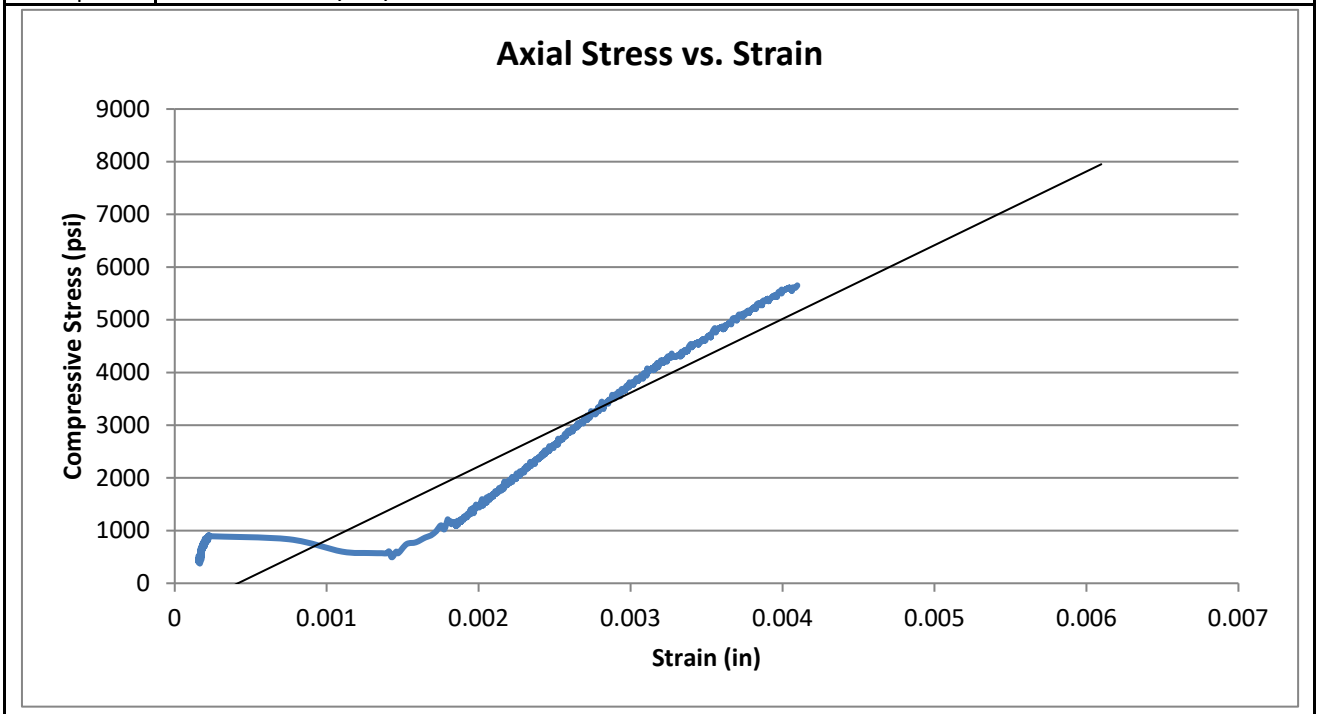
Test Results

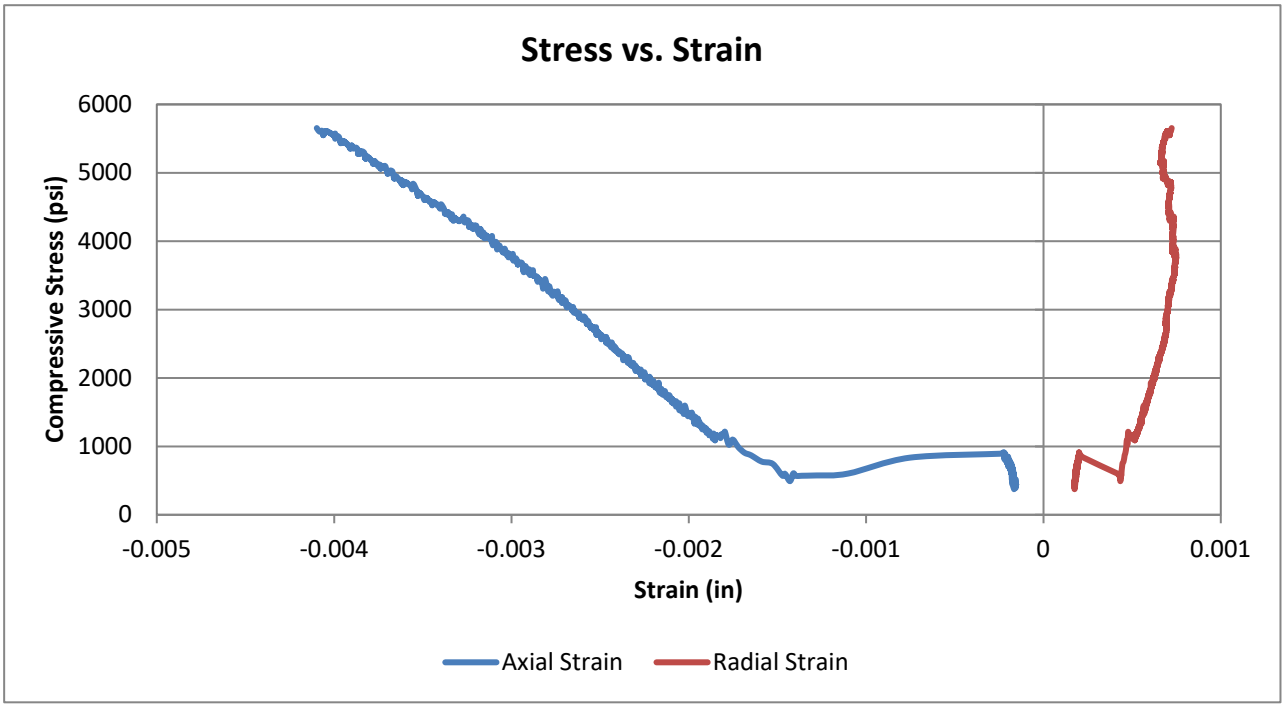
Unconfined Compressive Strength (psi)	**5,650**	Elastic Modulus (psi)	2.04E+06
		Poisson's Ratio in Elastic Range	0.27
Comments	Elastic range was taken as between 0.002 and 0.003 inches of axial strain. This range was chosen to avoid any non-linear behavior from the initial loading and the inflection point at the end of the elastic range.		

F&ME CONSULTANTS

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

Project	Carolina Crossroads - I-20/26/126 Corridor Improvements			Date	11/18/2020
Project No.	G5662.01	Sample Diameter (in.)	1.861	Tested By	WJG
SCDOT ID	P039718	Sample Length (in.)	4.139	Reviewed By	JSF
Boring	B-61A	Unit Weight (pcf)	175.1	Core Size	NQ
Sample No.	NQ-6 / 20-2943E	L/D Ratio	2.22	Recovery	88%
Depth	52.7 - 53.0'	Load Rate (psi/sec)	20	RQD	57%
Description	Blue/Green/Grey Phyllite				





APPENDIX

SECTION 6 SPT HAMMER ENERGY REPORTS












GRL engineers, inc.

SPT Energy Calibration Services

Job No. 209021-1

April 1, 2020

Project: Standard Penetration Test Energy Measurements
CME 550X S/N 269553
Chester, South Carolina

Prepared For: F&ME Consultants

By: Joel S. Webster, E.I. & Thomas G. Hyatt, P.E.

www.grlengineers.com

April 1, 2020

Mr. Jarod Ford
F&ME Consultants
3112 Devine St
Columbia, SC 29205

Re: Standard Penetration Test Energy Measurements
Chester, South Carolina GRL Job No. 209021-1

Dear Mr. Ford;

This report presents results of energy measurements obtained on March 13, 2020 during Standard Penetration Test (SPT) sampling. One automatic hammer mounted on a drill rig owned by F&ME Consultants was tested. The drill rig was an ATV mounted CME 550X. All dynamic tests were performed on AW drill rods having J threads. GRL Engineers, Inc. obtained the dynamic measurements using an 8G Model Pile Driving Analyzer® and an instrumented AW-J rod subsection. This report describes the testing procedures and summarizes the test results. Appendix A describes our measurement and analysis methods, Appendix B contains the instrumentation calibrations and certificates, and Appendix C contains a summary of the field data.

PURPOSE AND SCOPE OF WORK

At the request of F&ME Consultants, GRL Engineers conducted SPT energy measurements in general accordance with ASTM D4633-16 during SPT sampling at a site near the intersection of Lowry's Highway and Hardin Strait Rd in Chester County, South Carolina. SPT energy measurements were made on an automatic hammer mounted on a CME 550X drill rig (S/N 269553). The drilling method used to advance the boring was hollow stem auger. SPT energy measurements were performed at 5-foot sampling intervals between 23.5 and 45 feet. A total of five energy measurement events were performed for this drill rig. The SPT samples were driven for a total of three, 6 inch increments, or 1.5 feet, and the blow counts for each increment were recorded.

Instrumentation

An 8G Model Pile Driving Analyzer (PDA) (S/N 4763 LE) data acquisition system manufactured by Pile Dynamics, Inc. was used to collect and process the dynamic measurements of force and velocity. A two-foot long subsection of standard AW rod with J tapered threads (S/N 486AWJ) was instrumented with two full bridge foil resistance strain gages (S/N 486AWJ1 and 486AWJ2) and two piezoresistive accelerometers (S/N K4998 and K5001) mounted in the midpoint of the instrumented rod. The calibration records for all instrumentation used for this testing are included in Appendix B.

RESULTS

Upon return to the office, the records collected by the PDA were checked for consistency and accuracy. For example, records from very weak startup or final impacts were not included in average results. The results include the EFV (transferred energy by the FV method, as

recommended by ASTM D4633-16), ETR (energy transfer efficiency for the EFV method), BLC (increment blow count), BPM (hammer operating rate), FMX (maximum rod top force) and VMX (maximum rod top velocity). Appendix C contains summary plots of the ETR with respect to rod length, summary plots of sampling results (BLC, BPM, FMX, VMX, EFV, ETR) with respect to depth below grade, a representative plot of force and normalized velocity versus time, as well as tables of results for all hammer blows at each dynamically monitored sampling depth. The tables show statistical summaries for the last two 6 inch increments over which the SPT N value is calculated. At the end of each table is a statistical evaluation of these results which include the average and standard deviation.

The table below summarizes the average transferred energy values calculated by the EFV method. The Energy Transfer Ratio (ETR) is defined as the ratio of maximum transferred energy EFV divided by the theoretical hammer potential energy of 350 foot-pounds (i.e., computed from the 140 pound SPT hammer and the standard 30 inch drop as specified by ASTM D1586-99).

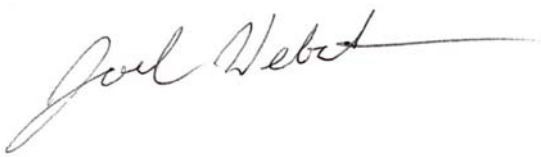
Drill Rig	Avg. EFV (ft-lbs)	Avg. ETR (%)	Range of EFV (ft-lbs)	Range of ETR (%)
CME 550X S/N 269553	301	86	287 – 315	82 – 90

Please review both ASTM D4633-16 and ASTM D1586-99 prior to applying these test results. The energy calibrations reported herein are valid for the same hammer/drill rig, with the same drill operator, same anvil dimensions, and same drilling methods.

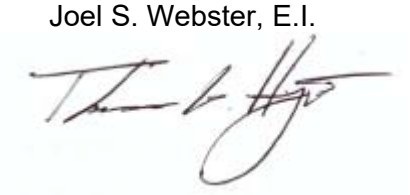
We appreciate the opportunity to be of assistance to you on this project. Please contact our office should you have any questions regarding this submittal, require additional information, or if we may be of further service.

Sincerely,

GRL Engineers, Inc.



Joel S. Webster, E.I.



Thomas G. Hyatt, P.E.

Appendix A

An Introduction into SPT Pile Testing

APPENDIX A
AN INTRODUCTION INTO SPT DYNAMIC PILE TESTING

1. BACKGROUND

The Standard Penetration Test is frequently conducted as an in-situ assessment of soil strength. This test requires that a 140 lb weight is dropped 30 inches onto a drive rod at whose bottom a sampler is usually installed. The sampler is driven for 18 inches; the number of blows required for the last 12 inches of driving is the so-called N-value. The N-value may be used as a strength indicator for foundation design or as a means of assessing the liquefaction potential of soils.

Obviously, the SPT hammer efficiency is an important consideration when using the N-values for design purposes. Measurements have indicated that the energy in the drive rod is sometimes only 30% and and may reach 90% of the potential or rated energy of the SPT hammer (E-rated = 0.35 kip-ft or 0.475 kJ). The type of hammer used to drive the rod is the main reason for these variations. On the average, the energy in the drive rod is 60% of the standard rated energy.

Because of the variability of energy, methods based on N-values are considered unreliable. However, measurements during SPT testing using the Case Method can be done on a routine basis and these measurements yield the transferred energy values. With measured energy, EMX, known, an adjustment of the measured N-value, N_m, can be made as follows.

$$N_{60} = N_m [E_m / (0.6E_r)] \quad (1)$$

Thus, if the measured energy value is equal to the normally expected transferred energy of 60% of E-rated then the adjusted and measured N-values are identical. On the other hand, if the measured energy is only 30% then the adjusted blow count will be reduced by 50%.

2. DYNAMIC TESTING AND ANALYSIS METHODS APPLIED TO SPT

The Case Method of dynamic pile testing, named after the Case Institute of Technology where it was developed between 1964 and 1975, requires that a substantial ram mass (e.g. a pile driving hammer) impacts the pile top such that the pile undergoes at least a small permanent set. Thus, the method is also referred to as a “High Strain Method”. The Case Method requires dynamic measurements on the pile or shaft under the ram impact and then a calculation of various quantities. Conveniently, for SPT applications, the measurements and analyses are done by a single piece of equipment: the SPT Analyzer. The Pile Driving Analyzer® (PDA) is also suitable to perform these measurements and data processing.

A related analysis method is the “Wave Equation Analysis” which calculates a relationship between bearing capacity, pile stresses, transferred energy and field blow count. The GRLWEAP™ program performs this analysis and provides a complete set of helpful information and input data. This program can be used very effectively to simulate the SPT driving process.

3. MEASUREMENTS

GRL uses equipment manufactured by Pile Dynamics, Inc. The system includes either an SPT-Analyzer™ (SPTA) or a Pile Driving Analyzer® (PDA), an instrumented rod section and two accelerometers. SPT energy testing is very closely related to and borrows procedures from dynamic pile testing. Those interested in the basis of the SPT energy testing method may obtain extensive literature on dynamic pile testing from GRL Engineers, Inc.

3.1 SPT Analyzer or Pile Driving Analyzer

The basis for the results calculated by the SPTA or PDA are strain and acceleration measured in an instrumented rod section. These signals are converted to rod top force, F(t), and rod top velocity, v(t). The SPTA or PDA conditions, calibrates and displays these signals and immediately computes average pile force and velocity thereby eliminating bending effects. The product of these two

measurements is then integrated over time which yields the energy transferred to the instrumented section as a function of time (see Section 4.1).

For convenience and accuracy, strain measurements are usually taken on an instrumented section of SPT drive rod. Ideally, the section properties of the instrumented rod and those of the drive rod are the same, however, using subs, other sections can also be utilized.

For the instrumented section, PDI provides a force calibration in such a way that the output of the instrumented rod is directly calculated without the need for an accurate elastic modulus or cross sectional area of the rod section.

The acceleration measurements are often demanding in the SPT environment, because of high frequency and high acceleration motion components. An experienced measurement engineer, therefore, has to evaluate the quality of this data before final conclusions are drawn from the numerical results calculated by SPTA or PDA.

SPTA or PDA records are taken while the standard N-value is acquired in the conventional manner. This then allows a direct correlation between N-value and average transferred energy.

3.2 HPA

The SPT hammer's ram velocity may be directly obtained using radar technology in the Hammer Performance Analyzer™. The impact velocity results can be automatically processed with a PC or recorded on a strip chart. HPA measurements yield a hammer kinetic energy, but not the energy transferred to the drive rod.

4 RECORD EVALUATION BY SPTA OR PDA

4.1 HAMMER PERFORMANCE

The PDA calculates the energy transferred to the pile top from:

$$E(t) = {}_0\int^t F(\tau)v(\tau)\, d\tau \qquad (2)$$

The maximum of the E(t) curve is often called **ENTHRU or EMX;** it is the most important quantity for an overall evaluation of the performance of a hammer and driving system. **EMX** allows for a classification of the hammer's performance when presented as, e_T, the rated transfer efficiency, also called energy transfer ratio (**ETR**) or global efficiency.

$$e_T = EMX/E_R \qquad (3)$$

where E_R is the hammer manufacturer's rated energy value or 0.35 kip-ft (0.475 kJ) in the case of the SPT hammer.

Often in the SPT literature one finds also reference to the EF2 energy. This evaluation is based on assumed proportionality between force and velocity (see also Section 5):

$$v(t) = F(t) / Z \qquad (4)$$

where Z = EA/c is the pile impedance, E is the elastic modulus, A is the cross sectional area and c is the speed of the stress wave in the pile material..

Combining equations 2 and 4 leads to

$$EF(t) = {}_0\int^t F(\tau)^2 / Z\, d\tau \qquad (5)$$

The EF2 transferred energy value is the EF-value at the time t = 2L/c, where L is the drive rod length and c is the stress wave speed in steel (16,800 ft/s or 5,124 m/s). Since the force is easier to measure than both force and velocity, Equation 5 is preferred by some test engineers. However, the EF method is fraught with errors and certain correction factors have to be applied to make it approximately correct. Among the error sources are the following:

- Proportionality is often violated prior to time 2L/c. The proportionality between force and velocity in a downward traveling wave only holds if the wave does not encounter a disturbance prior to reflecting off the pile toe. Such disturbances include a change in cross sectional area, an open or loose splice or joint, or resistance along the shaft.

- Using only one force measurement precludes a data quality check based on the proportionality between force and velocity. Thus, a force measurement that is for some reason in error may not be detectable, which will lead to errors in the EF2 value. Data quality checks will be discussed further in Section 5.

The use if EF2 is therefore not recommended but it is often included in result presentations for the sake of completeness.

4.2 STRESSES

During SPT monitoring, it is also of interest to monitor compressive stresses at both the top of the drive rod and at its bottom.

At the pile top (location of sensors) the maximum compression stress averaged over the rod's cross section, **CSX**, is directly obtained from the measurements. Note that this stress value refers to the instrumented section. If the rod has a different cross sectional area then the stress in the rod will be different from CSX.

The SPTA or PDA can also calculate, in an approximate manner, the force at the rod bottom, **CFB**. To obtain the corresponding stress, this force value should be divided by the appropriate cross sectional area, e.g. by the rod area just above the sampler or by the sampler area itself. Of course, non-uniform stress components as they might occur at the sampler tip due to a sloping rock are not considered in this calculation.

5. DATA QUALITY CHECKS

Quality data is the first and foremost requirement for accurate dynamic testing results. It is therefore important that the measurement engineer performing SPTA or PDA tests has the experience necessary to recognize measurement problems and take appropriate corrective action should problems develop. Fortunately, dynamic pile testing allows for certain data quality checks because two independent measurements are taken that have to conform to the so-called proportionality relationship.

As long as there is only a wave traveling in one direction, as is the case during impact when only a downward traveling wave exists in the rod, force and velocity measured at its top are proportional

$$F = v\,Z \qquad (5)$$

where Z is again the pile impedance, Z = EA/c. This relationship can also be expressed in terms of stress

$$\sigma = F/A = v\,(E/c) \qquad (6)$$

or strain

$$\epsilon = \sigma/E = v / c \qquad (7)$$

This means that the early portion of strain times wave speed must be equal to the velocity unless the proportionality is affected by high friction near the pile top or by a pile cross sectional change not far below the sensors. Checking the proportionality is an excellent means of assuring meaningful measurements but is only truly meaningful for perfectly uniform rods. Open or loose splices, for example, will lead to a non-proportionality. For SPT rods it is fortunate that usually no soil resistance acts along the shaft and for that reason, proportionality can exist until the stress wave returns from sampler top or rod bottom unless connectors are not sufficiently tightened or have a significant mass.

Velocity data quality can also be checked by looking at the final displacement, DFN, which is calculated from the acceleration by double integration. If the calculated final displacement is much higher or lower than indicated by the N-value, the accelerometer attachment may be loose or the sensor may be faulty. If major drift in the velocity is observed, the EMX value may be in error, even though proportionality from impact to time 2L/c exists. In this case, it may be useful to evaluate the energy transferred to the drill rod at time 2L/c, which is calculated by the PDA or SPTA as the E2E quantity.

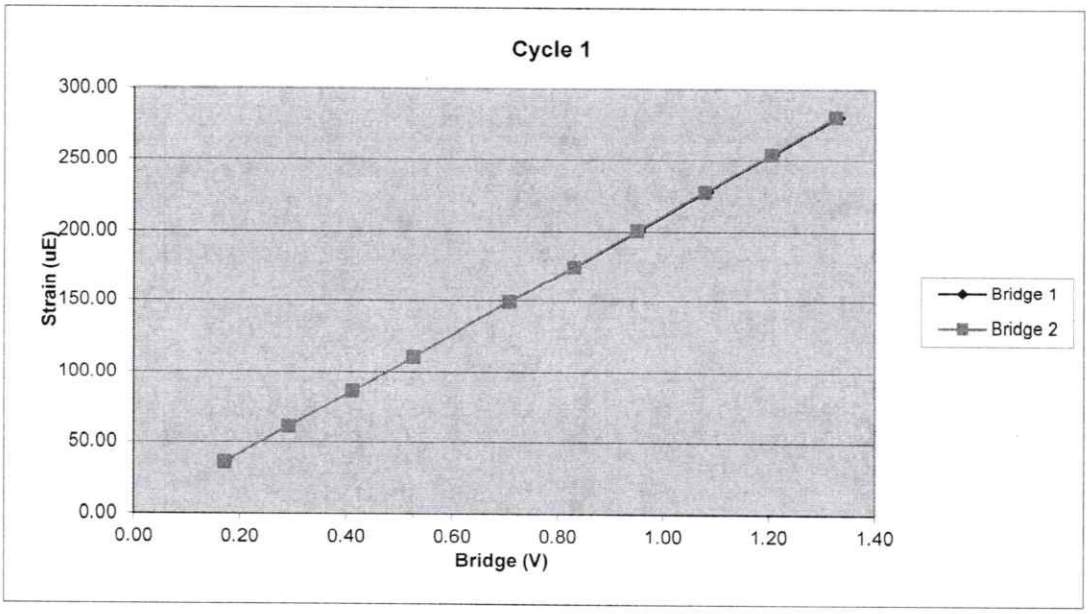
APPENDIX B

Instrumentation Calibration Information

486AWJ		Cycle 1		
Sample	**Force (lb)**	**Strain (μE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	1278.86	35.92	0.17	0.17
3	2168.60	61.34	0.29	0.29
4	3069.46	86.20	0.41	0.41
5	3937.33	110.67	0.53	0.53
6	5292.73	149.53	0.71	0.71
7	6220.93	174.88	0.83	0.83
8	7117.70	200.77	0.95	0.95
9	8072.65	227.79	1.08	1.08
10	9021.35	253.71	1.21	1.20
11	9942.13	280.21	1.33	1.33

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**7477.85**	**Force Calibration (lb/V)**	**7504.74**
Offset	-5.58	Offset	-12.71
Correlation	0.999998	Correlation	0.999999
Strain Calibration (μE/V)	**210.73**	**Strain Calibration (μE/V)**	**211.48**
Offset	-0.21	Offset	-0.41
Correlation	0.999995	Correlation	0.999993

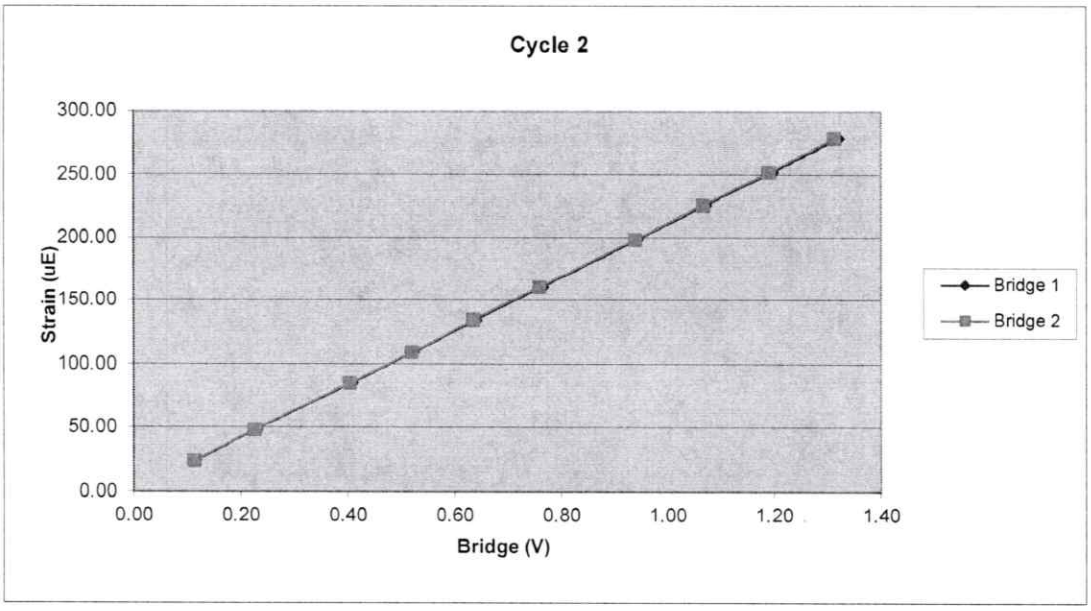
Force Strain Calibration	
EA (Kips)	**35485.64**
Offset	1.86
Correlation	0.999993



486AWJ		Cycle 2		
Sample	**Force (lb)**	**Strain (μE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	857.52	23.79	0.12	0.11
3	1698.64	47.94	0.23	0.23
4	3027.88	85.21	0.41	0.40
5	3889.89	109.21	0.52	0.52
6	4762.05	134.36	0.64	0.63
7	5693.77	160.38	0.76	0.76
8	7038.23	198.52	0.94	0.94
9	7993.57	225.63	1.07	1.07
10	8932.90	251.73	1.20	1.19
11	9856.61	278.11	1.32	1.31

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**7475.96**	**Force Calibration (lb/V)**	**7504.10**
Offset	**-6.95**	Offset	**0.64**
Correlation	**0.999999**	Correlation	**0.999998**
Strain Calibration (μE/V)	**211.12**	**Strain Calibration (μE/V)**	**211.91**
Offset	**-0.50**	Offset	**-0.28**
Correlation	**0.999997**	Correlation	**0.999996**

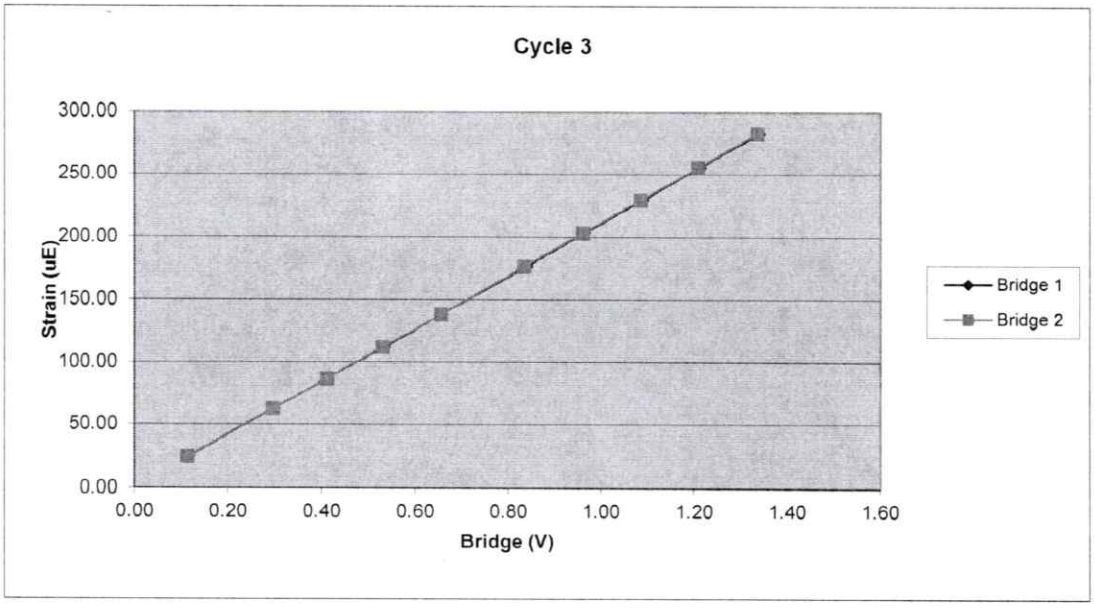
Force Strain Calibration	
EA (Kips)	**35411.39**
Offset	**10.65**
Correlation	**0.999997**



486AWJ		Cycle 3		
Sample	**Force (lb)**	**Strain (µE)**	**Bridge 1 (V)**	**Bridge 2 (V)**
1	0.00	0.00	0.00	0.00
2	862.99	24.53	0.11	0.11
3	2219.75	62.30	0.30	0.30
4	3088.60	86.68	0.41	0.41
5	3980.48	112.26	0.53	0.53
6	4903.80	138.19	0.66	0.66
7	6256.27	176.45	0.84	0.83
8	7193.06	203.18	0.96	0.96
9	8152.31	229.19	1.09	1.09
10	9051.42	255.15	1.21	1.21
11	10021.99	282.47	1.34	1.34

Bridge 1		**Bridge 2**	
Force Calibration (lb/V)	**7471.12**	**Force Calibration (lb/V)**	**7487.98**
Offset	**5.63**	Offset	**7.27**
Correlation	**0.999998**	Correlation	**0.999997**
Strain Calibration (µE/V)	**210.59**	**Strain Calibration (µE/V)**	**211.06**
Offset	**0.11**	Offset	**0.16**
Correlation	**0.999997**	Correlation	**0.999995**

Force Strain Calibration	
EA (Kips)	**35477.05**
Offset	**1.74**
Correlation	**0.999994**



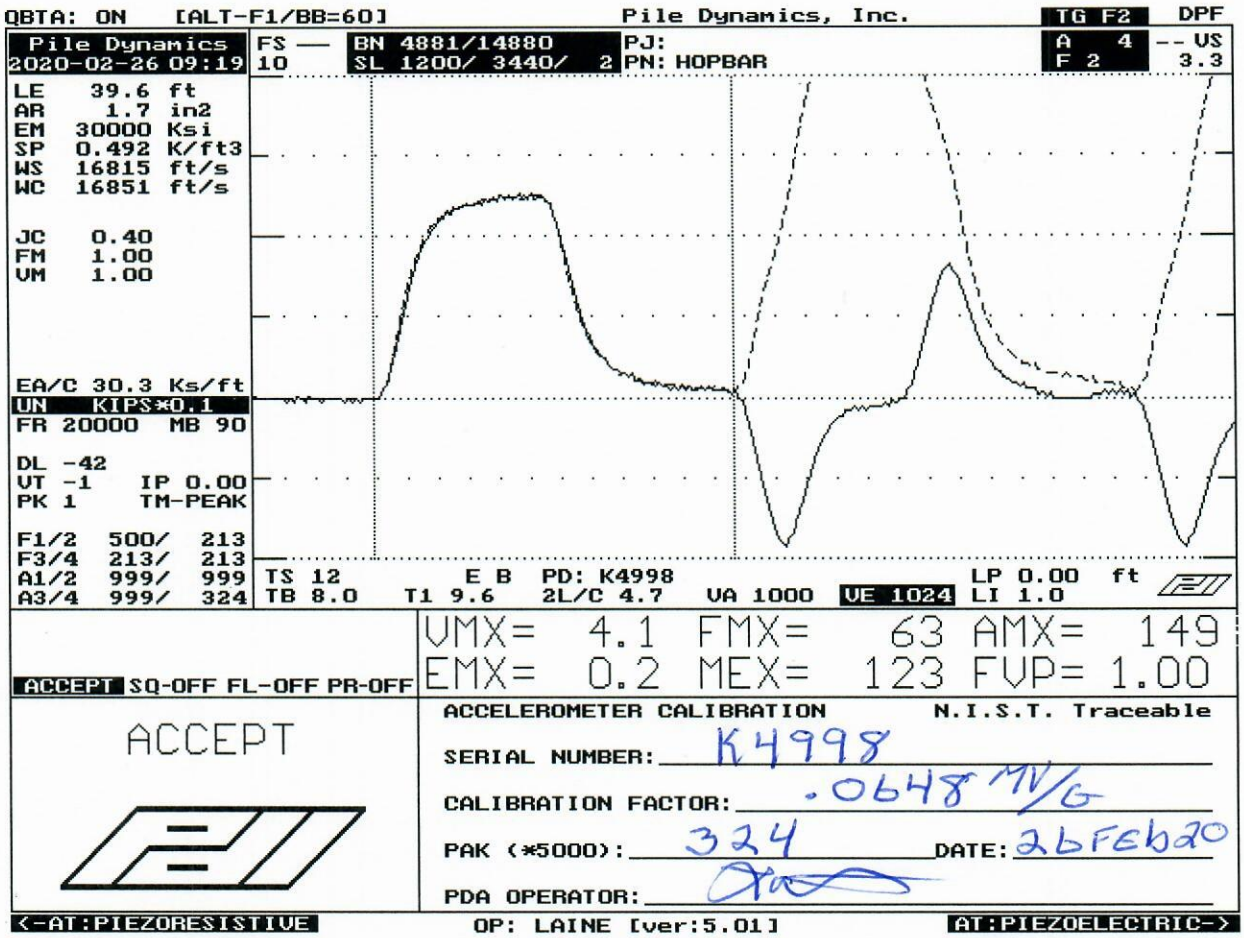
Bridge Excitation (V) 5
Shunt Resitor (ohm) 60.4k

Calibration Factors	486AWJ		
Bridge 1 (µE/V)	210.81	Bridge 2 (µE/V)	211.49
EA Factor (Kips)	35458.03	Area (in^2)	1.18

Calibrated by: David Brusk
Calibrated Date: 4/25/2019

Pile Dynamics Inc
30725 Aurora Rd
Solon, OH 44139

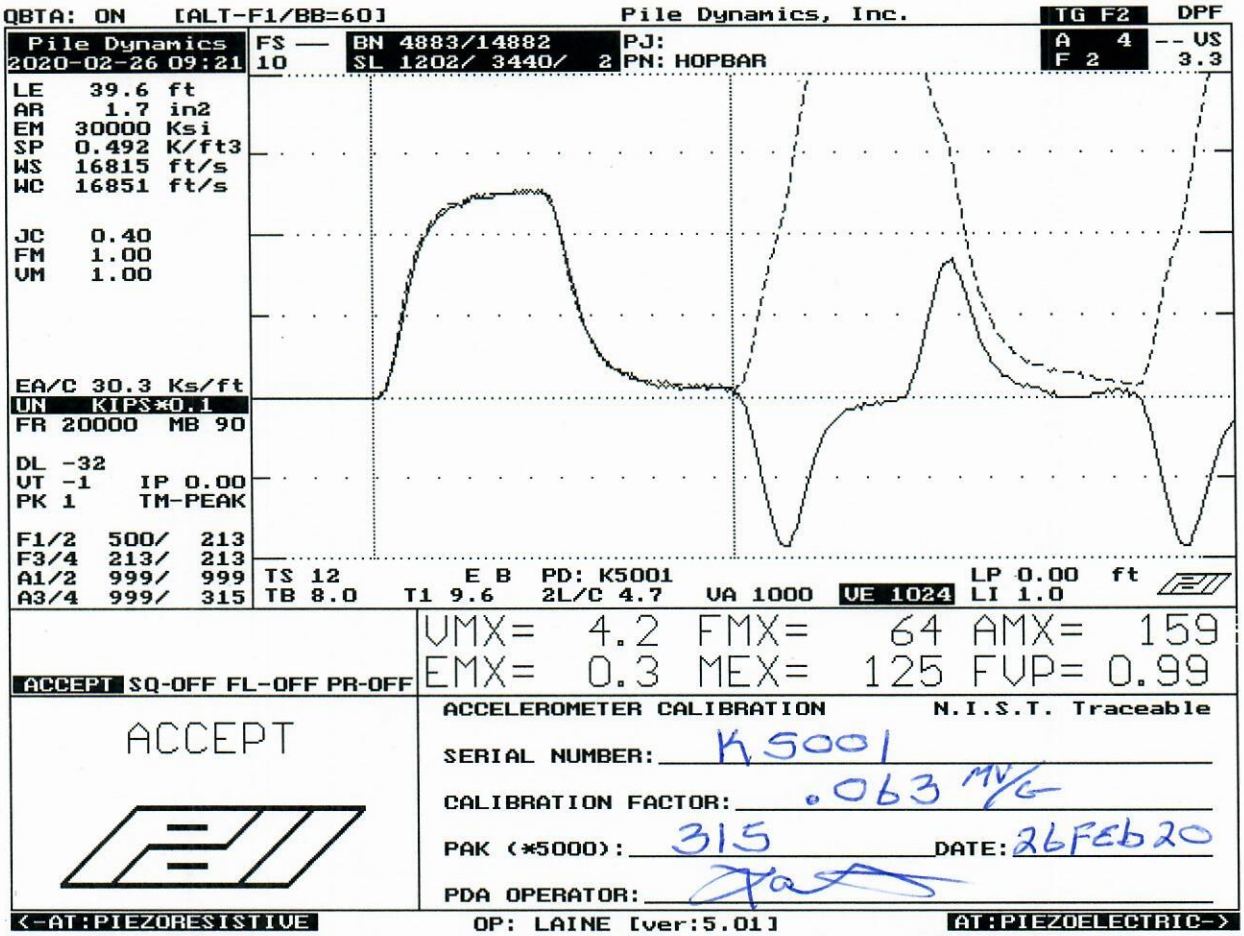
Traceable to N.I.S.T.



Smart Sensor

Programmed By: J.W.

CRC Value B9B1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Pile Dynamics, Inc.
TG F2
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Pile Dynamics
2020-02-26 09:21
FS —
10
BN 4883/14882
SL 1202/ 3440/ 2
PJ:
PN: HOPBAR
A 4
F 2
-- VS
3.3
LE 39.6 ft
AR 1.7 in2
EM 30000 Ksi
SP 0.492 K/ft3
WS 16815 ft/s
WC 16851 ft/s
JC 0.40
FM 1.00
VM 1.00
EA/C 30.3 Ks/ft
UN KIPS*0.1
FR 20000 MB 90
DL -32
VT -1 IP 0.00
PK 1 TM-PEAK
F1/2 500/ 213
F3/4 213/ 213
A1/2 999/ 999
A3/4 999/ 315
TS 12 E B PD: K5001
TB 8.0 T1 9.6 2L/C 4.7 VA 1000 VE 1024
LP 0.00 ft
LI 1.0
VMX= 4.2 FMX= 64 AMX= 159
EMX= 0.3 MEX= 125 FVP= 0.99
ACCEPT SQ-OFF FL-OFF PR-OFF
ACCEPT
ACCELEROMETER CALIBRATION N.I.S.T. Traceable
SERIAL NUMBER: K5001
CALIBRATION FACTOR: .063 MV/G
PAK (*5000): 315 DATE: 26Feb20
PDA OPERATOR:
<-AT:PIEZORESISTIVE
OP: LAINE [ver:5.01]
AT:PIEZOELECTRIC->
Smart Sensor
Programmed By: T.W.
CRC Value F77C

Certificate of Calibration

Pile Dynamics, Inc. certifies that the

Pile Driving Analyzer®, Model 8G

Serial Number: 4763 LE

was calibrated on 02 April 2019

using a PDA Calibration Box whose output was calibrated with test equipment traceable to NIST.

This certificate is valid for 2 years from above date.

Tested by:

Pile Dynamics, Inc.
30725 Aurora Road
Cleveland, Ohio 44139 USA

PDCA
PILE DRIVING CONTRACTORS ASSOCIATION

Pile Dynamics, Inc.

This documents that

Thomas Hyatt
GRL Engineers, Inc.

has on January 26, 2017 achieved the rank of

MASTER

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 Master level seek to attain Expert level through additional study within eight 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. 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. This certificate can be verified at www.PDAproficiencytest.com.

Steven A. Hall, Executive Director
Pile Driving Contractors Association

Garland Likins, Senior Partner
Pile Dynamics, Inc.

No. 2182

Appendix C

SPT Calibration Results

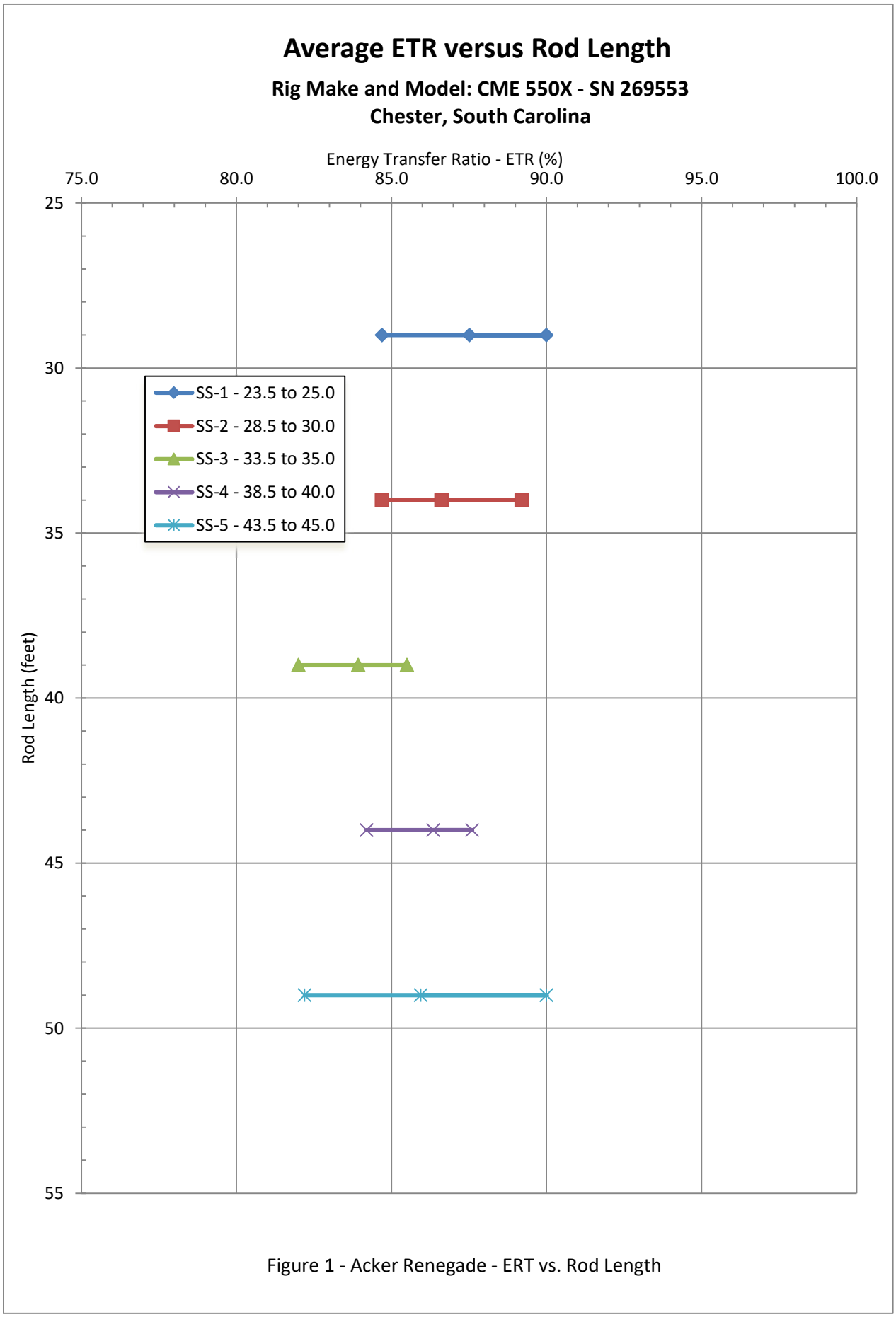


Figure 1 - Acker Renegade - ERT vs. Rod Length

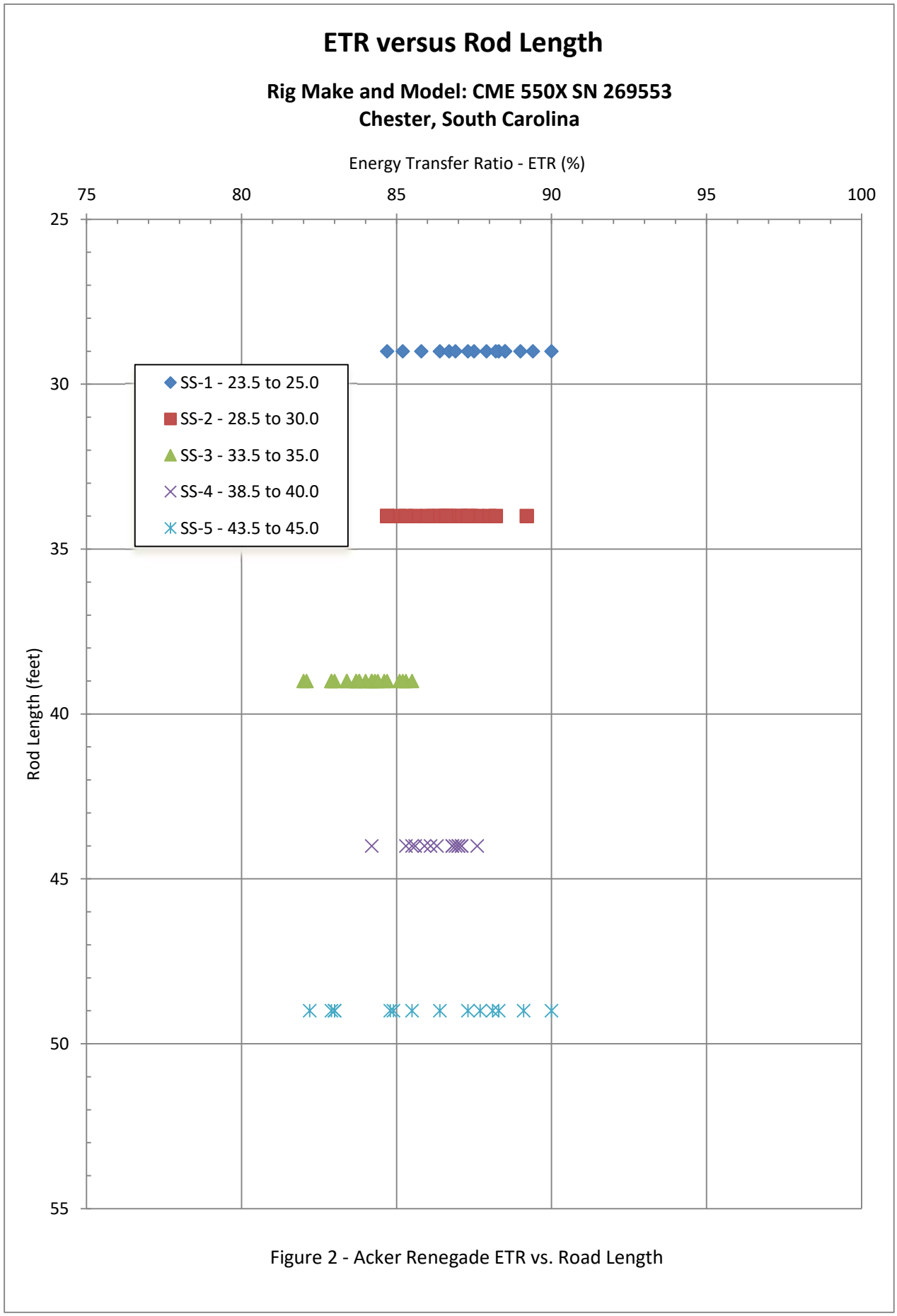


Figure 2 - Acker Renegade ETR vs. Road Length

GRL Engineers, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 3/19/2020

Summary of SPT Test Results

Project: F&ME - CME 550X - SN 269553, Test Date: 3/13/2020

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy

ETR: Energy Transfer Ratio - Rated
DFN: Final Displacement
FVP: Force/Velocity Proportionality

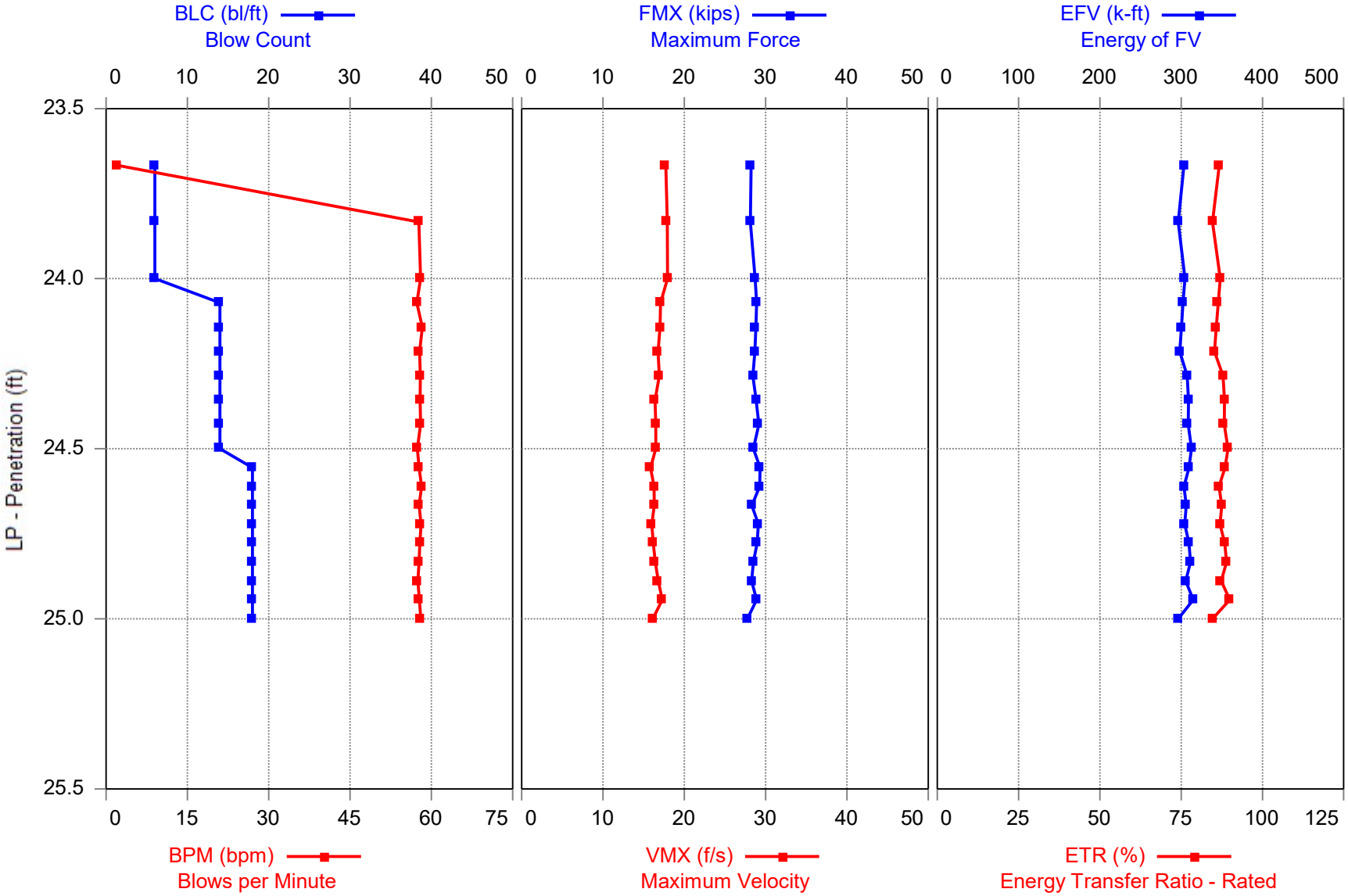
Instr. Length ft	Blows Applied /6"	Start Depth ft	Final Depth ft	**N Value**	**N60 Value**	Average FMX kips	Average VMX ft/s	Average BPM bpm	Average EFV ft-lb	Average ETR %	Average DFN in	Average FVP
28.50	**3-7-9**	23.50	25.00	**16**	**22**	29	16.5	57.8	306	87.5	0.75	0.84
33.50	**6-9-10**	28.50	30.00	**19**	**27**	28	16.2	57.3	303	86.6	0.63	0.82
38.50	**7-11-12**	33.50	35.00	**23**	**32**	28	15.9	56.8	294	83.9	0.52	0.83
43.50	**5-6-9**	38.50	40.00	**15**	**21**	29	16.1	56.5	302	86.3	0.80	0.87
48.50	**4-5-9**	43.50	45.00	**14**	**20**	29	16.0	57.0	301	85.9	0.85	0.86
				Overall Average Values:		28	16.2	57.1	301	85.9	0.69	0.84
				Standard Deviation:		1	0.4	0.5	7	1.9	0.18	0.02
				Overall Maximum Value:		30	17.3	58.3	315	90.0	1.20	0.89
				Overall Minimum Value:		27	15.3	56.0	287	82.0	0.49	0.81

GRL Engineers, Inc. - PDIPLOT2 Ver 2017.2.58.5 - Case Method & iCAP® Results

Printed: 20-March-2020

Test started: 13-March-2020

CME 550X SN 269553 - 23.5-25FT



GRL Engineers, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 3/19/2020

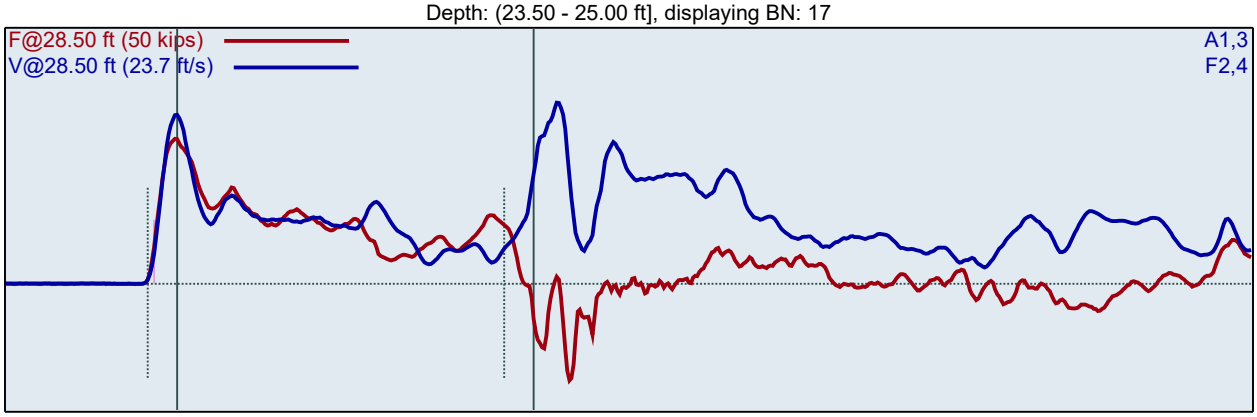
F&ME - CME 550X - SN 269553
TGH
TEST

SN 269553
Test date: 3/13/2020

AR: 1.18 in^2
LE: 28.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (23.50 - 25.00 ft], displaying BN: 17



F2 : [486AWJ1] 210.81 PDICAL (1) FF1
F4 : [486AWJ2] 211.49 PDICAL (1) FF1

A1 (PR): [K4998] 324 mv/6.4v/5000g (1) VF1
A3 (PR): [K5001] 315 mv/6.4v/5000g (1) VF1

FMX: Maximum Force
VMX: Maximum Velocity
BPM: Blows/Minute
EFV: Maximum Energy

ETR: Energy Transfer Ratio - Rated
DFN: Final Displacement
FVP: Force/Velocity Proportionality

BL#	BC /6"	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %	DFN in	FVP
1	3	23.67	28	17.7	1.9	304	86.7	2.00	0.80
2	3	23.83	28	17.9	57.7	296	84.7	2.00	0.80
3	3	24.00	29	17.9	58.0	305	87.0	2.00	0.84
4	7	24.07	29	17.1	57.3	302	86.4	0.86	0.83
5	7	24.14	29	17.0	58.3	300	85.8	0.86	0.83
6	7	24.21	29	16.8	57.8	298	85.2	0.86	0.83
7	7	24.29	28	16.9	58.0	308	87.9	0.86	0.84
8	7	24.36	29	16.4	57.9	309	88.3	0.86	0.84
9	7	24.43	29	16.5	58.0	309	88.2	0.86	0.83
10	7	24.50	28	16.5	57.4	313	89.4	0.86	0.85
11	9	24.56	29	15.9	57.7	310	88.5	0.67	0.84
12	9	24.61	29	16.3	58.2	303	86.7	0.67	0.88
13	9	24.67	28	16.3	57.7	306	87.5	0.67	0.85
14	9	24.72	29	16.0	58.1	304	86.9	0.67	0.85
15	9	24.78	29	16.2	57.9	310	88.5	0.67	0.86
16	9	24.83	28	16.4	57.7	311	89.0	0.67	0.85
17	9	24.89	28	16.8	57.5	306	87.3	0.67	0.86
18	9	24.94	29	17.3	57.8	315	90.0	0.67	0.85
19	9	25.00	28	16.1	58.1	296	84.7	0.67	0.82
		Average	29	16.5	57.8	306	87.5	0.75	0.84
		Std Dev	0	0.4	0.3	5	1.4	0.09	0.01
		Maximum	29	17.3	58.3	315	90.0	0.86	0.88
		Minimum	28	15.9	57.3	296	84.7	0.67	0.82

N-value: 16

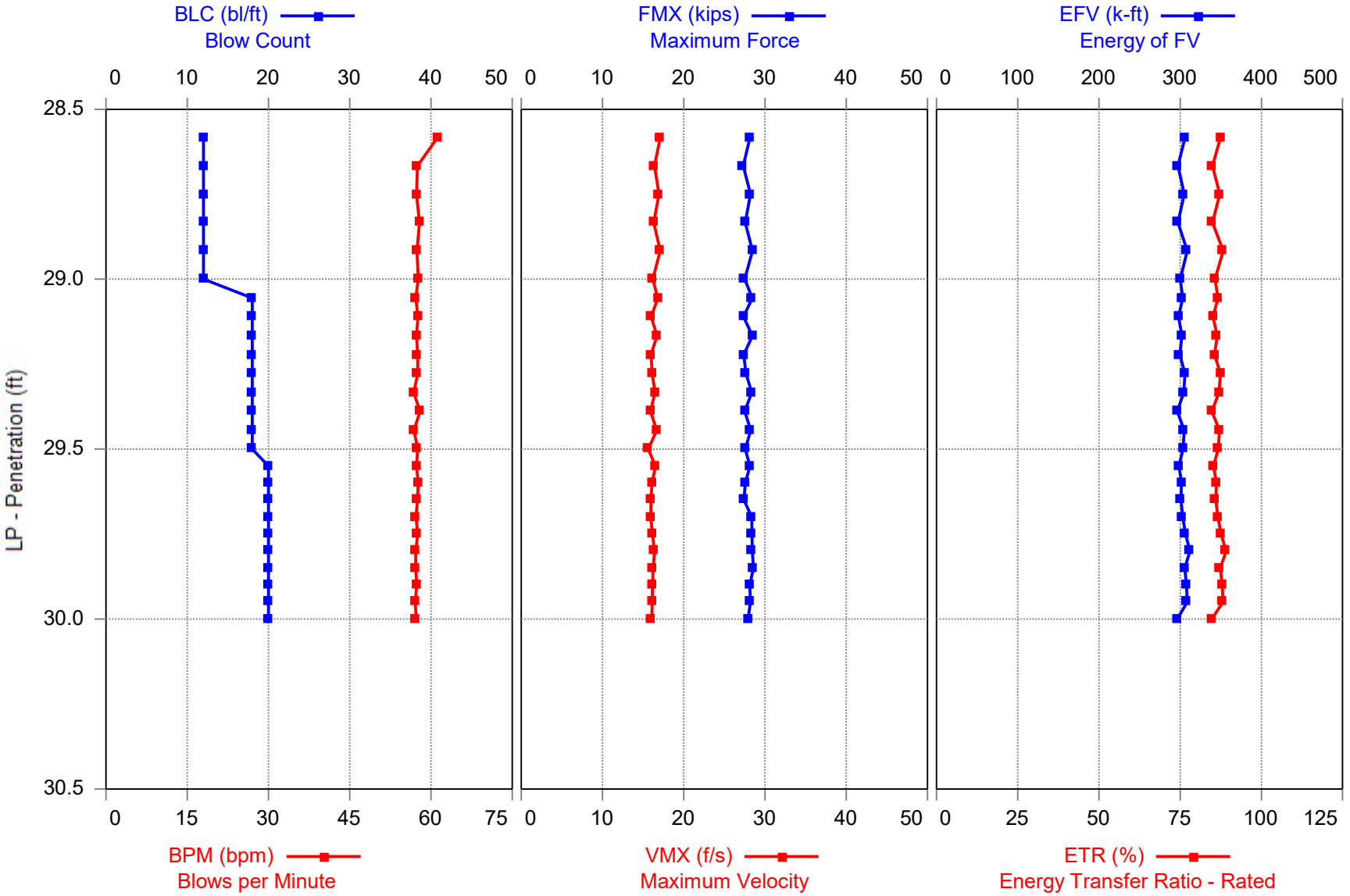
Sample Interval Time: 18.70 seconds.

GRL Engineers, Inc. - PDIPLOT2 Ver 2017.2.58.5 - Case Method & iCAP® Results

Printed: 20-March-2020

Test started: 13-March-2020

CME 550X SN 269553 - 28.5-30FT_1



GRL Engineers, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 3/19/2020

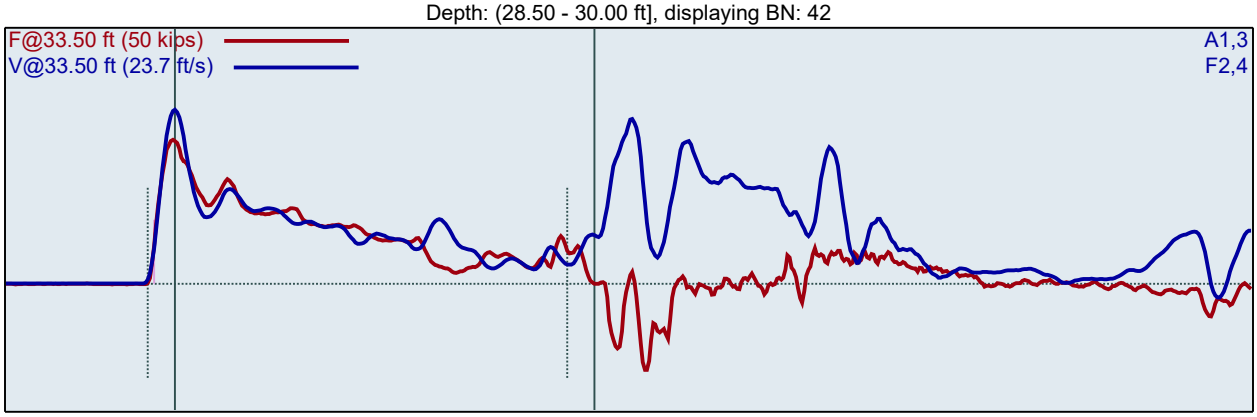
F&ME - CME 550X - SN 269553
TGH
TEST

SN 269553
Test date: 3/13/2020

AR: 1.18 in^2
LE: 33.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (28.50 - 30.00 ft], displaying BN: 42



F2 : [486AWJ1] 210.81 PDICAL (1) FF1
F4 : [486AWJ2] 211.49 PDICAL (1) FF1

A1 (PR): [K4998] 324 mv/6.4v/5000g (1) VF1
A3 (PR): [K5001] 315 mv/6.4v/5000g (1) VF1

BL#	BC /6"	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %	DFN in	FVP
20	6	28.58	28	17.1	61.2	306	87.4	1.00	0.78
21	6	28.67	27	16.4	57.5	297	84.9	1.00	0.78
22	6	28.75	28	17.0	57.3	305	87.2	1.00	0.79
23	6	28.83	28	16.3	57.9	297	85.0	1.00	0.79
24	6	28.92	28	17.1	57.4	309	88.2	1.00	0.80
25	6	29.00	28	16.2	57.6	300	85.7	1.00	0.80
26	9	29.06	28	16.8	57.2	303	86.6	0.67	0.81
27	9	29.11	27	16.0	57.6	298	85.1	0.67	0.81
28	9	29.17	28	16.7	57.3	302	86.4	0.67	0.82
29	9	29.22	27	16.0	57.6	300	85.6	0.67	0.81
30	9	29.28	28	16.1	57.6	306	87.4	0.67	0.81
31	9	29.33	28	16.5	56.8	304	87.0	0.67	0.82
32	9	29.39	28	15.9	58.0	297	84.7	0.67	0.83
33	9	29.44	28	16.7	56.8	305	87.1	0.67	0.82
34	9	29.50	28	15.6	57.5	303	86.7	0.67	0.83
35	10	29.55	28	16.5	57.3	298	85.3	0.60	0.82
36	10	29.60	28	16.1	57.6	302	86.2	0.60	0.83
37	10	29.65	27	16.0	57.5	301	86.0	0.60	0.83
38	10	29.70	28	15.9	57.2	303	86.6	0.60	0.84
39	10	29.75	28	16.2	57.5	306	87.6	0.60	0.83
40	10	29.80	28	16.4	57.2	312	89.2	0.60	0.83
41	10	29.85	29	16.2	57.2	306	87.3	0.60	0.83
42	10	29.90	28	16.1	57.4	308	88.0	0.60	0.82
43	10	29.95	28	16.1	57.1	309	88.2	0.60	0.82
44	10	30.00	28	16.1	57.3	297	84.7	0.60	0.82
		Average	28	16.2	57.3	303	86.6	0.63	0.82
		Std Dev	0	0.3	0.3	4	1.2	0.03	0.01
		Maximum	29	16.8	58.0	312	89.2	0.67	0.84
		Minimum	27	15.6	56.8	297	84.7	0.60	0.81

N-value: 19

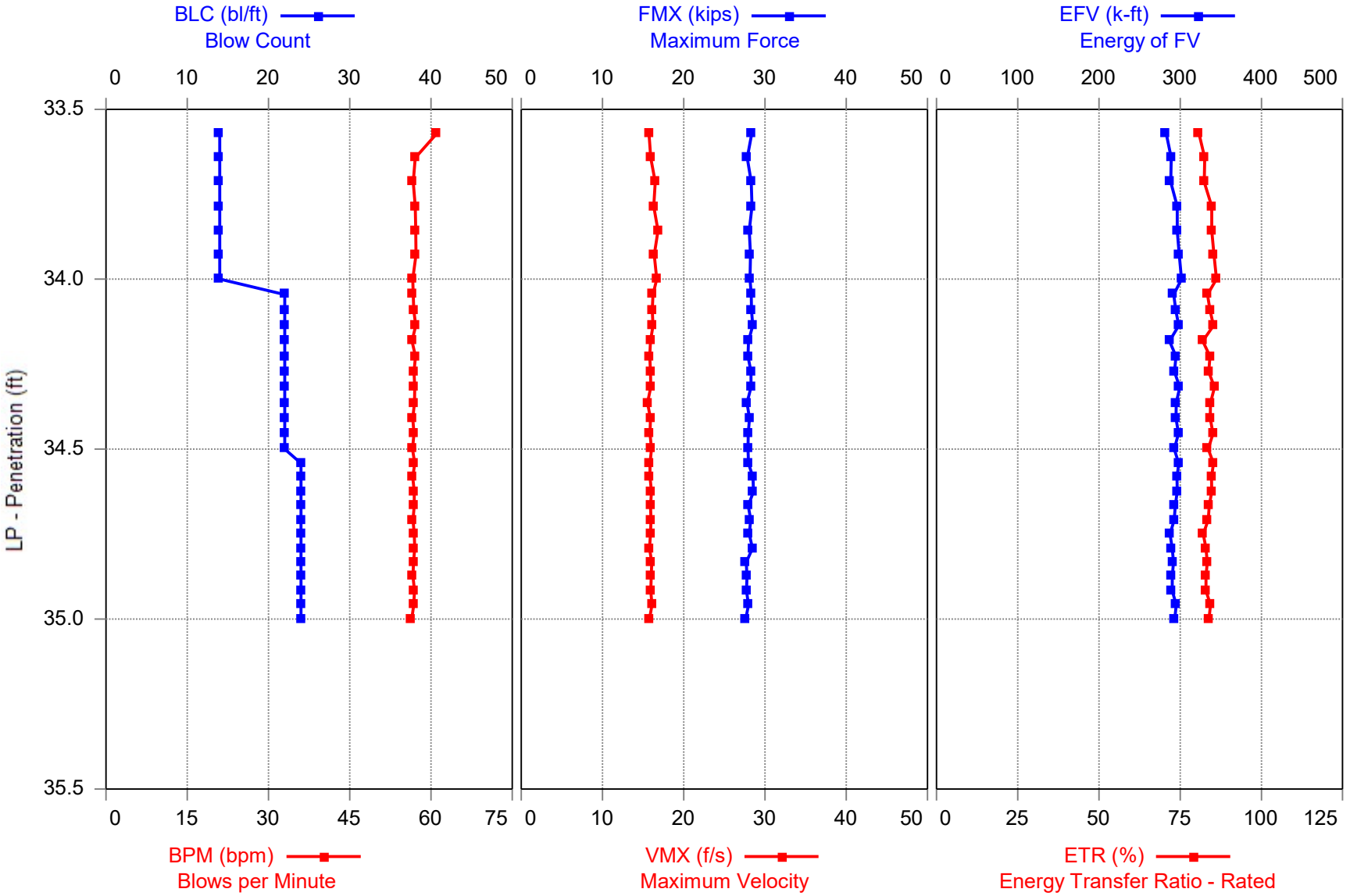
Sample Interval Time: 25.10 seconds.

GRL Engineers, Inc. - PDIPLOT2 Ver 2017.2.58.5 - Case Method & iCAP® Results

Printed: 20-March-2020

Test started: 13-March-2020

CME 550X SN 269553 - 33.5-35FT



GRL Engineers, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 3/19/2020

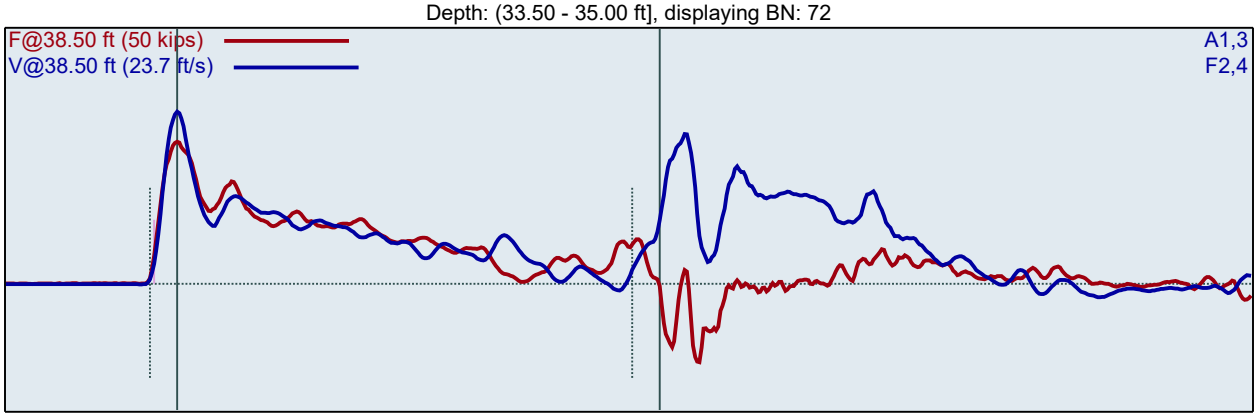
F&ME - CME 550X - SN 269553
TGH
TEST

SN 269553
Test date: 3/13/2020

AR: 1.18 in^2
LE: 38.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (33.50 - 35.00 ft], displaying BN: 72



F2 : [486AWJ1] 210.81 PDICAL (1) FF1
F4 : [486AWJ2] 211.49 PDICAL (1) FF1

A1 (PR): [K4998] 324 mv/6.4v/5000g (1) VF1
A3 (PR): [K5001] 315 mv/6.4v/5000g (1) VF1

BL#	BC /6"	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %	DFN in	FVP
45	7	33.57	28	15.7	61.1	283	80.8	0.85	0.86
46	7	33.64	28	15.9	57.1	289	82.6	0.85	0.83
47	7	33.71	28	16.5	56.7	289	82.4	0.85	0.81
48	7	33.79	28	16.3	57.1	297	84.7	0.85	0.83
49	7	33.86	28	16.8	57.2	296	84.7	0.85	0.81
50	7	33.93	28	16.4	57.2	299	85.4	0.85	0.82
51	7	34.00	28	16.7	56.6	302	86.2	0.86	0.82
52	11	34.05	28	16.2	56.7	292	83.4	0.54	0.83
53	11	34.09	28	16.1	56.8	295	84.2	0.54	0.84
54	11	34.14	28	16.2	57.2	298	85.3	0.54	0.82
55	11	34.18	28	15.9	56.5	287	82.0	0.54	0.84
56	11	34.23	28	15.8	57.1	295	84.2	0.54	0.84
57	11	34.27	28	15.9	56.8	293	83.8	0.54	0.84
58	11	34.32	28	15.9	57.0	299	85.5	0.54	0.84
59	11	34.36	28	15.5	56.9	295	84.3	0.54	0.83
60	11	34.41	28	15.9	56.6	295	84.2	0.54	0.83
61	11	34.45	28	15.8	56.8	298	85.1	0.54	0.83
62	11	34.50	28	16.0	56.6	293	83.7	0.54	0.83
63	12	34.54	28	15.9	57.0	298	85.2	0.50	0.84
64	12	34.58	29	15.8	56.6	296	84.6	0.50	0.86
65	12	34.63	29	16.0	56.9	296	84.7	0.50	0.84
66	12	34.67	28	15.9	56.9	294	84.0	0.50	0.83
67	12	34.71	28	16.0	56.7	293	83.7	0.50	0.84
68	12	34.75	28	15.9	56.9	287	82.1	0.49	0.84
69	12	34.79	28	15.8	57.0	290	82.9	0.50	0.85
70	12	34.83	28	16.1	56.8	292	83.4	0.50	0.82
71	12	34.88	28	16.0	56.7	290	83.0	0.50	0.82
72	12	34.92	28	15.9	56.9	290	82.9	0.50	0.82
73	12	34.96	28	16.1	56.8	295	84.4	0.50	0.82
74	12	35.00	28	15.8	56.4	293	83.8	0.50	0.83

Average	28	15.9	56.8	294	83.9	0.52	0.83
Std Dev	0	0.1	0.2	3	0.9	0.02	0.01
Maximum	29	16.2	57.2	299	85.5	0.54	0.86
Minimum	28	15.5	56.4	287	82.0	0.49	0.82

N-value: 23

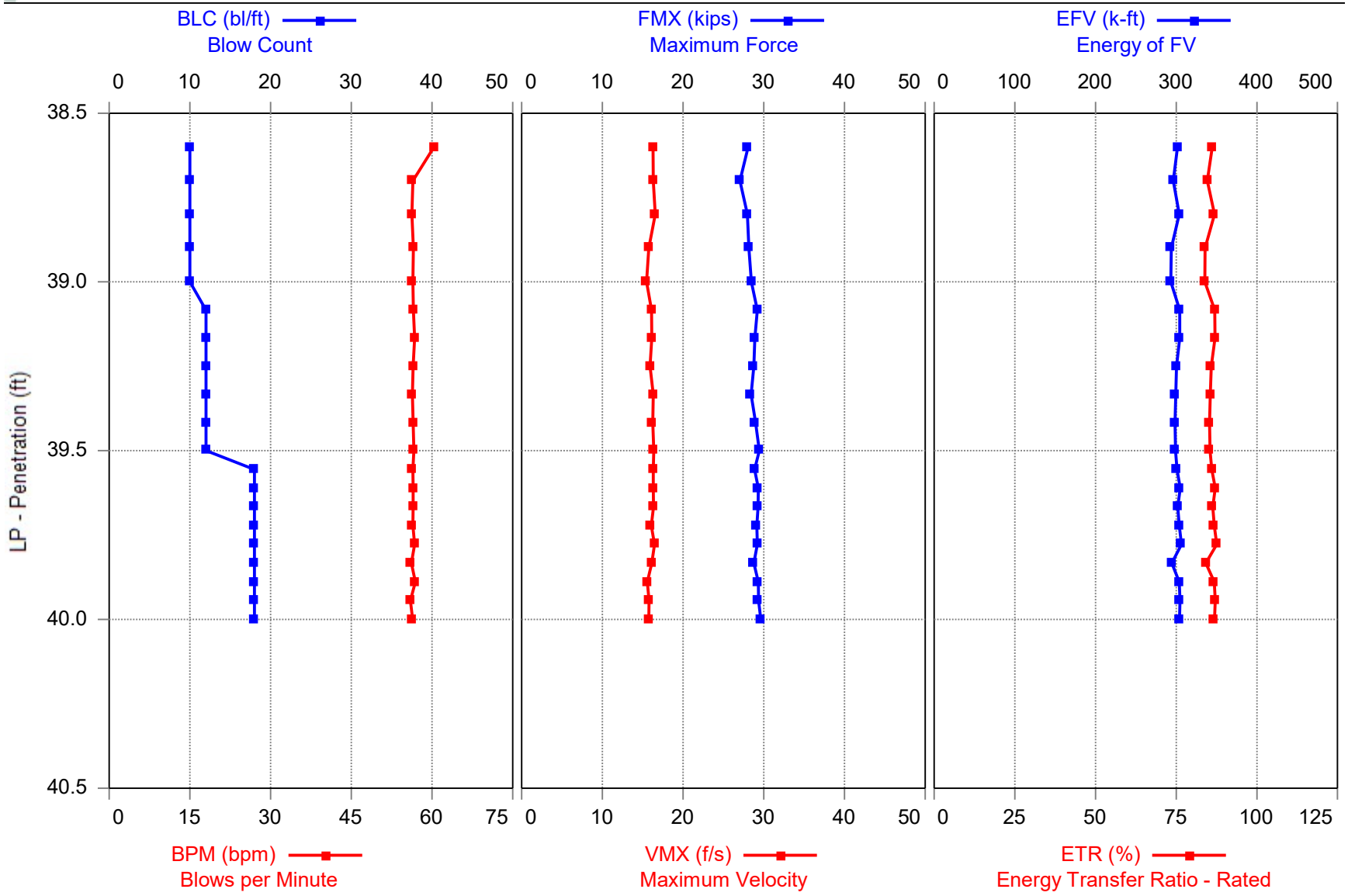
Sample Interval Time: 30.61 seconds.

GRL Engineers, Inc. - PDIPLOT2 Ver 2017.2.58.5 - Case Method & iCAP® Results

Printed: 20-March-2020

Test started: 13-March-2020

CME 550X SN 269553 - 38.5-40FT



GRL Engineers, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 3/19/2020

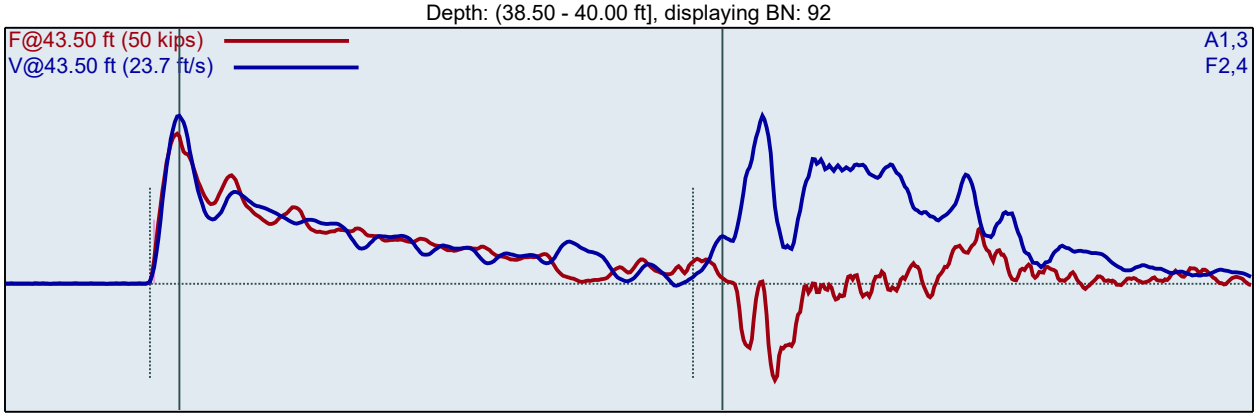
F&ME - CME 550X - SN 269553
TGH
TEST

SN 269553
Test date: 3/13/2020

AR: 1.18 in^2
LE: 43.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (38.50 - 40.00 ft], displaying BN: 92



F2 : [486AWJ1] 210.81 PDICAL (1) FF1
F4 : [486AWJ2] 211.49 PDICAL (1) FF1

A1 (PR): [K4998] 324 mv/6.4v/5000g (1) VF1
A3 (PR): [K5001] 315 mv/6.4v/5000g (1) VF1

BL#	BC /6"	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %	DFN in	FVP
75	5	38.60	28	16.3	60.4	302	86.2	1.20	0.82
76	5	38.70	27	16.3	56.4	296	84.7	1.20	0.83
77	5	38.80	28	16.5	56.3	304	86.8	1.20	0.81
78	5	38.90	28	15.8	56.5	294	84.0	1.20	0.86
79	5	39.00	28	15.5	56.4	293	83.9	1.20	0.87
80	6	39.08	29	16.1	56.6	304	87.0	1.00	0.87
81	6	39.17	29	16.1	56.7	305	87.0	1.00	0.86
82	6	39.25	29	15.9	56.5	300	85.9	1.00	0.86
83	6	39.33	28	16.3	56.3	299	85.6	1.00	0.85
84	6	39.42	29	16.2	56.5	299	85.3	1.00	0.87
85	6	39.50	29	16.4	56.6	299	85.5	1.00	0.88
86	9	39.56	29	16.3	56.4	301	86.1	0.67	0.87
87	9	39.61	29	16.3	56.5	305	87.1	0.67	0.85
88	9	39.67	29	16.3	56.5	302	86.3	0.67	0.87
89	9	39.72	29	16.1	56.4	304	86.8	0.67	0.86
90	9	39.78	29	16.5	56.7	307	87.6	0.67	0.88
91	9	39.83	29	16.1	56.2	295	84.2	0.67	0.88
92	9	39.89	29	15.6	56.9	304	86.8	0.67	0.88
93	9	39.94	29	15.8	56.0	305	87.1	0.67	0.88
94	9	40.00	30	15.8	56.4	304	86.9	0.67	0.89
		Average	29	16.1	56.5	302	86.3	0.80	0.87
		Std Dev	0	0.3	0.2	3	0.9	0.16	0.01
		Maximum	30	16.5	56.9	307	87.6	1.00	0.89
		Minimum	28	15.6	56.0	295	84.2	0.67	0.85
				N-value: 15					

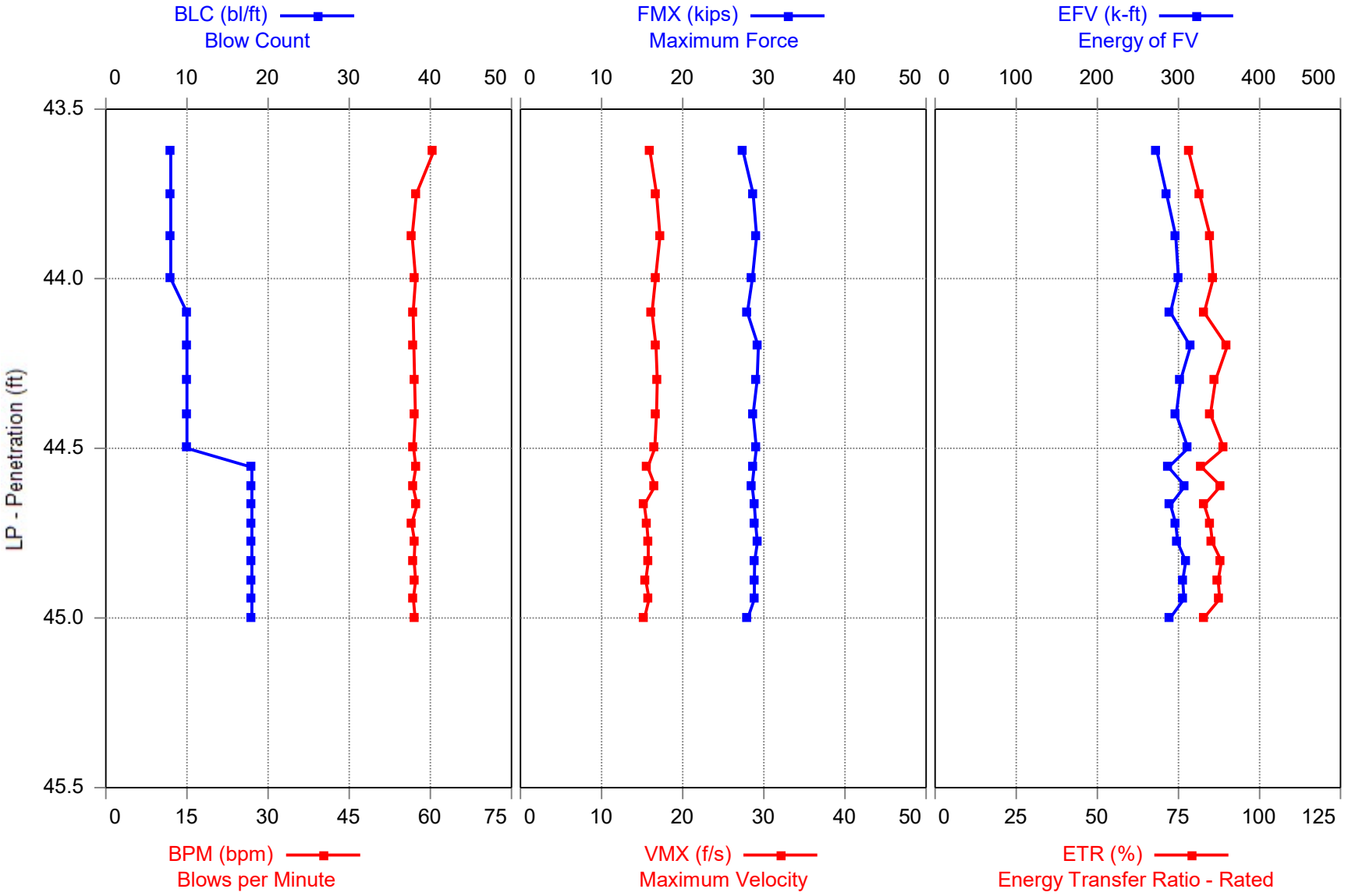
Sample Interval Time: 20.22 seconds.

GRL Engineers, Inc. - PDIPLOT2 Ver 2017.2.58.5 - Case Method & iCAP® Results

Printed: 20-March-2020

Test started: 13-March-2020

CME 550X SN 269553 - 43.5-45FT



GRL Engineers, Inc.
SPT Analyzer Results

PDA-S Ver. 2018.30 - Printed: 3/19/2020

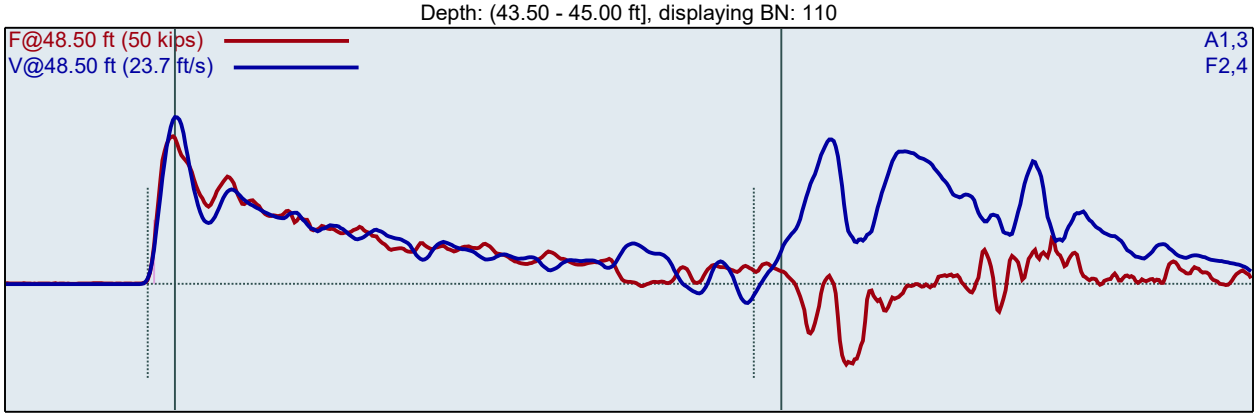
F&ME - CME 550X - SN 269553
TGH
TEST

SN 269553
Test date: 3/13/2020

AR: 1.18 in^2
LE: 48.50 ft
WS: 16807.9 ft/s

SP: 0.492 k/ft3
EM: 30000 ksi

Depth: (43.50 - 45.00 ft], displaying BN: 110



F2 : [486AWJ1] 210.81 PDICAL (1) FF1
F4 : [486AWJ2] 211.49 PDICAL (1) FF1

A1 (PR): [K4998] 324 mv/6.4v/5000g (1) VF1
A3 (PR): [K5001] 315 mv/6.4v/5000g (1) VF1

BL#	BC /6"	LP ft	FMX kips	VMX ft/s	BPM bpm	EFV ft-lb	ETR %	DFN in	FVP
95	4	43.63	27	16.0	60.6	274	78.2	1.49	0.83
96	4	43.75	29	16.8	57.4	285	81.5	1.49	0.86
97	4	43.88	29	17.2	56.6	297	84.8	1.49	0.88
98	4	44.00	29	16.6	57.3	300	85.7	1.50	0.85
99	5	44.10	28	16.2	56.8	290	83.0	1.20	0.85
100	5	44.20	29	16.7	57.0	315	90.0	1.20	0.88
101	5	44.30	29	16.9	57.1	302	86.4	1.20	0.86
102	5	44.40	29	16.8	57.2	297	84.9	1.20	0.85
103	5	44.50	29	16.6	56.9	312	89.1	1.20	0.87
104	9	44.56	29	15.7	57.3	288	82.2	0.66	0.85
105	9	44.61	29	16.6	56.8	308	88.1	0.67	0.84
106	9	44.67	29	15.3	57.6	290	83.0	0.66	0.84
107	9	44.72	29	15.6	56.5	297	84.8	0.66	0.87
108	9	44.78	29	15.7	57.1	299	85.5	0.66	0.83
109	9	44.83	29	15.8	57.0	309	88.3	0.67	0.86
110	9	44.89	29	15.5	57.3	305	87.3	0.67	0.87
111	9	44.94	29	15.8	56.9	307	87.7	0.67	0.86
112	9	45.00	28	15.3	57.2	290	82.9	0.66	0.85
		Average	29	16.0	57.0	301	85.9	0.85	0.86
		Std Dev	0	0.6	0.3	9	2.5	0.26	0.01
		Maximum	29	16.9	57.6	315	90.0	1.20	0.88
		Minimum	28	15.3	56.5	288	82.2	0.66	0.83
				N-value: 14					

Sample Interval Time: 17.91 seconds.

APPENDIX

SECTION 7 SCOPE OF SERVICES

This additional geotechnical scope of services is being requested for the Carolina Crossroads – Phase 1 project. Site soil testing will be required as described below and will consist of soil test borings (STB) with rock coring for the I-126 Ramp C bridge to obtain additional subsurface information at this location. All field and lab testing along with reporting of the results shall be performed and provided in accordance with the 2019 Geotechnical Design Manual Version 2.0 (GDM). **Any deviations from this request or the requirements set forth in the GDM shall be approved by the D/B GDS prior to execution of the tasks.**

CONSULTANT shall perform two soil test borings spaced out evenly between borings B-60 and B-61 that were previously conducted, approximately near Stations 5411+00 and 5414+50 on Ramp C. Borings shall be placed near the proposed centerline where practical, but should be offset to areas that do not require any clearing. Soil test borings shall be performed using mud-rotary drilling techniques and shall be extended to 100 feet each or refusal, which is anticipated to be encountered within 30 feet of the ground surface. If drilling refusal is encountered, a minimum of 20 feet of rock coring shall be performed, not to exceed 30 feet. Borings shall be backfilled at the completion of drilling and measurement of water levels. Test locations shall be located in the field using GPS survey equipment. Once field work has been completed, all test locations shall be surveyed.

Laboratory testing shall consist of performing up to 12 unconfined compressive strength of rock core tests to include rock core samples obtained from these additional borings as well as those obtained from borings B-60 and B-61.

After completion of the field and laboratory testing, the **CONSULTANT** will prepare a standalone supplemental geotechnical subsurface data report for this additional scope of services. The data report shall be completed in accordance with the 2019 GDM Version 2.0. In addition to the supplemental geotechnical report provide in kmz format the surveyed locations of all borings completed for the Carolina Crossroads Program.