

# **STRUCTURE FOUNDATION EXPLORATION- FINAL REPORT**

**HIG-247-0.04, PID NO. 93830  
BRIDGE NUMBER: 3603482  
HIGHLAND COUNTY, OHIO  
CTL PROJECT NO. 22050095COL**

**PREPARED FOR:**

**IBI GROUP  
23 TRIANGLE PARK DRIVE  
CINCINNATI, OHIO 45246**

**PREPARED BY:**

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**September 1, 2023**



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## **I. EXECUTIVE SUMMARY**

The project involves constructing a replacement structure for HIG-247-0.04 over Buck Run in Highland County, Ohio. According to the bridge site plan sheet provided, the proposed bridge will be a single-span, 48 feet long precast reinforced concrete structure with round section. It is understood that the proposed structure will be supported on spread foundations extending into underlying bedrock.

Two (2) test borings, identified as B-001-0-22 and B-002-0-22, were drilled for this structure. The borings generally exhibited layers of both fine-grained soils described as silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6) over bedrock. The top of bedrock was encountered at depths ranging from 3.5 to 8.5 feet below ground surface with top of bedrock elevations ranging from 908.0 to 911.4 feet. The bedrock was described as limestone or shale.

Based upon the soil and rock data obtained from the field and laboratory testing, it is CTL's opinion that the proposed bridge could be supported onto spread foundations extending into underlying coreable bedrock. Please refer to the *Analyses and Recommendations* section for additional information.

## **II. INTRODUCTION**

The project involves constructing a replacement structure for HIG-247-0.04 over Buck Run in Highland County, Ohio. According to the bridge site plan sheet provided, the proposed bridge will be a single-span, 48 feet long precast reinforced concrete structure with round section. It is understood that the proposed structure will be supported on spread foundations extending into underlying coreable bedrock.

This is a Final Structure Foundation Exploration Report.

## **III. GEOLOGY AND OBSERVATIONS OF THE PROJECT**

The ODNR, *Physiographic Regions of Ohio*, the site lies on the Dissected Illinoian Till Plain region of the Till Plains section of Ohio.

ODNR's, *Ohio Geology Interactive Map*, indicates the site is underlain by Silurian-age Estill Shale. The bedrock consists of shale and minor dolomite interbedded, reddish to greenish gray, weathers light gray, planar to irregular bedding, thin to thick bedded, 30 to 180 feet thick.

According to web-based *Soil Survey Report for Highland County, Ohio*, from United States Department of Agriculture (USDA), Natural Resources Conservation Service (NRCS), the



soils in the project area primarily consist of Gessie loam, frequently flooded (Gd). These soils are considered to be well drained with moderately high to high hydraulic conductivity (0.6 to 2.0 in/hr).

Based on the ODNR Mines of Ohio, the site is not known to have any mapped deep mines located below the project area.

According to the ODNR karst map, several field verified and suspected karst features were identified approximately 0.5 mile to the south and southeast of the project area.

A site visit was performed by an engineer from CTL on November 9, 2022. The existing bridge abutments are supported on spread footing foundations. Buck Creek flows below the structure. The creek flows in easterly direction below the bridge. Exposed bedrock was noted in the creek and on the creek banks. Spalling and exposed rebar were noted on the parapet walls of the bridge deck.

#### **IV. EXPLORATION**

Two (2) test borings, designated as B-001-0-22 and B-002-0-22, were drilled and cored to depths ranging from 21.0 to 24.0 feet below the existing ground surface.

The borings were performed with a CME 55 track mounted drill rig utilizing 3¼-inch hollow stem augers (HSA) and NQ 2-inch double tube wire-line rock core barrel system on November 10, 2022. Standard penetration tests were conducted using a 140-pound automatic hammer, falling 30 inches, to drive 2-inch O.D. split barrel samplers. The energy transfer ratio associated with the automatic SPT hammer was 79.3 percent.

Soil samples obtained were preserved in glass jars, visually classified in the field and laboratory, and tested for natural moisture content. Representative soil samples were subjected to laboratory testing including grain size distribution and Atterberg limits.

The recovered rock from the coring operations were placed in core boxes, visually described and the Rock Quality Designation (RQD) and percent core recovery values were determined. Representative samples of the recovered rock were subjected to compressive strength and unit weight testing.

Ground surface elevations, latitude, longitude information at the test boring locations were provided by personnel from IBI Group.

No historic records were found for this structure. However, the historic roadway borings (TIMS sub-batch 9666) indicate that the top of rock was encountered between El. 905 and 910 feet and limestone was exposed in the creek bed.

**V. FINDINGS**

The borings encountered 6 inches of asphalt over 5 inches of granular base near the surface. Below the surface cover, the borings encountered layers of cohesive fine grained soils to depths ranging from 8.5 to 11.0 feet below grade. The cohesive fill soils were described as silt and clay (A-6a), silty clay (A-6b), and clay (A-7-6) over bedrock. These soils exhibited corrected standard penetration  $N_{60}$  values ranging from 12 to 20 blows per foot (bpf), with moisture content values ranging from 11 to 21 percent. Hand penetrometer readings in the cohesive soils ranged from 2.5 to 3.75 tons per square foot (tsf).

Beneath the soil overburden, the borings encountered top of bedrock at depths ranging from 3.5 to 8.5 feet below grade, with top of bedrock elevations ranging from 908.0 to 911.4 feet. The upper portion of the bedrock was augered and sampled using soil sampling techniques. This augerable bedrock exhibited  $N_{60}$  values ranging from 50 blows for 5 inches of penetration to 50 blows for 1 inch of penetration. The augerable rock samples were described as limestone. Auger refusal was encountered in the borings at elevations ranging from 907.5 to 908.9 feet.

Rock coring was performed below the auger refusal depths. The recovered rock samples from rock coring operations were described as predominantly limestone with a minor amount of shale and exhibited rock quality designation (RQD) values ranging from 26 to 90 percent, with core recovery values ranging from 95 to 100 percent.

Unconfined Compressive Strength (UCS) testing was performed on two selected bedrock core samples representative of the bedrock units. Table 1 shows the results of these UCS tests.

**Table 1. Rock UCS Results**

<b>Boring No.</b>	<b>Sample Depth (ft)</b>	<b>Sample Elevation (ft)</b>	<b>Lithology</b>	<b>Unit Weight (pcf)</b>	<b>UCS (psi)</b>
B-001-0-22 (Rear Abutment)	9.3-9.8	905.6-905.1	Limestone	166.1	4,470
	20.3-20.8	894.6-894.1	Limestone	169.6	6,360
B-002-0-22 (Forward Abutment)	10.5-11.0	906.0-905.5	Limestone	170.9	8,500
	19.5-20.0	897.0-896.5	Limestone	162.3	4,620

No groundwater was encountered in the test borings during drilling operations. Accurate water level measurements at the completion of test boring were unable to be obtained due to the introduction of water during rock coring operations.

**VI. ANALYSES AND RECOMMENDATIONS**

Based on the soil and rock data obtained from the field and laboratory testing, the following recommendations are provided for the proposed structures.

**A. Scour Information**

CTL performed multi-layer scour analysis considering the differences in the RQD values in core runs NQ-1 and NQ-2 in both boring B-001-0-22 and B-002-0-22. The scour calculations are provided in Appendix E. Table 2 below summarizes the scour calculations.

**Table 2. Scour Information**

Location	Sample ID	Sample Elevation	D <sub>50</sub> (mm)	τ <sub>c</sub> (psf)	D <sub>50</sub> , equivalent (mm)	Erosion Category (EC)
B-001-0-22 (Rear Abutment)	NQ-1	908.9'-903.9'	N/A	105	5025	3.981
	NQ-2	903.9'-898.9'	N/A	161	7696	4.422
B-002-0-22 (Forward Abutment)	NQ-1	907.5'-902.5'	N/A	247	11846	4.422
	NQ-2	902.5'-897.5'	N/A	195	9344	4.422

**B. Foundation Support**

At the time that this report was prepared, a bridge site plan sheet was provided to us. According to the site plan, it is understood that the proposed abutments and wing walls are planned to be supported on spread foundations extending into underlying coreable bedrock. The elevation of the bottom of footings for both the rear and forward abutments is 904.48.

Bearing resistance calculations are provided in Appendix F and are summarized in Table 3.

**Table 3. Unfactored Bearing Resistance of Spread Footings**

<b>Location</b>	<b>Bottom of Footing Elevation, feet</b>	<b>Unfactored Bearing Resistance, <math>q_n</math> ksf</b>
B-001-0-22 (Rear Abutment)	904.48	100.23
B-002-0-22 (Forward Abutment)	904.48	171.05

A resistance factor of 0.45 should be used for determining factored bearing resistance in strength limit state. The resistance factor was obtained from AASHTO Table 10.5.5.2.2-1 for footing bearing on bedrock.

All bearing surfaces should be kept clean and dry until concrete is placed and should also be observed and approved by the Geotechnical Engineer or their designated representative. Surface water and groundwater should be expected during excavation and construction of spread footings. Dewatering within the excavation should be anticipated and it is anticipated to be controlled using sump and pump methods. Temporary cofferdams may need to be constructed to facilitate excavation and construction of the spread footings.

For lateral and vertical earth pressure calculations for the proposed structure, an equivalent friction angle for the retained soil of 25 degrees and a total unit weight of 120 pounds per cubic foot (pcf) should be used.

**C. General Construction and Earthwork**

1. Site preparation and earthwork should be performed in accordance with the ODOT Construction and Material Specifications, and applicable Geotechnical Bulletins.
2. Embankment side slopes should be seeded and vegetation growth permitted to limit erosion, sloughing and slope failure.
3. Temporary excavations in excess of 4 feet in depth should be sloped or shored according to OSHA requirements.

**VII. CHANGED CONDITIONS**

The evaluations, conclusions, and recommendations in this report are based on our interpretation of the field and laboratory data obtained during the exploration, our



understanding of the project and our experience with similar sites and subsurface conditions using generally accepted geotechnical engineering practices. Although individual test borings are representative of the subsurface conditions at the boring locations on the dates drilled, they are not necessarily representative of the subsurface conditions between boring locations or subsurface conditions during other seasons of the year.

In the event that changes in the project are proposed, additional information becomes available, or if it is apparent that subsurface conditions are different from those provided in this report, CTL Engineering should be notified so that our recommendations can be modified, if required.

### **VIII. TESTING AND OBSERVATION**

During the design process, it is recommended that CTL Engineering work with the project designers to confirm that the geotechnical recommendations are properly incorporated into the final plans and specifications, and to assist with establishing criteria for the construction observation and testing.

CTL Engineering is not responsible for independent conclusions, opinions and recommendations made by others based on the data and recommendations provided in this report. It is recommended that CTL be retained to provide construction quality control services on this project. If CTL Engineering is not retained for these services, CTL shall assume no responsibility for compliance with the design concepts or recommendations provided.

### **IX. CLOSING**

This report has been prepared for the exclusive use by the client for use only on this project. Our services have been performed in accordance with generally accepted Geotechnical Engineering principles and practices. No warranty is either expressed or implied.

CTL Engineering's assignment does not include, nor does this geotechnical report address the environmental aspects of this particular site.

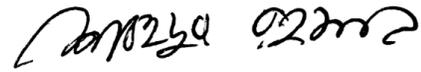
Specific design and construction recommendations have been provided in this report.  
Therefore, the report should be used in its entirety.

Respectfully Submitted,

**CTL ENGINEERING, INC.**



Sastry Malladi, P.E  
Project Engineer



Shahedur Rahman  
Geotechnical Engineer

**APPENDIX A**  
**GEOTECHNICAL PROFILE- BRIDGE**



**PROJECT DESCRIPTION**

THE PROJECT INVOLVES CONSTRUCTING A REPLACEMENT STRUCTURE FOR HIG-247-0.04 OVER BUCK RUN IN HIGHLAND COUNTY, OHIO.

**HISTORIC RECORDS**

NO HISTORIC RECORDS WERE FOUND FOR THIS STRUCTURE. HOWEVER, THE HISTORIC ROADWAY BORINGS (TIMS SUB-BATCH 9666) INDICATE THAT THE TOP OF ROCK WAS ENCOUNTERED BETWEEN EL. 905 AND 910 FEET AND LIMESTONE WAS EXPOSED IN THE CREEK BED.

**GEOLOGY**

THE ODNR PHYSIOGRAPHIC REGIONS OF OHIO, THE SITE LIES ON THE DISSECTED ILLINOIAN TILL PLAIN REGION OF THE TILL PLAINS SECTION OF OHIO. ODNR'S, OHIO GEOLOGY INTERACTIVE MAP, INDICATES THE SITE IS UNDERLAIN BY SILURIAN-AGE ESTILL SHALE. THE BEDROCK CONSISTS OF SHALE AND MINOR DOLOMITE INTERBEDDED, REDDISH TO GREENISH GRAY, WEATHERS LIGHT GRAY, PLANAR TO IRREGULAR BEDDING, THIN TO THICK BEDDED, 30 TO 180 FEET THICK. BASED ON THE ODNR MINES OF OHIO, THE SITE IS NOT KNOWN TO HAVE ANY MAPPED DEEP MINES LOCATED BELOW THE PROJECT AREA. ACCORDING TO THE ODNR KARST MAP, SEVERAL FIELD VERIFIED AND SUSPECTED KARST FEATURES WERE IDENTIFIED APPROXIMATELY 0.5 MILE TO THE SOUTH AND SOUTHEAST OF THE PROJECT AREA.

**RECONNAISSANCE**

A SITE VISIT WAS PERFORMED BY AN ENGINEER FROM CTL ON NOVEMBER 9, 2022. THE EXISTING BRIDGE ABUTMENTS ARE SUPPORTED ON SPREAD FOOTING FOUNDATIONS. BUCK CREEK FLOWS BELOW THE STRUCTURE. THE CREEK FLOWS IN EASTERLY DIRECTION BELOW THE BRIDGE. EXPOSED BEDROCK WAS NOTED IN THE CREEK AND ON THE CREEK BANKS. SPALLING AND EXPOSED REBAR WERE NOTED ON THE PARAPET WALLS OF THE BRIDGE DECK.

**SUBSURFACE EXPLORATION**

TWO (2) TEST BORINGS, DESIGNATED AS B-001-0-22 AND B-002-0-22, WERE DRILLED AND CORED TO DEPTHS RANGING FROM 21.0 TO 24.0 FEET BELOW THE EXISTING GROUND SURFACE. THE BORINGS WERE PERFORMED WITH A CME 55 TRACK MOUNTED DRILL RIG UTILIZING 3/4-INCH HOLLOW STEM AUGERS (HSA) AND NQ 2-INCH DOUBLE TUBE WIRE-LINE ROCK CORE BARREL SYSTEM ON NOVEMBER 10, 2022. STANDARD PENETRATION TESTS WERE CONDUCTED USING A 140- POUND AUTOMATIC HAMMER, FALLING 30 INCHES, TO DRIVE 2-INCH O.D. SPLIT BARREL SAMPLERS. THE AUTOMATIC SPT HAMMER SYSTEM USED WAS CALIBRATED ON NOVEMBER 4, 2022 WITH AN AVERAGE ENERGY TRANSFER RATIO OF 79.3 PERCENT.

**EXPLORATION FINDINGS**

THE BORINGS ENCOUNTERED 6 INCHES OF ASPHALT OVER 5 INCHES OF GRANULAR BASE NEAR THE SURFACE. BELOW THE SURFACE COVER, THE BORINGS ENCOUNTERED LAYERS OF COHESIVE FINE GRAINED SOILS TO DEPTHS RANGING FROM 8.5 TO 11.0 FEET BELOW GRADE. THE COHESIVE FILL SOILS WERE DESCRIBED AS SILT AND CLAY (A-6A), SILTY CLAY (A-6B), AND CLAY (A-7-6) OVER BEDROCK.

BENEATH THE SOIL OVERBURDEN, THE BORINGS ENCOUNTERED TOP OF BEDROCK AT DEPTHS RANGING FROM 3.5 TO 8.5 FEET BELOW GRADE, WITH TOP OF BEDROCK ELEVATIONS RANGING FROM 908.0 TO 911.4 FEET. THE UPPER PORTION OF THE BEDROCK WAS AUGERED AND SAMPLED USING SOIL SAMPLING TECHNIQUES. AUGER REFUSAL WAS ENCOUNTERED IN THE BORINGS AT DEPTHS RANGING FROM 6.0 TO 9.0 FEET BELOW GRADE, WITH ELEVATIONS RANGING FROM 907.5 TO 908.9 FEET. ROCK CORING WAS PERFORMED BELOW THE AUGER REFUSAL DEPTHS. THE RECOVERED ROCK SAMPLES WERE DESCRIBED AS PREDOMINANTLY LIMESTONE WITH A MINOR AMOUNT OF SHALE.

ALL BORINGS WERE REPORTED AS DRY AT COMPLETION OF SPLIT SPOON SAMPLING AND PRIOR TO CORING.

**SPECIFICATIONS**

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS, DATED JULY 2022.

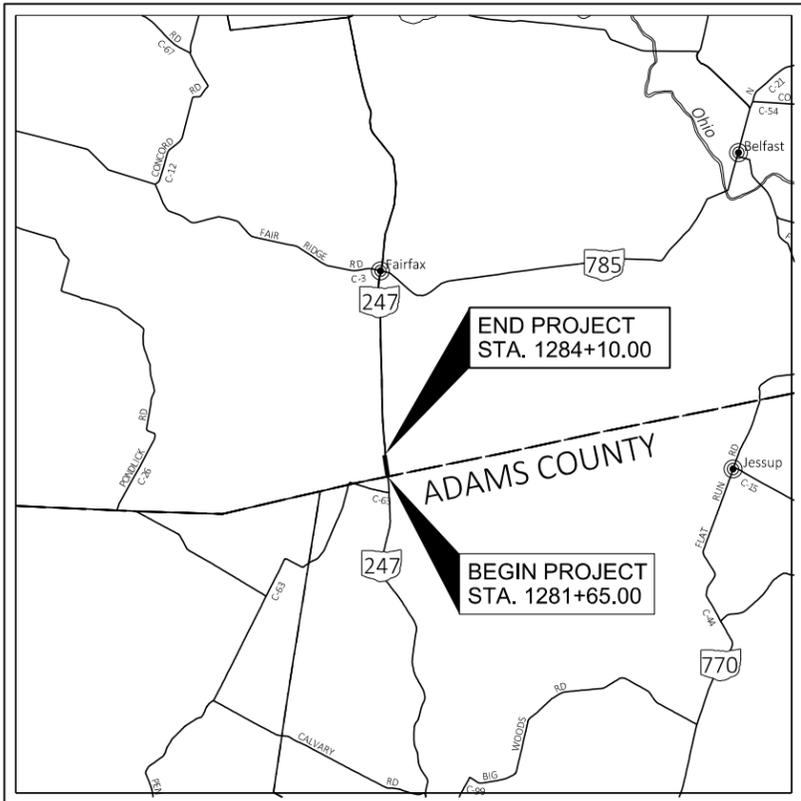
LEGEND		ODOT CLASS	CLASSIFIED MECH./VISUAL	
DESCRIPTION				
	SILT AND CLAY	A-6a (6)	1	0
	SILTY CLAY	A-6b (11)	1	1
	CLAY	A-7-6 (19)	1	0
		TOTAL	3	1
	LIMESTONE	VISUAL		
	SHALE	VISUAL		
	PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		
	EXPLORATION LOCATION - PLAN VIEW			
	DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.			
$N_{60}$	INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.			
X/Y/D"	NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X= NUMBER OF BLOWS FOR 6 INCHES (UNCORRECTED). Y/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.			
NQ	INDICATES ROCK CORE SAMPLE			
SS	INDICATES SPLIT-SPOON SAMPLE.			
TR	INDICATES TOP OF ROCK.			

**AVAILABLE INFORMATION**

THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE SOIL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.

BEDROCK TEST SUMMARY				
BORING NO.	SAMPLE ELEVATION	SAMPLE DEPTH	Qu (PSI)	LITHOLOGY
B-001-0-22	905.6' - 905.1'	9.3' - 9.8'	4,470	LIMESTONE
B-001-0-22	894.6' - 894.1'	20.3' - 20.8'	6,360	LIMESTONE
B-002-0-22	906.0' - 905.5'	10.5' - 11.0'	8,500	LIMESTONE
B-002-0-22	897.0' - 896.5'	19.5' - 20.0'	4,620	LIMESTONE

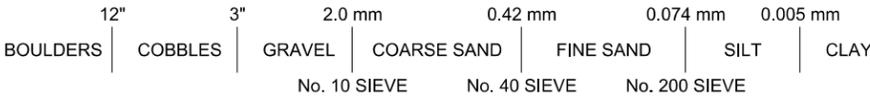
SCOUR ANALYSIS						
BORING NO.	SAMPLE ID	SAMPLE ELEVATION	D <sub>50</sub> (mm)	r <sub>c</sub> (psf)	D <sub>50</sub> equivalent (mm)	EROSION CATEGORY (EC)
B-001-0-22 (REAR ABUTMENT)	NQ-1	908.9' - 903.9'	N/A	105	5025	3.981
	NQ-2	903.9' - 898.9'	N/A	161	7696	4.422
B-002-0-22 (FORWARD ABUTMENT)	NQ-1	907.5' - 902.5'	N/A	247	11846	4.422
	NQ-2	902.5' - 897.5'	N/A	195	9344	4.422



LOCATION MAP  
SCALE IN MILES



**PARTICLE SIZE DEFINITIONS**



RECON. - SM 11/09/2022  
 DRILLING - CTL ENGINEERING, INC. 11/10/2022  
 DRAWN - N.K.S 08/31/2023  
 REVIEWED - SM 08/31/2023

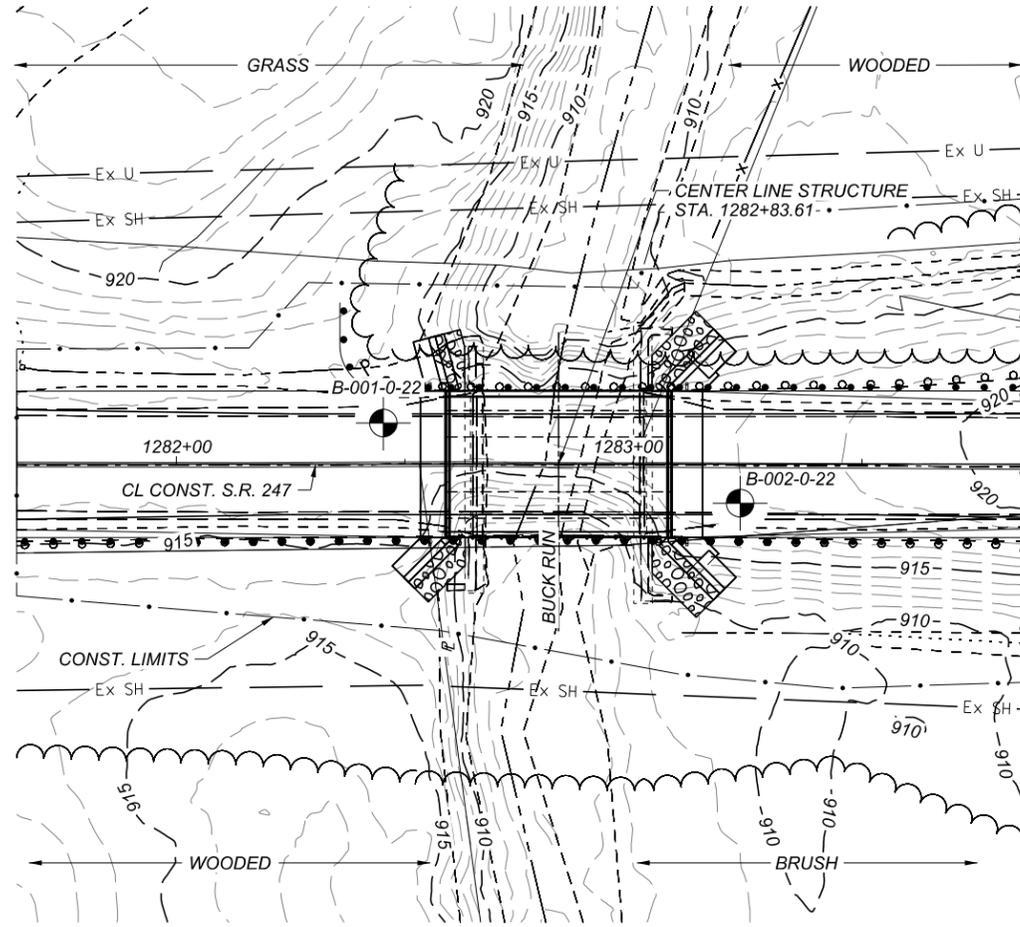
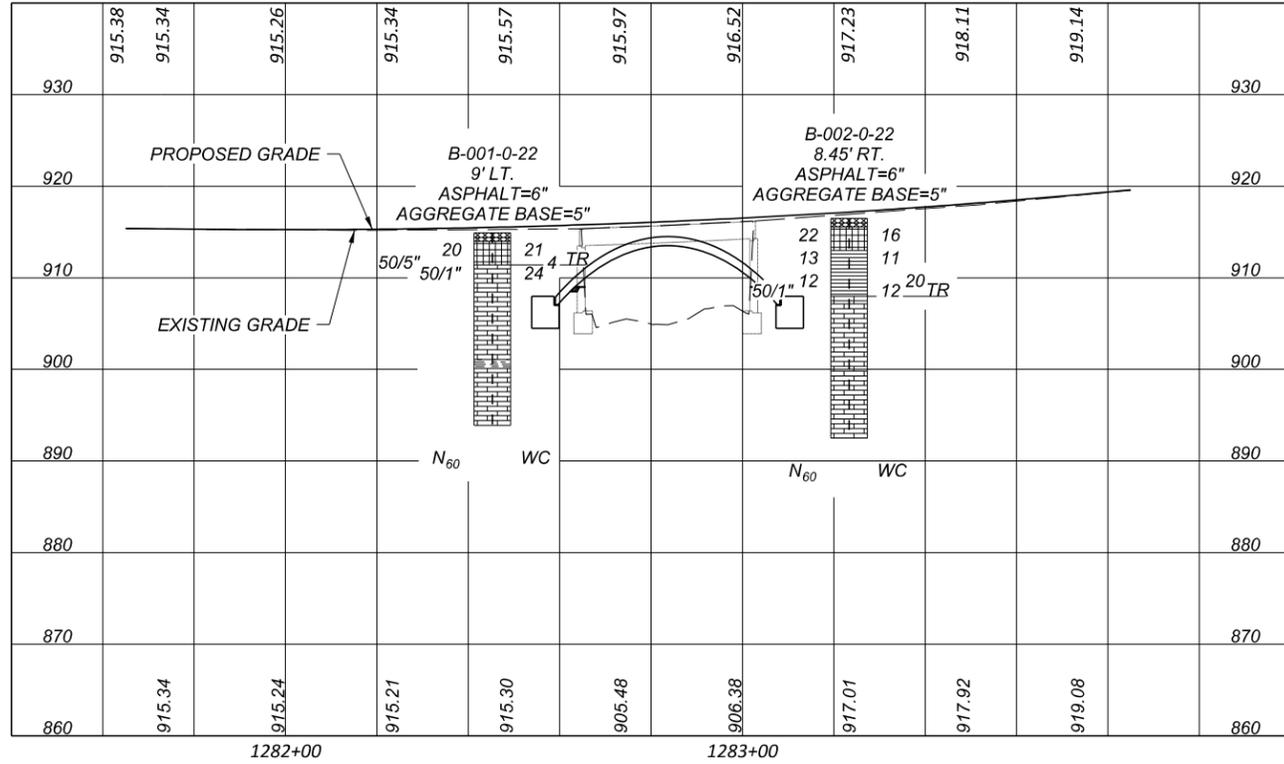
HIG-247-0.04

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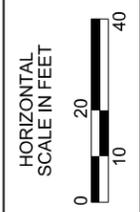
GEOTECHNICAL PROFILE - BRIDGE  
 BRIDGE NO. HIG-247-0.04 - S.R. 247 OVER BUCK RUN



DESIGNER	N.K.S
REVIEWER	SM 09-01-23
PROJECT ID	93830
SUBSET	TOTAL
1	7
SHEET	TOTAL
P.29	35



GEOTECHNICAL PROFILE - BRIDGE  
 BRIDGE NO. - HIG-247-0.04  
 S.R. 247 OVER BUCK RUN



DESIGN AGENCY  
**GTL**  
 ENGINEERING  
 2860 FISHER ROAD  
 COLUMBUS, OHIO 43204  
 PHONE: (614)276-8123  
 FAX: (614)276-8377

DESIGNER	N.K.S
REVIEWER	SM
PROJECT ID	93830
SUBSET	TOTAL
2	7
SHEET	TOTAL
P.30	35

HIG-247-0.04

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PROJECT:	HIG-247-0.04	DRILLING FIRM / OPERATOR:	CTL / TOM	STATION / OFFSET:	1282+45, 9' LT.	EXPLORATION ID	B-001-0-22
TYPE:	BRIDGE	SAMPLING FIRM / LOGGER:	CTL / TOM	ALIGNMENT:	SR 247	HOLE SEALED	
PID:	93830 SFN: 3603482	DRILLING METHOD:	3.25" HSA / NQ2	ELEVATION:	914.9 (MSL) EOB: 21.0 ft.	SO4 ppm	
START:	11-10-22 END: 11-10-22	SAMPLING METHOD:	SPT / NQ2	LAT / LONG:	39.024250, -83.585959	ODOT CLASS (GI)	
<b>MATERIAL DESCRIPTION AND NOTES</b>							
ASPHALT, (6")	ELEV: 914.9	DEPTHS	SPT/ RQD	REC SAMPLE ID	HP (tsf)	GRADATION (%)	ATTERBERG
AGGREGATE BASE, (5')	914.4	1	4			GR CS FS SI CL LL PL PI WC	
VERY STIFF, BROWN, CLAY, "AND" SILT, LITTLE SAND, TRACE GRAVEL, DAMP	914.0	2	6	SS-1	3.25	3 5 7 48 37 54 22 32	21
LIMESTONE, GRAY, SEVERELY WEATHERED, WEAK.	911.4	3	9				
		4	50/5"	SS-2	-	- - - - -	4
		5	50/1"	NQ-3	-	- - - - -	24
	908.9	6					
LIMESTONE, GRAY AND DARK GRAY, HIGHLY WEATHERED, MODERATELY STRONG, THIN BEDDED, ARGILLACEOUS; ROD 34%, REC 96%.		7					
@9.3'-9.8'; COMPRESSIVE STRENGTH= 4,470 PSI		8	26	NQ-1	95		CORE
		9					
		10					
		11					
		12					
		13					
	901.1	14	61	NQ-2	100		CORE
SHALE, GRAY, SLIGHTLY WEATHERED, WEAK TO SLIGHTLY STRONG, THIN BEDDED; ROD 100%, REC 100%.	900.1	15					
LIMESTONE, GRAY, MODERATELY WEATHERED, MODERATELY STRONG, THIN BEDDED; ROD 63%, REC 99%.		16					
		17					
		18					
		19	65	NQ-3	98		CORE
		20					
		21					
@20.3'-20.8'; COMPRESSIVE STRENGTH= 6,360 PSI	893.9	22					
		23					
		24					

STANDARD ODOT LOG W/ SULFATES (6.5 X 11) - OH DOT GDT - 18-8-23 17-58 - G:2023\AUGUST18\22050095COL\22050095COL.GPJ

NOTES: CAVED AT 5'  
 ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; AUGER CUTTINGS MIXED WITH BENTONITE GROUT

PROJECT:	HIG-247-0.04	DRILLING FIRM / OPERATOR:	CTL / TOM	STATION / OFFSET:	1283+23, 9' RT.	EXPLORATION ID	B-002-0-22
TYPE:	BRIDGE	SAMPLING FIRM / LOGGER:	CTL / TOM	ALIGNMENT:	SR 247	HOLE SEALED	
PID:	93830 SFN: 3603482	DRILLING METHOD:	3.25" HSA / NQ2	ELEVATION:	916.5 (MSL) EOB: 24.0 ft.	SO4 ppm	
START:	11-10-22 END: 11-10-22	SAMPLING METHOD:	SPT / NQ2	LAT / LONG:	39.024469, -83.585943	ODOT CLASS (GI)	
<b>MATERIAL DESCRIPTION AND NOTES</b>							
ASPHALT, (6")	ELEV: 916.5	DEPTHS	SPT/ RQD	REC SAMPLE ID	HP (tsf)	GRADATION (%)	ATTERBERG
AGGREGATE BASE, (5')	916.0	1	4			GR CS FS SI CL LL PL PI WC	
VERY STIFF, GRAY, SILT AND CLAY, SOME SAND, TRACE GRAVEL, FILL, DAMP	915.6	2	7	SS-1	3.00	8 22 38 23 28 17 11 16	A-6a (6)
		3	10				
		4	4	SS-2	3.75	8 16 38 25 39 18 21	A-6b (10)
VERY STIFF, BROWN, SILTY CLAY, SOME SAND, LITTLE GRAVEL, DAMP	913.0	5	6				
@6.0'; MOIST		6	4				
		7	4	SS-3	2.50	- - - - -	A-6b (V)
		8	5				
		9	50/1"	SS-4	-	- - - - -	12
LIMESTONE, GRAY, HIGHLY WEATHERED, WEAK.	908.0	10					
LIMESTONE, LIGHT TO DARK GRAY, SLIGHTLY WEATHERED, STRONG, THIN TO MEDIUM BEDDED; ROD 84%, REC 100%.	907.5	11					
@10.5'-11.0'; COMPRESSIVE STRENGTH= 8,500 PSI		12					
		13					
		14					
		15					
		16					
		17					
		18					
		19					
		20					
		21					
		22					
		23					
@14.0'; RED AND GRAY.	892.5	24					
@19.0'; MODERATELY STRONG.							
@19.5'-20.0'; COMPRESSIVE STRENGTH= 4,620 PSI							

STANDARD ODOT LOG W/ SULFATES (6.5 X 11) - OH DOT GDT - 18-8-23 17-58 - G:2023\AUGUST18\22050095COL\22050095COL.GPJ

NOTES: CAVED AT 8.3'  
 ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; AUGER CUTTINGS MIXED WITH BENTONITE GROUT

DESIGN AGENCY  
  
 2105 SCHAPPELLE LANE  
 CINCINNATI, OHIO 45246  
 PHONE: (513) 722-8665  
 FAX: (513) 834-8650

DESIGNER  
 N.K.S

REVIEWER  
 SM 09-01-23

PROJECT ID  
 93830

SUBSET	TOTAL
3	7

SHEET	TOTAL
P.31	35

GEOTECHNICAL PROFILE - BRIDGE  
 BORING LOG B-001-0-22 & B-002-0-22

B-001-0-22



Run #:	Depth	Recovery	RQD
NQ-1	6.0'	57/60	15.5/60
NQ-2	11.0'	60/60	36.5/60
HIG-247-0.04, PID 93830			



B-001-0-22



Run #:	Depth	Recovery	RQD
NQ-3	16.0'	59/60	39/60
		98%	66%
HIG-247-0.04, PID 93830			



DESIGN AGENCY



DESIGNER

N.K.S

REVIEWER

SM 09-01-23

PROJECT ID

93830

SUBSET TOTAL

4 7

SHEET TOTAL

P.32 35

B-002-0-22



Run #:	Depth	Recovery	RQD
NQ-1	9.0'	60/60	45.5/60
NQ-2	14.0'	60/60	52/60

HIG-247-0.04, PID 93830



B-002-0-22



Run #:	Depth	Recovery	RQD
NQ-3	19.0'	60/60	54/60
	24.0'	100%	90%

HIG-247-0.04, PID 93830



PROJECT NO: 22050095COL  
DATE: 6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



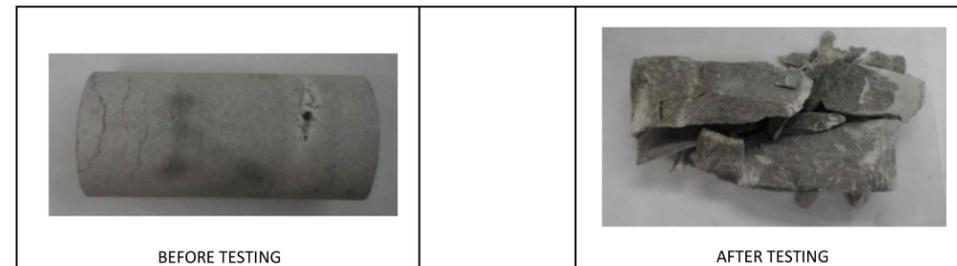
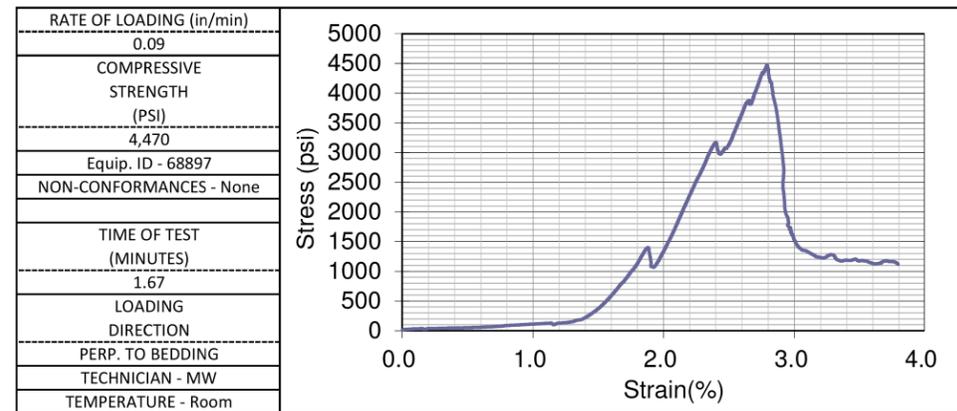
Method C

BORING NUMBER	B-001-0-22	TOP DEPTH(FT)	9.3	BOTTOM DEPTH(FT)	9.8
SAMPLE NUMBER	NQ-1	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Moderately Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.965	1.990
2	3.950	1.993
3	3.998	1.978
AVERAGE	3.971	1.987

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	537.0
UNIT WEIGHT(LBS/FT <sup>3</sup> )	166.1



PROJECT NO: 22050095COL  
DATE: 6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



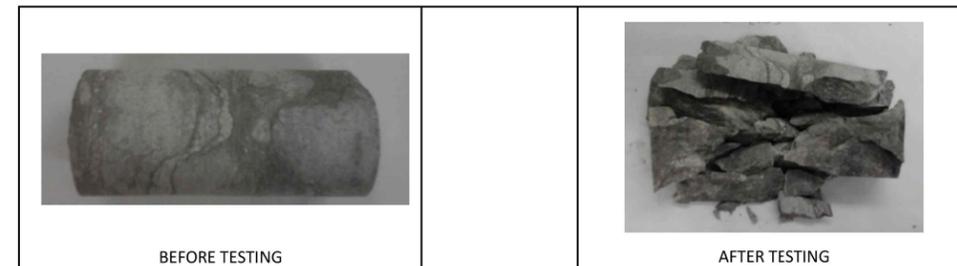
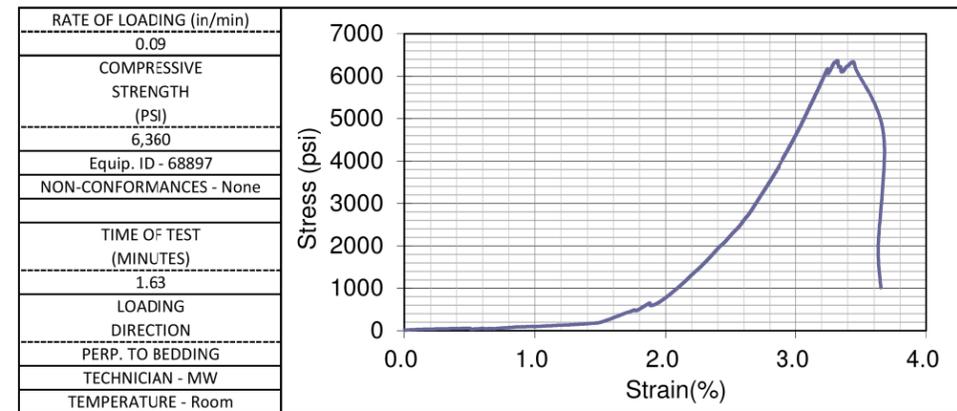
Method C

BORING NUMBER	B-001-0-22	TOP DEPTH(FT)	20.3	BOTTOM DEPTH(FT)	20.8
SAMPLE NUMBER	NQ-3	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Moderately Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.919	1.978
2	3.960	1.975
3	3.933	1.975
AVERAGE	3.937	1.976

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	537.5
UNIT WEIGHT(LBS/FT <sup>3</sup> )	169.6



HIG-247-0.04

MODEL: Sheet PAPER: 17x11 (in.) DATE: 01-09-2023 TIME: 13:19:49 USER: hp  
D:\Drop\_Box\CTL\_2023\September\Dept 05\COL\Shahed\22050095COL\_ODOT\Mod\_01\_09\_23\93830\ZD003.dgn

GEOTECHNICAL PROFILE - BRIDGE  
COMPRESSIVE STRENGTH TEST RESULT



DESIGNER	N.K.S
REVIEWER	SM
PROJECT ID	93830
SUBSET	TOTAL
6	7
SHEET	TOTAL
P.34	35

PROJECT NO: 22050095COL  
DATE: 6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



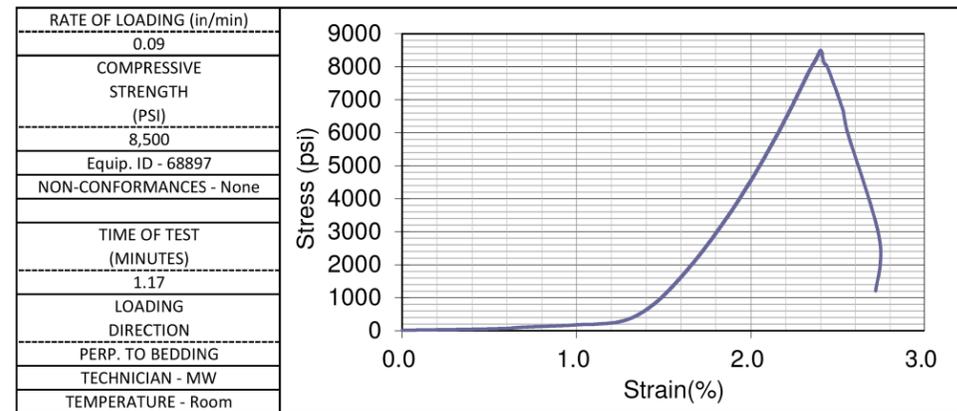
Method C

BORING NUMBER	B-002-0-22	TOP DEPTH(FT)	10.5	BOTTOM DEPTH(FT)	11.0
SAMPLE NUMBER	NQ-1	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.914	1.974
2	3.921	1.980
3	3.915	1.975
AVERAGE	3.917	1.976

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	539.1
UNIT WEIGHT(LBS/FT <sup>3</sup> )	170.9



BEFORE TESTING



AFTER TESTING

PROJECT NO: 22050095COL  
DATE: 6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



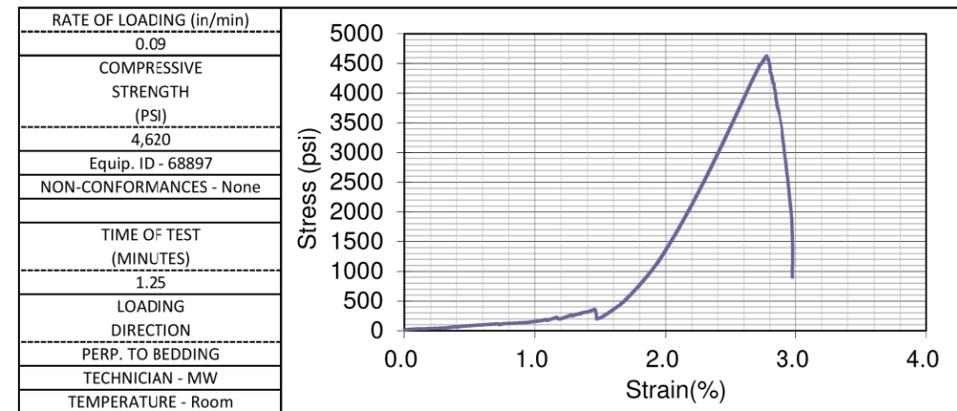
Method C

BORING NUMBER	B-002-0-22	TOP DEPTH(FT)	19.5	BOTTOM DEPTH(FT)	20.0
SAMPLE NUMBER	NQ-3	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Moderately Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.933	1.982
2	3.960	1.976
3	3.937	1.976
AVERAGE	3.943	1.978

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	516.1
UNIT WEIGHT(LBS/FT <sup>3</sup> )	162.3



BEFORE TESTING



AFTER TESTING

HIG-247-0.04

MODEL: Sheet PAPER SIZE: 17x11 (in.) DATE: 01-09-2023 TIME: 13:21:57 USER: hp  
D:\Drop\_Box\CTL\_2023\September\Dept 05\COL\Shahed\22050095COL\_ODOT\Mod\_01\_09\_23\93830\004.dgn

GEOTECHNICAL PROFILE - BRIDGE  
COMPRESSIVE STRENGTH TEST RESULT



DESIGNER	N.K.S
REVIEWER	SM 09-01-23
PROJECT ID	93830
SUBSET	TOTAL
7	7
SHEET	TOTAL
P.35	35

**APPENDIX B**  
**TEST BORING RECORDS**



## SOIL DESCRIPTION

Descriptors for soil consistency used in this report are based upon the Standard Penetration Test (SPT), ASTM D 1587, with the penetration (N) values corrected to  $N_{60}$ , based upon the efficiency of the SPT Hammer used for the soil sampling.

Descriptors for both non-cohesive and cohesive soils are presented below, with the corresponding range of corrected penetration values.

<u>NON-COHESIVE SOIL DESCRIPTION</u>	<u>CORRECTED PENETRATION VALUES BLOWS PER FOOT (BPF)</u>
Very Loose.....	0 – 4
Loose.....	5 – 10
Medium Dense.....	11- 30
Dense.....	31 – 50
Very Dense.....	Over 50

<u>COHESIVE SOIL DESCRIPTION</u>	<u>CORRECTED PENETRATION VALUES BLOWS PER FOOT (BPF)</u>
Very Soft.....	0 – 1
Soft.....	2 – 4
Medium Stiff.....	5 – 8
Stiff.....	9 – 15
Very Stiff.....	16 –30
Hard.....	Over 30

Moisture term descriptors for both non-cohesive and cohesive soils are presented below.

<u>NON-COHESIVE SOIL DESCRIPTION</u>	<u>MOISTURE TERMS</u>	<u>COHESIVE SOIL DESCRIPTION</u>
Powdery.....	Dry.....	Powdery
Some Moisture.....	Damp.....	Below Plastic Limit
Damp to the Touch.....	Moist.....	Above Plastic, Below Liquid Limit
Free Water.....	Wet.....	Above Liquid Limit



STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/25/23 10:10 - O:\PROJECT\2022\COL-05\22050095COL\REPORTS\LOGS\22050095COL.GPJ

PROJECT: <u>HIG-247-0.04</u>	DRILLING FIRM / OPERATOR: <u>CTL / TOM</u>	DRILL RIG: <u>CME 55 #393</u>	STATION / OFFSET: <u>1282+45, 9' LT.</u>	EXPLORATION ID <u>B-001-0-22</u>
TYPE: <u>BRIDGE</u>	SAMPLING FIRM / LOGGER: <u>CTL / TOM</u>	HAMMER: <u>CME AUTOMATIC</u>	ALIGNMENT: <u>SR 247</u>	
PID: <u>93830</u> SFN: <u>3603482</u>	DRILLING METHOD: <u>3.25" HSA / NQ2</u>	CALIBRATION DATE: <u>11/4/22</u>	ELEVATION: <u>914.9 (MSL)</u> EOB: <u>21.0 ft.</u>	PAGE 1 OF 1
START: <u>11/10/22</u> END: <u>11/10/22</u>	SAMPLING METHOD: <u>SPT / NQ2</u>	ENERGY RATIO (%): <u>79.3</u>	LAT / LONG: <u>39.024250, -83.585959</u>	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTH	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI	WC		
ASPHALT, (6")	914.9																	
AGGREGATE BASE, (5")	914.4																	
VERY STIFF, BROWN, CLAY, "AND" SILT, LITTLE SAND, TRACE GRAVEL, DAMP	914.0	1	4															
		2	6	20	100	SS-1	3.25	3	5	7	48	37	54	22	32	21	A-7-6 (19)	
		3																
LIMESTONE, GRAY, SEVERELY WEATHERED, WEAK.	911.4	TR																
		4	50/5"	-	100	SS-2	-	-	-	-	-	-	-	-	-	4	Rock (V)	
		5	50/1"	-	100	NQ-3	-	-	-	-	-	-	-	-	-	24	Rock (V)	
LIMESTONE, GRAY AND DARK GRAY, HIGHLY WEATHERED, MODERATELY STRONG, THIN BEDDED, ARGILLACEOUS; RQD 34%, REC 96%.	908.9																	
@9.3'-9.8'; COMPRESSIVE STRENGTH= 4,470 PSI		6																
		7																
		8	26		95	NQ-1												CORE
		9																
		10																
		11																
		12																
		13																
SHALE, GRAY, SLIGHTLY WEATHERED, WEAK TO SLIGHTLY STRONG, THIN BEDDED; RQD 100%, REC 100%.	901.1																	
	900.1																	
LIMESTONE, GRAY, MODERATELY WEATHERED, MODERATELY STRONG, THIN BEDDED; RQD 63%, REC 99%.																		
@20.3'-20.8'; COMPRESSIVE STRENGTH= 6,360 PSI		14	61		100	NQ-2												CORE
		15																
		16																
		17																
		18																
		19	65		98	NQ-3												CORE
		20																
	893.9	EOB																
		21																

NOTES: CAVED AT 5'  
 ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; AUGER CUTTINGS MIXED WITH BENTONITE GROUT

PROJECT: <u>HIG-247-0.04</u>	DRILLING FIRM / OPERATOR: <u>CTL / TOM</u>	DRILL RIG: <u>CME 55 #393</u>	STATION / OFFSET: <u>1283+23, 9' RT.</u>	EXPLORATION ID <u>B-002-0-22</u>
TYPE: <u>BRIDGE</u>	SAMPLING FIRM / LOGGER: <u>CTL / TOM</u>	HAMMER: <u>CME AUTOMATIC</u>	ALIGNMENT: <u>SR 247</u>	
PID: <u>93830</u> SFN: <u>3603482</u>	DRILLING METHOD: <u>3.25" HSA / NQ2</u>	CALIBRATION DATE: <u>11/4/22</u>	ELEVATION: <u>916.5 (MSL)</u> EOB: <u>24.0 ft.</u>	PAGE 1 OF 1
START: <u>11/10/22</u> END: <u>11/10/22</u>	SAMPLING METHOD: <u>SPT / NQ2</u>	ENERGY RATIO (%): <u>79.3</u>	LAT / LONG: <u>39.024469, -83.585943</u>	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N <sub>60</sub>	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
ASPHALT, (6")	916.5																	
AGGREGATE BASE, (5")	916.0 915.6	1	4															
VERY STIFF, GRAY, SILT AND CLAY, SOME SAND, TRACE GRAVEL, FILL, DAMP		2	7 10	22	100	SS-1	3.00	9	8	22	38	23	28	17	11	16	A-6a (6)	
	913.0	3																
VERY STIFF, BROWN, SILTY CLAY, SOME SAND, LITTLE GRAVEL, DAMP		4	3 4	13	100	SS-2	3.75	13	8	16	38	25	39	18	21	11	A-6b (10)	
@6.0'; MOIST		5																
		6	4															
		7	4 5	12	100	SS-3	2.50	-	-	-	-	-	-	-	-	20	A-6b (V)	
	908.0	8																
LIMESTONE, GRAY, HIGHLY WEATHERED, WEAK.	907.5	TR	50/1"	-	100	SS-4	-	-	-	-	-	-	-	-	-	12	Rock (V)	
LIMESTONE, LIGHT TO DARK GRAY, SLIGHTLY WEATHERED, STRONG, THIN TO MEDIUM BEDDED; RQD 84%, REC 100%. @10.5'-11.0'; COMPRESSIVE STRENGTH= 8,500 PSI		9																
		10																
@14.0'; RED AND GRAY.		11	76		100	NQ-1											CORE	
		12																
		13																
		14																
@19.0'; MODERATELY STRONG. @19.5'-20.0'; COMPRESSIVE STRENGTH= 4,620 PSI		15																
		16	87		100	NQ-2											CORE	
		17																
		18																
		19																
		20																
		21	90		100	NQ-3											CORE	
		22																
		23																
	892.5	24																
		EOB																

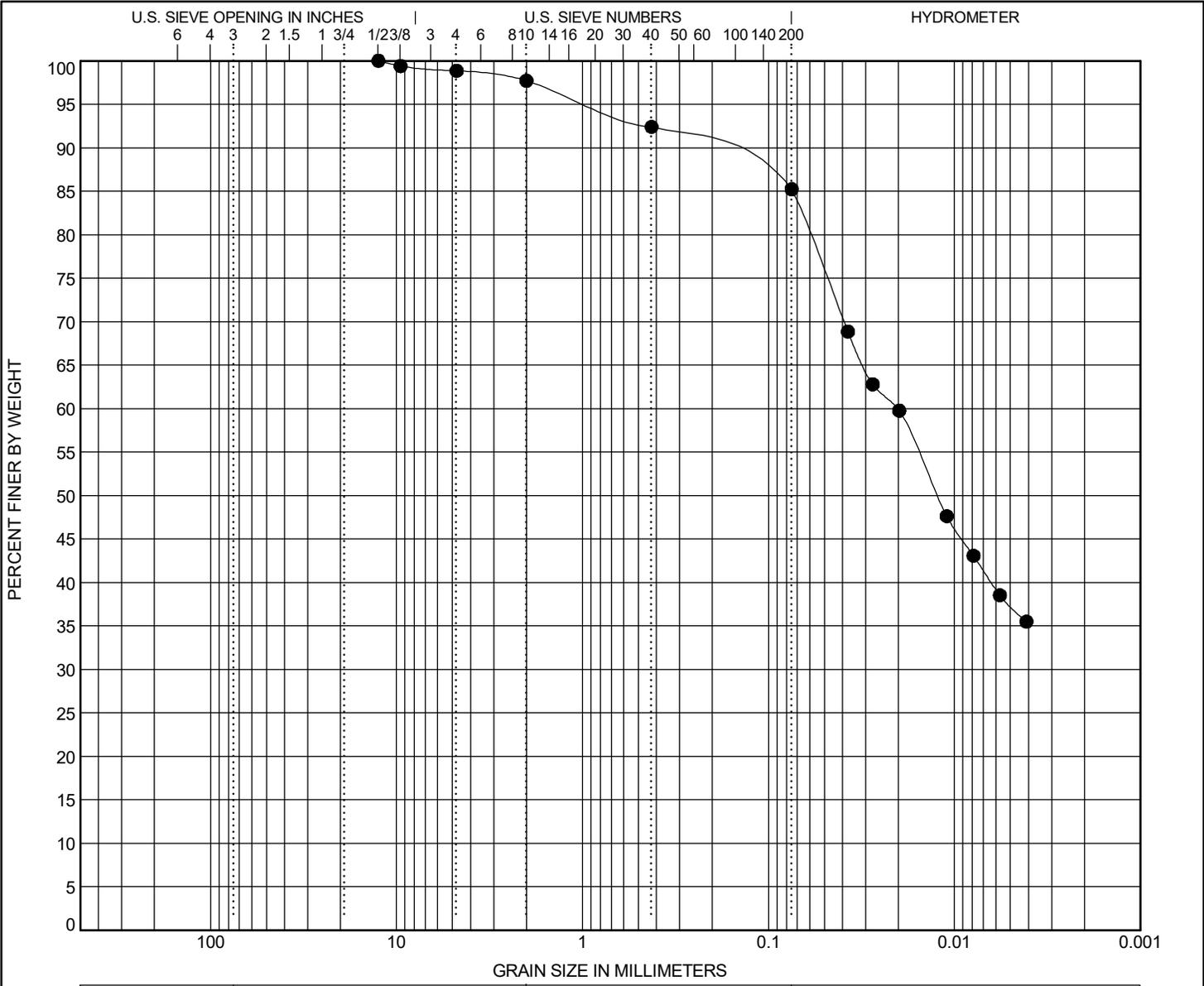
STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 7/25/23 10:10 - O:\PROJECT\2022\COL-05\22050095COL\REPORTS\LOGS\22050095COL.GPJ

NOTES: CAVED AT 8.3'  
 ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; AUGER CUTTINGS MIXED WITH BENTONITE GROUT

**APPENDIX C**  
**LABORATORY TEST RESULTS**



CTL GRADATION - 2014 ODOT.GDT - 6/15/23 10:25 - O:\PROJECT\2022\COL-05\220500095COLLREPORTS\LOGS\22050095COL.GPJ



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
<b>B-001-0-22</b>	<b>1.0</b>	<b>A-7-6(19)</b>	<b>21</b>	<b>54</b>	<b>22</b>	<b>32</b>		

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
<b>B-001-0-22</b>	<b>1.0</b>	<b>12.5</b>	<b>0.02</b>	<b>0.012</b>			<b>3</b>	<b>5</b>	<b>7</b>	<b>48</b>	<b>37</b>

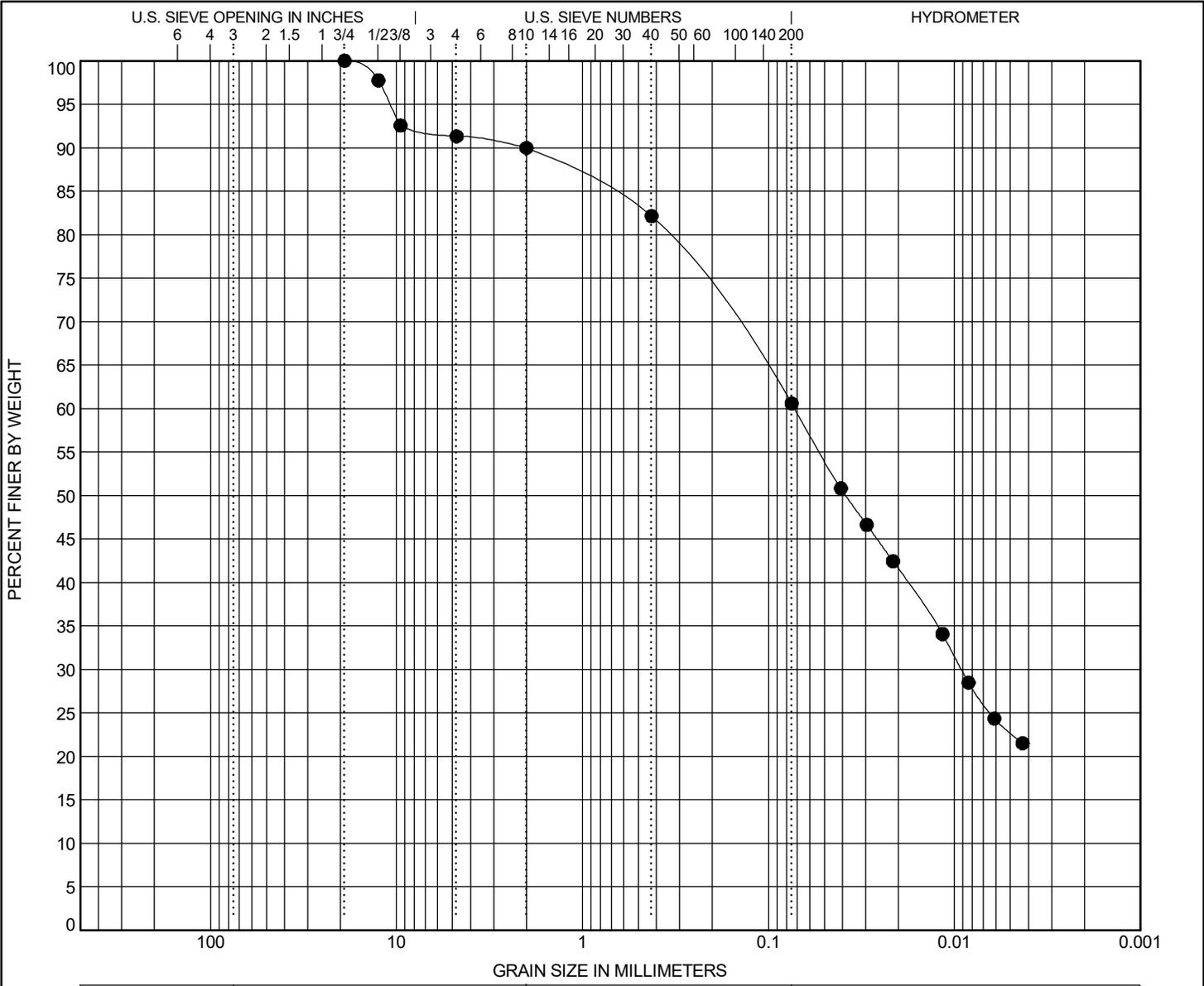


CTL Engineering, Inc.  
 2860 Fisher Road  
 Columbus, Ohio 43204  
 Telephone: 614-276-8123  
 Fax: 614-276-6377

### GRAIN SIZE DISTRIBUTION

Project: **HIG-247-0.04**  
 Location: **HIG COUNTY**  
 CTL Project Number:

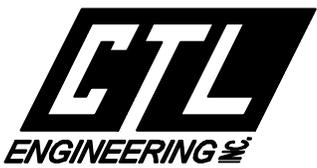
CTL GRADATION - 2014 ODOT.GDT - 6/15/23 10:25 - O:\PROJECT\2022\COL-05\220500095COLLREPORTS\LOGS\220500095COL.GPJ



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification	MC	LL	PL	PI	Cc	Cu
<b>B-002-0-22</b>	<b>1.0</b>	<b>A-6a(6)</b>	<b>16</b>	<b>28</b>	<b>17</b>	<b>11</b>		

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
<b>B-002-0-22</b>	<b>1.0</b>	<b>19</b>	<b>0.072</b>	<b>0.038</b>	<b>0.009</b>		<b>9</b>	<b>8</b>	<b>22</b>	<b>38</b>	<b>23</b>

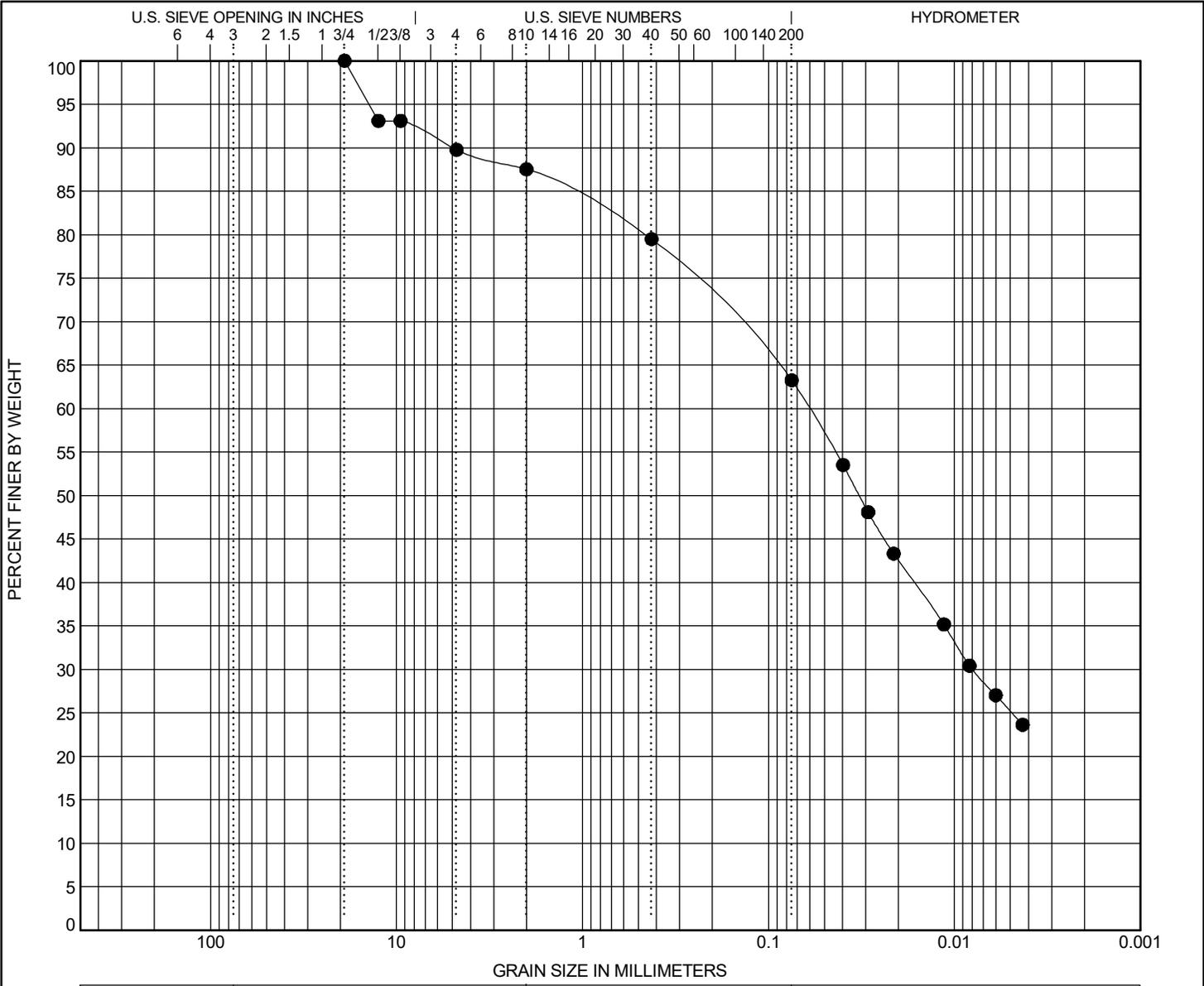


**CTL Engineering, Inc.**  
 2860 Fisher Road  
 Columbus, Ohio 43204  
 Telephone: 614-276-8123  
 Fax: 614-276-6377

### GRAIN SIZE DISTRIBUTION

Project: **HIG-247-0.04**  
 Location: **HIG COUNTY**  
 CTL Project Number:

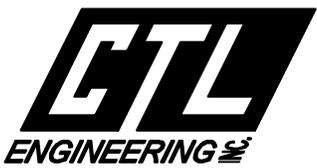
CTL GRADATION - 2014 ODOT.GDT - 6/15/23 10:25 - O:\PROJECT\2022\COL-05\220500095COLLREPORTS\LOGS\22050095COL.GPJ



COBBLES	GRAVEL		SAND		SILT OR CLAY
	coarse	fine	coarse	fine	

Specimen Identification	Depth	Classification					MC	LL	PL	PI	Cc	Cu
<b>B-002-0-22</b>	<b>3.5</b>	<b>A-6b(10)</b>					<b>11</b>	<b>39</b>	<b>18</b>	<b>21</b>		

Specimen Identification	Depth	D100	D60	D50	D30	D10	%Gravel	%Coarse Sand	%Fine Sand	%Silt	%Clay
<b>B-002-0-22</b>	<b>3.5</b>	<b>19</b>	<b>0.061</b>	<b>0.032</b>	<b>0.008</b>		<b>13</b>	<b>8</b>	<b>16</b>	<b>38</b>	<b>25</b>



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 2860 Fisher Road  
 Columbus, Ohio 43204  
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 Fax: 614-276-6377

### GRAIN SIZE DISTRIBUTION

Project: **HIG-247-0.04**  
 Location: **HIG COUNTY**  
 CTL Project Number:

PROJECT NO:	22050095COL
DATE:	6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



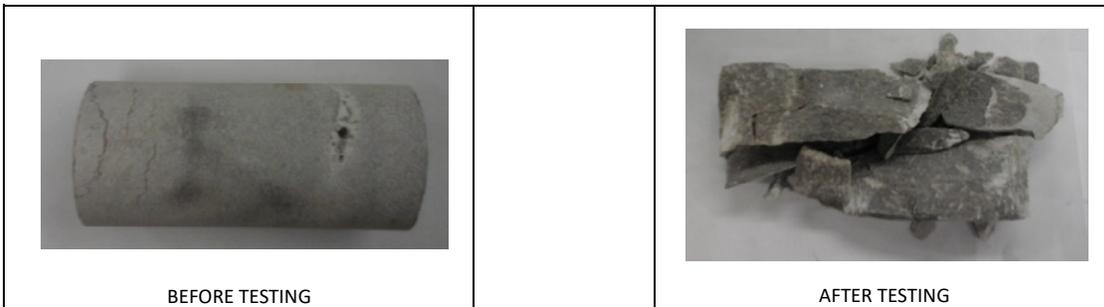
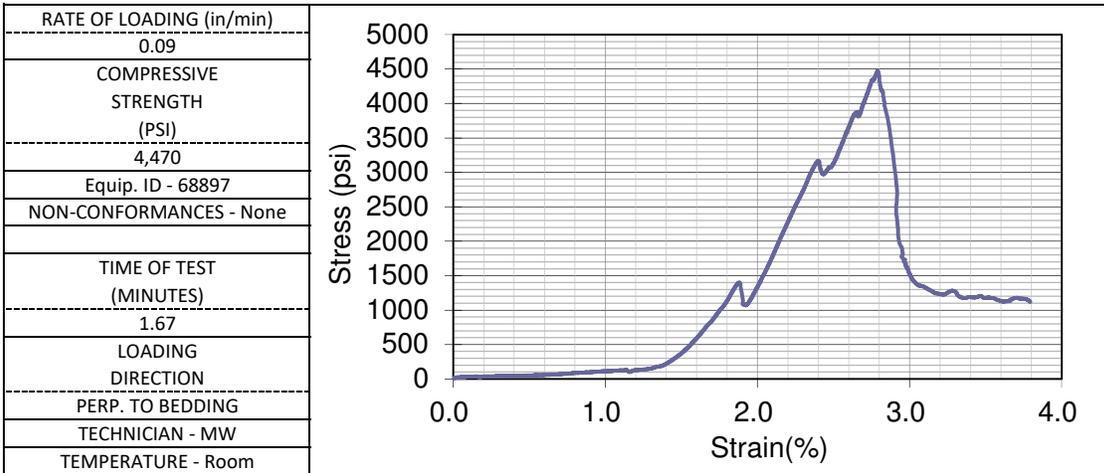
Method C

BORING NUMBER	B-001-0-22	TOP DEPTH(FT)	9.3	BOTTOM DEPTH(FT)	9.8
SAMPLE NUMBER	NQ-1	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Moderately Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.965	1.990
2	3.950	1.993
3	3.998	1.978
AVERAGE	3.971	1.987

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	537.0
UNIT WEIGHT(LBS/FT <sup>3</sup> )	166.1



PROJECT NO:	22050095COL
DATE:	6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



Method C

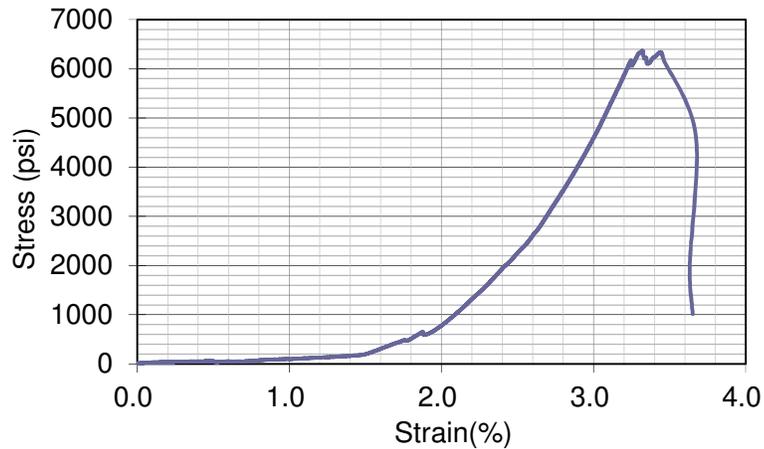
BORING NUMBER	B-001-0-22	TOP DEPTH(FT)	20.3	BOTTOM DEPTH(FT)	20.8
SAMPLE NUMBER	NQ-3	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Moderately Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.919	1.978
2	3.960	1.975
3	3.933	1.975
AVERAGE	3.937	1.976

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	537.5
UNIT WEIGHT(LBS/FT <sup>3</sup> )	169.6

RATE OF LOADING (in/min)	0.09
COMPRESSIVE STRENGTH (PSI)	6,360
Equip. ID - 68897	
NON-CONFORMANCES - None	
TIME OF TEST (MINUTES)	1.63
LOADING DIRECTION	PERP. TO BEDDING
TECHNICIAN - MW	
TEMPERATURE - Room	



PROJECT NO:	22050095COL
DATE:	6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



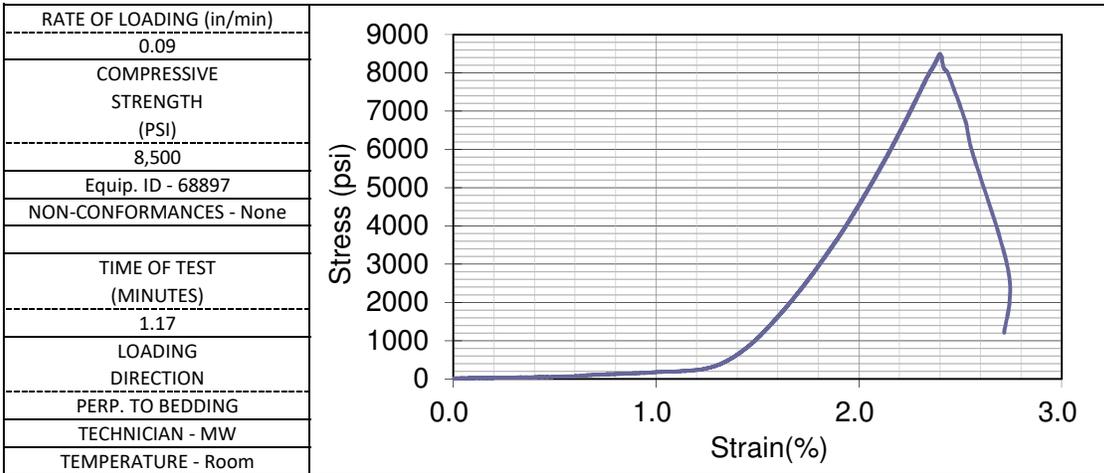
Method C

BORING NUMBER	B-002-0-22	TOP DEPTH(FT)	10.5	BOTTOM DEPTH(FT)	11.0
SAMPLE NUMBER	NQ-1	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.914	1.974
2	3.921	1.980
3	3.915	1.975
AVERAGE	3.917	1.976

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	539.1
UNIT WEIGHT(LBS/FT <sup>3</sup> )	170.9



PROJECT NO:	22050095COL
DATE:	6/13/2023

**UNIAXIAL COMPRESSIVE STRENGTH OF  
INTACT ROCK CORE - ASTM D 7012**



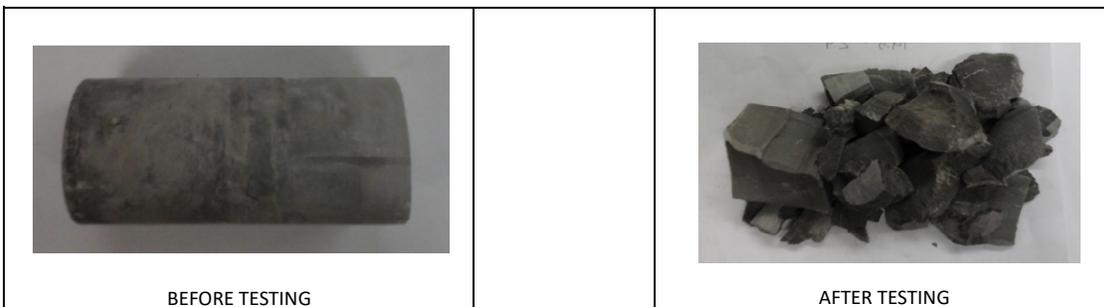
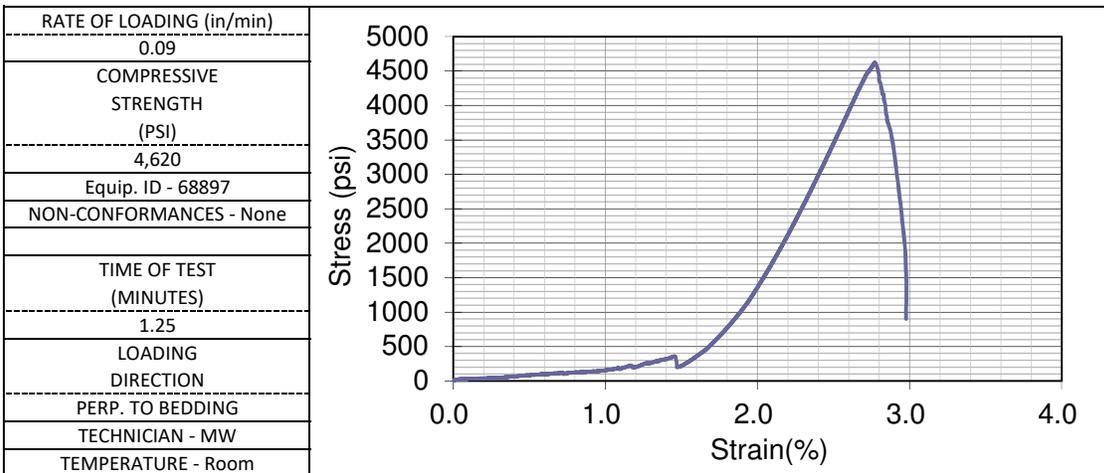
Method C

BORING NUMBER	B-002-0-22	TOP DEPTH(FT)	19.5	BOTTOM DEPTH(FT)	20.0
SAMPLE NUMBER	NQ-3	DISTRICT	9	PID NO.	93830
COUNTY	HIG	ROUTE	247	SECTION	0.04

FORMATION	Silurian Age, Estill Shale
DESCRIPTION	Limestone, Gray, Slightly Weathered, Moderately Strong
MOISTURE CONDITION	As Received

MEASUREMENT	LENGTH(INCHES)	DIAMETER(INCHES)
1	3.933	1.982
2	3.960	1.976
3	3.937	1.976
AVERAGE	3.943	1.978

LENGTH/DIAMETER	2.0
CORRECTION FACTOR	1
AREA(IN <sup>2</sup> )	3.1
MASS (GRAMS)	516.1
UNIT WEIGHT(LBS/FT <sup>3</sup> )	162.3



**APPENDIX D**  
**ROCK CORE PHOTOS**



B-001-0-22



Run #:	Depth		Recovery		RQD	
NQ-1	6.0'	11.0'	57/60	95%	15.5/60	27%
NQ-2	11.0'	16.0'	60/60	100%	36.5/60	61%

HIG-247-0.04, PID 93830



B-001-0-22



Run #:	Depth		Recovery		RQD	
NQ-3	16.0'	21.0'	59/60	98%	39/60	66%
HIG-247-0.04, PID 93830						



B-002-0-22

9.0'

Sample taken for  
compression test



19.0'

Run #:	Depth		Recovery		RQD	
NQ-1	9.0'	14.0'	60/60	100%	45.5/60	76%
NQ-2	14.0'	19.0'	60/60	100%	52/60	87%

HIG-247-0.04, PID 93830



B-002-0-22

19.0'



24.0'

Sample taken for compression test

Run #:	Depth		Recovery		RQD	
NQ-3	19.0'	24.0'	60/60	100%	54/60	90%

HIG-247-0.04, PID 93830



**APPENDIX E**  
**SCOUR INFORMATION**



# HIG-247-0.04

## Scour Information

### Rear Abutment

Boring No B-001-0-22

Compressive strength, Qu= 4470 psi B-001-0-22, NQ-1 Compressive Strength Test Result  
 30.82 Mpa

Rock Joint Set Number, Jn = 1.83 FHWA-HIF-12-003 (HEC 18), Table 4.23

Joint Roughness Number, Jr = 2 FHWA-HIF-12-003 (HEC 18), Table 4.24

Joint Alteration Number, Ja = 2 FHWA-HIF-12-003 (HEC 18), Table 4.25

Relative Joint Orientation Parameter, Js = 0.9 FHWA-HIF-12-003 (HEC 18), Table 4.26

Average Vertical Spacing between Joints= 76.2 mm NQ-1  
 177.8 mm NQ-2

Layer	Elevation (feet)	RQD (%)	Intact Rock Mass Strength Parameter, Ms	Block Size Parameter, Kb	Shear Strength Parameter, Kd	Relative Orientation Parameter, Js	Erodibility Index, K	Critical Shear Stress (Pa)	Critical Shear Stress (Psf)	Erosion Category (EC)
Bedrock	908.9-903.9	26	30.8	14.2	1.00	0.9	394	5025	105	3.981
Bedrock	903.9-898.9	61	30.8	33.3	1.00	0.9	925	7696	161	4.422

### Forward Abutment

Boring No= B-002-0-22

Compressive strength, Qu= 8500 psi B-002-0-22, NQ-1 Compressive Strength Test Result  
 58.61 Mpa  
 4620 psi B-002-0-22, NQ-3 Compressive Strength Test Result  
 31.85 Mpa

Rock Joint Set Number, Jn = 1.83 FHWA-HIF-12-003 (HEC 18), Table 4.23

Joint Roughness Number, Jr = 2 FHWA-HIF-12-003 (HEC 18), Table 4.24

Joint Alteration Number, Ja = 2 FHWA-HIF-12-003 (HEC 18), Table 4.25

Relative Joint Orientation Parameter, Js = 0.9 FHWA-HIF-12-003 (HEC 18), Table 4.26

Average Vertical Spacing between Joints= 177.8 mm NQ-1  
 177.8 mm NQ-2

Layer	Elevation (feet)	RQD (%)	Intact Rock Mass Strength Parameter, Ms	Block Size Parameter, Kb	Shear Strength Parameter, Kd	Relative Orientation Parameter, Js	Erodibility Index, K	Critical Shear Stress (Pa)	Critical Shear Stress (Psf)	Erosion Category (EC)
Bedrock	907.5-902.5	76	58.6	41.5	1.00	0.9	2190	11846	247	4.422
Bedrock	902.5-897.5	87	31.9	47.5	1.00	0.9	1363	9344	195	4.422

**APPENDIX F**  
**SPREAD FOOTING BEARING RESISTANCE**



**Rock Mass Rating (RMR)**

IBI Group  
**HIG-247-0.04 Bridge over Buck Run**  
 Highland County, Ohio  
 CTL Project No.: 22050095COL

Engineer: SR/SM  
 Date: 31-Aug-2023  
**Boring/Fnd: B-001-0-22, Rear Abt.**  
**Footing Elevation: 904.48**  
**Footing Width , B (ft): 6**

Field RQD (%) = 26 NQ-1  
 Lab qu (psi) = 4470.00 NQ-1  
 Lab γ (pcf) = 166.1 NQ-1



**AASHTO Table 10.4.6.4-1 - Geomechanics Classification of Rock Masses**

PARAMETER		RANGES OF VALUES						Rating		
1	Strength of Intact Rock Material	Point Load Strength Index	> 175 ksf	85 - 175 ksf	45 - 85 ksf	20 - 45 ksf	For this low range - uniaxial compressive test is preferred			4
		Uniaxial Compressive Strength	> 1,200 psi	600 to 1,200 psi	300 to 600 psi	150 to 300 psi	215 - 520 ksf	70 - 215 ksf	20 - 70 ksf	
		> 4320 ksf	2160 - 4320 ksf	1080 - 2160 ksf	520 - 1080 ksf	1,500 to 3,600 psi	500 to 1,500 psi	150 to 500 psi		
	Relative Rating		15	12	7	4	2	1	0	
2	Drill Core Quality (RQD)	90% to 100%	75% to 90%	50% to 75%	25% to 50%	< 25%				8
	Relative Rating		20	17	13	8	3			
3	Spacing of Joints	> 10 ft	3 to 10 ft.	1 to 3 ft.	2 in. to 1 ft.	< 2 in.				10
	Relative Rating		30	25	20	10	5			
4	Condition of Joints	- Very rough surfaces - Not continuous - No separation - Hard joint wall rock	- Slightly rough surfaces - Separation <0.05" - Hard joint wall rock	- Slightly rough surfaces - Separation <0.05" - Soft joint wall rock	- Slickensides surfaces or - Gouge <0.2" thick or - Joints open 0.05-0.2" - Continuous joints	- Soft gouge >0.2" thick or - Joints open >0.2" - Continuous joints				12
	Relative Rating		25	20	12	6	0			
5	Groundwater Conditions (use one of the three evaluation criteria as appropriate to the method of exploration)	Inflow per 30 ft tunnel length	None	< 400 gallons/hr.	400 to 2,000 gallons/hr.	> 2,000 gallons/hr.				7
		Ratio = joint water pressure / major principal stress	0	0.0 to 0.2	0.2 to 0.5	> 0.5				
	General Conditions	Completely Dry	Moist Only (interstitial water)	Water under Moderate Pressure	Severe Water Problems					
	Relative Rating		10	7	4	0				

Rock Mass Rating (RMR) = 41

**AASHTO Table 10.4.6.4-2 - Geomechanics Rating Adjustment for Joint Orientations**

Strike and Dip Orientations of Joints		Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable	Rating
Ratings	Tunnels	0	-2	-5	-10	-12	0
	Foundations	0	-2	-7	-15	-25	
	Slopes	0	-5	-25	-50	-60	

Adjusted Rock Mass Rating (RMR) = 41

**AASHTO Table 10.4.6.4-3 - Geomechanics Rock Mass Classes Determined from Total Ratings**

RMR	100 to 81	81 to 61	61 to 41	41 to 21	< 20	Class:
Class No.	I	II	III	IV	V	III
Description	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock	

**ODOT GDM 1303.3.3 - Calculated Rock Mass Parameters**

RMR =	41	see Adjusted Rock Mass Rating above
c' =	4.26	c' = (0.104 x RMR) (ksf) drained shear strength of rock mass
φ' =	26	φ' = ((RMR/2) + 5) (deg.) internal friction angle of rock mass
s =	0.00142	s = exp((RMR-100)/9) rock mass material constant defining intactness (quality) of rock mass
m =	0.8511	m = exp((RMR-100)/28)*m <sub>i</sub> rock mass material constant defining the shape of the Mohr's circle for uniaxial comp.
m <sub>i</sub> =	7	Sandstone, m <sub>i</sub> = 15 rock mass constant m for intact rock (where s = 100) Claystone/Shale, m <sub>i</sub> = 10 Limestone/Dolomite, m <sub>i</sub> = 7 Coal, m <sub>i</sub> = 1
E <sub>m</sub> =	124374.26	E <sub>m</sub> = 144*145*10 <sup>(RMR-10/40)</sup> (ksf)

## LRFD Strength Limit State Design for Bearing Resistance of Rock using Spread Footings

IBI Group

**HIG-247-0.04 Bridge over Buck Run**

Highland County, Ohio

CTL Project No.: 22050095COL

Engineer: SR/SM

Date: 31-Aug-2023

**Boring/Fnd: B-001-0-22, Rear Abt.**

**Footing Elevation: 904.48**



---

### ODOT GDM 1303.3.3 - Bearing Resistance of Bedrock (Moderately Strong or Less Strength Rock)

#### **Does foundation bedrock meet ALL of following three conditions:**

- bedrock surface under footing is not steeply sloping such that discontinuities would control the bearing resistance (a bedrock slope of 2H:1V or less)
- the foundation bedrock has a Rock Mass rating (RMR)  $\leq 70$
- the foundation bedrock is moderately strong or less in strength ( $q_u \leq 7500$  psi)

if YES to all three conditions, then use the Terzaghi/Vesic/Munfakh method to calculate nominal bearing resistance in accordance with AASHTO LRFD 10.6.3.1.2a

assuming footing parameters of:

B = 6.0 footing width, ft.

D = 4.4 footing depth, ft.

$$q_n = c'N_c + \gamma DN_q + 0.5\gamma_t BN_\gamma \quad \text{nominal bearing resistance}$$

where

$c'$  = 4.26 drained shear strength of rock mass, ksf

$\phi'$  = 26 internal friction angle of rock mass, deg.

$N_c$  = 21.5 cohesion bearing capacity factor

$\gamma$  = 0.058 unit weight of soil above footing, kcf

$N_q$  = 11.2 surcharge bearing capacity factor

$\gamma_t$  = 0.166 unit weight of rock below footing, kcf

$N_\gamma$  = 11.7 soil density factor

hence,

$$q_n = 100.23 \text{ ksf}$$

and,

$\phi_b$  = 0.45 strength limit state resistance factor

$$q_R = 45.11 \text{ strength limit state factored resistance, } \phi_b * q_n, \text{ ksf}$$

**Rock Mass Rating (RMR)**



IBI Group  
**HIG-247-0.04 Bridge over Buck Run**  
 Highland County, Ohio  
 CTL Project No.: 22050095COL

Engineer: SR/SM  
 Date: 31-Aug-2023  
**Boring/Fnd: B-002-0-22, Forward Abt.**  
**Footing Elevation: 904.48**  
**Footing Width , B (ft): 6**

Field RQD (%) = 76 NQ-1  
 87 NQ-2  
 Composite Field RQD (%) = 83  
 Lab qu (psi) = 8500 NQ-1  
 4620 NQ-3  
 Composite Lab qu (psi) = 5913  
 Lab γ (pcf) = 170.9 NQ-1  
 162.3 NQ-3  
 Composite Lab γ (pcf) = 165.2

**AASHTO Table 10.4.6.4-1 - Geomechanics Classification of Rock Masses**

PARAMETER		RANGES OF VALUES						Rating		
1	Strength of Intact Rock Material	Point Load Strength Index	> 175 ksf	85 - 175 ksf	45 - 85 ksf	20 - 45 ksf	For this low range - uniaxial compressive test is preferred			4
			> 1,200 psi	600 to 1,200 psi	300 to 600 psi	150 to 300 psi				
	Uniaxial Compressive Strength	> 4320 ksf	2160 - 4320 ksf	1080 - 2160 ksf	520 - 1080 ksf	215 - 520 ksf	70 - 215 ksf	20 - 70 ksf		
		> 30,000 psi	15,000 to 30,000 psi	7,500 to 15,000 psi	3,600 to 7,500 psi	1,500 to 3,600 psi	500 to 1,500 psi	150 to 500 psi		
Relative Rating		15	12	7	4	2	1	0		
2	Drill Core Quality (RQD)	90% to 100%	75% to 90%	50% to 75%	25% to 50%	< 25%			17	
	Relative Rating	20	17	13	8	3				
3	Spacing of Joints	> 10 ft	3 to 10 ft.	1 to 3 ft.	2 in. to 1 ft.	< 2 in.			10	
	Relative Rating	30	25	20	10	5				
4	Condition of Joints	- Very rough surfaces - Not continuous - No separation - Hard joint wall rock	- Slightly rough surfaces - Separation <0.05" - Hard joint wall rock	- Slightly rough surfaces - Separation <0.05" - Soft joint wall rock	- Slickensides surfaces or - Gouge <0.2" thick or - Joints open 0.05-0.2" - Continuous joints	- Soft gouge >0.2" thick or - Joints open >0.2" - Continuous joints				12
							Relative Rating	25	20	
5	Groundwater Conditions (use one of the three evaluation criteria as appropriate to the method of exploration)	Inflow per 30 ft tunnel length	None	< 400 gallons/hr.	400 to 2,000 gallons/hr.	> 2,000 gallons/hr.			7	
		Joint water pressure / major fractures	0	0.0 to 0.2	0.2 to 0.5	> 0.5				
	General Conditions	Completely Dry	Moist Only (interstitial water)	Water under Moderate Pressure	Severe Water Problems					
Relative Rating		10	7	4	0					

**Rock Mass Rating (RMR) = 50**

**AASHTO Table 10.4.6.4-2 - Geomechanics Rating Adjustment for Joint Orientations**

Strike and Dip Orientations of Joints		Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable	0
Ratings	Tunnels	0	-2	-5	-10	-12	
	Foundations	0	-2	-7	-15	-25	
	Slopes	0	-5	-25	-50	-60	

**Adjusted Rock Mass Rating (RMR) = 50**

**AASHTO Table 10.4.6.4-3 - Geomechanics Rock Mass Classes Determined from Total Ratings**

RMR	100 to 81	81 to 61	61 to 41	41 to 21	< 20	Class:
Class No.	I	II	III	IV	V	III
Description	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock	

**ODOT GDM 1303.3.3 - Calculated Rock Mass Parameters**

RMR =	50	see Adjusted Rock Mass Rating above
c' =	5.20	c' = (0.104 x RMR) (ksf) drained shear strength of rock mass
φ' =	30	φ' = ((RMR/2) + 5) (deg.) internal friction angle of rock mass
s =	0.00387	s = exp((RMR-100)/9) rock mass material constant defining intactness (quality) of rock mass
m =	1.1737	m = exp((RMR-100)/28)*m <sub>i</sub> rock mass material constant defining the shape of the Mohr's circle for uniaxial comp.
m <sub>i</sub> =	7	Sandstone, m <sub>i</sub> = 15 Claystone/Shale, m <sub>i</sub> = 10 Limestone/Dolomite, m <sub>i</sub> = 7 Coal, m <sub>i</sub> = 1
E <sub>m</sub> =	208800.00	E <sub>m</sub> = 144*145*10 <sup>(RMR-10)/40</sup> (ksf)

## LRFD Strength Limit State Design for Bearing Resistance of Rock using Spread Footings

IBI Group

**HIG-247-0.04 Bridge over Buck Run**

Highland County, Ohio

CTL Project No.: 22050095COL

Engineer: SR/SM

Date: 31-Aug-2023

**Boring/Fnd: B-002-0-22, Forward Abt.**

**Footing Elevation: 904.48**



---

### ODOT GDM 1303.3.3 - Bearing Resistance of Bedrock (Moderately Strong or Less Strength Rock)

#### **Does foundation bedrock meet ALL of following three conditions:**

- bedrock surface under footing is not steeply sloping such that discontinuities would control the bearing resistance (a bedrock slope of 2H:1V or less)
- the foundation bedrock has a Rock Mass rating (RMR)  $\leq 70$
- the foundation bedrock is moderately strong or less in strength ( $q_u \leq 7500$  psi)

if YES to all three conditions, then use the Terzaghi/Vesic/Munfakh method to calculate nominal bearing resistance in accordance with AASHTO LRFD 10.6.3.1.2a

assuming footing parameters of:

B = 6.0 footing width, ft.

D = 3.0 footing depth, ft.

$$q_n = c'N_c + \gamma DN_q + 0.5\gamma_t BN_\gamma \quad \text{nominal bearing resistance}$$

where

$c'$  = 5.20 drained shear strength of rock mass, ksf

$\phi'$  = 30 internal friction angle of rock mass, deg.

$N_c$  = 30.1 cohesion bearing capacity factor

$\gamma$  = 0.058 unit weight of soil above footing, kcf

$N_q$  = 18.4 surcharge bearing capacity factor

$\gamma_t$  = 0.165 unit weight of rock below footing, kcf

$N_\gamma$  = 22.4 soil density factor

hence,

$$q_n = 171.05 \quad \text{ksf}$$

and,

$\phi_b$  = 0.45 strength limit state resistance factor

$$q_R = 76.97 \quad \text{strength limit state factored resistance, } \phi_b * q_n, \text{ ksf}$$

**APPENDIX G  
RESPONSE TO ODOT COMMENTS**



August 29, 2023

IBI Group  
23 Triangle Park Drive  
Cincinnati OH 45246

Attention: Mr. Steven Butler PE  
Associate - Manager, Transportation Engineering

Reference: Response to Stage 2 Comments  
HIG-247-0.04, PID No. 93830  
Bridge Number: 3603482  
Highland County, Ohio  
CTL Project No. 22050095COL

Dear Mr. Butler

This letter provides our responses to the comments prepared by ODOT OGE on the Stage 2 Submittals. These comments were provided to CTL via email by IBI Group personnel on 07/23/2023.

1. Structure Foundation Exploration

- a. Page 2, Section IV Explorations – add a section for historic exploration and include the information presented in the comments for the Geotechnical Profile - Culvert sheets.

**Response:** Historic exploration information was added to the exploration section of the report and to the cover page of Geotechnical Profile -Bridge sheets.

- b. Page 3, Section V Findings – in the second line of the second paragraph, change “911” to “911.4.” Modify the second sentence of the third paragraph as follows: “... operations were described as predominantly limestone with a minor amount of shale and...”

**Response:** Findings section of the report has been updated per the comment.

- c. Page 4, Table 2 – note that the Erodibility Index (K) is in question (see Appendix E comments) so the values of  $\tau_c$ ,  $D50_{\text{equivalent}}$ , and EC will likely change.

**Response:** The Erodibility Index calculations were updated per the Appendix E comments.

- d. Page 4, Section VI.A, Scour Information – the bedrock encountered in the borings does not meet all the criteria for scour-resistant rock ( $RMR > 75$ ,  $K > 100$ ), as presented in ODOT Bridge Design Manual (BDM) Section 305.2.1.2.b.B, so the bedrock is not necessarily scour-resistant. Perform a scour analysis and provide the results. Consider

performing a multi-layer scour analysis considering the differences in the RQD values in core runs NQ-1 and NQ-2 in Boring B-001-0-22. For future reference, slake durability tests should have been performed on the limestone rock core samples.

**Response:** Scour Analysis for both NQ-1 and NQ-2 were included in Final Report. Comment regarding the slake durability test is noted for future projects.

- e. Page 4, Section VI.B, Foundation Support – it is unclear how the bearing elevations for the spread footings were determined. Explain. Even though the bearing elevations have been raised since the previous submission, it will still require much effort to excavate five feet into limestone bedrock to install the foundations. Consider shallower foundations if other design aspects permit.

**Response:** The upper 5.0 feet of coreable bedrock (NQ-1 layer) in boring B-001-0-22 exhibited a relatively low RQD value compared to RQD of the bedrock encountered in NQ-2 and NQ-3. Based on our discussions with IBI group, it was initially considered to extend the foundations 5.0 feet into the underlying coreable bedrock.

CTL agrees that shallower foundations can be considered if other design aspects permit for this project. CTL will discuss this with IBI group to check if shallower foundations can be utilized for this project.

Upon further discussions with IBI group, the bottom of footing elevations for both rear and forward abutment was raised to elevation 904.48.

- f. Page 5, Section VI.B, Foundation Support – sliding is not a valid failure mode for an arch culvert so the last two paragraphs regarding sliding calculations should be deleted. However, the horizontal (at-rest) earth pressure against the sides of the culvert and the vertical pressure on the top of the culvert should be provided as they may be used in structural design. Refer to ODOT Geotechnical Design Manual (GDM) Section 1402 for additional guidance.

**Response:** Paragraphs regarding sliding calculations were removed from VI.B Foundation Support section of the report. Equivalent friction angle and unit weight were provided for the retained soils.

- g. Appendix A, Site Plan - modify this sheet as directed in the comment on Sheet 14/24 Site Plan in the project plans. For future reference, this page is typically referred to as a Boring Location Plan and therefore the profile view is not needed. Refer to ODOT Specifications for Geotechnical Explorations (SGE) Section 706.8 for additional information.

**Response:** Comment noted.

- h. Appendix B, Boring Logs – include the stations and offsets of the borings in the headers of the boring logs. Recalculate the unit RQD of the first layer of limestone in Boring B-001-0-22. It is expected to be greater than 26 percent since it extends partway into core NQ-2, which has an RQD of 61 percent.

**Response:** Appendix B has been updated per the comment.

Appendix E, Scour Information – several of the parameters used to calculate the erodibility index (K) are overly conservative. The following values are recommended:

$J_n = 1.83$ , assuming there are two joint sets, which is typical of Ohio bedrock.

$J_r = 2$ , representing smooth undulating joint surfaces

$J_a = 2$  appears appropriate

$J_s = 0.9$  appears appropriate

Average vertical spacing between joints = 177.8 mm appears appropriate

Recalculate the scour parameters based on these updated values.

**Response:** The scour parameters have been recalculated considering the recommended values.

2. Geotechnical Profile – Culvert Sheets:

- a. General – replace “Structure Foundation Exploration” in the Title Block on each sheet with “Geotechnical Profile – Culvert,” in accordance with SGE Section 703. Add these sheets to the total sheet count of the Project Plans.

**Response:** Per IBI group, the proposed replacement structure is considered as a “bridge structure” instead of a “culvert structure”. Therefore, CTL updated the Title Block of each sheet with Geotechnical Profile- Bridge. Total sheet counts were also added to the bottom of sheets.

- b. Sheet 1/7 – revise the historic records section to say “No historic records were found for this structure. However, the historic roadway borings (TIMS sub-batch 9666) indicate that the top of rock was encountered between El. 905 and 910 feet and limestone was exposed in the creek bed.” In the second paragraph under “Exploration Findings,” change “911” to “911.4” in the third line. Also change the last sentence to “... samples were described as predominantly limestone with a minor amount of shale.” In the heading of the scour analysis table, use two lower case m’s to represent millimeters. Two capital M’s can be interpreted to mean millions.

**Response:** Sheet 1/7 has been updated per the comment.

- c. Sheet 2/7, Plan and Profile – show existing land usage descriptions in the plan view, in accordance with SGE Section 702.5.1. The callouts regarding the MGS guardrail and

rock channel protection are not needed and may be removed to reduce clutter. In the profile view, the thickness of shallow surface material, such as pavement or topsoil, is typically shown to the nearest inch, according to SGE Section 702.6.3.a. Tenths of feet are also permissible, but do not use hundredths of feet, as shown for the aggregate base.

**Response:** Sheet 2/7 has been updated per the comment.

- d. Sheet 5/7, Boring Logs – update the boring logs as directed in the comment about Appendix B of the SFE report.

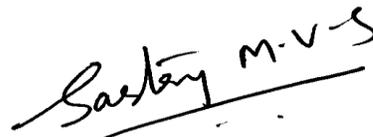
**Response:** Sheet 5/7 has been updated per the comment.

### **Closing**

We appreciate the opportunity to be of service to you on this project. If you have any questions or need further information, please do not hesitate to contact us.

Respectfully submitted,

**CTL Engineering, Inc.**



Sastry Malladi, P.E.  
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