Geotechnical Engineering Report

Ripley Road Bridge Replacement
Union Township, Brown County, Ohio
January 10, 2023
Terracon Project No. N1195264

Prepared for:
Brown County Engineer's Office
Georgetown, Ohio

Prepared by:
Terracon Consultants, Inc.
Cincinnati, Ohio

January 10, 2023

Brown County Engineer's Office
25 Veterans Blvd.
Georgetown, Ohio 45121

Attn: Mr. Todd Cluxton, P.E., P.S.
P: (937) 378-6456
E: tcluxton@browncountyengineer.org

Re: Geotechnical Engineering Report
Ripley Road Bridge Replacement
Ripley Road
Union Township, Brown County, Ohio
Terracon Project No. N1195264

Dear Mr. Cluxton

This report includes recommendations for the bridge foundations, earthwork, and roadway subgrade recommendations services for the proposed replacement of the bridge on Ripley Road over Red Oak Creek in Union Township, Brown County, Ohio. Revisions to this report have been made based on comments from ODOT on the report dated November 7, 2022. Our services were performed in general accordance with Terracon Proposal No. PN1195264 dated July 19, 2019 and authorized on August 15, 2019.

We appreciate the opportunity to be of service to you on this project. If you have any questions concerning this report or if we may be of further service, please contact us.

Sincerely,
Terracon Consultants, Inc.

Suraj Khadka, P.E.
Senior Staff Engineer

David W. Westendorf, P.E.
Principal/Group Manager

REPORT TOPICS

Note: This report was originally delivered in a web-based format. **Orange Bold** text in the report indicates a referenced section heading. The PDF version also includes hyperlinks which direct the reader to that section and clicking on the ***GeoReport*** logo will bring you back to this page. For more interactive features, please view your project online at client.terracon.com.

ATTACHMENTS

Note: Refer to each individual Attachment for a listing of contents.

Geotechnical Engineering Report

Ripley Road Bridge Replacement

Ripley Road

Union Township, Brown County, Ohio

Terracon Project No. N1195264

January 10, 2023

INTRODUCTION

This report presents the results of our subsurface exploration and geotechnical engineering services performed for the proposed replacement of the existing bridge on Ripley Road approximately 35-feet north of its intersection with Stringtown Road and over Red Oak Creek in Union Township, Brown County, Ohio. The purpose of these services is to provide information and geotechnical engineering recommendations relative to:

- subsurface soil and rock conditions
- short-term groundwater conditions
- site preparation and earthwork
- bridge foundation recommendations
- seismic site classification per IBC

The project includes replacement of the existing bridge on Ripley Road over Red Oak Creek. The geotechnical engineering Scope of Services for this project included the advancement of three (3) test borings to depths ranging from approximately 17.8 to 36.5 feet below existing site grades.

Maps showing the site and boring locations are shown in the **Site Location** and **Exploration Plan** sections, respectively. The results of the laboratory testing performed on soil and bedrock samples obtained from the site during the field exploration are included on the boring logs and/or as separate graphs in the **Exploration Results** section.

GEOLOGY AND OBSERVATIONS

The following description of site conditions is derived from our site visit in association with the field exploration and our review of publicly-available geologic and topographic maps.

Item	Description
Parcel Information	■ The project is located at the existing bridge on Ripley Road approximately 35-feet north of its intersection with Stringtown Road and over Red Oak Creek in Union Township, Brown County, Ohio. ■ Latitude/Longitude: 38.7572, -83.8294 (approximate) ■ See **Site Location**

Item	Description
Existing Improvements	Existing concrete deck bridge with asphalt surface supported on steel girders. The bridge is approximately 20 feet in width. The bridge is supported on a central pier and on concrete abutment walls.
Current Ground Cover	Ground cover below and adjacent to the bridge consists of grass and weed vegetation with trees/brush. The approaches at the east and west abutments consist of asphalt pavement and the bridge has a concrete deck with asphalt cover. The creek has limestone slabs exposed in the channels.
Existing Topography (from Google Earth Pro)	Relatively level at an Elevation of about 522 feet at the roadway grade. The elevation within the creek channel is approximately at El. 506 feet above MSL. The creek banks slope downward at about 4H:1V.
Geology	Our experience near the vicinity of the proposed bridge site or geologic maps indicates subsurface conditions consist of man-placed fill and native Nolin silt loam overburden soils of alluvial origin underlain by bedrock. According to bedrock geology maps, the subsurface soils at the site are underlain by Ordovician Age bedrock belonging to the Kope Formation primarily consisting of interbedded shale (75%) and limestone (25%). The top to bedrock elevation in our current test borings ranged between El. 499 feet to El. 503 feet above mean sea level.

PROJECT DESCRIPTION

Our initial understanding of the project was provided in our proposal and was discussed during project planning. A period of collaboration has transpired since the project was initiated, and our final understanding of the project conditions is as follows:

Item	Description
Information Provided	Information for this project was provided via phone and email correspondence with Mr. Cluxton on July 10, 2019.
Project Description	Replacement of an existing bridge on Ripley Road, near its intersection with Stringtown Road, over Red Oak Creek. The purpose of this study was to characterize the subsurface conditions at the proposed abutments and center pier locations to be used by the structural engineer to perform the bridge foundation design. The abutments and bridge span(s) will be designed by Palmer Engineering.
Proposed Structure	The new bridge will be located approximately in the same location as the existing bridge. It is anticipated the bridge will be supported on drilled shafts or shallow foundations with a cast-in-place concrete bridge deck.
Estimated Start of Construction	2020

EXPLORATION

A total of three (3) test borings were performed for the project by Terracon on August 30, 2019. Terracon personnel provided the boring layout. Coordinates and elevations were obtained from Google Earth Pro. If elevations and a more precise boring layout are desired, we recommend borings be surveyed in the field.

The test borings were performed with a Diedrich D-90 track-mounted drill rig. The average drill rod energy ratio (ER) was 78.8 percent (calibration date 8/1/2019). The test borings were drilled to depths of about 17.8 to 36.5 feet below the existing roadway and ground surface grades and terminated in bedrock.

Drilling and sampling procedures were performed in general accordance with the ODOT Specification for Geotechnical Explorations (SGE). The drill rig utilized hollow-stem augers to permit split-spoon sampling in overburden soils. In the split-barrel sampling procedure, a standard 2-inch outer diameter split-barrel sampling spoon was driven into the ground by a 140-pound automatic hammer falling at a distance of 30 inches. The number of blows required to advance the sampling spoon the last 12 inches of a normal 18-inch penetration is recorded as the Standard Penetration Test (SPT) resistance value. The SPT resistance values, also referred to as N-values, are indicated on the boring logs at the test depths.

Upon encountering bedrock, a bedrock sample was collected by over-driving the split-spoon sampler, followed by 10-feet of rock coring using a NQ2 rock core barrel sampler. Water was added to the borehole as drilling fluid during rock coring operations. Groundwater levels were observed during drilling and at completion of the drilling activities at each test boring location. No long-term (24-hour) water level readings were obtained at the test boring locations. Upon completion of the drilling activities and following water level observations, the boreholes were backfilled with auger cuttings. The test borings within the existing pavement were patched at the surface with asphalt after backfilling operations.

The sampling depths, penetration distances, and other sampling information was recorded on the field boring logs. The samples were placed in appropriate containers and taken to our soil laboratory for testing and classification by a Geotechnical Engineer. Our exploration team prepared field boring logs as part of the drilling operations. These field logs included visual classifications of the materials encountered during drilling and our interpretation of the subsurface conditions between samples. Final boring logs were prepared from the field logs. The final boring logs represent the Geotechnical Engineer's interpretation of the field logs and include modifications based on observations and tests of the samples in our laboratory.

The test boring logs were classified by the geotechnical engineer based on the drill foreman’s field notes, visual examination of the recovered samples and the results of the laboratory test performed in accordance with ODOT standards.

FINDINGS

Subsurface Profile

The subsurface profile in the test borings at the abutments generally consists of a mixture of granular and cohesive soils in the upper 19 to 21 feet overlying bedrock. Boring B-002-0-19, which was drilled in the creek at lower elevation, encountered bedrock beneath 7.5 feet of overburden materials. The soils in the upper 7.5 to 21 feet consisted of a mixture of A-1-a, A-1-b, A-6a, and A-6b. The upper soil profile consists primarily of gravel and/or sand with varying amounts of coarse and fine sand, silt and clay. These soils were generally medium dense to dense in consistency. The cohesive materials encountered in the subsurface consisted of silt and clay with varying amounts of sand and trace gravel. These soils were generally stiff to very stiff in terms of consistency. The top to bedrock elevation ranged from approximately El. 499 feet (at B-002-0-19) to El. 502.5 feet (at B-001-0-19). The bedrock consisted of interbedded shale (about 60%) and limestone (about 40%) with rock quality designation (RQD) ranging between 25 to 29%.

Conditions encountered at each boring location are indicated on the individual boring logs shown in the **Exploration Results** section and are attached to this report. Stratification boundaries on the boring logs represent the approximate location of changes in native soil types; in situ, the transition between materials may be gradual.

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. The groundwater levels observed in the boreholes can be found on the boring logs in **Exploration Results**, and are summarized in the following table.

Boring Number	Approximate Depth to Groundwater while Drilling (feet) [1]	Approximate Depth to Groundwater after Drilling (feet) [1, 3]
B-001-0-19	NW	20
B-002-0-19	1	2.5
B-003-0-19	16	7

1. Below ground surface
2. NW=No water encountered while drilling
3. The at-completion water levels are likely influenced by water added to the boreholes as drilling fluid during rock-coring operations.

Groundwater was not observed in boring B-001-0-19 while drilling, or for short duration that the boring was allowed to remain open. However, this does not necessarily mean these borings terminated above groundwater, or that the water levels summarized above are stable ground water

levels. The at-completion water levels are likely influenced by water added to the boreholes as a drill fluid during rock-coring operations. Long-term observations in piezometers, or observation wells sealed from the influence of surface water, are often required to define groundwater levels.

It is common to encounter groundwater seepage at the soil/bedrock interface and within fractures and between bedding planes within shale and limestone bedrock. Groundwater at the site will likely be impacted by the Red Oak Creek water levels (especially during wetter periods of the year).

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, the creek level, runoff and other factors not evident at the time the borings were performed. Therefore, groundwater levels during construction or at other times in the life of the structure may be higher or lower than the levels indicated on the boring logs. The possibility of groundwater level fluctuations should be considered when developing the design and construction plans for the project.

Depending on the weather conditions during the proposed construction, conventional dewatering techniques (sump and pump) may be required to deal with groundwater and surface runoff during shallow undercutting and fill placement operations. Sandbags or other methods to divert water from foundation excavations may also be needed. Dewatering should be the responsibility of the contractor.

GEOTECHNICAL OVERVIEW

A geotechnical engineering study has been completed for the proposed bridge replacement on Ripley Road in Brown County, Ohio. Three (3) borings, designated B-001-0-19 through B-003-0-19, were performed to a depth of approximately 17.8 to 36.5 feet below existing ground surface. Logs of the borings along with a site location plan and boring location plan are included in **Exploration Results** section of this report. Based on the information obtained from our subsurface exploration the following geotechnical considerations were identified:

- Test boring B-002-0-19, drilled along the creek flow line, encountered granular and cohesive materials to a depth of approximately 7.5 feet underlain by bedrock. The remaining two borings encountered granular and cohesive materials to about 21 feet below the ground surface where bedrock was encountered. The top to bedrock elevation ranged from approximately El. 499 feet (at B-002-0-19) to El. 502.5 feet (at B-001-0-19). The bedrock consisted of interbedded shale (about 60%) and limestone (about 40%).

- Based on the test boring results, the proposed replacement bridge can be supported on drilled shafts bearing in the shale/limestone bedrock. Recommendations for design of the foundations are provided in **Deep Foundations** section of the report.

This overview should be used in conjunction with the entire report for design purposes. It should be recognized that details were not included or fully developed in this section, and the report must be read in its entirety for a comprehensive understanding of the items contained herein. The **General Comments** section provides an understanding of the report limitations.

ANALYSES AND GEOTECHNICAL RECOMMENDATIONS

Site Preparation and Earthwork

Earthwork is anticipated to include clearing and grubbing, stripping of pavement and removal of the existing bridge and minimal excavation and fill placement. The following sections provide recommendations for use in the preparation of specifications for the work. Recommendations include critical quality criteria, as necessary, to render the site in the state considered in our geotechnical engineering evaluation for foundations.

Prior to placing any new fill, all vegetation, topsoil, existing pavement, and any otherwise unsuitable material should be removed from the construction areas. Wet or dry material should either be removed, or moisture conditioned and recompacted. After stripping and grubbing, the subgrade should be proof rolled where possible to aid in locating loose or soft areas. Proof-rolling can be performed with a loaded tandem-axle dump truck (minimum 20 ton). Soft, dry and low-density soil should be removed or disced and recompacted in place prior to placing fill.

Where fill is placed on existing slopes steeper than 5H:1V, level benches should be cut into the existing slopes prior to fill placement. The benches should have a minimum vertical face height of 1 foot and a maximum vertical face height of 3 feet and should be cut wide enough to accommodate the compaction equipment. This benching will help provide a positive bond between the fill and natural soils and reduce the possibility of failure along the fill/natural soil interface. Furthermore, we recommend that fill slopes be over-filled (over-steepened) and then cut back to the design grade to develop an adequately compacted slope face. Vegetation should be established on the slopes or other erosion control installed (designed by others) to limit erosion on the slopes.

We recommend all earthwork be performed per the ODOT Construction and Materials Specifications (ODOT CMS). Generally, the on-site soils appear suitable for re-use as engineered fill., provided they are properly moisture conditioned. Any excavated shale or limestone bedrock that will be used as fill material will require special preparation as outline in the ODOT CMS. All materials should be tested in the laboratory for their suitability for re-use as embankment fill, prior to using them as embankment fill.

Bridge Foundations

The proposed bridge is anticipated to consist of a two-span structure and approximately 120 feet long and 20 feet wide. Bedrock was encountered at a depth of about 20 feet (about Elevation 502

feet) below the existing grade at Boring B-001-0-19 near the southern abutment and about 21 feet (about Elevation 501 feet) below the existing grade at Boring B-002-0-19 near the northern abutment. Boring B-002-0-19, which was drilled at the creek level near center abutment, encountered bedrock at a depth of about 7.5 feet (about Elevation 499 feet) below the existing grade. The bedrock consisted of interbedded shale and limestone bedrock. Specifically, the drilled shafts should penetrate not less than 25 feet (about El. 495 feet) below existing pavement grades at the abutment (end support) locations and not less than 13 feet (about El. 493 feet) below existing grade at the pier locations.

Based on the test borings and laboratory testing, in the competent shale and limestone bedrock we recommend an unfactored unit tip resistance of 115 tsf and resistance factor of 0.5 be used for the design. An unfactored unit side resistance of 6.8 tsf and a resistance factor of 0.55 can be used in the gray shale and limestone. Per the ODOT Bridge Design Manual, a minimum drilled shaft diameter of 42 inches is required for drilled shafts supporting bridge pier columns. A minimum rock socket embedment of 1.5 times the diameter is required per AASHTO Section 10.8.

Anticipated Top of Bedrock Elevation (feet)	Unfactored Nominal Unit Tip Resistance, q_p (tsf)	Unfactored Nominal Unit Side Resistance, q_s (tsf)	Resistance Factor, φ_{stat}
499 to 502.5 feet	115	6.8 [1]	0.5 (Tip) 0.55 (Side)

1. For drilled shafts socketed into bedrock, side resistance in the overburden soils is disregarded due to insufficient shaft movement to mobilize this resistance. Neglect side resistance for rock sockets with a length less than 1.5 times the rock socket diameter. Otherwise, neglect the contribution to skin friction provided by the top 2-ft of the rock socket.

The drilled shaft length will need to be designed to satisfy axial compressive, uplift, and lateral load requirements. The penetration of the drilled shaft into shale and limestone bedrock may need to be increased over the minimum rock socket for bearing capacity based on the lateral resistance or uplift resistance requirements of the drilled shaft foundations

The following table provides input values for use in LPILE analyses. LPILE estimated values of k_h and E_{50} based on strength; however, non-default values of k_h were used where provided. The soil parameters were estimated based on the test borings, laboratory test results, and our experience with these soil types. The portion of the drilled shaft within 30 inches of finished grade should ignore any lateral soil resistance due to frost considerations.

Soil Layer/ Type[1]	LPILE Model	Unit Weight (pcf)	Soil Friction Angle (deg)	Undrained Cohesion (psf)	ε_{50}	K (pci)	Uniaxial Compressive Strength (psi)
Gravel/Stone Fragments w/ Sand	Sand (Reese)	120	34	-	-	75	-
Silty Clay	Stiff Clay w/ Free Water	115	-	2,000	0.005	1000	-
Shale and Limestone Bedrock (Elev. 502-497)	Weak Rock	130	-	-	-	-	120 [2]
Shale and Limestone Bedrock (Elev. 497-485.5)	Weak Rock	140	-	-	-	-	750 [3]

1. See test boring logs and **Findings** for more details on Stratigraphy.
2. For the upper shale and limestone bedrock we recommend a Strain Factor, k, of 0.0005 and Initial Modulus of Rock Mass of 11,000 psi. An RQD of 10% is recommended for this layer.
3. For the upper shale and limestone bedrock we recommend a Strain Factor, k, of 0.00025 and Initial Modulus of Rock Mass of 68,000 psi. An RQD of 25% is recommended for this layer.

Drilled Shaft Construction Recommendations

The materials, reinforcement, and installation of the drilled shafts should be in general accordance with the requirements outlined in the latest ODOT CMS and Bridge Design Manual. It is recommended that the following criteria be used in the design and construction of the drilled shaft foundations:

1. The concrete shall have a minimum 28-day specified compressive strength of 4,000 psi.

2. It is recommended that the approximate top of rock and design socket depths (summarized above) be shown for each drilled shaft on the plans, with these elevations being determined using the test borings and minimum embedment requirements from axial load analyses. The final bearing elevation should be determined by inspection of each shaft excavation in the field by a qualified geotechnical technician. The foundation

drawings should clearly identify those shafts where the minimum embedment lengths are based on axial and/or lateral load analyses.

3. The specifications should be clear that the design bottom of the drilled shaft elevations shown on the plans is for estimation purposes only. Actual determination of the bottom elevation will be made from examination of materials brought to the surface on the augers by the geotechnical technician working under supervision of the project geotechnical engineer.

4. The specifications should require that no concrete be placed until the dimensions, bottom elevation, bearing socket depth, and excavation for each shaft has been observed and approved by the geotechnical technician. Water seepage both from the creek and subsurface will likely enter the shafts. It is recommended that the specifications state that "the depth of water or loose materials at the bottom of the shaft excavation, just prior to placing concrete shall be less than 2 inches.

5. If more than 2 inches of water is present in the shaft excavation, a means of preventing concrete from intermixing with the water must be provided, such as a bottom discharge gate or rubber ball for a tremie pipe. In no case should concrete be placed through standing water in the shafts or tremie pipe.

6. The specifications should state that casing shall be made available on-site (by the contractor) and be placed wherever required to stabilize loose or caving materials, or to seal off any water bearing zones. Any casing should be extended into bedrock to cut off any water and prevent bottom blowout. Due to the encountered granular soils in the test borings, steel casing should be anticipated to install the drilled shafts.

7. It is recommended that the specifications state that the structural steel and concrete be placed the same day as the shaft excavation is completed. No completed drilled shaft excavation should be allowed to remain open overnight. It is suitable, however, for the contractor to excavate a portion of the drilled shaft and to complete the shaft excavation the next day. It is extremely important that seepage into shaft excavations be pumped out and the reinforcing steel and concrete be placed soon after reaching design bearing elevation. The bottom of the shaft excavation should be mucked of any soft material prior to placing reinforcing steel and shaft concrete.

SCOUR CONSIDERATIONS

The following table provides D50 and D95 values for laboratory tested soil samples.

Boring Number	Sample Number	Elevation	D50 (mm)	D95 (mm)
B-001-0-19	SS-3	516-514.5	10.97	35.19
	SS-5	511-509.5	0.09	6.09
	SS-7	507-505.5	0.84	22.69
	SS-8	505.5-504.6	1.20	30.84
B-002-0-19	SS-2	505.0-503.5	2.68	22.76
	SS-3	503.5-502.0	1.28	20.89
	SS-4	502.0-499.0	0.06	16.31
B-003-0-19	SS-3	516.0-514.5	0.02	1.96
	SS-6	508.5-507.0	2.55	33.00
	SS-7	507.0-506.2	7.41	23.83
	SS-8	505.5-504	2.99	34.21

Based on BDM and HEC18, the calculated Erodibility Index (K) of the shale and limestone bedrock for use in the scour analysis is 20.6. The following rock parameters were utilized in determining the K value.

Parameter	Value
Q_u	46 tsf (5 Mpa)
RQD	25%
M_s	3.95
J_s	1.02
J_n	1.22
J_r	1.0
J_a	4.0

K_b	20.5
K_d	0.25

SEISMIC CONSIDERATIONS

The seismic design requirements for buildings and other structures are based on Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with AASHTO Code. Based on the soil and bedrock properties encountered at the site and as described on the exploration logs and results, it is our professional opinion that the **Seismic Site Classification is C**. Subsurface explorations at this site were extended to a maximum depth of 36.5 feet below the existing site grade The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of geologic conditions of the general area. Additional deeper borings or geophysical testing may be performed to confirm the conditions below the current boring depth.

LATERAL EARTH PRESSURES

The proposed bridge abutments should be designed using the earth pressure parameters recommended in the following paragraphs. Lateral earth pressures will be influenced by structural design of the walls, conditions of wall restraint, methods of construction and/or compaction and the strength of the materials being restrained. The backfill immediately behind the wall should include a free-draining aggregate (ODOT 518 porous backfill) within a 2-foot rectangular zone behind the walls. Concrete or two-foot-thick cohesive soil cap should be placed at the surface to limit surface water infiltration into the backfill.

DESCRIPTION	DESIGN STATIC LATERAL PRESSURES	
	DRAINED [2]	UNDRAINED [3]
Abutment walls with level backslope [1]	Lateral earth pressure [4]: 33H psf (triangular distribution) + Surcharge pressure [4]: 0.28S psf (rectangular distribution)	Lateral earth pressure [5]: 16H psf (triangular distribution) + Hydrostatic Pressure [5]: 62.4h psf (triangular distribution) + Surcharge pressure [5]: 0.28S psf (rectangular distribution)

1. The earth pressures recommended above assume the abutments allow at least 0.1 inches of movement at the top of the abutment wall to fully develop "active" earth pressure conditions. If these assumptions on wall restraint are not accurate, then higher lateral earth pressure could develop on walls. Terracon should be notified immediately if the stated assumptions are not correct.
2. Effective drainage is provided, and hydrostatic pressures are not allowed to develop behind the wall.
3. Hydrostatic pressures can develop behind the wall.
4. "H" is the design height of the wall in feet; "S" is uniform surface surcharge in psf.
5. "h" is the height of water behind the wall in feet. If "h" < "H", then lateral earth pressures from the drained upper portion of the wall backfill should be added to the recommended undrained lateral earth pressure values.

The recommended design lateral pressures do not include compaction related forces. It is recommended that hand compaction be used within 5 feet of the wall's backface to minimize compaction forces

GENERAL COMMENTS

Our analysis and opinions are based upon our understanding of the project, the geotechnical conditions in the area, and the data obtained from our site exploration. Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. Terracon should be retained as the Geotechnical Engineer, where noted in this report, to provide observation and testing services during pertinent construction phases. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

Our Scope of Services does not include either specifically or by implication any environmental or biological (e.g., mold, fungi, bacteria) assessment of the site or identification or prevention of pollutants, hazardous materials, or conditions. If the owner is concerned about the potential for such contamination or pollution, other studies should be undertaken.

Our services and any correspondence or collaboration through this system are intended for the sole benefit and exclusive use of our client for specific application to the project discussed and are accomplished in accordance with generally accepted geotechnical engineering practices with no third-party beneficiaries intended. Any third-party access to services or correspondence is solely for information purposes to support the services provided by Terracon to our client. Reliance upon the services and any work product is limited to our client and is not intended for third parties. Any use or reliance of the provided information by third parties is done solely at their own risk. No warranties, either express or implied, are intended or made.

Site characteristics as provided are for design purposes and not to estimate excavation cost. Any use of our report in that regard is done at the sole risk of the excavating cost estimator as there may be variations on the site that are not apparent in the data that could significantly impact excavation cost. Any parties charged with estimating excavation costs should seek their own site characterization for specific purposes to obtain the specific level of detail necessary for costing. Site safety, and cost estimating including, excavation support, and dewatering requirements/design are the responsibility of others. If changes in the nature, design, or location of the project are planned, our conclusions and recommendations shall not be considered valid unless we review the changes and either verify or modify our conclusions in writing.

ATTACHMENTS

Contents:

Note: All attachments are one page unless noted above.

SITE LOCATION

Ripley Road Bridge Replacement ■ Union Township, Brown County, Ohio
January 10, 2023 ■ Terracon Project No. N1195264

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

DIAGRAM IS FOR GENERAL LOCATION ONLY, AND IS NOT INTENDED FOR CONSTRUCTION PURPOSES

MAP PROVIDED BY MICROSOFT BING MAPS

EXPLORATION RESULTS

Contents:

PROJECT: RIPLEY BRIDGE	DRILLING FIRM / OPERATOR: TERRACON / AM	DRILL RIG: D-90 766	STATION / OFFSET: 540+42, 7' RT.
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: TERRACON / AM	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: CR62
PID: 109440 SFN: 0833533	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/1/19	ELEVATION: 522.0 (MSL) EOB: 34.8 ft.
START: 8/30/19 END: 8/30/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 78.8	LAT / LONG: 38.757045, -83.829446

EXPLORATION ID B-001-0-19

MATERIAL DESCRIPTION AND NOTES	ELEV. 522.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT, (14 INCHES)	520.8																	
MEDIUM DENSE, GRAY AND BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DRY			6 6 5	14	100	SS-1	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
			8 12 12	32	100	SS-2	-	-	-	-	-	-	-	-	-	13	A-1-b (V)	
	514.5		12 12 8	26	100	SS-3	-	65	10	7	11	7	NP	NP	NP	8	A-1-b (0)	
VERY STIFF, BROWN, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, DAMP			2 8 5	17	100	SS-4	2.00	-	-	-	-	-	-	-	-	20	A-6b (V)	
			3 6 8	18	100	SS-5	2.00	17	17	17	21	28	35	18	17	18	A-6b (5)	
	507.0		6 8 14	29	11	SS-6	2.00	-	-	-	-	-	-	-	-	2	A-6b (V)	
MEDIUM DENSE TO DENSE, GRAY AND BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT AND CLAY, DAMP			8 10 18	37	100	SS-7	-	37	23	16	11	13	21	17	4	14	A-1-b (0)	
			10 50/5"	-	73	SS-8	-	43	20	14	13	10	21	19	2	14	A-1-b (0)	
	502.5		7 10 12	29	33	SS-9	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, LIGHT GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG.		▼ TR	50/3"	-	100	SS-10	-	-	-	-	-	-	-	-	-	1	Rock (V)	
Qu = 649.6 psi on Shale sample at 26.1'			29		93	C-1											CORE	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 11/7/22 14:07 - \\CINCINNATI1\DATA\PROJECTS\2019\N1195264\WORKING FILES\N1195264 RIPLEY ROAD- ODOT.GPJ

PID: 109440	SFN: 0833533	PROJECT: RIPLEY BRIDGE	STATION / OFFSET: 540+42, 7' RT.	START: 8/30/19	END: 8/30/19	PG 2 OF 2	B-001-0-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, LIGHT GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG. *(continued)*	492.0	31 32 33 34				NQ2												
	487.2	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

PROJECT: RIPLEY BRIDGE	DRILLING FIRM / OPERATOR: TERRACON / AM	DRILL RIG: D-90 766	STATION / OFFSET: 541+10, 7' RT.
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: TERRACON / AM	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: CR62
PID: 109440 SFN: 0833533	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/1/19	ELEVATION: 506.5 (MSL) EOB: 17.8 ft.
START: 8/30/19 END: 8/30/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 78.8	LAT / LONG: 38.757234, -83.829460

EXPLORATION ID B-002-0-19

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE TO DENSE, BROWN AND GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, MOIST	506.5	W 505.5	3 5 3	11	33	SS-1	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
		1	21 10 5	20	56	SS-2	-	54	17	10	12	7	NP	NP	NP	15	A-1-b (0)	
		2	9 50/4"	-	80	SS-3	-	42	29	11	12	6	NP	NP	NP	17	A-1-b (0)	
	502.0	3																
HARD, OLIVE GRAY, **SILT AND CLAY**, LITTLE SAND, SOME GRAVEL, TRACE ROCK FRAGMENTS, DAMP		4	50/5"	-	100	SS-4	4.50	29	11	7	29	24	29	17	12	15	A-6a (4)	
	499.0	5																
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, LIGHT GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG.		TR 6																
		7																
		8																
		9																
		10																
		11																
		12	25		97	NQ2											CORE	
		13																
		14																
		15																
		16																
Qu = 868.4 psi on Shale sample at 16.9'		17																
	488.7	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

PROJECT: RIPLEY BRIDGE	DRILLING FIRM / OPERATOR: TERRACON / AM	DRILL RIG: D-90 766	STATION / OFFSET: 541+72, 6' RT.	EXPLORATION ID B-003-0-19
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: TERRACON / AM	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: CR62	
PID: 109440 SFN: 0833533	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/1/19	ELEVATION: 522.0 (MSL) EOB: 36.5 ft.	PAGE 1 OF 2
START: 8/30/19 END: 8/30/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 78.8	LAT / LONG: 38.757422, -83.829463	

MATERIAL DESCRIPTION AND NOTES	ELEV. 522.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT, (14 INCHES)	520.8																	
MEDIUM DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DRY	518.5		7 5 8	17	67	SS-1	-	-	-	-	-	-	-	-	-	20	A-1-b (V)	
VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, SOME SAND AND IRON OXIDE STAINS, TRACE GRAVEL, DAMP			8 12 30	55	100	SS-2	2.00	-	-	-	-	-	-	-	-	7	A-6a (V)	
		▼	7 7 7	18	100	SS-3	2.00	5	12	13	43	27	34	23	11	25	A-6a (7)	
			75 5 50	72	100	SS-4	3.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
			5 9 8	22	100	SS-5	2.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
	508.5																	
MEDIUM DENSE TO DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS**, SOME TO "AND" SAND, TRACE SILT AND CLAY, MOIST			12 10 10	26	33	SS-6	-	55	26	10	5	4	NP	NP	NP	6	A-1-a (0)	
		W 506.0	12 50/4"	-	80	SS-7	-	65	18	8	6	3	NP	NP	NP	3	A-1-a (0)	
			6 7 9	21	100	SS-8	-	55	22	10	8	5	NP	NP	NP	18	A-1-a (0)	
			6 4 40	58	100	SS-9	-	-	-	-	-	-	-	-	-	23	A-1-a (V)	
	501.0		4 6 10	21	100	SS-10	-	-	-	-	-	-	-	-	-	90	A-1-a (V)	
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, GRAY, MODERATELY TO SLIGHTLY WEATHERED, VERY WEAK.		TR	50/4"	-	100	SS-11	-	-	-	-	-	-	-	-	-	-	Rock (V)	
			50/2"	-	100	SS-12	-	-	-	-	-	-	-	-	-	-		

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/10/23 15:44 - N:\PROJECTS\2019\N1195264\WORKING FILES\N1195264 RIPLEY ROAD- ODOT.GPJ

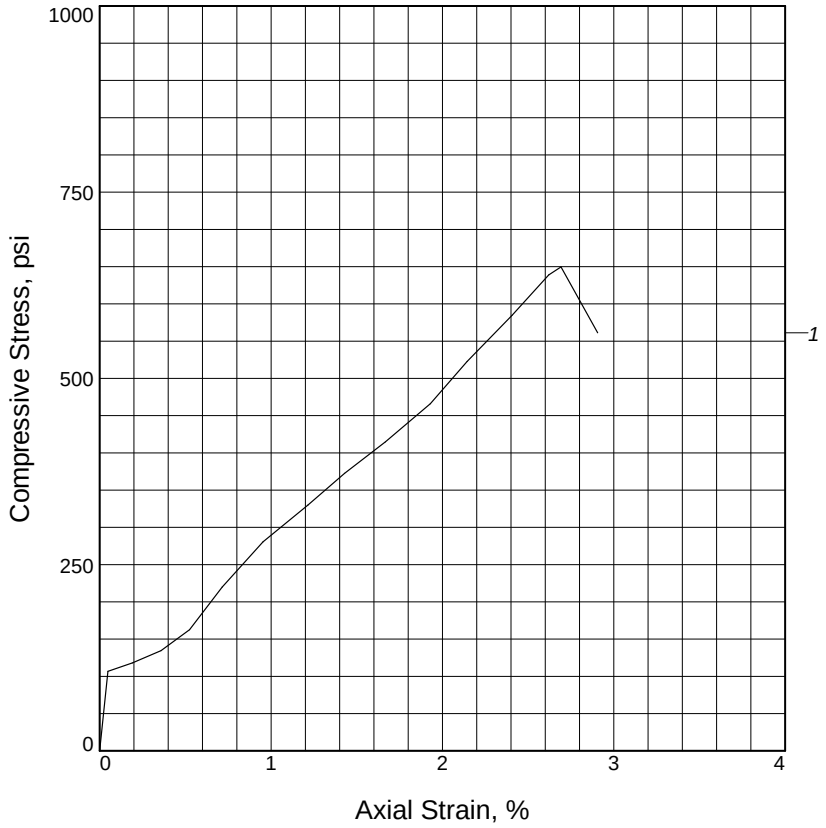
PID: 109440	SFN: 0833533	PROJECT: RIPLEY BRIDGE	STATION / OFFSET: 541+72, 6' RT.	START: 8/30/19	END: 8/30/19	PG 2 OF 2	B-003-0-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, GRAY, MODERATELY TO SLIGHTLY WEATHERED, VERY WEAK. *(continued)*	492.0	31 32 33 34 35 36	25		100	C-1 NQ2											CORE	
	485.5	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psi	649.582			
Undrained shear strength, psi	324.791			
Failure strain, %	2.7			
Strain rate, in./min.	0.041			
Water content, %	4.9			
Wet density, pcf	159.1			
Dry density, pcf	151.6			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.974			
Specimen height, in.	4.198			
Height/diameter ratio	2.13			

Description: SHALE AND LIMESTONE

LL =	**PL =**	**PI =**	**GS=2.7**	**Type:** Shale with limestone

Project No.: N1195264
Date Sampled: 10-2-19
Remarks:

Exhibit 6664

Client: BROWN COUNTY OH

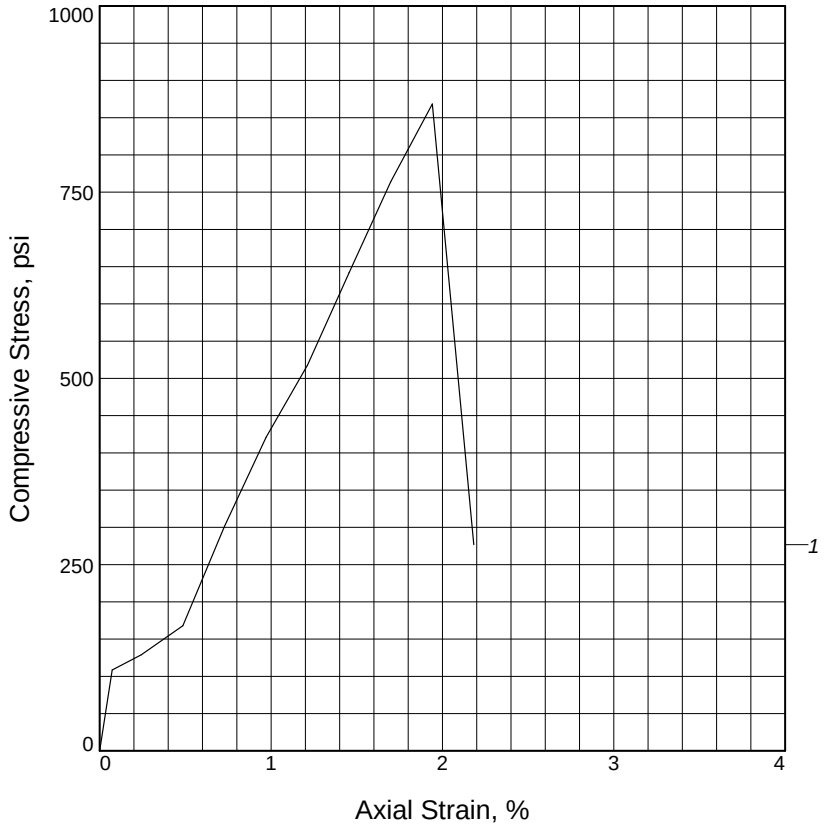
Project: RIPLEY ROAD BRIDGE REPLACEMENT

Source of Sample: B-1 **Depth:** 26.1-26.5'
Sample Number: C-1

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psi	868.388			
Undrained shear strength, psi	434.194			
Failure strain, %	1.9			
Strain rate, in./min.	0.041			
Water content, %	2.0			
Wet density, pcf	162.9			
Dry density, pcf	159.7			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.975			
Specimen height, in.	4.122			
Height/diameter ratio	2.09			

Description: LIMESTONE & SHALE

LL =	**PL =**	**PI =**	**GS= 2.7**	**Type:** Shale with Limestone

Project No.: N1195264
Date Sampled: 10-2-19
Remarks:

Exhibit 6671

Client: BROWN COUNTY OH

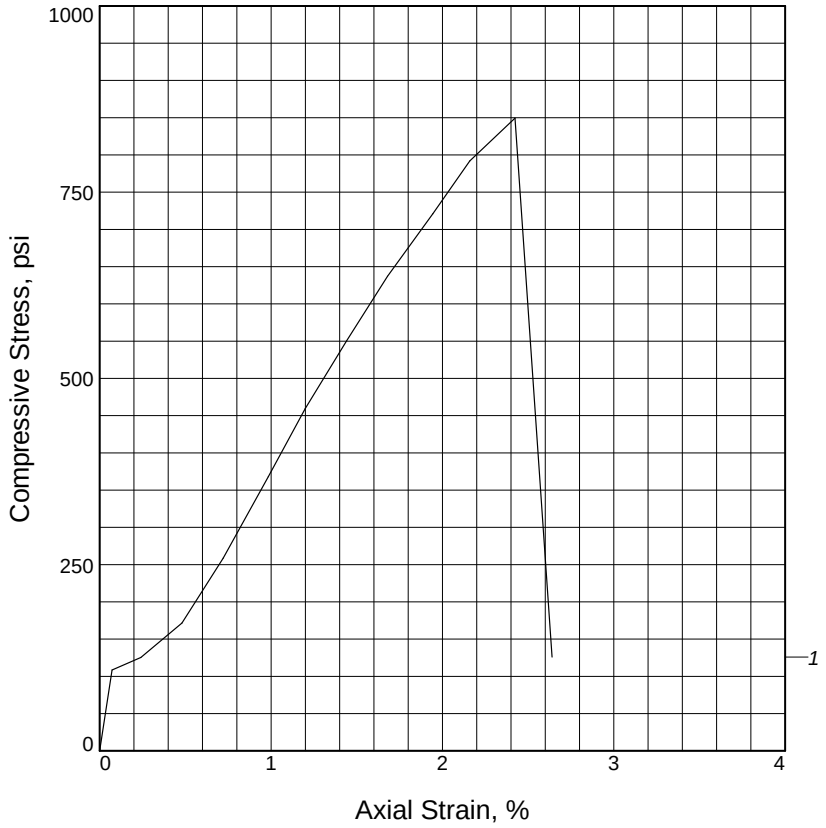
Project: RIPLEY ROAD BRIDGE REPLACEMENT

Source of Sample: B-2 **Depth:** 16.9-17.3'
Sample Number: C-1

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psi	849.460			
Undrained shear strength, psi	424.730			
Failure strain, %	2.4			
Strain rate, in./min.	0.041			
Water content, %	4.6			
Wet density, pcf	161.3			
Dry density, pcf	154.3			
Saturation, %	N/A			
Void ratio	N/A			
Specimen diameter, in.	1.975			
Specimen height, in.	4.167			
Height/diameter ratio	2.11			

Description: SHALE AND LIMESTONE

LL =	**PL =**	**PI =**	**GS=**	**Type:** Shale with Limestone

Project No.: N1195264
Date Sampled: 10-2-19
Remarks:

Exhibit 6688

Client: BROWN COUNTY OH

Project: RIPLEY ROAD BRIDGE REPLACEMENT

Source of Sample: B-3 **Depth:** 35.7-36.1'
Sample Number: C-1

UNCONFINED COMPRESSION TEST

Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

GEOTECHNICAL PROFILE-BRIDGE

PROJECT DESCRIPTION

THE PROJECT CONSISTS OF THE REPLACEMENT OF AN EXISTING BRIDGE ON RIPLEY ROAD, NEAR ITS INTERSECTION WITH STRINGTOWN ROAD, OVER RED OAK CREEK IN UNION TOWNSHIP, BROWN COUNTY, OHIO.

HISTORIC RECORDS

NO HISTORIC RECORDS WERE FOUND FOR THIS PROJECT.

GEOLOGY

OUR EXPERIENCE NEAR THE VICINITY OF THE PROPOSED BRIDGE SITE OR GEOLOGIC MAPS INDICATES SUBSURFACE CONDITIONS CONSIST OF MAN-PLACED FILL AND NATIVE NOLIN SILT LOAM OVERBURDEN SOILS OF ALLUVIAL ORIGIN UNDERLAIN BY BEDROCK. ACCORDING TO BEDROCK GEOLOGY MAPS, THE SUBSURFACE SOILS AT THE SITE ARE UNDERLAIN BY ORDOVICIAN AGE BEDROCK BELONGING TO THE KOPE FORMATION PRIMARILY CONSISTING OF INTERBEDDED SHALE (75%) AND LIMESTONE (25%).

RECONNAISSANCE

FIELD RECONNAISSANCE WAS COMPLETED ON JULY 15, 2019, BY TERRACON PERSONNEL. DURING THE FIELD RECONNAISSANCE, THE PAVEMENT WAS NOTED AS BEING IN GOOD CONDITION. THE EXISTING SLOPES ARE SLIGHTLY VEGETATED WITH BRUSH AND TREES. THE CREEK CHANNEL IS COVERED WITH ROCK FRAGMENTS AND SLABS WITH SAND AND GRAVEL SEDIMENT. MINIMAL EROSION OR SCOUR WAS NOTED AROUND THE BRIDGE ABUTMENTS AND PIERS.

SUBSURFACE EXPLORATION

A TOTAL OF THREE BORINGS (B-001-0-19 TO B-003-0-19) WERE PERFORMED AS A PART OF THE GEOTECHNICAL STUDY FOR THE PROPOSED BRIDGE REPLACEMENT PROJECT. THE TEST BORINGS WERE PERFORMED ON AUGUST 30, 2019, WITH A DIEDRICH D-90 TRACK MOUNTED ROTARY DRILL RIG, USING 3 ¼-INCH I.D. HOLLOW STEM AUGERS TO ADVANCE THE BORINGS. DISTURBED SAMPLES WERE COLLECTED IN ACCORDANCE WITH THE STANDARD PENETRATION TEST (AASHTO T206) AT CONTINUOUS AND 2.5-FOOT INTERVALS. THE BORINGS WERE ADVANCED TO DEPTHS RANGING FROM 17.8 TO 36.5 FEET BELOW THE EXISTING ROADWAY. ALL TEST BORINGS TERMINATED IN BEDROCK. THE HAMMER SYSTEM USED WAS LAST CALIBRATED ON AUGUST 1, 2019, AND THE AVERAGE DRILL ROD ENERGY RATIO (ER) WAS 78.8%.

EXPLORATION FINDINGS

THE SUBSURFACE PROFILE IN THE TEST BORINGS AT THE ABUTMENTS GENERALLY CONSISTS OF A MIXTURE OF GRANULAR AND COHESIVE SOILS IN THE UPPER 19 TO 21 FEET AND UNDERLAIN BY BEDROCK. BORING B-002-0-19, WHICH WAS DRILLED IN THE CREEK AT A LOWER ELEVATION, ENCOUNTERED BEDROCK BENEATH 7.5 FEET OF OVERBURDEN MATERIALS. THE SOILS IN THE UPPER 7.5 TO 21 FEET CONSISTED OF A MIXTURE OF A-1-A, A-1-B, A-6A, AND A-6B. THE UPPER SOIL PROFILE CONSISTS PRIMARILY OF GRAVEL AND/OR SAND WITH VARYING AMOUNTS OF COARSE AND FINE SAND, SILT, AND CLAY. THESE SOILS WERE GENERALLY MEDIUM-DENSE TO DENSE IN CONSISTENCY. THE COHESIVE MATERIALS ENCOUNTERED IN THE SUBSURFACE CONSISTED OF SILT AND CLAY WITH VARYING AMOUNTS OF SAND AND TRACE GRAVEL. THESE SOILS WERE GENERALLY STIFF TO VERY STIFF IN TERMS OF CONSISTENCY. THE TOP TO BEDROCK ELEVATION RANGED FROM APPROXIMATELY EL. 499 FEET (AT B-002-0-19) TO EL. 502.5 FEET (AT B-001-0-19). THE BEDROCK CONSISTED OF INTERBEDDED SHALE (ABOUT 60%) AND LIMESTONE (ABOUT 40%) WITH ROCK QUALITY DESIGNATION (RQD) RANGING BETWEEN 25 TO 29%. UPON ENCOUNTERING BEDROCK, A BEDROCK SAMPLE WAS COLLECTED BY OVER-DRIVING THE SPLIT-SPOON SAMPLER, FOLLOWED BY 10-FEET OF ROCK CORING USING A NQ2 ROCK CORE BARREL SAMPLER. WATER WAS ADDED TO THE BOREHOLE AS DRILLING FLUID DURING ROCK CORING OPERATIONS.

GROUNDWATER WAS ENCOUNTERED IN TEST BORINGS B-002-0-19 AND B-003-0-19 DURING DRILLING AT RESPECTIVE DEPTHS OF 1 AND 16 FEET BELOW THE GROUND SURFACE. GROUNDWATER WAS ENCOUNTERED AT ALL THREE TEST BORINGS AT DEPTHS RANGING BETWEEN 2.5 TO 20 FEET AFTER DRILLING.

SPECIFICATIONS

THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATIONS OF GEOTECHNICAL EXPLORATIONS, DATED AUGUST 2021.

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.

LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH./VISUAL	
GRAVEL AND/OR STONE FRAGMENTS	A-1-a	1	4
GRAVEL AND/OR STONE FRAGMENTS WITH SAND	A-1-b	5	5
SILT AND CLAY	A-6a	2	3
SILTY CLAY	A-6b	1	2
	TOTAL	9	14
INTERBEDDED SHALE AND LIMESTONE	VISUAL		
PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL		

BORING LOCATION - PLAN VIEW.

DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.

WC — INDICATES WATER CONTENT IN PERCENT.

N_{60} — INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

X/Y/Z — NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X= NUMBER OF BLOWS FOR FIRST 6 INCHES.
Y= NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z= NUMBER OF BLOWS FOR THIRD 6 INCHES.

W — INDICATES FREE WATER ELEVATION.

INDICATES STATIC WATER ELEVATION.

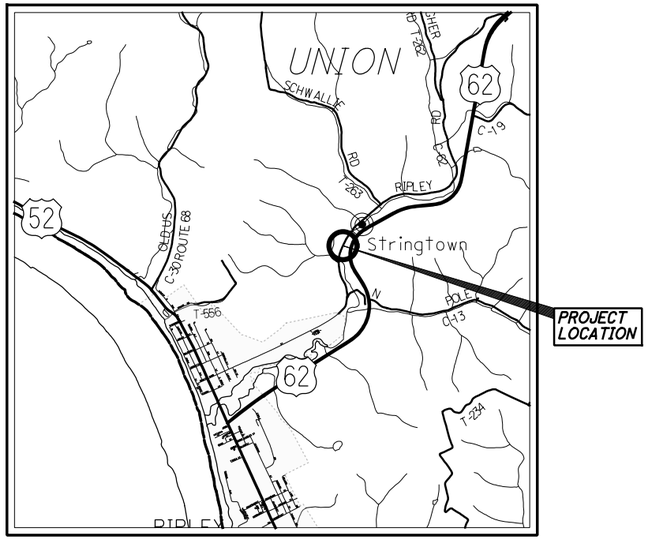
SS — INDICATES A SPLIT SPOON SAMPLE.

NP — INDICATES A NON-PLASTIC SAMPLE.

TR — INDICATES TOP OF ROCK.

QU — INDICATES ROCK COMPRESSION TEST, ASTM D7012, METHOD C, RESULTS.

NQ — N SERIES ROCK CORE BARREL OF "Q" WIRELINE BIT SIZE.



LOCATION MAP

SCALE IN MILES

0 1 2 3 4

N

PARTICLE SIZE DEFINITIONS

12"	3"	2.0 mm	0.42 mm	0.074 mm	0.005 mm
BOULDERS	COBBLES	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY
		No. 10 SIEVE	No. 40 SIEVE	No. 200 SIEVE		

D_{50} Values

Boring No.	Sample No.	Elevation	D_{50} Value
B-001-0-19	SS-3	514.5' - 516.0'	10.975 mm
	SS-5	509.5' - 511.0'	0.087 mm
	SS-7	505.5' - 507.0'	0.841 mm
	SS-8	504.0' - 505.5'	1.197 mm
B-002-0-19	SS-2	503.5' - 505.0'	2.68 mm
	SS-3	503.0' - 503.5'	1.285 mm
	SS-4	501.5' - 502.0'	0.055 mm
B-003-0-19	SS-3	514.5' - 516.0'	0.021 mm
	SS-6	507.0' - 508.5'	2.548 mm
	SS-7	506.0' - 507.0'	7.405 mm
	SS-8	504.0' - 505.5'	2.99 mm

BEDROCK TEST SUMMARY

BORING NO.	SAMPLE NO.	DEPTH	QU (PSI)
B-001-0-19	C-1	26.1' - 26.5'	649.6
B-002-0-19	C-1	16.9' - 17.3'	868.4
B-003-0-19	C-1	35.7' - 36.1'	849.5

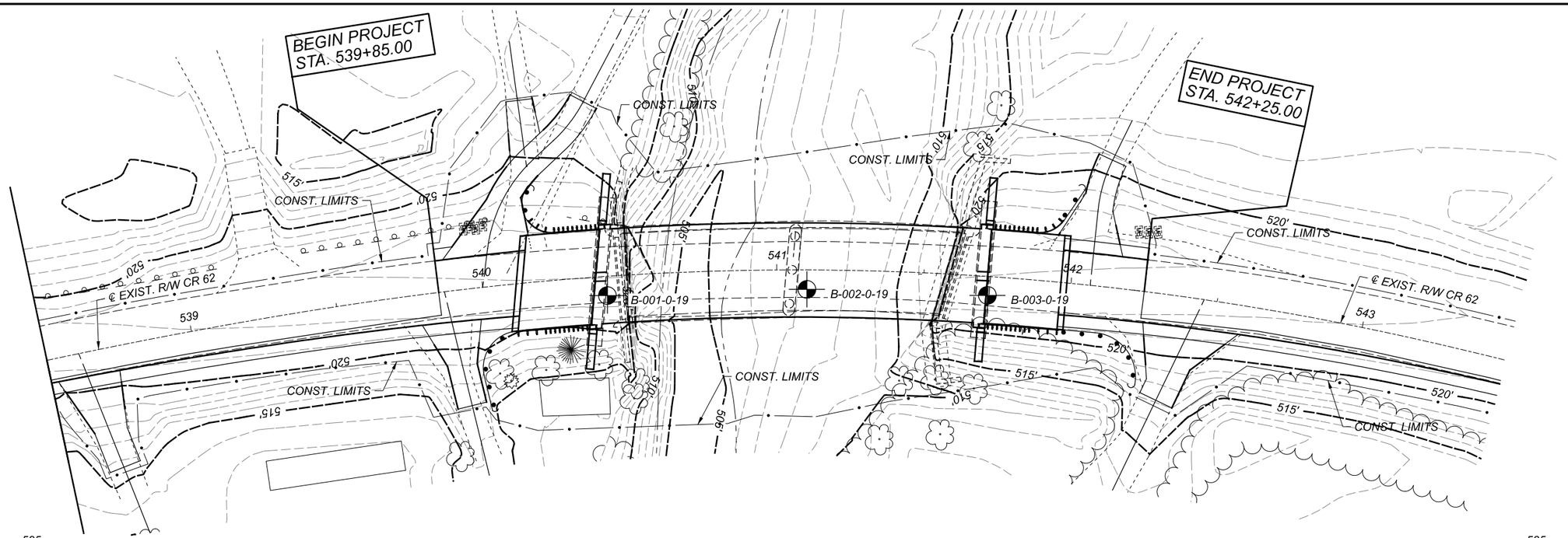
RECON. - ASK 7/15/2019
DRILLING - AM 8/30/2019
DRAWN - KM 8/12/2022
REVIEWED - DWW 8/18/2022

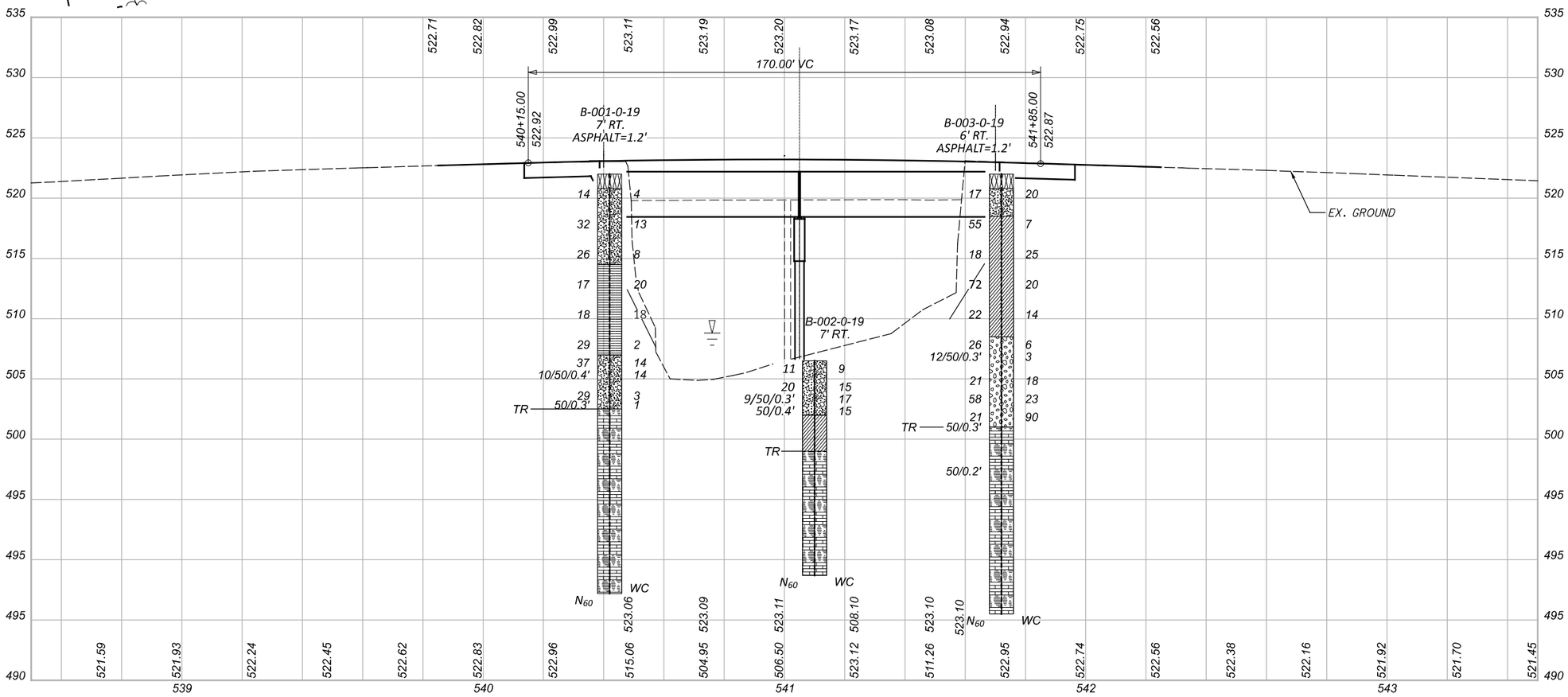
GEOTECHNICAL PROFILE - BRIDGE

DESIGN AGENCY
Terracon
Consulting Engineers and Scientists

DESIGNER DWW
REVIEWER DWW 08-18-22
PROJECT ID 109440
SHEET 1 TOTAL 6

BRO-CR62-0.42





HORIZONTAL SCALE IN FEET
0 10 20 40

GEOTECHNICAL PROFILE - BRIDGE
RIPLEY ROAD STA. 538+50.00 TO STA. 543+50.00

BRO-CR62-0.42

MODEL: Plan 5 (Sheet) PAPERSIZE: 17x11(in.) DATE: 10/26/2022 TIME: 12:54:40 PM USER: kjmankin
C:\Users\kjmankin\OneDrive - Terracon Consultants Inc\Desktop\DRAWINGS\N195264\109440_ZP001.dgn

DESIGN AGENCY
Terracon Consulting Engineers and Scientists

DESIGNER	DWW
REVIEWER	DWW 08-18-22
PROJECT ID	109440
SHEET	2
TOTAL	6

MODEL: COVER SHEET PAPERSIZE: 17x11 (in.) DATE: 11/7/2022 TIME: 3:00:29 PM USER: kjmankin
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PROJECT: RIPLEY BRIDGE	DRILLING FIRM / OPERATOR: TERRACON / AM	DRILL RIG: D-90 766	STATION / OFFSET: 540+42, 7' RT.
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: TERRACON / AM	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: CR62
PID: 109440 SFN: 0833533	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/1/19	ELEVATION: 522.0 (MSL) EOB: 34.8 ft.
START: 8/30/19 END: 8/30/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 78.8	LAT / LONG: 38.757045, -83.829446

EXPLORATION ID B-001-0-19

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT, (14 INCHES)	522.0																	
	520.8																	
MEDIUM DENSE, GRAY AND BROWN, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DRY			6 6 5	14	100	SS-1	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	
			8 12 12	32	100	SS-2	-	-	-	-	-	-	-	-	-	13	A-1-b (V)	
	514.5		12 12 8	26	100	SS-3	-	65	10	7	11	7	NP	NP	NP	8	A-1-b (0)	
VERY STIFF, BROWN, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, DAMP			2 8 5	17	100	SS-4	2.00	-	-	-	-	-	-	-	-	20	A-6b (V)	
			3 6 8	18	100	SS-5	2.00	17	17	17	21	28	35	18	17	18	A-6b (5)	
	507.0		6 8 14	29	11	SS-6	2.00	-	-	-	-	-	-	-	-	2	A-6b (V)	
MEDIUM DENSE TO DENSE, GRAY AND BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT AND CLAY, DAMP			8 10 18	37	100	SS-7	-	37	23	16	11	13	21	17	4	14	A-1-b (0)	
			10 50/5"	-	73	SS-8	-	43	20	14	13	10	21	19	2	14	A-1-b (0)	
			7 10 12	29	33	SS-9	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	
	502.5	TR	50/3"	-	100	SS-10	-	-	-	-	-	-	-	-	-	1	Rock (V)	
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, LIGHT GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG.																		
Qu = 649.6 psi on Shale sample at 26.1'			29		93	C-1 NQ2											CORE	
	487.2	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

GEOTECHNICAL PROFILE - BRIDGE
BORING LOG B-001-0-19

MODEL: COVER SHEET PAPERSIZE: 17x11 (in.) DATE: 11/7/2022 TIME: 3:01:21 PM USER: kjmankin
C:\Users\kjmankin\OneDrive - Terracon Consultants Inc\Desktop\DRAWINGS\1195264\109440_ZL002.dgn

PROJECT: RIPLEY BRIDGE	DRILLING FIRM / OPERATOR: TERRACON / AM	DRILL RIG: D-90 766	STATION / OFFSET: 541+10, 7' RT.
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: TERRACON / AM	HAMMER: DIEDRICH AUTOMATIC	ALIGNMENT: CR62
PID: 109440 SFN: 0833533	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/1/19	ELEVATION: 506.5 (MSL) EOB: 17.8 ft.
START: 8/30/19 END: 8/30/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 78.8	LAT / LONG: 38.757234, -83.829460

EXPLORATION ID B-002-0-19

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 506.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE TO DENSE, BROWN AND GRAY, **GRAVEL AND/OR STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, MOIST		▼ 505.5	3 5 3	11	33	SS-1	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
			21 10 5	20	56	SS-2	-	54	17	10	12	7	NP	NP	NP	15	A-1-b (0)	
	502.0		9 50/4"	-	80	SS-3	-	42	29	11	12	6	NP	NP	NP	17	A-1-b (0)	
HARD, OLIVE GRAY, **SILT AND CLAY**, LITTLE SAND, SOME GRAVEL, TRACE ROCK FRAGMENTS, DAMP			50/5"	-	100	SS-4	4.50	29	11	7	29	24	29	17	12	15	A-6a (4)	
	499.0	TR																
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, LIGHT GRAY, MODERATELY TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG.			25		97	NQ2											CORE	
Qu = 868.4 psi on Shale sample at 16.9'	488.7	EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

GEOTECHNICAL PROFILE - BRIDGE
BORING LOG B-002-0-19

MODEL: COVER SHEET PAPERSIZE: 17x11 (in.) DATE: 11/7/2022 TIME: 3:02:34 PM USER: kjmankin
C:\Users\kjmankin\OneDrive - Terracon Consultants Inc\Desktop\DRAWINGS\1195264\109440_ZL003.dgn

PROJECT: RIPLEY BRIDGE | DRILLING FIRM / OPERATOR: TERRACON / AM | DRILL RIG: D-90 766 | STATION / OFFSET: 541+72, 6' RT. | EXPLORATION ID B-003-0-19
TYPE: BRIDGE | SAMPLING FIRM / LOGGER: TERRACON / AM | HAMMER: DIEDRICH AUTOMATIC | ALIGNMENT: CR62
PID: 109440 SFN: 0833533 | DRILLING METHOD: 3.25" HSA / NQ2 | CALIBRATION DATE: 8/1/19 | ELEVATION: 522.0 (MSL) EOB: 36.5 ft. | PAGE 1 OF 1
START: 8/30/19 END: 8/30/19 | SAMPLING METHOD: SPT | ENERGY RATIO (%): 78.8 | LAT / LONG: 38.757422, -83.829463

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
ASPHALT, (14 INCHES)	522.0																	
	520.8																	
MEDIUM DENSE, GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DRY			7 5 8	17	67	SS-1	-	-	-	-	-	-	-	-	-	20	A-1-b (V)	
	518.5																	
VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, SOME SAND AND IRON OXIDE STAINS, TRACE GRAVEL, DAMP			8 12 30	55	100	SS-2	2.00	-	-	-	-	-	-	-	-	7	A-6a (V)	
		▼	7 7 7	18	100	SS-3	2.00	5	12	13	43	27	34	23	11	25	A-6a (7)	
			75 5 50	72	100	SS-4	3.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
			5 9 8	22	100	SS-5	2.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
	508.5																	
MEDIUM DENSE TO DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS**, SOME TO "AND" SAND, TRACE SILT AND CLAY, MOIST			12 10 10	26	33	SS-6	-	55	26	10	5	4	NP	NP	NP	6	A-1-a (0)	
			12 50/4"	-	80	SS-7	-	65	18	8	6	3	NP	NP	NP	3	A-1-a (0)	
		W 506.0																
			6 7 9	21	100	SS-8	-	55	22	10	8	5	NP	NP	NP	18	A-1-a (0)	
			6 4 40	58	100	SS-9	-	-	-	-	-	-	-	-	-	23	A-1-a (V)	
			4 6 10	21	100	SS-10	-	-	-	-	-	-	-	-	-	90	A-1-a (V)	
	501.0	TR																
INTERBEDDED SHALE (60%) AND LIMESTONE (40%); **SHALE**, GRAY, SLIGHTLY WEATHERED, WEAK; **LIMESTONE**, GRAY, MODERATELY TO SLIGHTLY WEATHERED, VERY WEAK.			50/4"	-	100	SS-11	-	-	-	-	-	-	-	-	-	-	Rock (V)	
			50/2"	-	100	SS-12	-	-	-	-	-	-	-	-	-	-		
			25		100	C-1 NQ2											CORE	
Qu = 849.5 psi on Shale sample at 35.7'	485.5	EOB																

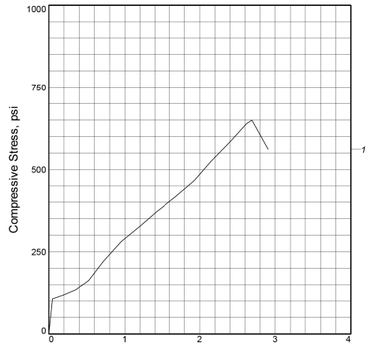
NOTES: NONE
ABANDONMENT METHODS, MATERIALS, QUANTITIES: BACKFILLED WITH AUGER CUTTINGS

STANDARD ODOT SOIL BORING LOG (11 X 17) - OH DOT.GDT - 11/7/22 14:19 - \\CINCINNATI1\DATA\PROJECTS\2019\N1195264\WORKING FILES\N1195264 RIPLEY ROAD- ODOT.GPJ

SHEET 5 | TOTAL 6
PROJECT ID 109440
REVIEWER DWW 08-18-22
DESIGNER DWW
DESIGN AGENCY Terracon Consulting Engineers and Scientists

GEOTECHNICAL PROFILE - BRIDGE
BORING LOG B-003-0-19

UNCONFINED COMPRESSION TEST



Sample No.	1				
Unconfined strength, psi	649.582				
Undrained shear strength, psi	324.791				
Failure strain, %	2.7				
Strain rate, in./min.	0.041				
Water content, %	4.9				
Wet density, pcf	159.1				
Dry density, pcf	151.6				
Saturation, %	N/A				
Void ratio	N/A				
Specimen diameter, in.	1.974				
Specimen height, in.	4.198				
Height/diameter ratio	2.13				

Description: SHALE AND LIMESTONE

LL =	PL =	PI =	GS=2.7	Type: Shale with limestone

Project No.: N1195264
Date Sampled: 10-2-19
Remarks:

Exhibit 6664

Client: BROWN COUNTY OH

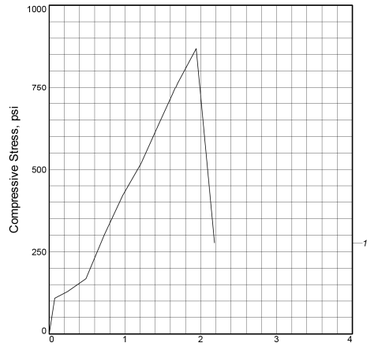
Project: RIPLEY ROAD BRIDGE REPLACEMENT

Source of Sample: B-1 **Depth:** 26.1-26.5'
Sample Number: C-1

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1				
Unconfined strength, psi	868.388				
Undrained shear strength, psi	434.194				
Failure strain, %	1.9				
Strain rate, in./min.	0.041				
Water content, %	2.0				
Wet density, pcf	162.9				
Dry density, pcf	159.7				
Saturation, %	N/A				
Void ratio	N/A				
Specimen diameter, in.	1.975				
Specimen height, in.	4.122				
Height/diameter ratio	2.09				

Description: LIMESTONE & SHALE

LL =	PL =	PI =	GS= 2.7	Type: Shale with Limestone

Project No.: N1195264
Date Sampled: 10-2-19
Remarks:

Exhibit 6671

Client: BROWN COUNTY OH

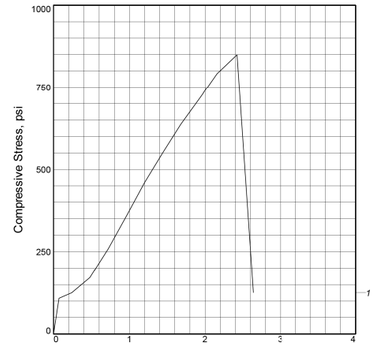
Project: RIPLEY ROAD BRIDGE REPLACEMENT

Source of Sample: B-2 **Depth:** 16.9-17.3'
Sample Number: C-1

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

UNCONFINED COMPRESSION TEST



Sample No.	1				
Unconfined strength, psi	849.460				
Undrained shear strength, psi	424.730				
Failure strain, %	2.4				
Strain rate, in./min.	0.041				
Water content, %	4.6				
Wet density, pcf	161.3				
Dry density, pcf	154.3				
Saturation, %	N/A				
Void ratio	N/A				
Specimen diameter, in.	1.975				
Specimen height, in.	4.167				
Height/diameter ratio	2.11				

Description: SHALE AND LIMESTONE

LL =	PL =	PI =	GS=	Type: Shale with Limestone

Project No.: N1195264
Date Sampled: 10-2-19
Remarks:

Exhibit 6688

Client: BROWN COUNTY OH

Project: RIPLEY ROAD BRIDGE REPLACEMENT

Source of Sample: B-3 **Depth:** 35.7-36.1'
Sample Number: C-1

UNCONFINED COMPRESSION TEST
Terracon, Inc.
Cincinnati, Ohio

Tested By: DR **Checked By:** GS

GEOTECHNICAL PROFILE - BRIDGE
LABORATORY TEST DATA

DESIGN AGENCY
Terracon
Consulting Engineers and Scientists

DESIGNER
DWW

REVIEWER
DWW 08-18-22

PROJECT ID
109440

SHEET 6 TOTAL 6

BRO-CR62-0.42

SUPPORTING INFORMATION

Unfactored Unit Tip Resistance

Unconfined Compressive Strength of Rock Mass (Q_u) = 46 tsf

Using FHWA Drilled Shaft Manual Eq. 10-23

Unfactored Unit Tip Resistance (q_p) = 2.5 * Q_u

= 2.5 * 46 tsf

= 115 tsf

Unfactored Unit Side Resistance

For drilled shafts socketed into bedrock, side resistance in the overburden soils is disregarded due to insufficient shaft movement to mobilize this resistance. Neglect side resistance for rock sockets with a length less than 1.5 times the rock socket diameter. Otherwise, neglect the contribution to skin friction provided by the top 2-ft of the rock socket.

Unconfined Compressive Strength of Rock Mass (Q_u) = 46 tsf

Using FHWA Drilled Shaft Manual Eq. 10-21

Side Resistance Regression Coefficient = 1.0 for normal conditions

Unfactored Unit Side Resistance (q_s)= 1.0 * $\sqrt{Qu}$

= 1.0* $\sqrt{}$ 46 tsf

= 6.8 tsf

APPENDIX A.1 - ODOT Quick Reference for Visual Description of Soils

1) STRENGTH OF SOIL:

Non-Cohesive (granular) Soils - Compactness	
Description	**Blows Per Ft.**
Very Loose	≤ 4
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	> 50

2) COLOR :

If a color is a uniform color throughout, the term is single, modified by an adjective such as light or dark. If the predominate color is shaded by a secondary color, the secondary color procedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled"

3) PRIMARY COMPONENT

Use **DESCRIPTION** from ODOT Soil Classification Chart on Back

Cohesive (fine grained) Soils - Consistency

Description	Qu (TSF)	Blows Per Ft.	Hand Manipulation
Very Soft	<0.25	<2	Easily penetrates 2" by fist
Soft	0.25-0.5	2 - 4	Easily penetrates 2" by thumb
Medium Stiff	0.5-1.0	5 - 8	Penetrates by thumb with moderate effort
Stiff	1.0-2.0	9 - 15	Readily indents by thumb, but not penetrate
Very Stiff	2.0-4.0	16 - 30	Readily indents by thumbnail
Hard	>4.0	>30	Indent with difficulty by thumbnail

4) COMPONENT MODIFIERS:

Description	Percentage By Weight
Trace	0% - 10%
Little	10% - 20%
Some	20% - 35%
"And"	35% -50%

5) Soil Organic Content

Description	% by Weight
Slightly Organic	2% - 4%
Moderately Organic	4% - 10%
Highly Organic	> 10%

6) Relative Visual Moisture

Description	Criteria	
	Cohesive Soil	**Non-cohesive Soils**
Dry	Powdery; Cannot be rolled; Water content well below the plastic limit	No moisture present
Damp	Leaves very little moisture when pressed between fingers; Crumbles at or before rolled to $^1/_8$"; Water content below plastic limit	Internal moisture, but no to little surface moisture
Moist	Leaves small amounts of moisture when pressed between fingers; Rolled to $^1/_8$" or smaller before crumbling; Water content above plastic limit to -3% of the liquid limit	Free water on surface, moist (shiny) appearance
Wet	Very mushy; Rolled multiple times to $^1/_8$" or smaller before crumbles; Near or above the liquid limit	Voids filled with free water, can be poured from split spoon.

CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart.
The first classification that the test data fits is the correct classification.)

SYMBOL	DESCRIPTION	Classifcation		$LL_O/LL \times 100$*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
		AASHTO	OHIO							
	Gravel and/or Stone Fragments	A-1-a			30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A-1-b			50 Max.	25 Max.		6 Max.	0	
	Fine Sand	A-3			51 Min.	10 Max.	NON-PLASTIC		0	
	Coarse and Fine Sand	--	A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4				35 Max.	40 Max.	10 Max.	0	
		A-2-5					41 Min.			
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6				35 Max.	40 Max.	11 Min.	4	
		A-2-7					41 Min.			
	Sandy Silt	A-4	A-4a	75 Min.		36 Min.	40 Max.	10 Max.	8	Less than 50% silt sizes
	Silt	A-4	A-4b	75 Min.		50 Min.	40 Max.	10 Max.	8	50% or more silt sizes
	Elastic Silt and Clay	A-5		75 Min.		36 Min.	41 Min.	10 Max.	12	
	Silt and Clay	A-6	A-6a	75 Min.		36 Min.	40 Max.	11 - 15	10	
	Silty Clay	A-6	A-6b	75 Min.		36 Min.	40 Max.	16 Min.	16	
	Elastic Clay	A-7-5		75 Min.		36 Min.	41 Min.	$\leq$LL-30	20	
	Clay	A-7-6		75 Min.		36 Min.	41 Min.	>LL-30	20	
	Organic Silt	A-8	A-8a	74 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	74 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6

MATERIAL CLASSIFIED BY VISUAL INSPECTION

 Sod and Topsoil

 Pavement or Base

 Uncontrolled Fill (Describe)

 Bouldery Zone

Peat

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

APPENDIX A.2 – ODOT Quick Reference Guide for Rock Description

1: ROCK TYPE: Common rock types are: Claystone; Coal; Dolomite; Limestone; Sandstone; Siltstone; & Shale.

2: COLOR: To be determined when rock is wet. When using the GSA Color charts use only Name, not code.

3: WEATHERING

Description	Field Parameter
Unweathered	No evidence of any chemical or mechanical alternation of the rock mass. Mineral crystals have a bright appearance with no discoloration. Fractures show little or no staining on surfaces.
Slightly weathered	Slight discoloration of the rock surface with minor alterations along discontinuities. Less than 10% of the rock volume presents alteration.
Moderately weathered	Portions of the rock mass are discolored as evident by a dull appearance. Surfaces may have a pitted appearance with weathering "halos" evident. Isolated zones of varying rock strengths due to alteration may be present. 10 to 15% of the rock volume presents alterations.
Highly weathered	Entire rock mass appears discolored and dull. Some pockets of slightly too moderately weathered rock may be present and some areas of severely weathered materials may be present.
Severely weathered	Majority of the rock mass reduced to a soil-like state with relic rock structure discernable. Zones of more resistant rock may be present, but the material can generally be molded and crumbled by hand pressures.

4: TEXTURE

Component		Grain Diameter
Boulder		>12"
Cobble		3"-12"
Gravel		0.08"-3"
Sand	Coarse	0.02"-0.08"
	Medium	0.01"-0.02"
	Fine	0.005"-0.01"
	Very Fine	0.003"-0.005"

5: RELATIVE STRENGTH

Description	Field Parameter
Very Weak	Core can be carved with a knife and scratched by fingernail. Can be excavated readily with a point of a pick. Pieces 1 inch or more in thickness can be broken by finger pressure.
Weak	Core can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments by moderate blows of a pick point. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Core can be grooved or gouged 0.05 inch deep by firm pressure of a knife or pick point. Can be excavated in small chips to pieces about 1-inch maximum size by hard blows of the point of a geologist's pick.
Moderately Strong	Core can be scratched with a knife or pick. Grooves or gouges to ¼" deep can be excavated by hand blows of a geologist's pick. Requires moderate hammer blows to detach hand specimen.
Strong	Core can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach hand specimen. Sharp and resistant edges are present on hand specimen.
Very Strong	Core cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires hard repeated blows of the geologist hammer.
Extremely strong	Core cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires hard repeated blows of the geologist hammer.

6: BEDDING

Description	Thickness
Very Thick	>36"
Thick	18" – 36"
Medium	10" – 18"
Thin	2" – 10"
Very Thin	0.4" – 2"
Laminated	0.1" – 0.4"
Thinly Laminated	<0.1"

7: DESCRIPTORS

Arenaceous – sandy	Argillaceous - clayey	Brecciated – contains angular to subangular gravel
Calcareous - contains calcium carbonate	Carbonaceous - contains carbon	Cherty- contains chert fragments
Conglomeritic - contains rounded to subrounded gravel	Crystalline – contains crystalline structure	Dolomitic- contains calcium/magnesium carbonate
Ferriferous – contains iron	Fissile – thin planner partings	Fossiliferous – contains fossils
Friable – easily broken down	Micaceous – contains mica	Pyritic – contains pyrite
Siliceous – contains silica	Stylolitic – contain stylotites (suture like structure)	Vuggy – contains openings

APPENDIX A.2 – ODOT Quick Reference Guide for Rock Description

8: DISCONTINUITIES

a: Discontinuity Types

Type	Parameters
Fault	Fracture which expresses displacement parallel to the surface that does not result in a polished surface.
Joint	Planar fracture that does not express displacement. Generally occurs at regularly spaced intervals.
Shear	Fracture which expresses displacement parallel to the surface that results in polished surfaces or slickensides.
Bedding	A surface produced along a bedding plane.
Contact	A surface produced along a contact plane. (generally not seen in Ohio)

b: Degree of Fracturing

Description	Spacing
Unfractured	> 10 ft.
Intact	3 ft. – 10 ft.
Slightly fractured	1 ft. – 3 ft.
Moderately fractured	4 in. – 12 in.
Fractured	2 in. – 4 in.
Highly fractured	< 2 in.

c: Aperture Width

Description	Spacing
Open	> 0.2 in.
Narrow	0.05 in. - 0.2 in.
Tight	<0.05 in.

d: Surface Roughness

Description	Criteria
Very Rough	Near vertical steps and ridges occur on the discontinuity surface.
Slightly Rough	Asperities on the discontinuity surface are distinguishable and can be felt.
Slickensided	Surface has a smooth, glassy finish with visual evidence of striation.

11: RECOVERY

$$Run\ \text{Recovery} = \left(\frac{R_R}{L_R}\right) * 100$$

L_R = Run Length
R_R – Run Recovery

$$Unit\ \text{Recovery} = \left(\frac{R_U}{L_U}\right) * 100$$

L_U = Rock Unit Length
R_U – Rock Unit Recovery

9: GSI DESCRIPTION

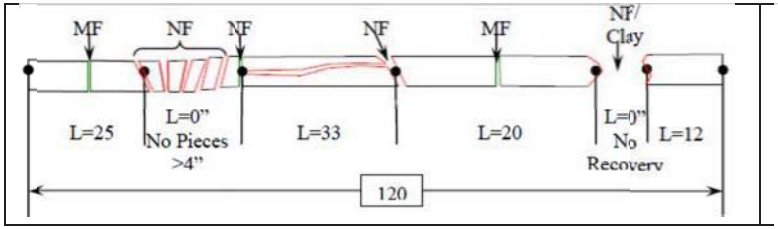
a: Structure

Description	Parameters
Intact or Massive	Intact rock with few widely spaced discontinuities
Blocky	Well interlocked undisturbed rock mass consisting of cubical blocks formed by three interesting discontinuity sets
Very Blocky	Interlocked, partially disturbed mass with multi-faceted angular blocks formed by 4 or more joint sets
Blocky/Disturbed/ Seamy	Angular blocks formed by many intersecting discontinuity sets, Persistence of bedding planes
Disintegrated	Poorly interlocked, heavily broken rock mass with mixture of angular and rounded rock pieces
Laminated/Sheared	Lack of blockiness due to close spacing of weak shear planes

b: Surface Condition

Description	Parameters
Very Good	Very rough, fresh unweathered surfaces
Good	Rough, slightly weathered, iron stained surface
Fair	Smooth, moderately weathered and altered surfaces
Poor	Slickensided, highly weathered surface with compact coatings or fillings or angular fragments
Very Poor	Slickensided, highly weathered surfaces with soft clay coating or fillings

10: RQD



$$RQD = \left(\frac{\sum Length\ of\ Pieces > 4inches}{Total\ Length\ of\ Core}\right) * 100$$

$$RQD = \left(\frac{25 + 33 + 20 + 12}{120}\right) * 100 = 75\%$$