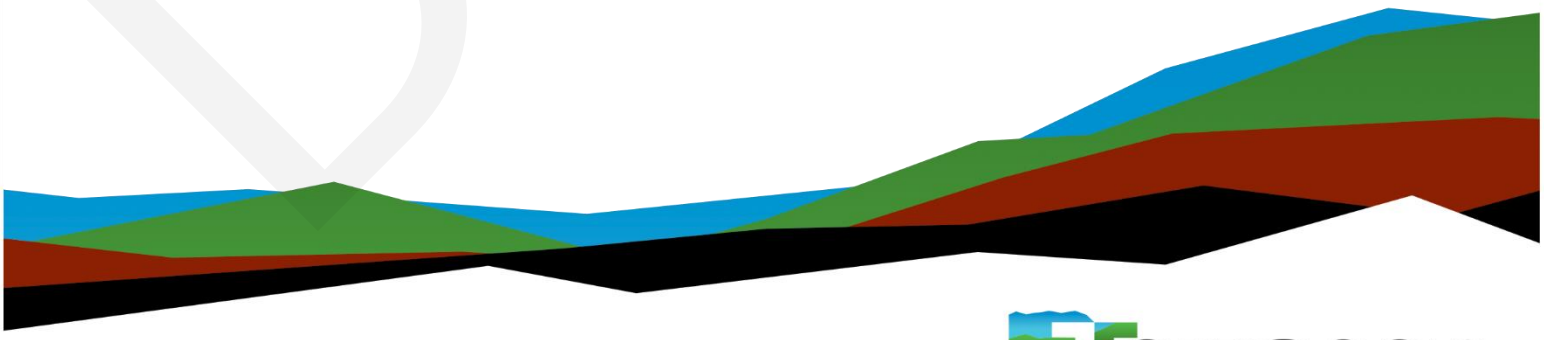
Village of Barnesville – Trail Expansion

Geotechnical Engineering Report

April 19, 2023 | Terracon Project No. N4225393

Prepared for:

Pennoni
2 Summit Park Drive, Suite 335
Independence, Ohio 44131



Terracon
Explore with us

Nationwide
Terracon.com

- Facilities
- Environmental
- Geotechnical
- Materials

800 Morrison Road
Columbus, Ohio 43219
P (614) 863-3113
Terracon.com

April 19, 2023

Pennoni
2 Summit Park Drive, Suite 335
Independence, Ohio 44131

Attn: Mark Powell, P.E.
P: (330) 222- 6282
E: mpowell@Pennoni.com

Re: Geotechnical Engineering Report
Village of Barnesville – Trail Expansion
Railroad Street
Barnesville, Ohio
Terracon Project No. N4225393

Dear Mr. Powell:

We have completed the scope of Geotechnical Engineering services for the above referenced project in general accordance with Terracon Proposal No. PN4225393 dated September 15, 2022. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork and the design and construction of foundation for the proposed wing walls, stability of slopes and pavements for the proposed project.

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.

Bijoy K. Halder, PhD, P.E.
Project Engineer

Kevin M. Ernst, P.E.
Principal / Regional Manager

Table of Contents

Attachments

Note: This report was originally delivered in a web-based format. **Blue 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 terracon logo will bring you back to this page. For more interactive features, please view your project online at **client.terracon.com**.

Refer to each individual Attachment for a listing of contents.

Executive Summary

The project consists of construction of a Shared Use Path on the abandoned B&O rail bed starting from northeast end of a culvert that supports East South Street until past the B&O Railroad Depot and along Railroad Street to Bethesda Street Extension. It also includes include ADA compliant trailhead parking at the Depot and rehabilitation (drainage improvements, support for portal wingwalls, tunnel lining, and lighting) of the railroad tunnel that supports State Route 147 (East Main Street) and South Arch Street.

A total of seven (7) borings, designated as B-001-0-22 through B-007-0-22 were performed for the proposed trail expansion and rehabilitation of railroad tunnel. The borings were performed during the period of November 28, 2022, to January 31, 2023, to depths ranging from 10.5 to 39 feet below existing surface.

In general, borings (borings B-001-0-22, B-002-0-22, and B-003-0-22) advanced for rehabilitation of tunnel area encountered native cohesive soil overlying granular soil and bedrock. Borings advanced along the alignment of the trail expansion (borings B-004-0-22 through B-007-0-22) encountered possible fill materials overlying native soils.

The possible fill materials encountered in the borings consisted of very loose to dense granular soils described as gravel (A-1a), gravel with sand (A-1b), gravel with sand and silt (A-2-4), gravel with sand, silt and clay (A-2-6/A-2-7), coarse sand and fine sand (A-3a) sandy silt (A-4a); or medium stiff to hard cohesive soils described as silty clay (A-6b) and clay (A-7-6).

The native granular and cohesive soils encountered in most of the borings included very dense sandy silt (A-4a), very stiff to hard silty clay (A-6b), and medium stiff to very stiff clay (A-7-6). With respect to sulfate content of the subgrade soils, based on the project laboratory testing program, sulfate content results were well below 5,000 parts per million (ppm) limit that prohibits subgrade stabilization using chemical stabilization methods according to ODOT Geotechnical Bulletin GB-1.

Bedrock was encountered in borings B-001-0-22, B-002-0-22, and B-003-0-22 at varying depths between 4.5 to 19 feet below existing grades (at an approximate elevation between 1230.5 feet to 1243 feet).

Groundwater was encountered only in boring B-002-0-22, at a depth of 0.3 feet below existing grades during drilling and at surface level after completion of boring. It should also be noted that the water observed at the completion of drilling was related to hydro excavation and water introduced by the driller into the boreholes for rock coring. The contractor is responsible for employing appropriate dewatering methods to control seepage and facilitate construction.

Based on the results of the GB1 subgrade analyses, a CBR value of 7 is recommended for the design of the proposed trail expansion after subgrade remediation measures are implemented.

Constructing soldier pile cantilever retaining wall with temporary Hardwood as lagging was considered to remediate tunnel wingwalls and adjacent slope areas. Proposed new knee walls for the steel tunnel liner may be supported on shallow spread footings due to relatively shallow bedrock.

Close monitoring of the construction operations discussed herein will be critical in achieving the proposed remediated slope design. We therefore recommend that Terracon be retained to monitor this portion of the work.

This summary 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 section titled General Comments should be read for an understanding of the report limitations.

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed trail expansion to be located in the Village of Barnesville, with its western terminus at East South Street, approximately 300 ft. east of SR-800, and its eastern terminus at the intersection of Railroad Street and Bethesda Street Extension in Barnesville, Ohio. The proposed improvement includes the construction of a 1.3 mile long Shared Use Path (SUP) along the alignment of an abandoned B&O rail bed starting from northeast end of culvert that supports East South Street until past the B&O Railroad Depot and along Railroad Street to Bethesda Street Extension. It also includes construction of ADA compliant trailhead parking at the Depot and rehabilitation (drainage improvements, portal wingwalls, tunnel lining, and lighting) of the railroad tunnel that supports State Route 147 (East Main Street) and South Arch Street.

The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil and rock conditions
- Groundwater conditions
- Seismic site classification per IBC
- Site preparation and earthwork
- Foundation design and construction
- Slope Stability analysis
- Lateral earth pressure
- Pavement design and construction

The geotechnical engineering Scope of Services for this project included the advancement of seven (7) test borings to depths ranging from 10.5 to 39 feet, laboratory testing, engineering analysis, and preparation of this report.

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

Geology

Based on the Ohio Department of Natural Resources Quaternary Geology Map of Ohio, the project site is located within the Marietta Plateau of the Allegheny Plateau physiographic province of Ohio. The region is characterized with a high relief dissected plateau with silty clay loam colluvium deposits. Fine-grained red shale bedrocks and red soils are relatively

common. Remnants of the ancient lacustrine clay- filled Teays drainage system Teays-age drainage system are common.

A desktop study was performed to understand the geology of the project site area using Geological Survey Maps from the Ohio State Department of Natural Resources. The bedrock at the site is Pennsylvanian-age Upper Conemaugh Group through Permian age Dunkard Group and consists of cyclic sequence of red and gray shales, and siltstones, sandstones, limestones, and coals.

Reconnaissance

Site reconnaissance was performed by Terracon on September 21, 2022. The existing railroad path is abandoned with rails and ties were removed from the path. The path is currently covered with gravel and light vegetation. The railroad path near the tunnel has steep 1H:1V slopes along the approaches to the tunnel on either side of the path. The height of the slopes near the tunnel portal ranges from about 10 to 15 feet above the path elevation. The existing East Main Street and South Arch Street cross over an old railroad tunnel structure. Terracon personnel observed tilted/leaning trees and shallow sloughing along the slopes. The existing railroad tunnel structure appears to be in good condition, with no visible signs of damage or settlement. However, the slopes at both portals have eroded significantly over time, which led to the exposure of wing-walls and the weakening of roadway embankments at all four corners near Stations (STA) 13+65 and 16+30.

The proposed trail path along Railroad Street is surrounded by commercial properties and residential dwellings. The railroad street is a two-lane roadway and the existing pavement appeared to fair to good condition.

Exploration

Field Exploration

A total of seven (7) borings, designated as B-001-0-22 through B-007-0-22 were performed during the period of November 28, 2022, to January 31, 2023, to depths ranging from 10.5 to 39 feet below existing surface.

The borings were performed in general accordance with Sections 303.3 and 303.7.3 of the Ohio Department of Transportation (ODOT) Specifications for Geotechnical Explorations (SGE).

The approximate locations of the borings are illustrated on the attached **Exploration Plan** and summarized in the following tables.

Exploration Number	Elevation[1] (feet)	Latitude	Longitude	Depth[2] (feet)
B-001-0-22	1235.0	39.987328	-81.175664	15.0
B-002-0-22	1235.0	39.987742	-81.174903	15.0
B-003-0-22	1262.0	39.987831	-81.174983	39.0
B-004-0-22	1235.0	39.988989	-81.171891	10.5
B-005-0-22	1236.0	39.989688	-81.167219	10.5
B-006-0-22	1250.0	39.990782	-81.161958	10.5
B-007-0-22	1261.0	39.991672	-81.156581	10.5

1. The coordinates were obtained using a hand-held GPS unit and surface elevations were obtained from Google Earth. Only surface elevations of borings B-001-0-22 and B-002-0-22 were obtained from the provided plan and profile prepared by Pennoni.
2. Below ground surface.

The boring locations were located in the field prior to drilling operations by Terracon personnel using a hand-held GPS unit. The coordinates presented on the preceding tables and on the logs were obtained using GPS unit and are approximate. Ground surface elevations presented on the preceding tables for boring locations were obtained using a hand-held GPS unit and from publicly available maps (Google Earth).

The borings were drilled with a track-mounted rotary drill rig utilizing a 3¼-inch I.D. continuous flight hollow stem auger to advance the boreholes between sampling attempts. Soil samples were obtained continuously until the termination depth of the borings B-004-0-22 through B-007-0-22. Hydro excavation was performed for top approximate 5 feet in borings B-001-0-22, B-002-0-22, and B-003-0-22 to minimize interference with private utilities during drilling. The soil samples were obtained using the split-barrel sampling procedure. In the split-barrel sampling procedure, a standard 2-inch O.D. sampling spoon is driven into the boring with a 140-pound automatic SPT (Standard Penetration Test) hammer falling 30 inches. We recorded the number of blows required to advance the sampling spoon and the last or middle 12 inches of an 18-inch or 24-inch sampling interval, respectively, as the standard penetration resistance value (N-value). This value is corrected to an equivalent (60 percent) energy ratio (N60) utilizing the hammer efficiency energy ratio. We observed and recorded groundwater levels during drilling and upon completion.

Upon encountering auger refusal, 10 feet of rock was cored in borings B-001-0-22, B-002-0-22 and B-003-0-22. Rock coring was performed using a NQ-size double tube-swivel core barrel. Percentage of recovery and rock quality designation (RQD) were calculated for the core samples and are noted at their depths of occurrence on the boring logs.

The field boring logs were prepared by a drilling crew that include sampling depths, penetration distances, and other relevant sampling information. Field logs include visual classifications of materials encountered during drilling, and our interpretation of subsurface conditions between samples. Final boring logs represent the Geotechnical Engineer's interpretation of field logs, and include modifications based on visual classification and laboratory test results.

Laboratory Testing Program

As part of the testing program, all samples were examined in the laboratory by a geotechnical engineer. Soil samples were classified in general accordance with ODOT SGE Section 600 Laboratory Testing based on the texture and plasticity of the soils.

Visual classification was performed on all recovered soil and rock samples. Atterberg limits, moisture content, grain size analysis and sulfate content testing were performed on selected soil samples. In addition, uniaxial compressive tests and slake durability tests were performed on selected rock core samples.

Findings

Boring logs have been prepared based on the information obtained from the field logs prepared at the time of drilling, and the visual examination performed in the laboratory. Soil classification was performed in general accordance with the current ODOT SGE. The logs have also been modified as necessary based on the results of the laboratory testing program. The following sections summarize the subsurface conditions encountered at the boring locations.

Subsurface Profile

Borings B-001-0-22 and B-002-0-22 encountered surface cover consisting of a gravel layer of thickness approximately 4 to 8 inches. Boring B-003-0-33 encountered topsoil 6 inches thick. Borings B-004-0-22 to B-007-0-22 did not encounter any distinguishable surface material.

Borings B-004-0-22 to B-007-022 encountered possible fill material up to a depth of 1.5 to 10.5 feet below existing grades. The possible fill materials encountered in the borings consisted of very loose to dense granular soils described as gravel (A-1a), gravel with sand (A-1b), gravel with sand and silt (A-2-4), gravel with sand, silt and clay (A-2-6/A-2-7), coarse sand and fine sand (A-3a) sandy silt (A-4a); or medium stiff to hard cohesive soils described as silty clay (A-6b) and clay (A-7-6).

The native granular and cohesive soils encountered in the borings included very dense sandy silt (A-4a), very stiff to hard silty clay (A-6b), and medium stiff to very stiff clay (A-7-6).

Possible granular and cohesive fill soils with natural moisture contents more than 4 percent above the optimum moisture contents were observed in borings B-004-0-22, B-006-0-22 and B-007-0-22 to depths of approximately between 0 and 2 feet indicating wet subgrade conditions.

In addition, granular soils with N60L (lowest N60 value) <15 and/or cohesive soils with N60L<12 or HP<2 tsf were encountered in borings B-004-0-22, B-005-0-22, B-007-0-22 indicating weak/loose and unstable subgrade conditions.

The table below summarizes the results of sulfate testing performed on subgrade samples. It should be noted that soils with sulfate content greater than 5,000 parts per million (ppm) prohibit subgrade stabilization using chemical stabilization methods according to ODOT Geotechnical Bulletin GB-1. None of the test results exceeded the 5,000-ppm sulfate concentration level.

Summary of Sulphate Testing Results

Exploration Number	Sample Depth[1] (feet)	Sulfate Concentration (ppm)
B-004-0-22	4.5 -6.0	Non- Detectable
B-005-0-22	1.5-3.0	Non- Detectable
B-006-0-22	1.5-3.0	1093
B-007-0-22	4.5-6.0	Non- Detectable

1. Below ground surface

Bedrock

Bedrock was encountered in borings B-001-0-22, B-002-022 and B-003-0-22 at depths varying between 4.5 to 19 feet below existing grades (at an approximate elevation between varying from 1230.5 feet to 1243 feet). Bedrock encountered in the borings consisted very weak, severely weathered shale and weak to moderately strong, slightly to moderately weathered siltstone and sandstone. The table below summarizes the results of unconfined compressive strength and slate durability testing performed on selected rock samples.

Summary of Rock Testing Results

Exploration Number	Sample Depth[1] (feet)	Unconfined Compressive Strength (psi)	Slake Durability Index (%)
B-001-0-22	12.4 – 12.7	3,993	--
B-002-0-22	8.0	--	32.7
B-002-0-22	10.0-10.3	4,299	--
B-002-0-22	11.3 – 11.6	4,710	--
B-003-0-22	35.5	--	98.2
B-003-0-22	35.5 - 35.8	3,998	

1. Below ground surface

Groundwater

Groundwater was encountered only in boring B-002-0-22, at a depth of 0.3 feet below existing grades during drilling and at surface level after completion of boring. It should also be noted that the water observed at the completion of drilling was related to hydro excavation and water introduced by the driller into the boreholes for rock coring.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, 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 pavement 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.

Pavement Analysis and Recommendations

Subgrade Analysis

A preliminary plan and profile drawing for the proposed widening was not available as of this report's preparation. It is anticipated that proposed subgrade elevations will closely match the existing subgrade. Hence, we are assuming that minimal cut/fill will be required to establish the proposed final grades, other than that required to remediate areas that currently have unsuitable/unstable subgrade. If the assumption is not consistent with the project plans, please notify Terracon.

In general, the soils encountered at or near the anticipated pavement subgrade consisted of granular possible fill described as medium dense gravel with sand (A-1b), dense gravel (A-1-a) and very loose gravel with sand, silt and clay (A-2-7).

Based on our laboratory testing, the subgrade soils to a depth of up to about 4.5 to 6 feet below the existing surface have moisture contents ranging from about 8 to 25 percent, with an average moisture content of the subgrade soils across the project area of about 19 percent. Plasticity indices ranged from about 9 to 12, with an average plasticity index of about 11. The N-values (N60L) ranged from about 3 to 20, with an average of 10.

The unconfined compressive strength of cohesive soil samples as determined by a hand penetrometer ranged from 3.0 to 4.0 tsf with an average value of about 3.67 tsf. A summary of the subgrade soils is tabulated on ODOT's GB-1 Subgrade Analysis spreadsheet in attachments section of this report.

Subgrade soils with a moisture content exceeding the optimum moisture content of the soil by four or more percentage points, or that have low N-values, are considered to be unstable soils, per ODOT Geotechnical Design Manual (GDM) guideline. Possible granular and cohesive fill soils with natural moisture contents more than 4 percent above the optimum moisture contents were observed in borings B-004-0-22, B-006-0-22, and B-007-0-22 to depths of between 0 and 2 feet indicating wet subgrade conditions.

In addition, granular soils with N60L<15 and/or cohesive soils with N60L<12 were encountered in borings B-007-0-22 indicating weak/loose and unstable subgrade conditions.

We recommend undercut the unstable subgrade soils encountered near boring B-007-0-22 up to a depth of 14 inches below the top of subgrade existing ground surface and replace with Item 204 Embankment.

Based on the results of our subgrade analyses, a CBR value of 7 is recommended for design of the proposed reconstruction and widening. The recommended CBR value assumes that the subgrade improvement/stabilization recommended in this report is performed.

Considering the high soil moisture contents encountered in the borings, installation of a drainage system including construction of underdrains and ditches are recommended as a practical solution to promote drainage of the subgrade and improve subgrade stability. Near boring B-007-0-22, we recommend that the subgrade be undercut below the design subgrade elevation to a depth of 12 inches and be replaced with Item 204 Granular Material Type B with ODOT Item 712.09 Geotextile fabric Type D installed at the bottom of the excavation.

The exposed subgrade in areas to receive fill and in areas of undercut should be densified and proof-rolled prior to installation of engineered controlled fill to identify possible soft

or loose yielding zones. Note that ODOT GDM specifies that Item 204 Granular Material Type B without a geotextile fabric be utilized to backfill undercuts performed in the vicinity of any underdrains.

The actual depths and limits of undercutting at pavement section should be determined by the Engineer in the field based on the results of proof-rolling and subgrade observations performed in accordance with ODOT CMS Item 204. Any areas that exhibit rutting, instability, or other indications of soft or loose soils should be over excavated and replaced in accordance with ODOT CMS Item 204. In addition, effective measures to promote drainage of groundwater and surface water should be incorporated into the design (i.e. grading of subgrade and surface, berms, ditches, etc.).

Once the design level drawings (plan and profile) become available, Terracon should be notified to review the proposed horizontal and vertical alignment changes (cut and fill) and make adjustments in our recommendations, if needed.

General Subgrade Preparation

Subgrade preparation for the new pavement, and shoulder areas should be performed in accordance with ODOT CMS Items 203 and 204. Prior to subgrade preparation, perform clearing and grubbing, including removal of stumps and roots, in accordance with ODOT CMS Item 201. The pavement subgrade should be stripped of any topsoil, organics, or other deleterious or unsuitable materials.

Once the pavement reconstruction areas have been stripped, excavated to the design subgrade elevation or to the design undercut elevation (if applicable), the exposed subgrade should be proof-rolled with a heavy piece of construction equipment to verify stability is achieved. It should be noted that fill containing organic materials or other deleterious materials may be encountered at other locations or at lower depths within the pavement alignment that were not disclosed by the borings. The actual depths and limits of undercutting should be determined by the Engineer in the field based on visual observations.

Any fill placed to achieve the final grade of the roadway pavement should follow requirements of ODOT CMS Item 203 and compacted to the specified percentage of the maximum dry density provided by ODOT CMS Item 204. The fill materials should be relatively free of debris, organic materials, and any deleterious materials deemed by the Engineer. No frozen materials should be incorporated into the fill, and no pavement, utilities, or fill should be placed on top of frozen materials.

All potential imported fill materials should be identified and approved by the Engineer prior to placement. Approval requires that moisture-density relationship tests, hydrometer analysis, and Atterberg limits be determined for each fill material prior to their placement. No particle size larger than two inches in any direction should be placed as fill, and any

particle size greater than 3-inches should be broken down to less than 2-inches or removed from the lift. Aggregate base and pavement construction must be performed in accordance with ODOT CMS 300 and 400.

Excavation Considerations

If the excavation depths are greater than 5 feet, the excavation sides will need to be laid back or shored. As a minimum, all excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. Reference to OSHA 29CFR, Part 1926, Subpart P should be included in the job specifications.

The grading contractor, by his contract, is usually responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. Slope heights, slope inclinations and/or excavation depths should in no case exceed those specified in local, state or federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

Under no circumstances should the information provided in this report be interpreted to mean that Terracon is responsible for construction site safety or the contractor's activities. Construction site safety is the sole responsibility of the contractor, who shall also be solely responsible for the means, methods, and sequencing of the construction operations.

Where structures, roadways, underground utilities, etc. exist adjacent to or within the zone of influence of the excavations, care must be taken to protect these structures, roadways, underground utilities, etc. from possible damages due to construction activities. If structures and underground utilities are located near an excavation, a pre-construction survey should be performed on all existing structures and underground utilities located within 100 feet of the excavation. It is the Contractor's responsibility to prevent undermining of existing foundations and prevent any damage to adjacent structures or facilities.

Retaining Wall Design and Construction

The existing railroad path is abandoned with rails and ties removed from the path. The path is currently covered with gravel and light vegetation. The railroad path near the tunnel has steep 1H:1V slopes along the approaches to the tunnel on either side of the path. The height of the slopes near the tunnel portal ranges from about 10 to 15 feet above the path elevation. According to the preliminary assessment report dated May 17, 2016, prepared by Apple Tree, the existing railroad tunnel structure appears to be in good condition, with no visible signs of damage or settlement. However, the slopes at both portals have eroded significantly over time, which led to the exposure of wing-walls and

the weakening of roadway embankments at all four corners near Stations (STA) 13+65 and 16+30. We understand that tunnel wing-wall and the slope required remediation. We have completed slope stability analyses and recommendations of the embankments near the tunnel portals to ensure their long-term stability and to reduce the risk of future sloughing and/or slips in this section.

Soldier Pile Cantilever Retaining Wall (Soldier Pile with Lagging) – Design Considerations

A "Soldier Pile Cantilever" retaining wall is presented as the recommended remedial designs to stabilize and protect the tunnel wing-walls and proposed embankment. Terracon designed the retaining wall to retain lateral forces imparted by the proposed retained soil height as proposed in the plans provided by Pennoni. The plan and cross sections provided by Pennoni and used for our analyses and design are included in **Supporting Information**.

Geotechnical analysis followed the procedures outlined by Geotechnical Design Manual (Section 900) "Design of Drilled Shaft for Landslide Stabilization". This design method uses back-calculated slope failure geometry with the deepest possible slip circle with a factor of safety against slippage and soil strength parameters from a conventional limit-equilibrium slope stability analysis. "Wedge Method" analysis was utilized to calculate the lateral loading act over one pile spacing above the design grade in front of the retaining wall for the design of steel beam sections resisting shear and moment due to lateral earth loadings.

The analyses were completed using the software programs Slide, and L-Pile. Critical failure surfaces were modeled using Spencer's Method for circular failure geometry. The critical slope stability profiles and slope stability analyses are also included in **Supporting Information**. For our analyses, the retained soil (such as ODOT 304 or approved equivalent) was modelled with using typical long-term strength values. Existing natural Soil strength data used in our analysis are presented on the slope stability profiles. Existing soil strength parameters used in our analysis are developed from laboratory testing of collected soil samples and back-calculated values fitting observed slope failure conditions in the field. Lateral deformations were analyzed using L-Pile software for the lateral forces from retained soil mass calculated using "Wedge Method".

Terracon used a minimum factor of safety (FS) in our analyses of 1.5 for new slope construction. A minimum FS of 1.5 is typically desired for new permanent slope design for long-term, static conditions. Fill backslopes should be constructed as reflected on the provided plan with slopes no steeper than 2H:1V. The analyses also utilized standard geotechnical measures, such as compaction keys, benching, and drains as described herein.

Stability and strength checks for the chosen structural steel section embedded in concrete were performed to ensure its adequacy against lateral failure. Composite section of concrete and steel reinforcement is considered for stability checks, while only steel section is checked for deflection and strength requirement.

Plan showing the approximate wall alignment at STA 13+65 and 16+30 is provided in the **Supporting Information** section of the Attachments. The analysis indicated that the pile head deflection is less than or equal to 2 inches, which meets ODOT requirements.

The following tables provide a summary of the recommended "Soldier Pile Cantilever" retaining wall design wall design with temporary Hardwood timber (i.e., Douglas Fir or approved equivalent) five inches thick as lagging:

STA 13+65 and 16+30 (Along Trail Path)	
Item	**Requirement**
Center-to-Center Structural Drilled Shaft Spacing	4 feet
Minimum Diameter of Structural Drilled Shaft	30 inches
Minimum Steel Pile Length	27 feet
Minimum rock socket[1]	10 feet
Structural Steel Section[2]	HP 14x89, Grade 50
Minimum 28-day Unconfined Compressive Strength of Concrete (f'_c) for drilled shafts	4,000 psi

Notes:

1. For approximate depth of bedrock encountered in borings, refer to boring logs.
2. The steel sections be painted or galvanized for corrosion protection. If sacrificial steel is being considered as corrosion protection, a larger section than that recommended should be used.

STA 13+65 and 16+30 (Along the Slope)	
Item	**Requirement**
Center-to-Center Structural Drilled Shaft Spacing	Variable (7 to 9.75 feet)
Minimum Diameter of Structural Drilled Shaft	30 inches
Minimum Steel Pile Length	27 feet

Minimum rock socket[1]	10 feet
Structural Steel Section[2]	HP 14x89, Grade 50
Minimum 28-day Unconfined Compressive Strength of Concrete (f'_c) for drilled shafts	4,000 psi

Notes:

1. For approximate depth of bedrock encountered in borings, refer to boring logs.
2. The steel sections be painted or galvanized for corrosion protection. If sacrificial steel is being considered as corrosion protection, a larger section than that recommended should be used.

The drilled concrete shafts are reinforced with HP 14X89 steel beam section placed centrally along the entire length of the drilled shaft excavation. Steel beam sections (structural drilled shafts/ soldier piles) are inserted vertically into the shafts and should be oriented such that the strong axis is parallel to the length of the wall.

Permanent lagging may be designed for lateral soil pressure. Any void between lagging must be backfilled with a permeable granular soil material that does not allow the buildup of hydrostatic pressure.

Soft Soil Over-excavations: Soft soils at the subgrade elevation of the proposed new placements should be removed prior to placing fill in these areas.

Benches and Compaction Keys: Benches and compaction keys should be used during fill placement to bond, or notch, new fills (such as ODOT 304 or approved equivalent) into residual soils/bedrock of the existing slopes for new embankment construction. Benches/compaction keys can be made manually excavating or using a dozer during fill placement. The benches/compaction keys should be constructed and extended a minimum of 4 feet horizontally in very stiff to hard, dense to very dense low plasticity residual soil, decomposed bedrock, or bedrock.

Subsurface Drains: Drain such as strip drains and perforated pipes installed near the back and bottom of the wall, should be provided behind structural walls in the wall design to prevent hydrostatic pressures from developing in the retained soil. If groundwater or seeps are encountered during construction, subsurface drains should be installed to collect and divert seeping water beyond and below the limits of new fill embankments. The collection and diversion of surface drainage away from fill embankment area is critical. Proper drainage design should include prevention of ponding water on or immediately adjacent to fill embankment areas. Concentrated runoff should be avoided in areas susceptible to erosion and slope instability.

Fill any void extending under wall face of the existing tunnel with ODOT 304/ lightweight cellular concrete/ flowable fill. A layer of low-permeability cohesive soil should be placed at the surface of the backfill to inhibit the infiltration of water into the backfill. The minimum thickness of low permeability cohesive soil layer placed to inhibit infiltration

should be 12 inches. A turf reinforcement mat or other form of armoring can be used to provide erosion control and surficial slope stabilization.

Soldier Pile Cantilever Wall – Construction Considerations

The following construction considerations should be adhered to during drilled shaft installation.

- The drilled shaft wall should be constructed by a "Specialty Contractor". Consideration should be given to contractor's previous experience in such type of construction during the bid approval process.
- The actual bearing elevation at each shaft location should be determined in the field during construction through inspection by an authorized representative of the geotechnical engineer.
- Temporary steel casing should be made available on site and used on an as needed basis.
- The bearing surface of each shaft should be cleaned of any loose material prior to concrete placement.
- If water seepage is encountered during drilling, specifications should state that no more than 2 inches of water should be allowed to collect at the bottom of the shaft hole prior to concreting. If water cannot be pumped out, then the concrete should be placed with a tremie pipe.
- It is recommended that no shaft holes be left open overnight without being filled with concrete.
- It is recommended that the bid document avoid use of "rock excavation" classification. Drilled shaft installation should either be bid per lineal foot for each diameter used or lump sum for the designated diameter and length, with an add or deduct for drill footage. An extra cost item should be included for any obstructions encountered in the overburden.
- Particular attention should be paid to the placement and orientation of the steel beam reinforcement. The steel beam should be oriented such that the strong axis is parallel to the length of the wall to resist the lateral force which will act in an upslope to downslope direction. The soldier pile that is placed within the hole must be vertical and not inclined more than 1 inch between top to bottom.
- The installation sequence shall be such that no drilled shaft is installed adjacent to either an open drilled shaft excavation or a drilled shaft in which the concrete has

less than a 48-hour cure. Installing the shafts in an alternating sequence or any other sequence that meets this criterion is permissible.

- For the drilled shaft wall, we anticipate the rolled steel sections would be extended to the top of the wall. The wall face could then be constructed of precast concrete lagging panels supported by the flanges of the rolled steel sections. The lagging panels can be placed between the flanges of the rolled steel sections.

- It is recommended that the concrete lagging panels be embedded to a depth of at least 2 feet below the downslope bench level (created to facilitate the drilled shaft construction).

- For temporary lagging Hardwood timber (i.e., Douglas Fir or approved equivalent) five inches thick should be used. Contractor must provide precast concrete lagging from a precast concrete manufacturer certified according to Supplement 1073 for permanent lagging. Class QC1 concrete with a 28-day design strength of at least 4000 psi according to C&MS 499 can be used. Reinforcing steel should be epoxy coated according to C&MS 709.00. Instead of epoxy coating, a corrosion inhibiting concrete admixture may be used at the specified dosage rate. The dimensions of the lagging or location of the reinforcing steel should not vary by more than ¼-inch. The panel must be placed between the flanges of the soldier piles and bearing against the flanges on the exposed side of the wall so that the soldier pile flange overlaps the end of the lagging by at least one inch more than the concrete cover over the reinforcing steel at both ends of the lagging. When installing the precast concrete lagging panels, hardwood wedges may be placed to hold the lagging panels against the front inside flange of the steel piles. The lagging can be placed after 12 hours of concrete placing in the shaft.

- A minimum 2 feet wide zone of compacted free-draining granular material should be included behind the shaft wall (upslope side). This granular filter material should be capped with a minimum 12 inches of cohesive soil to minimize surface water infiltration.

- Lateral drainage should be provided at the bottom of the lagging and minimum ¼ inch thick spacers be placed between the lagging panels to allow for seepage. A separate perforated underdrain pipe at the bottom of a porous backfill wrapped in filter fabric at the front of the wall is recommended to achieve effective drainage of seepage water from the retained earth.

Earthwork Considerations for Embankment Construction

The geotechnical engineer and/or their representative should be retained during the construction phase of the project to observe earthwork and to perform necessary tests and observations during construction of embankment.

It is anticipated that initial site grading activities associated with this existing slope reconfiguration process will include stripping of the existing vegetation and topsoil within the new embankment fill area.

Based on review of current site grades it is expected that the slope regrading process will involve removal of excess soil with minimal, if any, structural fill placement required. It is recommended that the excess soil obtained from the slope re-grading process should either be trucked to an off-site location. It is critical that the excess soil is not placed along any other section of the existing slope or near the crown portion of the overall slope.

As a minimum, all temporary excavations should be sloped or braced as required by Occupational Health and Safety Administration (OSHA) regulations to provide stability and safe working conditions. Temporary excavations will probably be required during grading operations. The grading contractor, by his contract, is responsible for designing and constructing stable, temporary excavations and should shore, slope or bench the sides of the excavations as required, to maintain stability of both the excavation sides and bottom. All excavations should comply with applicable local, state and federal safety regulations, including the current OSHA Excavation and Trench Safety Standards.

If any sections along the existing slope will require placement of new structural fill after removal of disturbed soil, it is recommended that the unsuitable surficial materials be undercut to expose firm native soils. Soft soil areas should be assessed by a representative of the geotechnical engineer to determine what additional depth of undercut is required. After the proof-rolling and undercutting operations, exposed native soils should be scarified and the material re-compacted to a minimum of 98% of the standard Proctor density, ASTM D698.

Fill operations should commence at the lowest part of the slope in the required fill areas. The structural fill should be placed in horizontal lifts and should be adequately benched into the natural slope in accordance with the criteria discussed below. Slope benches should expose competent native soils or bedrock.

Existing slopes that are 5H:1V (horizontal to vertical) or steeper should be benched into native soils of at least stiff consistency after removal of surficial unsuitable soils. These soil benches should be wide enough for construction equipment and configured on a 2H:1V bench width to height ratio. This construction measure is recommended to allow all of the

structural fill to be keyed into the sloping ground surface. The finished grades should be established with quality controlled structural fill.

Structural fill should be free of organics, debris, and other deleterious substances. We recommend that structural fill be placed in maximum 8-inch loose lifts and be uniformly moisture conditioned to within about 3 percent of its optimum moisture content. Each fill should be compacted to at least 98 percent of standard proctor density, ASTM D 698. Each fill lift should be witnessed and tested by geotechnical personnel and approved prior to placing subsequent lifts.

For utility trenches or other confined areas, small compaction equipment may be necessary, such as vibratory plate, jumping jack or walk-behind vibratory roller. In these cases, compactive energy levels are lower and require smaller lift thicknesses to achieve compaction throughout the lift. In these cases, lift thicknesses should be maintained at 4 to 6 inches, maximum. Each lift of backfill should be compacted to the same criteria as presented for structural fill.

The site grading of the slope could incorporate provisions to drain this area and prevent development of water within the slope. This could be accomplished by designing gravel-filled trench drains perpendicular to the slope contours to daylight at the slope face. These drains could be constructed using a free draining gravel, such as #57 crushed stone, wrapped with a suitable geotextile fabric to mitigate intrusion of fines into the gravel drain.

Adequate site grading provisions should be made to drain/divert surface runoff water so that its flow on to the reconstructed areas is reduced. Development of concentrated surface water discharge onto the slope and retaining wall should be avoided. In order to reduce the potential for future slope stability issues at this site, we recommend that the new embankment construction should include improvements to the surface and subsurface drainage at this site.

All slopes should be seeded and mulched upon completion of the slope re-grading/construction activities. Re-seeding may be required.

It is recommended that any site grading activities associated with the re-grading of the new embankment soil slope should be performed in conjunction with the soldier pile cantilever retaining wall construction.

Shallow Spread Footing Foundations

We understand that the proposed new knee walls for the steel tunnel liner will be supported on spread footing foundations. Borings B-001-0-22 and B-002-0-22 encountered bedrock at 4.5 feet below existing ground surface. Shallow spread footings bearing on weak to moderately strong sandstone/siltstone at a footing elevation of 1230

feet should be designed for a nominal bearing resistance of 168 ksf with a resistance factor of ϕ_b = 0.45, corresponding to a factored bearing resistance of 76 ksf. We estimate that total settlements of spread footing foundations bearing on rock will be on the order of up to 1/2 inch or less.

The foundation excavations should be examined during construction to verify that the entire bearing surface consists of suitable bedrock. All decomposed/weathered shale should be removed from the bottoms of the excavations prior to concrete placement over the sandstone/siltstone bedrock. Confine the excavation into bedrock for the minimum specified depth of keying within the area bounded by the outer edge of the footing. Fill excavation outside these limits and within and below the keyed depth with concrete per CMS 503.05. It is recommended that the geotechnical engineer be retained to observe and test the foundation bearing materials.

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. 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 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 effect 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. Construction and site development have the potential to affect adjacent properties. Such impacts can include damages due to vibration, modification of groundwater/surface water flow during construction, foundation movement due to undermining or subsidence from excavation, as well as noise or air quality concerns. Evaluation of these items on nearby properties are commonly associated with contractor means and methods and are not addressed in this report. The owner and contractor should consider a preconstruction/precondition survey of surrounding development. 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

Site Location and Exploration Plans

Contents:

Site Location
Exploration Plan

Note: All attachments are one page unless noted above.

Site Location (Landscape)

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

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan (11x17 Landscape)

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

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration and Laboratory Results

Contents:

PROJECT: VILLAGE OF BARNESVILLE
TYPE: RETAINING WALL
PID: 108050 SFN:
START: 1/30/23 END: 1/30/23

DRILLING FIRM / OPERATOR: TERRACON / JOE
SAMPLING FIRM / LOGGER: TERRACON / BEN
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT

DRILL RIG: CME 55/300
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 3/27/19
ENERGY RATIO (%): 90*

STATION / OFFSET:
ALIGNMENT:
ELEVATION: 1235.0 (MSL) EOB: 15.0 ft.
LAT / LONG: 39.987328, -81.175664

EXPLORATION ID B-001-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV. 1235.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
AGGREGATE BASE (8")	1234.3																	
Hydrovac 0 to 4.5-ft		1 2 3 4																
	1230.5	TR																
SHALE, GRAY, SEVERELY WEATHERED.	1230.0	5	50/4"	-	100	SS-1	-	-	-	-	-	-	-	-	-	-	Rock (V)	
SANDSTONE, GRAY, SLIGHTLY WEATHERED, SLIGHTLY TO MODERATELY STRONG, VERY THIN BEDDED, ARGILLACEOUS, MODERATELY FRACTURED, NARROW, SLIGHTLY ROUGH; RQD 87%, REC 100%.		6 7 8 9 10	87		100	NQ2-R1											CORE	
@12.4'-12.7'; Unit weight = 134 pcf; Qu =3,993 psi		11 12 13 14	73		100	NQ2-R2											CORE	
	1220.0	EOB 15																

NOTES: BORING WAS BACKFILLED WITH CEMENT AND BENTONITE GROUT

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SEALED WITH CEMENT AND BENTONITE GROUT

PROJECT: VILLAGE OF BARNESVILLE
TYPE: RETAINING WALL
PID: 108050 SFN:
START: 1/31/23 END: 1/31/23

DRILLING FIRM / OPERATOR: TERRACON / JOE
SAMPLING FIRM / LOGGER: TERRACON / BEN
DRILLING METHOD: 3.25" HSA / NQ2
SAMPLING METHOD: SPT

DRILL RIG: CME 55/300
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 3/27/19
ENERGY RATIO (%): 90*

STATION / OFFSET:
ALIGNMENT:
ELEVATION: 1235.0 (MSL) EOB: 15.0 ft.
LAT / LONG: 39.987742, -81.174903

EXPLORATION ID B-002-0-22
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)	SO4 ppm	HOLE SEALED
AGGREGATE BASE (4")	1235.0																		
Hydrovac 0 to 4.5-ft	1234.7	W 1234.7																	
		1																	
		2																	
		3																	
		4																	
	1230.5	TR																	
SHALE, GRAY, SEVERLY WEATHERED.	1230.0		50/4"	-	100	SS-1	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	
SILTSTONE, GRAY, MODERATELY WEATHERED, WEAK TO SLIGHTLY STRONG, VERY THIN BEDDED, ARGILLACEOUS, FRACTURED, NARROW, SLIGHTLY ROUGH; RQD 60%, REC 100%.		5	60		100	NQ2-R1											CORE		
		6																	
		7																	
		8																	
		9																	
	1225.0	10																	
SANDSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, FINE GRAINED, ARENACEOUS, MODERATELY TO SLIGHTLY FRACTURED, NARROW, SLIGHTLY ROUGH; RQD 92%, REC 100%.		11	93		100	NQ2-R2											CORE		
@10'-10.3'; Unit Weight = 146 pcf; Qu = 4,298 psi		12																	
@11.3'-11.6'; Unit Weight = 135 pcf; Qu =4,709 psi		13																	
		14																	
	1220.0	EOB 15																	

NOTES:BORING WAS BACKFILLED WITH CEMENT AND BENTONITE GROUT: HIGH WATER LEVEL ENCOUNTERED MAY BE DUE TO THE ADDITION OF WATER DURING HYDROVAC & ROCK CORING.
ABANDONMENT METHODS, MATERIALS, QUANTITIES: SEALED WITH CEMENT AND BENTONITE GROUT

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 4/13/23 13:33 - M:\PROJECTS\2022\N4225393\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\N4225393 -VILLAGE OF BA

PROJECT: VILLAGE OF BARNESVILLE	DRILLING FIRM / OPERATOR: TERRACON / JOE	DRILL RIG: CME 55/300	STATION / OFFSET:	EXPLORATION ID B-003-0-22
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: TERRACON / BEN	HAMMER: CME AUTOMATIC	ALIGNMENT:	
PID: 108050 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 3/27/19	ELEVATION: 1262.0 (MSL) EOB: 39.0 ft.	PAGE 1 OF 2
START: 1/30/23 END: 1/30/23	SAMPLING METHOD: SPT	ENERGY RATIO (%): 90*	LAT / LONG: 39.987831, -81.174983	

MATERIAL DESCRIPTION AND NOTES	ELEV. 1262.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
TOPSOIL (6")	1261.5																		
Hydrovac 0 to 4.5-ft																			
	1257.0																		
VERY STIFF, BROWN MOTTLED WITH GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	1255.5		3 5 8	20	100	SS-1	3.50	-	-	-	-	-	-	-	-	27	A-6b (V)	-	
HARD, BROWN, **CLAY**, "AND" SILT, LITTLE SAND, TRACE GRAVEL, MOIST			16 19 27	69	100	SS-2	4.50	4	1	18	42	35	44	24	20	26	A-7-6 (13)	-	
			6 14 20	51	100	SS-3	4.50	-	-	-	-	-	-	-	-	25	A-7-6 (V)	-	
			12 22 21	65	100	SS-4	4.50	-	-	-	-	-	-	-	-	26	A-7-6 (V)	-	
	1248.5																		
VERY DENSE, GREENISH BROWN TO GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, SHALE FRAGMENTS, DRY			13 28 49	116	100	SS-5	-	1	11	34	28	26	32	23	9	20	A-4a (4)	-	
	1243.0	TR	20 50/5"	-	91	SS-6A	-	-	-	-	-	-	-	-	-	15	A-4a (V)	-	
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK.						SS-6B	-	-	-	-	-	-	-	-	-	-	Rock (V)	-	

PID: 108050	SFN:	PROJECT: VILLAGE OF BARNESVILLE	STATION / OFFSET:	START: 1/30/23	END: 1/30/23	PG 2 OF 2	B-003-0-22

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)	SO4 ppm	HOLE SEALED
SHALE, GRAY, SEVERELY WEATHERED, VERY WEAK. *(continued)*	1242.0	21 22 23 24 25 26 27 28	32 50/3"	-	100	SS-7	-	-	-	-	-	-	-	-	-	8	Rock (V)	-	
	1233.0	29	50/5"	-	100	SS-8	-	-	-	-	-	-	-	-	-	5	Rock (V)	-	
SANDSTONE, GRAY, MODERATELY WEATHERED, WEAK, VERY THIN BEDDED, ARGILLACEOUS, FRACTURED, NARROW, SLIGHTLY ROUGH; RQD 68%, REC 100%.	1228.0	30 31 32 33 34	68		100	NQ2-R1											CORE		
SANDSTONE, GRAY, SLIGHTLY WEATHERED, MODERATELY STRONG, VERY THIN BEDDED, ARGILLACEOUS, MODERATELY FRACTURED, NARROW; RQD 80%, REC 100%. @35.5'-35.8'; Unit weight = 134 pcf; Qu =3,997 psi	1223.0	35 36 37 38 EOB 39	80		100	NQ2-R2											CORE		

NOTES: BORING WAS BACKFILLED WITH CEMENT AND BENTONITE GROUT

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SEALED WITH CEMENT AND BENTONITE GROUT

PROJECT: VILLAGE OF BARNESVILLE	DRILLING FIRM / OPERATOR: TC / Z.BEAHR	DRILL RIG: MOBILE B-57 (#594)	STATION / OFFSET:	EXPLORATION ID B-004-0-22
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: TC / CASEY	HAMMER: AUTOMATIC HAMMER	ALIGNMENT:	
PID: 108050 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/7/19	ELEVATION: 1235.0 (MSL) EOB: 10.5 ft.	PAGE 1 OF 1
START: 11/28/22 END: 11/28/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 90*	LAT / LONG: 39.988989, -81.171891	

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)	SO4 ppm	HOLE SEALED
MEDIUM DENSE, BLACK, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, WET (POSSIBLE FILL)	1235.0		4 5 5	15	89	SS-1	-	56	15	13	6	10	NP	NP	NP	22	A-1-b (0)	-	
STIFF, DARK BROWN, **CLAY**, SOME SILT, LITTLE SAND, TRACE GRAVEL, MOIST (POSSIBLE FILL)	1233.5	1																	
	1232.8	2	7 6 7	20	100	SS-2A	-	-	-	-	-	-	-	-	-	24	A-7-6 (V)	-	
MEDIUM DENSE, BLACK, **COARSE AND FINE SAND**, LITTLE CLAY, TRACE SILT, MOIST (POSSIBLE FILL)	1232.0	3				SS-2B	-	-	-	-	-	-	-	-	-	-	A-3a (V)	-	
MEDIUM STIFF, DARK GRAY, **CLAY**, LITTLE SAND, TRACE SILT, CONTAINS SANDSTONE AND COAL FRAGMENTS, MOIST (POSSIBLE FILL)	1230.5	4	3 3 3	9	100	SS-3	-	-	-	-	-	-	-	-	-	25	A-7-6 (V)	-	
STIFF, DARK GRAY, **SILTY CLAY**, MOIST (POSSIBLE FILL)	1230.0	5				SS-4A	-	29	10	19	10	32	37	20	17	24	A-6b (3)	-	
MEDIUM DENSE, DARK GRAY, **GRAVEL WITH SAND, SILT, AND CLAY**, MOIST (POSSIBLE FILL)	1229.0		6 4 8	18	100	SS-4B	-	-	-	-	-	-	-	-	-	-	A-2-6 (V)	-	
MEDIUM STIFF TO STIFF, GRAY AND BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, CONTAINS SANDSTONE AND COAL FRAGMENTS, MOIST (POSSIBLE FILL)		6	4 4 5	14	100	SS-5	1.50	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
		7	3 3 3	9	100	SS-6	1.00	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
		8																	
		9	3 3 4	11	100	SS-7	1.00	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
	1224.5	10 EOB																	

NOTES: BORING WAS BACKFILLED WITH CEMENT AND BENTONITE GROUT

ABANDONMENT METHODS, MATERIALS, QUANTITIES: MIXED WITH BACKFILLLED WITH AUGER CUTTINGS

PROJECT: VILLAGE OF BARNESVILLE
TYPE: ROADWAY
PID: 108050 SFN:
START: 11/28/22 END: 11/28/22

DRILLING FIRM / OPERATOR: TC / Z.BEAHR
SAMPLING FIRM / LOGGER: TC / CASEY
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: MOBILE B-57 (#594)
HAMMER: AUTOMATIC HAMMER
CALIBRATION DATE: 8/7/19
ENERGY RATIO (%): 90*

STATION / OFFSET:
ALIGNMENT:
ELEVATION: 1236.0 (MSL) EOB: 10.5 ft.
LAT / LONG: 39.989688, -81.167219

EXPLORATION ID B-005-0-22
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1236.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
LOOSE TO MEDIUM DENSE, BLACK, **GRAVEL WITH SAND**, LITTLE CLAY, SLIGHTY ORGANIC, MOIST (POSSIBLE FILL)		1	3 5 8	20	100	SS-1	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	-	
		2	4 3 3	9	39	SS-2	-	-	-	-	-	-	-	-	-	16	A-1-b (V)	-	
	1233.0																		
LOOSE, GRAY, **COARSE AND FINE SAND**, SOME GRAVEL, LITTLE CLAY, TRACE SILT, CONTAINS COAL FRAGMENTS, MOIST (POSSIBLE FILL)		3	2 3 3	9	33	SS-3	-	22	27	23	9	19	NP	NP	NP	18	A-3a (0)	-	
	1231.5																		
MEDIUM STIFF, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, MOIST (POSSIBLE FILL)	1231.0	4				SS-4A	-	7	18	30	14	31	30	21	9	20	A-4a (2)	-	
STIFF, GRAY, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS SANDSTONE AND COAL FRAGMENTS, MOIST (POSSIBLE FILL)	1230.0	5	3 3 4	11	100	SS-4B	-	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
VERY STIFF, GRAY, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS SANDSTONE AND COAL FRAGMENTS, MOIST (POSSIBLE FILL)	1228.5	6 7	3 3 3	9	89	SS-5	2.50	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
MEDIUM STIFF, BROWN, **CLAY**, SOME SAND, TRACE GRAVEL, MOIST		8	2 3 3	9	89	SS-6	0.25	-	-	-	-	-	-	-	-	-	A-7-6 (V)	-	
		9 10	2 3 4	11	100	SS-7	1.00	-	-	-	-	-	-	-	-	-	A-7-6 (V)	-	
	1225.5	EOB																	

NOTES: BORING WAS BACKFILLED WITH CEMENT AND BENTONITE GROUT

ABANDONMENT METHODS, MATERIALS, QUANTITIES: MIXED WITH BACKFILLLED WITH AUGER CUTTINGS

PROJECT: VILLAGE OF BARNESVILLE	DRILLING FIRM / OPERATOR: TC / Z.BEAHR	DRILL RIG: MOBILE B-57 (#594)	STATION / OFFSET:	EXPLORATION ID B-006-0-22
TYPE: ROADWAY	SAMPLING FIRM / LOGGER: TC / CASEY	HAMMER: AUTOMATIC HAMMER	ALIGNMENT:	
PID: 108050 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/7/19	ELEVATION: 1250.0 (MSL) EOB: 10.5 ft.	PAGE 1 OF 1
START: 11/28/22 END: 11/28/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 90*	LAT / LONG: 39.990782, -81.161958	

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)	SO4 ppm	HOLE SEALED
DENSE, BLACK, **GRAVEL**, TRACE CLAY, TRACE SILT, DAMP (POSSIBLE FILL)	1250.0	1	16 14 11	38	100	SS-1	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	-	
DENSE, GRAY, **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, WET (POSSIBLE FILL)	1248.5	2	9 13 12	38	100	SS-2A	-	25	27	22	8	18	NP	NP	NP	23	A-2-4 (0)	1093	
VERY STIFF, GRAY TO BROWN, **CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS COAL AND SANDSTONE FRAGMENTS, MOIST	1247.0	3	7 6 7	20	100	SS-3	-	-	-	-	-	-	-	-	-	16	A-7-6 (V)	-	
		4	4 8 10	27	100	SS-4	3.00	5	1	5	31	58	43	17	26	30	A-7-6 (15)	-	
HARD, BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS SHALE FRAGMENTS, MOIST	1244.0	5																	
		6	4 8 9	26	100	SS-5	-	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
		7																	
		8	5 10 11	32	100	SS-6	-	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
		9																	
	1239.5	10 EOB	12 15 18	50	100	SS-7	-	-	-	-	-	-	-	-	-	-	A-6b (V)	-	

NOTES: BORING WAS BACKFILLED WITH CEMENT AND BENTONITE GROUT

ABANDONMENT METHODS, MATERIALS, QUANTITIES: MIXED WITH BACKFILLLED WITH AUGER CUTTINGS

PROJECT: VILLAGE OF BARNESVILLE
TYPE: ROADWAY
PID: 108050 SFN:
START: 11/28/22 END: 11/28/22

DRILLING FIRM / OPERATOR: TC / Z.BEAHR
SAMPLING FIRM / LOGGER: TC / CASEY
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: MOBILE B-57 (#594)
HAMMER: AUTOMATIC HAMMER
CALIBRATION DATE: 8/7/19
ENERGY RATIO (%): 90*

STATION / OFFSET:
ALIGNMENT:
ELEVATION: 1261.0 (MSL) EOB: 10.5 ft.
LAT / LONG: 39.991672, -81.156581

EXPLORATION ID B-007-0-22
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 1261.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
VERY LOOSE, BLACK, **GRAVEL WITH SAND, SILT, AND CLAY**, SLIGHTLY ORGANIC, WET (POSSIBLE FILL)	1259.5	1	1 1 1	3	89	SS-1	-	32	18	19	10	21	41	29	12	24	A-2-7 (0)	-	
VERY STIFF TO HARD, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP TO MOIST		2	1 2 3	8	100	SS-2	4.00	-	-	-	-	-	-	-	-	21	A-6b (V)	-	
		3																	
		4	2 3 6	14	100	SS-3	3.00	-	-	-	-	-	-	-	-	23	A-6b (V)	-	
		5	6 9 9	27	100	SS-4	4.50	10	7	19	18	46	34	17	17	20	A-6b (9)	-	
@6.0'; CONTAINS SANDSTONE FRAGMENTS		6																	
		7	4 5 6	17	100	SS-5	-	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
		8	3 4 5	14	100	SS-6	4.00	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
		9																	
		10	6 8 8	24	100	SS-7	3.75	-	-	-	-	-	-	-	-	-	A-6b (V)	-	
	1250.5	EOB																	

NOTES: BORING WAS BACKFILLED WITH CEMENT AND BENTONITE GROUT

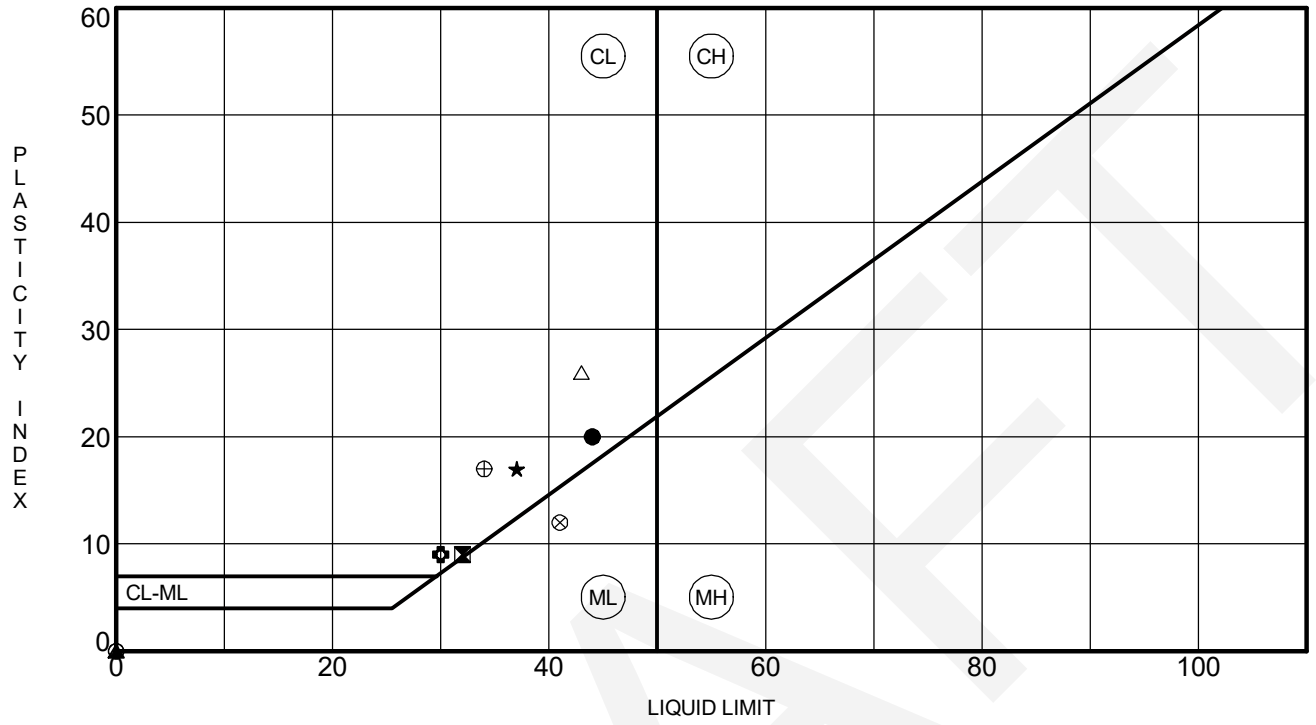
ABANDONMENT METHODS, MATERIALS, QUANTITIES: MIXED WITH BACKFILLLED WITH AUGER CUTTINGS

ATTERBERG LIMITS' RESULTS

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT VILLAGE OF BARNESVILLE **PID** 108050

OGE NUMBER N4225393 **PROJECT TYPE** STRUCTURE FOUNDATION



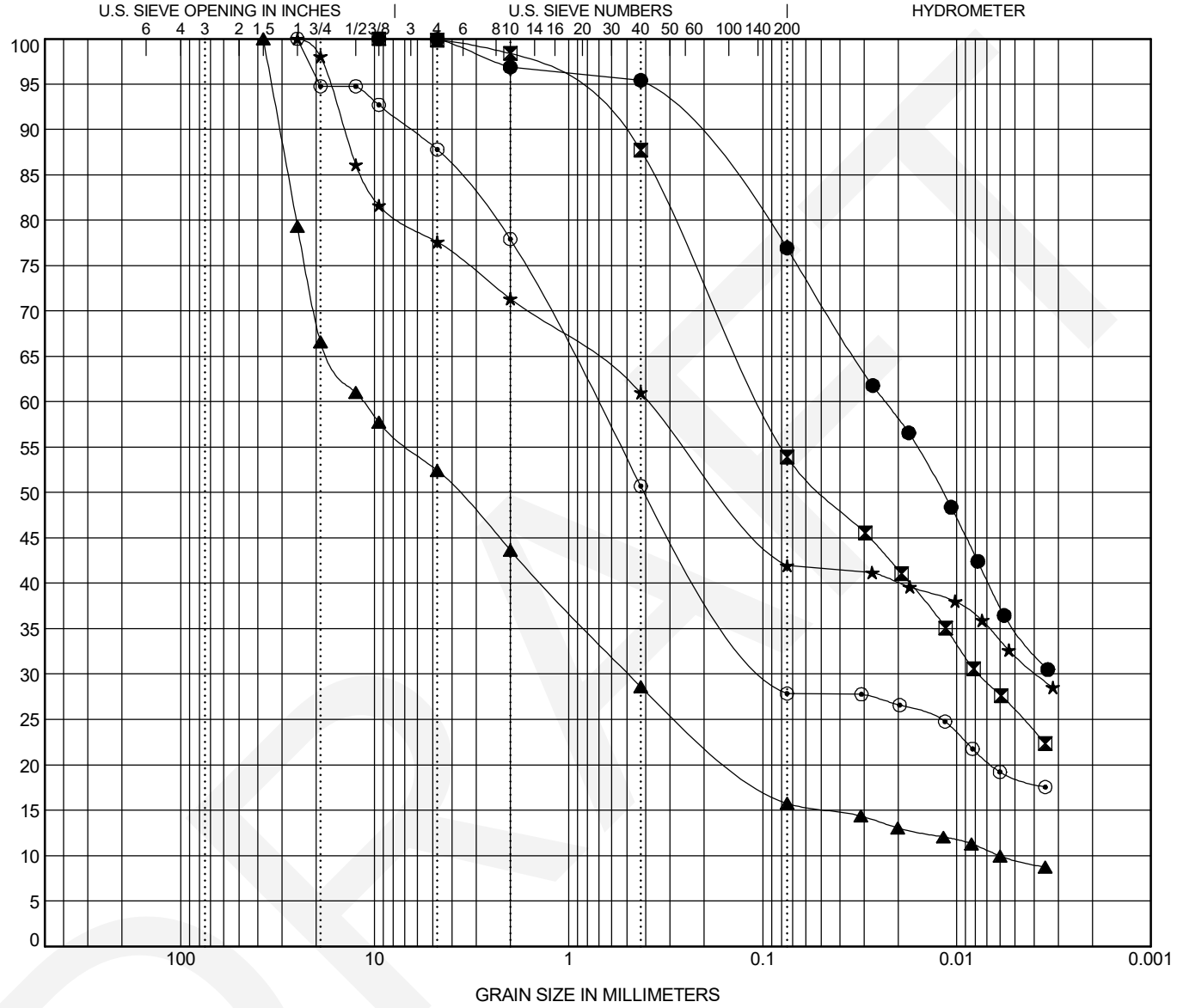
	Specimen Identification		LL	PL	PI	Fines	Classification
●	B-003-0-22	6.5	44	24	20	77	LEAN CLAY with SAND(CL)
⊠	B-003-0-22	13.5	32	23	9	54	SANDY LEAN CLAY(CL)
▲	B-004-0-22	0.0	NP	NP	NP	16	SILTY GRAVEL with SAND(GM)
★	B-004-0-22	4.5	37	20	17	42	CLAYEY SAND with GRAVEL(SC)
⊙	B-005-0-22	3.0	NP	NP	NP	28	SILTY SAND(SM)
✿	B-005-0-22	4.5	30	21	9	45	CLAYEY SAND(SC)
○	B-006-0-22	1.5	NP	NP	NP	26	SILTY SAND(SM)
△	B-006-0-22	4.5	43	17	26	89	LEAN CLAY(CL)
⊗	B-007-0-22	0.0	41	29	12	31	SILTY SAND with GRAVEL(SM)
⊕	B-007-0-22	4.5	34	17	17	64	SANDY LEAN CLAY(CL)

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT VILLAGE OF BARNESVILLE **PID** 108050

OGE NUMBER N4225393 **PROJECT TYPE** STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

	Specimen Identification		ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-003-0-22	6.5	A-7-6 ~ LEAN CLAY with SAND(CL)	44	24	20
⊠	B-003-0-22	13.5	A-4a ~ SANDY LEAN CLAY(CL)	32	23	9
▲	B-004-0-22	0.0	A-1-b ~ SILTY GRAVEL with SAND(GM)	NP	NP	NP
★	B-004-0-22	4.5	A-6b ~ CLAYEY SAND with GRAVEL(SC)	37	20	17
⊙	B-005-0-22	3.0	A-3a ~ SILTY SAND(SM)	NP	NP	NP

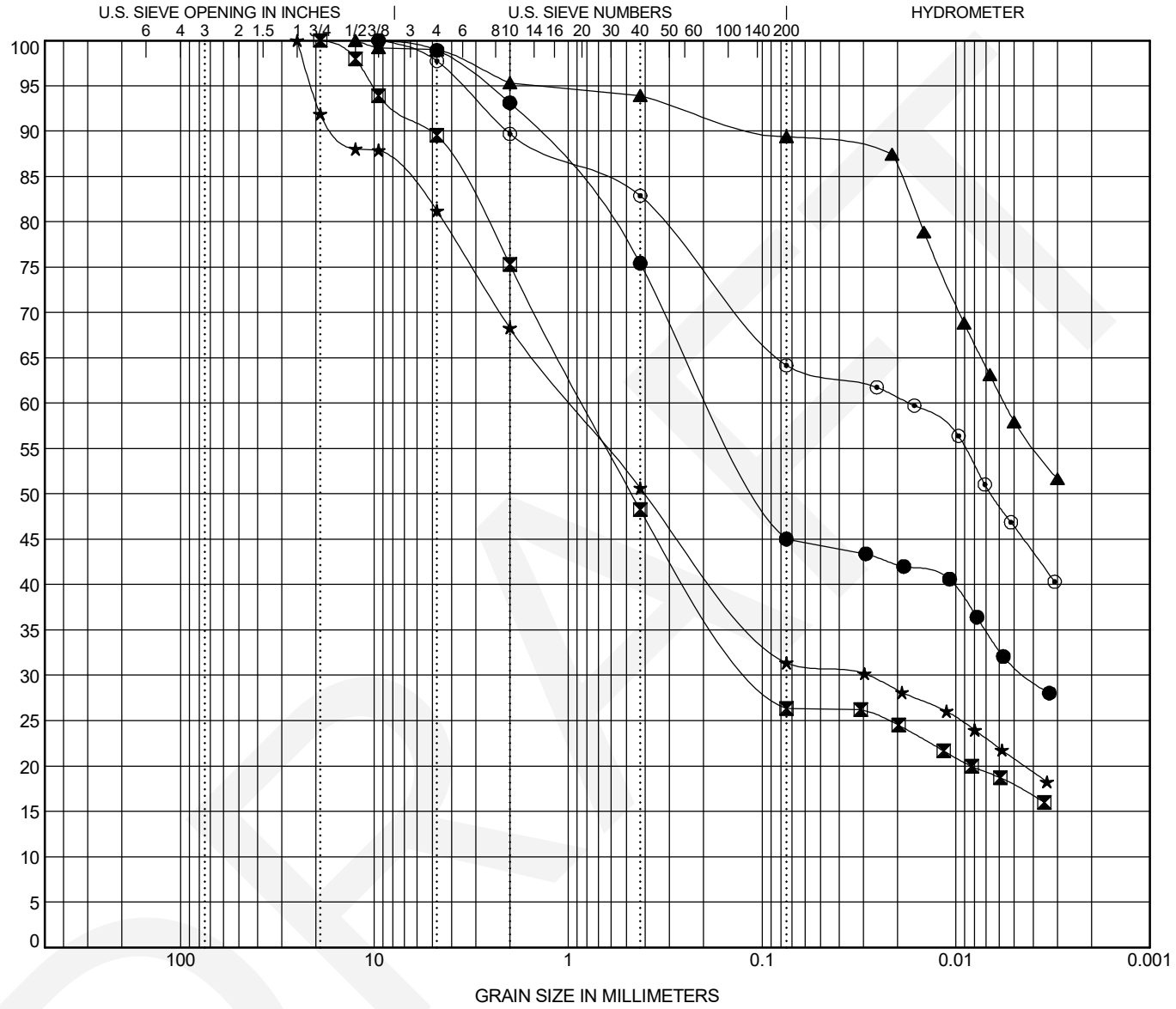
	Specimen Identification		D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-003-0-22	6.5	0.256	0.012			4	1	18	42	35		
⊠	B-003-0-22	13.5	0.59	0.049	0.008		1	11	34	28	26		
▲	B-004-0-22	0.0	30.813	3.734	0.491	0.006	56	15	13	6	10	3.47	1894.59
★	B-004-0-22	4.5	14.323	0.156	0.004		29	10	19	10	32		
⊙	B-005-0-22	3.0	6.475	0.403	0.088		22	27	23	9	19		

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT VILLAGE OF BARNESVILLE **PID** 108050

OGE NUMBER N4225393 **PROJECT TYPE** STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-005-0-22	4.5	A-4a ~ CLAYEY SAND(SC)	30	21	9
⊠	B-006-0-22	1.5	A-2-4 ~ SILTY SAND(SM)	NP	NP	NP
▲	B-006-0-22	4.5	A-7-6 ~ LEAN CLAY(CL)	43	17	26
★	B-007-0-22	0.0	A-2-7 ~ SILTY SAND with GRAVEL(SM)	41	29	12
⊙	B-007-0-22	4.5	A-6b ~ SANDY LEAN CLAY(CL)	34	17	17

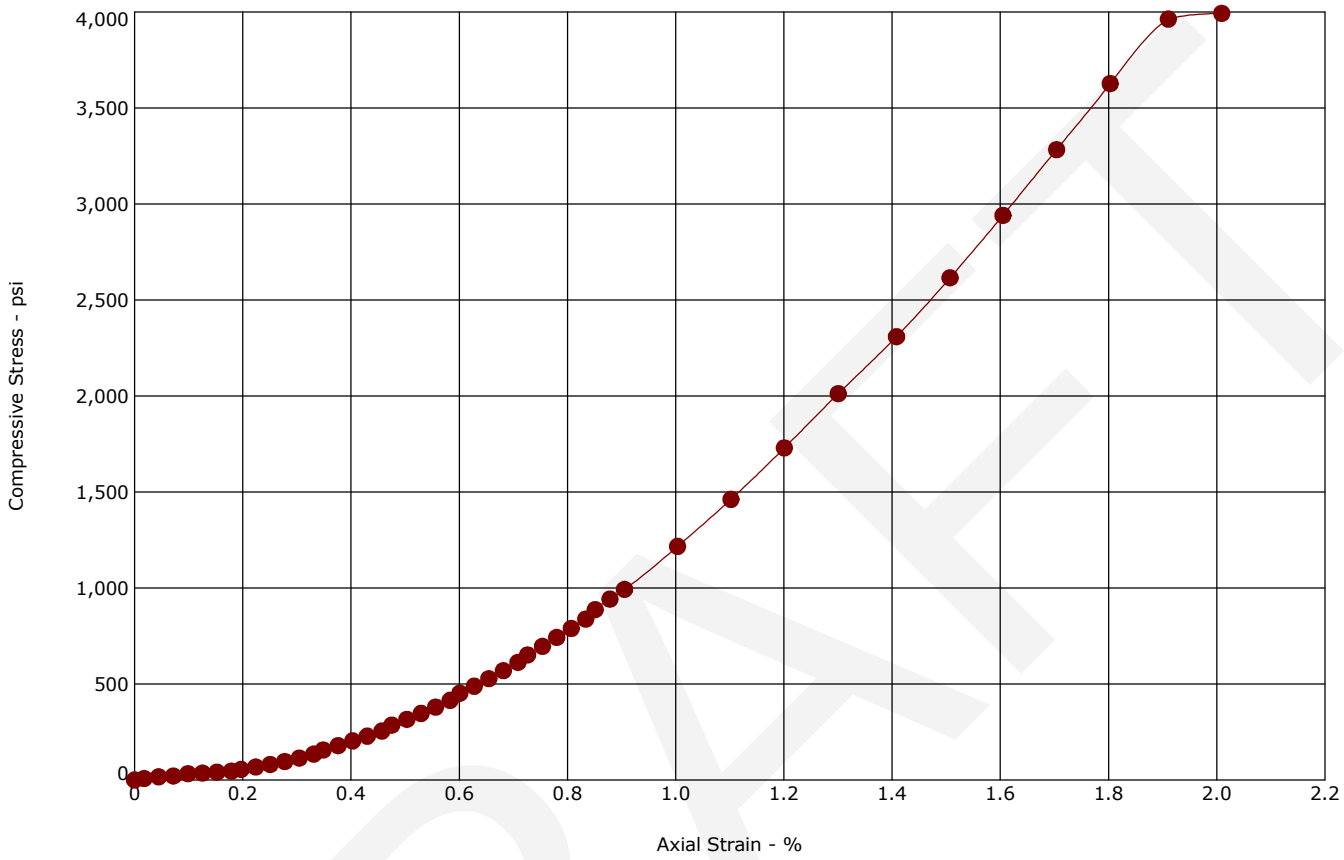
Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-005-0-22	4.5	1.52	0.1	0.004		7	18	30	14	31		
⊠	B-006-0-22	1.5	5.106	0.47	0.1		25	27	22	8	18		
▲	B-006-0-22	4.5	0.094				5	1	5	31	58		
★	B-007-0-22	0.0	15.467	0.401	0.029		32	18	19	10	21		
⊙	B-007-0-22	4.5	2.066	0.007			10	7	19	18	46		

Village of Barnesville Pedestrian Trail
Mulberry St | Barnesville, OH
Terracon Project No. N4225393

Terracon
800 Morrison Rd
Gahanna, OH

Unconfined Compression Test

ASTM D7012



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
B-001-0-22	12.4 - 12.7	NQ2-R2					SANDSTONE

Specimen Failure Mode

Specimen Test Data

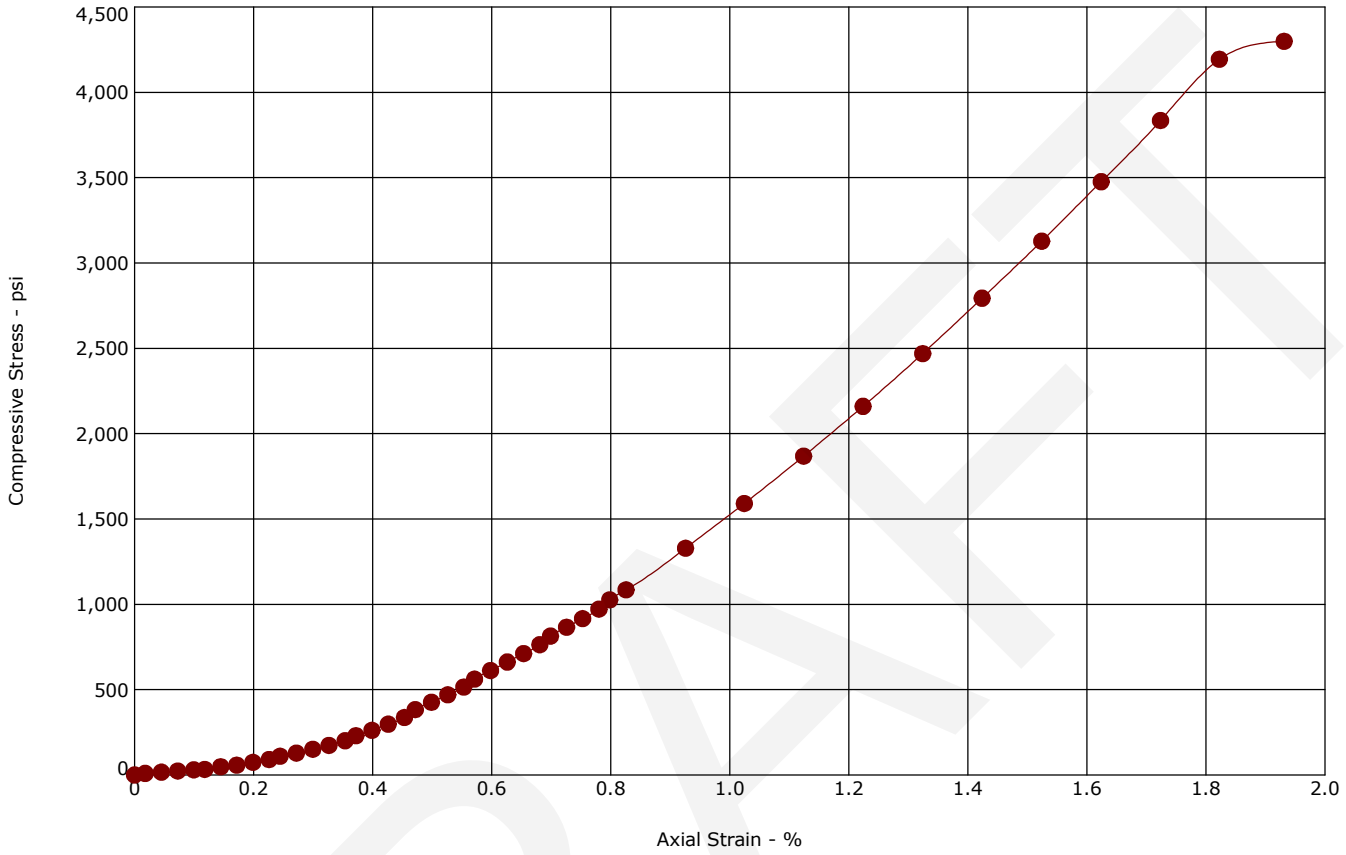
Moisture Content (%):	7.1
Dry Density (pcf):	134
Diameter (in.):	1.98
Height (in.):	4.05
Height / Diameter Ratio:	2.04
Calculated Saturation (%):	
Calculated Void Ratio:	
Assumed Specific Gravity:	
Failure Strain (%):	2.01
Unconfined Compressive Strength (psi):	3993
Undrained Shear Strength (psi):	1996
Strain Rate (in/min):	0.0403
Remarks:	

Village of Barnesville Pedestrian Trail
Mulberry St | Barnesville, OH
Terracon Project No. N4225393

Terracon
800 Morrison Rd
Gahanna, OH

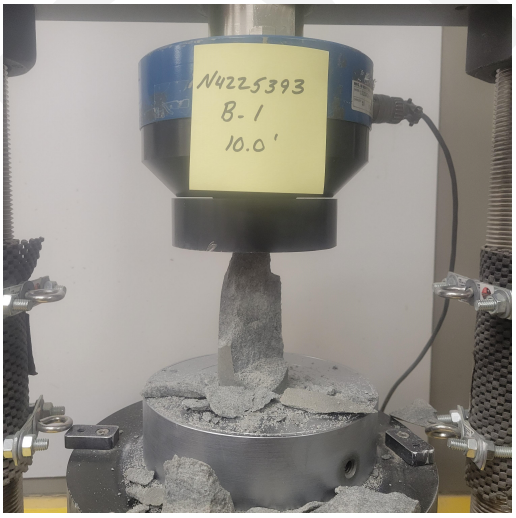
Unconfined Compression Test

ASTM D7012



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
B-002-0-22	10.0 -10.3	NQ2 -R2					SANDSTONE

Specimen Failure Mode



Specimen Test Data

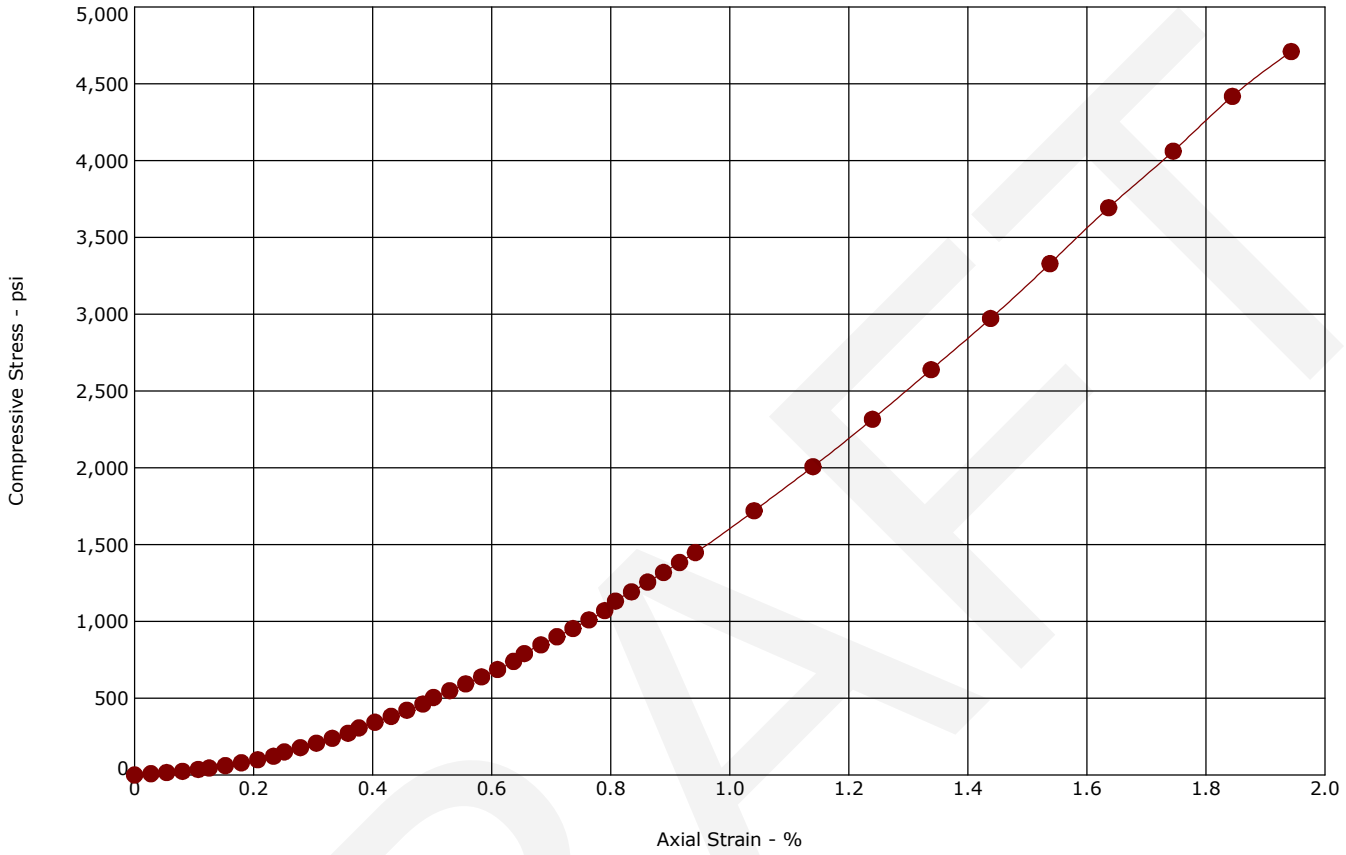
Moisture Content (%):	4.2
Dry Density (pcf):	146
Diameter (in.):	1.97
Height (in.):	3.98
Height / Diameter Ratio:	2.02
Calculated Saturation (%):	
Calculated Void Ratio:	
Assumed Specific Gravity:	
Failure Strain (%):	1.93
Unconfined Compressive Strength (psi):	4299
Undrained Shear Strength (psi):	2149
Strain Rate (in/min):	0.0398
Remarks:	

Village of Barnesville Pedestrian Trail
Mulberry St | Barnesville, OH
Terracon Project No. N4225393

Terracon
800 Morrison Rd
Gahanna, OH

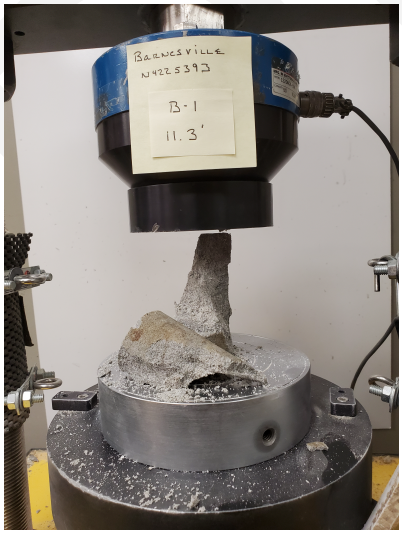
Unconfined Compression Test

ASTM D7012



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
B-002-0-22	11.3 - 11.6	NQ2 -R2					SANDSTONE

Specimen Failure Mode



Specimen Test Data

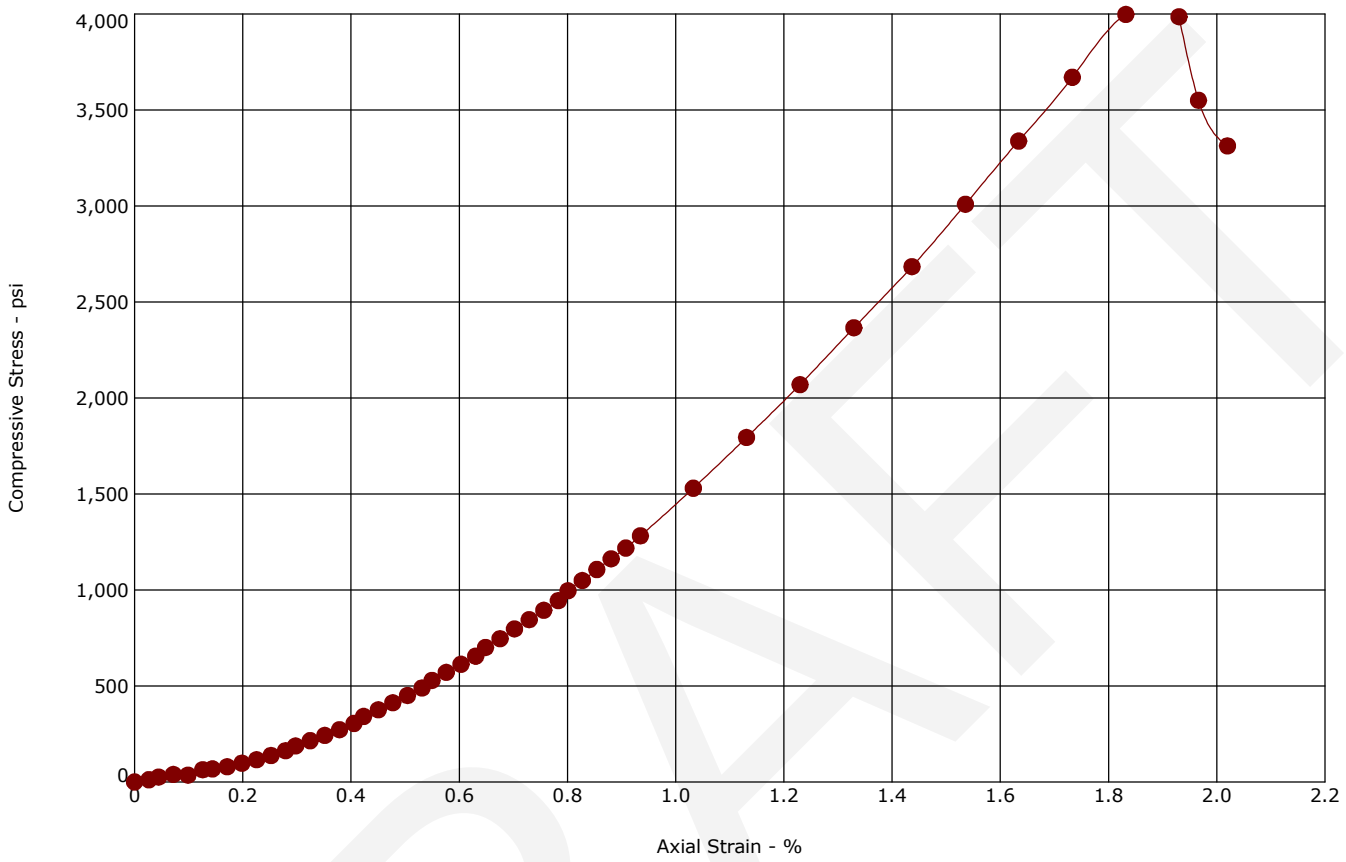
Moisture Content (%):	6.7
Dry Density (pcf):	135
Diameter (in.):	1.98
Height (in.):	4.05
Height / Diameter Ratio:	2.04
Calculated Saturation (%):	
Calculated Void Ratio:	
Assumed Specific Gravity:	
Failure Strain (%):	1.94
Unconfined Compressive Strength (psi):	4710
Undrained Shear Strength (psi):	2355
Strain Rate (in/min):	0.0407
Remarks:	

Village of Barnesville Pedestrian Trail
Mulberry St | Barnesville, OH
Terracon Project No. N4225393

Terracon
800 Morrison Rd
Gahanna, OH

Unconfined Compression Test

ASTM D7012



Boring ID	Depth (Ft)	Sample type	LL	PL	PI	Fines (%)	Description
B-003-0-22	35.5 - 35.8	NQ2 -R2					SANDSTONE

Specimen Failure Mode

Specimen Test Data

Moisture Content (%):	0.1
Dry Density (pcf):	134
Diameter (in.):	1.99
Height (in.):	4.01
Height / Diameter Ratio:	2.02
Calculated Saturation (%):	
Calculated Void Ratio:	
Assumed Specific Gravity:	
Failure Strain (%):	1.83
Unconfined Compressive Strength (psi):	3998
Undrained Shear Strength (psi):	1999
Strain Rate (in/min):	0.0398
Remarks:	

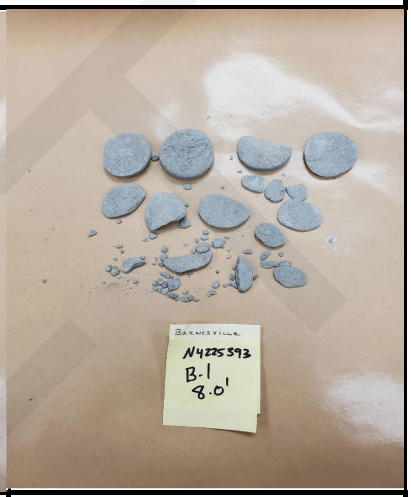
SLAKE DURABILITY INDEX (SDI)
TEST SUMMARY (ASTM D4644)

Terracon

Client:	Pennoni Associates, Inc.	Date:	2/20/2023
Project:	Village of Barnesville Pedestrian Trail	Project Number:	N4225393
Location:	Barnesville, OH		

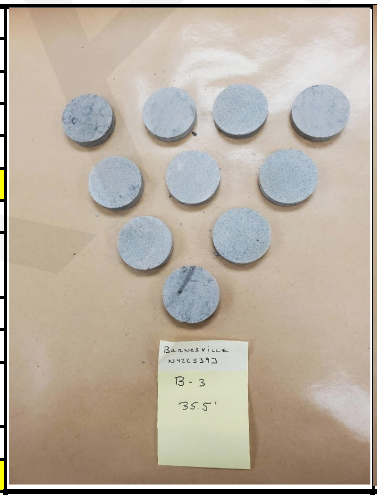
Boring No.			B-002-0-22
Depth (ft)			8.00
Tare Weight:			843.8
Moist weight (Sample+Tare):			1558.7
Dry weight (Sample+Tare):			1538.2
Natural Moisture Content (%):			3.0
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
74.1	75.9	75.0	1236.9
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
76	76	76	1070.7
SLAKE DURABILITY INDEX:			**32.7**
Fragments Retained - Type:			**II**
Material Description:			**Moderately weathered siltstone**
Notes/Comments:			**Per ODOT format, B-1 is renumbered as B-002-0-22**

Before Test



After Test

Boring No.			B-003-0-22
Depth (ft)			35.50
Tare Weight:			840.0
Moist weight (Sample+Tare):			1323.4
Dry weight (Sample+Tare):			1307.5
Natural Moisture Content (%):			3.4
After Cycle No. 1			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
73.8	75.1	74.5	1302.1
After Cycle No. 2			
Temperature (°F)			Dry Weight
Start	End	Average	(Sample+Tare)
75	75	75	1299.3
SLAKE DURABILITY INDEX:			**98.2**
Fragments Retained - Type:			**I**
Material Description:			**Slightly weathered sandstone**
Notes/Comments:			**Per ODOT format, B-3 is renumbered as B-003-0-22**



Before Test

After Test

Client

Pennoni Associates Inc.
1900 Market Street,
Suite 300
Philadelphia, PA 19103

Project

Village of Barnesville Pedestrian Trail
Mulberry St.
Barnesville, OH 43713

Project No. N4225393

SUPPLEMENT 1122
DETERMINING SULFATE CONTENT IN SOILS

SAMPLE INFORMATION

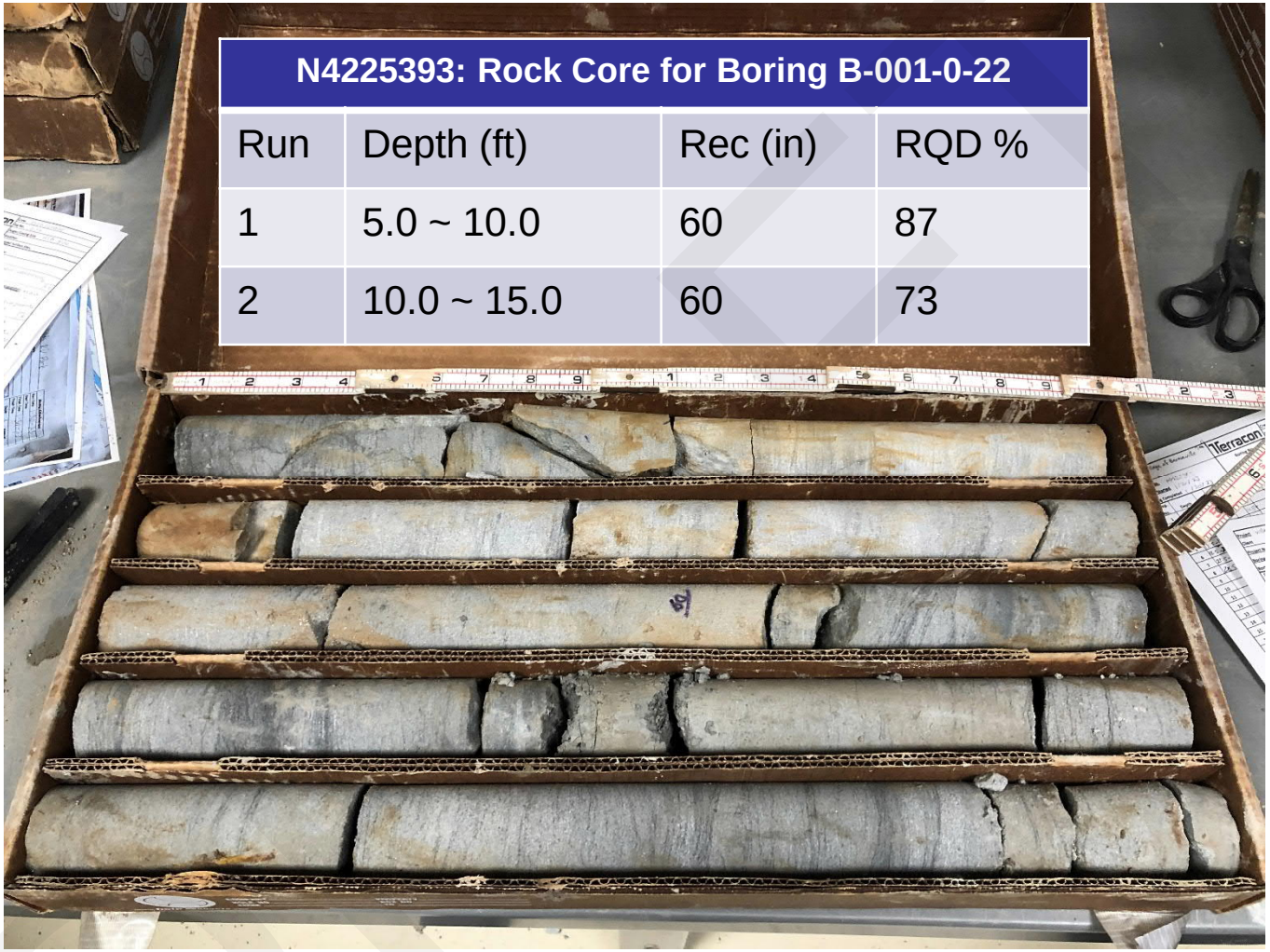
Sample Type: Splitspoon sample
Sample Location: ---

Lab Number	Hole Numer	Sample Number	Sample Depth	Sulfate Concentration, ppm
638	B-004-0-22, Sample 4	61	4.5-6.0	Non-Detectable
639	B-005-0-22, Sample 2	CNDYM	1.5-3.0	Non-Detectable
640	B-006-0-22, Sample 2	TIM-0	1.5-3.0	1093
641	B-007-0-22, Sample 4	59	4.5-6.0	Non-Detectable

Services:
Terracon Rep:
Reported To:
Contractor:

Report Distribution

N4225393 Village of Barnesville Trail Expansion



N4225393: Rock Core for Boring B-001-0-22			
Run	Depth (ft)	Rec (in)	RQD %
1	5.0 ~ 10.0	60	87
2	10.0 ~ 15.0	60	73

PHOTO 1: ROCK CORE OF BORING B-001-0-22

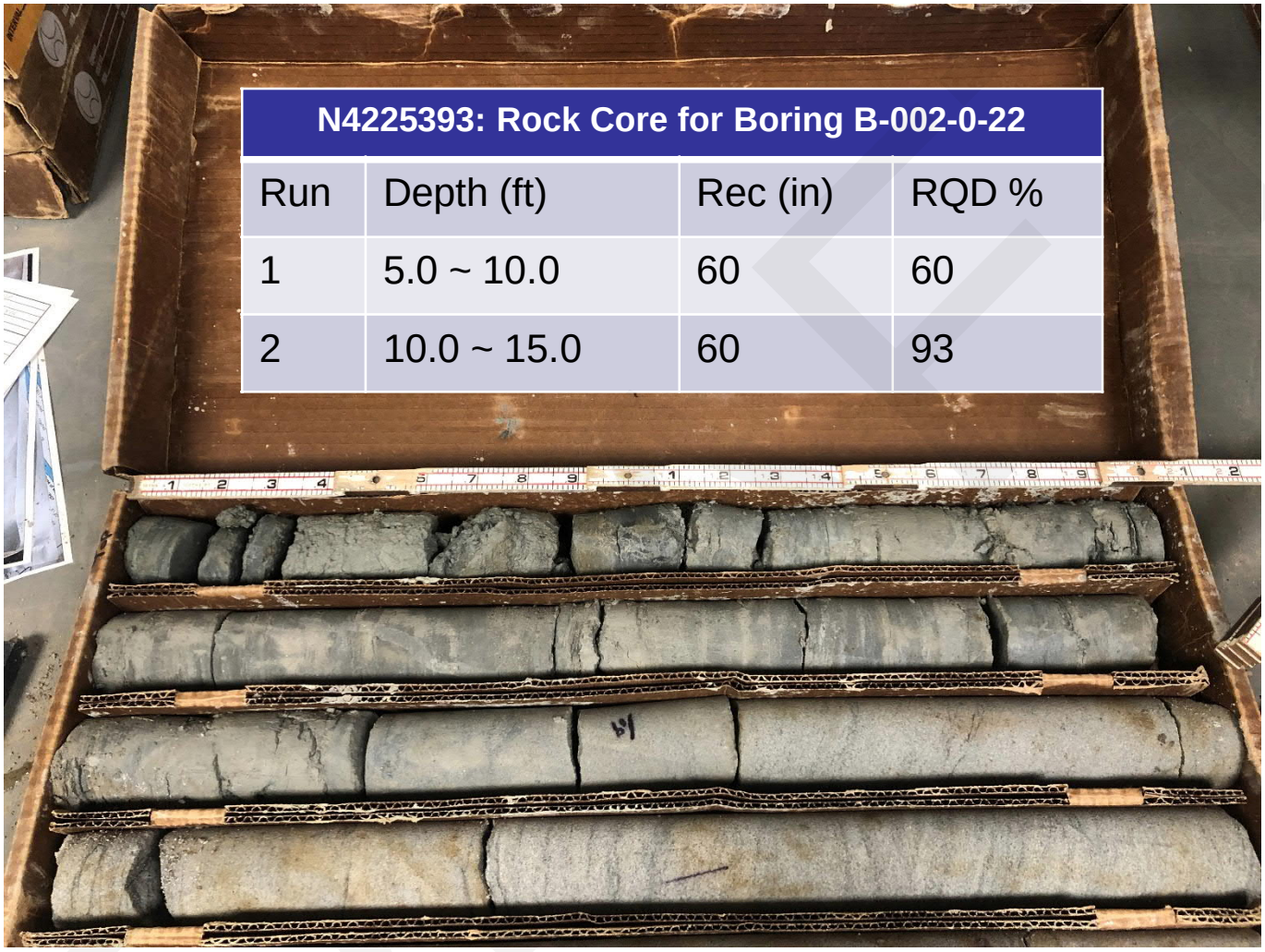
Project Manager:	AR
Drawn by:	NKM
Checked by:	BH
Approved by:	KE
Project No.	N4225393
Scale:	N.T.S.
File Name:	Rockcore Photos
Date:	02/09/2023

Terracon
Consulting Engineers & Scientists
800 Morrison Road Columbus, Ohio 43230
PH. (614) 863-3113 FAX. (614) 863-0475

ROCK CORE PHOTO OF BORING B-001-0-22

Village of Barnesville Trail Expansion
Geotechnical Investigation
Belmont County, Ohio

N4225393 Village of Barnesville Trail Expansion



N4225393: Rock Core for Boring B-002-0-22			
Run	Depth (ft)	Rec (in)	RQD %
1	5.0 ~ 10.0	60	60
2	10.0 ~ 15.0	60	93

PHOTO 2: ROCK CORE OF BORING B-002-0-22

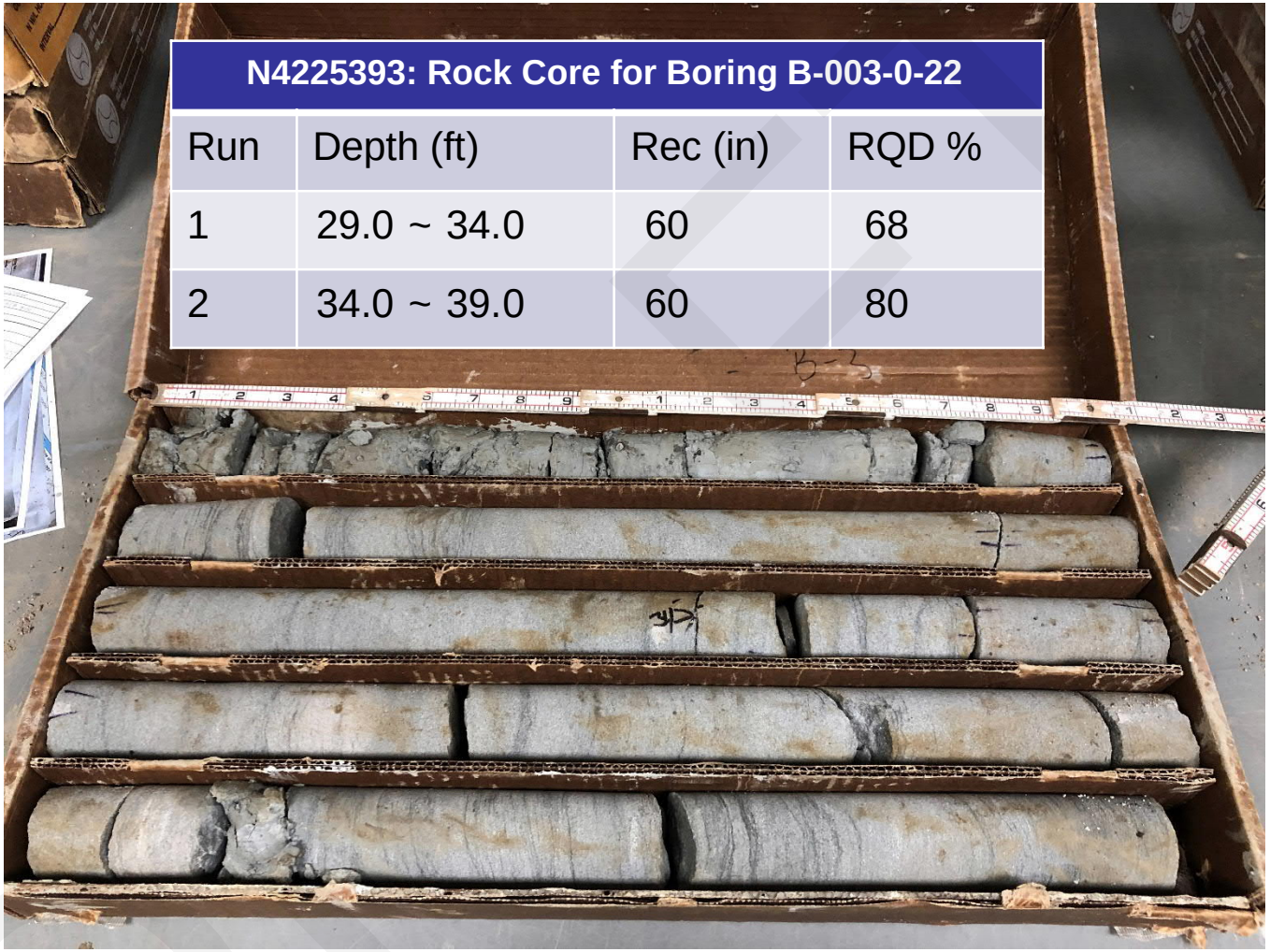
Project Manager: AR	Project No. N4225393
Drawn by: NKM	Scale: N.T.S.
Checked by: BH	File Name: Rockcore Photos
Approved by: KE	Date: 02/09/2023

Terracon
Consulting Engineers & Scientists
800 Morrison Road Columbus, Ohio 43230
PH. (614) 863-3113 FAX. (614) 863-0475

ROCK CORE PHOTO OF BORING B-002-0-22

Village of Barnesville Trail Expansion
Geotechnical Investigation
Belmont County, Ohio

N4225393 Village of Barnesville Trail Expansion



N4225393: Rock Core for Boring B-003-0-22			
Run	Depth (ft)	Rec (in)	RQD %
1	29.0 ~ 34.0	60	68
2	34.0 ~ 39.0	60	80

PHOTO 3: ROCK CORE OF BORING B-003-0-22

Project Manager:	AR
Drawn by:	NKM
Checked by:	BH
Approved by:	KE
Project No.	N4225393
Scale:	N.T.S.
File Name:	Rockcore Photos
Date:	02/09/2023

Terracon
Consulting Engineers & Scientists
800 Morrison Road Columbus, Ohio 43230
PH. (614) 863-3113 FAX. (614) 863-0475

ROCK CORE PHOTO OF BORING B-003-0-22

Village of Barnesville Trail Expansion
Geotechnical Investigation
Belmont County, Ohio

GB1 Subgrade Analysis

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

BEL - BARNESVILLE TRAIL
PID 108050

Village of Barnesville - Trail Expansion, Mulberry Street, Barnesville, Ohio

Terracon Consultants Inc

Prepared By: Nithya K Manikkam
Date prepared: Tuesday, April 11, 2023

Terracon Consultants Inc
800 Morrison Road
Gahanna, Ohio

(614) 863-3113
nithya.k.manikkam@terracon.com

NO. OF BORINGS: 4

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-004-0-22	Barnesville Trail				B-57 (#594)	90	1235.0	1234.2	0.8 C
2	B-005-0-22	Barnesville Trail				B-57 (#594)	90	1236.0	1235.2	0.8 C
3	B-006-0-22	Barnesville Trail				B-57 (#594)	90	1250.0	1249.2	0.8 C
4	B-007-0-22	Barnesville Trail				B-57 (#594)	90	1261.0	1260.2	0.8 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.5 1/18/2019

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation (Enter depth in inches)
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
1	B	SS-1	0.0	1.5	-0.8	0.7	15			NP	NP	NP	6	10	16	22	6	A-1-b	0						
	004-0	SS-2A	1.5	2.0	0.7	1.2	20									24	18	A-7-6	16			Mc			
	22	SS -2B	2.0	3.0	1.2	2.2	20										8	A-3a	0						
		SS-3	3.0	4.5	2.2	3.7	9	9								25	18	A-7-6	16						
2	B	SS-1	0.0	1.5	-0.8	0.7	20									10	6	A-1-b	0						
	005-0	SS-2	1.5	3.0	0.7	2.2	9									16	6	A-1-b	0						
	22	SS-3	3.0	4.5	2.2	3.7	9			NP	NP	NP	9	19	28	18	8	A-3a	0						
		SS-4A	4.5	5.0	3.7	4.2	11	9		30	21	9	14	31	45	20	16	A-4a	2						
3	B	SS-1	0.0	1.5	-0.8	0.7	38									8	6	A-1-a	0						
	006-0	SS-2A	1.5	2.0	0.7	1.2	38			NP	NP	NP	8	18	26	23	10	A-2-4	0	1093		Mc			
	22	SS -2B	2.0	3.0	1.2	2.2	38										6	A-1-a	0						
		SS-3	3.0	4.5	2.2	3.7	20	20								16	18	A-7-6	16						
4	B	SS-1	0.0	1.5	-0.8	0.7	3			41	29	12	10	21	31	24	10	A-2-7	0			N_{60} & Mc		**33"**	**Undercurt 14"**
	007-0	SS-2A	1.5	2.0	0.7	1.2	8		4							21	16	A-6b	16			N_{60} & Mc		**12"**	
	22	SS -2B	2.0	3.0	1.2	2.2	8		4								16	A-6b	16			N_{60}			
		SS-3	3.0	4.5	2.2	3.7	14	3	3							23	16	A-6b	16						

PID: PID 108050

County-Route-Section: BEL - BARNESVILLE TRAIL

No. of Borings: 4

Geotechnical Consultant: Terracon Consultants Inc

Prepared By: Nithya K Manikkam

Date prepared: 4/11/2023

Chemical Stabilization Options		
320	Rubblize & Roll	No
206	Cement Stabilization	Option
	Lime Stabilization	No
206	Depth	14"

Excavate and Replace Stabilization Options	
Global Geotextile Override(N60L):	12"
Override(HP):	0"
Global Geogrid Override(N60L):	0"
Override(HP):	0"

Design CBR	7

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	6%	HP ≤ 0.5	0%
$N_{60} < 12$	44%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	6%	1 < HP ≤ 2	0%
$N_{60} \geq 20$	44%	HP > 2	19%
M+	25%		
Rock	0%		
Unsuitable	6%		

Excavate and Replace at Surface	
Average	0"
Maximum	0"
Minimum	0"

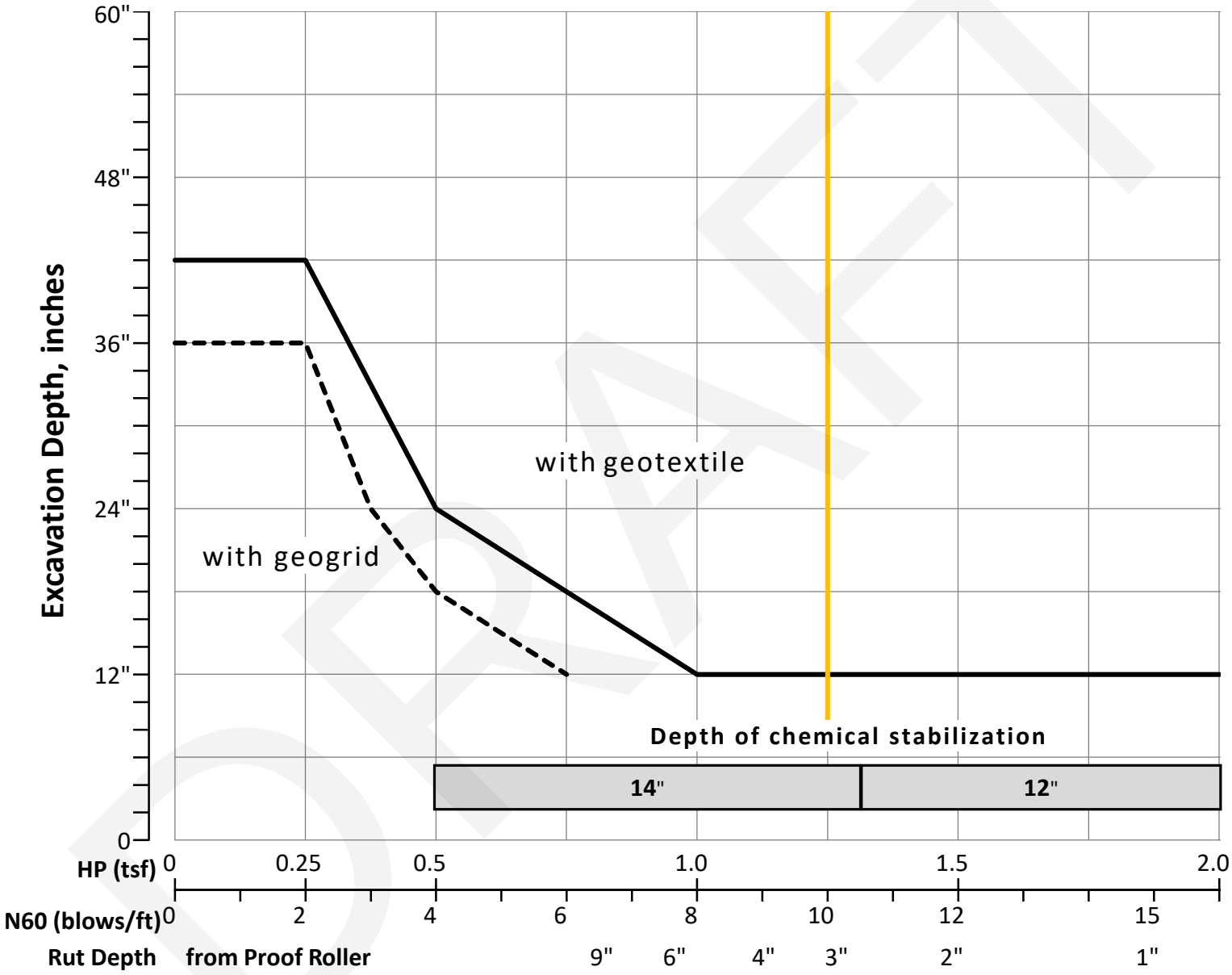
% Proposed Subgrade Surface	
Unstable & Unsuitable	33%
Unstable	33%
Unsuitable	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	18	10	3.67	36	25	11	9	20	29	19	12	6
Maximum	38	20	4.00	41	29	12	14	31	45	25	18	16
Minimum	3	3	3.00	30	21	9	6	10	16	8	6	0

Classification Counts by Sample

ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	2	3	1	0	0	1	0	2	1	0	0	0	3	0	3	0	0	16
Percent	0%	13%	19%	6%	0%	0%	6%	0%	13%	6%	0%	0%	0%	19%	0%	19%	0%	0%	100%
% Rock|Granular|Cohesive	0%	63%									38%								100%
Surface Class Count	0	2	3	1	0	0	1	0	2	0	0	0	0	3	0	3	0	0	15
Surface Class Percent	0%	13%	20%	7%	0%	0%	7%	0%	13%	0%	0%	0%	0%	20%	0%	20%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
3.67	3.00	☑ HP
10.25	10.00	☑ N60L

Average HP
Average N_{60L}

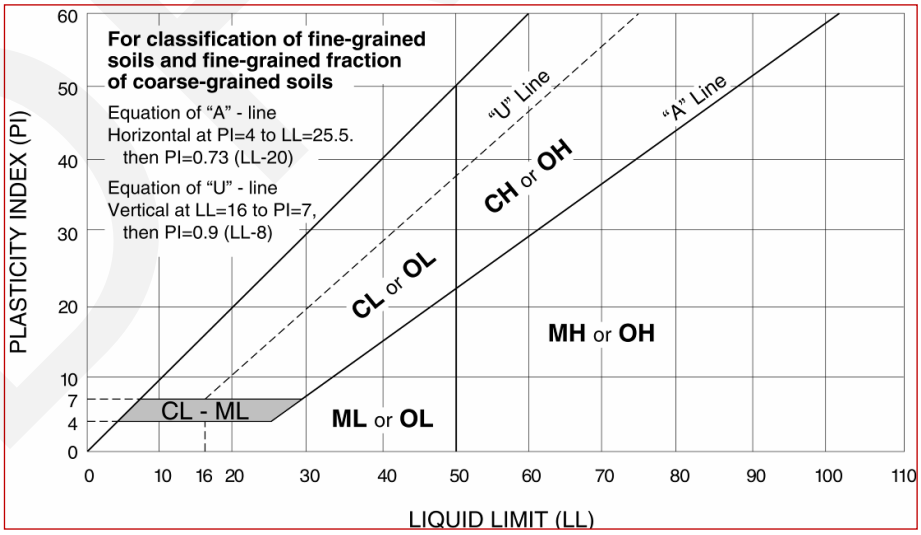
Supporting Information

Contents:

Unified Soil Classification System

Criteria for Assigning Group Symbols and Group Names Using Laboratory Tests [A]				Soil Classification	
				Group Symbol	Group Name [B]
Coarse-Grained Soils: More than 50% retained on No. 200 sieve	**Gravels:** More than 50% of coarse fraction retained on No. 4 sieve	**Clean Gravels:** Less than 5% fines [C]	Cu≥4 and 1≤Cc≤3 [E]	GW	Well-graded gravel [F]
			Cu<4 and/or [Cc<1 or Cc>3.0] [E]	GP	Poorly graded gravel [F]
		Gravels with Fines: More than 12% fines [C]	Fines classify as ML or MH	GM	Silty gravel [F, G, H]
			Fines classify as CL or CH	GC	Clayey gravel [F, G, H]
	Sands: 50% or more of coarse fraction passes No. 4 sieve	**Clean Sands:** Less than 5% fines [D]	Cu≥6 and 1≤Cc≤3 [E]	SW	Well-graded sand [I]
			Cu<6 and/or [Cc<1 or Cc>3.0] [E]	SP	Poorly graded sand [I]
		Sands with Fines: More than 12% fines [D]	Fines classify as ML or MH	SM	Silty sand [G, H, I]
			Fines classify as CL or CH	SC	Clayey sand [G, H, I]
Fine-Grained Soils: 50% or more passes the No. 200 sieve	**Silts and Clays:** Liquid limit less than 50	**Inorganic:**	PI > 7 and plots above "A" line [J]	CL	Lean clay [K, L, M]
			PI < 4 or plots below "A" line [J]	ML	Silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OL	Organic clay [K, L, M, N]
					Organic silt [K, L, M, O]
	Silts and Clays: Liquid limit 50 or more	**Inorganic:**	PI plots on or above "A" line	CH	Fat clay [K, L, M]
			PI plots below "A" line	MH	Elastic silt [K, L, M]
		Organic:	$\frac{LL\ oven\ dried}{LL\ not\ dried} < 0.75$	OH	Organic clay [K, L, M, P]
					Organic silt [K, L, M, Q]
Highly organic soils:	Primarily organic matter, dark in color, and organic odor			PT	Peat

[A] Based on the material passing the 3-inch (75-mm) sieve.
[B] If field sample contained cobbles or boulders, or both, add "with cobbles or boulders, or both" to group name.
[C] Gravels with 5 to 12% fines require dual symbols: GW-GM well-graded gravel with silt, GW-GC well-graded gravel with clay, GP-GM poorly graded gravel with silt, GP-GC poorly graded gravel with clay.
[D] Sands with 5 to 12% fines require dual symbols: SW-SM well-graded sand with silt, SW-SC well-graded sand with clay, SP-SM poorly graded sand with silt, SP-SC poorly graded sand with clay.
[E] $Cu = D_{60}/D_{10}$ $Cc = \frac{(D_{30})^2}{D_{10} \times D_{60}}$
[F] If soil contains ≥ 15% sand, add "with sand" to group name.
[G] If fines classify as CL-ML, use dual symbol GC-GM, or SC-SM.
[H] If fines are organic, add "with organic fines" to group name.
[I] If soil contains ≥ 15% gravel, add "with gravel" to group name.
[J] If Atterberg limits plot in shaded area, soil is a CL-ML, silty clay.
[K] If soil contains 15 to 29% plus No. 200, add "with sand" or "with gravel," whichever is predominant.
[L] If soil contains ≥ 30% plus No. 200 predominantly sand, add "sandy" to group name.
[M] If soil contains ≥ 30% plus No. 200, predominantly gravel, add "gravelly" to group name.
[N] PI ≥ 4 and plots on or above "A" line.
[O] PI < 4 or plots below "A" line.
[P] PI plots on or above "A" line.
[Q] PI plots below "A" line.



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 precedes 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 AASHTO	Classifcation OHIO	$LL_O/LL \times 100$*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
	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	76 Min.		36 Min.	40 Max.	10 Max.	8	Less than 50% silt sizes
	Silt	A-4	A-4b	76 Min.		50 Min.	40 Max.	10 Max.	8	50% or more silt sizes
	Elastic Silt and Clay	A-5		76 Min.		36 Min.	41 Min.	10 Max.	12	
	Silt and Clay	A-6	A-6a	76 Min.		36 Min.	40 Max.	11 - 15	10	
	Silty Clay	A-6	A-6b	76 Min.		36 Min.	40 Max.	16 Min.	16	
	Elastic Clay	A-7-5		76 Min.		36 Min.	41 Min.	≧LL-30	20	
	Clay	A-7-6		76 Min.		36 Min.	41 Min.	>LL-30	20	
	Organic Silt	A-8	A-8a	75 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	75 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

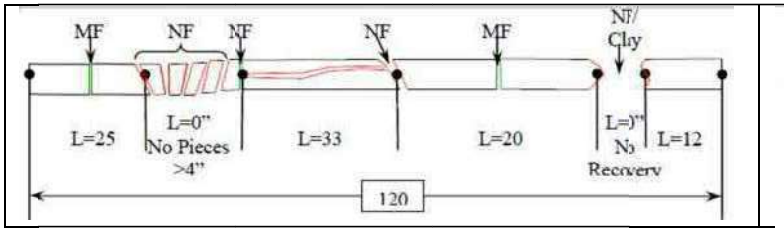
a: Structure

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

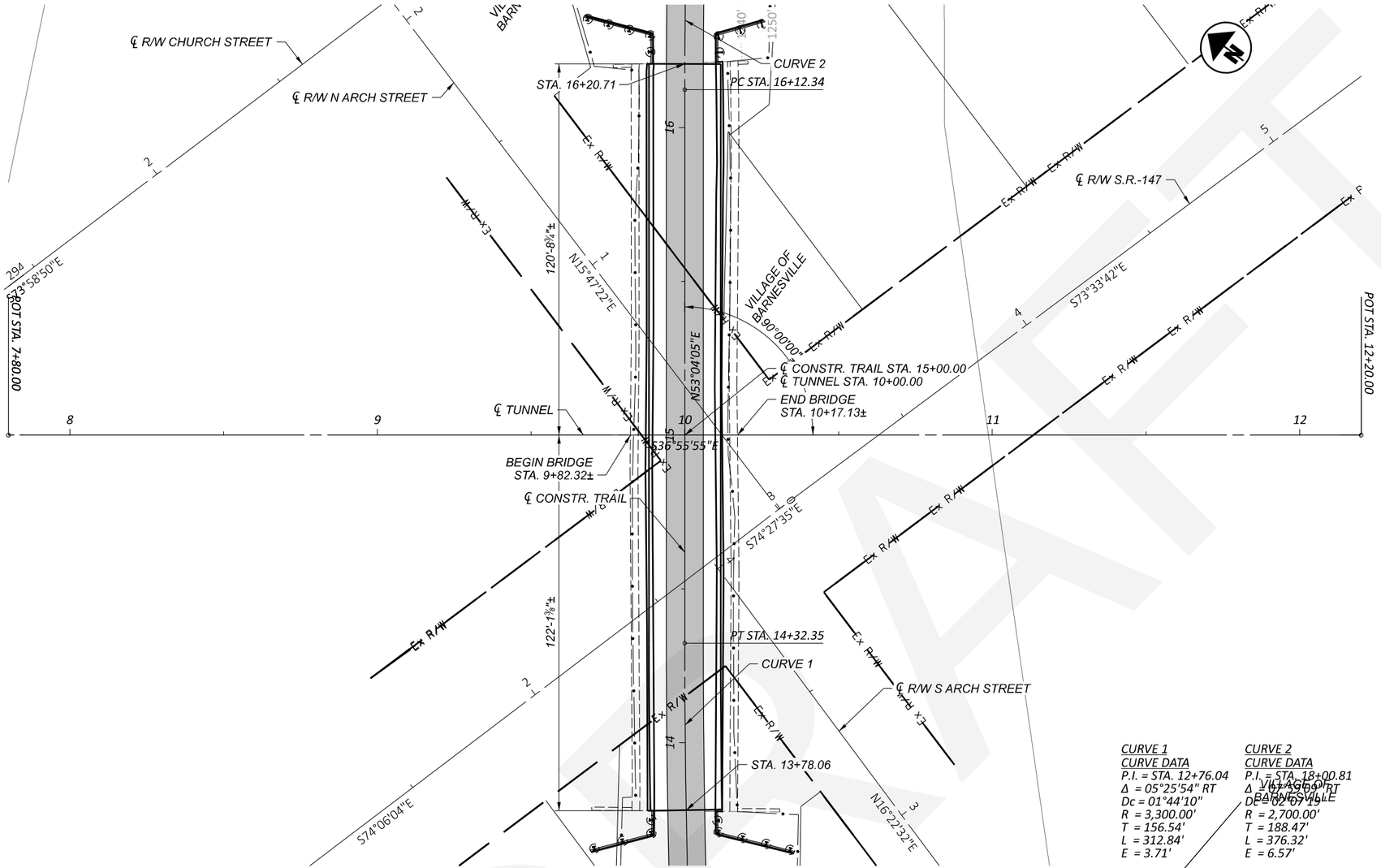
Description	Parameters
Very Good	Very rough, fresh unweathered surfaces
Good	Rough, slightly weathered, iron stained surface
Fair	Smooth, moderately weathered and altered surfaces
Poor	Slickensided, highly weathered surface with compact coatings or fillings or angular fragments
Very Poor	Slickensided,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

10: RQD



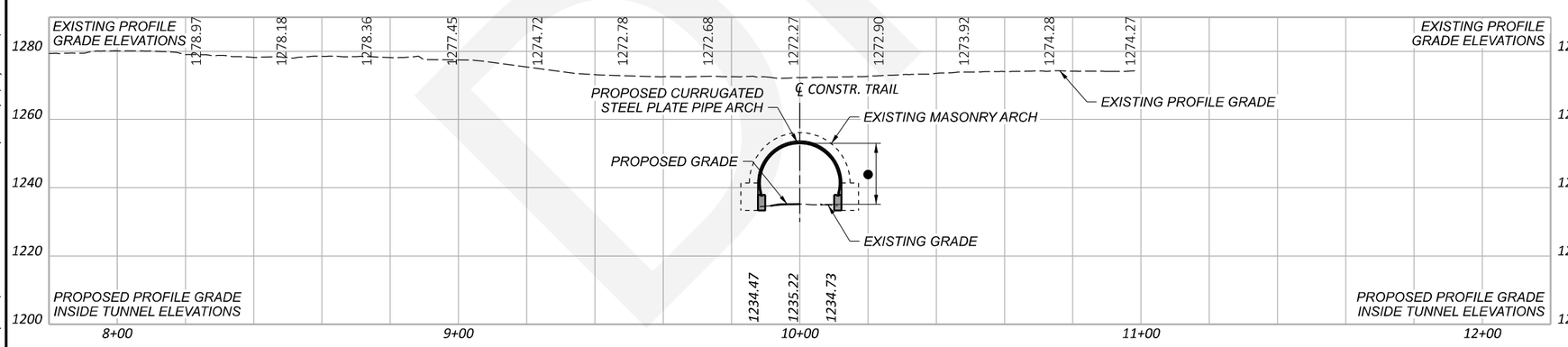
$$RQD = \left(\frac{\sum Length\ of\ Pieces > 4inches}{Total\ Length\ of\ Core}\right) * 100$$

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



PLAN

CURVE 1 CURVE DATA	CURVE 2 CURVE DATA
P.I. = STA. 12+76.04	P.I. = STA. 18+00.81
Δ = 05°25'54" RT	Δ = 07°46'09" RT
Dc = 01°44'10"	Dc = 02°07'15"
R = 3,300.00'	R = 2,700.00'
T = 156.54'	T = 188.47'
L = 312.84'	L = 376.32'
E = 3.71'	E = 6.57'



PROFILE ALONG ℄ TUNNEL

BENCHMARK DATA

BM #1	STA.	132+76.72,	ELEV.	1232.20,	OFFSET	31.49',	LT
BM #2	STA.	135+75.86,	ELEV.	1232.98,	OFFSET	30.82',	LT
BM #3	STA.	148+30.66,	ELEV.	1237.12	OFFSET	40.69',	RT
BM #4	STA.	165+72.29,	ELEV.	1258.89	OFFSET	43.29',	RT

FOR ADDITIONAL BENCHMARK INFORMATION. SEE ROADWAY PLAN SHEET

NOTES

EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

LEGEND

- BORING LOCATION
- 10'-0" REQUIRED MINIMUM VERTICAL CLEARANCE
- 17'-10⅞" ACTUAL MINIMUM VERTICAL CLEARANCE

EXISTING STRUCTURE

TYPE: MASONRY (SANDSTONE AND BRICK) ARCH ON MASONRY (SANDSTONE AND BRICK) WALLS AND WINGWALLS

SPANS: 24'-6"±

ROADWAY: 10'-0"± WIDE TRAIL

LOADING: UNKNOWN

SKEW: NONE

WEARING SURFACE: ASPHALT

APPROACH SLABS: NONE

ALIGNMENT: TANGENT

CROWN: 0.016± FT/FT

STRUCTURE FILE NUMBER: 0703400

DATE BUILT: 1870

DISPOSITION: TO BE REHABILITATED

PROPOSED STRUCTURE

TYPE: CORRUGATED METAL PIPE ARCH ON REINFORCED CONCRETE WALLS WITH SOLDIER PILE AND LAGGING WINGWALLS

SPANS: 23'-4"

ROADWAY: 12'-0" WIDE TRAIL

LOADING: HL93 AND 0.06 KSF FUTURE WEARING SURFACE

SKEW: NONE

WEARING SURFACE: ASPHALT

APPROACH SLABS: NONE

ALIGNMENT: TANGENT

CROWN: 0.016 FT/FT

DECK AREA: NONE

COORDINATES: LATITUDE 39° 59' 14.82" N
LONGITUDE 81° 10' 31.36" W

SITE PLAN
BRIDGE NO. BEL-147-0506
STATE ROUTE 147 OVER RAILROAD TUNNEL

BEL-BARNESVILLE TRAIL

SFN 703400

DESIGN AGENCY Pennoni

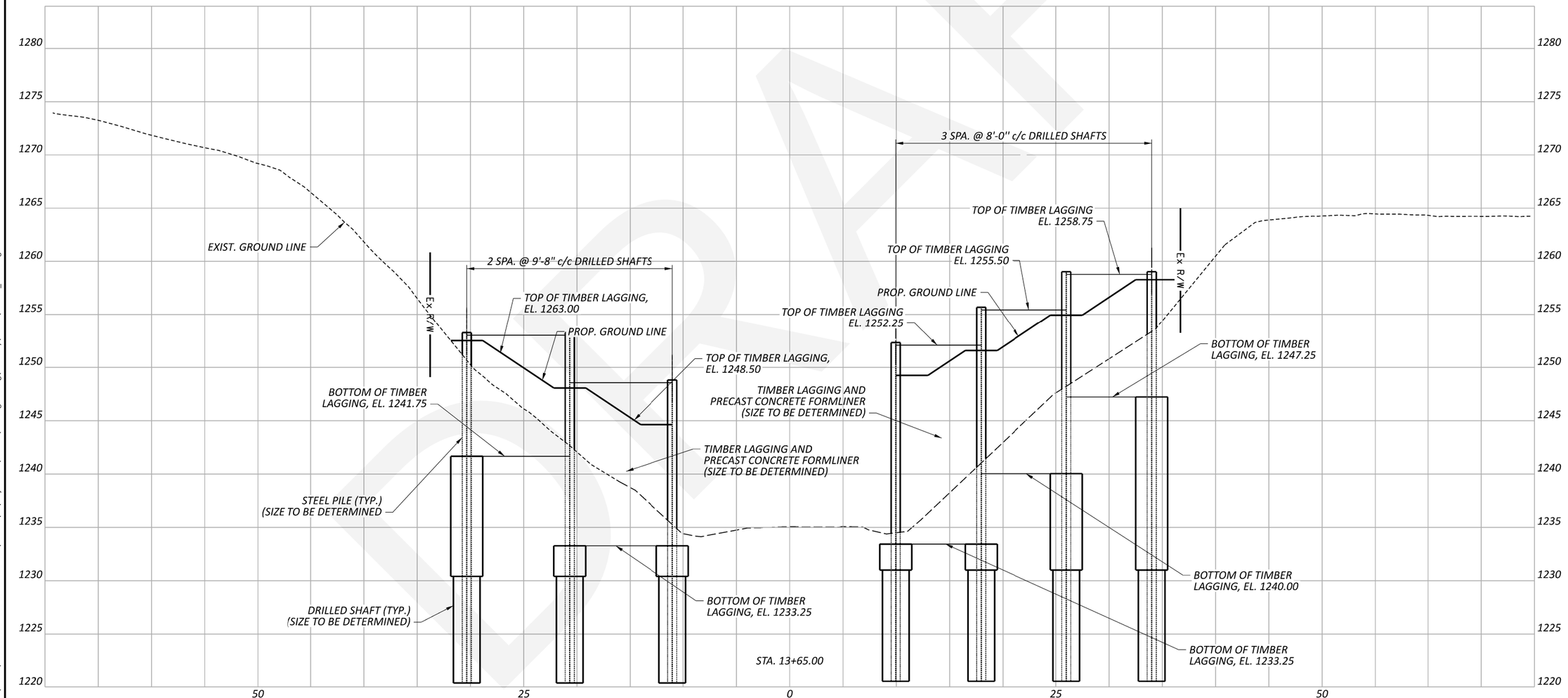
DESIGNER	CHECKER
AJK	ARA

REVIEWER MDP MM-DD-YY

PROJECT ID 108050

SUBSET	TOTAL
0	0

SHEET	TOTAL
P.0	0



CTY-RTE-SECTION

MODEL: CLP_Barnsville Trail-1 - 13+65.00 [Sheet] PAPERSIZE: 17x11 (in.) DATE: 3/15/2023 TIME: 3:38:41 PM USER: AEI-Ashram
U:\Accounts\BAVIO\BAVIO22001 - BEL-Barnesville Trail\DESIGN\CT\ProjectData\108050\400-Engineering\Roadway\Sheets\108050_XS005.dgn

SOUTH PORTAL SOLDIER PILE WALL CROSS-SECTION
BARNSVILLE TRAIL STA. 13+65.00

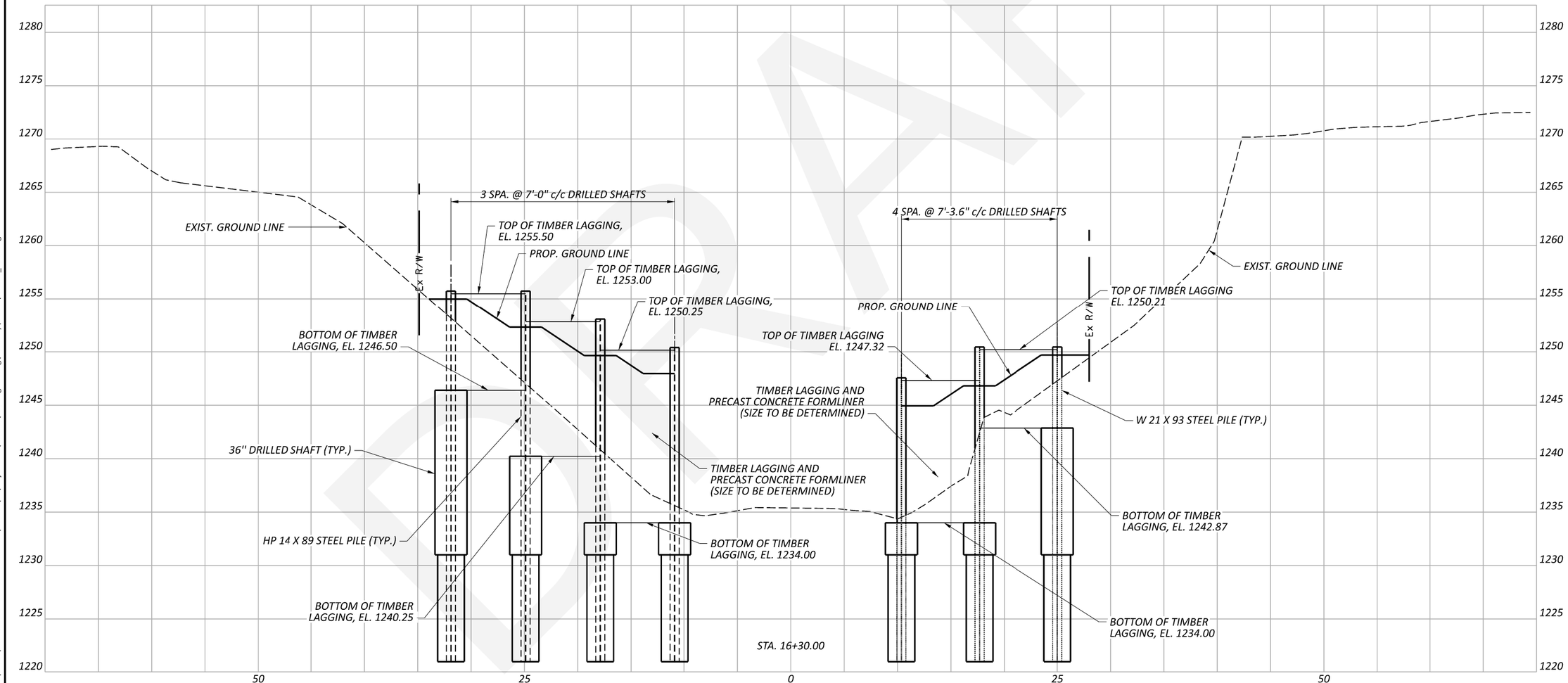
DESIGN AGENCY

DESIGNER XXX

REVIEWER XXX MM-DD-YY

PROJECT ID 0

SHEET P.0 | TOTAL 0



NORTH PORTAL SOLDIER PILE WALL CROSS-SECTION
BARNESVILLE TRAIL STA. 16+30.00

CTY-RTE-SECTION

MODEL: CLP_Barnseville Trail-1 - 16+30.00 |Sheet| PAPERSIZE: 17x11 (in.) DATE: 3/16/2023 TIME: 10:04:00 AM USER: AEI:Ashram
U:\Accounts\BAVIO\BAVIO22001 - BEL-Barnesville Trail\DESIGN\CT\ProjectData\108050\400-Engineering\Roadway\Sheets\108050_XS006.dgn

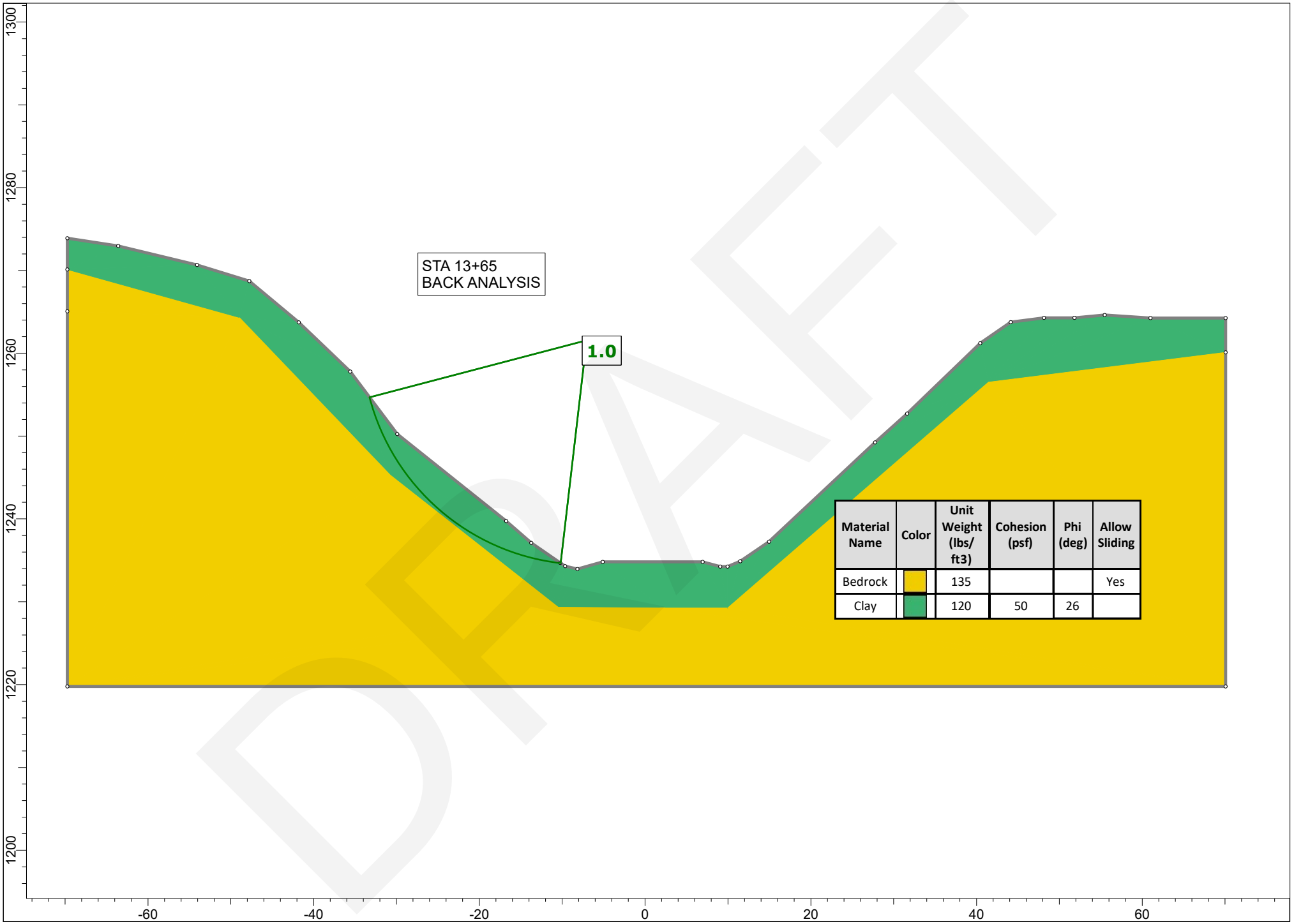
DESIGN AGENCY

DESIGNER XXX

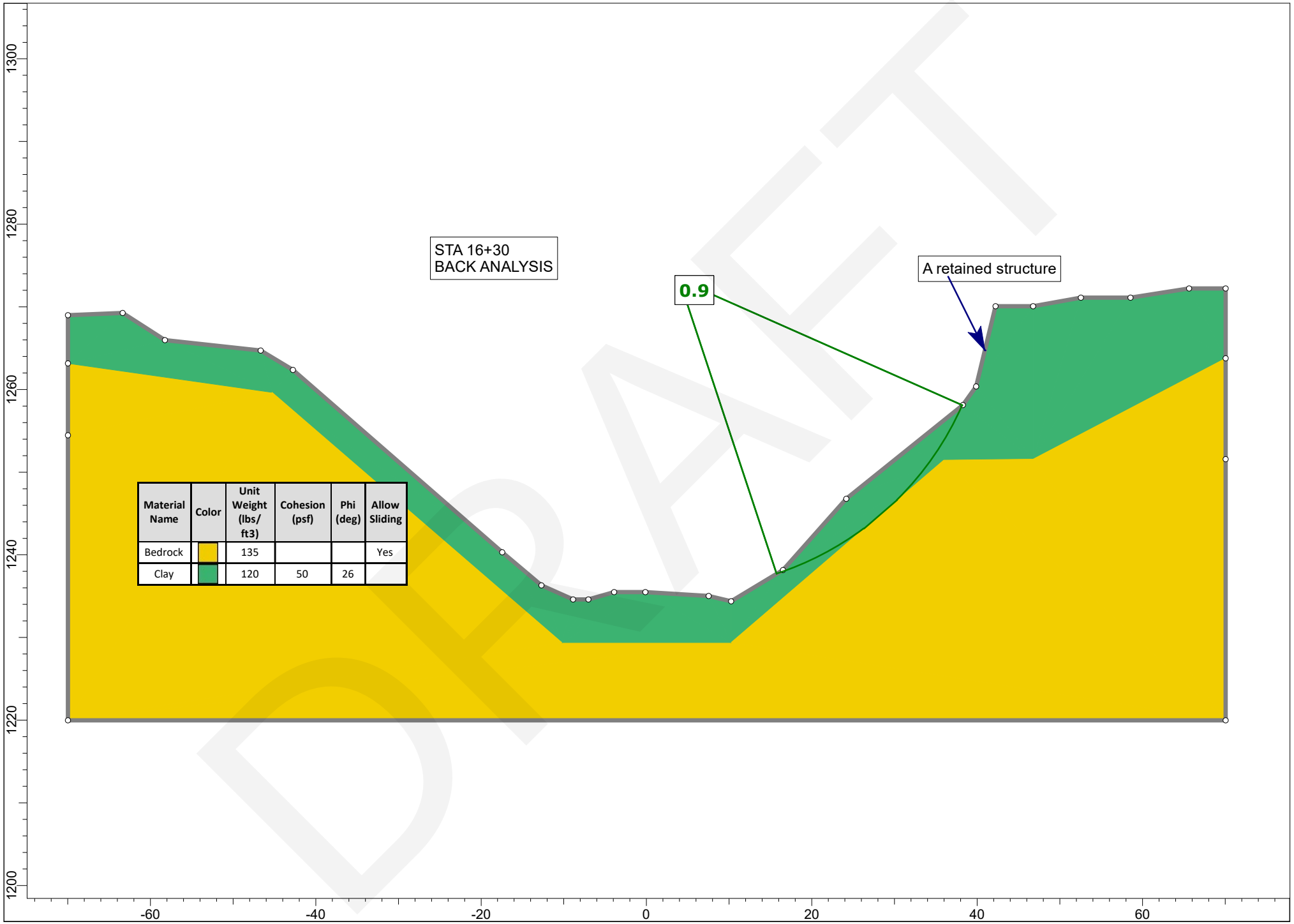
REVIEWER XXX MM-DD-YY

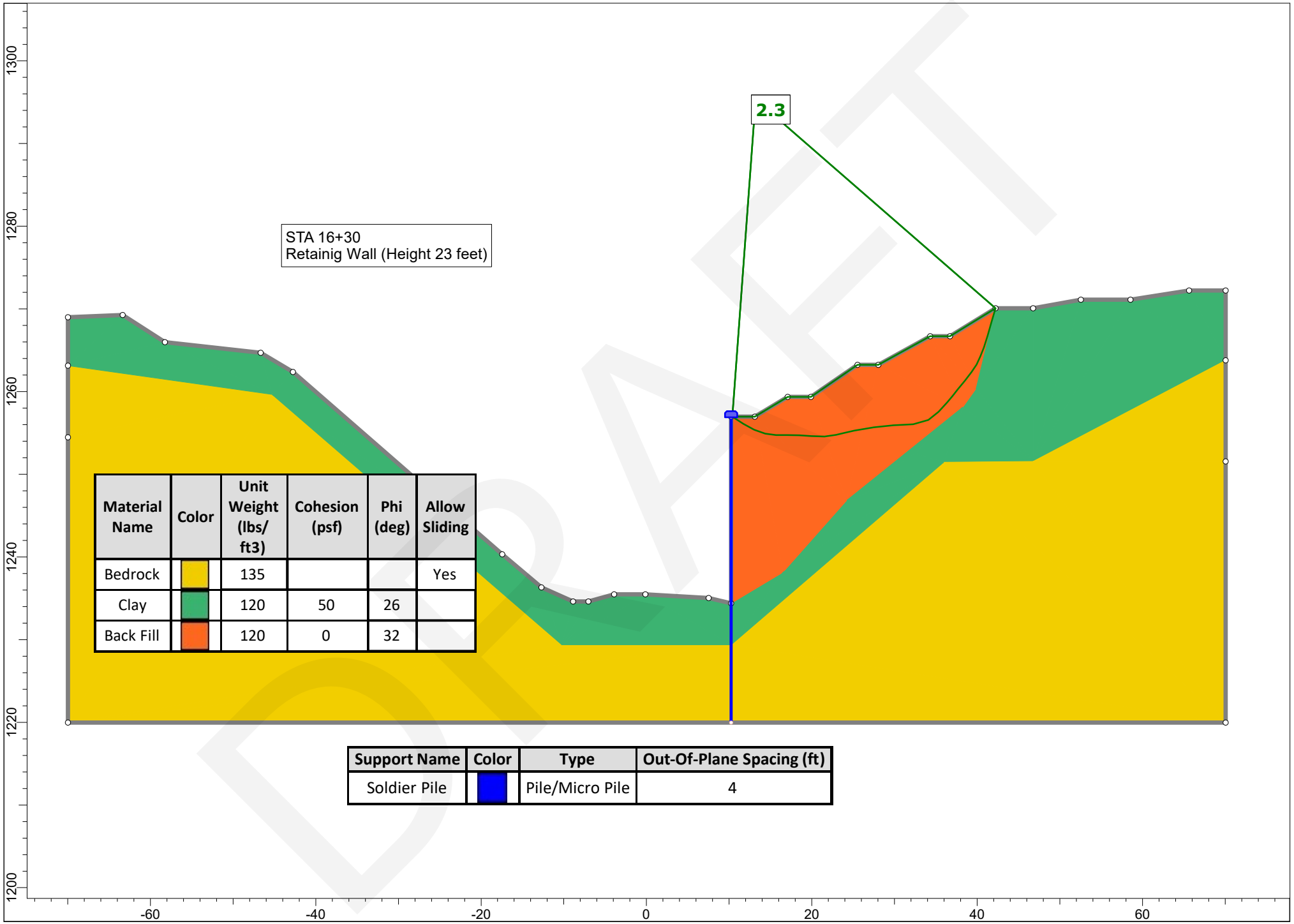
PROJECT ID 0

SHEET P.0 | TOTAL 0



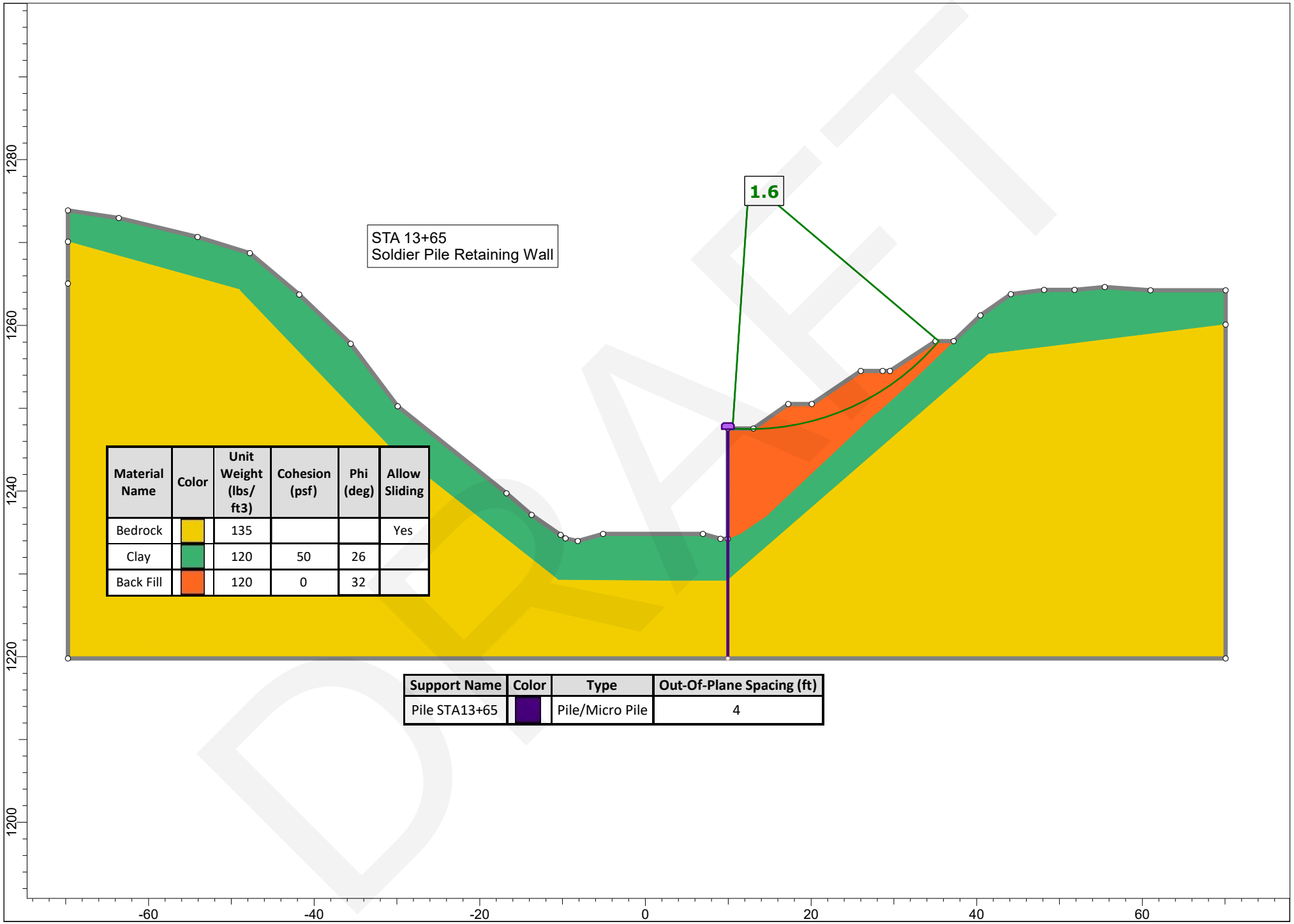
Material Name	Color	Unit Weight (lbs/ ft3)	Cohesion (psf)	Phi (deg)	Allow Sliding
Bedrock		135			Yes
Clay		120	50	26	


STA 16+30
BACK ANALYSIS
0.9
A retained structure
Material Name | Color | Unit Weight (lbs/ ft3) | Cohesion (psf) | Phi (deg) | Allow Sliding
Bedrock | 135 | | | Yes
Clay | 120 | 50 | 26 |
1300
1280
1260
1240
1220
1200
-60
-40
-20
0
20
40
60



Material Name	Color	Unit Weight (lbs/ ft3)	Cohesion (psf)	Phi (deg)	Allow Sliding
Bedrock		135			Yes
Clay		120	50	26	
Back Fill		120	0	32	

Support Name	Color	Type	Out-Of-Plane Spacing (ft)
Soldier Pile		Pile/Micro Pile	4

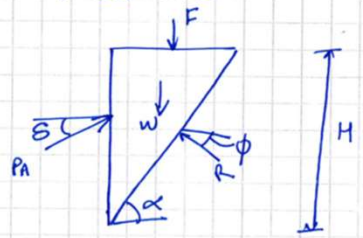


Material Name	Color	Unit Weight (lbs/ ft3)	Cohesion (psf)	Phi (deg)	Allow Sliding
Bedrock		135			Yes
Clay		120	50	26	
Back Fill		120	0	32	

Support Name	Color	Type	Out-Of-Plane Spacing (ft)
Pile STA13+65		Pile/Micro Pile	4

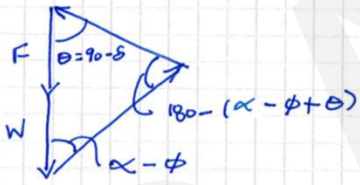
CLIENT:	Village of Barnesville
PROJECT:	Village of Barnesville - Trail Expansion
PROJECT NO.:	N4225393
CASE:	STA 13+65

CONSIDER THE FOLLOWING FORCE MODEL TO CALCULATE THE FORCE ACTING ON THE CANTILEVER WALL



WHERE
- F = TRAFFIC SURCHARGE related FORCE
- W = WEIGHT OF THE UNSTABLE SOIL WEDGE
- P_A = LATERAL FORCE DUE TO ACTIVE PRESSURE
- ϕ = ANGLE OF INTERNAL FRICTION AT THE FAILURE SURFACE
- δ = ANGLE OF FRICTION BETWEEN THE PIER AND THE SOIL SURFACE
- α = Failure Surface inclination

CONSIDER THE FOLLOWING FORCE POLYGON:



AREA OF ACTIVE SOIL WEDGE $= \frac{1}{2} H \frac{H}{\tan\alpha}$

$= \frac{0.5 H^2}{\tan\alpha}$

$\therefore$ WT. OF WEDGE $= \frac{0.5 H^2}{\tan\alpha} \times$ bulk

F = traffic intensity $\times H/\tan\alpha$

USING SINE RULE ON THE FORCE TRIANGLE

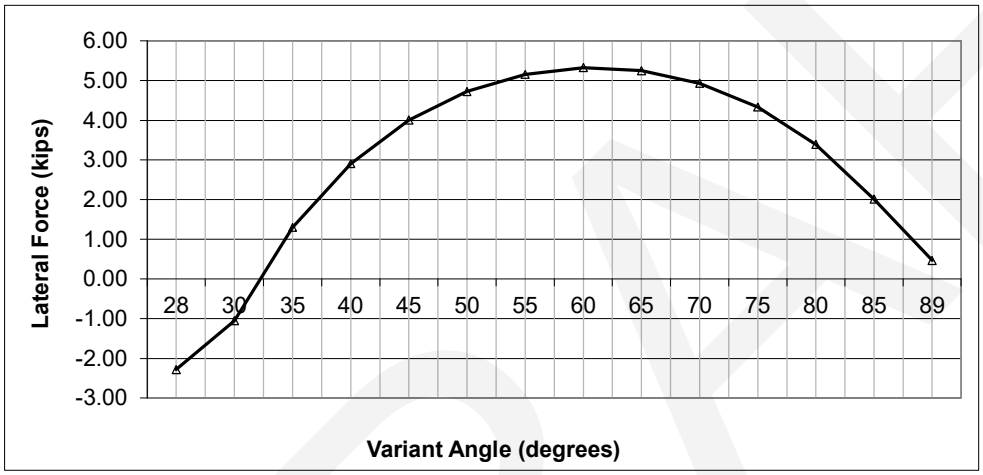
$$\frac{P_A}{\sin(\alpha-\phi)} = \frac{W+F}{\sin(180-\alpha+\phi-\theta)}$$

$$\therefore P_A = \frac{(W+F)(\sin\alpha-\phi)}{\sin(180-\alpha+\phi-90+\delta)}$$

CLIENT:	Village of Barnesville
PROJECT:	Village of Barnesville - Trail Expansion
PROJECT NO.:	N4225393
CASE:	STA 13+65

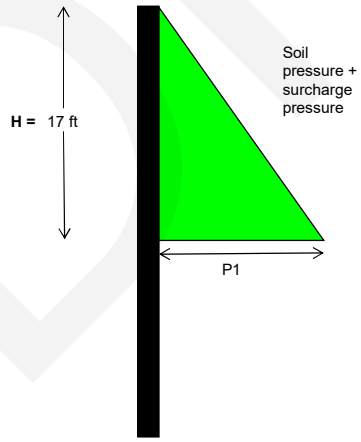
Angle of Internal Friction Φ:	32	degrees
Angle of Wall Friction δ:	0	degrees
Bulk Unit Weight γ:	0.12	kcf
Traffic Surcharge Intensity:	0	ksf
Depth to slip surface H:	17	feet

Variant Angle (α)	W (kips)	F (kips)	P_A (kips)
28	32.61	0.00	-2.28
30	30.03	0.00	-1.05
35	24.76	0.00	1.30
40	20.67	0.00	2.90
45	17.34	0.00	4.00
50	14.55	0.00	4.73
55	12.14	0.00	5.15
60	10.01	0.00	5.32
65	8.09	0.00	5.25
70	6.31	0.00	4.93
75	4.65	0.00	4.33
80	3.06	0.00	3.40
85	1.52	0.00	2.01
89	0.30	0.00	0.47



Maximum Value of P_A =	5.32	kips

Distribute this P_A over the depth of the wall on a per foot basis.



P1 = 0.63 kips/ft.

CLIENT:	Village of Barnesville
PROJECT:	Village of Barnesville - Trail Expansion
PROJECT NO.:	N4225393
CASE:	STA 13+65

Pile Spacing = 4 feet

Therefore contributing pressure for the wall section on each pier will be:

= 2.50 kips/ft.

= 208.75 lbs/in.

Perform L-pile Analysis:

Steel Section	Width, bf (in.)	Depth, d (in.)	Equivalent Diameter (in.)	Section Area ($in.^2$)	Ixx ($in.^4$)	Sxx (in.3)
HP 8 x 36	8.155	8.02	9.12	10.36	119	29.8
HP 10 x 42	10.075	9.7	11.15	12.4	210	43.4
HP 10 x 57	10.225	9.99	11.40	16.8	294	58.8
HP 12 x 53	12.045	11.78	13.44	15.5	393	66.8
HP 12 x 84	12.295	12.28	13.86	24.6	650	106
HP 14 x 73	14.585	13.61	15.90	21.4	729	107
HP 14 x 89	14.695	13.83	16.09	26.1	904	131
HP 14 x 117	14.885	14.21	16.41	34.4	1220	172
W 21 x 93	8.42	21.62	15.22	27.3	2070	192
W 21 x 132	12.44	21.83	18.59	38.8	3220	295
W 21 x 147	12.51	22.06	18.74	43.2	3630	329

Lpile Analyses: used HP14X89

Steel Section top displacement: 1.9 in (less than 1% of drilled shaft length above bedrock)

Bending Moment Check

Maximum bending moment from Lpile Analyses: 2.21E+06 in-lbs
184.36 kips-ft.

For 50 ksi steel
F_b allowable = 33 Ksi

S_{XX} (required) = 67 in^3

S_{XX} for selected section = 131 in^3 OK

==========

LPile for Windows, Version 2022-12.007

Analysis of Individual Piles and Drilled Shafts
Subjected to Lateral Loading Using the p-y Method

==========

This copy of LPile is being used by:

bkhalder
Terracon Consultants

Serial Number of Security Device: 138584418

This copy of LPile is licensed for exclusive use by:

Terracon, LPILE Global, Global License

Use of this software by employees of Terracon
other than those of the office site in LPILE Global, Global License
is a violation of the software license agreement.

Files Used for Analysis

Path to file locations:
\Projects\2022\N4225393\Working Files\Calculations-Analyses\LPILE\

Name of input data file:
Lpile Pile Wall N4225393- downslope wall.lp12d

Name of output report file:
Lpile Pile Wall N4225393- downslope wall.lp12o

Name of plot output file:
Lpile Pile Wall N4225393- downslope wall.lp12p

Name of runtime message file:
Lpile Pile Wall N4225393- downslope wall.lp12r

Date and Time of Analysis

Date: March 22, 2023 Time: 13:25:03

Problem Title

Village of Barnesville Pedestrian Trail

Job Number: N4225393

Client: Pennoni

Engineer: BKH

Description: STA 13+65 along bike path

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Analysis uses p-y modification factors for p-y curves
 - Analysis uses layering correction (Method of Georgiadis)
 - Analysis includes loading by multiple distributed lateral loads acting on pile
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1

- No p-y curves to be computed and reported for user-specified depths
- Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 31.500 ft
Depth of ground surface below top of pile = 17.0000 ft

Pile diameters used for p-y curve computations are defined using 4 points.

p-y curves are computed using pile diameter values interpolated with depth over the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	14.7000
2	17.000	14.7000
3	17.000	30.0000
4	31.500	30.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile
Cross-sectional Shape = Strong AISC Section Pile
Length of section = 17.000000 ft

AISC Section Type	=	HP
AISC Section Name	=	HP14X89
Flange Width	=	14.700000 in
Section Depth	=	13.800000 in
Flange Thickness	=	0.615000 in
Web Thickness	=	0.615000 in
Section Area	=	26.100000 sq. in
Moment of Inertia	=	904.000000 in^4
Elastic Modulus	=	29000000. psi

Pile Section No. 2:

Section 2 is an elastic pile		
Cross-sectional Shape	=	Circular Pile
Length of section	=	14.500000 ft
Width of top of section	=	30.000000 in
Width of bottom of section	=	30.000000 in
Top Area	=	26.100000 sq. in
Bottom Area	=	26.100000 sq. in
Moment of Inertia at Top	=	904.000000 in^4
Moment of Inertia at Bottom	=	904.000000 in^4
Elastic Modulus	=	29000000. psi

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	17.000000 ft
Distance from top of pile to bottom of layer	=	21.500000 ft
Effective unit weight at top of layer	=	125.000000 pcf
Effective unit weight at bottom of layer	=	125.000000 pcf
Undrained cohesion at top of layer	=	1000.000000 psf
Undrained cohesion at bottom of layer	=	1000.000000 psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 2 is weak rock, p-y criteria by Reese, 1997

Distance from top of pile to top of layer	=	21.500000 ft
Distance from top of pile to bottom of layer	=	40.000000 ft
Effective unit weight at top of layer	=	145.000000 pcf
Effective unit weight at bottom of layer	=	145.000000 pcf
Uniaxial compressive strength at top of layer	=	500.000000 psi
Uniaxial compressive strength at bottom of layer	=	500.000000 psi
Initial modulus of rock at top of layer	=	580000. psi
Initial modulus of rock at bottom of layer	=	580000. psi
RQD of rock at top of layer	=	78.000000 %
RQD of rock at bottom of layer	=	78.000000 %
k rm of rock at top of layer	=	0.0005000
k rm of rock at bottom of layer	=	0.0000500

(Depth of the lowest soil layer extends 8.500 ft below the pile tip)

Summary of Input Soil Properties

Layer	Soil Type	Layer	Effective	Cohesion	Uniaxial

Num.	Rock Mass Name (p-y Curve Type)	Depth ft	Unit Wt. pcf	qu psf	qu psi	RQD %	E50 or krm	Modulus psi
1	Stiff Clay w/o Free Water	17.0000	125.0000	1000.0000	--	--	0.00700	--
		21.5000	125.0000	1000.0000	--	--	0.00700	--
2	Weak Rock	21.5000	145.0000	--	500.0000	78.0000	5.00E-04	580000.
		40.0000	145.0000	--	500.0000	78.0000	5.00E-05	580000.

Modification Factors for p-y Curves

Distribution of p-y modifiers with depth defined using 3 points

Point No.	Depth X ft	p-mult	y-mult
1	23.500	0.7500	1.0000
2	27.500	0.7500	1.0000
3	27.500	1.0000	1.0000

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	17.000	208.750

Distributed lateral load intensity for Load Case 2 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	17.000	313.125

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load	Load	Condition	Condition	Axial Thrust	Compute
Top y	Run Analysis				

No.	Type	1	2	Force, lbs	vs. Pile Length	
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	Yes	Yes
2	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	No	Yes

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Moment-curvature properties were derived from elastic section properties

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	17.0000	0.00	N.A.	No	0.00	47184.
2	21.5000	4.5000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth	Deflect.	Bending	Shear	Slope	Total	Bending	Soil Res. Soil Spr.	Distrib.

X	y	Moment	Force	S	Stress	Stiffness	p	Es*H	Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	1.9048	1.26E-05	0.00	-0.00870	1.03E-07	2.62E+10	0.00	0.00	0.9670
0.3150	1.8719	6.9085	9.1382	-0.00870	0.05617	2.62E+10	0.00	0.00	3.8680
0.6300	1.8390	69.0847	31.0698	-0.00870	0.5617	2.62E+10	0.00	0.00	7.7360
0.9450	1.8061	241.7964	67.6226	-0.00870	1.9659	2.62E+10	0.00	0.00	11.6040
1.2600	1.7732	580.3113	118.7964	-0.00870	4.7182	2.62E+10	0.00	0.00	15.4721
1.5750	1.7404	1140.	184.5913	-0.00870	9.2680	2.62E+10	0.00	0.00	19.3401
1.8900	1.7075	1976.	265.0074	-0.00870	16.0645	2.62E+10	0.00	0.00	23.2081
2.2050	1.6746	3143.	360.0445	-0.00870	25.5571	2.62E+10	0.00	0.00	27.0761
2.5200	1.6417	4698.	469.7027	-0.00870	38.1953	2.62E+10	0.00	0.00	30.9441
2.8350	1.6089	6694.	593.9820	-0.00870	54.4283	2.62E+10	0.00	0.00	34.8121
3.1500	1.5760	9188.	732.8824	-0.00869	74.7054	2.62E+10	0.00	0.00	38.6801
3.4650	1.5431	12235.	886.4039	-0.00869	99.4762	2.62E+10	0.00	0.00	42.5482
3.7800	1.5103	15889.	1055.	-0.00869	129.1899	2.62E+10	0.00	0.00	46.4162
4.0950	1.4774	20207.	1237.	-0.00869	164.2958	2.62E+10	0.00	0.00	50.2842
4.4100	1.4446	25244.	1435.	-0.00869	205.2434	2.62E+10	0.00	0.00	54.1522
4.7250	1.4117	31054.	1647.	-0.00868	252.4819	2.62E+10	0.00		

```
0.00    58.0202
  5.0400     1.3789     37693.      1873.   -0.00868   306.4608   2.62E+10       0.00
0.00    61.8882
  5.3550     1.3462     45216.      2115.   -0.00867   367.6294   2.62E+10       0.00
0.00    65.7563
  5.6700     1.3134     53679.      2370.   -0.00866   436.4371   2.62E+10       0.00
0.00    69.6243
  5.9850     1.2807     63136.      2641.   -0.00865   513.3332   2.62E+10       0.00
0.00    73.4923
  6.3000     1.2480     73644.      2926.   -0.00865   598.7670   2.62E+10       0.00
0.00    77.3603
  6.6150     1.2153     85257.      3226.   -0.00863   693.1879   2.62E+10       0.00
0.00    81.2283
  6.9300     1.1827     98031.      3540.   -0.00862   797.0454   2.62E+10       0.00
0.00    85.0963
  7.2450     1.1501    112021.      3869.   -0.00861   910.7886   2.62E+10       0.00
0.00    88.9643
  7.5600     1.1176    127282.      4213.   -0.00859      1035.   2.62E+10       0.00
0.00    92.8324
  7.8750     1.0852    143869.      4571.   -0.00857      1170.   2.62E+10       0.00
0.00    96.7004
  8.1900     1.0529    161838.      4944.   -0.00855      1316.   2.62E+10       0.00
0.00   100.5684
  8.5050     1.0206    181244.      5331.   -0.00852      1474.   2.62E+10       0.00
0.00   104.4364
  8.8200     0.9884    202142.      5733.   -0.00849      1644.   2.62E+10       0.00
0.00   108.3044
  9.1350     0.9564    224587.      6150.   -0.00846      1826.   2.62E+10       0.00
0.00   112.1724
  9.4500     0.9244    248636.      6581.   -0.00843      2022.   2.62E+10       0.00
0.00   116.0404
  9.7650     0.8927    274342.      7027.   -0.00839      2231.   2.62E+10       0.00
0.00   119.9085
 10.0800     0.8610    301762.      7488.   -0.00835      2453.   2.62E+10       0.00
0.00   123.7765
 10.3950     0.8295    330950.      7963.   -0.00830      2691.   2.62E+10       0.00
0.00   127.6445
```

10.7100	0.7982	361962.	8453.	-0.00825	2943.	2.62E+10	0.00
0.00	131.5125						
11.0250	0.7671	394853.	8957.	-0.00820	3210.	2.62E+10	0.00
0.00	135.3805						
11.3400	0.7362	429679.	9476.	-0.00814	3494.	2.62E+10	0.00
0.00	139.2485						
11.6550	0.7056	466494.	10010.	-0.00808	3793.	2.62E+10	0.00
0.00	143.1165						
11.9700	0.6752	505354.	10558.	-0.00801	4109.	2.62E+10	0.00
0.00	146.9846						
12.2850	0.6451	546315.	11121.	-0.00793	4442.	2.62E+10	0.00
0.00	150.8526						
12.6000	0.6152	589430.	11699.	-0.00785	4792.	2.62E+10	0.00
0.00	154.7206						
12.9150	0.5857	634757.	12291.	-0.00776	5161.	2.62E+10	0.00
0.00	158.5886						
13.2300	0.5566	682349.	12898.	-0.00766	5548.	2.62E+10	0.00
0.00	162.4566						
13.5450	0.5278	732263.	13519.	-0.00756	5954.	2.62E+10	0.00
0.00	166.3246						
13.8600	0.4994	784553.	14155.	-0.00745	6379.	2.62E+10	0.00
0.00	170.1926						
14.1750	0.4714	839275.	14806.	-0.00734	6824.	2.62E+10	0.00
0.00	174.0607						
14.4900	0.4439	896484.	15471.	-0.00721	7289.	2.62E+10	0.00
0.00	177.9287						
14.8050	0.4169	956236.	16151.	-0.00708	7775.	2.62E+10	0.00
0.00	181.7967						
15.1200	0.3904	1018584.	16845.	-0.00694	8282.	2.62E+10	0.00
0.00	185.6647						
15.4350	0.3645	1083586.	17554.	-0.00678	8810.	2.62E+10	0.00
0.00	189.5327						
15.7500	0.3391	1151296.	18278.	-0.00662	9361.	2.62E+10	0.00
0.00	193.4007						
16.0650	0.3144	1221769.	19017.	-0.00645	9934.	2.62E+10	0.00
0.00	197.2687						
16.3800	0.2904	1295061.	19770.	-0.00627	10530.	2.62E+10	0.00

```
  0.00   201.1368
   16.6950     0.2670   1371227.     20537.   -0.00608     11149.   2.62E+10       0.00
  0.00   205.0048
   17.0100     0.2444   1450322.     20620.   -0.00587     24065.   2.62E+10   -258.414
3996.    97.3240
   17.3250     0.2226   1527116.     19822.   -0.00566     25339.   2.62E+10   -261.051
4433.       0.00
   17.6400     0.2016   1600179.     18832.   -0.00543     26552.   2.62E+10   -263.066
4932.       0.00
   17.9550     0.1815   1669483.     17835.   -0.00520     27702.   2.62E+10   -264.425
5506.       0.00
   18.2700     0.1623   1735010.     16834.   -0.00495     28789.   2.62E+10   -265.091
6173.       0.00
   18.5850     0.1441   1796748.     15832.   -0.00470     29813.   2.62E+10   -265.022
6953.       0.00
   18.9000     0.1268   1854700.     14832.   -0.00444     30775.   2.62E+10   -264.172
7875.       0.00
   19.2150     0.1105   1908877.     13837.   -0.00416     31674.   2.62E+10   -262.486
8976.       0.00
   19.5300    0.09532   1959304.     12849.   -0.00389     32511.   2.62E+10   -259.905
10306.       0.00
   19.8450    0.08117   2006017.     11873.   -0.00360     33286.   2.62E+10   -256.357
11938.       0.00
   20.1600    0.06811   2049068.     10913.   -0.00331     34000.   2.62E+10   -251.760
13972.       0.00
   20.4750    0.05617   2088520.      9972.   -0.00301     34655.   2.62E+10   -246.015
16555.       0.00
   20.7900    0.04537   2124458.      9056.   -0.00270     35251.   2.62E+10   -239.005
19914.       0.00
   21.1050    0.03572   2156981.      8168.   -0.00240     35791.   2.62E+10   -230.588
24400.       0.00
   21.4200    0.02725   2186209.      7315.   -0.00208     36276.   2.62E+10   -220.594
30598.       0.00
   21.7350    0.01997   2212285.     -1397.   -0.00177     36708.   2.62E+10     -4389.
830611.       0.00
   22.0500    0.01390   2175651.    -18483.   -0.00145     36100.   2.62E+10     -4652.
1264967.       0.00
```

22.3650	0.00901	2072552.	-36264.	-0.00114	34390.	2.62E+10	-4756.
1994616.	0.00						
22.6800	0.00526	1901494.	-54078.	-8.57E-04	31551.	2.62E+10	-4669.
3357913.	0.00						
22.9950	0.00254	1663722.	-71072.	-6.00E-04	27606.	2.62E+10	-4322.
6445294.	0.00						
23.3100	7.21E-04	1364190.	-85810.	-3.82E-04	22636.	2.62E+10	-3475.
1.82E+07	0.00						
23.6250	-3.50E-04	1014999.	-87895.	-2.10E-04	16842.	2.62E+10	2372.
2.56E+07	0.00						
23.9400	-8.68E-04	699700.	-77303.	-8.65E-05	11610.	2.62E+10	3233.
1.41E+07	0.00						
24.2550	-0.00100	430589.	-64354.	-4.98E-06	7145.	2.62E+10	3619.
1.36E+07	0.00						
24.5700	-9.05E-04	213185.	-50355.	4.14E-05	3537.	2.62E+10	3788.
1.58E+07	0.00						
24.8850	-6.91E-04	49907.	-36037.	6.04E-05	828.1005	2.62E+10	3787.
2.07E+07	0.00						
25.2000	-4.49E-04	-59259.	-22031.	5.97E-05	983.2756	2.62E+10	3624.
3.05E+07	0.00						
25.5150	-2.39E-04	-116644.	-8965.	4.70E-05	1935.	2.62E+10	3289.
5.20E+07	0.00						
25.8300	-9.30E-05	-127032.	2453.	2.95E-05	2108.	2.62E+10	2752.
1.12E+08	0.00						
26.1450	-1.62E-05	-98099.	11204.	1.32E-05	1628.	2.62E+10	1878.
4.38E+08	0.00						
26.4600	7.12E-06	-42333.	11907.	3.12E-06	702.4293	2.62E+10	-1506.
7.99E+08	0.00						
26.7750	7.37E-06	-8080.	5981.	-5.17E-07	134.0635	2.62E+10	-1630.
8.36E+08	0.00						
27.0900	3.21E-06	2885.	1498.	-8.91E-07	47.8765	2.62E+10	-742.156
8.73E+08	0.00						
27.4050	6.31E-07	3246.	-191.670	-4.49E-07	53.8614	2.62E+10	-151.900
9.10E+08	0.00						
27.7200	-1.82E-07	1436.	-392.431	-1.12E-07	23.8329	2.62E+10	45.6770
9.47E+08	0.00						
28.0350	-2.13E-07	279.2680	-201.293	1.20E-08	4.6339	2.62E+10	55.4544

```
9.83E+08       0.00
   28.3500  -9.17E-08    -85.442    -49.705   2.60E-08     1.4177   2.62E+10    24.7510
1.02E+09       0.00
   28.6650  -1.68E-08    -96.499     5.9633   1.29E-08     1.6012   2.62E+10     4.7029
1.06E+09       0.00
   28.9800   5.48E-09    -40.359    11.8567   2.99E-09     0.6697   2.62E+10     -1.585
1.09E+09       0.00
   29.2950   5.77E-09     -6.863     5.6967  -4.16E-10     0.1139   2.62E+10     -1.674
1.10E+09       0.00
   29.6100   2.33E-09     2.7082     1.2543  -7.16E-10    0.04494   2.62E+10     -0.676
1.10E+09       0.00
   29.9250   3.64E-10     2.6195     -0.223  -3.31E-10    0.04347   2.62E+10     -0.106
1.10E+09       0.00
   30.2400  -1.75E-10     1.0209     -0.327  -6.90E-11    0.01694   2.62E+10    0.05066
1.10E+09       0.00
   30.5550  -1.57E-10     0.1462     -0.145   1.51E-11    0.00243   2.62E+10    0.04564
1.10E+09       0.00
   30.8700  -6.04E-11   -0.07648   -0.02579   2.01E-11    0.00127   2.62E+10    0.01752
1.10E+09       0.00
   31.1850  -5.11E-12   -0.04883    0.01012   1.11E-11   8.10E-04   2.62E+10    0.00148
1.10E+09       0.00
   31.5000   2.36E-11       0.00       0.00   7.59E-12       0.00   2.62E+10   -0.00683
5.48E+08       0.00

* The above values of total stress are combined axial and bending stresses.


Output Summary for Load Case No. 1:

Pile-head deflection            =     1.90475322 inches
Computed slope at pile head     =     -0.0086983 radians
Maximum bending moment          =       2212285. inch-lbs
Maximum shear force             =        -87895. lbs
Depth of maximum bending moment =    21.73500000 feet below pile head
Depth of maximum shear force    =    23.62500000 feet below pile head
Number of iterations            =             26
Number of zero deflection points =             6
```

Pile deflection at ground = 0.24513288 inches

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

Shear = 0. lbs
Moment = 0. in-lbs
Axial Load = 0. lbs

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
31.50000	1.90475322	2212285.	-87895.
29.92500	1.87523109	2211363.	-86981.
28.35000	1.87296769	2204620.	-87057.
26.77500	1.91610357	2234190.	-89234.
25.20000	1.94819108	2229407.	-92703.
23.62500	18.19616419	1829673.	-124727.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. p	Soil Spr. Es*H	Distrib. Lat. Load
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	3.0622	-9.78E-06	0.00	-0.01379	7.95E-08	2.62E+10	0.00	0.00	1.4505
0.3150	3.0100	10.3627	13.7073	-0.01379	0.08425	2.62E+10	0.00	0.00	5.8020
0.6300	2.9579	103.6270	46.6047	-0.01379	0.8425	2.62E+10	0.00	0.00	11.6040
0.9450	2.9058	362.6946	101.4339	-0.01379	2.9489	2.62E+10	0.00	0.00	17.4061
1.2600	2.8537	870.4669	178.1946	-0.01379	7.0774	2.62E+10	0.00	0.00	23.2081
1.5750	2.8016	1710.	276.8870	-0.01379	13.9020	2.62E+10	0.00	0.00	29.0101
1.8900	2.7495	2964.	397.5110	-0.01379	24.0967	2.62E+10	0.00	0.00	34.8121
2.2050	2.6973	4715.	540.0667	-0.01379	38.3357	2.62E+10	0.00	0.00	40.6142
2.5200	2.6452	7047.	704.5540	-0.01379	57.2929	2.62E+10	0.00	0.00	46.4162
2.8350	2.5931	10041.	890.9730	-0.01378	81.6424	2.62E+10	0.00	0.00	52.2182
3.1500	2.5410	13782.	1099.	-0.01378	112.0582	2.62E+10	0.00	0.00	58.0202
3.4650	2.4889	18352.	1330.	-0.01378	149.2143	2.62E+10	0.00	0.00	63.8222
3.7800	2.4368	23834.	1582.	-0.01378	193.7848	2.62E+10	0.00	0.00	69.6243
4.0950	2.3848	30311.	1856.	-0.01377	246.4437	2.62E+10	0.00	0.00	75.4263

```
  4.4100     2.3327     37865.      2152.   -0.01377   307.8651   2.62E+10       0.00
0.00    81.2283
  4.7250     2.2807     46580.      2470.   -0.01376   378.7229   2.62E+10       0.00
0.00    87.0303
  5.0400     2.2287     56539.      2810.   -0.01375   459.6913   2.62E+10       0.00
0.00    92.8324
  5.3550     2.1767     67824.      3172.   -0.01375   551.4442   2.62E+10       0.00
0.00    98.6344
  5.6700     2.1248     80518.      3556.   -0.01374   654.6556   2.62E+10       0.00
0.00   104.4364
  5.9850     2.0729     94705.      3961.   -0.01372   769.9997   2.62E+10       0.00
0.00   110.2384
  6.3000     2.0210    110466.      4389.   -0.01371   898.1505   2.62E+10       0.00
0.00   116.0404
  6.6150     1.9692    127886.      4839.   -0.01369      1040.   2.62E+10       0.00
0.00   121.8425
  6.9300     1.9175    147047.      5310.   -0.01367      1196.   2.62E+10       0.00
0.00   127.6445
  7.2450     1.8659    168031.      5804.   -0.01365      1366.   2.62E+10       0.00
0.00   133.4465
  7.5600     1.8143    190922.      6319.   -0.01362      1552.   2.62E+10       0.00
0.00   139.2485
  7.8750     1.7629    215803.      6856.   -0.01359      1755.   2.62E+10       0.00
0.00   145.0506
  8.1900     1.7116    242757.      7416.   -0.01356      1974.   2.62E+10       0.00
0.00   150.8526
  8.5050     1.6604    271865.      7997.   -0.01352      2210.   2.62E+10       0.00
0.00   156.6546
  8.8200     1.6093    303213.      8600.   -0.01348      2465.   2.62E+10       0.00
0.00   162.4566
  9.1350     1.5585    336881.      9225.   -0.01344      2739.   2.62E+10       0.00
0.00   168.2586
  9.4500     1.5078    372954.      9872.   -0.01338      3032.   2.62E+10       0.00
0.00   174.0607
  9.7650     1.4573    411513.     10541.   -0.01333      3346.   2.62E+10       0.00
0.00   179.8627
 10.0800     1.4070    452643.     11232.   -0.01327      3680.   2.62E+10       0.00
```

0.00   185.6647
 10.3950   1.3570   496425.   11945.   -0.01320   4036.   2.62E+10   0.00
0.00   191.4667
 10.7100   1.3072   542943.   12679.   -0.01312   4414.   2.62E+10   0.00
0.00   197.2687
 11.0250   1.2578   592280.   13436.   -0.01304   4816.   2.62E+10   0.00
0.00   203.0708
 11.3400   1.2087   644519.   14214.   -0.01295   5240.   2.62E+10   0.00
0.00   208.8728
 11.6550   1.1599   699741.   15015.   -0.01285   5689.   2.62E+10   0.00
0.00   214.6748
 11.9700   1.1115   758032.   15837.   -0.01275   6163.   2.62E+10   0.00
0.00   220.4768
 12.2850   1.0635   819472.   16682.   -0.01263   6663.   2.62E+10   0.00
0.00   226.2789
 12.6000   1.0160   884146.   17548.   -0.01251   7189.   2.62E+10   0.00
0.00   232.0809
 12.9150   0.9689   952135.   18436.   -0.01238   7741.   2.62E+10   0.00
0.00   237.8829
 13.2300   0.9224   1023524.   19346.   -0.01224   8322.   2.62E+10   0.00
0.00   243.6849
 13.5450   0.8764   1098395.   20279.   -0.01208   8931.   2.62E+10   0.00
0.00   249.4869
 13.8600   0.8310   1176830.   21233.   -0.01192   9568.   2.62E+10   0.00
0.00   255.2890
 14.1750   0.7863   1258913.   22209.   -0.01174   10236.   2.62E+10   0.00
0.00   261.0910
 14.4900   0.7422   1344726.   23206.   -0.01156   10933.   2.62E+10   0.00
0.00   266.8930
 14.8050   0.6989   1434353.   24226.   -0.01136   11662.   2.62E+10   0.00
0.00   272.6950
 15.1200   0.6564   1527877.   25268.   -0.01114   12422.   2.62E+10   0.00
0.00   278.4971
 15.4350   0.6147   1625379.   26332.   -0.01092   13215.   2.62E+10   0.00
0.00   284.2991
 15.7500   0.5739   1726944.   27417.   -0.01067   14041.   2.62E+10   0.00
0.00   290.1011

```
  16.0650     0.5340   1832654.     28525.   -0.01042     14900.   2.62E+10       0.00
 0.00   295.9031
  16.3800     0.4951   1942592.     29654.   -0.01015     15794.   2.62E+10       0.00
 0.00   301.7051
  16.6950     0.4573   2056841.     30806.   -0.00986     16723.   2.62E+10       0.00
 0.00   307.5072
  17.0100     0.4206   2175483.     31103.   -0.00955     36098.   2.62E+10   -295.967
2660.   145.9859
  17.3250     0.3851   2291983.     30254.   -0.00923     38031.   2.62E+10   -299.380
2939.       0.00
  17.6400     0.3508   2404205.     29117.   -0.00889     39893.   2.62E+10   -302.127
3256.       0.00
  17.9550     0.3178   2512110.     27971.   -0.00854     41683.   2.62E+10   -304.174
3617.       0.00
  18.2700     0.2863   2615669.     26819.   -0.00817     43402.   2.62E+10   -305.483
4034.       0.00
  18.5850     0.2561   2714863.     25663.   -0.00778     45048.   2.62E+10   -306.010
4517.       0.00
  18.9000     0.2274   2809684.     24507.   -0.00738     46621.   2.62E+10   -305.710
5081.       0.00
  19.2150     0.2003   2900138.     23354.   -0.00697     48122.   2.62E+10   -304.528
5748.       0.00
  19.5300     0.1747   2986240.     22207.   -0.00655     49550.   2.62E+10   -302.405
6543.       0.00
  19.8450     0.1508   3068021.     21070.   -0.00611     50907.   2.62E+10   -299.274
7503.       0.00
  20.1600     0.1285   3145527.     19946.   -0.00566     52193.   2.62E+10   -295.054
8679.       0.00
  20.4750     0.1079   3218816.     18841.   -0.00521     53410.   2.62E+10   -289.655
10143.      0.00
  20.7900    0.08915   3287967.     17759.   -0.00474     54557.   2.62E+10   -282.972
11998.      0.00
  21.1050    0.07214   3353074.     16705.   -0.00426     55637.   2.62E+10   -274.881
14403.      0.00
  21.4200    0.05696   3414254.     15684.   -0.00377     56652.   2.62E+10   -265.238
17601.      0.00
  21.7350    0.04364   3471644.      5098.   -0.00327     57605.   2.62E+10     -5336.
```

```
462139.       0.00
   22.0500    0.03222   3452791.    -15835.   -0.00277     57292.   2.62E+10     -5739.
673372.       0.00
   22.3650    0.02267   3351931.    -38003.   -0.00228     55618.   2.62E+10     -5990.
998513.       0.00
   22.6800    0.01496   3165489.    -60784.   -0.00181     52525.   2.62E+10     -6064.
1532481.      0.00
   22.9950    0.00896   2892404.    -83446.   -0.00138     47993.   2.62E+10     -5927.
2498904.      0.00
   23.3100    0.00455   2534639.   -105052.  -9.85E-04     42057.   2.62E+10     -5506.
4574639.      0.00
   23.6250    0.00151   2098208.   -121934.  -6.51E-04     34815.   2.62E+10     -3427.
8550096.      0.00
   23.9400  -3.76E-04   1612814.   -123459.  -3.84E-04     26761.   2.62E+10      2620.
2.64E+07      0.00
   24.2550   -0.00139   1164861.   -111090.  -1.84E-04     19328.   2.62E+10      3924.
1.07E+07      0.00
   24.5700   -0.00176    772974.    -95214.  -4.39E-05     12826.   2.62E+10      4476.
9591079.      0.00
   24.8850   -0.00172    445043.    -77762.   4.39E-05      7385.   2.62E+10      4758.
1.05E+07      0.00
   25.2000   -0.00143    185094.    -59613.   8.93E-05      3071.   2.62E+10      4845.
1.28E+07      0.00
   25.5150   -0.00104     -5630.    -41466.   1.02E-04    93.4147   2.62E+10      4756.
1.72E+07      0.00
   25.8300  -6.60E-04   -128391.    -23987.   9.26E-05      2130.   2.62E+10      4492.
2.57E+07      0.00
   26.1450  -3.45E-04   -186970.     -7870.   6.98E-05      3102.   2.62E+10      4036.
4.43E+07      0.00
   26.4600  -1.32E-04   -187886.      6079.   4.28E-05      3118.   2.62E+10      3345.
9.60E+07      0.00
   26.7750  -2.11E-05   -141009.     16609.   1.91E-05      2340.   2.62E+10      2226.
3.99E+08      0.00
   27.0900   1.27E-05    -62325.     16927.   4.44E-06      1034.   2.62E+10     -2058.
6.12E+08      0.00
   27.4050   1.25E-05    -13040.      8977.  -9.94E-07   216.3782   2.62E+10     -2149.
6.50E+08      0.00
```

27.7200	5.18E-06	5545.	2463.	-1.53E-06	92.0022	2.62E+10	-1298.
9.47E+08	0.00						
28.0350	8.94E-07	5584.	-429.323	-7.32E-07	92.6467	2.62E+10	-232.592
9.83E+08	0.00						
28.3500	-3.52E-07	2299.	-689.232	-1.64E-07	38.1469	2.62E+10	95.0738
1.02E+09	0.00						
28.6650	-3.46E-07	372.9170	-326.892	2.87E-08	6.1878	2.62E+10	96.6404
1.06E+09	0.00						
28.9800	-1.36E-07	-172.315	-70.039	4.31E-08	2.8592	2.62E+10	39.2603
1.09E+09	0.00						
29.2950	-1.97E-08	-156.579	14.9407	1.94E-08	2.5981	2.62E+10	5.7025
1.10E+09	0.00						
29.6100	1.10E-08	-59.363	19.6881	3.83E-09	0.9850	2.62E+10	-3.191
1.10E+09	0.00						
29.9250	9.31E-09	-7.737	8.5525	-1.00E-09	0.1284	2.62E+10	-2.701
1.10E+09	0.00						
30.2400	3.41E-09	5.2937	1.5784	-1.18E-09	0.08784	2.62E+10	-0.989
1.10E+09	0.00						
30.5550	3.90E-10	4.1961	-0.504	-4.96E-10	0.06962	2.62E+10	-0.113
1.10E+09	0.00						
30.8700	-3.42E-10	1.4820	-0.530	-8.70E-11	0.02459	2.62E+10	0.09932
1.10E+09	0.00						
31.1850	-2.67E-10	0.1871	-0.196	3.34E-11	0.00310	2.62E+10	0.07754
1.10E+09	0.00						
31.5000	-9.03E-11	0.00	0.00	4.68E-11	0.00	2.62E+10	0.02618
5.48E+08	0.00						

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 2:

Pile-head deflection = 3.06215130 inches
Computed slope at pile head = -0.0137876 radians
Maximum bending moment = 3471644. inch-lbs
Maximum shear force = -123459. lbs
Depth of maximum bending moment = 21.73500000 feet below pile head

Depth of maximum shear force = 23.94000000 feet below pile head
Number of iterations = 29
Number of zero deflection points = 6
Pile deflection at ground = 0.42174061 inches

Summary of Pile-head Responses for Conventional Analyses

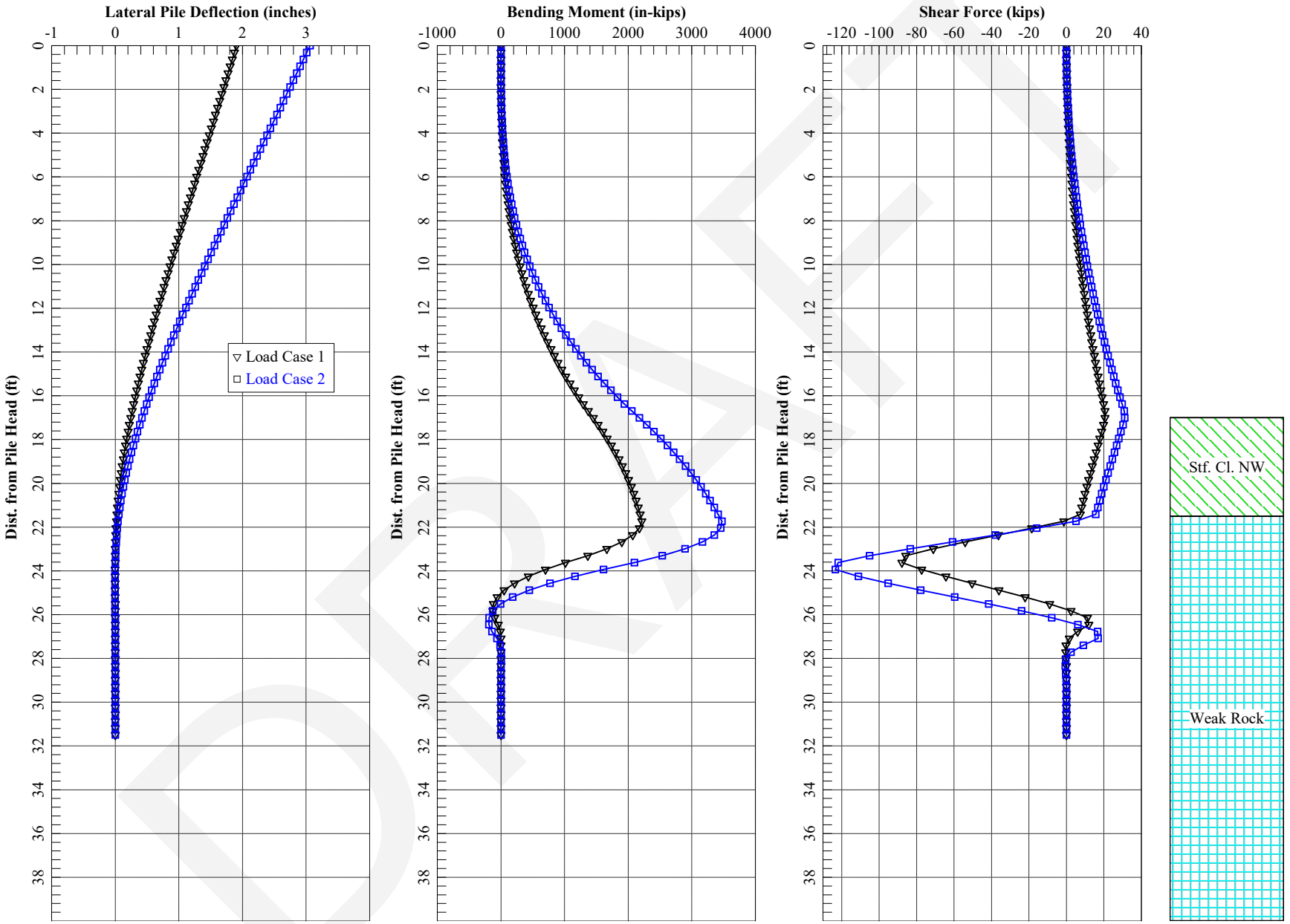
Definitions of Pile-head Loading Conditions:

Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type	Load 1	Load Type	Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.9048	-0.00870	-87895.	2212285.
2	V, lb	0.00	M, in-lb	0.00	0.00	3.0622	-0.01379	-123459.	3471644.

Maximum pile-head deflection = 3.0621513008 inches
Maximum pile-head rotation = -0.0137875597 radians = -0.789969 deg.

The analysis ended normally.


Lateral Pile Deflection (inches)
Bending Moment (in-kips)
Shear Force (kips)
Dist. from Pile Head (ft)
Load Case 1
Load Case 2
Stf. Cl. NW
Weak Rock

UCS and RQD Data

Boring	RQD	Run Length (ft)	
B-001	87	5	435
	73	5	365
B-002	60	5	300
	93	5	465
B-003	68	5	340
	80	5	400
			0
Total		30	2305

W. Average	77

Boring	Depth	UCS (ksf)
B-001	12.4'	575
B-002	10'	619
B-002	11.3'	678
B-003	35.5'	576

Average	612

Rock Mass Rating (RMR) per LRFD Table 10.4.6.4-1 Per Section 10 LRFD 5th Edition

	Relative Rating
Strength of Rock	
612	4
RQD	
77	17
Maximum Spacing of Joints (in.)	
13	20
Condition of Joints	12
GW Condition	7
Total	60
Adj for Joint Orientation	8
RMR	52
Class	3
Rock Type	Fair Rock

Choose appropriate m and s paramters Per LRFD Table 10.4.6.4-4 (See Ref.)

m	0.03
s	0.000003

Elastic Modulus of the Rock (LRFD 5th Edition Equation 10.4.6.4-1)

E	4.00 GPA
	5.8E+05 psi

PROJECT: VILLAGE OF BARNESVILLE Page 1 of 1

JOB NO. N4225393 Date 2/13/2023 Comp. By BKH CHECKED BY: KME

EARTH PRESSURE AT REST (PILE ALONG THE SLOPE)

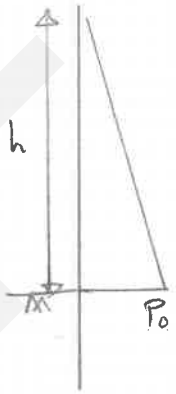
ASSUME RETAINED HT (h) = 15' (av.)

ϕ of BACKFILL = 32°

Unit wt. Backfill = 120 pcf

$K_o = 1 - \sin\phi = 0.47$

pile spacing s = 8 ft c/c



- PRESSURE FOR THE WALL SECTION ON EACH PIER

$P_o = \frac{1}{2} K_o \gamma h s/12 = 282$ lb/in (LOAD CASE 1 SERVICE; LOAD CASE 2 STRENGTH)

TOP DISPLACEMENT = 1.9" (USING HP 14X89)

MAX^m BENDING MOMENT FROM L-PILE ANALYSIS = 2550 k-in (Service)

= 3541 k-in (Strength)

$\Rightarrow \phi_b M_n = 0.9 \times 50 \times 146 \approx 6,570$ k-in > 3,541 k-in (ok)

DESIGN IS ADEQUATE

USE HP 14X89

PILE ALONG THE SLOPE

```
================================================================================

                    LPile for Windows, Version 2022-12.007

                 Analysis of Individual Piles and Drilled Shafts
                Subjected to Lateral Loading Using the p-y Method
                           © 1985-2022 by Ensoft, Inc.
                               All Rights Reserved

================================================================================

This copy of LPile is being used by:

bkhalder
Terracon Consultants


Serial Number of Security Device: 138584418

This copy of LPile is licensed for exclusive use by:

Terracon, LPILE Global, Global License

Use of this software by employees of Terracon
other than those of the office site in LPILE Global, Global License
is a violation of the software license agreement.

--------------------------------------------------------------------------------
                            Files Used for Analysis
--------------------------------------------------------------------------------

Path to file locations:
\Projects\2022\N4225393\Working Files\Calculations-Analyses\LPILE\

Name of input data file:
```

Lpile Pile Wall N4225393- along the slope.lp12d

Name of output report file:
Lpile Pile Wall N4225393- along the slope.lp12o

Name of plot output file:
Lpile Pile Wall N4225393- along the slope.lp12p

Name of runtime message file:
Lpile Pile Wall N4225393- along the slope.lp12r

Date and Time of Analysis

Date: February 14, 2023 Time: 7:25:12

Problem Title

Village of Barnesville Pedestrian Trail

Job Number: N4225393

Client: Pennoni

Engineer: BKH

Description:

Program Options and Settings

Computational Options:
 - Conventional Analysis
Engineering Units Used for Data Input and Computations:
 - US Customary System Units (pounds, feet, inches)

Analysis Control Options:

- Maximum number of iterations allowed	=	500
- Deflection tolerance for convergence	=	1.0000E-05 in
- Maximum allowable deflection	=	100.0000 in
- Number of pile increments	=	100

Loading Type and Number of Cycles of Loading:
 - Static loading specified

 - Use of p-y modification factors for p-y curves not selected
 - Analysis uses layering correction (Method of Georgiadis)
 - Analysis includes loading by multiple distributed lateral loads acting on pile
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

Output Options:
 - Output files use decimal points to denote decimal symbols.
 - Values of pile-head deflection, bending moment, shear force, and
   soil reaction are printed for full length of pile.
 - Printing Increment (nodal spacing of output points) = 1
 - No p-y curves to be computed and reported for user-specified depths
 - Print using wide report formats

Pile Structural Properties and Geometry

Number of pile sections defined = 1
Total length of pile = 30.000 ft
Depth of ground surface below top of pile = 15.0000 ft

Pile diameters used for p-y curve computations are defined using 2 points.

p-y curves are computed using pile diameter values interpolated with depth over
the length of the pile. A summary of values of pile diameter vs. depth follows.

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	24.0000
2	30.000	24.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is an elastic pile		
Cross-sectional Shape	=	Circular Pile
Length of section	=	30.000000 ft
Width of top of section	=	24.000000 in
Width of bottom of section	=	24.000000 in
Top Area	=	26.100000 sq. in
Bottom Area	=	26.100000 sq. in
Moment of Inertia at Top	=	904.000000 in^4
Moment of Inertia at Bottom	=	904.000000 in^4
Elastic Modulus	=	29000000. psi

Soil and Rock Layering Information

The soil profile is modelled using 2 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	15.000000 ft
Distance from top of pile to bottom of layer	=	19.500000 ft
Effective unit weight at top of layer	=	125.000000 pcf
Effective unit weight at bottom of layer	=	125.000000 pcf
Undrained cohesion at top of layer	=	1000.000000 psf
Undrained cohesion at bottom of layer	=	1000.000000 psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

Layer 2 is weak rock, p-y criteria by Reese, 1997

```
   Distance from top of pile to top of layer          =    19.500000 ft
   Distance from top of pile to bottom of layer       =    40.000000 ft
   Effective unit weight at top of layer              =   145.000000 pcf
   Effective unit weight at bottom of layer           =   145.000000 pcf
   Uniaxial compressive strength at top of layer      =   500.000000 psi
   Uniaxial compressive strength at bottom of layer   =   500.000000 psi
   Initial modulus of rock at top of layer            =      580000. psi
   Initial modulus of rock at bottom of layer         =      580000. psi
   RQD of rock at top of layer                        =    78.000000 %
   RQD of rock at bottom of layer                     =    78.000000 %
   k rm of rock at top of layer                       =    0.0005000
   k rm of rock at bottom of layer                    =    0.0000500


 (Depth of the lowest soil layer extends 10.000 ft below the pile tip)
```

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Uniaxial qu psi	RQD %	E50 or Rock Mass Modulus krm psi
1	Stiff Clay w/o Free Water	15.0000 19.5000	125.0000 125.0000	1000.0000 1000.0000	-- --	-- --	0.00700 0.00700

2	Weak	19.5000	145.0000	--	500.0000	78.0000
5.00E-04	580000.					
	Rock	40.0000	145.0000	--	500.0000	78.0000
5.00E-05	580000.					

Static Loading Type

Static loading criteria were used when computing p-y curves for all analyses.

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	15.000	282.000

Distributed lateral load intensity for Load Case 2 defined using 2 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	0.000
2	15.000	380.700

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 2

Load No.	Load Run Analysis Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1 Yes	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	Yes
2	1 Yes	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000	No

V = shear force applied normal to pile axis
M = bending moment applied to pile head
y = lateral deflection normal to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applied to pile head
Values of top y vs. pile lengths can be computed only for load types with
specified shear loading (Load Types 1, 2, and 3).
Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

Axial thrust force values were determined from pile-head loading conditions

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

---

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs
1	15.0000	0.00	N.A.	No	0.00	39049.
2	19.5000	4.5000	No	Yes	N.A.	N.A.

Notes: The F0 integral of Layer n+1 equals the sum of the F0 and F1 integrals for Layer n. Layering correction equivalent depths are computed only for soil types with both shallow-depth and deep-depth expressions for peak lateral load transfer. These soil types are soft and stiff clays, non-liquefied sands, and cemented c-phi soil.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 1

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Distrib. Es*H lb/inch	Lat. Load lb/inch
0.00	1.8908	2.29E-05	6.24E-08	-0.00939	3.04E-07	2.62E+10	0.00	0.00	1.4100
0.3000	1.8569	9.1368	12.6900	-0.00939	0.1213	2.62E+10	0.00	0.00	5.6400
0.6000	1.8231	91.3680	43.1460	-0.00939	1.2128	2.62E+10	0.00	0.00	11.2800
0.9000	1.7893	319.7880	93.9060	-0.00939	4.2450	2.62E+10	0.00	0.00	16.9200
1.2000	1.7555	767.4912	164.9700	-0.00939	10.1879	2.62E+10	0.00	0.00	22.5600
1.5000	1.7217	1508.	256.3380	-0.00939	20.0120	2.62E+10	0.00	0.00	28.2000
1.8000	1.6879	2613.	368.0100	-0.00939	34.6875	2.62E+10	0.00	0.00	33.8400
2.1000	1.6540	4157.	499.9860	-0.00939	55.1847	2.62E+10	0.00	0.00	39.4800
2.4000	1.6202	6213.	652.2660	-0.00939	82.4738	2.62E+10	0.00	0.00	45.1200
2.7000	1.5864	8854.	824.8500	-0.00939	117.5251	2.62E+10	0.00	0.00	

50.7600								
3.0000	1.5526	12152.	1018.	-0.00939	161.3090	2.62E+10	0.00	0.00
56.4000								
3.3000	1.5188	16181.	1231.	-0.00939	214.7957	2.62E+10	0.00	0.00
62.0400								
3.6000	1.4850	21015.	1464.	-0.00938	278.9554	2.62E+10	0.00	0.00
67.6800								
3.9000	1.4513	26725.	1718.	-0.00938	354.7585	2.62E+10	0.00	0.00
73.3200								
4.2000	1.4175	33386.	1992.	-0.00938	443.1752	2.62E+10	0.00	0.00
78.9600								
4.5000	1.3837	41070.	2287.	-0.00937	545.1759	2.62E+10	0.00	0.00
84.6000								
4.8000	1.3500	49850.	2601.	-0.00937	661.7307	2.62E+10	0.00	0.00
90.2400								
5.1000	1.3163	59800.	2936.	-0.00936	793.8100	2.62E+10	0.00	0.00
95.8800								
5.4000	1.2826	70993.	3292.	-0.00935	942.3841	2.62E+10	0.00	0.00
101.5200								
5.7000	1.2490	83501.	3667.	-0.00934	1108.	2.62E+10	0.00	0.00
107.1600								
6.0000	1.2154	97398.	4063.	-0.00933	1293.	2.62E+10	0.00	0.00
112.8000								
6.3000	1.1818	112757.	4480.	-0.00931	1497.	2.62E+10	0.00	0.00
118.4400								
6.6000	1.1483	129651.	4916.	-0.00930	1721.	2.62E+10	0.00	0.00
124.0800								
6.9000	1.1149	148153.	5373.	-0.00928	1967.	2.62E+10	0.00	0.00
129.7200								
7.2000	1.0815	168336.	5850.	-0.00925	2235.	2.62E+10	0.00	0.00
135.3600								
7.5000	1.0483	190274.	6348.	-0.00923	2526.	2.62E+10	0.00	0.00
141.0000								
7.8000	1.0151	214039.	6865.	-0.00920	2841.	2.62E+10	0.00	0.00
146.6400								

8.1000	0.9820	239704.	7403.	-0.00917	3182.	2.62E+10	0.00	0.00
152.2800								
8.4000	0.9491	267343.	7962.	-0.00914	3549.	2.62E+10	0.00	0.00
157.9200								
8.7000	0.9162	297028.	8540.	-0.00910	3943.	2.62E+10	0.00	0.00
163.5600								
9.0000	0.8836	328833.	9139.	-0.00905	4365.	2.62E+10	0.00	0.00
169.2000								
9.3000	0.8510	362831.	9759.	-0.00901	4816.	2.62E+10	0.00	0.00
174.8400								
9.6000	0.8187	399095.	10398.	-0.00895	5298.	2.62E+10	0.00	0.00
180.4800								
9.9000	0.7866	437698.	11058.	-0.00890	5810.	2.62E+10	0.00	0.00
186.1200								
10.2000	0.7546	478713.	11738.	-0.00883	6355.	2.62E+10	0.00	0.00
191.7600								
10.5000	0.7230	522214.	12439.	-0.00877	6932.	2.62E+10	0.00	0.00
197.4000								
10.8000	0.6915	568272.	13160.	-0.00869	7543.	2.62E+10	0.00	0.00
203.0400								
11.1000	0.6604	616962.	13901.	-0.00861	8190.	2.62E+10	0.00	0.00
208.6800								
11.4000	0.6295	668357.	14662.	-0.00852	8872.	2.62E+10	0.00	0.00
214.3200								
11.7000	0.5990	722529.	15444.	-0.00843	9591.	2.62E+10	0.00	0.00
219.9600								
12.0000	0.5689	779552.	16246.	-0.00832	10348.	2.62E+10	0.00	0.00
225.6000								
12.3000	0.5391	839498.	17068.	-0.00821	11144.	2.62E+10	0.00	0.00
231.2400								
12.6000	0.5098	902442.	17911.	-0.00809	11979.	2.62E+10	0.00	0.00
236.8800								
12.9000	0.4809	968455.	18774.	-0.00796	12856.	2.62E+10	0.00	0.00
242.5200								
13.2000	0.4524	1037612.	19657.	-0.00783	13774.	2.62E+10	0.00	0.00

248.1600								
13.5000	0.4245	1109984.	20560.	-0.00768	14734.	2.62E+10	0.00	0.00
253.8000								
13.8000	0.3971	1185646.	21484.	-0.00752	15739.	2.62E+10	0.00	0.00
259.4400								
14.1000	0.3704	1264670.	22428.	-0.00735	16788.	2.62E+10	0.00	0.00
265.0800								
14.4000	0.3442	1347130.	23393.	-0.00717	17882.	2.62E+10	0.00	0.00
270.7200								
14.7000	0.3187	1433098.	24377.	-0.00698	19023.	2.62E+10	0.00	0.00
276.3600								
15.0000	0.2939	1522648.	24716.	-0.00678	20212.	2.62E+10	-228.662	2801.
140.2950								
15.3000	0.2699	1611052.	24139.	-0.00656	21386.	2.62E+10	-232.232	3098.
0.00								
15.6000	0.2467	1696447.	23297.	-0.00634	22519.	2.62E+10	-235.272	3434.
0.00								
15.9000	0.2243	1778793.	22446.	-0.00610	23612.	2.62E+10	-237.755	3816.
0.00								
16.2000	0.2028	1858057.	21587.	-0.00585	24664.	2.62E+10	-239.651	4255.
0.00								
16.5000	0.1822	1934216.	20721.	-0.00559	25675.	2.62E+10	-240.928	4761.
0.00								
16.8000	0.1625	2007252.	19853.	-0.00532	26645.	2.62E+10	-241.548	5350.
0.00								
17.1000	0.1439	2077157.	18984.	-0.00504	27573.	2.62E+10	-241.473	6042.
0.00								
17.4000	0.1263	2143933.	18116.	-0.00475	28459.	2.62E+10	-240.657	6861.
0.00								
17.7000	0.1097	2207591.	17252.	-0.00445	29304.	2.62E+10	-239.048	7844.
0.00								
18.0000	0.09424	2268150.	16396.	-0.00414	30108.	2.62E+10	-236.588	9038.
0.00								
18.3000	0.07989	2325643.	15550.	-0.00383	30871.	2.62E+10	-233.210	10509.
0.00								

18.6000	0.06669	2380113.	14719.	-0.00350	31594.	2.62E+10	-228.835	12352.
0.00								
18.9000	0.05467	2431618.	13905.	-0.00317	32278.	2.62E+10	-223.374	14709.
0.00								
19.2000	0.04385	2480228.	13113.	-0.00284	32923.	2.62E+10	-216.723	17792.
0.00								
19.5000	0.03426	2526029.	9260.	-0.00249	33531.	2.62E+10	-1924.	202165.
0.00								
19.8000	0.02591	2546897.	-1833.	-0.00214	33808.	2.62E+10	-4239.	588825.
0.00								
20.1000	0.01883	2512833.	-17757.	-0.00180	33356.	2.62E+10	-4608.	881017.
0.00								
20.4000	0.01299	2419048.	-34757.	-0.00146	32111.	2.62E+10	-4837.	1340850.
0.00								
20.7000	0.00834	2262579.	-52292.	-0.00114	30034.	2.62E+10	-4905.	2117346.
0.00								
21.0000	0.00481	2042544.	-69723.	-8.40E-04	27113.	2.62E+10	-4779.	3576533.
0.00								
21.3000	0.00229	1760571.	-86234.	-5.79E-04	23370.	2.62E+10	-4393.	6901303.
0.00								
21.6000	6.43E-04	1421660.	-100459.	-3.60E-04	18872.	2.62E+10	-3510.	1.96E+07
0.00								
21.9000	-3.02E-04	1037265.	-101093.	-1.91E-04	13769.	2.62E+10	3157.	3.76E+07
0.00								
22.2000	-7.35E-04	693791.	-87721.	-7.26E-05	9210.	2.62E+10	4272.	2.09E+07
0.00								
22.5000	-8.25E-04	405677.	-71509.	2.88E-06	5385.	2.62E+10	4735.	2.07E+07
0.00								
22.8000	-7.15E-04	178924.	-54175.	4.30E-05	2375.	2.62E+10	4896.	2.47E+07
0.00								
23.1000	-5.15E-04	15617.	-36693.	5.64E-05	207.3019	2.62E+10	4817.	3.36E+07
0.00								
23.4000	-3.09E-04	-85267.	-19910.	5.16E-05	1132.	2.62E+10	4507.	5.26E+07
0.00								
23.7000	-1.44E-04	-127734.	-4685.	3.70E-05	1696.	2.62E+10	3951.	9.87E+07

0.00								
24.0000	-4.25E-05	-119000.	7969.	2.00E-05	1580.	2.62E+10	3079.	2.61E+08
0.00								
24.3000	1.49E-07	-70359.	13446.	7.02E-06	933.9636	2.62E+10	-36.279	8.77E+08
0.00								
24.6000	8.04E-06	-22187.	9686.	6.69E-07	294.5165	2.62E+10	-2053.	9.19E+08
0.00								
24.9000	4.97E-06	-616.265	3606.	-8.96E-07	8.1805	2.62E+10	-1326.	9.60E+08
0.00								
25.2000	1.59E-06	3774.	422.8576	-6.79E-07	50.0981	2.62E+10	-442.598	1.00E+09
0.00								
25.5000	7.66E-08	2428.	-413.822	-2.54E-07	32.2342	2.62E+10	-22.224	1.04E+09
0.00								
25.8000	-2.36E-07	794.5414	-330.591	-3.23E-08	10.5470	2.62E+10	68.4629	1.04E+09
0.00								
26.1000	-1.56E-07	48.0517	-125.923	2.55E-08	0.6379	2.62E+10	45.2418	1.04E+09
0.00								
26.4000	-5.22E-08	-112.105	-17.251	2.11E-08	1.4881	2.62E+10	15.1319	1.04E+09
0.00								
26.7000	-3.77E-09	-76.152	11.9553	8.22E-09	1.0109	2.62E+10	1.0936	1.04E+09
0.00								
27.0000	6.99E-09	-26.027	10.2744	1.20E-09	0.3455	2.62E+10	-2.027	1.04E+09
0.00								
27.3000	4.89E-09	-2.176	4.0744	-7.34E-10	0.02889	2.62E+10	-1.417	1.04E+09
0.00								
27.6000	1.71E-09	3.3089	0.6331	-6.56E-10	0.04392	2.62E+10	-0.495	1.04E+09
0.00								
27.9000	1.61E-10	2.3823	-0.342	-2.66E-10	0.03162	2.62E+10	-0.04679	1.04E+09
0.00								
28.2000	-2.06E-10	0.8494	-0.318	-4.36E-11	0.01128	2.62E+10	0.05963	1.04E+09
0.00								
28.5000	-1.53E-10	0.08933	-0.131	2.08E-11	0.00119	2.62E+10	0.04428	1.04E+09
0.00								
28.8000	-5.56E-11	-0.09687	-0.02271	2.03E-11	0.00129	2.62E+10	0.01612	1.04E+09
0.00								

29.1000	-6.37E-12	-0.07415	0.00964	8.58E-12	9.84E-04	2.62E+10	0.00185	1.04E+09
0.00								
29.4000	6.18E-12	-0.02747	0.00974	1.60E-12	3.65E-04	2.62E+10	-0.00179	1.04E+09
0.00								
29.7000	5.16E-12	-0.00403	0.00382	0.00	5.35E-05	2.62E+10	-0.00150	1.04E+09
0.00								
30.0000	2.15E-12	0.00	0.00	0.00	0.00	2.62E+10	-6.22E-04	5.22E+08
0.00								

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     1.89075660 inches
Computed slope at pile head      =     -0.0093935 radians
Maximum bending moment           =       2546897. inch-lbs
Maximum shear force              =       -101093. lbs
Depth of maximum bending moment  =    19.80000000 feet below pile head
Depth of maximum shear force     =    21.90000000 feet below pile head
Number of iterations             =             26
Number of zero deflection points =              7
Pile deflection at ground        =     0.29393457 inches
```

Pile-head Deflection vs. Pile Length for Load Case 1

Boundary Condition Type 1, Shear and Moment

```
Shear      =             0. lbs
Moment     =             0. in-lbs
Axial Load =             0. lbs
```

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
30.00000	1.89075660	2546897.	-101093.
28.50000	1.90405422	2566588.	-102520.
27.00000	1.91758991	2574976.	-103543.
25.50000	1.89670571	2556688.	-102982.
24.00000	1.91680295	2575010.	-102488.
22.50000	2.84148977	2473716.	-128134.

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 2

Pile-head conditions are Shear and Moment (Loading Type 1)

Shear force at pile head = 0.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/inch	Soil Spr. Es*H lb/inch	Distrib. Lat. Load lb/inch
0.00	2.6920	-1.26E-05	-1.25E-07	-0.01323	1.67E-07	2.62E+10	0.00	0.00	1.9035

0.3000	2.6443	12.3347	17.1315	-0.01323	0.1637	2.62E+10	0.00	0.00
7.6140								
0.6000	2.5967	123.3468	58.2471	-0.01323	1.6373	2.62E+10	0.00	0.00
15.2280								
0.9000	2.5491	431.7138	126.7731	-0.01323	5.7307	2.62E+10	0.00	0.00
22.8420								
1.2000	2.5015	1036.	222.7095	-0.01323	13.7537	2.62E+10	0.00	0.00
30.4560								
1.5000	2.4538	2035.	346.0563	-0.01323	27.0162	2.62E+10	0.00	0.00
38.0700								
1.8000	2.4062	3528.	496.8135	-0.01323	46.8281	2.62E+10	0.00	0.00
45.6840								
2.1000	2.3586	5612.	674.9811	-0.01323	74.4993	2.62E+10	0.00	0.00
53.2980								
2.4000	2.3110	8388.	880.5591	-0.01323	111.3396	2.62E+10	0.00	0.00
60.9120								
2.7000	2.2634	11952.	1114.	-0.01323	158.6589	2.62E+10	0.00	0.00
68.5260								
3.0000	2.2158	16405.	1374.	-0.01322	217.7671	2.62E+10	0.00	0.00
76.1400								
3.3000	2.1682	21845.	1662.	-0.01322	289.9741	2.62E+10	0.00	0.00
83.7540								
3.6000	2.1206	28370.	1977.	-0.01322	376.5898	2.62E+10	0.00	0.00
91.3680								
3.9000	2.0730	36079.	2320.	-0.01321	478.9240	2.62E+10	0.00	0.00
98.9820								
4.2000	2.0255	45071.	2690.	-0.01321	598.2866	2.62E+10	0.00	0.00
106.5960								
4.5000	1.9779	55444.	3087.	-0.01320	735.9874	2.62E+10	0.00	0.00
114.2100								
4.8000	1.9304	67298.	3512.	-0.01319	893.3365	2.62E+10	0.00	0.00
121.8240								
5.1000	1.8829	80730.	3964.	-0.01318	1072.	2.62E+10	0.00	0.00
129.4380								
5.4000	1.8355	95840.	4444.	-0.01317	1272.	2.62E+10	0.00	0.00

137.0520
5.7000 1.7881 112727. 4951. -0.01316 1496. 2.62E+10 0.00 0.00
144.6660
6.0000 1.7408 131488. 5486. -0.01314 1745. 2.62E+10 0.00 0.00
152.2800
6.3000 1.6935 152222. 6047. -0.01312 2021. 2.62E+10 0.00 0.00
159.8940
6.6000 1.6463 175029. 6637. -0.01310 2323. 2.62E+10 0.00 0.00
167.5080
6.9000 1.5992 200007. 7253. -0.01307 2655. 2.62E+10 0.00 0.00
175.1220
7.2000 1.5522 227254. 7898. -0.01304 3017. 2.62E+10 0.00 0.00
182.7360
7.5000 1.5053 256870. 8569. -0.01301 3410. 2.62E+10 0.00 0.00
190.3500
7.8000 1.4586 288952. 9268. -0.01297 3836. 2.62E+10 0.00 0.00
197.9640
8.1000 1.4119 323600. 9995. -0.01293 4296. 2.62E+10 0.00 0.00
205.5780
8.4000 1.3655 360913. 10748. -0.01288 4791. 2.62E+10 0.00 0.00
213.1920
8.7000 1.3192 400988. 11529. -0.01283 5323. 2.62E+10 0.00 0.00
220.8060
9.0000 1.2731 443925. 12338. -0.01277 5893. 2.62E+10 0.00 0.00
228.4200
9.3000 1.2272 489822. 13174. -0.01271 6502. 2.62E+10 0.00 0.00
236.0340
9.6000 1.1816 538779. 14038. -0.01264 7152. 2.62E+10 0.00 0.00
243.6480
9.9000 1.1363 590893. 14928. -0.01256 7844. 2.62E+10 0.00 0.00
251.2620
10.2000 1.0912 646263. 15847. -0.01247 8579. 2.62E+10 0.00 0.00
258.8760
10.5000 1.0464 704989. 16792. -0.01238 9358. 2.62E+10 0.00 0.00
266.4900

10.8000	1.0021	767168.	17765.	-0.01228	10184.	2.62E+10	0.00	0.00
274.1040								
11.1000	0.9580	832899.	18766.	-0.01217	11056.	2.62E+10	0.00	0.00
281.7180								
11.4000	0.9144	902282.	19794.	-0.01205	11977.	2.62E+10	0.00	0.00
289.3320								
11.7000	0.8713	975414.	20849.	-0.01192	12948.	2.62E+10	0.00	0.00
296.9460								
12.0000	0.8286	1052395.	21932.	-0.01178	13970.	2.62E+10	0.00	0.00
304.5600								
12.3000	0.7864	1133323.	23042.	-0.01163	15044.	2.62E+10	0.00	0.00
312.1740								
12.6000	0.7448	1218296.	24179.	-0.01147	16172.	2.62E+10	0.00	0.00
319.7880								
12.9000	0.7038	1307414.	25344.	-0.01130	17355.	2.62E+10	0.00	0.00
327.4020								
13.2000	0.6635	1400776.	26537.	-0.01111	18594.	2.62E+10	0.00	0.00
335.0160								
13.5000	0.6238	1498479.	27756.	-0.01091	19891.	2.62E+10	0.00	0.00
342.6300								
13.8000	0.5849	1600622.	29004.	-0.01070	21247.	2.62E+10	0.00	0.00
350.2440								
14.1000	0.5468	1707305.	30278.	-0.01047	22663.	2.62E+10	0.00	0.00
357.8580								
14.4000	0.5095	1818625.	31580.	-0.01023	24141.	2.62E+10	0.00	0.00
365.4720								
14.7000	0.4731	1934682.	32910.	-0.00997	25682.	2.62E+10	0.00	0.00
373.0860								
15.0000	0.4377	2055574.	33467.	-0.00970	27286.	2.62E+10	-252.594	2078.
189.3983								
15.3000	0.4033	2175648.	32891.	-0.00941	28880.	2.62E+10	-256.757	2292.
0.00								
15.6000	0.3700	2292393.	31961.	-0.00910	30430.	2.62E+10	-260.361	2534.
0.00								
15.9000	0.3378	2405765.	31018.	-0.00878	31935.	2.62E+10	-263.379	2807.

0.00								
16.2000	0.3067	2515722.	30065.	-0.00844	33395.	2.62E+10	-265.780	3119.
0.00								
16.5000	0.2770	2622236.	29106.	-0.00809	34808.	2.62E+10	-267.531	3477.
0.00								
16.8000	0.2485	2725282.	28140.	-0.00772	36176.	2.62E+10	-268.596	3891.
0.00								
17.1000	0.2214	2824847.	27173.	-0.00734	37498.	2.62E+10	-268.935	4373.
0.00								
17.4000	0.1957	2920927.	26206.	-0.00695	38773.	2.62E+10	-268.501	4940.
0.00								
17.7000	0.1714	3013527.	25241.	-0.00654	40003.	2.62E+10	-267.244	5614.
0.00								
18.0000	0.1486	3102664.	24283.	-0.00612	41186.	2.62E+10	-265.107	6424.
0.00								
18.3000	0.1273	3188365.	23334.	-0.00569	42323.	2.62E+10	-262.024	7409.
0.00								
18.6000	0.1076	3270670.	22398.	-0.00524	43416.	2.62E+10	-257.920	8627.
0.00								
18.9000	0.08956	3349632.	21479.	-0.00479	44464.	2.62E+10	-252.711	10158.
0.00								
19.2000	0.07315	3425319.	20581.	-0.00432	45469.	2.62E+10	-246.299	12121.
0.00								
19.5000	0.05844	3497814.	16180.	-0.00385	46431.	2.62E+10	-2199.	135448.
0.00								
19.8000	0.04545	3541816.	3443.	-0.00336	47015.	2.62E+10	-4878.	386375.
0.00								
20.1000	0.03421	3522603.	-14966.	-0.00288	46760.	2.62E+10	-5350.	562981.
0.00								
20.4000	0.02471	3434058.	-34821.	-0.00240	45585.	2.62E+10	-5681.	827541.
0.00								
20.7000	0.01691	3271891.	-55582.	-0.00194	43432.	2.62E+10	-5853.	1245737.
0.00								
21.0000	0.01073	3033869.	-76630.	-0.00151	40273.	2.62E+10	-5841.	1959006.
0.00								

21.3000	0.00605	2720154.	-97222.	-0.00111	36108.	2.62E+10	-5600.	3331031.
0.00								
21.6000	0.00272	2333868.	-116351.	-7.67E-04	30981.	2.62E+10	-5027.	6665483.
0.00								
21.9000	5.32E-04	1882430.	-131961.	-4.77E-04	24988.	2.62E+10	-3645.	2.46E+07
0.00								
22.2000	-7.20E-04	1383751.	-130873.	-2.53E-04	18368.	2.62E+10	4249.	2.12E+07
0.00								
22.5000	-0.00129	940142.	-113698.	-9.33E-05	12480.	2.62E+10	5293.	1.48E+07
0.00								
22.8000	-0.00139	565129.	-93759.	1.01E-05	7502.	2.62E+10	5784.	1.50E+07
0.00								
23.1000	-0.00122	265076.	-72602.	6.71E-05	3519.	2.62E+10	5970.	1.77E+07
0.00								
23.4000	-9.08E-04	42394.	-51227.	8.82E-05	562.7457	2.62E+10	5905.	2.34E+07
0.00								
23.7000	-5.80E-04	-103755.	-30517.	8.40E-05	1377.	2.62E+10	5600.	3.47E+07
0.00								
24.0000	-3.04E-04	-177332.	-11370.	6.47E-05	2354.	2.62E+10	5038.	5.97E+07
0.00								
24.3000	-1.15E-04	-185620.	5200.	3.98E-05	2464.	2.62E+10	4168.	1.31E+08
0.00								
24.6000	-1.75E-05	-139892.	17651.	1.74E-05	1857.	2.62E+10	2749.	5.66E+08
0.00								
24.9000	1.06E-05	-58536.	18047.	3.79E-06	777.0234	2.62E+10	-2529.	8.59E+08
0.00								
25.2000	9.76E-06	-9951.	8813.	-9.16E-07	132.0867	2.62E+10	-2601.	9.59E+08
0.00								
25.5000	4.01E-06	4921.	2040.	-1.26E-06	65.3256	2.62E+10	-1162.	1.04E+09
0.00								
25.8000	6.83E-07	4735.	-408.170	-5.98E-07	62.8581	2.62E+10	-198.074	1.04E+09
0.00								
26.1000	-2.99E-07	1982.	-608.394	-1.37E-07	26.3147	2.62E+10	86.8384	1.04E+09
0.00								
26.4000	-3.02E-07	354.8724	-294.492	2.37E-08	4.7107	2.62E+10	87.5516	1.04E+09

0.00								
26.7000	-1.29E-07	-137.963	-69.598	3.86E-08	1.8314	2.62E+10	37.3894	1.04E+09
0.00								
27.0000	-2.42E-08	-146.232	10.3135	1.91E-08	1.9411	2.62E+10	7.0058	1.04E+09
0.00								
27.3000	8.32E-09	-63.706	18.5795	4.65E-09	0.8457	2.62E+10	-2.414	1.04E+09
0.00								
27.6000	9.31E-09	-12.459	9.3754	-5.81E-10	0.1654	2.62E+10	-2.700	1.04E+09
0.00								
27.9000	4.14E-09	3.7970	2.3558	-1.18E-09	0.05040	2.62E+10	-1.200	1.04E+09
0.00								
28.2000	8.43E-10	4.5025	-0.244	-6.06E-10	0.05977	2.62E+10	-0.244	1.04E+09
0.00								
28.5000	-2.27E-10	2.0412	-0.565	-1.57E-10	0.02710	2.62E+10	0.06572	1.04E+09
0.00								
28.8000	-2.87E-10	0.4316	-0.297	1.29E-11	0.00573	2.62E+10	0.08316	1.04E+09
0.00								
29.1000	-1.34E-10	-0.100	-0.07801	3.57E-11	0.00133	2.62E+10	0.03873	1.04E+09
0.00								
29.4000	-2.99E-11	-0.130	0.00734	1.99E-11	0.00173	2.62E+10	0.00868	1.04E+09
0.00								
29.7000	9.38E-12	-0.04743	0.01807	7.66E-12	6.30E-04	2.62E+10	-0.00272	1.04E+09
0.00								
30.0000	2.52E-11	0.00	0.00	4.41E-12	0.00	2.62E+10	-0.00732	5.22E+08
0.00								

* The above values of total stress are combined axial and bending stresses.

Output Summary for Load Case No. 2:

Pile-head deflection = 2.69196428 inches
Computed slope at pile head = -0.0132288 radians
Maximum bending moment = 3541816. inch-lbs
Maximum shear force = -131961. lbs

Depth of maximum bending moment =   19.80000000 feet below pile head
Depth of maximum shear force   =   21.90000000 feet below pile head
Number of iterations   =   25
Number of zero deflection points =   6
Pile deflection at ground   =   0.43769712 inches

Summary of Pile-head Responses for Conventional Analyses

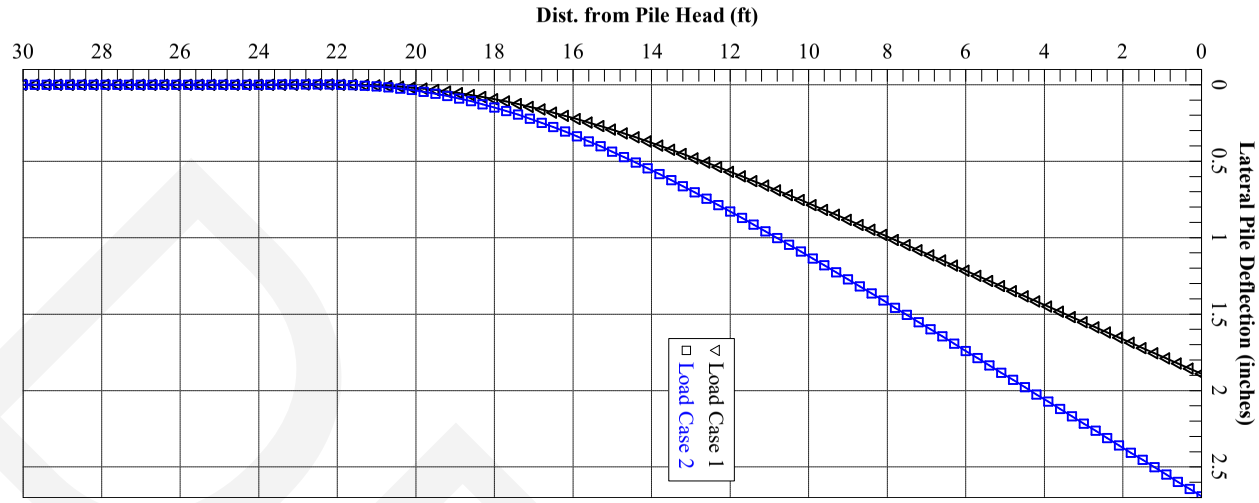
Definitions of Pile-head Loading Conditions:

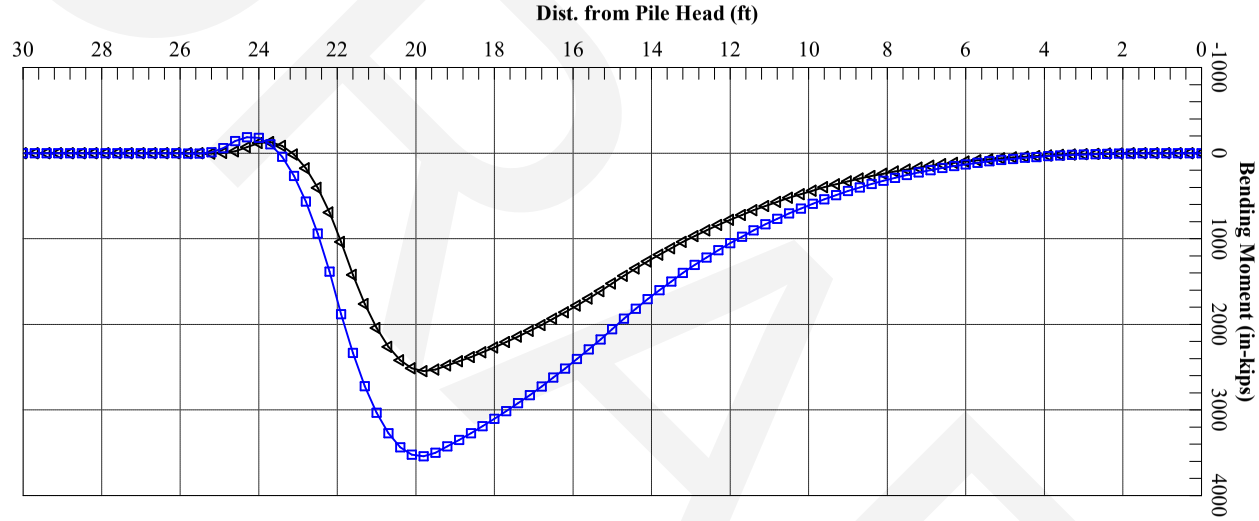
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

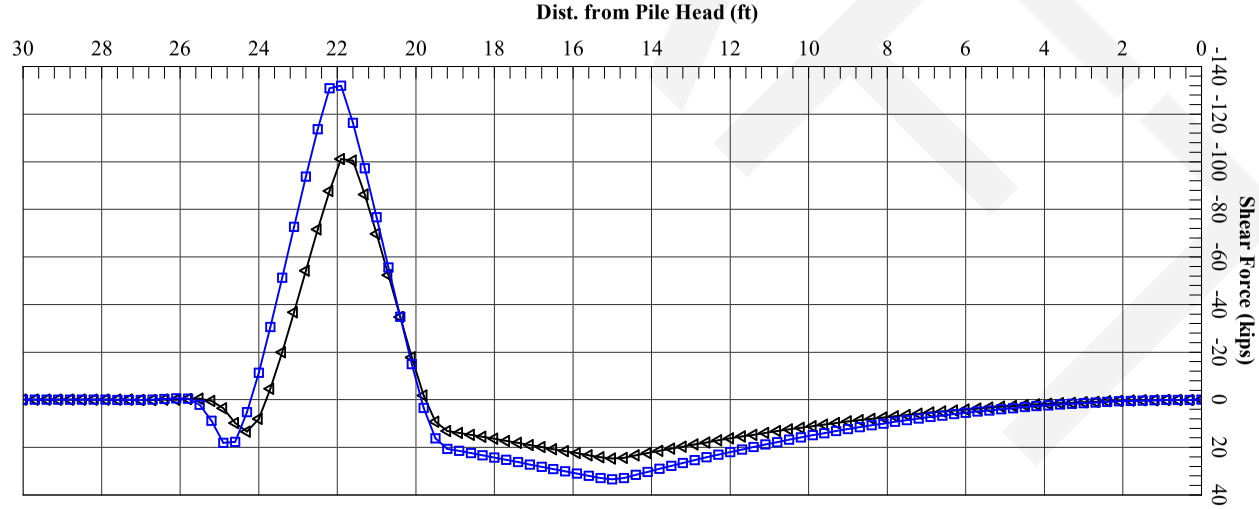
Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.8908	-0.00939	-101093.	2546897.
2	V, lb	0.00	M, in-lb	0.00	0.00	2.6920	-0.01323	-131961.	3541816.

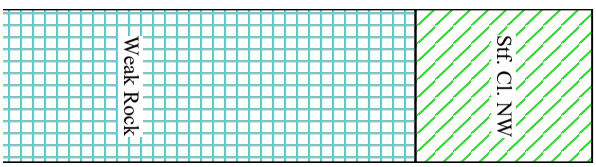
Maximum pile-head deflection = 2.6919642845 inches
Maximum pile-head rotation   = -0.0132287538 radians = -0.757952 deg.

The analysis ended normally.


Dist. from Pile Head (ft)
30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
Lateral Pile Deflection (inches)
0 0.5 1 1.5 2 2.5
Load Case 1
Load Case 2


Dist. from Pile Head (ft)
30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
Bending Moment (in-kips)
-1000 0 1000 2000 3000 4000


Dist. from Pile Head (ft)
30 28 26 24 22 20 18 16 14 12 10 8 6 4 2 0
Shear Force (kips)
-140 -120 -100 -80 -60 -40 -20 0 20 40


Weak Rock
Stf. Cl. NW

CLIENT:	Pennoni
PROJECT:	Village of Barnesville
W.O.:	N4225393
Date:	4/19/2023
Case:	Spread footings on Rock

UCS and RQD Data

Boring	RQD (per 5 ft.)
B-001	87
	73
B-002	60
	93

Average	78.25

Boring	Depth (Elevation)	UCS (ksf)
B-001	12.4'	575
B-002	10'	619
B-002	11.3'	678

Average	624

Rock Mass Rating (RMR) per LRFD Table 10.4.6.4-1 Per Section 10 LRFD 5th Edition

Spread footings on Rock	Relative Rating
Strength of Rock	
624	4
RQD	
78.25	17
Maximum Spacing of Joints (in.)	
13	20
Condition of Joints	12
GW Condition	7
Total	60
Adj for Joint Orientation	15
RMR	45
Class	3
Rock Type	Fair Rock

Per GDM 1303.3.3 for RMR < 70, use Bieniawski (1989) method to evaluate c' and φ' of the weak rock

$c' = 104 \times RMR$ (psf)

$= 4680$ psf

$= 5$ ksf

$\varphi' = 5 + RMR/2$

$= 28$ °

Per LRFD Eq. 10.6.3.1.2a-1 nominal bearing resistance of soil/weak rock in ksf is taken as

$q_n = c\,Ncm + \gamma Df\,Nqm\,Cwq + 0.5\gamma\,BN\gamma m\,Cw\gamma$

in which

Ncm = Nc Sc ic

Nqm = Nq Sq dq iq

Nγm = Nγ Sγ iγ

c = 5

Nc = 25.8 From Table 10.6.3.1.2a-1

Nq = 14.7 From Table 10.6.3.1.2a-1

Nγ = 16.7 From Table 10.6.3.1.2a-1

γ = 120

Df = 5

B = 2 L = 4

Cwq, Cwγ = 1 (correction factors for location of GW)

Sc = 1.28

Sγ = 0.80

Sq = 1.26

dq = 1 (assume 1 for rock)

ic, iγ, iq = 1 (Per recommendation in GDM 1303.3.1)

q_n = 168 ksf

Resistance Factors for Tip Resistance per LRFD Table 10.5.5.2.2-1

Resistance Factor for Bearing in rock	0.45

Factored Bearing Resistance =	**76**	**ksf**