

LAW-SR650-7.16

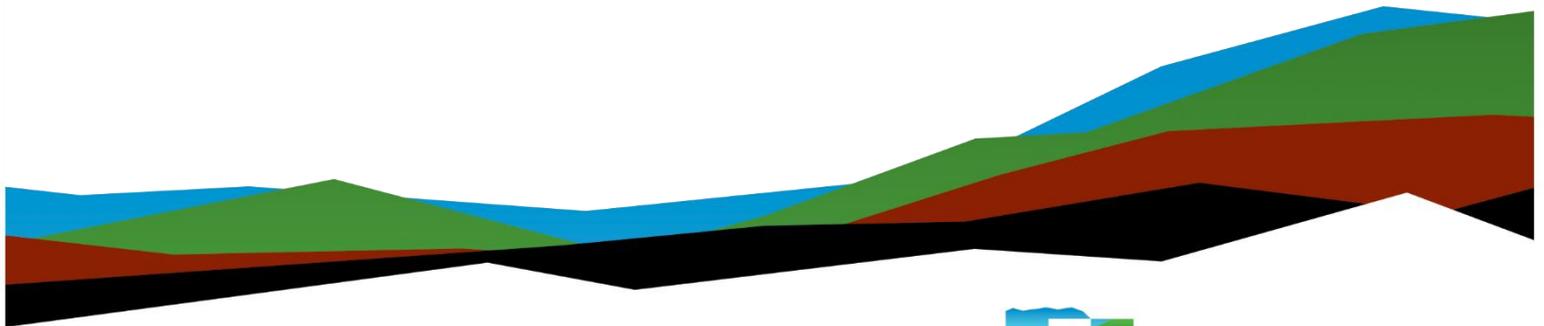
PID No.: 119775

Geotechnical Engineering Report

March 7, 2025 | Terracon Project No. N1245336

Prepared for:

CHA Consulting
471 E. Broad Street
Columbus, Ohio 43215



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March 7, 2025

CHA Consulting
471 E. Broad Street
Columbus, Ohio 43215

Attn: Mr. Douglas Miller, P.E., S.I., Section Manager
P: (937) 657-3563
E: dmiller@chasolutions.com

Re: Geotechnical Engineering Report
LAW-SR650-7.16
State Route 650 over Little Pine Creek
Pedro, Lawrence County, Ohio
ODOT PID No. 119775
Terracon Project No. N1245336

Dear Mr. Miller:

We have completed the scope of Geotechnical Engineering services for the above-referenced project in general accordance with Terracon Proposal No. PN1245336 dated October 23, 2024, and signed notice to proceed dated November 22, 2024. This report presents the findings of the subsurface exploration and provides geotechnical recommendations concerning earthwork, roadway subgrade, and bridge foundations 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

Munal Pandey, E.I.T.
Senior Staff Engineer

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



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Site Location and Exploration Plans

Rock Core Photography Log

Exploration Results (Boring Logs, Laboratory Data)

Supporting Information (ODOT Soil Classification System, ODOT Subgrade Analysis Spreadsheet, Driven Pile Calculations, Geotechnical Profile Sheets)

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 that 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 includes realignment of the curve of the road and pavement replacement for approximately 1,000 feet along State Route 650. It also includes the replacement of the existing bridge along State Route 650 over Little Pine Creek. The existing bridge is approximately 75 feet long.
- The geotechnical engineering Scope of Services for this project included the advancement of five (5) test borings including two (2) test bridge borings to a depth of approximately 85 feet below existing site grades and three (3) test roadway borings to a depth of approximately 10 to 12.5 feet below existing site grades, laboratory testing, engineering analysis, and preparation of this report.
- Based on ODOT's guidelines for determining CBR, we recommend an average CBR value of 7 to be utilized in pavement design. The recommended CBR value assumes that the subgrade stabilization/improvement recommended in this report is performed.
- Based on our field and laboratory test results, stabilization of the soils anticipated at the pavement subgrade for the proposed roadway will be required across approximately 60% of the borings (B-001-0-24, B-004-0-24, and B-005-0-24) based on the analysis. Currently, ODOT uses two options for establishing a stable subgrade: chemical stabilization, or excavate and replace. However, it is our understanding that ODOT typically prefers the chemical stabilization option.
- Based on the encountered conditions and existing bridge foundations, driven piles are the recommended foundation option for bridge replacement. Based on our analyses and anticipated load of 280 kips/pile, 12-inch diameter CIP pipe piles with a ¼-inch thick 45 ksi ASTM A252 Grade 3 steel shell or 50 ksi HP10x42 steel piles can be used. However, the grades and thicknesses above do not include the structural capacity of the piles and it is the responsibility of the structural engineer.
- Based on the soil conditions encountered at this site, we anticipate the proposed culvert and headwalls can be supported on the native cohesive soils (A-6a) encountered up to 11 feet below the existing site grades, or on the native cohesionless soils (A-3, and A-3a) encountered below 11 feet. We recommend that the culvert structure and the creek bed be protected from scouring and erosion with riprap or other alternatives, as specified in the ODOT Construction and Material Specifications.
- We recommend all earthwork and engineered fill placement be performed per the ODOT Construction and Materials Specifications (ODOT CMS).

Introduction

This report presents the results of our subsurface exploration and Geotechnical Engineering services performed for the proposed bridge and roadway realignment project to be located along State Route 650 over Little Pine Creek in Pedro, Lawrence County, Ohio. The purpose of these services was to provide information and geotechnical engineering recommendations relative to:

- Subsurface soil conditions
- Short-term groundwater conditions
- Site preparation and earthwork
- Pavement subgrade recommendations
- Bridge foundation recommendations

The project includes realignment of the curve of the road and pavement replacement for approximately 1,000 feet along State Route 650. It also includes the replacement of the existing bridge along State Route 650 over Little Pine Creek. The existing bridge is approximately 75 feet long.

The geotechnical engineering Scope of Services for this project included the advancement of five (5) test borings including two (2) test bridge borings to a depth of approximately 85 feet below existing site grades and three (3) test roadway borings to a depth of approximately 10 to 12.5 feet below existing site grades, laboratory testing, engineering analysis, and preparation of this report.

The 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 in the [Exploration Results](#) section.

Geology and Observations

Based on the ODNR physiographic regions of Ohio, the project is located in the Ironton Plateau of Ohio which is generally characterized by a moderately high relief dissected plateau and common lacustrine clay-filled Teays Valley remnants. Based on the ODNR surficial geology maps, the site consists of lacustrine deposits primarily made up of Minford Clay formed in the early-middle Pleistocene Age due to ice-dammed lakes.

Bedrock in the project area maps as Pennsylvanian Age Allegheny and Pottsville Groups Formation consisting of shale with interbedded limestone, siltstone, and underclay. Based on the ODNR bedrock contour maps, the top of the bedrock is located at about an elevation of 500 feet which is approximately 65 to 80 feet below the existing site grades.

During our field exploration, bedrock was encountered at the two bridge borings at depths of 74 and 74.5 feet below the existing road surface.

Field reconnaissance was performed by Terracon personnel on December 9, 2024. The area surrounding the project is generally agricultural or wooded with a few residential buildings located on either side of SR-650 and a used car business located northeast of SR-650 at about Station 387+00. The existing Little Pine Creek intersects SR-650 at about Station 383+00 and is approximately 16 feet deep at the deepest part of the channel from the existing road surface. An existing Little Pine Creek Road heading east intersects SR-650 at about Station 386+00. The existing pavement appeared to be in fair condition.

Exploration

A total of two (2) bridge borings and three (3) roadway borings were performed by Terracon between December 17, 2024, and December 24, 2024. The ground surface elevations and coordinates were measured by Terracon by using a survey-grade Emlid RX GPS unit with an approximate horizontal and vertical accuracy of +/- 1 foot and provided on the test boring logs.

The test borings were performed with a track-mounted drill rig. The drill rig utilized hollow-stem augers to permit split-spoon sampling in overburden soils. Drilling and sampling procedures were performed in general accordance with the ODOT SGE-7/19/2024. The average drill rig energy ratio (ER) for the CME-55 drill rig was 88.8 percent (calibration date 12/6/2024).

Groundwater levels were observed during drilling and at the completion of the drilling activities at each test boring location. No long-term (24-hour) water level readings were obtained at the test boring locations. Upon completion of the drilling activities and following water level observations, the boreholes were sealed with cement grout, and the pavement surface was patched with concrete plug and asphalt per SGE requirements.

Findings

Subsurface Profile

The test borings performed in the existing SR-650 roadway revealed approximately 4 to 12 inches of asphalt surface underlain by approximately 5 to 14 inches of aggregate base course indicating a total pavement and base thickness of approximately 15 to 24 inches. The test boring performed outside the roadway (B-004-0-24) in the existing field revealed a topsoil/plow zone layer of approximately 4 inches.

The subsurface profile in the test bridge borings generally consisted of shallow medium stiff to stiff cohesive fill (A-6a and A-4a) followed by some medium stiff to stiff native cohesive soils (A-4a) up to about 11 feet below the existing road surface. This upper cohesive overburden is underlain by very loose to loose cohesionless sand (A-3 and A-3a) up to about 48.5 feet below the existing road surface followed by medium stiff to stiff cohesive soil (A-6a) up to 68.5 feet below the existing road surface. There is an approximately 5-foot layer of very dense cohesionless soil (A-1-b) underneath, followed by interbedded shale and limestone bedrock. Bedrock was encountered at depths of 74 and 74½ feet below the existing road surface at the two bridge borings.

The subsurface profile in the test roadway borings generally consisted of very soft to very stiff cohesive soils (A-4a, A-6a, and A-6b). Very loose to medium dense cohesionless soils (A-3a) were encountered only at Boring B-001-0-24.

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

Groundwater Conditions

The boreholes were observed while drilling and after completion for the presence and level of groundwater. Groundwater was encountered at depths ranging from 6 to 16 feet below existing site grades as indicated on the boring logs in the [Exploration Results](#) section. However, this does not necessarily indicate a stable groundwater level at the boring locations. Another indicator of the groundwater levels is the color transition from brown to gray where gray-colored soils generally indicate soil under submerged conditions due to less oxidation. The brown-to-gray transition was observed at depths ranging from 11 to 15 feet below the existing site grades at the borings. A relatively long period may be necessary for the groundwater level to develop and stabilize in a borehole. Long-term piezometers or observation wells sealed from the influence of surface water are often required to define stable groundwater levels.

Groundwater level fluctuations occur due to seasonal variations in the amount of rainfall, runoff along Little Pine Creek, and other factors not evident at the time the borings were performed. Groundwater levels during construction and 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 or perched water should be considered when developing the design and construction plans for the project.

Analyses and Recommendations

Site Preparation and Earthwork

Prior to placing any fill, all vegetation, topsoil, existing pavement, and any otherwise unsuitable material should be removed from the construction areas. Wet or dry material should either be removed, or moisture-conditioned and recompacted. After stripping and grubbing, the subgrade should be proof-rolled where possible to aid in locating loose or soft areas. We recommend extra attention in the areas that are currently agricultural fields since there could be deeper pockets of topsoil or plowed material. Soft, dry, and low-density soil should be removed or compacted in place prior to placing the fill.

We recommend all earthwork and engineered fill placement be performed per the ODOT Construction and Materials Specifications (ODOT CMS). Generally, the on-site soils appear suitable for re-use as engineered fill following proper moisture conditioning. Some culling of unsuitable soils should be anticipated, even though our borings did not encounter any unsuitable soils.

Pavement Subgrade

The roadway test borings performed in this study generally encountered asphalt pavement with a thickness of about 4 to 12 inches with an aggregate base layer of 12 to 14 inches. One test boring performed outside the roadway along the new alignment area encountered a topsoil layer with a thickness of about 4 inches. Based on the anticipated alignment of the proposed upgrade, we anticipate the subgrade material will be comprised of medium stiff to stiff cohesive soils or very loose to loose cohesionless soils.

The overburden soils at/near the anticipated subgrade level typically classify as A-6a, A-6b, A-4a, A-3a, and A-4a. Based on laboratory testing, the existing subgrade soils have moisture contents ranging from about 10 to 34 percent, with an average moisture content of about 24 percent. Plasticity indices in subgrade soils (ignoring non-plastic soils) ranged from about 9 to 16, with an average plasticity index of about 13.

The moisture contents of the existing subgrade soils in the upper 6 feet of boring locations below the pavement ranged from approximately 4% below to 20% above the estimated optimum moisture contents (M_{OPT}) for the corresponding material type per the attached ODOT Subgrade Analysis. The average moisture content (M_c) of the existing subgrade soils is 11% above the estimated average optimum moisture content (M_{OPT}) per the attached ODOT Subgrade Analysis. The estimated optimum moisture content is based on the soil types and corresponding M_{OPT} , as outlined in the current ODOT Subgrade Analysis Spreadsheet.

The N_{60L} values (low N-values) for the anticipated subgrade soils encountered in the test borings ranged from 3 to 7 bpf (blows per foot), with an average N_{60L} value of 5 bpf. A summary of the subgrade soils is tabulated on ODOT's Subgrade Analysis spreadsheet in the Appendix.

Based on our field and laboratory test results, stabilization of the soils anticipated at the pavement subgrade for the proposed roadway will be required across approximately 60% of the borings (B-001-0-24, B-004-0-24, and B-005-0-24) based on the analysis. Currently, ODOT uses two options for establishing a stable subgrade: chemical stabilization, or excavate and replace. However, it is our understanding that ODOT typically prefers the chemical stabilization option.

For the chemical stabilization option, per the ODOT subgrade analysis, the road subgrade will require cement stabilization to a depth of 14 inches prior to placement of new structural fill and/or roadway construction or excavation and replacement with new granular fill. The stabilization should extend up to 18 inches beyond the edge of the surface of the pavement, paved shoulder, or paved medians, including new curbs and gutters. For estimating purposes, cement stabilization using 5% cement can be used.

For the "excavate and replace" method the subgrade should be excavated to at least 24 inches below the bottom of the final subgrade elevation. Please note that excavation and replacement will not be required in the realignment area, which will receive at least 2 feet of new fill. Also, the very loose to loose soils (A-3a) encountered towards the south of the proposed bridge will require reworking and compaction in place at the bottom of the excavation prior to the replacement. In accordance with ODOT Subgrade Analysis, the bottom of the excavation is to be lined with Item 204 Geotextile Fabric and replaced with Item 204 Granular Material Type B. Generally, for projects of this size (less than 1 mile), the undercut and replace option will be more economical, provided good weather conditions are encountered during construction. Areas, where subgrade soils have deteriorated either due to trafficking or water softening may require an additional undercut to provide a suitable surface for structural fill placement and/or stabilization methods. If wet weather conditions are encountered during construction, chemical drying/modification of subgrade soils may be required.

Laboratory California Bearing Ratio (CBR) testing was not performed on the anticipated subgrade soils for this project. Thus, the provided CBR value is based on the soil index testing and more specifically the ODOT Group Index relationship to the CBR value. The average Group Index for the proposed roadway subgrade soils encountered at the test boring locations was about 6. Thus, based on ODOT's guidelines for determining CBR, we recommend an average CBR value of 7 to be utilized in pavement design. The recommended CBR value assumes that the subgrade stabilization/improvement recommended in this report is performed. Construction of the subgrade stabilization/improvement should follow current ODOT Construction & Materials Specifications (CMS).

The soil samples in each boring were tested for soluble sulfate contents. It was reported as non-detectable in each boring. The results of soluble sulfate testing indicate samples on the on-site soils possess sulfate concentrations below the acceptable risk level (5,000 mg/kg SO₄) set by ODOT.

Bridge Foundations- Driven Piles

Based on the encountered conditions and existing bridge foundations, driven piles are the recommended foundation option for bridge replacement. Driven pile analyses were performed using APILE (version 2023.10.3) and in accordance with ODOT BDM requirements. The analyses considered 12-inch diameter cast-in-place (CIP) driven piles. The analysis was performed for each of the two borings drilled for this bridge due to slightly different subsurface conditions. The analyses showed some variability in resistance and drivability across the two borings. Driven piles should be spaced at least three pile diameters apart (center-to-center) when side friction is used for compressive loads. In addition, based on ODOT BDM, it is not recommended to batter piles with lengths less than 15 feet. Results and calculations for each of the analysis cases are included as attachments to this report.

We understand that the bridge superstructure will be supported on approximately 6.5-foot tall integral abutments supported over driven piles. Based on the information provided by CHA Consultants via email on March 3, 2025, the piles are anticipated to be subjected to a maximum factored load of 280 kips/pile. The APILE results are summarized in the tables below:

Boring ID	Approx. Pile Cut-Off Elevation (ft)	Approx. Tip Elevation (ft)	Side Resistance (kips)	End Bearing (kips)	UBV (kips) ³
B-002-0-23 (South/Forward Abutment)	566.0	505.0	83.1	246.9	330.0
B-003-0-23 (North/Rear Abutment)	566.0	506.0	78.0	246.6	324.6

1. Pile Type/Size= 12-inch; Steel Grade= 35 ksi; Estimated Length= 65 feet.
2. Please note that the UBV for piles increases sharply from 65 feet to 70 feet. Refer to the APILE output in the [Supporting Information](#) for the skin friction and end-bearing resistance along the pile length.

Alternatively, if driven H-piles are used for abutments and driven to refusal on bedrock, the following pile capacities can be used.

Structure	Approx. Pile Cut-Off Elevation (Ft) ¹	Approx. Tip Elevation (ft)	Steel Yield Stress (ksi)	Anticipated Factored Load (kips) ³	Factored Structural Resistance (kips) ²
HP10X42	566	500	50	280	310

1. Estimated Length= 70 feet.
2. The values listed are calculated in accordance with LRFD 6.9.4.1 and the assumptions in BDM C305.3.3. This value should be adjusted if any of the conditions are not consistent with the assumptions in BDM C305.3.3.
3. The anticipated factored loads were provided by CHA Consultants.

Preliminary driveability analyses for the 12-inch diameter cast-in-place (CIP) driven piles as well as HP10x42 piles were performed considering the Delmag D 19-42 hammer. Prior to construction, the contractor shall perform a drivability analysis using the pile hammer-cushion combination that will be used. These analyses were performed using GRLWEAP and considered 45 ksi ASTM A252 Grade 3 steel for 12-inch diameter CIP pipe piles with a wall thickness of ¼-inch and 50 ksi steel for HP10x42 piles. The analyses indicated that these piles would be acceptable for the anticipated driving conditions. Additionally, per BDM 305.1.2, p-y analysis is not necessary for stub abutment walls of 10 feet or less in height as long as there is no scour extending below the bottom of the footing since the lateral load will not be enough to substantially affect the piles. Please note that the grades and thicknesses provided above consider the geotechnical capacity and drivability only and do not include the structural capacity of the piles, which is the responsibility of the structural engineer.

Pile driving conditions, hammer efficiency, and stress on the pile during driving could be better evaluated during installation using a Pile Driving Analyzer (PDA) performed by a qualified pile testing contractor. Driving criteria for the driven CIP piles should be recommended by the pile testing contractor, based on the PDA results. Each pile should be observed and checked for buckling, crimping, and alignment in addition to recording penetration resistance, depth of embedment, and general pile driving operations.

The pile driving process should be performed under the direction of the Geotechnical Engineer or their representative. They should document the pile installation process including hammer blow counts and groundwater conditions encountered, consistency with expected conditions, and details of the installed pile.

Culvert Recommendations

Bearing Resistance Recommendations

One 60-inch culvert is planned for this project at about Station 381+60 towards the south of the proposed bridge replacement. No borings were performed for this culvert, hence the recommendations for this culvert have been provided based on the subsurface conditions encountered at the Boring B-002-0-24 performed for the bridge foundation. Additional details on the proposed culvert have not been provided at the time of this report. Based on the soil conditions encountered at this site, we anticipate the proposed culvert and headwalls can be supported on the native cohesive soils (A-6a) encountered up to 11 feet below the existing site grades, or on the native cohesionless soils (A-3, and A-3a) encountered below 11 feet. The following table provides the anticipated footing subgrade conditions based on the test boring, the anticipated bearing elevation, and the recommended factored bearing resistance based on the AASHTO LRFD Bridge Design Specifications. These recommendations will be finalized once the final location and elevation of the culverts are provided.

Anticipated Bearing Elevation (Feet)	Approximate Invert Depth (Feet)	Anticipated Bearing Material	Factored Bearing Resistance (psf)
564±	9	Native cohesive or cohesionless soils (A-4a, A-3, A-3a)	2,250 ¹

1. Nominal bearing resistance of 5,000 psf and resistance factor= 0.45
2. Over-excavate and replace at least 1 foot of the foundation soil under the footing with Granular Material.

The base of all foundation excavations should be free of water and loose soil and rock particles prior to placing concrete. Concrete should be placed soon after excavating to reduce disturbance. Should the soil at the bearing level become excessively dry, disturbed, or frozen, the affected soil should be removed prior to placing concrete. Place a lean concrete mud mat over the bearing stratum if the excavations must remain open for an extended period of time. It is recommended that the geotechnical engineer be retained to observe the foundation-bearing materials.

We recommend that the culvert structure and the creek bed be protected from scouring and erosion with riprap or other alternatives, as specified in the ODOT Construction and Material Specifications. Scour should be considered in determining the bottom elevation of the culvert footings.

Lateral Earth Pressure Recommendations

The details on the proposed wing walls have not been provided at this time of the report. The wing walls should be designed using the earth pressure parameters recommended in the following paragraphs. Earth pressures will be influenced by the structural design of the walls, conditions of wall restraint, methods of construction and/or compaction, and the strength of the materials being restrained.

Backfill placed against structures should consist of crushed stone (ODOT No. 57). The wing walls must be designed for internal and external stability. For external stability, forces that can cause sliding, overturning, bearing capacity failure and rotational slip-surface failure (global stability) must be considered. The retaining wall design will need to account for any slopes above the crest of the retaining wall or any surcharge loads applied at the crest of the wing walls.

Active Lateral Earth Pressure Design Parameters

Soil Type	Friction Angle Φ ($^{\circ}$) ¹	Unit weight γ_s (pcf)	Active Pressure Coefficient (K_a) ¹	Surcharge Pressure p_1 (psf) ¹	Design Static Lateral Pressure	
					Drained ¹	Undrained ¹
Granular Backfill (ODOT No.57 Stone-Crushed Limestone)	30	120	0.33	(0.33)S	(40)H	(82)H
Retained Soils (A-4a, A-6a)	26	120	0.39	(0.39)S	(47)H	(85)H

1. The lateral earth pressure design parameters provided above are for the level backslope condition.

Considering precast concrete on clean fine sand, a coefficient of friction of 0.35 should be used in the design for sliding.

Scour Parameters

Scour analysis is beyond the scope of this project. However, we performed the scour sampling at the approximate creek bottom elevation and performed laboratory testing to determine the scour parameters. The table below presents the related values for the scour samples along with their respective critical shear stress.

Soil Layer	Depth	Water Content (%)	Percent Fines by Weight (%)	PI	Unconfined Compressive Strength, q_u (tsf)	Mean Particle Grain Size, D_{50} (mm)	Critical Shear Stress, τ_c (psf)
B-002-0-24							
A-4a	8.5-10	21	68	2	0.5	-	0.0101
A-3	15-16.5	28	10	0	-	0.037	0.0008
A-3	18-19.5	30	9	0	-	0.028	0.0006
B-003-0-24							
A-4a	8.5-10	27	55	0	0.5	0.053	0.0011
A-3	13.5-15	27	1	0	-	0.037	0.0008
A-3	16.5-18	39	6	0	-	0.028	0.0006

Seismic Considerations

The seismic design requirements for buildings and other structures are based on the Seismic Design Category. Site Classification is required to determine the Seismic Design Category for a structure. The Site Classification is based on the upper 100 feet of the site profile defined by a weighted average value of either shear wave velocity, standard penetration resistance, or undrained shear strength in accordance with Section 20.4 of ASCE 7 and the International Building Code (IBC). Based on the soil/bedrock properties observed at the site and as described in the exploration logs and results, our professional opinion is that a **Seismic Site Classification of E** is considered for the project. Subsurface explorations at this site were extended to a maximum depth of 85 feet. The site properties below the boring depth to 100 feet were estimated based on our experience and knowledge of the geologic conditions of the general area. Additional geophysical testing may be performed to confirm the conditions below the current boring depth and provide direct measurements of shear wave velocity to potentially justify a higher Site Class.

General Comments

Natural variations will occur between exploration point locations or due to the modifying effects of construction or weather. The nature and extent of such variations may not become evident until during or after construction. If variations appear, we can provide further evaluation and supplemental recommendations. If variations are noted in the

absence of our observation and testing services on-site, we should be immediately notified so that we can provide evaluation and supplemental recommendations.

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

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

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

Geotechnical Engineering Report

LAW-SR650-7.16 | Pedro, Lawrence County, Ohio

March 7, 2025 | Terracon Project No. N1245336



Attachments

Rock Core Photography Log



Figure 1: Rock Core at Boring B-002-0-24

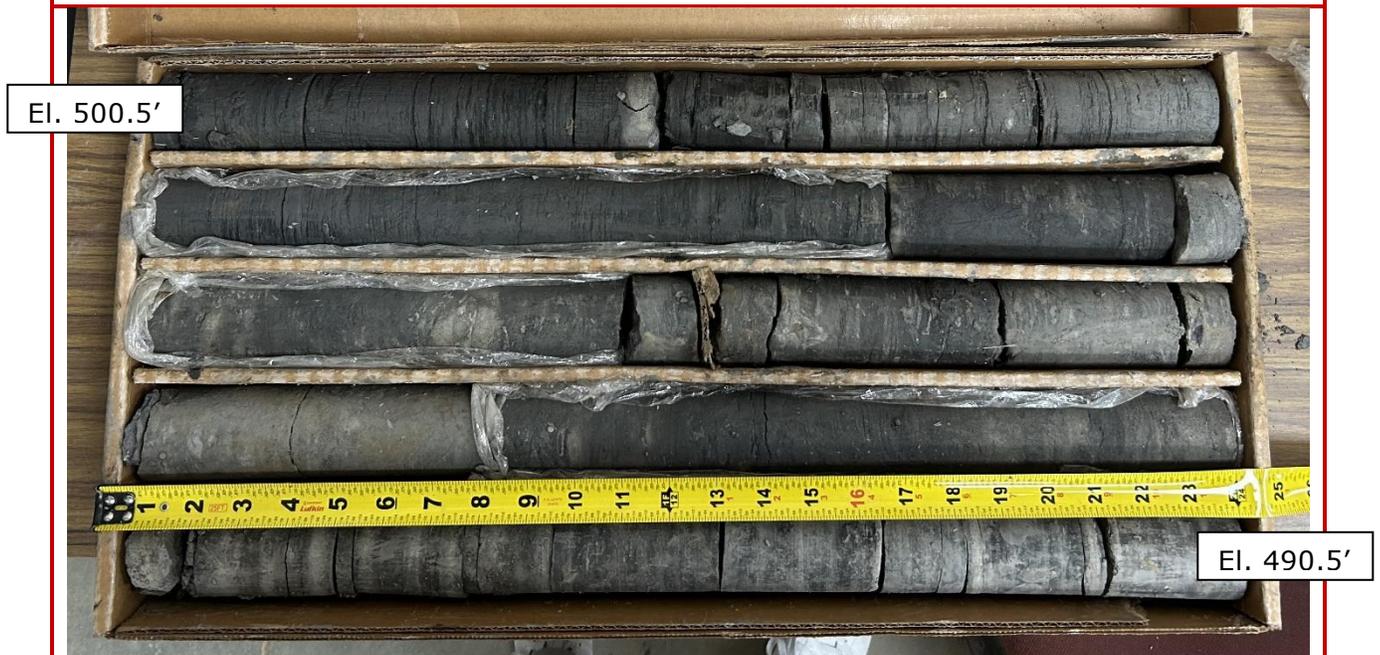


Figure 2: Rock Core at Boring B-003-0-24

Site Location and Exploration Plans

Contents:

Site Location Plan

Exploration Plan

Note: All attachments are one page unless noted above.

Geotechnical Engineering Report

LAW-SR650-7.16 | Pedro, Lawrence County, Ohio

March 7, 2025 | Terracon Project No. N1245336



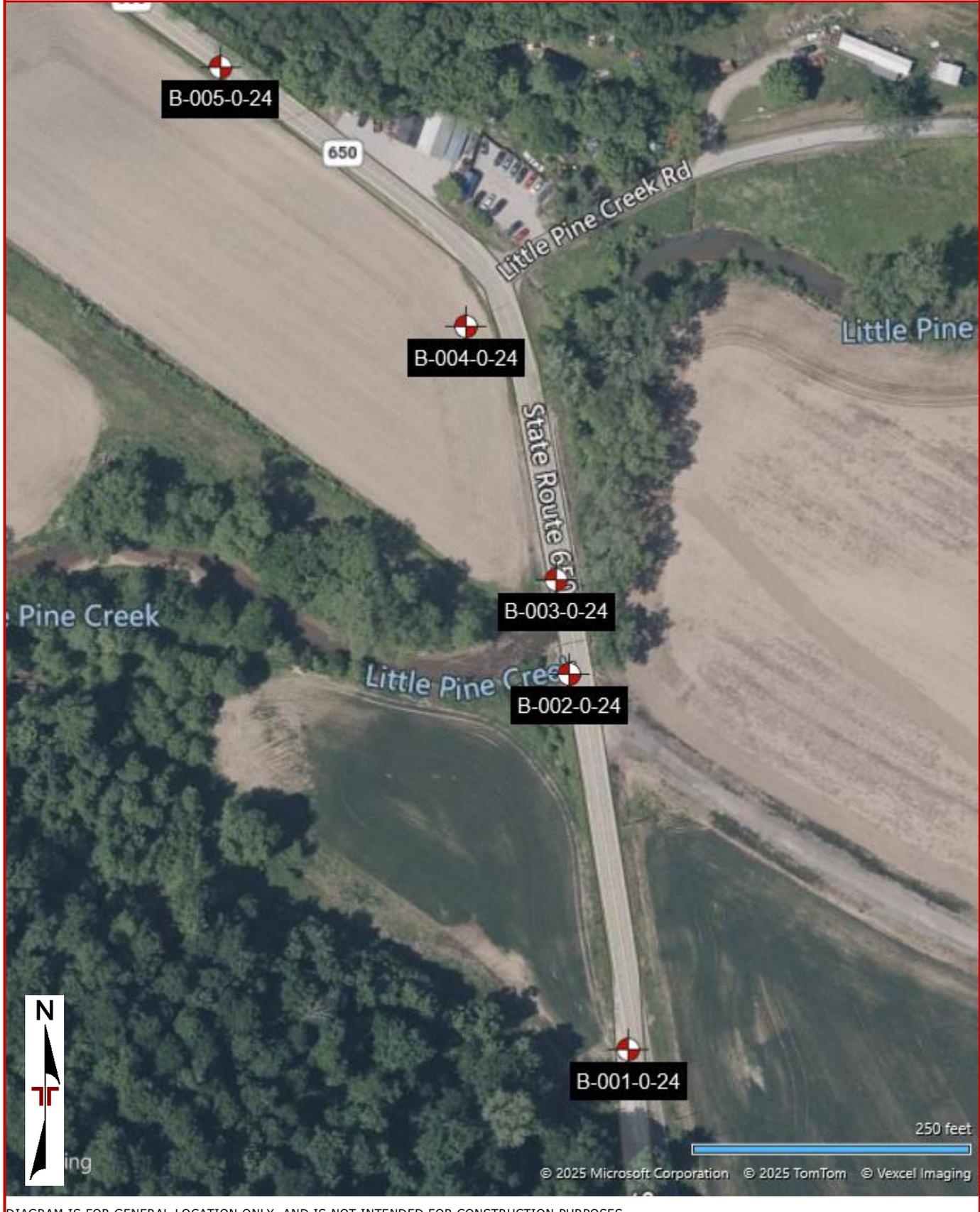
Site Location



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

MAP PROVIDED BY MICROSOFT BING MAPS

Exploration Plan



Exploration and Laboratory Results

Contents:

Boring Logs (B-001-0-24 through B-005-0-24) (9 pages)

Atterberg limits

Grain-Size Distribution (5 pages)

Unconfined Compressive Strength of Soil

Unconfined Compressive Strength of Rock (2 pages)

Sulfate Contents

Note: All attachments are one page unless noted above.

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/4/25 08:28 - E:\PROJECTS\2024\1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-1245336.GPJ

PROJECT: <u>LAW-SR-650-07.16</u>	DRILLING FIRM / OPERATOR: <u>TERRACON / CK</u>	DRILL RIG: <u>CME 55 TRACK</u>	STATION / OFFSET: <u>379+15, 10' LT.</u>	EXPLORATION ID <u>B-001-0-24</u>
TYPE: <u>ROADWAY</u>	SAMPLING FIRM / LOGGER: <u>TERRACON / JF</u>	HAMMER: <u>CME AUTOMATIC</u>	ALIGNMENT: <u>SR-650</u>	
PID: <u>119775</u> SFN: _____	DRILLING METHOD: <u>3.25" HSA</u>	CALIBRATION DATE: <u>12/6/24</u>	ELEVATION: <u>570.7 (MSL)</u> EOB: <u>12.5 ft.</u>	PAGE 1 OF 1
START: <u>12/23/24</u> END: <u>12/23/24</u>	SAMPLING METHOD: <u>SPT</u>	ENERGY RATIO (%): <u>88.8</u>	LAT / LONG: <u>38.629534, -82.731377</u>	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTH	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			ODOT CLASS (GI)	BACK FILL		
								GR	CS	FS	SI	CL	LL	PL	PI			WC	
ASPHALT CONCRETE (4 INCHES)	570.4																		
AGGREGATE BASE COURSE (14 INCHES)	569.2	1																	
STIFF, GRAYISH BROWN, SILT AND CLAY , LITTLE SAND, TRACE GRAVEL, MOIST (FILL)	567.7	2	6	4	10	56	SS-1	1.25	2	1	17	50	30	34	19	15	23	A-6a (10)	
VERY LOOSE TO LOOSE, BROWN, COARSE AND FINE SAND , SOME SILT, TRACE CLAY, TRACE GRAVEL, WET	564.7	3	3	2	6	72	SS-2	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
		4	2	2															
		5	1	3	78	SS-3	-	1	4	69	24	2	NP	NP	NP	24	A-3a (0)		
		6	0	1	0	100	SS-4	-	-	-	-	-	-	-	-	-	27	A-3a (V)	
		7	0	0															
MEDIUM DENSE, GRAY, COARSE AND FINE SAND , SOME SILT, LITTLE GRAVEL, TRACE CLAY, WET	559.7	8	0	1	3	89	SS-5	-	0	9	60	27	4	NP	NP	NP	30	A-3a (0)	
		9	0	1															
		10	1	3	12	89	SS-6	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
	558.2	12	5																

EOB

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/4/25 08:28 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

PROJECT: <u>LAW-SR-650-07.16</u>	DRILLING FIRM / OPERATOR: <u>TERRACON / CK</u>	DRILL RIG: <u>CME 55 TRACK</u>	STATION / OFFSET: <u>382+55, 7' RT.</u>	EXPLORATION ID <u>B-002-0-24</u>
TYPE: <u>BRIDGE</u>	SAMPLING FIRM / LOGGER: <u>TERRACON / JF</u>	HAMMER: <u>CME AUTOMATIC</u>	ALIGNMENT: <u>SR-650</u>	
PID: <u>119775</u> SFN: _____	DRILLING METHOD: <u>3.25" HSA / NQ2</u>	CALIBRATION DATE: <u>12/6/24</u>	ELEVATION: <u>575.4 (MSL)</u> EOB: <u>85.0 ft.</u>	PAGE 1 OF 3
START: <u>12/23/24</u> END: <u>12/23/24</u>	SAMPLING METHOD: <u>SPT / ST / NQ2</u>	ENERGY RATIO (%): <u>88.8</u>	LAT / LONG: <u>38.630458, -82.731563</u>	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
ASPHALT CONCRETE (10 INCHES)	575.4																	
AGGREGATE BASE COURSE (5 INCHES)	574.6	1	3															
STIFF, BROWN AND GRAY, SILT AND CLAY , LITTLE SAND, TRACE GRAVEL, MOIST (FILL)	574.2	2	4	13	100	SS-1	1.25	-	-	-	-	-	-	-	-	18	A-6a (V)	
		3	5															
	571.9	4	1	7	33	SS-2	1.25	15	1	24	44	16	27	19	8	20	A-4a (5)	
MEDIUM STIFF TO STIFF, BROWN, SANDY SILT , LITTLE CLAY, LITTLE GRAVEL, MOIST TO WET		5	2															
		6	3		50	ST-3	1.50	-	-	-	-	-	-	-	-	22	A-4a (V)	
		7																
		8	0	3	9	100	SS-4	0.75	-	-	-	-	-	-	-	26	A-4a (V)	
		9	0	3														
		10	1	3	83	SS-5	0.50	0	0	32	52	16	18	16	2	21	A-4b (7)	
		11	1															
	564.4	12	0	3	100	SS-6	-	-	-	-	-	-	-	-	-	28	A-3 (V)	
VERY LOOSE TO LOOSE, BROWN TO GRAY, FINE SAND , TRACE GRAVEL, WET		13	1															
		14	1	3	94	SS-7	-	-	-	-	-	-	-	-	-	31	A-3 (V)	
		15	2															
		16	1	3	89	SS-8	-	0	1	89	10	0	NP	NP	NP	28	A-3 (0)	
		17	0	3	100	SS-9	-	-	-	-	-	-	-	-	-	33	A-3 (V)	
		18	1															
		19	1	6	100	SS-10	-	2	29	60	9	0	NP	NP	NP	30	A-3 (0)	
		20	2															
		21																
		22																
		23																
	551.9	24	2	4	100	SS-11	-	-	-	-	-	-	-	-	-	29	A-3a (V)	
LOOSE TO MEDIUM DENSE, GRAY, COARSE AND FINE SAND , LITTLE SILT, TRACE CLAY, WET		25	1															
		26	2															
		27																
		28																
		29	2	6	100	SS-12	-	0	48	36	13	3	NP	NP	NP	19	A-3a (0)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/4/25 08:28 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

PID: 119775		SFN:		PROJECT: LAW-SR-650-07.16		STATION / OFFSET: 382+55, 7' RT.		START: 12/23/24		END: 12/23/24		PG 3 OF 3		B-002-0-24						
MATERIAL DESCRIPTION AND NOTES			ELEV. 513.3	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
										GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM STIFF TO STIFF, GRAY, SILT AND CLAY, TRACE SAND, MOIST TO WET (continued)			506.9	63	4	16	100	SS-19	1.75	-	-	-	-	-	-	-	-	25	A-6a (V)	
				64																
				65																
				66																
VERY DENSE, GRAY, GRAVEL WITH SAND, TRACE SILT, TRACE CLAY, WET			500.9	67	8	61	100	SS-20	-	-	-	-	-	-	-	-	-	19	A-1-b (V)	
				68																
				69																
				70																
INTERBEDDED SHALE (75%) AND LIMESTONE (25%), RQD 63%, REC. 100%; SHALE, GRAY TO DARK GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY WEAK TO WEAK, THIN TO THICK BEDDED, FISSILE; LIMESTONE, LIGHT GRAY TO GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, THIN BEDDED. @76'-76.5': Qu= 232 psi; Density= 148 psf			500.9	71	19	-	100	SS-21	-	-	-	-	-	-	-	-	-	23	A-1-b (V)	
				72																
				73																
				74																
			490.4	75	72		100	NQ2-1											CORE	
				76																
				77																
				78																
			490.4	79	55		100	NQ2-2											CORE	
				80																
				81																
				82																
			490.4	83																
				84																
				85	EOB															

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: POURED CEMENT-BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/4/25 08:28 - E:\PROJECTS\2024\1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

PID: 119775		SFN:		PROJECT: LAW-SR-650-07.16		STATION / OFFSET: 383+40, 17' RT.		START: 12/24/24		END: 12/24/24		PG 3 OF 3		B-003-0-24							
MATERIAL DESCRIPTION AND NOTES			ELEV. 513.4	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED	
										GR	CS	FS	SI	CL	LL	PL	PI				
MEDIUM STIFF, GRAY, SILT AND CLAY , LITTLE SAND, MOIST TO WET (continued)			507.0	63	0																
				64	3	9	100	SS-18	0.50	-	-	-	-	-	-	-	-	24	A-6a (V)		
				65	3																
VERY DENSE, GRAY, GRAVEL WITH SAND , TRACE SILT, WET			501.5	66																	
				67																	
				68																	
INTERBEDDED SHALE (70%) AND LIMESTONE (30%) , RQD 60%, REC. 100%; SHALE , GRAY TO DARK GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY WEAK TO WEAK, THIN TO THICK BEDDED, FISSILE; LIMESTONE , LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, THIN BEDDED.			490.5	69	12																
				70	23	86	100	SS-19	-	34	39	18	9	0	NP	NP	NP	17	A-1-b (0)		
				71	35																
			490.5	72																	
				73																	
				74	17	-	136	SS-20	-	-	-	-	-	-	-	-	-	16	A-1-b (V)		
			490.5	75	50/5"																
				76																	
				77	60		100	NQ2													
			490.5	78																	
				79																	
				80	60		100	NQ2													
			490.5	81																	
				82																	
				83																	
			490.5	84																	
				85																	
				EOB																	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: POURED CEMENT-BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/4/25 08:28 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

PROJECT: <u>LAW-SR-650-07.16</u>	DRILLING FIRM / OPERATOR: <u>TERRACON / CK</u>	DRILL RIG: <u>CME 55 TRACK</u>	STATION / OFFSET: <u>385+80, 5' RT.</u>	EXPLORATION ID <u>B-004-0-24</u>
TYPE: <u>ROADWAY</u>	SAMPLING FIRM / LOGGER: <u>TERRACON / JF</u>	HAMMER: <u>CME AUTOMATIC</u>	ALIGNMENT: <u>SR-650</u>	PAGE 1 OF 1
PID: <u>119775</u> SFN: _____	DRILLING METHOD: <u>3.25" HSA</u>	CALIBRATION DATE: <u>12/6/24</u>	ELEVATION: <u>568.9 (MSL)</u> EOB: <u>10.0 ft.</u>	
START: <u>12/24/24</u> END: <u>12/24/24</u>	SAMPLING METHOD: <u>SPT</u>	ENERGY RATIO (%): <u>88.8</u>	LAT / LONG: <u>38.631314, -82.731888</u>	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTH	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL	
								GR	CS	FS	SI	CL	LL	PL	PI	WC			
TOPSOIL (4 INCHES)	568.9																		
STIFF, GRAYISH BROWN, SILTY CLAY , TRACE SAND, MOIST	568.6	1	1	2	7	100	SS-1	2.00	-	-	-	-	-	-	-	-	-	27	A-6b (V)
		2	1	2	6	89	SS-2	1.25	0	0	9	62	29	37	21	16	27	A-6b (10)	
		3	1	2															
VERY SOFT TO SOFT, GRAYISH BROWN, SILT AND CLAY , SOME SAND, WET	565.9	4	1	1	4	78	SS-3	0.50	-	-	-	-	-	-	-	-	-	34	A-6a (V)
		5	0	1	3	100	SS-4	0.25	0	0	21	58	21	30	19	11	31	A-6a (8)	
		6	0	1															
		7	0	0	0	100	SS-5	0.25	-	-	-	-	-	-	-	-	-	35	A-6a (V)
		8																	
VERY STIFF, BROWN, SILTY CLAY , SOME SAND, TRACE GRAVEL, MOIST	560.4	9	3	5	16	89	SS-6	2.50	-	-	-	-	-	-	-	-	-	21	A-6b (V)
		10	6																
	558.9	EOB																	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH BENTONITE CHIPS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 3/4/25 08:28 - E:\PROJECTS\2024\1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

PROJECT: <u>LAW-SR-650-07.16</u>	DRILLING FIRM / OPERATOR: <u>TERRACON / CK</u>	DRILL RIG: <u>CME 55 TRACK</u>	STATION / OFFSET: <u>389+04, 4' LT.</u>	EXPLORATION ID <u>B-005-0-24</u>
TYPE: <u>ROADWAY</u>	SAMPLING FIRM / LOGGER: <u>TERRACON / JF</u>	HAMMER: <u>CME AUTOMATIC</u>	ALIGNMENT: <u>SR-650</u>	
PID: <u>119775</u> SFN: _____	DRILLING METHOD: <u>3.25" HSA</u>	CALIBRATION DATE: <u>12/6/24</u>	ELEVATION: <u>578.7 (MSL)</u> EOB: <u>10.0 ft.</u>	PAGE 1 OF 1
START: <u>12/17/24</u> END: <u>12/17/24</u>	SAMPLING METHOD: <u>SPT</u>	ENERGY RATIO (%): <u>88.8</u>	LAT / LONG: <u>38.631952, -82.732661</u>	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI	WC		
ASPHALT CONCRETE (12 INCHES)	578.7																	
AGGREGATE BASE COURSE (12 INCHES)	577.7	1	4															
STIFF, GRAYISH BROWN, SILT AND CLAY , SOME SAND, LITTLE GRAVEL, MOIST	576.7	2	6	19	17	SS-1	4.00	-	-	-	-	-	-	-	-	-	10	A-6a (V)
		3	4	12	61	SS-2	1.50	11	5	22	39	23	32	19	13	23	A-6a (7)	
STIFF TO VERY STIFF, BROWN TO LIGHT BROWN, SANDY SILT , SOME CLAY, LITTLE GRAVEL, MOIST	573.2	4	3	7	56	SS-3	1.00	-	-	-	-	-	-	-	-	-	22	A-6a (V)
		5	3	2														
	570.2	6	3	9	100	SS-4	1.25	19	4	21	35	21	25	16	9	19	A-4a (4)	
		7	3	3														
		8																
		9	2	15	56	SS-5	2.50	-	-	-	-	-	-	-	-	-	17	A-4a (V)
	568.7	10	4	6														

NOTES: NONE
 ABANDONMENT METHODS, MATERIALS, QUANTITIES: AUGER CUTTINGS MIXED WITH BENTONITE CHIPS



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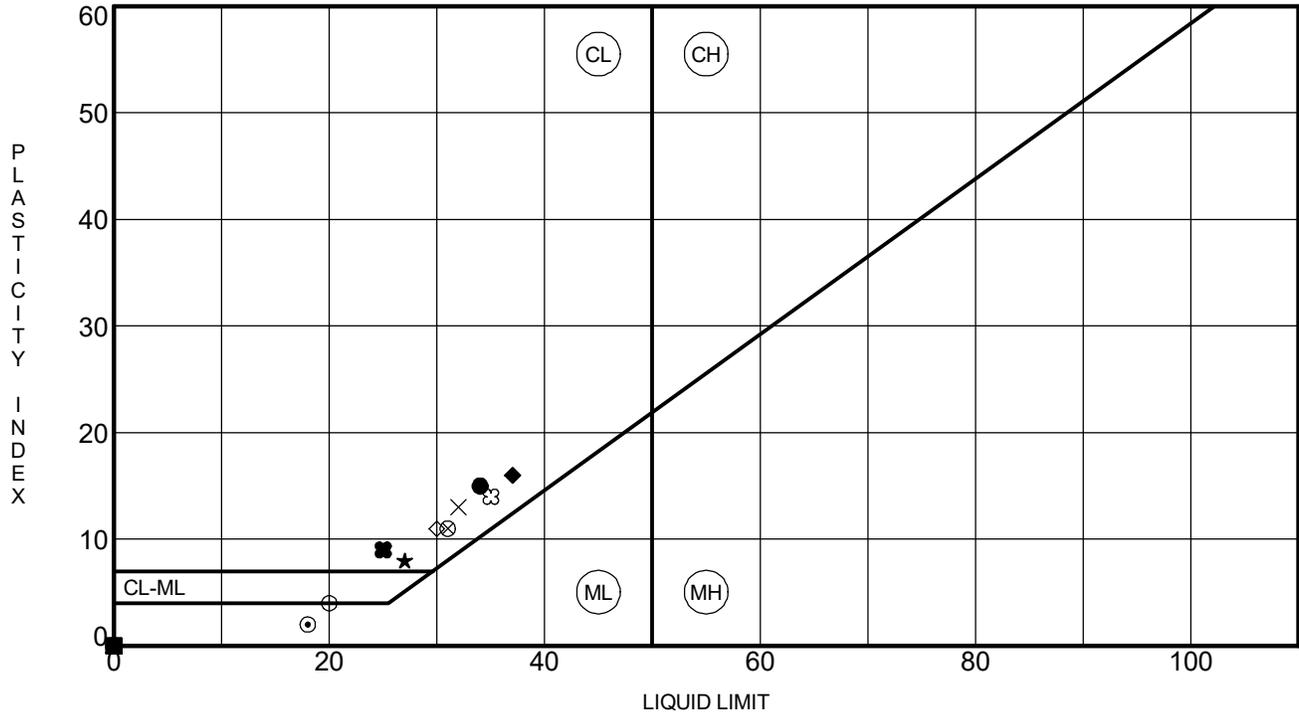
ATTERBERG LIMITS' RESULTS

PROJECT LAW-SR-650-07.16

PID 119775

OGE NUMBER N1245336

PROJECT TYPE STRUCTURE FOUNDATION



ATTERBERG LIMITS - OH DOT.GDT - 1/30/25 14:42 - E:\PROJECTS\2024\IN1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

Specimen Identification	LL	PL	PI	Fines	Classification	
● B-001-0-24	1.5	34	19	15	80	LEAN CLAY with SAND(CL)
▣ B-001-0-24	4.5	NP	NP	NP	26	SILTY SAND(SM)
▲ B-001-0-24	8.5	NP	NP	NP	31	SILTY SAND(SM)
★ B-002-0-24	3.5	27	19	8	60	SANDY LEAN CLAY(CL)
⊙ B-002-0-24	8.5	18	16	2	68	SANDY SILT(ML)
⊕ B-002-0-24	15.0	NP	NP	NP	10	POORLY GRADED SAND with SILT(SP-SM)
○ B-002-0-24	18.0	NP	NP	NP	9	POORLY GRADED SAND with SILT(SP-SM)
△ B-002-0-24	28.5	NP	NP	NP	16	SILTY SAND(SM)
⊗ B-002-0-24	53.5	31	20	11	93	LEAN CLAY(CL)
⊕ B-003-0-24	3.5	20	16	4	54	SANDY SILTY CLAY(CL-ML)
□ B-003-0-24	8.5	NP	NP	NP	55	SANDY SILT(ML)
⊕ B-003-0-24	13.5	NP	NP	NP	1	POORLY GRADED SAND(SP)
⊕ B-003-0-24	16.5	NP	NP	NP	6	POORLY GRADED SAND with SILT(SP-SM)
★ B-003-0-24	33.5	NP	NP	NP	12	SILTY SAND(SM)
⊗ B-003-0-24	53.5	35	21	14	84	LEAN CLAY with SAND(CL)
■ B-003-0-24	68.5	NP	NP	NP	9	WELL-GRADED SAND with SILT and GRAVEL(SW-SM)
◆ B-004-0-24	1.5	37	21	16	91	LEAN CLAY(CL)
◇ B-004-0-24	4.5	30	19	11	79	LEAN CLAY with SAND(CL)
× B-005-0-24	2.5	32	19	13	62	SANDY LEAN CLAY(CL)
■ B-005-0-24	5.5	25	16	9	56	SANDY LEAN CLAY with GRAVEL(CL)



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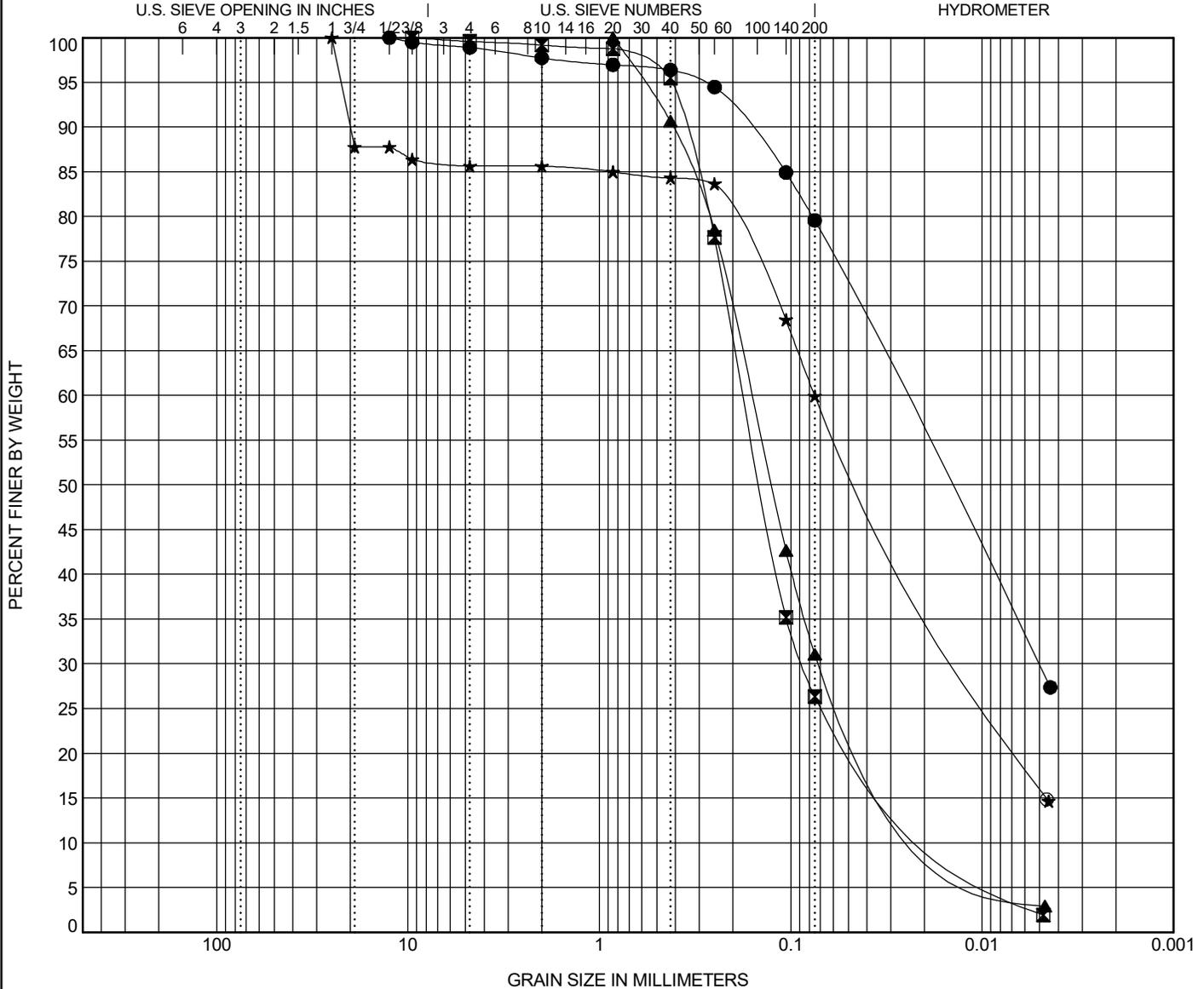
GRAIN SIZE DISTRIBUTION

PROJECT LAW-SR-650-07.16

PID 119775

OGE NUMBER N1245336

PROJECT TYPE STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification	ODOT (Modified AASHTO) ~ USCS Classification										LL	PL	PI
● B-001-0-24 1.5	A-6a ~ LEAN CLAY with SAND(CL)										34	19	15
☒ B-001-0-24 4.5	A-3a ~ SILTY SAND(SM)										NP	NP	NP
▲ B-001-0-24 8.5	A-3a ~ SILTY SAND(SM)										NP	NP	NP
★ B-002-0-24 3.5	A-4a ~ SANDY LEAN CLAY(CL)										27	19	8
◎ B-002-0-24 5.0	~												
Specimen Identification	D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu		
● B-001-0-24 1.5	0.167	0.015	0.005		2	1	17	50	30				
☒ B-001-0-24 4.5	0.361	0.143	0.087	0.012	1	4	69	24	2	3.59	14.67		
▲ B-001-0-24 8.5	0.413	0.126	0.068	0.009	0	9	60	27	4	3.01	16.98		
★ B-002-0-24 3.5	19.972	0.04	0.012		15	1	24	44	16				
◎ B-002-0-24 5.0													

GRAIN SIZE - OH.DOT.GDT - 1/30/25 14:43 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ



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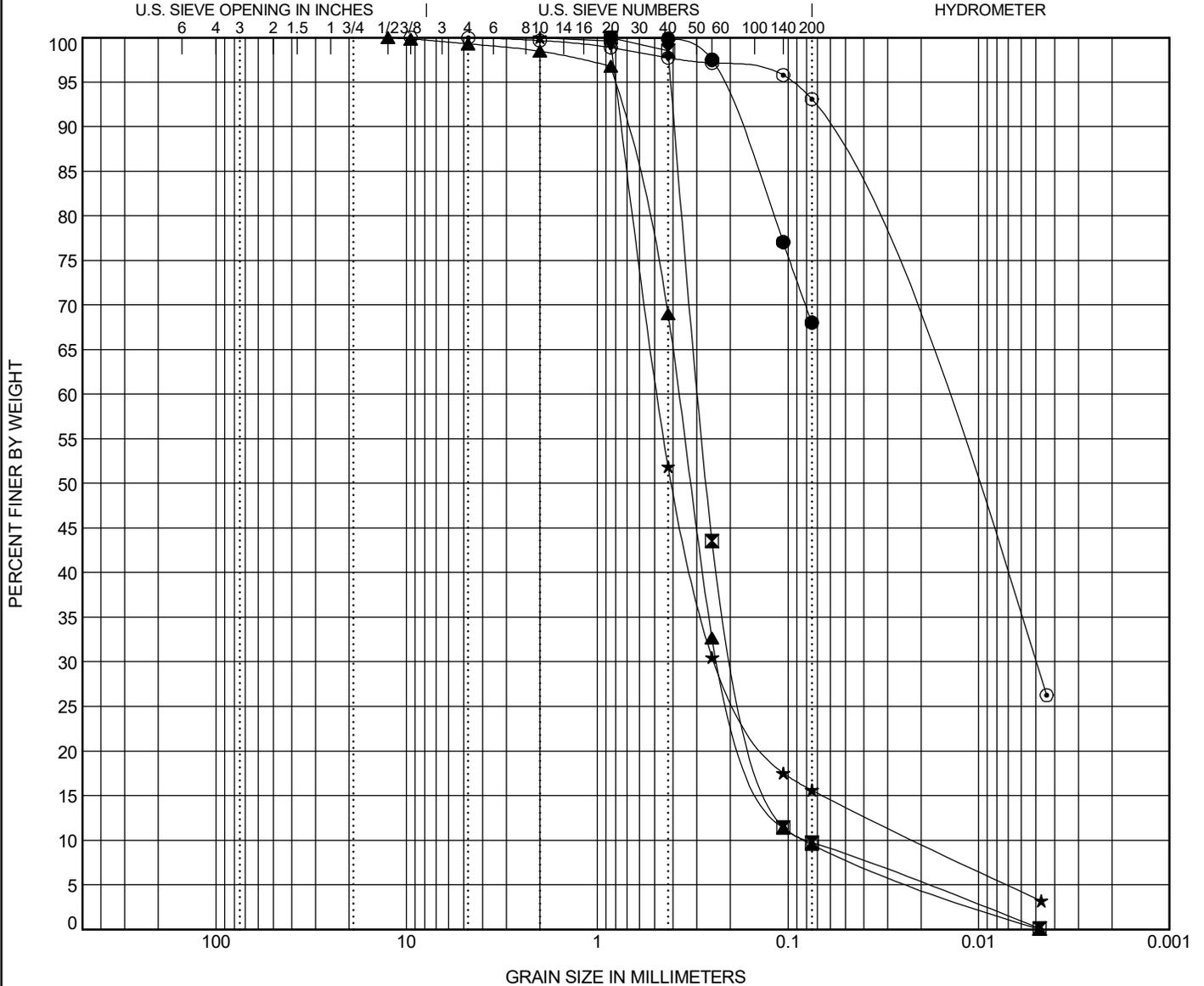
GRAIN SIZE DISTRIBUTION

PROJECT LAW-SR-650-07.16

PID 119775

OGE NUMBER N1245336

PROJECT TYPE STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification	ODOT (Modified AASHTO) ~ USCS Classification									LL	PL	PI
● B-002-0-24 8.5	A-4 ~ SANDY SILT (ML)									18	16	2
■ B-002-0-24 15.0	A-3 ~ POORLY GRADED SAND with SILT (SP-SM)									NP	NP	NP
▲ B-002-0-24 18.0	A-3 ~ POORLY GRADED SAND with SILT (SP-SM)									NP	NP	NP
★ B-002-0-24 28.5	A-3a ~ SILTY SAND (SM)									NP	NP	NP
○ B-002-0-24 53.5	A-6a ~ LEAN CLAY (CL)									31	20	11
Specimen Identification	D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu	
● B-002-0-24 8.5	0.182				0	0	32	68				
■ B-002-0-24 15.0	0.391	0.266	0.174	0.079	0	1	89	10	0	1.31	3.71	
▲ B-002-0-24 18.0	0.717	0.322	0.225	0.083	2	29	60	9	0	1.64	4.51	
★ B-002-0-24 28.5	0.739	0.406	0.242	0.021	0	48	36	13	3	5.70	22.25	
○ B-002-0-24 53.5	0.066	0.012	0.005		0	2	5	64	29			

GRAIN SIZE - OH.DOT.GDT - 1/30/25 14:43 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

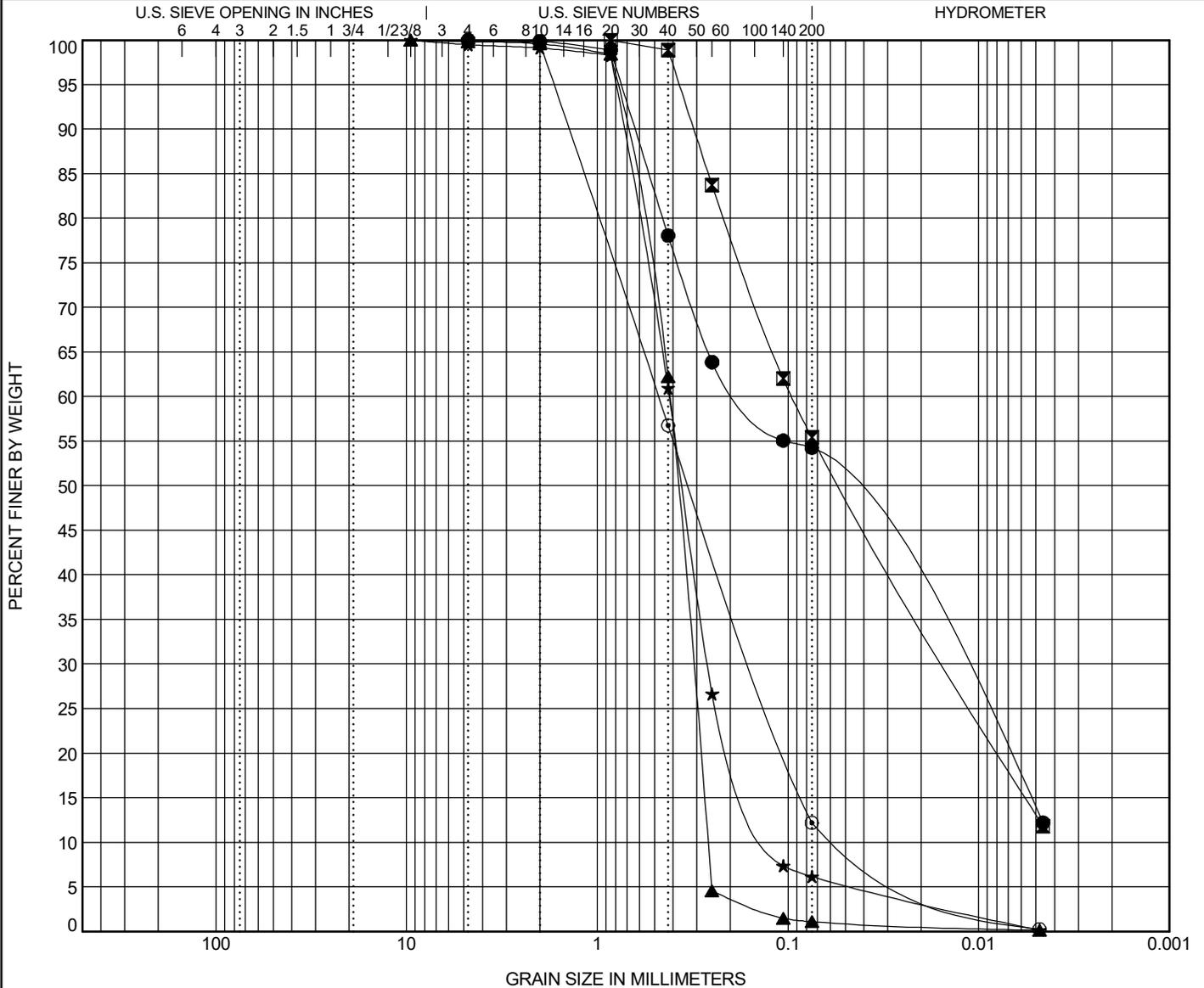


PROJECT LAW-SR-650-07.16

PID 119775

OGE NUMBER N1245336

PROJECT TYPE STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification	ODOT (Modified AASHTO) ~ USCS Classification										LL	PL	PI
● B-003-0-24 3.5	A-4a ~ SANDY SILTY CLAY (CL-ML)										20	16	4
☒ B-003-0-24 8.5	A-4a ~ SANDY SILT (ML)										NP	NP	NP
▲ B-003-0-24 13.5	A-3 ~ POORLY GRADED SAND (SP)										NP	NP	NP
★ B-003-0-24 16.5	A-3 ~ POORLY GRADED SAND with SILT (SP-SM)										NP	NP	NP
◎ B-003-0-24 33.5	A-3a ~ SILTY SAND (SM)										NP	NP	NP
Specimen Identification	D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu		
● B-003-0-24 3.5	0.633	0.057	0.015		0	22	24	41	13				
☒ B-003-0-24 8.5	0.311	0.053	0.015		0	2	43	42	13				
▲ B-003-0-24 13.5	0.724	0.38	0.316	0.263	1	37	61	1	0	0.91	1.58		
★ B-003-0-24 16.5	0.729	0.359	0.263	0.119	1	38	55	6	0	1.39	3.51		
◎ B-003-0-24 33.5	1.408	0.327	0.15	0.045	0	43	45	12	0	1.04	10.52		

GRAIN SIZE - OH.DOT.GDT - 1/30/25 14:43 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

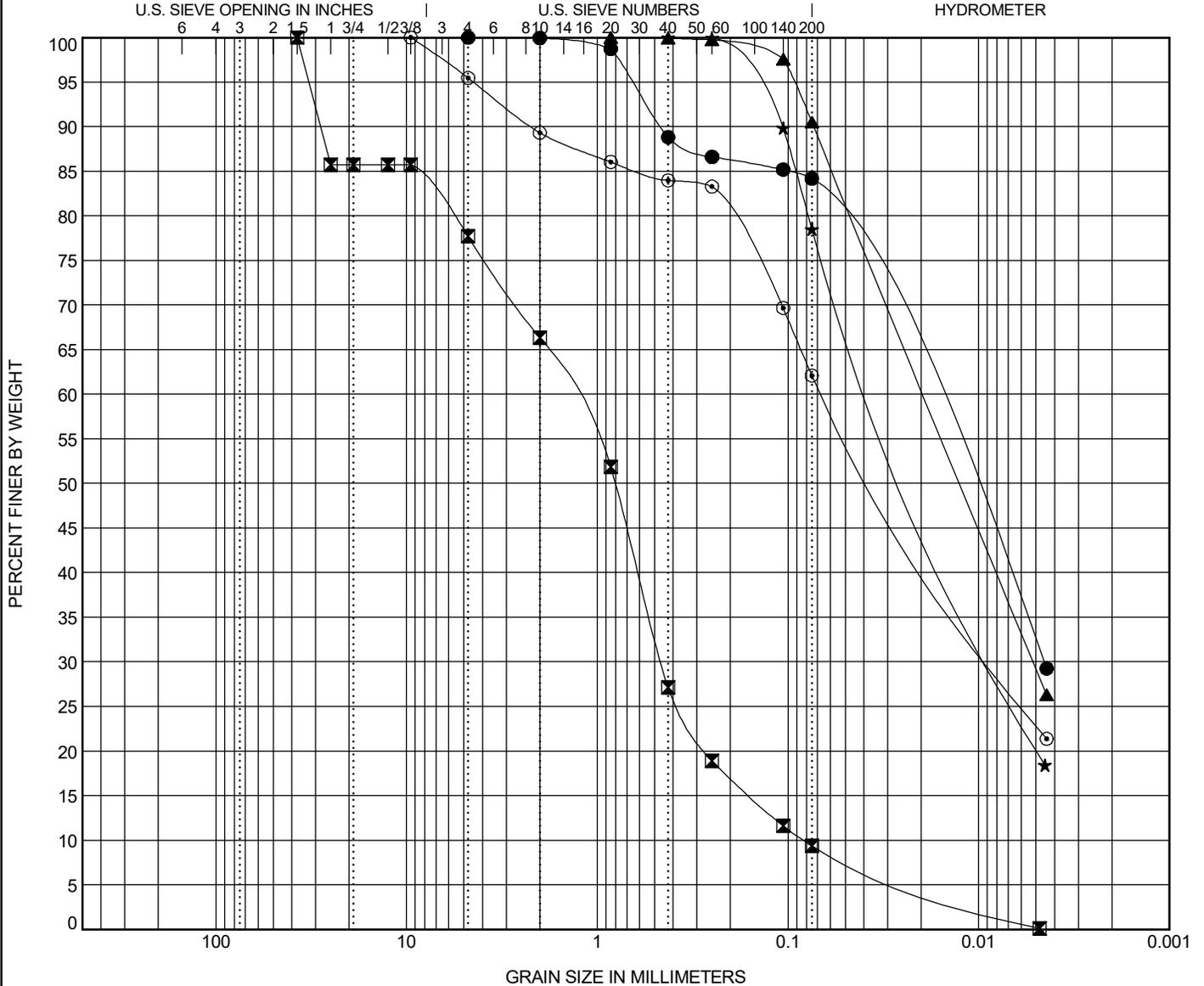


PROJECT LAW-SR-650-07.16

PID 119775

OGE NUMBER N1245336

PROJECT TYPE STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification	ODOT (Modified AASHTO) ~ USCS Classification										LL	PL	PI
● B-003-0-24 53.5	A-6a ~ LEAN CLAY with SAND(CL)										35	21	14
☒ B-003-0-24 68.5	A-1-b ~ WELL-GRADED SAND with SILT and GRAVEL(SW-SM)										NP	NP	NP
▲ B-004-0-24 1.5	A-6b ~ LEAN CLAY(CL)										37	21	16
★ B-004-0-24 4.5	A-6a ~ LEAN CLAY with SAND(CL)										30	19	11
◎ B-005-0-24 2.5	A-6a ~ SANDY LEAN CLAY(CL)										32	19	13
Specimen Identification	D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu		
● B-003-0-24 53.5	0.461	0.013	0.005		0	11	5	52	32				
☒ B-003-0-24 68.5	28.211	0.807	0.46	0.083	34	39	18	9	0	1.86	16.57		
▲ B-004-0-24 1.5	0.073	0.013	0.005		0	0	9	62	29				
★ B-004-0-24 4.5	0.107	0.02	0.008		0	0	21	58	21				
◎ B-005-0-24 2.5	2.202	0.032	0.008		11	5	22	39	23				

GRAIN SIZE - OH.DOT.GDT - 1/30/25 14:43 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ



OHIO DEPARTMENT OF TRANSPORTATION
OFFICE OF GEOTECHNICAL ENGINEERING

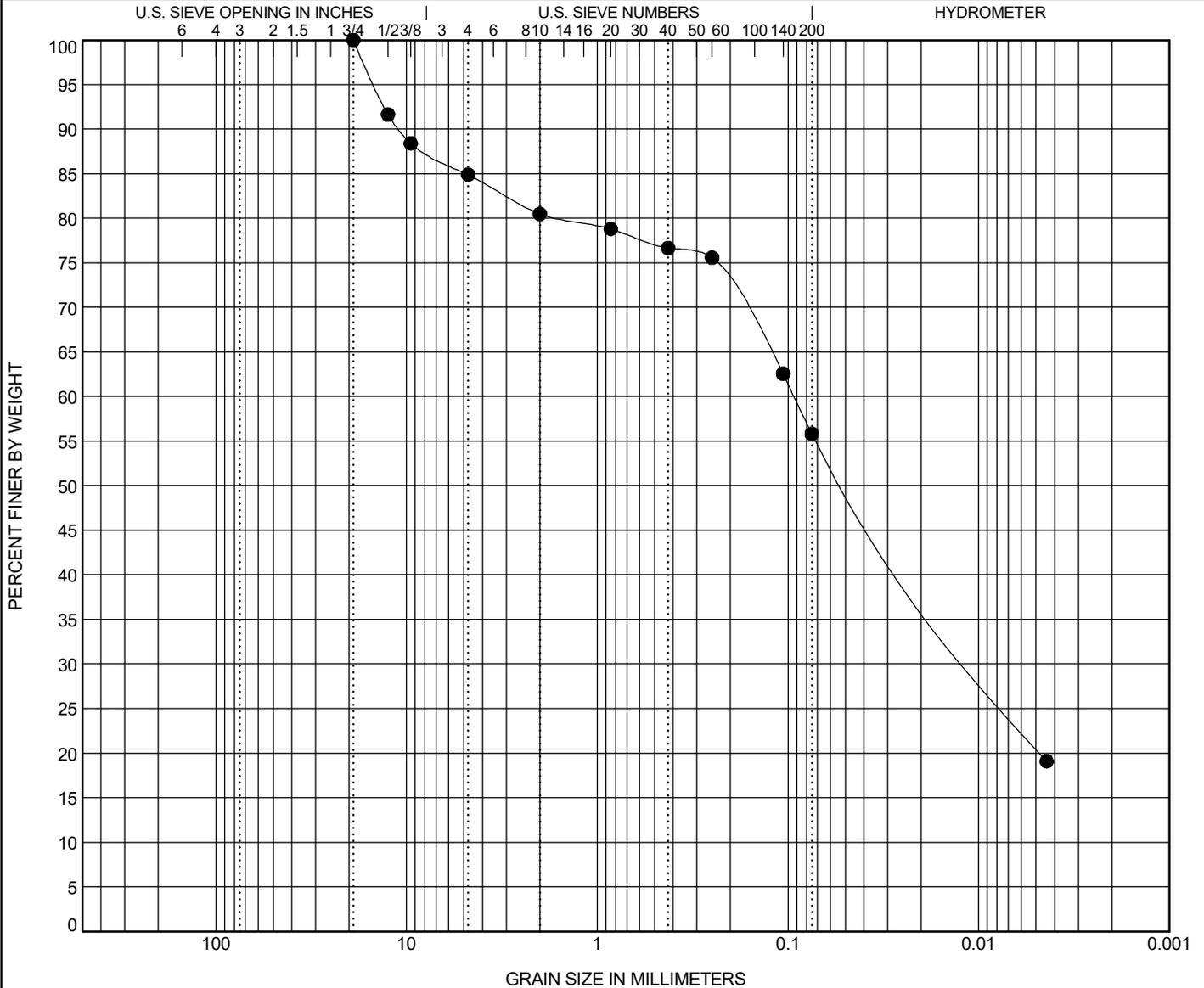
GRAIN SIZE DISTRIBUTION

PROJECT LAW-SR-650-07.16

PID 119775

OGE NUMBER N1245336

PROJECT TYPE STRUCTURE FOUNDATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification	ODOT (Modified AASHTO) ~ USCS Classification							LL	PL	PI
● B-005-0-24 5.5	A-4a ~ SANDY LEAN CLAY with GRAVEL (CL)							25	16	9

Specimen Identification	D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
● B-005-0-24 5.5	10.869	0.048	0.01		19	4	21	35	21		

GRAIN SIZE - OH DOT.GDT - 1/30/25 14:43 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ



OHIO DEPARTMENT OF TRANSPORTATION
OFFICE OF GEOTECHNICAL ENGINEERING

UNCONFINED COMPRESSION TEST
AASHTO T - 208

PROJECT LAW-SR-650-07.16

PID 119775

OGE NUMBER N1245336

PROJECT TYPE STRUCTURE FOUNDATION

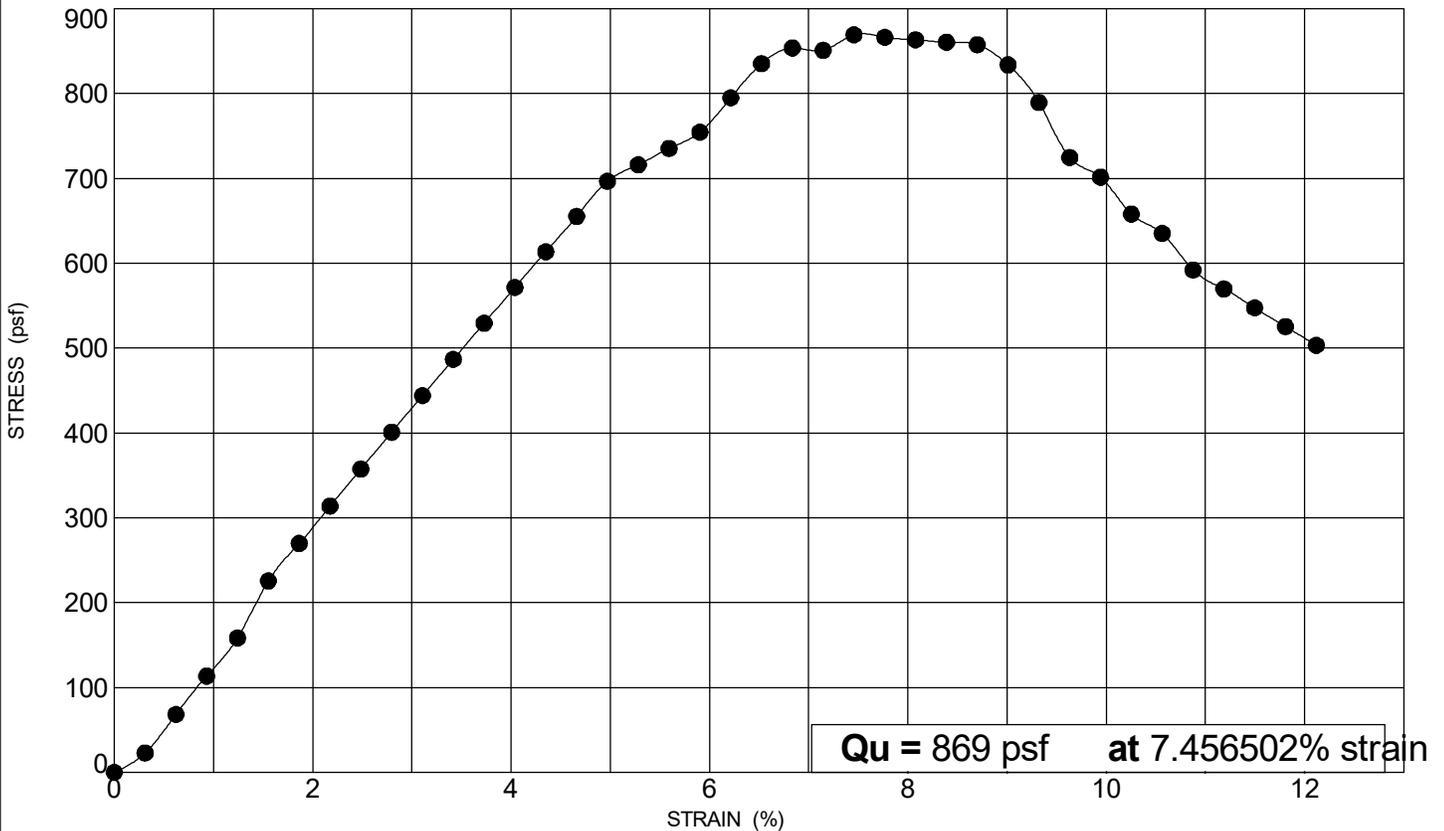
SAMPLE IDENTIFICATION

BORING ID: B-002-0-24

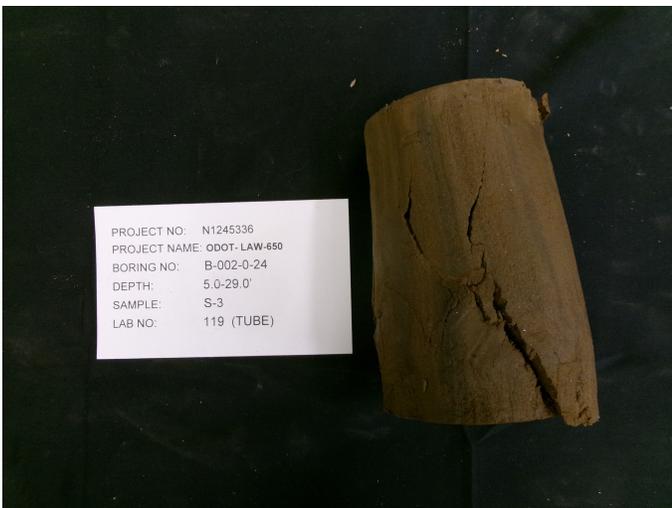
SAMPLE ID: ST-3

STATION: 382+55, 9' LT.

DEPTH: 5.0 - 7.0 feet



SPECIMEN FAILURE SKETCHES OR PHOTOGRAPHS



FRONT VIEW

SIDE VIEW

SPECIMEN DETAILS

HEIGHT: 6.44 inches

DIAMETER: 2.83 inches

WET UNIT WT: 110.34 pcf

DRY UNIT WT: 90.01 pcf

TESTED BY: CS 1/22/2025

CLASSIFICATION RESULTS

GRADATION (%)				
GR	CS	FS	SI	CL
-	-	-	-	-
ATTERBERG LIMITS			MOISTURE	
LL	PL	PI	WC	
-	-	-	22	

ODOT CLASS: _____ HP (tsf): 1.50

DESCRIPTION: _____

OHDOT UNCONFINED COMPRESSION - OH DOT.GDT - 1/30/25 14:36 - E:\PROJECTS\2024\N1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

Client

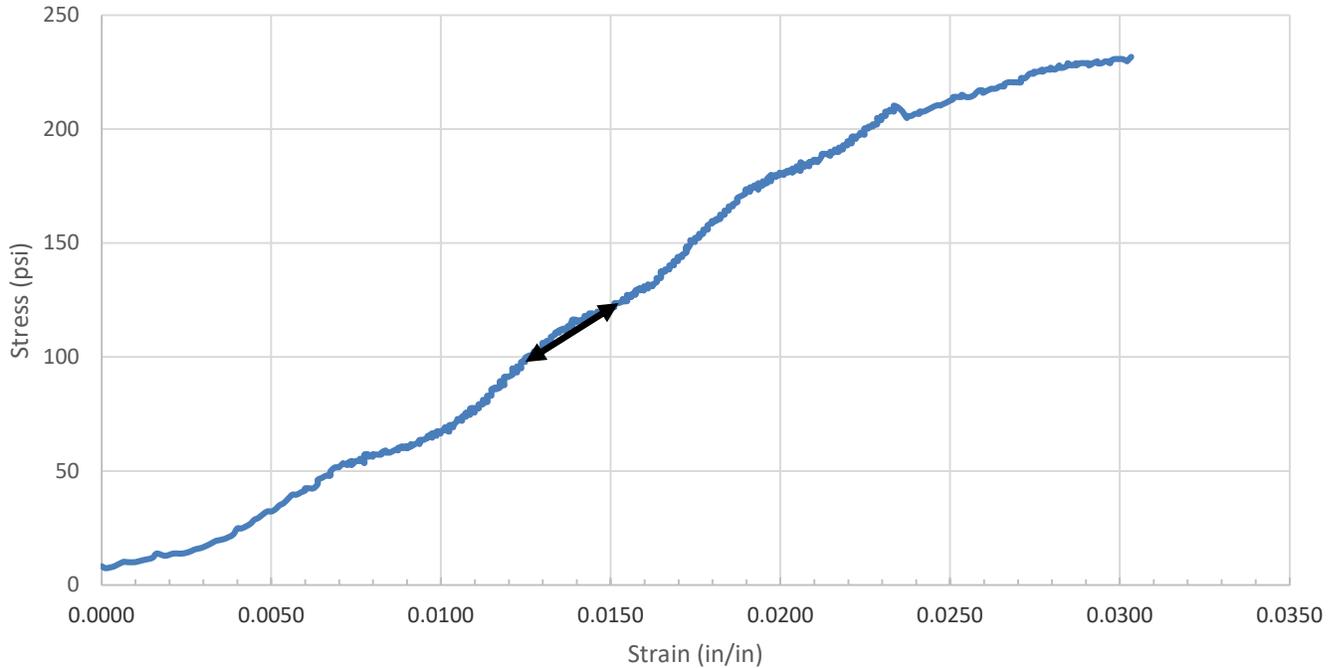
CHA Consulting Inc
 Attn: Douglas Miller
 471 E Broad St
 Columbus, OH 43215

Project

LAW-650-7.16
 SR-650
 Pedro, OH 45659

Project No. N1245336

ASTM D7012 Stress/ Strain Curve



— Axial ↔ Axial Tangent Line



SAMPLE LOCATION

Site:	LAW-650-7.16		
Description:	Shale		
Boring:	B-002-0-24	Depth (feet):	76

SPECIMEN INFORMATION

Sample No.:	1	Mass (g):	491.03
Length (in.):	4.0133	Diameter (in.):	2
L/D Ratio:	2.007	Density (pcf):	148.366

TEST RESULTS

Failure Load (lbs):	728
Failure Strain (in/in):	0.030
Unconfined Compressive Strength (psi):	232
Elastic Modulus, E, (ksi):	9
Time of Failure (min):	02:03
Rate of Loading (in/sec):	0.04
Moisture Content Post-break:	3.54%

Client

CHA Consulting Inc
Attn: Douglas Miller
471 E Broad St
Columbus, OH 43215

Project

LAW-650-7.16
SR-650
Pedro, OH 45659

Project No. N1245336

Equipment:

	TICCS ID:
Calipers	W-44049
Scale	B-71466
Dial Indicator	C-70608
Compression (spherically seated)	C-48999

Samples were prepared and tested in accordance with ASTM D4543 and D7012. Deviations, if any, are noted below:

Notes:

Per ASTM D4543, this specimen has not met the requirements for perpendicularity, by exceeding 0.250°.
Per ASTM D4543, this specimen has not met the requirements for flatness, by exceeding 0.001 inches.
Per ASTM D4543, this specimen has not met the requirements for parallelism, by exceeding 0.25°.
According to ASTM D7012 Section 8.2.1, this specimen, although not meeting all requirements of ASTM D4543 is acceptable for testing. However, the results reported may differ from results obtained from a test specimen that meets the requirements of D4543.

Client

CHA Consulting Inc
Attn: Douglas Miller
471 E Broad St
Columbus, OH 43215

Project

LAW-650-7.16
SR-650
Pedro, OH 45659

Project No. N1245336

**SUPPLEMENT 1122
DETERMINING SULFATE CONTENT IN SOILS**

SAMPLE INFORMATION

Sample Type: Split Spoon
Sample Location: Borings

Lab Number	Hole Number	Sample Number	Sample Depth	Sulfate Concentration, ppm
111	B-001-0-24	1	1.5-2.5	< 100
160	B-004-0-24	1	1.5-2.5	< 100
165	B-003-0-24	1	1.0-2.0	< 100

WEAP Supporting Information

Contents:

ODOT Soil Classification System (3 pages)
ODOT Subgrade Analysis Spreadsheet (8 pages)
Driven Pile Calculations (APILE & WEAP) (60 pages)
Geotechnical Profile Sheets (10 pages)

Note: All attachments are one page unless noted above.

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%

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	Classification		LL _O /LL × 100*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
		AASHTO	OHIO							
	Gravel and/or Stone Fragments	A-1-a			30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A-1-b			50 Max.	25 Max.		6 Max.	0	
	Fine Sand	A-3			51 Min.	10 Max.	NON-PLASTIC		0	
	Coarse and Fine Sand	--	A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4				35 Max.	40 Max.	10 Max.	0	
		A-2-5			41 Min.					
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6				35 Max.	40 Max.	11 Min.	4	
		A-2-7			41 Min.					
	Sandy Silt	A-4	A-4a	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		Uncontrolled Fill (Describe)		Bouldery Zone		Peat			
	Pavement or Base									

* 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 alteration 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
Calcareous - contains calcium carbonate
Conglomeritic - contains rounded to subrounded gravel
Feriferous – contains iron
Friable – easily broken down
Siliceous – contains silica

Argillaceous - clayey
Carbonaceous - contains carbon
Crystalline – contains crystalline structure
Fissile – thin planar partings
Micaceous – contains mica
Styolitic – contain stylotites (suture like structure)

Brecciated – contains angular to subangular gravel
Cherty- contains chert fragments
Dolomitic- contains calcium/magnesium carbonate
Fossiliferous – contains fossils
Pyritic – contains pyrite
Vuggy – contains openings

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES

Geotechnical Design Manual Section 600

Instructions: Enter data in the shaded cells only.

(Enter state route number, project description, county, consultant's name, prepared by name, and date prepared. This information will be transferred to all other sheets. The date prepared must be entered in the appropriate cell on this sheet to remove these instructions prior to printing.)

LAW-SR650-7.16
119775

Roadway realignment and new bridge construction

Terracon Consultants

Prepared By: David W. Westendorf, P.E.
Date prepared: Friday, January 31, 2025

611 Lunken Park Drive
Cincinnati, OH 45226

david.westendorf@terracon.com

NO. OF BORINGS: 3

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL.	Cut Fill
1	B-001-0-24	SR-650	379+15	14	left	CME Automatic	89	570.7	570.4	0.3 C
2	B-004-0-24	SR-650	385+90	42	left	CME Automatic	89	568.9	570.9	2.0 F
3	B-005-0-24	SR-650	389+30	4	left	CME Automatic	89	578.7	577.7	1.0 C



#	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 001-0 24	1	1.5	3.0	1.2	2.7	10	3	1.25	34	19	15	50	30	80	23	14	A-6a	10	0		HP & Mc			30 inches 204 Geotextile
		2	3.0	4.5	2.7	4.2	6		0	0	NP	24	2	26	21	8	A-3a	0	0						
		3	4.5	6.0	4.2	5.7	3		0	0	NP	24	2	26	24	8	A-3a	0	0						
2	B 004-0 24	1	0.0	1.5	2.0	3.5	7	4	2	37	21	16	62	29	91	27	16	A-6b	10	0		N ₆₀ & Mc			12 inches 204 Geotextile
		2	1.5	3.0	3.5	5.0	6		1.25	37	21	16	62	29	91	27	16	A-6b	10	0					
		3	3.0	4.5	5.0	6.5	4		0.5	30	19	11	58	21	79	34	14	A-6a	8	0					
		4	4.5	6.0	6.5	8.0	3		0.25	30	19	11	58	21	79	31	14	A-6a		0					
3	B 005-0 24	1	1.0	2.5	0.0	1.5	19	7	4	32	19	13	39	23	62	10	14	A-6a	7	0					18 inches 204 Geotextile
		2	2.5	4.0	1.5	3.0	12		1.5	32	19	13	39	23	62	23	14	A-6a	7	0		HP & Mc			
		3	4.0	5.5	3.0	4.5	7		1	32	19	13	39	23	62	22	14	A-6a	7	0					
		4	5.5	7.0	4.5	6.0	9		1.25	25	16	9	35	21	56	19	11	A-4a	4	0					

PID: 119775

County-Route-Section: LAW-SR650-7.16

No. of Borings: 3

Geotechnical Consultant: Terracon Consultants

Prepared By: David W. Westendorf, P.E.

Date prepared: 1/31/2025

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

Excavate and Replace Stabilization Options	
Global Geotextile Average(N60L):	24"
Average(HP):	12"
Global Geogrid Average(N60L):	18"
Average(HP):	0"

Design CBR	7
------------	---

% Samples within 3 feet of subgrade			
$N_{60} \leq 5$	0%	$HP \leq 0.5$	0%
$N_{60} < 12$	40%	$0.5 < HP \leq 1$	10%
$12 \leq N_{60} < 15$	10%	$1 < HP \leq 2$	30%
$N_{60} \geq 20$	0%	$HP > 2$	10%
M+	30%		
Rock	0%		
Unsuitable Soil	0%		

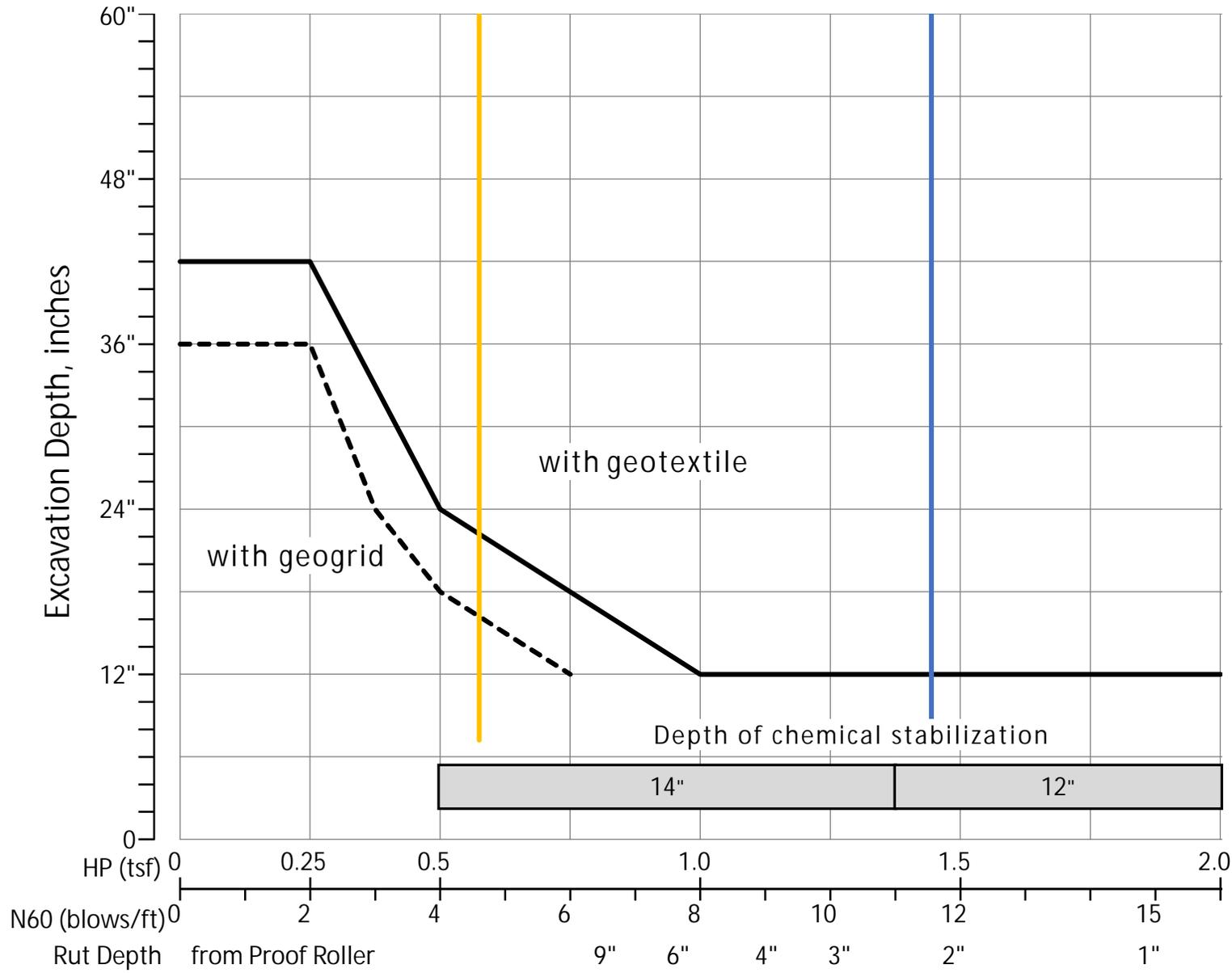
Excavate and Replace at Surface	
Average	
Maximum	0"
Minimum	0"

% Proposed Subgrade Surface	
Unstable & Unsuitable	60%
Unstable	60%
Unsuitable (Soil & Rock)	0%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	8	5	1.44	26	16	13	45	20	65	24	13	6
Maximum	19	7	4.00	37	21	16	62	30	91	34	16	10
Minimum	3	3	0.25	0	0	9	24	2	26	10	8	0

Classification Counts by Sample																					
ODOT Class	UCF	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	0	0	0	0	0	0	0	0	2	1	0	0	6	2	0	0	0	0	11	
Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	18%	9%	0%	0%	55%	18%	0%	0%	0%	0%	100%	
% Rock Granular Cohesive	0%	0%	27%									73%									100%
Surface Class Count	0	0	0	0	0	0	0	0	0	1	0	0	0	3	1	0	0	0	0	5	
Surface Class Percent	0%	0%	0%	0%	0%	0%	0%	0%	0%	20%	0%	0%	0%	60%	20%	0%	0%	0%	0%	100%	

Fig. 600-1 – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
1.44	0.50	<input type="checkbox"/> HP
4.67	6.00	<input type="checkbox"/> N60L

Average HP —
 Average N₆₀L —

The subgrade analysis workbook consists of five worksheets. Each worksheet functions independently. In all of the worksheets the fields are color coded as follows:

- Every yellow highlighted field indicates a field to be entered by the user.
- Every salmon field is to indicate a problem/issue.
- Every gray or green field is a heading/informational field.

IMPORTANT: The sequence of filling out the data needs to be followed as outlined below:

1. Cover Sheet: this worksheet is designed for the purpose of entering the project information. Enter all the following fields:

County-Route-Section	This includes the county, route, section number assigned to the project.
PID	the Project Identification Number
Project Description	See Cover Sheet for list of example details
Geotechnical Consultant	The Geotechnical Consultant performing the analysis.
Prepared By	The preparer of the subgrade analysis
Date prepared	The date the analysis is performed.
Contact Information	Name, address, telephone #, and email address
No. of Borings	Enter the total number of borings within the alignment that is being analyzed.

2. Boring Logs Entry Worksheet: this worksheet has a programming code that will run in the background every time the sheet is activated and will make the sheet unresponsive for less than a minute. The code is designed to read the total number of borings from the cover sheet and generate the needed number of fields.

- a. All yellow highlighted fields are user's entry.
- b. ODOT has developed a text table export from gINT (*GB 1 Borings Log Entry Tab*) that will allow for copy and paste of all highlighted fields with the exception of proposed subgrade elevation. The designer must provide a proposed subgrade elevation in order for the spreadsheet to function properly.
- c. The Cut/Fill field is a calculated field that, based on the difference between the boring elevation and the proposed subgrade elevation, will highlight the cell either gray and adds the letter "C" to the end in a cut situation or highlights the cell in light purple and adds the letter "F" to the end in a fill situation.
- d. Every duplicate boring ID will be highlighted in salmon background and red text.
- e. **IMPORTANT:** After entering all the borings' information, the user must click "Add Subgrade Analysis Entry Fields" button. This will generate all the required fields in the "Subgrade Analysis" Worksheet.

3. Subgrade Analysis Worksheet:

- a. The boring number and boring ID is read from the "Boring Logs Entry Worksheet" excluding every boring that has six feet or more of fill.
- b. All yellow highlighted fields are to be entered by the user and salmon highlighted fields indicates a problem or issue.
- c. Every sample that has a Sulfate Content greater than or equal to 3000 will be highlighted in light salmon background. Every sample that has a Sulfate Content greater than or equal to 8000 will be highlighted in darker salmon background. **Refer to Section 605 of the Geotechnical Design Manual for the latest guidance regarding high sulfate soils.**

d. Unsuitable/Unstable:

- i. Unsuitable samples that are within 3 feet of the top of subgrade will be highlighted with salmon background and the class will be showing in this field.
- ii. Unstable Samples that are within 3 feet of top of subgrade will be highlighted with salmon background and text to indicate the problem as follows:

Criterion	Stabilization Need Check	Text displayed in the field
A-1-a, A-1-b, A-3, or A-3a Soil Class	No Stabilization is needed	
$HP \geq 1.875$	No Stabilization is needed	
$N_{60} \geq 15$	No Stabilization is needed	
$1.875 \geq HP \geq 1.5$ and $M_c \geq \text{Opt. } M_c + 3$	Unstable Subgrade	HP & M_c
$15 \geq N_{60} \geq 12$ and $M_c \geq \text{Opt. } M_c + 3$	Unstable Subgrade	N_{60} & M_c
$HP \leq 1.5$	Unstable Subgrade	HP
$N_{60} \leq 12$	Unstable Subgrade	N_{60}

- iii. The field is formulated to check for HP first and check for N_{60} second.

f. Excavate and Replace (Item 204) is going to be calculated based on the subgrade depth for each sample indicating an unsuitable or unstable problem.

g. Recommendation:

- i. Geotextile Option is calculated and rounded to a multiple of 3 inches based on the subgrade depth for every sample indicating an unsuitable or unstable problem.
- ii. GEOGRID Option is only offered in case of unstable subgrade problem and if the geotextile option indicates the need to excavate greater than 12 inches.

PLEASE NOTE: The Problem, Excavate & Replace, and Recommendation Fields are the responsibility of the Designer. These fields are being enhanced to attempt to capture the ODOT philosophy regarding the subgrade stabilization chart, but are considered still under development. If there are discrepancies between the spreadsheet output and the stabilization chart - the chart governs in conjunction with engineering judgement. Please contact Steve Taliaferro at stephen.taliaferro@dot.ohio.gov if you have any questions.

PLEASE NOTE: It is the Designer's responsibility to identify the most representative data when samples have been separated into multiple specimen (say 1.5 to 2.3 feet and 2.3 to 3.0 feet). The spreadsheet is not capable at this time of addressing this issue within a direct data export from gINT.

4. Results Summary:

All fields in this sheet are password protected and are either calculated or read from the other worksheets.

The spreadsheet calculates the % unstable and % unsuitable soils based on the number of samples encountered within 3.0 feet of the bottom of subgrade (say if 10 samples are taken within 3.0 feet of the bottom of subgrade and two encounter unstable soils and three encounter unsuitable soils, then the spreadsheet will return unstable = 20% and unsuitable = 30% for a combined total of 50%).

5. Graph Worksheet:

This worksheet is designed to read the average N_{60L} and the average HP from the Cover Sheet and plot a blue line for Average HP and orange line for Average N_{60L} on GDM Figure 600-1 – Subgrade Stabilization. The Override Table can be used to enter HP and/or N_{60L} values that are different than the calculated averages. The Override values will change the global undercut recommendation in the Results Summary.

Driven Friction Pile Calculations

Project: LAW-650-7.16

Proj#: N1245336

Case: South Abutment (B-002-0-24)



Calculated By: MP

Reviewed By: DWW

References:

ODOT SGE 7-19-24, ODOT BDM 2020 7-19-24, ODOT C&MS, FHWA-NHI-16-064 (FHWA GEC 012)

Bridge Geometry

Substructure: Abutment- South Side

Elevation of Ground Surface, $EG := 575.4 \text{ ft}$ (Used ~Ground Surface Along Northern bank)

Approx. Top of Pile/Bottom of Pile Cap Elevation, $ETP := 566 \text{ ft}$ (Pile above this will be sleeved)

Scour Depth, $D_{Scour} := 0 \text{ ft}$

Depth to Water Below Top of Pile, $Depth_{GW} := 7 \text{ ft}$ Use normal creek/river level if adjacent

Soil Layers

Layer	Soil Type	Bot. Depth	TopElev	BotElev	Bot. Depth	γ	ϕ'	S_u	APILE
		from			Below Top				
		Surface	ft	ft	of Pile	pcf	deg	psf	Factor, f_{su}
1	A-6a, stiff	3.5	575.4	571.9	-5.9	120	-	1,250	1.00
2	A-4a, medium stiff to stiff	11.0	571.9	564.4	1.6	115	-	750	1.00
3	A-3, very loose to loose	23.5	564.4	551.9	14.1	118	26	-	1.00
4	A-3a, loose to medium dense	48.5	551.9	526.9	39.1	120	30	-	1.00
5	A-6a, very soft	53.5	526.9	521.9	44.1	105	-	250	1.00
6	A-6a, medium stiff to stiff	68.5	521.9	506.9	59.1	120	-	750	1.00
7	A-1-b, very dense	75	506.9	500.4	65.6	135	40	-	1.00

Driven Pile Capacity using APile 2023 (FHWA Method)

Driven Pile Capacity Summary (enter results from APile)

Pile Type/Size	Pile Driven Length (ft.)	Approx. Tip Elevation (ft.)	Side Resistance (kips)	End Bearing (kips)	UBV (kips)
12	61	505	83.1	246.9	330.0

Setup

The affected soil layers have APILE setup factors equal to 1. Thus the result is similar to the capacity with no setup considered.

See attached APILE Results

=====

APILE for Windows, Version 2023.10.3

Serial Number : 506768014

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.
(c) Copyright ENSOFT, Inc., 1987-2023
All Rights Reserved

=====

This program is licensed to :

Terracon, Inc.
APILE Global, Global License

Path to file locations : E:\Projects\2024\N1245336\Working
Files\Calculations-Analyses\Driven piles\APILE\B-002-0-24\
Name of input data file : B-002-0-24- 12 inches A Pile.ap10d
Name of output file : B-002-0-24- 12 inches A Pile.ap10o
Name of plot output file : B-002-0-24- 12 inches A Pile.ap10p

Time and Date of Analysis

Date: March 06, 2025 Time: 10:20:14

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* INPUT INFORMATION *

PROJECT DESCRIPTION :
B-002-0-24 12-inch pile
DESIGNER : MP
JOB NUMBER : N1245336

METHOD FOR UNIT LOAD TRANSFERS :
- FHWA (Federal Highway Administration)
Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :
- FHWA (Federal Highway Administration)

TYPE OF LOADING :

- COMPRESSION

PILE TYPE :

Steel pipe pile or non-tapered portion of monotube pile

- Close-Ended Pile

AVERAGE DEPTH TO ESTIMATE TIP RESISTANCE:

- USE 1.5 DIAMETERS ABOVE AND BELOW TIP

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI

- CROSS SECTION AREA = 9.23 IN²

CIRCULAR PILE PROPERTIES :

- OUTSIDE DIAMETER, OD = 12.00 IN.

- INTERNAL DIAMETER, ID = 11.50 IN.

- TOTAL PILE LENGTH, TL = 63.00 FT.

- BATTER ANGLE = 0.00 DEG

- PILE STICKUP LENGTH, PSL = 0.00 FT.

- ZERO FRICTION LENGTH, ZFL = 5.00 FT.

- INCREMENT OF PILE LENGTH
USED IN COMPUTATION = 1.00 FT.

- PRINTING INCREMENT = 1

- LENGTH OF ENHANCED
END SECTION = 63.00 FT.

- INTERNAL DIAMETER OF
ENHANCED END SECTION = 11.50 IN.

PLUGGED/UNPLUGGED CONDITIONS :

Internal Pile Plug Calculated by Program

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/FT ³	FRICTION ANGLE DEGREES	N _q FACTOR FHWA
0.00	CLAY	0.80*	120.00	0.00	4.80**
-5.90	CLAY	0.80*	120.00	0.00	4.80**
-5.90	CLAY	0.80*	115.00	0.00	4.80**
1.60	CLAY	0.80*	115.00	0.00	4.80**
1.60	SAND	0.80*	55.60	26.00	17.40**
14.10	SAND	0.80*	55.60	26.00	17.40**
14.10	SAND	0.80*	57.60	30.00	30.00**
39.10	SAND	0.80*	57.60	30.00	30.00**
39.10	CLAY	0.80*	42.60	0.00	4.80**
44.10	CLAY	0.80*	42.60	0.00	4.80**

44.10	CLAY	0.80*	57.60	0.00	4.80**
59.10	CLAY	0.80*	57.60	0.00	4.80**
59.10	SAND	0.80*	72.60	40.00	160.00**
65.60	SAND	0.80*	72.60	40.00	160.00**

* VALUE ASSUMED BY THE PROGRAM

** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDI STURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	1.25	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.25	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.75	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.75	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.25	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.25	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.75	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.75	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING WERE SET TO LARGE VALUES INDICATING THAT APILE USES THE LIMITS SPECIFIED BY EACH SELECTED CRITERIA (IF ANY).

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
-5.90	1.000	1.000
-5.90	1.000	1.000
1.60	1.000	1.000
1.60	1.000	1.000
14.10	1.000	1.000
14.10	1.000	1.000
39.10	1.000	1.000
39.10	1.000	1.000
44.10	1.000	1.000
44.10	1.000	1.000
59.10	1.000	1.000

59.10	1.000	1.000
65.60	1.000	1.000

DEPTH FT.	Z PEAK IN.	T RESI DUAL
0.00	0.120 *	0.90 **
-5.90	0.120 *	0.90 **
-5.90	0.120 *	0.90 **
1.60	0.120 *	0.90 **
1.60	0.120 *	0.00
14.10	0.120 *	0.00
14.10	0.120 *	0.00
39.10	0.120 *	0.00
39.10	0.120 *	0.90 **
44.10	0.120 *	0.90 **
44.10	0.120 *	0.90 **
59.10	0.120 *	0.90 **
59.10	0.120 *	0.00
65.60	0.120 *	0.00

* DEFAULT VALUE = 0.01 D

** DEFAULT VALUE = 0.9

1

 * COMPUTATION RESULT *

 * FED. HWY. METHOD *

PILE LENGTH BELOW GND. FT.	SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	2.7	2.7
1.00	0.0	3.8	3.8
2.00	0.0	3.6	3.6
3.00	0.0	2.6	2.6
4.00	0.0	2.3	2.3
5.00	0.1	2.7	2.8

6.00	0.4	3.0	3.4
7.00	0.7	3.4	4.1
8.00	1.0	3.8	4.8
9.00	1.3	4.2	5.5
10.00	1.7	4.5	6.3
11.00	2.2	4.9	7.1
12.00	2.6	5.3	7.9
13.00	3.1	5.7	8.8
14.00	3.6	6.7	10.3
15.00	4.2	8.3	12.5
16.00	4.9	9.8	14.7
17.00	5.8	10.5	16.2
18.00	6.7	10.5	17.2
19.00	7.7	10.5	18.1
20.00	8.7	10.5	19.1
21.00	9.7	10.5	20.2
22.00	10.8	10.5	21.3
23.00	12.0	10.5	22.4
24.00	13.2	10.5	23.6
25.00	14.4	10.5	24.9
26.00	15.7	10.5	26.2
27.00	17.1	10.5	27.5
28.00	18.5	10.5	28.9
29.00	19.9	10.5	30.4
30.00	21.4	10.5	31.9
31.00	22.9	10.5	33.4
32.00	24.5	10.5	35.0
33.00	26.1	10.5	36.6
34.00	27.8	10.5	38.3
35.00	29.6	10.5	40.0
36.00	31.3	10.5	41.8
37.00	33.2	10.5	43.6
38.00	35.0	10.5	45.5
39.00	36.9	9.0	46.0
40.00	38.9	6.1	45.0
41.00	40.3	3.2	43.5
42.00	41.1	1.8	42.9
43.00	41.9	1.8	43.6
44.00	42.7	2.4	45.0
45.00	43.4	3.5	47.0
46.00	45.0	4.7	49.7
47.00	47.4	5.3	52.7
48.00	49.7	5.3	55.0
49.00	52.1	5.3	57.4
50.00	54.4	5.3	59.7
51.00	56.7	5.3	62.0
52.00	59.1	5.3	64.4
53.00	61.4	5.3	66.7
54.00	63.8	5.3	69.1
55.00	66.1	5.3	71.4

56.00	68.5	5.3	73.8
57.00	70.8	5.3	76.1
58.00	73.2	5.3	78.5
59.00	75.5	53.6	129.1
60.00	77.9	150.3	228.1
61.00	83.1	246.9	330.0
62.00	91.3	295.3	386.5
63.00	99.6	295.3	394.9

NOTES:

- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

 * COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
 * CURVES FOR AXIAL LOADING *

T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.4167E-01	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01
2	10	0.8000E+00	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01
3	10	0.1558E+01	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01

			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01
4	10	0.1642E+01	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01
5	10	0.7850E+01	0.0000E+00	0.0000E+00
			0.2227E+00	0.1920E-01
			0.3712E+00	0.3720E-01
			0.5568E+00	0.6840E-01
			0.6682E+00	0.9600E-01
			0.7424E+00	0.1200E+00
			0.7424E+00	0.2400E+00
			0.7424E+00	0.3600E+00
			0.7424E+00	0.6000E+00
			0.7424E+00	0.2400E+01
6	10	0.1406E+02	0.0000E+00	0.0000E+00
			0.3612E+00	0.1920E-01
			0.6020E+00	0.3720E-01
			0.9030E+00	0.6840E-01
			0.1084E+01	0.9600E-01
			0.1204E+01	0.1200E+00
			0.1204E+01	0.2400E+00
			0.1204E+01	0.3600E+00
			0.1204E+01	0.6000E+00
			0.1204E+01	0.2400E+01
7	10	0.1414E+02	0.0000E+00	0.0000E+00
			0.3631E+00	0.1920E-01
			0.6051E+00	0.3720E-01
			0.9076E+00	0.6840E-01
			0.1089E+01	0.9600E-01
			0.1210E+01	0.1200E+00
			0.1210E+01	0.2400E+00

			0. 1210E+01	0. 3600E+00
			0. 1210E+01	0. 6000E+00
			0. 1210E+01	0. 2400E+01
8	10	0. 2660E+02	0. 0000E+00	0. 0000E+00
			0. 8950E+00	0. 1920E-01
			0. 1492E+01	0. 3720E-01
			0. 2238E+01	0. 6840E-01
			0. 2685E+01	0. 9600E-01
			0. 2983E+01	0. 1200E+00
			0. 2983E+01	0. 2400E+00
			0. 2983E+01	0. 3600E+00
			0. 2983E+01	0. 6000E+00
			0. 2983E+01	0. 2400E+01
9	10	0. 3906E+02	0. 0000E+00	0. 0000E+00
			0. 1291E+01	0. 1920E-01
			0. 2152E+01	0. 3720E-01
			0. 3228E+01	0. 6840E-01
			0. 3874E+01	0. 9600E-01
			0. 4304E+01	0. 1200E+00
			0. 4304E+01	0. 2400E+00
			0. 4304E+01	0. 3600E+00
			0. 4304E+01	0. 6000E+00
			0. 4304E+01	0. 2400E+01
10	10	0. 3914E+02	0. 0000E+00	0. 0000E+00
			0. 1294E+01	0. 1920E-01
			0. 2156E+01	0. 3720E-01
			0. 3235E+01	0. 6840E-01
			0. 3882E+01	0. 9600E-01
			0. 4313E+01	0. 1200E+00
			0. 3882E+01	0. 2400E+00
			0. 3882E+01	0. 3600E+00
			0. 3882E+01	0. 6000E+00
			0. 3882E+01	0. 2400E+01
11	10	0. 4160E+02	0. 0000E+00	0. 0000E+00
			0. 5208E+00	0. 1920E-01
			0. 8681E+00	0. 3720E-01
			0. 1302E+01	0. 6840E-01
			0. 1562E+01	0. 9600E-01
			0. 1736E+01	0. 1200E+00
			0. 1562E+01	0. 2400E+00
			0. 1562E+01	0. 3600E+00
			0. 1562E+01	0. 6000E+00
			0. 1562E+01	0. 2400E+01
12	10	0. 4406E+02	0. 0000E+00	0. 0000E+00
			0. 5208E+00	0. 1920E-01

			0. 8681E+00	0. 3720E-01
			0. 1302E+01	0. 6840E-01
			0. 1562E+01	0. 9600E-01
			0. 1736E+01	0. 1200E+00
			0. 1562E+01	0. 2400E+00
			0. 1562E+01	0. 3600E+00
			0. 1562E+01	0. 6000E+00
			0. 1562E+01	0. 2400E+01
13	10	0. 4414E+02		
			0. 0000E+00	0. 0000E+00
			0. 5208E+00	0. 1920E-01
			0. 8681E+00	0. 3720E-01
			0. 1302E+01	0. 6840E-01
			0. 1562E+01	0. 9600E-01
			0. 1736E+01	0. 1200E+00
			0. 1562E+01	0. 2400E+00
			0. 1562E+01	0. 3600E+00
			0. 1562E+01	0. 6000E+00
			0. 1562E+01	0. 2400E+01
14	10	0. 5160E+02		
			0. 0000E+00	0. 0000E+00
			0. 1556E+01	0. 1920E-01
			0. 2594E+01	0. 3720E-01
			0. 3891E+01	0. 6840E-01
			0. 4669E+01	0. 9600E-01
			0. 5187E+01	0. 1200E+00
			0. 4669E+01	0. 2400E+00
			0. 4669E+01	0. 3600E+00
			0. 4669E+01	0. 6000E+00
			0. 4669E+01	0. 2400E+01
15	10	0. 5906E+02		
			0. 0000E+00	0. 0000E+00
			0. 1555E+01	0. 1920E-01
			0. 2592E+01	0. 3720E-01
			0. 3888E+01	0. 6840E-01
			0. 4666E+01	0. 9600E-01
			0. 5185E+01	0. 1200E+00
			0. 4666E+01	0. 2400E+00
			0. 4666E+01	0. 3600E+00
			0. 4666E+01	0. 6000E+00
			0. 4666E+01	0. 2400E+01
16	10	0. 5914E+02		
			0. 0000E+00	0. 0000E+00
			0. 1554E+01	0. 1920E-01
			0. 2590E+01	0. 3720E-01
			0. 3885E+01	0. 6840E-01
			0. 4662E+01	0. 9600E-01
			0. 5180E+01	0. 1200E+00
			0. 5180E+01	0. 2400E+00
			0. 5180E+01	0. 3600E+00

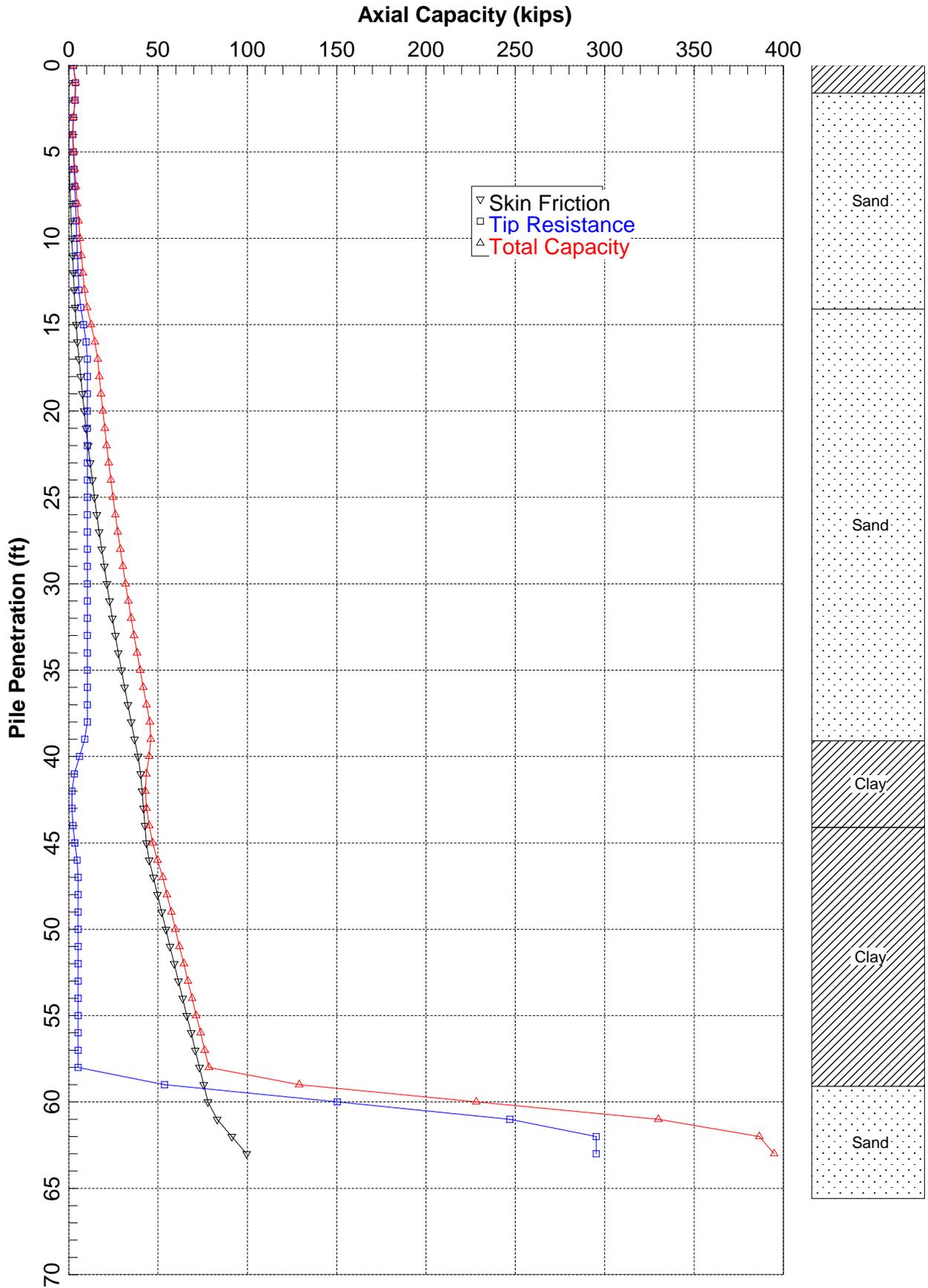
			0. 5180E+01	0. 6000E+00
			0. 5180E+01	0. 2400E+01
17	10	0. 6235E+02		
			0. 0000E+00	0. 0000E+00
			0. 5527E+01	0. 1920E-01
			0. 9212E+01	0. 3720E-01
			0. 1382E+02	0. 6840E-01
			0. 1658E+02	0. 9600E-01
			0. 1842E+02	0. 1200E+00
			0. 1842E+02	0. 2400E+00
			0. 1842E+02	0. 3600E+00
			0. 1842E+02	0. 6000E+00
			0. 1842E+02	0. 2400E+01
18	10	0. 6556E+02		
			0. 0000E+00	0. 0000E+00
			0. 5599E+01	0. 1920E-01
			0. 9332E+01	0. 3720E-01
			0. 1400E+02	0. 6840E-01
			0. 1680E+02	0. 9600E-01
			0. 1866E+02	0. 1200E+00
			0. 1866E+02	0. 2400E+00
			0. 1866E+02	0. 3600E+00
			0. 1866E+02	0. 6000E+00
			0. 1866E+02	0. 2400E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0. 0000E+00	0. 0000E+00
0. 1845E+02	0. 6000E-02
0. 3691E+02	0. 1200E-01
0. 7382E+02	0. 2400E-01
0. 1476E+03	0. 1560E+00
0. 2214E+03	0. 5040E+00
0. 2657E+03	0. 8760E+00
0. 2953E+03	0. 1200E+01
0. 2953E+03	0. 1800E+01
0. 2953E+03	0. 2400E+01

LOAD VERSUS SETTLEMENT CURVE

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
-----------------	---------------------	-----------------	---------------------

0. 1065E+01	0. 2056E-02	0. 3076E+00	0. 1000E-03
0. 1078E+02	0. 2072E-01	0. 3076E+01	0. 1000E-02
0. 4800E+02	0. 9864E-01	0. 1538E+02	0. 5000E-02
0. 8287E+02	0. 1814E+00	0. 3076E+02	0. 1000E-01
0. 1332E+03	0. 3196E+00	0. 6151E+02	0. 2000E-01
0. 1763E+03	0. 4663E+00	0. 8835E+02	0. 5000E-01
0. 1997E+03	0. 5617E+00	0. 1051E+03	0. 8000E-01
0. 2128E+03	0. 6189E+00	0. 1163E+03	0. 1000E+00
0. 2526E+03	0. 8320E+00	0. 1570E+03	0. 2000E+00
0. 3162E+03	0. 1312E+01	0. 2206E+03	0. 5000E+00
0. 3523E+03	0. 1714E+01	0. 2567E+03	0. 8000E+00
0. 3726E+03	0. 1971E+01	0. 2770E+03	0. 1000E+01
0. 3908E+03	0. 3023E+01	0. 2953E+03	0. 2000E+01



Driven Friction Pile Calculations

Project: LAW-650-7.16

Proj#: N1245336

Case: South Abutment (B-002-0-24)



Drivability Analysis (GRL WEAP 14)

100 blows per foot (bpf) considered to be practical refusal for friction pile. For piles to rock 20 blows per inch (240 bpf) or greater is practical refusal.

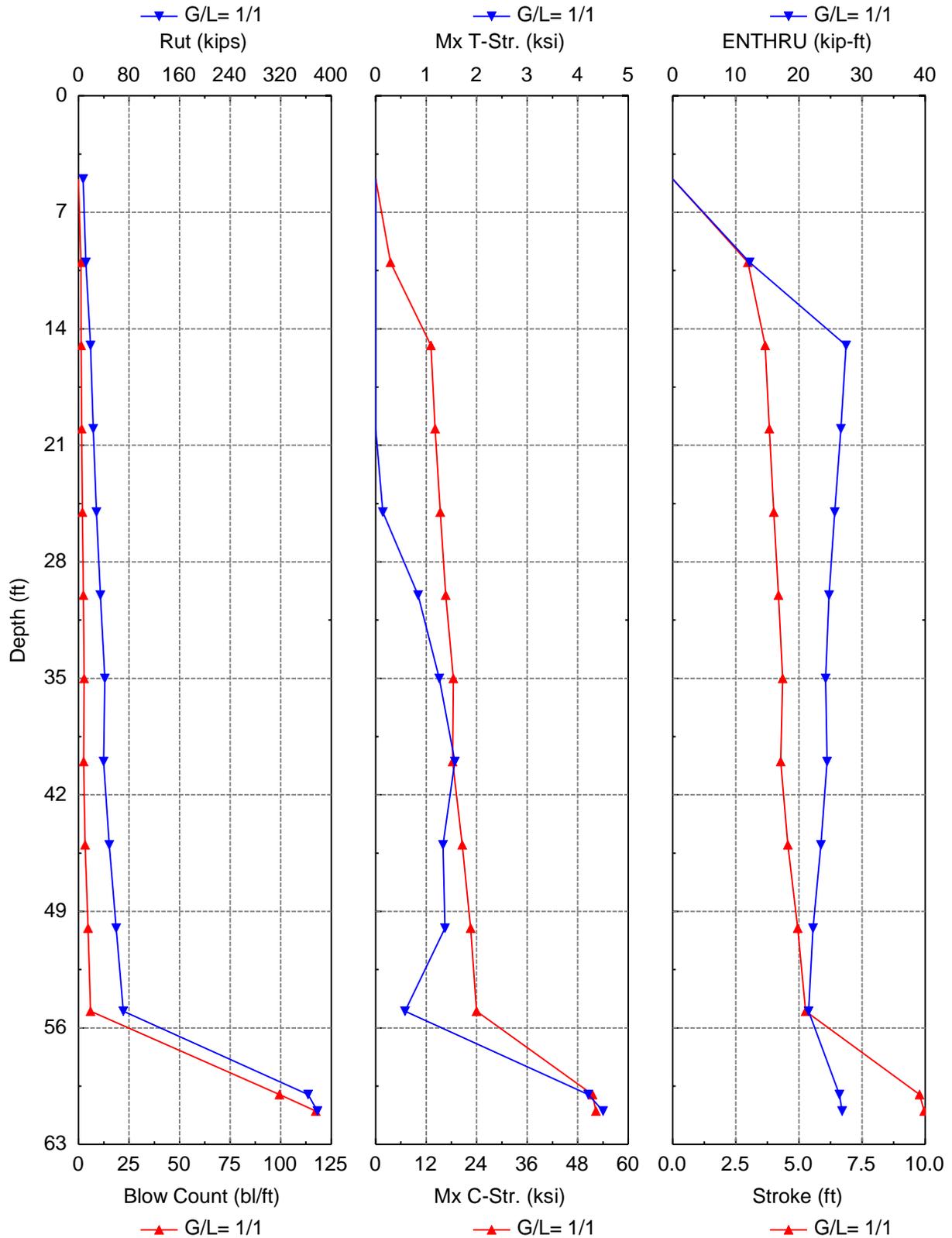
Allowable Stress during Driving for Steel = $0.9 \phi da f_y = 0.9 * 1.0 * 45 \text{ksi}$ (for 45 ksi pipe piles)

Summary of Driveability Analysis

Pile Type/ Size	Hammer	Wall Thickness (in)	Results
12	D19-42	0.25	Compressive Stress and Blow Count (OK for 45 ksi Grade-3 Steel)

See attached results of GRL Weap analyses

Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 1.000/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
5.0	7.2	3.6	3.6	0.0	0.000	0.000	0.00	0.0	D 19-42
10.0	11.7	5.5	6.2	1.2	3.555	0.000	2.98	12.2	D 19-42
15.0	19.0	8.5	10.5	1.3	13.167	0.000	3.66	27.5	D 19-42
20.0	23.3	12.9	10.5	1.6	14.132	0.000	3.83	26.6	D 19-42
25.0	28.5	18.1	10.5	1.9	15.361	0.143	4.00	25.6	D 19-42
30.0	34.6	24.1	10.5	2.4	16.656	0.841	4.18	24.8	D 19-42
35.0	41.5	31.1	10.5	2.8	18.490	1.262	4.35	24.2	D 19-42
40.0	39.9	38.1	1.8	2.5	18.274	1.568	4.28	24.4	D 19-42
45.0	48.6	43.3	5.3	3.3	20.562	1.334	4.55	23.5	D 19-42
50.0	59.8	54.5	5.3	4.7	22.588	1.375	4.95	22.2	D 19-42
55.0	71.0	65.7	5.3	6.0	23.968	0.585	5.26	21.5	D 19-42
60.0	363.5	81.4	282.1	99.4	51.523	4.207	9.77	26.4	D 19-42
61.0	378.3	88.9	289.5	117.4	52.327	4.500	9.95	26.8	D 19-42

Summary_Total driving time: 11 minutes; Total Number of Blows: 495 (starting at penetration 5.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

LAW-SR-650-7.16 + B-002-0-24

3/7/2025

TSVC

GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They **MUST** be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

SOIL PROFILE

Depth ft	Soil Type -	Spec. Wt lb/ft ³	Su ksf	Phi °	Unit Rs ksf	Unit Rt ksf
0.0	Clay	120.0	0.7	0.0	0.57	6.75
1.6	Clay	120.0	0.7	0.0	0.57	6.75
1.6	Sand	89.1	0.0	28.0	0.05	2.37
14.1	Sand	89.1	0.0	28.0	0.21	10.65
14.1	Sand	101.9	0.0	30.0	0.24	13.32
39.1	Sand	101.9	0.0	30.0	0.51	13.32
39.1	Clay	111.4	0.2	0.0	0.25	2.25
44.1	Clay	111.4	0.2	0.0	0.25	2.25
44.1	Clay	117.8	0.7	0.0	0.71	6.75
59.1	Clay	117.8	0.7	0.0	0.71	6.75
59.1	Sand	140.1	0.0	40.0	2.30	350.84
65.6	Sand	140.1	0.0	40.0	2.69	375.94

PILE INPUT

Uniform Pile		Pile Type:	Pipe
Pile Length: (ft)	65.000	Pile Penetration: (ft)	61.000
Pile Size: (ft)	1.00	Toe Area: (in ²)	113.10

Pile Profile

Lb Top ft	X-Area in ²	E-Modulus ksi	Spec. Wt lb/ft ³	Perim. ft	Crit. Index -
0.0	9.2	30,000.0	492.0	3.1	0
65.0	9.2	30,000.0	492.0	3.1	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt kips	Ram L. in	Ram Ar. in ²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

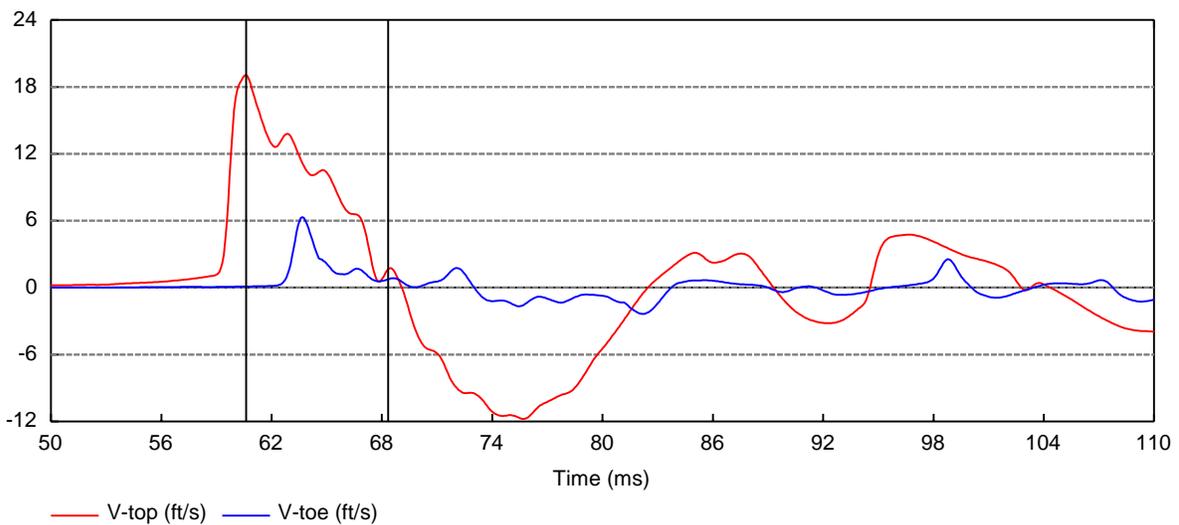
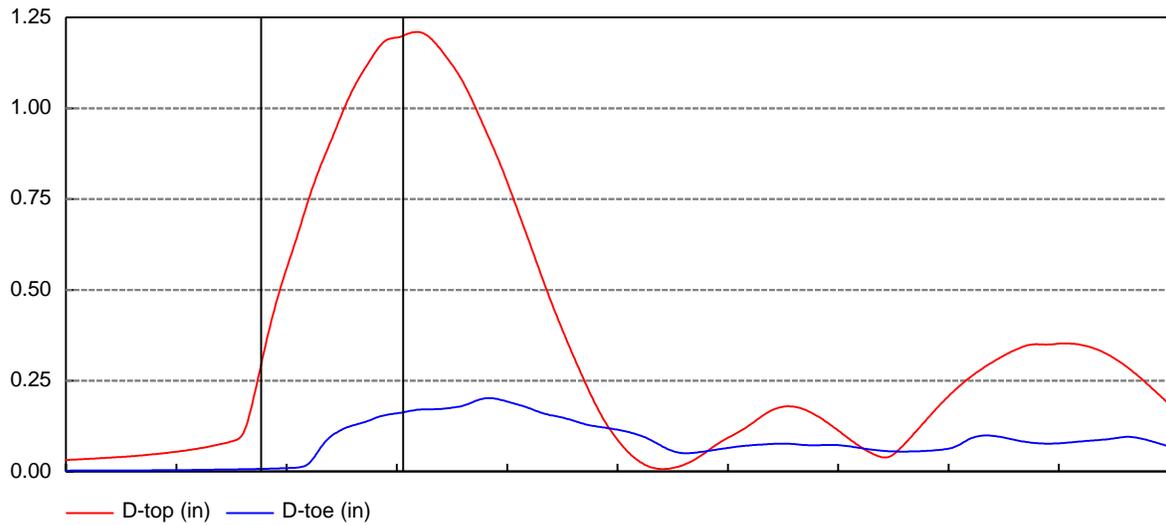
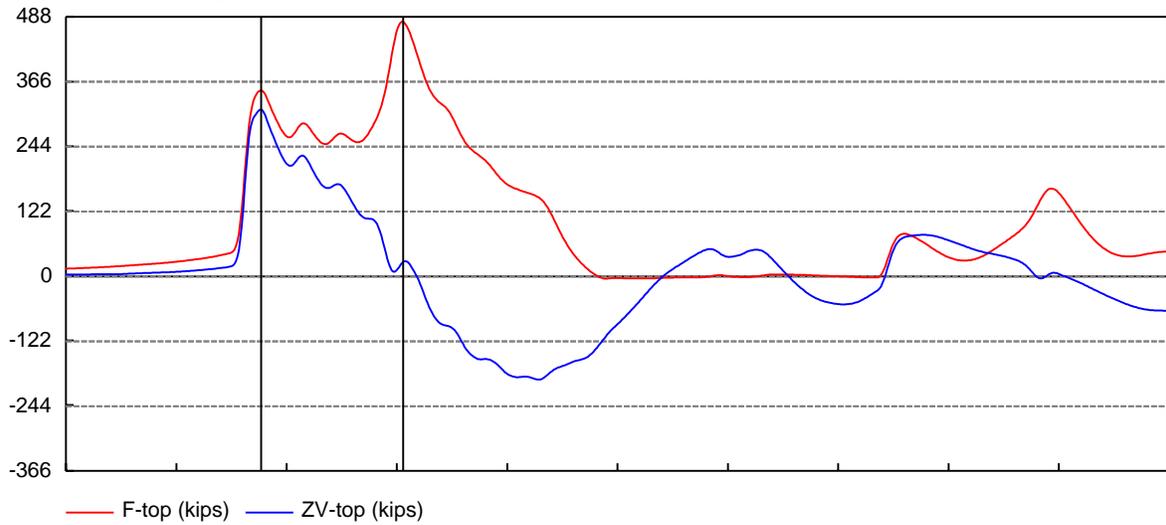
Type	X-Area in ²	E-Modulus ksi	Thickness in	COR	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

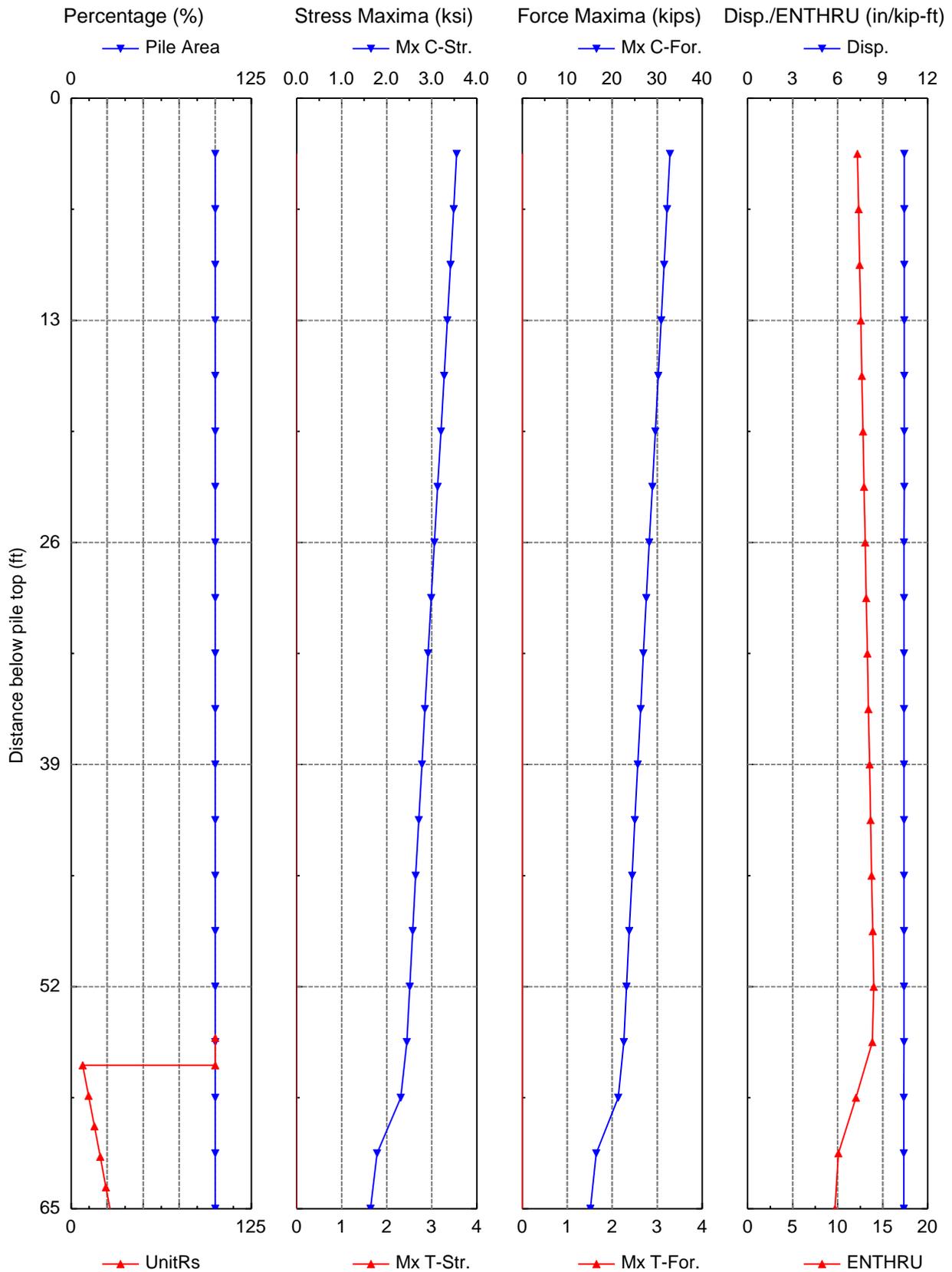
Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in ²
0.0	0.6	6.7	0.10	0.15	0.15	0.15	1.5	6.6	336.0	113.1
1.6	0.6	6.7	0.10	0.15	0.15	0.15	1.5	6.6	336.0	113.1
1.6	0.0	2.4	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
3.4	0.1	3.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
5.2	0.1	4.7	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
7.0	0.1	5.9	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
8.7	0.1	7.1	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
10.5	0.2	8.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
12.3	0.2	9.5	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
14.1	0.2	10.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
14.1	0.2	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
15.8	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
17.4	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
19.1	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
20.8	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
22.4	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
24.1	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
25.8	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
27.4	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
29.1	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
30.8	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
32.4	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
34.1	0.5	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
35.8	0.5	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
37.4	0.5	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
39.1	0.5	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
39.1	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	113.1
40.8	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	113.1
42.4	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	113.1
44.1	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	113.1
44.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
45.8	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
47.4	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
49.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
50.8	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
52.4	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
54.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1

55.8	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
57.4	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
59.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
59.1	2.3	350.8	0.10	0.10	0.05	0.15	1.0	6.6	24.0	113.1
61.3	2.4	371.0	0.10	0.10	0.05	0.15	1.0	6.6	24.0	113.1

Variable Time Histroy with DELMAG D 19-42; Depth = 61.00ft; Shaft/Toe G/L = 1.000/1.000



Extrema Results of Gain/Loss at Shaft/Toe = 1.000/1.000 and Depth = 10.00 ft



Driven Friction Pile Calculations

Project: LAW-650-7.16

Proj#: N1245336

Case: North Abutment (B-003-0-24)



Calculated By: MP

Reviewed By: DWW

References:

ODOT SGE 7-19-24, ODOT BDM 2020 7-19-24, ODOT C&MS, FHWA-NHI-16-064 (FHWA GEC 012)

Bridge Geometry

Substructure: Abutment- North Side

Elevation of Ground Surface, $EG := 575.5 \text{ ft}$ (Used ~Ground Surface Along Northern bank)

Approx. Top of Pile/Bottom of Pile Cap Elevation, $ETP := 566 \text{ ft}$ (Pile above this will be sleeved)

Scour Depth, $D_{Scour} := 0 \text{ ft}$

Depth to Water Below Top of Pile, $Depth_{GW} := 3 \text{ ft}$ Use normal creek/river level if adjacent

Soil Layers

Layer	Soil Type	Bot. Depth from Surface	TopElev	BotElev	Bot. Depth Below Top of Pile	γ	ϕ'	S_u	APILE Setup Factor, f_{su}
		ft	ft	ft	ft	pcf	deg	psf	
1	A-4a, stiff	3.5	575.5	572.0	-6.0	120	-	1,750	1.00
2	A-4a, medium stiff	11.0	572.0	564.5	1.5	112	-	500	1.00
3	A-3, very loose to loose	33.5	564.5	542.0	24.0	118	28	-	1.00
4	A-3a, loose to medium dense	48.5	542.0	527.0	39.0	120	32	-	1.00
5	A-6a, medium stiff	68.5	527.0	507.0	59.0	118	-	500	1.00
6	A-1-b, very dense	75	507.0	501.5	64.5	135	40	-	1.00

Driven Pile Capacity using APile 2023 (FHWA Method)

Driven Pile Capacity Summary *(enter results from APile)*

Pile Type/Size	Pile Driven Length (ft.)	Approx. Tip Elevation (ft.)	Side Resistance (kips)	End Bearing (kips)	UBV (kips)
12	60	506	78.0	246.6	324.6

Setup

The affected soil layers have APILE setup factors equal to 1. Thus the result is similar to the capacity with no setup considered.

See attached APILE Results

=====

APILE for Windows, Version 2023.10.3

Serial Number : 506768014

A Program for Analyzing the Axial Capacity
and Short-term Settlement of Driven Piles
under Axial Loading.
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This program is licensed to :

Terracon, Inc.
APILE Global, Global License

Path to file locations : E:\Projects\2024\N1245336\Working
Files\Calculations-Analyses\Driven piles\APILE\B-003-0-24\
Name of input data file : B-003-0-24- 12 inches A Pile.ap10d
Name of output file : B-003-0-24- 12 inches A Pile.ap10o
Name of plot output file : B-003-0-24- 12 inches A Pile.ap10p

Time and Date of Analysis

Date: March 06, 2025 Time: 10:24:21

1

* INPUT INFORMATION *

PROJECT DESCRIPTION :
B-003-0-24 12-inch pile
DESIGNER : MP
JOB NUMBER : N1245336

METHOD FOR UNIT LOAD TRANSFERS :
- FHWA (Federal Highway Administration)
Unfactored Unit Side Friction and Unit Side Resistance are used.

COMPUTATION METHOD(S) FOR PILE CAPACITY :
- FHWA (Federal Highway Administration)

TYPE OF LOADING :

- COMPRESSION

PILE TYPE :

Steel pipe pile or non-tapered portion of monotube pile

- Close-Ended Pile

AVERAGE DEPTH TO ESTIMATE TIP RESISTANCE:

- USE 1.5 DIAMETERS ABOVE AND BELOW TIP

DATA FOR AXIAL STIFFNESS :

- MODULUS OF ELASTICITY = 0.290E+08 PSI

- CROSS SECTION AREA = 9.23 IN²

CIRCULAR PILE PROPERTIES :

- OUTSIDE DIAMETER, OD = 12.00 IN.

- INTERNAL DIAMETER, ID = 11.50 IN.

- TOTAL PILE LENGTH, TL = 61.00 FT.

- BATTER ANGLE = 0.00 DEG

- PILE STICKUP LENGTH, PSL = 0.00 FT.

- ZERO FRICTION LENGTH, ZFL = 5.00 FT.

- INCREMENT OF PILE LENGTH
USED IN COMPUTATION = 1.00 FT.

- PRINTING INCREMENT = 1

- LENGTH OF ENHANCED
END SECTION = 61.00 FT.

- INTERNAL DIAMETER OF
ENHANCED END SECTION = 11.50 IN.

PLUGGED/UNPLUGGED CONDITIONS :

Internal Pile Plug Calculated by Program

SOIL INFORMATIONS :

DEPTH FT.	SOIL TYPE	LATERAL EARTH PRESSURE	EFFECTIVE UNIT WEIGHT LB/FT ³	FRICTION ANGLE DEGREES	Nq FACTOR FHWA
0.00	CLAY	0.80*	120.00	0.00	4.80**
-6.00	CLAY	0.80*	120.00	0.00	4.80**
-6.00	CLAY	0.80*	112.00	0.00	4.80**
1.50	CLAY	0.80*	112.00	0.00	4.80**
1.50	SAND	0.80*	55.60	28.00	22.80**
24.00	SAND	0.80*	55.60	28.00	22.80**
24.00	SAND	0.80*	57.60	32.00	40.40**
39.00	SAND	0.80*	57.60	32.00	40.40**
39.00	CLAY	0.80*	55.60	0.00	4.80**
59.00	CLAY	0.80*	55.60	0.00	4.80**

59.00	SAND	0.80*	72.60	40.00	160.00**
64.50	SAND	0.80*	72.60	40.00	160.00**

* VALUE ASSUMED BY THE PROGRAM

** VALUE ESTIMATED BY THE PROGRAM BASED ON FRICTION ANGLE

MAXIMUM UNIT FRICTION KSF	MAXIMUM UNIT BEARING KSF	UNDI STURB SHEAR STRENGTH KSF	REMOLDED SHEAR STRENGTH KSF	BLOW COUNT	UNIT SKIN FRICTION KSF	UNIT END BEARING KSF
0.10E+08*	0.10E+08*	1.75	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	1.75	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.50	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00
0.10E+08*	0.10E+08*	0.00	0.00	0.00	0.00	0.00

* MAXIMUM UNIT FRICTION AND/OR MAXIMUM UNIT BEARING WERE SET TO LARGE VALUES INDICATING THAT APILE USES THE LIMITS SPECIFIED BY EACH SELECTED CRITERIA (IF ANY).

DEPTH FT.	LRFD FACTOR ON UNIT FRICTION	LRFD FACTOR ON UNIT BEARING
0.00	1.000	1.000
-6.00	1.000	1.000
-6.00	1.000	1.000
1.50	1.000	1.000
1.50	1.000	1.000
24.00	1.000	1.000
24.00	1.000	1.000
39.00	1.000	1.000
39.00	1.000	1.000
59.00	1.000	1.000
59.00	1.000	1.000
64.50	1.000	1.000

DEPTH FT.	Z PEAK IN.	T RESIDUAL
0.00	0.120 *	0.90 **
-6.00	0.120 *	0.90 **
-6.00	0.120 *	0.90 **
1.50	0.120 *	0.90 **
1.50	0.120 *	0.00
24.00	0.120 *	0.00
24.00	0.120 *	0.00
39.00	0.120 *	0.00
39.00	0.120 *	0.90 **
59.00	0.120 *	0.90 **
59.00	0.120 *	0.00
64.50	0.120 *	0.00

* DEFAULT VALUE = 0.01 D

** DEFAULT VALUE = 0.9

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 * COMPUTATION RESULT *

 * FED. HWY. METHOD *

PILE LENGTH BELOW GND. FT.	SKIN FRICTION KIP	END BEARING KIP	ULTIMATE CAPACITY KIP
0.00	0.0	1.8	1.8
1.00	0.0	2.7	2.7
2.00	0.0	3.0	3.0
3.00	0.0	2.9	2.9
4.00	0.0	3.2	3.2
5.00	0.1	3.8	3.9
6.00	0.4	4.3	4.7
7.00	0.8	4.8	5.6
8.00	1.2	5.4	6.5
9.00	1.6	5.9	7.5
10.00	2.0	6.4	8.5
11.00	2.5	7.0	9.5
12.00	3.1	7.5	10.6
13.00	3.7	8.0	11.7

14.00	4.3	8.6	12.8
15.00	4.9	9.1	14.0
16.00	5.6	9.6	15.2
17.00	6.4	10.1	16.4
18.00	7.1	10.3	17.5
19.00	8.0	10.4	18.4
20.00	8.8	10.5	19.3
21.00	9.7	10.5	20.2
22.00	10.6	10.5	21.1
23.00	11.6	13.0	24.7
24.00	12.6	18.2	30.8
25.00	13.9	23.3	37.3
26.00	15.5	25.9	41.4
27.00	17.1	25.9	43.1
28.00	18.8	25.9	44.8
29.00	20.6	25.9	46.5
30.00	22.4	25.9	48.3
31.00	24.3	25.9	50.2
32.00	26.2	25.9	52.1
33.00	28.2	25.9	54.1
34.00	30.2	25.9	56.2
35.00	32.3	25.9	58.3
36.00	34.5	25.9	60.4
37.00	36.7	25.9	62.7
38.00	39.0	22.2	61.2
39.00	41.4	14.7	56.1
40.00	43.3	7.3	50.6
41.00	44.9	3.5	48.4
42.00	46.5	3.5	50.0
43.00	48.0	3.5	51.6
44.00	49.6	3.5	53.1
45.00	51.2	3.5	54.7
46.00	52.8	3.5	56.3
47.00	54.3	3.5	57.9
48.00	55.9	3.5	59.4
49.00	57.5	3.5	61.0
50.00	59.0	3.5	62.6
51.00	60.6	3.5	64.1
52.00	62.2	3.5	65.7
53.00	63.8	3.5	67.3
54.00	65.3	3.5	68.9
55.00	66.9	3.5	70.4
56.00	68.5	3.5	72.0
57.00	70.0	3.5	73.6
58.00	71.6	52.2	123.8
59.00	73.2	149.4	222.6
60.00	78.0	246.6	324.6
61.00	86.1	295.3	381.3

NOTES:

- AN ASTERISK IS PLACED IN THE END-BEARING COLUMN IF THE TIP RESISTANCE IS CONTROLLED BY THE FRICTION OF SOIL PLUG INSIDE AN OPEN-ENDED PIPE PILE.

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*****
* COMPUTE LOAD-DISTRIBUTION AND LOAD-SETTLEMENT *
* CURVES FOR AXIAL LOADING *
*****
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T-Z CURVE NO.	NO. OF POINTS	DEPTH TO CURVE FT.	LOAD TRANSFER PSI	PILE MOVEMENT IN.
1	10	0.4167E-01	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01
2	10	0.7500E+00	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01
3	10	0.1458E+01	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01
4	10	0.1542E+01	0.0000E+00	0.0000E+00
			0.0000E+00	0.1920E-01
			0.0000E+00	0.3720E-01
			0.0000E+00	0.6840E-01
			0.0000E+00	0.9600E-01
			0.0000E+00	0.1200E+00
			0.0000E+00	0.2400E+00
			0.0000E+00	0.3600E+00
			0.0000E+00	0.6000E+00
			0.0000E+00	0.2400E+01

			0. 0000E+00	0. 0000E+00
			0. 0000E+00	0. 1920E-01
			0. 0000E+00	0. 3720E-01
			0. 0000E+00	0. 6840E-01
			0. 0000E+00	0. 9600E-01
			0. 0000E+00	0. 1200E+00
			0. 0000E+00	0. 2400E+00
			0. 0000E+00	0. 3600E+00
			0. 0000E+00	0. 6000E+00
			0. 0000E+00	0. 2400E+01
5	10	0. 1275E+02	0. 0000E+00	0. 0000E+00
			0. 3901E+00	0. 1920E-01
			0. 6502E+00	0. 3720E-01
			0. 9753E+00	0. 6840E-01
			0. 1170E+01	0. 9600E-01
			0. 1300E+01	0. 1200E+00
			0. 1300E+01	0. 2400E+00
			0. 1300E+01	0. 3600E+00
			0. 1300E+01	0. 6000E+00
			0. 1300E+01	0. 2400E+01
6	10	0. 2396E+02	0. 0000E+00	0. 0000E+00
			0. 6860E+00	0. 1920E-01
			0. 1143E+01	0. 3720E-01
			0. 1715E+01	0. 6840E-01
			0. 2058E+01	0. 9600E-01
			0. 2287E+01	0. 1200E+00
			0. 2287E+01	0. 2400E+00
			0. 2287E+01	0. 3600E+00
			0. 2287E+01	0. 6000E+00
			0. 2287E+01	0. 2400E+01
7	10	0. 2404E+02	0. 0000E+00	0. 0000E+00
			0. 7011E+00	0. 1920E-01
			0. 1169E+01	0. 3720E-01
			0. 1753E+01	0. 6840E-01
			0. 2103E+01	0. 9600E-01
			0. 2337E+01	0. 1200E+00
			0. 2337E+01	0. 2400E+00
			0. 2337E+01	0. 3600E+00
			0. 2337E+01	0. 6000E+00
			0. 2337E+01	0. 2400E+01
8	10	0. 3150E+02	0. 0000E+00	0. 0000E+00
			0. 1280E+01	0. 1920E-01
			0. 2133E+01	0. 3720E-01
			0. 3199E+01	0. 6840E-01
			0. 3839E+01	0. 9600E-01
			0. 4265E+01	0. 1200E+00

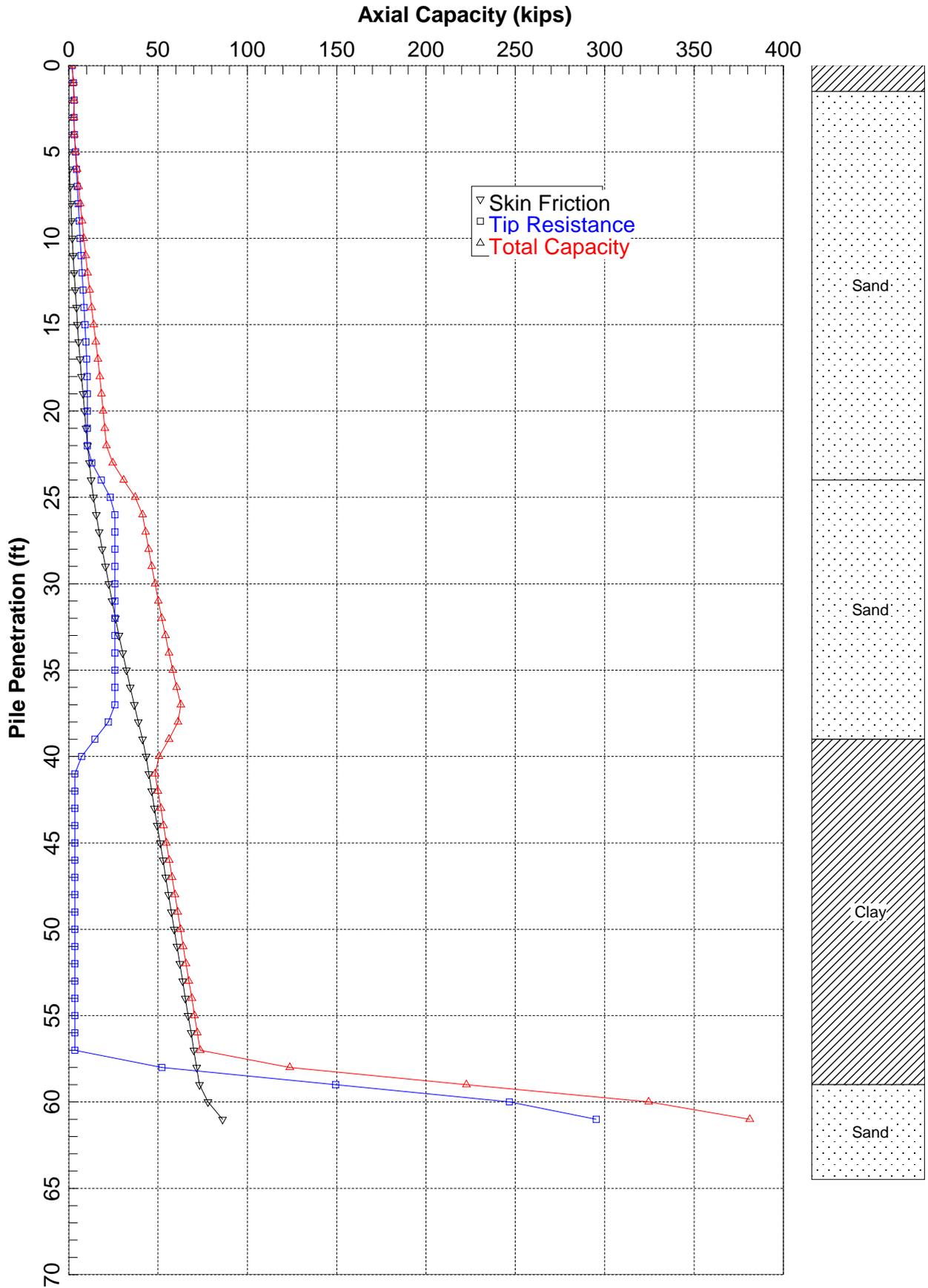
			0. 4265E+01	0. 2400E+00
			0. 4265E+01	0. 3600E+00
			0. 4265E+01	0. 6000E+00
			0. 4265E+01	0. 2400E+01
9	10	0. 3896E+02	0. 0000E+00	0. 0000E+00
			0. 1572E+01	0. 1920E-01
			0. 2620E+01	0. 3720E-01
			0. 3930E+01	0. 6840E-01
			0. 4717E+01	0. 9600E-01
			0. 5241E+01	0. 1200E+00
			0. 5241E+01	0. 2400E+00
			0. 5241E+01	0. 3600E+00
			0. 5241E+01	0. 6000E+00
			0. 5241E+01	0. 2400E+01
10	10	0. 3904E+02	0. 0000E+00	0. 0000E+00
			0. 1552E+01	0. 1920E-01
			0. 2586E+01	0. 3720E-01
			0. 3879E+01	0. 6840E-01
			0. 4655E+01	0. 9600E-01
			0. 5172E+01	0. 1200E+00
			0. 4655E+01	0. 2400E+00
			0. 4655E+01	0. 3600E+00
			0. 4655E+01	0. 6000E+00
			0. 4655E+01	0. 2400E+01
11	10	0. 4900E+02	0. 0000E+00	0. 0000E+00
			0. 1042E+01	0. 1920E-01
			0. 1736E+01	0. 3720E-01
			0. 2604E+01	0. 6840E-01
			0. 3125E+01	0. 9600E-01
			0. 3472E+01	0. 1200E+00
			0. 3125E+01	0. 2400E+00
			0. 3125E+01	0. 3600E+00
			0. 3125E+01	0. 6000E+00
			0. 3125E+01	0. 2400E+01
12	10	0. 5896E+02	0. 0000E+00	0. 0000E+00
			0. 1042E+01	0. 1920E-01
			0. 1736E+01	0. 3720E-01
			0. 2604E+01	0. 6840E-01
			0. 3125E+01	0. 9600E-01
			0. 3472E+01	0. 1200E+00
			0. 3125E+01	0. 2400E+00
			0. 3125E+01	0. 3600E+00
			0. 3125E+01	0. 6000E+00
			0. 3125E+01	0. 2400E+01
13	10	0. 5904E+02	0. 0000E+00	0. 0000E+00

			0. 1219E+01	0. 1920E-01
			0. 2032E+01	0. 3720E-01
			0. 3049E+01	0. 6840E-01
			0. 3658E+01	0. 9600E-01
			0. 4065E+01	0. 1200E+00
			0. 4065E+01	0. 2400E+00
			0. 4065E+01	0. 3600E+00
			0. 4065E+01	0. 6000E+00
			0. 4065E+01	0. 2400E+01
14	10	0. 6175E+02		
			0. 0000E+00	0. 0000E+00
			0. 5418E+01	0. 1920E-01
			0. 9030E+01	0. 3720E-01
			0. 1355E+02	0. 6840E-01
			0. 1625E+02	0. 9600E-01
			0. 1806E+02	0. 1200E+00
			0. 1806E+02	0. 2400E+00
			0. 1806E+02	0. 3600E+00
			0. 1806E+02	0. 6000E+00
			0. 1806E+02	0. 2400E+01
15	10	0. 6446E+02		
			0. 0000E+00	0. 0000E+00
			0. 5418E+01	0. 1920E-01
			0. 9030E+01	0. 3720E-01
			0. 1355E+02	0. 6840E-01
			0. 1625E+02	0. 9600E-01
			0. 1806E+02	0. 1200E+00
			0. 1806E+02	0. 2400E+00
			0. 1806E+02	0. 3600E+00
			0. 1806E+02	0. 6000E+00
			0. 1806E+02	0. 2400E+01

TIP LOAD KIP	TIP MOVEMENT IN.
0. 0000E+00	0. 0000E+00
0. 1845E+02	0. 6000E-02
0. 3691E+02	0. 1200E-01
0. 7382E+02	0. 2400E-01
0. 1476E+03	0. 1560E+00
0. 2214E+03	0. 5040E+00
0. 2657E+03	0. 8760E+00
0. 2953E+03	0. 1200E+01
0. 2953E+03	0. 1800E+01
0. 2953E+03	0. 2400E+01

LOAD VERSUS SETTLEMENT CURVE

TOP LOAD KIP	TOP MOVEMENT IN.	TIP LOAD KIP	TIP MOVEMENT IN.
0. 9784E+00	0. 1849E-02	0. 3076E+00	0. 1000E-03
0. 9897E+01	0. 1862E-01	0. 3076E+01	0. 1000E-02
0. 4477E+02	0. 8920E-01	0. 1538E+02	0. 5000E-02
0. 7788E+02	0. 1647E+00	0. 3076E+02	0. 1000E-01
0. 1270E+03	0. 2933E+00	0. 6151E+02	0. 2000E-01
0. 1663E+03	0. 4259E+00	0. 8835E+02	0. 5000E-01
0. 1876E+03	0. 5137E+00	0. 1051E+03	0. 8000E-01
0. 2000E+03	0. 5679E+00	0. 1163E+03	0. 1000E+00
0. 2398E+03	0. 7773E+00	0. 1570E+03	0. 2000E+00
0. 3033E+03	0. 1251E+01	0. 2206E+03	0. 5000E+00
0. 3394E+03	0. 1650E+01	0. 2567E+03	0. 8000E+00
0. 3598E+03	0. 1906E+01	0. 2770E+03	0. 1000E+01
0. 3780E+03	0. 2955E+01	0. 2953E+03	0. 2000E+01



Driven Friction Pile Calculations

Project: LAW-650-7.16

Proj#: N1245336

Case: North Abutment (B-003-0-24)



Drivability Analysis (GRL WEAP 14)

100 blows per foot (bpf) considered to be practical refusal for friction pile. For piles to rock 20 blows per inch (240 bpf) or greater is practical refusal.

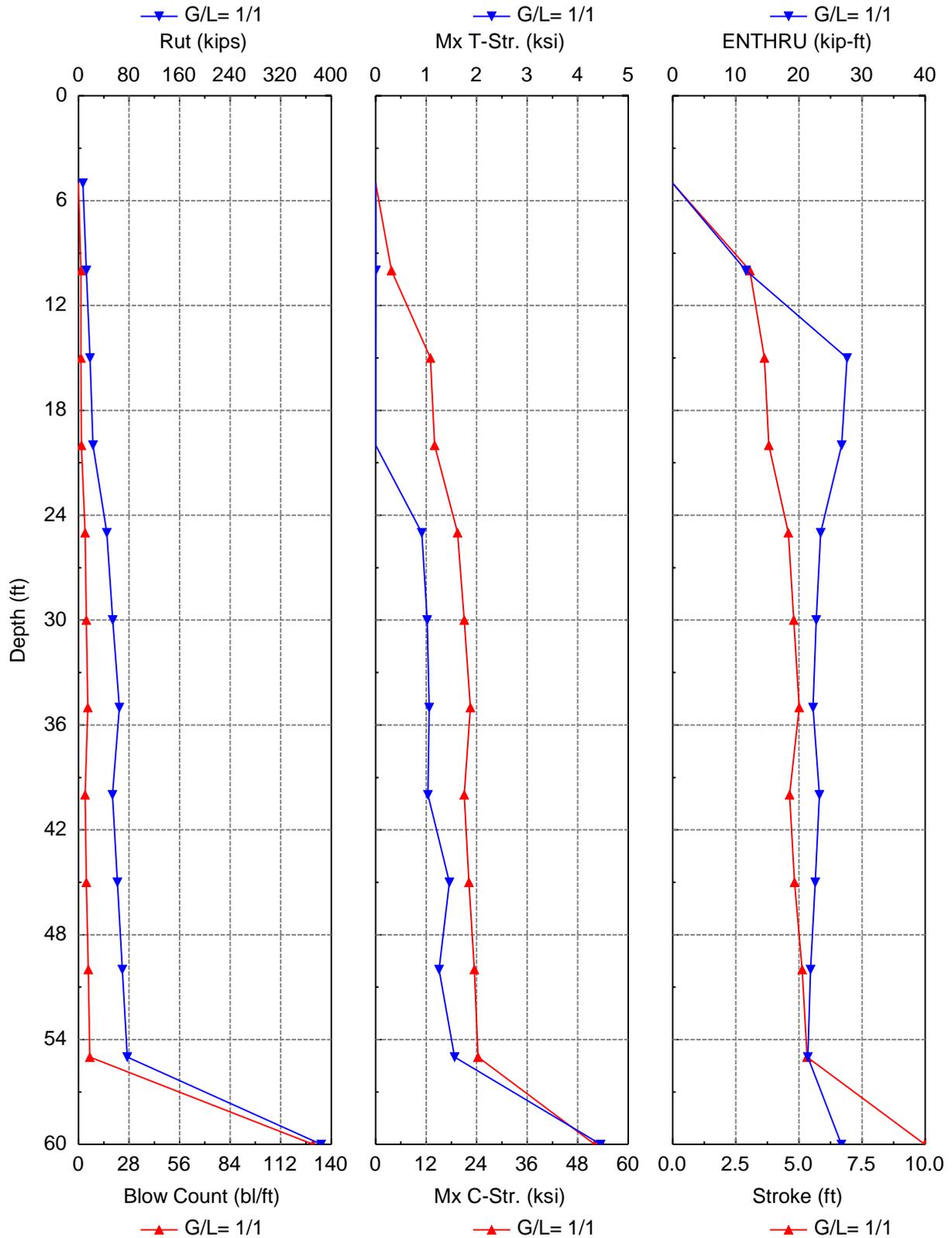
Allowable Stress during Driving for Steel = $0.9 \phi da f_y = 0.9 * 1.0 * 45 \text{ksi}$ (for 45 ksi pipe piles)

Summary of Driveability Analysis

Pile Type/ Size	Hammer	Wall Thickness (in)	Results
12	D19-42	0.25	Compressive Stress and Blow Count (OK for 45 ksi Grade-3 Steel)

See attached results of GRL Weap analyses

Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 1.000/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
5.0	6.9	2.5	4.4	0.0	0.000	0.000	0.00	0.0	D 19-42
10.0	12.5	4.7	7.9	1.3	3.788	0.005	3.06	11.6	D 19-42
15.0	18.5	8.0	10.4	1.3	13.029	0.000	3.63	27.6	D 19-42
20.0	23.0	12.6	10.5	1.6	14.016	0.000	3.81	26.7	D 19-42
25.0	44.7	18.8	26.0	3.6	19.476	0.913	4.58	23.4	D 19-42
30.0	54.0	28.0	26.0	4.3	21.042	1.020	4.79	22.7	D 19-42
35.0	64.9	38.9	26.0	5.1	22.517	1.060	5.00	22.2	D 19-42
40.0	53.8	50.2	3.5	3.6	21.056	1.037	4.63	23.2	D 19-42
45.0	61.6	58.1	3.5	4.3	22.145	1.459	4.82	22.6	D 19-42
50.0	69.5	65.9	3.5	5.4	23.458	1.255	5.13	21.8	D 19-42
55.0	77.3	73.8	3.5	6.3	24.329	1.565	5.32	21.4	D 19-42
60.0	384.0	88.7	295.3	130.0	52.059	4.453	9.97	26.7	D 19-42

Summary_ Total driving time: 11 minutes; Total Number of Blows: 508 (starting at penetration 5.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

LAW-SR-650-7.16 + B-003-0-24

3/7/2025

TSVC

GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They **MUST** be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

SOIL PROFILE

Depth ft	Soil Type -	Spec. Wt lb/ft ³	Su ksf	Phi °	Unit Rs ksf	Unit Rt ksf
0.0	Clay	112.0	0.5	0.0	0.37	4.50
1.5	Clay	112.0	0.5	0.0	0.37	4.50
1.5	Sand	118.0	0.0	29.0	0.04	2.49
24.0	Sand	118.0	0.0	29.0	0.39	13.32
24.0	Sand	120.0	0.0	32.0	0.52	33.09
39.0	Sand	120.0	0.0	32.0	0.82	33.09
39.0	Clay	118.0	0.5	0.0	0.50	4.50
59.0	Clay	118.0	0.5	0.0	0.50	4.50
59.0	Sand	135.0	0.0	40.0	2.74	375.94
64.5	Sand	135.0	0.0	40.0	3.05	375.94

PILE INPUT

Uniform Pile		Pile Type:	Pipe
Pile Length: (ft)	65.000	Pile Penetration: (ft)	60.000
Pile Size: (ft)	1.00	Toe Area: (in ²)	113.10

Pile Profile

Lb Top ft	X-Area in ²	E-Modulus ksi	Spec. Wt lb/ft ³	Perim. ft	Crit. Index -
0.0	9.2	30,000.0	492.0	3.1	0
65.0	9.2	30,000.0	492.0	3.1	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt kips	Ram L. in	Ram Ar. in ²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

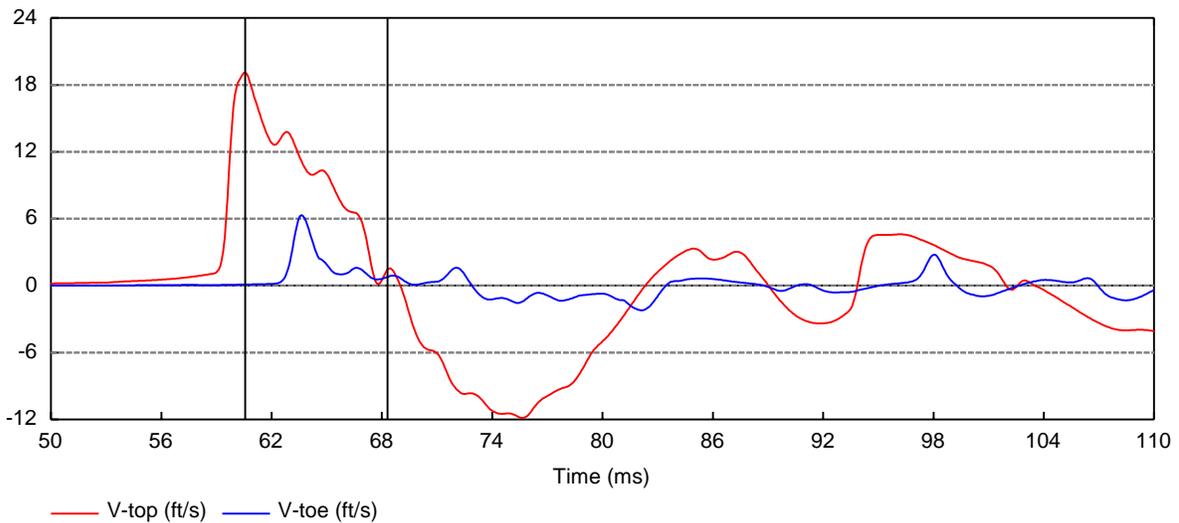
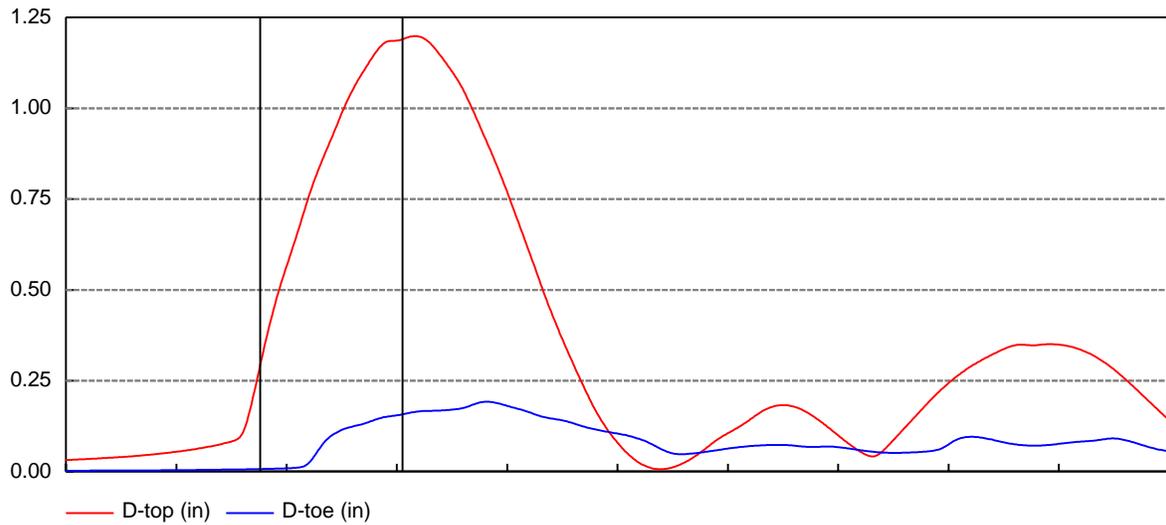
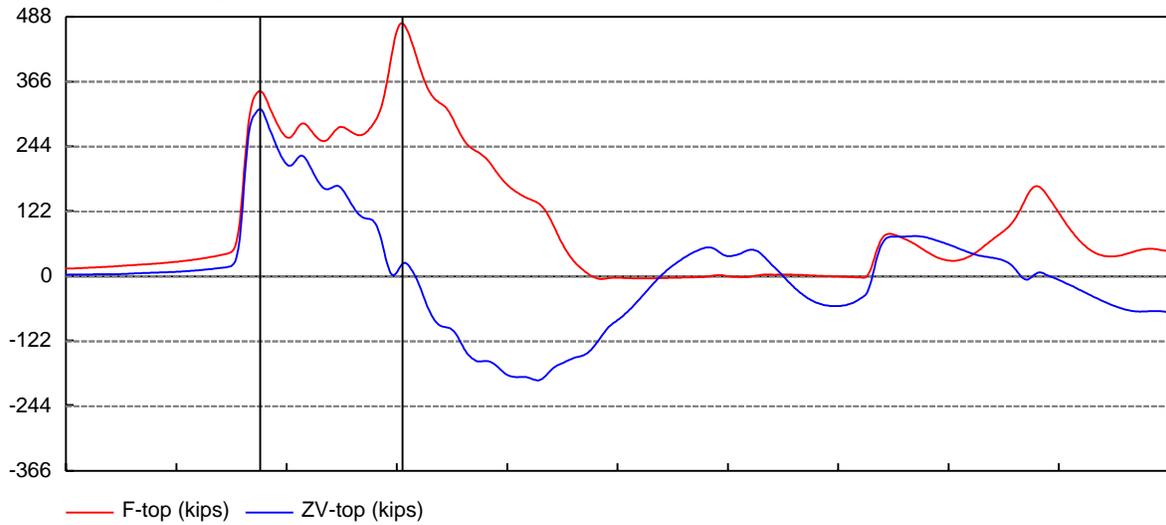
Type	X-Area in ²	E-Modulus ksi	Thickness in	COR	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in ²
0.0	0.4	4.5	0.10	0.15	0.15	0.15	1.5	6.6	336.0	113.1
1.5	0.4	4.5	0.10	0.15	0.15	0.15	1.5	6.6	336.0	113.1
1.5	0.0	2.5	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
3.2	0.1	4.0	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
5.0	0.1	5.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
6.7	0.1	7.1	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
8.4	0.2	8.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
10.2	0.2	10.2	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
11.9	0.2	11.7	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
13.6	0.2	13.2	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
15.3	0.3	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
17.1	0.3	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
18.8	0.3	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
20.5	0.3	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
22.3	0.4	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
24.0	0.4	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	113.1
24.0	0.5	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
25.7	0.6	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
27.3	0.6	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
29.0	0.6	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
30.7	0.7	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
32.3	0.7	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
34.0	0.7	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
35.7	0.8	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
37.3	0.8	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
39.0	0.8	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	113.1
39.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
40.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
42.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
44.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
45.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
47.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
49.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
50.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
52.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
54.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
55.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
57.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1
59.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	113.1

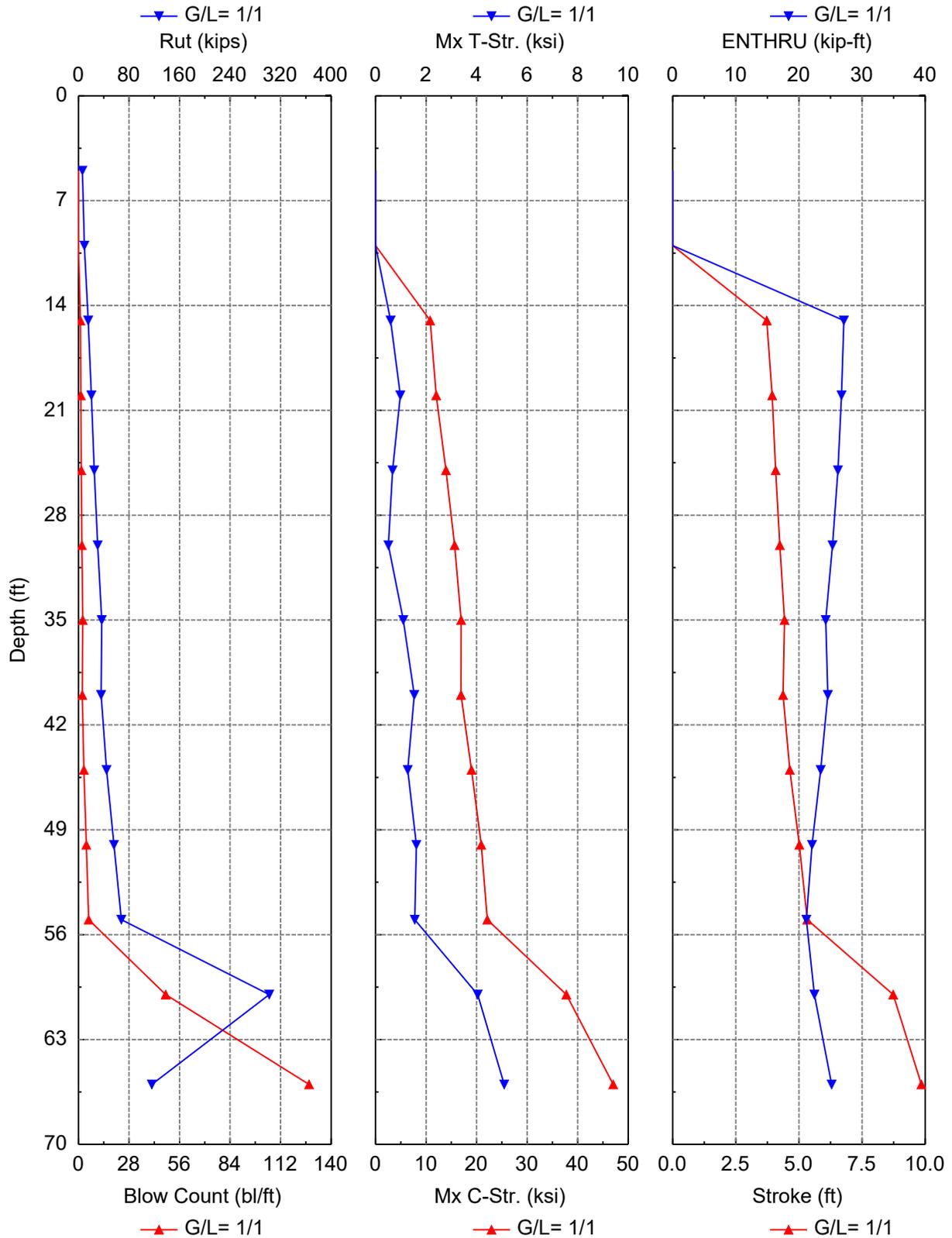
59.0	2.7	375.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	113.1
60.8	2.8	375.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	113.1

Variable Time Histroy with DELMAG D 19-42; Depth = 60.00ft; Shaft/Toe G/L = 1.000/1.000



WEAP Analyses results for HP10x42 Piles

Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 1.000/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
5.0	6.3	3.7	2.6	0.0	0.000	0.000	0.00	0.0	D 19-42
10.0	9.3	5.4	4.0	0.0	0.000	0.000	0.00	0.0	D 19-42
15.0	15.4	7.8	7.7	1.1	10.826	0.597	3.73	27.1	D 19-42
20.0	20.4	11.4	9.0	1.3	12.020	0.984	3.94	26.7	D 19-42
25.0	24.9	15.9	9.0	1.6	13.939	0.674	4.08	26.2	D 19-42
30.0	30.4	21.4	9.0	1.9	15.647	0.510	4.24	25.3	D 19-42
35.0	36.8	27.8	9.0	2.4	16.934	1.099	4.43	24.2	D 19-42
40.0	36.0	34.5	1.5	2.1	16.924	1.534	4.37	24.6	D 19-42
45.0	44.6	40.0	4.6	3.0	18.997	1.277	4.64	23.4	D 19-42
50.0	56.3	51.7	4.6	4.4	20.912	1.616	5.02	22.1	D 19-42
55.0	68.0	63.4	4.6	5.7	22.126	1.552	5.33	21.2	D 19-42
60.0	302.0	78.6	223.4	48.3	37.769	4.041	8.73	22.4	D 19-42
66.0	116.2	116.2	0.0	127.8	47.036	5.092	9.85	25.2	D 19-42

Summary_Total driving time: 19 minutes; Total Number of Blows: 766 (starting at penetration 5.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

LAW-SR-650-7.16 + B-002-0-24

3/7/2025

TSVC

GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They **MUST** be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

SOIL PROFILE

Depth ft	Soil Type -	Spec. Wt lb/ft ³	Su ksf	Phi °	Unit Rs ksf	Unit Rt ksf
0.0	Clay	120.0	0.7	0.0	0.57	6.75
1.6	Clay	120.0	0.7	0.0	0.57	6.75
1.6	Sand	89.1	0.0	28.0	0.05	2.37
14.1	Sand	89.1	0.0	28.0	0.16	7.56
14.1	Sand	101.9	0.0	30.0	0.18	10.66
39.1	Sand	101.9	0.0	30.0	0.46	13.32
39.1	Clay	111.4	0.2	0.0	0.25	2.25
44.1	Clay	111.4	0.2	0.0	0.25	2.25
44.1	Clay	117.8	0.7	0.0	0.71	6.75
59.1	Clay	117.8	0.7	0.0	0.71	6.75
59.1	Sand	140.1	0.0	40.0	1.84	320.86
65.6	Sand	140.1	0.0	40.0	2.19	375.94
65.6	Rock	145.0	0.0	0.0	0.00	0.00
76.0	Rock	145.0	0.0	0.0	0.00	0.00

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	70.000	Pile Penetration: (ft)	66.000
Pile Size: (ft)	0.84	Toe Area: (in ²)	97.73

Pile Profile

Lb Top ft	X-Area in ²	E-Modulus ksi	Spec. Wt lb/ft ³	Perim. ft	Crit. Index -
0.0	12.4	30,000.0	492.0	3.3	0
70.0	12.4	30,000.0	492.0	3.3	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt kips	Ram L. in	Ram Ar. in ²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type	X-Area in ²	E-Modulus ksi	Thickness in	COR	Round-out in	Stiffness kips/in
-				-		

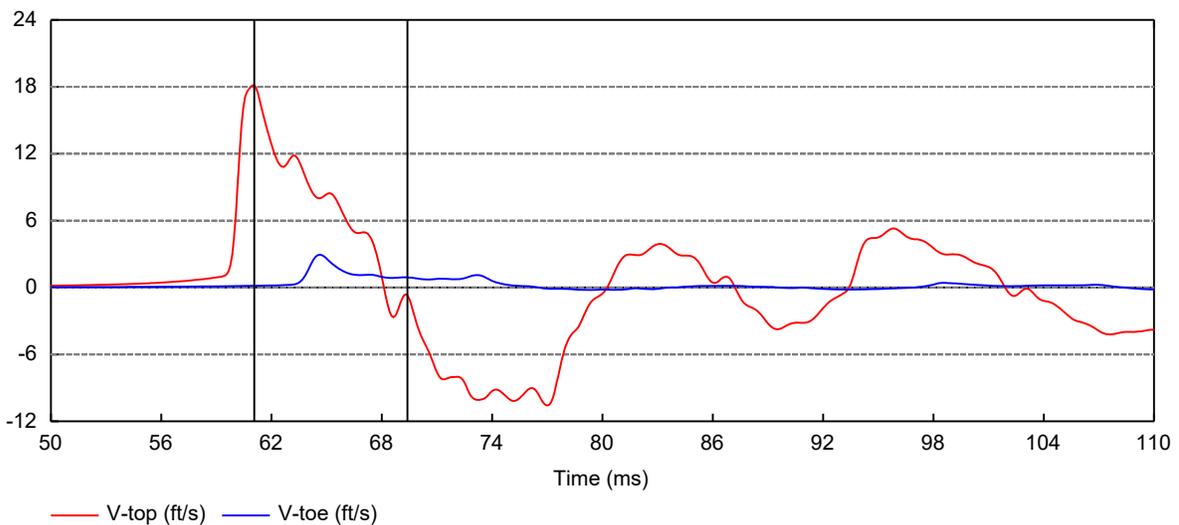
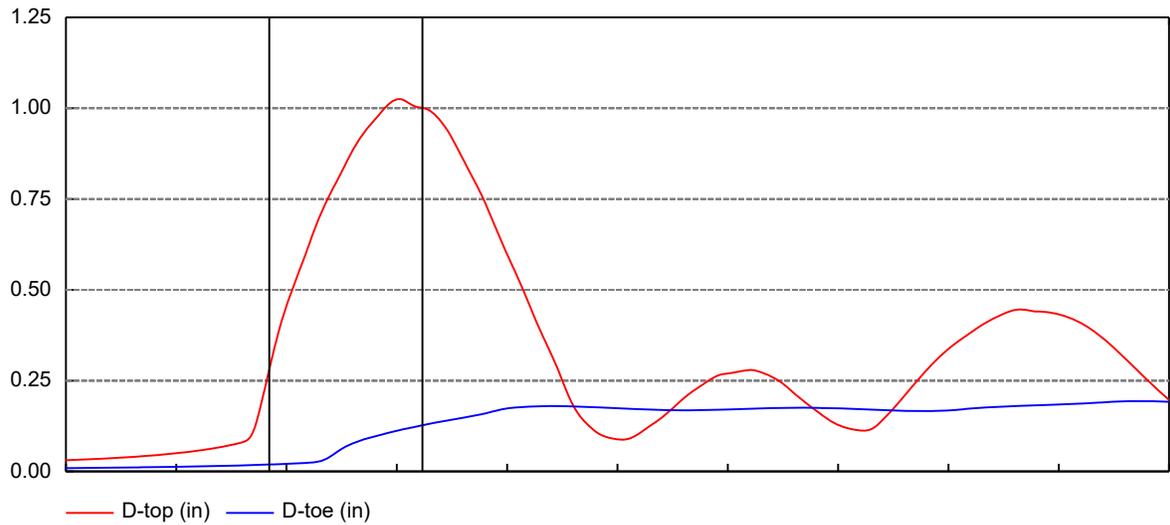
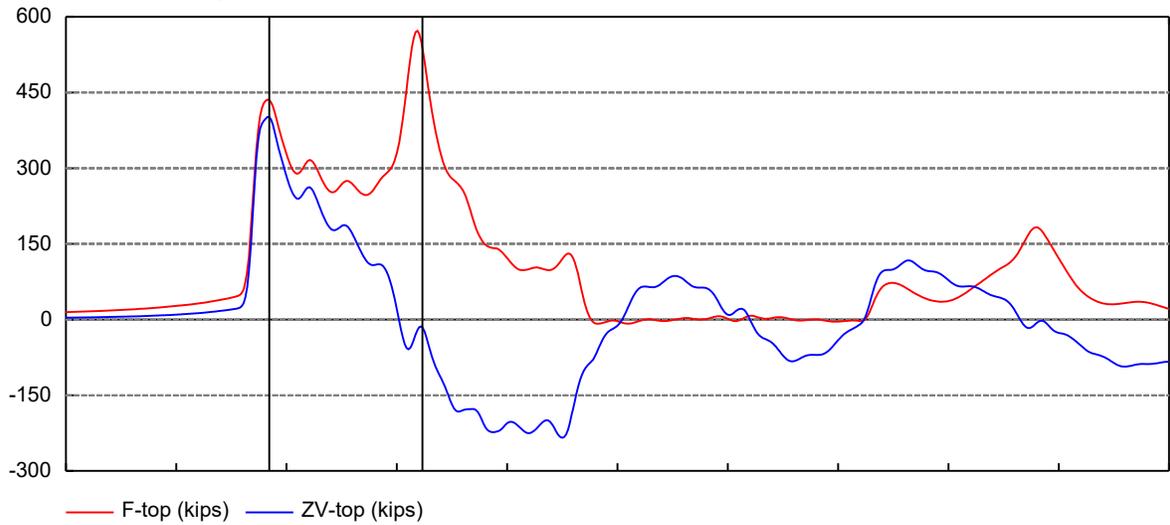
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kip				

SOIL RESISTANCE DISTRIBUTION

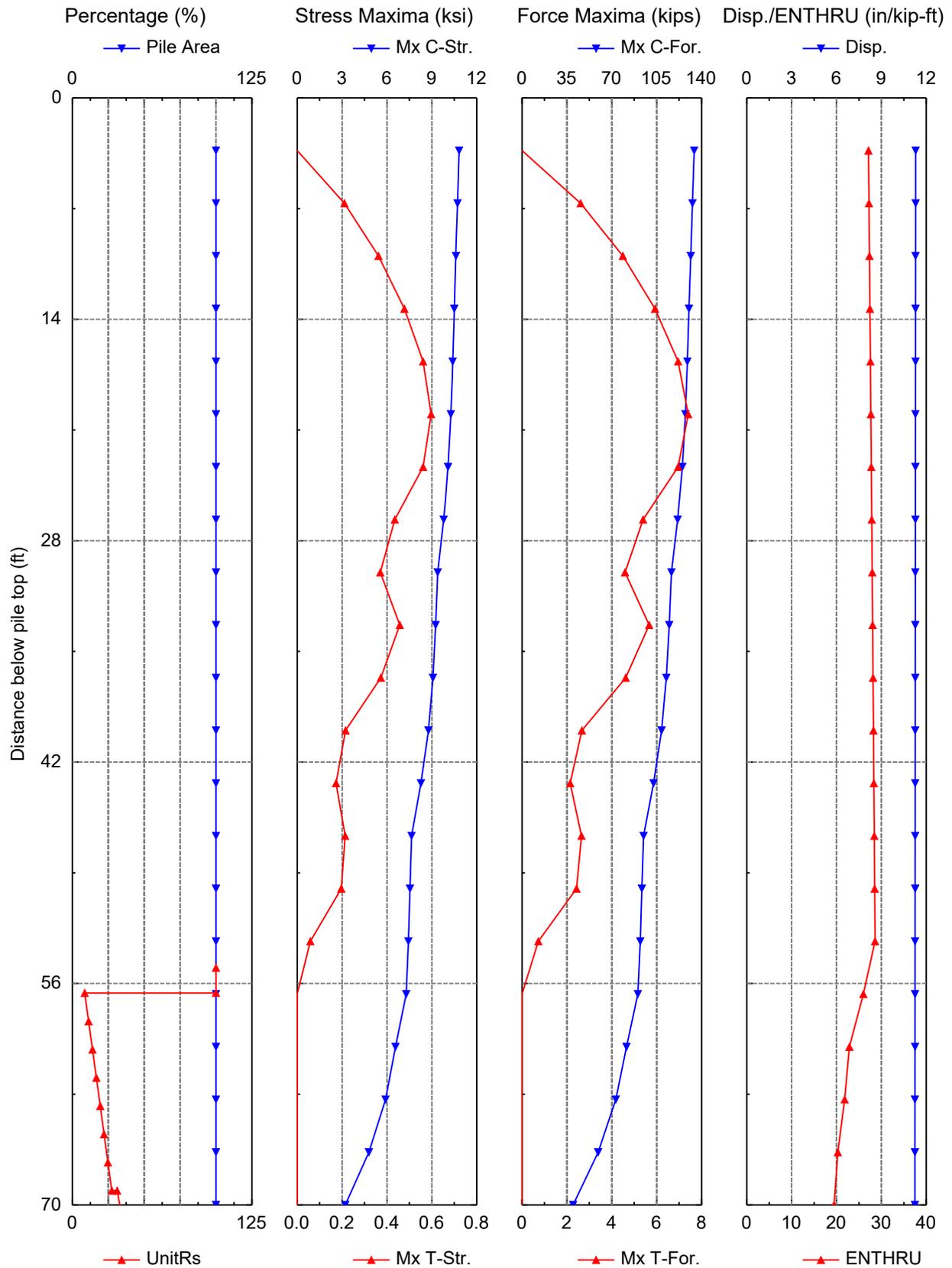
Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in ²
0.0	0.6	6.7	0.10	0.15	0.15	0.15	1.5	6.6	336.0	97.7
1.6	0.6	6.7	0.10	0.15	0.15	0.15	1.5	6.6	336.0	97.7
1.6	0.0	2.4	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
3.4	0.1	3.1	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
5.2	0.1	3.9	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
7.0	0.1	4.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
8.7	0.1	5.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
10.5	0.1	6.1	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
12.3	0.1	6.8	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
14.1	0.2	7.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
14.1	0.2	10.7	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
15.8	0.2	11.8	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
17.4	0.2	12.8	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
19.1	0.2	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
20.8	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
22.4	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
24.1	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
25.8	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
27.4	0.3	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
29.1	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
30.8	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
32.4	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
34.1	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
35.8	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
37.4	0.4	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
39.1	0.5	13.3	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
39.1	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	97.7
40.8	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	97.7
42.4	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	97.7
44.1	0.2	2.2	0.10	0.20	0.15	0.15	1.5	6.6	336.0	97.7
44.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
45.8	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
47.4	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
49.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
50.8	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7

52.4	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
54.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
55.8	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
57.4	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
59.1	0.7	6.7	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
59.1	1.8	320.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
61.3	2.0	341.1	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
63.4	2.1	361.2	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
65.6	2.2	375.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
65.6	0.0	0.0	0.10	0.08	35.00	0.15	1.4	1.0	24.0	97.7
76.0	0.0	0.0	0.10	0.08	35.00	0.15	1.4	1.0	24.0	97.7

Variable Time Histroy with DELMAG D 19-42; Depth = 66.00ft; Shaft/Toe G/L = 1.000/1.000



Extrema Results of Gain/Loss at Shaft/Toe = 1.000/1.000 and Depth = 15.00 ft

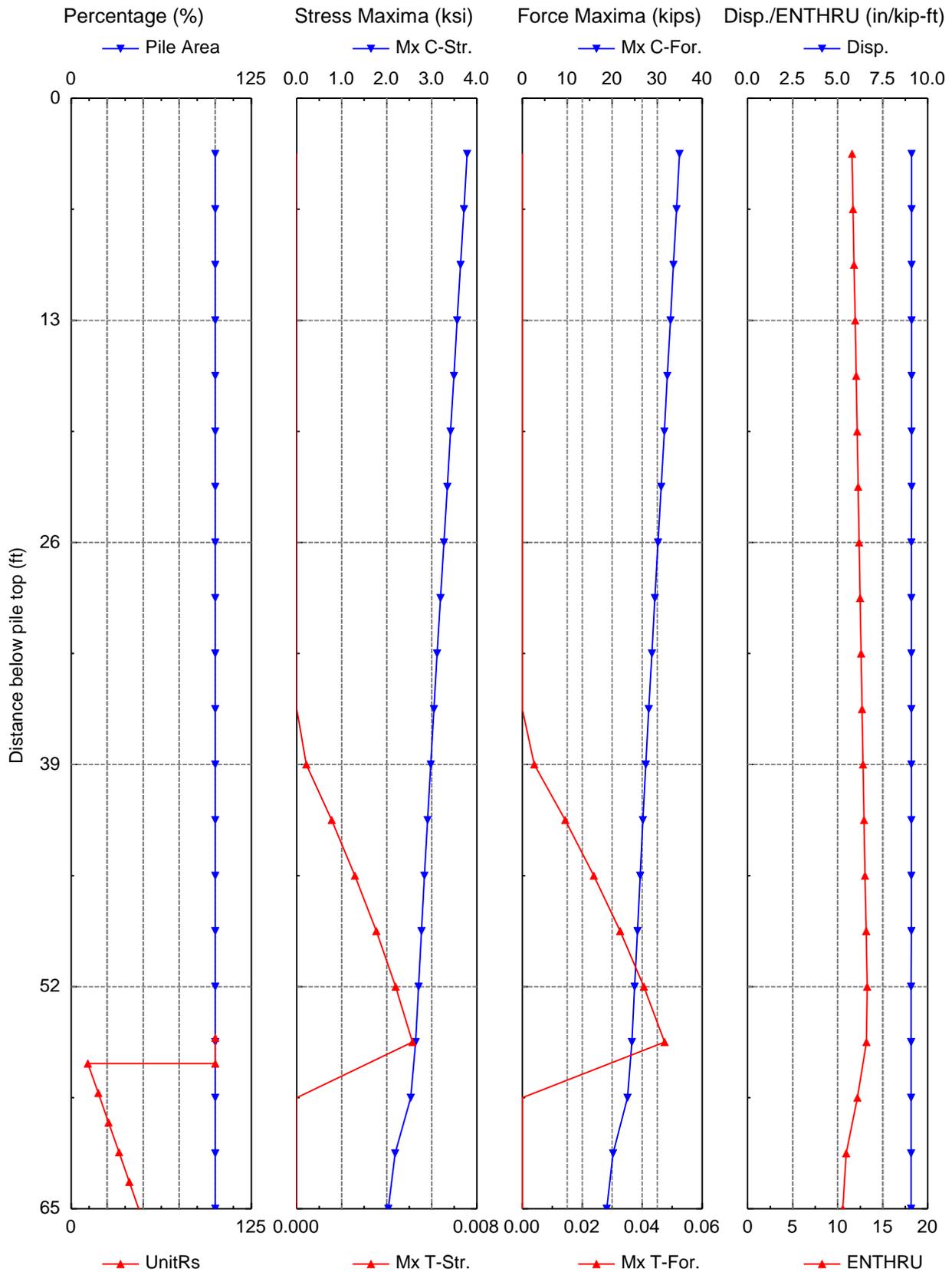


WEAP Analysis for North Abutment using HP12x42 Pile

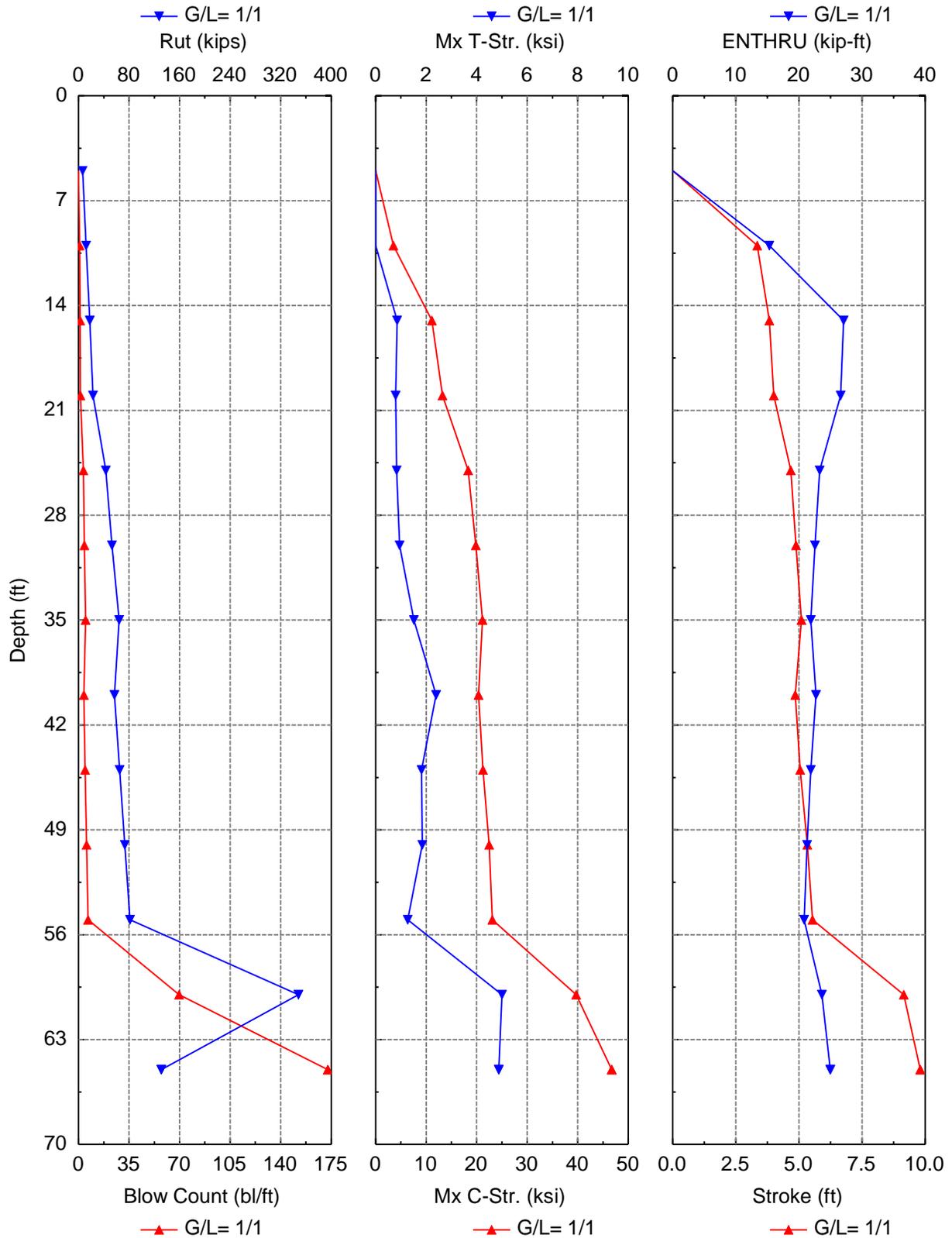
LAW-SR-650-7.16 + B-003-0-24

T SVC

Extrema Results of Gain/Loss at Shaft/Toe = 1.000/1.000 and Depth = 10.00 ft



Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 1.000/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
5.0	6.5	2.7	3.8	0.0	0.000	0.000	0.00	0.0	D 19-42
10.0	11.9	5.1	6.8	0.9	3.509	0.000	3.35	15.3	D 19-42
15.0	17.8	8.8	9.0	1.2	11.166	0.856	3.83	27.0	D 19-42
20.0	22.9	13.8	9.0	1.4	13.259	0.798	4.01	26.6	D 19-42
25.0	43.1	20.6	22.5	3.3	18.308	0.833	4.67	23.3	D 19-42
30.0	52.8	30.4	22.5	4.0	19.851	0.953	4.88	22.5	D 19-42
35.0	64.2	41.8	22.5	4.9	21.175	1.513	5.09	21.9	D 19-42
40.0	56.8	53.7	3.1	3.7	20.394	2.397	4.85	22.7	D 19-42
45.0	65.0	61.9	3.1	4.5	21.248	1.819	5.05	21.9	D 19-42
50.0	73.2	70.2	3.1	5.6	22.463	1.846	5.33	21.3	D 19-42
55.0	81.5	78.4	3.1	6.6	23.109	1.268	5.53	20.8	D 19-42
60.0	348.1	93.0	255.1	69.7	39.685	5.006	9.14	23.6	D 19-42
65.0	131.0	131.0	0.0	172.7	46.736	4.872	9.80	25.0	D 19-42
65.0	131.0	131.0	0.0	172.7	46.736	4.872	9.80	25.0	D 19-42

Summary_Total driving time: 23 minutes; Total Number of Blows: 961 (starting at penetration 5.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

LAW-SR-650-7.16 + B-003-0-24

3/7/2025

TSVC

GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

The GRLWEAP program simulates the behavior of a preformed pile driven by either an impact hammer or a vibratory hammer. The program is based on mathematical models, which describe motion and forces of hammer, driving system, pile and soil under the hammer action. Under certain conditions, the models only crudely approximate, often complex, dynamic situations.

A wave equation analysis generally relies on input data, which represents normal situations. In particular, the hammer data file supplied with the program assumes that the hammer is in good working order. All of the input data selected by the user may be the best available information at the time when the analysis is performed. However, input data and therefore results may significantly differ from actual field conditions.

Therefore, the program authors recommend prudent use of the GRLWEAP results. Soil response and hammer performance should be verified by static and/or dynamic testing and measurements. Estimates of bending or other local stresses (e.g., helmet or clamp contact, uneven rock surfaces etc.), prestress effects and others must also be accounted for by the user.

The calculated capacity-blow count relationship, i.e. the bearing graph, should be used in conjunction with observed blow counts for the capacity assessment of a driven pile. Soil setup occurring after pile installation may produce bearing capacity values that differ substantially from those expected from a wave equation analysis due to soil setup or relaxation. This is particularly true for pile driven with vibratory hammers. The GRLWEAP user must estimate such effects and should also use proper care when applying blow counts from restrike because of the variability of hammer energy, soil resistance and blow count during early restriking.

Finally, the GRLWEAP capacities are ultimate values. They **MUST** be reduced by means of an appropriate factor of safety to yield a design or working load. The selection of a factor of safety should consider the quality of the construction control, the variability of the site conditions, uncertainties in the loads, the importance of structure and other factors.

SOIL PROFILE

Depth ft	Soil Type -	Spec. Wt lb/ft ³	Su ksf	Phi °	Unit Rs ksf	Unit Rt ksf
0.0	Clay	112.0	0.5	0.0	0.37	4.50
1.5	Clay	112.0	0.5	0.0	0.37	4.50
1.5	Sand	118.0	0.0	29.0	0.05	2.49
24.0	Sand	118.0	0.0	29.0	0.41	13.32
24.0	Sand	120.0	0.0	32.0	0.52	33.09
39.0	Sand	120.0	0.0	32.0	0.82	33.09
39.0	Clay	118.0	0.5	0.0	0.50	4.50
59.0	Clay	118.0	0.5	0.0	0.50	4.50
59.0	Sand	135.0	0.0	40.0	2.40	375.94
64.5	Sand	135.0	0.0	40.0	2.68	375.94
64.5	Rock	148.0	0.0	40.0	0.00	0.00
76.0	Rock	148.0	0.0	40.0	0.00	0.00

PILE INPUT

Uniform Pile		Pile Type:	H Pile
Pile Length: (ft)	70.000	Pile Penetration: (ft)	65.000
Pile Size: (ft)	0.84	Toe Area: (in ²)	97.73

Pile Profile

Lb Top ft	X-Area in ²	E-Modulus ksi	Spec. Wt lb/ft ³	Perim. ft	Crit. Index -
0.0	12.4	30,000.0	492.0	3.3	0
70.0	12.4	30,000.0	492.0	3.3	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt kips	Ram L. in	Ram Ar. in ²	Rtd. Stk ft	Effic. -	Rtd. Energy kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

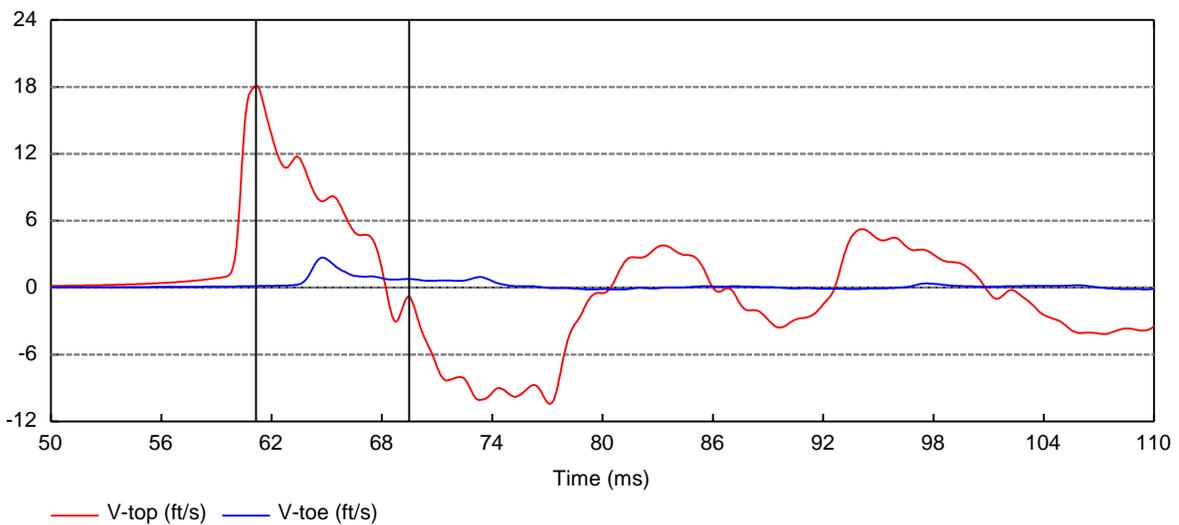
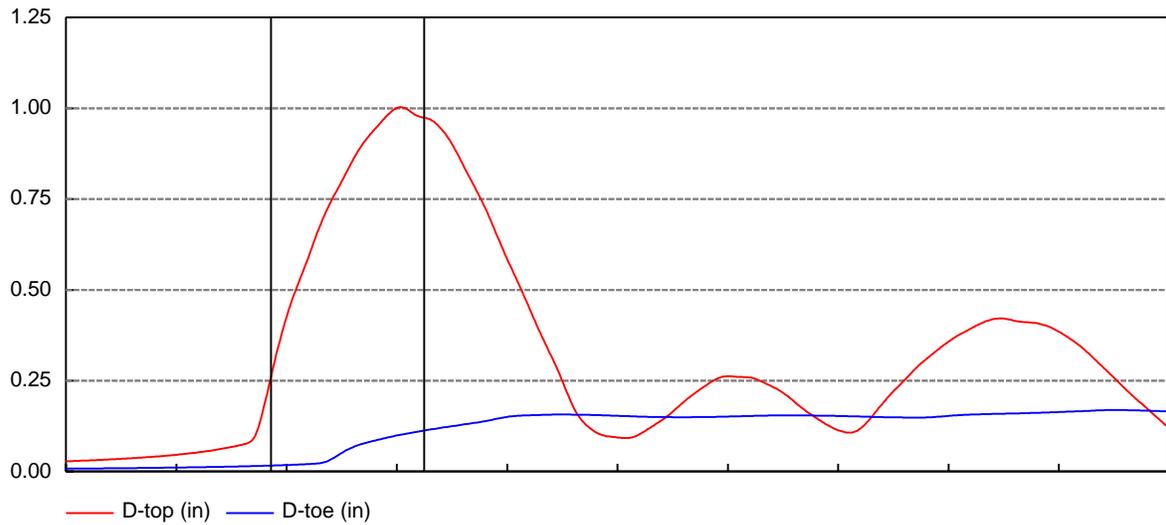
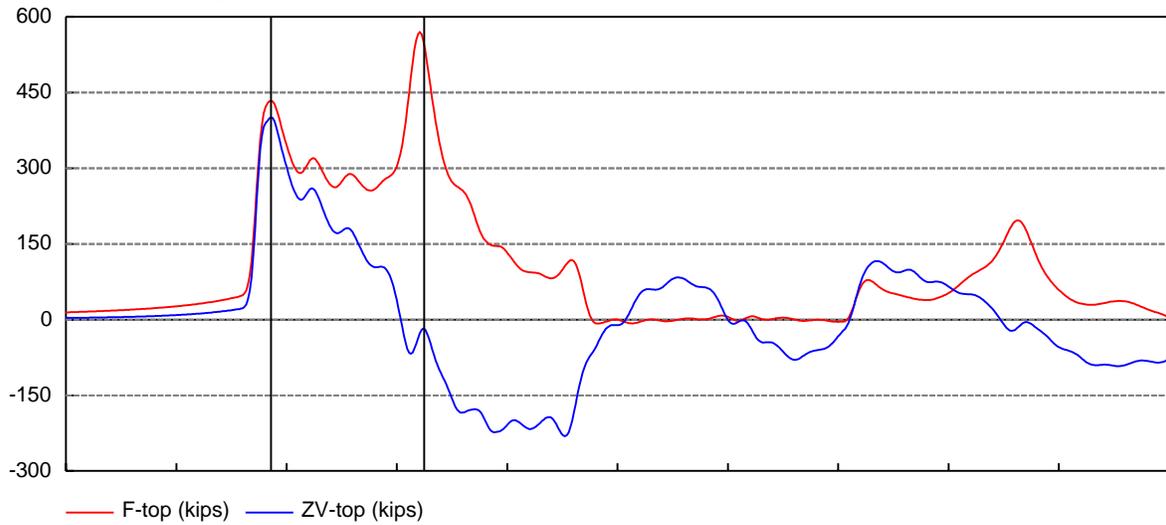
Type -	X-Area in ²	E-Modulus ksi	Thickness in	COR -	Round-out in	Stiffness kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.550
Helmet Wt.	1.900	kips				

SOIL RESISTANCE DISTRIBUTION

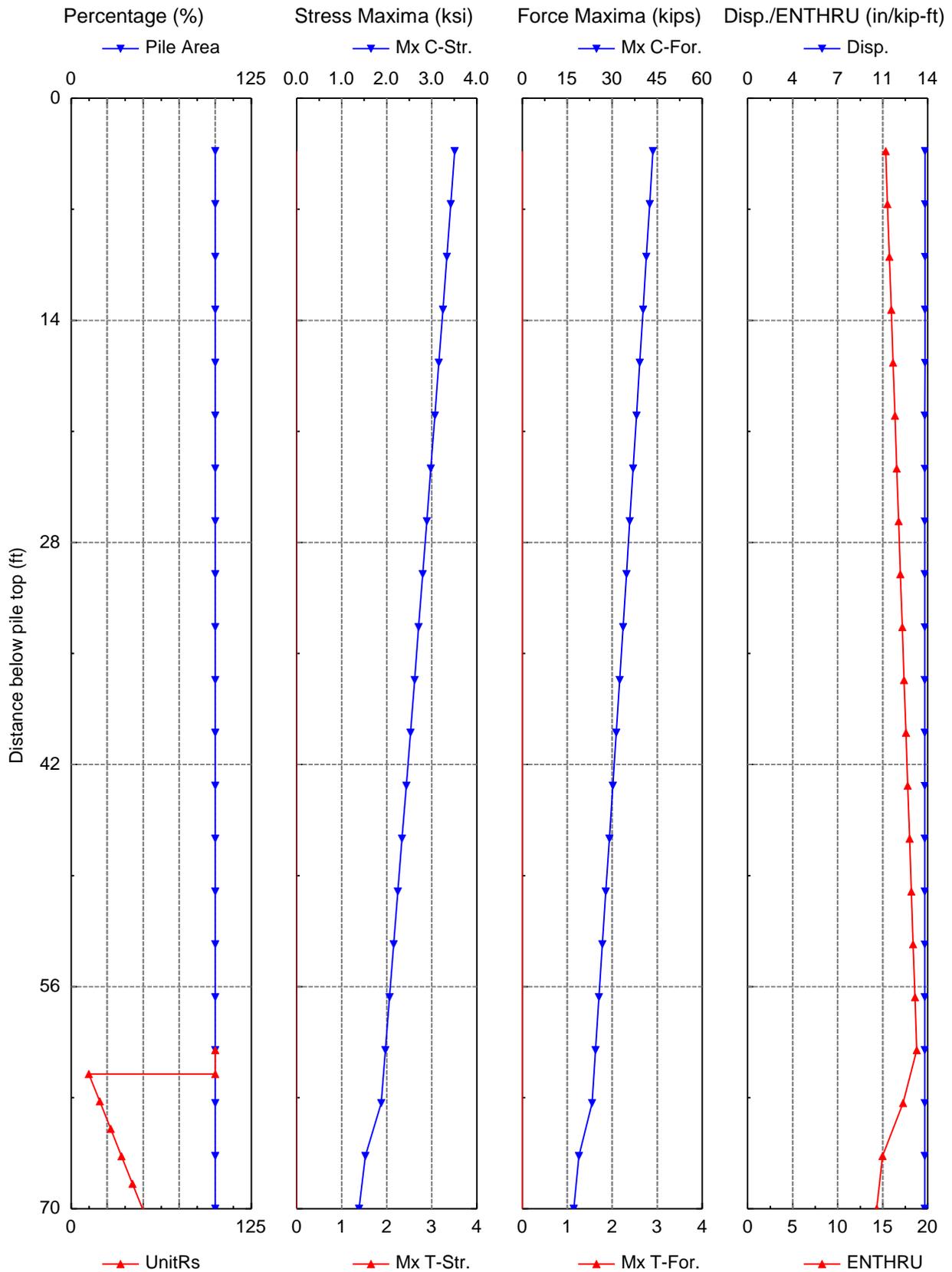
Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Set. F. -	Limit D. ft	Set. T. Hours	EB Area in ²
0.0	0.4	4.5	0.10	0.15	0.15	0.15	1.5	6.6	336.0	97.7
1.5	0.4	4.5	0.10	0.15	0.15	0.15	1.5	6.6	336.0	97.7
1.5	0.0	2.5	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
3.2	0.1	4.0	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
5.0	0.1	5.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
6.7	0.1	7.1	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
8.4	0.2	8.6	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
10.2	0.2	10.2	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
11.9	0.2	11.7	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
13.6	0.2	13.2	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
15.3	0.3	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
17.1	0.3	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
18.8	0.3	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
20.5	0.4	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
22.3	0.4	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
24.0	0.4	13.3	0.10	0.20	0.05	0.15	1.2	6.6	72.0	97.7
24.0	0.5	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
25.7	0.6	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
27.3	0.6	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
29.0	0.6	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
30.7	0.7	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
32.3	0.7	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
34.0	0.7	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
35.7	0.8	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
37.3	0.8	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
39.0	0.8	33.1	0.10	0.20	0.05	0.15	1.0	6.6	24.0	97.7
39.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
40.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
42.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
44.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
45.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
47.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
49.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
50.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
52.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
54.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
55.7	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7

57.3	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
59.0	0.5	4.5	0.10	0.13	0.15	0.15	1.5	6.6	336.0	97.7
59.0	2.4	375.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
60.8	2.5	375.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
62.7	2.6	375.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
64.5	2.7	375.9	0.10	0.10	0.05	0.15	1.0	6.6	24.0	97.7
64.5	0.0	0.0	0.10	0.08	35.00	0.15	1.4	1.0	24.0	97.7
76.0	0.0	0.0	0.10	0.08	35.00	0.15	1.4	1.0	24.0	97.7

Variable Time History with DELMAG D 19-42; Depth = 65.00ft; Shaft/Toe G/L = 1.000/1.000



Extrema Results of Gain/Loss at Shaft/Toe = 1.000/1.000 and Depth = 10.00 ft



PROJECT DESCRIPTION

THE PROJECT INCLUDES REALIGNMENT OF THE CURVE OF THE ROAD AND PAVEMENT REPLACEMENT FOR APPROXIMATELY 1,000 FEET ALONG STATE ROUTE 650. IT ALSO INCLUDES THE REPLACEMENT OF THE EXISTING BRIDGE ALONG STATE ROUTE 650 OVER LITTLE PINE CREEK.

HISTORIC RECORDS

NO HISTORICAL BORING LOGS ARE AVAILABLE AROUND THE PROJECT SITE.

GEOLOGY

THE PROJECT IS LOCATED IN THE IRONTON PLATEAU OF OHIO WHICH IS GENERALLY CHARACTERIZED BY A MODERATELY HIGH RELIEF DISSECTED PLATEAU AND COMMON LACUSTRINE CLAY-FILLED TEAYS VALLEY REMNANTS. THESE LACUSTRINE SOILS WERE ENCOUNTERED DURING OUR FIELD EXPLORATION.

BEDROCK IN THE PROJECT AREA MAPS AS PENNSYLVANIAN AGE ALLEGHENY AND POTTSVILLE GROUPS FORMATION CONSISTING OF SHALE WITH INTERBEDDED LIMESTONE, SILTSTONE, AND UNDERCLAY. DURING OUR FIELD EXPLORATION, BEDROCK WAS ENCOUNTERED AT THE TWO BRIDGE BORINGS AT DEPTHS OF 74 AND 74½ FEET BELOW THE EXISTING ROAD SURFACE.

RECONNAISSANCE

THE PROJECT INCLUDES REALIGNMENT OF THE CURVE OF THE ROAD AND PAVEMENT REPLACEMENT FOR APPROXIMATELY 1,000 FEET. RECONNAISSANCE WAS PERFORMED BY TERRACON PERSONNEL ON DECEMBER 9, 2024. THE AREA SURROUNDING THE PROJECT IS GENERALLY AGRICULTURAL OR WOODED WITH A FEW RESIDENTIAL BUILDINGS LOCATED ON EITHER SIDE OF SR-650 AND A USED CAR BUSINESS LOCATED NORTHEAST OF SR-650 AT ABOUT STATION 387+00. THE EXISTING LITTLE PINE CREEK INTERSECTS SR-650 AT ABOUT STATION 383+00 AND IS APPROXIMATELY 16 FEET DEEP AT THE DEEPEST PART OF THE CHANNEL FROM THE EXISTING ROAD SURFACE. AN EXISTING LITTLE PINE CREEK ROAD HEADING EAST INTERSECTS SR-650 AT ABOUT STATION 386+00. THE EXISTING PAVEMENT APPEARED TO BE IN FAIR CONDITION. 0 FEET ALONG STATE ROUTE 650. IT ALSO INCLUDES THE REPLACEMENT OF THE EXISTING BRIDGE ALONG STATE ROUTE 650 OVER LITTLE PINE CREEK.

SUBSURFACE EXPLORATION

THE PROJECT INCLUDES REALIGNMENT OF THE CURVE OF THE ROAD AND PAVEMENT REPLACEMENT FOR APPROXIMATELY 1,000 FEET. A TOTAL OF TWO (2) TEST BRIDGE BORINGS AND THREE (3) TEST ROADWAY BORINGS WERE PERFORMED BY TERRACON BETWEEN DECEMBER 17, 2024, AND DECEMBER 24, 2024. THE GROUND SURFACE ELEVATIONS AND COORDINATES WERE MEASURED BY TERRACON BY USING A SURVEY-GRADE EMLID FLOW GPS UNIT WITH AN APPROXIMATE HORIZONTAL AND VERTICAL ACCURACY OF +/- 1 FOOT AND PROVIDED ON THE TEST BORING LOGS.

THE TEST BORINGS WERE PERFORMED WITH A TRACK-MOUNTED DRILL RIG. THE DRILL RIG UTILIZED HOLLOW-STEM AUGERS TO PERMIT SPLIT-SPOON SAMPLING IN OVERBURDEN SOILS. DRILLING AND SAMPLING PROCEDURES WERE PERFORMED IN GENERAL ACCORDANCE WITH THE ODOT SGE- 7/19/2024. THE AVERAGE DRILL RIG ENERGY RATIO (ER) FOR THE CME-55 DRILL RIG WAS 88.8 PERCENT (CALIBRATION DATE 12/6/2024).

GROUNDWATER LEVELS WERE OBSERVED DURING DRILLING AND AT THE COMPLETION OF THE DRILLING ACTIVITIES AT EACH TEST BORING LOCATION. NO LONG-TERM (24-HOUR) WATER LEVEL READINGS WERE OBTAINED AT THE TEST BORING LOCATIONS. UPON COMPLETION OF THE DRILLING ACTIVITIES AND FOLLOWING WATER LEVEL OBSERVATIONS, THE BOREHOLES WERE SEALED WITH CEMENT GROUT, AND THE PAVEMENT SURFACE WAS PATCHED WITH CONCRETE PLUG AND ASPHALT PER SGE REQUIREMENTS. EET ALONG STATE ROUTE 650. IT ALSO INCLUDES THE REPLACEMENT OF THE EXISTING BRIDGE ALONG STATE ROUTE 650 OVER LITTLE PINE CREEK.

EXPLORATION FINDINGS

THE SUBSURFACE PROFILE IN THE TEST BRIDGE BORINGS GENERALLY CONSISTED OF SHALLOW MEDIUM STIFF TO STIFF COHESIVE FILL (A-6A AND A-4A) FOLLOWED BY SOME MEDIUM STIFF TO STIFF NATIVE COHESIVE SOILS (A-4A) UP TO ABOUT 11 FEET BELOW THE EXISTING ROAD SURFACE. THIS UPPER COHESIVE OVERBURDEN IS UNDERLAIN BY VERY LOOSE TO LOOSE COHESIONLESS SAND (A-3 AND A-3A) UP TO ABOUT 48.5 FEET BELOW THE EXISTING ROAD SURFACE FOLLOWED BY MEDIUM STIFF TO STIFF COHESIVE SOIL (A-6A) UP TO 68.5 FEET BELOW THE EXISTING ROAD SURFACE. THERE IS AN APPROXIMATELY 5-FOOT LAYER OF VERY DENSE COHESIONLESS SOIL (A-1-B) UNDERNEATH, FOLLOWED BY INTERBEDDED SHALE AND LIMESTONE BEDROCK. BEDROCK WAS ENCOUNTERED AT DEPTHS OF 74 AND 74½ FEET BELOW THE EXISTING ROAD SURFACE AT THE TWO BRIDGE BORINGS.

THE SUBSURFACE PROFILE IN THE TEST ROADWAY BORINGS GENERALLY CONSISTED OF VERY SOFT TO VERY STIFF COHESIVE SOILS (A-4A, A-6A, AND A-6B). VERY LOOSE TO MEDIUM DENSE COHESIONLESS SOILS (A-3A) WERE ENCOUNTERED ONLY AT BORING B-001-0-24.

THE BOREHOLES WERE OBSERVED WHILE DRILLING AND AFTER COMPLETION FOR THE PRESENCE AND LEVEL OF GROUNDWATER. GROUNDWATER WAS ENCOUNTERED AT DEPTHS RANGING FROM 6 TO 16 FEET BELOW EXISTING SITE GRADES AS INDICATED ON THE BORING LOGS

SPECIFICATIONS

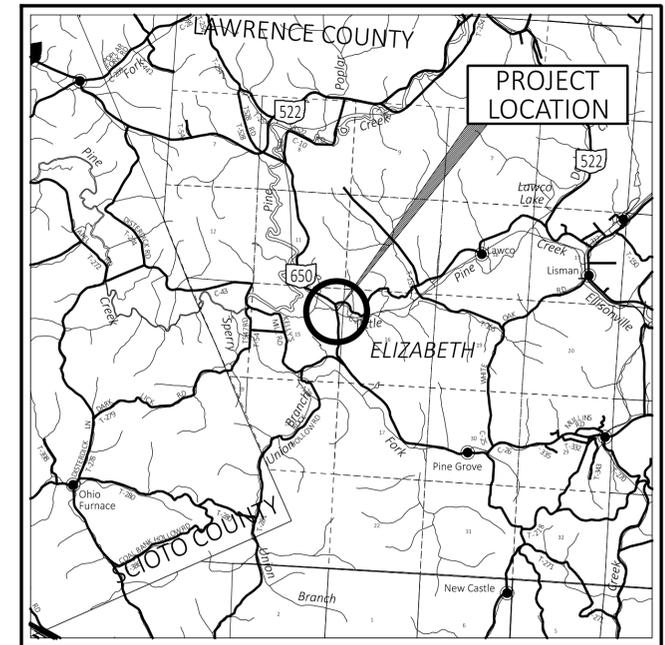
THIS GEOTECHNICAL EXPLORATION WAS PERFORMED IN ACCORDANCE WITH THE STATE OF OHIO, DEPARTMENT OF TRANSPORTATION, OFFICE OF GEOTECHNICAL ENGINEERING, SPECIFICATION FOR GEOTECHNICAL EXPLORATIONS, DATED JULY 2024.

AVAILABLE INFORMATION

ALL AVAILABLE SOIL AND BEDROCK INFORMATION THAT CAN BE CONVENIENTLY SHOWN ON THE GEOTECHNICAL EXPLORATION SHEETS HAS BEEN SO REPORTED. ADDITIONAL EXPLORATIONS MAY HAVE BEEN MADE TO STUDY SOME SPECIAL ASPECTS OF THE PROJECT. COPIES OF THIS DATA, IF ANY, MAY BE INSPECTED IN THE DISTRICT DEPUTY DIRECTOR'S OFFICE OR THE OFFICE OF GEOTECHNICAL ENGINEERING.

LEGEND

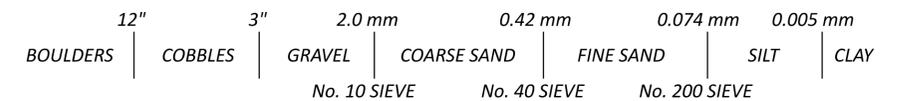
DESCRIPTION	ODOT CLASS	CLASSIFIED MECH./VISUAL
GRAVEL AND/OR STONE FRAGMENTS WITH SAND	A-1-b	1 3
FINE SAND	A-3	4 8
COARSE AND FINE SAND	A-3a	4 9
SANDY SILT	A-4a	4 5
SILT	A-4b	1 0
SILT AND CLAY	A-6a	5 11
SILTY CLAY	A-6b	1 2
	TOTAL	20 38
(ROCK)		
PAVEMENT OR BASE = X = APPROXIMATE THICKNESS	VISUAL	
SOD AND TOPSOIL = X = APPROXIMATE THICKNESS	VISUAL	
BORING LOCATION - PLAN VIEW.		
DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.		
WC	INDICATES WATER CONTENT IN PERCENT.	
N ₆₀	INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.	
X/Y/Z	NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT): X= NUMBER OF BLOWS FOR FIRST 6 INCHES. Y= NUMBER OF BLOWS FOR SECOND 6 INCHES. Z= NUMBER OF BLOWS FOR THIRD 6 INCHES.	
W	INDICATES FREE WATER ELEVATION.	
●	INDICATES A PLASTIC MATERIAL WITH A MOISTURE CONTENT EQUAL TO OR GREATER THAN THE LIQUID LIMIT MINUS 3.	
⊕	INDICATES A NON-PLASTIC MATERIAL WITH A MOISTURE CONTENT GREATER THAN 25 % OR GREATER THAN 19 % WITH A WET APPEARANCE.	
*	INDICATES A SAMPLE TAKEN WITHIN 3 FT OF PROPOSED GRADE.	
SS	INDICATES A SPLIT SPOON SAMPLE.	
NP	INDICATES A NON-PLASTIC SAMPLE.	



LOCATION MAP
SCALE IN MILES



PARTICLE SIZE DEFINITIONS



RECON. - MP 12/09/2024
DRILLING - CK/JF 12/17/2024 - 12/24/2024
DRAWN - BM 3/3/2025
REVIEWED - DWW 3/6/2024

SUMMARY OF SOIL TEST DATA

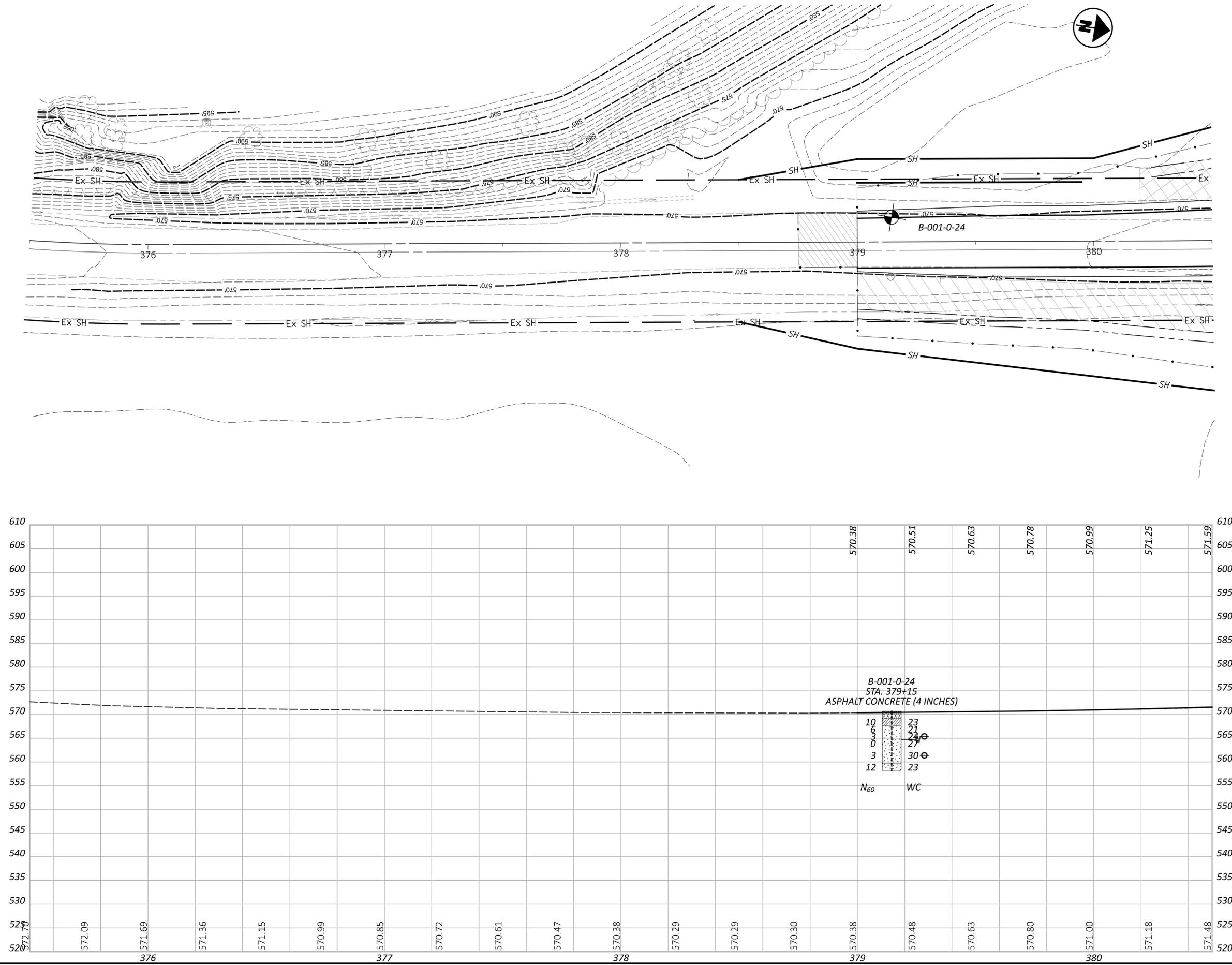
EXPLOR. ID	FROM - TO	SAMPLE ID	% REC	tsf	% GR	% CS	% FS	% SILT	% CLAY	LL	PL	PI	WC	ODOT CLASS (GI)	ppm SO4	
B-001-0-24	1.50 - 03.00	SS-1	10	56	1.25	2	1	17	50	30	34	19	15	23	A-6a (10)	-
STA. 379+15, 10' LT.	3.00 - 04.50	SS-2	6	72	-	-	-	-	-	-	-	-	21	A-3a (VISUAL)	-	
LATITUDE = 38.629534	4.50 - 06.00	SS-3	3	78	-	1	4	69	24	2	NP	NP	24	A-3a (0)	-	
LONGITUDE = -82.731377	6.00 - 07.50	SS-4	0	100	-	-	-	-	-	-	-	-	27	A-3a (VISUAL)	-	
	8.50 - 10.00	SS-5	3	89	-	0	9	60	27	4	NP	NP	30	A-3a (0)	-	
	11.00 - 12.50	SS-6	12	89	-	-	-	-	-	-	-	-	23	A-3a (VISUAL)	-	
REFER TO THE BORING LOGS IN SUBSET 7 THROUGH 9 FOR SUMMARY OF SOIL TEST DATA ON BRIDGE BORINGS B-002-0-24 AND B-003-0-24																
B-004-0-24	0.00 - 01.50	SS-1	7	100	2.00	-	-	-	-	-	-	-	27	A-6b (VISUAL)	-	
STA. 385+80, 5' RT.	1.50 - 03.00	SS-2	6	89	1.25	0	0	9	62	29	37	21	16	A-6b (10)	-	
LATITUDE = 38.631314	3.00 - 04.50	SS-3	4	78	0.50	-	-	-	-	-	-	-	34	A-6a (VISUAL)	-	
LONGITUDE = -82.731888	4.50 - 06.00	SS-4	3	100	0.25	0	0	21	58	21	30	19	11	A-6a (8)	-	
	6.00 - 07.50	SS-5	0	100	0.25	-	-	-	-	-	-	-	35	A-6a (VISUAL)	-	
	8.50 - 10.00	SS-6	16	89	2.50	-	-	-	-	-	-	-	21	A-6b (VISUAL)	-	
B-005-0-24	1.00 - 02.50	SS-1	19	17	4.00	-	-	-	-	-	-	-	10	A-6a (VISUAL)	-	
STA. 389+04, 4' LT.	2.50 - 04.00	SS-2	12	61	1.50	11	5	22	39	23	32	19	13	A-6a (7)	-	
LATITUDE = 38.631952	4.00 - 05.50	SS-3	7	56	1.00	-	-	-	-	-	-	-	22	A-6a (VISUAL)	-	
LONGITUDE = -82.732661	5.50 - 07.00	SS-4	9	100	1.25	19	4	21	35	21	25	16	9	A-4a (4)	-	
	8.50 - 10.00	SS-5	15	56	2.50	-	-	-	-	-	-	-	17	A-4a (VISUAL)	-	

LAW-650-7.16

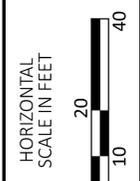
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GEOTECHNICAL PROFILE
LAW-650-7.16

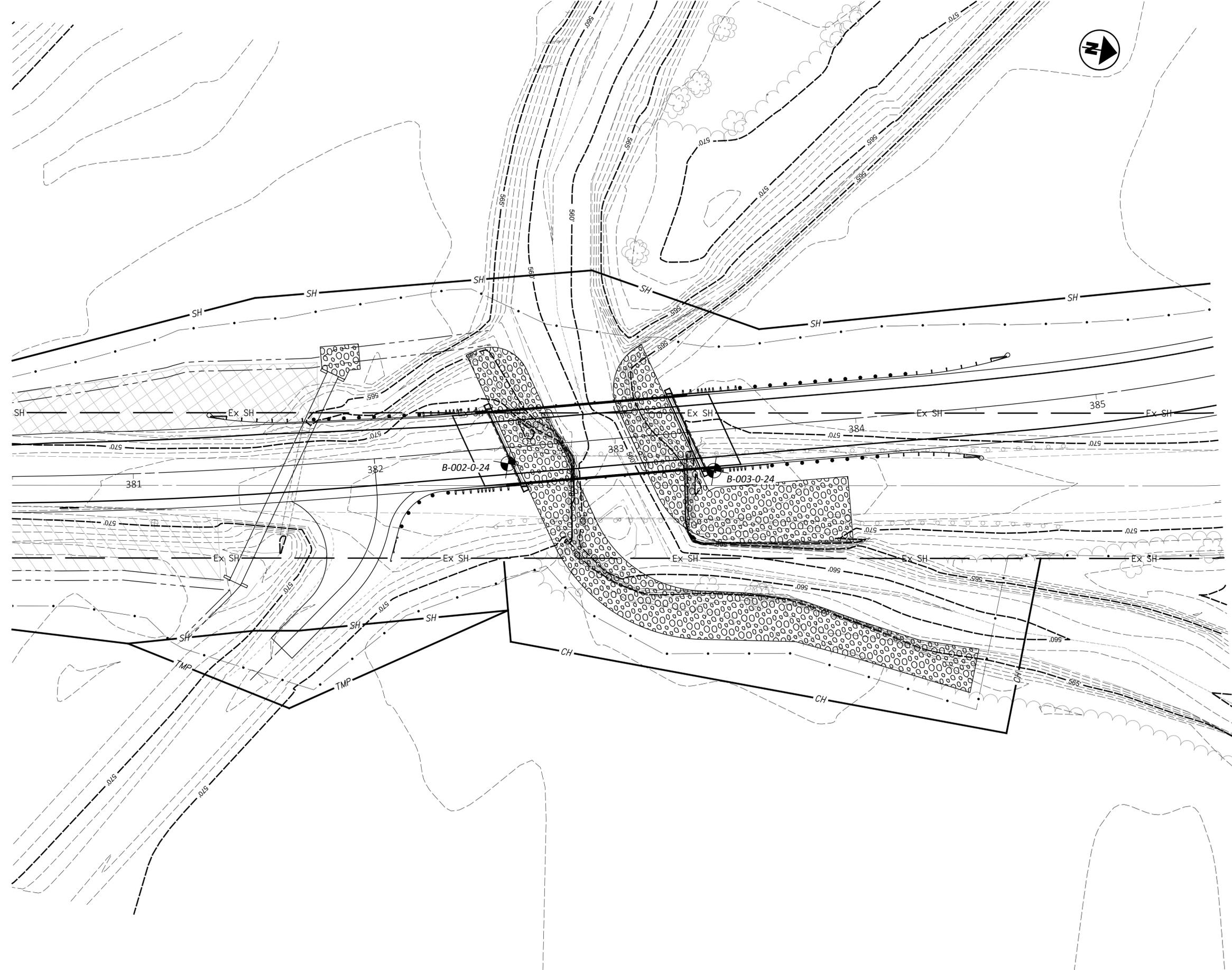
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DESIGNER	MP
REVIEWER	DWW 3-6-25
PROJECT ID	119775
SUBSET TOTAL	1 10
SHEET TOTAL	P.0 0



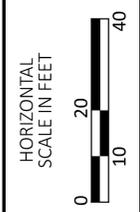
GEOTECHNICAL PROFILE - ROADWAY
 LAW-650-7.16
 STA. 375+50 TO STA. 380+50



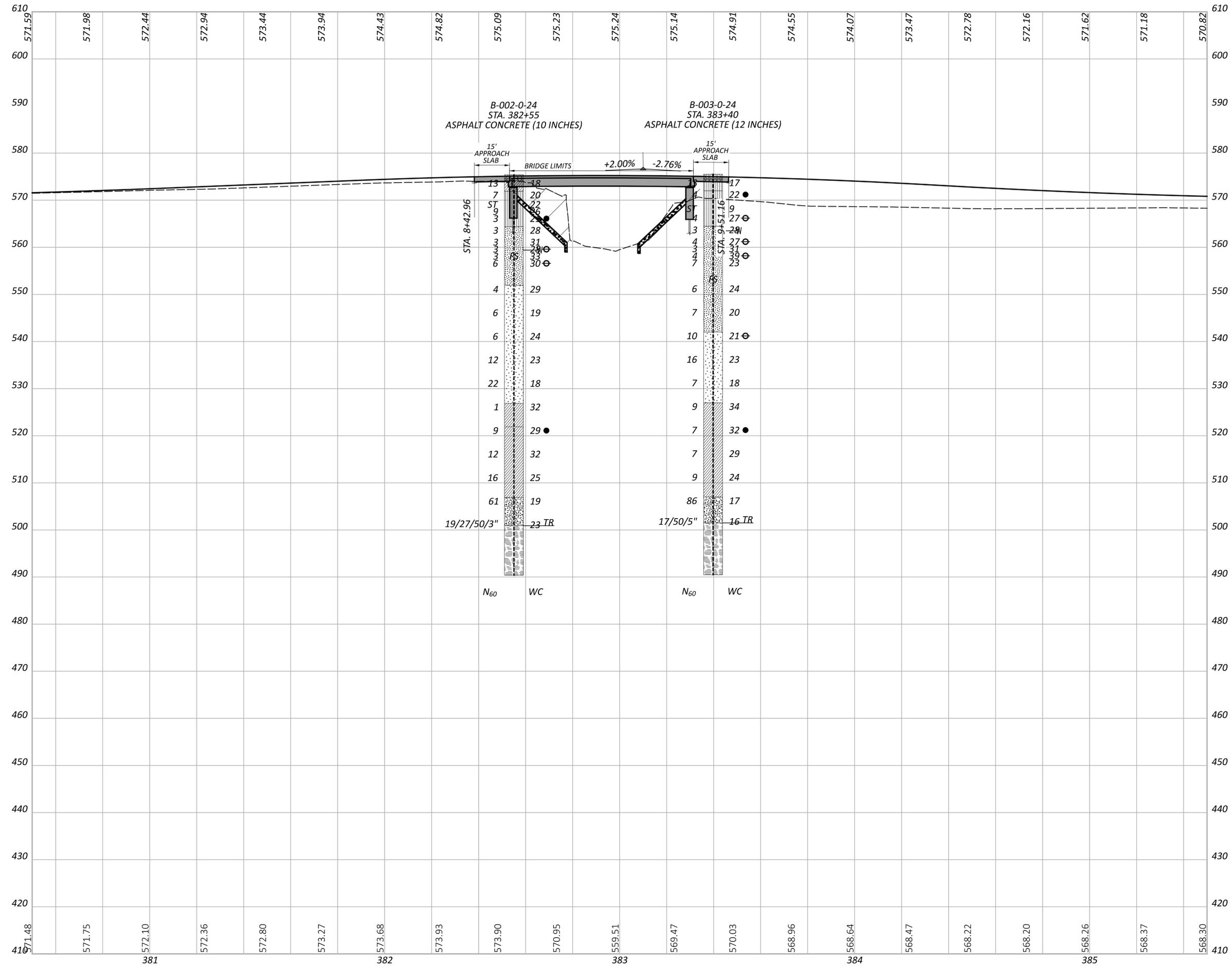
DESIGN AGENCY	
terracon	
DESIGNER	
MP	
REVIEWER	
DWW 3-6-25	
PROJECT ID	
119775	
SUBSET	TOTAL
2	10
SHEET	
P.0	
TOTAL	
0	



GEOTECHNICAL PROFILE - BRIDGE
 LAW-650-7.16
 STA. 380+50 TO STA. 385+50

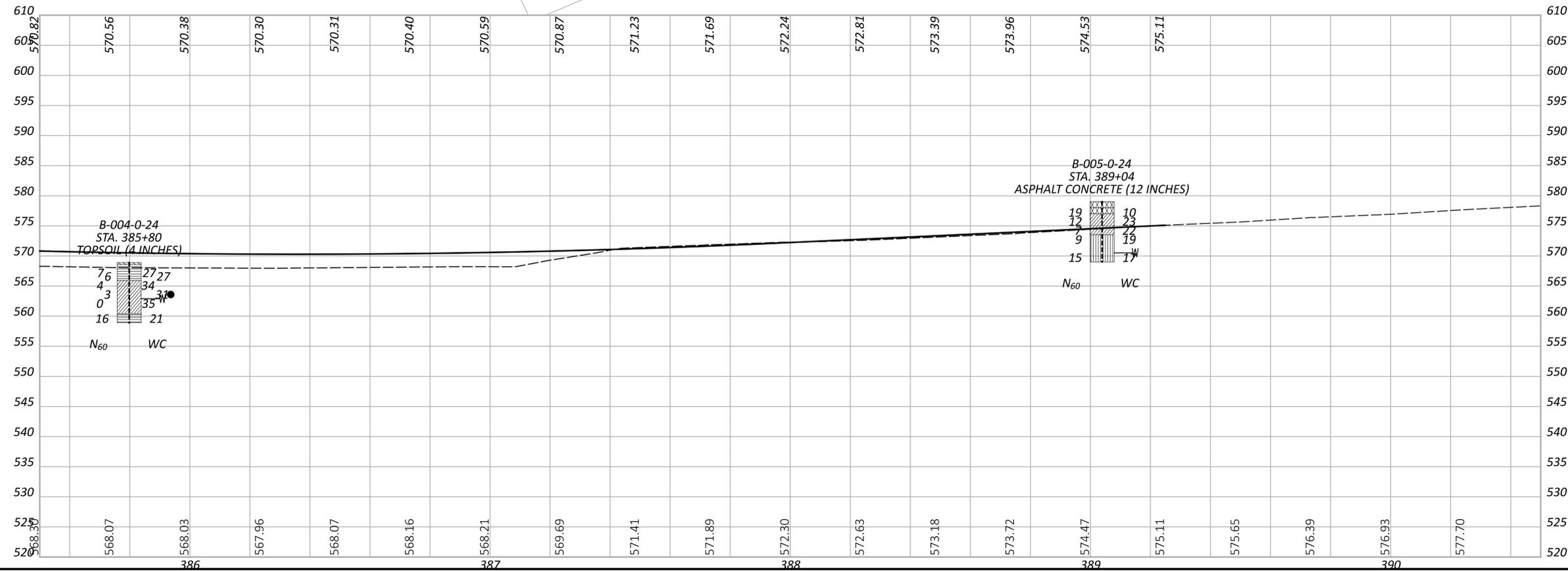


DESIGN AGENCY	
DESIGNER	
MP	
REVIEWER	
DWW	3-6-25
PROJECT ID	
119775	
SUBSET	TOTAL
3	10
SHEET	
P.0	0

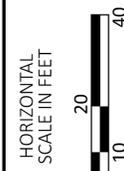


GEOTECHNICAL PROFILE - BRIDGE
 LAW-650-7.16
 STA. 380+50 TO STA. 385+50

DESIGN AGENCY	
DESIGNER	
MP	
REVIEWER	
DWW 3-6-25	
PROJECT ID	
119775	
SUBSET	TOTAL
4	10
SHEET	
P.0	
TOTAL	
0	



GEOTECHNICAL PROFILE - ROADWAY
 LAW-650-7.16
 STA. 385+50 TO STA. 390+50



DESIGN AGENCY



DESIGNER

MP

REVIEWER

DWW 3-6-25

PROJECT ID

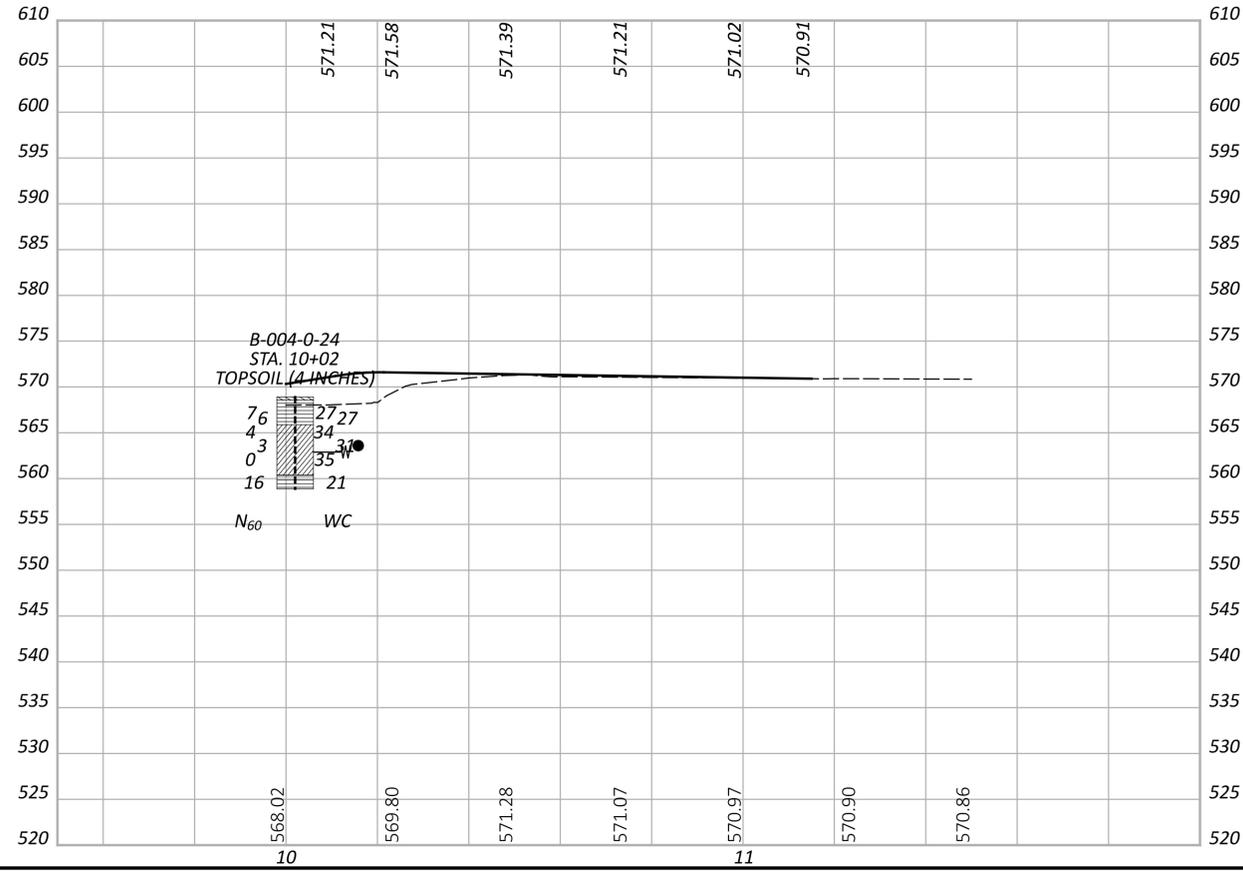
119775

SUBSET TOTAL

5 10

SHEET TOTAL

P.0 0



GEOTECHNICAL PROFILE - ROADWAY
 LITTLE PINE CREEK
 STA. 10+50 TO STA. 11+50

DESIGN AGENCY



DESIGNER

MP

REVIEWER

DWW 3-6-25

PROJECT ID

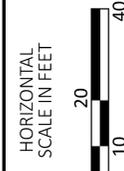
119775

SUBSET TOTAL

6 10

SHEET TOTAL

P.0 0



LAW-650-7.16

MODEL: LOG 1 PAPER SIZE: 34x22 (in.) DATE: 3/7/2025 TIME: 8:28:13 AM USER: bcmfliner
 C:\Users\bcmfliner\OneDrive - Terracon Consultants Inc\Desktop\CAD\CINCINNATI\1245336\119775_Z1001.dgn

PROJECT: LAW-SR-650-07.16		DRILLING FIRM / OPERATOR: TERRACON / CK		DRILL RIG: CME 55 TRACK		STATION / OFFSET: 382+55.7 RT.		EXPLORATION ID	
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: TERRACON / JF		HAMMER: CME AUTOMATIC		ALIGNMENT: SR-650		B-002-0-24	
PID: 119775 SFN: 12/23/24		3.25" HSA / NQ2		CALIBRATION DATE: 12/8/24		ELEVATION: 575.4 (MSL) EOB: 85.0 ft.		PAGE	
START: 12/23/24 END: 12/23/24		SPT / ST / NQ2		ENERGY RATIO (%): 88.8		LAT / LONG: 38.630458, -82.731563		1 OF 3	
MATERIAL DESCRIPTION		ELEV.		REC SAMPLE ID		GRADATION (%)		HOLE CLASS (G)	
AND NOTES		DEPTHS		N ₆₀		GR CS FS SI CL LL PL PI WC		ODOT CLASS (G)	
ASPHALT CONCRETE (10 INCHES)		574.6		3				A-6a (V)	
AGGREGATE BASE COURSE (5 INCHES)		574.2		4				A-6a (V)	
STIFF, BROWN AND GRAY, SILT AND CLAY, LITTLE SAND, TRACE GRAVEL, MOIST (FILL)		571.9		7				A-4a (5)	
MEDIUM STIFF TO STIFF, BROWN, SANDY SILT, LITTLE CLAY, LITTLE GRAVEL, MOIST TO WET				0				A-4a (V)	
VERY LOOSE TO LOOSE, BROWN TO GRAY, FINE SAND, TRACE GRAVEL, WET		564.4		0				A-3 (V)	
LOOSE TO MEDIUM DENSE GRAY, COARSE AND FINE SAND, LITTLE SILT, TRACE CLAY, WET		551.9		2				A-3a (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 3/4/25 08:28 - E:\PROJECTS\2024\1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-1245336.GPJ

PROJECT: LAW-SR-650-07.16		DRILLING FIRM / OPERATOR: TERRACON / CK		DRILL RIG: CME 55 TRACK		STATION / OFFSET: 382+55.7 RT.		EXPLORATION ID	
TYPE: BRIDGE		SAMPLING FIRM / LOGGER: TERRACON / JF		HAMMER: CME AUTOMATIC		ALIGNMENT: SR-650		B-002-0-24	
PID: 119775 SFN: 12/23/24		3.25" HSA / NQ2		CALIBRATION DATE: 12/8/24		ELEVATION: 575.4 (MSL) EOB: 85.0 ft.		PAGE	
START: 12/23/24 END: 12/23/24		SPT / ST / NQ2		ENERGY RATIO (%): 88.8		LAT / LONG: 38.630458, -82.731563		1 OF 3	
MATERIAL DESCRIPTION		ELEV.		REC SAMPLE ID		GRADATION (%)		HOLE CLASS (G)	
AND NOTES		DEPTHS		N ₆₀		GR CS FS SI CL LL PL PI WC		ODOT CLASS (G)	
LOOSE TO MEDIUM DENSE GRAY, COARSE AND FINE SAND, LITTLE SILT, TRACE CLAY, WET (continued)		545.4		6				A-3a (V)	
VERY SOFT, GRAY, SILT AND CLAY, TRACE SAND, WET		526.9		0				A-6a (V)	
MEDIUM STIFF TO STIFF, GRAY, SILT AND CLAY, TRACE SAND, MOIST TO WET		521.9		3				A-6a (8)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 3/4/25 08:28 - E:\PROJECTS\2024\1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-1245336.GPJ



DESIGN AGENCY
Terracon
 DESIGNER
 MP
 REVIEWER
 DWW 3-6-25
 PROJECT ID
 119775
 SUBSET TOTAL
 7 10
 SHEET TOTAL
 P.0 0

**BORING LOG B-002-0-24
 LAW-650-7.16**

LAW-650-7.16

MODEL: LOG 2 PAPER SIZE: 34x22 (in.) DATE: 3/7/2025 TIME: 8:27:14 AM USER: bcmfliner
 C:\Users\bcmfliner\OneDrive - Terracon Consultants Inc\Desktop\CAD\CINCINNATI\1245336\119775_Z1001.dgn

PID:	119775	SFN:	LAW-SR-650-07.16	PROJECT:	382+55.7 RT.	STATION / OFFSET:	START:	12/23/24	END:	12/23/24	PG 3 OF 3	B-002-0-24		
		MATERIAL DESCRIPTION AND NOTES		REC SAMPLE ID		GRADATION (%)		ATTERBERG		DOT CLASS (G)		SEALE		
		ELEV.		N ₆₀		GR		LL		PI		WC		
		DEPTHS		SPT / RQD		FS		SI		CL		PL		
MEDIUM STIFF TO STIFF, GRAY, SILT AND CLAY, TRACE SAND, MOIST TO WET (continued)		513.3	63	4	16	100	SS-19	1.75	-	-	-	25	A-6a (V)	
VERY DENSE GRAY, GRAVEL WITH SAND, TRACE SILT, TRACE CLAY, WET		506.9	64	5	6									
INTERBEDDED SHALE (75%) AND LIMESTONE (25%), RQD 63%, REC 100%; SHALE GRAY TO DARK GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY WEAK TO WEAK, THIN TO THICK BEDDED, FISSILE; LIMESTONE LIGHT GRAY TO GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, THIN BEDDED; @76'-76.5': Qu= 232 psi, Density= 148 pcf		500.9	65	8	18	61	SS-20	-	-	-	-	-	19	A-1-b (V)
			66	23										
			67	19										
			68	27										
			69	50										
			70											
			71											
			72											
			73											
			74											
			75											
			76											
			77	72		100	NO2-1						CORE	
			78											
			79											
			80											
			81											
			82											
			83	55		100	NO2-2						CORE	
			84											
			85											

NOTES: NONE
 ABANDONMENT METHODS, MATERIALS, QUANTITIES: POURED CEMENT-BENTONITE GROUT

PID:	119775	SFN:	LAW-SR-650-07.16	PROJECT:	383+40.17 RT.	STATION / OFFSET:	START:	12/23/24	END:	12/23/24	PG 3 OF 3	B-003-0-24						
		MATERIAL DESCRIPTION AND NOTES		REC SAMPLE ID		GRADATION (%)		ATTERBERG		DOT CLASS (G)		SEALE						
		ELEV.		N ₆₀		GR		LL		PI		WC						
		DEPTHS		SPT / RQD		FS		SI		CL		PL						
ASPHALT CONCRETE (12 INCHES)		575.5	1	6	13	100	SS-1	1.75	-	-	-	17	A-4a (V)					
AGGREGATE BASE COURSE (6 INCHES) STIFF, DARK GRAYISH BROWN, SANDY SILT, LITTLE CLAY, TRACE GRAVEL, WET (FILL)		574.5	2	5	4													
		574.0	3	4														
MEDIUM STIFF, BROWN, SANDY SILT, LITTLE CLAY, WET		572.0	4	2	4	33	SS-2	0.75	0	22	24	41	13	20	16	4	22	A-4a (4)
			5	1														
			6															
			7															
			8															
			9	1	4	83	SS-4	0.50	0	2	43	42	13	NP	NP	NP	27	A-4a (4)
			10	2														
VERY LOOSE TO LOOSE, BROWN TO GRAY, FINE SAND, TRACE SILT, TRACE GRAVEL, WET		564.5	11	0	3	100	SS-5	-	-	-	-	-	-	-	-	-	28	A-3 (V)
			12	1														
			13															
			14	2	1	94	SS-6	-	1	37	61	1	0	NP	NP	NP	27	A-3 (0)
			15	2														
			16	1	3	89	SS-7	-	-	-	-	-	-	-	-	-	31	A-3 (V)
			17	2	1	4	SS-8	-	1	38	55	6	0	NP	NP	NP	39	A-3 (0)
			18	1	2													
			19	2	7	100	SS-9	-	-	-	-	-	-	-	-	-	23	A-3 (V)
			20															
			21															
			22															
			23															
			24	2	2	6	SS-10	-	-	-	-	-	-	-	-	-	24	A-3 (V)
			25															
			26															
			27															
			28															
			29	3	3	7	SS-11	-	-	-	-	-	-	-	-	-	20	A-3 (V)

LAW-650-7.16

MODEL: LOG 3 PAPER SIZE: 34x22 (in.) DATE: 3/7/2025 TIME: 8:26:30 AM USER: bcmfliner
 C:\Users\bcmfliner\OneDrive - Terracon Consultants Inc\Desktop\CAD\CINCINNATI\1245336\119775_Z1001.dgn

PID	SFN	PROJECT	STATION / OFFSET	383+40.17 RT.	START: 12/24/24		END: 12/24/24		PG 2 OF 3	B-003-0-24
					GR	CS	FS	SI		
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	REC SAMPLE ID	HP (tsf)	GRADATION (%)	ATTEMBERG	DOT CLASS (G)	HOLE SEALED	
VERY LOOSE TO LOOSE, BROWN TO GRAY, FINE SAND, TRACE SILT, TRACE GRAVEL, WET (continued)		545.5	31-33							
LOOSE TO MEDIUM DENSE, GRAY, COARSE AND FINE SAND, LITTLE SILT, WET		542.0	34-38	33		0 43 45 12	NP NP NP	21	A-3a (0)	
MEDIUM STIFF, GRAY, SILT AND CLAY, LITTLE SAND, MOIST TO WET		527.0	39-48	100	0.50			23	A-3a (V)	
			49-51							
			52-53							
			54-55	7	0.75	5 52 32	35 21 14	32	A-6a (10)	
			56-58							
			59-61	7	0.50			29	A-6a (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 3/4/25 08:28 - E:\PROJECTS\2024\1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

PID	SFN	PROJECT	STATION / OFFSET	383+40.17 RT.	START: 12/24/24		END: 12/24/24		PG 3 OF 3	B-003-0-24
					GR	CS	FS	SI		
MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS	REC SAMPLE ID	HP (tsf)	GRADATION (%)	ATTEMBERG	DOT CLASS (G)	HOLE SEALED	
MEDIUM STIFF, GRAY, SILT AND CLAY, LITTLE SAND, MOIST TO WET (continued)		513.4	63-65	9	0.50			24	A-6a (V)	
VERY DENSE, GRAY, GRAVEL WITH SAND, TRACE SILT, WET		507.0	66-68							
INTERBEDDED SHALE (70%) AND LIMESTONE (30%), RQD 60%; REC: 100%; SHALE, GRAY TO DARK GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, VERY WEAK TO WEAK, THIN TO THICK BEDDED, FISSILE; LIMESTONE, LIGHT GRAY, UNWEATHERED TO SLIGHTLY WEATHERED, MODERATELY STRONG TO STRONG, THIN BEDDED.		501.5	69-74	86		34 39 18 9	NP NP NP	17	A-1-b (0)	
			75-77							
			78-84	100					CORE	
			85	100					CORE	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT GDT - 3/4/25 08:28 - E:\PROJECTS\2024\1245336\WORKING FILES\LABORATORY-FIELD DATA-BORING LOGS\ODOT-N1245336.GPJ

NOTES: NONE
 ABANDONMENT METHODS, MATERIALS, QUANTITIES: POURED CEMENT-BENTONITE GROUT



Office of Geotechnical Engineering

B-002-0-24



Run #:	Depth	Recovery	RQD
NQ2-1	75.0'	60/60	43/60
NQ2-2	80.0'	60/60	33/60
LAW-650-7.16 PID 119775			
		100%	72%
		100%	55%



Office of Geotechnical Engineering

B-003-0-24



Run #:	Depth	Recovery	RQD
NQ2-1	16.5'	60/60	36/60
NQ2-2	21.5'	60/60	36/60
LAW-650-7.16 PID 119775			
		100%	60%
		100%	60%

DESIGN AGENCY



DESIGNER
MP

REVIEWER
DWW 3-6-25

PROJECT ID
119775

SUBSET	TOTAL
10	10

SHEET	TOTAL
P.0	0