GEOHAZARD REPORT
RETAINING WALL
FOR LANDSLIDE MITIGATION

PROJECT: FUL-20A-19.20 (PID 119890)
FULTON COUNTY, OHIO

Tetra Tech Project No. 100-WTR-T44324
April 21, 2025

FINAL

Prepared for:
Ohio Department of Transportation
District 2
317 East Poe Road
Bowling Green, OH 43402-1330

Prepared by:
Tetra Tech, Inc.
1899 Powers Ferry Road, Suite 400
Atlanta, GA 30339

TETRA TECH

Ohio Department of Transportation

TETRA TECH

April 21, 2025

Mr. David Charville, P.E.
Senior Project Manager
Tetra Tech IEW
420 Madison Ave., Suite 1001
Toledo, OH 43604

Subject: Final Geohazard Report
Retaining Wall for Landslide Mitigation
FUL-20A-19.20 (PID 119890)
Delta, Ohio

Dear Mr. Charville:

The following is a final geotechnical report for landslide mitigation with drilled shaft retaining wall. This report contains a summary of subsurface conditions and laboratory tests, slope stability analysis, p-y analysis, and recommended dimensions of the drilled shaft wall.

Let me know if you have any questions or require additional information.

Sincerely,

STATE OF OHIO
BRIAN
LAWRENCE
E-91317
REGISTERED
PROFESSIONAL ENGINEER

Brian Lawrence, P.E.
Senior Geotechnical Engineer

Michael A. Brown, P.E.
Dam & Levee National Practice Lead

Tetra Tech, Inc.
1899 Powers Ferry Road, Suite 400, Atlanta, GA 30339
Tel +770.850.0949 | tetratech.com

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1.0 EXECUTIVE SUMMARY

A slope failure occurred at milepost 19.20 on Route U.S. 20A in Delta, Ohio. The town of Delta regraded, placed riprap, and installed sheet pile near the toe of the slope sometime in 2022. Movement of the slope has continued to the present, as evidenced by curved and drooping guardrail, a small head scarp, and separation of curb from the edge of pavement.

The site is located within areas mapped as glacial lake deposits (Ohio Department of Natural Resources (ODNR), 2005) and consist primarily of fine-grained silts and clays. Fill was placed over the Bad Creek in the 1930's to straighten Route U.S. 20A. Four (4) borings were drilled on U.S. Route 20A in July 2024. These explorations primarily encountered soils consisting of medium stiff to hard silty clay to depths of 65 feet. Bedrock is anticipated to be over 100 feet deep. Laboratory soil strength and index testing were performed.

A drilled shaft wall was selected to stabilize the slope. The wall will be placed at the top of the slope. Slope stability analysis of the existing slope indicated a low factor of safety (1.14). Analysis of this wall follows Method 2 from the Ohio DOT Geotechnical Design Manual (GDM), which allows for the slope below the wall to not be improved and assumes future sloughing and slope instability.

A 3-foot diameter drilled shaft wall, with W24x94 reinforcement, was selected after analysis indicated it would meet the 2-inch or less deflection criteria. Shear and moment criteria were also met. The upper 6 feet is not encased in concrete, but act as soldier piles, with panels as lagging. Plug piles extend 9 feet below top of drilled shaft, located between each drilled shaft. The total length of foundation element is 75 feet. This length was selected because bedrock is deep at this site (over 100 feet), the clays vary from medium stiff to hard, the zero crossing of the deflection curve is very gradual and occurs around approximately 60 feet deep, and the exact position of the existing failure surface below ground is not known.

Preliminary stability analysis was performed for construction activities with a surcharge to represent the weight of a typical drilled shaft rig. If the Contractor's equipment loading for drilled shaft installation is greater than assumed in the construction-stage slope stability analysis, or the location of the Contractor's equipment differs from assumptions provided in the geotechnical report, a new slope stability analysis should be run with the specific configuration, weight(s), and location(s) of the Contractor's equipment, prior to beginning construction activities on the site. Inclinometers should be installed to monitor movements during construction and can be left in place to allow for further monitoring of the wall deflections, if any.

2.0 INTRODUCTION

The project consists of a subsurface exploration and geotechnical engineering to mitigate instability caused by a landslide at U.S. 20A (W Main Street) at mile 19.20 in Fulton County, Ohio (FUL-20A-19.20). The landslide is located on the north side of U.S. 20A, east of the intersection of County Road FG and U.S. 20A, and west of the intersection of Highland Avenue with U.S. 20A.

The instability is on the slope between the westbound lane and Bad Creek. The historical slope failure occurred northward with the toe of the failure daylighting across the stream. Erosion on the streambank toe may have been a contributing factor. The current instability appears to be primarily on the embankment slope, but it has affected the edge of roadway pavement, causing separation between the curb and edge of shoulder. There was not visual evidence of slope movement near the toe, likely due to it being obscured by riprap and sheet pile wall. Guardrail has displaced horizontally and vertically. The limits of this project will extend approximately 259 feet, from 1013+73 to 1016+32. This mitigates the historical slope failure and the observed locations with recent slope movement. The slopes outside of these limits may have factors of

safety below minimums, but they are not currently showing signs of distress. Our understanding of the scope of work is to address the actively failing portion of the project and its immediate vicinity.

The exploration and engineering analyses performed for this project have been performed in general accordance with Agreement No. 40382 dated April 24, 2024 to the Ohio Department of Transportation (ODOT). The purpose of this exploration was to; 1) determine the subsurface conditions to the depths penetrated by the borings; 2) evaluate the engineering characteristics of the subsurface materials; and 3) provide information to assist in designing a retaining wall for landslide mitigation.

The geotechnical engineer has planned and supervised the performance of the geotechnical engineering services, has considered the findings, and has prepared this report in accordance with generally accepted geotechnical engineering practices. No other warranties, either expressed or implied, are made as to the professional advice included in this report.

3.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

3.1 General Geology

The project lies on the border of the Maumee Lake Plains Physiographic Region and the Maumee Sand Plains District of the Huron-Erie Lake Plains Section (ODNR, 1998). The project is within a glacial lake deposit (ODNR, 2005), an area of primarily very fine grained clay- and silt-size deposits. Surficial Geology Stack Map (ODNR, 2024) indicates an upper layer of discontinuous sand, up to 10 feet thick. Below the discontinuous sand is a predominantly Wisconsinan till, consisting of an unsorted mix of silt, clay, sand, gravel, and boulders, with variable carbonate content, deposited directly from several separate ice advances. The till average thickness is 130 feet. Underlying the till is a Devonian shale. The area is not located in an area of known or probable karst (ODNR, 2006).

Construction plans from 1934 (State of Ohio Department of Highways, 1934) show the current alignment was filled to straighten U.S. 20A (then called S.H. No. 20), and a portion of Bad Creek was relocated to the north. Therefore, the current embankment for U.S. 20A is constructed over the former stream channel. A 1961 plan set for road reconstruction (Ohio Department of Highways, 1961) was reviewed, but this only addressed pavement and drainage reconstruction, and bridge wearing surface replacement. No soil information was included in this plan set.

3.2 Site Reconnaissance

A site reconnaissance was conducted by CT Consultants on March 28, 2024 in preparation for the drilling activities. Another site reconnaissance was conducted by Tetra Tech on September 25, 2024.

The slide has deformed the guardrail and separated the curb from the edge of pavement (see Photos 1 and 2). The roadway is about 30 feet above the toe of the slope. The slope between 1013+90 and 1015+20 is primarily covered with riprap, except the upper 5 feet is grass. The slopes east and west of the riprap section are covered with small to medium trees and brush.

A previous remediation effort by the the Town of Delta consisted of installing steel sheet pile between approximate Stations 1013+90 and 1015+20 at the toe of slope (Photo 3). Based on personal communication with Anderzack-Pitzen Construction, the contractor that installed the sheet pile wall, this work was done in 2022, and the sheet pile consists of 35-foot long steel ZZ19-700 sheets. The distance between the sheet pile wall and Bad Creek was approximately 10 feet. Riprap was placed on the surface, both above and below

the sheet pile, up the slope to a point approximately 10 to 20 feet from the guardrail. The uppermost portion of the slope was vegetated.

An 18-inch high head scarp was observed near Station 1014+20, approximately 5 feet downslope from the guardrail (Photo 4).

4.0 EXPLORATION

4.1 Previous Subsurface Exploration

There was no subsurface information available in the 1934 or 1961 plans, but the location of the previous and relocated stream is shown. A well log and drilling report (No. 240994) from approximately ¼ mile west of the site shows approximately 100 feet of clay, over 16 feet for fine sand, over 16 feet of clay, over 14.75 feet of gravel, over shale bedrock. The static water level depth was at 57 feet. These documents are presented in Appendix A.

4.2 Current Subsurface Exploration

CT Consultants drilled four (4) borings at the top of the slope on the paved shoulder. No borings were drilled within the unstable slope due to slope safety concerns and difficulty of access. Since the four (4) borings were drilled outside the limits of the failure, no inclinometers were installed. The CT Consultants Report "Landslide Exploration: Slide Repair Along Bad Creek", which includes boring logs and laboratory test results, is presented in Appendix B.

Borings were advanced by a Diedrich D 70 track-mounted drill rigs using 3¼-inch inside diameter hollow-stem augers. The upper 3 feet of soil were not sampled, and thereafter samples were obtained continuously to depths of 65 feet below ground surface. SPT N-value data were collected on all soil samples in accordance with ASTM D 1586. The hammer/rod energy ratio for the Diedrich D 70 drill rig was 87.4 percent and was last calibrated on June 11, 2024. Split-spoon samples were retained for index testing. Relatively undisturbed Shelby tube samples were obtained by hydraulically pressing a 3-inch thin-walled sampler in order to obtain samples for laboratory testing. The results of the borings and the laboratory testing are presented on the boring logs and are discussed further in Section 5 of this report.

5.0 FINDINGS

The findings presented in this report are based on the results of the borings conducted for this exploration. General descriptions presented in the following paragraphs. For additional details, please refer to the boring logs and laboratory test reports presented in Appendix B.

5.1 Subsurface Conditions - Soil

The borings encountered roadway pavement materials at the surface. Borings B-1 through B-4 encountered 9.75 to 14.25 inches of asphalt pavement at the ground surface. In borings B-1 through B-3, 6.75 to 7.75 inches of concrete was below the asphalt pavement. In B-4, concrete was not encountered beneath the asphalt, but instead 10 inches of aggregate base was encountered.

Beneath the pavement sections, materials consisted of silts and clays with varying amounts of sand and gravel, and varying consistencies from medium stiff to hard. These were encountered to the maximum boring depths of 65 feet. Borings B-1 and B-4 encountered 1 to 3 feet of very stiff to hard, gray sandy silt at approximately 53 feet deep.

The distinction between fill and natural soils was not clear, however, organic material was encountered in borings B-3 (25.5 to 29 feet bgs) and B-4 (24 to 28 feet bgs), indicating the possible original natural ground surface at those depths. This reasonably correlates to the approximate 25 to 30 feet of elevation difference between the area near the streambed and roadway surface.

5.2 Subsurface Conditions - Bedrock

No bedrock was encountered to the depths of the borings. Geologic publications and well installation logs at nearby sites indicate that bedrock is greater than 100 feet below ground surface.

5.3 Subsurface Conditions - Groundwater

The driller's observations of groundwater are noted on the boring logs. Groundwater was not noted in borings B-2 and B-4. Groundwater in borings B-1 and B-4 was recorded at El. 675.5 and 707.6 (NAVD88), respectively. It is anticipated that the groundwater levels at the site are somewhat influenced by Bad Creek.

5.4 Laboratory Testing

Collected soil samples were visually examined and classified by a geotechnical engineer. Index tests (grain-size and plasticity tests) were performed on selected soil samples. Additionally, shear strength tests were conducted on soil samples. Laboratory strength test results are summarized in Table 1 – Summary of Laboratory Strength Test ResultsTable 1. Additional information can be found on the test reports, presented in Appendix B.

Table 1 – Summary of Laboratory Strength Test Results

Boring	Depth (ft)	Elev (ft)	Soil Description	Effective Shear Strength		Undrained Shear Strength
				c' (psf)	ϕ' (deg)	c (psf)
Unconfined Compressive Strength						
B-003	25.5–27.5	701.3–699.3	Lean Clay with Sand (CL)	-	-	1,120
UU Triaxial						
B-001	18.0–20.0	713.3–711.3	Lean Clay with Sand (CL)	-	-	3,312
B-002	13.5–15.5	715.4-713.4	Lean Clay with Sand (CL)	-	-	3,260
B-004	7.0–9.0	716.8-714.8	Lean Clay with Sand (CL)	-	-	1,220
Direct Shear						
B-002	13.5-15.5	715.4-713.4	Lean Clay with Sand (CL)	118	29.8	-
B-003	25.5-27.5	701.3-699.3	Lean Clay with Sand (CL)	422	27.4	-
B-004	7.0-9.0	716.8-714.8	Lean Clay with Sand (CL)	403	28.4	-

5.4.1 Soil - Index Testing

The general index tests consisted of grain-size with hydrometer, classification, moisture contents, plasticity determinations (Atterberg Limits), and pavement core logs. The results of the index tests are shown on the boring logs and individual test reports in Appendix B.

5.4.2 Soil – Shear Strength Testing

Triaxial shear strength testing was conducted on four (4) relatively undisturbed (Shelby tube) sample collected for this project. Unconfined compressive strength, unconsolidated-undrained triaxial compressive strength, and direct shear strength tests. The results of this test are presented in Appendix B.

6.0 ANALYSES AND RECOMMENDATIONS

A drilled shaft retaining wall will be used to stabilize the slope. The following sections present the engineering evaluations and design recommendations.

If the proposed plan should change in a substantive manner, Tetra Tech should be notified of such changes in order to consider the appropriateness of these recommendations and consider any necessary alterations.

6.1 Soil Design Parameters

Soil strength and weight parameters were determined from soil strength tests, with consideration of SPT and index tests. Design parameters for stability and LPILE analyses are summarized in Table 2. The drained strength parameters were based on laboratory and SPT sampling consistencies and descriptions. Borings describe soils that generally contain little to trace amounts of sand and gravel in the silty clay. However, some samples describe "some" sand or "silty clay and sand". Therefore, three layers were modeled as "sand and clay" with effective strength cohesion 0 psf and friction angle of 30 degrees.

6.2 Slope Stability Analyses

Per ODOT Geotechnical Design Manual, there are three methods of analysis that can be used to design a drilled shaft wall for landslides. Method 1 is the case where the downhill soil mass remains in place and a slope of 2H:1V or flatter. Method 2 is the case where the soil mass downhill of the retaining wall will be left as-is. If the downhill soil mass does not meet the minimum factor of safety of 1.3, an assumption is made that the downhill mass will continue to fall away from the wall, while the wall reains the uphill soil mass, but the ground surface is artificially lowered on the passive side for the LPILE analysis. Method 3 is the case where the downhill soil mass will be regraded to a stable slope (lower at the base of the wall than behind the wall).

The wall for FUL-20A-19.20 will be built above the failed slope. A representative cross-section at Station 1015+25 was selected for analysis. The lowest existing factor of safety downslope is 1.24 for the long term case, which is below the required 1.3. Therefore, Method 2 analysis, with an artificially lowered passive ground surface, was the selected method of analysis. The lowest factor of safety for all cases is 1.0 for the rapid drawdown condition. See Table 3 for a summary of slope stability analyses for existing conditions.

The groundwater level used in design was El 710 (NAVD88).

Stability for existing conditions was analyzed at Stations 1013+75, 1014+00, 1016+00, and 1016+25 to determine the western and eastern termini of the project. Long-term, drained analysis for the western side of the retaining wall resulted in factors of safety of 1.68 and 1.45 for Stations 1013+75 and 1014+00, respectively. For the eastern side, analyses resulted in factors of safety of 1.41 and 1.5 for Stations 1016+00 and 1016+25, respectively.

Table 2 – Selected Stability and LPILE Soil Parameters

Layer	Elev (ft)	Unit Weight (pcf)		Effective Strength Parameters		Total Strength Parameters
		Moist	Effective	c' (psf)	ϕ' (deg)	c (psf)
Concrete (Drilled Shaft and Pavement)	728 - 726.5	150	-	150,000	0	150,000
Medium stiff silty clay	728 - 723	130	67.6	120	26	800
Sand and Clay	723 – 721	130	67.6	0	30	-
Medium stiff silty clay	721 – 711	130	67.6	120	26	800
Stiff to very stiff silty clay	711 – 702	135	72.6	300	28	1,500
Sand and Clay	702 – 699	130	67.6	0	30	-
Stiff to very stiff silty clay	699 - 680	135	72.6	300	28	1,500
Medium stiff silty clay	680 - 675	130	67.6	120	26	800
Sand and Clay	675 - 670	130	67.6	0	30	-
Very stiff to hard silty clay	< 670	140	77.6	500	30	2,000

Table 3 – Summary of Slope Stability Analysis for Existing Conditions

Station	Case	Required FOS	Calculated FOS
1013+75	Long Term (Effective Stress)	1.5	1.68
	Rapid Drawdown	1.1	1.48
1014+00	Long Term (Effective Stress)	1.5	1.45
	Rapid Drawdown	1.1	1.24
1015+25	Long Term (Effective Stress)	1.5	1.24
	Rapid Drawdown	1.1	1.0
	Short Term (Total Stress)	1.3	1.41
1016+00	Long Term (Effective Stress)	1.5	1.41
	Rapid Drawdown	1.1	1.26
1016+25	Long Term (Effective Stress)	1.5	1.50
	Rapid Drawdown	1.1	1.28

6.3 Retaining Wall Analyses

The following sections provide details regarding the engineering evaluations and results of the analyses for the retaining wall design. For additional information, refer to the exhibits and computations presented in Appendix C.

The engineering evaluations were conducted using LRFD design methodology, substantially in accordance with AASHTO's LRFD Bridge Design Specifications and ODOT's Geotechnical Design Manual Design of Drilled Shafts for Landslide Stabilization.

6.3.1 Method of Analysis

In order to evaluate the proposed retaining walls, the soil-structure interaction program LPILE 2019 was used. This program is capable of computing the mobilized soil resistance in terms of deflection from active pressures by generating p-y curves based on the soil parameters and the bending stiffness of the pile.

The total length of drilled shaft piles is 75 feet. The piles were modeled in the program as an "Round Shaft with Casing and Core Insert" for the lower 69 feet of the piles, and as "Elastic Section (Non-yielding)" for the upper 6 feet of W-beam that acts as a soldier pile. This upper 6 feet of soldier pile will be spanned with panels. In general, the types of retaining walls considered consisted of soldier pile-type walls using drilled shafts with standard formed steel sections as the primary reinforcement. Where it is not practical to install lagging, "plug piles" should be considered. For this analysis, we assumed a plug pile length of 9 feet, measured from top of drilled shaft. Plug piles are, for all intents and purposes, the same as the soldier pile and lagging wall in terms of the technical evaluations.

It was assumed that the steel sections had a minimum yield stress of 50 ksi.

According to guidance provided by Reese (Reese & Van Impe, 2011), the efficiency of side-by-side piles should be reduced for pile spacing closer than $s/b \leq 3.75$; where s = spacing and b = pile diameter. The following equation was used to estimate the efficiency of side-by-side piles in soil:

$e=0.64(s/b)^{0.34}$ for $1 \leq s/b \leq 3.75$

The above-referenced efficiency value is taken as the p-y modification factor for group action and is manually input into LPILE in order to account for this reduction for closely spaced piles in soil. No such reduction is taken for shafts in bedrock.

For this project, an efficiency factor of 0.81 was calculated for the shaft diameter and spacing used. A lower efficiency factor of 0.64 was used from the ground surface to the toe depth of plug piles.
When considering the passive-side resistance in the soil, it is reasonable to assume that the lower, unstable slope will continue to fail, thus reducing the available passive resistance. ODOT's guidance for determining the level of the artificially lowered ground surface is generally as follows:

For $b < 45°$ lower the ground surface by: $d_t \tan(\beta_{dh})$
For $b \geq 45°$ lower the ground surface by: d_t
Where: b = angle of downhill slope from horizontal
d_t = depth to shear surface at drilled shaft location

The original failure condition is no longer visible because work was completed on a portion of this slope in 2022, which included riprap on the surface and sheet pile near the toe of slope. Although a newer looking head scarp is visible at the top of the failure, other potential indications of scarp location are obscured by the riprap covering the slope. The calculated passive reduction was 8 feet, but was conservatively increased to 12 feet due to the uncertainty of the slip surface below ground.

6.3.2 Design Requirements

For the design of the retaining walls considered, the following criteria were used:

Service Limits:

- Deflection of the wall is to be less than or equal to 1 percent of the length of the shaft.
- If the wall is within 10 feet of the road edge, the deflection is limited to 2 inches or less.

Since the wall is within 10 feet of the edge of the road, the deflection criteria is 2 inches or less.

Strength Limits:

- The computed internal shear (from LPILE) should not exceed the factored shear resistance. In this case; Fv = 1.0 as per AASHTO.
- The computed internal bending moment (from LPILE) should not exceed the factored bending resistance. In this case; Fb = 1.0 as per AASHTO.

Geotechnical Strength Limits:

- Per GDM Section 1501.7.9, the wall is geotechnically stable if deflection does not indicate failure (failure of program to converge or very large deflection (i.e. 100 inches).

6.3.3 Selected LPILE Profile and Design Loads

The selected LPILE profiles were developed based on the findings of the borings and are based on effective stress shear strength values. LPILE soil parameters are based on strengths and unit weights shown in Table 1.

The active driving pressures were developed and manually input into the LPILE program. Since the road-side wall does not intercept a known active failure plane, a slightly different approach was used to compute the active pressures acting on this wall. The active pressures were developed based solely on Coulomb's Theory, assuming a level backfill. Additional forces such as hydrostatic loading and traffic loading were also considered. Since the road-side wall could be within 10 feet of the edge of pavement, a traffic surcharge load was assumed. A traffic surcharge of 250 psf was applied at the roadway surface, and pressures on the wall were calculated using the Boussinesq stress distribution formula.

Load Cases Evaluated

LPILE evaluations were conducted for three (3) loading cases: Service, Strength, and Geotechnical.

The loading applied to the pile was scaled by the spacing considered for the structural piles. The scaled load was then converted into a load intensity value in units of pounds per inch depth (lbs/in), which is consistent with the input format in LPILE.

In the Service loading case, the lateral earth pressures, hydrostatic pressures, and surcharge pressures were unfactored. This load case was used to determine the anticipated deflection of the wall. If the estimated deflection exceeded the deflection limit, a "stiffer" section would be used, and the wall would be re-evaluated.

The Strength loading case was conducted in order to determine if the pile meets the strength criteria set forth by AASHTO. The individual loads (e.g., EH – lateral earth pressures, LS – live load surcharge, etc.) are factored by their respective load factors and the resultant factored loading is applied to the pile in the evaluation. The load factors considered in these evaluations are presented in Table 4, as per AASHTO Table 3.4.1-1:

Table 4 – Load Factor Combinations

Load Combination Limit State	**EH**	**LS**
Service 1	1.00	1.00
Strength 1	1.50	1.75

The Geotechnical loading case was conducted using Strength loading and comparing the deflection to the failure criteria listed in Section 5.2.2 (lack of analysis convergence or deflection over 100 inches).

6.3.4 Results

The results of the retaining wall evaluations are presented in the following paragraphs. The LPile results are presented in Appendix C.

Retaining Wall

For this type of wall, the slope below the roadway could continue to fail and slide toward the creek, while the wall would support the roadway. The drilled shafts should be 36 inches in diameter and use W24x94 steel sections as the drilled shaft reinforcement. The reinforced drilled shaft should be extended to a depth of 75 feet below the top of the wall. The drilled shafts should utilize a center-to-center spacing of 6 feet. Installation of lagging to a full 15 feet below finish grade is not practical at this location, due to the excavation required for installation. Therefore, we recommend that panels be installed in the upper 6 feet and that "plug piles" be installed from the top of drilled shaft to 9 feet below top of drilled shaft. Plug piles are essentially unreinforced drilled shafts that are situated between the reinforced shafts and serve the same purpose as lagging.

The results of the LPILE analyses for this wall are summarized in Table 5. The W24x94 and 36-inch diameter drilled shaft meet the deflection criteria of under 2 inches. Strength limit state shear and bending moment are also within allowable limits. Stability of the critical section with the wall in place have FOS's over 2.0 (see Table 6). Therefore, W24x94 steel sections embedded in 36-inch diameter drilled shafts, at 6-foot spacing and extended to a depth of 75 feet, are recommended.

Since erosion of the streambank can further destabilize the slope, riprap should be placed within the project limits where there is not currently riprap protection.

Table 5 - Summary of LPILE Results: Road-Side Retaining Wall

Section: W24x94			Rock Socket Depth: None		
Drilled Shaft Dia.: 36 inches			Rock Socket Dia.: n/a		
LOAD CASE	**M_u (in-k)**	**V_u (kips)**	**d (in.)**	**F_bM_n (in-k)**	**F_vV_n (kips)**
Service	4,440	35.4	1.5	12,700	375
Strength	8,104	70.4	3.5		

Table 6 – Summary of Slope Stability Analysis with Wall

Station	Case	Required FOS	Calculated FOS
1015+25	Long Term (Effective Stress)	1.5	3.18
	Rapid Drawdown	1.1	2.99
	Short Term (Total Stress)	1.3	2.16

7.0 CONSTRUCTION

7.1 Stability

The construction of this wall will require care to prevent unsafe loading of the slope. Analyses were performed which modeled a long reach drilled shaft excavator rig as a surcharge on the road above the slope. Preliminary construction phase stability was performed for Stations 1014+00, 1015+25, and 1016+00. The slope was modeled with a bench near the top of the slope, where excavation will be performed for installation of the drilled shaft wall. For construction, effective stress was analyzed in addition to total stress and rapid drawdown conditions. Although effective stress analysis is typically for long term conditions, it was analyzed for comparison except the required factor of safety was 1.3 because the construction case is a short term condition. This excavation near the top of slope increases the factor of safety somewhat, enabling drilled shafts to be installed. Station 1015+25 had a FOS of 1.35 for drained and 1.56 for undrained conditions during construction, with the excavated bench. Stations 1014+00 and 1016+00 had FOS's over 1.5 for drained and undrained conditions during construction, with the excavated bench. Results of construction phase slope stability are shown in Table 7.

Station 1014+00 is on the west end of the project appears to be the most stable, so construction should proceed from this side. Care should be taken to limit loading to only what is necessary for construction of the drilled shaft wall, and not load any areas to the east of whichever shaft is being constructed as it progresses east. Construction equipment for installing drilled shafts should work from behind an already installed retaining wall and operate from the roadway level (US Route 20A).

Table 7 – Summary of Slope Stability Analysis for Construction Conditions

Station	Case	Required FOS	Calculated FOS
1014+00	Short Term (Effective Stress)	1.3	1.52
	Rapid Drawdown	1.1	1.33
	Short Term (Total Stress)	1.3	1.59
1015+25	Short Term (Effective Stress)	1.3	1.35
	Rapid Drawdown	1.1	1.11
	Short Term (Total Stress)	1.3	1.56
1016+00	Short Term (Effective Stress)	1.3	1.56
	Rapid Drawdown	1.1	1.40
	Short Term (Total Stress)	1.3	1.54

If the Contractor's equipment loading for drilled shaft installation is greater than assumed in the construction-stage slope stability analysis, or the location of the Contractor's equipment differs from assumptions provided in the geotechnical report, a new slope stability analysis should be run with the specific configuration, weight(s), and location(s) of the Contractor's equipment, prior to beginning construction activities on the site.

The maximum safe slope for excavations is 1H:1V per OSHA 1926 Subpart P, Appendices A and B. The soil in the upper 5 to 10 feet, where the excavations will take place, are considered Type B. The Contractor should provide a work plan describing the sequencing of work, equipment used, instrumentation monitoring schedule, and action plans.

7.2 Construction Instrumentation

The slope is currently experiencing horizontal and vertical displacement. Therefore, the slope and will need to be monitored carefully throughout construction since any construction activity will add loading to the area. A construction instrumentation monitoring program will be necessary. Three (3) inclinometers should be installed between the wall and the roadway to monitor movements before and during construction. Inclinometers should be installed to 80 feet below proposed finish grade. Action levels and reporting requirements for inclinometers should be included in the plans (Table 8). Specific locations will need to consider proximity of utilities. Recommended locations are shown in Figure 1.

Inclinometers should be installed prior to beginning excavation or drilling for the drilled shafts and plug walls. Inclinometers should be read daily when construction activities are loading the slope or roadway. The Contractor should alert ODOT immediately if an alert threshold value is reached, and within 24 hours provide an analysis of the instrument response and recommended corrective action if needed.

If an action threshold is reached, the Contractor should immediately stop work and remove personnel from the work area, evaluate the instrument response. Document the following in an action threshold exceedance report: weather, construction activities when the action threshold was reached, analysis of causes of the exceedance, and recommendations for corrective actions. The Contractor should only resume suspended activities after receiving written instruction from the project engineer.

Table 8 – Inclinometer Reading Frequency and Threshold Values

		Threshold Values		
Instrument	**Instrument Reading Frequency**	**Unit**	**Alert Level**	**Action Level**
Inclinometers	Daily when construction loading on roadway or slope.	Inch	0.25	0.50
	Weekly during periods of no construction activity			

Key locations, such as points in the roadway, survey monuments, and installed drilled shafts, should be surveyed during construction to monitor any surface movements.

8.0 CLOSURE

Tetra Tech has endeavored to perform its evaluation using the degree of care and skill ordinarily exercised under similar circumstances by reputable geotechnical professionals with experience in this area in similar soil conditions. No other warranty, either expressed or implied, is made as to the conclusions and recommendations contained in this report.

We appreciate the opportunity to provide our professional services on this project. If you have any questions regarding this report or if we can be of further service, please do not hesitate to contact the undersigned.

9.0 REFERENCES

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State of Ohio, Department of Highways (1934). *Toledo-Wauseon Road, S.H. No. 20, Sec. Delta PT*, N.R.M. 555-E, Sheet 3 of 18.

State of Ohio, Department of Highways (1961). *FUL-20A (19.11-19.74), York Township and Village of Delta,* Sheets 1-22.

Figures

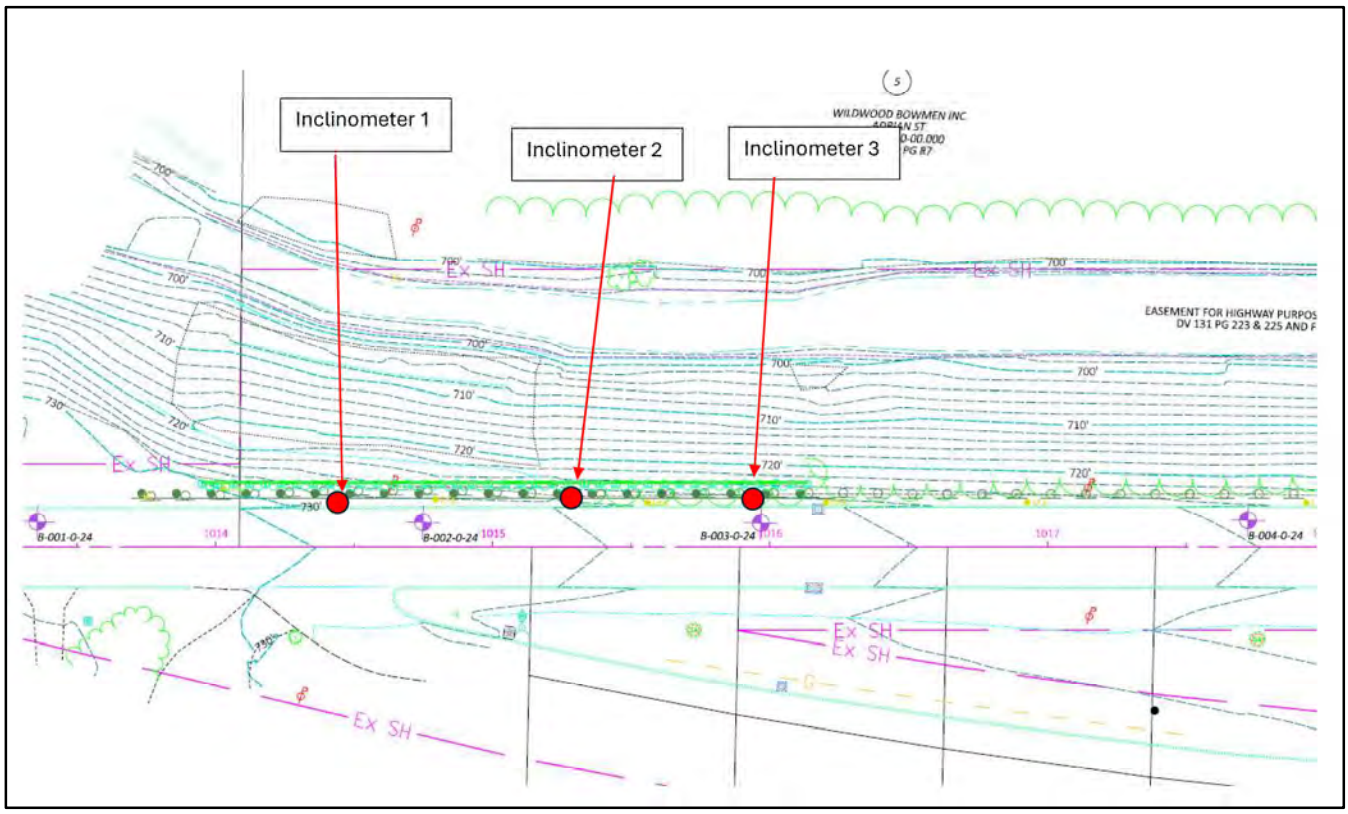


Figure 1 – Location of inclinometers during construction

Photos

Photo 1 - Looking northwest toward site, note distorted guardrail near light pole

Photo 2 – Looking west, separation of curb from edge of pavement

Photo 3 - Looking east near toe of slope; stream, sheet pile wall, and riprap surface

Photo 4 - Displacement of approximately 18 inches, apparent head scarp, near top of slope and guardrail

Appendix A
Previous Project Plans (1934 and 1961) and Nearby Well Log

1067

N.R.M. 555-E

U. S. PUBLIC WORKS
PROJECT NO.

FED AID DIST. NO	STATE	FED. AID PROJ NO	FISCAL YEAR
10	OHIO	NRM 555E	[illegible]

1/18

S.H. NO. 20 SEC. "DELTA" "PT."
FULTON COUNTY
PROPOSALS NO. 1 & 2

STATE OF OHIO
DEPARTMENT OF HIGHWAYS

TOLEDO—WAUSEON ROAD
FULTON COUNTY

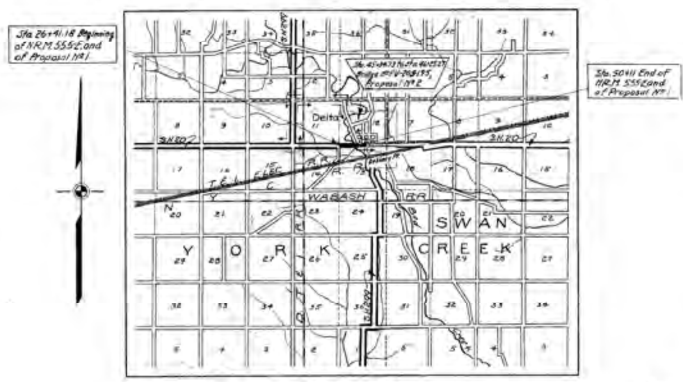
S.H. NO. 20 SEC. DELTA "PT."
BUREAU OF CONSTRUCTION

NET LENGTH OF PROJECT 2369.82 LIN. FT

CONVENTIONAL SIGNS

State Line
County Line
Township Line
Section Line
Center Line
Property Line
City or Village Line
Fence Line
Pole Line
Steam Railroad
Electric Railroad
Guard Rail
Drain Pipe New
Drain Pipe Old

INDEX OF SHEETS.



LOCATION PLAN
SCALE OF MILES

Portion to be improved
Detours shown thus
State roads
Other roads

SCALES

Plan	1" = 100'
Profile (Vertical)	1" = 10'
Profile (Horizontal)	1" = 100'
Cross-sections	1" = 5'

Supplemental Prints of Standard Drawings No. B-40-33, AS-33, BD-33, G-707, F-12-CC, T-70-J, 327-PC-1&2.

CHECKING RECORD		
Resident	G.W.E.	9-22-33
Division	F.W.S.	11-25-33
Central — Const.	W.H.T.	1-10-34
Central — Bridges	R.W.E.	1-8-34
Bureau of Public Roads		

The Standard Specifications of the State of Ohio Department of Highways together with the "Supplemental Specifications for National Recovery Highway Funds Projects," in force on date of contract will govern this improvement.

I hereby approve these plans and declare that the making of this improvement will require that the highway be closed to traffic and that a temporary road will be provided as shown on the plans and estimates.

Right of way for this Improvement has been provided.

Approved Bert Beucler
Date 11-17-1933 Resident District Deputy Director

Approved R.F. Neds
Date 11-18-1933 Resident Division Deputy Director

Approved [signature]
Date 1/13-34 Chief Engr. Bureau of Construction
1/13 34

Approved
Date Chief Engr. Bureau of Maintenance

Approved J.V. Burkey
Date 1-8-34 Chief Engr. Bureau of Bridges
1-8-34

Approved H.P. Chapman
Date 1-18-34 First Asst. Director and Chief Engr.

Approved [signature]
Date 1-18-34 Director of Highways
1-18-34

Recommended for Approval 1-18-34
Date Dist. Engr. Bureau of Public Roads

Recommended for Approval
Date Chief Engr. Bureau of Public Roads

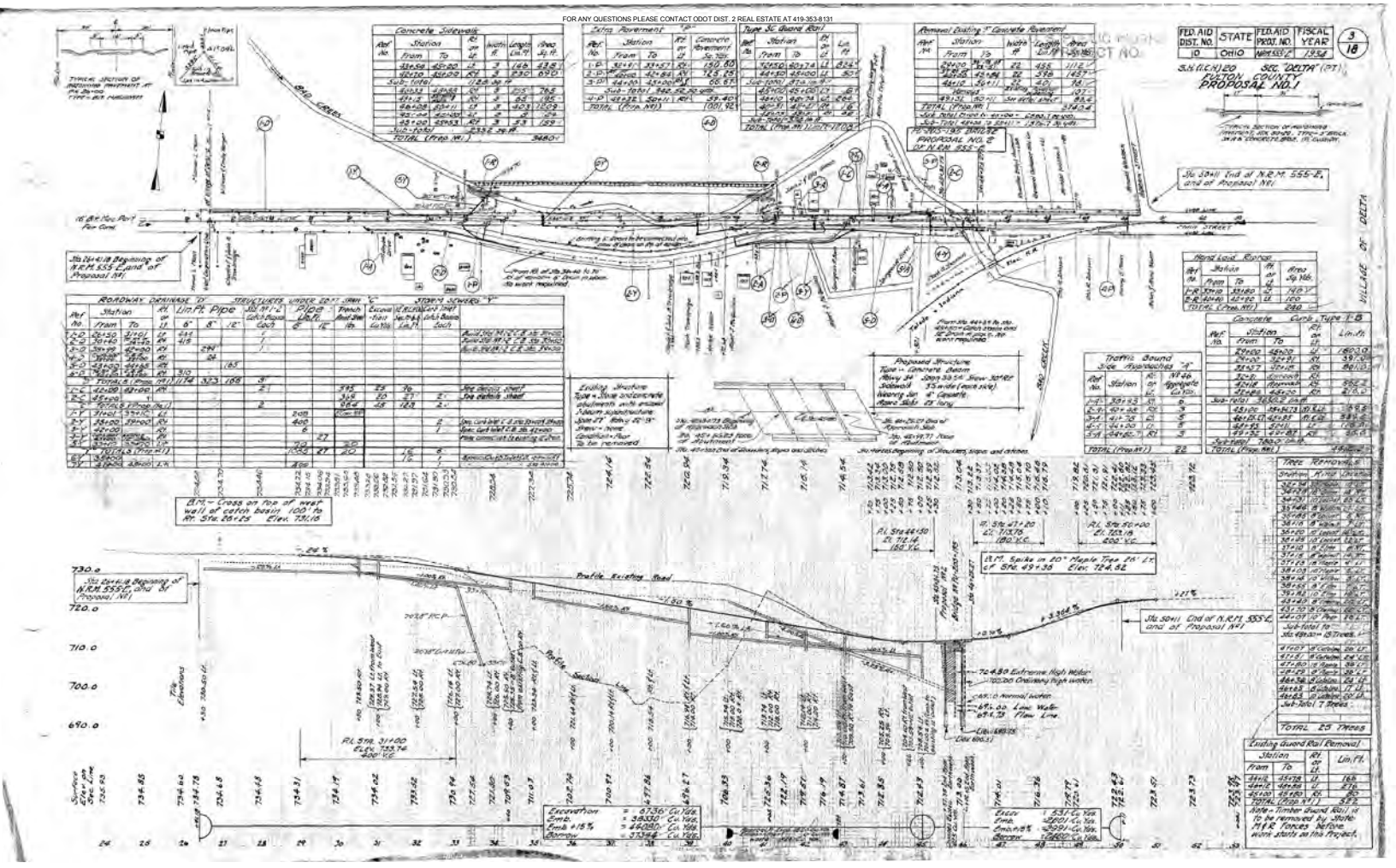
Approved
Date Chief of Bureau

CONSTRUCTION BUREAU
JUN 21 1955
GROUND PHOTOLAB

APPROVED
Planning Engineer Date
Remarks

1-8-34

FULTON - 20 - DELTA - PT.
1933 Contract No. 5894
Letting Date 2-17-34



ORIGINAL

WELL LOG AND DRILLING REPORT

State of Ohio
DEPARTMENT OF NATURAL RESOURCES
Division of Water
1562 W. First Avenue
Columbus, Ohio

PLEASE USE PENCIL OR TYPEWRITER. DO NOT USE INK.

No. 240994

County Fulton Township York Section of Township 13

Owner Delta Livestock Address Delta, Ohio

Location of property West Delta Ohio.

CONSTRUCTION DETAILS

Casing diameter 5 5/8 ID Length of casing 151-9

Type of screen ____ Length of screen ____

Type of pump Submersible

Capacity of pump ½ H.P.

Depth of pump setting 140 ft

Date of completion June 23, 1961

BAILING OR PUMPING TEST

Pumping rate ____ G.P.M. Duration of test ____ hrs.

Drawdown ____ ft. Date ____

Developed capacity ____

Static level—depth to water 57' ft.

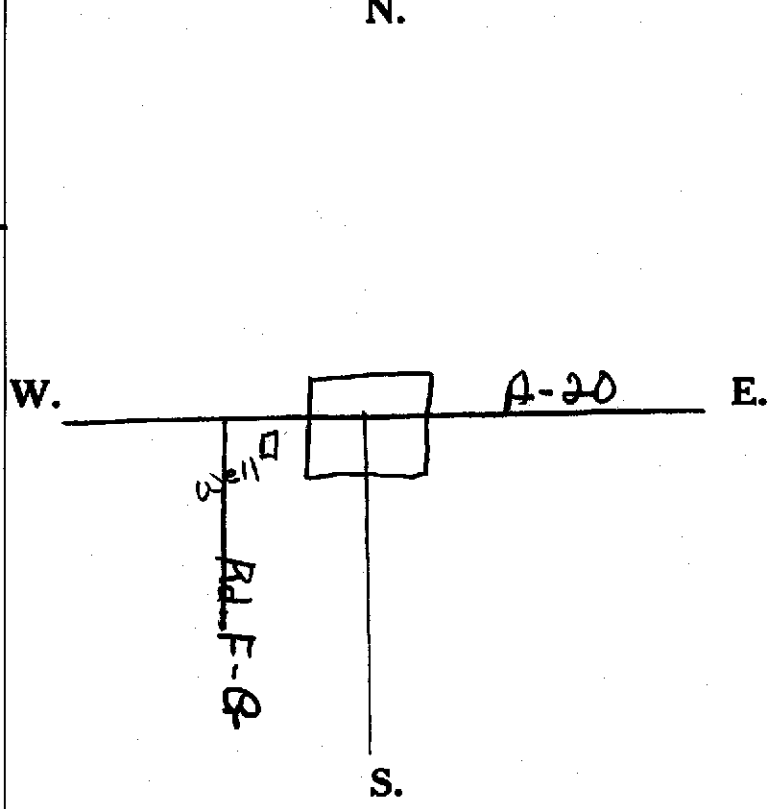
Pump installed by Ray Walter

WELL LOG

Formations Sandstone, shale, limestone, gravel and clay	From	To
Clay	0 Feet	127 Ft.
Fine sand	95	111
Clay	111	127
gravel	127	151-9
B. Shale	151-9	175

SKETCH SHOWING LOCATION

Locate in reference to numbered State Highways, St. Intersections, County roads, etc.



See reverse side for instructions

Drilling Firm Ray Walter Date June 23, 1961

Address Delta, Ohio Signed ____

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Appendix B
Geotechnical Data Report (Boring Location Plan, Logs of Borings, Laboratory Test Data)

LANDSLIDE EXPLORATION

Slide Repair along Bad Creek

FUL-20A-19.20, PID 119890

North Side of Route 20A

Delta, Fulton County, Ohio

Submitted to Tetra Tech
FINAL DATA REPORT Date *April 2025*

Prepared by

CT consultants
engineers • architects • planners

Ohio Department of Transportation

April 17, 2025 CT Project No. 241359

Mr. David T. Charville, P.E.
Senior Project Manager
Tetra Tech
420 Madison Avenue, Suite 1001
Toledo, Ohio 43604

FINAL Data Report
Landslide Exploration
FUL-20A-19.20, PID 119890
Slide Repair along Bad Creek, North side of US Route 20A
Delta, Fulton County, Ohio

Dear Mr. Charville:

Following is the final data report of our landslide exploration performed by CT Consultants, Inc. (CT) for the referenced site. This exploration was performed in accordance with CT Proposal No. 241359, dated April 3, 2024, and was authorized by Tetra Tech with a subconsultant services agreement for Tetra Tech Project No. 200-12914-24001, dated May 2, 2024.

This report contains the investigative procedures, laboratory test results, and logs of test borings for the exploration. In accordance with ODOT protocol, this report was submitted as a "Draft" to Tetra Tech and ODOT for review and comments on October 1, 2024. We were notified that no changes to the report were requested after review of the draft submittal, so this submittal is considered final.

Should you have any questions regarding this report or require additional information, please contact our office.

Sincerely,
CT Consultants, Inc.

Christopher P. Iott, P.E.
Chief Geotechnical Engineer

Curtis E. Roupe, P.E.
Vice President

H:\2024\241359\PHASE\01 Geotech\Reports and Other Deliverables\241359 CT FINAL Geotech Data Report FUL-20A-19.20 Slope Repair.doc

FINAL DATA REPORT
LANDSLIDE EXPLORATION
FUL-20A-19.20, PID 119890
SLIDE REPAIR ALONG BAD CREEK, NORTH SIDE OF US ROUTE 20A
DELTA, FULTON COUNTY, OHIO

FOR

TETRA TECH
420 MADISON AVENUE, SUITE 1001
TOLEDO, OHIO 43604

SUBMITTED

APRIL 17, 2025
CT PROJECT NO. 241359

CT CONSULTANTS, INC.
1915 N. 12TH STREET
TOLEDO, OHIO 43604
(419) 324-2222

CT consultants
engineers • architects • planners

TABLE OF CONTENTS

1.0 INTRODUCTION

This landslide exploration data report has been prepared for the proposed slide repair located along the north side of US Route 20A (US20A), approximately 1,000 feet west of Highland Avenue, in Delta, Ohio. This project has been designated as PID 119890, FUL-20A-19.20. The general project area is shown on the attached Site Location Map (Plate 1.0).

This exploration was performed in accordance with CT Proposal No. 241359, dated April 3, 2024, and was authorized by Tetra Tech with a subconsultant services agreement for Tetra Tech Project No. 200-12914-24001, dated May 2, 2024.

1.1 Purpose and Scope of Exploration

The purpose of this exploration was to obtain soils data for evaluation of repair for the landslide. To accomplish this, CT performed four (4) test borings, all of which included a pavement core, laboratory soil testing, and review of available geologic and soils data for the project area.

This data report describes the investigative and testing procedures utilized to provide soils data to evaluate the subsurface conditions at the site, and presents our findings from the field and laboratory testing.

Appendix A includes pertinent ODOT Geotechnical Engineering Design Checklists that apply to the scope of this report.

The scope of this study did not include an environmental assessment of the surface or subsurface materials at this site.

1.2 Proposed Construction

It is our understanding that the project includes slide repair along the north side of US 20A approximately 1,000 feet west of Highland Avenue in Delta, Ohio.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 General Geology and Hydrogeology

Published geologic maps from the Ohio Department of Natural Resources (ODNR) indicate that the project corridor is located on the border of the Maumee Lake Plains Physiographic Region and the Maumee Sand Plains District of the Huron-Erie Lake Plains Section. Within this area, it transitions from late Wisconsinan-age sand over clay till and lacustrine deposits to Pleistocene-age silt, clay, and wave-planed clayey till. The subsoils are underlain by Silurian- and Devonian-age carbonate rocks and shales.

The USDA Natural Resource Conservation Service (NRCS) Web Soil Survey indicates that soils in the project area are predominantly mapped as Glynwood loam. This material consists of till formed on end and ground moraines, and is considered moderately well drained.

Bedrock in the project area is broadly mapped on the "Geologic Map of Ohio" as Olentangy and Ohio shales, of the Devonian-age. Based on a published water well log for a well nearby the project area, bedrock is on the order of 150 feet below existing grades.

Review of the ODNR "Ohio Karst Areas" map indicated that the site is not located in an indicated area of probable karst.

A Review of the ODNR Map of Mines indicated no historic mining activity within the project vicinity.

2.2 Site Reconnaissance

CT performed site reconnaissance on March 28, 2024. The site includes predominantly treed/wooded slope down to Bad Creek. Some areas of previous ballast rock placement was observed and it is understood that this was placed as part of a previous landslide repair effort.

The landslide appeared to be most pronounced in the general area where Boring B-002 was performed. In this area, the curb had pulled away from the edge of pavement and the guardrail had tilted in the area of the landslide.

A stormwater drain and pipe extending down to Bad Creek was present in the middle portion of the project area.

The pavements along US20A were observed to be in generally fair to good condition. Signs of distress were not noticeable throughout much of the pavement areas in the project area.

3.0 EXPLORATION

3.1 Historic Borings

Review of ODOT records indicated that no historic test borings were drilled within the project area.

3.2 Project Exploration Program

This exploration included four (4) test borings, all of which included pavement cores prior to extension of the augers to perform the borings. The cores and borings were performed by TTL Engineering Services, LLC under the direction of CT during the period from July 16, 2024 through July 23, 2024.

The cores/borings were extended through the existing US20A pavements along the westbound lane. All borings were originally requested to be performed beyond the edge of the roadway, but were relocated into the roadway due to steep slopes just beyond the existing edge of roadway, overhead utilities, as well as a gas line that traverses close to the guardrail.

The test borings were designated as Borings B-001-0-24 through B-004-0-24. The borings are fully designated as in accordance with ODOT protocol, however the "-0-24" portion of the nomenclature is generally omitted for ease of identification in the discussions within this report. The borings were located in the field by CT in general accordance with plans provided with the proposal for this project. The approximate locations of the cores/borings are shown on the Test Boring Location Plan (Plate 2.0).

Coordinates were obtained by CT using a handheld GPS unit. Based on the coordinates, Tetra Tech provided Station, Offset, and ground surface elevation. These data are included on the logs of test borings.

In accordance with the ODOT Specifications for Geotechnical Explorations (SGE), the borings were performed as ODOT Type C5 borings to a depth of 30 feet below

estimated failure surface. The estimated failure surface was not expected deeper than 35 feet below existing grade, near the estimated Bad Creek level. As such, the borings were extended to the planned depth of 65 feet below existing grade.

Experience indicates that the actual subsoil conditions at a site could vary from those generalized on the basis of test borings made at specific locations. Therefore, it is essential that a geotechnical engineer be retained to provide soil engineering services during the site preparation, excavation, and landslide repair phases of the proposed project. This is to observe compliance with the design concepts, specifications, and recommendations, and to allow design changes in the event subsurface conditions differ from those anticipated prior to the start of construction.

3.3 Boring Methods

Pavement cores were obtained using a nominal 4-inch diameter core barrel at all test boring locations. Pavement core photographic logs are attached to this report.

The borings performed during this exploration were drilled with a Diedrich D 70 track-mounted drill rig utilizing 3¼-inch inside diameter hollow-stem augers. After pavement coring and extension through the surface materials, samples were obtained continuously generally using 18-inch split-spoon (SS) sample drives. The samples were sealed in jars and transported to our laboratory for further classification and testing. Prior to initiation of sampling in Borings B-001 through B-003, the borings were advanced only by augering to a depth of 3 feet due to the presence of the nearby underground utilities.

Split-spoon soil samples were obtained by the Standard Penetration Test Method (ASTM D 1586). The Standard Penetration Test (SPT) consists of driving a 2-inch outside diameter split-spoon sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler was driven in three successive 6-inch increments, with the number of blows per increment being recorded. The number of blows per increment was recorded at each depth interval, and these data are presented under the "SPT" column on the Logs of Test Borings attached to this report.

The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance, or Nm-value, and is typically reported in blows per foot (bpf). The Nm-values were corrected to an equivalent rod energy ratio of 60 percent, N_{60}. The hammer/rod energy ratio for the track-mounted Diedrich D 70 drill rig was 87.4 percent, and was last calibrated on June 11, 2024. The N60-values are presented on the attached Logs of Test Borings.

Shelby tube samples, designated ST on the Logs of Test Borings, were obtained at varying depths from selected borings as shown on the attached Logs of Test Borings. The Shelby tube samples were obtained by hydraulically advancing a 3-inch diameter, thin-walled sampler approximately 24 inches beyond the hollow-stem auger into relatively undisturbed soil in accordance with ASTM D 1587. The Shelby tubes were then extracted from the subsoils, and the ends were capped and sealed. The samples were transported to our laboratory where they were extruded, classified, and tested.

Pavement and soil conditions encountered in the test borings are presented in the Logs of Test Borings, along with information related to sample data, SPT results, water conditions observed in the borings, and laboratory test data. In conjunction with published data and typical correlations, the N_{60}-values can be evaluated as a measure of soil compactness/consistency as well as shear strength.

Field and laboratory data were incorporated into gINT™ software for presentation purposes. It should be noted that these logs have been prepared on the basis of laboratory classification and testing as well as field logs of the encountered soils.

3.4 Laboratory Testing Program

All samples were visually classified in accordance with the ODOT Soil Classification System. All recovered samples of the subsoils were also tested in our laboratory for moisture content (ASTM D 2216). Unconfined compressive strength tests (ASTM D 2166) were performed on select split-spoon samples and a Shelby tube sample. Unconfined compressive strength estimates were obtained for the remaining intact

cohesive samples using a calibrated hand penetrometer. These test results are presented on the Logs of Test Borings.

Mechanical soil classification consisting of an Atterberg limits test (ASTM D 4318) and a particle size analysis (ASTM D 6913 and D 7928) was performed for selected samples from each boring. These test results are presented on the Logs of Test Borings and Grain Size Distribution sheets.

One-point unconsolidated-undrained (UU) triaxial compressive strength tests (ASTM D 2850) were performed on selected Shelby tube samples. Each UU test was performed on a specimen tested at a confining pressure approximately equal to the existing overburden pressure at the sample depth. The results of these tests are attached to this report.

Direct shear tests (ASTM D 3080) were performed on selected Shelby tube samples. The direct shear tests were generally performed on specimens tested at confining pressures approximately equal to the existing overburden pressure at the sample depth, as well as half and double that pressure. Suitable intact sample was not available from Boring B-004 (ST-5) to perform the direct shear test using three confining pressures, so two were utilized. The results of these tests are attached to this report.

4.0 UNDISTURBED SAMPLE TEST RESULTS

4.1 Unconfined Compressive Strength Test Results

Results of the unconfined compressive strength test are summarized in the following table.

Table 4.1. Unconfined Compressive Strength Test Results						
Boring Number	Sample Number	Depth (ft)	Elev. (ft)	Class.	Unconfined Compressive Strength (tsf)	Dry Density (pcf)
B-003	ST-16	25.5-27.5	701.3-699.3	A-6b (10)	1.12	106.8

4.2 UU Triaxial Test Results

Results of the UU triaxial tests are summarized in the following table.

Table 4.2. UU Triaxial Test Results						
Boring Number	Sample Number	Depth (ft)	Elev. (ft)	Class.	Undrained Shear Strength (tsf)	Dry Density (pcf)
B-001	ST-11	18-20	713.3-711.3	A-6b (10)	1.66	117.2
B-002	ST-8	13.5-15.5	715.4-713.4	A-6b (10)	1.63	116.9
B-004	ST-5	7.0-9.0	716.8-714.8	A-6b (10)	0.61	110.0

4.3 Direct Shear Test Results

Results of the direct shear tests are summarized in the following table.

Table 4.3. Direct Shear Test Results							
Boring Number	Sample Number	Depth (ft)	Elev. (ft)	Class.	Internal Angle of Friction, deg (ϕ')	Residual Cohesion, c' (psf)	Dry Density (pcf)
B-002	ST-8	13.5-15.5	715.4-713.4	A-6b (10)	29.8	118	108.3
B-003	ST-16	25.5-27.5	701.3-699.3	A-6b (10)	27.4	422	102.0
B-004	ST-5	7.0-9.0	716.8-714.8	A-6b (10)	28.4	403	109.2

5.0 QUALIFICATIONS

The general pavement and subsurface conditions are based on the data obtained at specific pavement core and test boring locations. Regardless of the thoroughness of a subsurface exploration, there is the possibility that conditions between cores/borings will differ from those at the core/boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the site or soil conditions. This potential is increased for sites with previous construction operations. Therefore, experienced geotechnical engineers should observe slope repair to confirm that the conditions anticipated in design are noted.

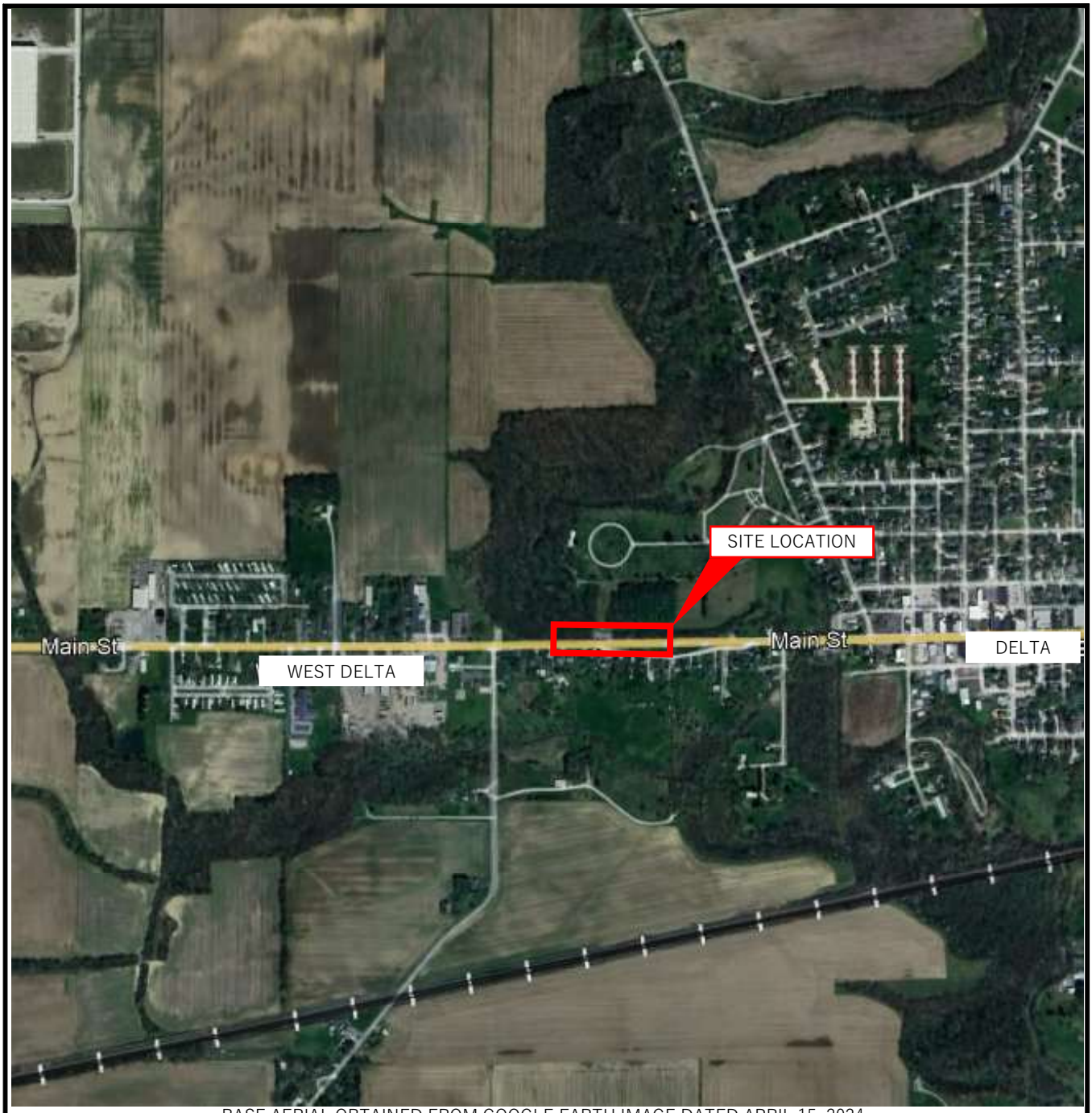
If project criteria or locations change, a qualified geotechnical engineer should be permitted to determine whether slope repair recommendations must be modified.

The nature and extent of variations between the borings may not become evident until the course of construction. If such variations are encountered, it will be necessary to reevaluate recommendations after on-site observations of the conditions.

Our professional services have been performed in accordance with generally accepted geotechnical engineering principles and practices. This warranty is in lieu of all other warranties either expressed or implied. CT is not responsible for the conclusions, opinions, or recommendations of others based on this data.

PLATES

Plate 1.0 Site Location Map
Plate 2.0 Test Boring Location Plan



BASE AERIAL OBTAINED FROM GOOGLE EARTH IMAGE DATED APRIL 15, 2024.

LEGEND

APPROXIMATE SITE LOCATION

N

APPROXIMATE SCALE – FEET

0 1,000 2,000

PLATE 1.0
SITE LOCATION MAP

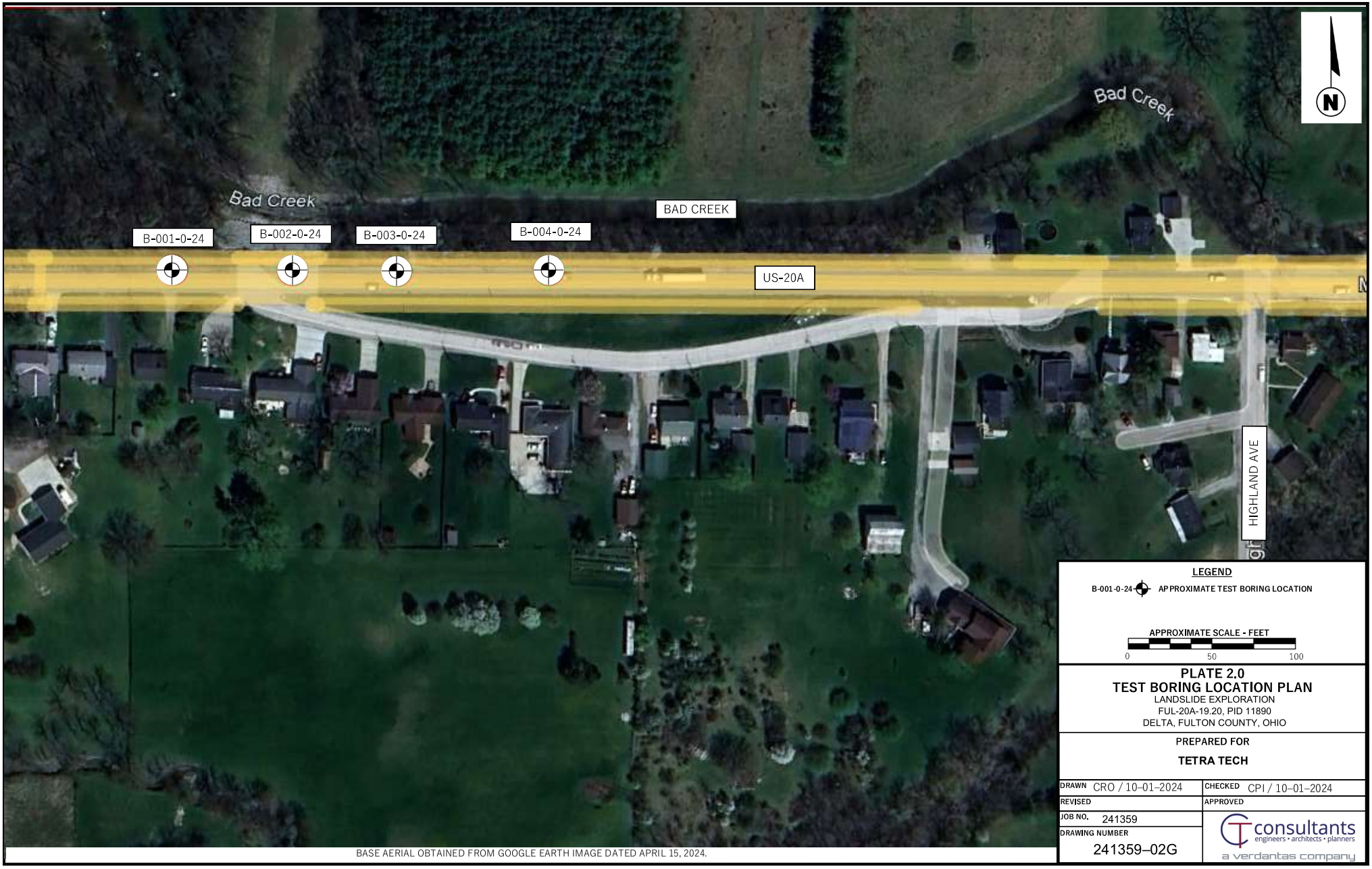
LANDSLIDE EXPLORATION
FUL-20A-19.20, PID 11890
DELTA, FULTON COUNTY, OHIO

PREPARED FOR

TETRA TECH

DRAWN CRO / 10–01–2024	CHECKED CPI / 10–01–2024
REVISED	APPROVED
JOB NO. 241359	
DRAWING NUMBER 241359–01G	

consultants
engineers • architects • planners
a verdantas company



BASE AERIAL OBTAINED FROM GOOGLE EARTH IMAGE DATED APRIL 15, 2024.

LEGEND

B-001-0-24 APPROXIMATE TEST BORING LOCATION

APPROXIMATE SCALE - FEET

0 50 100

PLATE 2.0
TEST BORING LOCATION PLAN

LANDSLIDE EXPLORATION
FUL-20A-19.20, PID 11890
DELTA, FULTON COUNTY, OHIO

PREPARED FOR

TETRA TECH

DRAWN CRO / 10-01-2024	CHECKED CPI / 10-01-2024
REVISED	APPROVED
JOB NO. 241359	
DRAWING NUMBER 241359-02G	

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FIGURES

Logs of Test Borings
Legend Key
Grain Size Distribution Curves
Unconfined Compressive Strength Test Results
UU Triaxial Strength Test Results
Direct Shear Test Results
Pavement Core Photographic Logs

PROJECT: FUL-20A-19.20	DRILLING FIRM / OPERATOR: TTL / TB	DRILL RIG: DIEDRICH D70 TRACK	STATION / OFFSET: 1013+36, 9' LT.	EXPLORATION ID B-001-0-24
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: TTL / TB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: US ROUTE 20A	
PID: 119890 SFN: N/A	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/11/24	ELEVATION: 731.3 (NAVD88) EOB: 65.0 ft.	PAGE 1 OF 3
START: 7/22/24 END: 7/23/24	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 87.4	LAT / LONG: 41.573686, -84.016175	

MATERIAL DESCRIPTION AND NOTES	ELEV. 731.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT - 9.75 INCHES	730.5																	
CONCRETE - 6.75 INCHES	729.9																	
VERY STIFF TO HARD, GRAY/BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, TRACE CALCITE STAIN SEAM, DAMP		1 2 3																
		4	4 6 10	23	92	SS-1	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
@4.5': BROWN, SOME SAND		5	6 9 11	29	67	SS-2	>4.5	5	6	16	27	46	31	19	12	16	A-6a (8)	
@6': GRAY/BROWN		6 7	4 9 15	35	83	SS-3	>4.5	-	-	-	-	-	-	-	-	14	A-6a (V)	
	723.8																	
HARD, GRAY/BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, TRACE IRON OXIDE STAIN SEAM, DAMP	722.3	8	12 15 19	50	83	SS-4	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
VERY STIFF TO HARD, BROWN/GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, TRACE IRON OXIDE STAIN SEAM, DAMP QU = 4.57 TSF, DD = 118.6 PCF		9	5 7 9	23	100	SS-5	>4.5	-	-	-	-	-	-	-	-	14	A-6a (V)	
@10.5': GRAY		10 11	8 10 12	32	100	SS-6	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		12	4 5 8	19	100	SS-7	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		13 14	2 4 7	16	100	SS-8	>4.5	5	5	14	30	46	27	16	11	15	A-6a (8)	
		15	9 11 14	36	100	SS-9	4.00	-	-	-	-	-	-	-	-	15	A-6a (V)	
		16 17	3 5 9	20	100	SS-10	>4.5	-	-	-	-	-	-	-	-	16	A-6a (V)	
	713.3	18			88	ST-11	3.75	6	5	11	23	55	34	18	16	15	A-6b (10)	
VERY STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP @18': UU TRIAXIAL - C = 1.66 TSF, DD = 117.2 PCF		19 20	4 6 9	22	100	SS-12	3.25	-	-	-	-	-	-	-	-	15	A-6b (V)	
		21	5 8 10	26	100	SS-13	4.25	-	-	-	-	-	-	-	-	16	A-6b (V)	
@23': VERY STIFF TO HARD		22 23	3 6 9	22	100	SS-14	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
@24.5': QU = 3.25 TSF, DD = 115.5 PCF		24 25	4 6 9	22	100	SS-15	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1013+36, 9' LT.	START: 7/22/24	END: 7/23/24	PG 2 OF 3	B-001-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP @18': UU TRIAXIAL - C = 1.66 TSF, DD = 117.2 PCF *(continued)*	705.3	27	4 7 12	28	100	SS-16	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
@27.5': HARD		28	10 10 13	34	100	SS-17	4.25	-	-	-	-	-	-	-	-	15	A-6b (V)	
@29': VERY STIFF		29	4 5 9	20	100	SS-18	3.50	-	-	-	-	-	-	-	-	17	A-6b (V)	
	700.8	30																
HARD, GRAY, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP		31	7 10 13	34	100	SS-19	>4.5	2	6	15	30	47	29	18	11	15	A-6a (8)	
@32': VERY STIFF, QU = 2.61 TSF, DD = 112.6 PCF		32	3 5 7	17	100	SS-20	3.75	-	-	-	-	-	-	-	-	15	A-6a (V)	
@33.5': VERY STIFF TO HARD		34	3 7 10	25	100	SS-21	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		35	5 8 11	28	100	SS-22	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		36																
		37	4 7 8	22	100	SS-23	4.25	-	-	-	-	-	-	-	-	16	A-6a (V)	
	693.3	38																
HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		39	12 15 20	51	100	SS-24	>4.5	-	-	-	-	-	-	-	-	12	A-6b (V)	
	691.8																	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		40	2 6 10	23	100	SS-25	>4.5	-	-	-	-	-	-	-	-	16	A-6a (V)	
		41	5 7 11	26	100	SS-26	>4.5	-	-	-	-	-	-	-	-	14	A-6a (V)	
		42																
		43	4 6 8	20	100	SS-27	4.25	-	-	-	-	-	-	-	-	13	A-6a (V)	
		44																
		45	4 4 8	17	100	SS-28	4.25	-	-	-	-	-	-	-	-	16	A-6a (V)	
@45.5': HARD		46	8 11 16	39	100	SS-29	>4.5	6	4	14	31	45	27	16	11	15	A-6a (8)	
	684.3	47																
VERY STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, MOIST		48	4 7 10	25	100	SS-30	2.75	0	2	4	26	68	42	23	19	31	A-7-6 (12)	
@48.5': STIFF TO VERY STIFF, QU = 1.60 TSF, DD = 99.3 PCF		49	3 4 6	15	100	SS-31	3.25	-	-	-	-	-	-	-	-	25	A-7-6 (V)	
@50': VERY STIFF		51	5 5 9	20	100	SS-32	2.50	-	-	-	-	-	-	-	-	26	A-7-6 (V)	
		52	5 6 9	22	100	SS-33	3.00	-	-	-	-	-	-	-	-	25	A-7-6 (V)	
	678.3	53																
			5															

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1013+36, 9' LT.	START: 7/22/24	END: 7/23/24	PG 3 OF 3	B-001-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 677.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY STIFF, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, MOIST *(continued)*			6 10	23	100	SS-34	3.25	-	-	-	-	-	-	-	-	14	A-4a (V)	
	675.3	W 675.5	2 4 7	16	100	SS-35	2.50	-	-	-	-	-	-	-	-	16	A-4a (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST QU = 2.10 TSF, DD = 122.9 PCF			3 5 7	17	100	SS-36	3.75	4	5	14	15	62	24	13	11	14	A-6a (8)	
@57.5': VERY STIFF TO HARD			3 8 9	25	100	SS-37	>4.5	-	-	-	-	-	-	-	-	13	A-6a (V)	
@59': STIFF	670.8		3 5 8	19	100	SS-38	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST			10 16 21	54	100	SS-39	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
			5 8 13	31	100	SS-40	>4.5	-	-	-	-	-	-	-	-	14	A-6b (V)	
	666.3	EOB	7 13 15	41	100	SS-41	4.25	-	-	-	-	-	-	-	-	15	A-6b (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 18 CF CEMENT-BENTONITE GROUT

PROJECT: FUL-20A-19.20	DRILLING FIRM / OPERATOR: TTL / TB	DRILL RIG: DIEDRICH D70 TRACK	STATION / OFFSET: 1014+75, 9' LT.
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: TTL / TB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: US ROUTE 20A
PID: 119890 SFN: N/A	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/11/24	ELEVATION: 728.9 (NAVD88) EOB: 65.0 ft.
START: 7/19/24 END: 7/22/24	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 87.4	LAT / LONG: 41.573693, -84.015669

EXPLORATION ID B-002-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV. 728.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT - 11 INCHES	728.0																	
CONCRETE - 7 INCHES	727.4																	
MEDIUM STIFF TO STIFF, BROWN/GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	724.4	1 2 3 4	2 2 2	6	67	SS-1	3.75	-	-	-	-	-	-	-	-	15	A-6b (V)	
STIFF TO VERY STIFF, BROWN/GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, TRACE IRON OXIDE STAIN SEAM, DAMP		5 6 7	2 3 3	9	78	SS-2	>4.5	-	-	-	-	-	-	-	-	17	A-6b (V)	
			2 3 3	9	44	SS-3	3.75	-	-	-	-	-	-	-	-	18	A-6b (V)	
@7.5': GRAY, SOME SAND, MOIST	719.9	8 9	3 4 4	12	33	SS-4	3.25	2	5	24	27	42	35	18	17	20	A-6b (10)	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP QU = 3.43 TSF, DD = 118.1 PCF		10	3 4 5	13	67	SS-5	>4.5	-	-	-	-	-	-	-	-	16	A-6b (V)	
@10.6': VERY STIFF TO HARD, TRACE CALCITE STAIN SEAM		11	4 5 7	17	61	SS-6	>4.5	-	-	-	-	-	-	-	-	16	A-6b (V)	
@12': BROWN/GRAY		12 13	4 5 7	17	67	SS-7	>4.5	-	-	-	-	-	-	-	-	16	A-6b (V)	
@13.5': UU TRIAXIAL - C = 1.63 TSF, DD = 116.9 PCF DIRECT SHEAR - C' = 118 PSF, PHI' = 29.8 DEG, DD = 108.3 PCF (WC=16%)		14 15			92	ST-8	>4.5	5	4	11	24	56	36	20	16	15	A-6b (10)	
@15.5': VERY STIFF		16 17	5 8 10	26	83	SS-9	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
		18	6 7 9	23	72	SS-10	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
@18.3': STIFF, QU = 3.02 TSF, DD = 115.5 PCF		19	3 6 8	20	100	SS-11	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
		20 21	5 6 9	22	100	SS-12	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
		22	3 6 9	22	100	SS-13	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
		23 24	5 6 9	22	100	SS-14	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
		25	3 4 6	15	100	SS-15	4.25	-	-	-	-	-	-	-	-	15	A-6b (V)	

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1014+75, 9' LT.	START: 7/19/24	END: 7/22/24	PG 2 OF 3	B-002-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP QU = 3.43 TSF, DD = 118.1 PCF *(continued)*	702.9	27	7 10 14	35	100	SS-16	3.00	-	-	-	-	-	-	-	-	16	A-6b (V)	
@27.5': VERY STIFF, QU = 3.31 TSF, DD = 117.6 PCF		28	3 6 13	28	100	SS-17	4.00	-	-	-	-	-	-	-	-	15	A-6b (V)	
@29': DRILLER NOTED PUSHED COBBLE DURING SPT, RESULTING IN ONLY 33% RECOVERY		29	3 8 11	28	33	SS-18	3.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
		30	6 6 9	22	100	SS-19	4.00	-	-	-	-	-	-	-	-	15	A-6b (V)	
@32': VERY STIFF TO HARD		31	4 7 14	31	100	SS-20	3.75	-	-	-	-	-	-	-	-	15	A-6b (V)	
		32	6 8 11	28	0	SS-21	-	-	-	-	-	-	-	-	-	-	A-6b (V)	
		33	9 12 13	36	61	SS-22	2.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
@36.5': VERY STIFF		34	5 7 9	23	50	SS-23	3.75	-	-	-	-	-	-	-	-	14	A-6b (V)	
@38': HARD		35	12 11 13	35	100	SS-24	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
@39.5': VERY STIFF	687.9	36	2 4 7	16	94	SS-25	3.75	-	-	-	-	-	-	-	-	15	A-6b (V)	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP QU = 2.89 TSF, DD = 114.7 PCF		37	4 5 8	19	100	SS-26	>4.5	4	5	9	20	62	28	16	12	15	A-6a (9)	
	684.9	38	4 6 7	19	100	SS-27	4.00	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, MOIST		39	4 4 5	13	100	SS-28	2.25	-	-	-	-	-	-	-	-	22	A-7-6 (V)	
@45.5': VERY STIFF TO HARD		40	8 10 12	32	100	SS-29	3.50	0	2	6	24	68	50	23	27	29	A-7-6 (17)	
@47': VERY STIFF	680.4	41	3 4 6	15	100	SS-30	3.25	-	-	-	-	-	-	-	-	27	A-7-6 (V)	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, TRACE SAND, MOIST	678.9	42	3 3 5	12	100	SS-31	2.25	0	2	5	25	68	39	20	19	25	A-6b (12)	
VERY STIFF, GRAY, **SILTY CLAY**, TRACE SAND, MOIST QU = 0.96 TSF (APPARENT MEDIUM STIFF), DD = 100.2 PCF		43	3 5 6	16	100	SS-32	2.50	-	-	-	-	-	-	-	-	27	A-6b (V)	
@51.5': LITTLE SAND, TRACE GRAVEL		44	4 6 7	19	100	SS-33	2.50	-	-	-	-	-	-	-	-	28	A-6b (V)	
		45	4															

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1014+75, 9' LT.	START: 7/19/24	END: 7/22/24	PG 3 OF 3	B-002-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
	675.1																	
	674.4		4 7	16	100	SS-34	3.00	-	-	-	-	-	-	-	-	26	A-6b (V)	
STIFF, GRAY, **SILT AND CLAY**, SOME SAND, MOIST		55	2 4 5	13	100	SS-35	2.00	0	3	18	26	53	24	13	11	19	A-6a (8)	
	671.9	56	3 5 6	16	100	SS-36A	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
VERY STIFF TO HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		57				SS-36B	4.00	-	-	-	-	-	-	-	-	13	A-6b (V)	
		58	4 6 10	23	100	SS-37	>4.5	-	-	-	-	-	-	-	-	14	A-6b (V)	
		59	3 6 11	25	100	SS-38	4.25	-	-	-	-	-	-	-	-	14	A-6b (V)	
@60.5': HARD		60	7 10 13	34	100	SS-39	>4.5	-	-	-	-	-	-	-	-	13	A-6b (V)	
		61	5 7 13	29	100	SS-40	>4.5	-	-	-	-	-	-	-	-	12	A-6b (V)	
		62	8 16 21	54	100	SS-41	>4.5	-	-	-	-	-	-	-	-	14	A-6b (V)	
	663.9	63																
		EOB 64																
		65																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 18 CF CEMENT-BENTONITE GROUT

PROJECT: FUL-20A-19.20	DRILLING FIRM / OPERATOR: TTL / TB	DRILL RIG: DIEDRICH D70 TRACK	STATION / OFFSET: 1015+97, 9' LT.	EXPLORATION ID B-003-0-24
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: TTL / TB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: US ROUTE 20A	
PID: 119890 SFN: N/A	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/11/24	ELEVATION: 726.8 (NAVD88) EOB: 65.0 ft.	PAGE 1 OF 3
START: 7/18/24 END: 7/19/24	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 87.4	LAT / LONG: 41.573700, -84.015228	

MATERIAL DESCRIPTION AND NOTES	ELEV. 726.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT - 14.25 INCHES	725.6	1																
CONCRETE - 7.75 INCHES	725.0	2																
MEDIUM STIFF TO STIFF, WHITE/DARK GRAY, **SILTY CLAY**, LITTLE SAND, TRACE CRUSHED STONE, CALCITE STAIN SEAM, DAMP FILL	722.3	3 4	2 2 2	6	33	SS-1	2.00	-	-	-	-	-	-	-	-	13	A-6b (V)	
STIFF TO VERY STIFF, GRAY/BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, CALCITE STAIN SEAM, DAMP		5	2 4 4	12	67	SS-2	3.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
		6 7	3 3 3	9	89	SS-3	3.75	-	-	-	-	-	-	-	-	18	A-6b (V)	
@7.5': BROWN		8	1 2 3	7	61	SS-4	3.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
	716.3	9 10	1 2 2	6	83	SS-5	2.75	-	-	-	-	-	-	-	-	18	A-6b (V)	
STIFF TO VERY STIFF, GRAY/BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP QU = 3.35 TSF, DD = 109.9 PCF		11	2 4 5	13	100	SS-6	4.00	3	5	12	23	57	39	20	19	17	A-6b (12)	
		12 13	3 5 6	16	78	SS-7	4.00	-	-	-	-	-	-	-	-	16	A-6b (V)	
		14	3 4 5	13	67	SS-8	4.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
		15 16	4 5 5	15	78	SS-9	>4.5	-	-	-	-	-	-	-	-	16	A-6b (V)	
	708.8	17	2 3 4	10	83	SS-10	4.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
VERY STIFF TO HARD, GRAY/BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	707.3	18 19	4 5 6	16	78	SS-11	>4.5	-	-	-	-	-	-	-	-	17	A-6b (V)	
STIFF TO VERY STIFF, GRAY/BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	705.8	20	2 3 5	12	50	SS-12	3.50	-	-	-	-	-	-	-	-	18	A-6b (V)	
VERY STIFF, GRAY/BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP	704.3	21 22	3 5 6	16	83	SS-13	3.50	-	-	-	-	-	-	-	-	18	A-6b (V)	
STIFF TO VERY STIFF, BROWN/GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP QU = 1.51 TSF, DD = 103.4 PCF	702.8	23	2 3 4	10	83	SS-14	3.25	2	4	17	25	52	33	18	15	18	A-6a (10)	
VERY STIFF, BROWN/GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	701.3	24 25	3 5 6	16	100	SS-15	3.00	-	-	-	-	-	-	-	-	19	A-6b (V)	

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1015+97, 9' LT.	START: 7/18/24	END: 7/19/24	PG 2 OF 3	B-003-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
STIFF TO VERY STIFF, BROWN/GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP QU = 1.12 TSF, DD = 106.8 PCF DIRECT SHEAR - C' = 422 PSF, PHI' = 27.4 DEG, DD = 102.0 PCF (WC=26%) *(continued)* @26.5': GRAY, TRACE GRAVEL	700.8	27			88	ST-16	2.00	11	4	15	22	48	40	22	18	19	A-6b (10)	
@27.5': MODERATELY ORGANIC (LOI = 4.1%)	697.8	28	3 5 7	17	94	SS-17	3.00	-	-	-	-	-	-	-	-	21	A-6b (V)	
VERY STIFF TO HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		29																
		30	5 9 9	26	100	SS-18	4.00	-	-	-	-	-	-	-	-	16	A-6b (V)	
		31	5 9 11	29	83	SS-19	4.25	-	-	-	-	-	-	-	-	17	A-6b (V)	
		32																
	693.3	33	4 7 10	25	100	SS-20	>4.5	-	-	-	-	-	-	-	-	14	A-6b (V)	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		34	5 6 8	20	100	SS-21	>4.5	4	4	11	22	59	31	17	14	15	A-6a (10)	
		35																
		36	7 10 13	34	100	SS-22	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
@36.5': QU = 3.55 TSF, DD = 122.1 PCF		37	5 7 10	25	100	SS-23	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		38																
		39	6 10 11	31	100	SS-24	>4.5	-	-	-	-	-	-	-	-	12	A-6a (V)	
		40	4 6 10	23	100	SS-25	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		41																
	684.3	42	6 9 13	32	100	SS-26	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
VERY STIFF TO HARD, GRAY, **CLAY**, SOME SILT, TRACE SAND, MOIST		43	5 6 7	19	100	SS-27	3.50	0	2	6	24	68	47	25	22	30	A-7-6 (14)	
		44																
		45	3 4 5	13	100	SS-28	3.25	-	-	-	-	-	-	-	-	29	A-7-6 (V)	
	681.3	46																
STIFF, GRAY, **SILTY CLAY**, TRACE SAND, MOIST		47	4 4 4	12	83	SS-29	1.50	-	-	-	-	-	-	-	-	28	A-6b (V)	
	679.8	48																
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, TRACE SAND, MOIST		49	3 4 6	15	100	SS-30	2.75	-	-	-	-	-	-	-	-	26	A-6b (V)	
		50	3 3 4	10	100	SS-31	2.50	-	-	-	-	-	-	-	-	22	A-6b (V)	
	676.8	51																
VERY STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, MOIST		52	5 6 6	17	100	SS-32	2.00	0	2	6	24	68	41	23	18	28	A-7-6 (11)	
@51.5': QU = 0.62 TSF (APPARENT MEDIUM STIFF), DD = 106.7 PCF		53	7 7 8	22	100	SS-33	2.50	-	-	-	-	-	-	-	-	23	A-7-6 (V)	
	673.8																	
VERY STIFF, GRAY, **SILTY CLAY**, TRACE SAND, MOIST			3															

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1015+97, 9' LT.	START: 7/18/24	END: 7/19/24	PG 3 OF 3	B-003-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY STIFF, GRAY, **SILTY CLAY**, TRACE SAND, MOIST	672.9		4 5	13	100	SS-34	3.75	-	-	-	-	-	-	-	-	17	A-6b (V)	
(continued)	672.3																	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		55	4 8 10	26	100	SS-35	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
@56': HARD		56																
		57	4 9 11	29	100	SS-36	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		58	10 13 17	44	100	SS-37	>4.5	4	6	16	25	49	30	17	13	15	A-6a (9)	
		59																
		60	5 8 11	28	100	SS-38	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
	666.3																	
HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		61	13 20 27	68	100	SS-39	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
	664.8																	
HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP QU = 3.87 TSF, DD = 112.6 PCF		62																
		63	6 9 14	34	100	SS-40	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
		64	8 10 16	38	100	SS-41	>4.5	-	-	-	-	-	-	-	-	15	A-6b (V)	
	661.8	EOB 65																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 18 CF CEMENT-BENTONITE GROUT

PROJECT: FUL-20A-19.20	DRILLING FIRM / OPERATOR: TTL / TB	DRILL RIG: DIEDRICH D70 TRACK	STATION / OFFSET: 1017+72, 10' LT.	EXPLORATION ID B-004-0-24
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: TTL / TB	HAMMER: AUTOMATIC HAMMER	ALIGNMENT: US ROUTE 20A	
PID: 119890 SFN: N/A	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 6/11/24	ELEVATION: 723.8 (NAVD88) EOB: 65.0 ft.	PAGE 1 OF 3
START: 7/16/24 END: 7/17/24	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 87.4	LAT / LONG: 41.573716, -84.014583	

MATERIAL DESCRIPTION AND NOTES	ELEV. 723.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
ASPHALT - 14 INCHES	722.6	1																
AGGREGATE BASE - 10 INCHES	721.8	2	44 8 5	19	44	SS-1A	-	-	-	-	-	-	-	-	-	14	A-1-b (V)	
						SS-1B	-	-	-	-	-	-	-	-	-	-	A-6b (V)	
STIFF TO VERY STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		3	4 3 3	9	0	SS-2	3.50	-	-	-	-	-	-	-	-	16	A-6b (V)	
@4': GRAY/BROWN, QU = 1.38 TSF, DD = 109.9 PCF		4 5	3 3 3	9	44	SS-3	3.25	-	-	-	-	-	-	-	-	19	A-6b (V)	
@5.5': BROWN		6	3 3 3	9	67	SS-4	3.75	-	-	-	-	-	-	-	-	17	A-6b (V)	
@7': UU TRIAXIAL - C = 0.61 TSF, DD = 110.0 PCF DIRECT SHEAR - C' = 403 PSF, PHI' = 28.4 DEG, DD = 109.2 PCF (WC=19%)		7 8			75	ST-5	2.25	3	5	12	21	59	35	19	16	17	A-6b (10)	
@9': GRAY/BROWN, MOIST		9 10	1 2 3	7	67	SS-6	2.25	-	-	-	-	-	-	-	-	19	A-6b (V)	
@10.5': BROWN. TRACE IRON OXIDE STAIN SEAM, DAMP		11	3 3 3	9	56	SS-7	>4.5	-	-	-	-	-	-	-	-	17	A-6b (V)	
@12': BROWN/GRAY		12 13	3 3 3	9	56	SS-8	>4.5	-	-	-	-	-	-	-	-	17	A-6b (V)	
@13.5': TRACE CALCITE STAIN SEAM	708.8	14	2 2 3	7	72	SS-9	3.50	-	-	-	-	-	-	-	-	17	A-6b (V)	
VERY STIFF TO HARD, BROWN/GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		15	4 5 7	17	78	SS-10	>4.5	-	-	-	-	-	-	-	-	17	A-6b (V)	
W 707.6		16 17	2 4 5	13	83	SS-11	>4.5	-	-	-	-	-	-	-	-	17	A-6b (V)	
		18 19	2 3 4	10	67	SS-12	>4.5	-	-	-	-	-	-	-	-	26	A-6b (V)	
@21': QU = 2.49 TSF, DD = 111.8 PCF		20	4 5 6	16	100	SS-13	>4.5	-	-	-	-	-	-	-	-	18	A-6b (V)	
		21 22	3 5 7	17	100	SS-14	>4.5	-	-	-	-	-	-	-	-	18	A-6b (V)	
		23	5 7 9	23	100	SS-15	>4.5	-	-	-	-	-	-	-	-	18	A-6b (V)	
	699.8	24																
STIFF, GRAY, **SILTY CLAY**, "AND" SAND, SLIGHTLY ORGANIC (LOI = 3.3%), MOIST		25	3 4 4	12	100	SS-16	1.50	0	5	34	29	32	33	17	16	28	A-6b (8)	
@25.5': SLIGHTLY ORGANIC (LOI = 3.3%)			3															

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1017+72, 10' LT.	START: 7/16/24	END: 7/17/24	PG 2 OF 3	B-004-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
STIFF, GRAY, **SILTY CLAY**, "AND" SAND, SLIGHTLY ORGANIC (LOI = 3.3%), MOIST *(continued)*	697.8	27	3 3	9	100	SS-17	0.50	-	-	-	-	-	-	-	-	27	A-6b (V)	
	695.8	28	4 6 8	20	100	SS-18A	-	-	-	-	-	-	-	-	-	-	A-6b (V)	
						SS-18B	>4.5	-	-	-	-	-	-	-	-	16	A-6b (V)	
VERY STIFF TO HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		29	3 5 10	22	100	SS-19	3.75	-	-	-	-	-	-	-	-	16	A-6b (V)	
@30': VERY STIFF		30 31	5 9 13	32	100	SS-20	>4.5	-	-	-	-	-	-	-	-	16	A-6b (V)	
		32	4 7 11	26	0	SS-21	-	-	-	-	-	-	-	-	-	-	A-6b (V)	
		33 34	5 7 10	25	0	SS-22	-	-	-	-	-	-	-	-	-	-	A-6b (V)	
		35	5 7 9	23	100	SS-23	3.75	-	-	-	-	-	-	-	-	16	A-6b (V)	
	686.3	36 37	5 6 11	25	100	SS-24	3.50	-	-	-	-	-	-	-	-	15	A-6b (V)	
STIFF TO VERY STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST QU = 1.21 TSF, DD = 90.1 PCF		38	5 7 9	23	100	SS-25	3.25	-	-	-	-	-	-	-	-	29	A-7-6 (V)	
@39': VERY STIFF		39 40	2 5 7	17	100	SS-26	3.25	1	2	6	23	68	47	25	22	29	A-7-6 (14)	
		41	5 7 7	20	100	SS-27	2.50	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
@42': STIFF TO VERY STIFF		42 43	3 4 5	13	100	SS-28	2.50	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
		44	3 4 5	13	100	SS-29	2.25	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
@45': VERY STIFF	677.3	45 46	3 5 6	16	100	SS-30	2.50	-	-	-	-	-	-	-	-	24	A-7-6 (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		47	3 5 6	16	100	SS-31	2.00	-	-	-	-	-	-	-	-	20	A-6a (V)	
	673.8	48 49	3 5 7	17	100	SS-32	2.50	1	2	5	24	68	31	20	11	26	A-6a (8)	
			1 4 8	17	100	SS-33A	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
VERY STIFF, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST		50				SS-33B	4.00	-	-	-	-	-	-	-	-	14	A-6b (V)	
	671.8	51	5 11 23	50	100	SS-34A	-	-	-	-	-	-	-	-	-	-	A-6b (V)	
HARD, GRAY, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, DAMP		52				SS-34B	-	-	-	-	-	-	-	-	-	8	A-4a (V)	
	670.8		8 10	35	100	SS-35A	-	-	-	-	-	-	-	-	-	-	A-4a (V)	
		53				SS-35B	>4.5	-	-	-	-	-	-	-	-	14	A-6b (V)	

PID: 119890	SFN: N/A	PROJECT: FUL-20A-19.20	STATION / OFFSET: 1017+72, 10' LT.	START: 7/16/24	END: 7/17/24	PG 3 OF 3	B-004-0-24

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
HARD, GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP *(continued)*	669.9		14															
@55.5': SOME SAND		55	4 7 16	34	83	SS-36	>4.5	-	-	-	-	-	-	-	-	13	A-6b (V)	
	666.8	56	16 24 26	73	100	SS-37	>4.5	-	-	-	-	-	-	-	-	14	A-6b (V)	
HARD, GRAY, **SILTY CLAY**, SOME SAND, TRACE GRAVEL, DAMP QU = 9.97 TSF, DD = 123.9 PCF		57	6 10 15	36	100	SS-38	>4.5	-	-	-	-	-	-	-	-	13	A-6a (V)	
		58	5 10 16	38	100	SS-39	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		59	6 11 16	39	100	SS-40	>4.5	4	4	18	25	49	30	18	12	15	A-6a (9)	
		60	6 12 17	42	100	SS-41	>4.5	-	-	-	-	-	-	-	-	15	A-6a (V)	
		61	6 9 12 14	31	100	SS-42	>4.5	-	-	-	-	-	-	-	-	16	A-6a (V)	
	658.8	EOB 62																
		63																
		64																
		65																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 18 CF CEMENT-BENTONITE GROUT

LEGEND KEY

LITHOLOGIC SYMBOLS
(Unified Soil Classification System)


A-4A: Ohio DOT: A-4a, sandy silt


A-6A: Ohio DOT: A-6a, silt and clay


A-6B: Ohio DOT: A-6b, silty clay


A-7-6: Ohio DOT: A-7-6, clay


PAVEMENT OR BASE: Ohio DOT: Pavement or Aggregate base

SAMPLER SYMBOLS


Thin Walled Undisturbed Sample

WELL CONSTRUCTION SYMBOLS


Bentonite: Bottom of hole


Asphalt or Concrete Pavement Patch

Notes:

1. Exploratory borings were drilled on July 16 through 23, 2024, using 3¼-inch inside diameter hollow-stem augers.

2. These logs are subject to the limitations, conclusions, and recommendations in the report and should not be interpreted separate from the report.

3. The test borings were located in the field by CT Consultants, Inc. based on plan provided with the proposal for this project.

4. Latitude and Longitude were obtained by CT using a handheld GPS unit. Station, offset, and ground surface elevation were provided by Tetra Tech.

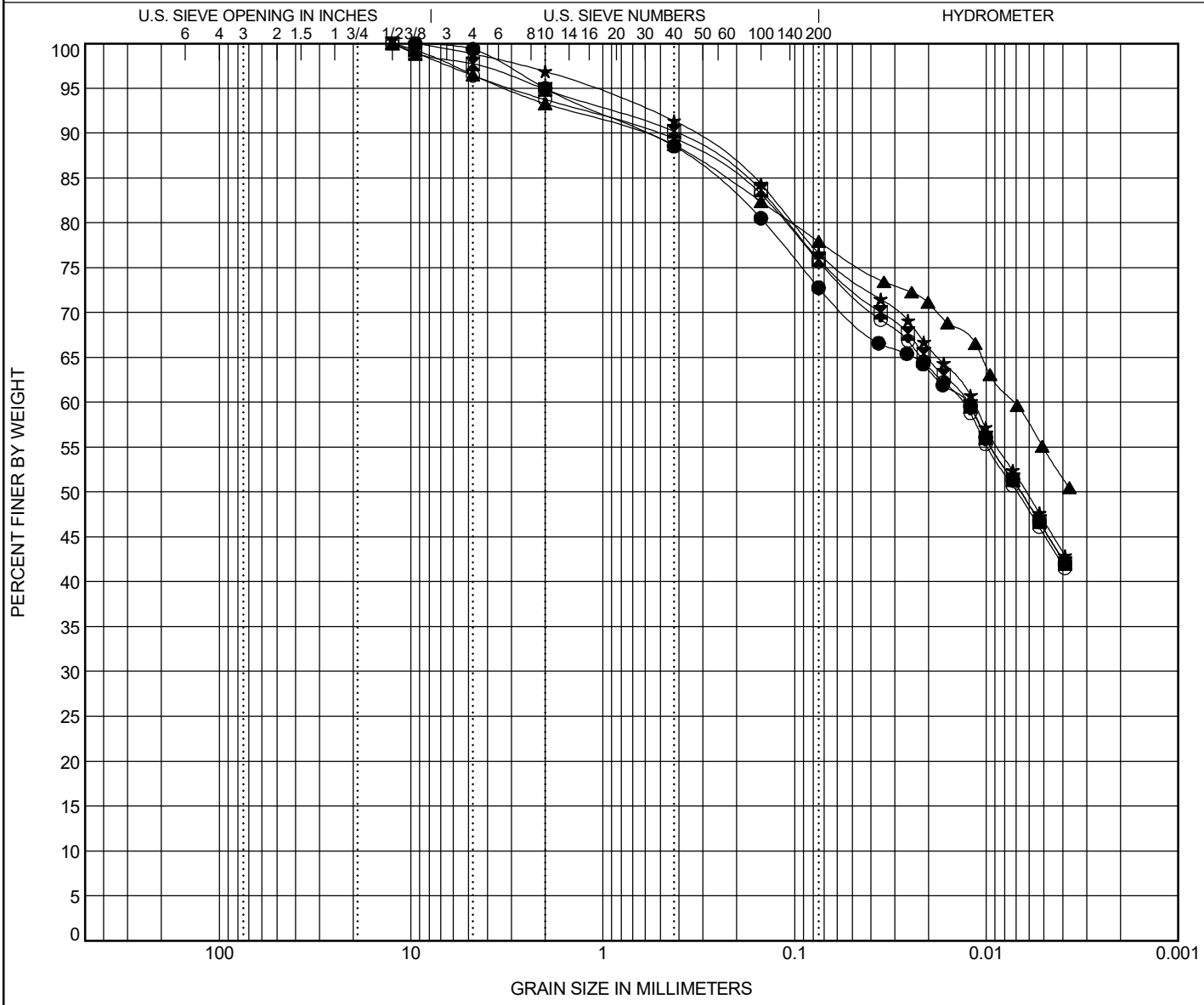
5. Material Description and Notes:
   Qu = unconfined compressive strength test by ASTM D 2166.
   UU Triaxial = UU test by ASTM D 2850, with associated DD = Dry Density
   Direct Shear = Direct Shear by ASTM D 3080, with associated DD = Dry Density

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT FUL-20A-19.20 **PID** 119890

OGE NUMBER N/A **PROJECT TYPE** GEOHAZARD EXPLORATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-001-0-24	4.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**31**	**19**	**12**
⊠	B-001-0-24	13.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**27**	**16**	**11**
▲	B-001-0-24	18.0	**A-6b ~ LEAN CLAY with SAND(CL)**	**34**	**18**	**16**
★	B-001-0-24	30.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**29**	**18**	**11**
⊙	B-001-0-24	45.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**27**	**16**	**11**

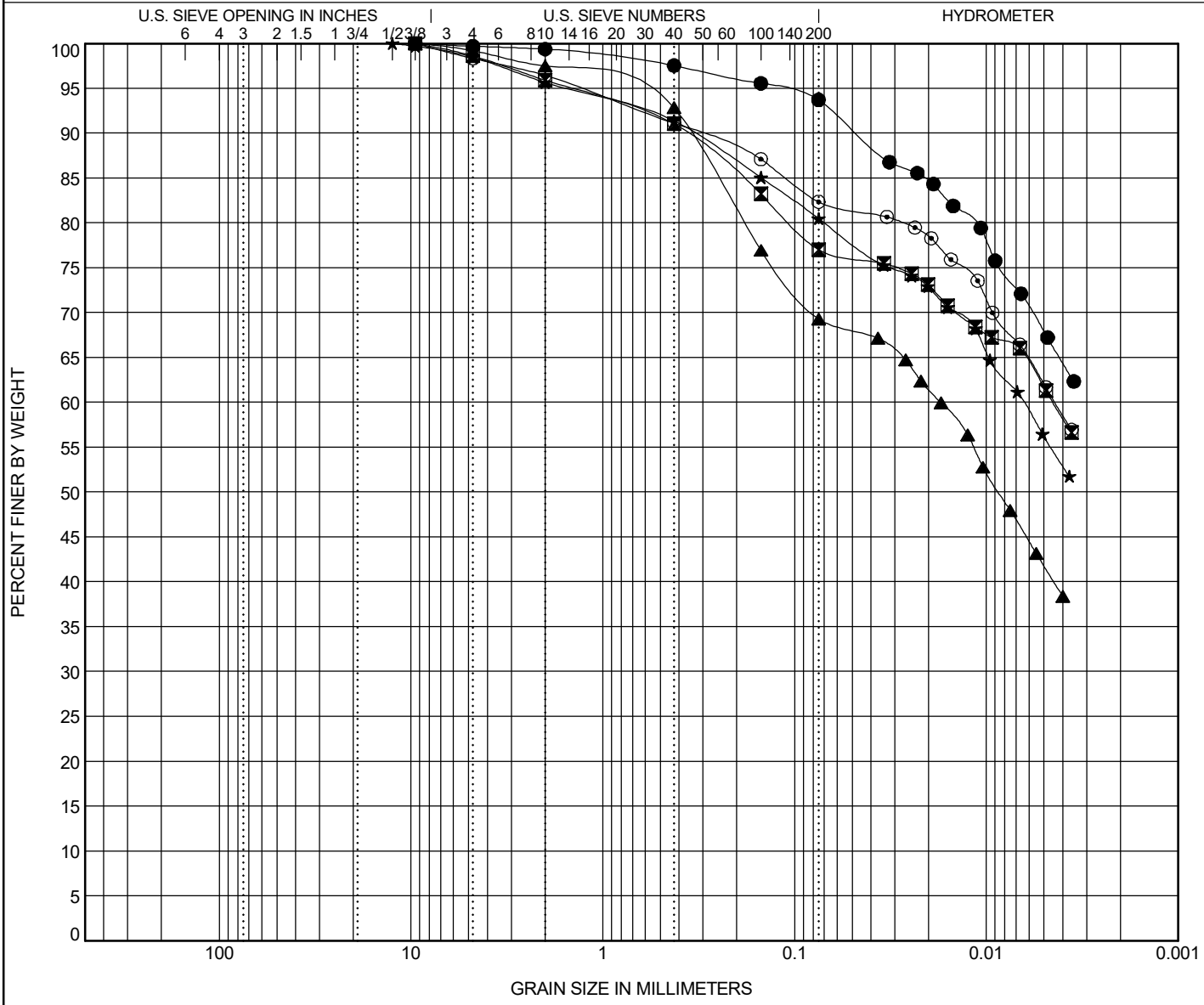
Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-0-24	4.5	**0.602**	**0.007**			**5**	**6**	**16**	**27**	**46**		
⊠	B-001-0-24	13.5	**0.41**	**0.007**			**5**	**5**	**14**	**30**	**46**		
▲	B-001-0-24	18.0	**0.66**				**6**	**5**	**11**	**23**	**55**		
★	B-001-0-24	30.5	**0.347**	**0.006**			**2**	**6**	**15**	**30**	**47**		
⊙	B-001-0-24	45.5	**0.523**	**0.007**			**6**	**4**	**14**	**31**	**45**		

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT FUL-20A-19.20 **PID** 119890

OGE NUMBER N/A **PROJECT TYPE** GEOHAZARD EXPLORATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-001-0-24	47.0	**A-7-6 ~ LEAN CLAY(CL)**	**42**	**23**	**19**
⊠	B-001-0-24	56.0	**A-6a ~ LEAN CLAY with SAND(CL)**	**24**	**13**	**11**
▲	B-002-0-24	7.5	**A-6b ~ SANDY LEAN CLAY(CL)**	**35**	**18**	**17**
★	B-002-0-24	13.5	**A-6b ~ LEAN CLAY with SAND(CL)**	**36**	**20**	**16**
⊙	B-002-0-24	41.0	**A-6a ~ LEAN CLAY with SAND(CL)**	**28**	**16**	**12**

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-001-0-24	47.0	**0.048**				**0**	**2**	**4**	**26**	**68**		
⊠	B-001-0-24	56.0	**0.37**				**4**	**5**	**14**	**15**	**62**		
▲	B-002-0-24	7.5	**0.353**	**0.009**			**2**	**5**	**24**	**27**	**42**		
★	B-002-0-24	13.5	**0.339**				**5**	**4**	**11**	**24**	**56**		
⊙	B-002-0-24	41.0	**0.319**				**4**	**5**	**9**	**20**	**62**		

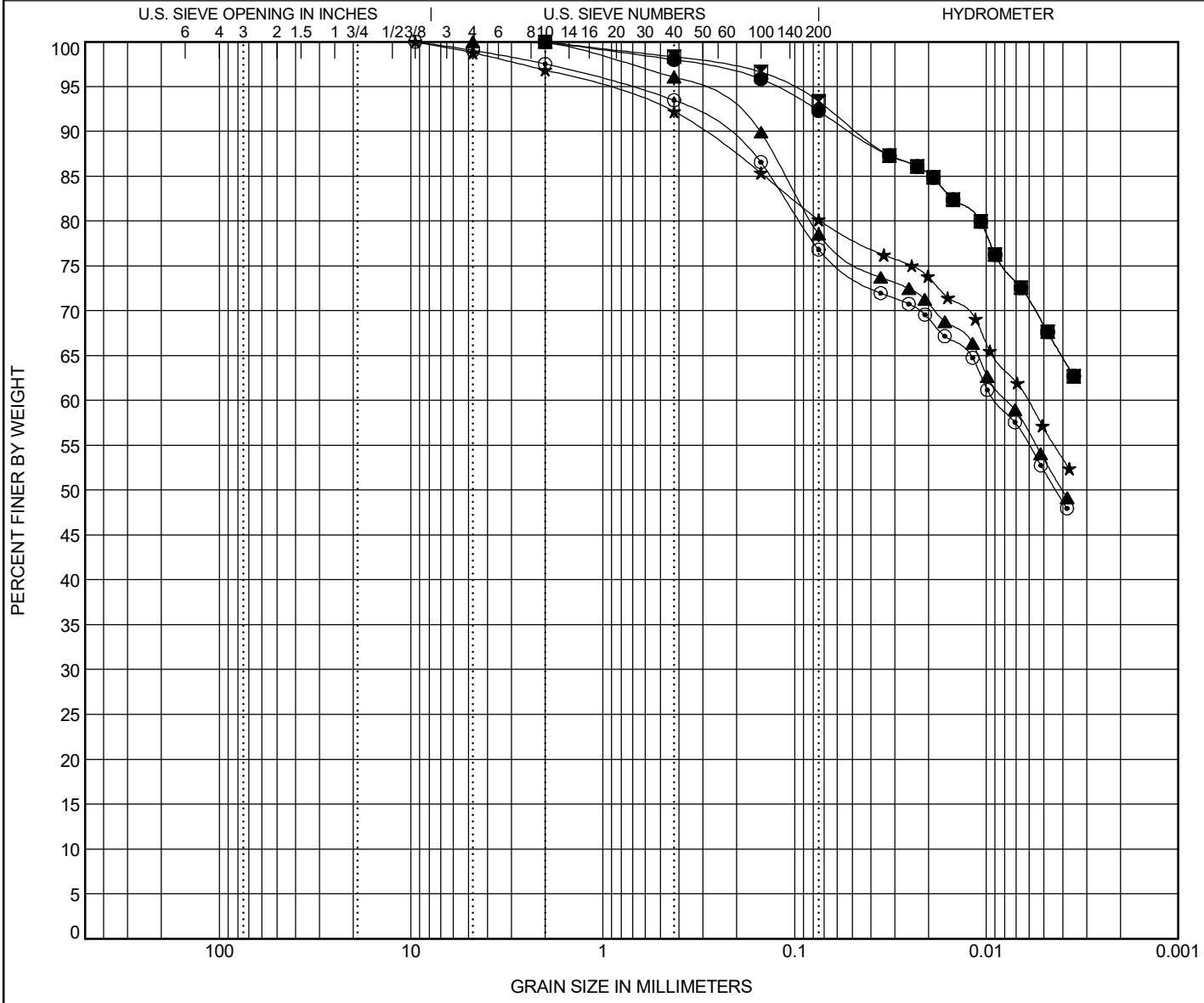
GRAIN SIZE - OH DOT.GDT - 10/1/24 13:14 - X:\PROJECTS\241359.GPJ

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT FUL-20A-19.20 **PID** 119890

OGE NUMBER N/A **PROJECT TYPE** GEOHAZARD EXPLORATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-002-0-24	45.5	A-7-6 ~ FAT CLAY(CH)	50	23	27
⊠	B-002-0-24	48.5	A-6b ~ LEAN CLAY(CL)	39	20	19
▲	B-002-0-24	54.5	A-6a ~ LEAN CLAY with SAND(CL)	24	13	11
★	B-003-0-24	10.5	A-6b ~ LEAN CLAY with SAND(CL)	39	20	19
⊙	B-003-0-24	22.5	A-6a ~ LEAN CLAY with SAND(CL)	33	18	15

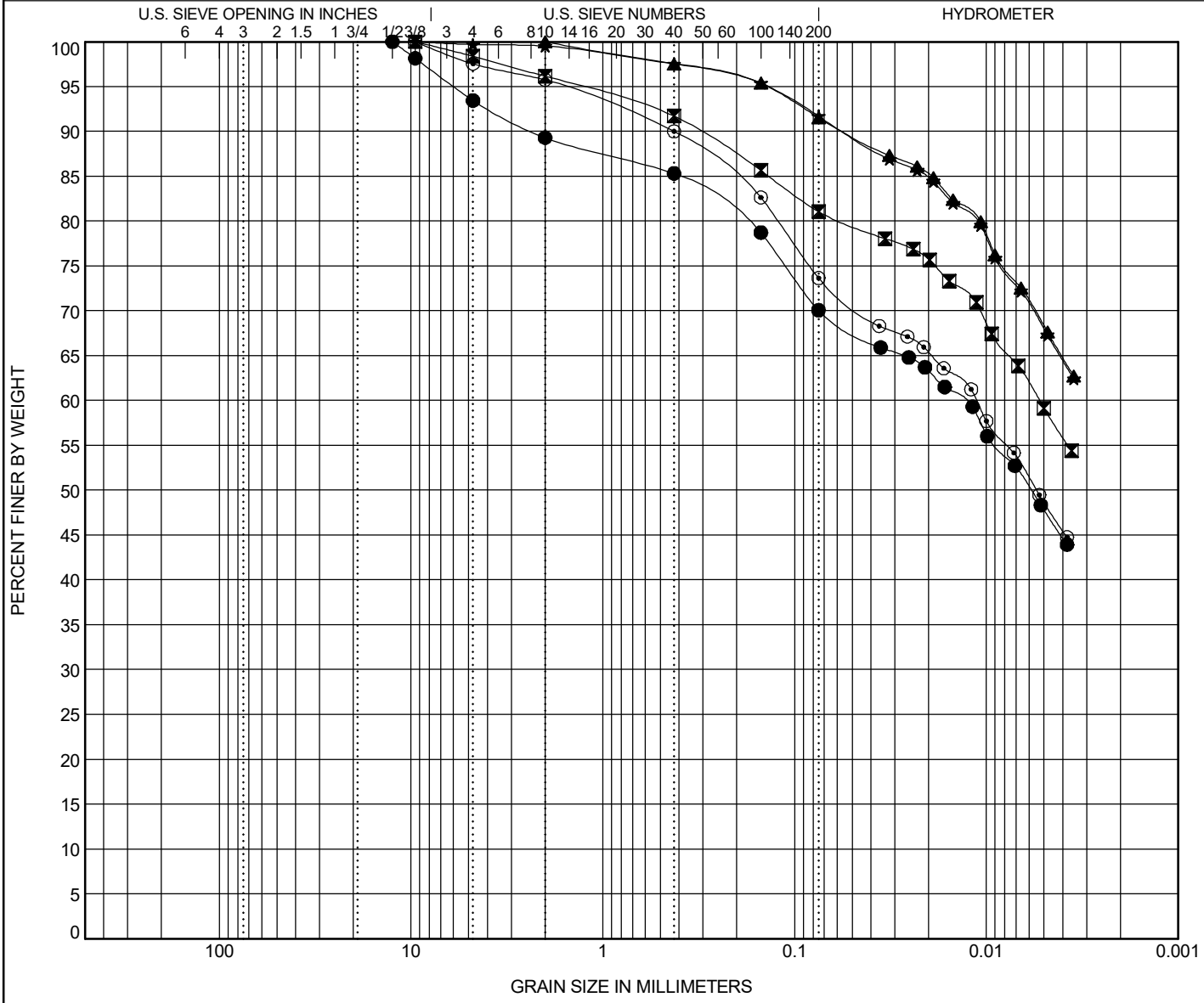
Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-002-0-24	45.5	0.051				0	2	6	24	68		
⊠	B-002-0-24	48.5	0.047				0	2	5	25	68		
▲	B-002-0-24	54.5	0.152	0.004			0	3	18	26	53		
★	B-003-0-24	10.5	0.303				3	5	12	23	57		
⊙	B-003-0-24	22.5	0.252	0.004			2	4	17	25	52		

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT FUL-20A-19.20 **PID** 119890

OGE NUMBER N/A **PROJECT TYPE** GEOHAZARD EXPLORATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-003-0-24	25.5	**A-6b ~ LEAN CLAY with SAND(CL)**	**40**	**22**	**18**
⊠	B-003-0-24	33.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**31**	**17**	**14**
▲	B-003-0-24	42.5	**A-7-6 ~ LEAN CLAY(CL)**	**47**	**25**	**22**
★	B-003-0-24	50.0	**A-7-6 ~ LEAN CLAY(CL)**	**41**	**23**	**18**
⊙	B-003-0-24	57.5	**A-6a ~ LEAN CLAY with SAND(CL)**	**30**	**17**	**13**

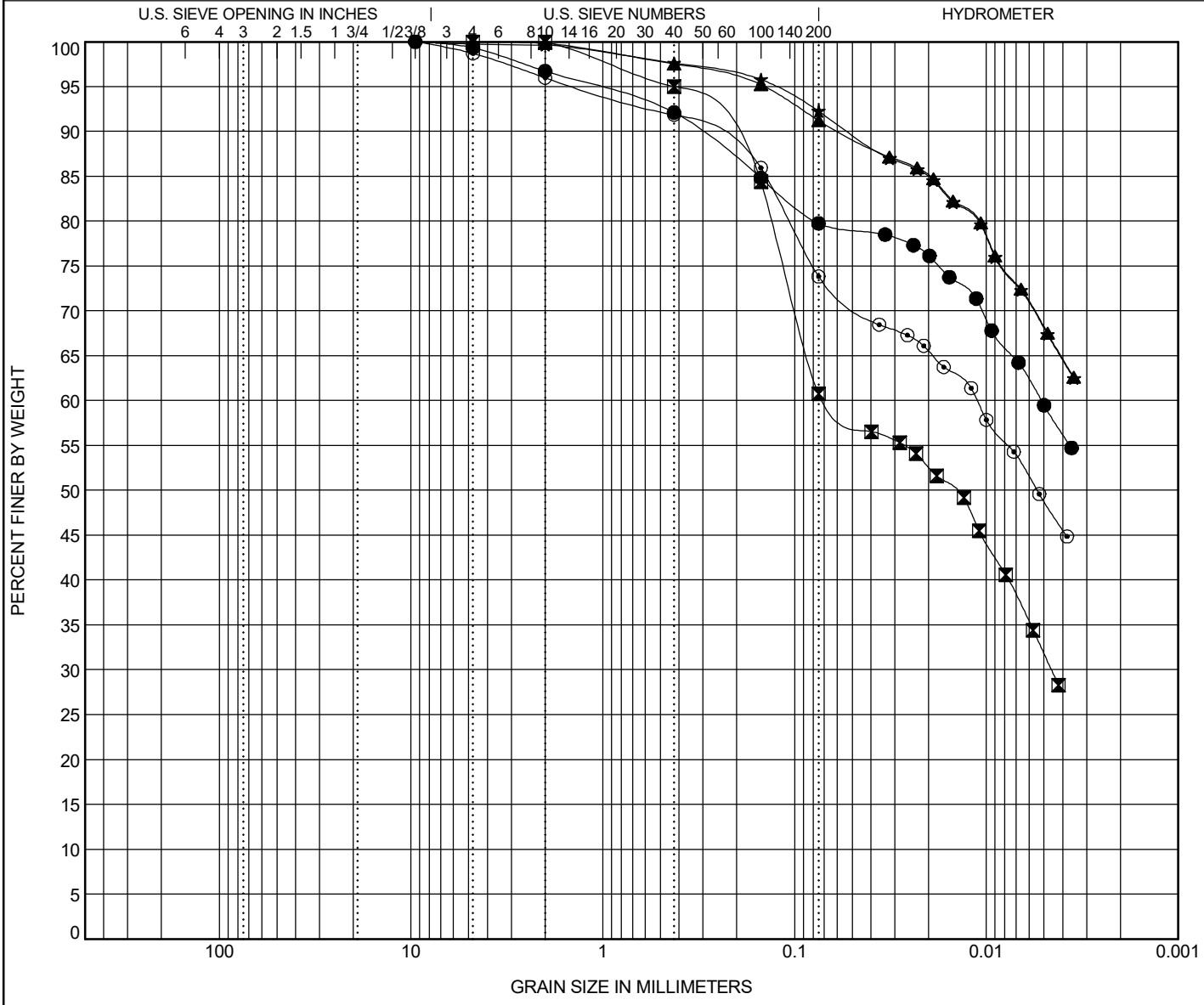
Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-003-0-24	25.5	**2.315**	**0.006**			**11**	**4**	**15**	**22**	**48**		
⊠	B-003-0-24	33.5	**0.317**				**4**	**4**	**11**	**22**	**59**		
▲	B-003-0-24	42.5	**0.055**				**0**	**2**	**6**	**24**	**68**		
★	B-003-0-24	50.0	**0.055**				**0**	**2**	**6**	**24**	**68**		
⊙	B-003-0-24	57.5	**0.425**	**0.005**			**4**	**6**	**16**	**25**	**49**		

GRAIN SIZE DISTRIBUTION

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT FUL-20A-19.20 **PID** 119890

OGE NUMBER N/A **PROJECT TYPE** GEOHAZARD EXPLORATION



COBBLES	GRAVEL	SAND		SILT	CLAY
		coarse	fine		

Specimen Identification			ODOT (Modified AASHTO) ~ USCS Classification	LL	PL	PI
●	B-004-0-24	7.0	**A-6b ~ LEAN CLAY with SAND(CL)**	**35**	**19**	**16**
⊠	B-004-0-24	24.0	**A-6b ~ SANDY LEAN CLAY(CL)**	**33**	**17**	**16**
▲	B-004-0-24	39.0	**A-7-6 ~ LEAN CLAY(CL)**	**47**	**25**	**22**
★	B-004-0-24	48.0	**A-6a ~ LEAN CLAY(CL)**	**31**	**20**	**11**
⊙	B-004-0-24	60.0	**A-6a ~ LEAN CLAY with SAND(CL)**	**30**	**18**	**12**

Specimen Identification			D90	D50	D30	D10	%G	%CS	%FS	%M	%C	Cc	Cu
●	B-004-0-24	7.0	**0.315**				**3**	**5**	**12**	**21**	**59**		
⊠	B-004-0-24	24.0	**0.26**	**0.015**	**0.005**		**0**	**5**	**34**	**29**	**32**		
▲	B-004-0-24	39.0	**0.058**				**1**	**2**	**6**	**23**	**68**		
★	B-004-0-24	48.0	**0.052**				**1**	**2**	**5**	**24**	**68**		
⊙	B-004-0-24	60.0	**0.307**	**0.005**			**4**	**4**	**18**	**25**	**49**		

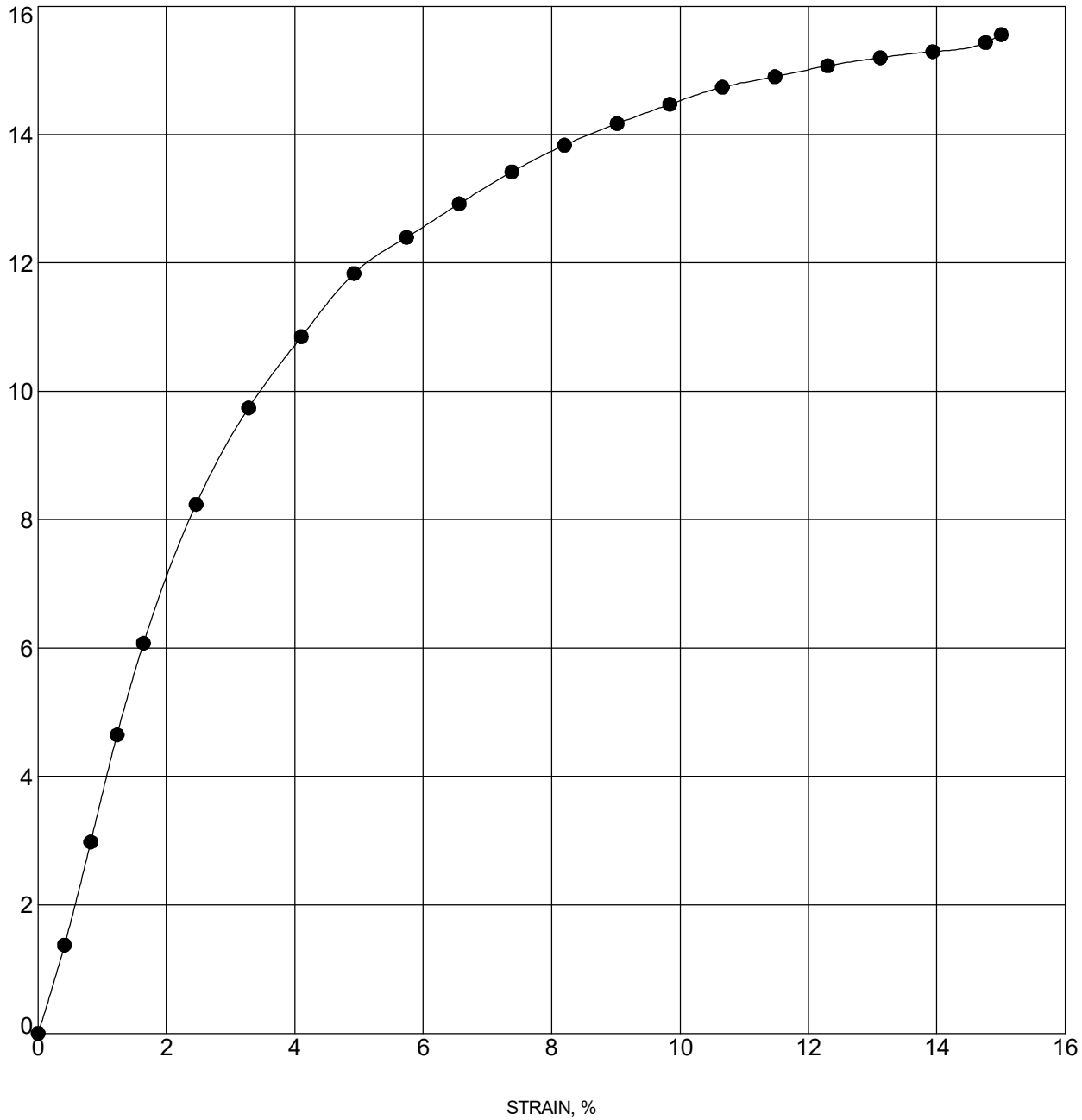
GRAIN SIZE - OH DOT.GDT - 10/1/24 13:21 - X:\PROJECTS\241359.GPJ

UNCONFINED COMPRESSION TEST

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT FUL-20A-19.20 **PID** 119890

OGE NUMBER N/A **PROJECT TYPE** GEOHAZARD EXPLORATION



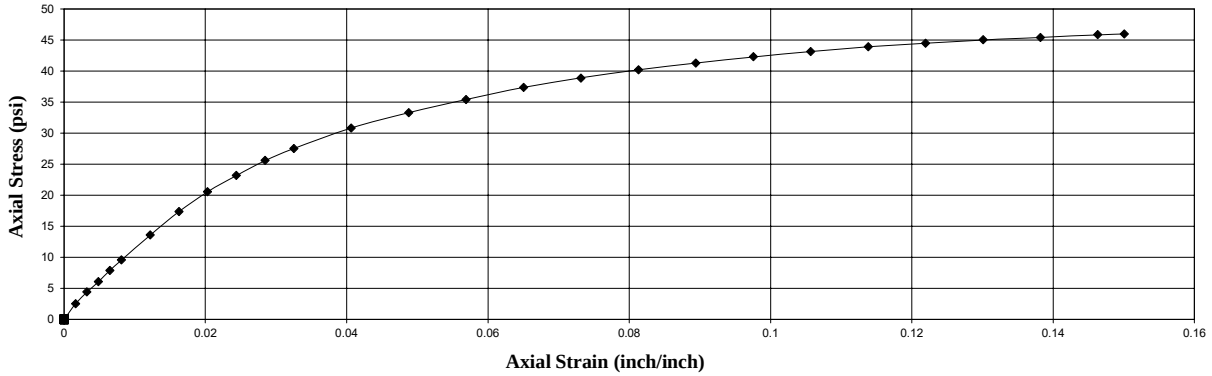
Specimen Identification		Classification	γ_d	MC%
●	**B-003-0-24 25.5**	**A-6b**	**107**	**19**

Unconsolidated - Undrained Triaxial Shear Strength Test

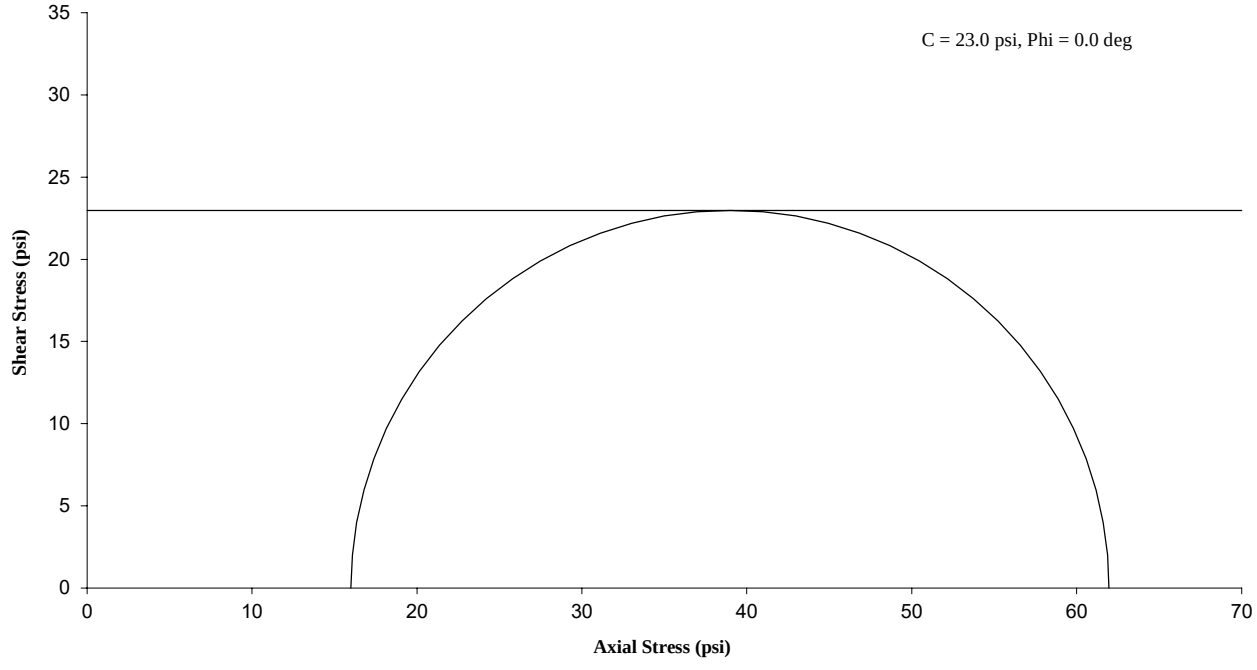
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
Project No.:	241359	Symbol	◆	■	●
Project:	FUL-20A-19.20	Init. Specimen Height (in.)	6.15	-	-
Sample ID:	B-001-0-24 ST-11	Init. Specimen Diameter (in.)	2.88	-	-
Sample Interval:	18.0 - 20.0'	Init. Moisture Content* (%)	14.5	-	-
Soil Description:	Gray SILTY CLAY, Little Sand, Trace Gravel A-6b (10)	Init. Dry Unit Weight (pcf)	117.2	-	-
				-	-
Liquid Limit:	34	Init. Void Ratio	0.46	-	-
Plastic Limit:	18	Init. Degree of Saturation (%)	86	-	-
Plasticity Index:	16	Minor Principal Stress (psi)	16.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	46.0	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	62.0	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	15.0	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

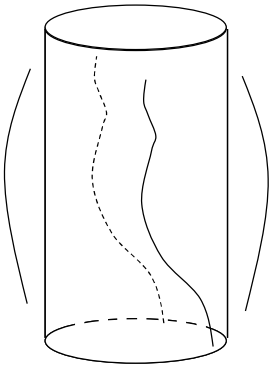
Project:	FUL-20A-19.20	Date:	7/29/2024
Client:	Tetra Tech	File:	241359B-001-0-24ST-11
Sample ID:	B-001-0-24 ST-11	Depth:	18.0 - 20.0'
Project No.:	241359	Specimen ID:	"D" (19.5 - 20.0 Feet)

SAMPLE PROPERTIES

Visual Description:	Gray SILTY CLAY, Little Sand, Trace Gravel A-6b (10)		
Diameter:	2.88 in.	Initial Dry Unit Weight of Sample:	117.2 pcf
Area:	6.514 in^2	Initial Moisture Content:	14.5 %
Length:	6.15 in.	Specific Gravity (assumed):	2.75
Initial Void Ratio:	0.46	Initial Degree of Saturation:	86 %
Chamber Pressure:	16 psi	Proving Ring Number:	1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	24.0	16.5	6.525	2.5
0.020	0.003	42.0	28.8	6.536	4.4
0.030	0.005	58.0	39.8	6.546	6.1
0.040	0.007	75.5	51.8	6.557	7.9
0.050	0.008	91.5	62.8	6.568	9.6
0.075	0.012	130.5	89.5	6.595	13.6
0.100	0.016	167.5	114.9	6.622	17.4
0.125	0.020	199.5	136.9	6.650	20.6
0.150	0.024	225.5	154.7	6.677	23.2
0.175	0.028	250.0	171.5	6.705	25.6
0.200	0.033	270.0	185.2	6.733	27.5
0.250	0.041	305.0	209.2	6.790	30.8
0.300	0.049	332.5	228.1	6.848	33.3
0.350	0.057	356.5	244.6	6.908	35.4
0.400	0.065	379.5	260.3	6.968	37.4
0.450	0.073	398.5	273.4	7.029	38.9
0.500	0.081	415.5	285.0	7.091	40.2
0.550	0.089	430.5	295.3	7.154	41.3
0.600	0.098	445.0	305.3	7.219	42.3
0.650	0.106	458.0	314.2	7.284	43.1
0.700	0.114	470.5	322.8	7.351	43.9
0.750	0.122	481.0	330.0	7.419	44.5
0.800	0.130	491.5	337.2	7.489	45.0
0.850	0.138	500.5	343.3	7.559	45.4
0.900	0.146	510.0	349.9	7.631	45.8
0.923	0.150	513.5	352.3	7.665	46.0



Sketch of Tested Specimen

RESULTS

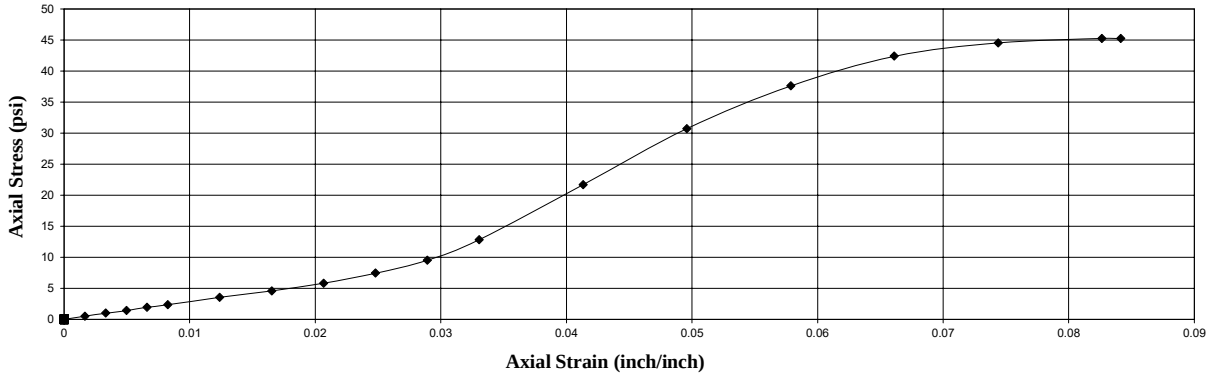
Maximum Deviator Stress 46.0 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

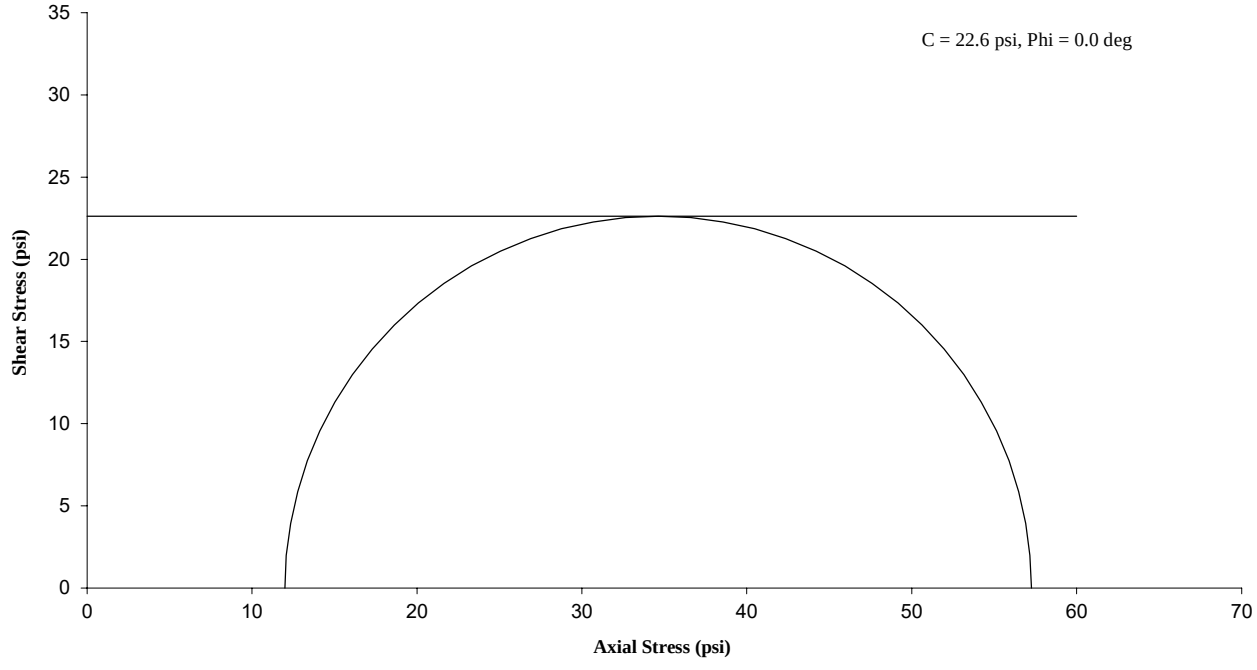
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
Project No.:	241359	Symbol	◆	■	●
Project:	FUL-20A-19.20	Init. Specimen Height (in.)	6.05	-	-
Sample ID:	B-002-0-24 ST-8	Init. Specimen Diameter (in.)	2.88	-	-
Sample Interval:	13.5 - 15.5'	Init. Moisture Content* (%)	14.9	-	-
Soil Description:	Brown/Gray SILTY CLAY, Little Sand, Trace Gravel A-6b (10)	Init. Dry Unit Weight (pcf)	116.9	-	-
				-	-
Liquid Limit:	36	Init. Void Ratio	0.47	-	-
Plastic Limit:	20	Init. Degree of Saturation (%)	88	-	-
Plasticity Index:	16	Minor Principal Stress (psi)	12.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	45.3	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	57.3	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	8.3	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

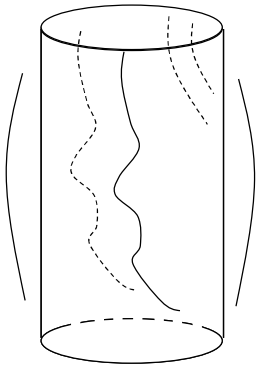
Project:	FUL-20A-19.20	Date:	7/29/2024
Client:	Tetra Tech	File:	241359B-002-0-24ST-8
Sample ID:	B-002-0-24 ST-8	Depth:	13.5 - 15.5'
Project No.:	241359	Specimen ID:	"D" (15.0 - 15.5 Feet)

SAMPLE PROPERTIES

Visual Description:	Brown/Gray SILTY CLAY, Little Sand, Trace Gravel A-6b (10)		
Diameter:	2.88 in.	Initial Dry Unit Weight of Sample:	116.9 pcf
Area:	6.514 in^2	Initial Moisture Content:	14.9 %
Length:	6.05 in.	Specific Gravity (assumed):	2.75
Initial Void Ratio:	0.47	Initial Degree of Saturation:	88 %
Chamber Pressure:	12 psi	Proving Ring Number:	1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	5.0	3.4	6.525	0.5
0.020	0.003	9.5	6.5	6.536	1.0
0.030	0.005	13.5	9.3	6.547	1.4
0.040	0.007	18.5	12.7	6.558	1.9
0.050	0.008	22.5	15.4	6.569	2.3
0.075	0.012	34.0	23.3	6.596	3.5
0.100	0.017	44.5	30.5	6.624	4.6
0.125	0.021	56.5	38.8	6.652	5.8
0.150	0.025	72.5	49.7	6.680	7.4
0.175	0.029	93.0	63.8	6.708	9.5
0.200	0.033	126.0	86.4	6.737	12.8
0.250	0.041	215.0	147.5	6.795	21.7
0.300	0.050	307.0	210.6	6.854	30.7
0.350	0.058	379.0	260.0	6.914	37.6
0.400	0.066	431.0	295.7	6.976	42.4
0.450	0.074	457.0	313.5	7.038	44.5
0.500	0.083	468.5	321.4	7.101	45.3
0.509	0.084	469.0	321.7	7.113	45.2



Sketch of Tested Specimen

RESULTS

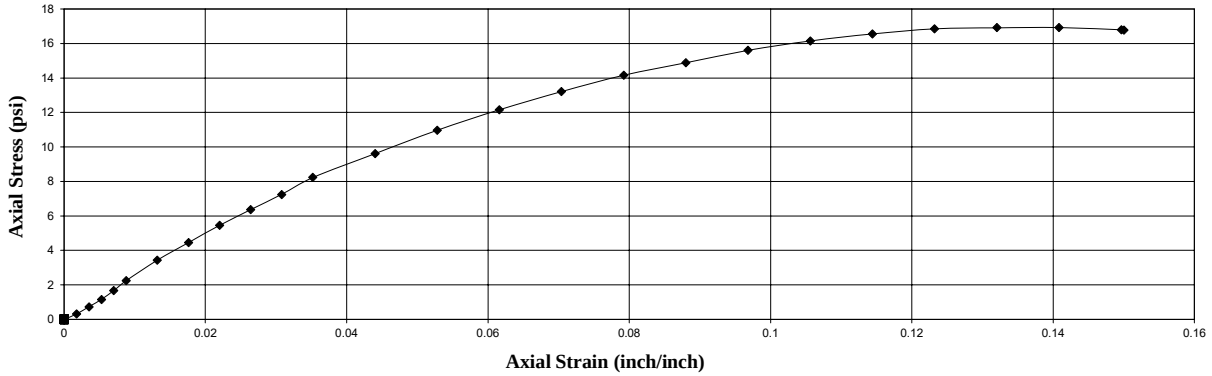
Maximum Deviator Stress 45.3 psi

Unconsolidated - Undrained Triaxial Shear Strength Test

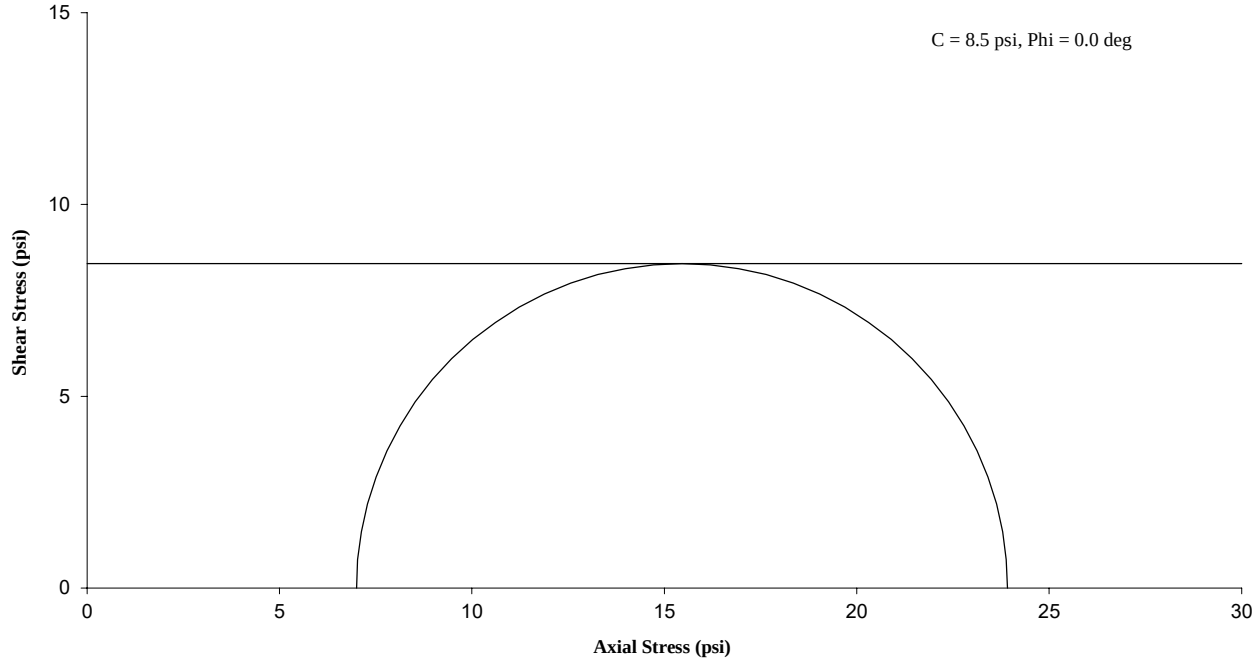
ASTM D 2850

General Sample Data		Triaxial Specimen Data			
Project No.:	241359	Symbol	◆	■	●
Project:	FUL-20A-19.20	Init. Specimen Height (in.)	5.68	-	-
Sample ID:	B-004-0-24 ST-5	Init. Specimen Diameter (in.)	2.88	-	-
Sample Interval:	7.0 - 9.0'	Init. Moisture Content* (%)	17.4	-	-
Soil Description:	Brown SILTY CLAY, Little Sand,Trace Gravel A-6b (10)	Init. Dry Unit Weight (pcf)	110.0	-	-
				-	-
Liquid Limit:	35	Init. Void Ratio	0.56	-	-
Plastic Limit:	19	Init. Degree of Saturation (%)	86	-	-
Plasticity Index:	16	Minor Principal Stress (psi)	7.0	-	-
Specific Gravity:	2.75 (Assumed)	Deviator Stress at Failure (psi)	16.9	-	-
Rate of Strain:	0.03 Inches per Minute	Major Principal Stress (psi)	23.9	-	-
Failure Criteria:	Peak Deviator Stress or Deviator Stress at 15% Axial Strain	Axial Strain at Failure (%)	14.1	-	-

Stress/Strain



Mohr Circle Plot



UNCONSOLIDATED, UNDRAINED COMPRESSIVE STRENGTH OF COHESIVE SOILS IN TRIAXIAL COMPRESSION (ASTM D 2850)

Project:	FUL-20A-19.20	Date:	7/31/2024
Client:	Tetra Tech	File:	241359B-004-0-24ST-5
Sample ID:	B-004-0-24 ST-5	Depth:	7.0 - 9.0'
Project No.:	241359	Specimen ID:	"B" (7.5 - 8.0 Feet)

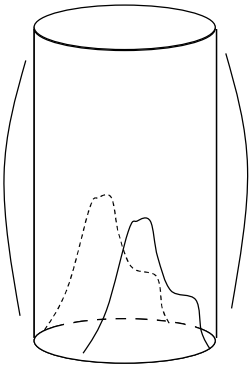
SAMPLE PROPERTIES

Visual Description: Brown SILTY CLAY, Little Sand,Trace Gravel A-6b (10)

Diameter:	2.88 in.	Initial Dry Unit Weight of Sample:	110.0 pcf
Area:	6.514 in^2	Initial Moisture Content:	17.4 %
Length:	5.68 in.	Specific Gravity (assumed):	2.75
Initial Void Ratio:	0.56	Initial Degree of Saturation:	86 %
Chamber Pressure:	7 psi	Proving Ring Number:	1155-12-13322

STRESS-STRAIN DATA

Speciman Deformation (in)	Vertical Strain	Proving Ring Reading	Piston Load (lbs)	Corrected Area (in^2)	Deviator Stress (psi)
0.000	0.000	0.0	0.0	6.514	0.0
0.010	0.002	3.0	2.1	6.526	0.3
0.020	0.004	7.0	4.8	6.537	0.7
0.030	0.005	11.0	7.5	6.549	1.2
0.040	0.007	16.0	11.0	6.561	1.7
0.050	0.009	21.5	14.7	6.572	2.2
0.075	0.013	33.0	22.6	6.602	3.4
0.100	0.018	43.0	29.5	6.631	4.4
0.125	0.022	53.0	36.4	6.661	5.5
0.150	0.026	62.0	42.5	6.691	6.4
0.175	0.031	71.0	48.7	6.721	7.2
0.200	0.035	81.0	55.6	6.752	8.2
0.250	0.044	95.5	65.5	6.814	9.6
0.300	0.053	110.0	75.5	6.878	11.0
0.350	0.062	123.0	84.4	6.942	12.2
0.400	0.070	135.0	92.6	7.008	13.2
0.450	0.079	146.0	100.2	7.075	14.2
0.500	0.088	155.0	106.3	7.143	14.9
0.550	0.097	164.0	112.5	7.213	15.6
0.600	0.106	171.5	117.6	7.284	16.2
0.650	0.114	177.5	121.8	7.356	16.6
0.700	0.123	182.5	125.2	7.430	16.8
0.750	0.132	185.0	126.9	7.505	16.9
0.800	0.141	187.0	128.3	7.582	16.9
0.850	0.150	187.5	128.6	7.661	16.8
0.852	0.150	187.5	128.6	7.664	16.8



Sketch of Tested Specimen

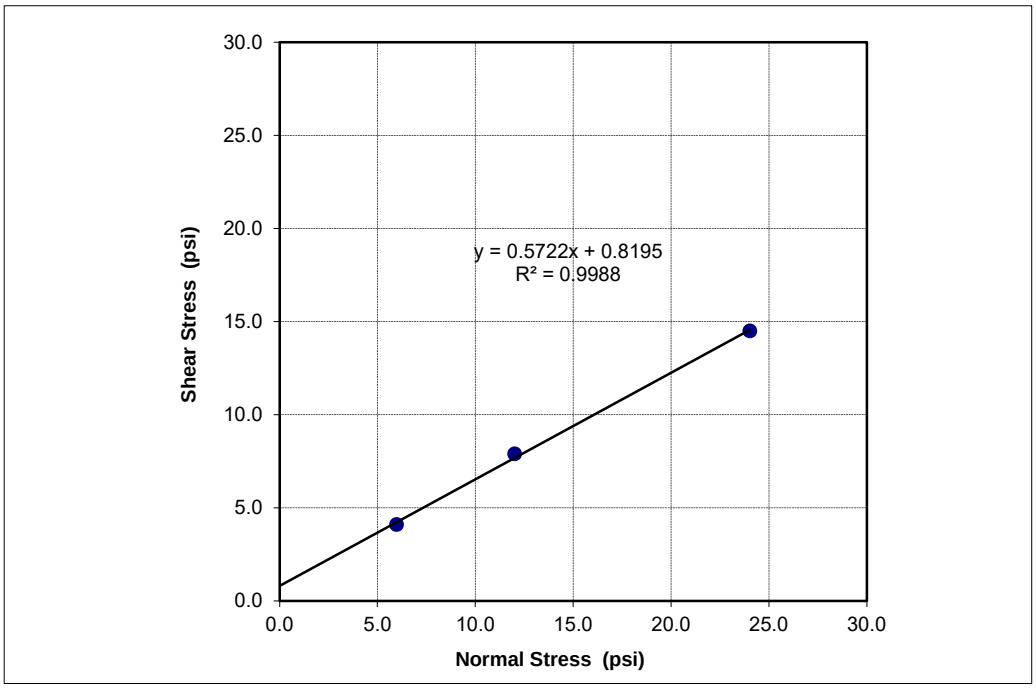
RESULTS

Maximum Deviator Stress 16.9 psi

DIRECT SHEAR TEST DATA

ASTM D 3080

Project Number:	241359	Boring Number.:	B-002-0-24
Project Name:	FUL-20A-19.20	Sample Number:	ST-8
Project Location:	Fulton County, OH	Sample Depth:	13.5 - 15.5'



Trial Number	Normal Stress (psi)	Shear Stress (psi)	ϕ (degrees)
1	6.0	4.1	29.8
2	12.0	7.9	
3	24.0	14.5	

Atterberg Limits:

Liquid Limit:	36
Plastic Limit:	20
Plasticity Index:	16

Particle Size Analysis:

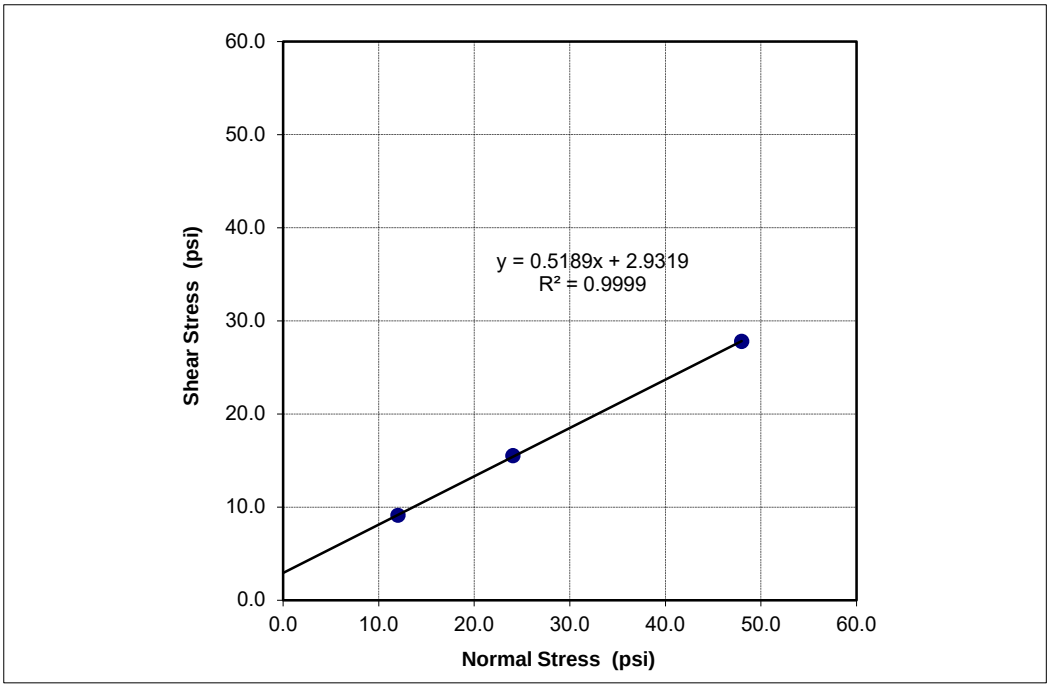
% Gravel:	5
% Sand:	15
% Silt:	24
% Clay:	56

Soil Classification: Brown/Gray SILTY CLAY, Little Sand, Trace Gravel A-6b (10)

DIRECT SHEAR TEST DATA

ASTM D 3080

Project Number:	241359	Boring Number.:	B-003-0-24
Project Name:	FUL-20A-19.20	Sample Number:	ST-16
Project Location:	Fulton County, OH	Sample Depth:	25.5 - 27.5'



Trial Number	Normal Stress (psi)	Shear Stress (psi)	ϕ (degrees)
1	12.0	9.1	
2	24.0	15.5	27.4
3	48.0	27.8	

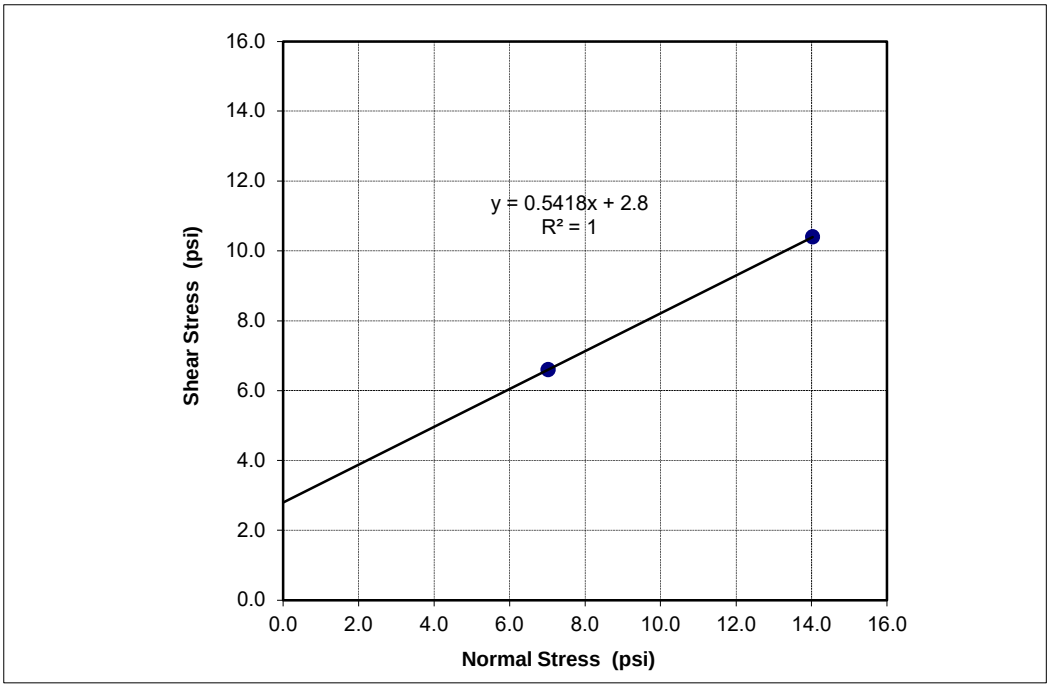
Atterberg Limits:		Particle Size Analysis:	
Liquid Limit:	40	% Gravel:	11
Plastic Limit:	22	% Sand:	19
Plasticity Index:	18	% Silt:	22
		% Clay:	48

Soil Classification: Brown/Gray SILTY CLAY, Little Sand, Little Gravel A-6b (10)

DIRECT SHEAR TEST DATA

ASTM D 3080

Project Number:	241359	Boring Number.:	B-004-0-24
Project Name:	FUL-20A-19.20	Sample Number:	ST-5
Project Location:	Fulton County, OH	Sample Depth:	7.0 - 9.0'



Trial Number	Normal Stress (psi)	Shear Stress (psi)	ϕ (degrees)
1	7.0	6.6	28.4
2	14.0	10.4	
3	-	-	

Atterberg Limits:		Particle Size Analysis:	
Liquid Limit:	35	% Gravel:	3
Plastic Limit:	19	% Sand:	17
Plasticity Index:	16	% Silt:	21
		% Clay:	59

Soil Classification: Brown SILTY CLAY, Little Sand, Trace Gravel A-6b (10)

CORE LOG for B-001-0-24

Project: FUL-20A Slide Repair

Project Location: Delta, OH

CT Project No. 241359

Core Date: July 22, 2024

ASPHALT THICKNESS (in)	=	9.75
CONCRETE THICKNESS (in)	=	6.75
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

Horizontal crack observed within concrete 3.5 and 5.5 inches below top of concrete.

CORE LOG for B-002-0-24

Project: FUL-20A Slide Repair

Project Location: Delta, OH

CT Project No. 241359

Core Date: July 19, 2024

ASPHALT THICKNESS (in)	=	11
CONCRETE THICKNESS (in)	=	7
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

CORE LOG for B-003-0-24

Project: FUL-20A Slide Repair

Project Location: Delta, OH

CT Project No. 241359

Core Date: July 18, 2024

ASPHALT THICKNESS (in)	=	14.25
CONCRETE THICKNESS (in)	=	7.75
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

CORE LOG for B-004-0-24

Project: FUL-20A Slide Repair

Project Location: Delta, OH

CT Project No. 241359

Core Date: July 16, 2024

ASPHALT THICKNESS (in)	=	14
CONCRETE THICKNESS (in)	=	0
CORE BARREL DIAMETER (in)	=	4.0

VISUAL DESCRIPTION:

Horizontal cracks at approximately 5.5 and 10.5 inches below top of pavement.

APPENDIX A

Geotechnical Engineering Design Checklists

I. Geotechnical Design Checklists	
Project: FUL-20A-19.20	PDP Path:
PID: 119890	Review Stage:

Checklist	Included in This Submission
II. Reconnaissance and Planning	✓
III. A. Centerline Cuts III. B. Embankments III. C. Subgrade	
IV. A. Foundations of Structures IV. B. Retaining Wall	
V. A. Landslide Remediation V. B. Rockfall Remediation V. C. Wetland or Peat Remediation V. D. Underground Mine Remediation V. E. Surface Mine Remediation V. F. Karst Remediation	
VI. A. Geotechnical Profile VI. D. Geotechnical Reports	✓

II. Reconnaissance and Planning Checklist

C-R-S:	FUL-20A-19.20	PID:	119890	Reviewer:	CPI	Date:	9/30/2024

Reconnaissance		(Y/N/X)	Notes:
1	Based on Section 302.1 in the SGE, have the necessary plans been developed in the following areas prior to the commencement of the subsurface exploration reconnaissance:	N	Plans to be prepared by Tetra Tech. Site location coordinated between Tetra Tech and ODOT D2 for the area of geotechnical exploration.
	Roadway plans		
	Structures plans		
	Geohazards plans		
2	Have the resources listed in Section 302.2.1 of the SGE been reviewed as part of the office reconnaissance?	Y	
3	Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance?	X	
4	If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded?	X	For geohazard, anticiapte topographic survey would identify.

Planning - General		(Y/N/X)	Notes:
5	In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and historic subsurface exploration work been considered?	Y	
6	Has the ODOT Transportation Information Mapping System (TIMS) been accessed to find all available historic boring information and inventoried geohazards?	Y	None available.
7	Have the borings been located to develop the maximum subsurface information while using a minimum number of borings, utilizing historic geotechnical explorations to the fullest extent possible?	Y	However no historic borings.
8	Have the topography, geologic origin of materials, surface manifestation of soil conditions, and any other special design considerations been utilized in determining the spacing and depth of borings?	Y	Borings throughout slide area and nearby drainage structure.
9	Have the borings been located so as to provide adequate overhead clearance for the equipment, clearance of underground utilities, minimize damage to private property, and minimize disruption of traffic, without compromising the quality of the exploration?	Y	

II. Reconnaissance and Planning Checklist

Planning - General	(Y/N/X)	Notes:
10 Have the scaled boring plans, showing all project and historic borings, and a schedule of borings in tabular format, been submitted to the District Geotechnical Engineer?	X	Included with proposal uploaded to SAFe for ODOT review.
The schedule of borings should present the following information for each boring:		
a. exploration identification number	Y	
b. location by station and offset	N	
c. estimated amount of rock and soil, including the total for each for the entire program.	Y	

Planning – Exploration Number	(Y/N/X)	Notes:
11 Have the coordinates, stations and offsets of all explorations (borings, soundings, test pits, etc.) been identified?	Y	
12 Has each exploration been assigned a unique identification number, in the following format X-ZZZ-W-YY, as per Section 303.2 of the SGE?	Y	
13 When referring to historic explorations that did not use the identification scheme in 12 above, have the historic explorations been assigned identification numbers according to Section 303.2 of the SGE?	X	

II. Reconnaissance and Planning Checklist

Planning – Boring Types		(Y/N/X)	Notes:
14	Based on Sections 303.3 to 303.7.6 of the SGE, have the location, depth, and sampling requirements for the following boring types been determined for the project?		
	Check all boring types utilized for this project:		
	Existing Subgrades (Type A)		
	Roadway Borings (Type B)		
	Embankment Foundations (Type B1)		
	Cut Sections (Type B2)		
	Sidehill Cut Sections (Type B3)		
	Sidehill Cut-Fill Sections (Type B4)		
	Sidehill Fill Sections on Unstable Slopes (Type B5)		
	Geohazard Borings (Type C)	✓	
	Lakes, Ponds, and Low-Lying Areas (Type C1)		
	Peat Deposits, Compressible Soils, and Low Strength Soils (Type C2)		
	Uncontrolled Fills, Waste Pits, and Reclaimed Surface Mines (Type C3)		
	Underground Mines (C4)		
	Landslides (Type C5)	✓	
	Rock Slope (Type C6)		
	Karst (Type C7)		
	Proposed Underground Utilities (Type D)		
	Structure Borings (Type E)		
	Bridges (Type E1)		
	Culverts (Type E2 a,b,c)		
	Retaining Walls (Type E3 a and b)		
	Noise Barrier (Type E4)		
	CCTV & High Mast Lighting Towers (Type E5)		
	Buildings and Salt Domes (Type E6)		

VI.B. Geotechnical Reports

C-R-S:	FUL-20A-19.20	PID:	119890	Reviewer:	CPI	Date:	4/17/2025

General		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'?	Y	
3	Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'?	Y	No comments received on the geotechnical data report. This is the final Submittal.
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files meet this demand?	Y	gINT project file is being provided with this final report Submittal.
5	Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ?	Y	
6	Have all geotechnical reports being submitted been titled correctly as prescribed in Section 706.1 of the SGE?	Y	Data report, so somewhat modified.
Report Body		(Y/N/X)	Notes:
7	Do all geotechnical reports being submitted contain the following:		
a.	an Executive Summary as described in Section 706.2 of the SGE?	N	Data report, so not included.
b.	an Introduction as described in Section 706.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 706.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 706.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 706.6 of the SGE?	N	Undisturbed sample laboratory test results provided instead.
f.	a section titled "Analyses and Recommendations," as described in Section 706.7 of the SGE?	X	Data report, so not included.
Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 706.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 706.8.1 of the SGE?	Y	

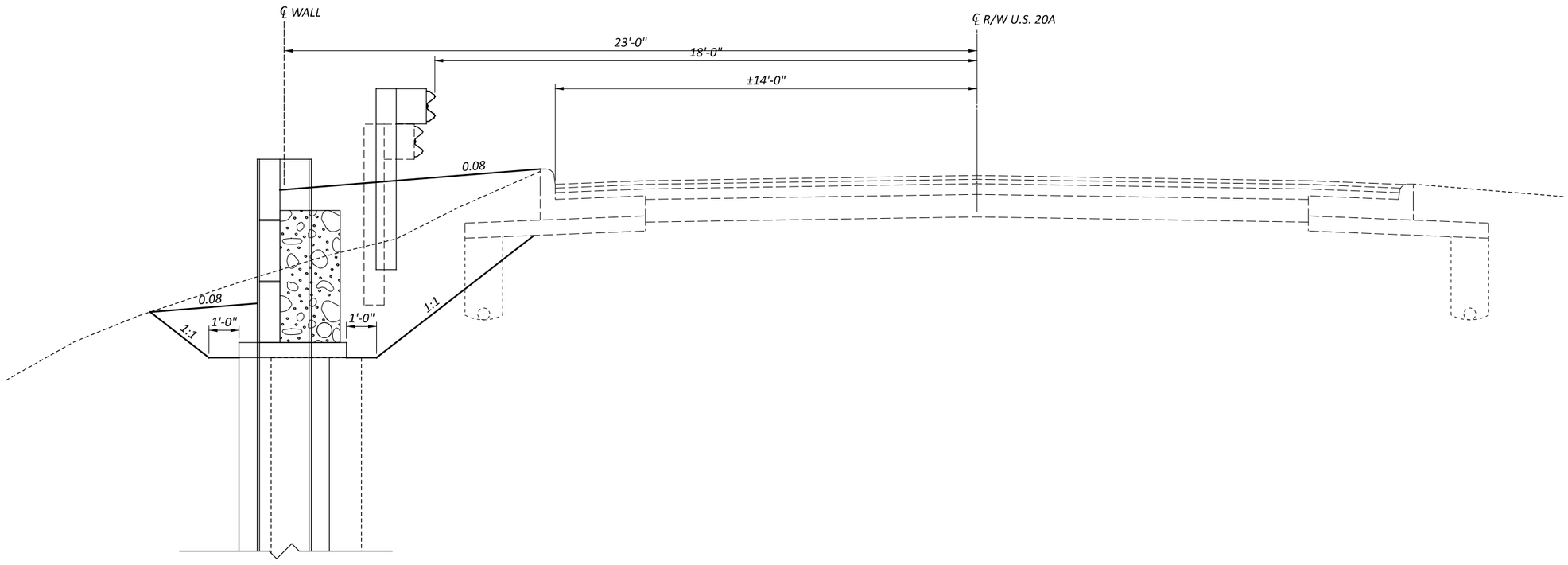
VI.B. Geotechnical Reports

Appendices		(Y/N/X)	Notes:
10	Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 706.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 706.8.3 of the SGE?	Y	
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 706.8.4 of the SGE?	X	Data report, so not included.

Appendix C
Engineering Analyses and Computations

CALCULATION AND DESIGN

SUMMARY



TYPICAL SECTION

APPLIES:
STA. 1013+93 TO STA. 1016+15

LEGEND

1. ITEM 202 - GUARDRAIL REMOVED
2. ITEM 202 - CURB REMOVED
3. ITEM 203 - EXCAVATION
4. ITEM 203 - EMBANKMENT
5. ITEM 609 - CURB, TYPE 6??
6. ITEM 606 - GUARDRAIL, TYPE MGS, HALF POST SPACING
7. ITEM 659 - SEEDING AND MULCHING

A. EXISTING ASPHALT CONCRETE

FUL-US20A-19.20 SLIDE REPAIR

MODEL: Sheet_SurvFt PAPERSIZE: 34x22 (in.) DATE: 9/29/2024 TIME: 8:45:28 PM USER: Dave,Charville
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TYPICAL SECTIONS

DESIGN AGENCY

DESIGNER GCB

REVIEWER DTC MM-DD-YY

PROJECT ID 119890

SHEET P.2 TOTAL 32

FUL-20A-19.20, Delta, Ohio
Slide Mitigation

Brian Lawrence
11/18/2024

903 LPILE Analysis - Ohio GDM

Loads on shafts determined, find displacement, shear, and moment distributions using p-y software.
Perform p-y analysis in accordance with Section 1501.7, except as modified in Section 903.

903.1 Conversion of Force per Shaft to Distributed Lateral Load.

NOTE: THIS HIGHLIGHTED STEP IS NOT REQUIRED - SEE 903.3.2, METHOD 2, BELOW.

Need to determine:
1. Depth to shear surface
2. Depth to bedrock
3. Single shaft resultant force

Then calculate a triangular distribution of loading, from 0 at GS to maximum depth of shear surface. This horizontal earth pressure (EH) load is solely horizontal, ignore vertical.

In LPILE, distributed load must be converted into units of lbs/in of length along drilled shaft.

Is horizontal distance between drilled shafts and traffic loading less than or equal to half the depth to the shear surface at location of drilled shafts (dT), apply unfactored vehicular live load surcharge of 250 psf per AASHTO LRFD 3.11.6.4.

Do not represent load on shaft as single resultant point load and cut off the top of shaft.

903.2 p-y Modification Factor

$D := 36\ in$ $S := 6\ ft$

$$P_m := 0.64 \cdot \left(\frac{S}{D}\right)^{0.34} = 0.81$$

For 1<S/D<3.75
where 0.5<Pm<1.0

Use Pm = 0.64 to depth of lowered ground level because plug piles are used to that depth

903.3 Soil Layering and p-y models

LPILE will calculate passive resistance "Mobilized Soil Reaction" for soil mass. Actual passive resistance of downhill soil mass will be reduced, but not usually become zero as full depth crack theories assert.
Method 2 applies for this project.

903.3.2 Method 2

Case where downhill soil mass left as-is, and downhill soil mass does not meet minimum required FS of 1.3

1. Determine angle of steepness of slope from horizontal, downhill of the drilled shafts

$\beta_{dh} := \operatorname{atan}\left(\frac{1}{1.5}\right) = 33.7\ deg$ Average slope approximately 1.7:1, but use steeper 1.5:1 seen in places on slope.

2. Determine depth to shear surface at location of the drilled shafts.

Drilled shafts 23 feet horizontal from CL, 9 feet from pavement edge
Estimate shear surface at 12 feet below ground at location of shaft.
$d_T := 12\ ft$

3. Lower ground surface by:

$GS := 0\ ft$

$\Delta GS := GS - d_T \cdot \tan\left(\beta_{dh}\right) = -8\ ft$ Conservatively assume 12-foot lowering of ground surface

4. GWT in logs generally below stream level. But B-4 it is at El 708. Assume GWT at El 710.

903.4 Drilled Shaft Length
Embed below in a solid stratum below shear failure, so drilled shaft head displacement within serviceability limits (903.8). Ideally embed in bedrock, but minimum 10 feet below shear surface. Also, must be geotechnically stable (903.9)

903.5 Steel reinforcement
Steel HP or W sections have advantages with installation. Use W-section.

903.6 Section Type, Dimensions, Cross-section properties
Choose in accordance with Section 1501.7.5
Ground surface should be represented as level, not inclined. Inclining slope is not relevant since we are already discounting soil resistance near the ground surface.

Use ASTM A709 minimum 50 ksi yield strength for steel reinforcing beam section. Typically use Class QC5 concrete. If shafts are 7 feet or greater diameter, used QC4 concrete.

1501.7.5: For a HP-section or W-section embedded in a concrete drilled shaft, including the portion of a soldier pile embedded in the drilled shaft foundation, analyze the vertical wall element as a "Round Shaft with Casing and Core/Insert" under "Section Type" in LPILE. Set the casing outside diameter to the nominal drilled shaft diameter, set the casing wall thickness to 0 inches unless a permanent steel casing is used, and set the number of bars to "0" for the rebars unless a supplemental reinforcing bar cage is used. For the core/insert type, choose either "Steel H Section Strong Axis" or "Steel AISC Section Strong Axis," depending on whether a HP-section or W-section is being used. This analysis method accounts for the additional stiffness from the composite action of the concrete contained within the web and flanges of the steel section. It will also produce a non-linear non-elastic analysis that accounts for the loss of stiffness from a cracked section with deflections beyond the tensile strain limit for the concrete.

903.7 Pile-Head Loadings and Options
Choose pile-head loadings and options IAW 1051.7.6
Run 2 p-y analyses for each loading case:

1. Unfactored loading for Service LS - to determine head deflection

2. Factored loading for Strength LS - check structural and geotechnical resistance

Check that the head deflection of the vertical wall element is less than the required serviceability limit (see Section 1501.6) and check the factored resistance of the vertical wall element versus the calculated factored maximum moment and maximum shear (see BDM Sections 307.6, 307.6.3, and 307.7.1)

1501.7.6 Pile-head Loading and Options
Use Shear = 0 and Moment = 0 at the head.
Set option Compute Top Y vs L to "Yes"

903.8 LPILE Output

Review LPILE for both states IAW 1501.7.7
For Strength LS - pay attention to possible artificial plastic hinging, modify as needed IAW 1501.7.8
If DS within 10 feet of edge of pavement, limit deflection to 2" or less

If fails deflection, resize and run again

1501.7.7 LPILE Output

Top deflection - Service Limit State

$y_{top} := 1.5\ in$ $y_{limit} := 2\ in$ OK

1501.7.8 Artificial Plastic Hinging

From LPILE plot, plastic hinge would form between 4 and 7 inches displacement. Since maximum displacement is under these values, an artificial plastic hinge does not form.

OK

903.9 Geotechnical Resistance

Check for overturning of DS either with p-y analysis method in LPILE or with moment equilibrium methods.
* Do not use Geotechnical Strength Limit State check per FHWA-NHI-18-024 (GEC 10). Not intended for retaining structures and will be overly conservative*

1501.7.9 Geotechnical Overturning Resistance

Perform Strength Limit State check.
Look at pile-head deflection in Strength LS p-y analysis.
If deflection does not indicate failure (failure of program to converge or very large deflection (100 inches) - then it is stable.

903.9.1 LPILE Deflection Analysis

Check geotechnical overturning using p-y methods IAW 1501.7.9 - simpler method to check geotechnical resistance.

Deflection (Strength)

$\delta_{strength} := 3.5\ in$ OK

904 Steel Beam Section Design

After checking Service LS deflection and Strength LS moment and shear distributions, check that shaft reinforcement capable of resisting calculated factored maximum moment and maximum shear force.
This section gives guidance for using HP or W sections for reinforcement.
ODOT using LRFD methods for design of steel beam sections resisting shear and moment due to lateral earth loadings.

904.1 Minimum Concrete Cover for Reinforcing Steel

For DS up to 4 feet, cover is 3 inches
For DS over 4 feet, cover is 6 inches

904.2 LRFD

Strength LS:
Live load surcharge - 1.75 load factor
Horizontal earth pressure - 1.50 load factor

Structural capacity (flexure and shear) of steel beam section.
Flexural resistance 1.0 resistance factor
Shear resistance 1.0 resistance factor

Check flexural resistance of steel beam section according to AASHTO LRFD 6.10.8

Check shear resistance AASHTO 6.10.9

If steel embedded in concrete drilled shaft, assume continuous lateral bracing and transverse stiffening.
If steel section extends above DS and is unbraced (as in a soldier pile wall) analyze steel section for flexural buckling with an unbraced length equal to exposed length per AASHTO 6.9.4.1.2.

Bending and Shear - Strength Limit State

$V_{max} := 71.3\ kip$ $M_{max} := 8091\ in \cdot kip$ OK

Fv*Vn = 375 kip Fb*Mn = 12,700 in-kip

Surcharge Calculation

FUL-20A-19.20

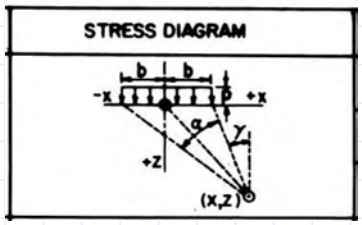
Brian Lawrence
10.04.24

From NAVFAC DM 7.1-166 - Uniform Strip load, vertical stress

$b := \frac{55\ ft}{2} = 27.5\ ft$

$q := 250\ psf$

$z_{15} := 15\ ft$



at z:0 ft (top of wall), surcharge = 0 psf

$K_A := 0.35$

At 15 ft

$\gamma_{15} := \operatorname{atan}\left(\frac{9\ ft}{z_{15}}\right) = 0.54$

$\omega_{15} := \operatorname{atan}\left(\frac{64\ ft}{z_{15}}\right) = 1.341$

$\alpha_{15} := \omega_{15} - \gamma_{15} = 0.8$

$\sigma_{z15} := \frac{q}{\pi} \cdot \left(\alpha_{15} + \sin\left(\alpha_{15}\right) \cdot \cos\left(\alpha_{15} + 2\ \gamma_{15}\right)\right) = 46.2\ psf$

$\sigma_{h15} := \sigma_{z15} \cdot K_A = 16.2\ psf$

At 30 ft

$z_{30} := 30\ ft$

$\gamma_{30} := \operatorname{atan}\left(\frac{9\ ft}{z_{30}}\right) = 0.291$

$\omega_{30} := \operatorname{atan}\left(\frac{64\ ft}{z_{30}}\right) = 1.132$

$\alpha_{30} := \omega_{30} - \gamma_{30} = 0.841$

$\sigma_{z30} := \frac{q}{\pi} \cdot \left(\alpha_{30} + \sin\left(\alpha_{30}\right) \cdot \cos\left(\alpha_{30} + 2\ \gamma_{30}\right)\right) = 75.6\ psf$

$\sigma_{h30} := \sigma_{z30} \cdot K_A = 26.5\ psf$

At 45 ft

$z_{45} := 45\ ft$

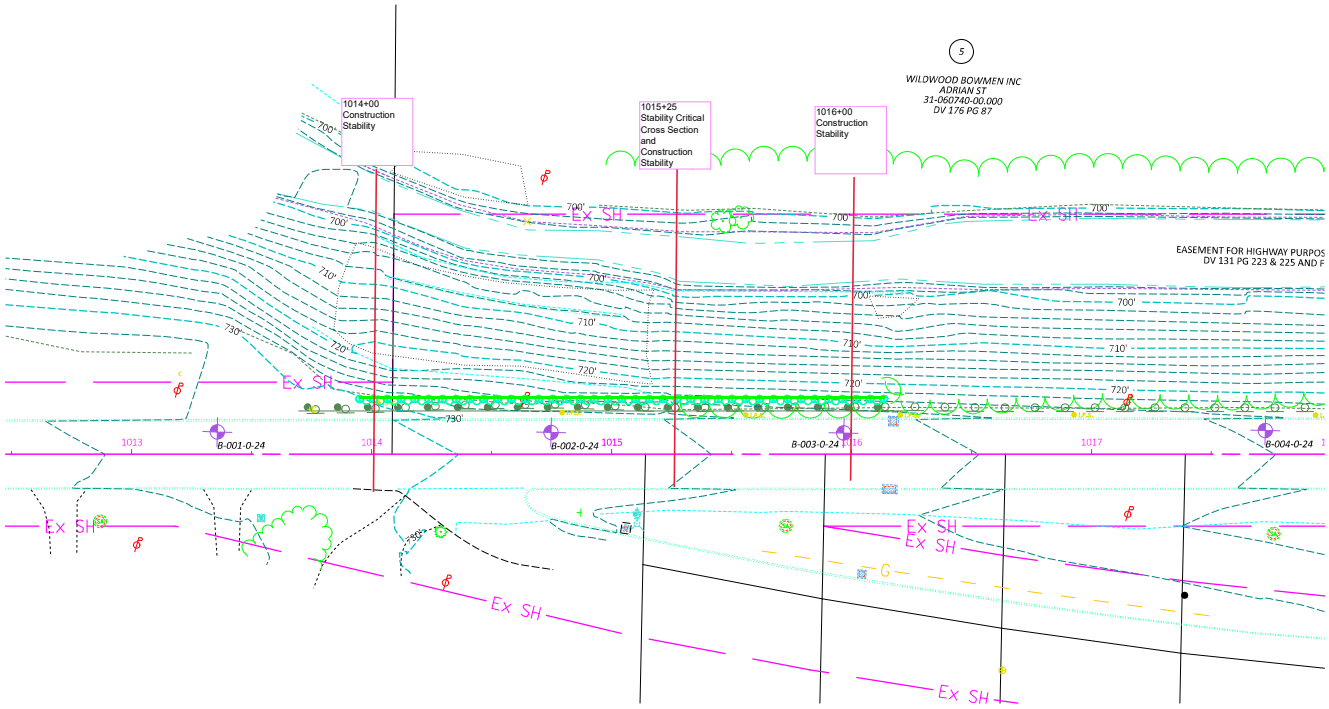
$\gamma_{45} := \operatorname{atan}\left(\frac{9\ ft}{z_{45}}\right) = 0.197$

$\omega_{45} := \operatorname{atan}\left(\frac{64\ ft}{z_{45}}\right) = 0.958$

$\alpha_{45} := \omega_{45} - \gamma_{45} = 0.761$

$\sigma_{z45} := \frac{q}{\pi} \cdot \left(\alpha_{45} + \sin\left(\alpha_{45}\right) \cdot \cos\left(\alpha_{45} + 2\ \gamma_{45}\right)\right) = 82.7\ psf$

$\sigma_{h45} := \sigma_{z45} \cdot K_A = 28.9\ psf$ Maximum approximately 29 psf vertical for surcharge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1014+00
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Stability
1015+25
Stability Critical
Cross Section
and
Construction
Stability
1016+00
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Stability
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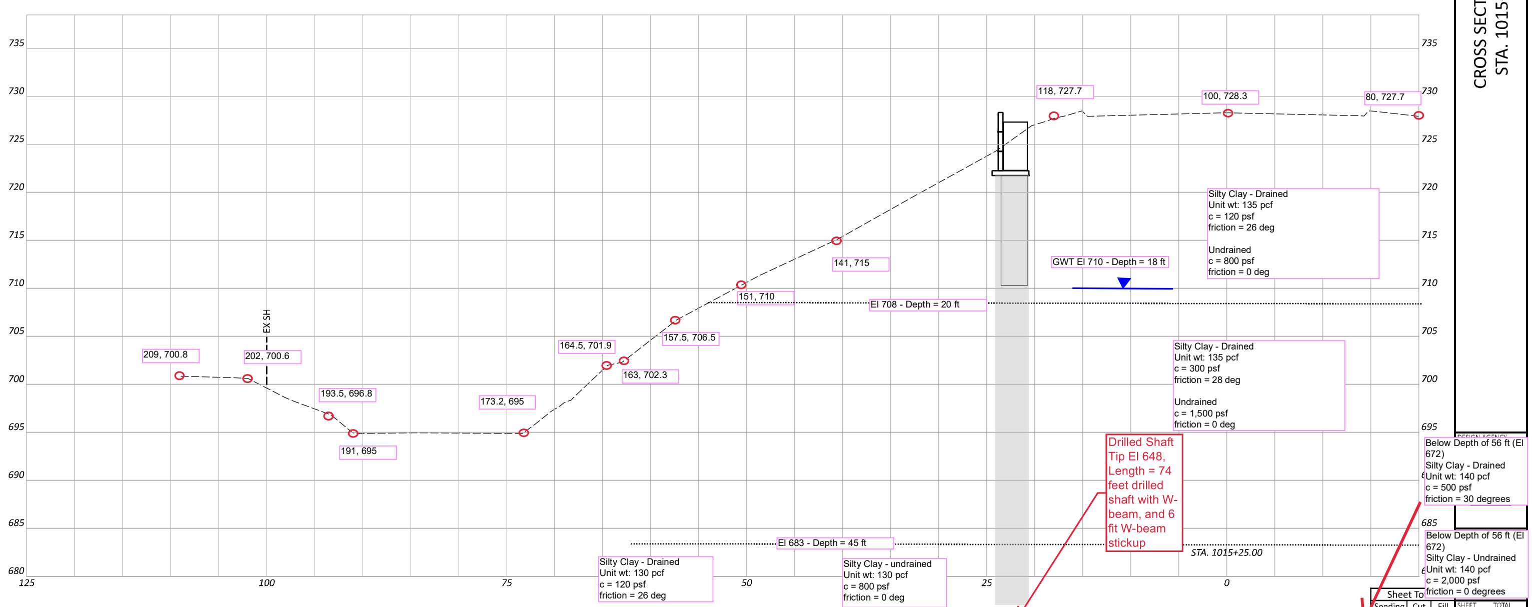
1016
1017

STABILITY 1015+25

EXISTING

STABILITY
SECTION 1015+25



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CROSS SECTIONS
STA. 1015+25

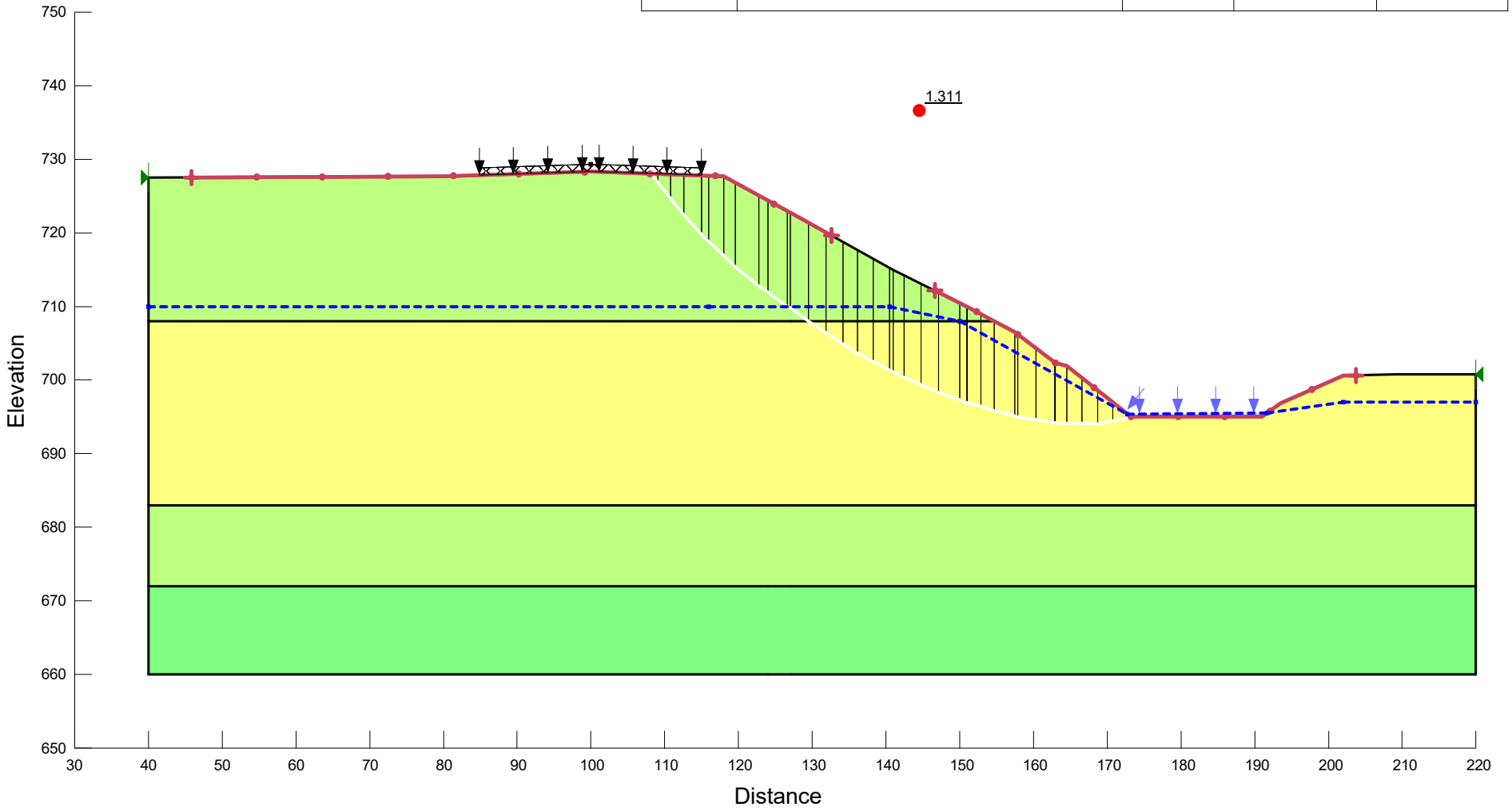
Sheet To		
Seeding	Cut	Fill

SHEET P.14 | TOTAL 32

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	MStiff Silty Clay - Drained	130	120	26
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30

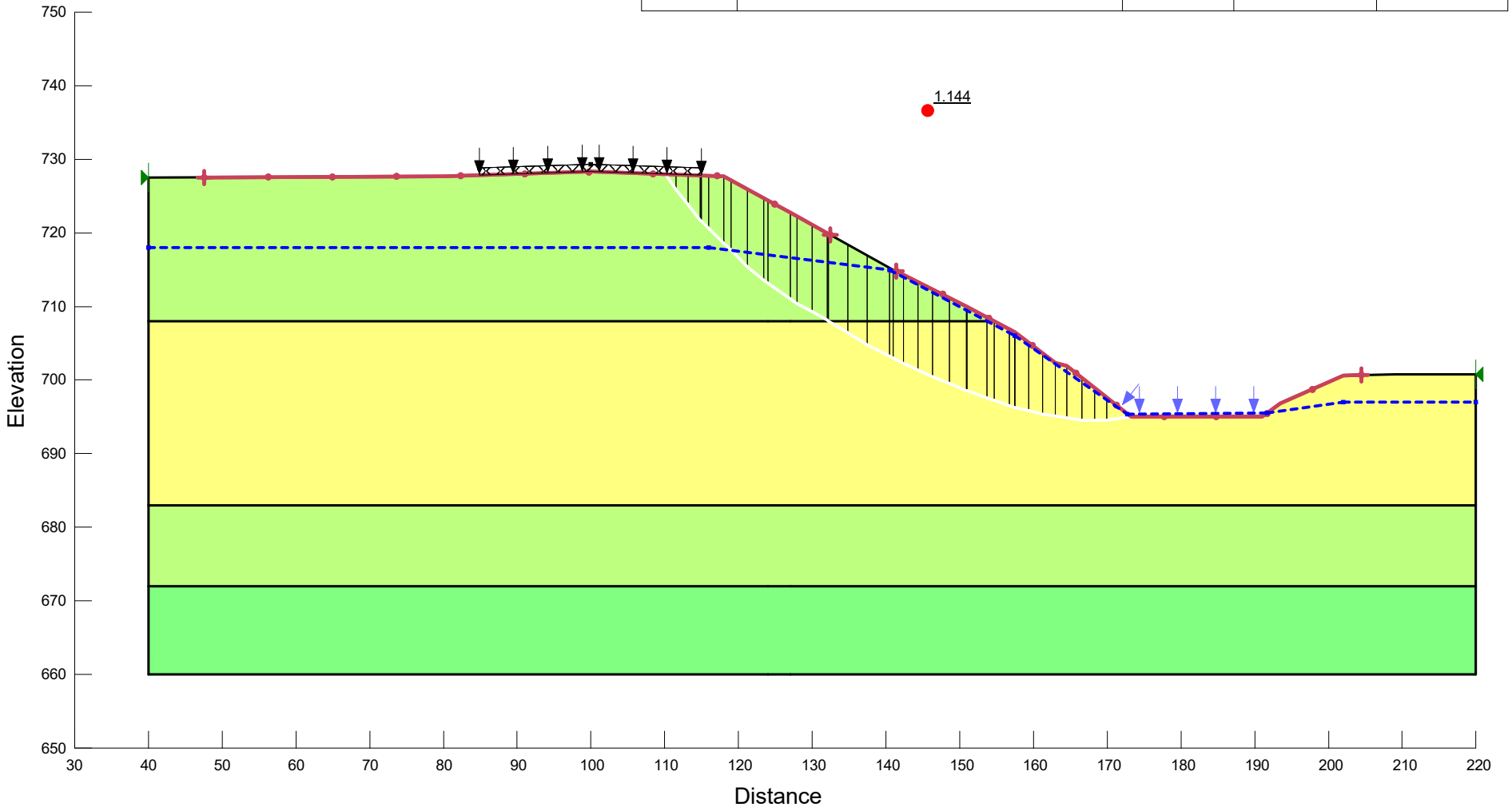
File Name: FUL-20A-19.20 1015+25 Existing.gsz
Description: Existing Condition, drained

Surcharge (Unit Weight): 250 pcf



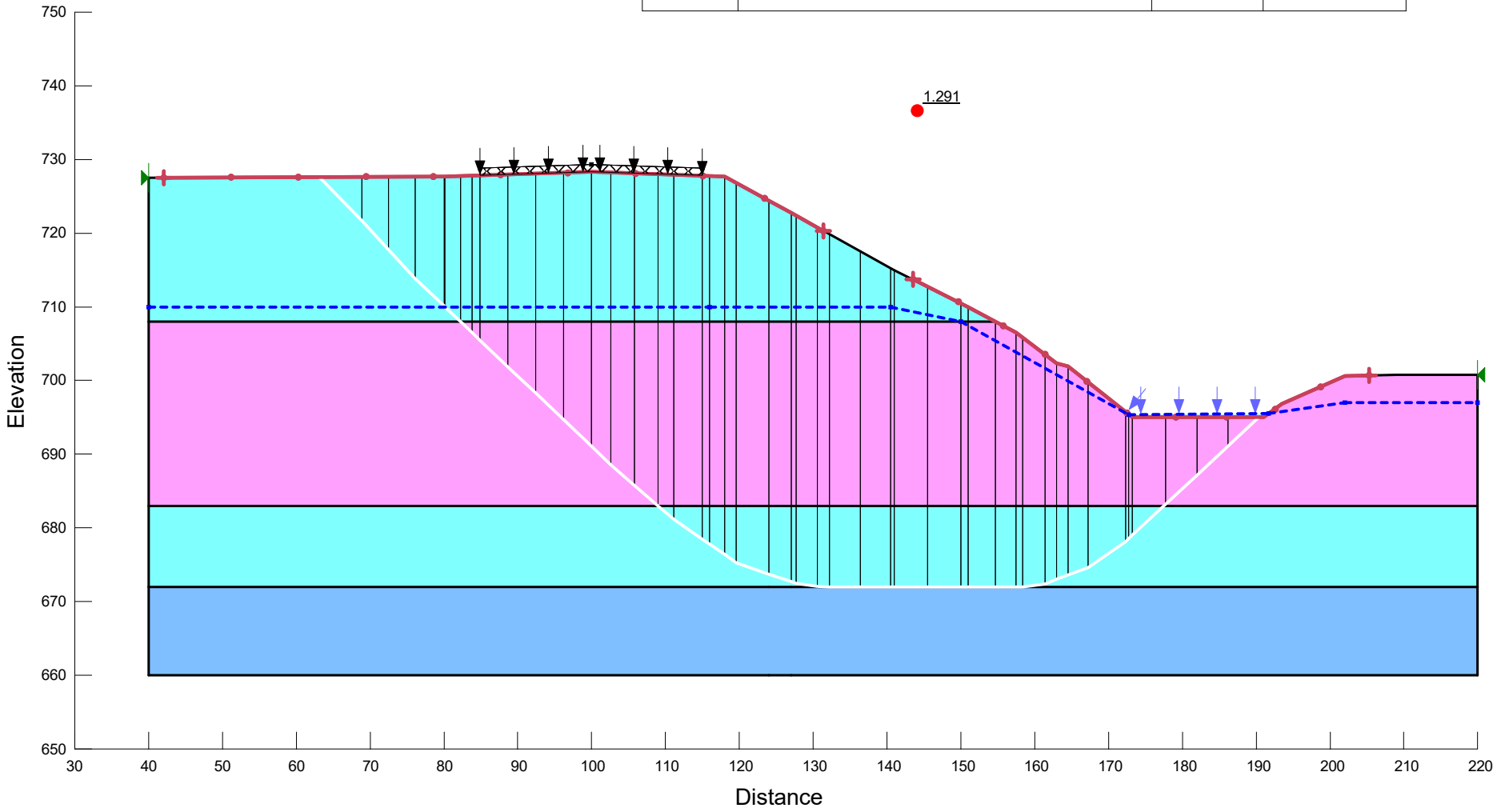
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	MStiff Silty Clay - Drained	130	120	26
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30

File Name: FUL-20A-19.20 1015+25 Existing.gsz
Description: Existing condition, RDD
Surcharge (Unit Weight): 250 pcf



Color	Name	Unit Weight (pcf)	Total Cohesion (psf)
	MStiff Silty Clay - Undrained	130	800
	Stiff to VStiff Silty Clay - Undrained	135	1,500
	VStiff to Hard Silty Clay - Undrained	140	2,000

File Name: FUL-20A-19.20 1015+25 Existing.gsz
Description: Existing condition, undrained
Surcharge (Unit Weight): 250 pcf

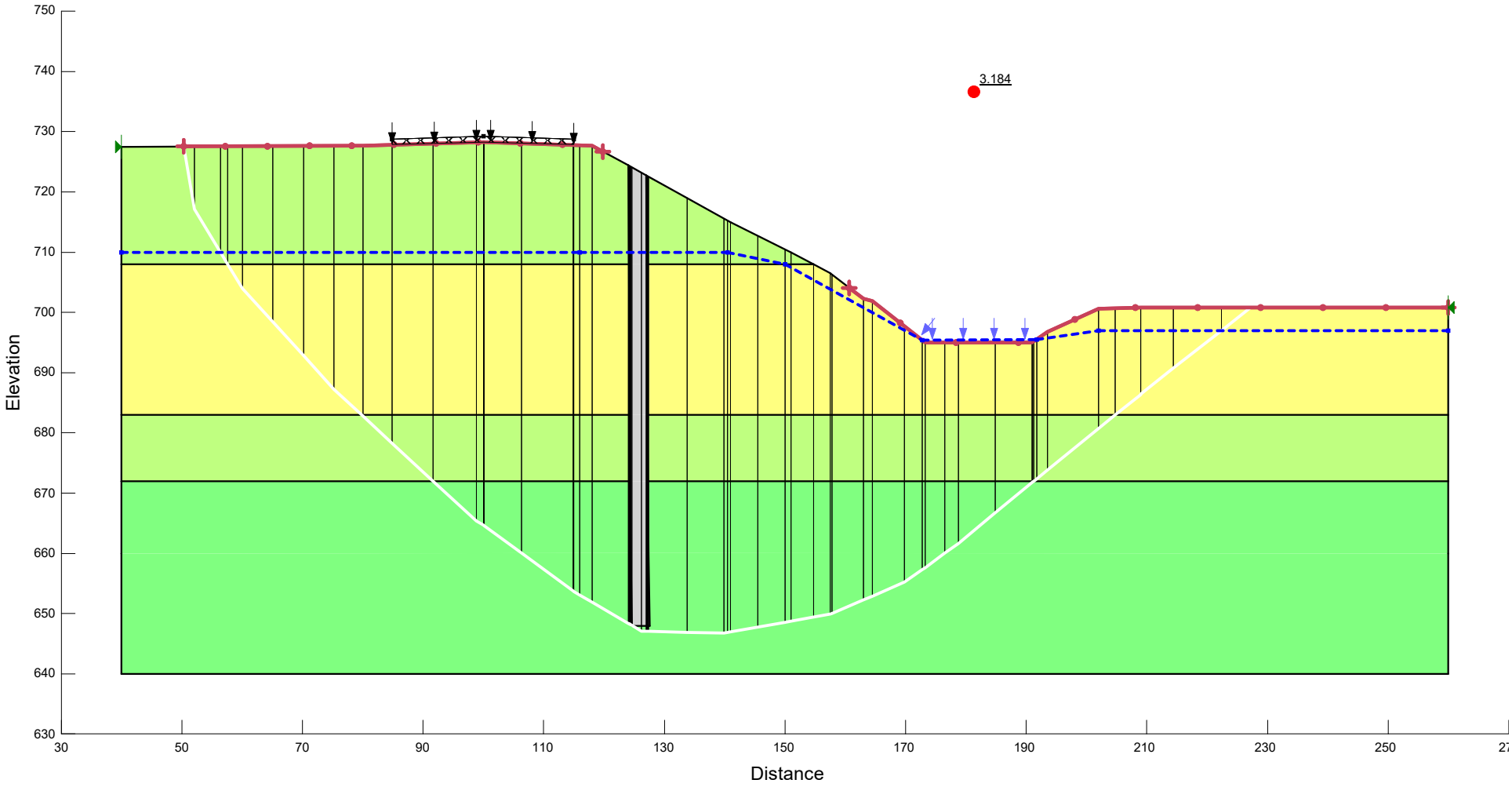


STABILITY 1015+25

WITH DRILLED SHAFT WALL

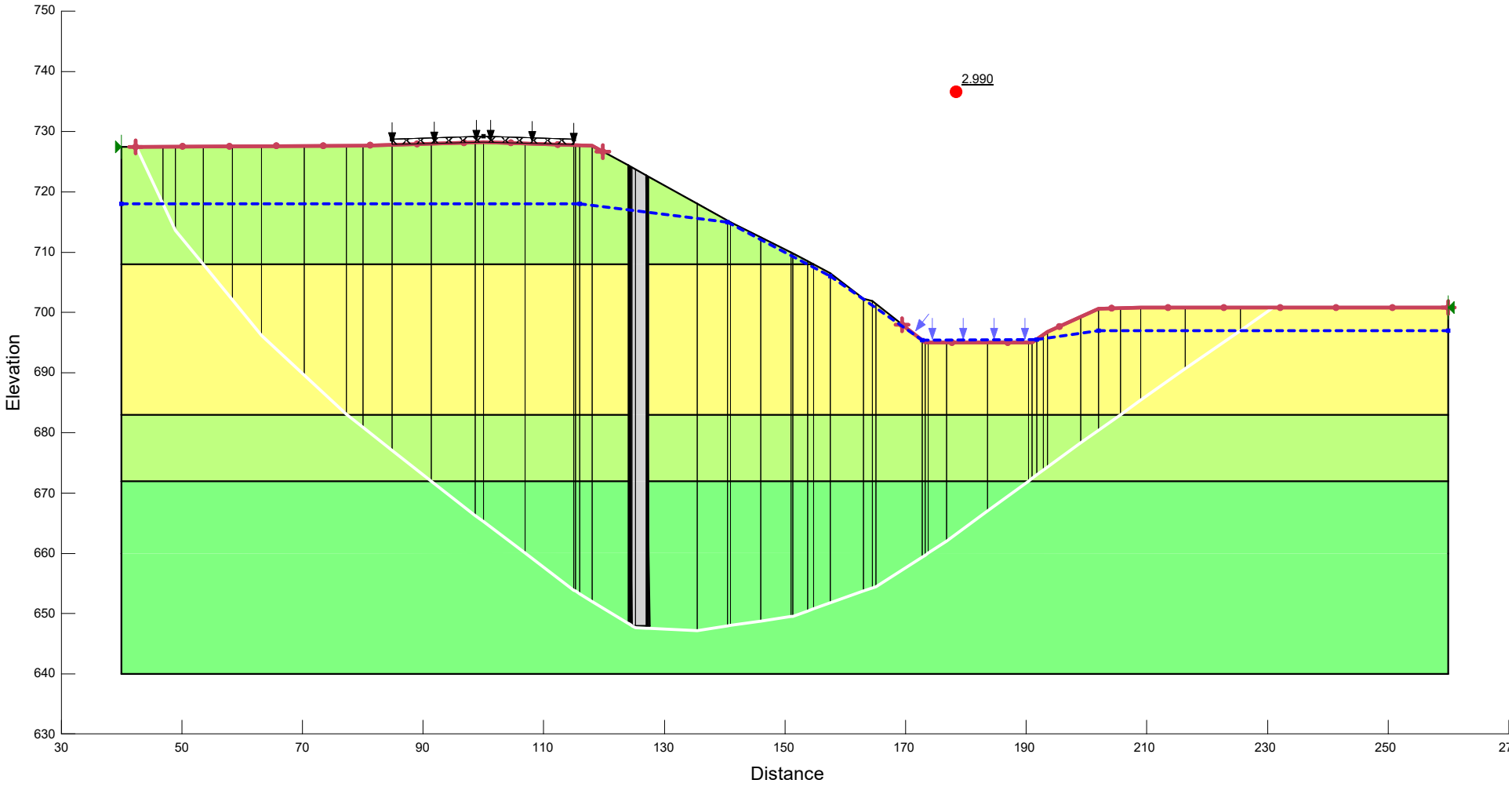
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Drilled Shaft	150		
	MStiff Silty Clay - Drained	130	120	26
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30

File Name: FUL-20A-19.20 1015+25 Existing.gsz
Description: With DS wall, drained
Surcharge (Unit Weight): 250 pcf



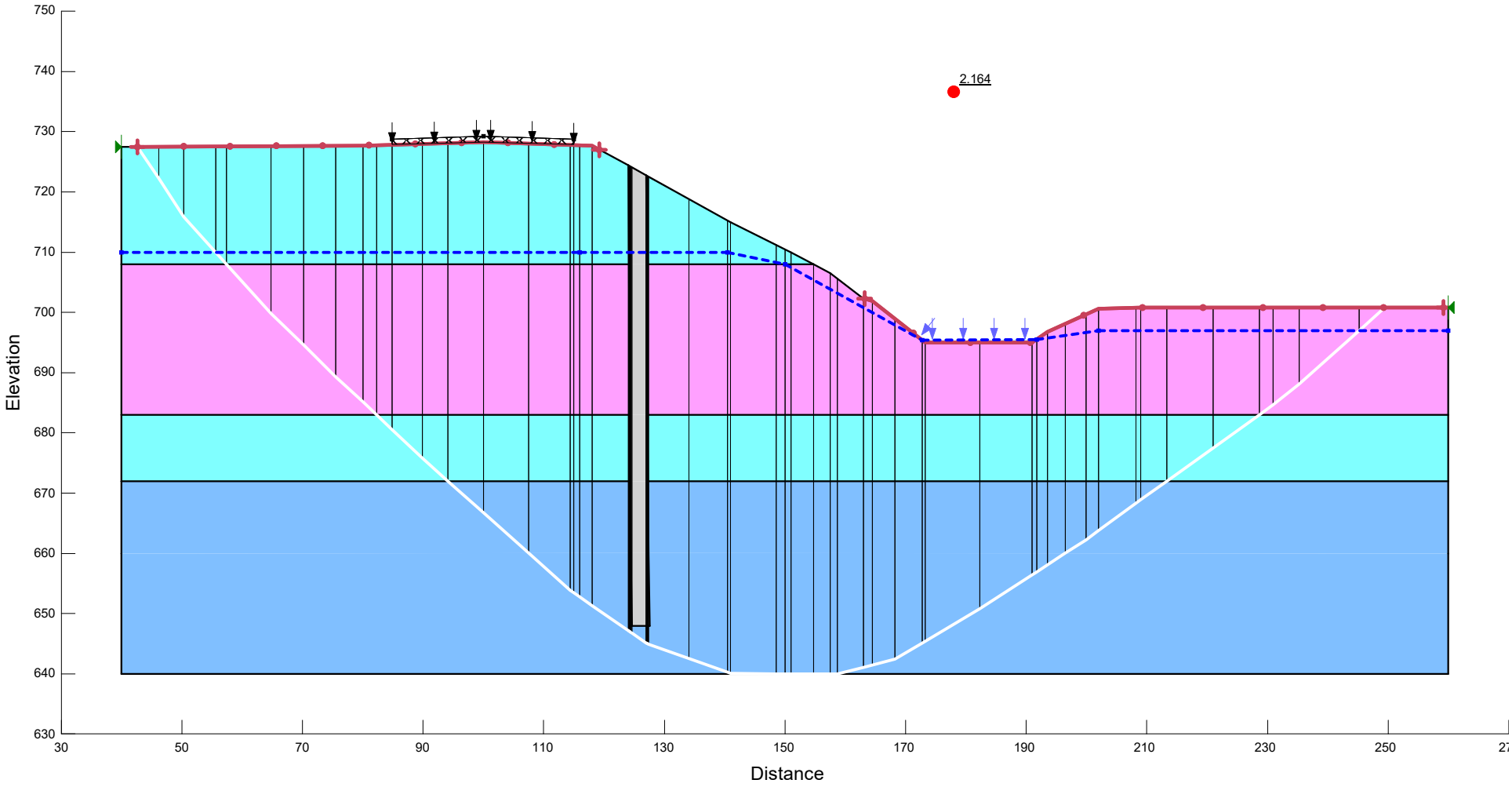
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Drilled Shaft	150		
	MStiff Silty Clay - Drained	130	120	26
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30

File Name: FUL-20A-19.20 1015+25 Existing.gsz
Description: With DS wall, RDD
Surcharge (Unit Weight): 250 pcf



Color	Name	Unit Weight (pcf)	Total Cohesion (psf)
	Drilled Shaft	150	
	MStiff Silty Clay - Undrained	130	800
	Stiff to VStiff Silty Clay - Undrained	135	1,500
	VStiff to Hard Silty Clay - Undrained	140	2,000

File Name: FUL-20A-19.20 1015+25 Existing.gsz
Description: With DS wall, undrained
Surcharge (Unit Weight): 250 pcf



STABILITY DURING CONSTRUCTION

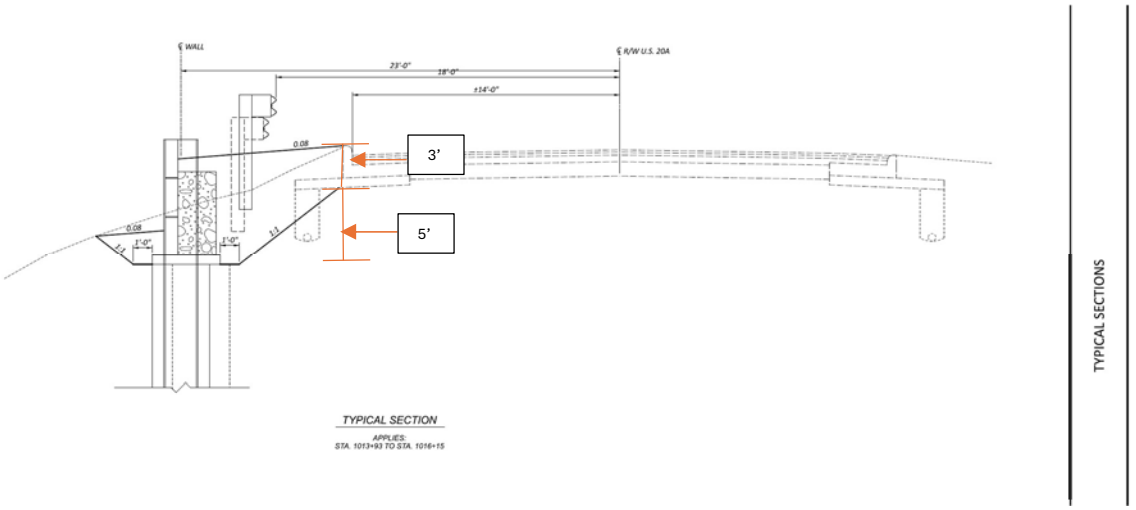
FOR DRILLED SHAFT WALL

1014+00

1015+25

1016+00

Typical Section



Drilled shaft rig, example dimensions, long-reach rig.

Extended (working) track width – 12’ 4”

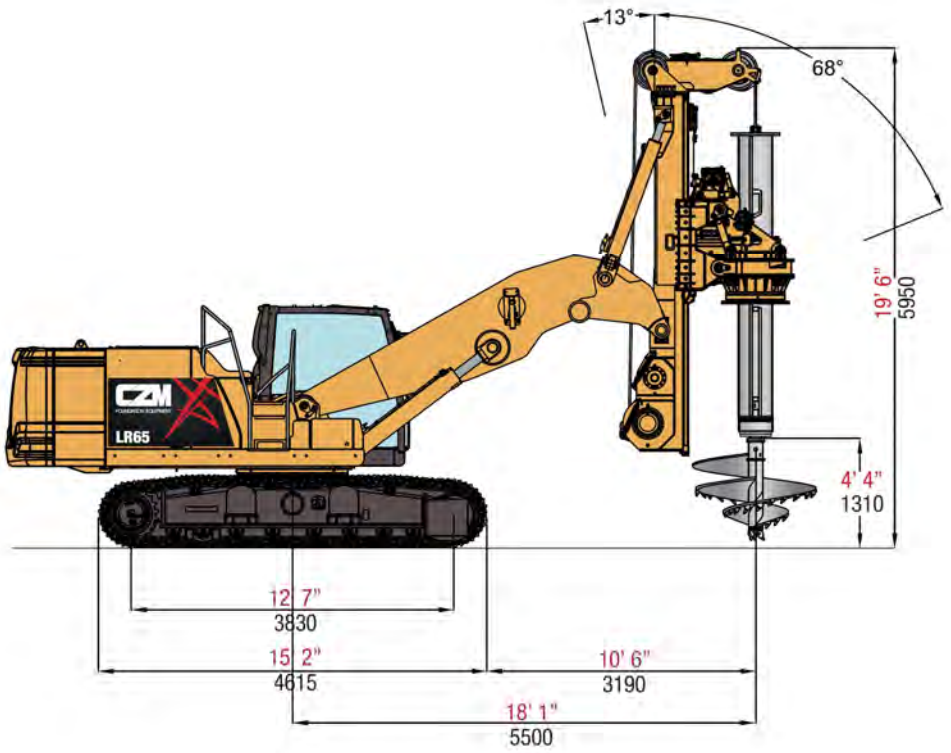
Track length – 12’7”

Weight – 80,000 lbs

Reach – 10’6” from front of track to center of drilled shaft bit.

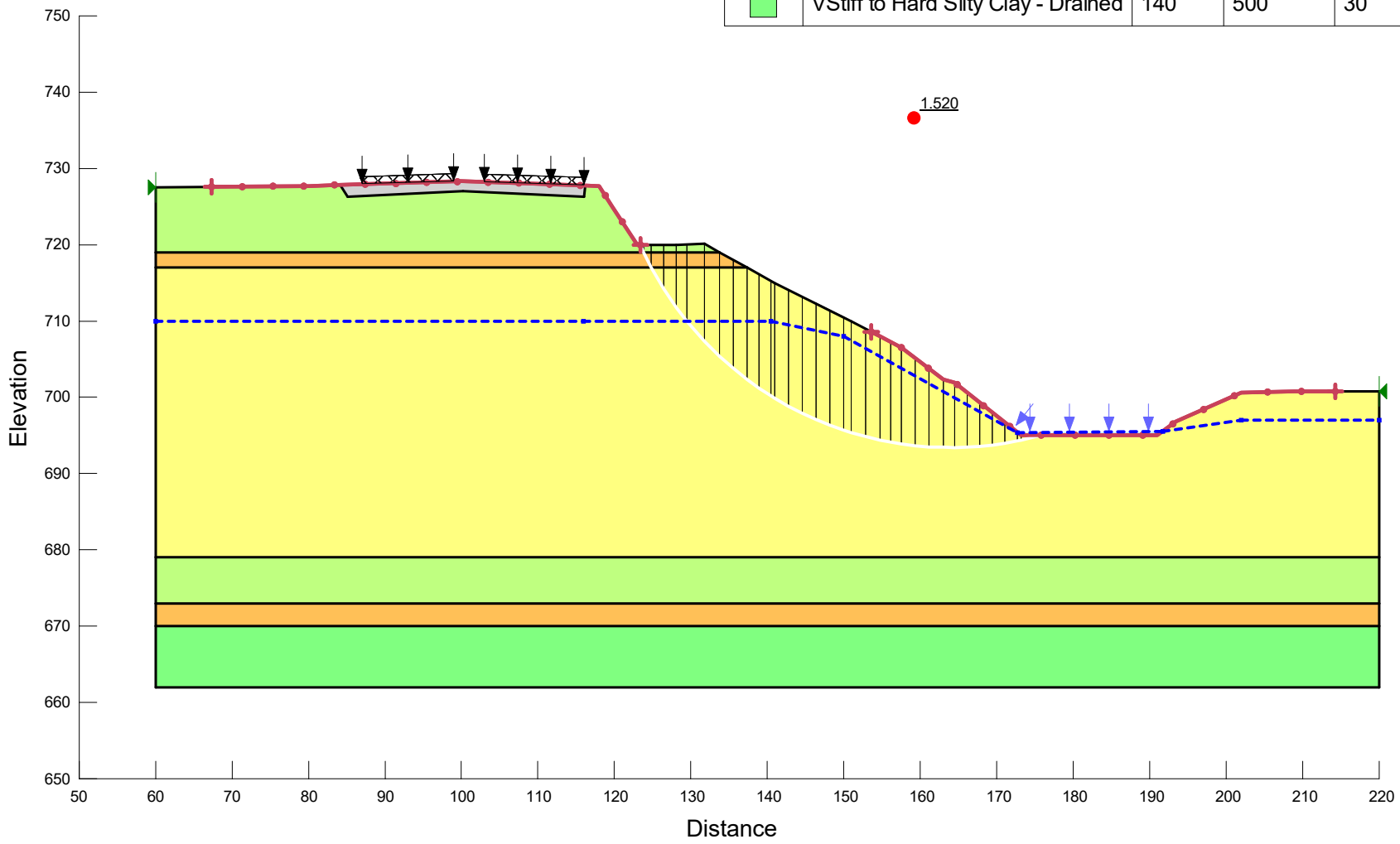
Distance from edge of pavement to drilled shaft approximately 9 feet.

Therefore, model as surcharge load 13’ wide by 13’ long, 1’ from crest. Load intensity is 80 kips/(13’) = 473 lb/ft – say 500 psf. Draw in SLOPE/W as 500 psf load, 1’ high, 13’ long from 1’ off crest to 14’ off crest into roadway.


13°
68°
19' 6"
5950
4' 4"
1310
LR65
12' 7"
3830
15' 2"
4615
10' 6"
3190
18' 1"
5500

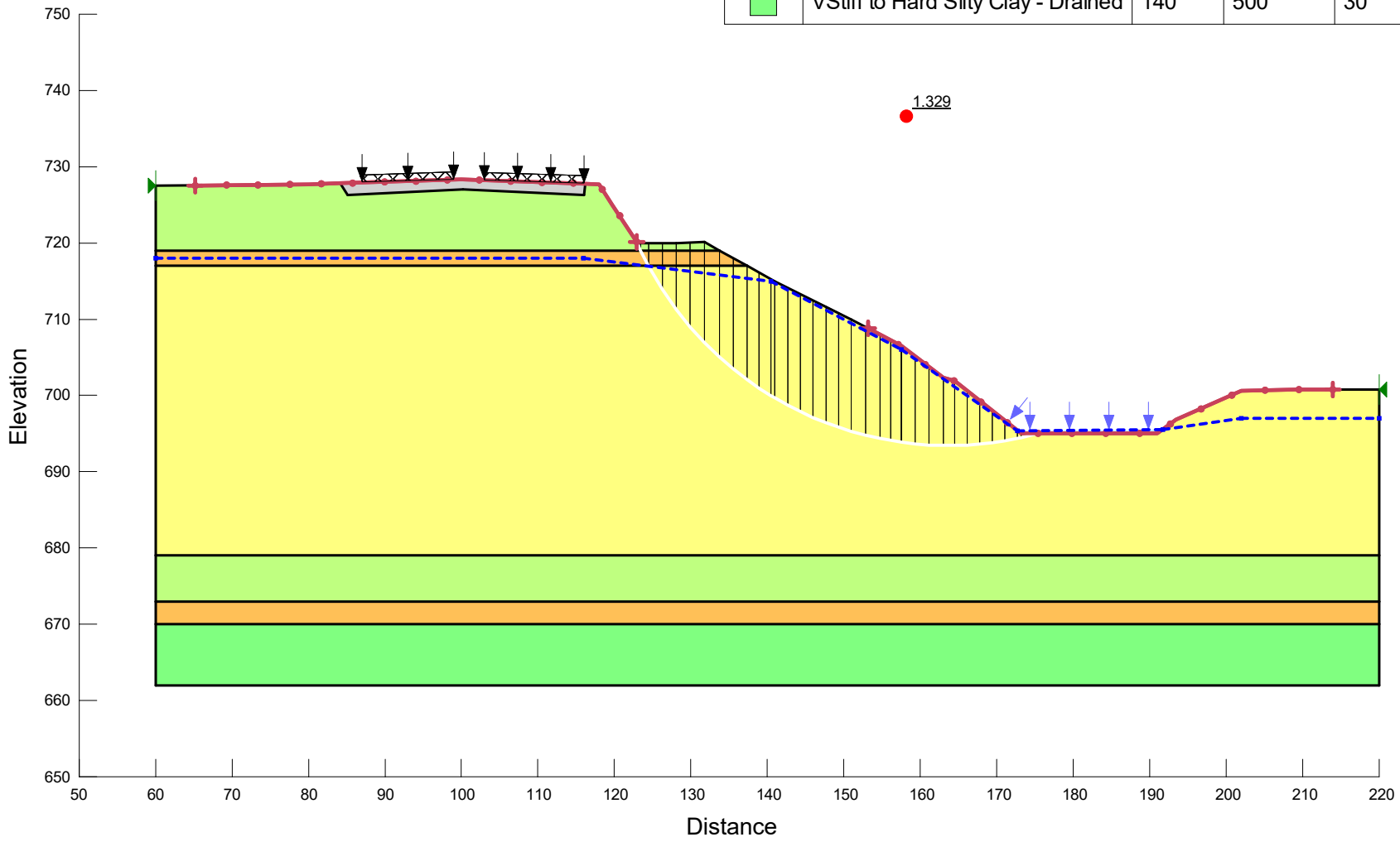
File Name: FUL-20A-19.20 1014+00 Construction Exc rev.gsz
Description: 1014+00 Construction, Drained
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Drilled Shaft_Pavement	150	10,000	0
	MStiff Silty Clay - Drained	130	120	26
	Silty Clay and Sand	130	0	30
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30



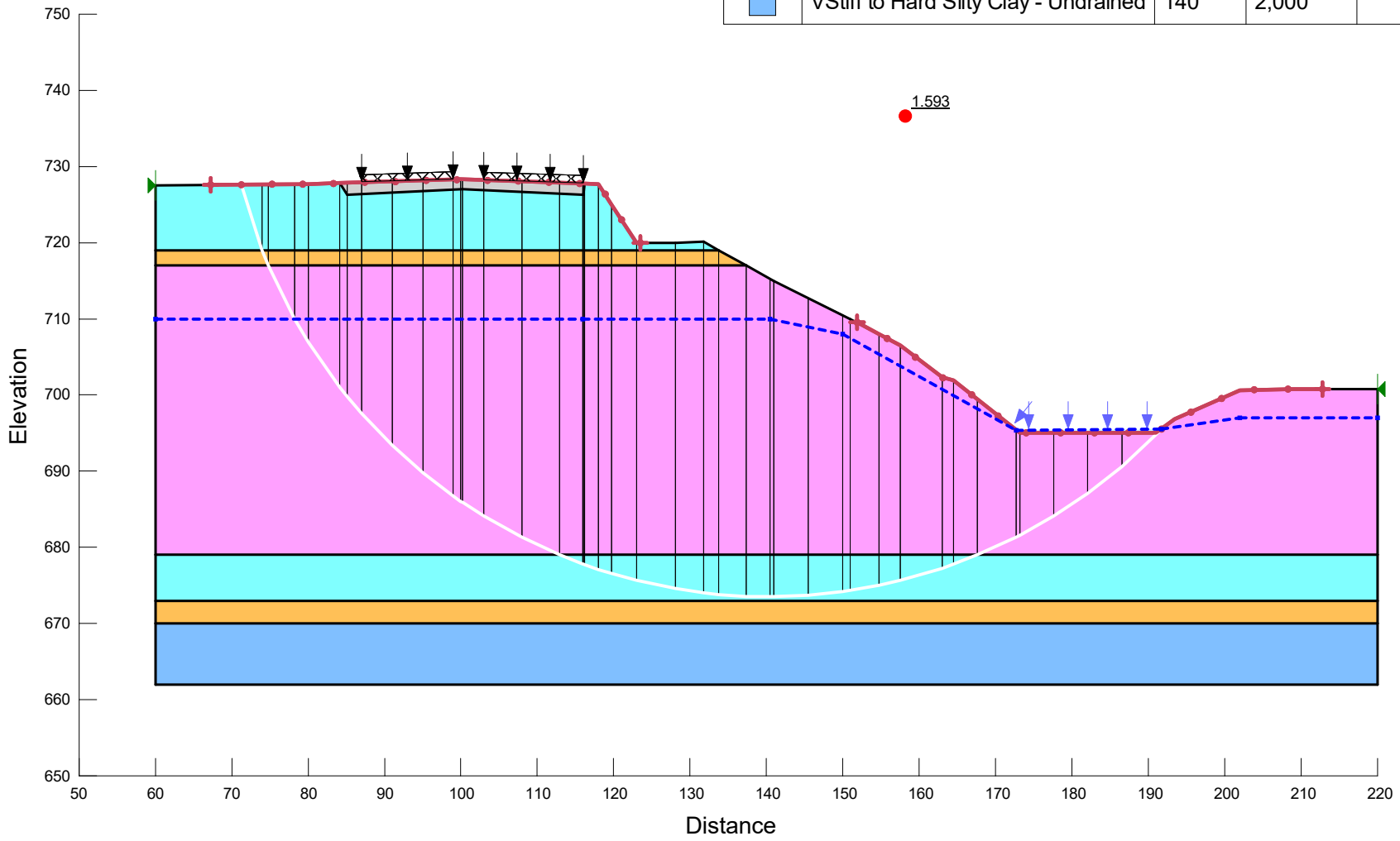
File Name: FUL-20A-19.20 1014+00 Construction Exc rev.gsz
Description: 1014+00 Construction, Rapid DD
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Drilled Shaft_Pavement	150	10,000	0
	MStiff Silty Clay - Drained	130	120	26
	Silty Clay and Sand	130	0	30
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30



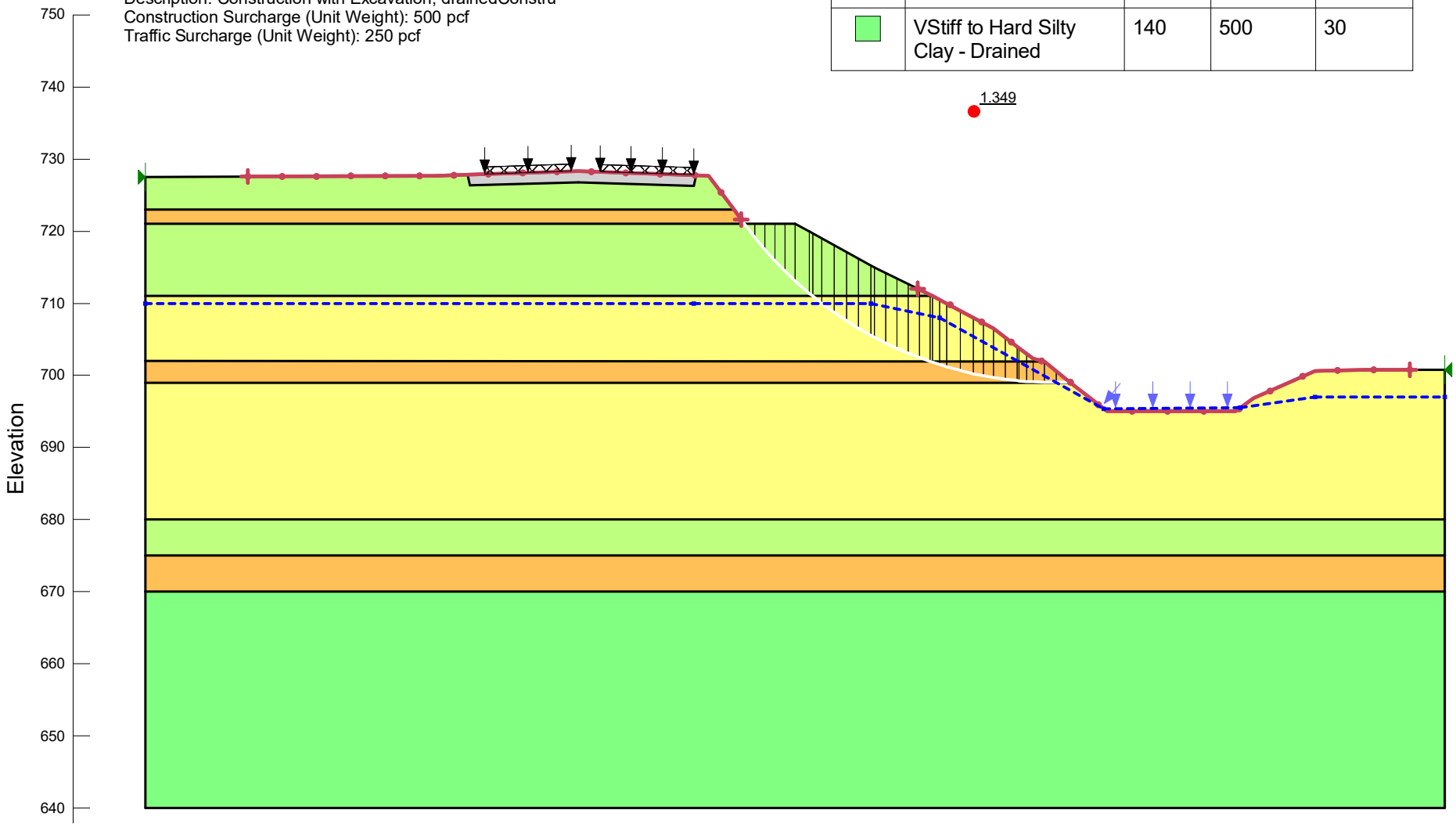
File Name: FUL-20A-19.20 1014+00 Construction Exc rev.gsz
Description: 1014+00 Construction, Undrained
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf

Color	Name	Unit Weight (pcf)	Total Cohesion (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	Drilled Shaft_Pavement	150		10,000	0
	MStiff Silty Clay - Undrained	130	800		
	Silty Clay and Sand	130		0	30
	Stiff to VStiff Silty Clay - Undrained	135	1,500		
	VStiff to Hard Silty Clay - Undrained	140	2,000		



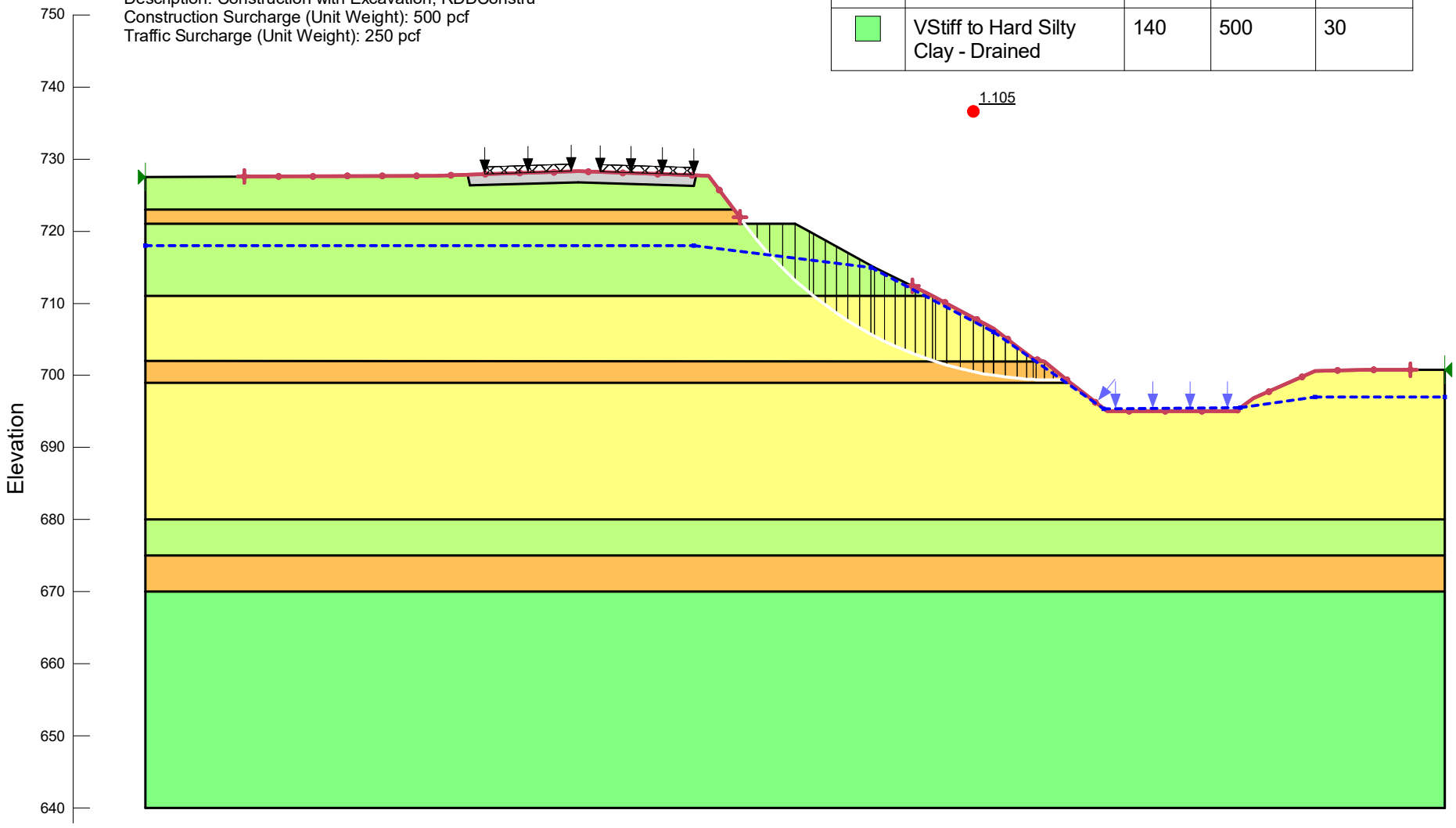
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	MStiff Silty Clay - Drained	130	120	26
	Pavement	150	10,000	0
	Silty Clay and Sand	130	0	30
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30

File Name: FUL-20A-19.20 1015+25 Construction Exc rev.gsz
Description: Construction with Excavation, drainedConstru
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf



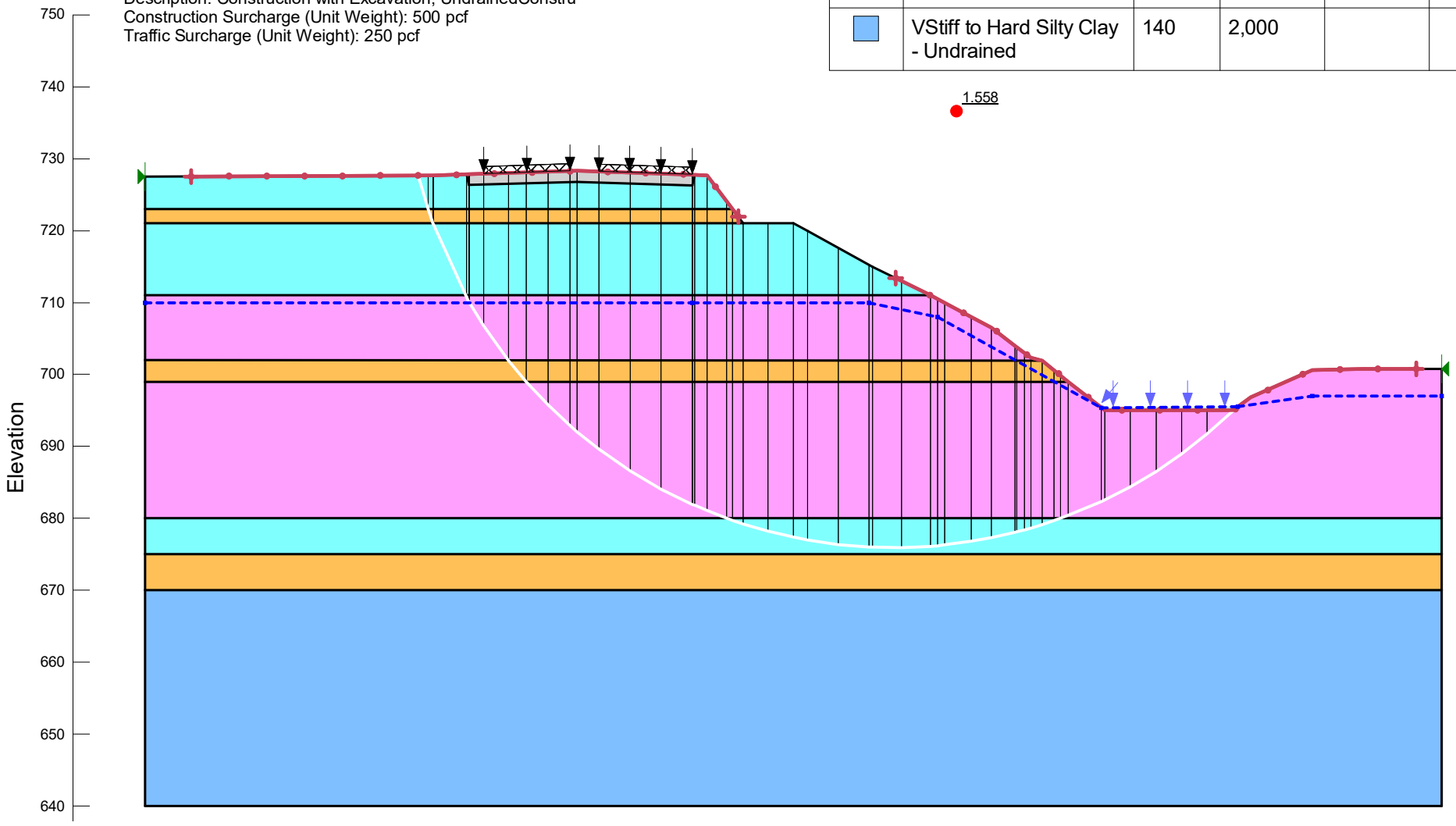
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	MStiff Silty Clay - Drained	130	120	26
	Pavement	150	10,000	0
	Silty Clay and Sand	130	0	30
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30

File Name: FUL-20A-19.20 1015+25 Construction Exc rev.gsz
Description: Construction with Excavation, RDDConstru
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf



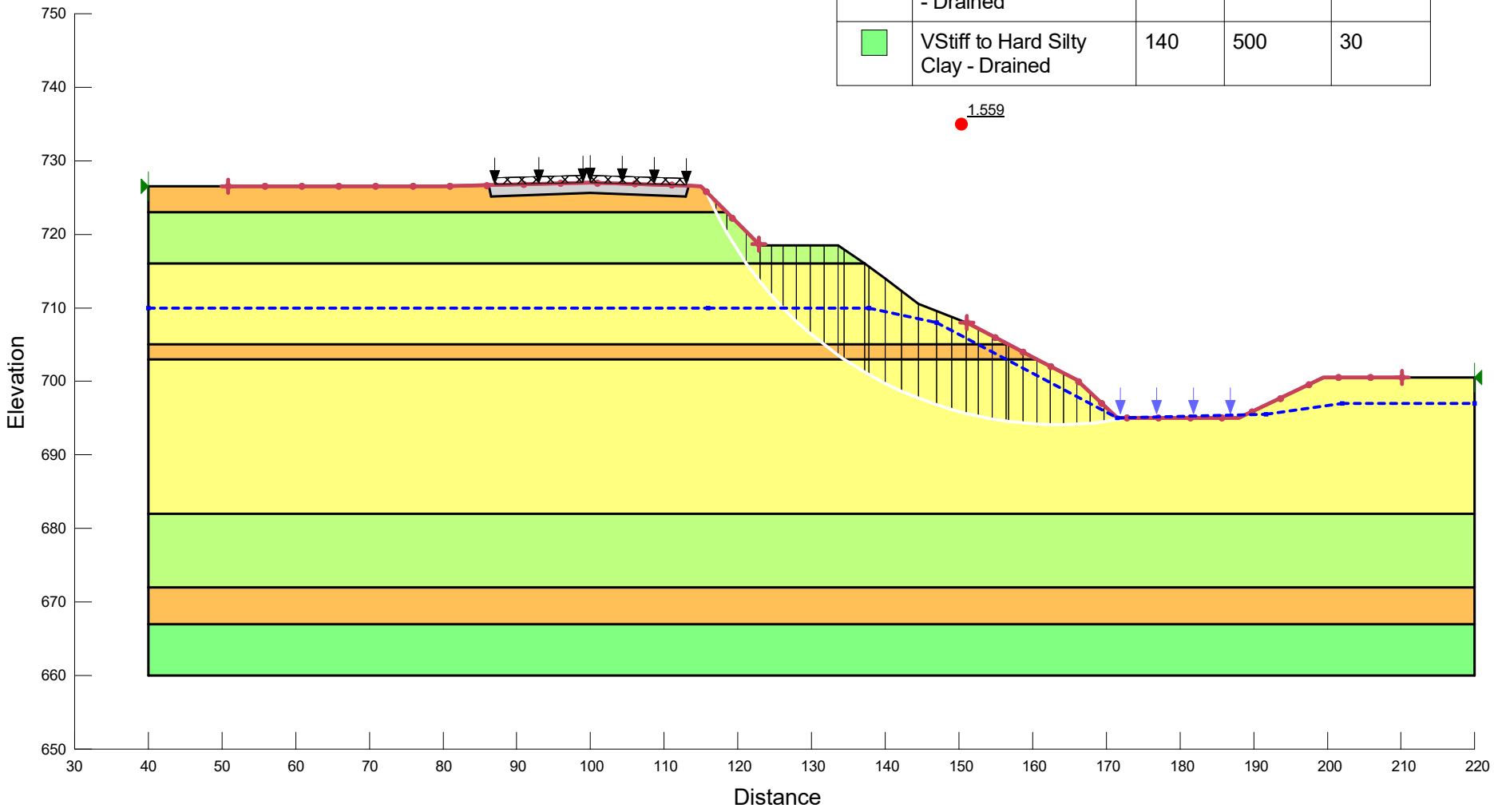
Color	Name	Unit Weight (pcf)	Total Cohesion (psf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	MStiff Silty Clay - Undrained	130		800	0
	Pavement	150		10,000	0
	Silty Clay and Sand	130		0	30
	Stiff to VStiff Silty Clay - Undrained	135	1,500		
	VStiff to Hard Silty Clay - Undrained	140	2,000		

File Name: FUL-20A-19.20 1015+25 Construction Exc rev.gsz
Description: Construction with Excavation, UndrainedConstru
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf



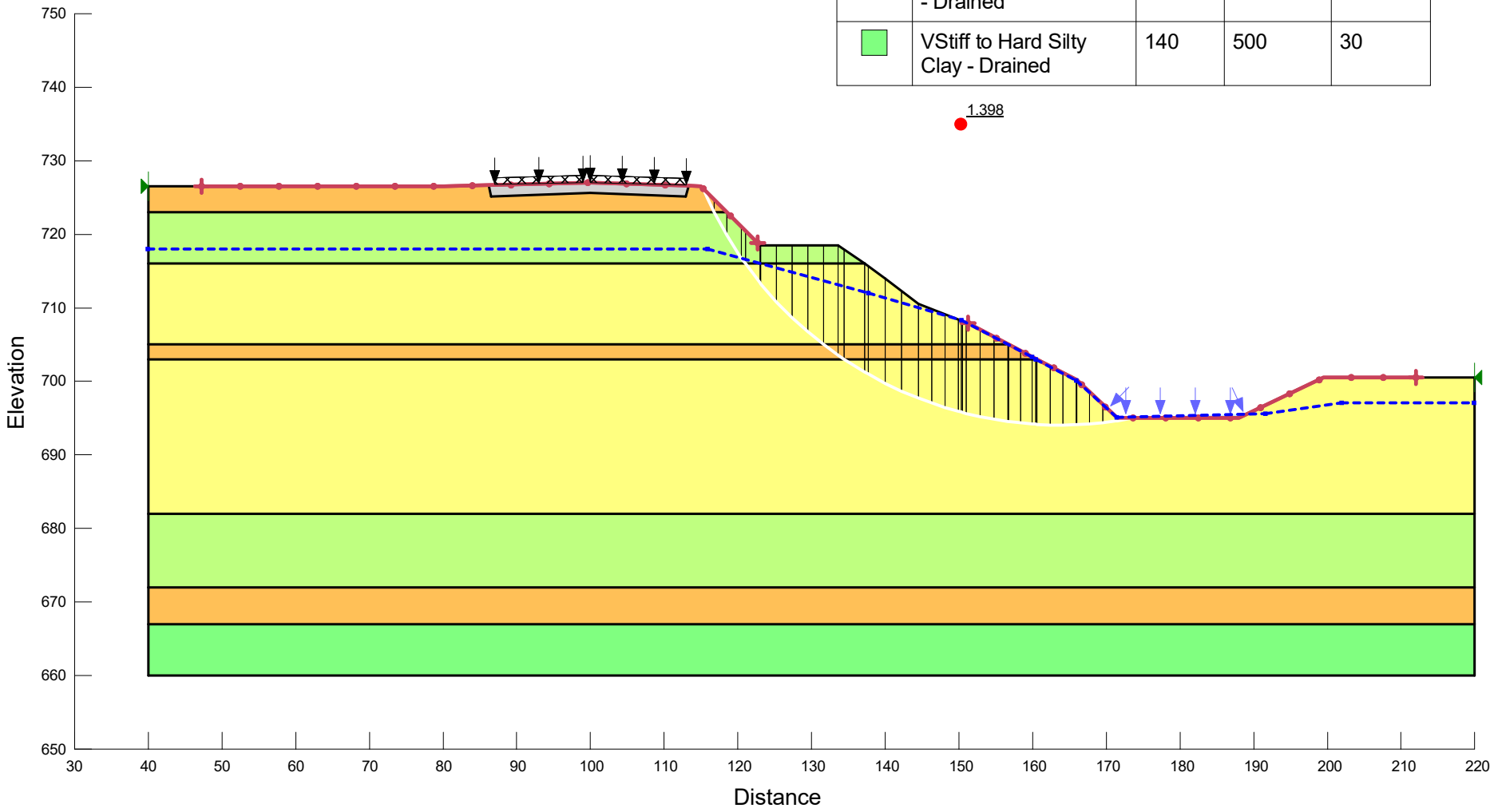
File Name: FUL-20A-19.20 1016+00 Construction Exc rev.gsz
Description: Construction with Excavation, drained
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	MStiff Silty Clay - Drained	130	120	26
	Pavement	150	10,000	0
	Silty Clay and Sand	130	0	30
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30



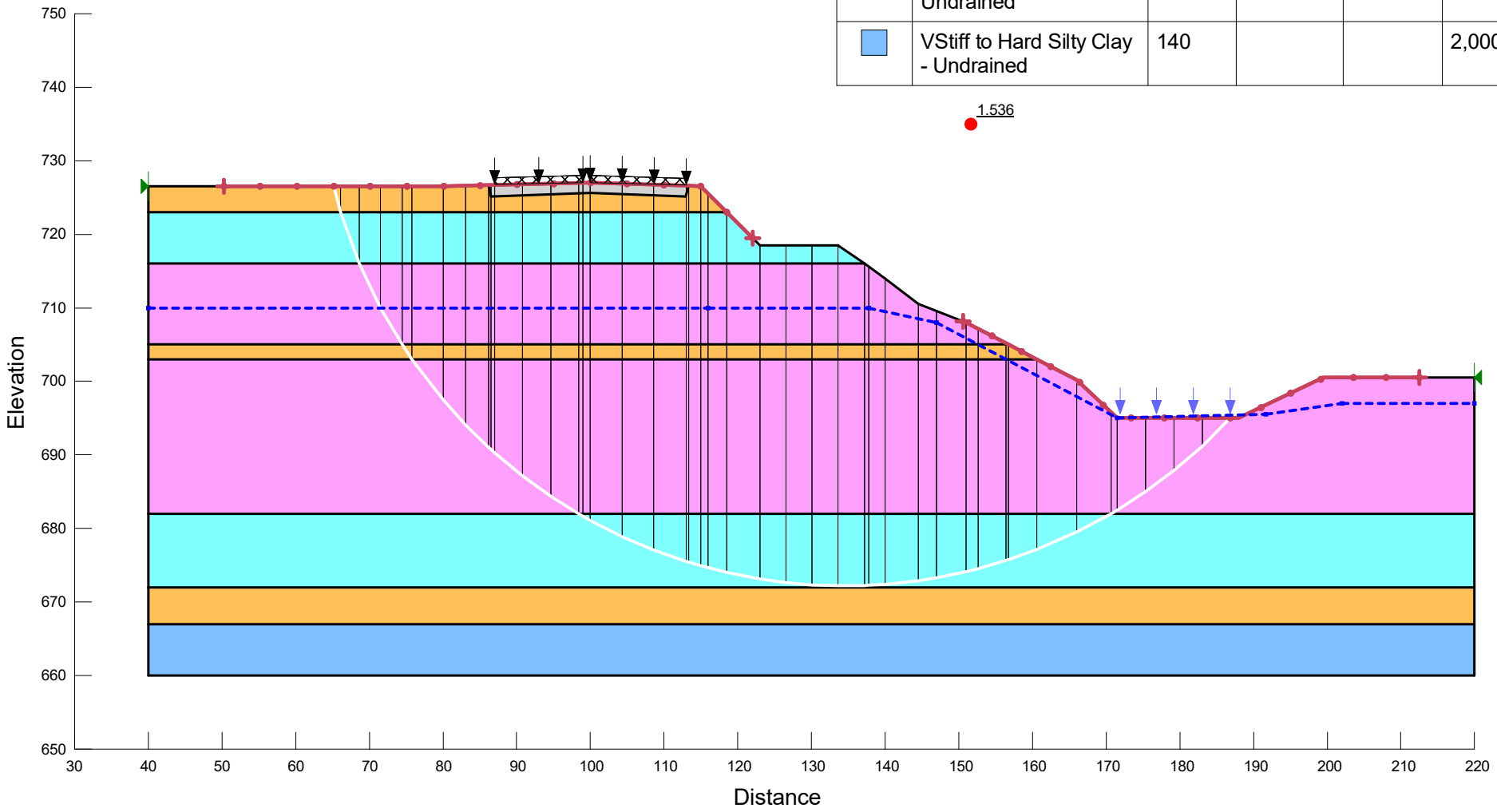
Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)
	MStiff Silty Clay - Drained	130	120	26
	Pavement	150	10,000	0
	Silty Clay and Sand	130	0	30
	Stiff to VStiff Silty Clay - Drained	135	300	28
	VStiff to Hard Silty Clay - Drained	140	500	30

File Name: FUL-20A-19.20 1016+00 Construction Exc rev.gsz
Description: Construction with Excavation, RDD
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf



File Name: FUL-20A-19.20 1016+00 Construction Exc rev.gsz
Description: Construction with Excavation, Undrained
Construction Surcharge (Unit Weight): 500 pcf
Traffic Surcharge (Unit Weight): 250 pcf

Color	Name	Unit Weight (pcf)	Effective Cohesion (psf)	Effective Friction Angle (°)	Total Cohesion (psf)
	MStiff Silty Clay - Undrained	130			800
	Pavement	150	10,000	0	
	Silty Clay and Sand	130	0	30	
	Stiff to VStiff Silty Clay - Undrained	135			1,500
	VStiff to Hard Silty Clay - Undrained	140			2,000

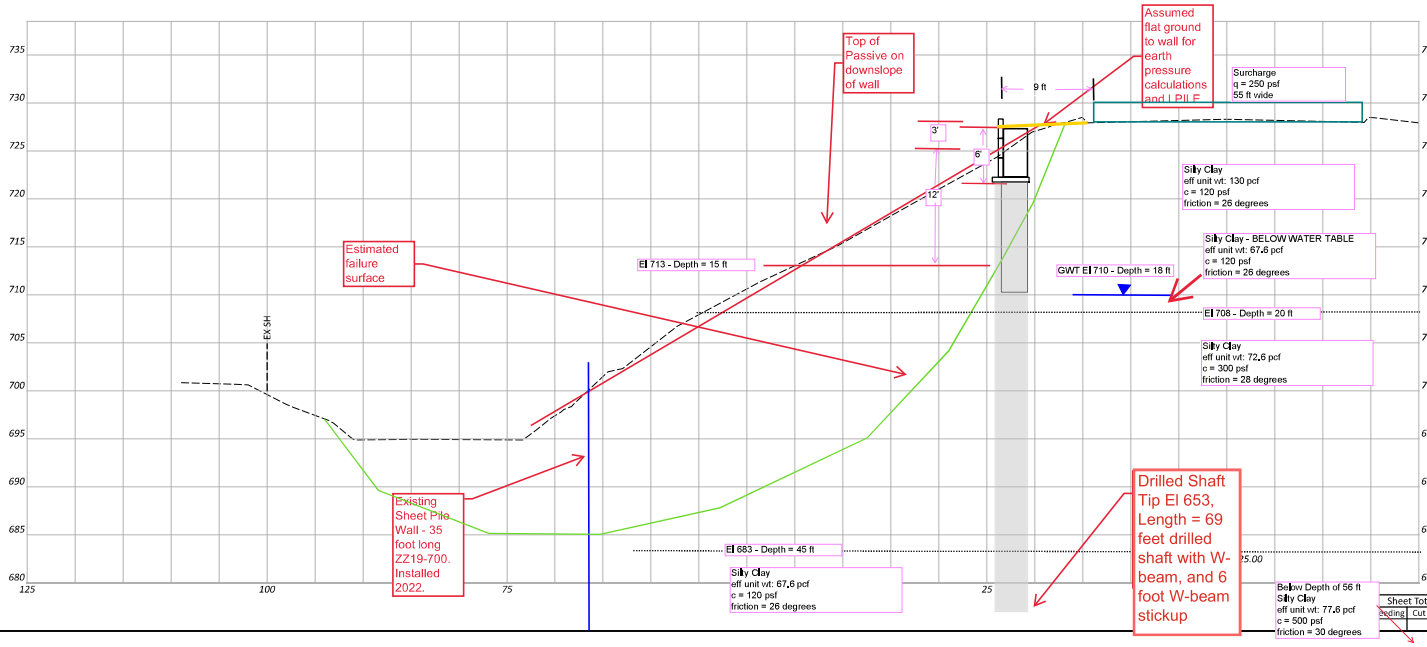


LPILE

1015+25

FUL-US20A-19.20 SLIDE REPAIR

LPILE SECTION



CROSS SECTIONS
STA. 1015+25

DESIGN AGENCY

DESIGNER GCB
REVIEWER DTC MM-DD-YY
PROJECT ID 119890

Sheet Totals				
Bedding	Cut	Fill	SHEET	TOTAL
			P.14	32

FUL-20A-19.20

Active Pressures Used in Design Evaluations

STA 1015+25 Assumed Depth of Active Loading: 15 feet

Depth	SERVICE				STRENGTH			
					g_p 1.50	g_p 1.00	g_p 1.75	
	p_a	p_w	p_{ts}	S p	$g_p p_a$	$g_p p_w$	$g_p p_{ts}$	S $g_p p$
(ft.)	(psf)	(psf)	(psf)	(psf)	(psf)	(psf)	(psf)	(psf)
0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6.0	273.0	0.0	3.5	276.5	409.5	0.0	6.1	415.6
15.0	683.0	0.0	16.1	699.1	1024.5	0.0	28.2	1052.7

Spacing: 6 ft

Load below multiplied by spacing (trib area)

Lpile Input		
Depth	Load Intensity	
	SERVICE	STRENGTH
(ft)	lb/in	lb/in
0.0	0.0	0.0
6.0	138.3	207.8
15.0	349.6	526.3

Since LPILE modeled without any soil to 15 feet, add active and traffic surcharge pressure from 15 ft depth to the distributed loads

Water load not added because LPILE only looks at effective unit weights and there is no input for water level.

GW is approximately balanced on both sides of wall.

	p_a	p_w	p_{ts}	S p	$g_p p_a$	$g_p p_w$	$g_p p_{ts}$	S $g_p p$
18.0	683.0	0.0	19.3	702.3	1024.5	0.0	33.8	1058.3
30.0	683.0	0	25.1	708.1	1024.5	0.0	43.9	1068.4
45.0	683.0	0	29.0	712.0	1024.5	0.0	50.8	1075.3
80.0	683.0	0	22.5	705.5	1024.5	0.0	39.4	1063.9

SERVICE	STRENGTH
351.2	529.1
354.1	534.2
356.0	537.6
352.8	531.9

SUMMARY OF RESULTS FOR LPILE EVALUATIONS

Client: ODOT
Project: FUL-20A-19.20
Subject: Summary of LPile Results

Project No.: WTR-100-T44324
Comp: BKL Check: STA
Date: 4/17/2025

TETRA TECH

ROAD-SIDE WALL

RESULTS OF EVALUATIONS

STA 1015+25 **W24x94**

Depth of Active Loading = 15 ft
Pile Spacing = 6 ft

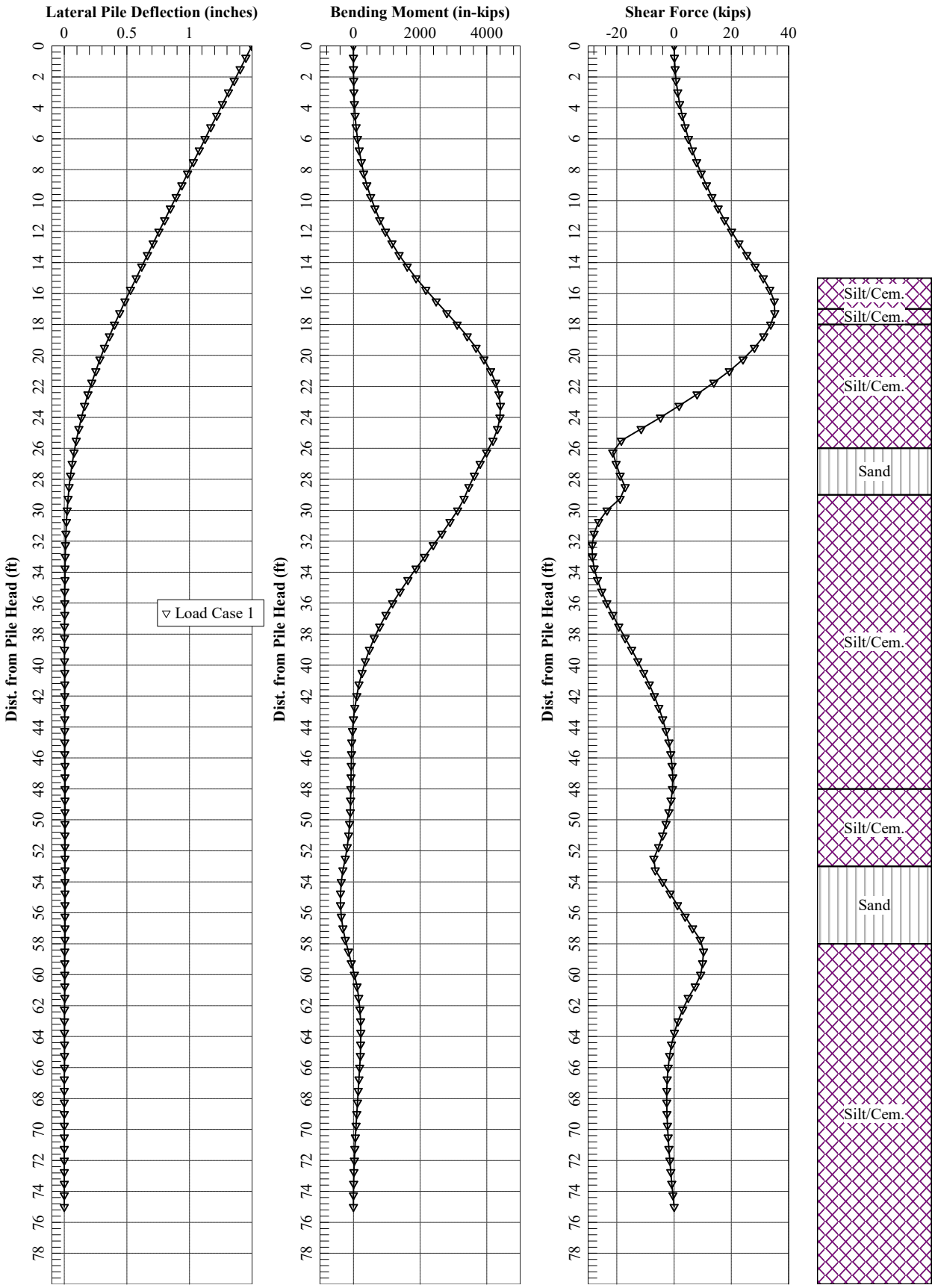
Shaft Dia. (in.)= 36.0

	M_u (in-kips)	V_u - peak (kips)	d (in) - top
SERVICE	4405	35.1	1.5
STRENGTH	8091	71.3	3.5

Section Properties

1.0 Mn, in-k	1.0 Vn, k
12700	375

Service Limit State
W24x94
3 foot shafts, 6 foot spacing



==========

LPile for Windows, Version 2022-12.009

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

==========

This copy of LPile is being used by:

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Jacksonville

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Files Used for Analysis

Path to file locations:
\Users\BRIAN.LAWRENCE\OneDrive - Tetra Tech, Inc\Projects\FUL-20A-19.20\05 Wall Design\01 Revised Analysis for Final Report\

Name of input data file:
FUL20A_3ft_6ft_W24x94_Service.lp12d

Name of output report file:
FUL20A_3ft_6ft_W24x94_Service.lp12o

Name of plot output file:
FUL20A_3ft_6ft_W24x94_Service.lp12p

Name of runtime message file:
FUL20A_3ft_6ft_W24x94_Service.lp12r

Date and Time of Analysis

Date: April 17, 2025 Time: 15:51:28

Problem Title

Project Name: FUL-20A-19.20

Job Number: 100-WTR-T44324

Client: Ohio DOT

Engineer: B Lawrence

Description: Drilled Shaft Wall, Service Loads

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified

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

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

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 75.000 ft
Depth of ground surface below top of pile = 15.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.0700
2	6.000	9.0700
3	6.000	36.0000
4	75.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is an elastic pile
   Cross-sectional Shape                              = Strong H-Pile
   Length of section                                  =     6.000000 ft
   Flange Width                                       =     9.070000 in
   Section Depth                                      =    24.300000 in
   Flange Thickness                                   =     0.875000 in
   Web Thickness                                      =     0.515000 in
   Section Area                                       =    27.485750 sq. in
   Moment of Inertia                                  =        2671. in^4
   Elastic Modulus                                    =    29000000. psi

Pile Section No. 2:

   Section 2 is a drilled shaft with casing and AISC section core/insert
   Length of section                                  =    69.000000 ft
   Section Diameter                                   =    36.000000 in
   Core/Insert AISC Section Type                      = W



   Core/Insert AISC Section Name                      = W24X94




---------------------------------------------------------------------------
                      Control Data for Pushover Analysis
---------------------------------------------------------------------------

Pile-head fixity condition                            = free and fixed head
Number of pushover points to generate                 =           20
Pushover point distribution method                    =  logarithmic

Minimum pushover pile-head deflection                 =    0.0001000 in
Maximum pushover pile-head deflection                 =    10.000000 in

Axial Thrust Force                                    =       0.0000 lbs
Stop Analyis if Second Hinge Developed (Only for Elastoplastic Moment-Curvature)



---------------------------------------------------------------------------
                      Soil and Rock Layering Information
---------------------------------------------------------------------------

The soil profile is modelled using 8 layers
```

Layer 1 is silt/cemented soil

Distance from top of pile to top of layer	=	15.000000 ft
Distance from top of pile to bottom of layer	=	17.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Cohesion at top of layer	=	120.000000 psf
Cohesion at bottom of layer	=	120.000000 psf
Friction angle at top of layer	=	26.000000 deg.
Friction angle at bottom of layer	=	26.000000 deg.
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for Epsilon-50 will be computed for this layer.
NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is silt/cemented soil

Distance from top of pile to top of layer	=	17.000000 ft
Distance from top of pile to bottom of layer	=	18.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Cohesion at top of layer	=	300.000000 psf
Cohesion at bottom of layer	=	300.000000 psf
Friction angle at top of layer	=	28.000000 deg.
Friction angle at bottom of layer	=	28.000000 deg.
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for Epsilon-50 will be computed for this layer.
NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is silt/cemented soil

Distance from top of pile to top of layer	=	18.000000 ft
Distance from top of pile to bottom of layer	=	26.000000 ft
Effective unit weight at top of layer	=	72.600000 pcf
Effective unit weight at bottom of layer	=	72.600000 pcf
Cohesion at top of layer	=	300.000000 psf
Cohesion at bottom of layer	=	300.000000 psf
Friction angle at top of layer	=	28.000000 deg.
Friction angle at bottom of layer	=	28.000000 deg.
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for Epsilon-50 will be computed for this layer.
NOTE: Default values for subgrade k will be computed for this layer.

Layer 4 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    26.000000 ft
   Distance from top of pile to bottom of layer        =    29.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 5 is silt/cemented soil

   Distance from top of pile to top of layer           =    29.000000 ft
   Distance from top of pile to bottom of layer        =    48.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Cohesion at top of layer                            =   300.000000 psf
   Cohesion at bottom of layer                         =   300.000000 psf
   Friction angle at top of layer                      =    28.000000 deg.
   Friction angle at bottom of layer                   =    28.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for Epsilon-50 will be computed for this layer.
   NOTE: Default values for subgrade k will be computed for this layer.

Layer 6 is silt/cemented soil

   Distance from top of pile to top of layer           =    48.000000 ft
   Distance from top of pile to bottom of layer        =    53.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Cohesion at top of layer                            =   120.000000 psf
   Cohesion at bottom of layer                         =   120.000000 psf
   Friction angle at top of layer                      =    26.000000 deg.
   Friction angle at bottom of layer                   =    26.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for Epsilon-50 will be computed for this layer.
   NOTE: Default values for subgrade k will be computed for this layer.

Layer 7 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    53.000000 ft
   Distance from top of pile to bottom of layer        =    58.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
```

```
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 8 is silt/cemented soil

   Distance from top of pile to top of layer           =    58.000000 ft
   Distance from top of pile to bottom of layer        =    80.000000 ft
   Effective unit weight at top of layer               =    77.600000 pcf
   Effective unit weight at bottom of layer            =    77.600000 pcf
   Cohesion at top of layer                            =   500.000000 psf
   Cohesion at bottom of layer                         =   500.000000 psf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for Epsilon-50 will be computed for this layer.
   NOTE: Default values for subgrade k will be computed for this layer.

 (Depth of the lowest soil layer extends 5.000 ft below the pile tip)
```

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.	kpy pci
1	Silt/ Cemented Soil	15.0000 17.0000	130.0000 130.0000	120.0000 120.0000	26.0000 26.0000	default default
2	Silt/ Cemented Soil	17.0000 18.0000	130.0000 130.0000	300.0000 300.0000	28.0000 28.0000	default default
3	Silt/ Cemented Soil	18.0000 26.0000	72.6000 72.6000	300.0000 300.0000	28.0000 28.0000	default default

default					
4	Sand	26.0000	67.6000	--	30.0000
default					
	(Reese, et al.)	29.0000	67.6000	--	30.0000
default					
5	Silt/	29.0000	72.6000	300.0000	28.0000
default					
	Cemented Soil	48.0000	72.6000	300.0000	28.0000
default					
6	Silt/	48.0000	67.6000	120.0000	26.0000
default					
	Cemented Soil	53.0000	67.6000	120.0000	26.0000
default					
7	Sand	53.0000	67.6000	--	30.0000
default					
	(Reese, et al.)	58.0000	67.6000	--	30.0000
default					
8	Silt/	58.0000	77.6000	500.0000	30.0000
default					
	Cemented Soil	80.0000	77.6000	500.0000	30.0000
default					

Modification Factors for p-y Curves

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

Point No.	Depth X ft	p-mult	y-mult
1	15.000	0.6400	1.0000
2	18.000	0.6400	1.0000
3	80.000	0.8100	1.0000

Static Loading Type

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

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 7 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	1.000
2	6.000	138.300
3	15.000	349.600
4	18.000	351.200
5	30.000	354.100
6	45.000	356.000
7	60.000	356.000

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

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

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

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

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

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and AISC Strong Axis Core/Insert:

Length of Section	=	69.000000	ft
Outside Diameter of Casing	=	36.000000	in
Casing Wall Thickness	=	0.0000	in
Moment of Inertia of Steel Casing	=	0.0000	in^4
Width Flange of Core/Insert	=	9.070000	in
Depth of Core/Insert	=	24.300000	in
Flange Thickness of Core/Insert	=	0.875000	in
Web Thickness of Core/Insert	=	0.515000	in
Moment of Inertia of Steel Core/Insert	=	2700.	in^4
Yield Stress of Casing	=	50000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Yield Stress of Core/Insert	=	50000.	psi
Elastic Modulus of Core/Insert	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Gross Area of Pile	=	1018.	sq. in.
Area of Concrete	=	990.390270	sq. in.
Cross-sectional Area of Steel Casing	=	0.0000	sq. in.
Cross-sectional Area of Steel Core/Insert	=	27.700000	sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	27.485750	sq. in.
Area Ratio of All Steel to Gross Area	=	2.70	percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4751.598	kips
Tensile Load for Cracking of Concrete	=	-504.501	kips
Nominal Axial Tensile Capacity	=	-1385.000	kips

Concrete Properties:

Compressive Strength of Concrete	=	4000.	psi

Modulus of Elasticity of Concrete = 3604997. psi
Modulus of Rupture of Concrete = -474.34165 psi
Compression Strain at Peak Stress = 0.001886
Tensile Strain at Fracture of Concrete = -0.0001154
Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 0.000 kips

Bending Max Conc Curvature Stress rad/in.	Bending Max Steel Moment Stress in-kip	Bending Max Casing Stiffness Stress kip-in2	Depth to Max Core N Axis Stress in	Run Msg	Max Comp Strain in/in	Max Tens Strain in/in
			ksi			
6.25000E-07	259.4623491	415139759.	18.0000000		0.00001125	-0.00001125
0.0470966	0.00000	0.00000	0.2185875			
0.00000125	518.0654643	414452371.	18.0000000		0.00002250	-0.00002250
0.0939143	0.00000	0.00000	0.4371750			
0.00000188	775.8093457	413764984.	18.0000000		0.00003375	-0.00003375
0.1404531	0.00000	0.00000	0.6557625			
0.00000250	1033.	413077597.	18.0000000		0.00004500	-0.00004500
0.1867130	0.00000	0.00000	0.8743500			

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0.00000313        1289.    412390210.    18.0000000    0.00005625   -0.00005625
0.2326940      0.00000       0.00000     1.0929375
0.00000375        1544.    411702823.    18.0000000    0.00006750   -0.00006750
0.2783960      0.00000       0.00000     1.3115250
0.00000438        1798.    411015436.    18.0000000    0.00007875   -0.00007875
0.3238192      0.00000       0.00000     1.5301125
0.00000500        2052.    410328049.    18.0000000    0.00009000   -0.00009000
0.3689635      0.00000       0.00000     1.7487000
0.00000563        2304.    409640662.    18.0000000     0.0001012     -0.000101
0.4138288      0.00000       0.00000     1.9672875
0.00000625        2556.    408953275.    18.0000000     0.0001125     -0.000113
0.4584153      0.00000       0.00000     2.1858750
0.00000688        2556.    371775704.    11.3948312    0.00007834     -0.000169
0.3203196      0.00000       0.00000     -3.721368 C
0.00000750        2556.    340794396.    11.3979043    0.00008548     -0.000185
0.3488701      0.00000       0.00000     -4.059006 C
0.00000813        2556.    314579442.    11.4009832    0.00009263     -0.000200
0.3773252      0.00000       0.00000     -4.396531 C
0.00000875        2556.    292109482.    11.4040678    0.00009979     -0.000215
0.4056846      0.00000       0.00000     -4.733943 C
0.00000938        2556.    272635516.    11.4071580     0.0001069     -0.000231
0.4339482      0.00000       0.00000     -5.071241 C
0.00001000        2556.    255595797.    11.4102541     0.0001141     -0.000246
0.4621159      0.00000       0.00000     -5.408426 C
0.00001063        2556.    240560750.    11.4133558     0.0001213     -0.000261
0.4901875      0.00000       0.00000     -5.745497 C
0.00001125        2556.    227196264.    11.4164634     0.0001284     -0.000277
0.5181630      0.00000       0.00000     -6.082454 C
0.00001188        2556.    215238566.    11.4195768     0.0001356     -0.000292
0.5460420      0.00000       0.00000     -6.419296 C
0.00001250        2556.    204476637.    11.4226960     0.0001428     -0.000307
0.5738246      0.00000       0.00000     -6.756023 C
0.00001313        2556.    194739655.    11.4258210     0.0001500     -0.000323
0.6015105      0.00000       0.00000     -7.092634 C
0.00001375        2556.    185887852.    11.4289520     0.0001571     -0.000338
0.6290996      0.00000       0.00000     -7.429130 C
0.00001438        2556.    177805772.    11.4320888     0.0001643     -0.000353
0.6565918      0.00000       0.00000     -7.765510 C
0.00001500        2556.    170397198.    11.4352315     0.0001715     -0.000368
0.6839869      0.00000       0.00000     -8.101774 C
0.00001563        2556.    163581310.    11.4383802     0.0001787     -0.000384
0.7112848      0.00000       0.00000     -8.437921 C
0.00001625        2556.    157289721.    11.4415349     0.0001859     -0.000399
0.7384853      0.00000       0.00000     -8.773952 C
0.00001688        2556.    151464176.    11.4446955     0.0001931     -0.000414
0.7655882      0.00000       0.00000     -9.109865 C
0.00001750        2565.    146578149.    11.4478622     0.0002003     -0.000430
0.7925935      0.00000       0.00000     -9.445660 C
0.00001813        2656.    146530823.    11.4510349     0.0002076     -0.000445
0.8195010      0.00000       0.00000     -9.781337 C
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0.00001875        2747.    146483420.    11.4542136     0.0002148     -0.000460
0.8463105      0.00000       0.00000    -10.116896 C
0.00001938        2837.    146435939.    11.4573985     0.0002220     -0.000476
0.8730218      0.00000       0.00000    -10.452337 C
0.00002000        2928.    146388379.    11.4605894     0.0002292     -0.000491
0.8996349      0.00000       0.00000    -10.787658 C
0.00002063        3018.    146340740.    11.4637865     0.0002364     -0.000506
0.9261495      0.00000       0.00000    -11.122860 C
0.00002125        3109.    146293023.    11.4669897     0.0002437     -0.000521
0.9525655      0.00000       0.00000    -11.457943 C
0.00002188        3199.    146245226.    11.4701991     0.0002509     -0.000537
0.9788828      0.00000       0.00000    -11.792905 C
0.00002250        3289.    146197349.    11.4734147     0.0002582     -0.000552
1.0051012      0.00000       0.00000    -12.127747 C
0.00002313        3380.    146149393.    11.4766365     0.0002654     -0.000567
1.0312206      0.00000       0.00000    -12.462468 C
0.00002375        3470.    146101356.    11.4798646     0.0002726     -0.000582
1.0572407      0.00000       0.00000    -12.797068 C
0.00002438        3560.    146053239.    11.4830990     0.0002799     -0.000598
1.0831615      0.00000       0.00000    -13.131547 C
0.00002563        3740.    145956762.    11.4895866     0.0002944     -0.000628
1.1347044      0.00000       0.00000    -13.800138 C
0.00002688        3920.    145859959.    11.4960997     0.0003090     -0.000659
1.1858479      0.00000       0.00000    -14.468240 C
0.00002813        4100.    145762829.    11.5026384     0.0003235     -0.000689
1.2365908      0.00000       0.00000    -15.135848 C
0.00002938        4279.    145665368.    11.5092029     0.0003381     -0.000719
1.2869318      0.00000       0.00000    -15.802960 C
0.00003063        4458.    145567575.    11.5157934     0.0003527     -0.000750
1.3368696      0.00000       0.00000    -16.469573 C
0.00003188        4637.    145469446.    11.5224101     0.0003673     -0.000780
1.3864029      0.00000       0.00000    -17.135685 C
0.00003313        4815.    145370979.    11.5290534     0.0003819     -0.000811
1.4355303      0.00000       0.00000    -17.801291 C
0.00003438        4994.    145272172.    11.5357232     0.0003965     -0.000841
1.4842506      0.00000       0.00000    -18.466388 C
0.00003563        5172.    145173022.    11.5424200     0.0004112     -0.000871
1.5325623      0.00000       0.00000    -19.130975 C
0.00003688        5350.    145073526.    11.5491439     0.0004259     -0.000902
1.5804642      0.00000       0.00000    -19.795047 C
0.00003813        5527.    144973682.    11.5558951     0.0004406     -0.000932
1.6279549      0.00000       0.00000    -20.458601 C
0.00003938        5704.    144873487.    11.5626739     0.0004553     -0.000962
1.6750329      0.00000       0.00000    -21.121634 C
0.00004063        5881.    144772938.    11.5694804     0.0004700     -0.000992
1.7216969      0.00000       0.00000    -21.784143 C
0.00004188        6058.    144672033.    11.5763150     0.0004848     -0.001023
1.7679455      0.00000       0.00000    -22.446125 C
0.00004313        6235.    144570768.    11.5831779     0.0004995     -0.001053
1.8137773      0.00000       0.00000    -23.107576 C
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0.00004438        6411.    144469142.    11.5900692    0.0005143    -0.001083
1.8591907      0.00000       0.00000   -23.768492 C
0.00004563        6587.    144367151.    11.5969893    0.0005291    -0.001113
1.9041845      0.00000       0.00000   -24.428871 C
0.00004688        6762.    144264791.    11.6039384    0.0005439    -0.001144
1.9487570      0.00000       0.00000   -25.088709 C
0.00004813        6938.    144162062.    11.6109167    0.0005588    -0.001174
1.9929069      0.00000       0.00000   -25.748002 C
0.00004938        7113.    144058958.    11.6179246    0.0005736    -0.001204
2.0366327      0.00000       0.00000   -26.406747 C
0.00005063        7288.    143955478.    11.6249621    0.0005885    -0.001234
2.0799328      0.00000       0.00000   -27.064940 C
0.00005188        7462.    143851618.    11.6320297    0.0006034    -0.001264
2.1228057      0.00000       0.00000   -27.722578 C
0.00005313        7637.    143747376.    11.6391275    0.0006183    -0.001294
2.1652500      0.00000       0.00000   -28.379657 C
0.00005438        7811.    143642747.    11.6462559    0.0006333    -0.001324
2.2072640      0.00000       0.00000   -29.036173 C
0.00005563        7984.    143537729.    11.6534150    0.0006482    -0.001354
2.2488461      0.00000       0.00000   -29.692122 C
0.00005688        8158.    143432319.    11.6606052    0.0006632    -0.001384
2.2899949      0.00000       0.00000   -30.347502 C
0.00005813        8331.    143326514.    11.6678268    0.0006782    -0.001414
2.3307087      0.00000       0.00000   -31.002307 C
0.00005938        8504.    143220310.    11.6750800    0.0006932    -0.001444
2.3709859      0.00000       0.00000   -31.656534 C
0.00006063        8676.    143113704.    11.6823651    0.0007082    -0.001474
2.4108249      0.00000       0.00000   -32.310179 C
0.00006188        8849.    143006692.    11.6896824    0.0007233    -0.001504
2.4502241      0.00000       0.00000   -32.963238 C
0.00006313        9021.    142899271.    11.6970322    0.0007384    -0.001534
2.4891817      0.00000       0.00000   -33.615708 C
0.00006438        9192.    142791522.    11.7042905    0.0007535    -0.001564
2.5276755      0.00000       0.00000   -34.267815 C
0.00006563        9364.    142683423.    11.7114967    0.0007686    -0.001594
2.5657100      0.00000       0.00000   -34.919495 C
0.00006688        9535.    142574918.    11.7187344    0.0007837    -0.001624
2.6032973      0.00000       0.00000   -35.570592 C
0.00006813        9705.    142466003.    11.7260039    0.0007988    -0.001654
2.6404355      0.00000       0.00000   -36.221101 C
0.00006938        9876.    142356674.    11.7333056    0.0008140    -0.001684
2.6771231      0.00000       0.00000   -36.871018 C
0.00007063       10046.    142246929.    11.7406396    0.0008292    -0.001713
2.7133583      0.00000       0.00000   -37.520340 C
0.00007188       10216.    142136763.    11.7480064    0.0008444    -0.001743
2.7491394      0.00000       0.00000   -38.169061 C
0.00007313       10386.    142026173.    11.7554062    0.0008596    -0.001773
2.7844646      0.00000       0.00000   -38.817179 C
0.00007438       10555.    141915155.    11.7628393    0.0008749    -0.001803
2.8193322      0.00000       0.00000   -39.464688 C
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0.00007938       11229.    141466733.    11.7929112     0.0009361     -0.001921
2.9541900      0.00000       0.00000    -42.048555 C
0.00008438       11898.    141011164.    11.8235419     0.0009976     -0.002040
3.0815791      0.00000       0.00000    -44.622333 C
0.00008938       12561.    140548189.    11.8547531     0.0010595     -0.002158
3.2013767      0.00000       0.00000    -47.185724 C
0.00009438       13220.    140077537.    11.8865679     0.0011218     -0.002276
3.3134545      0.00000       0.00000    -49.738412 C
0.00009938       13670.    137558586.    11.8489463     0.0011775     -0.002400
3.4063567      0.00000       0.00000    -50.000000 CY
 0.0001044       13913.    133297940.    11.7487715     0.0012263     -0.002531
3.4820231      0.00000       0.00000    -50.000000 CY
 0.0001094       14130.    129187288.    11.6495435     0.0012742     -0.002663
3.5512579      0.00000       0.00000    -50.000000 CY
 0.0001144       14325.    125247621.    11.5520683     0.0013213     -0.002796
3.6144861      0.00000       0.00000    -50.000000 CY
 0.0001194       14502.    121484452.    11.4582374     0.0013678     -0.002930
3.6722605      0.00000       0.00000    -50.000000 CY
 0.0001244       14663.    117896074.    11.3681425     0.0014139     -0.003064
3.7248207      0.00000       0.00000    -50.000000 CY
 0.0001294       14810.    114472841.    11.2795224     0.0014593     -0.003198
3.7720717      0.00000       0.00000    -50.000000 CY
 0.0001344       14944.    111207642.    11.1934120     0.0015041     -0.003333
3.8143740      0.00000       0.00000    -50.000000 CY
 0.0001394       15066.    108099638.    11.1110311     0.0015486     -0.003469
3.8520596      0.00000       0.00000    -50.000000 CY
 0.0001444       15180.    105140552.    11.0322650     0.0015928     -0.003605
3.8852571      0.00000       0.00000    -50.000000 CY
 0.0001494       15284.    102322946.    10.9561859     0.0016366     -0.003741
3.9140022      0.00000       0.00000    -50.000000 CY
 0.0001544       15380.     99627242.    10.8809311     0.0016797     -0.003878
3.9382765      0.00000       0.00000    -50.000000 CY
 0.0001594       15469.     97058787.    10.8091013     0.0017227     -0.004015
3.9584453      0.00000       0.00000    -50.000000 CY
 0.0001644       15551.     94609180.    10.7405055     0.0017655     -0.004152
3.9745741      0.00000       0.00000    -50.000000 CY
 0.0001694       15628.     92270875.    10.6749807     0.0018081     -0.004289
3.9867206      0.00000       0.00000    -50.000000 CY
 0.0001744       15700.     90036212.    10.6120192     0.0018505     -0.004427
3.9949251      0.00000       0.00000    -50.000000 CY
 0.0001794       15766.     87893958.    10.5492972     0.0018923     -0.004565
3.9992237      0.00000       0.00000    -50.000000 CY
 0.0001844       15828.     85844132.    10.4893810     0.0019340     -0.004704
3.9969772      0.00000       0.00000    -50.000000 CY
 0.0001894       15885.     83881530.    10.4321928     0.0019756     -0.004842
3.9998118      0.00000       0.00000    -50.000000 CY
 0.0001944       15939.     82001155.    10.3777011     0.0020172     -0.004980
3.9978193      0.00000       0.00000    -50.000000 CY
 0.0001994       15989.     80195264.    10.3253312     0.0020586     -0.005119
3.9999434      0.00000       0.00000    -50.000000 CY
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 0.0002044       16036.     78462073.    10.2754001     0.0021000     -0.005257
3.9978483      0.00000       0.00000    -50.000000 CY
 0.0002094       16079.     76796593.    10.2259935     0.0021411     -0.005396
3.9999086      0.00000       0.00000    -50.000000 CY
 0.0002144       16120.     75194131.    10.1779621     0.0021819     -0.005536
3.9970000      0.00000       0.00000    -50.000000 CY
 0.0002194       16157.     73651690.    10.1316367     0.0022226     -0.005675
3.9995928      0.00000       0.00000    -50.000000 CY
 0.0002244       16193.     72170409.    10.0875334     0.0022634     -0.005814
3.9957261      0.00000       0.00000    -50.000000 CY
 0.0002294       16227.     70742291.    10.0450210     0.0023041     -0.005953
3.9985140      0.00000       0.00000    -50.000000 CY
 0.0002344       16258.     69368267.    10.0042016     0.0023447     -0.006093
3.9999648      0.00000       0.00000    -50.000000 CY
 0.0002394       16288.     68043830.     9.9651745     0.0023854     -0.006232
3.9958175      0.00000       0.00000    -50.000000 CY
 0.0002444       16316.     66766204.     9.9274778     0.0024260     -0.006371
3.9988430      0.00000       0.00000    -50.000000 CY
 0.0002494       16343.     65534446.     9.8907619     0.0024665     -0.006511
3.9999878      0.00000       0.00000    -50.000000 CY
 0.0002544       16367.     64341289.     9.8537798     0.0025066     -0.006651
3.9950242      0.00000       0.00000    -50.000000 CY
 0.0002594       16390.     63190041.     9.8181740     0.0025466     -0.006791
3.9982017      0.00000       0.00000    -50.000000 CY
 0.0002644       16412.     62077971.     9.7837372     0.0025866     -0.006931
3.9997949      0.00000       0.00000    -50.000000 CY
 0.0002694       16432.     61001973.     9.7504661     0.0026265     -0.007071
3.9959403      0.00000       0.00000    -50.000000 CY
 0.0002744       16452.     59963095.     9.7187118     0.0026666     -0.007211
3.9960484      0.00000       0.00000    -50.000000 CY
 0.0003044       16551.     54378151.     9.5472479     0.0029059     -0.008052
3.9994904      0.00000       0.00000    -50.000000 CY
 0.0003344       16623.     49713725.     9.3958159     0.0031417     -0.008896
3.9999191      0.00000       0.00000    -50.000000 CY
 0.0003644       16677.     45768736.     9.2671097     0.0033767     -0.009741
3.9996325      0.00000       0.00000    -50.000000 CY
 0.0003944       16719.     42393688.     9.1556383     0.0036108     -0.010587
3.9971665      0.00000       0.00000    -50.000000 CY
 0.0004244       16750.     39469091.     9.0522872     0.0038416     -0.011436
3.9870881      0.00000       0.00000    -50.000000 CY


-------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 2
-------------------------------------------------------------------------------

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

 Load           Axial Thrust        Nominal Mom. Cap.      Max. Comp.      Max.
```

Tens. No.	kips	in-kip	Strain	Strain
1	0.000	16579.943	0.00300000	-0.00838832

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	0.0000	16580.	0.0000	10777.	141767436.
1	0.75	0.0000	16580.	0.0000	12435.	140636460.
1	0.90	0.0000	16580.	0.0000	14922.	111735012.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs

1	15.0000	0.00	N.A.	No	0.00	5411.
2	17.0000	1.8881	Yes	No	5411.	7752.
3	18.0000	2.8880	Yes	No	13163.	129086.
4	26.0000	10.8592	No	No	142249.	88785.
5	29.0000	14.9693	No	No	231034.	1561936.
6	48.0000	36.4805	Yes	No	1792970.	636386.
7	53.0000	36.2967	No	No	2429356.	1060475.
8	58.0000	41.4336	No	No	3489831.	N.A.

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

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

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

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

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*H	Soil Spr. Lat. Load	Distrib. p
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	1.4976	-4.46E-06	-1.18E-08	-0.00519	7.57E-09	7.74E+10	0.00	0.00	5.2906
0.7500	1.4509	214.2703	105.5391	-0.00519	0.3639	7.74E+10	0.00	0.00	18.1625
1.5000	1.4041	1900.	346.2328	-0.00519	3.2260	7.74E+10	0.00	0.00	35.3250
2.2500	1.3574	6446.	741.3891	-0.00519	10.9470	7.74E+10	0.00	0.00	52.4875
3.0000	1.3107	15245.	1291.	-0.00519	25.8877	7.74E+10	0.00	0.00	69.6500
3.7500	1.2639	29685.	1995.	-0.00519	50.4088	7.74E+10	0.00	0.00	86.8125

```
    4.5000     1.2173     51156.      2854.   -0.00518    86.8709   7.74E+10
0.00       0.00   103.9750
    5.2500     1.1706     81050.      3867.   -0.00518   137.6348   7.74E+10
0.00       0.00   121.1375
    6.0000     1.1241    120756.      5034.   -0.00517   205.0611   7.74E+10
0.00       0.00   138.3557
    6.7500     1.0777    171668.      6359.   -0.00516       0.00   4.15E+11
0.00       0.00   155.9083
    7.5000     1.0313    235210.      7841.   -0.00515       0.00   4.15E+11
0.00       0.00   173.5167
    8.2500     0.9849    312806.      9482.   -0.00515       0.00   4.15E+11
0.00       0.00   191.1250
    9.0000     0.9386    405883.     11281.   -0.00514       0.00   4.15E+11
0.00       0.00   208.7333
    9.7500     0.8924    515867.     13239.   -0.00513       0.00   4.14E+11
0.00       0.00   226.3417
   10.5000     0.8463    644186.     15355.   -0.00512       0.00   4.14E+11
0.00       0.00   243.9500
   11.2500     0.8003    792264.     17630.   -0.00510       0.00   4.14E+11
0.00       0.00   261.5583
   12.0000     0.7545    961528.     20063.   -0.00508       0.00   4.13E+11
0.00       0.00   279.1667
   12.7500     0.7089   1153405.     22655.   -0.00506       0.00   4.13E+11
0.00       0.00   296.7750
   13.5000     0.6635   1369321.     25405.   -0.00503       0.00   4.12E+11
0.00       0.00   314.3833
   14.2500     0.6183   1610702.     28314.   -0.00500       0.00   4.12E+11
0.00       0.00   331.9917
   15.0000     0.5735   1878974.     31122.   -0.00496       0.00   4.11E+11
-55.558   871.8345   347.4490
   15.7500     0.5291   2170889.     33420.   -0.00492       0.00   4.10E+11
-131.170      2231.   350.0000
   16.5000     0.4851   2480530.     34968.   -0.00486       0.00   4.09E+11
-225.266      4180.   350.4000
   17.2500     0.4415   2800306.     35135.   -0.00475       0.00   1.46E+11
-438.786      8944.   350.8000
   18.0000     0.3995   3112956.     33737.   -0.00457       0.00   1.46E+11
-573.872     12927.   351.1727
   18.7500     0.3593   3407566.     31316.   -0.00437       0.00   1.46E+11
-666.586     16698.   351.3813
   19.5000     0.3209   3676646.     28079.   -0.00415       0.00   1.46E+11
-755.783     21196.   351.5625
   20.2500     0.2846   3912983.     24048.   -0.00392       0.00   1.46E+11
-843.264     26668.   351.7437
   21.0000     0.2504   4109507.     19285.   -0.00367       0.00   1.46E+11
-918.924     33025.   351.9250
   21.7500     0.2186   4260105.     13895.   -0.00341       0.00   1.46E+11
-982.706     40468.   352.1062
   22.5000     0.1890   4359624.      8027.   -0.00314       0.00   1.46E+11
-1026.     48828.   352.2875
```

```
   23.2500     0.1620   4404599.      1784.   -0.00287       0.00   1.46E+11
-1067.     59264.   352.4688
   24.0000     0.1373   4391735.     -4730.   -0.00260       0.00   1.46E+11
-1086.     71167.   352.6500
   24.7500     0.1152   4319467.    -11469.   -0.00233       0.00   1.46E+11
-1117.     87305.   352.8313
   25.5000    0.09537   4185296.    -18411.   -0.00207       0.00   1.46E+11
-1132.    106777.   353.0125
   26.2500    0.07792   3988067.    -21408.   -0.00182       0.00   1.46E+11
-240.774     27812.   353.1938
   27.0000    0.06267   3799945.    -20245.   -0.00158       0.00   1.46E+11
-207.227     29758.   353.3750
   27.7500    0.04954   3623660.    -18782.   -0.00135       0.00   1.46E+11
-174.583     31715.   353.5562
   28.5000    0.03842   3461871.    -17032.   -0.00113       0.00   1.46E+11
-143.796     33685.   353.7375
   29.2500    0.02922   3317088.    -18844.  -9.20E-04       0.00   1.46E+11
-966.498    297718.   353.9188
   30.0000    0.02185   3122687.    -23430.  -7.22E-04       0.00   1.46E+11
-760.820    313347.   354.0892
   30.7500    0.01622   2895339.    -26335.  -5.37E-04       0.00   1.46E+11
-592.928    329066.   354.1950
   31.5000    0.01218   2648655.    -27916.  -3.67E-04       0.00   1.47E+11
-466.838    344875.   354.2900
   32.2500    0.00961   2392854.    -28562.  -2.59E-04       0.00   4.09E+11
-385.348    360774.   354.3850
   33.0000    0.00752   2134545.    -28522.  -2.10E-04       0.00   4.10E+11
-314.669    376763.   354.4800
   33.7500    0.00584   1879461.    -27895.  -1.65E-04       0.00   4.11E+11
-254.999    392841.   354.5750
   34.5000    0.00454   1632443.    -26779.  -1.27E-04       0.00   4.11E+11
-206.229    409010.   354.6700
   35.2500    0.00356   1397448.    -25270.  -9.39E-05       0.00   4.12E+11
-167.992    425269.   354.7650
   36.0000    0.00285   1177582.    -23461.  -6.58E-05       0.00   4.13E+11
-139.709    441617.   354.8600
   36.7500    0.00237    975143.    -21439.  -4.24E-05       0.00   4.13E+11
-120.640    458056.   354.9550
   37.5000    0.00208    791684.    -19281.  -2.31E-05       0.00   4.14E+11
-109.927    474585.   355.0500
   38.2500    0.00195    628079.    -17060.  -7.70E-06       0.00   4.14E+11
-106.643    491203.   355.1450
   39.0000    0.00195    484604.    -14837.   4.39E-06       0.00   4.14E+11
-109.828    507912.   355.2400
   39.7500    0.00203    361006.    -12667.   1.36E-05       0.00   4.15E+11
-118.524    524710.   355.3350
   40.5000    0.00219    256591.    -10595.   2.03E-05       0.00   4.15E+11
-131.808    541598.   355.4300
   41.2500    0.00240    170288.     -8659.   2.49E-05       0.00   4.15E+11
-148.814    558576.   355.5250
```

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   42.0000    0.00264    100729.     -6888.   2.78E-05       0.00   4.15E+11
-168.753    575645.   355.6200
   42.7500    0.00290     46307.     -5305.   2.94E-05       0.00   4.15E+11
-190.929    592803.   355.7150
   43.5000    0.00317      5232.     -3929.   3.00E-05       0.00   4.15E+11
-214.741    610051.   355.8100
   44.2500    0.00344    -24416.     -2771.   2.98E-05       0.00   4.15E+11
-239.691    627389.   355.9050
   45.0000    0.00370    -44651.     -1841.   2.90E-05       0.00   4.15E+11
-265.378    644817.   355.9881
   45.7500    0.00396    -57547.     -1143.   2.79E-05       0.00   4.15E+11
-291.493    662335.   356.0000
   46.5000    0.00421    -65217.   -680.374   2.66E-05       0.00   4.15E+11
-317.801    679943.   356.0000
   47.2500    0.00444    -69793.   -455.058   2.51E-05       0.00   4.15E+11
-344.129    697641.   356.0000
   48.0000    0.00466    -73408.   -589.349   2.36E-05       0.00   4.15E+11
-397.714    768317.   356.0000
   48.7500    0.00486    -80402.     -1087.   2.19E-05       0.00   4.15E+11
-424.956    786345.   356.0000
   49.5000    0.00505    -92981.     -1828.   2.00E-05       0.00   4.15E+11
-451.669    804463.   356.0000
   50.2500    0.00522   -113309.     -2806.   1.78E-05       0.00   4.15E+11
-477.537    822672.   356.0000
   51.0000    0.00537   -143482.     -4010.   1.50E-05       0.00   4.15E+11
-502.087    840970.   356.0000
   51.7500    0.00549   -185487.     -5426.   1.14E-05       0.00   4.15E+11
-524.624    859358.   356.0000
   52.5000    0.00558   -241152.     -7032.   6.82E-06       0.00   4.15E+11
-544.182    877836.   356.0000
   53.2500    0.00562   -312059.     -6572.   8.17E-07       0.00   4.15E+11
-65.610    105124.   356.0000
   54.0000    0.00559   -359444.     -3964.  -6.47E-06       0.00   4.15E+11
-66.807    107485.   356.0000
   54.7500    0.00550   -383405.     -1362.  -1.45E-05       0.00   4.15E+11
-67.142    109857.   356.0000
   55.5000    0.00533   -383968.      1240.  -2.29E-05       0.00   4.15E+11
-66.501    112240.   356.0000
   56.2500    0.00509   -361082.      3853.  -3.09E-05       0.00   4.15E+11
-64.823    114635.   356.0000
   57.0000    0.00478   -314611.      6486.  -3.83E-05       0.00   4.15E+11
-62.104    117042.   356.0000
   57.7500    0.00440   -244334.      9148.  -4.43E-05       0.00   4.15E+11
-58.408    119460.   356.0000
   58.5000    0.00398   -149952.     10262.  -4.86E-05       0.00   4.15E+11
-405.878    918371.   356.0000
   59.2500    0.00353    -59610.      9988.  -5.09E-05       0.00   4.15E+11
-367.185    937356.   356.0000
   60.0000    0.00306     29826.      9274.  -5.12E-05       0.00   4.15E+11
-325.381    956431.   178.0000
```

60.7500	0.00260	107324.	7341.	-4.97E-05	0.00	4.15E+11
-282.268	975595.	0.00				
61.5000	0.00217	161958.	4993.	-4.68E-05	0.00	4.15E+11
-239.540	994850.	0.00				
62.2500	0.00176	197190.	3021.	-4.29E-05	0.00	4.15E+11
-198.522	1014195.	0.00				
63.0000	0.00139	216341.	1407.	-3.84E-05	0.00	4.15E+11
-160.193	1033630.	0.00				
63.7500	0.00107	222517.	122.6496	-3.37E-05	0.00	4.15E+11
-125.230	1053155.	0.00				
64.5000	7.89E-04	218549.	-864.068	-2.89E-05	0.00	4.15E+11
-94.041	1072769.	0.00				
65.2500	5.50E-04	206964.	-1588.	-2.43E-05	0.00	4.15E+11
-66.807	1092474.	0.00				
66.0000	3.52E-04	189967.	-2084.	-2.00E-05	0.00	4.15E+11
-43.522	1112268.	0.00				
66.7500	1.91E-04	169445.	-2388.	-1.61E-05	0.00	4.15E+11
-24.029	1132153.	0.00				
67.5000	6.29E-05	146977.	-2533.	-1.26E-05	0.00	4.15E+11
-8.057	1152127.	0.00				
68.2500	-3.65E-05	123856.	-2548.	-9.70E-06	0.00	4.15E+11
4.7492	1172192.	0.00				
69.0000	-1.12E-04	101120.	-2460.	-7.26E-06	0.00	4.15E+11
14.7983	1192346.	0.00				
69.7500	-1.67E-04	79583.	-2292.	-5.30E-06	0.00	4.15E+11
22.5280	1212590.	0.00				
70.5000	-2.07E-04	59870.	-2063.	-3.79E-06	0.00	4.15E+11
28.3825	1232924.	0.00				
71.2500	-2.35E-04	42456.	-1787.	-2.68E-06	0.00	4.15E+11
32.7933	1253349.	0.00				
72.0000	-2.55E-04	27699.	-1477.	-1.92E-06	0.00	4.15E+11
36.1627	1273863.	0.00				
72.7500	-2.70E-04	15870.	-1139.	-1.45E-06	0.00	4.15E+11
38.8487	1294467.	0.00				
73.5000	-2.82E-04	7189.	-779.432	-1.20E-06	0.00	4.15E+11
41.1520	1315161.	0.00				
74.2500	-2.92E-04	1841.	-399.385	-1.10E-06	0.00	4.15E+11
43.3029	1335945.	0.00				
75.0000	-3.01E-04	0.00	0.00	-1.08E-06	0.00	4.15E+11
45.4494	678409.	0.00				

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     1.49763285 inches
Computed slope at pile head      =     -0.0051938 radians
Maximum bending moment           =       4404599. inch-lbs
Maximum shear force              =         35135. lbs
Depth of maximum bending moment  =    23.25000000 feet below pile head
Depth of maximum shear force     =    17.25000000 feet below pile head
Number of iterations             =             37
Number of zero deflection points =              1
Pile deflection at ground        =     0.57352487 inches
```

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

Boundary Condition Type 1, Shear and Moment

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

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
75.00000	1.49763285	4404599.	35135.
71.25000	1.50148094	4443602.	35575.
67.50000	1.52324470	4469600.	35743.
63.75000	1.51145826	4418965.	35384.
60.00000	1.50116191	4432601.	35403.
56.25000	1.50404080	4446962.	35575.
52.50000	1.51436213	4436687.	35540.
48.75000	1.48823879	4416459.	35409.
45.00000	1.50483566	4425830.	35575.
41.25000	1.50416652	4451403.	35728.
37.50000	1.53948082	4405660.	-41601.
33.75000	1.88924653	4321256.	-53856.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case No.	Load Type 1	Pile-head Load 1	Load Type 2	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	1.4976	-0.00519	35135.	4404599.

Maximum pile-head deflection = 1.4976328470 inches
Maximum pile-head rotation = -0.0051938171 radians = -0.297584 deg.

Results of Push-over Analysis

Computation Methods Used for Push-over Analyses:
- Computations use both pinned-head and fixed-head conditions
- Computations use a logarithmic distribution of pile-head deflections

Number of push-over steps = 20
Minimum pushover deflection = 0.0001000 in
Maximum pushover deflection = 10.000000 in
Axial thrust force for pushover analysis = 0.0000 lbs

Pushover Point Number	Pile-head Fixity Condition	Pile-head Deflection inches	Pile-head Shear lbs	Max Moment in Pile in-lb(abs)	Max Shear in Pile lbs (abs)	Depth to Max Moment feet	Depth to Max Shear feet
1	Pin-head	1.00E-04	-7556.	698522.	8151.	11.2500	52.5000
2	Pin-head	2.3139	20607.	6349051.	41379.	21.7500	30.7500
3	Pin-head	3.6673	30784.	9040401.	66470.	22.5000	31.5000
4	Pin-head	4.6276	37206.	1.08E+07	83122.	23.2500	32.2500
5	Pin-head	5.3725	41620.	1.22E+07	96325.	23.2500	

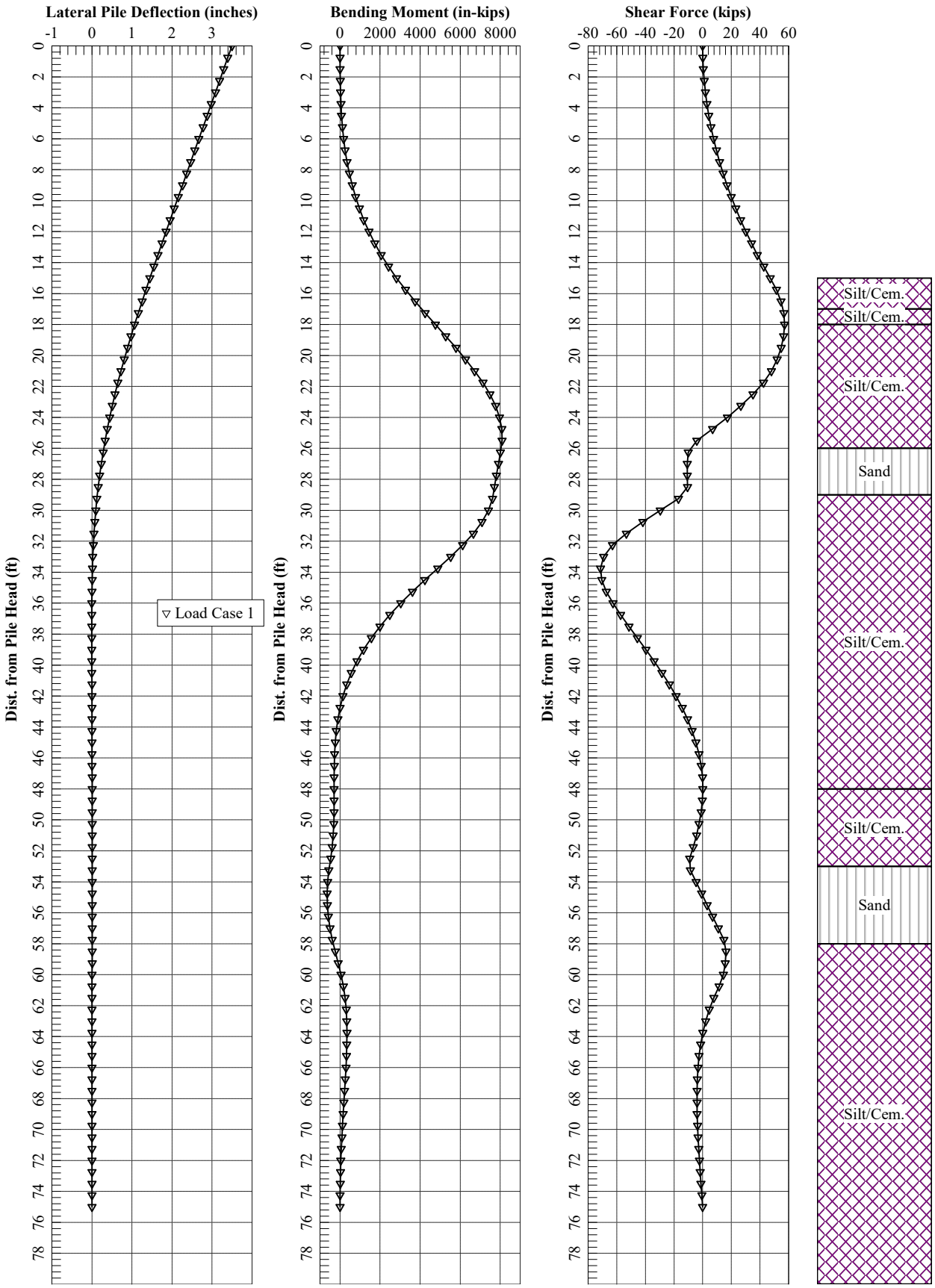
32.2500						
6	Pin-head	5.9811	44844.	1.31E+07	106824.	23.2500
33.0000						
7	Pin-head	6.4956	47198.	1.39E+07	115189.	24.0000
33.0000						
8	Pin-head	6.9414	48681.	1.44E+07	120152.	24.0000
33.0000						
9	Pin-head	7.3345	49772.	1.47E+07	123608.	24.0000
33.7500						
10	Pin-head	7.6862	50605.	1.50E+07	126703.	24.0000
33.7500						
11	Pin-head	8.0044	51189.	1.52E+07	130576.	24.7500
33.7500						
12	Pin-head	8.2948	51685.	1.54E+07	133137.	24.7500
33.7500						
13	Pin-head	8.5620	52113.	1.55E+07	134880.	24.7500
33.7500						
14	Pin-head	8.8094	52456.	1.56E+07	136154.	24.7500
33.7500						
15	Pin-head	9.0397	52719.	1.57E+07	137258.	24.7500
33.7500						
16	Pin-head	9.2551	52971.	1.58E+07	138193.	24.7500
33.7500						
17	Pin-head	9.4575	53182.	1.59E+07	139004.	24.7500
33.7500						
18	Pin-head	9.6483	53365.	1.60E+07	139724.	24.7500
33.7500						
19	Pin-head	9.8288	53522.	1.60E+07	140364.	24.7500
33.7500						
20	Pin-head	10.0000	53660.	1.61E+07	140940.	24.7500
33.7500						
21	Fixed-head	1.00E-04	-10546.	613519.	10546.	13.5000
0.00						
22	Fixed-head	2.3139	60288.	1.00E+07	73433.	0.00
15.7500						
23	Fixed-head	3.6673	85046.	1.46E+07	98423.	0.00
15.7500						
24	Fixed-head	4.6276	98670.	1.75E+07	121179.	0.00
34.5000						
25	Fixed-head	5.3725	107447.	1.95E+07	137735.	0.00
35.2500						
26	Fixed-head	5.9811	113322.	2.10E+07	144876.	0.00
35.2500						
27	Fixed-head	6.4956	117854.	2.23E+07	151653.	0.00
36.0000						
28	Fixed-head	6.9414	121785.	2.34E+07	155332.	0.00
36.0000						
29	Fixed-head	7.3345	125001.	2.44E+07	157846.	0.00
36.0000						
30	Fixed-head	7.6862	127581.	2.51E+07	159700.	0.00

36.0000
   31   Fixed-head   8.0044   129816.   2.58E+07   161009.   0.00
36.0000
   32   Fixed-head   8.2948   131791.   2.63E+07   161949.   0.00
36.0000
   33   Fixed-head   8.5620   133415.   2.68E+07   162656.   0.00
36.0000
   34   Fixed-head   8.8094   134731.   2.72E+07   163209.   0.00
36.0000
   35   Fixed-head   9.0397   135756.   2.75E+07   163625.   0.00
36.0000
   36   Fixed-head   9.2551   136517.   2.77E+07   163949.   0.00
36.0000
   37   Fixed-head   9.4575   136963.   2.78E+07   163955.   0.00
36.0000
   38   Fixed-head   9.6483   137266.   2.79E+07   163934.   0.00
36.0000
   39   Fixed-head   9.8288   137326.   2.79E+07   163904.   0.00
36.0000
   40   Fixed-head   10.0000   137365.   2.79E+07   163876.   0.00
36.0000

* WARNING: Some values of computed curvature exceeded the maximum curvature
calculated or entered by the user
           Fixed-head Condition   Step =   40 Node =   41

The analysis ended normally.

Strength Limit State
W24x94
3 foot shafts, 6 foot spacing



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LPile for Windows, Version 2022-12.009

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

==========

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Files Used for Analysis

Path to file locations:
\Users\BRIAN.LAWRENCE\OneDrive - Tetra Tech, Inc\Projects\FUL-20A-19.20\05 Wall Design\01 Revised Analysis for Final Report\

Name of input data file:
FUL20A_3ft_6ft_W24x94_Strength.lp12d

Name of output report file:
FUL20A_3ft_6ft_W24x94_Strength.lp12o

Name of plot output file:
FUL20A_3ft_6ft_W24x94_Strength.lp12p

Name of runtime message file:
FUL20A_3ft_6ft_W24x94_Strength.lp12r

Date and Time of Analysis

Date: April 17, 2025 Time: 15:57:53

Problem Title

Project Name: FUL-20A-19.20

Job Number: 100-WTR-T44324

Client: Ohio DOT

Engineer: B Lawrence

Description: Drilled Shaft Wall, Strength Load, 3ft_6ft W24x94

Program Options and Settings

Computational Options:
- Conventional Analysis

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

Analysis Control Options:

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

Loading Type and Number of Cycles of Loading:

- Static loading specified

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

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

Pile Structural Properties and Geometry

Number of pile sections defined = 2
Total length of pile = 75.000 ft
Depth of ground surface below top of pile = 15.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	9.0700
2	6.000	9.0700
3	6.000	36.0000
4	75.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

```
   Section 1 is an elastic pile
   Cross-sectional Shape                              = Strong H-Pile
   Length of section                                  =     6.000000 ft
   Flange Width                                       =     9.070000 in
   Section Depth                                      =    24.300000 in
   Flange Thickness                                   =     0.875000 in
   Web Thickness                                      =     0.515000 in
   Section Area                                       =    27.485750 sq. in
   Moment of Inertia                                  =        2671. in^4
   Elastic Modulus                                    =    29000000. psi

Pile Section No. 2:

   Section 2 is a drilled shaft with casing and AISC section core/insert
   Length of section                                  =    69.000000 ft
   Section Diameter                                   =    36.000000 in
   Core/Insert AISC Section Type                      = W



   Core/Insert AISC Section Name                      = W24X94




---------------------------------------------------------------------------
                      Control Data for Pushover Analysis
---------------------------------------------------------------------------

Pile-head fixity condition                            = free and fixed head
Number of pushover points to generate                 =           20
Pushover point distribution method                    =  logarithmic

Minimum pushover pile-head deflection                 =    0.0001000 in
Maximum pushover pile-head deflection                 =    10.000000 in

Axial Thrust Force                                    =       0.0000 lbs
Stop Analyis if Second Hinge Developed (Only for Elastoplastic Moment-Curvature)



---------------------------------------------------------------------------
                      Soil and Rock Layering Information
---------------------------------------------------------------------------

The soil profile is modelled using 8 layers
```

Layer 1 is silt/cemented soil

Distance from top of pile to top of layer	=	15.000000 ft
Distance from top of pile to bottom of layer	=	17.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Cohesion at top of layer	=	120.000000 psf
Cohesion at bottom of layer	=	120.000000 psf
Friction angle at top of layer	=	26.000000 deg.
Friction angle at bottom of layer	=	26.000000 deg.
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for Epsilon-50 will be computed for this layer.
NOTE: Default values for subgrade k will be computed for this layer.

Layer 2 is silt/cemented soil

Distance from top of pile to top of layer	=	17.000000 ft
Distance from top of pile to bottom of layer	=	18.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Cohesion at top of layer	=	300.000000 psf
Cohesion at bottom of layer	=	300.000000 psf
Friction angle at top of layer	=	28.000000 deg.
Friction angle at bottom of layer	=	28.000000 deg.
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for Epsilon-50 will be computed for this layer.
NOTE: Default values for subgrade k will be computed for this layer.

Layer 3 is silt/cemented soil

Distance from top of pile to top of layer	=	18.000000 ft
Distance from top of pile to bottom of layer	=	26.000000 ft
Effective unit weight at top of layer	=	72.600000 pcf
Effective unit weight at bottom of layer	=	72.600000 pcf
Cohesion at top of layer	=	300.000000 psf
Cohesion at bottom of layer	=	300.000000 psf
Friction angle at top of layer	=	28.000000 deg.
Friction angle at bottom of layer	=	28.000000 deg.
Subgrade k at top of layer	=	0.0000 pci
Subgrade k at bottom of layer	=	0.0000 pci

NOTE: Default values for Epsilon-50 will be computed for this layer.
NOTE: Default values for subgrade k will be computed for this layer.

Layer 4 is sand, p-y criteria by Reese et al., 1974

```
   Distance from top of pile to top of layer           =    26.000000 ft
   Distance from top of pile to bottom of layer        =    29.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 5 is silt/cemented soil

   Distance from top of pile to top of layer           =    29.000000 ft
   Distance from top of pile to bottom of layer        =    48.000000 ft
   Effective unit weight at top of layer               =    72.600000 pcf
   Effective unit weight at bottom of layer            =    72.600000 pcf
   Cohesion at top of layer                            =   300.000000 psf
   Cohesion at bottom of layer                         =   300.000000 psf
   Friction angle at top of layer                      =    28.000000 deg.
   Friction angle at bottom of layer                   =    28.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for Epsilon-50 will be computed for this layer.
   NOTE: Default values for subgrade k will be computed for this layer.

Layer 6 is silt/cemented soil

   Distance from top of pile to top of layer           =    48.000000 ft
   Distance from top of pile to bottom of layer        =    53.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
   Cohesion at top of layer                            =   120.000000 psf
   Cohesion at bottom of layer                         =   120.000000 psf
   Friction angle at top of layer                      =    26.000000 deg.
   Friction angle at bottom of layer                   =    26.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for Epsilon-50 will be computed for this layer.
   NOTE: Default values for subgrade k will be computed for this layer.

Layer 7 is sand, p-y criteria by Reese et al., 1974

   Distance from top of pile to top of layer           =    53.000000 ft
   Distance from top of pile to bottom of layer        =    58.000000 ft
   Effective unit weight at top of layer               =    67.600000 pcf
   Effective unit weight at bottom of layer            =    67.600000 pcf
```

```
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for subgrade k will be computed for this layer.

Layer 8 is silt/cemented soil

   Distance from top of pile to top of layer           =    58.000000 ft
   Distance from top of pile to bottom of layer        =    80.000000 ft
   Effective unit weight at top of layer               =    77.600000 pcf
   Effective unit weight at bottom of layer            =    77.600000 pcf
   Cohesion at top of layer                            =   500.000000 psf
   Cohesion at bottom of layer                         =   500.000000 psf
   Friction angle at top of layer                      =    30.000000 deg.
   Friction angle at bottom of layer                   =    30.000000 deg.
   Subgrade k at top of layer                          =       0.0000 pci
   Subgrade k at bottom of layer                       =       0.0000 pci

   NOTE: Default values for Epsilon-50 will be computed for this layer.
   NOTE: Default values for subgrade k will be computed for this layer.

 (Depth of the lowest soil layer extends 5.000 ft below the pile tip)
```

Summary of Input Soil Properties

Layer Num.	Soil Type Name (p-y Curve Type)	Layer Depth ft	Effective Unit Wt. pcf	Cohesion psf	Angle of Friction deg.	kpy pci
1	Silt/ Cemented Soil	15.0000 17.0000	130.0000 130.0000	120.0000 120.0000	26.0000 26.0000	default default
2	Silt/ Cemented Soil	17.0000 18.0000	130.0000 130.0000	300.0000 300.0000	28.0000 28.0000	default default
3	Silt/ Cemented Soil	18.0000 26.0000	72.6000 72.6000	300.0000 300.0000	28.0000 28.0000	default default

default					
4	Sand	26.0000	67.6000	--	30.0000
default					
	(Reese, et al.)	29.0000	67.6000	--	30.0000
default					
5	Silt/	29.0000	72.6000	300.0000	28.0000
default					
	Cemented Soil	48.0000	72.6000	300.0000	28.0000
default					
6	Silt/	48.0000	67.6000	120.0000	26.0000
default					
	Cemented Soil	53.0000	67.6000	120.0000	26.0000
default					
7	Sand	53.0000	67.6000	--	30.0000
default					
	(Reese, et al.)	58.0000	67.6000	--	30.0000
default					
8	Silt/	58.0000	77.6000	500.0000	30.0000
default					
	Cemented Soil	80.0000	77.6000	500.0000	30.0000
default					

Modification Factors for p-y Curves

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

Point No.	Depth X ft	p-mult	y-mult
1	15.000	0.6400	1.0000
2	18.000	0.6400	1.0000
3	80.000	0.8100	1.0000

Static Loading Type

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

Distributed Lateral Loading for Individual Load Cases

Distributed lateral load intensity for Load Case 1 defined using 7 points

Point No.	Depth X ft	Dist. Load lb/in
1	0.000	1.000
2	6.000	207.800
3	15.000	526.300
4	18.000	529.100
5	30.000	534.200
6	45.000	537.600
7	60.000	531.900

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 1

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

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

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

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

Number of Pile Sections Analyzed = 2

Pile Section No. 1:

Moment-curvature properties were derived from elastic section properties

Pile Section No. 2:

Dimensions and Properties of Drilled Shaft (Bored Pile) with Casing and AISC Strong Axis Core/Insert:

Length of Section	=	69.000000	ft
Outside Diameter of Casing	=	36.000000	in
Casing Wall Thickness	=	0.0000	in
Moment of Inertia of Steel Casing	=	0.0000	in^4
Width Flange of Core/Insert	=	9.070000	in
Depth of Core/Insert	=	24.300000	in
Flange Thickness of Core/Insert	=	0.875000	in
Web Thickness of Core/Insert	=	0.515000	in
Moment of Inertia of Steel Core/Insert	=	2700.	in^4
Yield Stress of Casing	=	50000.	psi
Elastic Modulus of Casing	=	29000000.	psi
Yield Stress of Core/Insert	=	50000.	psi
Elastic Modulus of Core/Insert	=	29000000.	psi
Number of Reinforcing Bars	=	0	bars
Gross Area of Pile	=	1018.	sq. in.
Area of Concrete	=	990.390270	sq. in.
Cross-sectional Area of Steel Casing	=	0.0000	sq. in.
Cross-sectional Area of Steel Core/Insert	=	27.700000	sq. in.
Area of All Steel (Casing, Core/Insert, and Bars)	=	27.485750	sq. in.
Area Ratio of All Steel to Gross Area	=	2.70	percent

Note that the core is assumed to be void of concrete.

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4751.598	kips
Tensile Load for Cracking of Concrete	=	-504.501	kips
Nominal Axial Tensile Capacity	=	-1385.000	kips

Concrete Properties:

Compressive Strength of Concrete	=	4000.	psi

Modulus of Elasticity of Concrete = 3604997. psi
Modulus of Rupture of Concrete = -474.34165 psi
Compression Strain at Peak Stress = 0.001886
Tensile Strain at Fracture of Concrete = -0.0001154
Maximum Coarse Aggregate Size = 0.750000 in

Number of Axial Thrust Force Values Determined from Pile-head Loadings = 1

Number	Axial Thrust Force kips
1	0.000

Definitions of Run Messages and Notes:

C = concrete in section has cracked in tension.
Y = stress in reinforcing steel has reached yield stress.
T = ACI 318 criteria for tension-controlled section met, tensile strain in reinforcement exceeds 0.005 while simultaneously compressive strain in concrete more than 0.003. See ACI 318-14, Section 21.2.3.
Z = depth of tensile zone in concrete section is less than 10 percent of section depth.

Bending Stiffness (EI) = Computed Bending Moment / Curvature.
Position of neutral axis is measured from edge of compression side of pile.
Compressive stresses and strains are positive in sign.
Tensile stresses and strains are negative in sign.

Axial Thrust Force = 0.000 kips

Bending Max Conc Curvature Stress rad/in.	Bending Max Steel Moment Stress in-kip	Bending Max Casing Stiffness Stress kip-in2	Depth to Max Core N Axis Stress in	Run Msg	Max Comp Strain in/in	Max Tens Strain in/in
			ksi			
6.25000E-07	259.4623491	415139759.	18.0000000		0.00001125	-0.00001125
0.0470966	0.00000	0.00000	0.2185875			
0.00000125	518.0654643	414452371.	18.0000000		0.00002250	-0.00002250
0.0939143	0.00000	0.00000	0.4371750			
0.00000188	775.8093457	413764984.	18.0000000		0.00003375	-0.00003375
0.1404531	0.00000	0.00000	0.6557625			
0.00000250	1033.	413077597.	18.0000000		0.00004500	-0.00004500
0.1867130	0.00000	0.00000	0.8743500			

```
0.00000313        1289.    412390210.    18.0000000    0.00005625   -0.00005625
0.2326940      0.00000       0.00000     1.0929375
0.00000375        1544.    411702823.    18.0000000    0.00006750   -0.00006750
0.2783960      0.00000       0.00000     1.3115250
0.00000438        1798.    411015436.    18.0000000    0.00007875   -0.00007875
0.3238192      0.00000       0.00000     1.5301125
0.00000500        2052.    410328049.    18.0000000    0.00009000   -0.00009000
0.3689635      0.00000       0.00000     1.7487000
0.00000563        2304.    409640662.    18.0000000     0.0001012     -0.000101
0.4138288      0.00000       0.00000     1.9672875
0.00000625        2556.    408953275.    18.0000000     0.0001125     -0.000113
0.4584153      0.00000       0.00000     2.1858750
0.00000688        2556.    371775704.    11.3948312    0.00007834     -0.000169
0.3203196      0.00000       0.00000     -3.721368 C
0.00000750        2556.    340794396.    11.3979043    0.00008548     -0.000185
0.3488701      0.00000       0.00000     -4.059006 C
0.00000813        2556.    314579442.    11.4009832    0.00009263     -0.000200
0.3773252      0.00000       0.00000     -4.396531 C
0.00000875        2556.    292109482.    11.4040678    0.00009979     -0.000215
0.4056846      0.00000       0.00000     -4.733943 C
0.00000938        2556.    272635516.    11.4071580     0.0001069     -0.000231
0.4339482      0.00000       0.00000     -5.071241 C
0.00001000        2556.    255595797.    11.4102541     0.0001141     -0.000246
0.4621159      0.00000       0.00000     -5.408426 C
0.00001063        2556.    240560750.    11.4133558     0.0001213     -0.000261
0.4901875      0.00000       0.00000     -5.745497 C
0.00001125        2556.    227196264.    11.4164634     0.0001284     -0.000277
0.5181630      0.00000       0.00000     -6.082454 C
0.00001188        2556.    215238566.    11.4195768     0.0001356     -0.000292
0.5460420      0.00000       0.00000     -6.419296 C
0.00001250        2556.    204476637.    11.4226960     0.0001428     -0.000307
0.5738246      0.00000       0.00000     -6.756023 C
0.00001313        2556.    194739655.    11.4258210     0.0001500     -0.000323
0.6015105      0.00000       0.00000     -7.092634 C
0.00001375        2556.    185887852.    11.4289520     0.0001571     -0.000338
0.6290996      0.00000       0.00000     -7.429130 C
0.00001438        2556.    177805772.    11.4320888     0.0001643     -0.000353
0.6565918      0.00000       0.00000     -7.765510 C
0.00001500        2556.    170397198.    11.4352315     0.0001715     -0.000368
0.6839869      0.00000       0.00000     -8.101774 C
0.00001563        2556.    163581310.    11.4383802     0.0001787     -0.000384
0.7112848      0.00000       0.00000     -8.437921 C
0.00001625        2556.    157289721.    11.4415349     0.0001859     -0.000399
0.7384853      0.00000       0.00000     -8.773952 C
0.00001688        2556.    151464176.    11.4446955     0.0001931     -0.000414
0.7655882      0.00000       0.00000     -9.109865 C
0.00001750        2565.    146578149.    11.4478622     0.0002003     -0.000430
0.7925935      0.00000       0.00000     -9.445660 C
0.00001813        2656.    146530823.    11.4510349     0.0002076     -0.000445
0.8195010      0.00000       0.00000     -9.781337 C
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0.00001875        2747.    146483420.    11.4542136     0.0002148     -0.000460
0.8463105      0.00000       0.00000    -10.116896 C
0.00001938        2837.    146435939.    11.4573985     0.0002220     -0.000476
0.8730218      0.00000       0.00000    -10.452337 C
0.00002000        2928.    146388379.    11.4605894     0.0002292     -0.000491
0.8996349      0.00000       0.00000    -10.787658 C
0.00002063        3018.    146340740.    11.4637865     0.0002364     -0.000506
0.9261495      0.00000       0.00000    -11.122860 C
0.00002125        3109.    146293023.    11.4669897     0.0002437     -0.000521
0.9525655      0.00000       0.00000    -11.457943 C
0.00002188        3199.    146245226.    11.4701991     0.0002509     -0.000537
0.9788828      0.00000       0.00000    -11.792905 C
0.00002250        3289.    146197349.    11.4734147     0.0002582     -0.000552
1.0051012      0.00000       0.00000    -12.127747 C
0.00002313        3380.    146149393.    11.4766365     0.0002654     -0.000567
1.0312206      0.00000       0.00000    -12.462468 C
0.00002375        3470.    146101356.    11.4798646     0.0002726     -0.000582
1.0572407      0.00000       0.00000    -12.797068 C
0.00002438        3560.    146053239.    11.4830990     0.0002799     -0.000598
1.0831615      0.00000       0.00000    -13.131547 C
0.00002563        3740.    145956762.    11.4895866     0.0002944     -0.000628
1.1347044      0.00000       0.00000    -13.800138 C
0.00002688        3920.    145859959.    11.4960997     0.0003090     -0.000659
1.1858479      0.00000       0.00000    -14.468240 C
0.00002813        4100.    145762829.    11.5026384     0.0003235     -0.000689
1.2365908      0.00000       0.00000    -15.135848 C
0.00002938        4279.    145665368.    11.5092029     0.0003381     -0.000719
1.2869318      0.00000       0.00000    -15.802960 C
0.00003063        4458.    145567575.    11.5157934     0.0003527     -0.000750
1.3368696      0.00000       0.00000    -16.469573 C
0.00003188        4637.    145469446.    11.5224101     0.0003673     -0.000780
1.3864029      0.00000       0.00000    -17.135685 C
0.00003313        4815.    145370979.    11.5290534     0.0003819     -0.000811
1.4355303      0.00000       0.00000    -17.801291 C
0.00003438        4994.    145272172.    11.5357232     0.0003965     -0.000841
1.4842506      0.00000       0.00000    -18.466388 C
0.00003563        5172.    145173022.    11.5424200     0.0004112     -0.000871
1.5325623      0.00000       0.00000    -19.130975 C
0.00003688        5350.    145073526.    11.5491439     0.0004259     -0.000902
1.5804642      0.00000       0.00000    -19.795047 C
0.00003813        5527.    144973682.    11.5558951     0.0004406     -0.000932
1.6279549      0.00000       0.00000    -20.458601 C
0.00003938        5704.    144873487.    11.5626739     0.0004553     -0.000962
1.6750329      0.00000       0.00000    -21.121634 C
0.00004063        5881.    144772938.    11.5694804     0.0004700     -0.000992
1.7216969      0.00000       0.00000    -21.784143 C
0.00004188        6058.    144672033.    11.5763150     0.0004848     -0.001023
1.7679455      0.00000       0.00000    -22.446125 C
0.00004313        6235.    144570768.    11.5831779     0.0004995     -0.001053
1.8137773      0.00000       0.00000    -23.107576 C
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0.00004438        6411.    144469142.    11.5900692    0.0005143    -0.001083
1.8591907      0.00000       0.00000   -23.768492 C
0.00004563        6587.    144367151.    11.5969893    0.0005291    -0.001113
1.9041845      0.00000       0.00000   -24.428871 C
0.00004688        6762.    144264791.    11.6039384    0.0005439    -0.001144
1.9487570      0.00000       0.00000   -25.088709 C
0.00004813        6938.    144162062.    11.6109167    0.0005588    -0.001174
1.9929069      0.00000       0.00000   -25.748002 C
0.00004938        7113.    144058958.    11.6179246    0.0005736    -0.001204
2.0366327      0.00000       0.00000   -26.406747 C
0.00005063        7288.    143955478.    11.6249621    0.0005885    -0.001234
2.0799328      0.00000       0.00000   -27.064940 C
0.00005188        7462.    143851618.    11.6320297    0.0006034    -0.001264
2.1228057      0.00000       0.00000   -27.722578 C
0.00005313        7637.    143747376.    11.6391275    0.0006183    -0.001294
2.1652500      0.00000       0.00000   -28.379657 C
0.00005438        7811.    143642747.    11.6462559    0.0006333    -0.001324
2.2072640      0.00000       0.00000   -29.036173 C
0.00005563        7984.    143537729.    11.6534150    0.0006482    -0.001354
2.2488461      0.00000       0.00000   -29.692122 C
0.00005688        8158.    143432319.    11.6606052    0.0006632    -0.001384
2.2899949      0.00000       0.00000   -30.347502 C
0.00005813        8331.    143326514.    11.6678268    0.0006782    -0.001414
2.3307087      0.00000       0.00000   -31.002307 C
0.00005938        8504.    143220310.    11.6750800    0.0006932    -0.001444
2.3709859      0.00000       0.00000   -31.656534 C
0.00006063        8676.    143113704.    11.6823651    0.0007082    -0.001474
2.4108249      0.00000       0.00000   -32.310179 C
0.00006188        8849.    143006692.    11.6896824    0.0007233    -0.001504
2.4502241      0.00000       0.00000   -32.963238 C
0.00006313        9021.    142899271.    11.6970322    0.0007384    -0.001534
2.4891817      0.00000       0.00000   -33.615708 C
0.00006438        9192.    142791522.    11.7042905    0.0007535    -0.001564
2.5276755      0.00000       0.00000   -34.267815 C
0.00006563        9364.    142683423.    11.7114967    0.0007686    -0.001594
2.5657100      0.00000       0.00000   -34.919495 C
0.00006688        9535.    142574918.    11.7187344    0.0007837    -0.001624
2.6032973      0.00000       0.00000   -35.570592 C
0.00006813        9705.    142466003.    11.7260039    0.0007988    -0.001654
2.6404355      0.00000       0.00000   -36.221101 C
0.00006938        9876.    142356674.    11.7333056    0.0008140    -0.001684
2.6771231      0.00000       0.00000   -36.871018 C
0.00007063       10046.    142246929.    11.7406396    0.0008292    -0.001713
2.7133583      0.00000       0.00000   -37.520340 C
0.00007188       10216.    142136763.    11.7480064    0.0008444    -0.001743
2.7491394      0.00000       0.00000   -38.169061 C
0.00007313       10386.    142026173.    11.7554062    0.0008596    -0.001773
2.7844646      0.00000       0.00000   -38.817179 C
0.00007438       10555.    141915155.    11.7628393    0.0008749    -0.001803
2.8193322      0.00000       0.00000   -39.464688 C
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0.00007938       11229.    141466733.    11.7929112     0.0009361     -0.001921
2.9541900      0.00000       0.00000    -42.048555 C
0.00008438       11898.    141011164.    11.8235419     0.0009976     -0.002040
3.0815791      0.00000       0.00000    -44.622333 C
0.00008938       12561.    140548189.    11.8547531     0.0010595     -0.002158
3.2013767      0.00000       0.00000    -47.185724 C
0.00009438       13220.    140077537.    11.8865679     0.0011218     -0.002276
3.3134545      0.00000       0.00000    -49.738412 C
0.00009938       13670.    137558586.    11.8489463     0.0011775     -0.002400
3.4063567      0.00000       0.00000    -50.000000 CY
 0.0001044       13913.    133297940.    11.7487715     0.0012263     -0.002531
3.4820231      0.00000       0.00000    -50.000000 CY
 0.0001094       14130.    129187288.    11.6495435     0.0012742     -0.002663
3.5512579      0.00000       0.00000    -50.000000 CY
 0.0001144       14325.    125247621.    11.5520683     0.0013213     -0.002796
3.6144861      0.00000       0.00000    -50.000000 CY
 0.0001194       14502.    121484452.    11.4582374     0.0013678     -0.002930
3.6722605      0.00000       0.00000    -50.000000 CY
 0.0001244       14663.    117896074.    11.3681425     0.0014139     -0.003064
3.7248207      0.00000       0.00000    -50.000000 CY
 0.0001294       14810.    114472841.    11.2795224     0.0014593     -0.003198
3.7720717      0.00000       0.00000    -50.000000 CY
 0.0001344       14944.    111207642.    11.1934120     0.0015041     -0.003333
3.8143740      0.00000       0.00000    -50.000000 CY
 0.0001394       15066.    108099638.    11.1110311     0.0015486     -0.003469
3.8520596      0.00000       0.00000    -50.000000 CY
 0.0001444       15180.    105140552.    11.0322650     0.0015928     -0.003605
3.8852571      0.00000       0.00000    -50.000000 CY
 0.0001494       15284.    102322946.    10.9561859     0.0016366     -0.003741
3.9140022      0.00000       0.00000    -50.000000 CY
 0.0001544       15380.     99627242.    10.8809311     0.0016797     -0.003878
3.9382765      0.00000       0.00000    -50.000000 CY
 0.0001594       15469.     97058787.    10.8091013     0.0017227     -0.004015
3.9584453      0.00000       0.00000    -50.000000 CY
 0.0001644       15551.     94609180.    10.7405055     0.0017655     -0.004152
3.9745741      0.00000       0.00000    -50.000000 CY
 0.0001694       15628.     92270875.    10.6749807     0.0018081     -0.004289
3.9867206      0.00000       0.00000    -50.000000 CY
 0.0001744       15700.     90036212.    10.6120192     0.0018505     -0.004427
3.9949251      0.00000       0.00000    -50.000000 CY
 0.0001794       15766.     87893958.    10.5492972     0.0018923     -0.004565
3.9992237      0.00000       0.00000    -50.000000 CY
 0.0001844       15828.     85844132.    10.4893810     0.0019340     -0.004704
3.9969772      0.00000       0.00000    -50.000000 CY
 0.0001894       15885.     83881530.    10.4321928     0.0019756     -0.004842
3.9998118      0.00000       0.00000    -50.000000 CY
 0.0001944       15939.     82001155.    10.3777011     0.0020172     -0.004980
3.9978193      0.00000       0.00000    -50.000000 CY
 0.0001994       15989.     80195264.    10.3253312     0.0020586     -0.005119
3.9999434      0.00000       0.00000    -50.000000 CY
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 0.0002044       16036.     78462073.    10.2754001     0.0021000     -0.005257
3.9978483      0.00000       0.00000    -50.000000 CY
 0.0002094       16079.     76796593.    10.2259935     0.0021411     -0.005396
3.9999086      0.00000       0.00000    -50.000000 CY
 0.0002144       16120.     75194131.    10.1779621     0.0021819     -0.005536
3.9970000      0.00000       0.00000    -50.000000 CY
 0.0002194       16157.     73651690.    10.1316367     0.0022226     -0.005675
3.9995928      0.00000       0.00000    -50.000000 CY
 0.0002244       16193.     72170409.    10.0875334     0.0022634     -0.005814
3.9957261      0.00000       0.00000    -50.000000 CY
 0.0002294       16227.     70742291.    10.0450210     0.0023041     -0.005953
3.9985140      0.00000       0.00000    -50.000000 CY
 0.0002344       16258.     69368267.    10.0042016     0.0023447     -0.006093
3.9999648      0.00000       0.00000    -50.000000 CY
 0.0002394       16288.     68043830.     9.9651745     0.0023854     -0.006232
3.9958175      0.00000       0.00000    -50.000000 CY
 0.0002444       16316.     66766204.     9.9274778     0.0024260     -0.006371
3.9988430      0.00000       0.00000    -50.000000 CY
 0.0002494       16343.     65534446.     9.8907619     0.0024665     -0.006511
3.9999878      0.00000       0.00000    -50.000000 CY
 0.0002544       16367.     64341289.     9.8537798     0.0025066     -0.006651
3.9950242      0.00000       0.00000    -50.000000 CY
 0.0002594       16390.     63190041.     9.8181740     0.0025466     -0.006791
3.9982017      0.00000       0.00000    -50.000000 CY
 0.0002644       16412.     62077971.     9.7837372     0.0025866     -0.006931
3.9997949      0.00000       0.00000    -50.000000 CY
 0.0002694       16432.     61001973.     9.7504661     0.0026265     -0.007071
3.9959403      0.00000       0.00000    -50.000000 CY
 0.0002744       16452.     59963095.     9.7187118     0.0026666     -0.007211
3.9960484      0.00000       0.00000    -50.000000 CY
 0.0003044       16551.     54378151.     9.5472479     0.0029059     -0.008052
3.9994904      0.00000       0.00000    -50.000000 CY
 0.0003344       16623.     49713725.     9.3958159     0.0031417     -0.008896
3.9999191      0.00000       0.00000    -50.000000 CY
 0.0003644       16677.     45768736.     9.2671097     0.0033767     -0.009741
3.9996325      0.00000       0.00000    -50.000000 CY
 0.0003944       16719.     42393688.     9.1556383     0.0036108     -0.010587
3.9971665      0.00000       0.00000    -50.000000 CY
 0.0004244       16750.     39469091.     9.0522872     0.0038416     -0.011436
3.9870881      0.00000       0.00000    -50.000000 CY


-------------------------------------------------------------------------------
   Summary of Results for Nominal Moment Capacity for Section 2
-------------------------------------------------------------------------------

Moment values interpolated at maximum compressive strain = 0.003
or maximum developed moment if pile fails at smaller strains.

 Load           Axial Thrust        Nominal Mom. Cap.      Max. Comp.      Max.
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Tens. No.	kips	in-kip	Strain	Strain
1	0.000	16579.943	0.00300000	-0.00838832

Note that the values of moment capacity in the table above are not
factored by a strength reduction factor (phi-factor).

In ACI 318, the value of the strength reduction factor depends on whether
the transverse reinforcing steel bars are tied hoops (0.65) or spirals (0.75).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318,
or the value required by the design standard being followed.

The following table presents factored moment capacities and corresponding
bending stiffnesses computed for common resistance factor values used for
reinforced concrete sections.

Axial Load No.	Resist. Factor	Nominal Ax. Thrust kips	Nominal Moment Cap in-kips	Ult. (Fac) Ax. Thrust kips	Ult. (Fac) Moment Cap in-kips	Bend. Stiff. at Ult Mom kip-in^2
1	0.65	0.0000	16580.	0.0000	10777.	141767436.
1	0.75	0.0000	16580.	0.0000	12435.	140636460.
1	0.90	0.0000	16580.	0.0000	14922.	111735012.

Layering Correction Equivalent Depths of Soil & Rock Layers

Layer No.	Top of Layer Below Pile Head ft	Equivalent Top Depth Below Grnd Surf ft	Same Layer Type As Layer Above	Layer is Rock or is Below Rock Layer	F0 Integral for Layer lbs	F1 Integral for Layer lbs

1	15.0000	0.00	N.A.	No	0.00	5411.
2	17.0000	1.8881	Yes	No	5411.	7752.
3	18.0000	2.8880	Yes	No	13163.	129086.
4	26.0000	10.8592	No	No	142249.	88785.
5	29.0000	14.9693	No	No	231034.	1561936.
6	48.0000	36.4805	Yes	No	1792970.	636386.
7	53.0000	36.2967	No	No	2429356.	1060475.
8	58.0000	41.4336	No	No	3489831.	N.A.

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

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

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

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

Depth X	Deflect. y	Bending Moment	Shear Force	Slope S	Total Stress	Bending Stiffness	Soil Res. Es*H	Soil Spr. Lat. Load	Distrib. p
feet	inches	in-lbs	lbs	radians	psi*	lb-in^2	lb/inch	lb/inch	lb/inch
0.00	3.4971	-8.07E-06	2.36E-08	-0.01147	1.37E-08	7.74E+10	0.00	0.00	7.4625
0.7500	3.3939	302.2312	154.4063	-0.01147	0.5132	7.74E+10	0.00	0.00	26.8500
1.5000	3.2907	2779.	512.3813	-0.01147	4.7197	7.74E+10	0.00	0.00	52.7000
2.2500	3.1875	9525.	1103.	-0.01147	16.1750	7.74E+10	0.00	0.00	78.5500
3.0000	3.0842	22633.	1926.	-0.01147	38.4349	7.74E+10	0.00	0.00	104.4000
3.7500	2.9811	44198.	2982.	-0.01146	75.0550	7.74E+10	0.00	0.00	130.2500

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    4.5000     2.8779     76313.      4271.   -0.01146   129.5909   7.74E+10
0.00       0.00   156.1000
    5.2500     2.7749    121072.      5792.   -0.01144   205.5984   7.74E+10
0.00       0.00   181.9500
    6.0000     2.6719    180569.      7546.   -0.01143   306.6331   7.74E+10
0.00       0.00   207.8865
    6.7500     2.5692    256905.      9536.   -0.01141       0.00   4.15E+11
0.00       0.00   234.3417
    7.5000     2.4665    352223.     11765.   -0.01141       0.00   4.15E+11
0.00       0.00   260.8833
    8.2500     2.3639    468672.     14232.   -0.01140       0.00   4.15E+11
0.00       0.00   287.4250
    9.0000     2.2614    608402.     16938.   -0.01139       0.00   4.14E+11
0.00       0.00   313.9667
    9.7500     2.1589    773564.     19884.   -0.01137       0.00   4.14E+11
0.00       0.00   340.5083
   10.5000     2.0567    966307.     23068.   -0.01135       0.00   4.13E+11
0.00       0.00   367.0500
   11.2500     1.9546   1188781.     26490.   -0.01133       0.00   4.13E+11
0.00       0.00   393.5917
   12.0000     1.8528   1443136.     30152.   -0.01130       0.00   4.12E+11
0.00       0.00   420.1333
   12.7500     1.7512   1731522.     34053.   -0.01126       0.00   4.11E+11
0.00       0.00   446.6750
   13.5000     1.6500   2056088.     38192.   -0.01122       0.00   4.10E+11
0.00       0.00   473.2167
   14.2500     1.5492   2418985.     42571.   -0.01117       0.00   4.09E+11
0.00       0.00   499.7583
   15.0000     1.4489   2822362.     47174.   -0.01106       0.00   1.46E+11
0.00       0.00   523.0698
   15.7500     1.3501   3268108.     51432.   -0.01087       0.00   1.46E+11
-103.725   691.4547   527.0000
   16.5000     1.2531   3748140.     54719.   -0.01066       0.00   1.46E+11
-220.482      1583.   527.7000
   17.2500     1.1583   4253056.     56677.   -0.01041       0.00   1.46E+11
-400.553      3112.   528.4000
   18.0000     1.0657   4768327.     57159.   -0.01013       0.00   1.45E+11
-549.903      4644.   529.0523
   18.7500     0.9759   5281910.     56499.   -0.00982       0.00   1.45E+11
-655.172      6042.   529.4188
   19.5000     0.8890   5785306.     54849.   -0.00948       0.00   1.45E+11
-770.596      7801.   529.7375
   20.2500     0.8053   6269194.     52073.   -0.00910       0.00   1.45E+11
-906.054     10126.   530.0563
   21.0000     0.7252   6722625.     47993.   -0.00870       0.00   1.44E+11
-1061.     13171.   530.3750
   21.7500     0.6488   7133059.     42401.   -0.00826       0.00   1.44E+11
-1242.     17235.   530.6938
   22.5000     0.5764   7485843.     35197.   -0.00781       0.00   1.44E+11
-1420.     22174.   531.0125
```

```
   23.2500     0.5082   7766612.     26685.   -0.00733       0.00   1.44E+11
-1534.     27161.   531.3312
   24.0000     0.4445   7966180.     17230.   -0.00684       0.00   1.44E+11
-1630.     33015.   531.6500
   24.7500     0.3852   8076749.      6947.   -0.00633       0.00   1.43E+11
-1718.     40150.   531.9688
   25.5000     0.3304   8091226.     -4045.   -0.00583       0.00   1.43E+11
-1789.     48716.   532.2875
   26.2500     0.2803   8003936.    -10130.   -0.00532       0.00   1.44E+11
-628.316     20175.   532.6063
   27.0000     0.2346   7908894.    -10687.   -0.00482       0.00   1.44E+11
-561.010     21518.   532.9250
   27.7500     0.1935   7811576.    -10795.   -0.00433       0.00   1.44E+11
-529.189     24617.   533.2438
   28.5000     0.1567   7714588.    -10624.   -0.00384       0.00   1.44E+11
-499.587     28694.   533.5625
   29.2500     0.1243   7620351.    -16892.   -0.00336       0.00   1.44E+11
-1961.    142008.   533.8813
   30.0000    0.09614   7410530.    -29549.   -0.00289       0.00   1.44E+11
-1920.    179735.   534.1814
   30.7500    0.07218   7088460.    -41767.   -0.00244       0.00   1.44E+11
-1864.    232372.   534.3700
   31.5000    0.05221   6658716.    -53364.   -0.00201       0.00   1.44E+11
-1782.    307224.   534.5400
   32.2500    0.03597   6127915.    -63060.   -0.00161       0.00   1.45E+11
-1442.    360774.   534.7100
   33.0000    0.02317   5523630.    -69100.   -0.00125       0.00   1.45E+11
-969.787    376763.   534.8800
   33.7500    0.01345   4884117.    -71291.  -9.29E-04       0.00   1.45E+11
-586.958    392841.   535.0500
   34.5000    0.00645   4240399.    -70435.  -6.46E-04       0.00   1.46E+11
-293.149    409010.   535.2200
   35.2500    0.00181   3616289.    -67321.  -4.04E-04       0.00   1.46E+11
-85.599    425269.   535.3900
   36.0000  -8.21E-04   3028613.    -62706.  -1.99E-04       0.00   1.46E+11
40.3094    441617.   535.5600
   36.7500   -0.00178   2487581.    -57297.  -7.89E-05       0.00   4.09E+11
90.4970    458056.   535.7300
   37.5000   -0.00224   1997274.    -51535.  -2.97E-05       0.00   4.10E+11
118.2362    474585.   535.9000
   38.2500   -0.00231   1559952.    -45611.   9.28E-06       0.00   4.12E+11
126.1957    491203.   536.0700
   39.0000   -0.00208   1176274.    -39691.   3.92E-05       0.00   4.13E+11
117.1149    507912.   536.2400
   39.7500   -0.00161    845517.    -33915.   6.12E-05       0.00   4.14E+11
93.7114    524710.   536.4100
   40.5000  -9.74E-04    565801.    -28401.   7.65E-05       0.00   4.14E+11
58.6066    541598.   536.5800
   41.2500  -2.30E-04    334294.    -23243.   8.63E-05       0.00   4.15E+11
14.2620    558576.   536.7500
```

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   42.0000   5.80E-04    147419.    -18515.   9.15E-05       0.00   4.15E+11
-37.070    575645.   536.9200
   42.7500    0.00142      1032.    -14269.   9.31E-05       0.00   4.15E+11
-93.381    592803.   537.0900
   43.5000    0.00226   -109414.    -10542.   9.20E-05       0.00   4.15E+11
-152.923    610051.   537.2600
   44.2500    0.00307   -188729.     -7358.   8.87E-05       0.00   4.15E+11
-214.222    627389.   537.4300
   45.0000    0.00385   -241865.     -4727.   8.41E-05       0.00   4.15E+11
-276.069    644817.   537.5431
   45.7500    0.00459   -273820.     -2652.   7.85E-05       0.00   4.15E+11
-337.511    662335.   537.3150
   46.5000    0.00527   -289592.     -1126.   7.24E-05       0.00   4.15E+11
-397.822    679943.   537.0300
   47.2500    0.00589   -294088.   -138.308   6.60E-05       0.00   4.15E+11
-456.470    697641.   536.7450
   48.0000    0.00645   -292082.   157.5013   5.97E-05       0.00   4.15E+11
-550.999    768317.   536.4600
   48.7500    0.00696   -291253.   -232.785   5.34E-05       0.00   4.15E+11
-608.366    786345.   536.1750
   49.5000    0.00741   -296272.     -1129.   4.70E-05       0.00   4.15E+11
-662.763    804463.   535.8900
   50.2500    0.00781   -311567.     -2501.   4.04E-05       0.00   4.15E+11
-713.772    822672.   535.6050
   51.0000    0.00814   -341295.     -4318.   3.33E-05       0.00   4.15E+11
-760.773    840970.   535.3200
   51.7500    0.00841   -389283.     -6537.   2.54E-05       0.00   4.15E+11
-802.850    859358.   535.0350
   52.5000    0.00860   -458965.     -9110.   1.62E-05       0.00   4.15E+11
-838.685    877836.   534.7500
   53.2500    0.00870   -553266.     -8530.   5.18E-06       0.00   4.14E+11
-101.612    105124.   534.4650
   54.0000    0.00869   -612505.     -4645.  -7.48E-06       0.00   4.14E+11
-103.805    107485.   534.1800
   54.7500    0.00856   -636884.   -776.710  -2.11E-05       0.00   4.14E+11
-104.543    109857.   533.8950
   55.5000    0.00831   -626486.      3090.  -3.48E-05       0.00   4.14E+11
-103.671    112240.   533.6100
   56.2500    0.00794   -581262.      6970.  -4.79E-05       0.00   4.14E+11
-101.115    114635.   533.3250
   57.0000    0.00745   -501030.     10877.  -5.97E-05       0.00   4.14E+11
-96.891    117042.   533.0400
   57.7500    0.00686   -385469.     14827.  -6.93E-05       0.00   4.15E+11
-91.115    119460.   532.7550
   58.5000    0.00620   -234136.     16362.  -7.60E-05       0.00   4.15E+11
-632.992    918371.   532.4700
   59.2500    0.00550    -90945.     15729.  -7.95E-05       0.00   4.15E+11
-572.452    937356.   532.1850
   60.0000    0.00477     48984.     14463.  -8.00E-05       0.00   4.15E+11
-507.091    956431.   265.9856
```

60.7500	0.00406	169384.	11399.	-7.76E-05	0.00	4.15E+11	
-439.736	975595.	0.00					
61.5000	0.00337	254166.	7742.	-7.30E-05	0.00	4.15E+11	
-373.021	994850.	0.00					
62.2500	0.00274	308732.	4672.	-6.69E-05	0.00	4.15E+11	
-309.003	1014195.	0.00					
63.0000	0.00217	338270.	2160.	-5.99E-05	0.00	4.15E+11	
-249.209	1033630.	0.00					
63.7500	0.00166	347621.	162.9436	-5.25E-05	0.00	4.15E+11	
-194.690	1053155.	0.00					
64.5000	0.00123	341203.	-1371.	-4.50E-05	0.00	4.15E+11	
-146.077	1072769.	0.00					
65.2500	8.54E-04	322952.	-2494.	-3.78E-05	0.00	4.15E+11	
-103.649	1092474.	0.00					
66.0000	5.45E-04	296306.	-3264.	-3.11E-05	0.00	4.15E+11	
-67.392	1112268.	0.00					
66.7500	2.95E-04	264201.	-3734.	-2.50E-05	0.00	4.15E+11	
-37.055	1132153.	0.00					
67.5000	9.54E-05	229094.	-3956.	-1.96E-05	0.00	4.15E+11	
-12.210	1152127.	0.00					
68.2500	-5.91E-05	192999.	-3976.	-1.51E-05	0.00	4.15E+11	
7.6982	1172192.	0.00					
69.0000	-1.76E-04	157527.	-3836.	-1.13E-05	0.00	4.15E+11	
23.3084	1192346.	0.00					
69.7500	-2.62E-04	123943.	-3573.	-8.22E-06	0.00	4.15E+11	
35.3038	1212590.	0.00					
70.5000	-3.24E-04	93219.	-3214.	-5.87E-06	0.00	4.15E+11	
44.3770	1232924.	0.00					
71.2500	-3.68E-04	66089.	-2784.	-4.14E-06	0.00	4.15E+11	
51.2009	1253349.	0.00					
72.0000	-3.98E-04	43106.	-2300.	-2.96E-06	0.00	4.15E+11	
56.4023	1273863.	0.00					
72.7500	-4.21E-04	24692.	-1774.	-2.22E-06	0.00	4.15E+11	
60.5387	1294467.	0.00					
73.5000	-4.39E-04	11182.	-1213.	-1.83E-06	0.00	4.15E+11	
64.0782	1315161.	0.00					
74.2500	-4.54E-04	2862.	-621.231	-1.68E-06	0.00	4.15E+11	
67.3793	1335945.	0.00					
75.0000	-4.69E-04	0.00	0.00	-1.65E-06	0.00	4.15E+11	
70.6721	678409.	0.00					

* This analysis computed pile response using nonlinear moment-curvature relationships. Values of total stress due to combined axial and bending stresses are computed only for elastic sections only and do not equal the actual stresses in concrete and steel. Stresses in concrete and steel may be interpolated from the output for nonlinear bending properties relative to the magnitude of bending moment developed in the pile.

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     3.49711433 inches
Computed slope at pile head      =     -0.0114689 radians
Maximum bending moment           =       8091226. inch-lbs
Maximum shear force              =        -71291. lbs
Depth of maximum bending moment  =    25.50000000 feet below pile head
Depth of maximum shear force     =    33.75000000 feet below pile head
Number of iterations             =             32
Number of zero deflection points =              3
Pile deflection at ground        =     1.44886133 inches
```

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

Boundary Condition Type 1, Shear and Moment

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

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
75.00000	3.49711433	8091226.	-71291.
71.25000	3.46654792	8073035.	-71488.
67.50000	3.45600044	8096062.	-71638.
63.75000	3.53147571	8084389.	-72024.
60.00000	3.48028589	8100260.	-70653.
56.25000	3.45833270	8092216.	-70566.
52.50000	3.51319670	8099099.	-71279.
48.75000	3.46918121	8073759.	-70533.
45.00000	3.51732141	8087643.	-71852.
41.25000	3.49306634	8097743.	-77740.
37.50000	6.45340168	9338060.	-155640.

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

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

Load Type 5: Load 1 = Top Deflection, y, inches, and Load 2 = Slope, S, radians

Load Case	Load Type	Pile-head Load 1	Load Type	Pile-head Load 2	Axial Loading lbs	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	V, lb	0.00	M, in-lb	0.00	0.00	3.4971	-0.01147	-71291.	8091226.

Maximum pile-head deflection = 3.4971143334 inches
Maximum pile-head rotation = -0.0114689459 radians = -0.657122 deg.

Results of Push-over Analysis

Computation Methods Used for Push-over Analyses:
- Computations use both pinned-head and fixed-head conditions
- Computations use a logarithmic distribution of pile-head deflections

Number of push-over steps	=	20
Minimum pushover deflection	=	0.0001000 in
Maximum pushover deflection	=	10.000000 in
Axial thrust force for pushover analysis	=	0.0000 lbs

Pushover Point Number	Pile-head Fixity Condition	Pile-head Deflection inches	Pile-head Shear lbs	Max Moment in Pile in-lb(abs)	Max Shear in Pile lbs (abs)	Depth to Max Moment feet	Depth to Max Shear feet
1	Pin-head	1.00E-04	-12761.	1184557.	12761.	12.0000	0.00
2	Pin-head	2.3139	13150.	6010927.	41026.	22.5000	32.2500
3	Pin-head	3.6673	22568.	8634837.	65770.	23.2500	32.2500
4	Pin-head	4.6276	28243.	1.03E+07	83699.	24.0000	33.0000
5	Pin-head	5.3725	32186.	1.16E+07	95501.	24.0000	33.7500

6	Pin-head	5.9811	35090.	1.25E+07	106263.	24.7500	33.7500
7	Pin-head	6.4956	37296.	1.33E+07	115302.	24.7500	33.7500
8	Pin-head	6.9414	38941.	1.39E+07	121116.	24.7500	34.5000
9	Pin-head	7.3345	40023.	1.42E+07	126109.	25.5000	34.5000
10	Pin-head	7.6862	40739.	1.45E+07	131208.	25.5000	34.5000
11	Pin-head	8.0044	41310.	1.48E+07	133691.	25.5000	34.5000
12	Pin-head	8.2948	41792.	1.49E+07	135679.	25.5000	34.5000
13	Pin-head	8.5620	42178.	1.51E+07	137334.	25.5000	34.5000
14	Pin-head	8.8094	42505.	1.52E+07	138713.	25.5000	34.5000
15	Pin-head	9.0397	42808.	1.53E+07	139892.	25.5000	34.5000
16	Pin-head	9.2551	43063.	1.54E+07	141031.	26.2500	35.2500
17	Pin-head	9.4575	43270.	1.55E+07	142858.	26.2500	35.2500
18	Pin-head	9.6483	43439.	1.56E+07	144677.	26.2500	35.2500
19	Pin-head	9.8288	43628.	1.57E+07	146052.	26.2500	35.2500
20	Pin-head	10.0000	43800.	1.57E+07	146882.	26.2500	35.2500
21	Fixed-head	1.00E-04	-17828.	1041744.	17828.	13.5000	0.00
22	Fixed-head	2.3139	47972.	9057393.	71422.	0.00	16.5000
23	Fixed-head	3.6673	70804.	1.35E+07	96011.	0.00	34.5000
24	Fixed-head	4.6276	83101.	1.62E+07	121147.	0.00	35.2500
25	Fixed-head	5.3725	91955.	1.82E+07	137641.	0.00	36.0000
26	Fixed-head	5.9811	97881.	1.97E+07	145940.	0.00	36.0000
27	Fixed-head	6.4956	102671.	2.10E+07	150208.	0.00	36.0000
28	Fixed-head	6.9414	106556.	2.21E+07	153204.	0.00	36.0000
29	Fixed-head	7.3345	109863.	2.30E+07	156556.	0.00	36.7500
30	Fixed-head	7.6862	112683.	2.38E+07	158955.	0.00	36.7500

```
   31    Fixed-head     8.0044    115005.   2.45E+07    160255.       0.00
36.7500
   32    Fixed-head     8.2948    116868.   2.50E+07    161234.       0.00
36.7500
   33    Fixed-head     8.5620    118454.   2.55E+07    162002.       0.00
36.7500
   34    Fixed-head     8.8094    119732.   2.59E+07    162600.       0.00
36.7500
   35    Fixed-head     9.0397    120760.   2.62E+07    163064.       0.00
36.7500
   36    Fixed-head     9.2551    121569.   2.64E+07    163421.       0.00
36.7500
   37    Fixed-head     9.4575    122184.   2.66E+07    163685.       0.00
36.7500
   38    Fixed-head     9.6483    122591.   2.67E+07    163735.       0.00
36.7500
   39    Fixed-head     9.8288    122846.   2.68E+07    163733.       0.00
36.7500
   40    Fixed-head    10.0000    122875.   2.68E+07    163716.       0.00
36.7500

* WARNING: Some values of computed curvature exceeded the maximum curvature
calculated or entered by the user
           Fixed-head Condition    Step =    40  Node =    42


The analysis ended normally.
```

Appendix D
Geotechnical Engineering Design Checklist

I. Geotechnical Design Checklists	
Project: FUL-20A-19.20	**PDP Path:**
PID: 119890	**Review Stage: 3**

Checklist	Included in This Submission
II. Reconnaissance and Planning	
III. A. Centerline Cuts III. B. Embankments III. C. Subgrade	
IV. A. Foundations of Structures IV. B. Retaining Wall	✓
V. A. Landslide Remediation V. B. Rockfall Remediation V. C. Wetland or Peat Remediation V. D. Underground Mine Remediation V. E. Surface Mine Remediation V. F. Karst Remediation	✓
VI. A. Geotechnical Profile VI. D. Geotechnical Reports	✓

IV.B. Retaining Wall Checklist

C-R-S:	FUL-20A-19.20	PID:	119890	Reviewer:	M. Brown	Date:	4/21/2025

If you do not have a retaining wall on the project, you do not have to fill out this checklist.

	Soil Data and Preliminary Calculations	(Y/N/X)	Notes:
1	Has a justification study been performed to determine the necessity of a wall as opposed to ROW purchase or other project alternatives?	X	
2	Have the necessary soil strength parameters and unit weights been determined?	Y	
	Check method used:		
	laboratory shear tests	✓	
	estimation from SPT or field tests	✓	
3	Has the groundwater elevation been determined?	Y	Groundwater measured in borings
4	Have the proper loading conditions been determined?	Y	
a.	If yes, check which loading conditions apply:		
	Backfill (Active Earth Pressure Loading):	✓	
	Backfill (Apparent Earth Pressure (AEP) Loading for Ground Anchors):		
	Backfill (At-Rest Earth Pressure Loading):		
	Backfill (Flat, No Slope):	✓	
	Backfill (Infinite Slope):		
	Backfill (Broken Back Slope):		
	Earth Surcharge:	✓	
	Live Load Surcharge:	✓	
	Other (describe):		
5	Have the correct Load Factors, Load Combinations, and Limit States been considered, per AASHTO LRFD 9th Ed. Articles 3.4.1, 10.5, and 11.5?	Y	Followed guidance in GDM 900 and 1500
6	Are earth pressure loads inclined at the soil-structure interaction friction angle, δ and has δ been determined per BDM 307.1.1?		CHECK
7	Have the correct Resistance Factors been considered, per AASHTO LRFD 9th Ed. Articles 10.5 and 11.5?	Y	Per GDM 900 and 15000
8	If applicable, has the influence of groundwater been taken into account with regards to soil unit weights and active pressures?	Y	Used saturated unit weights, buoyant unit weights, and groundwater pressure.
9	Has the Coulomb method been utilized to determine the lateral earth pressure?	Y	

IV.B. Retaining Wall Checklist

Design	(Y/N/X)	Notes:
10 For preliminary wall design, have the design criteria and wall type selection process been followed as instructed in BDM 201.1.2.5?		
11 Was an economic analysis performed to evaluate the cost benefits of the chosen wall type compared to others?		
12 Were representative sections analyzed for the entire length of the retaining wall for the following:	Y	
a. bearing resistance?	X	
b. sliding resistance?	X	
c. limiting eccentricity and overturning resistance? Analyze moment equilibrium about toe for non-gravity cantilever walls.	Y	Overturning per GDM 900 and 1500
d. total and differential settlement?	X	
e. overall (global) stability?	Y	
13 If poor foundation soils are present, has a solution been determined with respect to the following:	X	
a. excessive settlement?		
b. inadequate bearing resistance?		
c. inadequate sliding resistance?		
d. overall (global) instability?		
14 For non-proprietary walls, each wall type has design recommendations which need to be determined. For the wall type being evaluated, have the following design recommendations been determined by accepted design methods or, where applicable, FHWA design guidelines:	Y	
a. Rigid Gravity and Semigravity -- footing width and elevation, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance (BDM 307.1.5 & 307.2)		
b. Drilled Shafts - diameter, spacing, embedment, arrangement and percent reinforcement, maximum moment and lateral shear, maximum deflection (see BDM 307.6)	Y	
c. Soldier Pile -pile size and type, drilled hole diameter, embedment, spacing, lagging design, facing, maximum moment and lateral shear, section modulus, maximum deflection		

IV.B. Retaining Wall Checklist

Design	(Y/N/X)	Notes:
d. Sheet Pile - pile size, embedment, maximum moment and lateral shear, section modulus, maximum deflection (BDM 307.7.1)		
e. Cellular - type, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance, fill material (BDM 307.7.2)		
f. Soil Anchor - load per anchor, number of rows, wale design, anchor inclination and minimum length, type of anchor, pile size, type, spacing, and embedment, maximum moment and lateral shear, section modulus, lagging design, facing (BDM 307.8)		
g. Soil Nail - nail size, spacing, inclination, and length, loading per nail, facing (BDM 307.9)		
15 Has the need for load testing of the retaining wall elements been evaluated?	X	Load testing not necessary
a. If needed, have details and plan notes for load testing been included in the plans?		
16 Proprietary wall designs require a special process for detail design, as outlined in BDM 307.3 and 307.4. Has this procedure been followed for this project?	X	Not a proprietary wall
17 Temporary walls - have the same design requirements as permanent walls of the same type been followed, except the design service life is no more than three years (BDM 307.10)?	X	Not a temporary wall
18 The presence and quality of water behind the wall structure and in the backfill can be a major source of overloading and failure.		
a. Has the quality / chemistry of the groundwater been accounted for in the drainage system?		Curb and gutter keeps surface water from behind wall. Groundwater can flow between drilled shafts.
b. Has an adequate drainage system been included in the detail wall design?		Curb and gutter.
c. If there is a water source behind the wall, has additional drainage been added to control the effect of this water source on the wall?		Groundwater is typically below continuous retained portion of wall (plug piles).
19 Have the effects of the wall design and construction procedure been determined and accounted for on the construction schedule?		

IV.B. Retaining Wall Checklist

Design		(Y/N/X)	Notes:
20	Has the effect of the wall design and construction been evaluated with regard to structures (e.g., bridges, culverts, buildings, utilities), which may be subject to unusual stresses or require special design or construction considerations?		
Plans and Contract Documents		(Y/N/X)	Notes:
21	Have all the necessary notes, specifications, special provisions, and details for the construction of the wall system been included in the plans?	Y	
22	Have the need, location, type, plan notes, and reading schedule for any instrumentation been determined and included in the plans?	Y	

Check the types of instrumentation specified:	
settlement cells	
settlement platforms	
inclinometers	✓
monitoring wells / piezometers	
load cells	
strain gages	
other (describe other types)	

V.A. Landslide Remediation Checklist

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If you do not have a landslide remediation on the project, you do not have to fill out this checklist.

	Exploration	(Y/N/X)	Notes:
1	Is the site included in the GHMS/ Collector Landslide Inventory? If yes, provide the rating.		
2	Has a site reconnaissance been conducted to define the limits of the landslide?	Y	Site was previously attempted to be repaired with riprap and sheet pile. 1.5-foot head scarp noted during Sep 2024 site visit. Guardrail signficantly curved toward downslope and dropped. Curb is separating from edge of pavement.
	If yes, check the visible signs observed:		
	cracks in pavement		
	bulging toe		
	sloughed slopes	✓	
	scarp	✓	
	stream channel or ditch pinches		
	hydrophytic vegetation		
	rotated or dropped guardrail	✓	
	bent, cracked, or crushed pipe, culvert, or other structures		
	water seepage, flow from embankment, or ice		
	leaning, curved, J-shaped, deformed, or fallen trees or power poles		
	deflection of linear features		
	other (describe other visible signs)	✓	
3	Have a site plan and cross sections been provided to compare ground surface conditions before and after failure?	Y	1934 plans show previous profile line over creek. Current topo and sections provided.
4	Has the history of the landslide area been researched, including movement history, maintenance work, pavement drainage, and past corrective measures?	Y	History of corrective measures taken in 2022 by town to install sheet pile and riprap on slope.
5	Has a site specific geotechnical exploration been performed to investigate the landslide area?	Y	4 borings drilled in July 2024
6	Has a groundwater monitoring program been performed to identify the phreatic surface through the landslide area?	N	Groundwater observed during drilling, from nearby historical well log, and surface observations durign site visit.
7	Has a landslide failure plane been determined from field observations or instrumentation?	Y	Failure plane estimated from observed head scarp and shape of failure surface.

V.A. Landslide Remediation Checklist

Analysis		(Y/N/X)	Notes:
8	Has the landslide mode of failure been determined?	Y	Potential rotational and translational modes possible.
	Check those that apply:		
	rotational failure	✓	
	translational	✓	
	block failure		
	sheet		
	surface sloughing		
	slump		
	other (describe other failure modes)		
9	Have the subsurface conditions been identified which are the expected source of the failure mode?	Y	
	Check those that apply:		
	general shear strength failure of foundation soils	✓	
	loading		
	along sloped rock surfaces		
	erosion		
	through thin, weak soil layers		
	permeable materials		
	surface / groundwater		
	structure		
	Anthropogenic disturbances		
	weathering		
	impeded drainage		
	other (describe other sources)		
10	If water (static or flowing) significantly influences the stability of the landslide, has the source of water been identified, quantified, and water quality assessed?	Y	Water in borings is low, no observed seeps on surface. Potential rapid drawdown scenario could destabilize.
11	Have calculations been performed to determine the F.S. for stability? Indicate which program and which analysis method (Spencer, Bishop, etc) was used.	Y	FS for stability in existing condition of 1.16, using Spencer method. Preliminary construction stability also calculated.
12	Have the following F.S. been met or exceeded, as determined by the calculations, for the given stability conditions:	Y	
a.	1.30 for short term (undrained) condition	Y	2.16
b.	1.30 for long term (drained) condition	Y	3.18
c.	1.10 for rapid drawdown, flood condition	Y	2.99
d.	1.50 for slope containing or supporting a structural element	Y	2.16 minimum

V.A. Landslide Remediation Checklist

Analysis		(Y/N/X)	Notes:
13	When differing soil or loading conditions occur throughout the landslide area, have sufficient analyses been completed to evaluate the stability at locations representative of the most critical conditions?	Y	Location with combination of steep slope and proximity to observed slope/guardrail deformation selected.

Design		(Y/N/X)	Notes:
14	Has a landslide remediation method been determined?	Y	Drilled shaft wall with W-beam reinforcement, plug piles.
	If yes, check the methods that were evaluated and note the chosen remediation:		
	benching and regrading (See GDM 800)		
	counter berm and regrading		
	flatten slope		
	geosynthetic reinforced slope		
	install surface / subsurface drainage system		
	shear key (See GDM 800)		
	soil nails or tiebacks		
	walls, sheeting, or drilled shafts	✓	
	soil anchoring		
	relocate existing alignments		
	lightweight fills		
	soil removal / treatment		
	chemical treatment		
	Bioengineering		
	other (describe other methods)		
15	Based on accepted design practices, and where applicable, adhering to published guidelines and design recommendations from FHWA, were calculations performed to evaluate the effectiveness of the chosen solutions?	Y	Primary design document ODOT GDM Sections 900 and 1500.
16	Has a cost comparison been performed to evaluate a recommended solution compared to others?	N	

V.A. Landslide Remediation Checklist

	Plans and Contract Documents	(Y/N/X)	Notes:
17	Have all necessary notes, specifications, and plan details been developed?	Y	
18	Has the vertical and lateral extent of defined landslide conditions been included on the Cross Sections and Plan and Profile sheets?	Y	Project limits for landslide remediation included on plans.
19	Has the information obtained from the exploration and analysis been incorporated into the project design?	Y	
20	Have the need, location, plan notes, and monitoring schedule of instrumentation been determined?	Y	
21	Have the effects of the stability solution on the construction schedule and maintenance of traffic been accounted for in the plans?	Y	
22	Have the effects of the original failure and proposed remediation on any structures (e.g., bridges, buildings, culverts, utilities) or adjacent properties been evaluated and solutions to any issues incorporated into final design?		

VI.B. Geotechnical Reports

C-R-S:	FUL-20A-19.20	PID:	119890	Reviewer:	M. Brown	Date:	4/21/2025

General		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	Final report
2	Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'?	Y	
3	Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'?	Y	
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files meet this demand?	Y	gINT files submitted with final report
5	Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ?	Y	
6	Have all geotechnical reports being submitted been titled correctly as prescribed in Section 706.1 of the SGE?	Y	
Report Body		(Y/N/X)	Notes:
7	Do all geotechnical reports being submitted contain the following:		
a.	an Executive Summary as described in Section 706.2 of the SGE?	Y	
b.	an Introduction as described in Section 706.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 706.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 706.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 706.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 706.7 of the SGE?	Y	
Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 706.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 706.8.1 of the SGE?	Y	

VI.B. Geotechnical Reports

Appendices		(Y/N/X)	Notes:
10	Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 706.8.2 of the SGE?	Y	No rock
11	Do the Appendices include reports of undisturbed test data as described in Section 706.8.3 of the SGE?	Y	
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 706.8.4 of the SGE?	Y	