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FINAL REPORT
OF
LANDSLIDE EXPLORATION

PIK-CR50-02.55, PID NO. 108464

PIKE COUNTY, OHIO

Prepared For:

Pike County Engineer's Office
502 Pike Street
Waverly, OH 45690

Prepared By:

DLZ OHIO, INC.

DLZ Job No. 1921-1005.00

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EXECUTIVE SUMMARY

This report includes the findings of the subsurface exploration performed for the County Route 50 (CR-50) landslide repair located near section 2.55 in Jackson Township, Pike County, Ohio. This report is scoped to address only the portion of hillside immediately downslope of the roadway and does not address the larger instability at the site. It should be noted that the slope and roadway will likely continue to move if the larger landslide is not mitigated, even if the small landslide for this project is repaired.

The subsurface conditions were determined from a total of five borings drilled to depths of 46.1 to 65.5 feet below the ground surface. Soil and rock core samples were obtained for classification and general index testing. In general, the conditions encountered in the borings consisted predominantly of stiff to hard cohesive soils with isolated thin granular zones overlying relatively deep bedrock. The bedrock generally consisted of shale and sandstone. Groundwater was measured in B-001-0-19 at a depth of 47.8 feet below the existing ground surface after 24 hours. Groundwater was not observed in the other borings; however, iron-oxide staining observed in the samples within the overburden and bedrock indicated the presence of previous and/or intermittent water.

Site and office reconnaissance of the project site indicated that there may be a larger landslide beyond the relatively small landslide with the headscarp observed in the existing pavement (i.e. the landslide that is the focus of this project). The uphill terrain above the roadway was hummocky with multiple scarps and deformed trees noted. Historical LiDAR and aerial imagery also indicated signs of the larger landslide activity.

Site observations, survey of the slope, and review of the soil and bedrock from the borings indicate that the instability of the roadway is most likely due to the steep overburden slope below the road, between 1.4H:1V to 1.7H:1V (horizontal to vertical) in conjunction with seasonal or intermittent groundwater seepage. Given the presence of what appears to be a larger and deeper slip surface, additional exploration and instrumentation was previously recommended, including inclinometers for monitoring of the slopes above and below the existing roadway, and additional field reconnaissance to further delineate the limits of the large landslide (ref. Meeting Memorandum dated 10/4/2019). However, we understand that mitigating the larger landslide is beyond the budgetary constraints of the project. Therefore, this report was prepared with the intent to provide analysis and recommendations to stabilize the existing local failure along the shoulder and outside travel lane of the road using the Pike County Engineer's Office (PCEO) selected method consisting of anchored drilled shaft wall with plug piles and deadman shaft.

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APPENDIX II

1.0 INTRODUCTION

This report presents the findings of the Geohazard (landslide) Exploration performed for the landslide remediation on Watson Road, County Route 50 (CR-50), in Jackson Township, Pike County, Ohio. The project consists of remediating the existing failing roadway slope within a 240-foot long section of CR-50. This report is scoped to address only the landslide with headscarp in the shoulder and outside lane of the roadway (downslope side of road) using an anchored drilled shaft wall with drilled shaft deadmen for stabilization and does not address the larger instability at the site. It should be noted that the slope and roadway will likely continue to move if the larger landslide is not mitigated, even if the small landslide for this project is repaired.

The purpose of this exploration was to 1) explore the subsurface conditions to the depths of the borings, 2) evaluate the engineering characteristics of the subsurface materials, and 3) provide design recommendations for the remediation of the requested portion of slope. The exploration presented in this report was performed essentially in accordance with DLZ Ohio, Inc.'s (DLZ) geotechnical scope and fee proposal for this project dated May 14, 2019 and June 22, 2019. This exploration was also performed in general accordance with the July 2019 revision of the Ohio Department of Transportation (ODOT) Specifications for Geotechnical Exploration (SGE).

The geotechnical engineer has planned and supervised the performance of the geotechnical engineering services, considered the findings, and 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.

2.0 GENERAL PROJECT INFORMATION

The project site is located along CR-50 in Pike County, approximately 7 miles east of Waverly, Ohio. CR-50 is a two-lane road carrying traffic along the eastern edge of the Scioto River valley. The portion of roadway within the project limits was presumably constructed as a cut and fill roadway into the existing hillside. The existing roadway is constructed above a set of railroad tracks running parallel to the river and CR-50 alignment at the slip location. A Vicinity Map of the project location is included in the Appendix of this report. The project initially consists of drilled shaft wall landslide repair along 240 feet of CR-50 as established by the DDIR. However, evidence of larger/deeper landslide activity was identified during the exploration and should be considered in any proposed remediation. At the request of Pike County, the portion of the landslide immediately downslope of the roadway is the only portion of the slope to be stabilized utilizing an anchored wall with drilled shaft deadmen.

This report, and the recommendations provided herein, have been written under the consideration that the construction will be performed in accordance with the 2019 version of the ODOT Construction and Materials Specifications (CMS).

3.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

The site is located in the Shawnee-Mississippian Plateau Physiographic Region in the Allegheny (Kanawha) Plateau Section of the Appalachian Plateaus Provence. Generally, the region is characterized by highly dissected, high-relief, landslide prone topography with fine-grained rocks including Devonian- and Mississippian-age shales, siltstones, and locally thick sandstones. The area generally has relief from 400 feet to as much as 800 feet.

Based on information available from the web soil survey by the NRCS, the local soils are primarily Omulga silt loam with 6 to 12 percent slopes. According to the Abandoned Underground Maps of Ohio by the ODNR, the project site is located within approximately 5 miles of nearby mine locations (extents unknown) in coal bearing rock areas. Natural soils are colluvium on the hillsides and alluvium in the Scioto River valley according to the map of Quaternary Geology of Ohio from the Ohio Department of Natural Resources (ODNR), (Pavey et al, 1999). The colluvium derived from Mississippian-aged shales, including the Bedford Shale, along the Scioto River valley in the vicinity of the site is considered to be landslide prone, as identified in the GeoFacts No. 8 published by ODNR (Hansen, 1995).

A site reconnaissance was conducted on August 6, 2019. The project area is located on CR-50, approximately 1700 feet south/southwest of the intersection with Township Highway 515, Mutton Run Road. The existing CR-50 is a two-lane road, approximately 24 feet wide. The existing headscarp within the pavement was identified in the field and measured as approximately 154 feet in length, running along the outside/southbound lane of travel. Settlement and extensive pavement cracking were observed within the vicinity of the headscarp, as well as displaced and rotated guardrail. The slope downhill of the existing roadway appeared to be steeper than 2H:1V in most sections. Bedrock outcrops and boulders were observed in the uphill and downhill slopes north and south of the existing slide location (i.e. beyond the project alignment). CR-50 is a meandering road with a sloping site topography, generally towards south and west directions. It was observed during the site reconnaissance that the site drainage was primarily maintained through the ditch on the upslope side, draining north and south of the slide area, which is located at the peak of a vertical curve section of the roadway. The ditch was very soft at the time of the site reconnaissance. The slopes were generally covered by very dense vegetation. During the site reconnaissance a low-lying area and bulge was observed within the pavement, approximately 50 feet north of the existing slide, which can be indicative of more widespread movement or separate slide. Additionally, it was apparent that the hillside above the roadway was hummocky and several deformed trees were observed. As reported by ODOT personnel during their site visit for the geophysical exploration, the hillside above was hummocky with multiple historic scarps visible upslope.

Office reconnaissance was performed for the site by reviewing available topographic and aerial imagery of the site. Based on available information from Google Earth imagery and OSIP LiDAR, it is evident that the hillside above is hummocky to over 200 feet horizontally upslope of the roadway at the existing slide, and that the slopes vary between 1.4H:1V to 8.5H:1V. Historical records from the 1906 United States Geological Survey (USGS) indicate the roadway alignment was previously located at the base of the slope/edge of the valley near elevation 600, was later reconstructed further upslope at the current location near elevation 630. Aerial

imagery available from Google Earth also indicates extensive clearing of the tree-covered hillside above the site between December 2010 and November 2011 which may have altered drainage and groundwater conditions at the site. Based on the field survey performed, and comparison with LiDAR elevations, the site has slopes on the order of 1.4H:1V to 1.7H:1V from the immediate uphill slope of the existing roadway down to the river side slope below the existing railroad alignment. Based on available aerial imagery, the riverbank and railroad tracks below the road appear to have a "kink", indicating a possible toe bulge extending into the riverbed. A plan view sketch presenting signs of the larger slide along with a sketch of potential failure surfaces for this larger slide are provided in the Appendix of this report.

4.0 EXPLORATION

4.1 FIELD EXPLORATION

The geotechnical exploration was performed between the dates of August 12 and 15, 2019, and consisted of a total of five (5) borings located in both lanes of CR-50, designated as B-001-0-18 through B-003-0-18 and offsets designated as B-001-1-19 and B-003-1-19. The borings were located in the field by DLZ personnel. The borings were drilled to depths of approximately between 46.1 and 65.5 feet beneath the existing ground surface. The offset borings were both advanced to depths of 40 feet without sampling, and then sampled to the completion depth of each boring.

The borings were drilled using a CME-75 truck-mounted drill rig and were advanced between sampling intervals with 3 ¼-inch ID Hollow-Stem Augers (HSA). Disturbed soil samples were obtained with a 2-inch OD split-barrel sampler in general accordance with ASTM D-1586 (AASHTO T206), i.e. Standard Penetration Test (SPT) Method, at 1.5-foot intervals until split-spoon refusal was encountered upon the underlying bedrock. Boring B-002-0-19 was sampled at 2.5-foot intervals between depths of 7 and 45 feet below the existing ground surface. Bedrock was cored in boring B-003-0-19 in accordance with ASTM D2113 procedures, using NQ_2 double tube, wire line, core barrels. The hammer system used for the CME-75 was calibrated on August 15, 2019 and had an average drill rod energy efficiency ratio (ER) of 83.7 percent.

The approximate as-drilled boring locations are shown on the boring location plan presented in the Appendix. Boring logs and information concerning the drilling procedures are also presented in the Appendix. The boring locations and ground surface elevations at the boring locations were surveyed by DLZ and the information is listed on the individual boring logs. Water level measurements were taken in each boring during drilling, and prior to adding water for coring.

4.2 GEOPHYSICAL EXPLORATION

The geophysical exploration was performed by ODOT Office of Geotechnical Engineering (OGE) personnel at the site on September 10 to 12, 2019, and consisted of obtaining electrical resistivity (ER) data and seismic refraction (s-wave microtremor (ReMi) and p-wave) data along the proposed wall alignment. The geophysical exploration indicated that along the proposed wall alignment the top of bedrock was generally located

between elevation 574 and elevation 578 based on the resistivity data. However, south and north of the proposed wall, bedrock was indicated at elevations of approximately 600 and 610, respectively. Details and results of the exploration are presented in the Appendix.

4.3 LABORATORY TESTING PROGRAM

The laboratory testing program consisted of visual classifications of soil and rock samples, general index tests of soil samples, and unconfined compressive strength tests of rock and soil samples. The samples were classified in general accordance with the ODOT SGE Section 600 Laboratory Testing. The general index tests on soil samples consisted of grain-size analyses, moisture content, and plasticity determinations. The results of the index testing and visual classifications are shown on the individual boring logs in the Appendix. Results of the laboratory testing are included in the Appendix. Tables 1 and 2 below summarize the results of the unconfined compressive strength testing performed on selected rock and soil samples, respectively.

Table 1: Summary of Unconfined Compressive Strength Rock Testing

Boring	Run	Depth (ft)	Unconfined Compressive Strength, q_u (psi)	Rock Description
B-003-0-19	R-1	56.25'-56.75'	4,005	Sandstone
	R-1	62.5'-63.0'	3,534	Shale

Table 2: Summary of Unconfined Compressive Strength Soil Testing

Boring	Sample	Depth (ft)	Unconfined Compressive Strength, q_u (psf)	Undrained Shear Strength (psf)	Soil Description
B-001-0-19	ST-1	8.0'-10.0'	5,985	2,993	A-6b
B-002-0-19	ST-1	7.0'-9.0'	2,833	1,416	A-6a

5.0 FINDINGS

The following sections present the generalized subsurface conditions encountered by the borings. In the field, the actual soil and bedrock transitions might be different both vertically and laterally. For more detailed information, please refer to the boring logs presented in the Appendix. Please note that the strata contact lines shown on the boring logs represent approximate boundaries between soil types.

5.1 SOIL AND BEDROCK CONDITIONS

At the ground surface, the borings encountered between 12 and 18-inches of asphalt over 4-inches of aggregate base, with the exception of boring B-003-0-19, which encountered 30-inches of asphalt with no aggregate base. The surface materials were not measured in the offset borings, B-001-1-19 and B-003-1-19. Beneath the surface materials, the borings encountered soil overburden materials consisting of stiff to hard fine-grained soils (A-4a, A-6a, A-6b, and A-7-6) and isolated layers of medium to very dense granular soils (A-1-a) and rock fragments to depths ranging from 45 to 56 feet. Sandstone fragments, cobbles, and boulders

were identified throughout the overburden, as evident from rig chatter and from the split-spoon samples. Although no "fill" (i.e. manmade fill) was identified in the borings, it should be noted that man-made fill is difficult to differentiate from colluvium unless engineered or non-native materials are encountered within the fill.

Beneath the soils, bedrock was sampled using a split-spoon sampler to depths of 46.1 to 55.0 feet, with the exception of B-002-0-19 where bedrock was not encountered. The bedrock generally consisted of slightly to moderately weathered shale and sandstone. Rocking coring was performed in borings B-003-0-19 at a depth of 55.0 feet to 65.5 feet below the existing ground surface. The bedrock core samples generally consisted of interbedded slightly weathered sandstone and moderately weathered shale and appeared to be Bedford Shale.

The cored bedrock was generally slightly fractured with RQD values ranging from 81 to 100 percent. Unconfined compressive strength test results from intact rock core specimens are presented in Table 1, the Appendix, and listed on the boring log – it should be noted that these tests were performed on available intact samples.

5.2 GROUNDWATER CONDITIONS

Groundwater was measured in boring B-001-0-19 at a depth of approximately 47.8 feet below the existing ground surface after 24 hours. Groundwater was not observed in the other borings; however, iron-oxide staining was observed within the overburden samples and the split-spoon samples of bedrock, indicating the presence of previous and/or intermittent water. It should be noted that groundwater level observations were measured inside the hollow stem augers. Additionally, groundwater levels may fluctuate with seasonal variations and following periods of heavy or prolonged precipitation. Therefore, the readings indicated on the boring logs may not be representative of the long-term groundwater level. Long-term monitoring would be needed to obtain a more accurate estimate of the groundwater table elevation.

6.0 ANALYSIS AND RECOMMENDATIONS

Site observations, survey of the slope, and review of the soil and bedrock from the borings indicate that the landslide causing the existing pavement failure along the shoulder and outside lane is most likely due to the steep overburden slope below the road in conjunction with intermittent groundwater seepage. We anticipate this landslide is a relatively shallow, rotational type failure with a toe roughly between elevations 610 and 620. However, the hummocky terrain uphill, deformed trees, and steep uphill slope indicate the likely presence of a larger landslide(s) extending beyond the scarp observed in the roadway with a toe potentially located in the riverbed. The depth of the failure surface for the larger landslide(s) is unknown, particularly not without identification of a clearly defined toe-bulge.

Given the evidence for global instability (i.e. landslide) of the hillside above and below the existing roadway, and that rock is relatively deep and sloping, additional exploration and instrumentation was previously recommended, including inclinometers for monitoring of the slopes above and below the existing roadway,

and additional field reconnaissance to further delineate the limits of the large landslide (ref. Meeting Memorandum dated 10/4/2019). However, we understand that mitigating the larger landslide is beyond the budgetary constraints of the project. Therefore, this report was prepared with the intent to provide analysis and recommendations to stabilize the existing local failure along the shoulder and outside travel lane of the road using the Pike County Engineer's Office (PCEO) selected method consisting of anchored drilled shaft wall with plug piles and deadman shaft. In lieu of the anchored drilled shaft wall stabilization approach, consideration could be given to soil nail stabilization which is anticipated to be significantly less expensive and faster to construct. High-tension mesh with vegetation could be considered for "facing" of the soil nails using the existing slope with minor grading, instead of the significant cut required on the downhill side of the road for typical nearly vertical shotcrete faced soil nail wall. Recommendations for soil nail stabilization are beyond the scope of this report.

6.1 ANCHORED DRILLED SHAFT RETAINING WALL WITH PLUG PILES

Lateral Load analyses for a drilled shaft plug pile wall anchored to deadman shaft were performed using the cross section at Station 23+50. Subsurface conditions were determined using borings near the section analyzed. The proposed wall alignment was based on an offset to maintain the existing roadway centerline with a guardrail attached to the top of the drilled shaft wall. The proposed wall analyzed consisted of 36-inch diameter drilled shafts, reinforced with a reinforcing steel cage, and spaced at five foot on center with unreinforced concrete plug piles in between, in lieu of lagging. The retained height of the wall was analyzed as the depth to the estimated slope failure surface at the anticipated wall location, based on slope stability analysis (back analysis of the landslide) performed using Slide2 v9 by rocscience.

Back analysis of the landslide was performed using limit equilibrium (L-E) methodology considering the Spencer Method and GLE/Morgenstern-Price Method (GLE/M-P). Soil unit weight was estimated from laboratory results on available Shelby Tube specimens. Based on the borings and test results, the initial soil strength used in the analysis assumed the Mohr-Coulomb model with long-term shear strength parameters (ϕ' and c') in the range of stiff to very stiff clay from Table 2 of ODOT Geotechnical Bulletin 7 (GB7). The resulting minimum factor of safety (FS) from the back analysis was 1.1 with an entry point matching the location of the headscarp in the road. Furthermore, a FS of 1.1 indicates marginal stability, often resulting in settlement such as experienced along the existing headscarp located in the pavement. Therefore, the soil parameters assumed were validated by the back analysis and the unit weight and friction angle used in the subsequent lateral load analyses. A summary of the soil parameters and results of the slope stability analysis are listed in Table 3 and graphic results presented in the Appendix.

Table 3: Summary of Soil Parameters and Minimum FS used in Slope Stability Back Analysis

Section	Soil Layer	Unit Weight, pcf	Friction Angle, ϕ', degrees	Cohesion, c', psf	Min. FS, Spencer	Min. FS, GLE/M-P
1 (Sta. 23+50)	Colluvium	130	24	150	1.1	1.1

Lateral analyses were performed to calculate the lateral earth pressures/loads the wall would resist. Horizontal earth pressures and anchor loads at the drilled shaft wall were calculated using AASHTO LRFD Bridge Design Specifications (BDS), 9th Ed. section 3.11.5.7. The assumed sections for the analyses, including the assumed subsurface conditions are included in the Appendix. Horizontal earth pressures acting on the deadman drilled shaft were calculated using Broms method as described in FHWA Geotechnical Engineering Circular Number 4 (GEC 4), Section 5.5. For analysis purposes, the top of wall was considered as the top of the concrete cap above the drilled shafts.

The lateral analyses of the drilled shaft plug pile wall and deadman drilled shaft were performed using the computer program LPILE 2019 by Ensoft to model the soil-structure interaction. The drilled shaft analyses were performed with an anchor load 4 feet below the top of the wall and with a shear and moment at the top of the pile for the collision load (Extreme Event II load condition only). The deadman shaft was performed using the portion of shaft below the anchor attachment and included the anchor load applied at the top as a shear force. The drilled shaft and deadman shaft lengths were determined iteratively by a deflection criterion of approximately two inches or one percent of the retained height, whichever is less, using the Service-I loading case as well as sufficient resistance to not overturn the Extreme Event-II loading case. Axial resistance for the reinforced retaining wall drilled shafts (i.e. king piles) assumes the shafts derive axial support entirely from side resistance acting along the bottom 7.0 feet of the shafts. The factored axial resistance considers a resistance factor of 0.45 for drilled shaft side resistance in clay soils using the α-method per Table 10.5.5.2.4-1 of the AASHTO LRFD BDS. All analyses were performed in accordance with AASHTO LRFD BDS. Results of the analyses are included in the Appendix. Tables 4 through 9 below summarize the results of the wall analyses.

Table 4: Summary of Drilled Shaft Wall Lateral Load Analyses Assumptions

Section	Retained Height (Depth to Failure Surface at wall), ft	Depth to Anchor at Wall, ft	Shaft Diameter, in	Reinforcing Steel	Overall Shaft Length*, ft
1 (Sta. 23+50)	10	4	36	13, No. 8 bars	22

*overall shaft length listed here (used in analysis) includes the reinforced concrete cap thickness

Table 5: Summary of Deadman Shaft Lateral Load Analyses Assumptions

Section	Depth Below Anchor Attachment, ft	Depth to Anchor Attachment*, ft	Shaft Diameter, in	Reinforcing Steel	Overall Shaft Length, ft
1 (Sta. 23+50)	15	2	36	13, No. 8 bars	17

*below top of deadman shaft

Table 6: Summary of Drilled Shaft Wall Lateral Load Analyses – Anchor Load by Limit State

Limit State	Anchor Load, kips
Extreme Event II	68.3
Strength	32.1
Service	21.8

*assume test load of 33 kips and lockoff load of 22 kips for design purposes

Table 7: Summary of Drilled Shaft Wall Lateral Load Analyses – Max. Factored Load and Bending Moment Supported by and Produced within "King Pile" by Limit State

Limit State	Max Factored "", Supported By*		Max Factored "", Produced Within	
	Lateral Load, kips	Bending Moment, kip-ft	Shear, kips	Bending Moment, kip-ft
Extreme Event II	23.6	63.0	56.3	312.1
Strength	41.3	0.0	23.3	113.6
Service	27.8	0.0	7.4	22.9

*excludes the anchor load

Table 8: Summary of Drilled Shaft Wall Lateral Load Analyses – Max. Factored Load and Bending Moment Supported by and Produced within Deadman Drilled Shaft by Limit State

Limit State	Max Factored "", Supported By*		Max Factored "", Produced Within	
	Lateral Load, kips	Bending Moment, kip-ft	Shear, kips	Bending Moment, kip-ft
Extreme Event II	68.3	0.0	68.3	226.8
Strength	32.1	0.0	32.1	106.4
Service	21.8	0.0	21.8	71.8

Table 9: Maximum Factored Axial Load and Resistance of Each Drilled Shaft ("King Pile") for Wall

Shaft	Length of Shaft* (ft)	Maximum Factored Axial Load, kips	Factored Side Resistance**, kips	Factored Tip Resistance, kips
Drilled Shaft Wall	22	14.4	22.9	0

*overall shaft length listed here (used in analysis) includes the reinforced concrete cap thickness
**assumed to act along the bottom 7.0 feet of the drilled shaft

In the analysis, groundwater behind the wall was checked at both the "top of wall" condition as well as the "no groundwater" condition, and it was determined that the "no groundwater" condition was more critical due to the increased anchor loads. The anchor attachments were assumed to be at a depth of 2 feet below the top of deadman shaft and at a depth 4 feet below the top of the wall (including the concrete cap) for the purpose of

analysis. Drilled shafts should be installed in accordance with the ODOT CMS Item 524. Excavations, including those for drilled shafts, may encounter cobbles and/or boulders within the overburden, as well as materials from previous repairs, such as buried piles, drainage pipe and aggregate materials. The drilled shaft wall should be designed in accordance with section 307.6 ODOT BDM, 2020 edition.

6.2 EXCAVATIONS AND GROUNDWATER AND DRAINAGE CONSIDERATIONS

Free groundwater was not observed in any of the borings prior to rock coring. It should be noted that groundwater conditions vary seasonally and with the passage of time. Consequently, the contractor should be equipped to deal with groundwater, seepage, and surface water that may accumulate on the project site.

Caving and sloughing of wet and weak granular soils should be anticipated for open excavations. Even though groundwater was not encountered in the borings, perched or short-term groundwater may be encountered during construction, particularly in granular strata. Temporary casing may be needed to prevent caving or sloughing of the drilled shaft excavations through granular materials, such as those encountered in the upper 7 feet of boring B-001-0-19. Clay soils are prone to weathering and softening quickly when exposed, particularly in the presences of water. All excavations should be graded to drain to prevent ponding, during construction and long term, behind the structure or within the roadway slope.

It is anticipated that the uphill slope is marginally stable and prone to sliding/failure. Therefore, disturbance to the uphill slope and unsupported excavations at the toe should be minimized. It is recommended that unsupported excavations on the uphill side of the existing roadway pavement be limited to 4 feet or less. If excavations of greater than 4 feet are required, it is recommended that support of excavation methods be used in order to ensure the stability of the uphill slope as well as the temporary excavation. Consider prohibiting vibratory and/or percussive installation techniques for installation of sheeting, shoring, casing, etc. Anticipated methods of support of excavation include pressed-in place sheeting and trench boxes. Consider leaving any temporary shoring in place permanently if installed on the upslope side of the road to reduce disturbance and/or change in stresses that may be caused within the slope above by its removal. Furthermore, duration (time) and length / spacing (parallel to the roadway alignment) of any excavations should also be limited to mitigate the risk of destabilizing the slope above. Excavation of the entire roadway down to anchor level at one time shall not be permitted. Excavations required for the installation of the anchors should extend in narrow trenches, as narrow as feasible for constructability, and be no closer than every other anchor without backfilling.

7.0 CLOSING REMARKS

We appreciate having the opportunity to be of service to you on this project. Please do not hesitate to call if you have any questions concerning this report.

Respectfully submitted,

DLZ OHIO, INC.

D. Matt Lyon, P.E.
Geotechnical Engineer

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DML/hjh

APPENDIX I

General Information - Drilling Procedures and Logs of Borings
Legend - Boring Log Terminology
Vicinity Map
Landslide Reconnaissance Sketches
Boring Location Plan
Boring Logs (5)
Rock Core Photographs
Geophysical Exploration Results

GENERAL INFORMATION
DRILLING PROCEDURES AND LOGS OF BORINGS

Drilling and sampling were conducted in accordance with procedures generally recognized and accepted as standardized methods of investigation of subsurface conditions concerning geotechnical engineering considerations. Borings were drilled with either a truck-mounted or ATV-mounted drill rig.

Drive split-barrel sampling was performed in 1.5 foot increments at intervals not exceeding 5 feet. In the event the sampler encountered resistance to penetration of 6 inches or less after 50 blows of the drop hammer, the sampling increment was discontinued. Standard penetration data were recorded and one or more representative samples were preserved from each sampling increment.

In borings where rock was cored, NXM or NQ size diamond coring tools were used.

In the laboratory all samples were visually classified by a soils engineer. A limited number of samples, considered representative of foundation materials present, were selected for performance of grain-size analyses and plasticity characteristics tests. The results of these tests are shown on the boring logs.

The boring logs included in the Appendix have been prepared on the basis of the field record of drilling and sampling, and the results of the laboratory examination and testing of samples. Stratification lines on the boring logs indicating changes in soil stratigraphy represent depths of changes approximated by the driller, by sampling effort and recovery, and by laboratory test results. Actual depths to changes may differ somewhat from the estimated depths, or transitions may occur gradually and not be sharply defined. The boring logs presented in this report therefore contain both factual and interpretative information and are not an exact copy of the field log.

Although it is considered that the borings have disclosed information generally representative of site conditions, it should be expected that between borings conditions may occur which are not precisely represented by any one of the borings. Soil deposition processes and natural geologic forces are such that soil and rock types and conditions may change in short vertical intervals and horizontal distances.

Soil/rock samples will be stored at our laboratory for a period of six months. After this period of time, they will be discarded, unless notified to the contrary by the client.

LEGEND – BORING LOG TERMINOLOGY

Explanation of each column, progressing from left to right

1. Depth (in feet) – refers to distance below the ground surface.

2. Elevation (in feet) – is referenced to mean sea level, unless otherwise noted.

3. Standard Penetration (N) – the number of blows required to drive a 2-inch O.D., 1-3/8 inch I.D., split-barrel sampler, using a 140-pound hammer with a 30-inch free fall. The blows are recorded in 6-inch drive increments. Standard penetration resistance is determined from the total number of blows required for one foot of penetration by summing the second and third 6-inch increments of an 18-inch drive.

   50/n – indicates number of blows (50) to drive a split-barrel sampler a certain number of inches (n) other than the normal 6-inch increment.

4. The length of the sampler drive is indicated graphically by horizontal lines across the "Standard Penetration" and "Recovery" columns.

5. Sample recovery from each drive is indicated numerically in the column headed "Recovery".

6. The drive sample location is designated by the heavy vertical bar in the "Sample No., Drive" column.

7. The length of hydraulically pressed "Undisturbed" samples is indicated graphically by horizontal lines across the "Press" column.

8. Sample numbers are designated consecutively, increasing in depth.

9. Soil Description

   a. The following terms are used to describe the relative compactness and consistency of soils:

   Granular Soils – Compactness

Term	Blows/Foot Standard Penetration
Very Loose	less than 5
Loose	5 – 10
Medium Dense	11 – 30
Dense	31 – 50
Very Dense	over 50

   Cohesive Soils – Consistency

Term	Unconfined Compression tons/sq.ft.	Blows/Foot Standard Penetration	Hand Manipulation
Very Soft	less than 0.25	less than 2	Easily penetrated 2-in. by fist
Soft	0.25 – 0.50	2 – 4	Easily penetrated 2-in. by thumb
Medium Stiff	0.50 – 1.0	5 – 8	Penetrated by thumb with moderate effort
Stiff	1.0 – 2.0	9 – 15	Readily indented by thumb but not penetrated
Very Stiff	2.0 – 4.0	16 – 30	Readily indented by thumbnail
Hard	over 4.0	over 30	Indented with difficulty by thumbnail

   b. Color – If a soil is a uniform color throughout, the term is single, modified by such adjective as light and dark. If the predominant color is shaded by a secondary color, the secondary color precedes the primary color. If two major and distinct colors are swirled throughout the soil, the colors are modified by the term "mottled".

   c. Texture is based on the Ohio Department of Transportation Classification System. Soil particle size definitions are as follows:

Description		Size	Description		Size
Boulders		Larger than 12"	Sand	– Coarse	2.0 mm to 0.42 mm
Cobbles		12" to 3"		– Fine	0.42 mm to 0.074 mm
Gravel	– Coarse	3" to ¾"	Silt		0.074 mm to 0.005 mm
	– Fine	¾" to 2.0 mm	Clay		smaller than 0.005 mm

d. The main soil component is listed first. The minor components are listed in order of decreasing percentage of particle size.

e. Modifiers to main soil descriptions are indicated as a percentage by weight of particle sizes.

trace	0 to 10%
little	10 to 20%
some	20 to 35%
"and"	35 to 50%

f. Moisture content of **cohesionless soils** (sands and gravels) is described as follows:

Term	Relative Moisture or Appearance
Dry	Soil leaves no moisture when pressed between fingers
Damp	Soil leaves very little moisture when pressed between fingers.
Moist	Soil leaves small amount of moisture when pressed between fingers.
Wet	The pore space is filled with water and water can be poured from sample with ease.

g. The moisture content of **cohesive soils** (silts and clays) is expressed relative to plastic properties.

Term	Relative Moisture or Appearance
Dry	Brittle to powdery; Moisture content well below plastic limit
Damp	Moisture content below plastic limit
Moist	Moisture content above plastic limit to -3% liquid limit
Wet	Moisture content near or above liquid limit

10. Rock Hardness and Rock Quality Designation

a. The following terms are used to describe the relative strength of the **bedrock**.

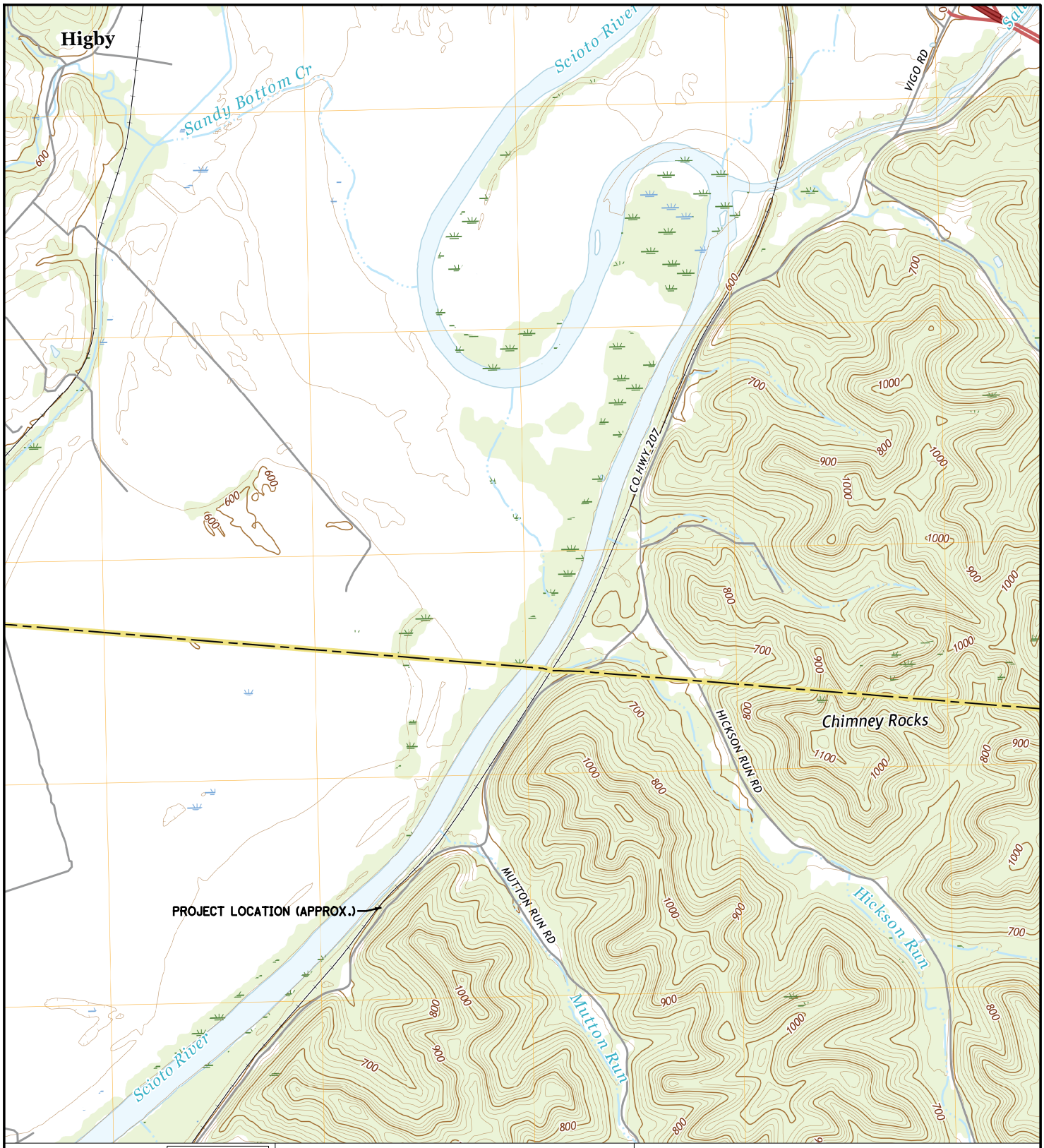
Term	Description
Very Weak	Core can be carved with a knife and scratched by fingernail. Can be excavated readily with a point of a pick. Pieces 1-inch or more in thickness can be broken by finger pressure.
Weak	Core can be grooved or gouged readily by a knife or pick. Can be excavated in small fragments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

b. Rock Quality Designation, RQD – This value is expressed in percent and is an indirect measure of rock soundness. It is obtained by summing the total length of all core pieces which are at least four inches long, and then dividing this sum by the total length of the core run.

11. Gradation – when tests are performed, the percentage of each particle size is listed in the appropriate column (defined in Item 9c).

12. When a test is performed to determine the natural moisture content, liquid limit moisture content, or plastic limit moisture content, the moisture content is indicated in tabular form.

13. The corrected standard penetration (N_{60}) value in blows per foot is indicated in tabular form.



USGS TOPOGRAPHIC MAP:
7.5-MINUTE MAP FOR RICHMOND DALE
AND WAVERLY, OH 2019

SCALE (FEET)

0 2000
1000 4000

DLZ OHIO, INC.
6121 HUNTLEY RD
COLUMBUS, OH 43229
OFFICE: (614) 888-0040
WWW.DLZ.COM

VICINITY MAP

PIK-CR50-2.55
Watson Road Landslide Exploration

DLZ PROJECT NUMBER	1921-1005.00
DRAWN BY (DATE)	MDK (02/14/2020)
CHECKED BY (DATE)	HJH (02/14/2020)
SCALE	GRAPHIC

SCIOTO RIVER

Reconnaissance Sketch

Suspected toe bulges (lowest likely extends below water, i.e. not visible)

Additional Suspected Scarps from 2011 Aerial Image from Google Earth

Anticipated Minor Slide Mass Limits from Scarp in Pavement

Approx. Location of Suspected Scarps from OSIP Lidar Topo and 2011 Aerial Image from Google Earth

APPROX. LOCATION OF 4" TREE OBSERVED

FLOOD DIRECTION NO OUTLET FOUND

RAISED PAVEMENT POSSIBLE TOE BULGE

DEPRESSED AREA POSS. DRAINAGE FEATURE

OVERHEAD TELECOM

SCARP LINE

TREES OBSERVED ON THE UPSLOPE

HUMMOCKY GROUND SURFACE OBSERVED UPSLOPE

*VERY SOFT GROUND OBSERVED ON UPSLOPE DITCH

*AS PLANNED BORING LOCATIONS SHOWN

HORIZONTAL SCALE IN FEET

0 10 20 40

DRAWN MDK

CHECKED HJH

OSIP LIDAR TOPO

PRELIM SKETCH OF LANDSLIDES

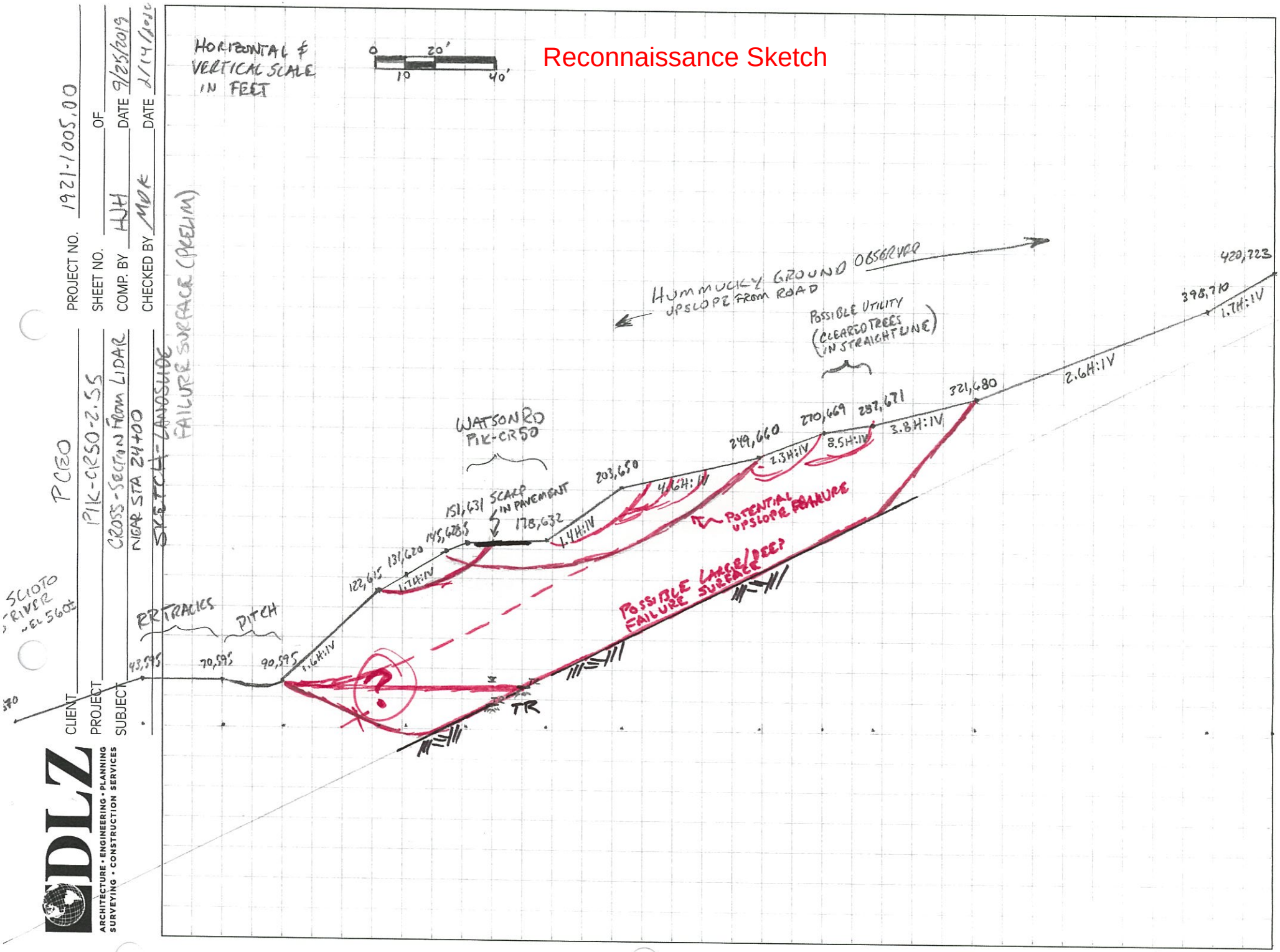
PIK-CR50-02.55

1 / 1

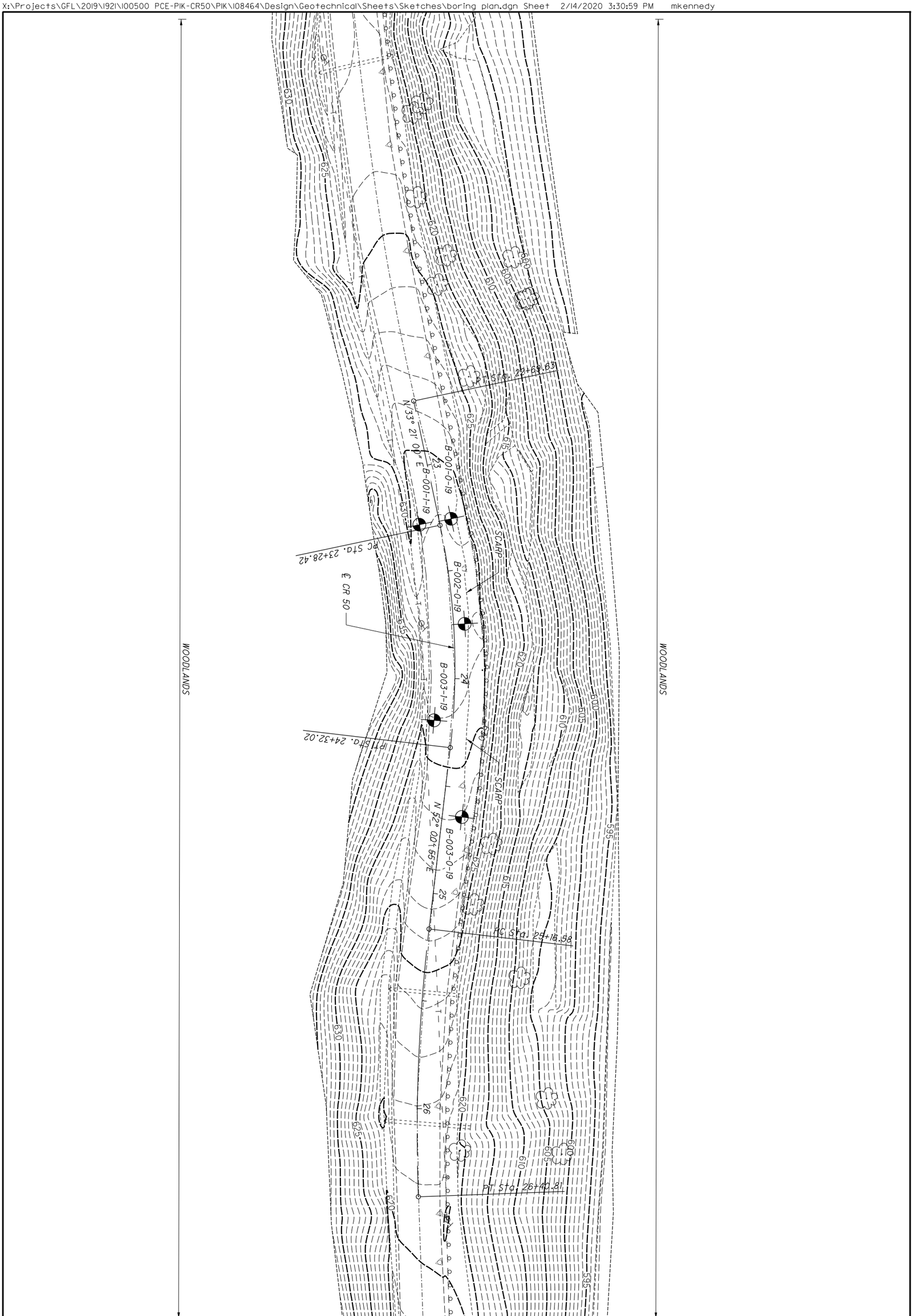
0 0

pw:\\PWidizcorp.com:DLZ\Documents\Projects\2019\192\1005\Design\Geotechnical\Sheets\Scratch\08464_YP001.dgn Sheet 10/3/2019 10:10:39 AM mkennedy

Reconnaissance Sketch



X:\Projects\GFL\2019\1921\100500 PCE-PIK-CR50\PIK\108464\Design\Geotechnical\Sheets\Sketches\boring plan.dgn Sheet 2/14/2020 3:30:59 PM mkennedy



	1 / 1	PIK-CR50-02.55	LANDSLIDE EXPLORATION BORING LOCATION PLAN	DRAWN MDK CHECKED HJH	0 20 10 40 HORIZONTAL SCALE IN FEET

PROJECT: PIK-CR50-02.55	DRILLING FIRM / OPERATOR: DLZ / K. REINHART	DRILL RIG: '19 CME 75-079-797	STATION / OFFSET: 23+27, 6' LT.	EXPLORATION ID B-001-0-19
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: DLZ / P. MORGAL	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-50	
PID: 108464 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/15/19	ELEVATION: 630.8 (MSL) EOB: 53.0 ft.	PAGE 1 OF 2
START: 8/13/19 END: 8/13/19	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 83.7	LAT / LONG: 39.162236, -82.848434	

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
ASPHALT = 18" BASE = 4"	630.8	1																
	629.0																	
STIFF TO VERY STIFF, BROWN WITH LITTLE GRAY, **SILTY CLAY**, TRACE TO LITTLE SAND, TRACE TO LITTLE GRAVEL, DAMP TO MOIST		2	2 3 3	8	67	1	2.50	7	5	4	40	44	38	18	20	21	A-6b (12)	
		3	1 2 5	10	61	2	2.25	-	-	-	-	-	-	-	-	20	A-6b (V)	
@4.5'-12.0', CONTAINS RED SANDSTONE FRAGMENTS @4.5'-22.5', CONTAINS POCKETS OF IRON OXIDE STAINING		4	3 4 3	10	17	3	2.75	-	-	-	-	-	-	-	-	16	A-6b (V)	
		5	2 3 3	8	50	4	2.25	-	-	-	-	-	-	-	-	15	A-6b (V)	
@8.0'-10.0', PRESSED SHELBY TUBE IN OFFSET HOLE, UCS = 2.993 TSF		6	2 3 7	14	67	5	3.50	-	-	-	-	-	-	-	-	18	A-6b (V)	
		7	2 4 2	8	50	6	2.25	-	-	-	-	-	-	-	-	13	A-6b (V)	
		8	1 2 3	7	44	7	1.75	-	-	-	-	-	-	-	-	18	A-6b (V)	
		9	1 2 2	6	67	8	1.25	13	6	5	48	28	35	17	18	19	A-6b (11)	
		10	1 3 3	8	78	9	1.50	-	-	-	-	-	-	-	-	23	A-6b (V)	
		11	2 3 5	11	100	10	1.25	7	4	4	42	43	38	18	20	18	A-6b (12)	
@16.5'-18.0', CONTAINS SANDSTONE FRAGMENTS		12	3 4 6	14	94	11	4.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
@18.0'-22.5', BROWN MOTTLED GRAY		13	3 5 5	14	78	12	4.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
@19.5'-22.5', CONTAINS TRACE SANDSTONE FRAGMENTS		14	3 3 4	10	89	13	2.75	-	-	-	-	-	-	-	-	21	A-6b (V)	
		15	2 4 5	13	100	14	3.00	-	-	-	-	-	-	-	-	16	A-6b (V)	
	608.3	16																
VERY STIFF, BROWN WITH LITTLE GRAY, **SILT AND CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, CONTAINS IRON OXIDE STAINING, DAMP		17	2 3 5	11	89	15	4.00	-	-	-	-	-	-	-	-	19	A-6a (V)	
		18	2 3 5	11	78	16	3.25	-	-	-	-	-	-	-	-	23	A-6a (V)	
@25.5'-27.0', CONTAINS SANDSTONE FRAGMENTS, POSSIBLE COBBLE		19	2 4 5	13	67	17	3.00	-	-	-	-	-	-	-	-	21	A-6a (V)	
		20	2 4 5	13	78	18	2.75	7	3	4	43	43	36	21	15	21	A-6a (10)	
		21	3 4 9	18	94	19	3.25	-	-	-	-	-	-	-	-	18	A-6a (V)	
		22																
		23																
		24																
		25																
		26																
		27																
		28																
		29																

PID: 108464	SFN:	PROJECT: PIK-CR50-02.55	STATION / OFFSET: 23+27, 6' LT.	START: 8/13/19	END: 8/13/19	PG 2 OF 2	B-001-0-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
@29.5', SANDSTONE FRAGMENT STUCK IN TIP OF SAMPLER, POSSIBLE COBBLE VERY STIFF, BROWN WITH LITTLE GRAY, **SILT AND CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, CONTAINS IRON OXIDE STAINING, DAMP *(continued)* @30.0'-33.0', CONTAINS SANDSTONE FRAGMENTS	600.8	31	5 4 6	14	78	20	3.00	-	-	-	-	-	-	-	-	18	A-6a (V)	
		32	5 6 8	20	100	21	3.75	-	-	-	-	-	-	-	-	18	A-6a (V)	
		33	3 7 8	21	94	22	3.50	-	-	-	-	-	-	-	-	18	A-6a (V)	
	595.8	34																
MEDIUM DENSE, REDDISH BROWN, **GRAVEL AND/OR STONE FRAGMENTS**, POSSIBLE SANDSTONE BOULDER, DAMP @35.0'-36.0', HARD AUGER CHATTER	594.8	35	3 10 10	28	67	23	-	-	-	-	-	-	-	-	-	12	A-1-a (V)	
		36	7 7 9	22	89	24	4.00	-	-	-	-	-	-	-	-	17	A-6b (V)	
VERY STIFF TO HARD, GRAY, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST @39.0'-42.0', CONTAINS IRON OXIDE STAINING		37	4 9 12	29	83	25	4.5+	-	-	-	-	-	-	-	-	19	A-6b (V)	
		38	6 7 12	27	78	26	4.50	-	-	-	-	-	-	-	-	23	A-6b (V)	
		39	5 10 9	27	100	27	4.50	-	-	-	-	-	-	-	-	19	A-6b (V)	
		40	3 3 8	15	67	28	4.00	7	4	4	40	45	36	17	19	20	A-6b (12)	
		41	3 6 7	18	67	29	4.00	-	-	-	-	-	-	-	-	17	A-6b (V)	
		42	4 6 9	21	72	30	4.5+	-	-	-	-	-	-	-	-	19	A-6b (V)	
@46.5'-48.0', CONTAINS RED SANDSTONE FRAGMENTS @46.5'-49.5', CONTAINS MICA @46.5'-51.0', CONTAINS IRON OXIDE STAINING		43	7 11 13	33	67	31	4.50	-	-	-	-	-	-	-	-	13	A-6b (V)	
	▼ 24 hrs	44	4 8 8	22	50	32	4.00	-	-	-	-	-	-	-	-	14	A-6b (V)	
		45	4 8 13	29	61	33	4.5+	-	-	-	-	-	-	-	-	18	A-6b (V)	
	579.8	46																
SHALE, GRAY, WEATHERED.		TR	34 50/3"	-	89	34	-	-	-	-	-	-	-	-	-	6	Rock (V)	
	577.8	EOB	50/5"	-	80	35	-	-	-	-	-	-	-	-	-	5	Rock (V)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; SOIL MIXED WITH BENTONITE CHIPS; BACKFILLED WITH BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 5/21/21 12:21 - X:\SHARED\DISCIPLINE\GEOTECH\GINT_AKRON\PROJECTS\PIK-CR50\1921-1005.00 PIK-CR50-2.55.GPJ

PROJECT: PIK-CR50-02.55	DRILLING FIRM / OPERATOR: DLZ / K. REINHART	DRILL RIG: '19 CME 75-079-797	STATION / OFFSET: 23+26, 9' RT.	EXPLORATION ID B-001-1-19
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: DLZ / P. MORGAL	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-50	
PID: 108464 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/15/19	ELEVATION: 630.3 (MSL) EOB: 47.1 ft.	PAGE 1 OF 2
START: 8/14/19 END: 8/14/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 83.7	LAT / LONG: 39.162205, -82.848377	

MATERIAL DESCRIPTION AND NOTES	ELEV. 630.3	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
NO SAMPLING		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29																

PID: 108464	SFN:	PROJECT: PIK-CR50-02.55	STATION / OFFSET: 23+26, 9' RT.	START: 8/14/19	END: 8/14/19	PG 2 OF 2	B-001-1-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
NO SAMPLING *(continued)*	600.3	31 32 33 34 35 36 37 38 39																
	590.3	40																
HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, CONTAINS GRAY SILT POCKETS, IRON OXIDE STAINING, DAMP	588.3	41	6 8 10	25	72	1	4.50	-	-	-	-	-	-	-	-	16	A-6a (V)	
DENSE, REDDISH BROWN, **GRAVEL AND/OR STONE FRAGMENTS**, SANDSTONE, DAMP	587.3	42	5 14 16	42	78	2	-	-	-	-	-	-	-	-	-	15	A-1-a (V)	
VERY STIFF TO HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE STONE FRAGMENTS, DAMP		43	5 8 12	28	67	3	4.00	-	-	-	-	-	-	-	-	18	A-6a (V)	
@45.0', SANDSTONE FRAGMENT STUCK IN SAMPLER TIP	584.3	44 45	5 7 10	24	33	4	4.50	-	-	-	-	-	-	-	-	16	A-6a (V)	
SANDSTONE, LIGHT BROWN AND RED, CONTAINS LITTLE GRAY CLAY.	583.3	TR 46	20 50/1"	-	100	5	-	-	-	-	-	-	-	-	-	9	Rock (V)	
		EOB 47	50/1"	-	100	6	-	-	-	-	-	-	-	-	-	8	Rock (V)	

NOTES: AUGER REFUSAL AT 47.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; SOIL MIXED WITH BENTONITE CHIPS; BACKFILLED WITH BENTONITE GROUT

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 5/21/21 12:21 - X:\SHARED\DISCIPLINE\GEOTECH\GINT_AKRON\PROJECTS\PIK-CR50\1921-1005.00 PIK-CR50-2.55.GPJ

PROJECT: PIK-CR50-02.55	DRILLING FIRM / OPERATOR: DLZ / K. REINHART	DRILL RIG: '19 CME 75-079-797	STATION / OFFSET: 23+75, 5' LT.	EXPLORATION ID B-002-0-19
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: DLZ / P. MORGAL	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-50	
PID: 108464 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/15/19	ELEVATION: 631.5 (MSL) EOB: 54.3 ft.	PAGE 1 OF 2
START: 8/15/19 END: 8/15/19	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 83.7	LAT / LONG: 39.162341, -82.848326	

MATERIAL DESCRIPTION AND NOTES	ELEV. 631.5	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
ASPHALT = 12" BASE = 4"	630.2	1																
STIFF, BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS GRAY SILT-FILLED DESSICATION CRACKS, TRACE IRON OXIDE STAINING, DAMP		2	2 2 3	7	44	1	1.25	6	4	4	39	47	34	18	16	18	A-6b (10)	
		3	2 2 2	6	39	2	1.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
	626.0	4 5	2 1 2	4	22	3	1.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, LITTLE GRAVEL, TRACE SAND, CONTAINS GRAY SILT-FILLED DESSICATION CRACKS, TRACE IRON OXIDE STAINING, DAMP		6	1 2 2	6	44	4	1.25	-	-	-	-	-	-	-	-	20	A-6a (V)	
@5.5'-7.0', CONTAINS SANDSTONE FRAGMENTS @7.0'-9.0', UCS = 1.416 TSF		7 8				ST-1	1.50	12	2	3	39	44	38	23	15	21	A-6a (10)	
		9	2 2 3	7	44	5	2.00	-	-	-	-	-	-	-	-	18	A-6a (V)	
		10 11 12 13																
@13.5'-24.0', CONTAINS TRACE SANDSTONE FRAGMENTS		14	4 4 6	14	67	6	3.25	-	-	-	-	-	-	-	-	18	A-6a (V)	
		15 16 17 18																
		19	2 4 5	13	72	7	3.25	-	-	-	-	-	-	-	-	15	A-6a (V)	
		20 21 22 23																
	607.5	24	2 6 23	40	50	8	-	-	-	-	-	-	-	-	-	15	A-1-a (V)	
DENSE, REDDISH BROWN, **GRAVEL AND/OR STONE FRAGMENTS**, TRACE SAND, CONTAINS SANDSTONE FRAGMENTS, DAMP	604.7	25 26 27 28																
STIFF, BROWN, **SANDY SILT**, LITTLE SAND, LITTLE GRAVEL, CONTAIN GRAY AND BLACK SILT POCKETS, TRACE SANDSTONE FRAGMENTS, DAMP	601.5	29	3 4 5	13	22	9	1.50	11	5	8	49	27	28	19	9	17	A-4a (8)	

PID: 108464	SFN:	PROJECT: PIK-CR50-02.55	STATION / OFFSET: 23+75, 5' LT.	START: 8/15/19	END: 8/15/19	PG 2 OF 2	B-002-0-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
STIFF, BROWN, **SANDY SILT**, LITTLE SAND, LITTLE GRAVEL, CONTAINS GRAY AND BLACK SILT POCKETS, TRACE SANDSTONE FRAGMENTS, DAMP	601.5	31																
	599.7	32																
MEDIUM DENSE, REDDISH BROWN, **GRAVEL AND/OR STONE FRAGMENTS**, LITTLE CLAY, TRACE SAND, CONTAINS SANDSTONE FRAGMENTS, DAMP		33																
		34	7 10 10	28	22	10	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
	596.5	35																
VERY STIFF, GRAYISH BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, CONTAINS SANDSTONE FRAGMENTS, DAMP		36																
		37																
		38																
		39	5 9 11	28	78	11	3.50	-	-	-	-	-	-	-	-	15	A-6a (V)	
		40																
		41																
		42																
		43																
@43.5', STIFF		44	50	-	100	12	1.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
@44.0', SANDSTONE COBBLE	586.5	45																
HARD, GRAY, **SILT AND CLAY**, LITTLE GRAVEL, TRACE SAND, [RESIDUAL SOIL], DAMP		46	11 16 19	49	100	13	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
@46.5'-48.0', CONTAINS BROWN SANDSTONE FRAGMENTS		47	8 10 12	31	89	14	4.50	11	0	1	46	42	32	20	12	15	A-6a (9)	
		48																
		49	8 10 12	31	83	15	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
		50	5 9 12	29	67	16	4.00	-	-	-	-	-	-	-	-	16	A-6a (V)	
@51.0'-52.5', CONTAINS REDDISH BROWN SANDSTONE FRAGMENTS		51																
		52	10 14 18	45	94	17	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
@52.5'-54.3', CONTAINS SHALE FRAGMENTS		53	7 27 50/1"	-	69	18	4.5+	-	-	-	-	-	-	-	-	11	A-6a (V)	
	577.2	54	50/3"	-	-	19	4.5+	-	-	-	-	-	-	-	-	15	A-6a (V)	
		EOB																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; SOIL MIXED WITH BENTONITE CHIPS; BACKFILLED WITH BENTONITE GROUT

PROJECT: PIK-CR50-02.55	DRILLING FIRM / OPERATOR: DLZ / K. REINHART	DRILL RIG: '19 CME 75-079-797	STATION / OFFSET: 24+63, 9' LT.	EXPLORATION ID B-003-0-19
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: DLZ / P. MORGAL	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-50	
PID: 108464 SFN:	DRILLING METHOD: 3.25" HSA / NQ2	CALIBRATION DATE: 8/15/19	ELEVATION: 629.0 (MSL) EOB: 65.5 ft.	PAGE 1 OF 3
START: 8/12/19 END: 8/12/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 83.7	LAT / LONG: 39.162508, -82.848094	

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
ASPHALT = 30"	629.0																	
	626.5	1	2 3 2	7	11	1	-	-	-	-	-	-	-	-	-	-		
LOOSE, LIGHT BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE GRAVEL, CONTAINS ROOTS, DAMP	625.0	2	2 3 2	7	11	2	-	-	-	-	-	-	-	-	-	7	A-3a (V)	
VERY STIFF, BROWN, **CLAY**, TRACE SAND, TRACE GRAVEL, TRACE IRON OXIDE STAINING, DAMP		3	2 2 3	7	39	3	3.50	3	4	3	41	49	42	22	20	18	A-7-6 (12)	
		4	1 2 4	8	67	4	3.50	-	-	-	-	-	-	-	-	20	A-7-6 (V)	
@7.0'-12.2', SANDSTONE COBBLE OR BOULDER		5	2 4 5	13	89	5	4.00	-	-	-	-	-	-	-	-	14	A-7-6 (V)	
@8.5'-11.5', CONTAINS GRAY SILT-FILLED DESSICATION CRACKS		6	1 4 4	11	78	6	3.75	7	3	3	38	49	41	20	21	19	A-7-6 (13)	
		7	2 4 6	14	67	7	4.00	-	-	-	-	-	-	-	-	19	A-7-6 (V)	
		8	50/3"	-	100	8	3.50	-	-	-	-	-	-	-	-	15	A-7-6 (V)	
	616.0	9																
HARD, BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS GRAY SILT POCKETS, SANDSTONE FRAGMENTS, TRACE IRON OXIDE STAINING, DAMP		10	7 7 10	24	78	9	4.5+	7	3	3	38	49	38	20	18	18	A-6b (11)	
	613.0	11	1 3 50/5"	-	88	10	4.50	-	-	-	-	-	-	-	-	20	A-6b (V)	
VERY DENSE, REDDISH BROWN, **GRAVEL AND/OR STONE FRAGMENTS**, TRACE SAND, CONTAINS POSSIBLE SANDSTONE BOULDER, DAMP	611.5	12	50	-	33	11	-	-	-	-	-	-	-	-	-	7	A-1-a (V)	
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE TO LITTLE GRAVEL, CONTAINS GRAY AND BLACK SILT POCKETS, SANDSTONE FRAGMENTS, DAMP		13																
		14																
		15																
		16																
		17																
		18	3 6 7	18	67	12	4.5+	-	-	-	-	-	-	-	-	23	A-6a (V)	
		19	2 4 8	17	72	13	2.50	-	-	-	-	-	-	-	-	20	A-6a (V)	
		20	1 3 5	11	67	14	3.00	12	9	7	34	38	30	19	11	17	A-6a (8)	
		21	3 3 5	11	83	15	3.50	-	-	-	-	-	-	-	-	17	A-6a (V)	
		22	3 3 5	11	94	16	2.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
		23	3 6 6	17	78	17	2.00	-	-	-	-	-	-	-	-	22	A-6a (V)	
		24	2 4 7	15	67	18	2.00	-	-	-	-	-	-	-	-	19	A-6a (V)	
		25	2 6 9	21	72	19	4.00	-	-	-	-	-	-	-	-	19	A-6a (V)	
		26	2															
		27																
		28																
		29																

PID: 108464	SFN:	PROJECT: PIK-CR50-02.55	STATION / OFFSET: 24+63, 9' LT.	START: 8/12/19	END: 8/12/19	PG 2 OF 3	B-003-0-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE TO LITTLE GRAVEL, CONTAINS GRAY AND BLACK SILT POCKETS, SANDSTONE FRAGMENTS, DAMP *(continued)*	599.0		5 7	17	67	20	3.50	1	5	6	42	46	37	23	14	19	A-6a (10)	
@31.0'-32.5', LITTLE GRAVEL, CONTAINS IRON OXIDE STAINING	595.5	31	9 8 10	25	33	21	3.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
MEDIUM DENSE TO DENSE, REDDISH BROWN, **GRAVEL AND/OR STONE FRAGMENTS**, TRACE SAND, [SANDSTONE FRAGMENTS], DAMP		32	3 12 50/2"	-	86	22	4.00	-	-	-	-	-	-	-	-	14	A-6a (V)	
@35.5'-37.0', LITTLE CLAY	592.0	33	10 13 15	39	83	23	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, CONTAINS IRON OXIDE STAINING, DAMP		34	13 10 11	29	22	24	-	-	-	-	-	-	-	-	-	12	A-1-a (V)	
@37.0'-38.5', CONTAINS BLACK SILT POCKETS		35	5 10 11	29	89	25	4.00	-	-	-	-	-	-	-	-	17	A-6a (V)	
@38.5'-41.5', CONTAINS REDDISH BROWN SANDSTONE FRAGMENTS		36	2 8 11	27	83	26	3.25	-	-	-	-	-	-	-	-	11	A-6a (V)	
		37	5 14 20	47	83	27	4.00	-	-	-	-	-	-	-	-	6	A-6a (V)	
		38	3 5 8	18	89	28	4.50	3	2	2	46	47	34	21	13	19	A-6a (9)	
@43.0'-44.5', CONTAINS REDDISH BROWN SANDSTONE FRAGMENTS		39	3 5 8	18	67	29	4.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
		40	6 7 8	21	78	30	3.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
		41	4 30 18	67	78	31	4.5+	-	-	-	-	-	-	-	-	4	A-6a (V)	
@46.7'-47.5', SANDSTONE COBBLE OR BOULDER	581.5	42	5 6 35	57	89	32	4.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
HARD, GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, DAMP		43	2 5 13	25	78	33	4.50	-	-	-	-	-	-	-	-	17	A-6a (V)	
@47.5'-49.0', CONTAINS GRAY SANDSTONE FRAGMENTS	578.5	44	5 50/5"	-	73	34	-	-	-	-	-	-	-	-	-	11	Rock (V)	
SHALE, GRAY, WEATHERED.		TR 45	50	-	100	35	-	-	-	-	-	-	-	-	-	6	Rock (V)	
		46	60/2"	-	100	36	-	-	-	-	-	-	-	-	-	6	Rock (V)	
	574.0	47																
INTERBEDDED SHALE (80%) AND SANDSTONE (20%), RQD 88%, REC. 98%; **SHALE**, GRAY, MODERATELY WEATHERED, SLIGHTLY TO MODERATELY STRONG, SLIGHTLY ARENACEOUS, SLIGHTLY FRACTURED; **SANDSTONE**, GRAY, SLIGHTLY WEATHERED, SLIGHTLY TO MODERATELY STRONG.		48																
@56.25'-56.75', Qu = 4,005 PSI [SANDSTONE]		49																
		50																
		51																
		52																
		53																
		54	81		97	NQ2-R-1											CORE	
		55																
		56																
		57																
		58																
		59																
		60																
		61																

PID: 108464	SFN:	PROJECT: PIK-CR50-02.55	STATION / OFFSET: 24+63, 9' LT.	START: 8/12/19	END: 8/12/19	PG 3 OF 3	B-003-0-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
@62.5'-63.0', Qu = 3,534 PSI [SHALE]	566.9	63	98		100	NQ2-R-2											CORE	
	563.5	64																
	EOB	65																

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; SOIL MIXED WITH BENTONITE CHIPS; BACKFILLED WITH BENTONITE GROUT

PROJECT: PIK-CR50-02.55	DRILLING FIRM / OPERATOR: DLZ / K. REINHART	DRILL RIG: '19 CME 75-079-797	STATION / OFFSET: 24+20, 9' RT.	EXPLORATION ID B-003-1-19
TYPE: LANDSLIDE	SAMPLING FIRM / LOGGER: DLZ / P. MORGAL	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-50	
PID: 108464 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 8/15/19	ELEVATION: 628.1 (MSL) EOB: 46.1 ft.	PAGE 1 OF 2
START: 8/14/19 END: 8/14/19	SAMPLING METHOD: SPT	ENERGY RATIO (%): 83.7	LAT / LONG: 39.162455, -82.848047	

MATERIAL DESCRIPTION AND NOTES	ELEV. 628.1	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
NO SAMPLING		1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 23 24 25 26 27 28 29																

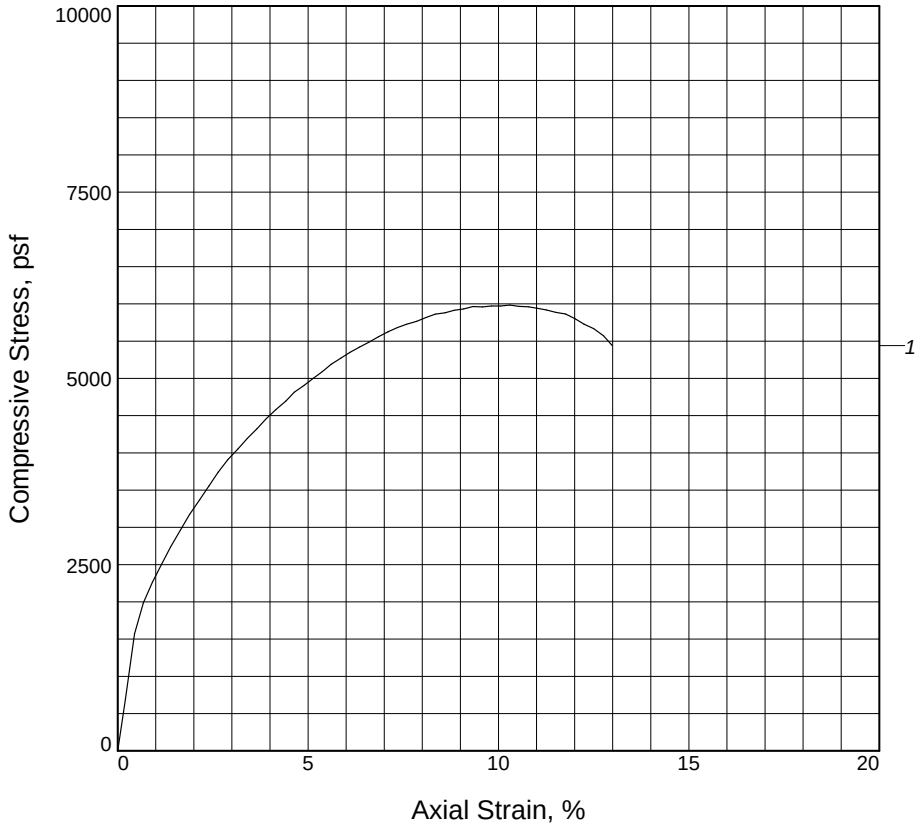
PID: 108464	SFN:	PROJECT: PIK-CR50-02.55	STATION / OFFSET: 24+20, 9' RT.	START: 8/14/19	END: 8/14/19	PG 2 OF 2	B-003-1-19

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
NO SAMPLING *(continued)*	598.1																	
	588.1																	
HARD, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, CONTAINS REDDISH BROWN SANDSTONE FRAGMENTS, DAMP	586.6		11 50/3"	-	78	1	4.5+	-	-	-	-	-	-	-	-	14	A-6a (V)	
HARD, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, DAMP @43.0'-45.0', CONTAINS BLACK SILT POCKETS			8 13 14	38	67	2	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
			6 10 15	35	94	3	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
	583.1	TR	50/5"	-	80	4	4.5+	-	-	-	-	-	-	-	-	16	A-6a (V)	
SANDSTONE, REDDISH BROWN, WEATHERED.	582.0	EOB	50/1"	-	100	5	-	-	-	-	-	-	-	-	-	10	Rock (V)	

NOTES: AUGER REFUSAL AT 46.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED ASPHALT PATCH; SOIL MIXED WITH BENTONITE CHIPS; BACKFILLED WITH BENTONITE GROUT

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	5985.2			
Undrained shear strength, psf	2992.6			
Failure strain, %	10.3			
Strain rate, in./min.	0.055			
Water content, %	19.3			
Wet density, pcf	131.9			
Dry density, pcf	110.6			
Saturation, %	99.2			
Void ratio	0.5240			
Specimen diameter, in.	2.835			
Specimen height, in.	5.552			
Height/diameter ratio	1.96			

Description: Very Stiff to Hard, Brown, Silty Clay (A-6b), Trace Gravel, Trace to Little Sand, Damp

LL = 37	**PL =** 20	**PI =** 17	**Assumed GS=** 2.7	**Type:** Intact

Project No.: 1921-1005.00

Date Sampled: 9-13-19

Remarks:
ASTM D2166

Figure _____

Client: Pike County Engineer

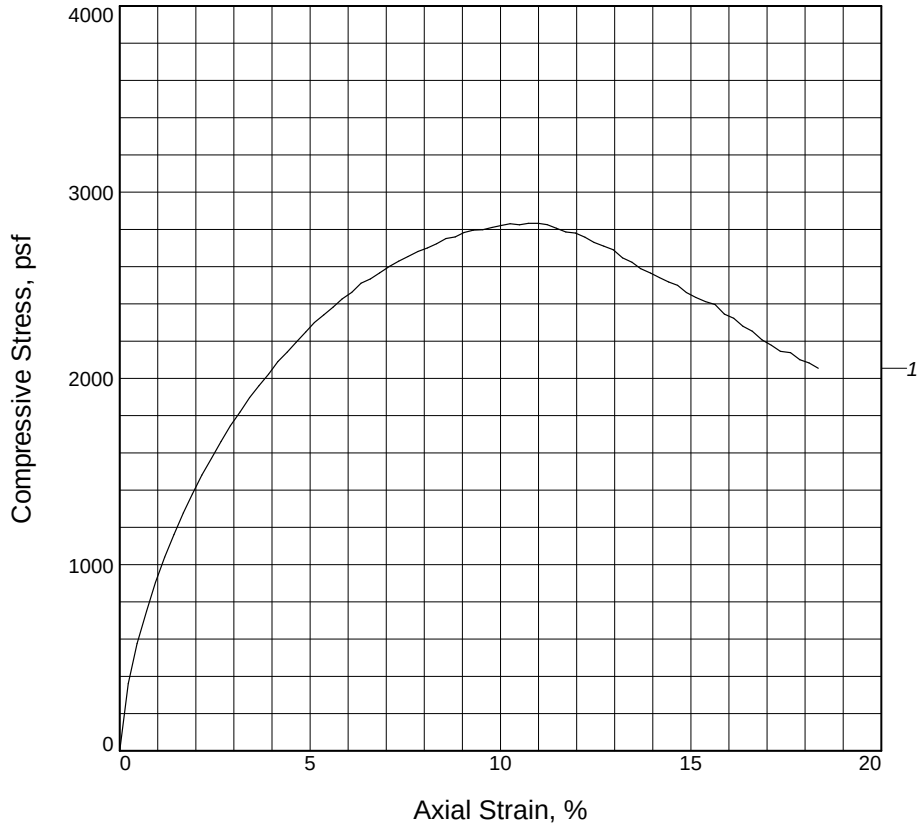
Project: PIK-CR50-2.55

Source of Sample: B-001-0-19 **Depth:** 8.0'-10.0'
Sample Number: ST-1

DLZ

Tested By: Paul Bailey

UNCONFINED COMPRESSION TEST



Sample No.	1			
Unconfined strength, psf	2832.6			
Undrained shear strength, psf	1416.3			
Failure strain, %	11.0			
Strain rate, in./min.	0.055			
Water content, %	21.0			
Wet density, pcf	131.6			
Dry density, pcf	108.7			
Saturation, %	99.9			
Void ratio	0.5792			
Specimen diameter, in.	2.829			
Specimen height, in.	5.589			
Height/diameter ratio	1.98			

Description: Stiff, Brown, Silt and Clay (A-6a), Trace Gravel, Little Sand, Damp

LL = 38	**PL =** 23	**PI =** 15	**Assumed GS=** 2.75	**Type:** Intact

Project No.: 1921-1005.00

Date Sampled: 9-13-19

Remarks:
ASTM D2166

Figure _____

Client: Pike County Engineer

Project: PIK-CR50-2.55

Source of Sample: B-002-0-19 **Depth:** 7.0'-9.0'
Sample Number: ST-1

DLZ

Tested By: Paul Bailey **Checked By:** Steve Robinson

CLIENT	PCEO	DLZ JOB NUMBER	1921-1005.00
PROJECT	PIK-CR50-02.55	SHEET NO.	2 OF 2
SUBJECT		TEST COMP. BY	WV DATE 9/26/19
EQUIPMENT	Concrete Load Frame	CHECKED BY	SR DATE 9/26/19

Unconfined Compressive Strength of Intact Rock Core Specimen (ASTM D7012, Method C)

Boring No.: B-003-0-19 Rock Description: Sandstone

Run No.: R-1 Moisture Condition at Test: As Received

Depth: 56.25'-56.75'

	D_1	D_2	D_3	D_4	D_5	D_6	D_{AVG}
Diameter:	1.987	1.987	1.985	1.981	1.984	1.984	**1.984** in

	L_1	L_2	L_3	L_{AVG}	$\frac{L}{D}$ =
Length:	4.595	4.594	4.571	**4.586** in	2.311

Volume: 0.008204166 ft^3 Mass: 576.40 g Unit Weight: **154.89** pcf

Failure Load: 12,385 lbs

Strength: 4,005 psi

Original Specimen

Fractured Specimen

Remarks:

6121 Huntley Road * Columbus, Ohio 43229-1003 * (614) 888-0040 * FAX (614) 431-4024

CLIENT	PCEO	DLZ JOB NUMBER	1921-1005.00
PROJECT	PIK-CR50-02.55	SHEET NO.	1 OF 2
SUBJECT		TEST COMP. BY	WV DATE 9/26/19
EQUIPMENT	Concrete Load Frame	CHECKED BY	SR DATE 9/26/19

Unconfined Compressive Strength of Intact Rock Core Specimen (ASTM D7012, Method C)

Boring No.: B-003-0-19 Rock Description: Shale

Run No.: R-2 Moisture Condition at Test: As Received

Depth: 62.5'-63'

Diameter:	1.972	1.972	1.976	1.951	1.963	1.975	**1.968** in
	(D_1)	(D_2)	(D_3)	(D_4)	(D_5)	(D_6)	(D_{AVG})

Length:	4.453	4.515	4.493	**4.487** in	$\frac{L}{D}$ = 2.280
	(L_1)	(L_2)	(L_3)	(L_{AVG})	

Volume: 0.007893822 ft^3 Mass: 559.83 g Unit Weight: **156.35** pcf

Failure Load: 10,750 lbs

Strength: 3,534 psi

Original Specimen

Fractured Specimen

Remarks:

6121 Huntley Road * Columbus, Ohio 43229-1003 * (614) 888-0040 * FAX (614) 431-4024

Boring: B-003-0-19	**Run: R-1**	**Depth: 55.0'-61.0'**	**REC: 97%**	**RQD: 81%**
Boring: B-003-0-19	**Run: R-2**	**Depth: 61.0'-65.5'**	**REC: 100%**	**RQD: 98%**

Boring: B-003-0-19	**Run: R-2 Continued**	**Depth: 61.0'-65.5'**	**REC: 100%**	**RQD: 98%**

Jason Hughes

From: Andrew.Jalbrzikowski@dot.ohio.gov
Sent: Wednesday, October 2, 2019 12:52 PM
To: Jason Hughes
Cc: Justin.Gardner@dot.ohio.gov; 'Pike County Engineers Office'; 1921.1004; 1921.1005; Christopher Selvaggio; Paul.Painter@dot.ohio.gov; Michael Kennedy, P.E.; Chris.Merklin@dot.ohio.gov; Christopher.Pridemore@dot.ohio.gov; Adam.Ross@dot.ohio.gov
Subject: PIK-CR50-2.55 PID 108464 Geophysical Testing
Attachments: PIK-CR50-2.55 Geophysics Summary.pdf

Jason,

The results of the geophysical exploration for the subject project are attached. The latitude, longitude, and elevation values used in these exhibits are from a Trimble Geo7X handheld GPS. The field work was completed September 10-12, 2019.

The electrical resistivity data was collected with an Advanced Geosciences Inc. (AGI) SuperSting R8 control unit. Fifty-three electrodes were used for line one and fifty-two electrodes were used for line two. The electrode spacing was approximately 5 feet for both lines. The electrodes were used to measure the potential field with Dipole-Dipole and Strong Gradient Arrays. The data was processed and surface elevation corrected using AGI's EarthImager 2D software.

The site constraints (limit of straight-line length and highly variable ground surface), buried steel, and high electrode contact resistance (due to loose granular materials at the ground surface) created quite a bit of noise in the data. This also limited the useful total depth of the inverted resistivity section to approximately 55 feet. This is approximately the same depth that the DLZ borings encountered refusal at interpreted top of bedrock. The subsurface conditions of dense or hard colluvium underlain by weak shale results in a non-sharp, gradual contrast at the top of rock along the wall alignment. The data does show an increase in resistivity with depth. In both lines, beyond the wall limits, there is a sharp resistivity increase at a shallower depth, indicating that the top of rock is probably present at a higher elevation beyond the proposed wall limits.

The s-wave refraction microtremor (ReMi) and p-wave refraction data was collected with a SeismicSource DAQlink III 24 channel seismograph along two survey lines using 24 geophones spaced approximately 10 feet apart. For each seismic survey line, seventy-five P-wave records were collected. Each consisted of a 0.5 second files using a .125 millisecond sampling interval collected at fifteen shot locations. Ten ReMi records were also collected for each line. Each consisted of 30 second records using a 2-millisecond sampling interval. Data was recorded with a laptop computer using SeismicSource Vibrascope software. A 16-pound sledge hammer struck against an aluminum plate or the pavement surface was used as the seismic source. The data was processed and surface elevation corrected by SubTerraSeis using Vibrascope, Geogiga Seismic Pro, and Golden Surfer software packages.

Due to loose aggregate at the surface, it was difficult to get a good geophone plant at several locations. This, along with the site constraints limited the useful depth of the seismic data. The ReMi data provided useful information to a depth of 100 feet, while the refraction data provided useful information to a depth of approximately 50 feet.

Both the refraction section and ReMi profile indicate sharp increase in velocity at a depth of 30-40 feet. This corresponds to the increase in density or consistency within the colluvial soils seen in the boring logs. This material,

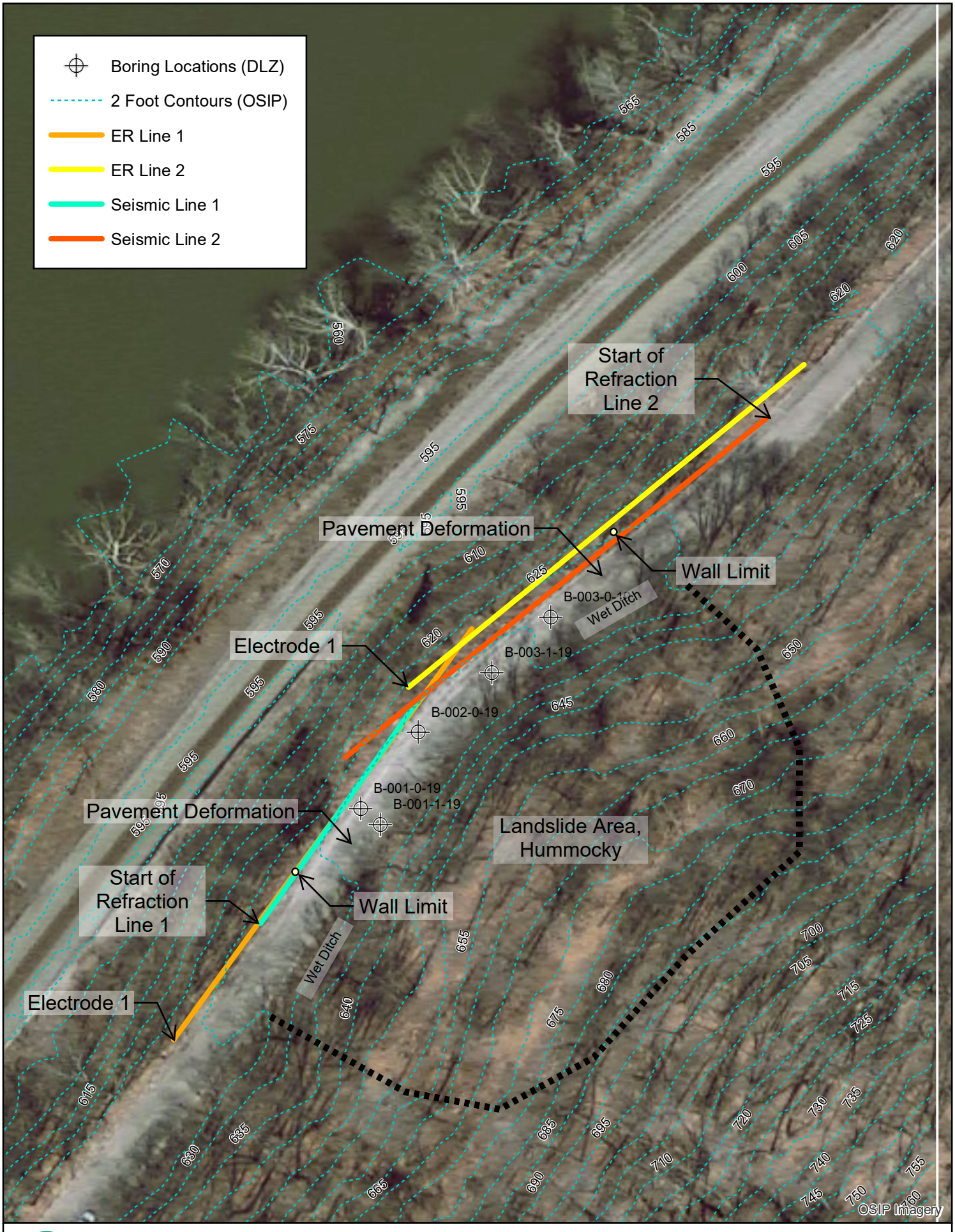
present at 30-40 feet, masked any contrast beyond this depth and prevented the imaging of the top of rock along the wall alignment. The refraction data does indicate the increase in velocity becomes shallower beyond current proposed wall limits.

While on site, it was apparent that the hillside above the road has experienced quite a bit of movement over time. The terrain is hummocky, the trees are deformed, and multiple historical scarps are visible upslope. The upslope ditch is very wet at the limits of the larger slide area. Areas of pavement deformation were also noted extending across the road near the proposed wall limits. The scarp along the failed section of CR50 appears to be minor scarp which is a part of a much larger landslide. The hummocky terrain is also visible in the OSIP elevation data and the approximate limits are outlined on the exploration plan.

I hope you find this information useful in the design of the landslide remediation. Please don't hesitate to call if you have any questions.

Thanks,

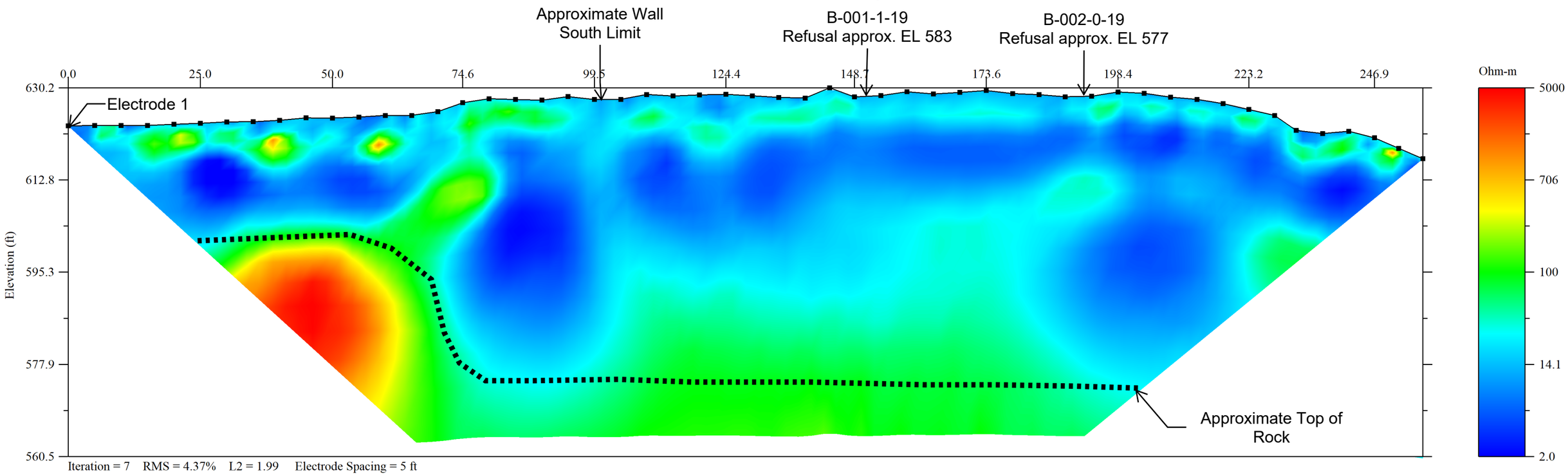
Andrew M. Jalbrzikowski
Field Exploration Manager
ODOT Office of Geotechnical Engineering
1600 W. Broad Street, Columbus, Ohio 43223
614.275.1305
transportation.ohio.gov



PIK-CR50-2.55
Exploration Plan

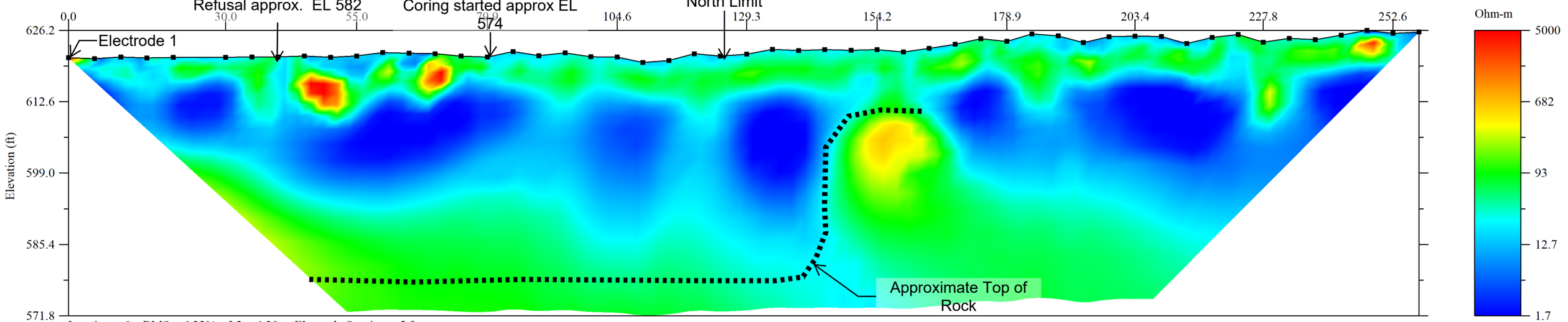
0 20 40 80
Feet

PIK-CR50-2.55 Line 1 Inverted Resistivity Section

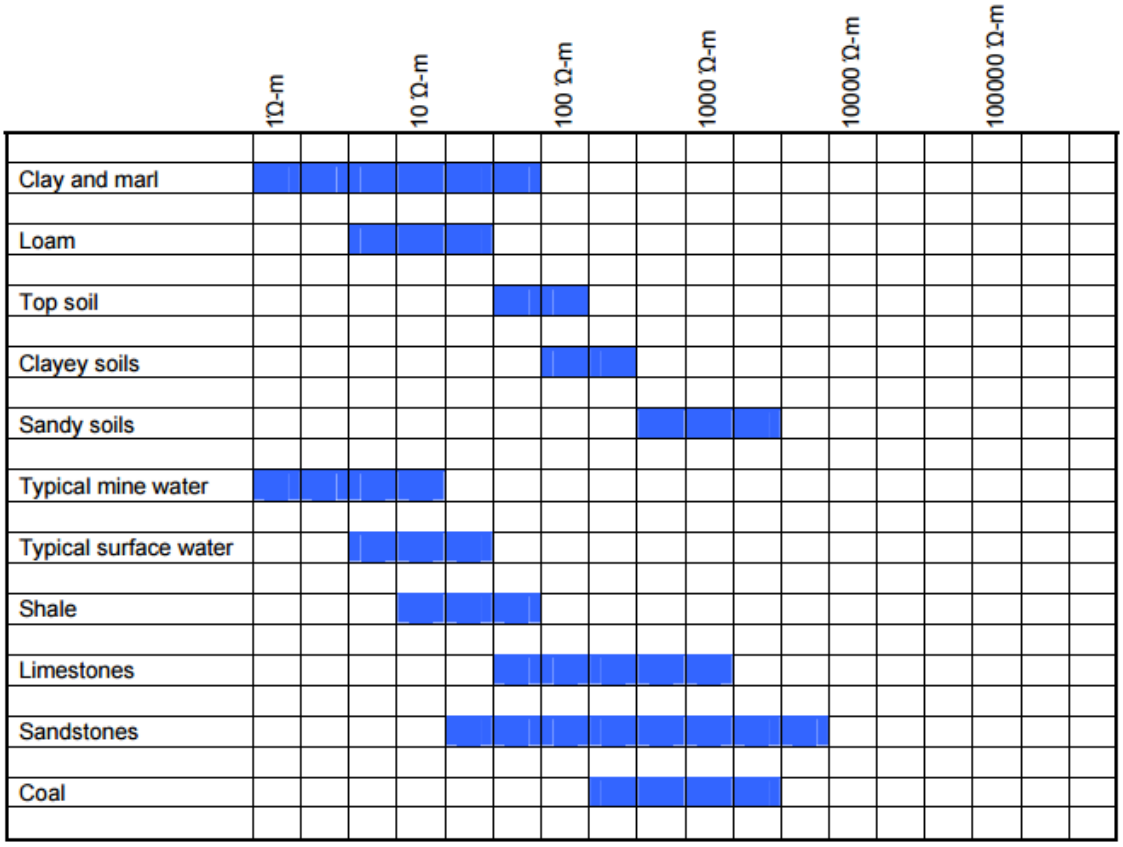


Iteration = 7 RMS = 4.37% L2 = 1.99 Electrode Spacing = 5 ft

PIK-CR50-2.55 Line 2 Inverted Resistivity Section



Iteration = 6 RMS = 6.32% L2 = 4.39 Electrode Spacing = 5 ft



Typical resistivity range of earth materials in ohm-meters

Johnson, J. (2003) Application of the Electrical Resistivity Method for Detection of Underground Mine Workings. Monroeville, PA. Retrieved December 17, 2015 from: https://www.fhwa.dot.gov/engineering/geotech/hazards/mine/workshops/ktwkshp/ky0311.pdf

PIK-CR50-2.55 Line 1 2D Refraction Section

South

North

Approx. South Wall Terminus

B-001-0-19
Refusal approx. EL 583

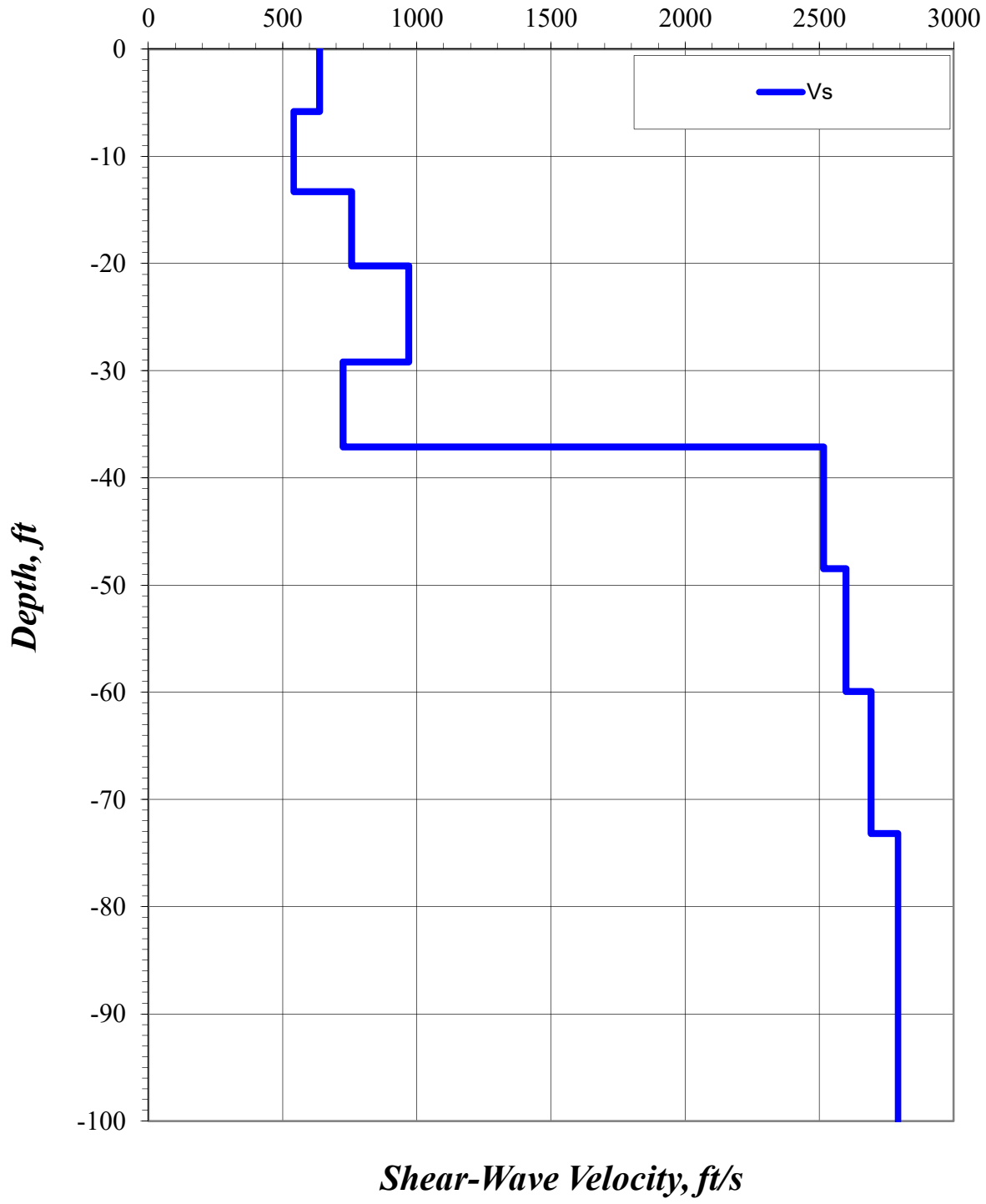
B-002-0-19
Refusal approx. EL 577

Elevation, ft

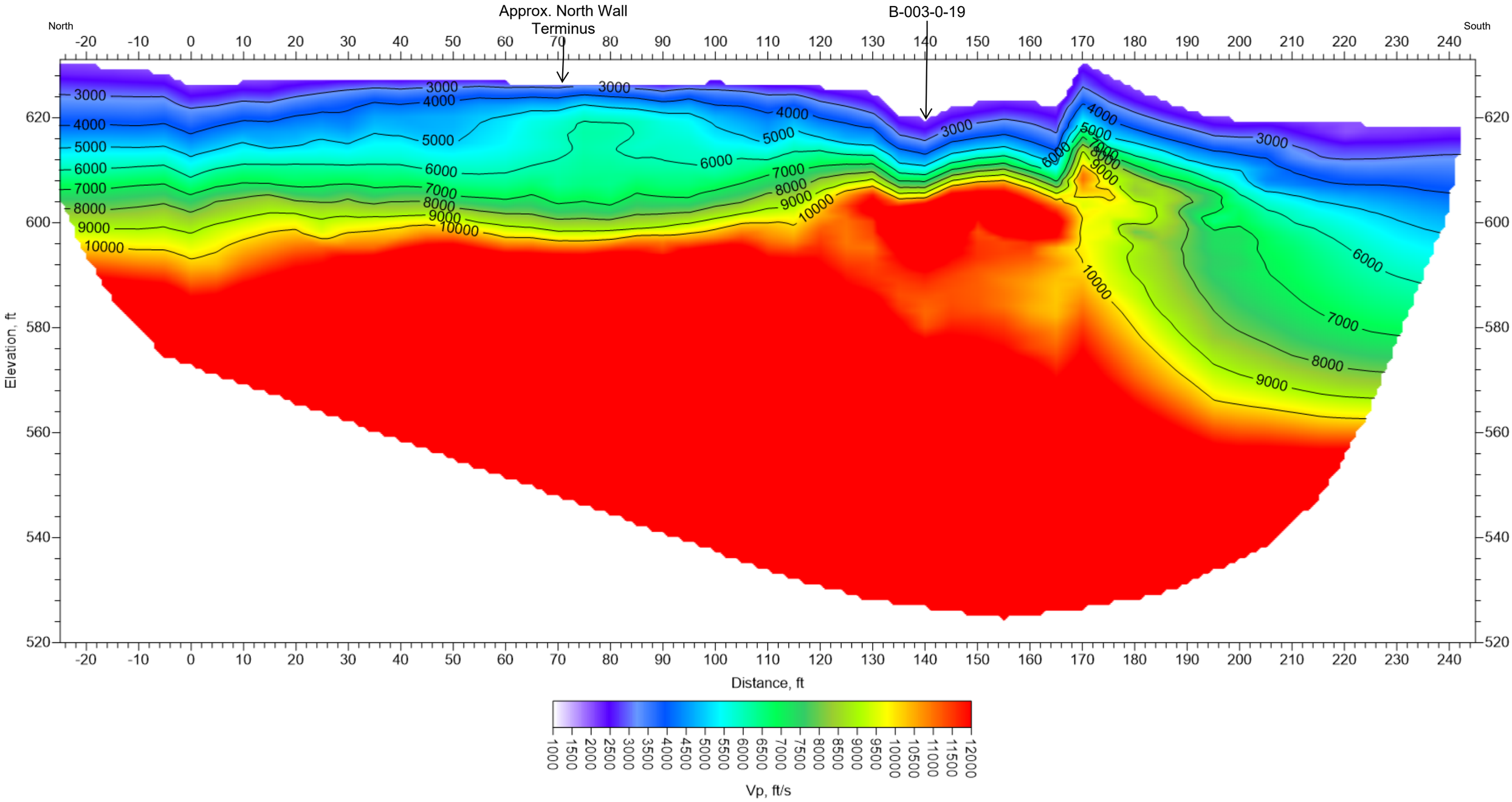
Distance, ft

Vp, ft/s

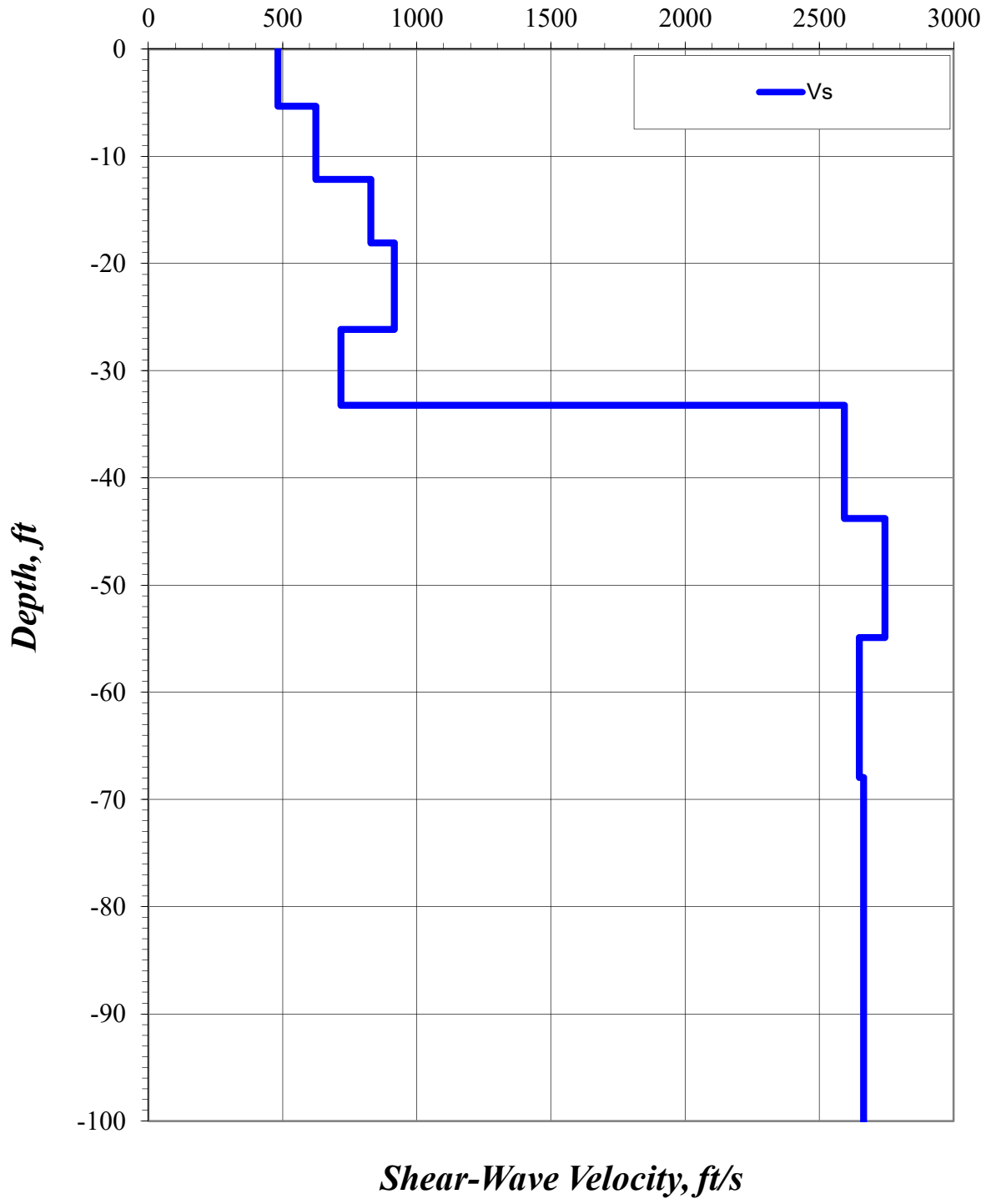
PIK-CR50-02.55 Refraction Microtremor Line 1: Vs Model



PIK-CR50-2.55 Line 2 2D Refraction Section



PIK-CR50-02.55 Refraction Microtremor Line 2: Vs Model



Parameters That Influence Seismic Velocity

Type of formation	P wave velocity (m/s) range		S wave velocity (m/s) range		Density (g/cm^3)	P wave velocity (ft/s) range		S wave velocity (ft/s) range	
	Low	High	Low	High		Low	High	Low	High
Scree, vegetal soil	300	700	100	300	1.7-2.4	980	2290	320	980
Dry sands	400	1200	100	500	1.5-1.7	1310	3930	320	1640
Wet sands	1500	2000	400	600	1.9-2.1	4920	6560	1310	1960
Saturated shales and clays	1100	2500	200	800	2.0-2.4	3600	8200	650	2620
Marls	2000	3000	750	1500	2.1-2.6	6560	9840	2460	4920
Saturated shale and sand sections	1500	2200	500	750	2.1-2.4	4920	7210	1640	2460
Porous and saturated sandstones	2000	3500	800	1800	2.1-2.4	6560	11480	2620	5900
Limestones	3500	6000	2000	3300	2.4-2.7	11480	19680	6560	10820
Chalk	2300	2600	1100	1300	1.8-3.1	7540	8530	3600	4260
Salt	4500	5500	2500	3100	2.1-2.3	14760	18040	8200	10170
Anhydrite	4000	5500	2200	3100	2.9-3.0	13120	18040	7210	10170
Dolomite	3500	6500	1900	3600	2.5-2.9	11480	21320	6230	11810
Granite	4500	6000	2500	3300	2.5-2.7	14760	19680	8200	10820
Basalt	5000	6000	2800	3400	2.7-3.1	16400	19680	9180	11150
Gneiss	4400	5200	2700	3200	2.5-2.7	14430	17060	8850	10490
Coal	2200	2700	1000	1400	1.3-1.8	7210	8850	3280	4590
Water	1450	1500	-	-	1.0	4750	4920	-	-
Ice	3400	3800	1700	1900	0.9	11150	12460	5570	6230
Oil	1200	1250	-	-	0.6-0.9	3930	4100	-	-

Adapted from typical rock velocities, from Bourbié, Coussy, and Zinszner. (1987) Acoustics of Porous Media, Gulf Publishing.

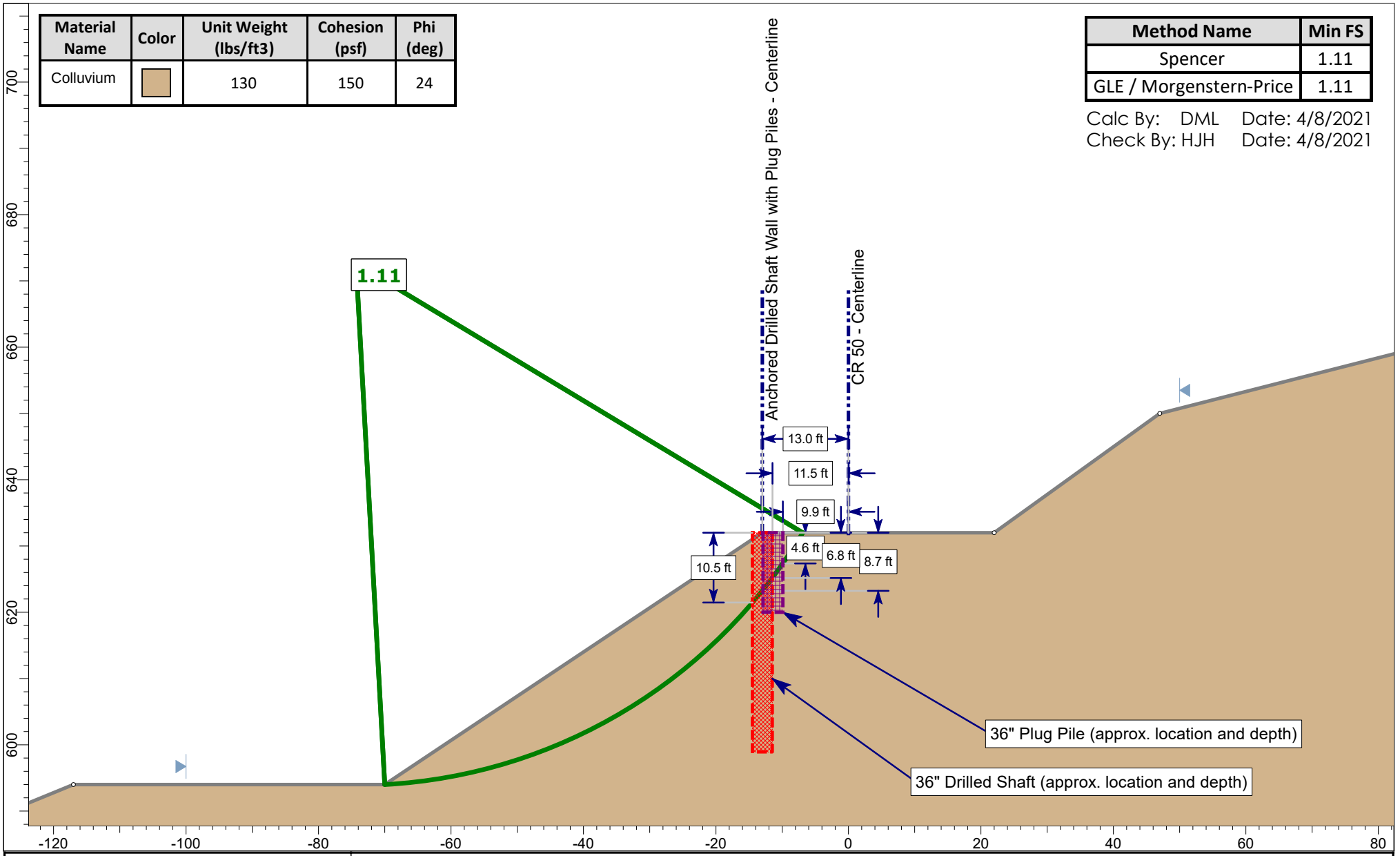
APPENDIX II

Calculations

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Colluvium		130	150	24

Method Name	Min FS
Spencer	1.11
GLE / Morgenstern-Price	1.11

Calc By: DML Date: 4/8/2021
Check By: HJH Date: 4/8/2021



DLZ

SLIDEINTERPRET 9.010

Project	PIK-CR50-2.55		
Analysis Description	Outer Edge of Pavement Slip		
Drawn By	DML	Scale	1:240
Company	DLZ		
Date	2021-04-08	File Name	Back Analysis.slmd

CLIENT	Pike County Engineer	JOB NUMBER	1921-1005.00		
PROJECT	PIK-CR50-02.55	SHEET NO.	1	OF	
SUBJECT	Earth Pressures for Anchored Walls	COMP. BY	DML	DATE	3/16/21
	Plug Pile Anchor Assumptions	CHECKED BY	HJH	DATE	3/22/21
	Extreme II Limit				

Soil Properties

Driving/Retained Side		Resisting Side	
γ'_s	130 pcf	γ'_s	130 pcf
ϕ'	24°	ϕ'	24°
k_a	0.42	k_p	2.37

Wall Information

# of anchors	1	
H	10.0 ft	
d	10.0 ft	(min. of 2 ft below the excavation if soft)
Shaft Spacing	5.0 ft	c-c
R=0?	No	
WA		(no groundwater)

Load Factors *Ref. AASHTO LRFD BDS Table 3.4.1-1 & Table 3.4.1-2*

EH - Active	1.00	LS	0.50
EH - At-Rest	1.00	WA	1.00
EH - AEP	1.00	CT	1.00

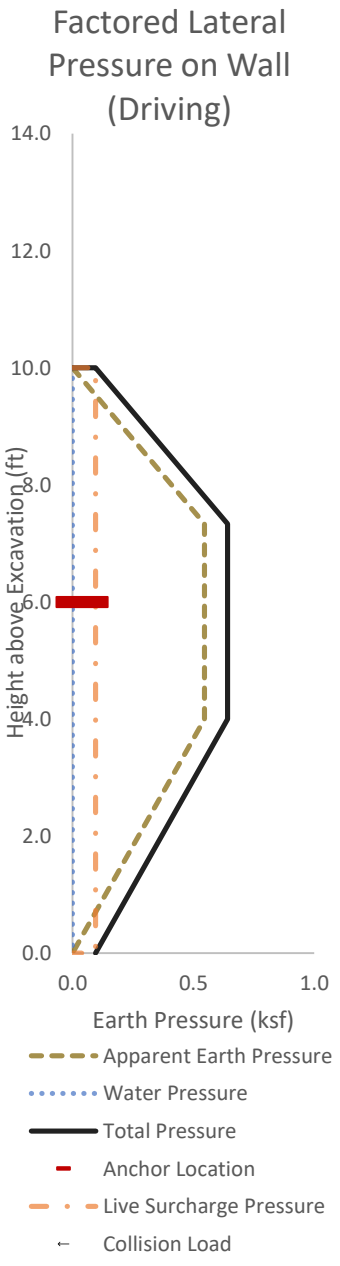
Loads

H_{eq}	3.5 ft	*Ref. AASHTO LRFD BDS Table 3.11.6.4-2*
γ_s	130 pcf	
ΔP_{LS}	0.19 ksf	*Ref. AASHTO LRFD BDS Eq. 3.11.6.4-1*
LS x ΔP_{LS}	0.10 ksf	or 4.78 kip resultant load @ 5 ft shaft spacing
p_a	0.55 ksf	*Ref. AASHTO LRFD BDS Eq. 3.11.5.7.1-1*
EH x p_a	0.55 ksf	or 18.2 kip resultant load @ 5 ft shaft spacing
CT x p_{ct}	4.72 kip/ft	located 2.7 ft above the top of wall

Increments of Height	Height
H1	4.0 ft
Hn+1	6.0 ft

Anchor	Load	
Th1	13.66 kip/ft	or 68.3 kip resultant load @ 5 ft shaft spacing

Reaction Force at Bottom Of Excavation		
R	-4.34 kip/ft	or -21.72 kip resultant load @ 5 ft shaft spacing



NOTE: For analysis purposes retained height includes concrete cap thickness

CLIENT	Pike County Engineer	JOB NUMBER	1921-1005.00		
PROJECT	PIK-CR50-02.55	SHEET NO.	1	OF	
SUBJECT	Earth Pressures for Anchored Walls	COMP. BY	DML	DATE	3/16/21
	Plug Pile Anchor Assumptions	CHECKED BY	HJH	DATE	3/22/21
	Strength Limit				

Soil Properties

Driving/Retained Side		Resisting Side	
γ'_s	130 pcf	γ'_s	130 pcf
ϕ'	24°	ϕ'	24°
k_a	0.42	k_p	2.37

Wall Information

# of anchors	1	
H	10.0 ft	
d	10.0 ft	(min. of 2 ft below the excavation if soft)
Shaft Spacing	5.0 ft	c-c
R=0?	No	
WA		(no groundwater)

Load Factors *Ref. AASHTO LRFD BDS Table 3.4.1-1 & Table 3.4.1-2*

EH - Active	1.50	LS	1.75
EH - At-Rest	1.35	WA	1.00
EH - AEP	1.35	CT	1.00

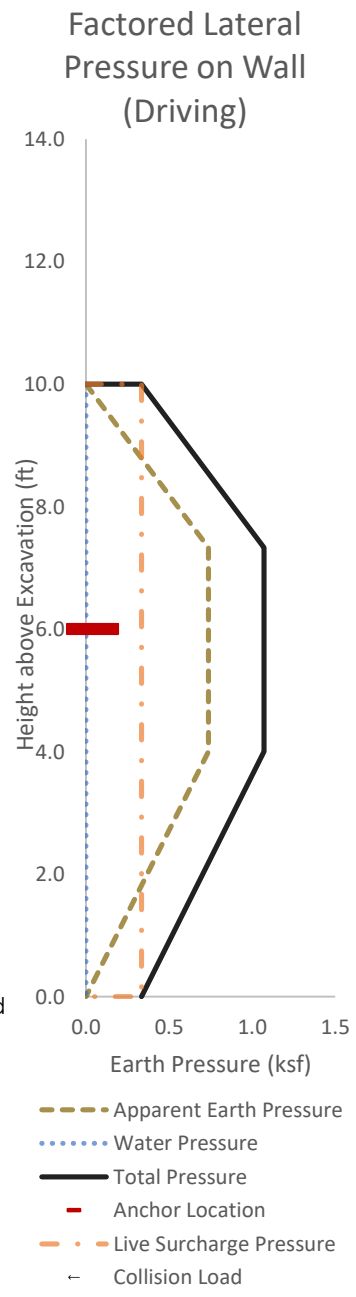
Loads

H_{eq}	3.5 ft	*Ref. AASHTO LRFD BDS Table 3.11.6.4-2*	
γ_s	130 pcf		
ΔP_{LS}	0.19 ksf	*Ref. AASHTO LRFD BDS Eq. 3.11.6.4-1*	
LS x ΔP_{LS}	0.33 ksf	or 16.72 kip resultant load @ 5 ft shaft spacing	
p_a	0.55 ksf	*Ref. AASHTO LRFD BDS Eq. 3.11.5.7.1-1*	
EH x p_a	0.74 ksf	or 24.57 kip resultant load @ 5 ft shaft spacing	
CT x p_{ct}		located 2.7 ft above the top of wall	
WA x P_{WA}			

Increments of Height	Height
H1	4.0 ft
Hn+1	6.0 ft

Anchor	Load	
Th1	6.43 kip/ft	or 32.13 kip resultant load @ 5 ft shaft spacing

Reaction Force at Bottom Of Excavation		
R	1.83 kip/ft	or 9.16 kip resultant load @ 5 ft shaft spacing



NOTE: For analysis purposes retained height includes concrete cap thickness

CLIENT	Pike County Engineer	JOB NUMBER	1921-1005.00		
PROJECT	PIK-CR50-02.55	SHEET NO.	1	OF	
SUBJECT	Earth Pressures for Anchored Walls	COMP. BY	DML	DATE	03-25-21
	Plug Pile Anchor Assumptions	CHECKED BY	HJH	DATE	04-13-21
	Service Limit				

Soil Properties

Driving/Retained Side		Resisting Side	
γ'_s	130 pcf	γ'_s	130 pcf
ϕ'	24°	ϕ'	24°
k_a	0.42	k_p	2.37

Wall Information

# of anchors	1	
H	10.0 ft	
d	10.0 ft	(min. of 2 ft below the excavation if soft)
Shaft Spacing	5.0 ft	c-c
R=0?	No	
WA		(no groundwater)

Load Factors *Ref. AASHTO LRFD BDS Table 3.4.1-1 & Table 3.4.1-2*

EH - Active	1.00	LS	1.00
EH - At-Rest	1.00	WA	1.00
EH - AEP	1.00	CT	1.00

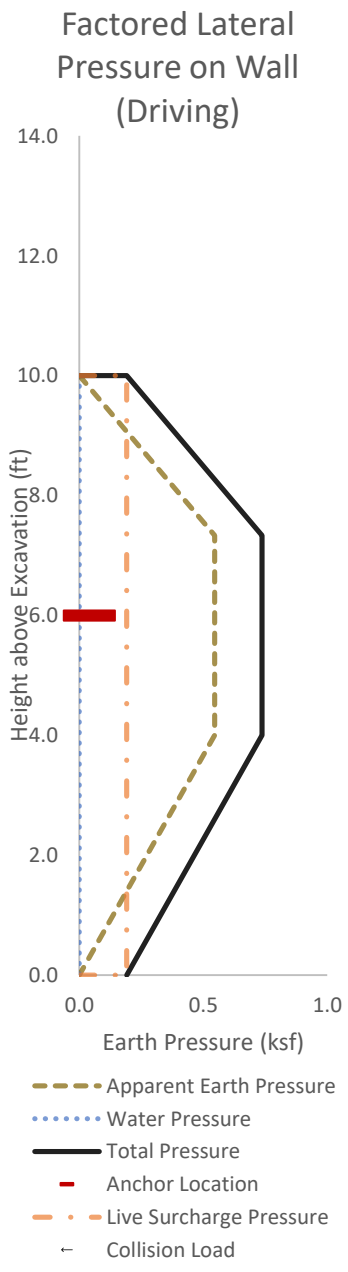
Loads

H_{eq}	3.5 ft	*Ref. AASHTO LRFD BDS Table 3.11.6.4-2*
γ_s	130 pcf	
ΔP_{LS}	0.19 ksf	*Ref. AASHTO LRFD BDS Eq. 3.11.6.4-1*
LS x ΔP_{LS}	0.19 ksf	or 9.56 kip resultant load @ 5 ft shaft spacing
p_a	0.55 ksf	*Ref. AASHTO LRFD BDS Eq. 3.11.5.7.1-1*
EH x p_a	0.55 ksf	or 18.2 kip resultant load @ 5 ft shaft spacing
CT x p_{ct}		located 2.7 ft above the top of wall

Increments of Height	Height
H1	4.0 ft
Hn+1	6.0 ft

Anchor	Load	
Th1	4.36 kip/ft	or 21.82 kip resultant load @ 5 ft shaft spacing

Reaction Force at Bottom Of Excavation		
R	1.19 kip/ft	or 5.94 kip resultant load @ 5 ft shaft spacing



NOTE: For analysis purposes retained height includes concrete cap thickness

CLIENT	Pike County Engineer	JOB NUMBER	1921-1005.00		
PROJECT	PIK-CR50-02.55	SHEET NO.	1	OF	1
SUBJECT	Pile Embedment Depth for Anchored Walls	COMP. BY	DML	DATE	4/12/2021
	GEC No. 4, Section 5.5 - Broms Method	CHECKED BY	HJH	DATE	4/13/2021
	Drained Condition - Strength Limit				

Soil Properties

Driving/Retained Side		Resisting Side	
γ'_s	130 pcf	γ'_s	130 pcf
ϕ'	24°	ϕ'	24°
k_a	0.42	k_p	2.37

Wall Information

H	10.0 ft	
d	12.0 ft	
b	3.0 ft	
R	9.2 kips	
Shaft Spacing	5.0 ft	c-c

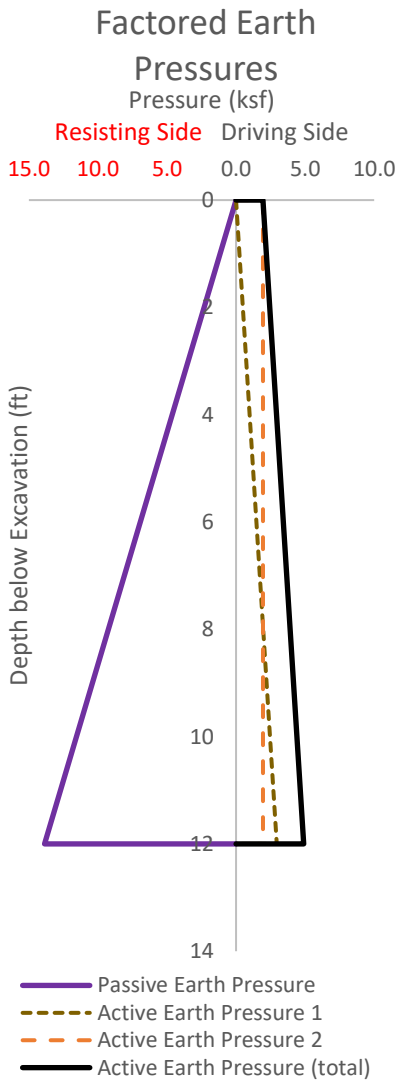
Load Factors *Ref. AASHTO LRFD BDS Table 3.4.1-1 & Table 3.4.1-2*

EH	1.5	
φ_{ep}	0.75	*Resistance FS ≈ 1.5 per GEC4, Sec 5.5.3*

Loads

		Distance	
		Above	Below
Load ID	Force	Toe	Excavation
$\varphi_{ep} \times P_p$	83.2 kips	4.0 ft	8.0 ft
EH x P_{a1}	17.7 kips	4.0 ft	8.0 ft
EH x P_{a2}	23.4 kips	6.0 ft	6.0 ft
R	9.2 kips	12.0 ft	0.0 ft

Mresisting/Mdriving	
1.036	GOOD



NOTE: Retained height, H, includes concrete cap thickness.

CLIENT	Pike County Engineer	JOB NUMBER	1921-1005.00		
PROJECT	PIK-CR50-02.55	SHEET NO.	1	OF	2
SUBJECT	Anchored Drilled Shaft Wall - Lateral Load Anlysis	COMP. BY	DML	DATE	4/14/2021
	Software: Lpile v 2019-11 by Ensoft, Inc.	CHECKED BY	HJH	DATE	4/21/2022

1 Assumptions

1 Load and Resistance Factor Design (LRFD) Methodology; AASHTO LRFD BDS, 9th Ed and ODOT 2020 BDM
2 Geotechnical information from DLZ Geotechnical Exploration Report dated February 18, 2020
3 Survey information provided by DLZ
4 Anchored wall retained height of 10 feet (includes concrete cap thickness). Rankine active earth pressure
5 Slide mass left in place
6 No drainage behind wall. Assuming no groundwater is conservative for the overall analyses.
7 Guardrail mounted on top of grade beam. Vehicle Collision load included for extreme event loading condition.
8 The "no groundwater" and "groundwater to the top of the surface" conditions were compared and the "no groundwater" condition was more critical for the strength condition. The no groundwater condition was therefore analyzed.
9 Analyze deadman using similar soil parameters & drilled shaft properties as shafts for wall accept length. See Lpile Report for details.

2 Soil/Rock Profile for LPile Analysis

No.	Layer Description	Lpile Model	Top* (ft)	Bot.* (ft)	Eff. UW, γ' (pcf)	q_u (psi)	E_i (psi)	RQD (%)	E50	Undrained Cohesion
1	Stiff clay w/o free water	Stiff Clay	10	50	130				0.007	1400

3 Pile Properties

Section Input

Section Diameter = 36 in
Concrete Compressive Strength, f_c' = 4,000 psi
Max. Coarse Aggregate Size = 0.75 in
Reinforcing Steel - No.8 bars equally spaced (13 total) with 3.5 in cover (assumes No. 5 spiral or ties)
As = 10.27 in 1.01%
Yield Stress, F_y = 60 ksi
Steel Elastic Modulus, E = 29000 ksi

Section	Lpile Model	Physical Model	Length (ft)
1	Bored Pile	Drilled Shaft	22

Note:
1. Bored Pile section length includes concrete cap thickness (3 feet) to account for lateral pressures against it.
2. A shear of 23,600 lbs and moment of 755,200 in-lb was applied to the top of the bored pile for the collision load.

4 Passive resistance reduction factor

p-multiplier, p = 0.76 ...neglecting any long term resistance from soil in front of 10' high retained zone.

5 Distributed Load (per Pile) for Each Limit State

Depth	Service Limit	Strength Limit	Strength Limit	Extreme Event II	Extreme Event II	
		lockoff load	full anchor load	lockoff load	full anchor load	
(ft)	Factored Load	Factored Load	Factored Load	Factored Load	Factored Load	
0	80 lb/in	139 lb/in	139 lb/in	40 lb/in	40 lb/in	
2.7	307 lb/in	446 lb/in	446 lb/in	267 lb/in	267 lb/in	
3.5	307 lb/in	446 lb/in	446 lb/in	267 lb/in	267 lb/in	
3.5	-1511 lb/in	-1372 lb/in	-2231 lb/in	-1551 lb/in	-5424 lb/in	Shift in load due to anchor at 4
4.5	-1511 lb/in	-1372 lb/in	-2231 lb/in	-1551 lb/in	-5424 lb/in	feet below top of wall
4.5	307 lb/in	446 lb/in	446 lb/in	267 lb/in	267 lb/in	
6	307 lb/in	446 lb/in	446 lb/in	267 lb/in	267 lb/in	
10	80 lb/in	139 lb/in	139 lb/in	40 lb/in	40 lb/in	

Note:
Concrete cap thickness (3 feet) was assumed as part of the drilled shaft for lateral analysis.

6 Pile-Head Loading

Load Case	Shear (lbs)	Moment (in-lbs)	Axial Load (lbs)
Service	0	0	0
Strength	0	0	0
Extreme Event II	23,600	755,200	0

7 Results

Load Case	Deflection	Max Moment @ Depth		Max Shear@ Depth	
	(in)	(in-kips)	(ft)	(kips)	(ft)
Service	0.02	275	13.5	7.4	3.0
Strength - lockoff load	1.64	1,363	13.5	-23.3	18.0
Strength - full anchor load	*0.05	450	14.0	11.1	3.0
Extreme Event II - lockoff load	30.41	3,745	12.0	-56.3	17.5
Extreme Event II - full anchor load	-*0.39	1,956	4.0	-32.3	5.0

Note:
Concrete cap thickness was included in the analysis.

*Deflection will be limited by the deadman which is 0.43 inches @ strength limit and 8.70 inches @ Extreme Event II (deadman embedded 15 feet deep below the anchor attachment).

See structural analysis for Moment and Shear checks.

8 Results - Deadman

Load Case	Anchor Load	Deflection	Max Moment @ Depth		Max Shear@ Depth	
	(kips)	(in)	(in-kips)	(ft)	(kips)	(ft)
Service/Lockoff Anchor Load	*21.82	0.10	861	6.3	21.8	0.0
Strength Limit Anchor Load	*32.13	0.43	1,277	6.3	32.1	0.0
Extreme Event II Limit Anchor Load	*68.30	8.70	2,721	6.3	68.3	0.0

Note:
Strength limit and Extreme Event II converge. This meets the overturning check requirements per BDM 305.1.2 & 307.1.4.

*Anchor Load applied at the top of the 15-ft shaft (neglecting portion of shaft above the anchor attachment) as a shear force.

CLIENT	PCEO	PROJECT #	1921-1005.00		
PROJECT	PIK-CR50-02.55	CALC BY	DML	DATE	2021-04-16
SUBJECT	LATERAL LOAD PILE ANALYSIS - GRANULAR SOILS	CHECK BY	HJH	DATE	2021-04-21
	OVERTURNING - MIN. PILE EMBEDMENT CHECK - BROMS METHOD				

D = Depth of pile embedment below design grade, assume design grade at anchor elevation

P_a = Active earth pressure load on pile

P_p = Passive earth pressure load on pile using Broms method (ref. GEC#4, Section 5.5).

T_{h1} = Anchor load on pile (driving force, same direction as active load)

DRAINED LOADING NOT APPLICABLE FOR EXTREME EVENT IN THESE SOIL TYPES

		Depth	Nominal Loads		Moment Arms, base of Pile			Service Limit Results						Strength Limit Results						Extreme Event II Results					
		D	Pa	Pp	r_{pp}	r_{Pa}	r_{Th1}	Y_p	φ_{ep}	Y_pP_a	$\varphi_{ep}P_p$	T_{h1}	ΣM_F	Y_p	φ_{ep}	Y_pP_a	$\varphi_{ep}P_p$	T_{h1}	ΣM_F	Y_p	φ_{ep}	Y_pP_a	$\varphi_{ep}P_p$	T_{h1}	ΣM_F
Y'_{eff}	0.13 kcf	1.00	0.08	0.77	0.33	0.33	1.00	1.00	0.75	0.08	0.58	21.82	21.65	1.50	0.75	0.12	0.58	32.13	31.98						
CTC	5.00 ft	2.00	0.33	3.08	0.67	0.67	2.00	1.00	0.75	0.33	2.31	21.82	42.32	1.50	0.75	0.49	2.31	32.13	63.05						
b	3.00 ft	3.00	0.74	6.93	1.00	1.00	3.00	1.00	0.75	0.74	5.20	21.82	61.00	1.50	0.75	1.11	5.20	32.13	92.30						
k_a	0.42	4.00	1.31	12.32	1.33	1.33	4.00	1.00	0.75	1.31	9.24	21.82	76.70	1.50	0.75	1.97	9.24	32.13	118.82						
k_p	2.37	5.00	2.05	19.26	1.67	1.67	5.00	1.00	0.75	2.05	14.44	21.82	88.44	1.50	0.75	3.07	14.44	32.13	141.70						
		6.00	2.95	27.73	2.00	2.00	6.00	1.00	0.75	2.95	20.80	21.82	95.22	1.50	0.75	4.42	20.80	32.13	160.03						
		7.00	4.01	37.74	2.33	2.33	7.00	1.00	0.75	4.01	28.31	21.82	96.05	1.50	0.75	6.02	28.31	32.13	172.91						
		8.00	5.24	49.30	2.67	2.67	8.00	1.00	0.75	5.24	36.97	21.82	89.95	1.50	0.75	7.86	36.97	32.13	179.41						
		9.00	6.63	62.39	3.00	3.00	9.00	1.00	0.75	6.63	46.79	21.82	75.90	1.50	0.75	9.95	46.79	32.13	178.64						
		10.00	8.19	77.03	3.33	3.33	10.00	1.00	0.75	8.19	57.77	21.82	52.94	1.50	0.75	12.29	57.77	32.13	169.69						
		11.00	9.91	93.20	3.67	3.67	11.00	1.00	0.75	9.91	69.90	21.82	20.06	1.50	0.75	14.86	69.90	32.13	151.63						
		12.00	11.79	110.92	4.00	4.00	12.00	1.00	0.75	11.79	83.19	21.82	**-23.73**	1.50	0.75	17.69	83.19	32.13	123.57						
		13.00	13.84	130.17	4.33	4.33	13.00	1.00	0.75	13.84	97.63	21.82	-79.42	1.50	0.75	20.76	97.63	32.13	84.60						
		14.00	16.05	150.97	4.67	4.67	14.00	1.00	0.75	16.05	113.23	21.82	-148.00	1.50	0.75	24.08	113.23	32.13	33.80						
		15.00	18.43	173.31	5.00	5.00	15.00	1.00	0.75	18.43	129.98	21.82	-230.46	1.50	0.75	27.64	129.98	32.13	**-29.74**						
		16.00	20.97	197.18	5.33	5.33	16.00	1.00	0.75	20.97	147.89	21.82	-327.80	1.50	0.75	31.45	147.89	32.13	-106.92						
		17.00	23.67	222.60	5.67	5.67	17.00	1.00	0.75	23.67	166.95	21.82	-440.99	1.50	0.75	35.50	166.95	32.13	-198.66						
		18.00	26.54	249.56	6.00	6.00	18.00	1.00	0.75	26.54	187.17	21.82	-571.05	1.50	0.75	39.80	187.17	32.13	-305.86						
		19.00	29.57	278.06	6.33	6.33	19.00	1.00	0.75	29.57	208.55	21.82	-718.96	1.50	0.75	44.35	208.55	32.13	-429.44						
		20.00	32.76	308.10	6.67	6.67	20.00	1.00	0.75	32.76	231.08	21.82	-885.70	1.50	0.75	49.14	231.08	32.13	-570.30						
		21.00	36.12	339.68	7.00	7.00	21.00	1.00	0.75	36.12	254.76	21.82	-1,072.28	1.50	0.75	54.18	254.76	32.13	-729.35						
		22.00	39.64	372.80	7.33	7.33	22.00	1.00	0.75	39.64	279.60	21.82	-1,279.68	1.50	0.75	59.46	279.60	32.13	-907.51						
		23.00	43.33	407.46	7.67	7.67	23.00	1.00	0.75	43.33	305.60	21.82	-1,508.89	1.50	0.75	64.99	305.60	32.13	-1,105.68						

$D_{min,service}$ =	**12.00**	ft	$D_{min,strength}$ =	**15.00**	ft	$D_{min,service}$ =	ft

CLIENT	PCEO	PROJECT #	1921-1005.00		
PROJECT	PIK-CR50-02.55	CALC BY	HJH	DATE	2021-04-13
SUBJECT	LATERAL LOAD PILE ANALYSIS - COHESIVE SOILS	CHECK BY	DML	DATE	2021-04-15
	OVERTURNING - MIN. PILE EMBEDMENT CHECK - BROMS METHOD				

D = Depth of pile embedment below design grade, assume design grade at anchor elevation

P_a = Active earth pressure load on pile

P_p = Passive earth pressure load on pile using Broms method

$P_{p\text{-}check}$ = Passive earth resistance for continuous wall in clay (ref. GEC#4, Appendix B, Eq. B-13, multiplied by pile embedment minus disturbed depth). Passive resistance for subsequent calcs takes the lesser of Broms and continuous wall value.

T_{h1} = Anchor load on pile (driving force, same direction as active load)

γ_{total}	0.13	kcf
CTC	5.00	ft
b	3.00	ft
H	0	ft
Su	1.40	ksf
β	0.0	°
$D_{disturbed}$*	2.50	ft

*assumes depth of anchor is 2.0 feet and disturbed depth is an additional 2.5 feet for total below ground surface = 4.5 ft

	Depth	Nominal Loads			Moment Arms, base of Pile			Service Limit Results						Strength Limit Results						Extreme Event II Results					
	D	Pa	Pp (Broms)	$P_{P\text{-}Check}$ (cont wall)	r_{PP}	r_{Pa}	r_{Th1}	γ_p	φ_{ep}	$\gamma_p P_a$	$\varphi_{ep} P_p$	T_{h1}	ΣM_F	γ_p	φ_{ep}	$\gamma_p P_a$	$\varphi_{ep} P_p$	T_{h1}	ΣM_F	γ_p	φ_{ep}	$\gamma_p P_a$	$\varphi_{ep} P_p$	T_{h1}	ΣM_F
	1.00	0.00	0.00	14.65	0.50	0.50	1.00	1.00	0.75	0.00	0.00	21.82	21.82	1.50	0.75	0.00	0.00	32.13	32.13	1.00	0.75	0.00	0.00	68.30	68.30
	1.50	0.00	0.00	22.46	0.75	0.75	1.50	1.00	0.75	0.00	0.00	21.82	32.73	1.50	0.75	0.00	0.00	32.13	48.20	1.00	0.75	0.00	0.00	68.30	102.45
	2.00	0.00	0.00	30.60	1.00	1.00	2.00	1.00	0.75	0.00	0.00	21.82	43.64	1.50	0.75	0.00	0.00	32.13	64.26	1.00	0.75	0.00	0.00	68.30	136.60
	2.50	0.00	0.00	39.06	1.25	1.25	2.50	1.00	0.75	0.00	0.00	21.82	54.55	1.50	0.75	0.00	0.00	32.13	80.33	1.00	0.75	0.00	0.00	68.30	170.75
	3.00	0.00	18.90	47.85	1.50	1.50	3.00	1.00	0.75	0.00	14.18	21.82	44.20	1.50	0.75	0.00	14.18	32.13	75.13	1.00	0.75	0.00	14.18	68.30	183.64
	3.50	0.00	37.80	56.96	1.75	1.75	3.50	1.00	0.75	0.00	28.35	21.82	26.76	1.50	0.75	0.00	28.35	32.13	62.84	1.00	0.75	0.00	28.35	68.30	189.44
	4.00	0.00	56.70	66.40	2.00	2.00	4.00	1.00	0.75	0.00	42.53	21.82	2.23	1.50	0.75	0.00	42.53	32.13	43.47	1.00	0.75	0.00	42.53	68.30	188.15
	4.50	0.00	75.60	76.16	2.25	2.25	4.50	1.00	0.75	0.00	56.70	21.82	-29.39	1.50	0.75	0.00	56.70	32.13	17.01	1.00	0.75	0.00	56.70	68.30	179.78
	5.00	0.00	94.50	86.25	2.50	2.50	5.00	1.00	0.75	0.00	64.69	21.82	-52.62	1.50	0.75	0.00	64.69	32.13	**-1.07**	1.00	0.75	0.00	64.69	68.30	179.78
	5.50	0.00	113.40	96.66	2.75	2.75	5.50	1.00	0.75	0.00	72.50	21.82	-79.36	1.50	0.75	0.00	72.50	32.13	-22.65	1.00	0.75	0.00	72.50	68.30	176.28
	6.00	0.00	132.30	107.40	3.00	3.00	6.00	1.00	0.75	0.00	80.55	21.82	-110.73	1.50	0.75	0.00	80.55	32.13	-48.87	1.00	0.75	0.00	80.55	68.30	168.15
	6.50	0.00	151.20	118.46	3.25	3.25	6.50	1.00	0.75	0.00	88.85	21.82	-146.92	1.50	0.75	0.00	88.85	32.13	-79.91	1.00	0.75	0.00	88.85	68.30	155.20
	7.00	0.00	170.10	129.85	3.50	3.50	7.00	1.00	0.75	0.00	97.39	21.82	-188.12	1.50	0.75	0.00	97.39	32.13	-115.95	1.00	0.75	0.00	97.39	68.30	137.24
	7.50	0.00	189.00	141.56	3.75	3.75	7.50	1.00	0.75	0.00	106.17	21.82	-234.49	1.50	0.75	0.00	106.17	32.13	-157.17	1.00	0.75	0.00	106.17	68.30	114.11
	8.00	0.00	207.90	153.60	4.00	4.00	8.00	1.00	0.75	0.00	115.20	21.82	-286.24	1.50	0.75	0.00	115.20	32.13	-203.76	1.00	0.75	0.00	115.20	68.30	85.60
	8.50	0.00	226.80	165.96	4.25	4.25	8.50	1.00	0.75	0.00	124.47	21.82	-343.54	1.50	0.75	0.00	124.47	32.13	-255.90	1.00	0.75	0.00	124.47	68.30	51.54
	9.00	0.00	245.70	178.65	4.50	4.50	9.00	1.00	0.75	0.00	133.99	21.82	-406.56	1.50	0.75	0.00	133.99	32.13	-313.77	1.00	0.75	0.00	133.99	68.30	11.76
	9.50	0.00	264.60	191.66	4.75	4.75	9.50	1.00	0.75	0.00	143.75	21.82	-475.51	1.50	0.75	0.00	143.75	32.13	-377.56	1.00	0.75	0.00	143.75	68.30	**-33.95**
	10.00	0.00	283.50	205.00	5.00	5.00	10.00	1.00	0.75	0.00	153.75	21.82	-550.55	1.50	0.75	0.00	153.75	32.13	-447.45	1.00	0.75	0.00	153.75	68.30	-85.75
	10.50	0.00	302.40	218.66	5.25	5.25	10.50	1.00	0.75	0.00	164.00	21.82	-631.87	1.50	0.75	0.00	164.00	32.13	-523.62	1.00	0.75	0.00	164.00	68.30	-143.83
	11.00	0.00	321.30	232.65	5.50	5.50	11.00	1.00	0.75	0.00	174.49	21.82	-719.66	1.50	0.75	0.00	174.49	32.13	-606.25	1.00	0.75	0.00	174.49	68.30	-208.38
	11.50	0.00	340.20	246.96	5.75	5.75	11.50	1.00	0.75	0.00	185.22	21.82	-814.10	1.50	0.75	0.00	185.22	32.13	-695.53	1.00	0.75	0.00	185.22	68.30	-279.58
	12.00	0.00	359.10	261.60	6.00	6.00	12.00	1.00	0.75	0.00	196.20	21.82	-915.36	1.50	0.75	0.00	196.20	32.13	-791.64	1.00	0.75	0.00	196.20	68.30	-357.60

$D_{min,service}$ =	**4.50**	ft

$D_{min,strength}$ =	**5.00**	ft

$D_{min,service}$ =	**9.50**	ft

DLZ

CLIENT:	Pike County Engineer	JOB NUMBER	1921-1005.00		
PROJECT:	PIK-CR50-02.55	SHEET NO.	1	of	1
SUBJECT:	Anchored Plug Pile Wall	COMP. BY	DML	DATE	2021-04-19
	Bearing Resistance - Drilled Shaft	CHECKED BY	HJH	DATE	2021-04-22

Drilled Shaft Diameter = 36 inches

Drilled Shaft Length* = 19 feet

*Excludes cap thickness (3 feet)

Reference: AASHTO LRFD Bridge Design Specifications, 9th Ed. (2020)

Skin Friction

No.	Top of Layer (ft)	Bot. of Layer (ft)	Soil Type	S_u (psf)	p_a (psf)	s_u/p_a	α	q_s (psf)	q_s * Dz (lb/LF	R_s (kips)	ΣR_s (kips)
1	0.0	5.0	Clay	-	2120	-	-	-	0	-	-
2	5.0	6.0	Clay	1400	2120	0.66	0.55	770 psf	770	7.3	
3	6.0	7.0	Clay	1400	2120	0.66	0.55	770 psf	770	7.3	
4	7.0	8.0	Clay	1400	2120	0.66	0.55	770 psf	770	7.3	
5	8.0	9.0	Clay	1400	2120	0.66	0.55	770 psf	770	7.3	
6	9.0	10.0	Clay	1400	2120	0.66	0.55	770 psf	770	7.3	
7	10.0	11.0	Clay	1400	2120	0.66	0.55	770 psf	770	7.3	
8	11.0	12.0	Clay	1400	2120	0.66	0.55	770 psf	770	7.3	
											50.8

50.8

Factored resistance of drilled shafts, R_R:

$\mathbf{R_R = \varphi R_n = \varphi_{qp} R_p + \varphi_{qs} R_s}$ *Eq. 10.8.3.5-1 (10-137)*

$\mathbf{R_s = q_s * A_s}$ *Eq. 10.8.3.5-3 (10-138)*

$\mathbf{q_s = \alpha * S_u}$ *Eq. 10.8.3.5.1b-1 (10-138)*

$$\alpha = 0.55 \text{ for } \frac{S_u}{p_a} \le 1.5 \qquad \textit{Eq. 10.8.3.5.1b-2 (10-138)}$$

$$\alpha = 0.55 - 0.1\left(\frac{S_u}{p_a} - 1.5\right) \text{ for } 1.5 \le \frac{S_u}{p_a} \le 2.5 \qquad \textit{Eq. 10.8.3.5.1b-3 (10-139)}$$

Resistance Factors:

Side Resistance Factor (φ_{qs}) = **0.45** *(a-method)* Table 10.5.5.2.4-1 (10-50)

		Service Limit		Strength Limit		EEII Limit	
	Load (kips)	Load Factors	Factored Load (kips)	Load Factors	Factored Load (kips)	Load Factors	Factored Load (kips)
CT	5.00	-	-	-	-	1.00	5.00
DC (cap)	6.75	1.00	6.75	1.25	8.44	1.00	6.75
DC (net shaft weight)	2.69	1.00	2.69	1.25	3.36	1.00	2.69
SUM			**9.44**		**11.80**		**14.44**

R_R = 0.45 x 50.8 = 22.9 kips

DLZ
ARCHITECTURE • ENGINEERING • PLANNING
SURVEYING • CONSTRUCTION SERVICES

CLIENT Pike County Engineer
PROJECT PIK-CR50-02.55
SUBJECT Drilled Shaft Axial Resistance Group Effect Check

PROJECT NO. 1921-1005.00
SHEET NO. 1 OF 1
COMP. BY DMC DATE 4/22/2021
CHECKED BY [illegible] DATE 4/22/2021

Drilled Shaft Axial Resistance
Group Effect Check (per FHWA-NHI-10-016, Section 14.4.1.1)

$$R_{Block} = f_{max}\left[2D(Z+B)\right] + q_{max}(ZB) \qquad Eq.\ 14\text{-}3$$

for $B = 0$ (conservative)

$$R_{Block} = f_{max}\, 2DZ$$

$$f_{max} = \alpha S_u = 0.55\, S_u \quad \text{for } \frac{S_u}{P_a} \le 1.5$$

$D = 7$ ft

$Z = 5$ ft

$S_u = 1.4$ ksf

$$R_{Block} = 0.55(1.4\text{ ksf})(2)(7\text{ ft})(5\text{ ft}) = 53.9\text{ kips}$$

$$R_R(GROUP) = \phi_{gs} R_{Block}$$

$\phi_{gs} = 0.45$ LRFD BDS Table 10.5.5.2.4-1 for side resistance in clay (Block Failure Resistance Factor of 0.55 not used to be conservative)

$R_R(GROUP) = 0.45(53.9\text{ kips})$

$= 24.3$ kips $> R_R = 22.9$ kips (for single shaft)

Use R_R instead of $R_R(GROUP)$

Service Limit Factored Load = 9.44 kips < 22.9 kips ✓

Strength Limit Factored Load = 11.80 kips < 22.9 kips ✓

Extreme Event II Limit Factored Load = 14.44 kips < 22.9 kips ✓

==========

LPile for Windows, Version 2019-11.004

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 on this computer:
\Projects\GFL\2019\1921\100500 PCE-PIK-CR50\PIK\108464\Design\Geotechnical\Spreadsheets and Calcs\LPILE\Plug Pile Wall\Service\

Name of the input data file:
Wall at Guardrail - 36in Shaft - Service.lp11d

Name of the output report file:
Wall at Guardrail - 36in Shaft - Service.lp11o

Name of the plot output file:
Wall at Guardrail - 36in Shaft - Service.lp11p

Name of the runtime message file:
Wall at Guardrail - 36in Shaft - Service.lp11r

Date and Time of Analysis

Date: April 22, 2021 Time: 18:23:30

Problem Title

Project Name: PIK-CR50-02.55

Job Number: 1921-1005.00

Client: Pike County

Engineer: DML

Description: Plug Pile Wall at Guardrail, 5ft Spacing, Service

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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	=	44

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 one distributed lateral load 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
- Input of side resistance moment along pile not selected
- Computation of pile-head foundation stiffness matrix not selected
- Push-over analysis of pile not selected
- Buckling analysis of pile not selected

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

Pile Structural Properties and Geometry

Number of pile sections defined	=	1
Total length of pile	=	22.000 ft
Depth of ground surface below top of pile	=	10.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	22.000	36.0000

Input Structural Properties for Pile Sections:

Pile Section No. 1:

Section 1 is a round drilled shaft, bored pile, or CIDH pile

Length of section	=	22.000000 ft
Shaft Diameter	=	36.000000 in

Shear capacity of section = 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	10.000000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Undrained cohesion at top of layer	=	1400. psf
Undrained cohesion at bottom of layer	=	1400. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

(Depth of the lowest soil layer extends 28.000 ft below the pile tip)

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p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.7600	1.0000
2	22.000	0.7600	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 8 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	79.625
2	32.400	307.125
3	42.000	307.125
4	42.000	-1510.979
5	54.000	-1510.979
6	54.000	307.125
7	72.000	307.125
8	120.000	79.625

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
1	1	V = 0.0000 lbs	M = 0.0000 in-lbs	0.0000000

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 = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	22.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.500000 in
Number of Reinforcing Bars	=	13 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.270000 sq. in.
Area Ratio of Steel Reinforcement	=	1.01 percent
Edge-to-Edge Bar Spacing	=	5.700839 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	7.60
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4042.060 kips
Tensile Load for Cracking of Concrete	=	-453.434 kips
Nominal Axial Tensile Capacity	=	-616.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.000000	0.790000	14.000000	0.00000
2	1.000000	0.790000	12.396384	6.506124
3	1.000000	0.790000	7.952906	11.521774
4	1.000000	0.790000	1.687514	13.897924
5	1.000000	0.790000	-4.964468	13.090227

6	1.000000	0.790000	-10.479150	9.283717
7	1.000000	0.790000	-13.593185	3.350419
8	1.000000	0.790000	-13.593185	-3.350419
9	1.000000	0.790000	-10.479150	-9.283717
10	1.000000	0.790000	-4.964468	-13.090227
11	1.000000	0.790000	1.687514	-13.897924
12	1.000000	0.790000	7.952906	-11.521774
13	1.000000	0.790000	12.396384	-6.506124

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 5.701 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.60

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 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, Section 10.3.4.
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 Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000006250	233.7218680467	373954989.	18.0000825595	
0.0000012500	466.5689419639	373255154.	18.0000827963	
0.0000018750	698.5412217518	372555318.	18.0000830341	
0.0000025000	929.6387074102	371855483.	18.0000832731	
0.0000031250	1160.	371155648.	18.0000835132	
0.0000037500	1389.	370455812.	18.0000837545	
0.0000043750	1618.	369755977.	18.0000839969	
0.0000050000	1845.	369056142.	18.0000842405	
0.0000056250	2072.	368356306.	18.0000844853	
0.0000062500	2298.	367656471.	18.0000847313	
0.0000068750	2298.	334233156.	8.6662704549	C
0.0000075000	2298.	306380393.	8.6684526289	C
0.0000081250	2298.	282812670.	8.6706386079	C
0.0000087500	2298.	262611765.	8.6728284052	C
0.0000093750	2298.	245104314.	8.6750220345	C
0.0000100000	2298.	229785294.	8.6772195093	C
0.0000106250	2298.	216268512.	8.6794208434	C
0.0000112500	2298.	204253595.	8.6816260505	C
0.0000118750	2298.	193503406.	8.6838351445	C
0.0000125000	2298.	183828236.	8.6860481393	C
0.0000131250	2298.	175074510.	8.6882650489	C
0.0000137500	2298.	167116578.	8.6904858875	C
0.0000143750	2298.	159850640.	8.6927106691	C
0.0000150000	2298.	153190196.	8.6949394080	C
0.0000156250	2298.	147062588.	8.6971721185	C
0.0000162500	2298.	141406335.	8.6994088150	C
0.0000168750	2298.	136169063.	8.7016495119	C
0.0000175000	2298.	131305883.	8.7038942239	C
0.0000181250	2298.	126778093.	8.7061429654	C
0.0000187500	2298.	122552157.	8.7083957512	C
0.0000193750	2298.	118598862.	8.7106525962	C
0.0000200000	2298.	114892647.	8.7129135151	C
0.0000206250	2298.	111411052.	8.7151785230	C
0.0000212500	2298.	108134256.	8.7174476347	C
0.0000218750	2298.	105044706.	8.7197208656	C
0.0000225000	2298.	102126798.	8.7219982307	C
0.0000231250	2298.	99366614.	8.7242797453	C
0.0000237500	2298.	96751703.	8.7265654248	C
0.0000243750	2298.	94270890.	8.7288552847	C
0.0000256250	2298.	89672310.	8.7334476078	C

0.0000268750	2298.	85501505.	8.7380568398	C
0.0000281250	2298.	81701438.	8.7426831077	C
0.0000293750	2298.	78224781.	8.7473265394	C
0.0000306250	2298.	75031933.	8.7519872649	C
0.0000318750	2298.	72089504.	8.7566654150	C
0.0000331250	2298.	69369145.	8.7613611226	C
0.0000343750	2355.	68508103.	8.7660745217	C
0.0000356250	2440.	68478657.	8.7708057480	C
0.0000368750	2524.	68449116.	8.7755549388	C
0.0000381250	2608.	68419478.	8.7803222331	C
0.0000393750	2693.	68389742.	8.7851077712	C
0.0000406250	2777.	68359907.	8.7899116954	C
0.0000418750	2861.	68329974.	8.7947341495	C
0.0000431250	2945.	68299941.	8.7995752789	C
0.0000443750	3029.	68269808.	8.8044352308	C
0.0000456250	3113.	68239573.	8.8093141544	C
0.0000468750	3197.	68209237.	8.8142122004	C
0.0000481250	3281.	68178798.	8.8191295214	C
0.0000493750	3365.	68148291.	8.8238892336	C
0.0000506250	3448.	68117692.	8.8286290397	C
0.0000518750	3532.	68086992.	8.8333869081	C
0.0000531250	3615.	68056192.	8.8381629810	C
0.0000543750	3699.	68025290.	8.8429574021	C
0.0000556250	3782.	67994285.	8.8477703169	C
0.0000568750	3865.	67963178.	8.8526018727	C
0.0000581250	3949.	67931967.	8.8574522185	C
0.0000593750	4032.	67900651.	8.8623215052	C
0.0000606250	4115.	67869229.	8.8672098854	C
0.0000618750	4197.	67837702.	8.8721175136	C
0.0000631250	4280.	67806067.	8.8770445463	C
0.0000643750	4363.	67774325.	8.8819911417	C
0.0000656250	4446.	67742474.	8.8869574603	C
0.0000668750	4528.	67710514.	8.8919436642	C
0.0000681250	4611.	67678443.	8.8969499178	C
0.0000693750	4693.	67646261.	8.9019763875	C
0.0000706250	4775.	67613967.	8.9070232417	C
0.0000718750	4857.	67581561.	8.9120906510	C
0.0000731250	4940.	67549040.	8.9171787881	C
0.0000743750	5022.	67516405.	8.9222878281	C
0.0000793750	5349.	67384701.	8.9429365938	C
0.0000843750	5674.	67251090.	8.9639343988	C
0.0000893750	5997.	67100912.	8.9846442900	CY
0.0000943750	6261.	66345414.	8.9781103992	CY
0.0000993750	6466.	65069477.	8.9466135093	CY
0.0001043750	6630.	63523046.	8.9001623016	CY
0.0001093750	6780.	61989682.	8.8530161477	CY
0.0001143750	6909.	60407201.	8.8000887428	CY
0.0001193750	7014.	58754596.	8.7389434559	CY
0.0001243750	7118.	57226145.	8.6834925884	CY
0.0001293750	7218.	55787822.	8.6316646677	CY

0.0001343750	7294.	54284434.	8.5723821243	CY
0.0001393750	7362.	52823712.	8.5135510238	CY
0.0001443750	7430.	51460668.	8.4595241559	CY
0.0001493750	7496.	50182631.	8.4067896920	CY
0.0001543750	7562.	48983508.	8.3581284747	CY
0.0001593750	7619.	47807630.	8.3085413079	CY
0.0001643750	7664.	46628126.	8.2554752625	CY
0.0001693750	7705.	45490327.	8.2035497450	CY
0.0001743750	7745.	44415680.	8.1551771023	CY
0.0001793750	7785.	43399235.	8.1101060048	CY
0.0001843750	7824.	42433842.	8.0657301600	CY
0.0001893750	7862.	41517143.	8.0235879396	CY
0.0001943750	7901.	40646072.	7.9841965308	CY
0.0001993750	7938.	39811976.	7.9466546824	CY
0.0002043750	7970.	38998835.	7.9089380488	CY
0.0002093750	7998.	38200403.	7.8703045093	CY
0.0002143750	8021.	37415727.	7.8307067402	CY
0.0002193750	8042.	36660567.	7.7926035954	CY
0.0002243750	8063.	35937552.	7.7565963940	CY
0.0002293750	8084.	35243704.	7.7211380146	CY
0.0002343750	8104.	34577303.	7.6863029796	CY
0.0002393750	8124.	33937793.	7.6533786870	CY
0.0002443750	8143.	33323506.	7.6222551448	CY
0.0002493750	8163.	32732915.	7.5928314382	CY
0.0002543750	8182.	32164602.	7.5650148499	CY
0.0002593750	8201.	31617005.	7.5388039695	CY
0.0002643750	8219.	31089166.	7.5140401262	CY
0.0002693750	8237.	30579805.	7.4905618084	CY
0.0002743750	8255.	30087790.	7.4684440982	CY
0.0003043750	8327.	27359282.	7.3313851032	CY
0.0003343750	8372.	25038864.	7.2065459877	CY
0.0003643750	8413.	23087969.	7.1115392048	CY
0.0003943750	8449.	21424132.	7.0387994684	CY
0.0004243750	8481.	19984836.	6.9769966026	CY
0.0004543750	8504.	18716680.	6.9192011486	CYT
0.0004843750	8518.	17584619.	6.8624058335	CYT
0.0005143750	8525.	16574324.	6.8105531203	CYT
0.0005443750	8531.	15671933.	6.7660506111	CYT
0.0005743750	8537.	14862538.	6.7284894935	CYT

Summary of Results for Nominal Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain

1	0.000	8486.052	0.00300000

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 (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 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 for Moment	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	8486.	0.0000	5516.	67316070.
1	0.75	8486.	0.0000	6365.	65702930.
1	0.90	8486.	0.0000	7637.	47334707.

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

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

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

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	0.01632	-5.406E-07	0.000	0.000	3.740E+11
0.50000	0.01569	1623.	635.73611	0.000	3.740E+11
1.00000	0.01506	7629.	1493.	0.000	3.740E+11
1.50000	0.01443	19535.	2602.	0.000	3.740E+11
2.00000	0.01380	38857.	3965.	0.000	3.740E+11

2.50000	0.01318	67112.	5579.	0.000	3.740E+11
3.00000	0.01256	105810.	7371.	0.000	3.740E+11
3.50000	0.01196	155564.	6487.	0.000	3.740E+11
4.00000	0.01136	183649.	147.87480	0.000	3.740E+11
4.50000	0.01079	157339.	-6191.	0.000	3.740E+11
5.00000	0.01023	109359.	-7075.	0.000	3.740E+11
5.50000	0.009683	72436.	-5233.	0.000	3.740E+11
6.00000	0.009142	46569.	-3400.	0.000	3.740E+11
6.50000	0.008605	31631.	-1654.	0.000	3.740E+11
7.00000	0.008071	26726.	-66.82853	0.000	3.740E+11
7.50000	0.007540	30829.	1349.	0.000	3.740E+11
8.00000	0.007012	42918.	2595.	0.000	3.740E+11
8.50000	0.006488	61968.	3670.	0.000	3.740E+11
9.00000	0.005970	86956.	4574.	0.000	3.740E+11
9.50000	0.005460	116858.	5308.	0.000	3.740E+11
10.00000	0.004962	150650.	5405.	-118.94090	3.740E+11
10.50000	0.004478	181722.	4816.	-120.94600	3.740E+11
11.00000	0.004012	208440.	4085.	-122.54772	3.740E+11
11.50000	0.003565	230746.	3346.	-123.72767	3.740E+11
12.00000	0.003141	248597.	2602.	-124.46535	3.739E+11
12.50000	0.002741	261968.	1854.	-124.73714	3.738E+11
13.00000	0.002366	270848.	1107.	-124.51457	3.738E+11
13.50000	0.002017	275246.	361.68838	-123.76171	3.737E+11
14.00000	0.001695	275189.	-376.88954	-122.43093	3.737E+11
14.50000	0.001399	270724.	-1106.	-120.45570	3.738E+11
15.00000	0.001129	261922.	-1820.	-117.73797	3.738E+11
15.50000	0.000884	248882.	-2516.	-114.12404	3.739E+11
16.00000	0.000664	231734.	-3166.	-102.75297	3.740E+11
16.50000	0.000466	210886.	-3697.	-74.11210	3.740E+11
17.00000	0.000288	187370.	-4060.	-47.04451	3.740E+11
17.50000	0.000128	162161.	-4266.	-21.43830	3.740E+11
18.00000	-1.674E-05	136180.	-4322.	2.88645	3.740E+11
18.50000	-0.000148	110303.	-4234.	26.16557	3.740E+11
19.00000	-0.000269	85368.	-4010.	48.67717	3.740E+11
19.50000	-0.000381	62185.	-3652.	70.72647	3.740E+11
20.00000	-0.000487	41548.	-3162.	92.62892	3.740E+11
20.50000	-0.000590	24246.	-2540.	114.69165	3.740E+11
21.00000	-0.000690	11073.	-1784.	137.19300	3.740E+11
21.50000	-0.000789	2839.	-922.74705	149.87115	3.740E+11
22.00000	-0.000888	0.000	0.000	157.71120	3.740E+11

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.01631667 inches
Computed slope at pile head      =    -0.00010495 radians
Maximum bending moment           =        275246. inch-lbs
Maximum shear force              =          7371. lbs
Depth of maximum bending moment  =    13.50000000 feet below pile head
Depth of maximum shear force     =     3.00000000 feet below pile head
Number of iterations             =             14
```

Number of zero deflection points = 1

Summary of Pile-head Responses for Conventional Analyses

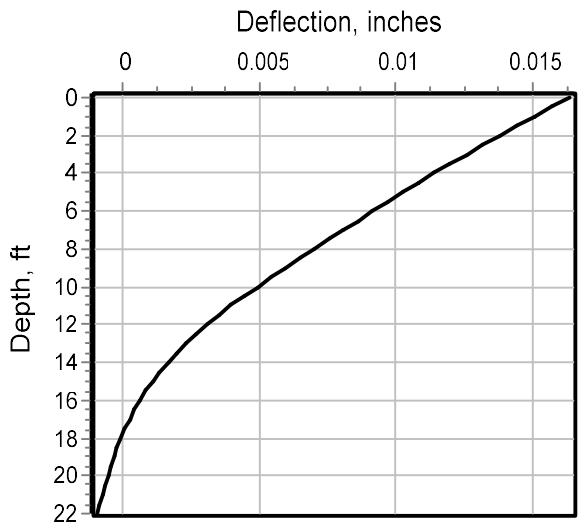
Definitions of Pile-head Loading Conditions:

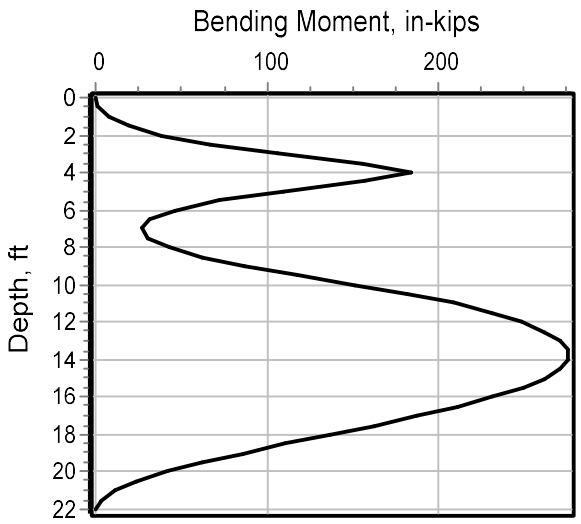
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

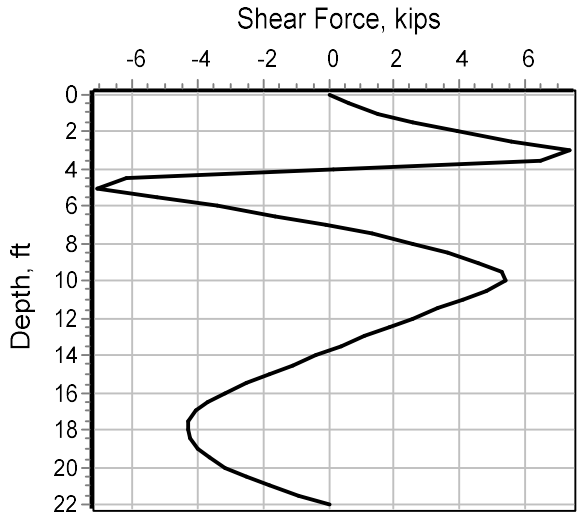
Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	1	0.016317	-0.0001049	7371.	275246.

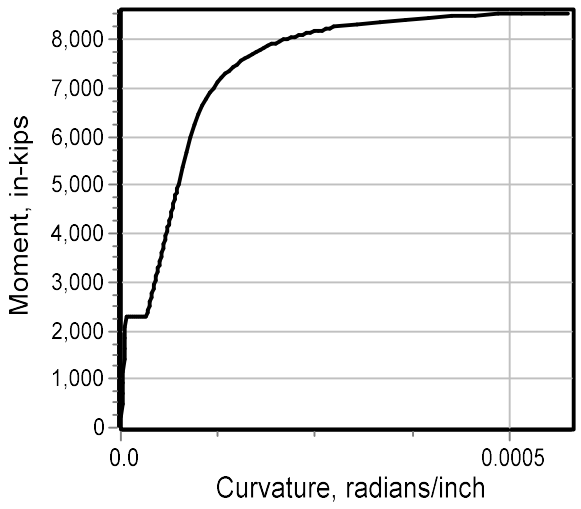
Maximum pile-head deflection = 0.0163166723 inches
Maximum pile-head rotation = -0.0001049458 radians = -0.006013 deg.

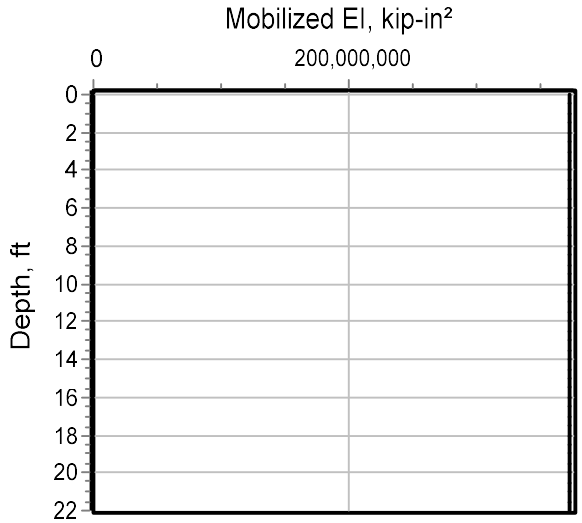
The analysis ended normally.

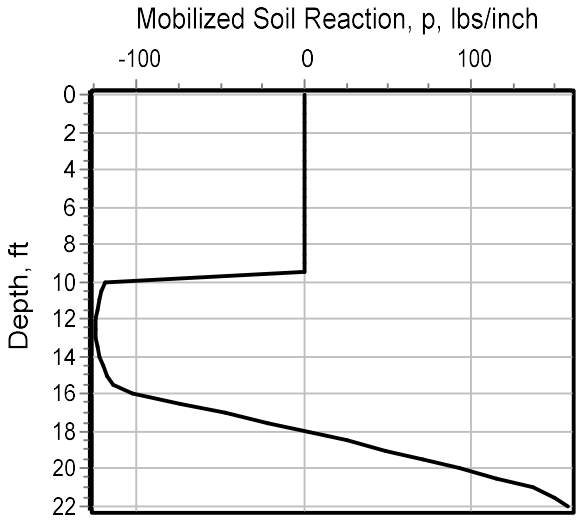

Deflection, inches
0
0.005
0.01
0.015
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Bending Moment, in-kips
0
100
200
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Shear Force, kips
-6
-4
-2
0
2
4
6
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Moment, in-kips
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.0005
Curvature, radians/inch


Mobilized EI, kip-in²
0
200,000,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Mobilized Soil Reaction, p, lbs/inch
-100
0
100
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22

==========

LPile for Windows, Version 2019-11.002

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 on this computer:
\Projects\GFL\2019\1921\100500 PCE-PIK-CR50\PIK\108464\Design\Geotechnical\Spreadsheets and Calcs\LPILE\Plug Pile Wall\Strength\

Name of the input data file:
Wall at Guardrail - 36in Shaft - Strength at lockoffload.lp11

Name of the output report file:
Wall at Guardrail - 36in Shaft - Strength at lockoffload.lp11

Name of the plot output file:
Wall at Guardrail - 36in Shaft - Strength at lockoffload.lp11

Name of the runtime message file:
Wall at Guardrail - 36in Shaft - Strength at lockoffload.lp11

Date and Time of Analysis

Date: April 22, 2021 Time: 19:43:08

Problem Title

Project Name: PIK-CR50-02.55

Job Number: 1921-1005.00

Client: Pike County

Engineer: DML

Description: Plug Pile Wall at Guardrail, 5ft Spacing, Strength

---

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	=	44

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 one distributed lateral load acting on pile
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

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



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =            1
Total length of pile                                   =       22.000 ft
Depth of ground surface below top of pile              =      10.0000 ft

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

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

            Depth Below           Pile
Point        Pile Head          Diameter
 No.            feet             inches
-----      -------------     -------------
  1             0.000           36.0000
  2            22.000           36.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                   =    22.000000 ft
   Shaft Diameter                                      =    36.000000 in
   Shear capacity of section                           =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	10.000000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Undrained cohesion at top of layer	=	1400. psf
Undrained cohesion at bottom of layer	=	1400. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

(Depth of the lowest soil layer extends 28.000 ft below the pile tip)

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p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.7600	1.0000
2	22.000	0.7600	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 8 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	139.344
2	32.400	446.469
3	42.000	446.469
4	42.000	-1371.635
5	54.000	-1371.635
6	54.000	446.469
7	72.000	446.469
8	120.000	139.344

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
1	1	V =	0.0000 lbs	M =	0.0000 in-lbs	0.0000000

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 = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	22.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.500000 in
Number of Reinforcing Bars	=	13 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.270000 sq. in.
Area Ratio of Steel Reinforcement	=	1.01 percent
Edge-to-Edge Bar Spacing	=	5.700839 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	7.60
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4042.060 kips
Tensile Load for Cracking of Concrete	=	-453.434 kips
Nominal Axial Tensile Capacity	=	-616.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.000000	0.790000	14.000000	0.00000
2	1.000000	0.790000	12.396384	6.506124
3	1.000000	0.790000	7.952906	11.521774
4	1.000000	0.790000	1.687514	13.897924
5	1.000000	0.790000	-4.964468	13.090227
6	1.000000	0.790000	-10.479150	9.283717

7	1.000000	0.790000	-13.593185	3.350419
8	1.000000	0.790000	-13.593185	-3.350419
9	1.000000	0.790000	-10.479150	-9.283717
10	1.000000	0.790000	-4.964468	-13.090227
11	1.000000	0.790000	1.687514	-13.897924
12	1.000000	0.790000	7.952906	-11.521774
13	1.000000	0.790000	12.396384	-6.506124

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 5.701 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.60

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 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, Section 10.3.4.
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 Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000006250	233.7218680467	373954989.	18.0000825595	
0.0000012500	466.5689419639	373255154.	18.0000827963	
0.0000018750	698.5412217518	372555318.	18.0000830341	
0.0000025000	929.6387074102	371855483.	18.0000832731	
0.0000031250	1160.	371155648.	18.0000835132	
0.0000037500	1389.	370455812.	18.0000837545	
0.0000043750	1618.	369755977.	18.0000839969	
0.0000050000	1845.	369056142.	18.0000842405	
0.0000056250	2072.	368356306.	18.0000844853	
0.0000062500	2298.	367656471.	18.0000847313	
0.0000068750	2298.	334233156.	8.6662704549	C
0.0000075000	2298.	306380393.	8.6684526289	C
0.0000081250	2298.	282812670.	8.6706386079	C
0.0000087500	2298.	262611765.	8.6728284052	C
0.0000093750	2298.	245104314.	8.6750220345	C
0.0000100000	2298.	229785294.	8.6772195093	C
0.0000106250	2298.	216268512.	8.6794208434	C
0.0000112500	2298.	204253595.	8.6816260505	C
0.0000118750	2298.	193503406.	8.6838351445	C
0.0000125000	2298.	183828236.	8.6860481393	C
0.0000131250	2298.	175074510.	8.6882650489	C
0.0000137500	2298.	167116578.	8.6904858875	C
0.0000143750	2298.	159850640.	8.6927106691	C
0.0000150000	2298.	153190196.	8.6949394080	C
0.0000156250	2298.	147062588.	8.6971721185	C
0.0000162500	2298.	141406335.	8.6994088150	C
0.0000168750	2298.	136169063.	8.7016495119	C
0.0000175000	2298.	131305883.	8.7038942239	C
0.0000181250	2298.	126778093.	8.7061429654	C
0.0000187500	2298.	122552157.	8.7083957512	C
0.0000193750	2298.	118598862.	8.7106525962	C
0.0000200000	2298.	114892647.	8.7129135151	C
0.0000206250	2298.	111411052.	8.7151785230	C
0.0000212500	2298.	108134256.	8.7174476347	C
0.0000218750	2298.	105044706.	8.7197208656	C
0.0000225000	2298.	102126798.	8.7219982307	C
0.0000231250	2298.	99366614.	8.7242797453	C
0.0000237500	2298.	96751703.	8.7265654248	C
0.0000243750	2298.	94270890.	8.7288552847	C
0.0000256250	2298.	89672310.	8.7334476078	C
0.0000268750	2298.	85501505.	8.7380568398	C

0.0000281250	2298.	81701438.	8.7426831077	C
0.0000293750	2298.	78224781.	8.7473265394	C
0.0000306250	2298.	75031933.	8.7519872649	C
0.0000318750	2298.	72089504.	8.7566654150	C
0.0000331250	2298.	69369145.	8.7613611226	C
0.0000343750	2355.	68508103.	8.7660745217	C
0.0000356250	2440.	68478657.	8.7708057480	C
0.0000368750	2524.	68449116.	8.7755549388	C
0.0000381250	2608.	68419478.	8.7803222331	C
0.0000393750	2693.	68389742.	8.7851077712	C
0.0000406250	2777.	68359907.	8.7899116954	C
0.0000418750	2861.	68329974.	8.7947341495	C
0.0000431250	2945.	68299941.	8.7995752789	C
0.0000443750	3029.	68269808.	8.8044352308	C
0.0000456250	3113.	68239573.	8.8093141544	C
0.0000468750	3197.	68209237.	8.8142122004	C
0.0000481250	3281.	68178798.	8.8191295214	C
0.0000493750	3365.	68148291.	8.8238892336	C
0.0000506250	3448.	68117692.	8.8286290397	C
0.0000518750	3532.	68086992.	8.8333869081	C
0.0000531250	3615.	68056192.	8.8381629810	C
0.0000543750	3699.	68025290.	8.8429574021	C
0.0000556250	3782.	67994285.	8.8477703169	C
0.0000568750	3865.	67963178.	8.8526018727	C
0.0000581250	3949.	67931967.	8.8574522185	C
0.0000593750	4032.	67900651.	8.8623215052	C
0.0000606250	4115.	67869229.	8.8672098854	C
0.0000618750	4197.	67837702.	8.8721175136	C
0.0000631250	4280.	67806067.	8.8770445463	C
0.0000643750	4363.	67774325.	8.8819911417	C
0.0000656250	4446.	67742474.	8.8869574603	C
0.0000668750	4528.	67710514.	8.8919436642	C
0.0000681250	4611.	67678443.	8.8969499178	C
0.0000693750	4693.	67646261.	8.9019763875	C
0.0000706250	4775.	67613967.	8.9070232417	C
0.0000718750	4857.	67581561.	8.9120906510	C
0.0000731250	4940.	67549040.	8.9171787881	C
0.0000743750	5022.	67516405.	8.9222878281	C
0.0000793750	5349.	67384701.	8.9429365938	C
0.0000843750	5674.	67251090.	8.9639343988	C
0.0000893750	5997.	67100912.	8.9846442900	CY
0.0000943750	6261.	66345414.	8.9781103992	CY
0.0000993750	6466.	65069477.	8.9466135093	CY
0.0001043750	6630.	63523046.	8.9001623016	CY
0.0001093750	6780.	61989682.	8.8530161477	CY
0.0001143750	6909.	60407201.	8.8000887428	CY
0.0001193750	7014.	58754596.	8.7389434559	CY
0.0001243750	7118.	57226145.	8.6834925884	CY
0.0001293750	7218.	55787822.	8.6316646677	CY
0.0001343750	7294.	54284434.	8.5723821243	CY

0.0001393750	7362.	52823712.	8.5135510238	CY
0.0001443750	7430.	51460668.	8.4595241559	CY
0.0001493750	7496.	50182631.	8.4067896920	CY
0.0001543750	7562.	48983508.	8.3581284747	CY
0.0001593750	7619.	47807630.	8.3085413079	CY
0.0001643750	7664.	46628126.	8.2554752625	CY
0.0001693750	7705.	45490327.	8.2035497450	CY
0.0001743750	7745.	44415680.	8.1551771023	CY
0.0001793750	7785.	43399235.	8.1101060048	CY
0.0001843750	7824.	42433842.	8.0657301600	CY
0.0001893750	7862.	41517143.	8.0235879396	CY
0.0001943750	7901.	40646072.	7.9841965308	CY
0.0001993750	7938.	39811976.	7.9466546824	CY
0.0002043750	7970.	38998835.	7.9089380488	CY
0.0002093750	7998.	38200403.	7.8703045093	CY
0.0002143750	8021.	37415727.	7.8307067402	CY
0.0002193750	8042.	36660567.	7.7926035954	CY
0.0002243750	8063.	35937552.	7.7565963940	CY
0.0002293750	8084.	35243704.	7.7211380146	CY
0.0002343750	8104.	34577303.	7.6863029796	CY
0.0002393750	8124.	33937793.	7.6533786870	CY
0.0002443750	8143.	33323506.	7.6222551448	CY
0.0002493750	8163.	32732915.	7.5928314382	CY
0.0002543750	8182.	32164602.	7.5650148499	CY
0.0002593750	8201.	31617005.	7.5388039695	CY
0.0002643750	8219.	31089166.	7.5140401262	CY
0.0002693750	8237.	30579805.	7.4905618084	CY
0.0002743750	8255.	30087790.	7.4684440982	CY
0.0003043750	8327.	27359282.	7.3313851032	CY
0.0003343750	8372.	25038864.	7.2065459877	CY
0.0003643750	8413.	23087969.	7.1115392048	CY
0.0003943750	8449.	21424132.	7.0387994684	CY
0.0004243750	8481.	19984836.	6.9769966026	CY
0.0004543750	8504.	18716680.	6.9192011486	CYT
0.0004843750	8518.	17584619.	6.8624058335	CYT
0.0005143750	8525.	16574324.	6.8105531203	CYT
0.0005443750	8531.	15671933.	6.7660506111	CYT
0.0005743750	8537.	14862538.	6.7284894935	CYT

Summary of Results for Nominal Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain

1	0.000	8486.052	0.00300000

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 (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 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 for Moment	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	8486.	0.0000	5516.	67316070.
1	0.75	8486.	0.0000	6365.	65702930.
1	0.90	8486.	0.0000	7637.	47334707.

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

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

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

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness in-lb^2
0.000	1.63907	4.382E-05	0.000	0.000	3.740E+11
0.50000	1.59290	2764.	1049.	0.000	3.740E+11
1.00000	1.54674	12592.	2397.	0.000	3.740E+11
1.50000	1.50058	31531.	4086.	0.000	3.740E+11
2.00000	1.45442	61630.	6117.	0.000	3.740E+11
2.50000	1.40827	104934.	8488.	0.000	3.740E+11

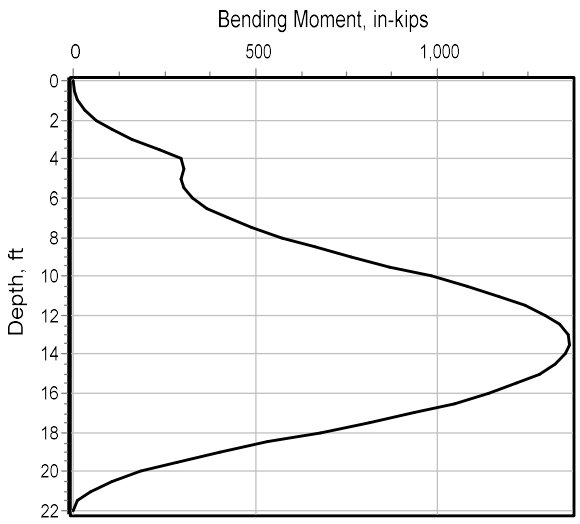
3.00000	1.36212	163483.	11097.	0.000	3.740E+11
3.50000	1.31599	238104.	11049.	0.000	3.739E+11
4.00000	1.26989	296072.	5546.	0.000	3.737E+11
4.50000	1.22381	304661.	43.79392	0.000	3.736E+11
5.00000	1.17777	296597.	-4.54980	0.000	3.737E+11
5.50000	1.13175	304607.	2674.	0.000	3.736E+11
6.00000	1.08576	328689.	5339.	0.000	3.735E+11
6.50000	1.03980	368671.	7888.	0.000	3.734E+11
7.00000	0.99388	423344.	10221.	0.000	3.733E+11
7.50000	0.94800	491325.	12324.	0.000	3.731E+11
8.00000	0.90216	571234.	14197.	0.000	3.729E+11
8.50000	0.85639	661687.	15839.	0.000	3.726E+11
9.00000	0.81067	761302.	17251.	0.000	3.723E+11
9.50000	0.76503	868698.	18433.	0.000	3.720E+11
10.00000	0.71947	982493.	17952.	-412.47083	3.717E+11
10.50000	0.67401	1084119.	15668.	-423.34699	3.714E+11
11.00000	0.62866	1170505.	13098.	-433.28694	3.711E+11
11.50000	0.58341	1241293.	10471.	-442.20168	3.709E+11
12.00000	0.53829	1296161.	7795.	-449.98444	3.707E+11
12.50000	0.49329	1334830.	5075.	-456.50526	3.706E+11
13.00000	0.44843	1357065.	2321.	-461.60309	3.705E+11
13.50000	0.40369	1362682.	-459.04271	-465.07417	3.705E+11
14.00000	0.35909	1351557.	-3254.	-466.65426	3.706E+11
14.50000	0.31462	1323632.	-6052.	-465.99012	3.706E+11
15.00000	0.27027	1278931.	-8838.	-462.59123	3.708E+11
15.50000	0.22606	1217577.	-11593.	-455.74196	3.710E+11
16.00000	0.18196	1139816.	-14293.	-444.32629	3.712E+11
16.50000	0.13797	1046059.	-16905.	-426.42906	3.715E+11
17.00000	0.09408	936951.	-19379.	-398.23120	3.718E+11
17.50000	0.05028	813507.	-21623.	-349.66816	3.722E+11
18.00000	0.006560	677475.	-23319.	-215.66247	3.726E+11
18.50000	-0.03709	533679.	-22943.	341.07111	3.730E+11
19.00000	-0.08070	402161.	-20646.	424.54565	3.734E+11
19.50000	-0.12426	285927.	-17919.	484.42773	3.737E+11
20.00000	-0.16780	187132.	-14862.	534.60386	3.740E+11
20.50000	-0.21131	107583.	-11520.	579.46292	3.740E+11
21.00000	-0.25482	48895.	-7918.	620.99255	3.740E+11
21.50000	-0.29832	12563.	-4075.	660.26750	3.740E+11
22.00000	-0.34183	0.000	0.000	697.93528	3.740E+11

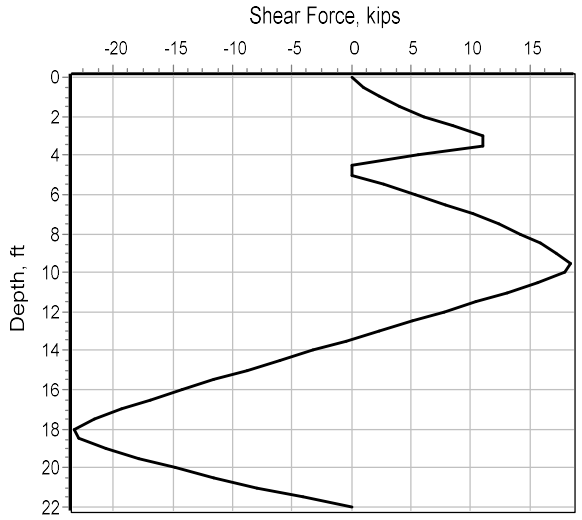
Output Summary for Load Case No. 1:

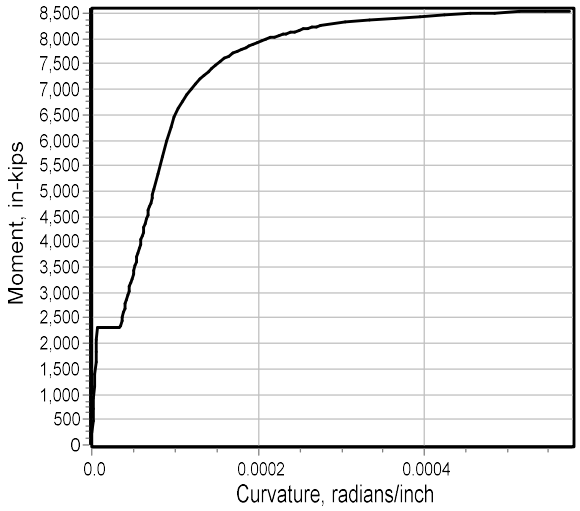
```
Pile-head deflection             =     1.63906846 inches
Computed slope at pile head      =    -0.00769401 radians
Maximum bending moment           =       1362682. inch-lbs
Maximum shear force              =        -23319. lbs
Depth of maximum bending moment  =    13.50000000 feet below pile head
Depth of maximum shear force     =    18.00000000 feet below pile head
Number of iterations             =             45
Number of zero deflection points =              1
```

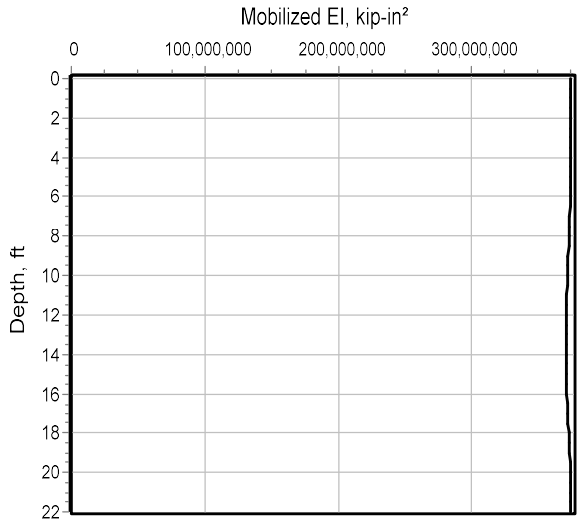
```
--------------------------------------------------------------------------------
            Summary of Pile-head Responses for Conventional Analyses
--------------------------------------------------------------------------------

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            Pile-head      Pile-head      Max Shear     Max Moment
Case   Load    Deflection      Rotation        in Pile        in Pile
 No.   Type      inches         radians          lbs          in-lbs
----   ----   ------------   ------------   ------------   ------------
  1      1       1.639068      -0.007694        -23319.       1362682.


Maximum pile-head deflection = 1.6390684591 inches
Maximum pile-head rotation   = -0.0076940052 radians = -0.440834 deg.

The analysis ended normally.
```

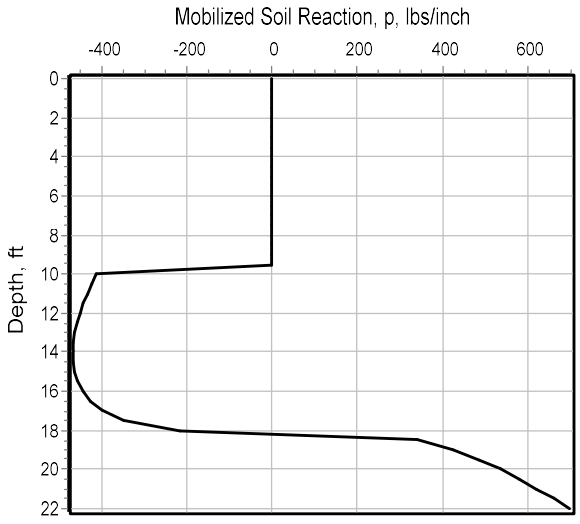

Deflection, inches
0
0.5
1
1.5
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Bending Moment, in-kips
0
500
1,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Shear Force, kips
-20
-15
-10
-5
0
5
10
15
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Moment, in-kips
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0
0.0002
0.0004
Curvature, radians/inch


Mobilized EI, kip-in²
0
100,000,000
200,000,000
300,000,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Mobilized Soil Reaction, p, lbs/inch
-400
-200
0
200
400
600
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22

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

                    LPile for Windows, Version 2019-11.002

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

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

Path to file locations on this computer:
\Projects\GFL\2019\1921\100500 PCE-PIK-CR50\PIK\108464\Design\Geotechnical\Sprea
dsheets and Calcs\LPILE\Plug Pile Wall\Strength\

Name of the input data file:
Wall at Guardrail - 36in Shaft - Strength.lp11

Name of the output report file:
Wall at Guardrail - 36in Shaft - Strength.lp11

Name of the plot output file:
Wall at Guardrail - 36in Shaft - Strength.lp11

Name of the runtime message file:
Wall at Guardrail - 36in Shaft - Strength.lp11

--------------------------------------------------------------------------------
                           Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  April 22, 2021              Time:  19:44:31
```

Problem Title

Project Name: PIK-CR50-02.55

Job Number: 1921-1005.00

Client: Pike County

Engineer: DML

Description: Plug Pile Wall at Guardrail, 5ft Spacing, Strength

---

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	=	44

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 one distributed lateral load acting on pile
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear resistance at the pile tip not selected
 - Input of moment resistance at the pile tip not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

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



--------------------------------------------------------------------------------
                     Pile Structural Properties and Geometry
--------------------------------------------------------------------------------

Number of pile sections defined                        =            1
Total length of pile                                   =       22.000 ft
Depth of ground surface below top of pile              =      10.0000 ft

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

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

            Depth Below           Pile
Point        Pile Head          Diameter
 No.            feet             inches
-----      -------------     -------------
  1             0.000           36.0000
  2            22.000           36.0000


Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                   =    22.000000 ft
   Shaft Diameter                                      =    36.000000 in
   Shear capacity of section                           =       0.0000 lbs
```

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	10.000000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Undrained cohesion at top of layer	=	1400. psf
Undrained cohesion at bottom of layer	=	1400. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

(Depth of the lowest soil layer extends 28.000 ft below the pile tip)

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.7600	1.0000
2	22.000	0.7600	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 8 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	139.344
2	32.400	446.469
3	42.000	446.469
4	42.000	-2230.922
5	54.000	-2230.922
6	54.000	446.469
7	72.000	446.469
8	120.000	139.344

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
1	1	V =	0.0000 lbs	M =	0.0000 in-lbs	0.0000000

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

```
--------------------------------------------------------------------------------
     Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness
--------------------------------------------------------------------------------

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:
-------------------

Dimensions and Properties of Drilled Shaft (Bored Pile):
--------------------------------------------------------

Length of Section                                      =    22.000000 ft
Shaft Diameter                                         =    36.000000 in
Concrete Cover Thickness (to edge of long. rebar)      =     3.500000 in
Number of Reinforcing Bars                             =           13 bars
Yield Stress of Reinforcing Bars                       =      60000. psi
Modulus of Elasticity of Reinforcing Bars              =    29000000. psi
Gross Area of Shaft                                    =        1018. sq. in.
Total Area of Reinforcing Steel                        =    10.270000 sq. in.
Area Ratio of Steel Reinforcement                      =         1.01 percent
Edge-to-Edge Bar Spacing                               =     5.700839 in
Maximum Concrete Aggregate Size                        =     0.750000 in
Ratio of Bar Spacing to Aggregate Size                 =         7.60
Offset of Center of Rebar Cage from Center of Pile     =       0.0000 in

Axial Structural Capacities:
----------------------------

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As    =     4042.060 kips
Tensile Load for Cracking of Concrete                  =     -453.434 kips
Nominal Axial Tensile Capacity                         =     -616.200 kips


Reinforcing Bar Dimensions and Positions Used in Computations:

     Bar          Bar Diam.      Bar Area          X             Y
    Number         inches         sq. in.        inches        inches
  ----------     ----------     ----------     ----------     ----------
      1            1.000000       0.790000      14.000000       0.00000
      2            1.000000       0.790000      12.396384       6.506124
      3            1.000000       0.790000       7.952906      11.521774
      4            1.000000       0.790000       1.687514      13.897924
      5            1.000000       0.790000      -4.964468      13.090227
      6            1.000000       0.790000     -10.479150       9.283717
```

7	1.000000	0.790000	-13.593185	3.350419
8	1.000000	0.790000	-13.593185	-3.350419
9	1.000000	0.790000	-10.479150	-9.283717
10	1.000000	0.790000	-4.964468	-13.090227
11	1.000000	0.790000	1.687514	-13.897924
12	1.000000	0.790000	7.952906	-11.521774
13	1.000000	0.790000	12.396384	-6.506124

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 5.701 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.60

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 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, Section 10.3.4.
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 Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000006250	233.7218680467	373954989.	18.0000825595	
0.0000012500	466.5689419639	373255154.	18.0000827963	
0.0000018750	698.5412217518	372555318.	18.0000830341	
0.0000025000	929.6387074102	371855483.	18.0000832731	
0.0000031250	1160.	371155648.	18.0000835132	
0.0000037500	1389.	370455812.	18.0000837545	
0.0000043750	1618.	369755977.	18.0000839969	
0.0000050000	1845.	369056142.	18.0000842405	
0.0000056250	2072.	368356306.	18.0000844853	
0.0000062500	2298.	367656471.	18.0000847313	
0.0000068750	2298.	334233156.	8.6662704549	C
0.0000075000	2298.	306380393.	8.6684526289	C
0.0000081250	2298.	282812670.	8.6706386079	C
0.0000087500	2298.	262611765.	8.6728284052	C
0.0000093750	2298.	245104314.	8.6750220345	C
0.0000100000	2298.	229785294.	8.6772195093	C
0.0000106250	2298.	216268512.	8.6794208434	C
0.0000112500	2298.	204253595.	8.6816260505	C
0.0000118750	2298.	193503406.	8.6838351445	C
0.0000125000	2298.	183828236.	8.6860481393	C
0.0000131250	2298.	175074510.	8.6882650489	C
0.0000137500	2298.	167116578.	8.6904858875	C
0.0000143750	2298.	159850640.	8.6927106691	C
0.0000150000	2298.	153190196.	8.6949394080	C
0.0000156250	2298.	147062588.	8.6971721185	C
0.0000162500	2298.	141406335.	8.6994088150	C
0.0000168750	2298.	136169063.	8.7016495119	C
0.0000175000	2298.	131305883.	8.7038942239	C
0.0000181250	2298.	126778093.	8.7061429654	C
0.0000187500	2298.	122552157.	8.7083957512	C
0.0000193750	2298.	118598862.	8.7106525962	C
0.0000200000	2298.	114892647.	8.7129135151	C
0.0000206250	2298.	111411052.	8.7151785230	C
0.0000212500	2298.	108134256.	8.7174476347	C
0.0000218750	2298.	105044706.	8.7197208656	C
0.0000225000	2298.	102126798.	8.7219982307	C
0.0000231250	2298.	99366614.	8.7242797453	C
0.0000237500	2298.	96751703.	8.7265654248	C
0.0000243750	2298.	94270890.	8.7288552847	C
0.0000256250	2298.	89672310.	8.7334476078	C
0.0000268750	2298.	85501505.	8.7380568398	C

0.0000281250	2298.	81701438.	8.7426831077	C
0.0000293750	2298.	78224781.	8.7473265394	C
0.0000306250	2298.	75031933.	8.7519872649	C
0.0000318750	2298.	72089504.	8.7566654150	C
0.0000331250	2298.	69369145.	8.7613611226	C
0.0000343750	2355.	68508103.	8.7660745217	C
0.0000356250	2440.	68478657.	8.7708057480	C
0.0000368750	2524.	68449116.	8.7755549388	C
0.0000381250	2608.	68419478.	8.7803222331	C
0.0000393750	2693.	68389742.	8.7851077712	C
0.0000406250	2777.	68359907.	8.7899116954	C
0.0000418750	2861.	68329974.	8.7947341495	C
0.0000431250	2945.	68299941.	8.7995752789	C
0.0000443750	3029.	68269808.	8.8044352308	C
0.0000456250	3113.	68239573.	8.8093141544	C
0.0000468750	3197.	68209237.	8.8142122004	C
0.0000481250	3281.	68178798.	8.8191295214	C
0.0000493750	3365.	68148291.	8.8238892336	C
0.0000506250	3448.	68117692.	8.8286290397	C
0.0000518750	3532.	68086992.	8.8333869081	C
0.0000531250	3615.	68056192.	8.8381629810	C
0.0000543750	3699.	68025290.	8.8429574021	C
0.0000556250	3782.	67994285.	8.8477703169	C
0.0000568750	3865.	67963178.	8.8526018727	C
0.0000581250	3949.	67931967.	8.8574522185	C
0.0000593750	4032.	67900651.	8.8623215052	C
0.0000606250	4115.	67869229.	8.8672098854	C
0.0000618750	4197.	67837702.	8.8721175136	C
0.0000631250	4280.	67806067.	8.8770445463	C
0.0000643750	4363.	67774325.	8.8819911417	C
0.0000656250	4446.	67742474.	8.8869574603	C
0.0000668750	4528.	67710514.	8.8919436642	C
0.0000681250	4611.	67678443.	8.8969499178	C
0.0000693750	4693.	67646261.	8.9019763875	C
0.0000706250	4775.	67613967.	8.9070232417	C
0.0000718750	4857.	67581561.	8.9120906510	C
0.0000731250	4940.	67549040.	8.9171787881	C
0.0000743750	5022.	67516405.	8.9222878281	C
0.0000793750	5349.	67384701.	8.9429365938	C
0.0000843750	5674.	67251090.	8.9639343988	C
0.0000893750	5997.	67100912.	8.9846442900	CY
0.0000943750	6261.	66345414.	8.9781103992	CY
0.0000993750	6466.	65069477.	8.9466135093	CY
0.0001043750	6630.	63523046.	8.9001623016	CY
0.0001093750	6780.	61989682.	8.8530161477	CY
0.0001143750	6909.	60407201.	8.8000887428	CY
0.0001193750	7014.	58754596.	8.7389434559	CY
0.0001243750	7118.	57226145.	8.6834925884	CY
0.0001293750	7218.	55787822.	8.6316646677	CY
0.0001343750	7294.	54284434.	8.5723821243	CY

0.0001393750	7362.	52823712.	8.5135510238	CY
0.0001443750	7430.	51460668.	8.4595241559	CY
0.0001493750	7496.	50182631.	8.4067896920	CY
0.0001543750	7562.	48983508.	8.3581284747	CY
0.0001593750	7619.	47807630.	8.3085413079	CY
0.0001643750	7664.	46628126.	8.2554752625	CY
0.0001693750	7705.	45490327.	8.2035497450	CY
0.0001743750	7745.	44415680.	8.1551771023	CY
0.0001793750	7785.	43399235.	8.1101060048	CY
0.0001843750	7824.	42433842.	8.0657301600	CY
0.0001893750	7862.	41517143.	8.0235879396	CY
0.0001943750	7901.	40646072.	7.9841965308	CY
0.0001993750	7938.	39811976.	7.9466546824	CY
0.0002043750	7970.	38998835.	7.9089380488	CY
0.0002093750	7998.	38200403.	7.8703045093	CY
0.0002143750	8021.	37415727.	7.8307067402	CY
0.0002193750	8042.	36660567.	7.7926035954	CY
0.0002243750	8063.	35937552.	7.7565963940	CY
0.0002293750	8084.	35243704.	7.7211380146	CY
0.0002343750	8104.	34577303.	7.6863029796	CY
0.0002393750	8124.	33937793.	7.6533786870	CY
0.0002443750	8143.	33323506.	7.6222551448	CY
0.0002493750	8163.	32732915.	7.5928314382	CY
0.0002543750	8182.	32164602.	7.5650148499	CY
0.0002593750	8201.	31617005.	7.5388039695	CY
0.0002643750	8219.	31089166.	7.5140401262	CY
0.0002693750	8237.	30579805.	7.4905618084	CY
0.0002743750	8255.	30087790.	7.4684440982	CY
0.0003043750	8327.	27359282.	7.3313851032	CY
0.0003343750	8372.	25038864.	7.2065459877	CY
0.0003643750	8413.	23087969.	7.1115392048	CY
0.0003943750	8449.	21424132.	7.0387994684	CY
0.0004243750	8481.	19984836.	6.9769966026	CY
0.0004543750	8504.	18716680.	6.9192011486	CYT
0.0004843750	8518.	17584619.	6.8624058335	CYT
0.0005143750	8525.	16574324.	6.8105531203	CYT
0.0005443750	8531.	15671933.	6.7660506111	CYT
0.0005743750	8537.	14862538.	6.7284894935	CYT

Summary of Results for Nominal Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain

1	0.000	8486.052	0.00300000

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 (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 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 for Moment	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	8486.	0.0000	5516.	67316070.
1	0.75	8486.	0.0000	6365.	65702930.
1	0.90	8486.	0.0000	7637.	47334707.

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

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

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

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness in-lb^2
0.000	0.05193	-1.009E-06	-6.007E-09	0.000	3.740E+11
0.50000	0.05022	2764.	1049.	0.000	3.740E+11
1.00000	0.04851	12592.	2397.	0.000	3.740E+11
1.50000	0.04680	31532.	4086.	0.000	3.740E+11
2.00000	0.04510	61630.	6117.	0.000	3.740E+11
2.50000	0.04340	104934.	8488.	0.000	3.740E+11

3.00000	0.04171	163483.	11097.	0.000	3.740E+11
3.50000	0.04003	238104.	9760.	0.000	3.739E+11
4.00000	0.03838	280605.	390.73110	0.000	3.737E+11
4.50000	0.03676	242793.	-8979.	0.000	3.739E+11
5.00000	0.03516	172860.	-10316.	0.000	3.740E+11
5.50000	0.03357	119001.	-7637.	0.000	3.740E+11
6.00000	0.03200	81214.	-4973.	0.000	3.740E+11
6.50000	0.03044	59328.	-2424.	0.000	3.740E+11
7.00000	0.02888	52132.	-90.21827	0.000	3.740E+11
7.50000	0.02732	58245.	2013.	0.000	3.740E+11
8.00000	0.02578	76285.	3885.	0.000	3.740E+11
8.50000	0.02423	104869.	5528.	0.000	3.740E+11
9.00000	0.02270	142616.	6940.	0.000	3.740E+11
9.50000	0.02119	188143.	8121.	0.000	3.740E+11
10.00000	0.01969	240069.	8374.	-167.78418	3.739E+11
10.50000	0.01821	288636.	7579.	-171.66436	3.737E+11
11.00000	0.01676	331023.	6539.	-175.11636	3.735E+11
11.50000	0.01535	367105.	5479.	-178.11354	3.734E+11
12.00000	0.01396	396776.	4403.	-180.62456	3.734E+11
12.50000	0.01262	419943.	3313.	-182.61163	3.733E+11
13.00000	0.01132	436537.	2214.	-184.02801	3.733E+11
13.50000	0.01006	446506.	1107.	-184.81444	3.733E+11
14.00000	0.008843	449822.	-2.08591	-184.89356	3.733E+11
14.50000	0.007669	446481.	-1109.	-184.16134	3.733E+11
15.00000	0.006538	436511.	-2209.	-182.47281	3.733E+11
15.50000	0.005450	419971.	-3295.	-179.61708	3.733E+11
16.00000	0.004402	396966.	-4360.	-175.26987	3.734E+11
16.50000	0.003392	367650.	-5393.	-168.89267	3.734E+11
17.00000	0.002418	332255.	-6378.	-159.48159	3.735E+11
17.50000	0.001476	291118.	-7290.	-144.75653	3.737E+11
18.00000	0.000561	244770.	-8015.	-96.78453	3.739E+11
18.50000	-0.000329	194938.	-8131.	58.22416	3.740E+11
19.00000	-0.001201	147201.	-7511.	148.32617	3.740E+11
19.50000	-0.002059	104805.	-6545.	173.84308	3.740E+11
20.00000	-0.002907	68667.	-5441.	193.99126	3.740E+11
20.50000	-0.003748	39512.	-4225.	211.51055	3.740E+11
21.00000	-0.004585	17972.	-2908.	227.48783	3.740E+11
21.50000	-0.005420	4622.	-1498.	242.46782	3.740E+11
22.00000	-0.006255	0.000	0.000	256.75996	3.740E+11

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.05193272 inches
Computed slope at pile head      =    -0.00028505 radians
Maximum bending moment           =        449822. inch-lbs
Maximum shear force              =         11097. lbs
Depth of maximum bending moment  =    14.00000000 feet below pile head
Depth of maximum shear force     =     3.00000000 feet below pile head
Number of iterations             =             28
Number of zero deflection points =              1
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

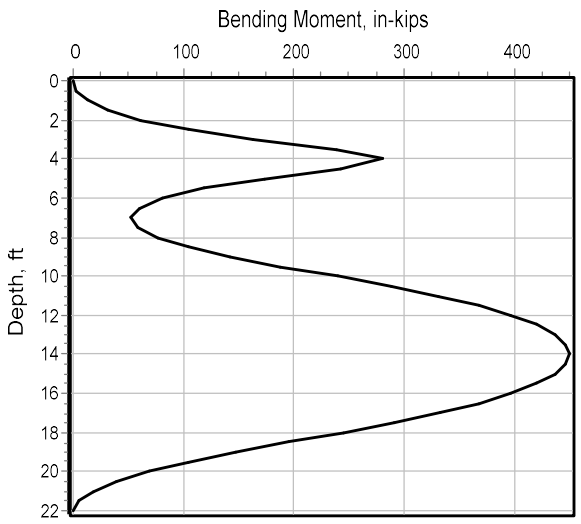
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

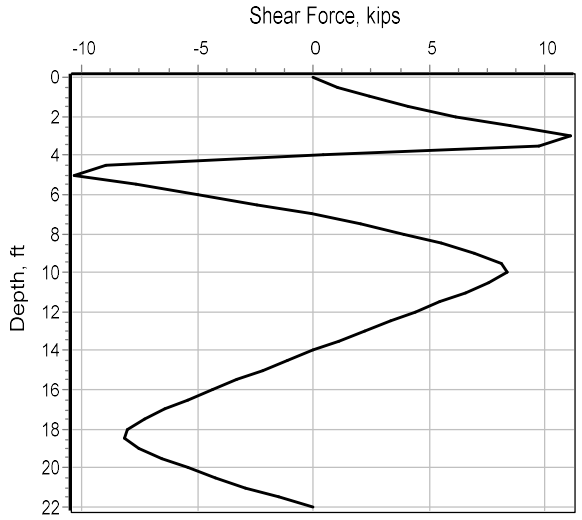
Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	1	0.051933	-0.0002851	11097.	449822.

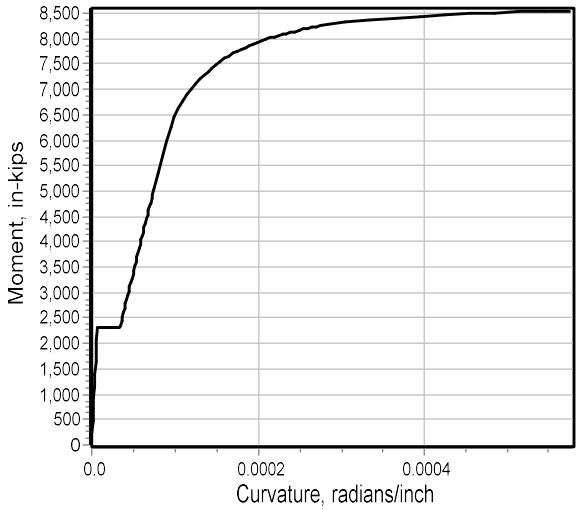
Maximum pile-head deflection = 0.0519327190 inches
Maximum pile-head rotation = -0.0002850538 radians = -0.016332 deg.

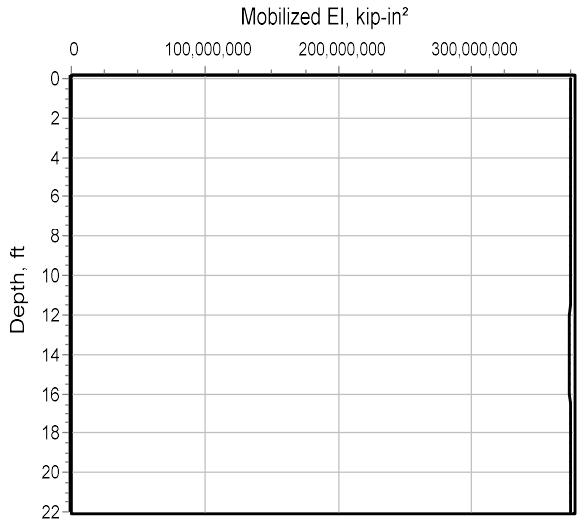
The analysis ended normally.

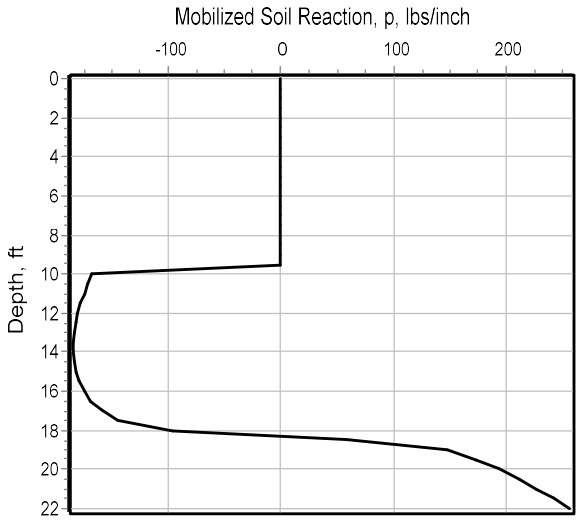

Deflection, inches
0
0.01
0.02
0.03
0.04
0.05
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Bending Moment, in-kips
0
100
200
300
400
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Shear Force, kips
-10
-5
0
5
10
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Moment, in-kips
8,500
8,000
7,500
7,000
6,500
6,000
5,500
5,000
4,500
4,000
3,500
3,000
2,500
2,000
1,500
1,000
500
0
0.0
0.0002
0.0004
Curvature, radians/inch


Mobilized EI, kip-in²
0
100,000,000
200,000,000
300,000,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Mobilized Soil Reaction, p, lbs/inch
-100
0
100
200
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22

==========

LPile for Windows, Version 2019-11.004

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

==========

This copy of LPile is being used by:

Matt Lyon (DLZ)
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Serial Number of Security Device: 140967459

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Files Used for Analysis

Path to file locations on this computer:
\Projects\GFL\2019\1921\100500 PCE-PIK-CR50\PIK\108464\Design\Geotechnical\Spreadsheets and Calcs\LPILE\Plug Pile Wall\Extreme Event\

Name of the input data file:
Wall at Guardrail - 36in Shaft - Extreme Event at lockoff.lp11d

Name of the output report file:
Wall at Guardrail - 36in Shaft - Extreme Event at lockoff.lp11o

Name of the plot output file:
Wall at Guardrail - 36in Shaft - Extreme Event at lockoff.lp11p

Name of the runtime message file:
Wall at Guardrail - 36in Shaft - Extreme Event at lockoff.lp11r

---

Date and Time of Analysis

Date: April 22, 2021 Time: 18:28:07

Problem Title

Project Name: PIK-CR50-02.55

Job Number: 1921-1005.00

Client: Pike County

Engineer: DML

Description: Plug Pile Wall at Guardrail, 5ft Spacing, Extreme at lockoff

---

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	=	44

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 one distributed lateral load 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
 - Input of side resistance moment along pile not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

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

Pile Structural Properties and Geometry

```
Number of pile sections defined                        =            1
Total length of pile                                   =       22.000 ft
Depth of ground surface below top of pile              =      10.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	22.000	36.0000

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                   =    22.000000 ft
   Shaft Diameter                                      =    36.000000 in
```

Shear capacity of section = 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	10.000000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Undrained cohesion at top of layer	=	1400. psf
Undrained cohesion at bottom of layer	=	1400. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

(Depth of the lowest soil layer extends 28.000 ft below the pile tip)

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.7600	1.0000
2	22.000	0.7600	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 8 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	39.812
2	32.400	267.312
3	42.000	267.312
4	42.000	-1550.792
5	54.000	-1550.792
6	54.000	267.312
7	72.000	267.312
8	120.000	39.812

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
1	1	V = 23600. lbs	M = 755200. in-lbs	0.0000000

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

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	22.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.500000 in
Number of Reinforcing Bars	=	13 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.270000 sq. in.
Area Ratio of Steel Reinforcement	=	1.01 percent
Edge-to-Edge Bar Spacing	=	5.700839 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	7.60
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4042.060 kips
Tensile Load for Cracking of Concrete	=	-453.434 kips
Nominal Axial Tensile Capacity	=	-616.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.000000	0.790000	14.000000	0.00000
2	1.000000	0.790000	12.396384	6.506124
3	1.000000	0.790000	7.952906	11.521774
4	1.000000	0.790000	1.687514	13.897924
5	1.000000	0.790000	-4.964468	13.090227

6	1.000000	0.790000	-10.479150	9.283717
7	1.000000	0.790000	-13.593185	3.350419
8	1.000000	0.790000	-13.593185	-3.350419
9	1.000000	0.790000	-10.479150	-9.283717
10	1.000000	0.790000	-4.964468	-13.090227
11	1.000000	0.790000	1.687514	-13.897924
12	1.000000	0.790000	7.952906	-11.521774
13	1.000000	0.790000	12.396384	-6.506124

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 5.701 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.60

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 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, Section 10.3.4.
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 Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000006250	233.7218680467	373954989.	18.0000825595	
0.0000012500	466.5689419639	373255154.	18.0000827963	
0.0000018750	698.5412217518	372555318.	18.0000830341	
0.0000025000	929.6387074102	371855483.	18.0000832731	
0.0000031250	1160.	371155648.	18.0000835132	
0.0000037500	1389.	370455812.	18.0000837545	
0.0000043750	1618.	369755977.	18.0000839969	
0.0000050000	1845.	369056142.	18.0000842405	
0.0000056250	2072.	368356306.	18.0000844853	
0.0000062500	2298.	367656471.	18.0000847313	
0.0000068750	2298.	334233156.	8.6662704549	C
0.0000075000	2298.	306380393.	8.6684526289	C
0.0000081250	2298.	282812670.	8.6706386079	C
0.0000087500	2298.	262611765.	8.6728284052	C
0.0000093750	2298.	245104314.	8.6750220345	C
0.0000100000	2298.	229785294.	8.6772195093	C
0.0000106250	2298.	216268512.	8.6794208434	C
0.0000112500	2298.	204253595.	8.6816260505	C
0.0000118750	2298.	193503406.	8.6838351445	C
0.0000125000	2298.	183828236.	8.6860481393	C
0.0000131250	2298.	175074510.	8.6882650489	C
0.0000137500	2298.	167116578.	8.6904858875	C
0.0000143750	2298.	159850640.	8.6927106691	C
0.0000150000	2298.	153190196.	8.6949394080	C
0.0000156250	2298.	147062588.	8.6971721185	C
0.0000162500	2298.	141406335.	8.6994088150	C
0.0000168750	2298.	136169063.	8.7016495119	C
0.0000175000	2298.	131305883.	8.7038942239	C
0.0000181250	2298.	126778093.	8.7061429654	C
0.0000187500	2298.	122552157.	8.7083957512	C
0.0000193750	2298.	118598862.	8.7106525962	C
0.0000200000	2298.	114892647.	8.7129135151	C
0.0000206250	2298.	111411052.	8.7151785230	C
0.0000212500	2298.	108134256.	8.7174476347	C
0.0000218750	2298.	105044706.	8.7197208656	C
0.0000225000	2298.	102126798.	8.7219982307	C
0.0000231250	2298.	99366614.	8.7242797453	C
0.0000237500	2298.	96751703.	8.7265654248	C
0.0000243750	2298.	94270890.	8.7288552847	C
0.0000256250	2298.	89672310.	8.7334476078	C

0.0000268750	2298.	85501505.	8.7380568398	C
0.0000281250	2298.	81701438.	8.7426831077	C
0.0000293750	2298.	78224781.	8.7473265394	C
0.0000306250	2298.	75031933.	8.7519872649	C
0.0000318750	2298.	72089504.	8.7566654150	C
0.0000331250	2298.	69369145.	8.7613611226	C
0.0000343750	2355.	68508103.	8.7660745217	C
0.0000356250	2440.	68478657.	8.7708057480	C
0.0000368750	2524.	68449116.	8.7755549388	C
0.0000381250	2608.	68419478.	8.7803222331	C
0.0000393750	2693.	68389742.	8.7851077712	C
0.0000406250	2777.	68359907.	8.7899116954	C
0.0000418750	2861.	68329974.	8.7947341495	C
0.0000431250	2945.	68299941.	8.7995752789	C
0.0000443750	3029.	68269808.	8.8044352308	C
0.0000456250	3113.	68239573.	8.8093141544	C
0.0000468750	3197.	68209237.	8.8142122004	C
0.0000481250	3281.	68178798.	8.8191295214	C
0.0000493750	3365.	68148291.	8.8238892336	C
0.0000506250	3448.	68117692.	8.8286290397	C
0.0000518750	3532.	68086992.	8.8333869081	C
0.0000531250	3615.	68056192.	8.8381629810	C
0.0000543750	3699.	68025290.	8.8429574021	C
0.0000556250	3782.	67994285.	8.8477703169	C
0.0000568750	3865.	67963178.	8.8526018727	C
0.0000581250	3949.	67931967.	8.8574522185	C
0.0000593750	4032.	67900651.	8.8623215052	C
0.0000606250	4115.	67869229.	8.8672098854	C
0.0000618750	4197.	67837702.	8.8721175136	C
0.0000631250	4280.	67806067.	8.8770445463	C
0.0000643750	4363.	67774325.	8.8819911417	C
0.0000656250	4446.	67742474.	8.8869574603	C
0.0000668750	4528.	67710514.	8.8919436642	C
0.0000681250	4611.	67678443.	8.8969499178	C
0.0000693750	4693.	67646261.	8.9019763875	C
0.0000706250	4775.	67613967.	8.9070232417	C
0.0000718750	4857.	67581561.	8.9120906510	C
0.0000731250	4940.	67549040.	8.9171787881	C
0.0000743750	5022.	67516405.	8.9222878281	C
0.0000793750	5349.	67384701.	8.9429365938	C
0.0000843750	5674.	67251090.	8.9639343988	C
0.0000893750	5997.	67100912.	8.9846442900	CY
0.0000943750	6261.	66345414.	8.9781103992	CY
0.0000993750	6466.	65069477.	8.9466135093	CY
0.0001043750	6630.	63523046.	8.9001623016	CY
0.0001093750	6780.	61989682.	8.8530161477	CY
0.0001143750	6909.	60407201.	8.8000887428	CY
0.0001193750	7014.	58754596.	8.7389434559	CY
0.0001243750	7118.	57226145.	8.6834925884	CY
0.0001293750	7218.	55787822.	8.6316646677	CY

0.0001343750	7294.	54284434.	8.5723821243	CY
0.0001393750	7362.	52823712.	8.5135510238	CY
0.0001443750	7430.	51460668.	8.4595241559	CY
0.0001493750	7496.	50182631.	8.4067896920	CY
0.0001543750	7562.	48983508.	8.3581284747	CY
0.0001593750	7619.	47807630.	8.3085413079	CY
0.0001643750	7664.	46628126.	8.2554752625	CY
0.0001693750	7705.	45490327.	8.2035497450	CY
0.0001743750	7745.	44415680.	8.1551771023	CY
0.0001793750	7785.	43399235.	8.1101060048	CY
0.0001843750	7824.	42433842.	8.0657301600	CY
0.0001893750	7862.	41517143.	8.0235879396	CY
0.0001943750	7901.	40646072.	7.9841965308	CY
0.0001993750	7938.	39811976.	7.9466546824	CY
0.0002043750	7970.	38998835.	7.9089380488	CY
0.0002093750	7998.	38200403.	7.8703045093	CY
0.0002143750	8021.	37415727.	7.8307067402	CY
0.0002193750	8042.	36660567.	7.7926035954	CY
0.0002243750	8063.	35937552.	7.7565963940	CY
0.0002293750	8084.	35243704.	7.7211380146	CY
0.0002343750	8104.	34577303.	7.6863029796	CY
0.0002393750	8124.	33937793.	7.6533786870	CY
0.0002443750	8143.	33323506.	7.6222551448	CY
0.0002493750	8163.	32732915.	7.5928314382	CY
0.0002543750	8182.	32164602.	7.5650148499	CY
0.0002593750	8201.	31617005.	7.5388039695	CY
0.0002643750	8219.	31089166.	7.5140401262	CY
0.0002693750	8237.	30579805.	7.4905618084	CY
0.0002743750	8255.	30087790.	7.4684440982	CY
0.0003043750	8327.	27359282.	7.3313851032	CY
0.0003343750	8372.	25038864.	7.2065459877	CY
0.0003643750	8413.	23087969.	7.1115392048	CY
0.0003943750	8449.	21424132.	7.0387994684	CY
0.0004243750	8481.	19984836.	6.9769966026	CY
0.0004543750	8504.	18716680.	6.9192011486	CYT
0.0004843750	8518.	17584619.	6.8624058335	CYT
0.0005143750	8525.	16574324.	6.8105531203	CYT
0.0005443750	8531.	15671933.	6.7660506111	CYT
0.0005743750	8537.	14862538.	6.7284894935	CYT

Summary of Results for Nominal Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain

1	0.000	8486.052	0.00300000

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 (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 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 for Moment	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	8486.	0.0000	5516.	67316070.
1	0.75	8486.	0.0000	6365.	65702930.
1	0.90	8486.	0.0000	7637.	47334707.

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 = 23600.0 lbs
Applied moment at pile head = 755200.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	30.41170	755200.	23600.	0.000	3.723E+11
0.50000	29.53306	897706.	23997.	0.000	3.723E+11
1.00000	28.65450	1043162.	24615.	0.000	3.715E+11
1.50000	27.77604	1193085.	25486.	0.000	3.710E+11
2.00000	26.89770	1348991.	26609.	0.000	3.706E+11

2.50000	26.01950	1512397.	27985.	0.000	3.701E+11
3.00000	25.14143	1684812.	29538.	0.000	3.695E+11
3.50000	24.26354	1866850.	28414.	0.000	3.690E+11
4.00000	23.38582	2025785.	21837.	0.000	3.685E+11
4.50000	22.50830	2128892.	15259.	0.000	3.682E+11
5.00000	21.63099	2208897.	14136.	0.000	3.679E+11
5.50000	20.75390	2298524.	15740.	0.000	3.599E+11
6.00000	19.87703	2397775.	17333.	0.000	6.849E+10
6.50000	19.00143	2506521.	18841.	0.000	6.846E+10
7.00000	18.12715	2623867.	20189.	0.000	6.841E+10
7.50000	17.25424	2748788.	21366.	0.000	6.837E+10
8.00000	16.38278	2880262.	22373.	0.000	6.832E+10
8.50000	15.51285	3017264.	23209.	0.000	6.827E+10
9.00000	14.64450	3158770.	23874.	0.000	6.822E+10
9.50000	13.77782	3303757.	24369.	0.000	6.817E+10
10.00000	12.91288	3451200.	22250.	-798.00022	6.812E+10
10.50000	12.04977	3570761.	17429.	-832.51690	6.807E+10
11.00000	11.18854	3660351.	12331.	-867.03357	6.804E+10
11.50000	10.32925	3718728.	7025.	-901.55025	6.802E+10
12.00000	9.47193	3744648.	1555.	-921.61894	6.801E+10
12.50000	8.61660	3737391.	-4009.	-933.25799	6.801E+10
13.00000	7.76324	3696536.	-9634.	-941.57504	6.803E+10
13.50000	6.91183	3621785.	-15297.	-946.03349	6.805E+10
14.00000	6.06235	3512976.	-20973.	-945.91768	6.809E+10
14.50000	5.21472	3370115.	-26631.	-940.23650	6.815E+10
15.00000	4.36887	3193404.	-32234.	-927.54872	6.821E+10
15.50000	3.52470	2983303.	-37734.	-905.61611	6.829E+10
16.00000	2.68211	2740598.	-43063.	-870.61969	6.837E+10
16.50000	1.84096	2466552.	-48119.	-815.01211	6.847E+10
17.00000	1.00111	2163165.	-52722.	-719.25676	3.681E+11
17.50000	0.16147	1833885.	-56284.	-468.09440	3.691E+11
18.00000	-0.67799	1487754.	-55626.	687.63814	3.701E+11
18.50000	-1.51730	1166377.	-50975.	862.55128	3.711E+11
19.00000	-2.35651	876052.	-45427.	986.90725	3.720E+11
19.50000	-3.19563	621256.	-39193.	1091.	3.727E+11
20.00000	-4.03468	405733.	-32369.	1184.	3.734E+11
20.50000	-4.87370	232827.	-25008.	1270.	3.740E+11
21.00000	-5.71270	105636.	-17145.	1351.	3.740E+11
21.50000	-6.55169	27090.	-8803.	1429.	3.740E+11
22.00000	-7.39067	0.000	0.000	1505.	3.740E+11

Output Summary for Load Case No. 1:

```
Pile-head deflection             =    30.41170125 inches
Computed slope at pile head      =    -0.14644673 radians
Maximum bending moment           =       3744648. inch-lbs
Maximum shear force              =        -56284. lbs
Depth of maximum bending moment  =    12.00000000 feet below pile head
Depth of maximum shear force     =    17.50000000 feet below pile head
Number of iterations             =             76
```

Number of zero deflection points = 1

Summary of Pile-head Responses for Conventional Analyses

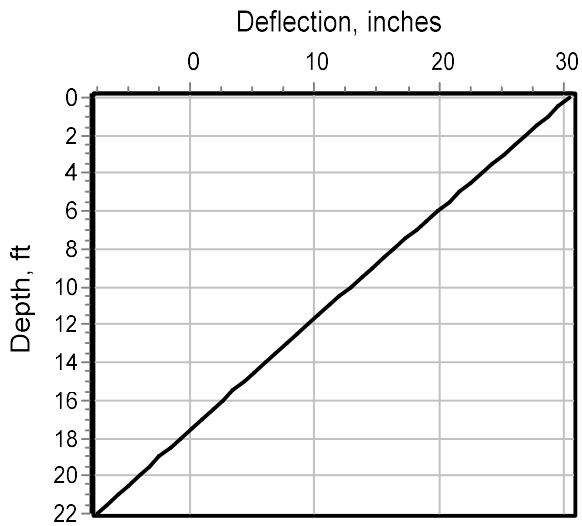
Definitions of Pile-head Loading Conditions:

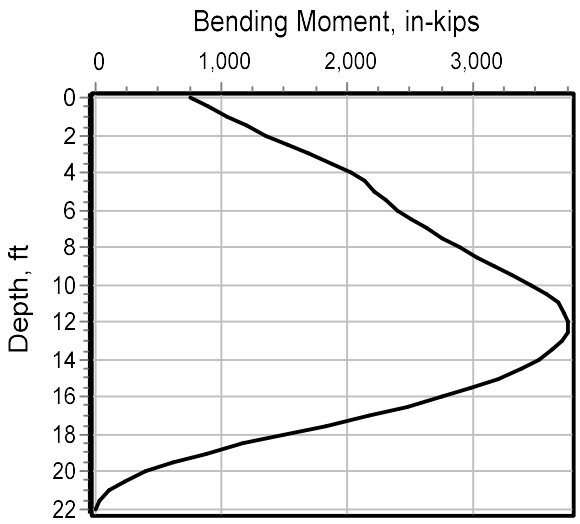
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

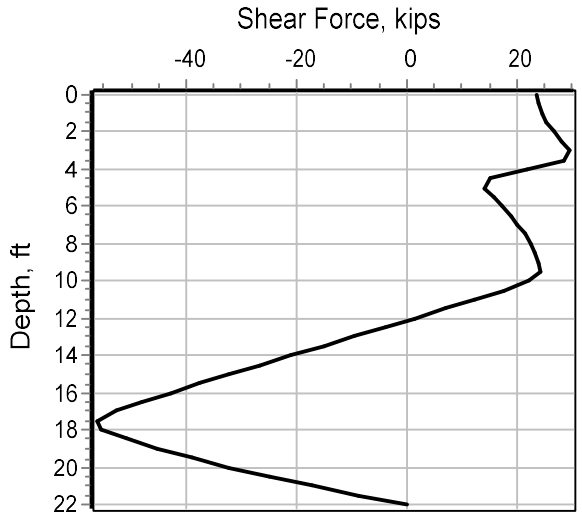
Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	1	30.411701	-0.146447	-56284.	3744648.

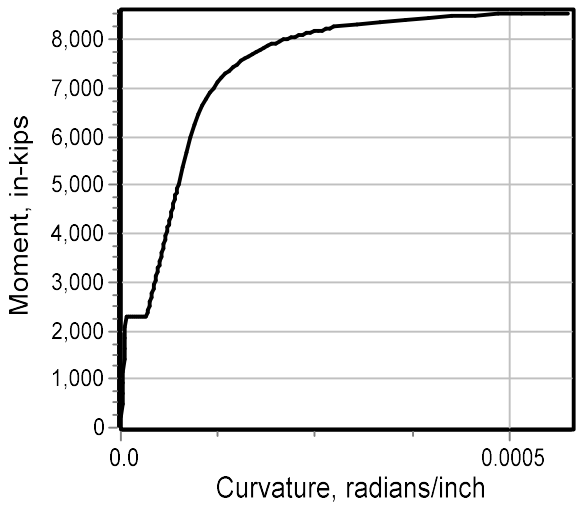
Maximum pile-head deflection = 30.4117012501 inches
Maximum pile-head rotation = -0.1464467254 radians = -8.390779 deg.

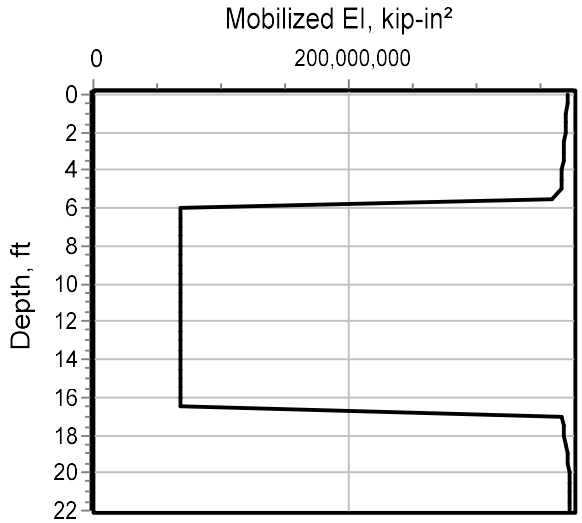
The analysis ended normally.

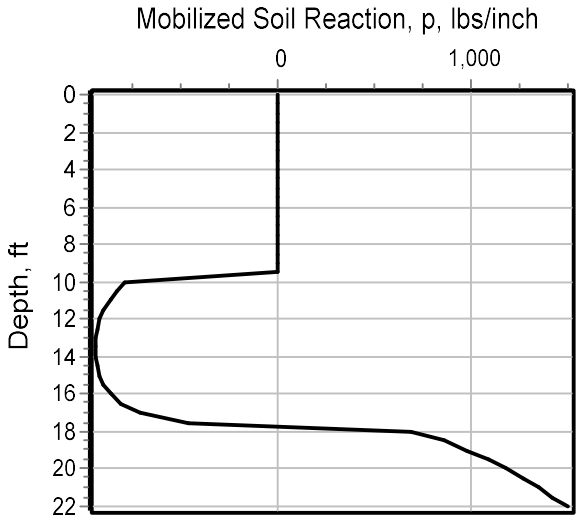

Deflection, inches
0
10
20
30
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Bending Moment, in-kips
0
1,000
2,000
3,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Shear Force, kips
-40
-20
0
20
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Moment, in-kips
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.0005
Curvature, radians/inch


Mobilized EI, kip-in²
0
200,000,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Mobilized Soil Reaction, p, lbs/inch
0
1,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22

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

                    LPile for Windows, Version 2019-11.004

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

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

Path to file locations on this computer:
\Projects\GFL\2019\1921\100500 PCE-PIK-CR50\PIK\108464\Design\Geotechnical\Sprea
dsheets and Calcs\LPILE\Plug Pile Wall\Extreme Event\

Name of the input data file:
Wall at Guardrail - 36in Shaft - Extreme Event.lp11d

Name of the output report file:
Wall at Guardrail - 36in Shaft - Extreme Event.lp11o

Name of the plot output file:
Wall at Guardrail - 36in Shaft - Extreme Event.lp11p

Name of the runtime message file:
Wall at Guardrail - 36in Shaft - Extreme Event.lp11r

--------------------------------------------------------------------------------
                           Date and Time of Analysis
--------------------------------------------------------------------------------

               Date:  April 22, 2021             Time:  18:26:58
```

Problem Title

Project Name: PIK-CR50-02.55

Job Number: 1921-1005.00

Client: Pike County

Engineer: DML

Description: Plug Pile Wall at Guardrail, 5ft Spacing, Extreme

---

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	=	44

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 one distributed lateral load 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
 - Input of side resistance moment along pile not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

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

Pile Structural Properties and Geometry

```
Number of pile sections defined                        =            1
Total length of pile                                   =       22.000 ft
Depth of ground surface below top of pile              =      10.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	22.000	36.0000

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                   =    22.000000 ft
   Shaft Diameter                                      =    36.000000 in
```

Shear capacity of section = 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer	=	10.000000 ft
Distance from top of pile to bottom of layer	=	50.000000 ft
Effective unit weight at top of layer	=	130.000000 pcf
Effective unit weight at bottom of layer	=	130.000000 pcf
Undrained cohesion at top of layer	=	1400. psf
Undrained cohesion at bottom of layer	=	1400. psf
Epsilon-50 at top of layer	=	0.007000
Epsilon-50 at bottom of layer	=	0.007000

(Depth of the lowest soil layer extends 28.000 ft below the pile tip)

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	10.000	0.7600	1.0000
2	22.000	0.7600	1.0000

Static Loading Type

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

Distributed Lateral Loading Used For All Load Cases

Distributed lateral load intensity defined using 8 points

Point No.	Depth X in	Dist. Load lb/in
1	0.000	39.812
2	32.400	267.312
3	42.000	267.312
4	42.000	-5423.956
5	54.000	-5423.956
6	54.000	267.312
7	72.000	267.312
8	120.000	39.812

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
1	1	V = 23600. lbs	M = 755200. in-lbs	0.0000000

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

Thrust force is assumed to be acting axially for all pile batter angles.

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section	=	22.000000 ft
Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	3.500000 in
Number of Reinforcing Bars	=	13 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.270000 sq. in.
Area Ratio of Steel Reinforcement	=	1.01 percent
Edge-to-Edge Bar Spacing	=	5.700839 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	7.60
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4042.060 kips
Tensile Load for Cracking of Concrete	=	-453.434 kips
Nominal Axial Tensile Capacity	=	-616.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.000000	0.790000	14.000000	0.00000
2	1.000000	0.790000	12.396384	6.506124
3	1.000000	0.790000	7.952906	11.521774
4	1.000000	0.790000	1.687514	13.897924
5	1.000000	0.790000	-4.964468	13.090227

6	1.000000	0.790000	-10.479150	9.283717
7	1.000000	0.790000	-13.593185	3.350419
8	1.000000	0.790000	-13.593185	-3.350419
9	1.000000	0.790000	-10.479150	-9.283717
10	1.000000	0.790000	-4.964468	-13.090227
11	1.000000	0.790000	1.687514	-13.897924
12	1.000000	0.790000	7.952906	-11.521774
13	1.000000	0.790000	12.396384	-6.506124

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 5.701 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.60

Concrete Properties:

Compressive Strength of Concrete	=	4000. psi
Modulus of Elasticity of Concrete	=	3604997. psi
Modulus of Rupture of Concrete	=	-474.341649 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, Section 10.3.4.
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 Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000006250	233.7218680467	373954989.	18.0000825595	
0.0000012500	466.5689419639	373255154.	18.0000827963	
0.0000018750	698.5412217518	372555318.	18.0000830341	
0.0000025000	929.6387074102	371855483.	18.0000832731	
0.0000031250	1160.	371155648.	18.0000835132	
0.0000037500	1389.	370455812.	18.0000837545	
0.0000043750	1618.	369755977.	18.0000839969	
0.0000050000	1845.	369056142.	18.0000842405	
0.0000056250	2072.	368356306.	18.0000844853	
0.0000062500	2298.	367656471.	18.0000847313	
0.0000068750	2298.	334233156.	8.6662704549	C
0.0000075000	2298.	306380393.	8.6684526289	C
0.0000081250	2298.	282812670.	8.6706386079	C
0.0000087500	2298.	262611765.	8.6728284052	C
0.0000093750	2298.	245104314.	8.6750220345	C
0.0000100000	2298.	229785294.	8.6772195093	C
0.0000106250	2298.	216268512.	8.6794208434	C
0.0000112500	2298.	204253595.	8.6816260505	C
0.0000118750	2298.	193503406.	8.6838351445	C
0.0000125000	2298.	183828236.	8.6860481393	C
0.0000131250	2298.	175074510.	8.6882650489	C
0.0000137500	2298.	167116578.	8.6904858875	C
0.0000143750	2298.	159850640.	8.6927106691	C
0.0000150000	2298.	153190196.	8.6949394080	C
0.0000156250	2298.	147062588.	8.6971721185	C
0.0000162500	2298.	141406335.	8.6994088150	C
0.0000168750	2298.	136169063.	8.7016495119	C
0.0000175000	2298.	131305883.	8.7038942239	C
0.0000181250	2298.	126778093.	8.7061429654	C
0.0000187500	2298.	122552157.	8.7083957512	C
0.0000193750	2298.	118598862.	8.7106525962	C
0.0000200000	2298.	114892647.	8.7129135151	C
0.0000206250	2298.	111411052.	8.7151785230	C
0.0000212500	2298.	108134256.	8.7174476347	C
0.0000218750	2298.	105044706.	8.7197208656	C
0.0000225000	2298.	102126798.	8.7219982307	C
0.0000231250	2298.	99366614.	8.7242797453	C
0.0000237500	2298.	96751703.	8.7265654248	C
0.0000243750	2298.	94270890.	8.7288552847	C
0.0000256250	2298.	89672310.	8.7334476078	C

0.0000268750	2298.	85501505.	8.7380568398	C
0.0000281250	2298.	81701438.	8.7426831077	C
0.0000293750	2298.	78224781.	8.7473265394	C
0.0000306250	2298.	75031933.	8.7519872649	C
0.0000318750	2298.	72089504.	8.7566654150	C
0.0000331250	2298.	69369145.	8.7613611226	C
0.0000343750	2355.	68508103.	8.7660745217	C
0.0000356250	2440.	68478657.	8.7708057480	C
0.0000368750	2524.	68449116.	8.7755549388	C
0.0000381250	2608.	68419478.	8.7803222331	C
0.0000393750	2693.	68389742.	8.7851077712	C
0.0000406250	2777.	68359907.	8.7899116954	C
0.0000418750	2861.	68329974.	8.7947341495	C
0.0000431250	2945.	68299941.	8.7995752789	C
0.0000443750	3029.	68269808.	8.8044352308	C
0.0000456250	3113.	68239573.	8.8093141544	C
0.0000468750	3197.	68209237.	8.8142122004	C
0.0000481250	3281.	68178798.	8.8191295214	C
0.0000493750	3365.	68148291.	8.8238892336	C
0.0000506250	3448.	68117692.	8.8286290397	C
0.0000518750	3532.	68086992.	8.8333869081	C
0.0000531250	3615.	68056192.	8.8381629810	C
0.0000543750	3699.	68025290.	8.8429574021	C
0.0000556250	3782.	67994285.	8.8477703169	C
0.0000568750	3865.	67963178.	8.8526018727	C
0.0000581250	3949.	67931967.	8.8574522185	C
0.0000593750	4032.	67900651.	8.8623215052	C
0.0000606250	4115.	67869229.	8.8672098854	C
0.0000618750	4197.	67837702.	8.8721175136	C
0.0000631250	4280.	67806067.	8.8770445463	C
0.0000643750	4363.	67774325.	8.8819911417	C
0.0000656250	4446.	67742474.	8.8869574603	C
0.0000668750	4528.	67710514.	8.8919436642	C
0.0000681250	4611.	67678443.	8.8969499178	C
0.0000693750	4693.	67646261.	8.9019763875	C
0.0000706250	4775.	67613967.	8.9070232417	C
0.0000718750	4857.	67581561.	8.9120906510	C
0.0000731250	4940.	67549040.	8.9171787881	C
0.0000743750	5022.	67516405.	8.9222878281	C
0.0000793750	5349.	67384701.	8.9429365938	C
0.0000843750	5674.	67251090.	8.9639343988	C
0.0000893750	5997.	67100912.	8.9846442900	CY
0.0000943750	6261.	66345414.	8.9781103992	CY
0.0000993750	6466.	65069477.	8.9466135093	CY
0.0001043750	6630.	63523046.	8.9001623016	CY
0.0001093750	6780.	61989682.	8.8530161477	CY
0.0001143750	6909.	60407201.	8.8000887428	CY
0.0001193750	7014.	58754596.	8.7389434559	CY
0.0001243750	7118.	57226145.	8.6834925884	CY
0.0001293750	7218.	55787822.	8.6316646677	CY

0.0001343750	7294.	54284434.	8.5723821243	CY
0.0001393750	7362.	52823712.	8.5135510238	CY
0.0001443750	7430.	51460668.	8.4595241559	CY
0.0001493750	7496.	50182631.	8.4067896920	CY
0.0001543750	7562.	48983508.	8.3581284747	CY
0.0001593750	7619.	47807630.	8.3085413079	CY
0.0001643750	7664.	46628126.	8.2554752625	CY
0.0001693750	7705.	45490327.	8.2035497450	CY
0.0001743750	7745.	44415680.	8.1551771023	CY
0.0001793750	7785.	43399235.	8.1101060048	CY
0.0001843750	7824.	42433842.	8.0657301600	CY
0.0001893750	7862.	41517143.	8.0235879396	CY
0.0001943750	7901.	40646072.	7.9841965308	CY
0.0001993750	7938.	39811976.	7.9466546824	CY
0.0002043750	7970.	38998835.	7.9089380488	CY
0.0002093750	7998.	38200403.	7.8703045093	CY
0.0002143750	8021.	37415727.	7.8307067402	CY
0.0002193750	8042.	36660567.	7.7926035954	CY
0.0002243750	8063.	35937552.	7.7565963940	CY
0.0002293750	8084.	35243704.	7.7211380146	CY
0.0002343750	8104.	34577303.	7.6863029796	CY
0.0002393750	8124.	33937793.	7.6533786870	CY
0.0002443750	8143.	33323506.	7.6222551448	CY
0.0002493750	8163.	32732915.	7.5928314382	CY
0.0002543750	8182.	32164602.	7.5650148499	CY
0.0002593750	8201.	31617005.	7.5388039695	CY
0.0002643750	8219.	31089166.	7.5140401262	CY
0.0002693750	8237.	30579805.	7.4905618084	CY
0.0002743750	8255.	30087790.	7.4684440982	CY
0.0003043750	8327.	27359282.	7.3313851032	CY
0.0003343750	8372.	25038864.	7.2065459877	CY
0.0003643750	8413.	23087969.	7.1115392048	CY
0.0003943750	8449.	21424132.	7.0387994684	CY
0.0004243750	8481.	19984836.	6.9769966026	CY
0.0004543750	8504.	18716680.	6.9192011486	CYT
0.0004843750	8518.	17584619.	6.8624058335	CYT
0.0005143750	8525.	16574324.	6.8105531203	CYT
0.0005443750	8531.	15671933.	6.7660506111	CYT
0.0005743750	8537.	14862538.	6.7284894935	CYT

Summary of Results for Nominal Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain

1	0.000	8486.052	0.00300000

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 (0.70).

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to ACI 318, Section 9.3.2.2 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 for Moment	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	8486.	0.0000	5516.	67316070.
1	0.75	8486.	0.0000	6365.	65702930.
1	0.90	8486.	0.0000	7637.	47334707.

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 = 23600.0 lbs
Applied moment at pile head = 755200.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	-0.39199	755200.	23600.	0.000	3.723E+11
0.50000	-0.38320	897706.	23997.	0.000	3.723E+11
1.00000	-0.37432	1043162.	24615.	0.000	3.715E+11
1.50000	-0.36533	1193085.	25486.	0.000	3.710E+11
2.00000	-0.35624	1348991.	26609.	0.000	3.706E+11

2.50000	-0.34701	1512397.	27985.	0.000	3.701E+11
3.00000	-0.33763	1684812.	29538.	0.000	3.695E+11
3.50000	-0.32809	1866850.	22605.	0.000	3.690E+11
4.00000	-0.31837	1956068.	-1402.	0.000	3.687E+11
4.50000	-0.30845	1850025.	-25409.	0.000	3.690E+11
5.00000	-0.29836	1651161.	-32342.	0.000	3.696E+11
5.50000	-0.28810	1461921.	-30738.	0.000	3.702E+11
6.00000	-0.27771	1282304.	-29145.	0.000	3.708E+11
6.50000	-0.26718	1112182.	-27637.	0.000	3.713E+11
7.00000	-0.25655	950660.	-26289.	0.000	3.718E+11
7.50000	-0.24583	796714.	-25112.	0.000	3.722E+11
8.00000	-0.23503	649319.	-24105.	0.000	3.727E+11
8.50000	-0.22417	507453.	-23269.	0.000	3.731E+11
9.00000	-0.21326	370091.	-22604.	0.000	3.734E+11
9.50000	-0.20232	236210.	-22109.	0.000	3.739E+11
10.00000	-0.19135	104787.	-20945.	296.21064	3.740E+11
10.50000	-0.18037	-15129.	-19072.	304.49152	3.740E+11
11.00000	-0.16939	-124083.	-17222.	312.17669	3.740E+11
11.50000	-0.15843	-221799.	-15328.	319.21856	3.740E+11
12.00000	-0.14748	-308023.	-13394.	325.56151	3.736E+11
12.50000	-0.13657	-382526.	-11424.	331.13960	3.734E+11
13.00000	-0.12569	-445109.	-9423.	335.87349	3.733E+11
13.50000	-0.11485	-495600.	-7396.	339.66606	3.731E+11
14.00000	-0.10407	-533863.	-5350.	342.39622	3.730E+11
14.50000	-0.09333	-559800.	-3291.	343.90952	3.729E+11
15.00000	-0.08265	-573356.	-1227.	344.00377	3.729E+11
15.50000	-0.07202	-574528.	831.88042	342.40563	3.729E+11
16.00000	-0.06145	-563374.	2875.	338.73034	3.729E+11
16.50000	-0.05094	-540025.	4889.	332.40707	3.730E+11
17.00000	-0.04047	-504709.	6853.	322.52559	3.731E+11
17.50000	-0.03006	-457783.	8743.	307.47349	3.733E+11
18.00000	-0.01969	-399787.	10518.	283.86304	3.734E+11
18.50000	-0.009355	-331573.	12094.	241.70318	3.735E+11
19.00000	0.000946	-254657.	12400.	-139.69395	3.738E+11
19.50000	0.01122	-182770.	11184.	-265.56444	3.740E+11
20.00000	0.02148	-120444.	9428.	-319.78204	3.740E+11
20.50000	0.03173	-69629.	7387.	-360.71031	3.740E+11
21.00000	0.04197	-31800.	5118.	-395.60541	3.740E+11
21.50000	0.05220	-8213.	2650.	-427.05277	3.740E+11
22.00000	0.06244	0.000	0.000	-456.28670	3.740E+11

Output Summary for Load Case No. 1:

```
Pile-head deflection             =    -0.39199373 inches
Computed slope at pile head      =     0.00145971 radians
Maximum bending moment           =      1956068. inch-lbs
Maximum shear force              =       -32342. lbs
Depth of maximum bending moment  =     4.00000000 feet below pile head
Depth of maximum shear force     =     5.00000000 feet below pile head
Number of iterations             =             39
```

Number of zero deflection points = 1

Summary of Pile-head Responses for Conventional Analyses

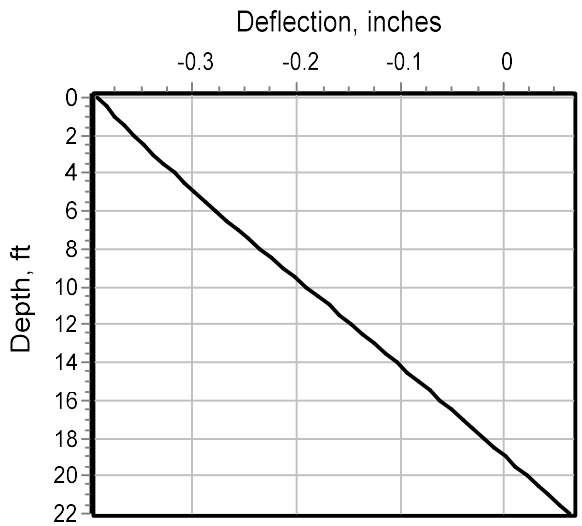
Definitions of Pile-head Loading Conditions:

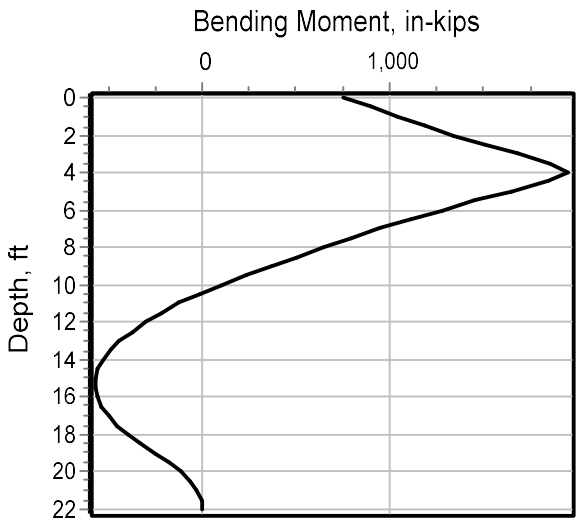
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

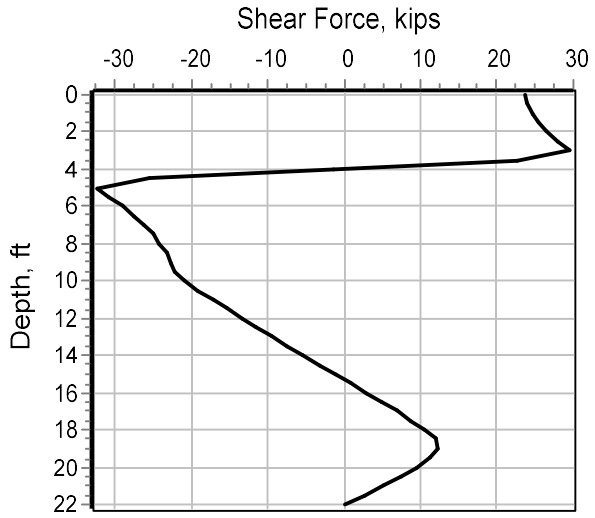
Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	1	-0.391994	0.001460	-32342.	1956068.

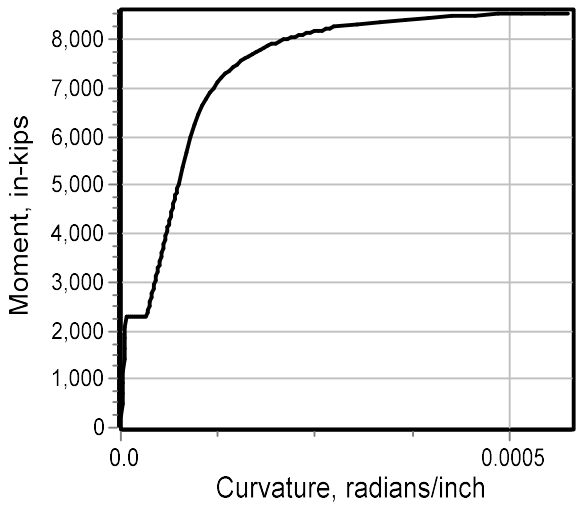
Maximum pile-head deflection = -0.3919937287 inches
Maximum pile-head rotation = 0.0014597082 radians = 0.083635 deg.

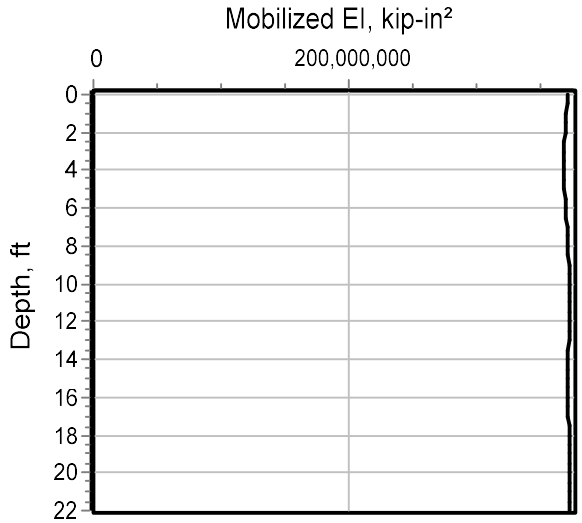
The analysis ended normally.

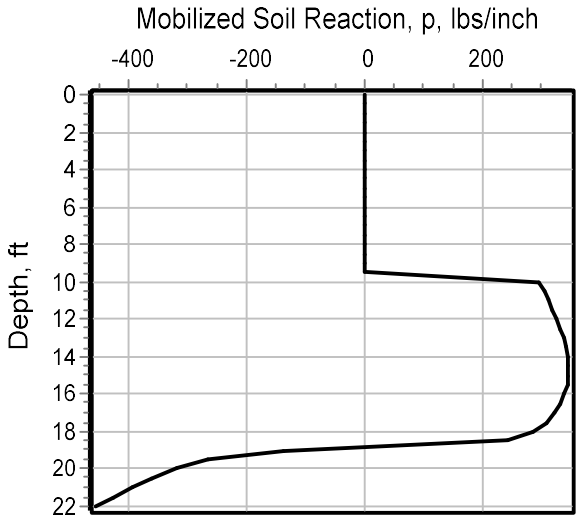

Deflection, inches
-0.3
-0.2
-0.1
0
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Bending Moment, in-kips
0
1,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Shear Force, kips
-30
-20
-10
0
10
20
30
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Moment, in-kips
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.0005
Curvature, radians/inch


Mobilized EI, kip-in²
0
200,000,000
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22


Mobilized Soil Reaction, p, lbs/inch
-400
-200
0
200
Depth, ft
0
2
4
6
8
10
12
14
16
18
20
22

==========

LPile for Windows, Version 2019-11.004

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

==========

This copy of LPile is being used by:

Matt Lyon (DLZ)
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Files Used for Analysis

Path to file locations on this computer:
\Projects\GFL\2019\1921\100500 PCE-PIK-CR50\PIK\108464\Design\Geotechnical\Spreadsheets and Calcs\LPILE\Plug Pile Wall\Deadman\

Name of the input data file:
Wall at Guardrail - Deadman - 36in Shaft - 3 Loads.lp11d

Name of the output report file:
Wall at Guardrail - Deadman - 36in Shaft - 3 Loads.lp11o

Name of the plot output file:
Wall at Guardrail - Deadman - 36in Shaft - 3 Loads.lp11p

Name of the runtime message file:
Wall at Guardrail - Deadman - 36in Shaft - 3 Loads.lp11r

Date and Time of Analysis

Date: April 22, 2021 Time: 18:18:55

Problem Title

Project Name: PIK-CR50-02.55

Job Number: 1921-1005.00

Client: Pike County

Engineer: DML

Description: Plug Pile Wall at Guardrail, Deadman, 5ft Spacing, 3 Load

---

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	=	50

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)

```
 - No distributed lateral loads are entered
 - 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
 - Input of side resistance moment along pile not selected
 - Computation of pile-head foundation stiffness matrix not selected
 - Push-over analysis of pile not selected
 - Buckling analysis of pile not selected

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

Pile Structural Properties and Geometry

```
Number of pile sections defined                        =            1
Total length of pile                                   =       15.000 ft
Depth of ground surface below top of pile              =       0.0000 ft

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

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

Point No.	Depth Below Pile Head feet	Pile Diameter inches
1	0.000	36.0000
2	15.000	36.0000

```
Input Structural Properties for Pile Sections:
----------------------------------------------

Pile Section No. 1:

   Section 1 is a round drilled shaft, bored pile, or CIDH pile
   Length of section                                   =    15.000000 ft
   Shaft Diameter                                      =    36.000000 in
```

Shear capacity of section = 0.0000 lbs

Ground Slope and Pile Batter Angles

Ground Slope Angle = 0.000 degrees
= 0.000 radians

Pile Batter Angle = 0.000 degrees
= 0.000 radians

Soil and Rock Layering Information

The soil profile is modelled using 1 layers

Layer 1 is stiff clay without free water

Distance from top of pile to top of layer = 0.0000 ft
Distance from top of pile to bottom of layer = 50.000000 ft
Effective unit weight at top of layer = 130.000000 pcf
Effective unit weight at bottom of layer = 130.000000 pcf
Undrained cohesion at top of layer = 1400. psf
Undrained cohesion at bottom of layer = 1400. psf
Epsilon-50 at top of layer = 0.007000
Epsilon-50 at bottom of layer = 0.007000

(Depth of the lowest soil layer extends 35.000 ft below the pile tip)

---

p-y Modification Factors for Group Action

Distribution of p-y modifiers with depth defined using 2 points

Point No.	Depth X ft	p-mult	y-mult
1	0.000	0.7600	1.0000
2	15.000	0.7600	1.0000

Static Loading Type

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

Pile-head Loading and Pile-head Fixity Conditions

Number of loads specified = 3

Load No.	Load Type	Condition 1		Condition 2		Axial Thrust Force, lbs
1	1	V =	21820. lbs	M =	0.0000 in-lbs	0.0000000
2	1	V =	32130. lbs	M =	0.0000 in-lbs	0.0000000
3	1	V =	68300. lbs	M =	0.0000 in-lbs	0.0000000

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

Computations of Nominal Moment Capacity and Nonlinear Bending Stiffness

---

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

Number of Pile Sections Analyzed = 1

Pile Section No. 1:

Dimensions and Properties of Drilled Shaft (Bored Pile):

Length of Section = 15.000000 ft

Shaft Diameter	=	36.000000 in
Concrete Cover Thickness (to edge of long. rebar)	=	4.000000 in
Number of Reinforcing Bars	=	13 bars
Yield Stress of Reinforcing Bars	=	60000. psi
Modulus of Elasticity of Reinforcing Bars	=	29000000. psi
Gross Area of Shaft	=	1018. sq. in.
Total Area of Reinforcing Steel	=	10.270000 sq. in.
Area Ratio of Steel Reinforcement	=	1.01 percent
Edge-to-Edge Bar Spacing	=	5.461523 in
Maximum Concrete Aggregate Size	=	0.750000 in
Ratio of Bar Spacing to Aggregate Size	=	7.28
Offset of Center of Rebar Cage from Center of Pile	=	0.0000 in

Axial Structural Capacities:

Nom. Axial Structural Capacity = 0.85 Fc Ac + Fy As	=	4042.060 kips
Tensile Load for Cracking of Concrete	=	-453.434 kips
Nominal Axial Tensile Capacity	=	-616.200 kips

Reinforcing Bar Dimensions and Positions Used in Computations:

Bar Number	Bar Diam. inches	Bar Area sq. in.	X inches	Y inches
1	1.000000	0.790000	13.500000	0.00000
2	1.000000	0.790000	11.953656	6.273763
3	1.000000	0.790000	7.668874	11.110282
4	1.000000	0.790000	1.627245	13.401570
5	1.000000	0.790000	-4.787166	12.622719
6	1.000000	0.790000	-10.104895	8.952156
7	1.000000	0.790000	-13.107715	3.230761
8	1.000000	0.790000	-13.107715	-3.230761
9	1.000000	0.790000	-10.104895	-8.952156
10	1.000000	0.790000	-4.787166	-12.622719
11	1.000000	0.790000	1.627245	-13.401570
12	1.000000	0.790000	7.668874	-11.110282
13	1.000000	0.790000	11.953656	-6.273763

NOTE: The positions of the above rebars were computed by LPile

Minimum spacing between any two bars not equal to zero = 5.462 inches
between bars 10 and 11.

Ratio of bar spacing to maximum aggregate size = 7.28

Concrete Properties:

Compressive Strength of Concrete = 4000. psi
Modulus of Elasticity of Concrete = 3604997. psi
Modulus of Rupture of Concrete = -474.341649 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, Section 10.3.4.
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 Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Run Msg
0.0000006250	232.6315785165	372210526.	18.0000851658	
0.0000012500	464.3872810701	371509825.	18.0000854098	
0.0000018750	695.2671076607	370809124.	18.0000856549	
0.0000025000	925.2710582882	370108423.	18.0000859012	
0.0000031250	1154.	369407723.	18.0000861487	
0.0000037500	1383.	368707022.	18.0000863974	
0.0000043750	1610.	368006321.	18.0000866473	
0.0000050000	1837.	367305620.	18.0000868984	
0.0000056250	2062.	366604919.	18.0000871506	

0.0000062500	2287.	365904219.	18.0000874042	
0.0000068750	2287.	332640199.	8.6617939620	C
0.0000075000	2287.	304920182.	8.6639745859	C
0.0000081250	2287.	281464784.	8.6661590096	C
0.0000087500	2287.	261360156.	8.6683472466	C
0.0000093750	2287.	243936146.	8.6705393104	C
0.0000100000	2287.	228690137.	8.6727352146	C
0.0000106250	2287.	215237776.	8.6749349729	C
0.0000112500	2287.	203280121.	8.6771385990	C
0.0000118750	2287.	192581168.	8.6793461069	C
0.0000125000	2287.	182952109.	8.6815575103	C
0.0000131250	2287.	174240104.	8.6837728233	C
0.0000137500	2287.	166320099.	8.6859920600	C
0.0000143750	2287.	159088791.	8.6882152343	C
0.0000150000	2287.	152460091.	8.6904423607	C
0.0000156250	2287.	146361687.	8.6926734533	C
0.0000162500	2287.	140732392.	8.6949085265	C
0.0000168750	2287.	135520081.	8.6971475947	C
0.0000175000	2287.	130680078.	8.6993906725	C
0.0000181250	2287.	126173869.	8.7016377745	C
0.0000187500	2287.	121968073.	8.7038889153	C
0.0000193750	2287.	118033619.	8.7061441097	C
0.0000200000	2287.	114345068.	8.7084033725	C
0.0000206250	2287.	110880066.	8.7106667187	C
0.0000212500	2287.	107618888.	8.7129341633	C
0.0000218750	2287.	104544062.	8.7152057213	C
0.0000225000	2287.	101640061.	8.7174814079	C
0.0000231250	2287.	98893032.	8.7197612383	C
0.0000237500	2287.	96290584.	8.7220452280	C
0.0000243750	2287.	93821595.	8.7243333924	C
0.0000256250	2287.	89244931.	8.7289223071	C
0.0000268750	2287.	85094004.	8.7335281075	C
0.0000281250	2287.	81312049.	8.7381509204	C
0.0000293750	2287.	77851961.	8.7427908735	C
0.0000306250	2287.	74674330.	8.7474480964	C
0.0000318750	2287.	71745925.	8.7521227199	C
0.0000331250	2287.	69038532.	8.7568148764	C
0.0000343750	2287.	66528040.	8.7615246998	C
0.0000356250	2368.	66467351.	8.7662523257	C
0.0000368750	2450.	66437818.	8.7709978910	C
0.0000381250	2532.	66408188.	8.7757615343	C
0.0000393750	2614.	66378461.	8.7805433959	C
0.0000406250	2695.	66348635.	8.7853436178	C
0.0000418750	2777.	66318710.	8.7901623433	C
0.0000431250	2859.	66288686.	8.7949997178	C
0.0000443750	2940.	66258561.	8.7998558883	C
0.0000456250	3022.	66228335.	8.8047310034	C
0.0000468750	3103.	66198008.	8.8096252137	C
0.0000481250	3184.	66167577.	8.8145386715	C
0.0000493750	3266.	66137043.	8.8194715309	C

0.0000506250	3347.	66106445.	8.8242305661	C
0.0000518750	3428.	66075752.	8.8289845781	C
0.0000531250	3509.	66044957.	8.8337567661	C
0.0000543750	3590.	66014061.	8.8385472736	C
0.0000556250	3670.	65983063.	8.8433562457	C
0.0000568750	3751.	65951962.	8.8481838294	C
0.0000581250	3832.	65920756.	8.8530301734	C
0.0000593750	3912.	65889447.	8.8578954283	C
0.0000606250	3993.	65858031.	8.8627797464	C
0.0000618750	4073.	65826510.	8.8676832819	C
0.0000631250	4153.	65794882.	8.8726061908	C
0.0000643750	4234.	65763146.	8.8775486313	C
0.0000656250	4314.	65731301.	8.8825107633	C
0.0000668750	4394.	65699347.	8.8874927486	C
0.0000681250	4474.	65667283.	8.8924947513	C
0.0000693750	4553.	65635108.	8.8975169374	C
0.0000706250	4633.	65602820.	8.9025594750	C
0.0000718750	4713.	65570420.	8.9076225342	C
0.0000731250	4792.	65537907.	8.9127062876	C
0.0000743750	4872.	65505278.	8.9178109096	C
0.0000793750	5189.	65373602.	8.9384416546	C
0.0000843750	5505.	65240019.	8.9594208608	C
0.0000893750	5819.	65104467.	8.9807608406	C
0.0000943750	6106.	64701245.	8.9901731949	CY
0.0000993750	6320.	63599978.	8.9662717630	CY
0.0001043750	6500.	62273458.	8.9301004771	CY
0.0001093750	6648.	60778888.	8.8837966412	CY
0.0001143750	6788.	59344267.	8.8391666425	CY
0.0001193750	6896.	57766034.	8.7821824319	CY
0.0001243750	6998.	56265679.	8.7270997353	CY
0.0001293750	7100.	54877043.	8.6773430707	CY
0.0001343750	7186.	53477402.	8.6241893853	CY
0.0001393750	7255.	52051497.	8.5664229905	CY
0.0001443750	7322.	50712452.	8.5128066119	CY
0.0001493750	7388.	49460179.	8.4635995600	CY
0.0001543750	7454.	48283353.	8.4156555062	CY
0.0001593750	7516.	47156654.	8.3692761043	CY
0.0001643750	7565.	46022764.	8.3191770325	CY
0.0001693750	7607.	44909554.	8.2681928281	CY
0.0001743750	7647.	43852508.	8.2201628035	CY
0.0001793750	7687.	42852589.	8.1754418964	CY
0.0001843750	7726.	41905119.	8.1337703215	CY
0.0001893750	7765.	41005564.	8.0945369098	CY
0.0001943750	7804.	40148369.	8.0555651357	CY
0.0001993750	7841.	39329108.	8.0186832898	CY
0.0002043750	7876.	38536593.	7.9825364254	CY
0.0002093750	7905.	37757545.	7.9453950072	CY
0.0002143750	7929.	36985237.	7.9062985350	CY
0.0002193750	7951.	36242766.	7.8688398789	CY
0.0002243750	7972.	35530230.	7.8332312144	CY

0.0002293750	7993.	34847625.	7.7996659918	CY
0.0002343750	8014.	34193028.	7.7680210725	CY
0.0002393750	8035.	33564535.	7.7380249020	CY
0.0002443750	8054.	32958877.	7.7074087159	CY
0.0002493750	8074.	32376484.	7.6785054970	CY
0.0002543750	8093.	31815790.	7.6512796331	CY
0.0002593750	8112.	31275557.	7.6256324223	CY
0.0002643750	8131.	30754823.	7.6014132746	CY
0.0002693750	8149.	30251485.	7.5784394261	CY
0.0002743750	8166.	29762863.	7.5563220209	CY
0.0003043750	8238.	27066313.	7.4260337128	CY
0.0003343750	8284.	24775320.	7.3100729176	CY
0.0003643750	8324.	22845951.	7.2189704552	CY
0.0003943750	8361.	21199952.	7.1499802188	CY
0.0004243750	8392.	19774947.	7.0961500187	CYT
0.0004543750	8413.	18514823.	7.0465101500	CYT
0.0004843750	8424.	17391151.	6.9954506679	CYT
0.0005143750	8430.	16388130.	6.9462908146	CYT
0.0005443750	8435.	15494028.	6.9053933230	CYT
0.0005743750	8435.	14684764.	6.9129989618	CYT

Summary of Results for Nominal Moment Capacity for Section 1

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

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip	Max. Comp. Strain
1	0.000	8390.129	0.00300000

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 (0.70).

The above values should be multiplied by the appropriate strength reduction
factor to compute ultimate moment capacity according to ACI 318, Section
9.3.2.2 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	Resist. Factor	Nominal Moment Cap	Ult. (Fac) Ax. Thrust	Ult. (Fac) Moment Cap	Bend. Stiff. at Ult Mom

No.	for Moment	in-kips	kips	in-kips	kip-in^2
1	0.65	8390.	0.0000	5454.	65261624.
1	0.75	8390.	0.0000	6293.	63742229.
1	0.90	8390.	0.0000	7551.	46341257.

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 = 21820.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	0.09729	3.587E-06	21820.	-250.14415	3.722E+11
0.30000	0.09429	76931.	20911.	-254.63201	3.722E+11
0.60000	0.09129	150562.	19987.	-258.97069	3.722E+11
0.90000	0.08829	220837.	19047.	-263.15575	3.722E+11
1.20000	0.08530	287701.	18092.	-267.18250	3.719E+11
1.50000	0.08233	351103.	17124.	-271.04595	3.717E+11
1.80000	0.07936	410992.	16141.	-274.74084	3.716E+11
2.10000	0.07641	467320.	15146.	-278.26149	3.715E+11
2.40000	0.07347	520042.	14138.	-281.60181	3.713E+11
2.70000	0.07056	569114.	13119.	-284.75523	3.711E+11
3.00000	0.06766	614496.	12088.	-287.71459	3.710E+11
3.30000	0.06478	656149.	11047.	-290.47208	3.709E+11
3.60000	0.06193	694038.	9997.	-293.01910	3.708E+11
3.90000	0.05910	728129.	8938.	-295.34617	3.707E+11
4.20000	0.05630	758392.	7871.	-297.44273	3.706E+11
4.50000	0.05352	784801.	6797.	-299.29698	3.705E+11
4.80000	0.05078	807331.	5717.	-300.89567	3.704E+11
5.10000	0.04805	825961.	4631.	-302.22376	3.704E+11
5.40000	0.04536	840674.	3541.	-303.26411	3.703E+11
5.70000	0.04270	851457.	2448.	-303.99706	3.703E+11
6.00000	0.04007	858300.	1353.	-304.39981	3.703E+11
6.30000	0.03747	861198.	257.03211	-304.44579	3.703E+11
6.60000	0.03489	860151.	-838.35689	-304.10366	3.703E+11
6.90000	0.03235	855162.	-1932.	-303.33614	3.703E+11

7.20000	0.02984	846242.	-3022.	-302.09832	3.703E+11
7.50000	0.02736	833407.	-4106.	-300.33539	3.703E+11
7.80000	0.02490	816679.	-5183.	-297.97942	3.704E+11
8.10000	0.02248	796090.	-6250.	-294.94474	3.705E+11
8.40000	0.02008	771678.	-7305.	-291.12089	3.705E+11
8.70000	0.01771	743494.	-8345.	-286.36175	3.706E+11
9.00000	0.01537	711598.	-9365.	-280.46770	3.707E+11
9.30000	0.01305	676067.	-10361.	-273.15457	3.708E+11
9.60000	0.01075	636996.	-11328.	-263.99534	3.709E+11
9.90000	0.008477	594504.	-12258.	-252.29850	3.710E+11
10.20000	0.006224	548742.	-13138.	-236.81367	3.712E+11
10.50000	0.003991	499911.	-13951.	-214.83060	3.714E+11
10.80000	0.001775	448295.	-14658.	-177.82069	3.715E+11
11.10000	-0.000426	394376.	-14825.	85.04693	3.716E+11
11.40000	-0.002612	341558.	-14310.	201.11954	3.718E+11
11.70000	-0.004787	291347.	-13521.	237.05730	3.719E+11
12.00000	-0.006952	244208.	-12620.	263.58699	3.721E+11
12.30000	-0.009108	200485.	-11631.	285.59460	3.722E+11
12.60000	-0.01126	160463.	-10568.	304.91459	3.722E+11
12.90000	-0.01340	124393.	-9439.	322.45037	3.722E+11
13.20000	-0.01554	92503.	-8249.	338.71755	3.722E+11
13.50000	-0.01768	65002.	-7002.	354.03947	3.722E+11
13.80000	-0.01981	42089.	-5701.	368.63266	3.722E+11
14.10000	-0.02194	23953.	-4349.	382.64925	3.722E+11
14.40000	-0.02407	10777.	-2947.	396.20010	3.722E+11
14.70000	-0.02620	2736.	-1497.	409.36832	3.722E+11
15.00000	-0.02833	0.000	0.000	422.21763	3.722E+11

Output Summary for Load Case No. 1:

```
Pile-head deflection             =     0.09729209 inches
Computed slope at pile head      =    -0.00083433 radians
Maximum bending moment           =        861198. inch-lbs
Maximum shear force              =         21820. lbs
Depth of maximum bending moment  =     6.30000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             33
Number of zero deflection points =              1
```

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

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

```
Shear force at pile head                          =      32130.0 lbs
Applied moment at pile head                       =          0.0 in-lbs
```

Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	0.43260	-5.261E-05	32130.	-363.21692	3.722E+11
0.30000	0.42035	113314.	30810.	-369.97766	3.722E+11
0.60000	0.40811	221834.	29467.	-376.54406	3.722E+11
0.90000	0.39588	325473.	28099.	-382.90943	3.718E+11
1.20000	0.38366	424150.	26710.	-389.06659	3.716E+11
1.50000	0.37145	517785.	25299.	-395.00786	3.713E+11
1.80000	0.35926	606300.	23866.	-400.72499	3.710E+11
2.10000	0.34709	689622.	22414.	-406.20907	3.708E+11
2.40000	0.33494	767679.	20942.	-411.45045	3.705E+11
2.70000	0.32283	840405.	19452.	-416.43867	3.703E+11
3.00000	0.31074	907733.	17944.	-421.16228	3.701E+11
3.30000	0.29868	969602.	16420.	-425.60879	3.699E+11
3.60000	0.28666	1025956.	14880.	-429.76443	3.698E+11
3.90000	0.27467	1076740.	13326.	-433.61399	3.696E+11
4.20000	0.26272	1121905.	11759.	-437.14064	3.695E+11
4.50000	0.25081	1161404.	10179.	-440.32555	3.694E+11
4.80000	0.23894	1195196.	8589.	-443.14765	3.693E+11
5.10000	0.22712	1223246.	6989.	-445.58318	3.692E+11
5.40000	0.21533	1245520.	5382.	-447.60519	3.691E+11
5.70000	0.20359	1261994.	3767.	-449.18289	3.690E+11
6.00000	0.19190	1272646.	2148.	-450.28090	3.690E+11
6.30000	0.18025	1277463.	526.38561	-450.85814	3.690E+11
6.60000	0.16864	1276436.	-1097.	-450.86655	3.690E+11
6.90000	0.15708	1269566.	-2719.	-450.24934	3.690E+11
7.20000	0.14556	1256861.	-4337.	-448.93856	3.691E+11
7.50000	0.13409	1238338.	-5950.	-446.85187	3.691E+11
7.80000	0.12266	1214023.	-7553.	-443.88798	3.692E+11
8.10000	0.11127	1183956.	-9144.	-439.91999	3.693E+11
8.40000	0.09993	1148188.	-10718.	-434.78554	3.694E+11
8.70000	0.08862	1106784.	-12272.	-428.27146	3.695E+11
9.00000	0.07736	1059830.	-13799.	-420.08892	3.697E+11
9.30000	0.06613	1007432.	-15293.	-409.83047	3.698E+11
9.60000	0.05493	949722.	-16745.	-396.89045	3.700E+11
9.90000	0.04377	886869.	-18144.	-380.30164	3.702E+11
10.20000	0.03265	819087.	-19473.	-358.34977	3.704E+11
10.50000	0.02154	746661.	-20708.	-327.44146	3.706E+11
10.80000	0.01047	669991.	-21796.	-277.11075	3.709E+11
11.10000	-0.000581	589730.	-22086.	116.04091	3.711E+11
11.40000	-0.01161	510972.	-21351.	292.00280	3.713E+11
11.70000	-0.02262	436000.	-20197.	349.49925	3.716E+11
12.00000	-0.03362	365556.	-18864.	390.86206	3.717E+11
12.30000	-0.04461	300178.	-17396.	424.82814	3.719E+11
12.60000	-0.05558	240306.	-15813.	454.48706	3.722E+11
12.90000	-0.06655	186324.	-14129.	481.31746	3.722E+11

13.20000	-0.07751	138580.	-12351.	506.14889	3.722E+11
13.50000	-0.08846	97396.	-10487.	529.49569	3.722E+11
13.80000	-0.09941	63073.	-8541.	551.69965	3.722E+11
14.10000	-0.11036	35901.	-6516.	572.99974	3.722E+11
14.40000	-0.12131	16155.	-4417.	593.56964	3.722E+11
14.70000	-0.13226	4102.	-2244.	613.53956	3.722E+11
15.00000	-0.14320	0.000	0.000	633.00950	3.722E+11

Output Summary for Load Case No. 2:

Pile-head deflection = 0.43260051 inches
Computed slope at pile head = -0.00340162 radians
Maximum bending moment = 1277463. inch-lbs
Maximum shear force = 32130. lbs
Depth of maximum bending moment = 6.30000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 40
Number of zero deflection points = 1

Computed Values of Pile Loading and Deflection
for Lateral Loading for Load Case Number 3

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

Shear force at pile head = 68300.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 0.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Soil Res. p lb/inch	Bending Stiffness lb-in^2
0.000	8.69683	0.002653	68300.	-769.09208	3.722E+11
0.30000	8.45772	240896.	65505.	-783.57145	3.722E+11
0.60000	8.21862	471637.	62659.	-797.65332	3.715E+11
0.90000	7.97953	692041.	59763.	-811.32267	3.708E+11
1.20000	7.74047	901930.	56818.	-824.56332	3.702E+11
1.50000	7.50144	1101132.	53827.	-837.35789	3.695E+11
1.80000	7.26245	1289483.	50790.	-849.68757	3.690E+11
2.10000	7.02350	1466821.	47710.	-861.53201	3.684E+11
2.40000	6.78461	1632994.	44588.	-872.86911	3.679E+11
2.70000	6.54577	1787855.	41426.	-883.67479	3.674E+11
3.00000	6.30699	1931263.	38227.	-893.92273	3.670E+11
3.30000	6.06829	2063086.	34991.	-903.58407	3.666E+11
3.60000	5.82965	2183198.	31722.	-912.62701	3.662E+11
3.90000	5.59110	2291483.	28421.	-921.01644	2.867E+11

4.20000	5.35265	2387832.	25092.	-928.71433	6.646E+10
4.50000	5.11466	2472144.	21736.	-935.69370	6.643E+10
4.80000	4.87715	2544330.	18356.	-941.90934	6.640E+10
5.10000	4.64015	2604308.	14956.	-947.31033	6.638E+10
5.40000	4.40365	2652010.	11537.	-951.83900	6.636E+10
5.70000	4.16767	2687375.	8104.	-955.42959	6.635E+10
6.00000	3.93221	2710358.	4660.	-958.00659	6.634E+10
6.30000	3.69728	2720926.	1208.	-959.48255	6.634E+10
6.60000	3.46289	2719059.	-2246.	-959.75533	6.634E+10
6.90000	3.22902	2704753.	-5700.	-958.70438	6.635E+10
7.20000	2.99568	2678022.	-9146.	-956.18583	6.635E+10
7.50000	2.76287	2638899.	-12581.	-952.02565	6.637E+10
7.80000	2.53057	2587438.	-15998.	-946.01020	6.639E+10
8.10000	2.29878	2523717.	-19389.	-937.87241	6.641E+10
8.40000	2.06748	2447841.	-22746.	-927.27144	6.644E+10
8.70000	1.83666	2359947.	-26060.	-913.76100	6.647E+10
9.00000	1.60630	2260211.	-29319.	-896.73825	3.660E+11
9.30000	1.37601	2148853.	-32508.	-875.29870	3.663E+11
9.60000	1.14581	2026152.	-35610.	-848.16422	3.667E+11
9.90000	0.91567	1892458.	-38601.	-813.30088	3.671E+11
10.20000	0.68560	1748224.	-41446.	-767.12100	3.676E+11
10.50000	0.45560	1594048.	-44091.	-702.16250	3.680E+11
10.80000	0.22565	1430771.	-46429.	-597.05764	3.685E+11
11.10000	-0.004252	1259758.	-47100.	224.18463	3.691E+11
11.40000	-0.23411	1091649.	-45583.	618.74686	3.696E+11
11.70000	-0.46393	931559.	-43131.	743.71900	3.701E+11
12.00000	-0.69371	781108.	-40292.	833.02303	3.705E+11
12.30000	-0.92347	641453.	-37162.	906.17723	3.709E+11
12.60000	-1.15320	513543.	-33785.	969.97537	3.713E+11
12.90000	-1.38292	398203.	-30189.	1028.	3.716E+11
13.20000	-1.61262	296181.	-26394.	1081.	3.719E+11
13.50000	-1.84232	208169.	-22412.	1131.	3.722E+11
13.80000	-2.07200	134816.	-18254.	1179.	3.722E+11
14.10000	-2.30168	76740.	-13928.	1224.	3.722E+11
14.40000	-2.53136	34534.	-9440.	1269.	3.722E+11
14.70000	-2.76104	8769.	-4796.	1311.	3.722E+11
15.00000	-2.99072	0.000	0.000	1353.	3.722E+11

Output Summary for Load Case No. 3:

```
Pile-head deflection             =     8.69683172 inches
Computed slope at pile head      =    -0.06641976 radians
Maximum bending moment           =       2720926. inch-lbs
Maximum shear force              =         68300. lbs
Depth of maximum bending moment  =     6.30000000 feet below pile head
Depth of maximum shear force     =       0.000000 feet below pile head
Number of iterations             =             53
Number of zero deflection points =              1
```

Summary of Pile-head Responses for Conventional Analyses

Definitions of Pile-head Loading Conditions:

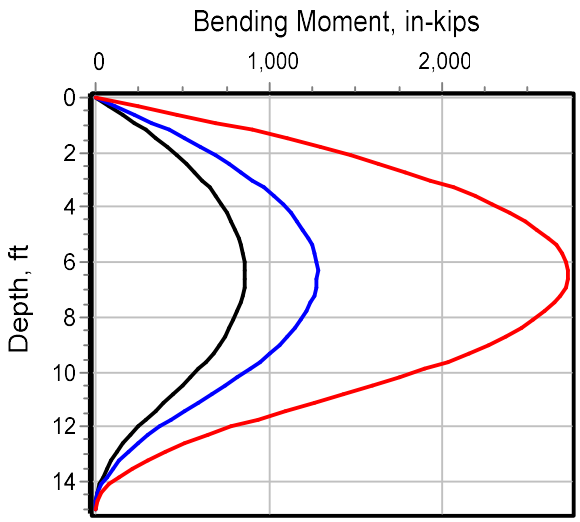
Load Type 1: Load 1 = Shear, V, lbs, and Load 2 = Moment, M, in-lbs
Load Type 2: Load 1 = Shear, V, lbs, and Load 2 = Slope, S, radians
Load Type 3: Load 1 = Shear, V, lbs, and Load 2 = Rot. Stiffness, R, in-lbs/rad.
Load Type 4: Load 1 = Top Deflection, y, inches, and Load 2 = Moment, M, in-lbs
Load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

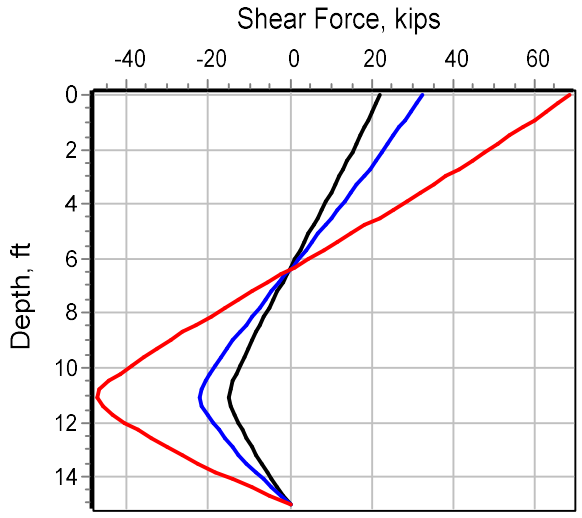
Load Case No.	Load Type	Pile-head Deflection inches	Pile-head Rotation radians	Max Shear in Pile lbs	Max Moment in Pile in-lbs
1	1	0.097292	-0.0008343	21820.	861198.
2	1	0.432601	-0.003402	32130.	1277463.
3	1	8.696832	-0.066420	68300.	2720926.

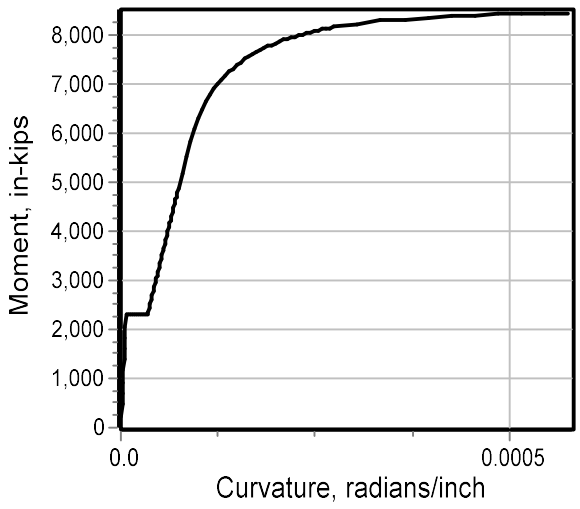
Maximum pile-head deflection = 8.6968317221 inches
Maximum pile-head rotation = -0.0664197591 radians = -3.805572 deg.

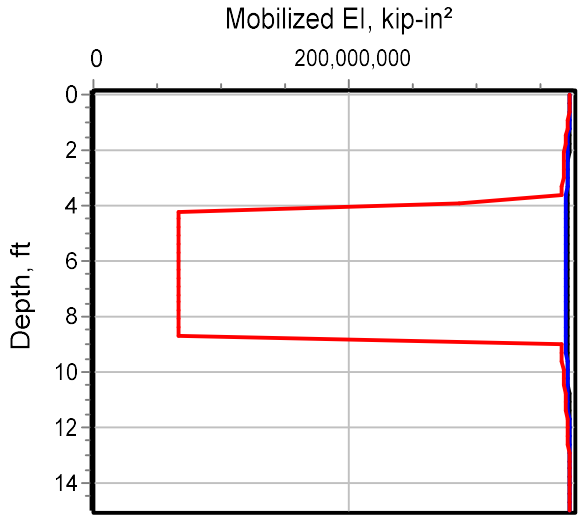
The analysis ended normally.

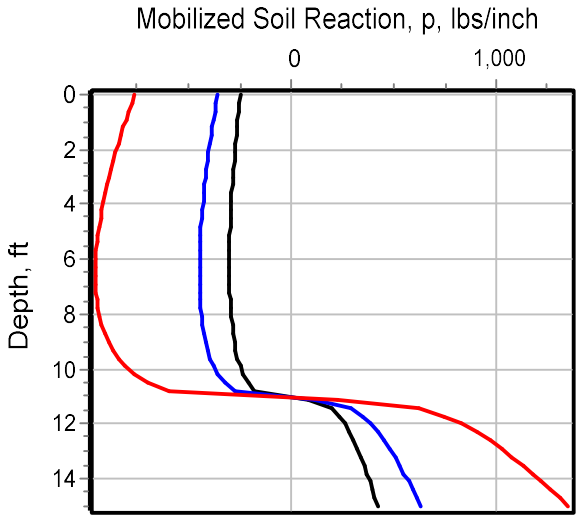

Deflection, inches
-2
0
2
4
6
8
Depth, ft
0
2
4
6
8
10
12
14


Bending Moment, in-kips
0
1,000
2,000
Depth, ft
0
2
4
6
8
10
12
14


Shear Force, kips
-40
-20
0
20
40
60
Depth, ft
0
2
4
6
8
10
12
14


Moment, in-kips
8,000
7,000
6,000
5,000
4,000
3,000
2,000
1,000
0
0.0
0.0005
Curvature, radians/inch


Mobilized EI, kip-in²
0
200,000,000
Depth, ft
0
2
4
6
8
10
12
14


Mobilized Soil Reaction, p, lbs/inch
0
1,000
Depth, ft
0
2
4
6
8
10
12
14

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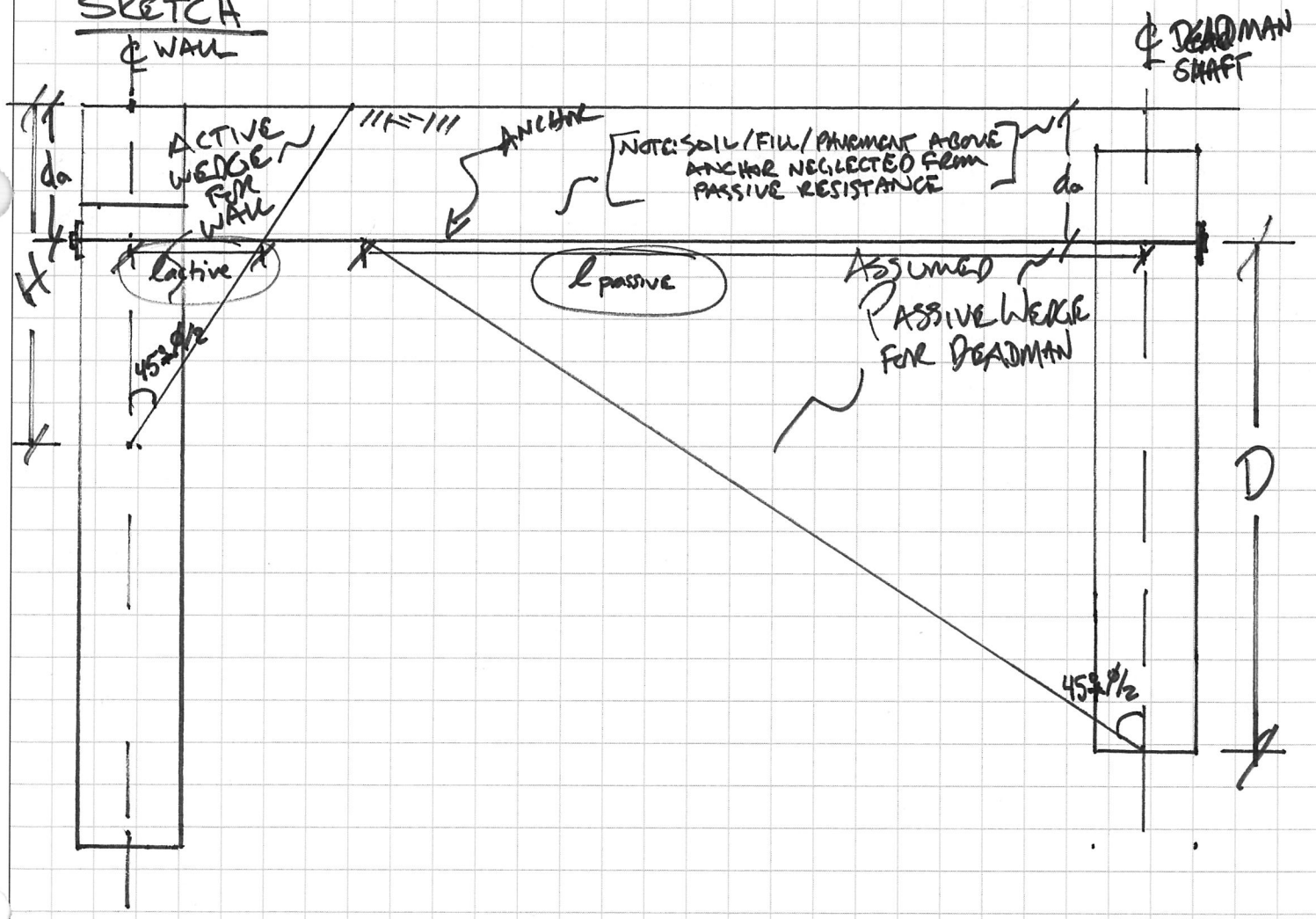
SURVEYING • CONSTRUCTION SERVICES

CLIENT Pike County Engineer PROJECT NO. 1921-1005.00
PROJECT PIK-CR50-2.55 SHEET NO. 1 OF 2
SUBJECT ~~RETAINING~~ WALL - LATERAL LOAD ANALYSIS COMP. BY [illegible] DATE 4-26-2021
CONFIRM SPACING BETWEEN WALL & DEADMAN SHAFTS TO MITIGATE OVERLAP OF ACTIVE & PASSIVE FAILURE WEDGES (RANKINE THEORETICAL) CHECKED BY EWT DATE 4-26-2021

ASSUMPTIONS

1. RANKINE EARTH PRESSURE THEORY
2. LONG-TERM LOADING CONDITION CONTROLS ⇒ ANALYZE SOILS AS "GRANULAR"
3. SOIL PARAMETER FOR ANALYSIS ⇒ EFFECTIVE FRICTION ANGLE, $\phi' = 24°$ TYPE
   EFFECTIVE COHESION, $C' = 0$ PSF
4. TOTAL RETAINED HEIGHT, H, OF 10 FEET WITH ANCHOR AT DEPTH OF 4.0 FEET.
5. REQUIRED EMBEDMENT DEPTH, D, FOR DEADMAN OF 15 FT BELOW ANCHOR FOR PASSIVE RESISTANCE, NEGLECTING PASSIVE RESISTANCE ABOVE ANCHOR.

SKETCH



CALCULATE MIN. REQUIRED SPACING (CTC) BETWEEN WALL & DEADMAN

$l_{active} = (H - d_a) \times \tan(45 - \phi/2) = (10' - 4') \times \tan(45 - 24/2) = 6' \tan 33° = 3.9'$

$l_{passive} = D \tan(45 + \phi/2) = 15' \tan(45 + 24/2) = 15' \tan 57° = 23.1'$

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CLIENT PIKE COUNTY ENGINEER PROJECT NO. 1921-1005-00
PROJECT PIK-CR50-2.55 SHEET NO. 2 OF 2
SUBJECT RETAINING WALL - LATERAL LOAD ANALYSIS COMP. BY KJM DATE 4-26-2021
MIN SPACING BETWEEN WALL AND DEADMAN CHECKED BY EWT DATE 4-26-2021

CALCULATION (CONTINUED)

MIN REQUIRED CTC SPACING BETWEEN WALL AND DEADMAN, l

$$l_{MIN} \geq l_{active} + l_{passive} = 3.9' + 23.1' = 27.0'$$

$$l_{min} \geq \underline{\underline{27.0'}}$$