FINAL REPORT
GEOTECHNICAL EXPLORATION REPORT
ROS-CR222-0383
ROSS COUNTY, OHIO
PID#: 106544

Prepared For:

CARPENTER MARTY TRANSPORTATION
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NEAS PROJECT 21-0053

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National Engineering & Architectural Services Inc.

EXECUTIVE SUMMARY

The Ohio Department of Transportation (ODOT) has proposed a bridge replacement project ROS-CR222-0383, PID 106544) for the existing Bridge ROS-CR222-0383 located along County Route (CR) 222 about 10 miles southeast of the City of Chillicothe in Ross County, Ohio. The proposed bridge replacement project is planned to consist of the replacement of the existing bridge within the project limits with a new three span bridge structure, as well as roadway realignment work along the project roadway segment.

National Engineering & Architectural Services, Inc. (NEAS) has been contracted to perform geotechnical engineering services for the project. The purpose of the geotechnical engineering services was to perform geotechnical explorations within the project limits to obtain information concerning the subsurface soil and groundwater conditions relevant to the design and construction of the project. Between December 20, 2021 and January 21, 2022, NEAS performed the subsurface exploration program for the project. The subsequent document presents the results of the geotechnical exploration with respect to the proposed replacement of Bridge ROS-CR222-0383 and the roadway realignment. As part of the project, NEAS advanced 11 project borings and conducted laboratory testing to characterize the soils for engineering purposes.

The subsurface profile at the project site is generally consistent with the geological model for the project in regard to the materials encountered. The subsurface profile within the proposed project area consists of surficial materials comprised of an existing pavement section or topsoil, generally underlain by natural overburden soils generally consisting of predominantly non-cohesive coarse-grained soils comprised of gravel, sand and silt mixtures and minorly cohesive silt and clay mixtures. Bedrock was not encountered within any of the project borings.

A deep foundation system analysis was performed at the referenced bridge site based on developed soil profiles at the boring locations. For the analyses, 12-inch closed-ended cast-in-place (CIP) friction pipe piles were considered at abutments and 14-inch closed-ended CIP friction pipe piles were considered at center piers. Based on loading information provided by Carpenter Marty Transportation, to obtain the required UBV (pile resistance) at each substructure location, estimated pile lengths are anticipated to range from 40 to 60 ft with pile tip elevations ranging from 600.1 ft and 642.3 ft amsl, depending on the location. Based on the pile drivability results, 12-inch CIP piles with a wall thickness of 0.375 inches at the abutments would not be overstressed for ASTM A 252 Grade 3 steel during the pile installation process, and 14-inch CIP piles with a wall thickness of 0.375 inches at the center piers would not be overstressed for ASTM A 252 Grade 3 steel during the pile installation process.

Global stability and settlement analyses were performed for the proposed bridge abutments. Based on our slope stability analyses for the referenced bridge abutments, the minimum slope stability safety factor for short-term (Total Stress) and long-term (Effective Stress) conditions exceeded the desired value of 1.54 (less than resistance factor 0.65). Based on the results of the analyses, it is our opinion that the subsurface conditions encountered at this location are generally satisfactory and the site can be stable at short-term and long-term condition. Based on our settlement analysis the ground surface at the rear abutment is estimated to experience about 4.8 inches of immediate settlement and 0.2 inches of long-term (consolidation) settlement from the induced loads associated with the 13.8-ft high embankment while at the forward abutment the ground surface is estimated to experience about 4.0 inches of immediate settlement from the induced loads associated with the12.3-ft high embankment. The immediate settlement is expected to take place during construction prior to bridge loading and is not anticipated to be a concern. Since the long-term settlement is less than 0.4 inches and the embankment fill at the abutment locations will be carried by the abutments, the surcharge loads will then be transferred from the abutments to the piles; therefore, it is our opinion that the piles will not be subjected to downdrag loads.

Based on our evaluation of the subsurface conditions and our geotechnical engineering analyses of the proposed intersection improvement project, it is our opinion that subgrade conditions are generally satisfactory, and pavement can be designed without the need for extreme levels of remediation.

Unsuitable soils A-4b were encountered in one boring B-001-0-21 within 3 feet of top of proposed subgrade. Unstable subgrade conditions, including areas of weak soils and high moisture content soils, were encountered in one boring B-008-0-21 within 3 feet of top of proposed grade. NEAS recommend spot stabilization in the form of Excavate and Replace to the depths between 21 inches and 36 inches below the proposed subgrade for the specified roadway limits. NEAS's opinion that the subgrade soils will provide adequate pavement support assuming it is designed and constructed in accordance with the recommendations provided within this report, as well as all applicable ODOT standards and specifications.

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1. INTRODUCTION

1.1. General

National Engineering and Architectural Services Inc. (NEAS) presents our Geotechncial Exploration Report for the proposed Ohio Department of Transportation (ODOT) project ROS-CR222-0383 (PID 106544) within Springfield Township approximately 10 miles southeast of the City of Chillicothe, Ross County, Ohio. As part of the referenced project ODOT intends to replace the existing bridge (ROS-CR222-0383) carrying County Route (CR) 222 over the CSX rail line as well as realign approximately 3,400 ft of CR-222 roadway. This report presents: 1) a summary of the encountered surficial and subsurface conditions; 2) our recommendations for bridge foundation design and construction in accordance with the Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication *LRFD Bridge Design Specifications, 9th Edition* (BDS) (AASHTO, 2020) and *ODOT's 2020 LRFD Bridge Design Manual* (BDM) (ODOT, 2020); and, 3) our recommendations for subgrade stabilization and pavement design parameters in accordance with ODOT's *Geotechnical Bulletin 1* (GB1) (ODOT [1], 2021) and *Pavement Design Manual* (PDM) (ODOT, 2021).

The exploration was conducted in general accordance with NEAS's proposal to Carpenter Marty Transportation (CMT) dated April 30, 2021 and with the provisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) (ODOT, 2021).

The scope of work performed by NEAS as part of the referenced project included: a review of published geotechnical information; performing 11 test borings; laboratory testing of soil samples in accordance with the SGE; performing geotechnical engineering analysis to assess foundation design and construction considerations, soil profile sheets; and development of this summary report.

1.2. Proposed Construction

The existing bridge ROS-CR222-0383 consists of a 3-span, through plate girder bridge which was originally built in 1927. The existing structure over the CSX rail line (ROS-CR222-0383) is about 193.9 ft in length (abutment to abutment) with a roadway width of about 20.3 ft (edge-to-edge). The structure carries two lanes of traffic on a through plate girder and steel floor beam system atop concrete full height type abutments and cap and column type piers.

Based on the available project documentation and our subsequent conversations with CMT, the roadway (totaling about 3,400 ft in length) is planned to be realigned to south of the existing alignment and the proposed structure designated ROS-CO222-04.221 will be constructed approximately 250 ft north of the existing structure (ROS-CR222-0383). The proposed structure is a three-span composite steel plate girder bridge on semi-integral abutments and cap and column piers supported by a deep foundation system consisting of friction pipe piles.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Illinoian Glaciated Allegheny Plateau, part of the Glaciated Allegheny Plateaus (ODGS, 1998). This is a moderate relief (200 ft), dissected, rugged hilly area comprised of loess and older drift on ridgetops, but absent on bedrock slopes. Dissection is similar to unglaciated regions of

the Allegheny Plateau. Soils in this region are characteristically colluvium and Illinoian-age till over Devonian- to Pennsylvanian-age shales, siltstones, and sandstones.

Based on the Quaternary Geology Map of Ohio (Pavey, et, al, 1999) The geology at the project site is mapped as a late Wisconsinan-age water-deposited soils of high-level outwash terraces comprised of sand and gravel with silt or loess cover.

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the central portion of the project area consists of shale and sandstone, of the Sunbury Shale, Berea Sandstone and Bedford Shale formations, Undivided. This formation is comprised of Devonian and/or Mississippian-age shale and sandstone. The shale in this formation is described as black to brown in color, carbonaceous, with thin, planar bedding. The sandstone in this in this formation is described as brown and weathers light brown to reddish brown in color, thin to thick bedded, planar to lenticular bedding with minor shale interbeds.

Based on the Bedrock Geologic Units Map of Ohio (USGS & ODGS, 2006), bedrock within the eastern and western ends of the project area consists of shale, of the Ohio Shale formation. This formation is comprised of Devonian-age shale and mudstone. The shale in this formation is described as brownish black to greenish gray and weathers brown in color, carbonaceous to clayey, laminated to thin bedded, with fissile partings, carbonate and/or siderite concretions and a petroliferous odor.

The bedrock appears to follow the natural topography of the site, rising from south to north (ODGS, 2003). Based on the ODNR bedrock topography map of Ohio, bedrock elevations at the project site can be expected to be between about 550 and 650 ft amsl, putting bedrock at a depth ranging from about 35 ft below ground surface (bgs) to about 100 ft below ground surface (bgs).

The soils at the project site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service (USDA, 2015) as Rodman gravelly loam from the beginning of the project to 800 ft south east, Ockley loam from 800 ft south east of the beginning of the project to the CSX railroad, Negley loam from the CSX railroad to 1000 ft south east of the CSX railroad, Ockley loam from 1000 ft to 1200 ft south east of the CSX railroad, Negley loam from 1200 ft to 1400 ft south east of the CSX railroad and Ockley loam from 1400 ft south east of the CSX railroad to the western end of the project. Soils in the Rodman series are characterized as very deep, excessively drained soils that are shallow to calcareous, stratified sandy and gravelly outwash. The Rodman series is formed in sandy and gravelly outwash. The Rodman series is comprised of both coarse- and fine-grained soils and classifies as A-1, A-2 and A-4 type soils according to the AASHTO method of soil classification. Soils in the Ockley series are characterized as very deep, well drained soils that are deep or very deep to calcareous, stratified sandy and gravelly outwash. The Ockley series is formed in loess or silty material and in the underlying loamy outwash on stream terraces and outwash plains and less commonly on kame moraines and eskers. The Ockley series is comprised of both coarse- and fine-grained soils and classifies as A-1, A-2, A-4, A-6 and A-7 type soils according to the AASHTO method of soil classification. Soils in the Negley series are characterized as very deep, well drained soils formed in loess and the underlying stratified outwash deposits on outwash terraces, kames, eskers, and kame terraces. The Negley series is comprised of both coarse- and fine-grained soils and classifies as A-2, A-4, A-6, and A-7 type soils according to the AASHTO method of soil classification.

2.2. Hydrology/Hydrogeology

Groundwater at the project site can be expected at an elevation consistent with that of the nearby Paint Creek as it is the most dominant hydraulic influence in the vicinity of the project's boundaries. The water level of the Scioto River may be generally representative of the local groundwater table. However, it should

be noted that perched groundwater systems may be existent in areas due to the presence of fine-grained soils making it difficult for groundwater to permeate to the phreatic surface.

The project site is not located within a regulatory flood hazard area area based on available mapping by the Federal Emergency Management Agency's (FEMA) National Flood Hazard mapping program (FEMA, 2016).

2.3. Mining and Oil/Gas Production

No mines are noted on ODNR's Mines of Ohio Locator in the vicinity of the project site (ODNR [1], 2012).

No oil or gas wells are noted on ODNR's Ohio Oil & Gas Locator in the vicinity of the project site (ODNR [2], 2020).

2.4. Historical Records and Previous Phases of Project Exploration

No historical report/plans were available for review and evaluation for this report from ODOTs Transportation Information Mapping System (TIMS).

2.5. Site Reconnaissance

A field reconnaissance visit for the overall project area was conducted on December 2, 2021. Site conditions, including the existing land conditions and pavement conditions, were noted, and photographed during the visit. Photographs of notable features and a summary of our observations are provided below.

2.5.1. Land Use and Cover

The land use of most of the project area consists of CSX Rail ROW (Right of Way), woodland and agricultural land.

2.5.2. CR-222 (Charleston Pike) West of the CSX Railroad

In general, the pavement condition along this project portion of CR-222 was observed to be fair to poor with signs of surface wear. Moderate severity longitudinal and transverse cracking was observed along this section as well as moderate severity wheel track cracking, edge cracking and crack sealing deficiencies (Photograph 1). The roadway from the beginning of the project to about 420 ft west of the CSX railroad sits on a bench cut in a slope running upwards from west to east. The slope is roughly 3H:1V (3 horizontal to 1 vertical). The area of the proposed roadway transitions to be relatively flat from 420 ft west of the CSX railroad to the railroad Right of Way (ROW). The railroad is positioned in a cut below the surrounding land. The existing bridge over the CSX railroad is a 3-span through plate girder bridge with full height wall type abutments and cap and column piers. The existing bridge is planned to be completely replaced when the roadway is realigned, so a more detailed reconnaissance of the bridge was not conducted. The roadway in this section rises from south to north longitudinally. The roadway drains to a drainage ditch to the east and directly off the shoulder down the slope to the west (Photograph 2). A possible natural drainage swale was observed on the slope above the roadway in this area (Photograph 3). The area is moderately vegetated for the most part with no signs of standing water observed. The area appeared to be stable with no signs of geotechnical instability.

Photograph 1: Overall Pavement Condition of CR-222

Photograph 2: Drainage of Roadway West of CSX Railroad

Photograph 3: Possible Drainage Swale East of Roadway

2.5.3. CR-222 (Charleston Pike) East of the CSX Railroad

In general, the pavement condition along the project portion of CR-222 was observed to be similar to the previously described section of roadway. The realigned proposed section of roadway from the CSX railroad to TR-288 sits on a series of rolling slopes that overall rise from south to north (Photograph 4). These slopes are roughly 3H:1V (3 horizontal to one vertical). The area of the proposed roadway transitions to be relatively flat from TR-288 to the eastern end of the project. The roadway rises from southeast to northwest longitudinally. The roadway drains to drainage ditches on either side of the roadway (Photograph 5). The existing culvert near the eastern end of the project was observed to be a flexible metal corrugated pipe culvert in fair to good condition. The area is lightly vegetated for the most part with no signs of standing water observed. The area appeared to be stable with no signs of geotechnical instability.

Photograph 4: Rolling Slopes at Proposed Roadway Realignment Location

Photograph 5: Drainage Ditches on Both Sides of Roadway

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The exploration for this project was conducted by NEAS between December 20, 2021 and January 21, 2022 and included 11 borings drilled to depths of 7.5 to 100.0 ft bgs. The boring locations were selected by NEAS in general accordance with the guidelines contained in the SGE with the intent to evaluate subsurface soil and groundwater conditions. Borings were typically drilled at/near the proposed substructure locations where drilling was were not restricted by maintenance of traffic or underground utilities. Each as-drilled project boring location and corresponding ground surface elevation was surveyed in the field by NEAS following completion. Each individual project boring log (included within Appendix B) includes the recorded boring latitude and longitude location (based on the surveyed Ohio State Plane South, NAD83, location) and the corresponding ground surface elevation. Stationing, offsets and elevations of the borings are shown on Table 1 and the boring locations are depicted the Boring Location Plan provided in Appendix A.

Table 1: Project Boring Summary

Boring Number	Location (Sta/Offset)	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Structure
B-001-0-21	212+74, 11 LT	39.321458	-82.918834	632.4	7.5	Existing Subgrade
B-002-0-21	215+90, 1 LT	39.320685	-82.918347	643.1	10.0	Proposed Roadway Subgrade
B-003-0-21	219+82, 4 RT	39.319951	-82.917341	660.7	10.0	Proposed Roadway Subgrade
B-004-0-21	222+76, 19 RT	39.319585	-82.916408	669.2	100.0	Rear Abutment
B-005-0-21	225+89, 20 LT	39.319382	-82.915326	678.4	90.0	Forward Abutment
B-006-0-21	227+78, 1 LT	39.319139	-82.914727	700.2	25.0	Proposed Roadway Subgrade
B-007-0-21	231+74, 4 RT	39.318490	-82.913614	682.3	10.0	Proposed Roadway Subgrade
B-008-0-21	235+84, 12 RT	39.317733	-82.912539	666.8	10.0	Proposed Roadway Subgrade
B-009-0-21	239+51, 0 CL	39.317334	-82.911334	667.1	24.4	Proposed Roadway Subgrade
B-010-0-21	242+47, 1 LT	39.317322	-82.910290	655.6	7.5	Existing Subgrade
B-011-0-21	244+78, 10 RT	39.317412	-82.909477	657.1	45.0	Proposed Culvert

Notes:
1. As-drilled boring location and corresponding ground surface elevation was surveyed in the field by NEAS, Inc.

Borings were drilled using a CME 55X track mounted drilling rig utilizing 2.75- and/or 3.25-inch diameter hollow stem augers depending on the boring. Soil samples were generally recovered using a split spoon sampler (AASHTO T-206 "Standard Method for Penetration Test and Split Barrel Sampling of Soils.") at 2.5-ft intervals to depths of up to 30 ft bgs at which time samples were recovered at 5.0-ft intervals until the boring termination. Samples collected from the subgrade borings were sampled continuously for subgrade evaluation purposes. The soil samples obtained from the exploration program were visually observed in the field by the NEAS field representative and preserved for review by a Geologist and possible laboratory testing. Standard Penetration Tests (SPT) were conducted using a CME auto hammer that has been calibrated to be 79.7% efficient as indicated on the boring logs. Bedrock was not encountered at the project site.

Field boring logs were prepared by drilling personnel, and included lithological description, SPT results recorded as blows per 6-inch increment of penetration, and estimated unconfined shear strength values on specimens exhibiting cohesion (estimated by means of hand-penetrometer). Groundwater level observations were recorded both during and after the completion of drilling. These groundwater level

observations are included on the individual boring logs. After completing the borings, the boreholes were backfilled with either auger cuttings, bentonite chips, bentonite grout, cement grout, or a combination of these materials and patched with asphalt cold patch and/or quick-set concrete where necessary.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing, grain-size distribution testing, moisture content determinations, and sulfate content determination. Data from the laboratory testing program was incorporated onto the boring logs (Appendix B). Soil samples are retained at the laboratory for 60 days following report submittal, after which time they will be discarded.

3.2.1. Classification Testing

Representative soil samples were selected for index properties (Atterberg Limits) and gradation testing for classification purposes on approximately 30% of the soil samples. At each boring location, samples were selected for testing with the intent of identification and classification of all significant soil units. Soils not selected for testing were compared to laboratory tested samples/strata and classified visually. Moisture content testing was conducted on all samples. The laboratory testing was performed in general accordance with applicable AASHTO specifications.

A final classification of the soil strata was made in accordance with AASHTO M-145 “Classification of Soils and Soil-Aggregate Mixtures for Highway Construction Purposes,” as modified by ODOT “Classification of Soils” once laboratory test results became available. The results of the soil classification are presented on the boring logs in Appendix B.

3.2.2. Standard Penetration Test Results

Standard Penetration Tests and split-barrel (split-spoon) sampling of soils were performed at varying intervals (i.e., continuously, 2.5-ft or 5-ft intervals) in the project borings performed. To account for the high efficiency (automatic) hammers used during SPT sampling, field SPT N-values were converted based on the calibrated efficiency (energy ratio) of the specific drill rig's hammer. Field N-values were converted to an equivalent rod energy of 60% (N_{60}) for use in analysis or for correlation purposes. The resulting N_{60} values are presented on the boring logs provided in Appendix B.

3.2.3. Sulfate Testing

Sulfate testing was generally performed on one sample for each subgrade/roadway boring performed for pavement/subgrade design purposes. The selected samples were tested in accordance with ODOT Supplement 1122, “Determining Sulfate Content in Soils” dated July 17, 2015. In general, the upper most sample (within 3 ft of the proposed subgrade elevation) from each boring was tested when feasible. Testing results are summarized in Table 2 below and presented on the boring logs within Appendix B.

Table 2: Sulfate Test Summary by Boring

Boring ID	Sample	Depth (ft)	Dilution Ratio	Average Sulfate Content (ppm)
B-001-0-21	SS-1	1.5 - 3.0	20	33
B-002-0-21	SS-1	1.0 - 2.5	20	0
B-003-0-21	SS-1	1.0 - 2.5	20	0
B-004-0-21	SS-1	1.0 - 2.5	20	0
B-005-0-21	SS-1	1.0 - 2.5	20	7
B-007-0-21	SS-2	3.5 - 5.0	20	13
B-008-0-21	SS-2	3.5 - 5.0	20	0
B-010-0-21	SS-1	1.5 - 3.0	20	13

4. GEOTECHNICAL FINDINGS

The subsurface conditions encountered during NEAS's explorations are described in the following subsections and on each boring log presented in Appendix B. The boring logs represent NEAS's interpretation of the subsurface conditions encountered at each boring location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project, results of available historical explorations, and consideration of the geological history of the site.

4.1. Existing Pavement

The pavement section thicknesses in terms of asphalt, concrete and granular base were measured at representative project subgrade borings during the subsurface exploration for the project and are recorded on the test boring logs provided in Appendix B. A summary of these measurements is provided in Table 3 below.

Table 3: Measured Pavement Thickness at Boring Locations

Boring ID	Proposed Alignment	Drilled Depth (ft)	Asphalt Thickness (in)	Concrete Thickness (in)	Base Thickness (in)	Total Thickness (in)
B-001-0-21	CR 222	7.5	12.0	0.0	6.0	18.0
B-002-0-21	CR 222	10.0	12.0	0.0	6.0	18.0
B-010-0-21	CR 222	7.5	6.0	0.0	6.0	12.0
B-011-0-21	CR 222	45.0	12.0	0.0	6.0	18.0

4.2. Subsurface Conditions

The subsurface profile at the project site is generally consistent with the geological model for the project in regard to the materials encountered. The subsurface profile within the proposed project area consists of surficial materials comprised of an existing pavement section or topsoil, generally underlain by natural overburden soils generally consisting of predominantly non-cohesive coarse-grained soils comprised of gravel, sand and silt mixtures and minorly cohesive silt and clay mixtures. Bedrock was not encountered within any of the project borings.

4.2.1. Overburden Soil

At the proposed bridge site, one general material was encountered below the surficial existing pavement section. In general, the overburden materials consisted of natural water deposited soils. This material and the general profile is further described below.

Soil visually identified as natural overburden soils comprised predominantly of coarse grained, non-cohesive water deposited soil was encountered in each of the bridge and roadway borings performed at the project site. These soils were encountered immediately below the pavement section/topsoil and extended to depths ranging from 7.5 to 100.0 ft bgs (approximate elevations 675.2 to 569.2 ft amsl). Based on laboratory testing results and a visual review of the soil samples obtained, the soil at the site is generally comprised of primarily non-cohesive gravel, sand and silt mixtures classified as Gravel and Stone Fragments (A-1-a), Gravel with Sand (A-1-b), Gravel with Sand and Silt (A-2-4), Coarse and Fine Sand (A-3a), Sandy Silt (A-4a), and Silt (A-4b). The exception being: 1) boring B-002 in which a sample of cohesive Silty Clay (A-6b) was encountered at a depth of 5.5 ft bgs (approximate elevation 661.3 ft asml); 2) boring B-004 in which a sample of cohesive Silt (A-4b) was encountered at depths of 41.8 ft bgs (approximate elevation 627.4 ft asml); a layer of cohesive Silty Clay (A-6b) was encountered at depths between 76.8 ft and 86.8 ft bgs (approximate elevations between 592.4 ft and 582.4 ft asml); a sample of cohesive Silt (A-4b) was encountered at a depth of 88.5 ft bgs (approximate elevation 580.9 ft asml); and, a sample of cohesive Silt and Clay (A-6a) was encountered at a depth of 96.8 ft bgs (approximate elevation 572.4 ft asml); 3) boring B-008 in which a sample of cohesive Silt and Clay (A-6a) was encountered at a depth 5.5 ft bgs (approximate elevation 661.3 ft asml); and, 4) B-011 in which a sample of cohesive Silt and Clay (A-6a) was encountered at a depth of 10.5 ft bgs (approximate elevation 646.6 ft asml).

With respect to the soil strength of the non-cohesive soils recovered, the soil can be described as having a relative compactness of very loose to very dense correlating to converted SPT-N values (N_{60}) ranging from 0 blows per foot (bpf) to refusal. The natural moisture contents of the granular soils ranged from 3 to 26 percent. With respect to the relative consistency of the cohesive soil recovered, the soil can be described as medium stiff to hard correlating to N_{60} values ranging from 7 to greater than 50 bpf and an unconfined compressive strength (estimated by means of hand penetrometer) ranging from 1.00 tons per square foot (tsf) to 3.5 tsf. Natural moisture contents of the cohesive soils ranged from 20 to 30 percent. Based on Atterberg Limits test performed on representative samples of the cohesive soils, the liquid and plastic limits ranged from 28 to 39 percent and from 16 to 21 percent, respectively.

4.2.2. Groundwater

Groundwater measurements were taken during the boring drilling procedures and immediately following the completion of each borehole. Groundwater was observed during drilling in each bridge and culvert boring performed as part of the referenced exploration while groundwater was not encountered within the existing subgrade borings performed. Based on the project bridge borings, groundwater was encountered at depths ranging from 38.5 to 73.4 ft bgs (approximate elevations 617.1 to 605.0 ft amsl). It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration. The specific groundwater readings are included on the boring logs located within Appendix B.

4.2.3. Bedrock

Bedrock was not encountered in any boring performed at the project site.

5. ANALYSES AND RECOMMENDATIONS

The proposed project improvements include the demolition of the existing structure ROS-CR 222-0383 and construction of a new structure designated as ROS-CO222-04.221 over the CSX railway with the roadway realignment (about 3,400 ft in length). The proposed structure is planned to be a three-span bridge structure on semi-integral type abutments and cap and column type piers supported on deep foundations comprised of friction pipe piles. Furthermore, it is anticipated that the indicated proposed substructure will be supported by the natural subsurface material through the use of a deep foundation system. For this purpose, a deep foundation system analysis was performed at the referenced bridge site. Additionally, as roadway work is also planned as part of the proposed project, an existing subgrade analysis was performed in accordance with ODOT's Geotechnical Bulletin 1 (GB1) to estimate pavement design parameters to be used for design and provide recommendations regarding proposed subgrade stabilization.

Based on the above information in addition to: 1) the soil characteristics gathered during the subsurface exploration (i.e., SPT results, laboratory test results, etc.); 2) the developed generalized soil profile and estimated engineering properties and other design assumptions presented in subsequent sections of this report; and, 3) the preliminary bridge site plan provided by Carpenter Marty Transportation, geotechnical design elements for the new bridge will include:

- Deep Foundation Design
  - Deep Foundation Analysis
  - Pile Drivability
  - Lateral Load Analysis
- Global Stability
- Settlement

The geotechnical engineering analyses were performed in accordance with ODOT's BDM (ODOT, 2021) and AASHTO's LRFD BDS (AASHTO, 2020). Design recommendations are provided in the following sections.

5.1. Soil Profile for Analysis

For analysis purposes, each substructure location (boring log) was reviewed and a generalized material profile was developed for analysis. Utilizing the generalized soil profile, engineering properties for each soil strata were estimated based on their field (i.e., SPT N_{60} values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. The developed soil profile and estimated engineering soil properties (with cited correlation/reference material) used in our analysis is summarized per substructure location (per boring) within Tables 4 and 5, below.

Table 4: Soil Profile and Estimated Engineering Properties (B-004-0-21)

Bridge Over CSX Railroad: Rear Abutment, B-004-0-21				
Soil Description	**Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**
Sandy Silt Elevation (669.2 ft - 663.7 ft)	110	-	-	30
Coarse and Fine Sand Elevation (663.7 ft - 656.2 ft)	108	-	-	29
Coarse and Fine Sand Elevation (656.2 ft - 632.4 ft)	115	-	-	31
Silt Elevation (632.4 ft - 627.4 ft)	122	-	-	27
Silt Elevation (627.4 ft - 624.3 ft)	122	2,400	150	25
Gravel with Sand Elevation (624.3 ft - 607.4 ft)	135	-	-	35
Silt Elevation (607.4 ft - 592.4 ft)	140	-	-	34
Silty Clay Elevation (592.4 ft - 582.4 ft)	135	5,300	250	27
Silt Elevation (582.4 ft - 577.4 ft)	135	5,850	250	28
Silt Elevation (577.4 ft - 572.4 ft)	140	-	-	34
Silt and Clay Elevation (572.4 ft - 569.2 ft)	140	8000	250	28

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

Table 5: Soil Profile and Estimated Engineering Properties (B-005-0-21)

Bridge Over CSX Railroad: Forward Abutment, B-005-0-21				
Soil Description	**Unit Weight[1] (pcf)**	**Undrained Shear Strength[2] (psf)**	**Effective Cohesion[3] (psf)**	**Effective Friction Angle[3] (degrees)**
Sandy Silt Elevation (678.4 ft - 672.9 ft)	112	-	-	32
Coarse and Fine Sand Elevation (672.9 ft - 662.9 ft)	115	-	-	32
Gravel with Sand Elevation (662.9 ft - 650.9 ft)	120	-	-	35
Gravel with Sand Elevation (650.9 ft - 636.6 ft)	130	-	-	37
Coarse and Fine Sand Elevation (636.6 ft - 621.6 ft)	125	-	-	35
Gravel with Sand Elevation (621.6 ft - 616.6 ft)	130	-	-	36
Coarse and Fine Sand Elevation (616.6 ft - 606.6 ft)	125	-	-	34
Gravel with Sand Elevation (606.6 ft - 598.4 ft)	140	-	-	35
Silt Elevation (598.4 ft - 588.4 ft)	132	-	-	30

Notes:
1. *Values interpreted from Geotechnical Bulletin 7 Table 1.*
2. *Values calculated from Terzaghi and Peck (1967) if $N1_{60}$<52, else Stroud and Butler (1975) was used.*
3. *Values interpreted from Geotechnical Bulletin 7 Table 2.*

5.2. Bridge Foundation Analysis and Recommendations

A foundation review was completed for a deep foundation system for the referenced bridge based on the following design information: 1) the Site Plan for Bridge conducted by CMT; and 2) subsequent

conversations with CMT. A driven pile foundation system was evaluated for all the substructure locations. The proposed deep foundation systems will be designed according to LRFD and ODOT BDM criteria. Utilizing the FHWA computer program *Driven*, a static pile analysis was performed to estimate required driven pile lengths needed to achieve the Ultimate Bearing Value (UBV) for a single pile. Input information for the *Driven* program was based on the soil characteristics gathered during the geotechnical exploration (i.e., SPT results, laboratory test results, etc.) and our geotechnical experience. Tables 4 and 5 in Section 5.1. of this report present each soil strata and their engineering properties that were used in the analysis. The summary and results of our deep foundation evaluation are presented in subsequent sections.

5.2.1. Deep Foundation Analysis

Based on the determined soil profile and our estimated engineering soil properties, a pile analysis was performed using the computer program *Driven* to determine the estimated geotechnical pile length at each substructure (*Driven* results included within Appendix C). For the purposes of this report and our analysis, the term 'geotechnical pile length' has been assumed to represent the length of pile from bottom of pile cap (assumed pier cap bearing elevations) to the depth at which the required Ultimate Bearing Value (UBV) is obtained. The EOID is determined due to the potential for soil disturbance caused during pile driving (development of high pore water pressure) near the pile perimeter. This disturbance could cause piles to potentially drive easily or “run” for extended depths and initial driving may not reach the indicated target UBV utilizing the estimated pile lengths. Therefore, it may be necessary to drive the CIP piles to the EOID and then let the piles “set-up” (reduction of pore water pressure in the soils adjacent to the pile) for an established time period based on the material at the substructure and the specific pile size.

The UBV and EOID values are determined in accordance with Section 305.3.2.4 of the ODOT BDM. The UBV is determined by dividing the total factored load for the highest loaded pile at each substructure by the appropriate driven pile resistance factor, while the EOID is determined by subtracting the amount of side resistance expected to gain from soil setup from the UBV value. The amount of side resistance expected to gain from soil setup is taken as the difference between the side resistance obtained in ultimate (post setup) conditions and the side resistance obtained during driving (dynamic) conditions at the determined geotechnical pile length. It is recommended that the piles for the referenced project be installed according to ODOT's Construction and Material Specifications (CMS) 507 and CMS 523, and therefore, a driven pile resistance factor of 0.7 should be used.

The estimated ultimate skin friction (Rs), pile tip bearing values (Rp) and required geotechnical pile length following pile setup for 12-inch and 14-inch diameter CIP piles driven to the respective target EOID resistance for per substructure location are given in Table 6 below (*Driven* results included within Appendix C).

Table 6: Deep Foundation Analysis Summary

Pile Type	Max Pile Reaction - Strength I (kips)	Required Ultimate Bearing Value[2] (kips)	Geotechnical Pile Length[1] (ft)	End of Initial Driving Value[3] (EOID)(kips)	Predicted Pile Length Accounting for Driving Losses (ft)	Pile Length Difference Ultimate vs. Driving Conditions (ft)	Setup Factor for Waiting Time	Wait Time (days)
Rear Abutment, B-004-0-21								
12-inch CIP	190.0	271.4	57.4	262.2	58.5	1.1	1.0	1.0
Pier 1, B-004-0-21								
14-inch CIP	263.6	376.6	51.7	343.4	61.8	10.1	1.1	1.0
Pier 2, B-005-0-21								
14-inch CIP	263.6	376.6	40.0	376.6	40.0	0.0	1.0	1.0
Forward Abutment, B-005-0-21								
12-inch CIP	190.0	271.4	35.0	271.2	35.1	0.1	1.0	1.0

Notes:
1. *The estimated length of pile from bottom of pile cap to the depth which the required UBV is obtained based on ultimate resistances.*
2. *The referenced resistance factor of 0.7 has been applied to Max Pile Reaction.*
3. *The EOID pile resistances per ODOT BDM Equation C305.3.2.4-4 based on driving resistances at the indicated geotechnical pile length.*

The estimated driving resistances at Pier 1 indicate driving losses that would increase the length of the pile during driving by more than 10-ft with EOID compared to the UBV. Therefore, NEAS recommends accounting for pile setup in the design of Pier 1.

5.2.1. Pile Drivability

The maximum UBV for 12-in and 14-in CIP pile are 330 kips and 390 kips, respectively, as listed in Section 305.3.4 of ODOT's 2022 BDM (ODOT, 2022). These maximum UBV values are based on pile drivability using commonly available hammers, and assuming a 0.375 inches pile wall thickness. NEAS's drivability evaluation estimated a Delmag D 19-42 diesel hammer to determine if the 12-inch CIP piles with wall thickness of 0.375 inches and the 14-inch CIP piles with wall thickness of 0.375 inches, would be overstressed at any time during pile installation. Based on the pile drivability results, 12-inch CIP piles with a wall thickness of 0.375 inches at the abutments would not be overstressed for ASTM A 252 Grade 3 steel during the pile installation process, and 14-inch CIP piles with a wall thickness of 0.375 inches at the center piers would not be overstressed for ASTM A 252 Grade 3 steel during the pile installation process. GRLWEAP Results can be found in Appendix C.

It should be noted that the driving resistance of CIP piles through soils encountered at the bridge site is expected to be high. Driveability is difficult to assess quantitatively as the field test results (i.e., SPT N_{60} values, pocket penetrometer values, etc.) tend to be very high. Furthermore, pile driveability is highly reliant upon the specific equipment used in construction; therefore, it is recommended that the contractor provide an analysis to demonstrate that the equipment and pile combination planned for use is capable of obtaining the UBV without over-stressing the piles.

Per the plan notes 606.7-1 of ODOT's 2022 BDM (ODOT, 2022), the maximum rated energy of the hammer used to install the piles shall be (44,000) foot-pounds. Ensure that stresses in the piles during driving do not exceed (45,000) pounds per square inch.

5.2.2. Deep Foundation Recommendations

Based on our evaluation of the subsurface conditions and our geotechnical engineering analysis for the proposed Bridge, it is our opinion that the bridge foundations can be supported on driven friction CIP piles seated within the dense natural glacial till material encountered at the site.

We recommend that a driven pile foundation be used for support for the referenced substructure foundations. CIP piles are recommended to be installed in accordance with Sections 507 and 523 of ODOT's CMS with 12-inch diameter piles installed at the abutments and 14-inch piles installed at the piers. During driving conditions and if driven to the UBVs indicated in Table 6 of this report, it is anticipated that the driven CIP piles would “run” for extended depths at Pier 1 location extending the indicated geotechnical pile lengths by greater than 10 ft. Therefore, it is recommended that the proposed piles at Pier 1 be driven to the full estimated length and pile/soil setup be utilized to achieve the required UBV. It is recommended that plan note 606.7-4 of ODOT’s 2020 BDM “Piles Driven to Full Estimated Length With Pile/Soil Setup” be including on the plans for Pier 1. At Pier 1 location, the first two piles at each substructure should be driven to the full Estimated Length indicated in Table 7 below. After driving and testing the first two piles, drive the remaining piles in the substructure to the same depth as the first two piles. After driving all piles to the estimated length, cease all driving operations at the substructure for a period specified in Table 8. After the specified waiting period, it is recommended that pile driving contractor perform a restrike on both of the first two piles at Pier 1. If the restrike test results indicate that both piles achieved the required UBV, all piles in the substructure may be accepted by the Engineer. If the restrike test results indicate that either of the two piles did not achieve the required UBV, immediately notify the Engineer so that the Engineer

can notify the District Geotechnical Engineer, the Office of Construction Administration, and the Office of Geotechnical Engineering.

When piles are installed in accordance with referenced construction specifications, utilizing the referenced method as specified in the ODOT BDM. CIP piles driven to the indicated UBVs may be used to support a total factored load (single pile) of the calculated result of the UBV multiplied by the driven pile resistance factor of 0.7. It should be noted that if preferred, methods B and C specified in Section 305.3.5.9 of ODOT's 2020 BDM can also be used to establish driving criteria accounting for the anticipated pile/soil setup.

Pile lengths based on: 1) our Deep Foundation Analysis (presented in Section 5.2.1); and, 2) the "Estimated Length" and "Order Length" definitions and formulas presented in Section 305.3.5.2 of the ODOT BDM, are presented in Table 7 below.

Table 7: Estimated Pile Lengths

Pile Type	Bottom of Pile Cap Elevation (ft amsl)	Assumed Pile Cutoff Elevation (ft amsl)	Required UBV per Pile(kips)	Geotechnical Pile Length (ft)	Geotechnical Pile Tip Elevation (ft amsl)	Estimated Pile Length (ft)	Order Length (ft)
Rear Abutment, B-004-0-21							
12-inch CIP	670.3	671.3	271.4	57.4	612.9	60	65
Pier 1, B-004-0-21							
14-inch CIP	651.8	652.8	376.6	51.7	600.1	55	60
Pier 2, B-005-0-21							
14-inch CIP	649.8	650.8	376.6	40.0	609.8	45	50
Forward Abutment, B-005-0-21							
12-inch CIP	677.3	678.3	271.4	35.0	642.3	40	45

The required values in the plan note 606.7-4 "Piles Driven to Full Estimated Length With Pile/Soil Setup" are summarized in Table 8 below.

Table 8: Required Values in Plan Note 606.7-4

Substructure	Pile Type	Required UBV per Pile(kips)	Estimated Pile Length (ft)	Waiting Perid (day)
Pier 1	14-inch CIP	376.6	55	1

5.2.3. Lateral Load Analysis

Deep foundation elements subjected to horizontal loads and/or moments should be analyzed for maximum bending moments and lateral deflections. Since axially loaded piles will require negligible moment, battered piles can be considered to resist the lateral loads. The required lateral load capacity can be obtained by increasing the diameter or the embedment depth of the foundation element. The generalized soil parameters, including recommended lateral soil modulus, and soil strain to be used to analyze the laterally loaded shaft by the p-y curve method using Lpile are presented in Table 9 below.

Based on the email from CMT, the longitudinal lateral loads at the piers are 2.7 kips for Service I Limit State and 2.6 kips for Strength I Limit State and the transverse lateral loads at the piers are 3.9 kips for Service I Limit State and 3.8 kips for Strength I Limit State. The transverse lateral loads, which are bigger than the longitudinal lateral loads, will control the design. The Lpile analyses summary is presented in Table 10 below. As can be seen, the lateral deflection at the pile head is between 0.03 in and 0.06 in and the second fixity point is between 13.2 ft and 18.6 ft below the pile head. Since the second fixity point is shorter than the pile length estimated from the axial direction, the axial load direction will control the pile length design, which is presented in the Table 7 above. The Lpile analysis results are presented in Appendix C.

Table 9: Generalized Soil Parameters for Lateral Load Analysis

p-y Curve Model	Soil Class	Elevation (ft)	Soil Modulus Parameter, k (lb/in^3)	Soil Strain Parameter, E_{50}
B-004-0-21				
Sand (Reese)	A-4a	670.3 - 663.7	46	-
Sand (Reese)	A-3a	663.7 - 656.3	46	-
Sand (Reese)	A-3a	656.3 - 632.45	108	-
Sand (Reese)	A-4b	632.45 - 627.45	26	-
Stiff Clay with Water	A-4b	627.45 - 624.35	833	0.0056
Sand (Reese)	A-1-b	624.35 - 607.45	245	-
Sand (Reese)	A-4b	607.45 - 592.45	177	-
Stiff Clay with Water	A-6b	592.45 - 582.45	1854	0.0040
Stiff Clay with Water	A-4b	582.45 - 577.45	2042	0.0039
Sand (Reese)	A-4b	577.45 - 572.45	177	-
Stiff Clay with Water	A-6a	572.45 - 569.25	3337	0.0034
B-005-0-21				
Sand (Reese)	A-4a	678.4 - 672.9	83	-
Sand (Reese)	A-3a	672.9 - 662.9	140	-
Sand (Reese)	A-1-b	662.9 - 650.9	537	-
Sand (Reese)	A-1-b	650.9 - 636.6	965	-
Sand (Reese)	A-3a	636.6 - 621.6	353	-
Sand (Reese)	A-1-b	621.6 - 616.6	656	-
Sand (Reese)	A-3a	616.6 - 606.6	226	-
Sand (Reese)	A-1-b	606.6 - 598.4	285	-
Sand (Reese)	A-4b	598.4 - 588.4	69	-

Table 10: Lpile Analysis Summary

Location	Maximum Moment in Pile - Strength Limit State (in-lbs)	Depth of Maximum Bending Moment below Pile Head (ft)	Maximum Shear in Pile - Strength Limit State (lbs)	Depth of Maximum Shear Force below Pile Head (ft)	Pile Head Deflection - Service Limit State (in)	First Fixity Point below Pile Head (ft)	Second Fixity Point below Pile Head (ft)
Pier 1	127,122	4.1	3,800	0.0	0.06	8.3	18.6
Pier 2	102,904	3.6	3,800	0.0	0.03	6.4	13.2

5.2.4. Global Stability Analysis

For purposes of evaluating the stability of the ROS-CO222-04.221 bridge abutments, NEAS developed representative profile models to use as the basis for global stability analyses. The models were developed from NEAS's interpretation of the available information which included: 1) Bridge ROS-CO222-04.221 site plan profile views provided to NEAS via email on March 11, 2022; 2) a live load surcharge of 250 psf accounting for traffic induced loads; and, 3) test borings and laboratory data developed as part of this project. With respect to the soil's engineering properties, the provided generalized soil profiles and estimated engineering properties presented in Section 5.1. of this report were used in our analysis as indicated.

The above referenced global stability models were analyzed for long-term (Effective Stress) and short-term (Total Stress) slope stability utilizing the software entitled Slide 7.0 by Rocscience, Inc. Specifically, the Bishop simplified, Spencer, and GLE/Morgenstern-Price analysis methods were used to calculate a factor of safety (FOS) for circular type slope failures. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.5 which equates to an AASHTO resistance factor of less than 0.65 (per AASHTO's LRFD BDS, the specified resistance factors are essentially the inverse of the FOS that should be targeted in slope stability programs). For this analysis, a resistance factor of 0.65 or lower is targeted.

Based on our slope stability analyses for the referenced bridge abutments, the minimum slope stability safety factor for short-term (Total Stress) and long-term (Effective Stress) conditions exceeded the desired

value of 1.54. The results of the analyses are summarized in Table 11. Based on the results of the analyses, it is our opinion that the subsurface conditions encountered at this location are generally satisfactory and the site can be considered to be stable at short-term and long-term condition. The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) is presented in Appendix D.

Table 11: Global Stability Analysis Summary

Global Stability Analsysis					
Location	**Boring No.**	**Description**	**Minimum Factor of Safety**	**Equivalent Resistance Factor**	**Status (OK/NG)**
Rear Abutment	B-004-0-21	Short Term	2.24	0.45	OK
		Long Term	1.70	0.59	OK
Forward Abutment	B-005-0-21	Short Term	1.53	0.65	OK
		Long Term	2.18	0.46	OK

5.2.5. Settlement

The planned bridge abutments are supported on full height semi-integral abutments founded on piles behind which there will be about 13.8 and 12.3 feet of new fill at the rear and forward abutments, respectively. In order to estimate the maximum total and differential settlement that could result within the subsurface soils supporting the proposed semi-integral abutments, NEAS reviewed: 1) the proposed Bridge Site Plan prepared by Carpenter Marty; 2) Service Limit State loading conditions; and, 3) test borings and laboratory data developed as part of this report. Utilizing this information and the software entitled FoSSA 2.0 by ADAMA Engineering, Inc., settlement models were developed and analyzed for both elastic (immediate) and consolidation (long term) settlement.

Based on our analysis the ground surface at the rear abutment is estimated to experience about 4.8 inches of immediate settlement and 0.2 inches of long-term (consolidation) settlement from the induced loads associated with the 13.8-ft high embankment. The ground surface at the forward abutment is estimated to experience about 4.0 inches of immediate settlement from the induced loads associated with the 12.3-ft high embankment. The settlement analysis results can be found in Appendix E. The immediate settlement is expected to take place during construction prior to bridge loading and is not anticipated to be a concern; however, it is anticipated that majority of the long-term settlement will take place following embankment construction. Since the long term settlement is less than 0.4 inches and the embankment fill at the abutment locations will be carried by the abutments, the surcharge loads will then be transferred from the abutments to the piles; therefore, it is our opinion that the piles will not be subjected to downdrag loads.

5.3. Subgrade Analysis and Recommendations

A subgrade analysis was performed to identify the method, location and dimensions (including depth) of subgrade stabilization for the proposed full depth pavement replacement and roadway realignment within the project limits. In addition to identifying stabilization recommendations, pavement design parameters are also determined to aid in pavement section design. The subgrade analysis was performed in accordance with ODOT's GB1 criteria utilizing the ODOT provided *GB1: Subgrade Analysis Spreadsheet* (GB1_SubgradeAnalysis.xls, Version 14.6 dated February 11, 2022). The subsections below present the results of our GB1 analysis including pavement design parameters and unsuitable/unstable subgrade conditions identified within the project limits. GB1 analysis spreadsheet is provided in Appendix F.

It should be noted that for the purposes of this report and our analysis, the term ' proposed subgrade' has been assumed to represent soils and/or soil conditions from 1.5 ft below proposed final pavement grades to a depth of 7.5 ft below the proposed pavement grades.

5.3.1. Pavement Design Recommendations

It is our understanding a pavement analysis is to be performed to determine the design pavement section for the roadway segment to undergo full depth replacement and realignment within the project limits. A GB1 analysis was performed using ODOT's *GB1: Subgrade Analysis Spreadsheet* as indicated above. Input information for the spreadsheet was based on the subgrade soil data obtained during our field exploration program. The subgrade analysis parameters recommended for use in pavement design are presented in Table 12 below. Provided in the table are ranges of maximum, minimum and average N_{60L} values as well as design CBR value recommended for use in pavement design.

Table 12: Pavement Design Values

Segment	Maximum N_{60L}	Minimum N_{60L}	Average N_{60L}	Average PI Values	Design CBR
CR 222	21	3	12	17	10

5.3.2. Unsuitable Subgrade

Per ODOT's GB1, the presence of select materials within the subgrade zone is prohibited for new pavement construction and will require some form of remediation. These prohibited subgrade materials generally include the presence of rock and specific soil types. With respect to the planned roadway work for the specific project conditions, these subgrade conditions are identified in the subsequent sections.

5.3.2.1. Prohibited Soils

Prohibited soil types per the GB1, which include A-4b, A-2-5, A-5, A-7-5, A-8a, A-8b, and soils with liquid limits greater than 65, were encountered within the subgrade in one (1) of the borings (B-001-0-21) performed within the project limits, as listed in Table 13 below. Soil classifying as Silt (A-4b) was encountered within the entire depth of the subgrade. Per ODOT's GB1, if A-4b soil is encountered within the top 3 ft of the subgrade it is to be removed or chemically stabilized. If the prohibited material is to be removed, it should be excavated to 3 ft below top of subgrade and replaced with Item 204 Embankment, unless the subgrade is to be chemically stabilized to a depth of 14 inches, in which case the A-4b soil may not have to be removed.

Table 13: Summary of Prohibited Soils

Boring ID	Prohibited Soil Type	Depth Below Subgrade (ft)	Remediation Depth (inches)	
			Excavate and Replace (Item 204 w/ Geotextile)	Chemical Stabilization (Item 206)
CR 2222				
B-001-0-21	A-4b	0.0- 4.3	36	14

5.3.3. Unstable Subgrade

Per ODOT's GB1, the presence of select subgrade conditions within the top 3 ft of subgrade indicate an unstable subgrade and requires stabilization beyond typical subgrade compaction practices. Subgrade stabilization depths are recommended per *Figure B - Subgrade Stabilization* within the GB1 for soils in which: 1) the lowest N_{60} value (N_{60L}) at the referenced boring location is less than or equal to 12 bpf; 2) the

average hand penetrometer value is less than or equal to 1.5 tsf; or, 3) the soil has either an N_{60L} less than or equal to 15 bpf or an average hand penetrometer value of 1.875 tsf where the moisture content is greater than optimum plus 3 percent as per *Figure A – Optimum Moisture Content* within the GB1. Based on N_{60L} and hand penetrometer values, our GB1 analysis suggests the need for either 14 inches of chemical stabilization or 21 inches of excavate and replace at (1) of the boring locations (B-008-0-21). A summary of the boring locations where unstable subgrade conditions were encountered and the associated GB1 recommended remediation depths are shown in Table 14 below.

Table 14: Summary of Unstable Subgrade

Boring ID	Average HP (tsf)	N_{60}	Moisture Above Optimum (%)	Depth Below Subgrade (ft)	Remediation Depth (inches)		
					Excavate and Replace (Item 204 w/ Geotextile)	Excavate and Replace (Item 204 w/ Geogrid - SS 861)	Chemical Stabilization (Item 206)
CR 222							
B-008-0-21	-	5	4	0.0 - 0.4	21	-	12
B-008-0-21	-	3	8	1.4 - 2.9	21	-	12

5.3.4. Stabilization Requirements

Based on the results of our analysis, subgrade soils designated by ODOT's GB1 as both "unsuitable" and "unstable" were present at two locations throughout the project. Subgrade soils designated as "unsuitable" consisted of soils classifying as A-4b were encountered in boring B-001-0-21 (Station 212+74). It is recommended that a minimum of 36 inches of Excavate and Replace (Item 204) with Geotextile be performed from Station 212+50 (approx. beginning of proposed pavement) extending to Station 214+32 (approx. midpoint between B-001-0-21 and B-002-0-21) where suitable soil is expected to be encountered. Subgrade soils designated as "unstable" were encountered in boring B-008-0-21 (Station 235+84). It is recommended that a minimum of 21 inches of Excavate and Replace (Item 204) with Geotextile be performed from Station 233+79 (approx. midpoint between B-007-0-21 and B-008-0-21) extending to Station 237+68 (approx. midpoint between B-008-0-21 and B-009-0-21) where stable soil is expected to be encountered. NEAS recommends spot stabilization using excavate and replace stabilization for the CR222. Our recommended limits for indicated project stabilization are provided in Table 15 below.

Table 15: Stabilization Recommendations

Start Station	End Station	Excavate and Replace w/ Item 204[(1)] (inches)	Unsuitable Subgrade Conditions	Borings Considered
CR 222				
Begin Project	214+32	36	A-4b (Silt)	B-001-0-21
233+79	237+68	21	N/A	B-008-0-21

Excavations are estimated to extend to a depth as indicated above with the excavated material being replaced with Item 204 - Granular Material Type B or C and underlain with Item 204 Geotextile Fabric. In areas where underdrains are to be provided, Item 204 - Granular Material Type B should be used as replacement material. Stabilization limits should extend 18-inches beyond the edge of the proposed paved roadway, shoulder or median.

6. QUALIFICATIONS

This investigation was performed in accordance with accepted geotechnical engineering practice for the purpose of characterizing the subsurface conditions at the site of Bridge ROS-CO222-04.221 carrying CR-222 over the CSX railway. This draft report has been prepared for CMT, ODOT and their design consultants

to be used solely in evaluating the soils underlying the bridge sites and presenting geotechnical engineering recommendations specific to this project. The assessment of general site environmental conditions or the presence of pollutants in the soil, rock and groundwater of the site was beyond the scope of this geotechnical exploration. Our recommendations are based on the results of our field explorations, laboratory test results from representative soil samples, and geotechnical engineering analyses. The results of the field explorations and laboratory tests, which form the basis of our recommendations, are presented in the appendices as noted. This report does not reflect any variations that may occur between the borings or elsewhere on the site, or variations whose nature and extent may not become evident until a later stage of construction. In the event that any change in the nature, design or location of the proposed bridge replacement project is made, the conclusions and recommendations contained in this preliminary report should not be considered valid until they are reviewed, and have been modified or verified in writing by a geotechnical engineer.

It has been a pleasure to be of service to CMT in performing this geotechnical exploration for the ROS-CR222-0383 project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

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APPENDIX A

BORING LOCATION PLAN

P:\21-0053 (106544 ROS-CR222-0383)\106544\admin\contracts\Geotech Fee Proposal\Target Boring Plan\ROS-CR222-0383 Target Boring Plan Alternative 4.dgn 11/30/2021 6:10:59 PM che

1 / 1	ROS-CR222-0383	BRIDGE ROS-CR222-0383 ON C.R. 222 TARGET BORING PLAN - ALTERNATIVE 4	DRAWN CH CHECKED	0 100 50 200 HORIZONTAL SCALE IN FEET	N

APPENDIX B

SOIL BORING LOGS

PROJECT: ROS-CR222-3.83
TYPE: SUBGRADE
PID: 106544 SFN:
START: 12/20/21 END: 12/20/21

DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT
SAMPLING FIRM / LOGGER: NEAS / E. BEYER
DRILLING METHOD: 2.75" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55X W
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 3/12/20
ENERGY RATIO (%): 79.7

STATION / OFFSET: 212+74, 11' LT.
ALIGNMENT: CR-222
ELEVATION: 632.4 (MSL) EOB: 7.5 ft.
LAT / LONG: 39.321458, -82.918834

EXPLORATION ID B-001-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 632.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
12.0" ASPHALT AND 6.0" BASE (DRILLERS DESCRIPTION)	630.9																		
MEDIUM DENSE TO DENSE, BROWN, **SILT**, TRACE TO LITTLE SAND, TRACE CLAY, TRACE GRAVEL, CONTAINS TRACE IRON STAINING, WET		1 2 3 4 5 6 7	9 12 14	35	83	SS-1	-	2	1	7	85	5	NP	NP	NP	23	A-4b (8)	33	
			6 12 14	35	61	SS-2	-	-	-	-	-	-	-	-	-	21	A-4b (V)	-	
			4 6 23	39	100	SS-3	-	0	3	13	78	6	NP	NP	NP	23	A-4b (8)	-	
	624.9	EOB	6 6 7	17	56	SS-4	-	-	-	-	-	-	-	-	-	20	A-4b (V)	-	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

PROJECT: ROS-CR222-3.83	DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT	DRILL RIG: CME 55X W	STATION / OFFSET: 215+90, 1' LT.
TYPE: EMBANKMENT	SAMPLING FIRM / LOGGER: NEAS / E. BEYER	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-222
PID: 106544 SFN:	DRILLING METHOD: 2.75" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 643.1 (MSL) EOB: 10.0 ft.
START: 12/20/21 END: 12/20/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.320685, -82.918347

EXPLORATION ID B-002-0-21

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
12.0" ASPHALT AND 6.0" BASE (DRILLERS DESCRIPTION)	643.1																		
	641.6																		
MEDIUM DENSE, BROWN, **SANDY SILT**, TRACE TO LITTLE CLAY, TRACE GRAVEL, MOIST TO DAMP		1	6 6 4	13	72	SS-1	-	2	10	45	31	12	NP	NP	NP	15	A-4a (2)	0	
		2																	
		3																	
		4	5 5 5	13	100	SS-2	-	-	-	-	-	-	-	-	-	7	A-4a (V)	-	
	637.6	5																	
STIFF, BROWN MOTTLED WITH ORANGISH BROWN AND GRAY, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST		6	3 3 4	9	100	SS-3	1.75	7	11	6	44	32	39	21	18	29	A-6b (11)	-	
	635.1	7																	
MEDIUM DENSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, DAMP		8																	
		9	7 7 7	19	100	SS-4	-	-	-	-	-	-	-	-	-	7	A-4a (V)	-	
	633.1	EOB 10																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

PROJECT: ROS-CR222-3.83	DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT	DRILL RIG: CME 55X W	STATION / OFFSET: 219+82, 4' RT.
TYPE: EMBANKMENT	SAMPLING FIRM / LOGGER: NEAS / E. BEYER	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-222
PID: 106544 SFN:	DRILLING METHOD: 2.75" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 660.7 (MSL) EOB: 10.0 ft.
START: 1/21/22 END: 1/21/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.319951, -82.917341

EXPLORATION ID B-003-0-21

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
8.0" TOPSOIL (DRILLERS DESCRIPTION)	660.0																		
LOOSE, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST TO WET	660.7	1	2 2 2	5	100	SS-1	-	1	15	48	25	11	NP	NP	NP	16	A-4a (0)	0	
		2																	
		3																	
		4	3 3 3	8	100	SS-2	-	-	-	-	-	-	-	-	-	17	A-4a (V)	-	
		5																	
		6																	
		7	3 3 3	8	100	SS-3	-	-	-	-	-	-	-	-	-	20	A-4a (V)	-	
	652.7	8																	
LOOSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE GRAVEL, TRACE CLAY, DAMP	650.7	9	3 3 4	9	100	SS-4	-	4	11	59	24	2	NP	NP	NP	10	A-3a (0)	-	
		EOB 10																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: ROS-CR222-3.83
TYPE: BRIDGE
PID: 106544 SFN:
START: 12/27/21 END: 1/21/22

DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT
SAMPLING FIRM / LOGGER: NEAS / E. BEYER
DRILLING METHOD: 4.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55X W
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 3/12/20
ENERGY RATIO (%): 79.7

STATION / OFFSET: 222+76, 19' RT.
ALIGNMENT: CR-222
ELEVATION: 669.2 (MSL) EOB: 100.0 ft.
LAT / LONG: 39.319585, -82.916408

EXPLORATION ID B-004-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
LOOSE, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST	669.2		3 3 4	9	100	SS-1	-	1	10	53	18	18	NP	NP	NP	16	A-4a (0)	0	
			1 2 3	7	100	SS-2	-	-	-	-	-	-	-	-	-	21	A-4a (V)	-	
VERY LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE TO LITTLE GRAVEL, TRACE CLAY, MOIST TO DAMP	663.7		1 1 1	3	89	SS-3	-	5	19	54	17	5	NP	NP	NP	13	A-3a (0)	-	
			0 1 2	4	89	SS-4	-	-	-	-	-	-	-	-	-	9	A-3a (V)	-	
			3 4 3	9	67	SS-5	-	-	-	-	-	-	-	-	-	5	A-3a (V)	-	
			10 8 6	19	83	SS-6	-	-	-	-	-	-	-	-	-	6	A-3a (V)	-	
			6 6 8	19	56	SS-7	-	-	-	-	-	-	-	-	-	7	A-3a (V)	-	
			4 4 5	12	100	SS-8	-	-	-	-	-	-	-	-	-	9	A-3a (V)	-	
			3 4 4	11	78	SS-9	-	-	-	-	-	-	-	-	-	9	A-3a (V)	-	
			6 6 8	19	100	SS-10	-	-	-	-	-	-	-	-	-	6	A-3a (V)	-	
			6 6 8	19	100	SS-11	-	-	-	-	-	-	-	-	-	7	A-3a (V)	-	
			4 5 11	21	100	SS-12	-	-	-	-	-	-	-	-	-	8	A-3a (V)	-	
			6 10 12	29	89	SS-13	-	-	-	-	-	-	-	-	-	7	A-3a (V)	-	
MEDIUM DENSE, BROWN, **SILT**, LITTLE SAND, LITTLE CLAY, TRACE GRAVEL, WET	632.4	W 630.7	1 2 6	11	94	SS-14	-	0	0	14	74	12	NP	NP	NP	22	A-4b (8)	-	
MEDIUM STIFF TO STIFF, BROWN, **SILT**, SOME CLAY, LITTLE SAND, TRACE GRAVEL, MOIST	627.4		9 9 6	20	100	SS-15	1.00	2	4	12	54	28	28	18	10	24	A-4b (8)	-	
VERY DENSE, BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, DAMP TO MOIST	624.3		16 24 28	69	83	SS-16	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	-	
			21 22 24	61	61	SS-17	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	-	
			12 16 23	52	56	SS-18	-	-	-	-	-	-	-	-	-	15	A-1-b (V)	-	

PID: 106544	SFN:	PROJECT: ROS-CR222-3.83	STATION / OFFSET: 222+76, 19' RT.	START: 12/27/21	END: 1/21/22	PG 2 OF 2	B-004-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
VERY DENSE, BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, DAMP TO MOIST *(continued)*	609.2																		
VERY DENSE, BROWN BECOMING GRAY, **SILT**, LITTLE TO SOME SAND, TRACE CLAY, TRACE GRAVEL, WET	607.4		15 22 35	76	67	SS-19	-	0	0	23	71	6	NP	NP	NP	25	A-4b (8)	-	
			45 50/5"	-	164	SS-20	-	-	-	-	-	-	-	-	-	23	A-4b (V)	-	
			40 50/2"	-	100	SS-21	-	-	-	-	-	-	-	-	-	23	A-4b (V)	-	
STIFF TO VERY STIFF, GRAY, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, MOIST	592.4		8 10 17	36	100	SS-22	1.75	1	0	7	46	46	38	21	17	26	A-6b (11)	-	
			13 16 24	53	100	SS-23	2.25	-	-	-	-	-	-	-	-	30	A-6b (V)	-	
VERY STIFF, GRAY, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST	582.4		4 12 25	49	100	SS-24	3.50	0	0	2	64	34	29	20	9	24	A-4b (8)	-	
VERY DENSE, GRAY, **SILT**, LITTLE SAND, TRACE CLAY, TRACE GRAVEL, WET	577.4		14 27 50/5"	-	100	SS-25	-	-	-	-	-	-	-	-	-	33	A-4b (V)	-	
STIFF TO VERY STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST	572.4		7 27 38	86	100	SS-26	2.00	0	0	1	68	31	30	18	12	24	A-6a (9)	-	
	569.2	EOB																	

NOTES: GROUNDWATER ENCOUNTERED AT 38.5' DURING DRILLING. HOLE CAVE IN AT 44.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 140 GAL. BENTONITE GROUT

PROJECT: ROS-CR222-3.83
TYPE: BRIDGE
PID: 106544 SFN:
START: 12/22/21 END: 12/23/21

DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT
SAMPLING FIRM / LOGGER: NEAS / E. BEYER
DRILLING METHOD: 4.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55X W
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 3/12/20
ENERGY RATIO (%): 79.7

STATION / OFFSET: 225+89, 20' LT.
ALIGNMENT: CR-222
ELEVATION: 678.4 (MSL) EOB: 90.0 ft.
LAT / LONG: 39.319382, -82.915326

EXPLORATION ID B-005-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 678.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
LOOSE TO MEDIUM DENSE, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST TO DAMP	672.9	1–4	2 3 4	9	100	SS-1	-	0	3	58	19	20	NP	NP	NP	17	A-4a (1)	7	
		3–8	3 4 8	16	100	SS-2	-	-	-	-	-	-	-	-	-	10	A-4a (V)	-	
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE TO LITTLE GRAVEL, TRACE CLAY, DRY TO DAMP	662.9	6–7	6 5 4	12	100	SS-3	-	5	25	49	18	3	NP	NP	NP	4	A-3a (0)	-	
		8–10	3 5 7	16	100	SS-4	-	-	-	-	-	-	-	-	-	4	A-3a (V)	-	
		11–12	3 5 6	15	100	SS-5	-	-	-	-	-	-	-	-	-	4	A-3a (V)	-	
		13–15	7 7 8	20	67	SS-6	-	-	-	-	-	-	-	-	-	5	A-3a (V)	-	
MEDIUM DENSE TO VERY DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DRY TO DAMP	636.6	16–17	11 14 20	45	56	SS-7	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	-	
		18–20	7 8 10	24	83	SS-8	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	-	
		21–22	19 19 19	50	100	SS-9	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	-	
		23–25	11 14 15	39	100	SS-10	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	-	
		26–27	22 22 22	58	100	SS-11	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	-	
		28–30	12 30 35	86	89	SS-12	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	-	
		31–34	18 30 36	88	100	SS-13	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	-	
		35–39	9 30 29	78	100	SS-14	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	-	
VERY DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, DRY	621.6	40–44	16 29 28	76	100	SS-15	-	10	14	62	13	1	NP	NP	NP	4	A-3a (0)	-	
		45–49	14 18 28	61	89	SS-16	-	-	-	-	-	-	-	-	-	3	A-3a (V)	-	
		50–54	13 19 24	57	100	SS-17	-	-	-	-	-	-	-	-	-	4	A-3a (V)	-	
VERY DENSE, BROWN AND GRAY, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP		55–59	30 31 36	89	100	SS-18	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	-	

PID: 106544	SFN:	PROJECT: ROS-CR222-3.83	STATION / OFFSET: 225+89, 20' LT.	START: 12/22/21	END: 12/23/21	PG 2 OF 2	B-005-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
VERY DENSE, BROWN AND GRAY, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP *(continued)*	618.4																		
	616.6																		
DENSE TO VERY DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE GRAVEL, TRACE CLAY, DAMP		61 62 63 64 65	15 13 15	37	100	SS-19	-	-	-	-	-	-	-	-	-	10	A-3a (V)	-	
@68.5'; BECOMES WET		66 67 68 69 70	7 18 41	78	100	SS-20	-	-	-	-	-	-	-	-	-	17	A-3a (V)	-	
	606.6	71 72																	
VERY DENSE, BROWN AND GRAY, **STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, WET		W 605.0 73 74	43 50/3"	-	100	SS-21	-	-	-	-	-	-	-	-	-	13	A-1-b (V)	-	
	598.4	75 76 77 78 79 80 81 82 83 84 85 86 87 88																	
VERY DENSE, GRAY, **SILT**, LITTLE CLAY, TRACE SAND, TRACE GRAVEL, WET		89	15 17 23	53	100	SS-22	-	0	0	2	86	12	NP	NP	NP	24	A-4b (8)	-	
	588.4	EOB 90																	

NOTES: GROUNDWATER ENCOUNTERED AT 73.4' DURING DRILLING. HOLE CAVE IN AT 42.5'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 160 GAL. BENTONITE GROUT

PROJECT: ROS-CR222-3.83	DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT	DRILL RIG: CME 55X W	STATION / OFFSET: 227+78, 1' LT.
TYPE: CUT SECTION	SAMPLING FIRM / LOGGER: NEAS / E. BEYER	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-222
PID: 106544 SFN:	DRILLING METHOD: 2.75" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 700.2 (MSL) EOB: 25.0 ft.
START: 12/21/21 END: 12/21/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.319139, -82.914727

EXPLORATION ID B-006-0-21

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MATERIAL DESCRIPTION AND NOTES	ELEV. 700.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, CONTAINS ROOTS, DAMP	697.2	1	3 4 5	12	61	SS-1	-	-	-	-	-	-	-	-	-	16	A-2-4 (V)	-	
MEDIUM DENSE TO DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	684.7	5	4 4 6	13	56	SS-2	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	-	
		10	5 10 14	32	100	SS-3	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	-	
		15	13 13 18	41	89	SS-4	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	-	
		20	11 13 13	35	100	SS-5	-	20	35	36	8	1	-	-	-	8	A-1-b (V)	-	
		25	6 7 9	21	100	SS-6	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	-	
VERY DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS**, SOME TO "AND" SAND, TRACE TO LITTLE SILT, TRACE CLAY, DAMP	675.2	30	12 21 20	54	100	SS-7	-	51	26	10	12	1	NP	NP	NP	6	A-1-a (0)	-	
		35	17 22 26	64	100	SS-8	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	-	
		40	14 18 23	54	100	SS-9	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	-	
EOB		45	17 21 24	60	100	SS-10	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	-	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: ROS-CR222-3.83	DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT	DRILL RIG: CME 55X W	STATION / OFFSET: 231+74, 4' RT.
TYPE: CUT SECTION	SAMPLING FIRM / LOGGER: NEAS / E. BEYER	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-222
PID: 106544 SFN:	DRILLING METHOD: 2.75" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 682.3 (MSL) EOB: 10.0 ft.
START: 12/21/21 END: 12/21/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.318490, -82.913614

EXPLORATION ID B-007-0-21

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
6.0" TOPSOIL (DRILLERS DESCRIPTION)	682.3 681.8																		
VERY LOOSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, MOIST	679.3	1 2	2 1 2	4	72	SS-1	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	-	
MEDIUM DENSE, BROWN, **GRAVEL**, SOME SAND, TRACE SILT, TRACE CLAY, DAMP	676.8	3 4 5	3 5 7	16	56	SS-2	-	58	25	7	9	1	NP	NP	NP	5	A-1-a (0)	13	
DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, POSSIBLE ENCOUNTER WITH SHALE COBBLE OR BOULDER, DAMP	674.3	6 7 8	6 17 17	45	100	SS-3	-	39	25	10	19	7	NP	NP	NP	8	A-2-4 (0)	-	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	672.3	9 EOB 10	6 9 12	28	100	SS-4	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	-	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: ROS-CR222-3.83	DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT	DRILL RIG: CME 55X W	STATION / OFFSET: 235+84, 12' RT.
TYPE: CUT SECTION	SAMPLING FIRM / LOGGER: NEAS / E. BEYER	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-222
PID: 106544 SFN:	DRILLING METHOD: 2.75" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 666.8 (MSL) EOB: 10.0 ft.
START: 12/21/21 END: 12/21/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.317733, -82.912539

EXPLORATION ID B-008-0-21

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
6.0" TOPSOIL (DRILLERS DESCRIPTION)	666.8																		
	666.3																		
VERY LOOSE TO LOOSE, BROWN, **SANDY SILT**, TRACE TO LITTLE CLAY, TRACE GRAVEL, WET TO MOIST		1	3 3 1	5	67	SS-1	-	-	-	-	-	-	-	-	-	14	A-4a (V)	-	
		2																	
		3																	
		4	1 1 1	3	100	SS-2	-	0	10	50	29	11	NP	NP	NP	19	A-4a (1)	0	
	661.3	5																	
STIFF, BROWN, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, MOIST		6	1 2 3	7	100	SS-3	1.25	3	7	33	36	21	31	16	15	20	A-6a (6)	-	
	658.8	7																	
LOOSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, MOIST		8																	
		9	2 2 2	5	100	SS-4	-	-	-	-	-	-	-	-	-	12	A-4a (V)	-	
	656.8	EOB 10																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: ROS-CR222-3.83	DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT	DRILL RIG: CME 55X W	STATION / OFFSET: 239+51, RT.
TYPE: CUT SECTION	SAMPLING FIRM / LOGGER: NEAS / E. BEYER	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-222
PID: 106544 SFN:	DRILLING METHOD: 2.75" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 667.1 (MSL) EOB: 24.4 ft.
START: 12/21/21 END: 12/21/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.317334, -82.911334

EXPLORATION ID B-009-0-21

PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
8.0" TOPSOIL (DRILLERS DESCRIPTION)	667.1 666.4																		
LOOSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, CONTAINS ROOTS, MOIST	664.1	1	3 3 4	9	100	SS-1	-	-	-	-	-	-	-	-	-	17	A-4a (V)	-	
MEDIUM DENSE TO DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE TO LITTLE SILT, TRACE CLAY, DAMP		2 3 4	3 3 5	11	83	SS-2	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	-	
		5 6	8 8 9	23	67	SS-3	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	-	
		7 8	7 9 9	24	100	SS-4	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	-	
	654.1	9 10	5 11 15	35	67	SS-5	-	42	31	12	12	3	NP	NP	NP	4	A-1-b (0)	-	
MEDIUM DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, DAMP	651.6	11 12 13	4 7 7	19	78	SS-6	-	25	27	20	25	3	NP	NP	NP	8	A-2-4 (0)	-	
MEDIUM DENSE TO VERY DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, DAMP		14 15	9 14 14	37	33	SS-7	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	-	
		16 17 18	8 9 12	28	56	SS-8	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	-	
		19 20	14 21 22	57	100	SS-9	-	41	21	29	8	1	NP	NP	NP	5	A-1-b (0)	-	
	642.7	21 22 23	30 50/5"	-	91	SS-10	-	27	48	15	9	1	NP	NP	NP	3	A-1-b (0)	-	
		EOB 24																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE CAVE IN AT 11.2'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: POURED 2 BAGS HOLE PLUG; SHOVELED SOIL CUTTINGS

STANDARD ODOT LOG W/ SULFATES (8.5 X 11) - OH DOT.GDT - 3/11/22 13:05 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\ROS-CR222-3.83\GINT FILES\ROS-CR-222.GPJ

PROJECT: ROS-CR222-3.83	DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT	DRILL RIG: CME 55X W	STATION / OFFSET: 242+47, 1' LT.
TYPE: SUBGRADE	SAMPLING FIRM / LOGGER: NEAS / E. BEYER	HAMMER: CME AUTOMATIC	ALIGNMENT: CR-222
PID: 106544 SFN:	DRILLING METHOD: 2.75" HSA	CALIBRATION DATE: 3/12/20	ELEVATION: 655.6 (MSL) EOB: 7.5 ft.
START: 12/21/21 END: 12/21/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 79.7	LAT / LONG: 39.317322, -82.910290

EXPLORATION ID B-010-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	BACK FILL
6.0" ASPHALT AND 6.0" BASE (DRILLERS DESCRIPTION)	655.6																		
	654.6																		
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP TO MOIST		1	6 7 8	20	56	SS-1	-	26	28	17	19	10	NP	NP	NP	9	A-2-4 (0)	13	
		2																	
		3	4 4 4	11	100	SS-2	-	-	-	-	-	-	-	-	-	13	A-2-4 (V)	-	
	651.1	4																	
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, TRACE GRAVEL, MOIST		5	4 6 12	24	100	SS-3	-	4	14	49	27	6	NP	NP	NP	11	A-3a (0)	-	
		6	10 10 7	23	100	SS-4	-	-	-	-	-	-	-	-	-	10	A-3a (V)	-	
	648.1	7 EOB																	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

PROJECT: ROS-CR222-3.83
TYPE: CULVERT
PID: 106544 SFN:
START: 12/20/21 END: 12/20/21

DRILLING FIRM / OPERATOR: WRIGHT / B. WRIGHT
SAMPLING FIRM / LOGGER: NEAS / E. BEYER
DRILLING METHOD: 4.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55X W
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 3/12/20
ENERGY RATIO (%): 79.7

STATION / OFFSET: 244+78, 10' RT.
ALIGNMENT: CR-222
ELEVATION: 657.1 (MSL) EOB: 45.0 ft.
LAT / LONG: 39.317412, -82.909477

EXPLORATION ID B-011-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 657.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	SO4 ppm	HOLE SEALED
12.0" ASPHALT AND 6.0" BASE (DRILLERS DESCRIPTION)	655.6																		
MEDIUM DENSE TO DENSE, BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP	652.6		7 20 15	46	100	SS-1	-	25	20	28	22	5	-	-	-	7	A-2-4 (V)	-	
			10 6 8	19	100	SS-2	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	-	
LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE TO LITTLE CLAY, TRACE GRAVEL, MOIST TO WET	646.6		4 4 5	12	89	SS-3	-	0	5	63	24	8	-	-	-	12	A-3a (V)	-	
			2 4 3	9	100	SS-4	-	3	9	58	13	17	NP	NP	NP	23	A-3a (0)	-	
			2 2 2	5	100	SS-5	-	-	-	-	-	-	-	-	-	21	A-3a (V)	-	
VERY STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	644.1		2 2 3	7	100	SS-6	2.75	2	7	12	45	34	32	19	13	23	A-6a (9)	-	
VERY LOOSE TO LOOSE, BROWN AND ORANGISH BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE GRAVEL, TRACE CLAY, CONTAINS IRON STAINING, DAMP TO WET			0 1 1	3	100	SS-7	-	-	-	-	-	-	-	-	-	7	A-3a (V)	-	
			0 0 0	0	100	SS-8	-	-	-	-	-	-	-	-	-	26	A-3a (V)	-	
			0 0 0	0	100	SS-9	-	-	-	-	-	-	-	-	-	11	A-3a (V)	-	
			1 1 5	8	100	SS-10	-	-	-	-	-	-	-	-	-	9	A-3a (V)	-	
@23.5'; SS-11 BECOMES MEDIUM DENSE			6 8 9	23	100	SS-11	-	-	-	-	-	-	-	-	-	9	A-3a (V)	-	
@26.0'; SS-12 BECOMES VERY DENSE	629.1		12 22 22	58	17	SS-12	-	-	-	-	-	-	-	-	-	6	A-3a (V)	-	
MEDIUM DENSE TO DENSE, BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, DAMP			6 13 22	46	100	SS-13	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	-	
			9 12 8	27	56	SS-14	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	-	
@38.5'; BECOMES WET	▽ 618.3		1 5 9	19	100	SS-15	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	-	
	W 617.1																		
	612.1	EOB	12 12 12	32	100	SS-16	-	-	-	-	-	-	-	-	-	23	A-1-b (V)	-	

NOTES: GROUNDWATER ENCOUNTERED AT 40.0' DURING DRILLING, 38.8' AT COMPLETION. HOLE CAVE IN AT 22.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 100 GAL. BENTONITE GROUT

OHIO DEPARTMENT OF TRANSPORTATION

DETERMINING SULFATE CONTENT IN SOILS

SUPPLEMENT 1122

Project C-R-S:	ROS-CR222-3.83
PID No:	106544
Report Date:	3/11/2022
Consultant:	NEAS Inc.
Technician:	L. Rosenbeck

Boring ID & Sample #	Station	Offset	Latitude & Longitude or State Plane Coordinates		Elevation	Soaking Time (hr)	Replicate Sample Readings						Sulfate Content (ppm)
							1		2		3		
							Dilution	Reading	Dilution	Reading	Dilution	Reading	
B-001-0-21 SS-1	21274	11L	39.32145807	-82.91883446	632.43	16.5	20	1	20	2	20	2	**33**
B-002-0-21 SS-1	21590	1L	39.32068453	-82.91834665	643.142	21.5	20	0	20	0	20	0	**0**
B-003-0-21 SS-1	21982	4R	39.31995088	-82.91734119	660.74	18.2	20	0	20	0	20	0	**0**
B-004-0-21 SS-1	22276	19R	39.31958534	-82.91640782	669.225	18.2	20	0	20	0	20	0	**0**
B-005-0-21 SS-1	22589	20L	39.31938192	-82.91532594	678.448	18.2	20	1	20	0	20	0	**7**
B-007-0-21 SS-2	23174	4R	39.31848953	-82.91361392	682.285	21.5	20	1	20	0	20	1	**13**
B-008-0-21 SS-2	23584	12R	39.31773303	-82.91253853	666.779	21.5	20	0	20	0	20	0	**0**
B-010-0-21 SS-1	24247	1L	39.31732245	-82.91028986	655.567	21.5	20	1	20	0	20	1	**13**

APPENDIX C

DEEP FOUNDATION ANALYSIS

DRIVEN ANALYSES

Rear Abutment

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: U:\RAB4.DVN
Project Name: ROS-CR222
Project Date: 03/01/2022
Project Client: Carpenter Marty
Computed By: ZM
Project Manager: CH

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	39.50 ft
	- Driving/Restrike	39.50 ft
	- Ultimate:	39.50 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	6.55 ft	17.00%	110.00 pcf	30.0/30.0	Nordlund
2	Cohesionless	7.50 ft	0.00%	108.00 pcf	29.0/29.0	Nordlund
3	Cohesionless	23.80 ft	0.00%	115.00 pcf	31.0/31.0	Nordlund
4	Cohesionless	5.00 ft	33.00%	122.00 pcf	27.0/27.0	Nordlund
5	Cohesive	3.10 ft	33.00%	122.00 pcf	2400.00 psf	T-80 Same
6	Cohesionless	16.90 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund
7	Cohesionless	15.00 ft	33.00%	140.00 pcf	34.0/34.0	Nordlund
8	Cohesive	10.00 ft	43.00%	135.00 pcf	5300.00 psf	T-80 Same
9	Cohesive	5.00 ft	33.00%	135.00 pcf	5850.00 psf	T-80 Same
10	Cohesionless	5.00 ft	33.00%	140.00 pcf	34.0/34.0	Nordlund
11	Cohesive	3.20 ft	33.00%	140.00 pcf	8000.00 psf	T-80 Same

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.55 psf	17.64	N/A	0.00 Kips
6.54 ft	Cohesionless	359.70 psf	17.64	N/A	2.03 Kips
6.56 ft	Cohesionless	721.04 psf	17.05	N/A	2.05 Kips
14.04 ft	Cohesionless	1124.96 psf	17.05	N/A	8.80 Kips
14.06 ft	Cohesionless	1531.08 psf	18.23	N/A	8.83 Kips
23.06 ft	Cohesionless	2048.57 psf	18.23	N/A	26.68 Kips
32.06 ft	Cohesionless	2566.07 psf	18.23	N/A	53.56 Kips
37.84 ft	Cohesionless	2898.43 psf	18.23	N/A	75.58 Kips
37.86 ft	Cohesionless	4268.11 psf	15.88	N/A	75.65 Kips
39.49 ft	Cohesionless	4367.54 psf	15.88	N/A	80.49 Kips
39.51 ft	Cohesionless	4469.10 psf	15.88	N/A	80.55 Kips
42.84 ft	Cohesionless	4568.33 psf	15.88	N/A	90.91 Kips
42.86 ft	Cohesive	N/A	N/A	1168.78 psf	90.98 Kips
45.94 ft	Cohesive	N/A	N/A	1168.78 psf	102.29 Kips
45.96 ft	Cohesionless	4853.58 psf	20.58	N/A	102.39 Kips
54.96 ft	Cohesionless	5180.28 psf	20.58	N/A	167.45 Kips
62.84 ft	Cohesionless	5466.33 psf	20.58	N/A	231.14 Kips
62.86 ft	Cohesionless	6080.55 psf	19.99	N/A	231.30 Kips
71.86 ft	Cohesionless	6429.75 psf	19.99	N/A	305.79 Kips
77.84 ft	Cohesionless	6661.77 psf	19.99	N/A	359.76 Kips
77.86 ft	Cohesive	N/A	N/A	1261.40 psf	359.89 Kips
86.86 ft	Cohesive	N/A	N/A	1261.40 psf	395.55 Kips
87.84 ft	Cohesive	N/A	N/A	1261.40 psf	399.44 Kips
87.86 ft	Cohesive	N/A	N/A	1392.30 psf	399.52 Kips
92.84 ft	Cohesive	N/A	N/A	1392.30 psf	421.30 Kips
92.86 ft	Cohesionless	8333.55 psf	19.99	N/A	421.45 Kips
97.84 ft	Cohesionless	8526.77 psf	19.99	N/A	476.11 Kips
97.86 ft	Cohesive	N/A	N/A	1904.00 psf	476.29 Kips
101.04 ft	Cohesive	N/A	N/A	1904.00 psf	495.31 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.10 psf	30.00	10.46 Kips	0.02 Kips
6.54 ft	Cohesionless	719.40 psf	30.00	10.46 Kips	9.83 Kips
6.56 ft	Cohesionless	721.58 psf	26.40	10.46 Kips	8.35 Kips
14.04 ft	Cohesionless	1529.42 psf	26.40	10.46 Kips	10.46 Kips
14.06 ft	Cohesionless	1531.65 psf	35.20	16.23 Kips	16.23 Kips
23.06 ft	Cohesionless	2566.65 psf	35.20	16.23 Kips	16.23 Kips
32.06 ft	Cohesionless	3601.65 psf	35.20	16.23 Kips	16.23 Kips
37.84 ft	Cohesionless	4266.35 psf	35.20	16.23 Kips	16.23 Kips
37.86 ft	Cohesionless	4268.72 psf	19.80	10.46 Kips	10.46 Kips
39.49 ft	Cohesionless	4467.58 psf	19.80	10.46 Kips	10.46 Kips
39.51 ft	Cohesionless	4469.40 psf	19.80	10.46 Kips	10.46 Kips
42.84 ft	Cohesionless	4667.86 psf	19.80	10.46 Kips	10.46 Kips
42.86 ft	Cohesive	N/A	N/A	N/A	16.96 Kips
45.94 ft	Cohesive	N/A	N/A	N/A	16.96 Kips
45.96 ft	Cohesionless	4853.95 psf	64.00	84.51 Kips	84.51 Kips
54.96 ft	Cohesionless	5507.35 psf	64.00	84.51 Kips	84.51 Kips
62.84 ft	Cohesionless	6079.43 psf	64.00	84.51 Kips	84.51 Kips
62.86 ft	Cohesionless	6080.94 psf	55.60	57.74 Kips	57.74 Kips
71.86 ft	Cohesionless	6779.34 psf	55.60	57.74 Kips	57.74 Kips
77.84 ft	Cohesionless	7243.38 psf	55.60	57.74 Kips	57.74 Kips
77.86 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
86.86 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
87.84 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
87.86 ft	Cohesive	N/A	N/A	N/A	41.35 Kips
92.84 ft	Cohesive	N/A	N/A	N/A	41.35 Kips
92.86 ft	Cohesionless	8333.94 psf	55.60	57.74 Kips	57.74 Kips
97.84 ft	Cohesionless	8720.38 psf	55.60	57.74 Kips	57.74 Kips
97.86 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
101.04 ft	Cohesive	N/A	N/A	N/A	56.55 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.02 Kips	0.02 Kips
6.54 ft	2.03 Kips	9.83 Kips	11.87 Kips
6.56 ft	2.05 Kips	8.35 Kips	10.40 Kips
14.04 ft	8.80 Kips	10.46 Kips	19.26 Kips
14.06 ft	8.83 Kips	16.23 Kips	25.06 Kips
23.06 ft	26.68 Kips	16.23 Kips	42.91 Kips
32.06 ft	53.56 Kips	16.23 Kips	69.79 Kips
37.84 ft	75.58 Kips	16.23 Kips	91.81 Kips
37.86 ft	75.65 Kips	10.46 Kips	86.11 Kips
39.49 ft	80.49 Kips	10.46 Kips	90.96 Kips
39.51 ft	80.55 Kips	10.46 Kips	91.02 Kips
42.84 ft	90.91 Kips	10.46 Kips	101.37 Kips
42.86 ft	90.98 Kips	16.96 Kips	107.95 Kips
45.94 ft	102.29 Kips	16.96 Kips	119.25 Kips
45.96 ft	102.39 Kips	84.51 Kips	186.90 Kips
54.96 ft	167.45 Kips	84.51 Kips	251.95 Kips
62.84 ft	231.14 Kips	84.51 Kips	315.65 Kips
62.86 ft	231.30 Kips	57.74 Kips	289.04 Kips
71.86 ft	305.79 Kips	57.74 Kips	363.53 Kips
77.84 ft	359.76 Kips	57.74 Kips	417.50 Kips
77.86 ft	359.89 Kips	37.46 Kips	397.35 Kips
86.86 ft	395.55 Kips	37.46 Kips	433.02 Kips
87.84 ft	399.44 Kips	37.46 Kips	436.90 Kips
87.86 ft	399.52 Kips	41.35 Kips	440.87 Kips
92.84 ft	421.30 Kips	41.35 Kips	462.65 Kips
92.86 ft	421.45 Kips	57.74 Kips	479.20 Kips
97.84 ft	476.11 Kips	57.74 Kips	533.86 Kips
97.86 ft	476.29 Kips	56.55 Kips	532.83 Kips
101.04 ft	495.31 Kips	56.55 Kips	551.86 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.55 psf	17.64	N/A	0.00 Kips
6.54 ft	Cohesionless	359.70 psf	17.64	N/A	1.69 Kips
6.56 ft	Cohesionless	721.04 psf	17.05	N/A	1.70 Kips
14.04 ft	Cohesionless	1124.96 psf	17.05	N/A	8.45 Kips
14.06 ft	Cohesionless	1531.08 psf	18.23	N/A	8.48 Kips
23.06 ft	Cohesionless	2048.57 psf	18.23	N/A	26.34 Kips
32.06 ft	Cohesionless	2566.07 psf	18.23	N/A	53.21 Kips
37.84 ft	Cohesionless	2898.43 psf	18.23	N/A	75.23 Kips
37.86 ft	Cohesionless	4268.11 psf	15.88	N/A	75.28 Kips
39.49 ft	Cohesionless	4367.54 psf	15.88	N/A	78.53 Kips
39.51 ft	Cohesionless	4469.10 psf	15.88	N/A	78.57 Kips
42.84 ft	Cohesionless	4568.33 psf	15.88	N/A	85.51 Kips
42.86 ft	Cohesive	N/A	N/A	1168.78 psf	85.55 Kips
45.94 ft	Cohesive	N/A	N/A	1168.78 psf	93.13 Kips
45.96 ft	Cohesionless	4853.58 psf	20.58	N/A	93.23 Kips
54.96 ft	Cohesionless	5180.28 psf	20.58	N/A	158.28 Kips
62.84 ft	Cohesionless	5466.33 psf	20.58	N/A	221.98 Kips
62.86 ft	Cohesionless	6080.55 psf	19.99	N/A	222.09 Kips
71.86 ft	Cohesionless	6429.75 psf	19.99	N/A	271.99 Kips
77.84 ft	Cohesionless	6661.77 psf	19.99	N/A	308.15 Kips
77.86 ft	Cohesive	N/A	N/A	1261.40 psf	308.23 Kips
86.86 ft	Cohesive	N/A	N/A	1261.40 psf	328.56 Kips
87.84 ft	Cohesive	N/A	N/A	1261.40 psf	330.77 Kips
87.86 ft	Cohesive	N/A	N/A	1392.30 psf	330.82 Kips
92.84 ft	Cohesive	N/A	N/A	1392.30 psf	345.42 Kips
92.86 ft	Cohesionless	8333.55 psf	19.99	N/A	345.52 Kips
97.84 ft	Cohesionless	8526.77 psf	19.99	N/A	382.14 Kips
97.86 ft	Cohesive	N/A	N/A	1904.00 psf	382.26 Kips
101.04 ft	Cohesive	N/A	N/A	1904.00 psf	395.00 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.10 psf	30.00	10.46 Kips	0.02 Kips
6.54 ft	Cohesionless	719.40 psf	30.00	10.46 Kips	9.83 Kips
6.56 ft	Cohesionless	721.58 psf	26.40	10.46 Kips	8.35 Kips
14.04 ft	Cohesionless	1529.42 psf	26.40	10.46 Kips	10.46 Kips
14.06 ft	Cohesionless	1531.65 psf	35.20	16.23 Kips	16.23 Kips
23.06 ft	Cohesionless	2566.65 psf	35.20	16.23 Kips	16.23 Kips
32.06 ft	Cohesionless	3601.65 psf	35.20	16.23 Kips	16.23 Kips
37.84 ft	Cohesionless	4266.35 psf	35.20	16.23 Kips	16.23 Kips
37.86 ft	Cohesionless	4268.72 psf	19.80	10.46 Kips	10.46 Kips
39.49 ft	Cohesionless	4467.58 psf	19.80	10.46 Kips	10.46 Kips
39.51 ft	Cohesionless	4469.40 psf	19.80	10.46 Kips	10.46 Kips
42.84 ft	Cohesionless	4667.86 psf	19.80	10.46 Kips	10.46 Kips
42.86 ft	Cohesive	N/A	N/A	N/A	16.96 Kips
45.94 ft	Cohesive	N/A	N/A	N/A	16.96 Kips
45.96 ft	Cohesionless	4853.95 psf	64.00	84.51 Kips	84.51 Kips
54.96 ft	Cohesionless	5507.35 psf	64.00	84.51 Kips	84.51 Kips
62.84 ft	Cohesionless	6079.43 psf	64.00	84.51 Kips	84.51 Kips
62.86 ft	Cohesionless	6080.94 psf	55.60	57.74 Kips	57.74 Kips
71.86 ft	Cohesionless	6779.34 psf	55.60	57.74 Kips	57.74 Kips
77.84 ft	Cohesionless	7243.38 psf	55.60	57.74 Kips	57.74 Kips
77.86 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
86.86 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
87.84 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
87.86 ft	Cohesive	N/A	N/A	N/A	41.35 Kips
92.84 ft	Cohesive	N/A	N/A	N/A	41.35 Kips
92.86 ft	Cohesionless	8333.94 psf	55.60	57.74 Kips	57.74 Kips
97.84 ft	Cohesionless	8720.38 psf	55.60	57.74 Kips	57.74 Kips
97.86 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
101.04 ft	Cohesive	N/A	N/A	N/A	56.55 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.02 Kips	0.02 Kips
6.54 ft	1.69 Kips	9.83 Kips	11.52 Kips
6.56 ft	1.70 Kips	8.35 Kips	10.05 Kips
14.04 ft	8.45 Kips	10.46 Kips	18.91 Kips
14.06 ft	8.48 Kips	16.23 Kips	24.71 Kips
23.06 ft	26.34 Kips	16.23 Kips	42.57 Kips
32.06 ft	53.21 Kips	16.23 Kips	69.44 Kips
37.84 ft	75.23 Kips	16.23 Kips	91.46 Kips
37.86 ft	75.28 Kips	10.46 Kips	85.74 Kips
39.49 ft	78.53 Kips	10.46 Kips	88.99 Kips
39.51 ft	78.57 Kips	10.46 Kips	89.03 Kips
42.84 ft	85.51 Kips	10.46 Kips	95.97 Kips
42.86 ft	85.55 Kips	16.96 Kips	102.52 Kips
45.94 ft	93.13 Kips	16.96 Kips	110.09 Kips
45.96 ft	93.23 Kips	84.51 Kips	177.74 Kips
54.96 ft	158.28 Kips	84.51 Kips	242.79 Kips
62.84 ft	221.98 Kips	84.51 Kips	306.48 Kips
62.86 ft	222.09 Kips	57.74 Kips	279.83 Kips
71.86 ft	271.99 Kips	57.74 Kips	329.73 Kips
77.84 ft	308.15 Kips	57.74 Kips	365.89 Kips
77.86 ft	308.23 Kips	37.46 Kips	345.69 Kips
86.86 ft	328.56 Kips	37.46 Kips	366.02 Kips
87.84 ft	330.77 Kips	37.46 Kips	368.23 Kips
87.86 ft	330.82 Kips	41.35 Kips	372.18 Kips
92.84 ft	345.42 Kips	41.35 Kips	386.77 Kips
92.86 ft	345.52 Kips	57.74 Kips	403.26 Kips
97.84 ft	382.14 Kips	57.74 Kips	439.88 Kips
97.86 ft	382.26 Kips	56.55 Kips	438.81 Kips
101.04 ft	395.00 Kips	56.55 Kips	451.55 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.55 psf	17.64	N/A	0.00 Kips
6.54 ft	Cohesionless	359.70 psf	17.64	N/A	2.03 Kips
6.56 ft	Cohesionless	721.04 psf	17.05	N/A	2.05 Kips
14.04 ft	Cohesionless	1124.96 psf	17.05	N/A	8.80 Kips
14.06 ft	Cohesionless	1531.08 psf	18.23	N/A	8.83 Kips
23.06 ft	Cohesionless	2048.57 psf	18.23	N/A	26.68 Kips
32.06 ft	Cohesionless	2566.07 psf	18.23	N/A	53.56 Kips
37.84 ft	Cohesionless	2898.43 psf	18.23	N/A	75.58 Kips
37.86 ft	Cohesionless	4268.11 psf	15.88	N/A	75.65 Kips
39.49 ft	Cohesionless	4367.54 psf	15.88	N/A	80.49 Kips
39.51 ft	Cohesionless	4469.10 psf	15.88	N/A	80.55 Kips
42.84 ft	Cohesionless	4568.33 psf	15.88	N/A	90.91 Kips
42.86 ft	Cohesive	N/A	N/A	1168.78 psf	90.98 Kips
45.94 ft	Cohesive	N/A	N/A	1168.78 psf	102.29 Kips
45.96 ft	Cohesionless	4853.58 psf	20.58	N/A	102.39 Kips
54.96 ft	Cohesionless	5180.28 psf	20.58	N/A	167.45 Kips
62.84 ft	Cohesionless	5466.33 psf	20.58	N/A	231.14 Kips
62.86 ft	Cohesionless	6080.55 psf	19.99	N/A	231.30 Kips
71.86 ft	Cohesionless	6429.75 psf	19.99	N/A	305.79 Kips
77.84 ft	Cohesionless	6661.77 psf	19.99	N/A	359.76 Kips
77.86 ft	Cohesive	N/A	N/A	1261.40 psf	359.89 Kips
86.86 ft	Cohesive	N/A	N/A	1261.40 psf	395.55 Kips
87.84 ft	Cohesive	N/A	N/A	1261.40 psf	399.44 Kips
87.86 ft	Cohesive	N/A	N/A	1392.30 psf	399.52 Kips
92.84 ft	Cohesive	N/A	N/A	1392.30 psf	421.30 Kips
92.86 ft	Cohesionless	8333.55 psf	19.99	N/A	421.45 Kips
97.84 ft	Cohesionless	8526.77 psf	19.99	N/A	476.11 Kips
97.86 ft	Cohesive	N/A	N/A	1904.00 psf	476.29 Kips
101.04 ft	Cohesive	N/A	N/A	1904.00 psf	495.31 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.10 psf	30.00	10.46 Kips	0.02 Kips
6.54 ft	Cohesionless	719.40 psf	30.00	10.46 Kips	9.83 Kips
6.56 ft	Cohesionless	721.58 psf	26.40	10.46 Kips	8.35 Kips
14.04 ft	Cohesionless	1529.42 psf	26.40	10.46 Kips	10.46 Kips
14.06 ft	Cohesionless	1531.65 psf	35.20	16.23 Kips	16.23 Kips
23.06 ft	Cohesionless	2566.65 psf	35.20	16.23 Kips	16.23 Kips
32.06 ft	Cohesionless	3601.65 psf	35.20	16.23 Kips	16.23 Kips
37.84 ft	Cohesionless	4266.35 psf	35.20	16.23 Kips	16.23 Kips
37.86 ft	Cohesionless	4268.72 psf	19.80	10.46 Kips	10.46 Kips
39.49 ft	Cohesionless	4467.58 psf	19.80	10.46 Kips	10.46 Kips
39.51 ft	Cohesionless	4469.40 psf	19.80	10.46 Kips	10.46 Kips
42.84 ft	Cohesionless	4667.86 psf	19.80	10.46 Kips	10.46 Kips
42.86 ft	Cohesive	N/A	N/A	N/A	16.96 Kips
45.94 ft	Cohesive	N/A	N/A	N/A	16.96 Kips
45.96 ft	Cohesionless	4853.95 psf	64.00	84.51 Kips	84.51 Kips
54.96 ft	Cohesionless	5507.35 psf	64.00	84.51 Kips	84.51 Kips
62.84 ft	Cohesionless	6079.43 psf	64.00	84.51 Kips	84.51 Kips
62.86 ft	Cohesionless	6080.94 psf	55.60	57.74 Kips	57.74 Kips
71.86 ft	Cohesionless	6779.34 psf	55.60	57.74 Kips	57.74 Kips
77.84 ft	Cohesionless	7243.38 psf	55.60	57.74 Kips	57.74 Kips
77.86 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
86.86 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
87.84 ft	Cohesive	N/A	N/A	N/A	37.46 Kips
87.86 ft	Cohesive	N/A	N/A	N/A	41.35 Kips
92.84 ft	Cohesive	N/A	N/A	N/A	41.35 Kips
92.86 ft	Cohesionless	8333.94 psf	55.60	57.74 Kips	57.74 Kips
97.84 ft	Cohesionless	8720.38 psf	55.60	57.74 Kips	57.74 Kips
97.86 ft	Cohesive	N/A	N/A	N/A	56.55 Kips
101.04 ft	Cohesive	N/A	N/A	N/A	56.55 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.02 Kips	0.02 Kips
6.54 ft	2.03 Kips	9.83 Kips	11.87 Kips
6.56 ft	2.05 Kips	8.35 Kips	10.40 Kips
14.04 ft	8.80 Kips	10.46 Kips	19.26 Kips
14.06 ft	8.83 Kips	16.23 Kips	25.06 Kips
23.06 ft	26.68 Kips	16.23 Kips	42.91 Kips
32.06 ft	53.56 Kips	16.23 Kips	69.79 Kips
37.84 ft	75.58 Kips	16.23 Kips	91.81 Kips
37.86 ft	75.65 Kips	10.46 Kips	86.11 Kips
39.49 ft	80.49 Kips	10.46 Kips	90.96 Kips
39.51 ft	80.55 Kips	10.46 Kips	91.02 Kips
42.84 ft	90.91 Kips	10.46 Kips	101.37 Kips
42.86 ft	90.98 Kips	16.96 Kips	107.95 Kips
45.94 ft	102.29 Kips	16.96 Kips	119.25 Kips
45.96 ft	102.39 Kips	84.51 Kips	186.90 Kips
54.96 ft	167.45 Kips	84.51 Kips	251.95 Kips
62.84 ft	231.14 Kips	84.51 Kips	315.65 Kips
62.86 ft	231.30 Kips	57.74 Kips	289.04 Kips
71.86 ft	305.79 Kips	57.74 Kips	363.53 Kips
77.84 ft	359.76 Kips	57.74 Kips	417.50 Kips
77.86 ft	359.89 Kips	37.46 Kips	397.35 Kips
86.86 ft	395.55 Kips	37.46 Kips	433.02 Kips
87.84 ft	399.44 Kips	37.46 Kips	436.90 Kips
87.86 ft	399.52 Kips	41.35 Kips	440.87 Kips
92.84 ft	421.30 Kips	41.35 Kips	462.65 Kips
92.86 ft	421.45 Kips	57.74 Kips	479.20 Kips
97.84 ft	476.11 Kips	57.74 Kips	533.86 Kips
97.86 ft	476.29 Kips	56.55 Kips	532.83 Kips
101.04 ft	495.31 Kips	56.55 Kips	551.86 Kips

Pier 1

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\PROGRA~1\DRIVEN\ROS-CR~1\RP1B4G.DVN
Project Name: ROS-CR222 Project Date: 11/23/2022
Project Client: Carpenter Marty
Computed By: ZM
Project Manager: CH

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 7.08 ft
Diameter of Pile: 14.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	26.88 ft
	- Driving/Restrike	26.88 ft
	- Ultimate:	26.88 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	2.58 ft	0.00%	108.00 pcf	29.0/29.0	Nordlund
2	Cohesionless	23.85 ft	0.00%	115.00 pcf	31.0/31.0	Nordlund
3	Cohesionless	5.00 ft	33.00%	122.00 pcf	27.0/27.0	Nordlund
4	Cohesive	3.10 ft	33.00%	122.00 pcf	2400.00 psf	T-80 Same
5	Cohesionless	16.90 ft	0.00%	135.00 pcf	35.0/35.0	Nordlund
6	Cohesionless	15.00 ft	33.00%	140.00 pcf	34.0/34.0	Nordlund
7	Cohesive	10.00 ft	43.00%	135.00 pcf	5300.00 psf	T-80 Same
8	Cohesive	5.00 ft	33.00%	135.00 pcf	5850.00 psf	T-80 Same
9	Cohesionless	5.00 ft	33.00%	140.00 pcf	34.0/34.0	Nordlund
10	Cohesive	3.20 ft	33.00%	140.00 pcf	8000.00 psf	T-80 Same

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
2.57 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
2.59 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.07 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.08 ft	Cohesionless	796.14 psf	20.66	N/A	0.00 Kips
11.59 ft	Cohesionless	1055.46 psf	20.66	N/A	6.70 Kips
20.59 ft	Cohesionless	1572.96 psf	20.66	N/A	29.91 Kips
26.42 ft	Cohesionless	1908.19 psf	20.66	N/A	51.94 Kips
26.44 ft	Cohesionless	3022.00 psf	18.00	N/A	52.01 Kips
26.87 ft	Cohesionless	3048.23 psf	18.00	N/A	53.28 Kips
26.89 ft	Cohesionless	3076.59 psf	18.00	N/A	53.34 Kips
31.42 ft	Cohesionless	3211.58 psf	18.00	N/A	67.45 Kips
31.44 ft	Cohesive	N/A	N/A	1168.78 psf	67.52 Kips
34.52 ft	Cohesive	N/A	N/A	1168.78 psf	80.72 Kips
34.54 ft	Cohesionless	3532.59 psf	23.33	N/A	80.83 Kips
43.54 ft	Cohesionless	3859.29 psf	23.33	N/A	153.00 Kips
51.42 ft	Cohesionless	4145.34 psf	23.33	N/A	226.21 Kips
51.44 ft	Cohesionless	4759.56 psf	22.66	N/A	226.40 Kips
60.44 ft	Cohesionless	5108.76 psf	22.66	N/A	314.01 Kips
66.42 ft	Cohesionless	5340.78 psf	22.66	N/A	378.84 Kips
66.44 ft	Cohesive	N/A	N/A	1261.40 psf	379.00 Kips
75.44 ft	Cohesive	N/A	N/A	1261.40 psf	420.61 Kips
76.42 ft	Cohesive	N/A	N/A	1261.40 psf	425.14 Kips
76.44 ft	Cohesive	N/A	N/A	1392.30 psf	425.23 Kips
81.42 ft	Cohesive	N/A	N/A	1392.30 psf	450.65 Kips
81.44 ft	Cohesionless	7012.56 psf	22.66	N/A	450.83 Kips
86.42 ft	Cohesionless	7205.78 psf	22.66	N/A	519.20 Kips
86.44 ft	Cohesive	N/A	N/A	1904.00 psf	519.42 Kips
89.62 ft	Cohesive	N/A	N/A	1904.00 psf	541.61 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	26.40	14.24 Kips	0.00 Kips
2.57 ft	Cohesionless	0.00 psf	26.40	14.24 Kips	0.00 Kips
2.59 ft	Cohesionless	0.00 psf	35.20	22.09 Kips	0.00 Kips
7.07 ft	Cohesionless	0.00 psf	35.20	22.09 Kips	0.00 Kips
7.08 ft	Cohesionless	796.14 psf	35.20	22.09 Kips	18.06 Kips
11.59 ft	Cohesionless	1314.79 psf	35.20	22.09 Kips	22.09 Kips
20.59 ft	Cohesionless	2349.79 psf	35.20	22.09 Kips	22.09 Kips
26.42 ft	Cohesionless	3020.24 psf	35.20	22.09 Kips	22.09 Kips
26.44 ft	Cohesionless	3022.61 psf	19.80	14.24 Kips	14.24 Kips
26.87 ft	Cohesionless	3075.07 psf	19.80	14.24 Kips	14.24 Kips
26.89 ft	Cohesionless	3076.89 psf	19.80	14.24 Kips	14.24 Kips
31.42 ft	Cohesionless	3346.87 psf	19.80	14.24 Kips	14.24 Kips
31.44 ft	Cohesive	N/A	N/A	N/A	23.09 Kips
34.52 ft	Cohesive	N/A	N/A	N/A	23.09 Kips
34.54 ft	Cohesionless	3532.96 psf	64.00	115.03 Kips	115.03 Kips
43.54 ft	Cohesionless	4186.36 psf	64.00	115.03 Kips	115.03 Kips
51.42 ft	Cohesionless	4758.44 psf	64.00	115.03 Kips	115.03 Kips
51.44 ft	Cohesionless	4759.95 psf	55.60	78.59 Kips	78.59 Kips
60.44 ft	Cohesionless	5458.35 psf	55.60	78.59 Kips	78.59 Kips
66.42 ft	Cohesionless	5922.39 psf	55.60	78.59 Kips	78.59 Kips
66.44 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
75.44 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
76.42 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
76.44 ft	Cohesive	N/A	N/A	N/A	56.28 Kips
81.42 ft	Cohesive	N/A	N/A	N/A	56.28 Kips
81.44 ft	Cohesionless	7012.95 psf	55.60	78.59 Kips	78.59 Kips
86.42 ft	Cohesionless	7399.39 psf	55.60	78.59 Kips	78.59 Kips
86.44 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
89.62 ft	Cohesive	N/A	N/A	N/A	76.97 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
2.57 ft	0.00 Kips	0.00 Kips	0.00 Kips
2.59 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.07 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.08 ft	0.00 Kips	18.06 Kips	18.06 Kips
11.59 ft	6.70 Kips	22.09 Kips	28.79 Kips
20.59 ft	29.91 Kips	22.09 Kips	52.00 Kips
26.42 ft	51.94 Kips	22.09 Kips	74.03 Kips
26.44 ft	52.01 Kips	14.24 Kips	66.25 Kips
26.87 ft	53.28 Kips	14.24 Kips	67.52 Kips
26.89 ft	53.34 Kips	14.24 Kips	67.58 Kips
31.42 ft	67.45 Kips	14.24 Kips	81.69 Kips
31.44 ft	67.52 Kips	23.09 Kips	90.62 Kips
34.52 ft	80.72 Kips	23.09 Kips	103.81 Kips
34.54 ft	80.83 Kips	115.03 Kips	195.86 Kips
43.54 ft	153.00 Kips	115.03 Kips	268.02 Kips
51.42 ft	226.21 Kips	115.03 Kips	341.23 Kips
51.44 ft	226.40 Kips	78.59 Kips	304.99 Kips
60.44 ft	314.01 Kips	78.59 Kips	392.60 Kips
66.42 ft	378.84 Kips	78.59 Kips	457.43 Kips
66.44 ft	379.00 Kips	50.99 Kips	429.99 Kips
75.44 ft	420.61 Kips	50.99 Kips	471.60 Kips
76.42 ft	425.14 Kips	50.99 Kips	476.13 Kips
76.44 ft	425.23 Kips	56.28 Kips	481.52 Kips
81.42 ft	450.65 Kips	56.28 Kips	506.93 Kips
81.44 ft	450.83 Kips	78.59 Kips	529.43 Kips
86.42 ft	519.20 Kips	78.59 Kips	597.80 Kips
86.44 ft	519.42 Kips	76.97 Kips	596.38 Kips
89.62 ft	541.61 Kips	76.97 Kips	618.58 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
2.57 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
2.59 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.07 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.08 ft	Cohesionless	796.14 psf	20.66	N/A	0.00 Kips
11.59 ft	Cohesionless	1055.46 psf	20.66	N/A	6.70 Kips
20.59 ft	Cohesionless	1572.96 psf	20.66	N/A	29.91 Kips
26.42 ft	Cohesionless	1908.19 psf	20.66	N/A	51.94 Kips
26.44 ft	Cohesionless	3022.00 psf	18.00	N/A	51.98 Kips
26.87 ft	Cohesionless	3048.23 psf	18.00	N/A	52.84 Kips
26.89 ft	Cohesionless	3076.59 psf	18.00	N/A	52.88 Kips
31.42 ft	Cohesionless	3211.58 psf	18.00	N/A	62.33 Kips
31.44 ft	Cohesive	N/A	N/A	1168.78 psf	62.38 Kips
34.52 ft	Cohesive	N/A	N/A	1168.78 psf	71.22 Kips
34.54 ft	Cohesionless	3532.59 psf	23.33	N/A	71.34 Kips
43.54 ft	Cohesionless	3859.29 psf	23.33	N/A	143.50 Kips
51.42 ft	Cohesionless	4145.34 psf	23.33	N/A	216.71 Kips
51.44 ft	Cohesionless	4759.56 psf	22.66	N/A	216.84 Kips
60.44 ft	Cohesionless	5108.76 psf	22.66	N/A	275.53 Kips
66.42 ft	Cohesionless	5340.78 psf	22.66	N/A	318.97 Kips
66.44 ft	Cohesive	N/A	N/A	1261.40 psf	319.06 Kips
75.44 ft	Cohesive	N/A	N/A	1261.40 psf	342.78 Kips
76.42 ft	Cohesive	N/A	N/A	1261.40 psf	345.36 Kips
76.44 ft	Cohesive	N/A	N/A	1392.30 psf	345.43 Kips
81.42 ft	Cohesive	N/A	N/A	1392.30 psf	362.45 Kips
81.44 ft	Cohesionless	7012.56 psf	22.66	N/A	362.58 Kips
86.42 ft	Cohesionless	7205.78 psf	22.66	N/A	408.39 Kips
86.44 ft	Cohesive	N/A	N/A	1904.00 psf	408.53 Kips
89.62 ft	Cohesive	N/A	N/A	1904.00 psf	423.40 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	26.40	14.24 Kips	0.00 Kips
2.57 ft	Cohesionless	0.00 psf	26.40	14.24 Kips	0.00 Kips
2.59 ft	Cohesionless	0.00 psf	35.20	22.09 Kips	0.00 Kips
7.07 ft	Cohesionless	0.00 psf	35.20	22.09 Kips	0.00 Kips
7.08 ft	Cohesionless	796.14 psf	35.20	22.09 Kips	18.06 Kips
11.59 ft	Cohesionless	1314.79 psf	35.20	22.09 Kips	22.09 Kips
20.59 ft	Cohesionless	2349.79 psf	35.20	22.09 Kips	22.09 Kips
26.42 ft	Cohesionless	3020.24 psf	35.20	22.09 Kips	22.09 Kips
26.44 ft	Cohesionless	3022.61 psf	19.80	14.24 Kips	14.24 Kips
26.87 ft	Cohesionless	3075.07 psf	19.80	14.24 Kips	14.24 Kips
26.89 ft	Cohesionless	3076.89 psf	19.80	14.24 Kips	14.24 Kips
31.42 ft	Cohesionless	3346.87 psf	19.80	14.24 Kips	14.24 Kips
31.44 ft	Cohesive	N/A	N/A	N/A	23.09 Kips
34.52 ft	Cohesive	N/A	N/A	N/A	23.09 Kips
34.54 ft	Cohesionless	3532.96 psf	64.00	115.03 Kips	115.03 Kips
43.54 ft	Cohesionless	4186.36 psf	64.00	115.03 Kips	115.03 Kips
51.42 ft	Cohesionless	4758.44 psf	64.00	115.03 Kips	115.03 Kips
51.44 ft	Cohesionless	4759.95 psf	55.60	78.59 Kips	78.59 Kips
60.44 ft	Cohesionless	5458.35 psf	55.60	78.59 Kips	78.59 Kips
66.42 ft	Cohesionless	5922.39 psf	55.60	78.59 Kips	78.59 Kips
66.44 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
75.44 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
76.42 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
76.44 ft	Cohesive	N/A	N/A	N/A	56.28 Kips
81.42 ft	Cohesive	N/A	N/A	N/A	56.28 Kips
81.44 ft	Cohesionless	7012.95 psf	55.60	78.59 Kips	78.59 Kips
86.42 ft	Cohesionless	7399.39 psf	55.60	78.59 Kips	78.59 Kips
86.44 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
89.62 ft	Cohesive	N/A	N/A	N/A	76.97 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
2.57 ft	0.00 Kips	0.00 Kips	0.00 Kips
2.59 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.07 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.08 ft	0.00 Kips	18.06 Kips	18.06 Kips
11.59 ft	6.70 Kips	22.09 Kips	28.79 Kips
20.59 ft	29.91 Kips	22.09 Kips	52.00 Kips
26.42 ft	51.94 Kips	22.09 Kips	74.03 Kips
26.44 ft	51.98 Kips	14.24 Kips	66.22 Kips
26.87 ft	52.84 Kips	14.24 Kips	67.08 Kips
26.89 ft	52.88 Kips	14.24 Kips	67.12 Kips
31.42 ft	62.33 Kips	14.24 Kips	76.57 Kips
31.44 ft	62.38 Kips	23.09 Kips	85.47 Kips
34.52 ft	71.22 Kips	23.09 Kips	94.31 Kips
34.54 ft	71.34 Kips	115.03 Kips	186.36 Kips
43.54 ft	143.50 Kips	115.03 Kips	258.52 Kips
51.42 ft	216.71 Kips	115.03 Kips	331.74 Kips
51.44 ft	216.84 Kips	78.59 Kips	295.43 Kips
60.44 ft	275.53 Kips	78.59 Kips	354.13 Kips
66.42 ft	318.97 Kips	78.59 Kips	397.57 Kips
66.44 ft	319.06 Kips	50.99 Kips	370.05 Kips
75.44 ft	342.78 Kips	50.99 Kips	393.77 Kips
76.42 ft	345.36 Kips	50.99 Kips	396.35 Kips
76.44 ft	345.43 Kips	56.28 Kips	401.71 Kips
81.42 ft	362.45 Kips	56.28 Kips	418.74 Kips
81.44 ft	362.58 Kips	78.59 Kips	441.17 Kips
86.42 ft	408.39 Kips	78.59 Kips	486.98 Kips
86.44 ft	408.53 Kips	76.97 Kips	485.50 Kips
89.62 ft	423.40 Kips	76.97 Kips	500.37 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
2.57 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
2.59 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.07 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.08 ft	Cohesionless	796.14 psf	20.66	N/A	0.00 Kips
11.59 ft	Cohesionless	1055.46 psf	20.66	N/A	6.70 Kips
20.59 ft	Cohesionless	1572.96 psf	20.66	N/A	29.91 Kips
26.42 ft	Cohesionless	1908.19 psf	20.66	N/A	51.94 Kips
26.44 ft	Cohesionless	3022.00 psf	18.00	N/A	52.01 Kips
26.87 ft	Cohesionless	3048.23 psf	18.00	N/A	53.28 Kips
26.89 ft	Cohesionless	3076.59 psf	18.00	N/A	53.34 Kips
31.42 ft	Cohesionless	3211.58 psf	18.00	N/A	67.45 Kips
31.44 ft	Cohesive	N/A	N/A	1168.78 psf	67.52 Kips
34.52 ft	Cohesive	N/A	N/A	1168.78 psf	80.72 Kips
34.54 ft	Cohesionless	3532.59 psf	23.33	N/A	80.83 Kips
43.54 ft	Cohesionless	3859.29 psf	23.33	N/A	153.00 Kips
51.42 ft	Cohesionless	4145.34 psf	23.33	N/A	226.21 Kips
51.44 ft	Cohesionless	4759.56 psf	22.66	N/A	226.40 Kips
60.44 ft	Cohesionless	5108.76 psf	22.66	N/A	314.01 Kips
66.42 ft	Cohesionless	5340.78 psf	22.66	N/A	378.84 Kips
66.44 ft	Cohesive	N/A	N/A	1261.40 psf	379.00 Kips
75.44 ft	Cohesive	N/A	N/A	1261.40 psf	420.61 Kips
76.42 ft	Cohesive	N/A	N/A	1261.40 psf	425.14 Kips
76.44 ft	Cohesive	N/A	N/A	1392.30 psf	425.23 Kips
81.42 ft	Cohesive	N/A	N/A	1392.30 psf	450.65 Kips
81.44 ft	Cohesionless	7012.56 psf	22.66	N/A	450.83 Kips
86.42 ft	Cohesionless	7205.78 psf	22.66	N/A	519.20 Kips
86.44 ft	Cohesive	N/A	N/A	1904.00 psf	519.42 Kips
89.62 ft	Cohesive	N/A	N/A	1904.00 psf	541.61 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	26.40	14.24 Kips	0.00 Kips
2.57 ft	Cohesionless	0.00 psf	26.40	14.24 Kips	0.00 Kips
2.59 ft	Cohesionless	0.00 psf	35.20	22.09 Kips	0.00 Kips
7.07 ft	Cohesionless	0.00 psf	35.20	22.09 Kips	0.00 Kips
7.08 ft	Cohesionless	796.14 psf	35.20	22.09 Kips	18.06 Kips
11.59 ft	Cohesionless	1314.79 psf	35.20	22.09 Kips	22.09 Kips
20.59 ft	Cohesionless	2349.79 psf	35.20	22.09 Kips	22.09 Kips
26.42 ft	Cohesionless	3020.24 psf	35.20	22.09 Kips	22.09 Kips
26.44 ft	Cohesionless	3022.61 psf	19.80	14.24 Kips	14.24 Kips
26.87 ft	Cohesionless	3075.07 psf	19.80	14.24 Kips	14.24 Kips
26.89 ft	Cohesionless	3076.89 psf	19.80	14.24 Kips	14.24 Kips
31.42 ft	Cohesionless	3346.87 psf	19.80	14.24 Kips	14.24 Kips
31.44 ft	Cohesive	N/A	N/A	N/A	23.09 Kips
34.52 ft	Cohesive	N/A	N/A	N/A	23.09 Kips
34.54 ft	Cohesionless	3532.96 psf	64.00	115.03 Kips	115.03 Kips
43.54 ft	Cohesionless	4186.36 psf	64.00	115.03 Kips	115.03 Kips
51.42 ft	Cohesionless	4758.44 psf	64.00	115.03 Kips	115.03 Kips
51.44 ft	Cohesionless	4759.95 psf	55.60	78.59 Kips	78.59 Kips
60.44 ft	Cohesionless	5458.35 psf	55.60	78.59 Kips	78.59 Kips
66.42 ft	Cohesionless	5922.39 psf	55.60	78.59 Kips	78.59 Kips
66.44 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
75.44 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
76.42 ft	Cohesive	N/A	N/A	N/A	50.99 Kips
76.44 ft	Cohesive	N/A	N/A	N/A	56.28 Kips
81.42 ft	Cohesive	N/A	N/A	N/A	56.28 Kips
81.44 ft	Cohesionless	7012.95 psf	55.60	78.59 Kips	78.59 Kips
86.42 ft	Cohesionless	7399.39 psf	55.60	78.59 Kips	78.59 Kips
86.44 ft	Cohesive	N/A	N/A	N/A	76.97 Kips
89.62 ft	Cohesive	N/A	N/A	N/A	76.97 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
2.57 ft	0.00 Kips	0.00 Kips	0.00 Kips
2.59 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.07 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.08 ft	0.00 Kips	18.06 Kips	18.06 Kips
11.59 ft	6.70 Kips	22.09 Kips	28.79 Kips
20.59 ft	29.91 Kips	22.09 Kips	52.00 Kips
26.42 ft	51.94 Kips	22.09 Kips	74.03 Kips
26.44 ft	52.01 Kips	14.24 Kips	66.25 Kips
26.87 ft	53.28 Kips	14.24 Kips	67.52 Kips
26.89 ft	53.34 Kips	14.24 Kips	67.58 Kips
31.42 ft	67.45 Kips	14.24 Kips	81.69 Kips
31.44 ft	67.52 Kips	23.09 Kips	90.62 Kips
34.52 ft	80.72 Kips	23.09 Kips	103.81 Kips
34.54 ft	80.83 Kips	115.03 Kips	195.86 Kips
43.54 ft	153.00 Kips	115.03 Kips	268.02 Kips
51.42 ft	226.21 Kips	115.03 Kips	341.23 Kips
51.44 ft	226.40 Kips	78.59 Kips	304.99 Kips
60.44 ft	314.01 Kips	78.59 Kips	392.60 Kips
66.42 ft	378.84 Kips	78.59 Kips	457.43 Kips
66.44 ft	379.00 Kips	50.99 Kips	429.99 Kips
75.44 ft	420.61 Kips	50.99 Kips	471.60 Kips
76.42 ft	425.14 Kips	50.99 Kips	476.13 Kips
76.44 ft	425.23 Kips	56.28 Kips	481.52 Kips
81.42 ft	450.65 Kips	56.28 Kips	506.93 Kips
81.44 ft	450.83 Kips	78.59 Kips	529.43 Kips
86.42 ft	519.20 Kips	78.59 Kips	597.80 Kips
86.44 ft	519.42 Kips	76.97 Kips	596.38 Kips
89.62 ft	541.61 Kips	76.97 Kips	618.58 Kips

Pier 2

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\PROGRA~1\DRIVEN\ROS-CR~1\FP2B5G.DVN
Project Name: ROS-CR222 Project Date: 11/23/2022
Project Client: Carpenter Marty
Computed By: ZM
Project Manager: CH

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 8.25 ft
Diameter of Pile: 14.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	32.00 ft
	- Driving/Restrike	32.00 ft
	- Ultimate:	32.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	7.10 ft	0.00%	120.00 pcf	35.0/35.0	Nordlund
2	Cohesionless	14.30 ft	0.00%	130.00 pcf	37.0/37.0	Nordlund
3	Cohesionless	15.00 ft	0.00%	125.00 pcf	35.0/35.0	Nordlund
4	Cohesionless	5.00 ft	0.00%	130.00 pcf	36.0/36.0	Nordlund
5	Cohesionless	10.00 ft	0.00%	125.00 pcf	34.0/34.0	Nordlund
6	Cohesionless	8.20 ft	0.00%	140.00 pcf	35.0/35.0	Nordlund
7	Cohesionless	10.00 ft	33.00%	132.00 pcf	30.0/30.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.09 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.11 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
8.24 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
8.25 ft	Cohesionless	1001.50 psf	24.66	N/A	0.00 Kips
16.11 ft	Cohesionless	1512.40 psf	24.66	N/A	32.67 Kips
21.39 ft	Cohesionless	1855.60 psf	24.66	N/A	67.02 Kips
21.41 ft	Cohesionless	2711.62 psf	23.33	N/A	67.15 Kips
30.41 ft	Cohesionless	3274.12 psf	23.33	N/A	128.37 Kips
31.99 ft	Cohesionless	3372.88 psf	23.33	N/A	141.29 Kips
32.01 ft	Cohesionless	4036.31 psf	23.33	N/A	141.46 Kips
36.39 ft	Cohesionless	4173.41 psf	23.33	N/A	179.44 Kips
36.41 ft	Cohesionless	4311.78 psf	23.99	N/A	179.63 Kips
41.39 ft	Cohesionless	4480.10 psf	23.99	N/A	233.40 Kips
41.41 ft	Cohesionless	4649.75 psf	22.66	N/A	233.60 Kips
50.41 ft	Cohesionless	4931.45 psf	22.66	N/A	318.16 Kips
51.39 ft	Cohesionless	4962.13 psf	22.66	N/A	327.96 Kips
51.41 ft	Cohesionless	5275.83 psf	23.33	N/A	328.17 Kips
59.59 ft	Cohesionless	5593.21 psf	23.33	N/A	423.22 Kips
59.61 ft	Cohesionless	5912.11 psf	19.99	N/A	423.41 Kips
68.61 ft	Cohesionless	6225.31 psf	19.99	N/A	493.38 Kips
69.59 ft	Cohesionless	6259.41 psf	19.99	N/A	501.42 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	64.00	115.03 Kips	0.00 Kips
7.09 ft	Cohesionless	0.00 psf	64.00	115.03 Kips	0.00 Kips
7.11 ft	Cohesionless	0.00 psf	91.20	220.26 Kips	0.00 Kips
8.24 ft	Cohesionless	0.00 psf	91.20	220.26 Kips	0.00 Kips
8.25 ft	Cohesionless	1001.50 psf	91.20	220.26 Kips	69.08 Kips
16.11 ft	Cohesionless	2023.30 psf	91.20	220.26 Kips	139.56 Kips
21.39 ft	Cohesionless	2709.70 psf	91.20	220.26 Kips	186.91 Kips
21.41 ft	Cohesionless	2712.25 psf	64.00	115.03 Kips	115.03 Kips
30.41 ft	Cohesionless	3837.25 psf	64.00	115.03 Kips	115.03 Kips
31.99 ft	Cohesionless	4034.75 psf	64.00	115.03 Kips	115.03 Kips
32.01 ft	Cohesionless	4036.63 psf	64.00	115.03 Kips	115.03 Kips
36.39 ft	Cohesionless	4310.81 psf	64.00	115.03 Kips	115.03 Kips
36.41 ft	Cohesionless	4312.12 psf	77.60	162.06 Kips	162.06 Kips
41.39 ft	Cohesionless	4648.76 psf	77.60	162.06 Kips	162.06 Kips
41.41 ft	Cohesionless	4650.07 psf	55.60	78.59 Kips	78.59 Kips
50.41 ft	Cohesionless	5213.47 psf	55.60	78.59 Kips	78.59 Kips
51.39 ft	Cohesionless	5274.81 psf	55.60	78.59 Kips	78.59 Kips
51.41 ft	Cohesionless	5276.22 psf	64.00	115.03 Kips	115.03 Kips
59.59 ft	Cohesionless	5910.98 psf	64.00	115.03 Kips	115.03 Kips
59.61 ft	Cohesionless	5912.46 psf	30.00	14.24 Kips	14.24 Kips
68.61 ft	Cohesionless	6538.86 psf	30.00	14.24 Kips	14.24 Kips
69.59 ft	Cohesionless	6607.06 psf	30.00	14.24 Kips	14.24 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.09 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.11 ft	0.00 Kips	0.00 Kips	0.00 Kips
8.24 ft	0.00 Kips	0.00 Kips	0.00 Kips
8.25 ft	0.00 Kips	69.08 Kips	69.08 Kips
16.11 ft	32.67 Kips	139.56 Kips	172.23 Kips
21.39 ft	67.02 Kips	186.91 Kips	253.92 Kips
21.41 ft	67.15 Kips	115.03 Kips	182.17 Kips
30.41 ft	128.37 Kips	115.03 Kips	243.40 Kips
31.99 ft	141.29 Kips	115.03 Kips	256.32 Kips
32.01 ft	141.46 Kips	115.03 Kips	256.49 Kips
36.39 ft	179.44 Kips	115.03 Kips	294.46 Kips
36.41 ft	179.63 Kips	162.06 Kips	341.69 Kips
41.39 ft	233.40 Kips	162.06 Kips	395.46 Kips
41.41 ft	233.60 Kips	78.59 Kips	312.19 Kips
50.41 ft	318.16 Kips	78.59 Kips	396.76 Kips
51.39 ft	327.96 Kips	78.59 Kips	406.55 Kips
51.41 ft	328.17 Kips	115.03 Kips	443.19 Kips
59.59 ft	423.22 Kips	115.03 Kips	538.24 Kips
59.61 ft	423.41 Kips	14.24 Kips	437.65 Kips
68.61 ft	493.38 Kips	14.24 Kips	507.62 Kips
69.59 ft	501.42 Kips	14.24 Kips	515.66 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.09 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.11 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
8.24 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
8.25 ft	Cohesionless	1001.50 psf	24.66	N/A	0.00 Kips
16.11 ft	Cohesionless	1512.40 psf	24.66	N/A	32.67 Kips
21.39 ft	Cohesionless	1855.60 psf	24.66	N/A	67.02 Kips
21.41 ft	Cohesionless	2711.62 psf	23.33	N/A	67.15 Kips
30.41 ft	Cohesionless	3274.12 psf	23.33	N/A	128.37 Kips
31.99 ft	Cohesionless	3372.88 psf	23.33	N/A	141.29 Kips
32.01 ft	Cohesionless	4036.31 psf	23.33	N/A	141.46 Kips
36.39 ft	Cohesionless	4173.41 psf	23.33	N/A	179.44 Kips
36.41 ft	Cohesionless	4311.78 psf	23.99	N/A	179.63 Kips
41.39 ft	Cohesionless	4480.10 psf	23.99	N/A	233.40 Kips
41.41 ft	Cohesionless	4649.75 psf	22.66	N/A	233.60 Kips
50.41 ft	Cohesionless	4931.45 psf	22.66	N/A	318.16 Kips
51.39 ft	Cohesionless	4962.13 psf	22.66	N/A	327.96 Kips
51.41 ft	Cohesionless	5275.83 psf	23.33	N/A	328.17 Kips
59.59 ft	Cohesionless	5593.21 psf	23.33	N/A	423.22 Kips
59.61 ft	Cohesionless	5912.11 psf	19.99	N/A	423.35 Kips
68.61 ft	Cohesionless	6225.31 psf	19.99	N/A	470.23 Kips
69.59 ft	Cohesionless	6259.41 psf	19.99	N/A	475.62 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	64.00	115.03 Kips	0.00 Kips
7.09 ft	Cohesionless	0.00 psf	64.00	115.03 Kips	0.00 Kips
7.11 ft	Cohesionless	0.00 psf	91.20	220.26 Kips	0.00 Kips
8.24 ft	Cohesionless	0.00 psf	91.20	220.26 Kips	0.00 Kips
8.25 ft	Cohesionless	1001.50 psf	91.20	220.26 Kips	69.08 Kips
16.11 ft	Cohesionless	2023.30 psf	91.20	220.26 Kips	139.56 Kips
21.39 ft	Cohesionless	2709.70 psf	91.20	220.26 Kips	186.91 Kips
21.41 ft	Cohesionless	2712.25 psf	64.00	115.03 Kips	115.03 Kips
30.41 ft	Cohesionless	3837.25 psf	64.00	115.03 Kips	115.03 Kips
31.99 ft	Cohesionless	4034.75 psf	64.00	115.03 Kips	115.03 Kips
32.01 ft	Cohesionless	4036.63 psf	64.00	115.03 Kips	115.03 Kips
36.39 ft	Cohesionless	4310.81 psf	64.00	115.03 Kips	115.03 Kips
36.41 ft	Cohesionless	4312.12 psf	77.60	162.06 Kips	162.06 Kips
41.39 ft	Cohesionless	4648.76 psf	77.60	162.06 Kips	162.06 Kips
41.41 ft	Cohesionless	4650.07 psf	55.60	78.59 Kips	78.59 Kips
50.41 ft	Cohesionless	5213.47 psf	55.60	78.59 Kips	78.59 Kips
51.39 ft	Cohesionless	5274.81 psf	55.60	78.59 Kips	78.59 Kips
51.41 ft	Cohesionless	5276.22 psf	64.00	115.03 Kips	115.03 Kips
59.59 ft	Cohesionless	5910.98 psf	64.00	115.03 Kips	115.03 Kips
59.61 ft	Cohesionless	5912.46 psf	30.00	14.24 Kips	14.24 Kips
68.61 ft	Cohesionless	6538.86 psf	30.00	14.24 Kips	14.24 Kips
69.59 ft	Cohesionless	6607.06 psf	30.00	14.24 Kips	14.24 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.09 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.11 ft	0.00 Kips	0.00 Kips	0.00 Kips
8.24 ft	0.00 Kips	0.00 Kips	0.00 Kips
8.25 ft	0.00 Kips	69.08 Kips	69.08 Kips
16.11 ft	32.67 Kips	139.56 Kips	172.23 Kips
21.39 ft	67.02 Kips	186.91 Kips	253.92 Kips
21.41 ft	67.15 Kips	115.03 Kips	182.17 Kips
30.41 ft	128.37 Kips	115.03 Kips	243.40 Kips
31.99 ft	141.29 Kips	115.03 Kips	256.32 Kips
32.01 ft	141.46 Kips	115.03 Kips	256.49 Kips
36.39 ft	179.44 Kips	115.03 Kips	294.46 Kips
36.41 ft	179.63 Kips	162.06 Kips	341.69 Kips
41.39 ft	233.40 Kips	162.06 Kips	395.46 Kips
41.41 ft	233.60 Kips	78.59 Kips	312.19 Kips
50.41 ft	318.16 Kips	78.59 Kips	396.76 Kips
51.39 ft	327.96 Kips	78.59 Kips	406.55 Kips
51.41 ft	328.17 Kips	115.03 Kips	443.19 Kips
59.59 ft	423.22 Kips	115.03 Kips	538.24 Kips
59.61 ft	423.35 Kips	14.24 Kips	437.59 Kips
68.61 ft	470.23 Kips	14.24 Kips	484.47 Kips
69.59 ft	475.62 Kips	14.24 Kips	489.85 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.09 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
7.11 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
8.24 ft	Cohesionless	0.00 psf	0.00	N/A	0.00 Kips
8.25 ft	Cohesionless	1001.50 psf	24.66	N/A	0.00 Kips
16.11 ft	Cohesionless	1512.40 psf	24.66	N/A	32.67 Kips
21.39 ft	Cohesionless	1855.60 psf	24.66	N/A	67.02 Kips
21.41 ft	Cohesionless	2711.62 psf	23.33	N/A	67.15 Kips
30.41 ft	Cohesionless	3274.12 psf	23.33	N/A	128.37 Kips
31.99 ft	Cohesionless	3372.88 psf	23.33	N/A	141.29 Kips
32.01 ft	Cohesionless	4036.31 psf	23.33	N/A	141.46 Kips
36.39 ft	Cohesionless	4173.41 psf	23.33	N/A	179.44 Kips
36.41 ft	Cohesionless	4311.78 psf	23.99	N/A	179.63 Kips
41.39 ft	Cohesionless	4480.10 psf	23.99	N/A	233.40 Kips
41.41 ft	Cohesionless	4649.75 psf	22.66	N/A	233.60 Kips
50.41 ft	Cohesionless	4931.45 psf	22.66	N/A	318.16 Kips
51.39 ft	Cohesionless	4962.13 psf	22.66	N/A	327.96 Kips
51.41 ft	Cohesionless	5275.83 psf	23.33	N/A	328.17 Kips
59.59 ft	Cohesionless	5593.21 psf	23.33	N/A	423.22 Kips
59.61 ft	Cohesionless	5912.11 psf	19.99	N/A	423.41 Kips
68.61 ft	Cohesionless	6225.31 psf	19.99	N/A	493.38 Kips
69.59 ft	Cohesionless	6259.41 psf	19.99	N/A	501.42 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	64.00	115.03 Kips	0.00 Kips
7.09 ft	Cohesionless	0.00 psf	64.00	115.03 Kips	0.00 Kips
7.11 ft	Cohesionless	0.00 psf	91.20	220.26 Kips	0.00 Kips
8.24 ft	Cohesionless	0.00 psf	91.20	220.26 Kips	0.00 Kips
8.25 ft	Cohesionless	1001.50 psf	91.20	220.26 Kips	69.08 Kips
16.11 ft	Cohesionless	2023.30 psf	91.20	220.26 Kips	139.56 Kips
21.39 ft	Cohesionless	2709.70 psf	91.20	220.26 Kips	186.91 Kips
21.41 ft	Cohesionless	2712.25 psf	64.00	115.03 Kips	115.03 Kips
30.41 ft	Cohesionless	3837.25 psf	64.00	115.03 Kips	115.03 Kips
31.99 ft	Cohesionless	4034.75 psf	64.00	115.03 Kips	115.03 Kips
32.01 ft	Cohesionless	4036.63 psf	64.00	115.03 Kips	115.03 Kips
36.39 ft	Cohesionless	4310.81 psf	64.00	115.03 Kips	115.03 Kips
36.41 ft	Cohesionless	4312.12 psf	77.60	162.06 Kips	162.06 Kips
41.39 ft	Cohesionless	4648.76 psf	77.60	162.06 Kips	162.06 Kips
41.41 ft	Cohesionless	4650.07 psf	55.60	78.59 Kips	78.59 Kips
50.41 ft	Cohesionless	5213.47 psf	55.60	78.59 Kips	78.59 Kips
51.39 ft	Cohesionless	5274.81 psf	55.60	78.59 Kips	78.59 Kips
51.41 ft	Cohesionless	5276.22 psf	64.00	115.03 Kips	115.03 Kips
59.59 ft	Cohesionless	5910.98 psf	64.00	115.03 Kips	115.03 Kips
59.61 ft	Cohesionless	5912.46 psf	30.00	14.24 Kips	14.24 Kips
68.61 ft	Cohesionless	6538.86 psf	30.00	14.24 Kips	14.24 Kips
69.59 ft	Cohesionless	6607.06 psf	30.00	14.24 Kips	14.24 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.09 ft	0.00 Kips	0.00 Kips	0.00 Kips
7.11 ft	0.00 Kips	0.00 Kips	0.00 Kips
8.24 ft	0.00 Kips	0.00 Kips	0.00 Kips
8.25 ft	0.00 Kips	69.08 Kips	69.08 Kips
16.11 ft	32.67 Kips	139.56 Kips	172.23 Kips
21.39 ft	67.02 Kips	186.91 Kips	253.92 Kips
21.41 ft	67.15 Kips	115.03 Kips	182.17 Kips
30.41 ft	128.37 Kips	115.03 Kips	243.40 Kips
31.99 ft	141.29 Kips	115.03 Kips	256.32 Kips
32.01 ft	141.46 Kips	115.03 Kips	256.49 Kips
36.39 ft	179.44 Kips	115.03 Kips	294.46 Kips
36.41 ft	179.63 Kips	162.06 Kips	341.69 Kips
41.39 ft	233.40 Kips	162.06 Kips	395.46 Kips
41.41 ft	233.60 Kips	78.59 Kips	312.19 Kips
50.41 ft	318.16 Kips	78.59 Kips	396.76 Kips
51.39 ft	327.96 Kips	78.59 Kips	406.55 Kips
51.41 ft	328.17 Kips	115.03 Kips	443.19 Kips
59.59 ft	423.22 Kips	115.03 Kips	538.24 Kips
59.61 ft	423.41 Kips	14.24 Kips	437.65 Kips
68.61 ft	493.38 Kips	14.24 Kips	507.62 Kips
69.59 ft	501.42 Kips	14.24 Kips	515.66 Kips

Forward Abutment

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: U:\DRIVEN\FAB5.DVN
Project Name: ROS-CR222
Project Date: 03/01/2022
Project Client: Carpenter Marty
Computed By: ZM
Project Manager: CH

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 12.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	72.25 ft
	- Driving/Restrike	72.25 ft
	- Ultimate:	72.25 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	4.35 ft	17.00%	112.00 pcf	32.0/32.0	Nordlund
2	Cohesionless	10.00 ft	0.00%	115.00 pcf	32.0/32.0	Nordlund
3	Cohesionless	12.00 ft	0.00%	120.00 pcf	35.0/35.0	Nordlund
4	Cohesionless	14.30 ft	0.00%	130.00 pcf	37.0/37.0	Nordlund
5	Cohesionless	15.00 ft	0.00%	125.00 pcf	35.0/35.0	Nordlund
6	Cohesionless	5.00 ft	0.00%	130.00 pcf	36.0/36.0	Nordlund
7	Cohesionless	10.00 ft	0.00%	125.00 pcf	34.0/34.0	Nordlund
8	Cohesionless	8.20 ft	0.00%	140.00 pcf	35.0/35.0	Nordlund
9	Cohesionless	10.00 ft	33.00%	132.00 pcf	30.0/30.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.56 psf	18.82	N/A	0.00 Kips
4.34 ft	Cohesionless	243.04 psf	18.82	N/A	1.13 Kips
4.36 ft	Cohesionless	487.77 psf	18.82	N/A	1.14 Kips
13.36 ft	Cohesionless	1005.28 psf	18.82	N/A	10.86 Kips
14.34 ft	Cohesionless	1061.62 psf	18.82	N/A	12.52 Kips
14.36 ft	Cohesionless	1637.80 psf	20.58	N/A	12.56 Kips
23.36 ft	Cohesionless	2177.80 psf	20.58	N/A	39.91 Kips
26.34 ft	Cohesionless	2356.60 psf	20.58	N/A	51.96 Kips
26.36 ft	Cohesionless	3077.85 psf	21.76	N/A	52.06 Kips
35.36 ft	Cohesionless	3662.85 psf	21.76	N/A	111.97 Kips
40.64 ft	Cohesionless	4006.05 psf	21.76	N/A	156.03 Kips
40.66 ft	Cohesionless	4936.82 psf	20.58	N/A	156.19 Kips
49.66 ft	Cohesionless	5499.32 psf	20.58	N/A	225.25 Kips
55.64 ft	Cohesionless	5873.08 psf	20.58	N/A	278.95 Kips
55.66 ft	Cohesionless	6811.85 psf	21.17	N/A	279.15 Kips
60.64 ft	Cohesionless	7135.55 psf	21.17	N/A	336.20 Kips
60.66 ft	Cohesionless	7461.82 psf	19.99	N/A	336.41 Kips
69.66 ft	Cohesionless	8024.32 psf	19.99	N/A	429.38 Kips
70.64 ft	Cohesionless	8085.58 psf	19.99	N/A	440.29 Kips
70.66 ft	Cohesionless	8711.90 psf	20.58	N/A	440.52 Kips
72.24 ft	Cohesionless	8822.50 psf	20.58	N/A	459.97 Kips
72.26 ft	Cohesionless	8935.59 psf	20.58	N/A	460.22 Kips
78.84 ft	Cohesionless	9190.89 psf	20.58	N/A	544.60 Kips
78.86 ft	Cohesionless	9447.71 psf	17.64	N/A	544.81 Kips
87.86 ft	Cohesionless	9760.91 psf	17.64	N/A	620.80 Kips
88.84 ft	Cohesionless	9795.01 psf	17.64	N/A	629.37 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.12 psf	40.40	25.92 Kips	0.02 Kips
4.34 ft	Cohesionless	486.08 psf	40.40	25.92 Kips	9.65 Kips
4.36 ft	Cohesionless	488.35 psf	40.40	25.92 Kips	9.69 Kips
13.36 ft	Cohesionless	1523.35 psf	40.40	25.92 Kips	25.92 Kips
14.34 ft	Cohesionless	1636.05 psf	40.40	25.92 Kips	25.92 Kips
14.36 ft	Cohesionless	1638.40 psf	64.00	84.51 Kips	56.00 Kips
23.36 ft	Cohesionless	2718.40 psf	64.00	84.51 Kips	84.51 Kips
26.34 ft	Cohesionless	3076.00 psf	64.00	84.51 Kips	84.51 Kips
26.36 ft	Cohesionless	3078.50 psf	91.20	161.82 Kips	156.01 Kips
35.36 ft	Cohesionless	4248.50 psf	91.20	161.82 Kips	161.82 Kips
40.64 ft	Cohesionless	4934.90 psf	91.20	161.82 Kips	161.82 Kips
40.66 ft	Cohesionless	4937.45 psf	64.00	84.51 Kips	84.51 Kips
49.66 ft	Cohesionless	6062.45 psf	64.00	84.51 Kips	84.51 Kips
55.64 ft	Cohesionless	6809.95 psf	64.00	84.51 Kips	84.51 Kips
55.66 ft	Cohesionless	6812.50 psf	77.60	119.07 Kips	119.07 Kips
60.64 ft	Cohesionless	7459.90 psf	77.60	119.07 Kips	119.07 Kips
60.66 ft	Cohesionless	7462.45 psf	55.60	57.74 Kips	57.74 Kips
69.66 ft	Cohesionless	8587.45 psf	55.60	57.74 Kips	57.74 Kips
70.64 ft	Cohesionless	8709.95 psf	55.60	57.74 Kips	57.74 Kips
70.66 ft	Cohesionless	8712.60 psf	64.00	84.51 Kips	84.51 Kips
72.24 ft	Cohesionless	8933.80 psf	64.00	84.51 Kips	84.51 Kips
72.26 ft	Cohesionless	8935.98 psf	64.00	84.51 Kips	84.51 Kips
78.84 ft	Cohesionless	9446.58 psf	64.00	84.51 Kips	84.51 Kips
78.86 ft	Cohesionless	9448.06 psf	30.00	10.46 Kips	10.46 Kips
87.86 ft	Cohesionless	10074.46 psf	30.00	10.46 Kips	10.46 Kips
88.84 ft	Cohesionless	10142.66 psf	30.00	10.46 Kips	10.46 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.02 Kips	0.02 Kips
4.34 ft	1.13 Kips	9.65 Kips	10.78 Kips
4.36 ft	1.14 Kips	9.69 Kips	10.84 Kips
13.36 ft	10.86 Kips	25.92 Kips	36.78 Kips
14.34 ft	12.52 Kips	25.92 Kips	38.44 Kips
14.36 ft	12.56 Kips	56.00 Kips	68.56 Kips
23.36 ft	39.91 Kips	84.51 Kips	124.42 Kips
26.34 ft	51.96 Kips	84.51 Kips	136.47 Kips
26.36 ft	52.06 Kips	156.01 Kips	208.07 Kips
35.36 ft	111.97 Kips	161.82 Kips	273.80 Kips
40.64 ft	156.03 Kips	161.82 Kips	317.85 Kips
40.66 ft	156.19 Kips	84.51 Kips	240.70 Kips
49.66 ft	225.25 Kips	84.51 Kips	309.76 Kips
55.64 ft	278.95 Kips	84.51 Kips	363.46 Kips
55.66 ft	279.15 Kips	119.07 Kips	398.22 Kips
60.64 ft	336.20 Kips	119.07 Kips	455.26 Kips
60.66 ft	336.41 Kips	57.74 Kips	394.16 Kips
69.66 ft	429.38 Kips	57.74 Kips	487.12 Kips
70.64 ft	440.29 Kips	57.74 Kips	498.03 Kips
70.66 ft	440.52 Kips	84.51 Kips	525.03 Kips
72.24 ft	459.97 Kips	84.51 Kips	544.48 Kips
72.26 ft	460.22 Kips	84.51 Kips	544.73 Kips
78.84 ft	544.60 Kips	84.51 Kips	629.11 Kips
78.86 ft	544.81 Kips	10.46 Kips	555.27 Kips
87.86 ft	620.80 Kips	10.46 Kips	631.26 Kips
88.84 ft	629.37 Kips	10.46 Kips	639.83 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.56 psf	18.82	N/A	0.00 Kips
4.34 ft	Cohesionless	243.04 psf	18.82	N/A	0.94 Kips
4.36 ft	Cohesionless	487.77 psf	18.82	N/A	0.95 Kips
13.36 ft	Cohesionless	1005.28 psf	18.82	N/A	10.67 Kips
14.34 ft	Cohesionless	1061.62 psf	18.82	N/A	12.33 Kips
14.36 ft	Cohesionless	1637.80 psf	20.58	N/A	12.37 Kips
23.36 ft	Cohesionless	2177.80 psf	20.58	N/A	39.72 Kips
26.34 ft	Cohesionless	2356.60 psf	20.58	N/A	51.77 Kips
26.36 ft	Cohesionless	3077.85 psf	21.76	N/A	51.87 Kips
35.36 ft	Cohesionless	3662.85 psf	21.76	N/A	111.78 Kips
40.64 ft	Cohesionless	4006.05 psf	21.76	N/A	155.84 Kips
40.66 ft	Cohesionless	4936.82 psf	20.58	N/A	156.00 Kips
49.66 ft	Cohesionless	5499.32 psf	20.58	N/A	225.06 Kips
55.64 ft	Cohesionless	5873.08 psf	20.58	N/A	278.75 Kips
55.66 ft	Cohesionless	6811.85 psf	21.17	N/A	278.96 Kips
60.64 ft	Cohesionless	7135.55 psf	21.17	N/A	336.01 Kips
60.66 ft	Cohesionless	7461.82 psf	19.99	N/A	336.22 Kips
69.66 ft	Cohesionless	8024.32 psf	19.99	N/A	429.18 Kips
70.64 ft	Cohesionless	8085.58 psf	19.99	N/A	440.09 Kips
70.66 ft	Cohesionless	8711.90 psf	20.58	N/A	440.33 Kips
72.24 ft	Cohesionless	8822.50 psf	20.58	N/A	459.78 Kips
72.26 ft	Cohesionless	8935.59 psf	20.58	N/A	460.03 Kips
78.84 ft	Cohesionless	9190.89 psf	20.58	N/A	544.40 Kips
78.86 ft	Cohesionless	9447.71 psf	17.64	N/A	544.55 Kips
87.86 ft	Cohesionless	9760.91 psf	17.64	N/A	595.46 Kips
88.84 ft	Cohesionless	9795.01 psf	17.64	N/A	601.20 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.12 psf	40.40	25.92 Kips	0.02 Kips
4.34 ft	Cohesionless	486.08 psf	40.40	25.92 Kips	9.65 Kips
4.36 ft	Cohesionless	488.35 psf	40.40	25.92 Kips	9.69 Kips
13.36 ft	Cohesionless	1523.35 psf	40.40	25.92 Kips	25.92 Kips
14.34 ft	Cohesionless	1636.05 psf	40.40	25.92 Kips	25.92 Kips
14.36 ft	Cohesionless	1638.40 psf	64.00	84.51 Kips	56.00 Kips
23.36 ft	Cohesionless	2718.40 psf	64.00	84.51 Kips	84.51 Kips
26.34 ft	Cohesionless	3076.00 psf	64.00	84.51 Kips	84.51 Kips
26.36 ft	Cohesionless	3078.50 psf	91.20	161.82 Kips	156.01 Kips
35.36 ft	Cohesionless	4248.50 psf	91.20	161.82 Kips	161.82 Kips
40.64 ft	Cohesionless	4934.90 psf	91.20	161.82 Kips	161.82 Kips
40.66 ft	Cohesionless	4937.45 psf	64.00	84.51 Kips	84.51 Kips
49.66 ft	Cohesionless	6062.45 psf	64.00	84.51 Kips	84.51 Kips
55.64 ft	Cohesionless	6809.95 psf	64.00	84.51 Kips	84.51 Kips
55.66 ft	Cohesionless	6812.50 psf	77.60	119.07 Kips	119.07 Kips
60.64 ft	Cohesionless	7459.90 psf	77.60	119.07 Kips	119.07 Kips
60.66 ft	Cohesionless	7462.45 psf	55.60	57.74 Kips	57.74 Kips
69.66 ft	Cohesionless	8587.45 psf	55.60	57.74 Kips	57.74 Kips
70.64 ft	Cohesionless	8709.95 psf	55.60	57.74 Kips	57.74 Kips
70.66 ft	Cohesionless	8712.60 psf	64.00	84.51 Kips	84.51 Kips
72.24 ft	Cohesionless	8933.80 psf	64.00	84.51 Kips	84.51 Kips
72.26 ft	Cohesionless	8935.98 psf	64.00	84.51 Kips	84.51 Kips
78.84 ft	Cohesionless	9446.58 psf	64.00	84.51 Kips	84.51 Kips
78.86 ft	Cohesionless	9448.06 psf	30.00	10.46 Kips	10.46 Kips
87.86 ft	Cohesionless	10074.46 psf	30.00	10.46 Kips	10.46 Kips
88.84 ft	Cohesionless	10142.66 psf	30.00	10.46 Kips	10.46 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.02 Kips	0.02 Kips
4.34 ft	0.94 Kips	9.65 Kips	10.59 Kips
4.36 ft	0.95 Kips	9.69 Kips	10.64 Kips
13.36 ft	10.67 Kips	25.92 Kips	36.58 Kips
14.34 ft	12.33 Kips	25.92 Kips	38.25 Kips
14.36 ft	12.37 Kips	56.00 Kips	68.37 Kips
23.36 ft	39.72 Kips	84.51 Kips	124.23 Kips
26.34 ft	51.77 Kips	84.51 Kips	136.28 Kips
26.36 ft	51.87 Kips	156.01 Kips	207.87 Kips
35.36 ft	111.78 Kips	161.82 Kips	273.60 Kips
40.64 ft	155.84 Kips	161.82 Kips	317.66 Kips
40.66 ft	156.00 Kips	84.51 Kips	240.51 Kips
49.66 ft	225.06 Kips	84.51 Kips	309.57 Kips
55.64 ft	278.75 Kips	84.51 Kips	363.26 Kips
55.66 ft	278.96 Kips	119.07 Kips	398.03 Kips
60.64 ft	336.01 Kips	119.07 Kips	455.07 Kips
60.66 ft	336.22 Kips	57.74 Kips	393.96 Kips
69.66 ft	429.18 Kips	57.74 Kips	486.93 Kips
70.64 ft	440.09 Kips	57.74 Kips	497.84 Kips
70.66 ft	440.33 Kips	84.51 Kips	524.84 Kips
72.24 ft	459.78 Kips	84.51 Kips	544.29 Kips
72.26 ft	460.03 Kips	84.51 Kips	544.54 Kips
78.84 ft	544.40 Kips	84.51 Kips	628.91 Kips
78.86 ft	544.55 Kips	10.46 Kips	555.01 Kips
87.86 ft	595.46 Kips	10.46 Kips	605.92 Kips
88.84 ft	601.20 Kips	10.46 Kips	611.66 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.56 psf	18.82	N/A	0.00 Kips
4.34 ft	Cohesionless	243.04 psf	18.82	N/A	1.13 Kips
4.36 ft	Cohesionless	487.77 psf	18.82	N/A	1.14 Kips
13.36 ft	Cohesionless	1005.28 psf	18.82	N/A	10.86 Kips
14.34 ft	Cohesionless	1061.62 psf	18.82	N/A	12.52 Kips
14.36 ft	Cohesionless	1637.80 psf	20.58	N/A	12.56 Kips
23.36 ft	Cohesionless	2177.80 psf	20.58	N/A	39.91 Kips
26.34 ft	Cohesionless	2356.60 psf	20.58	N/A	51.96 Kips
26.36 ft	Cohesionless	3077.85 psf	21.76	N/A	52.06 Kips
35.36 ft	Cohesionless	3662.85 psf	21.76	N/A	111.97 Kips
40.64 ft	Cohesionless	4006.05 psf	21.76	N/A	156.03 Kips
40.66 ft	Cohesionless	4936.82 psf	20.58	N/A	156.19 Kips
49.66 ft	Cohesionless	5499.32 psf	20.58	N/A	225.25 Kips
55.64 ft	Cohesionless	5873.08 psf	20.58	N/A	278.95 Kips
55.66 ft	Cohesionless	6811.85 psf	21.17	N/A	279.15 Kips
60.64 ft	Cohesionless	7135.55 psf	21.17	N/A	336.20 Kips
60.66 ft	Cohesionless	7461.82 psf	19.99	N/A	336.41 Kips
69.66 ft	Cohesionless	8024.32 psf	19.99	N/A	429.38 Kips
70.64 ft	Cohesionless	8085.58 psf	19.99	N/A	440.29 Kips
70.66 ft	Cohesionless	8711.90 psf	20.58	N/A	440.52 Kips
72.24 ft	Cohesionless	8822.50 psf	20.58	N/A	459.97 Kips
72.26 ft	Cohesionless	8935.59 psf	20.58	N/A	460.22 Kips
78.84 ft	Cohesionless	9190.89 psf	20.58	N/A	544.60 Kips
78.86 ft	Cohesionless	9447.71 psf	17.64	N/A	544.81 Kips
87.86 ft	Cohesionless	9760.91 psf	17.64	N/A	620.80 Kips
88.84 ft	Cohesionless	9795.01 psf	17.64	N/A	629.37 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.12 psf	40.40	25.92 Kips	0.02 Kips
4.34 ft	Cohesionless	486.08 psf	40.40	25.92 Kips	9.65 Kips
4.36 ft	Cohesionless	488.35 psf	40.40	25.92 Kips	9.69 Kips
13.36 ft	Cohesionless	1523.35 psf	40.40	25.92 Kips	25.92 Kips
14.34 ft	Cohesionless	1636.05 psf	40.40	25.92 Kips	25.92 Kips
14.36 ft	Cohesionless	1638.40 psf	64.00	84.51 Kips	56.00 Kips
23.36 ft	Cohesionless	2718.40 psf	64.00	84.51 Kips	84.51 Kips
26.34 ft	Cohesionless	3076.00 psf	64.00	84.51 Kips	84.51 Kips
26.36 ft	Cohesionless	3078.50 psf	91.20	161.82 Kips	156.01 Kips
35.36 ft	Cohesionless	4248.50 psf	91.20	161.82 Kips	161.82 Kips
40.64 ft	Cohesionless	4934.90 psf	91.20	161.82 Kips	161.82 Kips
40.66 ft	Cohesionless	4937.45 psf	64.00	84.51 Kips	84.51 Kips
49.66 ft	Cohesionless	6062.45 psf	64.00	84.51 Kips	84.51 Kips
55.64 ft	Cohesionless	6809.95 psf	64.00	84.51 Kips	84.51 Kips
55.66 ft	Cohesionless	6812.50 psf	77.60	119.07 Kips	119.07 Kips
60.64 ft	Cohesionless	7459.90 psf	77.60	119.07 Kips	119.07 Kips
60.66 ft	Cohesionless	7462.45 psf	55.60	57.74 Kips	57.74 Kips
69.66 ft	Cohesionless	8587.45 psf	55.60	57.74 Kips	57.74 Kips
70.64 ft	Cohesionless	8709.95 psf	55.60	57.74 Kips	57.74 Kips
70.66 ft	Cohesionless	8712.60 psf	64.00	84.51 Kips	84.51 Kips
72.24 ft	Cohesionless	8933.80 psf	64.00	84.51 Kips	84.51 Kips
72.26 ft	Cohesionless	8935.98 psf	64.00	84.51 Kips	84.51 Kips
78.84 ft	Cohesionless	9446.58 psf	64.00	84.51 Kips	84.51 Kips
78.86 ft	Cohesionless	9448.06 psf	30.00	10.46 Kips	10.46 Kips
87.86 ft	Cohesionless	10074.46 psf	30.00	10.46 Kips	10.46 Kips
88.84 ft	Cohesionless	10142.66 psf	30.00	10.46 Kips	10.46 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.02 Kips	0.02 Kips
4.34 ft	1.13 Kips	9.65 Kips	10.78 Kips
4.36 ft	1.14 Kips	9.69 Kips	10.84 Kips
13.36 ft	10.86 Kips	25.92 Kips	36.78 Kips
14.34 ft	12.52 Kips	25.92 Kips	38.44 Kips
14.36 ft	12.56 Kips	56.00 Kips	68.56 Kips
23.36 ft	39.91 Kips	84.51 Kips	124.42 Kips
26.34 ft	51.96 Kips	84.51 Kips	136.47 Kips
26.36 ft	52.06 Kips	156.01 Kips	208.07 Kips
35.36 ft	111.97 Kips	161.82 Kips	273.80 Kips
40.64 ft	156.03 Kips	161.82 Kips	317.85 Kips
40.66 ft	156.19 Kips	84.51 Kips	240.70 Kips
49.66 ft	225.25 Kips	84.51 Kips	309.76 Kips
55.64 ft	278.95 Kips	84.51 Kips	363.46 Kips
55.66 ft	279.15 Kips	119.07 Kips	398.22 Kips
60.64 ft	336.20 Kips	119.07 Kips	455.26 Kips
60.66 ft	336.41 Kips	57.74 Kips	394.16 Kips
69.66 ft	429.38 Kips	57.74 Kips	487.12 Kips
70.64 ft	440.29 Kips	57.74 Kips	498.03 Kips
70.66 ft	440.52 Kips	84.51 Kips	525.03 Kips
72.24 ft	459.97 Kips	84.51 Kips	544.48 Kips
72.26 ft	460.22 Kips	84.51 Kips	544.73 Kips
78.84 ft	544.60 Kips	84.51 Kips	629.11 Kips
78.86 ft	544.81 Kips	10.46 Kips	555.27 Kips
87.86 ft	620.80 Kips	10.46 Kips	631.26 Kips
88.84 ft	629.37 Kips	10.46 Kips	639.83 Kips

DRIVIABILITY ANALYSES

REAR ABUTMENT

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

Input File: P:\21-0053 (106544 ROS-CR222-0383)\106544\GEOTECHNICAL\BRIDGES\XXX-YY-ZZ.ZZ (CROSSING)\ANALYSIS\GRLWEAP\FILES\RBB4.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

ROS-CR222 : 03/01/2022 : ZM

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	113.090	12.000	Pipe

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
100.980	13.69	30000.0	492.000	3.141	0	0.850	0.010

FFatigue	F0	0-Bottom
0	0.000	0.000

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1600.00	1440.00	1295.00	1165.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1600.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.02	0.10	0.18	0.10	0.15	1.21	6.00	24.000
6.54	0.10	13.73	0.10	0.18	0.10	0.15	1.21	6.00	24.000
6.56	0.32	11.65	0.10	0.23	0.05	0.15	1.00	6.00	1.000
14.04	0.29	14.61	0.10	0.23	0.05	0.15	1.00	6.00	1.000
14.06	0.48	22.66	0.10	0.17	0.05	0.15	1.00	6.00	1.000

19.79	0.63	22.66	0.10	0.17	0.05	0.15	1.00	6.00	1.000
19.81	0.95	22.66	0.10	0.17	0.05	0.15	1.00	6.00	1.000
28.81	1.21	22.66	0.10	0.17	0.05	0.15	1.00	6.00	1.000
37.81	1.11	22.66	0.10	0.17	0.05	0.15	1.00	6.00	1.000
37.84	0.95	22.66	0.10	0.17	0.05	0.15	1.00	6.00	1.000
37.86	0.95	14.61	0.10	0.21	0.10	0.15	1.49	6.00	24.000
42.84	0.99	14.61	0.10	0.21	0.10	0.15	1.49	6.00	24.000
42.86	1.11	23.69	0.10	0.13	0.15	0.15	1.49	6.00	24.000
45.94	1.17	23.69	0.10	0.13	0.15	0.15	1.49	6.00	24.000
45.96	1.59	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
54.96	2.30	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
62.84	2.57	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
62.86	2.55	80.62	0.10	0.12	0.10	0.15	1.49	6.00	24.000
71.86	2.63	80.62	0.10	0.12	0.10	0.15	1.49	6.00	24.000
77.84	2.87	80.62	0.10	0.12	0.10	0.15	1.49	6.00	24.000
77.86	2.07	52.30	0.10	0.12	0.20	0.15	1.75	6.00	168.000
86.86	1.26	52.30	0.10	0.12	0.20	0.15	1.75	6.00	168.000
87.84	1.26	52.30	0.10	0.12	0.20	0.15	1.75	6.00	168.000
87.86	1.27	57.73	0.10	0.12	0.15	0.15	1.49	6.00	24.000
92.84	1.39	57.73	0.10	0.12	0.15	0.15	1.49	6.00	24.000
92.86	2.39	80.62	0.10	0.12	0.10	0.15	1.49	6.00	24.000
97.84	3.49	80.62	0.10	0.12	0.10	0.15	1.49	6.00	24.000
97.86	2.86	78.95	0.10	0.12	0.15	0.15	1.49	6.00	168.000
100.98	1.92	78.95	0.10	0.12	0.15	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

0.57000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
6.53	0.00	0.00	0.000	0.0	0.000	0.000	0.000
6.57	0.00	0.00	0.000	0.0	0.000	0.000	0.000
10.30	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.03	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.07	0.00	0.00	0.000	0.0	0.000	0.000	0.000
25.95	0.00	0.00	0.000	0.0	0.000	0.000	0.000
37.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
37.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.35	0.00	0.00	0.000	0.0	0.000	0.000	0.000
42.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
42.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000
44.40	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.93	0.00	0.00	0.000	0.0	0.000	0.000	0.000
45.97	0.00	0.00	0.000	0.0	0.000	0.000	0.000
54.40	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
62.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000
70.35	0.00	0.00	0.000	0.0	0.000	0.000	0.000
77.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
77.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000
82.85	0.00	0.00	0.000	0.0	0.000	0.000	0.000
87.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
87.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000
90.35	0.00	0.00	0.000	0.0	0.000	0.000	0.000
92.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
92.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000

95.35	0.00	0.00	0.000	0.0	0.000	0.000	0.000
97.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
97.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000
99.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
100.98	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

ROS-CR222 : 03/01/2022 : ZM

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR ft	C-Slk k/ft/s	Dampg
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top	9828.9				

HAMMER OPTIONS:
Hammer File ID No. 41 Hammer Type OE Diesel
Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010
Fuel Pump Setting Maximum

HAMMER DATA:
Ram Weight (kips) 4.00 Ram Length (inch) 129.10
Maximum Stroke (ft) 11.86
Rated Stroke (ft) 10.81 Efficiency 0.800

Maximum Pressure (psi) 1600.00 Actual Pressure (psi) 1600.00
Compression Exponent 1.350 Expansion Exponent 1.250
Ram Diameter (inch) 12.60
Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

Depth (ft) 6.5 Standard Soil Setup
Shaft Gain/Loss Factor 0.570 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 113.090 Pile Type Pipe
Pile Size (inch) 12.000

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.570 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
6.5	14.6	0.8	13.7	1.5	12.616	-1.985	4.16	23.5
6.6	12.5	0.9	11.7	1.4	11.245	-1.952	4.06	23.3
10.3	17.7	4.5	13.1	1.6	13.650	-2.020	4.28	23.8
14.0	22.6	8.0	14.6	1.8	14.770	-2.153	4.39	23.8
14.1	30.7	8.1	22.7	2.3	17.314	-2.468	4.72	24.0
26.0	60.8	38.1	22.7	4.5	21.145	-2.030	5.30	21.9
37.8	104.1	81.5	22.7	8.1	24.071	-1.515	5.89	20.4
37.9	96.2	81.6	14.6	7.1	23.514	-1.956	5.74	20.6
40.3	101.2	86.6	14.6	7.6	23.885	-1.985	5.83	20.4
42.8	106.3	91.7	14.6	8.2	24.227	-2.146	5.92	20.3
42.9	115.5	91.8	23.7	9.6	24.724	-3.102	6.05	20.0
44.4	119.1	95.4	23.7	10.2	24.913	-3.464	6.11	20.0
45.9	122.8	99.1	23.7	10.7	25.183	-3.620	6.18	19.9
46.0	217.3	99.3	118.0	24.8	29.016	-4.683	7.38	21.0
54.4	268.2	150.2	118.0	35.3	30.176	-5.601	7.81	21.8
62.8	332.4	214.4	118.0	60.5	30.911	-6.044	8.10	22.1
62.9	295.3	214.7	80.6	40.8	30.176	-5.015	7.85	21.4
70.3	335.9	255.3	80.6	59.6	30.931	-4.547	8.14	21.7
77.8	378.8	298.2	80.6	96.6	31.613	-4.285	8.45	22.0
77.9	350.7	298.4	52.3	66.8	31.200	-4.291	8.28	21.5
82.8	367.1	314.8	52.3	84.2	31.229	-3.317	8.35	21.3
87.8	379.6	327.3	52.3	100.1	31.342	-3.072	8.42	21.2
87.9	385.2	327.4	57.7	109.8	31.456	-3.008	8.46	21.2
90.3	392.0	334.2	57.7	122.0	31.454	-2.664	8.50	21.1
92.8	399.1	341.3	57.7	137.3	31.403	-2.570	8.51	21.0
92.9	422.1	341.5	80.6	219.8	31.703	-2.436	8.62	21.3
95.3	436.0	355.4	80.6	312.5	31.742	-2.200	8.66	21.1
97.8	452.8	372.2	80.6	502.0	31.793	-1.811	8.70	21.1
97.9	451.4	372.4	78.9	483.8	31.778	-1.820	8.70	21.1
99.4	459.9	380.9	78.9	602.8	31.731	-1.702	8.71	20.9
101.0	467.0	388.0	78.9	733.2	31.769	-1.559	8.73	20.9

Total Driving Time 168 minutes; Total No. of Blows 6851
Starting at penetration 6.5 ft

ROS-CR222 : 03/01/2022 : ZM 11/28/2022
National Engineering & Architectural GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp. Length ft	Wait Time hr	Equivalent Stroke ft	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
6.53	100.98	0.00	10.81	1.00	0.80	1.00	1.00
6.57	100.98	0.00	10.81	1.00	0.80	1.00	1.00
10.30	100.98	0.00	10.81	1.00	0.80	1.00	1.00
14.03	100.98	0.00	10.81	1.00	0.80	1.00	1.00
14.07	100.98	0.00	10.81	1.00	0.80	1.00	1.00
25.95	100.98	0.00	10.81	1.00	0.80	1.00	1.00
37.83	100.98	0.00	10.81	1.00	0.80	1.00	1.00
37.87	100.98	0.00	10.81	1.00	0.80	1.00	1.00
40.35	100.98	0.00	10.81	1.00	0.80	1.00	1.00
42.83	100.98	0.00	10.81	1.00	0.80	1.00	1.00
42.87	100.98	0.00	10.81	1.00	0.80	1.00	1.00
44.40	100.98	0.00	10.81	1.00	0.80	1.00	1.00
45.93	100.98	0.00	10.81	1.00	0.80	1.00	1.00
45.97	100.98	0.00	10.81	1.00	0.80	1.00	1.00
54.40	100.98	0.00	10.81	1.00	0.80	1.00	1.00
62.83	100.98	0.00	10.81	1.00	0.80	1.00	1.00
62.87	100.98	0.00	10.81	1.00	0.80	1.00	1.00
70.35	100.98	0.00	10.81	1.00	0.80	1.00	1.00
77.83	100.98	0.00	10.81	1.00	0.80	1.00	1.00
77.87	100.98	0.00	10.81	1.00	0.80	1.00	1.00
82.85	100.98	0.00	10.81	1.00	0.80	1.00	1.00
87.83	100.98	0.00	10.81	1.00	0.80	1.00	1.00
87.87	100.98	0.00	10.81	1.00	0.80	1.00	1.00
90.35	100.98	0.00	10.81	1.00	0.80	1.00	1.00
92.83	100.98	0.00	10.81	1.00	0.80	1.00	1.00
92.87	100.98	0.00	10.81	1.00	0.80	1.00	1.00
95.35	100.98	0.00	10.81	1.00	0.80	1.00	1.00
97.83	100.98	0.00	10.81	1.00	0.80	1.00	1.00
97.87	100.98	0.00	10.81	1.00	0.80	1.00	1.00
99.41	100.98	0.00	10.81	1.00	0.80	1.00	1.00
100.98	100.98	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth ft	Shaft Res. k/ft2	End Bearing kips	Shaft Quake inch	Toe Quake inch	Shaft Damping s/ft	Toe Damping s/ft	Soil Limit Normlzd	Setup ft	Time hrs
0.01	0.00	0.02	0.100	0.180	0.100	0.150	0.396	6.000	24.000
6.54	0.10	13.73	0.100	0.180	0.100	0.150	0.396	6.000	24.000
6.56	0.32	11.65	0.100	0.230	0.050	0.150	0.000	6.000	1.000
14.04	0.29	14.61	0.100	0.230	0.050	0.150	0.000	6.000	1.000
14.06	0.48	22.66	0.100	0.170	0.050	0.150	0.000	6.000	1.000
19.79	0.63	22.66	0.100	0.170	0.050	0.150	0.000	6.000	1.000
19.81	0.95	22.66	0.100	0.170	0.050	0.150	0.000	6.000	1.000
28.81	1.21	22.66	0.100	0.170	0.050	0.150	0.000	6.000	1.000
37.81	1.11	22.66	0.100	0.170	0.050	0.150	0.000	6.000	1.000
37.84	0.95	22.66	0.100	0.170	0.050	0.150	0.000	6.000	1.000
37.86	0.95	14.61	0.100	0.210	0.100	0.150	0.768	6.000	24.000
42.84	0.99	14.61	0.100	0.210	0.100	0.150	0.768	6.000	24.000

42.86	1.11	23.69	0.100	0.130	0.150	0.150	0.768	6.000	24.000
45.94	1.17	23.69	0.100	0.130	0.150	0.150	0.768	6.000	24.000
45.96	1.59	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
54.96	2.30	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
62.84	2.57	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
62.86	2.55	80.62	0.100	0.120	0.100	0.150	0.768	6.000	24.000
71.86	2.63	80.62	0.100	0.120	0.100	0.150	0.768	6.000	24.000
77.84	2.87	80.62	0.100	0.120	0.100	0.150	0.768	6.000	24.000
77.86	2.07	52.30	0.100	0.120	0.200	0.150	1.000	6.000	168.000
86.86	1.26	52.30	0.100	0.120	0.200	0.150	1.000	6.000	168.000
87.84	1.26	52.30	0.100	0.120	0.200	0.150	1.000	6.000	168.000
87.86	1.27	57.73	0.100	0.120	0.150	0.150	0.768	6.000	24.000
92.84	1.39	57.73	0.100	0.120	0.150	0.150	0.768	6.000	24.000
92.86	2.39	80.62	0.100	0.120	0.100	0.150	0.768	6.000	24.000
97.84	3.49	80.62	0.100	0.120	0.100	0.150	0.768	6.000	24.000
97.86	2.86	78.95	0.100	0.120	0.150	0.150	0.768	6.000	168.000
100.98	1.92	78.95	0.100	0.120	0.150	0.150	0.768	6.000	168.000

PIER 1

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

Input File: P:\21-0053 (106544 ROS-CR222-0383)\106544\GEOTECHNICAL\BRIDGES\XXX-YY-ZZ.ZZ (CROSSING)\ANALYSIS\GRLWEAP\FILES\P1B4G.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

ROS-CR222 : 11/23/2022 : ZM

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	153.930	14.000	Pipe

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
89.580	16.05	30000.0	492.000	3.665	0	0.850	0.010

FFatigue	F0	0-Bottom
0	0.000	0.000

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1600.00	1440.00	1295.00	1165.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1600.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.00	0.10	0.23	0.05	0.15	1.00	0.00	0.000
2.57	0.00	0.00	0.10	0.23	0.05	0.15	1.00	6.00	0.000
2.59	0.00	0.00	0.10	0.17	0.05	0.15	1.00	6.00	1.000
7.07	0.00	0.00	0.10	0.17	0.05	0.15	1.00	6.00	1.000
7.08	0.00	19.31	0.10	0.17	0.05	0.15	1.00	6.00	1.000

11.59	0.41	23.61	0.10	0.17	0.05	0.15	1.00	6.00	1.000
20.59	0.70	23.61	0.10	0.17	0.05	0.15	1.00	6.00	1.000
26.42	1.03	23.61	0.10	0.17	0.05	0.15	1.00	6.00	1.000
26.44	0.95	15.22	0.10	0.21	0.10	0.15	1.49	6.00	24.000
26.87	0.81	15.22	0.10	0.21	0.10	0.15	1.49	6.00	24.000
26.89	0.82	15.22	0.10	0.21	0.10	0.15	1.49	6.00	24.000
31.42	0.85	15.22	0.10	0.21	0.10	0.15	1.49	6.00	24.000
31.44	0.95	24.68	0.10	0.13	0.15	0.15	1.49	6.00	24.000
34.52	1.17	24.68	0.10	0.13	0.15	0.15	1.49	6.00	24.000
34.54	1.50	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
43.54	2.19	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
51.42	2.53	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
51.44	2.59	84.01	0.10	0.12	0.10	0.15	1.49	6.00	24.000
60.44	2.66	84.01	0.10	0.12	0.10	0.15	1.49	6.00	24.000
66.42	2.96	84.01	0.10	0.12	0.10	0.15	1.49	6.00	24.000
66.44	2.18	54.51	0.10	0.12	0.20	0.15	1.75	6.00	168.000
75.44	1.26	54.51	0.10	0.12	0.20	0.15	1.75	6.00	168.000
76.42	1.26	54.51	0.10	0.12	0.20	0.15	1.75	6.00	168.000
76.44	1.23	60.16	0.10	0.12	0.15	0.15	1.49	6.00	24.000
81.42	1.39	60.16	0.10	0.12	0.15	0.15	1.49	6.00	24.000
81.44	2.46	84.01	0.10	0.12	0.10	0.15	1.49	6.00	24.000
86.42	3.75	84.01	0.10	0.12	0.10	0.15	1.49	6.00	24.000
86.44	3.00	82.28	0.10	0.12	0.15	0.15	1.49	6.00	168.000
89.58	1.92	82.28	0.10	0.12	0.15	0.15	1.49	6.00	168.000

Gain/Loss factors: shaft and toe

0.57000	0.00000	0.00000	0.00000	0.00000
1.00000	1.00000	1.00000	1.00000	1.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
2.56	0.00	0.00	0.000	0.0	0.000	0.000	0.000
2.60	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.51	0.00	0.00	0.000	0.0	0.000	0.000	0.000
26.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
26.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000
28.93	0.00	0.00	0.000	0.0	0.000	0.000	0.000
31.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
31.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000
32.98	0.00	0.00	0.000	0.0	0.000	0.000	0.000
34.51	0.00	0.00	0.000	0.0	0.000	0.000	0.000
34.55	0.00	0.00	0.000	0.0	0.000	0.000	0.000
42.98	0.00	0.00	0.000	0.0	0.000	0.000	0.000
51.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
51.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000
58.93	0.00	0.00	0.000	0.0	0.000	0.000	0.000
66.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
66.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000
71.43	0.00	0.00	0.000	0.0	0.000	0.000	0.000
76.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
76.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000
78.93	0.00	0.00	0.000	0.0	0.000	0.000	0.000
81.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
81.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000
83.93	0.00	0.00	0.000	0.0	0.000	0.000	0.000
86.41	0.00	0.00	0.000	0.0	0.000	0.000	0.000
86.45	0.00	0.00	0.000	0.0	0.000	0.000	0.000

88.00 0.00 0.00 0.000 0.0 0.000 0.000 0.000
89.58 0.00 0.00 0.000 0.0 0.000 0.000 0.000
0.00 0.00 0.00 0.000 0.0 0.000 0.000 0.000

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

ROS-CR222 : 11/23/2022 : ZM

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR ft	C-Slk k/ft/s	Dampg
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		11690.8			

HAMMER OPTIONS:
Hammer File ID No. 41 Hammer Type OE Diesel
Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010
Fuel Pump Setting Maximum

HAMMER DATA:
Ram Weight (kips) 4.00 Ram Length (inch) 129.10
Maximum Stroke (ft) 11.86
Rated Stroke (ft) 10.81 Efficiency 0.800

Maximum Pressure (psi) 1600.00 Actual Pressure (psi) 1600.00
Compression Exponent 1.350 Expansion Exponent 1.250
Ram Diameter (inch) 12.60
Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION		PILE CUSHION	
Cross Sect. Area	(in2) 227.00	Cross Sect. Area	(in2) 0.00
Elastic-Modulus	(ksi) 530.0	Elastic-Modulus	(ksi) 0.0
Thickness	(inch) 2.00	Thickness	(inch) 0.00
Coeff of Restitution	0.8	Coeff of Restitution	1.0
RoundOut	(ft) 0.0	RoundOut	(ft) 0.0
Stiffness	(kips/in) 60155.0	Stiffness	(kips/in) 0.0

Depth (ft) 2.6 Standard Soil Setup
Shaft Gain/Loss Factor 0.570 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 153.930 Pile Type Pipe
Pile Size (inch) 14.000

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.570 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
2.6	0.0	0.0	0.0	0.0	0.000	0.000	10.81	0.0
2.6	0.0	0.0	0.0	0.0	0.000	0.000	10.81	0.0
14.5	31.9	8.3	23.6	2.4	17.088	-3.326	4.82	23.7
26.4	63.7	40.1	23.6	4.8	20.858	-2.957	5.42	21.6
26.5	55.5	40.3	15.2	3.8	19.866	-3.875	5.24	22.2
28.9	60.6	45.3	15.2	4.3	20.510	-3.534	5.34	21.8
31.4	65.7	50.5	15.2	4.8	21.152	-3.289	5.45	21.5
31.5	75.2	50.6	24.7	6.0	22.157	-2.276	5.65	20.9
33.0	79.0	54.3	24.7	6.5	22.443	-1.926	5.72	20.7
34.5	83.2	58.5	24.7	7.0	22.606	-1.397	5.75	20.3
34.5	181.6	58.7	123.0	20.6	27.373	-3.001	7.13	19.6
43.0	238.0	115.0	123.0	28.5	28.700	-4.093	7.57	20.1
51.4	310.5	187.6	123.0	45.1	29.861	-5.448	8.03	20.9
51.5	271.9	187.9	84.0	32.6	28.985	-4.102	7.70	20.1
58.9	320.0	236.0	84.0	45.5	30.312	-4.517	8.21	20.8
66.4	371.0	287.0	84.0	69.6	30.866	-4.362	8.47	21.0
66.4	341.7	287.2	54.5	52.5	30.477	-4.144	8.32	20.6
71.4	361.7	307.2	54.5	63.8	30.780	-4.105	8.47	20.6
76.4	376.5	322.0	54.5	74.9	30.821	-3.340	8.52	20.4
76.4	382.3	322.2	60.2	79.7	30.928	-3.362	8.56	20.5
78.9	390.0	329.9	60.2	85.9	31.003	-2.691	8.63	20.5
81.4	398.3	338.1	60.2	93.2	31.088	-2.420	8.68	20.4
81.4	422.3	338.3	84.0	126.1	31.445	-2.561	8.82	20.8
83.9	439.2	355.2	84.0	155.1	31.503	-2.415	8.88	20.7
86.4	460.1	376.1	84.0	206.7	31.554	-2.315	8.96	20.7
86.4	458.7	376.4	82.3	201.0	31.559	-2.314	8.95	20.7
88.0	469.1	386.8	82.3	242.0	31.553	-2.246	8.98	20.6
89.6	477.6	395.3	82.3	287.4	31.529	-2.130	8.99	20.5

Total Driving Time 98 minutes; Total No. of Blows 3979
Starting at penetration 2.6 ft

ROS-CR222 : 11/23/2022 : ZM 11/28/2022
National Engineering & Architectural GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth	Temp. Length	Wait Time	Equivalent Pressure Stroke	Ratio	Stiffn. Efficy.	Cushion Factor	CoR

ft	ft	hr	ft				
2.56	89.58	0.00	10.81	1.00	0.80	1.00	1.00
2.60	89.58	0.00	10.81	1.00	0.80	1.00	1.00
14.51	89.58	0.00	10.81	1.00	0.80	1.00	1.00
26.41	89.58	0.00	10.81	1.00	0.80	1.00	1.00
26.45	89.58	0.00	10.81	1.00	0.80	1.00	1.00
28.93	89.58	0.00	10.81	1.00	0.80	1.00	1.00
31.41	89.58	0.00	10.81	1.00	0.80	1.00	1.00
31.45	89.58	0.00	10.81	1.00	0.80	1.00	1.00
32.98	89.58	0.00	10.81	1.00	0.80	1.00	1.00
34.51	89.58	0.00	10.81	1.00	0.80	1.00	1.00
34.55	89.58	0.00	10.81	1.00	0.80	1.00	1.00
42.98	89.58	0.00	10.81	1.00	0.80	1.00	1.00
51.41	89.58	0.00	10.81	1.00	0.80	1.00	1.00
51.45	89.58	0.00	10.81	1.00	0.80	1.00	1.00
58.93	89.58	0.00	10.81	1.00	0.80	1.00	1.00
66.41	89.58	0.00	10.81	1.00	0.80	1.00	1.00
66.45	89.58	0.00	10.81	1.00	0.80	1.00	1.00
71.43	89.58	0.00	10.81	1.00	0.80	1.00	1.00
76.41	89.58	0.00	10.81	1.00	0.80	1.00	1.00
76.45	89.58	0.00	10.81	1.00	0.80	1.00	1.00
78.93	89.58	0.00	10.81	1.00	0.80	1.00	1.00
81.41	89.58	0.00	10.81	1.00	0.80	1.00	1.00
81.45	89.58	0.00	10.81	1.00	0.80	1.00	1.00
83.93	89.58	0.00	10.81	1.00	0.80	1.00	1.00
86.41	89.58	0.00	10.81	1.00	0.80	1.00	1.00
86.45	89.58	0.00	10.81	1.00	0.80	1.00	1.00
88.00	89.58	0.00	10.81	1.00	0.80	1.00	1.00
89.58	89.58	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Limit	Setup Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.00	0.100	0.230	0.050	0.150	0.000	0.000	0.000
2.57	0.00	0.00	0.100	0.230	0.050	0.150	0.000	6.000	0.000
2.59	0.00	0.00	0.100	0.170	0.050	0.150	0.000	6.000	1.000
7.07	0.00	0.00	0.100	0.170	0.050	0.150	0.000	6.000	1.000
7.08	0.00	19.31	0.100	0.170	0.050	0.150	0.000	6.000	1.000
11.59	0.41	23.61	0.100	0.170	0.050	0.150	0.000	6.000	1.000
20.59	0.70	23.61	0.100	0.170	0.050	0.150	0.000	6.000	1.000
26.42	1.03	23.61	0.100	0.170	0.050	0.150	0.000	6.000	1.000
26.44	0.95	15.22	0.100	0.210	0.100	0.150	0.768	6.000	24.000
26.87	0.81	15.22	0.100	0.210	0.100	0.150	0.768	6.000	24.000
26.89	0.82	15.22	0.100	0.210	0.100	0.150	0.768	6.000	24.000
31.42	0.85	15.22	0.100	0.210	0.100	0.150	0.768	6.000	24.000
31.44	0.95	24.68	0.100	0.130	0.150	0.150	0.768	6.000	24.000
34.52	1.17	24.68	0.100	0.130	0.150	0.150	0.768	6.000	24.000
34.54	1.50	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000
43.54	2.19	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000
51.42	2.53	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000
51.44	2.59	84.01	0.100	0.120	0.100	0.150	0.768	6.000	24.000
60.44	2.66	84.01	0.100	0.120	0.100	0.150	0.768	6.000	24.000

66.42	2.96	84.01	0.100	0.120	0.100	0.150	0.768	6.000	24.000
66.44	2.18	54.51	0.100	0.120	0.200	0.150	1.000	6.000	168.000
75.44	1.26	54.51	0.100	0.120	0.200	0.150	1.000	6.000	168.000
76.42	1.26	54.51	0.100	0.120	0.200	0.150	1.000	6.000	168.000
76.44	1.23	60.16	0.100	0.120	0.150	0.150	0.768	6.000	24.000
81.42	1.39	60.16	0.100	0.120	0.150	0.150	0.768	6.000	24.000
81.44	2.46	84.01	0.100	0.120	0.100	0.150	0.768	6.000	24.000
86.42	3.75	84.01	0.100	0.120	0.100	0.150	0.768	6.000	24.000
86.44	3.00	82.28	0.100	0.120	0.150	0.150	0.768	6.000	168.000
89.58	1.92	82.28	0.100	0.120	0.150	0.150	0.768	6.000	168.000

PIER 2

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

Input File: P:\21-0053 (106544 ROS-CR222-0383)\106544\GEOTECHNICAL\BRIDGES\XXX-YY-ZZ.ZZ (CROSSING)\ANALYSIS\GRLWEAP\FILES\P2B5G.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

ROS-CR222 : 11/23/2022 : ZM

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	153.930	14.000	Pipe

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
69.580	16.05	30000.0	492.000	3.665	0	0.850	0.010

FFatigue	F0	0-Bottom
0	0.000	0.000

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1600.00	1440.00	1295.00	1165.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1600.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.00	0.10	0.13	0.05	0.15	1.00	6.00	1.000
7.09	0.00	0.00	0.10	0.13	0.05	0.15	1.00	6.00	1.000
7.11	0.00	0.00	0.10	0.12	0.05	0.15	1.00	6.00	1.000
8.24	0.00	0.00	0.10	0.12	0.05	0.15	1.00	6.00	1.000
8.25	0.00	73.84	0.10	0.12	0.05	0.15	1.00	6.00	1.000

16.11	1.13	149.18	0.10	0.12	0.05	0.15	1.00	6.00	1.000
21.39	1.77	199.80	0.10	0.12	0.05	0.15	1.00	6.00	1.000
21.41	1.77	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
30.41	1.86	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
31.99	2.23	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
32.01	2.32	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
36.39	2.37	122.96	0.10	0.13	0.05	0.15	1.00	6.00	1.000
36.41	2.59	173.24	0.10	0.12	0.05	0.15	1.00	6.00	1.000
41.39	2.95	173.24	0.10	0.12	0.05	0.15	1.00	6.00	1.000
41.41	2.73	84.01	0.10	0.14	0.05	0.15	1.00	6.00	1.000
50.41	2.56	84.01	0.10	0.14	0.05	0.15	1.00	6.00	1.000
51.39	2.73	84.01	0.10	0.14	0.05	0.15	1.00	6.00	1.000
51.41	2.86	122.96	0.10	0.12	0.05	0.15	1.00	6.00	1.000
59.59	3.17	122.96	0.10	0.12	0.05	0.15	1.00	6.00	1.000
59.61	2.59	15.22	0.10	0.15	0.10	0.15	1.49	6.00	24.000
68.61	2.12	15.22	0.10	0.15	0.10	0.15	1.49	6.00	24.000
69.58	2.24	15.22	0.10	0.15	0.10	0.15	1.49	6.00	24.000

Gain/Loss factors: shaft and toe

0.67000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
7.08	0.00	0.00	0.000	0.0	0.000	0.000	0.000
7.12	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.25	0.00	0.00	0.000	0.0	0.000	0.000	0.000
21.38	0.00	0.00	0.000	0.0	0.000	0.000	0.000
21.42	0.00	0.00	0.000	0.0	0.000	0.000	0.000
28.90	0.00	0.00	0.000	0.0	0.000	0.000	0.000
36.38	0.00	0.00	0.000	0.0	0.000	0.000	0.000
36.42	0.00	0.00	0.000	0.0	0.000	0.000	0.000
38.90	0.00	0.00	0.000	0.0	0.000	0.000	0.000
41.38	0.00	0.00	0.000	0.0	0.000	0.000	0.000
41.42	0.00	0.00	0.000	0.0	0.000	0.000	0.000
46.40	0.00	0.00	0.000	0.0	0.000	0.000	0.000
51.38	0.00	0.00	0.000	0.0	0.000	0.000	0.000
51.42	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
59.58	0.00	0.00	0.000	0.0	0.000	0.000	0.000
59.62	0.00	0.00	0.000	0.0	0.000	0.000	0.000
64.58	0.00	0.00	0.000	0.0	0.000	0.000	0.000
69.58	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

ROS-CR222 : 11/23/2022 : ZM

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR	C-Slk ft	Dampg k/ft/s
1	0.800				
2	0.800	140046.6	1.000	0.0000	

3	0.800	140046.6	1.000	0.0000
4	0.800	140046.6	1.000	0.0000
5	0.800	140046.6	1.000	0.0000
Imp Block	0.753	70735.6	0.900	0.0100
Helmet	1.900	60155.0	0.800	0.0100
Combined Pile Top	11706.5			

HAMMER OPTIONS:

Hammer File ID No.	41	Hammer Type	OE Diesel
Stroke Option	FxdP-VarS	Stroke Convergence Crit.	0.010
Fuel Pump Setting	Maximum		

HAMMER DATA:

Ram Weight (kips)	4.00	Ram Length (inch)	129.10
Maximum Stroke (ft)	11.86		
Rated Stroke (ft)	10.81	Efficiency	0.800
Maximum Pressure (psi)	1600.00	Actual Pressure (psi)	1600.00
Compression Exponent	1.350	Expansion Exponent	1.250
Ram Diameter (inch)	12.60		
Combustion Delay (s)	0.00200	Ignition Duration (s)	0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION		PILE CUSHION	
Cross Sect. Area (in2)	227.00	Cross Sect. Area (in2)	0.00
Elastic-Modulus (ksi)	530.0	Elastic-Modulus (ksi)	0.0
Thickness (inch)	2.00	Thickness (inch)	0.00
Coeff of Restitution	0.8	Coeff of Restitution	1.0
RoundOut (ft)	0.0	RoundOut (ft)	0.0
Stiffness (kips/in)	60155.0	Stiffness (kips/in)	0.0

ROS-CR222 : 11/23/2022 : ZM 11/28/2022
National Engineering & Architectural GRLWEAP Version 2010

Depth (ft)	7.1	Standard Soil Setup	
Shaft Gain/Loss Factor	0.670	Toe Gain/Loss Factor	1.000

PILE PROFILE:

Toe Area (in2)	153.930	Pile Type	Pipe
Pile Size (inch)	14.000		

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.670 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
7.1	0.0	0.0	0.0	0.0	0.000	0.000	10.81	0.0
7.1	0.0	0.0	0.0	0.0	0.000	0.000	10.81	0.0

14.2	140.8	9.5	131.4	16.0	26.667	-0.686	6.89	19.3
21.4	244.0	44.3	199.7	30.3	34.408	-2.819	7.90	20.2
21.4	167.5	44.5	123.0	18.5	27.105	-1.780	7.04	19.2
28.9	217.0	94.1	123.0	24.3	28.733	-3.050	7.45	19.4
36.4	276.9	153.9	123.0	33.7	30.261	-3.925	8.00	20.1
36.4	327.5	154.3	173.2	47.5	31.919	-5.680	8.61	21.3
38.9	351.9	178.6	173.2	55.1	32.187	-5.850	8.72	21.6
41.4	377.9	204.6	173.2	65.2	32.616	-6.259	8.91	21.9
41.4	289.0	205.0	84.0	33.3	30.082	-3.629	7.94	19.8
46.4	338.0	254.0	84.0	44.1	30.987	-4.297	8.31	20.2
51.4	385.6	301.6	84.0	59.3	31.820	-3.975	8.66	20.7
51.4	424.9	302.0	123.0	83.4	32.650	-5.183	9.00	21.5
55.5	468.9	345.9	123.0	117.8	33.102	-4.411	9.22	21.6
59.6	515.1	392.2	123.0	179.8	33.371	-3.905	9.37	21.6
59.6	407.7	392.5	15.2	58.4	31.447	-4.457	8.57	19.5
64.6	437.7	422.5	15.2	72.2	31.797	-3.553	8.78	19.5
69.6	464.9	449.7	15.2	88.3	31.796	-2.459	8.84	19.2

Total Driving Time 76 minutes; Total No. of Blows 3082
Starting at penetration 7.1 ft

ROS-CR222 : 11/23/2022 : ZM 11/28/2022
National Engineering & Architectural GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth	Temp. Length	Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
7.08	69.58	0.00	10.81	1.00	0.80	1.00	1.00
7.12	69.58	0.00	10.81	1.00	0.80	1.00	1.00
14.25	69.58	0.00	10.81	1.00	0.80	1.00	1.00
21.38	69.58	0.00	10.81	1.00	0.80	1.00	1.00
21.42	69.58	0.00	10.81	1.00	0.80	1.00	1.00
28.90	69.58	0.00	10.81	1.00	0.80	1.00	1.00
36.38	69.58	0.00	10.81	1.00	0.80	1.00	1.00
36.42	69.58	0.00	10.81	1.00	0.80	1.00	1.00
38.90	69.58	0.00	10.81	1.00	0.80	1.00	1.00
41.38	69.58	0.00	10.81	1.00	0.80	1.00	1.00
41.42	69.58	0.00	10.81	1.00	0.80	1.00	1.00
46.40	69.58	0.00	10.81	1.00	0.80	1.00	1.00
51.38	69.58	0.00	10.81	1.00	0.80	1.00	1.00
51.42	69.58	0.00	10.81	1.00	0.80	1.00	1.00
55.50	69.58	0.00	10.81	1.00	0.80	1.00	1.00
59.58	69.58	0.00	10.81	1.00	0.80	1.00	1.00
59.62	69.58	0.00	10.81	1.00	0.80	1.00	1.00
64.58	69.58	0.00	10.81	1.00	0.80	1.00	1.00
69.58	69.58	0.00	10.81	1.00	0.80	1.00	1.00

Soil Layer Resistance Values

Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Limit Setup Distance	Setup Time

ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs	
0.01	0.00	0.00	0.100	0.130	0.050	0.150	0.000	6.000	1.000	
7.09	0.00	0.00	0.100	0.130	0.050	0.150	0.000	6.000	1.000	
7.11	0.00	0.00	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
8.24	0.00	0.00	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
8.25	0.00	73.84	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
16.11	1.13	149.18	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
21.39	1.77	199.80	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
21.41	1.77	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000	
30.41	1.86	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000	
31.99	2.23	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000	
32.01	2.32	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000	
36.39	2.37	122.96	0.100	0.130	0.050	0.150	0.000	6.000	1.000	
36.41	2.59	173.24	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
41.39	2.95	173.24	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
41.41	2.73	84.01	0.100	0.140	0.050	0.150	0.000	6.000	1.000	
50.41	2.56	84.01	0.100	0.140	0.050	0.150	0.000	6.000	1.000	
51.39	2.73	84.01	0.100	0.140	0.050	0.150	0.000	6.000	1.000	
51.41	2.86	122.96	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
59.59	3.17	122.96	0.100	0.120	0.050	0.150	0.000	6.000	1.000	
59.61	2.59	15.22	0.100	0.150	0.100	0.150	1.000	6.000	24.000	
68.61	2.12	15.22	0.100	0.150	0.100	0.150	1.000	6.000	24.000	
69.58	2.24	15.22	0.100	0.150	0.100	0.150	1.000	6.000	24.000	

FORWARD ABUTMENT

GRLWEAP - Version 2010
WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS

written by GRL Engineers, Inc. (formerly Goble Rausche Likins and Associates, Inc.) with cooperation from Pile Dynamics, Inc.

Input File: P:\21-0053 (106544 ROS-CR222-0383)\106544\GEOTECHNICAL\BRIDGES\XXX-YY-ZZ.ZZ (CROSSING)\ANALYSIS\GRLWEAP\FILES\FBB5.GWW
Hammer File: C:\ProgramData\PDI\GRLWEAP\2010\Resource\HAMMER2010.GW
Hammer File Version: 2003 (10/17/2016)

Input File Contents

ROS-CR222 : 03/01/2022 : ZM

OUT	OSG	HAM	STR	FUL	PEL	N	SPL	N-U	P-D	%SK	ISM	0	PHI	RSA	ITR	H-D	MXT	DEx
-100	0	41	0	0	0	0	0	0	1	0	0	0	0	0	0	0	0	0.000

Pile g	Hammer g	Toe Area	Pile Size	Pile Type
32.170	32.170	113.090	12.000	Pipe

W Cp	A Cp	E Cp	T Cp	CoR	ROut	StCp
1.900	227.000	530.0	2.000	0.800	0.010	0.0

A Cu	E Cu	T Cu	CoR	ROut	StCu
0.000	0.0	0.000	0.000	0.000	0.0

LPle	APle	EPle	WPle	Peri	CI	CoR	ROut
88.780	13.69	30000.0	492.000	3.141	0	0.850	0.010

FFatigue	F0	0-Bottom
0	0.000	0.000

Manufac	Hmr Name	HmrType	No Seg-s
DELMAG	D 19-42	1	5

Ram Wt	Ram L	Ram Dia	MaxStrk	RtdStrk	Efficy
4.00	129.10	12.60	11.86	10.81	0.80

IB. Wt	IB. L	IB.Dia	IB CoR	IB RO
0.75	25.30	12.60	0.900	0.010

CompStrk	A Chamber	V Chamber	C Delay	C Duratn	Exp Coeff	VolCStart	Vol CEnd
16.65	124.70	157.70	0.0020	0.0020	1.250	0.00	0.00

P atm	P1	P2	P3	P4	P5
14.70	1600.00	1440.00	1295.00	1165.00	0.00

Stroke	Effic.	Pressure	R-Weight	T-Delay	Exp-Coeff	Eps-Str	Total-AW
10.8100	0.8000	1600.0000	0.0000	0.0000	0.0000	0.0100	0.0000

Qs	Qt	Js	Jt	Qx	Jx	Rati	Dept
0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000

Research Soil Model: Atoe, Plug, Gap, Q-fac

0.000	0.000	0.000	0.000

Research Soil Model: RD-skn: m, d, toe: m, d

0.000	0.000	0.000	0.000

Res. Distribution

Dpth	Rskn	Rtoe	Qs	Qt	Js	Jt	SU F	LimL	TSf0
0.01	0.00	0.03	0.10	0.16	0.10	0.15	1.21	6.00	24.000
4.34	0.08	13.47	0.10	0.16	0.10	0.15	1.21	6.00	24.000
4.36	0.16	13.53	0.10	0.16	0.05	0.15	1.00	6.00	1.000
13.36	0.34	36.19	0.10	0.16	0.05	0.15	1.00	6.00	1.000
14.34	0.54	36.19	0.10	0.16	0.05	0.15	1.00	6.00	1.000

14.36	0.64	78.19	0.10	0.16	0.05	0.15	1.00	6.00	1.000
23.36	0.97	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
23.69	1.29	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
23.71	1.59	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
26.34	2.12	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
26.36	2.66	206.08	0.10	0.12	0.05	0.15	1.00	6.00	1.000
35.36	2.55	225.94	0.10	0.12	0.05	0.15	1.00	6.00	1.000
40.64	2.44	225.94	0.10	0.12	0.05	0.15	1.00	6.00	1.000
40.66	2.86	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
49.66	3.18	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
55.64	3.65	117.99	0.10	0.13	0.05	0.15	1.00	6.00	1.000
55.66	3.34	166.23	0.10	0.12	0.05	0.15	1.00	6.00	1.000
60.64	3.29	166.23	0.10	0.12	0.05	0.15	1.00	6.00	1.000
60.66	3.54	80.62	0.10	0.14	0.05	0.15	1.00	6.00	1.000
69.66	3.66	80.62	0.10	0.14	0.05	0.15	1.00	6.00	1.000
70.64	3.92	80.62	0.10	0.14	0.05	0.15	1.00	6.00	1.000
70.66	3.98	117.99	0.10	0.12	0.05	0.15	1.00	6.00	1.000
78.84	4.08	117.99	0.10	0.12	0.05	0.15	1.00	6.00	1.000
78.86	3.34	14.61	0.10	0.15	0.10	0.15	1.49	6.00	24.000
87.86	2.69	14.61	0.10	0.15	0.10	0.15	1.49	6.00	24.000
88.78	2.77	14.61	0.10	0.15	0.10	0.15	1.49	6.00	24.000

Gain/Loss factors: shaft and toe

0.67000	0.00000	0.00000	0.00000	0.00000
1.00000	0.00000	0.00000	0.00000	0.00000

Dpth	L	Wait	Strk	Pmx%	Eff.	Stff	CoR
4.33	0.00	0.00	0.000	0.0	0.000	0.000	0.000
4.37	0.00	0.00	0.000	0.0	0.000	0.000	0.000
9.35	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.33	0.00	0.00	0.000	0.0	0.000	0.000	0.000
14.37	0.00	0.00	0.000	0.0	0.000	0.000	0.000
20.35	0.00	0.00	0.000	0.0	0.000	0.000	0.000
26.33	0.00	0.00	0.000	0.0	0.000	0.000	0.000
26.37	0.00	0.00	0.000	0.0	0.000	0.000	0.000
33.50	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.63	0.00	0.00	0.000	0.0	0.000	0.000	0.000
40.67	0.00	0.00	0.000	0.0	0.000	0.000	0.000
48.15	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.63	0.00	0.00	0.000	0.0	0.000	0.000	0.000
55.67	0.00	0.00	0.000	0.0	0.000	0.000	0.000
58.15	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.63	0.00	0.00	0.000	0.0	0.000	0.000	0.000
60.67	0.00	0.00	0.000	0.0	0.000	0.000	0.000
65.65	0.00	0.00	0.000	0.0	0.000	0.000	0.000
70.63	0.00	0.00	0.000	0.0	0.000	0.000	0.000
70.67	0.00	0.00	0.000	0.0	0.000	0.000	0.000
74.75	0.00	0.00	0.000	0.0	0.000	0.000	0.000
78.83	0.00	0.00	0.000	0.0	0.000	0.000	0.000
78.87	0.00	0.00	0.000	0.0	0.000	0.000	0.000
83.80	0.00	0.00	0.000	0.0	0.000	0.000	0.000
88.78	0.00	0.00	0.000	0.0	0.000	0.000	0.000
0.00	0.00	0.00	0.000	0.0	0.000	0.000	0.000

GRLWEAP: WAVE EQUATION ANALYSIS OF PILE FOUNDATIONS
Version 2010
English Units

ROS-CR222 : 03/01/2022 : ZM

Hammer Model: D 19-42 Made by: DELMAG

No.	Weight kips	Stiffn k/inch	CoR ft	C-Slk k/ft/s	Dampg
1	0.800				
2	0.800	140046.6	1.000	0.0000	
3	0.800	140046.6	1.000	0.0000	
4	0.800	140046.6	1.000	0.0000	
5	0.800	140046.6	1.000	0.0000	
Imp Block	0.753	70735.6	0.900	0.0100	
Helmet	1.900	60155.0	0.800	0.0100	5.8
Combined Pile Top		10061.6			

HAMMER OPTIONS:
Hammer File ID No. 41 Hammer Type OE Diesel
Stroke Option FxdP-VarS Stroke Convergence Crit. 0.010
Fuel Pump Setting Maximum

HAMMER DATA:
Ram Weight (kips) 4.00 Ram Length (inch) 129.10
Maximum Stroke (ft) 11.86
Rated Stroke (ft) 10.81 Efficiency 0.800

Maximum Pressure (psi) 1600.00 Actual Pressure (psi) 1600.00
Compression Exponent 1.350 Expansion Exponent 1.250
Ram Diameter (inch) 12.60
Combustion Delay (s) 0.00200 Ignition Duration (s) 0.00200

The Hammer Data Includes Estimated (NON-MEASURED) Quantities

HAMMER CUSHION			PILE CUSHION		
Cross Sect. Area	(in2)	227.00	Cross Sect. Area	(in2)	0.00
Elastic-Modulus	(ksi)	530.0	Elastic-Modulus	(ksi)	0.0
Thickness	(inch)	2.00	Thickness	(inch)	0.00
Coeff of Restitution		0.8	Coeff of Restitution		1.0
RoundOut	(ft)	0.0	RoundOut	(ft)	0.0
Stiffness	(kips/in)	60155.0	Stiffness	(kips/in)	0.0

ROS-CR222 : 03/01/2022 : ZM 11/23/2022
National Engineering & Architectural GRLWEAP Version 2010

Depth (ft) 4.3 Standard Soil Setup
Shaft Gain/Loss Factor 0.670 Toe Gain/Loss Factor 1.000

PILE PROFILE:
Toe Area (in2) 113.090 Pile Type Pipe

Pile Size (inch) 12.000

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.670 1.000

Depth	Rut	Frictn	End Bg	Bl Ct	Com Str	Ten Str	Stroke	ENTHRU
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft
4.3	13.9	0.4	13.4	1.5	11.708	-1.220	4.05	24.1
4.4	14.0	0.5	13.6	1.5	11.788	-1.190	4.06	24.1
9.4	29.8	3.7	26.1	2.4	16.935	-1.419	4.65	24.1
14.3	45.1	8.9	36.2	3.8	19.474	-0.721	5.06	22.5
14.4	87.2	8.9	78.2	8.8	23.445	-0.660	5.87	20.2
20.4	127.7	23.0	104.7	13.5	26.036	-1.588	6.46	19.9
26.3	166.2	48.2	118.0	17.5	27.585	-2.746	6.90	20.2
26.4	254.6	48.5	206.1	33.0	37.823	-5.091	8.02	22.3
33.5	328.9	107.1	221.8	55.2	37.780	-8.027	8.88	24.3
40.6	389.3	163.4	225.9	88.6	35.476	-9.231	9.18	24.9
40.7	281.7	163.7	118.0	35.8	30.930	-6.559	8.04	22.1
48.2	352.0	234.0	118.0	60.4	32.353	-7.816	8.60	23.1
55.6	431.0	313.0	118.0	119.8	33.766	-8.292	9.16	24.0
55.7	479.7	313.4	166.2	239.9	34.145	-8.621	9.31	24.4
58.2	505.6	339.4	166.2	405.7	34.248	-8.394	9.38	24.4
60.6	531.3	365.1	166.2	675.9	34.325	-8.235	9.43	24.4
60.7	446.1	365.5	80.6	129.4	33.700	-7.329	9.16	23.6
65.7	502.0	421.4	80.6	282.7	33.948	-6.737	9.29	23.5
70.6	559.3	478.7	80.6	648.3	34.071	-6.605	9.40	23.3
70.7	597.2	479.2	118.0	9999.0	34.275	-6.562	9.48	23.6
74.8	648.5	530.5	118.0	9999.0	34.222	-7.285	9.51	23.4
78.8	700.5	582.5	118.0	9999.0	34.218	-7.311	9.53	23.0
78.9	597.5	582.9	14.6	692.3	34.030	-6.267	9.45	22.8
83.8	630.3	615.7	14.6	1092.2	34.085	-4.692	9.53	22.5
88.8	659.8	645.2	14.6	1818.3	34.210	-5.290	9.67	22.2

Refusal occurred; no driving time output possible

ROS-CR222 : 03/01/2022 : ZM 11/23/2022
National Engineering & Architectural GRLWEAP Version 2010

Table of Depths Analyzed with Driving System Modifiers

Depth	Length	Temp. Wait Time	Equivalent Stroke	Pressure Ratio	Efficy.	Stiffn. Factor	Cushion CoR
ft	ft	hr	ft				
4.33	88.78	0.00	10.81	1.00	0.80	1.00	1.00
4.37	88.78	0.00	10.81	1.00	0.80	1.00	1.00
9.35	88.78	0.00	10.81	1.00	0.80	1.00	1.00
14.33	88.78	0.00	10.81	1.00	0.80	1.00	1.00
14.37	88.78	0.00	10.81	1.00	0.80	1.00	1.00
20.35	88.78	0.00	10.81	1.00	0.80	1.00	1.00
26.33	88.78	0.00	10.81	1.00	0.80	1.00	1.00
26.37	88.78	0.00	10.81	1.00	0.80	1.00	1.00
33.50	88.78	0.00	10.81	1.00	0.80	1.00	1.00

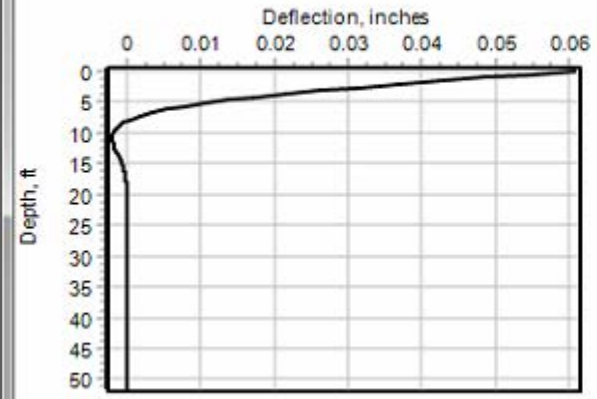
40.63	88.78	0.00	10.81	1.00	0.80	1.00	1.00
40.67	88.78	0.00	10.81	1.00	0.80	1.00	1.00
48.15	88.78	0.00	10.81	1.00	0.80	1.00	1.00
55.63	88.78	0.00	10.81	1.00	0.80	1.00	1.00
55.67	88.78	0.00	10.81	1.00	0.80	1.00	1.00
58.15	88.78	0.00	10.81	1.00	0.80	1.00	1.00
60.63	88.78	0.00	10.81	1.00	0.80	1.00	1.00
60.67	88.78	0.00	10.81	1.00	0.80	1.00	1.00
65.65	88.78	0.00	10.81	1.00	0.80	1.00	1.00
70.63	88.78	0.00	10.81	1.00	0.80	1.00	1.00
70.67	88.78	0.00	10.81	1.00	0.80	1.00	1.00
74.75	88.78	0.00	10.81	1.00	0.80	1.00	1.00
78.83	88.78	0.00	10.81	1.00	0.80	1.00	1.00
78.87	88.78	0.00	10.81	1.00	0.80	1.00	1.00
83.80	88.78	0.00	10.81	1.00	0.80	1.00	1.00
88.78	88.78	0.00	10.81	1.00	0.80	1.00	1.00

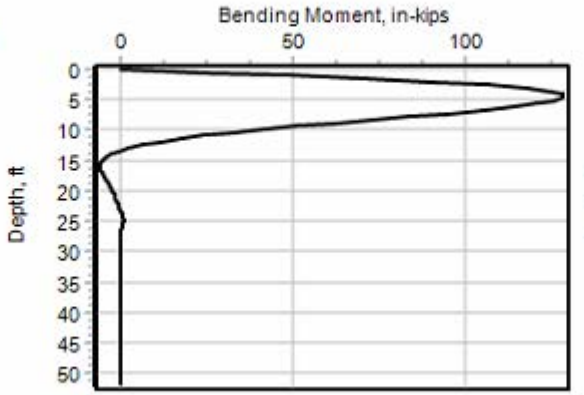
Soil Layer Resistance Values

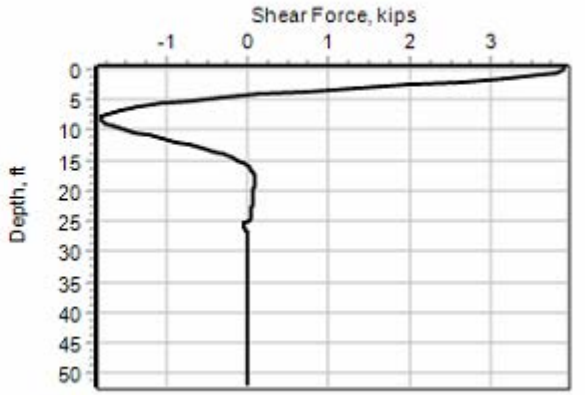
Depth	Shaft Res.	End Bearing	Shaft Quake	Toe Quake	Shaft Damping	Toe Damping	Soil Limit	Setup Distance	Setup Time
ft	k/ft2	kips	inch	inch	s/ft	s/ft	Normlzd	ft	hrs
0.01	0.00	0.03	0.100	0.160	0.100	0.150	0.515	6.000	24.000
4.34	0.08	13.47	0.100	0.160	0.100	0.150	0.515	6.000	24.000
4.36	0.16	13.53	0.100	0.160	0.050	0.150	0.000	6.000	1.000
13.36	0.34	36.19	0.100	0.160	0.050	0.150	0.000	6.000	1.000
14.34	0.54	36.19	0.100	0.160	0.050	0.150	0.000	6.000	1.000
14.36	0.64	78.19	0.100	0.160	0.050	0.150	0.000	6.000	1.000
23.36	0.97	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
23.69	1.29	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
23.71	1.59	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
26.34	2.12	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
26.36	2.66	206.08	0.100	0.120	0.050	0.150	0.000	6.000	1.000
35.36	2.55	225.94	0.100	0.120	0.050	0.150	0.000	6.000	1.000
40.64	2.44	225.94	0.100	0.120	0.050	0.150	0.000	6.000	1.000
40.66	2.86	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
49.66	3.18	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
55.64	3.65	117.99	0.100	0.130	0.050	0.150	0.000	6.000	1.000
55.66	3.34	166.23	0.100	0.120	0.050	0.150	0.000	6.000	1.000
60.64	3.29	166.23	0.100	0.120	0.050	0.150	0.000	6.000	1.000
60.66	3.54	80.62	0.100	0.140	0.050	0.150	0.000	6.000	1.000
69.66	3.66	80.62	0.100	0.140	0.050	0.150	0.000	6.000	1.000
70.64	3.92	80.62	0.100	0.140	0.050	0.150	0.000	6.000	1.000
70.66	3.98	117.99	0.100	0.120	0.050	0.150	0.000	6.000	1.000
78.84	4.08	117.99	0.100	0.120	0.050	0.150	0.000	6.000	1.000
78.86	3.34	14.61	0.100	0.150	0.100	0.150	1.000	6.000	24.000
87.86	2.69	14.61	0.100	0.150	0.100	0.150	1.000	6.000	24.000
88.78	2.77	14.61	0.100	0.150	0.100	0.150	1.000	6.000	24.000

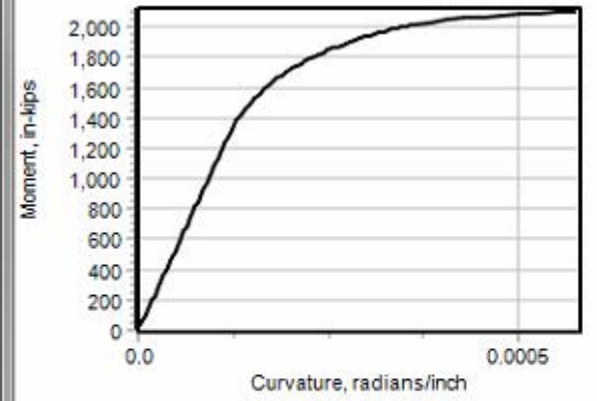
LPILE ANALYSES

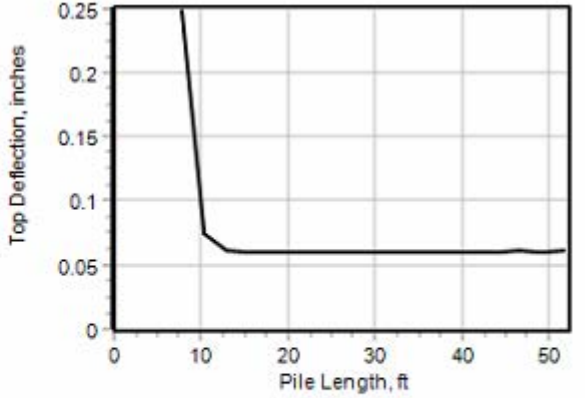
Results for ROS-222-0383 Bridge Rear Pier-Service-B04.lp7d











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LPile Plus for Windows, Version 2013-07.007

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: P:\21-0053 (106544 ROS-CR222-0383)\106544\geotechnical\bridges\XXX-YY-ZZ.ZZ (Crossing)\Analysis\Lpile\Files\
Name of input data file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7d
Name of output report file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7o
Name of plot output file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7p
Name of runtime messeage file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7r

---

Date and Time of Analysis

Date: November 29, 2022 Time: 11:00:41

Problem Title

Project Name: ROS-CR222-0383
Job Number: BRIDGE NO. ROS-CO222-04.221 OVER CSX RAILROAD
Client: Carpenter Marty Transportation/ODOT
Engineer: ZM
Description: Rear Pier

Program Options and Settings

Engineering Units of Input Data and Computations:
 - Engineering units are US Customary Units (pounds, feet, inches)

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

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

Computational Options:
 - Use unfactored loads in computations (conventional analysis)
 - Compute pile response under loading and nonlinear bending properties of pile
   (only if nonlinear pile properties are input)
 - Use of p-y modification factors for p-y curves not selected
 - Loading by lateral soil movements acting on pile not selected
 - Input of shear 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:
 - No p-y curves to be computed and reported for user-specified depths
 - 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

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 51.70 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameter values 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.

Point	Depth X ft	Pile Diameter in
1	0.00000	14.0000000
2	51.700000	14.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	= Steel Pipe Pile
Section Length	= 51.70000 ft
Pile Diameter	= 14.00000 in

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 9 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 0.0000 ft
Distance from top of pile to bottom of layer	= 19.30000 ft
Effective unit weight at top of layer	= 115.00000 pcf
Effective unit weight at bottom of layer	= 115.00000 pcf
Friction angle at top of layer	= 31.00000 deg.
Friction angle at bottom of layer	= 31.00000 deg.
Subgrade k at top of layer	= 108.00000 pci
Subgrade k at bottom of layer	= 108.00000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 19.30000 ft
Distance from top of pile to bottom of layer	= 24.30000 ft
Effective unit weight at top of layer	= 59.60000 pcf
Effective unit weight at bottom of layer	= 59.60000 pcf
Friction angle at top of layer	= 27.00000 deg.
Friction angle at bottom of layer	= 27.00000 deg.
Subgrade k at top of layer	= 26.00000 pci
Subgrade k at bottom of layer	= 26.00000 pci

Layer 3 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	= 24.30000 ft
Distance from top of pile to bottom of layer	= 27.40000 ft
Effective unit weight at top of layer	= 59.60000 pcf
Effective unit weight at bottom of layer	= 59.60000 pcf
Undrained cohesion at top of layer	= 2400.00000 psf
Undrained cohesion at bottom of layer	= 2400.00000 psf

Epsilon-50 at top of layer = 0.00560
Epsilon-50 at bottom of layer = 0.00560
Subgrade k at top of layer = 833.00000 pci
Subgrade k at bottom of layer = 833.00000 pci

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

Distance from top of pile to top of layer = 27.40000 ft
Distance from top of pile to bottom of layer = 44.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Friction angle at top of layer = 35.00000 deg.
Friction angle at bottom of layer = 35.00000 deg.
Subgrade k at top of layer = 245.00000 pci
Subgrade k at bottom of layer = 245.00000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 44.30000 ft
Distance from top of pile to bottom of layer = 59.30000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Friction angle at top of layer = 34.00000 deg.
Friction angle at bottom of layer = 34.00000 deg.
Subgrade k at top of layer = 177.00000 pci
Subgrade k at bottom of layer = 177.00000 pci

Layer 6 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 59.30000 ft
Distance from top of pile to bottom of layer = 69.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Undrained cohesion at top of layer = 5300.00000 psf
Undrained cohesion at bottom of layer = 5300.00000 psf
Epsilon-50 at top of layer = 0.00400
Epsilon-50 at bottom of layer = 0.00400
Subgrade k at top of layer = 1854.00000 pci
Subgrade k at bottom of layer = 1854.00000 pci

Layer 7 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 69.30000 ft
Distance from top of pile to bottom of layer = 74.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Undrained cohesion at top of layer = 5850.00000 psf
Undrained cohesion at bottom of layer = 5850.00000 psf
Epsilon-50 at top of layer = 0.00390
Epsilon-50 at bottom of layer = 0.00390
Subgrade k at top of layer = 2042.00000 pci
Subgrade k at bottom of layer = 2042.00000 pci

Layer 8 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 74.30000 ft
Distance from top of pile to bottom of layer = 79.30000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Friction angle at top of layer = 34.00000 deg.
Friction angle at bottom of layer = 34.00000 deg.
Subgrade k at top of layer = 177.00000 pci
Subgrade k at bottom of layer = 177.00000 pci

Layer 9 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 79.30000 ft
Distance from top of pile to bottom of layer = 82.50000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Undrained cohesion at top of layer = 8000.00000 psf
Undrained cohesion at bottom of layer = 8000.00000 psf
Epsilon-50 at top of layer = 0.00340
Epsilon-50 at bottom of layer = 0.00340
Subgrade k at top of layer = 3337.00000 pci
Subgrade k at bottom of layer = 3337.00000 pci

(Depth of lowest soil layer extends 30.80 ft below pile tip)

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Strain Factor Epsilon 50	kpy pci
1	Sand (Reese, et al.)	0.00	115.000	--	31.000	--	108.000
		19.300	115.000	--	31.000	--	108.000
2	Sand (Reese, et al.)	19.300	59.600	--	27.000	--	26.000
		24.300	59.600	--	27.000	--	26.000
3	Stiff Clay with Free Water	24.300	59.600	2400.000	--	0.00560	833.000
		27.400	59.600	2400.000	--	0.00560	833.000
4	Sand (Reese, et al.)	27.400	72.600	--	35.000	--	245.000
		44.300	72.600	--	35.000	--	245.000
5	Sand (Reese, et al.)	44.300	77.600	--	34.000	--	177.000
		59.300	77.600	--	34.000	--	177.000
6	Stiff Clay with Free Water	59.300	72.600	5300.000	--	0.00400	1854.000
		69.300	72.600	5300.000	--	0.00400	1854.000
7	Stiff Clay with Free Water	69.300	72.600	5850.000	--	0.00390	2042.000
		74.300	72.600	5850.000	--	0.00390	2042.000
8	Sand (Reese, et al.)	74.300	77.600	--	34.000	--	177.000
		79.300	77.600	--	34.000	--	177.000
9	Stiff Clay with Free Water	79.300	77.600	8000.000	--	0.00340	3337.000

	82.500	77.600	8000.000	--	0.00340	3337.000

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 = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 3900.00000 lbs	M = 0.0000 in-lbs	196000.	Yes

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust 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 Steel Pipe Pile:

Length of Section = 51.70000 ft
Outer Diameter of Pipe = 14.00000 in
Pipe Wall Thickness = 0.37500 in
Yield Stress of Pipe = 36.00000 ksi
Elastic Modulus = 29000. ksi
Cross-sectional Area = 16.05157 sq. in.
Moment of Inertia = 372.76021 in^4
Elastic Bending Stiffness = 10810046. kip-in^2
Plastic Modulus, Z = 69.63281 in^3
Plastic Moment Capacity = Fy Z = 2506.78125 in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 577.857 kips
Nominal Axial Tensile Capacity = -577.857 kips

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

Number	Axial Thrust Force kips
1	198.200

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 198.200 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.000003008	32.5186044	10810179.	148.5431894	12.9522453	
0.000006016	65.0372088	10810179.	77.7715947	13.5567925	
0.000009024	97.5558132	10810179.	54.1810631	14.1613395	
0.0000120	130.0744176	10810179.	42.3857973	14.7658871	
0.0000150	162.5930220	10810179.	35.3086379	15.3704343	
0.0000180	195.1116264	10810179.	30.5905316	15.9749815	
0.0000211	227.6302308	10810179.	27.2204556	16.5795290	
0.0000241	260.1488352	10810179.	24.6928987	17.1840762	
0.0000271	292.6674396	10810179.	22.7270210	17.7886233	
0.0000301	325.1860439	10810179.	21.1543189	18.3931707	
0.0000331	357.7046483	10810179.	19.8675627	18.9977179	
0.0000361	390.2232527	10810179.	18.7952658	19.6022653	
0.0000391	422.7418571	10810179.	17.8879376	20.2068125	
0.0000421	455.2604615	10810179.	17.1102278	20.8113597	
0.0000451	487.7790659	10810179.	16.4362126	21.4159070	
0.0000481	520.2976703	10810179.	15.8464493	22.0204542	
0.0000511	552.8162747	10810179.	15.3260700	22.6250015	
0.0000541	585.3348791	10810179.	14.8635105	23.2295488	
0.0000572	617.8534835	10810179.	14.4496415	23.8340961	
0.0000602	650.3720879	10810179.	14.0771595	24.4386433	
0.0000632	682.8906923	10810179.	13.7401519	25.0431906	
0.0000662	715.4092967	10810179.	13.4337813	25.6477379	
0.0000692	747.9279011	10810179.	13.1540517	26.2522851	
0.0000722	780.4465055	10810179.	12.8976329	26.8568324	
0.0000752	812.9651099	10810179.	12.6617276	27.4613797	
0.0000782	845.4837143	10810179.	12.4439688	28.0659269	
0.0000812	878.0023187	10810179.	12.2423403	28.6704742	
0.0000842	910.5209230	10810179.	12.0551139	29.2750215	
0.0000872	943.0395274	10810179.	11.8807996	29.8795687	

0.0000902	975.5581318	10810179.	11.7181063	30.4841160	
0.0000933	1008.0767362	10810179.	11.5659093	31.0886633	
0.0000963	1040.5953406	10810179.	11.4232247	31.6932105	
0.0000993	1073.1139450	10810179.	11.2891876	32.2977578	
0.0001023	1105.6325494	10810179.	11.1630350	32.9023051	
0.0001053	1138.1511538	10810179.	11.0440911	33.5068523	
0.0001083	1170.6697582	10810179.	10.9317553	34.1113996	
0.0001113	1203.1883626	10810179.	10.8254916	34.7159469	
0.0001143	1235.7069670	10810179.	10.7248208	35.3204941	
0.0001173	1268.2255714	10810179.	10.6293125	35.9250414	Y
0.0001233	1328.2783711	10769765.	10.4649850	36.0000000	Y
0.0001294	1378.5732004	10657672.	10.3403939	36.0000000	Y
0.0001354	1422.7010856	10509986.	10.2423474	36.0000000	Y
0.0001414	1462.2864094	10342739.	10.1640821	36.0000000	Y
0.0001474	1498.3063371	10164956.	10.1012059	36.0000000	Y
0.0001534	1531.3227357	9981540.	10.0508538	36.0000000	Y
0.0001594	1561.7738269	9795875.	10.0107972	36.0000000	Y
0.0001654	1590.0194162	9610383.	9.9792437	36.0000000	Y
0.0001715	1616.2981165	9426437.	9.9548942	36.0000000	Y
0.0001775	1640.7811656	9244845.	9.9367660	36.0000000	Y
0.0001835	1663.8265136	9067325.	9.9234856	36.0000000	Y
0.0001895	1685.3669042	8893135.	9.9148838	36.0000000	Y
0.0001955	1705.7713374	8723855.	9.9097100	36.0000000	Y
0.0002015	1724.9428067	8558563.	9.9079941	36.0000000	Y
0.0002076	1743.1079259	8398006.	9.9089531	36.0000000	Y
0.0002136	1760.3659791	8242246.	9.9121785	36.0000000	Y
0.0002196	1776.7739490	8091151.	9.9174003	36.0000000	Y
0.0002256	1792.3337154	7944354.	9.9245158	36.0000000	Y
0.0002316	1807.1517201	7801981.	9.9331656	36.0000000	Y
0.0002376	1821.3004255	7664000.	9.9430967	36.0000000	Y
0.0002437	1834.8258799	7530275.	9.9541385	36.0000000	Y
0.0002497	1847.7722203	7400675.	9.9661358	36.0000000	Y
0.0002557	1860.1817944	7275074.	9.9789472	36.0000000	Y
0.0002617	1872.0912407	7153338.	9.9924532	36.0000000	Y
0.0002677	1883.4626491	7035063.	10.0067378	36.0000000	Y
0.0002737	1894.3956044	6920385.	10.0215280	36.0000000	Y
0.0002798	1904.9271274	6809205.	10.0367193	36.0000000	Y
0.0002858	1915.0928499	6701426.	10.0522137	36.0000000	Y
0.0002918	1924.9270831	6596955.	10.0679191	36.0000000	Y
0.0002978	1934.3063009	6495178.	10.0841634	36.0000000	Y
0.0003038	1943.3874550	6396450.	10.1005392	36.0000000	Y
0.0003098	1952.2180167	6300747.	10.1169249	36.0000000	Y
0.0003159	1960.7039446	6207600.	10.1335731	36.0000000	Y
0.0003219	1968.8910696	6117006.	10.1503755	36.0000000	Y
0.0003279	1976.9021464	6029199.	10.1670145	36.0000000	Y
0.0003339	1984.3494347	5942869.	10.1830737	36.0000000	Y
0.0003399	1991.4607058	5858606.	10.1983259	36.0000000	Y
0.0003459	1998.3638836	5776672.	10.2136096	36.0000000	Y
0.0003520	2004.5581483	5695525.	10.2269075	36.0000000	Y
0.0003580	2010.4772656	5616337.	10.2393579	36.0000000	Y
0.0003820	2030.4949532	5314950.	10.2810453	36.0000000	Y
0.0004061	2046.0525365	5038300.	10.3114607	36.0000000	Y
0.0004302	2058.5248945	4785431.	10.3346734	36.0000000	Y
0.0004542	2068.9011606	4554742.	10.3534685	36.0000000	Y
0.0004783	2077.5144961	4343581.	10.3687348	36.0000000	Y
0.0005024	2084.7848836	4149978.	10.3813247	36.0000000	Y

0.0005264	2091.0116150	3972093.	10.3924056	36.0000000	Y
0.0005505	2096.4628210	3808352.	10.4025609	36.0000000	Y
0.0005746	2101.1044233	3656918.	10.4103695	36.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip
1	198.200	2101.1

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

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 = 3900.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 198200.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.0607	4.287E-08	3900.0000	-0.001007	12348.	1.081E+10	0.000	0.000	0.000
0.517	0.0545	25434.	3817.0835	-0.001000	12825.	1.081E+10	-26.7300	3044.8799	0.000
1.034	0.0483	49821.	3565.1536	-0.000978	13283.	1.081E+10	-54.4853	6997.7024	0.000
1.551	0.0423	72076.	3152.6856	-0.000943	13701.	1.081E+10	-78.4831	11504.	0.000
2.068	0.0366	91259.	2611.4770	-0.000896	14061.	1.081E+10	-95.9877	16270.	0.000
2.585	0.0312	106684.	1989.4515	-0.000840	14351.	1.081E+10	-104.5363	20784.	0.000
3.102	0.0262	118009.	1338.6400	-0.000775	14564.	1.081E+10	-105.2675	24941.	0.000
3.619	0.0216	125200.	706.3588	-0.000705	14699.	1.081E+10	-98.5626	28327.	0.000
4.136	0.0174	128508.	137.1293	-0.000632	14761.	1.081E+10	-84.9414	30228.	0.000
4.653	0.0137	128457.	-324.3875	-0.000559	14760.	1.081E+10	-63.8390	28829.	0.000
5.170	0.0105	125857.	-708.0018	-0.000486	14711.	1.081E+10	-59.8278	35348.	0.000
5.687	0.007711	120866.	-1059.5538	-0.000415	14617.	1.081E+10	-53.5030	43048.	0.000

6.204	0.005351	113731.	-1358.9921	-0.000348	14483.	1.081E+10	-43.0278	49883.	0.000
6.721	0.003397	104859.	-1584.2515	-0.000285	14317.	1.081E+10	-29.5897	54039.	0.000
7.238	0.001816	94774.	-1728.8806	-0.000228	14127.	1.081E+10	-17.0348	58196.	0.000
7.755	0.000572	83967.	-1799.5670	-0.000176	13924.	1.081E+10	-5.7526	62353.	0.000
8.272	-0.000372	72879.	-1805.0314	-0.000131	13716.	1.081E+10	3.9910	66510.	0.000
8.789	-0.001057	61893.	-1755.2880	-9.268E-05	13510.	1.081E+10	12.0449	70667.	0.000
9.306	-0.001522	51327.	-1660.9746	-6.019E-05	13312.	1.081E+10	18.3591	74824.	0.000
9.823	-0.001804	41432.	-1532.7724	-3.357E-05	13126.	1.081E+10	22.9697	78981.	0.000
10.340	-0.001939	32391.	-1380.9259	-1.239E-05	12956.	1.081E+10	25.9814	83138.	0.000
10.857	-0.001958	24328.	-1214.8691	3.886E-06	12805.	1.081E+10	27.5507	87294.	0.000
11.374	-0.001891	17307.	-1042.9577	1.583E-05	12673.	1.081E+10	27.8689	91451.	0.000
11.891	-0.001762	11348.	-872.2984	2.406E-05	12561.	1.081E+10	27.1470	95608.	0.000
12.408	-0.001592	6424.7770	-708.6692	2.916E-05	12468.	1.081E+10	25.6025	99765.	0.000
12.925	-0.001400	2482.7917	-556.5150	3.171E-05	12394.	1.081E+10	23.4478	103922.	0.000
13.442	-0.001199	-558.4477	-419.0057	3.226E-05	12358.	1.081E+10	20.8814	108079.	0.000
13.959	-0.000999	-2795.5765	-298.1433	3.130E-05	12400.	1.081E+10	18.0814	112236.	0.000
14.476	-0.000810	-4334.7881	-194.9009	2.926E-05	12429.	1.081E+10	15.2012	116393.	0.000
14.993	-0.000636	-5285.8539	-109.3836	2.649E-05	12447.	1.081E+10	12.3673	120549.	0.000
15.510	-0.000482	-5757.1772	-40.9964	2.333E-05	12456.	1.081E+10	9.6789	124706.	0.000
16.027	-0.000347	-5851.9021	11.3883	1.999E-05	12458.	1.081E+10	7.2085	128863.	0.000
16.544	-0.000233	-5665.0437	49.2739	1.669E-05	12454.	1.081E+10	5.0048	133020.	0.000
17.061	-0.000140	-5281.5563	74.3984	1.355E-05	12447.	1.081E+10	3.0947	137177.	0.000
17.578	-6.531E-05	-4775.2278	88.6133	1.066E-05	12437.	1.081E+10	1.4878	141334.	0.000
18.095	-7.658E-06	-4208.2646	93.7856	8.085E-06	12427.	1.081E+10	0.1796	145491.	0.000
18.612	3.501E-05	-3631.4195	91.7231	5.835E-06	12416.	1.081E+10	-0.8445	149648.	0.000
19.129	6.475E-05	-3084.5152	84.1243	3.908E-06	12406.	1.081E+10	-1.6052	153805.	0.000
19.646	8.350E-05	-2597.2161	77.2885	2.278E-06	12396.	1.081E+10	-0.5985	44469.	0.000
20.163	9.301E-05	-2131.1212	73.3173	9.210E-07	12388.	1.081E+10	-0.6817	45469.	0.000
20.680	9.493E-05	-1689.7598	68.9971	-1.754E-07	12379.	1.081E+10	-0.7111	46470.	0.000
21.197	9.083E-05	-1274.5745	64.6354	-1.026E-06	12372.	1.081E+10	-0.6950	47471.	0.000
21.714	8.220E-05	-885.2411	60.4872	-1.646E-06	12364.	1.081E+10	-0.6422	48471.	0.000
22.231	7.041E-05	-520.0019	56.7533	-2.049E-06	12357.	1.081E+10	-0.5615	49472.	0.000
22.748	5.678E-05	-176.0074	53.5787	-2.249E-06	12351.	1.081E+10	-0.4619	50473.	0.000
23.265	4.251E-05	150.3330	51.0518	-2.256E-06	12351.	1.081E+10	-0.3527	51474.	0.000
23.782	2.878E-05	462.9916	49.2025	-2.080E-06	12356.	1.081E+10	-0.2434	52474.	0.000
24.299	1.670E-05	765.9536	48.0008	-1.727E-06	12362.	1.081E+10	-0.1440	53475.	0.000
24.816	7.348E-06	1062.8343	9.0072	-1.203E-06	12368.	1.081E+10	-12.4265	10492544.	0.000
25.333	1.778E-06	880.6727	-45.7084	-6.450E-07	12364.	1.081E+10	-5.2123	18185572.	0.000
25.850	-6.556E-07	497.2713	-55.9055	-2.496E-07	12357.	1.081E+10	1.9250	18217634.	0.000
26.367	-1.319E-06	187.6113	-37.9008	-5.306E-08	12351.	1.081E+10	3.8792	18249696.	0.000
26.884	-1.314E-06	27.1287	-13.8569	8.559E-09	12348.	1.081E+10	3.8719	18281757.	0.000
27.401	-1.213E-06	15.6542	-1.6235	2.084E-08	12348.	1.081E+10	0.0718	367480.	0.000
27.918	-1.055E-06	6.9331	-1.2018	2.732E-08	12348.	1.081E+10	0.0641	376910.	0.000
28.435	-8.736E-07	0.6751	-0.8341	2.950E-08	12348.	1.081E+10	0.0544	386340.	0.000
28.952	-6.894E-07	-3.4896	-0.5290	2.869E-08	12348.	1.081E+10	0.0440	395770.	0.000
29.469	-5.176E-07	-5.9590	-0.2877	2.598E-08	12348.	1.081E+10	0.0338	405199.	0.000
29.986	-3.670E-07	-7.1232	-0.1067	2.223E-08	12348.	1.081E+10	0.0245	414629.	0.000
30.503	-2.418E-07	-7.3382	0.0206	1.808E-08	12348.	1.081E+10	0.0165	424059.	0.000
31.020	-1.427E-07	-6.9119	0.1028	1.399E-08	12348.	1.081E+10	0.009971	433489.	0.000
31.537	-6.823E-08	-6.0970	0.1489	1.026E-08	12348.	1.081E+10	0.004871	442919.	0.000
32.054	-1.546E-08	-5.0902	0.1675	7.045E-09	12348.	1.081E+10	0.001127	452349.	0.000
32.571	1.918E-08	-4.0365	0.1665	4.426E-09	12348.	1.081E+10	-0.001428	461779.	0.000
33.088	3.946E-08	-3.0348	0.1528	2.397E-09	12348.	1.081E+10	-0.002997	471209.	0.000
33.605	4.893E-08	-2.1464	0.1317	9.103E-10	12348.	1.081E+10	-0.003791	480639.	0.000
34.122	5.075E-08	-1.4024	0.1075	-1.081E-10	12348.	1.081E+10	-0.004009	490069.	0.000
34.639	4.759E-08	-0.8117	0.0832	-7.434E-10	12348.	1.081E+10	-0.003831	499499.	0.000

35.156	4.153E-08	-0.3679	0.0608	-1.082E-09	12348.	1.081E+10	-0.003407	508929.	0.000
35.673	3.416E-08	-0.0549	0.0414	-1.203E-09	12348.	1.081E+10	-0.002854	518359.	0.000
36.190	2.660E-08	0.1482	0.0255	-1.176E-09	12348.	1.081E+10	-0.002263	527789.	0.000
36.707	1.957E-08	0.2641	0.0132	-1.058E-09	12348.	1.081E+10	-0.001694	537219.	0.000
37.224	1.347E-08	0.3147	0.004266	-8.920E-10	12348.	1.081E+10	-0.001187	546649.	0.000
37.741	8.498E-09	0.3193	-0.001779	-7.101E-10	12348.	1.081E+10	-0.000762	556079.	0.000
38.258	4.661E-09	0.2943	-0.005460	-5.340E-10	12348.	1.081E+10	-0.000425	565509.	0.000
38.775	1.872E-09	0.2528	-0.007316	-3.770E-10	12348.	1.081E+10	-0.000174	574939.	0.000
39.292	-1.645E-11	0.2045	-0.007849	-2.458E-10	12348.	1.081E+10	1.550E-06	584369.	0.000
39.809	-1.177E-09	0.1560	-0.007495	-1.423E-10	12348.	1.081E+10	0.000113	593799.	0.000
40.326	-1.782E-09	0.1118	-0.006608	-6.545E-11	12348.	1.081E+10	0.000173	603229.	0.000
40.843	-1.989E-09	0.0742	-0.005461	-1.207E-11	12348.	1.081E+10	0.000196	612658.	0.000
41.360	-1.932E-09	0.0441	-0.004251	2.189E-11	12348.	1.081E+10	0.000194	622088.	0.000
41.877	-1.718E-09	0.0214	-0.003107	4.069E-11	12348.	1.081E+10	0.000175	631518.	0.000
42.394	-1.427E-09	0.005448	-0.002108	4.840E-11	12348.	1.081E+10	0.000147	640948.	0.000
42.911	-1.117E-09	-0.004851	-0.001287	4.857E-11	12348.	1.081E+10	0.000117	650378.	0.000
43.428	-8.246E-10	-0.0106	-0.000651	4.412E-11	12348.	1.081E+10	8.770E-05	659808.	0.000
43.945	-5.698E-10	-0.0130	-0.000189	3.733E-11	12348.	1.081E+10	6.146E-05	669238.	0.000
44.462	-3.614E-10	-0.0131	8.757E-05	2.983E-11	12348.	1.081E+10	2.762E-05	474138.	0.000
44.979	-1.996E-10	-0.0120	0.000221	2.263E-11	12348.	1.081E+10	1.547E-05	480950.	0.000
45.496	-8.058E-11	-0.0104	0.000289	1.620E-11	12348.	1.081E+10	6.335E-06	487763.	0.000
46.013	1.444E-12	-0.008485	0.000308	1.079E-11	12348.	1.081E+10	-1.151E-07	494576.	0.000
46.530	5.326E-11	-0.006585	0.000294	6.463E-12	12348.	1.081E+10	-4.304E-06	501388.	0.000
47.047	8.163E-11	-0.004847	0.000260	3.182E-12	12348.	1.081E+10	-6.687E-06	508201.	0.000
47.564	9.275E-11	-0.003362	0.000216	0.000	12348.	1.081E+10	-7.699E-06	515014.	0.000
48.081	9.189E-11	-0.002172	0.000168	0.000	12348.	1.081E+10	-7.729E-06	521826.	0.000
48.598	8.330E-11	-0.001277	0.000122	-1.751E-12	12348.	1.081E+10	-7.098E-06	528639.	0.000
49.115	7.016E-11	-0.000655	8.110E-05	-2.306E-12	12348.	1.081E+10	-6.055E-06	535452.	0.000
49.632	5.469E-11	-0.000265	4.749E-05	-2.570E-12	12348.	1.081E+10	-4.780E-06	542264.	0.000
50.149	3.828E-11	-5.943E-05	2.215E-05	-2.663E-12	12348.	1.081E+10	-3.388E-06	549077.	0.000
50.666	2.165E-11	1.608E-05	5.623E-06	-2.675E-12	12348.	1.081E+10	-1.940E-06	555890.	0.000
51.183	5.082E-12	1.692E-05	-1.824E-06	-2.666E-12	12348.	1.081E+10	-4.609E-07	562702.	0.000
51.700	-1.143E-11	0.000	0.000	-2.661E-12	12348.	1.081E+10	1.049E-06	284757.	0.000

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.0607109 inches
Computed slope at pile head = -0.0010071 radians
Maximum bending moment = 128508. inch-lbs
Maximum shear force = 3900.0000000 lbs
Depth of maximum bending moment = 4.1360000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 7
Number of zero deflection points = 7

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

Boundary Condition Type 1, Shear and Moment

Shear = 3900. lb
Moment = 0. in- lb
Axial Load = 198200. lb

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
51.7000	0.0607109	128508.	3900.0000000
49.1150	0.0605406	128864.	3900.0000000
46.5300	0.0606037	128513.	3900.0000000
43.9450	0.0605574	128760.	3900.0000000
41.3600	0.0604827	128505.	3900.0000000
38.7750	0.0605318	128495.	3900.0000000
36.1900	0.0604661	128522.	3900.0000000
33.6050	0.0604093	128469.	3900.0000000
31.0200	0.0603989	128428.	3900.0000000
28.4350	0.0603615	128339.	3900.0000000
25.8500	0.0603561	128360.	3900.0000000
23.2650	0.0603621	128322.	3900.0000000
20.6800	0.0603441	128283.	3900.0000000
18.0950	0.0603601	128232.	3900.0000000
15.5100	0.0603669	128227.	3900.0000000
12.9250	0.0611950	127386.	3900.0000000
10.3400	0.0746415	122749.	3900.0000001
7.7550	0.2480986	119363.	-4418.7686469

Summary of Pile Response(s)

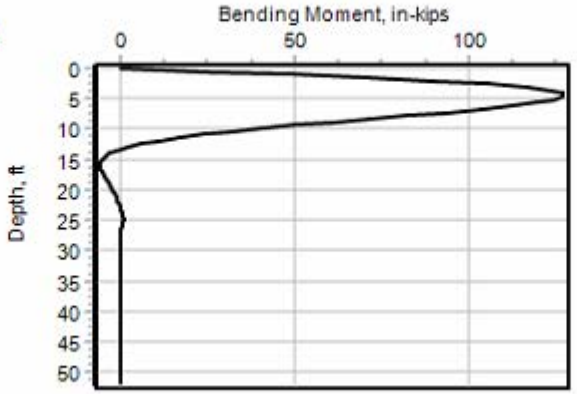
Definitions of Pile-head Loading Conditions:

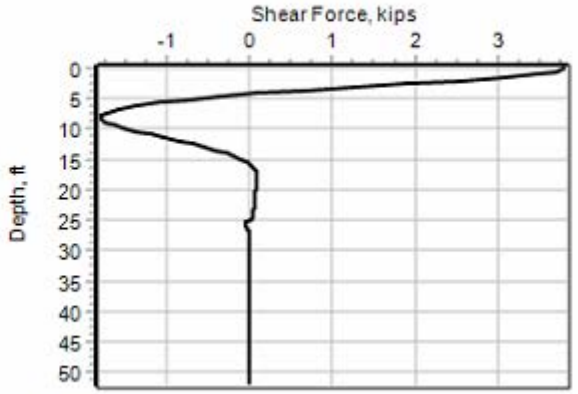
Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

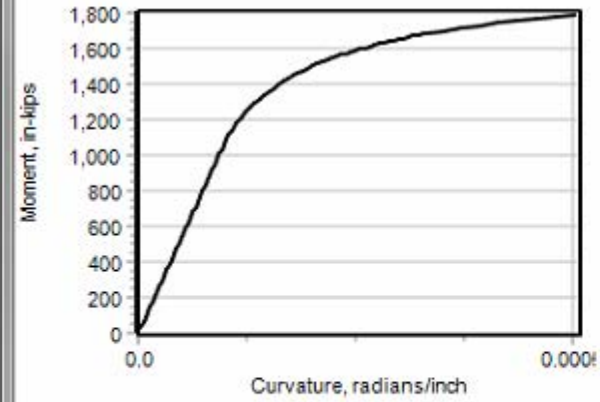
Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Maximum Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 3900.0000	M = 0.000	198200.	0.06071089	128508.	3900.0000	-0.00100710

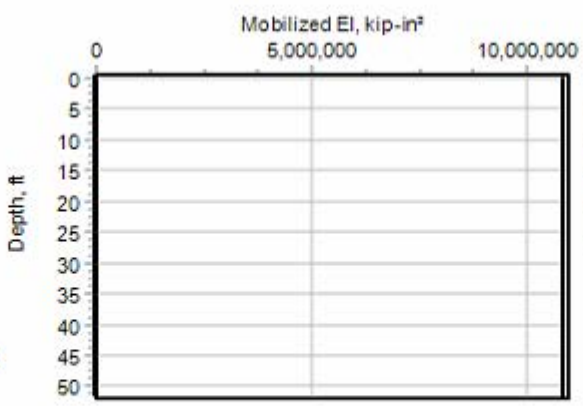
The analysis ended normally.

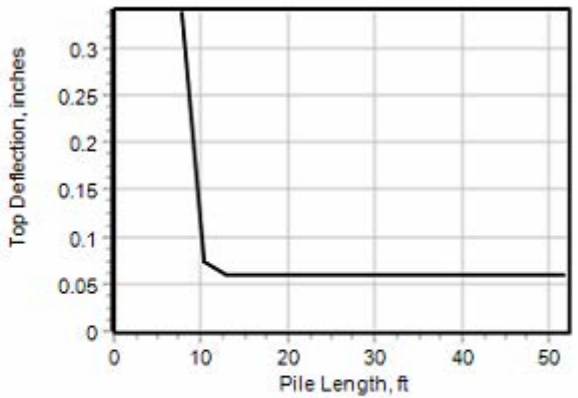
Results for ROS-222-0383 Bridge Rear Pier-Strength-B04.lp7d











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LPile Plus for Windows, Version 2013-07.007

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: P:\21-0053 (106544 ROS-CR222-0383)\106544\geotechnical\bridges\XXX-YY-ZZ.ZZ (Crossing)\Analysis\Lpile\Files\
Name of input data file: ROS-222-0383 Bridge Rear Pier-Strength-B04.lp7d
Name of output report file: ROS-222-0383 Bridge Rear Pier-Strength-B04.lp7o
Name of plot output file: ROS-222-0383 Bridge Rear Pier-Strength-B04.lp7p
Name of runtime messeage file: ROS-222-0383 Bridge Rear Pier-Strength-B04.lp7r

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Date and Time of Analysis

Date: November 29, 2022 Time: 11:04:00

Problem Title

Project Name: ROS-CR222-0383
Job Number: BRIDGE NO. ROS-CO222-04.221 OVER CSX RAILROAD
Client: Carpenter Marty Transportation/ODOT
Engineer: ZM
Description: Rear Pier

Program Options and Settings

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units (pounds, feet, inches)

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

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

Computational Options:
- Use unfactored loads in computations (conventional analysis)
- Compute pile response under loading and nonlinear bending properties of pile (only if nonlinear pile properties are input)
- Use of p-y modification factors for p-y curves not selected
- Loading by lateral soil movements acting on pile not selected
- Input of shear 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:
- No p-y curves to be computed and reported for user-specified depths
- 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

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 51.70 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameter values 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.

Point	Depth X ft	Pile Diameter in
1	0.00000	14.0000000
2	51.700000	14.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	= Steel Pipe Pile
Section Length	= 51.70000 ft
Pile Diameter	= 14.00000 in

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 9 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 0.0000 ft
Distance from top of pile to bottom of layer	= 19.30000 ft
Effective unit weight at top of layer	= 115.00000 pcf
Effective unit weight at bottom of layer	= 115.00000 pcf
Friction angle at top of layer	= 31.00000 deg.
Friction angle at bottom of layer	= 31.00000 deg.
Subgrade k at top of layer	= 108.00000 pci
Subgrade k at bottom of layer	= 108.00000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 19.30000 ft
Distance from top of pile to bottom of layer	= 24.30000 ft
Effective unit weight at top of layer	= 59.60000 pcf
Effective unit weight at bottom of layer	= 59.60000 pcf
Friction angle at top of layer	= 27.00000 deg.
Friction angle at bottom of layer	= 27.00000 deg.
Subgrade k at top of layer	= 26.00000 pci
Subgrade k at bottom of layer	= 26.00000 pci

Layer 3 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	= 24.30000 ft
Distance from top of pile to bottom of layer	= 27.40000 ft
Effective unit weight at top of layer	= 59.60000 pcf
Effective unit weight at bottom of layer	= 59.60000 pcf
Undrained cohesion at top of layer	= 2400.00000 psf
Undrained cohesion at bottom of layer	= 2400.00000 psf

Epsilon-50 at top of layer = 0.00560
Epsilon-50 at bottom of layer = 0.00560
Subgrade k at top of layer = 833.00000 pci
Subgrade k at bottom of layer = 833.00000 pci

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

Distance from top of pile to top of layer = 27.40000 ft
Distance from top of pile to bottom of layer = 44.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Friction angle at top of layer = 35.00000 deg.
Friction angle at bottom of layer = 35.00000 deg.
Subgrade k at top of layer = 245.00000 pci
Subgrade k at bottom of layer = 245.00000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 44.30000 ft
Distance from top of pile to bottom of layer = 59.30000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Friction angle at top of layer = 34.00000 deg.
Friction angle at bottom of layer = 34.00000 deg.
Subgrade k at top of layer = 177.00000 pci
Subgrade k at bottom of layer = 177.00000 pci

Layer 6 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 59.30000 ft
Distance from top of pile to bottom of layer = 69.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Undrained cohesion at top of layer = 5300.00000 psf
Undrained cohesion at bottom of layer = 5300.00000 psf
Epsilon-50 at top of layer = 0.00400
Epsilon-50 at bottom of layer = 0.00400
Subgrade k at top of layer = 1854.00000 pci
Subgrade k at bottom of layer = 1854.00000 pci

Layer 7 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 69.30000 ft
Distance from top of pile to bottom of layer = 74.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Undrained cohesion at top of layer = 5850.00000 psf
Undrained cohesion at bottom of layer = 5850.00000 psf
Epsilon-50 at top of layer = 0.00390
Epsilon-50 at bottom of layer = 0.00390
Subgrade k at top of layer = 2042.00000 pci
Subgrade k at bottom of layer = 2042.00000 pci

Layer 8 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 74.30000 ft
Distance from top of pile to bottom of layer = 79.30000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Friction angle at top of layer = 34.00000 deg.
Friction angle at bottom of layer = 34.00000 deg.
Subgrade k at top of layer = 177.00000 pci
Subgrade k at bottom of layer = 177.00000 pci

Layer 9 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 79.30000 ft
Distance from top of pile to bottom of layer = 82.50000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Undrained cohesion at top of layer = 8000.00000 psf
Undrained cohesion at bottom of layer = 8000.00000 psf
Epsilon-50 at top of layer = 0.00340
Epsilon-50 at bottom of layer = 0.00340
Subgrade k at top of layer = 3337.00000 pci
Subgrade k at bottom of layer = 3337.00000 pci

(Depth of lowest soil layer extends 30.80 ft below pile tip)

Summary of Soil Properties

Layer Num.	Layer Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Strain Factor Epsilon 50	kpy pci
1	Sand (Reese, et al.)	0.00	115.000	--	31.000	--	108.000
		19.300	115.000	--	31.000	--	108.000
2	Sand (Reese, et al.)	19.300	59.600	--	27.000	--	26.000
		24.300	59.600	--	27.000	--	26.000
3	Stiff Clay with Free Water	24.300	59.600	2400.000	--	0.00560	833.000
		27.400	59.600	2400.000	--	0.00560	833.000
4	Sand (Reese, et al.)	27.400	72.600	--	35.000	--	245.000
		44.300	72.600	--	35.000	--	245.000
5	Sand (Reese, et al.)	44.300	77.600	--	34.000	--	177.000
		59.300	77.600	--	34.000	--	177.000
6	Stiff Clay with Free Water	59.300	72.600	5300.000	--	0.00400	1854.000
		69.300	72.600	5300.000	--	0.00400	1854.000
7	Stiff Clay with Free Water	69.300	72.600	5850.000	--	0.00390	2042.000
		74.300	72.600	5850.000	--	0.00390	2042.000
8	Sand (Reese, et al.)	74.300	77.600	--	34.000	--	177.000
		79.300	77.600	--	34.000	--	177.000
9	Stiff Clay with Free Water	79.300	77.600	8000.000	--	0.00340	3337.000

	82.500	77.600	8000.000	--	0.00340	3337.000

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 = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 3800.00000 lbs	M = 0.0000 in-lbs	263600.	Yes

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust 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 Steel Pipe Pile:

Length of Section = 51.70000 ft
Outer Diameter of Pipe = 14.00000 in
Pipe Wall Thickness = 0.37500 in
Yield Stress of Pipe = 36.00000 ksi
Elastic Modulus = 29000. ksi
Cross-sectional Area = 16.05157 sq. in.
Moment of Inertia = 372.76021 in^4
Elastic Bending Stiffness = 10810046. kip-in^2
Plastic Modulus, Z = 69.63281 in^3
Plastic Moment Capacity = Fy Z = 2506.78125 in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 577.857 kips
Nominal Axial Tensile Capacity = -577.857 kips

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

Number	Axial Thrust Force kips
1	266.700

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 266.700 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.000002745	29.6779410	10810179.	215.6923233	17.1669290	
0.000005491	59.3558821	10810179.	111.3461616	17.7186661	
0.000008236	89.0338231	10810179.	76.5641078	18.2704029	
0.0000110	118.7117641	10810179.	59.1730808	18.8221401	
0.0000137	148.3897052	10810179.	48.7384647	19.3738772	
0.0000165	178.0676462	10810179.	41.7820539	19.9256140	
0.0000192	207.7455872	10810179.	36.8131890	20.4773514	
0.0000220	237.4235282	10810179.	33.0865404	21.0290882	
0.0000247	267.1014693	10810179.	30.1880359	21.5808251	
0.0000275	296.7794103	10810179.	27.8692323	22.1325624	
0.0000302	326.4573513	10810179.	25.9720294	22.6842993	
0.0000329	356.1352924	10810179.	24.3910269	23.2360365	
0.0000357	385.8132334	10810179.	23.0532556	23.7877734	
0.0000384	415.4911744	10810179.	21.9065945	24.3395103	
0.0000412	445.1691155	10810179.	20.9128216	24.8912473	
0.0000439	474.8470565	10810179.	20.0432702	25.4429845	
0.0000467	504.5249975	10810179.	19.2760190	25.9947216	
0.0000494	534.2029385	10810179.	18.5940180	26.5464586	
0.0000522	563.8808796	10810179.	17.9838065	27.0981957	
0.0000549	593.5588206	10810179.	17.4346162	27.6499325	
0.0000577	623.2367616	10810179.	16.9377297	28.2016696	
0.0000604	652.9147027	10810179.	16.4860147	28.7534066	
0.0000631	682.5926437	10810179.	16.0735793	29.3051437	
0.0000659	712.2705847	10810179.	15.6955135	29.8568807	
0.0000686	741.9485258	10810179.	15.3476929	30.4086178	
0.0000714	771.6264668	10810179.	15.0266278	30.9603548	
0.0000741	801.3044078	10810179.	14.7293453	31.5120917	
0.0000769	830.9823488	10810179.	14.4532973	32.0638289	
0.0000796	860.6602899	10810179.	14.1962870	32.6155658	

0.0000824	890.3382309	10810179.	13.9564108	33.1673029	
0.0000851	920.0161719	10810179.	13.7320104	33.7190399	
0.0000879	949.6941130	10810179.	13.5216351	34.2707769	
0.0000906	979.3720540	10810179.	13.3240098	34.8225139	
0.0000933	1009.0499950	10810179.	13.1380095	35.3742510	
0.0000961	1038.7279361	10810179.	12.9626378	35.9259880	Y
0.0000988	1067.2443934	10798427.	12.8006701	36.0000000	Y
0.0001016	1093.0674201	10760794.	12.6558970	36.0000000	Y
0.0001043	1116.4812143	10702049.	12.5262625	36.0000000	Y
0.0001071	1137.9333775	10627995.	12.4094104	36.0000000	Y
0.0001126	1177.0357450	10456947.	12.2045180	36.0000000	Y
0.0001181	1211.8248301	10265273.	12.0318776	36.0000000	Y
0.0001235	1243.2764265	10063621.	11.8848209	36.0000000	Y
0.0001290	1271.9520016	9857618.	11.7588091	36.0000000	Y
0.0001345	1298.2432086	9650706.	11.6504236	36.0000000	Y
0.0001400	1322.4745684	9445311.	11.5568939	36.0000000	Y
0.0001455	1344.9232784	9243166.	11.4759344	36.0000000	Y
0.0001510	1365.8312901	9045519.	11.4056301	36.0000000	Y
0.0001565	1385.3483289	8852853.	11.3445646	36.0000000	Y
0.0001620	1403.5740860	8665277.	11.2916491	36.0000000	Y
0.0001675	1420.7481754	8483721.	11.2454688	36.0000000	Y
0.0001730	1436.8604783	8307554.	11.2055236	36.0000000	Y
0.0001784	1452.0710618	8137174.	11.1708453	36.0000000	Y
0.0001839	1466.4922821	7972675.	11.1406959	36.0000000	Y
0.0001894	1480.1329255	7813592.	11.1147264	36.0000000	Y
0.0001949	1493.0414818	7659715.	11.0925066	36.0000000	Y
0.0002004	1505.3258501	7511156.	11.0734575	36.0000000	Y
0.0002059	1517.0279659	7367691.	11.0572463	36.0000000	Y
0.0002114	1528.1880455	7229116.	11.0435739	36.0000000	Y
0.0002169	1538.8446932	7095235.	11.0321704	36.0000000	Y
0.0002224	1549.0349971	6965869.	11.0227911	36.0000000	Y
0.0002279	1558.7946148	6840848.	11.0152134	36.0000000	Y
0.0002334	1568.1578505	6720011.	11.0092334	36.0000000	Y
0.0002388	1577.1476953	6603166.	11.0046964	36.0000000	Y
0.0002443	1585.7176206	6489854.	11.0016832	36.0000000	Y
0.0002498	1593.9710057	6380256.	10.9998023	36.0000000	Y
0.0002553	1601.9380613	6274251.	10.9989041	36.0000000	Y
0.0002608	1609.6479048	6171723.	10.9988483	36.0000000	Y
0.0002663	1617.0064064	6072103.	10.9998987	36.0000000	Y
0.0002718	1624.1147716	5975588.	11.0016995	36.0000000	Y
0.0002773	1631.0344858	5882215.	11.0040216	36.0000000	Y
0.0002828	1637.6617475	5791434.	11.0071717	36.0000000	Y
0.0002883	1644.0727129	5703361.	11.0108887	36.0000000	Y
0.0002938	1650.3541418	5618139.	11.0148704	36.0000000	Y
0.0002992	1656.3066279	5534946.	11.0197440	36.0000000	Y
0.0003047	1662.1697273	5454457.	11.0247274	36.0000000	Y
0.0003102	1667.7973418	5376058.	11.0302743	36.0000000	Y
0.0003157	1673.2848421	5299942.	11.0360750	36.0000000	Y
0.0003212	1678.6038231	5225904.	11.0422055	36.0000000	Y
0.0003267	1683.7608630	5153859.	11.0486457	36.0000000	Y
0.0003487	1703.0145510	4884428.	11.0765759	36.0000000	Y
0.0003706	1720.2952555	4641607.	11.1071412	36.0000000	Y
0.0003926	1735.8290020	4421504.	11.1395867	36.0000000	Y
0.0004146	1750.0437507	4221542.	11.1726004	36.0000000	Y
0.0004365	1762.9433054	4038688.	11.2063007	36.0000000	Y
0.0004585	1774.7851662	3871047.	11.2400105	36.0000000	Y

0.0004804	1785.1881225	3715738.	11.2705043	36.0000000	Y
0.0005024	1794.4448528	3571726.	11.2986741	36.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip
1	266.700	1794.4

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

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 = 3800.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 266700.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.0596	2.728E-08	3800.0000	-0.000992	16615.	1.081E+10	0.000	0.000	0.000
0.517	0.0534	25217.	3717.5293	-0.000985	17089.	1.081E+10	-26.5863	3086.9747	0.000
1.034	0.0474	49387.	3467.0199	-0.000964	17543.	1.081E+10	-54.1710	7095.5083	0.000
1.551	0.0415	71425.	3057.0308	-0.000929	17956.	1.081E+10	-77.9982	11668.	0.000
2.068	0.0358	90393.	2519.3260	-0.000883	18313.	1.081E+10	-95.3431	16505.	0.000
2.585	0.0305	105605.	1906.3730	-0.000826	18598.	1.081E+10	-102.2562	20784.	0.000
3.102	0.0256	116782.	1270.1242	-0.000763	18808.	1.081E+10	-102.8531	24941.	0.000
3.619	0.0211	123889.	648.3901	-0.000693	18942.	1.081E+10	-97.5770	28743.	0.000
4.136	0.0170	127122.	85.4847	-0.000621	19002.	1.081E+10	-83.8883	30651.	0.000
4.653	0.0134	127006.	-369.6325	-0.000549	19000.	1.081E+10	-62.8290	29197.	0.000
5.170	0.0102	124351.	-746.7396	-0.000476	18950.	1.081E+10	-58.7400	35821.	0.000
5.687	0.007439	119317.	-1091.3724	-0.000406	18856.	1.081E+10	-52.3602	43666.	0.000
6.204	0.005130	112154.	-1381.7400	-0.000340	18721.	1.081E+10	-41.2463	49883.	0.000

6.721	0.003220	103297.	-1596.6858	-0.000278	18555.	1.081E+10	-28.0463	54039.	0.000
7.238	0.001678	93263.	-1732.5012	-0.000222	18367.	1.081E+10	-15.7368	58196.	0.000
7.755	0.000467	82535.	-1795.8901	-0.000171	18165.	1.081E+10	-4.6980	62353.	0.000
8.272	-0.000449	71547.	-1795.5360	-0.000127	17959.	1.081E+10	4.8122	66510.	0.000
8.789	-0.001110	60676.	-1741.3728	-8.923E-05	17755.	1.081E+10	12.6486	70667.	0.000
9.306	-0.001556	50235.	-1643.9247	-5.740E-05	17559.	1.081E+10	18.7660	74824.	0.000
9.823	-0.001823	40468.	-1513.7354	-3.137E-05	17375.	1.081E+10	23.2035	78981.	0.000
10.340	-0.001945	31557.	-1360.8971	-1.070E-05	17208.	1.081E+10	26.0674	83138.	0.000
10.857	-0.001955	23618.	-1194.6854	5.129E-06	17059.	1.081E+10	27.5147	87294.	0.000
11.374	-0.001882	16716.	-1023.2973	1.670E-05	16929.	1.081E+10	27.7361	91451.	0.000
11.891	-0.001748	10866.	-853.6878	2.462E-05	16819.	1.081E+10	26.9414	95608.	0.000
12.408	-0.001576	6041.8640	-691.4933	2.947E-05	16729.	1.081E+10	25.3457	99765.	0.000
12.925	-0.001383	2187.9859	-541.0310	3.183E-05	16656.	1.081E+10	23.1592	103922.	0.000
13.442	-0.001181	-776.5814	-405.3596	3.224E-05	16630.	1.081E+10	20.5775	108079.	0.000
13.959	-0.000983	-2948.3899	-286.3869	3.117E-05	16671.	1.081E+10	17.7760	112236.	0.000
14.476	-0.000794	-4433.2058	-185.0092	2.905E-05	16698.	1.081E+10	14.9054	116393.	0.000
14.993	-0.000622	-5340.1107	-101.2718	2.624E-05	16715.	1.081E+10	12.0893	120549.	0.000
15.510	-0.000469	-5776.6323	-34.5360	2.305E-05	16724.	1.081E+10	9.4245	124706.	0.000
16.027	-0.000336	-5844.9231	16.3554	1.972E-05	16725.	1.081E+10	6.9815	128863.	0.000
16.544	-0.000224	-5638.9493	52.9225	1.642E-05	16721.	1.081E+10	4.8068	133020.	0.000
17.061	-0.000132	-5242.6098	76.9096	1.330E-05	16714.	1.081E+10	2.9260	137177.	0.000
17.578	-5.915E-05	-4728.6710	90.1657	1.044E-05	16704.	1.081E+10	1.3474	141334.	0.000
18.095	-2.795E-06	-4158.3810	94.5487	7.890E-06	16693.	1.081E+10	0.0655	145491.	0.000
18.612	3.875E-05	-3581.6194	91.8526	5.669E-06	16682.	1.081E+10	-0.9347	149648.	0.000
19.129	6.754E-05	-3037.4327	83.7591	3.769E-06	16672.	1.081E+10	-1.6744	153805.	0.000
19.646	8.552E-05	-2554.8105	76.6634	2.165E-06	16663.	1.081E+10	-0.6130	44469.	0.000
20.163	9.440E-05	-2093.3558	72.6158	8.308E-07	16655.	1.081E+10	-0.6919	45469.	0.000
20.680	9.583E-05	-1656.5430	68.2431	-2.452E-07	16646.	1.081E+10	-0.7178	46470.	0.000
21.197	9.136E-05	-1245.7845	63.8481	-1.078E-06	16639.	1.081E+10	-0.6990	47471.	0.000
21.714	8.245E-05	-860.7489	59.6813	-1.683E-06	16631.	1.081E+10	-0.6442	48471.	0.000
22.231	7.048E-05	-499.6908	55.9396	-2.073E-06	16625.	1.081E+10	-0.5620	49472.	0.000
22.748	5.673E-05	-159.7909	52.7644	-2.262E-06	16618.	1.081E+10	-0.4615	50473.	0.000
23.265	4.241E-05	162.4960	50.2411	-2.261E-06	16618.	1.081E+10	-0.3519	51474.	0.000
23.782	2.867E-05	471.0842	48.3972	-2.080E-06	16624.	1.081E+10	-0.2425	52474.	0.000
24.299	1.661E-05	769.8905	47.2008	-1.723E-06	16630.	1.081E+10	-0.1432	53475.	0.000
24.816	7.289E-06	1062.4550	8.3654	-1.198E-06	16635.	1.081E+10	-12.3763	10534458.	0.000
25.333	1.750E-06	877.6510	-45.9377	-6.409E-07	16632.	1.081E+10	-5.1295	18185572.	0.000
25.850	-6.640E-07	494.5808	-55.8014	-2.472E-07	16624.	1.081E+10	1.9497	18217634.	0.000
26.367	-1.317E-06	186.0855	-37.7364	-5.185E-08	16619.	1.081E+10	3.8739	18249696.	0.000
26.884	-1.307E-06	26.5189	-13.7693	9.157E-09	16616.	1.081E+10	3.8524	18281757.	0.000
27.401	-1.203E-06	15.2055	-1.5980	2.113E-08	16615.	1.081E+10	0.0713	367480.	0.000
27.918	-1.045E-06	6.6210	-1.1799	2.739E-08	16615.	1.081E+10	0.0635	376910.	0.000
28.435	-8.634E-07	0.4743	-0.8162	2.943E-08	16615.	1.081E+10	0.0538	386340.	0.000
28.952	-6.800E-07	-3.6035	-0.5148	2.853E-08	16615.	1.081E+10	0.0434	395770.	0.000
29.469	-5.094E-07	-6.0081	-0.2771	2.577E-08	16615.	1.081E+10	0.0333	405199.	0.000
29.986	-3.602E-07	-7.1265	-0.0992	2.200E-08	16615.	1.081E+10	0.0241	414629.	0.000
30.503	-2.364E-07	-7.3115	0.0256	1.786E-08	16615.	1.081E+10	0.0162	424059.	0.000
31.020	-1.386E-07	-6.8677	0.1058	1.379E-08	16615.	1.081E+10	0.009684	433489.	0.000
31.537	-6.525E-08	-6.0446	0.1503	1.009E-08	16615.	1.081E+10	0.004659	442919.	0.000
32.054	-1.343E-08	-5.0365	0.1678	6.907E-09	16615.	1.081E+10	0.000979	452349.	0.000
32.571	2.045E-08	-3.9859	0.1661	4.318E-09	16615.	1.081E+10	-0.001522	461779.	0.000
33.088	4.015E-08	-2.9901	0.1519	2.317E-09	16615.	1.081E+10	-0.003049	471209.	0.000
33.605	4.920E-08	-2.1088	0.1306	8.535E-10	16615.	1.081E+10	-0.003812	480639.	0.000
34.122	5.074E-08	-1.3722	0.1064	-1.454E-10	16615.	1.081E+10	-0.004008	490069.	0.000
34.639	4.739E-08	-0.7886	0.0821	-7.655E-10	16615.	1.081E+10	-0.003816	499499.	0.000
35.156	4.124E-08	-0.3511	0.0598	-1.093E-09	16615.	1.081E+10	-0.003383	508929.	0.000

35.673	3.384E-08	-0.0435	0.0405	-1.206E-09	16615.	1.081E+10	-0.002827	518359.	0.000
36.190	2.628E-08	0.1553	0.0248	-1.174E-09	16615.	1.081E+10	-0.002236	527789.	0.000
36.707	1.927E-08	0.2679	0.0127	-1.052E-09	16615.	1.081E+10	-0.001669	537219.	0.000
37.224	1.322E-08	0.3160	0.003884	-8.847E-10	16615.	1.081E+10	-0.001165	546649.	0.000
37.741	8.296E-09	0.3190	-0.002037	-7.025E-10	16615.	1.081E+10	-0.000744	556079.	0.000
38.258	4.506E-09	0.2931	-0.005618	-5.269E-10	16615.	1.081E+10	-0.000411	565509.	0.000
38.775	1.759E-09	0.2511	-0.007397	-3.707E-10	16615.	1.081E+10	-0.000163	574939.	0.000
39.292	-9.401E-11	0.2025	-0.007876	-2.406E-10	16615.	1.081E+10	8.855E-06	584369.	0.000
39.809	-1.226E-09	0.1541	-0.007484	-1.382E-10	16615.	1.081E+10	0.000117	593799.	0.000
40.326	-1.809E-09	0.1101	-0.006574	-6.239E-11	16615.	1.081E+10	0.000176	603229.	0.000
40.843	-2.000E-09	0.0728	-0.005416	-9.910E-12	16615.	1.081E+10	0.000198	612658.	0.000
41.360	-1.932E-09	0.0429	-0.004203	2.330E-11	16615.	1.081E+10	0.000194	622088.	0.000
41.877	-1.711E-09	0.0205	-0.003061	4.152E-11	16615.	1.081E+10	0.000174	631518.	0.000
42.394	-1.417E-09	0.004827	-0.002067	4.880E-11	16615.	1.081E+10	0.000146	640948.	0.000
42.911	-1.106E-09	-0.005263	-0.001253	4.867E-11	16615.	1.081E+10	0.000116	650378.	0.000
43.428	-8.130E-10	-0.0109	-0.000626	4.404E-11	16615.	1.081E+10	8.646E-05	659808.	0.000
43.945	-5.591E-10	-0.0132	-0.000170	3.713E-11	16615.	1.081E+10	6.032E-05	669238.	0.000
44.462	-3.522E-10	-0.0131	0.000100	2.959E-11	16615.	1.081E+10	2.692E-05	474138.	0.000
44.979	-1.920E-10	-0.0120	0.000230	2.237E-11	16615.	1.081E+10	1.489E-05	480950.	0.000
45.496	-7.467E-11	-0.0103	0.000294	1.595E-11	16615.	1.081E+10	5.870E-06	487763.	0.000
46.013	5.865E-12	-0.008429	0.000311	1.056E-11	16615.	1.081E+10	-4.676E-07	494576.	0.000
46.530	5.639E-11	-0.006521	0.000295	6.272E-12	16615.	1.081E+10	-4.557E-06	501388.	0.000
47.047	8.369E-11	-0.004783	0.000260	3.028E-12	16615.	1.081E+10	-6.856E-06	508201.	0.000
47.564	9.396E-11	-0.003305	0.000215	0.000	16615.	1.081E+10	-7.800E-06	515014.	0.000
48.081	9.247E-11	-0.002123	0.000166	0.000	16615.	1.081E+10	-7.778E-06	521826.	0.000
48.598	8.341E-11	-0.001239	0.000120	-1.815E-12	16615.	1.081E+10	-7.108E-06	528639.	0.000
49.115	6.995E-11	-0.000627	7.931E-05	-2.350E-12	16615.	1.081E+10	-6.037E-06	535452.	0.000
49.632	5.425E-11	-0.000247	4.587E-05	-2.601E-12	16615.	1.081E+10	-4.742E-06	542264.	0.000
50.149	3.767E-11	-4.938E-05	2.082E-05	-2.686E-12	16615.	1.081E+10	-3.334E-06	549077.	0.000
50.666	2.092E-11	2.011E-05	4.668E-06	-2.695E-12	16615.	1.081E+10	-1.874E-06	555890.	0.000
51.183	4.233E-12	1.745E-05	-2.337E-06	-2.684E-12	16615.	1.081E+10	-3.839E-07	562702.	0.000
51.700	-1.239E-11	0.000	0.000	-2.679E-12	16615.	1.081E+10	1.137E-06	284757.	0.000

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.0595879 inches
Computed slope at pile head = -0.0009923 radians
Maximum bending moment = 127122. inch-lbs
Maximum shear force = 3800.0000000 lbs
Depth of maximum bending moment = 4.1360000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 7
Number of zero deflection points = 7

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

Boundary Condition Type 1, Shear and Moment

Shear = 3800. lb
Moment = 0. in- lb
Axial Load = 266700. lb

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
51.7000	0.0595879	127122.	3800.0000000
49.1150	0.0594526	127460.	3800.0000000
46.5300	0.0595205	127139.	3800.0000000
43.9450	0.0594329	127342.	3800.0000000
41.3600	0.0593939	127088.	3800.0000000
38.7750	0.0594101	127104.	3800.0000000
36.1900	0.0593667	127122.	3800.0000000
33.6050	0.0593405	127085.	3800.0000000
31.0200	0.0593153	127031.	3800.0000000
28.4350	0.0592841	126956.	3800.0000000
25.8500	0.0592746	126957.	3800.0000000
23.2650	0.0592573	126910.	3800.0000000
20.6800	0.0592505	126885.	3800.0000000
18.0950	0.0592754	126841.	3800.0000000
15.5100	0.0592841	126837.	3800.0000000
12.9250	0.0600134	125964.	3800.0000000
10.3400	0.0731998	121646.	3800.0000000
7.7550	0.3368313	132884.	-5553.5403262
5.1700	-0.7282988	28733.	8031.0557688
2.5850	0.1353779	14953.	3800.0000013

Summary of Pile Response(s)

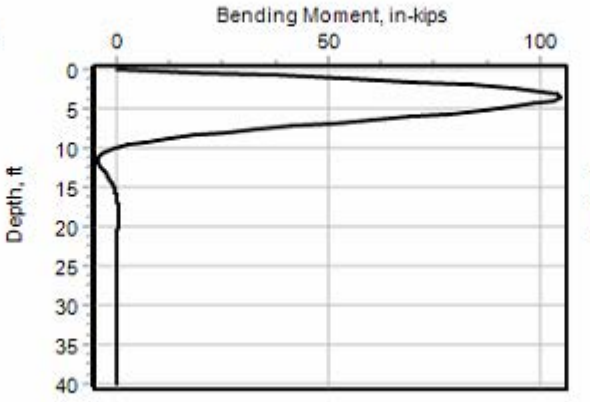
Definitions of Pile-head Loading Conditions:

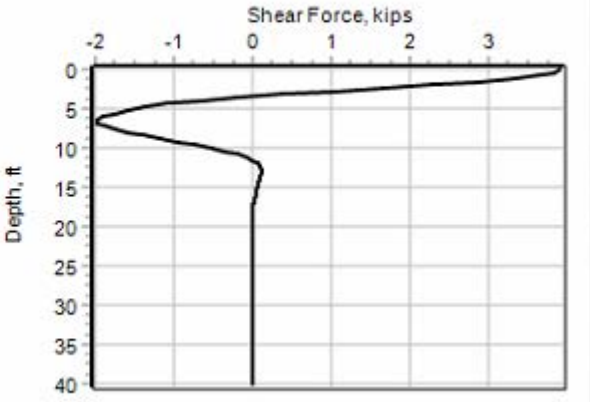
Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

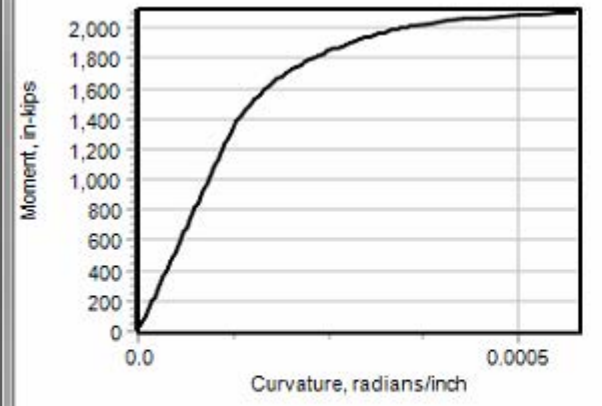
Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Maximum Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 3800.0000	M = 0.000	266700.	0.05958789	127122.	3800.0000	-0.00099234

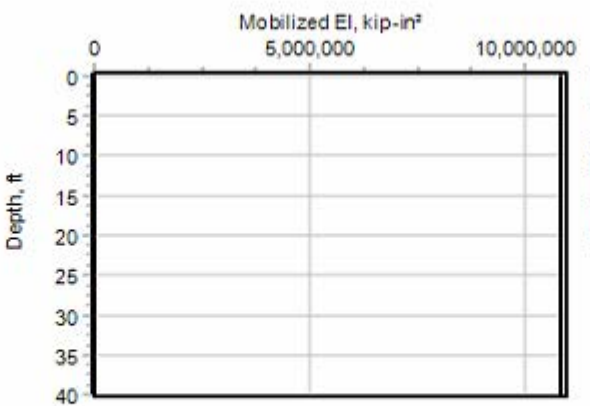
The analysis ended normally.

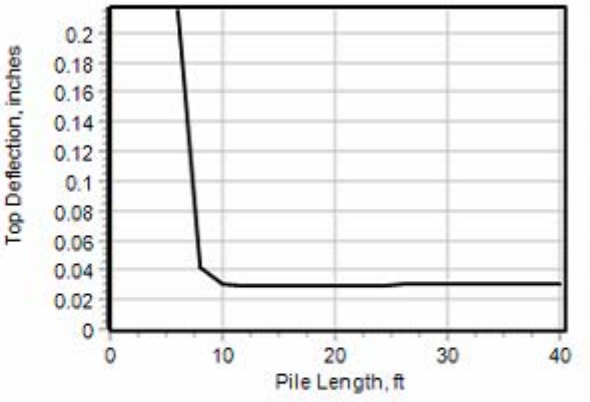
Results for ROS-222-0383 Bridge Forward Pier-Service-B04.lp7d











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LPile Plus for Windows, Version 2013-07.007

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: P:\21-0053 (106544 ROS-CR222-0383)\106544\geotechnical\bridges\XXX-YY-ZZ.ZZ (Crossing)\Analysis\Lpile\Files\
Name of input data file: ROS-222-0383 Bridge Forward Pier-Service-B04.lp7d
Name of output report file: ROS-222-0383 Bridge Forward Pier-Service-B04.lp7o
Name of plot output file: ROS-222-0383 Bridge Forward Pier-Service-B04.lp7p
Name of runtime messeage file: ROS-222-0383 Bridge Forward Pier-Service-B04.lp7r

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Date and Time of Analysis

Date: November 29, 2022 Time: 11:11:40

Problem Title

Project Name: ROS-CR222-0383
Job Number: BRIDGE NO. ROS-CO222-04.221 OVER CSX RAILROAD
Client: Carpenter Marty Transportation/ODOT
Engineer: ZM
Description: Forward Pier

Program Options and Settings

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units (pounds, feet, inches)

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

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

Computational Options:
- Use unfactored loads in computations (conventional analysis)
- Compute pile response under loading and nonlinear bending properties of pile (only if nonlinear pile properties are input)
- Use of p-y modification factors for p-y curves not selected
- Loading by lateral soil movements acting on pile not selected
- Input of shear 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:
- No p-y curves to be computed and reported for user-specified depths
- 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

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 40.00 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameter values 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.

Point	Depth X ft	Pile Diameter in
1	0.00000	14.0000000
2	40.000000	14.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	= Steel Pipe Pile
Section Length	= 40.00000 ft
Pile Diameter	= 14.00000 in

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 6 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 0.0000 ft
Distance from top of pile to bottom of layer	= 13.50000 ft
Effective unit weight at top of layer	= 130.00000 pcf
Effective unit weight at bottom of layer	= 130.00000 pcf
Friction angle at top of layer	= 37.00000 deg.
Friction angle at bottom of layer	= 37.00000 deg.
Subgrade k at top of layer	= 965.00000 pci
Subgrade k at bottom of layer	= 965.00000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 13.50000 ft
Distance from top of pile to bottom of layer	= 28.15000 ft
Effective unit weight at top of layer	= 125.00000 pcf
Effective unit weight at bottom of layer	= 125.00000 pcf
Friction angle at top of layer	= 35.00000 deg.
Friction angle at bottom of layer	= 35.00000 deg.
Subgrade k at top of layer	= 353.00000 pci
Subgrade k at bottom of layer	= 353.00000 pci

Layer 3 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 28.15000 ft
Distance from top of pile to bottom of layer	= 33.15000 ft
Effective unit weight at top of layer	= 130.00000 pcf
Effective unit weight at bottom of layer	= 130.00000 pcf
Friction angle at top of layer	= 36.00000 deg.
Friction angle at bottom of layer	= 36.00000 deg.

Subgrade k at top of layer = 656.00000 pci
Subgrade k at bottom of layer = 656.00000 pci

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

Distance from top of pile to top of layer = 33.15000 ft
Distance from top of pile to bottom of layer = 43.15000 ft
Effective unit weight at top of layer = 125.00000 pcf
Effective unit weight at bottom of layer = 125.00000 pcf
Friction angle at top of layer = 34.00000 deg.
Friction angle at bottom of layer = 34.00000 deg.
Subgrade k at top of layer = 226.00000 pci
Subgrade k at bottom of layer = 226.00000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 43.15000 ft
Distance from top of pile to bottom of layer = 51.35000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Friction angle at top of layer = 35.00000 deg.
Friction angle at bottom of layer = 35.00000 deg.
Subgrade k at top of layer = 285.00000 pci
Subgrade k at bottom of layer = 285.00000 pci

Layer 6 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 51.35000 ft
Distance from top of pile to bottom of layer = 61.35000 ft
Effective unit weight at top of layer = 69.60000 pcf
Effective unit weight at bottom of layer = 69.60000 pcf
Friction angle at top of layer = 30.00000 deg.
Friction angle at bottom of layer = 30.00000 deg.
Subgrade k at top of layer = 69.00000 pci
Subgrade k at bottom of layer = 69.00000 pci

(Depth of lowest soil layer extends 21.35 ft below pile tip)

Summary of Soil Properties

Layer Num.	Layer Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Angle of Friction deg.	kpy pci
1	Sand (Reese, et al.)	0.00	130.000	37.000	965.000
		13.500	130.000	37.000	965.000
2	Sand (Reese, et al.)	13.500	125.000	35.000	353.000
		28.150	125.000	35.000	353.000

3	Sand (Reese, et al.)	28.150	130.000	36.000	656.000
		33.150	130.000	36.000	656.000
4	Sand (Reese, et al.)	33.150	125.000	34.000	226.000
		43.150	125.000	34.000	226.000
5	Sand (Reese, et al.)	43.150	77.600	35.000	285.000
		51.350	77.600	35.000	285.000
6	Sand (Reese, et al.)	51.350	69.600	30.000	69.000
		61.350	69.600	30.000	69.000

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 = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 3900.00000 lbs	M = 0.0000 in-lbs	196000.	Yes

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust 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 Steel Pipe Pile:

Length of Section = 40.00000 ft
Outer Diameter of Pipe = 14.00000 in
Pipe Wall Thickness = 0.37500 in
Yield Stress of Pipe = 36.00000 ksi

Elastic Modulus = 29000. ksi
Cross-sectional Area = 16.05157 sq. in.
Moment of Inertia = 372.76021 in^4
Elastic Bending Stiffness = 10810046. kip-in^2
Plastic Modulus, Z = 69.63281 in^3
Plastic Moment Capacity = Fy Z = 2506.78125 in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 577.857 kips
Nominal Axial Tensile Capacity = -577.857 kips

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

Number	Axial Thrust Force kips
1	198.200

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 198.200 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.000003008	32.5186044	10810179.	148.5431894	12.9522453	
0.000006016	65.0372088	10810179.	77.7715947	13.5567925	
0.000009024	97.5558132	10810179.	54.1810631	14.1613395	
0.0000120	130.0744176	10810179.	42.3857973	14.7658871	
0.0000150	162.5930220	10810179.	35.3086379	15.3704343	
0.0000180	195.1116264	10810179.	30.5905316	15.9749815	
0.0000211	227.6302308	10810179.	27.2204556	16.5795290	
0.0000241	260.1488352	10810179.	24.6928987	17.1840762	
0.0000271	292.6674396	10810179.	22.7270210	17.7886233	
0.0000301	325.1860439	10810179.	21.1543189	18.3931707	
0.0000331	357.7046483	10810179.	19.8675627	18.9977179	
0.0000361	390.2232527	10810179.	18.7952658	19.6022653	
0.0000391	422.7418571	10810179.	17.8879376	20.2068125	
0.0000421	455.2604615	10810179.	17.1102278	20.8113597	
0.0000451	487.7790659	10810179.	16.4362126	21.4159070	
0.0000481	520.2976703	10810179.	15.8464493	22.0204542	
0.0000511	552.8162747	10810179.	15.3260700	22.6250015	
0.0000541	585.3348791	10810179.	14.8635105	23.2295488	
0.0000572	617.8534835	10810179.	14.4496415	23.8340961	
0.0000602	650.3720879	10810179.	14.0771595	24.4386433	
0.0000632	682.8906923	10810179.	13.7401519	25.0431906	
0.0000662	715.4092967	10810179.	13.4337813	25.6477379	

0.0000692	747.9279011	10810179.	13.1540517	26.2522851	
0.0000722	780.4465055	10810179.	12.8976329	26.8568324	
0.0000752	812.9651099	10810179.	12.6617276	27.4613797	
0.0000782	845.4837143	10810179.	12.4439688	28.0659269	
0.0000812	878.0023187	10810179.	12.2423403	28.6704742	
0.0000842	910.5209230	10810179.	12.0551139	29.2750215	
0.0000872	943.0395274	10810179.	11.8807996	29.8795687	
0.0000902	975.5581318	10810179.	11.7181063	30.4841160	
0.0000933	1008.0767362	10810179.	11.5659093	31.0886633	
0.0000963	1040.5953406	10810179.	11.4232247	31.6932105	
0.0000993	1073.1139450	10810179.	11.2891876	32.2977578	
0.0001023	1105.6325494	10810179.	11.1630350	32.9023051	
0.0001053	1138.1511538	10810179.	11.0440911	33.5068523	
0.0001083	1170.6697582	10810179.	10.9317553	34.1113996	
0.0001113	1203.1883626	10810179.	10.8254916	34.7159469	
0.0001143	1235.7069670	10810179.	10.7248208	35.3204941	
0.0001173	1268.2255714	10810179.	10.6293125	35.9250414	Y
0.0001233	1328.2783711	10769765.	10.4649850	36.0000000	Y
0.0001294	1378.5732004	10657672.	10.3403939	36.0000000	Y
0.0001354	1422.7010856	10509986.	10.2423474	36.0000000	Y
0.0001414	1462.2864094	10342739.	10.1640821	36.0000000	Y
0.0001474	1498.3063371	10164956.	10.1012059	36.0000000	Y
0.0001534	1531.3227357	9981540.	10.0508538	36.0000000	Y
0.0001594	1561.7738269	9795875.	10.0107972	36.0000000	Y
0.0001654	1590.0194162	9610383.	9.9792437	36.0000000	Y
0.0001715	1616.2981165	9426437.	9.9548942	36.0000000	Y
0.0001775	1640.7811656	9244845.	9.9367660	36.0000000	Y
0.0001835	1663.8265136	9067325.	9.9234856	36.0000000	Y
0.0001895	1685.3669042	8893135.	9.9148838	36.0000000	Y
0.0001955	1705.7713374	8723855.	9.9097100	36.0000000	Y
0.0002015	1724.9428067	8558563.	9.9079941	36.0000000	Y
0.0002076	1743.1079259	8398006.	9.9089531	36.0000000	Y
0.0002136	1760.3659791	8242246.	9.9121785	36.0000000	Y
0.0002196	1776.7739490	8091151.	9.9174003	36.0000000	Y
0.0002256	1792.3337154	7944354.	9.9245158	36.0000000	Y
0.0002316	1807.1517201	7801981.	9.9331656	36.0000000	Y
0.0002376	1821.3004255	7664000.	9.9430967	36.0000000	Y
0.0002437	1834.8258799	7530275.	9.9541385	36.0000000	Y
0.0002497	1847.7722203	7400675.	9.9661358	36.0000000	Y
0.0002557	1860.1817944	7275074.	9.9789472	36.0000000	Y
0.0002617	1872.0912407	7153338.	9.9924532	36.0000000	Y
0.0002677	1883.4626491	7035063.	10.0067378	36.0000000	Y
0.0002737	1894.3956044	6920385.	10.0215280	36.0000000	Y
0.0002798	1904.9271274	6809205.	10.0367193	36.0000000	Y
0.0002858	1915.0928499	6701426.	10.0522137	36.0000000	Y
0.0002918	1924.9270831	6596955.	10.0679191	36.0000000	Y
0.0002978	1934.3063009	6495178.	10.0841634	36.0000000	Y
0.0003038	1943.3874550	6396450.	10.1005392	36.0000000	Y
0.0003098	1952.2180167	6300747.	10.1169249	36.0000000	Y
0.0003159	1960.7039446	6207600.	10.1335731	36.0000000	Y
0.0003219	1968.8910696	6117006.	10.1503755	36.0000000	Y
0.0003279	1976.9021464	6029199.	10.1670145	36.0000000	Y
0.0003339	1984.3494347	5942869.	10.1830737	36.0000000	Y
0.0003399	1991.4607058	5858606.	10.1983259	36.0000000	Y
0.0003459	1998.3638836	5776672.	10.2136096	36.0000000	Y
0.0003520	2004.5581483	5695525.	10.2269075	36.0000000	Y

0.0003580	2010.4772656	5616337.	10.2393579	36.0000000	Y
0.0003820	2030.4949532	5314950.	10.2810453	36.0000000	Y
0.0004061	2046.0525365	5038300.	10.3114607	36.0000000	Y
0.0004302	2058.5248945	4785431.	10.3346734	36.0000000	Y
0.0004542	2068.9011606	4554742.	10.3534685	36.0000000	Y
0.0004783	2077.5144961	4343581.	10.3687348	36.0000000	Y
0.0005024	2084.7848836	4149978.	10.3813247	36.0000000	Y
0.0005264	2091.0116150	3972093.	10.3924056	36.0000000	Y
0.0005505	2096.4628210	3808352.	10.4025609	36.0000000	Y
0.0005746	2101.1044233	3656918.	10.4103695	36.0000000	Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip
1	198.200	2101.1

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

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 = 3900.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 198200.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.0298	-4.558E-08	3900.0000	-0.000628	12348.	1.081E+10	0.000	0.000	0.000
0.400	0.0268	19317.	3835.6451	-0.000624	12710.	1.081E+10	-26.8145	4801.7884	0.000
0.800	0.0238	38009.	3636.9070	-0.000611	13061.	1.081E+10	-55.9930	11278.	0.000
1.200	0.0209	55394.	3301.1632	-0.000590	13388.	1.081E+10	-83.9002	19232.	0.000
1.600	0.0182	70823.	2842.1147	-0.000562	13678.	1.081E+10	-107.3700	28369.	0.000

2.000	0.0155	83748.	2285.8793	-0.000528	13920.	1.081E+10	-124.3947	38411.	0.000
2.400	0.0131	93771.	1666.3794	-0.000488	14109.	1.081E+10	-133.7303	48998.	0.000
2.800	0.0109	100674.	1015.7122	-0.000445	14238.	1.081E+10	-137.3811	60740.	0.000
3.200	0.008827	104369.	375.1667	-0.000400	14308.	1.081E+10	-129.5129	70427.	0.000
3.600	0.007020	105036.	-205.5116	-0.000353	14320.	1.081E+10	-112.4364	76880.	0.000
4.000	0.005437	103068.	-697.8545	-0.000307	14283.	1.081E+10	-92.7064	81849.	0.000
4.400	0.004073	98921.	-1084.8828	-0.000262	14205.	1.081E+10	-68.5553	80789.	0.000
4.800	0.002920	93152.	-1368.4305	-0.000219	14097.	1.081E+10	-49.5896	81505.	0.000
5.200	0.001966	86201.	-1587.0898	-0.000180	13966.	1.081E+10	-41.5185	101355.	0.000
5.600	0.001196	78258.	-1763.1694	-0.000143	13817.	1.081E+10	-31.8480	127843.	0.000
6.000	0.000592	69547.	-1892.5088	-0.000110	13654.	1.081E+10	-22.0434	178704.	0.000
6.400	0.000137	60300.	-1969.7160	-8.150E-05	13480.	1.081E+10	-10.1263	355738.	0.000
6.800	-0.000190	50793.	-1960.6835	-5.683E-05	13302.	1.081E+10	13.8898	350348.	0.000
7.200	-0.000409	41585.	-1868.3094	-3.633E-05	13129.	1.081E+10	24.5994	288713.	0.000
7.600	-0.000539	32926.	-1732.0560	-1.978E-05	12966.	1.081E+10	32.1728	286499.	0.000
8.000	-0.000599	24995.	-1564.2604	-6.923E-06	12817.	1.081E+10	37.7420	302495.	0.000
8.400	-0.000605	17923.	-1373.7855	2.605E-06	12684.	1.081E+10	41.6225	329962.	0.000
8.800	-0.000574	11802.	-1168.3909	9.204E-06	12569.	1.081E+10	43.9586	367671.	0.000
9.200	-0.000517	6688.6534	-955.2347	1.331E-05	12473.	1.081E+10	44.8565	416359.	0.000
9.600	-0.000446	2606.1995	-740.9558	1.537E-05	12397.	1.081E+10	44.4264	478005.	0.000
10.000	-0.000370	-453.7721	-531.6269	1.585E-05	12356.	1.081E+10	42.7940	555840.	0.000
10.400	-0.000294	-2527.5779	-343.9584	1.519E-05	12395.	1.081E+10	35.4012	578074.	0.000
10.800	-0.000224	-3784.6725	-191.8393	1.379E-05	12419.	1.081E+10	27.9817	600307.	0.000
11.200	-0.000162	-4395.4689	-74.3839	1.197E-05	12430.	1.081E+10	20.9580	622541.	0.000
11.600	-0.000109	-4521.5354	10.9962	9.992E-06	12433.	1.081E+10	14.6170	644774.	0.000
12.000	-6.567E-05	-4308.9161	67.9799	8.031E-06	12429.	1.081E+10	9.1262	667008.	0.000
12.400	-3.172E-05	-3884.2093	100.8133	6.212E-06	12421.	1.081E+10	4.5544	689242.	0.000
12.800	-6.039E-06	-3352.9282	113.8922	4.605E-06	12411.	1.081E+10	0.8951	711475.	0.000
13.200	1.249E-05	-2799.6070	111.4572	3.239E-06	12400.	1.081E+10	-1.9097	733709.	0.000
13.600	2.506E-05	-2289.1026	103.2018	2.110E-06	12391.	1.081E+10	-1.5301	293081.	0.000
14.000	3.275E-05	-1812.8841	94.5978	1.199E-06	12382.	1.081E+10	-2.0549	301215.	0.000
14.400	3.657E-05	-1383.2448	84.0098	4.894E-07	12374.	1.081E+10	-2.3568	309348.	0.000
14.800	3.744E-05	-1007.3212	72.4097	-4.139E-08	12367.	1.081E+10	-2.4766	317481.	0.000
15.200	3.617E-05	-688.0327	60.5769	-4.178E-07	12361.	1.081E+10	-2.4537	325614.	0.000
15.600	3.343E-05	-424.9878	49.1089	-6.649E-07	12356.	1.081E+10	-2.3246	333747.	0.000
16.000	2.979E-05	-215.3226	38.4377	-8.070E-07	12352.	1.081E+10	-2.1217	341880.	0.000
16.400	2.569E-05	-54.4504	28.8505	-8.669E-07	12349.	1.081E+10	-1.8730	350013.	0.000
16.800	2.147E-05	63.2916	20.5113	-8.650E-07	12349.	1.081E+10	-1.6017	358146.	0.000
17.200	1.738E-05	144.1043	13.4840	-8.189E-07	12350.	1.081E+10	-1.3264	366280.	0.000
17.600	1.360E-05	194.2965	7.7539	-7.438E-07	12351.	1.081E+10	-1.0612	374413.	0.000
18.000	1.024E-05	219.9569	3.2482	-6.518E-07	12352.	1.081E+10	-0.8162	382546.	0.000
18.400	7.347E-06	226.7191	-0.1459	-5.527E-07	12352.	1.081E+10	-0.5980	390679.	0.000
18.800	4.936E-06	219.6080	-2.5653	-4.536E-07	12352.	1.081E+10	-0.4101	398812.	0.000
19.200	2.993E-06	202.9556	-4.1584	-3.598E-07	12352.	1.081E+10	-0.2537	406945.	0.000
19.600	1.482E-06	180.3715	-5.0750	-2.746E-07	12351.	1.081E+10	-0.1282	415078.	0.000
20.000	3.561E-07	154.7581	-5.4580	-2.002E-07	12351.	1.081E+10	-0.0314	423211.	0.000
20.400	-4.401E-07	128.3560	-5.4384	-1.374E-07	12350.	1.081E+10	0.0396	431344.	0.000
20.800	-9.628E-07	102.8109	-5.1319	-8.607E-08	12350.	1.081E+10	0.0882	439478.	0.000
21.200	-1.266E-06	79.2534	-4.6369	-4.565E-08	12349.	1.081E+10	0.1181	447611.	0.000
21.600	-1.401E-06	58.3834	-4.0342	-1.509E-08	12349.	1.081E+10	0.1330	455744.	0.000
22.000	-1.411E-06	40.5536	-3.3876	6.875E-09	12348.	1.081E+10	0.1364	463877.	0.000
22.400	-1.335E-06	25.8490	-2.7452	2.162E-08	12348.	1.081E+10	0.1313	472010.	0.000
22.800	-1.204E-06	14.1582	-2.1412	3.050E-08	12348.	1.081E+10	0.1204	480143.	0.000
23.200	-1.042E-06	5.2356	-1.5977	3.481E-08	12348.	1.081E+10	0.1060	488276.	0.000
23.600	-8.696E-07	-1.2464	-1.1275	3.569E-08	12348.	1.081E+10	0.0899	496409.	0.000
24.000	-6.996E-07	-5.6558	-0.7351	3.416E-08	12348.	1.081E+10	0.0735	504543.	0.000

24.400	-5.417E-07	-8.3685	-0.4198	3.104E-08	12348.	1.081E+10	0.0579	512676.	0.000
24.800	-4.016E-07	-9.7447	-0.1763	2.702E-08	12348.	1.081E+10	0.0436	520809.	0.000
25.200	-2.823E-07	-10.1129	0.002880	2.261E-08	12348.	1.081E+10	0.0311	528942.	0.000
25.600	-1.845E-07	-9.7601	0.1271	1.820E-08	12348.	1.081E+10	0.0206	537075.	0.000
26.000	-1.075E-07	-8.9276	0.2059	1.405E-08	12348.	1.081E+10	0.0122	545208.	0.000
26.400	-4.957E-08	-7.8100	0.2489	1.034E-08	12348.	1.081E+10	0.005714	553341.	0.000
26.800	-8.270E-09	-6.5575	0.2650	7.148E-09	12348.	1.081E+10	0.000967	561474.	0.000
27.200	1.905E-08	-5.2798	0.2619	4.520E-09	12348.	1.081E+10	-0.002261	569608.	0.000
27.600	3.512E-08	-4.0521	0.2463	2.448E-09	12348.	1.081E+10	-0.004227	577741.	0.000
28.000	4.256E-08	-2.9200	0.2237	9.003E-10	12348.	1.081E+10	-0.005194	585874.	0.000
28.400	4.377E-08	-1.9064	0.1892	-1.712E-10	12348.	1.081E+10	-0.009194	1008343.	0.000
28.800	4.091E-08	-1.1038	0.1462	-8.395E-10	12348.	1.081E+10	-0.008723	1023458.	0.000
29.200	3.571E-08	-0.5017	0.1067	-1.196E-09	12348.	1.081E+10	-0.007726	1038572.	0.000
29.600	2.943E-08	-0.0774	0.0726	-1.324E-09	12348.	1.081E+10	-0.006461	1053686.	0.000
30.000	2.299E-08	0.1981	0.0448	-1.298E-09	12348.	1.081E+10	-0.005119	1068800.	0.000
30.400	1.697E-08	0.3556	0.0234	-1.175E-09	12348.	1.081E+10	-0.003833	1083915.	0.000
30.800	1.171E-08	0.4245	0.007719	-1.002E-09	12348.	1.081E+10	-0.002682	1099029.	0.000
31.200	7.358E-09	0.4316	-0.002817	-8.115E-10	12348.	1.081E+10	-0.001708	1114143.	0.000
31.600	3.923E-09	0.3990	-0.009131	-6.271E-10	12348.	1.081E+10	-0.000923	1129257.	0.000
32.000	1.338E-09	0.3451	-0.0121	-4.619E-10	12348.	1.081E+10	-0.000319	1144372.	0.000
32.400	-5.113E-10	0.2837	-0.0126	-3.223E-10	12348.	1.081E+10	0.000123	1159486.	0.000
32.800	-1.756E-09	0.2249	-0.0113	-2.094E-10	12348.	1.081E+10	0.000430	1174600.	0.000
33.200	-2.521E-09	0.1760	-0.009681	-1.204E-10	12348.	1.081E+10	0.000225	428967.	0.000
33.600	-2.911E-09	0.1322	-0.008508	-5.192E-11	12348.	1.081E+10	0.000263	434174.	0.000
34.000	-3.020E-09	0.0945	-0.007213	-1.594E-12	12348.	1.081E+10	0.000276	439381.	0.000
34.400	-2.927E-09	0.0630	-0.005899	3.336E-11	12348.	1.081E+10	0.000271	444588.	0.000
34.800	-2.699E-09	0.0378	-0.004641	5.573E-11	12348.	1.081E+10	0.000253	449795.	0.000
35.200	-2.392E-09	0.0183	-0.003490	6.819E-11	12348.	1.081E+10	0.000227	455002.	0.000
35.600	-2.045E-09	0.004133	-0.002475	7.318E-11	12348.	1.081E+10	0.000196	460209.	0.000
36.000	-1.689E-09	-0.005559	-0.001611	7.286E-11	12348.	1.081E+10	0.000164	465416.	0.000
36.400	-1.345E-09	-0.0115	-0.000902	6.908E-11	12348.	1.081E+10	0.000132	470623.	0.000
36.800	-1.026E-09	-0.0143	-0.000341	6.335E-11	12348.	1.081E+10	0.000102	475830.	0.000
37.200	-7.373E-10	-0.0149	8.051E-05	5.686E-11	12348.	1.081E+10	7.389E-05	481037.	0.000
37.600	-4.802E-10	-0.0137	0.000375	5.052E-11	12348.	1.081E+10	4.865E-05	486244.	0.000
38.000	-2.523E-10	-0.0114	0.000553	4.496E-11	12348.	1.081E+10	2.583E-05	491451.	0.000
38.400	-4.859E-11	-0.008455	0.000627	4.056E-11	12348.	1.081E+10	5.027E-06	496658.	0.000
38.800	1.371E-10	-0.005422	0.000605	3.748E-11	12348.	1.081E+10	-1.433E-05	501865.	0.000
39.200	3.112E-10	-0.002718	0.000492	3.567E-11	12348.	1.081E+10	-3.288E-05	507072.	0.000
39.600	4.795E-10	-0.000770	0.000290	3.490E-11	12348.	1.081E+10	-5.118E-05	512279.	0.000
40.000	6.462E-10	0.000	0.000	3.473E-11	12348.	1.081E+10	-6.967E-05	258743.	0.000

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.0298182 inches
Computed slope at pile head = -0.0006278 radians
Maximum bending moment = 105036. inch-lbs
Maximum shear force = 3900.0000000 lbs
Depth of maximum bending moment = 3.6000000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head

Number of iterations = 14
Number of zero deflection points = 6

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

Boundary Condition Type 1, Shear and Moment

Shear = 3900. lb
Moment = 0. in- lb
Axial Load = 198200. lb

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
40.0000	0.0298182	105036.	3900.0000000
38.0000	0.0298112	105032.	3900.0000000
36.0000	0.0297985	104908.	3900.0000000
34.0000	0.0297796	104908.	3900.0000000
32.0000	0.0297568	104921.	3900.0000000
30.0000	0.0297488	104814.	3900.0000000
28.0000	0.0297314	104701.	3900.0000000
26.0000	0.0297312	104699.	3900.0000000
24.0000	0.0297060	104685.	3900.0000000
22.0000	0.0297037	104742.	3900.0000000
20.0000	0.0296903	104647.	3900.0000000
18.0000	0.0296868	104646.	3900.0000000
16.0000	0.0296794	104664.	3900.0000000
14.0000	0.0296869	104639.	3900.0000000
12.0000	0.0296953	104627.	3900.0000000
10.0000	0.0302124	104173.	3900.0000000
8.0000	0.0420205	98766.	3900.0000000
6.0000	0.2149196	97174.	-4951.4630502
4.0000	-0.8238505	23139.	8757.9371200
2.0000	0.1235857	11709.	3900.0759177

Summary of Pile Response(s)

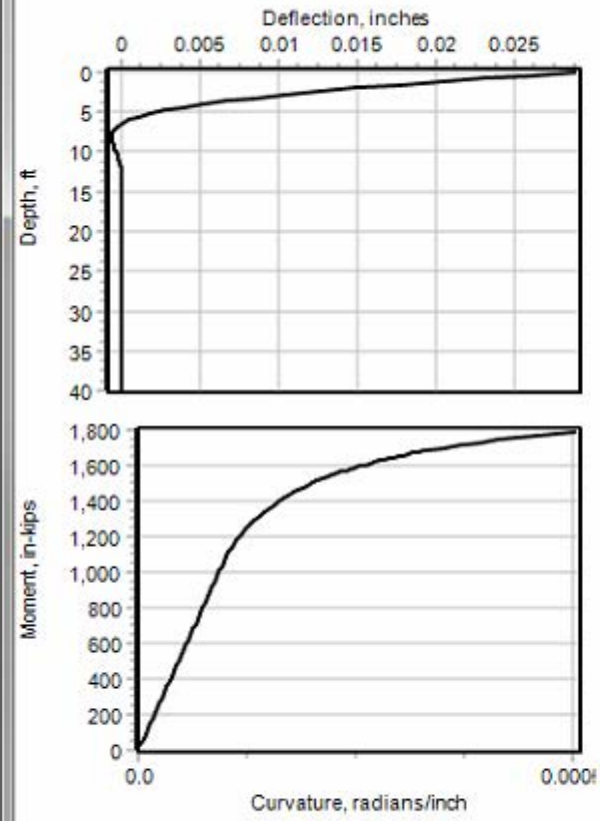
Definitions of Pile-head Loading Conditions:

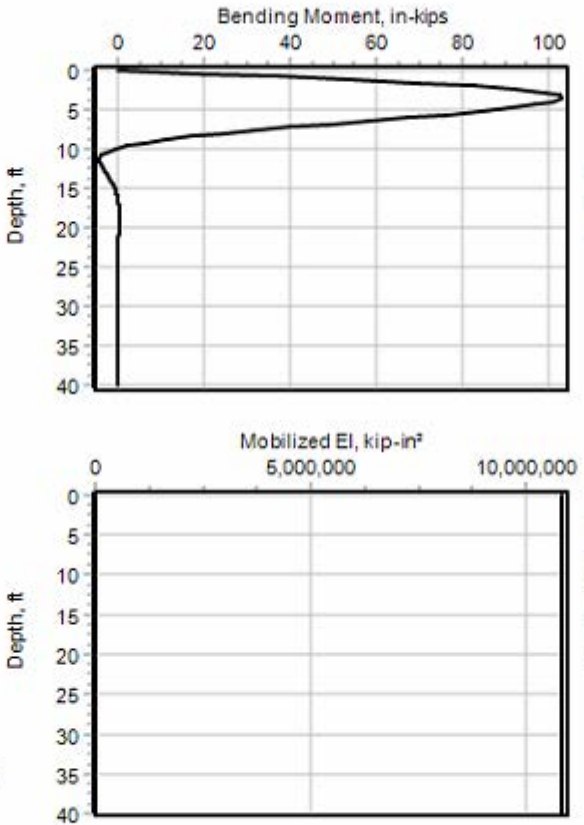
Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

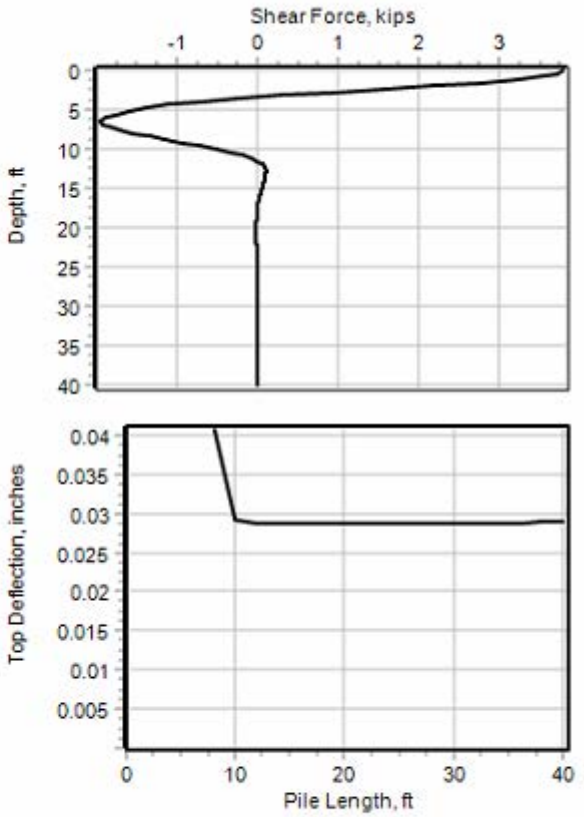
Load Case No.	Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Maximum Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 3900.0000	M = 0.000	198200.	0.02981820	105036.	3900.0000	-0.00062784

The analysis ended normally.

Results for ROS-222-0383 Bridge Forward Pier-Strength-B04.lp7d







Show All Legends

Close

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LPile Plus for Windows, Version 2013-07.007

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

==========

This copy of LPile is used by:

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Files Used for Analysis

Path to file locations: P:\21-0053 (106544 ROS-CR222-0383)\106544\geotechnical\bridges\XXX-YY-ZZ.ZZ (Crossing)\Analysis\Lpile\Files\
Name of input data file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7d
Name of output report file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7o
Name of plot output file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7p
Name of runtime messeage file: ROS-222-0383 Bridge Rear Pier-Service-B04.lp7r

---

Date and Time of Analysis

Date: November 29, 2022 Time: 11:00:41

Problem Title

Project Name: ROS-CR222-0383
Job Number: BRIDGE NO. ROS-CO222-04.221 OVER CSX RAILROAD
Client: Carpenter Marty Transportation/ODOT
Engineer: ZM
Description: Rear Pier

Program Options and Settings

Engineering Units of Input Data and Computations:
- Engineering units are US Customary Units (pounds, feet, inches)

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

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

Computational Options:
- Use unfactored loads in computations (conventional analysis)
- Compute pile response under loading and nonlinear bending properties of pile (only if nonlinear pile properties are input)
- Use of p-y modification factors for p-y curves not selected
- Loading by lateral soil movements acting on pile not selected
- Input of shear 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:
- No p-y curves to be computed and reported for user-specified depths
- 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

Pile Structural Properties and Geometry

Total number of pile sections = 1

Total length of pile = 51.70 ft

Depth of ground surface below top of pile = 0.00 ft

Pile diameter values 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.

Point	Depth X ft	Pile Diameter in
1	0.00000	14.0000000
2	51.700000	14.0000000

Input Structural Properties:

Pile Section No. 1:

Section Type	= Steel Pipe Pile
Section Length	= 51.70000 ft
Pile Diameter	= 14.00000 in

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 9 layers

Layer 1 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 0.0000 ft
Distance from top of pile to bottom of layer	= 19.30000 ft
Effective unit weight at top of layer	= 115.00000 pcf
Effective unit weight at bottom of layer	= 115.00000 pcf
Friction angle at top of layer	= 31.00000 deg.
Friction angle at bottom of layer	= 31.00000 deg.
Subgrade k at top of layer	= 108.00000 pci
Subgrade k at bottom of layer	= 108.00000 pci

Layer 2 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer	= 19.30000 ft
Distance from top of pile to bottom of layer	= 24.30000 ft
Effective unit weight at top of layer	= 59.60000 pcf
Effective unit weight at bottom of layer	= 59.60000 pcf
Friction angle at top of layer	= 27.00000 deg.
Friction angle at bottom of layer	= 27.00000 deg.
Subgrade k at top of layer	= 26.00000 pci
Subgrade k at bottom of layer	= 26.00000 pci

Layer 3 is stiff clay with water-induced erosion

Distance from top of pile to top of layer	= 24.30000 ft
Distance from top of pile to bottom of layer	= 27.40000 ft
Effective unit weight at top of layer	= 59.60000 pcf
Effective unit weight at bottom of layer	= 59.60000 pcf
Undrained cohesion at top of layer	= 2400.00000 psf
Undrained cohesion at bottom of layer	= 2400.00000 psf

Epsilon-50 at top of layer = 0.00560
Epsilon-50 at bottom of layer = 0.00560
Subgrade k at top of layer = 833.00000 pci
Subgrade k at bottom of layer = 833.00000 pci

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

Distance from top of pile to top of layer = 27.40000 ft
Distance from top of pile to bottom of layer = 44.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Friction angle at top of layer = 35.00000 deg.
Friction angle at bottom of layer = 35.00000 deg.
Subgrade k at top of layer = 245.00000 pci
Subgrade k at bottom of layer = 245.00000 pci

Layer 5 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 44.30000 ft
Distance from top of pile to bottom of layer = 59.30000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Friction angle at top of layer = 34.00000 deg.
Friction angle at bottom of layer = 34.00000 deg.
Subgrade k at top of layer = 177.00000 pci
Subgrade k at bottom of layer = 177.00000 pci

Layer 6 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 59.30000 ft
Distance from top of pile to bottom of layer = 69.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Undrained cohesion at top of layer = 5300.00000 psf
Undrained cohesion at bottom of layer = 5300.00000 psf
Epsilon-50 at top of layer = 0.00400
Epsilon-50 at bottom of layer = 0.00400
Subgrade k at top of layer = 1854.00000 pci
Subgrade k at bottom of layer = 1854.00000 pci

Layer 7 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 69.30000 ft
Distance from top of pile to bottom of layer = 74.30000 ft
Effective unit weight at top of layer = 72.60000 pcf
Effective unit weight at bottom of layer = 72.60000 pcf
Undrained cohesion at top of layer = 5850.00000 psf
Undrained cohesion at bottom of layer = 5850.00000 psf
Epsilon-50 at top of layer = 0.00390
Epsilon-50 at bottom of layer = 0.00390
Subgrade k at top of layer = 2042.00000 pci
Subgrade k at bottom of layer = 2042.00000 pci

Layer 8 is sand, p-y criteria by Reese et al., 1974

Distance from top of pile to top of layer = 74.30000 ft
Distance from top of pile to bottom of layer = 79.30000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Friction angle at top of layer = 34.00000 deg.
Friction angle at bottom of layer = 34.00000 deg.
Subgrade k at top of layer = 177.00000 pci
Subgrade k at bottom of layer = 177.00000 pci

Layer 9 is stiff clay with water-induced erosion

Distance from top of pile to top of layer = 79.30000 ft
Distance from top of pile to bottom of layer = 82.50000 ft
Effective unit weight at top of layer = 77.60000 pcf
Effective unit weight at bottom of layer = 77.60000 pcf
Undrained cohesion at top of layer = 8000.00000 psf
Undrained cohesion at bottom of layer = 8000.00000 psf
Epsilon-50 at top of layer = 0.00340
Epsilon-50 at bottom of layer = 0.00340
Subgrade k at top of layer = 3337.00000 pci
Subgrade k at bottom of layer = 3337.00000 pci

(Depth of lowest soil layer extends 30.80 ft below pile tip)

Summary of Soil Properties

Layer Num.	Soil Type (p-y Curve Criteria)	Layer Depth ft	Effective Unit Wt. pcf	Undrained Cohesion psf	Angle of Friction deg.	Strain Factor Epsilon 50	kpy pci
1	Sand (Reese, et al.)	0.00	115.000	--	31.000	--	108.000
		19.300	115.000	--	31.000	--	108.000
2	Sand (Reese, et al.)	19.300	59.600	--	27.000	--	26.000
		24.300	59.600	--	27.000	--	26.000
3	Stiff Clay with Free Water	24.300	59.600	2400.000	--	0.00560	833.000
		27.400	59.600	2400.000	--	0.00560	833.000
4	Sand (Reese, et al.)	27.400	72.600	--	35.000	--	245.000
		44.300	72.600	--	35.000	--	245.000
5	Sand (Reese, et al.)	44.300	77.600	--	34.000	--	177.000
		59.300	77.600	--	34.000	--	177.000
6	Stiff Clay with Free Water	59.300	72.600	5300.000	--	0.00400	1854.000
		69.300	72.600	5300.000	--	0.00400	1854.000
7	Stiff Clay with Free Water	69.300	72.600	5850.000	--	0.00390	2042.000
		74.300	72.600	5850.000	--	0.00390	2042.000
8	Sand (Reese, et al.)	74.300	77.600	--	34.000	--	177.000
		79.300	77.600	--	34.000	--	177.000
9	Stiff Clay with Free Water	79.300	77.600	8000.000	--	0.00340	3337.000

82.500	77.600	8000.000	--	0.00340	3337.000

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 = 1

Load No.	Load Type	Condition 1	Condition 2	Axial Thrust Force, lbs	Compute Top y vs. Pile Length
1	1	V = 3900.00000 lbs	M = 0.0000 in-lbs	198200.	Yes

V = perpendicular shear force applied to pile head
M = bending moment applied to pile head
y = lateral deflection relative to pile axis
S = pile slope relative to original pile batter angle
R = rotational stiffness applie to pile head
Axial thrust 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 Steel Pipe Pile:

Length of Section = 51.70000 ft
Outer Diameter of Pipe = 14.00000 in
Pipe Wall Thickness = 0.37500 in
Yield Stress of Pipe = 36.00000 ksi
Elastic Modulus = 29000. ksi
Cross-sectional Area = 16.05157 sq. in.
Moment of Inertia = 372.76021 in^4
Elastic Bending Stiffness = 10810046. kip-in^2
Plastic Modulus, Z = 69.63281 in^3
Plastic Moment Capacity = Fy Z = 2506.78125 in-kip

Axial Structural Capacities:

Nom. Axial Structural Capacity = Fy As = 577.857 kips
Nominal Axial Tensile Capacity = -577.857 kips

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

Number	Axial Thrust Force kips
1	198.200

Definition of Run Messages:

Y = part of pipe section has yielded.

Axial Thrust Force = 198.200 kips

Bending Curvature rad/in.	Bending Moment in-kip	Bending Stiffness kip-in2	Depth to N Axis in	Max Total Stress ksi	Run Msg
0.000003008	32.5186044	10810179.	148.5431894	12.9522453	
0.000006016	65.0372088	10810179.	77.7715947	13.5567925	
0.000009024	97.5558132	10810179.	54.1810631	14.1613395	
0.0000120	130.0744176	10810179.	42.3857973	14.7658871	
0.0000150	162.5930220	10810179.	35.3086379	15.3704343	
0.0000180	195.1116264	10810179.	30.5905316	15.9749815	
0.0000211	227.6302308	10810179.	27.2204556	16.5795290	
0.0000241	260.1488352	10810179.	24.6928987	17.1840762	
0.0000271	292.6674396	10810179.	22.7270210	17.7886233	
0.0000301	325.1860439	10810179.	21.1543189	18.3931707	
0.0000331	357.7046483	10810179.	19.8675627	18.9977179	
0.0000361	390.2232527	10810179.	18.7952658	19.6022653	
0.0000391	422.7418571	10810179.	17.8879376	20.2068125	
0.0000421	455.2604615	10810179.	17.1102278	20.8113597	
0.0000451	487.7790659	10810179.	16.4362126	21.4159070	
0.0000481	520.2976703	10810179.	15.8464493	22.0204542	
0.0000511	552.8162747	10810179.	15.3260700	22.6250015	
0.0000541	585.3348791	10810179.	14.8635105	23.2295488	
0.0000572	617.8534835	10810179.	14.4496415	23.8340961	
0.0000602	650.3720879	10810179.	14.0771595	24.4386433	
0.0000632	682.8906923	10810179.	13.7401519	25.0431906	
0.0000662	715.4092967	10810179.	13.4337813	25.6477379	
0.0000692	747.9279011	10810179.	13.1540517	26.2522851	
0.0000722	780.4465055	10810179.	12.8976329	26.8568324	
0.0000752	812.9651099	10810179.	12.6617276	27.4613797	
0.0000782	845.4837143	10810179.	12.4439688	28.0659269	
0.0000812	878.0023187	10810179.	12.2423403	28.6704742	
0.0000842	910.5209230	10810179.	12.0551139	29.2750215	
0.0000872	943.0395274	10810179.	11.8807996	29.8795687	

0.0000902	975.5581318	10810179.	11.7181063	30.4841160	
0.0000933	1008.0767362	10810179.	11.5659093	31.0886633	
0.0000963	1040.5953406	10810179.	11.4232247	31.6932105	
0.0000993	1073.1139450	10810179.	11.2891876	32.2977578	
0.0001023	1105.6325494	10810179.	11.1630350	32.9023051	
0.0001053	1138.1511538	10810179.	11.0440911	33.5068523	
0.0001083	1170.6697582	10810179.	10.9317553	34.1113996	
0.0001113	1203.1883626	10810179.	10.8254916	34.7159469	
0.0001143	1235.7069670	10810179.	10.7248208	35.3204941	
0.0001173	1268.2255714	10810179.	10.6293125	35.9250414	Y
0.0001233	1328.2783711	10769765.	10.4649850	36.0000000	Y
0.0001294	1378.5732004	10657672.	10.3403939	36.0000000	Y
0.0001354	1422.7010856	10509986.	10.2423474	36.0000000	Y
0.0001414	1462.2864094	10342739.	10.1640821	36.0000000	Y
0.0001474	1498.3063371	10164956.	10.1012059	36.0000000	Y
0.0001534	1531.3227357	9981540.	10.0508538	36.0000000	Y
0.0001594	1561.7738269	9795875.	10.0107972	36.0000000	Y
0.0001654	1590.0194162	9610383.	9.9792437	36.0000000	Y
0.0001715	1616.2981165	9426437.	9.9548942	36.0000000	Y
0.0001775	1640.7811656	9244845.	9.9367660	36.0000000	Y
0.0001835	1663.8265136	9067325.	9.9234856	36.0000000	Y
0.0001895	1685.3669042	8893135.	9.9148838	36.0000000	Y
0.0001955	1705.7713374	8723855.	9.9097100	36.0000000	Y
0.0002015	1724.9428067	8558563.	9.9079941	36.0000000	Y
0.0002076	1743.1079259	8398006.	9.9089531	36.0000000	Y
0.0002136	1760.3659791	8242246.	9.9121785	36.0000000	Y
0.0002196	1776.7739490	8091151.	9.9174003	36.0000000	Y
0.0002256	1792.3337154	7944354.	9.9245158	36.0000000	Y
0.0002316	1807.1517201	7801981.	9.9331656	36.0000000	Y
0.0002376	1821.3004255	7664000.	9.9430967	36.0000000	Y
0.0002437	1834.8258799	7530275.	9.9541385	36.0000000	Y
0.0002497	1847.7722203	7400675.	9.9661358	36.0000000	Y
0.0002557	1860.1817944	7275074.	9.9789472	36.0000000	Y
0.0002617	1872.0912407	7153338.	9.9924532	36.0000000	Y
0.0002677	1883.4626491	7035063.	10.0067378	36.0000000	Y
0.0002737	1894.3956044	6920385.	10.0215280	36.0000000	Y
0.0002798	1904.9271274	6809205.	10.0367193	36.0000000	Y
0.0002858	1915.0928499	6701426.	10.0522137	36.0000000	Y
0.0002918	1924.9270831	6596955.	10.0679191	36.0000000	Y
0.0002978	1934.3063009	6495178.	10.0841634	36.0000000	Y
0.0003038	1943.3874550	6396450.	10.1005392	36.0000000	Y
0.0003098	1952.2180167	6300747.	10.1169249	36.0000000	Y
0.0003159	1960.7039446	6207600.	10.1335731	36.0000000	Y
0.0003219	1968.8910696	6117006.	10.1503755	36.0000000	Y
0.0003279	1976.9021464	6029199.	10.1670145	36.0000000	Y
0.0003339	1984.3494347	5942869.	10.1830737	36.0000000	Y
0.0003399	1991.4607058	5858606.	10.1983259	36.0000000	Y
0.0003459	1998.3638836	5776672.	10.2136096	36.0000000	Y
0.0003520	2004.5581483	5695525.	10.2269075	36.0000000	Y
0.0003580	2010.4772656	5616337.	10.2393579	36.0000000	Y
0.0003820	2030.4949532	5314950.	10.2810453	36.0000000	Y
0.0004061	2046.0525365	5038300.	10.3114607	36.0000000	Y
0.0004302	2058.5248945	4785431.	10.3346734	36.0000000	Y
0.0004542	2068.9011606	4554742.	10.3534685	36.0000000	Y
0.0004783	2077.5144961	4343581.	10.3687348	36.0000000	Y
0.0005024	2084.7848836	4149978.	10.3813247	36.0000000	Y

0.0005264	2091.0116150	3972093.	10.3924056	36.0000000 Y
0.0005505	2096.4628210	3808352.	10.4025609	36.0000000 Y
0.0005746	2101.1044233	3656918.	10.4103695	36.0000000 Y

Summary of Results for Nominal (Unfactored) Moment Capacity for Section 1

Load No.	Axial Thrust kips	Nominal Mom. Cap. in-kip
1	198.200	2101.1

Note that the values in the above table are not factored by a strength reduction factor for LRFD.

The value of the strength reduction factor depends on the provisions of the LRFD code being followed.

The above values should be multiplied by the appropriate strength reduction factor to compute ultimate moment capacity according to the LRFD structural design standard being followed.

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 = 3900.0 lbs
Applied moment at pile head = 0.0 in-lbs
Axial thrust load on pile head = 198200.0 lbs

Depth X feet	Deflect. y inches	Bending Moment in-lbs	Shear Force lbs	Slope S radians	Total Stress psi*	Bending Stiffness lb-in^2	Soil Res. p lb/in	Soil Spr. Es*h lb/inch	Distrib. Lat. Load lb/inch
0.00	0.0607	4.287E-08	3900.0000	-0.001007	12348.	1.081E+10	0.000	0.000	0.000
0.517	0.0545	25434.	3817.0835	-0.001000	12825.	1.081E+10	-26.7300	3044.8799	0.000
1.034	0.0483	49821.	3565.1536	-0.000978	13283.	1.081E+10	-54.4853	6997.7024	0.000
1.551	0.0423	72076.	3152.6856	-0.000943	13701.	1.081E+10	-78.4831	11504.	0.000
2.068	0.0366	91259.	2611.4770	-0.000896	14061.	1.081E+10	-95.9877	16270.	0.000
2.585	0.0312	106684.	1989.4515	-0.000840	14351.	1.081E+10	-104.5363	20784.	0.000
3.102	0.0262	118009.	1338.6400	-0.000775	14564.	1.081E+10	-105.2675	24941.	0.000
3.619	0.0216	125200.	706.3588	-0.000705	14699.	1.081E+10	-98.5626	28327.	0.000
4.136	0.0174	128508.	137.1293	-0.000632	14761.	1.081E+10	-84.9414	30228.	0.000
4.653	0.0137	128457.	-324.3875	-0.000559	14760.	1.081E+10	-63.8390	28829.	0.000
5.170	0.0105	125857.	-708.0018	-0.000486	14711.	1.081E+10	-59.8278	35348.	0.000
5.687	0.007711	120866.	-1059.5538	-0.000415	14617.	1.081E+10	-53.5030	43048.	0.000

6.204	0.005351	113731.	-1358.9921	-0.000348	14483.	1.081E+10	-43.0278	49883.	0.000
6.721	0.003397	104859.	-1584.2515	-0.000285	14317.	1.081E+10	-29.5897	54039.	0.000
7.238	0.001816	94774.	-1728.8806	-0.000228	14127.	1.081E+10	-17.0348	58196.	0.000
7.755	0.000572	83967.	-1799.5670	-0.000176	13924.	1.081E+10	-5.7526	62353.	0.000
8.272	-0.000372	72879.	-1805.0314	-0.000131	13716.	1.081E+10	3.9910	66510.	0.000
8.789	-0.001057	61893.	-1755.2880	-9.268E-05	13510.	1.081E+10	12.0449	70667.	0.000
9.306	-0.001522	51327.	-1660.9746	-6.019E-05	13312.	1.081E+10	18.3591	74824.	0.000
9.823	-0.001804	41432.	-1532.7724	-3.357E-05	13126.	1.081E+10	22.9697	78981.	0.000
10.340	-0.001939	32391.	-1380.9259	-1.239E-05	12956.	1.081E+10	25.9814	83138.	0.000
10.857	-0.001958	24328.	-1214.8691	3.886E-06	12805.	1.081E+10	27.5507	87294.	0.000
11.374	-0.001891	17307.	-1042.9577	1.583E-05	12673.	1.081E+10	27.8689	91451.	0.000
11.891	-0.001762	11348.	-872.2984	2.406E-05	12561.	1.081E+10	27.1470	95608.	0.000
12.408	-0.001592	6424.7770	-708.6692	2.916E-05	12468.	1.081E+10	25.6025	99765.	0.000
12.925	-0.001400	2482.7917	-556.5150	3.171E-05	12394.	1.081E+10	23.4478	103922.	0.000
13.442	-0.001199	-558.4477	-419.0057	3.226E-05	12358.	1.081E+10	20.8814	108079.	0.000
13.959	-0.000999	-2795.5765	-298.1433	3.130E-05	12400.	1.081E+10	18.0814	112236.	0.000
14.476	-0.000810	-4334.7881	-194.9009	2.926E-05	12429.	1.081E+10	15.2012	116393.	0.000
14.993	-0.000636	-5285.8539	-109.3836	2.649E-05	12447.	1.081E+10	12.3673	120549.	0.000
15.510	-0.000482	-5757.1772	-40.9964	2.333E-05	12456.	1.081E+10	9.6789	124706.	0.000
16.027	-0.000347	-5851.9021	11.3883	1.999E-05	12458.	1.081E+10	7.2085	128863.	0.000
16.544	-0.000233	-5665.0437	49.2739	1.669E-05	12454.	1.081E+10	5.0048	133020.	0.000
17.061	-0.000140	-5281.5563	74.3984	1.355E-05	12447.	1.081E+10	3.0947	137177.	0.000
17.578	-6.531E-05	-4775.2278	88.6133	1.066E-05	12437.	1.081E+10	1.4878	141334.	0.000
18.095	-7.658E-06	-4208.2646	93.7856	8.085E-06	12427.	1.081E+10	0.1796	145491.	0.000
18.612	3.501E-05	-3631.4195	91.7231	5.835E-06	12416.	1.081E+10	-0.8445	149648.	0.000
19.129	6.475E-05	-3084.5152	84.1243	3.908E-06	12406.	1.081E+10	-1.6052	153805.	0.000
19.646	8.350E-05	-2597.2161	77.2885	2.278E-06	12396.	1.081E+10	-0.5985	44469.	0.000
20.163	9.301E-05	-2131.1212	73.3173	9.210E-07	12388.	1.081E+10	-0.6817	45469.	0.000
20.680	9.493E-05	-1689.7598	68.9971	-1.754E-07	12379.	1.081E+10	-0.7111	46470.	0.000
21.197	9.083E-05	-1274.5745	64.6354	-1.026E-06	12372.	1.081E+10	-0.6950	47471.	0.000
21.714	8.220E-05	-885.2411	60.4872	-1.646E-06	12364.	1.081E+10	-0.6422	48471.	0.000
22.231	7.041E-05	-520.0019	56.7533	-2.049E-06	12357.	1.081E+10	-0.5615	49472.	0.000
22.748	5.678E-05	-176.0074	53.5787	-2.249E-06	12351.	1.081E+10	-0.4619	50473.	0.000
23.265	4.251E-05	150.3330	51.0518	-2.256E-06	12351.	1.081E+10	-0.3527	51474.	0.000
23.782	2.878E-05	462.9916	49.2025	-2.080E-06	12356.	1.081E+10	-0.2434	52474.	0.000
24.299	1.670E-05	765.9536	48.0008	-1.727E-06	12362.	1.081E+10	-0.1440	53475.	0.000
24.816	7.348E-06	1062.8343	9.0072	-1.203E-06	12368.	1.081E+10	-12.4265	10492544.	0.000
25.333	1.778E-06	880.6727	-45.7084	-6.450E-07	12364.	1.081E+10	-5.2123	18185572.	0.000
25.850	-6.556E-07	497.2713	-55.9055	-2.496E-07	12357.	1.081E+10	1.9250	18217634.	0.000
26.367	-1.319E-06	187.6113	-37.9008	-5.306E-08	12351.	1.081E+10	3.8792	18249696.	0.000
26.884	-1.314E-06	27.1287	-13.8569	8.559E-09	12348.	1.081E+10	3.8719	18281757.	0.000
27.401	-1.213E-06	15.6542	-1.6235	2.084E-08	12348.	1.081E+10	0.0718	367480.	0.000
27.918	-1.055E-06	6.9331	-1.2018	2.732E-08	12348.	1.081E+10	0.0641	376910.	0.000
28.435	-8.736E-07	0.6751	-0.8341	2.950E-08	12348.	1.081E+10	0.0544	386340.	0.000
28.952	-6.894E-07	-3.4896	-0.5290	2.869E-08	12348.	1.081E+10	0.0440	395770.	0.000
29.469	-5.176E-07	-5.9590	-0.2877	2.598E-08	12348.	1.081E+10	0.0338	405199.	0.000
29.986	-3.670E-07	-7.1232	-0.1067	2.223E-08	12348.	1.081E+10	0.0245	414629.	0.000
30.503	-2.418E-07	-7.3382	0.0206	1.808E-08	12348.	1.081E+10	0.0165	424059.	0.000
31.020	-1.427E-07	-6.9119	0.1028	1.399E-08	12348.	1.081E+10	0.009971	433489.	0.000
31.537	-6.823E-08	-6.0970	0.1489	1.026E-08	12348.	1.081E+10	0.004871	442919.	0.000
32.054	-1.546E-08	-5.0902	0.1675	7.045E-09	12348.	1.081E+10	0.001127	452349.	0.000
32.571	1.918E-08	-4.0365	0.1665	4.426E-09	12348.	1.081E+10	-0.001428	461779.	0.000
33.088	3.946E-08	-3.0348	0.1528	2.397E-09	12348.	1.081E+10	-0.002997	471209.	0.000
33.605	4.893E-08	-2.1464	0.1317	9.103E-10	12348.	1.081E+10	-0.003791	480639.	0.000
34.122	5.075E-08	-1.4024	0.1075	-1.081E-10	12348.	1.081E+10	-0.004009	490069.	0.000
34.639	4.759E-08	-0.8117	0.0832	-7.434E-10	12348.	1.081E+10	-0.003831	499499.	0.000

35.156	4.153E-08	-0.3679	0.0608	-1.082E-09	12348.	1.081E+10	-0.003407	508929.	0.000
35.673	3.416E-08	-0.0549	0.0414	-1.203E-09	12348.	1.081E+10	-0.002854	518359.	0.000
36.190	2.660E-08	0.1482	0.0255	-1.176E-09	12348.	1.081E+10	-0.002263	527789.	0.000
36.707	1.957E-08	0.2641	0.0132	-1.058E-09	12348.	1.081E+10	-0.001694	537219.	0.000
37.224	1.347E-08	0.3147	0.004266	-8.920E-10	12348.	1.081E+10	-0.001187	546649.	0.000
37.741	8.498E-09	0.3193	-0.001779	-7.101E-10	12348.	1.081E+10	-0.000762	556079.	0.000
38.258	4.661E-09	0.2943	-0.005460	-5.340E-10	12348.	1.081E+10	-0.000425	565509.	0.000
38.775	1.872E-09	0.2528	-0.007316	-3.770E-10	12348.	1.081E+10	-0.000174	574939.	0.000
39.292	-1.645E-11	0.2045	-0.007849	-2.458E-10	12348.	1.081E+10	1.550E-06	584369.	0.000
39.809	-1.177E-09	0.1560	-0.007495	-1.423E-10	12348.	1.081E+10	0.000113	593799.	0.000
40.326	-1.782E-09	0.1118	-0.006608	-6.545E-11	12348.	1.081E+10	0.000173	603229.	0.000
40.843	-1.989E-09	0.0742	-0.005461	-1.207E-11	12348.	1.081E+10	0.000196	612658.	0.000
41.360	-1.932E-09	0.0441	-0.004251	2.189E-11	12348.	1.081E+10	0.000194	622088.	0.000
41.877	-1.718E-09	0.0214	-0.003107	4.069E-11	12348.	1.081E+10	0.000175	631518.	0.000
42.394	-1.427E-09	0.005448	-0.002108	4.840E-11	12348.	1.081E+10	0.000147	640948.	0.000
42.911	-1.117E-09	-0.004851	-0.001287	4.857E-11	12348.	1.081E+10	0.000117	650378.	0.000
43.428	-8.246E-10	-0.0106	-0.000651	4.412E-11	12348.	1.081E+10	8.770E-05	659808.	0.000
43.945	-5.698E-10	-0.0130	-0.000189	3.733E-11	12348.	1.081E+10	6.146E-05	669238.	0.000
44.462	-3.614E-10	-0.0131	8.757E-05	2.983E-11	12348.	1.081E+10	2.762E-05	474138.	0.000
44.979	-1.996E-10	-0.0120	0.000221	2.263E-11	12348.	1.081E+10	1.547E-05	480950.	0.000
45.496	-8.058E-11	-0.0104	0.000289	1.620E-11	12348.	1.081E+10	6.335E-06	487763.	0.000
46.013	1.444E-12	-0.008485	0.000308	1.079E-11	12348.	1.081E+10	-1.151E-07	494576.	0.000
46.530	5.326E-11	-0.006585	0.000294	6.463E-12	12348.	1.081E+10	-4.304E-06	501388.	0.000
47.047	8.163E-11	-0.004847	0.000260	3.182E-12	12348.	1.081E+10	-6.687E-06	508201.	0.000
47.564	9.275E-11	-0.003362	0.000216	0.000	12348.	1.081E+10	-7.699E-06	515014.	0.000
48.081	9.189E-11	-0.002172	0.000168	0.000	12348.	1.081E+10	-7.729E-06	521826.	0.000
48.598	8.330E-11	-0.001277	0.000122	-1.751E-12	12348.	1.081E+10	-7.098E-06	528639.	0.000
49.115	7.016E-11	-0.000655	8.110E-05	-2.306E-12	12348.	1.081E+10	-6.055E-06	535452.	0.000
49.632	5.469E-11	-0.000265	4.749E-05	-2.570E-12	12348.	1.081E+10	-4.780E-06	542264.	0.000
50.149	3.828E-11	-5.943E-05	2.215E-05	-2.663E-12	12348.	1.081E+10	-3.388E-06	549077.	0.000
50.666	2.165E-11	1.608E-05	5.623E-06	-2.675E-12	12348.	1.081E+10	-1.940E-06	555890.	0.000
51.183	5.082E-12	1.692E-05	-1.824E-06	-2.666E-12	12348.	1.081E+10	-4.609E-07	562702.	0.000
51.700	-1.143E-11	0.000	0.000	-2.661E-12	12348.	1.081E+10	1.049E-06	284757.	0.000

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

Output Summary for Load Case No. 1:

Pile-head deflection = 0.0607109 inches
Computed slope at pile head = -0.0010071 radians
Maximum bending moment = 128508. inch-lbs
Maximum shear force = 3900.0000000 lbs
Depth of maximum bending moment = 4.1360000 feet below pile head
Depth of maximum shear force = 0.000000 feet below pile head
Number of iterations = 7
Number of zero deflection points = 7

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

Boundary Condition Type 1, Shear and Moment

Shear = 3900. lb
Moment = 0. in- lb
Axial Load = 198200. lb

Pile Length feet	Pile Head Deflection inches	Maximum Moment ln-lbs	Maximum Shear lbs
51.7000	0.0607109	128508.	3900.0000000
49.1150	0.0605406	128864.	3900.0000000
46.5300	0.0606037	128513.	3900.0000000
43.9450	0.0605574	128760.	3900.0000000
41.3600	0.0604827	128505.	3900.0000000
38.7750	0.0605318	128495.	3900.0000000
36.1900	0.0604661	128522.	3900.0000000
33.6050	0.0604093	128469.	3900.0000000
31.0200	0.0603989	128428.	3900.0000000
28.4350	0.0603615	128339.	3900.0000000
25.8500	0.0603561	128360.	3900.0000000
23.2650	0.0603621	128322.	3900.0000000
20.6800	0.0603441	128283.	3900.0000000
18.0950	0.0603601	128232.	3900.0000000
15.5100	0.0603669	128227.	3900.0000000
12.9250	0.0611950	127386.	3900.0000000
10.3400	0.0746415	122749.	3900.0000001
7.7550	0.2480986	119363.	-4418.7686469

Summary of Pile Response(s)

Definitions of Pile-head Loading Conditions:

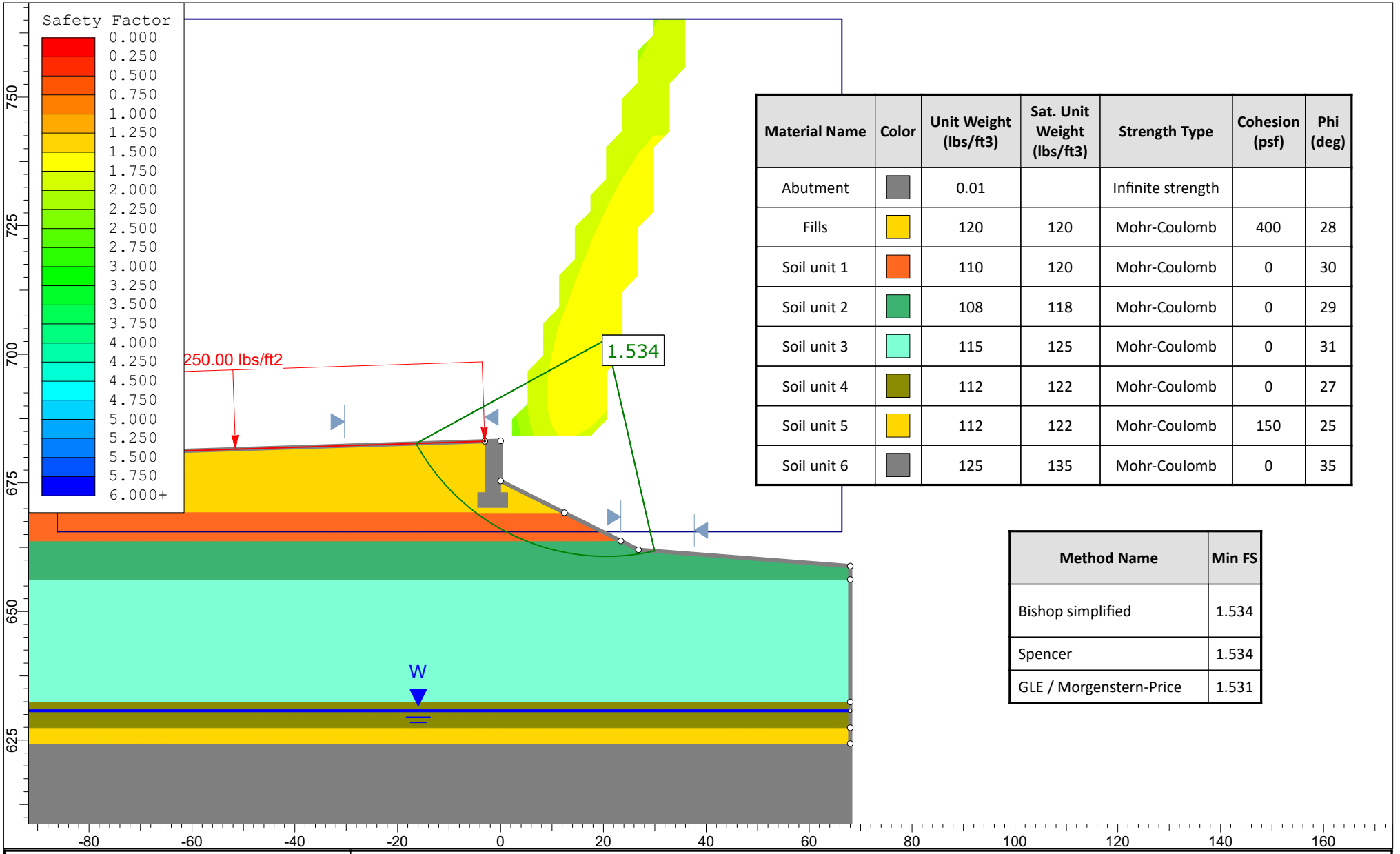
Load Type 1: Load 1 = Shear, lbs, and Load 2 = Moment, in-lbs
Load Type 2: Load 1 = Shear, lbs, and Load 2 = Slope, radians
Load Type 3: Load 1 = Shear, lbs, and Load 2 = Rotational Stiffness, in-lbs/radian
Load Type 4: Load 1 = Top Deflection, inches, and Load 2 = Moment, in-lbs
Load Type 5: Load 1 = Top Deflection, inches, and Load 2 = Slope, radians

Load Case No.	Pile-head Load Type No.	Pile-head Condition 1 V(lbs) or y(inches)	Pile-head Condition 2 in-lb, rad., or in-lb/rad.	Axial Loading lbs	Maximum Pile-head Deflection inches	Maximum Moment in Pile in-lbs	Maximum Shear in Pile lbs	Pile-head Rotation radians
1	1	V = 3900.0000	M = 0.000	198200.	0.06071089	128508.	3900.0000	-0.00100710

The analysis ended normally.

APPENDIX D

GLOBAL STABILITY ANALYSIS

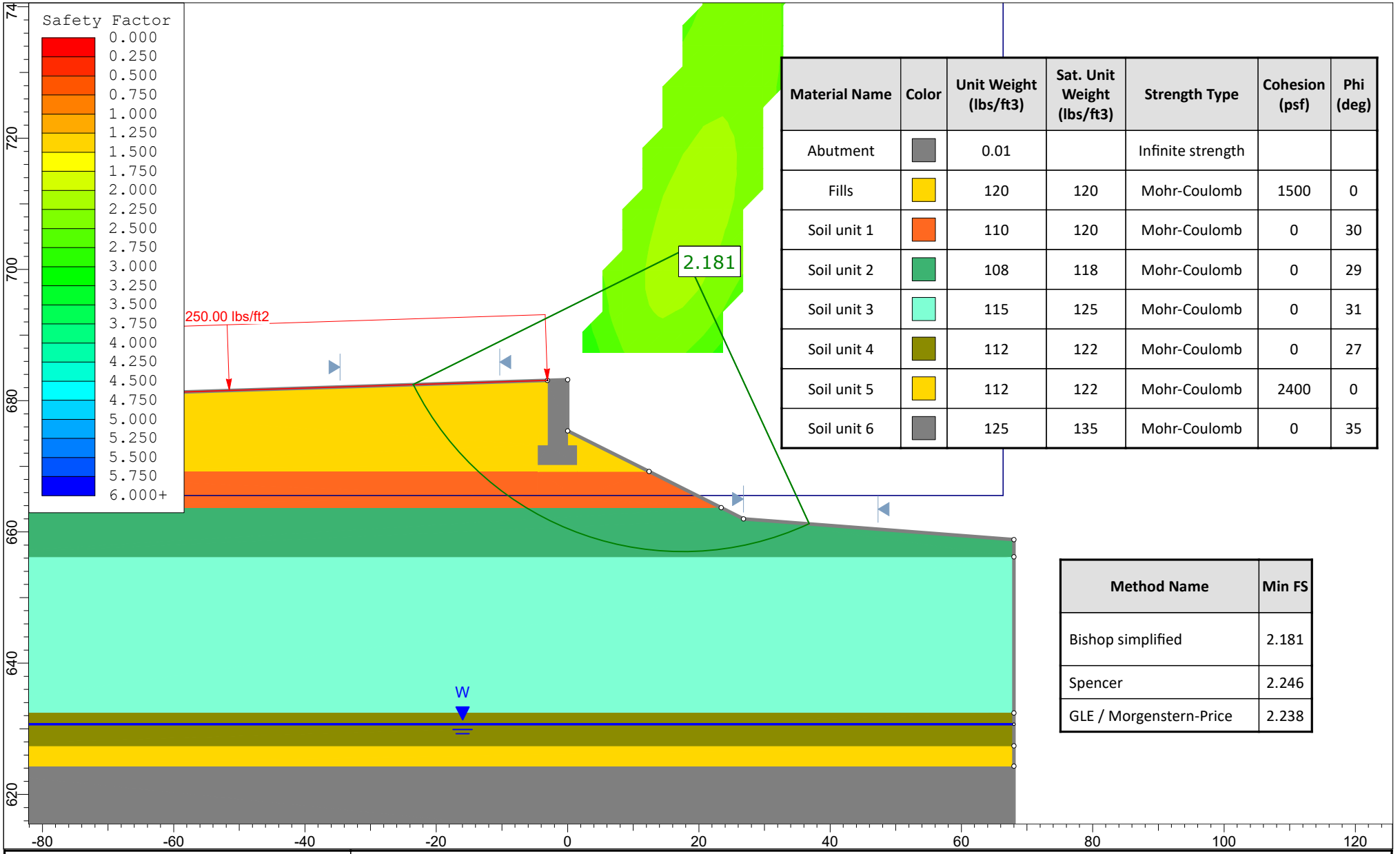


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Abutment		0.01		Infinite strength		
Fills		120	120	Mohr-Coulomb	400	28
Soil unit 1		110	120	Mohr-Coulomb	0	30
Soil unit 2		108	118	Mohr-Coulomb	0	29
Soil unit 3		115	125	Mohr-Coulomb	0	31
Soil unit 4		112	122	Mohr-Coulomb	0	27
Soil unit 5		112	122	Mohr-Coulomb	150	25
Soil unit 6		125	135	Mohr-Coulomb	0	35

Method Name	Min FS
Bishop simplified	1.534
Spencer	1.534
GLE / Morgenstern-Price	1.531

SLIDEINTERPRET 7.037

Project	ROS-CR222-03.83		
Analysis Description	Rear Abutment B-004-0-21		
Drawn By	ZM	Scale	1:309
Company	NEAS Inc.		
Date	3/14/2022	File Name	ROS-CR222-03.83_RearAbut_Effective_B-04.slim

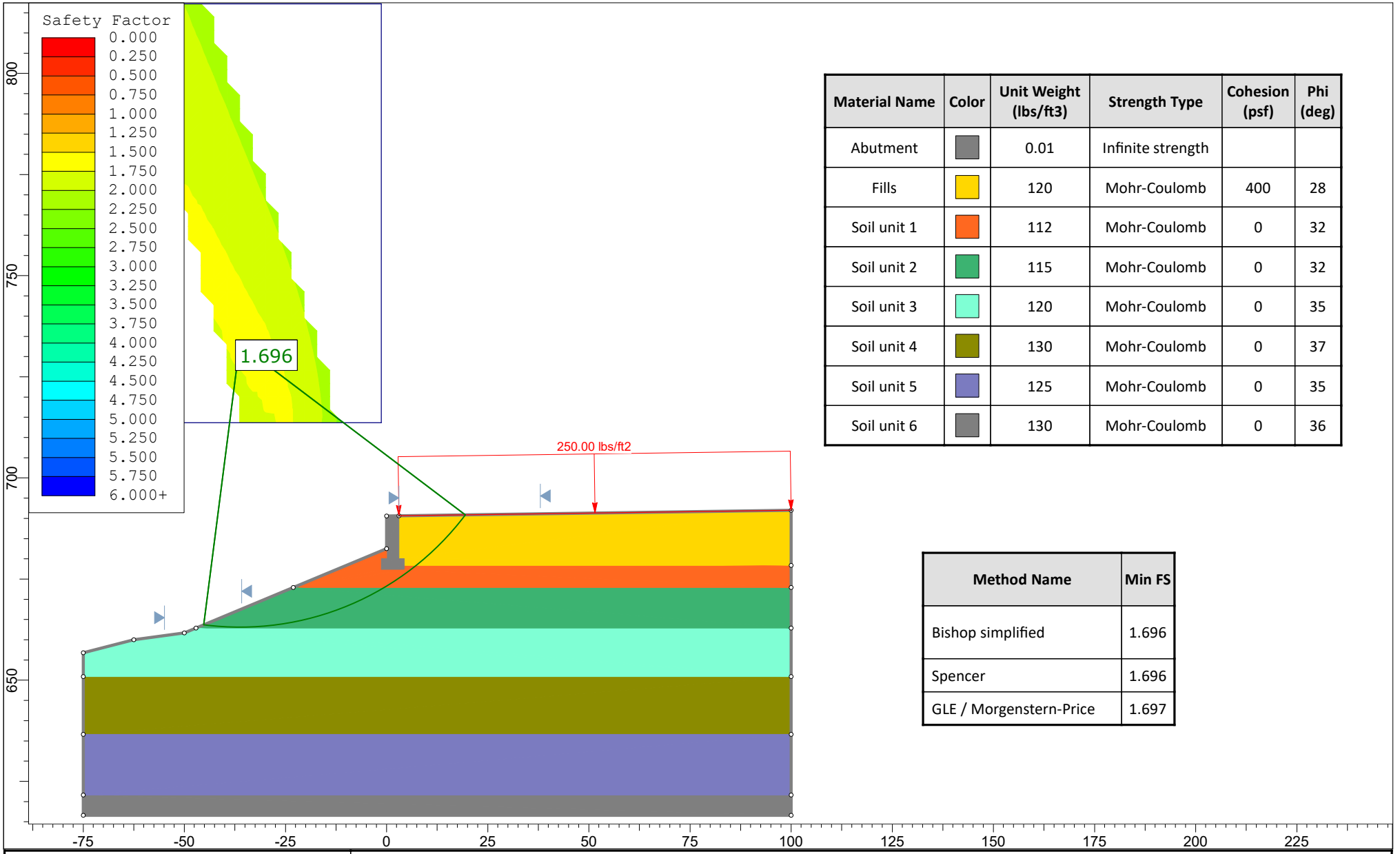


Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Abutment		0.01		Infinite strength		
Fills		120	120	Mohr-Coulomb	1500	0
Soil unit 1		110	120	Mohr-Coulomb	0	30
Soil unit 2		108	118	Mohr-Coulomb	0	29
Soil unit 3		115	125	Mohr-Coulomb	0	31
Soil unit 4		112	122	Mohr-Coulomb	0	27
Soil unit 5		112	122	Mohr-Coulomb	2400	0
Soil unit 6		125	135	Mohr-Coulomb	0	35

Method Name	Min FS
Bishop simplified	2.181
Spencer	2.246
GLE / Morgenstern-Price	2.238

Project	ROS-CR222-03.83		
Analysis Description	Rear Abutment B-004-0-21		
Drawn By	ZM	Scale 1:242	Company NEAS Inc.
Date	3/14/2022		File Name ROS-CR222-03.83_RearAbut_Total_B-04.slim

SLIDEINTERPRET 7.037

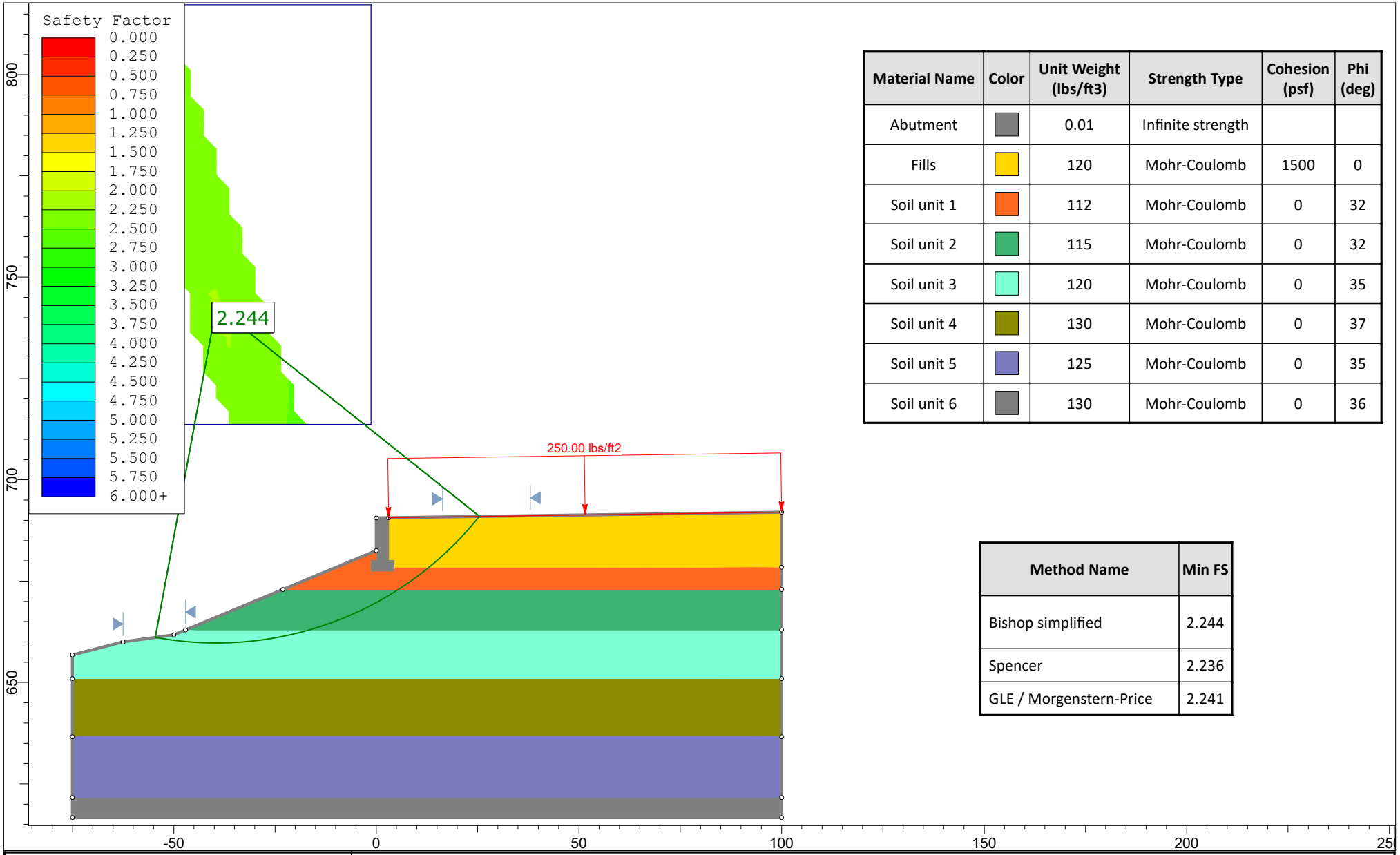


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Abutment		0.01	Infinite strength		
Fills		120	Mohr-Coulomb	400	28
Soil unit 1		112	Mohr-Coulomb	0	32
Soil unit 2		115	Mohr-Coulomb	0	32
Soil unit 3		120	Mohr-Coulomb	0	35
Soil unit 4		130	Mohr-Coulomb	0	37
Soil unit 5		125	Mohr-Coulomb	0	35
Soil unit 6		130	Mohr-Coulomb	0	36

Method Name	Min FS
Bishop simplified	1.696
Spencer	1.696
GLE / Morgenstern-Price	1.697

SLIDEINTERPRET 7.037

Project	ROS-CR222-03.83		
Analysis Description	Forward Abutment B-005-0-21		
Drawn By	ZM	Scale	1:393
Company	NEAS Inc.		
Date	3/14/2022	File Name	ROS-CR222-03.83_ForwAbut_Effective_B-05.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Abutment		0.01	Infinite strength		
Fills		120	Mohr-Coulomb	1500	0
Soil unit 1		112	Mohr-Coulomb	0	32
Soil unit 2		115	Mohr-Coulomb	0	32
Soil unit 3		120	Mohr-Coulomb	0	35
Soil unit 4		130	Mohr-Coulomb	0	37
Soil unit 5		125	Mohr-Coulomb	0	35
Soil unit 6		130	Mohr-Coulomb	0	36

Method Name	Min FS
Bishop simplified	2.244
Spencer	2.236
GLE / Morgenstern-Price	2.241

SLIDEINTERPRET 7.037

Project	ROS-CR222-03.83		
Analysis Description	Forward Abutment B-005-0-21		
Drawn By	ZM	Scale 1:393	Company NEAS Inc.
Date	3/14/2022		File Name ROS-CR222-03.83_ForwAbut_Total_B-05.slim

APPENDIX F

GEOTECHNICAL BULLETIN 1 SPREADSHEET

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

PLAN SUBGRADES
Geotechnical Bulletin GB1

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

ROS-CR222-0383
106544

Replacement of bridge ROS-CR222-0383, Construct a Box Culvert Carrying Lick Run under CR-222 and the realignment of of approximately 3,400 ft of CR-222

NEAS Inc.

Prepared By: ERGB
Date prepared: Monday, March 7, 2022

Melinda He
2800 Corporate Exchange Drive
Suite 240
Columbus, OH 43231
(216)-258-4072
che@neasinc.com

NO. OF BORINGS: 8

#	Boring ID	Alignment	Station	Offset	Dir	Drill Rig	ER	Boring EL.	Proposed Subgrade EL	Cut Fill
1	B-001-0-21	Centerline of CR222	212+74	11	LT	CME 55X W	80	632.4	629.2	3.2 C
2	B-002-0-21	Centerline of CR222	215+90	1	LT	CME 55X W	80	643.1	645.0	1.9 F
3	B-006-0-21	Centerline of CR222	227+78	1	LT	CME 55X W	80	700.2	689.7	10.5 C
4	B-007-0-21	Centerline of CR222	231+74	4	RT	CME 55X W	80	682.3	680.8	1.5 C
5	B-008-0-21	Centerline of CR222	235+84	12	RT	CME 55X W	80	666.8	664.7	2.1 C
6	B-009-0-21	Centerline of CR222	239+51	0	RT	CME 55X W	80	667.1	657.0	10.1 C
7	B-010-0-21	Centerline of CR222	242+47	1	LT	CME 55X W	80	655.6	655.8	0.3 F
8	B-011-0-21	Centerline of CR222	244+78	10	RT	CME 55X W	80	657.1	654.9	2.2 C

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.6 2/11/2022

#	Boring	Sample	Sample Depth		Subgrade Depth		Standard Penetration		HP (tsf)	Physical Characteristics						Moisture		Ohio DOT		Sulfate Content (ppm)	Problem		Excavate and Replace (Item 204)		Recommendation (Enter depth in inches)
			From	To	From	To	N_{60}	N_{60L}		LL	PL	PI	% Silt	% Clay	P200	M_C	M_{OPT}	Class	GI		Unsuitable	Unstable	Unsuitable	Unstable	
1	B	SS-1	1.5	3.0	-1.7	-0.2	35			NP	NP	NP	85	5	90	23	11	A-4b	8	33					
	001-0	SS-2	3.0	4.5	-0.2	1.3	35									21	10	A-4b	8		A-4b	Mc			
	21	SS-3	4.5	6.0	1.3	2.8	39			NP	NP	NP	78	6	84	23	11	A-4b	8		A-4b	Mc	**33"**		
		SS-4	6.0	7.5	2.8	4.3	17	17								20	10	A-4b	8						
2	B	SS-1	1.0	2.5	2.9	4.4	13			NP	NP	NP	31	12	43	15	11	A-4a	2	0					
	002-0	SS-2	3.5	5.0	5.4	6.9	13									7	10	A-4a							
	21	SS-3	6.0	7.5	7.9	9.4	9		1.75	39	21	18	44	32	76	29	16	A-6b							
		SS-4	8.5	10.0	10.4	11.9	19	13								7	10	A-4a							
3	B	SS-5	11.0	12.5	0.5	2.0	35			NP	NP	NP	8	1	9	8	6	A-1-b	0						
	006-0	SS-6	13.5	15.0	3.0	4.5	21									8	6	A-1-b	0						
	21	SS-7	16.0	17.5	5.5	7.0	54			NP	NP	NP	12	1	13	6	6	A-1-a							
		SS-8	18.5	20.0	8.0	9.5	64	21								4	6	A-1-a							
4	B	SS-1	1.0	2.5	-0.5	1.0	4									11	6	A-1-b	0						
	007-0	SS-2	3.5	5.0	2.0	3.5	16			NP	NP	NP	9	1	10	5	6	A-1-a	0	13					
	21	SS-3	6.0	7.5	4.5	6.0	45			NP	NP	NP	19	7	26	8	10	A-2-4	0						
		SS-4	8.5	10.0	7.0	8.5	28	4								8	6	A-1-b							
5	B	SS-1	1.0	2.5	-1.1	0.4	5									14	10	A-4a	8			N_{60} & Mc		**21"**	
	008-0	SS-2	3.5	5.0	1.4	2.9	3			NP	NP	NP	29	11	40	19	11	A-4a	1	0		N_{60} & Mc			
	21	SS-3	6.0	7.5	3.9	5.4	7		1.25	31	16	15	36	21	57	20	14	A-6a	6						
		SS-4	8.5	10.0	6.4	7.9	5	3								12	10	A-4a							
6	B	SS-5	11.0	12.5	0.9	2.4	35			NP	NP	NP	12	3	15	4	6	A-1-b	0						
	009-0	SS-6	13.5	15.0	3.4	4.9	19			NP	NP	NP	25	3	28	8	10	A-2-4	0						
	21	SS-7	16.0	17.5	5.9	7.4	37									6	6	A-1-b							
		SS-8	18.5	20.0	8.4	9.9	28	19								5	6	A-1-b							
7	B	SS-1	1.5	3.0	1.8	3.3	20			NP	NP	NP	19	10	29	9	10	A-2-4	0	13					
	010-0	SS-2	3.0	4.5	3.3	4.8	11									13	10	A-2-4	0						
	21	SS-3	4.5	6.0	4.8	6.3	24			NP	NP	NP	27	6	33	11	8	A-3a	0						
		SS-4	6.0	7.5	6.3	7.8	23	11								10	8	A-3a							
8	B	SS-1	1.5	3.0	-0.7	0.8	46			NP	NP	NP	22	5	27	7	10	A-2-4	0						
	011-0	SS-2	3.0	4.5	0.8	2.3	19									9	10	A-2-4	0						
	21	SS-3	4.5	6.0	2.3	3.8	12			NP	NP	NP	24	8	32	12	8	A-3a	0						
		SS-4	6.0	7.5	3.8	5.3	9	9		NP	NP	NP	13	17	30	23	8	A-3a	0						

OHIO DEPARTMENT OF TRANSPORTATION

Subgrade Analysis

V. 14.6 2/11/2022

PID: 106544

County-Route-Section: ROS-CR222-0383
No. of Borings: 8

Geotechnical Consultant: NEAS Inc.
Prepared By: ERGB
Date prepared: Monday, March 7, 2022

Chemical Stabilization Options		
320	Rubblize & Roll	Option
206	Cement Stabilization	Option
	Lime Stabilization	Option
206	Depth	12''

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

Design CBR	10

% Samples within 6 feet of subgrade			
$N_{60} \leq 5$	13%	HP ≤ 0.5	0%
$N_{60} < 12$	25%	0.5 < HP ≤ 1	0%
$12 \leq N_{60} < 15$	13%	1 < HP ≤ 2	4%
$N_{60} \geq 20$	46%	HP > 2	0%
M+	17%		
Rock	0%		
Unsuitable	10%		

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

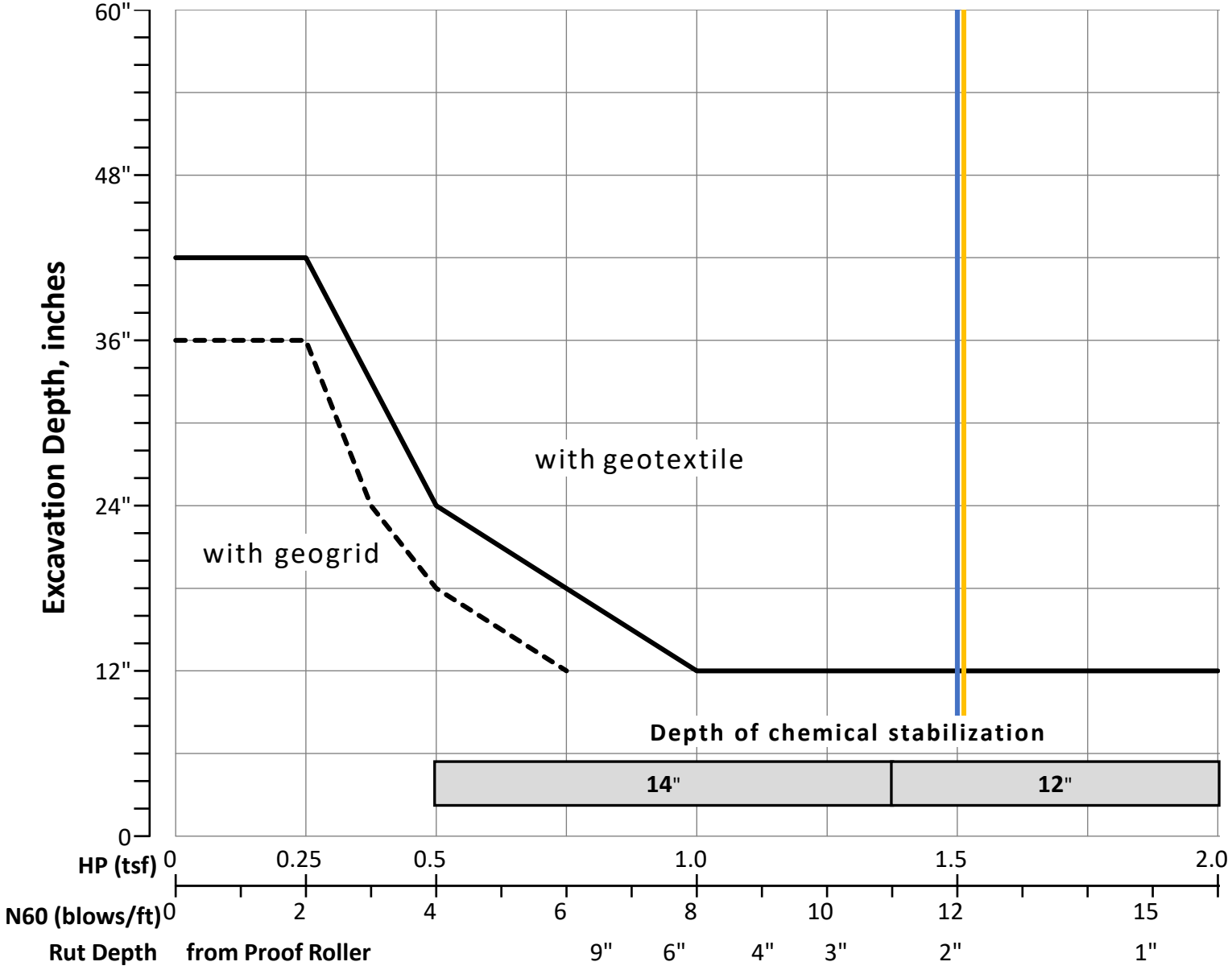
% Proposed Subgrade Surface	
Unstable & Unsuitable	43%
Unstable	29%
Unsuitable	14%

	N_{60}	N_{60L}	HP	LL	PL	PI	Silt	Clay	P 200	M_C	M_{OPT}	GI
Average	23	12	1.50	35	19	17	26	9	35	12	9	2
Maximum	64	21	1.75	39	21	18	85	32	90	29	16	8
Minimum	3	3	1.25	31	16	15	8	1	9	4	6	0

Classification Counts by Sample

ODOT Class	Rock	A-1-a	A-1-b	A-2-4	A-2-5	A-2-6	A-2-7	A-3	A-3a	A-4a	A-4b	A-5	A-6a	A-6b	A-7-5	A-7-6	A-8a	A-8b	Totals
Count	0	3	7	6	0	0	0	0	4	6	3	0	1	1	0	0	0	0	31
Percent	0%	10%	23%	19%	0%	0%	0%	0%	13%	19%	10%	0%	3%	3%	0%	0%	0%	0%	100%
% Rock|Granular|Cohesive	0%	84%									16%								100%
Surface Class Count	0	1	3	3	0	0	0	0	1	2	4	0	0	0	0	0	0	0	14
Surface Class Percent	0%	7%	21%	21%	0%	0%	0%	0%	7%	14%	29%	0%	0%	0%	0%	0%	0%	0%	100%

GB1 Figure B – Subgrade Stabilization



OVERRIDE TABLE

Calculated Average	New Values	Check to Override
1.50	0.50	☐ HP
12.13	6.00	☐ N60L

Average HP
Average N_{60L}