FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
BRIDGE NO. CUY-90-1653L&R
RETAINING WALL AC
CUY-90-16.28
CUYAHOGA COUNTY, OHIO
PID#: 82382

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NEAS PROJECT 21-0011

May 17, 2024

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1. INTRODUCTION

1.1. General

National Engineering & Architectural Services, Inc. (NEAS) presents our Structure Foundation Exploration Report for the proposed Bridge CUY-90-1653L&R structure and associated retaining wall, Retaining Wall AC, as part of the proposed Ohio Department of Transportation (ODOT) project CCG3A (CUY-90-16.28, PID 82382) in the City of Cleveland, Cuyahoga County, Ohio. The overall project objective is to reconstruct and improve the IR-77/IR-90 interchange, IR-90 and associated surface streets within the project limits. As part of the planned improvements, a realignment of IR-90 is proposed in the vicinity of East 14th St. To facilitate the realignment, the construction of one (1) twin bridge structure (CUY-90-1653L&R) and one retaining wall (RW-AC) is required. This report presents a summary of the encountered surficial and subsurface conditions and our recommendations for bridge and retaining wall foundation design and construction in accordance with Load and Resistance Factor Design (LRFD) method as set forth in AASHTO's Publication *LRFD Bridge Design Specifications, 9th Edition* (BDS) (AASHTO, 2020) and the 2021 revision of *ODOT's Bridge Design Manual 2020 Edition* (BDM) (ODOT [1], 2021).

The exploration was conducted in general accordance with Barr Engineering, Inc. DBA National Engineering & Architectural Services, Inc.'s (formerly Barr & Prevost) proposal to Michael Baker International (Baker) dated June 11, 2014, subsequent Modification 7 (MOD 7) proposal to Baker dated October 12, 2020 and with the provisions of the July 2014 (ODOT, 2014) and January 2021 (ODOT, 2021) revisions of ODOT's *Specifications for Geotechnical Explorations* (SGE) for the initial project exploration and the MOD 7 exploration, respectively.

The scope of work performed by NEAS as part of the CCG3A project included: 1) a review of published geotechnical information; 2) performing 182 total test soil borings (10 utilized within this report as a part of the indicated structure foundation exploration); 3) performing 30 total cone penetration test (CPT) soundings (1 utilized within this report as a part of the indicated structure foundation exploration); 4) laboratory testing of soil samples in accordance with the SGE; 5) performing geotechnical engineering analysis to assess foundation design and construction considerations; and 6) development of this summary report.

1.2. Proposed Construction

It is our understanding that ODOT plans to both horizontally and vertically realign the roadway carrying traffic along IR-90 in the vicinity of E. 14th St to IR-77 SB as part of the referenced interstate improvement project. To facilitate the proposed IR-90 alignment, the construction of one bridge structure and one retaining wall are required. The side-by-side bridge structure (CUY-90-1653L&R) is proposed to carry IR-90 over East 14th St while RW-AC will act as a wing wall for bridge CUY-90-1653L&R and will support the proposed bridge embankment soils as well as provide grade separation between IR-90 and Ramp A1.

The proposed RW-AC will consist of an anchored soldier pile lagging (SPL) type wall from the rear abutment of CUY-90-1653L extending about 238.8 ft to the west then transitioning to a mechanically stabilized earth (MSE) type walls for the remaining 380.3 ft of wall for a total length of about 619 ft. The top-down portion of RW-AC is anticipated to have maximum wall height of about 25.5 ft while the bottom-up portion of RW-AC is anticipated to have maximum wall height of about 21.9 ft.

The newly proposed side-by-side bridge structure carrying IR-90 over East 14th St will consist of 2-span continuous steel plate girder bridges (designated as CUY-90-1653L&R) supported on semi-integral abutments. The new structures (roadway surface) will be approximately 60-ft (right) and 72-ft (left) wide (parapet to parapet) with each being approximately 228 ft in total length. Substructures of the new bridges will likely be supported by a driven pile foundation consisting of closed-ended cast-in-place reinforced concrete pipe piles (CIP piles).

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The project site is located within the Erie Lake Plain, part of the Huron-Erie Lake Plains. This area is characterized as the edge of the very low-relief (10 ft), Ice-Age lake basin separated from the modern Lake Erie by shoreline cliffs with major streams in deep gorges being characteristic. The geology in this region is described as Pleistocene-age lacustrine sand, silt, clay and wave-planed glacial till over Devonian- and Mississippi-age shales and sandstones (ODGS, 1998).

The geology underlying the western portion of the site of the proposed Ramp B6 structures is mapped as an average of 10 ft or less of Wisconsinan-age sand atop an average of 90 ft of Wisconsinan-age lacustrine silt and clays followed by an average of 80 ft of Wisconsinan-age till underlain by an average of 10 ft or less of Wisconsinan-age sand all over Devonian-age Ohio Shale (ODGS, 2002). The geology underlying the eastern portion of the site is mapped as an average of 20 ft of Wisconsinan-age sand atop a maximum of 290 ft of Wisconsinan-age lacustrine soils thinning to an average of 90 ft in the proximity of the reference bridge site all over Devonian-age Ohio Shale. The Wisconsinan-age sand mapped at the site is characterized as well to moderately sorted, moderately to well rounded, finely stratified to massive and contains minor amounts of disseminated gravel or thin lenses of silt or clay. The lacustrine soils at the site is described as laminated silts and clays that may contain fine sand or gravel layers. The till is described as an unsorted mix of clay, silt, sand, gravel and boulders which may contain silt, sand and gravel lenses. Till in buried valleys and thicker areas are noted as potentially being older than Wisconsinan.

Bedrock beneath the proposed Ramp B6 has been mapped as sedimentary Devonian-age Ohio shale with carbonate and/or siderite concretions in the lowermost 50 ft. This brownish black to greenish gray shale is carbonaceous to clayey, laminated to thin bedded, and can have a petroliferous odor (USGS & ODGS, 2005). Based on the ODNR bedrock topography map of Ohio, bedrock elevations near the proposed Ramp B6 site can be expected to be between elevations of 450 and 400 ft above mean sea level (amsl), putting bedrock at a depth ranging from about 210 to 295 ft below ground surface (bgs).

The soils at the Ramp B6 site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service as Udorthents, loamy (Ua) and Urban Land (Ub). These are soils that have been disturbed by cutting or filling and are not rated for local roads (USDA, 2019).

2.2. Hydrology/Hydrogeology

The local hydro-geologic system is dominated by the valley of the Cuyahoga River, located approximately 0.4 to 0.7 miles to the southwest of the proposed structures and flows northwest discharging into Lake Erie. The elevation of the Cuyahoga River and Lake Erie is about 570 to 575 ft amsl in this region and is likely to be representative of the regional groundwater table. As mentioned previously, the surficial geology consists of primarily granular soils underlain by a relatively impermeable lacustrine or glacial silt and clay layer. It is possible for groundwater to become trapped in granular soils above the regional groundwater level by an underlying impermeable layer forming a perched water table. The project site follows a similar geological model and therefore, could result in a groundwater elevation within the project limits that is likely above the regional groundwater table elevation.

The proposed bridge and retaining wall site is not located within a special flood hazard 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 abandoned mines are noted on ODNR’s Abandoned Underground Mine Locator within the immediate vicinity of the proposed structures (ODNR [1], 2016).

No oil or gas wells are noted on ODNR’s Ohio Oil & Gas Locator within the immediate vicinity of the proposed structures (ODNR [2], 2016).

2.4. Historical Records and Previous Phases of Project Exploration

A historic record search was performed through ODOT’s Transportation Information Mapping System (TIMS); however, no geotechnical data or information was available for review within the immediate vicinity of the proposed bridge and retaining wall sites. Therefore, historic borings are not referenced within this report nor pictured within the associated developed Structure Foundation Exploration Sheets.

2.5. Site Reconnaissance

A field reconnaissance visit for the proposed structures was conducted on July 10, 2015, along IR-90, E. 14th St and the surrounding ramps. Site conditions were noted and photographed during the visit. A summary of our observations at the Bridge CUY-90-1653L&R RW-AC locations is provided below.

2.5.1. Retaining Wall AC

The location of the proposed wall RW-AC encompasses the area located to the north of the existing IR-90 WB and extending west from E. 14th St approximately 619 ft. Along this alignment the proposed wall traverses various active and former IR-90/IR-77 interchange ramps. The SPL wall portion of RW-AC begins near E. 14th St at the northern edge of the existing Bridge CUY-90-1652’s rear abutment and extends approximately 352.5 ft to the west along the existing embankment slopes which support the IR-90 WB ramp to IR-77 SB and the former ramp from E. 14th St to IR-77 SB. The MSE wall portion of RW-AC extends west approximately 266.5 ft from the end of the SPL wall portion, across the existing and former ramps from E. 14th St to IR-77 SB, and through multiple existing drainage swales adjacent to the referenced ramps.

The existing embankment slopes along the SPL wall portion of the proposed RW-AC alignment were observed to be either grassy or heavily vegetated sloping downward from south to north at about 2 Horizontal to 1 Vertical (2H:1V) (Photograph 1). The indicated area appeared to be stable with no apparent signs of instability observed during our visit either along the slopes or within the existing pavements along the length of the proposed SPL wall segment. The existing embankment slopes along the MSE wall portion of RW-AC were also observed to be either grassy or vegetated, sloping away from the referenced interchange ramps more gradually at about 4H:1V to 5H:1V (Photograph 2). These slopes also appeared stable with no apparent signs of instability observed during our visit. Additionally, the asphalt and concrete pavements of the referenced existing and former ramps along the proposed RW-AC alignment were observed to be in good condition with no significant signs of pavement distress observed during our visit.

Photograph 1: Embankments along SPL wall portion (east end) of proposed RW-AC alignment

Photograph 2: Embankments along MSE wall portion (west end) of proposed RW-AC alignment

2.5.2. Bridge CUY-90-1653L&R

The site of the proposed Bridge CUY-90-1653L&R location encompasses the northern half of and the area immediately to the north of the existing Bridge CUY-90-1652 structure carrying IR-90 over E. 14th St. The existing bridge is a continuous steel beam bridge with reinforced concrete deck and stub abutments. Existing spill-through slopes at both the rear and forward abutments were observed to be approximately 2H:1V and generally appeared to be in good condition with no visible slope instability. The embankment slopes were heavily vegetated on either side of the abutments with various grasses and brush, while spill through slopes underneath the bridge were concrete protected (Photograph 3).

Overall, the bridge appeared to be in good condition with no apparent signs of structural distress due to geotechnical concerns observed during our field reconnaissance visit. The deck surface of the bridge was observed to be in good condition showing little signs of distress. In general, the bridge structure appeared to be well-drained with no signs of standing water observed.

Photograph 3: Rear abutment spill-through/embankment slopes

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The exploration for the proposed Bridge CUY-90-1653L&R and associated retaining wall (Wall AC) structures was conducted by NEAS between October 21, 2014 and March 15, 2021 and included 10 borings drilled to depths ranging from of 9 to 125 ft bgs and 1 CPT sounding that was extended to a depth of 110.6 ft bgs. The exploration 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 located at/near proposed substructure locations and along wall alignments that were not restricted by maintenance of traffic, underground utilities or dictated by terrain (i.e. steep embankment slopes). Project exploration locations were located and surveyed in the field by NEAS after the completion of drilling/sounding. Each individual project boring log (included within Appendix B) includes the recorded boring latitude and longitude location (based on the surveyed Ohio State Plane North, NAD83, location) and the corresponding ground surface elevation. A summary of the exploration locations including stationing, offsets, location information and elevations of the indicated Bridge and Wall structure foundation exploration are shown in Table 1 below, while the locations are depicted on the Soil Profile Sheets provided within Appendix A.

Table 1: Project Boring Summary

Boring Number	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)	Structure
B-078-0-14	41.496226	-81.678129	670.9	112.0	Wall AC & CUY-77-1653L&R Rear Abutment
B-078-1-20	41.496503	-81.677982	667.0	110.0	CUY-77-1653L&R Pier
C-079-0-14	41.496600	-81.677693	670.1	110.6	CUY-77-1653L&R Forward Abutment
B-081-0-14	41.496578	-81.677243	686.8	9.0	CUY-77-1653L&R Forward Abutment
B-141-1-20	41.495547	41.495547	668.6	125.0	Wall AC (Consolidation Parameters)
B-142-0-14	41.495588	-81.680039	677.5	112.0	Wall AC
B-142-1-20	41.495780	-81.679499	681.2	75.0	Wall AC
B-142-2-20	41.495926	-81.679385	680.4	110.0	Wall AC
B-142-4-20	41.496169	-81.678701	690.5	66.5	Wall AC
B-144-0-14	41.496799	-81.677835	669.1	111.5	CUY-77-1653L&R Forward Abutment
B-166-0-14	41.495547	-81.680532	687.0	61.5	Wall AC

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

The borings were drilled using either a CME 45B, CME 55, CME 75T or Mobile B-58 truck mounted drilling rig utilizing 3.25-inch diameter hollow stem augers. Soil samples were generally recovered at 2.5-ft intervals to a depth of 30 ft bgs and at 5.0-ft intervals thereafter using a split spoon sampler (AASHTO T-206 "Standard Method for Penetration Test and Split Barrel Sampling of Soils"). 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 CME auto hammers that had been calibrated to be between 77.4% and 92.2% efficient as indicated on the boring log. 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 (using a 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 sealed or backfilled with auger cuttings and asphalt patched.

The CPT sounding was performed by ODOT utilizing a A.P. van den Berg twin-cylinder H-form HYSON 200-kN (45-kip) track mounted penetrometer with a model ELCI-CFXYP20-15 seismic piezocone. During testing, data was collected continuously by a GOnsite! Data acquisition system. The CPT sounding was conducted in accordance with ASTM D5778 "Standard Test Method for Electronic Friction Cone and Piezocone Penetration Testing of Soils". In general, the 15-cm^2 (2.3-in^2) seismic piezocone was advanced at a rate of 20 mm/sec (0.8 in/sec) utilizing 1-m (3.3-ft) long connector rods extending to the target termination depth. After the completion of the CPT sounding, the CPT log was generating by ODOT utilizing the software entitled CPeT-IT by GeoLogismiki. It should be noted that in instances where the angle of inclination of the cone deviated from vertical and/or cone tip pressures increased to tolerances that may result in damaging of the equipment, the CPT soundings was stopped prior to target termination depth. The continuously recorded sounding data can be found on the individual log included within Appendix B.

3.2. Laboratory Testing Program

The laboratory testing program consisted of classification testing and moisture content determinations. Data from the laboratory testing program was incorporated into the final boring logs included within 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 47% of the samples. At the 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 (SPT) and split-barrel (commonly known as split-spoon) sampling of soils were performed at varying intervals (i.e., 2.5-ft and 5.0-ft) 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.

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 exploration location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, laboratory test results as well as comparison of boring data. The lines designating the interfaces between various soil strata on the logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface 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 historical explorations, and consideration of the geological history of the site.

It should be noted, as soil borings and CPT soundings generate geotechnical data in different forms and because there are no direct design methods recommended by ODOT utilizing CPT data, the CPT data obtained during our exploration has been converted to equivalent soil boring data (i.e., SPT N_{60} and soil type). The CPT data was converted using correlations provided in published engineering manuals and guidance documents. The conversion process starts with determining the Soil Behavior Index (I_c) with depth to approximate soil type (i.e., cohesive or granular) followed by calculating an equivalent SPT N_{60} value with depth using the determined Soil Behavior Indices and the measured CPT cone tip resistances.

These converted values are then compared to nearby soil boring(s) to estimate the stratification and assign appropriate ODOT modified AASHTO classification to each distinct stratum. For the purposes of our analyses and this report, descriptions of the subsurface profile, soil characteristics and engineering soil properties are based on both the direct soil borings information as well as the indirect soil-boring-equated CPT data. See Sections 5.2.1. of this report for our sited correlation/reference material for CPT data conversion.

4.1. Subsurface Conditions

The general subsurface profile is relatively uniform and consistent with the geological model for the project. The subsurface profile at the site of proposed Bridge CUY-90-1653L&R and associated RW-AC generally consists of surficial materials (i.e., topsoil or pavement) underlain by existing embankment or historical fill soils followed by natural sands and gravels underlain by natural lacustrine and/or till soils. Where encountered, the embankment fill at the site can generally be described as loose to very dense non-cohesive, granular soils. The natural sands and gravels encountered at the site were generally comprised of very loose to very dense non-cohesive, granular material. The lacustrine/till soils at the site were highly variable though can generally be described as medium dense to very dense coarse- and fined-grained, non-cohesive material in the upper portion of the stratum and soft to hard fine-grained, cohesive and non-cohesive material in the lower portion of the stratum. Bedrock was not encountered within the depths of the explorations performed.

4.1.1. Overburden Soil

At the site of proposed structures, three different materials were encountered below the surficial material. In general, the three different overburden materials consisted of embankment “man-made” fill soils, natural sands and gravels, and natural lacustrine soils. These materials and the general profile underlying the site is further described below.

Fill soils were encountered in each boring performed for the proposed structures with the exception of boring B-078-1-14 in which the natural sands and gravels were encountered at the ground surface. These fill soils were encountered immediately below the topsoil, pavement section or at the ground surface and extended to depths ranging from 2.0 to 24.5 ft bgs (approximate elevations 670.9 to 653.0 ft amsl). Based on laboratory testing results, a visual review of the soil samples obtained, the fill at the site is comprised predominantly of granular material and is classified on the boring logs as Gravel with Sand (A-1-b), Coarse and Fine Sand (A-3a) and non-cohesive Sandy Silt (A-4a). The exception being an approximately 2-ft thick layer of fine-grained cohesive fill encountered underlying the surficial topsoil (elevation 670.7 ft amsl) in boring B-078-0-14. With respect to the soil strength, the granular fill soils can be described having a relative compactness of loose to very dense correlating to converted SPT-N values (N_{60}) between 5 and 118 blows per foot (bpf). Natural moisture contents of the granular fill ranged from 5 to 17 percent. With respect to the soil strength of the fine-grained cohesive fill, these soils can be described as having a consistency of stiff to very stiff correlating to an N_{60} value of 12 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 1.7 and 2.8 tons per square foot (tsf). Natural moisture content of the cohesive fill sample was determined to be 22 percent. Based on an Atterberg Limits test performed on a representative sample of the cohesive fill material, the liquid and plastic limits were 33 and 20 percent, respectively.

The stratum encountered immediately beneath the fill (or at the ground surface in boring B-078-1-14) consisted of a natural sand and gravel layer extending to depths between 22.0 and 66.5 ft bgs (approximate elevations 624.0 and 645.5 ft amsl). Based on laboratory testing results, a visual review of the soil samples obtained as well as the calculated Soil Behavior Index within this stratum, these soils are comprised of granular material and are classified on the boring logs as Gravel and/or Stone Fragments with Sand (A-1-b), Gravel with Sand and Silt (A-2-4), Fine Sand (A-3), Coarse and Fine Sand (A-3a), non-cohesive Sandy Silt (A-4a) and non-cohesive Silt (A-4b). The exception being a seam of fine-grained cohesive material that was encountered within each of the borings B-144-0-14 and B-078-1-20. A 1.0-ft thick seam of cohesive soil classified as Silty Clay (A-6b) was encountered at a depth of 12.0 ft bgs (elevation 655.0 ft amsl) in boring B-078-1-20 while a 2.5-ft thick seam of cohesive soil classified as Silt and Clay (A-6a) was encountered at a depth of 9.5 ft bgs (elevation 659.6 ft amsl) in boring B-144-0-14. With respect to the soil strength, the natural sands and gravels can be described having a relative compactness of very loose to very dense correlating to converted N_{60} values between 4 and SPT-N refusal (i.e., less than 6 inches of penetration over 50 blows). Natural moisture contents of the natural granular soils ranged from 4 to 31 percent. With respect to the soil strength of the fine-grained seams encountered within this stratum, these soils can be described as having a consistency of medium stiff to stiff correlating to N_{60} values of 5 and 7 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between 1.1 and 2.5 tsf. Natural moisture contents of the cohesive soils ranged from 24 to 25 percent. Based on Atterberg Limits tests performed on a representative sample of the cohesive material from boring B-144-0-14, the liquid and plastic limits were 32 and 18 percent, respectively.

The soils encountered directly underlying the natural sand layer encountered at the site consisted of highly variable lacustrine soils which consisted of an upper stratum comprised predominantly of non-cohesive, fine-grained soils and a lower stratum comprised of predominantly cohesive, fine-grained soils. The upper stratum of the lacustrine soils was encountered directly underlying the natural sands and gravels at the site in each of the borings performed and extended to depths between 38.3 and 38.0 ft bgs (approximate elevations 613.2 and 631.8 ft amsl). The exceptions being boring B-142-2-20, in which the natural granular soils extended to borehole termination depth, as well as boring B-166-0-14, in which the cohesive lacustrine soils were encountered directly underlying the natural granular soils. The upper non-cohesive lacustrine soils encountered at the site classified on the boring logs as non-cohesive Sandy Silt (A-4a) and non-cohesive Silt (A-4b) that can be described having a relative compactness of medium dense to very dense correlating to converted N_{60} values between 16 and 54 bpf. Natural moisture contents of the upper lacustrine soils ranged from 18 to 27 percent. The lower cohesive portion of the lacustrine stratum extended to termination depths ranging from 61.5 to 112.0 ft bgs (approximate elevations 625.5 and 558.9 ft amsl) and are classified on the boring logs as cohesive Silt (A-4b), Silt and Clay (A-6a), Silty Clay (A-6b) and Clay (A-7-6). With respect to the soil strength, the lower lacustrine soils can be described having a consistency of very soft to hard correlating to N_{60} values between 0 and 71 bpf and unconfined compressive strengths (estimated by means of hand penetrometer and laboratory test results) between 0 and in excess of 4.5 tsf. Natural moisture contents of the lower cohesive lacustrine soils ranged from 19 to 32 percent. Based on Atterberg Limits tests performed on representative samples of the lower lacustrine material, the liquid and plastic limits ranged from 25 to 44 percent and from 17 to 23 percent, respectively.

4.1.2. Groundwater

Groundwater measurements were taken during the boring drilling procedures and immediately following the completion of the boring performed. Groundwater was observed during drilling in each of the borings performed at the bridge and retaining wall site at depths ranging from 10.1 to 27.5 ft bgs (elevations 648.4 to 676.9 ft amsl). The specific groundwater readings are included on the logs located within Appendix B.

Pore pressure readings collected from CPT sounding data can also indicate groundwater levels at the site. However, it should be noted that pore pressure readings may suggest a groundwater level that is higher or lower than the static groundwater table when performed on specific soil types (i.e. contractive or dilative soils). Therefore, during a CPT sounding, a more accurate interpretation of the groundwater level can be made by performing a dissipation test in which the pushing of the cone is paused temporarily, and pore pressure readings are allowed to stabilize to the hydrostatic pressure at that depth. One (1) dissipation tests were performed within sounding C-079-0-14 at a depth of 44.3 ft bgs. However, the dissipation test performed at the sounding location was not performed long enough to stabilize, and therefore, does not provide an accurate static groundwater level reading.

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.

5. ANALYSES AND RECOMMENDATIONS

5.1. Retaining Wall AC Analysis and Recommendations

5.1.1. Retaining Wall Design Assumptions

As a portion of the proposed retaining wall (RW-AC) is planned as MSE type, ODOT's BDM and AASHTO's LRFD BDS dictate analysis parameters and design minimums/constraints to be used in the analysis and design process. The referenced parameters and design minimums/constraints that were significant to our analyses consist of the following:

- Minimum reinforcement strap lengths of proposed MSE walls are to be 70% of the total wall height (as measured from proposed profile grade at the face of the wall to the top of the leveling pad) or 8 ft, whichever is greater, at the section of wall being analyzed, per ODOT’s BDM section 307.4-A;
- Minimum MSE wall embedment depths (as measured from top of the leveling pad to the lowest point on the ground surface within 4-ft of the face of the wall) are to conform to Figure 201-5 presented in ODOT's BDM and be the larger of 3 ft or the local frost depth;
- Soils below the bottom of leveling pad will be undercut a minimum of 1 ft and replaced with Granular Material Type C according to requirements of ODOT’s Construction & Materials Specifications Section 204.07 (CMS 204.07);
- Maximum allowable differential settlement in the longitudinal direction is 1% (BDM Section 307.1.6); and,
- Reinforced Zone and Retained Fill soils will meet the minimum design soil parameters per Table 840.04-1 of the ODOT Supplemental Specification 840 (SS 840) as shown in Table 2 below.

Table 2: Design Soil Parameters for Fill Materials

Fill Zone	Type of Soil	Soil Unit Weight (pcf)	Friction Angle (°)	Cohesion (psf)
Reinforced Zone	Select Granular Backfill	120	34	0
Retained Soil	On-site soil varying from sandy lean clay to silty sand	120	30	0

Notes:
1. Table reproduced from Section 840.04 - A-1 of ODOT's SS 840.

With respect to design constraints and assumptions specific to the RW-AC MSE walls, the geometry of the proposed walls (i.e., exposed wall heights, existing ground elevations, proposed final grade behind/at the toe of the wall, etc.) is assumed to be consistent with that shown in the proposed structure basemaps developed by Baker and obtained via ProjectWise on September 10, 2021.

5.1.2. Soil Profile for Analysis

For external stability, settlement and global stability analyses purposes, each boring drilled for RW-AC was reviewed, and a generalized material profile was developed. Utilizing the generalized soil profile, engineering properties for each soil strata was estimated based on their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory test (i.e., Atterberg Limits, grain size, etc.) results using correlations provided in published engineering manuals, research reports and guidance documents. Engineering soil properties were estimated for each individual classified layer per boring location. Soil layers from each of the borings with similar behavior (i.e., cohesive or non-cohesive/granular) and characteristics (i.e., relative compactness/consistency, moisture content, etc.) were grouped into generalized soil units (i.e., Soil Types) and weighted average values of the estimated engineering soil properties were assigned to each Soil Type to develop a generalized soil profile for analysis. The summary of the generalized soil profile including designated Soil Types, elevations, average engineering soil properties per boring location are presented in Tables 3 through 7 below. Settlement parameters (with sited correlation/reference material) developed for each Soil Type are presented in Table 9 below.

Table 3: Soil Profile and Estimated Engineering Properties - At Boring B-078-0-14

Wall AC: Analysis for RW-AC, B-078-0-14							
Soil Description	**Moist Unit Weight(1) (pcf)**	**Total Cohesion(2) (psf)**	**Total Friction Angle (degrees)**	**Effective Cohesion(3) (psf)**	**Effective Friction Angle(3) (degrees)**	**Presumptive Ultimate Unit Bond Stress (ksf)**	
						Gravity Grouted (<50 psi)	**Pressure Grouted (50 psi - 400 psi)**
Soil Type 1 Depth (670.9 ft - 666.4 ft)	125	-	35	-	35	1.97	6.20
Soil Type 2 Depth (666.4 ft - 651.4 ft)	128	-	32	-	32	2.07	6.56
Soil Type 2B Depth (651.4 ft - 643.9 ft)	120	-	29	-	29	-	-
Soil Type 2 Depth (643.9 ft - 627.6 ft)	128	-	32	-	32	-	-
Soil Type 3 Depth (627.6 ft - 572.6 ft)	125	2800	0	250	26	-	-
Soil Type 4 Depth (572.6 ft - 558.9 ft)	122	2000	0	200	24	-	-

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 4: Soil Profile and Estimated Engineering Properties - At Boring B-142-4-20

Wall AC: Analysis for RW-AC, B-142-4-20							
Soil Description	**Moist Unit Weight(1) (pcf)**	**Total Cohesion(2) (psf)**	**Total Friction Angle(2) (degrees)**	**Effective Cohesion(3) (psf)**	**Effective Friction Angle(3) (degrees)**	**Presumptive Ultimate Unit Bond Stress (ksf)**	
						Gravity Grouted (<50 psi)	**Pressure Grouted (50 psi - 400 psi)**
Soil Type 1 Depth (690.5 ft - 668.5 ft)	125	-	35	-	35	1.97	6.20
Soil Type 2 Depth (668.5 ft - 624 ft)	128	-	32	-	32	2.01	6.56

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 5: Soil Profile and Estimated Engineering Properties - At Boring B-142-2-20

Wall AC: Analysis for RW-AC, B-142-2-20

Soil Description	Moist Unit Weight$^{(1)}$ (pcf)	Total Cohesion$^{(2)}$ (psf)	Total Friction Angle$^{(2)}$ (degrees)	Effective Cohesion$^{(3)}$ (psf)	Effective Friction Angle$^{(3)}$ (degrees)	Presumptive Ultimate Unit Bond Stress (ksf)	
						Gravity Grouted (<50 psi)	Pressure Grouted (50 psi - 400 psi)
Soil Type 1 Depth (680.4 ft - 668.4 ft)	125	-	35	-	35	1.97	6.20
Soil Type 2B Depth (668.4 ft - 653.4 ft)	120	-	29	-	29	1.40	1.46
Soil Type 2 Depth (653.4 ft - 622.1 ft)	128	-	32	-	32	-	-
Soil Type 3 Depth (622.1 ft - 572.9 ft)	125	2800	0	250	26	-	-
Soil Type 4 Depth (572.9 ft - 570.4 ft)	122	2000	0	200	24		

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 6: Soil Profile and Estimated Engineering Properties - At Boring B-142-1-20

Wall AC: Analysis for RW-AC, B-142-1-20

Soil Description	Moist Unit Weight$^{(1)}$ (pcf)	Total Cohesion$^{(2)}$ (psf)	Total Friction Angle$^{(2)}$ (degrees)	Effective Cohesion$^{(3)}$ (psf)	Effective Friction Angle$^{(3)}$ (degrees)	Presumptive Ultimate Unit Bond Stress (ksf)	
						Gravity Grouted (<50 psi)	Pressure Grouted (50 psi - 400 psi)
Soil Type 1 Depth (681.2 ft - 669.2 ft)	125	-	35	-	35	1.97	6.20
Soil Type 2B Depth (669.2 ft - 652.9 ft)	120	-	29	-	29	1.40	1.46
Soil Type 2 Depth (652.9 ft - 613.2 ft)	128	-	32	-	32	-	-
Soil Type 3 Depth (613.2 ft - 606.2 ft)	125	2800	0	250	26	-	-

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 7: Soil Profile and Estimated Engineering Properties – At Boring B-142-0-14

Wall AC: Analysis for RW-AC, B-142-0-14

Soil Description	Moist Unit Weight$^{(1)}$ (pcf)	Total Cohesion$^{(2)}$ (psf)	Total Friction Angle (degrees)	Effective Cohesion$^{(3)}$ (psf)	Effective Friction Angle$^{(3)}$ (degrees)
Soil Type 1 Depth (677.5 ft - 658 ft)	125	-	35	-	35
Soil Type 2B Depth (658 ft - 650.5 ft)	120	-	29	-	29
Soil Type 2 Depth (650.5 ft - 627.6 ft)	128	-	32	-	32
Soil Type 3 Depth (627.6 ft - 569.2 ft)	125	2800	0	250	26
Soil Type 4 Depth (569.2 ft - 565.5 ft)	122	2000	0	200	24

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 8: Soil Profile and Estimated Engineering Properties – At Boring B-166-0-14

Wall AC: Analysis for RW-AC, B-166-0-14

Soil Description	Moist Unit Weight(1) (pcf)	Total Cohesion(2) (psf)	Total Friction Angle (degrees)	Effective Cohesion(3) (psf)	Effective Friction Angle(3) (degrees)
Soil Type 1 Depth (687 ft - 667.5 ft)	125	-	35	-	35
Soil Type 2 Depth (667.5 ft - 628.5 ft)	128	-	32	-	32
Soil Type 3 Depth (628.5 ft - 625.5 ft)	125	2800	0	250	26

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 9: Settlement Parameters for Analysis - Retaining Wall AC

Retaining Wall AC: Settlement Analysis, B-078, B-142-4, B-142-2, B-142-1, B-142, B-166

Soil Description	Unit Weight (pcf)	Elastic Modulus(1) (psf)	Poissons Ratio(1), v	Void Ratio e_o	Compression Index(2), C_c	Recompression Index(3), C_r	OCR(4)	Coeff. of Consol.(5), C_v
Soil Type 1 - Granular	125	878000	0.25	-	-	-	-	-
Soil Type 2b - Granular	120	211000	0.25	-	-	-	-	-
Soil Type 2 - Granular	128	902000	0.30	-	-	-	-	-
Soil Type 3a - Cohesive(6)	130	2000000	0.45	0.542	0.06	0.005	1.5	0.55
Soil Type 3b - Cohesive(7)	130	2000000	0.45	0.600	0.09	0.013	1.1	0.38
Soil Type 4 - Cohesive	122	2000000	0.45	0.743	0.24	0.048	1.1	0.21

Notes:

1. *Values interpreted from 2017 AASHTO LRFD BDS Table C10.4.6.3-1*
2. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-6.*
3. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-9.*
4. *Values interpreted from Mayne and Kemper, 1988, Figure 7.*
5. *Values interpreted from FHWA GEC No. 5, Boeckmann, et al., 2016, Figure 6-37.*
6. *Based on laboratory test results from B-141-1-14, ST-1 & ST-2.*
7. *Based on laboratory test results from B-142-1-14.*

In addition to the Soil Type parameters presented above, a graphical depiction of the generalized subsurface profile is located within Appendix C. The generalized subsurface profile includes: a color-coded general interpretation of the Soil Types between borings, a graphical interpretation of the soil strata identified by the project soil borings along the referenced wall profiles, representative boring data (N_{60}-values, moisture contents, and groundwater levels), current ground surface elevation, proposed fill, and proposed wall location (i.e., top of leveling pad and top of coping).

5.1.3. Parameters for Lateral Load Analysis

Deep foundation elements subjected to horizontal loads and/or moments should be analyzed for maximum bending moments and lateral deflections. 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 are presented in Table 10 below. Furthermore, a resistance factor of 1.0 should be used when estimating the lateral geotechnical resistance of a single shaft/pile or shaft/pile group in accordance with LRFD BDS Tables 10.5.5.2.3-1 and 10.5.5.2.4-1.

Table 10: Genearlized Soil Parameters for Lateral Load Analysis – RW-AC

LPILE Parameters For Soil and Severely Weathered Bedrock							
Boring Number (Structure)	**p-y model**	**Elevation (ft)**	**Effective Unit Weight (pcf)**	**Friction Angle**	**Undrained Shear Strength (psf)**	**Lateral Soil Modulus Parameter, k (pci)**	**Soil Strain Parameter, E_{50} (%)**
B-078-0-14 & B-142-4-20 (Wall AC)	Sand (Reese)	690.5 - 668.5	125.0	35	-	175	-
	Sand (Reese)	668.5 - 651.4	128.0	32	-	80	-
	Sand (Reese)	651.4 - 643.9	85.9	29	-	25	-
	Sand (Reese)	643.9 - 627.6	65.6	32	-	55	-
	Stiff Clay with Water	627.6 - 572.6	62.6	26	2,800	940	0.005
	Stiff Clay with Water	572.6 - 558.9	59.6	24	2,000	665	0.006
B-142-2-20 (Wall AC)	Sand (Reese)	680.4 - 668.4	125.0	35	-	175	-
	Sand (Reese)	668.4 - 653.4	120.0	29	-	30	-
	Sand (Reese)	653.4 - 622.1	71.6	32	-	55	-
	Stiff Clay with Water	622.1 - 572.9	62.6	26	2,800	940	0.005
	Stiff Clay with Water	572.9 - 570.4	59.6	24	2,000	665	0.006

5.1.4. *External Stability Analysis*

Based on our estimated engineering soil properties, the developed generalized profile and the retaining wall design assumptions provided in Section 5.1.1. of this report, an external stability analysis of MSE wall portion of the proposed RW-AC was performed. External stability was evaluated at two (2) cross-sections along the MSE wall portion of the proposed RW-AC alignment at approximate STA. 02+78.8 and STA. 04+28.8. The cross-sections were evaluated for resistance to bearing pressure, sliding forces and overturning at the Strength Limit State in accordance with Section 11.10.5 of the AASHTO's LRFD BDS. The capacity to demand ratios (CDRs) calculated for the referenced cross-sections with respect to bearing, sliding and overturning, as well as the calculated factored bearing resistances are presented in Table 11 below. (External Stability and Bearing Resistance Calculation Results can be found in Appendix D)

Table 11: External Stability Analysis Summary

Dimensions		
Design Wall Height (feet)	21.9	15.4
Exposed Wall Height (feet)	18.4	11.9
Length of Reinforecement (feet)	15.3	10.8
Length of Reinf. To Height Ratio	0.7	0.7
Approximate Station (RW-AC Alignment)	02+78.8	04+22.5
Slope above wall	N/A	N/A
Capactiy Demand Ratio (CDR)		
Sliding	1.27	1.23
Overturning / Eccentricity	1.47	1.33
Bearing Capacity	1.65	2.20
Factored Bearing Resistance (ksf)(1)	9.4	9.4

Notes:

1. *Bearing Resistance calculated in accordance to Section 11.10.5.4 of 2018 LRFD BDS and factored using Resistance Factor provided in Table 11.5.7-1 of 2018 LRFD BDS.*

5.1.5. *Settlement Analysis*

In order to estimate the maximum total and differential settlement that could result within the subsurface soils supporting the proposed CIP retaining walls (RW-P & RW-Q), NEAS reviewed: 1) the RW-AC Stage 1 design information obtained via ProjectWise on September 10, 2021; 2) Service Limit State loading conditions; and, 3) the generalized subsurface profile and Settlement Parameters for Analysis provided in Section 5.1.2. of this report. Utilizing this information and the software entitled *FoSSA 2.0* by ADAMA Engineering, Inc., a settlement model was developed and analyzed for both elastic (immediate) consolidation (long term) settlement. For analysis purpose and in order to determine the maximum settlement along the proposed RW-AC alignments, the developed model for settlement analysis utilized the subsurface condition (existing soil profile and soil parameters) and proposed grading along the RW-AC alignment.

Based on our analysis, the estimated maximum total settlement that could occur along the length of proposed RW-AC as a result of the induced MSE retaining wall and proposed embankment fill loads is estimated to be about 5.5 inches. The maximum differential settlement across the width of the proposed retaining wall is estimated to be on the order of 0.25%. Per ODOT BDM Section 307.1.6, differential settlement for MSE walls should be limited to 1/100 (1%) regardless of size of panels. This settlement magnitude is not anticipated to be a concern as about 2.4 inches of the total settlement is expected to be elastic (immediate) and take place during construction, while the remaining expected long-term settlement time rates are not anticipated to be a concern with respect to pavements and at-grade structures (e.g., guardrails, signage, etc.). Outputs of the settlement analysis program are presented within Appendix E.

5.1.6. Global Stability Analysis

For purposes of evaluating the stability of RW-AC at the proposed Ramp IR-90 WB location, NEAS reviewed cross-sections along the length of the proposed retaining wall to determine the subsurface conditions that posed the greatest potential for slope instability. In general, cross-sections along the proposed wall alignment were reviewed to determine the section that would represent a combination of existing subsurface conditions and planned site grading that would be most critical to slope stability (i.e., maximum total wall height, maximum embankment height measured from toe of slope to top of wall, proposed/existing grades behind and in front of the wall, weak and/or thick soil layer, etc.). Based on our review of the available information at the referenced location and the associated soil properties, two (2) cross-sections were estimated to be most "critical" and was analyzed for global stability. The cross-sections analyzed for global stability consisted of the maximum wall height section along each of the proposed RW-AC wall type segments (i.e., MSE and SPL wall types) at approximate STA. 00+90 and STA. 02+78.8.

For the indicated cross-section, NEAS developed a representative cross-sectional model to use as the basis for global stability analysis. The model was developed from NEAS's interpretation of the available information which included: 1) the RW-AC Stage 1 design information obtained via ProjectWise on September 10, 2021; 2) a live load surcharge of 250 pounds per square foot (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 profile and estimated engineering properties presented in Section 5.1.2. 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 Spencer analysis methods was used to calculate a factor of safety (FOS) for both circular and block 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 1.3 which equates to an AASHTO resistance factor less than 0.75 (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 0.75 or lower is targeted as the proposed wall does not contain or support a structural element. Based on our slope stability analyses for the referenced RW-AC sections, the minimum slope stability factor was estimated to be about 1.34 (0.65 resistance factor). Graphical outputs of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) are presented within Appendix F.

5.2. Bridge No. CUY-90-1653L&R Analysis and Recommendations

5.2.1. Soil Profile for Analysis

For Bridge CUY-90-1653L&R friction pile, settlement and global stability analyses purposes, each boring log was reviewed, and a generalized material profile was developed. Utilizing the generalized soil profile, engineering properties for each soil stratum were estimated based on their field (i.e., SPT N_{60} Values, hand penetrometer values, etc.) and laboratory test (i.e., Atterberg Limits, grain size, etc.) results using correlations provided in published engineering manuals, research reports and guidance documents. Engineering soil properties were estimated for each individual classified layer per boring location. Additionally, some boring/sounding information combined when estimating engineering soil properties to either encompass existing embankment properties where structure borings were not performed through existing embankment soils (i.e., B-142-4-20 and B-081-0-20) or compliment data where exploration locations where both in close proximity to the proposed substructure (i.e., B-144-0-14 and C-079-0-14). The developed soil profiles and estimated engineering soil properties for use in analysis of Bridge CUY-90-1653L&R (with cited correlation/reference material) are summarized within Tables 12 through 14 below. Settlement parameters (with sited correlation/reference material) developed for the abutment locations are presented in Tables 15 and 16.

Table 12: Soil Profile and Estimated Engineering Properties - At Boring B-078-0-14 & B-142-4-20

Bridge CUY-90-1653L&R Over E. 14th St: Rear Abutment, B-142-4-20 & B-078-0-14						
Soil Description	**Moist Unit Weight(1) (pcf)**	**Total Cohesion(2) (psf)**	**Total Friction Angle (degrees)**	**Effective Cohesion(3) (psf)**	**Effective Friction Angle(3) (degrees)**	**Setup Factor (f_{su})**
Gravel with Sand Elevation (690.5 ft - 686.7 ft)	125	-	39	-	39	1.0
Coarse and Fine Sand Elevation (686.7 ft - 676 ft)	128	-	36	-	36	1.0
Coarse and Fine Sand Elevation (676 ft - 673.5 ft)	130	-	40	-	40	1.0
Coarse and Fine Sand Elevation (673.5 ft - 670.9 ft)	125	-	33	-	33	1.0
Silt and Clay Elevation (670.9 ft - 668.9 ft)	110	1500	0	150	23	1.5
Sandy Silt Elevation (668.9 ft - 666.4 ft)	125	-	32	-	32	1.2
Coarse and Fine Sand Elevation (666.4 ft - 655.2 ft)	122	-	30	-	30	1.0
Sandy Silt Elevation (655.2 ft - 651.4 ft)	125	-	31	-	31	1.2
Silt Elevation (651.4 ft - 643.9 ft)	110	-	27	-	27	1.5
Coarse and Fine Sand Elevation (643.9 ft - 632.6 ft)	128	-	32	-	32	1.0
Silt Elevation (632.6 ft - 627.6 ft)	130	-	33	-	33	1.5
Silt and Clay Elevation (627.6 ft - 617.4 ft)	125	3350	0	250	26	1.5
Silt Elevation (617.4 ft - 587.4 ft)	130	2700	0	250	26	1.5
Silt and Clay Elevation (587.4 ft - 582.6 ft)	135	6000	0	400	28	1.5
Silt Elevation (582.6 ft - 577.6 ft)	125	3350	0	250	27	1.5
Silt and Clay Elevation (577.6 ft - 572.6 ft)	125	2600	0	250	25	1.5
Silty Clay Elevation (572.6 ft - 558.9 ft)	122	1800	0	200	24	1.75

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 13: Soil Profile and Estimated Engineering Properties - At Boring B-078-1-20

Bridge CUY-90-1653L&R: Pier, B-078-1-20						
Soil Description	**Moist Unit Weight(1) (pcf)**	**Total Cohesion(2) (psf)**	**Total Friction Angle (degrees)**	**Effective Cohesion(3) (psf)**	**Effective Friction Angle(3) (degrees)**	**Setup Factor (f_{su})**
Coarse and Fine Sand Elevation (667 ft - 655 ft)	128	-	36	-	36	1.0
Coarse and Fine Sand Elevation (655 ft - 650 ft)	108	-	29	-	29	1.0
Gravel with Sand Elevation (650 ft - 647.5 ft)	120	-	30	-	30	1.0
Gravel with Sand and Silt Elevation (647.5 ft - 645 ft)	120	-	30	-	30	1.2
Sandy Silt Elevation (645 ft - 626 ft)	128	-	34	-	34	1.2
Silt Elevation (626 ft - 618.7 ft)	125	2900	0	250	26	1.5
Silt Elevation (618.7 ft - 608.7 ft)	122	-	28	-	28	1.5
Silt Elevation (608.7 ft - 598.7 ft)	122	1800	0	200	25	1.5
Silt and Clay Elevation (598.7 ft - 588.7 ft)	115	600	0	75	21	1.5
Silt and Clay Elevation (588.7 ft - 557 ft)	125	2550	0	250	25	1.5

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 14: Soil Profile and Estimated Engineering Properties - At Boring C-079-0-14 & B-144-0-14

Bridge CUY-90-1653L&R Over E. 14th St: Forward abutment, B-081-0-14, B-144-0-14 & C-079-0-14						
Soil Description	**Moist Unit Weight(1) (pcf)**	**Total Cohesion(2) (psf)**	**Total Friction Angle (degrees)**	**Effective Cohesion(3) (psf)**	**Effective Friction Angle(3) (degrees)**	**Setup Factor (f_{su})**
Coarse and Fine Sand Elevation (686.8 ft - 669.1 ft)	130	-	36	-	36	1.0
Gravel with Sand Elevation (669.1 ft - 667.1 ft)	128	-	35	-	35	1.0
Coarse and Fine Sand Elevation (667.1 ft - 659.6 ft)	110	-	28	-	28	1.0
Silt and Clay Elevation (659.6 ft - 657.1 ft)	105	600	0	75	21	1.5
Coarse and Fine Sand Elevation (657.1 ft - 645.5 ft)	128	-	33	-	33	1.0
Sandy Silt Elevation (645.5 ft - 631.8 ft)	130	-	34	-	34	1.2
Silt Elevation (631.8 ft - 616.1 ft)	130	2500	0	250	26	1.5
Silt and Clay Elevation (616.1 ft - 595.9 ft)	120	1600	0	150	23	1.5
Silt and Clay Elevation (595.9 ft - 590.3 ft)	130	3050	0	250	25	1.5
Silt and Clay Elevation (590.3 ft - 557.6 ft)	120	1600	0	150	23	1.75

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 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*

Table 15: Settlement Parameters for Analysis - Rear Abutment

Rear Abutment: Settlement Analysis, B-078-0-14 & B-142-4-20								
Soil Description	**Unit Weight (pcf)**	**Elastic Modulus(1) (psf)**	**Poissons Ratio(1), v**	**Void Ratio e_o**	**Compression Index(2), C_c**	**Recompression Index(3), C_r**	**OCR(4)**	**Coeff. of Consol.(5), C_v**
Granular Elevation (690.5 ft - 666.4 ft)	125	878000	0.25	-	-	-	-	-
Granular Elevation (666.4 ft - 651.4 ft)	128	902000	0.30	-	-	-	-	-
Granular Elevation (651.4 ft - 643.9 ft)	120	211000	0.25	-	-	-	-	-
Granular Elevation (643.9 ft - 627.6 ft)	128	902000	0.30	-	-	-	-	-
Cohesive(6) Elevation (627.6 ft - 612.1 ft)	130	2000000	0.45	0.542	0.06	0.005	1.5	0.55
Cohesive(7) Elevation (612.1 ft - 572.6 ft)	130	2000000	0.45	0.600	0.09	0.013	1.1	0.38
Cohesive Elevation (572.6 ft - 450 ft)	122	2000000	0.45	0.743	0.24	0.048	1.1	0.21

Notes:

1. *Values interpreted from 2017 AASHTO LRFD BDS Table C10.4.6.3-1*
2. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-6.*
3. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-9.*
4. *Values interpreted from Mayne and Kemper, 1988, Figure 7.*
5. *Values interpreted from FHWA GEC No. 5, Boeckmann, et al., 2016, Figure 6-37.*
6. *Based on laboratory test results from B-141-1-14, ST-1 & ST-2.*
7. *Based on laboratory test results from B-142-1-14.*

Table 16: Settlement Parameters for Analysis - Forward Abutment

Forward Abutment: Settlement Analysis, C-079-0-14, B-081-0-14 & B-144-0-14								
Soil Description	**Unit Weight (pcf)**	**Elastic Modulus(1) (psf)**	**Poissons Ratio(1), v**	**Void Ratio e_o**	**Compression Index(2), C_c**	**Recompression Index(3), C_r**	**OCR(4)**	**Coeff. of Consol.(5), C_v**
Granular Elevation (686.8 ft - 669.1 ft)	130	1209000	0.30	-	-	-	-	-
Granular Elevation (669.1 ft - 667.1 ft)	128	899000	0.30	-	-	-	-	-
Granular Elevation (667.1 ft - 659.6 ft)	110	280000	0.20	-	-	-	-	-
Cohesive Elevation (659.6 ft - 657.1 ft)	105	363000	0.40	0.983	0.19	0.038	1	0.35
Granular Elevation (657.1 ft - 645.5 ft)	128	948000	0.30	-	-	-	-	-
Granular Elevation (645.5 ft - 631.8 ft)	130	454000	0.30	-	-	-	-	-
Cohesive(6) Elevation (631.8 ft - 590.3 ft)	130	2000000	0.45	0.568	0.10	0.020	1.2	0.54
Cohesive Elevation (590.3 ft - 450 ft)	120	2000000	0.40	0.929	0.25	0.051	1.1	0.30

Notes:

1. *Values interpreted from 2017 AASHTO LRFD BDS Table C10.4.6.3-1*
2. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-6.*
3. *Values calculated from Kulhawy and Mayne, 1990, Equation 6-9.*
4. *Values interpreted from Mayne and Kemper, 1988, Figure 7.*
5. *Values interpreted from FHWA GEC No. 5, Boeckmann, et al., 2016, Figure 6-37.*
6. *Based on laboratory test results from B-144-0-14.*

With respect to backfill at the abutment locations, it was assumed that any backfill behind the proposed abutments will meet the minimum design soil parameters per Table 307-1 of the ODOT Bridge Design Manual as shown in Table 17 below.

Table 17: Design Soil Parameters for Fill Materials

Fill Zone	**Type of Soil**	**Soil Unit Weight (pcf)**	**Friction Angle (°)**	**Cohesion (psf)**
Backfill behind abutments or headwall	Granular Material Type B, per 703.16.C	120	32	0

Notes:

1. *Table reproduced from Section 307.1 of ODOT's BDM.*

5.2.2. Pile 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 needed to achieve the UBV required to support the design load for a single pile 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 pile cap bearing elevation) to the depth at which the required UBV is obtained. Based on the soil profile encountered at the site, it is our opinion that pile resistances obtained during dynamic testing (driving) may be reduced due to the potential for soil disturbance (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 resistances may not reach the indicated target UBV utilizing the estimated pile lengths. This reduced resistance value obtained at the end of driving the estimated pile length is designated as the End of Initial Driving resistance or EOID. If the EOID is significantly different than the required UBV, it may be necessary to let the piles "set up" (reduction of pore water pressure in the soils adjacent to the pile) for an established time period. To estimate the potential effects of this disturbance during driving, the setup factors are presented in Tables 12 through 14 of Section 5.2.1. of this report are used to estimate driving strength losses as well as the side resistance expected to gain following the setup period.

The UBV and EOID values are determined in accordance with Sections 305.3.2.4 and 305.3.5.9 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 results for our analysis including the estimated skin friction (Rs) and pile tip bearing (Rp) for ultimate and during driving conditions are summarized for each of the twin structures in Tables 18 and 19 below (*Driven* results included within Appendix C). The referenced table also includes 1) the required geotechnical pile length in ultimate conditions for 12-inch or 14-inch diameter CIP piles driven to the respective UBV per substructure location; 2) the length of driven pile required in driving conditions for 12-inch or 14-inch diameter CIP piles driven to the respective UBV per substructure location; and, 3) the estimated difference in pile length between a pile in ultimate and driving conditions.

Table 18: Deep Foundation Analysis Summary – CUY-90-1653L

Pile Type	Ultimate Conditions				Driving Conditions				Pile Length Difference Ultimate vs. Driving Conditions (ft)	End of Initial Driving Value[3] (kips)	Setup Factor (f_{su})
	Geotechnical Pile Length[1] (ft)	Ultimate Side Resistance[2] (kips)	Ultimate Point Resistance[2] (kips)	Ultimate Bearing Value[2] (kips)	Driven Pile Length[1] (ft)	Side Resistance During Driving[2] (kips)	Point Resistance During Driving[2] (kips)	Bearing Value During Driving[2][4] (kips)			
CUY-90-1653L Rear Abutment, B-142-4-20 & B-078-0-14											
12-inch CIP pile	89.6	302.5	21.8	324	118.1	297.5	12.7	310	> 28.5	248	1.3
CUY-90-1653L Pier, B-078-1-20											
14-inch CIP pile	92.7	336.9	24.5	361	102.0	289.3	24.5	314	> 9.3	265	1.4
CUY-90-1653L Forward Abutment, C-079-0-14 & B-144-0-14											
12-inch CIP pile	73.4	241.5	11.3	253	97.8	241.5	11.3	253	24	195	1.3

Notes:

1. *The length of pile from bottom of pile cap (pile cap bearing elevation) to the depth at which the required UBV is obtained.*
2. *Resistance factor for driven piles, dynamic analysis and static load test methods (BDM Table 305-1) for piles installed according to C&MS 507 using dynamic test methods according to C&MS 523 has not been applied to values calculated.*
3. *EOID is based on driving resistance obtained at the indicated geotechnical pile length.*
4. *At the Rear Abutment and Pier 1 the required UBV could not be obtained during driving conditions within the length of the boring performed.*

Table 19: Deep Foundation Analysis Summary – CUY-90-1653R

Pile Type	Ultimate Conditions				Driving Conditions				Pile Length Difference Ultimate vs. Driving Conditions (ft)	End of Initial Driving Value(3) (kips)	Setup Factor (f_{su})
	Geotechnical Pile Length(1) (ft)	Ultimate Side Resistance(2) (kips)	Ultimate Point Resistance(2) (kips)	Ultimate Bearing Value(2) (kips)	Driven Pile Length(1) (ft)	Side Resistance During Driving(2) (kips)	Point Resistance During Driving(2) (kips)	Bearing Value During Driving(2)(4) (kips)			
CUY-90-1653R Rear Abutment, B-142-4-20 & B-078-0-14											
12-inch CIP pile	88.7	296.6	19.1	316	118.1	297.5	12.7	310	> 29.4	244	1.3
CUY-90-1653R Pier, B-078-1-20											
14-inch CIP pile	95.1	359.8	24.5	384	102.0	289.3	24.5	314	> 6.9	281	1.4
CUY-90-1653R Forward Abutment, C-079-0-14 & B-144-0-14											
12-inch CIP pile	88.6	297.3	11.3	309	113.4	288.3	11.3	300	> 24.8	229	1.3

Notes:

1. *The length of pile from bottom of pile cap (pile cap bearing elevation) to the depth at which the required UBV is obtained.*
2. *Resistance factor for driven piles, dynamic analysis and static load test methods (BDM Table 305-1) for piles installed according to C&MS 507 using dynamic test methods according to C&MS 523 has not been applied to values calculated.*
3. *EOID is based on driving resistance obtained at the indicated geotechnical pile length.*
4. *At each substructure the required UBV could not be obtained during driving conditions within the length of the boring performed.*

5.2.3. Pile Drivability

NEAS's pile drivability evaluation estimated a Delmag D19-42 diesel hammer to determine if the pile type or size being considered would be overstressed (i.e., compressive stresses experienced by pile during driving are greater than 90% of the yield strength of the steel) at any time during pile installation. The results of the evaluation indicated that the ODOT preferred CIP pile sizes would not be overstressed during the pile installation process based on: 1) a minimum wall thickness of 0.25-inches; 2) the use of ASTM A 252 Grade 3 steel piles; 3) a pile hammer with a minimum rated energy of 42,000 ft-lbs; and, 4) our developed model used in the computer program *GRLWEAP* by GRL Engineers, Inc. *GRLWEAP* results for each substructure location are included within Appendix H.

It should be noted that the driving resistance of CIP piles through soils encountered at the bridge site is expected to be high. Drivability 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 drivability 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.

5.2.4. Pile Foundation Recommendations

Based on our evaluation of the subsurface conditions and our geotechnical engineering analysis for the proposed Bridge CUY-90-1653L&R, it is our opinion that the bridge foundations can be supported on driven friction CIP piles seated within the stiff to hard/medium dense natural subsurface material encountered at the site.

We recommend that a driven pile foundation be used for support for the proposed bridge abutment and pier foundations. New 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 18/19 of this report, it is anticipated that the newly driven CIP piles would "run" for extended depths at each substructure location extending the indicated geotechnical pile lengths by greater than 7 to 29 ft. Therefore, it is recommended that the proposed piles 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 included on the plans. The first two piles at each substructure should be driven to the full Estimated Length indicated in Table 20/21 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 of 7 days. After the specified waiting period, it is recommended that pile driving contractor perform a restrike on both of the first two piles at each substructure. 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 new piles are installed in accordance with referenced construction specifications utilizing the referenced method as specified in the ODOT BDM at CUY-90-1653L, 12-inch diameter CIP piles driven to the indicated UBVs may be used to support a total factored load (single pile) of 226.8 kips at the proposed Rear Abutment location and 177.1 kips at the proposed Forward Abutment location while 14-inch diameter CIP piles driven to the indicated UBV may be used to support a total factored load (single pile) of 257.2 kips at the proposed Pier 1 location. When new piles are installed in accordance with referenced construction specifications utilizing the referenced method as specified in the ODOT BDM at CUY-90-1653R, 12-inch diameter CIP piles driven to the indicated UBVs may be used to support a total factored load (single pile) of 221.2 kips at the proposed Rear Abutment location and 216.3 kips at the proposed Forward Abutment location while 14-inch diameter CIP piles driven to the indicated UBV may be used to support a total factored load (single pile) of 268.8 kips at the proposed Pier 1 location. 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 5.2.2); 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 Tables 20 and 21 below.

Table 20: Estimated Pile Lengths – CUY-90-1653L

Pile Type	Bottom of Pile Cap Elevation (ft amsl)	Geotechnical Pile Length (ft)	Geotechnical Pile Tip Elevation (ft amsl)	Estimated Pile Length(1) (ft)	Order Length(1) (ft)
CUY-90-1653L Rear Abutment, B-142-4-20 & B-078-0-14					
12-inch CIP	677.0	89.6	587.4	95	100
CUY-90-1653L Pier, B-078-1-20					
14-inch CIP	659.0	92.7	566.3	95	100
CUY-90-1653L Forward Abutment, C-079-0-14 & B-144-0-14					
12-inch CIP	671.0	73.4	597.6	80	85
Notes: *1. Based on definitions and formulas presented in Section 303.3.5.2 of the 2020 BDM.*					

Table 21: Estimated Pile Lengths – CUY-90-1653R

Pile Type	Bottom of Pile Cap Elevation (ft amsl)	Geotechnical Pile Length (ft)	Geotechnical Pile Tip Elevation (ft amsl)	Estimated Pile Length(1) (ft)	Order Length(1) (ft)
CUY-90-1653R Rear Abutment, B-142-4-20 & B-078-0-14					
12-inch CIP	677.0	88.7	588.3	95	100
CUY-90-1653R Pier, B-078-1-20					
14-inch CIP	659.0	95.1	563.9	100	105
CUY-90-1653R Forward Abutment, C-079-0-14 & B-144-0-14					
12-inch CIP	671.0	88.6	582.4	95	100
Notes: *1. Based on definitions and formulas presented in Section 303.3.5.2 of the 2020 BDM.*					

5.2.5. Settlement Analysis

In order to estimate the maximum total and differential settlement that could result within the subsurface soils supporting the proposed IR-90 embankment soils at the proposed Bridge CUY-90-1653L&R abutment locations, NEAS reviewed: 1) Bridge CUY-90-1653L&R site plan profile views accessed via ProjectWise on June 16, 2022; 2) Service Limit State loading conditions; and, 3) the generalized subsurface profile and Settlement Parameters for Analysis provided in Sections 5.2.1. of this report. Utilizing this information and the software entitled *FoSSA 2.0* by ADAMA Engineering, Inc., a settlement model was developed and analyzed to for both elastic (immediate) and consolidation (long term) settlement at the proposed abutment locations. Outputs of our *FoSSA 2.0* settlement analysis for the rear and forward abutments is included within Appendix I.

Based on our analyses, the estimated maximum total settlement associated with the loads induced by the proposed new embankment at the rear abutment location is about 0.6 inches while the maximum total settlement anticipated at the forward abutment location is about 5.0 inches. At the rear abutment location about 0.5 inches of the total settlement is expected to be elastic (immediate) and take place during construction while at the forward abutment location about 1.5 inch of the total settlement is expected to elastic and take place during construction. The indicated long term settlement magnitudes of approximately 0.1 inches and 3.5 inches are anticipated at the rear and forward abutments, respectively. However, per the recommendations provided in Section 5.1.5.2 of the "Bridge CUY-77-1587 and Retaining Walls N & AD Report" dated June 23, 2022, Light Weight Fill (LWF) is proposed as embankment fill behind and immediately adjacent to the proposed forward abutment of the left structure (i.e., Bridge 10) as well as the other areas noted with the referenced report. Utilizing this LWF at the indicated location, an additional settlement analysis was performed in which the total long-term settlement anticipated at this location is reduced from approximately 3.5 inches to less than one inch. However, as LWF is not proposed behind the proposed forward abutment of the right structure (i.e., Bridge 11), additionally settlement analyses were performed at this location. Based on our analyses at the proposed forward abutment of the right structure, the estimated maximum total settlement is about 2.0 inches with about 1.3 inches of the total settlement being long-term settlement. The majority (about 75 percent) of the long-term settlement (consolidation) is expected to be complete within the first 14 days following embankment construction. As the long-term settlement magnitude estimated at the forward abutment location exceeds 0.4 inches, downdrag loading may be induced on existing and proposed pile foundations at this location, and therefore should be considered in the design and construction sequencing. As the proposed pile foundations at the forward abutment are planned to be battered, it is recommended that a waiting period of 14 days be implemented at this location following the construction of the IR-90 embankment and prior to the driving of the referenced pile foundations.

5.2.1. Global Stability Analysis

For purposes of evaluating the stability of the CUY-90-1653L&R 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 CUY-90-1653L&R site plan profile views accessed via ProjectWise on June 16, 2022; 2) a live load surcharge of 250 pounds per square foot (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 5.2.1. 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 Spencer analysis method was used to calculate a factor of safety (FOS) for circular and block 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 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 as the proposed substructures do contain or support a structural element. Based on our slope stability analyses for the referenced abutments, the minimum slope stability factors were estimated to be about 2.0 (0.50 resistance factor). Graphical outputs of the slope stability program (cross-sectional models, calculated safety factors, and critical failure planes) are presented within Appendix J.

5.2.2. Seismic Site Class

It is NEAS's opinion that the subsurface conditions encountered at the proposed Bridge CUY-90-1653L&R site are characterized as a Seismic Site Class of D in accordance with Section 3.10.3.1, Method B, of the LRFD BDS. For the overall bridge site, seismic site class parameters were determined at each substructure and subsequently averaged to obtain an overall global Site Class Definition. Seismic Site Classification Calculation results are included within Appendix K.

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 the proposed Bridge CUY-90-1653L&R and Retaining Wall AC structures. This report has been prepared for Michael Baker International, ODOT and their design consultants to be used solely in evaluating the soils underlying the referenced proposed structures 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 changes in the nature, design or location of the proposed Bridge CUY-90-1653L&R or RW-AC structures is made, the conclusions and recommendations contained in this 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 Michael Baker International in performing this geotechnical exploration for the CUY-90-16.28 (CCG3A) project. Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Brendan P. Andrews, P.E.
Geotechnical Engineer

Kevin C. Arens, P.E.
Geotechnical Engineer

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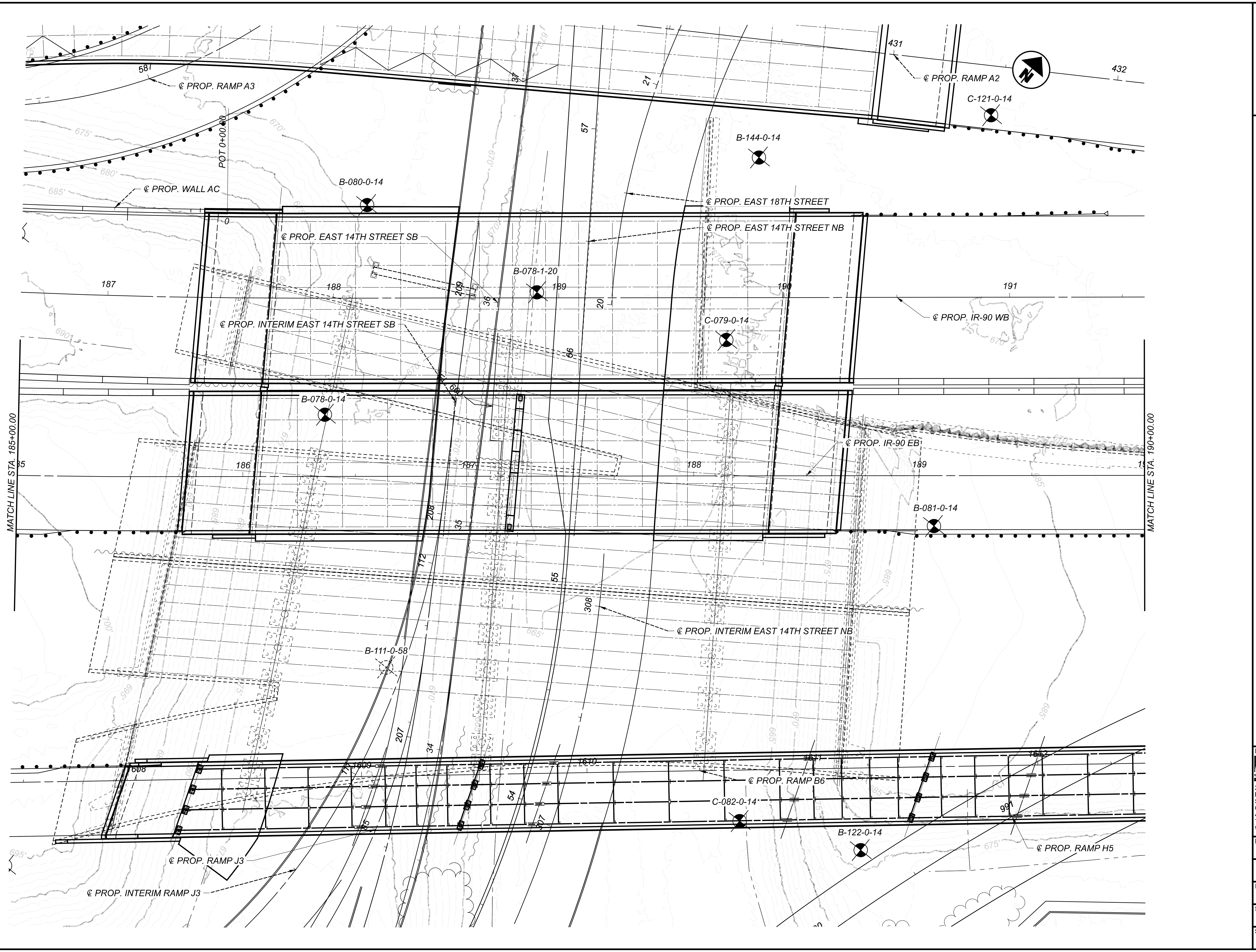

HORIZONTAL SCALE IN FEET
0 10 20 40

SOIL PROFILE - ROADWAY
STA. 185+00 TO STA. 190+00 IR-90 EB

DESIGN AGENCY
NEAS
National Engineering & Architectural Services Inc.
2800 CORPORATE
EXCHANGE DR,
SUITE 240
COLUMBUS, OH,
43231
TEL:614.714.0299
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DESIGNER	MWJ
REVIEWER	BPA 06/23/22
PROJECT ID	82382
SUBSET 19	TOTAL 302
SHEET P.0	TOTAL 0

CUY-90-16.28 (CCG3A)

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APPENDIX B

BORING/CPT LOGS AND LABORATORY TESTING RESULTS

PROJECT: CUY-CCG3
TYPE: BRIDGE
PID: 82380 SFN:
START: 1/21/15 END: 1/22/15

DRILLING FIRM / OPERATOR: BARR / T.GILBERT
SAMPLING FIRM / LOGGER: BARR / D.KLIMKOWICZ
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT / ST

DRILL RIG: CME 45B
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/26/14
ENERGY RATIO (%): 77.4

STATION / OFFSET: 186+36, 27' LT.
ALIGNMENT: IR-90 EB
ELEVATION: 670.9 (MSL) EOB: 112.0 ft.
LAT / LONG: 41.496226, -81.678129

EXPLORATION ID
B-078-0-14

PAGE
1 OF 4

MATERIAL DESCRIPTION AND NOTES	ELEV. 670.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
2.4", **TOPSOIL**	670.7																	
VERY STIFF, DARK BROWN, GRAY AND DARK GRAY, **SILT AND CLAY**, "AND" SAND, TRACE GRAVEL, CONTAINS FEW ROOTS, MOIST **(FILL)**	668.9	1	2 4 5	12	67	SS-1	2.25	6	12	26	34	22	33	20	13	22	A-6a (5)	
MEDIUM DENSE, BROWN AND DARK GRAY, **SANDY SILT**, LITTLE GRAVEL, LITTLE CLAY, CONTAINS BRICK FRAGMENTS AND FEW ROOTS, DAMP **(FILL)**	666.4	3	6 6 7	17	100	SS-2	-	-	-	-	-	-	-	-	-	12	A-4a (V)	
MEDIUM DENSE, BROWN AND DARK GRAY, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE TO LITTLE GRAVEL, TRACE CLAY, DAMP TO MOIST **(FILL)**		6	7 6 5	14	100	SS-3	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
@7.5'; SS-4 CONTAINS BRICK FRAGMENTS		8	5 5 5	13	100	SS-4	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
	658.9	11	3 3 7	13	100	SS-5	-	13	19	46	15	7	NP	NP	NP	12	A-3a (0)	
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	655.2	13	3 5 5	13	100	SS-6	-	-	-	-	-	-	-	-	-	8	A-3a (V)	
MEDIUM DENSE, BROWN MOTTLED WITH GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP TO WET		16	4 6 7	17	100	SS-7A	-	-	-	-	-	-	-	-	-	7	A-3a (V)	
						SS-7B	-	0	1	54	28	17	18	14	4	14	A-4a (2)	
	653.0	18	4 8 8	21	100	SS-8A	-	-	-	-	-	-	-	-	-	28	A-4a (V)	
MEDIUM DENSE, BROWN, **FINE SAND**, TRACE COARSE SAND, TRACE SILT, TRACE CLAY, TRACE GRAVEL, DAMP	651.4					SS-8B	-	-	-	-	-	-	-	-	-	8	A-3 (V)	
LOOSE, BROWN AND GRAY, **SILT**, LITTLE SAND, TRACE CLAY, TRACE GRAVEL, WET		21	3 3 3	8	100	SS-9	-	0	1	19	73	7	NP	NP	NP	30	A-4b (8)	
@22.5'; SS-10 NO RECOVERY	646.4	W 648.4 23	2 2 2	5	0	SS-10	-	-	-	-	-	-	-	-	-	-		
LOOSE TO DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, MOIST TO WET		26	3 1 5	8	100	SS-11	-	-	-	-	-	-	-	-	-	22	A-3a (V)	
@27.5'; SS-12 BECOMES BROWN AND GRAY		28	4 9 12	27	100	SS-12	-	-	-	-	-	-	-	-	-	18	A-3a (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 6/22/22 14:13 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2017 ARCHIVE\CUY-CCG3 82380\GINT FILES

PID: 82380	SFN:	PROJECT: CUY-CCG3	STATION / OFFSET: 186+36, 27' LT.	START: 1/21/15	END: 1/22/15	PG 2 OF 4	B-078-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 640.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
LOOSE TO DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, MOIST TO WET *(continued)* @30.0'; SS-13 BECOMES GRAYISH BROWN, SOME SILT		31	4 4 8	15	100	SS-13	-	0	2	69	24	5	NP	NP	NP	22	A-3a (0)	
		36	9 10 17	35	100	SS-14	-	-	-	-	-	-	-	-	-	19	A-3a (V)	
	632.6	38																
DENSE, GRAYISH BROWN, **SILT**, TRACE SAND, TRACE CLAY, TRACE GRAVEL, WET		41	9 10 18	36	100	SS-15	-	-	-	-	-	-	-	-	-	20	A-4b (V)	
	627.6	43																
STIFF TO VERY STIFF, GRAYISH BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST TO WET		46	6 9 12	27	100	SS-16	3.50	-	-	-	-	-	-	-	-	22	A-6a (V)	
@46.6'; UNIT WEIGHT: 127.7 PCF @ 22.0% MC		47																
		51			100	ST-17	1.75	0	0	5	58	37	29	18	11	28	A-6a (8)	
@51.7'; UNIT WEIGHT: 123.8 PCF @ 27.6% MC	617.4	53																
STIFF TO VERY STIFF, GRAYISH BROWN, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST TO WET		56	8 11 8	25	100	SS-18	2.00	-	-	-	-	-	-	-	-	21	A-4b (V)	
@60.0'; SS-19 TO SS-21 BECOMES GRAY		61	4 6 8	18	100	SS-19	1.75	-	-	-	-	-	-	-	-	22	A-4b (V)	

PID: 82380 | SFN: | PROJECT: CUY-CCG3 | STATION / OFFSET: 186+36, 27' LT. | START: 1/21/15 | END: 1/22/15 | PG 3 OF 4 | B-078-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 608.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
STIFF TO VERY STIFF, GRAYISH BROWN, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST TO WET *(continued)*		63																
		64																
		65																
		66			100	ST-20	2.50	0	0	2	65	33	27	18	9	20	A-4b (8)	
@66.7'; UNIT WEIGHT: 131.0 PCF @ 19.9% MC		67																
		68																
		69																
@70.0'; SS-21 AND SS-22 CONTAIN SILTY CLAY LENSES		70	5 6 9	19	100	SS-21	0.75	-	-	-	-	-	-	-	-	20	A-4b (V)	
		71																
		72																
		73																
		74																
@75.0'; SS-22 TO ST-23 BECOME GRAYISH BROWN		75	5 7 12	25	100	SS-22	1.75	-	-	-	-	-	-	-	-	21	A-4b (V)	
		76																
		77																
		78																
		79																
@80.0'; ST-23 BECOMES "AND" CLAY		80			100	ST-23	3.25	0	0	0	63	37	27	20	7	22	A-4b (8)	
		81																
		82																
	587.4	83																
STIFF, GRAYISH BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS FEW SILT LENSES, MOIST		84																
		85	12 17 20	48	100	SS-24	1.60	-	-	-	-	-	-	-	-	21	A-6a (V)	
		86																
		87																
	582.6	88																
STIFF, GRAYISH BROWN, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, CONTAINS SILTY CLAY LENSES, WET		89																
		90	5 8 13	27	100	SS-25	1.25	-	-	-	-	-	-	-	-	23	A-4b (V)	
		91																
		92																
	577.6	93																
		94																

PID: 82380	SFN:	PROJECT: CUY-CCG3	STATION / OFFSET: 186+36, 27' LT.	START: 1/21/15	END: 1/22/15	PG 4 OF 4	B-078-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 576.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM STIFF, GRAYISH BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS SILT LENSES, MOIST *(continued)*		95 96	6 6 10	21	100	SS-26	0.90	-	-	-	-	-	-	-	-	21	A-6a (V)	
	572.6	97 98																
VERY SOFT TO SOFT, GRAYISH BROWN, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		99																
		100 101	5 6 7	17	100	SS-27	0.25	-	-	-	-	-	-	-	-	24	A-6b (V)	
		102 103 104																
		105 106	2 3 6	12	100	SS-28	0.10	-	-	-	-	-	-	-	-	27	A-6b (V)	
		107 108 109																
@111.2'; UNIT WEIGHT: 123.1 PCF @ 30.5% MC	558.9	110 111 EOB 112			96	ST-29	0.40	0	1	1	23	75	40	20	20	31	A-6b (12)	

NOTES: GROUNDWATER ENCOUNTERED AT 22.5' DURING DRILLING. CAVE DEPTH 21.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: CUY-90-16.28 (CCG3A)
TYPE: BRIDGE
PID: 82382 SFN: 1807901
START: 3/12/21 END: 3/15/21

DRILLING FIRM / OPERATOR: NEAS / J. HODGES
SAMPLING FIRM / LOGGER: NEAS / J. HODGES
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 75T
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 5/1/19
ENERGY RATIO (%): 89

STATION / OFFSET: 188+90, 2' LT.
ALIGNMENT: IR-90 WB
ELEVATION: 667.0 (MSL) EOB: 110.0 ft.
LAT / LONG: 41.496503, -81.677982

EXPLORATION ID
B-078-1-20

PAGE
1 OF 4

MATERIAL DESCRIPTION AND NOTES	ELEV. 667.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE TO LITTLE GRAVEL, TRACE TO LITTLE CLAY, DAMP			13 11 17	42	78	SS-1	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
			5 12 16	42	100	SS-2	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
			3 8 12	30	89	SS-3	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
	655.0		3 7 8	22	100	SS-4	-	8	22	39	20	11	NP	NP	NP	11	A-3a (0)	
STIFF, BROWN, **SILTY CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	654.0		1 3 2	7	100	SS-5A	1.25	-	-	-	-	-	-	-	-	24	A-6b (V)	
VERY LOOSE TO LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME GRAVEL, TRACE SILT, TRACE CLAY, DAMP						SS-5B	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
	650.0	W 650.5	1 1 2	4	100	SS-6	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
LOOSE, BROWN AND GRAY, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, WET	647.5		1 2 2	6	89	SS-7	-	-	-	-	-	-	-	-	-	17	A-1-b (V)	
LOOSE, BROWN, **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, WET	645.0		6 3 2	7	100	SS-8	-	-	-	-	-	-	-	-	-	16	A-2-4 (V)	
MEDIUM DENSE TO DENSE, GRAY, **SANDY SILT**, TRACE TO LITTLE GRAVEL, TRACE CLAY, WET			4 5 8	19	100	SS-9	-	14	19	18	45	4	NP	NP	NP	20	A-4a (3)	
			6 9 14	34	100	SS-10	-	-	-	-	-	-	-	-	-	22	A-4a (V)	
			3 5 6	16	100	SS-11	-	-	-	-	-	-	-	-	-	23	A-4a (V)	

PID: 82382	SFN:	PROJECT: CUY-90-16.28 (CCG3A)	STATION / OFFSET: 188+90, 2' LT.	START: 3/12/21	END: 3/15/21	PG 2 OF 4	B-078-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 637.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM DENSE TO DENSE, GRAY, **SANDY SILT**, TRACE TO LITTLE GRAVEL, TRACE CLAY, WET *(continued)*		31	3 7 11	27	100	SS-12	-	-	-	-	-	-	-	-	-	23	A-4a (V)	
		32 33 34 35 36	7 10 12	33	100	SS-13	-	0	1	59	35	5	NP	NP	NP	20	A-4a (1)	
	626.0	37 38 39 40 41	4 8 9	25	100	SS-14A	-	-	-	-	-	-	-	-	-	23	A-4a (V)	
VERY STIFF, GRAY, **SILT**, LITTLE TO SOME CLAY, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST						SS-14B	3.00	-	-	-	-	-	-	-	-	20	A-4b (V)	
		42 43 44 45 46	4 7 8	22	100	SS-15	3.25	1	0	3	74	22	26	20	6	19	A-4b (8)	
		47 48 49 50 51	2 3 3	9	100	SS-16	2.25	-	-	-	-	-	-	-	-	21	A-4b (V)	
@55.0'; SS-17 BECOMES LOOSE, WET		52 53 54 55 56	3 3 4	10	100	SS-17	-	0	0	3	79	18	NP	NP	NP	23	A-4b (8)	
		57 58 59 60 61	3 5 6	16	100	SS-18	2.75	-	-	-	-	-	-	-	-	22	A-4b (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 6/22/22 13:24 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\CUY-90-16.28 (CCG3A - MOD#7)\GINT FILES\CUY-90-16.28 (CCG3

PID: 82382	SFN:	PROJECT: CUY-90-16.28 (CCG3A)	STATION / OFFSET: 188+90, 2' LT.	START: 3/12/21	END: 3/15/21	PG 3 OF 4	B-078-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 604.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY STIFF, GRAY, **SILT**, LITTLE TO SOME CLAY, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST *(continued)*		63 64																
		65 66	3 4 5	13	100	SS-19	2.50	0	0	1	65	34	28	20	8	21	A-4b (8)	
	598.7	67 68																
STIFF TO HARD, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST		69																
		70 71	1 1 2	4	100	SS-20	2.25	-	-	-	-	-	-	-	-	28	A-6a (V)	
		72 73 74																
		75 76	2 2 2	6	100	SS-21	2.25	0	0	1	61	38	31	19	12	25	A-6a (9)	
		77 78 79																
		80 81	5 8 15	34	100	SS-22	3.75	-	-	-	-	-	-	-	-	19	A-6a (V)	
		82 83 84																
		85 86	6 7 13	30	100	SS-23	4.25	-	-	-	-	-	-	-	-	20	A-6a (V)	
		87 88 89																
		90 91	6 6 8	21	100	SS-24	3.75	0	0	1	63	36	30	19	11	20	A-6a (8)	
		92 93 94																

PID: 82382	SFN:	PROJECT: CUY-90-16.28 (CCG3A)	STATION / OFFSET: 188+90, 2' LT.	START: 3/12/21	END: 3/15/21	PG 4 OF 4	B-078-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 572.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
STIFF TO HARD, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST *(continued)*		95 96	5 6 6	18	100	SS-25	4.50	-	-	-	-	-	-	-	-	20	A-6a (V)	
		97 98 99																
		100 101	5 5 4	13	100	SS-26	1.50	-	-	-	-	-	-	-	-	24	A-6a (V)	
		102 103 104																
		105 106	3 4 5	13	100	SS-27	1.75	0	1	2	55	42	32	19	13	24	A-6a (9)	
		107 108																
	557.0	109 EOB 110	2 4 6	15	100	SS-28	1.50	-	-	-	-	-	-	-	-	29	A-6a (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 16.5' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 100 GAL. BENTONITE GROUT; SHOVELED SOIL CUTTINGS

PROJECT: CUY-CCG3
TYPE: BRIDGE/RETAINING WALL
PID: 82380 BR ID: CUY-77-1651L
START: 5/20/2015 END: 5/20/2015

CONE FIRM/OPERATOR: OU/ISK/JJ

RIG: VERTEK 22-TON TRUCK
VELOCITY: V=20mm/s
CONE: 5901.101XX
SERIES:

STATION/OFFSET: 189+74, 19RT
ALIGNMENT: IR 90 WB
ELEVATION: 670.1
LAT/LONG: 41.496600, -81.677693

EXPLORATION ID
C-079-0-14

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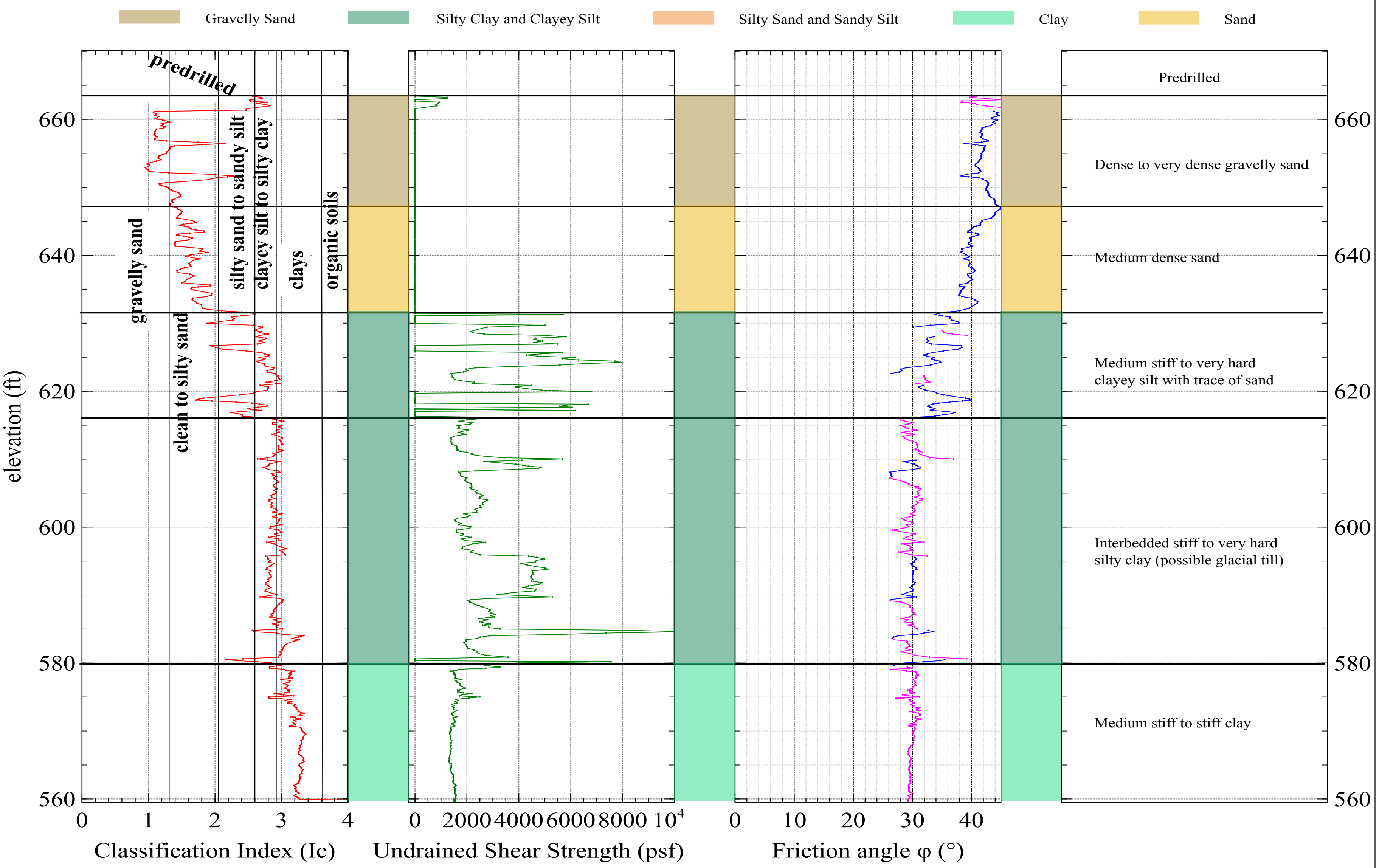

C-079-3-14 v = 20 mm/s

PROJECT: CUY-CCG3
TYPE: BRIDGE/RETAINING WALL
PID: 82380 BR ID: CUY-77-1561L
START: 5/20/2015 END: 5/20/2015

CONE FIRM/OPERATOR: OU/ISK/JJ

RIG: VERTEK 22-TON TRUCK
VELOCITY: V=20mm/s
CONE: 5901.101XX
SERIES:

STATION/OFFSET: 189+74, 19RT
ALIGNMENT: IR 90 WB
ELEVATION: 670.1
LAT/LONG: 41.496600, -81.677693

EXPLORATION ID
C-079-0-14

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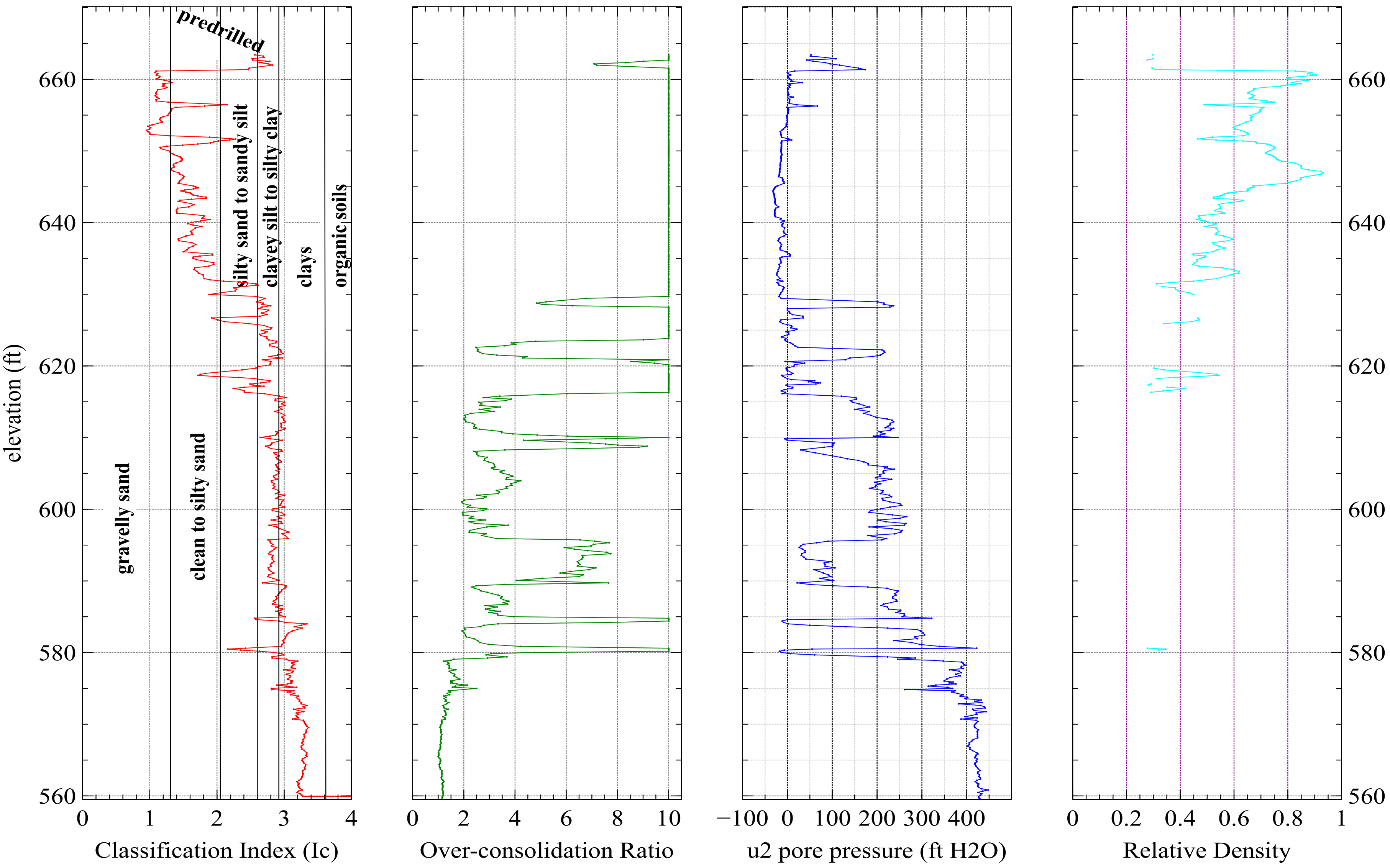

C-079-3-14 v = 20 mm/s

PROJECT: CUY-CCG3
TYPE: SUBGRADE
PID: 82380 SFN:
START: 12/22/14 END: 12/22/14

DRILLING FIRM / OPERATOR: BARR / P.STROUD
SAMPLING FIRM / LOGGER: BARR / C. PIERCE
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: MOBILE B-58
HAMMER: MOBILE AUTOMATIC
CALIBRATION DATE: 1/26/14
ENERGY RATIO (%): 90*

STATION / OFFSET: 188+15, 41' LT.
ALIGNMENT: IR-90 WB
ELEVATION: 669.4 (MSL) EOB: 9.0 ft.
LAT / LONG: 41.496459, -81.678286

EXPLORATION ID
B-080-0-14

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MATERIAL DESCRIPTION AND NOTES		ELEV. 669.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY STIFF, DARK GRAY AND BROWN, **SILT AND CLAY**, "AND" SAND, LITTLE GRAVEL, DAMP **(FILL)**		667.4	1 2	3 4 5	14	100	SS-1	3.25	11	15	32	26	16	33	21	12	18	A-6a (2)	
MEDIUM DENSE, ORANGISH BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, CONTAINS SILT LENSES, IRON STAINING, MOIST		664.9	3 4	4 5 5	15	100	SS-2	-	8	13	59	12	8	NP	NP	NP	12	A-3a (0)	
LOOSE, BROWN, **FINE SAND**, LITTLE COARSE SAND, TRACE GRAVEL, TRACE SILT, TRACE CLAY, DAMP	F.S	662.4	5 6 7	3 2 4	9	100	SS-3	-	-	-	-	-	-	-	-	-	8	A-3 (V)	
LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE GRAVEL, TRACE CLAY, DAMP		660.4	8 EOB 9	2 2 2	6	100	SS-4	-	-	-	-	-	-	-	-	-	9	A-3a (V)	

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

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

PROJECT: CUY-CCG3
TYPE: SUBGRADE
PID: 82380 SFN:
START: 12/16/14 END: 12/16/14

DRILLING FIRM / OPERATOR: BARR / P.STROUD
SAMPLING FIRM / LOGGER: BARR / C. PIERCE
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: MOBILE B-58
HAMMER: MOBILE AUTOMATIC
CALIBRATION DATE: 1/26/14
ENERGY RATIO (%): 90*

STATION / OFFSET: 189+07, 22' RT.
ALIGNMENT: IR-90 EB
ELEVATION: 686.8 (MSL) EOB: 9.0 ft.
LAT / LONG: 41.496578, -81.677243

EXPLORATION ID
B-081-0-14

PAGE
1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 686.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
4.0", **ASPHALT**	686.5																	
14.0", **CONCRETE**	685.6	1																
6.0", **GRANULAR BASE**	684.8	2																
DENSE TO VERY DENSE, GRAYISH BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, DAMP **(FILL)**		3	6 12 12	36	100	SS-1	-	4	18	59	13	6	NP	NP	NP	9	A-3a (0)	
		4																
		5 6	12 14 21	53	100	SS-2	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
		7																
@7.5'; SS-3 CHANGES TO SOME GRAVEL, CONTAINS BRICK FRAGMENTS	677.8	8 EOB 9	15 35 25	90	100	SS-3	-	-	-	-	-	-	-	-	-	8	A-3a (V)	

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

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED .5 BAG ASPHALT PATCH; SHOVELED SOIL CUTTINGS

PROJECT: CUY-90-16.28 (CCG3A)
TYPE: BRIDGE
PID: 82382 SFN: 1806910
START: 5/6/21 END: 5/7/21

DRILLING FIRM / OPERATOR: NEAS / J. HODGES
SAMPLING FIRM / LOGGER: NEAS / J. HODGES
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT / ST

DRILL RIG: CME 75T
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 5/1/19
ENERGY RATIO (%): 89

STATION / OFFSET: 423+20, 13' LT.
ALIGNMENT: RAMP A2
ELEVATION: 668.6 (MSL) EOB: 125.0 ft.
LAT / LONG: 41.495547, -81.679775

EXPLORATION ID
B-141-1-20

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1 OF 4

MATERIAL DESCRIPTION AND NOTES	ELEV. 668.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO VERY DENSE, BROWNISH GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, CONTAINS ASPHALT FRAGMENTS, DAMP **(FILL)**		1 2 3 4	20 22 26	71	100	SS-1	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
		5 6	16 10 8	27	100	SS-2	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
	661.6	7																
LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE TO LITTLE CLAY, TRACE TO LITTLE GRAVEL, CONTAINS SLAG, DAMP **(FILL)**		8 9	3 3 3	9	100	SS-3	-	-	-	-	-	-	-	-	-	8	A-3a (V)	
		10 11 12	4 7 5	18	100	SS-4	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
@12.5'; SS-5 CHANGES TO DENSE		13	8 19 12	46	67	SS-5	-	10	18	39	21	12	NP	NP	NP	9	A-3a (0)	
	654.1	14																
SOFT, BROWNISH GRAY, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, MOIST		15 16	3 10 10	30	39	SS-6	0.25	-	-	-	-	-	-	-	-	18	A-4a (V)	
	651.6	17																
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE TO LITTLE CLAY, TRACE GRAVEL, DAMP		18 19	4 5 10	22	17	SS-7	-	-	-	-	-	-	-	-	-	8	A-3a (V)	
@20.0' TO 36.5'; BECOMES WET		20 21 22 23 24	5 9 12	31	67	SS-8	-	3	17	47	22	11	NP	NP	NP	15	A-3a (0)	
		W 643.6 25 26 27 28 29	7 7 8	22	100	SS-9	-	-	-	-	-	-	-	-	-	24	A-3a (V)	

PID: 82382 | SFN: | PROJECT: CUY-90-16.28 (CCG3A) | STATION / OFFSET: 423+20, 13' LT. | START: 5/6/21 | END: 5/7/21 | PG 2 OF 4 | B-141-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 638.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE TO LITTLE CLAY, TRACE GRAVEL, DAMP *(continued)*		31 32 33 34	7 10 12	33	100	SS-10	-	-	-	-	-	-	-	-	-	20	A-3a (V)	
		35 36 37	7 8 15	34	100	SS-11	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
	630.3	38																
MEDIUM DENSE, GRAY, **SILT**, LITTLE TO "AND" CLAY, TRACE TO LITTLE SAND, TRACE GRAVEL, MOIST TO WET		39 40 41 42 43 44	9 6 6	18	100	SS-12	-	0	0	16	68	16	NP	NP	NP	20	A-4b (8)	
@45.0' TO 51.5'; BECOMES VERY STIFF TO HARD		45 46 47 48	7 8 8	24	100	SS-13	4.25	0	0	4	73	23	26	20	6	21	A-4b (8)	
@49.1' TO 49.6'; Qu = 1445 PSF @ 8.0%		49			100	ST-1	4.50	0	0	5	80	15	24	20	4	24	A-4b (8)	
@50.0' TO 51.5'; SS-14 BECOMES DAMP		50 51 52 53 54	8 8 9	25	100	SS-14	3.25	-	-	-	-	-	-	-	-	19	A-4b (V)	
@55.0' TO 61.5'; BECOMES SOFT TO MEDIUM STIFF		55 56 57 58 59	2 2 2	6	100	SS-15	0.50	0	0	4	64	32	28	20	8	24	A-4b (8)	
		60 61	2 3 3	9	100	SS-16	0.50	-	-	-	-	-	-	-	-	21	A-4b (V)	

PID: 82382	SFN:	PROJECT: CUY-90-16.28 (CCG3A)	STATION / OFFSET: 423+20, 13' LT.	START: 5/6/21	END: 5/7/21	PG 3 OF 4	B-141-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 606.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM DENSE, GRAY, **SILT**, LITTLE TO "AND" CLAY, TRACE TO LITTLE SAND, TRACE GRAVEL, MOIST TO WET *(continued)* @63.0' TO 96.5'; BECOMES VERY STIFF TO HARD @64.3' TO 64.8'; Qu = 2082 PSF @ 14.5%, DAMP		63																
		64			100	ST-2	3.50	0	0	2	70	28	26	20	6	20	A-4b (8)	
		65 66	5 8 9	25	100	SS-17	4.25	1	0	1	69	29	27	20	7	21	A-4b (8)	
		67 68 69																
		70 71	3 6 9	22	100	SS-18	2.75	0	0	3	66	31	26	18	8	21	A-4b (8)	
		72 73 74																
		75 76	4 8 10	27	100	SS-19	2.50	-	-	-	-	-	-	-	-	21	A-4b (V)	
		77 78 79																
		80 81	5 6 10	24	100	SS-20	2.50	0	0	1	60	39	29	19	10	22	A-4b (8)	
		82 83 84																
		85 86	6 9 14	34	100	SS-21	3.00	-	-	-	-	-	-	-	-	20	A-4b (V)	
		87 88 89																
		90 91	8 11 20	46	100	SS-22	3.75	0	0	1	71	28	26	21	5	23	A-4b (8)	
		92 93 94																

PID: 82382	SFN:	PROJECT: CUY-90-16.28 (CCG3A)	STATION / OFFSET: 423+20, 13' LT.	START: 5/6/21	END: 5/7/21	PG 4 OF 4	B-141-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 574.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, GRAY, **SILT**, LITTLE TO "AND" CLAY, TRACE TO LITTLE SAND, TRACE GRAVEL, MOIST TO WET *(continued)*	570.3	95–98	6 9 12	31	100	SS-23	3.25	-	-	-	-	-	-	-	-	22	A-4b (V)	
MEDIUM STIFF TO VERY STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		98–108	8 10 12	33	100	SS-24	0.75	2	1	2	53	42	30	18	12	24	A-6a (9)	
	560.3		4 5 6	16	100	SS-25	2.25	-	-	-	-	-	-	-	-	23	A-6a (V)	
SOFT TO MEDIUM STIFF, GRAY, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		108–125	1 3 4	10	100	SS-26	0.50	-	-	-	-	-	-	-	-	28	A-6b (V)	
			0 2 3	7	100	SS-27	0.75	0	1	2	38	59	36	20	16	27	A-6b (10)	
			1 3 5	12	100	SS-28	0.50	-	-	-	-	-	-	-	-	24	A-6b (V)	
	543.6	EOB 125	1 3 6	13	100	SS-29	0.50	-	-	-	-	-	-	-	-	29	A-6b (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 25.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 250 GAL. BENTONITE GROUT

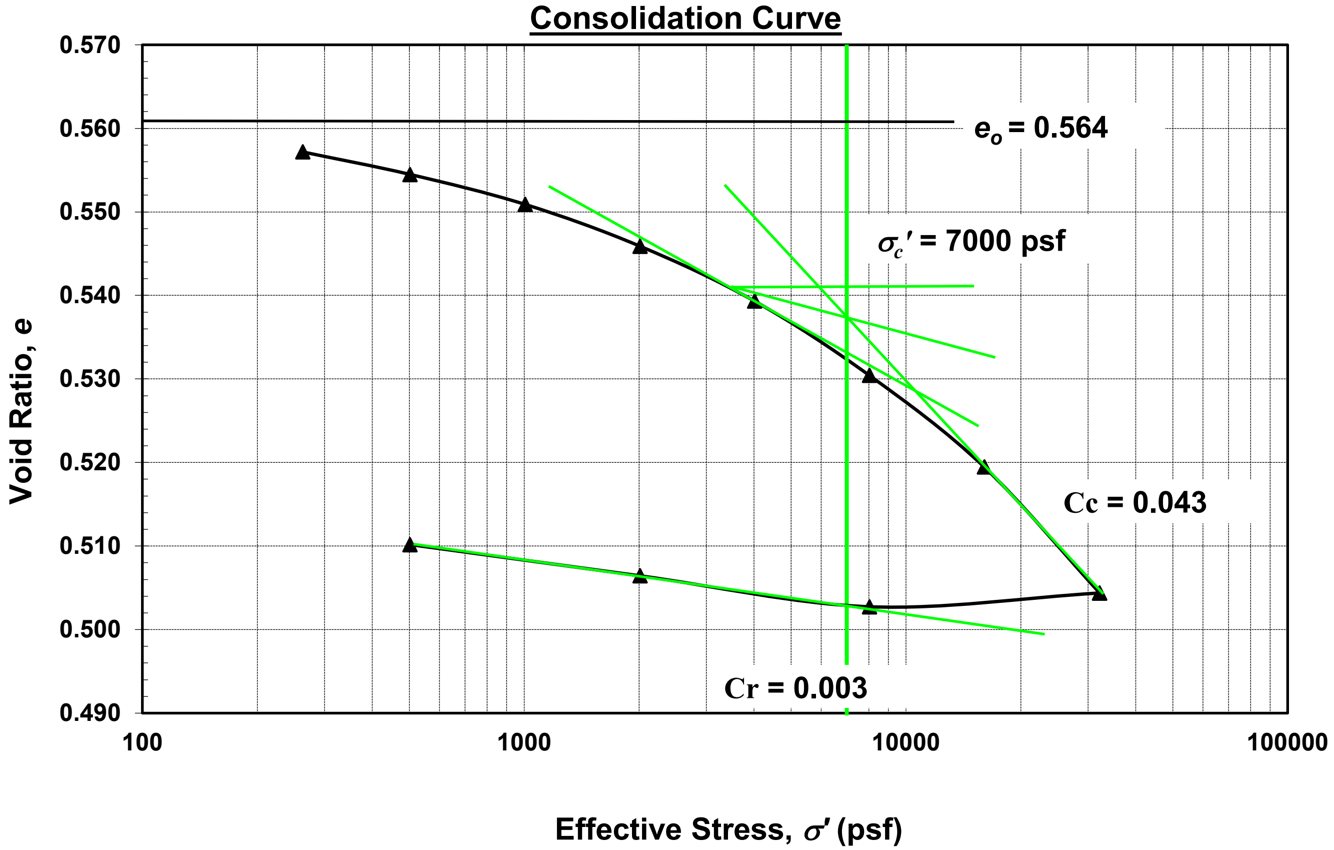
Consolidation Test

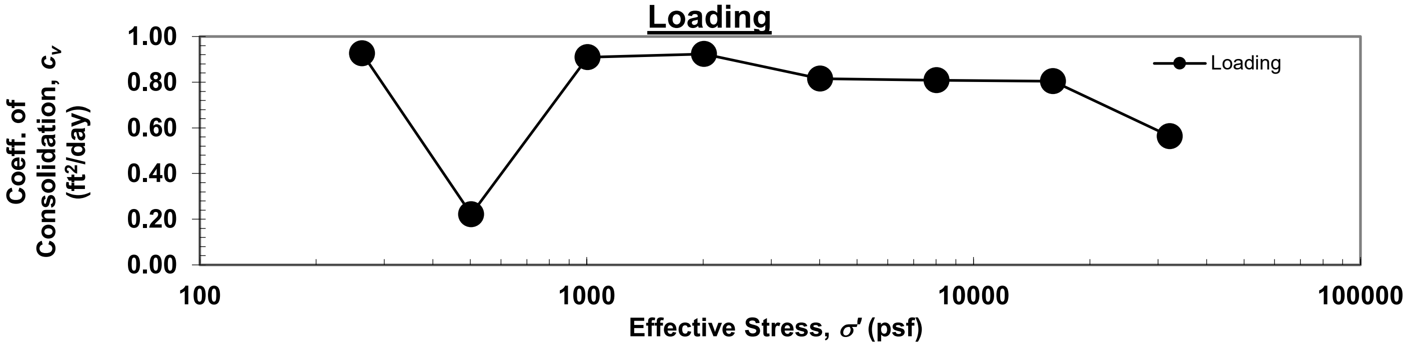
Project Name: CUY-90-16.28 (CCG3A)
Prepared by: LR
Source: B-141-1-20 ST-1 (49.8'-49.9')
Checked by: ZM
Description: Medium stiff, gray, SILT, some clay, trace sand, trace gravel, moist.
Date: 6/24/2021

Test Specification: ASTM D 2435
Initial Void Ratio: 0.564
Initial Bulk Unit Weight (lb/ft^3): 131
In-situ Vertical Effective Stress (psf): 4400
Dry Unit Weight (lb/ft^3): 108

Compression and Swelling Index

Compression Index (*Cc*): 0.043
Preconsolidation Pressure (σ_c')(psf): **7000**
Recompression Index (*Cr*): 0.003
Over-Consolidation Ratio (*OCR*): **1.6**





NEAS
National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, OH 43213
614.892.0162

Consolidation Test

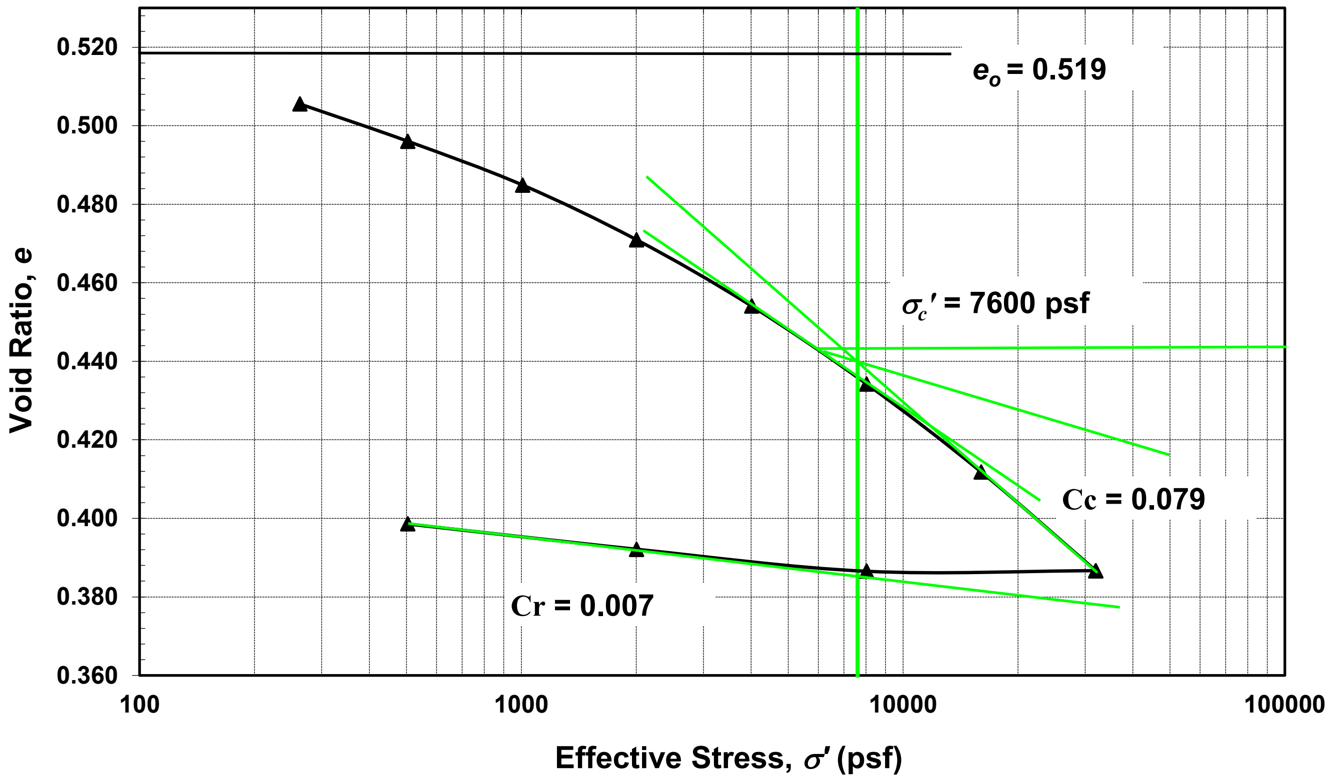
Project Name: CUY-90-16.28 (CCG3A)
Source: B-141-1-20 ST-2 (64.1'-64.2')
Description: Stiff, gray, SILT, some clay, trace sand, trace gravel, damp.
Prepared by: LR
Checked by: ZM
Date: 6/24/2021

Test Specification: ASTM D 2435
Initial Void Ratio: 0.519
In-situ Vertical Effective Stress (psf): 5300
Initial Bulk Unit Weight (lb/ft^3): 134
Dry Unit Weight (lb/ft^3): 111

Compression and Swelling Index

Compression Index (*Cc*): 0.079
Recompression Index (*Cr*): 0.007
Preconsolidation Pressure (σ_c')(psf): **7600**
Over-Consolidation Ratio (*OCR*): **1.4**

Consolidation Curve



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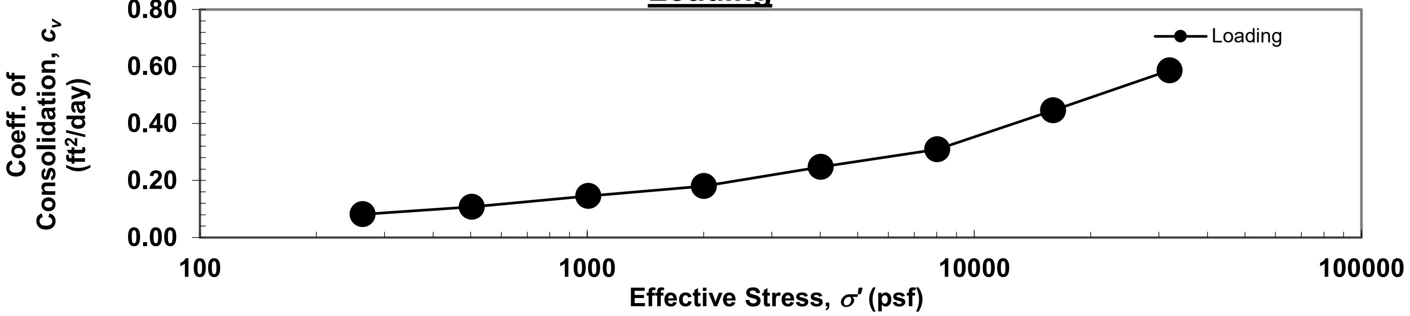


STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 6/22/22 14:18 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\1ARCHIVE BY YEAR\2017 ARCHIVE\CUY-CCG3 82380\GINT FILES

PROJECT: CUY-CCG3
TYPE: BRIDGE
PID: 82380 SFN:
START: 2/26/15 END: 3/9/15

DRILLING FIRM / OPERATOR: BARR / T.GILBERT
SAMPLING FIRM / LOGGER: BARR / D.KLIMKOWICZ
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT / ST

DRILL RIG: CME 55
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/26/14
ENERGY RATIO (%): 78.8

STATION / OFFSET: 182+31, 36' LT.
ALIGNMENT: IR-90 WB
ELEVATION: 677.5 (MSL) EOB: 112.0 ft.
LAT / LONG: 41.495588, -81.680039

EXPLORATION ID
B-142-0-14

PAGE
1 OF 4

MATERIAL DESCRIPTION AND NOTES	ELEV. 677.5	DEPTHS		SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
									GR	CS	FS	SI	CL	LL	PL	PI			
16.0", **CONCRETE**	676.2		1																
2.0", **GRANULAR BASE**	676.0		2																
VERY DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP **(FILL)**	673.0		3 4	17 45 37	108	100	SS-1	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	
MEDIUM DENSE TO VERY DENSE, BLACK, **COARSE AND FINE SAND**, SOME SILT, LITTLE GRAVEL, TRACE CLAY, CONTAINS ASPHALT AND BRICK FRAGMENTS, DAMP TO MOIST **(FILL)** @7.0'; SS-3 TO SS-5 CHANGE TO BROWN			5 6 7	11 15 10	33	100	SS-2	-	19	18	32	22	9	NP	NP	NP	11	A-3a (0)	
			8 9	9 9 14	30	100	SS-3	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
			10 11 12	9 16 26	55	100	SS-4	-	12	15	41	23	9	NP	NP	NP	10	A-3a (0)	
			13 14	3 5 5	13	100	SS-5	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
	660.5		15 16	13 20 15	46	100	SS-6	-	-	-	-	-	-	-	-	-	14	A-3a (V)	
LOOSE TO MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP			17 18 19	4 10 7	22	100	SS-7	-	17	32	28	16	7	NP	NP	NP	9	A-1-b (0)	
@20.0'; SS-8 NO RECOVERY			20 21 22	5 5 3	11	0	SS-8	-	-	-	-	-	-	-	-	-	-		
	653.0		23 24	3 2 2	5	100	SS-9	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
MEDIUM DENSE, BROWN, **SILT**, SOME SAND, LITTLE CLAY, TRACE GRAVEL, WET	650.5		25 26	2 3 5	11	100	SS-10	-	0	0	26	56	18	NP	NP	NP	31	A-4b (8)	
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, TRACE GRAVEL, WET		W 650.0	27 28 29	4 4 8	16	100	SS-11	-	-	-	-	-	-	-	-	-	24	A-3a (V)	

PID: 82380 | SFN: | PROJECT: CUY-CCG3 | STATION / OFFSET: 182+31, 36' LT. | START: 2/26/15 | END: 3/9/15 | PG 2 OF 4 | B-142-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 647.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, TRACE GRAVEL, WET *(continued)*		31	5 10 21	41	100	SS-12	-	-	-	-	-	-	-	-	-	18	A-3a (V)	
		32																
		33																
		34																
		35																
		36	10 16 16	42	100	SS-13	-	2	15	71	9	3	NP	NP	NP	21	A-3a (0)	
		37																
	639.2	38																
MEDIUM DENSE TO DENSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, WET		39																
		40																
		41	6 12 20	42	100	SS-14	-	-	-	-	-	-	-	-	-	18	A-4a (V)	
		42																
		43																
		44																
		45																
		46	6 8 15	30	100	SS-15	-	0	0	52	40	8	NP	NP	NP	25	A-4a (3)	
		47																
	629.2	48																
MEDIUM STIFF TO HARD, BROWN, **SILT**, LITTLE TO SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST TO WET		49																
		50																
		51	10 16 25	54	100	SS-16	2.50	-	-	-	-	-	-	-	-	22	A-4b (V)	
		52																
		53																
		54																
		55																
		56	6 7 7	18	100	SS-17	0.75	-	-	-	-	-	-	-	-	24	A-4b (V)	
		57																
		58																
		59																
		60																
		61	6 7 7	18	56	SS-18	1.30	-	-	-	-	-	-	-	-	24	A-4b (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 6/22/22 14:18 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE BY YEAR\2017 ARCHIVE\CUY-CCG3 82380\GINT FILES

PID: 82380	SFN:	PROJECT: CUY-CCG3	STATION / OFFSET: 182+31, 36' LT.	START: 2/26/15	END: 3/9/15	PG 3 OF 4	B-142-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 615.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM STIFF TO HARD, BROWN, **SILT**, LITTLE TO SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST TO WET *(continued)*		63 64																
@65.0'; UNIT WEIGHT: 132.4 PCF @ 19.4% MC		65 66 67			100	SS-19	2.10	0	0	3	75	22	25	19	6	19	A-4b (8)	
		68 69																
		70 71	5 8 12	26	100	SS-20	2.80	-	-	-	-	-	-	-	-	19	A-4b (V)	
		72 73 74																
@75.8'; UNIT WEIGHT: 134.5 PCF @ 25.2% MC		75 76 77			100	SS-21	1.50	0	0	1	72	27	25	19	6	19	A-4b (8)	
		78 79																
		80 81	0 6 7	17	100	SS-22	2.75	-	-	-	-	-	-	-	-	22	A-4b (V)	
		82 83 84																
		85 86	8 15 18	43	100	SS-23	4.10	-	-	-	-	-	-	-	-	19	A-4b (V)	
		87 88 89																
@90.0'; ST-24 TO ST-27 BECOME "AND" CLAY @91.1'; UNIT WEIGHT: 132.9 PCF @ 20.3% MC		90 91 92			100	SS-24	1.60	0	0	0	59	41	28	20	8	20	A-4b (8)	
		93 94																

PID: 82380	SFN:	PROJECT: CUY-CCG3	STATION / OFFSET: 182+31, 36' LT.	START: 2/26/15	END: 3/9/15	PG 4 OF 4	B-142-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 583.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM STIFF TO HARD, BROWN, **SILT**, LITTLE TO SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST TO WET *(continued)*		95 96	6 12 15	35	100	SS-25	2.90	-	-	-	-	-	-	-	-	24	A-4b (V)	
		97 98 99																
		100 101	4 5 9	18	100	SS-26	1.25	0	0	0	61	39	26	17	9	22	A-4b (8)	
		102 103 104																
		105 106	0 6 10	21	100	SS-27	1.50	-	-	-	-	-	-	-	-	20	A-4b (V)	
	569.2	107 108																
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		109																
@111.5'; UNIT WEIGHT: 129.5 PCF @ 24.3% MC	565.5	110 111 EOB 112			100	SS-28	2.50	1	2	4	38	55	31	19	12	24	A-6a (9)	

NOTES: GROUNDWATER ENCOUNTERED AT 27.5 DURING DRILLING. CAVE DEPTH 27.0'.

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

PROJECT: CUY-90-16.28 (CCG3A)
TYPE: RETAINING WALL
PID: 82382 SFN:
START: 3/15/21 END: 3/15/21

DRILLING FIRM / OPERATOR: NEAS / J. HODGES
SAMPLING FIRM / LOGGER: NEAS / J. HODGES
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT / ST

DRILL RIG: CME 75T
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 5/1/19
ENERGY RATIO (%): 89

STATION / OFFSET: 424+28, 27' RT.
ALIGNMENT: RAMP A2
ELEVATION: 681.2 (MSL) EOB: 75.0 ft.
LAT / LONG: 41.495780, -81.679499

EXPLORATION ID
B-142-1-20

PAGE
1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 681.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
4.0" ASPHALT AND 8.0" BASE (DRILLERS DESCRIPTION)	680.2																	
MEDIUM DENSE TO VERY DENSE, BROWN AND DARK GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, CONTAINS RED BRICK FRAGMENTS, GLASS, AND CONCRETE FRAGMENTS, DAMP **(FILL)**		1 2																
		3 4	5 6 9	22	44	SS-1	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
		5 6	3 10 27	55	100	SS-2	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
		7																
		8 9	3 7 11	27	100	SS-3	-	-	-	-	-	-	-	-	-	11	A-1-b (V)	
	669.2	10 11	6 6 7	19	100	SS-4	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
LOOSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE GRAVEL, TRACE SILT, TRACE CLAY, DAMP		12																
		13 14	2 2 4	9	100	SS-5	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
	664.2	15 16	2 3 4	10	100	SS-6	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
LOOSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP		17																
		18 19	1 2 3	7	100	SS-7	-	20	32	36	6	6	NP	NP	NP	8	A-1-b (0)	
		20 21	1 2 2	6	78	SS-8	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
	657.9	22 23																
LOOSE, LIGHT BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE CLAY, TRACE GRAVEL, DAMP		24																
		25 26	2 3 4	10	100	SS-9	-	-	-	-	-	-	-	-	-	5	A-3a (V)	
		27 28 29																

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/3/24 14:10 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2022 ARCHIVE\CUY-90-16.28 (CCG3A - MOD#7

PID: 82382	SFN:	PROJECT: CUY-90-16.28 (CCG3A)	STATION / OFFSET: 424+28, 27' RT.	START: 3/15/21	END: 3/15/21	PG 2 OF 3	B-142-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 651.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
LOOSE, LIGHT BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE CLAY, TRACE GRAVEL, DAMP *(continued)* @30.0'; SS-10 TO SS-14 BECOME MEDIUM DENSE TO VERY DENSE, BROWNISH GRAY, WET		31	3 5 8	19	100	SS-10	-	-	-	-	-	-	-	-	-	24	A-3a (V)	
		32 33 34																
		35 36	6 15 21	53	100	SS-11	-	-	-	-	-	-	-	-	-	18	A-3a (V)	
		37 38 39																
		40 41	10 14 19	49	100	SS-12	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
		42 43 44																
		45 46	5 8 8	24	100	SS-13	-	-	-	-	-	-	-	-	-	24	A-3a (V)	
		47 48 49																
		50 51	7 11 17	42	100	SS-14	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
	627.9	52 53																
MEDIUM DENSE TO DENSE, GRAY, **SILT**, LITTLE CLAY, TRACE TO LITTLE SAND, TRACE GRAVEL, WET		54																
		55 56	6 13 9	33	100	SS-15	-	0	0	14	67	19	NP	NP	NP	19	A-4b (8)	
		57 58 59																
		60 61	5 6 14	30	100	SS-16	-	-	-	-	-	-	-	-	-	20	A-4b (V)	

PID: 82382 | SFN: | PROJECT: CUY-90-16.28 (CCG3A) | STATION / OFFSET: 424+28, 27' RT. | START: 3/15/21 | END: 3/15/21 | PG 3 OF 3 | B-142-1-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 619.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, GRAY, **SILT**, LITTLE CLAY, TRACE TO LITTLE SAND, TRACE GRAVEL, WET *(continued)*		63 64																
		65 66	4 6 12	27	100	SS-17	-	0	0	8	72	20	NP	NP	NP	21	A-4b (8)	
	613.2	67 68																
MEDIUM STIFF TO VERY STIFF, GRAY, **SILT**, SOME TO "AND" CLAY, TRACE SAND, TRACE GRAVEL, MOIST @69.4' TO 69.9'; Qu = 1916 PSF @ 13.0%		69			100	ST-1	4.00	0	0	0	67	33	29	21	8	24	A-4b (8)	
		70 71	3 4 5	13	100	SS-18	1.25	-	-	-	-	-	-	-	-	23	A-4b (V)	
		72 73																
	606.2	74 EOB 75	2 6 3	13	100	SS-19	2.75	0	0	6	56	38	26	18	8	23	A-4b (8)	

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

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 50 GAL. BENTONITE GROUT; SHOVELED SOIL CUTTINGS

National Engineering & Architectural Services Inc.

5710 Westbourne Avenue
Columbus, OH 43213
614.892.0162

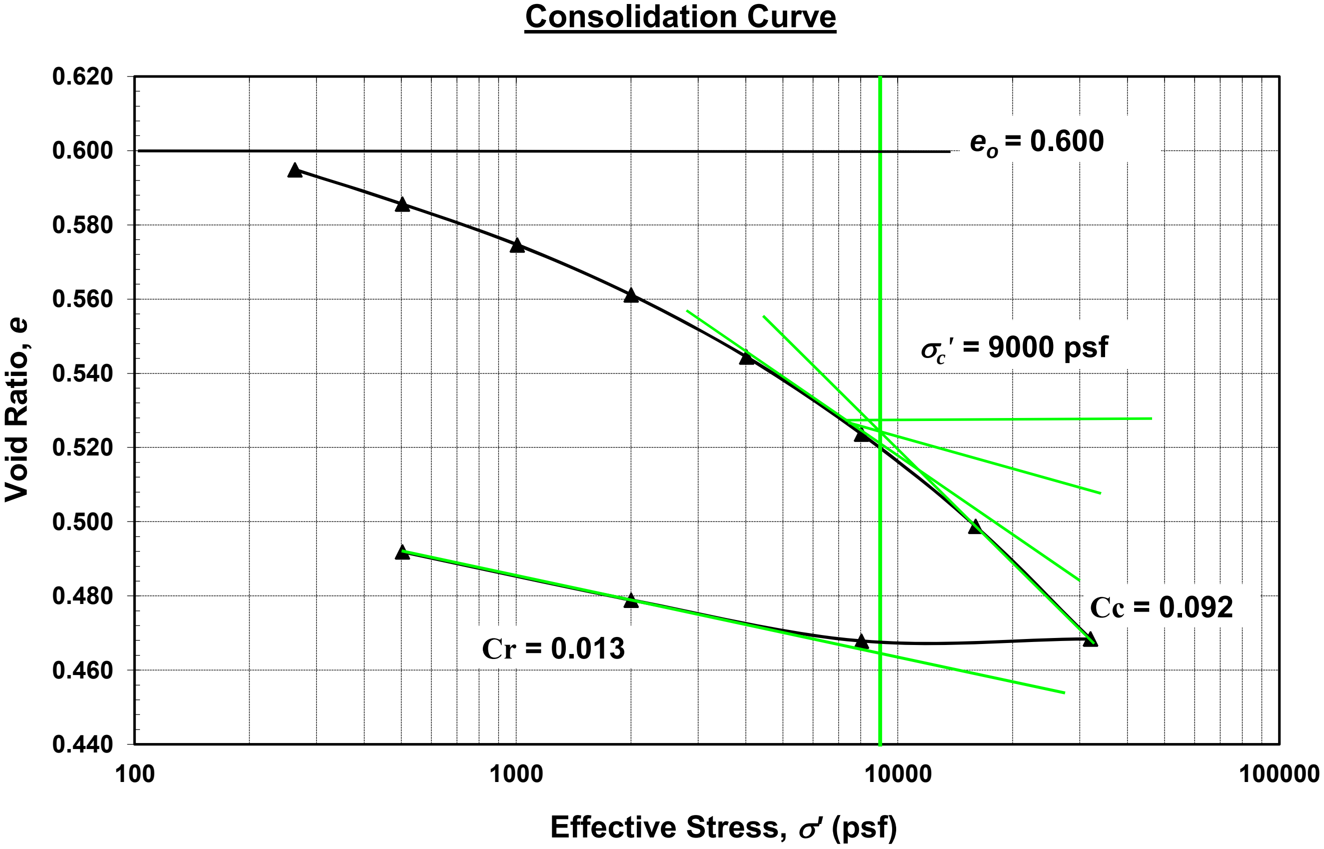
Consolidation Test

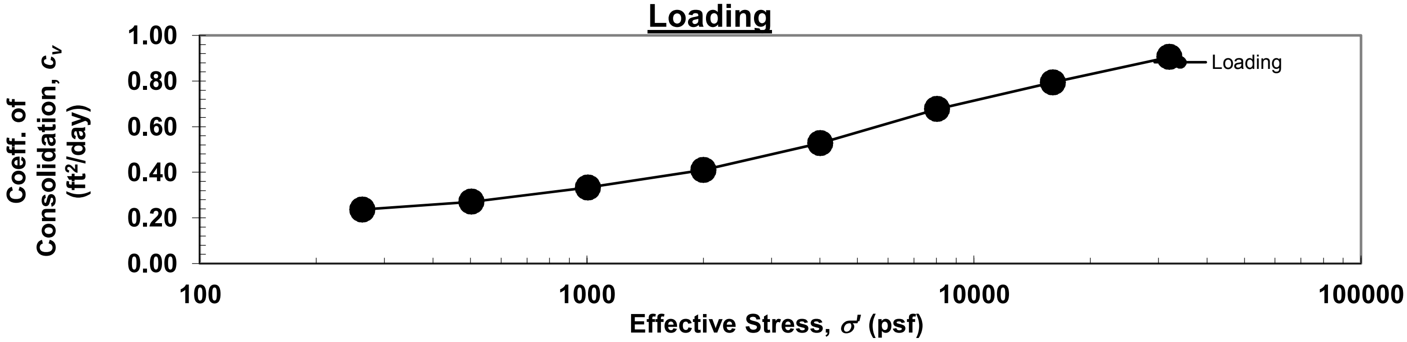
Project Name: CUY-90-16.28 (CCG3A)
Source: B-142-1-20 ST-1 (69.2' - 69.3')
Description: Medium stiff, gray, SILT, some clay, trace sand, trace gravel, moist.
Prepared by: LR
Checked by: ZM
Date: 4/26/2021

Test Specification: ASTM D 2435
Initial Void Ratio: 0.600
In-situ Vertical Effective Stress (psf): 8300
Initial Bulk Unit Weight (lb/ft^3): 130
Dry Unit Weight (lb/ft^3): 105

Compression and Swelling Index

Compression Index (*Cc*): 0.092
Recompression Index (*Cr*): 0.013
Preconsolidation Pressure (σ_c') (psf): **9000**
Over-Consolidation Ratio (*OCR*): **1.1**





PROJECT: CUY-90-16.28 (CCG3A)
TYPE: BRIDGE
PID: 82382 SFN: 1806910
START: 3/17/21 END: 3/17/21

DRILLING FIRM / OPERATOR: NEAS / J. HODGES
SAMPLING FIRM / LOGGER: NEAS / J. HODGES
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 75T
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 5/1/19
ENERGY RATIO (%): 89

STATION / OFFSET: 424+92, 29' RT.
ALIGNMENT: RAMP A2
ELEVATION: 680.4 (MSL) EOB: 110.0 ft.
LAT / LONG: 41.495926, -81.679385

EXPLORATION ID
B-142-2-20

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1 OF 4

MATERIAL DESCRIPTION AND NOTES	ELEV. 680.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
5.0" ASPHALT AND 10.0" BASE (DRILLERS DESCRIPTION)	679.1	1																
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE GRAVEL, TRACE CLAY, MOIST TO DAMP **(FILL)**		2																
		3	3 5 6	16	100	SS-1	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
		4																
		5																
		6	2 6 12	27	100	SS-2	-	-	-	-	-	-	-	-	-	7	A-3a (V)	
	673.4	7																
MEDIUM DENSE, BLACK AND BROWN, **STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS RED BRICK FRAGMENTS, MOIST **(FILL)**		8	4 5 4	13	100	SS-3	-	-	-	-	-	-	-	-	-	17	A-1-b (V)	
	670.9	9																
LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE GRAVEL, TRACE SILT, TRACE CLAY, WET TO MOIST		10																
		11	6 7 4	16	100	SS-4	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
		12																
		13	2 2 3	7	100	SS-5	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
		14																
		15																
		16	2 2 4	9	100	SS-6	-	-	-	-	-	-	-	-	-	12	A-3a (V)	
		17																
		18	1 3 3	9	56	SS-7	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
	660.9	19																
LOOSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS A 1.0" A-6B SEAM, DAMP		20																
		21	4 2 2	6	100	SS-8	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
	658.4	22																
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, WET		23	2 2 6	12	100	SS-9	-	-	-	-	-	-	-	-	-	17	A-3a (V)	
	655.9	24																
LOOSE, BROWN, **FINE SAND**, LITTLE COARSE SAND, TRACE SILT, TRACE GRAVEL, TRACE CLAY, DAMP		25																
		26	1 2 2	6	100	SS-10	-	-	-	-	-	-	-	-	-	8	A-3 (V)	
	653.4	27																
MEDIUM DENSE TO DENSE, GRAY, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, MOIST TO WET		28	7 9 10	28	100	SS-11	-	-	-	-	-	-	-	-	-	12	A-3a (V)	
		29																
		W 650.4																

PID: 82382 | SFN: | PROJECT: CUY-90-16.28 (CCG3A) | STATION / OFFSET: 424+92, 29' RT. | START: 3/17/21 | END: 3/17/21 | PG 2 OF 4 | B-142-2-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 650.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, GRAY, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, MOIST TO WET *(continued)*		31 32 33 34	4 5 7	18	100	SS-12	-	-	-	-	-	-	-	-	-	26	A-3a (V)	
		35 36 37 38 39	3 8 16	36	100	SS-13	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
		40 41 42 43 44	9 10 14	36	100	SS-14	-	-	-	-	-	-	-	-	-	18	A-3a (V)	
		45 46 47 48 49	5 8 9	25	100	SS-15	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
		50 51 52	3 6 10	24	100	SS-16	-	0	4	72	20	4	NP	NP	NP	16	A-3a (0)	
	627.1	53																
DENSE, GRAY, **SILT**, TRACE TO LITTLE SAND, LITTLE CLAY, TRACE GRAVEL, WET		54 55 56 57 58 59	9 7 15	33	100	SS-17	-	0	0	18	70	12	NP	NP	NP	19	A-4b (8)	
@60.0'; SS-18 BECOMES VERY STIFF		60 61	1 2 3	7	100	SS-18	3.25	-	-	-	-	-	-	-	-	24	A-4b (V)	

PID: 82382 | SFN: | PROJECT: CUY-90-16.28 (CCG3A) | STATION / OFFSET: 424+92, 29' RT. | START: 3/17/21 | END: 3/17/21 | PG 3 OF 4 | B-142-2-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 618.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
	617.1	63																
STIFF TO HARD, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		64																
		65	4 4 5	13	100	SS-19	1.75	0	0	1	62	37	31	20	11	26	A-6a (8)	
		66																
		67																
		68																
		69																
		70	3 6 10	24	100	SS-20	4.25	-	-	-	-	-	-	-	-	21	A-6a (V)	
		71																
		72																
		73																
		74																
		75	5 6 7	19	100	SS-21	2.00	0	0	1	58	41	31	20	11	22	A-6a (8)	
		76																
		77																
	602.1	78																
STIFF TO HARD, GRAY, **SILT**, "AND" CLAY, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST		79																
		80	2 5 10	22	100	SS-22	4.25	-	-	-	-	-	-	-	-	19	A-4b (V)	
		81																
		82																
		83																
		84																
		85	2 2 4	9	100	SS-23	2.00	-	-	-	-	-	-	-	-	26	A-4b (V)	
		86																
		87																
		88																
		89																
		90	4 16 11	40	100	SS-24	4.25	0	0	0	60	40	30	20	10	21	A-4b (8)	
		91																
		92																
		93																
		94																

PID: 82382 | SFN: | PROJECT: CUY-90-16.28 (CCG3A) | STATION / OFFSET: 424+92, 29' RT. | START: 3/17/21 | END: 3/17/21 | PG 4 OF 4 | B-142-2-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 586.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
STIFF TO HARD, GRAY, **SILT**, "AND" CLAY, TRACE SAND, TRACE GRAVEL, DAMP TO MOIST *(continued)*	582.1	95 96 97 98	2 6 8	21	100	SS-25	3.25	-	-	-	-	-	-	-	-	21	A-4b (V)	
VERY STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST TO DAMP		99 100 101 102 103 104	4 7 9	24	100	SS-26	3.00	0	0	0	60	40	30	19	11	21	A-6a (8)	
	572.9	105 106 107	4 8 10	27	100	SS-27	4.00	-	-	-	-	-	-	-	-	19	A-6a (V)	
SOFT TO MEDIUM STIFF, GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST	570.4	108 109 EOB 110	4 6 7	19	100	SS-28	0.50	0	1	3	22	74	44	23	21	32	A-7-6 (13)	

NOTES: GROUNDWATER ENCOUNTERED AT 30.0' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 240 GAL. BENTONITE GROUT

PROJECT: CUY-90-16.28 (CCG3A)
TYPE: RETAINING WALL
PID: 82382 SFN:
START: 6/24/21 END: 6/24/21

DRILLING FIRM / OPERATOR: NEAS / ASHBAUGH
SAMPLING FIRM / LOGGER: NEAS / ASHBAUGH
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME 55T
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 12/5/19
ENERGY RATIO (%): 68.4

STATION / OFFSET: 186+59, 26' LT.
ALIGNMENT: IR-90 WB
ELEVATION: 690.5 (MSL) EOB: 66.5 ft.
LAT / LONG: 41.496169, -81.678701

EXPLORATION ID
B-142-4-20

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1 OF 3

MATERIAL DESCRIPTION AND NOTES	ELEV. 690.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
10.0" ASPHALT AND 7.0" BASE (DRILLERS DESCRIPTION)	689.1	1																
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS BRICK FRAGMENTS AND IRON STAINING, DAMP **(FILL)**		2 3	6 10 11	24	67	SS-1A	-	18	33	25	19	5	NP	NP	NP	7	A-1-b (0)	
	686.7	4				SS-1B	-	-	-	-	-	-	-	-	-	8	A-3a (V)	
MEDIUM DENSE TO DENSE, BROWN BECOMING BROWN AND BLACK, **COARSE AND FINE SAND**, LITTLE GRAVEL, LITTLE SILT, TRACE CLAY, CONTAINS IRON STAINING, MOIST TO DAMP **(FILL)**		5 6	8 13 18	35	56	SS-2	-	11	25	41	17	6	NP	NP	NP	12	A-3a (0)	
		7 8 9	10 8 10	21	72	SS-3	-	18	23	36	16	7	NP	NP	NP	11	A-3a (0)	
		10 11	8 8 10	21	67	SS-4	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
	676.0	12 13 14	5 9 11	23	78	SS-5	-	-	-	-	-	-	-	-	-	8	A-3a (V)	
VERY DENSE, GRAY AND BLACK, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS IRON STAINING, DAMP **(FILL)**	673.5	15 16 17	21 24 41	74	61	SS-6	-	-	-	-	-	-	-	-	-	8	A-1-b (V)	
MEDIUM DENSE, DARK BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, CONTAINS BRICK AND TILE FRAGMENTS, CONTAINS IRON STAINING, WET **(FILL)**		18 19	7 10 12	25	67	SS-7	-	9	19	50	16	6	NP	NP	NP	15	A-3a (0)	
	668.5	20 21 22	5 6 8	16	56	SS-8	-	-	-	-	-	-	-	-	-	14	A-3a (V)	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP		23 24	7 5 6	13	50	SS-9	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	
	663.5	25 26 27	5 5 8	15	56	SS-10	-	16	47	26	8	3	NP	NP	NP	8	A-1-b (0)	
LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE GRAVEL, TRACE CLAY, MOIST TO WET		28 29	5 6 6	14	44	SS-11	-	-	-	-	-	-	-	-	-	13	A-3a (V)	

PID: 82382 | SFN: | PROJECT: CUY-90-16.28 (CCG3A) | STATION / OFFSET: 186+59, 26' LT. | START: 6/24/21 | END: 6/24/21 | PG 2 OF 3 | B-142-4-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 660.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE GRAVEL, TRACE CLAY, MOIST TO WET *(continued)*		31 32	5 4 5	10	44	SS-12	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
@32.5'; SS-13 CONTAINS A 3.0" A-6A SEAM		33 34	6 9 8	19	61	SS-13	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
		35 36 37	7 9 9	21	67	SS-14	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
		38 39	7 8 11	22	83	SS-15	-	7	31	48	10	4	NP	NP	NP	19	A-3a (0)	
		40 41 42	6 7 10	19	67	SS-16	-	-	-	-	-	-	-	-	-	20	A-3a (V)	
	W 647.7	43 44	6 8 13	24	61	SS-17	-	-	-	-	-	-	-	-	-	18	A-3a (V)	
		45 46 47 48 49	5 8 14	25	67	SS-18	-	-	-	-	-	-	-	-	-	19	A-3a (V)	
		50 51 52 53 54	6 10 13	26	56	SS-19	-	-	-	-	-	-	-	-	-	15	A-3a (V)	
@55.0'; SS-20 CONTAINS NO RECOVERY		55 56 57 58 59	8 11 13	27	0	SS-20	-	-	-	-	-	-	-	-	-	-		
		60 61	9 10 14	27	89	SS-21	-	-	-	-	-	-	-	-	-	13	A-3a (V)	

PID: 82382	SFN:	PROJECT: CUY-90-16.28 (CCG3A)	STATION / OFFSET: 186+59, 26' LT.	START: 6/24/21	END: 6/24/21	PG 3 OF 3	B-142-4-20

MATERIAL DESCRIPTION AND NOTES	ELEV. 628.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	HOLE SEALED
								GR	CS	FS	SI	CL	LL	PL	PI			
LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE GRAVEL, TRACE CLAY, MOIST TO WET *(continued)*		63 64																
	624.0	65 66 EOB	10 9 13	25	56	SS-22	-	-	-	-	-	-	-	-	-	12	A-3a (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 42.8' DURING DRILLING. HOLE DID NOT CAVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PLACED 0.5 BAG ASPHALT PATCH; PUMPED 150 GAL. BENTONITE GROUT

PROJECT: CUY-CCG3
TYPE: BRIDGE
PID: 82380 SFN:
START: 10/21/14 END: 10/22/14

DRILLING FIRM / OPERATOR: BARR / T.GILBERT
SAMPLING FIRM / LOGGER: BARR / Z.JEWELL
DRILLING METHOD: 3.25" HSA
SAMPLING METHOD: SPT / ST

DRILL RIG: CME 45B
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 1/26/14
ENERGY RATIO (%): 77.4

STATION / OFFSET: 430+46, 52' RT.
ALIGNMENT: RAMP A2
ELEVATION: 669.1 (MSL) EOB: 111.5 ft.
LAT / LONG: 41.496799, -81.677835

EXPLORATION ID
B-144-0-14

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MATERIAL DESCRIPTION AND NOTES	ELEV. 669.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, CONTAINS CONCRETE FRAGMENTS, MOIST **(FILL)**	667.1	1 2	5 11 8	25	44	SS-1	-	-	-	-	-	-	-	-	-	14	A-1-b (V)	
VERY LOOSE, BROWN, **COARSE AND FINE SAND**, LITTLE GRAVEL, TRACE SILT, TRACE CLAY, DAMP		3 4	2 2 1	4	100	SS-2	-	15	23	46	10	6	NP	NP	NP	8	A-3a (0)	
@5.0'; SS-3 BECOMES VERY DENSE		5 6 7	4 50/0"	-	100	SS-3	-	-	-	-	-	-	-	-	-	7	A-3a (V)	
@7.5'; SS-4 BECOMES LOOSE	659.6	8 9	3 3 3	8	94	SS-4	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
STIFF, BROWN MOTTLED WITH GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST	657.1	10 11	2 2 2	5	100	SS-5	1.50	0	0	1	56	43	32	18	14	25	A-6a (10)	
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME GRAVEL, TRACE SILT, TRACE CLAY, DAMP		12 13 14	8 9 9	23	89	SS-6	-	-	-	-	-	-	-	-	-	4	A-3a (V)	
		15 16 17	6 8 12	26	83	SS-7	-	-	-	-	-	-	-	-	-	4	A-3a (V)	
	649.6	18 19	6 7 9	21	94	SS-8	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, WET	647.1	W 649.1 20 21	6 6 10	21	100	SS-9	-	6	58	31	3	2	NP	NP	NP	19	A-1-b (0)	
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE GRAVEL, TRACE SILT, TRACE CLAY, MOIST TO WET		22 23 24	5 6 8	18	100	SS-10	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
@25.0'; SS-11 TO SS-12 BECOME LITTLE SILT, TRACE GRAVEL		25 26 27	6 12 18	39	100	SS-11	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
@27.5'; SS-12 BECOMES GRAY	639.1	28 29	5 7 9	21	89	SS-12	-	0	2	80	15	3	NP	NP	NP	24	A-3a (0)	

PID: 82380	SFN:	PROJECT: CUY-CCG3	STATION / OFFSET: 430+46, 52' RT.	START: 10/21/14	END: 10/22/14	PG 2 OF 4	B-144-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 639.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE TO DENSE, GRAYISH BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, WET		31 32 33 34	10 12 23	45	94	SS-13	-	-	-	-	-	-	-	-	-	24	A-4a (V)	
		35 36 37 38 39	6 12 19	40	89	SS-14	-	0	0	53	43	4	NP	NP	NP	27	A-4a (2)	
	626.1	40 41 42	4 7 9	21	100	SS-15	-	-	-	-	-	-	-	-	-	25	A-4a (V)	
MEDIUM DENSE, GRAY, **SILT**, LITTLE CLAY, TRACE SAND, TRACE GRAVEL, WET	622.1	43 44 45 46	7 7 9	21	100	SS-16	-	0	0	3	80	17	25	19	6	24	A-4b (8)	
STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST	616.1	47 48 49 50 51 52	4 5 5	13	100	SS-17	1.10	0	0	3	62	35	29	18	11	23	A-6a (8)	
MEDIUM DENSE, GRAY, **SILT**, LITTLE CLAY, TRACE SAND, TRACE GRAVEL, MOIST TO WET	610.6	53 54 55 56 57 58	9 8 9	22	100	SS-18	-	-	-	-	-	-	-	-	-	21	A-4b (V)	
STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		59 60 61	3 4 6	13	100	SS-19	1.10	-	-	-	-	-	-	-	-	23	A-6a (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/3/24 15:19 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2017 ARCHIVE\CUY-CCG3 82380\GINT FILES\CU

PID: 82380 | SFN: | PROJECT: CUY-CCG3 | STATION / OFFSET: 430+46, 52' RT. | START: 10/21/14 | END: 10/22/14 | PG 3 OF 4 | B-144-0-14

MATERIAL DESCRIPTION AND NOTES		ELEV. 607.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
									GR	CS	FS	SI	CL	LL	PL	PI			
STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST *(continued)*	▨		63																
			64																
			65																
			66	3 4 6	13	100	SS-20	1.40	-	-	-	-	-	-	-	-	24	A-6a (V)	
			67																
		600.6	68																
VERY STIFF, GRAY, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST	⊞		69																
			70																
			71			100	ST-21	2.50	0	0	1	66	33	27	18	9	20	A-4b (8)	
@71.5'; UNCONFINED: 6600 PSF @ 10.0% STRAIN @71.8'; UNIT WEIGHT: 133.3 PCF @ 19.9% MC			72																
		595.6	73																
STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST	▨		74																
			75																
			76	5 5 7	15	100	SS-22	1.50	-	-	-	-	-	-	-	-	22	A-6a (V)	
			77																
		590.6	78																
STIFF TO HARD, GRAY, **SILT**, "AND" CLAY, TRACE SAND, TRACE GRAVEL, MOIST	⊞		79																
			80																
			81			100	ST-23	4.50	0	0	0	65	35	28	18	10	20	A-4b (8)	
@81.8'; UNIT WEIGHT: 133.6 PCF @ 19.8% MC			82																
			83																
			84																
@85.0'; SS-24 BECOMES GRAYISH BROWN			85																
			86	5 7 12	25	100	SS-24	1.50	-	-	-	-	-	-	-	-	22	A-4b (V)	
			87																
		580.6	88																
MEDIUM STIFF TO STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS SILT LENSES, MOIST	▨		89																
			90																
			91	11 25 30	71	100	SS-25	1.00	-	-	-	-	-	-	-	-	26	A-6a (V)	
			92																
			93																
			94																

PID: 82380	SFN:	PROJECT: CUY-CCG3	STATION / OFFSET: 430+46, 52' RT.	START: 10/21/14	END: 10/22/14	PG 4 OF 4	B-144-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 574.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM STIFF TO STIFF, GRAY, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS SILT LENSES, MOIST *(continued)*		95 96	7 10 14	31	100	SS-26	1.20	-	-	-	-	-	-	-	-	21	A-6a (V)	
	570.6	97 98																
VERY SOFT TO SOFT, GRAY, **SILTY CLAY**, TRACE SAND, TRACE GRAVEL, MOIST		99 100 101	0 0 0	0	100	SS-27	0.20	0	1	3	34	62	37	18	19	29	A-6b (12)	
		102 103 104																
		105 106	4 5 6	14	100	SS-28	0.30	-	-	-	-	-	-	-	-	27	A-6b (V)	
		107 108 109																
	557.6	110 111 EOB	6 6 8	18	100	SS-29	0.40	-	-	-	-	-	-	-	-	26	A-6b (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 20.0' DURING DRILLING. CAVE DEPTH 21.0'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SHOVELED SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/3/24 15:19 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2017 ARCHIVE\CUY-CCG3 82380\GINT FILES\CU

BARR & PREVOST
ENGINEERING | TESTING | SURVEYING

5710 Westbourne Avenue
Columbus, OH 43213
614-892-0162

Consolidation Test

Project Name: CUY-77-13.80
Source: B-144-0-14, ST-21, 71.2' - 71.4'
Description: Very stiff, SILT, some clay, trace sand.

Prepared by: CH
Checked by:
Date: 12/9/2014

Test Specification: ASTM D 2435-04
Initial Void Ratio: 0.585
In-situ Vertical Effective Stress: 5900 psf

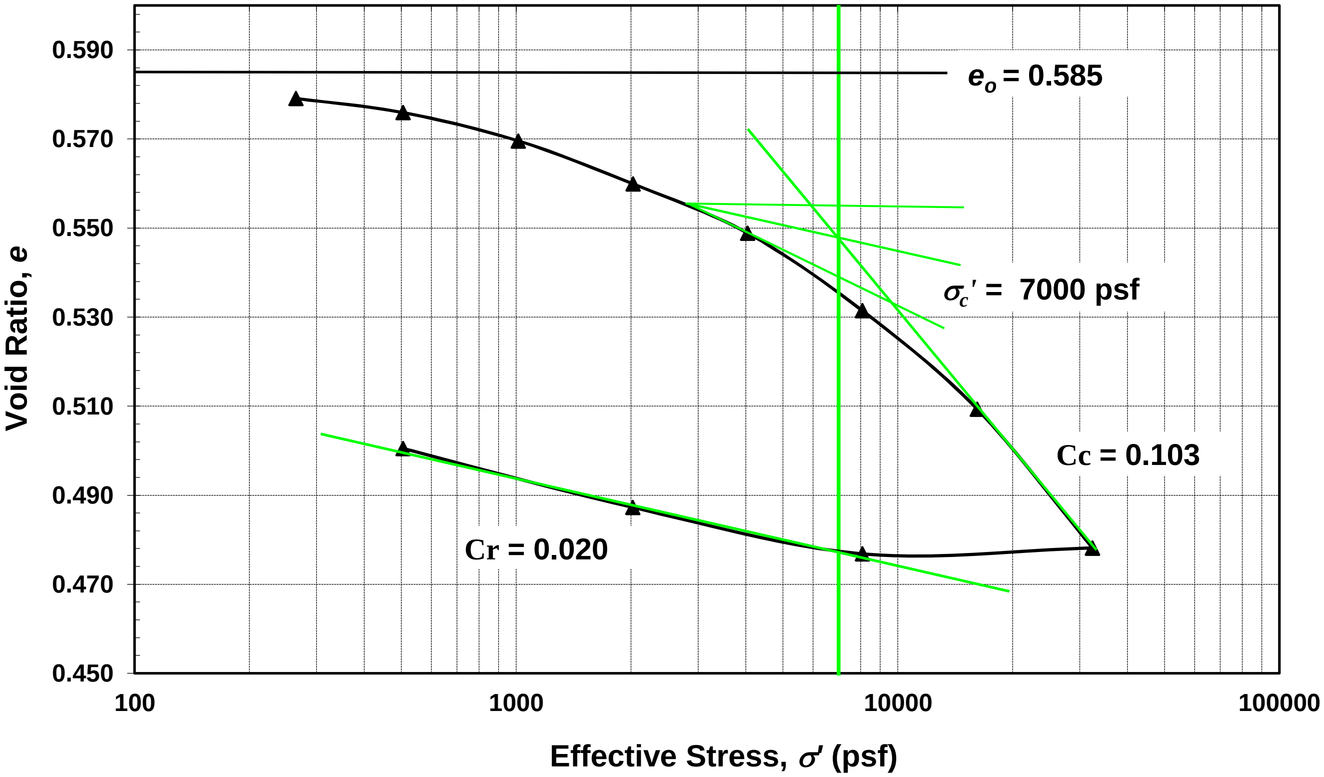
Initial Bulk Unit Weight (lb/ft^3): 128
Dry Unit Weight (lb/ft^3): 106

Compression and Swelling Index

Compression Index (*Cc*): 0.103
Recompression Index (*Cr*): 0.020

Preconsolidation Pressure (σ_c'): **7000 psf**
Over-Consolidation Ratio (*OCR*): **1.2**

Consolidation Curve



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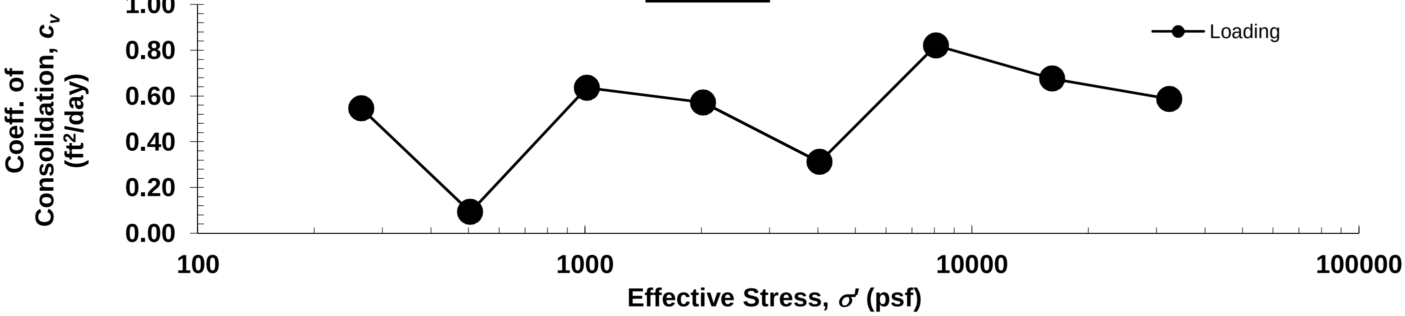


PROJECT: CUY-CCG3	DRILLING FIRM / OPERATOR: BARR / P.STROUD	DRILL RIG: MOBILE B-58	STATION / OFFSET: 581+00, 22' LT.
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: BARR / C. PIERCE	HAMMER: MOBILE AUTOMATIC	ALIGNMENT: RAMP A3
PID: 82380 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/26/14	ELEVATION: 687.0 (MSL) EOB: 61.5 ft.
START: 11/24/14 END: 11/25/14	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 90*	LAT / LONG: 41.495547, -81.680532

EXPLORATION ID
B-166-0-14

PAGE
1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 687.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
12.0", **CONCRETE**	686.0	1																
12.0", **GRANULAR BASE**	685.0	2																
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP **(FILL)**		3 4	12 8 8	24	78	SS-1	-	-	-	-	-	-	-	-	-	7	A-1-b (V)	
		5 6 7	21 6 7	20	56	SS-2	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
		8 9	6 7 7	21	100	SS-3	-	19	45	31	4	1	NP	NP	NP	5	A-1-b (0)	
		676.9 10 11 12	5 4 7	17	67	SS-4	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
@12.5'; SS-5 CHANGES TO GRAYISH BROWN	672.5	13 14	2 4 14	27	100	SS-5	-	38	34	21	5	2	NP	NP	NP	10	A-1-b (0)	
DENSE TO VERY DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, LITTLE GRAVEL, LITTLE CLAY, DAMP TO MOIST **(POSSIBLE FILL)**		15 16 17	7 14 18	48	100	SS-6	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
@17.5'; SS-7 CHANGES TO BROWN AND GRAY	667.5	18 19	18 35 42	116	100	SS-7	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, DAMP		20 21 22	13 16 14	45	100	SS-8	-	5	10	68	12	5	NP	NP	NP	8	A-3a (0)	
		23 24	4 5 4	14	100	SS-9	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
	660.0	25 26 27	5 8 8	24	100	SS-10	-	-	-	-	-	-	-	-	-	5	A-3a (V)	
MEDIUM DENSE, BROWN AND GRAY, **SILT**, LITTLE CLAY, TRACE SAND, TRACE GRAVEL, WET	657.5	28 29	2 4 4	12	100	SS-11	-	1	0	6	74	19	27	22	5	28	A-4b (8)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 1/3/24 15:20 - X:\ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE BY YEAR\2017 ARCHIVE\CUY-CCG3 82380\GINT FILES\CU

PID: 82380 | SFN: | PROJECT: CUY-CCG3 | STATION / OFFSET: 581+00, 22' LT. | START: 11/24/14 | END: 11/25/14 | PG 2 OF 2 | B-166-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 657.0	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
BROWN AND GRAY, **SILT**, LITTLE CLAY, TRACE SAND, TRACE GRAVEL, WET *(continued)* @31.6'; UNIT WEIGHT: 126.6 PCF @ 25.6% MC	653.7	31			100	ST-12	-	0	0	2	87	11	NP	NP	NP	26	A-4b (8)	
MEDIUM DENSE TO VERY DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, WET		35–36	4 4 8	18	100	SS-13	-	-	-	-	-	-	-	-	-	24	A-3a (V)	
@40.0'; SS-14 TO SS-17 BECOMES GRAYISH BROWN		40–41	4 5 12	26	100	SS-14	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
		45–46	7 10 13	35	100	SS-15	-	0	2	80	15	3	NP	NP	NP	22	A-3a (0)	
		50–51	11 17 18	53	100	SS-16	-	-	-	-	-	-	-	-	-	20	A-3a (V)	
	628.5	55–56	4 8 14	33	100	SS-17	-	-	-	-	-	-	-	-	-	26	A-3a (V)	
STIFF, GRAY, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST	625.5	60–61 EOB	5 6 6	18	100	SS-18	1.30	0	0	6	71	23	26	18	8	20	A-4b (8)	

NOTES: GROUNDWATER ENCOUNTERED AT 10.1' DURING DRILLING, 10.0' UPON COMPLETION. CAVE DEPTH 19.9'.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL MIXED WITH 1 BAG CEMENT

APPENDIX C

GENERALIZED SUBSURFACE PROFILE - RETAINING WALL AC

OHIO DEPARTMENT OF TRANSPORTATION
OFFICE OF GEOTECHNICAL ENGINEERING

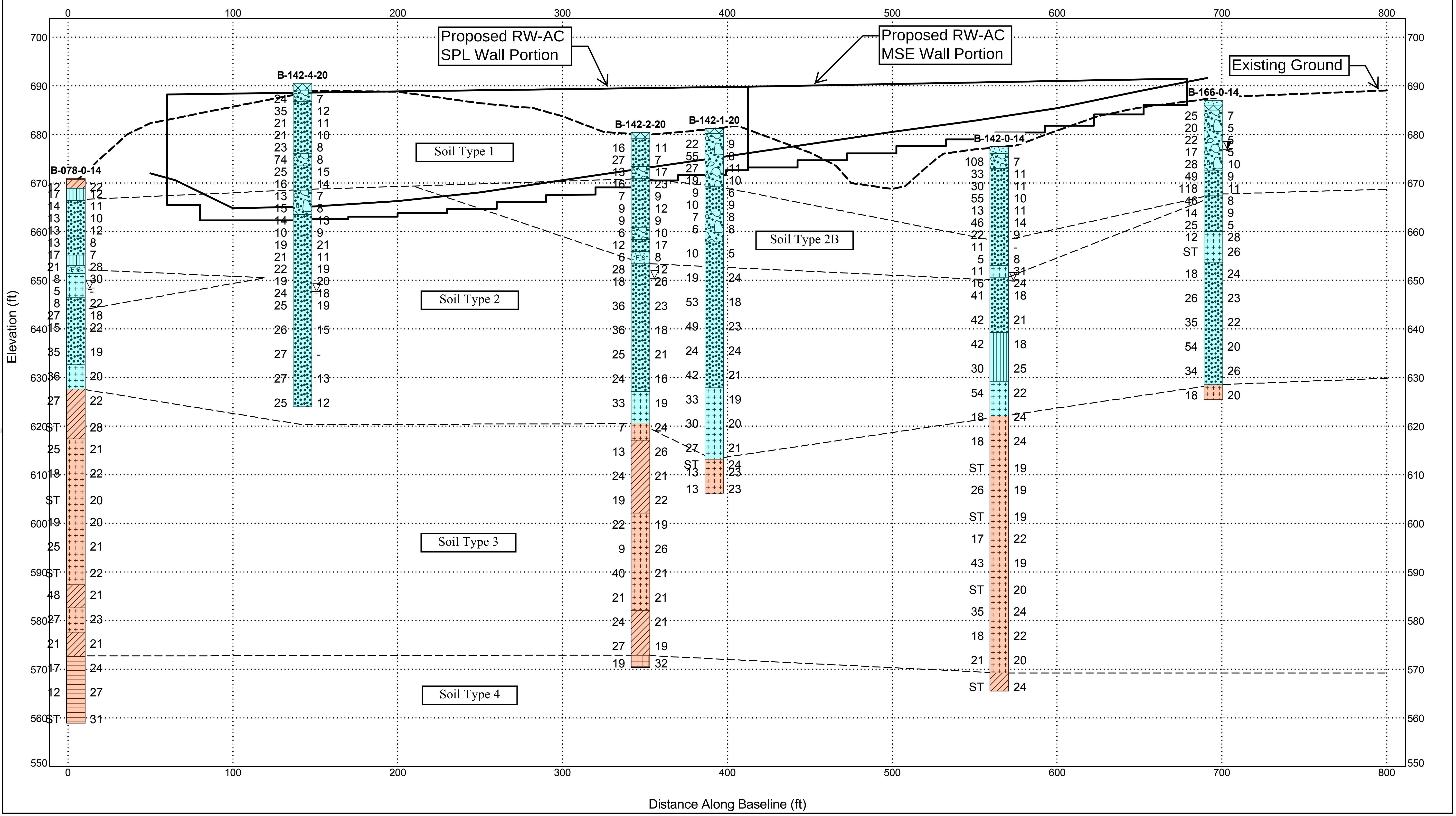
🟦 Non-cohesive
🟧 Cohesive

SUBSURFACE DIAGRAM
RETAINING WALL AC

▧ Ohio DOT: Sod and Topsoil	▨ Ohio DOT: A-6a, silt and clay	▥ Ohio DOT: A-4a, sandy silt
▩ Ohio DOT: A-3a, coarse and fine sand	▦ Ohio DOT: A-3, fine sand	⊞ Ohio DOT: A-4b, silt
▤ Ohio DOT: A-6b, silty clay	▧ Concrete	▩ Ohio DOT: Pavement or Aggregate base
▧ Ohio DOT: A-1-b, gravel and/or stone fragments with sand	▦ Ohio DOT: A-7-6, clay	

CLIENT Michael Baker International
PROJECT NUMBER 82382

PROJECT NAME CCG3A
PROJECT LOCATION Cuyahoga County, Ohio



STRATIGRAPHY & GW - B SIZE - OH DOT.GDT - 9/15/21 17:07 - C:\USERS\KARENS\DESKTOP\WALLAC_PROFILE091521.GPJ

APPENDIX D

EXTERNAL STABILITY ANALYSIS - RETAINING WALL AC

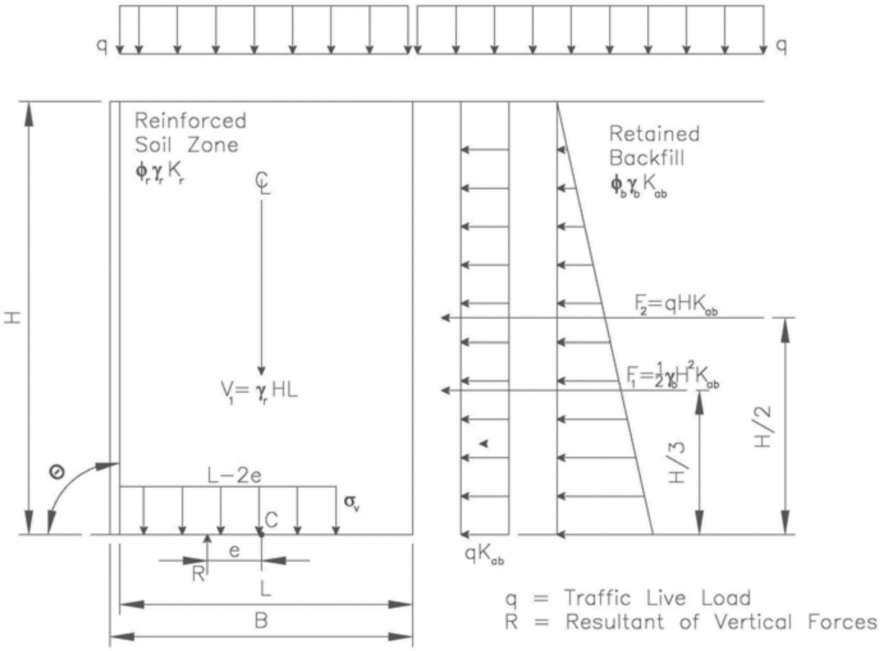
RETAINING WALL AC – STA. 02+78.8

Objective: **To evaluate the external stability of MSE wall design with vertical wall face and horizontal backfill.**

Method: **In accordance with ODOT Bridge Design Manual, 2013 [Sect. 307] LRFD Bridge Design Specifications, 8th Ed., 2018, [Sect. 11.10.5].**

Assumptions:

- **Horizontal backfill behind MSE wall on granular (drained) soils.**
- **For battered or vertical walls with a back face of wall angle of θ to horizontal.**
- **Not for sheet type reinforcement. If so, use different assessment for Sliding parameter ϕ_{μ}.**
- **MSE wall not acting as abutment, if so must meet minimum embedment depth of H/10 if no slope in front of wall**
- **Load combinations and wall configuration are as shown below:**



Givens:

Wall Geometry:

$H_e := 18.4 \cdot ft$ Exposed wall height

$\theta := 90 \cdot deg$ Angle of back face of wall to horizontal: 90 deg for vertical or near vertical walls (per Berg et al., 2009; near vertical = 80 deg < θ < 100 deg)

Reinforced Backfill Soil Design Parameters:

$\phi'_r := 34 \cdot deg$ Effective angle of internal friction (Per BDM [Table 307-1])

$\gamma_r := 120 \cdot \frac{lbf}{ft^3}$ Unit weight (Per BDM [Table 307-1])

$c'_r := 0 \cdot \frac{lbf}{ft^2}$ Effective Cohesion

Retained Backfill Soil Design Parameters:

$\phi'_b := 30 \cdot deg$ Effective angle of internal friction (Per BDM [Table 307-1])

$\gamma_b := 120 \cdot \frac{lbf}{ft^3}$ Unit weight (Per BDM [Table 307-1])

$c'_b := 0 \cdot \frac{lbf}{ft^2}$ Effective Cohesion

Foundation Soil Design Parameters:

Drained Conditions (Effective Stress):

$\phi'_f := 29 \cdot deg$ Effective angle of internal friction

$\gamma_f := 120 \cdot \frac{lbf}{ft^3}$ Unit weight

$c'_f := 0 \cdot \frac{lbf}{ft^2}$ Cohesion

Undrained Conditions (Total Stress):

$\phi_f := 29 \cdot deg$ Angle of internal friction (Same as Drained Conditions if Sand)

$\gamma_f = 120 \ \frac{lbf}{ft^3}$ Unit weight

$c_f := 0 \cdot \frac{lbf}{ft^2}$ Cohesion (Use Su if Angle of internal friction = 0 deg)

Foundation Surcharge Soil Parameters:

$\gamma_q := 120 \cdot \frac{lbf}{ft^3}$ Unit weight of Soil above bearing depth (Used in Bearing Resistance of Soil Calculation LRFD 10.6.3.1.2a-1)

Depth of Embedment Check:

$d_{frost} := 3.5\ ft$ $d_{user} := 0\ ft$ Local Frost Depth

$Slope_{fw} := 0\ deg$

Inclination of ground slope in front of wall :

- Horizontal: **0**
- 3H:1V: **18.435**
- 2H:1V: **26.565**
- 1.5H:1V: **33.690**

$d_{est} := \max\left(d_{frost}, 3\ ft, d_{user}\right)$ $d_{est} = 3.5\ ft$

$H_{est} := d_{est} + \left(4\ ft \cdot \tan\left(Slope_{fw}\right)\right) + H_e$ $H_{est} = 21.9\ ft$

$$d_{eSlope} := \text{if}\left(Slope_{fw} < 1\ deg, \frac{H_{est}}{20}, \text{if}\left(Slope_{fw} < 26.565\ deg, \frac{H_{est}}{10}, \text{if}\left(Slope_{fw} < 33.69\ deg, \frac{H_{est}}{7}, \frac{H_{est}}{5}\right)\right)\right)$$

$d_{eSlope} = 1.1\ ft$ Minimum Embedment Depth per Table C11.10.2.2-1 of LRFD BDS

$d_e := \max\left(d_{est}, d_{eSlope}\right)$ $d_e = 3.5\ ft$ Minimum Required Embedment Depth used in analysis.

$H := d_e + \left(4\ ft \cdot \tan\left(Slope_{fw}\right)\right) + H_e$ $H = 21.9\ ft$ Design Wall Height

Estimate Length of Reinforcement:

$L_{user} := 0 \cdot ft$ User inputted value (if changes need to be made to satisfy other requirements)

$L := \max\left(8 \cdot ft, 0.7 \cdot H, L_{user}\right)$ $L = 15.3\ ft$ Length of Reinforcement

Live Load Surcharge Parameters:

$SUR := 250 \cdot \frac{lbf}{ft^2}$

Live load surcharge (per **LRFD BDS [3.11.6.4]** & **BDM [307.1.1]**)
Note: If vehicular loading is within 1 ft of the backface of the wall and with a design height, H, less than 20 ft, see **LRFD BDS Section 3.11.6.4 and Table 3.11.6.4-2** for adjusted surcharge load calculation.
Note: When traffic vehicular live loads are not present within 0.5*H from the back of the reinforced zone let SUR equal 100 psf to account for construction loads.

Calculations:

Active Earth Pressure:

$\beta := 0 \qquad \delta := \beta$

Inclination of ground slope behind face of wall and angle of friction between retained backfill and reinforced soil

$$\Gamma := \left(1 + \sqrt{\frac{\left(\sin\left(\phi'_b + \delta\right) \cdot \sin\left(\phi'_b - \beta\right)\right)}{\left(\sin\left(\theta - \delta\right) \cdot \sin\left(\theta + \beta\right)\right)}}\right)^2$$

$$k_{af} := \left(\frac{\left(\sin\left(\theta + \phi'_b\right)\right)^2}{\left(\Gamma \cdot \left(\sin\left(\theta\right)\right)^2 \cdot \sin\left(\theta - \delta\right)\right)}\right) \qquad k_{af} = 0.3333$$

Active Earth Pressure Coefficient

$F_T := \frac{1}{2} \cdot \gamma_b \cdot H^2 \cdot k_{af} \qquad F_T = 9592.2 \ \frac{lbf}{ft}$ Active Earth Force Resultant (EH)

$F_{SUR} := SUR \cdot H \cdot k_{af} \qquad F_{SUR} = 1825 \ \frac{lbf}{ft}$ Live Load Surcharge (LS)

Vertical Loads:

$V_1 := \gamma_r \cdot H \cdot L \qquad V_1 = 40287.2 \ \frac{lbf}{ft}$ Soil backfill - reinforced soil (EV)

$V_2 := SUR \cdot L \qquad V_2 = 3832.5 \ \frac{lbf}{ft}$ Live Load Surcharge - (LS)

Moment Arm: Moment:

$d_{v1} := 0 \cdot ft \qquad d_{v1} = 0 \ ft \qquad MV_1 := V_1 \cdot d_{v1} \qquad MV_1 = 0 \ \frac{lbf \cdot ft}{ft}$

$d_{v2} := 0 \ ft \qquad d_{v2} = 0 \ ft \qquad MV_2 := V_2 \cdot d_{v2} \qquad MV_2 = 0 \ \frac{lbf \cdot ft}{ft}$

Horizontal Loads:

$H_1 := F_T = 9592.2 \ \frac{lbf}{ft}$ Active Earth Force Resultant (horizontal comp. - EH)

$H_2 := F_{SUR} = 1825 \ \frac{lbf}{ft}$ Live Load Surcharge Resultant (horizontal comp. - LS)

Moment Arm: Moment:

$d_{h1} := \frac{H}{3} \qquad d_{h1} = 7.3 \ ft \qquad MH_1 := H_1 \cdot d_{h1} \qquad MH_1 = 70023.1 \ \frac{lbf \cdot ft}{ft}$

$d_{h2} := \frac{H}{2} \qquad d_{h2} = 11 \ ft \qquad MH_2 := H_2 \cdot d_{h2} \qquad MH_2 = 19983.8 \ \frac{lbf \cdot ft}{ft}$

Unfactored Loads by Load Type

$V_{EV} := V_1$ $\quad V_{EV} = 40287.2 \ \frac{lbf}{ft}$

$V_{LS} := V_2$ $\quad V_{LS} = 3832.5 \ \frac{lbf}{ft}$

$H_{EH} := H_1$ $\quad H_{EH} = 9592.2 \ \frac{lbf}{ft}$

$H_{LS} := H_2$ $\quad H_{LS} = 1825 \ \frac{lbf}{ft}$

Unfactored Moments by Load Type

$M_{EV} := MV_1$ $\quad M_{EV} = 0 \ \frac{lbf \cdot ft}{ft}$

$M_{LS} := MV_2$ $\quad M_{LS} = 0 \ \frac{lbf \cdot ft}{ft}$

$M_{EH2} := MH_1$ $\quad M_{EH2} = 70023.1 \ \frac{lbf \cdot ft}{ft}$

$M_{LS2} := MH_2$ $\quad M_{LS2} = 19983.8 \ \frac{lbf \cdot ft}{ft}$

Load Combination Limit States:

$\eta := 1$ LRFD Load Modifier

Strength Limit State I: EV(min) = 1.00 EV(max) = 1.35
EH(min) = 0.90 EH(max) = 1.50
LS = 1.75

Strength Limit State Ia:
(Sliding and Eccentricity) $Ia_{EV} := 1$ $\quad Ia_{EH} := 1.5$ $\quad Ia_{LS} := 1.75$

Strength Limit State Ib:
(Bearing Capacity) $Ib_{EV} := 1.35$ $\quad Ib_{EH} := 1.5$ $\quad Ib_{LS} := 1.75$

Factored Vertical Loads by Limit State:

$V_{Ia} := \eta \cdot \left(Ia_{EV} \cdot V_{EV}\right)$ $\quad V_{Ia} = 40287.2 \ \frac{lbf}{ft}$

$V_{Ib} := \eta \cdot \left(\left(Ib_{EV} \cdot V_{EV}\right) + \left(Ib_{LS} \cdot V_{LS}\right)\right)$ $\quad V_{Ib} = 61094.6 \ \frac{lbf}{ft}$

Factored Horizontal Loads by Limit State:

$H_{Ia} := \eta \cdot \left(\left(Ia_{LS} \cdot H_{LS}\right) + \left(Ia_{EH} \cdot H_{EH}\right)\right)$ $\quad H_{Ia} = 17582.1 \ \frac{lbf}{ft}$

$H_{Ib} := \eta \cdot \left(\left(Ib_{LS} \cdot H_{LS}\right) + \left(Ib_{EH} \cdot H_{EH}\right)\right)$ $\quad H_{Ib} = 17582.1 \ \frac{lbf}{ft}$

Factored Moments Produced by Vertical Loads by Limit State:

$MV_{Ia} := \eta \cdot \left(Ia_{EV} \cdot M_{EV}\right)$ $\quad MV_{Ia} = 0 \ \frac{lbf \cdot ft}{ft}$

$MV_{Ib} := \eta \cdot \left(\left(Ib_{EV} \cdot M_{EV}\right) + \left(Ib_{LS} \cdot M_{LS}\right)\right)$ $\quad MV_{Ib} = 0 \ \frac{lbf \cdot ft}{ft}$

Factored Moments Produced by Horizontal Loads by Limit State:

$MH_{Ia} := \eta \cdot \left(\left(Ia_{LS} \cdot M_{LS2}\right) + \left(Ia_{EH} \cdot M_{EH2}\right)\right)$ $\quad MH_{Ia} = 140006.2 \ \frac{lbf \cdot ft}{ft}$

$MH_{Ib} := \eta \cdot \left(\left(Ib_{LS} \cdot M_{LS2}\right) + \left(Ib_{EH} \cdot M_{EH2}\right)\right)$ $\quad MH_{Ib} = 140006.2 \ \frac{lbf \cdot ft}{ft}$

Compute Bearing Resistance:

Compute the Effective Bearing Length (Strength Ib):

$\Sigma M_R := MV_{Ib}$ $\Sigma M_R = 0 \ \frac{lbf \cdot ft}{ft}$ Sum of Resisting Moments (Strength Ib)

$\Sigma M_O := MH_{Ib}$ $\Sigma M_O = 140006.2 \ \frac{lbf \cdot ft}{ft}$ Sum of Overturning Moments (Strength Ib)

$\Sigma V := V_{Ib}$ $\Sigma V = 61094.6 \ \frac{lbf}{ft}$ Sum of Vertical Loads (Strength Ib)

$e_{wall} := \frac{(\Sigma M_O - \Sigma M_R)}{\Sigma V}$ $e_{wall} = 2.3 \ ft$ Wall Eccentricity

$B' := \text{if}\left(e_{wall} > 0, L - 2 \cdot e_{wall}, L\right)$ $B' = 10.7 \ ft$ Effective Bearing Width

Foundation Layout:

$L_{Wall} := 30 \cdot ft$ Assumed Footing Length (Wall Section Length)

$H' := H_{Ib}$ $H' = 17582.1 \ \frac{lbf}{ft}$ Summation of Horizontal Loads (Strength Ib)

$V' := V_{Ib}$ $V' = 61094.6 \ \frac{lbf}{ft}$ Summation of Vertical Loads (Strength Ib)

$D_f := d_e$ $D_f = 3.5 \ ft$ Footing embedment

$d_w := 0 \cdot ft$ Depth of Groundwater below Bearing Grade

$\theta' := 90 \cdot deg$ Direction of H' and V' resultant measured from wall back face **LRFD [Figure C10.6.3.1.2a-1]**

Drained Conditions (Effective Stress):

$$N_q := \text{if}\left(\phi'_f > 0, e^{\pi \cdot \tan(\phi'_f)} \cdot \tan\left(45 \ deg + \frac{\phi'_f}{2}\right)^2, 1.0\right) \qquad N_q = 16.44$$

$$N_c := \text{if}\left(\phi'_f > 0, \frac{N_q - 1}{\tan(\phi'_f)}, 5.14\right) \qquad N_c = 27.86$$

$$N_\gamma := 2 \cdot (N_q + 1) \cdot \tan(\phi'_f) \qquad N_\gamma = 19.3$$

Compute shape correction factors per **LRFD [Table 10.6.3.1.2a-3]**:

$$s_c := \text{if}\left(\phi'_f > 0, 1 + \left(\frac{B'}{L_{Wall}}\right) \cdot \left(\frac{N_q}{N_c}\right), 1 + \left(\frac{B'}{5 \cdot L_{Wall}}\right)\right) \qquad s_c = 1.211$$

$$s_q := \text{if}\left(\phi'_f > 0, 1 + \left(\frac{B'}{L_{Wall}} \cdot \tan(\phi'_f)\right), 1\right) \qquad s_q = 1.199$$

$$s_\gamma := \text{if}\left(\phi'_f > 0, 1 - 0.4 \cdot \left(\frac{B'}{L_{Wall}}\right), 1\right) \qquad s_\gamma = 0.857$$

Load inclination factors using **LRFD [10.6.3.1.2a-5] thru [10.6.3.1.2a-9]:**

$i_q := 1$ $\quad\quad$ $i_q = 1$

$i_\gamma := 1$ $\quad\quad$ $i_\gamma = 1$

$i_c := 1$ $\quad\quad$ $i_c = 1$

Compute groundwater depth correction factors per **LRFD [Table 10.6.3.1.2a-2]**:

$C_{wq} := \text{if}\left(d_w \ge 0, 1, 0.5\right)$ $\quad\quad$ $C_{wq} = 1$

$C_{w\gamma} := \text{if}\left(d_w > 1.5 \cdot B', 1, 0.5\right)$ $\quad\quad$ $C_{w\gamma} = 0.5$

Depth Correction Factor per **Hanson (1970):**

$$d_q := \text{if}\left(\frac{D_f}{B'} \le 1, 1 + 2 \cdot \tan\left(\phi'_f\right) \cdot \left(1 - \sin\left(\phi'_f\right)\right)^2 \cdot \frac{D_f}{B'}, 1 + 2 \cdot \tan\left(\phi'_f\right) \cdot \left(1 - \sin\left(\phi'_f\right)\right)^2 \cdot \operatorname{atan}\left(\frac{D_f}{B'}\right)\right)$$

$d_q = 1.1$

Compute modified bearing capacity factors **LRFD [Equation 10.6.3.1.2a-2 to 10.6.3.1.2a-4]:**

$N_{cm} := N_c \cdot s_c \cdot i_c$ $\quad\quad$ $N_{cm} = 33.751$

$N_{qm} := N_q \cdot s_q \cdot i_q$ $\quad\quad$ $N_{qm} = 19.708$

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $\quad\quad$ $N_{\gamma m} = 16.567$

Compute nominal bearing resistance, **LRFD [Eq 10.6.3.1.2a-1]:**

$q_{nd} := c'_f \cdot N_{cm} + \gamma_q \cdot D_f \cdot N_{qm} \cdot d_q \cdot C_{wq} + 0.5 \cdot \gamma_f \cdot B' \cdot N_{\gamma m} \cdot C_{w\gamma}$ $\quad\quad$ $q_{nd} = 14412 \ \frac{lbf}{ft^2}$

Compute factored bearing resistance, **LRFD [Eq 10.6.3.1.1]:**

$\phi_b := 0.65$ $\quad\quad$ Bearing resistance factor **LRFD Table 11.5.7-1.**

$q_{Rd} := \phi_b \cdot q_{nd}$ $\quad\quad$ $q_{Rd} = 9.4 \ ksf$ $\quad\quad$ Factored bearing resistance Drained Conditions

Undrained Conditions (Effective Stress):

$N_q := \text{if}\left(\phi_f > 0, e^{\pi \cdot \tan\left(\phi_f\right)} \cdot \tan\left(45 \ deg + \frac{\phi_f}{2}\right)^2, 1.0\right)$ $\quad\quad$ $N_q = 16.44$

$N_c := \text{if}\left(\phi_f > 0, \frac{N_q - 1}{\tan\left(\phi_f\right)}, 5.14\right)$ $\quad\quad$ $N_c = 27.86$

$N_\gamma := 2 \cdot \left(N_q + 1\right) \cdot \tan\left(\phi_f\right)$ $\quad\quad$ $N_\gamma = 19.3$

Compute shape correction factors per **LRFD [Table 10.6.3.1.2a-3]**:

$s_c := \text{if}\left(\phi_f > 0, 1 + \left(\frac{B'}{L_{Wall}}\right) \cdot \left(\frac{N_q}{N_c}\right), 1 + \left(\frac{B'}{5 \cdot L_{Wall}}\right)\right)$ $s_c = 1.211$

$s_q := \text{if}\left(\phi_f > 0, 1 + \left(\frac{B'}{L_{Wall}} \cdot \tan\left(\phi_f\right)\right), 1\right)$ $s_q = 1.199$

$s_\gamma := \text{if}\left(\phi_f > 0, 1 - 0.4 \cdot \left(\frac{B'}{L_{Wall}}\right), 1\right)$ $s_\gamma = 0.857$

Load inclination factors using **LRFD [10.6.3.1.2a-5] thru [10.6.3.1.2a-9]:**

$i_q := 1$ $i_q = 1$

$i_\gamma := 1$ $i_\gamma = 1$

$i_c := 1$ $i_c = 1$

Compute modified bearing capacity factors **LRFD [Equation 10.6.3.1.2a-2 to 10.6.3.1.2a-4]:**

$N_{cm} := N_c \cdot s_c \cdot i_c$ $N_{cm} = 33.751$

$N_{qm} := N_q \cdot s_q \cdot i_q$ $N_{qm} = 19.708$

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $N_{\gamma m} = 16.567$

Compute nominal bearing resistance, **LRFD [Eq 10.6.3.1.2a-1:**

$q_{nu} := c_f \cdot N_{cm} + \gamma_q \cdot D_f \cdot N_{qm} \cdot d_q \cdot C_{wq} + 0.5 \cdot \gamma_f \cdot B' \cdot N_{\gamma m} \cdot C_{w\gamma}$ $q_{nu} = 14412 \ \frac{lbf}{ft^2}$

Compute factored bearing resistance, **LRFD [Eq 10.6.3.1.1]:**

$\phi_b := 0.65$ Bearing resistance factor **LRFD Table 11.5.7-1.**

$q_{Ru} := \phi_b \cdot q_{nu}$ $q_{Ru} = 9.4 \ ksf$ Factored bearing resistance Undrained Conditions

Factored Bearing Resistance Drained vs. Undrained Conditions:

Drained Conditions: $q_{Rd} = 9.4 \ ksf$

Undrained Conditions: $q_{Ru} = 9.4 \ ksf$

Factored Bearing Resistance to be used in CDR Calculations:

$q_R := q_{Rd}$

$q_R = 9.4 \ ksf$

Evaluate External Stability of Wall:

Bearing Resistance at Base of the Wall:

Compute the resultant location (distance from Point 'O'):

$\Sigma M_R := MV_{Ib}$ $\Sigma M_R = 0 \ \frac{lbf \cdot ft}{ft}$ Sum of Resisting Moments (Strength Ib)

$\Sigma M_O := MH_{Ib}$ $\Sigma M_O = 140006.2 \ \frac{lbf \cdot ft}{ft}$ Sum of Overturning Moments (Strength Ib)

$\Sigma V := V_{Ib}$ $\Sigma V = 61094.6 \ \frac{lbf}{ft}$ Sum of Vertical Loads (Strength Ib)

$e_{wall} := \frac{(\Sigma M_O - \Sigma M_R)}{\Sigma V}$ $e_{wall} = 2.3 \ ft$ Wall Eccentricity

$B' := \text{if}\left(e_{wall} > 0, L - 2 \cdot e_{wall}, L\right)$ $B' = 10.7 \ ft$ Effective Bearing Width

Compute the ultimate bearing stress:

$\sigma_v := \frac{\Sigma V}{B'}$ $\sigma_v = 5684.9 \ \frac{lbf}{ft^2}$ Ultimate Bearing Stress

Bearing Capacity:Demand Ratio (CDR)

$CDR_{Bearing} := \frac{q_R}{\sigma_v}$ Is the CDR > or = to 1.0? $CDR_{Bearing} = 1.65$

Limiting Eccentricity at Base of MSE Wall (Strength Ia):

$e_{max} := \frac{L}{3}$ $e_{max} = 5.1 \ ft$ Maximum Eccentricity **LRFD [C11.6.3.3.]**

$\Sigma M_R := MV_{Ia}$ $\Sigma M_R = 0 \ \frac{lbf \cdot ft}{ft}$ Sum of Resisting Moments (Strength Ia)

$\Sigma M_O := MH_{Ia}$ $\Sigma M_O = 140006.2 \ \frac{lbf \cdot ft}{ft}$ Sum of Overturning Moments (Strength Ia)

$\Sigma V := V_{Ia}$ $\Sigma V = 40287.2 \ \frac{lbf}{ft}$ Sum of Vertical Loads (Strength Ia)

$e_{wall} := \frac{(\Sigma M_O - \Sigma M_R)}{\Sigma V}$ $e_{wall} = 3.5 \ ft$

Eccentricity Capacity:Demand Ratio (CDR)

$CDR_{Eccentricity} := \frac{e_{max}}{e_{wall}}$ Is the CDR > or = to 1.0? $CDR_{Eccentricity} = 1.47$

Sliding Resistance at Base of Wall LRFD [10.6.3.4]:

Factored Sliding Force (Strength Ia):

$F_\tau := H_{Ia}$ $\qquad F_\tau = 17582.1\ \frac{lbf}{ft}$

Compute sliding resistance between soil and foundation:

Drained Conditions:

$\Sigma V := V_{Ia}$ $\qquad \Sigma V = 40287.2\ \frac{lbf}{ft}$ $\qquad$ Sum of Vertical Loads (Strength Ia)

$R_{\tau d} := \Sigma V \cdot \tan\left(\phi'_f\right)$ $\qquad R_{\tau d} = 22331.6\ \frac{lbf}{ft}$ $\qquad$ Nominal sliding resistance Drained Conditions

Nominal Sliding Resistance Drained Conditions:

Drained Conditions: $R_{\tau d} = 22.332\ \frac{kip}{ft}$

Nominal Sliding Resistance to be used in CDR Calculations: $R_\tau := R_{\tau d}$

Compute factored resistance against failure by sliding **LRFD [10.6.3.4]**:

$\phi_\tau := 1.0$ $\qquad$ Resistance factor for sliding resistance specified in **LRFD Table 11.5.7-1.**

$\phi R_n := \phi_\tau \cdot R_\tau$ $\qquad R_R := \phi R_n$

$R_R = 22.3\ \frac{kip}{ft}$

Sliding Capacity:Demand Ratio (CDR)

$CDR_{Sliding} := \frac{R_R}{F_\tau}$ $\qquad$ Is the CDR > or = to 1.0? $\qquad CDR_{Sliding} = 1.27$

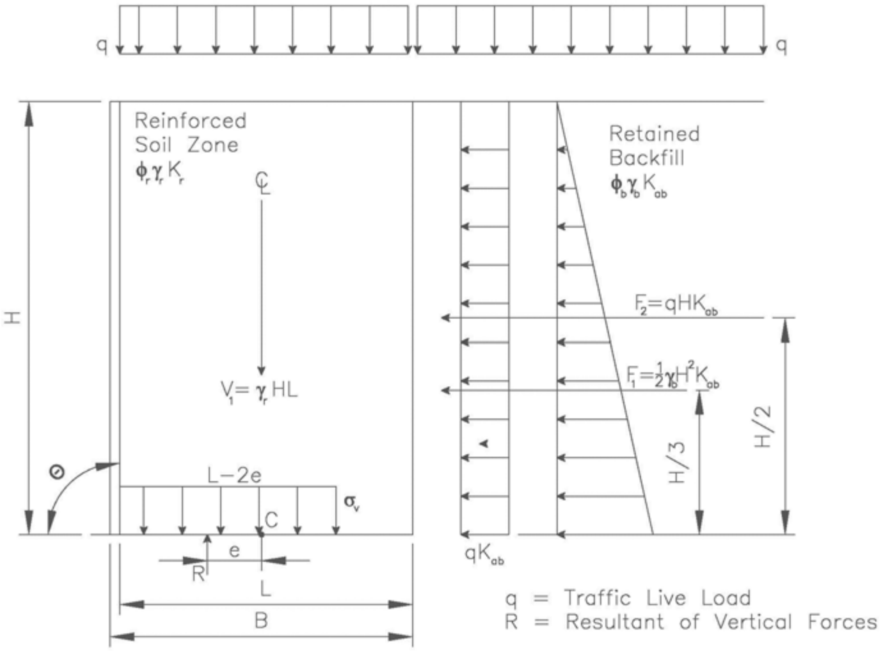
RETAINING WALL AC – STA. 04+28.8

Objective: To evaluate the external stability of MSE wall design with vertical wall face and horizontal backfill.

Method: In accordance with ODOT Bridge Design Manual, 2013 [Sect. 307] LRFD Bridge Design Specifications, 8th Ed., 2018, [Sect. 11.10.5].

Assumptions:

- **Horizontal backfill behind MSE wall on granular (drained) soils.**
- **For battered or vertical walls with a back face of wall angle of θ to horizontal.**
- **Not for sheet type reinforcement. If so, use different assessment for Sliding parameter ϕ_{μ}.**
- **MSE wall not acting as abutment, if so must meet minimum embedment depth of H/10 if no slope in front of wall**
- **Load combinations and wall configuration are as shown below:**



Givens:

Wall Geometry:

$H_e := 11.9 \cdot ft$ Exposed wall height

$\theta := 90 \cdot deg$ Angle of back face of wall to horizontal: 90 deg for vertical or near vertical walls (per Berg et al., 2009; near vertical = 80 deg < θ < 100 deg)

Reinforced Backfill Soil Design Parameters:

$\phi'_r := 34 \cdot deg$ Effective angle of internal friction (Per BDM [Table 307-1])

$\gamma_r := 120 \cdot \frac{lbf}{ft^3}$ Unit weight (Per BDM [Table 307-1])

$c'_r := 0 \cdot \frac{lbf}{ft^2}$ Effective Cohesion

Retained Backfill Soil Design Parameters:

$\phi'_b := 30 \cdot deg$ Effective angle of internal friction (Per BDM [Table 307-1])

$\gamma_b := 120 \cdot \frac{lbf}{ft^3}$ Unit weight (Per BDM [Table 307-1])

$c'_b := 0 \cdot \frac{lbf}{ft^2}$ Effective Cohesion

Foundation Soil Design Parameters:

Drained Conditions (Effective Stress):

$\phi'_f := 30 \cdot deg$

Effective angle of internal friction

$\gamma_f := 120 \cdot \frac{lbf}{ft^3}$

Unit weight

$c'_f := 0 \cdot \frac{lbf}{ft^2}$

Cohesion

Undrained Conditions (Total Stress):

$\phi_f := 30 \cdot deg$

Angle of internal friction (Same as Drained Conditions if Sand)

$\gamma_f = 120 \ \frac{lbf}{ft^3}$

Unit weight

$c_f := 0 \cdot \frac{lbf}{ft^2}$

Cohesion (Use Su if Angle of internal friction = 0 deg)

Foundation Surcharge Soil Parameters:

$\gamma_q := 120 \cdot \frac{lbf}{ft^3}$

Unit weight of Soil above bearing depth (Used in Bearing Resistance of Soil Calculation LRFD 10.6.3.1.2a-1)

Depth of Embedment Check:

$d_{frost} := 3.5 \ ft$ $d_{user} := 0 \ ft$

Local Frost Depth

$Slope_{fw} := 0 \ deg$

Inclination of ground slope in front of wall :

- Horizontal: **0**
- 3H:1V: **18.435**
- 2H:1V: **26.565**
- 1.5H:1V: **33.690**

$d_{est} := \max\left(d_{frost}, 3 \ ft, d_{user}\right)$ $d_{est} = 3.5 \ ft$

$H_{est} := d_{est} + \left(4 \ ft \cdot \tan\left(Slope_{fw}\right)\right) + H_e$ $H_{est} = 15.4 \ ft$

$$d_{eSlope} := \text{if}\left(Slope_{fw} < 1 \ deg, \frac{H_{est}}{20}, \text{if}\left(Slope_{fw} < 26.565 \ deg, \frac{H_{est}}{10}, \text{if}\left(Slope_{fw} < 33.69 \ deg, \frac{H_{est}}{7}, \frac{H_{est}}{5}\right)\right)\right)$$

$d_{eSlope} = 0.8 \ ft$

Minimum Embedment Depth per Table C11.10.2.2-1 of LRFD BDS

$d_e := \max\left(d_{est}, d_{eSlope}\right)$ $d_e = 3.5 \ ft$

Minimum Required Embedment Depth used in analysis.

$H := d_e + \left(4 \ ft \cdot \tan\left(Slope_{fw}\right)\right) + H_e$ $H = 15.4 \ ft$

Design Wall Height

Estimate Length of Reinforcement:

$L_{user} := 0 \cdot ft$

User inputted value (if changes need to be made to satisfy other requirements)

$L := \max\left(8 \cdot ft, 0.7 \cdot H, L_{user}\right)$ $L = 10.8 \ ft$

Length of Reinforcement

Live Load Surcharge Parameters:

$SUR := 250 \cdot \frac{lbf}{ft^2}$

Live load surcharge (per **LRFD BDS [3.11.6.4]** & **BDM [307.1.1]**)
Note: If vehicular loading is within 1 ft of the backface of the wall and with a design height, H, less than 20 ft, see **LRFD BDS Section 3.11.6.4 and Table 3.11.6.4-2** for adjusted surcharge load calculation.
Note: When traffic vehicular live loads are not present within 0.5*H from the back of the reinforced zone let SUR equal 100 psf to account for construction loads.

Calculations:

Active Earth Pressure:

$\beta := 0 \qquad \delta := \beta$

Inclination of ground slope behind face of wall and angle of friction between retained backfill and reinforced soil

$$\Gamma := \left(1 + \sqrt{\frac{\left(\sin\left(\phi'_b + \delta\right) \cdot \sin\left(\phi'_b - \beta\right)\right)}{\left(\sin\left(\theta - \delta\right) \cdot \sin\left(\theta + \beta\right)\right)}}\right)^2$$

$$k_{af} := \left(\frac{\left(\sin\left(\theta + \phi'_b\right)\right)^2}{\left(\Gamma \cdot \left(\sin\left(\theta\right)\right)^2 \cdot \sin\left(\theta - \delta\right)\right)}\right) \qquad k_{af} = 0.3333$$

Active Earth Pressure Coefficient

$F_T := \frac{1}{2} \cdot \gamma_b \cdot H^2 \cdot k_{af} \qquad F_T = 4743.2\ \frac{lbf}{ft}$ Active Earth Force Resultant (EH)

$F_{SUR} := SUR \cdot H \cdot k_{af} \qquad F_{SUR} = 1283.3\ \frac{lbf}{ft}$ Live Load Surcharge (LS)

Vertical Loads:

$V_1 := \gamma_r \cdot H \cdot L \qquad V_1 = 19921.4\ \frac{lbf}{ft}$ Soil backfill - reinforced soil (EV)

$V_2 := SUR \cdot L \qquad V_2 = 2695\ \frac{lbf}{ft}$ Live Load Surcharge - (LS)

Moment Arm: Moment:

$d_{v1} := 0 \cdot ft \qquad d_{v1} = 0\ ft \qquad MV_1 := V_1 \cdot d_{v1} \qquad MV_1 = 0\ \frac{lbf \cdot ft}{ft}$

$d_{v2} := 0\ ft \qquad d_{v2} = 0\ ft \qquad MV_2 := V_2 \cdot d_{v2} \qquad MV_2 = 0\ \frac{lbf \cdot ft}{ft}$

Horizontal Loads:

$H_1 := F_T = 4743.2\ \frac{lbf}{ft}$ Active Earth Force Resultant (horizontal comp. - EH)

$H_2 := F_{SUR} = 1283.3\ \frac{lbf}{ft}$ Live Load Surcharge Resultant (horizontal comp. - LS)

Moment Arm: Moment:

$d_{h1} := \frac{H}{3} \qquad d_{h1} = 5.1\ ft \qquad MH_1 := H_1 \cdot d_{h1} \qquad MH_1 = 24348.4\ \frac{lbf \cdot ft}{ft}$

$d_{h2} := \frac{H}{2} \qquad d_{h2} = 7.7\ ft \qquad MH_2 := H_2 \cdot d_{h2} \qquad MH_2 = 9881.7\ \frac{lbf \cdot ft}{ft}$

Unfactored Loads by Load Type

$V_{EV} := V_1$ $\qquad V_{EV} = 19921.4\ \frac{lbf}{ft}$

$V_{LS} := V_2$ $\qquad V_{LS} = 2695\ \frac{lbf}{ft}$

$H_{EH} := H_1$ $\qquad H_{EH} = 4743.2\ \frac{lbf}{ft}$

$H_{LS} := H_2$ $\qquad H_{LS} = 1283.3\ \frac{lbf}{ft}$

Unfactored Moments by Load Type

$M_{EV} := MV_1$ $\qquad M_{EV} = 0\ \frac{lbf \cdot ft}{ft}$

$M_{LS} := MV_2$ $\qquad M_{LS} = 0\ \frac{lbf \cdot ft}{ft}$

$M_{EH2} := MH_1$ $\qquad M_{EH2} = 24348.4\ \frac{lbf \cdot ft}{ft}$

$M_{LS2} := MH_2$ $\qquad M_{LS2} = 9881.7\ \frac{lbf \cdot ft}{ft}$

Load Combination Limit States:

$\eta := 1$ LRFD Load Modifier

Strength Limit State I: EV(min) = 1.00 EV(max) = 1.35
EH(min) = 0.90 EH(max) = 1.50
LS = 1.75

Strength Limit State Ia:
(Sliding and Eccentricity) $\quad Ia_{EV} := 1 \quad Ia_{EH} := 1.5 \quad Ia_{LS} := 1.75$

Strength Limit State Ib:
(Bearing Capacity) $\quad Ib_{EV} := 1.35 \quad Ib_{EH} := 1.5 \quad Ib_{LS} := 1.75$

Factored Vertical Loads by Limit State:

$V_{Ia} := \eta \cdot \left(Ia_{EV} \cdot V_{EV}\right)$ $\qquad V_{Ia} = 19921.4\ \frac{lbf}{ft}$

$V_{Ib} := \eta \cdot \left(\left(Ib_{EV} \cdot V_{EV}\right) + \left(Ib_{LS} \cdot V_{LS}\right)\right)$ $\qquad V_{Ib} = 31610.2\ \frac{lbf}{ft}$

Factored Horizontal Loads by Limit State:

$H_{Ia} := \eta \cdot \left(\left(Ia_{LS} \cdot H_{LS}\right) + \left(Ia_{EH} \cdot H_{EH}\right)\right)$ $\qquad H_{Ia} = 9360.6\ \frac{lbf}{ft}$

$H_{Ib} := \eta \cdot \left(\left(Ib_{LS} \cdot H_{LS}\right) + \left(Ib_{EH} \cdot H_{EH}\right)\right)$ $\qquad H_{Ib} = 9360.6\ \frac{lbf}{ft}$

Factored Moments Produced by Vertical Loads by Limit State:

$MV_{Ia} := \eta \cdot \left(Ia_{EV} \cdot M_{EV}\right)$ $\qquad MV_{Ia} = 0\ \frac{lbf \cdot ft}{ft}$

$MV_{Ib} := \eta \cdot \left(\left(Ib_{EV} \cdot M_{EV}\right) + \left(Ib_{LS} \cdot M_{LS}\right)\right)$ $\qquad MV_{Ib} = 0\ \frac{lbf \cdot ft}{ft}$

Factored Moments Produced by Horizontal Loads by Limit State:

$MH_{Ia} := \eta \cdot \left(\left(Ia_{LS} \cdot M_{LS2}\right) + \left(Ia_{EH} \cdot M_{EH2}\right)\right)$ $\qquad MH_{Ia} = 53815.6\ \frac{lbf \cdot ft}{ft}$

$MH_{Ib} := \eta \cdot \left(\left(Ib_{LS} \cdot M_{LS2}\right) + \left(Ib_{EH} \cdot M_{EH2}\right)\right)$ $\qquad MH_{Ib} = 53815.6\ \frac{lbf \cdot ft}{ft}$

Compute Bearing Resistance:

Compute the Effective Bearing Length (Strength Ib):

$\Sigma M_R := MV_{Ib}$	$\Sigma M_R = 0 \ \frac{lbf \cdot ft}{ft}$	Sum of Resisting Moments (Strength Ib)
$\Sigma M_O := MH_{Ib}$	$\Sigma M_O = 53815.6 \ \frac{lbf \cdot ft}{ft}$	Sum of Overturning Moments (Strength Ib)
$\Sigma V := V_{Ib}$	$\Sigma V = 31610.2 \ \frac{lbf}{ft}$	Sum of Vertical Loads (Strength Ib)
$e_{wall} := \frac{(\Sigma M_O - \Sigma M_R)}{\Sigma V}$	$e_{wall} = 1.7 \ ft$	Wall Eccentricity
$B' := \text{if}\left(e_{wall} > 0, L - 2 \cdot e_{wall}, L\right)$	$B' = 7.4 \ ft$	Effective Bearing Width

Foundation Layout:

$L_{Wall} := 30 \cdot ft$		Assumed Footing Length (Wall Section Length)
$H' := H_{Ib}$	$H' = 9360.6 \ \frac{lbf}{ft}$	Summation of Horizontal Loads (Strength Ib)
$V' := V_{Ib}$	$V' = 31610.2 \ \frac{lbf}{ft}$	Summation of Vertical Loads (Strength Ib)
$D_f := d_e$	$D_f = 3.5 \ ft$	Footing embedment
$d_w := 0 \cdot ft$		Depth of Groundwater below Bearing Grade
$\theta' := 90 \cdot deg$		Direction of H' and V' resultant measured from wall back face **LRFD [Figure C10.6.3.1.2a-1]**

Drained Conditions (Effective Stress):

$$N_q := \text{if}\left(\phi'_f > 0, e^{\pi \cdot \tan(\phi'_f)} \cdot \tan\left(45 \ deg + \frac{\phi'_f}{2}\right)^2, 1.0\right) \qquad N_q = 18.4$$

$$N_c := \text{if}\left(\phi'_f > 0, \frac{N_q - 1}{\tan(\phi'_f)}, 5.14\right) \qquad N_c = 30.14$$

$$N_\gamma := 2 \cdot (N_q + 1) \cdot \tan(\phi'_f) \qquad N_\gamma = 22.4$$

Compute shape correction factors per **LRFD [Table 10.6.3.1.2a-3]**:

$$s_c := \text{if}\left(\phi'_f > 0, 1 + \left(\frac{B'}{L_{Wall}}\right) \cdot \left(\frac{N_q}{N_c}\right), 1 + \left(\frac{B'}{5 \cdot L_{Wall}}\right)\right) \qquad s_c = 1.15$$

$$s_q := \text{if}\left(\phi'_f > 0, 1 + \left(\frac{B'}{L_{Wall}} \cdot \tan(\phi'_f)\right), 1\right) \qquad s_q = 1.142$$

$$s_\gamma := \text{if}\left(\phi'_f > 0, 1 - 0.4 \cdot \left(\frac{B'}{L_{Wall}}\right), 1\right) \qquad s_\gamma = 0.902$$

Load inclination factors using **LRFD [10.6.3.1.2a-5] thru [10.6.3.1.2a-9]:**

$i_q := 1$ $\qquad$ $i_q = 1$

$i_\gamma := 1$ $\qquad$ $i_\gamma = 1$

$i_c := 1$ $\qquad$ $i_c = 1$

Compute groundwater depth correction factors per **LRFD [Table 10.6.3.1.2a-2]**:

$C_{wq} := \text{if}\left(d_w \geq 0, 1, 0.5\right)$ $\qquad$ $C_{wq} = 1$

$C_{w\gamma} := \text{if}\left(d_w > 1.5 \cdot B', 1, 0.5\right)$ $\qquad$ $C_{w\gamma} = 0.5$

Depth Correction Factor per **Hanson (1970):**

$$d_q := \text{if}\left(\frac{D_f}{B'} \leq 1, 1 + 2 \cdot \tan\left(\phi'_f\right) \cdot \left(1 - \sin\left(\phi'_f\right)\right)^2 \cdot \frac{D_f}{B'}, 1 + 2 \cdot \tan\left(\phi'_f\right) \cdot \left(1 - \sin\left(\phi'_f\right)\right)^2 \cdot \text{atan}\left(\frac{D_f}{B'}\right)\right)$$

$d_q = 1.1$

Compute modified bearing capacity factors **LRFD [Equation 10.6.3.1.2a-2 to 10.6.3.1.2a-4]:**

$N_{cm} := N_c \cdot s_c \cdot i_c$ $\qquad$ $N_{cm} = 34.663$

$N_{qm} := N_q \cdot s_q \cdot i_q$ $\qquad$ $N_{qm} = 21.013$

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $\qquad$ $N_{\gamma m} = 20.2$

Compute nominal bearing resistance, **LRFD [Eq 10.6.3.1.2a-1]:**

$q_{nd} := c'_f \cdot N_{cm} + \gamma_q \cdot D_f \cdot N_{qm} \cdot d_q \cdot C_{wq} + 0.5 \cdot \gamma_f \cdot B' \cdot N_{\gamma m} \cdot C_{w\gamma}$ $\qquad$ $q_{nd} = 14503.6\ \frac{\mathbf{lbf}}{\mathbf{ft}^2}$

Compute factored bearing resistance, **LRFD [Eq 10.6.3.1.1]:**

$\phi_b := 0.65$ $\qquad$ Bearing resistance factor **LRFD Table 11.5.7-1.**

$q_{Rd} := \phi_b \cdot q_{nd}$ $\qquad$ $q_{Rd} = 9.4\ \mathbf{ksf}$ $\qquad$ Factored bearing resistance Drained Conditions

Undrained Conditions (Effective Stress):

$N_q := \text{if}\left(\phi_f > 0, e^{\pi \cdot \tan\left(\phi_f\right)} \cdot \tan\left(45\ \mathbf{deg} + \frac{\phi_f}{2}\right)^2, 1.0\right)$ $\qquad$ $N_q = 18.4$

$N_c := \text{if}\left(\phi_f > 0, \frac{N_q - 1}{\tan\left(\phi_f\right)}, 5.14\right)$ $\qquad$ $N_c = 30.14$

$N_\gamma := 2 \cdot \left(N_q + 1\right) \cdot \tan\left(\phi_f\right)$ $\qquad$ $N_\gamma = 22.4$

Compute shape correction factors per **LRFD [Table 10.6.3.1.2a-3]**:

$s_c := \text{if}\left(\phi_f > 0, 1 + \left(\frac{B'}{L_{Wall}}\right) \cdot \left(\frac{N_q}{N_c}\right), 1 + \left(\frac{B'}{5 \cdot L_{Wall}}\right)\right)$ $s_c = 1.15$

$s_q := \text{if}\left(\phi_f > 0, 1 + \frac{B'}{L_{Wall}} \cdot \tan\left(\phi_f\right), 1\right)$ $s_q = 1.142$

$s_\gamma := \text{if}\left(\phi_f > 0, 1 - 0.4 \cdot \left(\frac{B'}{L_{Wall}}\right), 1\right)$ $s_\gamma = 0.902$

Load inclination factors using **LRFD [10.6.3.1.2a-5] thru [10.6.3.1.2a-9]:**

$i_q := 1$ $i_q = 1$

$i_\gamma := 1$ $i_\gamma = 1$

$i_c := 1$ $i_c = 1$

Compute modified bearing capacity factors **LRFD [Equation 10.6.3.1.2a-2 to 10.6.3.1.2a-4]:**

$N_{cm} := N_c \cdot s_c \cdot i_c$ $N_{cm} = 34.663$

$N_{qm} := N_q \cdot s_q \cdot i_q$ $N_{qm} = 21.013$

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $N_{\gamma m} = 20.2$

Compute nominal bearing resistance, **LRFD [Eq 10.6.3.1.2a-1:**

$q_{nu} := c_f \cdot N_{cm} + \gamma_q \cdot D_f \cdot N_{qm} \cdot d_q \cdot C_{wq} + 0.5 \cdot \gamma_f \cdot B' \cdot N_{\gamma m} \cdot C_{w\gamma}$ $q_{nu} = 14503.6 \ \frac{lbf}{ft^2}$

Compute factored bearing resistance, **LRFD [Eq 10.6.3.1.1]:**

$\phi_b := 0.65$ Bearing resistance factor **LRFD Table 11.5.7-1.**

$q_{Ru} := \phi_b \cdot q_{nu}$ $q_{Ru} = 9.4 \ ksf$ Factored bearing resistance Undrained Conditions

Factored Bearing Resistance Drained vs. Undrained Conditions:

Drained Conditions: $q_{Rd} = 9.4 \ ksf$

Undrained Conditions: $q_{Ru} = 9.4 \ ksf$

Factored Bearing Resistance to be used in CDR Calculations:

$q_R := q_{Rd}$

$q_R = 9.4 \ ksf$

Evaluate External Stability of Wall:

Bearing Resistance at Base of the Wall:

Compute the resultant location (distance from Point 'O'):

$\Sigma M_R := MV_{Ib}$ $\Sigma M_R = 0\ \frac{lbf \cdot ft}{ft}$ Sum of Resisting Moments (Strength Ib)

$\Sigma M_O := MH_{Ib}$ $\Sigma M_O = 53815.6\ \frac{lbf \cdot ft}{ft}$ Sum of Overturning Moments (Strength Ib)

$\Sigma V := V_{Ib}$ $\Sigma V = 31610.2\ \frac{lbf}{ft}$ Sum of Vertical Loads (Strength Ib)

$e_{wall} := \frac{\left(\Sigma M_O - \Sigma M_R\right)}{\Sigma V}$ $e_{wall} = 1.7\ ft$ Wall Eccentricity

$B' := \text{if}\left(e_{wall} > 0, L - 2 \cdot e_{wall}, L\right)$ $B' = 7.4\ ft$ Effective Bearing Width

Compute the ultimate bearing stress:

$\sigma_v := \frac{\Sigma V}{B'}$ $\sigma_v = 4286.1\ \frac{lbf}{ft^2}$ Ultimate Bearing Stress

Bearing Capacity:Demand Ratio (CDR)

$CDR_{Bearing} := \frac{q_R}{\sigma_v}$ Is the CDR > or = to 1.0? $CDR_{Bearing} = 2.20$

Limiting Eccentricity at Base of MSE Wall (Strength Ia):

$e_{max} := \frac{L}{3}$ $e_{max} = 3.6\ ft$ Maximum Eccentricity **LRFD [C11.6.3.3.]**

$\Sigma M_R := MV_{Ia}$ $\Sigma M_R = 0\ \frac{lbf \cdot ft}{ft}$ Sum of Resisting Moments (Strength Ia)

$\Sigma M_O := MH_{Ia}$ $\Sigma M_O = 53815.6\ \frac{lbf \cdot ft}{ft}$ Sum of Overturning Moments (Strength Ia)

$\Sigma V := V_{Ia}$ $\Sigma V = 19921.4\ \frac{lbf}{ft}$ Sum of Vertical Loads (Strength Ia)

$e_{wall} := \frac{\left(\Sigma M_O - \Sigma M_R\right)}{\Sigma V}$ $e_{wall} = 2.7\ ft$

Eccentricity Capacity:Demand Ratio (CDR)

$CDR_{Eccentricity} := \frac{e_{max}}{e_{wall}}$ Is the CDR > or = to 1.0? $CDR_{Eccentricity} = 1.33$

Sliding Resistance at Base of Wall LRFD [10.6.3.4]:

Factored Sliding Force (Strength Ia):

$F_\tau := H_{Ia}$ $\qquad F_\tau = 9360.6\ \dfrac{lbf}{ft}$

Compute sliding resistance between soil and foundation:

Drained Conditions:

$\Sigma V := V_{Ia}$ $\qquad \Sigma V = 19921.4\ \dfrac{lbf}{ft}$ Sum of Vertical Loads (Strength Ia)

$R_{\tau d} := \Sigma V \cdot \tan\left(\phi'_f\right)$ $\qquad R_{\tau d} = 11501.6\ \dfrac{lbf}{ft}$ Nominal sliding resistance Drained Conditions

Nominal Sliding Resistance Drained Conditions:

Drained Conditions: $R_{\tau d} = 11.502\ \dfrac{kip}{ft}$

Nominal Sliding Resistance to be used in CDR Calculations: $R_\tau := R_{\tau d}$

Compute factored resistance against failure by sliding **LRFD [10.6.3.4]**:

$\phi_\tau := 1.0$ Resistance factor for sliding resistance specified in **LRFD Table 11.5.7-1.**

$\phi R_n := \phi_\tau \cdot R_\tau$ $\qquad R_R := \phi R_n$

$R_R = 11.5\ \dfrac{kip}{ft}$

Sliding Capacity:Demand Ratio (CDR)

$CDR_{Sliding} := \dfrac{R_R}{F_\tau}$ Is the CDR > or = to 1.0? $CDR_{Sliding} = 1.23$

APPENDIX E

SETTLEMENT ANALYSIS - RETAINING WALL AC

CUY-90-16.28 (CCGA)

PROJECT IDENTIFICATION

Title:	CUY-90-16.28 (CCGA)
Project Number:	PID 82382 -
Client:	Michael Baker International
Designer:	KCA
Station Number:	

Description:

Company's information:

Name:	NEAS Inc.
Street:	2800 Corporate Exchange Drive, Suite 240 Columbus, OH 43231
Telephone #:	614-714-0299
Fax #:	614-714-0251
E-Mail:	brendan.andrews@neasinc.com

Original file path and name: P:\21-0011 ..... \Analysis\WallAC\Settlement\WallAC_FOSSA091721.2ST
Original date and time of creating this file: Fri Sep 17 15:08:29 2021

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 7 layers

	Wet Unit Weight, γ [lb/ft³]	**Poisson's Ratio μ**	**Description of Soil**
1	125.00	0.25	Soil Type 1
2	120.00	0.25	Soil Type 2B
3	128.00	0.30	Soil Type 2
4	130.00	0.45	Soil Type 3A
5	130.00	0.45	Soil Type 3B
6	122.00	0.45	Soil Type 4
7	150.00	0.20	Termination Layer

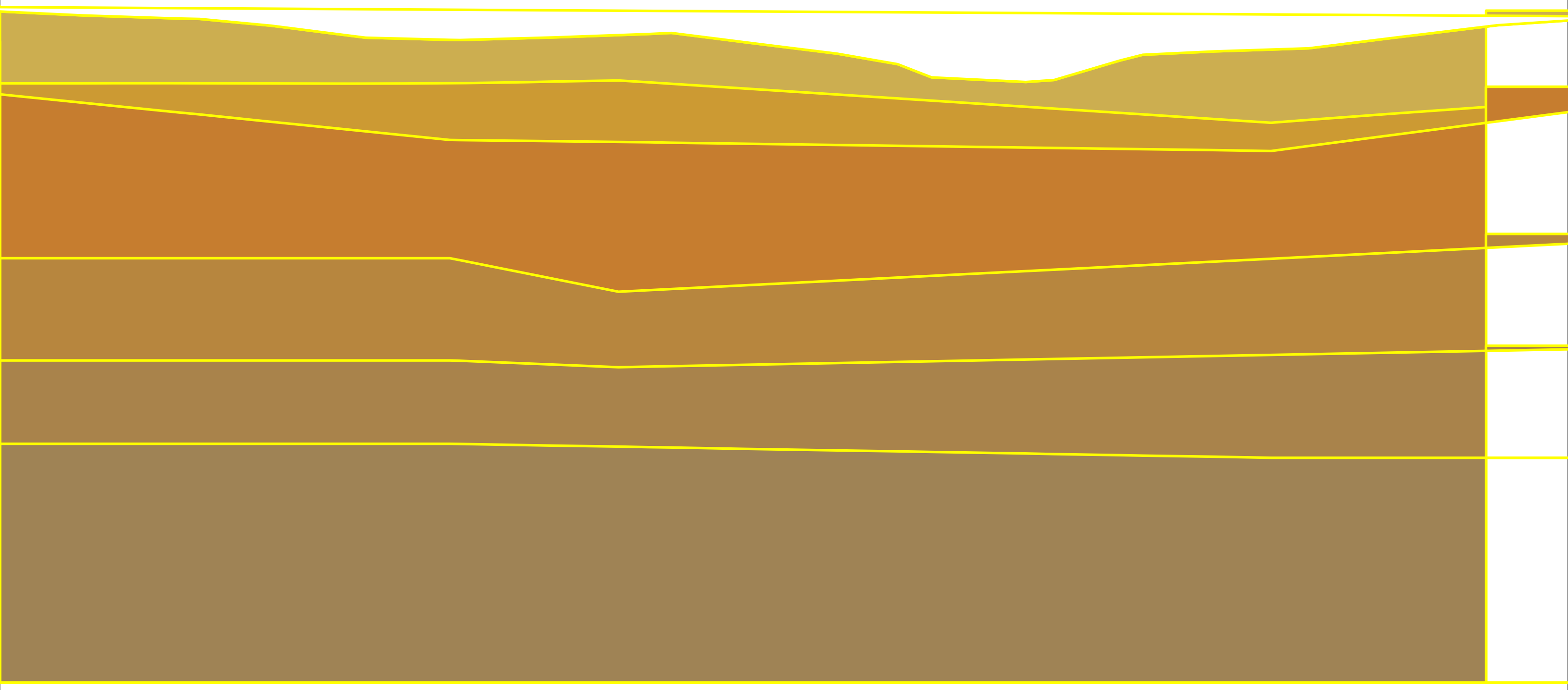
INPUT DATA – EMBANKMENT LAYERS -- 1 layers

	Wet Unit Weight, γ [lb/ft³]	**Description of Soil**
1	120.00	Proposed Embankment/Retaining Wall

INPUT DATA OF WATER

Point #	**Coordinates (X, Z) : (X) [ft.]**	**(Z) [ft.]**
1	150.00	650.40
2	515.00	650.00
3	645.00	677.00
4	650.00	677.00

DRAWING OF SPECIFIED GEOMETRY



INPUT DATA FOR CONSOLIDATION –– $\alpha = 1/2$

Layer #	Underging Consolidation [Yes/No]	OCR = Pc / Po	Cc	Cr	e0	Cv [ft ²/day]	Drains at :
1	No	N/A	N/A	N/A	N/A	N/A	N/A
2	No	N/A	N/A	N/A	N/A	N/A	N/A
3	No	N/A	N/A	N/A	N/A	N/A	N/A
4	Yes	1.50	0.060	0.005	0.542	0.5500	Top
5	Yes	1.10	0.090	0.013	0.600	0.3800	Top
6	Yes	1.10	0.240	0.048	0.743	0.2100	Top
7	No	N/A	N/A	N/A	N/A	N/A	N/A

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	150.00	0.00	1	878000	0.2500	-0.0000	688.80	688.80	-0.00
			2	211000	0.2500	0.0000			
			3	902000	0.3000	-0.0012			
			4	2000000	0.4500	-0.0012			
			5	2000000	0.4500	-0.0008			
			6	2000000	0.4500	0.0010			
			7	1000000000(	0.2000	0.0000			
2	170.00	0.00	1	878000	0.2500	0.0014	687.84	687.83	0.01
			2	211000	0.2500	0.0005			
			3	902000	0.3000	0.0010			
			4	2000000	0.4500	-0.0008			
			5	2000000	0.4500	-0.0004			
			6	2000000	0.4500	0.0034			
			7	1000000000(	0.2000	0.0000			
3	190.00	0.00	1	878000	0.2500	0.0028	686.88	686.87	0.01
			2	211000	0.2500	0.0023			
			3	902000	0.3000	0.0037			
			4	2000000	0.4500	-0.0002			
			5	2000000	0.4500	0.0001			
			6	2000000	0.4500	0.0062			
			7	1000000000(	0.2000	0.0000			
4	210.00	0.00	1	878000	0.2500	0.0038	686.08	686.05	0.03
			2	211000	0.2500	0.0051			
			3	902000	0.3000	0.0064			
			4	2000000	0.4500	0.0005			
			5	2000000	0.4500	0.0008			
			6	2000000	0.4500	0.0094			
			7	1000000000(	0.2000	0.0000			
5	230.00	0.00	1	878000	0.2500	0.0045	685.52	685.48	0.04
			2	211000	0.2500	0.0092			
			3	902000	0.3000	0.0096			
			4	2000000	0.4500	0.0015			
			5	2000000	0.4500	0.0015			
			6	2000000	0.4500	0.0128			
			7	1000000000(	0.2000	0.0000			
6	250.00	0.00	1	878000	0.2500	0.0065	683.70	683.64	0.06
			2	211000	0.2500	0.0188			
			3	902000	0.3000	0.0138			
			4	2000000	0.4500	0.0025			
			5	2000000	0.4500	0.0023			
			6	2000000	0.4500	0.0165			
			7	1000000000(	0.2000	0.0000			
7	270.00	0.00	1	878000	0.2500	0.0083	681.14	681.05	0.09
			2	211000	0.2500	0.0328			
			3	902000	0.3000	0.0176			
			4	2000000	0.4500	0.0035			
			5	2000000	0.4500	0.0031			
			6	2000000	0.4500	0.0203			
			7	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
8	290.00	0.00	1	878000	0.2500	0.0088	680.14	680.04	0.10
			2	211000	0.2500	0.0438			
			3	902000	0.3000	0.0192			
			4	2000000	0.4500	0.0043			
			5	2000000	0.4500	0.0037			
			6	2000000	0.4500	0.0239			
			7	1000000000(	0.2000	0.0000			
9	310.00	0.00	1	878000	0.2500	0.0084	680.18	680.07	0.11
			2	211000	0.2500	0.0456			
			3	902000	0.3000	0.0207			
			4	2000000	0.4500	0.0044			
			5	2000000	0.4500	0.0042			
			6	2000000	0.4500	0.0274			
			7	1000000000(	0.2000	0.0000			
10	330.00	0.00	1	878000	0.2500	0.0074	680.78	680.67	0.11
			2	211000	0.2500	0.0425			
			3	902000	0.3000	0.0227			
			4	2000000	0.4500	0.0042			
			5	2000000	0.4500	0.0047			
			6	2000000	0.4500	0.0308			
			7	1000000000(	0.2000	0.0000			
11	350.00	0.00	1	878000	0.2500	0.0070	681.50	681.39	0.11
			2	211000	0.2500	0.0392			
			3	902000	0.3000	0.0247			
			4	2000000	0.4500	0.0044			
			5	2000000	0.4500	0.0054			
			6	2000000	0.4500	0.0341			
			7	1000000000(	0.2000	0.0000			
12	370.00	0.00	1	878000	0.2500	0.0084	680.03	679.90	0.13
			2	211000	0.2500	0.0442			
			3	902000	0.3000	0.0280			
			4	2000000	0.4500	0.0054			
			5	2000000	0.4500	0.0064			
			6	2000000	0.4500	0.0373			
			7	1000000000(	0.2000	0.0000			
13	390.00	0.00	1	878000	0.2500	0.0103	677.54	677.38	0.16
			2	211000	0.2500	0.0561			
			3	902000	0.3000	0.0342			
			4	2000000	0.4500	0.0068			
			5	2000000	0.4500	0.0077			
			6	2000000	0.4500	0.0401			
			7	1000000000(	0.2000	0.0000			
14	410.00	0.00	1	878000	0.2500	0.0122	674.55	674.37	0.18
			2	211000	0.2500	0.0707			
			3	902000	0.3000	0.0415			
			4	2000000	0.4500	0.0085			
			5	2000000	0.4500	0.0090			
			6	2000000	0.4500	0.0422			
			7	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
15	430.00	0.00	1	878000	0.2500	0.0109	669.76	669.56	0.20
			2	211000	0.2500	0.0824			
			3	902000	0.3000	0.0469			
			4	2000000	0.4500	0.0099			
			5	2000000	0.4500	0.0100			
			6	2000000	0.4500	0.0432			
			7	1000000000(	0.2000	0.0000			
16	450.00	0.00	1	878000	0.2500	0.0119	668.80	668.60	0.20
			2	211000	0.2500	0.0759			
			3	902000	0.3000	0.0462			
			4	2000000	0.4500	0.0104			
			5	2000000	0.4500	0.0104			
			6	2000000	0.4500	0.0427			
			7	1000000000(	0.2000	0.0000			
17	470.00	0.00	1	878000	0.2500	0.0166	673.01	672.84	0.17
			2	211000	0.2500	0.0576			
			3	902000	0.3000	0.0395			
			4	2000000	0.4500	0.0098			
			5	2000000	0.4500	0.0102			
			6	2000000	0.4500	0.0407			
			7	1000000000(	0.2000	0.0000			
18	490.00	0.00	1	878000	0.2500	0.0171	676.43	676.28	0.14
			2	211000	0.2500	0.0404			
			3	902000	0.3000	0.0312			
			4	2000000	0.4500	0.0085			
			5	2000000	0.4500	0.0092			
			6	2000000	0.4500	0.0373			
			7	1000000000(	0.2000	0.0000			
19	510.00	0.00	1	878000	0.2500	0.0169	677.22	677.10	0.12
			2	211000	0.2500	0.0302			
			3	902000	0.3000	0.0246			
			4	2000000	0.4500	0.0069			
			5	2000000	0.4500	0.0078			
			6	2000000	0.4500	0.0328			
			7	1000000000(	0.2000	0.0000			
20	530.00	0.00	1	878000	0.2500	0.0146	678.32	678.23	0.09
			2	211000	0.2500	0.0215			
			3	902000	0.3000	0.0196			
			4	2000000	0.4500	0.0052			
			5	2000000	0.4500	0.0060			
			6	2000000	0.4500	0.0279			
			7	1000000000(	0.2000	0.0000			
21	550.00	0.00	1	878000	0.2500	0.0105	680.80	680.73	0.07
			2	211000	0.2500	0.0120			
			3	902000	0.3000	0.0143			
			4	2000000	0.4500	0.0033			
			5	2000000	0.4500	0.0043			
			6	2000000	0.4500	0.0226			
			7	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
22	570.00	0.00	1	878000	0.2500	0.0058	683.20	683.16	0.04
			2	211000	0.2500	0.0053			
			3	902000	0.3000	0.0082			
			4	2000000	0.4500	0.0015			
			5	2000000	0.4500	0.0025			
			6	2000000	0.4500	0.0173			
			7	1000000000(	0.2000	0.0000			
23	590.00	0.00	1	878000	0.2500	0.0022	684.82	684.80	0.02
			2	211000	0.2500	0.0012			
			3	902000	0.3000	0.0028			
			4	2000000	0.4500	-0.0001			
			5	2000000	0.4500	0.0010			
			6	2000000	0.4500	0.0124			
			7	1000000000(	0.2000	0.0000			
24	610.00	0.00	1	878000	0.2500	-0.0001	685.94	685.93	0.01
			2	211000	0.2500	-0.0002			
			3	902000	0.3000	-0.0008			
			4	2000000	0.4500	-0.0012			
			5	2000000	0.4500	-0.0002			
			6	2000000	0.4500	0.0082			
			7	1000000000(	0.2000	0.0000			
25	630.00	0.00	1	878000	0.2500	-0.0003	686.82	686.82	-0.00
			2	211000	0.2500	-0.0002			
			3	902000	0.3000	-0.0023			
			4	2000000	0.4500	-0.0018			
			5	2000000	0.4500	-0.0010			
			6	2000000	0.4500	0.0046			
			7	1000000000(	0.2000	0.0000			
26	650.00	0.00	1	878000	0.2500	-0.0002	687.70	687.70	-0.00
			2	211000	0.2500	0.0000			
			3	902000	0.3000	-0.0025			
			4	2000000	0.4500	-0.0021			
			5	2000000	0.4500	-0.0015			
			6	2000000	0.4500	0.0017			
			7	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	150.00	0.00	688.80	0.03	688.77
2	170.00	0.00	687.84	0.03	687.81
3	190.00	0.00	686.88	0.04	686.84
4	210.00	0.00	686.08	0.05	686.03
5	230.00	0.00	685.52	0.06	685.46
6	250.00	0.00	683.70	0.07	683.63
7	270.00	0.00	681.14	0.08	681.06
8	290.00	0.00	680.14	0.09	680.05
9	310.00	0.00	680.18	0.10	680.08
10	330.00	0.00	680.78	0.11	680.67
11	350.00	0.00	681.50	0.12	681.38
12	370.00	0.00	680.03	0.15	679.89
13	390.00	0.00	677.54	0.18	677.36
14	410.00	0.00	674.55	0.21	674.34
15	430.00	0.00	669.76	0.25	669.51
16	450.00	0.00	668.80	0.26	668.54
17	470.00	0.00	673.01	0.21	672.80
18	490.00	0.00	676.43	0.17	676.26
19	510.00	0.00	677.22	0.14	677.08
20	530.00	0.00	678.32	0.11	678.21
21	550.00	0.00	680.80	0.09	680.71
22	570.00	0.00	683.20	0.08	683.12
23	590.00	0.00	684.82	0.06	684.76
24	610.00	0.00	685.94	0.05	685.89
25	630.00	0.00	686.82	0.04	686.78

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
26	650.00	0.00	687.70	0.03	687.67

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	1	150.00	688.80	Soil Type 1
	2	200.00	686.40	
	3	225.00	685.60	
	4	231.00	685.50	
	5	250.00	683.70	
	6	275.00	680.50	
	7	300.00	679.90	
	8	325.00	680.60	
	9	350.00	681.50	
	10	356.00	681.80	
	11	375.00	679.40	
	12	400.00	676.30	
	13	416.00	673.50	
	14	425.00	670.00	
	15	450.00	668.80	
	16	457.50	669.30	
	17	475.00	674.50	
	18	481.00	676.00	
	19	500.00	676.90	
	20	525.00	677.70	
	21	550.00	680.80	
	22	575.00	683.80	
	23	600.00	685.50	
	24	650.00	687.70	
2	1	150.00	668.40	Soil Type 2B
	2	297.30	668.40	
	3	342.00	669.20	
	4	515.00	658.00	
	5	645.00	667.50	
	6	650.00	667.50	
3	1	150.00	668.39	Soil Type 2
	2	297.30	653.40	
	3	342.00	652.90	
	4	515.00	650.50	
	5	645.00	667.49	
	6	650.00	667.49	
4	1	150.00	622.10	Soil Type 3A
	2	297.30	622.10	
	3	342.00	613.20	
	4	645.00	628.50	
	5	650.00	628.50	
5	1	150.00	595.00	Soil Type 3B
	2	297.30	595.00	
	3	342.00	593.20	
	4	645.00	598.90	
	5	650.00	598.90	
6	1	150.00	572.90	Soil Type 4
	2	297.30	572.90	
	3	515.00	569.20	
	4	650.00	569.20	

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
7	1	150.00	450.00	Termination Layer
	2	650.00	450.00	

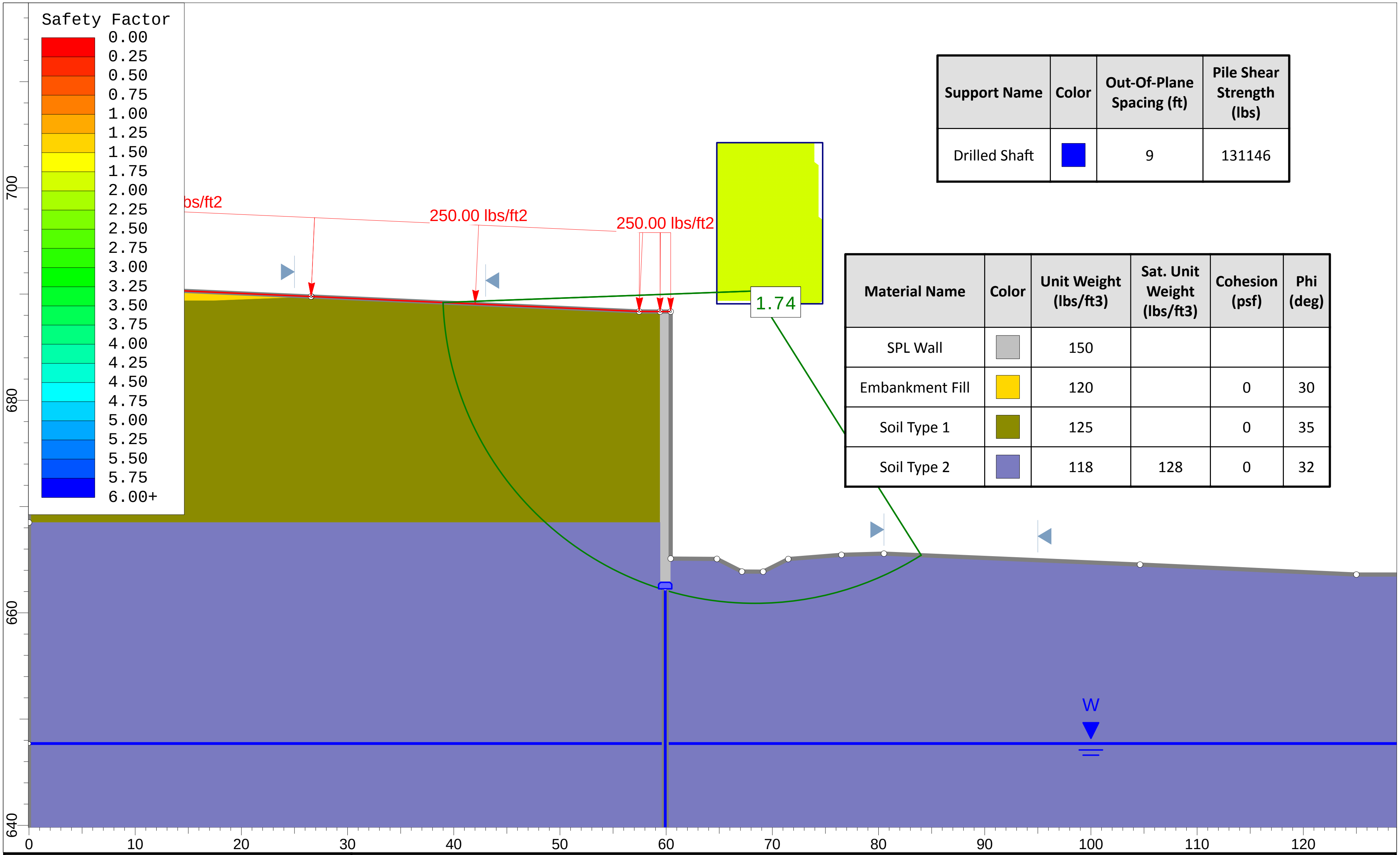
TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #		Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	D E S C R I P T I O N
1	X1 = 150.00 [ft]	1	150.00	688.80	Proposed Embankment/Retaining Wall
	X2 = 629.00 [ft]	2	629.00	686.00	
		3	629.00	691.50	

APPENDIX F

GLOBAL STABILITY ANALYSIS - RETAINING WALL AC

RETAINING WALL AC – STA. 00+90



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
Drilled Shaft	🟦	9	131146

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SPL Wall	⬜	150			
Embankment Fill	🟨	120		0	30
Soil Type 1	🟫	125		0	35
Soil Type 2	🟪	118	128	0	32

rocscience

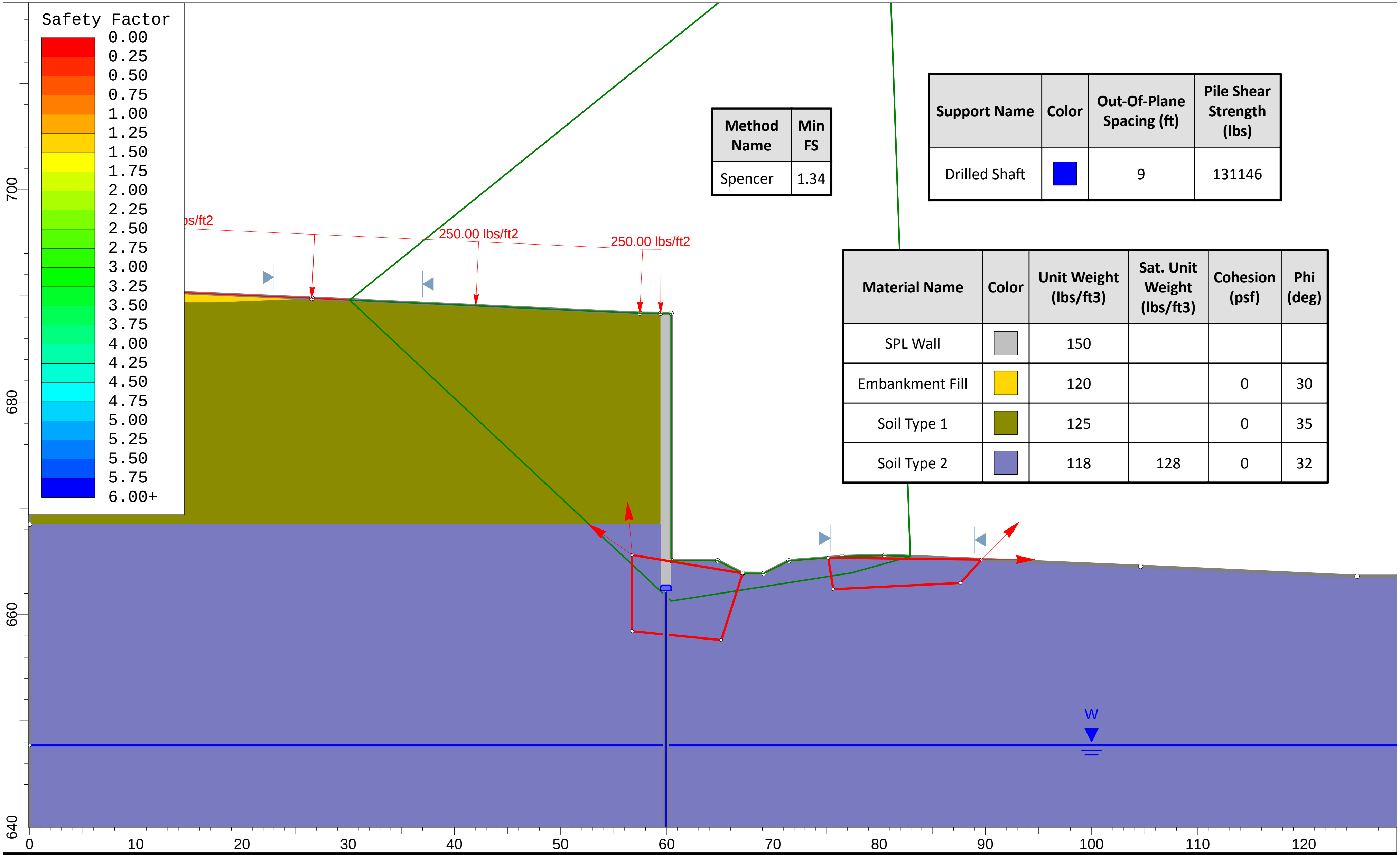
SLIDEINTERPRET 7.038

Project
CUY-90-16.28 (CCG3A), PID 82382

Analysis Description
Wall AC @ STA. 0+90, Global Stabiltiy - Effective Stress, Circular Failure

Drawn By KCA
Scale 1:150
Company NEAS, Inc.

Date 8/10/2021, 11:23:13 AM
File Name WallAC_STA0+90_EffCircular091621.slim



Method Name	Min FS
Spencer	1.34

Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
Drilled Shaft	🟦	9	131146

Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
SPL Wall	⬜	150			
Embankment Fill	🟨	120		0	30
Soil Type 1	🟫	125		0	35
Soil Type 2	🟪	118	128	0	32

SLIDEINTERPRET 7.038

Project CUY-90-16.28 (CCG3A), PID 82382

Analysis Description Wall AC @ STA. 00+90, Global Stability - Effective Stress, Block Stress

Drawn By M. Jasiewicz

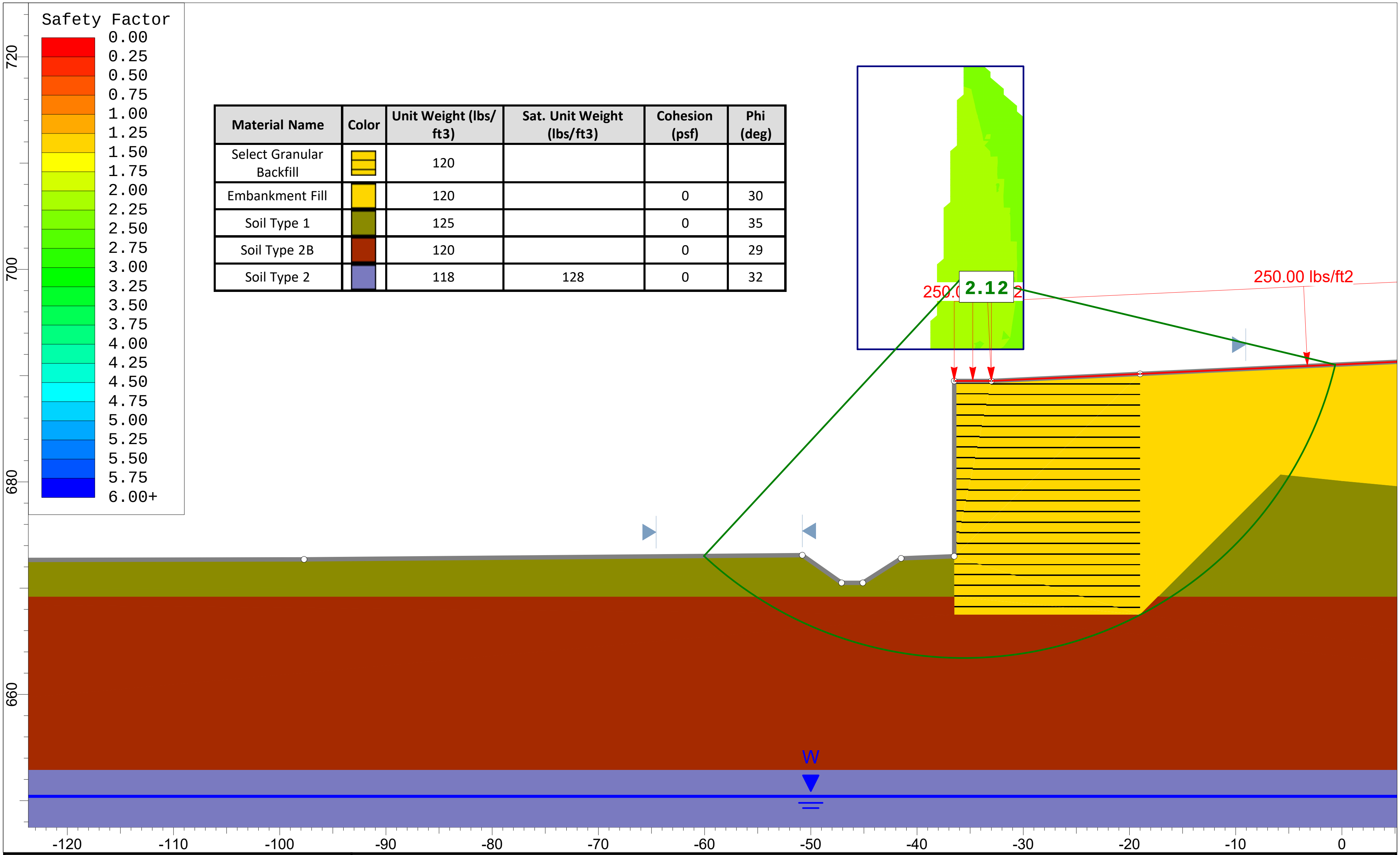
Scale 1:150

Company NEAS, Inc.

Date 8/10/2021, 11:23:13 AM

File Name WallAC_STA0+90_EffBlock091621.slim

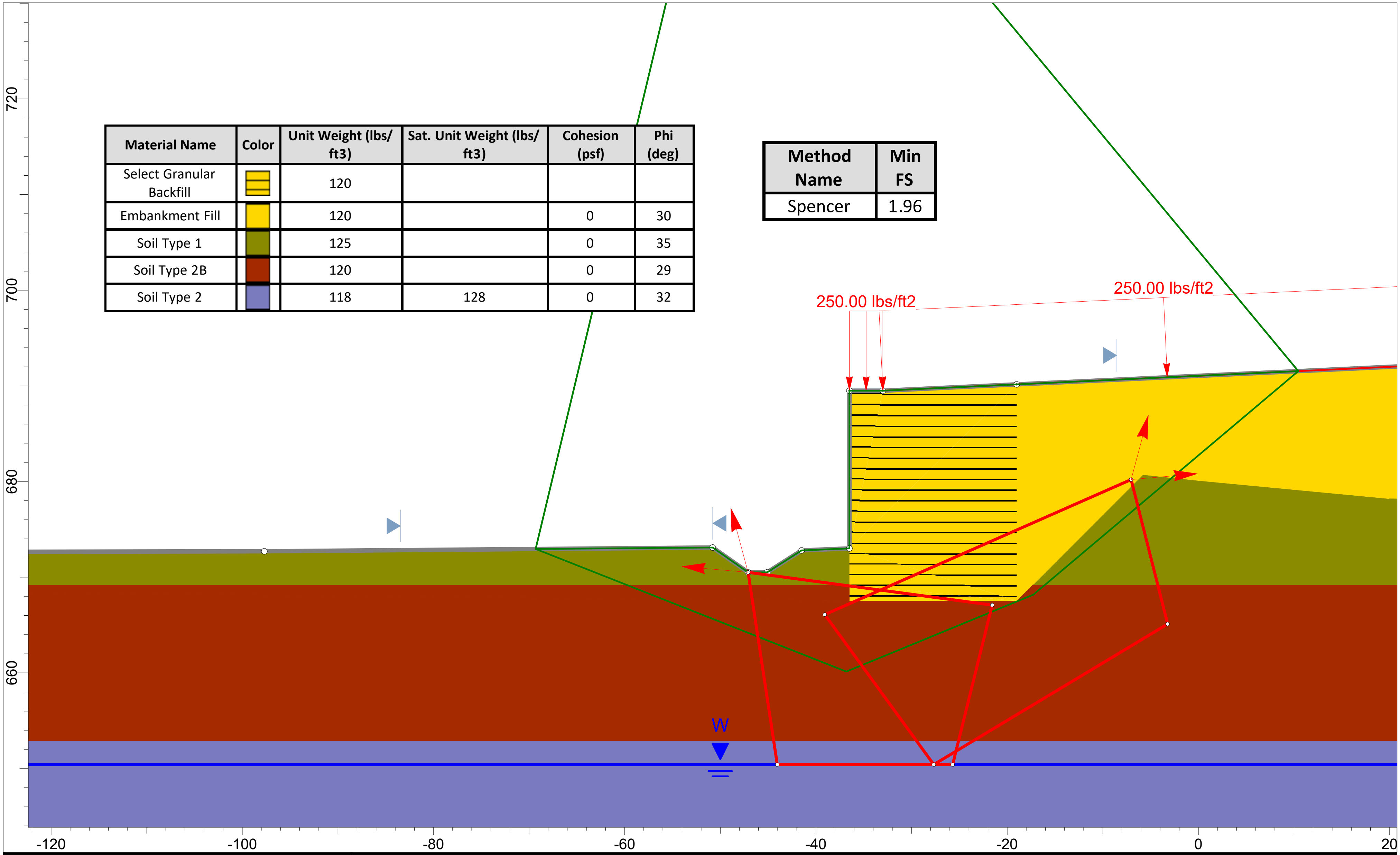
RETAINING WALL AC – STA. 03+92.5



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Select Granular Backfill	🟨	120			
Embankment Fill	🟨	120		0	30
Soil Type 1	🟫	125		0	35
Soil Type 2B	🟥	120		0	29
Soil Type 2	🟪	118	128	0	32

SLIDEINTERPRET 9.025

Project	CUY-90-16.28 (CCG3A), PID 82382
Analysis Description	Wall AC @ STA. 2+78.8, Global Stability - Effective Stress, Circular Failure
Drawn By	K. Arens
Company	NEAS, Inc.
Date	1/15/2024, 10:23:13 PM
File Name	WallAC_STA2+78.8_EffCircular091621.slim



Material Name	Color	Unit Weight (lbs/ ft3)	Sat. Unit Weight (lbs/ ft3)	Cohesion (psf)	Phi (deg)
Select Granular Backfill	▤	120			
Embankment Fill	🟨	120		0	30
Soil Type 1	🟩	125		0	35
Soil Type 2B	🟥	120		0	29
Soil Type 2	🟪	118	128	0	32

Method Name	Min FS
Spencer	1.96

SLIDEINTERPRET 9.025

Project
CUY-90-16.28 (CCG3A), PID 82382

Analysis Description
Wall AC @ STA. 2+78.8, Global Stability - Effective Stress, Circular Failure

Drawn By
K. Arens

Company
NEAS, Inc.

Date
1/15/2024, 10:23:13 PM

File Name
WallAC_STA2+78.8_EffBlock011524.slim

APPENDIX G

DRIVEN ANALYSIS

REAR ABUTMENT

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\CCG3\BRIDGE~1\B10REAR.DVN
Project Name: CUY-90-16.28 Project Date: 06/22/2022
Project Client: Michael Baker
Computed By: M. Jasiewicz
Project Manager: B. Andrews

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:	28.60 ft
	- Driving/Restrike	28.60 ft
	- Ultimate:	28.60 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	1.00 ft	0.00%	128.00 pcf	36.0/36.0	Nordlund
2	Cohesionless	2.50 ft	0.00%	130.00 pcf	40.0/40.0	Nordlund
3	Cohesionless	2.60 ft	0.00%	125.00 pcf	33.0/33.0	Nordlund
4	Cohesive	2.00 ft	33.00%	110.00 pcf	1500.00 psf	T-80 Same
5	Cohesionless	2.50 ft	17.00%	125.00 pcf	32.0/32.0	Nordlund
6	Cohesionless	11.20 ft	0.00%	122.00 pcf	30.0/30.0	Nordlund
7	Cohesionless	3.80 ft	17.00%	125.00 pcf	31.0/31.0	Nordlund
8	Cohesionless	7.50 ft	33.00%	110.00 pcf	27.0/27.0	Nordlund
9	Cohesionless	11.30 ft	0.00%	128.00 pcf	32.0/32.0	Nordlund
10	Cohesionless	5.00 ft	33.00%	130.00 pcf	33.0/33.0	Nordlund
11	Cohesive	10.20 ft	33.00%	125.00 pcf	3350.00 psf	T-80 Same
12	Cohesive	30.00 ft	33.00%	130.00 pcf	2700.00 psf	T-80 Same
13	Cohesive	4.80 ft	33.00%	135.00 pcf	6000.00 psf	T-80 Same
14	Cohesive	5.00 ft	33.00%	125.00 pcf	3350.00 psf	T-80 Same
15	Cohesive	5.00 ft	33.00%	125.00 pcf	2600.00 psf	T-80 Same
16	Cohesive	13.70 ft	43.00%	122.00 pcf	1800.00 psf	T-80 Same

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.64 psf	21.17	N/A	0.00 Kips
0.99 ft	Cohesionless	63.36 psf	21.17	N/A	0.10 Kips
1.01 ft	Cohesionless	128.65 psf	23.52	N/A	0.11 Kips
3.49 ft	Cohesionless	289.85 psf	23.52	N/A	1.87 Kips
3.51 ft	Cohesionless	453.62 psf	19.41	N/A	1.88 Kips
6.09 ft	Cohesionless	614.88 psf	19.41	N/A	3.75 Kips
6.11 ft	Cohesive	N/A	N/A	1242.97 psf	3.79 Kips
8.09 ft	Cohesive	N/A	N/A	1242.97 psf	8.97 Kips
8.11 ft	Cohesionless	998.63 psf	18.82	N/A	9.01 Kips
10.59 ft	Cohesionless	1153.62 psf	18.82	N/A	11.56 Kips
10.61 ft	Cohesionless	1311.11 psf	17.64	N/A	11.58 Kips
19.61 ft	Cohesionless	1860.11 psf	17.64	N/A	26.07 Kips
21.79 ft	Cohesionless	1993.09 psf	17.64	N/A	30.86 Kips
21.81 ft	Cohesionless	2677.53 psf	18.23	N/A	30.90 Kips
25.59 ft	Cohesionless	2913.77 psf	18.23	N/A	39.76 Kips
25.61 ft	Cohesionless	3152.45 psf	15.88	N/A	39.79 Kips
28.59 ft	Cohesionless	3316.35 psf	15.88	N/A	44.30 Kips
28.61 ft	Cohesionless	3482.14 psf	15.88	N/A	44.33 Kips
33.09 ft	Cohesionless	3588.76 psf	15.88	N/A	51.67 Kips
33.11 ft	Cohesionless	3696.43 psf	18.82	N/A	51.73 Kips
42.11 ft	Cohesionless	3991.63 psf	18.82	N/A	90.29 Kips
44.39 ft	Cohesionless	4066.41 psf	18.82	N/A	100.96 Kips
44.41 ft	Cohesionless	4437.72 psf	19.41	N/A	101.03 Kips
49.39 ft	Cohesionless	4606.04 psf	19.41	N/A	119.16 Kips
49.41 ft	Cohesive	N/A	N/A	842.47 psf	119.22 Kips
58.41 ft	Cohesive	N/A	N/A	842.47 psf	135.18 Kips
59.59 ft	Cohesive	N/A	N/A	845.91 psf	137.34 Kips
59.61 ft	Cohesive	N/A	N/A	1009.50 psf	137.39 Kips
68.61 ft	Cohesive	N/A	N/A	1009.50 psf	156.51 Kips
77.61 ft	Cohesive	N/A	N/A	1185.03 psf	182.29 Kips
86.61 ft	Cohesive	N/A	N/A	1382.27 psf	215.95 Kips
89.59 ft	Cohesive	N/A	N/A	1447.57 psf	228.74 Kips
89.61 ft	Cohesive	N/A	N/A	1428.00 psf	228.82 Kips
94.39 ft	Cohesive	N/A	N/A	1428.00 psf	243.19 Kips
94.41 ft	Cohesive	N/A	N/A	842.47 psf	243.23 Kips
99.39 ft	Cohesive	N/A	N/A	842.47 psf	252.06 Kips
99.41 ft	Cohesive	N/A	N/A	1050.60 psf	252.10 Kips
104.39 ft	Cohesive	N/A	N/A	1050.60 psf	263.12 Kips
104.41 ft	Cohesive	N/A	N/A	1357.70 psf	263.16 Kips
113.41 ft	Cohesive	N/A	N/A	1357.70 psf	285.04 Kips
118.09 ft	Cohesive	N/A	N/A	1402.80 psf	297.52 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.28 psf	77.60	119.07 Kips	0.05 Kips
0.99 ft	Cohesionless	126.72 psf	77.60	119.07 Kips	5.35 Kips
1.01 ft	Cohesionless	129.30 psf	160.00	327.98 Kips	12.19 Kips
3.49 ft	Cohesionless	451.70 psf	160.00	327.98 Kips	42.57 Kips
3.51 ft	Cohesionless	454.25 psf	47.20	39.27 Kips	10.87 Kips
6.09 ft	Cohesionless	776.75 psf	47.20	39.27 Kips	18.59 Kips
6.11 ft	Cohesive	N/A	N/A	N/A	10.60 Kips
8.09 ft	Cohesive	N/A	N/A	N/A	10.60 Kips
8.11 ft	Cohesionless	999.25 psf	40.40	25.92 Kips	19.84 Kips
10.59 ft	Cohesionless	1309.25 psf	40.40	25.92 Kips	25.92 Kips
10.61 ft	Cohesionless	1311.72 psf	30.00	10.46 Kips	10.46 Kips
19.61 ft	Cohesionless	2409.72 psf	30.00	10.46 Kips	10.46 Kips
21.79 ft	Cohesionless	2675.68 psf	30.00	10.46 Kips	10.46 Kips
21.81 ft	Cohesionless	2678.15 psf	35.20	16.23 Kips	16.23 Kips
25.59 ft	Cohesionless	3150.65 psf	35.20	16.23 Kips	16.23 Kips
25.61 ft	Cohesionless	3153.00 psf	19.80	10.46 Kips	10.46 Kips
28.59 ft	Cohesionless	3480.80 psf	19.80	10.46 Kips	10.46 Kips
28.61 ft	Cohesionless	3482.38 psf	19.80	10.46 Kips	10.46 Kips
33.09 ft	Cohesionless	3695.62 psf	19.80	10.46 Kips	10.46 Kips
33.11 ft	Cohesionless	3696.76 psf	40.40	25.92 Kips	25.92 Kips
42.11 ft	Cohesionless	4287.16 psf	40.40	25.92 Kips	25.92 Kips
44.39 ft	Cohesionless	4436.72 psf	40.40	25.92 Kips	25.92 Kips
44.41 ft	Cohesionless	4438.06 psf	47.20	39.27 Kips	39.27 Kips
49.39 ft	Cohesionless	4774.70 psf	47.20	39.27 Kips	39.27 Kips
49.41 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
58.41 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
59.59 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
59.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
68.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
77.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
86.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
89.59 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
89.61 ft	Cohesive	N/A	N/A	N/A	42.41 Kips
94.39 ft	Cohesive	N/A	N/A	N/A	42.41 Kips
94.41 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
99.39 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
99.41 ft	Cohesive	N/A	N/A	N/A	18.38 Kips
104.39 ft	Cohesive	N/A	N/A	N/A	18.38 Kips
104.41 ft	Cohesive	N/A	N/A	N/A	12.72 Kips
113.41 ft	Cohesive	N/A	N/A	N/A	12.72 Kips
118.09 ft	Cohesive	N/A	N/A	N/A	12.72 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.05 Kips	0.05 Kips
0.99 ft	0.10 Kips	5.35 Kips	5.46 Kips
1.01 ft	0.11 Kips	12.19 Kips	12.29 Kips
3.49 ft	1.87 Kips	42.57 Kips	44.44 Kips
3.51 ft	1.88 Kips	10.87 Kips	12.75 Kips
6.09 ft	3.75 Kips	18.59 Kips	22.34 Kips
6.11 ft	3.79 Kips	10.60 Kips	14.39 Kips
8.09 ft	8.97 Kips	10.60 Kips	19.57 Kips
8.11 ft	9.01 Kips	19.84 Kips	28.84 Kips
10.59 ft	11.56 Kips	25.92 Kips	37.48 Kips
10.61 ft	11.58 Kips	10.46 Kips	22.05 Kips
19.61 ft	26.07 Kips	10.46 Kips	36.53 Kips
21.79 ft	30.86 Kips	10.46 Kips	41.32 Kips
21.81 ft	30.90 Kips	16.23 Kips	47.13 Kips
25.59 ft	39.76 Kips	16.23 Kips	55.99 Kips
25.61 ft	39.79 Kips	10.46 Kips	50.25 Kips
28.59 ft	44.30 Kips	10.46 Kips	54.76 Kips
28.61 ft	44.33 Kips	10.46 Kips	54.79 Kips
33.09 ft	51.67 Kips	10.46 Kips	62.13 Kips
33.11 ft	51.73 Kips	25.92 Kips	77.65 Kips
42.11 ft	90.29 Kips	25.92 Kips	116.21 Kips
44.39 ft	100.96 Kips	25.92 Kips	126.88 Kips
44.41 ft	101.03 Kips	39.27 Kips	140.30 Kips
49.39 ft	119.16 Kips	39.27 Kips	158.43 Kips
49.41 ft	119.22 Kips	23.68 Kips	142.90 Kips
58.41 ft	135.18 Kips	23.68 Kips	158.86 Kips
59.59 ft	137.34 Kips	23.68 Kips	161.02 Kips
59.61 ft	137.39 Kips	19.09 Kips	156.47 Kips
68.61 ft	156.51 Kips	19.09 Kips	175.60 Kips
77.61 ft	182.29 Kips	19.09 Kips	201.37 Kips
86.61 ft	215.95 Kips	19.09 Kips	235.04 Kips
89.59 ft	228.74 Kips	19.09 Kips	247.83 Kips
89.61 ft	228.82 Kips	42.41 Kips	271.23 Kips
94.39 ft	243.19 Kips	42.41 Kips	285.60 Kips
94.41 ft	243.23 Kips	23.68 Kips	266.91 Kips
99.39 ft	252.06 Kips	23.68 Kips	275.74 Kips
99.41 ft	252.10 Kips	18.38 Kips	270.48 Kips
104.39 ft	263.12 Kips	18.38 Kips	281.49 Kips
104.41 ft	263.16 Kips	12.72 Kips	275.88 Kips
113.41 ft	285.04 Kips	12.72 Kips	297.76 Kips
118.09 ft	297.52 Kips	12.72 Kips	310.25 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.64 psf	21.17	N/A	0.00 Kips
0.99 ft	Cohesionless	63.36 psf	21.17	N/A	0.10 Kips
1.01 ft	Cohesionless	128.65 psf	23.52	N/A	0.11 Kips
3.49 ft	Cohesionless	289.85 psf	23.52	N/A	1.87 Kips
3.51 ft	Cohesionless	453.62 psf	19.41	N/A	1.88 Kips
6.09 ft	Cohesionless	614.88 psf	19.41	N/A	3.75 Kips
6.11 ft	Cohesive	N/A	N/A	1242.97 psf	3.80 Kips
8.09 ft	Cohesive	N/A	N/A	1242.97 psf	11.53 Kips
8.11 ft	Cohesionless	998.63 psf	18.82	N/A	11.58 Kips
10.59 ft	Cohesionless	1153.62 psf	18.82	N/A	14.66 Kips
10.61 ft	Cohesionless	1311.11 psf	17.64	N/A	14.68 Kips
19.61 ft	Cohesionless	1860.11 psf	17.64	N/A	29.17 Kips
21.79 ft	Cohesionless	1993.09 psf	17.64	N/A	33.96 Kips
21.81 ft	Cohesionless	2677.53 psf	18.23	N/A	34.01 Kips
25.59 ft	Cohesionless	2913.77 psf	18.23	N/A	44.68 Kips
25.61 ft	Cohesionless	3152.45 psf	15.88	N/A	44.73 Kips
28.59 ft	Cohesionless	3316.35 psf	15.88	N/A	51.46 Kips
28.61 ft	Cohesionless	3482.14 psf	15.88	N/A	51.51 Kips
33.09 ft	Cohesionless	3588.76 psf	15.88	N/A	62.45 Kips
33.11 ft	Cohesionless	3696.43 psf	18.82	N/A	62.52 Kips
42.11 ft	Cohesionless	3991.63 psf	18.82	N/A	101.08 Kips
44.39 ft	Cohesionless	4066.41 psf	18.82	N/A	111.75 Kips
44.41 ft	Cohesionless	4437.72 psf	19.41	N/A	111.85 Kips
49.39 ft	Cohesionless	4606.04 psf	19.41	N/A	138.91 Kips
49.41 ft	Cohesive	N/A	N/A	842.47 psf	138.99 Kips
58.41 ft	Cohesive	N/A	N/A	842.47 psf	162.81 Kips
59.59 ft	Cohesive	N/A	N/A	845.91 psf	166.05 Kips
59.61 ft	Cohesive	N/A	N/A	1009.50 psf	166.11 Kips
68.61 ft	Cohesive	N/A	N/A	1009.50 psf	194.65 Kips
77.61 ft	Cohesive	N/A	N/A	1185.03 psf	233.13 Kips
86.61 ft	Cohesive	N/A	N/A	1382.27 psf	283.37 Kips
89.59 ft	Cohesive	N/A	N/A	1447.57 psf	302.46 Kips
89.61 ft	Cohesive	N/A	N/A	1428.00 psf	302.58 Kips
94.39 ft	Cohesive	N/A	N/A	1428.00 psf	324.02 Kips
94.41 ft	Cohesive	N/A	N/A	842.47 psf	324.09 Kips
99.39 ft	Cohesive	N/A	N/A	842.47 psf	337.27 Kips
99.41 ft	Cohesive	N/A	N/A	1050.60 psf	337.33 Kips
104.39 ft	Cohesive	N/A	N/A	1050.60 psf	353.77 Kips
104.41 ft	Cohesive	N/A	N/A	1357.70 psf	353.84 Kips
113.41 ft	Cohesive	N/A	N/A	1357.70 psf	392.23 Kips
118.09 ft	Cohesive	N/A	N/A	1402.80 psf	414.13 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.28 psf	77.60	119.07 Kips	0.05 Kips
0.99 ft	Cohesionless	126.72 psf	77.60	119.07 Kips	5.35 Kips
1.01 ft	Cohesionless	129.30 psf	160.00	327.98 Kips	12.19 Kips
3.49 ft	Cohesionless	451.70 psf	160.00	327.98 Kips	42.57 Kips
3.51 ft	Cohesionless	454.25 psf	47.20	39.27 Kips	10.87 Kips
6.09 ft	Cohesionless	776.75 psf	47.20	39.27 Kips	18.59 Kips
6.11 ft	Cohesive	N/A	N/A	N/A	10.60 Kips
8.09 ft	Cohesive	N/A	N/A	N/A	10.60 Kips
8.11 ft	Cohesionless	999.25 psf	40.40	25.92 Kips	19.84 Kips
10.59 ft	Cohesionless	1309.25 psf	40.40	25.92 Kips	25.92 Kips
10.61 ft	Cohesionless	1311.72 psf	30.00	10.46 Kips	10.46 Kips
19.61 ft	Cohesionless	2409.72 psf	30.00	10.46 Kips	10.46 Kips
21.79 ft	Cohesionless	2675.68 psf	30.00	10.46 Kips	10.46 Kips
21.81 ft	Cohesionless	2678.15 psf	35.20	16.23 Kips	16.23 Kips
25.59 ft	Cohesionless	3150.65 psf	35.20	16.23 Kips	16.23 Kips
25.61 ft	Cohesionless	3153.00 psf	19.80	10.46 Kips	10.46 Kips
28.59 ft	Cohesionless	3480.80 psf	19.80	10.46 Kips	10.46 Kips
28.61 ft	Cohesionless	3482.38 psf	19.80	10.46 Kips	10.46 Kips
33.09 ft	Cohesionless	3695.62 psf	19.80	10.46 Kips	10.46 Kips
33.11 ft	Cohesionless	3696.76 psf	40.40	25.92 Kips	25.92 Kips
42.11 ft	Cohesionless	4287.16 psf	40.40	25.92 Kips	25.92 Kips
44.39 ft	Cohesionless	4436.72 psf	40.40	25.92 Kips	25.92 Kips
44.41 ft	Cohesionless	4438.06 psf	47.20	39.27 Kips	39.27 Kips
49.39 ft	Cohesionless	4774.70 psf	47.20	39.27 Kips	39.27 Kips
49.41 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
58.41 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
59.59 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
59.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
68.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
77.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
86.61 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
89.59 ft	Cohesive	N/A	N/A	N/A	19.09 Kips
89.61 ft	Cohesive	N/A	N/A	N/A	42.41 Kips
94.39 ft	Cohesive	N/A	N/A	N/A	42.41 Kips
94.41 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
99.39 ft	Cohesive	N/A	N/A	N/A	23.68 Kips
99.41 ft	Cohesive	N/A	N/A	N/A	18.38 Kips
104.39 ft	Cohesive	N/A	N/A	N/A	18.38 Kips
104.41 ft	Cohesive	N/A	N/A	N/A	12.72 Kips
113.41 ft	Cohesive	N/A	N/A	N/A	12.72 Kips
118.09 ft	Cohesive	N/A	N/A	N/A	12.72 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.05 Kips	0.05 Kips
0.99 ft	0.10 Kips	5.35 Kips	5.46 Kips
1.01 ft	0.11 Kips	12.19 Kips	12.29 Kips
3.49 ft	1.87 Kips	42.57 Kips	44.44 Kips
3.51 ft	1.88 Kips	10.87 Kips	12.75 Kips
6.09 ft	3.75 Kips	18.59 Kips	22.34 Kips
6.11 ft	3.80 Kips	10.60 Kips	14.41 Kips
8.09 ft	11.53 Kips	10.60 Kips	22.14 Kips
8.11 ft	11.58 Kips	19.84 Kips	31.42 Kips
10.59 ft	14.66 Kips	25.92 Kips	40.57 Kips
10.61 ft	14.68 Kips	10.46 Kips	25.14 Kips
19.61 ft	29.17 Kips	10.46 Kips	39.63 Kips
21.79 ft	33.96 Kips	10.46 Kips	44.42 Kips
21.81 ft	34.01 Kips	16.23 Kips	50.24 Kips
25.59 ft	44.68 Kips	16.23 Kips	60.91 Kips
25.61 ft	44.73 Kips	10.46 Kips	55.19 Kips
28.59 ft	51.46 Kips	10.46 Kips	61.92 Kips
28.61 ft	51.51 Kips	10.46 Kips	61.97 Kips
33.09 ft	62.45 Kips	10.46 Kips	72.91 Kips
33.11 ft	62.52 Kips	25.92 Kips	88.44 Kips
42.11 ft	101.08 Kips	25.92 Kips	126.99 Kips
44.39 ft	111.75 Kips	25.92 Kips	137.67 Kips
44.41 ft	111.85 Kips	39.27 Kips	151.12 Kips
49.39 ft	138.91 Kips	39.27 Kips	178.18 Kips
49.41 ft	138.99 Kips	23.68 Kips	162.67 Kips
58.41 ft	162.81 Kips	23.68 Kips	186.49 Kips
59.59 ft	166.05 Kips	23.68 Kips	189.73 Kips
59.61 ft	166.11 Kips	19.09 Kips	185.20 Kips
68.61 ft	194.65 Kips	19.09 Kips	213.74 Kips
77.61 ft	233.13 Kips	19.09 Kips	252.21 Kips
86.61 ft	283.37 Kips	19.09 Kips	302.46 Kips
89.59 ft	302.46 Kips	19.09 Kips	321.55 Kips
89.61 ft	302.58 Kips	42.41 Kips	344.99 Kips
94.39 ft	324.02 Kips	42.41 Kips	366.43 Kips
94.41 ft	324.09 Kips	23.68 Kips	347.77 Kips
99.39 ft	337.27 Kips	23.68 Kips	360.95 Kips
99.41 ft	337.33 Kips	18.38 Kips	355.71 Kips
104.39 ft	353.77 Kips	18.38 Kips	372.15 Kips
104.41 ft	353.84 Kips	12.72 Kips	366.57 Kips
113.41 ft	392.23 Kips	12.72 Kips	404.95 Kips
118.09 ft	414.13 Kips	12.72 Kips	426.86 Kips

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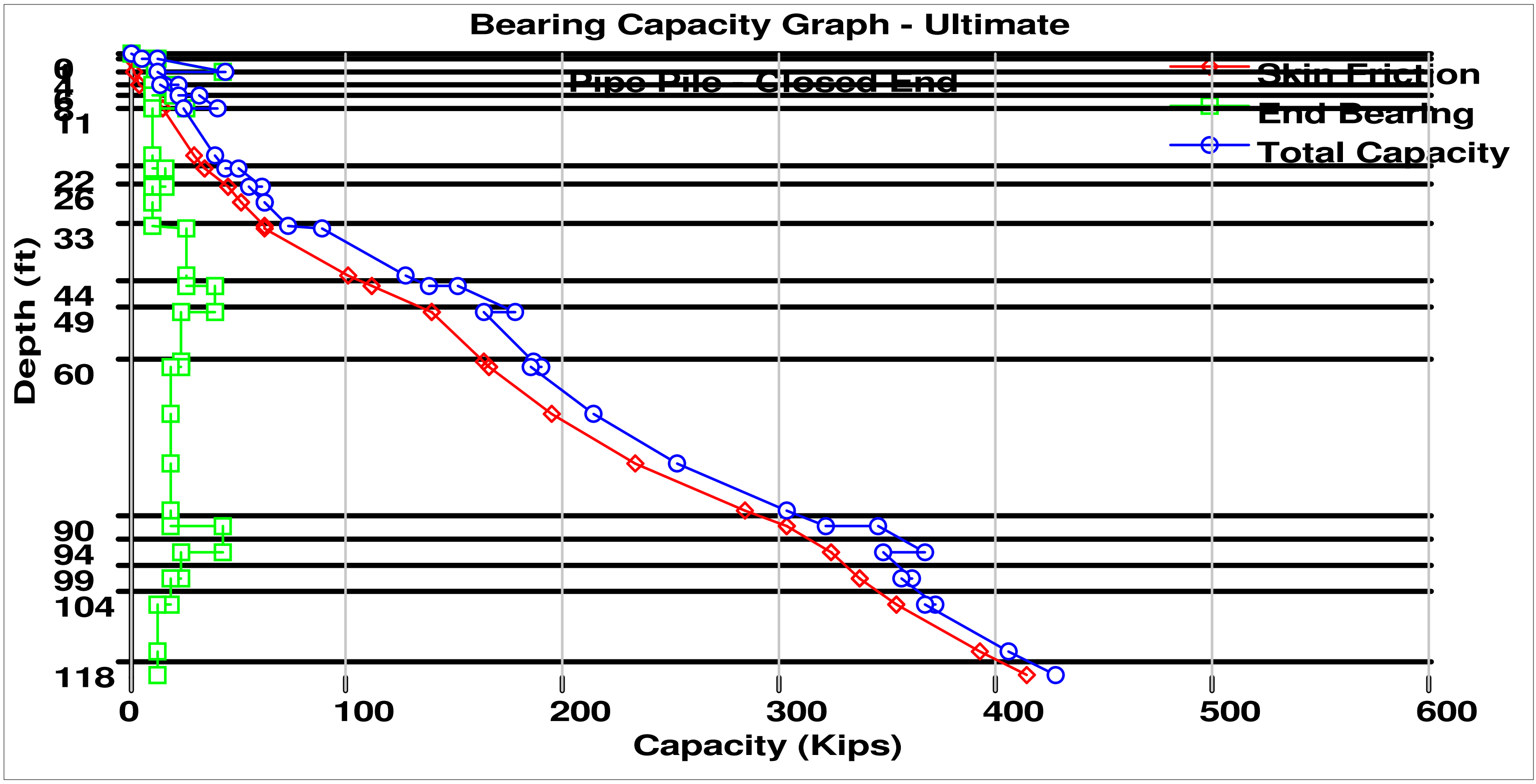

PIER 1

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\CCG3\BRIDGE~1\PIER.DVN
Project Name: CUY-90-16.28 Project Date: 06/22/2022
Project Client: Michael Baker
Computed By: M. Jasiewicz
Project Manager: B. Andrews

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 14.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	8.50 ft
	- Driving/Restrike	8.50 ft
	- Ultimate:	8.50 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	4.00 ft	0.00%	128.00 pcf	36.0/36.0	Nordlund
2	Cohesionless	5.00 ft	0.00%	108.00 pcf	29.0/29.0	Nordlund
3	Cohesionless	2.50 ft	0.00%	120.00 pcf	30.0/30.0	Nordlund
4	Cohesionless	2.50 ft	17.00%	120.00 pcf	30.0/30.0	Nordlund
5	Cohesionless	19.00 ft	17.00%	128.00 pcf	34.0/34.0	Nordlund
6	Cohesive	7.30 ft	33.00%	125.00 pcf	2900.00 psf	T-80 Same
7	Cohesionless	10.00 ft	33.00%	122.00 pcf	28.0/28.0	Nordlund
8	Cohesive	10.00 ft	33.00%	122.00 pcf	1800.00 psf	T-80 Same
9	Cohesive	10.00 ft	33.00%	115.00 pcf	600.00 psf	T-80 Same
10	Cohesive	31.70 ft	33.00%	125.00 pcf	2550.00 psf	T-80 Clay

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.64 psf	23.99	N/A	0.00 Kips
3.99 ft	Cohesionless	255.36 psf	23.99	N/A	2.46 Kips
4.01 ft	Cohesionless	512.54 psf	19.33	N/A	2.47 Kips
8.49 ft	Cohesionless	754.46 psf	19.33	N/A	6.37 Kips
8.51 ft	Cohesionless	998.23 psf	19.33	N/A	6.40 Kips
8.99 ft	Cohesionless	1009.17 psf	19.33	N/A	6.95 Kips
9.01 ft	Cohesionless	1021.09 psf	19.99	N/A	6.98 Kips
11.49 ft	Cohesionless	1092.51 psf	19.99	N/A	10.36 Kips
11.51 ft	Cohesionless	1165.09 psf	19.99	N/A	10.39 Kips
13.99 ft	Cohesionless	1236.51 psf	19.99	N/A	13.57 Kips
14.01 ft	Cohesionless	1309.13 psf	22.66	N/A	13.60 Kips
23.01 ft	Cohesionless	1604.33 psf	22.66	N/A	36.44 Kips
32.01 ft	Cohesionless	1899.53 psf	22.66	N/A	67.68 Kips
32.99 ft	Cohesionless	1931.67 psf	22.66	N/A	71.59 Kips
33.01 ft	Cohesive	N/A	N/A	938.55 psf	71.64 Kips
40.29 ft	Cohesive	N/A	N/A	938.55 psf	88.42 Kips
40.31 ft	Cohesionless	3012.48 psf	18.66	N/A	88.47 Kips
49.31 ft	Cohesionless	3280.68 psf	18.66	N/A	109.44 Kips
50.29 ft	Cohesionless	3309.88 psf	18.66	N/A	111.93 Kips
50.31 ft	Cohesive	N/A	N/A	1357.70 psf	111.99 Kips
59.31 ft	Cohesive	N/A	N/A	1357.70 psf	141.99 Kips
60.29 ft	Cohesive	N/A	N/A	1357.70 psf	145.26 Kips
60.31 ft	Cohesive	N/A	N/A	582.11 psf	145.31 Kips
69.31 ft	Cohesive	N/A	N/A	582.11 psf	158.17 Kips
70.29 ft	Cohesive	N/A	N/A	582.11 psf	159.57 Kips
70.31 ft	Cohesive	N/A	N/A	689.07 psf	159.61 Kips
79.31 ft	Cohesive	N/A	N/A	689.07 psf	174.83 Kips
88.31 ft	Cohesive	N/A	N/A	1220.62 psf	213.57 Kips
97.31 ft	Cohesive	N/A	N/A	1666.69 psf	270.14 Kips
101.99 ft	Cohesive	N/A	N/A	1666.69 psf	289.29 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.28 psf	77.60	162.06 Kips	0.07 Kips
3.99 ft	Cohesionless	510.72 psf	77.60	162.06 Kips	29.37 Kips
4.01 ft	Cohesionless	513.08 psf	26.40	14.24 Kips	8.08 Kips
8.49 ft	Cohesionless	996.92 psf	26.40	14.24 Kips	14.24 Kips
8.51 ft	Cohesionless	998.46 psf	26.40	14.24 Kips	14.24 Kips
8.99 ft	Cohesionless	1020.34 psf	26.40	14.24 Kips	14.24 Kips
9.01 ft	Cohesionless	1021.38 psf	30.00	14.24 Kips	14.24 Kips
11.49 ft	Cohesionless	1164.22 psf	30.00	14.24 Kips	14.24 Kips
11.51 ft	Cohesionless	1165.38 psf	30.00	14.24 Kips	14.24 Kips
13.99 ft	Cohesionless	1308.22 psf	30.00	14.24 Kips	14.24 Kips
14.01 ft	Cohesionless	1309.46 psf	55.60	78.59 Kips	51.59 Kips
23.01 ft	Cohesionless	1899.86 psf	55.60	78.59 Kips	74.84 Kips
32.01 ft	Cohesionless	2490.26 psf	55.60	78.59 Kips	78.59 Kips
32.99 ft	Cohesionless	2554.54 psf	55.60	78.59 Kips	78.59 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	27.90 Kips
40.29 ft	Cohesive	N/A	N/A	N/A	27.90 Kips
40.31 ft	Cohesionless	3012.78 psf	22.80	14.24 Kips	14.24 Kips
49.31 ft	Cohesionless	3549.18 psf	22.80	14.24 Kips	14.24 Kips
50.29 ft	Cohesionless	3607.58 psf	22.80	14.24 Kips	14.24 Kips
50.31 ft	Cohesive	N/A	N/A	N/A	17.32 Kips
59.31 ft	Cohesive	N/A	N/A	N/A	17.32 Kips
60.29 ft	Cohesive	N/A	N/A	N/A	17.32 Kips
60.31 ft	Cohesive	N/A	N/A	N/A	5.77 Kips
69.31 ft	Cohesive	N/A	N/A	N/A	5.77 Kips
70.29 ft	Cohesive	N/A	N/A	N/A	5.77 Kips
70.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
79.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
88.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
97.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
101.99 ft	Cohesive	N/A	N/A	N/A	24.53 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.07 Kips	0.07 Kips
3.99 ft	2.46 Kips	29.37 Kips	31.83 Kips
4.01 ft	2.47 Kips	8.08 Kips	10.55 Kips
8.49 ft	6.37 Kips	14.24 Kips	20.61 Kips
8.51 ft	6.40 Kips	14.24 Kips	20.64 Kips
8.99 ft	6.95 Kips	14.24 Kips	21.19 Kips
9.01 ft	6.98 Kips	14.24 Kips	21.22 Kips
11.49 ft	10.36 Kips	14.24 Kips	24.60 Kips
11.51 ft	10.39 Kips	14.24 Kips	24.63 Kips
13.99 ft	13.57 Kips	14.24 Kips	27.81 Kips
14.01 ft	13.60 Kips	51.59 Kips	65.19 Kips
23.01 ft	36.44 Kips	74.84 Kips	111.28 Kips
32.01 ft	67.68 Kips	78.59 Kips	146.27 Kips
32.99 ft	71.59 Kips	78.59 Kips	150.18 Kips
33.01 ft	71.64 Kips	27.90 Kips	99.54 Kips
40.29 ft	88.42 Kips	27.90 Kips	116.32 Kips
40.31 ft	88.47 Kips	14.24 Kips	102.71 Kips
49.31 ft	109.44 Kips	14.24 Kips	123.68 Kips
50.29 ft	111.93 Kips	14.24 Kips	126.17 Kips
50.31 ft	111.99 Kips	17.32 Kips	129.30 Kips
59.31 ft	141.99 Kips	17.32 Kips	159.31 Kips
60.29 ft	145.26 Kips	17.32 Kips	162.58 Kips
60.31 ft	145.31 Kips	5.77 Kips	151.08 Kips
69.31 ft	158.17 Kips	5.77 Kips	163.95 Kips
70.29 ft	159.57 Kips	5.77 Kips	165.35 Kips
70.31 ft	159.61 Kips	24.53 Kips	184.14 Kips
79.31 ft	174.83 Kips	24.53 Kips	199.37 Kips
88.31 ft	213.57 Kips	24.53 Kips	238.11 Kips
97.31 ft	270.14 Kips	24.53 Kips	294.67 Kips
101.99 ft	289.29 Kips	24.53 Kips	313.83 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.64 psf	23.99	N/A	0.00 Kips
3.99 ft	Cohesionless	255.36 psf	23.99	N/A	2.46 Kips
4.01 ft	Cohesionless	512.54 psf	19.33	N/A	2.47 Kips
8.49 ft	Cohesionless	754.46 psf	19.33	N/A	6.37 Kips
8.51 ft	Cohesionless	998.23 psf	19.33	N/A	6.40 Kips
8.99 ft	Cohesionless	1009.17 psf	19.33	N/A	6.95 Kips
9.01 ft	Cohesionless	1021.09 psf	19.99	N/A	6.98 Kips
11.49 ft	Cohesionless	1092.51 psf	19.99	N/A	10.36 Kips
11.51 ft	Cohesionless	1165.09 psf	19.99	N/A	10.39 Kips
13.99 ft	Cohesionless	1236.51 psf	19.99	N/A	14.22 Kips
14.01 ft	Cohesionless	1309.13 psf	22.66	N/A	14.26 Kips
23.01 ft	Cohesionless	1604.33 psf	22.66	N/A	41.78 Kips
32.01 ft	Cohesionless	1899.53 psf	22.66	N/A	79.42 Kips
32.99 ft	Cohesionless	1931.67 psf	22.66	N/A	84.13 Kips
33.01 ft	Cohesive	N/A	N/A	938.55 psf	84.21 Kips
40.29 ft	Cohesive	N/A	N/A	938.55 psf	109.25 Kips
40.31 ft	Cohesionless	3012.48 psf	18.66	N/A	109.32 Kips
49.31 ft	Cohesionless	3280.68 psf	18.66	N/A	140.62 Kips
50.29 ft	Cohesionless	3309.88 psf	18.66	N/A	144.34 Kips
50.31 ft	Cohesive	N/A	N/A	1357.70 psf	144.42 Kips
59.31 ft	Cohesive	N/A	N/A	1357.70 psf	189.21 Kips
60.29 ft	Cohesive	N/A	N/A	1357.70 psf	194.09 Kips
60.31 ft	Cohesive	N/A	N/A	582.11 psf	194.16 Kips
69.31 ft	Cohesive	N/A	N/A	582.11 psf	213.36 Kips
70.29 ft	Cohesive	N/A	N/A	582.11 psf	215.45 Kips
70.31 ft	Cohesive	N/A	N/A	689.07 psf	215.50 Kips
79.31 ft	Cohesive	N/A	N/A	689.07 psf	238.23 Kips
88.31 ft	Cohesive	N/A	N/A	1220.62 psf	296.05 Kips
97.31 ft	Cohesive	N/A	N/A	1666.69 psf	380.47 Kips
101.99 ft	Cohesive	N/A	N/A	1666.69 psf	409.06 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.28 psf	77.60	162.06 Kips	0.07 Kips
3.99 ft	Cohesionless	510.72 psf	77.60	162.06 Kips	29.37 Kips
4.01 ft	Cohesionless	513.08 psf	26.40	14.24 Kips	8.08 Kips
8.49 ft	Cohesionless	996.92 psf	26.40	14.24 Kips	14.24 Kips
8.51 ft	Cohesionless	998.46 psf	26.40	14.24 Kips	14.24 Kips
8.99 ft	Cohesionless	1020.34 psf	26.40	14.24 Kips	14.24 Kips
9.01 ft	Cohesionless	1021.38 psf	30.00	14.24 Kips	14.24 Kips
11.49 ft	Cohesionless	1164.22 psf	30.00	14.24 Kips	14.24 Kips
11.51 ft	Cohesionless	1165.38 psf	30.00	14.24 Kips	14.24 Kips
13.99 ft	Cohesionless	1308.22 psf	30.00	14.24 Kips	14.24 Kips
14.01 ft	Cohesionless	1309.46 psf	55.60	78.59 Kips	51.59 Kips
23.01 ft	Cohesionless	1899.86 psf	55.60	78.59 Kips	74.84 Kips
32.01 ft	Cohesionless	2490.26 psf	55.60	78.59 Kips	78.59 Kips
32.99 ft	Cohesionless	2554.54 psf	55.60	78.59 Kips	78.59 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	27.90 Kips
40.29 ft	Cohesive	N/A	N/A	N/A	27.90 Kips
40.31 ft	Cohesionless	3012.78 psf	22.80	14.24 Kips	14.24 Kips
49.31 ft	Cohesionless	3549.18 psf	22.80	14.24 Kips	14.24 Kips
50.29 ft	Cohesionless	3607.58 psf	22.80	14.24 Kips	14.24 Kips
50.31 ft	Cohesive	N/A	N/A	N/A	17.32 Kips
59.31 ft	Cohesive	N/A	N/A	N/A	17.32 Kips
60.29 ft	Cohesive	N/A	N/A	N/A	17.32 Kips
60.31 ft	Cohesive	N/A	N/A	N/A	5.77 Kips
69.31 ft	Cohesive	N/A	N/A	N/A	5.77 Kips
70.29 ft	Cohesive	N/A	N/A	N/A	5.77 Kips
70.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
79.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
88.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
97.31 ft	Cohesive	N/A	N/A	N/A	24.53 Kips
101.99 ft	Cohesive	N/A	N/A	N/A	24.53 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.07 Kips	0.07 Kips
3.99 ft	2.46 Kips	29.37 Kips	31.83 Kips
4.01 ft	2.47 Kips	8.08 Kips	10.55 Kips
8.49 ft	6.37 Kips	14.24 Kips	20.61 Kips
8.51 ft	6.40 Kips	14.24 Kips	20.64 Kips
8.99 ft	6.95 Kips	14.24 Kips	21.19 Kips
9.01 ft	6.98 Kips	14.24 Kips	21.22 Kips
11.49 ft	10.36 Kips	14.24 Kips	24.60 Kips
11.51 ft	10.39 Kips	14.24 Kips	24.63 Kips
13.99 ft	14.22 Kips	14.24 Kips	28.46 Kips
14.01 ft	14.26 Kips	51.59 Kips	65.85 Kips
23.01 ft	41.78 Kips	74.84 Kips	116.62 Kips
32.01 ft	79.42 Kips	78.59 Kips	158.01 Kips
32.99 ft	84.13 Kips	78.59 Kips	162.72 Kips
33.01 ft	84.21 Kips	27.90 Kips	112.11 Kips
40.29 ft	109.25 Kips	27.90 Kips	137.16 Kips
40.31 ft	109.32 Kips	14.24 Kips	123.56 Kips
49.31 ft	140.62 Kips	14.24 Kips	154.86 Kips
50.29 ft	144.34 Kips	14.24 Kips	158.58 Kips
50.31 ft	144.42 Kips	17.32 Kips	161.74 Kips
59.31 ft	189.21 Kips	17.32 Kips	206.53 Kips
60.29 ft	194.09 Kips	17.32 Kips	211.41 Kips
60.31 ft	194.16 Kips	5.77 Kips	199.93 Kips
69.31 ft	213.36 Kips	5.77 Kips	219.13 Kips
70.29 ft	215.45 Kips	5.77 Kips	221.22 Kips
70.31 ft	215.50 Kips	24.53 Kips	240.03 Kips
79.31 ft	238.23 Kips	24.53 Kips	262.76 Kips
88.31 ft	296.05 Kips	24.53 Kips	320.58 Kips
97.31 ft	380.47 Kips	24.53 Kips	405.00 Kips
101.99 ft	409.06 Kips	24.53 Kips	433.59 Kips

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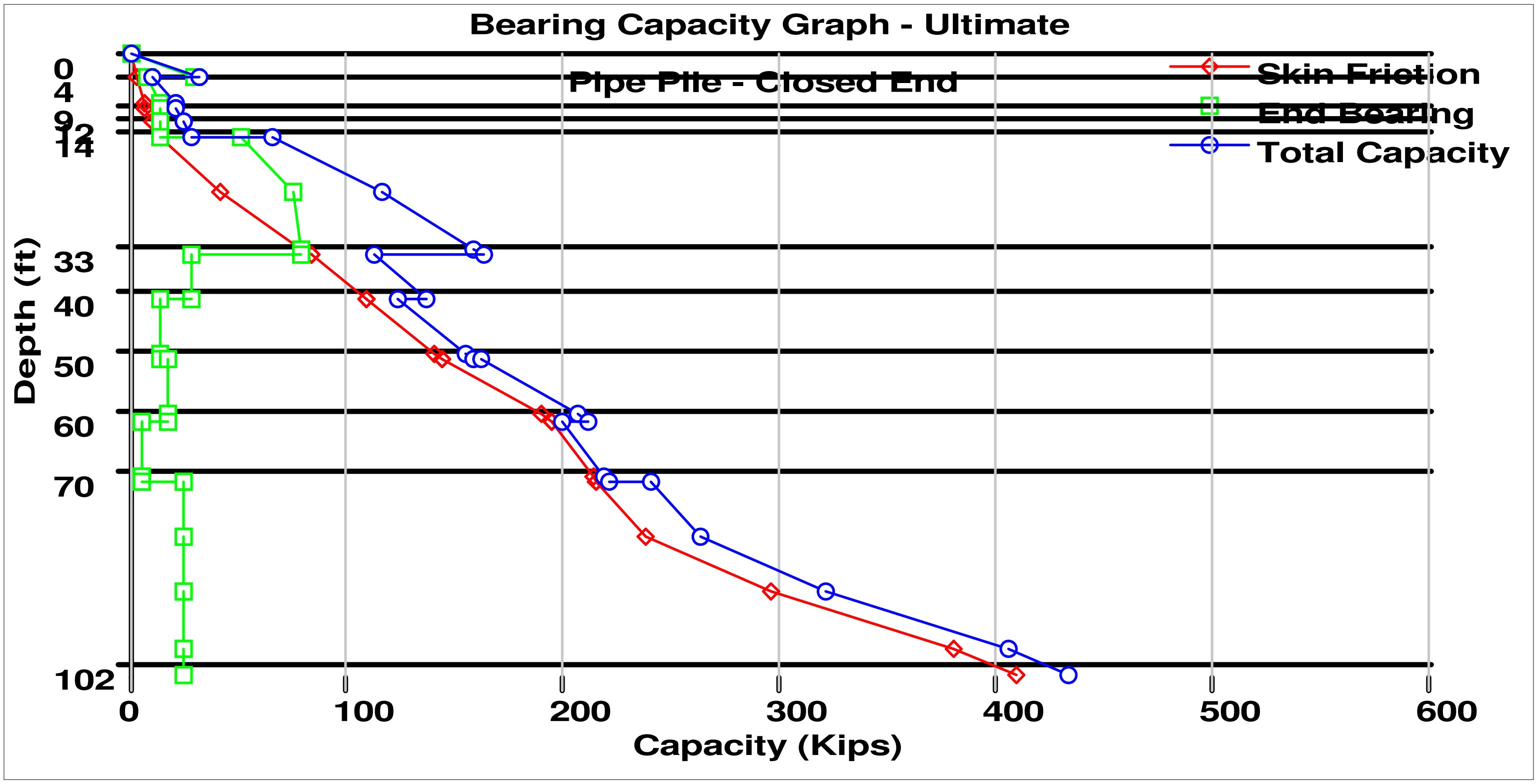

FORWARD ABUTMENT

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\XPMUSER\DESKTOP\CCG3\BRIDGE~1\B10FWD.DVN
Project Name: CUY-90-16.28 Project Date: 06/22/2022
Project Client: Michael Baker
Computed By: M. Jasiewicz
Project Manager: B. Andrews

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:	21.90 ft
	- Driving/Restrike	21.90 ft
	- Ultimate:	21.90 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	1.90 ft	0.00%	130.00 pcf	36.0/36.0	Nordlund
2	Cohesionless	2.00 ft	0.00%	128.00 pcf	35.0/35.0	Nordlund
3	Cohesionless	7.50 ft	0.00%	110.00 pcf	28.0/28.0	Nordlund
4	Cohesive	2.50 ft	33.00%	105.00 pcf	600.00 psf	T-80 Same
5	Cohesionless	11.60 ft	0.00%	128.00 pcf	33.0/33.0	Nordlund
6	Cohesionless	13.70 ft	17.00%	130.00 pcf	34.0/34.0	Nordlund
7	Cohesive	15.70 ft	33.00%	130.00 pcf	2500.00 psf	T-80 Same
8	Cohesive	20.20 ft	33.00%	120.00 pcf	1600.00 psf	T-80 Same
9	Cohesive	5.60 ft	33.00%	130.00 pcf	3050.00 psf	T-80 Same
10	Cohesive	32.70 ft	43.00%	120.00 pcf	1600.00 psf	T-80 Same

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.65 psf	21.17	N/A	0.00 Kips
1.89 ft	Cohesionless	122.85 psf	21.17	N/A	0.37 Kips
1.91 ft	Cohesionless	247.64 psf	20.58	N/A	0.38 Kips
3.89 ft	Cohesionless	374.36 psf	20.58	N/A	1.42 Kips
3.91 ft	Cohesionless	503.55 psf	16.46	N/A	1.43 Kips
11.39 ft	Cohesionless	914.95 psf	16.46	N/A	6.50 Kips
11.41 ft	Cohesive	N/A	N/A	582.11 psf	6.52 Kips
13.89 ft	Cohesive	N/A	N/A	582.11 psf	9.56 Kips
13.91 ft	Cohesionless	1591.14 psf	19.41	N/A	9.59 Kips
21.89 ft	Cohesionless	2101.86 psf	19.41	N/A	29.39 Kips
21.91 ft	Cohesionless	2614.83 psf	19.41	N/A	29.45 Kips
25.49 ft	Cohesionless	2732.25 psf	19.41	N/A	40.99 Kips
25.51 ft	Cohesionless	2851.00 psf	19.99	N/A	41.05 Kips
34.51 ft	Cohesionless	3155.20 psf	19.99	N/A	71.39 Kips
39.19 ft	Cohesionless	3313.38 psf	19.99	N/A	89.47 Kips
39.21 ft	Cohesive	N/A	N/A	1108.65 psf	89.53 Kips
48.21 ft	Cohesive	N/A	N/A	1108.65 psf	110.53 Kips
54.89 ft	Cohesive	N/A	N/A	1230.82 psf	130.16 Kips
54.91 ft	Cohesive	N/A	N/A	1287.72 psf	130.22 Kips
63.91 ft	Cohesive	N/A	N/A	1287.72 psf	154.61 Kips
72.91 ft	Cohesive	N/A	N/A	1367.37 psf	182.02 Kips
75.09 ft	Cohesive	N/A	N/A	1389.05 psf	189.22 Kips
75.11 ft	Cohesive	N/A	N/A	890.68 psf	189.27 Kips
80.69 ft	Cohesive	N/A	N/A	890.68 psf	199.73 Kips
80.71 ft	Cohesive	N/A	N/A	1287.72 psf	199.77 Kips
89.71 ft	Cohesive	N/A	N/A	1287.72 psf	220.52 Kips
98.71 ft	Cohesive	N/A	N/A	1367.37 psf	243.85 Kips
107.71 ft	Cohesive	N/A	N/A	1456.86 psf	270.21 Kips
113.39 ft	Cohesive	N/A	N/A	1513.34 psf	288.34 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.30 psf	77.60	119.07 Kips	0.05 Kips
1.89 ft	Cohesionless	245.70 psf	77.60	119.07 Kips	10.38 Kips
1.91 ft	Cohesionless	248.28 psf	64.00	84.51 Kips	8.49 Kips
3.89 ft	Cohesionless	501.72 psf	64.00	84.51 Kips	17.15 Kips
3.91 ft	Cohesionless	504.10 psf	22.80	10.46 Kips	4.84 Kips
11.39 ft	Cohesionless	1326.90 psf	22.80	10.46 Kips	10.46 Kips
11.41 ft	Cohesive	N/A	N/A	N/A	4.24 Kips
13.89 ft	Cohesive	N/A	N/A	N/A	4.24 Kips
13.91 ft	Cohesionless	1591.78 psf	47.20	39.27 Kips	38.10 Kips
21.89 ft	Cohesionless	2613.22 psf	47.20	39.27 Kips	39.27 Kips
21.91 ft	Cohesionless	2615.16 psf	47.20	39.27 Kips	39.27 Kips
25.49 ft	Cohesionless	2850.00 psf	47.20	39.27 Kips	39.27 Kips
25.51 ft	Cohesionless	2851.34 psf	55.60	57.74 Kips	57.74 Kips
34.51 ft	Cohesionless	3459.74 psf	55.60	57.74 Kips	57.74 Kips
39.19 ft	Cohesionless	3776.10 psf	55.60	57.74 Kips	57.74 Kips
39.21 ft	Cohesive	N/A	N/A	N/A	17.67 Kips
48.21 ft	Cohesive	N/A	N/A	N/A	17.67 Kips
54.89 ft	Cohesive	N/A	N/A	N/A	17.67 Kips
54.91 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
63.91 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
72.91 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
75.09 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
75.11 ft	Cohesive	N/A	N/A	N/A	21.56 Kips
80.69 ft	Cohesive	N/A	N/A	N/A	21.56 Kips
80.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
89.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
98.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
107.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
113.39 ft	Cohesive	N/A	N/A	N/A	11.31 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.05 Kips	0.05 Kips
1.89 ft	0.37 Kips	10.38 Kips	10.76 Kips
1.91 ft	0.38 Kips	8.49 Kips	8.87 Kips
3.89 ft	1.42 Kips	17.15 Kips	18.57 Kips
3.91 ft	1.43 Kips	4.84 Kips	6.27 Kips
11.39 ft	6.50 Kips	10.46 Kips	16.96 Kips
11.41 ft	6.52 Kips	4.24 Kips	10.76 Kips
13.89 ft	9.56 Kips	4.24 Kips	13.80 Kips
13.91 ft	9.59 Kips	38.10 Kips	47.69 Kips
21.89 ft	29.39 Kips	39.27 Kips	68.66 Kips
21.91 ft	29.45 Kips	39.27 Kips	68.72 Kips
25.49 ft	40.99 Kips	39.27 Kips	80.26 Kips
25.51 ft	41.05 Kips	57.74 Kips	98.79 Kips
34.51 ft	71.39 Kips	57.74 Kips	129.13 Kips
39.19 ft	89.47 Kips	57.74 Kips	147.22 Kips
39.21 ft	89.53 Kips	17.67 Kips	107.20 Kips
48.21 ft	110.53 Kips	17.67 Kips	128.20 Kips
54.89 ft	130.16 Kips	17.67 Kips	147.83 Kips
54.91 ft	130.22 Kips	11.31 Kips	141.52 Kips
63.91 ft	154.61 Kips	11.31 Kips	165.92 Kips
72.91 ft	182.02 Kips	11.31 Kips	193.33 Kips
75.09 ft	189.22 Kips	11.31 Kips	200.53 Kips
75.11 ft	189.27 Kips	21.56 Kips	210.83 Kips
80.69 ft	199.73 Kips	21.56 Kips	221.29 Kips
80.71 ft	199.77 Kips	11.31 Kips	211.08 Kips
89.71 ft	220.52 Kips	11.31 Kips	231.83 Kips
98.71 ft	243.85 Kips	11.31 Kips	255.16 Kips
107.71 ft	270.21 Kips	11.31 Kips	281.52 Kips
113.39 ft	288.34 Kips	11.31 Kips	299.65 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.65 psf	21.17	N/A	0.00 Kips
1.89 ft	Cohesionless	122.85 psf	21.17	N/A	0.37 Kips
1.91 ft	Cohesionless	247.64 psf	20.58	N/A	0.38 Kips
3.89 ft	Cohesionless	374.36 psf	20.58	N/A	1.42 Kips
3.91 ft	Cohesionless	503.55 psf	16.46	N/A	1.43 Kips
11.39 ft	Cohesionless	914.95 psf	16.46	N/A	6.50 Kips
11.41 ft	Cohesive	N/A	N/A	582.11 psf	6.53 Kips
13.89 ft	Cohesive	N/A	N/A	582.11 psf	11.06 Kips
13.91 ft	Cohesionless	1591.14 psf	19.41	N/A	11.10 Kips
21.89 ft	Cohesionless	2101.86 psf	19.41	N/A	30.89 Kips
21.91 ft	Cohesionless	2614.83 psf	19.41	N/A	30.95 Kips
25.49 ft	Cohesionless	2732.25 psf	19.41	N/A	42.49 Kips
25.51 ft	Cohesionless	2851.00 psf	19.99	N/A	42.56 Kips
34.51 ft	Cohesionless	3155.20 psf	19.99	N/A	79.12 Kips
39.19 ft	Cohesionless	3313.38 psf	19.99	N/A	100.91 Kips
39.21 ft	Cohesive	N/A	N/A	1108.65 psf	100.99 Kips
48.21 ft	Cohesive	N/A	N/A	1108.65 psf	132.34 Kips
54.89 ft	Cohesive	N/A	N/A	1230.82 psf	161.63 Kips
54.91 ft	Cohesive	N/A	N/A	1287.72 psf	161.72 Kips
63.91 ft	Cohesive	N/A	N/A	1287.72 psf	198.13 Kips
72.91 ft	Cohesive	N/A	N/A	1367.37 psf	239.04 Kips
75.09 ft	Cohesive	N/A	N/A	1389.05 psf	249.78 Kips
75.11 ft	Cohesive	N/A	N/A	890.68 psf	249.86 Kips
80.69 ft	Cohesive	N/A	N/A	890.68 psf	265.48 Kips
80.71 ft	Cohesive	N/A	N/A	1287.72 psf	265.54 Kips
89.71 ft	Cohesive	N/A	N/A	1287.72 psf	301.95 Kips
98.71 ft	Cohesive	N/A	N/A	1367.37 psf	342.87 Kips
107.71 ft	Cohesive	N/A	N/A	1456.86 psf	389.12 Kips
113.39 ft	Cohesive	N/A	N/A	1513.34 psf	420.92 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.30 psf	77.60	119.07 Kips	0.05 Kips
1.89 ft	Cohesionless	245.70 psf	77.60	119.07 Kips	10.38 Kips
1.91 ft	Cohesionless	248.28 psf	64.00	84.51 Kips	8.49 Kips
3.89 ft	Cohesionless	501.72 psf	64.00	84.51 Kips	17.15 Kips
3.91 ft	Cohesionless	504.10 psf	22.80	10.46 Kips	4.84 Kips
11.39 ft	Cohesionless	1326.90 psf	22.80	10.46 Kips	10.46 Kips
11.41 ft	Cohesive	N/A	N/A	N/A	4.24 Kips
13.89 ft	Cohesive	N/A	N/A	N/A	4.24 Kips
13.91 ft	Cohesionless	1591.78 psf	47.20	39.27 Kips	38.10 Kips
21.89 ft	Cohesionless	2613.22 psf	47.20	39.27 Kips	39.27 Kips
21.91 ft	Cohesionless	2615.16 psf	47.20	39.27 Kips	39.27 Kips
25.49 ft	Cohesionless	2850.00 psf	47.20	39.27 Kips	39.27 Kips
25.51 ft	Cohesionless	2851.34 psf	55.60	57.74 Kips	57.74 Kips
34.51 ft	Cohesionless	3459.74 psf	55.60	57.74 Kips	57.74 Kips
39.19 ft	Cohesionless	3776.10 psf	55.60	57.74 Kips	57.74 Kips
39.21 ft	Cohesive	N/A	N/A	N/A	17.67 Kips
48.21 ft	Cohesive	N/A	N/A	N/A	17.67 Kips
54.89 ft	Cohesive	N/A	N/A	N/A	17.67 Kips
54.91 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
63.91 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
72.91 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
75.09 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
75.11 ft	Cohesive	N/A	N/A	N/A	21.56 Kips
80.69 ft	Cohesive	N/A	N/A	N/A	21.56 Kips
80.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
89.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
98.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
107.71 ft	Cohesive	N/A	N/A	N/A	11.31 Kips
113.39 ft	Cohesive	N/A	N/A	N/A	11.31 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.05 Kips	0.05 Kips
1.89 ft	0.37 Kips	10.38 Kips	10.76 Kips
1.91 ft	0.38 Kips	8.49 Kips	8.87 Kips
3.89 ft	1.42 Kips	17.15 Kips	18.57 Kips
3.91 ft	1.43 Kips	4.84 Kips	6.27 Kips
11.39 ft	6.50 Kips	10.46 Kips	16.96 Kips
11.41 ft	6.53 Kips	4.24 Kips	10.77 Kips
13.89 ft	11.06 Kips	4.24 Kips	15.30 Kips
13.91 ft	11.10 Kips	38.10 Kips	49.20 Kips
21.89 ft	30.89 Kips	39.27 Kips	70.16 Kips
21.91 ft	30.95 Kips	39.27 Kips	70.22 Kips
25.49 ft	42.49 Kips	39.27 Kips	81.76 Kips
25.51 ft	42.56 Kips	57.74 Kips	100.31 Kips
34.51 ft	79.12 Kips	57.74 Kips	136.86 Kips
39.19 ft	100.91 Kips	57.74 Kips	158.65 Kips
39.21 ft	100.99 Kips	17.67 Kips	118.67 Kips
48.21 ft	132.34 Kips	17.67 Kips	150.01 Kips
54.89 ft	161.63 Kips	17.67 Kips	179.30 Kips
54.91 ft	161.72 Kips	11.31 Kips	173.03 Kips
63.91 ft	198.13 Kips	11.31 Kips	209.44 Kips
72.91 ft	239.04 Kips	11.31 Kips	250.35 Kips
75.09 ft	249.78 Kips	11.31 Kips	261.09 Kips
75.11 ft	249.86 Kips	21.56 Kips	271.42 Kips
80.69 ft	265.48 Kips	21.56 Kips	287.03 Kips
80.71 ft	265.54 Kips	11.31 Kips	276.85 Kips
89.71 ft	301.95 Kips	11.31 Kips	313.26 Kips
98.71 ft	342.87 Kips	11.31 Kips	354.18 Kips
107.71 ft	389.12 Kips	11.31 Kips	400.43 Kips
113.39 ft	420.92 Kips	11.31 Kips	432.23 Kips

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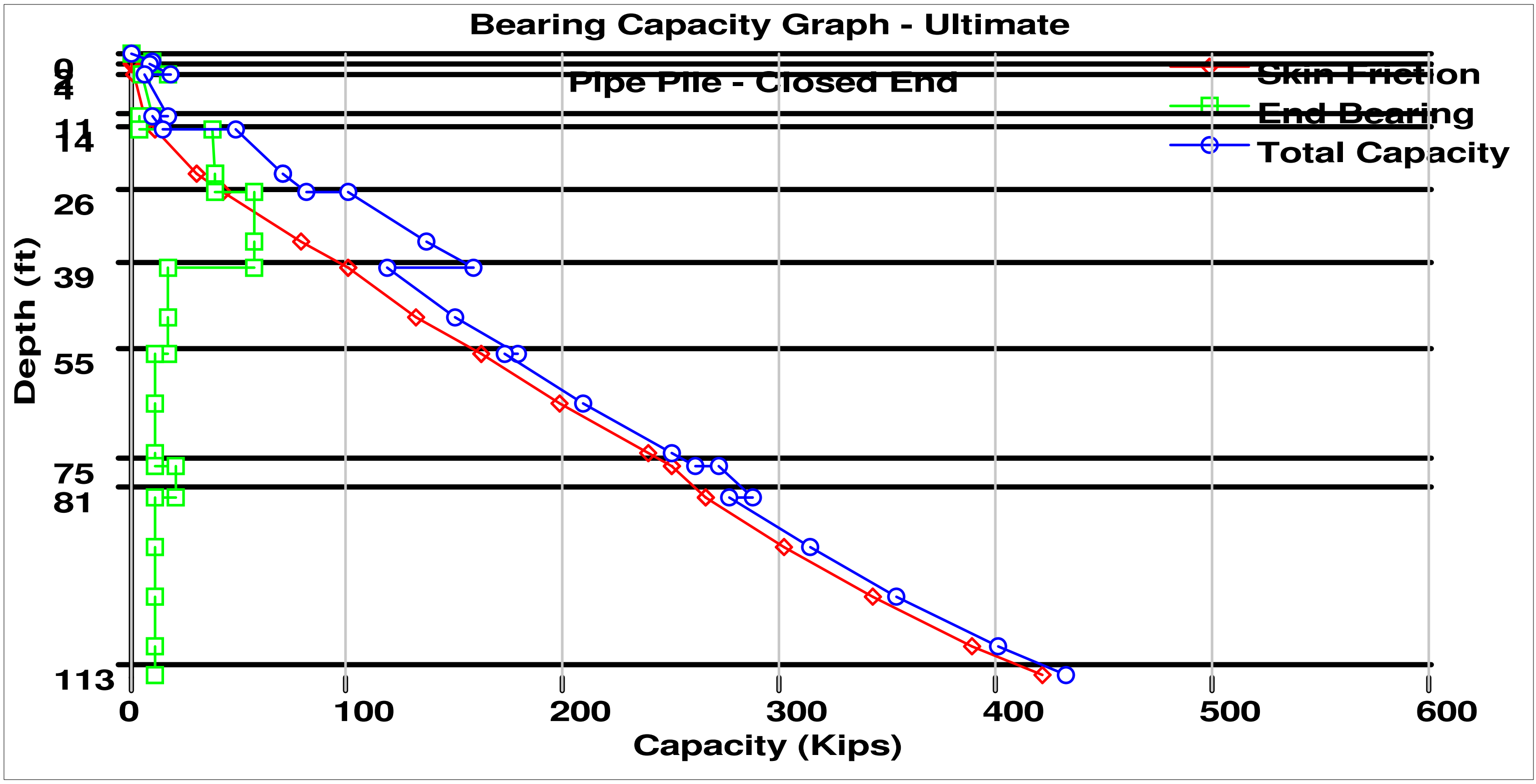


APPENDIX H

DRIVABILITY ANALYSIS

REAR ABUTMENT

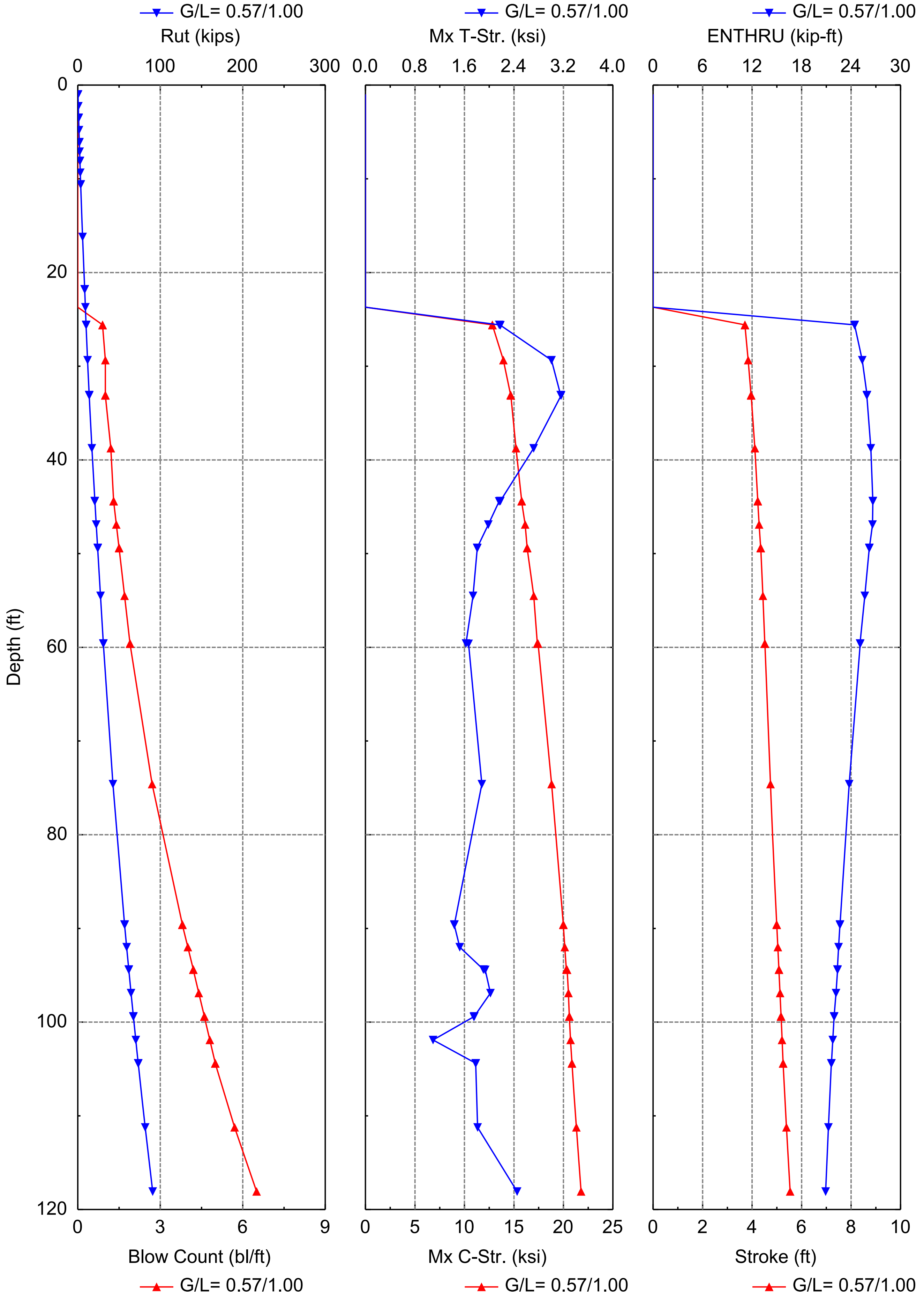
Driveability Analysis Summary

Gain/Loss Factor at Shaft/Toe = 0.570/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.0	0.3	0.0	0.3	0.3	0.000	0.000	10.81	0.0	D 19-42
1.0	0.3	0.0	0.3	0.3	0.000	0.000	10.81	0.0	D 19-42
2.3	0.6	0.0	0.6	0.3	0.000	0.000	10.81	0.0	D 19-42
3.5	1.0	0.1	0.9	0.3	0.000	0.000	10.81	0.0	D 19-42
3.5	1.0	0.1	0.9	0.3	0.000	0.000	10.81	0.0	D 19-42
4.8	1.4	0.1	1.3	0.3	0.000	0.000	10.81	0.0	D 19-42
6.1	1.8	0.2	1.6	0.3	0.000	0.000	10.81	0.0	D 19-42
6.1	1.8	0.2	1.6	0.3	0.000	0.000	10.81	0.0	D 19-42
7.1	2.2	0.3	1.9	0.3	0.000	0.000	10.81	0.0	D 19-42
8.1	2.5	0.4	2.1	0.3	0.000	0.000	10.81	0.0	D 19-42
8.1	2.5	0.4	2.1	0.3	0.000	0.000	10.81	0.0	D 19-42
9.4	3.0	0.5	2.5	0.3	0.000	0.000	10.81	0.0	D 19-42
10.6	3.4	0.6	2.8	0.3	0.000	0.000	10.81	0.0	D 19-42
10.6	3.5	0.6	2.8	0.3	0.000	0.000	10.81	0.0	D 19-42
16.2	5.8	1.5	4.3	0.3	0.000	0.000	10.81	0.0	D 19-42
21.8	8.4	2.7	5.6	0.0	0.000	0.000	0.00	0.0	D 19-42
21.8	8.4	2.7	5.6	0.0	0.000	0.000	0.00	0.0	D 19-42
23.7	9.2	3.2	6.0	0.0	0.000	0.000	0.00	0.0	D 19-42
25.6	10.1	3.8	6.3	0.9	12.815	2.163	3.71	24.4	D 19-42
25.6	10.1	3.8	6.3	0.9	12.833	2.180	3.71	24.4	D 19-42
29.4	11.8	5.0	6.9	1.0	13.928	3.006	3.84	25.4	D 19-42
33.1	13.8	6.3	7.5	1.0	14.665	3.154	3.96	25.9	D 19-42
33.1	13.8	6.3	7.5	1.0	14.691	3.161	3.96	25.9	D 19-42
38.8	17.0	8.6	8.4	1.2	15.210	2.719	4.11	26.4	D 19-42
44.4	20.5	11.3	9.2	1.3	15.783	2.181	4.23	26.6	D 19-42
44.4	20.5	11.4	9.2	1.3	15.767	2.161	4.23	26.6	D 19-42
46.9	22.3	12.7	9.6	1.4	16.132	1.985	4.28	26.6	D 19-42
49.4	24.2	14.0	10.1	1.5	16.336	1.806	4.35	26.2	D 19-42
49.4	24.2	14.1	10.1	1.5	16.335	1.806	4.35	26.2	D 19-42
54.5	27.6	17.1	10.5	1.7	17.003	1.738	4.44	25.7	D 19-42
59.6	30.9	20.4	10.5	1.9	17.363	1.625	4.51	25.1	D 19-42
59.6	30.9	20.5	10.5	1.9	17.435	1.666	4.52	25.1	D 19-42
74.6	42.5	32.0	10.5	2.7	18.806	1.881	4.74	23.8	D 19-42
89.6	56.7	46.2	10.5	3.8	19.992	1.438	4.99	22.7	D 19-42
89.6	56.7	46.3	10.5	3.8	19.991	1.435	4.99	22.6	D 19-42
92.0	59.2	48.7	10.5	4.0	20.136	1.524	5.04	22.5	D 19-42
94.4	61.8	51.3	10.5	4.2	20.289	1.907	5.09	22.3	D 19-42
94.4	61.8	51.3	10.5	4.2	20.373	1.936	5.09	22.4	D 19-42
96.9	64.5	54.1	10.5	4.4	20.503	2.021	5.13	22.2	D 19-42
99.4	67.3	56.9	10.5	4.6	20.597	1.760	5.17	21.9	D 19-42
99.4	67.4	56.9	10.5	4.6	20.588	1.752	5.17	21.9	D 19-42
101.9	70.3	59.8	10.5	4.8	20.720	1.092	5.21	21.8	D 19-42

101.9	70.3	59.8	10.5	4.8	20.720	1.092	5.21	21.8	D 19-42
104.4	73.2	62.7	10.5	5.0	20.862	1.782	5.25	21.6	D 19-42
104.4	73.3	62.8	10.5	5.0	20.853	1.782	5.25	21.6	D 19-42
111.2	81.7	71.3	10.5	5.7	21.312	1.812	5.39	21.3	D 19-42
118.1	90.8	80.3	10.5	6.5	21.779	2.450	5.53	20.9	D 19-42

Total driving time: 5 minutes; Total Number of Blows: 278 (starting at penetration 1.0 ft)


G/L= 0.57/1.00
Rut (kips)
0
100
200
300
G/L= 0.57/1.00
Mx T-Str. (ksi)
0.0
0.8
1.6
2.4
3.2
4.0
G/L= 0.57/1.00
ENTHRU (kip-ft)
0
6
12
18
24
30
Depth (ft)
0
20
40
60
80
100
120
0
3
6
9
Blow Count (bl/ft)
G/L= 0.57/1.00
0
5
10
15
20
25
Mx C-Str. (ksi)
G/L= 0.57/1.00
0
2
4
6
8
10
Stroke (ft)
G/L= 0.57/1.00

CUY-90-16.28 : 06/22/2022 : M. Jasiewicz 5/17/2024
NATIONAL ENGINEERING AND ARCHITECTURAL GRLWEAP 14.1.20.1

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

HAMMER DATA

Hammer Model:	D 19-42	Made By:	DELMAG
Hammer ID:	41	Hammer Type:	OED
Hammer Database Type:	PDI		
Hammer Database Name:			PDIHammer.gwh

Hammer and Drive System Segment Data

Segment -	Weight kips	Stiffness kips/in	COR -	C-Slack in	Damping kips/ft/s
1	0.800	140,084.4	1.000	0.000	
2	0.800	140,084.4	1.000	0.000	
3	0.800	140,084.4	1.000	0.000	
4	0.800	140,084.4	1.000	0.000	
5	0.800	70,754.7	0.900	0.120	
Imp Block	0.753	3,394.7	0.800	0.120	
Helmet	2.500				1.2

Ram Weight: (kips)	4.00	Ram Length: (ft)	10.76
Ram Area: (in²)	124.69		
Maximum (Eq) Stroke: (ft)	10.81	Actual (Eq) Stroke: (ft)	10.81
Efficiency:	0.800	Rated Energy: (kip-ft)	43.24
Maximum Pressure: (psi)	1,600.00	Actual Pressure: (psi)	1,600.00
Combustion Delay: (ms)	2.00	Ignition Duration: (ms)	2.00
Expansion Exponent:	1.25		

Hammer Cushion		Pile Cushion	
Cross Sect. Area: (in²)	12.81	Cross Sect. Area: (in²)	0.00
Elastic Modulus: (ksi)	530.0	Elastic Modulus: (ksi)	0.0
Thickness: (in)	2.00	Thickness: (in)	0.00
Coeff. of Restitution:	0.800	Coeff. of Restitution:	0.500
RoundOut: (in)	0.120	RoundOut: (in)	0.120
Stiffness: (kips/in)	3,394.7	Stiffness: (kips/in)	0.0
Helmet Weight: (kips)	2.500		

PILE INPUT

Uniform Pile		Pile Type:	Closed-End Pipe
Pile Length: (ft)	118.080	Pile Penetration: (ft)	118.080
Pile Size: (ft)	1.00	Toe Area: (in²)	113.10

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp Length ft	Wait Time Hr	Hammer -
0.98	118.1	0.0	DELMAG D 19-42
1.02	118.1	0.0	DELMAG D 19-42
2.25	118.1	0.0	DELMAG D 19-42
3.48	118.1	0.0	DELMAG D 19-42
3.52	118.1	0.0	DELMAG D 19-42
4.80	118.1	0.0	DELMAG D 19-42
6.08	118.1	0.0	DELMAG D 19-42
6.12	118.1	0.0	DELMAG D 19-42
7.10	118.1	0.0	DELMAG D 19-42
8.08	118.1	0.0	DELMAG D 19-42
8.12	118.1	0.0	DELMAG D 19-42
9.35	118.1	0.0	DELMAG D 19-42
10.58	118.1	0.0	DELMAG D 19-42
10.62	118.1	0.0	DELMAG D 19-42
16.20	118.1	0.0	DELMAG D 19-42
21.78	118.1	0.0	DELMAG D 19-42
21.82	118.1	0.0	DELMAG D 19-42
23.70	118.1	0.0	DELMAG D 19-42
25.58	118.1	0.0	DELMAG D 19-42
25.62	118.1	0.0	DELMAG D 19-42
29.35	118.1	0.0	DELMAG D 19-42
33.08	118.1	0.0	DELMAG D 19-42
33.12	118.1	0.0	DELMAG D 19-42
38.75	118.1	0.0	DELMAG D 19-42
44.38	118.1	0.0	DELMAG D 19-42
44.42	118.1	0.0	DELMAG D 19-42
46.90	118.1	0.0	DELMAG D 19-42
49.38	118.1	0.0	DELMAG D 19-42
49.42	118.1	0.0	DELMAG D 19-42
54.50	118.1	0.0	DELMAG D 19-42
59.58	118.1	0.0	DELMAG D 19-42
59.62	118.1	0.0	DELMAG D 19-42
74.60	118.1	0.0	DELMAG D 19-42
89.58	118.1	0.0	DELMAG D 19-42
89.62	118.1	0.0	DELMAG D 19-42
92.00	118.1	0.0	DELMAG D 19-42
94.38	118.1	0.0	DELMAG D 19-42
94.42	118.1	0.0	DELMAG D 19-42

96.90	118.1	0.0	DELMAG D 19-42
99.38	118.1	0.0	DELMAG D 19-42
99.42	118.1	0.0	DELMAG D 19-42
101.90	118.1	0.0	DELMAG D 19-42
104.38	118.1	0.0	DELMAG D 19-42
104.42	118.1	0.0	DELMAG D 19-42
111.23	118.1	0.0	DELMAG D 19-42
118.08	118.1	0.0	DELMAG D 19-42

Other Information for DELMAG D 19-42

Depth ft	Stroke ft	Diesel Pressure %	Efficiency -	P.C. Stiff. Fact. -	P.C. COR -
0.98	10.8	100.0	0.80	1.0	0.50
1.02	10.8	100.0	0.80	1.0	0.50
2.25	10.8	100.0	0.80	1.0	0.50
3.48	10.8	100.0	0.80	1.0	0.50
3.52	10.8	100.0	0.80	1.0	0.50
4.80	10.8	100.0	0.80	1.0	0.50
6.08	10.8	100.0	0.80	1.0	0.50
6.12	10.8	100.0	0.80	1.0	0.50
7.10	10.8	100.0	0.80	1.0	0.50
8.08	10.8	100.0	0.80	1.0	0.50
8.12	10.8	100.0	0.80	1.0	0.50
9.35	10.8	100.0	0.80	1.0	0.50
10.58	10.8	100.0	0.80	1.0	0.50
10.62	10.8	100.0	0.80	1.0	0.50
16.20	10.8	100.0	0.80	1.0	0.50
21.78	10.8	100.0	0.80	1.0	0.50
21.82	10.8	100.0	0.80	1.0	0.50
23.70	10.8	100.0	0.80	1.0	0.50
25.58	10.8	100.0	0.80	1.0	0.50
25.62	10.8	100.0	0.80	1.0	0.50
29.35	10.8	100.0	0.80	1.0	0.50
33.08	10.8	100.0	0.80	1.0	0.50
33.12	10.8	100.0	0.80	1.0	0.50
38.75	10.8	100.0	0.80	1.0	0.50
44.38	10.8	100.0	0.80	1.0	0.50
44.42	10.8	100.0	0.80	1.0	0.50
46.90	10.8	100.0	0.80	1.0	0.50
49.38	10.8	100.0	0.80	1.0	0.50
49.42	10.8	100.0	0.80	1.0	0.50

54.50	10.8	100.0	0.80	1.0	0.50
59.58	10.8	100.0	0.80	1.0	0.50
59.62	10.8	100.0	0.80	1.0	0.50
74.60	10.8	100.0	0.80	1.0	0.50
89.58	10.8	100.0	0.80	1.0	0.50
89.62	10.8	100.0	0.80	1.0	0.50
92.00	10.8	100.0	0.80	1.0	0.50
94.38	10.8	100.0	0.80	1.0	0.50
94.42	10.8	100.0	0.80	1.0	0.50
96.90	10.8	100.0	0.80	1.0	0.50
99.38	10.8	100.0	0.80	1.0	0.50
99.42	10.8	100.0	0.80	1.0	0.50
101.90	10.8	100.0	0.80	1.0	0.50
104.38	10.8	100.0	0.80	1.0	0.50
104.42	10.8	100.0	0.80	1.0	0.50
111.23	10.8	100.0	0.80	1.0	0.50
118.08	10.8	100.0	0.80	1.0	0.50

PILE, SOIL, ANALYSIS OPTIONS

Analysis type:	Driveability Analysis	Soil Damping Option:	Smith
Max No Analysis Iterations:	0	Time Increment/Critical:	160
Residual Stress Analysis:	0	Analysis Time-Input(ms):	0
Output Level:	Normal	Gravitational Acceleration (ft/s²):	32.169
Hammer Gravity (ft/s²):	32.170	Pile Gravity (ft/s²):	32.170

DRIVEABILITY ANALYSIS

Analysis Depth (ft)	118.08	Standard Soil Setup	
Hammer Name	DELMAG D 19-42	Hammer ID	41
Diesel Pressure: (psi)	230.40	Stroke (ft)	10.81
Efficiency	0.80		
Shaft Gain/Loss Factor	0.570	Toe Gain/Loss Factor	1.000

SOIL RESISTANCE PARAMETERS

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Setup F. -	Limit D. ft	Setup T. Hours	EB Area in²
0.00	0.0	0.0	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
1.66	0.0	0.6	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
3.33	0.0	1.1	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
4.99	0.0	1.7	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
6.65	0.0	2.2	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
8.32	0.1	2.8	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
9.98	0.1	3.4	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
11.64	0.1	3.9	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
13.30	0.1	4.5	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
14.97	0.1	5.0	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
16.63	0.1	5.6	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
18.29	0.1	6.1	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
19.96	0.1	6.7	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
21.62	0.1	7.1	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
23.28	0.1	7.5	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
24.95	0.2	7.9	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
26.61	0.2	8.2	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
28.27	0.2	8.6	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
29.94	0.2	8.9	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
31.60	0.2	9.2	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
33.26	0.2	9.6	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
34.93	0.2	9.9	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
36.59	0.2	10.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
38.25	0.2	10.6	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
39.91	0.3	10.9	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
41.58	0.3	11.2	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
43.24	0.3	11.5	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
44.90	0.3	11.7	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
46.57	0.3	12.2	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
48.23	0.3	12.6	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
49.89	0.3	13.0	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10

51.56	0.3	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
53.22	0.3	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
54.88	0.4	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
69.85	0.4	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
71.51	0.5	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
84.82	0.5	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
86.48	0.6	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
99.79	0.6	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
101.45	0.7	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
116.42	0.7	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10
118.08	0.8	13.3	0.10	0.100	0.050	0.1	1.2	6.56	1.0	113.10

PILE PROFILE

Lb Top	X-Area	E-Mod	Spec. Wt	Perim.	C-Index	Wave Sp	Impedance
ft	in²	ksi	lb/ft³	ft	-	ft/s	kips/ft/s
0.00	9.2	30,000	492.00	3.142	0	16,806.4	16.5
118.08	9.2	30,000	492.00	3.142	0	16,806.4	16.5

PILE AND SOIL MODEL Total Capacity Rut (kips): 90.759

Seg.	Weight	Stiffn.	C-Slk	T-Slk	COR	Ru	Js/Jt	Qs/Qt	LbTop	Perim.	X-Area
-	kips	kips/in	in	in	-	kips	s/ft	in	ft	ft	in²
1	0.10	7,034	0.12	0.00	0.85	0.1	0.050	0.10	3.28	3.14	9.2
2	0.10	7,034	0.00	0.00	1.00	0.2	0.050	0.10	6.56	3.14	9.2
3	0.10	7,034	0.00	0.00	1.00	0.3	0.050	0.10	9.84	3.14	9.2
4	0.10	7,034	0.00	0.00	1.00	0.4	0.050	0.10	13.12	3.14	9.2
5	0.10	7,034	0.00	0.00	1.00	0.6	0.050	0.10	16.40	3.14	9.2
6	0.10	7,034	0.00	0.00	1.00	0.7	0.050	0.10	19.68	3.14	9.2
7	0.10	7,034	0.00	0.00	1.00	0.8	0.050	0.10	22.96	3.14	9.2
8	0.10	7,034	0.00	0.00	1.00	0.9	0.050	0.10	26.24	3.14	9.2
9	0.10	7,034	0.00	0.00	1.00	1.1	0.050	0.10	29.52	3.14	9.2
10	0.10	7,034	0.00	0.00	1.00	1.2	0.050	0.10	32.80	3.14	9.2
11	0.10	7,034	0.00	0.00	1.00	1.3	0.050	0.10	36.08	3.14	9.2
12	0.10	7,034	0.00	0.00	1.00	1.4	0.050	0.10	39.36	3.14	9.2
13	0.10	7,034	0.00	0.00	1.00	1.5	0.050	0.10	42.64	3.14	9.2
14	0.10	7,034	0.00	0.00	1.00	1.7	0.050	0.10	45.92	3.14	9.2
15	0.10	7,034	0.00	0.00	1.00	1.8	0.050	0.10	49.20	3.14	9.2
16	0.10	7,034	0.00	0.00	1.00	1.9	0.050	0.10	52.48	3.14	9.2
17	0.10	7,034	0.00	0.00	1.00	2.0	0.050	0.10	55.76	3.14	9.2
18	0.10	7,034	0.00	0.00	1.00	2.2	0.050	0.10	59.04	3.14	9.2
19	0.10	7,034	0.00	0.00	1.00	2.3	0.050	0.10	62.32	3.14	9.2
20	0.10	7,034	0.00	0.00	1.00	2.4	0.050	0.10	65.60	3.14	9.2

21	0.10	7,034	0.00	0.00	1.00	2.5	0.050	0.10	68.88	3.14	9.2
22	0.10	7,034	0.00	0.00	1.00	2.7	0.050	0.10	72.16	3.14	9.2
23	0.10	7,034	0.00	0.00	1.00	2.8	0.050	0.10	75.44	3.14	9.2
24	0.10	7,034	0.00	0.00	1.00	2.9	0.050	0.10	78.72	3.14	9.2
25	0.10	7,034	0.00	0.00	1.00	3.0	0.050	0.10	82.00	3.14	9.2
26	0.10	7,034	0.00	0.00	1.00	3.2	0.050	0.10	85.28	3.14	9.2
27	0.10	7,034	0.00	0.00	1.00	3.3	0.050	0.10	88.56	3.14	9.2
28	0.10	7,034	0.00	0.00	1.00	3.4	0.050	0.10	91.84	3.14	9.2
29	0.10	7,034	0.00	0.00	1.00	3.5	0.050	0.10	95.12	3.14	9.2
30	0.10	7,034	0.00	0.00	1.00	3.7	0.050	0.10	98.40	3.14	9.2
31	0.10	7,034	0.00	0.00	1.00	3.8	0.050	0.10	101.68	3.14	9.2
32	0.10	7,034	0.00	0.00	1.00	3.9	0.050	0.10	104.96	3.14	9.2
33	0.10	7,034	0.00	0.00	1.00	4.0	0.050	0.10	108.24	3.14	9.2
34	0.10	7,034	0.00	0.00	1.00	4.2	0.050	0.10	111.52	3.14	9.2
35	0.10	7,034	0.00	0.00	1.00	4.3	0.050	0.10	114.80	3.14	9.2
36	0.10	7,034	0.00	0.00	1.00	4.4	0.050	0.10	118.08	3.14	9.2
Toe						10.5	0.149	0.10	118.08		

3.723 kips total unreduced pile weight (g = 32.169 ft/s²)
3.723 kips total reduced pile weight (g = 32.169 ft/s²)

OTHER OPTIONS

Pile Damping (%):	1	Pile Damping Fact. (kips/ft/s):	0.329

EXTREMA TABLE at 118.1 FT; HAMMER: D 19-42

Shaft/Toe Gain/Loss Factor = 0.570/1.000

Rut = 90.8 kips Rtoe = 10.5 kips Time Inc. = 0.076 ms

Hammer DELMAG D 19-42 Efficiency 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
3.3	0.0	199.1	0.00	21.58	9.97	2.136	20.92
6.6	3.9	199.8	0.42	21.65	9.93	2.124	20.89
9.8	7.5	200.3	0.81	21.71	9.88	2.113	20.83
13.1	10.7	200.7	1.16	21.75	9.84	2.102	20.74
16.4	13.6	200.9	1.47	21.77	9.79	2.091	20.63
19.7	16.0	201.0	1.74	21.78	9.74	2.080	20.49
23.0	18.2	200.9	1.97	21.77	9.68	2.070	20.32
26.2	19.8	200.7	2.14	21.75	9.63	2.062	20.14
29.5	21.1	200.4	2.29	21.71	9.57	2.054	19.94
32.8	22.2	199.9	2.41	21.66	9.51	2.047	19.71
36.1	22.6	199.3	2.45	21.59	9.44	2.040	19.46
39.4	22.3	198.5	2.41	21.51	9.38	2.033	19.17
42.6	21.4	197.6	2.32	21.41	9.49	2.026	18.86
45.9	20.3	196.5	2.20	21.30	9.71	2.018	18.52
49.2	19.3	195.4	2.09	21.17	9.84	2.010	18.16
52.5	18.3	194.1	1.99	21.03	9.89	2.002	17.76
55.8	17.6	192.6	1.91	20.87	9.87	1.994	17.34
59.0	16.8	191.1	1.83	20.70	9.83	1.987	16.89
62.3	15.9	189.3	1.72	20.52	9.91	1.980	16.42
65.6	14.7	187.5	1.59	20.31	10.36	1.975	15.93
68.9	13.5	185.5	1.46	20.10	10.78	1.970	15.41
72.2	13.0	183.3	1.41	19.86	11.10	1.967	14.87
75.4	13.2	181.0	1.43	19.61	11.38	1.964	14.29
78.7	13.3	178.5	1.44	19.34	11.73	1.961	13.69
82.0	13.1	175.8	1.42	19.05	11.99	1.959	13.06
85.3	12.6	172.6	1.37	18.71	12.14	1.956	12.40
88.6	11.8	168.5	1.28	18.26	12.17	1.954	11.72
91.8	10.7	162.5	1.16	17.61	12.09	1.951	11.00
95.1	9.5	154.2	1.03	16.71	11.92	1.949	10.25
98.4	8.3	143.0	0.90	15.49	11.71	1.946	9.48
101.7	7.1	129.2	0.77	14.00	11.64	1.944	8.67
105.0	5.9	116.2	0.64	12.59	11.96	1.941	7.84
108.2	4.5	103.5	0.49	11.22	12.31	1.939	6.97
111.5	3.0	87.1	0.32	9.43	12.66	1.936	6.08
114.8	1.3	67.5	0.14	7.31	12.92	1.935	5.16

118.1	0.0	46.3	0.00	5.02	13.07	1.933	4.70

Converged Stroke (ft) 5.53 Fixed Combustion Pressure (psi) 1,600.0

(Eq) Strokes Analyzed and Last Return (ft)

10.81	4.56	5.86	5.46	5.56	5.53

SUMMARY TABLE at 118.1 FT; HAMMER: D 19-42

Rut kips	Bl Ct b/ft	Stk Dn ft	Stk Up ft	Mx T-Str ksi	LTop ft	Mx C-Str ksi	LTop ft	ENTHRU kip-ft	Bl Rt b/min	ActRes kips
90.8	6.5	5.53	0.00	2.45	36.1	21.78	19.7	20.9	49.9	90.8

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.570/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Bl Ct b/ft	Mx C-Str ksi	Mx T-Str ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.0	0.3	0.0	0.3	0.0	0.00	0.00	10.81	0.0	D 19-42
1.0	0.3	0.0	0.3	0.0	0.00	0.00	10.81	0.0	D 19-42
2.3	0.6	0.0	0.6	0.0	0.00	0.00	10.81	0.0	D 19-42
3.5	1.0	0.1	0.9	0.0	0.00	0.00	10.81	0.0	D 19-42
3.5	1.0	0.1	0.9	0.0	0.00	0.00	10.81	0.0	D 19-42
4.8	1.4	0.1	1.3	0.0	0.00	0.00	10.81	0.0	D 19-42
6.1	1.8	0.2	1.6	0.0	0.00	0.00	10.81	0.0	D 19-42
6.1	1.8	0.2	1.6	0.0	0.00	0.00	10.81	0.0	D 19-42
7.1	2.2	0.3	1.9	0.0	0.00	0.00	10.81	0.0	D 19-42
8.1	2.5	0.4	2.1	0.0	0.00	0.00	10.81	0.0	D 19-42
8.1	2.5	0.4	2.1	0.0	0.00	0.00	10.81	0.0	D 19-42
9.4	3.0	0.5	2.5	0.0	0.00	0.00	10.81	0.0	D 19-42
10.6	3.4	0.6	2.8	0.0	0.00	0.00	10.81	0.0	D 19-42
10.6	3.5	0.6	2.8	0.0	0.00	0.00	10.81	0.0	D 19-42
16.2	5.8	1.5	4.3	0.0	0.00	0.00	10.81	0.0	D 19-42
21.8	8.4	2.7	5.6	0.0	0.00	0.00	0.00	0.0	D 19-42
21.8	8.4	2.7	5.6	0.0	0.00	0.00	0.00	0.0	D 19-42
23.7	9.2	3.2	6.0	0.0	0.00	0.00	0.00	0.0	D 19-42
25.6	10.1	3.8	6.3	0.9	12.81	2.16	3.71	24.4	D 19-42
25.6	10.1	3.8	6.3	0.9	12.83	2.18	3.71	24.4	D 19-42
29.4	11.8	5.0	6.9	1.0	13.93	3.01	3.84	25.4	D 19-42
33.1	13.8	6.3	7.5	1.0	14.66	3.15	3.96	25.9	D 19-42
33.1	13.8	6.3	7.5	1.0	14.69	3.16	3.96	25.9	D 19-42
38.8	17.0	8.6	8.4	1.2	15.21	2.72	4.11	26.4	D 19-42
44.4	20.5	11.3	9.2	1.3	15.78	2.18	4.23	26.6	D 19-42
44.4	20.5	11.4	9.2	1.3	15.77	2.16	4.23	26.6	D 19-42
46.9	22.3	12.7	9.6	1.4	16.13	1.98	4.28	26.6	D 19-42
49.4	24.2	14.0	10.1	1.5	16.34	1.81	4.35	26.2	D 19-42
49.4	24.2	14.1	10.1	1.5	16.33	1.81	4.35	26.2	D 19-42
54.5	27.6	17.1	10.5	1.7	17.00	1.74	4.44	25.7	D 19-42
59.6	30.9	20.4	10.5	1.9	17.36	1.62	4.51	25.1	D 19-42
59.6	30.9	20.5	10.5	1.9	17.43	1.67	4.52	25.1	D 19-42
74.6	42.5	32.0	10.5	2.7	18.81	1.88	4.74	23.8	D 19-42
89.6	56.7	46.2	10.5	3.8	19.99	1.44	4.99	22.7	D 19-42
89.6	56.7	46.3	10.5	3.8	19.99	1.43	4.99	22.6	D 19-42
92.0	59.2	48.7	10.5	4.0	20.14	1.52	5.04	22.5	D 19-42
94.4	61.8	51.3	10.5	4.2	20.29	1.91	5.09	22.3	D 19-42

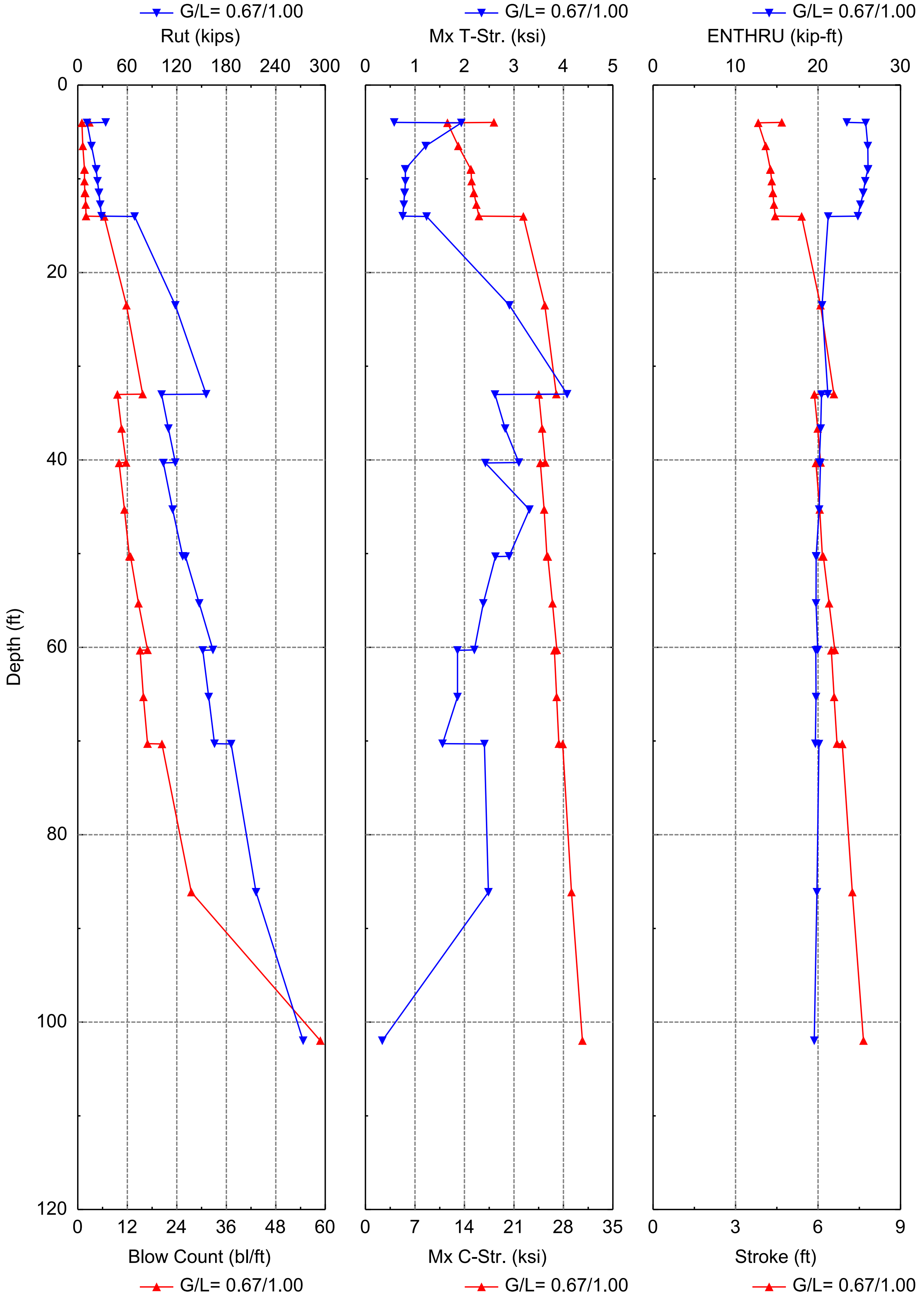
PIER 1

Driveability Analysis Summary

Gain/Loss Factor at Shaft/Toe = 0.670/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
4.0	33.8	2.4	31.3	2.8	18.163	0.581	4.68	23.5	D 19-42
4.0	11.1	2.5	8.7	1.0	11.599	1.935	3.82	25.8	D 19-42
6.5	16.6	4.3	12.3	1.2	13.133	1.216	4.09	26.0	D 19-42
9.0	22.2	6.9	15.2	1.6	14.902	0.802	4.26	26.1	D 19-42
9.0	22.2	7.0	15.2	1.6	14.920	0.807	4.27	26.0	D 19-42
10.3	23.8	8.6	15.2	1.6	15.010	0.807	4.31	25.7	D 19-42
11.5	25.6	10.3	15.2	1.7	15.329	0.795	4.35	25.4	D 19-42
11.5	25.6	10.4	15.2	1.8	15.342	0.789	4.36	25.5	D 19-42
12.8	27.2	11.9	15.2	1.9	15.692	0.775	4.40	25.1	D 19-42
14.0	28.8	13.6	15.2	2.0	16.056	0.752	4.44	24.8	D 19-42
14.0	68.8	13.6	55.2	6.4	22.324	1.235	5.40	21.2	D 19-42
23.5	118.2	37.9	80.2	11.8	25.367	2.908	6.09	20.5	D 19-42
33.0	155.6	71.6	84.0	15.7	26.984	4.074	6.57	21.2	D 19-42
33.0	101.5	71.7	29.8	9.6	24.508	2.616	5.87	20.4	D 19-42
36.7	109.9	80.1	29.8	10.6	24.985	2.823	5.98	20.3	D 19-42
40.3	118.2	88.4	29.8	11.7	25.432	3.100	6.09	20.1	D 19-42
40.3	103.7	88.5	15.2	10.0	24.730	2.424	5.92	20.3	D 19-42
45.3	114.9	99.7	15.2	11.3	25.268	3.313	6.06	20.1	D 19-42
50.3	127.1	111.9	15.2	12.5	25.655	2.901	6.16	19.8	D 19-42
50.3	130.5	112.0	18.5	12.8	25.790	2.626	6.19	19.8	D 19-42
55.3	147.2	128.6	18.5	14.7	26.458	2.382	6.40	19.7	D 19-42
60.3	163.8	145.2	18.5	16.9	27.074	2.201	6.61	20.0	D 19-42
60.3	151.5	145.3	6.2	15.1	26.715	1.859	6.48	19.7	D 19-42
65.3	158.6	152.5	6.2	15.9	27.039	1.859	6.58	19.8	D 19-42
70.3	165.7	159.6	6.2	16.9	27.344	1.557	6.69	19.7	D 19-42
70.3	185.9	159.6	26.2	20.4	27.885	2.403	6.88	20.1	D 19-42
86.1	216.0	189.8	26.2	27.5	29.141	2.485	7.25	19.9	D 19-42
102.0	273.2	247.0	26.2	58.8	30.677	0.339	7.65	19.5	D 19-42

Total driving time: 40 minutes; Total Number of Blows: 1794 (starting at penetration 4.0 ft)


G/L= 0.67/1.00
Rut (kips)
0
60
120
180
240
300
G/L= 0.67/1.00
Mx T-Str. (ksi)
0
1
2
3
4
5
G/L= 0.67/1.00
ENTHRU (kip-ft)
0
10
20
30
Depth (ft)
0
20
40
60
80
100
120
0
12
24
36
48
60
Blow Count (bl/ft)
G/L= 0.67/1.00
0
7
14
21
28
35
Mx C-Str. (ksi)
G/L= 0.67/1.00
0
3
6
9
Stroke (ft)
G/L= 0.67/1.00

CUY-90-16.28 : 06/22/2022 : M. Jasiewicz 5/17/2024
NATIONAL ENGINEERING AND ARCHITECTURAL GRLWEAP 14.1.20.1

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

HAMMER DATA

Hammer Model:	D 19-42	Made By:	DELMAG
Hammer ID:	41	Hammer Type:	OED
Hammer Database Type:	PDI		
Hammer Database Name:			PDIHammer.gwh

Hammer and Drive System Segment Data

Segment -	Weight kips	Stiffness kips/in	COR -	C-Slack in	Damping kips/ft/s
1	0.800	140,084.4	1.000	0.000	
2	0.800	140,084.4	1.000	0.000	
3	0.800	140,084.4	1.000	0.000	
4	0.800	140,084.4	1.000	0.000	
5	0.800	70,754.7	0.900	0.120	
Imp Block	0.753	109,976.0	0.800	0.120	
Helmet	2.500				5.3

Ram Weight: (kips)	4.00	Ram Length: (ft)	10.76
Ram Area: (in²)	124.69		
Maximum (Eq) Stroke: (ft)	10.81	Actual (Eq) Stroke: (ft)	10.81
Efficiency:	0.800	Rated Energy: (kip-ft)	43.24
Maximum Pressure: (psi)	1,600.00	Actual Pressure: (psi)	1,600.00
Combustion Delay: (ms)	2.00	Ignition Duration: (ms)	2.00
Expansion Exponent:	1.25		

Hammer Cushion		Pile Cushion	
Cross Sect. Area: (in²)	415.00	Cross Sect. Area: (in²)	0.00
Elastic Modulus: (ksi)	530.0	Elastic Modulus: (ksi)	0.0
Thickness: (in)	2.00	Thickness: (in)	0.00
Coeff. of Restitution:	0.800	Coeff. of Restitution:	0.500
RoundOut: (in)	0.120	RoundOut: (in)	0.120
Stiffness: (kips/in)	109,976.0	Stiffness: (kips/in)	0.0
Helmet Weight: (kips)	2.500		

PILE INPUT

Uniform Pile		Pile Type:	Closed-End Pipe
Pile Length: (ft)	101.980	Pile Penetration: (ft)	101.980
Pile Size: (ft)	1.17	Toe Area: (in²)	153.94

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp Length ft	Wait Time Hr	Hammer -
3.98	102.0	0.0	DELMAG D 19-42
4.02	102.0	0.0	DELMAG D 19-42
6.50	102.0	0.0	DELMAG D 19-42
8.98	102.0	0.0	DELMAG D 19-42
9.02	102.0	0.0	DELMAG D 19-42
10.25	102.0	0.0	DELMAG D 19-42
11.48	102.0	0.0	DELMAG D 19-42
11.52	102.0	0.0	DELMAG D 19-42
12.75	102.0	0.0	DELMAG D 19-42
13.98	102.0	0.0	DELMAG D 19-42
14.02	102.0	0.0	DELMAG D 19-42
23.50	102.0	0.0	DELMAG D 19-42
32.98	102.0	0.0	DELMAG D 19-42
33.02	102.0	0.0	DELMAG D 19-42
36.65	102.0	0.0	DELMAG D 19-42
40.28	102.0	0.0	DELMAG D 19-42
40.32	102.0	0.0	DELMAG D 19-42
45.30	102.0	0.0	DELMAG D 19-42
50.28	102.0	0.0	DELMAG D 19-42
50.32	102.0	0.0	DELMAG D 19-42
55.30	102.0	0.0	DELMAG D 19-42
60.28	102.0	0.0	DELMAG D 19-42
60.32	102.0	0.0	DELMAG D 19-42
65.30	102.0	0.0	DELMAG D 19-42
70.28	102.0	0.0	DELMAG D 19-42
70.32	102.0	0.0	DELMAG D 19-42
86.13	102.0	0.0	DELMAG D 19-42
101.98	102.0	0.0	DELMAG D 19-42

Other Information for DELMAG D 19-42

Depth ft	Stroke ft	Diesel Pressure %	Efficiency -	P.C. Stiff. Fact. -	P.C. COR -
3.98	10.8	100.0	0.80	1.0	0.50
4.02	10.8	100.0	0.80	1.0	0.50
6.50	10.8	100.0	0.80	1.0	0.50
8.98	10.8	100.0	0.80	1.0	0.50
9.02	10.8	100.0	0.80	1.0	0.50
10.25	10.8	100.0	0.80	1.0	0.50

11.48	10.8	100.0	0.80	1.0	0.50
11.52	10.8	100.0	0.80	1.0	0.50
12.75	10.8	100.0	0.80	1.0	0.50
13.98	10.8	100.0	0.80	1.0	0.50
14.02	10.8	100.0	0.80	1.0	0.50
23.50	10.8	100.0	0.80	1.0	0.50
32.98	10.8	100.0	0.80	1.0	0.50
33.02	10.8	100.0	0.80	1.0	0.50
36.65	10.8	100.0	0.80	1.0	0.50
40.28	10.8	100.0	0.80	1.0	0.50
40.32	10.8	100.0	0.80	1.0	0.50
45.30	10.8	100.0	0.80	1.0	0.50
50.28	10.8	100.0	0.80	1.0	0.50
50.32	10.8	100.0	0.80	1.0	0.50
55.30	10.8	100.0	0.80	1.0	0.50
60.28	10.8	100.0	0.80	1.0	0.50
60.32	10.8	100.0	0.80	1.0	0.50
65.30	10.8	100.0	0.80	1.0	0.50
70.28	10.8	100.0	0.80	1.0	0.50
70.32	10.8	100.0	0.80	1.0	0.50
86.13	10.8	100.0	0.80	1.0	0.50
101.98	10.8	100.0	0.80	1.0	0.50

PILE, SOIL, ANALYSIS OPTIONS

Analysis type:	Driveability Analysis	Soil Damping Option:	Smith
Max No Analysis Iterations:	0	Time Increment/Critical:	160
Residual Stress Analysis:	0	Analysis Time-Input(ms):	0
Output Level:	Normal	Gravitational Acceleration (ft/s²):	32.169
Hammer Gravity (ft/s²):	32.170	Pile Gravity (ft/s²):	32.170

DRIVEABILITY ANALYSIS

Analysis Depth (ft)	101.98	Standard Soil Setup	
Hammer Name	DELMAG D 19-42	Hammer ID	41
Diesel Pressure: (psi)	230.40	Stroke (ft)	10.81
Efficiency	0.80		
Shaft Gain/Loss Factor	0.670	Toe Gain/Loss Factor	1.000

SOIL RESISTANCE PARAMETERS

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Setup -	F.Limit ft	D.Setup T Hours	EB Area in²
0.01	0.0	0.1	0.10	0.140	0.050	0.2	1.0	6.00	1.0	153.94
3.99	0.3	29.4	0.10	0.140	0.050	0.2	1.0	6.00	1.0	153.94
4.01	0.2	8.1	0.10	0.230	0.050	0.2	1.0	6.00	1.0	153.94
8.49	0.3	14.2	0.10	0.230	0.050	0.2	1.0	6.00	1.0	153.94
9.01	0.3	14.2	0.10	0.230	0.050	0.2	1.0	6.00	1.0	153.94
11.49	0.4	14.2	0.10	0.230	0.050	0.2	1.0	6.00	1.0	153.94
11.51	0.4	14.2	0.10	0.230	0.100	0.2	1.2	6.00	24.0	153.94
13.99	0.4	14.2	0.10	0.230	0.100	0.2	1.2	6.00	24.0	153.94
14.01	0.7	51.6	0.10	0.150	0.100	0.2	1.2	6.00	24.0	153.94
23.01	1.0	74.8	0.10	0.150	0.100	0.2	1.2	6.00	24.0	153.94
32.01	1.3	78.6	0.10	0.150	0.100	0.2	1.2	6.00	24.0	153.94
32.99	1.3	78.6	0.10	0.150	0.100	0.2	1.2	6.00	24.0	153.94
33.01	0.9	27.9	0.10	0.130	0.150	0.2	1.5	6.00	24.0	153.94
40.29	0.9	27.9	0.10	0.130	0.150	0.2	1.5	6.00	24.0	153.94
40.31	0.9	14.2	0.10	0.220	0.100	0.2	1.5	6.00	24.0	153.94
49.31	1.0	14.2	0.10	0.220	0.100	0.2	1.5	6.00	24.0	153.94
50.29	1.0	14.2	0.10	0.220	0.100	0.2	1.5	6.00	24.0	153.94
50.31	1.4	17.3	0.10	0.140	0.150	0.2	1.5	6.00	24.0	153.94
60.29	1.4	17.3	0.10	0.140	0.150	0.2	1.5	6.00	24.0	153.94
60.31	0.6	5.8	0.10	0.190	0.150	0.2	1.5	6.00	168.0	153.94
70.29	0.6	5.8	0.10	0.190	0.150	0.2	1.5	6.00	168.0	153.94
70.31	0.7	24.5	0.10	0.130	0.150	0.2	1.5	6.00	168.0	153.94
79.31	0.7	24.5	0.10	0.130	0.150	0.2	1.5	6.00	168.0	153.94
88.31	1.2	24.5	0.10	0.130	0.150	0.2	1.5	6.00	168.0	153.94
97.31	1.7	24.5	0.10	0.130	0.150	0.2	1.5	6.00	168.0	153.94
101.98	1.7	24.5	0.10	0.130	0.150	0.2	1.5	6.00	168.0	153.94

PILE PROFILE

Lb Top ft	X-Area in²	E-Mod ksi	Spec. Wt lb/ft³	Perim. ft	C-Index -	Wave Sp ft/s	Impedance kips/ft/s
0.00	10.8	30,000	492.00	3.665	0	16,806.4	19.3

101.98	10.8	30,000	492.00	3.665	0	16,806.4	19.3

PILE AND SOIL MODEL Total Capacity Rut (kips): 273.213

Seg.	Weight	Stiffn.	C-Slk	T-Slk	COR	Ru	Js/Jt	Qs/Qt	LbTop	Perim.	X-Area
-	kips	kips/in	in	in	-	kips	s/ft	in	ft	ft	in²
1	0.12	8,207	0.12	0.00	0.85	1.7	0.050	0.10	3.29	3.67	10.8
2	0.12	8,207	0.00	0.00	1.00	2.7	0.050	0.10	6.58	3.67	10.8
3	0.12	8,207	0.00	0.00	1.00	3.7	0.050	0.10	9.87	3.67	10.8
4	0.12	8,207	0.00	0.00	1.00	4.4	0.076	0.10	13.16	3.67	10.8
5	0.12	8,207	0.00	0.00	1.00	6.5	0.100	0.10	16.45	3.67	10.8
6	0.12	8,207	0.00	0.00	1.00	8.2	0.100	0.10	19.74	3.67	10.8
7	0.12	8,207	0.00	0.00	1.00	9.3	0.100	0.10	23.03	3.67	10.8
8	0.12	8,207	0.00	0.00	1.00	10.5	0.100	0.10	26.32	3.67	10.8
9	0.12	8,207	0.00	0.00	1.00	11.6	0.100	0.10	29.61	3.67	10.8
10	0.12	8,207	0.00	0.00	1.00	12.7	0.100	0.10	32.90	3.67	10.8
11	0.12	8,207	0.00	0.00	1.00	7.8	0.148	0.10	36.19	3.67	10.8
12	0.12	8,207	0.00	0.00	1.00	7.6	0.150	0.10	39.48	3.67	10.8
13	0.12	8,207	0.00	0.00	1.00	7.3	0.113	0.10	42.77	3.67	10.8
14	0.12	8,207	0.00	0.00	1.00	7.6	0.100	0.10	46.06	3.67	10.8
15	0.12	8,207	0.00	0.00	1.00	8.1	0.100	0.10	49.35	3.67	10.8
16	0.12	8,207	0.00	0.00	1.00	10.2	0.138	0.10	52.63	3.67	10.8
17	0.12	8,207	0.00	0.00	1.00	11.0	0.150	0.10	55.92	3.67	10.8
18	0.12	8,207	0.00	0.00	1.00	11.0	0.150	0.10	59.21	3.67	10.8
19	0.12	8,207	0.00	0.00	1.00	6.8	0.150	0.10	62.50	3.67	10.8
20	0.12	8,207	0.00	0.00	1.00	4.7	0.150	0.10	65.79	3.67	10.8
21	0.12	8,207	0.00	0.00	1.00	4.7	0.150	0.10	69.08	3.67	10.8
22	0.12	8,207	0.00	0.00	1.00	5.2	0.150	0.10	72.37	3.67	10.8
23	0.12	8,207	0.00	0.00	1.00	5.6	0.150	0.10	75.66	3.67	10.8
24	0.12	8,207	0.00	0.00	1.00	5.6	0.150	0.10	78.95	3.67	10.8
25	0.12	8,207	0.00	0.00	1.00	6.2	0.150	0.10	82.24	3.67	10.8
26	0.12	8,207	0.00	0.00	1.00	7.8	0.150	0.10	85.53	3.67	10.8
27	0.12	8,207	0.00	0.00	1.00	9.3	0.150	0.10	88.82	3.67	10.8
28	0.12	8,207	0.00	0.00	1.00	10.7	0.150	0.10	92.11	3.67	10.8
29	0.12	8,207	0.00	0.00	1.00	12.0	0.150	0.10	95.40	3.67	10.8
30	0.12	8,207	0.00	0.00	1.00	13.2	0.150	0.10	98.69	3.67	10.8
31	0.12	8,207	0.00	0.00	1.00	13.5	0.150	0.10	101.98	3.67	10.8
Toe						26.2	0.150	0.13	101.98		

3.763 kips total unreduced pile weight (g = 32.169 ft/s²)
3.763 kips total reduced pile weight (g = 32.169 ft/s²)

OTHER OPTIONS

Pile Damping (%):	1	Pile Damping Fact. (kips/ft/s):	0.386

EXTREMA TABLE at 102.0 FT; HAMMER: D 19-42

Shaft/Toe Gain/Loss Factor = 0.670/1.000

Rut = 273.2 kips Rtoe = 26.2 kips Time Inc. = 0.076 ms

Hammer DELMAG D 19-42 Efficiency 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
3.3	0.0	330.9	0.00	30.64	14.73	0.862	19.53
6.6	2.6	331.3	0.24	30.68	14.53	0.831	19.00
9.9	3.7	330.9	0.34	30.64	14.22	0.799	18.39
13.2	3.2	330.7	0.30	30.62	13.83	0.768	17.69
16.4	1.6	329.4	0.15	30.50	13.38	0.736	16.82
19.7	0.0	322.8	0.00	29.89	12.92	0.706	15.78
23.0	0.0	315.9	0.00	29.25	12.42	0.676	14.67
26.3	0.0	305.6	0.00	28.30	11.89	0.651	13.58
29.6	0.0	292.0	0.00	27.04	11.34	0.627	12.49
32.9	0.0	276.3	0.00	25.58	10.85	0.604	11.36
36.2	0.0	261.2	0.00	24.18	10.40	0.581	10.38
39.5	0.0	251.8	0.00	23.32	10.00	0.558	9.56
42.8	0.0	240.8	0.00	22.30	9.61	0.534	8.83
46.1	0.0	233.0	0.00	21.58	9.20	0.512	8.19
49.3	0.0	225.9	0.00	20.92	8.82	0.490	7.58
52.6	0.0	218.5	0.00	20.23	8.38	0.470	6.92
55.9	0.0	205.0	0.00	18.98	7.98	0.452	6.19
59.2	0.0	186.4	0.00	17.26	7.64	0.436	5.49
62.5	0.0	171.7	0.00	15.89	7.44	0.422	4.94
65.8	0.0	165.5	0.00	15.33	7.27	0.408	4.59
69.1	0.0	161.3	0.00	14.94	7.12	0.395	4.31
72.4	0.0	159.8	0.00	14.80	6.94	0.383	4.04
75.7	0.0	154.9	0.00	14.34	6.78	0.371	3.76
79.0	0.0	149.6	0.00	13.85	6.59	0.360	3.49
82.2	0.0	144.4	0.00	13.37	6.40	0.349	3.22
85.5	0.0	136.3	0.00	12.62	6.17	0.340	2.94
88.8	0.0	131.5	0.00	12.18	5.96	0.331	2.61
92.1	0.0	124.3	0.00	11.51	5.89	0.323	2.24
95.4	0.0	111.5	0.00	10.32	6.39	0.316	1.85
98.7	0.0	88.5	0.00	8.19	7.35	0.310	1.43
102.0	0.0	62.3	0.00	5.77	7.82	0.306	1.21

Converged Stroke (ft) 7.65 Fixed Combustion Pressure (psi) 1,600.0

(Eq) Strokes Analyzed and Last Return (ft)

10.81 7.49 7.64 7.65

SUMMARY TABLE at 102.0 FT; HAMMER: D 19-42

Rut kips	Bl Ct b/ft	Stk Dn ft	Stk Up ft	Mx T-Str ksi	LTop ft	Mx C-Str ksi	LTop ft	ENTHRU kip-ft	Bl Rt b/min	ActRes kips
273.2	58.8	7.65	0.00	0.34	9.9	30.68	6.6	19.5	42.6	273.2

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.670/1.000

Depth	Rut	Rshaft	Rtoe	Bl Ct	Mx C-Str	Mx T-Str	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	b/ft	ksi	ksi	ft	kip-ft	-
4.0	33.8	2.4	31.3	2.8	18.16	0.58	4.68	23.5	D 19-42
4.0	11.1	2.5	8.7	1.0	11.60	1.94	3.82	25.8	D 19-42
6.5	16.6	4.3	12.3	1.2	13.13	1.22	4.09	26.0	D 19-42
9.0	22.2	6.9	15.2	1.6	14.90	0.80	4.26	26.1	D 19-42
9.0	22.2	7.0	15.2	1.6	14.92	0.81	4.27	26.0	D 19-42
10.3	23.8	8.6	15.2	1.6	15.01	0.81	4.31	25.7	D 19-42
11.5	25.6	10.3	15.2	1.7	15.33	0.80	4.35	25.4	D 19-42
11.5	25.6	10.4	15.2	1.8	15.34	0.79	4.36	25.5	D 19-42
12.8	27.2	11.9	15.2	1.9	15.69	0.77	4.40	25.1	D 19-42
14.0	28.8	13.6	15.2	2.0	16.06	0.75	4.44	24.8	D 19-42
14.0	68.8	13.6	55.2	6.4	22.32	1.23	5.40	21.2	D 19-42
23.5	118.2	37.9	80.2	11.8	25.37	2.91	6.09	20.5	D 19-42
33.0	155.6	71.6	84.0	15.7	26.98	4.07	6.57	21.2	D 19-42
33.0	101.5	71.7	29.8	9.6	24.51	2.62	5.87	20.4	D 19-42
36.7	109.9	80.1	29.8	10.6	24.99	2.82	5.98	20.3	D 19-42
40.3	118.2	88.4	29.8	11.7	25.43	3.10	6.09	20.1	D 19-42
40.3	103.7	88.5	15.2	10.0	24.73	2.42	5.92	20.3	D 19-42
45.3	114.9	99.7	15.2	11.3	25.27	3.31	6.06	20.1	D 19-42
50.3	127.1	111.9	15.2	12.5	25.66	2.90	6.16	19.8	D 19-42
50.3	130.5	112.0	18.5	12.8	25.79	2.63	6.19	19.8	D 19-42
55.3	147.2	128.6	18.5	14.7	26.46	2.38	6.40	19.7	D 19-42
60.3	163.8	145.2	18.5	16.9	27.07	2.20	6.61	20.0	D 19-42
60.3	151.5	145.3	6.2	15.1	26.72	1.86	6.48	19.7	D 19-42
65.3	158.6	152.5	6.2	15.9	27.04	1.86	6.58	19.8	D 19-42
70.3	165.7	159.6	6.2	16.9	27.34	1.56	6.69	19.7	D 19-42
70.3	185.9	159.6	26.2	20.4	27.88	2.40	6.88	20.1	D 19-42
86.1	216.0	189.8	26.2	27.5	29.14	2.48	7.25	19.9	D 19-42
102.0	273.2	247.0	26.2	58.8	30.68	0.34	7.65	19.5	D 19-42

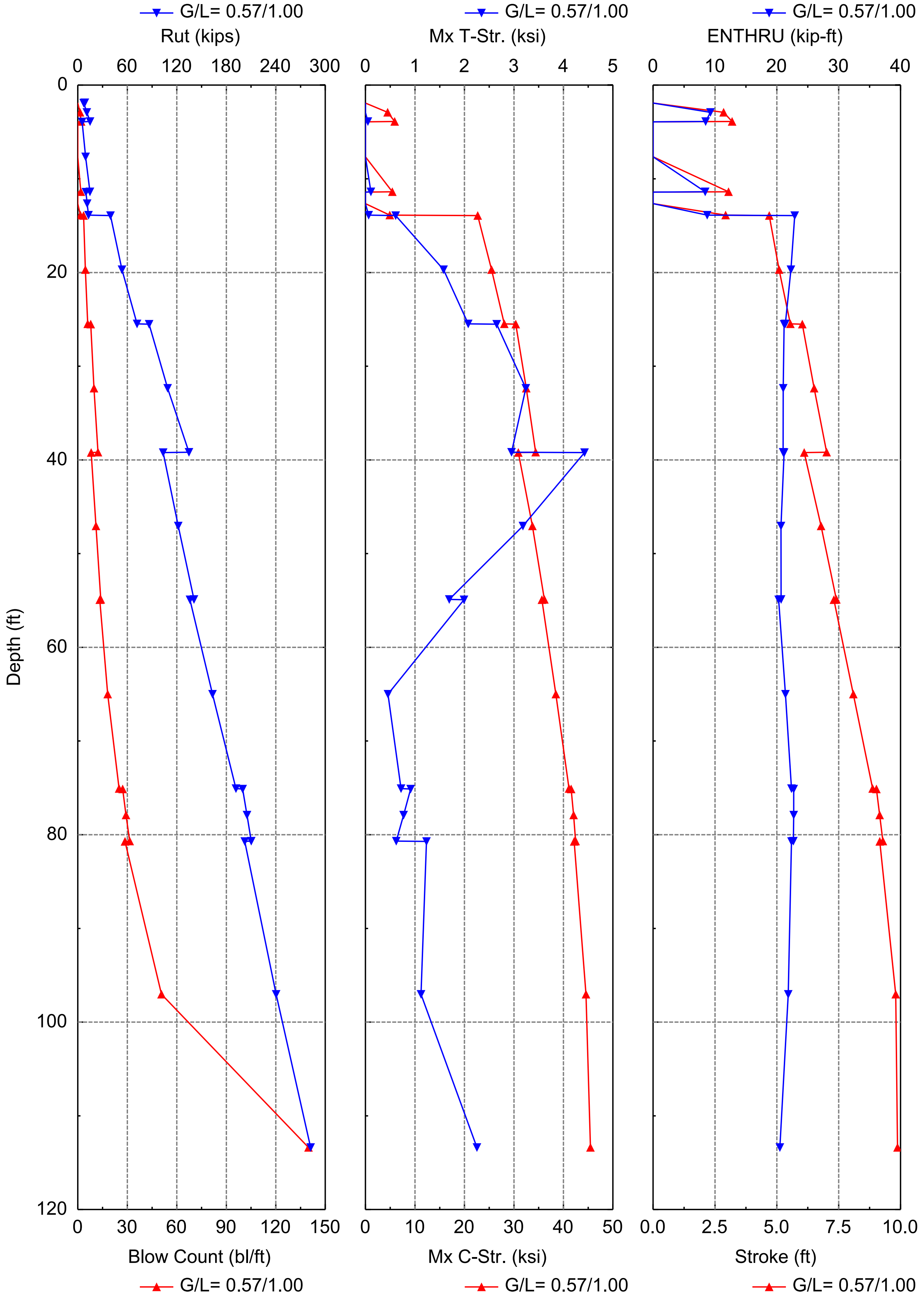
FORWARD ABUTMENT

Driveability Analysis Summary

Gain/Loss Factor at Shaft/Toe = 0.570/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Blow Ct bl/ft	Mx C-Str ksi	Mx T-Str. ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.9	8.5	0.4	8.1	0.0	0.000	0.000	0.00	0.0	D 19-42
1.9	7.1	0.4	6.7	0.0	0.000	0.000	0.00	0.0	D 19-42
2.9	10.9	0.8	10.1	1.3	4.482	0.000	2.85	9.3	D 19-42
3.9	14.8	1.4	13.4	2.0	5.900	0.049	3.19	8.5	D 19-42
3.9	5.2	1.4	3.8	0.0	0.000	0.000	0.00	0.0	D 19-42
7.7	9.4	3.4	6.0	0.0	0.000	0.000	0.00	0.0	D 19-42
11.4	14.7	6.5	8.2	1.8	5.430	0.109	3.05	8.4	D 19-42
11.4	9.9	6.5	3.3	0.0	0.000	0.000	0.00	0.0	D 19-42
12.7	11.4	8.0	3.3	0.0	0.000	0.000	0.00	0.0	D 19-42
13.9	12.9	9.5	3.3	1.5	4.913	0.065	2.93	8.7	D 19-42
13.9	39.5	9.6	29.9	3.5	22.682	0.611	4.69	22.9	D 19-42
19.7	53.6	23.0	30.6	4.6	25.480	1.579	5.09	22.3	D 19-42
25.5	71.8	41.0	30.8	6.0	28.035	2.076	5.54	21.4	D 19-42
25.5	86.4	41.1	45.3	7.8	30.378	2.652	6.03	21.2	D 19-42
32.4	108.9	63.6	45.3	9.8	32.479	3.240	6.51	21.0	D 19-42
39.2	134.8	89.4	45.3	12.2	34.375	2.950	7.01	21.0	D 19-42
39.2	103.4	89.5	13.9	8.1	30.898	4.427	6.11	21.2	D 19-42
47.1	121.7	107.8	13.9	11.0	33.735	3.181	6.79	20.7	D 19-42
54.9	140.8	126.9	13.9	13.9	36.151	1.693	7.41	20.7	D 19-42
54.9	135.9	127.0	8.9	13.3	35.653	1.990	7.30	20.3	D 19-42
65.0	163.3	154.4	8.9	18.1	38.470	0.454	8.09	21.4	D 19-42
75.1	191.7	182.8	8.9	25.0	41.124	0.718	8.87	22.4	D 19-42
75.1	199.9	182.9	16.9	27.2	41.552	0.913	9.02	22.7	D 19-42
77.9	205.1	188.1	16.9	29.2	42.057	0.770	9.15	22.7	D 19-42
80.7	210.3	193.4	16.9	31.4	42.453	0.621	9.28	22.7	D 19-42
80.7	202.3	193.4	8.9	28.6	42.158	1.232	9.16	22.4	D 19-42
97.0	240.4	231.5	8.9	50.7	44.563	1.122	9.81	21.8	D 19-42
113.4	282.3	273.4	8.9	139.8	45.461	2.253	9.87	20.5	D 19-42

Total driving time: 80 minutes; Total Number of Blows: 3115 (starting at penetration 1.9 ft)


G/L= 0.57/1.00
Rut (kips)
0
60
120
180
240
300
G/L= 0.57/1.00
Mx T-Str. (ksi)
0
1
2
3
4
5
G/L= 0.57/1.00
ENTHRU (kip-ft)
0
10
20
30
40
Depth (ft)
0
20
40
60
80
100
120
0
30
60
90
120
150
Blow Count (bl/ft)
G/L= 0.57/1.00
0
10
20
30
40
50
Mx C-Str. (ksi)
G/L= 0.57/1.00
0.0
2.5
5.0
7.5
10.0
Stroke (ft)
G/L= 0.57/1.00

GRLWEAP: Wave Equation Analysis of Pile Foundations

CUY-90-16.28 : 06/22/2022 : M. Jasiewicz 5/17/2024
NATIONAL ENGINEERING AND ARCHITECTURAL GRLWEAP 14.1.20.1

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

HAMMER DATA

Hammer Model:	D 19-42	Made By:	DELMAG
Hammer ID:	41	Hammer Type:	OED
Hammer Database Type:	PDI		
Hammer Database Name:			PDIHammer.gwh

Hammer and Drive System Segment Data

Segment -	Weight kips	Stiffness kips/in	COR -	C-Slack in	Damping kips/ft/s
1	0.800	140,084.4	1.000	0.000	
2	0.800	140,084.4	1.000	0.000	
3	0.800	140,084.4	1.000	0.000	
4	0.800	140,084.4	1.000	0.000	
5	0.800	70,754.7	0.900	0.120	
Imp Block	0.753	9,999,999.0	1.000	0.120	
Helmet	0.000				0.0

Ram Weight: (kips)	4.00	Ram Length: (ft)	10.76
Ram Area: (in²)	124.69		
Maximum (Eq) Stroke: (ft)	10.81	Actual (Eq) Stroke: (ft)	10.81
Efficiency:	0.800	Rated Energy: (kip-ft)	43.24
Maximum Pressure: (psi)	1,600.00	Actual Pressure: (psi)	1,600.00
Combustion Delay: (ms)	2.00	Ignition Duration: (ms)	2.00
Expansion Exponent:	1.25		

Hammer Cushion		Pile Cushion	
Cross Sect. Area: (in²)	0.00	Cross Sect. Area: (in²)	0.00
Elastic Modulus: (ksi)	0.0	Elastic Modulus: (ksi)	0.0
Thickness: (in)	0.00	Thickness: (in)	0.00
Coeff. of Restitution:	0.000	Coeff. of Restitution:	0.500
RoundOut: (in)	0.120	RoundOut: (in)	0.120
Stiffness: (kips/in)	0.0	Stiffness: (kips/in)	0.0

PILE INPUT

Uniform Pile		Pile Type:	Closed-End Pipe
Pile Length: (ft)	113.380	Pile Penetration: (ft)	113.380
Pile Size: (ft)	1.00	Toe Area: (in²)	113.10

Table of Depths Analyzed with Driving System Modifiers

Depth ft	Temp Length ft	Wait Time Hr	Hammer -
1.88	113.4	0.0	DELMAG D 19-42
1.92	113.4	0.0	DELMAG D 19-42
2.90	113.4	0.0	DELMAG D 19-42
3.88	113.4	0.0	DELMAG D 19-42
3.92	113.4	0.0	DELMAG D 19-42
7.65	113.4	0.0	DELMAG D 19-42
11.38	113.4	0.0	DELMAG D 19-42
11.42	113.4	0.0	DELMAG D 19-42
12.65	113.4	0.0	DELMAG D 19-42
13.88	113.4	0.0	DELMAG D 19-42
13.92	113.4	0.0	DELMAG D 19-42
19.70	113.4	0.0	DELMAG D 19-42
25.48	113.4	0.0	DELMAG D 19-42
25.52	113.4	0.0	DELMAG D 19-42
32.35	113.4	0.0	DELMAG D 19-42
39.18	113.4	0.0	DELMAG D 19-42
39.22	113.4	0.0	DELMAG D 19-42
47.05	113.4	0.0	DELMAG D 19-42
54.88	113.4	0.0	DELMAG D 19-42
54.92	113.4	0.0	DELMAG D 19-42
65.00	113.4	0.0	DELMAG D 19-42
75.08	113.4	0.0	DELMAG D 19-42
75.12	113.4	0.0	DELMAG D 19-42
77.90	113.4	0.0	DELMAG D 19-42
80.68	113.4	0.0	DELMAG D 19-42
80.72	113.4	0.0	DELMAG D 19-42
97.03	113.4	0.0	DELMAG D 19-42
113.38	113.4	0.0	DELMAG D 19-42

Other Information for DELMAG D 19-42

Depth ft	Stroke ft	Diesel Pressure %	Efficiency -	P.C. Stiff. Fact. -	P.C. COR -
1.88	10.8	100.0	0.80	1.0	0.50
1.92	10.8	100.0	0.80	1.0	0.50
2.90	10.8	100.0	0.80	1.0	0.50
3.88	10.8	100.0	0.80	1.0	0.50
3.92	10.8	100.0	0.80	1.0	0.50
7.65	10.8	100.0	0.80	1.0	0.50

11.38	10.8	100.0	0.80	1.0	0.50
11.42	10.8	100.0	0.80	1.0	0.50
12.65	10.8	100.0	0.80	1.0	0.50
13.88	10.8	100.0	0.80	1.0	0.50
13.92	10.8	100.0	0.80	1.0	0.50
19.70	10.8	100.0	0.80	1.0	0.50
25.48	10.8	100.0	0.80	1.0	0.50
25.52	10.8	100.0	0.80	1.0	0.50
32.35	10.8	100.0	0.80	1.0	0.50
39.18	10.8	100.0	0.80	1.0	0.50
39.22	10.8	100.0	0.80	1.0	0.50
47.05	10.8	100.0	0.80	1.0	0.50
54.88	10.8	100.0	0.80	1.0	0.50
54.92	10.8	100.0	0.80	1.0	0.50
65.00	10.8	100.0	0.80	1.0	0.50
75.08	10.8	100.0	0.80	1.0	0.50
75.12	10.8	100.0	0.80	1.0	0.50
77.90	10.8	100.0	0.80	1.0	0.50
80.68	10.8	100.0	0.80	1.0	0.50
80.72	10.8	100.0	0.80	1.0	0.50
97.03	10.8	100.0	0.80	1.0	0.50
113.38	10.8	100.0	0.80	1.0	0.50

PILE, SOIL, ANALYSIS OPTIONS

Analysis type:	Driveability Analysis	Soil Damping Option:	Smith
Max No Analysis Iterations:	0	Time Increment/Critical:	160
Residual Stress Analysis:	0	Analysis Time-Input(ms):	0
Output Level:	Normal	Gravitational Acceleration (ft/s²):	32.169
Hammer Gravity (ft/s²):	32.170	Pile Gravity (ft/s²):	32.170

DRIVEABILITY ANALYSIS

Analysis Depth (ft)	113.38	Standard Soil Setup	
Hammer Name	DELMAG D 19-42	Hammer ID	41
Diesel Pressure: (psi)	230.40	Stroke (ft)	10.81
Efficiency	0.80		
Shaft Gain/Loss Factor	0.570	Toe Gain/Loss Factor	1.000

SOIL RESISTANCE PARAMETERS

Depth ft	Unit Rs ksf	Unit Rt ksf	Qs in	Qt in	Js s/ft	Jt s/ft	Setup F. -	Limit D. ft	Setup T. Hours	EB Area in²
0.01	0.0	0.0	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
1.89	0.1	10.4	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
1.91	0.1	8.5	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
3.89	0.2	17.1	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
3.91	0.1	4.8	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
11.39	0.3	10.5	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
11.41	0.6	4.2	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
13.89	0.6	4.2	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
13.91	0.6	38.1	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
21.89	1.0	39.3	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
21.91	1.0	39.3	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
25.49	1.1	39.3	0.10	0.098	0.050	0.2	1.0	0.00	0.0	113.10
25.51	1.2	57.7	0.10	0.098	0.050	0.2	1.2	0.00	0.0	113.10
34.51	1.4	57.7	0.10	0.098	0.050	0.2	1.2	0.00	0.0	113.10
39.19	1.5	57.7	0.10	0.098	0.050	0.2	1.2	0.00	0.0	113.10
39.21	1.1	17.7	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
48.21	1.1	17.7	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
54.89	1.2	17.7	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
54.91	1.3	11.3	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
63.91	1.3	11.3	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
72.91	1.4	11.3	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
75.09	1.4	11.3	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
75.11	0.9	21.6	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
80.69	0.9	21.6	0.10	0.098	0.198	0.2	1.5	0.00	0.0	113.10
80.71	1.3	11.3	0.10	0.098	0.198	0.2	1.8	0.00	0.0	113.10
89.71	1.3	11.3	0.10	0.098	0.198	0.2	1.8	0.00	0.0	113.10
98.71	1.4	11.3	0.10	0.098	0.198	0.2	1.8	0.00	0.0	113.10
107.71	1.5	11.3	0.10	0.098	0.198	0.2	1.8	0.00	0.0	113.10
113.38	1.5	11.3	0.10	0.098	0.198	0.2	1.8	0.00	0.0	113.10

PILE PROFILE

Lb Top ft	X-Area in²	E-Mod ksi	Spec. Wt lb/ft³	Perim. ft	C-Index -	Wave Sp ft/s	Impedance kips/ft/s
0.00	9.2	29,000	492.00	3.142	0	16,524.0	16.2
113.38	9.2	29,000	492.00	3.142	0	16,524.0	16.2

PILE AND SOIL MODEL Total Capacity Rut (kips): 282.281

Seg. -	Weight kips	Stiffn. kips/in	C-Slk in	T-Slk in	COR -	Ru kips	Js/Jt s/ft	Qs/Qt in	LbTop ft	Perim. ft	X-Area in²
1	0.10	6,885	0.12	0.00	0.85	1.0	0.050	0.10	3.24	3.14	9.2
2	0.10	6,885	0.00	0.00	1.00	1.7	0.050	0.10	6.48	3.14	9.2
3	0.10	6,885	0.00	0.00	1.00	2.3	0.050	0.10	9.72	3.14	9.2
4	0.10	6,885	0.00	0.00	1.00	3.4	0.146	0.10	12.96	3.14	9.2
5	0.10	6,885	0.00	0.00	1.00	5.9	0.090	0.10	16.20	3.14	9.2
6	0.10	6,885	0.00	0.00	1.00	8.0	0.050	0.10	19.44	3.14	9.2
7	0.10	6,885	0.00	0.00	1.00	9.6	0.050	0.10	22.68	3.14	9.2
8	0.10	6,885	0.00	0.00	1.00	10.5	0.050	0.10	25.92	3.14	9.2
9	0.10	6,885	0.00	0.00	1.00	10.3	0.050	0.10	29.15	3.14	9.2
10	0.10	6,885	0.00	0.00	1.00	11.1	0.050	0.10	32.39	3.14	9.2
11	0.10	6,885	0.00	0.00	1.00	11.9	0.050	0.10	35.63	3.14	9.2
12	0.10	6,885	0.00	0.00	1.00	12.6	0.050	0.10	38.87	3.14	9.2
13	0.10	6,885	0.00	0.00	1.00	8.1	0.178	0.10	42.11	3.14	9.2
14	0.10	6,885	0.00	0.00	1.00	7.6	0.200	0.10	45.35	3.14	9.2
15	0.10	6,885	0.00	0.00	1.00	7.6	0.200	0.10	48.59	3.14	9.2
16	0.10	6,885	0.00	0.00	1.00	7.8	0.200	0.10	51.83	3.14	9.2
17	0.10	6,885	0.00	0.00	1.00	8.2	0.200	0.10	55.07	3.14	9.2
18	0.10	6,885	0.00	0.00	1.00	8.8	0.200	0.10	58.31	3.14	9.2
20	0.10	6,885	0.00	0.00	1.00	8.8	0.200	0.10	64.79	3.14	9.2
21	0.10	6,885	0.00	0.00	1.00	8.9	0.200	0.10	68.03	3.14	9.2
22	0.10	6,885	0.00	0.00	1.00	9.1	0.200	0.10	71.27	3.14	9.2
23	0.10	6,885	0.00	0.00	1.00	9.3	0.200	0.10	74.51	3.14	9.2
24	0.10	6,885	0.00	0.00	1.00	6.7	0.200	0.10	77.75	3.14	9.2
25	0.10	6,885	0.00	0.00	1.00	6.2	0.200	0.10	80.99	3.14	9.2
26	0.10	6,885	0.00	0.00	1.00	7.5	0.200	0.10	84.23	3.14	9.2
28	0.10	6,885	0.00	0.00	1.00	7.5	0.200	0.10	90.70	3.14	9.2
29	0.10	6,885	0.00	0.00	1.00	7.6	0.200	0.10	93.94	3.14	9.2
30	0.10	6,885	0.00	0.00	1.00	7.8	0.200	0.10	97.18	3.14	9.2
31	0.10	6,885	0.00	0.00	1.00	7.9	0.200	0.10	100.42	3.14	9.2
32	0.10	6,885	0.00	0.00	1.00	8.1	0.200	0.10	103.66	3.14	9.2
33	0.10	6,885	0.00	0.00	1.00	8.3	0.200	0.10	106.90	3.14	9.2
34	0.10	6,885	0.00	0.00	1.00	8.5	0.200	0.10	110.14	3.14	9.2
35	0.10	6,885	0.00	0.00	1.00	8.7	0.200	0.10	113.38	3.14	9.2

Toe	8.9	0.150	0.10	113.38

3.575 kips total unreduced pile weight (g = 32.169 ft/s²)
3.575 kips total reduced pile weight (g = 32.169 ft/s²)

OTHER OPTIONS

Pile Damping (%):	1	Pile Damping Fact. (kips/ft/s):	0.324

EXTREMA TABLE at 113.4 FT; HAMMER: D 19-42

Shaft/Toe Gain/Loss Factor = 0.570/1.000

Rut = 282.3 kips Rtoe = 8.9 kips Time Inc. = 0.076 ms

Hammer DELMAG D 19-42 Efficiency 0.800

Lb Top ft	Mx.T-For. kips	Mx.C-For kips	Mx.T-Str. ksi	Mx.C-Str. ksi	Mx Vel. ft/s	Mx Dis. in	ENTHRU kip-ft
3.2	0.0	413.9	0.00	44.85	23.15	0.912	20.48
6.5	0.0	416.9	0.00	45.17	23.10	0.874	19.89
9.7	0.0	417.8	0.00	45.27	22.86	0.837	19.31
13.0	0.0	419.5	0.00	45.46	22.34	0.800	18.52
16.2	0.0	413.2	0.00	44.77	21.76	0.763	17.50
19.4	0.0	403.9	0.00	43.76	21.30	0.726	16.42
22.7	0.0	395.1	0.00	42.81	20.74	0.689	15.30
25.9	0.0	383.2	0.00	41.52	20.10	0.653	14.15
29.2	0.0	369.1	0.00	39.99	19.39	0.618	13.05
32.4	0.0	357.5	0.00	38.74	18.77	0.584	12.00
35.6	0.0	344.8	0.00	37.37	18.06	0.552	10.98
38.9	0.0	331.5	0.00	35.92	17.17	0.521	10.00
42.1	0.0	320.2	0.00	34.69	16.19	0.494	9.07
45.4	0.0	301.5	0.00	32.68	15.19	0.469	8.19
48.6	0.0	283.6	0.00	30.73	14.27	0.443	7.36
51.8	0.0	266.2	0.00	28.84	13.37	0.417	6.59
55.1	0.0	250.4	0.00	27.13	12.56	0.392	5.87
58.3	0.0	234.1	0.00	25.37	11.76	0.369	5.19
61.5	0.0	218.1	0.00	23.63	11.04	0.351	4.62
64.8	0.0	203.5	0.00	22.06	10.41	0.334	4.09
68.0	0.0	190.4	0.00	20.63	9.78	0.317	3.61
71.3	0.0	178.3	0.00	19.32	9.24	0.299	3.16
74.5	0.0	167.0	0.00	18.10	8.75	0.284	2.75
77.7	0.0	155.0	0.00	16.80	8.39	0.271	2.42
81.0	0.0	147.9	0.00	16.03	8.05	0.258	2.17
84.2	0.0	142.6	0.00	15.45	7.69	0.247	1.93
87.5	0.0	135.6	0.00	14.70	7.36	0.236	1.69
90.7	0.0	129.3	0.00	14.01	7.04	0.225	1.47
93.9	0.0	123.0	0.00	13.33	6.74	0.216	1.27
97.2	0.0	117.5	0.00	12.73	6.45	0.207	1.09
100.4	2.8	111.4	0.31	12.07	6.20	0.199	0.92
103.7	13.7	105.4	1.49	11.43	6.04	0.194	0.76
106.9	20.5	95.9	2.23	10.40	6.37	0.190	0.60
110.1	20.8	77.6	2.25	8.41	7.72	0.186	0.43
113.4	7.6	46.5	0.82	5.04	8.79	0.184	0.35

Converged Stroke (ft) 9.87 Fixed Combustion Pressure (psi) 1,600.0

(Eq) Strokes Analyzed and Last Return (ft)

10.81 9.96 9.87

SUMMARY TABLE at 113.4 FT; HAMMER: D 19-42

Rut kips	Bl Ct b/ft	Stk Dn ft	Stk Up ft	Mx T-Str ksi	LTop ft	Mx C-Str ksi	LTop ft	ENTHRU kip-ft	Bl Rt b/min	ActRes kips
282.3	139.8	9.87	0.00	2.25	110.1	45.46	13.0	20.5	37.5	282.3

SUMMARY OVER DEPTHS

G/L at Shaft and Toe: 0.570/1.000

Depth ft	Rut kips	Rshaft kips	Rtoe kips	Bl Ct b/ft	Mx C-Str ksi	Mx T-Str ksi	Stroke ft	ENTHRU kip-ft	Hammer -
1.9	8.5	0.4	8.1	0.0	0.00	0.00	0.00	0.0	D 19-42
1.9	7.1	0.4	6.7	0.0	0.00	0.00	0.00	0.0	D 19-42
2.9	10.9	0.8	10.1	1.3	4.48	0.00	2.85	9.3	D 19-42
3.9	14.8	1.4	13.4	2.0	5.90	0.05	3.19	8.5	D 19-42
3.9	5.2	1.4	3.8	0.0	0.00	0.00	0.00	0.0	D 19-42
7.7	9.4	3.4	6.0	0.0	0.00	0.00	0.00	0.0	D 19-42
11.4	14.7	6.5	8.2	1.8	5.43	0.11	3.05	8.4	D 19-42
11.4	9.9	6.5	3.3	0.0	0.00	0.00	0.00	0.0	D 19-42
12.7	11.4	8.0	3.3	0.0	0.00	0.00	0.00	0.0	D 19-42
13.9	12.9	9.5	3.3	1.5	4.91	0.06	2.93	8.7	D 19-42
13.9	39.5	9.6	29.9	3.5	22.68	0.61	4.69	22.9	D 19-42
19.7	53.6	23.0	30.6	4.6	25.48	1.58	5.09	22.3	D 19-42
25.5	71.8	41.0	30.8	6.0	28.03	2.08	5.54	21.4	D 19-42
25.5	86.4	41.1	45.3	7.8	30.38	2.65	6.03	21.2	D 19-42
32.4	108.9	63.6	45.3	9.8	32.48	3.24	6.51	21.0	D 19-42
39.2	134.8	89.4	45.3	12.2	34.38	2.95	7.01	21.0	D 19-42
39.2	103.4	89.5	13.9	8.1	30.90	4.43	6.11	21.2	D 19-42
47.1	121.7	107.8	13.9	11.0	33.74	3.18	6.79	20.7	D 19-42
54.9	140.8	126.9	13.9	13.9	36.15	1.69	7.41	20.7	D 19-42
54.9	135.9	127.0	8.9	13.3	35.65	1.99	7.30	20.3	D 19-42
65.0	163.3	154.4	8.9	18.1	38.47	0.45	8.09	21.4	D 19-42
75.1	191.7	182.8	8.9	25.0	41.12	0.72	8.87	22.4	D 19-42
75.1	199.9	182.9	16.9	27.2	41.55	0.91	9.02	22.7	D 19-42
77.9	205.1	188.1	16.9	29.2	42.06	0.77	9.15	22.7	D 19-42
80.7	210.3	193.4	16.9	31.4	42.45	0.62	9.28	22.7	D 19-42
80.7	202.3	193.4	8.9	28.6	42.16	1.23	9.16	22.4	D 19-42
97.0	240.4	231.5	8.9	50.7	44.56	1.12	9.81	21.8	D 19-42
113.4	282.3	273.4	8.9	139.8	45.46	2.25	9.87	20.5	D 19-42

APPENDIX I

SETTLEMENT ANALYSIS –
REAR AND FORWARD ABUTMENT

REAR ABUTMENT

CUY-90-16.28 (CCGA)

PROJECT IDENTIFICATION

Title:	CUY-90-16.28 (CCGA)
Project Number:	PID 82382 -
Client:	Michael Baker International
Designer:	KCA
Station Number:	

Description:

Company's information:

Name:	NEAS Inc.
Street:	2800 Corporate Exchange Drive, Suite 240 Columbus, OH 43231
Telephone #:	614-714-0299
Fax #:	614-714-0251
E-Mail:	brendan.andrews@neasinc.com

Original file path and name: P:\21-0011 ..... Wall AC\Analysis\Settlement\RA\RA_FOSSA091721.2ST
Original date and time of creating this file: Fri Sep 17 15:08:29 2021

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 8 layers

	Wet Unit Weight, γ [lb/ft³]	Poisson's Ratio μ	Description of Soil
1	125.00	0.25	Granular 1
2	128.00	0.30	Granular 2
3	120.00	0.25	Granular 3
4	128.00	0.30	Granular 4
5	130.00	0.45	Cohesive 1
6	130.00	0.45	Cohesive 2
7	122.00	0.45	Cohesive 3
8	150.00	0.20	Termination Layer

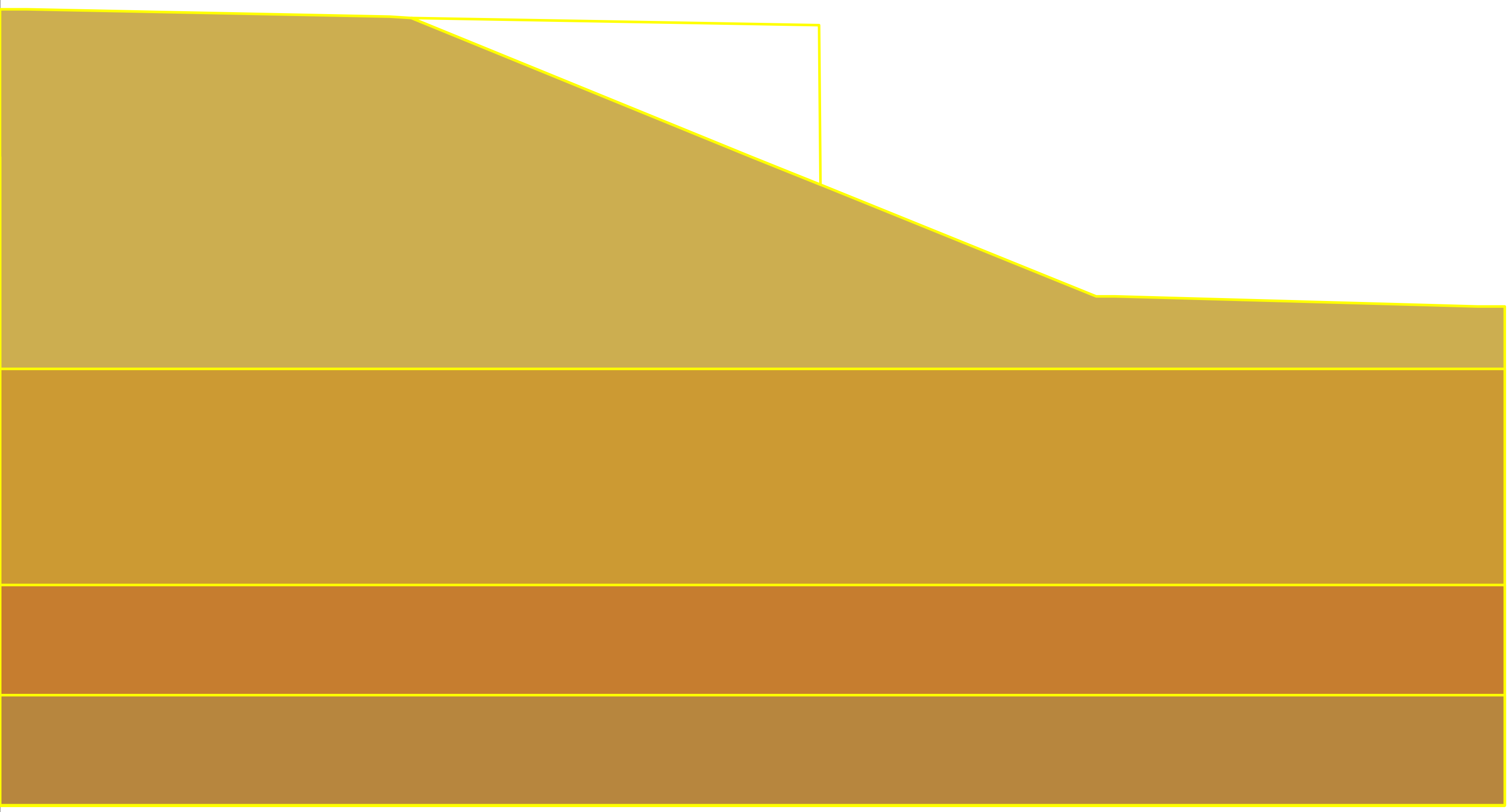
INPUT DATA – EMBANKMENT LAYERS -- 1 layers

	Wet Unit Weight, γ [lb/ft³]	Description of Soil
1	120.00	Proposed Embankment

INPUT DATA OF WATER

Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]
1	0.00	648.40
2	100.00	648.40

DRAWING OF SPECIFIED GEOMETRY



INPUT DATA FOR CONSOLIDATION -- $\alpha = 1/2$

Layer #	Underging Consolidation [Yes/No]	OCR = Pc / Po	Cc	Cr	e0	Cv [ft ²/day]	Drains at :
1	No	N/A	N/A	N/A	N/A	N/A	N/A
2	No	N/A	N/A	N/A	N/A	N/A	N/A
3	No	N/A	N/A	N/A	N/A	N/A	N/A
4	No	N/A	N/A	N/A	N/A	N/A	N/A
5	Yes	1.50	0.060	0.005	0.542	0.5500	Top
6	Yes	1.10	0.090	0.013	0.600	0.3800	Top
7	Yes	1.10	0.240	0.048	0.743	0.2100	Top
8	No	N/A	N/A	N/A	N/A	N/A	N/A

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft^2]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	20.00	0.00	1	878000	0.2500	-0.0002	690.80	690.79	0.01
			2	902000	0.3000	0.0010			
			3	211000	0.2500	0.0043			
			4	902000	0.3000	0.0021			
			5	2000000	0.4500	0.0007			
			6	2000000	0.4500	0.0016			
			7	2000000	0.4500	0.0028			
			8	1000000000(	0.2000	0.0000			
2	22.00	0.00	1	878000	0.2500	-0.0001	690.76	690.75	0.01
			2	902000	0.3000	0.0013			
			3	211000	0.2500	0.0049			
			4	902000	0.3000	0.0024			
			5	2000000	0.4500	0.0008			
			6	2000000	0.4500	0.0016			
			7	2000000	0.4500	0.0029			
			8	1000000000(	0.2000	0.0000			
3	24.00	0.00	1	878000	0.2500	0.0002	690.72	690.70	0.02
			2	902000	0.3000	0.0017			
			3	211000	0.2500	0.0056			
			4	902000	0.3000	0.0026			
			5	2000000	0.4500	0.0008			
			6	2000000	0.4500	0.0017			
			7	2000000	0.4500	0.0029			
			8	1000000000(	0.2000	0.0000			
4	26.00	0.00	1	878000	0.2500	0.0007	690.63	690.62	0.02
			2	902000	0.3000	0.0022			
			3	211000	0.2500	0.0063			
			4	902000	0.3000	0.0028			
			5	2000000	0.4500	0.0009			
			6	2000000	0.4500	0.0017			
			7	2000000	0.4500	0.0029			
			8	1000000000(	0.2000	0.0000			
5	28.00	0.00	1	878000	0.2500	0.0018	689.99	689.97	0.02
			2	902000	0.3000	0.0027			
			3	211000	0.2500	0.0070			
			4	902000	0.3000	0.0030			
			5	2000000	0.4500	0.0009			
			6	2000000	0.4500	0.0018			
			7	2000000	0.4500	0.0029			
			8	1000000000(	0.2000	0.0000			
6	30.00	0.00	1	878000	0.2500	0.0032	689.17	689.15	0.02
			2	902000	0.3000	0.0032			
			3	211000	0.2500	0.0077			
			4	902000	0.3000	0.0032			
			5	2000000	0.4500	0.0010			
			6	2000000	0.4500	0.0018			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
7	32.00	0.00	1	878000	0.2500	0.0047	688.35	688.33	0.03
			2	902000	0.3000	0.0038			
			3	211000	0.2500	0.0084			
			4	902000	0.3000	0.0033			
			5	2000000	0.4500	0.0010			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
8	34.00	0.00	1	878000	0.2500	0.0062	687.54	687.51	0.03
			2	902000	0.3000	0.0044			
			3	211000	0.2500	0.0090			
			4	902000	0.3000	0.0035			
			5	2000000	0.4500	0.0010			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
9	36.00	0.00	1	878000	0.2500	0.0075	686.72	686.69	0.03
			2	902000	0.3000	0.0050			
			3	211000	0.2500	0.0097			
			4	902000	0.3000	0.0037			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
10	38.00	0.00	1	878000	0.2500	0.0088	685.90	685.87	0.03
			2	902000	0.3000	0.0056			
			3	211000	0.2500	0.0102			
			4	902000	0.3000	0.0038			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
11	40.00	0.00	1	878000	0.2500	0.0098	685.09	685.05	0.04
			2	902000	0.3000	0.0061			
			3	211000	0.2500	0.0106			
			4	902000	0.3000	0.0039			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0020			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
12	42.00	0.00	1	878000	0.2500	0.0108	684.27	684.23	0.04
			2	902000	0.3000	0.0065			
			3	211000	0.2500	0.0110			
			4	902000	0.3000	0.0040			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0020			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
13	44.00	0.00	1	878000	0.2500	0.0114	683.45	683.41	0.04
			2	902000	0.3000	0.0067			
			3	211000	0.2500	0.0111			
			4	902000	0.3000	0.0040			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0020			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
14	46.00	0.00	1	878000	0.2500	0.0120	682.63	682.59	0.04
			2	902000	0.3000	0.0069			
			3	211000	0.2500	0.0112			
			4	902000	0.3000	0.0040			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0020			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
15	48.00	0.00	1	878000	0.2500	0.0120	681.82	681.78	0.04
			2	902000	0.3000	0.0068			
			3	211000	0.2500	0.0110			
			4	902000	0.3000	0.0040			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0020			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
16	50.00	0.00	1	878000	0.2500	0.0116	681.00	680.96	0.04
			2	902000	0.3000	0.0065			
			3	211000	0.2500	0.0108			
			4	902000	0.3000	0.0039			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
17	52.00	0.00	1	878000	0.2500	0.0105	680.19	680.15	0.04
			2	902000	0.3000	0.0061			
			3	211000	0.2500	0.0104			
			4	902000	0.3000	0.0038			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
18	54.00	0.00	1	878000	0.2500	0.0075	679.38	679.35	0.03
			2	902000	0.3000	0.0055			
			3	211000	0.2500	0.0099			
			4	902000	0.3000	0.0037			
			5	2000000	0.4500	0.0011			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
19	56.00	0.00	1	878000	0.2500	0.0042	678.57	678.55	0.03
			2	902000	0.3000	0.0048			
			3	211000	0.2500	0.0093			
			4	902000	0.3000	0.0036			
			5	2000000	0.4500	0.0010			
			6	2000000	0.4500	0.0019			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
20	58.00	0.00	1	878000	0.2500	0.0023	677.76	677.74	0.02
			2	902000	0.3000	0.0041			
			3	211000	0.2500	0.0086			
			4	902000	0.3000	0.0034			
			5	2000000	0.4500	0.0010			
			6	2000000	0.4500	0.0018			
			7	2000000	0.4500	0.0030			
			8	1000000000(	0.2000	0.0000			
21	60.00	0.00	1	878000	0.2500	0.0013	676.95	676.93	0.02
			2	902000	0.3000	0.0034			
			3	211000	0.2500	0.0078			
			4	902000	0.3000	0.0032			
			5	2000000	0.4500	0.0010			
			6	2000000	0.4500	0.0018			
			7	2000000	0.4500	0.0029			
			8	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	20.00	0.00	690.80	0.01	690.79
2	22.00	0.00	690.76	0.01	690.75
3	24.00	0.00	690.72	0.01	690.71
4	26.00	0.00	690.63	0.01	690.62
5	28.00	0.00	689.99	0.01	689.98
6	30.00	0.00	689.17	0.01	689.16
7	32.00	0.00	688.35	0.01	688.34
8	34.00	0.00	687.54	0.01	687.53
9	36.00	0.00	686.72	0.01	686.71
10	38.00	0.00	685.90	0.01	685.89
11	40.00	0.00	685.09	0.01	685.08
12	42.00	0.00	684.27	0.01	684.26
13	44.00	0.00	683.45	0.01	683.44
14	46.00	0.00	682.63	0.01	682.62
15	48.00	0.00	681.82	0.01	681.81
16	50.00	0.00	681.00	0.01	680.99
17	52.00	0.00	680.19	0.01	680.18
18	54.00	0.00	679.38	0.01	679.37
19	56.00	0.00	678.57	0.01	678.56
20	58.00	0.00	677.76	0.01	677.75
21	60.00	0.00	676.95	0.01	676.94

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	D E S C R I P T I O N
1	1	0.00	691.20	Granular 1
	2	25.00	690.70	
	3	26.50	690.60	
	4	50.00	681.00	
	5	54.70	679.10	
	6	73.70	671.40	
	7	75.00	671.40	
	8	100.00	670.70	
2	1	0.00	666.40	Granular 2
	2	100.00	666.40	
3	1	0.00	651.50	Granular 3
	2	100.00	651.50	
4	1	0.00	643.90	Granular 4
	2	100.00	643.90	
5	1	0.00	627.60	Cohesive 1
	2	100.00	627.60	
6	1	0.00	612.10	Cohesive 2
	2	100.00	612.10	
7	1	0.00	572.60	Cohesive 3
	2	100.00	572.60	
8	1	0.00	450.00	Termination Layer
	2	100.00	450.00	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #		Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	X1 = 26.50 [ft]	1	26.50	690.60	Proposed Embankment
	X2 = 54.70 [ft]	2	54.60	690.10	
		3	54.70	679.10	

FORWARD ABUTMENT

CUY-90-16.28 (CCGA)

PROJECT IDENTIFICATION

Title:	CUY-90-16.28 (CCGA)
Project Number:	PID 82382 -
Client:	Michael Baker International
Designer:	KCA
Station Number:	

Description:

Company's information:

Name:	NEAS Inc.
Street:	2800 Corporate Exchange Drive, Suite 240 Columbus, OH 43231
Telephone #:	614-714-0299
Fax #:	614-714-0251
E-Mail:	brendan.andrews@neasinc.com

Original file path and name: C:\Users\karens\Desktop\FA-10 FOSSA062322.2ST
Original date and time of creating this file: Fri Sep 17 15:08:29 2021

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 9 layers

	Wet Unit Weight, γ [lb/ft³]	**Poisson's Ratio μ**	**Description of Soil**
1	130.00	0.30	Granular 1
2	128.00	0.30	Granular 2
3	110.00	0.20	Granular 3
4	105.00	0.40	Cohesive 1
5	128.00	0.30	Granular 4
6	130.00	0.30	Granular 5
7	130.00	0.45	Cohesive 2
8	120.00	0.40	Cohesive 3
9	150.00	0.20	Termination Layer

INPUT DATA – EMBANKMENT LAYERS -- 2 layers

	Wet Unit Weight, γ [lb/ft³]	**Description of Soil**
1	120.00	Proposed Embankment
2	120.00	Proposed Embankment

INPUT DATA OF WATER

Point #	**Coordinates (X, Z) :** (X) [ft.]	(Z) [ft.]
1	0.00	649.10
2	250.00	649.10

DRAWING OF SPECIFIED GEOMETRY

INPUT DATA FOR CONSOLIDATION –– $\alpha = 1/2$

Layer #	Underging Consolidation [Yes/No]	OCR = Pc / Po	Cc	Cr	e0	Cv [ft ²/day]	Drains at :
1	No	N/A	N/A	N/A	N/A	N/A	N/A
2	No	N/A	N/A	N/A	N/A	N/A	N/A
3	No	N/A	N/A	N/A	N/A	N/A	N/A
4	Yes	1.00	0.190	0.038	0.983	0.3500	Top & Bot.
5	No	N/A	N/A	N/A	N/A	N/A	N/A
6	No	N/A	N/A	N/A	N/A	N/A	N/A
7	Yes	1.20	0.100	0.020	0.568	0.5400	Top
8	Yes	1.10	0.250	0.051	0.929	0.3000	Top
9	No	N/A	N/A	N/A	N/A	N/A	N/A

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	30.00	0.00	1	1209000	0.3000	-0.0000	670.15	670.12	0.03
			2	899000	0.3000	-0.0001			
			3	280000	0.2000	0.0001			
			4	363000	0.4000	-0.0010			
			5	948000	0.3000	-0.0000			
			6	454000	0.3000	0.0032			
			7	2000000	0.4500	0.0019			
			8	2000000	0.4000	0.0280			
			9	1000000000(	0.2000	0.0000			
2	32.50	0.00	1	1209000	0.3000	0.0001	670.10	670.06	0.04
			2	899000	0.3000	0.0001			
			3	280000	0.2000	0.0016			
			4	363000	0.4000	-0.0007			
			5	948000	0.3000	0.0005			
			6	454000	0.3000	0.0046			
			7	2000000	0.4500	0.0026			
			8	2000000	0.4000	0.0292			
			9	1000000000(	0.2000	0.0000			
3	35.00	0.00	1	1209000	0.3000	0.0001	670.10	670.06	0.04
			2	899000	0.3000	0.0003			
			3	280000	0.2000	0.0039			
			4	363000	0.4000	-0.0004			
			5	948000	0.3000	0.0012			
			6	454000	0.3000	0.0061			
			7	2000000	0.4500	0.0033			
			8	2000000	0.4000	0.0304			
			9	1000000000(	0.2000	0.0000			
4	37.50	0.00	1	1209000	0.3000	0.0002	670.10	670.05	0.05
			2	899000	0.3000	0.0004			
			3	280000	0.2000	0.0065			
			4	363000	0.4000	0.0000			
			5	948000	0.3000	0.0019			
			6	454000	0.3000	0.0077			
			7	2000000	0.4500	0.0041			
			8	2000000	0.4000	0.0315			
			9	1000000000(	0.2000	0.0000			
5	40.00	0.00	1	1209000	0.3000	0.0003	670.10	670.04	0.06
			2	899000	0.3000	0.0006			
			3	280000	0.2000	0.0090			
			4	363000	0.4000	0.0004			
			5	948000	0.3000	0.0027			
			6	454000	0.3000	0.0096			
			7	2000000	0.4500	0.0049			
			8	2000000	0.4000	0.0327			
			9	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
6	42.50	0.00	1	1209000	0.3000	0.0004	670.10	670.03	0.07
			2	899000	0.3000	0.0008			
			3	280000	0.2000	0.0112			
			4	363000	0.4000	0.0008			
			5	948000	0.3000	0.0035			
			6	454000	0.3000	0.0116			
			7	2000000	0.4500	0.0057			
			8	2000000	0.4000	0.0339			
			9	1000000000(	0.2000	0.0000			
7	45.00	0.00	1	1209000	0.3000	0.0005	670.10	670.03	0.07
			2	899000	0.3000	0.0010			
			3	280000	0.2000	0.0125			
			4	363000	0.4000	0.0010			
			5	948000	0.3000	0.0045			
			6	454000	0.3000	0.0136			
			7	2000000	0.4500	0.0065			
			8	2000000	0.4000	0.0351			
			9	1000000000(	0.2000	0.0000			
8	47.50	0.00	1	1209000	0.3000	0.0006	670.10	670.02	0.08
			2	899000	0.3000	0.0008			
			3	280000	0.2000	0.0118			
			4	363000	0.4000	0.0013			
			5	948000	0.3000	0.0055			
			6	454000	0.3000	0.0158			
			7	2000000	0.4500	0.0074			
			8	2000000	0.4000	0.0363			
			9	1000000000(	0.2000	0.0000			
9	50.00	0.00	1	1209000	0.3000	0.0001	670.10	670.02	0.08
			2	899000	0.3000	0.0001			
			3	280000	0.2000	0.0112			
			4	363000	0.4000	0.0018			
			5	948000	0.3000	0.0066			
			6	454000	0.3000	0.0181			
			7	2000000	0.4500	0.0083			
			8	2000000	0.4000	0.0375			
			9	1000000000(	0.2000	0.0000			
10	52.50	0.00	1	1209000	0.3000	0.0001	670.10	670.01	0.09
			2	899000	0.3000	0.0001			
			3	280000	0.2000	0.0156			
			4	363000	0.4000	0.0027			
			5	948000	0.3000	0.0080			
			6	454000	0.3000	0.0205			
			7	2000000	0.4500	0.0091			
			8	2000000	0.4000	0.0387			
			9	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
11	55.00	0.00	1	1209000	0.3000	0.0012	670.09	669.98	0.11
			2	899000	0.3000	0.0020			
			3	280000	0.2000	0.0257			
			4	363000	0.4000	0.0038			
			5	948000	0.3000	0.0094			
			6	454000	0.3000	0.0228			
			7	2000000	0.4500	0.0100			
			8	2000000	0.4000	0.0399			
			9	1000000000(	0.2000	0.0000			
12	57.50	0.00	1	1209000	0.3000	0.0012	670.07	669.94	0.13
			2	899000	0.3000	0.0026			
			3	280000	0.2000	0.0342			
			4	363000	0.4000	0.0050			
			5	948000	0.3000	0.0108			
			6	454000	0.3000	0.0251			
			7	2000000	0.4500	0.0108			
			8	2000000	0.4000	0.0410			
			9	1000000000(	0.2000	0.0000			
13	60.00	0.00	1	1209000	0.3000	0.0012	670.05	669.90	0.14
			2	899000	0.3000	0.0026			
			3	280000	0.2000	0.0380			
			4	363000	0.4000	0.0059			
			5	948000	0.3000	0.0121			
			6	454000	0.3000	0.0271			
			7	2000000	0.4500	0.0117			
			8	2000000	0.4000	0.0421			
			9	1000000000(	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0

FoSSA -- Foundation Stress & Settlement Analysis
Present Date/Time: Thu Jun 23 15:49:15 2022

CUY-90-16.28 (CCGA)
C:\Users\karens\Desktop\FA-10_FOSSA062322.2ST

Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0 FoSSA Version 2.0

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	30.00	0.00	670.15	0.14	670.01
2	32.50	0.00	670.10	0.15	669.95
3	35.00	0.00	670.10	0.16	669.94
4	37.50	0.00	670.10	0.17	669.93
5	40.00	0.00	670.10	0.19	669.91
6	42.50	0.00	670.10	0.20	669.90
7	45.00	0.00	670.10	0.22	669.88
8	47.50	0.00	670.10	0.23	669.87
9	50.00	0.00	670.10	0.25	669.85
10	52.50	0.00	670.10	0.27	669.83
11	55.00	0.00	670.09	0.29	669.80
12	57.50	0.00	670.07	0.32	669.75
13	60.00	0.00	670.05	0.34	669.71

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	DESCRIPTION
1	1	0.00	667.10	Granular 1
	2	14.60	669.01	
	3	25.00	670.40	
	4	31.00	670.10	
	5	50.00	670.10	
	6	54.40	670.10	
	7	75.00	669.90	
	8	100.00	669.80	
	9	125.00	669.90	
	10	150.00	670.00	
	11	250.00	670.00	
2	1	0.00	667.09	Granular 2
	2	12.80	667.49	
	3	14.60	669.00	
	4	205.00	669.10	
	5	250.00	669.10	
3	1	0.00	667.08	Granular 3
	2	250.00	667.10	
4	1	0.00	659.60	Cohesive 1
	2	250.00	659.60	
5	1	0.00	657.10	Granular 4
	2	250.00	657.10	
6	1	0.00	645.50	Granular 5
	2	250.00	645.50	
7	1	0.00	631.80	Cohesive 2
	2	250.00	631.80	
8	1	0.00	590.30	Cohesive 3
	2	250.00	590.30	
9	1	0.00	450.00	Termination Layer
	2	250.00	450.00	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

Embank. Soil #		Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	D E S C R I P T I O N
1	X1 = 31.00 [ft]	1	31.00	670.10	Proposed Embankment
	X2 = 54.40 [ft]	2	47.90	677.90	
		3	47.91	672.25	
		4	54.39	672.25	
		5	54.40	670.10	
2	X1 = 31.00 [ft]	1	31.00	670.11	Proposed Embankment
	X2 = 250.01 [ft]	2	47.90	677.91	
		3	47.90	672.26	
		4	54.39	672.26	
		5	54.40	686.30	
		6	75.00	685.80	
		7	100.00	685.20	
		8	125.00	684.60	
		9	150.00	683.90	
		10	250.00	681.30	
		11	250.01	670.00	

FORWARD ABUTMENT – WITH LIGHTWEIGHT FILL

CUY-90-16.28 (CCGA)

PROJECT IDENTIFICATION

Title: CUY-90-16.28 (CCGA)
Project Number: PID 82383 -
Client: Michael Baker International
Designer: KCA
Station Number:

Description:

Company's information:

Name: NEAS Inc.
Street: 2800 Corporate Exchange Drive, Suite 240
Columbus, OH 43231
Telephone #: 614-714-0299
Fax #: 614-714-0251
E-Mail: brendan.andrews@neasinc.com

Original file path and name: P:\21-0011 ..... ll AC\Analysis\Settlement\FA\FA-11_FOSSA051624.2ST
Original date and time of creating this file: Thu Jun 23 15:58:23 2022

GEOMETRY: Analysis of a 2D geometry

INPUT DATA – FOUNDATION LAYERS – 6 layers

	Wet Unit Weight, γ [lb/ft³]	**Poisson's Ratio μ**	**Description of Soil**
1	110.00	0.20	Granular 3
2	105.00	0.40	Cohesive 1
3	128.00	0.30	Granular 4
4	130.00	0.30	Granular 5
5	130.00	0.45	Cohesive 2
6	150.00	0.20	Termination Layer

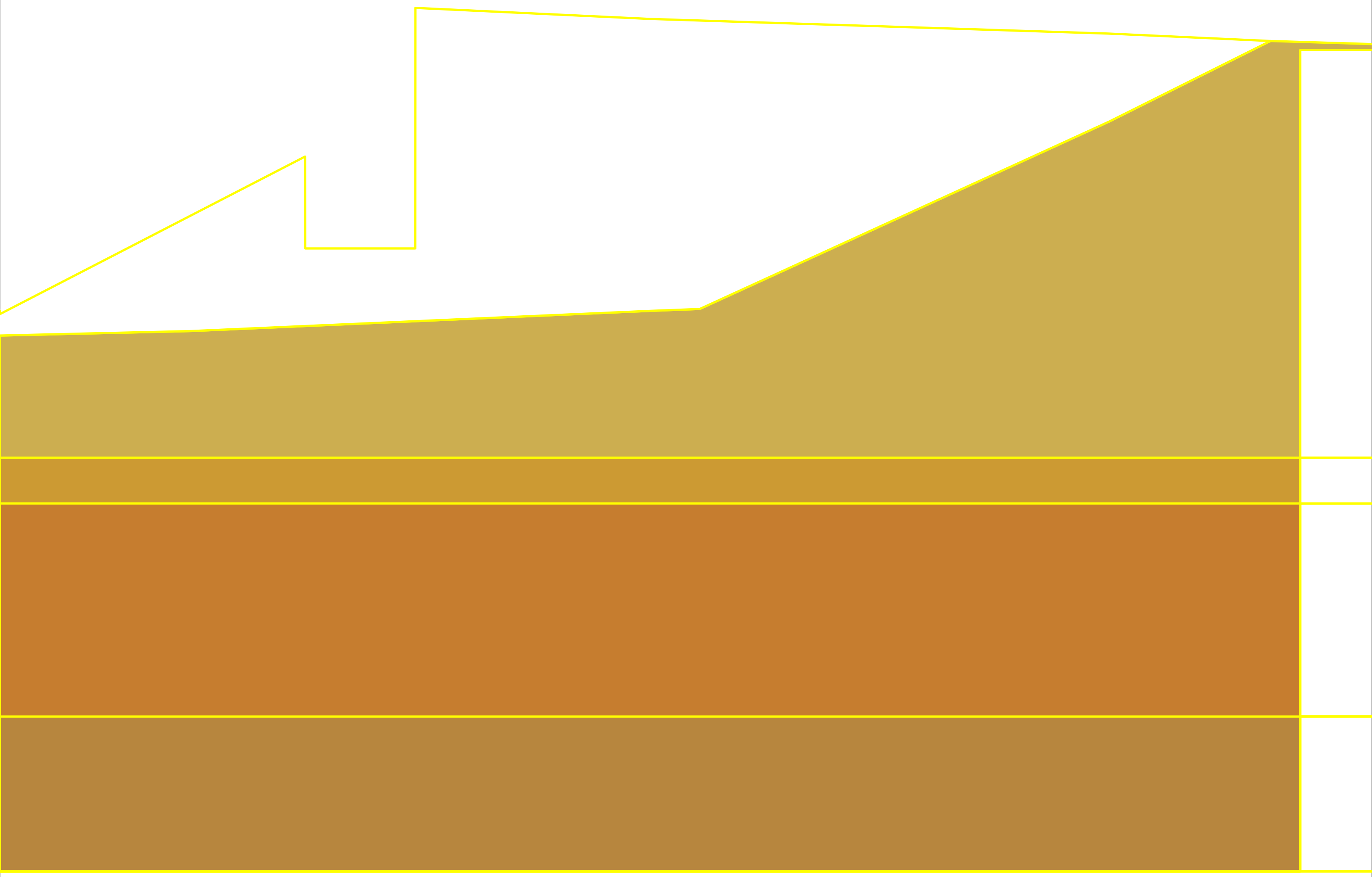
INPUT DATA – EMBANKMENT LAYERS -- 1 layers

	Wet Unit Weight, γ [lb/ft³]	**Description of Soil**
1	120.00	Proposed Embankment

INPUT DATA OF WATER

Point #	**Coordinates (X, Z) :** (X) [ft.]	(Z) [ft.]
1	0.00	649.10
2	150.00	649.10

DRAWING OF SPECIFIED GEOMETRY



INPUT DATA FOR CONSOLIDATION –– $\alpha = 1/2$

Layer #	Underging Consolidation [Yes/No]	OCR = Pc / Po	Cc	Cr	e0	Cv [ft ²/day]	Drains at :
1	No	N/A	N/A	N/A	N/A	N/A	N/A
2	Yes	1.00	0.190	0.038	0.983	0.3500	Top & Bot.
3	No	N/A	N/A	N/A	N/A	N/A	N/A
4	No	N/A	N/A	N/A	N/A	N/A	N/A
5	Yes	1.20	0.100	0.020	0.568	0.5400	Top
6	No	N/A	N/A	N/A	N/A	N/A	N/A

IMMEDIATE SETTLEMENT, Si

Node #	Settlement along section: X [ft.]	Y [ft.]	Layer (k)	Young's Modulus, E [lb/ft ²]	Poisson's Ratio, μ	Settlement of each layer, Si(k) [ft.]	Initial Z [ft.]	Final Z * [ft.]	Total Settlement Sum of Si(k), [ft.]
1	82.20	0.00	1	280000	0.2000	0.0123	666.82	666.77	0.05
			2	363000	0.4000	0.0025			
			3	948000	0.3000	0.0084			
			4	454000	0.3000	0.0218			
			5	2000000	0.4500	0.0053			
			6	99999999999	0.2000	0.0000			
2	83.20	0.00	1	280000	0.2000	0.0124	666.86	666.81	0.05
			2	363000	0.4000	0.0027			
			3	948000	0.3000	0.0089			
			4	454000	0.3000	0.0227			
			5	2000000	0.4500	0.0054			
			6	99999999999	0.2000	0.0000			
3	84.20	0.00	1	280000	0.2000	0.0127	666.90	666.85	0.05
			2	363000	0.4000	0.0030			
			3	948000	0.3000	0.0094			
			4	454000	0.3000	0.0235			
			5	2000000	0.4500	0.0056			
			6	99999999999	0.2000	0.0000			
4	85.20	0.00	1	280000	0.2000	0.0141	666.95	666.89	0.06
			2	363000	0.4000	0.0034			
			3	948000	0.3000	0.0100			
			4	454000	0.3000	0.0244			
			5	2000000	0.4500	0.0057			
			6	99999999999	0.2000	0.0000			
5	86.20	0.00	1	280000	0.2000	0.0169	666.99	666.93	0.06
			2	363000	0.4000	0.0040			
			3	948000	0.3000	0.0106			
			4	454000	0.3000	0.0252			
			5	2000000	0.4500	0.0059			
			6	99999999999	0.2000	0.0000			

*Note: Final Z is calculated assuming only 'Immediate Settlement' exists.

ULTIMATE SETTLEMENT, Sc

Node #	X [ft.]	Y [ft.]	Original Z [ft.]	Settlement Sc [ft.]	Final Z * [ft.]
1	82.20	0.00	666.82	0.09	666.72
2	83.20	0.00	666.86	0.10	666.76
3	84.20	0.00	666.90	0.10	666.80
4	85.20	0.00	666.95	0.11	666.84
5	86.20	0.00	666.99	0.11	666.88

*Note: Final Z is calculated assuming only 'Ultimate Settlement' exists.

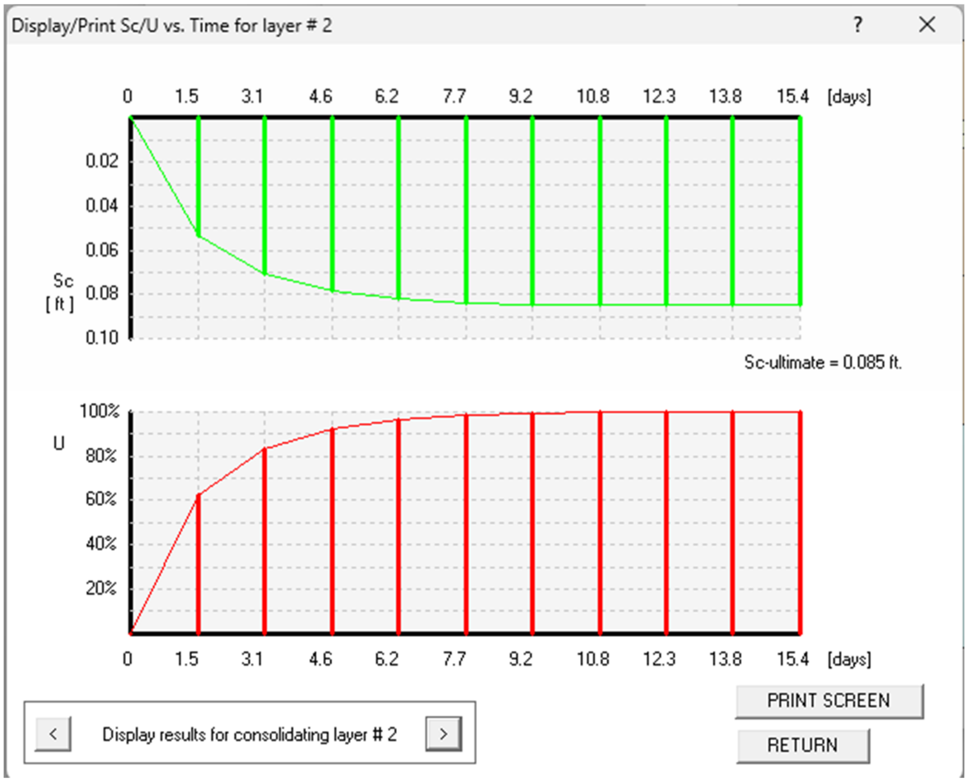
TABULATED GEOMETRY: INPUT OF FOUNDATION SOILS

Found. Soil #	Point #	Coordinates (X, Z) :		DESCRIPTION
		(X) [ft.]	(Z) [ft.]	
1	1	0.00	666.00	Granular 3
	2	25.00	665.70	
	3	50.00	665.80	
	4	62.20	666.20	
	5	75.00	666.50	
	6	100.00	667.60	
	7	102.70	667.70	
	8	125.00	677.90	
	9	133.80	682.30	
	10	150.00	681.80	
2	1	0.00	659.60	Cohesive 1
	2	150.00	659.60	
3	1	0.00	657.10	Granular 4
	2	150.00	657.10	
4	1	0.00	645.50	Granular 5
	2	150.00	645.50	
5	1	0.00	631.80	Cohesive 2
	2	150.00	631.80	
6	1	0.00	611.50	Termination Layer
	2	150.00	611.50	

TABULATED GEOMETRY: INPUT OF EMBANKMENT SOILS

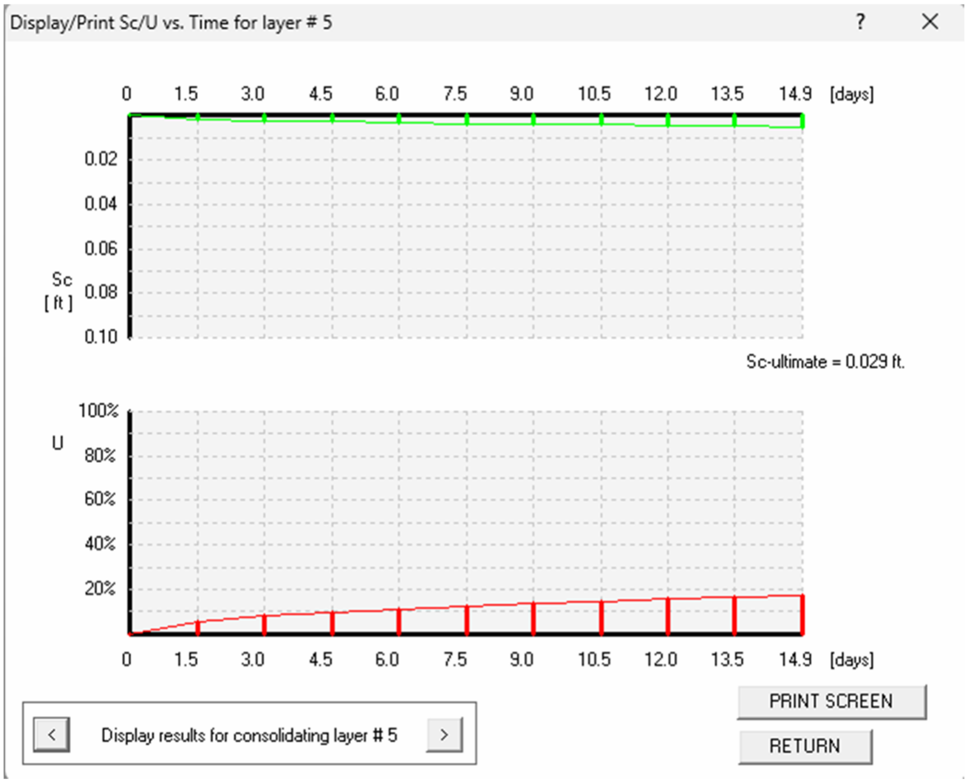
Embank. Soil #		Point #	Coordinates (X, Z) : (X) [ft.]	(Z) [ft.]	D E S C R I P T I O N
1	X1 = 62.20 [ft]	1	62.20	666.20	Proposed Embankment
	X2 = 133.80 [ft]	2	81.20	676.00	
		3	81.21	671.00	
		4	87.20	671.00	
		5	87.21	684.10	
		6	100.00	683.50	
		7	125.00	682.70	
		8	133.80	682.30	

FoSSA Time Rate Calculations



Sc-ultimate = 0.085 ft.

Display results for consolidating layer # 2



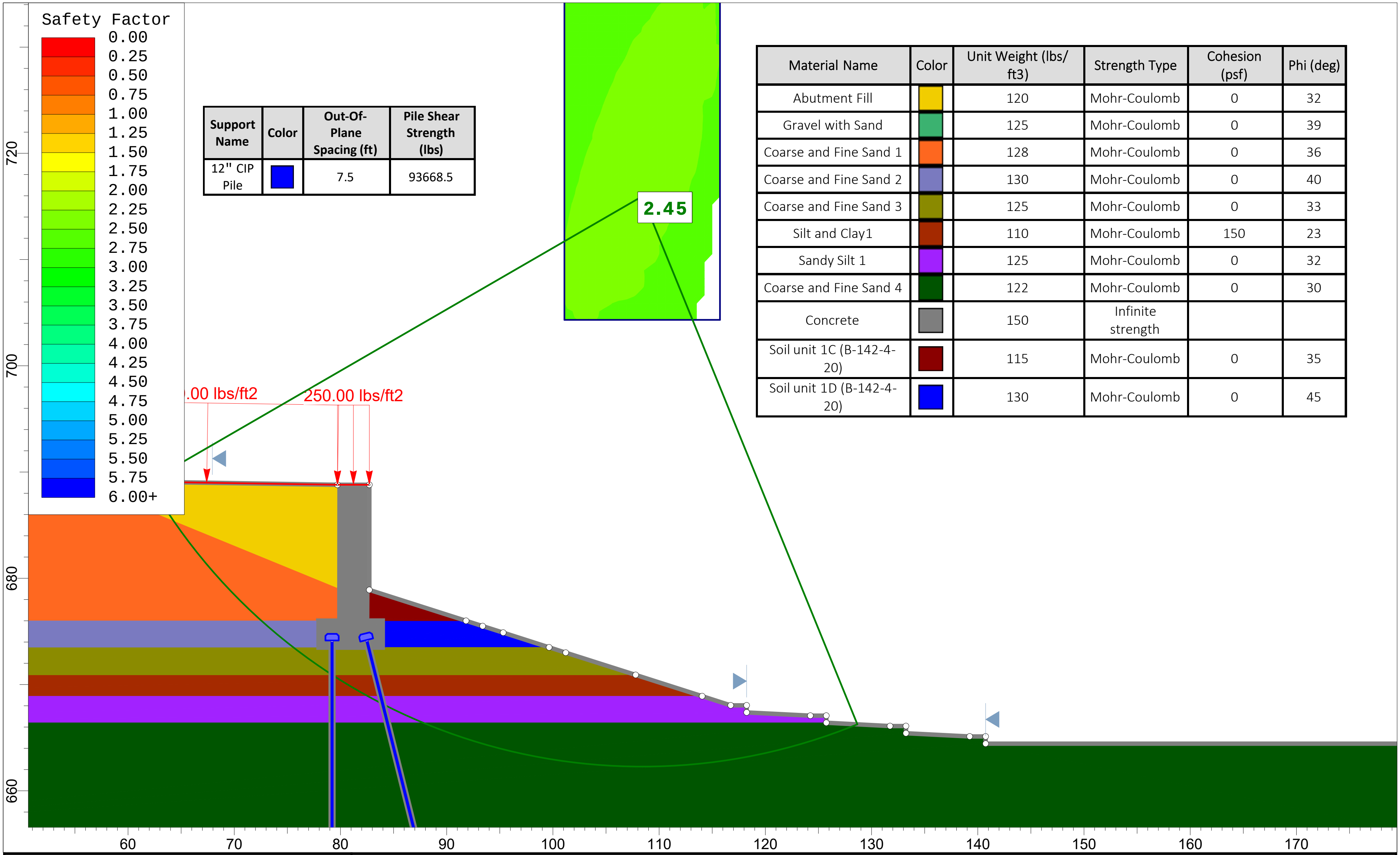
Sc-ultimate = 0.029 ft.

Display results for consolidating layer # 5

APPENDIX J

GLOBAL STABILITY ANALYSIS -
REAR AND FORWARD ABUTMENT

REAR ABUTMENT



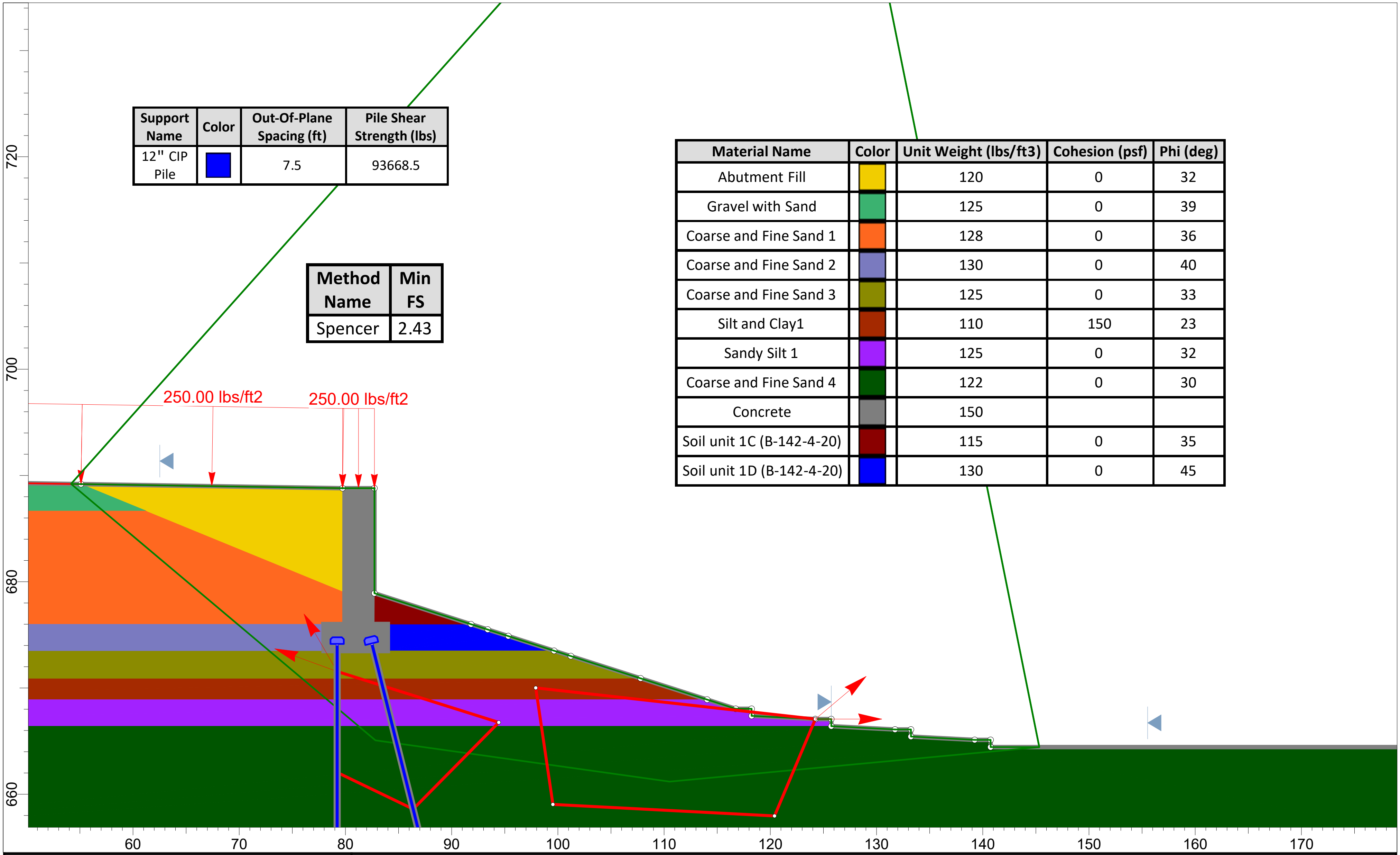
Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
12" CIP Pile	🟦	7.5	93668.5

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	Mohr-Coulomb	0	32
Gravel with Sand	🟩	125	Mohr-Coulomb	0	39
Coarse and Fine Sand 1	🟧	128	Mohr-Coulomb	0	36
Coarse and Fine Sand 2	🟪	130	Mohr-Coulomb	0	40
Coarse and Fine Sand 3	🟫	125	Mohr-Coulomb	0	33
Silt and Clay1	🟫	110	Mohr-Coulomb	150	23
Sandy Silt 1	🟪	125	Mohr-Coulomb	0	32
Coarse and Fine Sand 4	🟩	122	Mohr-Coulomb	0	30
Concrete	⬜	150	Infinite strength		
Soil unit 1C (B-142-4-20)	🟥	115	Mohr-Coulomb	0	35
Soil unit 1D (B-142-4-20)	🟦	130	Mohr-Coulomb	0	45

rocscience

SLIDEINTERPRET 9.025

Project	CUY-90-16.28 (CCG3A), PID 82382
Analysis Description	Rear Abutment, Global Stability - Effective Stress, Circular Failure
Drawn By	M. Jasiewicz
Company	NEAS Inc.
Date	6/28/2021, 11:47:34 PM
File Name	RA_EffCircular091721.slim



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
12" CIP Pile	🟦	7.5	93668.5

Method Name	Min FS
Spencer	2.43

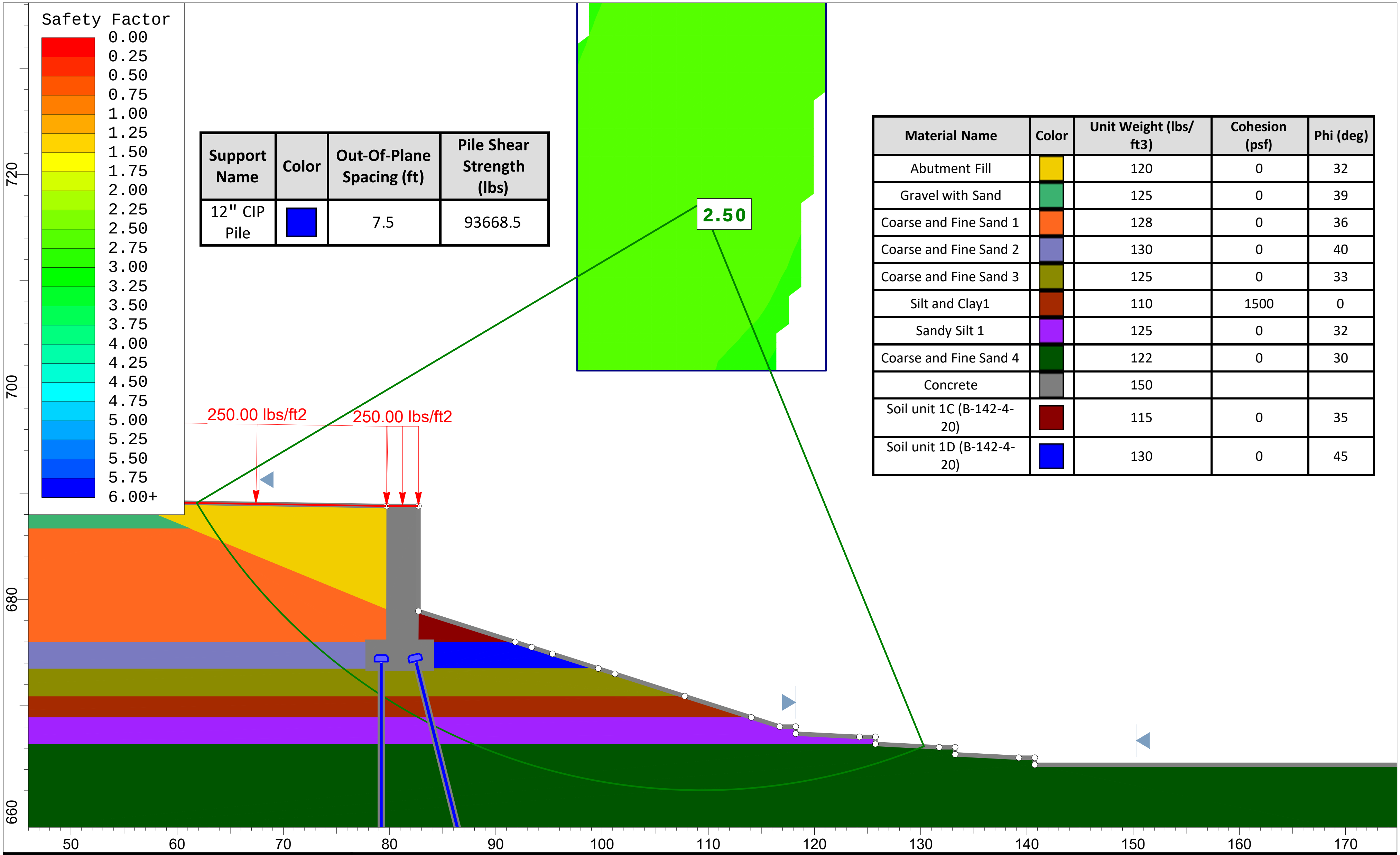
Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	0	32
Gravel with Sand	🟩	125	0	39
Coarse and Fine Sand 1	🟧	128	0	36
Coarse and Fine Sand 2	🟪	130	0	40
Coarse and Fine Sand 3	🟫	125	0	33
Silt and Clay1	🟫	110	150	23
Sandy Silt 1	🟪	125	0	32
Coarse and Fine Sand 4	🟩	122	0	30
Concrete	⬛	150		
Soil unit 1C (B-142-4-20)	🟥	115	0	35
Soil unit 1D (B-142-4-20)	🟦	130	0	45

rocscience

SLIDEINTERPRET 9.025

Project	CUY-90-16.28 (CCG3A), PID 82382
Analysis Description	Rear Abutment, Global Stability - Effective Stress, Block Failure

Drawn By	M. Jasiewicz	*Company*	NEAS Inc.
Date	6/28/2021, 11:47:34 PM	*File Name*	RA_EffBlock091721.slim



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
12" CIP Pile	🟦	7.5	93668.5

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	0	32
Gravel with Sand	🟩	125	0	39
Coarse and Fine Sand 1	🟧	128	0	36
Coarse and Fine Sand 2	🟪	130	0	40
Coarse and Fine Sand 3	🟫	125	0	33
Silt and Clay1	🟫	110	1500	0
Sandy Silt 1	🟪	125	0	32
Coarse and Fine Sand 4	🟩	122	0	30
Concrete	⬛	150		
Soil unit 1C (B-142-4-20)	🟥	115	0	35
Soil unit 1D (B-142-4-20)	🟦	130	0	45

rocscience

SLIDEINTERPRET 9.025

Project
CUY-90-16.28 (CCG3A), PID 82382

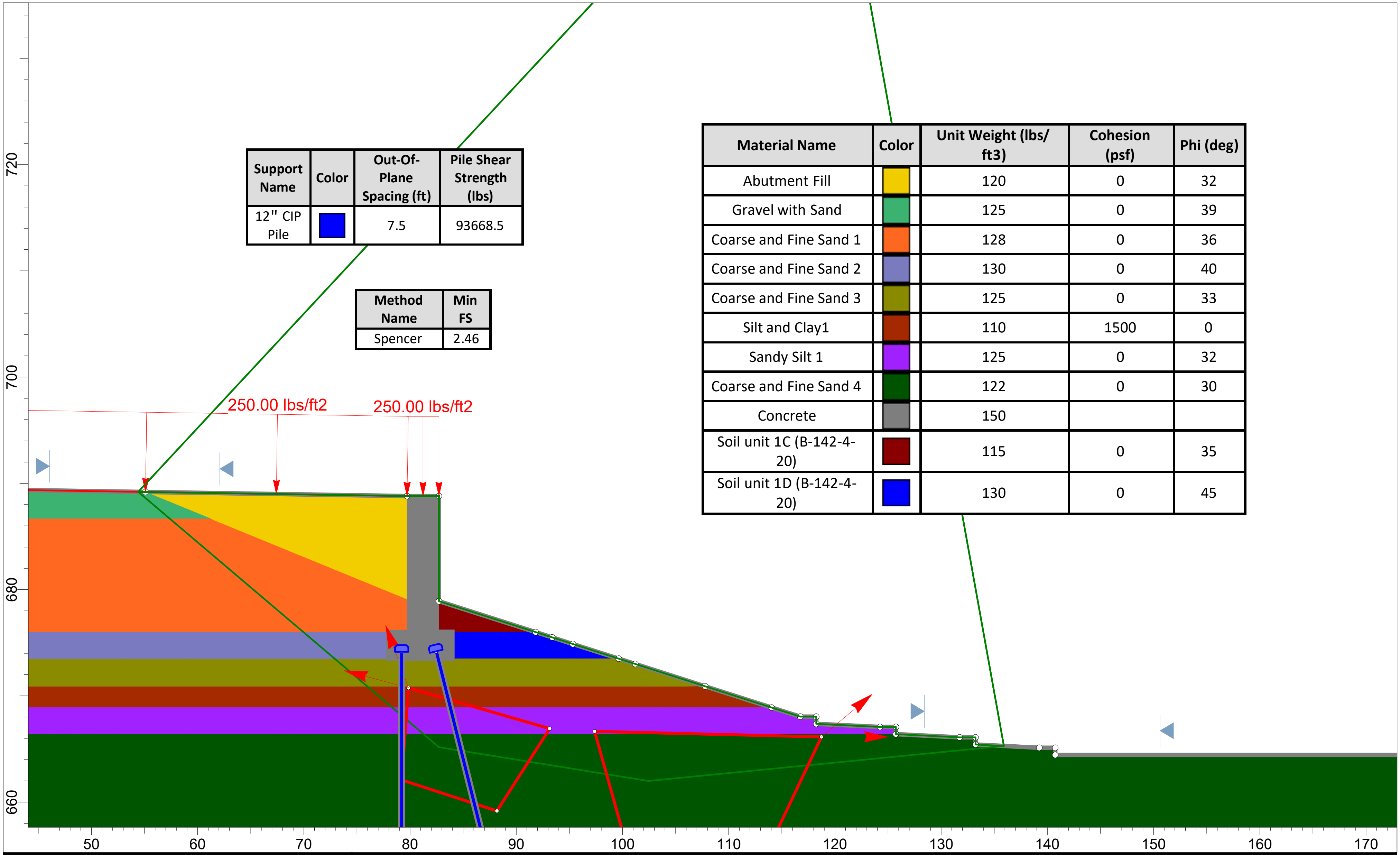
Analysis Description
Rear Abutment, Global Stability - Total Stress, Circular Failure

Drawn By
M. Jasiewicz

Company
NEAS Inc.

Date
6/28/2021, 11:47:34 PM

File Name
RA_TotalCircular091721.slim



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
12" CIP Pile	🟦	7.5	93668.5

Method Name	Min FS
Spencer	2.46

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	0	32
Gravel with Sand	🟩	125	0	39
Coarse and Fine Sand 1	🟧	128	0	36
Coarse and Fine Sand 2	🟪	130	0	40
Coarse and Fine Sand 3	🟫	125	0	33
Silt and Clay1	🟥	110	1500	0
Sandy Silt 1	🟪	125	0	32
Coarse and Fine Sand 4	🟩	122	0	30
Concrete	⬛	150		
Soil unit 1C (B-142-4-20)	🟥	115	0	35
Soil unit 1D (B-142-4-20)	🟦	130	0	45

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SLIDEINTERPRET 9.025

Project CUY-90-16.28 (CCG3A), PID 82382

Analysis Description Rear Abutment, Global Stability - Total Stress, Block Failure

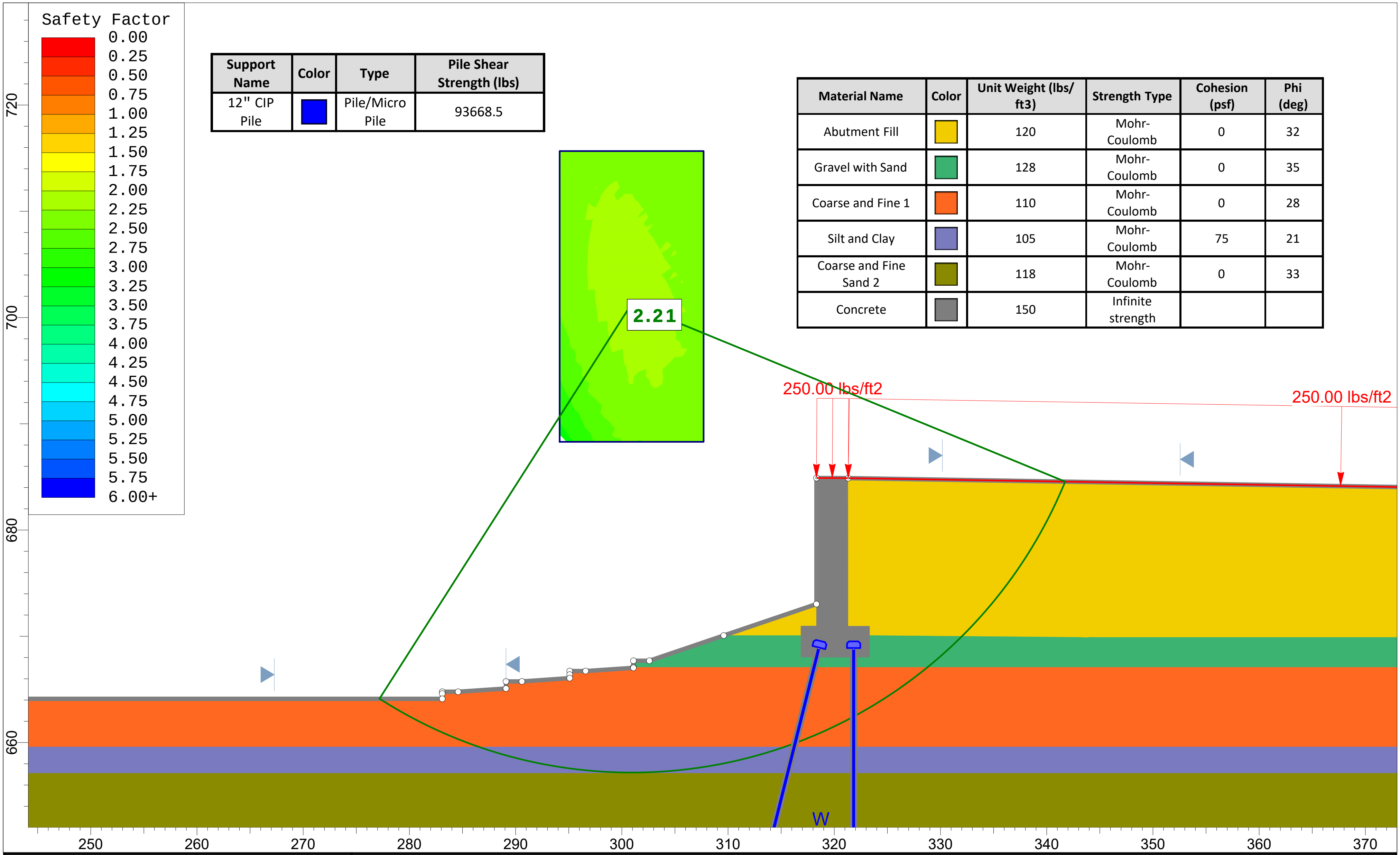
Drawn By M. Jasiewicz

Company NEAS Inc.

Date 6/28/2021, 11:47:34 PM

File Name RA_TotalBlock091721.slim

FORWARD ABUTMENT



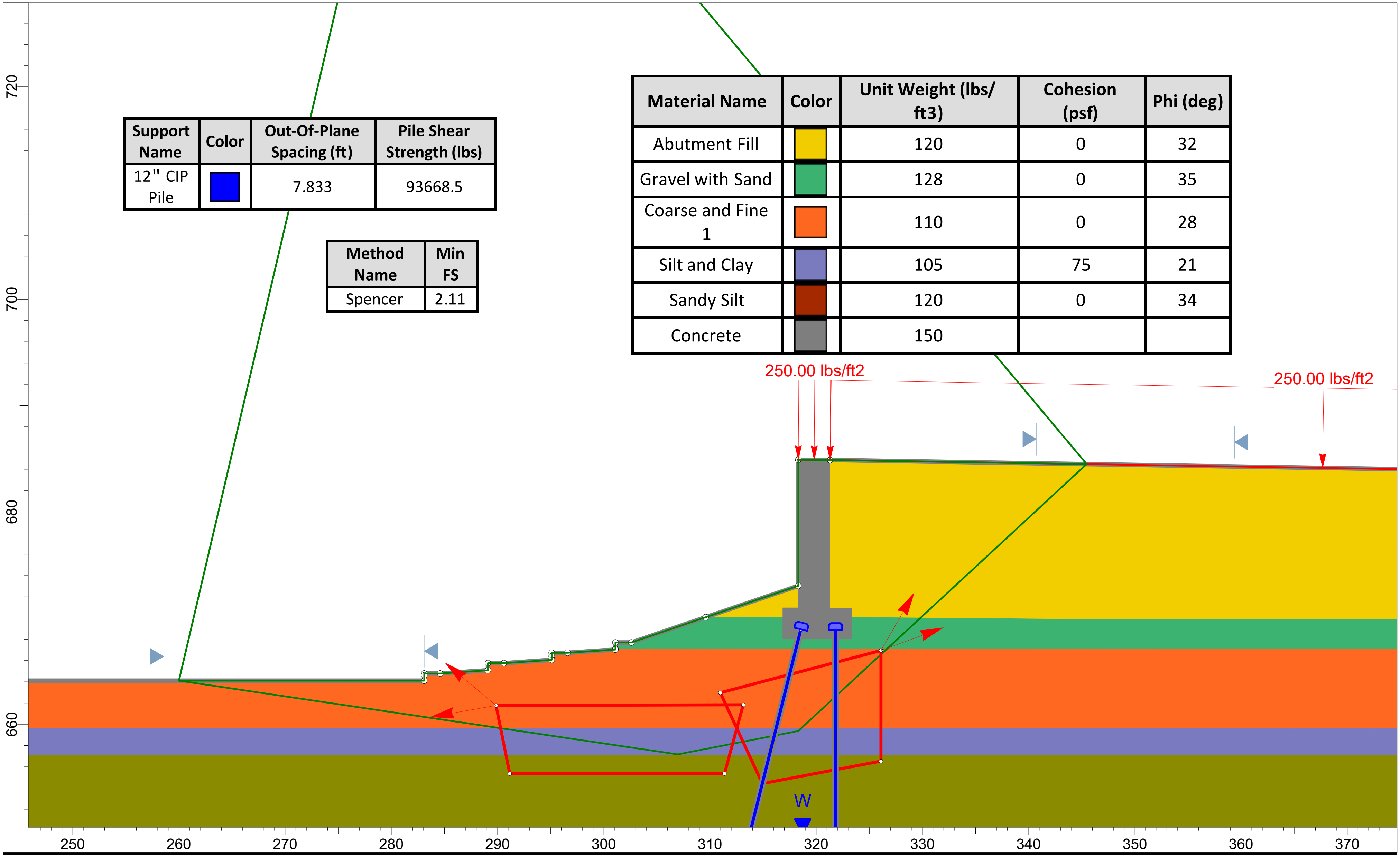
Support Name	Color	Type	Pile Shear Strength (lbs)
12" CIP Pile	🟦	Pile/Micro Pile	93668.5

Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	Mohr-Coulomb	0	32
Gravel with Sand	🟩	128	Mohr-Coulomb	0	35
Coarse and Fine 1	🟧	110	Mohr-Coulomb	0	28
Silt and Clay	🟪	105	Mohr-Coulomb	75	21
Coarse and Fine Sand 2	🟫	118	Mohr-Coulomb	0	33
Concrete	⬛	150	Infinite strength		

rocscience

SLIDEINTERPRET 9.025

Project	CUY-90-16.28 (CCG3A), PID 82382
Analysis Description	Forward Abutment, Global Stability - Effective Stress, Circular Failure
Drawn By	M. Jasiewicz
Company	NEAS Inc.
Date	6/28/2021, 11:47:34 PM
File Name	FA_EffCircular091721.slim



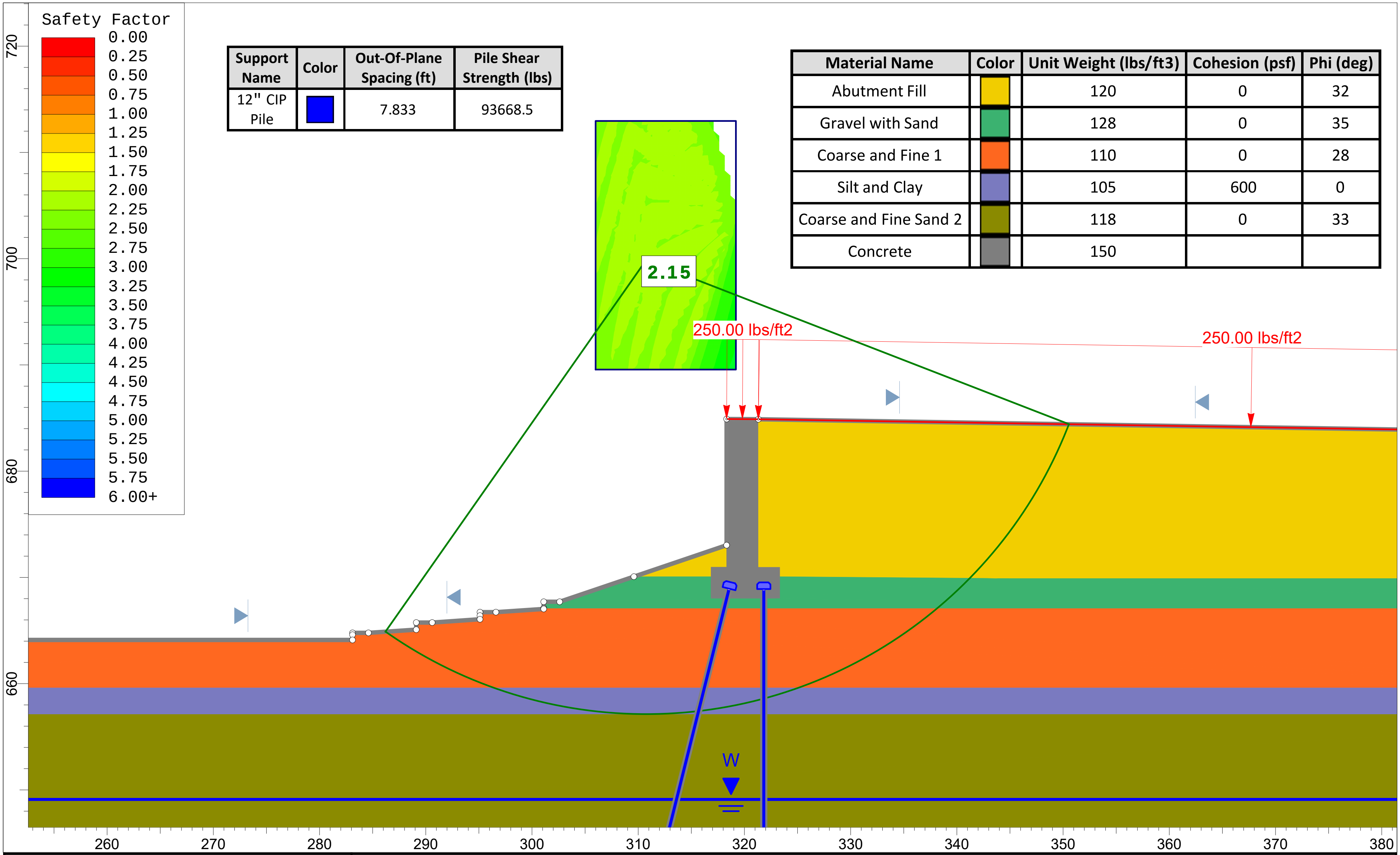
Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
12" CIP Pile	🟦	7.833	93668.5

Method Name	Min FS
Spencer	2.11

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	0	32
Gravel with Sand	🟩	128	0	35
Coarse and Fine 1	🟧	110	0	28
Silt and Clay	🟪	105	75	21
Sandy Silt	🟫	120	0	34
Concrete	⬛	150		

Project	CUY-90-16.28 (CCG3A), PID 82382
Analysis Description	Forward Abutment, Global Stability - Effective Stress, Block Failure
Drawn By	M. Jasiewicz
Company	NEAS Inc.
Date	6/28/2021, 11:47:34 PM
File Name	FA_EffBlock091721.slim

SLIDEINTERPRET 9.025



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
12" CIP Pile	🟦	7.833	93668.5

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	0	32
Gravel with Sand	🟩	128	0	35
Coarse and Fine 1	🟧	110	0	28
Silt and Clay	🟪	105	600	0
Coarse and Fine Sand 2	🟫	118	0	33
Concrete	■	150		

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SLIDEINTERPRET 9.025

Project CUY-90-16.28 (CCG3A), PID 82382

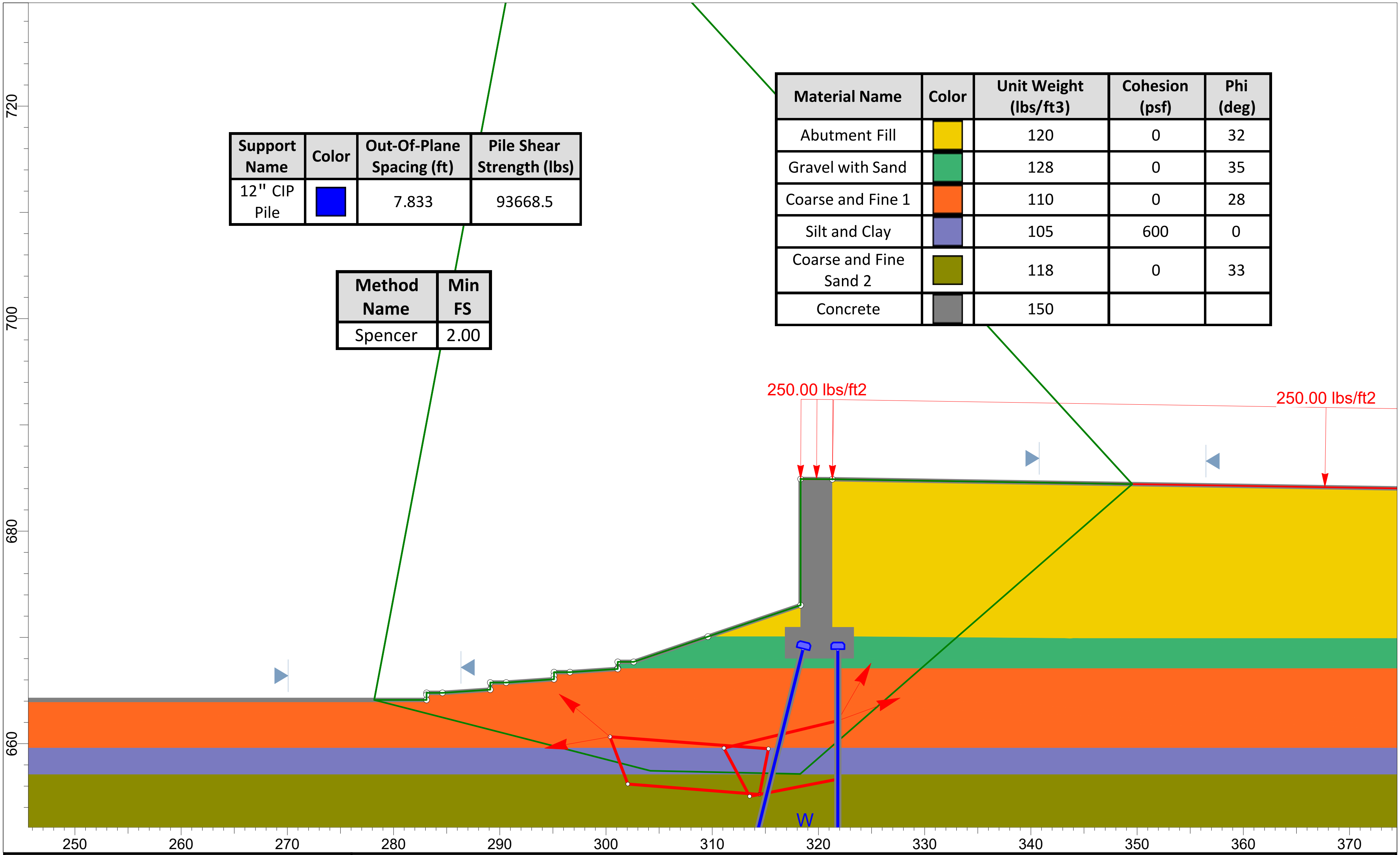
Analysis Description Forward Abutment, Global Stability - Total Stress, Circular Failure

Drawn By M. Jasiewicz

Company NEAS Inc.

Date 6/28/2021, 11:47:34 PM

File Name FA_TotalCircular091721.slim



Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
12" CIP Pile	🟦	7.833	93668.5

Method Name	Min FS
Spencer	2.00

Material Name	Color	Unit Weight (lbs/ft3)	Cohesion (psf)	Phi (deg)
Abutment Fill	🟨	120	0	32
Gravel with Sand	🟩	128	0	35
Coarse and Fine 1	🟧	110	0	28
Silt and Clay	🟪	105	600	0
Coarse and Fine Sand 2	🟫	118	0	33
Concrete	⬛	150		

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SLIDEINTERPRET 9.025

Project CUY-90-16.28 (CCG3A), PID 82382

Analysis Description Forward Abutment, Global Stability - Total Stress, Block Failure

Drawn By M. Jasiewicz

Company NEAS Inc.

Date 6/28/2021, 11:47:34 PM

File Name FA_TotalBlock091721.slim

APPENDIX K

SEISMIC SITE CLASSIFICATION CALCULATION

Seismic Site Classification - Bridge CUY-90-1653L

B-142-4-20 & B-078-0-14

Depth (ft)	Layer Thickness, d (ft)	Avg. SPT Value, N (bpf)	d/N
2.4	2.4	20.5	0.11
4.4	2.0	12.0	0.17
6.9	2.5	17.0	0.15
18.1	11.2	13.3	0.85
21.9	3.8	19.0	0.20
29.4	7.5	7.0	1.07
40.7	11.3	25.7	0.44
45.7	5.0	36.0	0.14
55.9	10.2	27.0	0.38
85.9	30.0	21.8	1.38
90.7	4.8	48.0	0.10
95.7	5.0	27.0	0.19
100.0	4.4	21.0	0.21
Sum	100.0		5.374
N-avg	18.6		

B-078-1-20

Depth (ft)	Layer Thickness, d (ft)	Avg. SPT Value, N (bpf)	d/N
5.0	5.0	26.0	0.19
10.0	5.0	5.5	0.91
12.5	2.5	6.0	0.42
15.0	2.5	7.0	0.36
34.0	19.0	25.7	0.74
41.3	7.3	23.5	0.31
51.3	10.0	9.5	1.05
61.3	10.0	14.5	0.69
71.3	10.0	5.0	2.00
100.0	28.7	20.6	1.40
Sum	100.0		8.064
N-avg	12.4		

C-079-0-14 & B-144-0-14

Depth (ft)	Layer Thickness, d (ft)	Avg. SPT Value, N (bpf)	d/N
0.8	0.8	25.0	0.03
8.3	7.5	6.0	1.25
10.8	2.5	5.0	0.50
22.4	11.6	27.4	0.42
36.1	13.7	35.4	0.39
51.8	15.7	20.2	0.78
72.0	20.2	12.9	1.57
77.6	5.6	24.6	0.23
100.0	22.4	12.8	1.75
Sum	100.0		6.912
N-avg	14.5		

Site Average	15.2