FINAL REPORT
STRUCTURE FOUNDATION EXPLORATION
RETAINING WALL S
CUY-90-16.28 (CCG3A)
CUYAHOGA COUNTY, OHIO
PID#: 82382

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NEAS PROJECT 21-0011

May 15, 2024

National Engineering & Architectural Services Inc.

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1. INTRODUCTION

1.1. General

National Engineering & Architectural Services, Inc. (NEAS) presents our Structure Foundation Exploration Report for the proposed Retaining Wall S (RW-S) structure as part of the proposed Ohio Department of Transportation (ODOT) project CCG3A (CUY-90-16.28, PID 82380) 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. The referenced retaining wall is proposed along the south side of Ramp A2 located south of IR-77 near East 22nd St. As a part of the interchange improvement project, it is our understanding that ODOT is planning to construct Ramp A2 to realign access to IR-77 southbound (SB) from IR-90 westbound (WB). In order to allow for the construction of the proposed Ramp A2, RW-S is planned to provide grade separation between Orange Avenue (Ave) and the future Ramp J2. This report presents a summary of the encountered surficial and subsurface conditions and our recommendations for 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 *ODOT's 2021 LRFD Bridge Design Manual* (BDM) (ODOT, 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. The exploration was also conducted in general accordance with the provisions of the July 2014 (ODOT, 2014) and January 2021 (ODOT, 2021) revisions of ODOT's *Specifications for Geotechnical Explorations* (SGE).

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 (2 utilized within this report as a part of the indicated structure foundation exploration); 3) performing 30 total cone penetration test (CPT) soundings (2 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

The proposed construction of Ramp A2 as part of the overall CCG3A project (CUY-90-16.28, PID 82380) will require the construction of RW-S to provide grade separation between Orange Ave, the future Ramp J2, as well as the future bridge associated with the construction of Ramp J2. The existing topography at the wall location consists of an embankment slope for the existing IR-77 SB. The existing embankment slope is graded at about 2 Horizontal to 1 Vertical (2H:1V). RW-S is proposed along the south side of Ramp A2, starting from approximate STA 405+45.95 and ending at approximate STA 408+33.13.

Based on design information provided within the Retaining Wall S, Stage 2 plan set developed by Michael Baker International (MB) and dated January 12, 2024, the proposed RW-S will be a solider pile lagging (SPL) wall. It is our understanding that the wall will be approximately 247.4 ft in length and will have a maximum total height of approximately 21 ft at about RW-S Station 452+75.

2. GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1. Geology and Physiography

The retaining wall 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 at the proposed retaining wall site is mapped as an average of 10 ft of Wisconsinan-age sand atop an average of 90 ft of Wisconsinan-age lacustrine silt and clay followed by an average of 80 ft of Wisconsinan-age till underlain by Wisconsinan-age sand all over Devonian-age Ohio Shale (ODGS, 2002). 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 retaining wall 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, 2006). Based on the ODNR bedrock topography map of Ohio, bedrock elevations near the proposed retaining wall 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 240 to 300 ft below ground surface (bgs).

The soils at the retaining wall site have been mapped (Web Soil Survey) by the Natural Resources Conservation Service as Udorthents, loamy (Ua). These are soils that have been disturbed by cutting or filling and are not rated for local roads (USDA, 2015).

2.2. Hydrology/Hydrogeology

The local hydro-geologic system is dominated by the valley of the Cuyahoga River, located approximately a quarter to a half mile to the southwest and flows northwest discharging into Lake Erie. The elevation of the Cuyahoga River and Lake Erie is about 570 to 575 ft amsl 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 RW-S 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, 2019).

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 RW-S location (ODNR [1], 2016).

No oil or gas wells are noted on ODNR's Ohio Oil & Gas Locator within the immediate vicinity of the proposed RW-S location (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 retaining wall site. 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 RW-S site was conducted. During the site visit, site conditions were noted along the proposed RW-S alignment. No geohazards were observed within the immediate vicinity of the referenced wall site.

The existing topography at the wall location consists of a slope that extends downward from IR-77 SB grades to the lower lying Orange Ave. The existing embankment slope was observed to have an average slope of about 2 Horizontal to 1 Vertical (2H:1V). From the beginning of RW-S at STA. 450+14 to STA. 452+94.53, slopes appeared to vary with grades ranging from 2H:1V to 3H:1V. The embankment slopes in this area is vegetated with what appears to be mowed grass. At the toe of the embankment slope, overhead utilities and associated utility poles are present. No erosion or poor drainage was observed along the slope.

The pavement condition at the existing IR-77 SB near the wall site appeared to be in fair condition with minor signs of distress. The roadways appeared to be well drained with no observable signs of standing water. Nearby signs and light poles appeared to be in fair to good condition without apparent signs of distress related to the underlying soil conditions.

3. GEOTECHNICAL EXPLORATION

3.1. Field Exploration Program

The exploration for this retaining wall was conducted by NEAS between December 2, 2014 and May 20, 2021 and included 2 borings each drilled to a depth of 61.5 ft bgs and 2 CPT soundings that were extended to depths ranging from 113.5 to 113.7 ft bgs. The boring locations were selected by NEAS in general accordance with the guidelines contained in the SGE at the time of the exploration with the intent to evaluate subsurface soil and groundwater conditions. Borings were typically located at/near proposed wall location that were not restricted by maintenance of traffic, underground utilities or dictated by terrain (i.e. steep embankment slopes). Project boring locations were located and surveyed in the field by NEAS after the completion of drilling. Each individual project boring log/CPT 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 borings including stationing, offsets, location information and elevations of the RW-S structure borings are shown in Table 1 below, while the boring 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
C-130-0-14	41.492128	-81.676060	677.8	113.5	RW-S
B-132-0-14	41.492381	-81.676260	698.5	61.5	RW-S
C-133-0-14	41.492263	-81.676612	678.1	113.7	RW-S
B-134-0-14	41.492580	-81.676947	697.9	61.5	RW-S

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

The borings were drilled using a CME 45B 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 77.4% 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 log. After completing the borings, the boreholes were backfilled with either auger cuttings, bentonite chips, or a combination of these materials.

The CPT soundings were 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 soundings were 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 soundings, the CPT log was generated 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. The individual laboratory data sheets and results are included in Appendix B. Additionally, data from the laboratory testing program was incorporated onto the final borings logs. 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 31% of the samples. At each boring location, samples were selected for testing with the intent of identification and classification of all significant soil units. Soils not selected for testing were compared to laboratory tested samples/strata and classified visually. Moisture content testing was conducted on all samples. The laboratory testing was performed in general accordance with applicable AASHTO specifications.

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

3.2.2. Standard Penetration Test Results

Standard Penetration Tests (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 boring location based on our site observations, field logs, visual review of the soil samples by NEAS's geologist, and laboratory test results. The lines designating the interfaces between various soil strata on the boring logs represent the approximate interface location; the actual transition between strata may be gradual and indistinct. The subsurface soil and groundwater characterizations included herein, including summary test data, are based on the subsurface findings from the geotechnical explorations performed by NEAS as part of the referenced project, results of 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 5.1.2. 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 RW-S site generally consists of surficial materials (i.e., pavement section) underlain by existing embankment fill soils followed by natural sands and gravels underlain by natural lacustrine soils. The embankment fills at the site can generally be described as very loose to very dense non cohesive, granular soils while the natural sands and gravels encountered at the site were comprised of very loose to dense, granular material. The natural lacustrine soils at the site were variable, though can generally be described as medium dense to dense coarse- and fined-grained, non-cohesive material in the upper portion of the stratum and stiff to hard fine-grained, cohesive, and non-cohesive material in the lower portion. Bedrock was not encountered within the depths of the explorations performed.

4.1.1. Overburden Soil

At the site of proposed RW-S, 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 retaining wall. These fill soils were encountered immediately below the pavement section and extended to depths ranging from 24.5 to 29.5 ft bgs (approximate elevations 688.4 to 674.0 ft amsl). Based on laboratory testing results and a visual review of the soil samples obtained in the referenced borings, the fill at the RW-S site consisted of predominantly non-cohesive, granular material which was comprised of Gravel with Sand (A-1-b), Gravel with Sand and Silt (A-2-4), Coarse and Fine Sand (A-3a) and Sandy Silt (A-4a). With respect to the soil strength, the granular fill soils can be described having a relative compactness of very loose to very dense correlating to converted SPT N values (N60) between 0 (Weight of Hamer) and refusal. Relatively thin layers of cohesive material were encountered within the fill, these layers were classified as Silt and Clay (A-6a) on the boring logs. The cohesive fill soils can be described as stiff to hard in consistency. Natural moisture contents of the fill ranged from 7 to 46 percent.

The stratum encountered immediately beneath the fill consisted of a natural sand layer extending to depths between 61.5 and 65.6 ft bgs (approximate elevations 632.3 and 636.4 ft amsl). The soils in this stratum are generally classified on the boring logs as Fine Sand (A-3), Coarse and Fine Sand (A-3a), Sandy Silt (A-4a) and Silt (A-4b). With respect to the relative compactness of the natural sand, the descriptions varied from very loose to dense, correlating to N60 values between 9 and 46 bpf. Natural moisture contents of the granular material ranged from 5 to 27 percent.

The soils encountered directly underlying the natural sand layer encountered at the site consisted of variable lacustrine soils which consisted of an upper stratum comprised predominantly of non-cohesive, coarse- and fine-grained soils and a lower stratum comprised of predominantly cohesive, fine-grained soils. The upper stratum of the lacustrine soils extended to depths between 74.7 and 76.1 ft bgs (approximate elevations 621.9 and 623.3 ft amsl) and are classified on the boring logs as Sandy Silt (A-4a), and Silt (A-4b). With respect to the soil strength, the upper lacustrine soils can be described having a relative compactness of medium dense to dense correlating to converted N60 between 14 and 46 bpf. The lower lacustrine stratum extended to termination depths between 113.45 and 113.65 ft bgs (approximate elevations 562.3 and 563.8 ft amsl) and are classified on the boring logs as Silt (A-4b), and Silty Clay (A-6b). With respect to the soil strength, the lower lacustrine soils can be described having a consistency of stiff to hard correlating to converted N60 between 15 and 44 bpf.

4.1.2. Groundwater

Groundwater measurements were taken during the boring drilling procedures and immediately following the completion of the borings performed. Groundwater was observed during drilling in both of the borings performed at the retaining wall site at depths ranging from 45.0 to 52.7 ft bgs (elevations 645.8 to 652.9 ft amsl). It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration. The specific groundwater and pore pressure 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. Two (2) dissipation tests were performed within sounding C-130-0-14 at depths of 47.0 ft and 95.5 ft bgs, while one (1) dissipation test was performed within sounding C-133-0-14 at a depth of 68.6 ft bgs. However, the dissipation tests performed at these sounding locations were not performed long enough to stabilize, and therefore, do 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

A foundation review was completed for the foundations of the proposed SPL retaining wall based on: 1) information gathered during the subsurface exploration (i.e., SPT results, laboratory test results, etc.); 2) the soil profile, estimated engineering properties and other design assumptions presented in previous sections of this report; and, 3) Stage 2/3 Plan sheets of the proposed retaining wall provided by MBI on September 15, 2021. Geotechnical analyses consisting of global stability, moment equilibrium and lateral load resistance were performed for the proposed SPL wall. The geotechnical engineering analyses were performed in accordance with ODOT's BDM (ODOT, 2007) and AASHTO's LRFD BDS 9th Edition (AASHTO, 2020).

5.1.1. Soil Profile for Analysis

For analysis purposes, each boring/CPT log 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 (i.e., Atterberg Limits, grain size, etc.) test 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 boring 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 and average engineering soil properties per boring location are presented in Tables 2 through 5 below.

Table 2: Soil Profile and Estimated Engineering Properties - At Boring C-130-0-14

Retaining Wall S: Stability Analysis, C-130-0-14					
Soil Description(5)	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 (677.8 ft - 675.1 ft)	130	-	38	-	38
Soil Type 3 Depth (675.1 ft - 661 ft)	122	-	30	-	30
Soil Type 4 Depth (661 ft - 632.3 ft)	130	-	36	-	36
Soil Type 5 Depth (632.3 ft - 628 ft)	118	1910	0	150	26
Soil Type 6 Depth (628 ft - 621.9 ft)	125	-	35	-	35
Soil Type 7 Depth (621.9 ft - 603.5 ft)	115	1370	0	100	25
Soil Type 8 Depth (603.5 ft - 575 ft)	127	5350	0	350	28
Soil Type 9 Depth (575 ft - 563.8 ft)	112	890	0	90	25

Notes:
1. *Values calculated per Robertson (2014).*
2. *Remolded undrained shear strenght taken to be sleeve resistance per Robertson (2014).*
3. *Values calculated per ODOT OGE's guidance provided via email on April 19, 2021.*
4. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*
5. *Soil Description based on average Soil Behavior Type Index value of soil stratum per soil type correlations given by Robertson (2014).*
6. *Setup factor per 2020 ODOT BDM Table 305-2 with ODOT Class estimated by comparison of nearby logs to Soil Behavior Type Index interpretation from Robertson (2014).*
7. *N60 values used in sited correlations calculated per Robertson (2012) with Soil Behavior Type Index calculated and interpreted from Robertson (2014).*

Table 3: Soil Profile and Estimated Engineering Properties - At Boring B-132-0-14

Retaining Wall S: Stability Analysis, B-132-0-14					
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 (698.5 ft - 676.5 ft)	130	-	38	-	38
Soil Type 2 Depth (676.5 ft - 671.5 ft)	108	-	28	-	28
Soil Type 3 Depth (671.5 ft - 655.2 ft)	122	-	30	-	30
Soil Type 4 Depth (655.2 ft - 637 ft)	130	-	36	-	36

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 C-133-0-14

Retaining Wall S: Stability Analysis, C-133-0-14					
Soil Description(5)	Moist Unit Weight(1) (pcf)	Total Cohesion(2) (psf)	Total Friction Angle (degrees)	Effective Cohesion(3) (psf)	Effective Friction Angle(3) (degrees)
Soil Type 2 Depth (678.1 ft - 673.5 ft)	108	-	28	-	28
Soil Type 3 Depth (673.5 ft - 660.6 ft)	122	-	30	-	30
Soil Type 4 Depth (660.6 ft - 635.5 ft)	130	-	36	-	36
Soil Type 5 Depth (635.5 ft - 627.8 ft)	118	1910	0	150	26
Soil Type 6 Depth (627.8 ft - 623.3 ft)	125	-	35	-	35
Soil Type 7 Depth (623.3 ft - 598 ft)	115	1370	0	100	25
Soil Type 8 Depth (598 ft - 579 ft)	127	5350	0	350	28
Soil Type 9 Depth (579 ft - 562.3 ft)	112	890	0	90	25

Notes:
1. *Values calculated per Robertson (2014).*
2. *Remolded undrained shear strenght taken to be sleeve resistance per Robertson (2014).*
3. *Values calculated per ODOT OGE's guidance provided via email on April 19, 2021.*
4. *Values interpreted from Geotechnical Bulletin 7 Table 2 for cohesive soils and Kulhawy & Mayne (1990) for granular soils.*
5. *Soil Description based on average Soil Behavior Type Index value of soil stratum per soil type correlations given by Robertson (2014).*
6. *Setup factor per 2020 ODOT BDM Table 305-2 with ODOT Class estimated by comparison of nearby logs to Soil Behavior Type Index interpretation from Robertson (2014).*
7. *N60 values used in sited correlations calculated per Robertson (2012) with Soil Behavior Type Index calculated and interpreted from Robertson (2014).*

Table 5: Soil Profile and Estimated Engineering Properties - At Boring B-134-0-14

Retaining Wall S: Stability Analysis, B-134-0-14					
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 (697.9 ft - 675.9 ft)	130	-	38	-	38
Soil Type 2 Depth (675.9 ft - 668.4 ft)	108	-	28	-	28
Soil Type 3 Depth (668.4 ft - 659.6 ft)	122	-	30	-	30
Soil Type 4 Depth (659.6 ft - 636.4 ft)	130	-	36	-	36

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.*

5.1.2. 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 and rock parameters, including recommended lateral soil/rock modulus, and soil/rock strain to be used to analyze the laterally loaded shaft by the p-y curve method are presented in Table 6 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 6: Generalized Soil Parameters for Lateral Load Analysis

p-y Curve Model	Elevation (ft)	Undrained Shear Strength, S_u (psf)	Soil Modulus Parameter, k (lb/in^3)	Soil Strain Parameter, E_{50}
C-130-0-14				
Sand (Reese)	677.8 - 675.1	-	656	-
Sand (Reese)	675.1 - 661.0	-	83	-
Sand (Reese)	661.0 - 632.3	-	125	-
Stiff Clay with Water	632.3 - 628.0	1910	944	0.0052
Sand (Reese)	628.0 - 621.9	-	85	-
Stiff Clay with Water	621.9 - 603.5	1370	634	0.0064
Stiff Clay with Water	603.5 - 575.0	5350	1481	0.0043
Stiff Clay with Water	575.0 - 563.8	890	688	0.0061
B-132-0-14				
Sand (Reese)	698.5 - 676.5	-	353	-
Sand (Reese)	676.5 - 671.5	-	15	-
Sand (Reese)	671.5 - 655.2	-	62	-
Sand (Reese)	655.2 - 637.0	-	85	-
C-133-0-14				
Sand (Reese)	678.1 - 673.5	-	26	-
Sand (Reese)	673.5 - 660.6	-	83	-
Sand (Reese)	660.6 - 635.5	-	125	-
Stiff Clay with Water	635.5 - 627.8	1910	944	0.0052
Sand (Reese)	627.8 - 623.3	-	85	-
Stiff Clay with Water	623.3 - 598.0	1370	634	0.0064
Stiff Clay with Water	598.0 - 579.0	5350	1481	0.0043
Stiff Clay with Water	579.0 - 562.3	890	688	0.0061
B-134-0-14				
Sand (Reese)	697.9 - 675.9	-	353	-
Sand (Reese)	675.9 - 668.4	-	15	-
Sand (Reese)	668.4 - 659.6	-	62	-
Sand (Reese)	659.6 - 636.4	-	85	-

5.1.3. Drilled Shaft Lateral Load Analysis

The lateral load analysis of the project drilled shafts has been performed by MBI. These calculations will be provided to ODOT as part of a separate submission.

5.1.4. Global Stability

For purposes of evaluating the stability of the proposed RW-S site, NEAS reviewed one cross-section within the project limits that was interpreted to represent conditions that posed the greatest potential for slope instability. In general, cross-sections along the proposed wall alignment were reviewed to determine if the section 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 coping, proposed cut into existing embankment slopes, weak or thick soil layer, etc.). Based on our review of the available information at the referenced locations and the associated soil properties, one (1) cross-section was estimated to be most "critical" and was analyzed for global stability. The one cross-section analyzed for global stability include STA 452+75 in reference to the RW-S alignment.

For the cross-section, NEAS developed a representative cross-sectional model to use as the basis for global stability analyses. The model was developed from NEAS's interpretation of the available information which included: 1) The proposed RW-S site plan developed by MBI on September 15, 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 report; 4) the steel reinforcing beam W30x235 has 50 kips per square inch (ksi) (ASTM grade 50) yield strength. With respect to the soil's engineering properties, the provided Soil Profile and Estimated Engineering Properties are presented in Section 5.1.1. of this report were used in our analyses.

The above referenced slope stability model was 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 Modified Bishop, Corrected Janbu, Spencer and GLE analysis methods were used to calculate a factor of safety (FOS) for circular and block type slope failures, respectively. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.33 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 slope does not contain or support a structural element.

Based on our slope stability analyses for the referenced retaining wall section, the minimum slope stability safety factor is about 3.234 (0.31 resistance factor). The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) is presented in Appendix C.

5.1.5. Settlement

For solider pile and lagging walls settlement are not anticipated to be a concern as this wall type is generally constructed within “cut” sections where additional fill (load) is not added. Therefore, settlement is not anticipated.

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 Retaining Wall S for the CCG3A project (CUY-90-16.28, PID 82380). This report has been prepared for MBI, ODOT and their design consultants to be used solely in evaluating the soils underlying the retaining wall site 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 tests 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 retaining wall (RW-S) 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 CCG3A project (CUY-90-16.28, PID 82380). Please call if there are any questions, or if we can be of further service.

Respectfully Submitted,

Zhao Mankoci, Ph.D., P.E.
Geotechnical Engineer

Brendan P. Andrews, P.E.
Geotechnical Engineer

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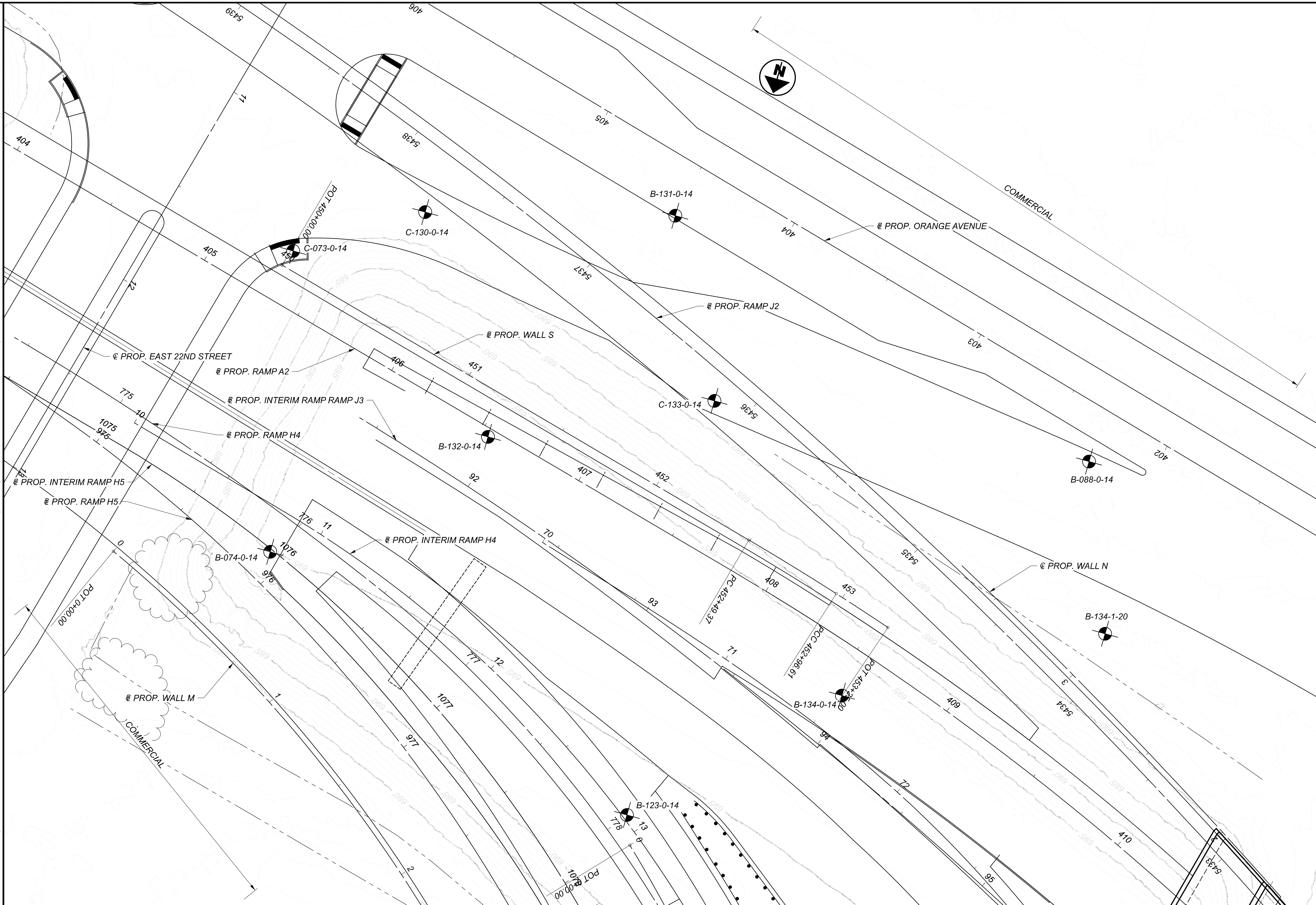
APPENDIX A

SOIL PROFILE SHEETS



HORIZONTAL SCALE IN FEET

0 10 20 40

SOIL PROFILE - ROADWAY
BEGIN TO END RETAINING WALL S

DESIGN AGENCY

NEAS

National Engineering & Architectural Services Inc.

2800 CORPORATE EXCHANGE DR, SUITE 240
COLUMBUS, OH, 43231
TEL:614.714.0299
WWW.NEASINC.COM

DESIGNER	
MWJ	
REVIEWER	
BPA	06/23/22
PROJECT ID	
82382	
SUBSET	TOTAL
100	302
SHEET	TOTAL
P.0	0

CUY-90-16.28 (CCG3A)

MODEL: 82382_ZP290I PAPERSIZE: 17x11 (in.) DATE: 6/23/2022 TIME: 4:36:00 PM USER: mjasiewicz
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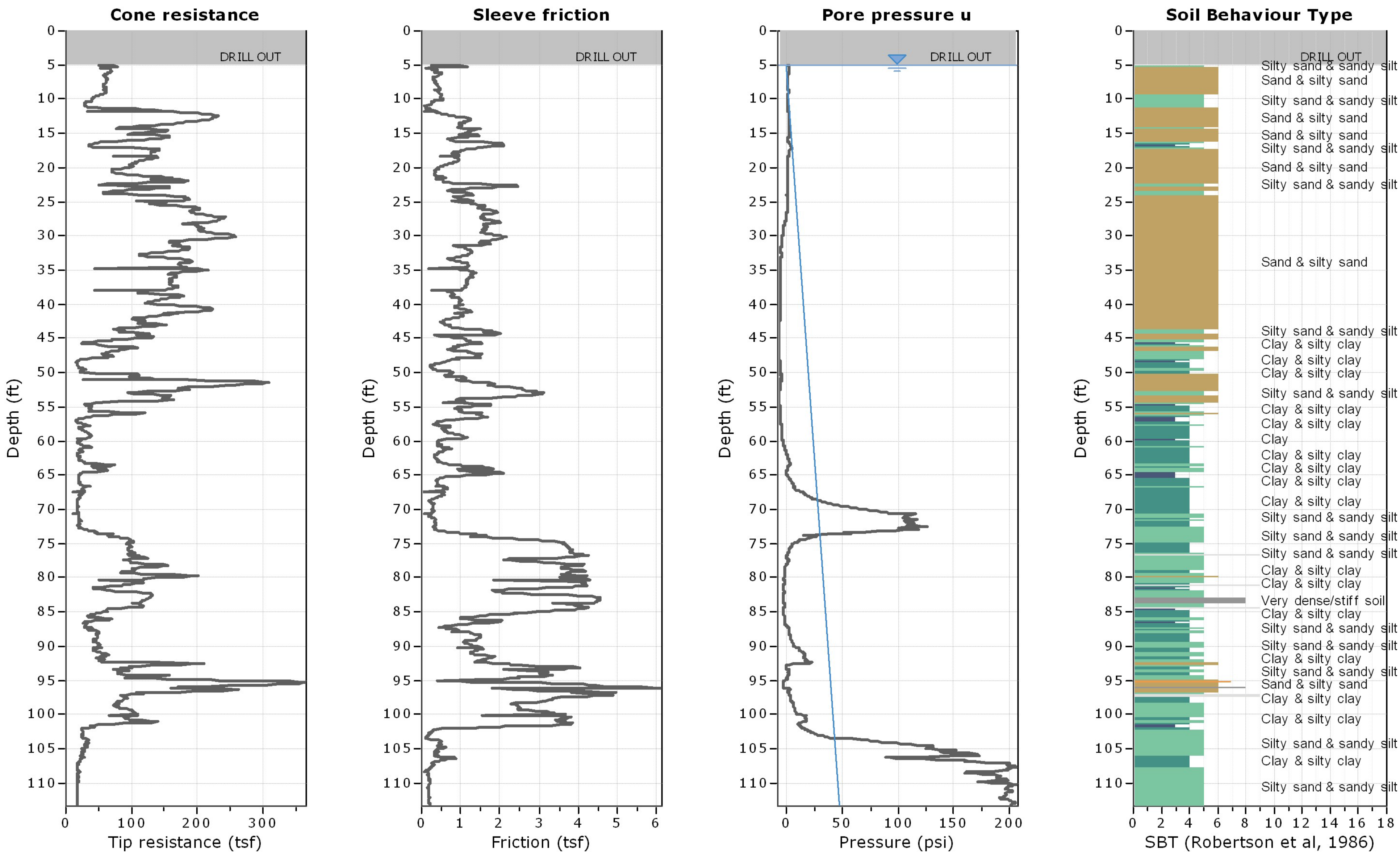
APPENDIX B

SOIL BORING LOGS AND LABORATORY TESTING RESULTS

Office of Geotechnical Engineering
Geology, Exploration and Laboratory Section
http://portal.dot.state.oh.us/Divisions/Engineering/Geotechnical

Project: CUY-77-90-14.96-16.33 CCG3
Location: Cuyahoga County

CPT: C-130-0-14
Total depth: 113.45 ft, Date: 5/20/2015



Dissipation Tests Results

Dissipation tests

Dissipation tests consists of stopping the piezocone penetration and observing porepressures (u) with elapsed time (t). The data are automatic recorded by the field computer and should take place until a minimum of 50% dissipation.

The porepressures are plotted as a function of square root of (t). The graphical technique suggested by Robertson and Campanella (1989), yields a value for t_{50}, which corresponds to the time for 50% consolidation.

The value of the coefficient of consolidation in the radial or horizontal direction c_h was then calculated by Houlsby and Teh's (1988) theory using the following equation:

$$c_h = \frac{T \times r^2 \times I_r^{0.5}}{t_{50}}$$

where:

T: time factor given by Houlsby and Teh's (1988) theory corresponding to the porepressure position
r: piezocone radius
I_r: stiffness index, equal to shear modulus G divided by the undrained strength of clay (S_u).
t_{50}: time corresponding to 50% consolidation

Permeability estimates based on dissipation test

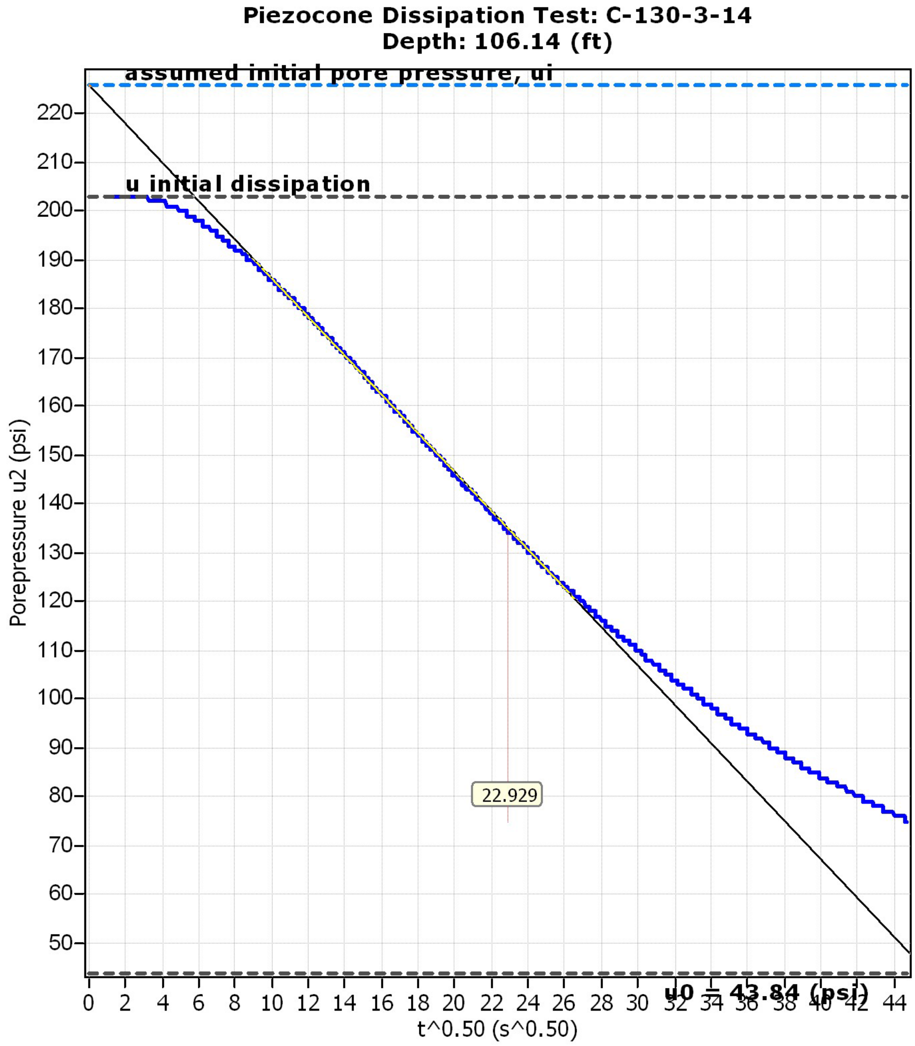
The dissipation of pore pressures during a CPTu dissipation test is controlled by the coefficient of consolidation in the horizontal direction (c_h) which is influenced by a combination of the soil permeability (k_h) and compressibility (M), as defined by the following:

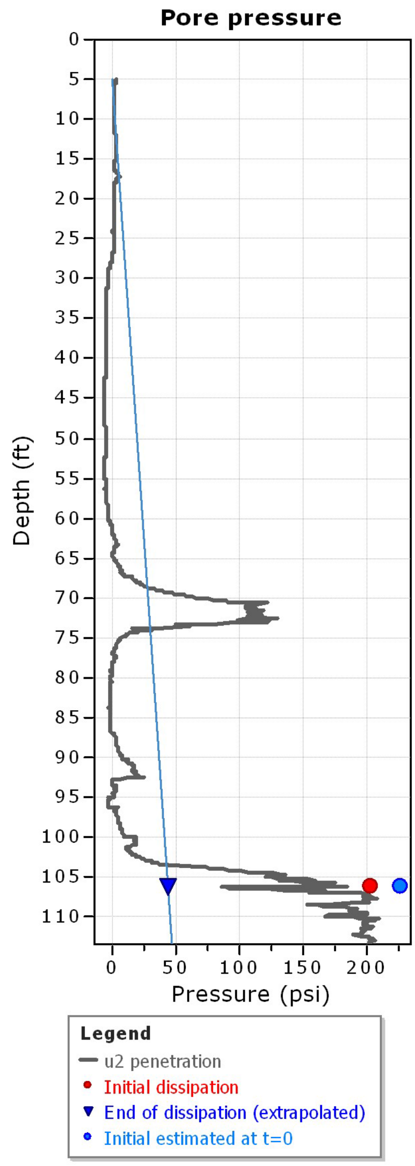
$$k_h = c_h \times \gamma_w / M$$

where: M is the 1-D constrained modulus and γ_w is the unit weight of water, in compatible units.

Tabular results

CPTU Borehole	Depth (ft)	$(t_{50})^{0.50}$	t_{50} (s)	t_{50} (years)	G/S_u	c_h (ft^2/s)	c_h ($ft^2/year$)	M (tsf)	k_h (ft/s)
C-130-0-14	106.14	22.9	526	1.67E-005	667675.75	1.37E-003	43287	100.53	4.26E-007


Piezocone Dissipation Test: C-130-3-14
Depth: 106.14 (ft)
assumed initial pore pressure, ui
u initial dissipation
22.929
u0 = 43.84 (psi)
Porepressure u2 (psi)
t^0.50 (s^0.50)


Pore pressure
Depth (ft)
Pressure (psi)
Legend
u2 penetration
Initial dissipation
End of dissipation (extrapolated)
Initial estimated at t=0

PROJECT: CUY-CCG3	DRILLING FIRM / OPERATOR: BARR / T.GILBERT	DRILL RIG: CME 45B	STATION / OFFSET: 406+54, 4' RT.
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: BARR / D.LYON	HAMMER: CME AUTOMATIC	ALIGNMENT: RAMP A2
PID: 82380 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/26/14	ELEVATION: 698.5 (MSL) EOB: 61.5 ft.
START: 12/3/14 END: 12/3/14	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 77.4	LAT / LONG: 41.492381, -81.676260

EXPLORATION ID B-132-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 698.5
4.0", **ASPHALT**	698.2
10.0", **CONCRETE**	697.3
MEDIUM DENSE, BROWN AND GRAY, **COARSE AND FINE SAND**, SOME GRAVEL, LITTLE SILT, TRACE CLAY, SS-1 CONTAINS BRICK FRAGMENTS, DAMP TO MOIST **(FILL)**	694.7
VERY STIFF, BROWN AND DARK GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, CONTAINS FEW ASPHALT FRAGMENTS, DAMP **(FILL)**	693.7
DENSE TO VERY DENSE, BROWN AND DARK GRAY, **COARSE AND FINE SAND**, SOME SILT, TRACE GRAVEL, TRACE CLAY, DAMP **(FILL)** @7.5'; SS-4 TO SS-6 CHANGE TO BROWN @15.0'; SS-7 TO SS-8 CHANGE TO GRAYISH BROWN	679.0
DENSE, BROWN, REDDISH BROWN, AND GRAY, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, CONTAINS BRICK AND CONCRETE FRAGMENTS, MOIST **(FILL)**	676.5
VERY LOOSE, DARK GRAY AND BROWN, **COARSE AND FINE SAND**, LITTLE SILT, LITTLE GRAVEL, TRACE CLAY, CONTAINS PLASTIC, WET **(FILL)**	674.0
VERY LOOSE, BROWN, **FINE SAND**, TRACE COARSE SAND, TRACE SILT, TRACE CLAY, TRACE GRAVEL, DAMP TO MOIST @27.5'; SS-12 TO SS-15 BECOME MEDIUM DENSE	

SPT/ RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
6-7-6	17	100	SS-1	-	21	14	37	19	9	NP	NP	NP	12	A-3a (0)
6-5-5	13	100	SS-2A	-	-	-	-	-	-	-	-	-	9	A-3a (V)
			SS-2B	3.75	-	-	-	-	-	-	-	-	17	A-6a (V)
5-13-27	52	100	SS-3	-	10	14	48	21	7	NP	NP	NP	8	A-3a (0)
13-16-16	41	100	SS-4	-	-	-	-	-	-	-	-	-	7	A-3a (V)
12-19-23	54	100	SS-5	-	0	2	67	27	4	NP	NP	NP	8	A-3a (0)
13-17-17	44	100	SS-6	-	-	-	-	-	-	-	-	-	7	A-3a (V)
14-23-23	59	100	SS-7	-	-	-	-	-	-	-	-	-	9	A-3a (V)
11-20-50/5"	-	100	SS-8	-	-	-	-	-	-	-	-	-	11	A-3a (V)
48-19-14	43	100	SS-9	-	-	-	-	-	-	-	-	-	9	A-1-b (V)
3-1-2	4	100	SS-10	-	13	25	34	19	9	NP	NP	NP	36	A-3a (0)
2-1-2	4	94	SS-11	-	-	-	-	-	-	-	-	-	5	A-3 (V)
4-6-13	25	100	SS-12	-	-	-	-	-	-	-	-	-	5	A-3 (V)

PID: 82380 | SFN: | PROJECT: CUY-CCG3 | STATION / OFFSET: 406+54, 4' RT. | START: 12/3/14 | END: 12/3/14 | | B-132-0-14

MATERIAL DESCRIPTION AND NOTES	ELEV. 668.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
VERY LOOSE, BROWN, **FINE SAND**, TRACE COARSE SAND, TRACE SILT, TRACE CLAY, TRACE GRAVEL, DAMP TO MOIST *(continued)*		30–31.5	6 4 5	12	100	SS-13	-	-	-	-	-	-	-	-	-	11	A-3 (V)	
@35.0'; BECOMES SOME COARSE SAND		35–36.5	9 10 11	27	100	SS-14	-	8	34	50	6	2	NP	NP	NP	6	A-3 (0)	
FS		40–41.5	9 5 7	15	100	SS-15	-	-	-	-	-	-	-	-	-	9	A-3 (V)	
	655.2	43.3																
MEDIUM DENSE TO DENSE, GRAY AND BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, MOIST TO WET		45–46.5	6 11 16	35	100	SS-16	-	-	-	-	-	-	-	-	-	12	A-3a (V)	
		W 649.5																
@50.0'; SS-17 TO SS-20 BECOMES GRAY		50–51.5	6 10 11	27	100	SS-17	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
		▼																
		55–56.5	5 11 13	31	100	SS-18	-	-	-	-	-	-	-	-	-	24	A-3a (V)	
@58.9'; UNIT WEIGHT: 121.8 PCF @ 26.8% MC		58–60			100	ST-19	-	0	1	86	12	1	NP	NP	NP	27	A-3a (0)	
	637.0	60–61.5 EOB	8 15 21	46	100	SS-20	-	-	-	-	-	-	-	-	-	25	A-3a (V)	

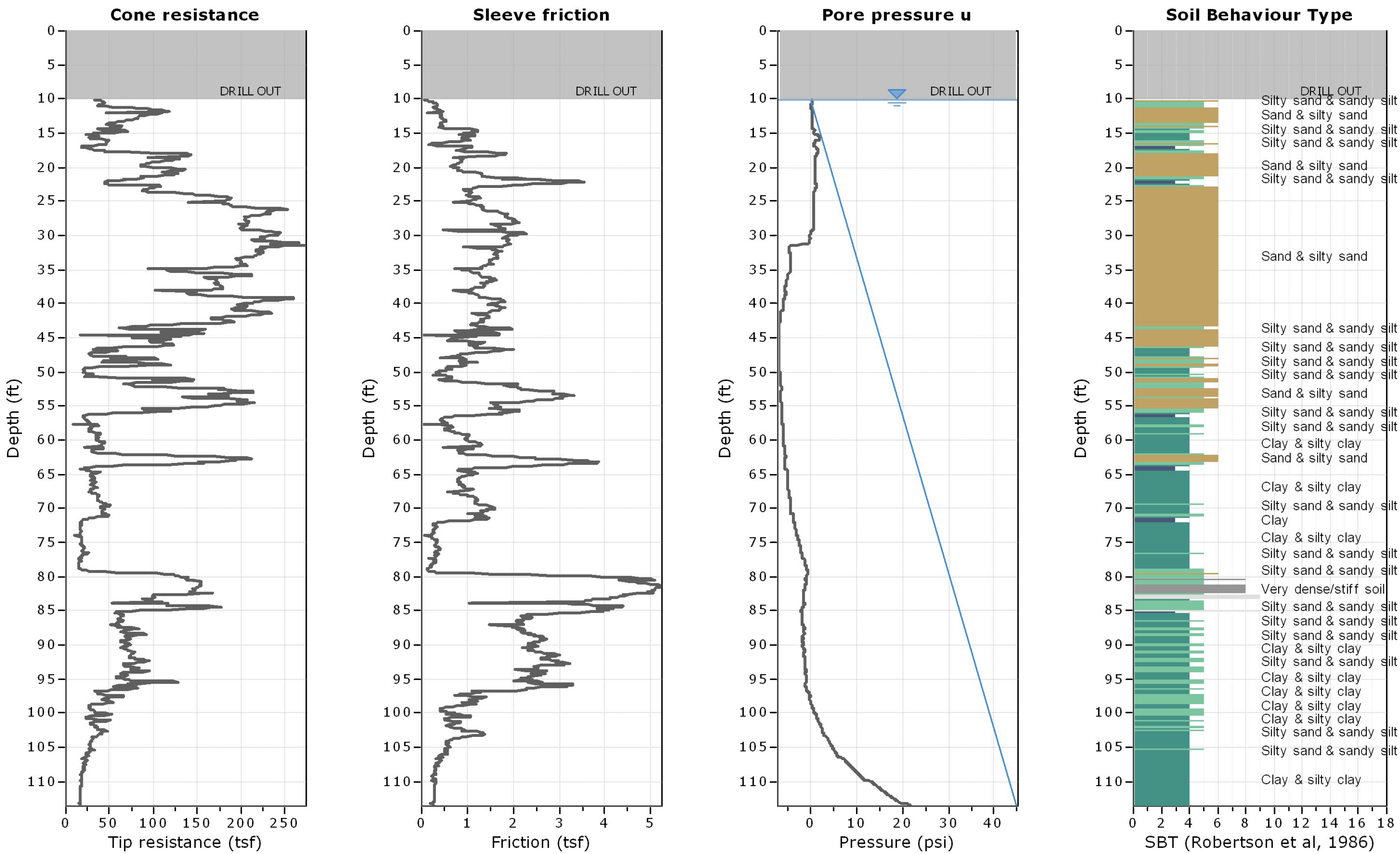
NOTES: GROUNDWATER ENCOUNTERED AT 49.0' DURING DRILLING, 52.7' UPON COMPLETION. CAVE DEPTH 42.3'.

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

Office of Geotechnical Engineering
Geology, Exploration and Laboratory Section
http://portal.dot.state.oh.us/Divisions/Engineering/Geotechnical

Project: **CUY-77-90-14.96-16.33 CCG3**
Location: **Cuyahoga County**

CPT: C-133-0-14
Total depth: 113.65 ft, Date: 5/20/2015



PROJECT: CUY-CCG3	DRILLING FIRM / OPERATOR: BARR / T.GILBERT	DRILL RIG: CME 45B	STATION / OFFSET: 408+56, 22' RT.	EXPLORATION ID B-134-0-14
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: BARR / D.LYON	HAMMER: CME AUTOMATIC	ALIGNMENT: RAMP A2	
PID: 82380 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 1/26/14	ELEVATION: 697.9 (MSL) EOB: 61.5 ft.	PAGE 1 OF 2
START: 12/2/14 END: 12/2/14	SAMPLING METHOD: SPT / ST	ENERGY RATIO (%): 77.4	LAT / LONG: 41.492580, -81.676947	

MATERIAL DESCRIPTION AND NOTES	ELEV. 697.9	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
6.0", **ASPHALT**	697.4																	
9.0", **CONCRETE**	696.7	1																
MEDIUM DENSE TO DENSE, DARK GRAY AND BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE TO LITTLE CLAY, TRACE TO LITTLE GRAVEL, DAMP TO MOIST **(FILL)**		2 - 4	5 6 10	21	100	SS-1	-	8	10	51	20	11	NP	NP	NP	12	A-3a (0)	
@5.0'; SS-2 CHANGES TO BROWN AND GRAY, CONTAINS CONCRETE FRAGMENTS		5 - 7	9 15 11	34	67	SS-2	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
@7.5'; SS-3 CHANGES TO DARK GRAY AND BROWN, CONTAINS CONCRETE FRAGMENTS		8 - 9	9 12 14	34	100	SS-3	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
@10.0'; SS-4 AND SS-5 CHANGE TO VERY DENSE GRAY BROWN, SS-4 CONTAINS CONCRETE FRAGMENTS		10 - 12	14 23 23	59	100	SS-4	-	-	-	-	-	-	-	-	-	7	A-3a (V)	
		13 - 14	11 22 23	58	100	SS-5	-	3	12	58	20	7	NP	NP	NP	8	A-3a (0)	
@15.0'; SS-6 CHANGES TO DENSE, DARK BROWN, CONTAINS PROCELAIN		15 - 17	14 15 12	35	100	SS-6	-	-	-	-	-	-	-	-	-	9	A-3a (V)	
@17.5'; SS-7 CHANGES TO LOOSE, BROWN AND DARK GRAY, CONTAINS CONCRETE FRAGMENTS		18 - 19	4 3 4	9	94	SS-7	-	-	-	-	-	-	-	-	-	13	A-3a (V)	
@20.0'; SS-8 CHANGES TO MEDIUM DENSE, CONTAINS BRICK FRAGMENTS	675.9	20 - 22	5 5 6	14	100	SS-8	-	-	-	-	-	-	-	-	-	12	A-3a (V)	
VERY LOOSE, DARK GRAY, BROWN, AND REDDISH BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, CONTAINS MANY BRICK FRAGMENTS, MOIST **(FILL)**	673.4	23 - 24	3 0 1	1	44	SS-9	-	28	18	32	16	6	NP	NP	NP	17	A-2-4 (0)	
VERY LOOSE, DARK GRAY, **COARSE AND FINE SAND**, SOME GRAVEL, LITTLE SILT, TRACE CLAY, CONTAINS BRICK FRAGMENTS, WET **(FILL)**	670.9	25 - 27	1 1 0	1	72	SS-10	-	26	15	42	11	6	NP	NP	NP	20	A-3a (0)	
VERY LOOSE, DARK GRAY AND BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, CONTAINS CINDERS, GLASS, AND PORCELAIN FRAGMENTS, WET **(FILL)**	668.4	28 - 29	0 0 0	0	39	SS-11	-	-	-	-	-	-	-	-	-	46	A-4a (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 6/22/22 14:17 - 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: 408+56, 22' RT.	START: 12/2/14	END: 12/2/14	PG 2 OF 2	B-134-0-14

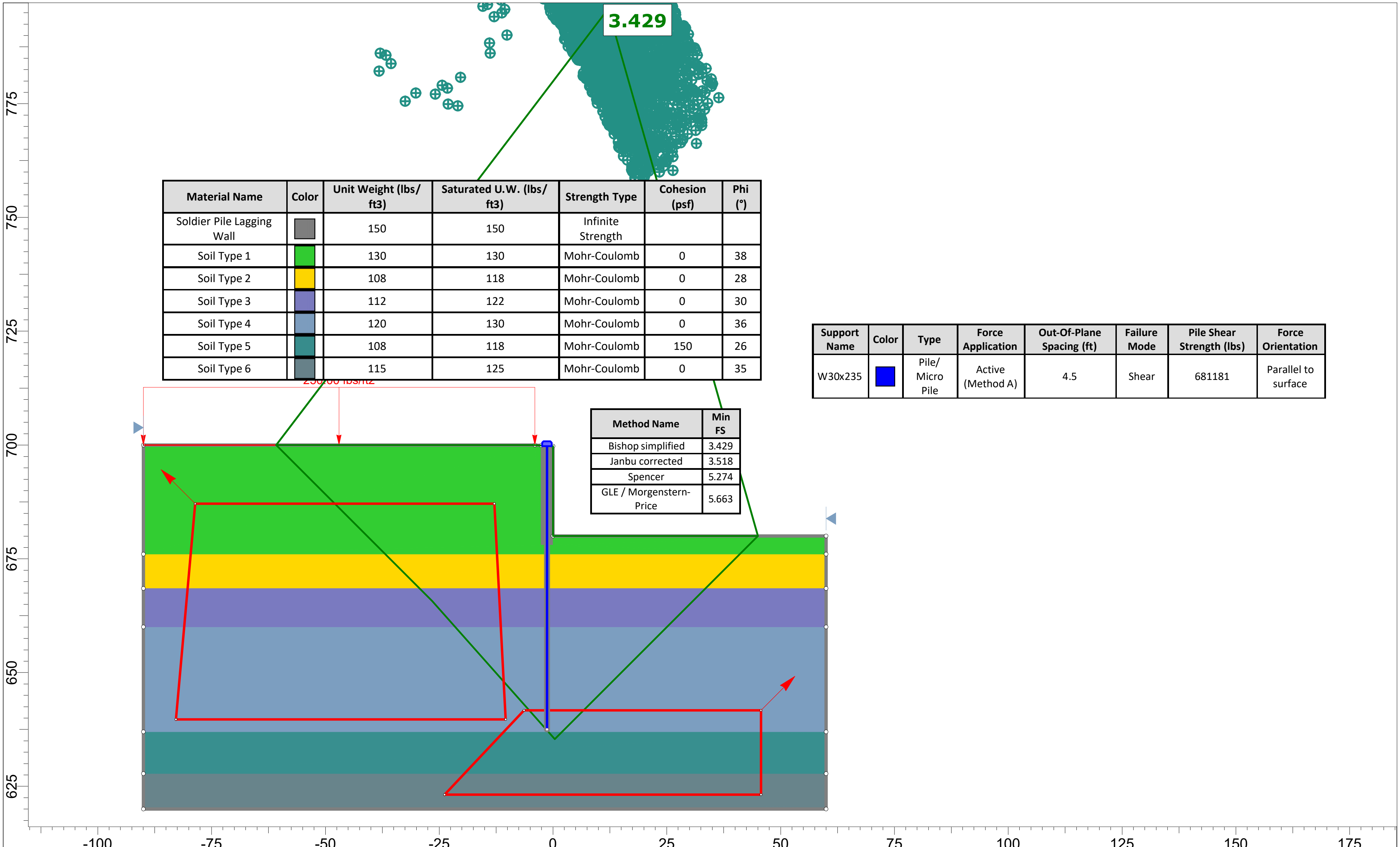
MATERIAL DESCRIPTION AND NOTES	ELEV. 667.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE GRAVEL, TRACE SILT, TRACE CLAY, DAMP *(continued)*		30 – 31.5	5 4 5	12	94	SS-12	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
	661.9	35 – 36	4 4 3	9	100	SS-13A	-	-	-	-	-	-	-	-	-	5	A-3a (V)	
LOOSE, BROWN, **SILT**, TRACE SAND, TRACE CLAY, TRACE GRAVEL, CONTAINS 2.5" SEAM OF "SILT AND CLAY", WET	659.6	36 – 36.5				SS-13B	-	-	-	-	-	-	-	-	-	30	A-4b (V)	
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, TRACE GRAVEL, DAMP TO WET		40 – 41.5	4 7 13	26	100	SS-14	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
@45.0'; SS-15 BECOMES GRAYISH BROWN	W 652.9	45 – 46.5	11 13 18	40	100	SS-15	-	0	2	75	21	2	NP	NP	NP	21	A-3a (0)	
@50.0'; SS-16 TO SS-19 BECOME GRAY	644.6	50 – 51.5	4 9 11	26	100	SS-16	-	-	-	-	-	-	-	-	-	25	A-3a (V)	
DENSE, GRAY, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, WET		55 – 56.5	6 11 14	32	100	SS-17	-	-	-	-	-	-	-	-	-	24	A-4a (V)	
@58.6'; UNIT WEIGHT: 123.6 PCF @ 25.9% MC		58 – 60			100	ST-18	-	0	0	54	43	3	NP	NP	NP	26	A-4a (2)	
	636.4	60 – 61.5 EOB	4 10 14	31	100	SS-19	-	-	-	-	-	-	-	-	-	26	A-4a (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 45.0' DURING DRILLING. CAVE DEPTH 38.2'.

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

APPENDIX C

GLOBAL STABILITY ANALYSIS



Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Soldier Pile Lagging Wall		150	150	Infinite Strength		
Soil Type 1		130	130	Mohr-Coulomb	0	38
Soil Type 2		108	118	Mohr-Coulomb	0	28
Soil Type 3		112	122	Mohr-Coulomb	0	30
Soil Type 4		120	130	Mohr-Coulomb	0	36
Soil Type 5		108	118	Mohr-Coulomb	150	26
Soil Type 6		115	125	Mohr-Coulomb	0	35

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Failure Mode	Pile Shear Strength (lbs)	Force Orientation
W30x235		Pile/ Micro Pile	Active (Method A)	4.5	Shear	681181	Parallel to surface

Method Name	Min FS
Bishop simplified	3.429
Janbu corrected	3.518
Spencer	5.274
GLE / Morgenstern-Price	5.663

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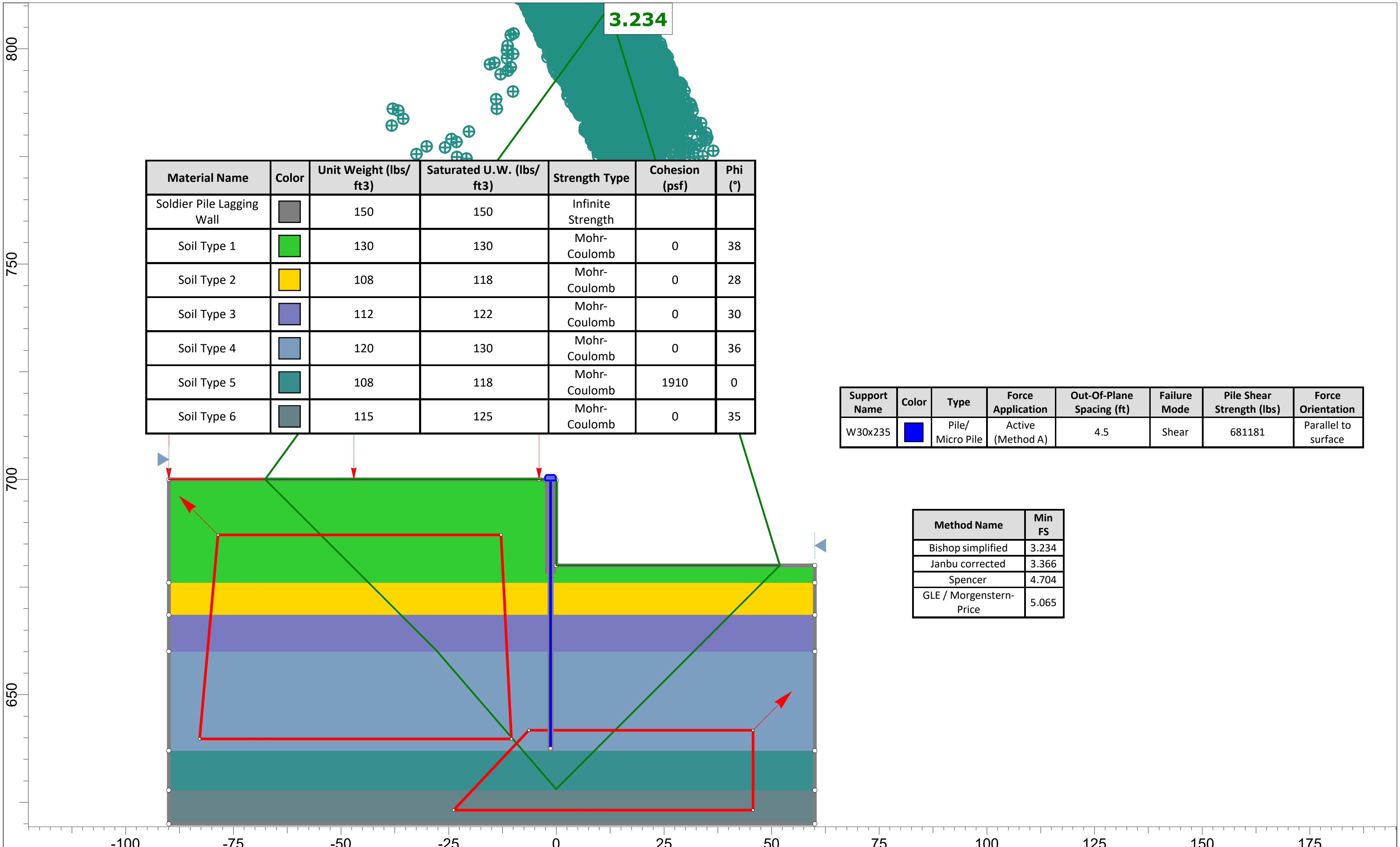
SLIDEINTERPRET 9.029

Project	CCGA Retaining Wall-S
Analysis Description	STA 452+75
Drawn By	ZM
Company	National Engineering & Architectural Services, Inc
Date	9/20/2021
File Name	WallS_STA452+75_Block_Effective_091921.slim



Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Soldier Pile Lagging Wall		150	150	Infinite Strength		
Soil Type 1		130	130	Mohr-Coulomb	0	38
Soil Type 2		108	118	Mohr-Coulomb	0	28
Soil Type 3		112	122	Mohr-Coulomb	0	30
Soil Type 4		120	130	Mohr-Coulomb	0	36
Soil Type 5		108	118	Mohr-Coulomb	1910	0
Soil Type 6		115	125	Mohr-Coulomb	0	35

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Failure Mode	Pile Shear Strength (lbs)	Force Orientation
W30x235		Pile/ Micro Pile	Active (Method A)	4.5	Shear	681181	Parallel to surface

Method Name	Min FS
Bishop simplified	3.234
Janbu corrected	3.366
Spencer	4.704
GLE / Morgenstern-Price	5.065

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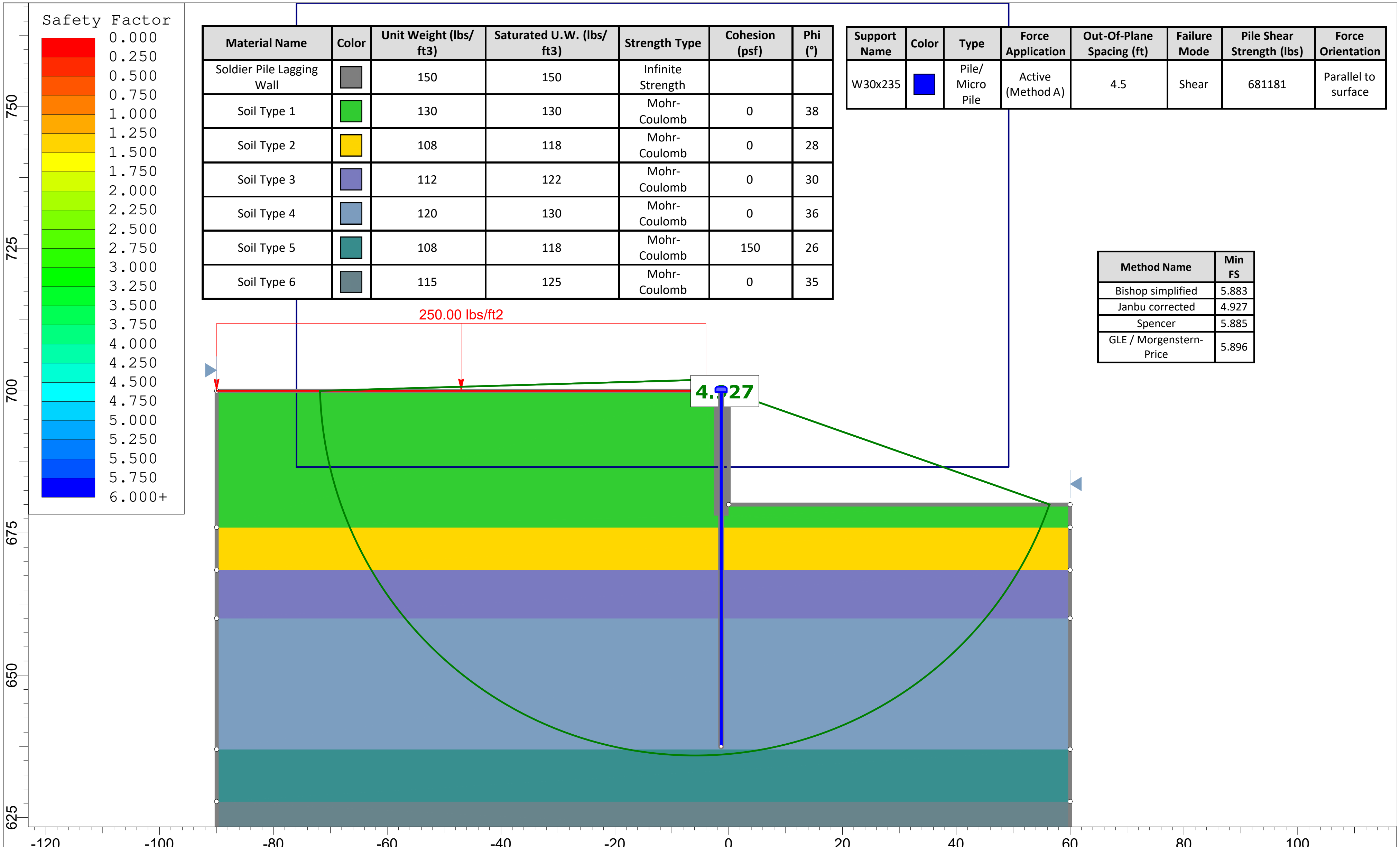
SLIDEINTERPRET 9.029

Project	CCGA Retaining Wall-S		
Analysis Description	STA 452+75		
Drawn By	ZM	*Company*	National Engineering & Architectural Services, Inc
Date	9/20/2021	*File Name*	WallS_STA452+75_Block_Total_091921.slim



Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (°)
Soldier Pile Lagging Wall		150	150	Infinite Strength		
Soil Type 1		130	130	Mohr-Coulomb	0	38
Soil Type 2		108	118	Mohr-Coulomb	0	28
Soil Type 3		112	122	Mohr-Coulomb	0	30
Soil Type 4		120	130	Mohr-Coulomb	0	36
Soil Type 5		108	118	Mohr-Coulomb	150	26
Soil Type 6		115	125	Mohr-Coulomb	0	35

Support Name	Color	Type	Force Application	Out-Of-Plane Spacing (ft)	Failure Mode	Pile Shear Strength (lbs)	Force Orientation
W30x235		Pile/ Micro Pile	Active (Method A)	4.5	Shear	681181	Parallel to surface

Method Name	Min FS
Bishop simplified	5.883
Janbu corrected	4.927
Spencer	5.885
GLE / Morgenstern-Price	5.896

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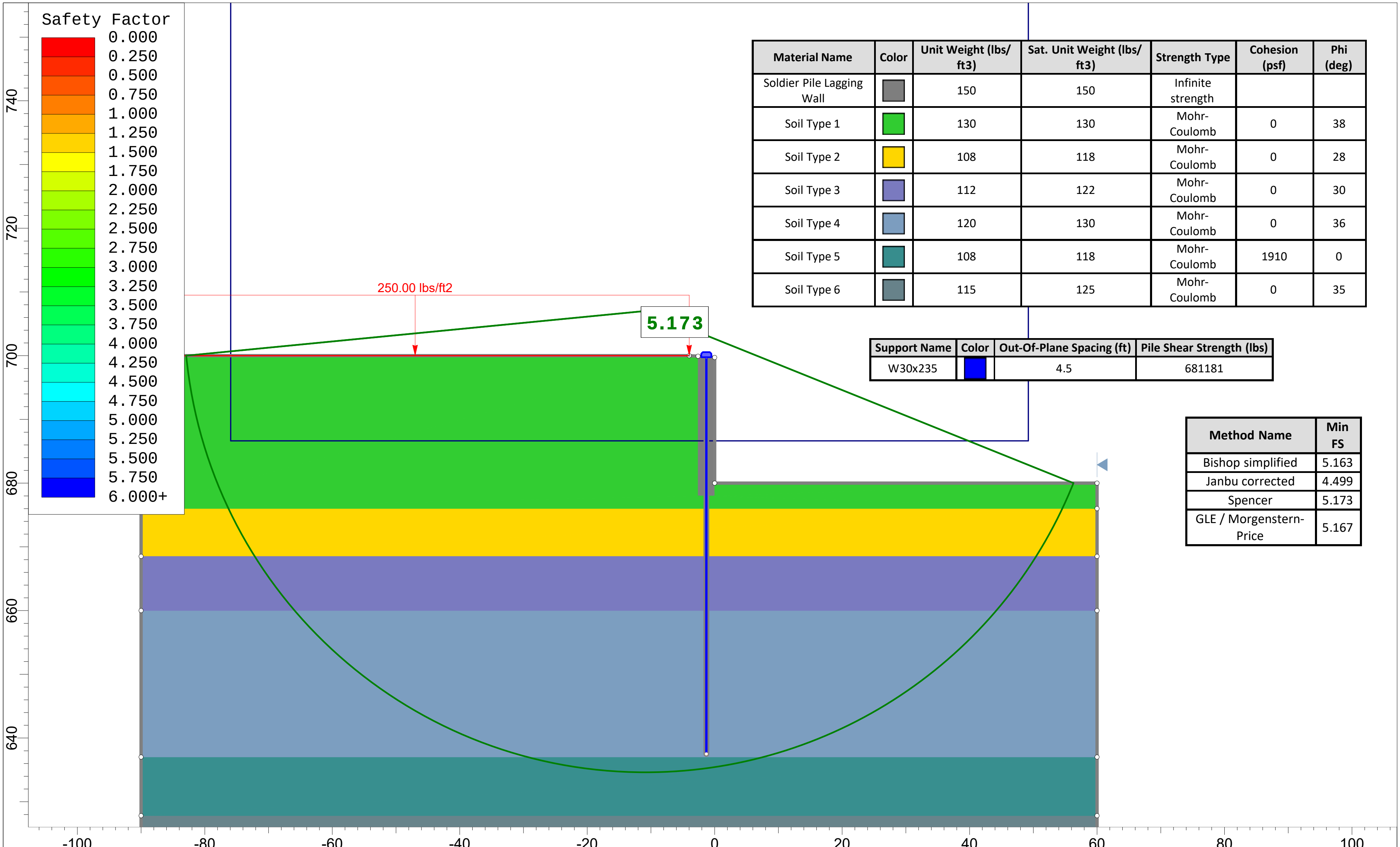
SLIDEINTERPRET 9.029

Project	CCGA Retaining Wall-S
Analysis Description	STA 452+75
Drawn By	ZM
Company	National Engineering & Architectural Services, Inc
Date	9/20/2021
File Name	WallS_STA452+75_Circular_Effective_091921.slim



Material Name	Color	Unit Weight (lbs/ft3)	Sat. Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
Soldier Pile Lagging Wall		150	150	Infinite strength		
Soil Type 1		130	130	Mohr-Coulomb	0	38
Soil Type 2		108	118	Mohr-Coulomb	0	28
Soil Type 3		112	122	Mohr-Coulomb	0	30
Soil Type 4		120	130	Mohr-Coulomb	0	36
Soil Type 5		108	118	Mohr-Coulomb	1910	0
Soil Type 6		115	125	Mohr-Coulomb	0	35

Support Name	Color	Out-Of-Plane Spacing (ft)	Pile Shear Strength (lbs)
W30x235		4.5	681181

Method Name	Min FS
Bishop simplified	5.163
Janbu corrected	4.499
Spencer	5.173
GLE / Morgenstern-Price	5.167

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SLIDEINTERPRET 9.025

Project	CCGA Retaining Wall-S
Analysis Description	STA 452+75
Drawn By	ZM
Company	National Engineering & Architectural Services, Inc
Date	9/20/2021
File Name	WallS_STA452+75_Circular_Total_091921.slim