KS Associates
Elyria, Ohio

Geotechnical Subsurface Investigation
OTIC 71-19-02 - Slope Remediation - Commodore Perry Service Plaza Exit Ramp
Sandusky County, Ohio

July 2020

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July 2, 2020 **TTL Project No. 1852901-Mod1**

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Elyria, OH 44035

Geotechnical Subsurface Investigation
OTIC 71-19-02 - Slope Remediation - Commodore Perry Service Plaza Exit Ramp
Sandusky County, Ohio

Dear Mr. Hamid:

Following is the report of the geotechnical subsurface investigation performed by TTL Associates, Inc. (TTL) at the site of the referenced project. This investigation was performed in general accordance with TTL Proposal No. 1852901-Mod1, dated January 20, 2020 and subsequent authorization. TTL previously submitted a report and recommendations for the bridge demolition portion of this project (TTL Project No. 1852901).

This final report contains the results of our study, incorporates furnished ground surface elevations into the boring logs, and provides our construction recommendations for the slope remediation and pavement construction.

Soil samples collected during this investigation will be stored at our laboratory for 90 days from the date of this report. The samples will be discarded after this time unless you request that they be saved or delivered to you.

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

Sincerely,

TTL Associates, Inc.

Imad El Hajjar
Geotechnical Project Manager

David M. Vovak, P.E.
Cleveland Operations Director

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GEOTECHNICAL SUBSURFACE INVESTIGATION
OTIC 71-19-02 - SLOPE REMEDIATION - COMMODORE PERRY SERVICE PLAZA EXIT RAMP
SANDUSKY COUNTY, OHIO

FOR

KS ASSOCIATES INC
260 BURNS ROAD, SUITE 100
ELYRIA, OH 44035

SUBMITTED

July 2, 2020
TTL PROJECT NO. 1852901-Mod1

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1.0 INTRODUCTION

This geotechnical subsurface investigation report has been prepared for the slope remediation project along the Commodore Perry Service Plaza ramp in Sandusky County, Ohio. The project is located along the eastbound lanes just prior to the service plaza at mile post (MP) 99.8 of the James W. Shocknessy Ohio Turnpike (Interstate Route 90 [IR-90]), as shown on the attached Site Location Map (Plate 1.0).

This report summarizes our understanding of the proposed construction, describes the investigative and testing procedures utilized to evaluate the subsurface conditions at the site, presents our findings from the field and laboratory testing, and provides our design and construction recommendations for slope remediation and associated pavement repair.

This investigation was performed in general accordance with TTL Proposal No. 1852901-Mod1, dated January 20, 2020 and subsequent authorization.

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

2.0 PROJECT DESCIPTION

We understand that pavement distress and potential failure of the slope along the eastbound lanes just prior to the service plaza at MP 99.8 (Commodore Perry Service Plaza) has been observed and reported by the OTIC. On January 16, 2020, TTL Performed a site reconnaissance to assess the condition of the slope identified by the OTIC. Based on the observations of the existing slope conditions during the site reconnaissance, it appeared that an existing "flimsy" sheet pile wall (of sorts) was installed at the location of the reported slope failure. We also noticed that this wall is overturning and jetting forward which is an indication that it has insufficient stiffness and/or embedment. The wall was placed at roughly mid-slope on an approximately 20 foot embankment having roughly 2:1 slope. In addition, tension cracks were noted within the pavement immediately up-slope from the above noted wall, and the nearby guardrail and adjacent light tower were overserved to be leaning (i.e., tilting) downslope roughly 10-to-15 degrees out of plumb. The tensions cracks were observed starting approximately 1 to 2 feet inside the guardrail. A water swale was observed at the toe of the existing slope, the swale was observed to be partially full.

Based on information provided by KS, we understand that it is proposed to remove the existing wall and reconfigure the slope back to its original configuration, as shown below in Figure 1. In order to achieve this, the re-construction of an embankment, roughly 35 feet in width and about 20 feet in height will be required. It should be noted that an existing swale is located at the toe of the proposed slope.

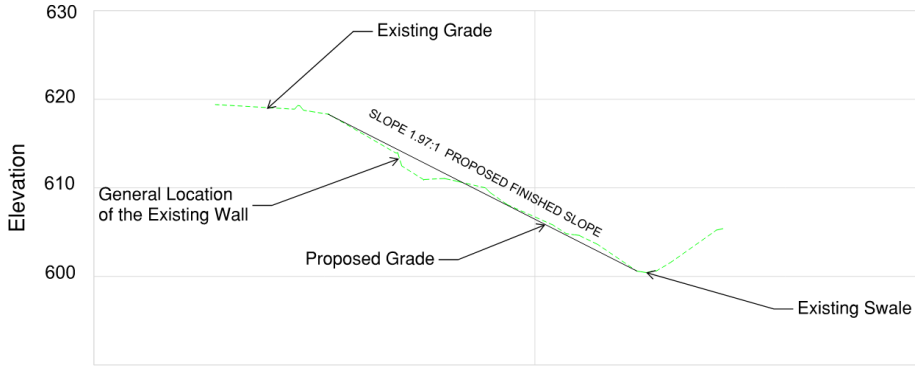


Figure 1: Slope Repair Most Critical Cross-Sections

3.0 INVESTIGATIVE PROCEDURE

3.1 Field Sampling and Testing

One test boring, designated as Borings B-3, was drilled by TTL on April 20, 2020. The boring was enumerated starting at B-3 since TTL previously performed two (2) test borings, designated as B-1 and B-2, for the bridge demolition portion of this project.

The test boring was performed on the pavement shoulder upslope from the midpoint of the existing wall. The boring location was established in the field by TTL based on the provided information. Ground surface elevations at the boring locations was provided by KS. The approximate location of the test boring is shown on the attached Test Boring Location Plan (Plate 2.0).

The test boring was performed in general accordance with geotechnical investigative procedures outlined in ASTM Standards D 1586 and D 5434. The test boring performed during this investigation were drilled with a truck-mounted rotary drilling rig utilizing 4¼-inch inside diameter hollow-stem augers. Boring B-1 was terminated at the target depth of 50 feet below existing grade (approximate Elev. 569 feet).

During auger advancement, soil samples were collected continuously to a depth of 20 feet and at 5-foot intervals thereafter to boring termination. Split-spoon (SS) samples were obtained by the Standard Penetration Test (SPT) Method (ASTM D 1586), which consists of driving a 2-inch outside diameter split-spoon sampler into the soil with a 140-pound weight falling freely through a distance of 30 inches. The sampler was driven in four or three successive 6-inch increments with the number of blows per increment being recorded. The sum of the number of blows required to advance the sampler the second and third 6-inch increments is termed the Standard Penetration Resistance (N-value) and is presented on the Logs of Test Boring attached to this report. The samples were sealed in jars and shipped to our laboratory for further classification and testing.

Two Shelby tube (ST) samples were obtained by hydraulically advancing a 3-inch diameter, thin-walled sampler approximately 24 inches beyond the hollow-stem auger into relatively undisturbed soil, in general accordance with ASTM D 1587. The Shelby tube samples were sealed with end caps and transported to our laboratory, where it was extruded, classified, and tested. Additional information regarding the depth and the location of the Shelby Tubes are provided in the following table:

Shelby Tube Location

Boring Number	Sample ID	Sample Depth Interval
B-1	ST-1	10 to 12 feet
	ST-2	27 to 29 feet

Soil conditions encountered in the test borings are presented in the Logs of Test Borings, along with information related to sample data, SPT results, water conditions observed in the borings, and laboratory test data. It should be noted that these logs have been prepared on the basis of laboratory classification and testing as well as field logs of the encountered soils.

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

3.2 Laboratory Testing

All of the recovered samples of the subsoils were visually or manually classified in accordance with the Unified Soil Classification System (USCS) (ASTM D 2487 and D 2488). All samples were tested in our laboratory for moisture content (ASTM D 2216). Selected intact cohesive split-spoon samples were tested for dry density. Unconfined compressive strength estimates were obtained for the intact cohesive samples using a calibrated hand penetrometer. Atterberg limits tests (ASTM D 4318) and particle size analyses (ASTM D 422) were performed on six selected samples from each boring. Additionally, a consolidated-undrained (CU') triaxial compressive strength test (ASTM D 4767) with pore water pressure measurements was performed using a confining pressure approximately equal to the approximate overburden pressure at the sample depth, as well as double the overburden pressure. The results of these tests are presented on the Logs of Test Borings, and Tabulation of Test Data sheets attached to this report.

4.0 GENERAL SITE AND SUBSURFACE CONDITIONS

1.1 General Surface Conditions

The surface materials encountered in Boring B-3 consisted of an approximately 7½ inches thick layer of asphalt underlain by approximately 2½ inches of crushed stone.

1.2 Site Geology

Published geologic maps from the Ohio Department of Natural Resources (ODNR) indicate that the project site is located within the glaciated portion of Ohio. These regions include upper profile soils consisting of **Lacustrine Silt (LL)**, deposited in low-velocity water of glacial and slack-water lakes; may contain fine sand or clay; well-laminated in distal portions of deltas, poorly-laminated elsewhere. These lacustrine deposits are underlain by predominantly silty and clayey glacial till, before encountering bedrock.

Bedrock at the site consist of the Upper and Lower Silurian Salina Group formation. The formation consists **of interbedded layers of Dolomite, anhydrite, gypsum, salt, and shale**. ODNR references indicate top of rock between approximate elevations 550 and 560 feet.

1.3 General Soil Conditions

Based on the results of our field and laboratory tests, the subsoils encountered underlying the crushed stone can generally be characterized by a layer of fill material overlying native lacustrine soils overlying a layer of cohesive glacial till. Additional descriptions of the soil stratigraphy encountered in the borings are presented on the Logs of Test Borings attached to the report.

Stratum I consisted of cohesive fill material and was encountered underlying the crushed stone to depths of 15 feet below existing grades (approximate Elev. 604). The cohesive fill contained varying amounts of sand and gravel. SPT N-values for the cohesive fill materials generally ranged from 9 to 21 blows per foot (bpf), indicating stiff to very consistency. Unconfined compressive strengths ranged from 3,500 to greater than 9,000 pounds per square foot (psf) (the highest obtainable reading using a calibrated hand penetrometer). Moisture contents generally ranged from 14 to 26 percent and dry densities ranged from 103 to 108 pounds per cubic foot (pcf). Liquid limits ranging from 34 to 42 percent , as well as plasticity indices limits ranging from 14 to 22 percent, were determined for three samples obtained from this stratum. These values, along with gradation results, are indicative of a USCS lean clay

(CL) designation.

Stratum II consisted of predominantly stiff to very stiff native cohesive lacustrine soils encountered underlying Stratum I to depths of 29 feet (approximate Elev. 590 feet). Stratum II consisted of lean clay (CL) with sand and trace amount of gravel. SPT N-values for the Stratum II soils ranged from 9 to 28 bpf. Unconfined compressive strengths ranged from 3,000 to greater than 9,000 psf. Moisture contents generally ranged from 17 to 19 percent and dry densities ranged from 107 to 110 pcf. A liquid limit of 31 percent, as well as a plasticity index of 13 percent, were determined for a sample obtained from this stratum. These values, along with gradation results, are indicative of a USCS lean clay (CL) designation.

A consolidated-undrained (CU') triaxial compressive strength test performed for a Shelby tube sample obtained from Stratum I (ST-2) yielded the following results:
ϕ' = 24.6 degrees; c' = 214 psf

Stratum III consisted of predominantly medium stiff native cohesive lacustrine soils encountered underlying Stratum II to depths of 43½ (approximate Elev. 575). Stratum III consisted predominantly of lean clay (CL) with sand and trace amount of gravel. SPT N-values for the Stratum III soils ranged from 5 to 6 blows per foot (bpf). Unconfined compressive strengths ranged from less than 1,000 to 1,500 pounds per square foot (psf) were recorded within this stratum using a hand penetrometer. Moisture contents generally ranged from 17 to 19 percent and a dry density of 108 pcf was determined for a tested representative sample from this stratum. A liquid limit of 29 percent, as well as a plasticity index of 10 percent, were determined for a sample obtained from this stratum. These values, along with gradation results, are indicative of a USCS lean clay (CL) designation.

Stratum VI consisted of predominantly **soft** to medium stiff native cohesive lacustrine soils encountered underlying Stratum II to depths of 48½ feet (approximate Elev. 570). Stratum III consisted predominantly of lean clay (CL) with sand and trace amounts of gravel. An SPT N-value of 4 bpf was reported within this stratum. Unconfined compressive strength of 1,500 psf was recorded within this stratum using a hand penetrometer. A moisture contents of 19 percent, a dry density of 108 pcf, a liquid limit of 30 percent, as well as a plasticity index of 10 percent, were determined for a sample obtained from this stratum. These values, along with gradation results, are indicative of a USCS lean clay (CL) designation.

Stratum V consisted of predominantly medium stiff native cohesive till soils encountered underlying Stratum IV to the planned boring termination depth of 50 feet (approximate Elev.

569). Stratum II consisted predominantly of lean clay (CL) with sand and trace amounts of gravel. An SPT N-value of 4 bpf was reported within this stratum. Unconfined compressive strength of 1,500 psf was recorded within this stratum using a hand penetrometer. A moisture contents of 19 percent, a dry density of 108 pcf, a liquid limit of 30 percent, as well as a plasticity index of 10 percent, were determined for a sample obtained from this stratum. These values, along with gradation results, are indicative of a USCS lean clay (CL) designation.

1.4 Groundwater Conditions

Groundwater was generally not observed during drilling operations or upon completion of drilling of the test boring. It should be noted that the boring was drilled and backfilled within the same day. As such, stabilized water levels may not have occurred over this limited time period. Instrumentation was not installed to observe long-term groundwater levels.

Based on the soil characteristics and groundwater conditions encountered in the borings, it is our opinion that the "normal" long-term groundwater table will be generally encountered at depths of approximately 15 feet or lower, corresponding to approximate Elev. 601 or deeper. This elevation also corresponds to a condition where the existing water swale located at the toe of the slope is full. However, groundwater elevations can fluctuate with seasonal and climatic influences. In particular, "perched" water may be encountered in fill materials underlain by relatively impermeable cohesive soils. Therefore, the groundwater conditions may vary at different times of the year from those encountered during this investigation.

5.0 DESIGN RECOMMENDATIONS

The following conclusions and recommendations are based on our understanding of the proposed construction and the data obtained during our field investigation. If the project information or location as outlined is incorrect or should change significantly, a review of these recommendations should be made by TTL. These recommendations are subject to satisfactory completion of the recommended site and subgrade preparation and fill placement operations described in Section 6.0, "Construction Recommendations."

1.5 New Embankment Fill

Fill will be placed for the new embankment in order to restore the slope back to its original configuration. In order to achieve this, the re-construction of an embankment, roughly 35 feet in width and about 20 feet in height will be required. It should be noted that an existing swale is located at the toe of the proposed slope.

5.1.1 Special Benching and Sidehill Embankment Fills

Where fill will be placed along slight slopes, this new fill should be placed in horizontal lifts in accordance with ODOT Construction and Materials Specifications (CMS) Item 203.05, which describes "standard specification" benching. In areas where the existing slope is steeper (approaching 3:1), fill placement would fall under the specifications of ODOT Geotechnical Bulletin GB-2, "Special Benching and Sidehill Embankment Fills," dated January 17, 2020. Specifically, in accordance with Figure 4 in Section F. Special Benching for Embankment Stability over Soft Foundation Soil with the following:

- Minimum 5 feet deep and 8 feet wide Toe Key (i.e. Shear Key); and
- Toe Key drains are not be required.

The limits of the slope repair should extend 10 feet to the east and west of the limits of the existing wall to incorporate the new embankment fill with the adjacent stable areas. The contractor should plan to excavate a toe key having the above noted dimensions at the shear of the proposed slope extending below the existing swale. The toe key subgrade should consist of stiff to very stiff native cohesive soils consistent with the soil encountered in the test borings. The toe key shall be backfilled ODOT Item 703 No. 1 and No. 2 stone. The side slopes of the key should be graded no steeper than 1H:1V, and the bottom of the shear key should be 8.0 feet wide. A filter (geotextile) fabric (ODOT Item 712.09, Type B) should be placed along

surface of the shear key excavation prior to placement of the No. 1 and No. 2 stone, and the surface of the No. 1 and No. 2 stone should be covered with filter fabric prior to construction of the embankment to prevent the migration of fines into the void space of the aggregate. The shear key should only extend along the actual limits of the slope repair.

The soils in the project area where the excavation will be performed consist of predominantly existing fill material. For these soils, GB-2 indicates that a 1H:1V backslope should be planned. Based on the conditions encountered in the borings and on the slope stability analysis for the temporary conditions during construction conditions, a 1H:1V backslope should be generally achievable for short-term excavations.

In general, and as shown on the stability analysis outputs presented in Appendix E, one (1) bench is prescribed for the existing slope and the prescribed toe key shall be excavated at the back of the bench. The approximate location of the bench and toe key along with their dimensions is shown on the slope stability outputs provided in Appendix E. The backslope associated with this bench will intercept existing roadway approximately 3 feet inside the guardrail, special measures for maintenance of traffic (MOT) will be required. A temporary support of excavation could be utilized if MOT cannot be established.

5.1.2 Global Stability

We performed global slope stability analyses using the 2-D Limit Equilibrium Slope Stability Program Slide 6.0 by Rocscience to evaluate proposed 2H:1V embankment slope throughout the Site, and to ensure permanent embankment slope designs having factors of safety greater than 1.3 for static conditions. The slope stability analysis of the existing slope was performed for was perform on the most critical section within slope repair area of the respective site. Schematic cross sections of the existing slopes were provided by KS.

We performed this analysis simulating a 20 foot embankment. We also analyzed a long term scenario while having the swale located at the toe of the slope full of water. Using this program, a myriad of potential failure surfaces can be generated theoretically, from which the factor of safety can be determined as to whether sufficient resisting soil strength can be mobilized to counteract the driving forces (weight of soil, seepage, and surcharge loads) that would cause the slope to move downward. The factor of safety is the ratio of the resisting forces to the driving forces.

Global instability typically is manifested by pronounced movements of a large arc or wedge of soil that result in bulging at the toe of the slope as well as observable displacement of soil at or near the crest of the slope. This crest displacement may be exhibited by a near-vertical tension crack at the back edge of the displaced soil mass, or may be significant enough to exhibit a downward movement of soil that creates a "scarp" such that a sharp drop occurs in an otherwise level ground surface. Global instability of the embankment at this site could create a significant impact due to the potential for such movement to encompass a portion of the roadway.

We analyzed one typical embankment section located along the center of the proposed new embankment. The short term conditions where simulated using total stress soil parameters (TSSP) and the long term conditions using effective stress soil parameters (ESSP). The groundwater table was modeled along the ground surface based on the observed conditions in the field and at Elev. 601 feet simulating a full swale scenario as indicated by KS.

Shear strength parameters for the new embankment fill were determined using ODOT GB-2 as a general guideline. Remaining soil strengths were evaluated based on unconfined compressive strength test results, hand penetrometer readings, consolidated-undrained triaxial strength test results as well as SPT N-values, moisture content, unit weight (density), and soil plasticity data of the encountered soils. Correlations with published data were also utilized to estimate soil properties.

It should be noted that the properties of the soil strata vary somewhat with layer and depth; the layers and assigned soil properties used in the analyses are detailed in the attached slope stability outputs that illustrate the toe key, potential critical failure surfaces associated with the global stability of the embankment, as well as slope geometry and potential critical failure surfaces associated with the slope. The soil parameters utilized for analysis of the wall are also presented on the wall slope stability outputs attached to this report. The results are summarized in the following table.

Summary of Slope Stability Calculations

Model	Method	Factor of Safety
1	Total Stress Soil Parameters (TSSP) *No Toe Key*	2.13
2	Effective Stress Soil Parameters (ESSP) *No Toe Key*	**1.21**
3	Total Stress Soil Parameters (TSSP) *5-foot deep 8 foot-wide Toe Key*	2.13
4	Effective Stress Soil Parameters (ESSP) *5-foot deep 8 foot-wide Toe Key*	1.30
6	Total Stress Soil Parameters (TSSP) *Inside Slope Temporary Conditions*	1.69
7	Total Stress Soil Parameters (TSSP) *Outside Slope Temporary Conditions*	4.59

As stated above and shown on the attached slope stability outputs, a 5 feet deep and 8 feet wide Toe Key will be required at the toe of the existing slope in order to achieve adequate factors of safety. The factor of safety for the short-term (end-of-construction) case using TSSP was greater than the required minimum factor of safety of 1.1. The factor of safety for the long-term (post-construction) case using ESSP meets the required minimum factor of safety of 1.3.

We also analyzed the conditions of the back slopes during construction using Total Stress Soil Parameters resulted in a factor of safety greater than 1.5 as shown on the attached slope stability outputs.

5.2 Subgrades

5.2.1 Pavement Subgrade

The subgrade along the pavement area is anticipated to consist of newly placed engineered fill material (ODOT item 203) used to re-construct the existing embankment. These soils are considered adequate to support the proposed pavement. If loose or soft soils are encountered during the subgrade proofroll, we recommend over-excavating this material and backfilling

with ODOT Construction and Materials Specifications (CMS) Item 203.02 granular fill type B material.

5.2.2 Modified Subgrade

If soils wet of optimum are encountered, lowering the moisture content by scarification and aeration (discing and exposure to sun and wind) may be required. Very moist to wet soils will "pump" under the operation of heavy equipment, resulting in deep rutting and perhaps rendering the operation of grading and paving equipment difficult or impossible. The granular subgrade soils should be generally conducive for drying using scarification and aeration.

If the schedule does not allow for scarification and aeration, other methods of subgrade modification may be required in areas of high moisture content. Modification may be achieved by undercutting and replacement with granular subbase (possibly in combination with a geotextile separation layer or geogrid reinforcement), mixing stone into the subgrade, or treating the subgrade with cement. The method of subgrade modification should be determined at the time of construction (See Section 6.1, "Construction Recommendations - Site and Subgrade Preparation").

5.3 Flexible (Asphalt) Pavement Design

We understand the subgrade of the pavement shoulder will consist of properly compacted engineered fill. Based on our experience with similar soils, and on the results of the plasticity and gradation testing for the upper profile cohesive subgrade soil samples, we recommend a subgrade CBR value of 6 percent. This CBR value is based on subgrade soils that are placed and compacted in accordance with ODOT Item #203.

It should be noted that we are not privy to the design traffic loads or intended design life. The subgrade support recommendations indicated herein should be reviewed by the site engineer in conjunction with the design traffic criteria to determine the required pavement sections.

All paving operations should conform to the Ohio Turnpike Commission and the Ohio Department of Transportation (ODOT) specifications. The pavement and subgrade preparation procedures outlined in this report should result in a reasonably workable and satisfactory pavement. It should be recognized, however, that all flexible pavements need repairs or overlays from time to time as a result of progressive yielding under repeated traffic loads for a prolonged period of time, as well as exposure to freeze-thaw conditions.

5.4 Groundwater Control and Pavement Drainage

As stated previously, groundwater was generally not observed during drilling operations or upon completion of drilling of the test boring. Based on the soil characteristics and groundwater conditions encountered in the borings, it is our opinion that the "normal" long-term groundwater table will be generally encountered at depths of approximately 15 feet or lower, corresponding to approximate Elev. 601 or deeper. This elevation also corresponds to a condition where the existing water swale located at the toe of the slope is full.

In order re-to construct the embankment, sheet pile wall cutoff or cofferdam installation or a pump conveyance system, may be required to dewater the areas of proposed construction. The contractor is responsible to design the dewatering measures. It should be noted that we assumed an empty swale when performing the slope stability analysis for short term conditions.

Construction planning should include potential remedial measures to be implemented where excessive groundwater seepage or unstable subgrades are encountered in the proposed excavations. Dewatering methods may include multiple sumps or a system of well points. The type of dewatering system utilized will depend on construction practices, soil conditions encountered in the foundation excavations, seasonal conditions, and the depth of excavation. Additionally, the contractor will need to exercise diligence to control seepage and runoff to maintain a stable subgrade. Installation of utilities early in the site development may also alleviate unstable subgrade conditions.

Based on the poorly-drained nature of the clayey soils present at the site and anticipated cohesive fill material, it is anticipated that surface water infiltration may collect in the aggregate base course. Without adequate drainage, water will remain in the base for extended periods of time, creating localized wet, soft pockets. The presence of these pockets will increase the likelihood that pavement distress (cracking, potholes, etc.) will develop. Drainage features may include grading the subgrade surface to slope downward to the outside edge of pavements and/or providing longitudinal edge drains connected to storm sewers or other outlets.

6.0 CONSTRUCTION RECOMMENDATIONS

6.1 Site and Subgrade Preparation

Site and subgrade preparation activities should conform to ODOT Construction and Materials Specifications (CMS) Item 204 specifications. Prior to proceeding with construction operations, all pavements, vegetation, topsoil, root systems, debris, and other deleterious non-soil materials should be stripped from the proposed construction area. Suitable topsoil may be stockpiled for later use in landscaped areas. The actual amount of required stripping should be determined in the field by a geotechnical engineer or qualified representative. The Pavement thickness presented in the borings are not intended as a basis for project quantity estimates or bid purposes.

It should be noted that the topsoil thickness may vary across the site. Dark soils having the appearance of topsoil, but exhibiting only root "hairs" or trace organics less than approximately three percent, may not require stripping for the full depth of the darkly colored zone, provided the subgrade can be satisfactorily proof rolled as described below. Conversely, the site may contain areas where additional excavation will be required beyond the darkly colored zone due to organics in order to provide a stable subgrade for construction.

In addition, and as stated previously, the contractor should plan to excavate a toe key at the toe of the proposed toe of slope extending 5 feet below the bottom elevation inside the swale. The approximate location of the toe key is shown on the slope stability outputs provided in Appendix E. The toe key subgrade should consist of stiff to very stiff native cohesive soils consistent with the soil encountered in the test borings.

Upon completion of the stripping and clearing, the areas intended to support new fill, and pavements should be carefully inspected by a geotechnical engineer. Pavement subgrades should be proof rolled in general accordance with ODOT CMS 204.06. At the time of inspection, the engineer may require proof rolling of the cohesive subgrades utilizing a 20- to 30-ton loaded truck or other pneumatic-tired vehicle of similar size and weight. If granular subgrade soils are present at the proposed subgrade elevation, proof rolling/compaction should be performed using a vibratory smooth-drum roller. The vehicle should make a sufficient number of passes, in two perpendicular directions, covering the proposed development area, to locate any soft, weak, or excessively wet soils that may be present at the time of construction.

The purpose of proof rolling the clayey subgrades is to locate any weak, soft, or excessively wet soils that may be present at the time of construction. Any unsuitable materials observed during the inspection and proof-rolling operations should be undercut and replaced with compacted fill or stabilized in place utilizing conventional remedial measures such as discing, aeration, and recompaction. Once the site has been proof rolled, inspected, and stabilized, the proof-rolled or inspected subgrades should not be exposed to wet conditions. It should be recognized that during periods of wet weather, the clayey soils that will be exposed at design subgrades will tend to pond water for short periods of time, with the potential to deteriorate the prepared subgrade. Additionally, we recommend that the fill areas be constantly sloped for positive gravity drainage to avoid ponded water on fills, and that fill areas be sealed at the end of each day by smooth-drum rolling when there is a threat of precipitation.

The results of the proof-rolling and inspection operations will be partially dependent on construction operations, the moisture content of the soil, and the weather conditions prevalent at the time. If pumping or rutting is encountered and difficulty is experienced in the operation of construction equipment, TTL should be notified to determine which method of subgrade modification may be best suited for the conditions encountered. At that time, we may recommend that a small test area be used to determine the necessary depth of undercutting and stone replacement to achieve a stable subgrade condition.

Due to the presence of the predominantly clay subgrade soils and the potential for seasonal high water table conditions (perched or ponded), it is our opinion that completion of the excavation and site work activities will require care and diligence by the contractor to avoid loss of subgrade strength and to reduce undercut areas.

If wet soils are encountered during excavation of the prescribed bench, slope drains should be installed at the back of the excavation in accordance with specifications of ODOT Geotechnical Bulletin GB-2, "Special Benching and Sidehill Embankment Fills," dated January 17, 2020. A typical slope drain detail is also shown in Figure 2 below.

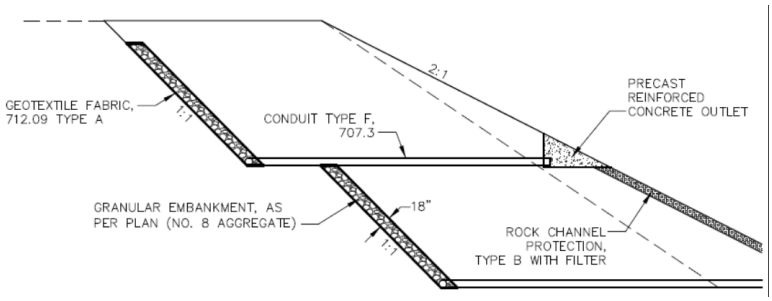


Figure 2: Slope Drain Typical Detail

These drains should consist of ODOT Item 203 granular embankment (No. 8 aggregate), ODOT Item 204 geotextile fabric, 712.09 Type A, and ODOT Item 611 conduit, 707.31 Type CP (perforated). The granular embankment should be placed in lifts as the benching backfill is constructed. Transverse outlet drains consisting of ODOT Item 611 conduit, 707.33 Type F, should outlet from the aggregate drain at the low end of the benches. The transverse outlet should be installed at a minimum 1.0 percent slope and outlet through the face of the slope. It is recommended that ODOT Item 601 rock channel protection with filter fabric lining or other erosion protection be provided below the outlets, extending to the toe of the slope, to prevent erosion.

6.2 Fill

Material for engineered fill or backfill required to achieve design grades should meet ODOT Item 203 "Embankment Fill" placement and compaction requirements. 1. New embankment fill shall be placed in accordance with ODOT Item 203 and shall consist of natural soils classified as A-4a, A-6a or A-6b with a maximum dry density of 110 pcf or greater as determined by ODOT Supplement 1015. In general, the majority of the existing embankment soils on site would meet the above-noted requirements, provided that the soils are moisture conditioned and/or blended as required to meet ODOT Item 203 compaction requirements. On-site soils may be used as engineered fill materials provided that they are free of organic matter, debris, excessive moisture, and rock or stone fragments larger than 3 inches in diameter. Depending on seasonal conditions, the on-site soils may be wet of optimum and may require scarification and aeration to achieve satisfactory compaction.

Fill placement shall be performed as symmetrical as possible across the entire site to prevent lateral stresses from developing on the existing bridge piers and their foundation components. Compaction of the new fill placement around existing structures shall be accomplished through the use of portable compaction equipment (hand operated tampers or other equipment approved by the engineer).

The on-site soils consist of native cohesive soils. For the cohesive soils, a sheepsfoot roller should provide the most effective soil compaction. If new granular engineered fill is placed, a vibratory smooth-drum roller would be required to provide effective compaction.

Scarified subgrade soils and all fill material should be within 3 percent of the optimum moisture content to facilitate compaction. Furthermore, fill material should not be frozen or placed on a frozen base. It is recommended that all earthwork and site preparation activities be conducted under adequate specifications and properly monitored in the field by a qualified geotechnical testing firm.

7.0 QUALIFICATIONS OF RECOMMENDATIONS

Our evaluation of construction conditions for embankment fill placement has been based on our understanding of the site and project information and the data obtained during our field investigation. The general subsurface conditions were based on interpretation of the subsurface data at specific boring locations. Regardless of the thoroughness of a subsurface investigation, there is the possibility that conditions between borings will differ from those at the boring locations, that conditions are not as anticipated by the designers, or that the construction process has altered the soil conditions. Therefore, experienced geotechnical engineers should observe earthwork and foundation construction to confirm that the conditions anticipated in design are noted. Otherwise, TTL assumes no responsibility for construction compliance with the design concepts, specifications, or recommendations.

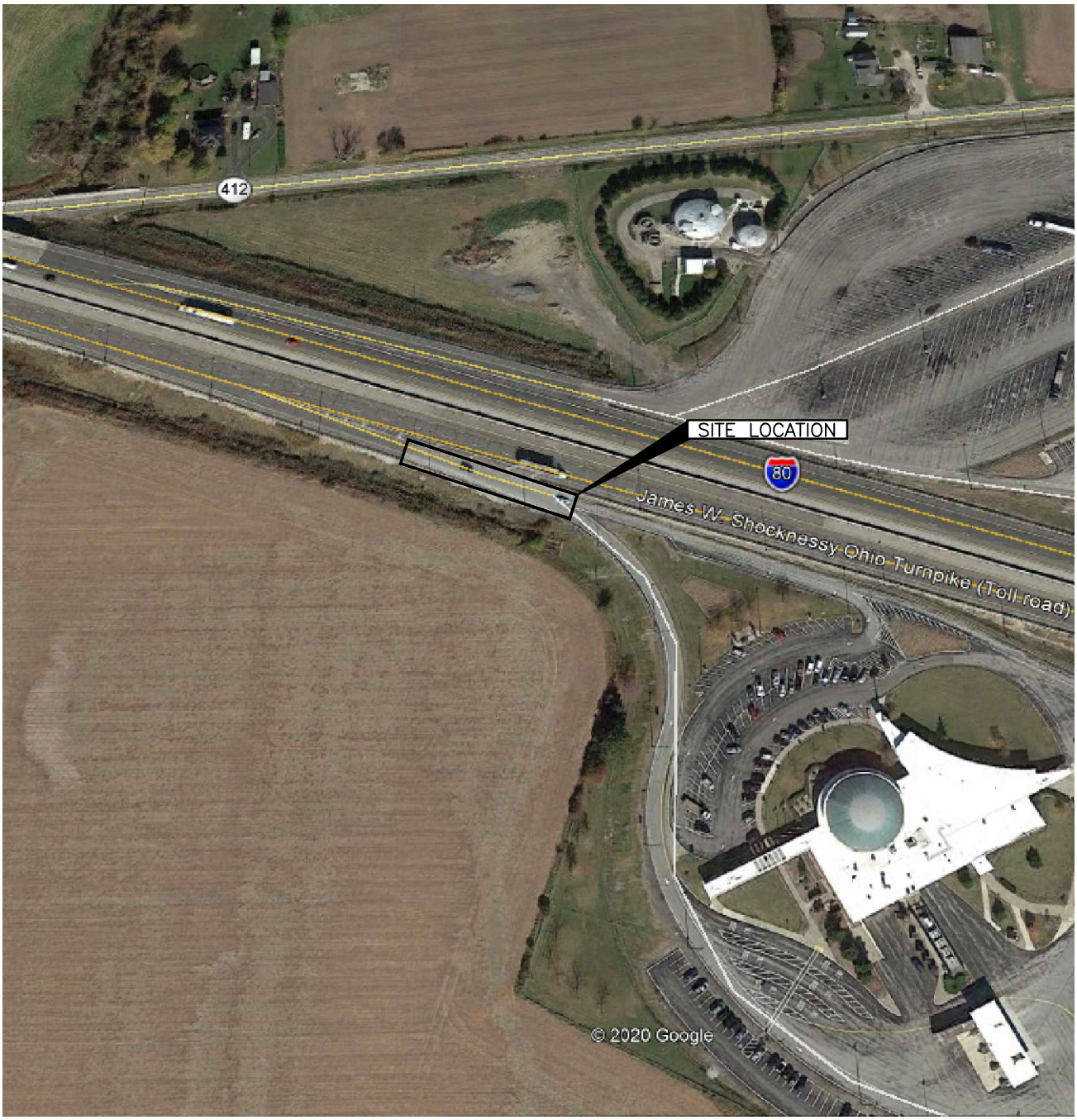
The evaluations and recommendations presented in this report have been formulated on the basis of reported or assumed data relating to the location and finished grades for the proposed structure. Any significant change in this data in the final design plans should be brought to our attention for review and evaluation with respect to the prevailing subsoil conditions.

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

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

Plates

Plate 1.0 Site Location Map
Plate 2.0 Test Boring Location Plan



LEGEND

APPROXIMATE SITE LOCATION

N

APPROXIMATE SCALE – FEET

0 200 400

PLATE 1.0
SITE LOCATION MAP
OTIC 71–19–02–BRIDGE DEMOLITION MP 98.9
OVER ABANDONED NORFOLK SOUTHERN RAILROAD

PREPARED FOR
KS ASSOCIATES INC.
260 BURNS ROAD, SUITE 100
ELYRIA, OHIO 44035

DRAWN	TRR/6–19–20	CHECKED	IEH/
REVISED		APPROVED	
JOB NO.	1852901–MOD1		
DRAWING NUMBER	1852901–MOD 1–01G		

TTL associates inc
Environmental, Geotechnical Engineering & Testing

PLATE 2.0
TEST BORING LOCATION PLAN
OTIC 71–19–02–BRIDGE DEMOLITION MP 98.9
OVER ABANDONED NORFOLK SOUTHERN RAILROAD

PREPARED FOR
KS ASSOCIAITES INC.
260 BURNS ROAD, SUITE 100
ELYRIA, OHIO 44035

DRAWN	TRR/6–19–20	CHECKED	IEH/ 6–19–20
REVISED		APPROVED	
JOB NO.	1852901–MOD1		
DRAWING NUMBER	1852901–MOD1–02G		

TTL associates inc
Environmental, Geotechnical Engineering & Testing

APPENDIX A

Log of Test Borings

TTL Associates, Inc.
1915 N 12th Street
Toledo, Ohio 43624
Telephone: 419-324-2222
Fax: 419-241-1808

BORING NUMBER B-3

CLIENT KS Associates
PROJECT NAME OTIC 71-19-02 Bridge Demolition
PROJECT NUMBER 1852901
PROJECT LOCATION OTIC MP 98.9, Sandusky County, OH
DRILLING CONTRACTOR TTL Associates IC DH
RIG NO. 111
GROUND ELEVATION 618.74 ft
DRILLING METHOD 4-1/4 in. HSA
GROUND WATER LEVELS:
DATE STARTED 4/20/20 **COMPLETED** 4/20/20
AT TIME OF DRILLING None
LOGGED BY KKC **CHECKED BY** IEH
AT END OF DRILLING None
NOTES A bulk sample was taken from auger cuttings from 1 - 6'.
0hrs AFTER DRILLING Backfilled w/Cuttings and Bentonite Chips

ELEVATION (ft)	DEPTH (ft)	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL / MC / LL (20 40 60 80) ▲ SPT N VALUE ▲ (20 40 60 80)
	0	ASPHALT - 7.5 Inches (0.6')	SS 1	58	2-4-6-5 (10)	4.00	108	19
		CRUSHED STONE - 2.5 Inches (0.8')						
615		FILL - Moist Stiff Brown/Gray LEAN CLAY w/Trace Sand, Crushed Stone, and Iron Oxide Stain Seam @2': Very Stiff	SS 2	88	8-11-10-10 (21)	2.50		26
	5	@4': Stiff	SS 3	63	4-4-5-6 (9)	1.75		22
		@6': Gray/Brown	SS 4	50	6-8-7-6 (15)	2.50	103	22
610	10	(10.0')	SS 5	75	2-5-7-13 (12)	>4.5		26
		FILL - Moist Stiff Dark Gray GRAVELLY (Crushed Stone) LEAN CLAY w/Sand	ST 1	79				14
605		@13': Gray/Brown	SS 6	67	4-5-7-10 (12)	3.50		22
	15	(15.0') Moist Stiff Gray/Brown LEAN CLAY w/Sand, Trace Gravel, Shale Fragments, and Iron Oxide Stain Seam (CL)	SS 7	79	4-5-8-10 (13)	>4.5	107	19
		@16': Very Stiff	SS 8	83	4-7-9-11 (16)	>4.5		17
600	20		SS 9	96	11-13-15-13 (28)	>4.5	110	19
595	25	@24.1': Stiff, Gray	SS 10	100	3-4-5 (9)	1.50		17
590		(28.6') Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL)	ST 2	100				17
	30		SS 11	100	2-3-3 (6)	0.50	108	17

(Continued Next Page)

TTL Associates, Inc.
1915 N 12th Street
Toledo, Ohio 43624
Telephone: 419-324-2222
Fax: 419-241-1808

BORING NUMBER B-3

CLIENT KS Associates
PROJECT NAME OTIC 71-19-02 Bridge Demolition
PROJECT NUMBER 1852901
PROJECT LOCATION OTIC MP 98.9, Sandusky County, OH

ELEVATION (ft)	DEPTH (ft)	GRAPHIC LOG	MATERIAL DESCRIPTION	SAMPLE TYPE NUMBER	RECOVERY % (RQD)	BLOW COUNTS (N VALUE)	UNCONF. COMP. STR. (tsf)	DRY UNIT WT. (pcf)	PL MC LL (20 40 60 80) ▲ SPT N VALUE ▲ (20 40 60 80)
585	35			SS 12	100	0-2-3 (5)	0.75		19
580	40			SS 13	100	0-2-3 (5)	0.50		17
575	45		43.5' Moist Soft Gray SANDY LEAN CLAY w/Trace Gravel (CL)	SS 14	100	2-2-2 (4)	0.75	108	19
570	50		48.5' Moist Medium Stiff Gray LEAN CLAY w/Sand and Trace Gravel (CL) 50.0'	SS 15	100	0-2-5 (7)	2.75		18

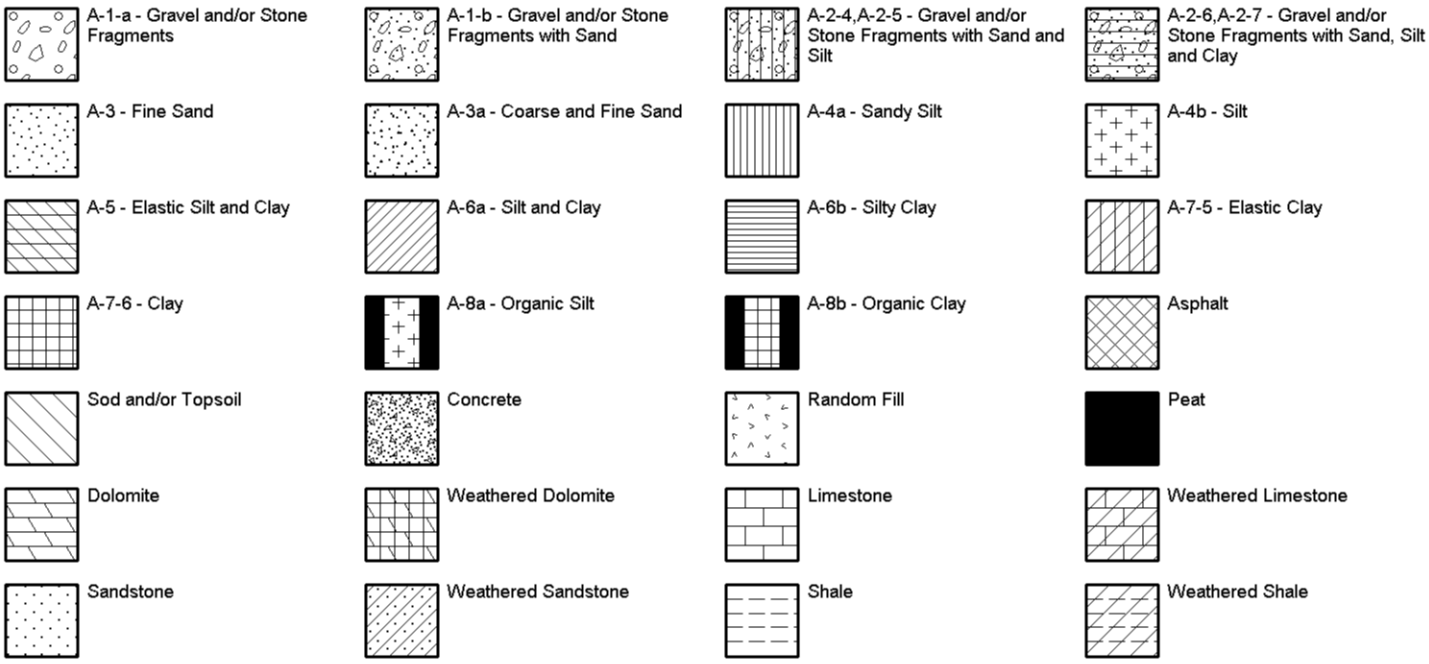
Bottom of hole at 50.0 feet.

APPENDIX B

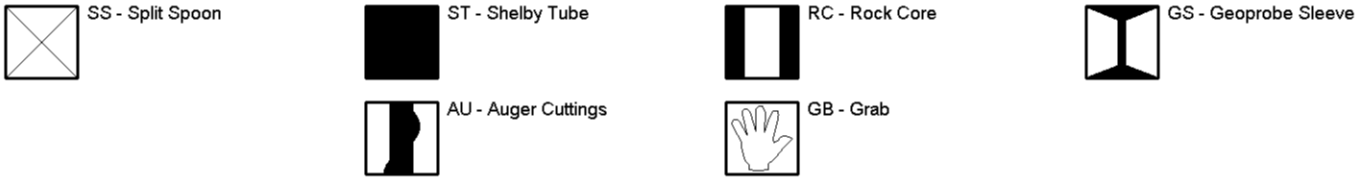
Legend Key

LEGEND KEY

Ohio Department of Transportation Soil Symbols



Sample Symbols



Notes:

1. Exploratory boring was drilled on April 20, 2020, using 4.25-inch diameter Hollow-stem augers.

2. This log is subject to the limitations, conclusions, and recommendations in the report and should not be interpreted separate from the report.

3. The boring was located in the field by TTL, Inc. based on the provided information by KS Associates Inc.

4. Unconfined Compressive Strength (tsf):
   NP = Non-Plastic
   NI = Not Intact

APPENDIX C

Tabulation of Test Data

PROJECT: OTIC 71-19-02 Deck Replacement, OTIC MP 98.9, Sandusky County, OH	**TTL Associates, Inc.**	PROJECT NO: 1852901

TABULATION OF TEST DATA

Boring Number	Sample Number	Sample Interval Depth (Feet)		Standard Penetration (Blows per Foot)	Natural Moisture Content (% of Dry Weight)	In-Place Dry Density (Pounds per Cubic Foot)	Unconfined Compressive Strength (Pounds per Square Foot)		Particle Size Distribution (%)						Atterberg Limits (%)			Unified Soil Classification
									Gravel	Coarse Sand	Medium Sand	Fine Sand	Silt	Clay	Liquid Limit	Plastic Limit	Plasticity Index	
B-3	SS-1	0.0-2.0		10	19.3	108.1	*8,000		2	1	4	7	24	62	41	20	21	CL
	SS-2	2.0-4.0		21	26.4		*5,000								42	20	22	
	SS-3	4.0-6.0		9	22.0		*3,500											
	SS-4	6.0-8.0		15	21.6	102.8	*5,000											
	SS-5	8.0-10.0		12	25.6		*9,000+											
	ST-1	10.0-12.0			13.8				19	7	4	6	17	47	34	20	14	CL
	SS-6	12.0-14.0		12	22.2		*7,000											
	SS-7	14.0-16.0		13	18.6	106.6	*9,000+											
	SS-8	16.0-18.0		16	17.4		*9,000+											
	SS-9	18.0-20.0		28	18.9	109.8	*9,000+											
	SS-10	23.5-25.0		9	16.8		*3,000											
	ST-2	27.0-29.0			17.4				3	5	9	9	20	54	31	18	13	CL
	SS-11	29.0-30.5		6	17.1	107.7	*1,000											
	SS-12	33.5-35.0		5	19.4		*1,500								29	19	10	
	SS-13	38.5-40.0		5	16.5		*1,000											
	SS-14	43.5-45.0		4	18.6	107.9	*1,500		10	5	8	8	20	49	30	20	10	CL
	SS-15	48.5-50.0		7	17.8		*5,500											

*Unconfined compressive strength derived from a calibrated hand penetrometer

APPENDIX D

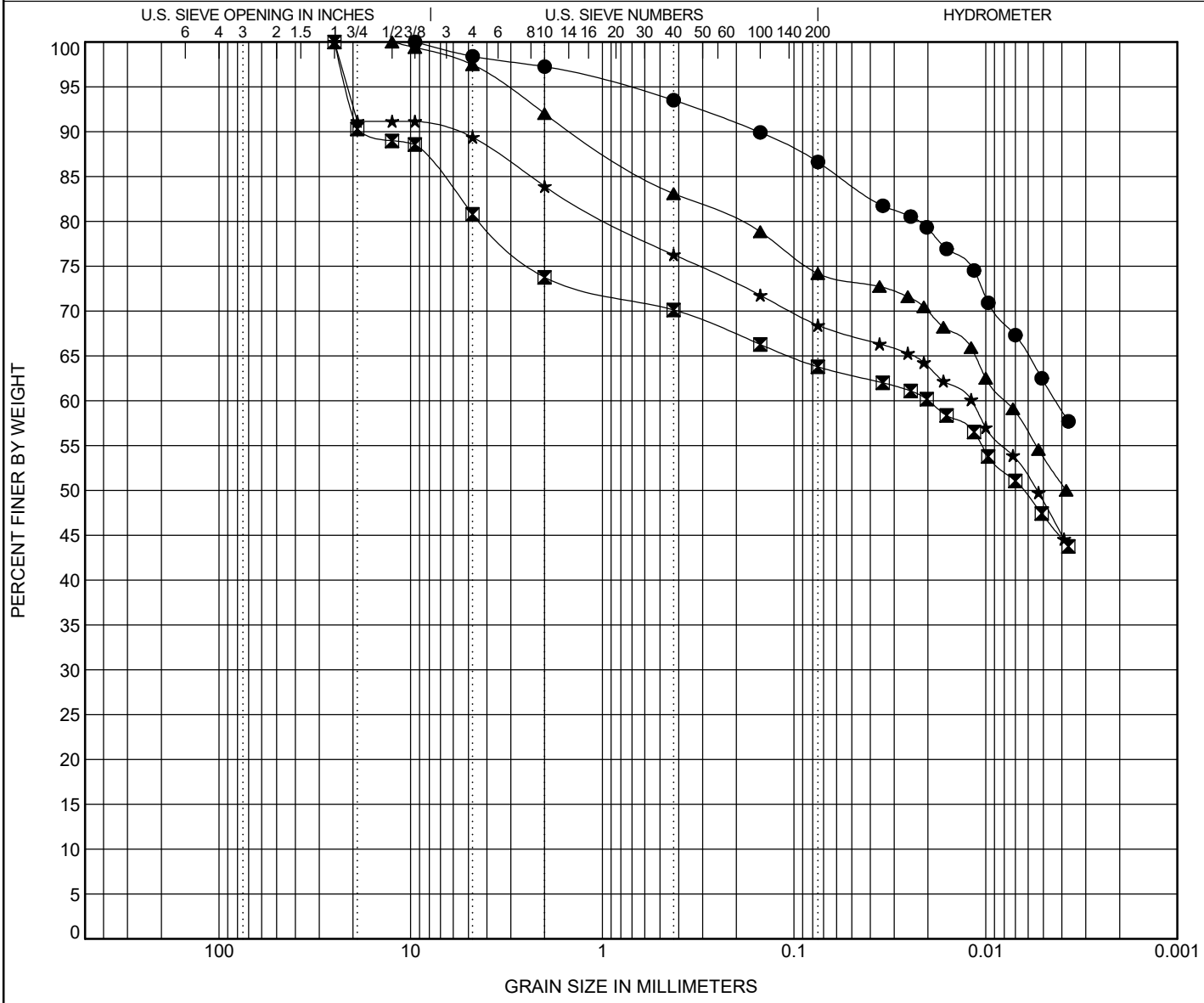
Laboratory Test Results

TTL Associates, Inc.
1915 N 12th Street
Toledo, Ohio 43624
Telephone: 419-324-2222
Fax: 419-241-1808

GRAIN SIZE DISTRIBUTION

CLIENT KS Associates **PROJECT NAME** OTIC 71-19-02 Bridge Demolition

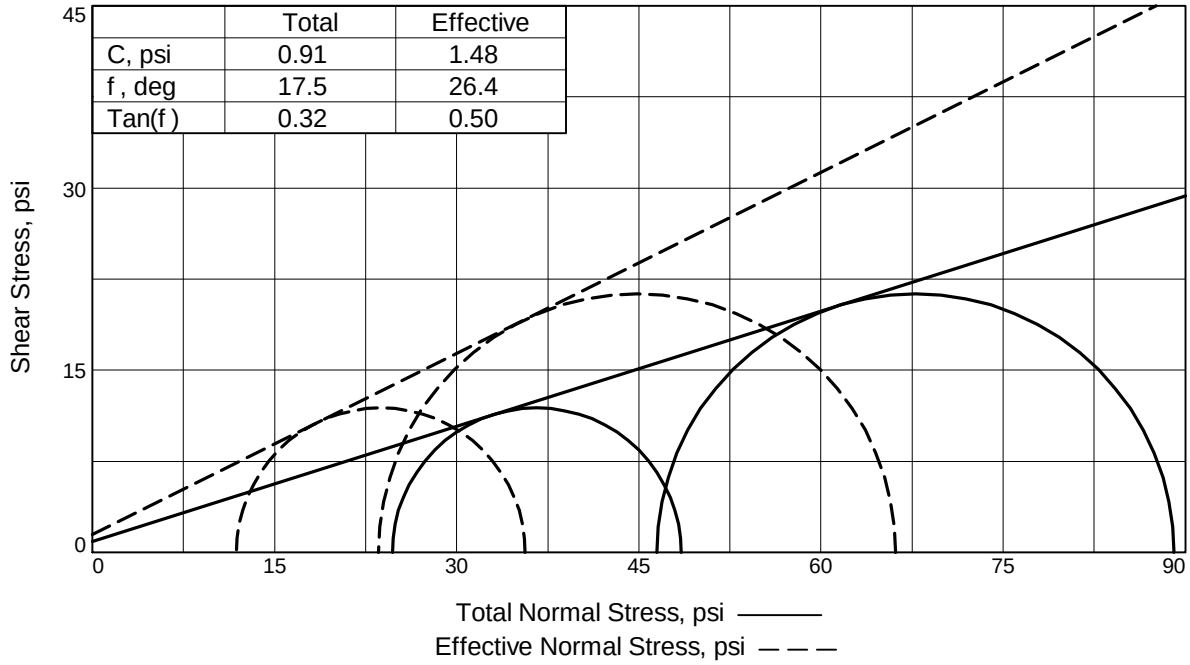
PROJECT NUMBER 1852901 **PROJECT LOCATION** OTIC MP 98.9, Sandusky County, OH



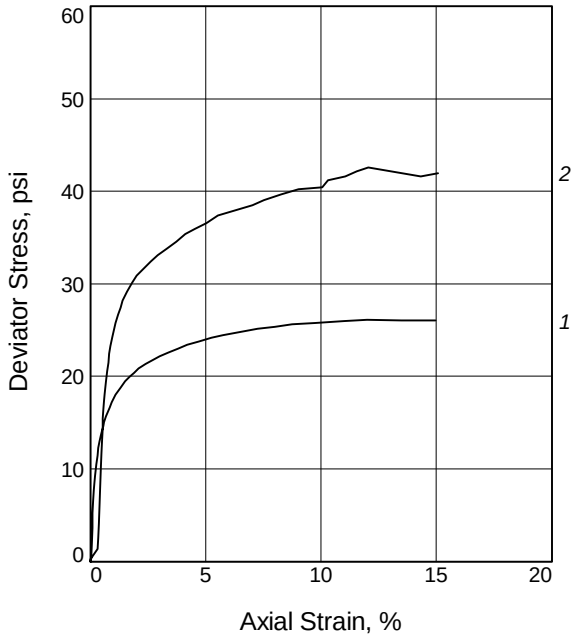
COBBLES	GRAVEL		SAND			SILT OR CLAY
	coarse	fine	coarse	medium	fine	

	Specimen Identification		USCS Classification	LL	PL	PI	Cc	Cu
●	B-3	0.0	**LEAN CLAY (CL)**	**41**	**20**	**21**		
⊠	B-3	10.0	**GRAVELLY LEAN CLAY with SAND (CL)**	**34**	**20**	**14**		
▲	B-3	27.0	**LEAN CLAY with SAND (CL)**	**31**	**18**	**13**		
★	B-3	43.5	**SANDY LEAN CLAY (CL)**	**30**	**20**	**10**		

	Specimen Identification		D100	D60	D30	D10	%Gravel	%Sand	%Silt	%Clay
●	B-3	0.0	**9.5**	**0.004**			**1.6**	**11.8**	**24.4**	**62.2**
⊠	B-3	10.0	**25**	**0.02**			**19.2**	**17.0**	**16.6**	**47.2**
▲	B-3	27.0	**12.5**	**0.008**			**2.5**	**23.3**	**20.4**	**53.8**
★	B-3	43.5	**25**	**0.012**			**10.6**	**21.0**	**19.6**	**48.8**



	Total	Effective
C, psi	0.91	1.48
f , deg	17.5	26.4
Tan(f)	0.32	0.50



Sample No.		1	2
Initial	Water Content, %	18.2	18.6
	Dry Density, pcf	115.3	114.6
	Saturation, %	106.4	106.5
	Void Ratio	0.4619	0.4706
	Diameter, in.	2.846	2.854
	Height, in.	5.670	5.659
At Test	Water Content, %	16.5	15.6
	Dry Density, pcf	116.6	118.6
	Saturation, %	100.0	100.0
	Void Ratio	0.4450	0.4207
	Diameter, in.	2.844	2.825
	Height, in.	5.612	5.579
Strain rate, in./min.		0.001	0.001
Back Pressure, psi		50.0	50.0
Cell Pressure, psi		74.7	96.5
Fail. Stress, psi		23.8	42.6
Excess Pore Pr., psi		12.8	22.9
Ult. Stress, psi			
Excess Pore Pr., psi			
$\bar{s}_1$ Failure, psi		35.6	66.2
$\bar{s}_3$ Failure, psi		11.9	23.6

Type of Test:
CU with Pore Pressures
Sample Type: Tube
Description: brown clay

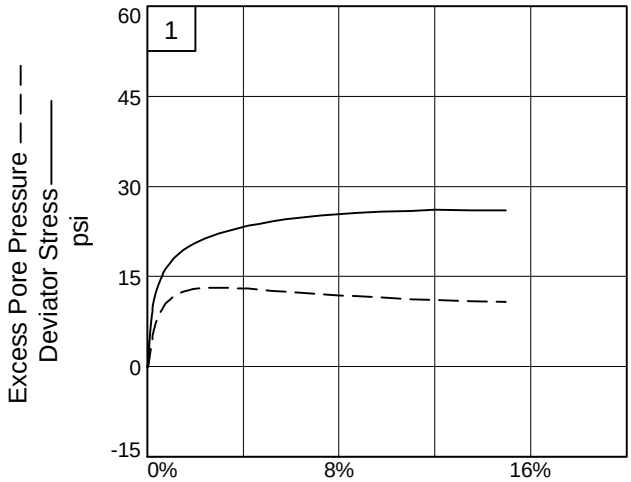
Assumed Specific Gravity= 2.7
Remarks: 2-specimen series

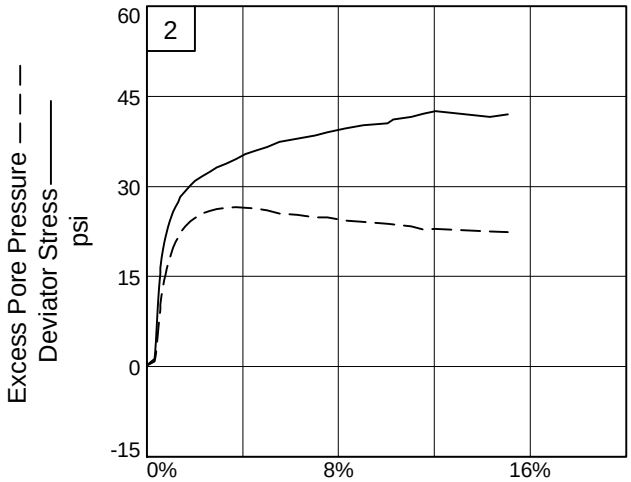
Client: TTL Associates, Inc

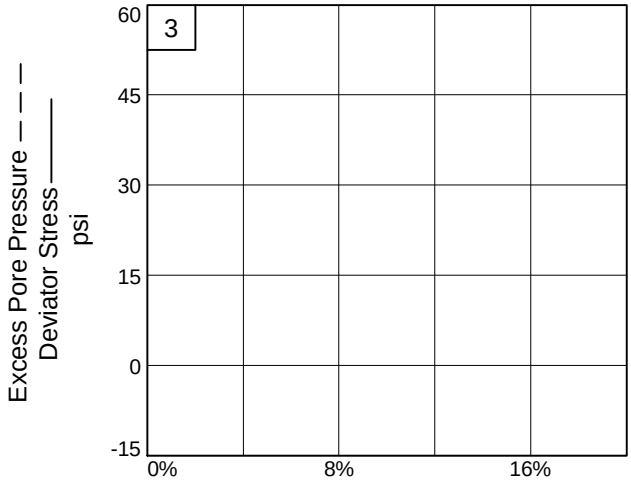
Project: OTIC 71-19-02-Bridge Demo MP 98.0 Abandon NSRR

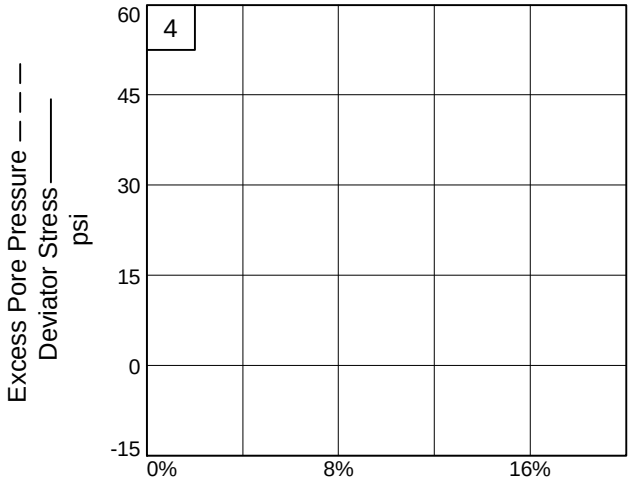
Source of Sample: B-3 **Depth:** 27.0-29.0 ft
Sample Number: ST-2
Proj. No.: N4201120 **Date Sampled:** N/A

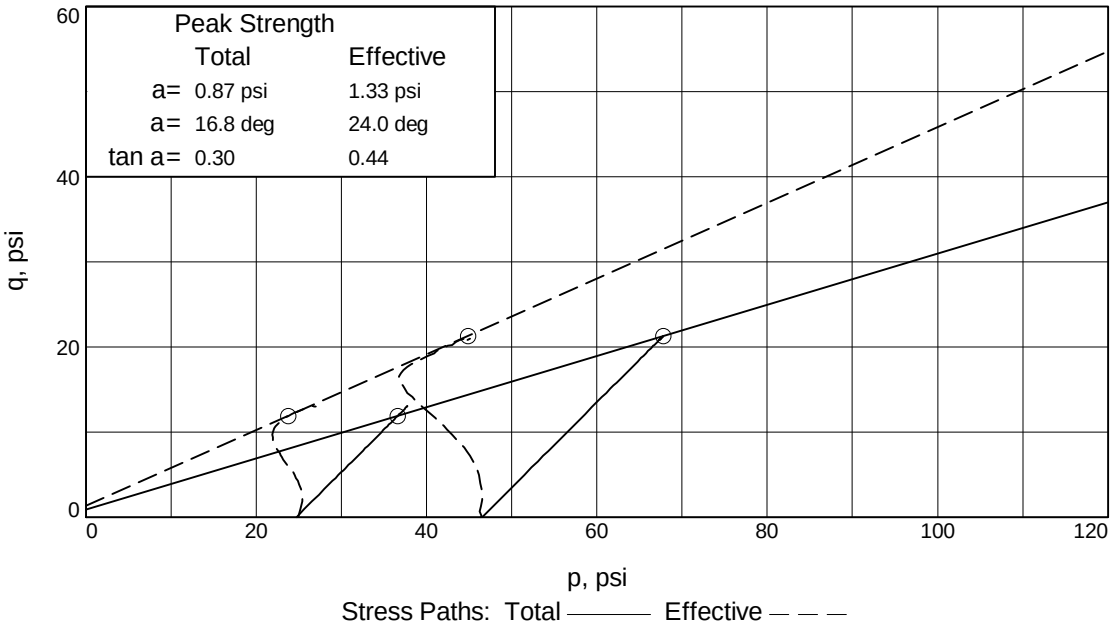
TRIAXIAL SHEAR TEST REPORT
Terracon Consultants, Inc.
Columbus, OH











Stress Paths: Total ——— Effective — — —

Client: TTL Associates, Inc

Project: OTIC 71-19-02-Bridge Demo MP 98.0 Abandon NSRR

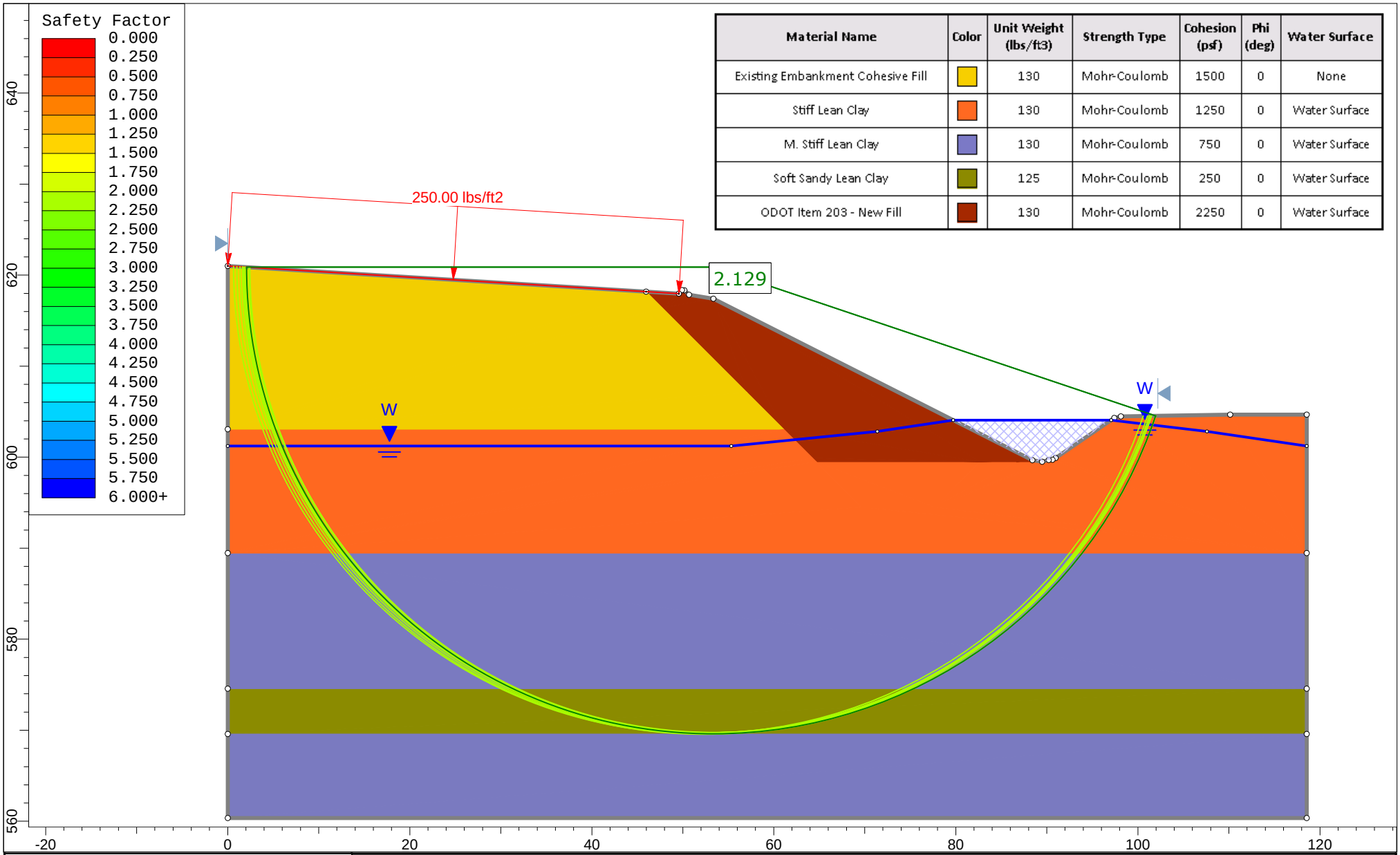
Source of Sample: B-3 **Depth:** 27.0-29.0 ft **Sample Number:** ST-2

Project No.: N4201120

Terracon Consultants, Inc.

APPENDIX E

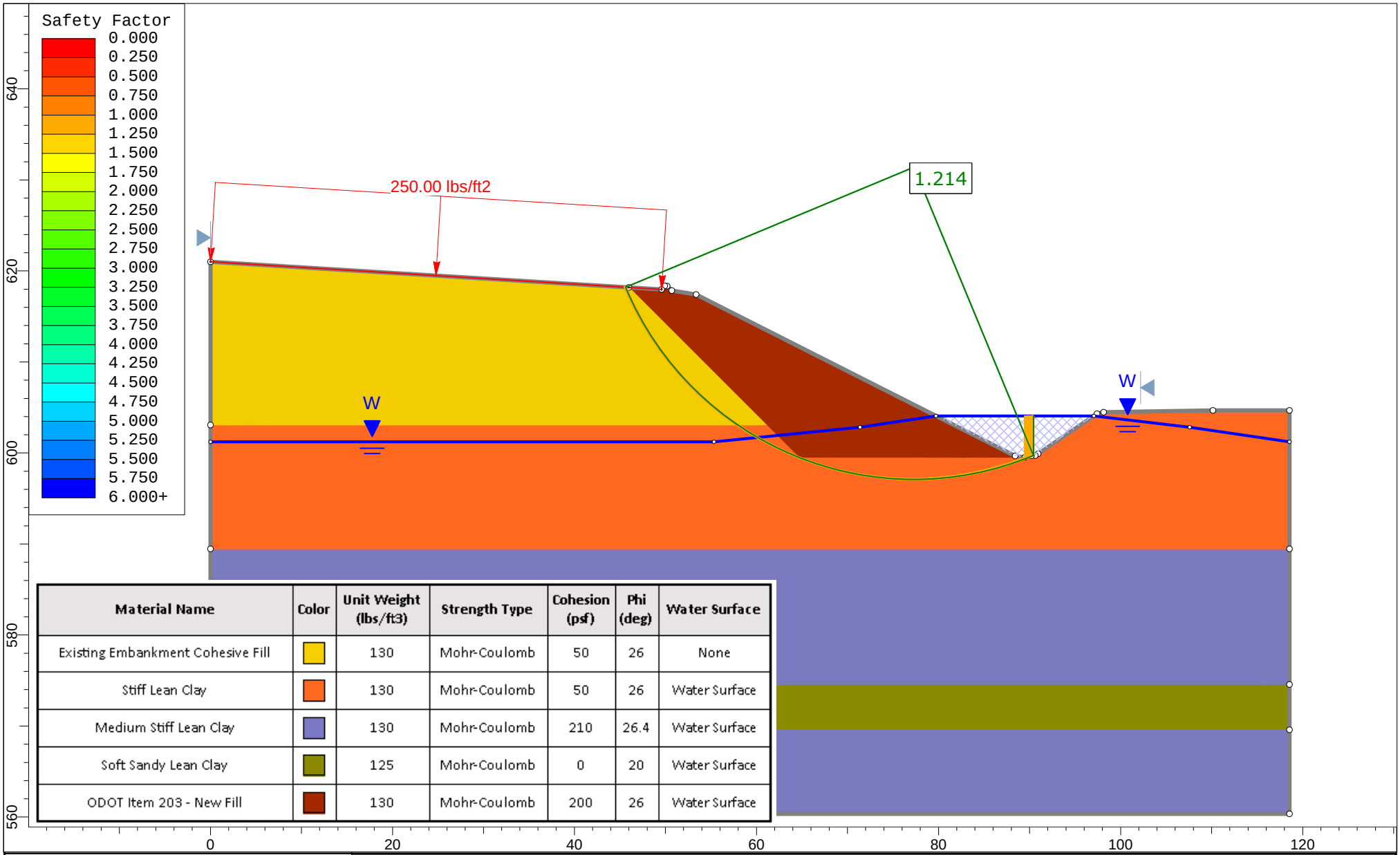
Slope Stability Analysis Outputs



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Existing Embankment Cohesive Fill		130	Mohr-Coulomb	1500	0	None
Stiff Lean Clay		130	Mohr-Coulomb	1250	0	Water Surface
M. Stiff Lean Clay		130	Mohr-Coulomb	750	0	Water Surface
Soft Sandy Lean Clay		125	Mohr-Coulomb	250	0	Water Surface
ODOT Item 203 - New Fill		130	Mohr-Coulomb	2250	0	Water Surface

TTL associates inc
Environmental, Geotechnical Engineering & Testing

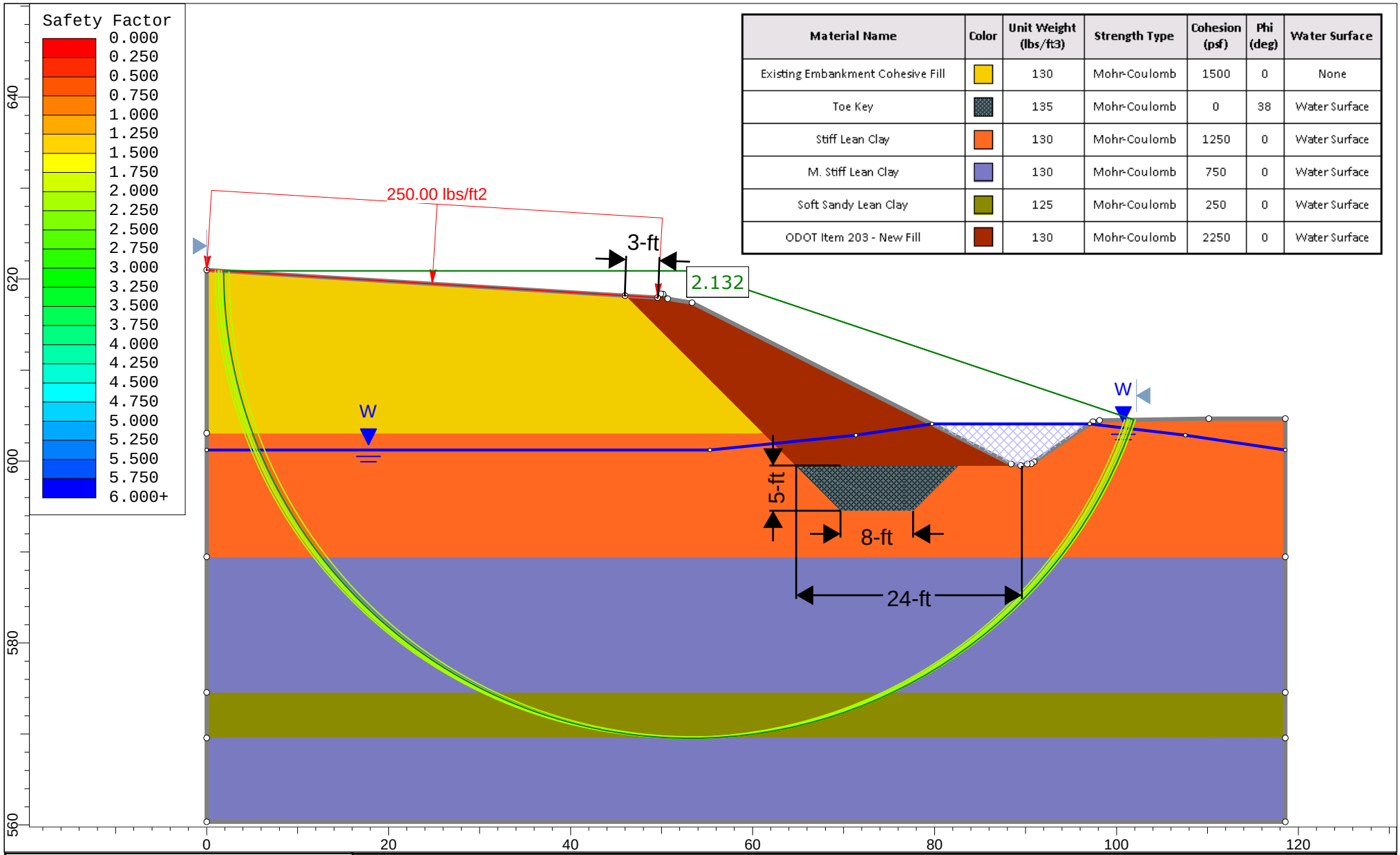
Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:175	*Company*
Date	7/1/2020, 7:05:13 PM		*File Name* TSSP - no Toekey.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Existing Embankment Cohesive Fill		130	Mohr-Coulomb	50	26	None
Stiff Lean Clay		130	Mohr-Coulomb	50	26	Water Surface
Medium Stiff Lean Clay		130	Mohr-Coulomb	210	26.4	Water Surface
Soft Sandy Lean Clay		125	Mohr-Coulomb	0	20	Water Surface
ODOT Item 203 - New Fill		130	Mohr-Coulomb	200	26	Water Surface

TTL associates inc
Environmental, Geotechnical Engineering & Testing

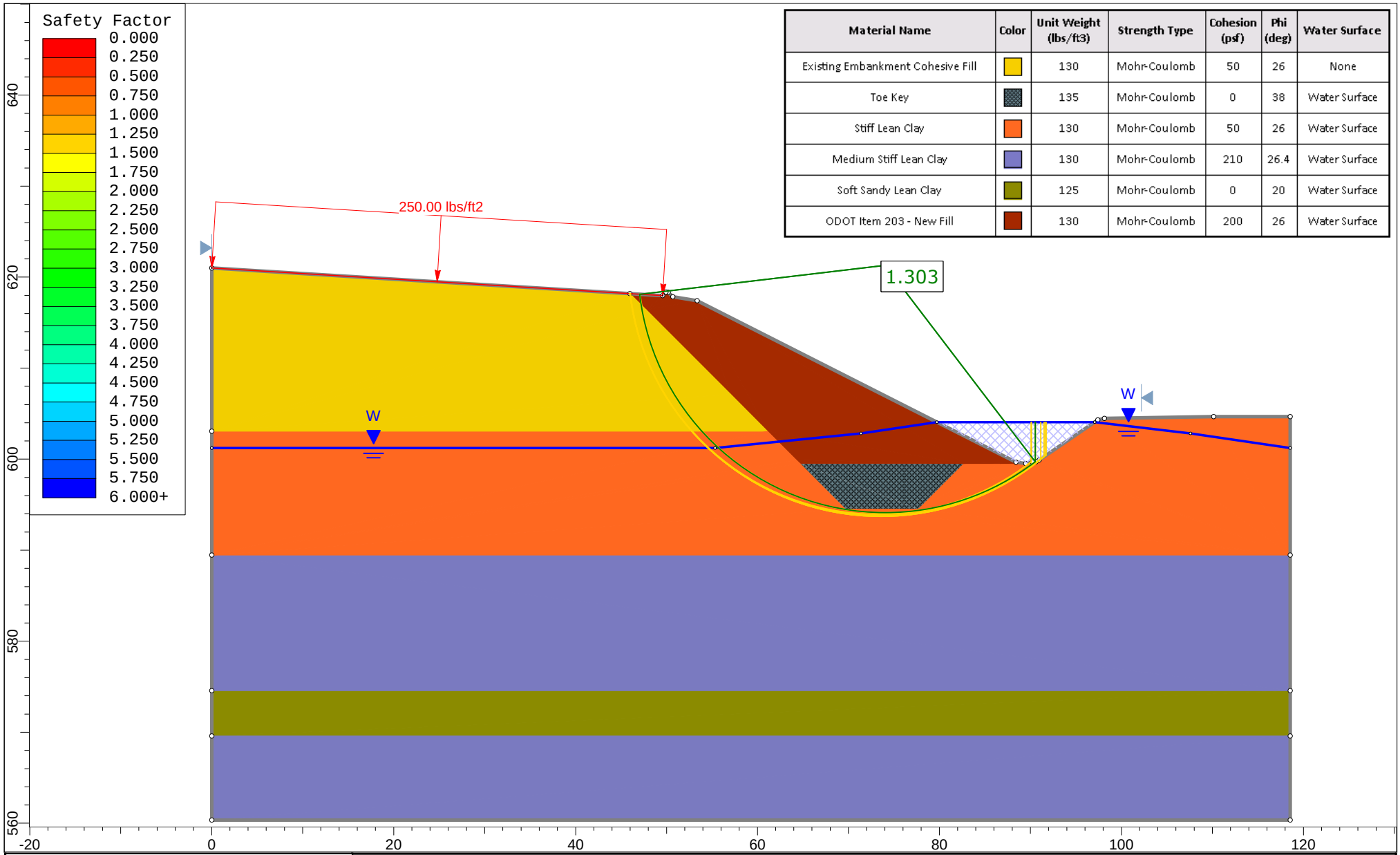
Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:175	*Company*
Date	7/1/2020, 7:05:13 PM		*File Name* ESSP - no Toekey.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Existing Embankment Cohesive Fill		130	Mohr-Coulomb	1500	0	None
Toe Key		135	Mohr-Coulomb	0	38	Water Surface
Stiff Lean Clay		130	Mohr-Coulomb	1250	0	Water Surface
M. Stiff Lean Clay		130	Mohr-Coulomb	750	0	Water Surface
Soft Sandy Lean Clay		125	Mohr-Coulomb	250	0	Water Surface
ODOT Item 203 - New Fill		130	Mohr-Coulomb	2250	0	Water Surface

TTL associates inc
Environmental, Geotechnical Engineering & Testing

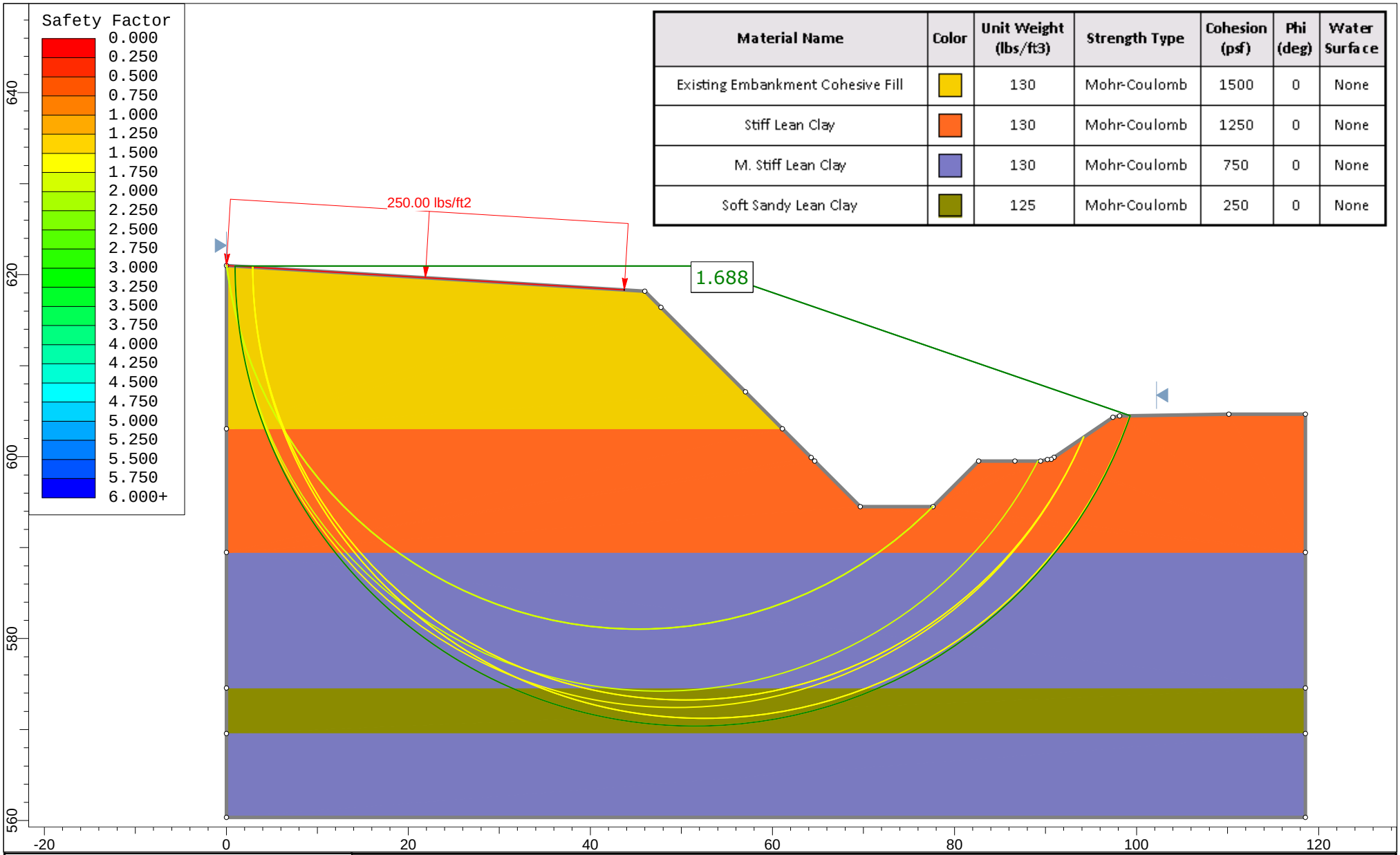
Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:175	*Company*
Date	7/1/2020, 7:05:13 PM		*File Name* TSSP - 5-ftToekey.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Existing Embankment Cohesive Fill		130	Mohr-Coulomb	50	26	None
Toe Key		135	Mohr-Coulomb	0	38	Water Surface
Stiff Lean Clay		130	Mohr-Coulomb	50	26	Water Surface
Medium Stiff Lean Clay		130	Mohr-Coulomb	210	26.4	Water Surface
Soft Sandy Lean Clay		125	Mohr-Coulomb	0	20	Water Surface
ODOT Item 203 - New Fill		130	Mohr-Coulomb	200	26	Water Surface

TTL associates inc
Environmental, Geotechnical Engineering & Testing

Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:175	*Company*
Date	7/1/2020, 7:05:13 PM		*File Name* ESSP - 5-ftToekey.slim



Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)	Water Surface
Existing Embankment Cohesive Fill		130	Mohr-Coulomb	1500	0	None
Stiff Lean Clay		130	Mohr-Coulomb	1250	0	None
M. Stiff Lean Clay		130	Mohr-Coulomb	750	0	None
Soft Sandy Lean Clay		125	Mohr-Coulomb	250	0	None

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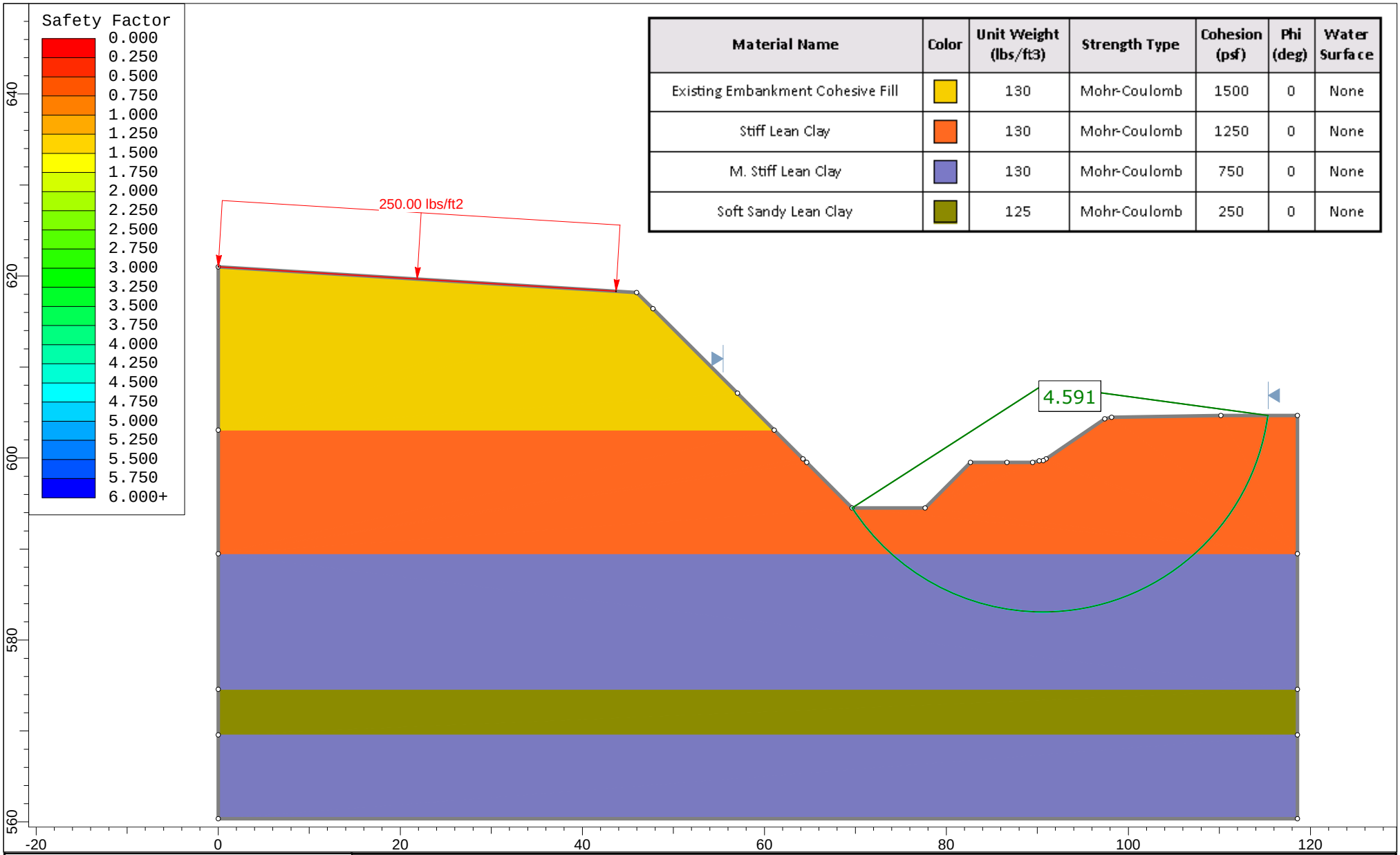
Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		Scale 1:175	Company
Date	7/1/2020, 7:05:13 PM		File Name Temp Conditions - Inside Slope.slim



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Project	SLIDE - An Interactive Slope Stability Program		
Analysis Description			
Drawn By		*Scale* 1:175	*Company*
Date	7/1/2020, 7:05:13 PM		*File Name* Temp Conditions - Outside Slope.slim