National Engineering & Architectural Services Inc.

2800 Corporate Exchange Dr.
Suite 240
Columbus, Ohio 43231
614.714.0299

DESIGN MEMORANDUM

Date: April 8, 2025

To: Mr. Vince Amato, Burgess & Niple, Inc.

From: Brendan P. Andrews P.E., NEAS Inc.

RE: **Geotechnical Design Memorandum**
Project HAM-75-1.05, PID 113361/122048
Retaining Wall 2
City of Cincinnati, Hamilton County, Ohio

INTRODUCTION

Per your request, this memorandum presents foundation design information for the proposed Retaining Wall 2 (RW-2) as part of the overall Ohio Department of Transportation (ODOT) HAM-75-1.05 (PID 113361) project located in the City of Cincinnati, Hamilton County, Ohio. A summary of: 1) the proposed structure; 2) the existing site conditions; 3) the surficial and subsurface conditions via historical and project borings; and, 4) our recommendations for retaining foundation design is presented below.

NEAS's analyses have been performed 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, 2022).

PROPOSED/EXISTING SITE CONDITIONS

Proposed Construction

The eastern limits of Interstate Route 75 (IR-75) northbound (NB) from Linn Street to the Freeman Avenue (Ave) Bridge and IR-75 NB entrance ramp is planned to be realigned and improved as part of the referenced project. The improvements to IR-75 at this location will also include alterations to Winchell Ave and Ramp V as well as the addition of a 12 foot wide shared use path planned along Winchell Ave. In order to facilitate the proposed improvements, RW-2 is planned to provide grade separation between the new shared use path, Winchell Ave and the existing, upslope grades located east of the referenced roadways.

Based on design information provided within the Retaining Wall 2, Stage 2/3 Plan Set developed by B&N, dated January 6, 2025, the proposed RW-2 will have a total wall length of approximately 1,010 ft and comprised of three different wall types. The first 280 ft (Sta. 1+00 to Sta. 3+80, RW-2 Alignment), starting adjacent to the Linn St Bridge, is planned to be a soldier pile and lagging (SPL) type wall with a max height of about 15 ft. The SPL portion is followed by approximately 610 ft of wall (Sta. 3+80 to Sta. 9+90.5, RW-2 Alignment) designed as a tangent drilled shaft wall with a max exposed height of about 20 ft (top of copping to bottom of footing). The remaining 120 ft (Sta. 9+90.5 to Sta. 11+10, RW-2 Alignment) is planned to be a cast-in-place (CIP) concrete retaining wall with a max height of 10.5 ft. The SPL and tangent drilled shaft wall will be supported on deep foundation elements while the proposed CIP wall will likely be supported on a shallow foundation.

Historical Records

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.

Site Reconnaissance

A field reconnaissance visit for the proposed RW-2 was conducted on January 13, 2022, during which site conditions were noted and photographed. During our field reconnaissance, no geohazards were observed within the immediate vicinity of the proposed retaining wall site. Land use of the area surrounding the proposed project site can be described as commercial property.

A portion of RW-2 is proposed to be constructed adjacent to the Linn St Bridge northern abutment. The land in this area slopes up from IR-75 to meet the northern abutment roadway embankment with slopes of roughly 3 Horizontal to 1 Vertical (3H:1V). The area is lightly vegetated with no signs of standing water observed. The area appeared to be stable with no signs of geotechnical instability.

The remaining portions of RW-2 are proposed to be constructed on the west shoulder of the West Court Street (St) and the east shoulder of Winchell Ave. An existing retaining is present along the west shoulder of the West Court St which provides grade separation between West Court St and the lower Winchell Ave. The existing wall terminates as Winchell Ave travels upslope to the north, northeast and West Court St ends. The existing wall appeared to be stable with no signs of geotechnical instability. Atop the existing wall at West Court St grades (Photograph 1), the land in this area is relatively flat with the exception of an embankment leading down to Winchell Ave near the end of the existing wall. This embankment is lightly vegetated for the most part with no signs of standing water observed, however freezing conditions during the site visit made this difficult to determine. In general, the pavement condition along West Court St was observed to be fair to good with signs of surface wear. Moderate severity longitudinal and transverse cracking was observed along this section as well as occasional map cracking and crack sealing deficiencies. The roadway drains to drainage basins on each shoulder of the roadway. The area appeared to be stable with no signs of geotechnical instability.

Photograph 1: West Court St atop existing retaining wall

SUBSURFACE EXPLORATION

The exploration for the RW-2 was conducted by NEAS between November 29, 2021 and March 10, 2022. The exploration for the referenced structure included 7 borings drilled to depths ranging from 21.5 to 106.5 ft below ground surface (bgs). Boring logs for the borings performed are attached. A summary of the exploration locations including latitude/longitude location information and elevations of the subject structure exploration are shown in Table 1 below. Additional information with respect to the subsurface exploration can be found in the Geotechnical Exploration Report for the overall project, HAM-75-1.05 (PID 113361).

Table 1: Structure Boring Summary

Boring Number	Latitude	Longitude	Elevation (NAVD 88) (ft)	Depth (ft)
B-010-0-21	39.105334	-84.528510	518.0	106.5
B-014-0-21	39.105714	-84.529250	505.4	51.5
B-015-0-21	39.105820	-84.529597	506.7	50.0
B-018-0-21	39.106145	-84.529913	507.1	51.5
B-021-0-21	39.106357	-84.530089	504.8	50.0
B-022-0-21	39.106626	-84.530240	506.9	21.5
B-026-0-21	39.107057	-84.530375	505.6	85.0

Notes:
1. *As-drilled boring location and corresponding ground surface elevation was surveyed in the field by NEAS Inc or estimated off topographic data collected along IR-75.*

SUBSURFACE CONDITIONS

At the site of the proposed structure, three different materials were encountered below the surficial material. In general, the three different overburden materials consisted of historical or embankment “man-made” fill soils, natural alluvial deposits, followed by natural sands. These materials and the general profile underlying the site is further described below.

Fill soils were encountered in each of the borings performed for the proposed structure with the fill being encountered immediately below the pavement section and extended to depths ranging from 9.5 to 27.5 ft bgs (approximate elevations 497.7 to 477.8 ft above mean sea level (amsl)). Based on laboratory testing results and a visual review of the soil samples obtained, the fill at the site is comprised of both cohesive fine-grained and non-cohesive coarse-grained material and is classified on the boring logs as Gravel and Stone Fragments with Sand and Silt (A-2-4), Gravel with Sand (A-1-b), Silt and Clay (A-6a), Silty Clay (A-6b), Sandy Silt (A-4a), Silt (A-4b), Coarse and Fine Sand (A-3a), and Clay (A-7-6). With respect to the soil strength, the non-cohesive fill soils can be described as having a relative compactness of medium dense to dense correlating to converted SPT-N values (N_{60}) between 13 and 36 blows per foot (bpf). Natural moisture contents of the non-cohesive fill ranged from 5 to 24 percent. With respect to the soil strength of the cohesive fill, these soils can be described as having a consistency of medium stiff to hard correlating to N_{60} values between 6 and 30 bpf and unconfined compressive strengths (estimated by means of hand penetrometer) between approximately 0.75 and 4.5 tons per square foot (tsf). Natural moisture contents of the cohesive fill ranged from 12 to 34 percent. Based on Atterberg Limits tests performed on representative samples of the cohesive fill material, the liquid and plastic limits ranged from 21 to 45 percent and from 15 to 24 percent, respectively.

The stratum encountered immediately beneath the fill consisted of natural alluvial soils comprised predominantly of fine-grained non-cohesive soils and extends to depths ranging from 70.5 to 78.3 ft bgs (approximate elevations 435.1 and 439.7 ft amsl). Based on laboratory testing results and a visual review of the soil samples obtained within this stratum, these soils are comprised of non-cohesive material classified on the boring logs as Coarse and Fine Sand (A-3a), Silt (A-4b) and Sandy Silt (A-4a). With respect to the soil strength, the non-cohesive alluvium can be described as having a relative compactness of loose to dense correlating to N_{60} values between 4 and 31 bpf. Natural moisture contents of the non-cohesive soils ranged from 3 to 31 percent.

The stratum encountered immediately beneath the alluvium, consisted of a natural sand layer which extended to termination depth of the borings between 85.0 and 106.5 ft bgs (approximate elevations 420.6 and 411.5 ft amsl). Based on laboratory testing results and a visual review of the soil samples obtained within this stratum, these soils are comprised of granular material and are classified on the boring logs as Coarse and Fine Sand (A-3a). With respect to the soil strength, the natural sands can be described as having a relative compactness of medium dense to dense correlating to N_{60} values between 18 and 31 bpf. Natural moisture contents of the sands ranged from 12 to 24 percent.

Groundwater

Groundwater measurements were taken during the boring drilling procedures at each borehole location. Groundwater was encountered during drilling in the 3 of the 7 project borings performed at the retaining wall site. Groundwater was encountered at depths ranging from 17.5 to 68.2 ft bgs (elevations 489.2 to 449.8 ft amsl). It should be noted that groundwater is affected by many hydrologic characteristics in the area and may vary from those measured at the time of the exploration. The specific groundwater readings are included on the attached boring logs.

ANALYSES AND RECOMMENDATIONS

Soil Profile for Analysis

For analysis purposes, each boring log was reviewed and a generalized material profile was developed for analysis. Utilizing the generalized soil profile, engineering properties for each soil strata was estimated based on their field (i.e., SPT N60 Values, hand penetrometer values, etc.) and laboratory (i.e., Atterberg Limits, grain size, etc.) test results using correlations provided in published engineering manuals, research reports and guidance documents. The developed soil profile and estimated engineering soil properties (with sited correlation/reference material) used in our analysis is summarized per boring location within Tables 2 through 8, below.

Table 2: Soil Profile and Estimated Engineering Properties - At Boring B-010-0-21

Retaining Wall 2: Drilled Shaft /SPL/CIP Wall, B-010-0-21				
Soil Description	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (degrees)
Gravel with Sand and Silt Depth (518 ft - 471 ft)	122	-	-	34
Silt Depth (471 ft - 453 ft)	125	-	-	30
Fine Sand Depth (453 ft - 411.5 ft)	128	-	-	32
Notes: *1. Values calculated per ODOT GDM Section 404/1304 and/or ODOT BDM Table 305-2.*				

Table 3: Soil Profile and Estimated Engineering Properties - At Boring B-014-0-21

Retaining Wall 2: Drilled Shaft /SPL/CIP Wall, B-014-0-21				
Soil Description	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (degrees)
Silt and Clay Depth (505.4 ft - 477.8 ft)	122	1900	190	24
Silt Depth (477.8 ft - 453.9 ft)	128	-	-	33
Notes: *1. Values calculated per ODOT GDM Section 404/1304 and/or ODOT BDM Table 305-2.*				

Table 4: Soil Profile and Estimated Engineering Properties - At Boring B-015-0-21

Retaining Wall 2: Drilled Shaft /SPL/CIP Wall, B-015-0-21				
Soil Description	Unit Weight (pcf)	Undrained Shear Strength (psf)	Effective Cohesion (psf)	Effective Friction Angle (degrees)
Sandy Silt Depth (506.7 ft - 497.2 ft)	122	-	-	33
Silt and Clay Depth (497.2 ft - 487.2 ft)	118	1200	120	22
Silt Depth (487.2 ft - 456.7 ft)	125	-	-	31
'alues calculated per ODOT GDM Section 404/1304 and/or ODOT BDM Table 305-2.				

Table 5: Soil Profile and Estimated Engineering Properties - At Boring B-018-0-21

Retaining Wall 2: Drilled Shaft /SPL/CIP Wall, B-018-0-21				
Soil Description	**Unit Weight (pcf)**	**Undrained Shear Strength (psf)**	**Effective Cohesion (psf)**	**Effective Friction Angle (degrees)**
Gravel with Sand and Silt Depth (507.1 ft - 487.6 ft)	128	-	-	36
Silt Depth (487.6 ft - 455.6 ft)	128	-	-	33
Values calculated per ODOT GDM Section 404/1304 and/or ODOT BDM Table 305-2.				

Table 6: Soil Profile and Estimated Engineering Properties - At Boring B-021-0-21

Retaining Wall 2: Drilled Shaft /SPL/CIP Wall, B-021-0-21				
Soil Description	**Unit Weight (pcf)**	**Undrained Shear Strength (psf)**	**Effective Cohesion (psf)**	**Effective Friction Angle (degrees)**
Clay Depth (504.8 ft - 492.8 ft)	110	1000	100	21
Coarse and Fine Sand Depth (492.8 ft - 473.5 ft)	125	-	-	33
Silt Depth (473.5 ft - 463.3 ft)	125	-	-	31
Silt Depth (463.3 ft - 454.8 ft)	120	-	-	27
Notes: *1. Values calculated per ODOT GDM Section 404/1304 and/or ODOT BDM Table 305-2.*				

Table 7: Soil Profile and Estimated Engineering Properties - At Boring B-022-0-21

Retaining Wall 2: Drilled Shaft /SPL/CIP Wall, B-022-0-21 (w/ B-021-0-21 & B-026-0-21)				
Soil Description	**Unit Weight (pcf)**	**Undrained Shear Strength (psf)**	**Effective Cohesion (psf)**	**Effective Friction Angle (degrees)**
Silt and Clay Depth (506.9 ft - 497.4 ft)	110	1000	100	22
Coarse and Fine Sand Depth (497.4 ft - 482.3 ft)	125	-	-	34
Silt Depth (482.3 ft - 463.3 ft)	125	-	-	31
Silt Depth (463.3 ft - 441.9 ft)	120	-	-	28
Coarse and Fine Sand Depth (441.9 ft - 420.6 ft)	125	-	-	32
Notes: *1. Values calculated per ODOT GDM Section 404/1304 and/or ODOT BDM Table 305-2.*				

Table 8: Soil Profile and Estimated Engineering Properties - At Boring B-026-0-21

Retaining Wall 2: Drilled Shaft /SPL/CIP Wall, B-026-0-21				
Soil Description	**Unit Weight (pcf)**	**Undrained Shear Strength (psf)**	**Effective Cohesion (psf)**	**Effective Friction Angle (degrees)**
Sandy Silt Depth (505.6 ft - 492.6 ft)	125	-	-	33
Silt Depth (492.6 ft - 474.1 ft)	125	-	-	32
Silt Depth (474.1 ft - 454.1 ft)	115	-	-	29
Silt Depth (454.1 ft - 440.6 ft)	110	-	-	27
Coarse and Fine Sand Depth (440.6 ft - 420.6 ft)	125	-	-	33
Notes: *1. Values calculated per ODOT GDM Section 404/1304 and/or ODOT BDM Table 305-2.*				

RETAINING WALL 2 (STA. 1+00.0 TO STA. 9+90.5)

SPL Retaining Wall Design Assumptions

As a portion of RW-2 is planned as a SPL retaining wall, ODOT's BDM and AASHTO's LRFD BDS dictate analysis parameters and design minimums/constraints to be used in analysis and design process. The referenced parameters and design minimums/constraints that were significant to our analysis consist of the following:

- Minimum SPL wall embedment depths (as measured from top of drilled shaft to the proposed ground surface) shall be 3 ft;
- SPL wall analyses performed assuming a simplified earth distribution as shown in LRFD BDS Figure 3.11.5.6-4 "Unfactored Simplified Earth Pressure Distribution for Temporary Nongravity Cantilevered Walls with Discrete Vertical Elements Embedded in Cohesive Soils and Retaining Granular Soils";
- Simplified Earth Pressure "Design Grade" is equal to top of shaft/bottom of facing elevation of the proposed wall;
- Soldier pile analyzed in software L-pile as an "Elastic Section (Non-yielding)" type with "Circular without Void" shape with section properties equal to that of the steel section assuming a yield strength of 50 kips per square inch (ksi) and an elastic modulus of 29,000 ksi;
- Retained Fill soils will be compacted on-site fill material as specified and meeting the minimum design soil parameters per ODOT BDM Table 307-1 and provided in Table 9 below.

Table 9: Design Soil Parameters for Fill Materials

Fill Zone	Type of Soil	Soil Unit Weight (pcf)	Friction Angle (°)	Cohesion (psf)
SPL Wall Backfill	On-site soil varying from sandy lean clay to silty sand, per 703.16.A	120	30	0
Notes: *1. Per Section Table 307-1 of the ODOT BDM.*				

With respect to design constraints and assumptions specific to the portion of SPL retaining wall, the geometry of the proposed wall (i.e., exposed heights, existing ground elevations, proposed final grade behind/at the toe of the well, etc.) is assumed to be consistent with the Retaining Wall 2, Stage 2/3 Plan Set developed by B&N, dated January 6, 2025.

Tangent Drilled Shaft Retaining Wall Design Assumptions

As a portion of RW-2 is planned as tangent drilled shaft wall type with a reinforced concrete wall facing, ODOT's BDM and AASHTO's LRFD BDS dictate analysis parameters and design minimums/constraints to be used in the analysis and design process. The referenced parameters and design minimums/constraints that were significant to their analyses consist of the following:

- Measure the design retained height (H) of drilled shaft walls from the top of the retained earth to the design grade, according to LRFD Figures 3.11.5.6-1 through 3.11.5.6-7.
- Minimum embedment (D) for drilled shaft walls shall be equal to the retained height (H) such that the embedment-to-length ratio (D/L) shall not be less than 0.5.
- For drilled shaft walls with a cast-in-place concrete facing, provide a structural attachment between the facing and the exposed face of the discrete vertical wall elements.; and,

- For tangent drilled shaft walls with a permanent cast-in-place facing, place wall drainage between the permanent facing and the drilled shafts at the joints between the adjacent drilled shafts. Provide vertical drainage paths with a minimum width of 18-inch.

With respect to design constraints and assumptions specific to the RW-2, the geometry of the proposed walls (i.e., exposed wall heights, existing ground elevations, proposed final grade behind/at the toe of the wall, etc.) is assumed to be consistent with that shown in the available the Retaining Wall 2, Stage 2/3 Plan Set developed by B&N, dated January 6, 2025.

Parameters for Lateral Load Analysis

Deep foundation elements subjected to horizontal loads and/or moments should be analyzed for maximum bending moments and lateral deflections. The required lateral load capacity can be obtained by increasing the diameter or the embedment depth of the foundation element. The generalized soil parameters, including recommended lateral soil modulus, and soil strain to be used to analyze the laterally loaded shaft by the p-y curve method are presented in Table 10 below. Furthermore, a resistance factor of 1.0 should be used when estimating the lateral geotechnical resistance of a single shaft/pile or shaft/pile group in accordance with LRFD BDS Tables 10.5.5.2.3-1 and 10.5.5.2.4-1.

Table 10: Soil Parameters for Lateral Load Analysis - RW-2

LPILE Parameters Retaining Wall 2							
Soil Description	**p-y model**	**Elevation (ft amsl)**	**Total Unit Weight (pcf)**	**Friction Angle**	**Undrained Shear Strength (psf)**	**Lateral Soil Modulus Parameter, k (pci)**	**Soil Strain Parameter, E_{50} (%)**
Soil Profile at Boring B-010-0-21							
Silty, Clayey Sand & Gravel	Sand (Reese)	518.0 - 471.0	122	34	-	85	-
Non-Cohesive Silt / Sandy Silt	Sand (Reese)	471.0 - 453.0	125	30	-	35	-
Coarse and Fine Sand	Sand (Reese)	453.0 - 411.5	128	32	-	50	-
Soil Profile at Boring B-014-0-21							
Silt and Clay	Stiff Clay w/o Water	505.4 - 477.8	122	-	1,900	635	0.0064
Non-Cohesive Silt / Sandy Silt	Sand (Reese)	477.8 - 453.9	128	33	-	70	-
Soil Profile at Boring B-015-0-21							
Sand / Silty Sand	Sand (Reese)	506.7 - 497.2	122	33	-	105	-
Silt and Clay	Stiff Clay w/o Water	497.2 - 487.2	118	-	1,200	330	0.0083
Non-Cohesive Silt / Sandy Silt	Sand (Reese)	487.2 - 456.7	125	31	-	45	-
Soil Profile at Boring B-018-0-21							
Silty, Clayey Sand & Gravel	Sand (Reese)	507.1 - 487.6	128	36	-	225	-
Non-Cohesive Silt / Sandy Silt	Sand (Reese)	487.6 - 455.6	128	33	-	70	-
Soil Profile at Boring B-021-0-21							
Silt and Clay	Stiff Clay w/o Water	504.8 - 492.8	110	-	1,000	230	0.0094
Coarse and Fine Sand	Sand (Reese)	492.8 - 473.5	125	33	-	65	-
Non-Cohesive Silt	Sand (Reese)	473.5 - 463.3	125	31	-	45	-
Non-Cohesive Silt	Sand (Reese)	463.3 - 454.8	120	27	-	15	-
Soil Profile at Boring B-022-0-21 (w/ B-021-0-21 and B-026-021)							
Silt and Clay	Stiff Clay w/o Water	506.9 - 497.4	110	-	1,000	230	0.0094
Sand / Silty Sand	Sand (Reese)	497.4 - 482.3	125	34	-	140	-
Non-Cohesive Silt / Sandy Silt	Sand (Reese)	482.3 - 463.3	125	31	-	45	-
Non-Cohesive Silt	Sand (Reese)	463.3 - 441.9	120	28	-	20	-
Sand / Silty Sand	Sand (Reese)	441.9 - 420.6	125	32	-	60	-
Soil Profile at Boring B-026-0-21							
Sand / Silty Sand & Gravel	Sand (Reese)	505.6 - 492.6	125	33	-	105	-
Non-Cohesive Silt / Sandy Silt	Sand (Reese)	492.6 - 474.1	125	32	-	55	-
Non-Cohesive Silt / Sandy Silt	Sand (Reese)	474.1 - 454.1	115	29	-	25	-
Non-Cohesive Silt	Sand (Reese)	454.1 - 440.6	110	27	-	15	-
Sand / Silty Sand	Sand (Reese)	440.6 - 420.6	125	33	-	70	-

Global Stability

For purposes of evaluating the stability of the SPL and tangent drilled shaft wall type segments of the proposed RW-2, NEAS reviewed the available cross-sections that were 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 sections that would represent a combination of existing subsurface conditions and planned site grading that would be most critical to slope stability (i.e., maximum total wall height, maximum embankment height measured from toe of slope to top of wall 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, two (2) cross-sections were estimated to be most "critical" and were analyzed for global stability. The cross-sections analyzed for global stability were the maximum total wall height section of each individual wall type (i.e., SPL and tangent drilled shaft). The analyzed cross-sections include the section at approximate STA. 1+00 (RW-2 alignment) and approximate STA. 6+90 (RW-2 alignment) for the for the SPL and tangent drilled shaft wall type segments, respectively.

For each of the referenced cross-sections, NEAS developed a representative cross-sectional model to use as the basis for global stability analyses. The models were developed from NEAS's interpretation of the available information which included: 1) the available Retaining Wall 2, Stage 2/3 Plan Set developed by B&N, dated January 6, 2025; 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 memo. With respect to the soil's engineering properties, the provided Soil Profile and Estimated Engineering Properties of borings B-010-0-21 and B-021-0-21 presented in the *Soil Profile for Analysis* section of this memo were used in our analyses at approximate STA. 1+00 (RW-2 alignment) and STA. 6+90 (RW-2 alignment), respectively.

The above referenced slope stability model was analyzed for long-term (Effective Stress) and short-term (Total Stress) slope stability utilizing the software entitled Slide2 by Rocscience, Inc. Specifically, the Spencer analysis method was used to calculate a factor of safety (FOS) for circular and non-circular type slope failures. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.33 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 retaining wall does not contain or support a structural element.

Based on our slope stability analysis for the referenced retaining wall sections, the minimum slope stability safety factor is about 1.38 (0.72 resistance factor). The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) is attached.

Tangent Drilled Shaft and SPL Retaining Wall Analyses

Internal and external stability analyses of the proposed RW-2 tangent drilled shaft and SPL wall including lateral load analysis of the proposed drilled shaft foundations has been performed by the project design team. These calculations will be provided to ODOT as part of a separate submission.

RETAINING WALL 2 (STA. 9+90.5 TO STA. 11+10.0)

Cast-In-Place Wall and Spread Footing Design Assumptions

As a portion of the RW-2 structure is proposed to be a cast-in-place (CIP) wall founded on the existing soil at the site, ODOT's BDM, AASHTO's LRFD BDS, and the project conditions dictate analysis parameters and design minimums/constraints to be used in the analysis and design process. The referenced parameters and design minimums/constraints that where significant to our analyses consist of the following:

- Retained soils are to consist of material placed and compacted in accordance with Item 203, Roadway Excavation and Embankment, of the ODOT CMS;
- The soil parameters of the new fill were assumed to be consistent with those recommended in the ODOT BDM Section 307.1 for "On-site soil varying from sandy lean clay to silty sand" for behind the wall heel and for Granular Embankment for wall backfill and are presented in Table 11 below.

Table 11: Design Soil Parameters for Fill Materials

Type of Soil	Soil Unit Weight (pcf)	Effective Friction Angle (°)	Effective Cohesion (psf)
On-site soil varying from sandy lean clay to silty sand, per 703.16A	120	30	0
Granular Embankment, per 703.16B	120	32	0
Notes: *1. Per Section 307.1 of the 2020 ODOT BDM.*			

With respect to design constraints and assumptions specific to RW1, the geometry of the proposed wall (i.e., exposed wall heights, existing ground elevations, proposed final grade behind/at the toe of the wall, etc.) is assumed to be consistent with that shown in the Retaining Wall 2, Stage 2/3 Plan Set developed by B&N, dated January 6, 2025.

External Stability Analysis

Based on our estimated engineering soil properties and the RW-2 CIP design assumptions provided in previous sections of this memo, an external stability analysis of the proposed CIP wall was performed. The cross-section selected for external stability analysis is the tallest wall section with a footing width of 7-ft and 1.5 ft key located near STA. 9+90.5 (RW-2 alignment). This cross-section was evaluated for resistance to bearing pressure, sliding forces, and overturning at the Strength Limit State in accordance with Section 11.5.3 of the AASHTO's LRFD BDS.

The capacity to demand ratios (CDRs) calculated for the referenced cross-sections with respect to bearing, sliding and overturning, as well as the calculated factored bearing resistances are presented in Table 12 below. (External Stability Results are attached). A CDR ratio greater than 1.0 indicates an acceptable design per AASHTO's LRFD.

Table 12: External Stability Analysis Summary

Retaining Wall 2 CIP External Analysis Summary	
Estimated Top of Wall (feet)	505.0
Estimated Bottom of Footing (feet)	494.5
Exposed Wall Height (feet)	5.8
Design Wall Height (feet)	10.5
Depth of Key (feet)	1.5
Approximate Station(1)	9+90.5
Capacity Demand Ratio (CDR)	
Sliding	1.9
Overturning / Eccentricity	2.3
Bearing Capacity (Undrained/Drained)	7.8/7.8
Factored Bearing Resistance (ksf)(2)	12.5
Notes: *1. Stationing in reference to the proposed Retaining Wall 2 alignment* *2. Bearing Resistance calculated in accordance to Section 11.10.5.4 of 2021 LRFD BDS and factored using Resistance Factor provided in Table 11.5.7-1 of 2021 LRFD BDS.*	

Global Stability

For purposes of evaluating the stability of the CIP type segment of the proposed RW-2, NEAS reviewed the available cross-sections that were interpreted to represent conditions that posed the greatest potential for slope instability. In general, cross-sections along the proposed CIP wall alignment were reviewed to determine sections that would represent a combination of existing subsurface conditions and planned site grading that would be most critical to slope stability (i.e., maximum total wall height, maximum embankment height measured from toe of slope to top of wall 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 cross-section analyzed for global stability was the maximum total CIP wall height section at approximate STA. 9+90.5 (RW-2 alignment).

For the referenced 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 available Retaining Wall 2, Stage 2/3 Plan Set developed by B&N, dated January 6, 2025; 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 memo. With respect to the soil's engineering properties, the provided Soil Profile and Estimated Engineering Properties of boring B-026-0-21 presented in the *Soil Profile for Analysis* section of this memo 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 Slide2 by Rocscience, Inc. Specifically, the Spencer analysis method was used to calculate a factor of safety (FOS) for circular and non-circular type slope failures. The FOS is the ratio of the resisting forces and the driving forces, with the desired safety factor being more than about 1.33 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 retaining wall does not contain or support a structural element.

Based on our slope stability analysis for the referenced retaining wall section, the minimum slope stability safety factor is about 2.56 (0.39 resistance factor). The graphical output of the slope stability program (cross-sectional model, calculated safety factor, and critical failure plane) is attached.

Settlement

Settlement is not anticipated to be a concern at the proposed wall location as minimal amount of new fill is planned as part of the proposed construction of the wall and therefore the increase in loading is minimal.

Temporary Excavations

It is recommended that all temporary excavations comply with the most recent Occupational Safety and Health Administration (OSHA) Excavating and Trenching Standard, Title 29 of the Code of Federal Regulation (CFR) Part 1926, Subpart P. The contractor is responsible for designing and constructing stable, temporary excavations and should shore, slope, or bench the sides of the excavations as required to maintain stability of both the excavation sides and bottom. Per Title 29 CFR Part 1926, the contractor's competent person should evaluate the soil exposed in the excavations as part of their safety procedures. In no case should slope height, slope inclination, or excavation depth, including utility trench excavation depth, exceed those specified in local, state, and federal safety regulations. Based on the natural soils encountered at the site (Type C Soil), it is recommended that temporary excavation slopes (exceeding a depth of 3 ft and less than 20 ft) be laid back to at least 1.5H:1V and these slopes should be braced or backfilled if the excavation slope will be maintained for more than a day

SOIL BORING LOGS

PROJECT: HAM-75-1.05	DRILLING FIRM / OPERATOR: NEAS / ASHBAUGH	DRILL RIG: CME 55T	STATION / OFFSET: 110+26, 28' LT.	EXPLORATION ID B-010-0-21
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / ASHBAUGH	HAMMER: CME AUTOMATIC	ALIGNMENT: LINN ST	
PID: 113361 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 518.0 (MSL) EOB: 106.5 ft.	PAGE 1 OF 4
START: 11/29/21 END: 11/30/21	SAMPLING METHOD: SPT	ENERGY RATIO (%): 68.4	LAT / LONG: 39.105334, -84.528510	

MATERIAL DESCRIPTION AND NOTES	ELEV. 518.0
6.0" ASPHALT AND 6.0" CONCRETE AND 5.0" BASE (DRILLERS DESCRIPTION)	516.6
MEDIUM DENSE, BROWN AND GRAY, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, CONTAINS TRACE BRICK FRAGMENTS, MOIST TO DAMP **(FILL)**	511.0
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, LITTLE TO SOME GRAVEL AND STONE FRAGMENTS, LITTLE TO SOME SAND, CONTAINS BRICK FRAGMENTS, DAMP **(FILL)**	501.0
MEDIUM DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, TRACE SILT, TRACE CLAY, DAMP	499.3
VERY STIFF, BROWN, **SILTY CLAY**, SOME SAND, LITTLE GRAVEL, DAMP TO MOIST	496.0
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE GRAVEL, TRACE CLAY, DAMP TO MOIST @25.0' TO 29.0'; CONTAINS IRON STAINING	

DEPTHS: 1 – 29

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
4 5 7	14	11	SS-1	-	-	-	-	-	-	-	-	-	14	A-2-4 (V)	
4 7 8	17	22	SS-2	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
5 6 6	14	56	SS-3	4.25	28	12	13	28	19	30	17	13	12	A-6a (3)	
5 4 5	10	39	SS-4	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
2 3 2	6	50	SS-5	4.25	-	-	-	-	-	-	-	-	16	A-6a (V)	
3 4 5	10	44	SS-6	2.50	-	-	-	-	-	-	-	-	17	A-6a (V)	
4 6 7	15	61	SS-7A	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	
			SS-7B	2.25	-	-	-	-	-	-	-	-	18	A-6b (V)	
3 3 3	7	72	SS-8	2.25	13	12	9	33	33	36	18	18	21	A-6b (9)	
5 7 8	17	56	SS-9	-	-	-	-	-	-	-	-	-	3	A-3a (V)	
6 7 6	15	67	SS-10	-	5	44	31	18	2	NP	NP	NP	6	A-3a (0)	
8 9 13	25	78	SS-11	-	-	-	-	-	-	-	-	-	6	A-3a (V)	

MATERIAL DESCRIPTION AND NOTES	ELEV. 488.0	DEPTHS	SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, BROWN, **COARSE AND FINE SAND**, TRACE TO LITTLE SILT, TRACE GRAVEL, TRACE CLAY, DAMP TO MOIST *(continued)*		31	10 11 16	31	100	SS-12	-	-	-	-	-	-	-	-	-	4	A-3a (V)	
		35–36	5 4 6	11	100	SS-13	-	-	-	-	-	-	-	-	-	5	A-3a (V)	
@40.0' TO 46.5'; CONTAINS INTERBEDDED SILT SEAMS		40–41	4 6 7	15	67	SS-14	-	-	-	-	-	-	-	-	-	11	A-3a (V)	
	471.0	45–46	5 6 7	15	61	SS-15	-	-	-	-	-	-	-	-	-	14	A-3a (V)	
MEDIUM DENSE, BROWN BECOMING BROWN AND GRAY, **SILT**, LITTLE SAND, TRACE TO LITTLE CLAY, TRACE GRAVEL, WET		50–51	5 7 7	16	72	SS-16	-	0	1	12	78	9	NP	NP	NP	26	A-4b (8)	
		55–56	5 8 6	16	67	SS-17	-	-	-	-	-	-	-	-	-	27	A-4b (V)	
		60–61	4 7 8	17	78	SS-18	-	-	-	-	-	-	-	-	-	27	A-4b (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 4/10/25 12:05 - X:\1ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2024 ARCHIVE\HAM-75-1.05\GINT FILES\HAI

MATERIAL DESCRIPTION AND NOTES	ELEV. 455.9	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, BROWN BECOMING BROWN AND GRAY, **SILT**, LITTLE SAND, TRACE TO LITTLE CLAY, TRACE GRAVEL, WET *(continued)*		63–65																
		65–66.5	6 10 11	24	78	SS-19	-	-	-	-	-	-	-	-	-	25	A-4b (V)	
	449.7	W 449.8 (68)																
MEDIUM DENSE TO DENSE, GRAY, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, WET																		
		70–71.5	7 14 13	31	67	SS-20	-	0	1	49	45	5	NP	NP	NP	28	A-4a (3)	
		75–76.5	7 12 11	26	72	SS-21	-	-	-	-	-	-	-	-	-	31	A-4a (V)	
	439.7	78																
MEDIUM DENSE TO DENSE, GRAY, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, TRACE GRAVEL, WET																		
		80–81.5	7 11 11	25	78	SS-22	-	-	-	-	-	-	-	-	-	20	A-3a (V)	
		85–86.5	8 10 12	25	78	SS-23	-	1	3	85	9	2	NP	NP	NP	21	A-3a (0)	
		90–91.5	9 10 12	25	78	SS-24	-	-	-	-	-	-	-	-	-	21	A-3a (V)	
		92–94																

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 4/10/25 12:05 - X:\1ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2024 ARCHIVE\HAM-75-1.05\GINT FILES\HA

PID: 113361	SFN:	PROJECT: HAM-75-1.05	STATION / OFFSET: 110+26, 28' LT.	START: 11/29/21	END: 11/30/21	PG 4 OF 4	B-010-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 423.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, GRAY, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, TRACE GRAVEL, WET *(continued)*		95 – 96	11 11 12	26	72	SS-25	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
		100 – 101	10 13 13	30	83	SS-26	-	-	-	-	-	-	-	-	-	24	A-3a (V)	
	411.5	105 – 106 EOB	12 13 14	31	78	SS-27	-	-	-	-	-	-	-	-	-	21	A-3a (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 68.2' DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 230 GAL. BENTONITE GROUT

PROJECT: HAM-75-1.05	DRILLING FIRM / OPERATOR: NEAS / ASHBAUGH	DRILL RIG: CME 75T	STATION / OFFSET: 758+24, 54' RT.	EXPLORATION ID B-014-0-21
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / ASHBAUGH	HAMMER: CME AUTOMATIC	ALIGNMENT: WINCHELL AVE	
PID: 113361 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 5/1/19	ELEVATION: 505.4 (MSL) EOB: 51.5 ft.	PAGE 1 OF 2
START: 2/24/22 END: 2/24/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 89	LAT / LONG: 39.105714, -84.529250	

MATERIAL DESCRIPTION AND NOTES	ELEV. 505.4
7.0" ASPHALT AND 7.5" BASE (DRILLERS DESCRIPTION)	504.2
STIFF TO VERY STIFF, BROWN AND GRAY, **SILT AND CLAY**, TRACE TO LITTLE SAND, TRACE GRAVEL, MOIST	495.9
VERY STIFF, BROWN AND GRAY, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST	494.0
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, LITTLE CLAY, TRACE GRAVEL, MOIST	490.9
STIFF, BROWN AND GRAY, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	487.7
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME GRAVEL, TRACE SILT, TRACE CLAY, DAMP	485.9
STIFF, BROWN, **SILT AND CLAY**, LITTLE SAND, TRACE GRAVEL, MOIST	483.4
MEDIUM STIFF TO STIFF, BROWN, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST	479.9
VERY STIFF, BROWN, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, CONTAINS NO INTACT SOIL FOR HP READING, MOIST	477.8
MEDIUM DENSE, LIGHT BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE CLAY, TRACE GRAVEL, MOIST	

DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
3	5 7 6	19	100	SS-1	3.50	-	-	-	-	-	-	-	-	26	A-6a (V)	
5–6	4 4 5	13	100	SS-2	2.75	1	3	5	47	44	34	19	15	27	A-6a (10)	
8	5 5 6	16	100	SS-3	2.00	-	-	-	-	-	-	-	-	24	A-6a (V)	
10–11	7 4 6	15	100	SS-4	2.25	1	1	3	61	34	29	19	10	26	A-4b (8)	
13	4 4 5	13	100	SS-5	-	-	-	-	-	-	-	-	-	17	A-3a (V)	
15–16	6 5 5	15	100	SS-6	1.50	-	-	-	-	-	-	-	-	27	A-6a (V)	
18	5 4 7	16	100	SS-7	-	-	-	-	-	-	-	-	-	5	A-3a (V)	
20–21	6 6 7	19	100	SS-8	1.25	1	7	7	54	31	28	16	12	22	A-6a (9)	
23	6 7 7	21	100	SS-9	0.75	-	-	-	-	-	-	-	-	34	A-7-6 (V)	
25–26	5 6 8	21	100	SS-10A	1.25	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
				SS-10B	-	0	1	7	70	22	25	19	6	23	A-4b (8)	
28	7 7 9	24	72	SS-11	-	-	-	-	-	-	-	-	-	18	A-3a (V)	

PID: 113361	SFN:	PROJECT: HAM-75-1.05	STATION / OFFSET: 758+24, 54' RT.	START: 2/24/22	END: 2/24/22	PG 2 OF 2	B-014-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 475.4	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, LIGHT BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE CLAY, TRACE GRAVEL, MOIST *(continued)*	473.4	31 – 32	6 8 8	24	61	SS-12	-	-	-	-	-	-	-	-	-	16	A-3a (V)	
MEDIUM DENSE, LIGHT BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET	470.9	33 – 34	7 8 9	25	83	SS-13	-	0	0	2	90	8	NP	NP	NP	23	A-4b (8)	
MEDIUM DENSE, BROWN, **SILT**, SOME SAND, TRACE CLAY, TRACE GRAVEL, WET	467.1	35 – 38	6 8 10	27	100	SS-14	-	0	0	29	65	6	NP	NP	NP	24	A-4b (7)	
MEDIUM DENSE TO DENSE, BROWN, **SILT**, LITTLE TO SOME CLAY, LITTLE TO SOME SAND, TRACE GRAVEL, WET TO MOIST		39 – 41	7 7 11	27	78	SS-15	-	-	-	-	-	-	-	-	-	23	A-4b (V)	
		42 – 46	8 9 11	30	94	SS-16	-	-	-	-	-	-	-	-	-	22	A-4b (V)	
	453.9	47 – 51, EOB	9 8 13	31	100	SS-17	-	-	-	-	-	-	-	-	-	20	A-4b (V)	

NOTES: GROUNWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 110 GAL. BENTONITE GROUT

PROJECT: HAM-75-1.05	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 759+22, 10' RT.	EXPLORATION ID B-015-0-21
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: WINCHELL AVE	
PID: 113361 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 506.7 (MSL) EOB: 50.0 ft.	PAGE 1 OF 2
START: 3/10/22 END: 3/10/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.9	LAT / LONG: 39.105820, -84.529597	

MATERIAL DESCRIPTION AND NOTES	ELEV. 506.7	DEPTHS
3.0" ASPHALT AND 8.0" CONCRETE AND 6.0" BASE (DRILLERS DESCRIPTION)	505.3	
HARD, BROWN, **SANDY SILT**, SOME CLAY, TRACE GRAVEL, CONTAINS BRICK FRAGMENTS, DAMP **(FILL)**	502.2	
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE GRAVEL, TRACE CLAY, CONTAINS BRICK FRAGMENTS, DAMP **(FILL)**	499.7	
VERY STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, LITTLE GRAVEL, CONTAINS BRICK FRAGMENTS, DAMP **(FILL)**	497.2	
VERY STIFF, BROWN, **SILT AND CLAY**, SOME SAND, TRACE GRAVEL, DAMP	494.1	
MEDIUM DENSE, BROWN, **GRAVEL WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP	491.5	
STIFF, BROWN, **SANDY SILT**, LITTLE CLAY, TRACE GRAVEL, DAMP	489.7	W 489.2
SOFT TO MEDIUM STIFF, BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, MOIST	487.9	
MEDIUM DENSE, BROWN, **SILT**, SOME SAND, TRACE CLAY, TRACE GRAVEL, MOIST	484.7	
MEDIUM DENSE, BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET	482.2	
MEDIUM DENSE, BROWN, **SILT**, SOME SAND, TRACE CLAY, TRACE GRAVEL, MOIST	479.7	
MEDIUM DENSE, BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET		

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
3 4 6	14	100	SS-1	4.25	-	-	-	-	-	-	-	-	15	A-4a (V)	
3 5 6	15	100	SS-2	-	-	-	-	-	-	-	-	-	10	A-3a (V)	
4 4 7	15	100	SS-3	3.00	14	20	26	26	14	21	11	10	11	A-4a (1)	
3 3 4	10	100	SS-4	2.75	7	15	11	35	32	33	19	14	19	A-6a (8)	
3 4 10	19	100	SS-5	-	17	45	20	12	6	NP	NP	NP	5	A-1-b (0)	
3 3 4	10	100	SS-6	1.50	5	28	10	37	20	24	16	8	16	A-4a (4)	
2 2 4	8	100	SS-7	0.50	-	-	-	-	-	-	-	-	27	A-6a (V)	
3 7 10	23	100	SS-8	-	-	-	-	-	-	-	-	-	17	A-4b (V)	
4 7 8	20	100	SS-9	-	0	0	0	94	6	NP	NP	NP	25	A-4b (8)	
5 6 7	18	44	SS-10	-	-	-	-	-	-	-	-	-	16	A-4b (V)	
4 7 8	20	100	SS-11	-	-	-	-	-	-	-	-	-	25	A-4b (V)	

PID: 113361	SFN:	PROJECT: HAM-75-1.05	STATION / OFFSET: 759+22, 10' RT.	START: 3/10/22	END: 3/10/22	PG 2 OF 2	B-015-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 476.7	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET *(continued)*		31, 32	5 7 7	19	100	SS-12	-	-	-	-	-	-	-	-	-	24	A-4b (V)	
		33, 34	2 3 5	11	100	SS-13	-	0	0	2	89	9	NP	NP	NP	26	A-4b (8)	
		35, 36	3 4 6	14	100	SS-14	-	-	-	-	-	-	-	-	-	25	A-4b (V)	
		37, 38, 39																
		40, 41	3 4 5	12	100	SS-15	-	-	-	-	-	-	-	-	-	24	A-4b (V)	
	463.4	42, 43																
MEDIUM DENSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, WET		44, 45, 46	2 3 7	14	100	SS-16	-	0	0	50	46	4	NP	NP	NP	28	A-4a (3)	
		47, 48																
	456.7	49, EOB 50	2 4 5	12	100	SS-17	-	-	-	-	-	-	-	-	-	21	A-4a (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 17.5' DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

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

PROJECT: HAM-75-1.05
TYPE: RETAINING WALL
PID: 113361 SFN:
START: 2/23/22 END: 2/23/22

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

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

STATION / OFFSET: 760+71, 35' RT.
ALIGNMENT: WINCHELL AVE
ELEVATION: 507.1 (MSL) EOB: 51.5 ft.
LAT / LONG: 39.106145, -84.529913

EXPLORATION ID B-018-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 507.1
5.0" ASPHALT AND 6.0" CONCRETE AND 5.0" BASE (DRILLERS DESCRIPTION)	505.8
VERY STIFF TO HARD, BROWN, **SILT AND CLAY**, "AND" SAND, LITTLE GRAVEL, DAMP **(FILL)**	499.6
MEDIUM DENSE TO DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND**, LITTLE SILT, TRACE CLAY, DAMP **(FILL)**	495.1
MEDIUM DENSE TO DENSE, BROWN, **GRAVEL AND STONE FRAGMENTS WITH SAND AND SILT**, TRACE CLAY, (GRAVEL WITH SAND INTERBEDDED WITH SANDY SILT LAYERS), SS-7 CONTAINS BRICK AND CONCRETE FRAGMENTS, DAMP **(FILL)**	487.6
DENSE, BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET	484.5
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, SOME SILT, TRACE CLAY, TRACE GRAVEL, MOIST	483.2
MEDIUM DENSE, BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET	479.2
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, TRACE GRAVEL, DAMP	477.6

DEPTHS: 1–29

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
6 7 11	27	100	SS-1	2.75	-	-	-	-	-	-	-	-	9	A-6a (V)
5 8 12	30	100	SS-2	4.50	18	20	17	26	19	26	15	11	10	A-6a (2)
7 7 12	28	100	SS-3	-	-	-	-	-	-	-	-	-	9	A-1-b (V)
10 10 12	33	100	SS-4	-	33	25	17	15	10	NP	NP	NP	5	A-1-b (0)
9 9 10	28	100	SS-5	-	-	-	-	-	-	-	-	-	6	A-2-4 (V)
8 10 14	36	33	SS-6	-	-	-	-	-	-	-	-	-	6	A-2-4 (V)
9 8 12	30	78	SS-7	-	31	26	14	19	10	NP	NP	NP	8	A-2-4 (0)
8 10 12	33	56	SS-8	-	1	1	1	92	5	NP	NP	NP	22	A-4b (8)
10 10 10	30	39	SS-9	-	-	-	-	-	-	-	-	-	15	A-3a (V)
5 8 9	25	56	SS-10	-	1	0	4	86	9	NP	NP	NP	26	A-4b (8)
7 8 12	30	89	SS-11A	-	-	-	-	-	-	-	-	-	22	A-4b (V)
			SS-11B	-	-	-	-	-	-	-	-	-	8	A-3a (V)

HOLE SEALED

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 4/10/25 12:05 - X:\1ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2024 ARCHIVE\HAM-75-1.05\GINT FILES\HA

PID: 113361	SFN:	PROJECT: HAM-75-1.05	STATION / OFFSET: 760+71, 35' RT.	START: 2/23/22	END: 2/23/22	PG 2 OF 2	B-018-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 477.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE TO DENSE, BROWN BECOMING GRAY, **SILT**, TRACE TO LITTLE CLAY, TRACE TO LITTLE SAND, TRACE GRAVEL, WET *(continued)*		31	5 7 8	22	78	SS-12	-	-	-	-	-	-	-	-	-	25	A-4b (V)	
		32																
SS-13 CONTAINS IRON STAINING		33	6 8 9	25	78	SS-13	-	0	2	3	83	12	NP	NP	NP	25	A-4b (8)	
		34																
		35–36	5 5 7	18	89	SS-14	-	-	-	-	-	-	-	-	-	28	A-4b (V)	
		37–39																
		40–41	6 8 11	28	100	SS-15	-	-	-	-	-	-	-	-	-	22	A-4b (V)	
		42–44																
		45–46	7 8 13	31	100	SS-16	-	0	0	18	74	8	NP	NP	NP	25	A-4b (8)	
		47–49																
	455.6	50–51 EOB	8 8 12	30	100	SS-17	-	-	-	-	-	-	-	-	-	25	A-4b (V)	

NOTES: GROUNWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 110 GAL. BENTONITE GROUT

PROJECT: HAM-75-1.05	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 761+66, 11' RT.	EXPLORATION ID B-021-0-21
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: WINCHELL AVE	
PID: 113361 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 504.8 (MSL) EOB: 50.0 ft.	PAGE 1 OF 2
START: 2/21/22 END: 2/21/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.9	LAT / LONG: 39.106357, -84.530089	

MATERIAL DESCRIPTION AND NOTES	ELEV. 504.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)
2.0" ASPHALT AND 12.0" CONCRETE AND 6.0" BASE (DRILLERS DESCRIPTION)	503.3	1															
STIFF TO VERY STIFF, BROWN, **SILT AND CLAY**, "AND" SAND, LITTLE GRAVEL, CONTAINS BRICK FRAGMENTS, DAMP **(FILL)**		2, 3, 4	4 4 3	10	44	SS-1	1.75	-	-	-	-	-	-	-	-	14	A-6a (V)
	497.8	5, 6, 7	2 3 3	8	44	SS-2	2.00	11	20	17	28	24	32	17	15	14	A-6a (5)
VERY STIFF, BROWN WITH TRACE GRAY MOTTLES, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, CONTAINS IRON STAINING, MOIST		8, 9	2 2 2	5	100	SS-3	2.50	-	-	-	-	-	-	-	-	31	A-7-6 (V)
	492.8	10, 11, 12	2 2 1	4	100	SS-4	2.50	0	1	3	31	65	43	24	19	30	A-7-6 (12)
LOOSE TO MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE TO SOME SILT, TRACE CLAY, TRACE GRAVEL, DAMP		13, 14	2 2 2	5	100	SS-5	-	-	-	-	-	-	-	-	-	12	A-3a (V)
		15, 16, 17	2 5 6	15	100	SS-6	-	1	40	44	12	3	NP	NP	NP	4	A-3a (0)
	485.3	18, 19	2 3 5	11	39	SS-7	-	-	-	-	-	-	-	-	-	4	A-3a (V)
LOOSE, BROWN, **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP	482.8	20, 21, 22	2 3 4	10	56	SS-8	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, DAMP		23, 24	3 6 7	18	44	SS-9	-	-	-	-	-	-	-	-	-	6	A-3a (V)
		25, 26, 27	6 8 9	23	50	SS-10	-	0	1	84	12	3	NP	NP	NP	5	A-3a (0)
		28, 29	4 7 7	19	72	SS-11	-	-	-	-	-	-	-	-	-	8	A-3a (V)

HOLE SEALED

PID: 113361	SFN:	PROJECT: HAM-75-1.05	STATION / OFFSET: 761+66, 11' RT.	START: 2/21/22	END: 2/21/22	PG 2 OF 2	B-021-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 474.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, LITTLE SILT, TRACE CLAY, TRACE GRAVEL, DAMP *(continued)*		31	5/6/7	18	100	SS-12	-	-	-	-	-	-	-	-	-	23	A-3a (V)	
SS-12 BECOMES WET	473.5	W 472.3 / 32																
LOOSE TO MEDIUM DENSE, BROWNISH GRAY BECOMING GRAY, **SILT**, LITTLE TO SOME SAND, TRACE CLAY, TRACE GRAVEL, WET		33–34	2/4/6	14	100	SS-13	-	-	-	-	-	-	-	-	-	28	A-4b (V)	
		35–36	4/7/8	20	100	SS-14	-	0	0	30	61	9	NP	NP	NP	26	A-4b (7)	
		37–39																
		40–41	2/6/6	16	100	SS-15	-	-	-	-	-	-	-	-	-	27	A-4b (V)	
		42–44																
		45–46	2/3/3	8	100	SS-16	-	0	0	12	79	9	NP	NP	NP	28	A-4b (8)	
		47–48																
	454.8	49 – EOB 50	1/2/2	5	100	SS-17	-	-	-	-	-	-	-	-	-	29	A-4b (V)	

NOTES: GROUNDWATER ENCOUNTERED AT 32.5' DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

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

PROJECT: HAM-75-1.05	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 762+74, 17' RT.
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: WINCHELL AVE
PID: 113361 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 506.9 (MSL) EOB: 21.5 ft.
START: 2/1/22 END: 2/1/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.9	LAT / LONG: 39.106626, -84.530240

EXPLORATION ID B-022-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 506.9
2.0" ASPHALT AND 12.0" CONCRETE AND 6.0" BASE (DRILLERS DESCRIPTION)	505.2
HARD, BROWN, **SILT AND CLAY**, SOME SAND, LITTLE GRAVEL, DAMP	502.4
STIFF TO HARD, BROWN AND ORANGISH BROWN, **SILT AND CLAY**, TRACE SAND, TRACE GRAVEL, CONTAINS IRON STAINING, MOIST	497.4
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE GRAVEL, TRACE CLAY, DAMP	494.9
MEDIUM DENSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, DAMP	492.4
MEDIUM DENSE, BROWN, **COARSE AND FINE SAND**, TRACE SILT, TRACE GRAVEL, TRACE CLAY, DAMP	485.4

EOB

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)
6 13 9	30	28	SS-1	4.50	11	9	14	32	34	31	19	12	15	A-6a (7)
2 3 5	11	100	SS-2	4.50	-	-	-	-	-	-	-	-	27	A-6a (V)
3 3 5	11	100	SS-3	2.00	1	1	7	55	36	34	23	11	26	A-6a (8)
2 5 6	15	56	SS-4	-	-	-	-	-	-	-	-	-	3	A-3a (V)
1 4 8	16	100	SS-5	-	1	24	35	33	7	NP	NP	NP	13	A-4a (1)
3 9 10	26	100	SS-6	-	-	-	-	-	-	-	-	-	3	A-3a (V)
2 6 7	18	100	SS-7	-	-	-	-	-	-	-	-	-	7	A-3a (V)
5 8 8	22	100	SS-8	-	-	-	-	-	-	-	-	-	4	A-3a (V)

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

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

PROJECT: HAM-75-1.05	DRILLING FIRM / OPERATOR: NEAS / J. HODGES	DRILL RIG: CME 55X	STATION / OFFSET: 65+05, 211' RT.	EXPLORATION ID B-026-0-21
TYPE: BRIDGE	SAMPLING FIRM / LOGGER: NEAS / J. HODGES	HAMMER: CME AUTOMATIC	ALIGNMENT: IR-75	
PID: 113361 SFN:	DRILLING METHOD: 3.25" HSA	CALIBRATION DATE: 12/5/19	ELEVATION: 505.6 (MSL) EOB: 85.0 ft.	PAGE 1 OF 3
START: 1/26/22 END: 1/27/22	SAMPLING METHOD: SPT	ENERGY RATIO (%): 81.9	LAT / LONG: 39.107057, -84.530375	

DEPTHS: 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19, 20, 21, 22, 23, 24, 25, 26, 27, 28, 29

MATERIAL DESCRIPTION AND NOTES	ELEV. 505.6
MEDIUM DENSE, BROWN, **SANDY SILT**, TRACE CLAY, TRACE GRAVEL, CONTAINS COAL AND BRICK FRAGMENTS, MOIST **(FILL)**	497.1
HARD, BROWNISH GRAY, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST **(FILL)**	495.1
MEDIUM DENSE, BROWN AND GRAY, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, DAMP **(FILL)**	492.6
VERY STIFF, BROWN, **CLAY**, SOME SILT, TRACE SAND, TRACE GRAVEL, MOIST **(FILL)**	491.1
MEDIUM DENSE, BROWN, **SILT**, LITTLE CLAY, LITTLE SAND, TRACE GRAVEL, WET **(FILL)**	487.6
MEDIUM DENSE, BROWN AND GRAY, **GRAVEL WITH SAND**, TRACE SILT, TRACE CLAY, CONTAINS BRICK FRAGMENTS, DAMP **(FILL)**	486.1
MEDIUM DENSE, BROWN AND ORANGISH BROWN, **FINE SAND**, TRACE COARSE SAND, TRACE SILT, TRACE CLAY, TRACE GRAVEL, CONTAINS IRON STAINING, DAMP	484.2
MEDIUM DENSE, BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET	

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
6 5 3	11	22	SS-1	-	-	-	-	-	-	-	-	-	14	A-4a (V)	
1 5 6	15	39	SS-2	-	5	18	35	32	10	NP	NP	NP	16	A-4a (1)	
8 5 9	19	100	SS-3A	-	-	-	-	-	-	-	-	-	15	A-4a (V)	
			SS-3B	4.50	0	1	1	32	66	45	24	21	25	A-7-6 (13)	
7 5 9	19	100	SS-4A	4.50	-	-	-	-	-	-	-	-	24	A-7-6 (V)	
			SS-4B	-	-	-	-	-	-	-	-	-	2	A-1-b (V)	
8 5 9	19	100	SS-5A	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	
			SS-5B	4.00	-	-	-	-	-	-	-	-	28	A-7-6 (V)	
3 6 7	18	100	SS-6	-	0	0	13	73	14	NP	NP	NP	22	A-4b (8)	
3 11 10	29	100	SS-7A	-	-	-	-	-	-	-	-	-	21	A-4b (V)	
			SS-7B	-	-	-	-	-	-	-	-	-	10	A-1-b (V)	
3 8 7	20	100	SS-8	-	-	-	-	-	-	-	-	-	6	A-3 (V)	
2 4 8	16	100	SS-9	-	-	-	-	-	-	-	-	-	27	A-4b (V)	
2 4 5	12	100	SS-10	-	0	0	6	85	9	NP	NP	NP	24	A-4b (8)	

MATERIAL DESCRIPTION AND NOTES	ELEV. 475.6	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
MEDIUM DENSE, BROWN, **SILT**, TRACE CLAY, TRACE SAND, TRACE GRAVEL, WET *(continued)*		31	3 7 7	19	100	SS-11	-	-	-	-	-	-	-	-	-	24	A-4b (V)	
	472.3																	
MEDIUM DENSE, BROWN, **FINE SAND**, TRACE COARSE SAND, TRACE SILT, TRACE CLAY, TRACE GRAVEL, WET		36	4 4 4	11	100	SS-12	-	-	-	-	-	-	-	-	-	30	A-3 (V)	
	467.3																	
VERY STIFF, GRAY, **SILT**, SOME CLAY, TRACE SAND, TRACE GRAVEL, MOIST		41	3 4 5	12	100	SS-13	2.25	0	0	3	76	21	27	21	6	24	A-4b (8)	
	462.3																	
VERY LOOSE TO MEDIUM DENSE, GRAY, **SILT**, TRACE TO LITTLE CLAY, TRACE SAND, TRACE GRAVEL, WET		46	2 3 4	10	100	SS-14	-	-	-	-	-	-	-	-	-	25	A-4b (V)	
		51	2 3 4	10	100	SS-15	-	-	-	-	-	-	-	-	-	30	A-4b (V)	
		56	0 2 3	7	100	SS-16	-	0	0	1	86	13	NP	NP	NP	28	A-4b (8)	
		61	0 0 3	4	100	SS-17	-	-	-	-	-	-	-	-	-	32	A-4b (V)	

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 4/10/25 12:05 - X:\1ACTIVE PROJECTS\ACTIVE SOIL PROJECTS\1ARCHIVE\ARCHIVE BY YEAR\2024 ARCHIVE\HAM-75-1.05\GINT FILES\HAI

PID: 113361	SFN:	PROJECT: HAM-75-1.05	STATION / OFFSET: 65+05, 211' RT.	START: 1/26/22	END: 1/27/22	PG 3 OF 3	B-026-0-21

MATERIAL DESCRIPTION AND NOTES	ELEV. 443.5	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	HOLE SEALED
VERY LOOSE TO MEDIUM DENSE, GRAY, **SILT**, TRACE TO LITTLE CLAY, TRACE SAND, TRACE GRAVEL, WET *(continued)*		63 – 64																
		65 – 66	2 6 6	16	100	SS-18	-	0	0	8	85	7	NP	NP	NP	26	A-4b (8)	
	435.1	67 – 69																
MEDIUM DENSE, GRAY, **COARSE AND FINE SAND**, TRACE SILT, TRACE CLAY, TRACE GRAVEL, MOIST		70 – 71	2 6 7	18	100	SS-19A	-	-	-	-	-	-	-	-	-	21	A-4b (V)	
						SS-19B	-	-	-	-	-	-	-	-	-	16	A-3a (V)	
		72 – 74																
		75 – 76	4 6 7	18	100	SS-20	-	-	-	-	-	-	-	-	-	14	A-3a (V)	
		77 – 79																
		80 – 81	6 7 8	20	100	SS-21	-	-	-	-	-	-	-	-	-	14	A-3a (V)	
		82 – 83																
	420.6	84 – EOB 85	7 7 9	22	56	SS-22	-	-	-	-	-	-	-	-	-	12	A-3a (V)	

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING. HOLE DID NOT CAVE. DRILLED AS STAKED.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 50 GAL. BENTONITE GROUT; SHOVELED SOIL CUTTINGS

EXTERNAL STABILITY ANALYSIS

Objective: **To evaluate the external stability of CIP wall's with level backfill (no backslope).**
Method: **In accordance with ODOT Bridge Design Manual, 2019 [Sect. 204.6.2.2] LRFD Bridge Design Specifications, 8th Ed., Nov. 2017, [Sect. 11.6.1, Sect. 11.6.2, and Sect. 11.6.3].**

Givens:

Backfill Soil Design Parameters:

$\phi'_f := 30\ deg$ — Effective angle of internal friction

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

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

$\delta := 0.67 \cdot \phi'_f$ $\quad \delta = 20.1\ deg$ — Friction angle between backfill and wall taken as specified in **LRFD BDS C3.11.5.3 (degrees)**

Foundation Soil Design Parameters:

Drained Conditions (Effective Stress):

$\phi'_{fd} := 32\ deg$ — Effective angle of internal friction

$\gamma_{fd} := 120\ \frac{lbf}{ft^3}$ — Unit weight

$c'_{fd} := 0\ \frac{lbf}{ft^2}$ — Effective Cohesion

$\delta_{fd} := 0.67 \cdot \phi'_{fd}$ $\quad \delta_{fd} = 21.4\ deg$ — Friction angle between foundation soils and footing taken as specified in **LRFD BDS C3.11.5.3 (degrees)**

Undrained Conditions (Total Stress):

$\phi_{fdu} := 32\ deg$ — Angle of internal friction (Same as Drained Conditions if granular soils)

$\gamma_{fd} = 120\ \frac{lbf}{ft^3}$ — Unit weight

$Su_{fdu} := 0\ \frac{lbf}{ft^2}$ — Undrained Shear Strength

$\delta_{fdu} := 0.67 \cdot \phi_{fdu}$ $\quad \delta_{fdu} = 21.4\ deg$ — Friction angle between foundation soils and footing taken as specified in **LRFD BDS C3.11.5.3 (degrees)**

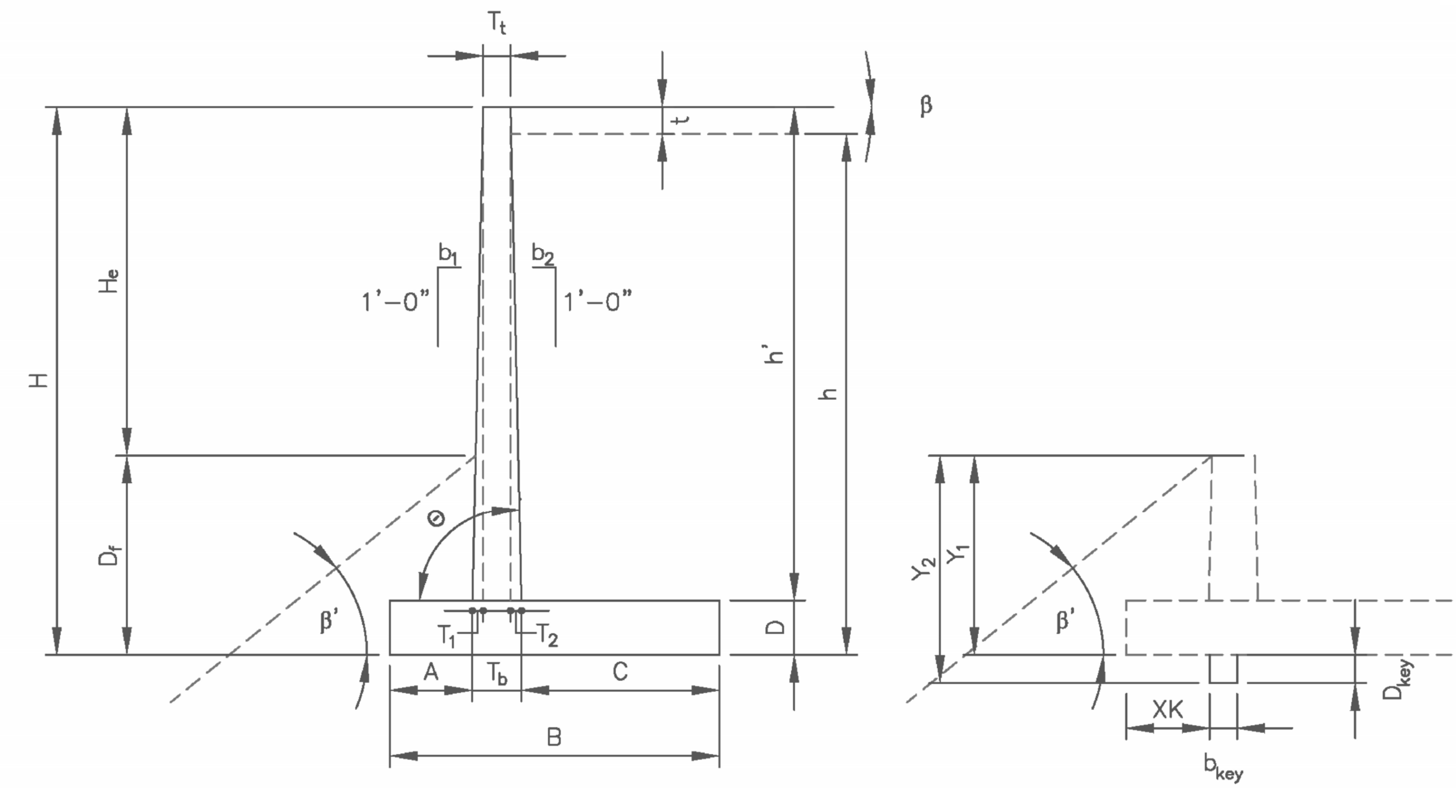
Foundation Surcharge Soil Parameters:

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

Other Parameters:

$\gamma_c := 150\ \frac{lbf}{ft^3}$ — Concrete Unit weight

$\gamma_p := 150\ \frac{lbf}{ft^3}$ — Pavement Unit weight



Wall Geometry:

$H_e := 5.75\ ft$ — Exposed wall height

$D_f := 4.75\ ft$ — Footing cover at Toe

Note: Where the potential for scour, erosion of undermining exists, spread footings shall be located to bear below the maximum depth of scour or undermining. Spread footings shall be located below the depth of potential frost. **LRFD BDS 10.6.1.2.**

$H := H_e + D_f$ $\quad H = 10.5\ ft$ — Design Wall Height

$T_t := 12\ in$ — Stem thickness at top of wall

$b_1 := 0 \cdot \left(\frac{in}{ft}\right)$ — Frontwall batter, (b1H:12V)

$b_2 := 0 \cdot \left(\frac{in}{ft}\right)$ — Backwall batter, (b2H:12V)

$\beta := 0\ deg$

Inclination of ground slope:

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

Inclination of ground slope behind face of wall. Horizontal backfill behind CIP wall, β = 0 deg

$\beta' := 0\ deg$

Inclination of ground slope in front of wall. If it is horizontal backfill in front of CIP wall, β' = 0 deg. A negative angle (-) indicates grades slope up from front of wall. Positive angle (+) indicates grade slope down from wall as shown in above figure.

$t := 0 \cdot ft$ — Pavement thickness

Preliminary Wall Dimensioning:

$B:=7\ ft$	$\frac{2}{5}\cdot H=4.2\ ft$	to	$\frac{3}{5}\cdot H=6.3\ ft$	Footing base width (2/5H to 3/5H)
$A:=5\ ft$	$\frac{H}{8}=1.31\ ft$	to	$\frac{H}{5}=2.1\ ft$	Toe projection (H/8 to H/5)
$D:=2\ ft$	$\frac{H}{8}=1.31\ ft$	to	$\frac{H}{5}=2.1\ ft$	Footing thickness (H/8 to H/5)

Shear Key Dimensioning:

$D_{key}:=1.5\ ft$ — Depth of shear key from bottom of footing
Note: Footings on rock typically require shear key

$b_{key}:=1.5\ ft$ — Width of shear key

$XK:=0$ — Distance from toe to shear key

Other Wall Dimensions:

$h':=H-D$	$h'=8.5\ ft$	Stem height
$T_1:=b_1\cdot h'$	$T_1=0\ ft$	Stem front batter width
$T_2:=b_2\cdot h'$	$T_2=0\ ft$	Stem back batter width
$T_b:=T_1+T_2+T_t$	$T_b=1\ ft$	Stem thickness at bottom of wall
$C:=B-A-T_b$	$C=1\ ft$	Heel projection
$\theta:=90\ deg$		Angle of back face of wall to horizontal = *atan(12/b2)*
$b:=12\ in$	$b=1\ ft$	Concrete strip width (for design)
$y_1:=D_f$	$y_1=4.8\ ft$	Depth to where passive pressure may begin to be utilized in front of wall. (Typically Df)
$y_2:=D_f+D_{key}$	$y_2=6.3\ ft$	Bottom of shear key/footing depth i.e. depth to where passive pressure may no longer be utilized.
$h:=H-t$	$h=10.5\ ft$	Height of retained fill at back of heel

Live Load Surcharge Parameters:

$\lambda:=1\ ft$ — Horizontal distance from the back of the wall to point of traffic surcharge load

$$SUR:=\text{if}\left(\lambda<\frac{H}{2},240\ \frac{lbf}{ft^2},100\ \frac{lbf}{ft^2}\right)=240\ \frac{lbf}{ft^2}$$

Live load surcharge (per LRFD BDS [3.11.6.4])
Note: If vehicular loading is within 1 ft of the backface of the wall and with a design height, H, less than 20 ft, see LRFD BDS Section 3.11.6.4 and Table 3.11.6.4-2 for adjusted surcharge load calculation.
Note: when λ< H/2, SUR equal 100 psf to account for construction loads

Calculations:

Earth Pressure Coefficients:

Backfill Active Earth:

$$\Gamma := \left(1+\sqrt{\frac{\left(\sin\left(\phi'_f+\delta\right)\cdot\sin\left(\phi'_f-\beta\right)\right)}{\left(\sin\left(\theta-\delta\right)\cdot\sin\left(\theta+\beta\right)\right)}}\right)^2 \qquad \Gamma = 2.687$$

$$k_{af} := \left(\frac{\left(\sin\left(\theta+\phi'_f\right)\right)^2}{\left(\Gamma\cdot\left(\sin\left(\theta\right)\right)^2\cdot\sin\left(\theta-\delta\right)\right)}\right) \qquad k_{af} = 0.297$$

Active Earth Pressure Coefficient (**per LRFD Sect. 3.11.5.3**)

Foundation Soil Passive Earth:

Drained Conditions assuming($\phi'_{fd} > 0$):
Input Parameters for **LRFD Figure 3.11.5.4-2**, assumes θ = 90 degrees

$$\frac{-\beta'}{\phi'_{fd}} = 0 \qquad \frac{-\delta_{fd}}{\phi'_{fd}} = -0.67$$

$k'_p := 7.71$ — Passive Earth Pressure Coefficient from **LRFD Figure 3.11.5.4-2**

Determine Reduction Factor (R) by interpolation:

$R_d := .839$ — Reduction Factor

$k_{pd} := R_d \cdot k'_p \qquad k_{pd} = 6.469$ — Passive Earth Pressure Coefficient for Drained Conditions

Undrained Conditions ($\phi_{fdu} > 0$): **Note:** Expand window below to complete calculation

Input Parameters for **LRFD Figure 3.11.5.4-2**, assumes θ = 90 degrees

$$\frac{-\beta'}{\phi_{fdu}} = 0 \qquad \frac{-\delta_{fdu}}{\phi_{fdu}} = -0.67$$

$k'_p := 7.71$ — Passive Earth Pressure Coefficient from **LRFD Figure 3.11.5.4-2**

Determine Reduction Factor (R) by interpolation:

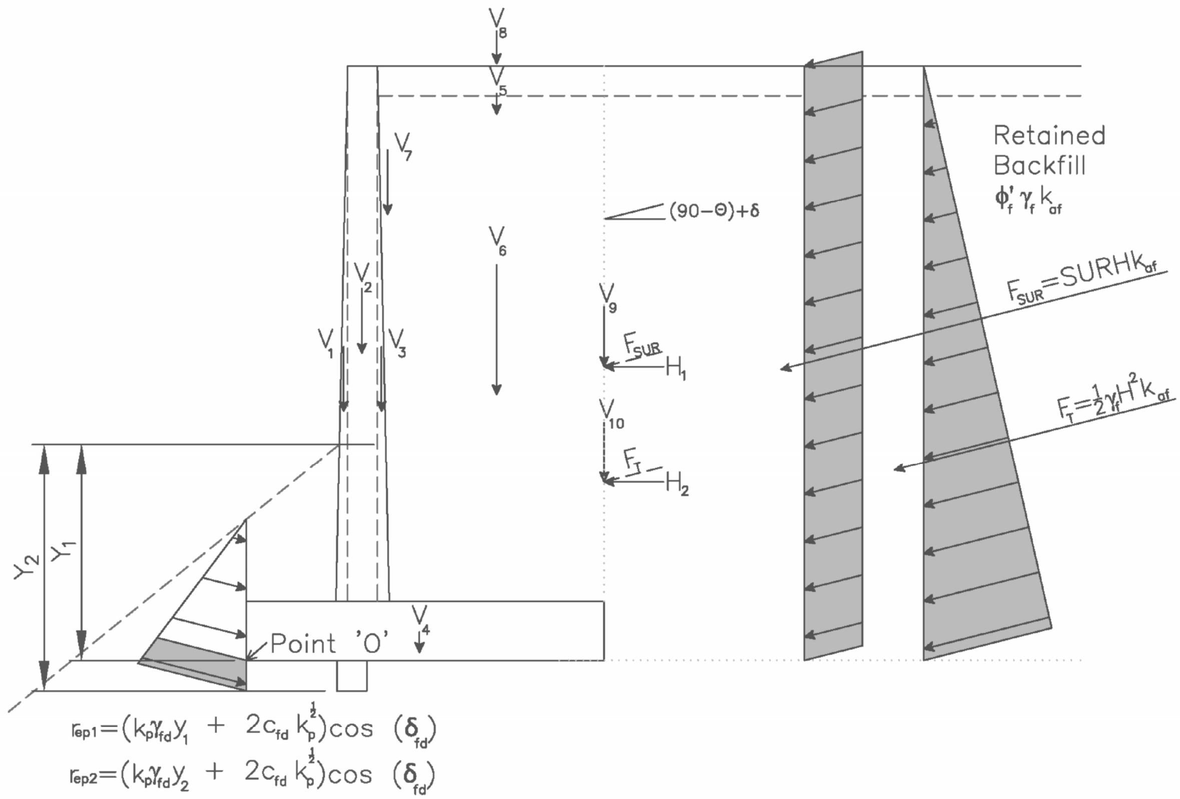
$R_{du} := .839$ — Reduction Factor

$k_{pu} := R_{du} \cdot k'_p \qquad k_{pu} = 6.469$ — Passive Earth Pressure Coefficient for Resistance Undrained Conditions

Undrained Conditions:

$k_{pu} := \text{if}\left(\phi_{fdu} > 0, k_{pu}, 1\right) \qquad k_{pu} = 6.469$ — Passive Earth Pressure Coefficient for Resistance Undrained Conditions

Compute Unfactored Loads LRFD [Tables 3.4.1-1 and 3.4.1-2]:



$F_T := \frac{1}{2} \cdot \gamma_f \cdot H^2 \cdot k_{af}$ | $F_T = 1966.4\ \frac{lbf}{ft}$ | Active Earth Force Resultant (EH)

$F_{SUR} := SUR \cdot H \cdot k_{af}$ | $F_{SUR} = 749.1\ \frac{lbf}{ft}$ | Live Load Surcharge (LS)

Vertical Loads:

$V_1 := \frac{1}{2} \cdot T_1 \cdot h' \cdot \gamma_c$ | $V_1 = 0\ \frac{lbf}{ft}$ | Wall stem front batter (DC)

$V_2 := T_t \cdot h' \cdot \gamma_c$ | $V_2 = 1275\ \frac{lbf}{ft}$ | Wall stem (DC)

$V_3 := \frac{1}{2} \cdot T_2 \cdot h' \cdot \gamma_c$ | $V_3 = 0\ \frac{lbf}{ft}$ | Wall stem back batter (DC)

$V_4 := D \cdot B \cdot \gamma_c$ | $V_4 = 2100\ \frac{lbf}{ft}$ | Wall Footing (DC)

$V_5 := t \cdot (T_2 + C) \cdot \gamma_p$ | $V_5 = 0\ \frac{lbf}{ft}$ | Pavement (DC)

$V_6 := C \cdot (h' - t) \cdot \gamma_f$ | $V_6 = 1020\ \frac{lbf}{ft}$ | Soil Backfill - Heel (EV)

$V_7 := \frac{1}{2} \cdot b_2 \cdot (h' - t)^2 \cdot \gamma_f$ | $V_7 = 0\ \frac{lbf}{ft}$ | Soil Backfill - Batter (EV)

$V_8 := SUR \cdot (T_2 + C)$ | $V_8 = 240\ \frac{lbf}{ft}$ | Live Load Surcharge above Heel- (LS) - Strength Ib

$V_9 := F_{SUR} \cdot \sin(90 \cdot deg - \theta + \delta)$ | $V_9 = 257.4\ \frac{lbf}{ft}$ | Live Load Surcharge Resultant (vertical comp. - LS) - Strength Ia

$V_{10} := F_T \cdot \sin(90 \cdot deg - \theta + \delta)$ | $V_{10} = 675.8\ \frac{lbf}{ft}$ | Active earth force resultant (vertical component - EH)

$V_{11} := A \cdot (D_f - D) \cdot \gamma_f$ | $V_{11} = 1650\ \frac{lbf}{ft}$ | Soil Backfill - Toe (EV)

Moment Arm: Moment:

Moments produced from vertical loads about Point 'O'

$d_{v1} := A + \frac{2}{3} \cdot T_1 = 5\ ft$ $MV_1 := V_1 \cdot d_{v1} = 0\ lbf$

$d_{v2} := A + T_1 + \frac{T_t}{2} = 5.5\ ft$ $MV_2 := V_2 \cdot d_{v2} = 7012.5\ lbf$

$d_{v3} := A + T_1 + T_t + \frac{T_2}{3} = 6\ ft$ $MV_3 := V_3 \cdot d_{v3} = 0\ lbf$

$d_{v4} := \frac{B}{2} = 3.5\ ft$ $MV_4 := V_4 \cdot d_{v4} = 7350\ lbf$

$d_{v5} := B - \frac{T_2 + C}{2} = 6.5\ ft$ $MV_5 := V_5 \cdot d_{v5} = 0\ lbf$

$d_{v6} := B - \frac{C}{2} = 6.5\ ft$ $MV_6 := V_6 \cdot d_{v6} = 6630\ lbf$

$d_{v7} := A + T_1 + T_t + \left(\frac{2}{3} \cdot b_2 \cdot (h' - t)\right) = 6\ ft$ $MV_7 := V_7 \cdot d_{v7} = 0\ lbf$

$d_{v8} := B - \frac{T_2 + C}{2} = 6.5\ ft$ $MV_8 := V_8 \cdot d_{v8} = 1560\ lbf$

$d_{v9} := B = 7\ ft$ $MV_9 := V_9 \cdot d_{v9} = 1802\ lbf$

$d_{v10} := B = 7\ ft$ $MV_{10} := V_{10} \cdot d_{v10} = 4730.3\ lbf$

$d_{v11} := \frac{A}{2} = 2.5\ ft$ $MV_{11} := V_{11} \cdot d_{v11} = 4125\ lbf$

Horizontal Loads:

$H_1 := F_{SUR} \cdot \cos(90 \cdot deg - \theta + \delta)$ $H_1 = 703.5\ \frac{lbf}{ft}$ Live Load Surcharge Resultant (horizontal comp. - LS)

$H_2 := F_T \cdot \cos(90 \cdot deg - \theta + \delta)$ $H_2 = 1846.6\ \frac{lbf}{ft}$ Active Earth Force Resultant (horizontal comp. - EH)

Moment Arm: Moment:

$d_{h1} := \frac{H}{2}$ $d_{h1} = 5.3\ ft$ $MH_1 := H_1 \cdot d_{h1}$ $MH_1 = 3693.2\ \frac{lbf \cdot ft}{ft}$

$d_{h2} := \frac{H}{3}$ $d_{h2} = 3.5\ ft$ $MH_2 := H_2 \cdot d_{h2}$ $MH_2 = 6463.1\ \frac{lbf \cdot ft}{ft}$

Unfactored Loads by Load Type:

$V_{DC} := V_1 + V_2 + V_3 + V_4 + V_5$ $V_{DC} = 3375\ \frac{lbf}{ft}$ $V_{EV} := V_6 + V_7 + V_{11}$ $V_{EV} = 2670\ \frac{lbf}{ft}$

$V_{LS\_Ia} := V_9$ $V_{LS\_Ia} = 257.4\ \frac{lbf}{ft}$ $V_{LS\_Ib} := V_8 + V_9$ $V_{LS\_Ib} = 497.4\ \frac{lbf}{ft}$

$V_{EH} := V_{10}$ $V_{EH} = 675.8\ \frac{lbf}{ft}$ $H_{LS} := H_1$ $H_{LS} = 703.5\ \frac{lbf}{ft}$

$H_{EH} := H_2$ $H_{EH} = 1846.6\ \frac{lbf}{ft}$

Unfactored Moments by Load Type

$M_{DC} := MV_1 + MV_2 + MV_3 + MV_4 + MV_5$ $\qquad M_{DC} = 14362.5\ \frac{lbf \cdot ft}{ft}$

$M_{EV} := MV_6 + MV_7 + MV_{11}$ $\qquad M_{EV} = 10755\ \frac{lbf \cdot ft}{ft}$

$M_{LSV\_Ia} := MV_9$ $\qquad M_{LSV\_Ia} = 1802\ \frac{lbf \cdot ft}{ft}$

$M_{LSV\_Ib} := MV_8 + MV_9$ $\qquad M_{LSV\_Ib} = 3362\ \frac{lbf \cdot ft}{ft}$

$M_{EH1} := MV_{10}$ $\qquad M_{EH1} = 4730.3\ \frac{lbf \cdot ft}{ft}$

$M_{LSH} := MH_1$ $\qquad M_{LSH} = 3693.2\ \frac{lbf \cdot ft}{ft}$

$M_{EH2} := MH_2$ $\qquad M_{EH2} = 6463.1\ \frac{lbf \cdot ft}{ft}$

Load Combination Limit States:

$\eta := 1$ LRFD Load Modifier

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

Strength Limit State Ia: (Sliding and Eccentricity) $Ia_{DC} := 0.9$ $\quad Ia_{EV} := 1$ $\quad Ia_{EH} := 1.5$ $\quad Ia_{LS} := 1.75$

Strength Limit State Ib: (Bearing Capacity) $Ib_{DC} := 1.25$ $\quad Ib_{EV} := 1.35$ $\quad Ib_{EH} := 1.5$ $\quad Ib_{LS} := 1.75$

Factored Vertical Loads by Limit State:

$V_{Ia} := \eta \cdot \left(\left(Ia_{DC} \cdot V_{DC} \right) + \left(Ia_{EV} \cdot V_{EV} \right) + \left(Ia_{EH} \cdot V_{EH} \right) + \left(Ia_{LS} \cdot V_{LS\_Ia} \right) \right)$ $\qquad V_{Ia} = 7171.7\ \frac{lbf}{ft}$

$V_{Ib} := \eta \cdot \left(\left(Ib_{DC} \cdot V_{DC} \right) + \left(Ib_{EV} \cdot V_{EV} \right) + \left(Ib_{EH} \cdot V_{EH} \right) + \left(Ib_{LS} \cdot V_{LS\_Ib} \right) \right)$ $\qquad V_{Ib} = 9707.4\ \frac{lbf}{ft}$

Factored Horizontal Loads by Limit State:

$H_{Ia} := \eta \cdot \left(\left(Ia_{LS} \cdot H_{LS} \right) + \left(Ia_{EH} \cdot H_{EH} \right) \right)$ $\qquad H_{Ia} = 4001\ \frac{lbf}{ft}$

$H_{Ib} := \eta \cdot \left(\left(Ib_{LS} \cdot H_{LS} \right) + \left(Ib_{EH} \cdot H_{EH} \right) \right)$ $\qquad H_{Ib} = 4001\ \frac{lbf}{ft}$

Factored Moments Produced by Vertical Loads by Limit State:

$MV_{Ia} := \eta \cdot \left(\left(Ia_{DC} \cdot M_{DC} \right) + \left(Ia_{EV} \cdot M_{EV} \right) + \left(Ia_{EH} \cdot M_{EH1} \right) + \left(Ia_{LS} \cdot M_{LSV\_Ia} \right) \right)$ $\qquad MV_{Ia} = 33930.3\ \frac{lbf \cdot ft}{ft}$

$MV_{Ib} := \eta \cdot \left(\left(Ib_{DC} \cdot M_{DC} \right) + \left(Ib_{EV} \cdot M_{EV} \right) + \left(Ib_{EH} \cdot M_{EH1} \right) + \left(Ib_{LS} \cdot M_{LSV\_Ib} \right) \right)$ $\qquad MV_{Ib} = 45451.5\ \frac{lbf \cdot ft}{ft}$

Factored Moments Produced by Horizontal Loads by Limit State:

$MH_{Ia} := \eta \cdot \left(\left(Ia_{LS} \cdot M_{LSH} \right) + \left(Ia_{EH} \cdot M_{EH2} \right) \right)$ $\qquad MH_{Ia} = 16157.8\ \frac{lbf \cdot ft}{ft}$

$MH_{Ib} := \eta \cdot \left(\left(Ib_{LS} \cdot M_{LSH} \right) + \left(Ib_{EH} \cdot M_{EH2} \right) \right)$ $\qquad MH_{Ib} = 16157.8\ \frac{lbf \cdot ft}{ft}$

Compute Bearing Resistance:

Compute the resultant location about the toe of the base length (distance from "O") Strength Ib:

$\Sigma M_R := MV_{Ib}$	$\Sigma M_R = 45451.5\ \frac{lbf \cdot ft}{ft}$	Sum of Resisting Moments (Strength Ib)
$\Sigma M_O := MH_{Ib}$	$\Sigma M_O = 16157.8\ \frac{lbf \cdot ft}{ft}$	Sum of Overturning Moments (Strength Ib)
$\Sigma V := V_{Ib}$	$\Sigma V = 9707.4\ \frac{lbf}{ft}$	Sum of Vertical Loads (Strength Ib)
$x := \frac{(\Sigma M_R - \Sigma M_O)}{\Sigma V}$	$x = 3\ ft$	Distance from Point "O" the resultant intersects the base
$e := \left\lvert \frac{B}{2} - x \right\rvert$	$e = 0.48\ ft$	Wall eccentricity, **Note:** The vertical stress is assumed to be uniformly distributed over the effective bearing width, B', since the wall is supported by a soil foundation **LRFD [11.6.3.2]**. The effective bearing width is equal to B-2e. When the foundation eccentricity is negative the absolute value is used.

Foundation Layout:

$B' := B - 2 \cdot e$	$B' = 6\ ft$	Effective Footing Width
$L' := 29.5\ ft$		Effective Footing Length (Assumed)
$H' := H_{Ib}$	$H' = 4001\ \frac{lbf}{ft}$	Summation of Horizontal Loads (Strength Ib)
$V' := V_{Ib}$	$V' = 9707.4\ \frac{lbf}{ft}$	Summation of Vertical Loads (Strength Ib)
$D_f = 4.8\ ft$		Footing embedment
$d_w := 4.75\ ft$		Depth of Groundwater below ground surface at front of wall.

Drained Conditions (Effective Stress):

$$N_q := \text{if}\left(\phi'_{fd} > 0, e^{\pi \cdot \tan(\phi'_{fd})} \cdot \tan\left(45\ deg + \frac{\phi'_{fd}}{2}\right)^2, 1.0\right) \qquad N_q = 23.18$$

$$N_c := \text{if}\left(\phi'_{fd} > 0, \frac{N_q - 1}{\tan(\phi'_{fd})}, 5.14\right) \qquad N_c = 35.49$$

$$N_\gamma := 2 \cdot (N_q + 1) \cdot \tan(\phi'_{fd}) \qquad N_\gamma = 30.2$$

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

$$s_c := \text{if}\left(\phi'_{fd} > 0, 1 + \left(\frac{B'}{L'}\right) \cdot \left(\frac{N_q}{N_c}\right), 1 + \left(\frac{B'}{5 \cdot L'}\right)\right) \qquad s_c = 1.134$$

$$s_q := \text{if}\left(\phi'_{fd} > 0, 1 + \left(\frac{B'}{L'} \cdot \tan(\phi'_{fd})\right), 1\right) \qquad s_q = 1.128$$

$$s_\gamma := \text{if}\left(\phi'_{fd} > 0, 1 - 0.4 \cdot \left(\frac{B'}{L'}\right), 1\right) \qquad s_\gamma = 0.918$$

Load inclination factors:

$i_q := 1$

$i_\gamma := 1$

$i_c := 1$

Assumed to be 1.0, see **LRFD BDS C10.6.3.1.2a**. "Most geotechnical engineers do not used the load inclination factors". If desired, use LRFD Equations [10.6.3.1.2a-5] thru [10.6.3.1.2a-9].

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

$C_{wq} := \text{if}\left(d_w \ge D_f, 1.0, 0.5\right)$ $\qquad C_{wq} = 1$

$C_{w\gamma} := \text{if}\left(d_w \ge (1.5 \cdot B) + D_f, 1.0, 0.5\right)$ $\qquad C_{w\gamma} = 0.5$

Depth Correction Factor per Hanson (1970):

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

$d_q = 1.19$

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

$N_{cm} := N_c \cdot s_c \cdot i_c$ $\qquad N_{cm} = 40.232$

$N_{qm} := N_q \cdot s_q \cdot i_q$ $\qquad N_{qm} = 26.14$

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $\qquad N_{\gamma m} = 27.742$

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

$q_{nd} := c'_{fd} \cdot N_{cm} + \gamma_{fd} \cdot D_f \cdot N_{qm} \cdot d_q \cdot C_{wq} + 0.5 \cdot \gamma_{fd} \cdot B' \cdot N_{\gamma m} \cdot C_{w\gamma}$ $\qquad q_{nd} = 22714.7 \ \frac{lbf}{ft^2}$

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

$\phi_b := .55$ $\qquad$ Bearing resistance factor **LRFD Table 11.5.7-1.**

$q_{Rd} := \phi_b \cdot q_{nd}$ $\qquad q_{Rd} = 12.5 \ ksf$ $\qquad$ Factored bearing resistance Drained Conditions

Undrained Conditions (Effective Stress):

$N_q := \text{if}\left(\phi_{fdu} > 0, e^{\pi \cdot \tan\left(\phi_{fdu}\right)} \cdot \tan\left(45 \ deg + \frac{\phi_{fdu}}{2}\right)^2, 1.0\right)$ $\qquad N_q = 23.18$

$N_c := \text{if}\left(\phi_{fdu} > 0, \frac{N_q - 1}{\tan\left(\phi_{fdu}\right)}, 5.14\right)$ $\qquad N_c = 35.49$

$N_\gamma := 2 \cdot \left(N_q + 1\right) \cdot \tan\left(\phi_{fdu}\right)$ $\qquad N_\gamma = 30.2$

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

$$s_c := \text{if}\left(\phi_{fdu} > 0, 1 + \left(\frac{B'}{L'}\right) \cdot \left(\frac{N_q}{N_c}\right), 1 + \left(\frac{B'}{5 \cdot L'}\right)\right)$$ $s_c = 1.134$

$$s_q := \text{if}\left(\phi_{fdu} > 0, 1 + \left(\frac{B'}{L'} \cdot \tan(\phi_{fdu})\right), 1\right)$$ $s_q = 1.128$

$$s_\gamma := \text{if}\left(\phi_{fdu} > 0, 1 - 0.4 \cdot \left(\frac{B'}{L'}\right), 1\right)$$ $s_\gamma = 0.918$

Load inclination factors:

$i_q := 1$

$i_\gamma := 1$

$i_c := 1$

Assumed to be 1.0, see **LRFD BDS C10.6.3.1.2a**. "Most geotechnical engineers do not used the load inclination factors". If desired, use LRFD Equations [10.6.3.1.2a-5] thru [10.6.3.1.2a-9].

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

$N_{cm} := N_c \cdot s_c \cdot i_c$ $N_{cm} = 40.232$

$N_{qm} := N_q \cdot s_q \cdot i_q$ $N_{qm} = 26.14$

$N_{\gamma m} := N_\gamma \cdot s_\gamma \cdot i_\gamma$ $N_{\gamma m} = 27.742$

Depth Correction Factor per Hanson (1970):

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

$d_q = 1.19$

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

$$q_{nu} := Su_{fdu} \cdot N_{cm} + \gamma_{fd} \cdot D_f \cdot N_{qm} \cdot d_q \cdot C_{wq} + 0.5 \cdot \gamma_{fd} \cdot B' \cdot N_{\gamma m} \cdot C_{w\gamma}$$ $q_{nu} = 22714.7 \ \frac{lbf}{ft^2}$

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

$\phi_b := .55$ Bearing resistance factor **LRFD Table 11.5.7-1.**

$q_{Ru} := \phi_b \cdot q_{nu}$ $q_{Ru} = 12.5 \ ksf$ Factored bearing resistance Undrained Conditions

Factored Bearing Resistance Drained vs. Undrained Conditions:

Drained Conditions: $q_{Rd} = 12.5 \ ksf$

Undrained Conditions: $q_{Ru} = 12.5 \ ksf$

Evaluate External Stability of Wall:

Compute the ultimate bearing stress :

$e = 0.48\ ft$

$\sigma_V := \dfrac{\Sigma V}{B - 2 \cdot e}$ $\sigma_V = 1.608\ ksf$

Bearing Capacity:Demand Ratio (CDR)

Drained Conditions: $CDR_{Bearing\_D} := \dfrac{q_{Rd}}{\sigma_V}$ Is the CDR > or = to 1.0? $CDR_{Bearing\_D} = 7.77$

Undrained Conditions: $CDR_{Bearing\_U} := \dfrac{q_{Ru}}{\sigma_V}$ Is the CDR > or = to 1.0? $CDR_{Bearing\_U} = 7.77$

Limiting Eccentricity at Base of Wall (Strength Ia):

Compute the resultant location about the toe "O" of the base length (distance from Pivot):

$e_{max} := \dfrac{B}{3}$ $e_{max} = 2.3\ ft$ Maximum Eccentricity **LRFD [11.6.3.3.] Equals B/3 for soil.**

$\Sigma M_R := MV_{Ia}$ $\Sigma M_R = 33930.3\ \dfrac{lbf \cdot ft}{ft}$ Sum of Resisting Moments (Strength Ia)

$\Sigma M_O := MH_{Ia}$ $\Sigma M_O = 16157.8\ \dfrac{lbf \cdot ft}{ft}$ Sum of Overturning Moments (Strength Ia)

$\Sigma V := V_{Ia}$ $\Sigma V = 7171.7\ \dfrac{lbf}{ft}$ Sum of Vertical Loads (Strength Ia)

$x := \dfrac{(\Sigma M_R - \Sigma M_O)}{\Sigma V}$ $x = 2.5\ ft$ Distance from Point "O" the resultant intersects the base

$e := \text{abs}\left(\dfrac{B}{2} - x\right)$ $e = 1.02\ ft$ Wall eccentricity, **Note:** The vertical stress is assumed to be uniformly distributed over the effective bearing width, B', since the wall is supported by a soil foundation **LRFD [11.6.3.2**]. The effective bearing width is equal to B-2e. .

Eccentricity Capacity:Demand Ratio (CDR)

$CDR_{Eccentricity} := \dfrac{e_{max}}{e}$ Is the CDR > or = to 1.0? $CDR_{Eccentricity} = 2.28$

Sliding Resistance at Base of Wall LRFD [10.6.3.4]:

Factored Sliding Force (Strength Ia):

$R_u := H_{Ia}$ $\qquad R_u = 4001\ \frac{lbf}{ft}$

Drained Conditions (Effective Stress):

Compute passive resistance throughout the design life of the wall **LRFD [Eq 3.11.5.4-1]:**:

$r_{ep1} := \left(k_{pd} \cdot \gamma_{fd} \cdot y_1 + 2 \cdot c'_{fd} \cdot \sqrt{k_{pd}}\right) \cdot \cos\left(\delta_{fd}\right)$ Nominal passive pressure at y1

$r_{ep2} := \left(k_{pd} \cdot \gamma_{fd} \cdot y_2 + 2 \cdot c'_{fd} \cdot \sqrt{k_{pd}}\right) \cdot \cos\left(\delta_{fd}\right)$ Nominal passive pressure at y2

$R_{ep} := \frac{r_{ep1} + r_{ep2}}{2} \cdot \left(y_2 - y_1\right)$ $\qquad R_{ep} = 5960.9\ \frac{lbf}{ft}$ Nominal passive resistance Drained Conditions

416 Note: Passive Resistance shall be neglected in stability computations, unless the base of the wall extends below the depth of maximum scour, freeze-thaw or other disturbances. In the latter case, only the embedment below the greater of these depths shall be considered effective **LRFD [11.6.3.5**].

Compute sliding resistance between soil and foundation:

$c := 1.0$ c = 1.0 for Cast-in-Place
c = 0.8 for Precast

$\Sigma V := V_{Ia}$ $\qquad \Sigma V = 7171.7\ \frac{lbf}{ft}$ Sum of Vertical Loads (Strength Ia)

$R_\tau := c \cdot \Sigma V \cdot \tan\left(\phi'_{fd}\right)$ $\qquad R_\tau = 4481.3\ \frac{lbf}{ft}$ Nominal sliding resistance Cohesionless Soils

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

$\phi_{ep} := 0.5$ Resistance factor for passive resistance specified in **LRFD Table 10.5.5.2.2-1**

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

$\phi R_n := \phi_\tau \cdot R_\tau + \phi_{ep} \cdot R_{ep}$ $\qquad R_R := \phi R_n$

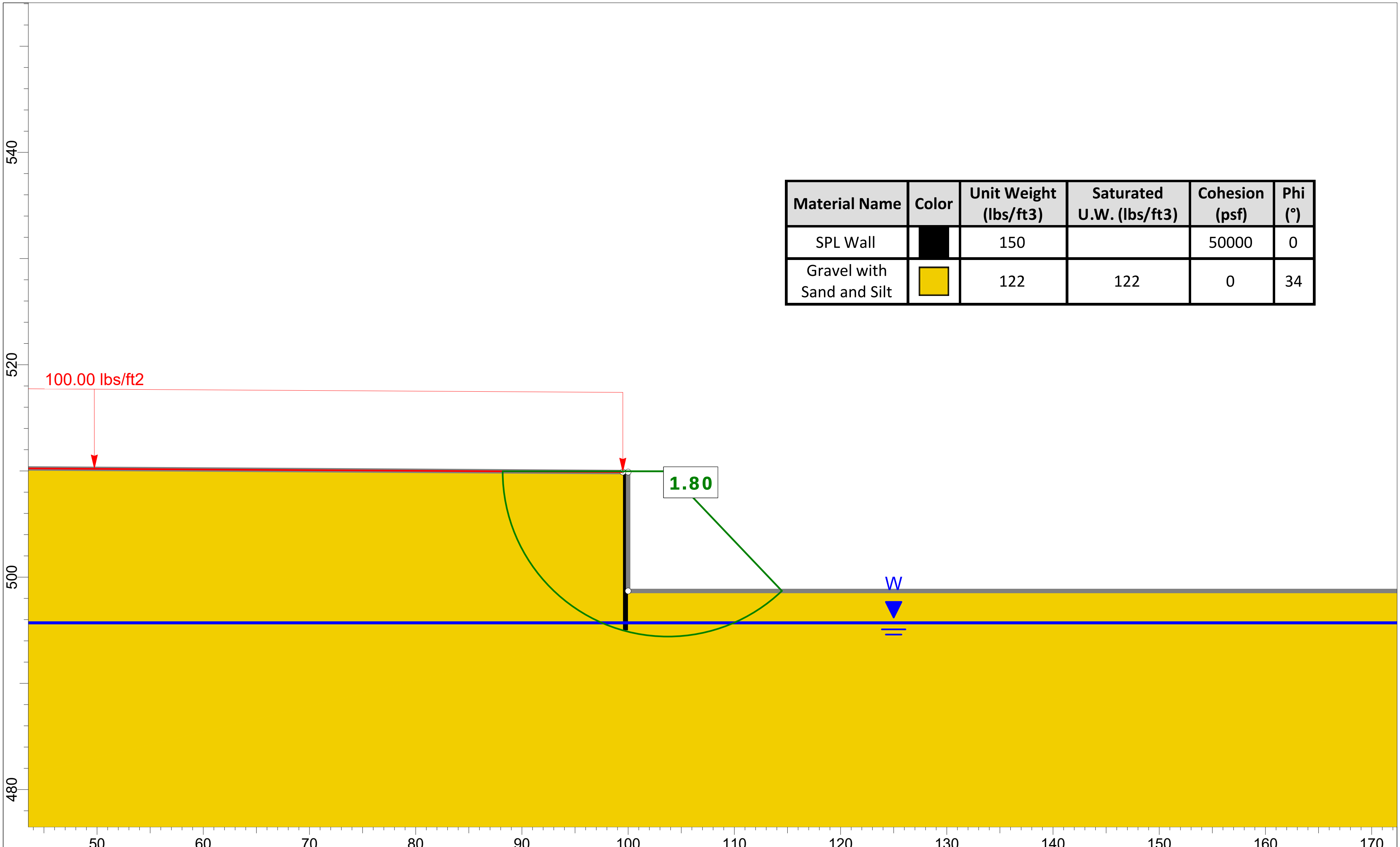
Factored Sliding Resistance to be used in CDR Calculations: $R_R = 7461.773\ \frac{lbf}{ft}$

Sliding Capacity:Demand Ratio (CDR)

$CDR_{Sliding} := \frac{R_R}{R_u}$ Is the CDR > or = to 1.0? $CDR_{Sliding} = 1.86$

GLOBAL STABILITY ANALYSIS

STA. 1+00 (RW-2 ALIGNMENT)

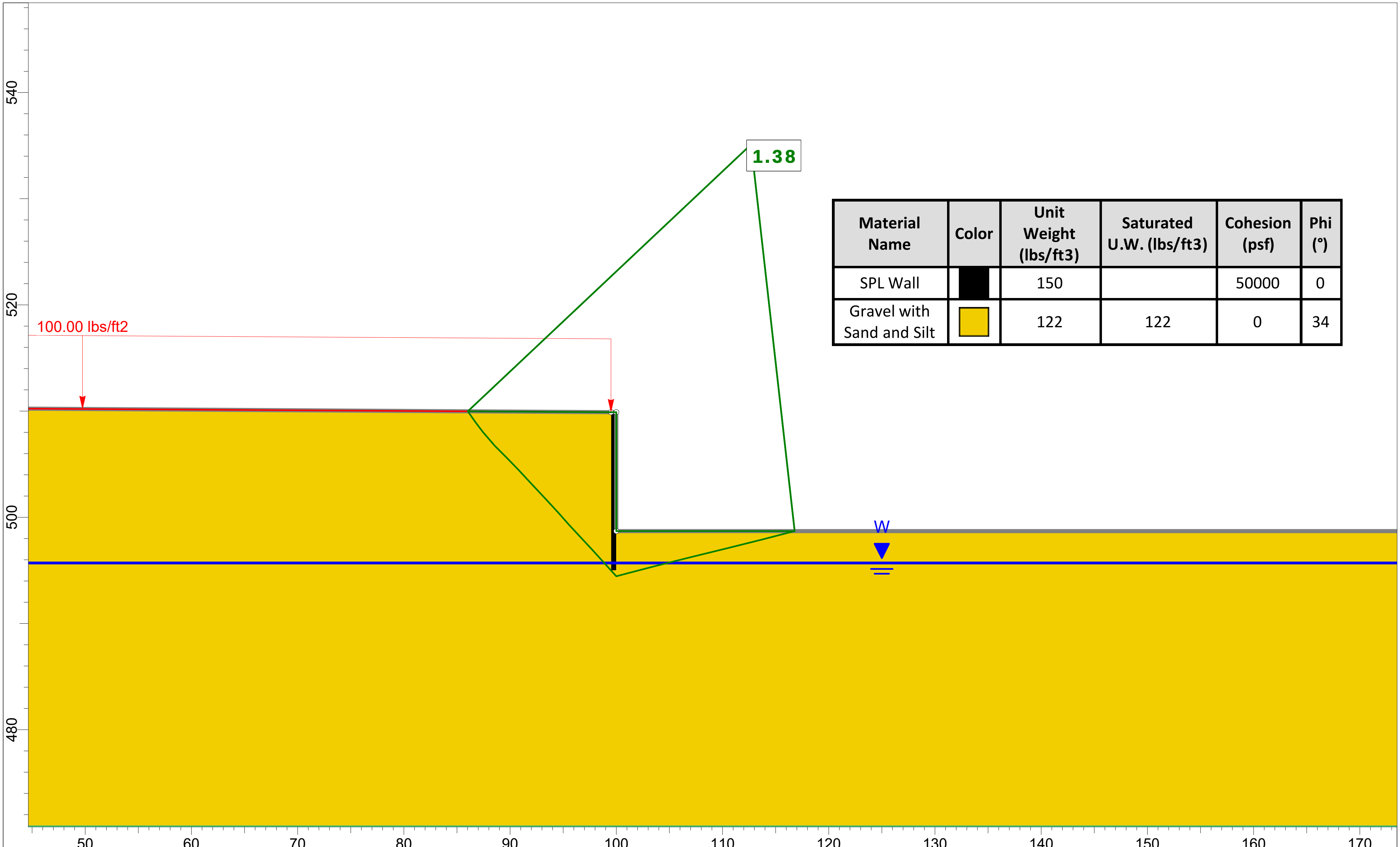


Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Cohesion (psf)	Phi (°)
SPL Wall		150		50000	0
Gravel with Sand and Silt		122	122	0	34

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Effective - Circular	*Scenario*	STA. 1+00 (RW-2)
Drawn By	KCA	*Company*	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	*File Name*	RW-2_STA1+00_031825.slmd



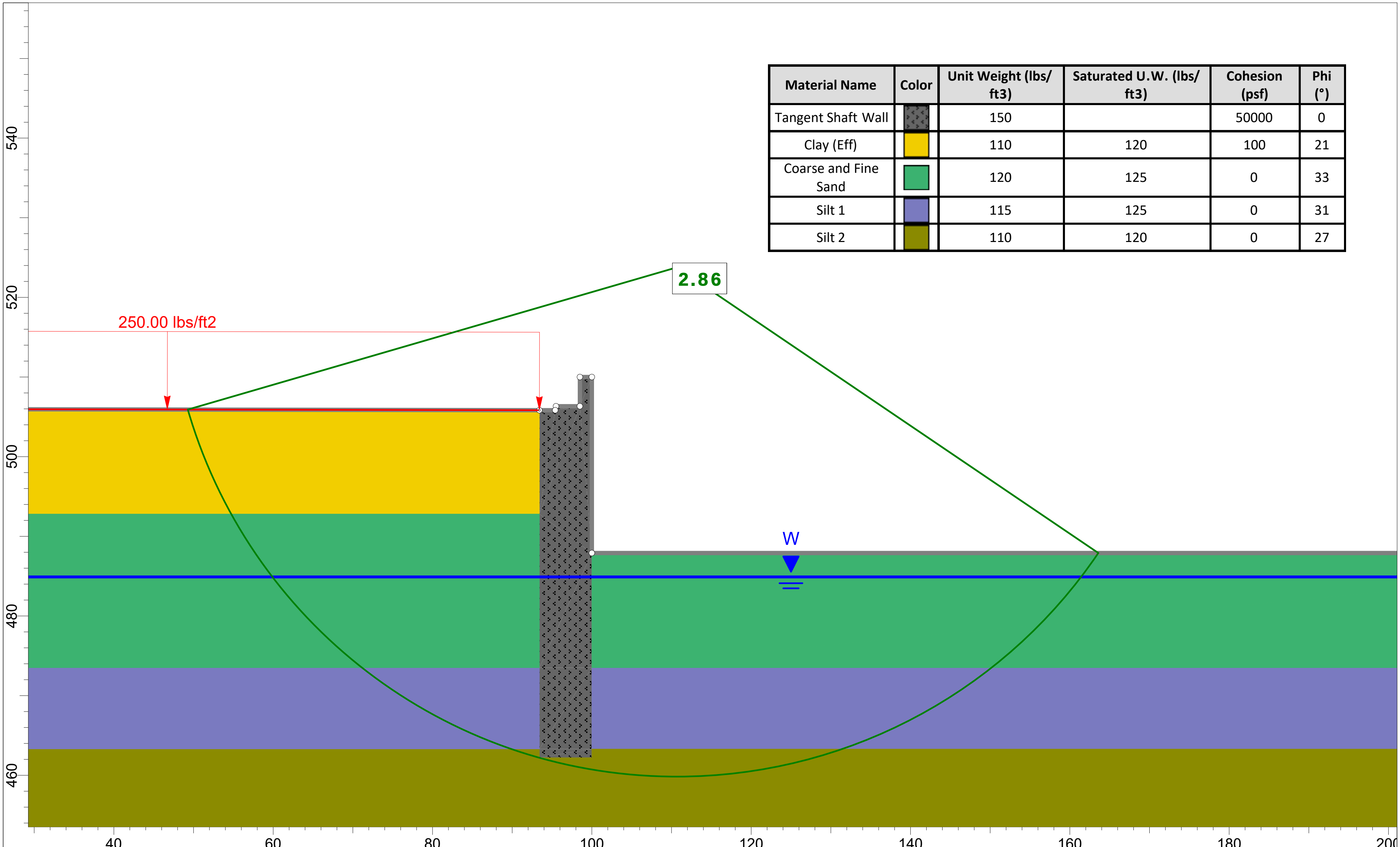
Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Cohesion (psf)	Phi (°)
SPL Wall		150		50000	0
Gravel with Sand and Silt		122	122	0	34

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Effective - Non-Circular	Scenario	STA. 1+00 (RW-2)
Drawn By	KCA	Company	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	File Name	RW-2_STA1+00_031825.slmd

STA. 6+90 (RW-2 ALIGNMENT)

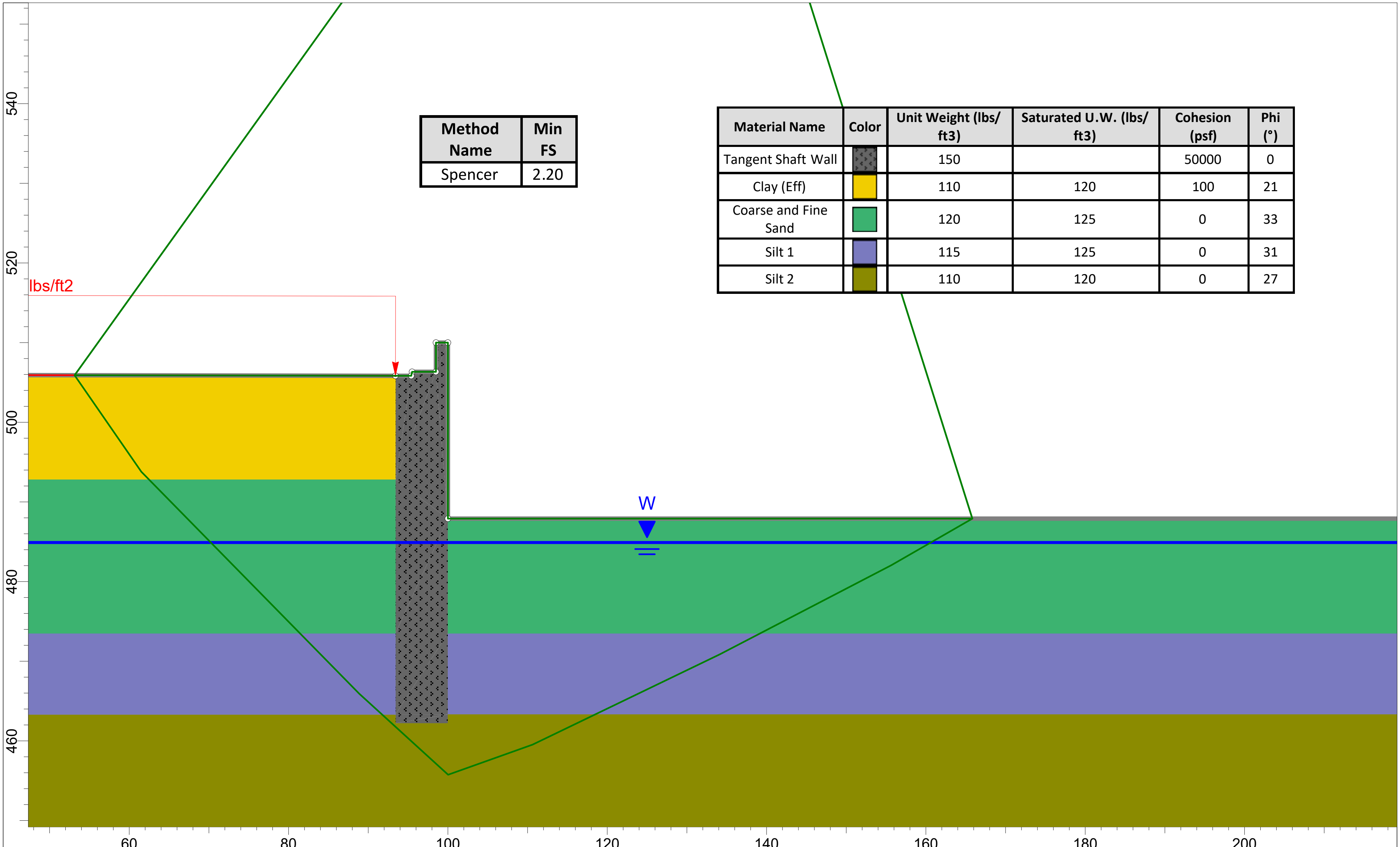


Material Name	Color	Unit Weight (lbs/ ft3)	Saturated U.W. (lbs/ ft3)	Cohesion (psf)	Phi (°)
Tangent Shaft Wall		150		50000	0
Clay (Eff)		110	120	100	21
Coarse and Fine Sand		120	125	0	33
Silt 1		115	125	0	31
Silt 2		110	120	0	27

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Effective - Circular	*Scenario*	STA. 6+90 to STA. 8+40 (RW-2)
Drawn By	KCA	*Company*	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	*File Name*	RW-2_STA6+90-STA8+40_031825.slmd



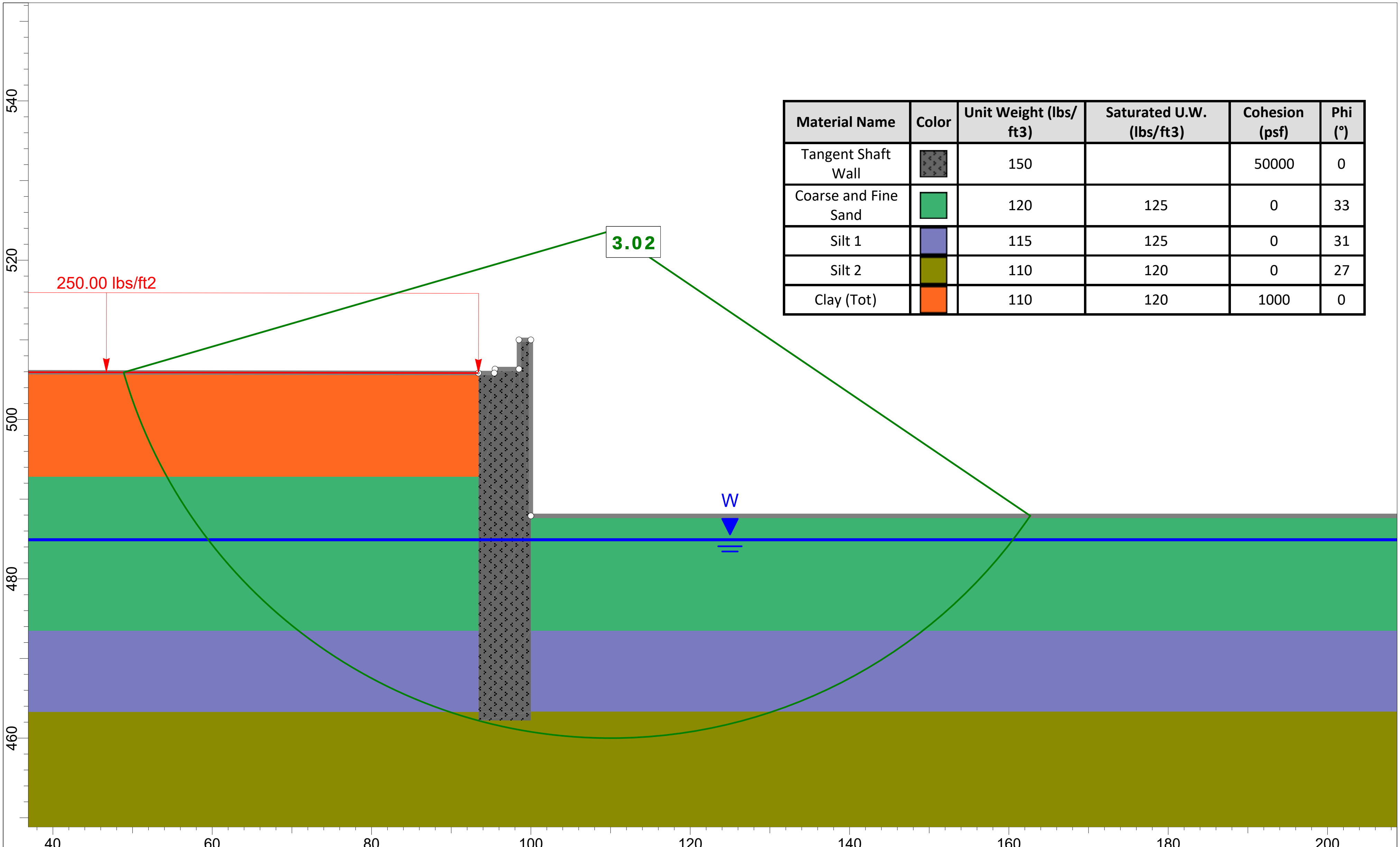
Method Name	Min FS
Spencer	2.20

Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Cohesion (psf)	Phi (°)
Tangent Shaft Wall		150		50000	0
Clay (Eff)		110	120	100	21
Coarse and Fine Sand		120	125	0	33
Silt 1		115	125	0	31
Silt 2		110	120	0	27

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Effective - Non-Circular	*Scenario*	STA. 6+90 to STA. 8+40 (RW-2)
Drawn By	KCA	*Company*	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	*File Name*	RW-2_STA6+90-STA8+40_031825.slmd

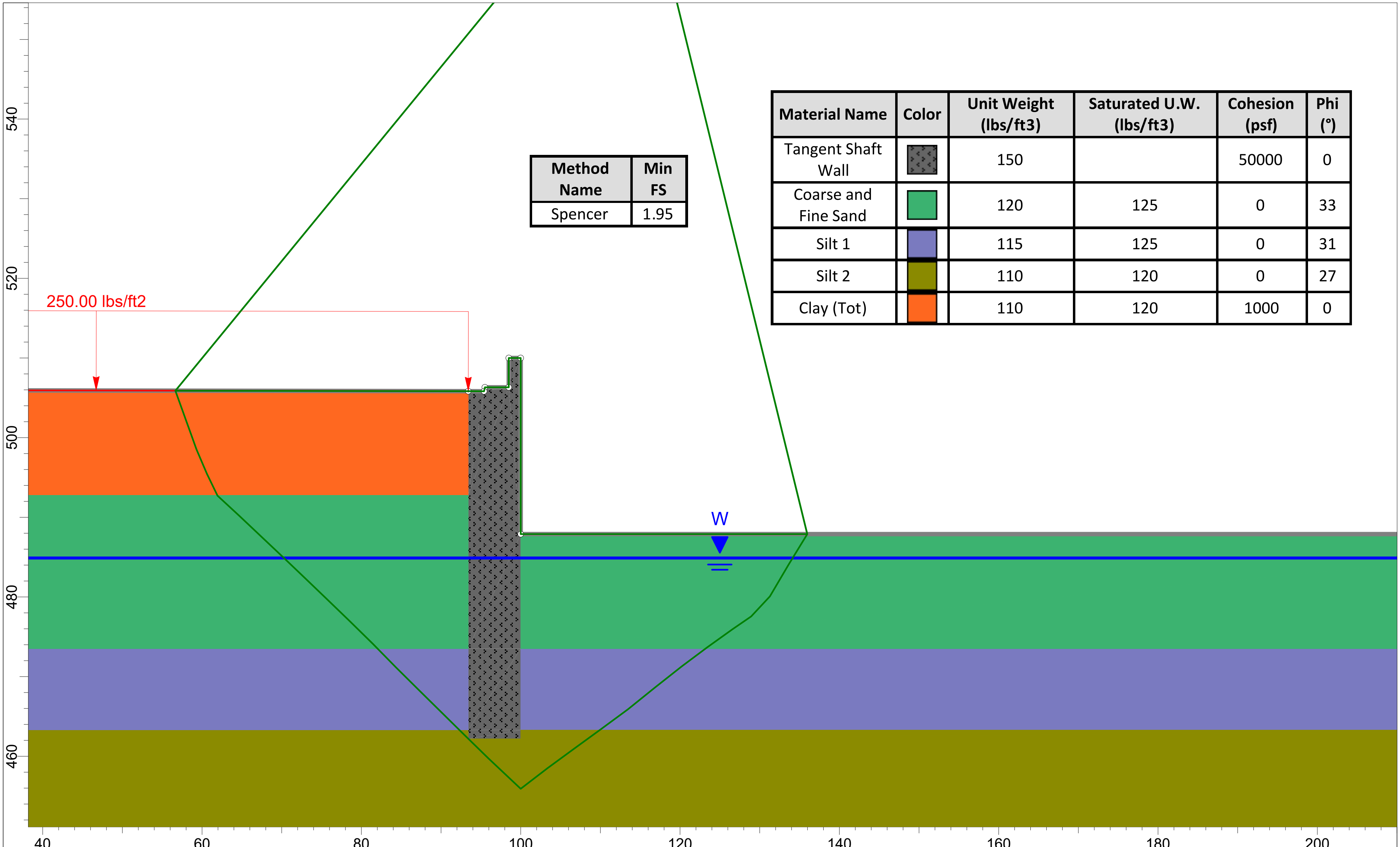


Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Cohesion (psf)	Phi (°)
Tangent Shaft Wall		150		50000	0
Coarse and Fine Sand		120	125	0	33
Silt 1		115	125	0	31
Silt 2		110	120	0	27
Clay (Tot)		110	120	1000	0

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Total - Circular	*Scenario*	STA. 6+90 to STA. 8+40 (RW-2)
Drawn By	KCA	*Company*	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	*File Name*	RW-2_STA6+90-STA8+40_031825.slmd



Method Name	Min FS
Spencer	1.95

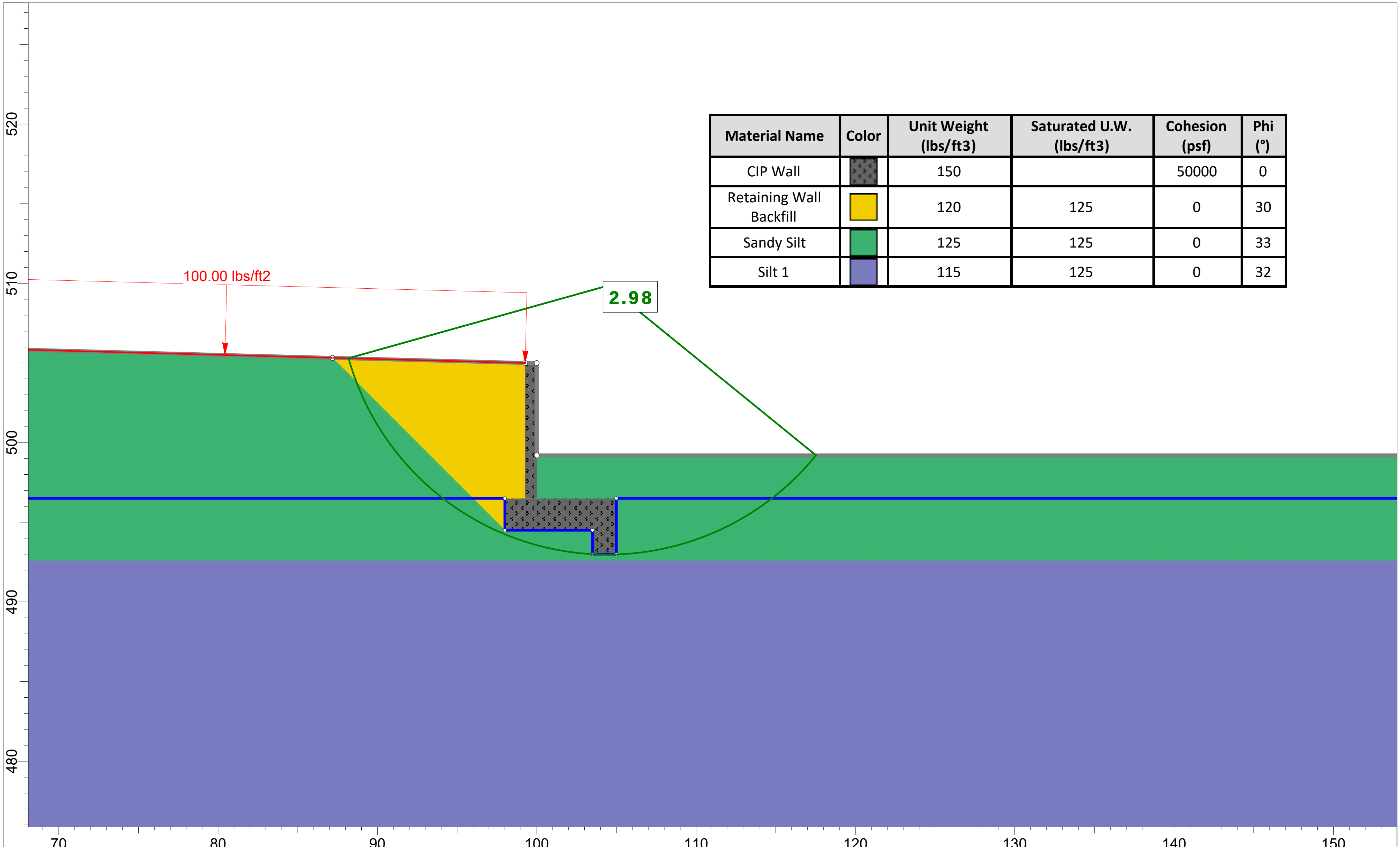
Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Cohesion (psf)	Phi (°)
Tangent Shaft Wall		150		50000	0
Coarse and Fine Sand		120	125	0	33
Silt 1		115	125	0	31
Silt 2		110	120	0	27
Clay (Tot)		110	120	1000	0

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Total - Non-Circular	Scenario	STA. 6+90 to STA. 8+40 (RW-2)
Drawn By	KCA	Company	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	File Name	RW-2_STA6+90-STA8+40_031825.slmd

STA. 9+90.5 (RW-2 ALIGNMENT)

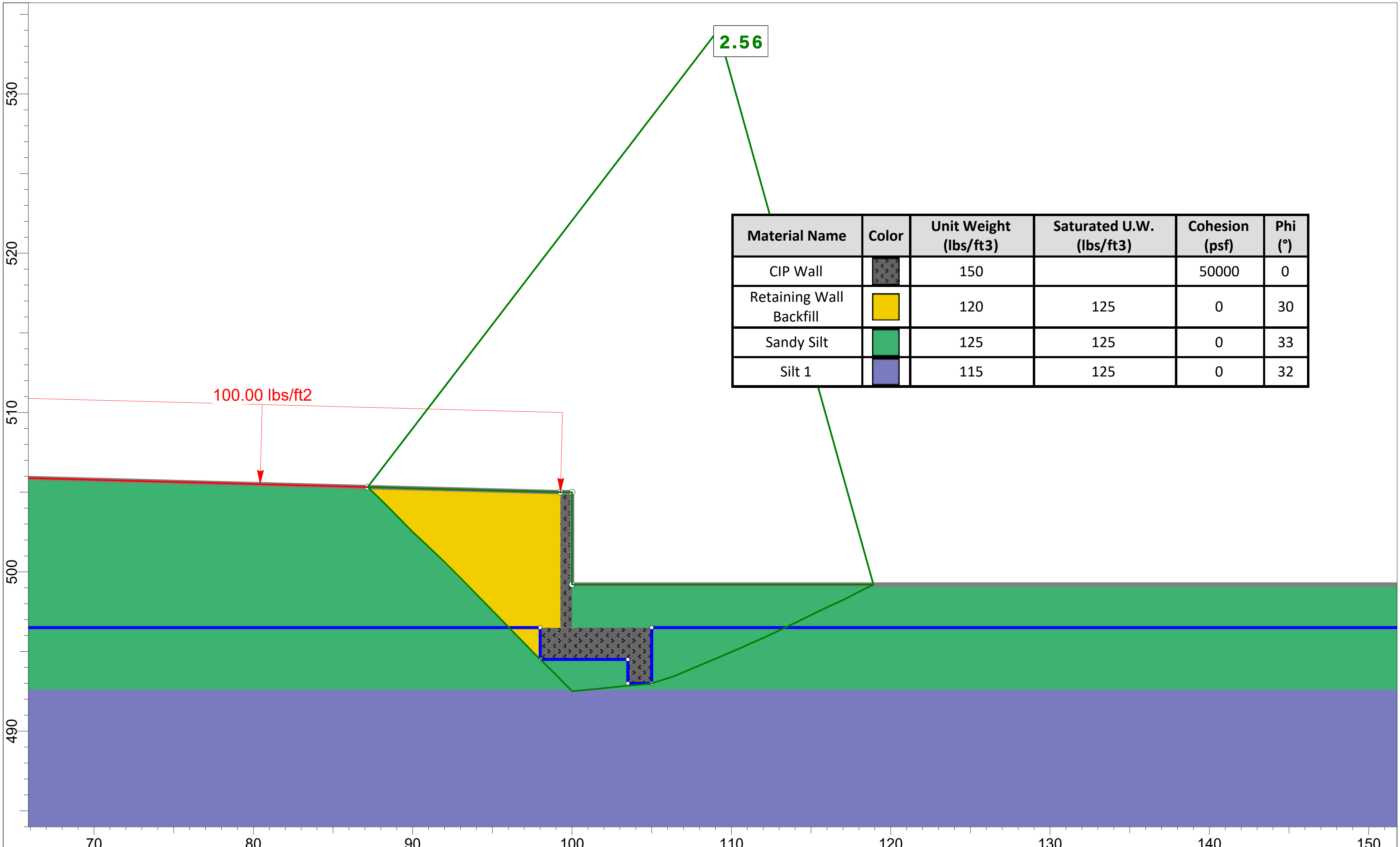


Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Cohesion (psf)	Phi (°)
CIP Wall		150		50000	0
Retaining Wall Backfill		120	125	0	30
Sandy Silt		125	125	0	33
Silt 1		115	125	0	32

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Effective - Circular	*Scenario*	STA. 9+90.5 (RW-2)
Drawn By	KCA	*Company*	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	*File Name*	RW-2_STA9+90.5_031825.slmd



Material Name	Color	Unit Weight (lbs/ft3)	Saturated U.W. (lbs/ft3)	Cohesion (psf)	Phi (°)
CIP Wall		150		50000	0
Retaining Wall Backfill		120	125	0	30
Sandy Silt		125	125	0	33
Silt 1		115	125	0	32

rocscience

SLIDEINTERPRET 9.038

Project	HAM-75-1.05, PID 113361/122048		
Group	Effective - Non-Circular	*Scenario*	STA. 9+90.5 (RW-2)
Drawn By	KCA	*Company*	NEAS Inc.
Date	3/18/2025, 3:40:08 PM	*File Name*	RW-2_STA9+90.5_031825.slmd