Structure Foundation Exploration - Final Report (revised)
HAM-74-13.35 Bridge Replacement (PID 110563)
Hamilton County, Ohio
S&ME Project No. 22-78-0033

PREPARED FOR:

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February 12, 2024

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Attention: Mr. Jonathan P. Carroll, P.E.
E: jpcarroll@fishbeck.com

Reference: **Structure Foundation Exploration - Final Report (revised)**
HAM-74-13.35 Bridge Replacement (PID 110563)
Hamilton County, Ohio
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Dear Mr. Carroll:

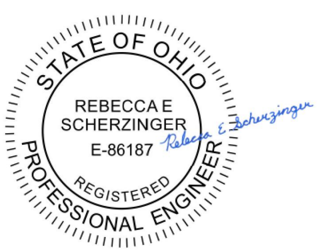
In accordance with our revised proposal dated April 19, 2022, which was authorized on May 31, 2022, S&ME, Inc. (S&ME) has completed a Structure Foundation Exploration for the HAM-74-13.35 bridge replacement, which carries Race Road over IR-74 in Hamilton County, Ohio (see Vicinity Map, Figure 1 in Appendix A).

In accordance with Section 701 of the current ODOT Specifications for Geotechnical Explorations (SGE), S&ME submitted a "draft" version of this report. The draft report contained the information obtained from the borings and laboratory test results, as well as analyses and recommendations for the planned replacement structure at this site. Draft ODOT Structure Foundation Report plan sheets are included in Appendix E. S&ME has received and reviewed comments on our draft report. This revised "final" report includes the temporary shoring design for the intermediate pier (Project Modification 01).

We appreciate having been given the opportunity to be of service. Please do not hesitate to contact us if you have any questions regarding this submission.

Sincerely,

S&ME, Inc.



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Project Engineer I

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1.0 Executive Summary

Based on discussions with Fishbeck, S&ME understands that it is proposed to replace the existing 4-span bridge along Race Road over IR-74 with a 2-span bridge. The HAM-74-13.35 bridge carries Race Road over IR-74 in Hamilton County, Ohio. The planned replacement structure is proposed to be a pre-stressed I-beam bridge, with 12-foot lanes and Mechanically stabilized earth (MSE) retaining walls at the abutments. The abutments are to be supported on driven H-piles to bedrock. The intermediate pier is planned to be supported by spread foundations bearing on bedrock. S&ME designed the temporary shoring for the intermediate pier, consisting of a soldier pile and lagging (SPL) wall.

Three (3) borings were planned for the exploration of this bridge replacement. Each of the borings encountered 2 to 18 inches of topsoil/rootmat. Beneath these surficial materials, the borings generally encountered cohesive soils over bedrock, although boring B-001-0-22 encountered granular soils. The subsurface conditions encountered in the borings performed for the current exploration at this site may be described, in descending order as follows:

- 1.5 to 8 feet of cohesive soils which can be described as very-stiff to hard brown and gray SILT AND CLAY (A-6a), very-stiff to hard brown and gray SILTY CLAY (A-6b), and very-stiff brown and gray CLAY (A-7-6).
- 2 to 5 feet of granular soils in boring B-001-0-22 which can be described as very loose brown GRAVEL (A-1-a), brown GRAVEL WITH SAND (A-1-b), and loose brown COARSE AND FINE SAND (A-3a).

Boring B-002-0-22 augered through highly weathered, very-weak gray SHALE, and then cored 13.4 feet into interbedded SHALE (20-75%) and LIMESTONE (30-80%). Borings B-001-0-22 and B-003-0-22 cored 15 and 14.7 feet, respectively, into the interbedded SHALE (50-55%) and LIMESTONE (45-50%) bedrock. The shale was dark gray, severely to moderately weathered, and weak to slightly strong. The limestone was light gray, moderately to slightly weathered, and moderately strong to very strong.

Groundwater was not observed during drilling or prior to coring bedrock in each of the borings. Groundwater levels can fluctuate due to seasonal variations in precipitation, construction activities, etc. The borings were backfilled upon completion; therefore, long term groundwater readings were not obtained.

The MSE walls for the Forward and Rear Abutments will bear on competent, very-stiff cohesive soils and the abutments themselves will be supported by driven H-piles bearing on bedrock. Refer to Section 6.4 for the foundation recommendations, 6.5 for the intermediate pier temporary shoring SPL design, and 6.6 for the MSE Wall recommendations.

2.0 Introduction

The HAM-74-13.35 bridge carries Race Road over IR-74 in Hamilton County, Ohio. Information provided by Fishbeck, Inc. (Fishbeck) indicates that this bridge is to be replaced with a new two-span bridge with mechanically stabilized earth (MSE) retaining walls at the forward and rear abutments and an intermediate pier supported on shallow foundations bearing on bedrock. Fishbeck recommends the pier be supported by shallow foundations since the entire existing pier and combined spread footing are to be removed to facilitate the construction of the new pier in the same approximate location.

The Structure Foundation Exploration was performed in general accordance with the January 2022 update to the ODOT SGE.

3.0 Geology and Observations of the Project

3.1 Geology

Geologic references indicate that this project site is located within the Outer Bluegrass physiographic region. Surficial geology mapping indicates the overburden soils in the area consist predominantly of silty clay to clay soil derived from the underlying bedrock. These overburden soils overlie interbedded shale and limestone from the Grant Lake Formation of Ordovician age. Available ODNR Water Well logs indicate that the top of bedrock in the project area is present at depths of 20 feet and up to 50 feet below grade. The borings performed for this Structure Exploration encountered bedrock at depths ranging from 5.3 and 14.5 feet below existing grades.

A review of the ODNR "Ohio Karst Areas" map indicates the site lies in an area not known to contain karst features. A review of the ODNR "Landslides in Ohio" map reveals the site is not in an area susceptible to landslides, and the ODNR "Abandoned Underground Mines of Ohio" map indicates the site lies in an area with no mapped abandoned mines within a 3-mile radius. There is a historic surface mine less than 1-mile south of the site.

3.2 Available Information

Based on review of the ODOT Transportation Information Management System (TIMS) webpage, the historic boring logs for the initial construction of the HAM-74-13.35 bridge were available. The historic boring logs are included in Appendix A.

3.3 Reconnaissance

On September 19, 2022, S&ME performed a site reconnaissance of the HAM-74-13.35 bridge to observe current conditions and to stake the planned boring locations. The site consists of the eastbound and westbound lanes of IR-74 below the existing bridge and off road sections covered with grass, shrubs, and trees. Signs of slope instability were not present during our site reconnaissance. Photographs of the existing bridge site are presented in Appendix A.

4.0 Exploration

4.1 Field Investigation

From September 23 to 29, 2022, three (3) borings were performed for the HAM-74-13.35 bridge exploration to explore the existing soils and bedrock in the area of the planned replacement structure. The borings were numbered B-001-0-22, B-002-0-22, and B-003-0-22. The locations of the borings are shown on the Plan of Borings included as Figure 2 of Appendix A. The locations and elevations and plan and profile information were provided by Fishbeck. Logs of historic borings performed in the vicinity of the HAM-74-13.35 bridge are also included in Appendix A of this report.

The current borings were performed by a track-mounted drilling rig using a 3¼-inch I.D. hollow-stem auger to advance the borings between sampling attempts. Disturbed but representative soil samples were obtained by lowering a 2-inch O.D. split-barrel sampler through the auger stem to the bottom of the boring and then driving the sampler into the soil with blows from a 140-pound hammer freely falling 30 inches (ASTM D1586 - Standard Penetration Test). SPT samples were examined immediately after recovery and representative portions were preserved in airtight glass jars. Ten (10) to fifteen (15) feet of bedrock was cored in each of the borings using an NQ core barrel with a diamond bit utilizing water as a circulating fluid.

In accordance with the current ODOT SGE, the hammer system on the drill rig had been calibrated in accordance with ASTM D 4633 to determine the drill rod energy ratio (69.8% on June 7, 2022). At the completion of drilling, the borings were backfilled with cuttings mixed with bentonite chips.

In the field, experienced S&ME personnel performed the following: 1) examined all samples recovered from the borings; 2) preserved representative portions of all samples in airtight glass jars; 3) prepared a log of each boring; 4) made seepage and groundwater observations; 5) made hand-penetrometer measurements in soil specimens exhibiting cohesion; and, 6) provided liaison between the field work and the Engineer so the exploration program could be modified in the event unusual or unexpected subsurface conditions were encountered. All recovered samples were transported to the soils laboratory of S&ME for further examination and testing.

4.2 Laboratory Testing

In the laboratory, the soil and rock samples were visually identified and soil samples were tested for natural moisture content. Classification testing (liquid/plastic limit determinations and grain-size analyses) was also performed on selected representative specimens. In addition to the soil testing, unconfined compressive strength tests were performed on selected rock cores specimens. The results of the laboratory index tests are recorded numerically on individual boring logs and the results of the strength tests are presented graphically in Appendix C. The results of the rock core testing performed on samples recovered from our borings are summarized in Table 4-1, on the following page.

Table 4-1: Summary of Unconfined Compressive Tests on Bedrock

Boring	Specimen Depth (feet)	Specimen Elevation (feet)	Unconfined Compressive Strength (psi)	Bedrock Description
B-001-0-22	15.8 – 16.2	770.6 – 771.0	8,986	LIMESTONE, gray, strong
B-002-0-22	22.8 – 23.2	762.1 – 762.5	3,888	SHALE, gray, moderately strong
B-003-0-22	11.8 – 12.2	773.1 – 773.4	1,455	Interbedded SHALE/LIMESTONE, gray, weak
B-003-0-22	14.9 – 15.3	769.9 – 770.3	8,195	LIMESTONE, gray, strong

Based upon the results of the laboratory testing program, the field logs were modified, if necessary, and copies of the laboratory corrected logs are submitted in Appendix A. Shown on these logs are: descriptions of the soil stratigraphy encountered; depths from which samples were preserved; sampling efforts (blow-counts) required to obtain the specimens in the borings; calculated N_{60} values; laboratory testing results; seepage and groundwater observations made at the time of drilling; and, values of hand-penetrometer measurements made in soil samples exhibiting cohesion. For your reference, hand-penetrometer values are roughly equivalent to the unconfined compressive strength of the cohesive fraction of the soil sample. Photographs of the recovered rock core from the borings are included in Appendix A.

Soils have been classified in accordance with Section 603 of the ODOT SGE, and described in general accordance with Section 602. An explanation of the symbols and terms used on the boring logs, definitions of the special adjectives used to denote the minor soil components, and information pertaining to sampling and identification are presented on Plate 3 of Appendix A. A similar explanation of symbols and terms related to bedrock description and classification is presented as Plate 4 of Appendix A. Group Indices determined from the results of the laboratory testing program are also provided on the boring logs.

5.0 Findings

5.1 Subsurface Stratigraphy

Each of the borings encountered 2 to 18 inches of topsoil/rootmat. Beneath these surficial materials, the borings generally encountered cohesive soils over bedrock, although boring B-001-0-22 encountered granular soils. The subsurface conditions encountered in the borings performed for the current exploration at this site may be described, in descending order as follows:

- 1.5 to 8 feet of cohesive soils which can be described as very-stiff to hard brown and gray SILT AND CLAY (A-6a), very-stiff to hard brown and gray SILTY CLAY (A-6b), and very-stiff brown and gray CLAY (A-7-6).
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Boring B-002-0-22 augered through highly weathered, very-weak gray SHALE, and then coring 13.4 feet into interbedded SHALE (20-75%) and LIMESTONE (30-80%). Borings B-001-0-22 and B-003-0-22 cored 15 and 14.7 feet, respectively, into the interbedded SHALE (50-55%) and LIMESTONE (45-50%) bedrock. The shale was dark gray, severely to moderately weathered, and weak to slightly strong. The limestone was light gray, moderately to slightly weathered, and moderately strong to very strong. Table 5-1 summarizes the top of bedrock encountered in our explorations.

Table 5-1 – Summary of Top of Bedrock

Boring ID	Ground Surface Elev.	Depth to Top of Bedrock (feet)	Elev. of Top of Bedrock
B-001-0-22	786.8	14.5	772.3
B-002-0-22	785.3	12.5	772.8
B-003-0-22	785.2	5.3	779.9

5.2 Groundwater Observations

Groundwater was not observed during drilling or prior to coring bedrock in each of the borings. Groundwater levels can fluctuate due to seasonal variations in precipitation, construction activities, etc. The borings were backfilled upon completion; therefore, long term groundwater readings were not obtained.

6.0 Analyses and Recommendations

6.1 General Discussion

Based on discussions with Fishbeck, S&ME understands that it is proposed to replace the existing 4-span bridge along Race Road over IR-74 with a 2-span bridge. The planned replacement structure is proposed to be a pre-stressed I-beam bridge, with 12-foot lanes and Mechanically stabilized earth (MSE) retaining walls at the abutments. The abutments are to be supported on driven H-piles to bedrock. The intermediate pier is planned to be supported by spread foundations bearing on bedrock, with temporary shoring consisting of a soldier pile and lagging (SPL) wall. The following sections of this report present our geotechnical recommendations for the new HAM-74-13.35 bridge.

6.2 Site Preparation and New Fill Placement

The existing piers and abutments should be completely removed prior to construction of the new abutments and intermediate pier. Following the removal of these materials, it is recommended that the entire exposed foundation surface be examined by a qualified Geotechnical Engineer to identify any weak, wet, organic, or otherwise unsuitable materials that were not encountered during the subsurface investigation.

New fill material placed for embankments should consist of inorganic soil free of all miscellaneous materials, cobbles and boulders. The new fill should be placed in uniform, thin layers. Embankment construction should be in accordance with ODOT Construction and Materials Specification Items 203 and 204. Borrow materials should not be placed in a frozen condition or upon a frozen surface, and any sloping surfaces on which new fill is to be placed should first be benched in accordance with the procedures outlined in the ODOT Geotechnical Bulletin GB2, Special Benching and Sidehill Embankment Fills.

6.3 Seismic Coefficients

Based on the soil type and Standard Penetration Test (SPT), the Site Class for this specific bridge is Class D in accordance with AASHTO LRFD Bridge Design Specifications, 9th Edition (2020) Table 3.10.3.1-1. Using a Site Class D, the Horizontal Response Spectral Acceleration Coefficient at 1.0 sec period on rock (S_1) is 0.05g. As stated in the ODOT Bridge Design Manual (BDM), the Site Factor for Long Period Range of Spectral Acceleration (F_v) is 2.4 which gives an Acceleration Coefficient (SD_1) of 0.12g. Based on this SD_1 value, Table 3.10.6-1, Seismic Zones, of the AASHTO LRFD manual indicates this site is in Seismic Zone 1.

Based on the Acceleration Coefficient (SD_1) of 0.12g, the structural designer should ensure the transverse reinforcement requirements at the top and bottom of columns shall meet the criteria of LRFD 5.11.4.1.4 and 5.11.4.1.5.

6.4 Foundation Recommendations

Based on conversations with Fishbeck and the subsurface stratigraphy encountered, we understand the intermediate pier will be supported on shallow foundations bearing on bedrock. The MSE walls for the Forward and Rear Abutments will bear on competent, very-stiff cohesive soils and the abutments themselves will be supported by driven H-piles bearing on bedrock.

6.4.1 H-Piles to Bedrock

Fishbeck has indicated that the new Rear and Forward Abutments will be supported on HP10x42 piles driven to bedrock. The maximum factored axial loads are 208 kips per pile at each abutment.

According to Section 202.2.3.2.a of the 2007 ODOT Bridge Design Manual (BDM), the factored resistance for piles driven to refusal on bedrock is typically governed by the structural capacity of the piles. The 2007 ODOT BDM recommends a maximum factored structural resistance of 310 kips for an HP10x42 pile. This value considers that each H-pile is axially loaded with negligible moment, the steel has a yield strength of 50 ksi, and that each pile is fully supported by soil along its length (no scour anticipated).

We understand the piles are planned to be prebored through the MSE wall backfill into the bedrock.

6.4.1.1 Estimated Pile Lengths

The table below summarizes the estimated pile lengths at the abutments. Pay lengths of piles are to be rounded up to the nearest 5 feet.

Table 6-1: Estimated Pile Lengths

Location	Boring No.	Top of Pile El. (MSL)	Estimated Tip El. (MSL) [1]	Pile Length (ft)
Rear Abutment	B-001-0-22	796.55	767.3	35
Forward Abutment	B-003-0-22	803.61	774.9	30

[1] Piles to extend 5 feet into bedrock

6.4.2 *Spread Foundations on Bedrock*

Based on the subsurface conditions encountered in the borings performed at the proposed Intermediate Pier, recommended maximum values of nominal (q_n) and factored (q_R) bearing resistance at the service and strength limit states for spread foundations bearing on interbedded shale and limestone bedrock are presented in Table 6-2. In order to achieve the recommended factored bearing resistances provided in Table 6-2, the bearing surfaces should be carefully cleaned and free of loose rock fragments prior to placement of concrete. The rock bearing resistance determination is presented on forms contained in Appendix C.

Table 6-2: Recommended Bearing Capacities for Spread Footings

Location	Minimum Bearing Elevation (ft)	Limit State	Preliminary Nominal Bearing Resistance, q_n (ksf)	Resistance Factor, φ_b	Preliminary Factored Bearing Resistance, q_R (ksf)
Intermediate Pier	772.8	Service	25	1.0	25.0
		Strength	56	0.45	25.2

If soil or very weak shale is present at or just below the proposed bottom of foundation elevation, the material should be over-excavated and the foundation lowered to bear on suitable rock, or the over-excavation below plan foundation bearing elevation should be backfilled in accordance with the most current ODOT CMS. The spread foundations should bear at least 3 inches below the top of bedrock elevation.

It is recommended that any surface or subsurface water flowing into the foundation excavation be diverted away from the bearing surface area during excavation and construction of the spread foundations. The foundation bearing surfaces should be kept dry and free from standing water during all construction activities. The shale bedrock encountered at the approximate bearing elevation can become weak and compressible when exposed to water. If the foundation materials become wet or loose, additional excavation may be necessary prior to placing foundation concrete.

6.4.2.1 Sliding Resistance

The factored resistance against failure by sliding (R_R) should be determined using Eq. 10.6.3.4-1 of the current AASHTO LRFD Bridge Design Specifications.

For footing foundations bearing on interbedded shale and limestone at or below the above noted bearing elevations (see Table 6-2), the nominal sliding resistance (R_τ) between the bedrock and the pier foundations should be taken as the total vertical force (V) acting on the foundation multiplied by a coefficient of friction (tan δ) equal to 0.53 (ϕ_i = 28°) as per Table 3.11.5.3-1 of the AASHTO LRFD Manual. For cast in place pier footings, the factored sliding resistance may then be determined by applying a resistance factor (φ_τ) of 0.9 to the nominal value for shearing between the footing and bedrock.

Additional resistance to sliding of spread footings could be derived from increasing the width of the footing or from passive pressure developed along the inside toe of the footing. S&ME recommends a passive resistance of 200 psf per foot from the surrounding soil. If additional passive resistance is needed, a foundation key can be designed. The foundation key should be located within the middle-half of the foundation. S&ME recommends a passive resistance of 415 psf per foot of embedment into bedrock.

6.4.2.2 Settlement

The Intermediate Pier is planned to bear on interbedded shale and limestone bedrock. As such, settlement of the foundation is anticipated to be negligible.

6.4.2.3 Eccentricity

Eccentricity of the spread footings should be checked in accordance with AASHTO LRFD Article 10.6.3.3 for footings on rock.

6.5 Temporary Shoring for Intermediate Pier

S&ME recommends a soldier pile and lagging (SPL) wall to be used for the temporary shoring for the intermediate pier construction. The results of our analyses indicate that a drilled shaft, cantilever wall using 30-inch diameter drilled shafts, 24-feet long with W18x76 steel piles spaced at 5-feet center-to-center can be used for the temporary shoring. We recommend the lagging consist of 4-inch thick, untreated timber. The piles should be located to allow a 3-feet clearance between the inside of the shoring and the outer edges of the proposed pier foundations. The SPL wall should be installed using top-down construction, and under the supervision of a qualified engineering representative to ensure that the correct embedment depths are achieved and that the wall is constructed in accordance with ODOT specifications and the design plans. Utilities should be verified in the field prior to construction. Conceptual sketches and details for the temporary shoring are included with the SPL wall calculations in Appendix C to aid Fishbeck in preparation of the project drawings.

6.6 Mechanically Stabilized Earth (MSE) Retaining Walls

MSE retaining walls are proposed at the rear and forward abutments as part of the construction. The proposed abutments will consist of three sides of MSE Walls tying into the existing slope.

Our analyses of the MSE walls included external geotechnical stability based on the AASHTO LRFD Bridge Design Specifications manual (9th Edition). Global stability analyses were performed using 2D limit equilibrium modeling software (Slide2 9.024). Computations supporting these analyses are provided in Appendix C. One (1) cross-section was analyzed at the centerline of the bridge for both the forward and rear abutments. An explanation of the methods used along with results summaries are contained in the following report sections.

6.6.1 MSE Wall Global Stability

The global stability of the transverse and longitudinal slopes of the earthen approach embankments behind the reinforced MSE wall embankments at both the rear and forward abutments were evaluated using Slide2. The transverse and longitudinal slopes were analyzed under short-term (total stress, end-of-construction) and long-term (effective stress). Anticipated traffic loading was included in the global stability analyses.

In general accordance with AASHTO, FHWA, and ODOT design requirements, a minimum Factor of Safety of 1.5 was considered acceptable for evaluation of the global stability of embankments containing or supporting a structural element. This minimum Factor of Safety is required for both the short-term and long-term strength conditions.

The results of the global stability analyses of the MSE wall embankment section at the rear and forward abutments indicate that the proposed MSE walls constructed to the currently proposed profile grades, without staging, and with a minimum reinforced zone length of 0.7(H), will provide a Factor of Safety in excess of 1.5. A summary of the analyses results is shown in Table 6-3 and the individual analyses output are included in Appendix C.

Table 6-3: Summary of Global Slope Stability Analyses

Abutment	Minimum Factor of Safety		
	Short-term	Long-term	Acceptable?
Rear	3.01	1.82	Yes
Forward	2.76	1.69	Yes

6.6.2 *MSE Wall External Stability (LRFD)*

The bearing capacity, sliding, and overturning analyses for the MSE walls are based on AASHTO LRFD Bridge Design Specifications, 9th Edition, Sections 10 and 11. The wall cross-sections analyzed were selected based on subsurface conditions encountered in the borings, wall height and slopes proposed above the wall, as shown on the plan information provided by Fishbeck. For each wall analysis, the anticipated bearing material consisted of natural overburden soils.

6.6.2.1 Bearing Resistance

The external stability analyses indicates a minimum reinforcement length of approximately 0.76(H) to 0.79(H) is sufficient to achieve a Capacity-to-Demand (CDR) ratio of at least 1.0 for bearing resistance. Factored bearing resistances were computed for the MSE walls at both the rear and forward abutments, and the results of these analyses are summarized in Table 6-4.

Table 6-4: Summary of MSE Wall External Stability Analyses Results

Abutment	Total Retained Height (H)	Minimum MSE Reinforcement Length[1]	Maximum Bearing Pressure (ksf)		Ratio of Reinforcement Length to Total Retained Height	Factored Bearing Resistance (Strength Limit)
			Service Limit State	Strength Limit State		
Rear	25.98 ft.	20.0 ft.	4.0	6.7	0.77	7.0 ksf
Forward	30.29 ft.	23.0 ft.	5.4	7.7	0.76	7.8 ksf

[1] Reinforcement length required to satisfy 0.7(H) minimum AASHTO requirement and provide Capacity-to-Demand ratio greater than 1.0.

6.6.2.2 Sliding

Sliding stability analyses were performed for the MSE walls at both abutments to determine the minimum reinforcement length required to provide a factored sliding resistance in excess of the factored lateral load at the base of the MSE wall. The sliding analyses indicate that the MSE walls at both the rear and forward abutments, when constructed with the reinforcement lengths summarized in Table 6-2, will provide a CDR greater than 1.0 for effective stress (drained-long term) conditions.

6.6.2.3 Eccentricity

The results of the overturning (eccentricity) analyses for the MSE walls at both abutments indicate the reinforcement lengths summarized in Table 6-2 will permit the eccentricity to be maintained within the middle two-thirds of the reinforced zone, in accordance with AASHTO criteria.

6.6.2.4 Summary

Table 6-5 contains a summary of the capacity-to-demand ratio (CDR) computed values for the MSE wall external stability analyses performed at the rear and forward abutments. See Appendix C for the full external stability analysis output for each abutment.

Table 6-5: Summary of MSE Wall External Stability Analyses

Abutment	Computed Capacity-Demand Ratio (CDR)[A] / Acceptable?				
	Sliding		Bearing Resistance		Overturning / Eccentricity
	Drained	Undrained	Drained	Undrained	
Rear	1.04 / Yes	1.11 / Yes	1.18 / Yes	1.30 / Yes	1.61 / Yes
Forward	1.09 / Yes	1.12 / Yes	1.02 / Yes	1.18 / Yes	1.58 / Yes

[A] CDR values of 1.0 or greater indicate the factored resistance is equal to or greater than the factored loads/moments and indicated the results are acceptable.

6.6.3 MSE Wall Settlement

As discussed above, it is anticipated that the Rear Abutment is anticipated to bear on overburden soils. Settlement analyses for the Rear Abutment were performed using software (Settle3 5.017). Computations supporting these analyses are provided in Appendix C. Total settlement at the Rear Abutment is expected to be less than 1.5 inches. The Forward Abutment is anticipated to bear in close proximity to the underlying bedrock, therefore, settlement below the Forward Abutment is anticipated to be negligible and will occur during MSE wall construction.

6.6.4 *Summary of MSE Wall Analyses*

Based upon the information available for the proposed MSE walls and the foundation soils, the external stability analyses performed for the proposed MSE walls at the abutments indicate that adequate resistance is available against sliding, overturning, bearing capacity failure and overall global stability, given the minimum reinforcement lengths exceed 70% of the currently proposed MSE wall heights. The existing embankment soils at the MSE wall foundation bearing level should be observed and evaluated as necessary by the onsite Geotechnical Engineer to assess whether the materials present beneath the walls are consistent with those recommended in this report.

6.6.5 *Additional MSE Wall Foundation Considerations*

The determination of removal of weak foundation bedrock or soil should be made by Geotechnical Engineer of Record present during foundation excavations. Loose rock and debris at the spread foundation bearing level should be removed prior to placing concrete for foundations.

6.7 Bedrock Excavation Considerations

Interbedded shale and limestone bedrock was encountered near the anticipated bearing elevation for the forward abutment foundations. Consequently, rock excavation may be required. Based on the rock core retrieved from historic and current borings, the RQD ranged from 0 to 92 percent. Samples of the shale bedrock from the borings had unconfined compressive strengths ranging from 1,455 psi to 3.888 psi. It should be noted that the limestone portions of the bedrock strata will have significantly higher unconfined compressive strengths than the shale portions. It should be emphasized that a direct correlation should not be made between the performance of the drilling rigs and the ability of construction equipment to excavate the bedrock at this site.

Additionally, all excavations should be either sloped back or braced in accordance with the most recent OSHA excavation guidelines.

6.8 Lateral Earth Pressures

The proposed bridge abutments must be designed to withstand lateral earth pressures as well as hydrostatic pressures that may develop behind the structure. The magnitude of the lateral earth pressures varies on the basis of soil type, permissible wall movement, and the configuration of the backfill.

To minimize lateral earth pressures, the zone behind the abutment walls should be backfilled with granular soil, and the backfill should be effectively drained. For effective drainage, a zone of free-draining gravel (ODOT CMS Item 518.03) should be used directly behind the abutments for a minimum thickness of 24 inches in accordance with ODOT CMS Item 518.05. This granular zone should drain to either weepholes or a pipe, so that hydrostatic pressures do not develop against the walls

The type of backfill beyond the free-draining granular zone will govern the magnitude of the pressure to be used for structural design. Pressures of a relatively low magnitude will be developed by the use of granular backfill, whereas a cohesive (clay) backfill will result in the development of much higher pressures.

To minimize lateral pressures, it is recommended that granular backfill be used behind the abutments. The backfill should be placed in a wedge formed by the back of the structure and a line rising from the base of the structure base at an angle no greater than 60 degrees from the horizontal. Granular backfill behind the structure should be compacted in accordance with ODOT Item 203, "Roadway Excavation and Embankment", of the most recent CMS. Over-compaction in areas directly behind the walls should be avoided as this might cause damage to the structure.

If proper drainage is used and the granular backfill is placed and compacted in the wedge described previously, an equivalent fluid unit weight of 55 pounds per cubic foot (pcf) may be used assuming an “at rest” earth pressure condition, meaning wall movements less than 0.25 percent of the wall height is permitted (such as the sidewalls of the culvert). If proper drainage is not provided, an “at rest” equivalent fluid unit weight of 90 pcf is recommended for use during design.

If, however, wall movement greater than 0.25 percent the height of the abutment wall (H) occurs, the active earth pressure condition should be utilized. If proper drainage is incorporated and granular backfill is provided and compacted as specified, an equivalent fluid unit weight of 35 pcf may be used. Without proper drainage, but with granular backfill and permissible wall movement, an equivalent fluid unit weight of 80 pcf should be used.

Compacted cohesive materials tend alternatively to shrink, expand and creep over periods of time and create significant lateral pressures on any adjacent structures. Cohesive materials also require a greater amount of movement to mobilize an active earth pressure condition. To mobilize the active earth pressure condition in cohesive materials, wall movement 1.0 percent of the height of the wall (H) must occur. Because of the long-term adverse effects, it is recommended that, if proper drainage (ODOT CMS Item 518.03) is provided, equivalent fluid unit weights of 65 pcf (active) and 90 pcf (at-rest) be used for design of the structure resisting the lateral loads imparted by drained, cohesive backfill. Without proper drainage, S&ME recommends that the structural design be performed using equivalent fluid unit weights of 95 pcf (active) and 110 pcf (at-rest).

The structure must also be designed to withstand the vertical load resulting from the weight of any fill and pavement that may be placed over the structure in addition to traffic surcharge loads. To estimate vertical loading, total unit weights of 120 pcf and 115 pcf may be used for compacted cohesive and granular soil, respectively.

7.0 Final Considerations

This report has been prepared in accordance with generally accepted geotechnical engineering practice for specific application to this project. The conclusions and recommendations contained in this report are based upon applicable standards of our practice in this geographic area at the time this report was prepared. No other representation or warranty either express or implied, is made.

We relied on project information given to us to develop our conclusions and recommendations. If project information described in this report is not accurate, or if it changes during project development, we should be notified of the changes so that we can modify our recommendations based on this additional information if necessary.

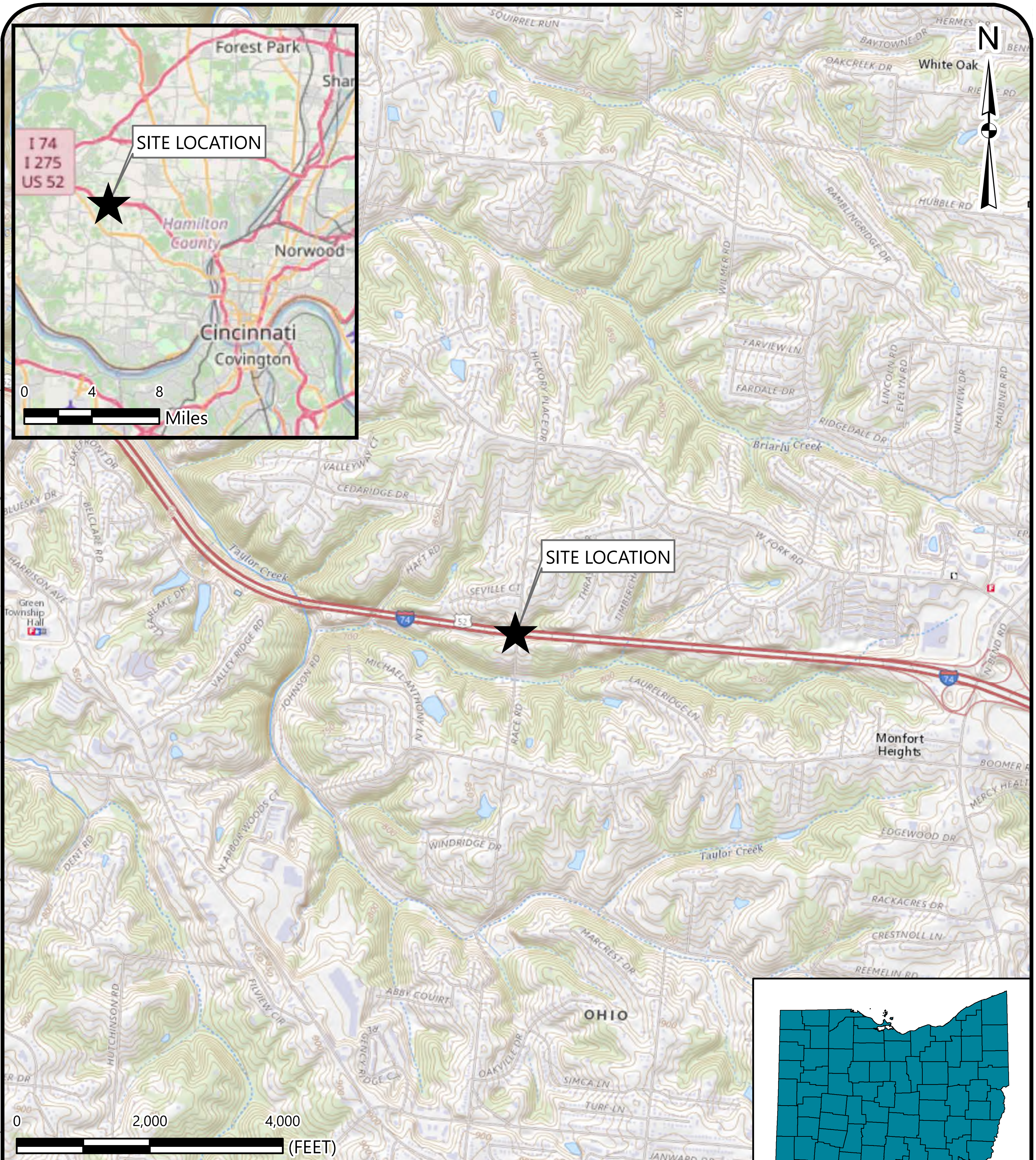
Our conclusions and recommendations are based on limited data from a field exploration program. Subsurface conditions can vary widely between explored areas. Some variations may not become evident until construction. If conditions are encountered which appear different than those described in our report, we should be notified. This report should not be construed to represent subsurface conditions for the entire site.

Unless specifically noted otherwise, our field exploration program did not include an assessment of regulatory compliance, environmental conditions or pollutants or presence of any biological materials (mold, fungi, bacteria). If there is a concern about these items, other studies should be performed. S&ME can provide a proposal and perform these services if requested.

S&ME should be retained to review the final plans and specifications to confirm that earthwork, foundation, and other recommendations are properly interpreted and implemented. The recommendations in this report are contingent on S&ME's review of final plans and specifications followed by our observation and monitoring of earthwork and foundation construction activities.

Appendices

Appendix A – Exploration



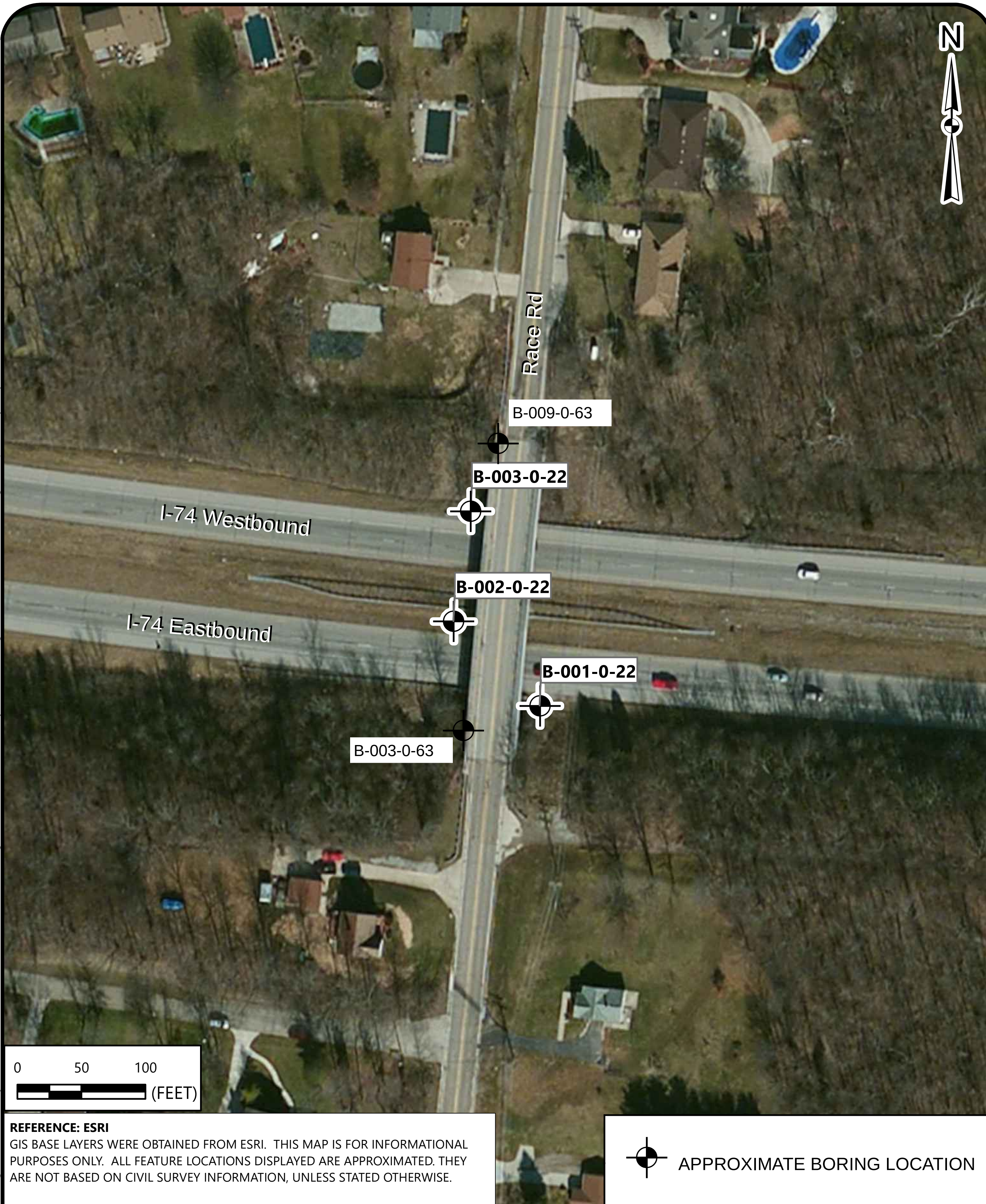
REFERENCE/NOTES:
GIS BASE LAYERS WERE OBTAINED FROM USGS *THE NATIONAL MAP* AND *OPENSTREETMAP* ©. THIS MAP IS FOR INFORMATIONAL PURPOSES ONLY. ALL FEATURE LOCATIONS DISPLAYED ARE APPROXIMATED, THEY ARE NOT BASED ON CIVIL SURVEY INFORMATION, UNLESS STATED OTHERWISE.

Drawing Path: T:\GEO\Projects\2022\22780033_Fishbeck_HAM-74-13 35 Bridge_Cincinnati OH\4 GEO\Project Docs\GIS Figures\V-Map_HAM-74-13.35 Bridge.mxd plotted by JHaydu 10-05-2022

VICINITY MAP

HAM-74-13.35 BRIDGE REPLACMENT (PID 110563)
GREEN TOWNSHIP, HAMILTON COUNTY, OHIO

SCALE: 1 " = 2,000 '	FIGURE No.
DATE: 10-5-22	1
PROJECT NUMBER 22-78-0033	



REFERENCE: ESRI
GIS BASE LAYERS WERE OBTAINED FROM ESRI. THIS MAP IS FOR INFORMATIONAL PURPOSES ONLY. ALL FEATURE LOCATIONS DISPLAYED ARE APPROXIMATED. THEY ARE NOT BASED ON CIVIL SURVEY INFORMATION, UNLESS STATED OTHERWISE.

APPROXIMATE BORING LOCATION

Drawing Path: T:\GEO\Projects\2022\22780033_Fishbeck_HAM-74-13 35 Bridge_Cincinnati OH\4 GEO\Project Docs\GIS Figures\POB_HAM-74-13.35 Bridge.mxd plotted by JHaydu 10-05-2022

PLAN OF BORINGS

HAM-74-13.35 BRIDGE REPLACMENT (PID 110563)
GREEN TOWNSHIP, HAMILTON COUNTY, OHIO

SCALE: 1 " = 100 '
DATE: 10-5-22
PROJECT NUMBER 22-78-0033

FIGURE No. 2

EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF SOIL

SAMPLING DATA

▮	-	Indicates sample was attempted within this depth interval.
2 3 5	-	The number of blows required for each 6-inch increment of penetration of a "Standard" 2-inch O.D. split-barrel sampler, driven a distance of 18 inches by a 140-pound hammer freely falling 30 inches (SPT). The raw "blowcount" or "N" is equal to the sum of the second and third 6-inch increments of penetration.
N_{60}	-	Corrected Blowcount = [(Drill Rod Energy Ratio) / (0.60 Standard)] X N
SS	-	Split-barrel sampler, any size.
ST	-	Shelby tube sampler, 3″ O.D., hydraulically pushed.
R	-	Refusal of sampler in very-hard or dense soil, or on a resistant surface.
50-0.3′	-	Number of blows (50) to drive a split-barrel sampler a certain distance (0.3 feet), other than the normal 6-inch increment.

DEPTH DATA

W	-	Depth of water or seepage encountered during drilling.
▼ AD	-	Depth to water in boring after drilling (AD) is terminated.
▼ 5 days	-	Depth to water in monitoring well or piezometer in boring a certain number of days (5) after termination of drilling.
TR	-	Depth to top of rock.

SOIL DESCRIPTIONS

Soils have been classified in general accordance with Section 603 of the most recent ODOT SGE, and described in general accordance with Section 602, including the use of special adjectives to designate approximate percentages of minor components as follows:

Adjective	Percent by Weight
trace	1 to 10
little	10 to 20
some	20 to 35
"and"	35 to 50

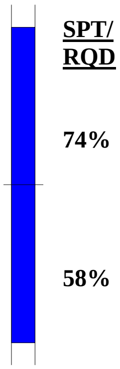
The following terms are used to describe density and consistency of soils:

Term (Granular Soils)	Blows per foot (N_{60})
Very-loose	Less than 5
Loose	5 to 10
Medium-dense	11 to 30
Dense	31 to 50
Very-dense	Over 50

Term (Cohesive Soils)	Qu (tsf)
Very-soft	Less than 0.25
Soft	0.25 to 0.5
Medium-stiff	0.5 to 1.0
Stiff	1.0 to 2.0
Very-stiff	2.0 to 4.0
Hard	Over 4.0

EXPLANATION OF SYMBOLS AND TERMS USED ON BORING LOGS FOR SAMPLING AND DESCRIPTION OF ROCK

SAMPLING DATA



When bedrock is encountered and rock core samples are attempted, the length of core recovered and lost during the core run is reported in the "REC" column. The type of rock core barrel utilized is recorded under the heading "Sampling Method" at the top of the boring log, and also in the "SAMPLE ID" column. Rock-core barrels can be of either single- or double-tube construction, and a special series of double-tube barrels, designated by the suffix M, may also be used to obtain maximum core recovery in very-soft or fractured rock. Four basic groups of barrels are used most often in subsurface investigations for engineering purposes, and these groups and the diameters of the cores obtained are as follows:

AX, AW, AXM, AWM	-	1-1/8 inches
BX, BW, BXM, BWM	-	1-5/8 inches
NX, NW, NXM, NWM	-	2-1/8 inches
NQ, NQ2	-	1-7/8 inches

Rock Quality Designation (RQD) is expressed as a percentage and is obtained by summing the total length of all core pieces which are at least 4 inches long and then dividing this sum by, either, the total length of core run or the length of the core run in a particular bedrock stratum. The RQD value is reported as a percentage in the "SPT/RQD" column. It has been found that there is a reasonably good relationship between the RQD value and the general quality of rock for engineering purposes. This relationship is shown as follows:

RQD - %	General Quality
0 - 25	Very-poor
25 - 50	Poor
50 - 75	Fair
75 - 90	Good
90 - 100	Excellent

ROCK HARDNESS

Recovered bedrock samples are described in general accordance with Section 605 of the 2007 ODOT SGE and subsequent revisions, where necessary. The following terms are used to describe rock hardness:

Term	Meaning
Very Weak	Rock can be excavated readily with the point of a pick and carved with a knife. Pieces 1 inch or greater in thickness can be broken by finger pressure. Can be scratched with a fingernail.
Weak	Rock can be grooved or gouged readily by a knife or pick, and can be excavated in small fragments with moderate blows from a pick point. Small, thin pieces may be broken with finger pressure.
Slightly Strong	Rock can be grooved or gouged 0.05 inches deep with firm pressure from a knife or pick point, and can be excavated in small chips to pieces of 1 inch maximum size using hard blows from the point of a geologist's pick.
Moderately Strong	Rock can be scratched with a knife or pick. Grooves or gouges to ¼ inch deep can be excavated by hard blows of a geologist's pick. Requires moderate hammer blows to detach a hand specimen.
Strong	Rock can be scratched with a knife or pick only with difficulty. Requires hard hammer blows to detach a hand specimen. Sharp and resistant edges are present on hand specimens.
Very Strong	Rock cannot be scratched by a knife or sharp pick. Breaking of hand specimens requires repeated hard blows of a geologist's hammer.
Extremely Strong	Rock cannot be scratched by a knife or sharp pick. Chipping of hand specimens requires repeated hard blows of a geologist's hammer.

PROJECT: HAM-74-13.35	DRILLING FIRM / OPERATOR: S&ME / T. FROST	DRILL RIG: S&ME D50 (R61)	STATION / OFFSET: 19+27, 35' RT.	EXPLORATION ID B-001-0-22
TYPE: BRIDGE REPLACEMENT	SAMPLING FIRM / LOGGER: S&ME / M. TORRES	HAMMER: CME AUTOMATIC	ALIGNMENT: RACE RD CL	
PID: 110563 SFN: 3108680	DRILLING METHOD: 3.25" HSA / NQ	CALIBRATION DATE: 6/7/22	ELEVATION: 786.8 (MSL) EOB: 30.0 ft.	PAGE 1 OF 2
START: 9/23/22 END: 9/23/22	SAMPLING METHOD: SPT / NQ / ST	ENERGY RATIO (%): 69.8	LAT / LONG: 39.186380, -84.627904	

MATERIAL DESCRIPTION AND NOTES	ELEV. 786.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
TOPSOIL/ROOTMAT - 2 INCHES	786.6																	
Hard brown **SILTY CLAY**, little gravel, little fine to coarse sand, damp.	783.8	1 – 3	7 9 9	21	100	SS-1	4.5	-	-	-	-	-	29	16	13	6	A-6b (V)	
Loose brown **GRAVEL WITH SAND**, trace silt, trace clay, damp.	781.8	3 – 5	ST		33	ST-2	-	49	21	17	9	4	NP	NP	NP	5	A-1-b (0)	
Loose brown **COARSE AND FINE SAND**, little gravel, little clay, trace silt, damp.	778.8	5 – 8	4 4 2	7	44	SS-3	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
Very-loose brown **GRAVEL**, trace fine to coarse sand, trace silt, trace clay, moist.		8 – 13	1 1 1	2	0		-	-	-	-	-	-	-	-	-	-		
			2	-	100	2S-4	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
			1 1 1	2	0		-	-	-	-	-	-	-	-	-	-		
	773.8		2	-	100	2S-5	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
SHALE, gray, highly weathered, very weak, with limestone layers.	772.3	13 – 14.5 (TR)	31 50	-	67	SS-6	-	-	-	-	-	-	-	-	-	-	Rock (V)	
INTERBEDDED LIMESTONE (75%) AND SHALE (25%) RUN RQD (57%), RUN REC. (100%) **LIMESTONE**, light gray, moderately weathered, strong, very thin to thinly bedded, fossiliferous, fractured to moderately fractured. **SHALE**, dark gray, moderately weathered with zones of highly weathered, weak, laminated, calcareous, fractured to highly fractured. UCS = 8,986 psi at 15.8'-16.2' (Limestone)	768.1	15 – 20	57		100	NQ-7											CORE	
INTERBEDDED SHALE (70%) AND LIMESTONE (30%) RUN RQD (85%), RUN REC. (100%) **SHALE**, dark gray, slightly weathered, weak to slightly strong, laminated, calcareous, moderately fractured. **LIMESTONE**, light gray, moderately to slightly weathered, strong, very thin to thinly bedded, fossiliferous. Vuggy at 20.3 feet.	761.8	20 – 25	92		100	NQ-8											CORE	

PID: 110563	SFN: 3108680	PROJECT: HAM-74-13.35	STATION / OFFSET: 19+27, 35' RT.	START: 9/23/22	END: 9/23/22	PG 2 OF 2	B-001-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV. 761.8	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
INTERBEDDED LIMESTONE (80%) AND SHALE (20%) RUN RQD (63%), RUN REC. (100%) **LIMESTONE**, light gray, slightly weathered, strong to very strong, thin to medium bedded, fossiliferous, moderately to slightly fractured. **SHALE**, dark gray, slightly weathered, slightly strong, laminated, calcareous.	756.8	26 27 28 29 EOB 30	63		100	NQ-9											CORE	

NOTES:
- Groundwater not encountered prior to rock coring.
- Began rock coring using NQ core barrel with water as circulating fluid at 15.0'.
- Water level at 6.0' after rock coring.
- Boring caved at 10.0' upon removal of augers.

NOTES: SEE ABOVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS MIXED WITH BENTONITE

PROJECT: HAM-74-13.35	DRILLING FIRM / OPERATOR: S&ME / C. BRUMMAGE	DRILL RIG: S&ME D50 (R61)	STATION / OFFSET: 19+85, 39' LT.
TYPE: BRIDGE REPLACEMENT	SAMPLING FIRM / LOGGER: S&ME / M. TORRES	HAMMER: CME AUTOMATIC	ALIGNMENT: RACE RD CL
PID: 110563 SFN: 3108680	DRILLING METHOD: 3.25" HSA / NQ	CALIBRATION DATE: 6/7/22	ELEVATION: 785.3 (MSL) EOB: 31.2 ft.
START: 9/29/22 END: 9/29/22	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 69.8	LAT / LONG: 39.186573, -84.628108

EXPLORATION ID B-002-0-22

PAGE 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV. 785.3
TOPSOIL/ROOTMAT - 18 INCHES	783.8
Very-stiff brown **SILTY CLAY**, "and" gravel, some fine to coarse sand, damp.	780.8
Very-stiff brown and gray **CLAY**, some to little gravel, some to little fine to coarse sand, trace silt, contains limestone fragments, moist to damp.	772.8
SHALE, gray, highly weathered, very weak, with limestone layers.	767.5
INTERBEDDED SHALE (55%) AND LIMESTONE (45%) RUN RQD (44%), RUN REC. (75%) **SHALE**, dark gray, highly to slightly weathered, weak to moderately strong, laminated, highly fractured. **LIMESTONE**, light gray, moderately weathered, moderately strong, very thin to medium bedded, fossiliferous. UCS = 3,888 psi at 22.8'-23.2' (Shale)	

DEPTHS: TR at 12.5

SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
7 10 10	23	67	SS-1	-	-	-	-	-	-	-	-	-	-		
7 15 19	40	44	SS-2	2.5	37	11	9	19	24	40	20	20	9	A-6b (4)	
2 4 4	9	100	SS-3	3.8	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
8 4 8	14	100	SS-4	3.8	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
8 35 12	55	100	SS-5	3.3	33	14	12	9	32	44	20	24	12	A-7-6 (5)	
50/4"	-	100	SS-6	-	44	13	8	15	20	30	15	15	3	Rock (V)	
50/3"	-	100	SS-7	-	-	-	-	-	-	-	-	-	-	Rock (V)	
50/4"	-	100	SS-8	-	-	-	-	-	-	-	-	-	-	Rock (V)	
19		52	NQ-9											CORE	

S&ME JOB: 22780033

PID: 110563	SFN: 3108680	PROJECT: HAM-74-13.35	STATION / OFFSET: 19+85, 39' LT.	START: 9/29/22	END: 9/29/22	PG 2 OF 2	B-002-0-22

MATERIAL DESCRIPTION AND NOTES	ELEV. 760.3	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
INTERBEDDED SHALE (55%) AND LIMESTONE (45%) RUN RQD (44%), RUN REC. (75%) **SHALE**, dark gray, highly to slightly weathered, weak to moderately strong, laminated, highly fractured. **LIMESTONE**, light gray, moderately weathered, moderately strong, very thin to medium bedded, fossiliferous. *(continued)*		26 – 30	50		86	NQ-10											CORE	
	754.1	EOB 31	74		78	NQ-11											CORE	

NOTES:
- Groundwater not encountered prior to rock coring.
- Began rock coring using NQ core barrel with water as circulating fluid at 18.0'.
- Water level at 4.0' after rock coring.
- Boring caved at 11.0' upon removal of augers.

NOTES: SEE ABOVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS

STANDARD ODOT SOIL BORING LOG (8.5 X 11) - OH DOT.GDT - 10/28/22 14:38 - \\EGNYTEDRIVE\OPS\GEO\PROJECTS\2022\22780033_FISHBECK_HAM-74-13.35 BRIDGE_CINCINNATI OH\4 GEOFI

S&ME JOB: 22780033

PROJECT: HAM-74-13.35	DRILLING FIRM / OPERATOR: S&ME / C. BRUMMAGE	DRILL RIG: S&ME D50 (R61)	STATION / OFFSET: 20+71, 33' LT.	EXPLORATION ID B-003-0-22
TYPE: BRIDGE REPLACEMENT	SAMPLING FIRM / LOGGER: S&ME / M. TORRES	HAMMER: CME AUTOMATIC	ALIGNMENT: RACE RD CL	
PID: 110563 SFN: 3108680	DRILLING METHOD: 3.25" HSA / NQ	CALIBRATION DATE: 6/7/22	ELEVATION: 785.2 (MSL) EOB: 20.2 ft.	PAGE 1 OF 1
START: 9/29/22 END: 9/29/22	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 69.8	LAT / LONG: 39.186817, -84.628081	

MATERIAL DESCRIPTION AND NOTES	ELEV. 785.2	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
								GRADATION (%)					ATTERBERG					
TOPSOIL/ROOTMAT - 7 INCHES	784.6																	
Very-stiff to hard brown and gray **SILT AND CLAY**, "and" gravel, little fine to coarse sand, moist to damp, with limestone floaters, slighty organic.		1	2 3 5	9	39	SS-1	2.8	-	-	-	-	-	-	-	-	25	A-6a (V)	
		3	3 15 50/4"	-	75	SS-2	2.3	44	8	5	26	17	36	21	15	10	A-6a (3)	
	779.9	5 TR	50/3"	-	67	SS-3	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
INTERBEDDED LIMESTONE (50%) AND SHALE (50%) RUN RQD (17%), RUN REC. (88%) **LIMESTONE**, light gray, moderately weathered, moderately to very strong, very thin to medium bedded, fossiliferous. **SHALE**, dark gray, severely to moderately weathered, weak to slightly strong, laminated, highly fractured.		6	0		89	NQ-4											CORE	
		9	20		75	NQ-5											CORE	
UCS = 1,455 psi at 11.8'-12.2' (Interbedded Limestone and Shale)		12																
UCS = 8,195 psi at 14.9'-15.3' (Limestone)		15	20		95	NQ-6											CORE	
		19	14		94	NQ-7											CORE	
	765.0	20 EOB																

NOTES:
- Groundwater not encountered prior to rock coring.
- Began rock coring using NQ core barrel with water as circulating fluid at 5.5'.
- Water level at 4.0' after rock coring.
- Boring caved at 9.0' upon removal of augers.

NOTES: SEE ABOVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS

B-003-0-63

State of Ohio
Department of Highways
Testing Laboratory

LOG OF BORING

Date Started 2-7-63 Sampler Type SS Dia. 1 3/8" Water Elev. ______
Date Completed 2-7-63 Casing: Length ______ Dia. ______

Project Identification HAMILTON
HAM-52-11.37
HAM-52-13.46
RACE ROAD OVER USR 52

Boring No. B-3 Station & Offset 19+30, 18' Lt.(REAR PIER) Surface Elev. 791.1

Elev.	Depth	Std. Pen. (N)	Rec. ft.	Loss ft.	Description	Field No.	Lab. Nos. So	% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class
791.1	0															
786.1	6	3/3			Brown Gravelly Clay	1	6170	29	2	3	21	45	49	26	27	
781.1	10–12	2/2			Brown and Gray Gravelly Clay	2	6171	26	3	3	25	43	46	22	26	
776.1																
775.1	16	5/7			Brown and Gray Clayey Silt	3	6172	0	1	2	51	46	PL=	29	35	
	18		2.6	1.4	Brown Clayey Silt and limestone cobbles.											
771.1	20				TOP OF ROCK											
	22–26		4.7	0.3	Shale, dark gray, fissile, firm, moderately weathered in top 3.0'; with thin, irregular limestone interbeds (gray, crystalline, fossiliferous, hard) comprising 34% of the interval. Core loss 3%.											
	28		5.0	0.0												
761.1	30				BOTTOM OF BORING											

PLATE 10

B-009-0-63

State of Ohio
Department of Highways
Testing Laboratory

LOG OF BORING

Water Elev. ____

Project Identification: HAMILTON
HAM-52-11.37
HAM-52-1346
RACE ROAD OVER USR 52

Date Started 2-7-63 Date Completed 2-8-63

Boring No. B-9 Station & Offset 21+31, 18' Lt. (FORWARD ABUTMENT) Surface Elev. 808.8

Elev.	Depth	Rec. ft.	Loss ft.	Description
808.8	0			
	2			
	4	0.5	4.5	Brown Silty Clay with Limestone Boulders and Cobbles.
	6			
	8	1.8	2.2	
	10			
	12			
794.8	14	4.0	1.0	TOP OF ROCK
	16			
	18	5.0	0.0	Shale, gray, fissile, firm, calcareous, with interbedded limestone (gray, crystalline, fossiliferous, hard) comprising 50% of the interval; with soft clay seams less than 1 inch in thickness throughout. Core loss 10%.
	20			
	22			
	24	3.4	1.6	
783.8				BOTTOM OF BORING

PLATE 11

Date: 9/15/2022

Photographer: JCH

1	**Location / Orientation**	East of B-001-0-22 facing West. South of I-74 Eastbound.
	Remarks	Offset from Existing Pier

Date: 9/15/2022

Photographer: JCH

2	**Location / Orientation**	West of B-002-0-22 facing East. In the median of I-74.
	Remarks	Offset from Existing Pier

Date: 9/15/2022

Photographer: JCH

3	**Location / Orientation**	West of B-003-0-22 facing East. North of I-74 Westbound.
	Remarks	Offset from Existing Pier

Date: 9/29/2022

Photographer: BCD

4	**Boring**	B-001-0-22
	Depth	15.0 feet to 30.0 feet / Box 1 of 1

Date: 9/29/2022

Photographer: BCD

5	**Boring**	B-002-0-22
	Depth	18.0 feet to 31.2 feet / Box 1 of 1

Date: 9/29/2022

Photographer: BCD

6	**Boring**	B-003-0-22
	Depth	5.3 feet to 17.2 feet / Box 1 of 2

Date: 9/29/2022

Photographer: BCD

7	**Boring**	B-003-0-22
	Depth	17.2 feet to 20.2 feet / Box 2 of 2

Important Information About Your
Geotechnical Engineering Report

Variations in subsurface conditions can be a principal cause of construction delays, cost overruns and claims. The following information is provided to assist you in understanding and managing the risk of these variations.

Geotechnical Findings Are Professional Opinions

Geotechnical engineers cannot specify material properties as other design engineers do. Geotechnical material properties have a far broader range on a given site than any manufactured construction material, and some geotechnical material properties may change over time because of exposure to air and water, or human activity.

Site exploration identifies subsurface conditions at the time of exploration and only at the points where subsurface tests are performed or samples obtained. Geotechnical engineers review field and laboratory data and then apply their judgment to render professional opinions about site subsurface conditions. Their recommendations rely upon these professional opinions. Variations in the vertical and lateral extent of subsurface materials may be encountered during construction that significantly impact construction schedules, methods and material volumes. While higher levels of subsurface exploration can mitigate the risk of encountering unanticipated subsurface conditions, no level of subsurface exploration can eliminate this risk.

Geotechnical Findings Are Professional Opinions

Professional geotechnical engineering judgment is required to develop a geotechnical exploration scope to obtain information necessary to support design and construction. A number of unique project factors are considered in developing the scope of geotechnical services, such as the exploration objective; the location, type, size and weight of the proposed structure; proposed site grades and improvements; the construction schedule and sequence; and the site geology.

Geotechnical engineers apply their experience with construction methods, subsurface conditions and exploration methods to develop the exploration scope. The scope of each exploration is unique based on available project and site information. Incomplete project information or constraints on the scope of exploration increases the risk of variations in subsurface conditions not being identified and addressed in the geotechnical report.

Services Are Performed for Specific Projects

Because the scope of each geotechnical exploration is unique, each geotechnical report is unique. Subsurface conditions are explored and recommendations are made for a specific project.

Subsurface information and recommendations may not be adequate for other uses. Changes in a proposed structure location, foundation loads, grades, schedule, etc. may require additional geotechnical exploration, analyses, and consultation. The geotechnical engineer should be consulted to determine if additional services are required in response to changes in proposed construction, location, loads, grades, schedule, etc.

Geo-Environmental Issues

The equipment, techniques, and personnel used to perform a geo-environmental study differ significantly from those used for a geotechnical exploration. Indications of environmental contamination may be encountered incidental to performance of a geotechnical exploration but go unrecognized. Determination of the presence, type or extent of environmental contamination is beyond the scope of a geotechnical exploration.

Geotechnical Recommendations Are Not Final

Recommendations are developed based on the geotechnical engineer's understanding of the proposed construction and professional opinion of site subsurface conditions. Observations and tests must be performed during construction to confirm subsurface conditions exposed by construction excavations are consistent with those assumed in development of recommendations. It is advisable to retain the geotechnical engineer that performed the exploration and developed the geotechnical recommendations to conduct tests and observations during construction. This may reduce the risk that variations in subsurface conditions will not be addressed as recommended in the geotechnical report.

Appendix B – Laboratory Testing

SUMMARY OF LABORATORY RESULTS

OHIO DEPARTMENT OF TRANSPORTION
OFFICE OF GEOTECHNICAL ENGINEERING

PROJECT HAM-74-13.35 **PID** 110563

OGE NUMBER HAM-74-13.35 **PROJECT TYPE** BRIDGE REPLACEMENT

Borehole	Depth	Sample	Lab ID	G (%)	CS (%)	FS (%)	M (%)	C (%)	LL	PL	PI	M (%)	LOI (%)	ODOT CLASS	USCS CLASS	FLAGS LL	FLAGS PL	FLAGS M	FLAGS OC	FLAGS NP
B-001-0-22	1.0	SS- 1	1						29	16	13	6								
B-001-0-22	3.0	ST- 2	2	49	21	17	9	4	NP	NP	NP	5		A-1-b	SM					
B-001-0-22	6.0	SS- 3	3									6								
B-001-0-22	10.0	2S- 4	4																	
B-001-0-22	12.5	2S- 5	5																	
B-001-0-22	13.5	SS- 6	6																	
B-001-0-22	15.0	NQ- 7	7																	
B-001-0-22	20.0	NQ- 8	8																	
B-001-0-22	25.0	NQ- 9	9																	
B-002-0-22	0.0	SS- 1	1																	
B-002-0-22	2.5	SS- 2	2	37	11	9	19	24	40	20	20	9		A-6b	GC					
B-002-0-22	5.0	SS- 3	3									11								
B-002-0-22	7.5	SS- 4	4									21								
B-002-0-22	10.0	SS- 5	5	33	14	12	9	32	44	20	24	12		A-7-6	SC					
B-002-0-22	12.5	SS- 6	6	44	13	8	15	20	30	15	15	3		A-2-6	GC				X	
B-002-0-22	15.0	SS- 7	7																	
B-002-0-22	17.5	SS- 8	8																	
B-002-0-22	18.0	NQ- 9	9																	
B-002-0-22	22.3	NQ- 10	10																	
B-002-0-22	29.5	NQ- 11	11																	
B-003-0-22	0.0	SS- 1	1									25								
B-003-0-22	2.5	SS- 2	2	44	8	5	26	17	36	21	15	10		A-6a	GC					
B-003-0-22	5.0	SS- 3	3																	
B-003-0-22	5.5	NQ- 4	4																	
B-003-0-22	6.9	NQ- 5	5																	
B-003-0-22	12.2	NQ- 6	6																	
B-003-0-22	17.2	NQ- 7	7																	

EXPLANATION OF FLAGS

LL - Check LL (flagged if less than PL or greater than 60)
PL - Check PL (flagged if greater than 50)
M - Check Moisture (flagged if greater than LL)
OC - Check ODOT Class (flagged if different from Visual class)
NP - Check NP (flagged if NP sample has significant clay content vs silt)

Form No. TR-D7012C-01
Revision No. 1
Revision Date: 07/14/17

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C

Quality Assurance

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-001-0-22, NQ-7	Depth/Elev., ft:	15.8'-16.2'
Sample Description:	LIMESTONE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content ***0.9*** **%** ***Dry Unit Weight*** ***164.2*** **pcf**

Compressive Strength ***8,986*** **psi**

Before Test

After Test

Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543.**

Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples.

Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

Form No. TR-D7012C-01
Revision No. 1
Revision Date: 07/14/17

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C

Quality Assurance

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-002-0-22, NQ-10	Depth/Elev., ft:	22.8'-23.2'
Sample Description:	SHALE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content ***5.0*** % ***Dry Unit Weight*** ***149.9*** pcf

Compressive Strength ***3,888*** psi

Before Test

After Test

Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543.**

Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples.

Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

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Form No. TR-D7012C-01
Revision No. 1
Revision Date: 07/14/17

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C

Quality Assurance

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-003-0-22, NQ-5	Depth/Elev., ft:	11.8'-12.2'
Sample Description:	INTERBEDDED SHALE/LIMESTONE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content ***1.2*** % ***Dry Unit Weight*** ***159.3*** pcf

Compressive Strength ***1,455*** psi

Before Test

After Test

Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543.**

Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples.

Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C

Quality Assurance

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-003-0-22, NQ-6	Depth/Elev., ft:	14.9'-15.3'
Sample Description:	LIMESTONE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content ***1.3*** **%** ***Dry Unit Weight*** ***165.7*** **pcf**

Compressive Strength ***8,195*** **psi**

Before Test

After Test

Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543.**

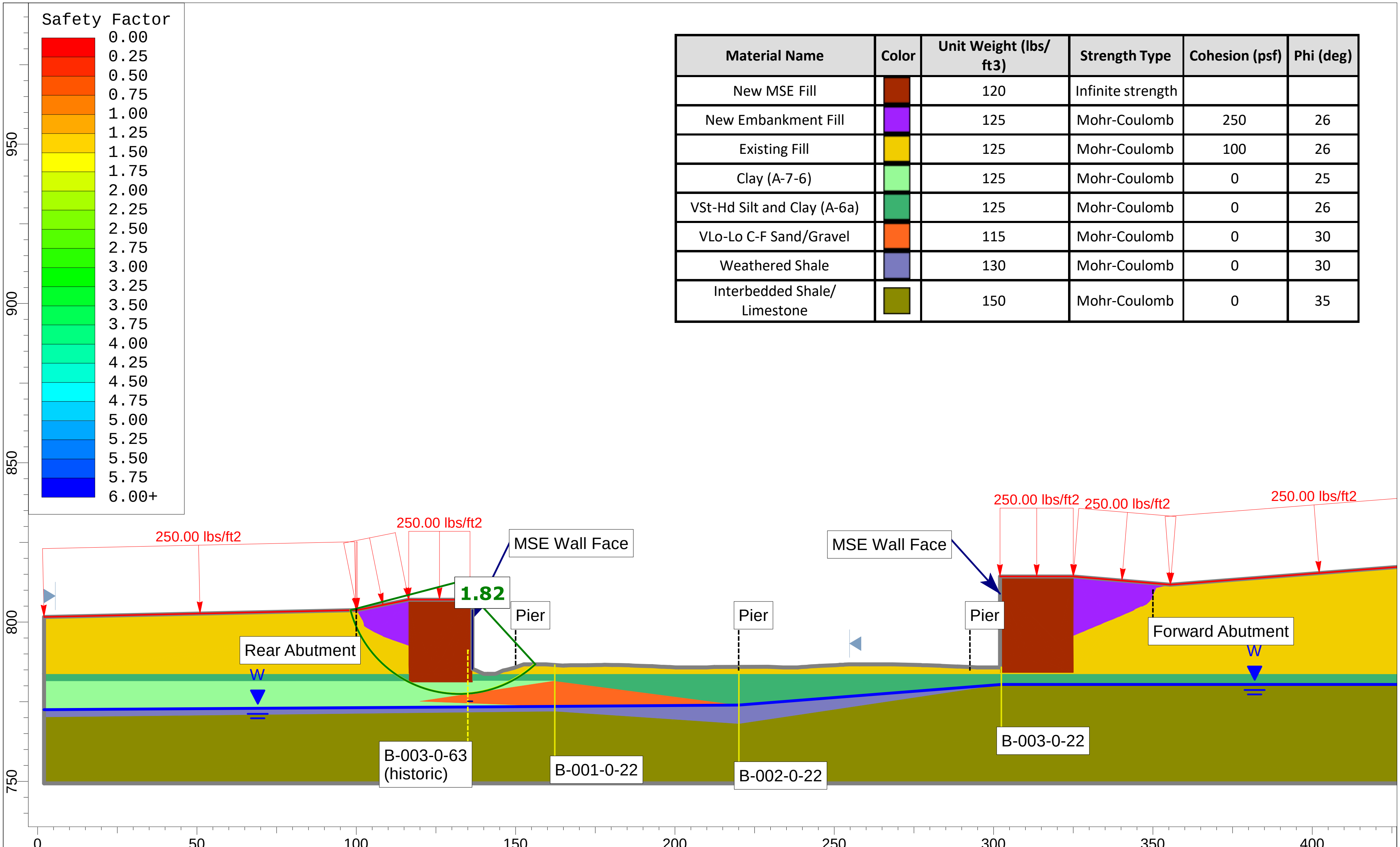
Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples.

Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

Appendix C – Calculations

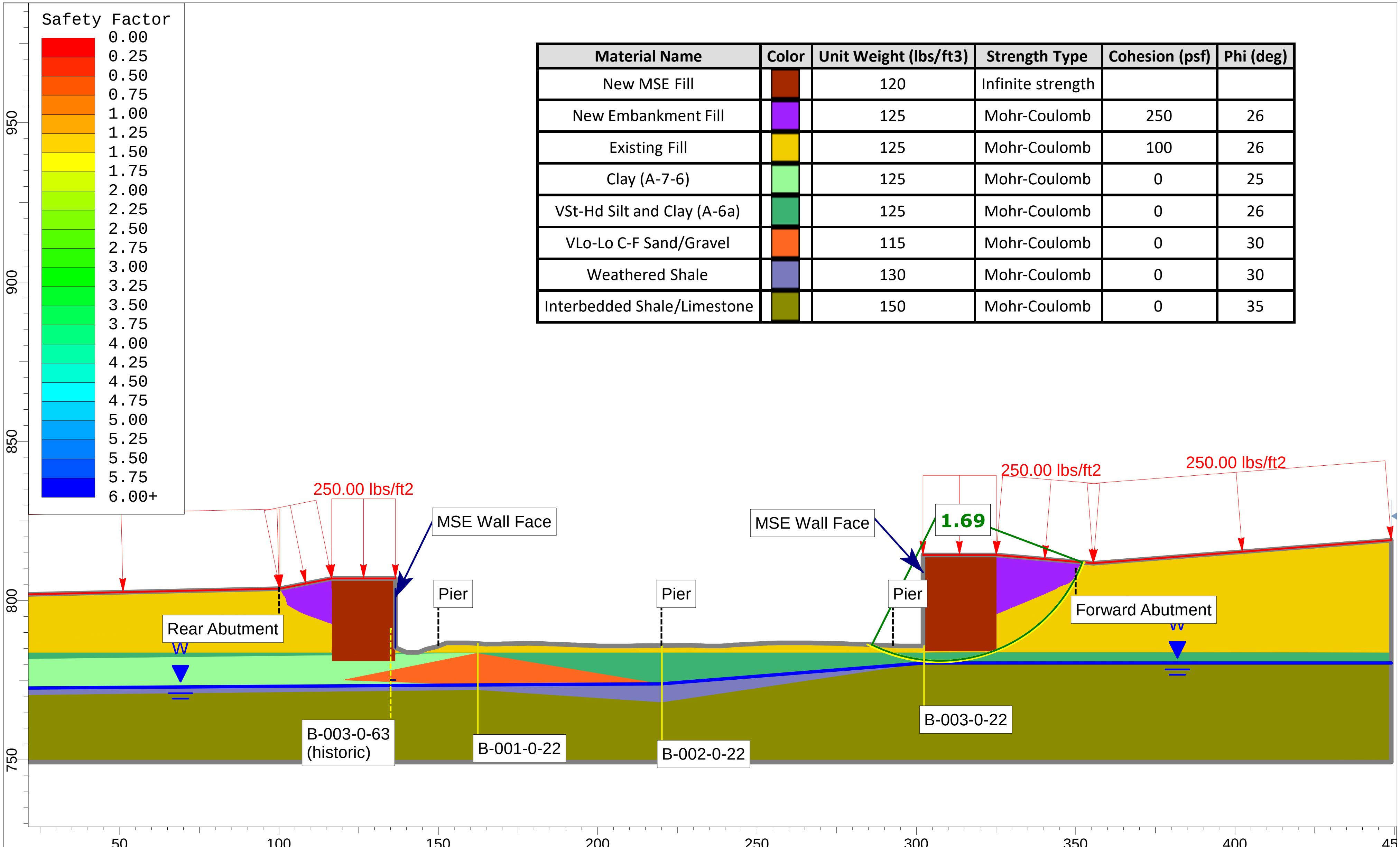
Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New MSE Fill		120	Infinite strength		
New Embankment Fill		125	Mohr-Coulomb	250	26
Existing Fill		125	Mohr-Coulomb	100	26
Clay (A-7-6)		125	Mohr-Coulomb	0	25
VSt-Hd Silt and Clay (A-6a)		125	Mohr-Coulomb	0	26
VLo-Lo C-F Sand/Gravel		115	Mohr-Coulomb	0	30
Weathered Shale		130	Mohr-Coulomb	0	30
Interbedded Shale/ Limestone		150	Mohr-Coulomb	0	35



SLIDEINTERPRET 9.025

Project	HAM-74-13.35 Bridge Replacement		
Analysis Description	Proposed MSE Wall		
Drawn By RES	*Scale* 1:500	*Company*	S&ME, Inc.
Date	10/18/2022	*Comment*	Left, Effective Stress

PLATE 1

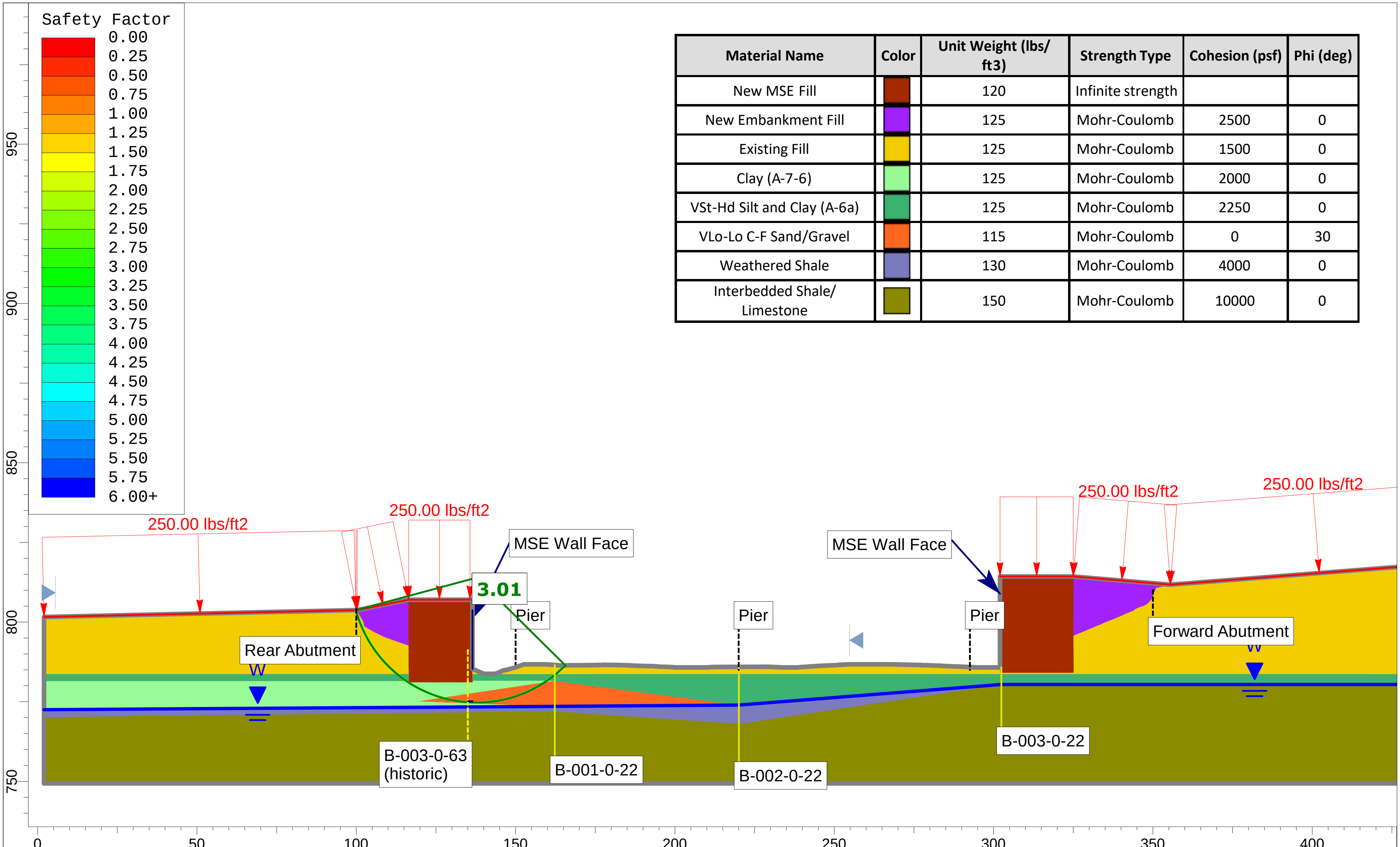


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New MSE Fill		120	Infinite strength		
New Embankment Fill		125	Mohr-Coulomb	250	26
Existing Fill		125	Mohr-Coulomb	100	26
Clay (A-7-6)		125	Mohr-Coulomb	0	25
VSt-Hd Silt and Clay (A-6a)		125	Mohr-Coulomb	0	26
VLo-Lo C-F Sand/Gravel		115	Mohr-Coulomb	0	30
Weathered Shale		130	Mohr-Coulomb	0	30
Interbedded Shale/Limestone		150	Mohr-Coulomb	0	35

Project	HAM-74-13.35 Bridge Replacement		
Analysis Description	Proposed MSE Wall		
Drawn By RES	*Scale* 1:500	*Company*	S&ME, Inc.
Date	10/18/2022	*Comment*	Right, Effective Stress

SLIDEINTERPRET 9.025

PLATE 2

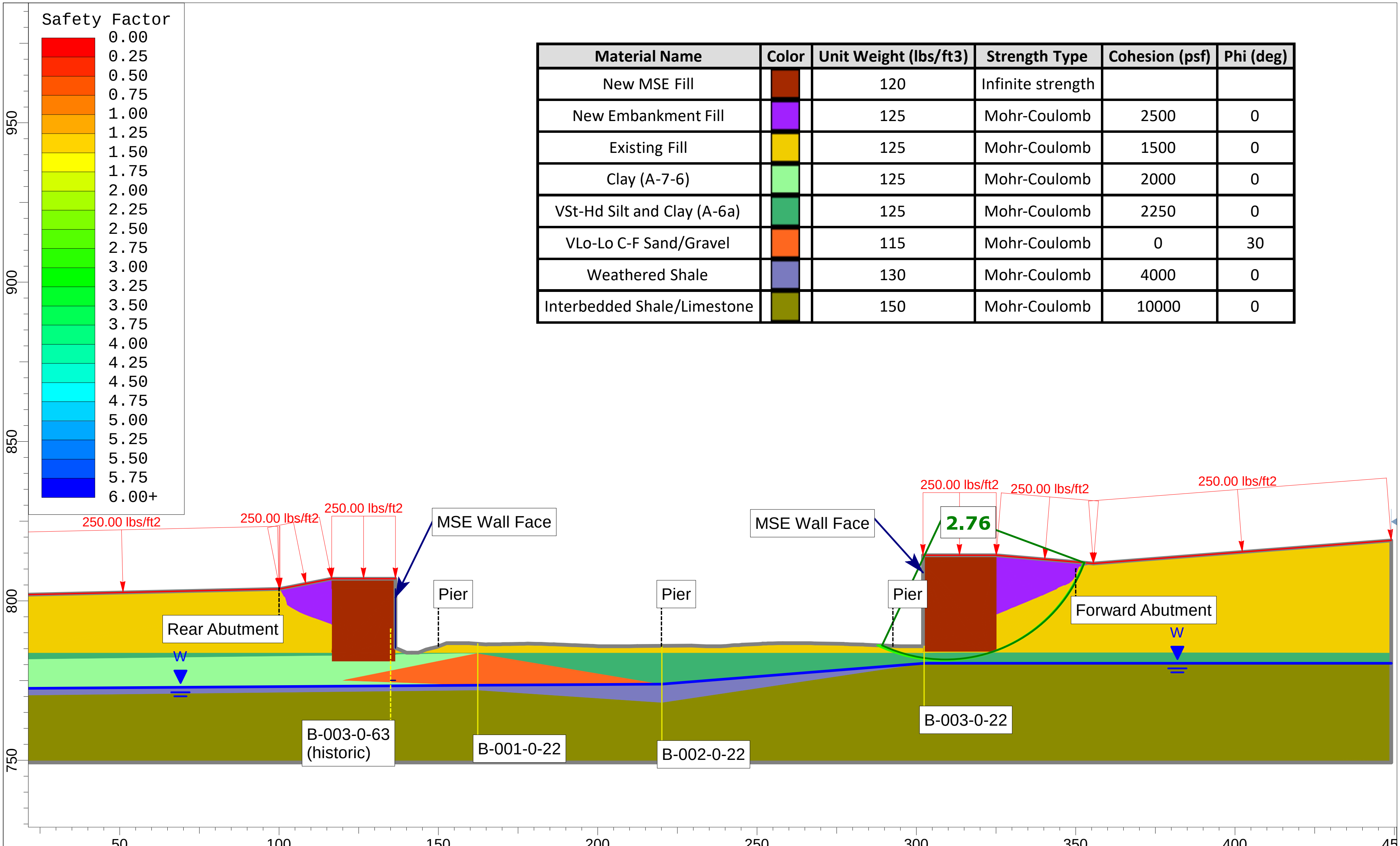


Material Name	Color	Unit Weight (lbs/ ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New MSE Fill		120	Infinite strength		
New Embankment Fill		125	Mohr-Coulomb	2500	0
Existing Fill		125	Mohr-Coulomb	1500	0
Clay (A-7-6)		125	Mohr-Coulomb	2000	0
VSt-Hd Silt and Clay (A-6a)		125	Mohr-Coulomb	2250	0
VLo-Lo C-F Sand/Gravel		115	Mohr-Coulomb	0	30
Weathered Shale		130	Mohr-Coulomb	4000	0
Interbedded Shale/ Limestone		150	Mohr-Coulomb	10000	0

Project	HAM-74-13.35 Bridge Replacement		
Analysis Description	Proposed MSE Wall		
Drawn By RES	*Scale* 1:500	*Company*	S&ME, Inc.
Date	10/18/2022	*Comment*	Left, Total Stress

SLIDEINTERPRET 9.025

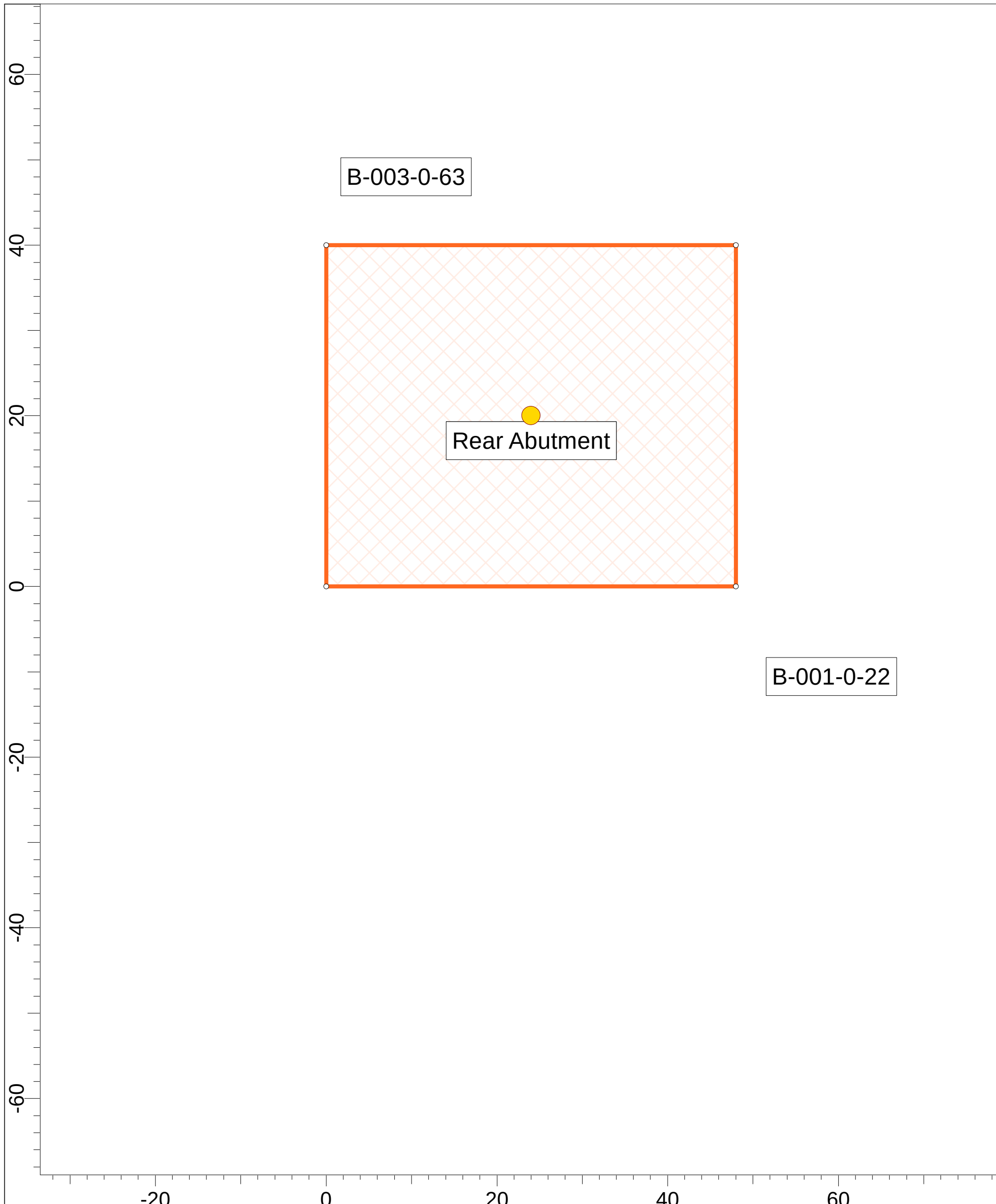
PLATE 3

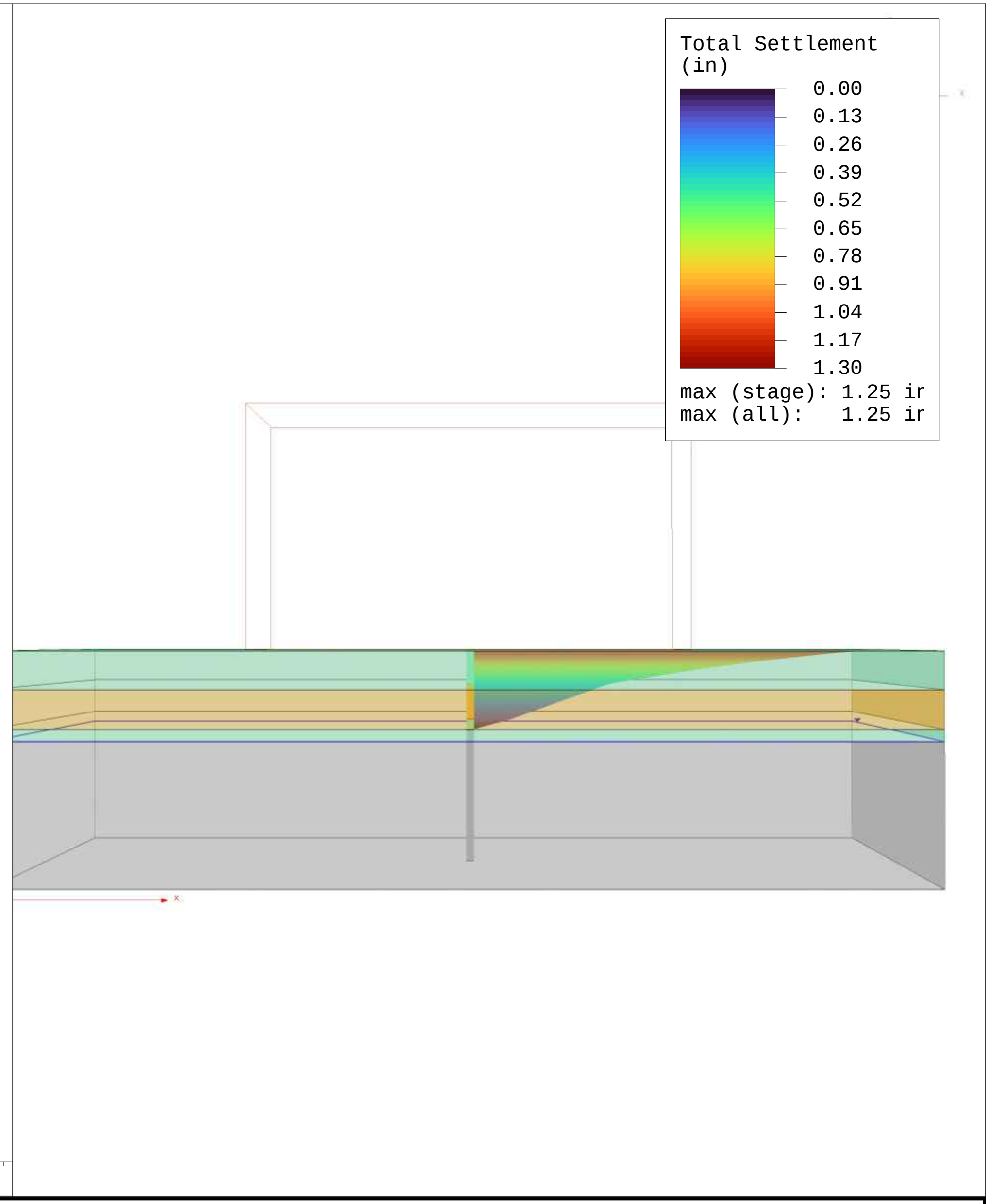


Material Name	Color	Unit Weight (lbs/ft3)	Strength Type	Cohesion (psf)	Phi (deg)
New MSE Fill		120	Infinite strength		
New Embankment Fill		125	Mohr-Coulomb	2500	0
Existing Fill		125	Mohr-Coulomb	1500	0
Clay (A-7-6)		125	Mohr-Coulomb	2000	0
VSt-Hd Silt and Clay (A-6a)		125	Mohr-Coulomb	2250	0
VLo-Lo C-F Sand/Gravel		115	Mohr-Coulomb	0	30
Weathered Shale		130	Mohr-Coulomb	4000	0
Interbedded Shale/Limestone		150	Mohr-Coulomb	10000	0

SLIDEINTERPRET 9.025	*Project*	HAM-74-13.35 Bridge Replacement	
	Analysis Description	Proposed MSE Wall	
	Drawn By RES	*Scale* 1:500	*Company* S&ME, Inc.
	Date 10/18/2022		*Comment* Right, Total Stress

PLATE 4





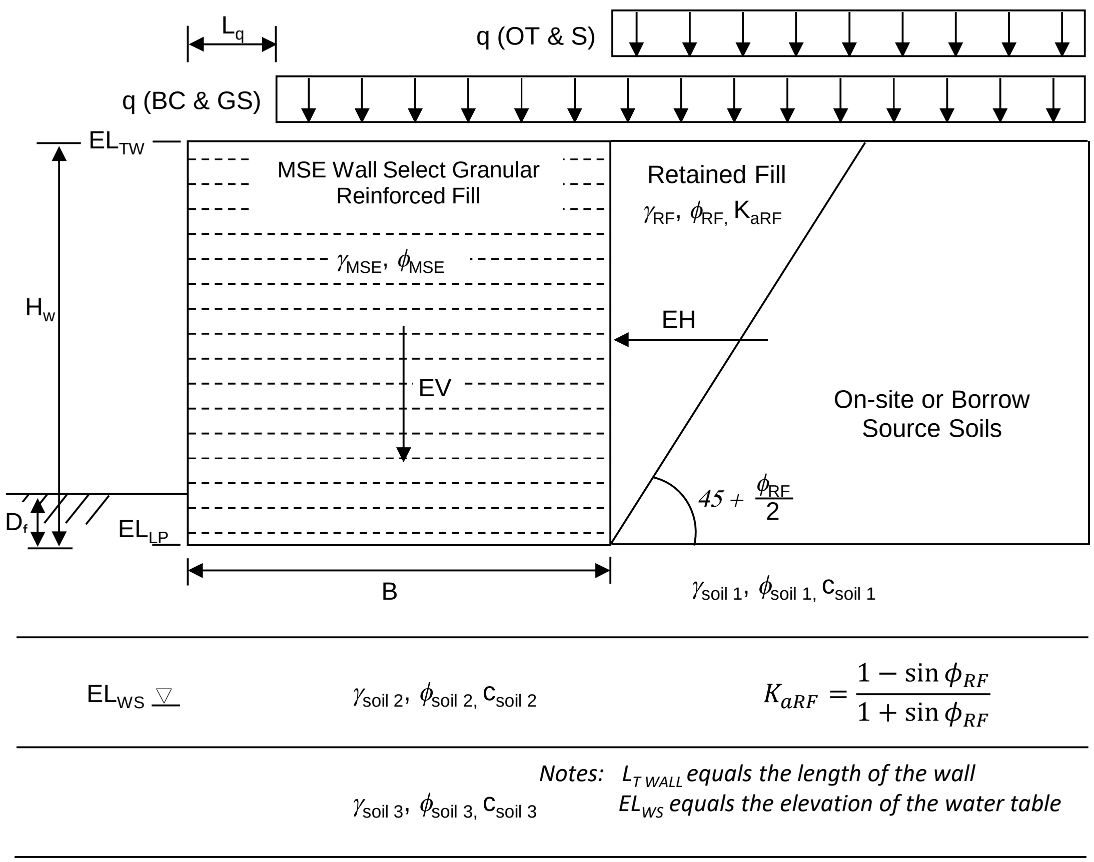
SETTLE3 5.017

Project	HAM-74-13.35 Bridge Replacement		
Analysis Description	MSE Wall, Rear Abutment		
Drawn By	R. Scherzinger	*Company*	S&ME, Inc.
Date	10/28/2022	*File Name*	MSE Wall.s3z

PLATE 5

S&ME Project #22-78-0033, Rear Abutment (Strength Limit)

MSE Wall Stability Diagram and Design Parameters



γ_{MSE}	=	125	pcf
H_W	=	25.98	ft
H_2	=		ft
EL_{LP}	=	781	
EL_{AS}	=	806.98	
EL_{TA}	=	806.98	
H_T	=	25.98	ft
B	=	**20**	ft
L_{AS}	=		

ϕ'_{MSE}	=	32	deg
γ_{RF}	=	125	pcf
ϕ'_{RF}	=	26	deg
K_{aRF}	=	0.39	
q	=	250	psf
L_q	=	0	ft

Representative Soil Profile: B-001-0-22

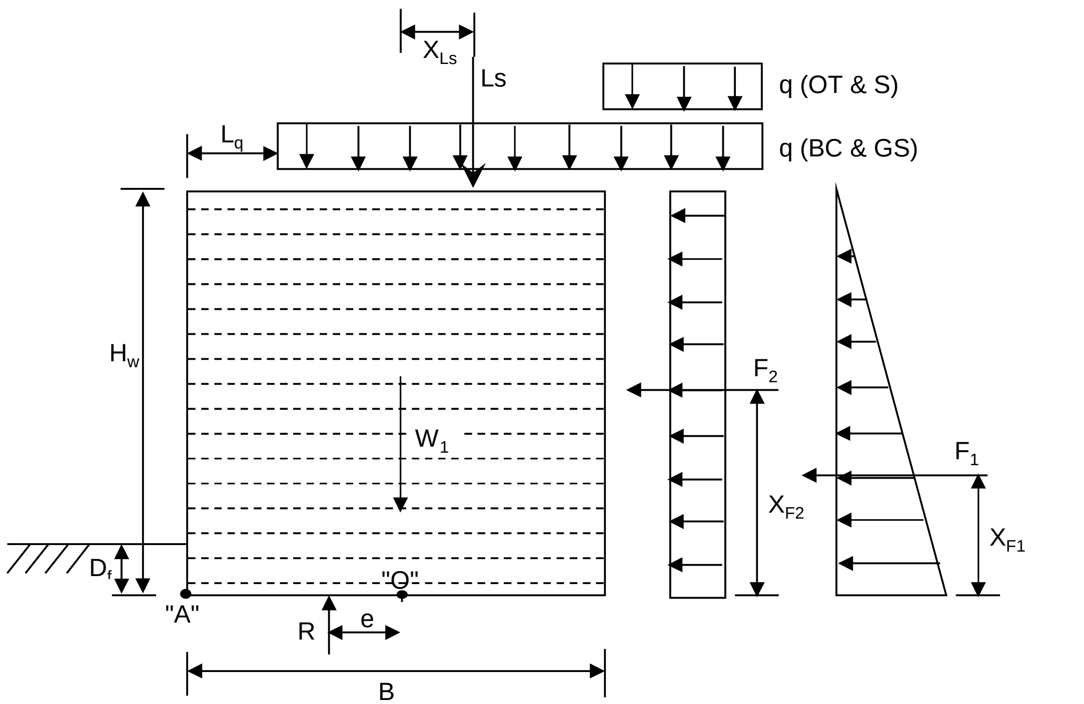
$L_{T\ WALL}$	=	136	ft
EL_{WS}*	=	773	MSL
D_w	=	11	ft
D_f	=	3	ft

*To ensure correct usage of effective vs. saturated unit weights, break up soil layers at the water surface elevation.

	Soil Layer 1		*Soil Layer 2*		*Soil Layer 3*	
Upper El.	781	MSL	776.4	MSL	774.8	MSL
Lower El.	776.4	MSL	774.8	MSL	773.3	MSL
γ_{soil}	125	pcf	115	pcf	125	pcf
γ'_{soil}	125	pcf	115	pcf	125	pcf
ϕ'_{soil}	25	deg	30	deg	25	deg
c'_{soil}	0	psf	0	psf	0	psf
ϕ_{soil}	0	deg	30	deg	0	deg
c_{soil}	2000	psf	0	psf	2000	psf

S&ME Project #22-78-0033, Rear Abutment (Strength Limit)

External Stability Diagram and Force Definitions



CDR Values (***Drained*** Undrained)

Sliding	***1.04***	1.12
Eccentricity		1.59
Bearing Resistance	***1.04***	1.04

Resistance and Load Factors (Tables 3.4.1-1, 3.4.1-2 & 11.5.7-1)

Sliding

φ_τ =	1.0
γ_{EH} =	1.5
γ_{EV} =	1.0
γ_{LS} =	1.75

Overturning

γ_{EH} =	1.5
γ_{EV} =	1.0
γ_{LS} =	1.75

Bearing Resistance

φ_b =	0.65
γ_{EH} =	1.5
γ_{EV} =	1.35
γ_{LS} =	1.75

Interim Calculations

Force Calculations

W_1 = 64950.0 plf $W_1 = H_W B \gamma_{MSE}$

W_2 = 0.0 plf $W_2 = H_2 \gamma_{MSE}(B - L_{AS})$

F_1 = 16452.2 plf $F_1 = 0.5\gamma_{rf} H_T^2 K_{aRF}$

F_2 = 2533.1 plf $F_2 = q H_T K_{aRF}$

L_S = 5000.0 plf $L_S = q(B - L_q)$

(For F_2 and L_s: use only if $L_q < (B + \frac{H_w}{2})$)

Moment Arm Equations

$\bar{X}_{W1}$ = 0 (passes through "O")

$$\bar{X}_{W2} = \left(\frac{B - L_{AS}}{2}\right) - \frac{B}{2}$$

$$\bar{X}_{F1} = \frac{H_T}{3}$$

$$\bar{X}_{F2} = \frac{H_T}{2}$$

$$\bar{X}_{LS} = \left(\frac{B - L_q}{2}\right) - \frac{B}{2}$$

S&ME Project #22-78-0033, Rear Abutment (Strength Limit)

Moment Arm Calculations			*Moment Calculations - Eccentricity*			*Moment Calculations - Bearing*		
X_{W1} =	0.00	ft	M_{W1} =	0.0	lb-ft/ft	M_{W1} =	0.0	lb-ft/ft
X_{W2} =	0.00	ft	M_{W2} =	0.0	lb-ft/ft	M_{W2} =	0.0	lb-ft/ft
X_{F1} =	8.66	ft	M_{F1} =	213714.1	lb-ft/ft	M_{F1} =	213714.1	lb-ft/ft
X_{F2} =	12.99	ft	M_{F2} =	57583.7	lb-ft/ft	M_{F2} =	57583.7	lb-ft/ft
X_{LS} =	0.00	ft	$M_x = \gamma_x F_x \bar{X}_x$			M_{LS} =	0.0	lb-ft/ft

Drained Analysis

Sliding (Articles 11.10.5.3 & 10.6.3.4)			*Eccentricity (Overturning) (Articles 11.10.5.5 & 11.6.3.3)*			*Eccentricity for BR (Article 11.10.5.4)*		
δ =	25	deg	R =	64950.0	plf	R =	96432.5	plf
Tan(δ) =	0.466		e =	4.18	ft	e =	2.81	ft
$R_R = \varphi_\tau R_\tau$ =	30286.7	plf						
Q_S =	29111.2	plf	M_R =	271297.8	lb-ft/ft	M_R =	271297.8	lb-ft/ft
Is $R_R > Q_S$?	**Yes**		Is e < B/3?	**Yes**		Moment equations are solved by summing moments about the midpoint (Point "O") of the reinforcement length (B) in the counterclockwise direction.		
B/H_W =	77%							
B/H_{WT} =	77%		Effective Wall Width			Effective Wall Width (BR)		
Is B $\geq$ 0.7H_W	**Yes**		B' =	11.64	ft	B' =	14.38	ft

EQUATIONS - Sliding Only

R_τ = V tan δ
(where δ is lesser of ϕ'_{MSE} or $\phi'_{soil\ 1}$)

V = $\gamma_{EV}\ [W_1 + W_2]$

$Q_s = \gamma_{EH} F_1 + \gamma_{LS} F_2$

Note: Passive resistance is neglected when checking for stability in sliding.

EQUATIONS - Eccentricity and Bearing Resistance

$$(+\sum M_{at}\ 0$$

$$= \gamma_{EV}\ [W_2 \bar{X}_{w2}] + \gamma_{EH}(F_1 \bar{X}_{F1}) + \gamma_{LS}(F_2 \bar{X}_{F2} + L_S \bar{X}_{LS}) + \text{Re} = 0$$

$$R = \sum V = \gamma_{EV}(W_1 + W_2) + \gamma_{LS} L_s$$

Note: Load Factors (max or min) applicable to each analysis (Eccentricity or Bearing Resistance) are to be applied in the equation above. Also, M_{LS} is not included in the equation to calculate eccentricity for Overturning (L_s=0), but is included to calculate eccentricity for Bearing Resistance.

S&ME Project #22-78-0033, Rear Abutment (Strength Limit)

Bearing Resistance - 2 Potential Alternative Approaches (Articles 11.10.5.4, 10.6.3.1 & 10.6.3.2)

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

Parameter		Value	Unit	Parameter		Value	Unit
$c'_{soil\,1}$	=	0	psf	$c'_{soil\,1}$	=	0	psf
N_c	=	20.7	dim.	N_c	=	30.1	dim.
s_c	=	1.055	dim.	s_c	=	1.065	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	21.8	dim.	N_{cm}	=	32.1	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	10.7	dim.	N_q	=	18.4	dim.
s_q	=	1.049	dim.	s_q	=	1.061	dim.
d_q	=	1.06	dim.	d_q	=	1.06	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	11.9	dim.	N_{qm}	=	20.7	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.
$\gamma'_{soil\,1}$	=	125	pcf	$\gamma'_{soil\,2}$	=	115	pcf
B'	=	14.38	ft	B'	=	14.38	ft
N_γ	=	10.9	dim.	N_γ	=	22.4	dim.
s_γ	=	0.958	dim.	s_γ	=	0.958	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	10.4	dim.	$N_{\gamma m}$	=	21.5	dim.
$C_{w\gamma}$	=	0.67	dim.	$C_{w\gamma}$	=	0.66	dim.

$$N_c = (N_q - 1)\cot\varphi' \text{ for } \phi_{soil\,i} > 0$$

$$N_c = 5.14 \text{ for } \phi_{soil\,i} = 0$$

$$S_c = 1 + \left(\frac{B'}{L}\right)\left(\frac{N_q}{N_c}\right) \; for\ \phi_{soil\,i} > 0$$

$$S_c = 1 + \left(\frac{B'}{5L}\right) \; for\ \phi_{soil\,i} = 0$$

$$N_{CM} = N_C S_c i_c$$

$$N_q = e^{\pi \tan\varphi'} \tan^2\left(45 + \frac{\varphi'}{2}\right)$$

$$S_q = 1 + \left(\frac{B'}{L}\right)(\tan\varphi'_1) \; for\ \phi_{soil\,i} > 0$$

$$S_q = 1 \; for\ \phi_{soil\,i} = 0$$

$$d_q = 1 + 2\tan(\phi_{soil\,i})(1 - \sin\phi_{soil\,i})^2 \tan^{-1}(D_f/B')$$

(Hansen, 1968)

$$N_{qm} = N_q S_q d_q i_q$$

$$N_\gamma = 2(N_q + 1)\tan\varphi'$$

$$S_\gamma = 1 - 0.4\left(\frac{B'}{L}\right) \; for\ \phi_{soil\,i} > 0$$

$$S_\gamma = 1 \; for\ \phi_{soil\,i} = 0$$

$$N_{\gamma m} = N_\gamma S_\gamma i_\gamma$$

	Value	Unit		Value	Unit
Cohesion	0.0	psf	Cohesion	0.0	psf
Surcharge	4462.5	psf	Surcharge	7762.5	psf
Embedment	6262.5	psf	Embedment	11733.0	psf
q_{N1}	10725.0	psf	q_{N2}	19495.5	psf

Note: Inclination factors are neglected and assumed to equal 1.0.

Table 10.6.3.1.2a-2

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
>1.5B+D_f	1.0	1.0

$$q_n = \underbrace{cN_{cm}}_{\text{Cohesion}} + \underbrace{\gamma D_f N_{qm} C_{wq}}_{\text{Surcharge}} + \underbrace{0.5\gamma B' N_{\gamma m} C_{w\gamma}}_{\text{Embedment}}$$

$$\sigma_V = \frac{\sum V}{B - 2e}$$

First Layer Only Solution

		Unit
$q_N = q_{N1}$ =	10725	psf
$q_R = \varphi_b q_N$ =	6971.25	psf
σ_V =	6706	psf
Is $\sigma_V < q_R$?	Yes	

2-Layer Approach - Article 10.6.3.1.2d

B'	=	14.38	ft
H_{CRIT}	=	-11.66	ft
Use 2-layer solution?		No	

2-Layer Solution - Drained Case Article 10.6.3.1.2f

K	=	N/A	dim.
q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		N/A	

where H = $EL_{LP} - EL_{Soil\ 1\ Lower}$

where K = $\frac{1 - \sin^2(\varphi'_1)}{1 + \sin^2(\varphi'_1)}$

$$H_{CRIT} = \frac{(3B')\ln\left(\frac{q_{N1}}{q_{N2}}\right)}{2\left(1 + \frac{B'}{L_T}\right)}$$

$$q_N = \left[q_{N2} + \left(\frac{1}{K}\right)C'_1\cot(\varphi'_1)\right] e^{2\left[1+\left(\frac{B'}{L}\right)\right]KTAN\varphi'_1\left(\frac{H}{B'}\right)} - \left(\frac{1}{K}\right)C'_1\cot(\varphi'_1)$$

S&ME Project #22-78-0033, Rear Abutment (Strength Limit)

Undrained Analysis

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

Parameter		Value	Unit	Parameter		Value	Unit
$c_{soil\ 1}$	=	2000	psf	$c_{soil\ 2}$	=	0	psf
N_c	=	5.14	dim.	N_c	=	30.1	dim.
s_c	=	1.021	dim.	s_c	=	1.065	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	5.2	dim.	N_{cm}	=	32.1	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	1	dim.	N_q	=	18.4	dim.
s_q	=	1	dim.	s_q	=	1.061	dim.
d_q	=	1	dim.	d_q	=	1.06	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	1	dim.	N_{qm}	=	20.7	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.
$\gamma_{soil\ 1}$	=	125	pcf	$\gamma_{soil\ 2}$	=	115	pcf
B'	=	14.38	ft	B'	=	14.38	ft
N_γ	=	0	dim.	N_γ	=	22.4	dim.
s_γ	=	1	dim.	s_γ	=	0.958	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	0	dim.	$N_{\gamma m}$	=	21.5	dim.
$C_{w\gamma}$	=	0.67	dim.	$C_{w\gamma}$	=	0.67	dim.
Cohesion		10400.0	psf	Cohesion		0.0	psf
Surcharge		375.0	psf	Surcharge		7762.5	psf
Embedment		0.0	psf	Embedment		11910.8	psf
q_{N1}		10775.0	psf	q_{N2}		19673.3	psf

See Sheet 4 for Bearing Capacity Equations

2-Layer Approach - Article 10.6.3.1.2d

B'	=	14.38	ft
H_{CRIT}	=	11.74	ft
Use 2-layer solution?		**Yes**	

2-Layer Solution - Undrained Case Article 10.6.3.1.2e

For stiff over soft layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

For soft over stiff layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_*	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

2-Layer Solution - Undrained Case

q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		**N/A**	

$$N_m = \frac{\kappa N_*(N_* + \beta - 1)[(\kappa + 1)N_*^2 + (1 + \kappa\beta)N_* + \beta - 1]}{[\kappa(\kappa + 1)N_* + \kappa + \beta - 1][(N_* + \beta)N_* + \beta - 1] - [(\kappa N_* + \beta - 1)(N_* + 1)]}$$

↑ *For soft over stiff (EPRI, 1983)*

$$\beta_m = \frac{BL_{TWALL}}{2(B + L_{TWALL})(EL_{LP} - EL_{Upper2})}$$

For stiff over soft ↓

$$N_m = \left(\frac{1}{\beta_m} + \kappa s_c N_c\right) \le s_c N_c$$

$$\kappa = \frac{c_1}{c_2} \qquad N_* = s_c N_c$$

Sliding - Undrained Analysis (Articles 11.10.5.3 & 10.6.3.4)

S_u	=	2000	psf
$0.5\sigma'_v$	=	1623.75	psf
q_s	=	1623.75	psf
B	=	20	ft
$R_R = \varphi_\tau R_\tau$	=	32475	psf
Q_S	=	29111.2	psf
Is $R_R > Q_S$?		**Yes**	

Equations for Sliding - Undrained

$$q_s = \text{lesser of } S_u \text{ or } 0.5\sigma'_v$$

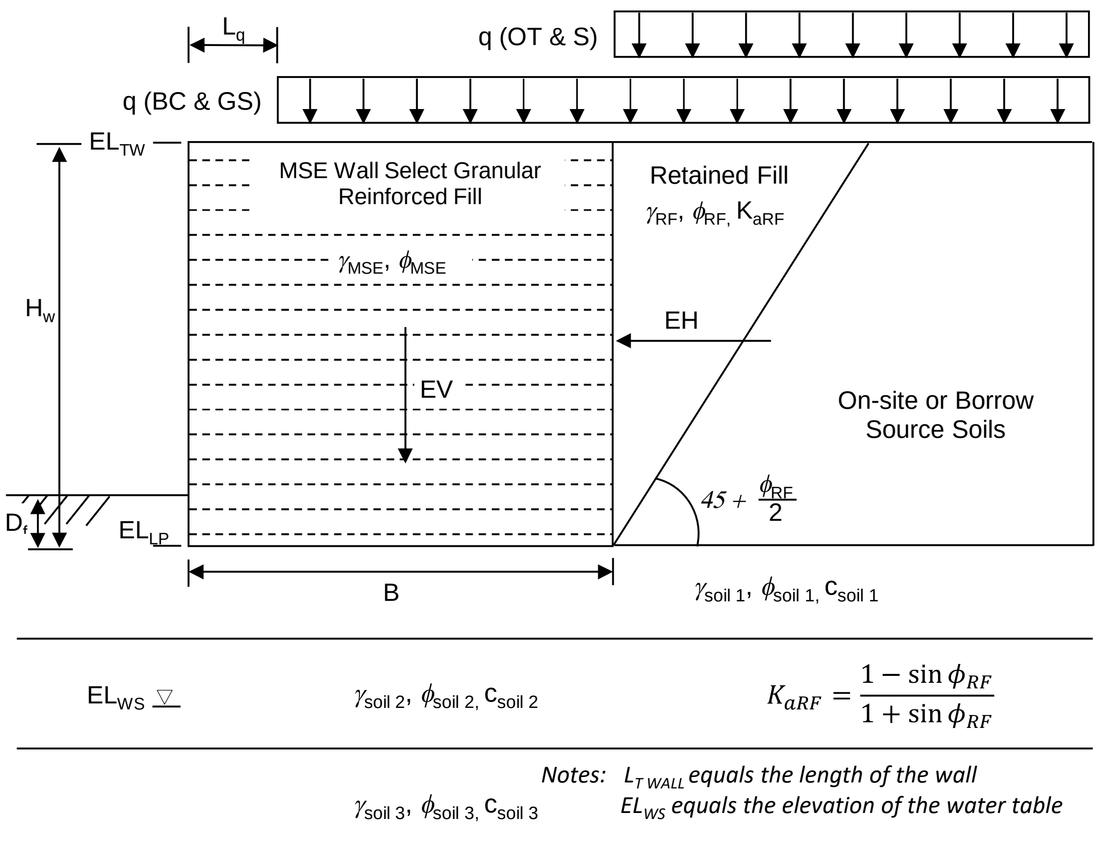
$$R_\tau = Bq_s$$

One Layer Only Solution

Calculate for:		Layer 1	
$q_N = q_{N1}$	=	10775	psf
$q_R = \varphi_b q_N$	=	7003.75	psf
σ_V	=	6706	psf
Is $\sigma_V < q_R$?		**Yes**	

S&ME Project #22-78-0033, Forward Abutment (Strength Limit)

MSE Wall Stability Diagram and Design Parameters



$$K_{aRF} = \frac{1 - \sin\phi_{RF}}{1 + \sin\phi_{RF}}$$

Notes: $L_{T\,WALL}$ equals the length of the wall
EL_{WS} equals the elevation of the water table

γ_{MSE}	=	125	pcf	ϕ'_{MSE}	=	32	deg	$L_{T\,WALL}$	=	170 ft
H_W	=	30.29	ft	γ_{RF}	=	125	pcf	EL_{WS}*	=	780 MSL
H_2	=		ft	ϕ'_{RF}	=	26	deg	D_w	=	7 ft
EL_{LP}	=	784		K_{aRF}	=	0.39		D_f	=	3 ft
EL_{AS}	=	814.29								
EL_{TA}	=	814.29		q	=	250	psf			
H_T	=	30.29	ft	L_q	=	0	ft			
B	=	**23**	ft							
L_{AS}	=									

Representative Soil Profile: B-003-0-22

*To ensure correct usage of effective vs. saturated unit weights, break up soil layers at the water surface elevation.

Soil Layer 1				*Soil Layer 2*				*Soil Layer 3*			
Upper El.	=	784	MSL	Upper El.	=	783.8	MSL	Upper El.	=	765	MSL
Lower El.	=	783.8	MSL	Lower El.	=	765	MSL	Lower El.	=	0	MSL
$\gamma_{soil\,1}$	=	125	pcf	$\gamma_{soil\,2}$	=	130	pcf	$\gamma_{soil\,3}$	=	0	pcf
$\gamma'_{soil\,1}$	=	125	pcf	$\gamma'_{soil\,2}$	=	67.6	pcf	$\gamma'_{soil\,3}$	=	-62.4	pcf
$\phi'_{soil\,1}$	=	26	deg	$\phi'_{soil\,2}$	=	30	deg	$\phi'_{soil\,3}$	=	0	deg
$c'_{soil\,1}$	=	0	psf	$c'_{soil\,2}$	=	0	psf	$c'_{soil\,3}$	=	0	psf
$\phi_{soil\,1}$	=	0	deg	$\phi_{soil\,2}$	=	0	deg	$\phi_{soil\,3}$	=	0	deg
$c_{soil\,1}$	=	2250	psf	$c_{soil\,2}$	=	4000	psf	$c_{soil\,3}$	=	4000	psf

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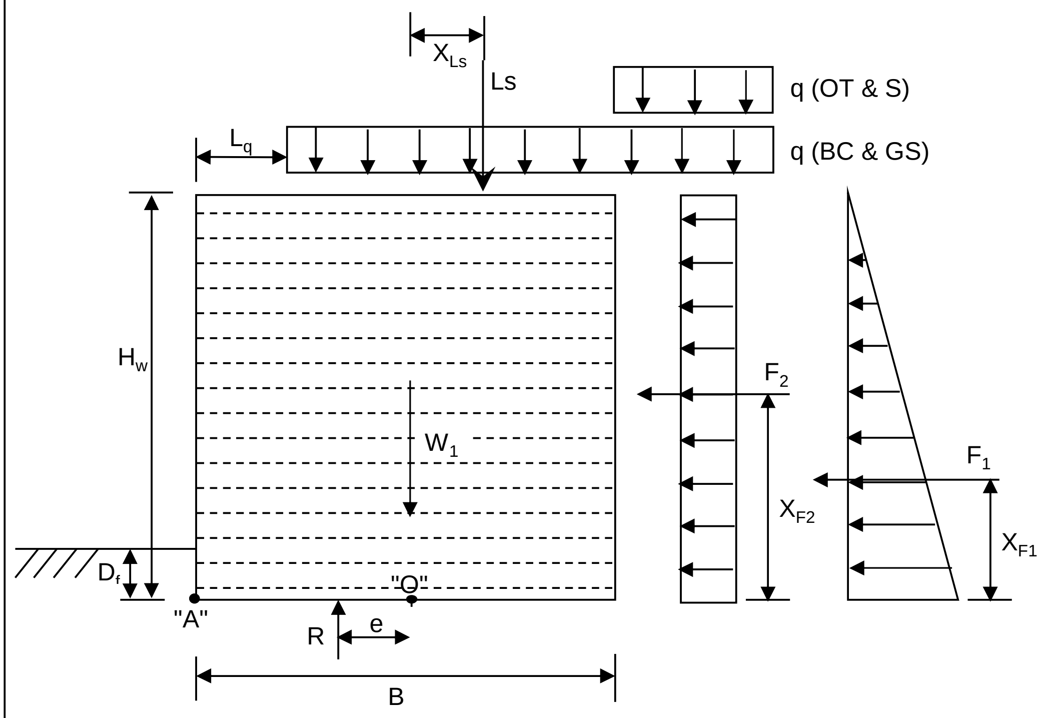
S&ME Project #22-78-0033, Forward Abutment (Strength Limit)

External Stability Diagram and Force Definitions



CDR Values (***Drained*** Undrained)
Sliding ***1.10*** 1.12
Eccen-tricity 1.60
Bearing Resis-tance ***1.03*** 2.12

Resistance and Load Factors (Tables 3.4.1-1, 3.4.1-2 & 11.5.7-1)

Sliding

φ_τ	=	1.0
γ_{EH}	=	1.5
γ_{EV}	=	1.0
γ_{LS}	=	1.75

Overturning

γ_{EH}	=	1.5
γ_{EV}	=	1.0
γ_{LS}	=	1.75

Bearing Resis-tance

φ_b	=	0.65
γ_{EH}	=	1.5
γ_{EV}	=	1.35
γ_{LS}	=	1.75

Interim Calculations

Force Calculations

W_1	=	87083.8	plf	$W_1 = H_W B \gamma_{MSE}$
W_2	=	0.0	plf	$W_2 = H_2 \gamma_{MSE}(B - L_{AS})$
F_1	=	22363.7	plf	$F_1 = 0.5\gamma_{rf} H_T^2 K_{aRF}$
F_2	=	2953.3	plf	$F_2 = q H_T K_{aRF}$
L_S	=	5750.0	plf	$L_S = q(B - L_q)$

(For F_2 and L_s: use only if $L_q < (B + \frac{H_w}{2})$)

Moment Arm Equations

$\bar{X}_{W1}$ = 0 (passes through "O")

$$\bar{X}_{W2} = \left(\frac{B - L_{AS}}{2}\right) - \frac{B}{2}$$

$$\bar{X}_{F1} = \frac{H_T}{3}$$

$$\bar{X}_{F2} = \frac{H_T}{2}$$

$$\bar{X}_{LS} = \left(\frac{B - L_q}{2}\right) - \frac{B}{2}$$

S&ME Project #22-78-0033, Forward Abutment (Strength Limit)

Moment Arm Calculations			*Moment Calculations - Eccentricity*			*Moment Calculations - Bearing*		
X_{W1} =	0.00	ft	M_{W1} =	0.0	lb-ft/ft	M_{W1} =	0.0	lb-ft/ft
X_{W2} =	0.00	ft	M_{W2} =	0.0	lb-ft/ft	M_{W2} =	0.0	lb-ft/ft
X_{F1} =	10.10	ft	M_{F1} =	338810.1	lb-ft/ft	M_{F1} =	338810.1	lb-ft/ft
X_{F2} =	15.15	ft	M_{F2} =	78299.4	lb-ft/ft	M_{F2} =	78299.4	lb-ft/ft
X_{LS} =	0.00	ft	$M_x = \gamma_x F_x \bar{X}_x$			M_{LS} =	0.0	lb-ft/ft

Drained Analysis

Sliding (Articles 11.10.5.3 & 10.6.3.4)			*Eccentricity (Overturning) (Articles 11.10.5.5 & 11.6.3.3)*			*Eccentricity for BR (Article 11.10.5.4)*		
δ =	26	deg	R =	87083.8	plf	R =	127625.6	plf
Tan(δ) =	0.488		e =	4.79	ft	e =	3.27	ft
$R_R = \varphi_\tau R_\tau$ =	42473.6	plf						
Q_S =	38713.8	plf	M_R =	417109.5	lb-ft/ft	M_R =	417109.5	lb-ft/ft
Is $R_R > Q_S$?	**Yes**		Is e < B/3?	**Yes**				

Moment equations are solved by summing moments about the midpoint (Point "O") of the reinforcement length (B) in the counterclockwise direction.

B/H_W =	76%							
B/H_{WT} =	76%		Effective Wall Width			Effective Wall Width (BR)		
Is B ≥ $0.7H_W$	**Yes**		B' =	13.42	ft	B' =	16.46	ft

EQUATIONS - Sliding Only

R_τ = V tan δ
(where δ is lesser of ϕ'_{MSE} or $\phi'_{soil\ 1}$)

V = $\gamma_{EV}\ [W_1 + W_2]$

$Q_s = \gamma_{EH} F_1 + \gamma_{LS} F_2$

Note: Passive resistance is neglected when checking for stability in sliding.

EQUATIONS - Eccentricity and Bearing Resistance

$$(+\sum M_{at}\ 0 = \gamma_{EV}\ [W_2 \bar{X}_{w2}] + \gamma_{EH}(F_1 \bar{X}_{F1}) + \gamma_{LS}(F_2 \bar{X}_{F2} + L_S \bar{X}_{LS}) + Re = 0$$

$$R = \sum V = \gamma_{EV}(W_1 + W_2) + \gamma_{LS} L_s$$

Note: Load Factors (max or min) applicable to each analysis (Eccentricity or Bearing Resistance) are to be applied in the equation above. Also, M_{LS} is not included in the equation to calculate eccentricity for Overturning (L_s=0), but is included to calculate eccentricity for Bearing Resistance.

S&ME Project #22-78-0033, Forward Abutment (Strength Limit)

Bearing Resistance - 2 Potential Alternative Approaches (Articles 11.10.5.4, 10.6.3.1 & 10.6.3.2)

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

Parameter		Soil 1	Units	Parameter		Soil 2	Units
$c'_{soil\ 1}$	=	0	psf	$c'_{soil\ 1}$	=	0	psf
N_c	=	22.3	dim.	N_c	=	30.1	dim.
s_c	=	1.052	dim.	s_c	=	1.059	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	23.5	dim.	N_{cm}	=	31.9	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	11.9	dim.	N_q	=	18.4	dim.
s_q	=	1.047	dim.	s_q	=	1.056	dim.
d_q	=	1.06	dim.	d_q	=	1.05	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	13.2	dim.	N_{qm}	=	20.4	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.
$\gamma'_{soil\ 1}$	=	125	pcf	$\gamma'_{soil\ 2}$	=	130	pcf
B'	=	16.46	ft	B'	=	16.46	ft
N_γ	=	12.5	dim.	N_γ	=	22.4	dim.
s_γ	=	0.961	dim.	s_γ	=	0.961	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	12	dim.	$N_{\gamma m}$	=	21.5	dim.
$C_{w\gamma}$	=	0.59	dim.	$C_{w\gamma}$	=	0.59	dim.

$$N_c = (N_q - 1)\cot\varphi' \text{ for } \phi_{soil\ i} > 0$$

$$N_c = 5.14 \text{ for } \phi_{soil\ i} = 0$$

$$S_c = 1 + \left(\frac{B'}{L}\right)\left(\frac{N_q}{N_C}\right) \ for\ \phi_{soil\ i} > 0$$

$$S_c = 1 + \left(\frac{B'}{5L}\right) \ for\ \phi_{soil\ i} = 0$$

$$N_{CM} = N_C S_c i_c$$

$$N_q = e^{\pi \tan\varphi'} \tan^2\left(45 + \frac{\varphi'}{2}\right)$$

$$S_q = 1 + \left(\frac{B'}{L}\right)(\tan\varphi'_1) \ for\ \phi_{soil\ i} > 0$$

$$S_q = 1 \ for\ \phi_{soil\ i} = 0$$

$$d_q = 1 + 2\tan(\phi_{soil\ i})(1 - \sin\phi_{soil\ i})^2 \tan^{-1}(D_f/B')$$

(Hansen, 1968)

$$N_{qm} = N_q S_q d_q i_q$$

$$N_\gamma = 2(N_q + 1)\tan\varphi'$$

$$S_\gamma = 1 - 0.4\left(\frac{B'}{L}\right) \ for\ \phi_{soil\ i} > 0$$

$$S_\gamma = 1 \ for\ \phi_{soil\ i} = 0$$

$$N_{\gamma m} = N_\gamma S_\gamma i_\gamma$$

	Soil 1			Soil 2	
Cohesion	0.0	psf	Cohesion	0.0	psf
Surcharge	4950.0	psf	Surcharge	7650.0	psf
Embedment	7283.6	psf	Embedment	13571.7	psf
q_{N1}	12233.6	psf	q_{N2}	21221.7	psf

Note: Inclination factors are neglected and assumed to equal 1.0.

Table 10.6.3.1.2a-2

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
>1.5B+D_f	1.0	1.0

$$q_n = \underbrace{cN_{cm}}_{\text{Cohesion}} + \underbrace{\gamma D_f N_{qm} C_{wq}}_{\text{Surcharge}} + \underbrace{0.5\gamma B' N_{\gamma m} C_{w\gamma}}_{\text{Embedment}}$$

$$\sigma_V = \frac{\sum V}{B - 2e}$$

First Layer Only Solution

$q_N = q_{N1}$ =	12233.6	psf
$q_R = \varphi_b q_N$ =	7951.84	psf
σ_V =	7753.7	psf
Is $\sigma_V < q_R$?	Yes	

2-Layer Approach - Article 10.6.3.1.2d

B'	=	16.46	ft
H_{CRIT}	=	-12.40	ft
Use 2-layer solution?		No	

2-Layer Solution - Drained Case Article 10.6.3.1.2f

K	=	N/A	dim.
q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		N/A	

where H = $EL_{LP} - EL_{Soil\ 1\ Lower}$

where K = $\frac{1 - sin^2(\varphi'_1)}{1 + sin^2(\varphi'_1)}$

$$H_{CRIT} = \frac{(3B')\ln\left(\frac{q_{N1}}{q_{N2}}\right)}{2\left(1 + \frac{B'}{L_T}\right)}$$

$$q_N = \left[q_{N2} + \left(\frac{1}{K}\right)C_1'\cot(\varphi'_1)\right] e^{2\left[1+\left(\frac{B'}{L}\right)\right]KTAN\varphi'_1\left(\frac{H}{B'}\right)} - \left(\frac{1}{K}\right)C_1'\cot(\varphi'_1)$$

S&ME Project #22-78-0033, Forward Abutment (Strength Limit)

Undrained Analysis

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

$c_{soil\ 1}$	=	2250	psf	$c_{soil\ 2}$	=	4000	psf
N_c	=	5.14	dim.	N_c	=	5.14	dim.
s_c	=	1.019	dim.	s_c	=	1.019	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	5.2	dim.	N_{cm}	=	5.2	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	1	dim.	N_q	=	1	dim.
s_q	=	1	dim.	s_q	=	1	dim.
d_q	=	1	dim.	d_q	=	1	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	1	dim.	N_{qm}	=	1	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.
$\gamma_{soil\ 1}$	=	125	pcf	$\gamma_{soil\ 2}$	=	130	pcf
B'	=	16.46	ft	B'	=	16.46	ft
N_γ	=	0	dim.	N_γ	=	0	dim.
s_γ	=	1	dim.	s_γ	=	1	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	0	dim.	$N_{\gamma m}$	=	0	dim.
$C_{w\gamma}$	=	0.59	dim.	$C_{w\gamma}$	=	0.59	dim.
Cohesion		11700.0	psf	Cohesion		20800.0	psf
Surcharge		375.0	psf	Surcharge		375.0	psf
Embedment		0.0	psf	Embedment		0.0	psf
q_{N1}		12075.0	psf	q_{N2}		21175.0	psf

See Sheet 4 for Bearing Capacity Equations

2-Layer Approach - Article 10.6.3.1.2d

B'	=	16.46	ft
H_{CRIT}	=	12.64	ft
Use 2-layer solution?		**Yes**	

2-Layer Solution - Undrained Case Article 10.6.3.1.2e

For stiff over soft layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

For soft over stiff layering

κ	=	1.778	dim.
β_m	=	37.517	dim.
N_*	=	5.238	dim.
N_m	=	11.064	dim.
q_N	=	25269.0	psf

2-Layer Solution - Undrained Case

q_N	=	25269	psf
$q_R = \varphi_b q_N$	=	16424.85	psf
σ_V	=	7753.7	psf
Is $\sigma_V < q_R$?		**Yes**	

$$N_m = \frac{\kappa N_*(N_* + \beta - 1)[(\kappa+1)N_*^2 + (1+\kappa\beta)N_* + \beta - 1]}{[\kappa(\kappa+1)N_* + \kappa + \beta - 1][(N_* + \beta)N_* + \beta - 1] - [(\kappa N_* + \beta - 1)(N_* + 1)]}$$

↑ *For soft over stiff (EPRI, 1983)*

$$\beta_m = \frac{BL_{TWALL}}{2(B + L_{TWALL})(EL_{LP} - EL_{Upper2})}$$

$$\kappa = \frac{c_1}{c_2} \qquad N_* = s_c N_c$$

For stiff over soft ↓

$$N_m = \left(\frac{1}{\beta_m} + \kappa s_c N_c\right) \le s_c N_c$$

Sliding - Undrained Analysis (Articles 11.10.5.3 & 10.6.3.4)

S_u	=	2250	psf
$0.5\sigma'_v$	=	1893.125	psf
q_s	=	1893.125	psf
B	=	23	ft
$R_R = \varphi_\tau R_\tau$	=	43541.875	psf
Q_S	=	38713.8	psf
Is $R_R > Q_S$?		**Yes**	

Equations for Sliding - Undrained

$$q_s = \text{lesser of } S_u \text{ or } 0.5\sigma'_v$$

$$R_\tau = Bq_s$$

One Layer Only Solution

Calculate for:		Layer 1	
$q_N = q_{N1}$	=	12075	psf
$q_R = \varphi_b q_N$	=	7848.75	psf
σ_V	=	7753.7	psf
Is $\sigma_V < q_R$?		**Yes**	

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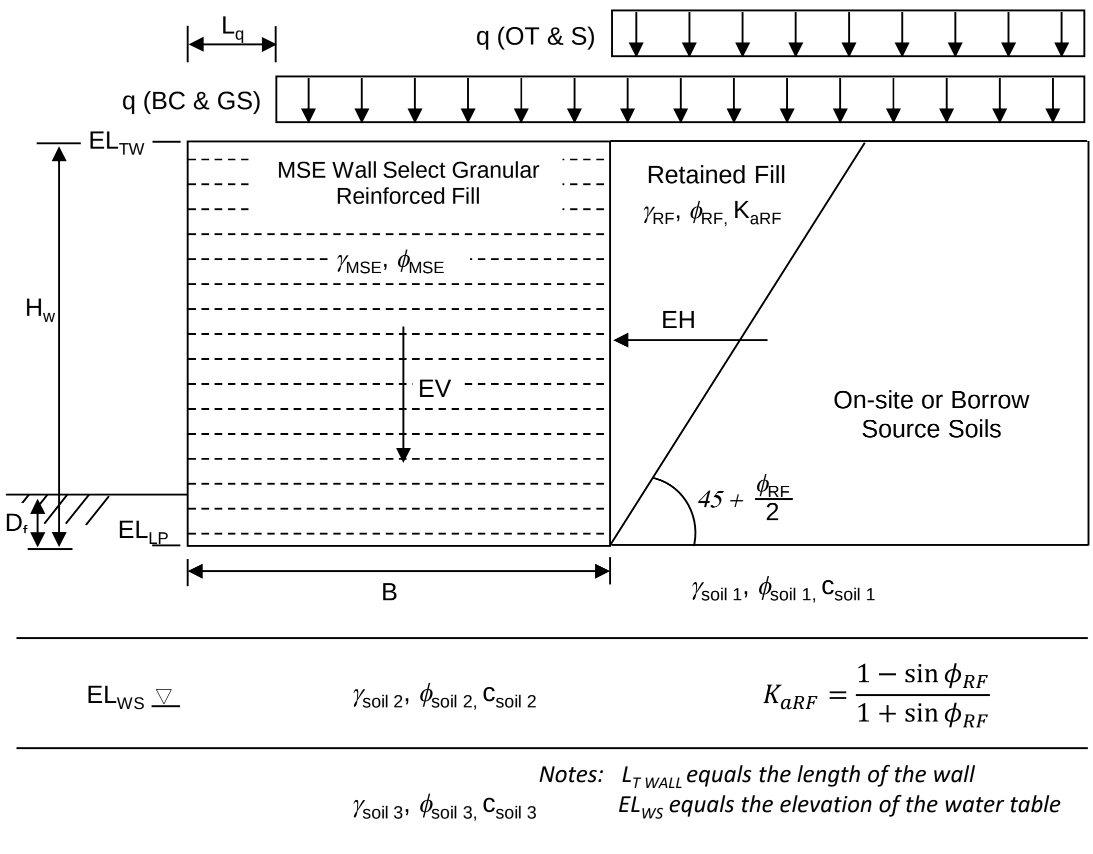
MSE Wall Stability Diagram and Design Parameters



$$K_{aRF} = \frac{1 - \sin\phi_{RF}}{1 + \sin\phi_{RF}}$$

Notes: $L_{T\,WALL}$ equals the length of the wall
EL_{WS} equals the elevation of the water table

γ_{MSE}	=	125 pcf		ϕ'_{MSE}	=	32 deg		$L_{T\,WALL}$	=	136 ft
H_W	=	25.98 ft		γ_{RF}	=	125 pcf		EL_{WS}*	=	773 MSL
H_2	=	ft		ϕ'_{RF}	=	26 deg		D_w	=	11 ft
EL_{LP}	=	781		K_{aRF}	=	0.39		D_f	=	3 ft
EL_{AS}	=	806.98								
EL_{TA}	=	806.98		q	=	250 psf				
H_T	=	25.98 ft		L_q	=	0 ft				
B	=	**20** ft								
L_{AS}	=									

Representative Soil Profile: B-001-0-22

*To ensure correct usage of effective vs. saturated unit weights, break up soil layers at the water surface elevation.

Soil Layer 1			Soil Layer 2			Soil Layer 3		
Upper El.	=	781 MSL	Upper El.	=	776.4 MSL	Upper El.	=	774.8 MSL
Lower El.	=	776.4 MSL	Lower El.	=	774.8 MSL	Lower El.	=	773.3 MSL
$\gamma_{soil\,1}$	=	125 pcf	$\gamma_{soil\,2}$	=	115 pcf	$\gamma_{soil\,3}$	=	125 pcf
$\gamma'_{soil\,1}$	=	125 pcf	$\gamma'_{soil\,2}$	=	115 pcf	$\gamma'_{soil\,3}$	=	125 pcf
$\phi'_{soil\,1}$	=	25 deg	$\phi'_{soil\,2}$	=	30 deg	$\phi'_{soil\,3}$	=	25 deg
$c'_{soil\,1}$	=	0 psf	$c'_{soil\,2}$	=	0 psf	$c'_{soil\,3}$	=	0 psf
$\phi_{soil\,1}$	=	0 deg	$\phi_{soil\,2}$	=	30 deg	$\phi_{soil\,3}$	=	0 deg
$c_{soil\,1}$	=	2000 psf	$c_{soil\,2}$	=	0 psf	$c_{soil\,3}$	=	2000 psf

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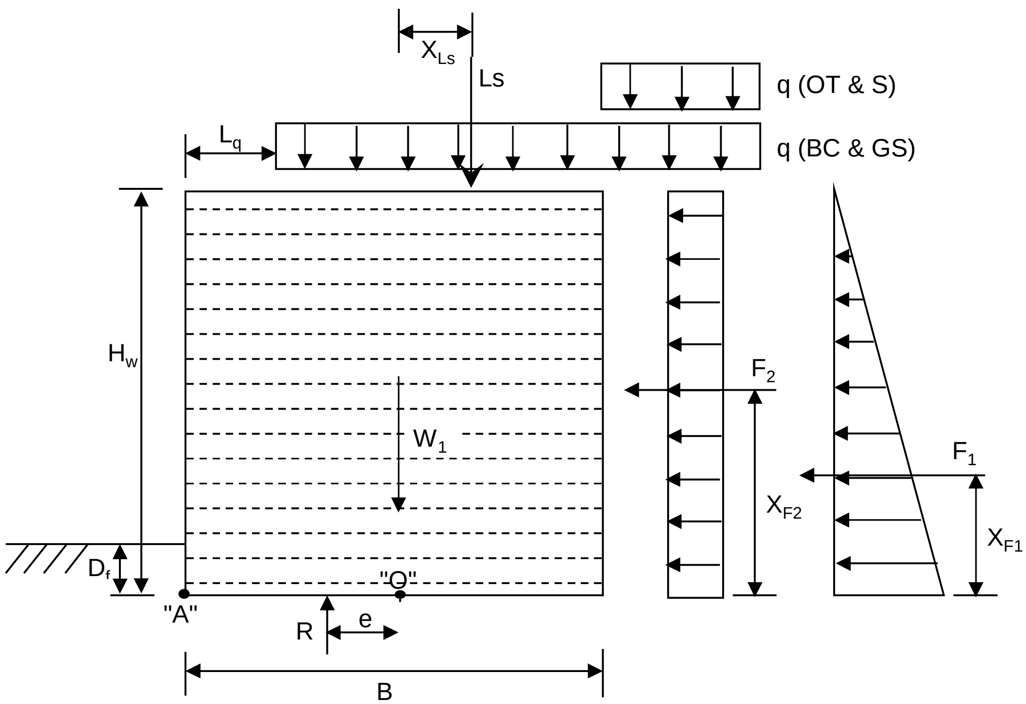
External Stability Diagram and Force Definitions



CDR Values (***Drained*** Undrained)

Sliding
1.04
1.12

Eccen-tricity
1.59

Bearing Resis-tance
2.35
2.35

Resistance and Load Factors (Tables 3.4.1-1, 3.4.1-2 & 11.5.7-1)

φ_τ	=	1.0	Sliding	γ_{EH}	=	1.5	Overturning	φ_b	=	1	Bearing Resis-tance
γ_{EH}	=	1.5		γ_{EV}	=	1.0		γ_{EH}	=	1	
γ_{EV}	=	1.0		γ_{LS}	=	1.75		γ_{EV}	=	1	
γ_{LS}	=	1.75						γ_{LS}	=	1	

Interim Calculations

Force Calculations					*Moment Arm Equations*
W_1	=	64950.0	plf	$W_1 = H_W B \gamma_{MSE}$	$\bar{X}_{W1}$ = 0 (passes through "O")
W_2	=	0.0	plf	$W_2 = H_2 \gamma_{MSE}(B - L_{AS})$	$\bar{X}_{W2} = \left(\frac{B - L_{AS}}{2}\right) - \frac{B}{2}$
F_1	=	16452.2	plf	$F_1 = 0.5 \gamma_{rf} H_T^2 K_{aRF}$	$\bar{X}_{F1} = \frac{H_T}{3}$
F_2	=	2533.1	plf	$F_2 = q H_T K_{aRF}$	$\bar{X}_{F2} = \frac{H_T}{2}$
L_S	=	5000.0	plf	$L_S = q(B - L_q)$	$\bar{X}_{LS} = \left(\frac{B - L_q}{2}\right) - \frac{B}{2}$

(For F_2 and L_s: use only if $L_q < (B + \frac{H_w}{2})$

S&ME Project #22-78-0033, Rear Abutment (Service Limit)

Moment Arm Calculations

X_{W1}	=	0.00	ft
X_{W2}	=	0.00	ft
X_{F1}	=	8.66	ft
X_{F2}	=	12.99	ft
X_{LS}	=	0.00	ft

Moment Calculations - Eccentricity

M_{W1}	=	0.0	lb-ft/ft
M_{W2}	=	0.0	lb-ft/ft
M_{F1}	=	213714.1	lb-ft/ft
M_{F2}	=	57583.7	lb-ft/ft

$$M_x = \gamma_x F_x \bar{X}_x$$

Moment Calculations - Bearing

M_{W1}	=	0.0	lb-ft/ft
M_{W2}	=	0.0	lb-ft/ft
M_{F1}	=	142476.1	lb-ft/ft
M_{F2}	=	32905.0	lb-ft/ft
M_{LS}	=	0.0	lb-ft/ft

Drained Analysis

Sliding
(Articles 11.10.5.3 & 10.6.3.4)

δ	=	25	deg
Tan(δ)	=	0.466	
$R_R = \varphi_\tau R_\tau$	=	30286.7	plf
Q_S	=	29111.2	plf
Is $R_R > Q_S$?		**Yes**	
B/H_W	=	77%	
B/H_{WT}	=	77%	
Is $B \geq 0.7H_W$		**Yes**	

Eccentricity (Overturning)
(Articles 11.10.5.5 & 11.6.3.3)

R	=	64950.0	plf
e	=	4.18	ft
M_R	=	271297.8	lb-ft/ft
Is e < B/3?		**Yes**	

Effective Wall Width

B'	=	11.64	ft

Eccentricity for BR
(Article 11.10.5.4)

R	=	69950.0	plf
e	=	2.51	ft
M_R	=	175381.1	lb-ft/ft

Moment equations are solved by summing moments about the midpoint (Point "O") of the reinforcement length (B) in the counterclockwise direction.

Effective Wall Width (BR)

B'	=	14.98	ft

EQUATIONS - Sliding Only

R_τ = V tan δ
(where δ is lesser of ϕ'_{MSE} or $\phi'_{soil\ 1}$)

$V = \gamma_{EV}\ [W_1 + W_2]$

$Q_s = \gamma_{EH} F_1 + \gamma_{LS} F_2$

Note: Passive resistance is neglected when checking for stability in sliding.

EQUATIONS - Eccentricity and Bearing Resistance

$$(+\sum M_{at\ 0} = \gamma_{EV}\ [W_2 \bar{X}_{w2}] + \gamma_{EH}(F_1 \bar{X}_{F1}) + \gamma_{LS}(F_2 \bar{X}_{F2} + L_S \bar{X}_{LS}) + \mathrm{Re} = 0$$

$$R = \sum V = \gamma_{EV}(W_1 + W_2) + \gamma_{LS} L_s$$

Note: Load Factors (max or min) applicable to each analysis (Eccentricity or Bearing Resistance) are to be applied in the equation above. Also, M_{LS} is not included in the equation to calculate eccentricity for Overturning (L_s=0), but is included to calculate eccentricity for Bearing Resistance.

S&ME Project #22-78-0033, Rear Abutment (Service Limit)

Bearing Resistance - 2 Potential Alternative Approaches (Articles 11.10.5.4, 10.6.3.1 & 10.6.3.2)

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

$c'_{soil\ 1}$	=	0	psf	$c'_{soil\ 1}$	=	0	psf
N_c	=	20.7	dim.	N_c	=	30.1	dim.
s_c	=	1.057	dim.	s_c	=	1.067	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	21.9	dim.	N_{cm}	=	32.1	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	10.7	dim.	N_q	=	18.4	dim.
s_q	=	1.051	dim.	s_q	=	1.064	dim.
d_q	=	1.06	dim.	d_q	=	1.06	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	11.9	dim.	N_{qm}	=	20.8	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.
$\gamma'_{soil\ 1}$	=	125	pcf	$\gamma'_{soil\ 2}$	=	115	pcf
B'	=	14.98	ft	B'	=	14.98	ft
N_γ	=	10.9	dim.	N_γ	=	22.4	dim.
s_γ	=	0.956	dim.	s_γ	=	0.956	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	10.4	dim.	$N_{\gamma m}$	=	21.4	dim.
$C_{w\gamma}$	=	0.67	dim.	$C_{w\gamma}$	=	0.66	dim.
Cohesion		0.0	psf	Cohesion		0.0	psf
Surcharge		4462.5	psf	Surcharge		7800.0	psf
Embedment		6523.8	psf	Embedment		12165.7	psf
q_{N1}		10986.3	psf	q_{N2}		19965.7	psf

$$N_c = (N_q - 1)\cot\varphi' \text{ for } \phi_{soil\ i} > 0$$

$$N_c = 5.14 \text{ for } \phi_{soil\ i} = 0$$

$$S_c = 1 + \left(\frac{B'}{L}\right)\left(\frac{N_q}{N_C}\right) \; for \; \phi_{soil\ i} > 0$$

$$S_c = 1 + \left(\frac{B'}{5L}\right) \; for \; \phi_{soil\ i} = 0$$

$$N_{CM} = N_C S_c i_c$$

$$N_q = e^{\pi \tan\varphi'} \tan^2\left(45 + \frac{\varphi'}{2}\right)$$

$$S_q = 1 + \left(\frac{B'}{L}\right)(\tan\varphi'_1) \; for \; \phi_{soil\ i} > 0$$

$$S_q = 1 \; for \; \phi_{soil\ i} = 0$$

$$d_q = 1 + 2\tan(\phi_{soil\ i})(1 - \sin\phi_{soil\ i})^2 \tan^{-1}(D_f/B')$$

(Hansen, 1968)

$$N_{qm} = N_q S_q d_q i_q$$

$$N_\gamma = 2(N_q + 1)\tan\varphi'$$

$$S_\gamma = 1 - 0.4\left(\frac{B'}{L}\right) \; for \; \phi_{soil\ i} > 0$$

$$S_\gamma = 1 \; for \; \phi_{soil\ i} = 0$$

$$N_{\gamma m} = N_\gamma S_\gamma i_\gamma$$

Note: Inclination factors are neglected and assumed to equal 1.0.

Table 10.6.3.1.2a-2

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
>1.5B+D_f	1.0	1.0

$$q_n = \underbrace{cN_{cm}}_{\text{Cohesion}} + \underbrace{\gamma D_f N_{qm} C_{wq}}_{\text{Surcharge}} + \underbrace{0.5\gamma B' N_{\gamma m} C_{w\gamma}}_{\text{Embedment}}$$

$$\sigma_V = \frac{\sum V}{B - 2e}$$

First Layer Only Solution

$q_N = q_{N1}$ =	10986.3	psf
$q_R = \varphi_b q_N$ =	10986.3	psf
σ_V =	4669.6	psf
Is $\sigma_V < q_R$?		**Yes**

2-Layer Approach - Article 10.6.3.1.2d

B'	=	14.98	ft
H_{CRIT}	=	-12.09	ft
Use 2-layer solution?		**No**	

2-Layer Solution - Drained Case Article 10.6.3.1.2f

K	=	N/A	dim.
q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		**N/A**	

where H = $EL_{LP} - EL_{Soil\ 1\ Lower}$

where K = $\frac{1 - sin^2(\varphi'_1)}{1 + sin^2(\varphi'_1)}$

$$H_{CRIT} = \frac{(3B')\ln\left(\frac{q_{N1}}{q_{N2}}\right)}{2\left(1 + \frac{B'}{L_T}\right)}$$

$$q_N = \left[q_{N2} + \left(\frac{1}{K}\right)C'_1\cot(\varphi'_1)\right] e^{2\left[1+\left(\frac{B'}{L}\right)\right]KTAN\varphi'_1\left(\frac{H}{B'}\right)} - \left(\frac{1}{K}\right)C'_1\cot(\varphi'_1)$$

S&ME Project #22-78-0033, Rear Abutment (Service Limit)

Undrained Analysis

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

$c_{soil\ 1}$	=	2000	psf	$c_{soil\ 2}$	=	0	psf
N_c	=	5.14	dim.	N_c	=	30.1	dim.
s_c	=	1.022	dim.	s_c	=	1.067	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	5.3	dim.	N_{cm}	=	32.1	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	1	dim.	N_q	=	18.4	dim.
s_q	=	1	dim.	s_q	=	1.064	dim.
d_q	=	1	dim.	d_q	=	1.06	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	1	dim.	N_{qm}	=	20.8	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.
$\gamma_{soil\ 1}$	=	125	pcf	$\gamma_{soil\ 2}$	=	115	pcf
B'	=	14.98	ft	B'	=	14.98	ft
N_γ	=	0	dim.	N_γ	=	22.4	dim.
s_γ	=	1	dim.	s_γ	=	0.956	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	0	dim.	$N_{\gamma m}$	=	21.4	dim.
$C_{w\gamma}$	=	0.67	dim.	$C_{w\gamma}$	=	0.67	dim.
Cohesion		10600.0	psf	Cohesion		0.0	psf
Surcharge		375.0	psf	Surcharge		7800.0	psf
Embedment		0.0	psf	Embedment		12350.0	psf
q_{N1}		10975.0	psf	q_{N2}		20150.0	psf

$$N_m = \frac{\kappa N_*(N_* + \beta - 1)[(\kappa+1)N_*^2 + (1+\kappa\beta)N_* + \beta - 1]}{[\kappa(\kappa+1)N_* + \kappa + \beta - 1][(N_*+\beta)N_* + \beta - 1] - [(\kappa N_* + \beta - 1)(N_*+1)]}$$

↑ *For soft over stiff (EPRI, 1983)*

For stiff over soft ↓

$$N_m = \left(\frac{1}{\beta_m} + \kappa s_c N_c\right) \leq s_c N_c$$

See Sheet 4 for Bearing Capacity Equations

2-Layer Approach - Article 10.6.3.1.2d

B'	=	14.98	ft
H_{CRIT}	=	12.30	ft
Use 2-layer solution?		Yes	

2-Layer Solution - Undrained Case Article 10.6.3.1.2e

For stiff over soft layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

For soft over stiff layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_*	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

2-Layer Solution - Undrained Case

q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		N/A	

$$\beta_m = \frac{BL_{TWALL}}{2(B + L_{TWALL})(EL_{LP} - EL_{Upper2})}$$

$$\kappa = \frac{c_1}{c_2} \qquad N_* = s_c N_c$$

One Layer Only Solution

Calculate for:		Layer 1	
$q_N = q_{N1}$	=	10975	psf
$q_R = \varphi_b q_N$	=	10975	psf
σ_V	=	4669.6	psf
Is $\sigma_V < q_R$?		Yes	

Sliding - Undrained Analysis (Articles 11.10.5.3 & 10.6.3.4)

S_u	=	2000	psf
$0.5\sigma'_v$	=	1623.75	psf
q_s	=	1623.75	psf
B	=	20	ft
$R_R = \varphi_\tau R_\tau$	=	32475	psf
Q_S	=	29111.2	psf
Is $R_R > Q_S$?		Yes	

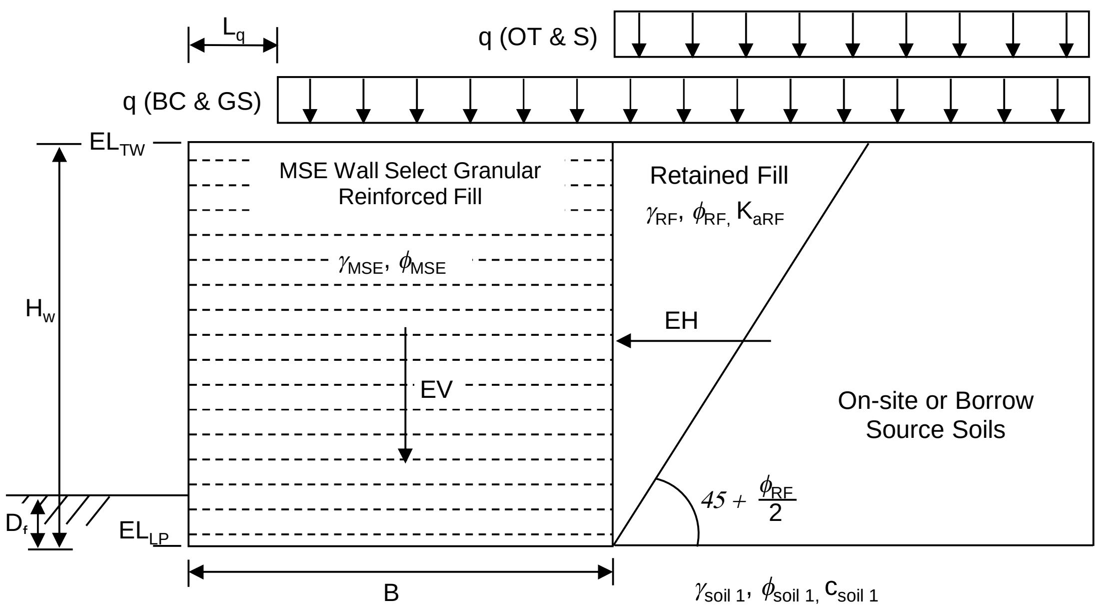
Equations for Sliding - Undrained

$$q_s = \text{lesser of } S_u \text{ or } 0.5\sigma'_v$$

$$R_\tau = Bq_s$$

S&ME Project #22-78-0033, Forward Abutment (Service Limit)

MSE Wall Stability Diagram and Design Parameters



$$K_{aRF} = \frac{1 - \sin\phi_{RF}}{1 + \sin\phi_{RF}}$$

Notes: $L_{T\,WALL}$ equals the length of the wall
EL_{WS} equals the elevation of the water table

γ_{MSE}	=	125	pcf	ϕ'_{MSE}	=	32	deg	$L_{T\,WALL}$	=	170	ft
H_W	=	30.29	ft	γ_{RF}	=	125	pcf	EL_{WS}*	=	780	MSL
H_2	=		ft	ϕ'_{RF}	=	26	deg	D_w	=	7	ft
EL_{LP}	=	784		K_{aRF}	=	0.39		D_f	=	3	ft
EL_{AS}	=	814.29									
EL_{TA}	=	814.29		q	=	250	psf				
H_T	=	30.29	ft	L_q	=	0	ft				
B	=	**23**	ft								
L_{AS}	=										

Representative Soil Profile: B-003-0-22

*To ensure correct usage of effective vs. saturated unit weights, break up soil layers at the water surface elevation.

Soil Layer 1				*Soil Layer 2*				*Soil Layer 3*			
Upper El.	=	784	MSL	Upper El.	=	783.8	MSL	Upper El.	=	765	MSL
Lower El.	=	783.8	MSL	Lower El.	=	765	MSL	Lower El.	=	0	MSL
$\gamma_{soil\,1}$	=	125	pcf	$\gamma_{soil\,2}$	=	130	pcf	$\gamma_{soil\,3}$	=	0	pcf
$\gamma'_{soil\,1}$	=	125	pcf	$\gamma'_{soil\,2}$	=	67.6	pcf	$\gamma'_{soil\,3}$	=	-62.4	pcf
$\phi'_{soil\,1}$	=	26	deg	$\phi'_{soil\,2}$	=	30	deg	$\phi'_{soil\,3}$	=	0	deg
$c'_{soil\,1}$	=	0	psf	$c'_{soil\,2}$	=	0	psf	$c'_{soil\,3}$	=	0	psf
$\phi_{soil\,1}$	=	0	deg	$\phi_{soil\,2}$	=	0	deg	$\phi_{soil\,3}$	=	0	deg
$c_{soil\,1}$	=	2250	psf	$c_{soil\,2}$	=	4000	psf	$c_{soil\,3}$	=	4000	psf

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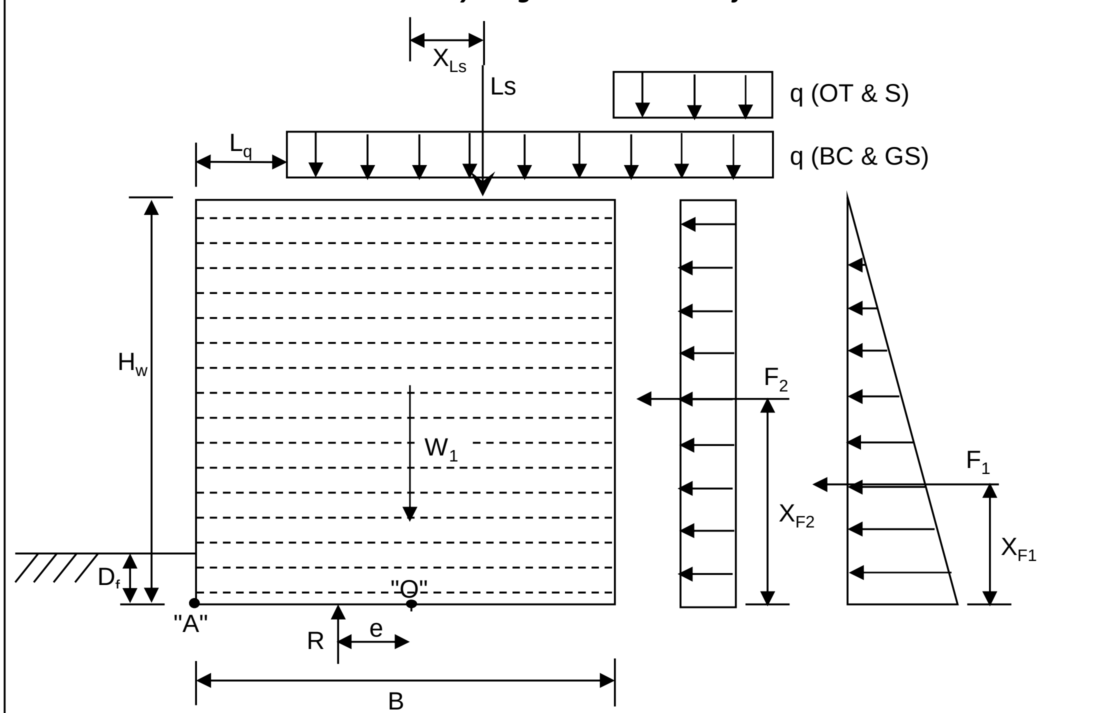


CDR Values (**Drained** Undrained)	
Sliding	***1.10*** / 1.12
Eccentricity	1.60
Bearing Resistance	***2.31*** / 4.71

Resistance and Load Factors (Tables 3.4.1-1, 3.4.1-2 & 11.5.7-1)

φ_τ =	1.0	Sliding	γ_{EH} =	1.5	Overturning	φ_b =	1	Bearing Resistance
γ_{EH} =	1.5		γ_{EV} =	1.0		γ_{EH} =	1	
γ_{EV} =	1.0		γ_{LS} =	1.75		γ_{EV} =	1	
γ_{LS} =	1.75					γ_{LS} =	1	

Interim Calculations

Force Calculations			*Moment Arm Equations*
W_1 =	87083.8 plf	$W_1 = H_W B \gamma_{MSE}$	$\bar{X}_{W1}$ = 0 (passes through "O")
W_2 =	0.0 plf	$W_2 = H_2 \gamma_{MSE}(B - L_{AS})$	$\bar{X}_{W2} = \left(\frac{B - L_{AS}}{2}\right) - \frac{B}{2}$
F_1 =	22363.7 plf	$F_1 = 0.5\gamma_{rf} H_T^2 K_{aRF}$	$\bar{X}_{F1} = \frac{H_T}{3}$
F_2 =	2953.3 plf	$F_2 = q H_T K_{aRF}$	$\bar{X}_{F2} = \frac{H_T}{2}$
L_S =	5750.0 plf	$L_S = q(B - L_q)$	$\bar{X}_{LS} = \left(\frac{B - L_q}{2}\right) - \frac{B}{2}$

(For F_2 and L_s: use only if $L_q < (B + \frac{H_w}{2})$

S&ME Project #22-78-0033, Forward Abutment (Service Limit)

Moment Arm Calculations			*Moment Calculations - Eccentricity*			*Moment Calculations - Bearing*		
X_{W1} =	0.00	ft	M_{W1} =	0.0	lb-ft/ft	M_{W1} =	0.0	lb-ft/ft
X_{W2} =	0.00	ft	M_{W2} =	0.0	lb-ft/ft	M_{W2} =	0.0	lb-ft/ft
X_{F1} =	10.10	ft	M_{F1} =	338810.1	lb-ft/ft	M_{F1} =	225873.4	lb-ft/ft
X_{F2} =	15.15	ft	M_{F2} =	78299.4	lb-ft/ft	M_{F2} =	44742.5	lb-ft/ft
X_{LS} =	0.00	ft	$M_x = \gamma_x F_x \bar{X}_x$			M_{LS} =	0.0	lb-ft/ft

Drained Analysis

Sliding (Articles 11.10.5.3 & 10.6.3.4)			*Eccentricity (Overturning) (Articles 11.10.5.5 & 11.6.3.3)*			*Eccentricity for BR (Article 11.10.5.4)*		
δ =	26	deg	R =	87083.8	plf	R =	92833.8	plf
$\tan(\delta)$ =	0.488		e =	4.79	ft	e =	2.92	ft
$R_R = \varphi_\tau R_\tau$ =	42473.6	plf						
Q_S =	38713.8	plf	M_R =	417109.5	lb-ft/ft	M_R =	270615.9	lb-ft/ft
Is $R_R > Q_S$?	Yes		Is e < B/3?	Yes				
B/H_W =	76%							
B/H_{WT} =	76%		Effective Wall Width			Effective Wall Width (BR)		
Is $B \geq 0.7H_W$	Yes		B' =	13.42	ft	B' =	17.16	ft

Moment equations are solved by summing moments about the midpoint (Point "O") of the reinforcement length (B) in the counterclockwise direction.

EQUATIONS - Sliding Only

R_τ = V tan δ
(where δ is lesser of ϕ'_{MSE} or $\phi'_{soil\ 1}$)

$V = \gamma_{EV}\ [W_1 + W_2]$

$Q_s = \gamma_{EH} F_1 + \gamma_{LS} F_2$

Note: Passive resistance is neglected when checking for stability in sliding.

EQUATIONS - Eccentricity and Bearing Resistance

$$\circlearrowleft\!+\sum M_{at\ 0} = \gamma_{EV}\ [W_2 \bar{X}_{w2}] + \gamma_{EH}(F_1 \bar{X}_{F1}) + \gamma_{LS}(F_2 \bar{X}_{F2} + L_S \bar{X}_{LS}) + \text{Re} = 0$$

$$R = \sum V = \gamma_{EV}(W_1 + W_2) + \gamma_{LS} L_s$$

Note: Load Factors (max or min) applicable to each analysis (Eccentricity or Bearing Resistance) are to be applied in the equation above. Also, M_{LS} is not included in the equation to calculate eccentricity for Overturning (L_s=0), but is included to calculate eccentricity for Bearing Resistance.

S&ME Project #22-78-0033, Forward Abutment (Service Limit)

Bearing Resistance - 2 Potential Alternative Approaches (Articles 11.10.5.4, 10.6.3.1 & 10.6.3.2)

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

Parameter		Value	Unit	Parameter		Value	Unit
$c'_{soil\ 1}$	=	0	psf	$c'_{soil\ 1}$	=	0	psf
N_c	=	22.3	dim.	N_c	=	30.1	dim.
s_c	=	1.054	dim.	s_c	=	1.062	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	23.5	dim.	N_{cm}	=	32	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	11.9	dim.	N_q	=	18.4	dim.
s_q	=	1.049	dim.	s_q	=	1.058	dim.
d_q	=	1.05	dim.	d_q	=	1.05	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	13.1	dim.	N_{qm}	=	20.4	dim.
c_{wq}	=	1	dim.	c_{wq}	=	1	dim.
$\gamma'_{soil\ 1}$	=	125	pcf	$\gamma'_{soil\ 2}$	=	130	pcf
B'	=	17.16	ft	B'	=	17.16	ft
N_γ	=	12.5	dim.	N_γ	=	22.4	dim.
s_γ	=	0.96	dim.	s_γ	=	0.96	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	12	dim.	$N_{\gamma m}$	=	21.5	dim.
$C_{w\gamma}$	=	0.59	dim.	$C_{w\gamma}$	=	0.59	dim.
Cohesion		0.0	psf	Cohesion		0.0	psf
Surcharge		4912.5	psf	Surcharge		7650.0	psf
Embedment		7593.3	psf	Embedment		14148.8	psf
q_{N1}		12505.8	psf	q_{N2}		21798.8	psf

$$N_c = (N_q - 1)\cot\varphi' \text{ for } \phi_{soil\ i} > 0$$
$$N_c = 5.14 \text{ for } \phi_{soil\ i} = 0$$
$$S_c = 1 + \left(\frac{B'}{L}\right)\left(\frac{N_q}{N_C}\right) \ for\ \phi_{soil\ i} > 0$$
$$S_c = 1 + \left(\frac{B'}{5L}\right) \ for\ \phi_{soil\ i} = 0$$
$$N_{CM} = N_C S_c i_c$$
$$N_q = e^{\pi \tan\varphi'} \tan^2\left(45 + \frac{\varphi'}{2}\right)$$
$$S_q = 1 + \left(\frac{B'}{L}\right)(\tan\varphi'_1) \ for\ \phi_{soil\ i} > 0$$
$$S_q = 1 \ for\ \phi_{soil\ i} = 0$$
$$d_q = 1 + 2\tan(\phi_{soil\ i})(1 - \sin\phi_{soil\ i})^2 \tan^{-1}(D_f/B')$$
(Hansen, 1968)
$$N_{qm} = N_q S_q d_q i_q$$
$$N_\gamma = 2(N_q + 1)\tan\varphi'$$
$$S_\gamma = 1 - 0.4\left(\frac{B'}{L}\right) \ for\ \phi_{soil\ i} > 0$$
$$S_\gamma = 1 \ for\ \phi_{soil\ i} = 0$$
$$N_{\gamma m} = N_\gamma S_\gamma i_\gamma$$

Note: Inclination factors are neglected and assumed to equal 1.0.

Table 10.6.3.1.2a-2

D_w	C_{wq}	$C_{w\gamma}$
0.0	0.5	0.5
D_f	1.0	0.5
>1.5B+D_f	1.0	1.0

$$q_n = \underbrace{cN_{cm}}_{\text{Cohesion}} + \underbrace{\gamma D_f N_{qm} C_{wq}}_{\text{Surcharge}} + \underbrace{0.5\gamma B' N_{\gamma m} C_{w\gamma}}_{\text{Embedment}}$$

$$\sigma_V = \frac{\sum V}{B - 2e}$$

First Layer Only Solution

$q_N = q_{N1}$ =	12505.8	psf
$q_R = \varphi_b q_N$ =	12505.8	psf
σ_V =	5409.9	psf
Is $\sigma_V < q_R$?	**Yes**	

2-Layer Approach - Article 10.6.3.1.2d

B'	=	17.16	ft
H_{CRIT}	=	-12.99	ft
Use 2-layer solution?		**No**	

$$H_{CRIT} = \frac{(3B')\ln\left(\frac{q_{N1}}{q_{N2}}\right)}{2\left(1 + \frac{B'}{L_T}\right)}$$

2-Layer Solution - Drained Case Article 10.6.3.1.2f

K	=	N/A	dim.
q_N	=	N/A	psf
$q_R = \varphi_b q_N$	=	N/A	psf
σ_V	=	N/A	psf
Is $\sigma_V < q_R$?		**N/A**	

where H = $EL_{LP} - EL_{Soil\ 1\ Lower}$

where K = $\frac{1 - sin^2(\varphi'_1)}{1 + sin^2(\varphi'_1)}$

$$q_N = \left[q_{N2} + \left(\frac{1}{K}\right)C'_1\cot(\varphi'_1)\right]e^{2\left[1+\left(\frac{B'}{L}\right)\right]KTAN\varphi'_1\left(\frac{H}{B'}\right)} - \left(\frac{1}{K}\right)C'_1\cot(\varphi'_1)$$

S&ME Project #22-78-0033, Forward Abutment (Service Limit)

Undrained Analysis

General Bearing Capacity Equation (Munfakh et al., 2001) - Article 10.6.3.1

Layer 1				Layer 2			
$c_{soil\ 1}$	=	2250	psf	$c_{soil\ 2}$	=	4000	psf
N_c	=	5.14	dim.	N_c	=	5.14	dim.
s_c	=	1.02	dim.	s_c	=	1.02	dim.
i_c	=	1	dim.	i_c	=	1	dim.
N_{cm}	=	5.2	dim.	N_{cm}	=	5.2	dim.
γ_{MSE}	=	125	pcf	γ_{MSE}	=	125	pcf
D_f	=	3	ft	D_f	=	3	ft
N_q	=	1	dim.	N_q	=	1	dim.
s_q	=	1	dim.	s_q	=	1	dim.
d_q	=	1	dim.	d_q	=	1	dim.
i_q	=	1	dim.	i_q	=	1	dim.
N_{qm}	=	1	dim.	N_{qm}	=	1	dim.
C_{wq}	=	1	dim.	C_{wq}	=	1	dim.
$\gamma_{soil\ 1}$	=	125	pcf	$\gamma_{soil\ 2}$	=	130	pcf
B'	=	17.16	ft	B'	=	17.16	ft
N_γ	=	0	dim.	N_γ	=	0	dim.
s_γ	=	1	dim.	s_γ	=	1	dim.
i_γ	=	1	dim.	i_γ	=	1	dim.
$N_{\gamma m}$	=	0	dim.	$N_{\gamma m}$	=	0	dim.
$C_{w\gamma}$	=	0.59	dim.	$C_{w\gamma}$	=	0.59	dim.
Cohesion		11700.0	psf	Cohesion		20800.0	psf
Surcharge		375.0	psf	Surcharge		375.0	psf
Embedment		0.0	psf	Embedment		0.0	psf
q_{N1}		12075.0	psf	q_{N2}		21175.0	psf

See Sheet 4 for Bearing Capacity Equations

2-Layer Approach - Article 10.6.3.1.2d

B'	=	17.16	ft
H_{CRIT}	=	13.13	ft
Use 2-layer solution?		**Yes**	

2-Layer Solution - Undrained Case Article 10.6.3.1.2e

For stiff over soft layering

κ	=	N/A	dim.
β_m	=	N/A	dim.
N_m	=	N/A	dim.
q_N	=	N/A	psf

For soft over stiff layering

κ	=	1.778	dim.
β_m	=	38.967	dim.
N_*	=	5.243	dim.
N_m	=	11.169	dim.
q_N	=	25505.3	psf

2-Layer Solution - Undrained Case

q_N	=	25505.3	psf
$q_R = \varphi_b q_N$	=	25505.3	psf
σ_V	=	5409.9	psf
Is $\sigma_V < q_R$?		**Yes**	

$$N_m = \frac{\kappa N_*(N_* + \beta - 1)[(\kappa+1)N_*^2 + (1+\kappa\beta)N_* + \beta - 1]}{[\kappa(\kappa+1)N_* + \kappa + \beta - 1][(N_* + \beta)N_* + \beta - 1] - [(\kappa N_* + \beta - 1)(N_* + 1)]}$$

↑ *For soft over stiff (EPRI, 1983)*

$$\beta_m = \frac{BL_{TWALL}}{2(B + L_{TWALL})(EL_{LP} - EL_{Upper2})}$$

$$\kappa = \frac{c_1}{c_2} \qquad N_* = s_c N_c$$

For stiff over soft ↓

$$N_m = \left(\frac{1}{\beta_m} + \kappa s_c N_c\right) \le s_c N_c$$

One Layer Only Solution

Calculate for:		Layer 1	
$q_N = q_{N1}$	=	12075	psf
$q_R = \varphi_b q_N$	=	12075	psf
σ_V	=	5409.9	psf
Is $\sigma_V < q_R$?		**Yes**	

Sliding - Undrained Analysis (Articles 11.10.5.3 & 10.6.3.4)

S_u	=	2250	psf
$0.5\sigma'_v$	=	1893.125	psf
q_s	=	1893.125	psf
B	=	23	ft
$R_R = \varphi_\tau R_\tau$	=	43541.875	psf
Q_S	=	38713.8	psf
Is $R_R > Q_S$?		**Yes**	

Equations for Sliding - Undrained

$$q_s = \text{lesser of } S_u \text{ or } 0.5\sigma'_v$$

$$R_\tau = Bq_s$$

Project Number:	22-78-0033	Calculated By:	RES
Project Name:	HAM-74-13.35	Date:	2/24/2023
Project Location:	Race Road, Hamilton County	Checked By:	BCD
Client Name:	Fishbeck	Date:	2/24/2023

Version 2.0 (6/11/2015)

SHALLOW FOUNDATION BEARING RESISTANCE CALCULATION SUMMARY

(Example calculations with reference equations and information are provided on additional sheets)

Bridge Structure Identification		HAM-74-13.35 (SFN: 3108680)	
Boring ID	B-002-0-22	Foundation Element Description	Interm. Pier
Surface Elev.	785.3	Footing Base Elevation	772.8

Analysis Desc.	Term/Info Description	Unit	Layer 1	Layer 2	Layer 3
Boring/Layer Information	Bedrock Type/Description		Wx Shale	Shale	Interbed SH/LS
	Layer Top Depth (from G.S.)	ft	12.5	15	18
	Layer Top Elevation	MSL	772.8	770.3	767.3
	Layer Bottom Depth (from G.S.)	ft	15	18	31.2
	Layer Bottom Elevation	MSL	770.3	767.3	754.1
	Layer Thickness	ft	2.5	3	13.2
Rock Mass Rating (RMR) Information (per AASHTO LRFD 10.6.3.2)	Compressive Strength, q_u	psi	500	1000	3888
	RQD	%	0	20	44
	Joint Spacing Selection		E	D	D to E
	Joint Condition Selection		D	C to D	C
	Groundwater Selection		B	B	B
	Analysis Type Selection		Foundations	Foundations	Foundations
	Joint Strike and Dip Selection		B	B	B
	RMR		20	28	36
Nominal Bearing Resistance Calculations (per AASHTO LRFD 10.6.3.1.1 & 10.6.3.2)	Compressive Strength, q_u	psi	500	1000	3888
	Rock Type (A, B or C)		B	B	B
	m		0.033	0.059	0.104
	s		0.00000165	0.00000623	0.00002346
	q_N (Carter & Kulhawy, 1988)	ksf	0.57	2.14	15.57
	Rock Type Selection ID (NAVFAC)		5	5	3
	q_N (Presumptive, NAVFAC 1986)	ksf	50	50	100
	Rock Type Selection ID (Peck)		6	5	4
	q_N (Suggested Values, Peck 1974)	ksf	50	150	325
	q_N (Use)	ksf	25	56	75
	q_N (Use)	**tsf**	**12.5**	**28**	**37.5**

Factored Bearing Resistance (per AASHTO LRFD 10.6.3.1.1)	Term	Unit	Value
	q_N	ksf	56
	φ_b	ksf	0.45
	q_R	ksf	25.2

(per AASHTO LRFD Table 10.5.5.2.2-1)

$$q_R = \varphi_b q_N$$

NOTE: The presumptive NAVFAC and suggested Peck values have been multiplied by an assumed applied factor of safety of 2.5 to convert from allowable to ultimate capacities.

Project Number:	22-78-0033	Boring(s):	B-002-0-22	Calculated By:	RES
Project Name:	HAM-74-13.35	Layer Depth Range:	12.5' - 15'	Date:	2/24/2023
Project Location:	Race Road, Hamilton County	Layer Elevation Range:	772.8' - 770.3'	Checked By:	BCD
Client Name:	Fishbeck	Foundation Element:	Interm. Pier	Date:	2/24/2023

Version 2.0
(6/11/2015)

ESTIMATION OF ROCK MASS RATING (RMR) FOR BEDROCK LAYERS (SEE AASHTO LRFD 10.4.6.4, TABLES 10.4.6.4-1, 2 & 3)

Parameter	Specimen Result	Relative Rating	RANGE OF VALUES AND RELATIVE RATINGS						
Strength of Intact Rock (UC Strength, psi)	500	1	> 30000	30000 - 15000	15000 - 7500	7500 - 3610	3610 - 1495	1495 - 485	485 - 138
			RELATIVE RATING						
			15	12	7	4	2	1	0
Drill Core Quality, RQD (%)	0	3	100% - 90%	90% - 75%	75% - 50%	50% - 25%		25% - 0%	
			RELATIVE RATING						
			20	17	13	8		3	
Spacing of Joints (ft)	E	5	A	B	C	D		E	
			> 10	10 - 3	3 - 1	1 - 0.167		< 0.167	
			RELATIVE RATING						
			30	25	20	10		5	
Condition of Joints	D	6	A	B	C	D		E	
			Very Rough Surfaces Not Continuous No Separation Hard Joint Wall Rock	Slightly Rough Surfaces Separation < 0.05 in Hard Joint Wall Rock	Slightly Rough Surfaces Separation < 0.05 in Soft Joint Wall Rock	Slicken-sided Surfaces, Gouge < 0.2 in thick OR Joints Open 0.05 - 0.2 in Continuous Joints		Soft Gouge > 0.2 in OR Joints Open > 0.2 in Continuous Joints	
			RELATIVE RATING						
			25	20	12	6		0	
Groundwater Conditions (General Conditions criteria)	B	7	A	B		C		D	
			Completely Dry	Moist Only (Interstitial Water)		Water Under Moderate Pressure		Severe Water Problems	
			RELATIVE RATING						
			10	7		4		0	

Strike and Dip Orientations of Joints			A	B	C	D	E
Project Type	Project Analysis	Rating	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable
Tunnels		N/A	0	-2	-5	-10	-12
Foundations	B	-2	0	-2	-7	-15	-25
Slopes		N/A	0	-5	-25	-50	-60

Layer RMR	RMR Rating	100 - 81	80 - 61	60 - 41	40 - 21	20 - 0
20	Class No.	I	II	III	IV	V
	Description	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock

Project Number:	22-78-0033	Boring(s):	B-002-0-22	Calculated By:	RES
Project Name:	HAM-74-13.35	Layer Depth Range:	15' - 18'	Date:	2/24/2023
Project Location:	Race Road, Hamilton County	Layer Elevation Range:	770.3' - 767.3'	Checked By:	BCD
Client Name:	Fishbeck	Foundation Element:	Interm. Pier	Date:	2/24/2023

Version 2.0 (6/11/2015)

ESTIMATION OF ROCK MASS RATING (RMR) FOR BEDROCK LAYERS (SEE AASHTO LRFD 10.4.6.4, TABLES 10.4.6.4-1, 2 & 3)

Parameter	Specimen Result	Relative Rating	RANGE OF VALUES AND RELATIVE RATINGS						
Strength of Intact Rock (UC Strength, psi)	1000	1	> 30000	30000 - 15000	15000 - 7500	7500 - 3610	3610 - 1495	1495 - 485	485 - 138
			RELATIVE RATING						
			15	12	7	4	2	1	0
Drill Core Quality, RQD (%)	20	3	100% - 90%	90% - 75%	75% - 50%	50% - 25%		25% - 0%	
			RELATIVE RATING						
			20	17	13	8		3	
Spacing of Joints (ft)	D	10	A	B	C	D		E	
			> 10	10 - 3	3 - 1	1 - 0.167		< 0.167	
			RELATIVE RATING						
			30	25	20	10		5	
Condition of Joints	C to D	9	A	B	C	D		E	
			Very Rough Surfaces Not Continuous No Separation Hard Joint Wall Rock	Slightly Rough Surfaces Separation < 0.05 in Hard Joint Wall Rock	Slightly Rough Surfaces Separation < 0.05 in Soft Joint Wall Rock	Slicken-sided Surfaces, Gouge < 0.2 in thick OR Joints Open 0.05 - 0.2 in Continuous Joints		Soft Gouge > 0.2 in OR Joints Open > 0.2 in Continuous Joints	
			RELATIVE RATING						
			25	20	12	6		0	
Groundwater Conditions (General Conditions criteria)	B	7	A	B		C		D	
			Completely Dry	Moist Only (Interstitial Water)		Water Under Moderate Pressure		Severe Water Problems	
			RELATIVE RATING						
			10	7		4		0	

Strike and Dip Orientations of Joints			A	B	C	D	E
Project Type	Project Analysis	Rating	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable
Tunnels		N/A	0	-2	-5	-10	-12
Foundations	B	-2	0	-2	-7	-15	-25
Slopes		N/A	0	-5	-25	-50	-60

Layer RMR	RMR Rating	100 - 81	80 - 61	60 - 41	40 - 21	20 - 0
28	Class No.	I	II	III	IV	V
	Description	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock

Project Number:	22-78-0033	Boring(s):	B-002-0-22	Calculated By:	RES
Project Name:	HAM-74-13.35	Layer Depth Range:	18' - 31.2'	Date:	2/24/2023
Project Location:	Race Road, Hamilton County	Layer Elevation Range:	767.3' - 754.1'	Checked By:	BCD
Client Name:	Fishbeck	Foundation Element:	Interm. Pier	Date:	2/24/2023

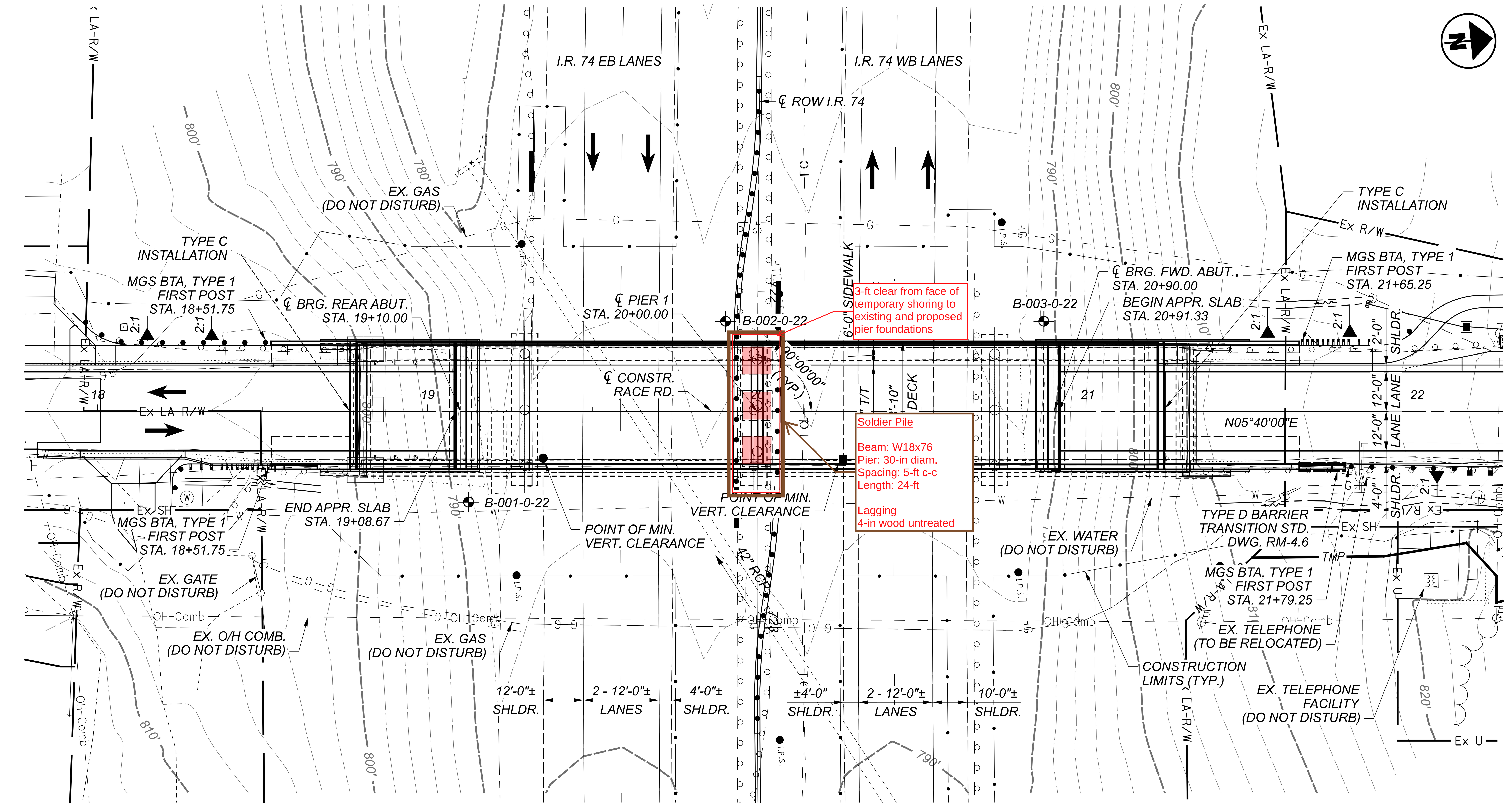
Version 2.0
(6/11/2015)

ESTIMATION OF ROCK MASS RATING (RMR) FOR BEDROCK LAYERS (SEE AASHTO LRFD 10.4.6.4, TABLES 10.4.6.4-1, 2 & 3)

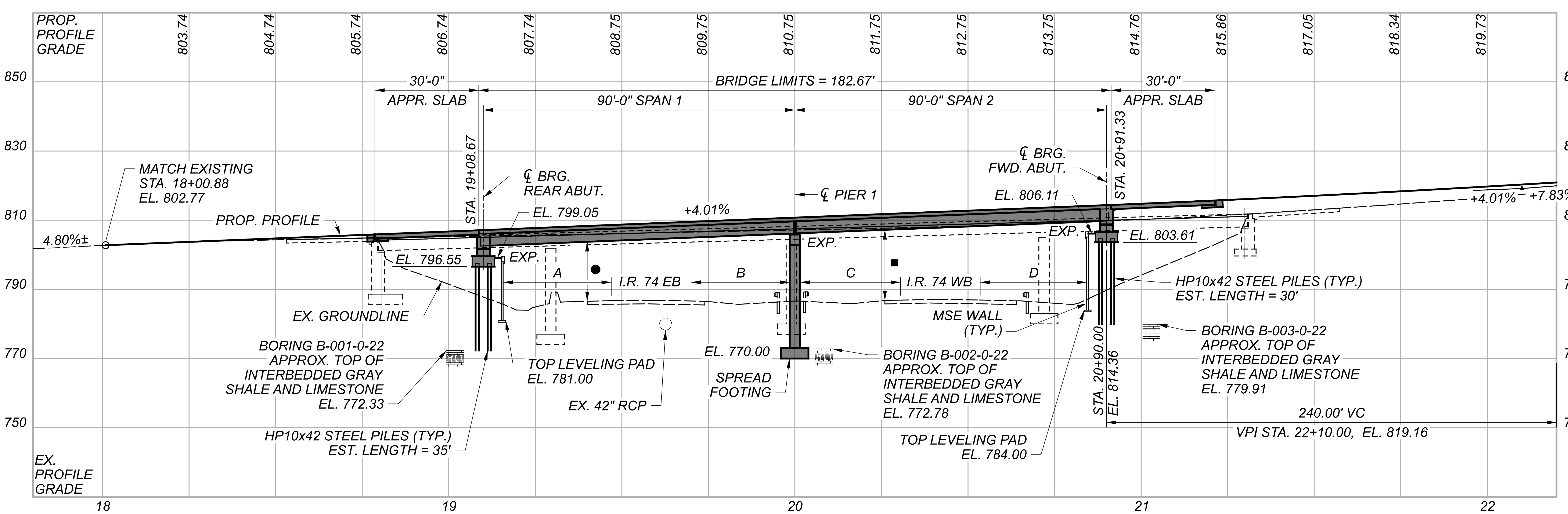
Parameter	Specimen Result	Relative Rating	RANGE OF VALUES AND RELATIVE RATINGS						
Strength of Intact Rock (UC Strength, psi)	3888	4	> 30000	30000 - 15000	15000 - 7500	7500 - 3610	3610 - 1495	1495 - 485	485 - 138
			RELATIVE RATING						
			15	12	7	4	2	1	0
Drill Core Quality, RQD (%)	44	8	100% - 90%	90% - 75%	75% - 50%	50% - 25%		25% - 0%	
			RELATIVE RATING						
			20	17	13	8		3	
Spacing of Joints (ft)	D to E	7	A	B	C	D		E	
			> 10	10 - 3	3 - 1	1 - 0.167		< 0.167	
			RELATIVE RATING						
			30	25	20	10		5	
Condition of Joints	C	12	A	B	C	D		E	
			Very Rough Surfaces Not Continuous No Separation Hard Joint Wall Rock	Slightly Rough Surfaces Separation < 0.05 in Hard Joint Wall Rock	Slightly Rough Surfaces Separation < 0.05 in Soft Joint Wall Rock	Slicken-sided Surfaces, Gouge < 0.2 in thick OR Joints Open 0.05 - 0.2 in Continuous Joints		Soft Gouge > 0.2 in OR Joints Open > 0.2 in Continuous Joints	
			RELATIVE RATING						
			25	20	12	6		0	
Groundwater Conditions (General Conditions criteria)	B	7	A	B		C		D	
			Completely Dry	Moist Only (Interstitial Water)		Water Under Moderate Pressure		Severe Water Problems	
			RELATIVE RATING						
			10	7		4		0	

Strike and Dip Orientations of Joints			A	B	C	D	E
Project Type	Project Analysis	Rating	Very Favorable	Favorable	Fair	Unfavorable	Very Unfavorable
Tunnels		N/A	0	-2	-5	-10	-12
Foundations	B	-2	0	-2	-7	-15	-25
Slopes		N/A	0	-5	-25	-50	-60

Layer RMR						
36	RMR Rating	100 - 81	80 - 61	60 - 41	40 - 21	20 - 0
	Class No.	I	II	III	IV	V
	Description	Very Good Rock	Good Rock	Fair Rock	Poor Rock	Very Poor Rock



PLAN



PROFILE ALONG ℄ CONSTRUCTION RACE ROAD

BENCHMARK DATA

BM 500 STA. 18+04.17,	ELEV. 802.675,	OFFSET 19.65' RT.
BM 501 STA. 24+25.28,	ELEV. 835.668,	OFFSET 31.96' LT.
CP 158 STA. 20+06.71,	ELEV. 785.512	OFFSET 35.56' LT.

FOR ADDITIONAL BENCHMARK INFORMATION SEE ROADWAY PLAN SHEET P.02/P.68.

FOR MEDIAN AND SHOULDER GUARDRAIL WORK SEE ROADWAY PLAN SHEET P.25/P.68.

NOTES

EARTHWORK LIMITS SHOWN ARE APPROXIMATE. ACTUAL SLOPES SHALL CONFORM TO PLAN CROSS SECTIONS.

DESIGN TRAFFIC:
2026 ADT = 6,400 2026 ADTT = 64
2046 ADT = 7,600 2046 ADTT = 76
DIRECTIONAL DISTRIBUTION = 0.51

LEGEND

BORING LOCATION

● EASTBOUND I.R. 74
16'-6" REQUIRED MINIMUM VERTICAL CLEARANCE
16'-10" ACTUAL MINIMUM VERTICAL CLEARANCE

■ WESTBOUND I.R. 74
16'-6" REQUIRED MINIMUM VERTICAL CLEARANCE
19'-11½" ACTUAL MINIMUM VERTICAL CLEARANCE

BTA = BRIDGE TERMINAL ASSEMBLY
A = MIN. HORIZ. CLEARANCE = 31'-3"
REQ'D. HORIZ. CLEARANCE = 30'-0"
B = MIN. HORIZ. CLEARANCE = 28'-6"
REQ'D. HORIZ. CLEARANCE = 10'-0"
C = MIN. HORIZ. CLEARANCE = 29'-0"
REQ'D. HORIZ. CLEARANCE = 10'-0"
D = MIN. HORIZ. CLEARANCE = 30'-9"
REQ'D. HORIZ. CLEARANCE = 30'-0"

EXISTING STRUCTURE

TYPE: 4-SPAN CONTINUOUS ROLLED STEEL BEAM WITH REINFORCED CONCRETE DECK AND SUBSTRUCTURE

SPANS: 49'-0"±, 69'-6"±, 73'-0"±, 58'-0"± C/C BEARINGS

ROADWAY: 30'-0"± T/T CURB WITH 4'-0"± SIDEWALKS

LOADING: CF-400 (57)

SKEW: NONE

WEARING SURFACE: 1"± MONOLITHIC CONCRETE & 1"± SDC OVERLAY

APPROACH SLABS: 25'± LONG (AS-1-54)

ALIGNMENT: TANGENT

CROWN: 0.016± FT/ FT

STRUCTURE FILE NUMBER: 3108678

DATE BUILT: 1969 REHABILITATED: 1992

DISPOSITION: TO BE REPLACED

PROPOSED STRUCTURE

TYPE: 2-SPAN PRESTRESSED CONCRETE WIDE FLANGE BEAM COMPOSITE WITH REINFORCED CONCRETE DECK ON SEMI-INTEGRAL ABUTMENTS AND CAP & COLUMN PIER

SPANS: 88'-11", 88'-11" C/C BEARINGS

ROADWAY: 30'-0" T/T, 6'-0" SIDEWALK LEFT SIDE

LOADING: HL93 AND 0.06 KSF FUTURE WEARING SURFACE

SKEW: NONE

WEARING SURFACE: 1" MONOLITHIC CONCRETE

APPROACH SLABS: 30'-0" LONG (AS-1-15, AS-2-15)

ALIGNMENT: TANGENT

CROWN: 0.016 FT/FT

DECK AREA: 7,094 SF

COORDINATES: LATITUDE 39°11'11.84" N
LONGITUDE 84°37'40.94" W

HORIZONTAL SCALE IN FEET 0 10 20 40

SITE PLAN
BRIDGE NO. HAM-00145-02.030
RACE ROAD OVER I.R. 74

For Review 03/28/2023 8:17:13 AM

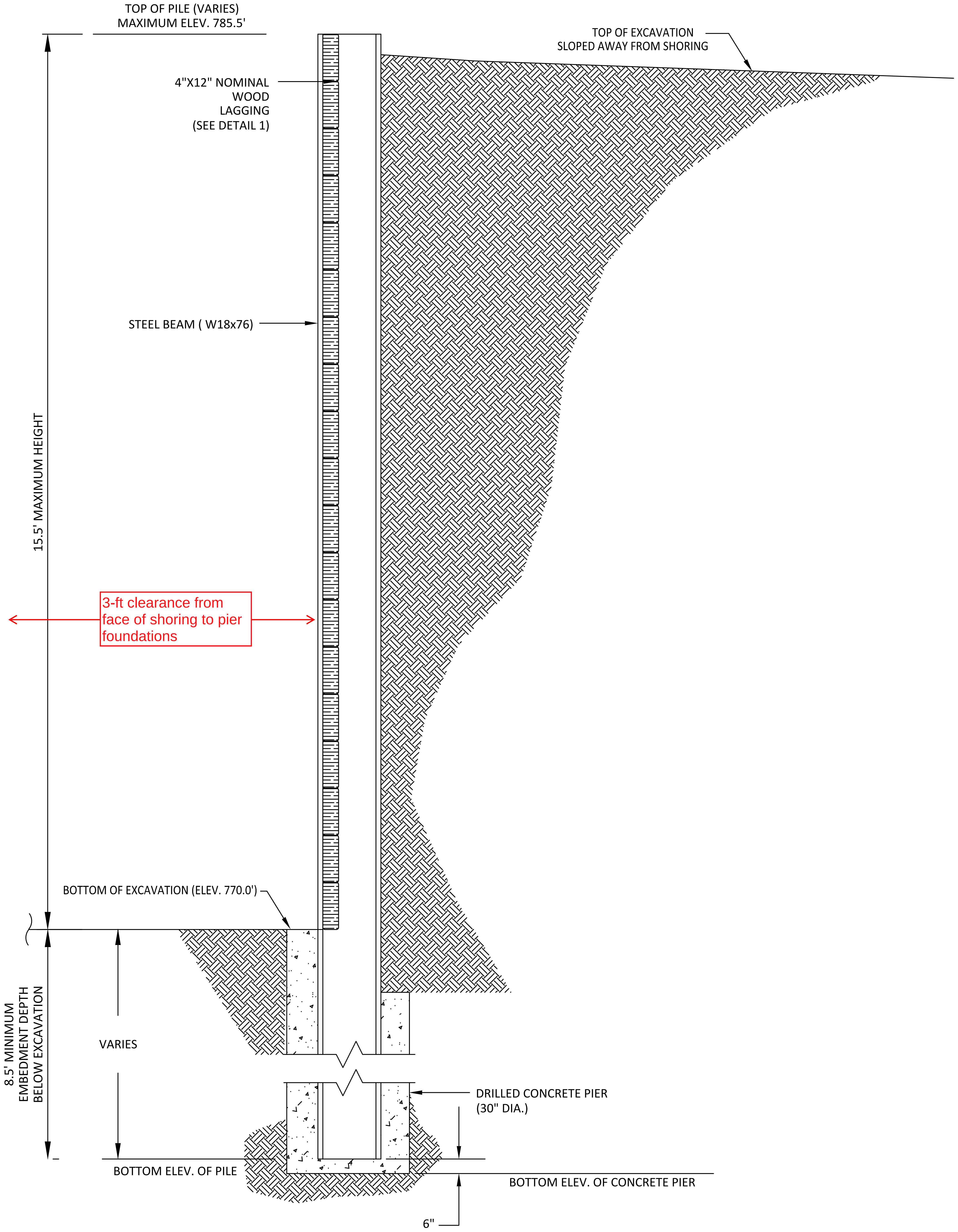
SFN 3108680

DESIGN AGENCY fishbeck

DESIGNER	CHECKER
BMV	JPC
REVIEWER XXX 03/03/23	
PROJECT ID 110563	
SUBSET S.01	TOTAL S.41
SHEET P.27	TOTAL P.68

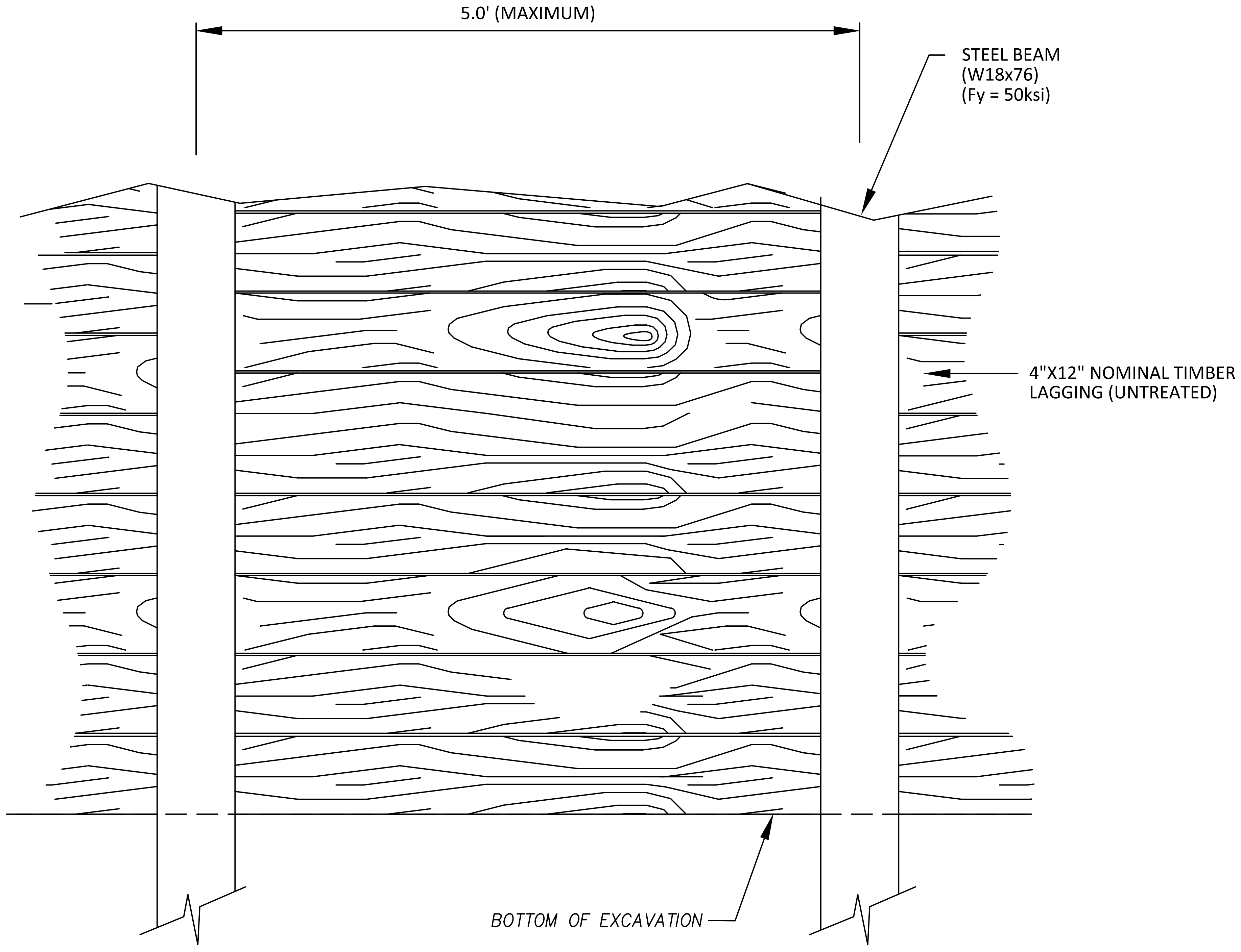
HAM-74-13.35

MODEL: Sheet PAPERSIZE: 34x22 (in.) DATE: 3/28/2023 TIME: 8:13:51 AM USER: bvasaris
Z:\2022\220827\CAD\ODOT\110563\400-Engineering\Structures\SFN_3108680\Sheets\110563_SFN_3108680_SP001.dgn



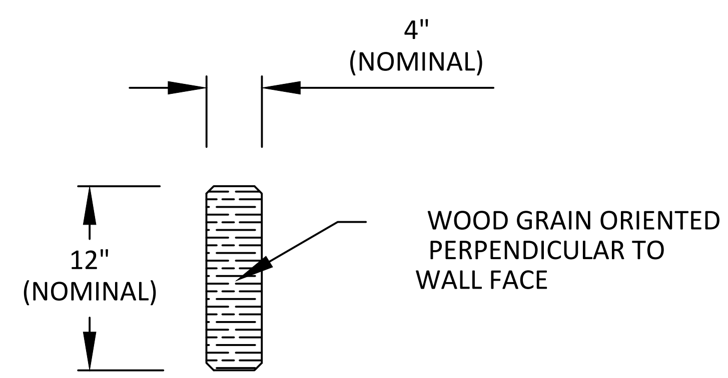
TYPICAL SHORING SECTION

SCALE: NOT TO SCALE

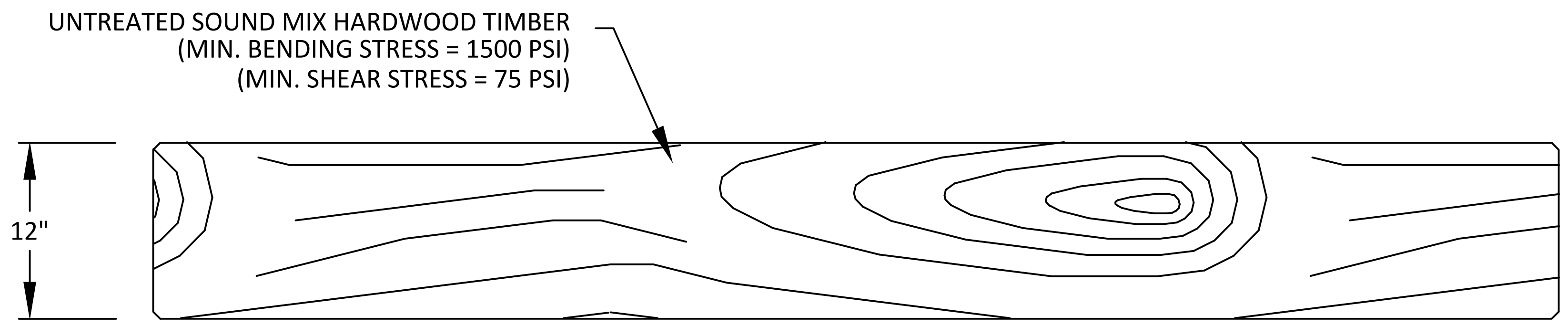


TYPICAL SHORING SECTIONS

SCALE: NOT TO SCALE



SIDE VIEW



FRONT VIEW

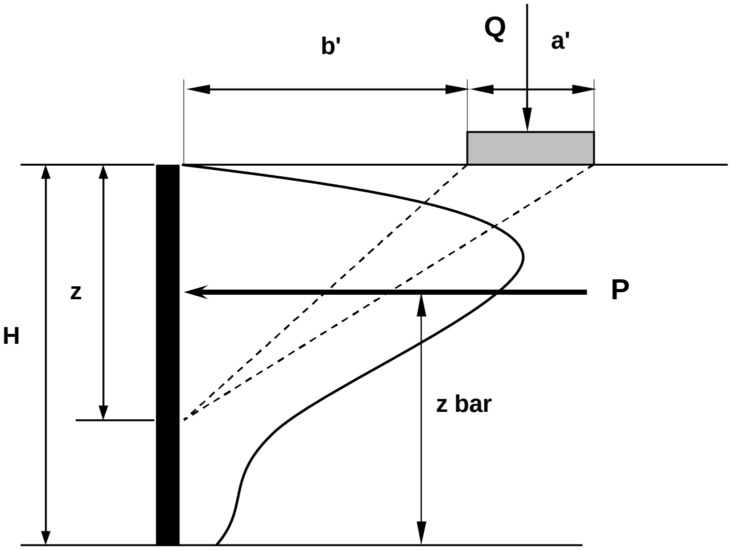
DETAIL 1 - TYPICAL WOOD LAGGING DETAIL

SCALE: NOT TO SCALE

Stress on rigid retaining due to line or strip loading . (Das 2nd edition, pages 279-281) RES 2/12/24
based on the theory of elasticity.

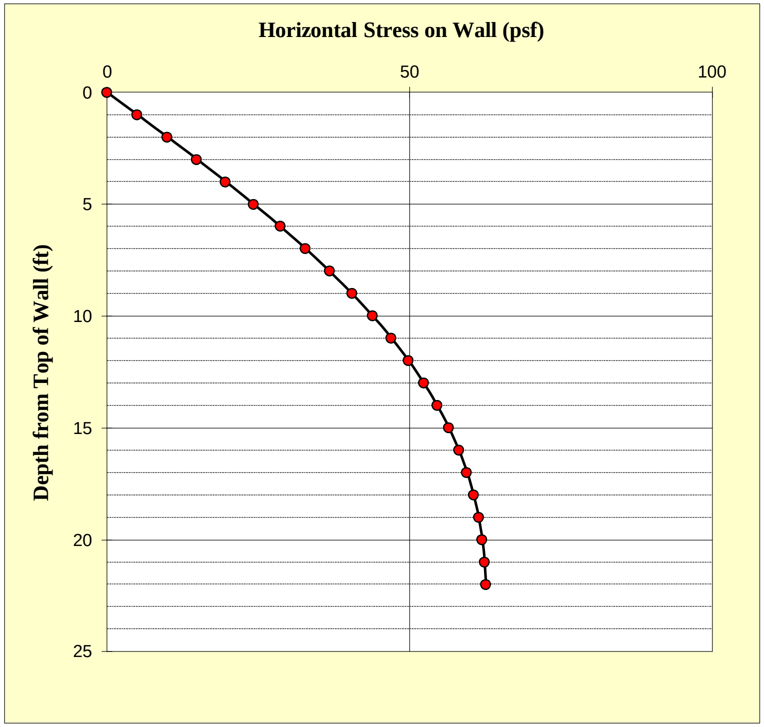
I-74 EB Traffic Surcharge

Q =	5.88	kplf
B (a') =	24	ft
b' =	28.6	ft
q =	250	psf/lf
H =	24	ft
P =	**1.018**	kips
z bar =	**9.14**	ft
Ko =	0.50	
$q_{(v)eqiv.}$	**85**	psf



Theta1 (deg)	Theta2 (deg)	R	Q
50.0	65.3	67136.3	32720.1

Depth (ft)	alpha (rad)	beta (rad)	stress (psf)
0	na	na	0
1	1.55	0.02	5
2	1.52	0.03	10
3	1.50	0.05	15
4	1.47	0.06	20
5	1.45	0.08	24
6	1.42	0.09	29
7	1.40	0.11	33
8	1.38	0.12	37
9	1.35	0.13	41
10	1.33	0.15	44
11	1.30	0.16	47
12	1.28	0.17	50
13	1.26	0.18	52
14	1.24	0.19	55
15	1.21	0.20	57
16	1.19	0.21	58
17	1.17	0.22	60
18	1.15	0.23	61
19	1.13	0.24	61
20	1.11	0.24	62
21	1.09	0.25	62
22	1.07	0.26	63



Wood Lagging

Surcharge	385	psf	
Spacing	5	ft	
Load	0.63	k/ft	
Moment	23.7	in-kips	$=w*l^2/8$
Shear	2.4	kips	$=1.5*w*l/2$

Panel				
	b	12.0	in	
	h	4.0	in	
	Area	48.00	in^2	$=b*h$
	S_x	32	in^3	$=b*h^2/6$

Hardwood Grade	1500.0	psi	allowable bending stress
	75.0	psi	allowable shear stress

12.0 in

4 in

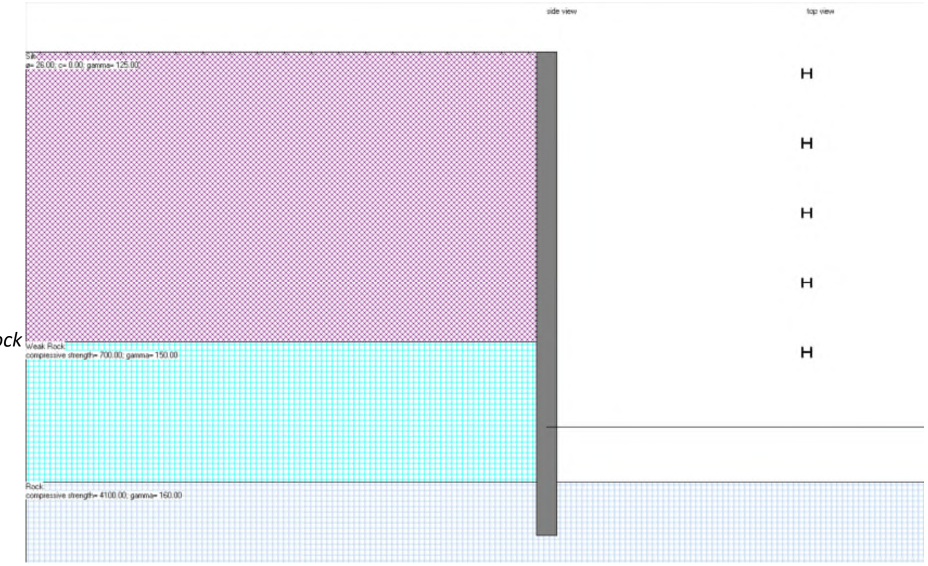
Arching Factor	0.6		
K_a	0.39		
Unit Weight	120	pcf	
H	15.5	ft	
Soil Pressure	435.2	psf	= Arching Factor * K_a *γ * H
Maximum Soil Pressure	400.0	psf	*from CALTRANS Trenching and Shoring Manual*
Surcharge Pressure	231.0	psf	=Arching Factor * Surcharge
Total Pressure	631.0	psf	= Max Soil Pressure + Surcharge Pressure

M_{cap}	48.0	in-kips	OK
V_{cap}	3.6	kips	OK

HAM-74-13.35
Project # **22-78-0033**

Profile View

γ_{LS} =	1.75			
Traffic Surcharge =	85	psf	*(from Surcharge Calculations)*	
Equipment Surcharge =	300	psf		
Total Surcharge =	385	psf	Service I	
=	449	psf	Strength I	
Backslope	0	degrees		
Exposed Height	15.5	ft	*Assumes no support aboove bedrock*	
Tie Back	N/A	inclination	N/A	degrees
Pile Spacing	5	ft		
Pier Diameter	30	in		
Pile Size	HP18X76		50	ksi
Total Length	24	ft		
Rock Socket	8.5	ft		



Soil Layers

Layer #	Soil Layer	Top Depth	Bottom Depth	Soil Type (PYWall)	Total Unit Weight (pcf)	C (psf)	ϕ (deg) [1]	E50	Kpy (pci)
1	SiltyClay/Clay (A-6b, A-7-	0	12.5	Silt (c-phi soil)	125	0.1	26	0.007	500

Layer #	Soil Layer	Top Depth	Bottom Depth	Soil Type (PYWall)	Total Unit Weight (pcf)	C (psf)	ϕ (deg)	Elastic Modulus (psi)	Krm (pci)	RQD (%)	UCS (psi)
2	Weathered Shale	12.5	17.8	Weak Rock (Reese)	150	--	--	130900	0.0005	0	374 [2]
3	Interbedded SH/LS	17.8	31.2	Vuggy Limestone	160	--	--	--	--	--	5,335 [3]

Reference:
1. Parameters from slope stability analyses
2. From B-003-0-13 (North Bend over I-74 S&ME No. 1178-13-021)
3. Weighted average of Shale/Limestone tests for 55% Shale, 45% LS

Project #	22-78-0033

W18x76

Service I Limit State

Surcharge =	385	psf
Landslide Load =	0	lbs
Modified Earth Pressure Factor =	1	

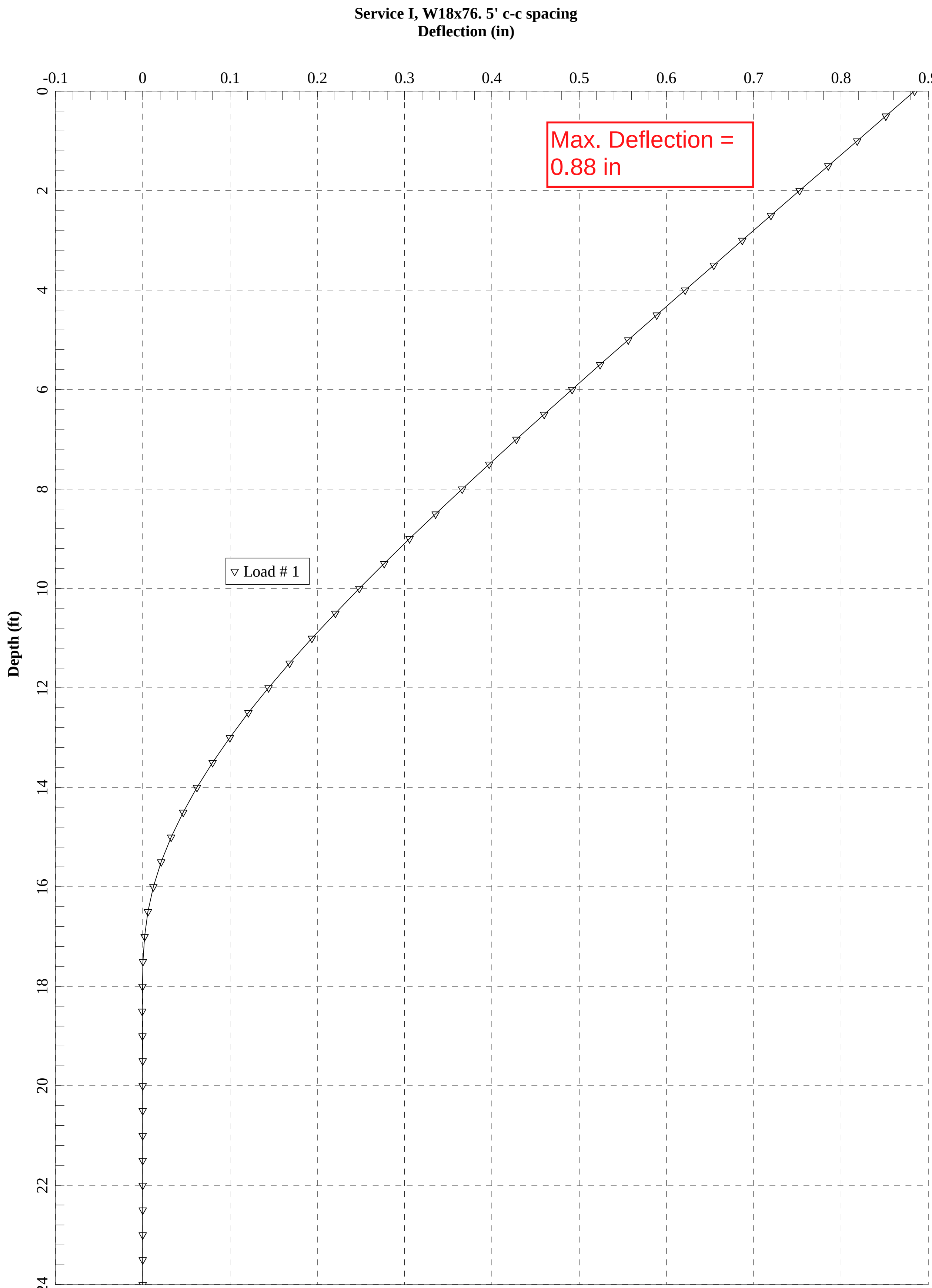
Pile Properties

Pile Length	**24**	ft		
Exposed Height	**15.5**	ft		
Pile Spacing	**5**	ft	**60**	in
Depth to 1st Anchor	**N/A**	ft		
Depth to 2nd Anchor	**N/A**			

Lateral Deflection at Top	0.88	in	from PY Wall
Allowable Deflection	**1.86**	in	OK

Maximum Deflection per GB7 spec:

* 1% or less of the drilled shaft length above bedrock
* 1% of total drilled shaft length if not embedded in bedrock
* 2" or less if within 10-ft of edge of pavement


Service I, W18x76. 5' c-c spacing
Deflection (in)
-0.1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Depth (ft)
0
2
4
6
8
10
12
14
16
18
20
22
24
Max. Deflection =
0.88 in
Load # 1

=====================================

PYWALL for Windows, Version 2019.6.8

Serial Number : 653551717

A Program for the Analysis of
Flexible Retaining Walls

=====================================

This program is licensed to :

S&ME, Inc.
Cincinnati, OH

Path to file locations : T:\Cincinnati-1178\Projects\2022\22780033_Fishbeck_HAM-74-13 35 Bridge_Cincinnati OH\4 GEO\Project Docs\Calcs\CO 1 - Temporary Shoring - Interm Pier\PYWall Files\
Name of input data file : Interm Pier_Service I_W.py6d
Name of output file : Interm Pier_Service I_W.py6o
Name of plot output file : Interm Pier_Service I_W.py6p

Time and Date of Analysis

Date: February 12, 2024 Time: 16:19:39

HAM-74-13.35 Bridge, Intermediate Pier, Temporary Shoring

****
* PROGRAM CONTROL PARAMETERS *
****

NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES = 0
NO OF WALL SECTIONS = 1
NO OF CROSS SECTIONS = 1
GENERATE EARTH PRESSURE INTERNALLY = 1
GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY = 1
NO OF P-Y MODIFICATION FACTORS FOR GEN P-Y CURVES = 0
NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES = 0
NO OF TIE BACKS = 0

HEIGHT OF WALL = 24.000 FT
NUMBER OF INCREMENTS = 48
INCREMENT LENGTH = 6.000 IN
MAXIMUM ALLOWABLE DEFLECTION = 100.000 IN
DEFLECTION CLOSURE TOLERANCE = 1.000E-05 IN
MAXIMUM NUMBER OF ITERATIONS = 100

* WALL SECTIONS *

SECT	TOP FT	BOTTOM FT	SECTION
1	0.00000	24.0000	1

* CROSS SECTIONS *

CROSS SECTION : 1
SECTION NAME : W18X76
TYPE : ELASTIC
CROSS SECTION TYPE : AISC SECTION (W)
AISC SECTION NAME : W18X76
EQUIVALENT DIAMETER : 11.0000 IN
EXTERNAL WIDTH : 11.0000 IN
EXTERNAL DEPTH : 18.2000 IN
FLANGE THICKNESS : 0.68000 IN
WEB THICKNESS : 0.42500 IN
YOUNG MODULUS : 2.90000E+07 LBS/IN**2

* CROSS SECTIONS PROPERTIES *

ELASTIC SECTIONS

SECT	DIAM,IN	I,IN**4
1	11.0000	1330.00

****
* STIFFNESS AND LOAD DATA *
****

EI - FLEXURAL RIGIDITY, Q - TRANSVERSE LOAD,
S - STIFFNESS OF TRANSVERSE RESISTANCE,
T - TORQUE, P - AXIAL LOAD,
R - STIFFNESS OF TORSIONAL RESISTANCE

FROM	TO	CONTD	EI	Q	S	T	R	P
			LBS-IN**2	LBS	LBS/IN	IN-LBS	IN-LBS	LBS
0		1	3.857E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00
	48	0	3.857E+10	0.000E+00	0.000E+00	0.000E+00	0.000E+00	0.000E+00

****
* WALL INFORMATION *
****

FREE HEIGHT OF WALL = 1.550E+01 FT
WIDTH FOR EARTH PRESSURE, WA = 6.000E+01 IN
WIDTH FOR SOIL RESISTANCE, WP = 3.000E+01 IN
DEPTH TO THE WATER TABLE AT BACKFILL = 1.250E+01 FT
DEPTH TO THE WATER TABLE AT EXCAVATION = 1.250E+01 FT
UNIT WEIGHT OF WATER = 3.600E-02 LBS/IN**3
SLOPE OF THE BACKFILL (deg.) = 0.000E+00
SLOPE OF THE EXCAVATION GROUND (deg.) = 0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE = 1.000E+00

****
* SURCHARGE INFORMATION *
****

UNIFORM SURFACE PRESSURE = 2.674E+00 LBS/IN**2

****
* SOIL INFORMATION *

****

	TOTAL	COHESION/		TOTAL UNIT		
LAYER	THICKNESS	STRENGTH	PHI	WEIGHT	DRAINED	ZTOP
NO.	FT	PSI	DEG	PCI	T OR F	FT
1	12.5	0.0	26.0	0.072	T	0.00
2	3.0	374.0	0.0	0.087	T	12.50
3	2.3	374.0	0.0	0.087	T	15.50
4	13.4	5335.0	0.0	0.093	T	17.80

****
* EFFECTIVE OVERBURDEN STRESS *
****

DEPTH FT	STRESS LBS/IN**2
0.000E+00	2.674E+00
1.250E+01	1.352E+01
1.550E+01	1.535E+01
1.780E+01	1.676E+01

****
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT *
****

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH(*) COEFFICIENT	OPTIONAL EARTH(**) COEFFICIENT
1	3.905E-01	2.561E+00	0.000E+00
2	1.000E+00	1.000E+00	0.000E+00
3	1.000E+00	1.000E+00	0.000E+00
4	1.000E+00	1.000E+00	0.000E+00

NOTES:
(*) PASSIVE EARTH COEFFICIENT IS PRINTED ONLY FOR REFERENCE,
IT IS NOT USED FOR ANALYSIS
(**) OPTIONAL EARTH COEFFICIENT IS USED TO ESTIMATE ACTIVE PRESSURE
IF IT IS DIFFERENT THAN ZERO

****
* ACTIVE EARTH PRESSURE OF EACH LAYER *
****

LAYER NO	PA1 LBS/IN	Z1 FT	PA2 LBS/IN	Z2 FT	PA3 LBS/IN	Z3 FT	PA4 LBS/IN
1	156.59	6.25	317.76	8.33	-0.13	-0.00	0.00
2	0.00	14.00	0.00	14.50	0.00	416.07	0.00

****
* ACTIVE WATER PRESSURE OF EACH LAYER *
****

LAYER NO	PW1 LBS/IN	Z1 FT	PW2 LBS/IN	Z2 FT
2	0.00	14.00	23.33	14.50

DEPTH FT	ACTIVE EARTH PRESSURE LBS/IN
0.00000E+00	6.26340E+01
5.00000E-01	7.27500E+01

1.00000E+00	8.29200E+01
1.50000E+00	9.30900E+01
2.00000E+00	1.03260E+02
2.50000E+00	1.13424E+02
3.00000E+00	1.23594E+02
3.50000E+00	1.33764E+02
4.00000E+00	1.43928E+02
4.50000E+00	1.54098E+02
5.00000E+00	1.64268E+02
5.50000E+00	1.74438E+02
6.00000E+00	1.84602E+02
6.50000E+00	1.94772E+02
7.00000E+00	2.04942E+02
7.50000E+00	2.15106E+02
8.00000E+00	2.25276E+02
8.50000E+00	2.35446E+02
9.00000E+00	2.45616E+02
9.50000E+00	2.55780E+02
1.00000E+01	2.65950E+02
1.05000E+01	2.76120E+02
1.10000E+01	2.86284E+02
1.15000E+01	2.96454E+02
1.20000E+01	3.06624E+02
1.25000E+01	3.16794E+02
1.30000E+01	9.42000E-09
1.35000E+01	9.78000E-09
1.40000E+01	1.01400E-08
1.45000E+01	1.05000E-08
1.50000E+01	1.08600E-08
1.55000E+01	1.12200E-08
1.59925E+01	5.79000E-09
1.64858E+01	5.97000E-09
1.69783E+01	6.15000E-09
1.74717E+01	6.33000E-09
1.79667E+01	6.51000E-09
1.84658E+01	6.69000E-09
1.89650E+01	6.87000E-09
1.94650E+01	7.05000E-09
1.99642E+01	7.23000E-09
2.04633E+01	7.41000E-09
2.09625E+01	7.59000E-09
2.14625E+01	7.77000E-09
2.19617E+01	7.95000E-09
2.24608E+01	8.13000E-09
2.29600E+01	8.31000E-09
2.34600E+01	8.49000E-09
2.39592E+01	8.67000E-09

****
*   SOIL LAYERS AND STRENGTH DATA   *
****

X AT THE SURFACE OF EXCAVATION SIDE = 15.50 FT

2 LAYER(S) OF SOIL

LAYER 1
THE LAYER IS WEAK ROCK

LAYER 2
THE LAYER IS ROCK

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
4 POINTS

X,FT	WEIGHT,LBS/IN**3
15.5000	5.0806E-02
17.8000	5.0806E-02
17.8000	5.6593E-02
31.2000	5.6593E-02

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
4 POINTS

X,FT	S,LBS/IN**2	PH,DEGREE	E50	KPY,LBS/IN**3
15.50	3.7400E+02	0.000	5.0000E-04	1.3090E+05
17.80	3.7400E+02	0.000	5.0000E-04	1.3090E+05
17.80	5.3350E+03	0.000	-----	0.0000E+00
25.00	5.3350E+03	0.000	-----	0.0000E+00

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH FT	DIAM IN	Qu LBS/IN**2	Eu LBS/IN**2	GAMMA AVG LBS/IN**3	E50
0.01	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y IN	P LBS/IN
0.750E-05	0.986E+02
0.150E-04	0.197E+03
0.450E-04	0.592E+03
0.900E-04	0.118E+04
0.135E-03	0.174E+04
0.300E-03	0.212E+04
0.600E-03	0.252E+04
0.900E-03	0.279E+04
0.120E-02	0.300E+04
0.150E-02	0.317E+04
0.375E-02	0.399E+04
0.750E-02	0.474E+04
0.112E-01	0.525E+04
0.150E-01	0.564E+04
0.600E-01	0.797E+04
0.120E+00	0.948E+04
0.180E+00	0.105E+05

AT THE BACKFILL SIDE

DEPTH FT	DIAM IN	Qu LBS/IN**2	Eu LBS/IN**2	GAMMA AVG LBS/IN**3	E50
15.51	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y IN	P LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05

0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

AT THE EXCAVATION SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
0.58	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.128E+03
0.150E-04	0.257E+03
0.450E-04	0.770E+03
0.900E-04	0.154E+04
0.135E-03	0.228E+04
0.300E-03	0.279E+04
0.600E-03	0.332E+04
0.900E-03	0.367E+04
0.120E-02	0.394E+04
0.150E-02	0.417E+04
0.375E-02	0.524E+04
0.750E-02	0.624E+04
0.112E-01	0.690E+04
0.150E-01	0.742E+04
0.600E-01	0.105E+05
0.120E+00	0.125E+05
0.180E+00	0.138E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
16.07	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05
0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

AT THE EXCAVATION SIDE

DEPTH DIAM Qu Eu GAMMA AVG E50

FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
1.15	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.158E+03
0.150E-04	0.317E+03
0.450E-04	0.950E+03
0.900E-04	0.190E+04
0.135E-03	0.284E+04
0.300E-03	0.347E+04
0.600E-03	0.412E+04
0.900E-03	0.456E+04
0.120E-02	0.490E+04
0.150E-02	0.519E+04
0.375E-02	0.652E+04
0.750E-02	0.776E+04
0.112E-01	0.858E+04
0.150E-01	0.922E+04
0.600E-01	0.130E+05
0.120E+00	0.155E+05
0.180E+00	0.172E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
16.65	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05
0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

AT THE EXCAVATION SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
1.72	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.188E+03
0.150E-04	0.377E+03
0.450E-04	0.113E+04
0.900E-04	0.226E+04
0.135E-03	0.339E+04
0.300E-03	0.415E+04
0.600E-03	0.493E+04
0.900E-03	0.546E+04
0.120E-02	0.587E+04

0.150E-02	0.620E+04
0.375E-02	0.780E+04
0.750E-02	0.927E+04
0.112E-01	0.103E+05
0.150E-01	0.110E+05
0.600E-01	0.156E+05
0.120E+00	0.185E+05
0.180E+00	0.205E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
17.22	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05
0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

AT THE EXCAVATION SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
2.29	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.218E+03
0.150E-04	0.436E+03
0.450E-04	0.131E+04
0.900E-04	0.262E+04
0.135E-03	0.393E+04
0.300E-03	0.482E+04
0.600E-03	0.573E+04
0.900E-03	0.634E+04
0.120E-02	0.681E+04
0.150E-02	0.720E+04
0.375E-02	0.906E+04
0.750E-02	0.108E+05
0.112E-01	0.119E+05
0.150E-01	0.128E+05
0.600E-01	0.181E+05
0.120E+00	0.215E+05
0.180E+00	0.238E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
17.79	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05
0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

DEPTH-EXCAVATION SIDE	DIAM	C
IN	IN	LBS/IN**2
27.70	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.211D+02
0.768D-01	0.211D+02

DEPTH-BACKFILL SIDE	DIAM	C
IN	IN	LBS/IN**2
213.70	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05

0.672D-01	0.787D+05
0.720D-01	0.163D+03
0.768D-01	0.163D+03

DEPTH-EXCAVATION SIDE	DIAM	C
IN	IN	LBS/IN**2
49.20	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.394D+02
0.768D-01	0.394D+02

DEPTH-BACKFILL SIDE	DIAM	C
IN	IN	LBS/IN**2
235.20	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.188D+03
0.768D-01	0.188D+03

DEPTH-EXCAVATION SIDE	DIAM	C
IN	IN	LBS/IN**2
70.80	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05

0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.577D+02
0.768D-01	0.577D+02

DEPTH-BACKFILL SIDE	DIAM	C
IN	IN	LBS/IN**2
256.80	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.209D+03
0.768D-01	0.209D+03

DEPTH-EXCAVATION SIDE	DIAM	C
IN	IN	LBS/IN**2
92.40	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.760D+02
0.768D-01	0.760D+02

DEPTH-BACKFILL SIDE	DIAM	C
IN	IN	LBS/IN**2
278.40	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05

0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.229D+03
0.768D-01	0.229D+03

DEPTH-EXCAVATION SIDE DIAM C
IN IN LBS/IN**2
113.90 30.000 2.7E+03

Y IN	P LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.943D+02
0.768D-01	0.943D+02

DEPTH-BACKFILL SIDE DIAM C
IN IN LBS/IN**2
299.90 30.000 2.7E+03

Y IN	P LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.248D+03
0.768D-01	0.248D+03

HAM-74-13.35 Bridge, Intermediate Pier, Temporary Shoring

RESULTS

NUMBER OF ITERATIONS : 6

STA I	X FT	DEFL. IN	SLOPE RAD	MOMENT LBS-IN	SHEAR LBS	SOIL_REACT LBS/IN	NET_FORCE/STA LBS	EI LBS-IN**2
0	0.000E+00	8.842E-01	-5.481E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.857E+10
1	5.000E-01	8.513E-01	-5.481E-03	0.000E+00	2.182E+02	0.000E+00	4.365E+02	3.857E+10
2	1.000E+00	8.184E-01	-5.480E-03	2.619E+03	6.853E+02	0.000E+00	4.975E+02	3.857E+10
3	1.500E+00	7.856E-01	-5.479E-03	8.223E+03	1.213E+03	0.000E+00	5.585E+02	3.857E+10
4	2.000E+00	7.527E-01	-5.478E-03	1.718E+04	1.802E+03	0.000E+00	6.196E+02	3.857E+10
5	2.500E+00	7.198E-01	-5.474E-03	2.985E+04	2.452E+03	0.000E+00	6.805E+02	3.857E+10
6	3.000E+00	6.870E-01	-5.468E-03	4.661E+04	3.163E+03	0.000E+00	7.416E+02	3.857E+10
7	3.500E+00	6.542E-01	-5.459E-03	6.781E+04	3.936E+03	0.000E+00	8.026E+02	3.857E+10
8	4.000E+00	6.215E-01	-5.446E-03	9.383E+04	4.769E+03	0.000E+00	8.636E+02	3.857E+10
9	4.500E+00	5.888E-01	-5.429E-03	1.250E+05	5.663E+03	0.000E+00	9.246E+02	3.857E+10
10	5.000E+00	5.563E-01	-5.407E-03	1.618E+05	6.618E+03	0.000E+00	9.856E+02	3.857E+10
11	5.500E+00	5.240E-01	-5.379E-03	2.044E+05	7.634E+03	0.000E+00	1.047E+03	3.857E+10
12	6.000E+00	4.918E-01	-5.343E-03	2.534E+05	8.711E+03	0.000E+00	1.108E+03	3.857E+10
13	6.500E+00	4.598E-01	-5.299E-03	3.090E+05	9.849E+03	0.000E+00	1.169E+03	3.857E+10
14	7.000E+00	4.282E-01	-5.246E-03	3.716E+05	1.105E+04	0.000E+00	1.230E+03	3.857E+10
15	7.500E+00	3.969E-01	-5.183E-03	4.416E+05	1.231E+04	0.000E+00	1.291E+03	3.857E+10
16	8.000E+00	3.660E-01	-5.108E-03	5.193E+05	1.363E+04	0.000E+00	1.352E+03	3.857E+10
17	8.500E+00	3.356E-01	-5.021E-03	6.051E+05	1.501E+04	0.000E+00	1.413E+03	3.857E+10
18	9.000E+00	3.057E-01	-4.919E-03	6.994E+05	1.645E+04	0.000E+00	1.474E+03	3.857E+10
19	9.500E+00	2.766E-01	-4.803E-03	8.026E+05	1.796E+04	0.000E+00	1.535E+03	3.857E+10
20	1.000E+01	2.481E-01	-4.669E-03	9.149E+05	1.952E+04	0.000E+00	1.596E+03	3.857E+10
21	1.050E+01	2.205E-01	-4.517E-03	1.037E+06	2.115E+04	0.000E+00	1.657E+03	3.857E+10
22	1.100E+01	1.939E-01	-4.346E-03	1.169E+06	2.284E+04	0.000E+00	1.718E+03	3.857E+10
23	1.150E+01	1.684E-01	-4.153E-03	1.311E+06	2.459E+04	0.000E+00	1.779E+03	3.857E+10
24	1.200E+01	1.441E-01	-3.937E-03	1.464E+06	2.640E+04	0.000E+00	1.840E+03	3.857E+10
25	1.250E+01	1.211E-01	-3.696E-03	1.628E+06	2.827E+04	0.000E+00	1.901E+03	3.857E+10
26	1.300E+01	9.972E-02	-3.430E-03	1.803E+06	2.922E+04	0.000E+00	5.452E-08	3.857E+10
27	1.350E+01	7.998E-02	-3.136E-03	1.978E+06	2.922E+04	0.000E+00	6.442E-08	3.857E+10
28	1.400E+01	6.209E-02	-2.814E-03	2.154E+06	2.922E+04	0.000E+00	5.697E-08	3.857E+10
29	1.450E+01	4.621E-02	-2.466E-03	2.329E+06	2.922E+04	0.000E+00	6.139E-08	3.857E+10
30	1.500E+01	3.251E-02	-2.090E-03	2.504E+06	2.922E+04	0.000E+00	6.752E-08	3.857E+10
31	1.550E+01	2.114E-02	-1.686E-03	2.679E+06	2.028E+04	-2.979E+03	-1.787E+04	3.857E+10
32	1.600E+01	1.227E-02	-1.264E-03	2.747E+06	-9.797E+03	-7.047E+03	-4.228E+04	3.857E+10
33	1.650E+01	5.967E-03	-8.514E-04	2.562E+06	-5.270E+04	-7.253E+03	-4.352E+04	3.857E+10
34	1.700E+01	2.054E-03	-4.876E-04	2.115E+06	-9.424E+04	-6.594E+03	-3.957E+04	3.857E+10
35	1.750E+01	1.159E-04	-2.118E-04	1.431E+06	-1.234E+05	-3.142E+03	-1.885E+04	3.857E+10
36	1.800E+01	-4.869E-04	-5.118E-05	6.338E+05	-1.041E+05	9.593E+03	5.756E+04	3.857E+10
37	1.850E+01	-4.982E-04	1.227E-05	1.819E+05	-5.334E+04	7.322E+03	4.393E+04	3.857E+10
38	1.900E+01	-3.397E-04	2.593E-05	-6.355E+03	-1.895E+04	4.143E+03	2.486E+04	3.857E+10
39	1.950E+01	-1.871E-04	2.189E-05	-4.549E+04	-3.528E+03	9.983E+02	5.990E+03	3.857E+10
40	2.000E+01	-7.698E-05	1.457E-05	-4.869E+04	6.993E+02	4.107E+02	2.464E+03	3.857E+10
41	2.050E+01	-1.230E-05	7.895E-06	-3.710E+04	2.128E+03	6.563E+01	3.938E+02	3.857E+10
42	2.100E+01	1.775E-05	3.209E-06	-2.315E+04	2.103E+03	-7.420E+01	-4.452E+02	3.857E+10
43	2.150E+01	2.620E-05	4.854E-07	-1.187E+04	1.552E+03	-1.095E+02	-6.571E+02	3.857E+10
44	2.200E+01	2.358E-05	-7.898E-07	-4.528E+03	9.275E+02	-9.854E+01	-5.912E+02	3.857E+10
45	2.250E+01	1.673E-05	-1.199E-06	-7.366E+02	4.222E+02	-6.990E+01	-4.194E+02	3.857E+10
46	2.300E+01	9.187E-06	-1.215E-06	5.382E+02	9.728E+01	-3.839E+01	-2.304E+02	3.857E+10
47	2.350E+01	2.150E-06	-1.139E-06	4.308E+02	-4.485E+01	-8.984E+00	-5.390E+01	3.857E+10
48	2.400E+01	-4.486E-06	-1.106E-06	0.000E+00	-3.590E+01	1.197E+01	7.180E+01	3.857E+10

END OF ANALYSIS

Project #	22-78-0033		W18x76

Strength I Limit State

Surcharge =	449	psf
Landslide Load =	0	lbs
Modified Earth Pressure Factor =	1.5	

Pile Properties

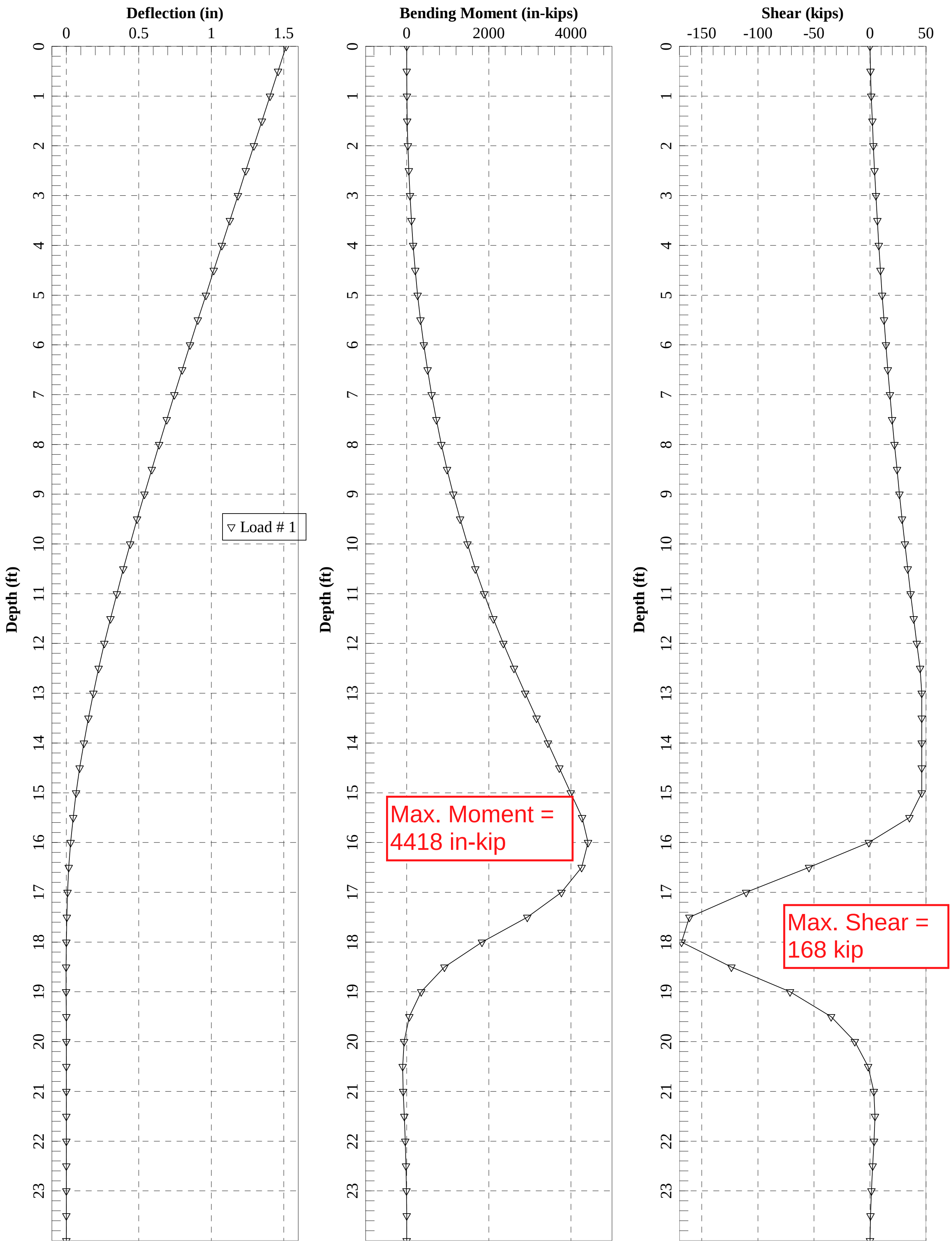
Pile Length	**24**	ft					
Exposed Height	**15.5**	ft		60	in		
Pile Spacing	**5**	ft					
Depth to 1st Anchor	**N/A**	ft					
Depth to 2nd Anchor	**N/A**						
Concrete Pile							
Diameter	30	in	c	15	in	outer fiber to neutral axis	
Area	706.9	in^2					
Moment of Inertia (I_g)	39760.8	in^4					
Cracked Moment of Inertia (I_{cr})	19880.4	in^4	=.5 to 0.7*I_g			use	0.5 *I_g
Concrete Strength (f'_c)	**4000**	psi					conserv
Modulus of Elasticity	3605.0	ksi	=57* sqrt of f'c				
f_r (modulus of rupture)	474.3	psi	=7.5*sqrt of f'c				
Moment Cracking (M_{cr})	1257.3	in-kips	$=f_r*I_g/c$				
Applied Moment (M_a)	4418	in-kips	from PY Wall				
Applied Shear (V)	168	kips	from PY Wall				
M_{cr}/M_a	0.28						
Effective Moment of Inertia (I_e)	20338.65						

$$I_e = \left(\frac{M_{cr}}{M_a}\right)^3 I_g + \left[1 - \left(\frac{M_{cr}}{M_a}\right)^3\right] I_{cr}$$

Use I_e

n (modular Ratio)	8.0					
Steel Beam						
W18x76						
Area	22.3	in^2	r_y	2.61	in	
Section Modulus	146	in^3				
Moment of Inertia	1330	in^4	I_{equiv} (concrete)	10699.0394	in^4	
Modulus of Elasticity	29,000	ksi				
Yield Strength	50	ksi				
Allowable Bending Stress	33.5	ksi				
Allowable Moment	4891	in-kips	OK			
Allowable Shear	446	kips	OK			
EI	3.857E+10		above grade			
Total I	31037.7	in^4	$(I_e + I_{equiv})$			
Total EI	1.119E+11	$lb\text{-}in^2$	(below Grade)			
Lateral Deflection at Top	1.52	in	from PY Wall			

Strength I, W18x76, 5' c-c spacing



===

PYWALL for Windows, Version 2019.6.8

Serial Number : 653551717

A Program for the Analysis of
Flexible Retaining Walls

===

This program is licensed to :

S&ME, Inc.
Cincinnati, OH

Path to file locations : T:\Cincinnati-1178\Projects\2022\22780033_Fishbeck_HAM-74-13 35 Bridge_Cincinnati OH\4 GEO\Project Docs\Calcs\C.O. 1 - Temporary Shoring - Interm. Pier\PYWall Files\
Name of input data file : Interm Pier_Strength I_W.py6d
Name of output file : Interm Pier_Strength I_W.py6o
Name of plot output file : Interm Pier_Strength I_W.py6p

Time and Date of Analysis

Date: February 12, 2024 Time: 16:28:54

HAM-74-13.35 Bridge, Intermediate Pier, Temporary Shoring

****
* PROGRAM CONTROL PARAMETERS *
****

NO OF POINTS FOR SPECIFIED DEFLECTIONS AND SLOPES = 0
NO OF WALL SECTIONS = 1
NO OF CROSS SECTIONS = 1
GENERATE EARTH PRESSURE INTERNALLY = 1
GENERATE SOIL RESISTANCE (P-Y) CURVES INTERNALLY = 1
NO OF P-Y MODIFICATION FACTORS FOR GEN. P-Y CURVES = 0
NO OF USER-SPECIFIED SOIL RESISTANCE (P-Y) CURVES = 0
NO OF TIE BACKS = 0

HEIGHT OF WALL = 24.000 FT
NUMBER OF INCREMENTS = 48
INCREMENT LENGTH = 6.000 IN
MAXIMUM ALLOWABLE DEFLECTION = 100.000 IN
DEFLECTION CLOSURE TOLERANCE = 1.000E-05 IN
MAXIMUM NUMBER OF ITERATIONS = 100

* WALL SECTIONS *

SECT	TOP FT	BOTTOM FT	SECTION
1	0.00000	24.0000	1

* CROSS SECTIONS *

```
CROSS SECTION       :   1
SECTION NAME        : W18X76
TYPE                : ELASTIC
CROSS SECTION TYPE  : AISC SECTION (W)
AISC SECTION NAME   : W18X76
EQUIVALENT DIAMETER :      11.0000 IN
EXTERNAL WIDTH      :      11.0000 IN
EXTERNAL DEPTH      :      18.2000 IN
FLANGE THICKNESS    :      0.68000 IN
WEB THICKNESS       :      0.42500 IN
YOUNG MODULUS       :  2.90000E+07 LBS/IN**2


* CROSS SECTIONS PROPERTIES *

     ELASTIC SECTIONS

 SECT        DIAM,IN     I,IN**4
   1         11.0000     1330.00



*****************************************************
*       STIFFNESS AND LOAD DATA                     *
*****************************************************

EI - FLEXURAL RIGIDITY,  Q - TRANSVERSE LOAD,
S - STIFFNESS OF TRANSVERSE RESISTANCE,
T - TORQUE,              P - AXIAL LOAD,
R - STIFFNESS OF TORSIONAL RESISTANCE


FROM TO CONTD   EI        Q        S        T        R        P
          LBS-IN**2     LBS    LBS/IN   IN-LBS   IN-LBS     LBS
  0    1  3.857E+10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00
    48  0  3.857E+10 0.000E+00 0.000E+00 0.000E+00 0.000E+00 0.000E+00


*****************************************************
*            WALL INFORMATION                       *
*****************************************************


FREE HEIGHT OF WALL                     = 1.550E+01 FT
WIDTH FOR EARTH PRESSURE, WA            = 6.000E+01 IN
WIDTH FOR SOIL RESISTANCE, WP           = 3.000E+01 IN
DEPTH TO THE WATER TABLE AT BACKFILL    = 1.250E+01 FT
DEPTH TO THE WATER TABLE AT EXCAVATION= 1.250E+01 FT
UNIT WEIGHT OF WATER                    = 3.600E-02 LBS/IN**3
SLOPE OF THE BACKFILL (deg.)            = 0.000E+00
SLOPE OF THE EXCAVATION GROUND (deg.)  = 0.000E+00
MODIFICATION FOR ACTIVE EARTH PRESSURE = 1.500E+00



*****************************************************
*          SURCHARGE INFORMATION                    *
*****************************************************


UNIFORM SURFACE PRESSURE      = 3.118E+00 LBS/IN**2


*****************************************************
*            SOIL INFORMATION                       *
```

****

LAYER NO.	THICKNESS FT	COHESION/ STRENGTH PSI	PHI DEG	TOTAL UNIT WEIGHT PCI	DRAINED T OR F	ZTOP FT
1	12.5	0.0	26.0	0.072	T	0.00
2	3.0	374.0	0.0	0.087	T	12.50
3	2.3	374.0	0.0	0.087	T	15.50
4	13.4	5335.0	0.0	0.093	T	17.80

****
* EFFECTIVE OVERBURDEN STRESS *
****

DEPTH FT	STRESS LBS/IN**2
0.000E+00	3.118E+00
1.250E+01	1.397E+01
1.550E+01	1.580E+01
1.780E+01	1.720E+01

****
* ACTIVE AND PASSIVE EARTH PRESSURE COEFFICIENT *
****

LAYER NO.	ACTIVE EARTH COEFFICIENT	PASSIVE EARTH(*) COEFFICIENT	OPTIONAL EARTH(**) COEFFICIENT
1	3.905E-01	2.561E+00	0.000E+00
2	1.000E+00	1.000E+00	0.000E+00
3	1.000E+00	1.000E+00	0.000E+00
4	1.000E+00	1.000E+00	0.000E+00

NOTES:
(*) PASSIVE EARTH COEFFICIENT IS PRINTED ONLY FOR REFERENCE,
IT IS NOT USED FOR ANALYSIS
(**) OPTIONAL EARTH COEFFICIENT IS USED TO ESTIMATE ACTIVE PRESSURE
IF IT IS DIFFERENT THAN ZERO

****
* ACTIVE EARTH PRESSURE OF EACH LAYER *
****

LAYER NO	PA1 LBS/IN	Z1 FT	PA2 LBS/IN	Z2 FT	PA3 LBS/IN	Z3 FT	PA4 LBS/IN
1	273.93	6.25	476.64	8.33	-0.20	-0.00	0.00
2	0.00	14.00	0.00	14.50	0.00	415.83	0.00

****
* ACTIVE WATER PRESSURE OF EACH LAYER *
****

LAYER NO	PW1 LBS/IN	Z1 FT	PW2 LBS/IN	Z2 FT
2	0.00	14.00	34.99	14.50

DEPTH FT	ACTIVE EARTH PRESSURE LBS/IN
0.00000E+00	1.09572E+02
5.00000E-01	1.24746E+02

1.00000E+00	1.39998E+02
1.50000E+00	1.55250E+02
2.00000E+00	1.70502E+02
2.50000E+00	1.85760E+02
3.00000E+00	2.01012E+02
3.50000E+00	2.16264E+02
4.00000E+00	2.31516E+02
4.50000E+00	2.46768E+02
5.00000E+00	2.62020E+02
5.50000E+00	2.77272E+02
6.00000E+00	2.92524E+02
6.50000E+00	3.07776E+02
7.00000E+00	3.23028E+02
7.50000E+00	3.38280E+02
8.00000E+00	3.53532E+02
8.50000E+00	3.68784E+02
9.00000E+00	3.84036E+02
9.50000E+00	3.99288E+02
1.00000E+01	4.14546E+02
1.05000E+01	4.29798E+02
1.10000E+01	4.45050E+02
1.15000E+01	4.60302E+02
1.20000E+01	4.75554E+02
1.25000E+01	4.90806E+02
1.30000E+01	9.42000E-09
1.35000E+01	9.78000E-09
1.40000E+01	1.01400E-08
1.45000E+01	1.05000E-08
1.50000E+01	1.08600E-08
1.55000E+01	1.12200E-08
1.59925E+01	5.79000E-09
1.64858E+01	5.97000E-09
1.69783E+01	6.15000E-09
1.74717E+01	6.33000E-09
1.79667E+01	6.51000E-09
1.84658E+01	6.69000E-09
1.89650E+01	6.87000E-09
1.94650E+01	7.05000E-09
1.99642E+01	7.23000E-09
2.04633E+01	7.41000E-09
2.09625E+01	7.59000E-09
2.14625E+01	7.77000E-09
2.19617E+01	7.95000E-09
2.24608E+01	8.13000E-09
2.29600E+01	8.31000E-09
2.34600E+01	8.49000E-09
2.39592E+01	8.67000E-09

****

*   SOIL LAYERS AND STRENGTH DATA   *

****

X AT THE SURFACE OF EXCAVATION SIDE   =   15.50 FT

2 LAYER(S) OF SOIL

LAYER 1
THE LAYER IS WEAK ROCK

LAYER 2
THE LAYER IS ROCK

DISTRIBUTION OF EFFECTIVE UNIT WEIGHT WITH DEPTH
4 POINTS

X,FT	WEIGHT,LBS/IN**3
15.5000	5.0806E-02
17.8000	5.0806E-02
17.8000	5.6593E-02
31.2000	5.6593E-02

DISTRIBUTION OF STRENGTH PARAMETERS WITH DEPTH
4 POINTS

X,FT	S,LBS/IN**2	PH,DEGREE	E50	KPY,LBS/IN**3
15.50	3.7400E+02	0.000	5.0000E-04	1.3090E+05
17.80	3.7400E+02	0.000	5.0000E-04	1.3090E+05
17.80	5.3350E+03	0.000	-----	0.0000E+00
25.00	5.3350E+03	0.000	-----	0.0000E+00

P-Y CURVES DATA

AT THE EXCAVATION SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
0.01	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.986E+02
0.150E-04	0.197E+03
0.450E-04	0.592E+03
0.900E-04	0.118E+04
0.135E-03	0.174E+04
0.300E-03	0.212E+04
0.600E-03	0.252E+04
0.900E-03	0.279E+04
0.120E-02	0.300E+04
0.150E-02	0.317E+04
0.375E-02	0.399E+04
0.750E-02	0.474E+04
0.112E-01	0.525E+04
0.150E-01	0.564E+04
0.600E-01	0.797E+04
0.120E+00	0.948E+04
0.180E+00	0.105E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
15.51	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05

```
          0.375E-02        0.162E+05
          0.750E-02        0.192E+05
          0.112E-01        0.213E+05
          0.150E-01        0.229E+05
          0.600E-01        0.323E+05
          0.120E+00        0.384E+05
          0.180E+00        0.425E+05
```

AT THE EXCAVATION SIDE

```
 DEPTH   DIAM     Qu       Eu   GAMMA AVG    E50
  FT      IN  LBS/IN**2 LBS/IN**2 LBS/IN**3
  0.58  30.000  3.74E+02  1.31E+05  5.08E-02  5.000E-04
             Y              P
             IN           LBS/IN
          0.750E-05        0.128E+03
          0.150E-04        0.257E+03
          0.450E-04        0.770E+03
          0.900E-04        0.154E+04
          0.135E-03        0.228E+04
          0.300E-03        0.279E+04
          0.600E-03        0.332E+04
          0.900E-03        0.367E+04
          0.120E-02        0.394E+04
          0.150E-02        0.417E+04
          0.375E-02        0.524E+04
          0.750E-02        0.624E+04
          0.112E-01        0.690E+04
          0.150E-01        0.742E+04
          0.600E-01        0.105E+05
          0.120E+00        0.125E+05
          0.180E+00        0.138E+05
```

AT THE BACKFILL SIDE

```
 DEPTH   DIAM     Qu       Eu   GAMMA AVG    E50
  FT      IN  LBS/IN**2 LBS/IN**2 LBS/IN**3
 16.07  30.000  3.74E+02  1.31E+05  5.08E-02  5.000E-04
             Y              P
             IN           LBS/IN
          0.750E-05        0.385E+03
          0.150E-04        0.769E+03
          0.450E-04        0.231E+04
          0.900E-04        0.461E+04
          0.135E-03        0.692E+04
          0.300E-03        0.859E+04
          0.600E-03        0.102E+05
          0.900E-03        0.113E+05
          0.120E-02        0.122E+05
          0.150E-02        0.129E+05
          0.375E-02        0.162E+05
          0.750E-02        0.192E+05
          0.112E-01        0.213E+05
          0.150E-01        0.229E+05
          0.600E-01        0.323E+05
          0.120E+00        0.384E+05
          0.180E+00        0.425E+05
```

AT THE EXCAVATION SIDE

```
 DEPTH   DIAM     Qu       Eu   GAMMA AVG    E50
```

FT IN LBS/IN**2 LBS/IN**2 LBS/IN**3
1.15 30.000 3.74E+02 1.31E+05 5.08E-02 5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.158E+03
0.150E-04	0.317E+03
0.450E-04	0.950E+03
0.900E-04	0.190E+04
0.135E-03	0.284E+04
0.300E-03	0.347E+04
0.600E-03	0.412E+04
0.900E-03	0.456E+04
0.120E-02	0.490E+04
0.150E-02	0.519E+04
0.375E-02	0.652E+04
0.750E-02	0.776E+04
0.112E-01	0.858E+04
0.150E-01	0.922E+04
0.600E-01	0.130E+05
0.120E+00	0.155E+05
0.180E+00	0.172E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
16.65	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05
0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

AT THE EXCAVATION SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
1.72	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.188E+03
0.150E-04	0.377E+03
0.450E-04	0.113E+04
0.900E-04	0.226E+04
0.135E-03	0.339E+04
0.300E-03	0.415E+04
0.600E-03	0.493E+04
0.900E-03	0.546E+04
0.120E-02	0.587E+04

0.150E-02	0.620E+04
0.375E-02	0.780E+04
0.750E-02	0.927E+04
0.112E-01	0.103E+05
0.150E-01	0.110E+05
0.600E-01	0.156E+05
0.120E+00	0.185E+05
0.180E+00	0.205E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
17.22	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05
0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

AT THE EXCAVATION SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
2.29	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.218E+03
0.150E-04	0.436E+03
0.450E-04	0.131E+04
0.900E-04	0.262E+04
0.135E-03	0.393E+04
0.300E-03	0.482E+04
0.600E-03	0.573E+04
0.900E-03	0.634E+04
0.120E-02	0.681E+04
0.150E-02	0.720E+04
0.375E-02	0.906E+04
0.750E-02	0.108E+05
0.112E-01	0.119E+05
0.150E-01	0.128E+05
0.600E-01	0.181E+05
0.120E+00	0.215E+05
0.180E+00	0.238E+05

AT THE BACKFILL SIDE

DEPTH	DIAM	Qu	Eu	GAMMA AVG	E50
FT	IN	LBS/IN**2	LBS/IN**2	LBS/IN**3	
17.79	30.000	3.74E+02	1.31E+05	5.08E-02	5.000E-04

Y	P
IN	LBS/IN
0.750E-05	0.385E+03
0.150E-04	0.769E+03
0.450E-04	0.231E+04
0.900E-04	0.461E+04
0.135E-03	0.692E+04
0.300E-03	0.859E+04
0.600E-03	0.102E+05
0.900E-03	0.113E+05
0.120E-02	0.122E+05
0.150E-02	0.129E+05
0.375E-02	0.162E+05
0.750E-02	0.192E+05
0.112E-01	0.213E+05
0.150E-01	0.229E+05
0.600E-01	0.323E+05
0.120E+00	0.384E+05
0.180E+00	0.425E+05

DEPTH-EXCAVATION SIDE	DIAM	C
IN	IN	LBS/IN**2
27.70	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.211D+02
0.768D-01	0.211D+02

DEPTH-BACKFILL SIDE	DIAM	C
IN	IN	LBS/IN**2
213.70	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05

0.672D-01	0.787D+05
0.720D-01	0.163D+03
0.768D-01	0.163D+03

DEPTH-EXCAVATION SIDE DIAM C
IN IN LBS/IN**2
49.20 30.000 2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.394D+02
0.768D-01	0.394D+02

DEPTH-BACKFILL SIDE DIAM C
IN IN LBS/IN**2
235.20 30.000 2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.188D+03
0.768D-01	0.188D+03

DEPTH-EXCAVATION SIDE DIAM C
IN IN LBS/IN**2
70.80 30.000 2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05

0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.577D+02
0.768D-01	0.577D+02

DEPTH-BACKFILL SIDE	DIAM	C
IN	IN	LBS/IN**2
256.80	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.209D+03
0.768D-01	0.209D+03

DEPTH-EXCAVATION SIDE	DIAM	C
IN	IN	LBS/IN**2
92.40	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.760D+02
0.768D-01	0.760D+02

DEPTH-BACKFILL SIDE	DIAM	C
IN	IN	LBS/IN**2
278.40	30.000	2.7E+03

Y	P
IN	LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05

0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.229D+03
0.768D-01	0.229D+03

DEPTH-EXCAVATION SIDE DIAM C
IN IN LBS/IN**2
113.90 30.000 2.7E+03

Y IN	P LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.201D+05
0.960D-02	0.401D+05
0.144D-01	0.507D+05
0.192D-01	0.517D+05
0.240D-01	0.527D+05
0.288D-01	0.537D+05
0.336D-01	0.547D+05
0.384D-01	0.557D+05
0.432D-01	0.567D+05
0.480D-01	0.577D+05
0.528D-01	0.587D+05
0.576D-01	0.597D+05
0.624D-01	0.607D+05
0.672D-01	0.617D+05
0.720D-01	0.943D+02
0.768D-01	0.943D+02

DEPTH-BACKFILL SIDE DIAM C
IN IN LBS/IN**2
299.90 30.000 2.7E+03

Y IN	P LBS/IN
0.000D+00	0.000D+00
0.480D-02	0.256D+05
0.960D-02	0.512D+05
0.144D-01	0.647D+05
0.192D-01	0.659D+05
0.240D-01	0.672D+05
0.288D-01	0.685D+05
0.336D-01	0.698D+05
0.384D-01	0.711D+05
0.432D-01	0.723D+05
0.480D-01	0.736D+05
0.528D-01	0.749D+05
0.576D-01	0.762D+05
0.624D-01	0.775D+05
0.672D-01	0.787D+05
0.720D-01	0.248D+03
0.768D-01	0.248D+03

HAM-74-13.35 Bridge, Intermediate Pier, Temporary Shoring

RESULTS

NUMBER OF ITERATIONS : 7

STA I	X FT	DEFL. IN	SLOPE RAD	MOMENT LBS-IN	SHEAR LBS	SOIL_REACT LBS/IN	NET_FORCE/STA LBS	EI LBS-IN**2
0	0.000E+00	1.517E+00	-9.265E-03	0.000E+00	0.000E+00	0.000E+00	0.000E+00	3.857E+10
1	5.000E-01	1.461E+00	-9.265E-03	0.000E+00	3.742E+02	0.000E+00	7.485E+02	3.857E+10
2	1.000E+00	1.405E+00	-9.265E-03	4.491E+03	1.168E+03	0.000E+00	8.400E+02	3.857E+10
3	1.500E+00	1.350E+00	-9.264E-03	1.402E+04	2.054E+03	0.000E+00	9.315E+02	3.857E+10
4	2.000E+00	1.294E+00	-9.260E-03	2.914E+04	3.031E+03	0.000E+00	1.023E+03	3.857E+10
5	2.500E+00	1.239E+00	-9.254E-03	5.040E+04	4.100E+03	0.000E+00	1.115E+03	3.857E+10
6	3.000E+00	1.183E+00	-9.244E-03	7.834E+04	5.261E+03	0.000E+00	1.206E+03	3.857E+10
7	3.500E+00	1.128E+00	-9.229E-03	1.135E+05	6.512E+03	0.000E+00	1.298E+03	3.857E+10
8	4.000E+00	1.073E+00	-9.208E-03	1.565E+05	7.856E+03	0.000E+00	1.389E+03	3.857E+10
9	4.500E+00	1.017E+00	-9.180E-03	2.078E+05	9.291E+03	0.000E+00	1.481E+03	3.857E+10
10	5.000E+00	9.624E-01	-9.143E-03	2.680E+05	1.082E+04	0.000E+00	1.572E+03	3.857E+10
11	5.500E+00	9.076E-01	-9.096E-03	3.376E+05	1.243E+04	0.000E+00	1.664E+03	3.857E+10
12	6.000E+00	8.532E-01	-9.037E-03	4.172E+05	1.414E+04	0.000E+00	1.755E+03	3.857E+10
13	6.500E+00	7.992E-01	-8.965E-03	5.073E+05	1.595E+04	0.000E+00	1.847E+03	3.857E+10
14	7.000E+00	7.456E-01	-8.878E-03	6.085E+05	1.784E+04	0.000E+00	1.938E+03	3.857E+10
15	7.500E+00	6.927E-01	-8.775E-03	7.214E+05	1.982E+04	0.000E+00	2.030E+03	3.857E+10
16	8.000E+00	6.403E-01	-8.653E-03	8.464E+05	2.190E+04	0.000E+00	2.121E+03	3.857E+10
17	8.500E+00	5.888E-01	-8.511E-03	9.841E+05	2.406E+04	0.000E+00	2.213E+03	3.857E+10
18	9.000E+00	5.382E-01	-8.346E-03	1.135E+06	2.632E+04	0.000E+00	2.304E+03	3.857E+10
19	9.500E+00	4.887E-01	-8.156E-03	1.300E+06	2.867E+04	0.000E+00	2.396E+03	3.857E+10
20	1.000E+01	4.403E-01	-7.940E-03	1.479E+06	3.111E+04	0.000E+00	2.487E+03	3.857E+10
21	1.050E+01	3.934E-01	-7.695E-03	1.673E+06	3.365E+04	0.000E+00	2.579E+03	3.857E+10
22	1.100E+01	3.480E-01	-7.418E-03	1.883E+06	3.627E+04	0.000E+00	2.670E+03	3.857E+10
23	1.150E+01	3.044E-01	-7.108E-03	2.109E+06	3.899E+04	0.000E+00	2.762E+03	3.857E+10
24	1.200E+01	2.627E-01	-6.761E-03	2.351E+06	4.179E+04	0.000E+00	2.853E+03	3.857E+10
25	1.250E+01	2.232E-01	-6.375E-03	2.610E+06	4.469E+04	0.000E+00	2.945E+03	3.857E+10
26	1.300E+01	1.862E-01	-5.948E-03	2.887E+06	4.617E+04	0.000E+00	5.215E-08	3.857E+10
27	1.350E+01	1.519E-01	-5.477E-03	3.164E+06	4.617E+04	0.000E+00	5.689E-08	3.857E+10
28	1.400E+01	1.205E-01	-4.963E-03	3.441E+06	4.617E+04	0.000E+00	5.704E-08	3.857E+10
29	1.450E+01	9.231E-02	-4.406E-03	3.718E+06	4.617E+04	0.000E+00	6.698E-08	3.857E+10
30	1.500E+01	6.760E-02	-3.806E-03	3.995E+06	4.617E+04	0.000E+00	6.442E-08	3.857E+10
31	1.550E+01	4.663E-02	-3.163E-03	4.272E+06	3.525E+04	-3.639E+03	-2.183E+04	3.857E+10
32	1.600E+01	2.965E-02	-2.487E-03	4.418E+06	-9.341E+02	-8.422E+03	-5.053E+04	3.857E+10
33	1.650E+01	1.678E-02	-1.812E-03	4.261E+06	-5.431E+04	-9.370E+03	-5.622E+04	3.857E+10
34	1.700E+01	7.898E-03	-1.188E-03	3.766E+06	-1.106E+05	-9.381E+03	-5.629E+04	3.857E+10
35	1.750E+01	2.529E-03	-6.667E-04	2.934E+06	-1.612E+05	-7.491E+03	-4.495E+04	3.857E+10
36	1.800E+01	-1.019E-04	-2.960E-04	1.832E+06	-1.680E+05	5.222E+03	3.133E+04	3.857E+10
37	1.850E+01	-1.023E-03	-8.200E-05	9.184E+05	-1.235E+05	9.597E+03	5.758E+04	3.857E+10
38	1.900E+01	-1.086E-03	1.665E-05	3.499E+05	-7.129E+04	7.815E+03	4.689E+04	3.857E+10
39	1.950E+01	-8.228E-04	4.876E-05	6.288E+04	-3.468E+04	4.390E+03	2.634E+04	3.857E+10
40	2.000E+01	-5.009E-04	4.850E-05	-6.616E+04	-1.349E+04	2.672E+03	1.603E+04	3.857E+10
41	2.050E+01	-2.407E-04	3.565E-05	-9.900E+04	-1.619E+03	1.284E+03	7.707E+03	3.857E+10
42	2.100E+01	-7.302E-05	2.130E-05	-8.559E+04	3.403E+03	3.896E+02	2.337E+03	3.857E+10
43	2.150E+01	1.482E-05	1.012E-05	-5.816E+04	4.386E+03	-6.194E+01	-3.717E+02	3.857E+10
44	2.200E+01	4.837E-05	3.028E-06	-3.296E+04	3.594E+03	-2.022E+02	-1.213E+03	3.857E+10
45	2.250E+01	5.115E-05	-7.061E-07	-1.504E+04	2.346E+03	-2.138E+02	-1.283E+03	3.857E+10
46	2.300E+01	3.990E-05	-2.250E-06	-4.814E+03	1.204E+03	-1.667E+02	-1.000E+03	3.857E+10
47	2.350E+01	2.415E-05	-2.671E-06	-5.904E+02	4.012E+02	-1.009E+02	-6.055E+02	3.857E+10
48	2.400E+01	7.849E-06	-2.717E-06	0.000E+00	4.920E+01	-1.640E+01	-9.841E+01	3.857E+10

END OF ANALYSIS

Appendix D – ODOT Checklists

II. Reconnaissance and Planning Checklist

C-R-S: HAM-74-13.35 Bridge Replacement	**PID:** 110563	**Reviewer:** RES	**Date:** 4/4/2023

Reconnaissance		(Y/N/X)	Notes:
1	Based on Section 302.1 in the SGE, have the necessary plans been developed in the following areas prior to the commencement of the subsurface exploration reconnaissance:		
	Roadway plans		
	Structures plans	✓	
	Geohazards plans		
2	Have the resources listed in Section 302.2.1 of the SGE been reviewed as part of the office reconnaissance?	Y	
3	Have all the features listed in Section 302.3 of the SGE been observed and evaluated during the field reconnaissance?	Y	
4	If notable features were discovered in the field reconnaissance, were the GPS coordinates of these features recorded?	X	

Planning - General		(Y/N/X)	Notes:
5	In planning the geotechnical exploration program for the project, have the specific geologic conditions, the proposed work, and historic subsurface exploration work been considered?	Y	
6	Has the ODOT Transportation Information Mapping System (TIMS) been accessed to find all available historic boring information and inventoried geohazards?	Y	
7	Have the borings been located to develop the maximum subsurface information while using a minimum number of borings, utilizing historic geotechnical explorations to the fullest extent possible?	Y	
8	Have the topography, geologic origin of materials, surface manifestation of soil conditions, and any other special design considerations been utilized in determining the spacing and depth of borings?	Y	
9	Have the borings been located so as to provide adequate overhead clearance for the equipment, clearance of underground utilities, minimize damage to private property, and minimize disruption of traffic, without compromising the quality of the exploration?	Y	

II. Reconnaissance and Planning Checklist

Planning - General		(Y/N/X)	Notes:
10	Have the scaled boring plans, showing all project and historic borings, and a schedule of borings in tabular format, been submitted to the District Geotechnical Engineer?	Y	
	The schedule of borings should present the following information for each boring:		
a.	exploration identification number	Y	
b.	location by station and offset	Y	
c.	estimated amount of rock and soil, including the total for each for the entire program.	Y	
Planning – Exploration Number		(Y/N/X)	Notes:
11	Have the coordinates, stations and offsets of all explorations (borings, probes, test pits, etc.) been identified?	Y	
12	Has each exploration been assigned a unique identification number, in the following format X-ZZZ-W-YY, as per Section 303.2 of the SGE?	Y	
13	When referring to historic explorations that did not use the identification scheme in 12 above, have the historic explorations been assigned identification numbers according to Section 303.2 of the SGE?	Y	

II. Reconnaissance and Planning Checklist

Planning – Boring Types		(Y/N/X)	Notes:
14	Based on Sections 303.3 to 303.7.6 of the SGE, have the location, depth, and sampling requirements for the following boring types been determined for the project?		
	Check all boring types utilized for this project:		
	Existing Subgrades (Type A)		
	Roadway Borings (Type B)		
	Embankment Foundations (Type B1)		
	Cut Sections (Type B2)		
	Sidehill Cut Sections (Type B3)		
	Sidehill Cut-Fill Sections (Type B4)		
	Sidehill Fill Sections on Unstable Slopes (Type B5)		
	Geohazard Borings (Type C)		
	Lakes, Ponds, and Low-Lying Areas (Type C1)		
	Peat Deposits, Compressible Soils, and Low Strength Soils (Type C2)		
	Uncontrolled Fills, Waste Pits, and Reclaimed Surface Mines (Type C3)		
	Underground Mines (C4)		
	Landslides (Type C5)		
	Rockfall (Type C6)		
	Karst (Type C7)		
	Proposed Underground Utilities (Type D)		
	Structure Borings (Type E)	✓	
	Bridges (Type E1)		
	Culverts (Type E2 a,b,c)		
	Retaining Walls (Type E3 a,b,c)	✓	
	Noise Barrier (Type E4)		
	CCTV & High Mast Lighting Towers (Type E5)		
	Buildings and Salt Domes (Type E6)		

IV.A Foundations of Structures Checklist

C-R-S: HAM-74-13.35 Bridge Replacement	PID: 110563	Reviewer: RES	Date: 4/4/2023

If you do not have such a foundation or structure on the project, you do not have to fill out this checklist.

Soil and Bedrock Strength Data		(Y/N/X)	Notes:
1	Has the shear strength of the foundation soils been determined?		
	Check method used:		
	laboratory shear tests		
	estimation from SPT or field tests	✓	
2	Have sufficient soil shear strength, consolidation, and other parameters been determined so that the required allowable loads for the foundation/structure can be designed?	Y	
3	Has the shear strength of the foundation bedrock been determined?		
	Check method used:		
	laboratory shear tests		
	other (describe other methods)	✓	
Spread Footings		(Y/N/X)	Notes:
4	Are there spread footings on the project? If no, go to Question 11		
5	Have the recommended bottom of footing elevation and reason for this recommendation been provided?	Y	
a.	Has the recommended bottom of footing elevation taken scour from streams or other water flow into account?	X	
6	Were representative sections analyzed for the entire length of the structure for the following:		
a.	factored bearing resistance?	Y	
b.	factored sliding resistance?	Y	
c.	eccentric load limitations (overturning)?	Y	
d.	predicted settlement?	Y	
e.	overall (global) stability?		
7	Has the need for a shear key been evaluated?		
a.	If needed, have the details been included in the plans?	X	
8	If special conditions exist (e.g. geometry, sloping rock, varying soil conditions), was the bottom of footing "stepped" to accommodate them?	X	
9	Have the Service I and Maximum Strength Limit States for bearing pressure on soil or rock been provided?	Y	

IV.A Foundations of Structures Checklist

Spread Footings		(Y/N/X)	Notes:
10	If weak soil is present at the proposed foundation level, has the removal / treatment of this soil been developed and included in the plans?	X	
a.	Have the procedure and quantities related to this removal / treatment been included in the plans?		
Pile Structures		(Y/N/X)	Notes:
11	Are there piles on the project? If no, go to Question 17		
12	Has an appropriate pile type been selected?		
	Check the type selected:		
	H-pile (driven)	✓	
	H-pile (prebored)	✓	
	Cast In-place Reinforced Concrete Pipe		
	Micropile		
	Continuous Flight Auger (CFA)		
	other (describe other types)		
13	Have the estimated pile length or tip elevation and section (diameter) based on either the Ultimate Bearing Value (UBV) or the depth to top of bedrock been specified? Indicate method used.	Y	Piles to bedrock
14	If scour is predicted, has pile resistance in the scour zone been neglected?		
15	Has a wave equation drivability analysis been performed as per BDM 305.4.1.2 to determine whether the pile can be driven to either the UBV, the pile tip elevation, or refusal on bedrock without overstressing the pile?	N	
16	If required for design, have sufficient soil parameters been provided and calculations performed to evaluate the:	X	
a.	Nominal unit tip resistance and maximum settlement of the piles?		
b.	Nominal unit side resistance for each contributing soil layer and maximum deflection of the piles?		
c.	Downdrag load on piles driven through new embankment or compressible soil layers, as per BDM 305.4.2.2?		
d.	Potential for and impact of lateral squeeze from soft foundation soils?		

IV.A Foundations of Structures Checklist

Pile Structures		(Y/N/X)	Notes:
17	If piles are to be driven to strong bedrock (Q_u >7.5 ksi) or through very dense granular soils or overburden containing boulders, have "pile points" been recommended in order to protect the tips of the steel piling, as per BDM 305.4.5.6?	X	
18	If subsurface obstacles exist, has preboring been recommended to avoid these obstructions?	X	
19	If piles will be driven through 15 feet or more of new embankment, has preboring been specified as per BDM 305.4.5.7?	Y	

IV.A Foundations of Structures Checklist

Drilled Shafts		(Y/N/X)	Notes:
20	Are there drilled shafts on the project? If no, go to the next checklist.	N	
21	Have the drilled shaft diameter and embedment length been specified?		
22	Have the recommended drilled shaft diameter and embedment been developed based on the nominal unit side resistance and nominal unit tip resistance for vertical loading situations?		
23	For shafts undergoing lateral loading, have the following been determined:		
a.	total factored lateral shear?		
b.	total factored bending moment?		
c.	maximum deflection?		
d.	reinforcement design?		
24	If a bedrock socket is required, has a minimum rock socket length equal to 1.5 times the rock socket diameter been used, as per BDM 305.5.2?		
25	Generally, bedrock sockets are 6" smaller in diameter than the soil embedment section of the drilled shaft. Has this factor been accounted for in the drilled shaft design?		
26	If scour is predicted, has shaft resistance in the scour zone been neglected?		
27	Has the site been assessed for groundwater influence?		
a.	If yes, and if artesian flow is a potential concern, does the design address control of groundwater flow during construction?		
28	Have all the proper items been included in the plans for integrity testing?		
29	If special construction features (e.g., slurry, casing, load tests) are required, have all the proper items been included in the plans?		
30	If necessary, have wet construction methods been specified?		
General		(Y/N/X)	Notes:
31	Has the need for load testing of the foundations been evaluated?		
a.	If needed, have details and plan notes for load testing been included in the plans?		

IV.B. Retaining Wall Checklist

C-R-S: HAM-74-13.35 Bridge Replacement	**PID:** 110563	**Reviewer:** RES	**Date:** 4/4/2023
	PDP Path:		

If you do not have a retaining wall on the project, you do not have to fill out this checklist.

Soil Data and Preliminary Calculations		(Y/N/X)	Notes:
1	Has a justification study been performed to determine the necessity of a wall as opposed to ROW purchase or other project alternatives?	X	
2	Have the necessary soil strength parameters and unit weights been determined?		
	Check method used:		
	laboratory shear tests		
	estimation from SPT or field tests	✓	
3	Has the groundwater elevation been determined?	N	
4	Have the proper loading conditions been determined?		
a.	If yes, check which loading conditions apply:		
	Backfill (Active Earth Pressure Loading):	✓	
	Backfill (Apparent Earth Pressure (AEP) Loading for Ground Anchors):		
	Backfill (At-Rest Earth Pressure Loading):		
	Backfill (Flat, No Slope):		
	Backfill (Infinite Slope):		
	Backfill (Broken Back Slope):		
	Earth Surcharge:		
	Live Load Surcharge:	✓	
	Other (describe):		
5	Have the correct Load Factors, Load Combinations, and Limit States been considered, per AASHTO LRFD 8th Ed. Articles 3.4.1, 10.5, and 11.5?	Y	
6	Are earth pressure loads inclined at the soil-structure interaction friction angle, δ and has δ been determined per BDM 307.1.1?	N	
7	Have the correct Resistance Factors been considered, per AASHTO LRFD 8th Ed. Articles 10.5 and 11.5?	Y	
8	If applicable, has the influence of groundwater been taken into account with regards to soil unit weights and active pressures?	Y	
9	Has the Coulomb method been utilized to determine the lateral earth pressure?	Y	

IV.B. Retaining Wall Checklist

Design		(Y/N/X)	Notes:
10	For preliminary wall design, have the design criteria and wall type selection process been followed as instructed in BDM 201.2.5?	Y	
11	Was an economic analysis performed to evaluate the cost benefits of the chosen wall type compared to others?	X	
12	Were representative sections analyzed for the entire length of the retaining wall for the following:		
a.	bearing resistance?	Y	
b.	sliding resistance?	Y	
c.	limiting eccentricity and overturning resistance? Analyze moment equilibrium about toe for non-gravity cantilever walls.	Y	
d.	total and differential settlement?	Y	
e.	overall (global) stability?	Y	
13	If poor foundation soils are present, has a solution been determined with respect to the following:	X	
a.	excessive settlement?		
b.	inadequate bearing resistance?		
c.	inadequate sliding resistance?		
d.	overall (global) instability?		
14	For non-proprietary walls, each wall type has design recommendations which need to be determined. For the wall type being evaluated, have the following design recommendations been determined by accepted design methods or, where applicable, FHWA design guidelines:	X	
a.	Rigid Gravity and Semigravity -- footing width and elevation, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance (BDM 307.1.5 & 307.2)		
b.	Drilled Shafts - diameter, spacing, embedment, arrangement and percent reinforcement, maximum moment and lateral shear, maximum deflection (see BDM 307.6)		
c.	Soldier Pile -pile size and type, drilled hole diameter, embedment, spacing, lagging design, facing, maximum moment and lateral shear, section modulus, maximum deflection		

IV.B. Retaining Wall Checklist

Design		(Y/N/X)	Notes:
d.	Sheet Pile - pile size, embedment, maximum moment and lateral shear, section modulus, maximum deflection (BDM 307.7.1)		
e.	Cellular - type, maximum factored Service and Strength Limit State bearing pressures, factored bearing resistance, fill material (BDM 307.7.2)		
f.	Soil Anchor - load per anchor, number of rows, wale design, anchor inclination and minimum length, type of anchor, pile size, type, spacing, and embedment, maximum moment and lateral shear, section modulus, lagging design, facing (BDM 307.8)		
g.	Soil Nail - nail size, spacing, inclination, and length, loading per nail, facing (BDM 307.9)		
15	Has the need for load testing of the retaining wall elements been evaluated?	Y	
a.	If needed, have details and plan notes for load testing been included in the plans?	N	
16	Proprietary wall designs require a special process for detail design, as outlined in BDM 307.3 and 307.4. Has this procedure been followed for this project?	Y	
17	Temporary walls - have the same design requirements as permanent walls of the same type been followed, except the design service life is no more than three years (BDM 307.10)?	X	
18	The presence and quality of water behind the wall structure and in the backfill can be a major source of overloading and failure.		
a.	Has the quality / chemistry of the groundwater been accounted for in the drainage system?	X	
b.	Has an adequate drainage system been included in the detail wall design?	Y	
c.	If there is a water source behind the wall, has additional drainage been added to control the effect of this water source on the wall?	X	
19	Have the effects of the wall design and construction procedure been determined and accounted for on the construction schedule?	X	

IV.B. Retaining Wall Checklist

Design		(Y/N/X)	Notes:
20	Has the effect of the wall design and construction been evaluated with regard to structures (e.g., bridges, culverts, buildings, utilities), which may be subject to unusual stresses or require special design or construction considerations?	X	
Plans and Contract Documents		(Y/N/X)	Notes:
21	Have all the necessary notes, specifications, special provisions, and details for the construction of the wall system been included in the plans?	Y	
22	Have the need, location, type, plan notes, and reading schedule for any instrumentation been determined and included in the plans?	X	
	Check the types of instrumentation specified:		
	settlement cells		
	settlement platforms		
	inclinometers		
	monitoring wells / piezometers		
	load cells		
	strain gages		
	other (describe other types)		

VI.A. Soil Profile Checklist

C-R-S: HAM-74-13.35 Bridge Replacement	PID: 110563	Reviewer: RES	Date: 4/4/2023

General Presentation		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	N	
2	Have the cadd files been prepared using the appropriate version of the ODOT CADD standards?	Y	
3	Has the geotechnical specification (title and date) under which the work was performed been clearly identified on every submission (reports, plans, etc.)?	Y	
4	Has the first complete version of all documents being submitted been labeled as 'Draft'?	Y	
5	Subsequent to ODOT's review and approval, has the complete version of the revised documents being submitted been labeled as 'Final'?	X	
a.	Have the C-R-S, PID number, and product title been included in the folder name?	Y	
6	If the project includes structures, have all structure explorations been presented together under the same cover sheet? (Do not create separate Structure Foundation Exploration Sheets)	Y	
7	Has a scale of 1"=1' been used for cover sheets, laboratory test data sheets, and boring log sheets, if applicable?	Y	
8	Based on the project length, has the correct horizontal scale been used to plot the project data?		
	Check scale used:		
	1" = 5', 10', 20', 25', 40', or 50' for projects 1500' or less (use largest scale appropriate to present entire plan on one sheet)	✓	
	1" = 50' projects greater than 1500'		
9	Has a scale of 1" = 10' been utilized for the vertical scale of the project data?	Y	
10	If the project includes structures, has the plan and profile view been shown at the same scale as the Site Plan for the proposed structure(s), when possible?	Y	

VI.A. Soil Profile Checklist

General Presentation		(Y/N/X)	Notes:
11	If the project includes culverts, have the plan and profile been presented along the flowline of the culvert?	X	
12	Have the cross-sections been plotted at a scale of 1" = 10' (preferred) or 1" = 20' (for higher or wider slopes)?	X	
Cover Sheet		(Y/N/X)	Notes:
13	Has the following general information been provided on the cover sheet:		
a.	Brief description of the project, including the bridge number of each bridge involved in the plan set, if any?	Y	
b.	Brief description of historic geotechnical explorations referenced in this exploration? State if no historic records are available.	Y	
c.	Generalized information about the geology of the project area, including terrain, soil origin, bedrock types, and age?	Y	
d.	Brief presentation of geological and topographical information derived from the field reconnaissance? Include comments on structure and pavement conditions.	Y	
e.	Brief presentation of test boring and sampling methods? Include date of last calibration and drill rod energy ratio as a percent for the hammer systems used.	Y	
f.	Summary of general soil, bedrock, and groundwater conditions, including a generalized interpretation of findings?	Y	
g.	A statement of which version (date) of the SGE specification the exploration was performed in accordance with?	Y	
h.	Statement of where geotechnical reports are available for review?	Y	
i.	Initials of personnel and dates they performed field reconnaissance, subsurface exploration and preparation of the soil profile?	Y	

VI.A. Soil Profile Checklist

Cover Sheet		(Y/N/X)	Notes:
14	Has a Legend been provided?	Y	
15	Have the following items been included in the Legend:		
a.	Symbols and usual descriptions for only the soil and bedrock types presented in the Soil Profile, as per the Soil and Rock Symbology Chart in Appendix D of the SGE?	Y	
b.	All miscellaneous symbols and acronyms, used on any of the sheets, defined?	Y	
c.	The number of soil samples for each classification that were mechanically classified and visually described in the current exploration?	Y	
16	Has a Location Map, showing the beginning and end stations for the project, been shown on the cover sheet, sized per the L&D3 Manual?	Y	
17	Have the station limits for each plan and profile sheet for projects with multiple alignments, or greater than 1500', been identified in a table?	X	
18	Have the station limits for any cross section sheets been identified in the same table?	X	
19	Has a list of any structures for which structure foundation explorations been performed been identified in the same table?	X	
20	If sampling and testing for a scour analysis was performed, has this data been shown in tabular form?	X	
21	Has a summary table of test data for all roadway and subgrade boring samples been shown?	X	
22	If borings from previous subsurface explorations are being used, has that data been shown in a separate table?	X	
23	In the summary table, has the data been displayed by roadway and subgrade boring in ascending stationing order for each roadway?	X	
24	Have the centerline or baseline station, offset, and exploration identification number been provided for each boring presented in the table?	X	

VI.A. Soil Profile Checklist

Cover Sheet		(Y/N/X)	Notes:
25	For each sample, has the following information been provided in the summary table:	X	
a.	Sample depth interval?		
b.	Sample number and type?		
c.	N_{60}?		
d.	Percent recovery?		
e.	Hand Penetrometer?		
f.	Percentage of aggregate, coarse sand, fine sand, silt, and clay size particles?		
g.	Liquid limit, plastic limit, plasticity index, and water content, all rounded to the nearest percent or whole number?		
h.	ODOT classification and Group Index?		
i.	Visual description of samples not mechanically classified, including water content, and estimated ODOT classification with 'Visual' in parentheses?		
j.	Sulfate Content test results?		
26	Have all undisturbed test results been displayed in graphical format on the sheet prior to the plan and profile sheets?	Y	
Surface Data		(Y/N/X)	Notes:
27	Has the following information been shown on each roadway plan drawing:		
a.	Existing surface features described in Section 702.5.1?	X	
b.	Proposed construction items, as described in Section 702.5.2?	Y	
c.	Project and historic boring locations, with appropriate exploration targets and exploration identification numbers?	Y	
d.	Notes regarding observations not readily shown by drawings?	X	
28	Have the existing ground surface contours been presented?	Y	
29	If cross sections are to be developed for stationing covered on a plan sheet, has an index for the appropriate cross section sheets been included on the plan sheet?	X	

VI.A. Soil Profile Checklist

Subsurface Data		(Y/N/X)	Notes:
30	Has all the subsurface data been presented in the form of a profile along the centerline or baseline, and on cross sections where applicable?	Y	
31	Have the graphical boring logs been correctly shown, as follows:		
a.	Location and depth of boring indicated by a heavy dashed vertical line?	Y	
b.	Exploration identification number above the boring?	Y	
c.	Logs indicate soil and bedrock layers with symbols 0.4” wide and centered on the heavy dashed vertical line where possible?	Y	
d.	Bedrock exposures with 0.4” wide symbols, but without a heavy dashed vertical line?	X	
e.	Soil and bedrock symbols as per ODOT Soil and Rock Symbology chart (SGE - Appendix D)?	Y	
f.	Historical borings shown in same manner with the exploration identification number above the boring?	Y	
32	Have the proposed groundline and existing groundline been shown on the profile view, according to ODOT CADD standards?	Y	
33	Have the locations of the proposed structure foundation elements been shown on the profile view?	Y	
34	Have the offsets from centerline or baseline been indicated above the borings in the profile view?	X	
35	Have borings located immediately adjacent to the centerline or baseline and considered representative of centerline or baseline subsurface conditions been referenced directly to the centerline or baseline?	X	
36	Have offset borings in or near the same elevation interval of a centerline or baseline boring been plotted either on a cross section or immediately above or below the centerline boring in a box containing an elevation scale?	X	
37	Have cross-sections been developed to show subsurface conditions disclosed by a series of borings drilled transverse to centerline or baseline?	X	

VI.A. Soil Profile Checklist

Subsurface Data		(Y/N/X)	Notes:
38	Have the existing and proposed groundlines been displayed on cross section sheets according to ODOT CADD standards?	Y	
39	Have bedrock exposures shown on the cross sections been plotted along the contour of the cross section?	X	
40	Has the following information been provided adjacent to the graphical logs or bedrock exposure:		
a.	Thickness, to the nearest inch, of sod/topsoil or other shallow surface material written above the boring (with corresponding symbology at top of log)?	Y	
b.	Moisture content, to nearest whole percent, with the bottom of the text aligned with the bottom of the sample? Label this column as 'WC' at bottom of the boring.	Y	
c.	N_{60}, aligned with the bottom of sample? Label column as 'N_{60}' at bottom of boring.	Y	
d.	Free water indicated by a horizontal line with a 'w' attached, and water level at the end of drilling indicated by an open equilateral triangle, point down?	Y	
e.	Complete geologic description of each bedrock unit, including unit core loss, unit RQD, SDI, and compressive strength test results? (Do not present geologic descriptions for structure borings for which this information is presented on the boring logs as described in 703.3)	X	
f.	Visual description of any uncontrolled fill or interval not adequately defined by a graphical symbol?	X	
g.	Organic content with modifiers, per 603.5?	X	
h.	Designate a plastic soil with moisture content equal to or greater than the liquid limit minus three with a 1/8" solid black circle adjacent to the moisture content?	X	
i.	Designate a non-plastic soil with moisture content exceeding 25% or exceeding 19% but appearing wet initially, with a 1/8" open circle with a horizontal line through it adjacent to the moisture content?	X	
j.	The reason for discontinuing a boring prior to reaching the planned depth indicated immediately below the boring?	X	

VI.A. Soil Profile Checklist

Boring Logs		(Y/N/X)	Notes:
41	Have the boring logs of all structure borings, all geohazard borings, and any roadway borings drilled in the vicinity of the structures or geohazard been shown on the boring log sheets following the plan and profile sheets? (Create the logs in accordance with 703.3)	Y	
42	Have the boring logs been developed by integrating the driller's field logs, laboratory test data, and visual descriptions?	Y	
43	Has the following boring information been included in the heading of each boring log:		
a.	Exploration identification number?	Y	
b.	Project designation (C-R-S) and PID?	Y	
c.	Structure File Number (if applicable) and project type.	Y	
d.	Centerline or baseline name, station, offset, and surface elevation?	Y	
e.	Coordinates?	Y	
f.	Method of drilling?	Y	
g.	Date started and date completed?	Y	
h.	Method and material (including quantity) used for backfilling or sealing, including type of instrumentation, if any?	Y	
i.	Date of last calibration and drill rod energy ratio (ER) in percent for the hammer system(s) used?	Y	
44	Has the following boring information been included in each boring log:		
a.	A depth and elevation scale?	Y	
b.	Indication of stratum change?	Y	
c.	Description of material in each stratum?	Y	
d.	Depth of bottom of boring?	Y	
e.	Depth of boulders or cobbles, if encountered?	X	
f.	Caving depth?	X	
g.	Water level observations?	Y	
h.	Artesian water level and height of rise?	X	
i.	Heaving sand?	X	
j.	Cavities or other unusual conditions?	X	
k.	Depth interval represented by sample?	Y	
l.	Sample number and type?	Y	
m.	Percent recovery for each sample?	Y	
n.	Measured blow counts for each 6 inches of drive for split spoon samples?	Y	
o.	N_{60} to the nearest whole number?	Y	
p.	Hand penetrometer?	Y	

VI.A. Soil Profile Checklist

Boring Logs		(Y/N/X)	Notes:
q.	Particle-size analysis?	Y	
r.	Liquid limit, plastic limit, plasticity index?	Y	
s.	Water content?	Y	
t.	ODOT soil classifications, with "V" in parentheses for those samples that are not mechanically classified?	Y	
u.	Top of bedrock and bedrock descriptions?	Y	
v.	Run rock core percent recovery?	Y	
w.	Run RQD?	Y	
x.	Unit rock core percent recovery?	Y	
y.	Unit RQD?	Y	
z.	SDI, if applicable?	X	
aa.	Rock compressive strength test results, if applicable?	Y	

VI.B. Geotechnical Reports

C-R-S: HAM-74-13.35 Bridge Replacement	PID: 110563	Reviewer: RES	Date: 4/4/2023

General		(Y/N/X)	Notes:
1	Has an electronic copy of all geotechnical submissions been provided to the District Geotechnical Engineer (DGE)?	Y	
2	Has the first complete version of a geotechnical report being submitted been labeled as 'Draft'?	Y	
3	Subsequent to ODOT's review and approval, has the complete version of the revised geotechnical report being submitted been labeled 'Final'?	Y	
4	Has the boring data been submitted in a native format that is DIGGS (Data Interchange for Geotechnical and Geoenvironmental) compatable? gINT files may be used for this.		
5	Does the report cover format follow ODOT's Brand and Identity Guidelines Report Standards found at http://www.dot.state.oh.us/brand/Pages/default.aspx ?	Y	
6	Have all geotechnical reports being submitted been titled correctly as prescribed in Section 705.1 of the SGE?	Y	
Report Body		(Y/N/X)	Notes:
7	Do all geotechnical reports being submitted contain the following:		
a.	an Executive Summary as described in Section 705.2 of the SGE?	Y	
b.	an Introduction as described in Section 705.3 of the SGE?	Y	
c.	a section titled "Geology and Observations of the Project," as described in Section 705.4 of the SGE?	Y	
d.	a section titled "Exploration," as described in Section 705.5 of the SGE?	Y	
e.	a section titled "Findings," as described in Section 705.6 of the SGE?	Y	
f.	a section titled "Analyses and Recommendations," as described in Section 705.7 of the SGE?	Y	

VI.B. Geotechnical Reports

Appendices		(Y/N/X)	Notes:
8	Do all geotechnical reports being submitted contain all applicable Appendices as described in Section 705.8 of the SGE?	Y	
9	Do the Appendices present a site Boring Plan showing all boring locations as described in Section 705.8.1 of the SGE?	Y	
10	Do the Appendices include boring logs and color pictures of rock, if applicable, as described in Section 705.8.2 of the SGE?	Y	
11	Do the Appendices include reports of undisturbed test data as described in Section 705.8.3 of the SGE?	Y	
12	Do the Appendices include calculations in a logical format to support recommendations as described in Section 705.8.4 of the SGE?	Y	

OHIO DEPARTMENT OF TRANSPORTATION

OFFICE OF GEOTECHNICAL ENGINEERING

HAM-74-13.35

110563

HAM-74-13.35 Bridge Replacement

S&ME, Inc.

Prepared By: **Rebecca E. Scherzinger, P.E.**

Date prepared: **November 1, 2022**

BORING LOG LOCATION SUMMARY

Boring ID	Latitude	Longitude	Filename Log	Filename Plan	Filename Profile
B-001-0-22	39.186380	-84.627904			
B-002-0-22	39.186573	-84.628108			
B-003-0-22	39.186817	-84.628081			

Appendix E – ODOT Soil Profile Sheets

PROJECT DESCRIPTION

THE HAM-74-13.35 BRIDGE CARRIES RACE ROAD OVER IR-74 IN HAMILTON COUNTY, OHIO. S&ME UNDERSTANDS THIS BRIDGE IS TO BE REPLACED WITH A NEW TWO-SPAN BRIDGE WITH MECHANICALLY STABILIZED EARTH (MSE) RETAINING WALLS AT THE FORWARD AND REAR ABUTMENTS AND AN INTERMEDIATE PIER SUPPORTED ON SHALLOW FOUNDATIONS BEARING ON BEDROCK. FISHBECK RECOMMENDS THE INTERMEDIATE PIER BE SUPPORTED BY SHALLOW FOUNDATIONS SINCE THE ENTIRE EXISTING PIER AND COMBINED SPREAD FOOTING ARE TO BE REMOVED TO FACILITATE THE CONSTRUCTION OF THE NEW PIER IN THE SAME APPROXIMATE LOCATION.

HISTORIC RECORDS

BASED ON REVIEW OF THE ODOT TRANSPORTATION INFORMATION MANAGEMENT SYSTEM (TIMS) WEBPAGE, THE HISTORIC BORING LOGS FOR THE INITIAL CONSTRUCTION OF THE HAM-74-13.35 BRIDGE WERE AVAILABLE.

GEOLOGY

GEOLOGIC REFERENCES INDICATE THAT THIS PROJECT SITE IS LOCATED WITHIN THE OUTER BLUEGRASS PHYSIOGRAPHIC REGION. SURFICIAL GEOLOGY MAPPING INDICATES THE OVERBURDEN SOILS IN THE AREA CONSIST PREDOMINANTLY OF SILTY CLAY TO CLAY SOIL DERIVED FROM THE UNDERLYING BEDROCK. THESE OVERBURDEN SOILS OVERLIE INTERBEDDED SHALE AND LIMESTONE FROM THE GRANT LAKE FORMATION OF ORDOVICIAN AGE. AVAILABLE ODNR WATER WELL LOGS INDICATE THAT THE TOP OF BEDROCK IN THE PROJECT AREA IS PRESENT AT DEPTHS OF 20 FEET AND UP TO 50 FEET BELOW GRADE. THE BORINGS PERFORMED FOR THIS STRUCTURE EXPLORATION ENCOUNTERED BEDROCK AT DEPTHS RANGING FROM 5.3 AND 14.5 FEET BELOW EXISTING GRADES.

A REVIEW OF THE ODNR "OHIO KARST AREAS" MAP INDICATES THE SITE LIES IN AN AREA NOT KNOWN TO CONTAIN KARST FEATURES. A REVIEW OF THE ODNR "LANDSLIDES IN OHIO" MAP REVEALS THE SITE IS NOT IN AN AREA SUSCEPTIBLE TO LANDSLIDES, AND THE ODNR "ABANDONED UNDERGROUND MINES OF OHIO" MAP INDICATES THE SITE LIES IN AN AREA WITH NO MAPPED ABANDONED MINES WITHIN A 3-MILE RADIUS. THERE IS A HISTORIC SURFACE MINE LESS THAN 1-MILE SOUTH OF THE SITE.

RECONNAISSANCE

ON SEPTEMBER 19, 2022, S&ME PERFORMED A SITE RECONNAISSANCE OF THE HAM-74-13.35 BRIDGE TO OBSERVE CURRENT CONDITIONS AND TO STAKE THE PLANNED BORING LOCATIONS. THE SITE CONSISTS OF THE EASTBOUND AND WESTBOUND LANES OF IR-74 BELOW THE EXISTING BRIDGE AND OFF ROAD SECTIONS COVERED WITH GRASS, SHRUBS, AND TREES. SIGNS OF SLOPE INSTABILITY WERE NOT PRESENT DURING OUR SITE RECONNAISSANCE.

SUBSURFACE EXPLORATION

FROM SEPTEMBER 23 TO 29, 2022, THREE (3) BORINGS WERE PERFORMED FOR THE HAM-74-13.35 BRIDGE EXPLORATION TO EXPLORE THE EXISTING SOILS AND BEDROCK IN THE AREA OF THE PLANNED REPLACEMENT STRUCTURE. THE BORINGS WERE NUMBERED B-001-0-22, B-002-0-22, AND B-003-0-22. THE LOCATIONS AND ELEVATIONS AND PLAN AND PROFILE INFORMATION WERE PROVIDED BY FISHBECK. LOGS OF HISTORIC BORINGS PERFORMED IN THE VICINITY OF THE HAM-74-13.35 BRIDGE ARE ALSO INCLUDED.

THE CURRENT BORINGS WERE PERFORMED BY A TRACK-MOUNTED DRILLING RIG USING A 3¼-INCH I.D. HOLLOW-STEM AUGER TO ADVANCE THE BORINGS BETWEEN SAMPLING ATTEMPTS. DISTURBED BUT REPRESENTATIVE SOIL SAMPLES WERE OBTAINED BY LOWERING A 2-INCH O.D. SPLIT-BARREL SAMPLER THROUGH THE AUGER STEM TO THE BOTTOM OF THE BORING AND THEN DRIVING THE SAMPLER INTO THE SOIL WITH BLOWS FROM A 140-POUND HAMMER FREELY FALLING 30 INCHES (ASTM D1586 - STANDARD PENETRATION TEST). SPT SAMPLES WERE EXAMINED IMMEDIATELY AFTER RECOVERY AND REPRESENTATIVE PORTIONS WERE PRESERVED IN AIRTIGHT GLASS JARS. TEN (10) TO FIFTEEN (15) FEET OF BEDROCK WAS CORED IN EACH OF THE BORINGS USING AN NQ CORE BARREL WITH A DIAMOND BIT UTILIZING WATER AS A CIRCULATING FLUID.

IN ACCORDANCE WITH THE CURRENT ODOT SGE, THE HAMMER SYSTEM ON THE DRILL RIG HAD BEEN CALIBRATED IN ACCORDANCE WITH ASTM D 4633 TO DETERMINE THE DRILL ROD ENERGY RATIO (69.8% ON JUNE 7, 2022). AT THE COMPLETION OF DRILLING, THE BORINGS WERE BACKFILLED WITH CUTTINGS MIXED WITH BENTONITE CHIPS.

IN THE FIELD, EXPERIENCED S&ME PERSONNEL PERFORMED THE FOLLOWING: 1) EXAMINED ALL SAMPLES RECOVERED FROM THE BORINGS; 2) PRESERVED REPRESENTATIVE PORTIONS OF ALL SAMPLES IN AIRTIGHT GLASS JARS; 3) PREPARED A LOG OF EACH BORING; 4) MADE SEEPAGE AND GROUNDWATER OBSERVATIONS; 5) MADE HAND-PENETROMETER MEASUREMENTS IN SOIL SPECIMENS EXHIBITING COHESION; AND, 6) PROVIDED LIAISON BETWEEN THE FIELD WORK AND THE ENGINEER SO THE EXPLORATION PROGRAM COULD BE MODIFIED IN THE EVENT UNUSUAL OR UNEXPECTED SUBSURFACE CONDITIONS WERE ENCOUNTERED. ALL RECOVERED SAMPLES WERE TRANSPORTED TO THE SOILS LABORATORY OF S&ME FOR FURTHER EXAMINATION AND TESTING.

EXPLORATION FINDINGS

EACH OF THE THREE (3) BORINGS ENCOUNTERED 2 TO 18 INCHES OF TOPSOIL/ROOTMAT. BENEATH THESE SURFICIAL MATERIALS, THE BORINGS GENERALLY ENCOUNTERED COHESIVE SOILS OVER BEDROCK, ALTHOUGH BORING B-001-0-22 ENCOUNTERED GRANULAR SOILS. THE SUBSURFACE CONDITIONS ENCOUNTERED IN THE BORINGS PERFORMED FOR THE CURRENT EXPLORATION AT THIS SITE MAY BE DESCRIBED, IN DESCENDING ORDER AS FOLLOWS: 1.5 TO 8 FEET OF COHESIVE SOILS WHICH CAN BE DESCRIBED AS VERY-STIFF TO HARD BROWN AND GRAY SILT AND CLAY (A-6a), VERY-STIFF TO HARD BROWN AND GRAY SILTY CLAY (A-6b), AND VERY-STIFF BROWN AND GRAY CLAY (A-7-6). 2 TO 5 FEET OF GRANULAR SOILS IN BORING B-001-0-22 WHICH CAN BE DESCRIBED AS VERY LOOSE BROWN GRAVEL (A-1-a), BROWN GRAVEL WITH SAND (A-1-b), AND LOOSE BROWN COARSE AND FINE SAND (A-3a).

BORING B-002-0-22 AUGERED THROUGH HIGHLY WEATHERED, VERY-WEAK GRAY SHALE, AND THEN CORED 13.4 FEET INTO INTERBEDDED SHALE (20-75%) AND LIMESTONE (30-80%). BORINGS B-001-0-22 AND B-003-0-22 CORED 15 AND 14.7 FEET, RESPECTIVELY, INTO THE INTERBEDDED SHALE (50-55%) AND LIMESTONE (45-50%) BEDROCK. THE SHALE WAS DARK GRAY, SEVERELY TO MODERATELY WEATHERED, AND WEAK TO SLIGHTLY STRONG. THE LIMESTONE WAS LIGHT GRAY, MODERATELY TO SLIGHTLY WEATHERED, AND MODERATELY STRONG TO VERY STRONG.

GROUNDWATER WAS NOT OBSERVED DURING DRILLING OR PRIOR TO CORING BEDROCK IN EACH OF THE BORINGS. GROUNDWATER LEVELS CAN FLUCTUATE DUE TO SEASONAL VARIATIONS IN PRECIPITATION, CONSTRUCTION ACTIVITIES, ETC. THE BORINGS WERE BACKFILLED UPON COMPLETION; THEREFORE, LONG TERM GROUNDWATER READINGS WERE NOT OBTAINED.

LEGEND

DESCRIPTION	ODOT CLASS	CLASSIFIED MECH.	CLASSIFIED VISUAL
GRAVEL	A-1-A	-	2
GRAVEL WITH SAND	A-1-b	1	-
COARSE AND FINE SAND	A-3a	-	1
SILT AND CLAY	A-6a	1	2
SILTY CLAY	A-6b	1	1
CLAY	A-7-6	1	2
	TOTAL	4	8
SHALE	VISUAL		
INTERBEDDED SHALE AND LIMESTONE	VISUAL		
SOD AND TOPSOIL = X = APPROXIMATE THICKNESS	VISUAL		

BORING LOCATION - PLAN VIEW.

HISTORIC BORING LOCATION - PLAN VIEW.

DRIVE SAMPLE AND/OR ROCK CORE BORING PLOTTED TO VERTICAL SCALE ONLY. HORIZONTAL BAR INDICATES A CHANGE IN STRATIGRAPHY.

WC INDICATES WATER CONTENT IN PERCENT.

N_{60} INDICATES STANDARD PENETRATION RESISTANCE NORMALIZED TO 60% DRILL ROD ENERGY RATIO.

X/Y/Z NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X = NUMBER OF BLOWS FOR FIRST 6 INCHES.
Y = NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z = NUMBER OF BLOWS FOR THIRD 6 INCHES.

X/Y/Z/D" NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X = NUMBER OF BLOWS FOR FIRST 6 INCHES.
Y = NUMBER OF BLOWS FOR SECOND 6 INCHES.
Z/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PERETRATION AT REFUSAL.

X/Y/D" NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X = NUMBER OF BLOWS FOR FIRST 6 INCHES (UNCORRECTED).
Y/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.

X/D" NUMBER OF BLOWS FOR STANDARD PENETRATION TEST (SPT):
X/D" = NUMBER OF BLOWS (UNCORRECTED) FOR D" OF PENETRATION AT REFUSAL.

W— INDICATES FREE WATER ELEVATION.

SS INDICATES A SPLIT SPOON SAMPLE.

NP INDICATES A NON-PLASTIC SAMPLE.

TR INDICATES TOP OF ROCK

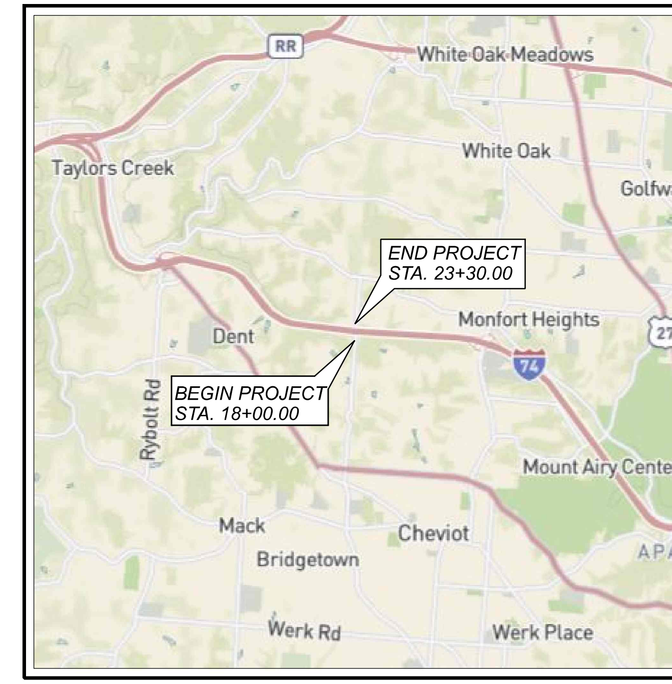
QU INDICATES ROCK COMPRESSION TEST, ASTM D7014, METHOD C, RESULTS

SPECIFICATIONS

S&ME UNDERSTANDS THAT THIS EXPLORATION PROGRAM IS TO BE PERFORMED FOR THIS PROJECT IN ACCORDANCE WITH THE JANUARY 2021 UPDATE TO THE ODOT SPECIFICATIONS FOR GEOTECHNICAL EXPLORATIONS (SGE).

ADDITIONAL INFORMATION

THE SOIL, BEDROCK, AND GROUNDWATER INFORMATION COLLECTED FOR THIS SUBSURFACE EXPLORATION THAT CAN BE CONVENIENTLY DISPLAYED ON THE SOIL PROFILE SHEETS HAS BEEN PRESENTED. GEOTECHNICAL REPORTS, IF PREPARED, ARE AVAILABLE FOR REVIEW ON THE OFFICE OF CONTRACT SALES WEBSITE.



LOCATION MAP

SCALE IN MILES

0 1 2 3 4

N

PARTICLE SIZE DEFINITIONS

12"	3"	2.0 mm	0.42 mm	0.074 mm	0.005 mm	
BOULDERS	COBBLES	GRAVEL	COARSE SAND	FINE SAND	SILT	CLAY
		No. 10 SIEVE	No. 40 SIEVE	No. 200 SIEVE		

BEDROCK TEST SUMMARY

BORING N0	SAMPLE	DEPTH	QU (PSI)
B-001-0-22	NQ-7	15.8' - 16.2'	8,986
B-002-0-22	NQ-10	22.8' - 23.2'	3,888
B-003-0-22	NQ-5 NQ-6	11.8' - 12.2' 14.9' - 15.3'	1,455 8,195

RECON. - *S&ME (9-19-2022)*
DRILLING - *S&ME (9-23-2022 to 9-29-2022)*
DRAWN - *DWM (12-12-2022 to 12-14-2022, 12-20-2022)*
REVIEWED - *BCD (01/17/2023)*

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74

DESIGN AGENCY
S&ME

DESIGNER
DWM

REVIEWER
BCD 01-17-23

PROJECT ID
110563

SUBSET 1 TOTAL 12

SHEET 68 TOTAL 79

HAM-74-13.35

Form No. TR-D7012C-01
Revision No. 1
Revision Date: 07/14/17

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C

Quality Assurance

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-001-0-22, NQ-7	Depth/Elev., ft:	15.8'-16.2'
Sample Description:	LIMESTONE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content ***0.9*** **%** ***Dry Unit Weight*** ***164.2*** **pcf**

Compressive Strength ***8,986*** **psi**

Before Test

After Test

Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543.**
Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples.
Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

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Form No. TR-D7012C-01
Revision No. 1
Revision Date: 07/14/17

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C

Quality Assurance

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-002-0-22, NQ-10	Depth/Elev., ft:	22.8'-23.2'
Sample Description:	SHALE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content ***5.0*** **%** ***Dry Unit Weight*** ***149.9*** **pcf**

Compressive Strength ***3,888*** **psi**

Before Test

After Test

Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543.**
Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples.
Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

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SOIL PROFILE - BRIDGE
LABORATORY DATA

DESIGN AGENCY	S&ME
DESIGNER	DWM
REVIEWER	BCD 01-17-23
PROJECT ID	110563
SUBSET 2	TOTAL 12
SHEET 69	TOTAL 79

Form No. TR-D7012C-01
Revision No. 1
Revision Date: 07/14/17

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C *Quality Assurance*

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-003-0-22, NQ-5	Depth/Elev., ft:	11.8'-12.2'
Sample Description:	INTERBEDDED SHALE/LIMESTONE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content *1.2* % ***Dry Unit Weight*** *159.3* pcf
Compressive Strength *1,455* psi

Before Test

After Test

Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543. Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples. Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.**

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

Form No. TR-D7012C-01
Revision No. 1
Revision Date: 07/14/17

UNIAXIAL COMPRESSIVE STRENGTH OF ROCK

ASTM D 7012 Method C *Quality Assurance*

S&ME, Inc. - Columbus: 6190 Enterprise Court, Dublin, Ohio 43016

Project No.:	22-78-0033	Report Date:	10/24/22
Project Name:	HAM-74-13.35 Bridge Replacement	Test Date(s):	10/13/22
Client Name:	Fishbeck, Inc.		
Client Address:	11353 Reed Hartman Hwy, Suite 500, Cincinnati, OH 45241	Received Date:	09/29/22
Boring ID:	B-003-0-22, NQ-6	Depth/Elev., ft:	14.9'-15.3'
Sample Description:	LIMESTONE, gray		

Angle of load relative to lithology: Approximately perpendicular to bedding plane

Test Results

Moisture Content *1.3* % ***Dry Unit Weight*** *165.7* pcf
Compressive Strength *8,195* psi

Before Test

After Test

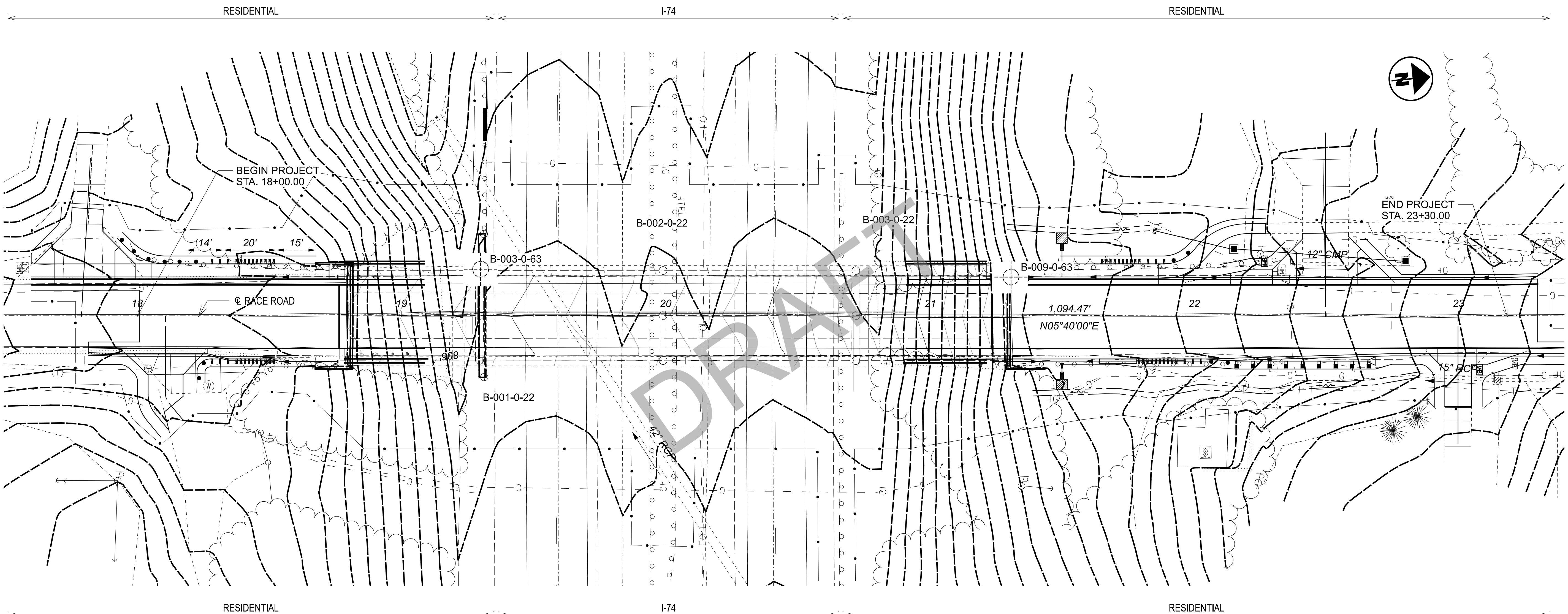
Strain rate: 0.03 in/min.

Notes / Deviations / References: **Specimen end preparation was not done in accordance with ASTM D4543. Specimen was capped using Sulfur in accordance with ASTM C617, based on previous similar samples. Test results for specimens not meeting this requirement may differ from test results obtained from specimens meeting this requirement.**

Paula J. Manning	Paula J. Manning	Laboratory Manager	10/24/2022
Technical Responsibility	*Signature*	*Position*	*Date*

SOIL PROFILE - BRIDGE
LABORATORY DATA

DESIGN AGENCY	S&ME
DESIGNER	DWM
REVIEWER	BCD 01-17-23
PROJECT ID	110563
SUBSET / TOTAL	3 / 12
SHEET / TOTAL	70 / 79



HORIZONTAL
SCALE IN FEET
0 10 20 40

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74

DESIGN AGENCY

DESIGNER	DWM
REVIEWER	BCD 01-17-23
PROJECT ID	110563
SUBSET 4	TOTAL 12
SHEET 71	TOTAL 79

HAM-74-13.35

MODEL: CLP_RACE_ROAD - Plan | PAPERSIZE: 17x11 (in.) DATE: 4/6/2023 TIME: 11:52:13 AM USER: dmorales
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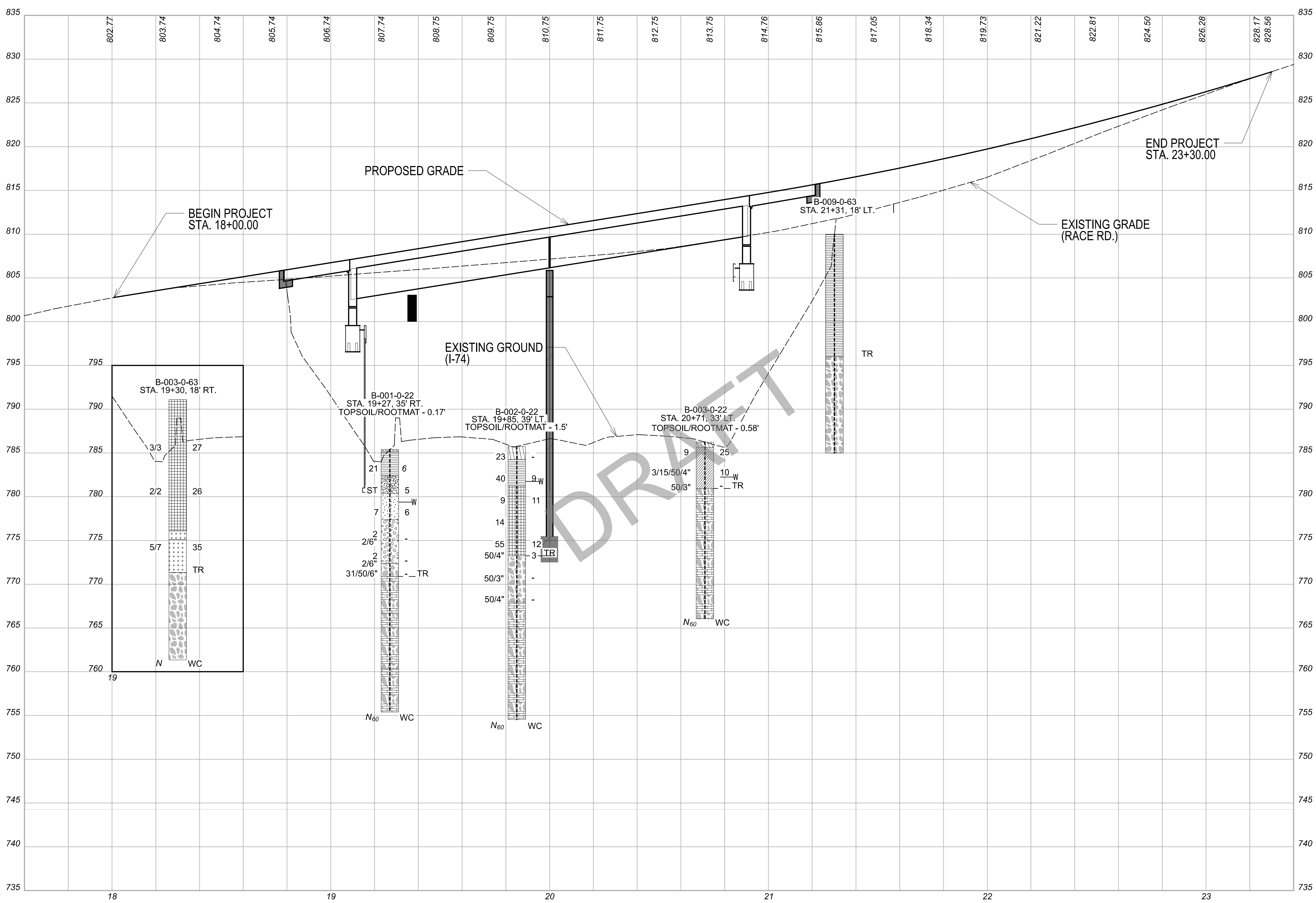

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74
STA. 18+00 TO STA. 23+30

HAM-74-13.35

MODEL: CLP_RACE_ROAD-I - Profile I PAPERSIZE: 17x11(in.) DATE: 4/5/2023 TIME: 3:02:48 PM USER: dmorales
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DESIGN AGENCY

DESIGNER	DWM
REVIEWER	BCD 01-17-23
PROJECT ID	110563
SUBSET / TOTAL	5 / 12
SHEET / TOTAL	72 / 79

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 4/5/2023 TIME: 3:03:56 PM USER: dmorales
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PROJECT:	HAM-74-13.35	DRILLING FIRM / OPERATOR:	S&ME / T. FROST	DRILL RIG:	S&ME D50 (R61)	STATION / OFFSET:	19+27, 35' RT.
TYPE:	BRIDGE REPLACEMENT	SAMPLING FIRM / LOGGER:	S&ME / M. TORRES	HAMMER:	CME AUTOMATIC	ALIGNMENT:	RACE RD CL
PID: 110563	SFN: 3108680	DRILLING METHOD:	3.25" HSA / NQ	CALIBRATION DATE:	6/7/22	ELEVATION:	786.8 (MSL) EOB: 30.0 ft.
START: 9/23/22	END: 9/23/22	SAMPLING METHOD:	SPT / NQ / ST	ENERGY RATIO (%):	69.8	LAT / LONG:	39.186380, -84.627904

EXPLORATION ID B-001-0-22
PAGE 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV. 786.8
TOPSOIL/ROOTMAT - 2 INCHES<<C>>	786.6
Hard brown SILTY CLAY, little gravel, little fine to coarse sand, damp.	783.8
Loose brown GRAVEL WITH SAND, trace silt, trace clay, damp.	781.8
Loose brown COARSE AND FINE SAND, little gravel, little clay, trace silt, damp.	778.8
Very-loose brown GRAVEL, trace fine to coarse sand, trace silt, trace clay, moist.	773.8
SHALE, gray, highly weathered, very weak, with limestone layers.	772.3
INTERBEDDED LIMESTONE (75%) AND SHALE (25%) RUN RQD (57%), RUN REC. (100%) LIMESTONE, light gray, moderately weathered, strong, very thin to thinly bedded, fossiliferous, fractured to moderately fractured. SHALE, dark gray, moderately weathered with zones of highly weathered, weak, laminated, calcareous, fractured to highly fractured. UCS = 8,986 psi at 15.8'-16.2' (Limestone)	768.1
INTERBEDDED SHALE (70%) AND LIMESTONE (30%) RUN RQD (85%), RUN REC. (100%) SHALE, dark gray, slightly weathered, weak to slightly strong, laminated, calcareous, moderately fractured. LIMESTONE, light gray, moderately to slightly weathered, strong, very thin to thinly bedded, fossiliferous. Vuggy at 20.3 feet.	761.8

DEPTHS: W 780.8; TR (at 772.3)

SPT/RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
7 9 9	21	100	SS-1	4.50	-	-	-	-	-	29	16	13	6	A-6b (V)	
ST		33	ST-2	-	49	21	17	9	4	NP	NP	NP	5	A-1-b (0)	
4 4 2	7	44	SS-3	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
1 1 1	2	0		-	-	-	-	-	-	-	-	-	-		
2	-	100	2S-4	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
1 1 1	2	0		-	-	-	-	-	-	-	-	-	-		
2	-	100	2S-5	-	-	-	-	-	-	-	-	-	-	A-1-a (V)	
31 50	-	67	SS-6	-	-	-	-	-	-	-	-	-	-	Rock (V)	
57		100	NQ-7											CORE	
92		100	NQ-8											CORE	

DRAFT

DESIGN AGENCY
DESIGNER DWM
REVIEWER BCD 01-17-23
PROJECT ID 110563
SUBSET 6 TOTAL 12
SHEET 73 TOTAL 79

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74
BORING LOG B-001-0-22

Description	Elev.		Depth	RQD		REC	Sample ID		Backfill
INTERBEDDED LIMESTONE (80%) AND SHALE (20%) RUN RQD (63%), RUN REC. (100%) LIMESTONE, light gray, slightly weathered, strong to very strong, thin to medium bedded, fossiliferous, moderately to slightly fractured. SHALE, dark gray, slightly weathered, slightly strong, laminated, calcareous.	756.8	EOB	26, 27, 28, 29, 30	63		100	NQ-9	CORE	

NOTES:
- Groundwater not encountered prior to rock coring.
- Began rock coring using NQ core barrel with water as circulating fluid at 15.0'.
- Water level at 6.0' after rock coring.
- Boring caved at 10.0' upon removal of augers.

SEE ABOVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS MIXED WITH BENTONITE

PROJECT: HAM-74-13.35	DRILLING FIRM / OPERATOR: S&ME / C. BRUMMAGE	DRILL RIG: S&ME D50 (R61)	STATION / OFFSET: 19+85, 39' LT.	EXPLORATION ID B-002-0-22
TYPE: BRIDGE REPLACEMENT	SAMPLING FIRM / LOGGER: S&ME / M. TORRES	HAMMER: CME AUTOMATIC	ALIGNMENT: RACE RD CL	
PID: 110563 SFN: 3108680	DRILLING METHOD: 3.25" HSA / NQ	CALIBRATION DATE: 6/7/22	ELEVATION: 785.3 (MSL) EOB: 31.2 ft.	PAGE 1 OF 1
START: 9/29/22 END: 9/29/22	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 69.8	LAT / LONG: 39.186573, -84.628108	

MATERIAL DESCRIPTION AND NOTES	ELEV. 785.3	DEPTHS	SPT/ RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
TOPSOIL/ROOTMAT - 18 INCHES<<C>>	783.8		7 10 10	23	67	SS-1	-	-	-	-	-	-	-	-	-	-		
Very-stiff brown SILTY CLAY, "and" gravel, some fine to coarse sand, damp.	780.8	W 781.3	7 15 19	40	44	SS-2	2.50	37	11	9	19	24	40	20	20	9	A-6b (4)	
Very-stiff brown and gray CLAY, some to little gravel, some to little fine to coarse sand, trace silt, contains limestone fragments, moist to damp.			2 4 4	9	100	SS-3	3.75	-	-	-	-	-	-	-	-	11	A-7-6 (V)	
			8 4 8	14	100	SS-4	3.75	-	-	-	-	-	-	-	-	21	A-7-6 (V)	
	772.8		8 35 12	55	100	SS-5	3.25	33	14	12	9	32	44	20	24	12	A-7-6 (5)	
SHALE, gray, highly weathered, very weak, with limestone layers.		TR	50/4"	-	100	SS-6	-	44	13	8	15	20	30	15	15	3	Rock (V)	
			50/3"	-	100	SS-7	-	-	-	-	-	-	-	-	-	-	Rock (V)	
	767.5		50/4"	-	100	SS-8	-	-	-	-	-	-	-	-	-	-	Rock (V)	

Depth scale: 1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17

DRAFT

DESIGN AGENCY	S&ME
DESIGNER	DWM
REVIEWER	BCD 01-17-23
PROJECT ID	110563
SUBSET 8	TOTAL 12
SHEET 75	TOTAL 79

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74
BORING LOG B-002-0-22

Description	Elev.		Depth	RQD		REC	Sample ID									Type
INTERBEDDED SHALE (55%) AND LIMESTONE (45%) RUN RQD (44%), RUN REC. (75%) SHALE, dark gray, highly to slightly weathered, weak to moderately strong, laminated, highly fractured. LIMESTONE, light gray, moderately weathered, moderately strong, very thin to medium bedded, fossiliferous.			18–22	19		52	NQ-9									CORE
UCS = 3,888 psi at 22.8'–23.2' (Shale)			22–29.5	50		86	NQ-10									CORE
	754.1	EOB	29.5–31	74		78	NQ-11									CORE

DRAFT

NOTES:
- Groundwater not encountered prior to rock coring.
- Began rock coring using NQ core barrel with water as circulating fluid at 18.0'.
- Water level at 4.0' after rock coring.
- Boring caved at 11.0' upon removal of augers.

NOTES: SEE ABOVE.

ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74
BORING LOG B-002-0-22 (continued)

DESIGN AGENCY

DESIGNER: DWM
REVIEWER: BCD 01-17-23
PROJECT ID: 110563
SUBSET 9 TOTAL 12

PROJECT: HAM-74-13.35	DRILLING FIRM / OPERATOR: S&ME / C. BRUMMAGE	DRILL RIG: S&ME D50 (R61)	STATION / OFFSET: 20+71, 33' LT.	EXPLORATION ID B-003-0-22
TYPE: BRIDGE REPLACEMENT	SAMPLING FIRM / LOGGER: S&ME / M. TORRES	HAMMER: CME AUTOMATIC	ALIGNMENT: RACE RD CL	
PID: 110563 SFN: 3108680	DRILLING METHOD: 3.25" HSA / NQ	CALIBRATION DATE: 6/7/22	ELEVATION: 785.2 (MSL) EOB: 20.2 ft.	PAGE 1 OF 1
START: 9/29/22 END: 9/29/22	SAMPLING METHOD: SPT / NQ	ENERGY RATIO (%): 69.8	LAT / LONG: 39.186817, -84.628081	

MATERIAL DESCRIPTION AND NOTES	ELEV. 785.2	DEPTHS	SPT/ RQD	N60	REC (%)	SAMPLE ID	HP (tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
TOPSOIL/ROOTMAT - 7 INCHES<<C>>	784.6																	
Very-stiff to hard brown and gray SILT AND CLAY, "and" gravel, little fine to coarse sand, moist to damp, with limestone floaters, slighty organic.		0–1.5	2 3 5	9	39	SS-1	2.75	-	-	-	-	-	-	-	-	25	A-6a (V)	
		2.5–3.8; W 781.2	3 15 50/4"	-	75	SS-2	2.25	44	8	5	26	17	36	21	15	10	A-6a (3)	
	779.9	5.0–5.3; TR	50/3"	-	67	SS-3	-	-	-	-	-	-	-	-	-	-	A-6a (V)	
INTERBEDDED LIMESTONE (50%) AND SHALE (50%) RUN RQD (17%), RUN REC. (88%) LIMESTONE, light gray, moderately weathered, moderately to very strong, very thin to medium bedded, fossiliferous. SHALE, dark gray, severely to moderately weathered, weak to slightly strong, laminated, highly fractured.		5.5–6.9	0		89	NQ-4											CORE	
		6.9–12.2	20		75	NQ-5											CORE	
UCS = 1,455 psi at 11.8'-12.2' (Interbedded Limestone and Shale)																		
UCS = 8,195 psi at 14.9'-15.3' (Limestone)		12.2–17.2	20		95	NQ-6											CORE	
	765.0	17.2–20.2; EOB	14		94	NQ-7											CORE	

NOTES:
- Groundwater not encountered prior to rock coring.
- Began rock coring using NQ core barrel with water as circulating fluid at 5.5'.
- Water level at 4.0' after rock coring.
- Boring caved at 9.0' upon removal of augers.

NOTES: SEE ABOVE.
ABANDONMENT METHODS, MATERIALS, QUANTITIES: SOIL CUTTINGS

DESIGN AGENCY
DESIGNER DWM
REVIEWER BCD 01-17-23
PROJECT ID 110563
SUBSET 10 TOTAL 12
SHEET 77 TOTAL 79

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74
BORING LOG B-003-0-22

DRAFT

Structure Foundation Exploration
HAM-74-13.35 Bridge Replacement (PID 110563)
Hamilton County, Ohio
S&ME Project No. 22-78-0033

Date: 9/29/2022
Photographer: BCD

1	**Boring**	B-001-0-22
	Depth	15.0 feet to 30.0 feet / Box 1 of 1

Date: 9/29/2022
Photographer: BCD

2	**Boring**	B-002-0-22
	Depth	18.0 feet to 31.2 feet / Box 1 of 1

Structure Foundation Exploration
HAM-74-13.35 Bridge Replacement (PID 110563)
Hamilton County, Ohio
S&ME Project No. 22-78-0033

Date: 9/29/2022
Photographer: BCD

3	**Boring**	B-003-0-22
	Depth	5.3 feet to 17.2 feet / Box 1 of 2

Date: 9/29/2022
Photographer: BCD

4	**Boring**	B-003-0-22
	Depth	17.2 feet to 20.2 feet / Box 2 of 2

SOIL PROFILE - BRIDGE
ROCK CORE PHOTOGRAPHS

DESIGN AGENCY

DESIGNER	DWM
REVIEWER	BCD 01-17-23
PROJECT ID	110563
SUBSET 11	TOTAL 12
SHEET 78	TOTAL 79

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 4/5/2023 TIME: 3:28:04 PM USER: dmorales
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HAM-74-13.35

MODEL: Sheet PAPERSIZE: 17x11 (in.) DATE: 4/5/2023 TIME: 3:29:07 PM USER: dmorales
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State of Ohio
Department of Highways
Testing Laboratory

LOG OF BORING

Date Started 2-7-63 Sampler Type SS Dia. 1 3/8" Water Elev. ____
Date Completed 2-7-63 Casing: Length ____ Dia. ____

Project Identification: HAMILTON
HAM-52-11.37
HAM-52-1346
RACE ROAD OVER USR 52

Boring No. B-3 Station & Offset 19+30, 18' Lt. (REAR PIER) Surface Elev. 791.1

Elev.	Depth	Std. Pen. (N)	Rec. ft	Loss ft	Description	Field No.	Lab. Nos. So	% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	SHTL Class
791.1	0															
786.1	6	3/3			Brown Gravelly Clay	1	6170	29	2	3	21	45	49	26	27	
781.1	10	2/2			Brown and Gray Gravelly Clay	2	6171	26	3	3	25	43	46	22	26	
776.1 775.1	16	5/7			Brown and Gray Clayey Silt	3	6172	0	1	2	51	46	PI=	29	35	
771.1	20		2.6	1.4	Brown Clayey Silt and limestone cobbles.											
	20				TOP OF ROCK											
	24		4.7	0.3	Shale, dark gray, fissile, firm, moderately weathered in top 3.0'; with thin, irregular limestone interbeds (gray, crystalline, fossiliferous, hard) comprising 34% of the interval. Core loss 3%.											
761.1	30		5.0	0.0												

BOTTOM OF BORING

State of Ohio
Department of Highways
Testing Laboratory

LOG OF BORING

Water Elev. ____

Date Started 2-7-63 Date Completed 2-8-63

Project Identification: HAMILTON
HAM-52-11.37
HAM-52-1346
RACE ROAD OVER USR 52

Boring No. B-9 Station & Offset 21+31, 18' Lt. (FORWARD ABUTMENT) Surface Elev. 808.8

Elev.	Depth	Rec. ft	Loss ft	Description
808.8	0			
	4	0.5	4.5	Brown Silty Clay with Limestone Boulders and Cobbles.
	8	1.8	2.2	
794.8	14	4.0	1.0	
	14			TOP OF ROCK
	18	5.0	0.0	Shale, gray, fissile, firm, calcareous, with interbedded limestone (gray, crystalline, fossiliferous, hard) comprising 50% of the interval; with soft clay seams less than 1 inch in thickness throughout. Core loss 10%.
783.8	24	3 3/4	1.6	

BOTTOM OF BORING

DRAFT

DESIGN AGENCY
DESIGNER DWM
REVIEWER BCD 01-17-23
PROJECT ID 110563
SUBSET 12 TOTAL 12
SHEET 79 TOTAL 79

SOIL PROFILE - BRIDGE
HAM-74-13.35 OVER I-74
HISTORIC BORING LOGS B-003-0-63 & B-009-0-63