Resource International, Inc.

HAM-75-7.85
HAM-75-0823
I-75 OVER LAIDLAW AVENUE
PID NO. 77889
HAMILTON COUNTY, OHIO

STRUCTURE FOUNDATION EXPLORATION REPORT

Prepared For:
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Rii Project No. B-10-020

May 2023

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ISO 9001:2015 Certified QMS
An ISO 9001:2015 QMS Certified Firm

May 17, 2023

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Columbus, Ohio 43054

Re: Structure Foundation Exploration
HAM-75-7.85
HAM-75-0823 – I-75 over Laidlaw Avenue
PID No. 77889
Rii Project No. B-10-020

Ms. Cueva:

Resource International, Inc. (Rii) is pleased to submit this structure foundation exploration report for the referenced project. Engineering logs have been prepared and are attached to this report along with the results of laboratory testing. This report includes recommendations for the proposed replacement of the HAM-75-0823 bridge carrying I-75 over Laidlaw Avenue as part of the HAM-75-7.85 project. The proposed bridge is located approximately 2.2 miles south of the Lockland Split on the north side of Cincinnati, in Hamilton County, Ohio.

We sincerely appreciate the opportunity to be of service to you on this project. If you have any questions regarding the structure foundation exploration or this report, please contact us.

Sincerely,

RESOURCE INTERNATIONAL, INC.

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Vice President – Geotechnical Planning

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Enclosure: Structure Foundation Exploration Report

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EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration performed for the HAM-75-0823 bridge structure carrying I-75 over Laidlaw Avenue. The existing structure is a three-span bridge with a total length of approximately 145 feet. It is understood that the existing structure will be completely removed and that the proposed structure will consist of a single-span bridge with semi-integral abutments supported on deep foundations consisting of driven piles behind MSE walls.

A preliminary structure foundation exploration was performed by CTL Engineering for this bridge structure replacement as part of the HAM-75-2.30 Step 7 Preliminary Engineering (PID No. 76257) and their findings are presented in the report dated December 15, 2007. No additional borings were obtained at this structure for the current exploration. Therefore, all recommendations contained herein are based on information obtained from the preliminary exploration. For a complete summary of the field operations and findings for the borings performed by CTL Engineering, please reference the December 2007 report.

Exploration and Findings

Two borings, designated as B-168-0-07 and B-169-0-07, were performed by CTL for this bridge, one on each side of the bridge structure near the proposed abutment location. The borings were advanced to depths of 110.0 and 95.0 feet below the existing ground surface, respectively, and SPT sampling was performed at a maximum of 5.0-foot intervals to obtain representative soil samples for laboratory classification testing.

In general, the borings performed by CTL encountered soft to very stiff cohesive soils generally described as brown, dark gray and gray sandy silt, silt and clay and clay (ODOT A-4a, A-6a, A-7-6) alternating with very loose to dense granular soils generally described as brown, light brown, dark brown and gray gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, fine sand and coarse and fine sand (ODOT A-1-b, A-2-4, A-2-6, A-3, A-3a). Groundwater was encountered in borings B-168 and B-169 at an elevation of 512.5 and 510.7 feet msl, respectively.

Analyses and Recommendations

Design details of the structure proposed were provided to Rii by EMH&T and JMT. It is understood that the existing three-span structure will be completely removed and replaced with a single-span prestressed I-beam structure with a reinforced concrete deck, semi-integral abutments supported on deep foundation systems comprised of driven piles and MSE walls.

Bridge Foundation Recommendations

It is recommended that a deep foundation system consisting of driven piles be employed for support of the proposed bridge foundation elements. Based on the soil encountered at this site, it is recommended that cast-in-place (CIP) pipe piles (ODOT Item 507.06) be employed for foundation support. The following table shows recommended pile lengths of CIP pipe piles and the corresponding ultimate bearing value (R_{ndr}) and LRFD reduction factors (φ).

Pile Recommendations

Boring No.	Ground Elevation [1] (feet msl)	Pile Size [2]	Elevations (feet msl)		Embedment Depth [4] (feet)	R_{ndr} [5,6] (kips/pile)	Sleeve Length [7] (feet)	φ [8]
			Top [3]	Tip				
B-168 (Rear Abutment)	541.5	16" CIP	530.5	458.8	58	240 / 355	13.7	0.70
B-169 (Forward Abutment)	544.7	16" CIP	528.8	456.5	61	234 / 329	11.3	0.70

1. *Ground elevation listed is the ground elevation at the boring location.*
2. *The pile wall thickness utilized in the analysis was determined in accordance with the equation provided in ODOT Item 507.06 and was rounded up to the nearest 1/16-inch increment.*
3. *Pile top elevation is at the proposed bottom of footing elevation.*
4. *Embedment depths represent the length of pile in contact with the soil.*
5. *The embedment depth and corresponding ultimate bearing value listed above are based on the structural loading information provided by EMH&T and JMT.*
6. *The ultimate bearing value listed does not include capacity reduction due to downdrag loads at the rear abutment. Downdrag loads and considerations are presented in Section 5.1.2 of the full report. The first value listed is the ultimate bearing value during the driven condition (immediately after driving the pile). The second value listed is the ultimate bearing value after soil setup has occurred following* ***a minimum waiting period of 7 days after the initial drive*** *(at the time of restrike on the pile). Note that the values provided are based on the static analysis performed and represent the anticipated resistance available. The design plans should list the required UBV based on the pile loading.*
7. *Sleeve length represents the required length of pile that should be sleeved within the MSE wall backfill.*
8. *The resistance factor listed assumes dynamic testing of the pile elements per Section 303.4.2.7 of the ODOT BDM. Alternate resistance factors may be applied based on the type and frequency of field testing specified.*

NOTE: The top of pile elevation coincides with the bottom of footing elevations, and the estimated pile lengths reflect exclusively the length of the pile in contact with the soil. **Embedment length of the pile into the footing is not included.** Estimated pile lengths are rounded up to the nearest foot.

The anticipated total settlement at the facing of the MSE wall at the rear and forward abutment is 3.57 and 2.99 inches, respectively. Given the anticipated amount of settlement at the MSE wall facing, downdrag loads may be induced on the pile elements if installed to the final tip elevation prior to construction of the walls. Based on the results of the settlement analysis, the time rate of consolidation to achieve 0.4 inches of total settlement is 280 and 38 days, respectively, which is well beyond a reasonable timeframe for a hold period at the rear abutment. Therefore, it is recommended that the abutments be designed to accommodate the estimated drag loads.

The depth of the neutral plane is 26.0 and 32.0 feet below the bottom of wall elevation at the rear and forward abutment, respectively, and the calculated drag load based on the depth of the neutral plane is 90 and 137 kips. Per Section 305.3.2.2 of the 2020 ODOT BDM, the factored structural axial resistance of the pile at the strength limit state shall equal or exceed the combined effect of the factored drag load and the maximum factored load per pile. Based on a maximum factored load of 226 and 224 kips/pile and a drag load of 95 and 144 kips at the rear and forward abutment, respectively, the combined factored load of 321 and 368 kips/pile at the rear and forward abutment is less than the factored structural pile resistance.

In addition to resisting the factored drag load on the piles, the bridge design will need to accommodate the anticipated soil settlement and elastic compression of the pile due to the combined structure load and drag load under service (unfactored) loading conditions within the depth to the neutral plane. Based on a combined service load of 175 and 174 kips/pile at the rear and forward abutment, respectively, the resulting elastic compression is 0.129 and 0.174 inches.

The total settlements noted in the last column in the following table will need to be accommodated in the bridge design, provided the piles are driven to the final pile tip elevation following completion of construction of the MSE wall (including placement of a surcharge up to the roadway profile grade) or specified hold period at the rear and forward abutment.

Summary of Settlement Analysis at Rear and Forward Abutment [1]

Boring No.	Duration Following Completion of Construction (days)	Settlement within Depth of Neutral Plane (inches)	Elastic Compression of Pile within Depth of Neutral Plane (inches)	Total Settlement within Depth of Neutral Plane (inches)
B-168 (Rear Abutment)	0	0.623	0.129	0.752
	30	0.172	0.129	0.301
	45	0.141	0.129	0.270
	60	0.122	0.129	0.251
	75	0.111	0.129	0.240
	90	0.101	0.129	0.230
B-169 (Forward Abutment)	0	1.239	0.174	1.413
	30	0.332	0.174	0.506
	45	0.234	0.174	0.408
	60	0.164	0.174	0.338
	75	0.121	0.174	0.295
	90	0.090	0.174	0.264

1. *The analysis assumes the placement of a surcharge load in order to preload the site under the full weight of the MSE wall height (from the bottom of wall elevation to the profile grade of the roadway).*

MSE Wall Recommendations

It is proposed to construct MSE walls at the forward and rear abutments. Based upon the proposed plan information, wall heights at the rear and forward abutments are anticipated to be 24.7 and 23.2 feet, respectively, from the top of the leveling pad to the proposed profile grade of the roadway.

Medium dense gravel and sand and coarse and fine sand (ODOT A-1-b, A-3a) were encountered at the proposed bearing elevation in borings B-168 and B-169. These soils in their current condition are adequate for structural support. However, please note that the bearing soils present at the proposed bearing elevation along the length of the abutments may vary from those encountered in the borings performed for this exploration. The entire bearing surface at each abutment location should be closely observed to verify that adequate bearing soils are present at the proposed bearing elevation.

The anticipated bearing materials at the abutment locations consist of medium dense gravel and sand (ODOT A-1-b, A-3a). MSE wall foundations bearing on these soils or engineered fill, placed and compacted as described in Section 5.4 of the full report, may be proportioned for a nominal bearing resistance as indicated in the following table. A geotechnical resistance factor of φ_b=0.65 was considered in calculating the factored nominal bearing resistance at the strength limit state. Based on the minimum length of reinforced soil mass presented in the table below and utilizing the soil parameters listed in Section 5.2.1 of the full report, the bearing pressures on the front portion of the wall **will not exceed** the factored nominal bearing resistance at the strength limit state at either of the abutments.

HAM-75-0823 MSE Wall Spread Footing Design Parameters

Boring No.	Maximum Wall Height (ft)	Minimum Reinforcement Length [1]	Nominal Bearing Resistance (ksf)		Total Settlement [3] (in)
			Service	Strength [2]	
B-168 (Rear Abutment)	24.7	0.70(H)	8.7	26.0	2.43 / 1.99
B-169 (Forward Abutment)	23.2	0.70(H)	8.3	24.9	2.05 / 1.54

1. *The minimum reinforcement length is expressed as a percentage of the wall height, H, at the respective location.*
2. *The nominal bearing resistance at the strength limit state is unfactored. Rii recommends that a resistance factor of φ_b=0.65 be considered when calculating the factored nominal bearing resistance at the strength limit state.*
3. *The first value represents the anticipated total settlement at the center of the reinforced soil mass, and the second values represents the anticipated total settlement at the facing of the wall.*

Based on the results of the external and global stability analysis performed for the MSE walls, the recommended controlling strap length is 0.7 times the maximum height of the MSE wall (measured from the top of the leveling pad to the proposed profile grade of the roadway) at the rear and forward abutments. All of the external and global stability calculations indicate that adequate resistance is available for support of the MSE walls at the rear and forward abutments for a strap length equal to 70 percent of the wall height.

Please note that this executive summary does not contain all the information presented in the report. The unabridged subsurface exploration report should be read in its entirety to obtain a more complete understanding of the information presented.

1.0 INTRODUCTION

The overall purpose of this project is to provide detailed subsurface information and recommendations for the design and construction of the HAM-75-7.85 project in Hamilton County, Ohio. This project represents the northern portion of HAM-75-2.30 Mill Creek Expressway improvements. The overall project will consist of roadway improvements, and several retaining wall and bridge replacements along I-75 from Vine Street to State Route 126. The project site is located in the community limits of St. Bernard, Elmwood Place, Roselawn, and Cincinnati, in Hamilton County, Ohio.

This report is a presentation of the structure foundation exploration performed for the HAM-75-0823 bridge structure carrying I-75 over Laidlaw Avenue, as shown on the vicinity map and boring plan presented in Appendix II. The existing structure is a three-span bridge with a total length of approximately 145 feet. It is understood that the existing structure will be completely removed and that the proposed structure will consist of a single-span bridge with semi-integral abutments supported on deep foundations consisting of driven piles and MSE walls embankments.

A preliminary structure foundation exploration was performed by CTL Engineering for this bridge structure replacement as part of the HAM-75-2.30 Step 7 Preliminary Engineering (PID No. 76257) and their findings are presented in the report dated December 15, 2007. No additional borings were obtained at this structure for the current exploration. Therefore, all recommendations contained herein are based on information obtained from the preliminary exploration. For a complete summary of the field operations and findings for the borings performed by CTL Engineering, please reference the December 2007 report.

2.0 GEOLOGY AND OBSERVATIONS OF THE PROJECT

2.1 Site Geology

Both the Illinoian and Wisconsinan glaciers advanced over two-thirds of the State of Ohio, leaving behind glacial features such as moraines, kame deposits, lacustrine deposits and outwash terraces. The glacial and non-glacial regions comprise five physiographic sections grouped by age, depositional process and geomorphic occurrence. Physiographically, the site lies within the Illinoian Till Plain of the Till Plains Section. This area is characterized by rolling ground moraine deposits with many buried valleys alternating between broad floodplains and bedrock gorges. The project area contains silty loam till deposited as ground moraine covered with loess and dissected by the modern day Mill Creek. Ground moraines are deposited during the retreat of a glacier which results in an undifferentiated mixture of clay, silt, sand and gravel. The valley area also contains outwash and alluvium which eroded from hills and valleys with moderate relief. Outwash deposits consist of undifferentiated sand and gravel deposited by meltwater in front of glacial ice and often occurs as valley terraces or low plains.

Alluvium and alluvial terrace deposits range in composition from silty clay size particles to cobbles, usually deposited in present and former floodplain areas.

Based on bedrock geology and topography maps of the area, the underlying bedrock consists of the Ordovician-aged Point Pleasant Formation. The Point Pleasant Formation is comprised of interbedded limestone and shale, averaging 60 percent limestone and 40 percent shale, and ranges from 0 to 80 feet thick. The bedrock surface forms a valley, roughly beneath and following the alignment of Mill Creek, which is aligned northeast-to-southwest. I-75 roughly follows parallel to this bedrock valley approximately from State Route 126 to Laidlaw Avenue, and lies just east of the bottom of the valley. In this area, the bedrock surface directly beneath I-75 is positioned along the slope of the bedrock valley, with the top of bedrock ranging between approximate elevations of 375 to 425 feet msl. Overall, the bedrock surface slopes down to the west beneath the bridge site. According to bedrock topography mapping, the bedrock surface in the vicinity of the structure is approximately 130 feet below existing grade. An illustration of the general geology of Ohio is presented in Appendix I.

2.2 Existing Conditions

The site for the proposed HAM-75-0823 structure is located at the existing overpass of I-75 over Laidlaw Avenue, approximately 2.2 miles south of the Lockland Split. The existing structure is a three-span bridge that is approximately 120 feet wide and 145 feet long and carries both the northbound and southbound traffic for I-75 over Laidlaw Avenue. I-75 at the existing structure location is a seven-lane, asphalt paved roadway with no interchange ramps between I-75 and Laidlaw Avenue. Laidlaw Avenue is aligned east-to-west and extends east to the intersection with Matlock Avenue. West of the structure, the roadway is named Murray Road. The existing Laidlaw Avenue roadway is a two-lane, asphalt paved roadway with parking lanes on both sides that traverses residential and commercial properties.

3.0 EXPLORATION

A preliminary geotechnical exploration was performed within this project study area by CTL Engineering for the HAM-75-2.30 project (PID No. 76257). Their findings were published in a report dated December 15, 2007. Two borings, designated as B-168-0-07 and B-169-0-07, were performed by CTL for this bridge, one on each side of the bridge structure near the proposed abutment location. The borings were advanced to depths of 110.0 and 95.0 feet below the existing ground surface, respectively, and SPT sampling was performed at a maximum of 5.0-foot intervals to obtain representative soil samples for laboratory classification testing. Rii has included a plan showing the location of the soil borings performed in the project area in Appendix II.

An automatic drop hammer was utilized by CTL Engineering to generate consistent energy transfer to the sampler. The driving resistance is presented on the boring logs in terms of blows per 6.0-inch interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). For SPT testing conducted using an automatic drop hammer, the measured blow count (N) values are corrected to an equivalent (60%) energy ratio, N_{60}, by the following equation.

$$N_{60} = N_m*(ER/60)$$

Where:
N_m = measured N value
ER = drill rod energy ratio, expressed as a percent, for the system used

No calibration data is available for the hammer used during the SPT testing at the time these borings were performed. Therefore, an estimated drill rod energy ratio of 80 percent was utilized to determine the energy corrected blow counts.

4.0 FINDINGS

In general, the borings performed by CTL encountered soft to very stiff cohesive soils generally described as brown, dark gray and gray sandy silt, silt and clay and clay (ODOT A-4a, A-6a, A-7-6) alternating with very loose to dense granular soils generally described as brown, light brown, dark brown and gray gravel and sand, gravel with sand and silt, gravel with sand, silt and clay, fine sand and coarse and fine sand (ODOT A-1-b, A-2-4, A-2-6, A-3, A-3a). Groundwater was encountered in borings B-168 and B-169 at an elevation of 512.5 and 510.7 feet msl, respectively.

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from the drilling and testing program have been used to determine foundation support capabilities and the settlement potential for the soil encountered at the site. These parameters have been used to provide guidelines for the design of the structure foundation systems, as well as the construction specifications related to the placement of foundation systems and general earthwork recommendations, which are discussed in the following paragraphs.

Design details of the structure proposed were provided to Rii by EMH&T and JMT. It is understood that the existing three-span structure will be completely removed and replaced with a single-span prestressed I-beam structure with a reinforced concrete deck, semi-integral abutments supported on deep foundation systems comprised of driven piles and MSE walls.

Proposed structural data was obtained from design details provided by EMH&T and are included in Table 1:

Table 1. Structure and Bridge Design Elevations

Reference	Structure Component	Elevation (feet) [1]
Rear Abutment	Profile Grade	542.0
	Bottom of Footing	530.5
	Bottom of Wall (Leveling Pad)	516.8
Forward Abutment	Profile Grade	540.5
	Bottom of Footing	528.8
	Bottom of Wall (Leveling Pad)	517.5

1. Elevations based on structure information provided by EMH&T and JMT.

In addition to the design elevations, proposed structural loading information was provided by EMH&T for each substructure unit and are included in Table 2:

Table 2. Structural Loading Details

Substructure Reference	Maximum Service Load (kips/pile)	Maximum Factored Load (kips/pile)	Required R_{ndr} per Pile [1] (kips/pile)
Rear Abutment	175	226	323
Forward Abutment	174	225	322

1. Required R_{ndr} based on a resistance factor of 0.7.

5.1 Deep Foundation Recommendations

It is recommended that a deep foundation system consisting of driven piles be employed for support of the proposed bridge foundation elements. Based on the soil encountered at this site, it is recommended that cast-in-place (CIP) pipe piles (ODOT Item 507.06) be employed for foundation support. Table 3 shows recommended pile lengths of CIP pipe piles and the corresponding ultimate bearing value (R_{ndr}) and LRFD reduction factors (φ).

Table 3. Pile Recommendations

Boring No.	Ground Elevation [1] (feet msl)	Pile Size [2]	Elevations (feet msl)		Embedment Depth [4] (feet)	R_{ndr} [5,6] (kips/pile)	Sleeve Length [7] (feet)	φ [8]
			Top [3]	Tip				
B-168 (Rear Abutment)	541.5	16" CIP	530.5	458.8	58	240 / 355	13.7	0.70
B-169 (Forward Abutment)	544.7	16" CIP	528.8	456.5	61	234 / 329	11.3	0.70

1. *Ground elevation listed is the ground elevation at the boring location.*
2. *The pile wall thickness utilized in the analysis was determined in accordance with the equation provided in ODOT Item 507.06 and was rounded up to the nearest 1/16-inch increment.*
3. *Pile top elevation is at the proposed bottom of footing elevation.*
4. *Embedment depths represent the length of pile in contact with the soil.*
5. *The embedment depth and corresponding ultimate bearing value listed above are based on the structural loading information provided by EMH&T and JMT.*
6. *The ultimate bearing value listed does not include capacity reduction due to downdrag loads at the rear abutment. Downdrag loads and considerations are presented in Section 5.1.2. The first value listed is the ultimate bearing value during the driven condition (immediately after driving the pile). The second value listed is the ultimate bearing value after soil setup has occurred following* ***a minimum waiting period of 7 days after the initial drive*** *(at the time of restrike on the pile). Note that the values provided are based on the static analysis performed and represent the anticipated resistance available. The design plans should list the required UBV based on the pile loading.*
7. *Sleeve length represents the required length of pile that should be sleeved within the MSE wall backfill.*
8. *The resistance factor listed assumes dynamic testing of the pile elements per Section 303.4.2.7 of the ODOT BDM. Alternate resistance factors may be applied based on the type and frequency of field testing specified.*

NOTE: The top of pile elevation coincides with the bottom of footing elevations, and the estimated pile lengths reflect exclusively the length of the pile in contact with the soil. **Embedment length of the pile into the footing is not included.** Estimated pile lengths are rounded up to the nearest foot.

The piles were analyzed utilizing the DRIVEN software (Appendix V). The ultimate bearing values listed represent the calculated ultimate bearing value at the end of driving the pile (driven condition) and after soil setup has occurred following a specified waiting period (at restrike), respectively. If it is not intended to verify the pile capacity after a specified waiting period has passed through dynamic testing (restrike of the driven pile), then the ultimate bearing value for the driven condition should be specified in the design documents and utilized in the foundation design. If a dynamic restrike of the pile is specified, then the ultimate bearing value at restrike should be specified in the design documents and utilized in the foundation design. Based on the subsurface conditions encountered, it is recommended that a minimum hold period of seven (7) days be specified between the end of driving the pile and the time of restrike to allow

adequate soil setup to occur. However, given the high plasticity of the cohesive material encountered in boring B-168, a longer hold period may be required if the full capacity provided above is not achieved at the end of the initial seven day hold period. If the capacity specified at restrike is not achieved, then consideration should be given to performing a second restrike of the test pile after an additional seven (7) day hold period (total of fourteen (14) days from the end of initial drive). Note that the values provided in Table 3 are based on the static analysis performed and represent the anticipated resistance available. The design plans should list the required UBV based on the pile loading. Settlement is estimated to be less than 1.0 inch for piles driven to frictional capacity.

A drivability analysis in accordance with Section 10.7.8 of the 2010 AASHTO LRFD Bridge Design Specifications (BDS) was also performed using the GRLWEAP program, and results of this analysis are presented in Section 5.1.1 of this report. Please note that the embedment depth and corresponding ultimate bearing value for CIP piles presented in Table 3 were determined based on the required factored resistance for the proposed structural loading at each substructure unit provided by EMH&T and JMT. The minimum wall thickness utilized in the driveability analysis for CIP piles was determined from the following equation per ODOT Item 507.06 for the ultimate bearing values listed in Table 3.

$$t = UBV / 900{,}000$$

Where:
t = pile wall thickness in inches
UBV = design ultimate bearing value in pounds

We emphasize that the pile lengths and ultimate bearing values presented in Table 3 are estimates using empirical equations based on the derived characteristics of the soils encountered in the subject borings drilled. The most accurate method for determining pile capacities and lengths is to drive test piling at the site and perform static load testing in accordance with the ASTM D1143 procedure. Dynamic pile load testing should be performed in accordance with ASTM D4945. The actual pile capacities should be verified using static or dynamic pile load testing as detailed in the 2007 ODOT Bridge Design Manual (BDM). Further installation considerations are presented in Section 0.

The geotechnical resistance factor listed in Table 3 represents the recommended value based on the performance of a minimum of two dynamic pile load tests at the site as specified in Section 303.4.2.7 of the 2007 ODOT BDM. A higher resistance factor may be utilized if alternate or additional field load testing of the pile elements is performed. The 2010 AASHTO LRFD BDS provides alternate resistance factors for use in design based on the type and frequency of field load testing. Figure 1 presents the various testing types and frequency of testing, and lists the corresponding resistance factor that may be selected. ***If no field load testing of the piles (static or dynamic) is performed, then a geotechnical resistance factor of 0.35 should be used for design.*** Based on the similar subsurface soils encountered in each of the borings, it is recommended that the entire site be considered as a single site condition.

Figure 1: AASHTO Resistance Factors for Driven Pile Foundations

Table 10.5.5.2.3-1—Resistance Factors for Driven Piles

Condition/Resistance Determination Method		Resistance Factor
Nominal Bearing Resistance of Single Pile—Dynamic Analysis and Static Load Test Methods, φ_{dyn}	Driving criteria established by successful static load test of at least one pile per site condition and dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.80
	Driving criteria established by successful static load test of at least one pile per site condition without dynamic testing	0.75
	Driving criteria established by dynamic testing* conducted on 100% of production piles	0.75
	Driving criteria established by dynamic testing,* quality control by dynamic testing* of at least two piles per site condition, but no less than 2% of the production piles	0.65
	Wave equation analysis, without pile dynamic measurements or load test but with field confirmation of hammer performance	0.50
	FHWA-modified Gates dynamic pile formula (End of Drive condition only)	0.40
	Engineering News (as defined in Article 10.7.3.8.5) dynamic pile formula (End of Drive condition only)	0.10

* Dynamic testing requires signal matching, and best estimates of nominal resistance are made from a restrike. Dynamic tests are calibrated to the static load test, when available.

5.1.1 Drivability

Rii performed a drivability analysis using GRLWEAP (Appendix VI). In the drivability analysis, a Delmag 19-42 hammer with a rated energy of approximately 43,000 ft-lbs was used in conjunction with the CIP pipe pile sections. Based on the results of this analysis using a wall thickness as determined from ODOT Item 507.06, it appears that the driving stresses induced on the CIP pipe piles **would not exceed** 90 percent of the yield stress for A252, Grade 2 steel (f_y = 35 ksi, 0.9f_y = 31.5 ksi) if driven to the depths provided in Table 3. Please note that the required pile wall thickness was determined using the equation provided in ODOT Item 507.06, and that the pile wall thickness utilized in the driveability analysis was rounded up to the near 1/16-inch increment unless otherwise noted in Table 3.

Actual driving conditions during pile installation may differ from the conditions predicted in the analysis. It is recommended that test piles be installed at both abutments locations at both the east and west ends of the abutment to verify that the driving conditions predicted will be valid for all of the piles installed along the length of the abutments.

5.1.2 Downdrag Forces

The anticipated total settlement at the facing of the MSE wall at the rear and forward abutment is 3.57 and 2.99 inches, respectively. Given the anticipated amount of settlement at the MSE wall facing, downdrag loads may be induced on the pile elements if installed to the final tip elevation prior to construction of the walls. To reduce the amount of downdrag induced on the piles, it is recommended that the piles be pre-driven into the soil only as far as necessary to remain vertical, and that the MSE walls should be constructed around the piles and then allowed to sit for a specified holding period such that settlement of the underlying foundation soils can occur prior to driving the piles the to the design tip elevation and reduce or eliminate the amount of downdrag on the piles. Downdrag loads will fully develop when then relative movement of the soil surrounding the piles exceeds 0.4 inches. Per Section 305.3.2.2 of the 2020 ODOT BDM, downdrag should be evaluated using the neutral plane method as outlined in Section 7.3.5.7 and 7.3.6.1 of FHWA Geotechnical Engineering Circular 12 (GEC 12) “Design and Construction of Driven Pile Foundations” (FHWA-NHI-16-009/010). Per the neutral plane methodology, drag loads will develop along the length of the pile above the neutral plane.

Based on the results of the settlement analysis, the time rate of consolidation to achieve 0.4 inches of total settlement at the rear and forward abutment is 280 and 38 days, respectively, which is well beyond a reasonable timeframe for a hold period. Therefore, the abutments will need to be designed to accommodate the estimated drag load. Figure 2 and Figure 3 are plots of the axial load and resistance based on the bearing resistance from the DRIVEN analysis included in Appendix V and service load on the piles of 175 and 174 kips, respectively, at the rear and forward abutment, which indicates the neutral plane depth below the bottom of footing based on fully mobilized toe resistance in accordance with Section 305.3.2.2 of the 2020 ODOT BDM.

Figure 2. Axial Load and Resistance Graph – Rear Abutment

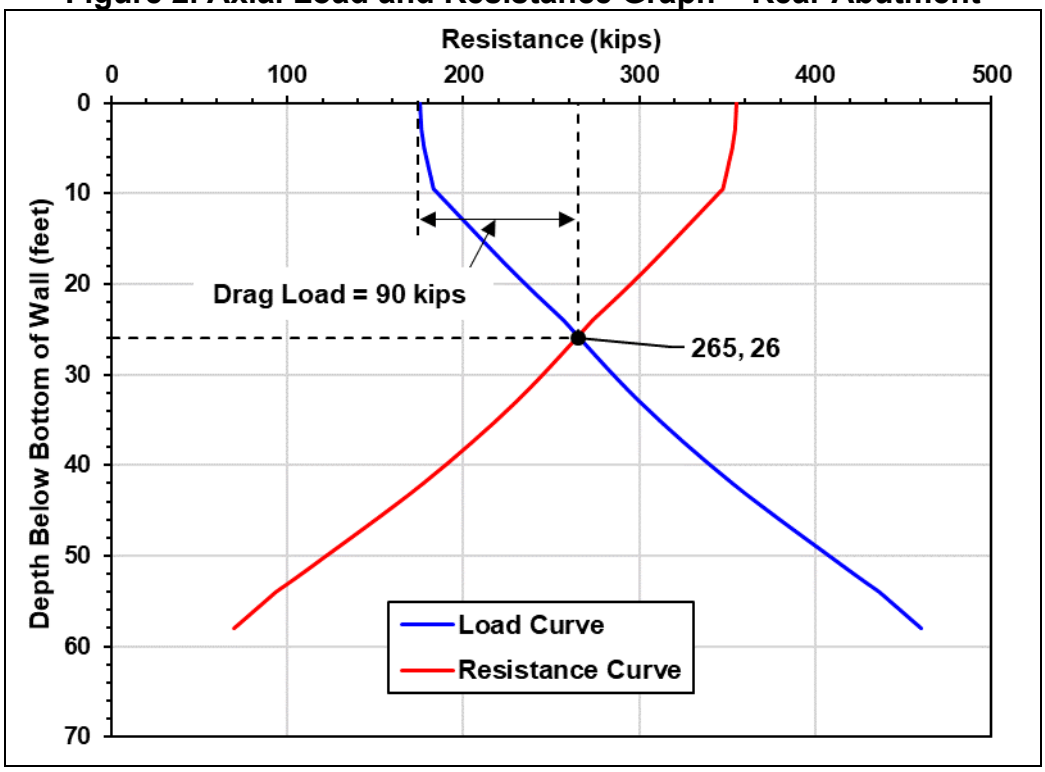
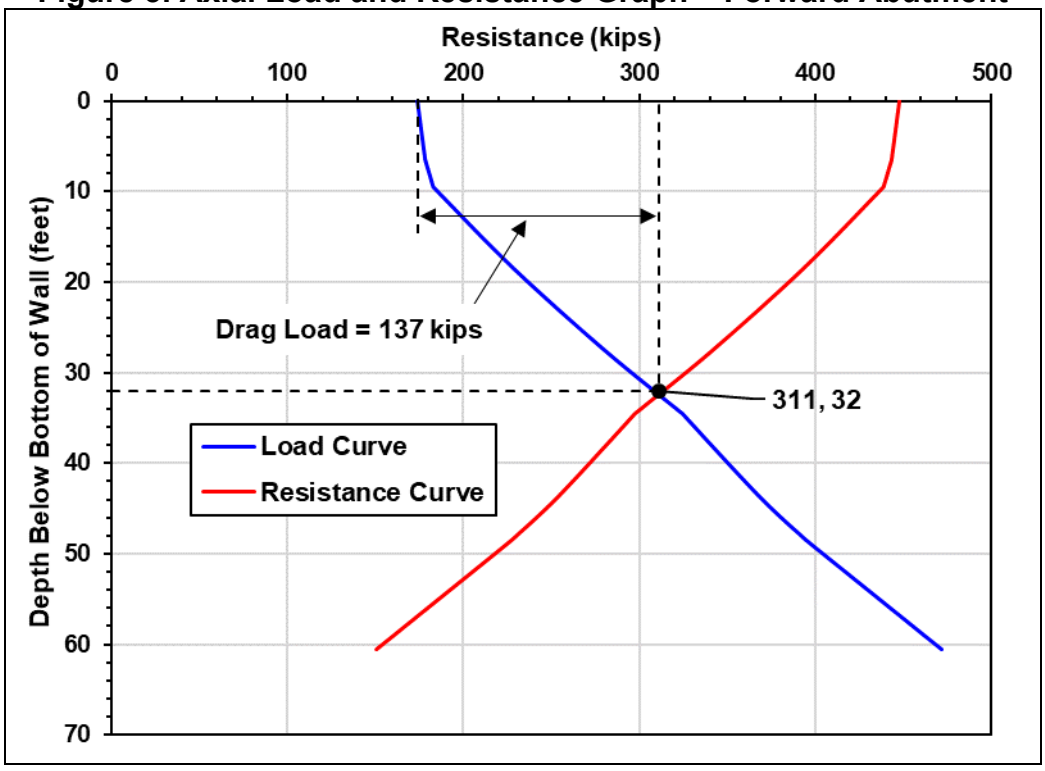


Figure 3. Axial Load and Resistance Graph – Forward Abutment



Based on the results of the bearing plots, the depth of the neutral plane is 26.0 and 32.0 feet below the bottom of wall elevation at the rear and forward abutment, respectively, and the calculated drag load based on the depth of the neutral plane is 90 and 137 kips.

Per Section 305.3.2.2 of the 2020 ODOT BDM, the factored structural axial resistance of the pile at the strength limit state shall equal or exceed the combined effect of the factored drag load and the maximum factored load per pile. For piles subject to downdrag loads, the factored structural resistance of the pile shall consider a resistance factor of 0.7, which results in a factored structural resistance of 886 kips for a 16-inch pipe pile with a pile wall thickness of 0.375 (3/8) inches. A load factor of 1.05 should be applied to the unfactored downdrag load when determining the factored downdrag load per pile at the strength limit state and should be added to the factored load per pile from the superstructure. Based on a maximum factored load of 226 and 224 kips/pile and a drag load of 95 and 144 kips at the rear and forward abutment, respectively, the combined factored load of 321 and 368 kips/pile at the rear and forward abutment is less than the factored structural pile resistance.

In addition to resisting the factored drag load on the piles, the bridge design will need to accommodate the anticipated soil settlement and elastic compression of the pile due to the combined structure load and drag load under service (unfactored) loading conditions within the depth to the neutral plane. For the elastic compression of the pile, since the drag load increases with depth from 0 kips at the top of the pile and bottom of wall elevation to the maximum drag load at the depth of the neutral plane, the average drag load was used in the calculation. Based on a combined service load of 175 and 174 kips/pile at the rear and forward abutment, respectively, the resulting elastic compression is 0.129 and 0.174 inches.

For the soil settlement within the depth of the neutral plane, consideration can be given to either driving the piles to the design pile tip elevation immediately following construction of the MSE wall, or a hold period can be specified following the completion of construction to drive the piles to the required pile tip elevation in an effort to reduce the amount of settlement that will need to be accommodated within the depth of the neutral plane. In order to consolidate the underlying soil to the required settlement, consideration should be given to the placement of a surcharge load in order to preload the site under the full weight of the MSE wall height (from the bottom of wall elevation to the profile grade of the roadway) and left in place until the end of the specified hold period in order to reduce the settlement along the pile length to the neutral plane.

To determine the estimated settlement remaining following completion of a specified hold period, the time rate of settlement will need to be evaluated. The remaining settlement will depend on the degree of consolidation, which represents the amount of primary consolidation that has occurred during the hold period expressed as a percentage of the total settlement that is anticipated and is calculated using the following equations:

$$U = \sqrt{\frac{4T_v}{\pi}} \times 100\% \text{ for } T_v \leq 0.217;$$

$$U = \left[1 + 10^{-\left(\frac{0.085+T_v}{0.933}\right)}\right] \times 100\% \text{ for } T_v > 0.217;$$

$$T_v = \frac{c_v t}{H_{dr}^{\ 2}}$$

Where:

U = the degree of consolidation
T_v = time factor
c_v = coefficient of consolidation
t = hold period
H_{dr} = length of longest drainage path (half the thickness of the compressible stratum)

Results of the settlement analysis and time rate of consolidation at the rear abutment are summarized in Table 4 below. The total settlements noted in the last column in Table 4 will need to be accommodated in the bridge design, provided the piles are driven to the final pile tip elevation following completion of construction of the MSE wall (including placement of a surcharge up to the roadway profile grade, as outlined in the previous paragraph) or specified hold period at the rear abutment.

Table 4. Summary of Settlement Analysis at Rear and Forward Abutment [1]

Boring No.	Duration Following Completion of Construction (days)	Settlement within Depth of Neutral Plane (inches)	Elastic Compression of Pile within Depth of Neutral Plane (inches)	Total Settlement within Depth of Neutral Plane (inches)
B-168 (Rear Abutment)	0	0.623	0.129	0.752
	30	0.172	0.129	0.301
	45	0.141	0.129	0.270
	60	0.122	0.129	0.251
	75	0.111	0.129	0.240
	90	0.101	0.129	0.230
B-169 (Forward Abutment)	0	1.239	0.174	1.413
	30	0.332	0.174	0.506
	45	0.234	0.174	0.408
	60	0.164	0.174	0.338
	75	0.121	0.174	0.295
	90	0.090	0.174	0.264

1. *The analysis assumes the placement of a surcharge load in order to preload the site under the full weight of the MSE wall height (from the bottom of wall elevation to the profile grade of the roadway).*

It is recommended to install settlement platforms within the MSE wall mass at each abutment as close to the abutment footing as possible, with a minimum of one (1) settlement platform installed for each phase of construction. Settlement platforms should be installed once the embankment surcharge has been placed to monitor the settlement of the embankment over time. A shorter or longer hold period than specified may be required based on the settlement platform readings as directed by the geotechnical engineer.

5.1.3 Driven Pile Considerations

Proper pile installation is as important as pile design in order to obtain a cost effective and safe product. Driven piles must be installed to develop adequate soil resistance without structural damage. Because piles cannot be visually inspected after installation, direct quality control of the finished product is impossible. Consequently, substantial control must be exercised over peripheral operations leading to the pile placement within the foundation. It is essential that installation be considered during the design stage to insure that piles shown on the plans can be installed. Construction monitoring should be employed in (1) pile materials, (2) installation equipment, and (3) the estimation of the static load capacity.

It is recommended that the contractor submit a wave equation analysis (bearing graph) of his driving equipment, or the necessary pile driving and equipment data to perform the wave equation analysis, for hammer approval. A constant capacity wave equation analysis (inspector's chart) should also be performed to assist field personnel during inspection in accordance with the 2007 ODOT BDM.

5.2 MSE Wall Recommendations

It is proposed to construct MSE walls at the forward and rear abutments. MSE walls are constructed on earthen foundations at a minimum depth of 3.0 feet below grade, as defined by the top of the leveling pad to the ground surface located 4.0 feet from the face of the wall. Note that the reinforced soil mass extends from the foundation bearing elevation to the profile grade of the roadway. The width of the MSE wall foundation (B) is defined by the length of the reinforced soil mass. Per the ODOT BDM (October 2007) and Supplemental Specification (SS) 840, the minimum length of the reinforced soil mass is equal to 70 percent of the height of the MSE wall or 8.0 feet whichever is greater. A non-structural bearing leveling pad consisting of a minimum of 6.0-inches of unreinforced concrete should be placed at the base of the wall facing for constructability purposes. Please note that the leveling pad is not a structural foundation.

Based upon the proposed plan information, wall heights at the rear and forward abutments are anticipated to be 24.7 and 23.2 feet, respectively, from the top of the leveling pad to the proposed profile grade of the roadway. Therefore, it is considered that the minimum reinforcement length and the effective foundation width (B) of the rear and forward abutment MSE walls for external and global stability calculations will be 17.3 and 16.2 feet respectively. For the analysis, the foundation width was set at 70 percent of the wall height and the foundation width was increased, if required, until external and global stability requirements were satisfied.

It is recommended that the foundation subgrade (beneath the reinforced soil mass) for the MSE wall be critically proof-rolled and stabilized to create a workable subgrade for the MSE wall reinforced soil mass. Unstable soils, primarily those containing silt (A-4a/A-4b), if encountered, may be stabilized as noted below:

- Undercut 24 inches +/- pending results of proof-roll;
- Place ODOT Item 712.09 Type D Geotextile Fabric;
- Placement of 24 inches of 703. 02A Granular Fill.

Please note that this recommendation for stabilization of unsuitable soils, as identified during the proof roll of the subgrade, are in addition to the foundation preparation measures provided in ODOT SS 840.

Medium dense gravel and sand and coarse and fine sand (ODOT A-1-b, A-3a) were encountered at the proposed bearing elevation in borings B-168 and B-169. These soils in their current condition are adequate for structural support. However, please note that the bearing soils present at the proposed bearing elevation along the length of the abutments may vary from those encountered in the borings performed for this exploration. The entire bearing surface at each abutment location should be closely observed to verify that adequate bearing soils are present at the proposed bearing elevation.

Per ODOT SS 840, following foundation subgrade inspection and acceptance, a geotextile fabric should be placed on the subgrade soil and a minimum of 12.0 inches of ODOT Item 703.16.C, Granular Material Type C, should be placed on top of the geotextile fabric and compacted in accordance with ODOT Item 204.07.

5.2.1 Strength Parameters Utilized in External and Global Stability Analyses

The shear strength parameters utilized in the external and global stability analyses for the MSE walls at the abutments are provided in Table 5.

Table 5. Shear Strength Parameters Utilized in Stability Analyses

Material Type	Unit Weight, γ (pcf)	Effective Friction Angle, φ' (°)	Effective Cohesion, c' (psf)	Undrained Shear Strength, S_u (psf)
MSE Wall Backfill (Select granular fill)	120	34	0	N/A
Embankment Fill (Fill material derived from onsite soils)	125	30	400	1,700
Stiff to Very Stiff Silt and Clay (ODOT A-6a) [1]	115 to 120	27	235	1,750 to 2,500
Stiff to Very Stiff Clay (ODOT A-7-6) [2]	115 to 120	21	0	1,750 to 2,750
Granular Soils (ODOT A-1-b, A-2-4, A-3, A-3a)	125 to 130	29 to 35	0	N/A

1. *Based on laboratory consolidated undrained triaxial testing performed on an undisturbed sample from boring B-016-0-11.*
2. *Based on laboratory consolidated undrained triaxial testing performed on an undisturbed samples from the HAM-75-12.60 Part I project*

Shear strength parameters for the reinforced soil backfill are provided in ODOT SS 840. Per SS 840, the select granular backfill in the reinforced zone must meet the shear strength requirements provided in Table 5. Shear strength parameters for new embankment fill were determined using ODOT Geotechnical Bulletin 6 (GB-6) as a guide. The shear strength parameters for the embankment fill listed in Table 5 above are the limiting values based on the assumption that the embankment fill utilized will consist of silt and clay, sandy silt (ODOT A-6a, A-4a) or granular material.

The long term shear strength parameters (drained/effective stress) for the natural cohesive soils were determined from consolidated undrained (CU) triaxial compression tests performed on undisturbed samples from boring B-016-0-11, performed by Rii for Retaining Wall H, and from CU triaxial compression tests performed on undisturbed samples from the HAM-75-12.60 project that is adjacent to this project location to the north. The undrained shear strength for the cohesive soils is based on indirect correlations with SPT blow counts of the soil. The friction angle for the natural granular soils encountered was determined based on correlations with the N-value from the SPT testing of the soil. The laboratory test results referenced above are provided in Appendix IV.

5.2.2 Bearing Stability

The anticipated bearing materials at the abutment locations consist of medium dense gravel and sand (ODOT A-1-b, A-3a). MSE wall foundations bearing on these soils or engineered fill, placed and compacted as described in Section 5.4, may be proportioned for a nominal bearing resistance as indicated in Table 6. A geotechnical resistance factor of φ_b=0.65 was considered in calculating the factored nominal bearing resistance at the strength limit state. The reinforcement lengths presented in the following table represent the minimum foundation widths required to satisfy external and global stability requirements, expressed as a percentage of the wall height.

Table 6. HAM-75-0823 MSE Wall Spread Footing Design Parameters

Boring No.	Maximum Wall Height (ft)	Minimum Reinforcement Length [1]	Nominal Bearing Resistance (ksf)		Total Settlement [3] (in)
			Service	Strength [2]	
B-168 (Rear Abutment)	24.7	0.70(H)	8.7	26.0	2.43 / 1.99
B-169 (Forward Abutment)	23.2	0.70(H)	8.3	24.9	2.05 / 1.54

1. *The minimum reinforcement length is expressed as a percentage of the wall height, H, at the respective location.*
2. *The nominal bearing resistance at the strength limit state is unfactored. Rii recommends that a resistance factor of φ_b=0.65 be considered when calculating the factored nominal bearing resistance at the strength limit state.*
3. *The first value represents the anticipated total settlement at the center of the reinforced soil mass, and the second values represents the anticipated total settlement at the facing of the wall.*

Rii performed a verification of the bearing pressure exerted on the subgrade soils for the maximum specified wall heights indicated in Table 6. Based on the minimum length of reinforced soil mass presented in Table 6 and utilizing the soil parameters listed in Section 5.2.1, the bearing pressures on the front portion of the wall **will not exceed** the factored nominal bearing resistance at the strength limit state at either of the abutments.

Based on profile information provided by EMH&T and JMT, it is anticipated that approximately 6.0 feet of cut will be required achieve the proposed bottom of wall elevation at both abutments. Therefore, the net embankment height (embankment height above existing grade up to the proposed profile grade) considered in the settlement calculations at the rear and forward abutment is 19.0 and 17.5 feet, respectively.

Per Section 204.6.2.1 of the ODOT BDM, “the maximum allowable differential settlement in the longitudinal direction (regardless of the size of panels) is one (1) percent.” Based on the total anticipated settlement at the facing of the wall, maximum differential settlement in the longitudinal direction is anticipated to be 1/250, which is within the tolerable limit of 1/100. If either the total or differential settlement predicted presents an issue with respect to the deformation tolerances that the walls can withstand, then measures should be taken to minimize the amount of settlement that will occur. This can be achieved by preloading the site and consolidating the underlying soils prior to constructing the wall.

Settlement calculations are provided in Appendix VII and consolidation test results are provided in Appendix IV.

5.2.3 Eccentricity (Overturning Stability)

The resistance of the MSE wall to overturning will be dependent on the on the location of the resultant force at the bottom of the wall due to the overturning and resisting moments acting on the wall. For MSE walls, overturning stability is determined by calculating the eccentricity of the resultant force from the midpoint of the base of the wall and comparing this value to a limiting eccentricity value. Per Section 11.10.5.5 of the 2010 AASHTO LRFD BDS, for foundations bearing on soil or bedrock, the location of the resultant of the reaction forces shall be within the middle one-half of the base width. Therefore, the limiting eccentricity is one-fourth of the base width of the wall. Rii performed a verification of the eccentricity of the resultant force for the maximum specified wall heights indicated in Table 6. Based on the minimum length of reinforced soil mass presented in Table 6 and utilizing the soil parameters listed in Section 5.2.1 for the retained embankment material, the calculated eccentricity of the resultant force **will not exceed** the limiting eccentricity at the strength limit state.

5.2.4 Sliding Stability

The resistance of the MSE walls to sliding will be dependent on the friction between the reinforced soil backfill and bearing soils per Section 11.10.5.3 of the 2010 AASHTO LRFD BDS. For MSE walls, sliding resistance is determined by multiplying a coefficient of sliding friction “f” times the total vertical force at the base of the wall. The coefficient of sliding friction is determined based on the limiting friction angle between the foundation soil and the reinforced soil backfill. Based on the soil parameters listed in Section 5.2.1 for the foundation and retained material, a coefficient of sliding friction of 0.55 was utilized for design at the rear and forward abutments. A geotechnical resistance factor of φ_τ=1.0 was considered when calculating the factored shear resistance between the soil and foundation for sliding. Based on the minimum length of reinforced soil mass presented in Table 6 and utilizing the soil parameters listed in Section 5.2.1 for the retained embankment material, the resultant horizontal forces on the back of the MSE wall **will not exceed** the factored shear resistance at the strength limit state.

5.2.5 Overall (Global) Stability

A slope stability analysis was performed to check the global stability of the wall. As per AASHTO LRFD BDS, safety against soil failure shall be evaluated at the service limit state by assuming the reinforced soil mass to be a rigid body. Soil parameters utilized in external stability analyses are presented in Section 5.2.1. For the global stability condition, it was considered that the failure plane will not cross through the reinforced soil mass.

Per Section 11.6.2.3 of the 2010 AASHTO LRFD BDS, overall (global) stability for MSE walls supporting structural foundations on spread footings is satisfied if the product of the factor of safety from the slope stability output multiplied by the resistance factor φ=0.65 is greater than 1.0. Therefore, global stability is satisfied when a minimum factor of safety of 1.5 is obtained. For MSE walls designed with minimum strap lengths listed in Table 6, the resulting factor of safety under drained conditions (long-term stability) was greater than 1.5. The wall was also evaluated under undrained conditions (short-term stability) to verify the stability of the wall during and immediately following construction. The resulting factor of safety under undrained conditions was also greater than 1.5.

Calculations for external (bearing and sliding resistance and limiting eccentricity) and overall (global) stability of the MSE walls are provided in Appendix VIII.

5.2.6 Final MSE Wall Considerations

Based on the results of the external and global stability analysis performed for the MSE walls, the recommended controlling strap length is 0.7 times the maximum height of the MSE wall (measured from the top of the leveling pad to the proposed profile grade of the roadway) at the rear and forward abutments. All of the external and global stability calculations indicate that adequate resistance is available for support of the MSE walls at the rear and forward abutments for a strap length equal to 70 percent of the wall height.

5.3 Lateral Earth Pressure

For the soil types encountered in the borings, the “in-situ” unit weight (γ), cohesion (c), effective angle of friction (φ’), and lateral earth pressure coefficients for at-rest conditions (k_o), active conditions (k_a), and passive conditions (k_p) have been estimated and are provided in Table 7 and Table 8.

Table 7. Estimated Undrained (Short-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ'	k_a	k_o	k_p
Soft to Medium Stiff Cohesive Soil	110	750	0°	1.0	1.0	1.0
Stiff Cohesive Soil	115	1,500	0°	1.0	1.0	1.0
Very Stiff to Hard Cohesive Soil	120	3,000	0°	1.0	1.0	1.0
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	130	0	34°	0.28	0.44	3.54
Compacted Cohesive Engineered Fill	125	1,500	0°	1.0	1.0	1.0
Compacted Granular Engineered Fill	135	0	33°	0.30	0.46	3.39

1. *When below groundwater table, use effective unit weight, γ' = γ - 62.4 pcf and add hydrostatic water pressure.*

Table 8. Estimated Drained (Long-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ'	k_a	k_o	k_p
Soft to Medium Stiff Cohesive Soil	110	0	21°	0.47	0.36	2.12
Stiff to Hard Cohesive Soil	115	0	27°	0.38	0.55	2.63
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	130	0	34°	0.28	0.44	3.54
Compacted Cohesive Engineered Fill	125	0	28°	0.36	0.53	2.77
Compacted Granular Engineered Fill	135	0	33°	0.30	0.46	3.39

1. *When below groundwater table, use effective unit weight, γ' = γ - 62.4 pcf and add hydrostatic water pressure.*

These parameters are considered appropriate for the design of all subsurface structures and any excavation support systems. Subsurface structures (where the top of the structure is restrained from movement) should be designed based on at-rest conditions (k_o). For proposed temporary retaining structures (where the top of the structure is allowed to move), earth pressure distributions should be based on active (k_a) and passive (k_p) conditions. The values in this table have been estimated from correlation charts based on minimum standards specified for compacted engineered fill materials. These recommendations do not take into consideration the effect of any surcharge loading or a sloped ground surface (a flat surface is assumed). Earth pressures on excavation support systems will be dependent on the type of sheeting and method of bracing or anchorage.

5.4 Construction Considerations

All site work shall conform to local codes and to the latest ODOT Construction and Materials Specifications (CMS), including that all excavation and embankment preparation and construction should follow ODOT Item 200 (Earthwork).

5.4.1 Excavation Considerations

All excavations should be shored / braced or laid back at a safe angle in accordance with Occupational Safety and Health Administration (OSHA) guidelines. During excavation, if slopes cannot be laid back to OSHA Standards due to adjacent structures or other obstructions, temporary shoring may be required. The following table should be utilized as a general guide for implementing OSHA guidelines when estimating excavation back slopes at the various boring locations. Actual excavation back slopes must be field verified by qualified personnel at the time of excavation in strict accordance with OSHA guidelines.

Table 9. Excavation Back Slopes

Soil	Maximum Back Slope	Notes
Soft to Medium Stiff Cohesive	1.5 : 1.0	Above Ground Water Table and No Seepage
Stiff Cohesive	1.0 : 1.0	Above Ground Water Table and No Seepage
Very Stiff to Hard Cohesive	0.75 : 1.0	Above Ground Water Table and No Seepage
All Granular & Cohesive Soil Below Ground Water Table or with Seepage	1.5 : 1.0	None

5.4.2 Groundwater Considerations

Based on the groundwater observations made during drilling, little to no groundwater seepage is anticipated during construction. However, where/if groundwater is encountered, proper groundwater control should be employed and maintained to prevent disturbance to excavation bottoms consisting of cohesive soil, and to prevent the possible development of a quick or "boiling" condition where soft silts and/or fine sands are encountered. It is preferable that the groundwater level, if encountered, be maintained at least 36.0 inches below the deepest excavation. Any seepage or groundwater encountered at this site should be able to be controlled by pumping from temporary sumps. Additional measures may be required depending on seasonal fluctuations of the groundwater level. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor.

6.0 LIMITATIONS OF STUDY

The above recommendations are predicated upon construction inspection by a qualified soil technician under the direct supervision of a professional geotechnical engineer. Adequate testing and inspection during construction are considered necessary to assure an adequate foundation system and are part of our recommendations.

The recommendations for this project were developed utilizing soil and bedrock information obtained from the test borings that were made at the proposed site for the previous investigation. Resource International is not responsible for the data, conclusions, opinions or recommendations made by others during previous investigations at this site. At this time we would like to point out that soil borings only depict the soil and bedrock conditions at the specific locations and time at which they were made. The conditions at other locations on the site may differ from those occurring at the boring locations.

The conclusions and recommendations herein have been based upon the available soil and bedrock information and the preliminary design details furnished by a representative of the owner of the proposed project. Any revision in the plans for the proposed construction from those anticipated in this report should be brought to the attention of the geotechnical engineer to determine whether any changes in the foundation or earthwork recommendations are necessary. If deviations from the noted subsurface conditions are encountered during construction, they should also be brought to the attention of the geotechnical engineer.

The scope of our services does not include any environmental assessment or investigation for the presence or absence of hazardous or toxic materials in the soil, groundwater or surface water within or beyond the site studied. Any statements in this report or on the test boring logs regarding odors, staining of soils or other unusual conditions observed are strictly for the information of our client.

Our professional services have been performed, our findings obtained and our recommendations prepared in accordance with generally accepted geotechnical engineering principles and practices. Resource International is not responsible for the conclusions, opinions or recommendations made by others based upon the data included.

APPENDIX I

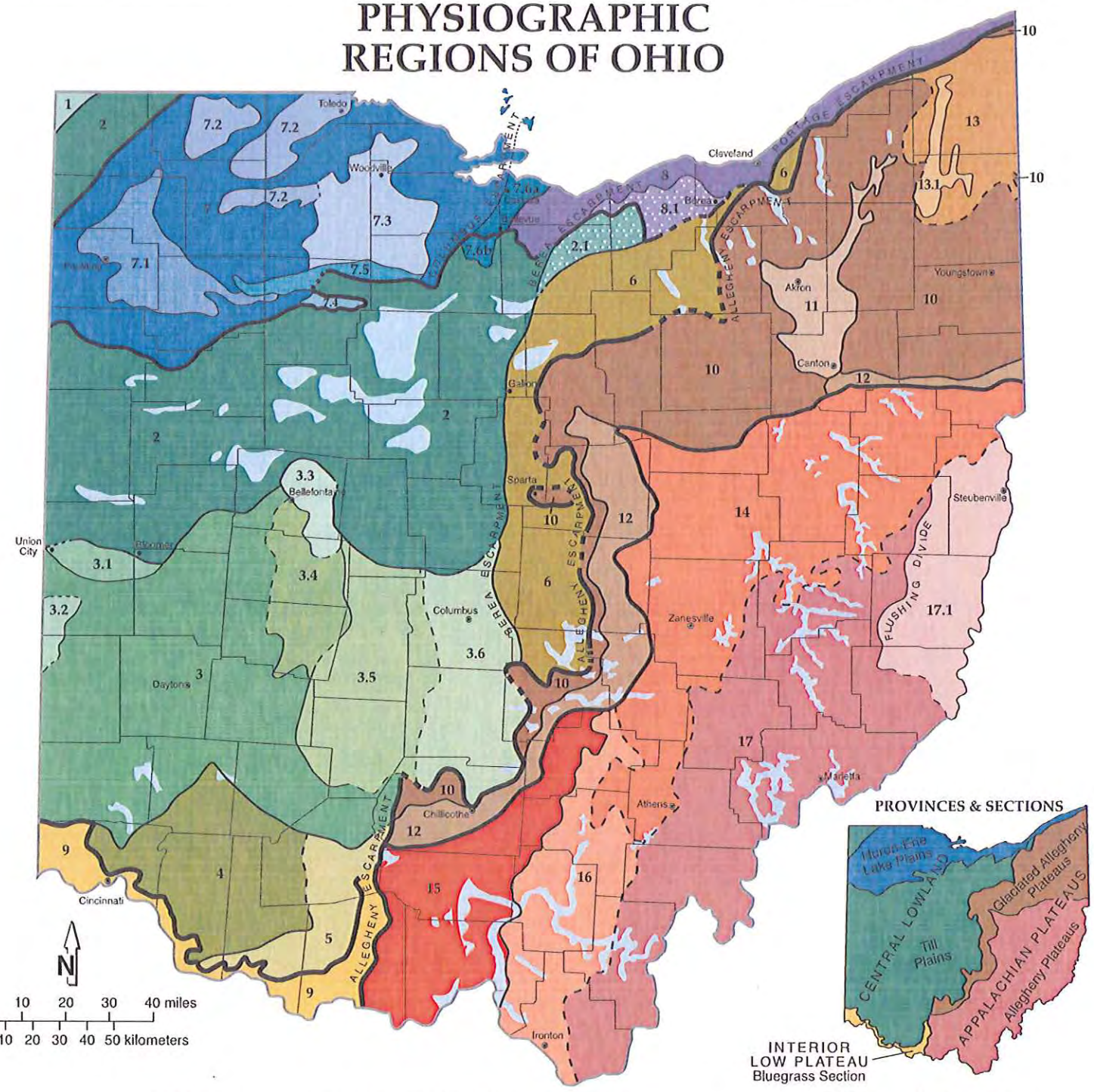
STATE GEOLOGY

STATE OF OHIO
Ted Strickland, Governor

DEPARTMENT OF NATURAL RESOURCES
Sean D. Logan, Director

DIVISION OF GEOLOGICAL SURVEY
Lawrence H. Wickstrom, Chief

PHYSIOGRAPHIC REGIONS OF OHIO



Till Plains

- 1. Steuben Till Plain
- 2. Central Ohio Clayey Till Plain
  - 2.1. Berea Headlands of the Till Plain
- 3. Southern Ohio Loamy Till Plain
  - 3.1. Union City-Bloomer Transitional Terrain
  - 3.2. Whitewater Interlobate Plain
  - 3.3. Bellefontaine Upland
  - 3.4. Mad River Interlobate Plain
  - 3.5. Darby Plain
  - 3.6. Columbus Lowland
- 4. Illinoian Till Plain
- 5. Dissected Illinoian Till Plain
- 6. Galion Glaciated Low Plateau

Transitional boundary

Lake basin/deposits outside Huron-Erie Lake Plains

Huron-Erie Lake Plains

- 7. Maumee Lake Plains
  - 7.1. Paulding Clay Basin
  - 7.2. Maumee Sand Plains
  - 7.3. Woodville Lake-Plain Reefs
  - 7.4. Findlay Embayment
  - 7.5. Fostoria Lake-Plain Shoals
  - 7.6a and 7.6b. Bellevue-Castalia Karst Plain
- 8. Erie Lake Plain
  - 8.1. Berea Headlands of the Erie Lake Plain

Bluegrass Section

- 9. Outer Bluegrass Region

Glaciated Allegheny Plateaus

- 10. Killbuck-Glaciated Pittsburgh Plateau
- 11. Akron-Canton Interlobate Plateau
- 12. Illinoian Glaciated Allegheny Plateau
- 13. Grand River Low Plateau
  - 13.1 Grand River Finger-Lake Plain

Allegheny Plateaus

- 14. Muskingum-Pittsburgh Plateau
- 15. Shawnee-Mississippian Plateau
- 16. Ironton Plateau
- 17. Marietta Plateau
  - 17.1. Little Switzerland Plateau

4/98

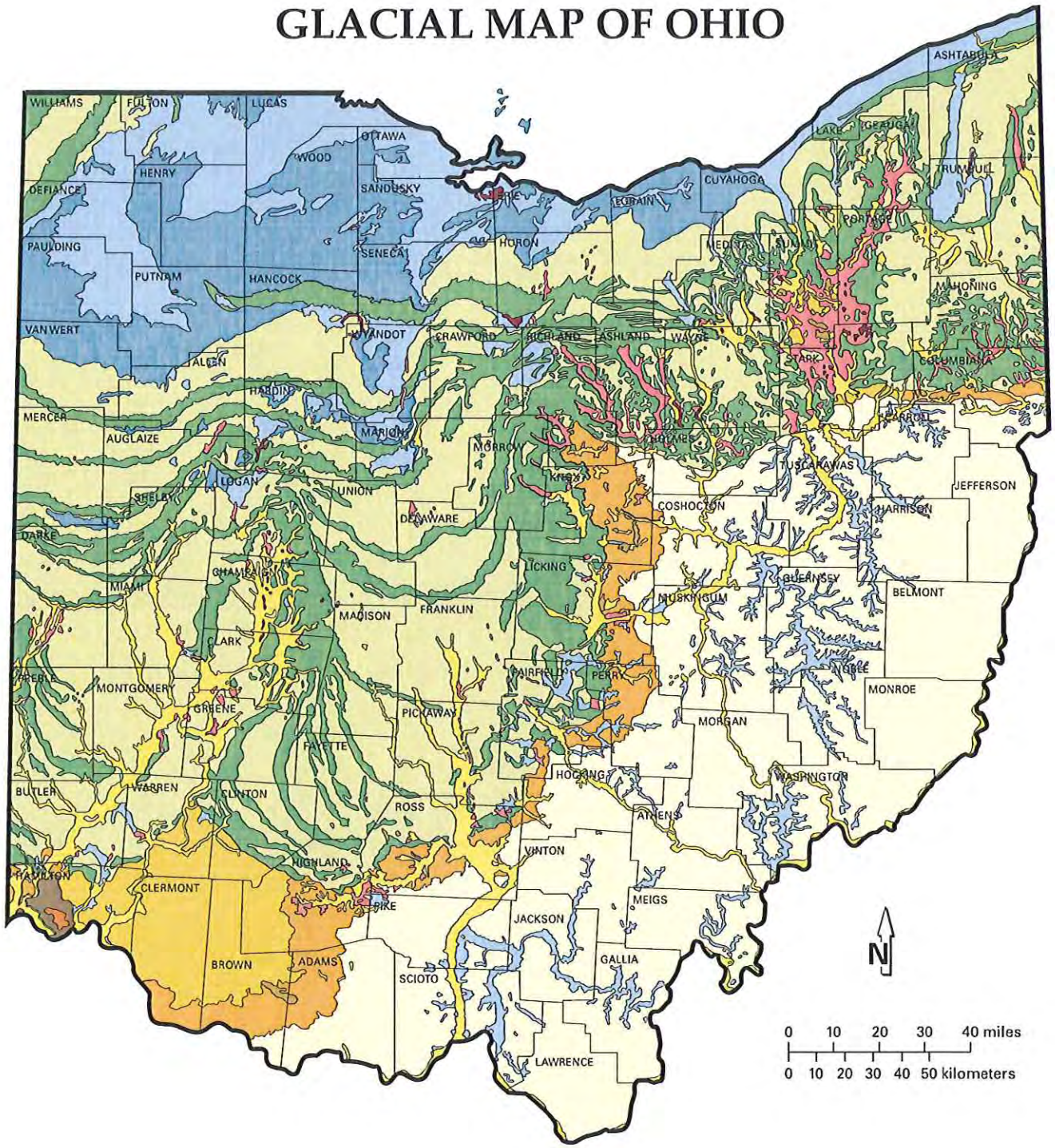
Recommended citation: Ohio Division of Geological Survey, 1998, Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,100,00.

STATE OF OHIO
Bob Taft, Governor

DEPARTMENT OF NATURAL RESOURCES
Samuel W. Speck, Director

DIVISION OF GEOLOGICAL SURVEY
Thomas M. Berg, Chief

GLACIAL MAP OF OHIO



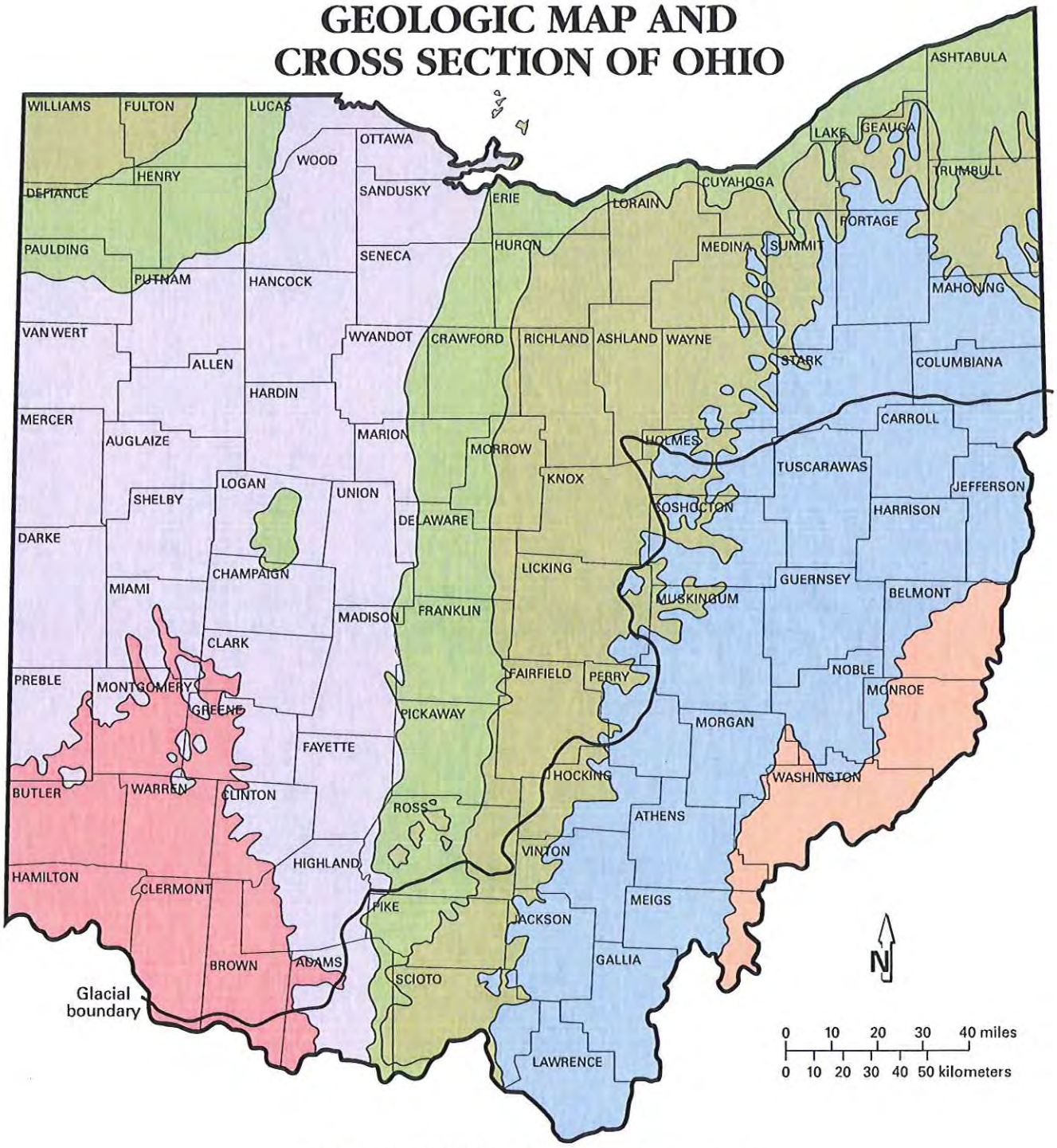
WISCONSINAN (14,000 to 24,000 years old)	ILLINOIAN (130,000 to 300,000 years old)	PRE-ILLINOIAN (older than 300,000 years)	
Ground moraine	Ground moraine	Ground moraine	Kames and eskers
Wave-planed ground moraine	Dissected ground moraine	Dissected ground moraine	Outwash
End moraine	Hummocky moraine		Lake deposits
			Peat
			Colluvium

STATE OF OHIO
Bob Taft, Governor

DEPARTMENT OF NATURAL RESOURCES
Samuel W. Speck, Director

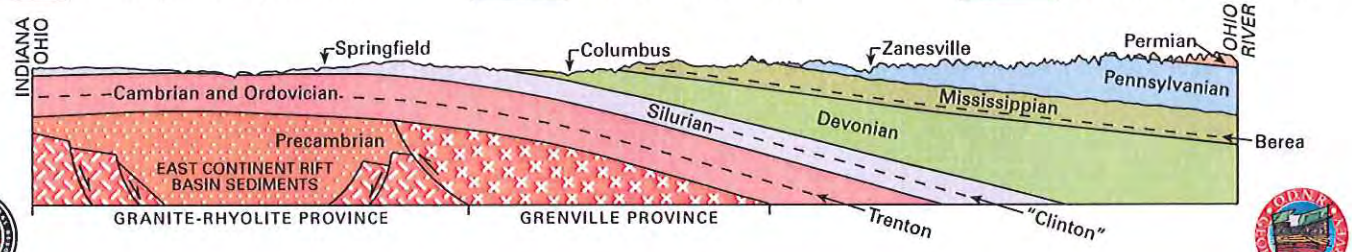
DIVISION OF GEOLOGICAL SURVEY
Thomas M. Berg, Chief

GEOLOGIC MAP AND CROSS SECTION OF OHIO



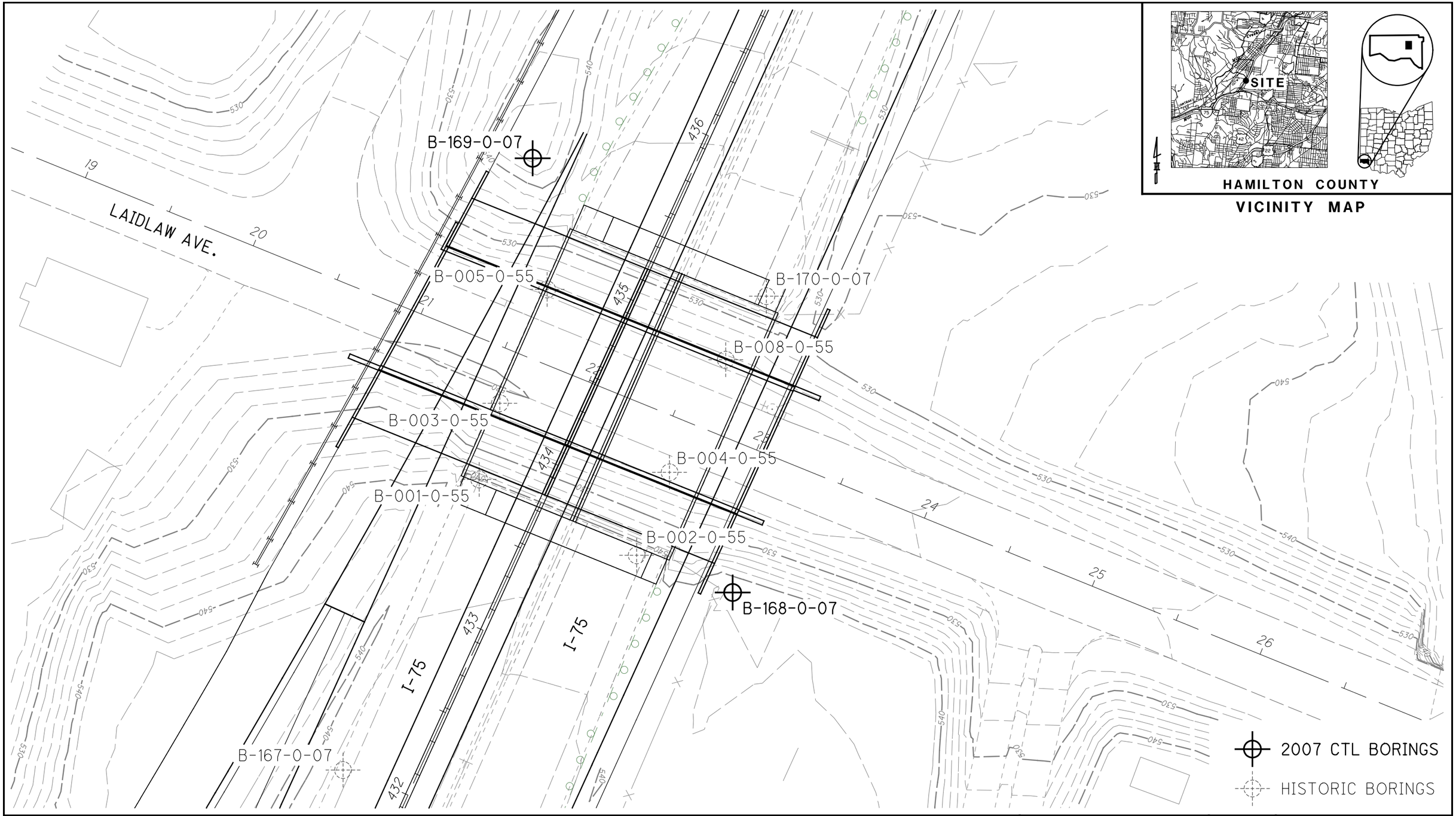
GEOLOGIC SYSTEM (million years before present)

- Permian (286-245)
- Pennsylvanian (320-286)
- Mississippian (360-320)
- Devonian (408-360)
- Silurian (438-408)
- Ordovician (505-438)



APPENDIX II

VICINITY MAP AND BORING PLAN



VICINITY MAP

BORING PLAN

HAM-75-0823

HAMILTON COUNTY, OHIO

PROJECT NO. Rii B-10-020		DRAWN RRM
SCALE: 1"=100' 0 50 100	N	REVIEWED BRT
		DATE 7-10-13

RESOURCE INTERNATIONAL, INC.

APPENDIX III

2007 CTL ENGINEERING BORING LOGS

LOG OF BORING

Project Identification: HAM-75-2.30 PID 76257
Hamilton County, Ohio

Date Started 7/30/07 Sampler: Type SS Dia. 1.375"
Date Completed 7/30/07 Casing: Length 110ft Dia. 3.25"
Water Elev. 512.5ft

Boring No. B-168 Station & Offset 433+76.1, 116.8 RT Surface Elev. 541.5ft

CTL Project No. 04120070g

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)	Description	Sample No.	Physical Characteristics % Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	ODOT Class
541.5	0				0.2' TOPSOIL (.2')										
541.5		AUGERED													VISUAL
540.5		6/10/15			MEDIUM DENSE, DARK BROWN GRAVEL AND/ OR STONE FRAGMENTS WITH SAND, SILT AND CLAY, DRY	1								4	VISUAL
	2				3.0'										
538.0	4	8/6/6			STIFF, BROWN SANDY SILT, LITTLE CLAY, TRACE GRAVEL, DAMP	2								9	VISUAL
					5.0'										
535.5	6	2/1/2			SOFT, BROWN SANDY SILT, TRACE CLAY, MOIST - CHEMICAL ODOR	3	0	7	51	40	2	NP	NP	17	A-4a
533.0	8	1/1/1				4								15	VISUAL
	10				11.0'										
530.5	12	1/1/1			VERY LOOSE, BROWN COARSE AND FINE SAND, SOME SILT,TRACE CLAY, MOIST	5	0	11	56	30	3	NP	NP	14	A-3a
528.0	14	1/0/1				6								14	VISUAL
525.5	16	2/2/2			16.0' VERY LOOSE TO MEDIUM DENSE, BROWN COARSE AND FINE SAND, LITTLE CLAY, TRACE GRAVEL, TRACE SILT, DAMP	7	4	23	53	4	16	NP	NP	5	A-3a
523.0	18	2/2/3				8								5	VISUAL
	20														
	22														
518.0	24	3/5/6				9								4	VISUAL
	26														
					27.0'										
	28														
513.0	30	5/7/6			MEDIUM DENSE, BROWN GRAVEL AND/ OR STONE FRAGMENTS WITH SAND, TRACE SILT, WET	10	20	52	21	7	0	NP	NP	21	A-1-b
	32														
508.0	34	3/4/6			33.5' STIFF, DARK GRAY SILT AND CLAY, TRACE SAND, MOIST -SILT LAYERS ARE INTERBEDDED	11	0	0	1	65	34	29	12	25	A-6a

Particle Sizes: Agg => 2.00mm, Coarse Sand = 2.00-0.42mm, Fine Sand = 0.42-0.074mm, Silt = 0.074-0.005mm, Clay =< 0.005mm.

Project Identification: HAM-75-2.30 PID 76257
Hamilton County, Ohio

Boring No. B-168

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)			Description	Sample No.	Physical Characteristics % Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	ODOT Class
506.5																	
	36																
	38																
503.0		3/4/5						12								28	VISUAL
	40																
	42																
498.0																	
	44	5/6/7						13								26	VISUAL
	46																
	48																
493.0						48.5'											
		4/5/8					STIFF TO VERY STIFF, DARK GRAY CLAY, LITTLE TO AND SILT, TRACE TO NO GRAVEL, MOIST	14	0	0	0	55	45	41	20	25	A-7-6
	50																
	52																
488.0																	
	54	5/9/11						15								24	VISUAL
	56																
	58																
483.0																	
		5/7/9					-SILT LAYERS ARE INTERBEDDED	16								26	VISUAL
	60																
	62																
478.0																	
	64	6/7/8						17	0	0	0	20	80	42	20	23	A-7-6
	66																
	68																
473.0																	
		4/6/7						18								24	VISUAL
	70																

Project Identification: HAM-75-2.30 PID 76257
Hamilton County, Ohio

Boring No. B-168

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)			Description	Sample No.	Physical Characteristics % Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	ODOT Class
470.4																	
	72																
468.0	74	4/5/7					- SILT LAYERS ARE INTERBEDDED	19								28	VISUAL
	76																
	78					78.0'											
463.0		5/7/10			FS		MEDIUM DENSE, GRAY FINE SAND, TRACE SILT, TRACE CLAY, MOIST	20	0	17	77	2	4	NP	NP	15	A-3
	80																
	82					82.0'											
458.0	84	7/11/13					MEDIUM DENSE TO DENSE, BROWN GRAVEL AND/ OR STONE FRAGMENTS WITH SAND AND SILT, MOIST	21								13	VISUAL
	86																
	88																
453.0	90	8/14/17						22								9	VISUAL
	92					93.0'											
448.0	94	5/6/5					MEDIUM DENSE, BROWN COARSE AND FINE SAND, LITTLE GRAVEL, LITTLE CLAY, TRACE SILT, MOIST	23	11	6	69	3	11	NP	NP	18	A-3a
	96																
	98																
443.0	100	7/10/12						24								17	VISUAL
	102																
438.0	104	8/10/14						25								14	VISUAL
	106																

Project Identification: HAM-75-2.30 PID 76257
Hamilton County, Ohio

Boring No. B-168

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)			Description	Sample No.	Physical Characteristics								ODOT Class
									% Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	
434.4																	
	108																
433.0		10/13/17				108.5'											
					FS		MEDIUM DENSE, BROWN FINE SAND, TRACE GRAVEL, TRACE SILT, TRACE CLAY, WET	26	4	27	59	5	5	NP	NP	20	A-3
431.5	110					110.0'											
							BOTTOM OF BORING = 110.0'										

LOG OF BORING

Project Identification: HAM-75-2.30 PID 76257
Hamilton County, Ohio

Date Started 8/6/07 Sampler: Type SS Dia. 1.375"
Date Completed 8/6/07 Casing: Length 95.0ft Dia. 3.25"

Water Elev. 510.7ft

Boring No. B-169 Station & Offset 435+48.5, 83.2 LT Surface Elev. 544.7ft

CTL Project No. 04120070g

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)			Description	Sample No.	Physical Characteristics % Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	ODOT Class
544.7	0					0.2'	TOPSOIL (.2')										VISUAL
543.7		AUGERED															
		8/11/16					VERY STIFF, BROWN SILT AND CLAY, SOME GRAVEL, DAMP	1								5	VISUAL
	2					3.0'											
541.2																	
	4	4/4/4					MEDIUM STIFF, BROWN SANDY SILT, TRACE GRAVEL, SOME CLAY, DAMP	2	3	15	39	15	28	NP	NP	5	A-4a
538.7	6					6.0'											
		5/4/3					LOOSE, BROWN FINE SAND, TRACE GRAVEL, DRY TO MOIST -HYDROCARBON ODOR	3								3	VISUAL
	8																
536.2		3/2/3				FS		4	10	34	47	4	5	NP	NP	18	A-3
	10																
533.7						11.0'											
		4/7/9					LOOSE TO MEDIUM DENSE, LIGHT BROWN COARSE AND FINE SAND, LITTLE TO TRACE GRAVEL, TRACE SILT, TRACE TO LITTLE CLAY, DRY	5								2	VISUAL
	12																
531.2																	
	14	5/8/12						6	13	36	35	6	10	NP	NP	3	A-3a
528.7	16																
		7/10/13						7								3	VISUAL
	18																
526.2																	
		6/9/11						8								3	VISUAL
	20																
	22																
521.2																	
	24	3/4/5						9	7	34	37	10	12	NP	NP	5	A-3a
	26																
						27.0'											
	28																
516.2		5/6/6					MEDIUM DENSE, BROWN GRAVEL AND/ OR STONE FRAGMENTS WITH SAND, LITTLE SILT, TRACE CLAY, DAMP	10	45	31	10	12	2	NP	NP	5	A-1-b
	30																
	32																
510.7	34					34.0'											
		6/8/9					MEDIUM DENSE, BROWN GRAVEL AND/ OR STONE FRAGMENTS WITH	11								16	VISUAL

Particle Sizes: Agg => 2.00mm, Coarse Sand = 2.00-0.42mm, Fine Sand = 0.42-0.074mm, Silt = 0.074-0.005mm, Clay =< 0.005mm.

Project Identification: HAM-75-2.30 PID 76257
Hamilton County, Ohio

Boring No. B-169

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)	Description	Sample No.	Physical Characteristics % Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	ODOT Class
509.7	36				SAND AND SILT, WET										
					37.0'										
506.2	38	3/4/6			STIFF, GRAY CLAY, AND SILT, MOIST	12	0	0	0	48	52	46	25	30	A-7-6
	40														
	42														
501.2					43.5'										
	44	3/5/7			STIFF, GRAY SILT AND CLAY, TRACE SAND, MOIST	13	0	0	0	54	46	39	15	24	A-6a
	46														
	48														
496.2		4/5/6				14								28	VISUAL
	50														
	52														
491.2	54	4/6/7				15								30	VISUAL
	56														
	58														
486.2		4/4/6				16	0	1	2	26	71	37	15	27	A-6a
	60														
	62				62.0'										
481.2	64	7/11/13			STIFF TO VERY STIFF, GRAY SILT AND CLAY, LITTLE TO TRACE SAND, MOIST	17								24	VISUAL
	66														
	68														
476.2		6/8/10				18								23	VISUAL
	70														

Project Identification: HAM-75-2.30 PID 76257
Hamilton County, Ohio

Boring No. B-169

Elev. (ft)	Depth (ft)	Std. Pen./ RQD	Rec. (ft)	Loss (ft)	Description	Sample No.	Physical Characteristics % Agg	% C.S.	% F.S.	% Silt	% Clay	L.L.	P.I.	W.C.	ODOT Class
473.6															
	72														
471.2															
	74	7/9/11				19	0	0	0	71	29	31	12	27	A-6a
	76														
	78														
466.2		4/6/9				20								26	VISUAL
	80														
	82														
461.2															
	84	4/5/8			-INTERBEDDED COARSE AND FINE SAND	21								23	VISUAL
	86														
	88				88.0'										
456.2		7/14/18			DENSE, GRAY COARSE AND FINE SAND, LITTLE GRAVEL,TRACE SILT, MOIST	22								11	VISUAL
	90														
	92														
451.2															
	94	9/16/19				23	11	30	49	10	0	NP	NP	10	A-3a
449.7					95.0'										

BOTTOM OF BORING = 95.0"

APPENDIX IV

LABORATORY TEST RESULTS

6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

CONSOLIDATED, UNDRAINED TRIAXIAL

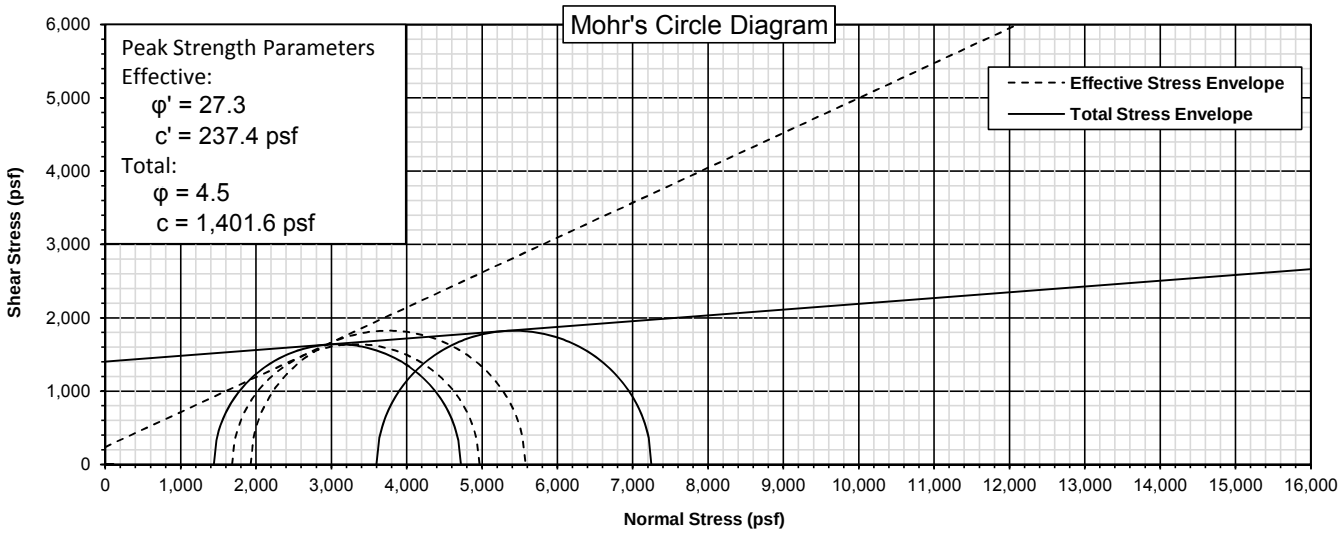
ASTM D-4767

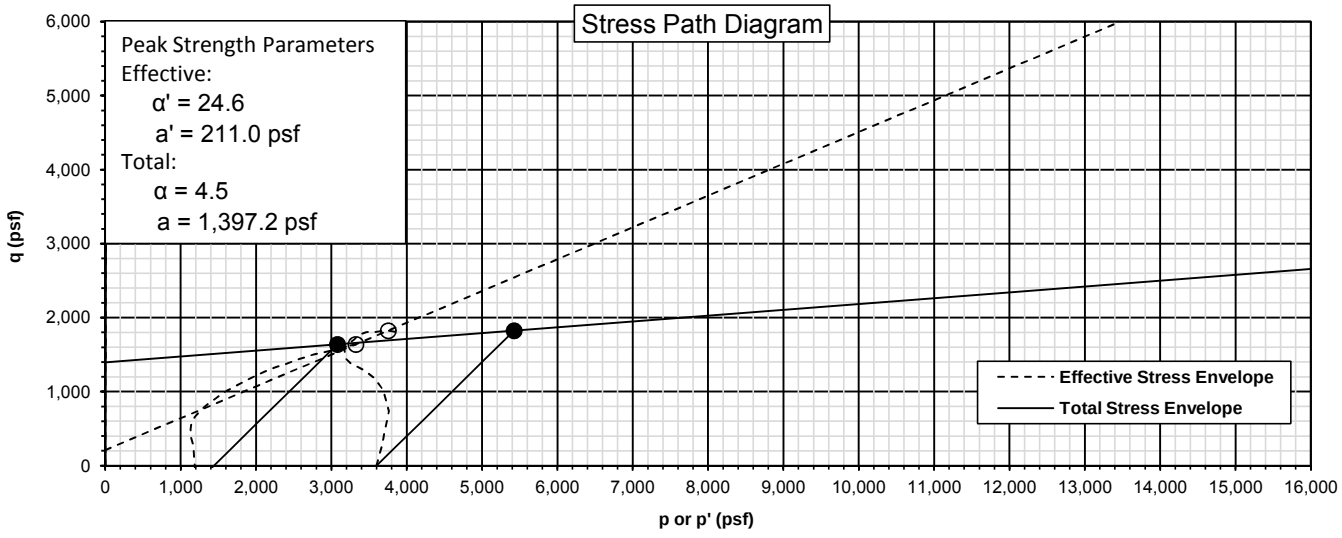
PROJECT NAME:	HAM-75-7.85
JOB NUMBER:	B-10-020
BORING NUMBER:	B-016-0-11A
SAMPLE NUMBER:	ST-3
SAMPLE DEPTH:	6.5 to 7.0 feet
DATE OF TESTING:	12/12/2011-12/28/11
TESTED BY:	Hoyt

Soil Description: Brown SILT and CLAY, and coarse to fine sand, trace fine gravel.
Soil Classification: ODOT A-6a

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	29	14	15	7	9	32	29	23

Stage	Boring No.	Sample No.	Depth (ft)	$(\sigma_3)_f$ (psf)	$(\sigma_1)_f$ (psf)	$(\sigma_3')_f$ (psf)	$(\sigma_1')_f$ (psf)	p'_f (psf)	q_f (psf)
1	B-016-0-11A	ST-3	7.0	1,440.0	4,719.1	1,684.8	4,963.9	3,324.3	1,639.5
2	B-016-0-11A	ST-3	6.5	3,600.0	7,248.0	1,929.6	5,577.6	3,753.6	1,824.0





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Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

CONSOLIDATED, UNDRAINED TRIAXIAL

ASTM D-4767

PROJECT NAME:	HAM-75-7.85
JOB NUMBER:	B-10-020
BORING NUMBER:	B-016-0-11A
SAMPLE NUMBER:	ST-3
SAMPLE DEPTH:	7.0
DATE OF TESTING:	12/28/2011
TESTED BY:	Hoyt

Data for Specimen No. 1

Soil Description: Brown SILT and CLAY, and coarse to fine sand, trace fine gravel.
Soil Classification: ODOT A-6a

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C.Sand%	F.Sand%	Silt%	Clay%
	29	14	15	7	9	32	29	23

Diameter, D_0	2.861	in	Volume of Solids , V_s :	25.349	in^3
Area, A_0	6.429	in^2	Initial Volume of Voids, V_v :	11.766	in^3
Height, L_0	5.773	in	Initial Void Ratio, e_o :	0.464	
Volume, V_0	37.115	in^3	Initial Degree of Saturation, S_0 :	111.729	%

Water Content BEFORE Test

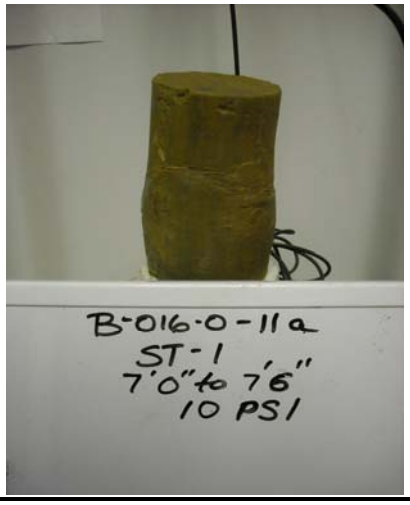
Tin No.:	WC-32	g
Wet Soil + Tin :	105.78	g
Dry Soil + Tin :	94.18	g
Tin Weight :	34.46	g
Dry Mass :	59.72	g
Weight of water :	11.6	g
Moisture :	19.42	%

Water Content AFTER Test (Total Specimen)

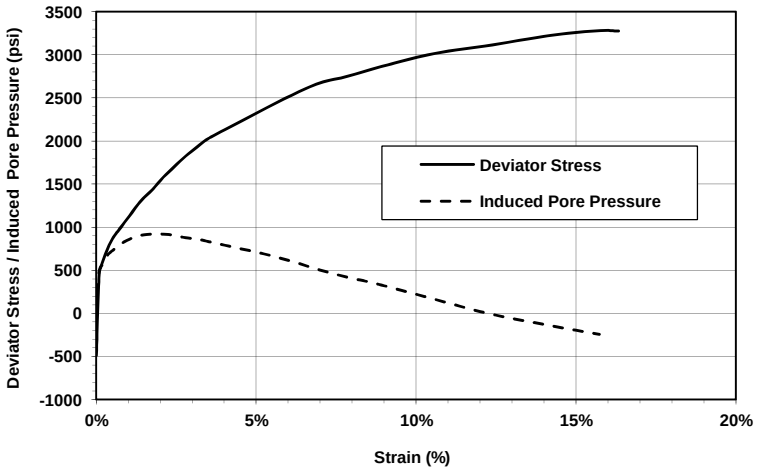
Tin No.:	BIG CAT	g
Wet Soil + Tin :	1393.10	g
Dry Soil + Tin :	1198.10	g
Tin Weight :	89.00	g
Dry Mass :	1109.10	g
Weight of water :	195.00	g
Moisture :	17.58	%
Wet Density :	133.85	pcf
Dry Density :	113.84	pcf

Consolidation Cell Pressure:	145.0	psi	Deviator Stress @ Failure, Ds:	3279.09	psf
Consolidation Back Pressure:	135.0	psi	Axial Strain @ Failure:	15.74	%
Effective Confining Stress, σ_3:	10.0	psi	Major Principal Stress @ Failure, σ_1:	4719.09	psf
	1440.00	psf	Induced Pore Pressure @ Failure:	-244.80	psf
Strain Rate:	0.0040	in/min	Effective Minor Principal Stress,σ'_3:	1684.80	psf
			Effective Major Principal Stress, σ'_1:	4963.89	psf

Failure Sketch



CU Compressive Strength and Induced Pore Pressure



6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

CONSOLIDATED, UNDRAINED TRIAXIAL

ASTM D-4767

PROJECT NAME:	HAM-75-7.85
JOB NUMBER:	B-10-020
BORING NUMBER:	B-016-0-11A
SAMPLE NUMBER:	ST-3
SAMPLE DEPTH:	6.5
DATE OF TESTING:	12/23/2011
TESTED BY:	Hoyt

Data for Specimen No. 2

Soil Description: Brown SILT and CLAY, and coarse to fine sand, trace fine gravel.
Soil Classification: ODOT A-6a

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C.Sand%	F.Sand%	Silt%	Clay%
	29	14	15	7	9	32	29	23

Diameter, D_0	2.843	in	Volume of Solids , V_s :	26.099	in^3
Area, A_0	6.350	in^2	Initial Volume of Voids, V_v :	11.933	in^3
Height, L_0	5.990	in	Initial Void Ratio, e_o :	0.457	
Volume, V_0	38.032	in^3	Initial Degree of Saturation, S_0 :	106.30	%

Water Content BEFORE Test

Tin No.:	WC-32	g
Wet Soil + Tin :	105.78	g
Dry Soil + Tin :	94.18	g
Tin Weight :	30.46	g
Dry Mass :	63.72	g
Weight of water :	11.6	g
Moisture :	18.20	%

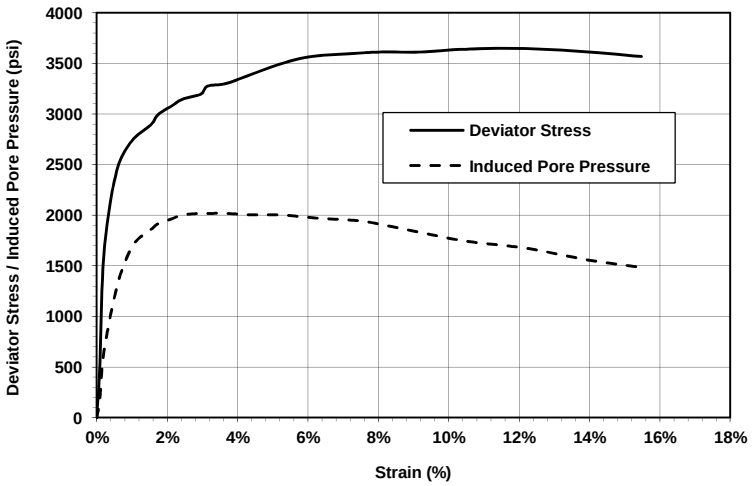
Water Content AFTER Test (Total Specimen)

Tin No.:	OHIO	g
Wet Soil + Tin :	1445.60	g
Dry Soil + Tin :	1268.90	g
Tin Weight :	127.00	g
Dry Mass :	1141.90	g
Weight of water :	176.70	g
Moisture :	15.47	%
Wet Density :	132.08	pcf
Dry Density :	114.38	pcf

Consolidation Cell Pressure:	118.0	psi	Deviator Stress @ Failure, Ds:	3648.02	psf
Consolidation Back Pressure:	93.0	psi	Axial Strain @ Failure:	12.24	%
Effective Confining Stress, σ_3:	25.0	psi	Major Principal Stress @ Failure, σ_1:	7248.02	psf
	3600.00	psf	Induced Pore Pressure @ Failure:	1670.40	psf
Strain Rate:	0.0030	in/min	Effective Minor Principal Stress,σ'_3:	1929.60	psf
			Effective Major Principal Stress, σ'_1:	5577.62	psf

Failure Sketch

CU Compressive Strength and Induced Pore Pressure



6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

CONSOLIDATED, UNDRAINED TRIAXIAL

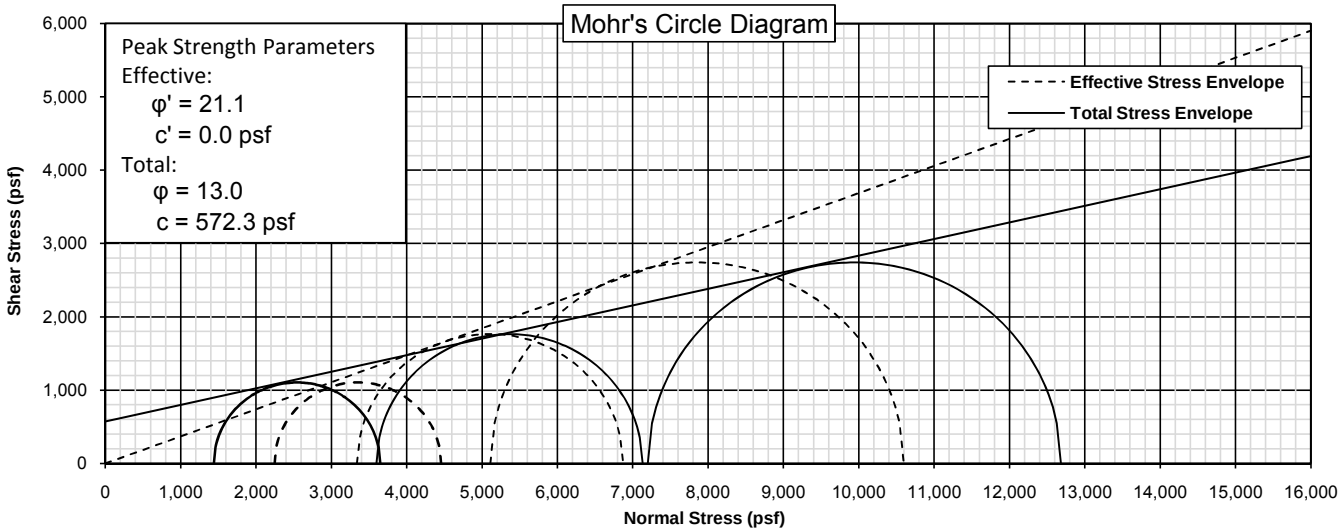
ASTM D-4767

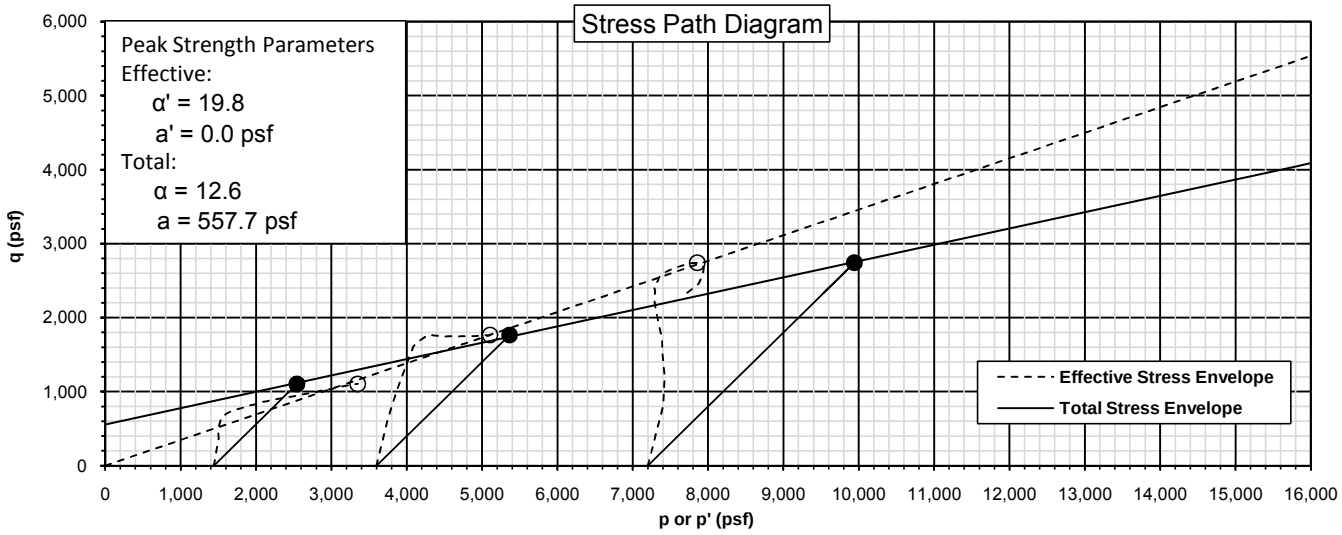
PROJECT NAME:	HAM-75-12.60
JOB NUMBER:	B-10-024
BORING NUMBER:	B-017-0-10
SAMPLE NUMBER:	ST-8a
SAMPLE DEPTH:	19.0 ft - 20.5 ft
DATE OF TESTING:	9/20/2011 through 9/26/2011
TESTED BY:	JH

Soil Description: CLAY With little silt trace sand and Gravel
Soil Classification: CL / A-7-6

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	50	22	28	2.5	1.7	2.4	23.5	69.9

Stage	Boring No.	Sample No.	Depth (ft)	$(\sigma_3)_f$ (psf)	$(\sigma_1)_f$ (psf)	$(\sigma_3')_f$ (psf)	$(\sigma_1')_f$ (psf)	p'_f (psf)	q_f (psf)
1	B-017-0-10	ST-8a	19.0	7,200.0	12,684.3	5,112.0	10,596.3	7,854.2	2,742.2
2	B-017-0-10	ST-8b	19.5	3,600.0	7,130.6	3,340.8	6,871.4	5,106.1	1,765.3
3	B-017-0-10	ST-8c	20	1,440.0	3,648.6	2,246.4	4,455.0	3,350.7	1,104.3





6350 Presidential Gateway
Columbus, Ohio 43231
Telephone: (614) 823-4949
Fax Number: (614) 823-4990

CONSOLIDATED, UNDRAINED TRIAXIAL

ASTM D-4767

PROJECT NAME:	HAM-75-12.60
JOB NUMBER:	B-10-024
BORING NUMBER:	B-017-0-10
SAMPLE NUMBER:	ST-8a
SAMPLE DEPTH:	19.0 ft
DATE OF TESTING:	9/20/2011
TESTED BY:	JH

Data for Specimen No. 1

Soil Description: CLAY With little silt trace sand and Gravel
Soil Classification: CL / A-7-6

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	50	22	28	2.5	1.7	2.4	23.5	69.9

Diameter, D_0	2.869	in	Volume of Solids , V_s :	23.836	in^3
Area, A_0	6.466	in^2	Initial Volume of Voids, V_v :	13.160	in^3
Height, L_0	5.721	in	Initial Void Ratio, e_o :	0.552	
Volume, V_0	36.996	in^3	Initial Degree of Saturation, S_0 :	120.191	%

Water Content BEFORE Test

Tin No.:	Paper	g
Wet Soil + Tin :	197.89	g
Dry Soil + Tin :	164.53	g
Tin Weight :	30.3	g
Dry Mass :	134.23	g
Weight of water :	33.36	g
Moisture :	24.85	%

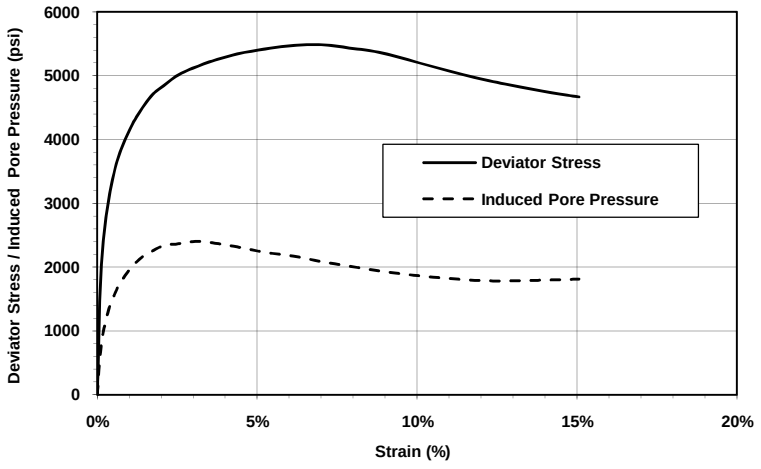
Water Content AFTER Test (Total Specimen)

Tin No.:	KDW	g
Wet Soil + Tin :	1331.20	g
Dry Soil + Tin :	1120.90	g
Tin Weight :	78.00	g
Dry Mass :	1042.90	g
Weight of water :	210.30	g
Moisture :	20.16	%
Wet Density :	129.05	pcf
Dry Density :	107.39	pcf

Consolidation Cell Pressure:	130.0	psi	Deviator Stress @ Failure, Ds:	5484.32	psf
Consolidation Back Pressure:	80.0	psi	Axial Strain @ Failure:	7.01	%
Effective Confining Stress, σ_3:	50.0	psi	Major Principal Stress @ Failure, σ_1:	12684.32	psf
	7200.00	psf	Induced Pore Pressure @ Failure:	2088.00	psf
Strain Rate:	0.0030	in/min	Effective Minor Principal Stress,σ'_3:	5112.00	psf
			Effective Major Principal Stress, σ'_1:	10596.32	psf

Failure Sketch

CU Compressive Strength and Induced Pore Pressure



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CONSOLIDATED, UNDRAINED TRIAXIAL

ASTM D-4767

PROJECT NAME:	HAM-75-12.60
JOB NUMBER:	B-10-024
BORING NUMBER:	B-017-0-10
SAMPLE NUMBER:	ST-8b
SAMPLE DEPTH:	19.5 ft
DATE OF TESTING:	9/22/2011
TESTED BY:	JH

Data for Specimen No. 2

Soil Description: CLAY With little silt trace sand and Gravel
Soil Classification: CL / A-7-6

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	50	22	28	2.5	1.7	2.4	23.5	69.9

Diameter, D_0	2.870	in	Volume of Solids , V_s :	23.427	in^3
Area, A_0	6.469	in^2	Initial Volume of Voids, V_v :	14.531	in^3
Height, L_0	5.867	in	Initial Void Ratio, e_o :	0.620	
Volume, V_0	37.957	in^3	Initial Degree of Saturation, S_0 :	106.98	%

Water Content BEFORE Test

Tin No.:	Paper	g
Wet Soil + Tin :	197.89	g
Dry Soil + Tin :	164.53	g
Tin Weight :	30.3	g
Dry Mass :	134.23	g
Weight of water :	33.36	g
Moisture :	24.85	%

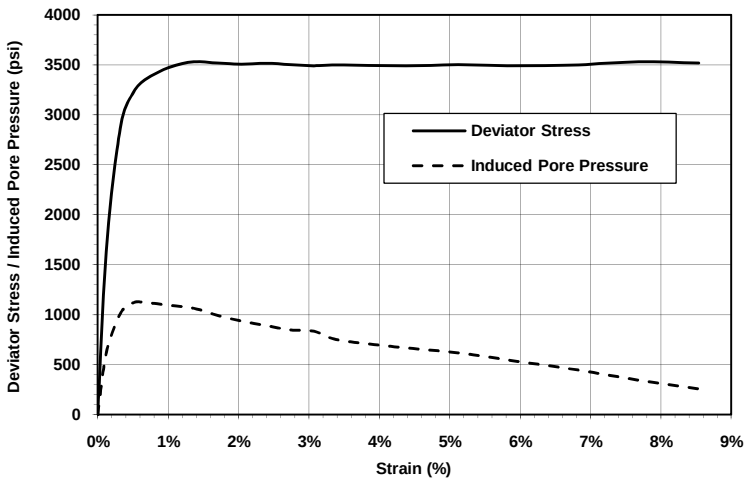
Water Content AFTER Test (Total Specimen)

Tin No.:	Freddy	g
Wet Soil + Tin :	1346.50	g
Dry Soil + Tin :	1108.90	g
Tin Weight :	83.90	g
Dry Mass :	1025.00	g
Weight of water :	237.60	g
Moisture :	23.18	%
Wet Density :	126.72	pcf
Dry Density :	102.87	pcf

Consolidation Cell Pressure:	135.0	psi	Deviator Stress @ Failure, Ds:	3530.56	psf
Consolidation Back Pressure:	110.0	psi	Axial Strain @ Failure:	8.54	%
Effective Confining Stress, σ_3:	25.0	psi	Major Principal Stress @ Failure, σ_1:	7130.56	psf
	3600.00	psf	Induced Pore Pressure @ Failure:	259.20	psf
Strain Rate:	0.0030	in/min	Effective Minor Principal Stress,σ'_3:	3340.80	psf
			Effective Major Principal Stress, σ'_1:	6871.36	psf

Failure Sketch

CU Compressive Strength and Induced Pore Pressure



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CONSOLIDATED, UNDRAINED TRIAXIAL

ASTM D-4767

PROJECT NAME:	HAM-75-12.60
JOB NUMBER:	B-10-024
BORING NUMBER:	B-017-0-10
SAMPLE NUMBER:	ST-8c
SAMPLE DEPTH:	20.0 ft
DATE OF TESTING:	9/26/2011
TESTED BY:	Hoyt

Data for Specimen No. 3

Soil Description: CLAY With little silt trace sand and Gravel
Soil Classification: CL / A-7-6

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	50	22	28	2.5	1.7	2.4	23.5	69.9

Diameter, D_0	2.869	in	Volume of Solids , V_s :	22.291	in^3
Area, A_0	6.466	in^2	Initial Volume of Voids, V_v :	15.912	in^3
Height, L_0	5.908	in	Initial Void Ratio, e_o :	0.714	
Volume, V_0	38.203	in^3	Initial Degree of Saturation, S_0 :	92.960	%

Water Content BEFORE Test

Tin No.:	Paper	g
Wet Soil + Tin :	197.89	g
Dry Soil + Tin :	164.53	g
Tin Weight :	30.3	g
Dry Mass :	134.23	g
Weight of water :	33.36	g
Moisture :	24.85286449	%

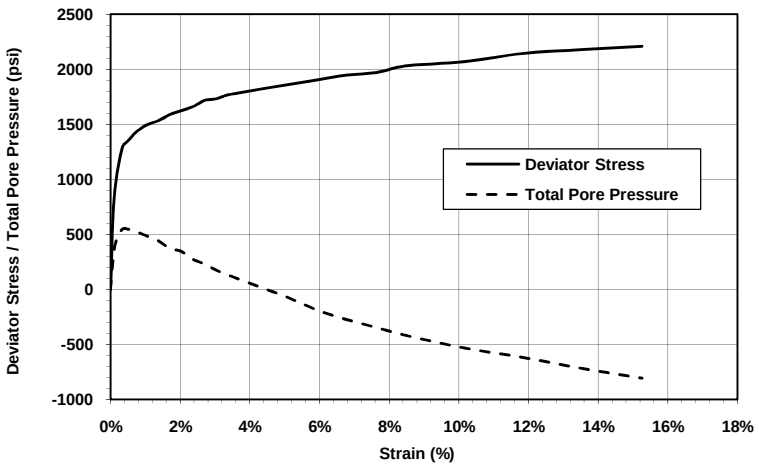
Water Content AFTER Test (Total Specimen)

Tin No.:	KDW	g
Wet Soil + Tin :	1334.20	g
Dry Soil + Tin :	1053.10	g
Tin Weight :	77.80	g
Dry Mass :	975.30	g
Weight of water :	281.10	g
Moisture :	28.82	%
Wet Density :	125.29	pcf
Dry Density :	97.26	pcf

Consolidation Cell Pressure:	120.0	psi	Deviator Stress @ Failure, Ds:	2208.58	psf
Consolidation Back Pressure:	110.0	psi	Axial Strain @ Failure:	15.25	%
Effective Confining Stress, σ_3:	10.0	psi	Major Principal Stress @ Failure, σ_1:	3648.58	psf
	1440.00	psf	Induced Pore Pressure @ Failure:	-806.40	psf
Strain Rate:	0.0030	in/min	Effective Minor Principal Stress,σ'_3:	2246.40	psf
			Effective Major Principal Stress, σ'_1:	4454.98	psf

Failure Sketch

CU Compressive Strength and Induced Pore Pressure



One-Dimensional Consolidation Test Report (ASTM D2435)

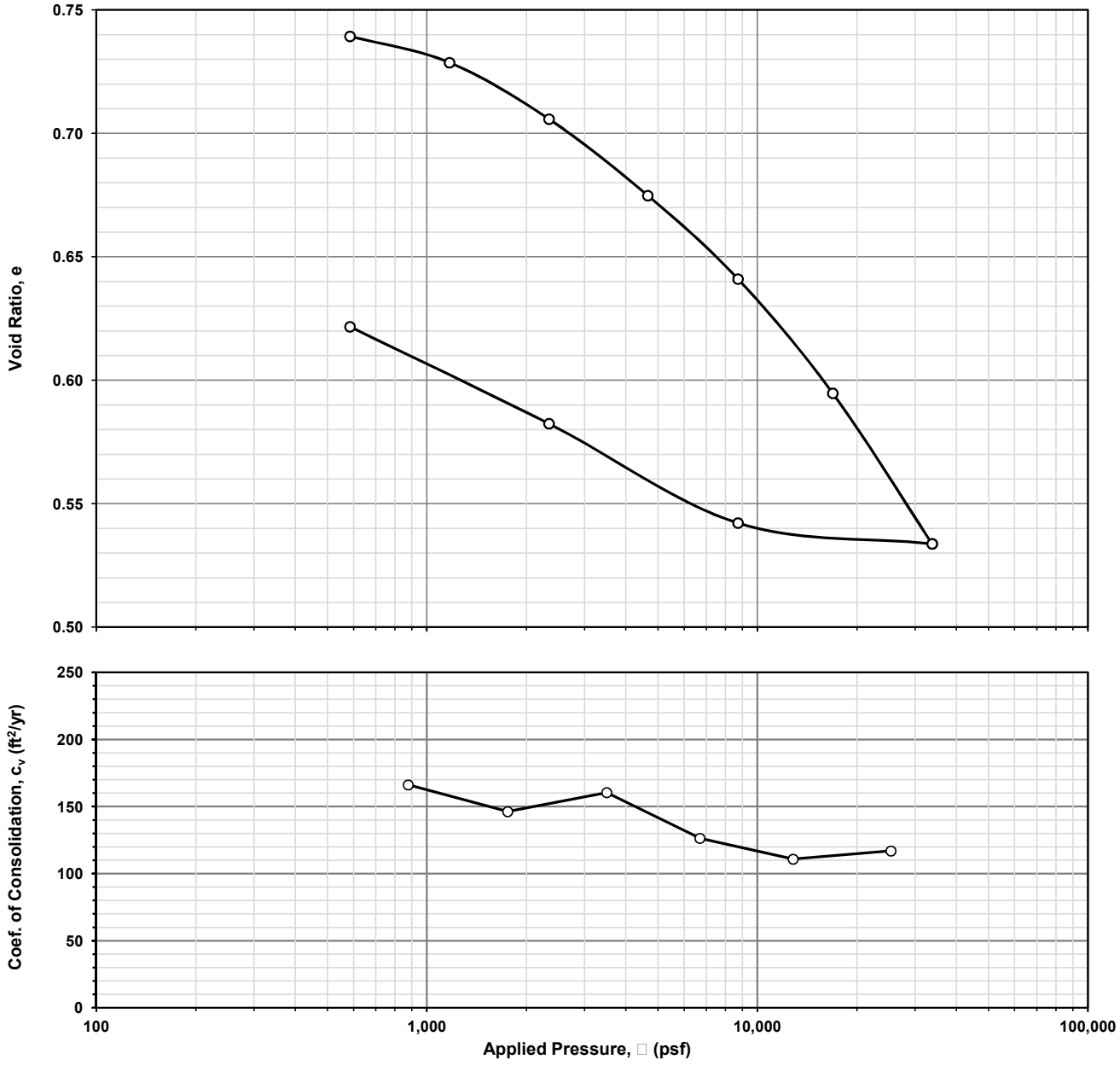
Project Number:	B-10-020	Boring Number:	B-008-0-11
Project Name:	HAM-75-7.85	Sample No. / Depth:	ST-10 / 24.0 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	11/3/2011 to 11/16/2011
Client:	EMH&T	Technician:	JJH

Soil Description: Gray CLAY, trace silt

Soil Classification: ODOT A-7-6

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	54	23	31	0	0	0	8	91

Natural S_o	Natural w_o	γ_d (pcf)	γ_{sat} (pcf)	σ_{vo}' (psf)	S_G	e_o	σ_p' (psf)	c_c	c_r
102.2%	28.9%	94.1	121.9	2880	2.67	0.771	4886	0.230	0.068



APPENDIX V

DRIVEN ANALYSIS OUTPUT

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\LEGACY\DESKTOP\B-168.DVN
Project Name: HAM-75-0823 Project Date: 05/16/2023
Project Client: Barr _Prevost
Computed By: BRT
Project Manager: Brian Trenner

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 16.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	5.00 ft
	- Driving/Restrike	5.00 ft
	- Ultimate:	5.00 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	39.00 ft
	(Downdrag Condition)	

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	3.00 ft	0.00%	125.00 pcf	29.0/29.0	Nordlund
2	Cohesionless	6.50 ft	0.00%	125.00 pcf	29.0/29.0	Nordlund
3	Cohesive	14.50 ft	33.00%	115.00 pcf	1750.00 psf	T-79 Steel
4	Cohesive	30.00 ft	50.00%	120.00 pcf	2750.00 psf	T-79 Steel
5	Cohesionless	4.00 ft	0.00%	125.00 pcf	30.0/30.0	Nordlund
6	Cohesionless	11.00 ft	0.00%	130.00 pcf	33.0/33.0	Nordlund
7	Cohesionless	17.00 ft	0.00%	130.00 pcf	32.0/32.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.62 psf	21.24	N/A	0.00 Kips
2.99 ft	Cohesionless	186.88 psf	21.24	N/A	0.87 Kips
3.01 ft	Cohesionless	375.62 psf	21.24	N/A	0.88 Kips
4.99 ft	Cohesionless	499.38 psf	21.24	N/A	2.41 Kips
5.01 ft	Cohesionless	625.31 psf	21.24	N/A	2.43 Kips
9.49 ft	Cohesionless	765.54 psf	21.24	N/A	7.74 Kips
9.51 ft	Cohesive	N/A	N/A	1140.00 psf	7.80 Kips
18.51 ft	Cohesive	N/A	N/A	1177.53 psf	52.20 Kips
23.99 ft	Cohesive	N/A	N/A	1217.26 psf	81.64 Kips
24.01 ft	Cohesive	N/A	N/A	1025.89 psf	81.74 Kips
33.01 ft	Cohesive	N/A	N/A	1149.92 psf	125.09 Kips
42.01 ft	Cohesive	N/A	N/A	1273.95 psf	177.80 Kips
51.01 ft	Cohesive	N/A	N/A	1397.98 psf	239.86 Kips
53.99 ft	Cohesive	N/A	N/A	1430.00 psf	261.33 Kips
54.01 ft	Cohesionless	3397.71 psf	21.97	N/A	261.45 Kips
57.99 ft	Cohesionless	3522.29 psf	21.97	N/A	285.04 Kips
58.01 ft	Cohesionless	3648.14 psf	24.17	N/A	285.18 Kips
67.01 ft	Cohesionless	3952.34 psf	24.17	N/A	369.69 Kips
68.99 ft	Cohesionless	4019.26 psf	24.17	N/A	390.02 Kips
69.01 ft	Cohesionless	4391.74 psf	23.44	N/A	390.22 Kips
78.01 ft	Cohesionless	4695.94 psf	23.44	N/A	480.57 Kips
85.99 ft	Cohesionless	4965.66 psf	23.44	N/A	570.48 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.25 psf	26.40	18.60 Kips	0.03 Kips
2.99 ft	Cohesionless	373.75 psf	26.40	18.60 Kips	7.69 Kips
3.01 ft	Cohesionless	376.25 psf	26.40	18.60 Kips	7.74 Kips
4.99 ft	Cohesionless	623.75 psf	26.40	18.60 Kips	12.83 Kips
5.01 ft	Cohesionless	625.63 psf	26.40	18.60 Kips	12.87 Kips
9.49 ft	Cohesionless	906.07 psf	26.40	18.60 Kips	18.60 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	21.99 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	21.99 Kips
23.99 ft	Cohesive	N/A	N/A	N/A	21.99 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
42.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
51.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
53.99 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
54.01 ft	Cohesionless	3398.03 psf	30.00	18.60 Kips	18.60 Kips
57.99 ft	Cohesionless	3647.17 psf	30.00	18.60 Kips	18.60 Kips
58.01 ft	Cohesionless	3648.48 psf	47.20	69.81 Kips	69.81 Kips
67.01 ft	Cohesionless	4256.88 psf	47.20	69.81 Kips	69.81 Kips
68.99 ft	Cohesionless	4390.72 psf	47.20	69.81 Kips	69.81 Kips
69.01 ft	Cohesionless	4392.08 psf	40.40	46.08 Kips	46.08 Kips
78.01 ft	Cohesionless	5000.48 psf	40.40	46.08 Kips	46.08 Kips
85.99 ft	Cohesionless	5539.92 psf	40.40	46.08 Kips	46.08 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.03 Kips	0.03 Kips
2.99 ft	0.87 Kips	7.69 Kips	8.55 Kips
3.01 ft	0.88 Kips	7.74 Kips	8.62 Kips
4.99 ft	2.41 Kips	12.83 Kips	15.24 Kips
5.01 ft	2.43 Kips	12.87 Kips	15.30 Kips
9.49 ft	7.74 Kips	18.60 Kips	26.34 Kips
9.51 ft	7.80 Kips	21.99 Kips	29.79 Kips
18.51 ft	52.20 Kips	21.99 Kips	74.19 Kips
23.99 ft	81.64 Kips	21.99 Kips	103.63 Kips
24.01 ft	81.74 Kips	34.56 Kips	116.29 Kips
33.01 ft	125.09 Kips	34.56 Kips	159.65 Kips
42.01 ft	177.80 Kips	34.56 Kips	212.36 Kips
51.01 ft	239.86 Kips	34.56 Kips	274.42 Kips
53.99 ft	261.33 Kips	34.56 Kips	295.89 Kips
54.01 ft	261.45 Kips	18.60 Kips	280.05 Kips
57.99 ft	285.04 Kips	18.60 Kips	303.63 Kips
58.01 ft	285.18 Kips	69.81 Kips	355.00 Kips
67.01 ft	369.69 Kips	69.81 Kips	439.50 Kips
68.99 ft	390.02 Kips	69.81 Kips	459.84 Kips
69.01 ft	390.22 Kips	46.08 Kips	436.30 Kips
78.01 ft	480.57 Kips	46.08 Kips	526.65 Kips
85.99 ft	570.48 Kips	46.08 Kips	616.56 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.62 psf	21.24	N/A	0.00 Kips
2.99 ft	Cohesionless	186.88 psf	21.24	N/A	0.87 Kips
3.01 ft	Cohesionless	375.62 psf	21.24	N/A	0.88 Kips
4.99 ft	Cohesionless	499.38 psf	21.24	N/A	2.41 Kips
5.01 ft	Cohesionless	625.31 psf	21.24	N/A	2.43 Kips
9.49 ft	Cohesionless	765.54 psf	21.24	N/A	7.74 Kips
9.51 ft	Cohesive	N/A	N/A	1140.00 psf	7.78 Kips
18.51 ft	Cohesive	N/A	N/A	1177.53 psf	37.53 Kips
23.99 ft	Cohesive	N/A	N/A	1217.26 psf	57.25 Kips
24.01 ft	Cohesive	N/A	N/A	1025.89 psf	57.30 Kips
33.01 ft	Cohesive	N/A	N/A	1149.92 psf	78.98 Kips
42.01 ft	Cohesive	N/A	N/A	1273.95 psf	105.33 Kips
51.01 ft	Cohesive	N/A	N/A	1397.98 psf	136.36 Kips
53.99 ft	Cohesive	N/A	N/A	1430.00 psf	147.10 Kips
54.01 ft	Cohesionless	3397.71 psf	21.97	N/A	147.22 Kips
57.99 ft	Cohesionless	3522.29 psf	21.97	N/A	170.80 Kips
58.01 ft	Cohesionless	3648.14 psf	24.17	N/A	170.95 Kips
67.01 ft	Cohesionless	3952.34 psf	24.17	N/A	255.45 Kips
68.99 ft	Cohesionless	4019.26 psf	24.17	N/A	275.79 Kips
69.01 ft	Cohesionless	4391.74 psf	23.44	N/A	275.99 Kips
78.01 ft	Cohesionless	4695.94 psf	23.44	N/A	366.34 Kips
85.99 ft	Cohesionless	4965.66 psf	23.44	N/A	456.25 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.25 psf	26.40	18.60 Kips	0.03 Kips
2.99 ft	Cohesionless	373.75 psf	26.40	18.60 Kips	7.69 Kips
3.01 ft	Cohesionless	376.25 psf	26.40	18.60 Kips	7.74 Kips
4.99 ft	Cohesionless	623.75 psf	26.40	18.60 Kips	12.83 Kips
5.01 ft	Cohesionless	625.63 psf	26.40	18.60 Kips	12.87 Kips
9.49 ft	Cohesionless	906.07 psf	26.40	18.60 Kips	18.60 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	21.99 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	21.99 Kips
23.99 ft	Cohesive	N/A	N/A	N/A	21.99 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
42.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
51.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
53.99 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
54.01 ft	Cohesionless	3398.03 psf	30.00	18.60 Kips	18.60 Kips
57.99 ft	Cohesionless	3647.17 psf	30.00	18.60 Kips	18.60 Kips
58.01 ft	Cohesionless	3648.48 psf	47.20	69.81 Kips	69.81 Kips
67.01 ft	Cohesionless	4256.88 psf	47.20	69.81 Kips	69.81 Kips
68.99 ft	Cohesionless	4390.72 psf	47.20	69.81 Kips	69.81 Kips
69.01 ft	Cohesionless	4392.08 psf	40.40	46.08 Kips	46.08 Kips
78.01 ft	Cohesionless	5000.48 psf	40.40	46.08 Kips	46.08 Kips
85.99 ft	Cohesionless	5539.92 psf	40.40	46.08 Kips	46.08 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.03 Kips	0.03 Kips
2.99 ft	0.87 Kips	7.69 Kips	8.55 Kips
3.01 ft	0.88 Kips	7.74 Kips	8.62 Kips
4.99 ft	2.41 Kips	12.83 Kips	15.24 Kips
5.01 ft	2.43 Kips	12.87 Kips	15.30 Kips
9.49 ft	7.74 Kips	18.60 Kips	26.34 Kips
9.51 ft	7.78 Kips	21.99 Kips	29.77 Kips
18.51 ft	37.53 Kips	21.99 Kips	59.52 Kips
23.99 ft	57.25 Kips	21.99 Kips	79.24 Kips
24.01 ft	57.30 Kips	34.56 Kips	91.86 Kips
33.01 ft	78.98 Kips	34.56 Kips	113.54 Kips
42.01 ft	105.33 Kips	34.56 Kips	139.89 Kips
51.01 ft	136.36 Kips	34.56 Kips	170.92 Kips
53.99 ft	147.10 Kips	34.56 Kips	181.66 Kips
54.01 ft	147.22 Kips	18.60 Kips	165.81 Kips
57.99 ft	170.80 Kips	18.60 Kips	189.40 Kips
58.01 ft	170.95 Kips	69.81 Kips	240.76 Kips
67.01 ft	255.45 Kips	69.81 Kips	325.27 Kips
68.99 ft	275.79 Kips	69.81 Kips	345.60 Kips
69.01 ft	275.99 Kips	46.08 Kips	322.06 Kips
78.01 ft	366.34 Kips	46.08 Kips	412.42 Kips
85.99 ft	456.25 Kips	46.08 Kips	502.32 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.62 psf	21.24	N/A	0.00 Kips
2.99 ft	Cohesionless	186.88 psf	21.24	N/A	-0.87 Kips
3.01 ft	Cohesionless	375.62 psf	21.24	N/A	-0.88 Kips
4.99 ft	Cohesionless	499.38 psf	21.24	N/A	-2.41 Kips
5.01 ft	Cohesionless	625.31 psf	21.24	N/A	-2.43 Kips
9.49 ft	Cohesionless	765.54 psf	21.24	N/A	-7.74 Kips
9.51 ft	Cohesive	N/A	N/A	1140.00 psf	-7.80 Kips
18.51 ft	Cohesive	N/A	N/A	1177.53 psf	-52.20 Kips
23.99 ft	Cohesive	N/A	N/A	1217.26 psf	-81.64 Kips
24.01 ft	Cohesive	N/A	N/A	1025.89 psf	-81.74 Kips
33.01 ft	Cohesive	N/A	N/A	1149.92 psf	-125.09 Kips
38.99 ft	Cohesive	N/A	N/A	1232.33 psf	-159.07 Kips
39.00 ft	Cohesive	N/A	N/A	1232.47 psf	-159.13 Kips
42.01 ft	Cohesive	N/A	N/A	1273.95 psf	-143.07 Kips
51.01 ft	Cohesive	N/A	N/A	1397.98 psf	-88.80 Kips
53.99 ft	Cohesive	N/A	N/A	1430.00 psf	-69.34 Kips
54.01 ft	Cohesionless	3397.71 psf	21.97	N/A	-69.22 Kips
57.99 ft	Cohesionless	3522.29 psf	21.97	N/A	-45.64 Kips
58.01 ft	Cohesionless	3648.14 psf	24.17	N/A	-45.49 Kips
67.01 ft	Cohesionless	3952.34 psf	24.17	N/A	39.01 Kips
68.99 ft	Cohesionless	4019.26 psf	24.17	N/A	59.35 Kips
69.01 ft	Cohesionless	4391.74 psf	23.44	N/A	59.55 Kips
78.01 ft	Cohesionless	4695.94 psf	23.44	N/A	149.90 Kips
85.99 ft	Cohesionless	4965.66 psf	23.44	N/A	239.81 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	0.00 psf	0.00	0.00 Kips	0.00 Kips
2.99 ft	Cohesionless	0.00 psf	0.00	0.00 Kips	0.00 Kips
3.01 ft	Cohesionless	0.00 psf	0.00	0.00 Kips	0.00 Kips
4.99 ft	Cohesionless	0.00 psf	0.00	0.00 Kips	0.00 Kips
5.01 ft	Cohesionless	0.00 psf	0.00	0.00 Kips	0.00 Kips
9.49 ft	Cohesionless	0.00 psf	0.00	0.00 Kips	0.00 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
23.99 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
24.01 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
33.01 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
38.99 ft	Cohesive	N/A	N/A	N/A	0.00 Kips
39.00 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
42.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
51.01 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
53.99 ft	Cohesive	N/A	N/A	N/A	34.56 Kips
54.01 ft	Cohesionless	3398.03 psf	30.00	18.60 Kips	18.60 Kips
57.99 ft	Cohesionless	3647.17 psf	30.00	18.60 Kips	18.60 Kips
58.01 ft	Cohesionless	3648.48 psf	47.20	69.81 Kips	69.81 Kips
67.01 ft	Cohesionless	4256.88 psf	47.20	69.81 Kips	69.81 Kips
68.99 ft	Cohesionless	4390.72 psf	47.20	69.81 Kips	69.81 Kips
69.01 ft	Cohesionless	4392.08 psf	40.40	46.08 Kips	46.08 Kips
78.01 ft	Cohesionless	5000.48 psf	40.40	46.08 Kips	46.08 Kips
85.99 ft	Cohesionless	5539.92 psf	40.40	46.08 Kips	46.08 Kips

ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.00 Kips	0.00 Kips
2.99 ft	-0.87 Kips	0.00 Kips	-0.87 Kips
3.01 ft	-0.88 Kips	0.00 Kips	-0.88 Kips
4.99 ft	-2.41 Kips	0.00 Kips	-2.41 Kips
5.01 ft	-2.43 Kips	0.00 Kips	-2.43 Kips
9.49 ft	-7.74 Kips	0.00 Kips	-7.74 Kips
9.51 ft	-7.80 Kips	0.00 Kips	-7.80 Kips
18.51 ft	-52.20 Kips	0.00 Kips	-52.20 Kips
23.99 ft	-81.64 Kips	0.00 Kips	-81.64 Kips
24.01 ft	-81.74 Kips	0.00 Kips	-81.74 Kips
33.01 ft	-125.09 Kips	0.00 Kips	-125.09 Kips
38.99 ft	-159.07 Kips	0.00 Kips	-159.07 Kips
39.00 ft	-159.13 Kips	34.56 Kips	-124.57 Kips
42.01 ft	-143.07 Kips	34.56 Kips	-108.51 Kips
51.01 ft	-88.80 Kips	34.56 Kips	-54.24 Kips
53.99 ft	-69.34 Kips	34.56 Kips	-34.78 Kips
54.01 ft	-69.22 Kips	18.60 Kips	-50.63 Kips
57.99 ft	-45.64 Kips	18.60 Kips	-27.04 Kips
58.01 ft	-45.49 Kips	69.81 Kips	24.32 Kips
67.01 ft	39.01 Kips	69.81 Kips	108.83 Kips
68.99 ft	59.35 Kips	69.81 Kips	129.16 Kips
69.01 ft	59.55 Kips	46.08 Kips	105.62 Kips
78.01 ft	149.90 Kips	46.08 Kips	195.98 Kips
85.99 ft	239.81 Kips	46.08 Kips	285.88 Kips

DRIVEN 1.2

GENERAL PROJECT INFORMATION

Filename: C:\DOCUME~1\LEGACY\DESKTOP\B-169.DVN
Project Name: HAM-75-0823 Project Date: 06/12/2013
Project Client: Barr _Prevost
Computed By: Vijay Veluchamy
Project Manager: Brain Trenner

PILE INFORMATION

Pile Type: Pipe Pile - Closed End
Top of Pile: 0.00 ft
Diameter of Pile: 16.00 in

ULTIMATE CONSIDERATIONS

Water Table Depth At Time Of:	- Drilling:	6.50 ft
	- Driving/Restrike	6.50 ft
	- Ultimate:	6.50 ft
Ultimate Considerations:	- Local Scour:	0.00 ft
	- Long Term Scour:	0.00 ft
	- Soft Soil:	0.00 ft

ULTIMATE PROFILE

Layer	Type	Thickness	Driving Loss	Unit Weight	Strength	Ultimate Curve
1	Cohesionless	9.50 ft	0.00%	125.00 pcf	30.0/30.0	Nordlund
2	Cohesive	25.00 ft	33.00%	115.00 pcf	2000.00 psf	T-79 Steel
3	Cohesive	14.00 ft	33.00%	125.00 pcf	3750.00 psf	T-79 Steel
4	Cohesive	12.00 ft	33.00%	120.00 pcf	2500.00 psf	T-79 Steel
5	Cohesionless	4.50 ft	0.00%	130.00 pcf	35.0/35.0	Nordlund
6	Cohesionless	2.50 ft	0.00%	130.00 pcf	35.0/35.0	Nordlund

RESTRIKE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.62 psf	21.97	N/A	0.00 Kips
6.49 ft	Cohesionless	405.62 psf	21.97	N/A	4.43 Kips
6.51 ft	Cohesionless	812.81 psf	21.97	N/A	4.46 Kips
9.49 ft	Cohesionless	906.09 psf	21.97	N/A	9.00 Kips
9.51 ft	Cohesive	N/A	N/A	1165.00 psf	9.07 Kips
18.51 ft	Cohesive	N/A	N/A	1210.30 psf	54.70 Kips
27.51 ft	Cohesive	N/A	N/A	1289.05 psf	106.26 Kips
34.49 ft	Cohesive	N/A	N/A	1350.12 psf	150.35 Kips
34.51 ft	Cohesive	N/A	N/A	1029.41 psf	150.45 Kips
43.51 ft	Cohesive	N/A	N/A	1139.66 psf	193.42 Kips
48.49 ft	Cohesive	N/A	N/A	1200.67 psf	220.77 Kips
48.51 ft	Cohesive	N/A	N/A	1461.69 psf	220.89 Kips
57.51 ft	Cohesive	N/A	N/A	1525.00 psf	278.38 Kips
60.49 ft	Cohesive	N/A	N/A	1525.00 psf	297.42 Kips
60.51 ft	Cohesionless	3883.24 psf	25.63	N/A	297.60 Kips
64.99 ft	Cohesionless	4034.66 psf	25.63	N/A	349.45 Kips
65.01 ft	Cohesionless	4187.44 psf	25.63	N/A	349.69 Kips
67.49 ft	Cohesionless	4271.26 psf	25.63	N/A	380.08 Kips

RESTRIKE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.25 psf	30.00	18.60 Kips	0.03 Kips
6.49 ft	Cohesionless	811.25 psf	30.00	18.60 Kips	18.60 Kips
6.51 ft	Cohesionless	813.13 psf	30.00	18.60 Kips	18.60 Kips
9.49 ft	Cohesionless	999.67 psf	30.00	18.60 Kips	18.60 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
34.49 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
34.51 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
43.51 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
48.49 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
48.51 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
57.51 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
60.49 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
60.51 ft	Cohesionless	3883.58 psf	64.00	150.24 Kips	150.24 Kips
64.99 ft	Cohesionless	4186.42 psf	64.00	150.24 Kips	150.24 Kips
65.01 ft	Cohesionless	4187.78 psf	64.00	150.24 Kips	150.24 Kips
67.49 ft	Cohesionless	4355.42 psf	64.00	150.24 Kips	150.24 Kips

RESTRIKE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.03 Kips	0.03 Kips
6.49 ft	4.43 Kips	18.60 Kips	23.03 Kips
6.51 ft	4.46 Kips	18.60 Kips	23.05 Kips
9.49 ft	9.00 Kips	18.60 Kips	27.60 Kips
9.51 ft	9.07 Kips	25.13 Kips	34.20 Kips
18.51 ft	54.70 Kips	25.13 Kips	79.83 Kips
27.51 ft	106.26 Kips	25.13 Kips	131.40 Kips
34.49 ft	150.35 Kips	25.13 Kips	175.48 Kips
34.51 ft	150.45 Kips	47.12 Kips	197.58 Kips
43.51 ft	193.42 Kips	47.12 Kips	240.55 Kips
48.49 ft	220.77 Kips	47.12 Kips	267.90 Kips
48.51 ft	220.89 Kips	31.42 Kips	252.31 Kips
57.51 ft	278.38 Kips	31.42 Kips	309.80 Kips
60.49 ft	297.42 Kips	31.42 Kips	328.84 Kips
60.51 ft	297.60 Kips	150.24 Kips	447.83 Kips
64.99 ft	349.45 Kips	150.24 Kips	499.69 Kips
65.01 ft	349.69 Kips	150.24 Kips	499.93 Kips
67.49 ft	380.08 Kips	150.24 Kips	530.32 Kips

DRIVING - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.62 psf	21.97	N/A	0.00 Kips
6.49 ft	Cohesionless	405.62 psf	21.97	N/A	4.43 Kips
6.51 ft	Cohesionless	812.81 psf	21.97	N/A	4.46 Kips
9.49 ft	Cohesionless	906.09 psf	21.97	N/A	9.00 Kips
9.51 ft	Cohesive	N/A	N/A	1165.00 psf	9.04 Kips
18.51 ft	Cohesive	N/A	N/A	1210.30 psf	39.62 Kips
27.51 ft	Cohesive	N/A	N/A	1289.05 psf	74.17 Kips
34.49 ft	Cohesive	N/A	N/A	1350.12 psf	103.70 Kips
34.51 ft	Cohesive	N/A	N/A	1029.41 psf	103.77 Kips
43.51 ft	Cohesive	N/A	N/A	1139.66 psf	132.56 Kips
48.49 ft	Cohesive	N/A	N/A	1200.67 psf	150.89 Kips
48.51 ft	Cohesive	N/A	N/A	1461.69 psf	150.97 Kips
57.51 ft	Cohesive	N/A	N/A	1525.00 psf	189.49 Kips
60.49 ft	Cohesive	N/A	N/A	1525.00 psf	202.24 Kips
60.51 ft	Cohesionless	3883.24 psf	25.63	N/A	202.42 Kips
64.99 ft	Cohesionless	4034.66 psf	25.63	N/A	254.27 Kips
65.01 ft	Cohesionless	4187.44 psf	25.63	N/A	254.51 Kips
67.49 ft	Cohesionless	4271.26 psf	25.63	N/A	284.90 Kips

DRIVING - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.25 psf	30.00	18.60 Kips	0.03 Kips
6.49 ft	Cohesionless	811.25 psf	30.00	18.60 Kips	18.60 Kips
6.51 ft	Cohesionless	813.13 psf	30.00	18.60 Kips	18.60 Kips
9.49 ft	Cohesionless	999.67 psf	30.00	18.60 Kips	18.60 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
34.49 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
34.51 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
43.51 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
48.49 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
48.51 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
57.51 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
60.49 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
60.51 ft	Cohesionless	3883.58 psf	64.00	150.24 Kips	150.24 Kips
64.99 ft	Cohesionless	4186.42 psf	64.00	150.24 Kips	150.24 Kips
65.01 ft	Cohesionless	4187.78 psf	64.00	150.24 Kips	150.24 Kips
67.49 ft	Cohesionless	4355.42 psf	64.00	150.24 Kips	150.24 Kips

DRIVING - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.03 Kips	0.03 Kips
6.49 ft	4.43 Kips	18.60 Kips	23.03 Kips
6.51 ft	4.46 Kips	18.60 Kips	23.05 Kips
9.49 ft	9.00 Kips	18.60 Kips	27.60 Kips
9.51 ft	9.04 Kips	25.13 Kips	34.18 Kips
18.51 ft	39.62 Kips	25.13 Kips	64.75 Kips
27.51 ft	74.17 Kips	25.13 Kips	99.30 Kips
34.49 ft	103.70 Kips	25.13 Kips	128.83 Kips
34.51 ft	103.77 Kips	47.12 Kips	150.90 Kips
43.51 ft	132.56 Kips	47.12 Kips	179.69 Kips
48.49 ft	150.89 Kips	47.12 Kips	198.01 Kips
48.51 ft	150.97 Kips	31.42 Kips	182.38 Kips
57.51 ft	189.49 Kips	31.42 Kips	220.90 Kips
60.49 ft	202.24 Kips	31.42 Kips	233.66 Kips
60.51 ft	202.42 Kips	150.24 Kips	352.65 Kips
64.99 ft	254.27 Kips	150.24 Kips	404.51 Kips
65.01 ft	254.51 Kips	150.24 Kips	404.75 Kips
67.49 ft	284.90 Kips	150.24 Kips	435.14 Kips

ULTIMATE - SKIN FRICTION

Depth	Soil Type	Effective Stress At Midpoint	Sliding Friction Angle	Adhesion	Skin Friction
0.01 ft	Cohesionless	0.62 psf	21.97	N/A	0.00 Kips
6.49 ft	Cohesionless	405.62 psf	21.97	N/A	4.43 Kips
6.51 ft	Cohesionless	812.81 psf	21.97	N/A	4.46 Kips
9.49 ft	Cohesionless	906.09 psf	21.97	N/A	9.00 Kips
9.51 ft	Cohesive	N/A	N/A	1165.00 psf	9.07 Kips
18.51 ft	Cohesive	N/A	N/A	1210.30 psf	54.70 Kips
27.51 ft	Cohesive	N/A	N/A	1289.05 psf	106.26 Kips
34.49 ft	Cohesive	N/A	N/A	1350.12 psf	150.35 Kips
34.51 ft	Cohesive	N/A	N/A	1029.41 psf	150.45 Kips
43.51 ft	Cohesive	N/A	N/A	1139.66 psf	193.42 Kips
48.49 ft	Cohesive	N/A	N/A	1200.67 psf	220.77 Kips
48.51 ft	Cohesive	N/A	N/A	1461.69 psf	220.89 Kips
57.51 ft	Cohesive	N/A	N/A	1525.00 psf	278.38 Kips
60.49 ft	Cohesive	N/A	N/A	1525.00 psf	297.42 Kips
60.51 ft	Cohesionless	3883.24 psf	25.63	N/A	297.60 Kips
64.99 ft	Cohesionless	4034.66 psf	25.63	N/A	349.45 Kips
65.01 ft	Cohesionless	4187.44 psf	25.63	N/A	349.69 Kips
67.49 ft	Cohesionless	4271.26 psf	25.63	N/A	380.08 Kips

ULTIMATE - END BEARING

Depth	Soil Type	Effective Stress At Tip	Bearing Cap. Factor	Limiting End Bearing	End Bearing
0.01 ft	Cohesionless	1.25 psf	30.00	18.60 Kips	0.03 Kips
6.49 ft	Cohesionless	811.25 psf	30.00	18.60 Kips	18.60 Kips
6.51 ft	Cohesionless	813.13 psf	30.00	18.60 Kips	18.60 Kips
9.49 ft	Cohesionless	999.67 psf	30.00	18.60 Kips	18.60 Kips
9.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
18.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
27.51 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
34.49 ft	Cohesive	N/A	N/A	N/A	25.13 Kips
34.51 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
43.51 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
48.49 ft	Cohesive	N/A	N/A	N/A	47.12 Kips
48.51 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
57.51 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
60.49 ft	Cohesive	N/A	N/A	N/A	31.42 Kips
60.51 ft	Cohesionless	3883.58 psf	64.00	150.24 Kips	150.24 Kips
64.99 ft	Cohesionless	4186.42 psf	64.00	150.24 Kips	150.24 Kips
65.01 ft	Cohesionless	4187.78 psf	64.00	150.24 Kips	150.24 Kips
67.49 ft	Cohesionless	4355.42 psf	64.00	150.24 Kips	150.24 Kips

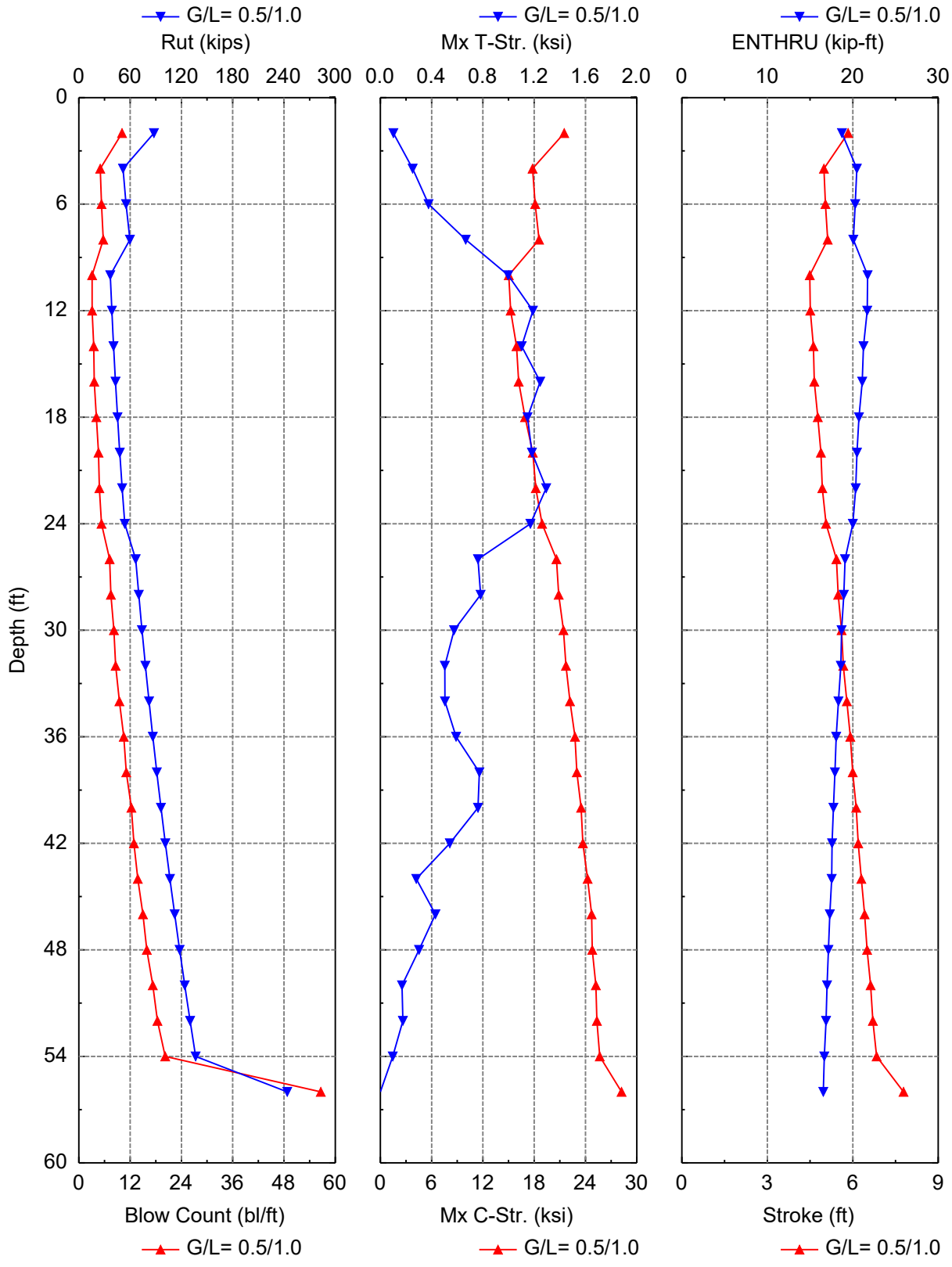
ULTIMATE - SUMMARY OF CAPACITIES

Depth	Skin Friction	End Bearing	Total Capacity
0.01 ft	0.00 Kips	0.03 Kips	0.03 Kips
6.49 ft	4.43 Kips	18.60 Kips	23.03 Kips
6.51 ft	4.46 Kips	18.60 Kips	23.05 Kips
9.49 ft	9.00 Kips	18.60 Kips	27.60 Kips
9.51 ft	9.07 Kips	25.13 Kips	34.20 Kips
18.51 ft	54.70 Kips	25.13 Kips	79.83 Kips
27.51 ft	106.26 Kips	25.13 Kips	131.40 Kips
34.49 ft	150.35 Kips	25.13 Kips	175.48 Kips
34.51 ft	150.45 Kips	47.12 Kips	197.58 Kips
43.51 ft	193.42 Kips	47.12 Kips	240.55 Kips
48.49 ft	220.77 Kips	47.12 Kips	267.90 Kips
48.51 ft	220.89 Kips	31.42 Kips	252.31 Kips
57.51 ft	278.38 Kips	31.42 Kips	309.80 Kips
60.49 ft	297.42 Kips	31.42 Kips	328.84 Kips
60.51 ft	297.60 Kips	150.24 Kips	447.83 Kips
64.99 ft	349.45 Kips	150.24 Kips	499.69 Kips
65.01 ft	349.69 Kips	150.24 Kips	499.93 Kips
67.49 ft	380.08 Kips	150.24 Kips	530.32 Kips

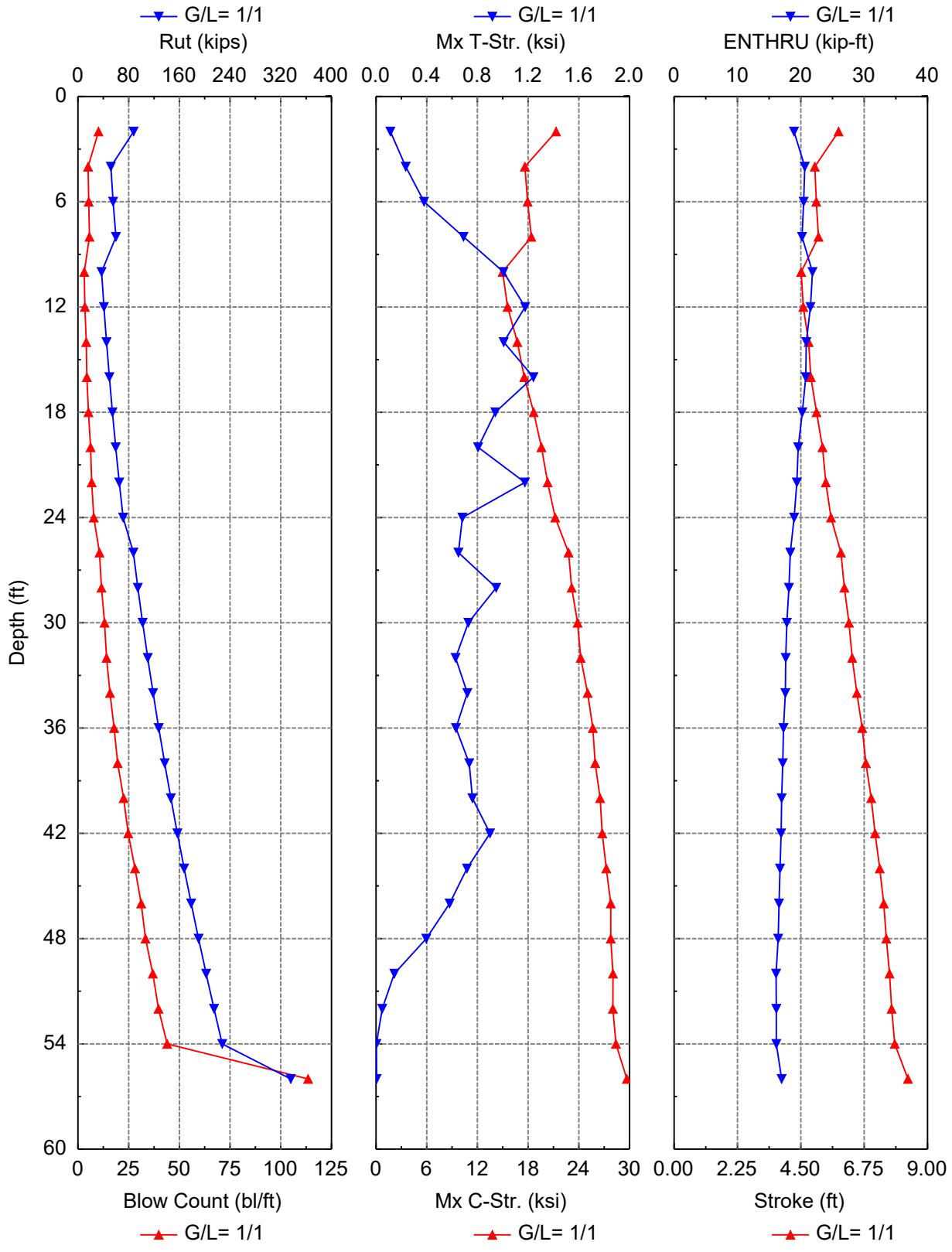
APPENDIX VI

GRLWEAP DRIVEABILITY ANALYSIS

Driveability Analysis Summary



Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 0.500/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
2.0	87.8	0.4	87.5	10.1	21.512	0.101	5.84	18.7	D 19-42
4.0	51.7	2.1	49.6	5.0	17.812	0.252	4.99	20.5	D 19-42
6.0	55.2	5.6	49.6	5.3	18.116	0.376	5.04	20.3	D 19-42
8.0	59.8	10.2	49.6	5.7	18.576	0.666	5.12	20.1	D 19-42
10.0	36.8	14.7	22.0	3.1	15.022	0.996	4.49	21.7	D 19-42
12.0	38.6	16.5	22.0	3.1	15.240	1.190	4.51	21.7	D 19-42
14.0	40.6	18.6	22.0	3.5	15.928	1.102	4.62	21.2	D 19-42
16.0	42.9	20.8	22.0	3.6	16.186	1.247	4.65	21.1	D 19-42
18.0	45.3	23.2	22.0	4.1	16.932	1.149	4.77	20.7	D 19-42
20.0	47.9	25.9	22.0	4.6	17.833	1.182	4.88	20.5	D 19-42
22.0	50.7	28.7	22.0	4.8	18.184	1.294	4.93	20.3	D 19-42
24.0	53.7	31.7	22.0	5.3	18.926	1.171	5.06	20.0	D 19-42
26.0	66.5	35.0	31.5	7.2	20.604	0.762	5.43	19.1	D 19-42
28.0	70.1	38.6	31.5	7.5	20.862	0.782	5.49	19.0	D 19-42
30.0	73.9	42.4	31.5	8.2	21.431	0.575	5.61	18.7	D 19-42
32.0	77.9	46.4	31.5	8.6	21.711	0.503	5.67	18.6	D 19-42
34.0	82.1	50.6	31.5	9.5	22.192	0.504	5.79	18.3	D 19-42
36.0	86.6	55.1	31.5	10.5	22.775	0.591	5.92	18.1	D 19-42
38.0	91.2	59.7	31.5	11.1	22.992	0.773	6.00	17.9	D 19-42
40.0	96.1	64.6	31.5	12.3	23.492	0.762	6.12	17.7	D 19-42
42.0	101.2	69.8	31.5	12.9	23.692	0.542	6.19	17.6	D 19-42
44.0	106.6	75.1	31.5	13.8	24.254	0.281	6.30	17.5	D 19-42
46.0	112.2	80.7	31.5	15.0	24.712	0.430	6.42	17.3	D 19-42
48.0	117.9	86.4	31.5	15.9	24.793	0.302	6.50	17.1	D 19-42
50.0	124.0	92.5	31.5	17.3	25.220	0.169	6.62	17.0	D 19-42
52.0	130.2	98.7	31.5	18.4	25.334	0.176	6.71	16.9	D 19-42
54.0	136.6	105.1	31.5	20.2	25.669	0.096	6.84	16.7	D 19-42
56.0	243.8	109.6	134.1	56.6	28.225	0.000	7.78	16.6	D 19-42

Summary_Total driving time: 11 minutes; Total Number of Blows: 539 (starting at penetration 2.0 ft)

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

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
2.0	87.9	0.4	87.5	10.1	21.309	0.114	5.84	18.9	D 19-42
4.0	51.9	2.3	49.6	5.0	17.625	0.234	5.00	20.6	D 19-42
6.0	55.4	5.8	49.6	5.3	17.942	0.379	5.05	20.4	D 19-42
8.0	59.9	10.3	49.6	5.7	18.382	0.691	5.13	20.2	D 19-42

10.0	37.3	15.3	22.0	3.1	14.984	1.006	4.51	21.8	D 19-42
12.0	41.0	19.0	22.0	3.4	15.570	1.177	4.59	21.5	D 19-42
14.0	45.1	23.0	22.0	4.1	16.726	1.008	4.78	20.9	D 19-42
16.0	49.5	27.5	22.0	4.4	17.548	1.242	4.86	20.8	D 19-42
18.0	54.4	32.4	22.0	5.2	18.651	0.941	5.06	20.2	D 19-42
20.0	59.6	37.6	22.0	6.2	19.585	0.806	5.27	19.6	D 19-42
22.0	65.3	43.2	22.0	6.8	20.310	1.174	5.39	19.4	D 19-42
24.0	71.3	49.3	22.0	7.8	21.199	0.681	5.57	18.9	D 19-42
26.0	87.4	55.9	31.5	10.6	22.780	0.650	5.92	18.3	D 19-42
28.0	94.6	63.1	31.5	11.6	23.149	0.948	6.05	18.1	D 19-42
30.0	102.1	70.6	31.5	13.1	23.852	0.728	6.21	17.8	D 19-42
32.0	110.1	78.6	31.5	14.1	24.219	0.628	6.32	17.6	D 19-42
34.0	118.6	87.1	31.5	15.8	25.041	0.720	6.49	17.6	D 19-42
36.0	127.5	96.0	31.5	17.8	25.657	0.630	6.68	17.3	D 19-42
38.0	136.8	105.3	31.5	19.6	25.937	0.736	6.81	17.2	D 19-42
40.0	146.6	115.1	31.5	22.5	26.515	0.761	7.00	17.0	D 19-42
42.0	156.9	125.4	31.5	24.8	26.763	0.899	7.14	16.9	D 19-42
44.0	167.6	136.1	31.5	28.1	27.253	0.718	7.30	16.7	D 19-42
46.0	178.7	147.2	31.5	31.2	27.780	0.581	7.44	16.6	D 19-42
48.0	190.3	158.8	31.5	33.3	27.779	0.397	7.53	16.4	D 19-42
50.0	202.3	170.8	31.5	36.9	28.037	0.145	7.65	16.1	D 19-42
52.0	214.8	183.3	31.5	39.7	28.027	0.049	7.72	16.1	D 19-42
54.0	227.7	196.2	31.5	44.0	28.391	0.003	7.83	16.1	D 19-42
56.0	335.7	201.6	134.1	113.5	29.679	0.006	8.30	17.0	D 19-42

Summary_Total driving time: 22 minutes; Total Number of Blows: 964 (starting at penetration 2.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

HAM-75-0823 - Rear Abut- B-168 - 16" CIP 5/16/2023
RESOURCE INTERNATIONAL INC GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

SOIL PROFILE

Depth	Soil Type	Spec. Wt	Su	Phi	Unit Rs	Unit Rt
ft	-	lb/ft³	ksf	°	ksf	ksf
0.0	Sand	125.0	0.0	41.8	0.00	62.66
3.0	Sand	125.0	0.0	40.9	0.15	62.66
3.0	Gravel	125.0	0.0	43.1	0.29	35.51
9.5	Gravel	125.0	0.0	42.6	0.70	35.51
9.5	Clay	115.0	0.0	24.0	0.40	15.79
24.0	Clay	115.0	0.0	24.0	0.74	15.79
24.0	Clay	120.0	0.0	27.0	0.77	22.56
54.0	Clay	120.0	0.0	27.0	1.57	22.56
54.0	Sand	125.0	0.0	37.7	0.63	96.07
58.0	Sand	125.0	0.0	37.5	0.68	96.07
58.0	Gravel	130.0	0.0	43.0	1.16	77.28
69.0	Gravel	130.0	0.0	42.8	1.40	77.28
69.0	Sand	130.0	0.0	37.9	0.82	121.14
86.0	Sand	130.0	0.0	37.3	1.03	121.14

PILE INPUT

Uniform Pile		Pile Type:	Pipe
Pile Length: (ft)	56.000	Pile Penetration: (ft)	56.000
Pile Size: (ft)	1.33	Toe Area: (in²)	201.06

Pile Profile

Lb Top	X-Area	E-Modulus	Spec. Wt	Perim.	Crit. Index
ft	in²	ksi	lb/ft³	ft	-
0.0	18.4	30,000.0	492.0	4.2	0
56.0	18.4	30,000.0	492.0	4.2	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt	Ram L.	Ram Ar.	Rtd. Stk	Effic.	Rtd. Energy
-	kips	in	in²	ft	-	kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

Type	X-Area	E-Modulus	Thickness	COR	Round-out	Stiffness
-	in²	ksi	in	-	in	kips/in

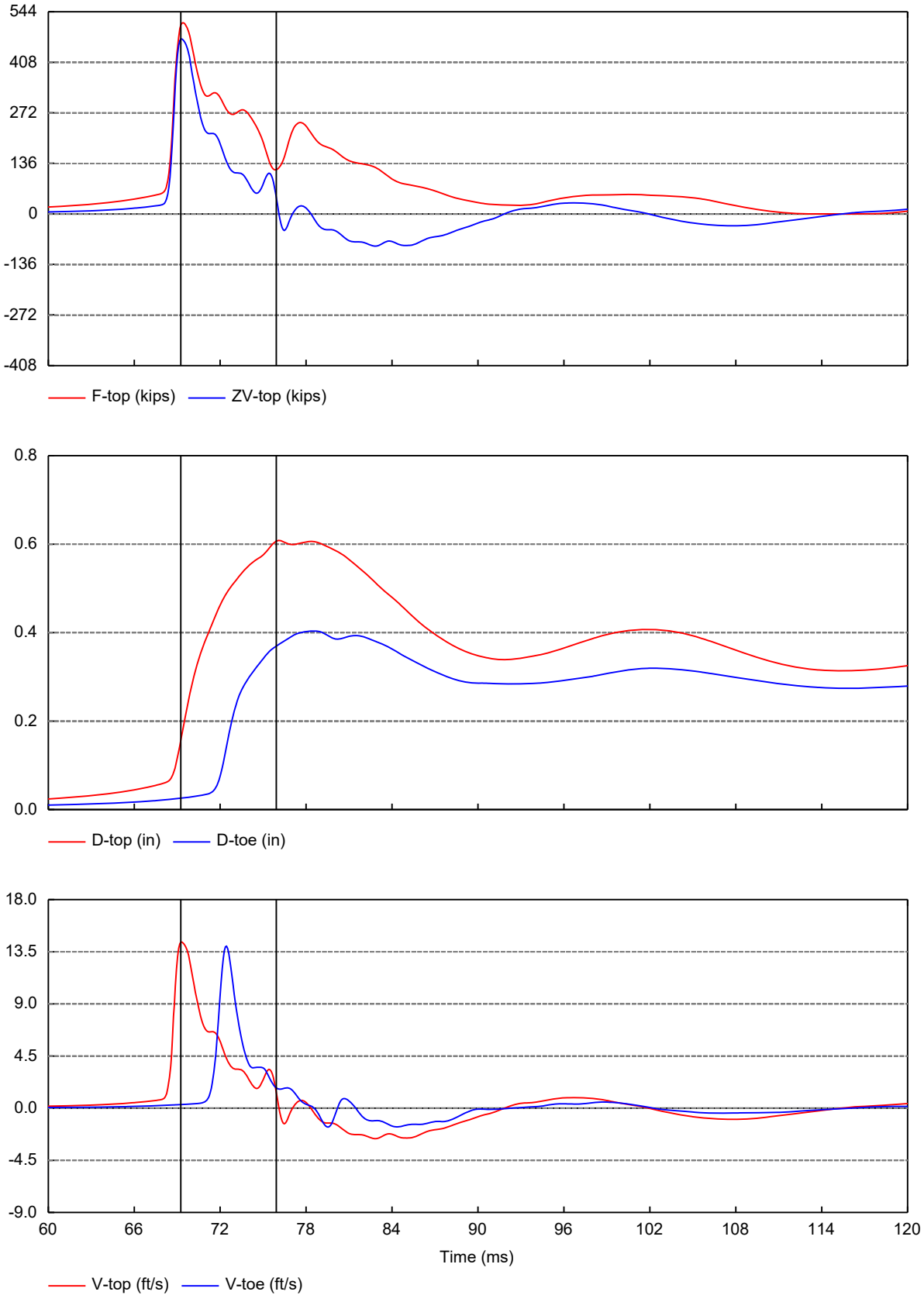
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.563
Helmet Wt.	1.700	kips				

SOIL RESISTANCE DISTRIBUTION

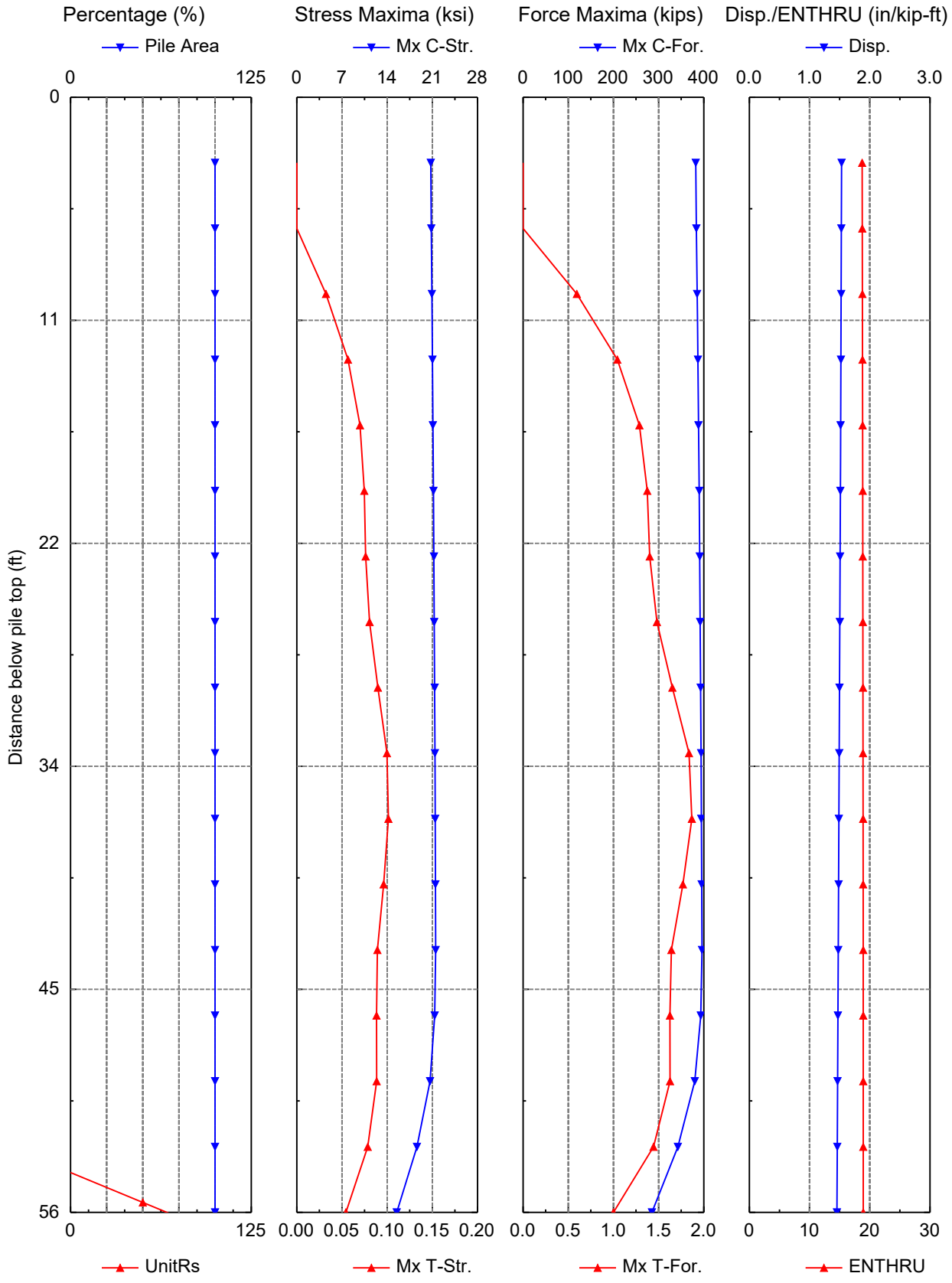
Depth	Unit Rs	Unit Rt	Qs	Qt	Js	Jt	Set. F.	Limit D.	Set. T.	EB Area
ft	ksf	ksf	in	in	s/ft	s/ft	-	ft	Hours	in²
0.0	0.0	62.7	0.10	0.27	0.05	0.15	1.2	6.6	1.0	201.1
1.5	0.1	62.7	0.10	0.27	0.05	0.15	1.2	6.6	1.0	201.1
3.0	0.2	62.7	0.10	0.27	0.05	0.15	1.2	6.6	1.0	201.1
3.0	0.3	35.5	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
5.2	0.4	35.5	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
7.3	0.6	35.5	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
9.5	0.7	35.5	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
9.5	0.4	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
11.3	0.4	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
13.1	0.5	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
14.9	0.5	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
16.8	0.6	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
18.6	0.6	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
20.4	0.7	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
22.2	0.7	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
24.0	0.7	15.8	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
24.0	0.8	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
25.7	0.8	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
27.3	0.9	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
29.0	0.9	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
30.7	0.9	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
32.3	1.0	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
34.0	1.0	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
35.7	1.1	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
37.3	1.1	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
39.0	1.2	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
40.7	1.2	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
42.3	1.3	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
44.0	1.3	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
45.7	1.3	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
47.3	1.4	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
49.0	1.4	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
50.7	1.5	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
52.3	1.5	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
54.0	1.6	22.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1

54.0	0.6	96.1	0.10	0.27	0.05	0.15	1.2	6.6	1.0	201.1
56.0	0.7	96.1	0.10	0.27	0.05	0.15	1.2	6.6	1.0	201.1

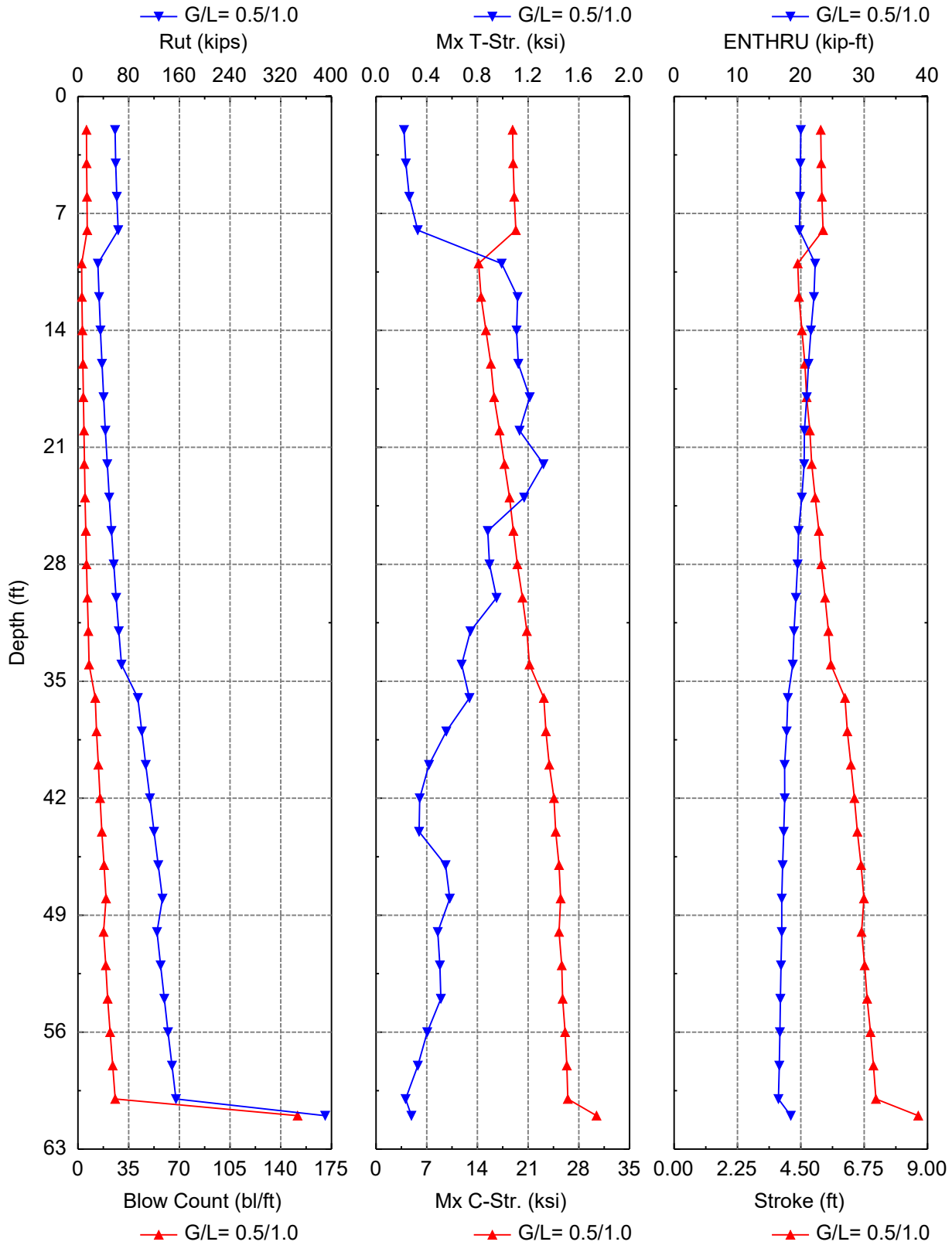
Variable Time Hisotry with DELMAG D 19-42; Depth = 56.00ft; Shaft/Toe G/L = 0.500/1.000



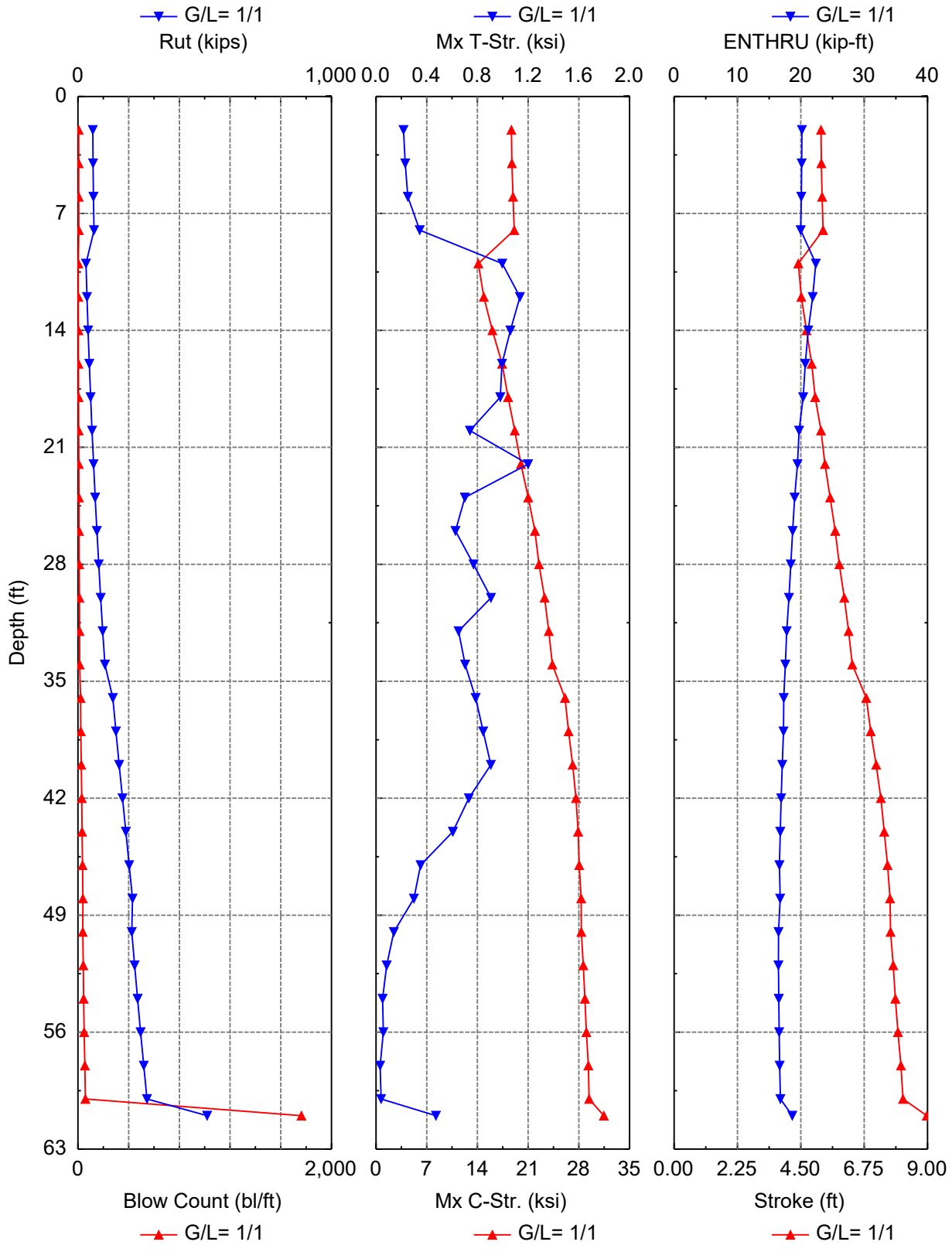
Extrema Results of Gain/Loss at Shaft/Toe = 0.500/1.000 and Depth = 2.00 ft



Driveability Analysis Summary



Driveability Analysis Summary



Gain/Loss Factor at Shaft/Toe = 0.500/1.000

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
2.0	58.6	0.3	58.3	5.9	18.864	0.221	5.21	20.0	D 19-42
4.0	59.6	1.3	58.3	6.0	18.936	0.236	5.22	19.9	D 19-42
6.0	61.2	2.9	58.3	6.2	19.089	0.263	5.25	19.9	D 19-42
8.0	63.5	5.2	58.3	6.4	19.299	0.329	5.29	19.8	D 19-42
10.0	31.4	7.8	23.6	2.6	14.157	0.991	4.39	22.3	D 19-42
12.0	33.4	9.7	23.6	2.7	14.502	1.117	4.43	22.1	D 19-42
14.0	35.5	11.9	23.6	3.1	15.177	1.109	4.54	21.6	D 19-42
16.0	37.9	14.3	23.6	3.5	15.854	1.123	4.64	21.2	D 19-42
18.0	40.5	16.9	23.6	3.7	16.308	1.213	4.71	20.9	D 19-42
20.0	43.3	19.7	23.6	4.2	17.046	1.133	4.82	20.6	D 19-42
22.0	46.3	22.7	23.6	4.4	17.742	1.321	4.89	20.5	D 19-42
24.0	49.5	25.9	23.6	4.9	18.442	1.169	5.01	20.1	D 19-42
26.0	52.9	29.3	23.6	5.5	18.959	0.882	5.14	19.7	D 19-42
28.0	56.5	32.9	23.6	5.9	19.509	0.895	5.23	19.5	D 19-42
30.0	60.3	36.7	23.6	6.6	20.216	0.951	5.36	19.2	D 19-42
32.0	64.4	40.8	23.6	7.2	20.827	0.745	5.48	18.9	D 19-42
34.0	68.6	45.0	23.6	7.7	21.184	0.676	5.57	18.7	D 19-42
36.0	94.6	50.5	44.1	12.0	23.165	0.737	6.07	18.0	D 19-42
38.0	100.7	56.6	44.1	12.8	23.453	0.555	6.15	17.8	D 19-42
40.0	107.0	62.9	44.1	14.1	23.912	0.418	6.28	17.4	D 19-42
42.0	113.6	69.5	44.1	15.3	24.569	0.345	6.40	17.5	D 19-42
44.0	120.1	76.0	44.1	16.5	24.808	0.340	6.51	17.3	D 19-42
46.0	126.7	82.6	44.1	18.0	25.275	0.549	6.64	17.1	D 19-42
48.0	133.3	89.2	44.1	19.4	25.488	0.582	6.74	17.0	D 19-42
50.0	124.8	94.9	29.9	17.7	25.273	0.487	6.66	17.0	D 19-42
52.0	130.4	100.5	29.9	19.2	25.641	0.504	6.77	16.9	D 19-42
54.0	136.2	106.3	29.9	20.5	25.757	0.512	6.86	16.8	D 19-42
56.0	142.2	112.3	29.9	22.2	26.109	0.405	6.97	16.7	D 19-42
58.0	148.4	118.4	29.9	24.0	26.347	0.330	7.08	16.6	D 19-42
60.0	154.7	124.8	29.9	25.7	26.488	0.234	7.17	16.5	D 19-42
61.0	390.2	127.7	262.5	151.6	30.443	0.279	8.67	18.4	D 19-42

Summary_Total driving time: 15 minutes; Total Number of Blows: 705 (starting at penetration 2.0 ft)

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

Depth	Rut	Rshaft	Rtoe	Blow Ct	Mx C-Str	Mx T-Str.	Stroke	ENTHRU	Hammer
ft	kips	kips	kips	bl/ft	ksi	ksi	ft	kip-ft	-
2.0	58.6	0.3	58.3	5.9	18.697	0.217	5.21	20.2	D 19-42

4.0	59.6	1.3	58.3	6.0	18.766	0.230	5.23	20.1	D 19-42
6.0	61.2	2.9	58.3	6.2	18.907	0.251	5.26	20.1	D 19-42
8.0	63.5	5.2	58.3	6.4	19.089	0.345	5.29	20.0	D 19-42
10.0	31.9	8.2	23.6	2.6	14.130	0.996	4.41	22.4	D 19-42
12.0	35.8	12.2	23.6	3.0	14.875	1.136	4.52	21.9	D 19-42
14.0	40.1	16.5	23.6	3.6	16.062	1.060	4.70	21.2	D 19-42
16.0	44.9	21.2	23.6	4.4	17.418	0.993	4.89	20.7	D 19-42
18.0	50.0	26.4	23.6	4.9	18.231	0.980	5.01	20.4	D 19-42
20.0	55.6	32.0	23.6	5.9	19.148	0.741	5.22	19.7	D 19-42
22.0	61.6	38.0	23.6	6.6	20.003	1.200	5.36	19.5	D 19-42
24.0	68.0	44.4	23.6	7.6	21.008	0.701	5.54	19.0	D 19-42
26.0	74.9	51.2	23.6	8.8	21.942	0.627	5.72	18.7	D 19-42
28.0	82.1	58.5	23.6	9.8	22.503	0.770	5.87	18.4	D 19-42
30.0	89.8	66.1	23.6	11.3	23.277	0.908	6.04	18.1	D 19-42
32.0	97.8	74.2	23.6	12.7	23.854	0.651	6.19	17.8	D 19-42
34.0	106.3	82.7	23.6	13.9	24.350	0.703	6.33	17.6	D 19-42
36.0	137.7	93.6	44.1	20.4	26.087	0.786	6.82	17.3	D 19-42
38.0	149.9	105.8	44.1	22.9	26.580	0.846	6.98	17.3	D 19-42
40.0	162.7	118.6	44.1	26.3	27.140	0.906	7.18	17.1	D 19-42
42.0	175.7	131.6	44.1	30.0	27.601	0.732	7.34	16.9	D 19-42
44.0	188.9	144.8	44.1	32.4	27.895	0.606	7.46	16.8	D 19-42
46.0	202.0	157.9	44.1	36.0	28.055	0.351	7.58	16.6	D 19-42
48.0	215.1	171.0	44.1	38.8	28.335	0.299	7.67	16.7	D 19-42
50.0	212.4	182.5	29.9	38.3	28.352	0.141	7.68	16.5	D 19-42
52.0	223.6	193.7	29.9	41.8	28.626	0.084	7.78	16.5	D 19-42
54.0	235.2	205.3	29.9	44.8	28.831	0.052	7.86	16.5	D 19-42
56.0	247.1	217.2	29.9	49.2	29.047	0.058	7.95	16.6	D 19-42
58.0	259.5	229.5	29.9	54.5	29.319	0.033	8.05	16.7	D 19-42
60.0	272.2	242.3	29.9	58.9	29.420	0.040	8.13	16.8	D 19-42
61.0	509.5	247.1	262.5	1762.8	31.447	0.473	8.97	18.6	D 19-42

Summary_Total driving time: 49 minutes; Total Number of Blows: 2073 (starting at penetration 2.0 ft)

GRLWEAP: Wave Equation Analysis of Pile Foundations

HAM-75-0823 - For Abut - B-169 - 16" CIP 5/16/2023
RESOURCE INTERNATIONAL INC GRLWEAP 14.1.15.0

ABOUT THE WAVE EQUATION ANALYSIS RESULTS

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

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

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

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

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

SOIL PROFILE

Depth	Soil Type	Spec. Wt	Su	Phi	Unit Rs	Unit Rt
ft	-	lb/ft³	ksf	°	ksf	ksf
0.0	Gravel	125.0	0.0	43.9	0.00	41.77
9.5	Gravel	125.0	0.0	43.0	0.37	41.77
9.5	Clay	120.0	0.0	24.5	0.43	16.92
34.5	Clay	120.0	0.0	24.5	1.05	16.92
34.5	Clay	125.0	0.0	31.0	1.37	31.58
48.5	Clay	125.0	0.0	31.0	1.57	31.58
48.5	Clay	120.0	0.0	26.5	1.28	21.43
60.5	Clay	120.0	0.0	26.5	1.55	21.43
60.5	Sand	130.0	0.0	41.6	0.75	187.97
68.0	Sand	130.0	0.0	41.2	0.84	187.97

PILE INPUT

Uniform Pile		Pile Type:	Pipe
Pile Length: (ft)	61.000	Pile Penetration: (ft)	61.000
Pile Size: (ft)	1.33	Toe Area: (in²)	201.06

Pile Profile

Lb Top	X-Area	E-Modulus	Spec. Wt	Perim.	Crit. Index
ft	in²	ksi	lb/ft³	ft	-
0.0	18.4	30,000.0	492.0	4.2	0
61.0	18.4	30,000.0	492.0	4.2	0

HAMMER INPUT

ID	41	Made By:	DELMAG
Model	D 19-42	Type:	OED

Hammer Data

ID	Ram Wt	Ram L.	Ram Ar.	Rtd. Stk	Effic.	Rtd. Energy
-	kips	in	in²	ft	-	kip-ft
41	4.000	129.1	124.7	10.8	0.80	43.2

DRIVE SYSTEM FOR DELMAG D 19-42-OED

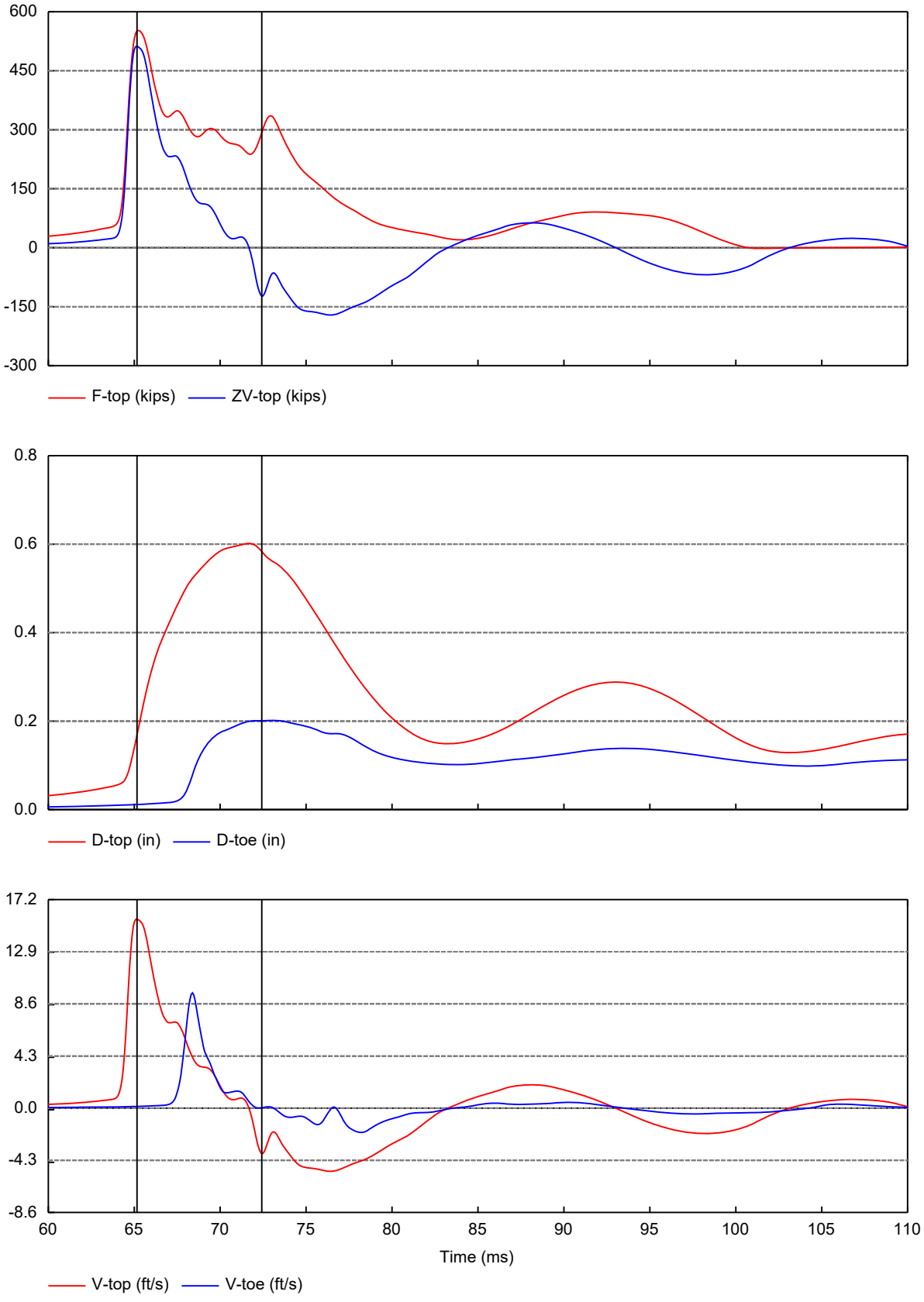
Type	X-Area	E-Modulus	Thickness	COR	Round-out	Stiffness
-	in²	ksi	in	-	in	kips/in
Hammer C.	227.000	530.000	2.000	0.800	0.120	60155.563
Helmet Wt.	1.700	kips				

SOIL RESISTANCE DISTRIBUTION

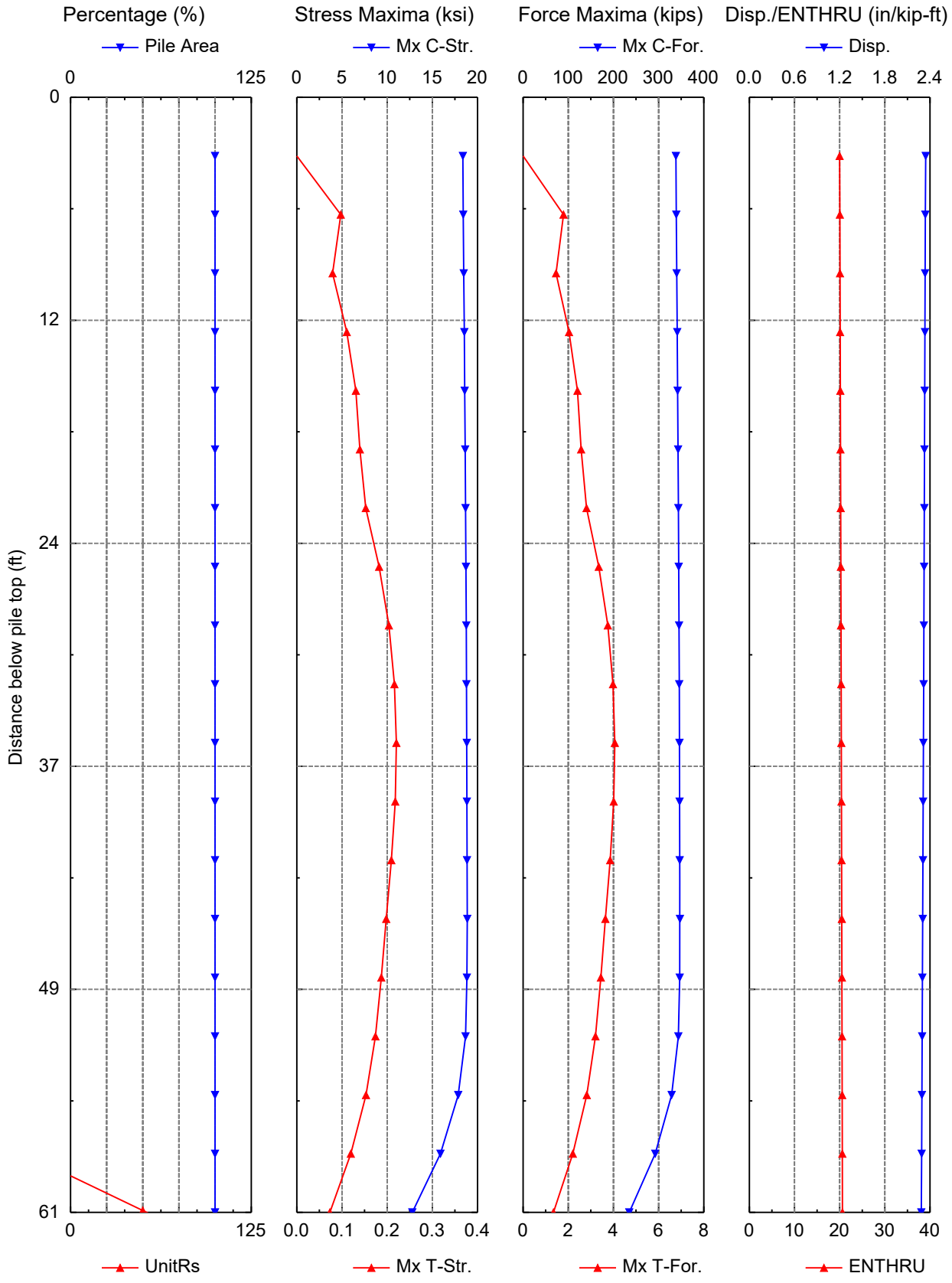
Depth	Unit Rs	Unit Rt	Qs	Qt	Js	Jt	Set. F.	Limit D.	Set. T.	EB Area
ft	ksf	ksf	in	in	s/ft	s/ft	-	ft	Hours	in²
0.0	0.0	41.8	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
1.9	0.1	41.8	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
3.8	0.1	41.8	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
5.7	0.2	41.8	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
7.6	0.3	41.8	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
9.5	0.4	41.8	0.10	0.27	0.05	0.15	1.0	6.6	1.0	201.1
9.5	0.4	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
11.2	0.5	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
12.8	0.5	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
14.5	0.6	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
16.2	0.6	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
17.8	0.6	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
19.5	0.7	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
21.2	0.7	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
22.8	0.8	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
24.5	0.8	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
26.2	0.8	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
27.8	0.9	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
29.5	0.9	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
31.2	1.0	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
32.8	1.0	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
34.5	1.1	16.9	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
34.5	1.4	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
36.3	1.4	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
38.0	1.5	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
39.8	1.5	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
41.5	1.6	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
43.3	1.6	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
45.0	1.6	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
46.8	1.6	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
48.5	1.6	31.6	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
48.5	1.3	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
50.2	1.3	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
51.9	1.4	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
53.6	1.4	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
55.4	1.4	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
57.1	1.5	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
58.8	1.5	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1
60.5	1.6	21.4	0.10	0.27	0.20	0.15	2.0	6.6	168.0	201.1

60.5	0.7	188.0	0.10	0.13	0.05	0.15	1.2	6.6	1.0	201.1
62.4	0.8	188.0	0.10	0.13	0.05	0.15	1.2	6.6	1.0	201.1

Variable Time Hisotry with DELMAG D 19-42; Depth = 61.00ft; Shaft/Toe G/L = 0.500/1.000



Extrema Results of Gain/Loss at Shaft/Toe = 0.500/1.000 and Depth = 2.00 ft



APPENDIX VII

SETTLEMENT CALCULATIONS

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120	pcf	Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

																			Total Settlement at Center of Reinforced Soil Mass					Total Settlement at Facing of Wall				
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (1) (psf)	LL	C_c (2)	C_r (3)	e_o (4)	N_{60}	$(N1)_{60}$ (5)	C' (6)	Z_f/B	I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)	I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.998	2,275	2,463	0.050	0.605	0.500	1,140	1,327	0.038	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.955	2,178	2,740	0.029	0.348	0.497	1,132	1,695	0.020	0.242
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.851	1,941	2,738	0.027	0.330	0.485	1,105	1,902	0.019	0.232
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.751	1,713	2,672	0.010	0.122	0.468	1,066	2,025	0.007	0.089
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.675	1,540	2,617	0.011	0.132	0.450	1,026	2,103	0.008	0.099
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.602	1,372	2,581	0.009	0.113	0.428	976	2,185	0.007	0.088
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.539	1,230	2,570	0.008	0.097	0.405	923	2,264	0.006	0.078
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.464	1,058	2,596	0.013	0.156	0.371	846	2,384	0.011	0.130
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.389	886	2,700	0.033	0.398	0.330	752	2,565	0.029	0.347
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.333	760	2,861	0.026	0.309	0.294	671	2,772	0.023	0.277
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.291	663	3,053	0.020	0.245	0.264	602	2,992	0.019	0.225
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.258	588	3,266	0.017	0.199	0.239	544	3,222	0.015	0.185
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.232	528	3,493	0.014	0.164	0.217	496	3,461	0.013	0.155
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.210	479	3,732	0.011	0.137	0.199	454	3,708	0.011	0.131
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.194	441	3,964	0.004	0.051	0.185	422	3,945	0.004	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.171	391	4,410	0.006	0.070	0.165	377	4,397	0.006	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.148	339	5,034	0.005	0.057	0.145	330	5,025	0.005	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.133	304	5,574	0.003	0.042	0.130	297	5,568	0.003	0.041
																						Total Settlement:	3.573 in				Total Settlement:	2.952 in	

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$, Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 26, FHWA GEC 5
3. $C_r = 0.15(C_c)$ for medium stiff to stiff natural soil deposits and existing fill material, 0.075 to $0.10(C_c)$ for very stiff to hard natural soil deposits, and 0.05(Cc) for new embankment fill; Ref. Section 5.4.2.5 of FHWA GEC 5
4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
5. $(N1)_{60} = C_N N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for continuous footing
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

t = 0 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 39% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.500	1,140	1,327	0.038	0.460	0.460				100	0.460	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.497	1,132	1,695	0.020	0.242	0.474				100	0.242	0.474
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.485	1,105	1,902	0.019	0.232					100	0.232	
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.468	1,066	2,025	0.007	0.089	0.484	800	2.0	0.000	0	0.000	0.000
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.450	1,026	2,103	0.008	0.099		800	4.5	0.000	0	0.000	
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.428	976	2,185	0.007	0.088		800	7.0	0.000	0	0.000	
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.405	923	2,264	0.006	0.078		800	9.5	0.000	0	0.000	
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.371	846	2,384	0.011	0.130		800	14.5	0.000	0	0.000	
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.330	752	2,565	0.029	0.347	1.320	150	19.5	0.000	0	0.000	0.000
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.294	671	2,772	0.023	0.277		150	22.3	0.000	0	0.000	
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.264	602	2,992	0.019	0.225		150	20.0	0.000	0	0.000	
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.239	544	3,222	0.015	0.185		150	15.0	0.000	0	0.000	
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.217	496	3,461	0.013	0.155		150	10.0	0.000	0	0.000	
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.199	454	3,708	0.011	0.131		150	5.0	0.000	0	0.000	
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.185	422	3,945	0.004	0.048	0.048				100	0.048	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.165	377	4,397	0.006	0.068	0.068				100	0.068	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.145	330	5,025	0.005	0.056	0.056				100	0.056	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.130	297	5,568	0.003	0.041	0.041				100	0.041	0.041

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 1.148 in

Settlement Remaining After Hold Period: 1.804 in

Depth of Neutral Plane: 26 ft

Remaining Settlement within Depth of Neutral Plane: 0.623 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

t = 30 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 66% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.500	1,140	1,327	0.038	0.460	0.460				100	0.460	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.497	1,132	1,695	0.020	0.242	0.474				100	0.242	0.474
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.485	1,105	1,902	0.019	0.232					100	0.232	
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.468	1,066	2,025	0.007	0.089	0.484	800	2.0	16.438	100	0.089	0.423
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.450	1,026	2,103	0.008	0.099		800	4.5	3.247	100	0.099	
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.428	976	2,185	0.007	0.088		800	7.0	1.342	97	0.085	
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.405	923	2,264	0.006	0.078		800	9.5	0.729	87	0.068	
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.371	846	2,384	0.011	0.130		800	14.5	0.313	63	0.082	
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.330	752	2,565	0.029	0.347	1.320	150	19.5	0.032	20	0.069	0.374
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.294	671	2,772	0.023	0.277		150	22.3	0.025	18	0.050	
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.264	602	2,992	0.019	0.225		150	20.0	0.031	20	0.045	
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.239	544	3,222	0.015	0.185		150	15.0	0.055	26	0.048	
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.217	496	3,461	0.013	0.155		150	10.0	0.123	40	0.062	
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.199	454	3,708	0.011	0.131		150	5.0	0.493	76	0.099	
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.185	422	3,945	0.004	0.048	0.048				100	0.048	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.165	377	4,397	0.006	0.068	0.068				100	0.068	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.145	330	5,025	0.005	0.056	0.056				100	0.056	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.130	297	5,568	0.003	0.041	0.041				100	0.041	0.041

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 1.945 in

Settlement Remaining After Hold Period: 1.007 in

Depth of Neutral Plane: 26 ft

Remaining Settlement within Depth of Neutral Plane: 0.172 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

t = 45 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 69% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.500	1,140	1,327	0.038	0.460	0.460				100	0.460	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.497	1,132	1,695	0.020	0.242	0.474				100	0.242	0.474
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.485	1,105	1,902	0.019	0.232					100	0.232	
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.468	1,066	2,025	0.007	0.089	0.484	800	2.0	24.658	100	0.089	0.447
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.450	1,026	2,103	0.008	0.099		800	4.5	4.871	100	0.099	
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.428	976	2,185	0.007	0.088		800	7.0	2.013	99	0.087	
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.405	923	2,264	0.006	0.078		800	9.5	1.093	95	0.074	
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.371	846	2,384	0.011	0.130		800	14.5	0.469	75	0.098	
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.330	752	2,565	0.029	0.347	1.320	150	19.5	0.049	25	0.087	0.451
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.294	671	2,772	0.023	0.277		150	22.3	0.037	22	0.061	
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.264	602	2,992	0.019	0.225		150	20.0	0.046	24	0.054	
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.239	544	3,222	0.015	0.185		150	15.0	0.082	32	0.059	
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.217	496	3,461	0.013	0.155		150	10.0	0.185	49	0.076	
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.199	454	3,708	0.011	0.131		150	5.0	0.740	87	0.114	
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.185	422	3,945	0.004	0.048	0.048				100	0.048	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.165	377	4,397	0.006	0.068	0.068				100	0.068	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.145	330	5,025	0.005	0.056	0.056				100	0.056	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.130	297	5,568	0.003	0.041	0.041				100	0.041	0.041

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.045 in

Settlement Remaining After Hold Period: 0.907 in

Depth of Neutral Plane: 26 ft

Remaining Settlement within Depth of Neutral Plane: 0.141 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

t = 60 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 72% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.500	1,140	1,327	0.038	0.460	0.460				100	0.460	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.497	1,132	1,695	0.020	0.242	0.474				100	0.242	0.474
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.485	1,105	1,902	0.019	0.232					100	0.232	
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.468	1,066	2,025	0.007	0.089	0.484	800	2.0	32.877	100	0.089	0.461
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.450	1,026	2,103	0.008	0.099		800	4.5	6.494	100	0.099	
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.428	976	2,185	0.007	0.088		800	7.0	2.684	100	0.088	
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.405	923	2,264	0.006	0.078		800	9.5	1.457	98	0.076	
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.371	846	2,384	0.011	0.130		800	14.5	0.625	83	0.108	
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.330	752	2,565	0.029	0.347	1.320	150	19.5	0.065	29	0.101	0.510
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.294	671	2,772	0.023	0.277		150	22.3	0.050	25	0.069	
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.264	602	2,992	0.019	0.225		150	20.0	0.062	28	0.063	
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.239	544	3,222	0.015	0.185		150	15.0	0.110	37	0.069	
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.217	496	3,461	0.013	0.155		150	10.0	0.247	56	0.087	
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.199	454	3,708	0.011	0.131		150	5.0	0.986	93	0.122	
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.185	422	3,945	0.004	0.048	0.048				100	0.048	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.165	377	4,397	0.006	0.068	0.068				100	0.068	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.145	330	5,025	0.005	0.056	0.056				100	0.056	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.130	297	5,568	0.003	0.041	0.041				100	0.041	0.041

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.118 in

Settlement Remaining After Hold Period: 0.834 in

Depth of Neutral Plane: 26 ft

Remaining Settlement within Depth of Neutral Plane: 0.122 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

t = 75 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 74% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.500	1,140	1,327	0.038	0.460	0.460				100	0.460	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.497	1,132	1,695	0.020	0.242	0.474				100	0.242	0.474
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.485	1,105	1,902	0.019	0.232					100	0.232	
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.468	1,066	2,025	0.007	0.089	0.484	800	2.0	41.096	100	0.089	0.468
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.450	1,026	2,103	0.008	0.099		800	4.5	8.118	100	0.099	
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.428	976	2,185	0.007	0.088		800	7.0	3.355	100	0.088	
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.405	923	2,264	0.006	0.078		800	9.5	1.821	99	0.077	
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.371	846	2,384	0.011	0.130		800	14.5	0.782	88	0.115	
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.330	752	2,565	0.029	0.347	1.320	150	19.5	0.081	32	0.111	0.558
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.294	671	2,772	0.023	0.277		150	22.3	0.062	28	0.078	
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.264	602	2,992	0.019	0.225		150	20.0	0.077	31	0.070	
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.239	544	3,222	0.015	0.185		150	15.0	0.137	42	0.078	
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.217	496	3,461	0.013	0.155		150	10.0	0.308	62	0.096	
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.199	454	3,708	0.011	0.131		150	5.0	1.233	96	0.126	
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.185	422	3,945	0.004	0.048	0.048				100	0.048	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.165	377	4,397	0.006	0.068	0.068				100	0.068	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.145	330	5,025	0.005	0.056	0.056				100	0.056	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.130	297	5,568	0.003	0.041	0.041				100	0.041	0.041

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.173 in

Settlement Remaining After Hold Period: 0.779 in

Depth of Neutral Plane: 26 ft

Remaining Settlement within Depth of Neutral Plane: 0.111 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

t = 90 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 75% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.500	1,140	1,327	0.038	0.460	0.460				100	0.460	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.497	1,132	1,695	0.020	0.242	0.474				100	0.242	0.474
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.485	1,105	1,902	0.019	0.232					100	0.232	
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.468	1,066	2,025	0.007	0.089	0.484	800	2.0	49.315	100	0.089	0.474
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.450	1,026	2,103	0.008	0.099		800	4.5	9.741	100	0.099	
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.428	976	2,185	0.007	0.088		800	7.0	4.026	100	0.088	
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.405	923	2,264	0.006	0.078		800	9.5	2.186	100	0.078	
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.371	846	2,384	0.011	0.130		800	14.5	0.938	92	0.120	
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.330	752	2,565	0.029	0.347	1.320	150	19.5	0.097	35	0.121	0.601
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.294	671	2,772	0.023	0.277		150	22.3	0.075	31	0.086	
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.264	602	2,992	0.019	0.225		150	20.0	0.092	34	0.076	
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.239	544	3,222	0.015	0.185		150	15.0	0.164	46	0.085	
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.217	496	3,461	0.013	0.155		150	10.0	0.370	67	0.104	
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.199	454	3,708	0.011	0.131		150	5.0	1.479	98	0.128	
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.185	422	3,945	0.004	0.048	0.048				100	0.048	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.165	377	4,397	0.006	0.068	0.068				100	0.068	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.145	330	5,025	0.005	0.056	0.056				100	0.056	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.130	297	5,568	0.003	0.041	0.041				100	0.041	0.041

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.222 in

Settlement Remaining After Hold Period: 0.729 in

Depth of Neutral Plane: 26 ft

Remaining Settlement within Depth of Neutral Plane: 0.101 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Rear Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-168-0-07

H =	24.7	ft	Wall height
B =	17.3	ft	Width of wall
D_w =	5.0	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,964		Bearing pressure at bottom of wall
q_{net} =	2,280	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 542.0 for a net embankment height of 19.0'

t = 280 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 86% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-3a	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					11	20	67	0.09	0.500	1,140	1,327	0.038	0.460	0.460				100	0.460	0.460
2	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					13	19	71	0.26	0.497	1,132	1,695	0.020	0.242	0.474				100	0.242	0.474
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	797	3,797					13	17	68	0.45	0.485	1,105	1,902	0.019	0.232					100	0.232	
3	A-6a	C	9.5	11.5	2.0	10.5	115	1,418	1,303	959	3,959	29	0.171	0.017	0.499				0.61	0.468	1,066	2,025	0.007	0.089	0.484	800	2.0	153.425	100	0.089	0.484
	A-6a	C	11.5	14.0	2.5	12.8	115	1,705	1,561	1,078	4,078	29	0.171	0.017	0.499				0.74	0.450	1,026	2,103	0.008	0.099		800	4.5	30.306	100	0.099	
	A-6a	C	14.0	16.5	2.5	15.3	115	1,993	1,849	1,209	4,209	29	0.171	0.017	0.499				0.88	0.428	976	2,185	0.007	0.088		800	7.0	12.524	100	0.088	
	A-6a	C	16.5	19.0	2.5	17.8	115	2,280	2,136	1,341	4,341	29	0.171	0.017	0.499				1.03	0.405	923	2,264	0.006	0.078		800	9.5	6.800	100	0.078	
	A-6a	C	19.0	24.0	5.0	21.5	115	2,855	2,568	1,538	4,538	29	0.171	0.017	0.499				1.24	0.371	846	2,384	0.011	0.130		800	14.5	2.919	100	0.130	
4	A-7-6	C	24.0	29.0	5.0	26.5	120	3,455	3,155	1,813	4,813	41	0.230	0.068	0.771				1.53	0.330	752	2,565	0.029	0.347	1.320	150	19.5	0.303	62	0.215	0.920
	A-7-6	C	29.0	34.0	5.0	31.5	120	4,055	3,755	2,101	5,101	41	0.230	0.068	0.771				1.82	0.294	671	2,772	0.023	0.277		150	22.3	0.232	54	0.150	
	A-7-6	C	34.0	39.0	5.0	36.5	120	4,655	4,355	2,389	5,389	41	0.230	0.068	0.771				2.11	0.264	602	2,992	0.019	0.225		150	20.0	0.288	60	0.135	
	A-7-6	C	39.0	44.0	5.0	41.5	120	5,255	4,955	2,677	5,677	42	0.230	0.068	0.771				2.40	0.239	544	3,222	0.015	0.185		150	15.0	0.511	77	0.143	
	A-7-6	C	44.0	49.0	5.0	46.5	120	5,855	5,555	2,965	5,965	42	0.230	0.068	0.771				2.69	0.217	496	3,461	0.013	0.155		150	10.0	1.151	95	0.147	
	A-7-6	C	49.0	54.0	5.0	51.5	120	6,455	6,155	3,253	6,253	42	0.230	0.068	0.771				2.98	0.199	454	3,708	0.011	0.131		150	5.0	4.603	100	0.131	
5	A-3	G	54.0	58.0	4.0	56.0	125	6,955	6,705	3,523	6,523					17	14	49	3.24	0.185	422	3,945	0.004	0.048	0.048				100	0.048	0.048
6	A-2-4	G	58.0	69.0	11.0	63.5	130	8,385	7,670	4,020	7,020					27	21	76	3.67	0.165	377	4,397	0.006	0.068	0.068				100	0.068	0.068
7	A-3a	G	69.0	78.0	9.0	73.5	130	9,555	8,970	4,696	7,696					19	14	57	4.25	0.145	330	5,025	0.005	0.056	0.056				100	0.056	0.056
	A-3a	G	78.0	86.0	8.0	82.0	130	10,595	10,075	5,270	8,270					19	13	56	4.74	0.130	297	5,568	0.003	0.041	0.041				100	0.041	0.041

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_{fe}(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.552 in

Settlement Remaining After Hold Period: 0.400 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120	pcf	Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

																			Total Settlement at Center of Reinforced Soil Mass					Total Settlement at Facing of Wall				
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' (1) (psf)	LL	C_c (2)	C_r (3)	e_o (4)	N_{60}	$(N1)_{60}$ (5)	C' (6)	Z_f/B	I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)	I (7)	$\Delta\sigma_v$ (8) (psf)	σ_{vf}' Midpoint (psf)	S_c (9,10) (ft)	S_c (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.997	2,095	2,282	0.038	0.455	0.500	1,050	1,237	0.029	0.343
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.947	1,990	2,552	0.027	0.319	0.496	1,041	1,604	0.018	0.221
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.832	1,747	2,638	0.024	0.284	0.482	1,012	1,903	0.017	0.198
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.708	1,487	2,566	0.043	0.520	0.458	962	2,041	0.032	0.383
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.603	1,265	2,516	0.041	0.490	0.428	899	2,149	0.032	0.380
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.519	1,089	2,510	0.012	0.147	0.396	832	2,254	0.010	0.119
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.457	960	2,539	0.010	0.123	0.368	772	2,351	0.009	0.103
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.407	856	2,592	0.009	0.104	0.341	716	2,453	0.007	0.089
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.367	770	2,665	0.007	0.088	0.316	664	2,559	0.006	0.078
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.333	700	2,752	0.006	0.076	0.294	618	2,670	0.006	0.068
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.303	636	2,859	0.006	0.076	0.273	573	2,796	0.006	0.069
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.274	575	3,015	0.006	0.069	0.251	527	2,968	0.005	0.063
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.248	521	3,212	0.005	0.057	0.231	485	3,176	0.004	0.054
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.224	471	3,444	0.005	0.060	0.211	444	3,417	0.005	0.056
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.201	422	3,724	0.004	0.047	0.191	402	3,704	0.004	0.045
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.180	378	4,026	0.003	0.038	0.173	364	4,011	0.003	0.037
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.167	351	4,273	0.001	0.017	0.162	339	4,261	0.001	0.017
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.158	332	4,491	0.002	0.021	0.154	322	4,481	0.002	0.020
																				Total Settlement:			2.990 in			Total Settlement:		2.344 in

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$, Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 26, FHWA GEC 5
3. $C_r = 0.15(C_c)$ for medium stiff to stiff natural soil deposits and existing fill material, 0.075 to $0.10(C_c)$ for very stiff to hard natural soil deposits, and 0.05(Cc) for new embankment fill; Ref. Section 5.4.2.5 of FHWA GEC 5
4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
5. $(N1)_{60} = C_N N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for continuous footing
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

t = 0 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 34% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.500	1,050	1,237	0.029	0.343					100	0.343	
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.496	1,041	1,604	0.018	0.221	0.762				100	0.221	0.762
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.482	1,012	1,903	0.017	0.198					100	0.198	
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.458	962	2,041	0.032	0.383		150	3.0	0.000	0	0.000	
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.428	899	2,149	0.032	0.380	0.762	150	6.5	0.000	0	0.000	0.000
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.396	832	2,254	0.010	0.119		800	9.5	0.000	0	0.000	
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.368	772	2,351	0.009	0.103		800	12.5	0.000	0	0.000	
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.341	716	2,453	0.007	0.089	0.527	800	15.5	0.000	0	0.000	0.000
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.316	664	2,559	0.006	0.078		800	18.5	0.000	0	0.000	
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.294	618	2,670	0.006	0.068		800	21.5	0.000	0	0.000	
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.273	573	2,796	0.006	0.069		800	25.0	0.000	0	0.000	
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.251	527	2,968	0.005	0.063		800	25.0	0.000	0	0.000	
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.231	485	3,176	0.004	0.054	0.174	800	21.0	0.000	0	0.000	0.000
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.211	444	3,417	0.005	0.056		800	17.0	0.000	0	0.000	
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.191	402	3,704	0.004	0.045		800	12.0	0.000	0	0.000	
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.173	364	4,011	0.003	0.037	0.082	800	6.0	0.000	0	0.000	0.000
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.162	339	4,261	0.001	0.017					100	0.017	
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.154	322	4,481	0.002	0.020	0.037				100	0.020	0.037

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 0.799 in

Settlement Remaining After Hold Period: 1.544 in

Depth of Neutral Plane: 32 ft

Remaining Settlement within Depth of Neutral Plane: 1.239 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

t = 30 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 80% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.500	1,050	1,237	0.029	0.343					100	0.343	
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.496	1,041	1,604	0.018	0.221	0.762				100	0.221	0.762
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.482	1,012	1,903	0.017	0.198					100	0.198	
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.458	962	2,041	0.032	0.383		150	3.0	1.370	97	0.371	0.603
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.428	899	2,149	0.032	0.380	0.762	150	6.5	0.292	61	0.232	
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.396	832	2,254	0.010	0.119		800	9.5	0.729	87	0.104	
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.368	772	2,351	0.009	0.103		800	12.5	0.421	71	0.073	
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.341	716	2,453	0.007	0.089		800	15.5	0.274	59	0.053	
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.316	664	2,559	0.006	0.078	0.527	800	18.5	0.192	49	0.038	0.323
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.294	618	2,670	0.006	0.068		800	21.5	0.142	43	0.029	
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.273	573	2,796	0.006	0.069		800	25.0	0.105	37	0.026	
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.251	527	2,968	0.005	0.063		800	25.0	0.105	37	0.023	
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.231	485	3,176	0.004	0.054	0.174	800	21.0	0.149	44	0.024	0.078
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.211	444	3,417	0.005	0.056		800	17.0	0.228	54	0.030	
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.191	402	3,704	0.004	0.045	0.082	800	12.0	0.457	74	0.033	0.070
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.173	364	4,011	0.003	0.037		800	6.0	1.826	99	0.037	
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.162	339	4,261	0.001	0.017	0.037				100	0.017	0.037
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.154	322	4,481	0.002	0.020					100	0.020	

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 1.872 in

Settlement Remaining After Hold Period: 0.472 in

Depth of Neutral Plane: 32 ft

Remaining Settlement within Depth of Neutral Plane: 0.332 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

t = 45 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 85% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.500	1,050	1,237	0.029	0.343					100	0.343	
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.496	1,041	1,604	0.018	0.221	0.762				100	0.221	0.762
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.482	1,012	1,903	0.017	0.198					100	0.198	
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.458	962	2,041	0.032	0.383		150	3.0	2.055	99	0.379	0.652
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.428	899	2,149	0.032	0.380	0.762	150	6.5	0.438	72	0.273	
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.396	832	2,254	0.010	0.119		800	9.5	1.093	95	0.113	
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.368	772	2,351	0.009	0.103		800	12.5	0.631	83	0.086	
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.341	716	2,453	0.007	0.089		800	15.5	0.411	71	0.063	
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.316	664	2,559	0.006	0.078	0.527	800	18.5	0.288	60	0.047	0.375
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.294	618	2,670	0.006	0.068		800	21.5	0.213	52	0.035	
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.273	573	2,796	0.006	0.069		800	25.0	0.158	45	0.031	
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.251	527	2,968	0.005	0.063		800	25.0	0.158	45	0.029	
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.231	485	3,176	0.004	0.054	0.174	800	21.0	0.224	53	0.028	0.094
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.211	444	3,417	0.005	0.056		800	17.0	0.341	65	0.037	
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.191	402	3,704	0.004	0.045	0.082	800	12.0	0.685	85	0.038	0.075
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.173	364	4,011	0.003	0.037		800	6.0	2.740	100	0.037	
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.162	339	4,261	0.001	0.017	0.037				100	0.017	0.037
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.154	322	4,481	0.002	0.020					100	0.020	

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 1.996 in

Settlement Remaining After Hold Period: 0.348 in

Depth of Neutral Plane: 32 ft

Remaining Settlement within Depth of Neutral Plane: 0.234 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

t = 60 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 89% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.500	1,050	1,237	0.029	0.343					100	0.343	
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.496	1,041	1,604	0.018	0.221	0.762				100	0.221	0.762
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.482	1,012	1,903	0.017	0.198					100	0.198	
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.458	962	2,041	0.032	0.383		150	3.0	2.740	100	0.383	0.690
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.428	899	2,149	0.032	0.380	0.762	150	6.5	0.584	81	0.307	
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.396	832	2,254	0.010	0.119		800	9.5	1.457	98	0.117	
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.368	772	2,351	0.009	0.103		800	12.5	0.842	90	0.093	
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.341	716	2,453	0.007	0.089	0.527	800	15.5	0.547	79	0.071	0.411
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.316	664	2,559	0.006	0.078		800	18.5	0.384	69	0.054	
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.294	618	2,670	0.006	0.068		800	21.5	0.284	60	0.041	
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.273	573	2,796	0.006	0.069		800	25.0	0.210	52	0.036	
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.251	527	2,968	0.005	0.063		800	25.0	0.210	52	0.033	
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.231	485	3,176	0.004	0.054	0.174	800	21.0	0.298	61	0.033	0.108
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.211	444	3,417	0.005	0.056		800	17.0	0.455	74	0.042	
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.191	402	3,704	0.004	0.045	0.082	800	12.0	0.913	91	0.041	0.078
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.173	364	4,011	0.003	0.037		800	6.0	3.653	100	0.037	
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.162	339	4,261	0.001	0.017	0.037				100	0.017	0.037
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.154	322	4,481	0.002	0.020					100	0.020	

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.086 in

Settlement Remaining After Hold Period: 0.258 in

Depth of Neutral Plane: 32 ft

Remaining Settlement within Depth of Neutral Plane: 0.164 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

t = 75 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 92% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.500	1,050	1,237	0.029	0.343					100	0.343	
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.496	1,041	1,604	0.018	0.221	0.762				100	0.221	0.762
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.482	1,012	1,903	0.017	0.198					100	0.198	
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.458	962	2,041	0.032	0.383		150	3.0	3.425	100	0.383	0.713
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.428	899	2,149	0.032	0.380	0.762	150	6.5	0.730	87	0.330	
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.396	832	2,254	0.010	0.119		800	9.5	1.821	99	0.118	
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.368	772	2,351	0.009	0.103		800	12.5	1.052	94	0.097	
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.341	716	2,453	0.007	0.089	0.527	800	15.5	0.684	85	0.076	0.434
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.316	664	2,559	0.006	0.078		800	18.5	0.480	75	0.058	
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.294	618	2,670	0.006	0.068		800	21.5	0.356	66	0.045	
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.273	573	2,796	0.006	0.069		800	25.0	0.263	58	0.040	
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.251	527	2,968	0.005	0.063		800	25.0	0.263	58	0.037	
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.231	485	3,176	0.004	0.054	0.174	800	21.0	0.373	68	0.037	0.119
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.211	444	3,417	0.005	0.056		800	17.0	0.569	80	0.045	
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.191	402	3,704	0.004	0.045	0.082	800	12.0	1.142	95	0.043	0.080
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.173	364	4,011	0.003	0.037		800	6.0	4.566	100	0.037	
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.162	339	4,261	0.001	0.017	0.037				100	0.017	0.037
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.154	322	4,481	0.002	0.020					100	0.020	

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.145 in

Settlement Remaining After Hold Period: 0.199 in

Depth of Neutral Plane: 32 ft

Remaining Settlement within Depth of Neutral Plane: 0.121 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

t = 90 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 93% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.500	1,050	1,237	0.029	0.343	0.762				100	0.343	0.762
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.496	1,041	1,604	0.018	0.221					100	0.221	
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.482	1,012	1,903	0.017	0.198					100	0.198	
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.458	962	2,041	0.032	0.383	0.762	150	3.0	4.110	100	0.383	0.728
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.428	899	2,149	0.032	0.380		150	6.5	0.875	91	0.345	
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.396	832	2,254	0.010	0.119	0.527	800	9.5	2.186	100	0.119	0.453
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.368	772	2,351	0.009	0.103		800	12.5	1.262	96	0.099	
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.341	716	2,453	0.007	0.089		800	15.5	0.821	89	0.079	
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.316	664	2,559	0.006	0.078		800	18.5	0.576	80	0.062	
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.294	618	2,670	0.006	0.068		800	21.5	0.427	72	0.049	
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.273	573	2,796	0.006	0.069		800	25.0	0.316	63	0.044	
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.251	527	2,968	0.005	0.063	0.174	800	25.0	0.316	63	0.040	0.127
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.231	485	3,176	0.004	0.054		800	21.0	0.447	73	0.039	
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.211	444	3,417	0.005	0.056		800	17.0	0.683	85	0.048	
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.191	402	3,704	0.004	0.045	0.082	800	12.0	1.370	97	0.043	0.081
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.173	364	4,011	0.003	0.037		800	6.0	5.479	100	0.037	
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.162	339	4,261	0.001	0.017	0.037				100	0.017	0.037
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.154	322	4,481	0.002	0.020					100	0.020	

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_e(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 2.188 in

Settlement Remaining After Hold Period: 0.156 in

Depth of Neutral Plane: 32 ft

Remaining Settlement within Depth of Neutral Plane: 0.090 in

HAM-75-7.85 - HAM-75-0823 I-75 over Laidlaw Avenue - Forward Abutment
MSE Wall Settlement

Calculated By: BRT Date: 5/16/2023
Checked By: JPS Date: 5/17/2023

Boring B-169-0-07

H =	23.2	ft	Wall height
B =	16.2	ft	Width of wall
D_w =	6.5	ft	Depth below bottom of wall
γ_{BF} =	120		Unit weight of backfill
q =	2,784		Bearing pressure at bottom of wall
q_{net} =	2,100	psf	Bottom of wall at 517.3, existing grade is at 523.0 and proposed profile grade is at 540.5 for a net embankment height of 17.5'

t = 38 days Time following completion of construction

																						Total Settlement at Facing of Wall			Settlement Complete at 83% of Primary Consolidation					
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ_{vo} Bottom (psf)	σ_{vo} Midpoint (psf)	σ_{vo}' Midpoint (psf)	σ_p' [1] (psf)	LL	C_c [2]	C_r [3]	e_o [4]	N_{60}	$(N1)_{60}$ [5]	C' [6]	Z_f/B	I [7]	$\Delta\sigma_v$ [8] (psf)	σ_{vf}' Midpoint (psf)	S_c [9,10] (ft)	S_c (in)	Layer Settlement (in)	c_v (ft^2/yr)	H_{dr} (ft)	T_v	U (%)	$(S_c)_t$ [11] (in)	Layer Settlement (in)
1	A-1-b	G	0.0	3.0	3.0	1.5	125	375	188	188	3,188					14	25	86	0.09	0.500	1,050	1,237	0.029	0.343					100	0.343	
	A-1-b	G	3.0	6.0	3.0	4.5	125	750	563	563	3,563					14	20	74	0.28	0.496	1,041	1,604	0.018	0.221	0.762				100	0.221	0.762
	A-1-b	G	6.0	9.5	3.5	7.8	125	1,188	969	891	3,891					14	18	70	0.48	0.482	1,012	1,903	0.017	0.198					100	0.198	
2	A-7-6	C	9.5	12.5	3.0	11.0	115	1,533	1,360	1,079	4,079	46	0.230	0.068	0.771				0.68	0.458	962	2,041	0.032	0.383		150	3.0	1.735	99	0.379	0.633
	A-7-6	C	12.5	16.0	3.5	14.3	115	1,935	1,734	1,250	4,250	46	0.230	0.068	0.771				0.88	0.428	899	2,149	0.032	0.380	0.762	150	6.5	0.370	67	0.254	
3	A-6a	C	16.0	19.0	3.0	17.5	115	2,280	2,108	1,421	4,421	39	0.261	0.026	0.577				1.08	0.396	832	2,254	0.010	0.119		800	9.5	0.923	92	0.110	
	A-6a	C	19.0	22.0	3.0	20.5	115	2,625	2,453	1,579	4,579	39	0.261	0.026	0.577				1.27	0.368	772	2,351	0.009	0.103		800	12.5	0.533	78	0.080	
	A-6a	C	22.0	25.0	3.0	23.5	115	2,970	2,798	1,737	4,737	39	0.261	0.026	0.577				1.45	0.341	716	2,453	0.007	0.089		800	15.5	0.347	66	0.059	
	A-6a	C	25.0	28.0	3.0	26.5	115	3,315	3,143	1,895	4,895	39	0.261	0.026	0.577				1.64	0.316	664	2,559	0.006	0.078	0.527	800	18.5	0.243	56	0.044	0.354
	A-6a	C	28.0	31.0	3.0	29.5	115	3,660	3,488	2,052	5,052	39	0.261	0.026	0.577				1.82	0.294	618	2,670	0.006	0.068		800	21.5	0.180	48	0.033	
	A-6a	C	31.0	34.5	3.5	32.8	115	4,063	3,861	2,223	5,223	39	0.261	0.026	0.577				2.02	0.273	573	2,796	0.006	0.069		800	25.0	0.133	41	0.028	
4	A-6a	C	34.5	38.5	4.0	36.5	125	4,563	4,313	2,441	5,441	37	0.243	0.024	0.561				2.25	0.251	527	2,968	0.005	0.063		800	25.0	0.133	41	0.026	
	A-6a	C	38.5	42.5	4.0	40.5	125	5,063	4,813	2,691	5,691	37	0.243	0.024	0.561				2.50	0.231	485	3,176	0.004	0.054	0.174	800	21.0	0.189	49	0.026	0.086
	A-6a	C	42.5	47.5	5.0	45.0	125	5,688	5,375	2,973	5,973	37	0.243	0.024	0.561				2.78	0.211	444	3,417	0.005	0.056		800	17.0	0.288	60	0.034	
5	A-6a	C	47.5	53.5	6.0	50.5	120	6,408	6,048	3,302	6,302	31	0.189	0.019	0.514				3.12	0.191	402	3,704	0.004	0.045	0.082	800	12.0	0.578	81	0.036	0.073
	A-6a	C	53.5	59.5	6.0	56.5	120	7,128	6,768	3,648	6,648	31	0.189	0.019	0.514				3.49	0.173	364	4,011	0.003	0.037		800	6.0	2.314	100	0.037	
6	A-3a	G	59.5	62.5	3.0	61.0	130	7,518	7,323	3,922	6,922					33	26	78	3.77	0.162	339	4,261	0.001	0.017	0.037				100	0.017	0.037
	A-3a	G	62.5	66.5	4.0	64.5	130	8,038	7,778	4,158	7,158					33	25	76	3.98	0.154	322	4,481	0.002	0.020					100	0.020	

1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 3,000 psf for moderately overconsolidated soil deposit; Ref. Table 11.2, Coduto 2003
2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
3. $C_r = 0.10(C_c)$; Ref. Chapter 8.11, Holtz and Kovacs 1981
4. $e_o = (C_c/0.54)+0.35$; Ref. Table 6-11, FHWA GEC 5
5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77\log(40/\sigma_{vo}')] \leq 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
7. Influence factor for strip loaded footing; $I = [\beta+\sin(\beta)\cos(\beta+2\delta)]/\pi$, where $\beta = \tan^{-1}[(x+B/2)/Z_f]-\delta$, $\delta = \tan^{-1}[(x-B/2)/Z_f]$ and x = horizontal distance from center of footing; Ref. Figure 6.13 and Equation 6.24, Das 2005
8. $\Delta\sigma_v = q_{fe}(I)$
9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')+[C_c/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_p')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)
10. $S_c = H(1/C')\log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

$(S_c)_t$ = 1.946 in

Settlement Remaining After Hold Period: 0.398 in

APPENDIX VIII

MSE WALL CALCULATIONS

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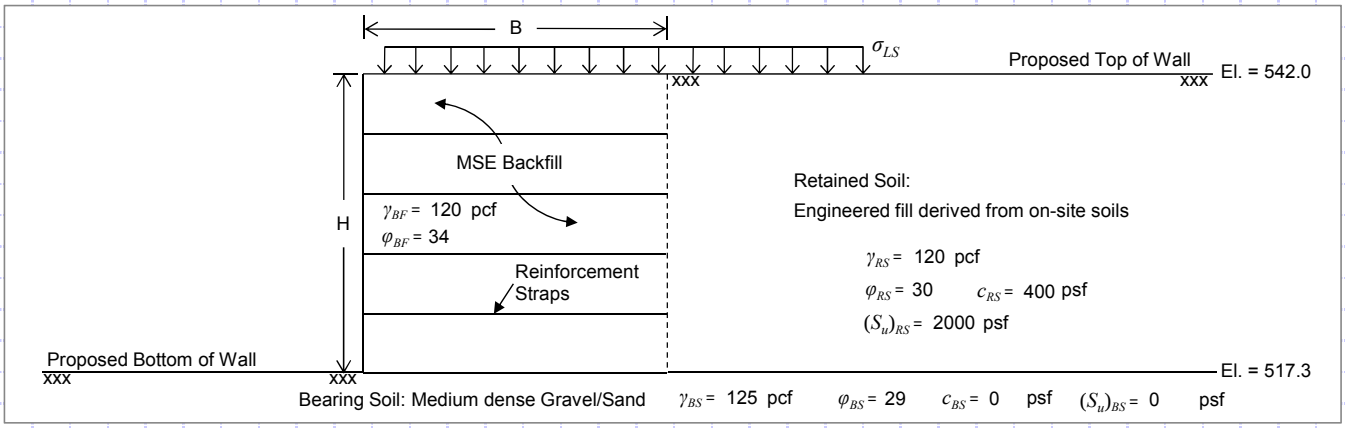
JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	1	OF	5
CALCULATED BY	VJV	DATE	6/12/2013
CHECKED BY	BRT	DATE	7/8/2013

HAM-75-0823 - MSE Wall - Rear Abutment

MSE Wall - Rear Abutment - B-168-0-07 - (24.7 ft. Wall Height)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	24.7	ft
MSE Wall Width (Reinforcement Length), (B) =	17.3	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	0	psf
Embedment Depth, (D) =	3.0	ft

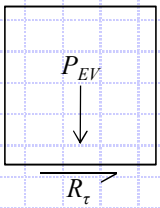
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Sections 11.6.3.6 and 11.10.5.3

Nominal Sliding Resistance: $R_\tau = P_{EV} \cdot \tan\delta$



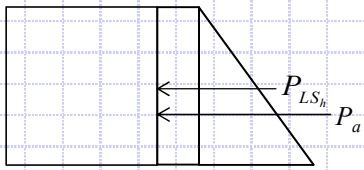
$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$ = (120 pcf)(24.7 ft)(17.29 ft)(1.00) = 51.25 kip/ft

$\tan\delta = (\tan\varphi_{BS} \le \tan\varphi_{BF})$

$\tan\delta =$ tan(29) ≤ tan(34) ⟶ 0.55 ≤ 0.67 ⟶ $\tan\delta =$ 0.55

R_τ = (51.25 kip/ft)(0.55) = 28.19 kip/ft

Sliding Force: $P_H = P_{EH} + P_{LS_h}$



$P_{EH} = \frac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH}$ = ½(120 pcf)(24.7 ft)²(0.333)(1.5) = 18.28 kip/ft

$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS}$ = (240 psf)(24.7 ft)(0.333)(1.75) = 3.45 kip/ft

P_H = 18.28 kip/ft + 3.45 kip/ft = 21.73 kip/ft

Check Sliding Resistance

$P_H \le R_\tau \cdot \phi_\tau$ ⟶ 21.73 kip/ft ≤ (28.19 kip/ft)(1.0) = 28.19 kip/ft ⟶ 21.73 kip/ft ≤ 28.19 kip/ft **OK**

Use φ_τ = **1.0** *(Per AASHTO LRFD BDM Table 11.5.6-1)*

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JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	2	OF	5
CALCULATED BY	VJV	DATE	6/12/2013
CHECKED BY	BRT	DATE	7/8/2013

HAM-75-0823 - MSE Wall - Rear Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	24.7	ft
MSE Wall Width (Reinforcement Length), (B) =	17.29	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

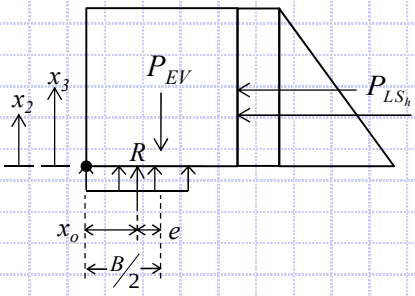
Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	0	psf
Embedment Depth, (D) =	3.0	ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3



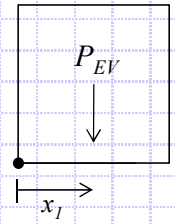
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (443.31 \text{ kip·ft/ft} - 193.05 \text{ kip·ft/ft}) / (51.25 \text{ kip/ft}) = 4.88 \text{ ft}$$

M_{EV} = 443.31 kip·ft/ft
M_H = 193.05 kip·ft/ft
P_{EV} = 51.25 kip/ft
} Defined below

$e =$ (17.29 ft)/2 - 4.88 ft = 3.77 ft

Resisting Moment, M_{EV}:



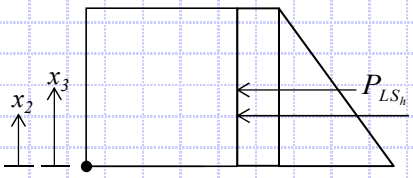
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(24.7 \text{ ft})(17.29 \text{ ft})(1.00) = 51.25 \text{ kip/ft}$$

$$x_1 = B/2 = (17.29 \text{ ft}) / 2 = 8.65 \text{ ft}$$

$$M_{EV} = (51.25 \text{ kip/ft})(8.65 \text{ ft}) = 443.31 \text{ kip·ft/ft}$$

Overturning Moment, M_H:



$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3)$$

$$P_{EH} = \tfrac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH} = \tfrac{1}{2}(120 \text{ pcf})(24.7 \text{ ft})^2(0.333)(1.5) = 18.28 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(24.7 \text{ ft})(0.333)(1.75) = 3.45 \text{ kip/ft}$$

$$x_2 = H/3 = (24.7 \text{ ft}) / 3 = 8.23 \text{ ft}$$

$$x_3 = H/2 = (24.7 \text{ ft}) / 2 = 12.35 \text{ ft}$$

$$M_H = (18.28 \text{ kip/ft})(8.23 \text{ ft}) + (3.45 \text{ kip/ft})(12.35 \text{ ft}) = 193.05 \text{ kip·ft/ft}$$

Limiting Eccentricity:

$$e_{max} = B/4 \longrightarrow e_{max} = (17.29 \text{ ft}) / 4 = 4.32 \text{ ft}$$

Check Eccentricity

$$e < e_{max} \longrightarrow 3.77 \text{ ft} \le 4.32 \text{ ft} \quad \text{OK}$$

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JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	3	OF	5
CALCULATED BY	VJV	DATE	6/12/2013
CHECKED BY	BRT	DATE	7/8/2013

HAM-75-0823 - MSE Wall - Rear Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	24.7	ft
MSE Wall Width (Reinforcement Length), (B) =	17.29	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, [(S_u)$_{RS}$] =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

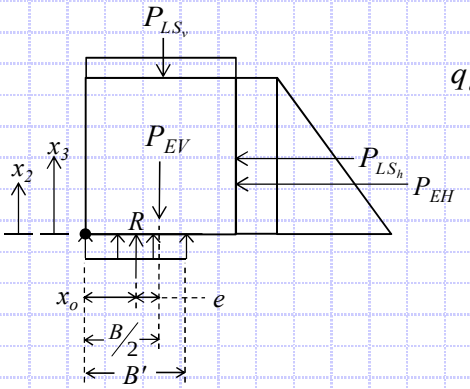
Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	0	psf
Embedment Depth, (D) =	3.0	ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = P_V / B'$$

$B' = B - 2e$ = 17.3 ft - 2(2.525 ft) = 12.24 ft

$e = B/2 - x_o$ = (17.3 ft) / 2 - 6.12 ft = 2.53 ft

$x_o = \frac{M_V - M_H}{P_V}$ = (661.26 kip·ft/ft - 193.14 kip·ft/ft) / 76.45 kip/ft = 6.12 ft

q_{eq} = (76.45 kip/ft) / (12.24 ft) = 6.25 ksf

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

M_V = [(120 pcf)(24.7 ft)(17.29 ft)(1.35)](8.65 ft) + [(240 psf)(17.29 ft)(1.75)](8.65 ft) = 661.26 kip·ft/ft

$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3) = (\tfrac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH})(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

M_H = [½(120 pcf)(24.7 ft)²(0.333)(1.5)](8.23 ft) + [(240 psf)(24.7 ft)(0.333)(1.75)](12.35 ft) = 193.14 kip·ft/ft

$$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

P_V = (120 pcf)(24.7 ft)(17.3 ft)(1.35) + (240 psf)(17.3 ft)(1.75) = 76.45 kip/ft

Nominal Bearing Resistance:

$q_n = cN_c + \gamma D N_q + \tfrac{1}{2}\gamma B N_\gamma$ = (0 psf)(34.2) + (125 pcf)(3.0 ft)(20.0) + ½(125 pcf)(17.29 ft)(17.1) = 26.0 ksf

N_c = 34.2 N_q = 20.0 N_γ = 17.1

Check Bearing Capacity

$q_{eq} \le q_n \cdot \phi_b$ ⟶ 6.25 ksf ≤ (26.0 ksf)(0.65) = 16.90 ksf ⟶ 6.25 ksf ≤ 16.90 ksf **OK**

Use φ_b = **0.65** *(Per AASHTO LRFD BDM Table 11.5.6-1)*

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JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	4	OF	5
CALCULATED BY	VJV	DATE	6/12/2013
CHECKED BY	BRT	DATE	7/8/2013

HAM-75-0823 - MSE Wall - Rear Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	24.7	ft
MSE Wall Width (Reinforcement Length), (B) =	17.29	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	0	psf
Embedment Depth, (D) =	3.0	ft

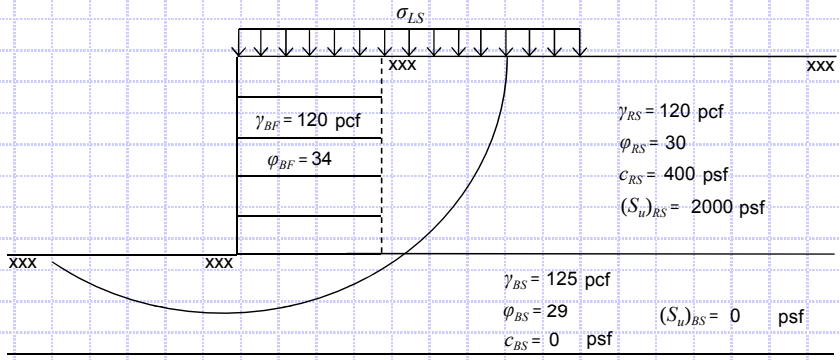
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

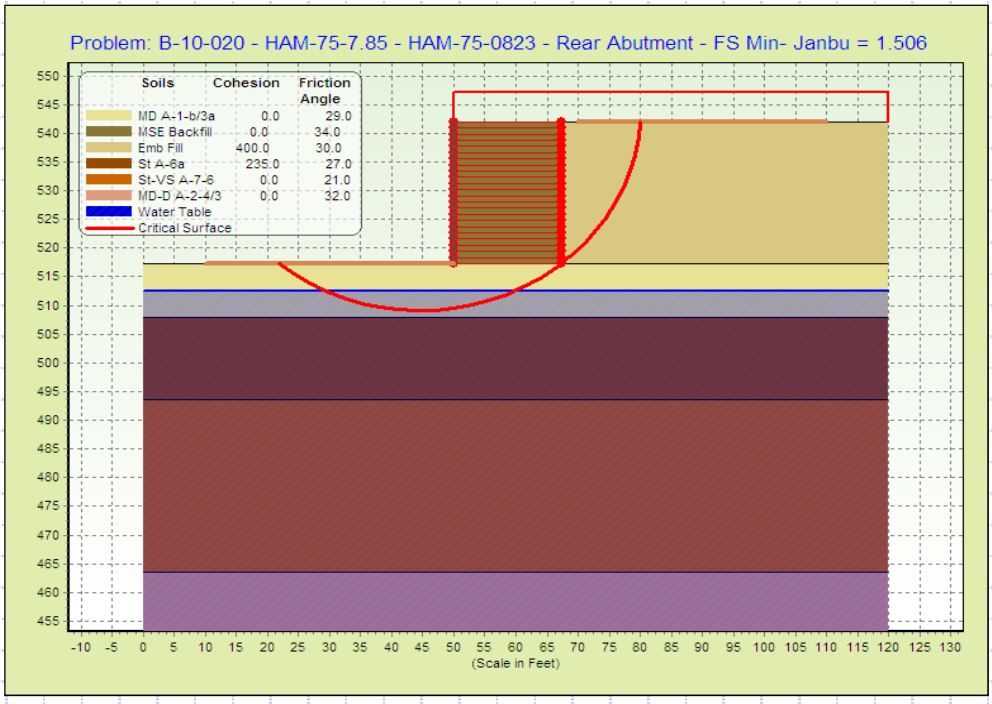
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

Long Term Stability - Drained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.0 ≤ (1.506)(0.65) = 1.0 ⟶ 1.0 ≤ 1.0 **OK**

FS = **1.506** *(From STABL Slope Stability Analysis)*

Use φ_{GS} = **0.65** *(Per AASHTO LRFD BDM Section 11.6.2.3)*

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JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	5	OF	5
CALCULATED BY	VJV	DATE	6/12/2013
CHECKED BY	BRT	DATE	7/8/2013

HAM-75-0823 - MSE Wall - Rear Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	24.7	ft
MSE Wall Width (Reinforcement Length), (B) =	17.29	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, [(S_u)$_{RS}$] =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	0	psf
Embedment Depth, (D) =	3.0	ft

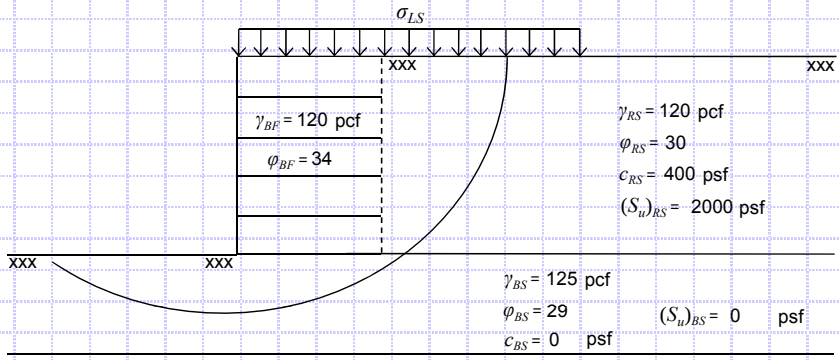
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

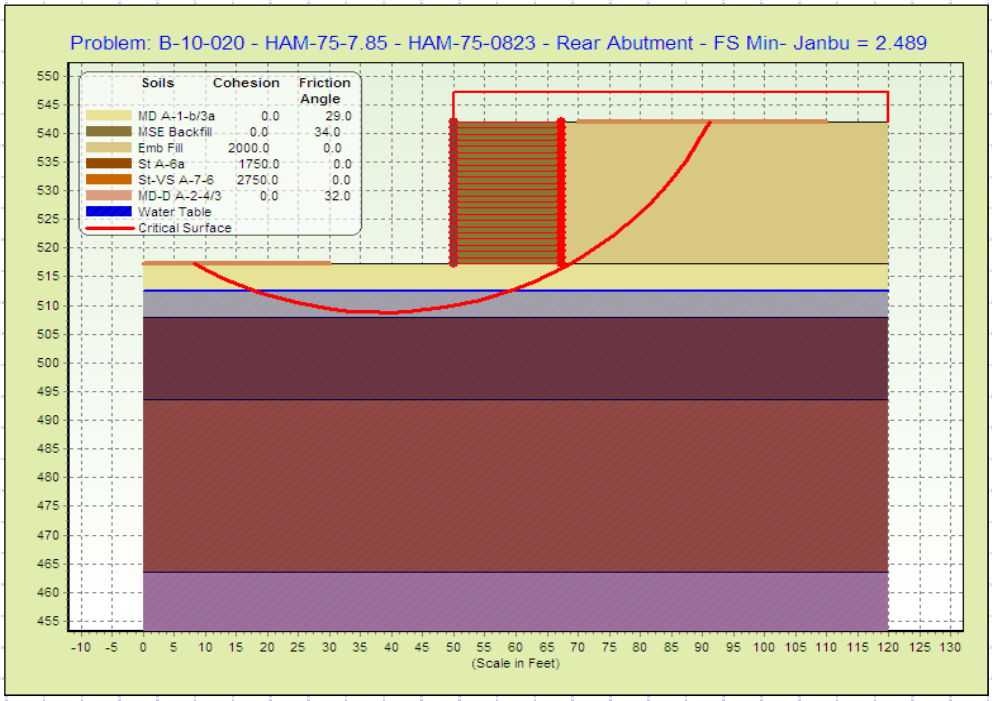
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 ***(Cont'd)***

Short Term Stability - Undrained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.0 ≤ (2.489)(0.65) = 1.6 ⟶ 1.0 ≤ 1.6 **OK**

FS = **2.489** *(From STABL Slope Stability Analysis)* Use φ_{GS} = **0.65** *(Per AASHTO LRFD BDM Section 11.6.2.3)*

** STABL for WINDOWS **
by
Geotechnical Software Solutions

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: U.S.C.
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0823 - R
ear Abutment

BOUNDARY COORDINATES

4 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	517.30	50.00	517.30	3
2	50.00	517.30	50.10	542.00	1
3	50.10	542.00	67.40	542.00	1
4	67.40	542.00	120.00	542.00	2
5	50.00	517.30	67.30	517.30	3
6	67.30	517.30	67.40	542.00	2
7	67.30	517.30	120.00	517.30	3
8	0.00	508.00	120.00	508.00	4
9	0.00	493.50	120.00	493.50	5
10	0.00	463.50	120.00	463.50	6

1

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	400.0	30.0	0.00	0.0	1
3	125.0	130.0	0.0	29.0	0.00	0.0	1
4	115.0	125.0	235.0	27.0	0.00	0.0	1
5	120.0	130.0	0.0	21.0	0.00	0.0	1
6	130.0	135.0	0.0	32.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point	X-Water	Y-Water

No.	(ft)	(ft)
1	0.00	512.50
2	120.00	512.50

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	120.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	517.3	542.0	24	17.3	-1.07	1.0	7500.0

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

750 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 75 Points Equally Spaced Along The Ground Surface Between X = 10.00 ft.
and X = 50.00 ft.

Each Surface Terminates Between X = 70.00 ft.
and X = 110.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =400.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

Factor Of Safety Calculation Has Gone Through 30 Iterations, without convergence

The Trial Failure Surface In Question Is Defined By The Following 21 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.92	517.30
2	31.78	516.39
3	34.71	515.75

4	37.69	515.38
5	40.69	515.28
6	43.68	515.46
7	46.65	515.90
8	49.56	516.61
9	52.40	517.59
10	55.13	518.82
11	57.75	520.29
12	60.22	522.00
13	62.52	523.92
14	64.64	526.04
15	66.56	528.35
16	68.25	530.82
17	69.72	533.44
18	70.94	536.18
19	71.91	539.02
20	72.62	541.93
21	72.63	542.00

Factor Of Safety For The Preceding Specified Surface = -3.882

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.89	517.30
2	24.28	515.48
3	26.81	513.87
4	29.46	512.47
5	32.23	511.31
6	35.08	510.38
7	38.00	509.70
8	40.97	509.26
9	43.96	509.08
10	46.96	509.15
11	49.95	509.47
12	52.89	510.05
13	55.78	510.87
14	58.58	511.93
15	61.29	513.22
16	63.88	514.74
17	66.33	516.47
18	68.63	518.40
19	70.75	520.52
20	72.69	522.80
21	74.43	525.25
22	75.96	527.83
23	77.26	530.53
24	78.33	533.34
25	79.16	536.22
26	79.75	539.16
27	80.07	542.00

*** 1.506 ***

Individual data on the 33 slices

Water Force	Water Force	Force	Force	Earthquake Force	Surcharge

Slice No.	Width (ft)	Weight (lbs)	Top (lbs)	Bot (lbs)	Norm (lbs)	Tan (lbs)	Hor (lbs)	Ver (lbs)	Load (lbs)
1	2.4	271.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.5	830.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.6	1340.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.1	31.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.8	1877.8	0.0	114.1	0.0	0.0	0.0	0.0	0.0
6	2.9	2325.8	0.0	309.9	0.0	0.0	0.0	0.0	0.0
7	2.9	2687.1	0.0	460.7	0.0	0.0	0.0	0.0	0.0
8	3.0	2946.3	0.0	565.3	0.0	0.0	0.0	0.0	0.0
9	3.0	3092.4	0.0	623.1	0.0	0.0	0.0	0.0	0.0
10	3.0	3119.1	0.0	633.6	0.0	0.0	0.0	0.0	0.0
11	3.0	3025.5	0.0	596.8	0.0	0.0	0.0	0.0	0.0
12	0.1	53.2	0.0	10.3	0.0	0.0	0.0	0.0	0.0
13	0.1	247.3	0.0	19.1	0.0	0.0	0.0	0.0	0.0
14	2.8	10936.0	0.0	483.4	0.0	0.0	0.0	0.0	669.9
15	2.9	11051.2	0.0	382.4	0.0	0.0	0.0	0.0	692.6
16	2.8	10404.0	0.0	206.4	0.0	0.0	0.0	0.0	673.5
17	1.2	4313.3	0.0	23.7	0.0	0.0	0.0	0.0	287.5
18	1.5	5310.7	0.0	0.0	0.0	0.0	0.0	0.0	362.2
19	2.6	8745.6	0.0	0.0	0.0	0.0	0.0	0.0	621.2
20	2.5	7784.7	0.0	0.0	0.0	0.0	0.0	0.0	588.2
21	1.0	2928.6	0.0	0.0	0.0	0.0	0.0	0.0	233.0
22	0.0	56.2	0.0	0.0	0.0	0.0	0.0	0.0	4.6
23	0.1	239.8	0.0	0.0	0.0	0.0	0.0	0.0	19.4
24	1.2	3547.1	0.0	0.0	0.0	0.0	0.0	0.0	294.2
25	2.1	5749.4	0.0	0.0	0.0	0.0	0.0	0.0	510.1
26	1.9	4733.2	0.0	0.0	0.0	0.0	0.0	0.0	465.4
27	1.7	3751.1	0.0	0.0	0.0	0.0	0.0	0.0	417.4
28	1.5	2832.6	0.0	0.0	0.0	0.0	0.0	0.0	366.5
29	1.3	2005.1	0.0	0.0	0.0	0.0	0.0	0.0	312.9
30	1.1	1293.7	0.0	0.0	0.0	0.0	0.0	0.0	257.1
31	0.8	720.2	0.0	0.0	0.0	0.0	0.0	0.0	199.4
32	0.6	302.5	0.0	0.0	0.0	0.0	0.0	0.0	140.4
33	0.3	54.3	0.0	0.0	0.0	0.0	0.0	0.0	76.5

Individual data on the 24 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	50.1	542.0	67.4	542.0	0.0	17.3	7500.0	0.0
1	2	0	50.1	540.9	67.4	540.9	0.0	17.3	7500.0	0.0
1	3	0	50.1	539.9	67.4	539.9	0.0	17.3	7500.0	0.0
1	4	0	50.1	538.8	67.4	538.8	0.0	17.3	7500.0	0.0
1	5	0	50.1	537.7	67.4	537.7	0.0	17.3	7500.0	0.0
1	6	0	50.1	536.6	67.4	536.6	0.0	17.3	7500.0	0.0
1	7	0	50.1	535.6	67.4	535.6	0.0	17.3	7500.0	0.0
1	8	0	50.1	534.5	67.4	534.5	0.0	17.3	7500.0	0.0
1	9	0	50.1	533.4	67.4	533.4	0.0	17.3	7500.0	0.0
1	10	0	50.1	532.3	67.4	532.3	0.0	17.3	7500.0	0.0
1	11	0	50.1	531.3	67.4	531.3	0.0	17.3	7500.0	0.0
1	12	0	50.1	530.2	67.4	530.2	0.0	17.3	7500.0	0.0
1	13	0	50.0	529.1	67.3	529.1	0.0	17.3	7500.0	0.0
1	14	0	50.0	528.0	67.3	528.0	0.0	17.3	7500.0	0.0
1	15	0	50.0	527.0	67.3	527.0	0.0	17.3	7500.0	0.0
1	16	0	50.0	525.9	67.3	525.9	0.0	17.3	7500.0	0.0
1	17	0	50.0	524.8	67.3	524.8	0.0	17.3	7500.0	0.0
1	18	0	50.0	523.7	67.3	523.7	0.0	17.3	7500.0	0.0
1	19	0	50.0	522.7	67.3	522.7	0.0	17.3	7500.0	0.0
1	20	0	50.0	521.6	67.3	521.6	0.0	17.3	7500.0	0.0
1	21	0	50.0	520.5	67.3	520.5	0.0	17.3	7500.0	0.0
1	22	0	50.0	519.4	67.3	519.4	0.0	17.3	7500.0	0.0
1	23	0	50.0	518.4	67.3	518.4	0.0	17.3	7500.0	0.0
1	24	0	50.0	517.3	67.3	517.3	0.0	17.3	7500.0	0.0

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	18.11	517.30
2	20.51	515.51
3	23.05	513.90
4	25.69	512.49
5	28.44	511.27

6	31.26	510.27
7	34.16	509.49
8	37.11	508.92
9	40.09	508.57
10	43.08	508.45
11	46.08	508.56
12	49.06	508.88
13	52.01	509.44
14	54.91	510.21
15	57.74	511.19
16	60.50	512.39
17	63.15	513.79
18	65.69	515.38
19	68.11	517.16
20	70.38	519.12
21	72.50	521.24
22	74.46	523.51
23	76.24	525.93
24	77.83	528.47
25	79.23	531.12
26	80.43	533.87
27	81.42	536.71
28	82.19	539.61
29	82.64	542.00

*** 1.526 ***

1

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.78	517.30
2	16.24	515.58
3	18.81	514.03
4	21.48	512.66
5	24.23	511.46
6	27.05	510.45
7	29.94	509.63
8	32.87	509.00
9	35.84	508.57
10	38.83	508.34
11	41.83	508.30
12	44.83	508.47
13	47.81	508.83
14	50.75	509.39
15	53.66	510.15
16	56.50	511.09
17	59.28	512.22
18	61.98	513.54
19	64.58	515.03
20	67.08	516.69
21	69.46	518.51
22	71.72	520.49
23	73.84	522.61
24	75.82	524.87
25	77.64	527.25
26	79.29	529.75
27	80.78	532.36
28	82.10	535.06
29	83.23	537.83
30	84.17	540.68
31	84.51	542.00

*** 1.545 ***

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.54	517.30
2	13.02	515.61
3	15.60	514.08
4	18.27	512.72
5	21.02	511.52
6	23.84	510.49
7	26.72	509.64
8	29.64	508.97
9	32.60	508.48
10	35.59	508.18
11	38.58	508.06
12	41.58	508.13
13	44.57	508.38
14	47.54	508.82
15	50.48	509.44
16	53.37	510.24
17	56.20	511.22
18	58.97	512.37
19	61.67	513.69
20	64.27	515.18
21	66.78	516.82
22	69.18	518.62
23	71.47	520.56
24	73.63	522.64
25	75.66	524.85
26	77.55	527.18
27	79.29	529.63
28	80.87	532.18
29	82.30	534.82
30	83.55	537.54
31	84.64	540.34
32	85.17	542.00

*** 1.562 ***

1

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	19.19	517.30
2	21.54	515.44
3	24.03	513.76
4	26.64	512.28
5	29.35	510.99
6	32.15	509.92
7	35.03	509.07
8	37.96	508.43
9	40.93	508.02
10	43.92	507.84
11	46.92	507.89
12	49.91	508.16
13	52.87	508.66
14	55.78	509.39
15	58.63	510.33
16	61.40	511.49
17	64.07	512.85
18	66.63	514.41
19	69.06	516.17
20	71.36	518.10
21	73.50	520.21
22	75.47	522.46
23	77.27	524.87
24	78.87	527.40
25	80.29	530.05
26	81.49	532.79
27	82.48	535.62
28	83.26	538.52
29	83.81	541.47
30	83.87	542.00

*** 1.584 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	18.11	517.30
2	20.60	515.63
3	23.20	514.14
4	25.91	512.84
5	28.70	511.74
6	31.56	510.85
7	34.49	510.17
8	37.45	509.70
9	40.44	509.45
10	43.44	509.42
11	46.43	509.60
12	49.41	510.00
13	52.34	510.62
14	55.23	511.44
15	58.04	512.48
16	60.78	513.71
17	63.41	515.14
18	65.94	516.76
19	68.34	518.55
20	70.61	520.52
21	72.73	522.65
22	74.68	524.92
23	76.47	527.33
24	78.08	529.86
25	79.50	532.50
26	80.73	535.24
27	81.75	538.06
28	82.57	540.95
29	82.78	542.00

*** 1.585 ***

1

Failure Surface Specified By 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.92	517.30
2	31.56	515.87
3	34.30	514.65
4	37.12	513.65
5	40.02	512.87
6	42.97	512.32
7	45.95	512.00
8	48.95	511.92
9	51.95	512.07
10	54.92	512.45
11	57.86	513.07
12	60.74	513.92
13	63.54	514.98
14	66.25	516.27
15	68.86	517.76
16	71.33	519.45
17	73.67	521.33
18	75.86	523.39
19	77.87	525.61
20	79.71	527.98
21	81.36	530.49
22	82.80	533.12
23	84.03	535.85

24	85.05	538.67
25	85.84	541.57
26	85.93	542.00

*** 1.597 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	22.43	517.30
2	24.84	515.51
3	27.37	513.91
4	30.03	512.50
5	32.77	511.30
6	35.61	510.31
7	38.51	509.54
8	41.46	509.00
9	44.44	508.67
10	47.44	508.58
11	50.44	508.72
12	53.41	509.08
13	56.35	509.67
14	59.24	510.48
15	62.06	511.51
16	64.79	512.75
17	67.42	514.19
18	69.94	515.83
19	72.32	517.65
20	74.55	519.66
21	76.63	521.82
22	78.53	524.14
23	80.26	526.59
24	81.79	529.17
25	83.12	531.86
26	84.24	534.64
27	85.15	537.50
28	85.84	540.42
29	86.09	542.00

*** 1.600 ***

1

Failure Surface Specified By 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.60	517.30
2	27.00	515.51
3	29.54	513.91
4	32.21	512.53
5	34.97	511.37
6	37.82	510.43
7	40.74	509.72
8	43.70	509.25
9	46.69	509.02
10	49.69	509.04
11	52.68	509.29
12	55.64	509.78
13	58.55	510.51
14	61.39	511.48
15	64.14	512.66
16	66.79	514.07
17	69.32	515.68
18	71.71	517.49
19	73.95	519.49
20	76.02	521.66

21	77.91	524.00
22	79.60	526.47
23	81.09	529.08
24	82.37	531.79
25	83.42	534.60
26	84.24	537.49
27	84.83	540.43
28	85.01	542.00

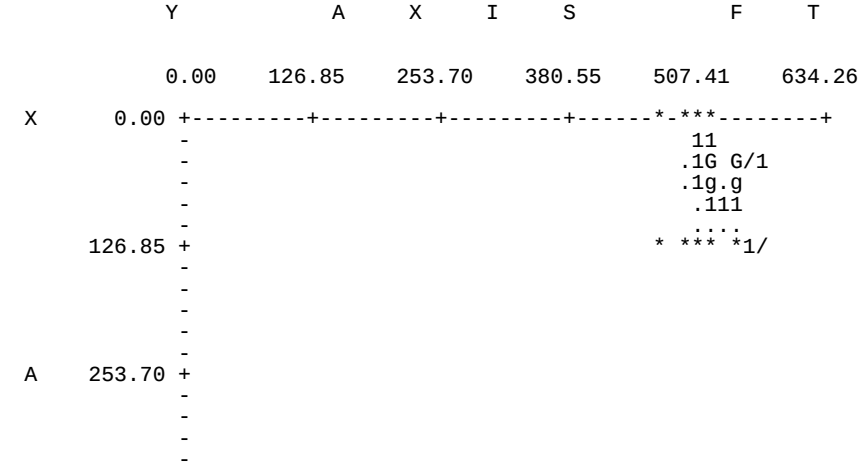
*** 1.600 ***

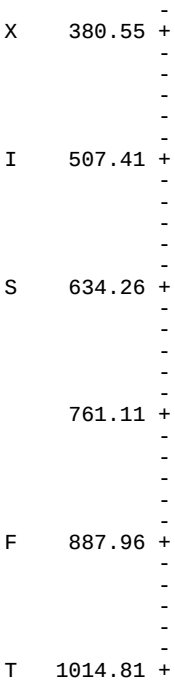
Failure Surface Specified By 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	22.97	517.30
2	25.62	515.89
3	28.36	514.66
4	31.17	513.61
5	34.04	512.74
6	36.96	512.07
7	39.93	511.60
8	42.91	511.32
9	45.91	511.24
10	48.91	511.36
11	51.89	511.67
12	54.85	512.19
13	57.76	512.89
14	60.63	513.79
15	63.42	514.88
16	66.14	516.14
17	68.77	517.59
18	71.30	519.20
19	73.72	520.98
20	76.01	522.91
21	78.17	525.00
22	80.19	527.22
23	82.06	529.56
24	83.76	532.03
25	85.30	534.60
26	86.67	537.27
27	87.86	540.03
28	88.56	542.00

*** 1.606 ***

1




X 380.55
I 507.41
S 634.26
761.11
F 887.96
T 1014.81

** STABL for WINDOWS **
by
Geotechnical Software Solutions

1

--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: U.S.C.
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0823 - R
ear Abutment

BOUNDARY COORDINATES

4 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	517.30	50.00	517.30	3
2	50.00	517.30	50.10	542.00	1
3	50.10	542.00	67.40	542.00	1
4	67.40	542.00	120.00	542.00	2
5	50.00	517.30	67.30	517.30	3
6	67.30	517.30	67.40	542.00	2
7	67.30	517.30	120.00	517.30	3
8	0.00	508.00	120.00	508.00	4
9	0.00	493.50	120.00	493.50	5
10	0.00	463.50	120.00	463.50	6

1

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	2000.0	0.0	0.00	0.0	1
3	125.0	130.0	0.0	29.0	0.00	0.0	1
4	115.0	125.0	1750.0	0.0	0.00	0.0	1
5	120.0	130.0	2750.0	0.0	0.00	0.0	1
6	130.0	135.0	0.0	32.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point	X-Water	Y-Water

No.	(ft)	(ft)
1	0.00	512.50
2	120.00	512.50

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	120.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	517.3	542.0	24	17.3	-1.07	1.0	7500.0

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

750 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 75 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft.
and X = 30.00 ft.

Each Surface Terminates Between X = 70.00 ft.
and X = 110.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =400.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.11	517.30
2	10.71	515.81

3	13.39	514.45
4	16.13	513.24
5	18.93	512.17
6	21.79	511.24
7	24.68	510.46
8	27.61	509.82
9	30.58	509.34
10	33.56	509.01
11	36.55	508.84
12	39.55	508.82
13	42.55	508.95
14	45.54	509.24
15	48.50	509.68
16	51.45	510.27
17	54.35	511.01
18	57.22	511.89
19	60.03	512.93
20	62.79	514.11
21	65.49	515.42
22	68.11	516.88
23	70.66	518.46
24	73.12	520.18
25	75.49	522.01
26	77.77	523.97
27	79.94	526.04
28	82.00	528.22
29	83.94	530.51
30	85.77	532.88
31	87.47	535.35
32	89.05	537.91
33	90.49	540.54
34	91.19	542.00

*** 2.489 ***

Individual data on the 40 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.6	242.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.7	725.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.7	1183.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.9	1067.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.9	542.9	0.0	9.8	0.0	0.0	0.0	0.0	0.0
6	2.9	2007.9	0.0	149.6	0.0	0.0	0.0	0.0	0.0
7	2.9	2360.7	0.0	309.6	0.0	0.0	0.0	0.0	0.0
8	2.9	2659.6	0.0	441.9	0.0	0.0	0.0	0.0	0.0
9	3.0	2899.6	0.0	546.0	0.0	0.0	0.0	0.0	0.0
10	3.0	3076.7	0.0	621.7	0.0	0.0	0.0	0.0	0.0
11	3.0	3187.9	0.0	668.8	0.0	0.0	0.0	0.0	0.0
12	3.0	3231.5	0.0	687.2	0.0	0.0	0.0	0.0	0.0
13	3.0	3206.8	0.0	676.8	0.0	0.0	0.0	0.0	0.0
14	3.0	3114.0	0.0	637.6	0.0	0.0	0.0	0.0	0.0
15	3.0	2954.8	0.0	569.7	0.0	0.0	0.0	0.0	0.0
16	1.5	1417.8	0.0	254.6	0.0	0.0	0.0	0.0	0.0
17	0.1	240.9	0.0	16.0	0.0	0.0	0.0	0.0	0.0
18	1.3	5208.5	0.0	202.8	0.0	0.0	0.0	0.0	322.8
19	2.9	11065.8	0.0	348.9	0.0	0.0	0.0	0.0	697.7
20	2.9	10603.5	0.0	196.5	0.0	0.0	0.0	0.0	687.7
21	1.6	5941.4	0.0	33.2	0.0	0.0	0.0	0.0	395.7
22	1.2	4129.1	0.0	0.0	0.0	0.0	0.0	0.0	280.2
23	2.8	9484.0	0.0	0.0	0.0	0.0	0.0	0.0	662.3
24	2.7	8844.0	0.0	0.0	0.0	0.0	0.0	0.0	646.9
25	1.8	5679.1	0.0	0.0	0.0	0.0	0.0	0.0	434.6
26	0.1	307.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0
27	0.7	2170.5	0.0	0.0	0.0	0.0	0.0	0.0	171.3
28	0.7	2037.6	0.0	0.0	0.0	0.0	0.0	0.0	163.5
29	1.9	5398.5	0.0	0.0	0.0	0.0	0.0	0.0	447.6
30	2.5	6700.7	0.0	0.0	0.0	0.0	0.0	0.0	590.9
31	2.4	5947.4	0.0	0.0	0.0	0.0	0.0	0.0	569.0
32	2.3	5185.5	0.0	0.0	0.0	0.0	0.0	0.0	545.6
33	2.2	4425.2	0.0	0.0	0.0	0.0	0.0	0.0	520.8

34	2.1	3677.2	0.0	0.0	0.0	0.0	0.0	0.0	494.7
35	1.9	2951.8	0.0	0.0	0.0	0.0	0.0	0.0	467.2
36	1.8	2259.4	0.0	0.0	0.0	0.0	0.0	0.0	438.5
37	1.7	1610.2	0.0	0.0	0.0	0.0	0.0	0.0	408.7
38	1.6	1013.9	0.0	0.0	0.0	0.0	0.0	0.0	377.7
39	1.4	480.0	0.0	0.0	0.0	0.0	0.0	0.0	345.8
40	0.7	61.7	0.0	0.0	0.0	0.0	0.0	0.0	169.2

Individual data on the 24 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	50.1	542.0	67.4	542.0	0.0	17.3	7500.0	0.0
1	2	0	50.1	540.9	67.4	540.9	0.0	17.3	7500.0	0.0
1	3	0	50.1	539.9	67.4	539.9	0.0	17.3	7500.0	0.0
1	4	0	50.1	538.8	67.4	538.8	0.0	17.3	7500.0	0.0
1	5	0	50.1	537.7	67.4	537.7	0.0	17.3	7500.0	0.0
1	6	0	50.1	536.6	67.4	536.6	0.0	17.3	7500.0	0.0
1	7	0	50.1	535.6	67.4	535.6	0.0	17.3	7500.0	0.0
1	8	0	50.1	534.5	67.4	534.5	0.0	17.3	7500.0	0.0
1	9	0	50.1	533.4	67.4	533.4	0.0	17.3	7500.0	0.0
1	10	0	50.1	532.3	67.4	532.3	0.0	17.3	7500.0	0.0
1	11	0	50.1	531.3	67.4	531.3	0.0	17.3	7500.0	0.0
1	12	0	50.1	530.2	67.4	530.2	0.0	17.3	7500.0	0.0
1	13	0	50.0	529.1	67.3	529.1	0.0	17.3	7500.0	0.0
1	14	0	50.0	528.0	67.3	528.0	0.0	17.3	7500.0	0.0
1	15	0	50.0	527.0	67.3	527.0	0.0	17.3	7500.0	0.0
1	16	0	50.0	525.9	67.3	525.9	0.0	17.3	7500.0	0.0
1	17	0	50.0	524.8	67.3	524.8	0.0	17.3	7500.0	0.0
1	18	0	50.0	523.7	67.3	523.7	0.0	17.3	7500.0	0.0
1	19	0	50.0	522.7	67.3	522.7	0.0	17.3	7500.0	0.0
1	20	0	50.0	521.6	67.3	521.6	0.0	17.3	7500.0	0.0
1	21	0	50.0	520.5	67.3	520.5	0.0	17.3	7500.0	0.0
1	22	0	50.0	519.4	67.3	519.4	0.0	17.3	7500.0	0.0
1	23	0	50.0	518.4	67.3	518.4	0.0	17.3	7500.0	0.0
1	24	0	50.0	517.3	67.3	517.3	0.0	17.3	7500.0	0.0

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.92	517.30
2	11.51	515.78
3	14.17	514.40
4	16.90	513.16
5	19.70	512.07
6	22.54	511.12
7	25.43	510.32
8	28.36	509.67
9	31.32	509.18
10	34.30	508.84
11	37.30	508.66
12	40.30	508.63
13	43.29	508.76
14	46.28	509.04
15	49.25	509.48
16	52.19	510.08
17	55.09	510.83
18	57.96	511.72
19	60.77	512.77
20	63.52	513.96
21	66.21	515.29
22	68.82	516.76
23	71.36	518.37
24	73.81	520.10
25	76.16	521.96
26	78.41	523.94
27	80.56	526.04
28	82.60	528.24
29	84.51	530.55
30	86.31	532.96
31	87.97	535.45
32	89.51	538.03
33	90.91	540.68

34	91.52	542.00

*** 2.490 ***

1

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.30	517.30
2	9.91	515.82
3	12.59	514.47
4	15.33	513.25
5	18.12	512.16
6	20.96	511.20
7	23.85	510.37
8	26.77	509.68
9	29.72	509.13
10	32.69	508.72
11	35.68	508.45
12	38.67	508.32
13	41.67	508.33
14	44.67	508.48
15	47.65	508.77
16	50.62	509.20
17	53.57	509.77
18	56.48	510.48
19	59.36	511.33
20	62.20	512.31
21	64.98	513.42
22	67.71	514.66
23	70.38	516.03
24	72.99	517.52
25	75.51	519.14
26	77.96	520.87
27	80.33	522.71
28	82.61	524.67
29	84.79	526.72
30	86.87	528.88
31	88.85	531.14
32	90.72	533.48
33	92.48	535.91
34	94.12	538.42
35	95.65	541.01
36	96.17	542.00

*** 2.502 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.11	517.30
2	10.75	515.87
3	13.45	514.57
4	16.21	513.39
5	19.02	512.35
6	21.88	511.44
7	24.78	510.67
8	27.71	510.03
9	30.67	509.54
10	33.65	509.18
11	36.64	508.97
12	39.64	508.90
13	42.64	508.97
14	45.63	509.18
15	48.61	509.53

16	51.57	510.03
17	54.50	510.66
18	57.40	511.43
19	60.26	512.34
20	63.08	513.38
21	65.84	514.55
22	68.54	515.85
23	71.18	517.28
24	73.75	518.83
25	76.24	520.50
26	78.65	522.29
27	80.97	524.19
28	83.20	526.20
29	85.33	528.31
30	87.36	530.52
31	89.29	532.82
32	91.10	535.21
33	92.80	537.68
34	94.38	540.23
35	95.36	542.00

*** 2.506 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.35	517.30
2	13.89	515.70
3	16.51	514.24
4	19.21	512.93
5	21.98	511.77
6	24.80	510.77
7	27.68	509.92
8	30.60	509.24
9	33.56	508.72
10	36.54	508.36
11	39.53	508.17
12	42.53	508.15
13	45.53	508.30
14	48.51	508.61
15	51.47	509.08
16	54.40	509.72
17	57.29	510.53
18	60.14	511.49
19	62.92	512.61
20	65.64	513.88
21	68.28	515.30
22	70.84	516.86
23	73.31	518.56
24	75.68	520.40
25	77.94	522.37
26	80.10	524.46
27	82.13	526.67
28	84.03	528.98
29	85.81	531.40
30	87.45	533.92
31	88.94	536.52
32	90.29	539.20
33	91.49	541.95
34	91.51	542.00

*** 2.506 ***

Failure Surface Specified By 36 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	7.70	517.30
2	10.33	515.85
3	13.02	514.53
4	15.77	513.33
5	18.57	512.26
6	21.42	511.31
7	24.31	510.50
8	27.23	509.83
9	30.18	509.29
10	33.16	508.88
11	36.15	508.62
12	39.14	508.49
13	42.14	508.50
14	45.14	508.64
15	48.13	508.93
16	51.10	509.35
17	54.04	509.91
18	56.96	510.60
19	59.85	511.43
20	62.69	512.39
21	65.48	513.48
22	68.23	514.69
23	70.91	516.03
24	73.53	517.50
25	76.08	519.08
26	78.55	520.78
27	80.94	522.59
28	83.25	524.51
29	85.47	526.53
30	87.59	528.65
31	89.61	530.87
32	91.52	533.18
33	93.33	535.57
34	95.03	538.04
35	96.61	540.59
36	97.39	542.00

*** 2.514 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.76	517.30
2	14.38	515.85
3	17.07	514.52
4	19.83	513.34
5	22.64	512.29
6	25.50	511.38
7	28.40	510.62
8	31.34	510.00
9	34.30	509.53
10	37.28	509.21
11	40.28	509.03
12	43.28	509.01
13	46.27	509.13
14	49.26	509.40
15	52.23	509.83
16	55.18	510.39
17	58.09	511.11
18	60.97	511.97
19	63.79	512.97
20	66.57	514.11
21	69.28	515.38
22	71.93	516.79
23	74.51	518.33
24	77.00	520.00
25	79.41	521.79
26	81.73	523.70
27	83.95	525.71

28	86.06	527.84
29	88.07	530.07
30	89.96	532.40
31	91.74	534.82
32	93.39	537.32
33	94.92	539.90
34	96.02	542.00

*** 2.517 ***

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.89	517.30
2	9.47	515.76
3	12.12	514.36
4	14.84	513.10
5	17.63	511.99
6	20.47	511.03
7	23.36	510.22
8	26.29	509.57
9	29.25	509.07
10	32.23	508.74
11	35.22	508.56
12	38.22	508.55
13	41.22	508.70
14	44.20	509.00
15	47.17	509.47
16	50.10	510.09
17	53.00	510.87
18	55.85	511.80
19	58.65	512.88
20	61.38	514.12
21	64.05	515.49
22	66.64	517.01
23	69.14	518.66
24	71.55	520.45
25	73.87	522.36
26	76.07	524.39
27	78.17	526.54
28	80.14	528.79
29	82.00	531.15
30	83.72	533.61
31	85.32	536.15
32	86.77	538.77
33	88.08	541.47
34	88.30	542.00

*** 2.521 ***

1

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	12.97	517.30
2	15.64	515.92
3	18.37	514.68
4	21.15	513.57
5	23.99	512.60
6	26.88	511.77
7	29.80	511.09
8	32.75	510.56
9	35.73	510.17
10	38.72	509.93
11	41.72	509.84

12	44.72	509.90
13	47.71	510.11
14	50.69	510.46
15	53.64	510.96
16	56.57	511.62
17	59.47	512.41
18	62.32	513.35
19	65.11	514.43
20	67.86	515.64
21	70.54	516.99
22	73.14	518.48
23	75.68	520.09
24	78.12	521.82
25	80.48	523.67
26	82.75	525.64
27	84.91	527.72
28	86.97	529.90
29	88.91	532.19
30	90.74	534.56
31	92.45	537.03
32	94.04	539.58
33	95.38	542.00

*** 2.525 ***

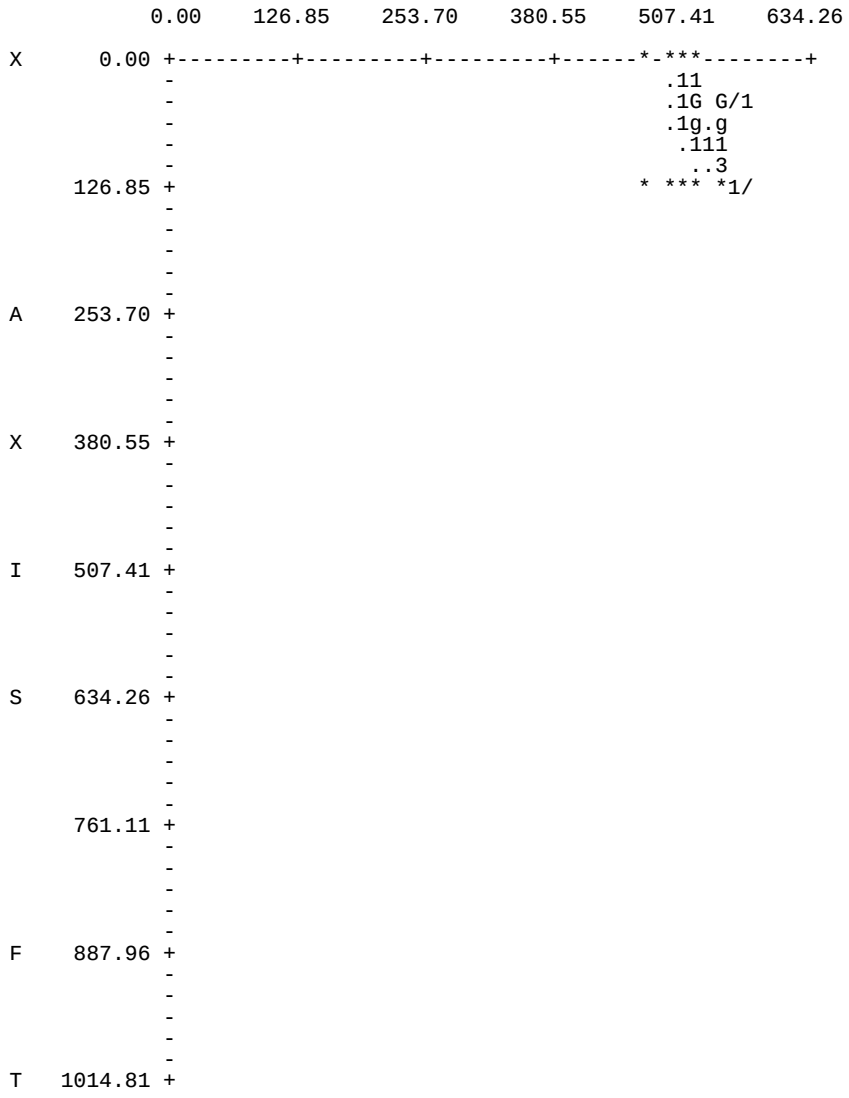
Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.73	517.30
2	12.42	515.97
3	15.17	514.77
4	17.97	513.69
5	20.82	512.75
6	23.70	511.94
7	26.63	511.26
8	29.58	510.72
9	32.55	510.31
10	35.54	510.04
11	38.54	509.92
12	41.54	509.93
13	44.53	510.07
14	47.52	510.36
15	50.49	510.78
16	53.43	511.35
17	56.35	512.04
18	59.24	512.87
19	62.08	513.84
20	64.87	514.93
21	67.61	516.15
22	70.29	517.50
23	72.91	518.96
24	75.45	520.55
25	77.92	522.26
26	80.31	524.07
27	82.61	526.00
28	84.82	528.03
29	86.93	530.16
30	88.95	532.38
31	90.86	534.69
32	92.65	537.10
33	94.34	539.58
34	95.83	542.00

*** 2.527 ***

1

Y A X I S F T


0.00
126.85
253.70
380.55
507.41
634.26
X
0.00
126.85
A
253.70
X
380.55
I
507.41
S
634.26
761.11
F
887.96
T
1014.81

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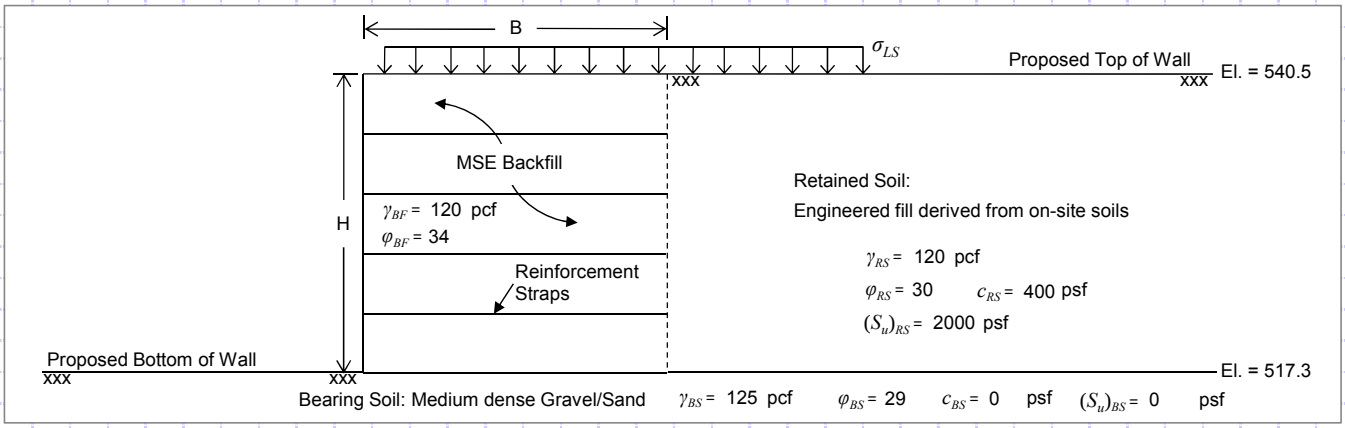
JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	1	OF	5
CALCULATED BY	VJV	DATE	6/12/2013
CHECKED BY	BRT	DATE	7/8/2013

HAM-75-0823 - MSE Wall - Forward Abutment

MSE Wall - Forward Abutment - B-169-0-07 - (23.2 ft. Wall Height)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	23.2	ft
MSE Wall Width (Reinforcement Length), (B) =	16.2	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	0	psf
Embedment Depth, (D) =	3.0	ft

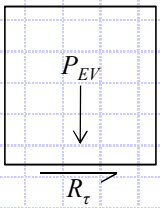
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Sections 11.6.3.6 and 11.10.5.3

Nominal Sliding Resistance: $R_\tau = P_{EV} \cdot \tan\delta$



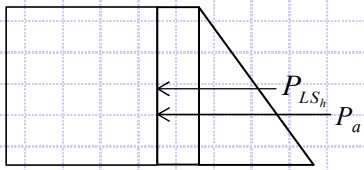
$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$ = (120 pcf)(23.2 ft)(16.24 ft)(1.00) = 45.21 kip/ft

$\tan\delta = (\tan\varphi_{BS} \le \tan\varphi_{BF})$

$\tan\delta =$ tan(29) ≤ tan(34) ⟶ 0.55 ≤ 0.67 ⟶ $\tan\delta =$ 0.55

R_τ = (45.21 kip/ft)(0.55) = 24.87 kip/ft

Sliding Force: $P_H = P_{EH} + P_{LS_h}$



$P_{EH} = \frac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH}$ = ½(120 pcf)(23.2 ft)²(0.333)(1.5) = 16.13 kip/ft

$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS}$ = (240 psf)(23.2 ft)(0.333)(1.75) = 3.24 kip/ft

P_H = 16.13 kip/ft + 3.24 kip/ft = 19.37 kip/ft

Check Sliding Resistance

$P_H \le R_\tau \cdot \phi_\tau$ ⟶ 19.37 kip/ft ≤ (24.87 kip/ft)(1.0) = 24.87 kip/ft ⟶ 19.37 kip/ft ≤ 24.87 kip/ft **OK**

Use φ_τ = **1.0** *(Per AASHTO LRFD BDM Table 11.5.6-1)*

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JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	2	OF	5
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CHECKED BY	BRT	DATE	7/8/2013

HAM-75-0823 - MSE Wall - Forward Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	23.2	ft
MSE Wall Width (Reinforcement Length), (B) =	16.24	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

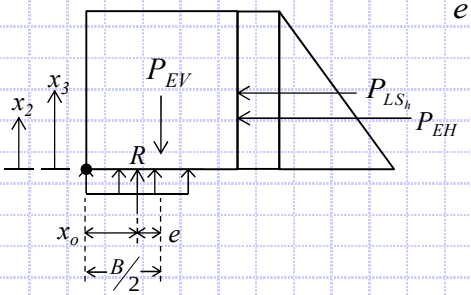
Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	0	psf
Embedment Depth, (D) =	3.0	ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3



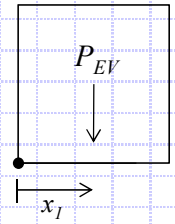
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = \text{(367.11 kip·ft/ft - 162.27 kip·ft/ft) / (45.21 kip/ft)} = 4.53 \text{ ft}$$

M_{EV} = 367.11 kip·ft/ft
M_H = 162.27 kip·ft/ft
P_{EV} = 45.21 kip/ft
} Defined below

$e =$ (16.24 ft)/2 - 4.53 ft = 3.59 ft

Resisting Moment, M_{EV}:



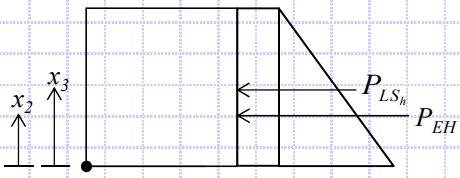
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = \text{(120 pcf)(23.2 ft)(16.24 ft)(1.00)} = 45.21 \text{ kip/ft}$$

$$x_1 = B/2 = \text{(16.24 ft) / 2} = 8.12 \text{ ft}$$

$$M_{EV} = \text{(45.21 kip/ft)(8.12 ft)} = 367.11 \text{ kip·ft/ft}$$

Overturning Moment, M_H:



$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3)$$

$$P_{EH} = \tfrac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH} = \text{½(120 pcf)(23.2 ft)²(0.333)(1.5)} = 16.13 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = \text{(240 psf)(23.2 ft)(0.333)(1.75)} = 3.24 \text{ kip/ft}$$

$$x_2 = H/3 = \text{(23.2 ft) / 3} = 7.73 \text{ ft}$$

$$x_3 = H/2 = \text{(23.2 ft) / 2} = 11.60 \text{ ft}$$

$$M_H = \text{(16.13 kip/ft)(7.73 ft) + (3.24 kip/ft)(11.6 ft)} = 162.27 \text{ kip·ft/ft}$$

Limiting Eccentricity:

$$e_{max} = B/4 \longrightarrow e_{max} = \text{(16.24 ft) / 4} = 4.06 \text{ ft}$$

Check Eccentricity

$$e < e_{max} \longrightarrow 3.59 \text{ ft} \le 4.06 \text{ ft} \quad \text{OK}$$

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JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	3	OF	5
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HAM-75-0823 - MSE Wall - Forward Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	23.2	ft
MSE Wall Width (Reinforcement Length), (B) =	16.24	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, [(S_u)$_{RS}$] =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

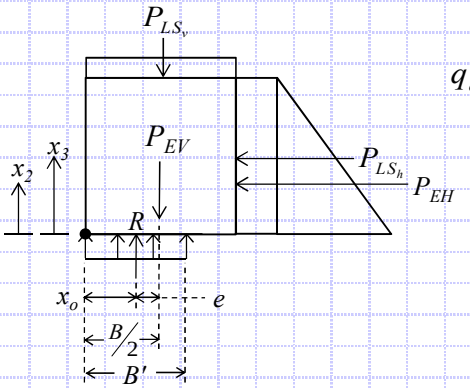
Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	0	psf
Embedment Depth, (D) =	3.0	ft

LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

Check Bearing Capacity (Loading Case - Strength Ib) - AASHTO LRFD BDM Section 11.6.3.2



$$q_{eq} = P_V / B'$$

$B' = B - 2e$ = 16.2 ft - 2(2.39 ft) = 11.46 ft

$e = B/2 - x_o$ = (16.2 ft) / 2 - 5.73 ft = 2.39 ft

$x_o = \frac{M_V - M_H}{P_V}$ = (551.00 kip·ft/ft - 162.33 kip·ft/ft) / 67.86 kip/ft = 5.73 ft

q_{eq} = (67.86 kip/ft) / (11.46 ft) = 5.92 ksf

$$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

M_V = [(120 pcf)(23.2 ft)(16.24 ft)(1.35)](8.12 ft) + [(240 psf)(16.24 ft)(1.75)](8.12 ft) = 551.00 kip·ft/ft

$$M_H = P_{EH}(x_2) + P_{LS_h}(x_3) = (\tfrac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH})(x_2) + (\sigma_{LS} H K_a \gamma_{LS})(x_3)$$

M_H = [½(120 pcf)(23.2 ft)²(0.333)(1.5)](7.73 ft) + [(240 psf)(23.2 ft)(0.333)(1.75)](11.6 ft) = 162.33 kip·ft/ft

$$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} + \sigma_{LS} \cdot B \cdot \gamma_{LS}$$

P_V = (120 pcf)(23.2 ft)(16.2 ft)(1.35) + (240 psf)(16.2 ft)(1.75) = 67.86 kip/ft

Nominal Bearing Resistance:

$q_n = cN_c + \gamma D N_q + \tfrac{1}{2}\gamma B N_\gamma$ = (0 psf)(34.2) + (125 pcf)(3.0 ft)(20.0) + ½(125 pcf)(16.24 ft)(17.1) = 24.9 ksf

N_c = 34.2 N_q = 20.0 N_γ = 17.1

Check Bearing Capacity

$q_{eq} \le q_n \cdot \phi_b$ ⟶ 5.92 ksf ≤ (24.9 ksf)(0.65) = 16.19 ksf ⟶ 5.92 ksf ≤ 16.19 ksf **OK**

Use φ_b = **0.65** *(Per AASHTO LRFD BDM Table 11.5.6-1)*

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JOB	HAM-75-7.85	NO.	B-10-020
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CALCULATED BY	VJV	DATE	6/12/2013
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HAM-75-0823 - MSE Wall - Forward Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	23.2	ft
MSE Wall Width (Reinforcement Length), (B) =	16.24	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, [(S_u)$_{RS}$] =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	0	psf
Embedment Depth, (D) =	3.0	ft

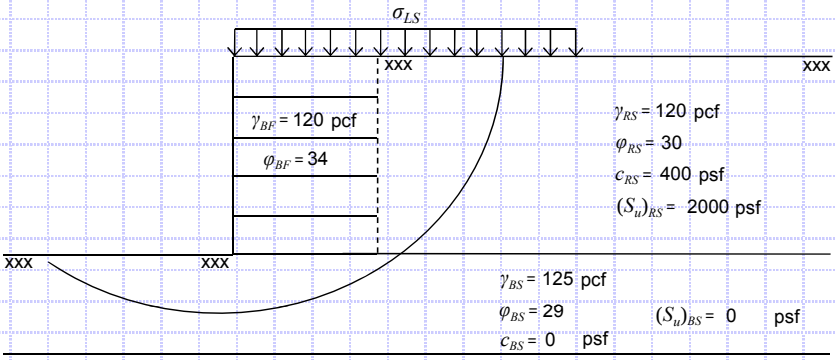
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

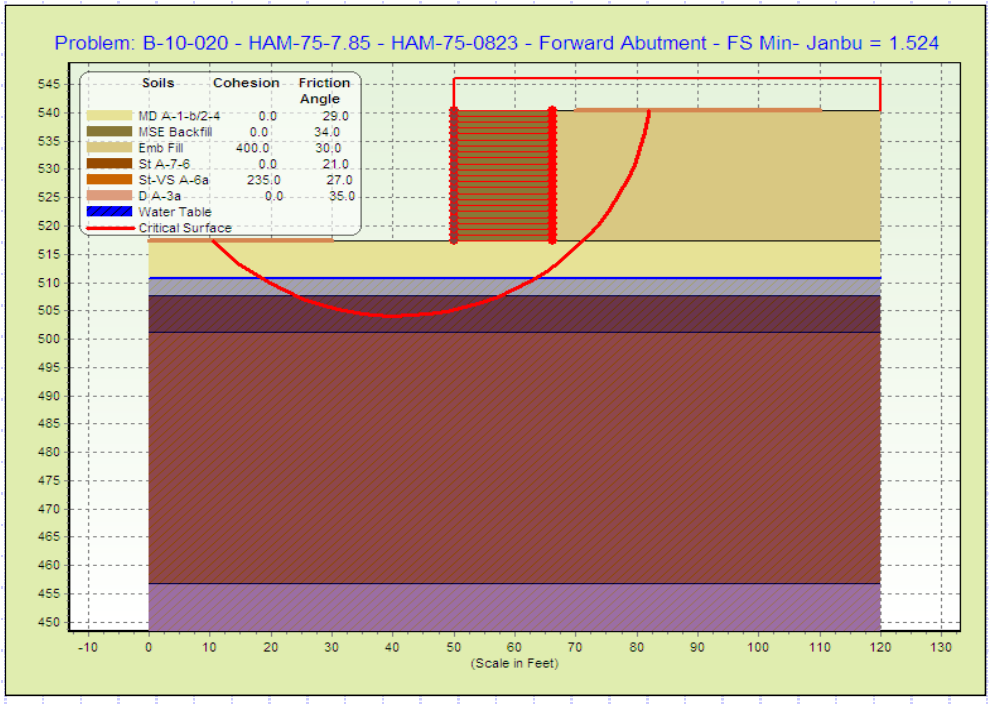
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

Long Term Stability - Drained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.0 ≤ (1.524)(0.65) = 1.0 ⟶ 1.0 ≤ 1.0 **OK**

FS = **1.524** *(From STABL Slope Stability Analysis)* Use φ_{GS} = **0.65** *(Per AASHTO LRFD BDM Section 11.6.2.3)*

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HAM-75-0823 - MSE Wall - Forward Abutment

MSE Wall - Rear Abutment - B-168 - (12.03 ft. Wall Height)

MSE Wall Height, (H) =	23.2	ft
MSE Wall Width (Reinforcement Length), (B) =	16.24	ft
Live Surcharge Load, (σ_{LS}) =	240	psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	°
Retained Soil Drained Cohesion, (c_{BS}) =	400	psf
Retained Soil Undrained Shear Strength, [(S_u)$_{RS}$] =	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333	
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34	°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	125	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	29	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	0	psf
Embedment Depth, (D) =	3.0	ft

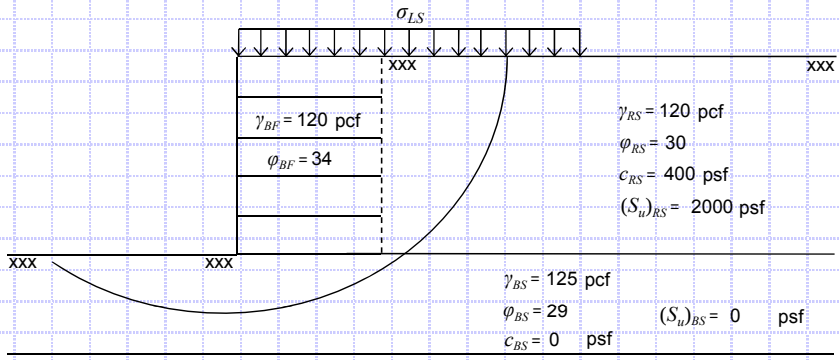
LRFD Load Factors

	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)

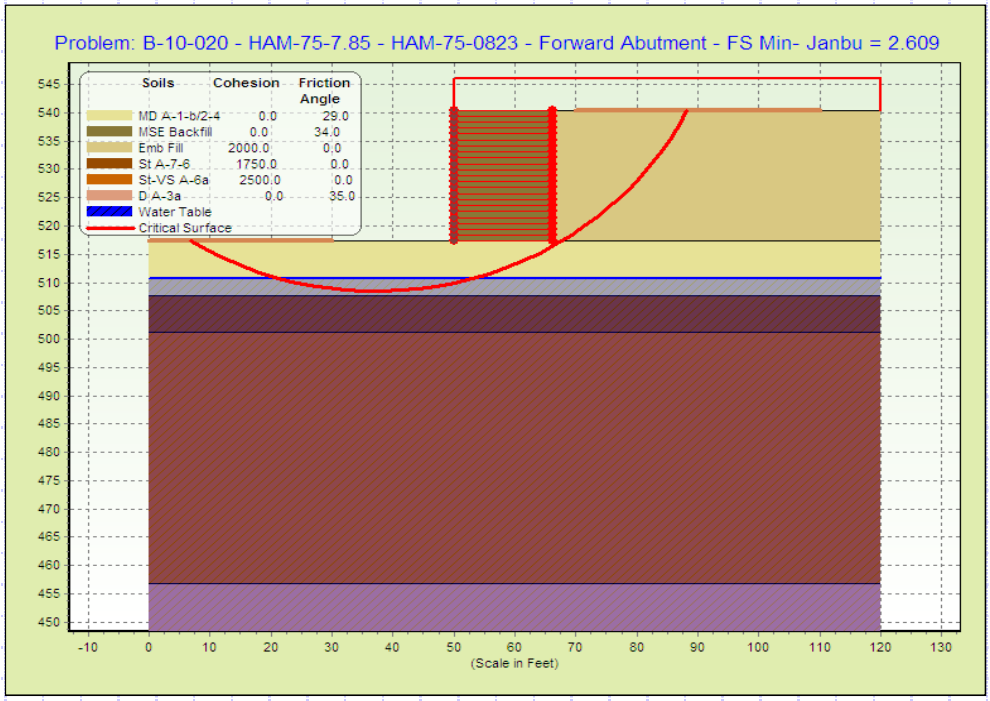
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 ***(Cont'd)***

Short Term Stability - Undrained Conditions



Loading scenario modeled as shown to the left and analyzed for slope stability using STABL for Windows software.

Graphical output shown below and tabular output results are provided as a separate attachment.



Check Overall (Global) Stability

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.0 ≤ (2.609)(0.65) = 1.7 ⟶ 1.0 ≤ 1.7 **OK**

FS = **2.609** *(From STABL Slope Stability Analysis)* Use φ_{GS} = **0.65** *(Per AASHTO LRFD BDM Section 11.6.2.3)*

** STABL for WINDOWS **
by
Geotechnical Software Solutions

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--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: U.S.C.
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0823 - F
orward Abutment

BOUNDARY COORDINATES

4 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	517.30	50.00	517.30	3
2	50.00	517.30	50.10	540.50	1
3	50.10	540.50	66.30	540.50	1
4	66.30	540.50	120.00	540.50	2
5	50.00	517.30	66.20	517.30	3
6	66.20	517.30	66.30	540.50	2
7	66.20	517.30	120.00	517.30	3
8	0.00	507.70	120.00	507.70	4
9	0.00	501.20	120.00	501.20	5
10	0.00	456.70	120.00	456.70	6

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ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	400.0	30.0	0.00	0.0	1
3	125.0	130.0	0.0	29.0	0.00	0.0	1
4	115.0	125.0	0.0	21.0	0.00	0.0	1
5	120.0	130.0	235.0	27.0	0.00	0.0	1
6	130.0	135.0	0.0	35.0	0.00	0.0	1

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1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point	X-Water	Y-Water

No.	(ft)	(ft)
1	0.00	510.70
2	120.00	510.70

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BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	120.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	517.3	540.5	23	16.2	-1.05	1.0	7500.0

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A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

750 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 75 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft.
and X = 30.00 ft.

Each Surface Terminates Between X = 70.00 ft.
and X = 110.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =400.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

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Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.54	517.30
2	12.67	515.18

3	14.94	513.22
4	17.34	511.43
5	19.88	509.82
6	22.52	508.40
7	25.25	507.17
8	28.07	506.14
9	30.96	505.32
10	33.89	504.71
11	36.87	504.31
12	39.86	504.13
13	42.86	504.17
14	45.85	504.42
15	48.81	504.89
16	51.74	505.57
17	54.60	506.46
18	57.39	507.56
19	60.10	508.86
20	62.70	510.34
21	65.19	512.02
22	67.56	513.86
23	69.78	515.88
24	71.85	518.05
25	73.76	520.36
26	75.50	522.81
27	77.06	525.37
28	78.42	528.04
29	79.59	530.80
30	80.56	533.64
31	81.32	536.55
32	81.87	539.50
33	81.98	540.50

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Individual data on the 41 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.1	281.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.3	879.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.4	1496.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.2	897.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.4	1217.0	0.0	44.8	0.0	0.0	0.0	0.0	0.0
6	2.6	2724.4	0.0	297.7	0.0	0.0	0.0	0.0	0.0
7	1.6	1818.2	0.0	281.9	0.0	0.0	0.0	0.0	0.0
8	1.2	1475.6	0.0	264.1	0.0	0.0	0.0	0.0	0.0
9	2.8	3792.5	0.0	757.2	0.0	0.0	0.0	0.0	0.0
10	2.9	4216.0	0.0	930.3	0.0	0.0	0.0	0.0	0.0
11	2.9	4554.7	0.0	1064.3	0.0	0.0	0.0	0.0	0.0
12	3.0	4798.4	0.0	1158.6	0.0	0.0	0.0	0.0	0.0
13	3.0	4940.1	0.0	1212.6	0.0	0.0	0.0	0.0	0.0
14	3.0	4975.7	0.0	1226.1	0.0	0.0	0.0	0.0	0.0
15	3.0	4904.1	0.0	1198.9	0.0	0.0	0.0	0.0	0.0
16	3.0	4727.4	0.0	1131.3	0.0	0.0	0.0	0.0	0.0
17	1.2	1836.1	0.0	430.8	0.0	0.0	0.0	0.0	0.0
18	0.1	292.2	0.0	35.4	0.0	0.0	0.0	0.0	0.0
19	1.6	7016.2	0.0	557.5	0.0	0.0	0.0	0.0	392.6
20	2.9	12057.1	0.0	876.3	0.0	0.0	0.0	0.0	687.5
21	2.8	11407.3	0.0	690.3	0.0	0.0	0.0	0.0	670.2
22	0.3	1166.4	0.0	61.8	0.0	0.0	0.0	0.0	69.8
23	2.4	9475.8	0.0	404.6	0.0	0.0	0.0	0.0	579.6
24	2.6	9774.7	0.0	206.0	0.0	0.0	0.0	0.0	625.2
25	0.5	1928.2	0.0	7.1	0.0	0.0	0.0	0.0	127.4
26	2.0	6912.1	0.0	0.0	0.0	0.0	0.0	0.0	470.4
27	1.0	3412.8	0.0	0.0	0.0	0.0	0.0	0.0	241.2
28	0.1	334.2	0.0	0.0	0.0	0.0	0.0	0.0	24.0
29	1.3	4120.7	0.0	0.0	0.0	0.0	0.0	0.0	302.0
30	2.2	6865.5	0.0	0.0	0.0	0.0	0.0	0.0	533.6
31	1.4	3903.0	0.0	0.0	0.0	0.0	0.0	0.0	326.1
32	0.7	1954.4	0.0	0.0	0.0	0.0	0.0	0.0	171.2
33	1.9	4880.4	0.0	0.0	0.0	0.0	0.0	0.0	458.3
34	1.7	3943.9	0.0	0.0	0.0	0.0	0.0	0.0	417.0

35	1.6	3064.3	0.0	0.0	0.0	0.0	0.0	0.0	373.4
36	1.4	2261.8	0.0	0.0	0.0	0.0	0.0	0.0	327.9
37	1.2	1554.8	0.0	0.0	0.0	0.0	0.0	0.0	280.7
38	1.0	960.2	0.0	0.0	0.0	0.0	0.0	0.0	232.1
39	0.8	492.2	0.0	0.0	0.0	0.0	0.0	0.0	182.2
40	0.5	162.7	0.0	0.0	0.0	0.0	0.0	0.0	131.3
41	0.1	6.7	0.0	0.0	0.0	0.0	0.0	0.0	26.8

Individual data on the 23 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	50.1	540.5	66.3	540.5	0.0	16.2	7500.0	0.0
1	2	0	50.1	539.4	66.3	539.4	0.0	16.2	7500.0	0.0
1	3	0	50.1	538.4	66.3	538.4	0.0	16.2	7500.0	0.0
1	4	0	50.1	537.3	66.3	537.3	0.0	16.2	7500.0	0.0
1	5	0	50.1	536.3	66.3	536.3	0.0	16.2	7500.0	0.0
1	6	0	50.1	535.2	66.3	535.2	0.0	16.2	7500.0	0.0
1	7	0	50.1	534.2	66.3	534.2	0.0	16.2	7500.0	0.0
1	8	0	50.1	533.1	66.3	533.1	0.0	16.2	7500.0	0.0
1	9	0	50.1	532.1	66.3	532.1	0.0	16.2	7500.0	0.0
1	10	0	50.1	531.0	66.3	531.0	0.0	16.2	7500.0	0.0
1	11	0	50.1	530.0	66.3	530.0	0.0	16.2	7500.0	0.0
1	12	0	50.0	528.9	66.2	528.9	0.0	16.2	7500.0	0.0
1	13	0	50.0	527.8	66.2	527.8	0.0	16.2	7500.0	0.0
1	14	0	50.0	526.8	66.2	526.8	0.0	16.2	7500.0	0.0
1	15	0	50.0	525.7	66.2	525.7	0.0	16.2	7500.0	0.0
1	16	0	50.0	524.7	66.2	524.7	0.0	16.2	7500.0	0.0
1	17	0	50.0	523.6	66.2	523.6	0.0	16.2	7500.0	0.0
1	18	0	50.0	522.6	66.2	522.6	0.0	16.2	7500.0	0.0
1	19	0	50.0	521.5	66.2	521.5	0.0	16.2	7500.0	0.0
1	20	0	50.0	520.5	66.2	520.5	0.0	16.2	7500.0	0.0
1	21	0	50.0	519.4	66.2	519.4	0.0	16.2	7500.0	0.0
1	22	0	50.0	518.4	66.2	518.4	0.0	16.2	7500.0	0.0
1	23	0	50.0	517.3	66.2	517.3	0.0	16.2	7500.0	0.0

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.35	517.30
2	13.49	515.20
3	15.79	513.27
4	18.24	511.53
5	20.81	509.99
6	23.50	508.66
7	26.28	507.53
8	29.14	506.63
9	32.06	505.96
10	35.03	505.51
11	38.02	505.30
12	41.02	505.33
13	44.01	505.59
14	46.97	506.08
15	49.88	506.80
16	52.73	507.75
17	55.49	508.92
18	58.16	510.30
19	60.70	511.89
20	63.12	513.67
21	65.39	515.63
22	67.49	517.77
23	69.43	520.06
24	71.17	522.50
25	72.73	525.07
26	74.07	527.75
27	75.21	530.53
28	76.12	533.38
29	76.80	536.30
30	77.26	539.27
31	77.35	540.50

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Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	10.95	517.30
2	13.08	515.19
3	15.37	513.25
4	17.81	511.50
5	20.37	509.94
6	23.05	508.59
7	25.82	507.45
8	28.68	506.53
9	31.59	505.83
10	34.56	505.37
11	37.55	505.13
12	40.55	505.13
13	43.54	505.36
14	46.50	505.83
15	49.42	506.52
16	52.28	507.44
17	55.05	508.58
18	57.73	509.93
19	60.30	511.49
20	62.73	513.24
21	65.03	515.17
22	67.16	517.28
23	69.12	519.55
24	70.91	521.96
25	72.49	524.51
26	73.88	527.17
27	75.05	529.93
28	76.01	532.77
29	76.74	535.68
30	77.24	538.64
31	77.41	540.50

*** 1.526 ***

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.92	517.30
2	11.10	515.24
3	13.42	513.34
4	15.88	511.62
5	18.45	510.07
6	21.13	508.72
7	23.90	507.56
8	26.74	506.61
9	29.65	505.86
10	32.60	505.33
11	35.58	505.01
12	38.58	504.91
13	41.58	505.02
14	44.56	505.35
15	47.51	505.89
16	50.41	506.65
17	53.25	507.61
18	56.02	508.77
19	58.69	510.14
20	61.26	511.69
21	63.71	513.42
22	66.02	515.33
23	68.20	517.39
24	70.22	519.61

25	72.07	521.97
26	73.75	524.46
27	75.24	527.06
28	76.55	529.76
29	77.65	532.55
30	78.55	535.41
31	79.24	538.33
32	79.59	540.50

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Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	5.68	517.30
2	7.80	515.18
3	10.07	513.22
4	12.47	511.42
5	14.99	509.79
6	17.61	508.34
7	20.34	507.08
8	23.14	506.01
9	26.01	505.14
10	28.94	504.48
11	31.90	504.02
12	34.89	503.77
13	37.89	503.72
14	40.89	503.89
15	43.86	504.27
16	46.80	504.85
17	49.70	505.64
18	52.53	506.63
19	55.29	507.82
20	57.95	509.19
21	60.52	510.75
22	62.97	512.48
23	65.29	514.38
24	67.47	516.44
25	69.50	518.65
26	71.38	520.99
27	73.08	523.46
28	74.61	526.04
29	75.96	528.72
30	77.11	531.49
31	78.07	534.33
32	78.83	537.23
33	79.38	540.18
34	79.42	540.50

*** 1.531 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.41	517.30
2	17.53	515.18
3	19.82	513.25
4	22.27	511.51
5	24.85	509.98
6	27.55	508.66
7	30.34	507.58
8	33.22	506.73
9	36.16	506.12
10	39.13	505.75

11	42.13	505.63
12	45.13	505.76
13	48.10	506.13
14	51.04	506.75
15	53.91	507.62
16	56.71	508.71
17	59.40	510.03
18	61.98	511.57
19	64.41	513.32
20	66.70	515.26
21	68.82	517.38
22	70.75	519.68
23	72.49	522.12
24	74.03	524.70
25	75.34	527.40
26	76.43	530.19
27	77.28	533.07
28	77.89	536.01
29	78.26	538.98
30	78.32	540.50

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Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.87	517.30
2	7.00	515.19
3	9.27	513.23
4	11.68	511.44
5	14.20	509.82
6	16.83	508.38
7	19.56	507.13
8	22.37	506.08
9	25.25	505.22
10	28.17	504.57
11	31.14	504.12
12	34.13	503.89
13	37.13	503.86
14	40.13	504.05
15	43.10	504.44
16	46.04	505.04
17	48.93	505.85
18	51.75	506.85
19	54.50	508.06
20	57.16	509.45
21	59.71	511.02
22	62.15	512.77
23	64.46	514.69
24	66.62	516.77
25	68.64	518.99
26	70.50	521.34
27	72.18	523.82
28	73.69	526.42
29	75.01	529.11
30	76.14	531.89
31	77.08	534.74
32	77.81	537.65
33	78.31	540.50

*** 1.539 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)

1	17.43	517.30
2	19.55	515.18
3	21.84	513.24
4	24.28	511.49
5	26.85	509.95
6	29.54	508.62
7	32.33	507.51
8	35.20	506.64
9	38.13	506.00
10	41.11	505.61
11	44.10	505.45
12	47.10	505.55
13	50.08	505.88
14	53.03	506.46
15	55.91	507.28
16	58.72	508.33
17	61.44	509.60
18	64.04	511.10
19	66.51	512.79
20	68.84	514.69
21	71.00	516.77
22	72.99	519.02
23	74.79	521.42
24	76.38	523.96
25	77.76	526.62
26	78.92	529.39
27	79.85	532.24
28	80.55	535.16
29	81.01	538.12
30	81.17	540.50

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Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.11	517.30
2	10.33	515.28
3	12.67	513.41
4	15.14	511.71
5	17.72	510.18
6	20.40	508.82
7	23.16	507.66
8	26.00	506.68
9	28.89	505.89
10	31.84	505.30
11	34.81	504.92
12	37.81	504.73
13	40.81	504.75
14	43.80	504.98
15	46.77	505.40
16	49.70	506.03
17	52.59	506.85
18	55.41	507.87
19	58.16	509.07
20	60.82	510.46
21	63.38	512.02
22	65.82	513.76
23	68.15	515.66
24	70.34	517.71
25	72.38	519.90
26	74.28	522.23
27	76.01	524.68
28	77.57	527.24
29	78.95	529.90
30	80.15	532.65
31	81.17	535.47
32	81.98	538.36
33	82.44	540.50

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Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.38	517.30
2	15.60	515.28
3	17.96	513.43
4	20.45	511.76
5	23.06	510.29
6	25.78	509.01
7	28.58	507.93
8	31.45	507.07
9	34.38	506.43
10	37.35	506.00
11	40.35	505.80
12	43.34	505.82
13	46.34	506.06
14	49.30	506.53
15	52.22	507.21
16	55.08	508.11
17	57.87	509.22
18	60.56	510.54
19	63.15	512.05
20	65.63	513.75
21	67.96	515.63
22	70.15	517.68
23	72.19	519.89
24	74.05	522.24
25	75.73	524.73
26	77.22	527.33
27	78.52	530.04
28	79.60	532.83
29	80.48	535.70
30	81.14	538.63
31	81.42	540.50

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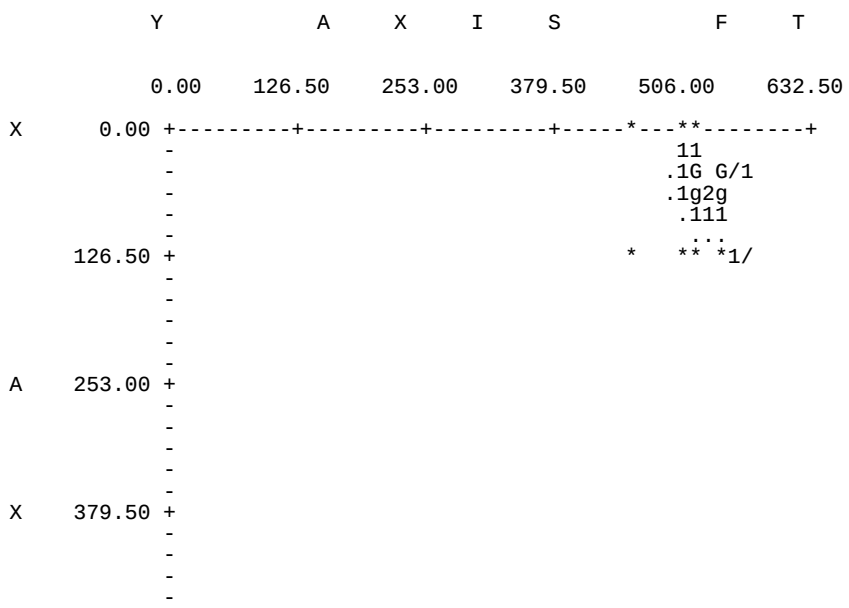

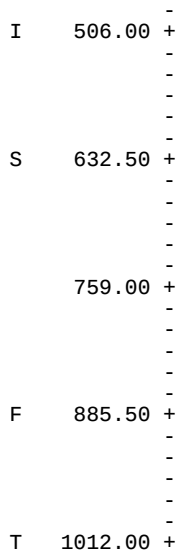
I
506.00
S
632.50
759.00
F
885.50
T
1012.00

** STABL for WINDOWS **
by
Geotechnical Software Solutions

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--Slope Stability Analysis--
Simplified Janbu, Simplified Bishop
or Spencer`s Method of Slices

Run Date:
Time of Run:
Run By:
Input Data Filename: run.in
Output Filename: result.out
Unit: U.S.C.
Plotted Output Filename: result.plt

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - HAM-75-0823 - F
orward Abutment

BOUNDARY COORDINATES

4 Top Boundaries
10 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	517.30	50.00	517.30	3
2	50.00	517.30	50.10	540.50	1
3	50.10	540.50	66.30	540.50	1
4	66.30	540.50	120.00	540.50	2
5	50.00	517.30	66.20	517.30	3
6	66.20	517.30	66.30	540.50	2
7	66.20	517.30	120.00	517.30	3
8	0.00	507.70	120.00	507.70	4
9	0.00	501.20	120.00	501.20	5
10	0.00	456.70	120.00	456.70	6

1

ISOTROPIC SOIL PARAMETERS

6 Type(s) of Soil

Soil Type No.	Total Unit Wt. (pcf)	Saturated Unit Wt. (pcf)	Cohesion Intercept (psf)	Friction Angle (deg)	Pore Pressure Param.	Pressure Constant (psf)	Piez. Surface No.
1	120.0	125.0	0.0	34.0	0.00	0.0	1
2	120.0	130.0	2000.0	0.0	0.00	0.0	1
3	125.0	130.0	0.0	29.0	0.00	0.0	1
4	115.0	125.0	1750.0	0.0	0.00	0.0	1
5	120.0	130.0	2500.0	0.0	0.00	0.0	1
6	130.0	135.0	0.0	35.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point	X-Water	Y-Water

No.	(ft)	(ft)
1	0.00	510.70
2	120.00	510.70

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	50.10	120.00	240.0	0.0

NOTE - Intensity Is Specified As A Uniformly Distributed Force Acting On A Horizontally Projected Surface.

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	517.3	540.5	23	16.2	-1.05	1.0	7500.0

1

A Critical Failure Surface Searching Method, Using A Random Technique For Generating Circular Surfaces, Has Been Specified.

750 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 75 Points Equally Spaced Along The Ground Surface Between X = 0.00 ft.
and X = 30.00 ft.

Each Surface Terminates Between X = 70.00 ft.
and X = 110.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =400.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

1

Following Are Displayed The Ten Most Critical Of The Trial Failure Surfaces Examined. They Are Ordered - Most Critical First.

* * Safety Factors Are Calculated By The Modified Janbu Method * *

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.89	517.30
2	9.47	515.76

3	12.12	514.35
4	14.84	513.09
5	17.62	511.98
6	20.46	511.01
7	23.35	510.20
8	26.28	509.54
9	29.24	509.04
10	32.22	508.69
11	35.21	508.50
12	38.21	508.47
13	41.21	508.60
14	44.19	508.89
15	47.16	509.34
16	50.10	509.94
17	53.00	510.70
18	55.86	511.61
19	58.67	512.67
20	61.41	513.88
21	64.09	515.23
22	66.69	516.72
23	69.21	518.35
24	71.64	520.11
25	73.98	522.00
26	76.21	524.00
27	78.33	526.13
28	80.33	528.36
29	82.22	530.69
30	83.97	533.12
31	85.60	535.64
32	87.09	538.25
33	88.23	540.50

*** 2.609 ***

Individual data on the 39 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.6	248.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.7	743.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.7	1216.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.8	1658.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.8	2060.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.1	894.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	1.8	1524.3	0.0	28.9	0.0	0.0	0.0	0.0	0.0
8	2.9	2730.5	0.0	155.5	0.0	0.0	0.0	0.0	0.0
9	3.0	2982.9	0.0	264.4	0.0	0.0	0.0	0.0	0.0
10	3.0	3170.3	0.0	344.0	0.0	0.0	0.0	0.0	0.0
11	3.0	3289.3	0.0	394.0	0.0	0.0	0.0	0.0	0.0
12	3.0	3337.9	0.0	414.3	0.0	0.0	0.0	0.0	0.0
13	3.0	3315.2	0.0	404.8	0.0	0.0	0.0	0.0	0.0
14	3.0	3221.6	0.0	365.6	0.0	0.0	0.0	0.0	0.0
15	3.0	3058.7	0.0	296.7	0.0	0.0	0.0	0.0	0.0
16	2.8	2738.2	0.0	193.6	0.0	0.0	0.0	0.0	0.0
17	0.1	227.0	0.0	4.8	0.0	0.0	0.0	0.0	0.0
18	0.0	4.6	0.0	0.1	0.0	0.0	0.0	0.0	0.0
19	2.9	10614.2	0.0	71.0	0.0	0.0	0.0	0.0	696.3
20	0.0	5.9	0.0	0.0	0.0	0.0	0.0	0.0	0.4
21	2.9	10147.5	0.0	0.0	0.0	0.0	0.0	0.0	685.6
22	2.8	9621.7	0.0	0.0	0.0	0.0	0.0	0.0	673.5
23	2.7	9025.9	0.0	0.0	0.0	0.0	0.0	0.0	659.0
24	2.7	8374.2	0.0	0.0	0.0	0.0	0.0	0.0	642.7
25	2.1	6260.8	0.0	0.0	0.0	0.0	0.0	0.0	506.5
26	0.1	288.8	0.0	0.0	0.0	0.0	0.0	0.0	24.0
27	0.4	1126.1	0.0	0.0	0.0	0.0	0.0	0.0	94.2
28	0.9	2514.1	0.0	0.0	0.0	0.0	0.0	0.0	214.0
29	1.6	4430.5	0.0	0.0	0.0	0.0	0.0	0.0	390.8
30	2.4	6202.0	0.0	0.0	0.0	0.0	0.0	0.0	583.2
31	2.3	5445.1	0.0	0.0	0.0	0.0	0.0	0.0	560.0
32	2.2	4683.4	0.0	0.0	0.0	0.0	0.0	0.0	535.2
33	2.1	3928.2	0.0	0.0	0.0	0.0	0.0	0.0	509.0
34	2.0	3190.6	0.0	0.0	0.0	0.0	0.0	0.0	481.3

35	1.9	2481.8	0.0	0.0	0.0	0.0	0.0	0.0	452.2
36	1.8	1812.7	0.0	0.0	0.0	0.0	0.0	0.0	421.9
37	1.6	1194.1	0.0	0.0	0.0	0.0	0.0	0.0	390.4
38	1.5	636.0	0.0	0.0	0.0	0.0	0.0	0.0	357.8
39	1.1	153.7	0.0	0.0	0.0	0.0	0.0	0.0	272.7

Individual data on the 23 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	50.1	540.5	66.3	540.5	0.0	16.2	7500.0	0.0
1	2	0	50.1	539.4	66.3	539.4	0.0	16.2	7500.0	0.0
1	3	0	50.1	538.4	66.3	538.4	0.0	16.2	7500.0	0.0
1	4	0	50.1	537.3	66.3	537.3	0.0	16.2	7500.0	0.0
1	5	0	50.1	536.3	66.3	536.3	0.0	16.2	7500.0	0.0
1	6	0	50.1	535.2	66.3	535.2	0.0	16.2	7500.0	0.0
1	7	0	50.1	534.2	66.3	534.2	0.0	16.2	7500.0	0.0
1	8	0	50.1	533.1	66.3	533.1	0.0	16.2	7500.0	0.0
1	9	0	50.1	532.1	66.3	532.1	0.0	16.2	7500.0	0.0
1	10	0	50.1	531.0	66.3	531.0	0.0	16.2	7500.0	0.0
1	11	0	50.1	530.0	66.3	530.0	0.0	16.2	7500.0	0.0
1	12	0	50.0	528.9	66.2	528.9	0.0	16.2	7500.0	0.0
1	13	0	50.0	527.8	66.2	527.8	0.0	16.2	7500.0	0.0
1	14	0	50.0	526.8	66.2	526.8	0.0	16.2	7500.0	0.0
1	15	0	50.0	525.7	66.2	525.7	0.0	16.2	7500.0	0.0
1	16	0	50.0	524.7	66.2	524.7	0.0	16.2	7500.0	0.0
1	17	0	50.0	523.6	66.2	523.6	0.0	16.2	7500.0	0.0
1	18	0	50.0	522.6	66.2	522.6	0.0	16.2	7500.0	0.0
1	19	0	50.0	521.5	66.2	521.5	0.0	16.2	7500.0	0.0
1	20	0	50.0	520.5	66.2	520.5	0.0	16.2	7500.0	0.0
1	21	0	50.0	519.4	66.2	519.4	0.0	16.2	7500.0	0.0
1	22	0	50.0	518.4	66.2	518.4	0.0	16.2	7500.0	0.0
1	23	0	50.0	517.3	66.2	517.3	0.0	16.2	7500.0	0.0

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.70	517.30
2	10.23	515.69
3	12.85	514.22
4	15.54	512.89
5	18.30	511.71
6	21.12	510.68
7	23.99	509.81
8	26.90	509.09
9	29.84	508.52
10	32.82	508.12
11	35.81	507.88
12	38.81	507.80
13	41.81	507.88
14	44.80	508.13
15	47.77	508.53
16	50.71	509.09
17	53.63	509.82
18	56.49	510.69
19	59.31	511.73
20	62.07	512.91
21	64.76	514.24
22	67.37	515.71
23	69.90	517.32
24	72.34	519.07
25	74.68	520.94
26	76.92	522.94
27	79.05	525.05
28	81.06	527.28
29	82.95	529.62
30	84.70	532.05
31	86.33	534.57
32	87.81	537.17
33	89.16	539.86
34	89.44	540.50

*** 2.609 ***

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Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.89	517.30
2	9.45	515.74
3	12.09	514.31
4	14.79	513.01
5	17.56	511.85
6	20.38	510.82
7	23.25	509.94
8	26.16	509.20
9	29.10	508.61
10	32.06	508.17
11	35.05	507.87
12	38.05	507.73
13	41.05	507.73
14	44.04	507.88
15	47.03	508.18
16	49.99	508.63
17	52.93	509.23
18	55.84	509.97
19	58.71	510.86
20	61.52	511.89
21	64.29	513.06
22	66.99	514.36
23	69.62	515.80
24	72.18	517.37
25	74.66	519.06
26	77.05	520.87
27	79.34	522.80
28	81.54	524.85
29	83.63	526.99
30	85.62	529.25
31	87.48	531.59
32	89.23	534.03
33	90.86	536.55
34	92.36	539.15
35	93.05	540.50

*** 2.614 ***

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.92	517.30
2	11.51	515.78
3	14.17	514.40
4	16.90	513.16
5	19.69	512.06
6	22.54	511.10
7	25.43	510.30
8	28.35	509.64
9	31.31	509.14
10	34.29	508.79
11	37.28	508.59
12	40.28	508.55
13	43.28	508.66
14	46.27	508.93
15	49.24	509.36
16	52.18	509.93
17	55.09	510.66
18	57.96	511.53
19	60.78	512.55

20	63.55	513.72
21	66.25	515.03
22	68.88	516.48
23	71.43	518.05
24	73.89	519.76
25	76.27	521.60
26	78.54	523.55
27	80.72	525.62
28	82.78	527.80
29	84.73	530.08
30	86.55	532.46
31	88.25	534.93
32	89.83	537.49
33	91.26	540.12
34	91.45	540.50

*** 2.614 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.11	517.30
2	10.71	515.81
3	13.39	514.45
4	16.13	513.24
5	18.93	512.16
6	21.78	511.22
7	24.67	510.43
8	27.61	509.79
9	30.57	509.30
10	33.55	508.96
11	36.54	508.77
12	39.54	508.74
13	42.54	508.86
14	45.53	509.12
15	48.50	509.54
16	51.44	510.11
17	54.35	510.83
18	57.23	511.70
19	60.05	512.71
20	62.82	513.86
21	65.53	515.15
22	68.17	516.58
23	70.73	518.14
24	73.21	519.83
25	75.60	521.64
26	77.90	523.57
27	80.09	525.61
28	82.18	527.76
29	84.16	530.02
30	86.02	532.38
31	87.76	534.82
32	89.37	537.35
33	90.85	539.96
34	91.12	540.50

*** 2.616 ***

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	8.51	517.30
2	11.07	515.73
3	13.70	514.29

4	16.40	512.99
5	19.17	511.82
6	21.99	510.80
7	24.86	509.92
8	27.77	509.19
9	30.71	508.61
10	33.68	508.19
11	36.67	507.91
12	39.67	507.78
13	42.67	507.81
14	45.66	507.99
15	48.64	508.33
16	51.60	508.81
17	54.53	509.45
18	57.43	510.23
19	60.28	511.17
20	63.08	512.24
21	65.82	513.46
22	68.50	514.81
23	71.10	516.30
24	73.63	517.92
25	76.07	519.67
26	78.42	521.54
27	80.66	523.52
28	82.81	525.62
29	84.84	527.83
30	86.76	530.13
31	88.56	532.53
32	90.24	535.02
33	91.78	537.59
34	93.19	540.24
35	93.32	540.50

*** 2.617 ***

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Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	3.65	517.30
2	6.27	515.83
3	8.95	514.49
4	11.69	513.28
5	14.49	512.20
6	17.34	511.26
7	20.23	510.45
8	23.16	509.79
9	26.11	509.26
10	29.09	508.88
11	32.08	508.64
12	35.07	508.54
13	38.07	508.59
14	41.07	508.78
15	44.05	509.11
16	47.01	509.59
17	49.95	510.20
18	52.85	510.96
19	55.71	511.86
20	58.53	512.89
21	61.30	514.05
22	64.00	515.35
23	66.64	516.77
24	69.21	518.32
25	71.71	519.99
26	74.12	521.77
27	76.44	523.67
28	78.66	525.68
29	80.79	527.80
30	82.82	530.01
31	84.74	532.32
32	86.54	534.71
33	88.23	537.19

34	89.80	539.75
35	90.21	540.50

*** 2.625 ***

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	12.16	517.30
2	14.74	515.77
3	17.40	514.38
4	20.13	513.13
5	22.92	512.04
6	25.77	511.09
7	28.66	510.29
8	31.59	509.65
9	34.55	509.17
10	37.54	508.84
11	40.53	508.68
12	43.53	508.67
13	46.53	508.83
14	49.51	509.14
15	52.47	509.61
16	55.41	510.24
17	58.30	511.03
18	61.15	511.97
19	63.95	513.06
20	66.68	514.29
21	69.34	515.67
22	71.93	517.19
23	74.43	518.85
24	76.84	520.63
25	79.15	522.55
26	81.36	524.58
27	83.45	526.73
28	85.43	528.98
29	87.28	531.34
30	89.01	533.80
31	90.60	536.34
32	92.06	538.96
33	92.81	540.50

*** 2.627 ***

1

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.73	517.30
2	12.23	515.64
3	14.82	514.12
4	17.49	512.77
5	20.24	511.57
6	23.06	510.54
7	25.93	509.67
8	28.85	508.98
9	31.81	508.46
10	34.79	508.11
11	37.78	507.94
12	40.78	507.95
13	43.78	508.14
14	46.75	508.50
15	49.71	509.04
16	52.62	509.75
17	55.49	510.63

18	58.30	511.68
19	61.04	512.89
20	63.71	514.27
21	66.29	515.79
22	68.78	517.47
23	71.16	519.29
24	73.43	521.25
25	75.59	523.34
26	77.61	525.56
27	79.50	527.88
28	81.25	530.32
29	82.86	532.86
30	84.31	535.48
31	85.60	538.19
32	86.54	540.50

*** 2.629 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	7.30	517.30
2	9.91	515.82
3	12.59	514.47
4	15.33	513.25
5	18.12	512.15
6	20.96	511.18
7	23.84	510.35
8	26.76	509.65
9	29.70	509.09
10	32.67	508.67
11	35.66	508.38
12	38.66	508.24
13	41.66	508.23
14	44.65	508.36
15	47.64	508.64
16	50.61	509.05
17	53.56	509.60
18	56.48	510.29
19	59.37	511.11
20	62.21	512.06
21	65.01	513.15
22	67.75	514.37
23	70.43	515.71
24	73.05	517.17
25	75.60	518.76
26	78.07	520.46
27	80.46	522.28
28	82.76	524.20
29	84.97	526.23
30	87.08	528.36
31	89.09	530.59
32	91.00	532.91
33	92.79	535.31
34	94.47	537.79
35	96.04	540.35
36	96.12	540.50

*** 2.640 ***

1

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            Y           A     X     I     S           F     T

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X      0.00 +---------+---------+---------+-----*---**--------+
             -                                    11
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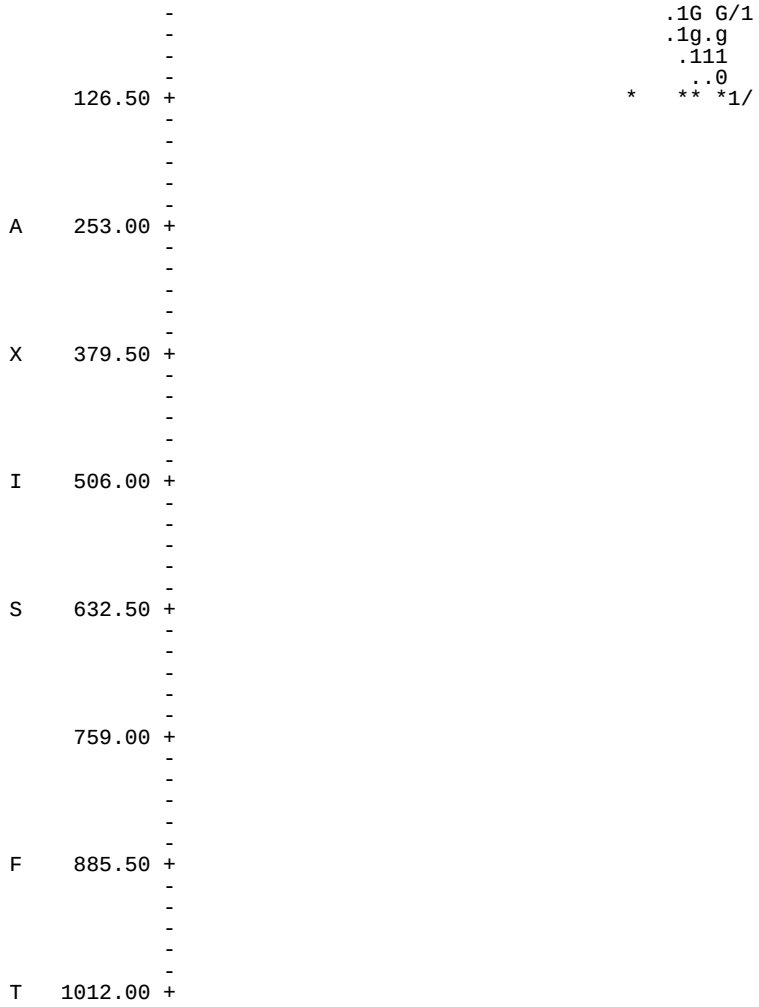
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