Resource International, Inc.

HAM-75-7.85
RETAINING WALL H
PID NO. 77889
HAMILTON COUNTY, OHIO

DRAFT STRUCTURE FOUNDATION EXPLORATION REPORT

Prepared For:
EMH&T
5500 New Albany Road
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Prepared By:
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Rii Project No. B-10-020

August, 2013

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June 22, 2012 (Revised August 8, 2013)

Mr. Edward D. Kagel, P.E.
Director of Transportation
EMH&T
5500 New Albany Road
Columbus, Ohio 43054

Re: Draft Structure Foundation Exploration
HAM-75-7.85
Retaining Wall H
PID No. 77889
Rii Project No. B-10-020

Dear Mr. Kagel:

Resource International, Inc. (Rii) is pleased to submit this DRAFT 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 design and construction of proposed Retaining Wall H as part of the HAM-75-7.85 project. The proposed wall will be located on the south side of the proposed HAM-75-0857 I-75 over Towne Street bridge structure 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.

Brian R. Trenner, P.E.
Project Engineer

Jonathan P. Sterenberg, P.E.
Director of Geotechnical Services

Enclosure: DRAFT Structure Foundation Exploration Report

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APPENDICIES

EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a DRAFT structure foundation exploration for the design and construction of proposed Retaining Wall H as part of the HAM-75-7.85 project. It is understood that this wall will be connected to the rear abutment of the proposed HAM-75-0857 I-75 over Towne Street bridge structure at the north end of the wall alignment and will extend south. According to design details provided by the Rii design team, the rear abutment for the bridge structure is currently proposed to be a mechanically stabilized earth (MSE) wall type abutment. To provide continuity, it is understood that a MSE wall type is being considered as the preferred wall type for the entire alignment of Retaining Wall H. The total wall length is approximately 315 lineal feet.

Exploration and Findings

Between October 7 and November 29, 2011, two (2) structural borings, designated as B-015-0-11 and B-016-0-11, were drilled to a depth of 50.0 feet each below the ground surface at the locations illustrated on the boring plan presented in Appendix II of the full report.

Both of the borings were drilled along the embankment separating the I-75 mainline and a residential property to the west and encountered 7.0 and 6.0 inches of topsoil, respectively, at the existing ground surface, identified by the significant presence of organic matter and vegetation.

Beneath the surface material in borings B-015 and B-016, material identified as fill or possible fill was encountered to a depth of 13.0 and 18.0 feet below the ground surface, respectively. The fill material consisted of brownish gray and brown sandy silt and silty clay (ODOT A-4a, A-6b).

Underlying the surface materials and existing fill, natural cohesive and granular soils were encountered. The cohesive soils were generally described as brownish gray and dark gray sandy silt, and clay (ODOT A-4a, A-7-6). The granular soils were generally described as brown and gray gravel with sand and silt and fine sand (ODOT A-2-4, A-3).

Bedrock was not encountered in either of the borings performed for this exploration.

Analyses and Recommendations

Design details of the proposed retaining wall were provided by the Rii design team. It is understood that the proposed retaining wall will be a MSE wall type that will connect to the rear abutment of the proposed HAM-75-0857 I-75 over Towne Street bridge structure at the north end of the wall alignment.

It is understood that a MSE retaining wall is being considered for use in supporting the proposed widened alignment along the west side of I-75. Based upon the proposed plan and cross section information provided by the Rii design team, wall heights along the alignment are anticipated to range between 7.5 and 27.5 feet.

The anticipated bearing materials along the proposed alignment will primarily consist of existing embankment fill described as stiff sandy silt and silty clay (ODOT A-4a, A-6b). MSE wall foundations bearing on these soils or engineered fill, placed and compacted as described in Section 5.3 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 5.1.1 of the full report, the bearing pressure on the front portion of the wall **will not exceed** the factored nominal bearing resistance at the strength limit state at the rear abutment provided the subgrade is prepared as noted Section 5.1 of the full report.

Retaining Wall H Spread Footing Design Parameters

From Station [1]	To Station [1]	Representative Borings	Maximum Wall Height (ft)	Minimum Reinforcement Length [2]	Nominal Bearing Resistance (ksf)		Total Settlement [4] (in)
					Service	Strength [3]	
448+45	449+50	B-015	16.9	0.70(H)	3.9	11.8	1.02 / 0.68
449+50	451+60	B-015 and B-016	27.5	0.70(H)	3.9	11.8	5.65 / 2.84

1. *Limits of wall determined from plan information provided by the Rii design team. Stationing listed is referenced to the mainline I-75 centerline.*
2. *The required foundation width is expressed as a percentage of the wall height, H, at the respective location.*
3. *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.*
4. *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.*

As noted in Section 4.2, material identified as possible fill was identified in borings B-015 and B-016 to a depth of 13.0 and 18.0 feet below existing grade, respectively. The material did not contain deleterious material based on the samples recovered, and the material appears to be uniform with depth throughout the fill zone. During construction of the proposed retaining wall, it is recommended that the bearing soils along the alignment be closely observed to verify that adequate bearing material is present prior to construction of the wall. If the bearing material contains any deleterious material, such as concrete fragments or wood fibers, the material should be over excavated until competent natural soils are encountered and backfilled with structural fill as noted in Section 5.3 to the proposed bearing elevation.

For MSE walls bearing on soil, the limiting eccentricity is one-fourth of the base width of the wall. Based on the soil parameters listed in Section 5.1.1 of the full report, for an MSE wall designed with a minimum strap length as noted above, the calculated eccentricity of the resultant force **will not exceed** the limiting eccentricity at the strength limit state.

Based on the soil parameters listed in Section 5.1.1 of the full report for the foundation and reinforced soil backfill, a coefficient of sliding friction of 0.51 and 0.60 was utilized for design along the wall alignment. A geotechnical resistance factor of φ_τ=1.0 was considered when calculating the factored shear resistance between the foundation soil and reinforced soil backfill for sliding. Based on the minimum length of reinforced soil mass presented above and utilizing the soil parameters listed in Section 5.1.1 of the full report for the for the foundation and reinforced soil backfill, the resultant horizontal forces on the back of the MSE wall **will not exceed** the factored shear resistance at the strength limit state.

Overall (global) stability for MSE walls supporting structural elements is satisfied when a minimum factor of safety of 1.33 is obtained under loading conditions at the service limit state. Based on the soil parameters listed in Section 5.1.1 of the full report, for MSE walls designed with minimum strap lengths as noted above, the resulting factor of safety under drained and undrained conditions was greater than 1.33.

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 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 DRAFT report is a presentation of the structure foundation exploration performed for the design and construction of proposed Retaining Wall H as part of the HAM-75-7.85 project, as shown on the Vicinity Map and Boring Plan presented in Appendix II. It is understood that this wall will be connected to the rear abutment of the proposed HAM-75-0857 I-75 over Towne Street bridge structure at the north end of the wall alignment and will extend south. According to design details provided by the Rii design team, the rear abutment for the bridge structure is currently proposed to be a mechanically stabilized earth (MSE) wall type abutment. To provide continuity, it is understood that a MSE wall type is being considered as the preferred wall type for the entire alignment of Retaining Wall H. The total wall length is approximately 315 lineal feet.

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 site 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, from the Ohio Department of Natural Resources (ODNR), 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 is aligned roughly parallel to this main bedrock valley from the approximate intersection with State Route 126 to the approximate intersection with Regina Graeter Way, and lies just east of the bottom of the bedrock valley. Along the project alignment, the bedrock surface directly beneath I-75 lies along the slope of the bedrock valley and the bedrock surface ranges between approximate elevations of 385 to 425 feet msl. A smaller bedrock valley branches off to the southeast of the bedrock valley that follows Mill Creek just south of the interchange with State Route 562, and runs roughly parallel with Ross Run and generally beneath the SR 562 alignment. Overall, the bedrock surface along the majority of the project alignment slopes downward to the northwest. According to bedrock topography mapping, the depth to top of bedrock in the vicinity of the project ranges from approximately 120 to 170 feet below the existing ground surface. An illustration of the general geology of Ohio is presented in Appendix I.

2.2 Existing Conditions

The site for the proposed Retaining Wall H is located along the west side of I-75, just south of the HAM-75-0857 I-75 over Towne Street bridge structure. Overall, the project is located approximately 2.0 miles south of the Lockland split. The proposed wall begins at Station 448+45 and continues north to Station 451+60 along the west side of I-75. The wall will be located along the west side of I-75, separating the proposed widened alignment for I-75 southbound from existing residential properties. The existing I-75 roadway that runs adjacent to the proposed structure is a six-lane, asphalt paved road and the existing HAM-75-0857 bridge structure is a three-span structure that crosses Towne Street, which is a two-lane asphalt paved road. The existing I-75 mainline profile is elevated approximately 25 to 30 feet above the surrounding terrain in the vicinity of the wall where the existing roadway embankment connects to the HAM-75-0857 bridge structure.

3.0 EXPLORATION

Between October 7 and November 29, 2011, two (2) structural borings, designated as B-015-0-11 and B-016-0-11, were drilled to a depth of 50.0 feet each below the ground surface at the locations illustrated on the boring plan presented in Appendix II.

Table 1. Test Boring Summary

Boring Number	Station	Offset	Latitude	Longitude	Ground Elevation (feet)	Boring Depth
B-015-0-11	449+93.73	76.2' Lt.	39.183244191 °N	84.484352815 °W	545.1	50.0
B-016-0-11	451+00.66	80.1' Lt.	39.183518190 °N	84.484216773 °W	543.1	50.0

The boring locations were determined and located in the field by Rii representatives. Geographic latitude and longitude coordinates as well as ground surface elevations at the boring locations are included on the boring logs provided in Appendix IV.

The borings were drilled using an all terrain vehicle (ATV)-mounted rotary drilling machine, utilizing a 4.25-inch inside diameter, hollow-stem auger to advance the hole. The borings were terminated after achieving a minimum of 20 feet of 30-blow material below the anticipated bottom of footing elevation and were advanced to depths greater than 1.5 times the wall height below the proposed bottom of footing elevation per the current Ohio Department of Transportation (ODOT) Specifications for Geotechnical Explorations (SGE).

Standard penetration testing (SPT) and split spoon sampling were performed in the boring at 2.5-foot increments of depth to 30 feet and at 5.0-foot increments thereafter to the boring termination depth. The SPT, per the American Society for Testing and Materials (ASTM) designation D1586, is conducted by letting a 140-pound hammer falling 30.0 inches to drive a 2.0-inch outer diameter split spoon sampler 18.0 inches. Rii utilized a calibrated automatic drop hammer to generate consistent energy transfer to the sampler. Driving resistance is recorded on the boring logs in terms of blows per 6-inch interval of the driving distance. The second and third intervals are added to obtain the number of blows per foot (N). Standard penetration blow counts aid in determining soil properties applicable in foundation system design. Measured blow count (N) values are corrected to an equivalent (60%) energy ratio, N_{60}, by the following equation. Both values are represented on boring logs in Appendix IV.

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

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

The hammer for the ATV-mounted drill rig used for this project was calibrated on May 6, 2011, and has a drill rod energy ratio of 77.1 percent.

During drilling, Rii personnel prepared field logs showing the encountered subsurface conditions. Soil samples obtained from the drilling operation were preserved and sealed in glass jars and delivered to the soil laboratory. In the laboratory, the soil samples were visually classified and select samples were tested, as noted in Table 2.

Table 2. Laboratory Test Schedule

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	ASTM D 2216	32
Plastic and Liquid Limits	AASHTO T89, T90	10
Sieve/Hydrometers	AASHTO T88	10
One Dimensional Consolidation	ASTM D 2435	2
Consolidated Undrained (CU) Triaxial Test (2-Points)	ASTM D4767	1

The tests performed are necessary to classify existing soil according to the ODOT classification system and to estimate engineering properties of importance in determining foundation design and construction recommendations. Results of the laboratory testing are presented, in part, on the boring logs in Appendix IV and also in Appendix V. A description of the soil terms used throughout this report is presented in Appendix III.

Hand penetrometer readings, which provide a rough estimate of the unconfined compressive strength of the soil, were reported on the boring logs in units of tons per square foot (tsf) and were utilized to classify the consistency of the cohesive soil in each layer. An indirect estimate of the unconfined compressive strength of the cohesive split spoon samples can also be made from a correlation with the blow counts (N_{60}). Please note that split spoon samples are considered to be disturbed and the laboratory determination of their shear strengths may vary from undisturbed conditions.

4.0 FINDINGS

Interpreted engineering logs have been prepared from the field logs, visual examination of samples, and laboratory testing. Classification follows the July 15, 2011, version of the ODOT SGE. The following is a summary of what was found in the test borings and what is represented on the boring logs.

4.1 Surficial Material

Both of the borings were drilled along the embankment separating the I-75 mainline and a residential property to the west and encountered 7.0 and 6.0 inches of topsoil, respectively, at the existing ground surface, identified by the significant presence of organic matter and vegetation.

4.2 Subsurface Soils

Beneath the surface material in borings B-015 and B-016, material identified as fill or possible fill was encountered to a depth of 13.0 and 18.0 feet below the ground surface, respectively. The fill material consisted of brownish gray and brown sandy silt and silty clay (ODOT A-4a, A-6b).

Underlying the surface materials and existing fill, natural cohesive and granular soils were encountered. The cohesive soils were generally described as brownish gray and dark gray sandy silt, and clay (ODOT A-4a, A-7-6). The granular soils were generally described as brown and gray gravel with sand and silt and fine sand (ODOT A-2-4, A-3).

The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soil encountered ranged from medium stiff (0.5 < HP £ 1.0 tsf) to hard (HP > 4.0 tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.75 to over 4.5 tsf (limit of instrument). The relative density of granular soils is primarily derived from SPT blow counts (N_{60}). Based on the SPT blow counts obtained, the granular soil encountered ranged from loose ($5 \leq N_{60} \leq 10$ blows per foot [bpf]) to very dense ($N_{60} > 50$ bpf). Overall blow counts recorded from the SPT sampling ranged from 3 bpf to split spoon sampler refusal, generally increasing with depth. Split spoon refusal is defined as obtaining in excess of 50 blows with less than 6 inches of penetration.

Natural moisture contents of the inorganic soil samples tested ranged from 3 to 32 percent. The natural moisture content of samples tested for plasticity index, ranged from 3 percent below to 7 percent above the corresponding plastic limit. The moisture contents of the native soils are generally considered to be slightly below to moderately above the optimum moisture levels.

4.3 Bedrock

Bedrock was not encountered in either of the borings performed in this exploration.

4.4 Groundwater

Groundwater was encountered in the borings as noted in Table 3.

Table 3. Groundwater

Boring Number	Ground Elevation (feet) [1]	Initial Groundwater		At Completion		Cave-in Depth	
		Depth	Elevation	Depth	Elevation	Depth	Elevation
B-015-0-11	545.1	42.0	503.1	N/A	N/A	N/A	N/A
B-016-0-11	543.1	43.0	500.1	37.0 [2]	506.1	28.8	516.3

1. Ground elevation listed is the ground surface elevation at the boring location.
2. Groundwater level at completion was measured inside the auger stems.

Groundwater was encountered initially during the drilling process in boring B-015 and B-016 at a depth of 42.0 and 43.0 feet below the ground surface, respectively. At the completion of drilling and after removing the augers, groundwater accumulated in the borehole in boring B-016 to a depth of 37.0 feet below the ground surface. Please note that short-term water level readings, especially in cohesive soils, are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels or the presence of groundwater are considered to be dependent on seasonal fluctuations in precipitation.

A more comprehensive description of what was encountered during the drilling process may be found on the boring logs in Appendix IV.

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 proposed retaining wall were provided by the Rii design team. It is understood that the proposed retaining wall will be a MSE wall type that will connect to the rear abutment of the proposed HAM-75-0857 I-75 over Towne Street bridge structure at the north end of the wall alignment.

5.1 MSE Wall Recommendations

It is understood that a MSE retaining wall is being considered for use in supporting the proposed widened alignment along the west side of I-75. 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 top of MSE wall. The width of the MSE wall foundation (B) is defined by the length of the reinforced soil mass. Per the 2007 ODOT Bridge Design Manual (BDM) and Supplemental Specification (SS) 840, the minimum length of the reinforced soil mass is equal to 70 percent the height of the MSE wall or 8 feet whichever is greater. A non-structural bearing leveling pad consisting of a minimum of 6-inches of unreinforced concrete should be placed at the base of the wall for constructability purposes. Please note that the leveling pad is not a structural foundation.

Based upon the proposed plan and cross section information provided by the Rii design team, wall heights along the alignment are anticipated to range between 7.5 and 27.5 feet. Therefore, it is considered that the minimum reinforcement lengths and the effective foundation width (B) of the MSE wall for external stability calculations and global stability analysis will range from 11.8 and 19.3 feet along the alignment. For the analysis, the foundation width was set at 70 percent of the wall height (or 8.0 feet for wall heights less than 11.4 feet) and the foundation width was increased, if required, until external and global stability requirements were satisfied for various wall heights and subsurface conditions.

It is recommended that the foundation subgrade (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 703.16C Type C Granular Fill.

It should be noted that existing embankment fill was encountered in borings B-015 and B-016 at the proposed bearing elevation along the wall alignment. Based on the SPT blow counts and hand penetrometer readings of the material, and also due to the fact that the fill does not contain any deleterious material, the existing fill appears to be adequate for foundation support. However, the entire subgrade should be closely observed during construction to verify that adequate bearing soils are present along the alignment of the wall. Any unstable or unsuitable soils encountered should be stabilized as noted above.

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.

5.1.1 Strength Parameters Utilized in External and Global Stability Analyses

The shear strength parameters utilized in the external and global stability analysis of the retaining wall are provided in Table 4.

Table 4. 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 (Select fill material)	120	30	400	2,000
Medium Stiff to Stiff Sandy Silt (ODOT A-4a) [1]	115	31	0	2,000
Stiff to Very Stiff Silty Clay (ODOT A-6b) [2]	115	27	235	2,000
Very Stiff Clay (ODOT A-7-6) [3]	120	21	0	3,000
Dense to Very Dense Gravel with Sand and Silt (ODOT A-2-4)	130	34	0	N/A
Medium Dense to Dense Fine Sand (ODOT A-3)	125	30 to 32	0	N/A

1. *Based on laboratory consolidated undrained triaxial testing performed on an undisturbed samples from the adjacent HAM-75-11.09 project.*
2. *Based on laboratory consolidated undrained triaxial testing performed on an undisturbed sample from boring B-016-0-11.*
3. *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 4. 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 4 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 and from CU triaxial compression tests performed on undisturbed samples from the HAM-75-11.09 and HAM-75-12.60 projects that are adjacent to this project location to the north. The undrained shear strength for the soils is based on hand penetrometer values and indirect correlations with SPT blow counts of the soil immediately below the bottom of footing elevation. The friction angle for the natural granular soil encountered was determined based on correlations with the N_{60} value from the SPT testing of the soil. The laboratory test results referenced above are provided in Appendix V.

5.1.2 Bearing Stability

The anticipated bearing materials along the proposed alignment will primarily consist of existing embankment fill described as stiff sandy silt and silty clay (ODOT A-4a, A-6b). MSE wall foundations bearing on these soils or engineered fill, placed and compacted as described in Section 5.3, may be proportioned for a nominal bearing resistance as indicated in Table 5. 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 length presented in the following table represents the minimum foundation width required to satisfy external and global stability requirements, expressed as a percentage of the wall height. The corresponding settlement values presented in the following tables were determined using the equivalent bearing pressure based on the net increase in stress due to the construction of the wall (the vertical change in grade from the existing condition at the wall location to the proposed profile grade at the top of the wall) and corresponding minimum reinforcement length as noted below for each section of the wall. Settlement calculations are provided in Appendix VI and consolidation test results are provided in Appendix V.

Table 5. Retaining Wall H Spread Footing Design Parameters

From Station [1]	To Station [1]	Representative Borings	Maximum Wall Height (ft)	Minimum Reinforcement Length [2]	Nominal Bearing Resistance (ksf)		Total Settlement [4] (in)
					Service	Strength [3]	
448+45	449+50	B-015	16.9	0.70(H)	3.9	11.8	1.02 / 0.68
449+50	451+60	B-015 and B-016	27.5	0.70(H)	3.9	11.8	5.65 / 2.84

1. *Limits of wall determined from plan information provided by the Rii design team. Stationing listed is referenced to the mainline I-75 centerline.*
2. *The required foundation width is expressed as a percentage of the wall height, H, at the respective location.*
3. *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.*
4. *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.*

As noted in Section 4.2, material identified as possible fill was identified in borings B-015 and B-016 to a depth of 13.0 and 18.0 feet below existing grade, respectively. The material did not contain deleterious material based on the samples recovered, and the material appears to be uniform with depth throughout the fill zone. During construction of the proposed retaining wall, it is recommended that the bearing soils along the alignment be closely observed to verify that adequate bearing material is present prior to construction of the wall. If the bearing material contains any deleterious material, such as concrete fragments or wood fibers, the material should be over excavated until competent natural soils are encountered and backfilled with structural fill as noted in Section 5.3 to the proposed bearing elevation.

Rii performed a verification of the bearing pressure exerted on the subgrade material for the maximum specified wall heights indicated in the previous tables. Based on the minimum lengths of reinforced soil mass presented, the bearing pressure exerted at the front of the wall **will not exceed** the factored nominal bearing resistance at the strength limit state.

Total settlements of 1.02 to 5.65 inches at the center of the reinforced soil mass and 0.68 to 2.84 inches at the facing of the wall are anticipated along the proposed wall alignment. 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 1/1000, 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. If preloading the site is not a desired option, then consideration could be given to ground improvement through the use of stone columns.

5.1.3 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 height indicated in Table 5. Based on the minimum length of reinforced soil mass presented in Table 5 and utilizing the soil parameters listed in Section 5.1.1 for the retained embankment material, the calculated eccentricity of the resultant force **will not exceed** the limiting eccentricity at the strength limit state.

5.1.4 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 5.1.1 for the foundation and retained material, a coefficient of sliding friction of 0.51 and 0.60 was utilized for design. A geotechnical resistance factor of φ_τ=1.0 was considered when calculating the factored shear resistance between the reinforced soil backfill and foundation soil for sliding. Based on the minimum length of reinforced soil mass presented in Table 5 and utilizing the soil parameters listed in Section 5.1.1 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.

5.1.5 Global (Overall) Stability

A slope stability analysis was performed to check the global stability of the wall along the alignment. 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 Section 5.1.1. 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 not 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=0.75 is greater than 1.0. Therefore, global stability is satisfied when a minimum factor of safety of 1.33 is obtained. For an MSE walls designed with minimum strap lengths listed in Table 5, the resulting factor of safety under drained conditions (long-term stability) along the alignment was greater than 1.33. 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 along the alignment under undrained conditions was also greater than 1.33.

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

5.1.6 Final MSE Wall Considerations

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

5.2 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 6 and Table 7.

Table 6. Estimated Undrained (Short-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ'	k_a	k_o	k_p
Medium Stiff Cohesive Soil	115	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	2,500	0°	1.0	1.0	1.0
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	135	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 7. Estimated Drained (Long-term) Soil Parameters for Design

Soil Type	γ (pcf) [1]	c (psf)	φ'	k_a	k_o	k_p
Natural Cohesive Soil	115	0	26°	0.39	0..56	2.56
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	135	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 subsurface walls and excavation support systems. It is recommended that the retaining wall structure be designed based on active 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 considered based on cross section information provided by the Rii design team). Earth pressures on excavation support systems will be dependent on the type of sheeting and method of bracing or anchorage.

5.3 Construction Considerations

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

Fill soil placed for foundation support should be placed in loose lifts not to exceed 8.0 inches. Fill soil placed under structures shall be compacted to not less than 100 percent of the maximum dry density obtained by the Standard Proctor Test (ASTM D698). Fill soil containing excess moisture shall be required to dry prior to or during compaction to a moisture content not greater than 3.0 percent above or below optimum. However, for material that displays pronounced elasticity or deformation under the action of loaded rubber tire construction equipment, the moisture content shall be reduced to optimum if necessary to secure stability. Drying of wet soil shall be expedited by the use of plows, discs, or by other approved methods when so ordered by the site geotechnical engineer.

Generally, materials utilized for engineered fill should free of waste construction debris and other deleterious materials and meet the following requirements:

- Maximum Dry Density per ASTM D698 > 110 pcf
- Liquid Limit < 40
- Plasticity Index < 15
- Organic Matter < 3 percent
- Maximum Particle Size < 3 inches
- Silt Content (between 0.075 and 0.005 mm) < 45 percent

Compacted granular fill shall meet the above specification and additionally shall have a maximum 35 percent passing the No. 200 sieve.

5.3.1 Excavation Considerations

All excavations should be shored / braced or laid back at a safe angle in accordance to 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, sheeting boxes 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 6. 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
Rock to 3.0' +/- below Auger Refusal	0.75 : 1.0	Above Ground Water Table and No Seepage
Stable Rock	Vertical	Above Ground Water Table and No Seepage

5.3.2 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 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.

Our 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 current 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

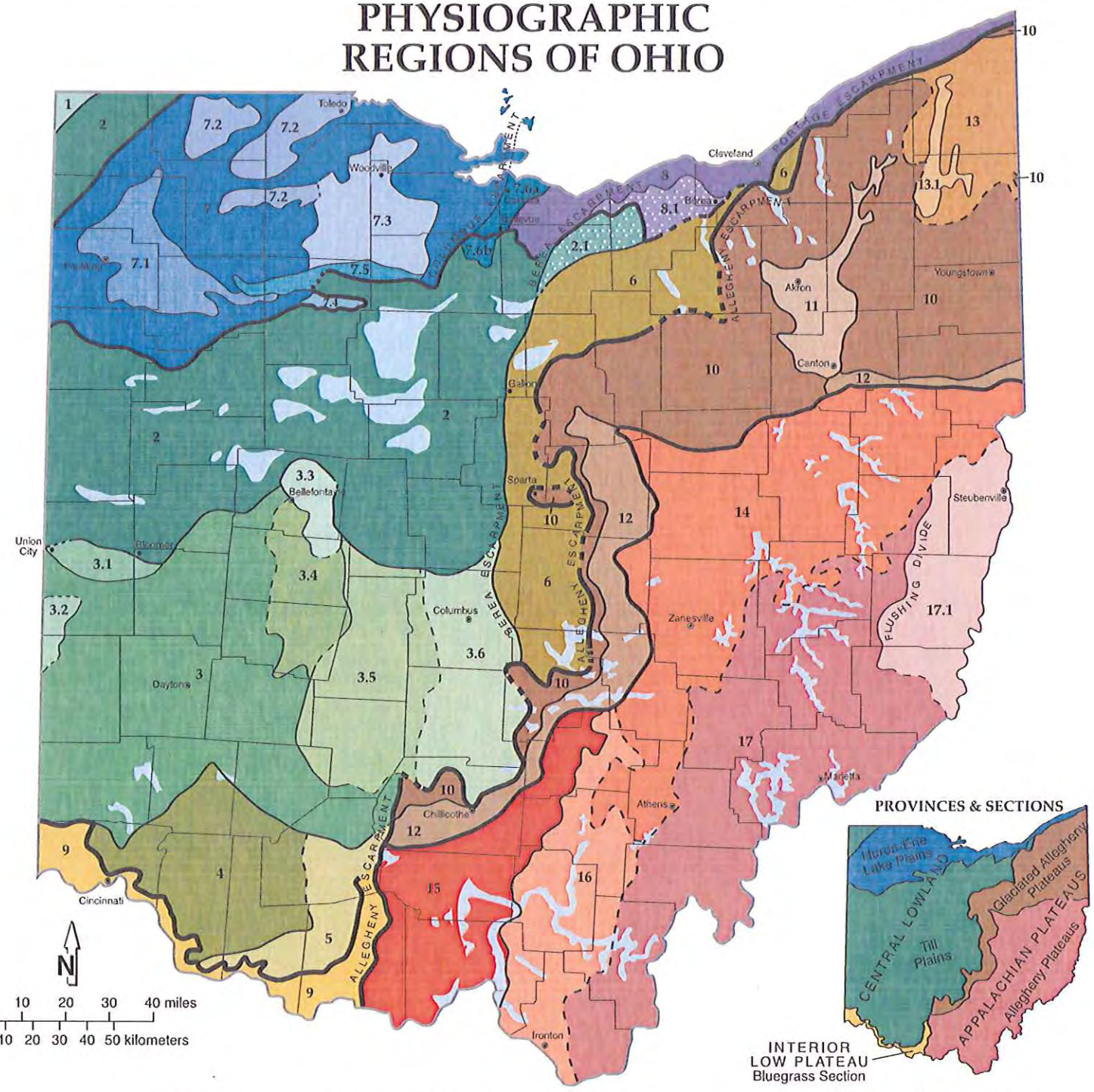
STATE GEOLOGY

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

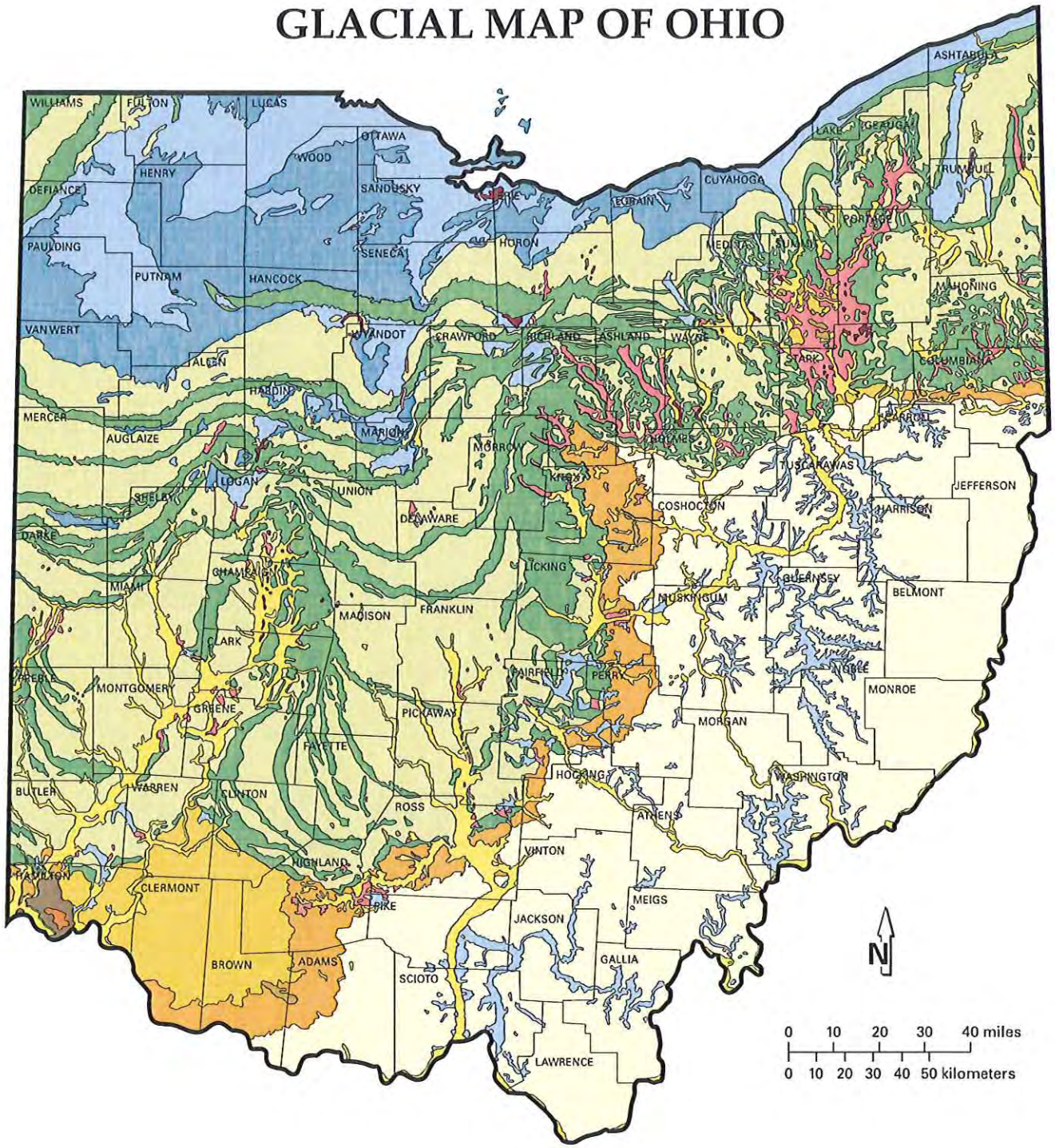
Recommended citation: Ohio Division of Geological Survey, 1998, Physiographic regions of Ohio: Ohio Department of Natural Resources, Division of Geological Survey, page-size map with text, 2 p., scale 1:2,100,00.

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



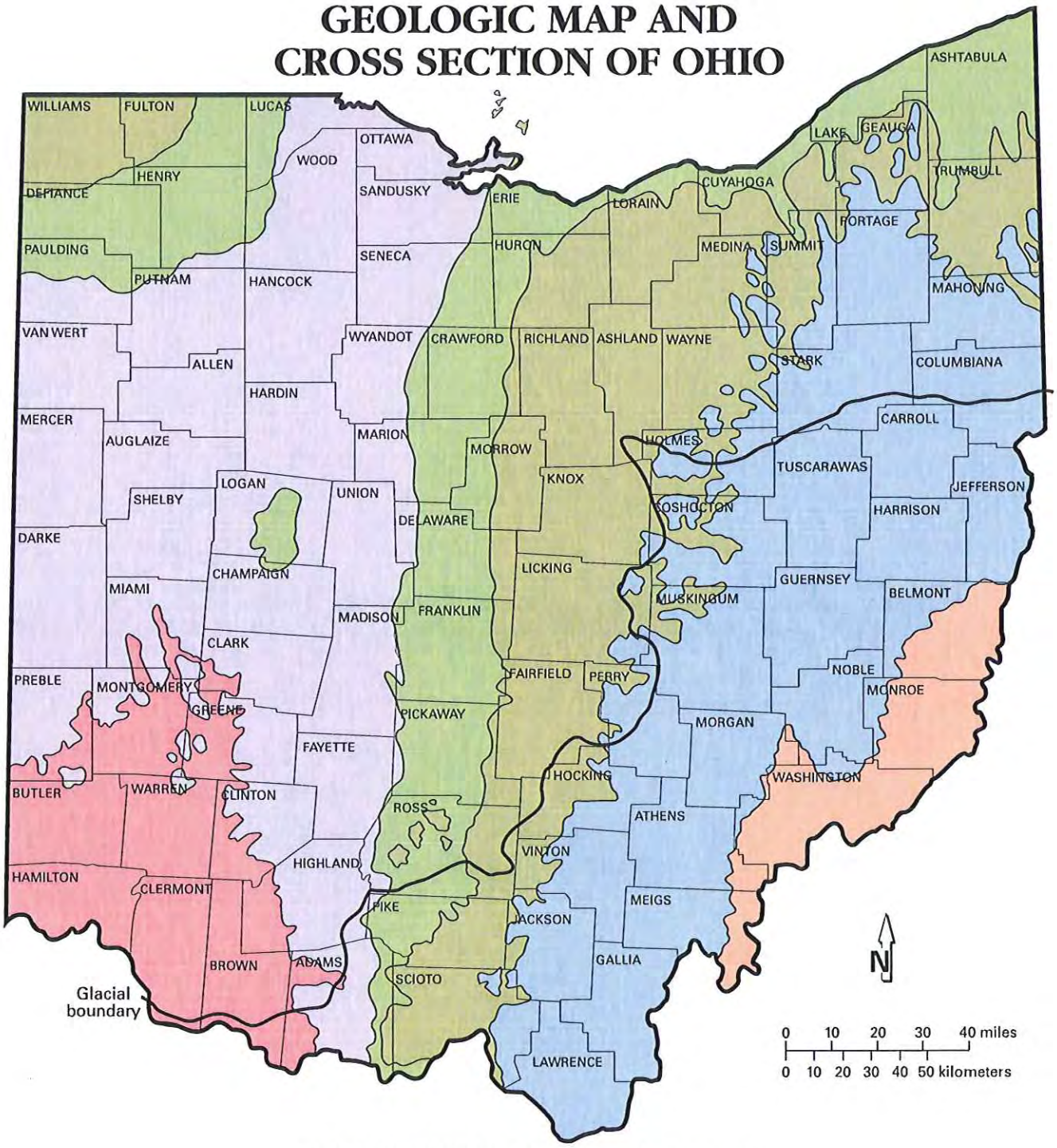
WISCONSINAN (14,000 to 24,000 years old)	ILLINOIAN (130,000 to 300,000 years old)	PRE-ILLINOIAN (older than 300,000 years)	
Ground moraine	Ground moraine	Ground moraine	Kames and eskers
Wave-planed ground moraine	Dissected ground moraine	Dissected ground moraine	Outwash
End moraine	Hummocky moraine	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

STATE OF OHIO
Bob Taft, Governor

DEPARTMENT OF NATURAL RESOURCES
Samuel W. Speck, Director

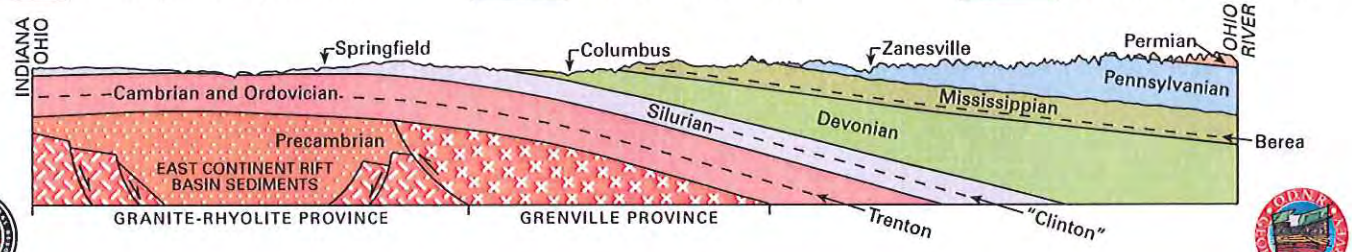
DIVISION OF GEOLOGICAL SURVEY
Thomas M. Berg, Chief

GEOLOGIC MAP AND CROSS SECTION OF OHIO



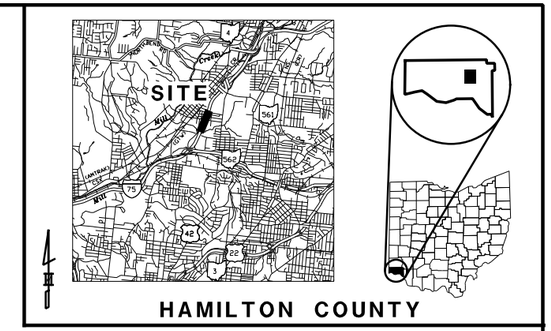
GEOLOGIC SYSTEM (million years before present)

- 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

TOWNSHIP AVE.

CEDAR ST.

RETAINING WALL H

B-013-0-11

B-015-0-11

B-016-0-11

B-001-0-55

B-003-0-55

B-005-0-55

B-182-0-07

B-183-0-07

B-017-0-11

447 448 449 450 451 452 453 454

B-002-0-55

B-004-0-55

B-180-0-07

B-181-0-07

B-006-0-55

B-008-0-55

B-012-0-11

B-014-0-11

2011 RETAINING WALL BORINGS

2011 RII BORINGS

HISTORIC BORINGS

BORING PLAN

HAM-75-7.85 RETAINING WALL H
HAMILTON COUNTY, OHIO

PROJECT NO.
Rii B-10-020

SCALE: 1"=50'
0 25 50

DRAWN
RRM

REVIEWED
BRT

DATE
6-13-12

RESOURCE
INTERNATIONAL, INC.

APPENDIX III

DESCRIPTION OF SOIL TERMS

DESCRIPTION OF SOIL TERMS

The following terminology was used to describe soils throughout this report and is generally adapted from ASTM 2487/2488 and ODOT Specifications for Geotechnical Explorations.

Granular Soils - The relative compactness of granular soils is described as:
ODOT A-1, A-2, A-3, A-4 (non-plastic) or USCS GW, GP, GM, GC, SW, SP, SM, SC, ML (non-plastic)

Description	Blows per foot – SPT (N_{60})		
Very Loose	Below		5
Loose	5	-	10
Medium Dense	11	-	30
Dense	31	-	50
Very Dense	Over		50

Cohesive Soils - The relative consistency of cohesive soils is described as:
ODOT A-4, A-5, A-6, A-7, A-8 or USCS ML, CL, OL, MH, CH, OH, PT

Description	Blows per foot – SPT (N_{60})			Unconfined Compression (tsf)
Very Soft	Below		2	UCS ≤ 0.25
Soft	2	-	4	0.25 < UCS ≤ 0.5
Medium Stiff	5	-	8	0.5 < UCS ≤ 1.0
Stiff	9	-	15	1.0 < UCS ≤ 2.0
Very Stiff	16	-	30	2.0 < UCS ≤ 4.0
Hard	Over		30	UCS > 4.0

Gradation - The following size-related denominations are used to describe soils:

Soil Fraction		USCS Size	ODOT Size
Boulders		Larger than 12”	Larger than 12”
Cobbles		12” to 3”	12” to 3”
Gravel	coarse	3” to ¾”	3” to ¾“
	fine	¾” to 4.75 mm (¾” to #4 Sieve)	¾” to 2.0 mm (¾” to #10 Sieve)
Sand	coarse	4.75 mm to 2.0 mm (#4 to #10 Sieve)	2.0 mm to 0.42 mm (#10 to #40 Sieve)
	medium	2.0 mm to 0.42 mm (#10 to #40 Sieve)	-
	fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt		0.074 mm to 0.005 mm (#200 to 0.005 mm)	0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay		Smaller than 0.005 mm	Smaller than 0.005 mm

Modifiers of Components - Modifiers of components are as follows:

Term	Range		
Trace	0%	-	10%
Little	10%	-	20%
Some	20%	-	35%
And	35%	-	50%

Moisture Table - The following moisture-related denominations are used to describe cohesive soils:

Term	Range - USCS	Range - ODOT
Dry	0% to 10%	Well below Plastic Limit
Damp	>2% below Plastic Limit	Below Plastic Limit
Moist	2% below to 2% above Plastic Limit	Above PL to 3% below LL
Very Moist	>2% above Plastic Limit	
Wet	≥ Liquid Limit	3% below LL to above LL

Organic Content – The following terms are used to describe organic soils:

Term	Organic Content (%)
Slightly organic	2-4
Moderately organic	4-10
Highly organic	>10

Bedrock – The following terms are used to describe bedrock hardness:

Term		Blows per foot – SPT (N)		
Very Soft		Below		50
Soft		50/5”	–	50/6”
Medium Hard		50/3”	–	50/4”
Hard		50/1”	–	50/2”
Very Hard	50/0”			

CLASSIFICATION OF SOILS

Ohio Department of Transportation

(The classification of a soil is found by proceeding from top to bottom of the chart.
The first classification that the test data fits is the correct classification.)

SYMBOL	DESCRIPTION	Classifcation AASHTO	Classifcation OHIO	$LL_0/LL \times 100$*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
	Gravel and/or Stone Fragments	A-1-a			30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A-1-b			50 Max.	25 Max.		6 Max.	0	
F S	Fine Sand	A-3			51 Min.	10 Max.	NON-PLASTIC		0	
	Coarse and Fine Sand	--	A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt	A-2-4				35 Max.	40 Max.	10 Max.	0	
		A-2-5					41 Min.			
	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-2-6				35 Max.	40 Max.	11 Min.	4	
		A-2-7					41 Min.			
	Sandy Silt	A-4	A-4a	76 Min.		36 Min.	40 Max.	10 Max.	8	Less than 50% silt sizes
	Silt	A-4	A-4b	76 Min.		50 Min.	40 Max.	10 Max.	8	50% or more silt sizes
	Elastic Silt and Clay	A-5		76 Min.		36 Min.	41 Min.	10 Max.	12	
	Silt and Clay	A-6	A-6a	76 Min.		36 Min.	40 Max.	11 - 15	10	
	Silty Clay	A-6	A-6b	76 Min.		36 Min.	40 Max.	16 Min.	16	
	Elastic Clay	A-7-5		76 Min.		36 Min.	41 Min.	$\leq$LL-30	20	
	Clay	A-7-6		76 Min.		36 Min.	41 Min.	>LL-30	20	
	Organic Silt	A-8	A-8a	75 Max.		36 Min.				W/o organics would classify as A-4a or A-4b
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6

MATERIAL CLASSIFIED BY VISUAL INSPECTION

- Sod and Topsoil
- Pavement or Base
- Uncontrolled Fill (Describe)
- Bouldery Zone
- Peat, S-Sedimentary W-Woody F-Fibrous L-Loamy & etc

* Only perform the oven-dried liquid limit test and this calculation if organic material is present in the sample.

APPENDIX IV

BORING LOGS:

B-015-0-11 and B-016-0-11

Definitions of Abbreviations for Boring Logs

A	=	Adhesion (pounds per square foot)
AS	=	Auger Sample
BCP	=	Bentonite Chips or Pellets
C	=	Cohesion (pounds per square foot)
CB	=	Cased (Concentric) Boring
C/B	=	Neat Cement/Bentonite Grout
Cl^-	=	Chloride Ion Concentration (parts per million)
FA	=	Angle of Internal Friction (degrees)
FF	=	Friction Factor
GS	=	Geoprobe Sample
HSA	=	Hollow Stem Auger
HSB	=	High Solids Content Bentonite Grout
K	=	Modulus of Horizontal Subgrade Reaction (kips per cubic foot)
LOI	=	Percent Organic Content (by weight) as determined by ASTM D-2974 (loss on ignition test)
MD	=	Rotary Mud Drilling
NQ	=	Wireline Method (1.875-inch diameter rock core)
NX	=	Conventional Method (2.126-inch diameter rock core)
PC	=	Neat Portland Cement Grout
PID	=	Photo-Ionization Detector Reading (parts per million)
qh	=	Unconfined Compressive Strength of Soil as determined by a hand penetrometer (tons per square foot)
qr	=	Unconfined Compressive Strength of Intact Rock Core as determined by ASTM D-2938 (pounds per square inch)
qu	=	Unconfined Compressive Strength of Soil as determined by ASTM D-2166 (tons per square foot)
quu	=	Unconsolidated-Undrained Triaxial Compressive Strength as determined by ASTM D-2850 (pounds per square foot)
RC	=	Rock Coring
SO^{4-}	=	Sulfate Concentration
SFA	=	Solid Flight Auger
SS	=	Split Spoon Sample
3S	=	For instances of no recovery from standard SS interval, a 3.0 inch O.D. split spoon is driven the full length of the standard SS interval plus an additional 6.0 inches to obtain a representative sample. Only the final 6.0 inches of sample is retained. Blow counts from 3S sampling are not correlated with N_{60} values.
ss	=	Soluble Salts (conductivity)
ST	=	Thin-walled (Shelby) Tube Sample
uw	=	“In-Situ” Unit Weight of Soil (pounds per cubic foot)
VIS	=	Visual classification only, no testing performed
WOH	=	Weight of Hammer and Drill Rods “pushed” split spoon sampler 6-inches.
WD	=	Rotary Wash Drilling

RESOURCE INTERNATIONAL, INC.

PROJECT: HAM-75-7.85	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 449+93.73 / 76.2' Lt	EXPLORATION ID B-015-0-11
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: RII / S.M.	HAMMER: CME AUTOMATIC	ALIGNMENT: PROPOSED CL I-75	
PID: 77889 BR ID: NA	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/6/11	ELEVATION: 545.1 (MSL) EOB: 50.0 ft.	PAGE 1 OF 2
START: 10/7/11 END: 10/7/11	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG : 39.183244191 ° N / 84.484352815 ° W	

MATERIAL DESCRIPTION AND NOTES	ELEV. 545.1
0.6' - TOPSOIL (7.0")	544.5
FILL: STIFF TO VERY STIFF, BROWNISH GRAY CHANGING TO BROWN **SANDY SILT**, SOME CLAY, TRACE FINE GRAVEL, DAMP TO MOIST.	532.1
MEDIUM STIFF TO VERY STIFF, DARK GRAY TO BROWNISH GRAY **SANDY SILT**, LITTLE TO SOME CLAY, TRACE FINE GRAVEL, DAMP TO MOIST. -TRACE ROOT FIBERS PRESENT IN SS-6 -ORGANIC ODOR PRESENT IN SS-7 -CONSOLIDATION TEST PERFORMED @ 20.3'	522.1
DENSE TO VERY DENSE, GRAY **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, DAMP. -COBBLES PRESENT THROUGHOUT	

SPT/RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
2 2 2	5	67	SS-1	2.00	-	-	-	-	-	-	-	-	16	A-4a (V)	
3 3 5	10	67	SS-2	1.50	3	13	43	27	14	NP	NP	NP	17	A-4a (1)	
3 4 5	12	56	SS-3	3.75	-	-	-	-	-	-	-	-	21	A-4a (V)	
3 5 6	14	67	SS-4	2.00	-	-	-	-	-	-	-	-	16	A-4a (V)	
4 4 5	12	67	SS-5	2.00	-	-	-	-	-	-	-	-	15	A-4a (V)	
3 5 3	10	44	SS-6	2.00	2	4	23	42	29	25	15	10	22	A-4a (7)	
3 3 2	6	33	SS-7	1.00	-	-	-	-	-	-	-	-	23	A-4a (V)	
		42	ST-8	1.25	7	6	31	37	19	24	15	9	15	A-4a (4)	
4 8 13	27	100	SS-9	3.75	-	-	-	-	-	-	-	-	12	A-4a (V)	
13 14 15	37	0	SS-10	-	-	-	-	-	-	-	-	-	-		
24	-	100	3S-10A	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
8 50/0"	-	67	SS-11	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	

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

PID: 77889	BR ID: NA	PROJECT: HAM-75-7.85	STATION / OFFSET: 449+93.73 / 76.2' Lt	START: 10/7/11	END: 10/7/11	PG 2 OF 2	B-015-0-11

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
DENSE TO VERY DENSE, GRAY **GRAVEL WITH SAND AND SILT**, LITTLE CLAY, DAMP. *(same as above)*	517.1	29	18 19 23	54	89	SS-12	-	-	-	-	-	-	-	-	-	8	A-2-4 (V)	
-COBBLES PRESENT THROUGHOUT		30																
		31																
	513.1	32																
MEDIUM DENSE TO DENSE, BROWN **FINE SAND**, LITTLE COARSE SAND, TRACE SILT, TRACE CLAY, TRACE FINE GRAVEL, DRY TO WET.		33																
		34	7 13 13	33	67	SS-13	-	-	-	-	-	-	-	-	-	3	A-3 (V)	
		35																
		36																
		37																
		38																
		39	3 7 13	26	72	SS-14	-	2	16	74	6	2	NP	NP	NP	3	A-3 (0)	
-COBBLES PRESENT THROUGHOUT		40																
		41																
		42																
		43																
		44	3 4 7	14	67	SS-15	-	-	-	-	-	-	-	-	-	21	A-3 (V)	
		45																
		46																
		47																
		48																
		49	3 5 10	19	56	SS-16	-	-	-	-	-	-	-	-	-	21	A-3 (V)	
	495.1	50 EOB																

F S

W

NOTES: GROUNDWATER INITIALLY ENCOUNTERED @ 42.0'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: TREMIED 188 LBS CEMENT / 25 LBS BENTONITE POWDER / 40 GAL WATER

RESOURCE INTERNATIONAL, INC.

PROJECT: HAM-75-7.85	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 451+00.66 / 80.1' Lt	**EXPLORATION ID B-016-0-11**	
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: RII / S.M.	HAMMER: CME AUTOMATIC	ALIGNMENT: PROPOSED CL I-75		
PID: 77889 BR ID: NA	DRILLING METHOD: 4.25" HSA	CALIBRATION DATE: 5/6/11	ELEVATION: 543.1 (MSL) EOB: 50.0 ft.		PAGE 1 OF 2
START: 11/29/11 END: 11/29/11	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG : 39.18351819 ° N / 84.484216773 ° W		

MATERIAL DESCRIPTION AND NOTES	ELEV. 543.1	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
0.5' - Topsoil (6.0")	542.6																	
POSSIBLE FILL: MEDIUM STIFF, BROWN **SILTY CLAY**, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.		1 2 3 4 5	WOH 1 1	3	67	SS-1	0.75	-	-	-	-	-	-	-	-	16	A-6b (V)	
			1 1 3	5	78	SS-2	1.00	6	6	21	35	32	32	16	16	17	A-6b (9)	
	537.6																	
POSSIBLE FILL: STIFF TO HARD, BROWN TO BROWNISH GRAY **SILTY CLAY**, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.		6 7 8 9 10	3 6 7	17	78	SS-3	2.00	-	-	-	-	-	-	-	-	17	A-6b (V)	
			6 6 9	19	100	SS-4	2.00	-	-	-	-	-	-	-	-	17	A-6b (V)	
		11 12 13 14 15 16 17 18	5 9 11	26	89	SS-5	4.5+	8	6	10	35	41	40	19	21	17	A-6b (12)	
			5 6 9	19	89	SS-6	3.50	-	-	-	-	-	-	-	-	17	A-6b (V)	
			6 9 13	28	78	SS-7	2.00	-	-	-	-	-	-	-	-	18	A-6b (V)	
	525.1																	
VERY STIFF, BROWNISH GRAY **CLAY**, AND FINE TO COARSE SAND, TRACE FINE GRAVEL, DAMP.		19 20 21 22 23	5 5 8	17	78	SS-8	3.00	6	39	16	12	27	62	25	37	22	A-7-6 (6)	
			5 5 14	24	89	SS-9	3.50	-	-	-	-	-	-	-	-	17	A-7-6 (V)	
	520.1																	
DENSE TO VERY DENSE, GRAY TO BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP TO MOIST.		24 25 26 27	6 11 15	33	83	SS-10	-	-	-	-	-	-	-	-	-	10	A-2-4 (V)	
			22 35 42	99	89	SS-11	-	-	-	-	-	-	-	-	-	11	A-2-4 (V)	

2010 ODOT BORING LOG-RII-WITH LAT/LONG - OH DOT.GDT - 6/18/12 13:35 - G:\GINT8\PROJECTS\2010\B-10-020\B-10-020 B-015-16.GPJ

PID: 77889	BR ID: NA	PROJECT: HAM-75-7.85	STATION / OFFSET: 451+00.66 / 80.1' Lt	START: 11/29/11	END: 11/29/11	PG 2 OF 2	B-016-0-11

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
DENSE TO VERY DENSE, GRAY TO BROWN **GRAVEL WITH SAND AND SILT**, TRACE CLAY, DAMP TO MOIST. *(same as above)*	515.1	29	13 13 19	41	89	SS-12	-	-	-	-	-	-	-	-	-	9	A-2-4 (V)	
		30																
		31																
	511.1	32																
MEDIUM DENSE TO DENSE, BROWN **FINE SAND**, SOME COARSE SAND, TRACE SILT, TRACE FINE GRAVEL, TRACE CLAY, DRY TO WET.		33																
		34	11 10 14	31	56	SS-13	-	-	-	-	-	-	-	-	-	3	A-3 (V)	
		35																
		36																
		37																
		38																
		39	4 9 12	27	61	SS-14	-	3	29	60	5	3	NP	NP	NP	3	A-3 (0)	
F S		40																
		41																
		42																
W		43																
		44	6 9 15	31	56	SS-15	-	-	-	-	-	-	-	-	-	17	A-3 (V)	
		45																
		46																
		47																
		48																
		49	5 11 15	33	56	SS-16	-	-	-	-	-	-	-	-	-	32	A-3 (V)	
	493.1	EOB 50																

NOTES: GROUNDWATER ENCOUNTERED INITIALLY @ 43.0' AND AT COMPLETION @ 37.0' (IN AUGER STEMS); CAVE-IN DEPTH @ 28.8'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 50 LBS BENTONITE CHIPS AND SOIL CUTTINGS

RESOURCE INTERNATIONAL, INC.

PROJECT: HAM-75-7.85	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 450+97.66 / 80.1' Lt	**EXPLORATION ID**	
TYPE: RETAINING WALL	SAMPLING FIRM / LOGGER: RII / T.F.	HAMMER: CME AUTOMATIC	ALIGNMENT: PROPOSED CL I-75	**B-016-1-11**	
PID: 77889 BR ID: NA	DRILLING METHOD: 4.25" - CFA	CALIBRATION DATE: 5/6/11	ELEVATION: 546.0 (MSL) EOB: 10.0 ft.	PAGE	
START: 11/28/11 END: 11/29/11	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG : 39.183503049 ° N / 84.484216229 ° W	1 OF 1	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N_{60}	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%) GR	CS	FS	SI	CL	ATTERBERG LL	PL	PI	WC	ODOT CLASS (GI)	BACK FILL
SEE BORING B-016-0-11	546.0	1 2 3 4 5																
	540.0	6																
HARD, DARK BROWNISH GRAY **SILT AND CLAY**, AND COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST. -CU TRIAXIAL TEST PERFORMED @ 6.5'	538.0	7			81	ST-1	4.50	7	9	32	29	23	29	14	15	14	A-6a (5)	
HARD, BROWN TO GRAY **CLAY**, SOME SILT, LITTLE FINE TO COARSE SAND, TRACE FINE GRAVEL, DAMP. -CONSOLIDATION TEST PERFORMED @ 9.4'	536.0	8 9 EOB 10			76	ST-2	4.50	8	7	5	34	46	44	21	23	20	A-7-6 (14)	

NOTES: NONE

ABANDONMENT METHODS, MATERIALS, QUANTITIES: NOT RECORDED

APPENDIX V
LABORATORY TESTING RESULTS

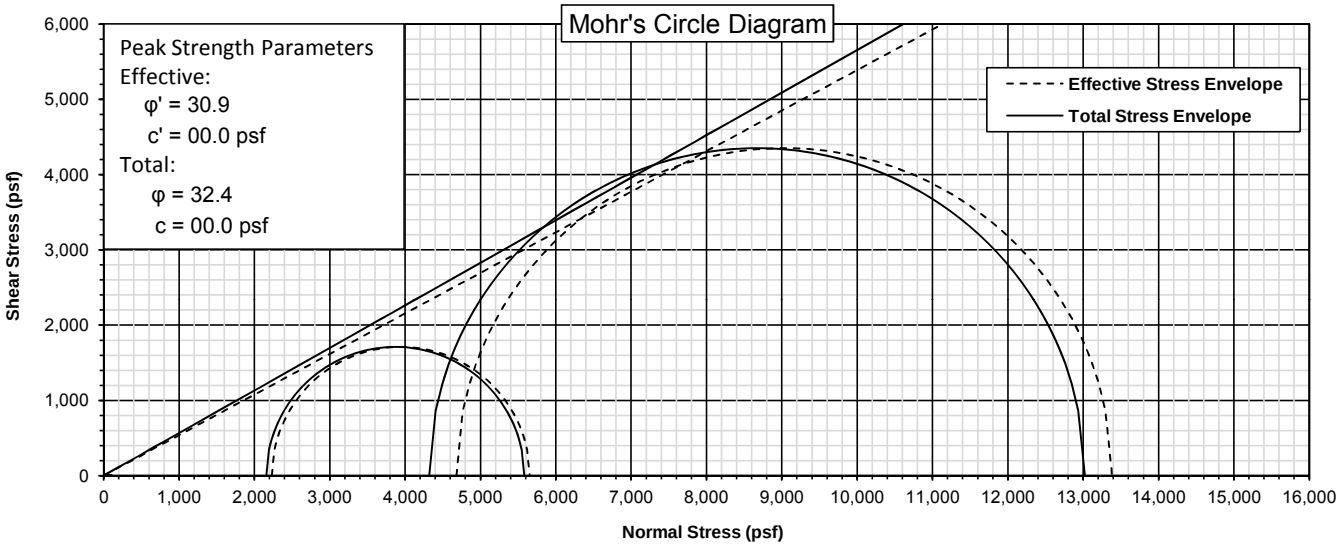
Consolidated, Undrained Triaxial Compression Test Report (ASTM D4767)

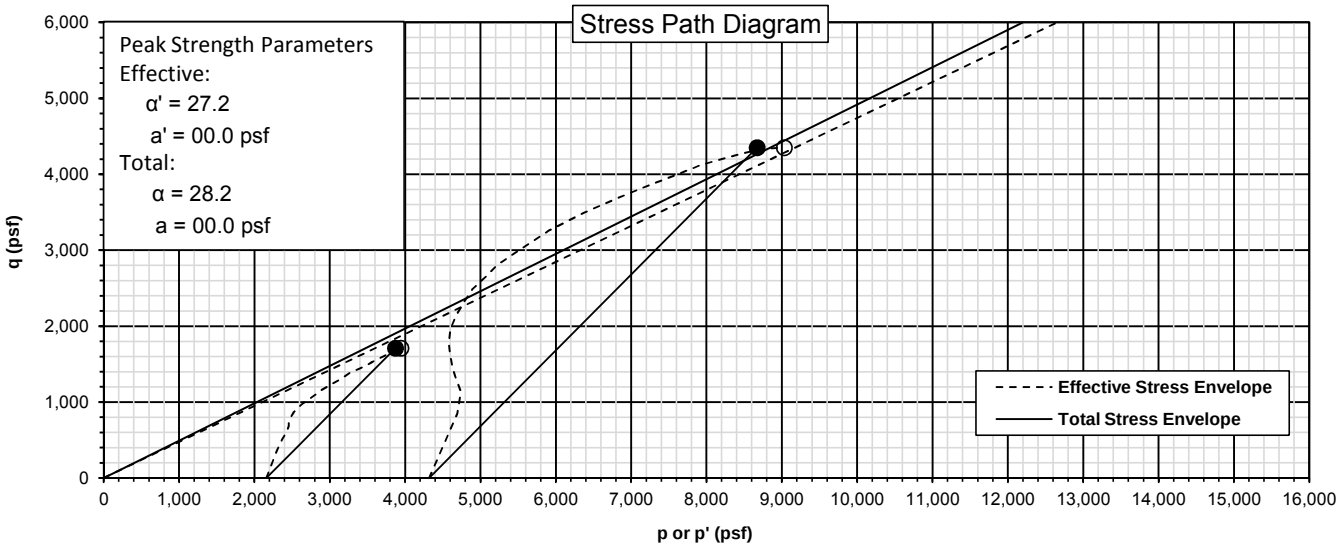
Project Number:	B-11-010	Boring Number:	B-004-0-11
Project Name:	HAM-75-11.09	Sample No. / Depth:	ST-2 and ST-3 / 9.5 ft to 11.4 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	05/11/2012 to 05/17/2012
Client:	M•E Companies, Inc.	Technician:	JJH

Soil Description: Brown SILT, some clay, trace coarse to fine sand.
Soil Classification: ODOT A-4b

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	26	17	9	0	1	6	61	32

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-004-0-11	ST-2	9.5	2,160.0	5,580.9	2,232.0	5,652.9	3,942.5	1,710.5
2	B-004-0-11	ST-3	11.4	4,320.0	13,022.3	4,680.0	13,382.3	9,031.2	4,351.2





Notes: Third point of test eliminated from final results. Physical properties listed based on testing performed on cuttings when samples were trimmed.

Consolidated, Undrained Triaxial Compression Test (ASTM D4767)

Project Number:	B-11-010	Boring Number:	B-004-0-11
Project Name:	HAM-75-11.09	Sample No. / Depth:	ST-2 / 9.5 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	5/11/2012
Client:	M•E Companies, Inc.	Technician:	JJH

Data for Specimen No. 1

Soil Description: Brown SILT, little clay, little fine sand, trace fine gravel.
Soil Classification: ODOT A-4b

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	25	18	7	1	0	17	63	19

Diameter, D_0	2.836	in	Volume of Solids , V_s :	22.844	in^3
Area, A_0	6.315	in^2	Initial Volume of Voids, V_v :	14.495	in^3
Height, L_0	5.912	in	Initial Void Ratio, e_o :	0.635	
Volume, V_0	37.339	in^3	Initial Degree of Saturation, S_0 :	106.037	%

Water Content BEFORE Test

Tin No.:	R-68	g
Wet Soil + Tin :	90.64	g
Dry Soil + Tin :	77.67	g
Tin Weight :	26.2	g
Dry Mass :	51.47	g
Weight of water :	12.97	g
Moisture :	25.20	%

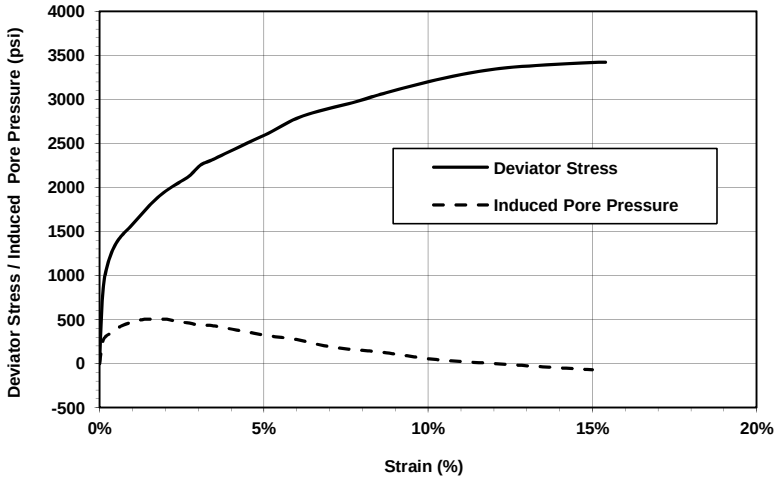
Water Content AFTER Test (Total Specimen)

Tin No.:	ST	g
Wet Soil + Tin :	1399.80	g
Dry Soil + Tin :	1163.40	g
Tin Weight :	163.90	g
Dry Mass :	999.50	g
Weight of water :	236.40	g
Moisture :	23.65	%
Wet Density :	126.09	pcf
Dry Density :	101.98	pcf

Consolidation Cell Pressure:	130.0	psi	Deviator Stress @ Failure, Ds:	3420.90	psf
Consolidation Back Pressure:	115.0	psi	Axial Strain @ Failure:	15.39	%
Effective Confining Stress, σ_3:	15.0	psi	Major Principal Stress @ Failure, σ_1:	5580.90	psf
	2160.00	psf	Induced Pore Pressure @ Failure:	-72.00	psf
Strain Rate:	0.0030	in/min	Effective Minor Principal Stress,σ'_3:	2232.00	psf
			Effective Major Principal Stress, σ'_1:	5652.90	psf

Failure Sketch

CU Compressive Strength and Induced Pore Pressure



Notes:

Consolidated, Undrained Triaxial Compression Test (ASTM D4767)

Project Number:	B-11-010	Boring Number:	B-004-0-11
Project Name:	HAM-75-11.09	Sample No. / Depth:	ST-3 / 11.4 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	5/17/2012
Client:	M•E Companies, Inc.	Technician:	JJH

Data for Specimen No. 2

Soil Description: Brown SILT, and clay, trace coarse to fine sand.
Soil Classification: ODOT A-4b

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	25	16	9	0	1	1	52	46

Diameter, D_0	2.843	in	Volume of Solids , V_s :	27.218	in^3
Area, A_0	6.347	in^2	Initial Volume of Voids, V_v :	10.265	in^3
Height, L_0	5.906	in	Initial Void Ratio, e_o :	0.377	
Volume, V_0	37.483	in^3	Initial Degree of Saturation, S_0 :	92.53	%

Water Content BEFORE Test

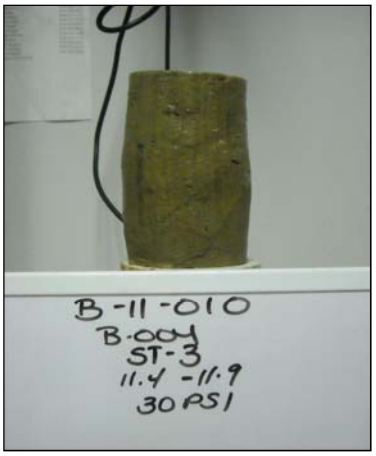
Tin No.:	T-26	g
Wet Soil + Tin :	123.78	g
Dry Soil + Tin :	112.71	g
Tin Weight :	28.01	g
Dry Mass :	84.7	g
Weight of water :	11.07	g
Moisture :	13.07	%

Water Content AFTER Test (Total Specimen)

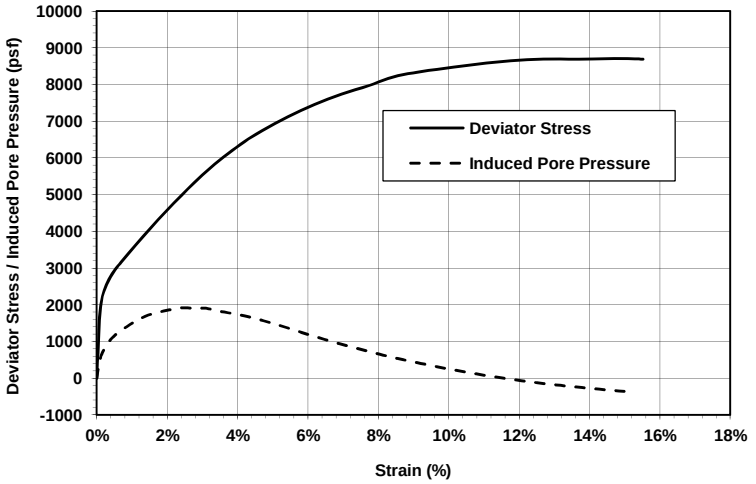
Tin No.:	ST	g
Wet Soil + Tin :	1473.90	g
Dry Soil + Tin :	1309.00	g
Tin Weight :	118.10	g
Dry Mass :	1190.90	g
Weight of water :	164.90	g
Moisture :	13.85	%
Wet Density :	137.79	pcf
Dry Density :	121.03	pcf

Consolidation Cell Pressure:	143.0	psi	Deviator Stress @ Failure, Ds:	8702.33	psf
Consolidation Back Pressure:	113.0	psi	Axial Strain @ Failure:	14.99	%
Effective Confining Stress, σ_3:	30.0	psi	Major Principal Stress @ Failure, σ_1:	13022.33	psf
	4320.00	psf	Induced Pore Pressure @ Failure:	-360.00	psf
Strain Rate:	0.0036	in/min	Effective Minor Principal Stress,σ'_3:	4680.00	psf
			Effective Major Principal Stress, σ'_1:	13382.33	psf

Failure Sketch



CU Compressive Strength and Induced Pore Pressure



Notes:

Consolidated, Undrained Triaxial Compression Test (ASTM D4767)

Project Number:	B-11-010	Boring Number:	B-004-0-11
Project Name:	HAM-75-11.09	Sample No. / Depth:	ST-2 / 9.0 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	5/15/2012
Client:	M•E Companies, Inc.	Technician:	JJH

Data for Specimen No. 3

Soil Description: Brown SILTY and CLAY, some coarse to fine sand, little fine gravel.
Soil Classification: ODOT A-6a

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	27	15	12	11	9	14	38	28

Diameter, D_0	2.837	in	Volume of Solids , V_s :	22.794	in^3
Area, A_0	6.320	in^2	Initial Volume of Voids, V_v :	14.563	in^3
Height, L_0	5.911	in	Initial Void Ratio, e_o :	0.639	
Volume, V_0	37.357	in^3	Initial Degree of Saturation, S_0 :	99.713	%

Water Content BEFORE Test

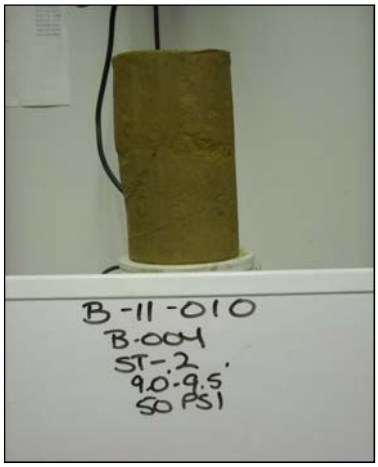
Tin No.:	T-33	g
Wet Soil + Tin :	85.25	g
Dry Soil + Tin :	74.1	g
Tin Weight :	27.37	g
Dry Mass :	46.73	g
Weight of water :	11.15	g
Moisture :	23.86047507	%

Water Content AFTER Test (Total Specimen)

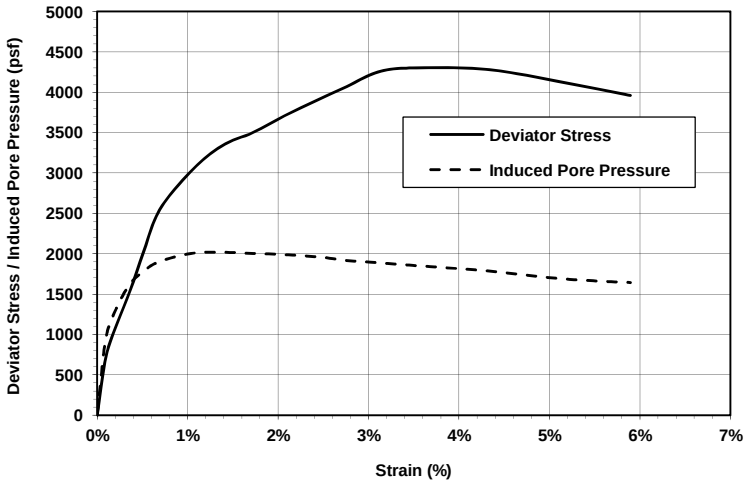
Tin No.:	S	g
Wet Soil + Tin :	1356.80	g
Dry Soil + Tin :	1115.30	g
Tin Weight :	118.00	g
Dry Mass :	997.30	g
Weight of water :	241.50	g
Moisture :	24.22	%
Wet Density :	126.33	pcf
Dry Density :	101.70	pcf

Consolidation Cell Pressure:	140.0	psi	Deviator Stress @ Failure, Ds:	4298.80	psf
Consolidation Back Pressure:	90.0	psi	Axial Strain @ Failure:	5.89	%
Effective Confining Stress, σ_3:	50.0	psi	Major Principal Stress @ Failure, σ_1:	11498.80	psf
	7200.00	psf	Induced Pore Pressure @ Failure:	1641.60	psf
Strain Rate:	0.0030	in/min	Effective Minor Principal Stress,σ'_3:	5558.40	psf
			Effective Major Principal Stress, σ'_1:	9857.20	psf

Failure Sketch



CU Compressive Strength and Induced Pore Pressure



Notes: Point classified as A-6a material type, which is different than the first two points of the test. Results of this point do not line up with remainder of points. Therefore, the results of this point are not utilized in the final results of the test.

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

CONSOLIDATED, UNDRAINED TRIAXIAL

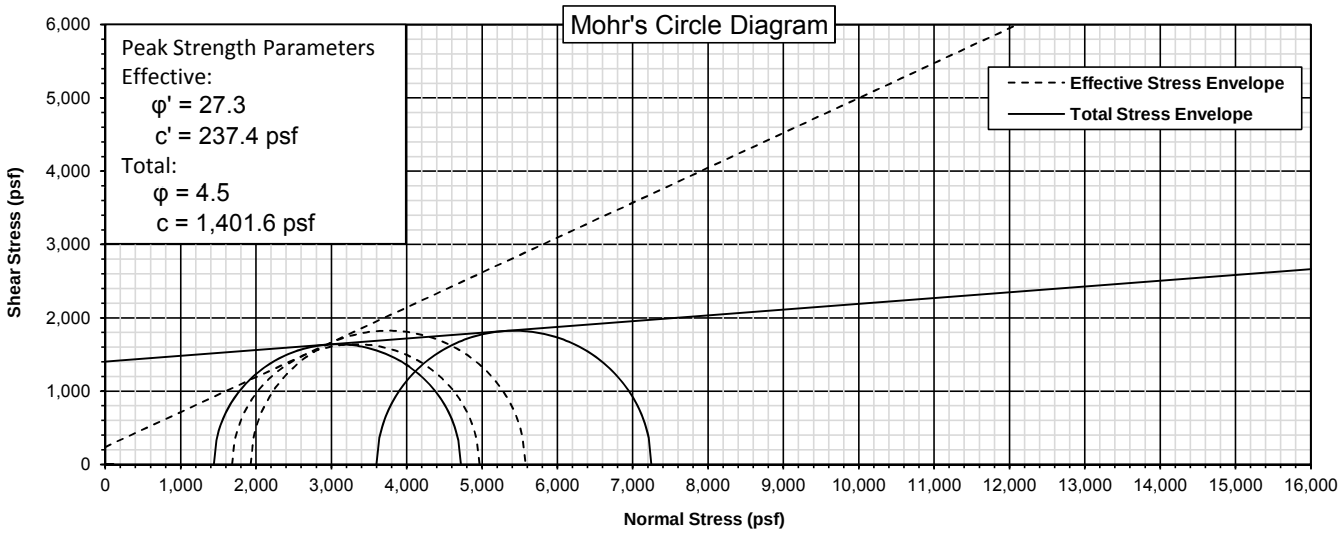
ASTM D-4767

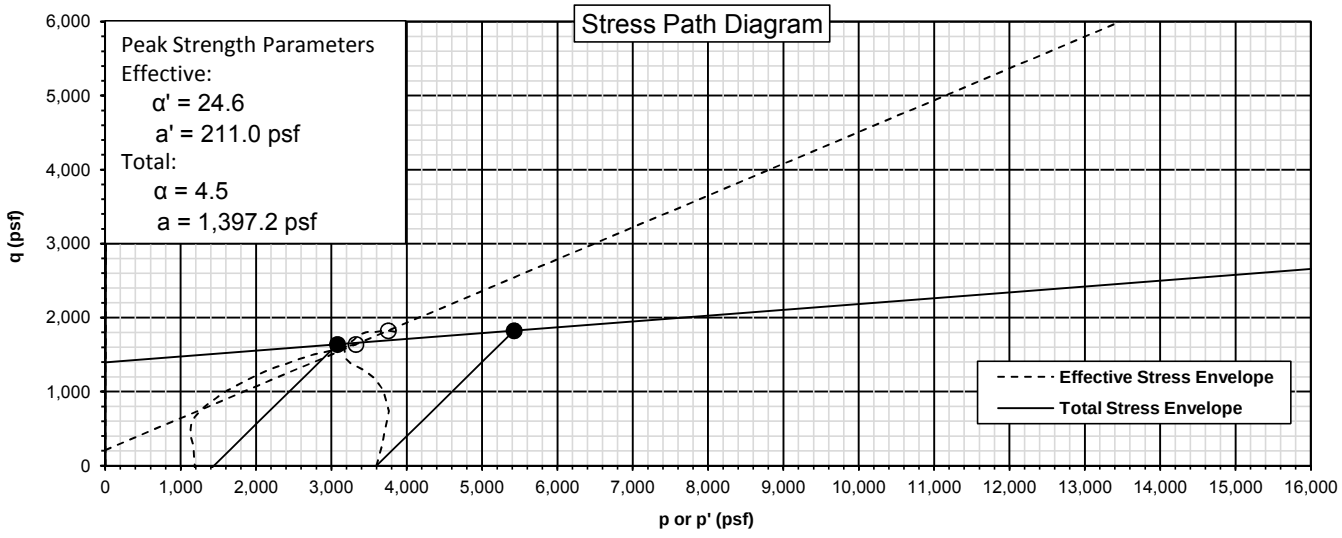
PROJECT NAME:	HAM-75-7.85
JOB NUMBER:	B-10-020
BORING NUMBER:	B-016-0-11A
SAMPLE NUMBER:	ST-3
SAMPLE DEPTH:	6.5 to 7.0 feet
DATE OF TESTING:	12/12/2011-12/28/11
TESTED BY:	Hoyt

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





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:	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

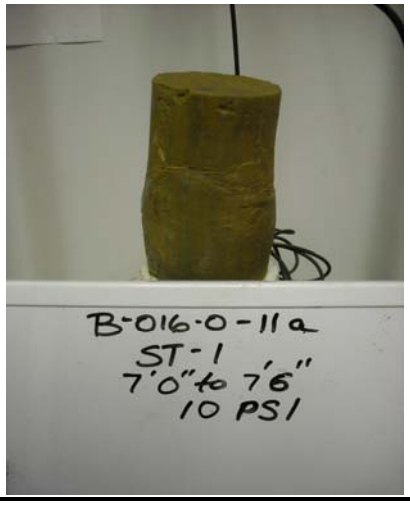
Tin No.:	WC-32	g
Wet Soil + Tin :	105.78	g
Dry Soil + Tin :	94.18	g
Tin Weight :	34.46	g
Dry Mass :	59.72	g
Weight of water :	11.6	g
Moisture :	19.42	%

Water Content AFTER Test (Total Specimen)

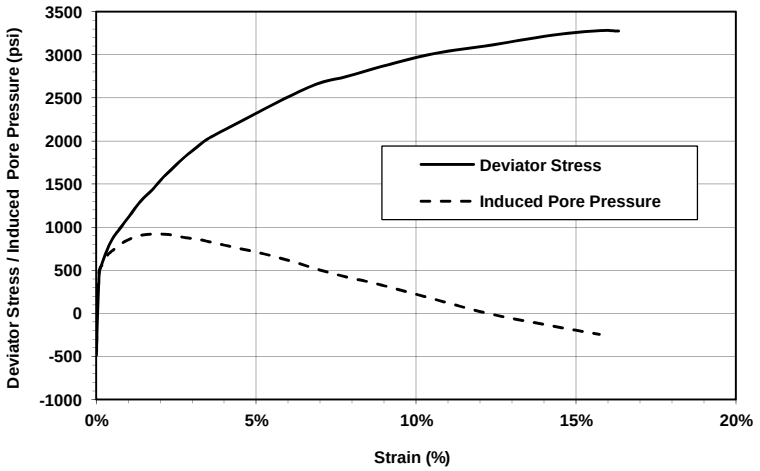
Tin No.:	BIG CAT	g
Wet Soil + Tin :	1393.10	g
Dry Soil + Tin :	1198.10	g
Tin Weight :	89.00	g
Dry Mass :	1109.10	g
Weight of water :	195.00	g
Moisture :	17.58	%
Wet Density :	133.85	pcf
Dry Density :	113.84	pcf

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



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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	%

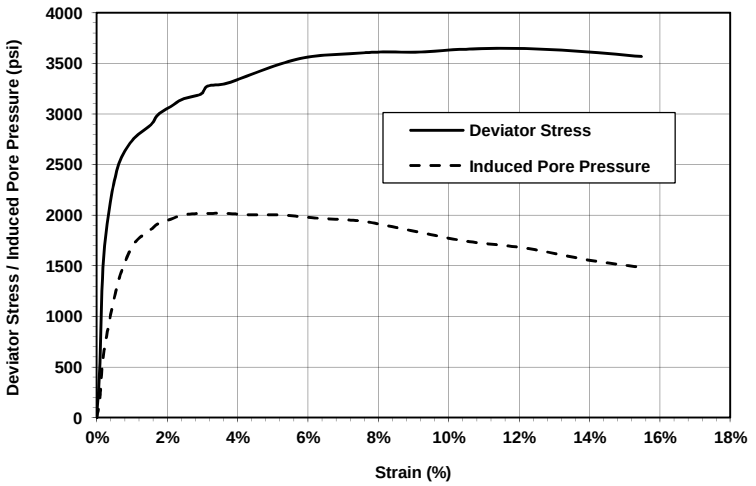
Water Content AFTER Test (Total Specimen)

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



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CONSOLIDATED, UNDRAINED TRIAXIAL

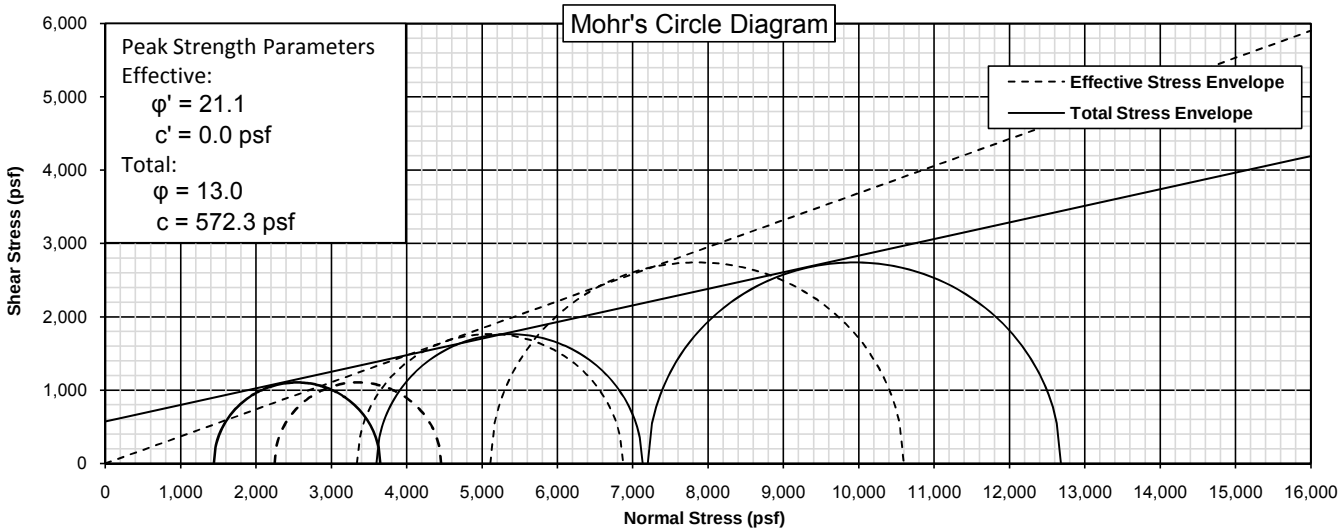
ASTM D-4767

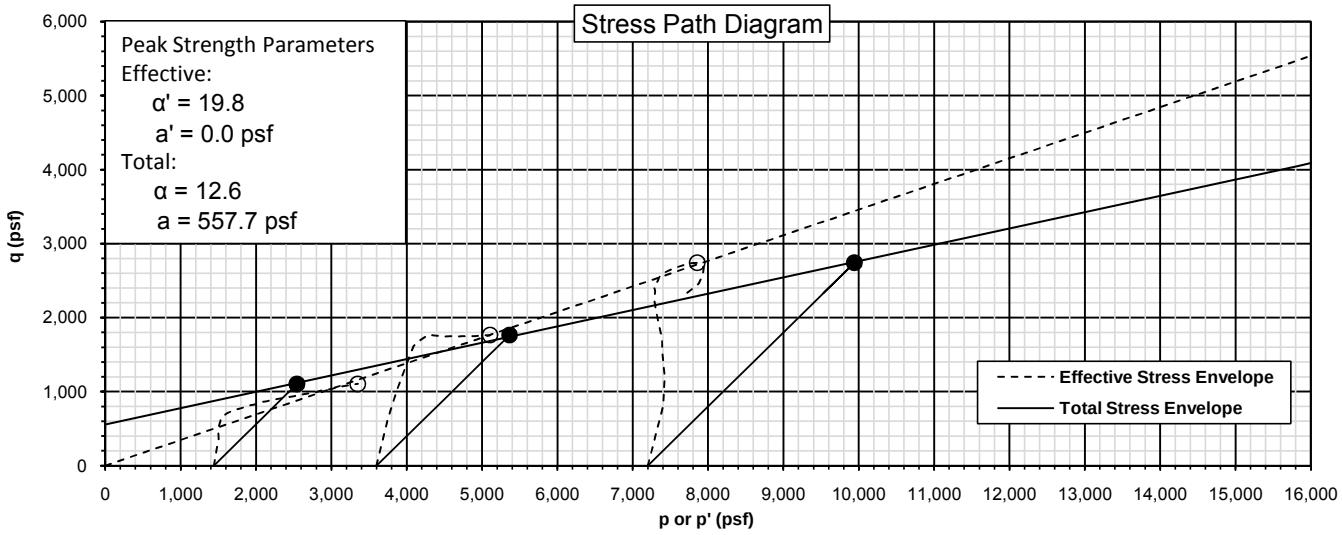
PROJECT NAME:	HAM-75-12.60
JOB NUMBER:	B-10-024
BORING NUMBER:	B-017-0-10
SAMPLE NUMBER:	ST-8a
SAMPLE DEPTH:	19.0 ft - 20.5 ft
DATE OF TESTING:	9/20/2011 through 9/26/2011
TESTED BY:	JH

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





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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-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	%

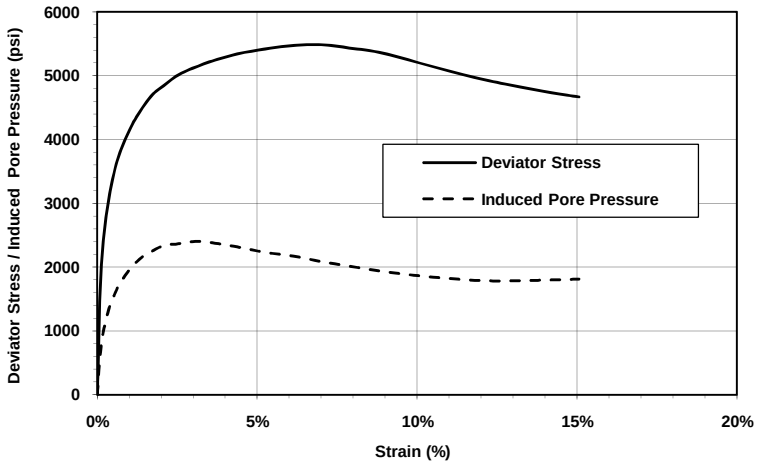
Water Content AFTER Test (Total Specimen)

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	%

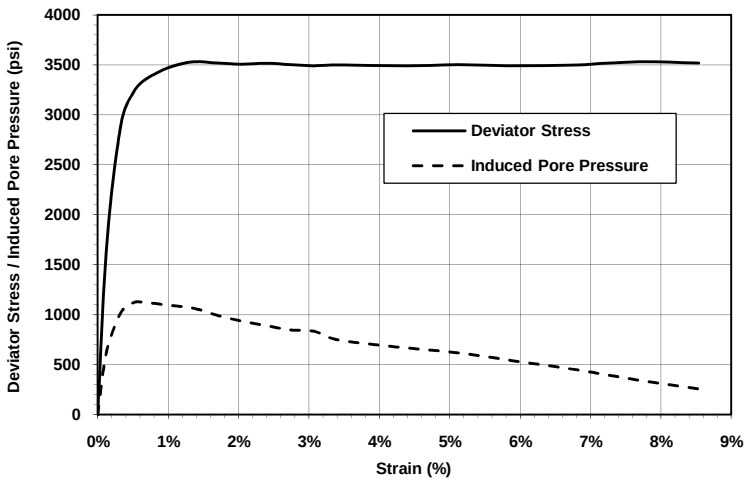
Water Content AFTER Test (Total Specimen)

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	%

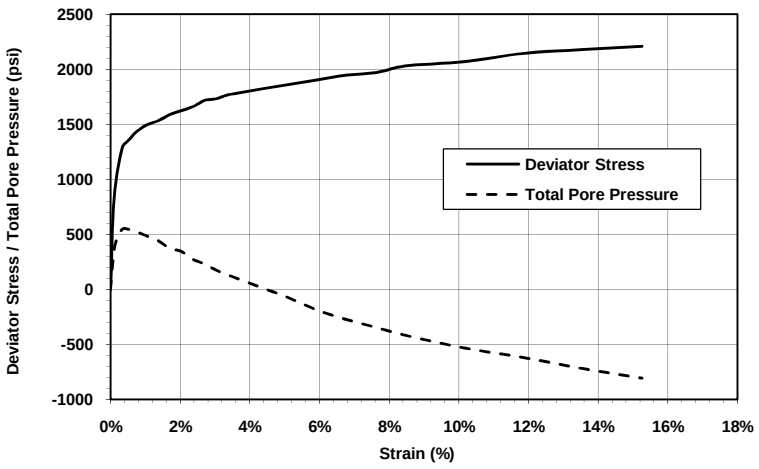
Water Content AFTER Test (Total Specimen)

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)

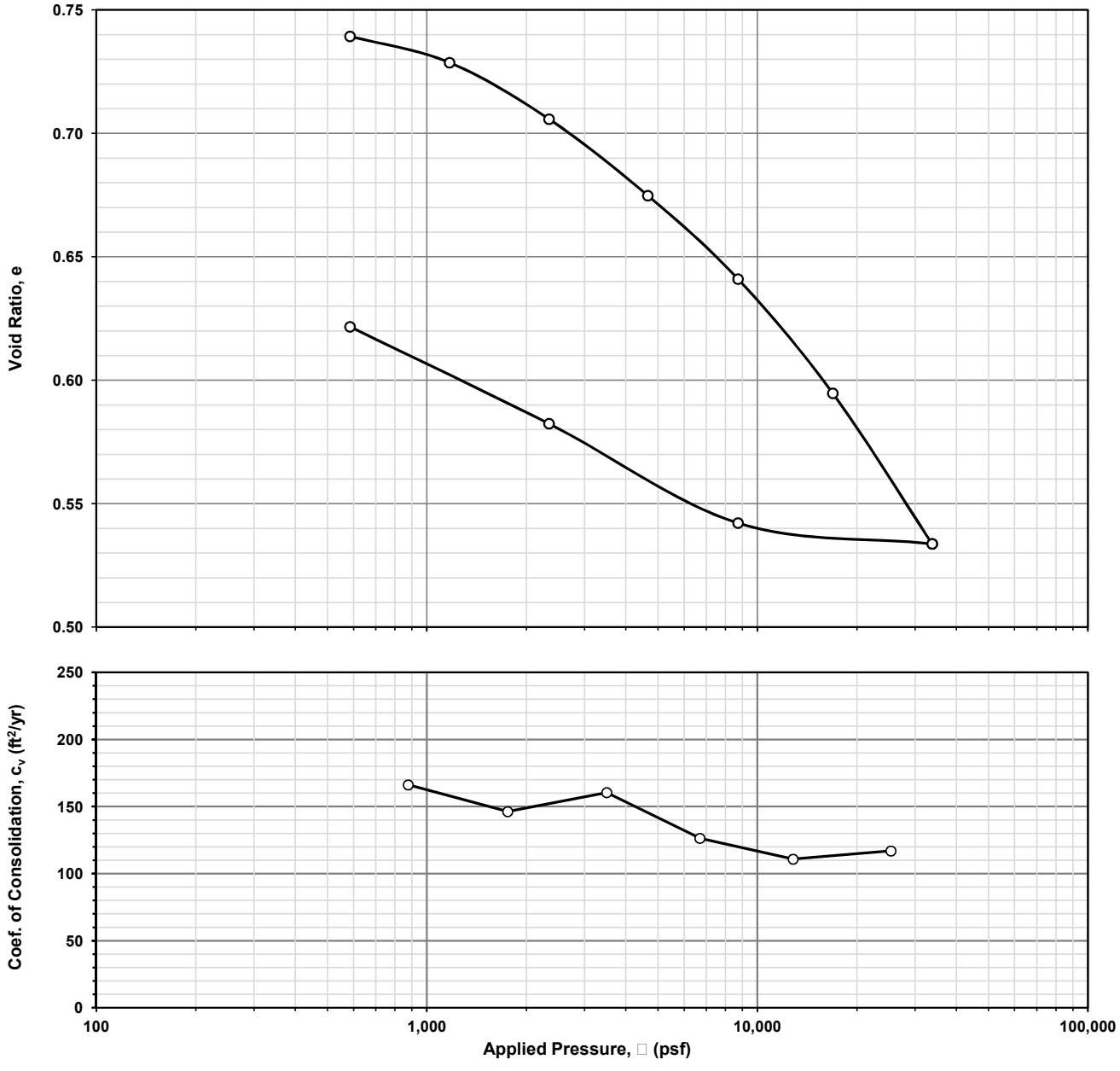
Project Number:	B-10-020	Boring Number:	B-008-0-11
Project Name:	HAM-75-7.85	Sample No. / Depth:	ST-10 / 24.0 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	11/3/2011 to 11/16/2011
Client:	EMH&T	Technician:	JJH

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



One-Dimensional Consolidation Test Report (ASTM D2435)

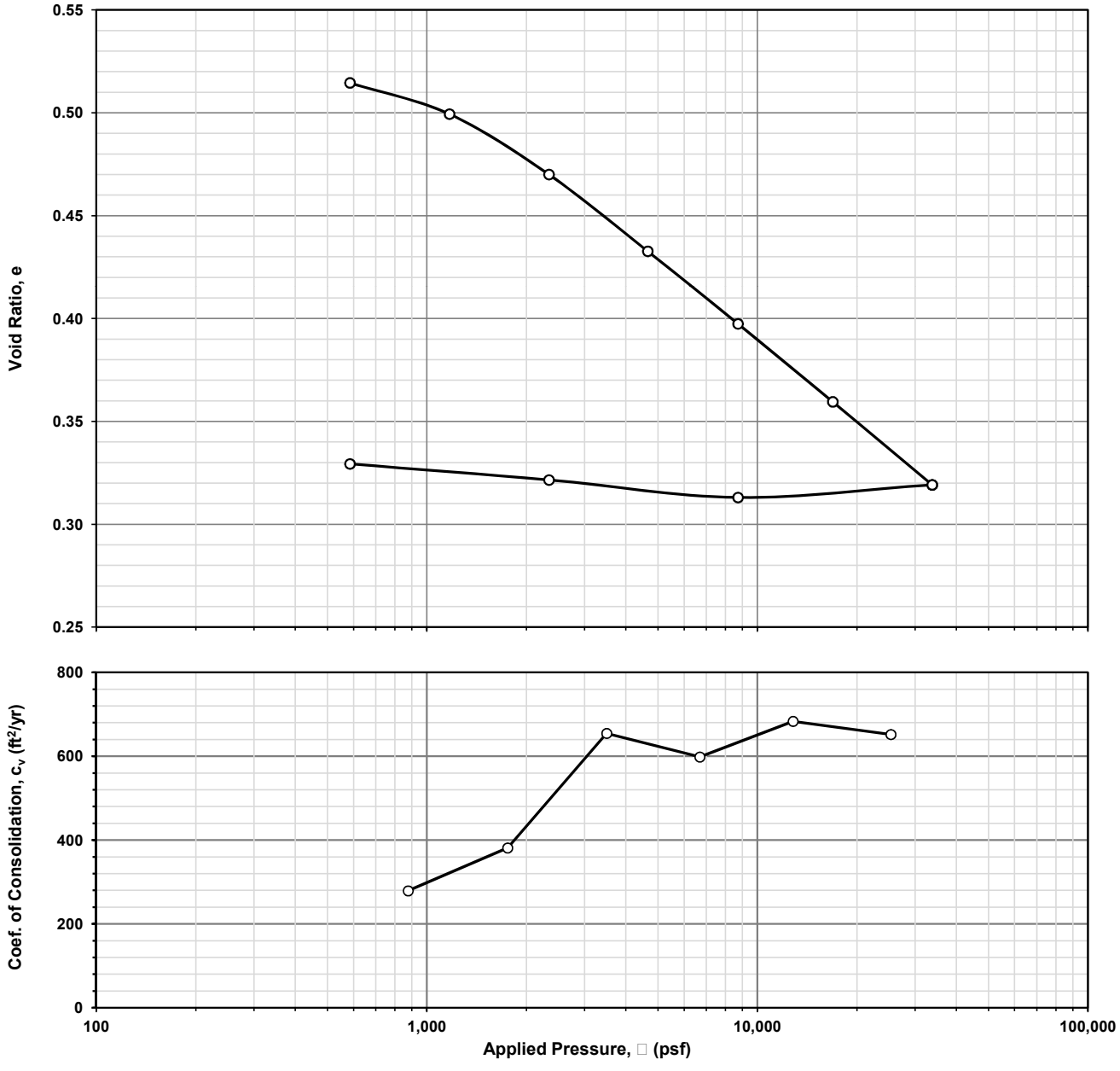
Project Number:	B-10-020	Boring Number:	B-015-0-11
Project Name:	HAM-75-7.85	Sample No. / Depth:	ST-8 / 20.3 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	10/14/2011 to 10/28/2011
Client:	EMH&T	Technician:	JJH

Soil Description: Brownish gray SANDY SILT, little clay, trace fine gravel

Soil Classification: ODOT A-4a

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	24	15	9	7	6	31	37	19

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
85.1%	15.0%	108.6	127.1	2,556	2.67	0.535	1,857	0.134	0.014



One-Dimensional Consolidation Test Report (ASTM D2435)

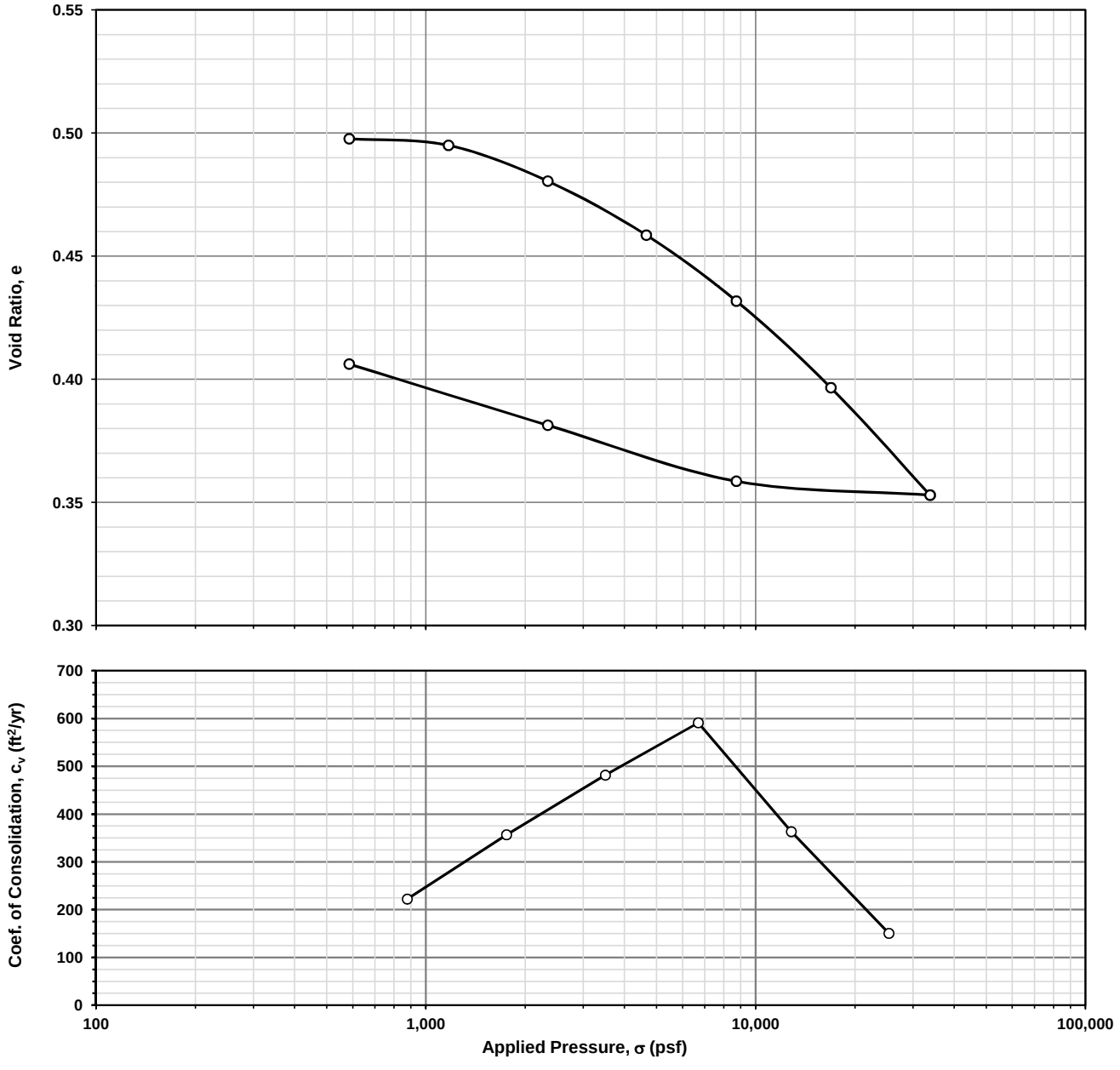
Project Number:	B-10-020	Boring Number:	B-053-0-11
Project Name:	HAM-75-7.85	Sample No. / Depth:	ST-4 / 8.5 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	11/18/2011 to 12/2/2011
Client:	EMH&T	Technician:	JJH

Soil Description: Brown SILTY CLAY, little coarse to fine sand, trace fine gravel

Soil Classification: ODOT A-6b

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	35	16	19	1	3	17	37	42

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
98.4%	19.3%	110.1	130.6	1,020	2.65	0.503	4,645	0.145	0.041



One-Dimensional Consolidation Test Report (ASTM D2435)

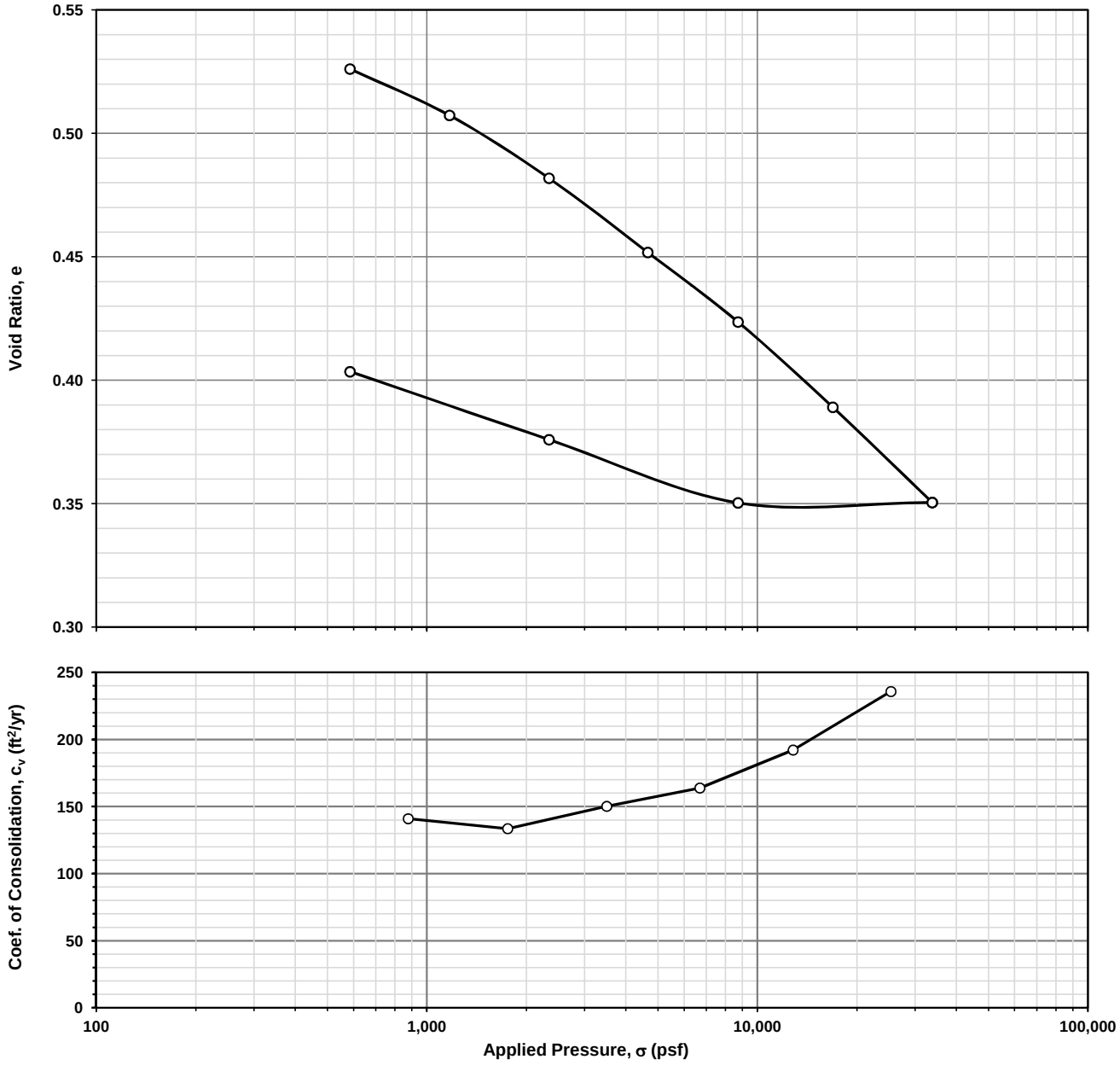
Project Number:	B-10-020	Boring Number:	B-016-0-11
Project Name:	HAM-75-7.85	Sample No. / Depth:	ST-4 / 9.4 ft
Project Location:	Hamilton County, Ohio	Date of Testing:	12/8/2011 to 12/21/2011
Client:	EMH&T	Technician:	JJH

Soil Description: Brown CLAY, some silt, little coarse to fine sand, trace fine gravel

Soil Classification: ODOT A-7-6

Physical Characteristics	L.L.	P.L.	P.I.	Gravel%	C. Sand%	F. Sand%	Silt%	Clay%
	44	21	23	8	7	5	34	46

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
99.6%	19.7%	107.1	129.3	1,128	2.67	0.556	2,736	0.152	0.045



APPENDIX VI

SETTLEMENT CALCULATIONS

B-10-020 HAM-75-7.85 (Retaining Wall H)
MSE Wall - Consolidation Settlement

Calculated By: BRT Date: 8/8/2013
Checked By: NCK Date: 8/8/2013

Boring B-015 - Sta. 448+45 to 449+50

12.4' MSE wall height net loading considered

H=	12.4	ft	
B=	11.8	ft	
γ_{BF} =	120	pcf	
D_w =	35.5	ft	depth below bottom of footing
γ_w =	62.4	pcf	
ΔP =	1488	psf	at surface

															Total Settlement at Center of Reinforced Soil Mass					Total Settlement at Facing of Wall				
Layer	Soil Type	Depth		Thickness	Depth to Midpoint	γ	LL	C_c	C_r	e_o	σ_p'	σ_{vo} Bottom	σ_{vo} Midpoint	σ_{vo}' Midpoint	z_f/B	I	$\Delta\sigma_v$	σ_{vf}' Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	σ_{vf}' Midpoint	S_c (ft)	S_c (in)
1	A-4a	0.0	2.0	2.0	1.0	115	25	0.134	0.014	0.535	1571	230	115	115	0.08	0.982	1462	1577	0.021	0.249	0.500	744	859	0.016	0.191
		2.0	4.0	2.0	3.0	115	25	0.134	0.014	0.535	1801	460	345	345	0.25	0.941	1400	1745	0.013	0.154	0.500	744	1089	0.009	0.109
		4.0	6.0	2.0	5.0	115	25	0.134	0.014	0.535	2031	690	575	575	0.42	0.900	1339	1914	0.010	0.114	0.472	702	1277	0.006	0.076
		6.0	8.0	2.0	7.0	115	25	0.134	0.014	0.535	2261	920	805	805	0.59	0.767	1141	1946	0.007	0.084	0.444	661	1466	0.005	0.057
		8.0	10.0	2.0	9.0	115	25	0.134	0.014	0.535	2491	1150	1035	1035	0.76	0.667	992	2027	0.005	0.064	0.416	619	1654	0.004	0.045
		10.0	12.0	2.0	11.0	115	25	0.134	0.014	0.535	2721	1380	1265	1265	0.93	0.600	893	2158	0.004	0.051	0.394	587	1852	0.003	0.036
		12.0	14.0	2.0	13.0	115	25	0.134	0.014	0.535	2951	1610	1495	1495	1.10	0.522	777	2272	0.003	0.040	0.374	557	2052	0.003	0.030
		14.0	16.0	2.0	15.0	120	25	0.134	0.014	0.535	3186	1850	1730	1730	1.27	0.464	691	2421	0.003	0.032	0.354	527	2257	0.002	0.025
2	A-2-4	16.0	25.0	9.0	20.5	130	Calculated Separately					3020	2435	2435	1.74	Calculated Separately			0.008	0.095	Calculated Separately			0.004	0.044
3	A-3	25.0	43.0	18.0	34.0	125	Calculated Separately					5270	4145	4145	2.88	Calculated Separately			0.011	0.136	Calculated Separately			0.005	0.063

Settlement at Center of Reinforced Soil Mass: 1.019 in

Settlement at Facing of Wall: 0.677 in

B-10-020 HAM-75-7.85 (Retaining Wall H)
MSE Wall - Consolidation Settlement

Calculated By: BRT Date: 8/8/2013
Checked By: NCK Date: 8/8/2013

Borings B-015 and B⁻016 - Sta. 449+50 to 451+60

22.5' MSE wall height net loading considered

H=	22.5	ft	
B=	19.3	ft	
γ_{BF} =	120	pcf	
D_w =	33.4	ft	depth below bottom of footing
γ_w =	62.4	pcf	
ΔP =	2700	psf	at surface

															Total Settlement at Center of Reinforced Soil Mass					Total Settlement at Facing of Wall				
Layer	Soil Type	Depth		Thickness	Depth to Midpoint	γ	LL	C_c	C_r	e_o	σ_p'	σ_{vo} Bottom	σ_{vo} Midpoint	σ_{vo}' Midpoint	Z_f/B	I	$\Delta\sigma_v$	σ_{vf}' Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	σ_{vf}' Midpoint	S_c (ft)	S_c (in)
1	A-6b	0.0	2.0	2.0	1.0	120	40	0.145	0.041	0.503	1728	240	120	120	0.05	0.988	2668	2788	0.103	1.239	0.500	1350	1470	0.059	0.712
		2.0	4.0	2.0	3.0	120	40	0.145	0.041	0.503	1968	480	360	360	0.16	0.965	2605	2965	0.075	0.895	0.500	1350	1710	0.037	0.443
		4.0	6.0	2.0	5.0	120	40	0.145	0.041	0.503	2208	720	600	600	0.26	0.941	2541	3141	0.060	0.725	0.500	1350	1950	0.028	0.335
		6.0	8.0	2.0	7.0	120	40	0.145	0.041	0.503	2448	960	840	840	0.36	0.912	2462	3302	0.050	0.605	0.480	1296	2136	0.022	0.265
2	A-7-6	8.0	10.0	2.0	9.0	120	62	0.203	0.068	0.771	2688	1200	1080	1080	0.47	0.860	2322	3402	0.054	0.646	0.464	1253	2333	0.026	0.308
		10.0	12.0	2.0	11.0	120	62	0.203	0.068	0.771	2928	1440	1320	1320	0.57	0.783	2115	3435	0.042	0.510	0.448	1210	2530	0.022	0.260
		12.0	14.0	2.0	13.0	120	62	0.203	0.068	0.771	3168	1680	1560	1560	0.67	0.717	1935	3495	0.033	0.401	0.432	1166	2726	0.019	0.223
3	A-2-4	14.0	23.0	9.0	18.5	130	Calculated Separately					2850	2265	2265	0.96	Calculated Separately			0.018	0.215	Calculated Separately			0.008	0.100
4	A-3	23.0	41.0	18.0	32.0	130	Calculated Separately					5190	4020	4020	1.66	Calculated Separately			0.035	0.416	Calculated Separately			0.016	0.193

Settlement at Center of Reinforced Soil Mass: 5.653 in

Settlement at Facing of Wall: 2.841 in

APPENDIX VII

MSE WALL CALCULATIONS

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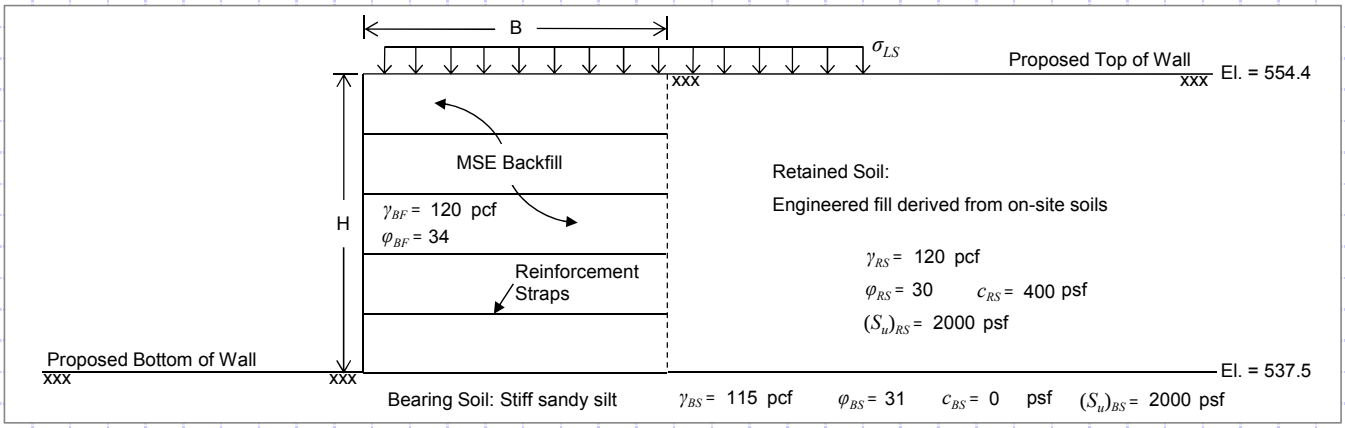
JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	1	OF	5
CALCULATED BY	BRT	DATE	8/8/2013
CHECKED BY	NCK	DATE	8/8/2013

Retaining Wall H - Sta. 448+45 to Sta. 449+50

Retaining WallH - MSE Wall - 16.9 ft. Maximum Wall Height - B-015-0-11



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	16.9	ft
MSE Wall Width (Reinforcement Length), (B) =	11.8	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}) =	115	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	31	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2000	psf
Embedment Depth, (D) =	3.0	ft

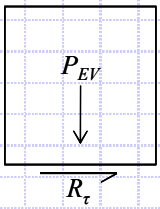
LRFD Load Factors

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



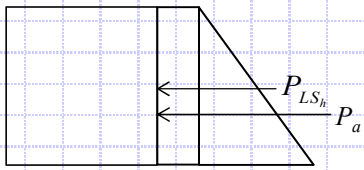
$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$ = (120 pcf)(16.9 ft)(11.8 ft)(1.00) = 23.93 kip/ft

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

$\tan\delta =$ tan(31) ≤ tan(34) ⟶ 0.6 ≤ 0.67 ⟶ $\tan\delta =$ 0.60

R_τ = (23.93 kip/ft)(0.6) = 14.36 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)(16.9 ft)²(0.333)(1.5) = 8.56 kip/ft

$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS}$ = (240 psf)(16.9 ft)(0.333)(1.75) = 2.36 kip/ft

P_H = 8.56 kip/ft + 2.36 kip/ft = 10.92 kip/ft

Check Sliding Resistance

$P_H \le R_\tau \cdot \phi_\tau$ ⟶ 10.92 kip/ft ≤ (14.36 kip/ft)(1.0) = 14.36 kip/ft ⟶ 10.92 kip/ft ≤ 14.36 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	BRT	DATE	8/8/2013
CHECKED BY	NCK	DATE	8/8/2013

Retaining Wall H - Sta. 448+45 to Sta. 449+50

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	16.9	ft
MSE Wall Width (Reinforcement Length), (B) =	11.8	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:

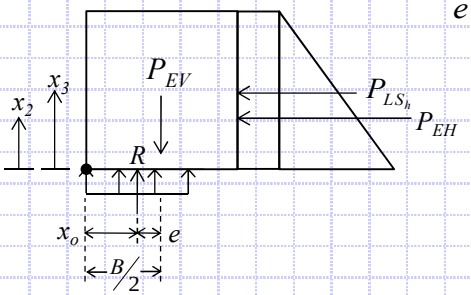
Bearing Soil Unit Weight, (γ_{BS}) =	115	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	31	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	2000	psf
Embedment Depth, (D) =	3.0	ft

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



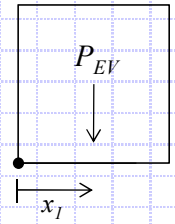
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (141.19 \text{ kip·ft/ft} - 68.13 \text{ kip·ft/ft}) / (23.93 \text{ kip/ft}) = 3.05 \text{ ft}$$

M_{EV} = 141.19 kip·ft/ft
M_H = 68.13 kip·ft/ft
P_{EV} = 23.93 kip/ft
} Defined below

$e =$ (11.8 ft)/2 - 3.05 ft = 2.85 ft

Resisting Moment, M_{EV}:



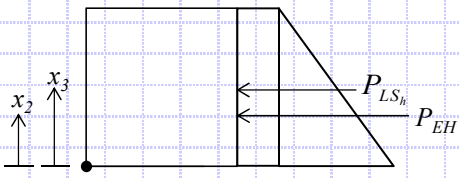
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(16.9 \text{ ft})(11.8 \text{ ft})(1.00) = 23.93 \text{ kip/ft}$$

$$x_1 = B/2 = (11.8 \text{ ft}) / 2 = 5.90 \text{ ft}$$

$$M_{EV} = (23.93 \text{ kip/ft})(5.9 \text{ ft}) = 141.19 \text{ kip·ft/ft}$$

Overturning Moment, M_H:



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

$$P_{EH} = \tfrac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH} = \tfrac{1}{2}(120 \text{ pcf})(16.9 \text{ ft})^2(0.333)(1.5) = 8.56 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(16.9 \text{ ft})(0.333)(1.75) = 2.36 \text{ kip/ft}$$

$$x_2 = H/3 = (16.9 \text{ ft}) / 3 = 5.63 \text{ ft}$$

$$x_3 = H/2 = (16.9 \text{ ft}) / 2 = 8.45 \text{ ft}$$

$$M_H = (8.56 \text{ kip/ft})(5.63 \text{ ft}) + (2.36 \text{ kip/ft})(8.45 \text{ ft}) = 68.13 \text{ kip·ft/ft}$$

Limiting Eccentricity:

$$e_{max} = B/4 \longrightarrow e_{max} = (11.8 \text{ ft}) / 4 = 2.95 \text{ ft}$$

Check Eccentricity

$$e < e_{max} \longrightarrow 2.85 \text{ ft} < 2.95 \text{ ft} \quad \textbf{OK}$$

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

Retaining Wall H - Sta. 448+45 to Sta. 449+50

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	16.9	ft
MSE Wall Width (Reinforcement Length), (B) =	11.8	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:

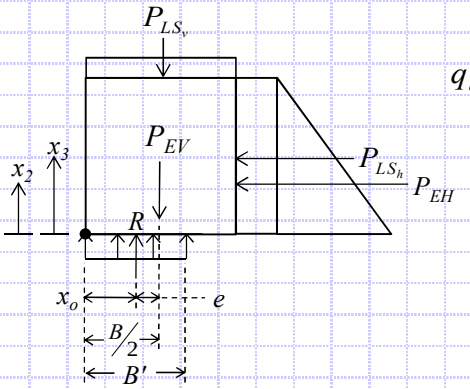
Bearing Soil Unit Weight, (γ_{BS}) =	115	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	31	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	2000	psf
Embedment Depth, (D) =	3.0	ft

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



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

$B' = B - 2e$ = 11.8 ft - 2(1.83 ft) = 8.14 ft

$e = B/2 - x_o$ = (11.8 ft) / 2 - 4.07 ft = 1.83 ft

$x_o = \frac{M_V - M_H}{P_V}$ = (219.85 kip·ft/ft - 68.16 kip·ft/ft) / 37.26 kip/ft = 4.07 ft

q_{eq} = (37.26 kip/ft) / (8.14 ft) = 4.58 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)(16.9 ft)(11.8 ft)(1.35)](5.9 ft) + [(240 psf)(11.8 ft)(1.75)](5.9 ft) = 219.85 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)(16.9 ft)²(0.333)(1.5)](5.63 ft) + [(240 psf)(16.9 ft)(0.333)(1.75)](8.45 ft) = 68.16 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)(16.9 ft)(11.8 ft)(1.35) + (240 psf)(11.8 ft)(1.75) = 37.26 kip/ft

Nominal Bearing Resistance:

$q_n = cN_c + \gamma D N_q + \tfrac{1}{2}\gamma B N_\gamma$ = (2000 psf)(5.7) + (115 pcf)(3.0 ft)(1.0) + ½(115 pcf)(11.8 ft)(0.0) = 11.7 ksf

N_c = 5.7 N_q = 1.0 N_γ = 0.0

Check Bearing Capacity

$q_{eq} \le q_n \cdot \phi_b$ ⟶ 4.58 ksf ≤ (11.7 ksf)(0.65) = 7.61 ksf ⟶ 4.58 ksf ≤ 7.61 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	BRT	DATE	8/8/2013
CHECKED BY	NCK	DATE	8/8/2013

Retaining Wall H - Sta. 448+45 to Sta. 449+50

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	16.9	ft
MSE Wall Width (Reinforcement Length), (B) =	11.8	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}) =	115	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	31	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	2000	psf
Embedment Depth, (D) =	3.0	ft

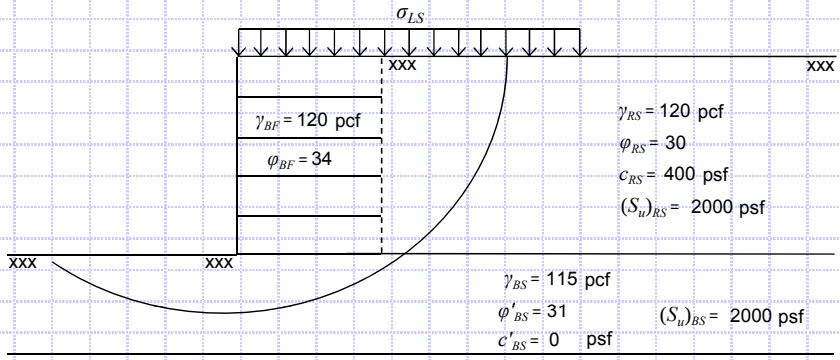
LRFD Load Factors

	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)

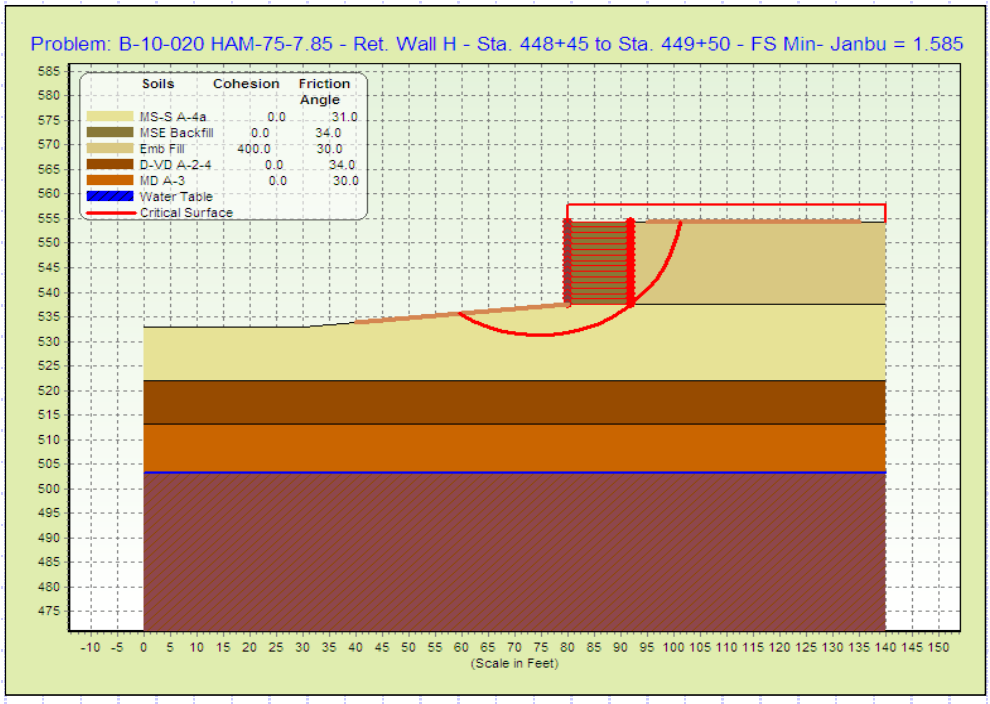
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

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

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.00 ≤ (1.585)(0.75) = 1.19 ⟶ 1.00 ≤ 1.19 **OK**

FS = **1.585** *(From STABL Slope Stability Analysis)*

Use φ_{GS} = **0.75** *(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	BRT	DATE	8/8/2013
CHECKED BY	NCK	DATE	8/8/2013

Retaining Wall H - Sta. 448+45 to Sta. 449+50

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	16.9	ft
MSE Wall Width (Reinforcement Length), (B) =	11.8	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}) =	115	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	31	°
Bearing Soil Drained Cohesion, (c_{BS}) =	0	psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	2000	psf
Embedment Depth, (D) =	3.0	ft

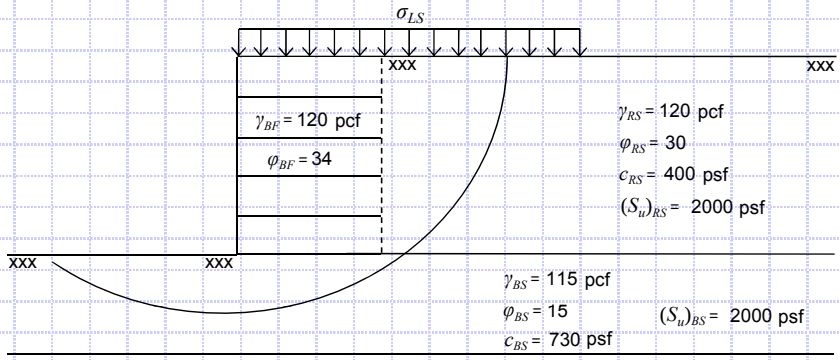
LRFD Load Factors

	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)

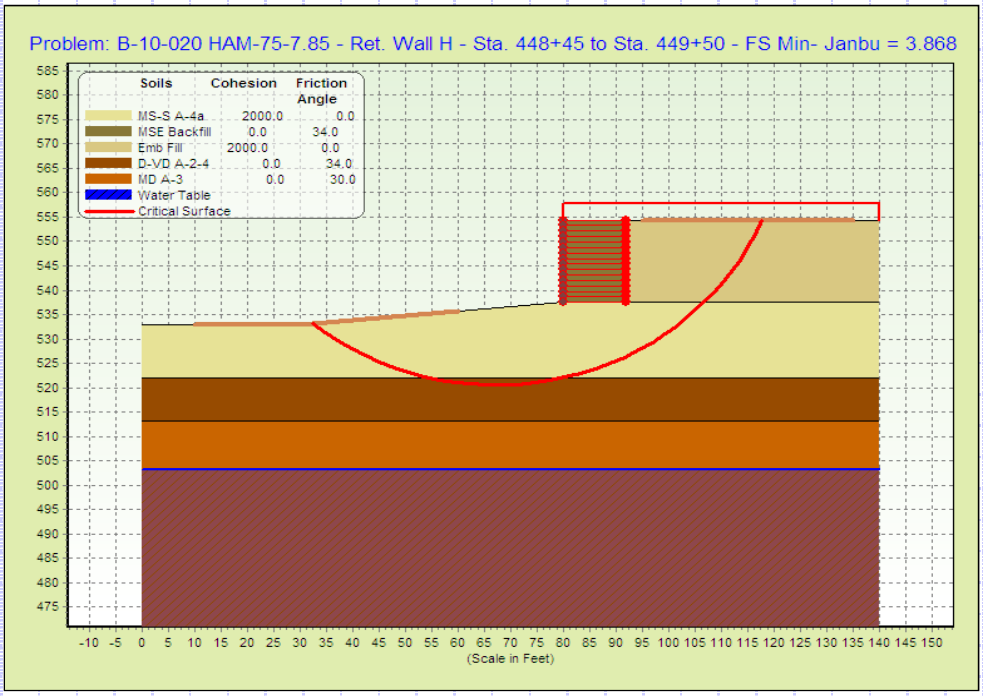
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 *(Cont'd)*

Short Term Stability - Undrained Conditions



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

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



Check Overall (Global) Stability

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.00 ≤ (3.868)(0.75) = 2.90 ⟶ 1.00 ≤ 2.90 **OK**

FS = **3.868** *(From STABL Slope Stability Analysis)*

Use φ_{GS} = **0.75** *(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 - Ret. Wall H - Sta
. 448+45 to Sta. 449+50

BOUNDARY COORDINATES

5 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	533.00	30.00	533.00	3
2	30.00	533.00	80.00	537.50	3
3	80.00	537.50	80.10	554.40	1
4	80.10	554.40	91.90	554.40	1
5	91.90	554.40	140.00	554.40	2
6	80.00	537.50	91.80	537.50	3
7	91.80	537.50	91.90	554.40	2
8	91.80	537.50	140.00	537.50	3
9	0.00	522.10	140.00	522.10	4
10	0.00	513.10	140.00	513.10	5

1

ISOTROPIC SOIL PARAMETERS

5 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	115.0	125.0	0.0	31.0	0.00	0.0	1
4	130.0	135.0	0.0	34.0	0.00	0.0	1
5	125.0	130.0	0.0	30.0	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 No.	X-Water (ft)	Y-Water (ft)

1	0.00	503.10
2	140.00	503.10

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	80.10	140.00	240.0	1.0

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	3	554.4	537.5	16	11.8	1.13	1.0	7500.0

1

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

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 40.00 ft.
and X = 80.00 ft.

Each Surface Terminates Between X = 95.00 ft.
and X = 135.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =500.00 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 19 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	53.06	535.08
2	55.94	534.23
3	58.88	533.64
4	61.86	533.31

5	64.86	533.25
6	67.86	533.45
7	70.82	533.92
8	73.73	534.64
9	76.57	535.62
10	79.31	536.84
11	81.93	538.31
12	84.41	539.99
13	86.73	541.89
14	88.87	543.99
15	90.83	546.27
16	92.57	548.71
17	94.09	551.29
18	95.38	554.00
19	95.53	554.40

Factor Of Safety For The Preceding Specified Surface = -2.125

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 20 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	59.59	535.66
2	62.18	534.15
3	64.93	532.94
4	67.79	532.03
5	70.73	531.45
6	73.72	531.20
7	76.72	531.29
8	79.69	531.70
9	82.60	532.44
10	85.40	533.50
11	88.08	534.87
12	90.58	536.52
13	92.88	538.44
14	94.96	540.61
15	96.79	542.99
16	98.34	545.55
17	99.59	548.28
18	100.54	551.13
19	101.16	554.06
20	101.20	554.40

*** 1.585 ***

Individual data on the 24 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	260.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.7	780.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.9	1245.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.9	1621.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3.0	1880.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	3.0	2008.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	3.0	1996.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.3	204.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0

9	0.1	167.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.5	6608.6	0.0	0.0	0.0	0.0	0.0	0.0	599.4
11	2.8	7152.3	0.0	0.0	0.0	0.0	0.0	0.0	673.6
12	2.7	6436.2	0.0	0.0	0.0	0.0	0.0	0.0	641.2
13	2.5	5597.6	0.0	0.0	0.0	0.0	0.0	0.0	600.9
14	1.2	2448.7	0.0	0.0	0.0	0.0	0.0	0.0	282.0
15	0.0	92.5	0.0	0.0	79.6	95.5	0.0	0.0	11.0
16	0.1	201.4	0.0	0.0	0.0	0.0	0.0	0.0	23.9
17	1.0	1934.5	0.0	0.0	0.0	0.0	0.0	0.0	236.4
18	2.1	3709.7	0.0	0.0	0.0	0.0	0.0	0.0	498.7
19	1.8	2760.7	0.0	0.0	0.0	0.0	0.0	0.0	438.1
20	1.5	1884.1	0.0	0.0	0.0	0.0	0.0	0.0	372.0
21	1.3	1127.4	0.0	0.0	0.0	0.0	0.0	0.0	301.3
22	0.9	533.0	0.0	0.0	0.0	0.0	0.0	0.0	226.9
23	0.6	135.3	0.0	0.0	0.0	0.0	0.0	0.0	149.8
24	0.0	0.7	0.0	0.0	0.0	0.0	0.0	0.0	8.0

Individual data on the 16 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	15	80.0	537.5	91.8	537.5	124.3	11.8	7500.0	1.7
1	2	0	80.0	538.6	91.8	538.6	0.0	11.8	7500.0	0.0
1	3	0	80.0	539.8	91.8	539.8	0.0	11.8	7500.0	0.0
1	4	0	80.0	540.9	91.8	540.9	0.0	11.8	7500.0	0.0
1	5	0	80.0	542.0	91.8	542.0	0.0	11.8	7500.0	0.0
1	6	0	80.0	543.1	91.8	543.1	0.0	11.8	7500.0	0.0
1	7	0	80.0	544.3	91.8	544.3	0.0	11.8	7500.0	0.0
1	8	0	80.0	545.4	91.8	545.4	0.0	11.8	7500.0	0.0
1	9	0	80.1	546.5	91.9	546.5	0.0	11.8	7500.0	0.0
1	10	0	80.1	547.6	91.9	547.6	0.0	11.8	7500.0	0.0
1	11	0	80.1	548.8	91.9	548.8	0.0	11.8	7500.0	0.0
1	12	0	80.1	549.9	91.9	549.9	0.0	11.8	7500.0	0.0
1	13	0	80.1	551.0	91.9	551.0	0.0	11.8	7500.0	0.0
1	14	0	80.1	552.1	91.9	552.1	0.0	11.8	7500.0	0.0
1	15	0	80.1	553.3	91.9	553.3	0.0	11.8	7500.0	0.0
1	16	0	80.1	554.4	91.9	554.4	0.0	11.8	7500.0	0.0

Failure Surface Specified By 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	65.31	536.18
2	68.00	534.86
3	70.84	533.87
4	73.76	533.22
5	76.75	532.91
6	79.75	532.95
7	82.72	533.33
8	85.63	534.06
9	88.44	535.12
10	91.10	536.50
11	93.59	538.18
12	95.86	540.14
13	97.89	542.34
14	99.65	544.77
15	101.12	547.39
16	102.28	550.16
17	103.10	553.04
18	103.32	554.40

*** 1.657 ***

1

Failure Surface Specified By 18 Coordinate Points

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

1	66.12	536.25
2	68.84	534.97
3	71.68	534.02
4	74.62	533.42
5	77.61	533.17
6	80.61	533.27
7	83.57	533.73
8	86.46	534.54
9	89.23	535.69
10	91.85	537.15
11	94.27	538.92
12	96.47	540.96
13	98.41	543.25
14	100.07	545.76
15	101.41	548.44
16	102.43	551.26
17	103.10	554.18
18	103.13	554.40

*** 1.661 ***

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.69	535.22
2	57.41	533.95
3	60.22	532.89
4	63.10	532.06
5	66.04	531.45
6	69.02	531.08
7	72.01	530.95
8	75.01	531.05
9	77.99	531.39
10	80.94	531.97
11	83.83	532.77
12	86.64	533.80
13	89.37	535.05
14	91.99	536.51
15	94.49	538.17
16	96.85	540.02
17	99.05	542.06
18	101.09	544.26
19	102.95	546.61
20	104.62	549.11
21	106.08	551.73
22	107.31	554.40

*** 1.675 ***

1

Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.69	535.22
2	57.26	533.66
3	59.95	532.34
4	62.75	531.26
5	65.63	530.43
6	68.58	529.86
7	71.56	529.56
8	74.56	529.52
9	77.55	529.75
10	80.51	530.24
11	83.42	530.99
12	86.24	532.00

13	88.96	533.26
14	91.57	534.75
15	94.03	536.47
16	96.32	538.40
17	98.44	540.52
18	100.36	542.83
19	102.07	545.30
20	103.55	547.90
21	104.79	550.63
22	105.79	553.46
23	106.03	554.40

*** 1.688 ***

Failure Surface Specified By 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.25	535.00
2	54.60	533.14
3	57.12	531.52
4	59.80	530.17
5	62.60	529.09
6	65.50	528.31
7	68.46	527.82
8	71.45	527.64
9	74.45	527.76
10	77.42	528.19
11	80.33	528.91
12	83.15	529.93
13	85.86	531.23
14	88.42	532.79
15	90.80	534.61
16	93.00	536.66
17	94.97	538.92
18	96.70	541.37
19	98.17	543.98
20	99.37	546.73
21	100.29	549.59
22	100.91	552.52
23	101.11	554.40

*** 1.703 ***

1

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.35	534.56
2	49.86	532.92
3	52.49	531.48
4	55.24	530.27
5	58.07	529.28
6	60.97	528.53
7	63.93	528.01
8	66.92	527.74
9	69.91	527.71
10	72.91	527.92
11	75.87	528.38
12	78.79	529.07
13	81.64	530.01
14	84.41	531.16
15	87.07	532.55
16	89.62	534.14
17	92.02	535.93
18	94.27	537.91

19	96.35	540.07
20	98.25	542.40
21	99.96	544.86
22	101.46	547.46
23	102.74	550.18
24	103.80	552.98
25	104.20	554.40

*** 1.706 ***

Failure Surface Specified By 22 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	57.14	535.44
2	59.75	533.97
3	62.49	532.73
4	65.32	531.73
5	68.22	530.98
6	71.18	530.50
7	74.17	530.27
8	77.17	530.31
9	80.16	530.62
10	83.10	531.18
11	85.99	532.00
12	88.79	533.07
13	91.49	534.38
14	94.06	535.93
15	96.49	537.69
16	98.75	539.66
17	100.83	541.82
18	102.71	544.16
19	104.38	546.65
20	105.83	549.28
21	107.04	552.03
22	107.84	554.40

*** 1.719 ***

1

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	45.71	534.41
2	48.06	532.55
3	50.57	530.90
4	53.22	529.49
5	55.98	528.32
6	58.83	527.40
7	61.76	526.74
8	64.74	526.34
9	67.73	526.21
10	70.73	526.36
11	73.70	526.77
12	76.62	527.44
13	79.47	528.38
14	82.23	529.57
15	84.87	531.00
16	87.37	532.66
17	89.71	534.53
18	91.87	536.61
19	93.83	538.88
20	95.59	541.31
21	97.12	543.89
22	98.41	546.60
23	99.46	549.41

24	100.25	552.31
25	100.62	554.40

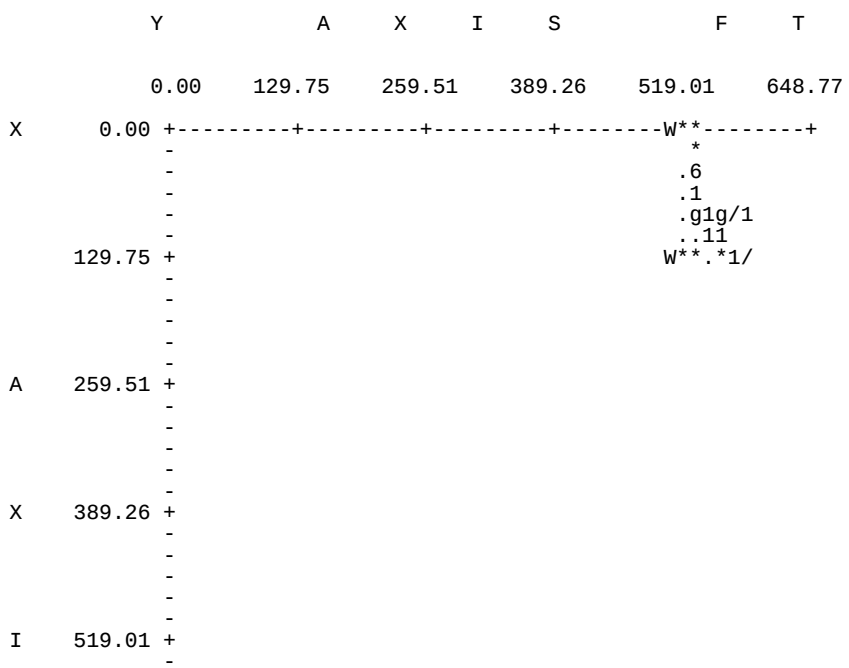
*** 1.745 ***

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	45.71	534.41
2	48.07	532.56
3	50.58	530.91
4	53.23	529.50
5	55.99	528.33
6	58.84	527.40
7	61.77	526.73
8	64.74	526.32
9	67.73	526.18
10	70.73	526.31
11	73.71	526.69
12	76.63	527.34
13	79.49	528.25
14	82.26	529.41
15	84.92	530.81
16	87.44	532.43
17	89.80	534.28
18	92.00	536.32
19	94.00	538.55
20	95.80	540.95
21	97.38	543.50
22	98.73	546.19
23	99.83	548.97
24	100.69	551.85
25	101.20	554.40

*** 1.748 ***

1



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** 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 - Ret. Wall H - Sta
. 448+45 to Sta. 449+50

BOUNDARY COORDINATES

5 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	533.00	30.00	533.00	3
2	30.00	533.00	80.00	537.50	3
3	80.00	537.50	80.10	554.40	1
4	80.10	554.40	91.90	554.40	1
5	91.90	554.40	140.00	554.40	2
6	80.00	537.50	91.80	537.50	3
7	91.80	537.50	91.90	554.40	2
8	91.80	537.50	140.00	537.50	3
9	0.00	522.10	140.00	522.10	4
10	0.00	513.10	140.00	513.10	5

1

ISOTROPIC SOIL PARAMETERS

5 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	115.0	125.0	2000.0	0.0	0.00	0.0	1
4	130.0	135.0	0.0	34.0	0.00	0.0	1
5	125.0	130.0	0.0	30.0	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 No.	X-Water (ft)	Y-Water (ft)

1	0.00	503.10
2	140.00	503.10

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	80.10	140.00	240.0	1.0

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	3	554.4	537.5	16	11.8	1.13	1.0	7500.0

1

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

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 10.00 ft.
and X = 60.00 ft.

Each Surface Terminates Between X = 95.00 ft.
and X = 135.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =500.00 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 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	32.45	533.22
2	34.80	531.36
3	37.25	529.63

4	39.80	528.04
5	42.42	526.59
6	45.13	525.29
7	47.90	524.14
8	50.73	523.14
9	53.61	522.31
10	56.53	521.63
11	59.49	521.12
12	62.47	520.77
13	65.46	520.59
14	68.46	520.57
15	71.46	520.71
16	74.44	521.03
17	77.40	521.51
18	80.33	522.15
19	83.22	522.95
20	86.07	523.91
21	88.85	525.02
22	91.57	526.29
23	94.21	527.71
24	96.78	529.27
25	99.25	530.97
26	101.62	532.80
27	103.89	534.77
28	106.05	536.85
29	108.09	539.05
30	110.00	541.36
31	111.78	543.77
32	113.43	546.28
33	114.94	548.88
34	116.30	551.55
35	117.51	554.30
36	117.55	554.40

*** 3.868 ***

Individual data on the 42 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	2.4	280.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.5	859.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.5	1443.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.6	2020.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.7	2580.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	2.8	3114.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.8	3612.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.9	4065.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.9	1336.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.0	3136.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	3.0	4840.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	3.0	5138.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	3.0	5360.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	3.0	5502.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	3.0	5563.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	3.0	5542.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	3.0	5440.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	2.6	4669.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	0.1	278.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	0.0	79.8	0.0	0.0	0.0	0.0	0.0	0.0	5.0
21	0.2	807.7	0.0	0.0	0.0	0.0	0.0	0.0	51.1
22	2.9	10833.7	0.0	0.0	0.0	0.0	0.0	0.0	693.8
23	2.8	10363.1	0.0	0.0	0.0	0.0	0.0	0.0	682.1
24	2.8	9821.2	0.0	0.0	0.0	0.0	0.0	0.0	668.3
25	2.7	9215.8	0.0	0.0	0.0	0.0	0.0	0.0	652.5
26	0.2	760.6	0.0	0.0	0.0	0.0	0.0	0.0	55.2
27	0.1	330.0	0.0	0.0	0.0	0.0	0.0	0.0	24.0
28	2.3	7465.3	0.0	0.0	0.0	0.0	0.0	0.0	555.5
29	2.6	7850.8	0.0	0.0	0.0	0.0	0.0	0.0	614.9
30	2.5	7110.9	0.0	0.0	0.0	0.0	0.0	0.0	593.3
31	2.4	6347.3	0.0	0.0	0.0	0.0	0.0	0.0	569.8
32	2.3	5571.2	0.0	0.0	0.0	0.0	0.0	0.0	544.6

33	2.2	4794.3	0.0	0.0	0.0	0.0	0.0	0.0	517.7
34	0.6	1241.0	0.0	0.0	0.0	0.0	0.0	0.0	144.2
35	1.4	2781.8	0.0	0.0	0.0	0.0	0.0	0.0	345.1
36	1.9	3259.5	0.0	0.0	0.0	0.0	0.0	0.0	459.3
37	1.8	2531.7	0.0	0.0	0.0	0.0	0.0	0.0	428.0
38	1.6	1852.2	0.0	0.0	0.0	0.0	0.0	0.0	395.3
39	1.5	1232.5	0.0	0.0	0.0	0.0	0.0	0.0	361.4
40	1.4	683.3	0.0	0.0	0.0	0.0	0.0	0.0	326.4
41	1.2	214.4	0.0	0.0	0.0	0.0	0.0	0.0	290.5
42	0.0	0.2	0.0	0.0	0.0	0.0	0.0	0.0	9.4

Individual data on the 16 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	80.0	537.5	91.8	537.5	0.0	11.8	7500.0	0.0
1	2	0	80.0	538.6	91.8	538.6	0.0	11.8	7500.0	0.0
1	3	0	80.0	539.8	91.8	539.8	0.0	11.8	7500.0	0.0
1	4	0	80.0	540.9	91.8	540.9	0.0	11.8	7500.0	0.0
1	5	0	80.0	542.0	91.8	542.0	0.0	11.8	7500.0	0.0
1	6	0	80.0	543.1	91.8	543.1	0.0	11.8	7500.0	0.0
1	7	0	80.0	544.3	91.8	544.3	0.0	11.8	7500.0	0.0
1	8	0	80.0	545.4	91.8	545.4	0.0	11.8	7500.0	0.0
1	9	0	80.1	546.5	91.9	546.5	0.0	11.8	7500.0	0.0
1	10	0	80.1	547.6	91.9	547.6	0.0	11.8	7500.0	0.0
1	11	0	80.1	548.8	91.9	548.8	0.0	11.8	7500.0	0.0
1	12	0	80.1	549.9	91.9	549.9	0.0	11.8	7500.0	0.0
1	13	0	80.1	551.0	91.9	551.0	0.0	11.8	7500.0	0.0
1	14	0	80.1	552.1	91.9	552.1	0.0	11.8	7500.0	0.0
1	15	0	80.1	553.3	91.9	553.3	0.0	11.8	7500.0	0.0
1	16	0	80.1	554.4	91.9	554.4	0.0	11.8	7500.0	0.0

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.41	533.04
2	32.74	531.15
3	35.18	529.40
4	37.69	527.77
5	40.29	526.27
6	42.97	524.91
7	45.71	523.68
8	48.51	522.61
9	51.36	521.67
10	54.25	520.89
11	57.19	520.26
12	60.15	519.78
13	63.13	519.45
14	66.12	519.28
15	69.12	519.26
16	72.12	519.40
17	75.11	519.70
18	78.07	520.15
19	81.01	520.75
20	83.92	521.50
21	86.78	522.40
22	89.59	523.45
23	92.34	524.64
24	95.03	525.97
25	97.64	527.44
26	100.18	529.05
27	102.63	530.78
28	104.98	532.64
29	107.24	534.61
30	109.39	536.70
31	111.43	538.90
32	113.36	541.20
33	115.16	543.60
34	116.84	546.09
35	118.38	548.66
36	119.79	551.31
37	121.06	554.03
38	121.22	554.40

*** 3.868 ***

1

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.31	533.00
2	27.67	531.16
3	30.13	529.43
4	32.67	527.84
5	35.29	526.38
6	37.98	525.05
7	40.73	523.86
8	43.54	522.81
9	46.41	521.91
10	49.31	521.15
11	52.25	520.54
12	55.21	520.08
13	58.19	519.77
14	61.19	519.62
15	64.19	519.61
16	67.19	519.76
17	70.17	520.07
18	73.14	520.52
19	76.08	521.12
20	78.98	521.87
21	81.84	522.77
22	84.66	523.81
23	87.41	525.00
24	90.10	526.32
25	92.73	527.78
26	95.27	529.37
27	97.73	531.09
28	100.10	532.93
29	102.37	534.88
30	104.55	536.95
31	106.61	539.13
32	108.56	541.41
33	110.39	543.79
34	112.10	546.25
35	113.68	548.80
36	115.12	551.43
37	116.44	554.13
38	116.55	554.40

*** 3.878 ***

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.31	533.00
2	27.59	531.05
3	29.97	529.22
4	32.43	527.52
5	34.98	525.94
6	37.61	524.49
7	40.31	523.17
8	43.07	521.99
9	45.88	520.95
10	48.74	520.06
11	51.65	519.31
12	54.59	518.71
13	57.55	518.25
14	60.54	517.95

15	63.53	517.80
16	66.53	517.80
17	69.53	517.94
18	72.51	518.24
19	75.48	518.69
20	78.42	519.29
21	81.33	520.04
22	84.19	520.93
23	87.01	521.97
24	89.77	523.14
25	92.46	524.45
26	95.09	525.90
27	97.64	527.48
28	100.11	529.18
29	102.49	531.01
30	104.78	532.95
31	106.96	535.01
32	109.04	537.17
33	111.01	539.44
34	112.86	541.80
35	114.59	544.25
36	116.19	546.79
37	117.66	549.40
38	119.00	552.08
39	120.01	554.40

*** 3.886 ***

1

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.29	533.00
2	26.58	531.07
3	28.97	529.25
4	31.45	527.57
5	34.02	526.01
6	36.66	524.60
7	39.38	523.32
8	42.15	522.18
9	44.98	521.19
10	47.86	520.35
11	50.78	519.66
12	53.73	519.12
13	56.71	518.73
14	59.70	518.51
15	62.70	518.43
16	65.70	518.52
17	68.69	518.76
18	71.66	519.15
19	74.61	519.70
20	77.53	520.40
21	80.41	521.25
22	83.23	522.25
23	86.01	523.40
24	88.72	524.69
25	91.35	526.11
26	93.91	527.68
27	96.39	529.37
28	98.77	531.19
29	101.06	533.13
30	103.24	535.19
31	105.32	537.36
32	107.27	539.63
33	109.11	542.01
34	110.82	544.47
35	112.40	547.02
36	113.84	549.65
37	115.15	552.35
38	116.01	554.40

*** 3.887 ***

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.33	533.00
2	28.61	531.05
3	30.99	529.22
4	33.45	527.51
5	36.00	525.92
6	38.62	524.46
7	41.31	523.13
8	44.06	521.94
9	46.86	520.88
10	49.72	519.96
11	52.62	519.19
12	55.55	518.55
13	58.51	518.07
14	61.49	517.73
15	64.49	517.53
16	67.49	517.49
17	70.48	517.59
18	73.47	517.84
19	76.45	518.24
20	79.40	518.78
21	82.32	519.47
22	85.20	520.30
23	88.04	521.27
24	90.82	522.39
25	93.55	523.63
26	96.22	525.01
27	98.81	526.52
28	101.32	528.16
29	103.75	529.92
30	106.09	531.79
31	108.34	533.78
32	110.48	535.88
33	112.52	538.08
34	114.45	540.38
35	116.26	542.77
36	117.96	545.25
37	119.52	547.81
38	120.96	550.44
39	122.27	553.14
40	122.81	554.40

*** 3.899 ***

1

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	31.43	533.13
2	33.68	531.14
3	36.04	529.29
4	38.50	527.58
5	41.06	526.01
6	43.70	524.59
7	46.42	523.32
8	49.21	522.22
9	52.06	521.28
10	54.96	520.50
11	57.89	519.89
12	60.86	519.45
13	63.85	519.19
14	66.85	519.09

15	69.85	519.17
16	72.84	519.42
17	75.81	519.85
18	78.75	520.44
19	81.65	521.21
20	84.50	522.14
21	87.29	523.23
22	90.02	524.48
23	92.67	525.89
24	95.23	527.44
25	97.71	529.15
26	100.07	530.99
27	102.33	532.96
28	104.47	535.06
29	106.49	537.29
30	108.37	539.62
31	110.12	542.06
32	111.72	544.60
33	113.17	547.22
34	114.47	549.92
35	115.62	552.70
36	116.21	554.40

*** 3.900 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	29.39	533.00
2	31.60	530.97
3	33.92	529.07
4	36.34	527.30
5	38.86	525.66
6	41.46	524.17
7	44.14	522.82
8	46.89	521.62
9	49.70	520.57
10	52.56	519.68
11	55.47	518.95
12	58.42	518.38
13	61.39	517.98
14	64.38	517.74
15	67.38	517.66
16	70.38	517.75
17	73.37	518.00
18	76.34	518.42
19	79.28	519.00
20	82.19	519.74
21	85.05	520.64
22	87.86	521.70
23	90.60	522.91
24	93.28	524.27
25	95.87	525.77
26	98.38	527.42
27	100.80	529.20
28	103.11	531.11
29	105.31	533.14
30	107.40	535.30
31	109.37	537.56
32	111.21	539.93
33	112.91	542.40
34	114.48	544.96
35	115.90	547.60
36	117.18	550.32
37	118.30	553.10
38	118.75	554.40

*** 3.914 ***

1

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.31	533.00
2	27.55	531.00
3	29.88	529.12
4	32.31	527.36
5	34.82	525.72
6	37.42	524.21
7	40.08	522.83
8	42.81	521.59
9	45.60	520.48
10	48.44	519.52
11	51.33	518.70
12	54.25	518.03
13	57.20	517.50
14	60.18	517.12
15	63.17	516.89
16	66.17	516.81
17	69.17	516.88
18	72.16	517.11
19	75.14	517.48
20	78.09	518.00
21	81.02	518.67
22	83.90	519.48
23	86.75	520.44
24	89.54	521.53
25	92.27	522.77
26	94.94	524.14
27	97.54	525.65
28	100.05	527.28
29	102.48	529.04
30	104.82	530.91
31	107.07	532.90
32	109.21	535.01
33	111.24	537.21
34	113.16	539.52
35	114.97	541.91
36	116.65	544.40
37	118.20	546.97
38	119.62	549.61
39	120.91	552.32
40	121.78	554.40

*** 3.914 ***

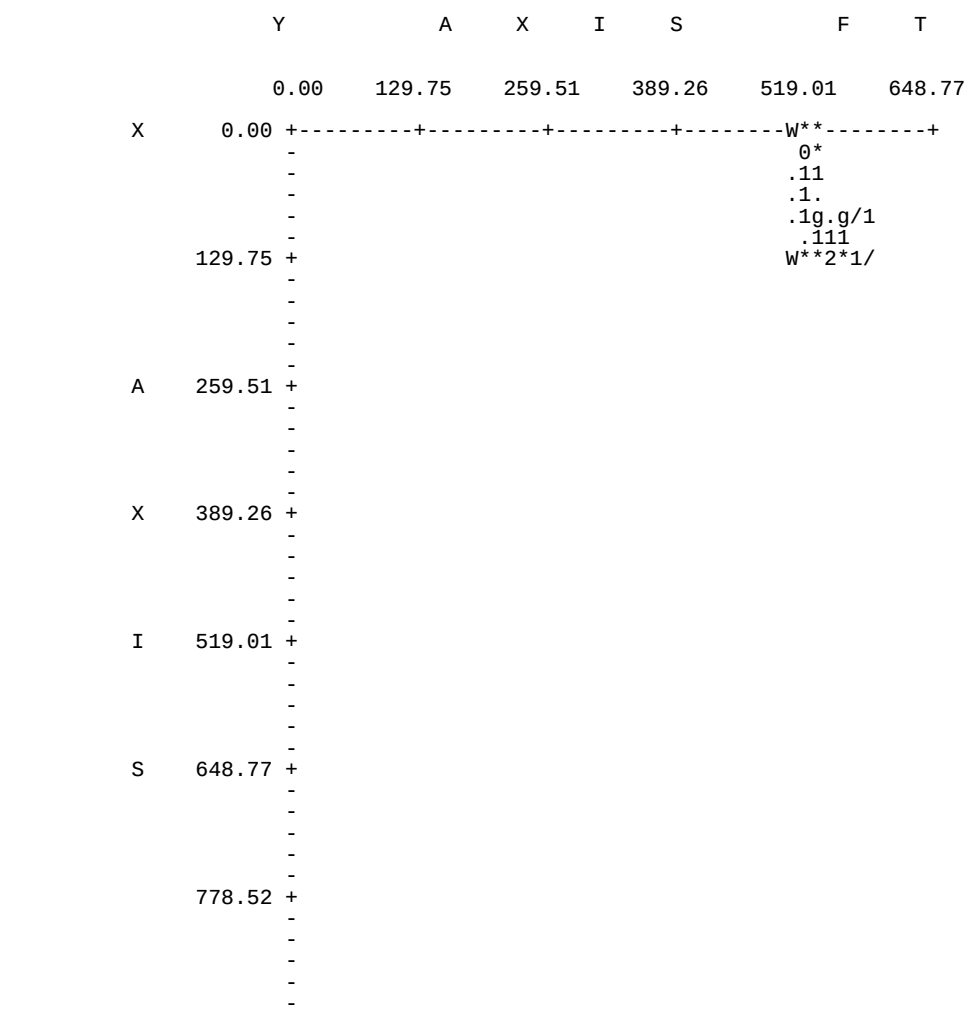
Failure Surface Specified By 42 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	19.18	533.00
2	21.57	531.18
3	24.04	529.48
4	26.58	527.88
5	29.18	526.39
6	31.85	525.02
7	34.58	523.76
8	37.35	522.63
9	40.18	521.62
10	43.04	520.73
11	45.94	519.97
12	48.88	519.34
13	51.83	518.83
14	54.81	518.46
15	57.80	518.21
16	60.80	518.10
17	63.80	518.12
18	66.80	518.27

19	69.78	518.55
20	72.75	518.96
21	75.71	519.50
22	78.63	520.16
23	81.52	520.96
24	84.38	521.88
25	87.19	522.92
26	89.95	524.09
27	92.66	525.38
28	95.32	526.78
29	97.90	528.30
30	100.42	529.93
31	102.87	531.66
32	105.24	533.51
33	107.52	535.45
34	109.72	537.49
35	111.82	539.63
36	113.83	541.86
37	115.74	544.17
38	117.55	546.56
39	119.25	549.03
40	120.85	551.58
41	122.33	554.19
42	122.43	554.40

*** 3.924 ***

1



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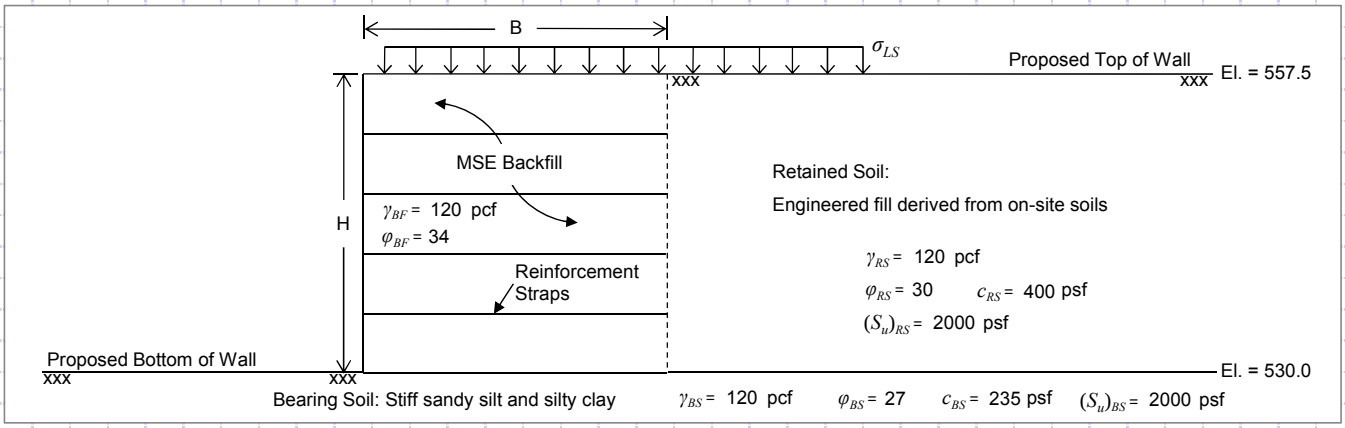
JOB	HAM-75-7.85	NO.	B-10-020
SHEET NO.	1	OF	5
CALCULATED BY	BRT	DATE	8/8/2013
CHECKED BY	JPS	DATE	8/8/2013

Retaining Wall H - Sta. 449+50 to Sta. 451+60

Retaining Wall H - MSE Wall - 27.5 ft. Maximum Wall Height - B-015-0-11 and B-016-0-11



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	27.5	ft
MSE Wall Width (Reinforcement Length), (B) =	19.3	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}) =	120	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	27	°
Bearing Soil Drained Cohesion, (c_{BS}) =	235	psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2000	psf
Embedment Depth, (D) =	3.0	ft

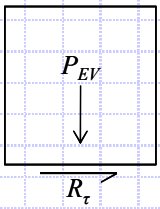
LRFD Load Factors

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



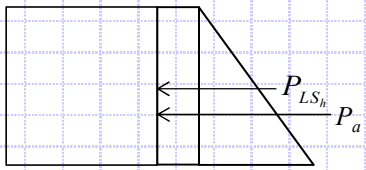
$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$ = (120 pcf)(27.5 ft)(19.3 ft)(1.00) = 63.69 kip/ft

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

$\tan\delta =$ tan(27) ≤ tan(34) ⟶ 0.51 ≤ 0.67 ⟶ $\tan\delta =$ 0.51

R_τ = (63.69 kip/ft)(0.51) = 32.48 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)(27.5 ft)²(0.333)(1.5) = 22.66 kip/ft

$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS}$ = (240 psf)(27.5 ft)(0.333)(1.75) = 3.85 kip/ft

P_H = 22.66 kip/ft + 3.85 kip/ft = 26.51 kip/ft

Check Sliding Resistance

$P_H \le R_\tau \cdot \phi_\tau$ ⟶ 26.51 kip/ft ≤ (32.48 kip/ft)(1.0) = 32.48 kip/ft ⟶ 26.51 kip/ft ≤ 32.48 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	BRT	DATE	8/8/2013
CHECKED BY	JPS	DATE	8/8/2013

Retaining Wall H - Sta. 449+50 to Sta. 451+60

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	27.5	ft
MSE Wall Width (Reinforcement Length), (B) =	19.3	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:

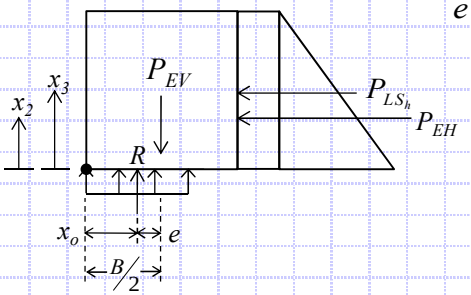
Bearing Soil Unit Weight, (γ_{BS}) =	120	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	27	°
Bearing Soil Drained Cohesion, (c_{BS}) =	235	psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	2000	psf
Embedment Depth, (D) =	3.0	ft

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



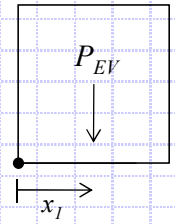
$$e = B/2 - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = \text{(614.61 kip·ft/ft - 260.73 kip·ft/ft) / (63.69 kip/ft)} = 5.56 \text{ ft}$$

M_{EV} = 614.61 kip·ft/ft
M_H = 260.73 kip·ft/ft
P_{EV} = 63.69 kip/ft
} Defined below

$e =$ (19.3 ft)/2 - 5.56 ft = 4.09 ft

Resisting Moment, M_{EV}:



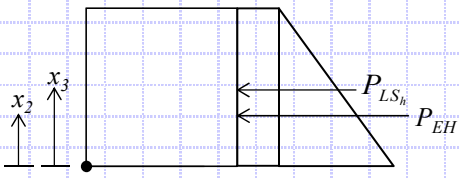
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = \text{(120 pcf)(27.5 ft)(19.3 ft)(1.00)} = 63.69 \text{ kip/ft}$$

$$x_1 = B/2 = \text{(19.3 ft) / 2} = 9.65 \text{ ft}$$

$$M_{EV} = \text{(63.69 kip/ft)(9.65 ft)} = 614.61 \text{ kip·ft/ft}$$

Overturning Moment, M_H:



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

$$P_{EH} = \tfrac{1}{2}\gamma_{RS} H^2 K_a \gamma_{EH} = \text{½(120 pcf)(27.5 ft)²(0.333)(1.5)} = 22.66 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = \text{(240 psf)(27.5 ft)(0.333)(1.75)} = 3.85 \text{ kip/ft}$$

$$x_2 = H/3 = \text{(27.5 ft) / 3} = 9.17 \text{ ft}$$

$$x_3 = H/2 = \text{(27.5 ft) / 2} = 13.75 \text{ ft}$$

$$M_H = \text{(22.66 kip/ft)(9.17 ft) + (3.85 kip/ft)(13.75 ft)} = 260.73 \text{ kip·ft/ft}$$

Limiting Eccentricity:

$$e_{max} = B/4 \longrightarrow e_{max} = \text{(19.3 ft) / 4} = 4.83 \text{ ft}$$

Check Eccentricity

$e < e_{max} \longrightarrow$ 4.09 ft < 4.83 ft **OK**

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

Retaining Wall H - Sta. 449+50 to Sta. 451+60

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	27.5	ft
MSE Wall Width (Reinforcement Length), (B) =	19.3	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:

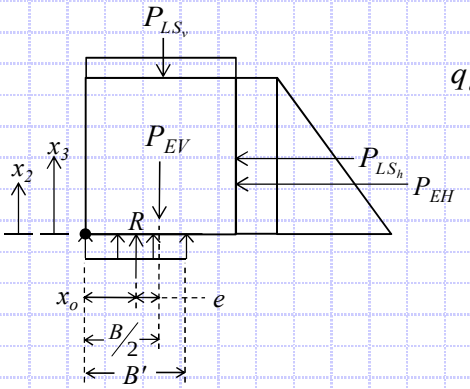
Bearing Soil Unit Weight, (γ_{BS}) =	120	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	27	°
Bearing Soil Drained Cohesion, (c_{BS}) =	235	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	2000	psf
Embedment Depth, (D) =	3.0	ft

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



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

$B' = B - 2e$ = 19.3 ft - 2(2.77 ft) = 13.76 ft

$e = B/2 - x_o$ = (19.3 ft) / 2 - 6.88 ft = 2.77 ft

$x_o = \frac{M_V - M_H}{P_V}$ = (907.94 kip·ft/ft - 260.72 kip·ft/ft) / 94.09 kip/ft = 6.88 ft

q_{eq} = (94.09 kip/ft) / (13.76 ft) = 6.84 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)(27.5 ft)(19.3 ft)(1.35)](9.65 ft) + [(240 psf)(19.3 ft)(1.75)](9.65 ft) = 907.94 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)(27.5 ft)²(0.333)(1.5)](9.17 ft) + [(240 psf)(27.5 ft)(0.333)(1.75)](13.75 ft) = 260.72 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)(27.5 ft)(19.3 ft)(1.35) + (240 psf)(19.3 ft)(1.75) = 94.09 kip/ft

Nominal Bearing Resistance:

$q_n = cN_c + \gamma D N_q + \tfrac{1}{2}\gamma B N_\gamma$ = (2000 psf)(5.7) + (120 pcf)(3.0 ft)(1.0) + ½(120 pcf)(19.3 ft)(0.0) = 11.8 ksf

N_c = 5.7 N_q = 1.0 N_γ = 0.0

Check Bearing Capacity

$q_{eq} \le q_n \cdot \phi_b$ ⟶ 6.84 ksf ≤ (11.8 ksf)(0.65) = 7.67 ksf ⟶ 6.84 ksf ≤ 7.67 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	BRT	DATE	8/8/2013
CHECKED BY	JPS	DATE	8/8/2013

Retaining Wall H - Sta. 449+50 to Sta. 451+60

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	27.5	ft
MSE Wall Width (Reinforcement Length), (B) =	19.3	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}) =	120	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	27	°
Bearing Soil Drained Cohesion, (c_{BS}) =	235	psf
Bearing Soil Undrained Shear Strength, [(s_u)$_{BS}$] =	2000	psf
Embedment Depth, (D) =	3.0	ft

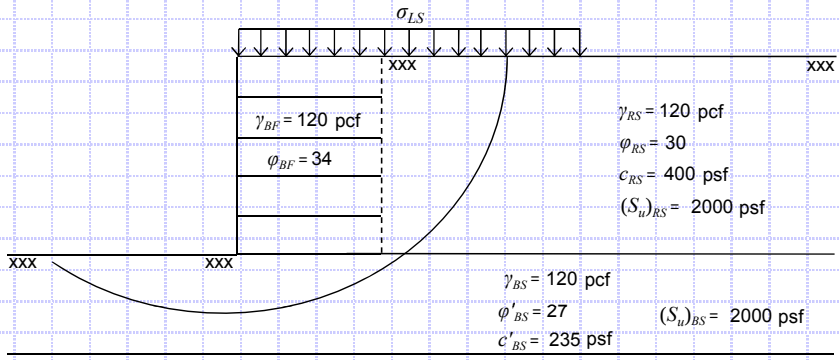
LRFD Load Factors

	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)

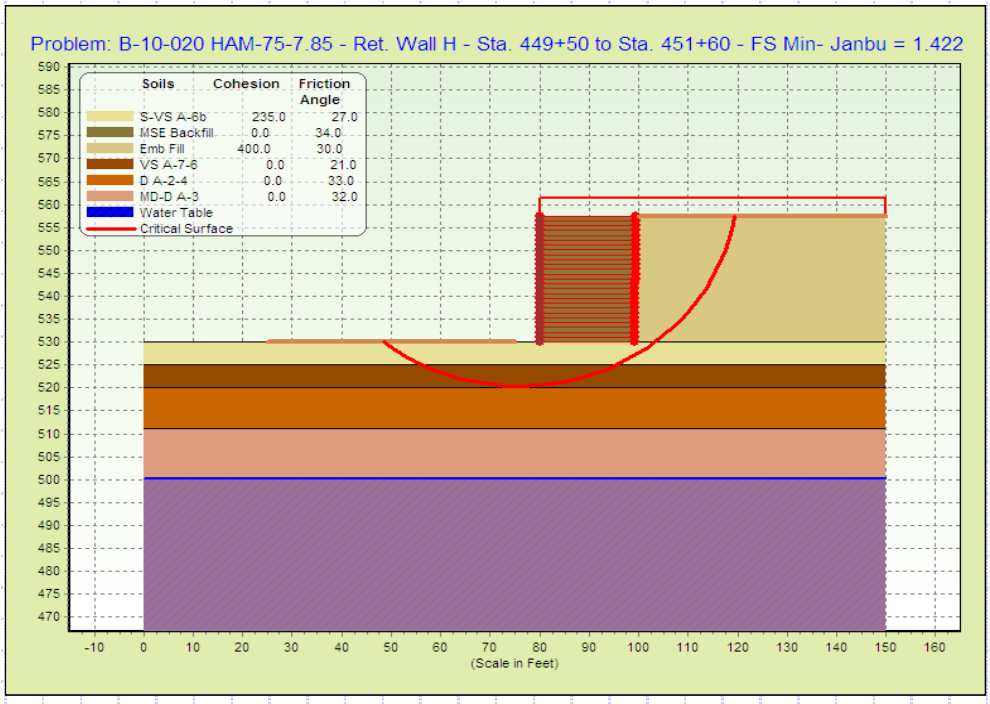
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

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

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.00 ≤ (1.422)(0.75) = 1.07 ⟶ 1.00 ≤ 1.07 **OK**

FS = **1.422** *(From STABL Slope Stability Analysis)*

Use φ_{GS} = **0.75** *(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	BRT	DATE	8/8/2013
CHECKED BY	JPS	DATE	8/8/2013

Retaining Wall H - Sta. 449+50 to Sta. 451+60

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	27.5	ft
MSE Wall Width (Reinforcement Length), (B) =	19.3	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}) =	120	pcf
Bearing Soil Friction Angle, (φ_{BS}) =	27	°
Bearing Soil Drained Cohesion, (c_{BS}) =	235	psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	2000	psf
Embedment Depth, (D) =	3.0	ft

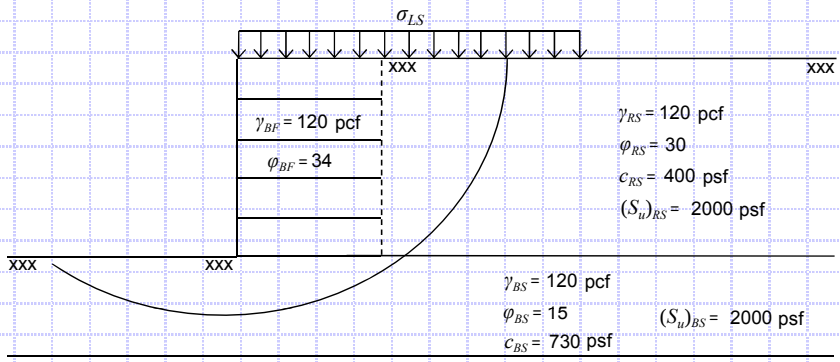
LRFD Load Factors

	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)

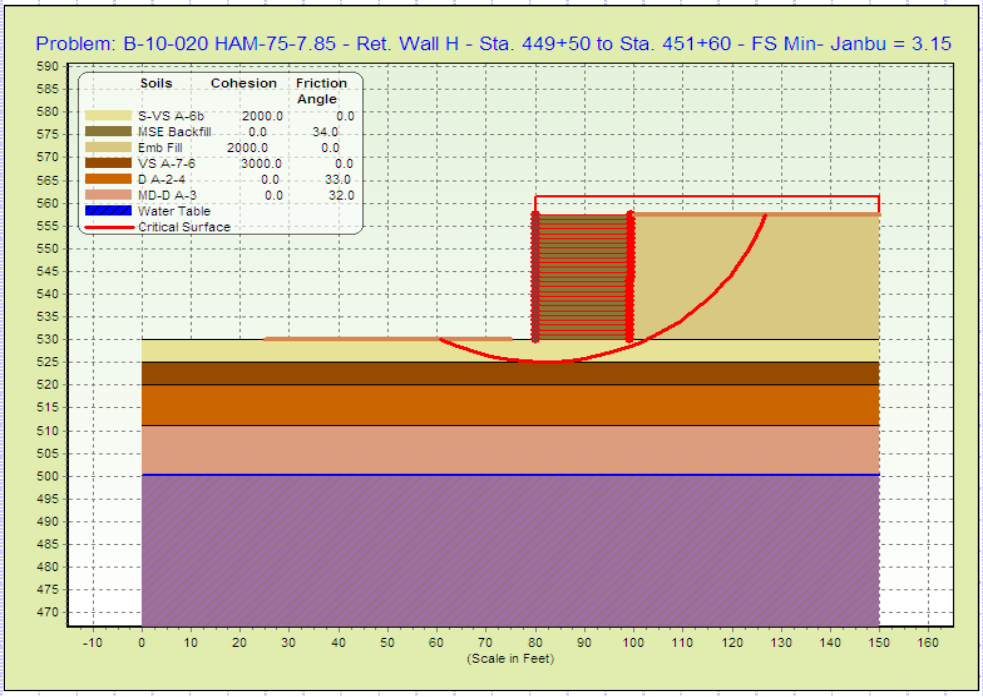
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 ***(Cont'd)***

Short Term Stability - Undrained Conditions



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

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



Check Overall (Global) Stability

$1.0 \le FS \cdot \phi_{GS}$ ⟶ 1.00 ≤ (3.15)(0.75) = 2.36 ⟶ 1.00 ≤ 2.36 **OK**

FS = **3.15** *(From STABL Slope Stability Analysis)*

Use φ_{GS} = **0.75** *(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 - Ret. Wall H - Sta
. 449+50 to Sta. 451+60

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	530.00	80.00	530.00	3
2	80.00	530.00	80.10	557.50	1
3	80.10	557.50	99.40	557.50	1
4	99.40	557.50	150.00	557.50	2
5	80.00	530.00	99.30	530.00	3
6	99.30	530.00	99.40	557.50	2
7	99.30	530.00	150.00	530.00	3
8	0.00	525.10	150.00	525.10	4
9	0.00	520.10	150.00	520.10	5
10	0.00	511.10	150.00	511.10	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	120.0	130.0	235.0	27.0	0.00	0.0	1
4	120.0	130.0	0.0	21.0	0.00	0.0	1
5	130.0	135.0	0.0	33.0	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	500.10
2	150.00	500.10

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	80.10	150.00	240.0	1.0

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	557.5	530.0	27	19.3	1.06	1.0	7500.0

1

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

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 25.00 ft.
and X = 75.00 ft.

Each Surface Terminates Between X = 100.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =500.00 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 26 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.45	530.00
2	50.01	528.43
3	52.69	527.09

4	55.48	525.99
5	58.36	525.15
6	61.30	524.55
7	64.28	524.22
8	67.28	524.16
9	70.28	524.35
10	73.24	524.81
11	76.15	525.53
12	78.99	526.50
13	81.73	527.72
14	84.36	529.17
15	86.85	530.85
16	89.18	532.74
17	91.33	534.82
18	93.29	537.09
19	95.05	539.52
20	96.59	542.10
21	97.89	544.80
22	98.95	547.61
23	99.76	550.50
24	100.31	553.45
25	100.60	556.43
26	100.61	557.50

Factor Of Safety For The Preceding Specified Surface = -2.054

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	60.71	530.00
2	63.58	529.09
3	66.51	528.47
4	69.49	528.12
5	72.49	528.06
6	75.48	528.28
7	78.44	528.79
8	81.33	529.58
9	84.14	530.64
10	86.83	531.96
11	89.39	533.53
12	91.78	535.34
13	93.99	537.37
14	96.00	539.60
15	97.79	542.01
16	99.33	544.58
17	100.63	547.28
18	101.67	550.10
19	102.43	553.00
20	102.91	555.96
21	103.01	557.50

Factor Of Safety For The Preceding Specified Surface = -4.812

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 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	48.47	530.00
2	50.88	528.21
3	53.40	526.59
4	56.03	525.14
5	58.75	523.87
6	61.55	522.80
7	64.41	521.91
8	67.33	521.23
9	70.29	520.74
10	73.28	520.46
11	76.28	520.38
12	79.28	520.50
13	82.26	520.83
14	85.21	521.37
15	88.12	522.10
16	90.97	523.03
17	93.76	524.15
18	96.46	525.46
19	99.06	526.95
20	101.56	528.61
21	103.94	530.44
22	106.18	532.43
23	108.29	534.56
24	110.25	536.83
25	112.04	539.24
26	113.67	541.76
27	115.13	544.38
28	116.40	547.10
29	117.48	549.90
30	118.37	552.76
31	119.06	555.68
32	119.37	557.50

*** 1.422 ***

Individual data on the 38 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	2.4	258.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.5	788.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.6	1305.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.1	47.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.6	1746.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	2.8	2239.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.9	2630.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.9	2954.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	3.0	3203.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.0	3369.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	3.0	3448.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	3.0	3438.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.7	819.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.1	277.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	2.2	9532.1	0.0	0.0	0.0	0.0	0.0	0.0	518.3
16	3.0	12896.0	0.0	0.0	0.0	0.0	0.0	0.0	708.6
17	2.9	12486.8	0.0	0.0	0.0	0.0	0.0	0.0	698.2
18	2.9	11959.3	0.0	0.0	0.0	0.0	0.0	0.0	684.6
19	2.8	11323.9	0.0	0.0	0.0	0.0	0.0	0.0	667.8
20	2.0	7746.6	0.0	0.0	0.0	0.0	0.0	0.0	471.3
21	0.7	2846.6	0.0	0.0	0.0	0.0	0.0	0.0	176.7
22	2.6	9781.8	0.0	0.0	0.0	0.0	0.0	0.0	625.1
23	0.2	875.8	0.0	0.0	0.0	0.0	0.0	0.0	57.5
24	0.1	364.3	0.0	0.0	0.0	0.0	0.0	0.0	24.0
25	2.2	7665.6	0.0	0.0	0.0	0.0	0.0	0.0	517.8

26	1.8	6118.9	0.0	0.0	0.0	0.0	0.0	0.0	434.0
27	0.6	1863.8	0.0	0.0	0.0	0.0	0.0	0.0	136.6
28	2.2	7030.9	0.0	0.0	0.0	0.0	0.0	0.0	539.4
29	2.1	6069.8	0.0	0.0	0.0	0.0	0.0	0.0	505.7
30	2.0	5118.8	0.0	0.0	0.0	0.0	0.0	0.0	469.6
31	1.8	4197.2	0.0	0.0	0.0	0.0	0.0	0.0	431.3
32	1.6	3324.1	0.0	0.0	0.0	0.0	0.0	0.0	391.0
33	1.5	2517.5	0.0	0.0	0.0	0.0	0.0	0.0	348.9
34	1.3	1794.5	0.0	0.0	0.0	0.0	0.0	0.0	305.2
35	1.1	1170.5	0.0	0.0	0.0	0.0	0.0	0.0	260.0
36	0.9	659.4	0.0	0.0	0.0	0.0	0.0	0.0	213.7
37	0.7	272.8	0.0	0.0	0.0	0.0	0.0	0.0	166.3
38	0.3	33.1	0.0	0.0	0.0	0.0	0.0	0.0	72.7

Individual data on the 27 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	80.0	530.0	99.3	530.0	0.0	19.3	7500.0	0.0
1	2	0	80.0	531.1	99.3	531.1	0.0	19.3	7500.0	0.0
1	3	0	80.0	532.1	99.3	532.1	0.0	19.3	7500.0	0.0
1	4	0	80.0	533.2	99.3	533.2	0.0	19.3	7500.0	0.0
1	5	0	80.0	534.2	99.3	534.2	0.0	19.3	7500.0	0.0
1	6	0	80.0	535.3	99.3	535.3	0.0	19.3	7500.0	0.0
1	7	0	80.0	536.3	99.3	536.3	0.0	19.3	7500.0	0.0
1	8	0	80.0	537.4	99.3	537.4	0.0	19.3	7500.0	0.0
1	9	0	80.0	538.5	99.3	538.5	0.0	19.3	7500.0	0.0
1	10	0	80.0	539.5	99.3	539.5	0.0	19.3	7500.0	0.0
1	11	0	80.0	540.6	99.3	540.6	0.0	19.3	7500.0	0.0
1	12	0	80.0	541.6	99.3	541.6	0.0	19.3	7500.0	0.0
1	13	0	80.0	542.7	99.3	542.7	0.0	19.3	7500.0	0.0
1	14	0	80.1	543.8	99.4	543.8	0.0	19.3	7500.0	0.0
1	15	0	80.1	544.8	99.4	544.8	0.0	19.3	7500.0	0.0
1	16	0	80.1	545.9	99.4	545.9	0.0	19.3	7500.0	0.0
1	17	0	80.1	546.9	99.4	546.9	0.0	19.3	7500.0	0.0
1	18	0	80.1	548.0	99.4	548.0	0.0	19.3	7500.0	0.0
1	19	0	80.1	549.0	99.4	549.0	0.0	19.3	7500.0	0.0
1	20	0	80.1	550.1	99.4	550.1	0.0	19.3	7500.0	0.0
1	21	0	80.1	551.2	99.4	551.2	0.0	19.3	7500.0	0.0
1	22	0	80.1	552.2	99.4	552.2	0.0	19.3	7500.0	0.0
1	23	0	80.1	553.3	99.4	553.3	0.0	19.3	7500.0	0.0
1	24	0	80.1	554.3	99.4	554.3	0.0	19.3	7500.0	0.0
1	25	0	80.1	555.4	99.4	555.4	0.0	19.3	7500.0	0.0
1	26	0	80.1	556.4	99.4	556.4	0.0	19.3	7500.0	0.0
1	27	0	80.1	557.5	99.4	557.5	0.0	19.3	7500.0	0.0

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	53.57	530.00
2	55.98	528.21
3	58.51	526.60
4	61.16	525.19
5	63.91	523.99
6	66.74	522.99
7	69.64	522.22
8	72.58	521.66
9	75.57	521.33
10	78.56	521.23
11	81.56	521.35
12	84.54	521.70
13	87.49	522.27
14	90.38	523.06
15	93.20	524.08
16	95.94	525.30
17	98.58	526.72
18	101.11	528.34
19	103.50	530.15
20	105.76	532.13
21	107.85	534.28
22	109.78	536.58
23	111.53	539.02
24	113.08	541.58

25	114.44	544.25
26	115.60	547.02
27	116.54	549.87
28	117.26	552.78
29	117.76	555.74
30	117.92	557.50

*** 1.440 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	42.35	530.00
2	44.92	528.46
3	47.58	527.06
4	50.31	525.82
5	53.10	524.73
6	55.95	523.80
7	58.85	523.03
8	61.79	522.43
9	64.76	521.99
10	67.75	521.72
11	70.75	521.62
12	73.75	521.68
13	76.74	521.92
14	79.71	522.32
15	82.66	522.89
16	85.56	523.62
17	88.43	524.52
18	91.24	525.57
19	93.98	526.78
20	96.65	528.14
21	99.25	529.65
22	101.75	531.31
23	104.16	533.10
24	106.46	535.02
25	108.65	537.07
26	110.72	539.24
27	112.67	541.53
28	114.48	543.92
29	116.16	546.40
30	117.69	548.98
31	119.08	551.64
32	120.32	554.37
33	121.40	557.17
34	121.51	557.50

*** 1.467 ***

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	50.51	530.00
2	52.82	528.09
3	55.28	526.36
4	57.85	524.82
5	60.53	523.47
6	63.30	522.33
7	66.15	521.39
8	69.06	520.67
9	72.02	520.17
10	75.01	519.90
11	78.01	519.84
12	81.01	520.01

13	83.98	520.41
14	86.92	521.02
15	89.80	521.85
16	92.61	522.90
17	95.34	524.15
18	97.96	525.60
19	100.47	527.24
20	102.85	529.06
21	105.09	531.06
22	107.18	533.22
23	109.09	535.53
24	110.83	537.97
25	112.38	540.54
26	113.74	543.22
27	114.89	545.99
28	115.83	548.84
29	116.56	551.75
30	117.07	554.70
31	117.33	557.50

*** 1.486 ***

1

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.37	530.00
2	45.84	528.30
3	48.40	526.74
4	51.05	525.34
5	53.78	524.09
6	56.58	523.00
7	59.43	522.07
8	62.33	521.32
9	65.28	520.73
10	68.25	520.31
11	71.24	520.07
12	74.24	520.00
13	77.23	520.10
14	80.22	520.38
15	83.19	520.83
16	86.12	521.45
17	89.02	522.24
18	91.86	523.20
19	94.64	524.32
20	97.35	525.60
21	99.99	527.04
22	102.54	528.62
23	104.99	530.35
24	107.33	532.22
25	109.57	534.22
26	111.68	536.35
27	113.67	538.60
28	115.52	540.96
29	117.23	543.42
30	118.80	545.98
31	120.22	548.62
32	121.48	551.34
33	122.58	554.14
34	123.52	556.99
35	123.66	557.50

*** 1.487 ***

Failure Surface Specified By 34 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	42.35	530.00
2	44.69	528.12
3	47.15	526.41
4	49.71	524.85
5	52.38	523.47
6	55.13	522.27
7	57.95	521.26
8	60.83	520.43
9	63.77	519.79
10	66.73	519.35
11	69.72	519.11
12	72.72	519.06
13	75.72	519.21
14	78.70	519.56
15	81.65	520.11
16	84.56	520.85
17	87.41	521.78
18	90.19	522.89
19	92.90	524.19
20	95.51	525.66
21	98.02	527.30
22	100.42	529.11
23	102.69	531.07
24	104.83	533.17
25	106.83	535.41
26	108.67	537.78
27	110.35	540.26
28	111.87	542.85
29	113.21	545.53
30	114.37	548.30
31	115.34	551.14
32	116.13	554.03
33	116.72	556.97
34	116.79	557.50

*** 1.511 ***

1

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.45	530.00
2	50.08	528.56
3	52.79	527.27
4	55.57	526.14
5	58.41	525.17
6	61.30	524.36
7	64.23	523.72
8	67.19	523.24
9	70.17	522.94
10	73.17	522.80
11	76.17	522.84
12	79.16	523.04
13	82.14	523.42
14	85.09	523.96
15	88.00	524.67
16	90.87	525.55
17	93.69	526.58
18	96.44	527.78
19	99.12	529.13
20	101.72	530.63
21	104.23	532.28
22	106.64	534.06
23	108.94	535.98
24	111.13	538.03
25	113.21	540.20
26	115.15	542.48
27	116.96	544.87
28	118.64	547.36
29	120.17	549.94

30	121.55	552.61
31	122.77	555.35
32	123.59	557.50

*** 1.520 ***

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	42.35	530.00
2	44.91	528.44
3	47.55	527.01
4	50.26	525.72
5	53.03	524.58
6	55.86	523.58
7	58.74	522.73
8	61.65	522.03
9	64.60	521.48
10	67.58	521.08
11	70.57	520.84
12	73.56	520.76
13	76.56	520.83
14	79.56	521.05
15	82.53	521.43
16	85.48	521.97
17	88.40	522.66
18	91.28	523.50
19	94.12	524.48
20	96.90	525.61
21	99.61	526.89
22	102.26	528.30
23	104.83	529.85
24	107.31	531.53
25	109.71	533.34
26	112.00	535.27
27	114.20	537.31
28	116.28	539.47
29	118.25	541.73
30	120.10	544.09
31	121.83	546.55
32	123.43	549.09
33	124.89	551.71
34	126.21	554.40
35	127.39	557.16
36	127.52	557.50

*** 1.521 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	46.43	530.00
2	48.98	528.43
3	51.62	527.00
4	54.33	525.72
5	57.11	524.59
6	59.95	523.61
7	62.84	522.79
8	65.76	522.13
9	68.72	521.64
10	71.70	521.30
11	74.70	521.13
12	77.70	521.13
13	80.69	521.29

14	83.68	521.62
15	86.64	522.11
16	89.56	522.76
17	92.45	523.57
18	95.29	524.54
19	98.07	525.66
20	100.79	526.93
21	103.43	528.36
22	105.99	529.92
23	108.46	531.62
24	110.83	533.46
25	113.10	535.42
26	115.26	537.51
27	117.29	539.71
28	119.21	542.02
29	120.99	544.43
30	122.64	546.94
31	124.15	549.53
32	125.51	552.21
33	126.73	554.95
34	127.69	557.50

*** 1.526 ***

Failure Surface Specified By 31 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	53.57	530.00
2	56.11	528.40
3	58.74	526.96
4	61.46	525.70
5	64.26	524.61
6	67.12	523.71
7	70.03	522.99
8	72.99	522.46
9	75.97	522.12
10	78.96	521.97
11	81.96	522.02
12	84.95	522.26
13	87.92	522.68
14	90.86	523.30
15	93.75	524.11
16	96.58	525.10
17	99.34	526.27
18	102.02	527.62
19	104.61	529.13
20	107.10	530.81
21	109.47	532.65
22	111.72	534.63
23	113.84	536.75
24	115.82	539.01
25	117.65	541.39
26	119.32	543.88
27	120.83	546.47
28	122.17	549.15
29	123.33	551.92
30	124.32	554.75
31	125.08	557.50

*** 1.526 ***

1

```
          Y           A     X     I     S           F     T

          0.00    130.48    260.96    391.44    521.92    652.39

X      0.00 +---------+---------+---------+-------W***--------+
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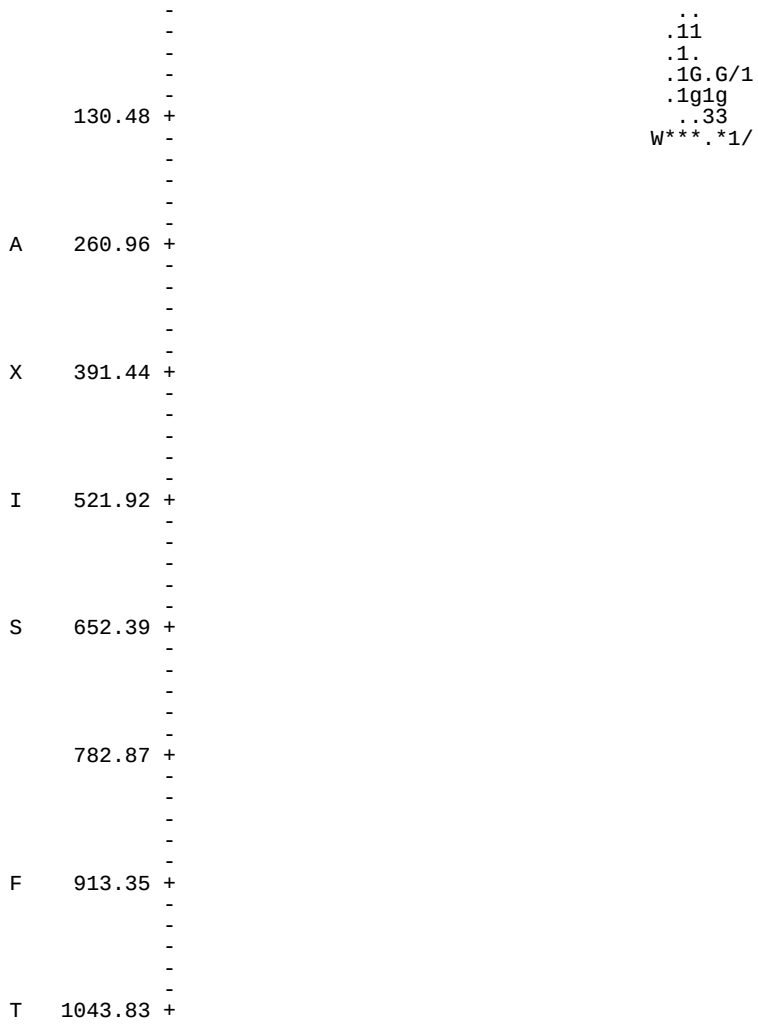
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X 391.44
I 521.92
S 652.39
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F 913.35
T 1043.83

** 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 - Ret. Wall H - Sta
. 449+50 to Sta. 451+60

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	530.00	80.00	530.00	3
2	80.00	530.00	80.10	557.50	1
3	80.10	557.50	99.40	557.50	1
4	99.40	557.50	150.00	557.50	2
5	80.00	530.00	99.30	530.00	3
6	99.30	530.00	99.40	557.50	2
7	99.30	530.00	150.00	530.00	3
8	0.00	525.10	150.00	525.10	4
9	0.00	520.10	150.00	520.10	5
10	0.00	511.10	150.00	511.10	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	120.0	130.0	2000.0	0.0	0.00	0.0	1
4	120.0	130.0	3000.0	0.0	0.00	0.0	1
5	130.0	135.0	0.0	33.0	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	500.10
2	150.00	500.10

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	80.10	150.00	240.0	1.0

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	557.5	530.0	27	19.3	1.06	1.0	7500.0

1

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

500 Trial Surfaces Have Been Generated.

10 Surfaces Initiate From Each Of 50 Points Equally Spaced Along The Ground Surface Between X = 25.00 ft.
and X = 75.00 ft.

Each Surface Terminates Between X = 100.00 ft.
and X = 150.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y =500.00 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 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	60.71	530.00
2	63.45	528.76

3	66.25	527.70
4	69.12	526.81
5	72.03	526.11
6	74.99	525.59
7	77.97	525.26
8	80.97	525.12
9	83.97	525.17
10	86.96	525.41
11	89.93	525.84
12	92.86	526.46
13	95.76	527.26
14	98.59	528.24
15	101.36	529.39
16	104.05	530.72
17	106.65	532.22
18	109.15	533.88
19	111.54	535.69
20	113.81	537.65
21	115.95	539.75
22	117.96	541.98
23	119.82	544.33
24	121.53	546.80
25	123.08	549.37
26	124.46	552.03
27	125.67	554.78
28	126.68	557.50

*** 3.150 ***

Individual data on the 32 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Earthquake Force Tan (lbs)	Force Hor (lbs)	Force Ver (lbs)	Surcharge Load (lbs)
1	2.7	203.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.8	596.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.9	944.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.9	1238.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	3.0	1471.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	3.0	1635.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.0	1163.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.1	223.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.9	3373.4	0.0	0.0	0.0	0.0	0.0	0.0	208.5
10	3.0	11644.5	0.0	0.0	0.0	0.0	0.0	0.0	719.9
11	3.0	11557.1	0.0	0.0	0.0	0.0	0.0	0.0	717.7
12	3.0	11356.6	0.0	0.0	0.0	0.0	0.0	0.0	712.6
13	2.9	11046.9	0.0	0.0	0.0	0.0	0.0	0.0	704.7
14	2.9	10633.5	0.0	0.0	0.0	0.0	0.0	0.0	694.0
15	2.8	10124.0	0.0	0.0	0.0	0.0	0.0	0.0	680.5
16	0.7	2474.9	0.0	0.0	0.0	0.0	0.0	0.0	170.0
17	0.1	347.4	0.0	0.0	0.0	0.0	0.0	0.0	24.0
18	2.0	6705.6	0.0	0.0	0.0	0.0	0.0	0.0	470.3
19	1.2	4098.7	0.0	0.0	0.0	0.0	0.0	0.0	294.8
20	1.5	4757.2	0.0	0.0	0.0	0.0	0.0	0.0	350.6
21	2.6	8120.6	0.0	0.0	0.0	0.0	0.0	0.0	624.0
22	2.5	7335.7	0.0	0.0	0.0	0.0	0.0	0.0	600.0
23	2.4	6515.9	0.0	0.0	0.0	0.0	0.0	0.0	573.7
24	2.3	5676.5	0.0	0.0	0.0	0.0	0.0	0.0	545.0
25	2.1	4833.7	0.0	0.0	0.0	0.0	0.0	0.0	514.2
26	2.0	4003.6	0.0	0.0	0.0	0.0	0.0	0.0	481.4
27	1.9	3202.4	0.0	0.0	0.0	0.0	0.0	0.0	446.6
28	1.7	2446.2	0.0	0.0	0.0	0.0	0.0	0.0	410.0
29	1.5	1750.2	0.0	0.0	0.0	0.0	0.0	0.0	371.8
30	1.4	1129.0	0.0	0.0	0.0	0.0	0.0	0.0	332.1
31	1.2	596.2	0.0	0.0	0.0	0.0	0.0	0.0	291.1
32	1.0	164.1	0.0	0.0	0.0	0.0	0.0	0.0	240.9

Individual data on the 27 geosynthetics

Group	Level	Slice	Head Coordinates (ft)	End Coordinates (ft)	T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %

1	1	0	80.0	530.0	99.3	530.0	0.0	19.3	7500.0	0.0
1	2	0	80.0	531.1	99.3	531.1	0.0	19.3	7500.0	0.0
1	3	0	80.0	532.1	99.3	532.1	0.0	19.3	7500.0	0.0
1	4	0	80.0	533.2	99.3	533.2	0.0	19.3	7500.0	0.0
1	5	0	80.0	534.2	99.3	534.2	0.0	19.3	7500.0	0.0
1	6	0	80.0	535.3	99.3	535.3	0.0	19.3	7500.0	0.0
1	7	0	80.0	536.3	99.3	536.3	0.0	19.3	7500.0	0.0
1	8	0	80.0	537.4	99.3	537.4	0.0	19.3	7500.0	0.0
1	9	0	80.0	538.5	99.3	538.5	0.0	19.3	7500.0	0.0
1	10	0	80.0	539.5	99.3	539.5	0.0	19.3	7500.0	0.0
1	11	0	80.0	540.6	99.3	540.6	0.0	19.3	7500.0	0.0
1	12	0	80.0	541.6	99.3	541.6	0.0	19.3	7500.0	0.0
1	13	0	80.0	542.7	99.3	542.7	0.0	19.3	7500.0	0.0
1	14	0	80.1	543.8	99.4	543.8	0.0	19.3	7500.0	0.0
1	15	0	80.1	544.8	99.4	544.8	0.0	19.3	7500.0	0.0
1	16	0	80.1	545.9	99.4	545.9	0.0	19.3	7500.0	0.0
1	17	0	80.1	546.9	99.4	546.9	0.0	19.3	7500.0	0.0
1	18	0	80.1	548.0	99.4	548.0	0.0	19.3	7500.0	0.0
1	19	0	80.1	549.0	99.4	549.0	0.0	19.3	7500.0	0.0
1	20	0	80.1	550.1	99.4	550.1	0.0	19.3	7500.0	0.0
1	21	0	80.1	551.2	99.4	551.2	0.0	19.3	7500.0	0.0
1	22	0	80.1	552.2	99.4	552.2	0.0	19.3	7500.0	0.0
1	23	0	80.1	553.3	99.4	553.3	0.0	19.3	7500.0	0.0
1	24	0	80.1	554.3	99.4	554.3	0.0	19.3	7500.0	0.0
1	25	0	80.1	555.4	99.4	555.4	0.0	19.3	7500.0	0.0
1	26	0	80.1	556.4	99.4	556.4	0.0	19.3	7500.0	0.0
1	27	0	80.1	557.5	99.4	557.5	0.0	19.3	7500.0	0.0

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	59.69	530.00
2	62.52	528.98
3	65.39	528.11
4	68.30	527.40
5	71.25	526.85
6	74.23	526.47
7	77.22	526.24
8	80.22	526.18
9	83.22	526.27
10	86.20	526.54
11	89.17	526.96
12	92.12	527.54
13	95.02	528.29
14	97.89	529.19
15	100.69	530.24
16	103.44	531.44
17	106.12	532.80
18	108.72	534.29
19	111.24	535.93
20	113.66	537.69
21	115.98	539.59
22	118.20	541.61
23	120.31	543.75
24	122.29	546.00
25	124.15	548.35
26	125.88	550.80
27	127.47	553.35
28	128.93	555.97
29	129.67	557.50

*** 3.153 ***

1

Failure Surface Specified By 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	72.96	530.00

2	75.85	529.19
3	78.78	528.57
4	81.75	528.14
5	84.74	527.91
6	87.74	527.87
7	90.74	528.02
8	93.72	528.37
9	96.67	528.91
10	99.58	529.64
11	102.44	530.55
12	105.23	531.65
13	107.94	532.93
14	110.57	534.38
15	113.10	536.00
16	115.51	537.78
17	117.81	539.71
18	119.97	541.79
19	122.00	544.00
20	123.88	546.33
21	125.61	548.79
22	127.17	551.35
23	128.56	554.01
24	129.78	556.75
25	130.05	557.50

*** 3.210 ***

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	62.76	530.00
2	65.60	529.04
3	68.48	528.22
4	71.41	527.54
5	74.36	527.01
6	77.33	526.62
7	80.32	526.38
8	83.32	526.28
9	86.32	526.33
10	89.32	526.52
11	92.30	526.86
12	95.26	527.34
13	98.19	527.97
14	101.09	528.74
15	103.95	529.65
16	106.76	530.70
17	109.52	531.88
18	112.21	533.20
19	114.84	534.65
20	117.39	536.22
21	119.87	537.92
22	122.26	539.73
23	124.56	541.66
24	126.76	543.70
25	128.86	545.84
26	130.85	548.08
27	132.73	550.42
28	134.50	552.84
29	136.14	555.35
30	137.40	557.50

*** 3.228 ***

1

Failure Surface Specified By 29 Coordinate Points

Point	X-Surf	Y-Surf

No.	(ft)	(ft)
1	66.84	530.00
2	69.72	529.19
3	72.65	528.52
4	75.60	527.99
5	78.58	527.62
6	81.57	527.39
7	84.57	527.31
8	87.57	527.37
9	90.56	527.59
10	93.54	527.96
11	96.49	528.47
12	99.42	529.12
13	102.31	529.93
14	105.16	530.87
15	107.96	531.95
16	110.70	533.18
17	113.37	534.53
18	115.98	536.02
19	118.51	537.63
20	120.95	539.37
21	123.31	541.22
22	125.57	543.20
23	127.73	545.28
24	129.79	547.46
25	131.74	549.74
26	133.57	552.12
27	135.27	554.59
28	136.86	557.13
29	137.06	557.50

*** 3.234 ***

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	67.86	530.00
2	70.71	529.08
3	73.61	528.31
4	76.55	527.70
5	79.51	527.24
6	82.50	526.94
7	85.50	526.79
8	88.50	526.81
9	91.49	526.98
10	94.47	527.32
11	97.43	527.81
12	100.36	528.45
13	103.25	529.25
14	106.10	530.20
15	108.89	531.30
16	111.62	532.54
17	114.28	533.93
18	116.86	535.46
19	119.36	537.12
20	121.77	538.91
21	124.08	540.82
22	126.28	542.86
23	128.38	545.01
24	130.35	547.26
25	132.21	549.62
26	133.94	552.07
27	135.54	554.61
28	137.00	557.23
29	137.13	557.50

*** 3.237 ***

1

Failure Surface Specified By 41 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.10	530.00
2	32.44	528.13
3	34.88	526.37
4	37.39	524.73
5	39.98	523.22
6	42.65	521.85
7	45.38	520.60
8	48.16	519.49
9	51.00	518.52
10	53.89	517.69
11	56.81	517.00
12	59.76	516.45
13	62.73	516.06
14	65.72	515.81
15	68.72	515.70
16	71.72	515.75
17	74.71	515.94
18	77.69	516.28
19	80.65	516.77
20	83.58	517.40
21	86.48	518.18
22	89.34	519.09
23	92.15	520.15
24	94.90	521.34
25	97.59	522.67
26	100.21	524.13
27	102.76	525.72
28	105.22	527.43
29	107.60	529.26
30	109.88	531.20
31	112.07	533.26
32	114.15	535.42
33	116.13	537.68
34	117.99	540.03
35	119.73	542.47
36	121.35	545.00
37	122.84	547.60
38	124.20	550.27
39	125.43	553.01
40	126.52	555.80
41	127.09	557.50

*** 3.253 ***

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	31.12	530.00
2	33.49	528.16
3	35.95	526.44
4	38.49	524.84
5	41.11	523.38
6	43.79	522.05
7	46.55	520.85
8	49.36	519.80
9	52.22	518.89
10	55.12	518.13
11	58.05	517.51
12	61.02	517.04
13	64.00	516.73
14	67.00	516.56
15	70.00	516.55
16	72.99	516.68
17	75.98	516.97

18	78.95	517.41
19	81.89	518.00
20	84.80	518.74
21	87.66	519.62
22	90.48	520.64
23	93.25	521.81
24	95.95	523.12
25	98.58	524.55
26	101.14	526.13
27	103.61	527.82
28	105.99	529.64
29	108.28	531.58
30	110.47	533.63
31	112.55	535.79
32	114.52	538.06
33	116.38	540.41
34	118.11	542.86
35	119.72	545.40
36	121.19	548.01
37	122.54	550.69
38	123.74	553.44
39	124.81	556.24
40	125.21	557.50

*** 3.254 ***

1

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.16	530.00
2	35.60	528.25
3	38.12	526.63
4	40.72	525.13
5	43.39	523.76
6	46.13	522.52
7	48.92	521.42
8	51.76	520.46
9	54.65	519.65
10	57.57	518.97
11	60.52	518.44
12	63.50	518.06
13	66.49	517.82
14	69.49	517.73
15	72.48	517.79
16	75.48	517.99
17	78.46	518.35
18	81.41	518.85
19	84.34	519.50
20	87.24	520.29
21	90.09	521.22
22	92.89	522.29
23	95.64	523.50
24	98.32	524.84
25	100.94	526.31
26	103.47	527.91
27	105.93	529.63
28	108.30	531.48
29	110.57	533.43
30	112.75	535.50
31	114.82	537.67
32	116.78	539.94
33	118.62	542.31
34	120.35	544.76
35	121.95	547.29
36	123.43	549.91
37	124.78	552.59
38	125.99	555.33
39	126.82	557.50

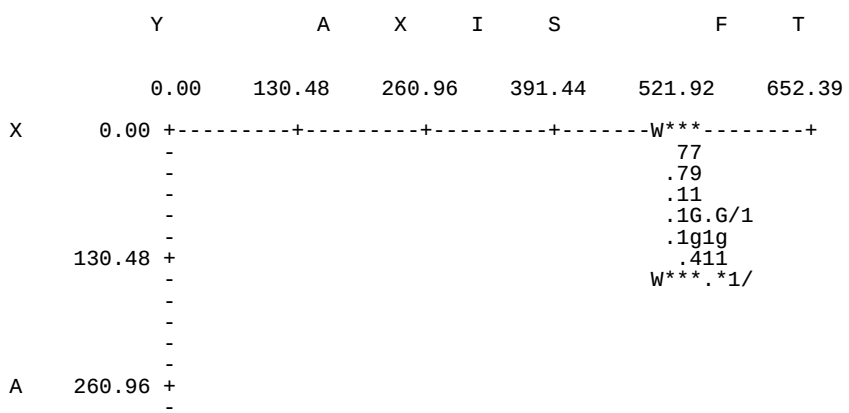
*** 3.263 ***

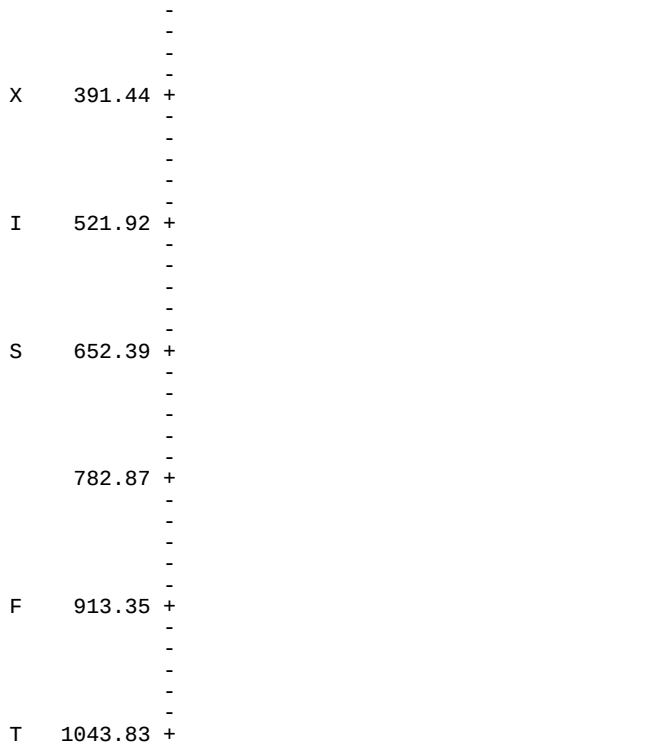
Failure Surface Specified By 42 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	30.10	530.00
2	32.54	528.25
3	35.05	526.60
4	37.62	525.07
5	40.27	523.65
6	42.98	522.36
7	45.74	521.18
8	48.55	520.13
9	51.40	519.21
10	54.29	518.41
11	57.22	517.75
12	60.17	517.21
13	63.14	516.81
14	66.13	516.53
15	69.13	516.40
16	72.13	516.39
17	75.12	516.52
18	78.11	516.78
19	81.09	517.18
20	84.04	517.70
21	86.97	518.36
22	89.86	519.15
23	92.72	520.06
24	95.53	521.10
25	98.30	522.27
26	101.01	523.55
27	103.66	524.96
28	106.24	526.48
29	108.76	528.12
30	111.20	529.86
31	113.56	531.72
32	115.83	533.67
33	118.01	535.73
34	120.11	537.88
35	122.10	540.12
36	123.99	542.45
37	125.78	544.86
38	127.46	547.35
39	129.02	549.91
40	130.47	552.53
41	131.80	555.22
42	132.81	557.50

*** 3.264 ***

1

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