

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

**DRAFT STRUCTURE
FOUNDATION EXPLORATION
REPORT**

Prepared For:
EMH&T

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Columbus, Ohio 43054**

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

August, 2013



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June 28, 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 I
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 I as part of the HAM-75-7.85 project. The proposed wall will be located on the north side of the proposed HAM-75-0857 bridge carrying I-75 over Towne Street 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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EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a DRAFT structure foundation exploration for the design and construction of proposed Retaining Wall I as part of the HAM-75-7.85 Project. It is understood that this wall will be connected to the forward abutment of the proposed HAM-75-0857 I-75 over Towne Street bridge structure at the south end of the wall alignment and will extend north. According to design details provided by the Rii design team, the forward 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 I. The total wall length is approximately 1,165 lineal feet.

Exploration and Findings

Between October 6 and November 2, 2011, seven (7) structural borings, designated as B-017-0-11 through B-023-0-11, were drilled to depths ranging from 25.0 to 50.0 feet below the ground surface at the locations illustrated on the boring plan presented in Appendix II of the full report.

Beneath the surface material in all of the borings, existing fill was encountered to depths ranging from 8.0 to 28.0 feet below the ground surface. The fill material consisted of brown, gray, dark brown, light brown and dark gray gravel and sand, gravel with sand, silt and clay, coarse and fine sand, sandy silt, silt, silt and clay and silty clay (ODOT A-1-b, A-2-6, A-3a, A-4a, A-4b, A-6a, A-6b).

Underlying the surface materials and existing fill, natural cohesive and granular soils were encountered. The cohesive soils encountered were generally described as brown, gray, grayish brown and dark brown sandy silt, silt, silt and clay, silty clay and clay (ODOT A-4a, A-4b, A-6a, A-6b, A-7-6). The granular soils encountered were generally described as brown, gray, dark brown and light brown gravel and sand, gravel with sand, silt, and clay, fine sand, coarse and fine sand and sandy silt (ODOT A-1-b, A-2-6, A-3, A-3a, A-4a).

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 forward abutment of the proposed HAM-75-0857 bridge carrying I-75 over Towne Street at the south end of the wall alignment.

Based on the limits and alignment of the proposed wall, one boring, designated as B-182-0-07, from the HAM-75-0857 exploration performed by CTL Engineering as part of the HAM-75-2.30 project was also utilized in the analysis for the portion of the alignment just north of the HAM-75-0857 structure.

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 9.1 and 30.7 feet.

Soft to medium stiff silt and clay (ODOT A-6a) was encountered in boring B-182 extending to a depth of 7.5 feet below the ground surface. Hand penetrometer values were not provided on the boring logs; however, based on the low blow counts obtained within this soil layer, it recommended that this material be stabilized or excavated and replaced with suitable embankment fill to provide a stable bearing surface for the MSE wall. In addition, it should be noted that existing embankment fill was encountered in borings B-017 through B-023 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.

The anticipated bearing materials along the proposed alignment will consist of existing embankment fill described as soft to hard sandy silt, silt and clay and silty clay (ODOT A-4a, A-6a, A-6b) and medium dense to dense coarse and fine sand (ODOT A-3a). As noted above, it is recommended that the soft to medium stiff silt and clay encountered at the bearing elevation in boring B-182 be over excavated and replaced with suitable embankment material as noted in Section 5.1.1 of the full report. 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 $\phi_b=0.65$ 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 provided the subgrade is prepared as noted Section 5.1 of the full report.

Retaining Wall I 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	
452+15	453+60	B-182	30.7	0.70(H)	3.9	11.8	1.83 / 0.94
453+60	456+40	B-017 and B-018	29.2	0.70(H)	6.8	20.3	3.06 / 1.97
456+40	460+40	B-019 and B-020	28.8	0.77(H)	3.4	10.3	4.63 / 2.22
460+40	463+82	B-021 through B-023	17.3	0.70(H)	7.2	21.7	1.15 / 0.74

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 $\phi_b=0.65$ 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 of the full report, material identified as existing embankment fill was identified in borings B-017 through B-023 to depths ranging from 8.0 to 28.0 feet below existing grade. 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 and asphalt fragments or wood fibers encountered in several borings, the material should be over excavated until competent natural soils are encountered and backfilled with structural fill as noted in Section 5.3 of the full report 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 0.42 to 0.58 was utilized for design along the wall alignment. A geotechnical resistance factor of $\phi_t=1.0$ 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 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 I 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 forward abutment of the proposed HAM-75-0857 I-75 over Towne Street bridge structure at the south end of the wall alignment and will extend north. According to design details provided by the Rii design team, the forward 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 I. The total wall length is approximately 1,165 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 S 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 I is located along the west side of I-75, just north of the HAM-75-0857 I-75 over Towne Street bridge structure. Overall, the project is located approximately 1.8 miles south of the Lockland split. The proposed wall begins at Station 452+52 and continues north to Station 462+56 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 and Elmwood Place Park at the north end of the alignment. 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 6 and November 2, 2011, seven (7) structural borings, designated as B-017-0-11 through B-023-0-11, were drilled to depths ranging from 25.0 to 50.0 feet 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-017-0-11	454+71.82	47.0' Lt.	39.184419052 °N	84.483606946 °W	553.6	50.0
B-018-0-11	456+14.66	48.3' Lt.	39.184784282 °N	84.483431210 °W	549.8	50.0
B-019-0-11	457+34.72	49.5' Lt.	39.185093098 °N	84.483290141 °W	547.2	50.0
B-020-0-11	458+91.16	48.3' Lt.	39.185495190 °N	84.483105261 °W	545.1	50.0
B-021-0-11	460+63.47	74.8' Lt.	39.185964136 °N	84.483006019 °W	543.2	50.0
B-022-0-11	461+59.39	75.0' Lt.	39.186215212 °N	84.482904319 °W	545.1	25.0
B-023-0-11	462+77.77	85.2' Lt.	39.186533569 °N	84.482812865 °W	546.9	25.0

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, continuous hollow-stem auger to advance the hole. 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.

$$N_{60} = N_m \cdot (ER/60)$$

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	102
Plastic and Liquid Limits	AASHTO T89, T90	27
Sieve/Hydrometers	AASHTO T88	27
One Dimensional Consolidation	ASTM D 2435	1
Consolidated Undrained (CU) Triaxial Test (2-Points)	ASTM D4767	1
Unconfined Compression Test	ASTM D2166	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 current version of the ODOT Specifications for Geotechnical Explorations (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

Borings B-017 through B-020 were drilled along the existing shoulder of I-75 southbound and encountered 12.0 inches of asphalt overlying 6.0 inches of concrete followed by 6.0 inches of aggregate base in boring B-020. Borings B-021 through B-023 were drilled along the embankment separating the I-75 mainline and Elmwood Place Park to the west and encountered 6.0 to 7.0 inches of topsoil at the existing ground surface, identified by the significant presence of organic matter and vegetation.

4.2 Subsurface Soils

Beneath the surface material in all of the borings, existing fill was encountered to depths ranging from 8.0 to 28.0 feet below the ground surface. The fill material consisted of brown, gray, dark brown, light brown and dark gray gravel and sand, gravel with sand, silt and clay, coarse and fine sand, sandy silt, silt, silt and clay and silty clay (ODOT A-1-b, A-2-6, A-3a, A-4a, A-4b, A-6a, A-6b).

Underlying the surface materials and existing fill, natural cohesive and granular soils were encountered. The cohesive soils encountered were generally described as brown, gray, grayish brown and dark brown sandy silt, silt, silt and clay, silty clay and clay (ODOT A-4a, A-4b, A-6a, A-6b, A-7-6). The granular soils encountered were generally described as brown, gray, dark brown and light brown gravel and sand, gravel with sand, silt, and clay, fine sand, coarse and fine sand and sandy silt (ODOT A-1-b, A-2-6, A-3, A-3a, A-4a).

The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soil encountered ranged from soft ($0.25 < \text{HP} \leq 0.5$ tsf) to hard ($\text{HP} > 4.0$ tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 0.5 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 very loose ($N_{60} < 5$ blows per foot [bpf]) to very dense ($N_{60} > 50$ bpf). Overall blow counts recorded from the SPT sampling ranged from 4 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 37 percent. The natural moisture content of samples tested for plasticity index, ranged from 1 percent below to 8 percent above the corresponding plastic limit. The moisture contents of the native soils are generally considered to be slightly below to significantly 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-017-0-11	553.6	Dry	Dry	Dry	Dry	32.6	521.0
B-018-0-11	549.8	Dry	Dry	Dry	Dry	28.2	521.6
B-019-0-11	547.2	Dry	Dry	Dry	Dry	24.0	523.2
B-020-0-11	545.1	46.0	499.1	Dry	Dry	25.5	519.6
B-021-0-11	543.2	43.0	500.2	39.0	504.2	N/A	N/A
B-022-0-11	545.1	18.5	526.6	22.5 ²	522.6	13.2	531.9
B-023-0-11	546.9	Dry	Dry	Dry	Dry	13.0	533.9

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 borings B-020 through B-022 at depths ranging from 18.5 to 46.0 feet below the ground surface. At the completion of drilling and after removing the augers, groundwater accumulated in the borehole in borings B-021 and B-022 to a depth of 39.0 and 22.5 feet below the ground surface, respectively. The remaining borings were observed to be dry, meaning no measureable amount of water had accumulated within the boreholes during or at the completion of drilling. 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 forward abutment of the proposed HAM-75-0857 bridge carrying I-75 over Towne Street at the south end of the wall alignment.

Based on the limits and alignment of the proposed wall, one boring, designated as B-182-0-07, from the HAM-75-0857 exploration performed by CTL Engineering as part of the HAM-75-2.30 project was also utilized in the analysis for the portion of the alignment just north of the HAM-75-0857 structure.

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 considered 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 9.1 and 30.7 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 8.0 and 21.5 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.

Soft to medium stiff silt and clay (ODOT A-6a) was encountered in boring B-182 extending to a depth of 7.5 feet below the ground surface. Hand penetrometer values were not provided on the boring logs; however, based on the low blow counts obtained within this soil layer, it recommended that this material be stabilized or excavated and replaced with suitable embankment fill to provide a stable bearing surface for the MSE wall. In addition, it should be noted that existing embankment fill was encountered in borings B-017 through B-023 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

Material Type	Unit Weight, γ (pcf)	Effective Friction Angle, ϕ' (°)	Effective Cohesion, c' (psf)	Undrained Shear Strength, S_u (psf)
Soft to Very Stiff Silty and Clay (ODOT A-6a) ¹	115 to 120	27	235	500 to 3,750
Medium Stiff to Very Stiff Silty Clay (ODOT A-6b) ²	115 to 120	23	426	1,250 to 3,500
Very Stiff Clay (ODOT A-7-6) ²	115	21	0	2,000
Very Loose to Very Dense Granular Soil (ODOT A-1-a, A-1-b, A-2-6, A-3a)	130	34	0	N/A

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

Shear strength parameters for the reinforced soil backfill are provided in ODOT SS 840. Per SS 840, the select granular backfill in the reinforced zone must meet the shear strength requirements provided in Table 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-75-12.60 project that is 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 soils 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 consist of existing embankment fill described as soft to hard sandy silt, silt and clay and silty clay (ODOT A-4a, A-6a, A-6b) and medium dense to dense coarse and fine sand (ODOT A-3a). As noted in Section 5.1, it is recommended that the soft to medium stiff silt and clay encountered at the bearing elevation in boring B-182 be over excavated and replaced with suitable embankment material as noted in Section 5.1.1. 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 $\phi_b=0.65$ 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 table 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 I 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	
452+15	453+60	B-182	30.7	0.70(H)	3.9	11.8	1.83 / 0.94
453+60	456+40	B-017 and B-018	29.2	0.70(H)	6.8	20.3	3.06 / 1.97
456+40	460+40	B-019 and B-020	28.8	0.77(H)	3.4	10.3	4.63 / 2.22
460+40	463+82	B-021 through B-023	17.3	0.70(H)	7.2	21.7	1.15 / 0.74

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 $\phi_b=0.65$ 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 existing embankment fill was identified in borings B-017 through B-023 to depths ranging from 8.0 to 28.0 feet below existing

grade. 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 and asphalt fragments or wood fibers encountered in several borings, 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 1.15 to 4.63 inches at the center of the reinforced soil mass and 0.74 to 2.22 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 0.42 to 0.58 was utilized for design. A geotechnical resistance factor of $\phi_r=1.0$ 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 $\phi=0.75$ 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 to 0.77 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 using a strap length equal to 70 percent of the wall height between Stations 452+15 to 456+40 and 460+40 to 463+82. Bearing resistance was the controlling factor in the determination of the recommended strap length of 77 percent of the wall height required between Stations 456+40 to 460+40.

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
Soft to 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	3,000	0°	1.0	1.0	1.0
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	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, $\gamma' = \gamma - 62.4$ 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
Very Loose to Loose Granular Soil	120	0	28°	0.36	0.53	2.77
Medium Dense Granular Soil	125	0	30°	0.33	0.50	3.00
Dense to Very Dense Granular Soil	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, $\gamma' = \gamma - 62.4$ 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 be 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, shoring or sheeting 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.

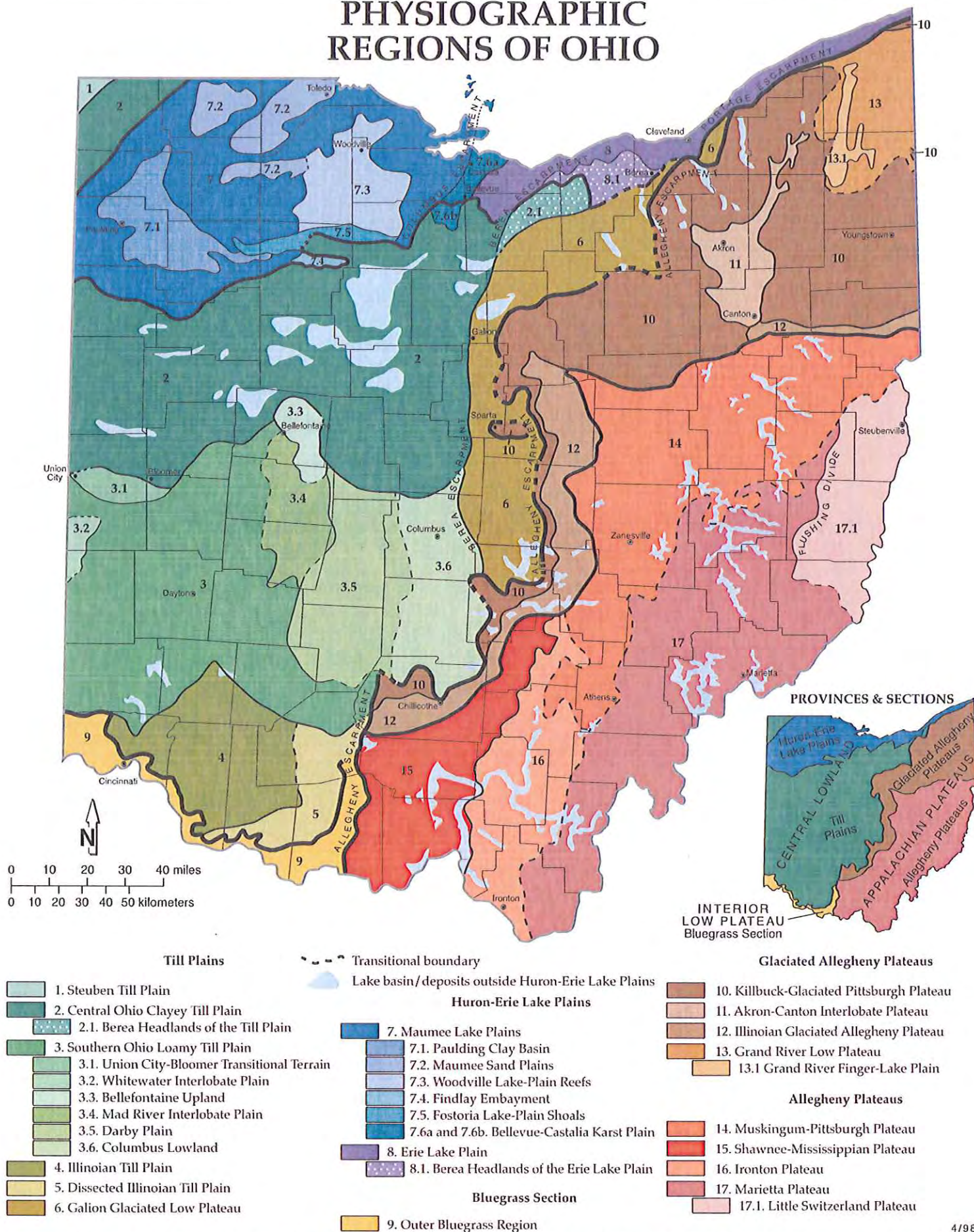
Our professional services have been performed, our findings obtained, and our recommendations prepared in accordance with generally accepted Geotechnical engineering principles and practices. Resource International is not responsible for the conclusions, opinions or recommendations made by others based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



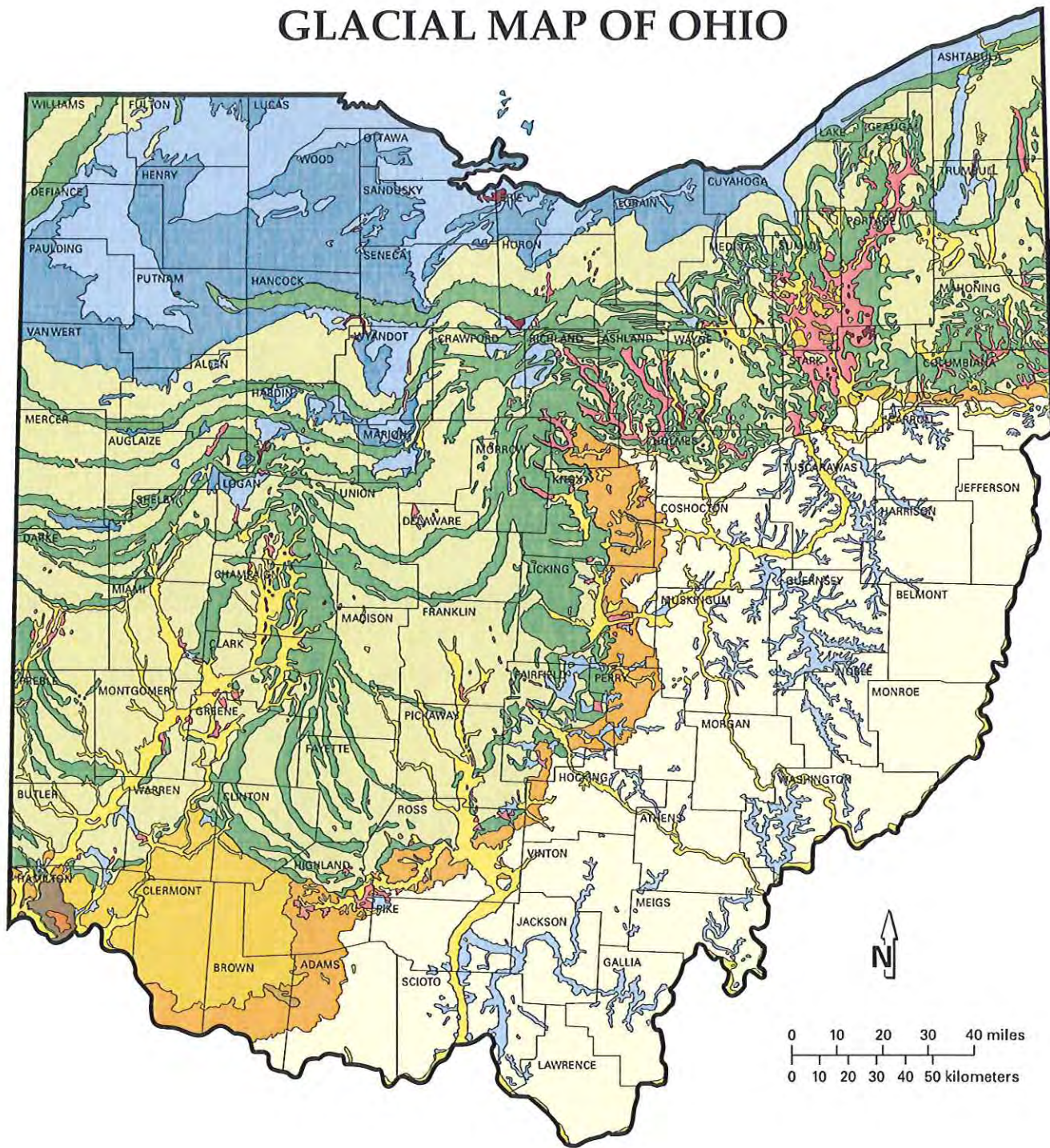
APPENDIX I

STATE GEOLOGY

PHYSIOGRAPHIC REGIONS OF OHIO



GLACIAL MAP OF OHIO



WISCONSINAN
(14,000 to 24,000 years old)

- Ground moraine
- Wave-planed ground moraine
- End moraine

ILLINOIAN
(130,000 to 300,000 years old)

- Ground moraine
- Dissected ground moraine
- Hummocky moraine

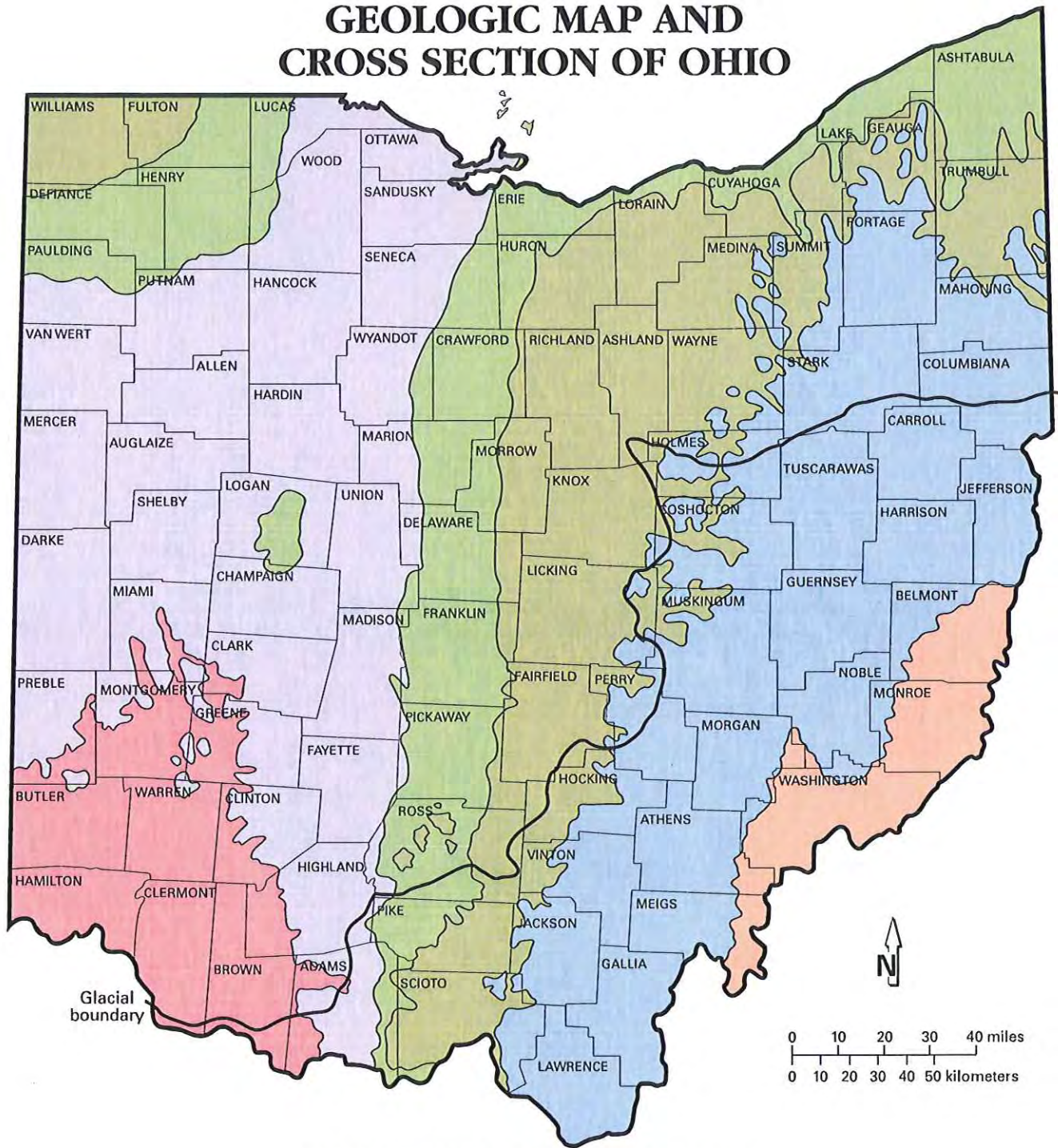
PRE-ILLINOIAN
(older than 300,000 years)

- Ground moraine
- Dissected ground moraine

- Kames and eskers
- Outwash
- Lake deposits
- Peat
- Colluvium

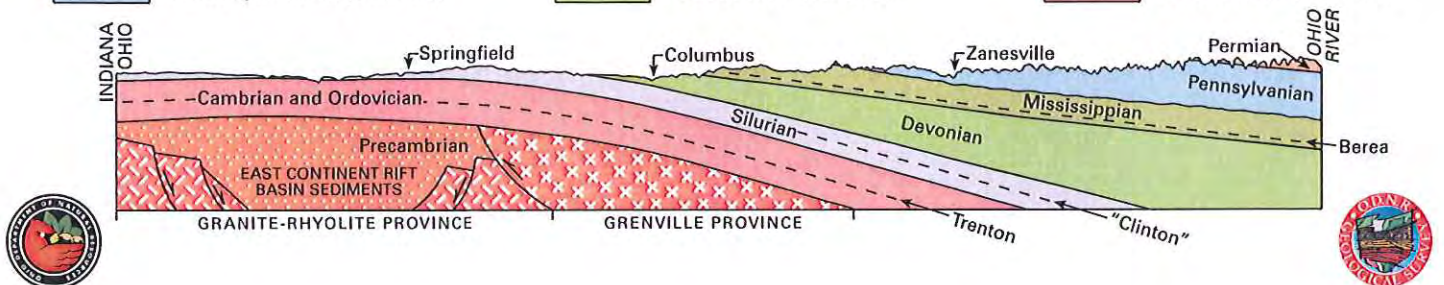


GEOLOGIC MAP AND CROSS SECTION OF OHIO



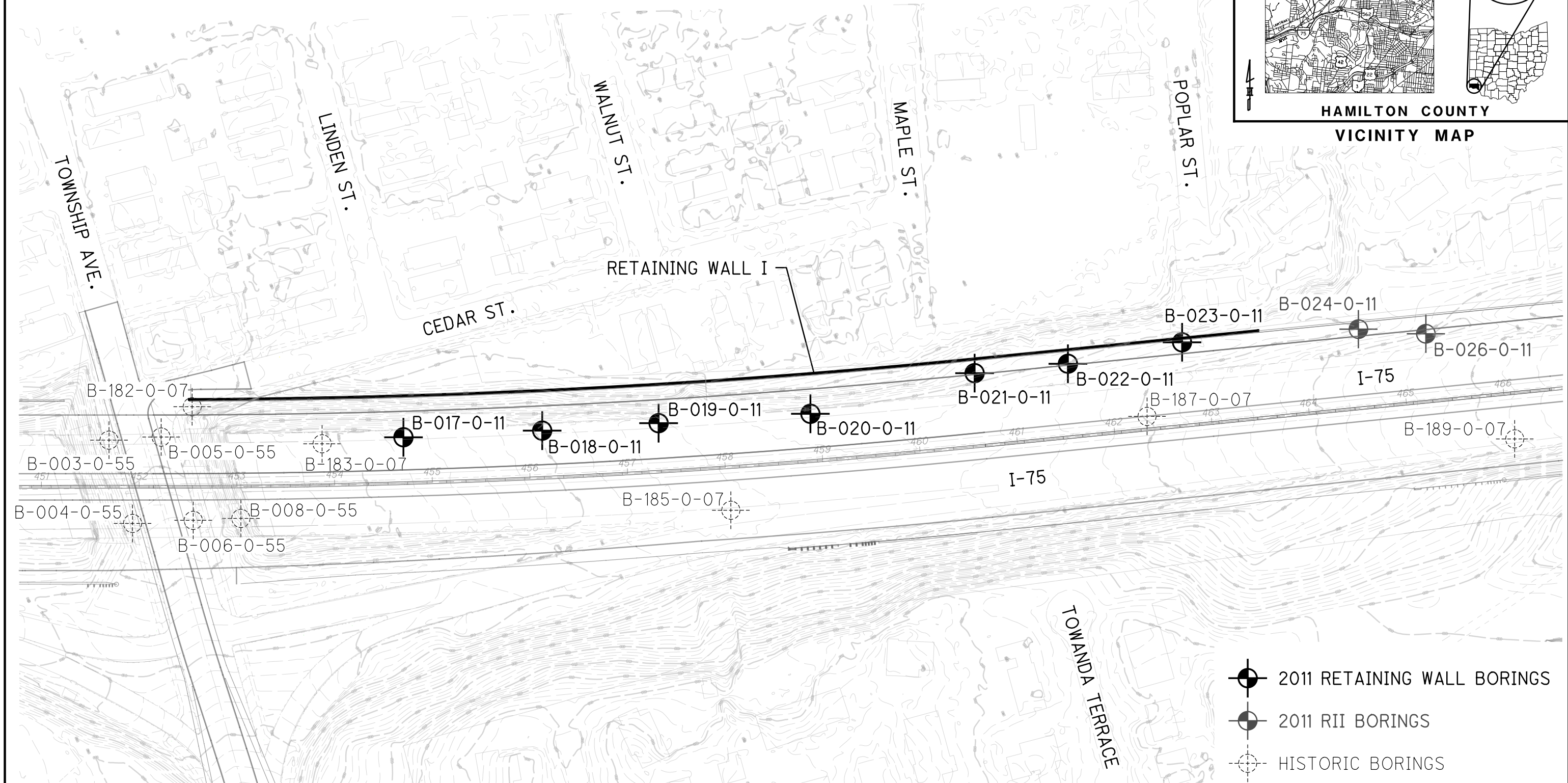
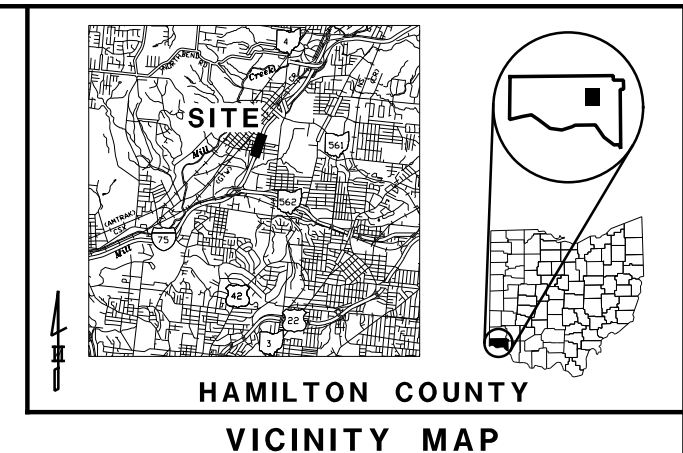
GEOLOGIC SYSTEM (million years before present)

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



APPENDIX II

VICINITY MAP AND BORING PLAN

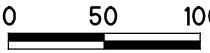


-  2011 RETAINING WALL BORINGS
-  2011 RII BORINGS
-  HISTORIC BORINGS

BORING PLAN

HAM-75-7.85 RETAINING WALL I

HAMILTON COUNTY, OHIO

PROJECT NO. Rii B-10-020		DRAWN RRM		
SCALE: 1"=100'		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)

<u>Description</u>	<u>Blows per foot – SPT (N₆₀)</u>		
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

<u>Description</u>	<u>Blows per foot – SPT (N₆₀)</u>			<u>Unconfined Compression (tsf)</u>
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:

<u>Soil Fraction</u>	<u>USCS Size</u>	<u>ODOT Size</u>
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:

<u>Term</u>	<u>Range</u>		
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:

<u>Term</u>	<u>Range - USCS</u>	<u>Range - ODOT</u>
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:

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

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

<u>Term</u>	<u>Blows per foot – SPT (N)</u>		
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	Classification		LL _O /LL x 100*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
		AASHTO	OHIO							
	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	
	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.	≤ 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			Uncontrolled Fill (Describe)			Bouldery Zone			Peat, S-Sedimentary W-Woody F-Fibrous L-Loamy & etc
	Pavement or Base									

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

APPENDIX IV

BORING LOGS:

B-017-0-11 through B-023-0-11

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

	PROJECT: HAM-75-7.85		DRILLING FIRM / OPERATOR: RII / T.F.		DRILL RIG: CME-750X (SN 310218)		STATION / OFFSET: 454+71.82 / 47.0' Lt		EXPLORATION ID B-017-0-11												
	TYPE: RETAINING WALL		SAMPLING FIRM / LOGGER: RII / S.M.		HAMMER: CME AUTOMATIC		ALIGNMENT: PROPOSED CL I-75		PAGE												
	PID: 77889	BR ID: NA	DRILLING METHOD: 4.25" HSA		CALIBRATION DATE: 5/6/11		ELEVATION: 553.6 (MSL) EOB: 50.0 ft.		1 OF 2												
	START: 11/2/11 END: 11/2/11		SAMPLING METHOD: SPT		ENERGY RATIO (%): 77.1		LAT / LONG : 39.184419052 ° N / 84.483606946 ° W														
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
			553.6																		
1.0' - ASPHALT (12.0")			552.6																		
0.5' - CONCRETE (6.0")			552.1																		
FILL: HARD, BROWN SILT, SOME COARSE TO FINE SAND, LITTLE CLAY, MOIST.			550.6																		
FILL: VERY STIFF, BROWN SANDY SILT, LITTLE CLAY, TRACE TO LITTLE FINE GRAVEL, MOIST.																					

	PROJECT: HAM-75-7.85	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 456+14.66 / 48.3' Lt	EXPLORATION ID B-018-0-11
	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: 549.8 (MSL) EOB: 50.0 ft.	PAGE
	START: 11/2/11 END: 11/2/11	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG : 39.184784282 ° N / 84.48343121 ° W	1 OF 2

MATERIAL DESCRIPTION AND NOTES		ELEV. 549.8	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL		
									GR	CS	FS	SI	CL	LL	PL	PI					
1.0' - ASPHALT (12.0")		548.8	1																		
0.5' - CONCRETE (6.0")		548.3																			
FILL: MEDIUM DENSE, LIGHT BROWN GRAVEL AND SAND, LITTLE SILT, DAMP.		546.8	2	7	6	14	22	SS-1	-	-	-	-	-	-	-	4	A-1-b (V)				
FILL: STIFF, BROWN SILT AND CLAY, SOME COARSE TO FINE SAND, LITTLE FINE GRAVEL, MOIST.			3																		
			4	1	3	8	44	SS-2	1.50	11	6	17	40	26	31	16	15	A-6a (8)			
		544.3	5																		
FILL: STIFF, BROWN TO BROWNISH GRAY SANDY SILT, LITTLE CLAY, TRACE FINE GRAVEL, MOIST.			6	3																	
			7		3	7	13	100	SS-3	1.50	-	-	-	-	-	-	16		A-4a (V)		
			8																		
		539.3	9																		
			10				33	ST-4	-	6	5	36	35	18	22	14	8	A-4a (4)			
FILL: STIFF TO VERY STIFF, BLUISH GRAY AND BROWN SILT AND CLAY, SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			11	8																	
			12		8	10	23	56	SS-5	1.75	-	-	-	-	-	-	-	19	A-6a (V)		
			13																		
			14	5	7		15	78	SS-6	2.50	-	-	-	-	-	-	-	20	A-6a (V)		
			15																		
			16	5																	
		531.8	17		6	7	17	78	SS-7	2.25	-	-	-	-	-	-	-	24		A-6a (V)	
FILL: DENSE TO VERY DENSE, BROWN COARSE AND FINE SAND, LITTLE SILT, TRACE CLAY, MOIST.			18																		
			19	8	13		44	83	SS-8	-	0	11	60	19	10	NP	NP	NP		11	A-3a (0)
			20																		
			21	12	21																
			22		32	68	78	SS-9	-	-	-	-	-	-	-	-	-	11	A-3a (V)		
		526.8	23																		
STIFF TO VERY STIFF, BROWN SILTY CLAY, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			24	12	5		14	67	SS-10	2.00	1	6	14	44	35	37	17	20	19	A-6b (12)	
			25			6															
-COBBLES PRESENT THROUGHOUT			26	5																	
			27		8	11	24	72	SS-11	4.00	-	-	-	-	-	-	-	21	A-6b (V)		

PID: 77889	BR ID: NA	PROJECT: HAM-75-7.85	STATION / OFFSET: 456+14.66 / 48.3' Lt						START: 11/2/11					END: 11/2/11			PG 2 OF 2		B-018-0-11	
MATERIAL DESCRIPTION AND NOTES			ELEV. 521.8	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
										GR	CS	FS	SI	CL	LL	PL	PI			
MEDIUM DENSE, BROWN GRAVEL AND SAND, LITTLE SILT, DAMP.				29	9	18	67	SS-12	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	<L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L> <L> >L>

	PROJECT: HAM-75-7.85		DRILLING FIRM / OPERATOR: RII / T.F.		DRILL RIG: CME-750X (SN 310218)		STATION / OFFSET: 457+34.72 / 49.5' Lt		EXPLORATION ID B-019-0-11												
	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: 547.2 (MSL) EOB: 50.0 ft.		PAGE 1 OF 2												
	START: 11/1/11 END: 11/1/11		SAMPLING METHOD: SPT		ENERGY RATIO (%): 77.1		LAT / LONG : 39.185093098 ° N / 84.483290141 ° W														
MATERIAL DESCRIPTION AND NOTES			ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
1.0' - ASPHALT (12.0")			547.2																		
0.5' - CONCRETE (6.0")			546.2	1																	
FILL: VERY LOOSE, BROWNISH GRAY GRAVEL AND SAND , LITTLE SILT, DAMP (AGGREGATE BASE). -PVC DRAIN TILE PRESENT IN SS-1			545.7	2		5 1	4	33	SS-1	-	-	-	-	-	-	-	-	4	A-1-b (V)		
FILL: VERY STIFF, BROWN AND GRAY SILT , SOME FINE SAND, LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			544.2	3																	
FILL: VERY STIFF, BROWN AND GRAY SILT , SOME FINE SAND, LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			541.7	4		11 4	10	6	SS-2	2.50	8	0	29	50	13	21	16	5	15	A-4b (6)	
FILL: VERY STIFF, MOTTLED BROWN AND GRAY SILTY CLAY , SOME FINE SAND, TRACE FINE GRAVEL, MOIST.			536.7	5																	
FILL: VERY STIFF, MOTTLED BROWN AND GRAY SILTY CLAY , SOME FINE SAND, TRACE FINE GRAVEL, MOIST.			534.2	6		4 5	14	67	SS-3	2.25	-	-	-	-	-	-	-	-	23	A-6b (V)	
FILL: VERY STIFF, MOTTLED BROWN AND GRAY SILT AND CLAY , SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.			536.7	7																	
FILL: VERY STIFF, MOTTLED BROWN AND GRAY SILT AND CLAY , SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.			534.2	8																	
FILL: DENSE TO VERY DENSE, BROWN SANDY SILT , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			529.2	9				60	ST-4	-	1	0	20	36	43	32	14	18	17	A-6b (11)	
FILL: DENSE TO VERY DENSE, BROWN SANDY SILT , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			529.2	10																	
FILL: DENSE TO VERY DENSE, BROWN SANDY SILT , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			526.7	11		5 5	15	67	SS-5	2.50	-	-	-	-	-	-	-	-	13	A-6a (V)	
FILL: DENSE TO VERY DENSE, BROWN SANDY SILT , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			526.7	12																	
FILL: DENSE TO VERY DENSE, BROWN SANDY SILT , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			529.2	13		5 10	35	78	SS-6	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
FILL: DENSE TO VERY DENSE, BROWN SANDY SILT , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			529.2	14																	
FILL: DENSE TO VERY DENSE, BROWN SANDY SILT , LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			529.2	15		12 21	62	67	SS-7	-	-	-	-	-	-	-	-	-	7	A-4a (V)	
FILL: STIFF, BROWN SANDY SILT , TRACE CLAY, DAMP.			526.7	16																	
FILL: STIFF, BROWN SANDY SILT , TRACE CLAY, DAMP.			526.7	17		3 5	13	78	SS-8	1.50	0	20	38	25	17	18	13	5	11	A-4a (1)	
FILL: STIFF, BROWN SANDY SILT , TRACE CLAY, DAMP.			526.7	18																	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	19		3 5	18	89	SS-9	3.50	-	-	-	-	-	-	-	-	19	A-6a (V)	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	20																	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	21		3 5	13	78	SS-10	4.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	22																	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	23																	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	24		3 5	13	78	SS-10	4.25	-	-	-	-	-	-	-	-	19	A-6a (V)	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	25																	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	26		3 3	9	33	SS-11	-	-	-	-	-	-	-	-	-	8	A-2-6 (V)	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	27																	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.			521.7	27																	



PROJECT: HAM-75-7.85
TYPE: RETAINING WALL
PID: 77889 BR ID: NA
START: 11/1/11 END: 11/1/11

DRILLING FIRM / OPERATOR: RII / T.F.
SAMPLING FIRM / LOGGER: RII / S.M.
DRILLING METHOD: 4.25" HSA
SAMPLING METHOD: SPT

DRILL RIG: CME-750X (SN 310218)
HAMMER: CME AUTOMATIC
CALIBRATION DATE: 5/6/11
ENERGY RATIO (%): 77.1

STATION / OFFSET: 458+91.16 / 48.3' Lt
ALIGNMENT: PROPOSED CL I-75
ELEVATION: 545.1 (MSL) EOB: 50.0 ft.
LAT / LONG: 39.18549519 ° N / 84.483105261 ° W

EXPLORATION ID
B-020-0-11

PAGE
1 OF 2

MATERIAL DESCRIPTION AND NOTES		ELEV.	DEPTHS		SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG				ODOT CLASS (GI)	BACK FILL
										GR	CS	FS	SI	CL	LL	PL	PI	WC		
1.0' - ASPHALT (12.0")		545.1																		
0.5' - CONCRETE (6.0")		544.1	1																	
0.5' - AGGREGATE BASE (6.0")		543.6	2	6	5	13	33	SS-1	-	-	-	-	-	-	-	-	-	3	A-1-b (V)	
FILL: MEDIUM DENSE, BROWNISH GRAY GRAVEL WITH SAND, SILT, AND CLAY, MOIST.		543.1	3						-	-	-	-	-	-	-	-	-	11	A-2-6 (V)	
FILL: STIFF, MOTTLED BROWN AND GRAY SILTY CLAY, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.		541.6	4	4	2	8	56	SS-2	1.50	10	4	13	33	40	36	17	19	21	A-6b (11)	
		539.6	5																	
FILL: MEDIUM DENSE, GRAY SILTY SAND, LITTLE CLAY, MOIST.			6	5	14	35	78	SS-3	-	-	-	-	-	-	-	-	-	10	A-4a (V)	
		536.6	7		13															
			8																	
FILL: MEDIUM DENSE TO DENSE, GRAY TO BROWN COARSE AND FINE SAND, LITTLE SILT, LITTLE CLAY, TRACE FINE GRAVEL, MOIST.			9	9	15	46	67	ST-4	-	-	-	-	-	-	-	-	-	-		
			10		21			SS-4A	-	0	9	64	15	12	NP	NP	NP	8	A-3a (0)	
			11	5	11	28	78	SS-5	-											
			12		11				-	-	-	-	-	-	-	-	-	6	A-3a (V)	
			13																	
			14	4	4	12	78	SS-6	-	-	-	-	-	-	-	-	-	8	A-3a (V)	
			15		5															
			16	4	5	13	89	SS-7	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
		527.1	17		5															
FILL: VERY STIFF, GRAY SILTY CLAY, TRACE COARSE TO FINE SAND, MOIST.			18	4	5	14	78	SS-8	3.50	0	1	5	58	36	37	17	20	17	A-6b (12)	
		524.6	19		6															
FILL: MEDIUM DENSE, GRAY AND BROWN SANDY SILT, SOME CLAY, TRACE FINE GRAVEL, DAMP.			20																	
			21	5	7	19	78	SS-9	-	-	-	-	-	-	-	-	-	11	A-4a (V)	
		522.1	22		8															
			23																	
MEDIUM DENSE, BROWN COARSE AND FINE SAND, LITTLE SILT, LITTLE CLAY, TRACE FINE GRAVEL, DAMP.			24	9	5	15	67	SS-10	-	-	-	-	-	-	-	-	-	5	A-3a (V)	
			25		7															
			26	7	7	18	78	SS-11	-	-	-	-	-	-	-	-	-	4	A-3a (V)	
			27		7															



PROJECT: HAM-75-7.85
 TYPE: RETAINING WALL
 PID: 77889 BR ID: NA
 START: 10/6/11 END: 10/6/11

DRILLING FIRM / OPERATOR: RII / T.F.
 SAMPLING FIRM / LOGGER: RII / S.M.
 DRILLING METHOD: 4.25" HSA
 SAMPLING METHOD: SPT

DRILL RIG: CME-750X (SN 310218)
 HAMMER: CME AUTOMATIC
 CALIBRATION DATE: 5/6/11
 ENERGY RATIO (%): 77.1

STATION / OFFSET: 460+63.47 / 74.8' Lt
 ALIGNMENT: PROPOSED CL I-75
 ELEVATION: 543.2 (MSL) EOB: 50.0 ft.
 LAT / LONG: 39.185964136 ° N / 84.483006019 ° W

EXPLORATION ID
B-021-0-11

PAGE
 1 OF 2

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.6' - TOPSOIL (7.0")	542.6																	
FILL: VERY STIFF TO HARD, BROWN SILT AND CLAY, AND COARSE TO FINE SAND, DAMP TO MOIST.		1	2	8	56	SS-1	2.25	-	-	-	-	-	-	-	-	12	A-6a (V)	
		2	4															
		3																
		4	3	18	67	SS-2	3.75	-	-	-	-	-	-	-	-	11	A-6a (V)	
		5																
		6	5															
		7	8	22	78	SS-3	4.50	0	13	48	22	17	24	13	11	11	A-6a (1)	
		8																
		9	5	13	56	SS-4	4.50	-	-	-	-	-	-	-	-	10	A-6a (V)	
		10	7	3														
	530.2	11	4															
		12	5	12	89	SS-5	3.50	-	-	-	-	-	-	-	-	16	A-6a (V)	
		13																
VERY STIFF, BROWN SILT AND CLAY, SOME COARSE TO FINE SAND, MOIST. -ROOT AND WOOD FIBERS PRESENT IN SS-6	527.7	14	4	17	67	SS-6	3.00	-	-	-	-	-	-	-	-	21	A-6a (V)	
		15	7	6														
LOOSE, BROWN FINE SAND, TRACE FINE GRAVEL, TRACE SILT, WET.	525.2	16	2															
		17	1	5	89	SS-7	-	-	-	-	-	-	-	-	-	19	A-3 (V)	
		18	3															
STIFF, BROWN CLAY, AND SILT, LITTLE FINE GRAVEL, TRACE COARSE TO FINE SAND, MOIST. -COBBLES PRESENT IN SS-8	522.7	19	10	15	28	SS-8	2.00	12	3	7	36	42	41	19	22	23	A-7-6 (13)	
		20	7	5														
LOOSE, BROWN COARSE AND FINE SAND, TRACE FINE GRAVEL, TRACE SILT, TRACE CLAY, DAMP.	520.2	21	4															
		22	3	9	39	SS-9	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
		23	4															
MEDIUM DENSE TO DENSE, BROWN COARSE AND FINE SAND, TRACE FINE GRAVEL, TRACE SILT, TRACE CLAY, DRY TO DAMP.		24	5	33	44	SS-10	-	-	-	-	-	-	-	-	-	5	A-3a (V)	
		25	10	16														
		26	5															
		27	11	35	56	SS-11	-	9	34	44	10	3	NP	NP	NP	5	A-3a (0)	
			16															



PROJECT: HAM-75-7.85
 TYPE: RETAINING WALL
 PID: 77889 BR ID: NA
 START: 10/6/11 END: 10/6/11

DRILLING FIRM / OPERATOR: RII / T.F.
 SAMPLING FIRM / LOGGER: RII / S.M.
 DRILLING METHOD: 4.25" HSA
 SAMPLING METHOD: SPT

DRILL RIG: CME-750X (SN 310218)
 HAMMER: CME AUTOMATIC
 CALIBRATION DATE: 5/6/11
 ENERGY RATIO (%): 77.1

STATION / OFFSET: 461+59.39 / 75.0' Lt
 ALIGNMENT: PROPOSED CL I-75
 ELEVATION: 545.1 (MSL) EOB: 25.0 ft.
 LAT / LONG : 39.186215212 ° N / 84.482904319 ° W

EXPLORATION ID
B-022-0-11

PAGE
 1 OF 1

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.5' - TOPSOIL (6.0") FILL: MEDIUM DENSE TO DENSE, BROWN COARSE AND FINE SAND , LITTLE SILT, LITTLE CLAY, TRACE FINE GRAVEL, DAMP TO MOIST.	545.1 544.6																	
		1	4	14	56	SS-1	-	-	-	-	-	-	-	-	-	6	A-3a (V)	
		2	5															
		3	6															
		4	5	23	56	SS-2	-	4	13	54	15	14	NP	NP	NP	12	A-3a (0)	
		5	10	8														
		6	8															
		7	6	33	78	SS-3	-	-	-	-	-	-	-	-	-	12	A-3a (V)	
		8	12	14														
MEDIUM STIFF, BROWN SILTY CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, MOIST.	537.1																	
		9	2	6	67	SS-4	1.00	2	5	15	39	39	40	20	20	30	A-6b (12)	
		10	1	4														
MEDIUM DENSE, BROWN FINE SAND , TRACE SILT, MOIST.	534.6																	
		11	5	22	56	SS-5	-	-	-	-	-	-	-	-	-	11	A-3 (V)	
		12	8	9														
STIFF, BROWN SILTY CLAY , SOME COARSE TO FINE SAND, TRACE FINE GRAVEL, WET.	532.1																	
		13	4	14	67	SS-6	1.25	2	4	19	40	35	37	19	18	37	A-6b (11)	
		14	5	6														
MEDIUM DENSE, BROWN COARSE AND FINE SAND , LITTLE SILT, TRACE FINE GRAVEL, WET.	529.6																	
-TRACE COBBLES PRESENT IN SS-7		16	6	21	78	SS-7	-	-	-	-	-	-	-	-	-	17	A-3a (V)	
		17	9	7														
MEDIUM DENSE, BROWN FINE SAND , TRACE FINE GRAVEL, TRACE SILT, WET.	527.1																	
		18	4	15	78	SS-8	-	-	-	-	-	-	-	-	-	20	A-3 (V)	
		19	5	7														
		20	7															
		21	6	18	100	SS-9	-	-	-	-	-	-	-	-	-	16	A-3 (V)	
		22	5	9														
		23	9															
		24	4	22	100	SS-10	-	-	-	-	-	-	-	-	-	22	A-3 (V)	
		25	9	8														
	520.1	EOB																

NOTES: GROUNDWATER ENCOUNTERED INITIALLY @ 18.5' AND AT COMPLETION @ 22.5'; CAVE-IN DEPTH @ 13.2'

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

	PROJECT: HAM-75-7.85	DRILLING FIRM / OPERATOR: RII / T.F.	DRILL RIG: CME-750X (SN 310218)	STATION / OFFSET: 462+77.77 / 85.2' Lt	EXPLORATION ID B-023-0-11
	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: 546.9 (MSL) EOB: 25.0 ft.	PAGE 1 OF 1
	START: 10/6/11 END: 10/6/11	SAMPLING METHOD: SPT	ENERGY RATIO (%): 77.1	LAT / LONG: 39.186533569 ° N / 84.482812865 ° W	

MATERIAL DESCRIPTION AND NOTES	ELEV.	DEPTHS	SPT/ RQD	N ₆₀	REC (%)	SAMPLE ID	HP (tsf)	GRADATION (%)					ATTERBERG			WC	ODOT CLASS (GI)	BACK FILL
								GR	CS	FS	SI	CL	LL	PL	PI			
0.6' - TOPSOIL (7.0")	546.9																	
FILL: VERY STIFF TO HARD, DARK AND LIGHT BROWN SILT AND CLAY, LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP TO MOIST. -TRACE ROOT FIBERS PRESENT IN SS-1	546.3	1	2	6	56	SS-1	3.25	-	-	-	-	-	-	-	-	18	A-6a (V)	
		2	2	3														
		3																
		4	2	7	17	SS-2	4.50	0	6	28	40	26	29	16	13	11	A-6a (7)	
		5		6														
		6	4	8	23	SS-3	4.50	-	-	-	-	-	-	-	-	14	A-6a (V)	
		7		10														
		8																
		9	7	8	23	SS-4	4.50	-	-	-	-	-	-	-	-	8	A-6a (V)	
		10		10														
LOOSE TO MEDIUM DENSE, BROWN SANDY SILT , TRACE CLAY, TRACE FINE GRAVEL, MOIST.	536.4	11	8	26	78	SS-5	-	-	-	-	-	-	-	-	-	14	A-4a (V)	
		12	10	10														
		13																
		14	2	3	8	SS-6	-	8	10	39	34	9	NP	NP	NP	18	A-4a (2)	
		15		3														
		16	4															
		17	3	4	9	SS-7	-	-	-	-	-	-	-	-	-	16	A-4a (V)	
	528.9	18																
		19	3	2	5	SS-8	-	2	43	21	28	6	NP	NP	NP	22	A-3a (0)	
		20		2														
LOOSE, DARK BROWN COARSE AND FINE SAND , SOME SILT, TRACE CLAY, TRACE FINE GRAVEL, WET.	526.4	21	50/4"	-	50	SS-9	-	-	-	-	-	-	-	-	-	5	A-1-b (V)	
		22																
VERY DENSE, GRAY GRAVEL AND SAND , LITTLE SILT, TRACE CLAY, DAMP. -DROVE SPOON ON COBBLE @ 21.0'	523.9	23																
		24	20	6	18	SS-10	4.50	-	-	-	-	-	-	-	-	15	A-6b (V)	
HARD, BROWN SILTY CLAY , LITTLE COARSE TO FINE SAND, TRACE FINE GRAVEL, DAMP.	521.9	25		8														
		EOB																

NOTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING; CAVE-IN DEPTH @ 13.0'

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

APPENDIX V
LABORATORY TESTING RESULTS



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

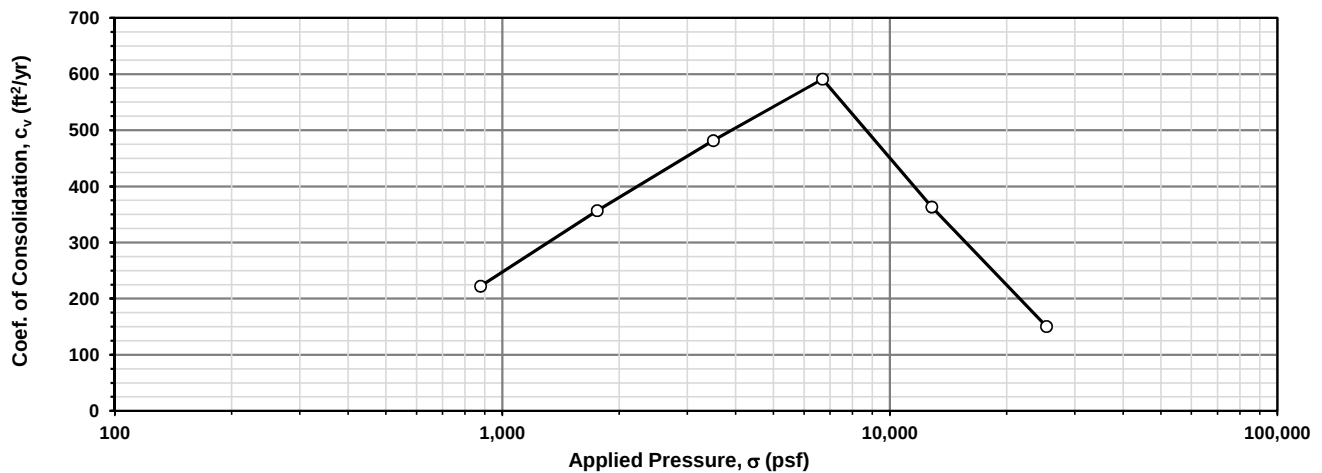
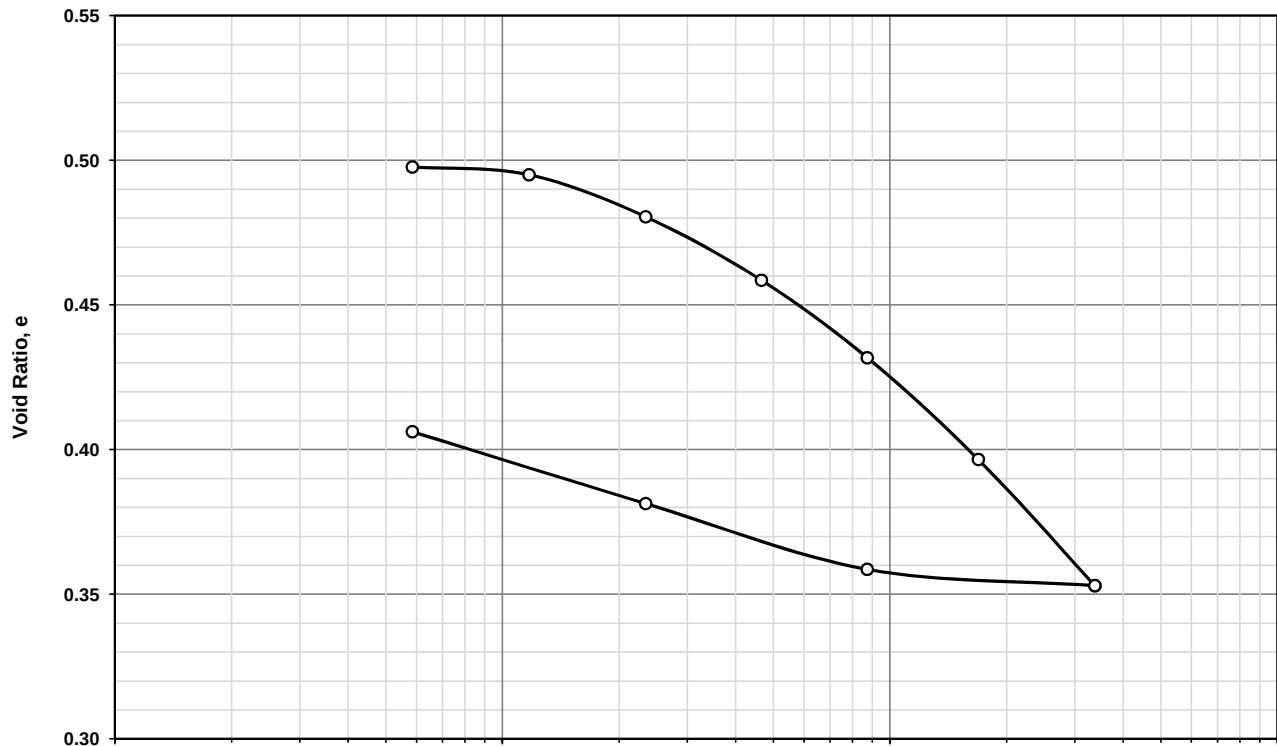
Client: EMH&T

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		γ_d (pcf)	γ_{sat} (pcf)	σ_{vo}' (psf)	S_G	e_o	σ_p' (psf)	c_c	c_r
S_o	w_o								
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-017-0-11

Project Name: HAM-75-7.85

Sample No. / Depth: ST-4 / 10.0 ft

Project Location: Hamilton County, Ohio

Date of Testing: 11/11/2011 to 11/28/2011

Client: EMH&T

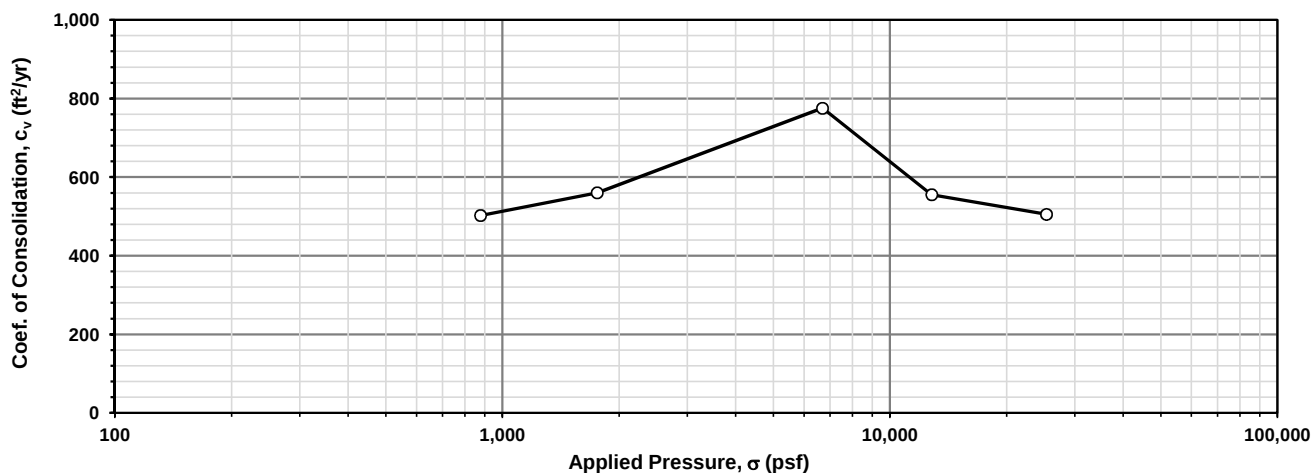
Technician: JJH

Soil Description: Brown SANDY SILT, little clay, little 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	11	7	29	39	14

Natural		γ_d (pcf)	γ_{sat} (pcf)	σ_{vo}' (psf)	S_G	e_o	σ_p' (psf)	c_c	c_r
S_o	w_o								
88.4%	14.7%	111.6	129.8	1,200	2.67	0.494	2,656	0.155	0.015





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

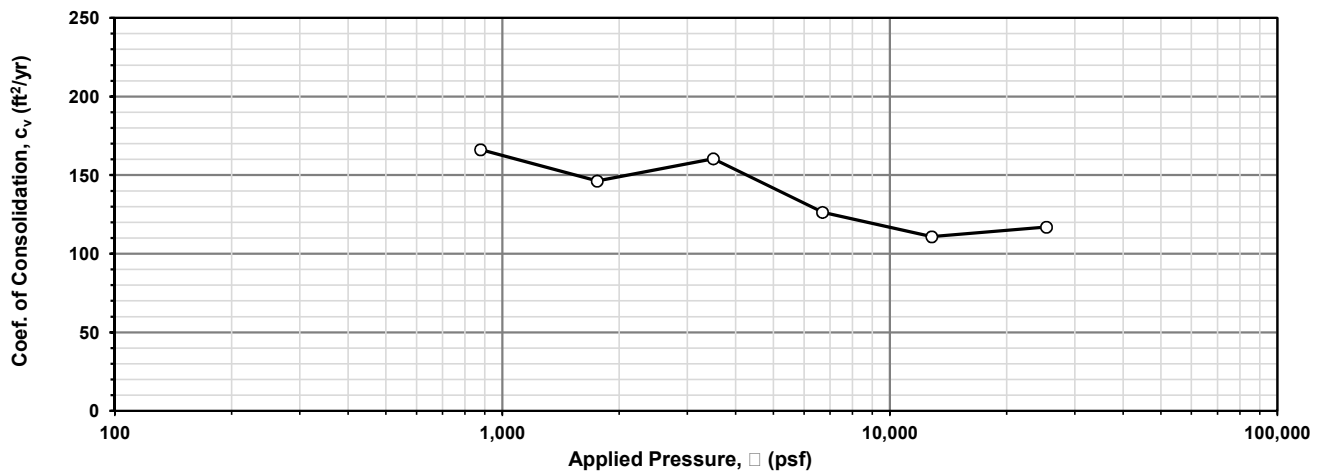
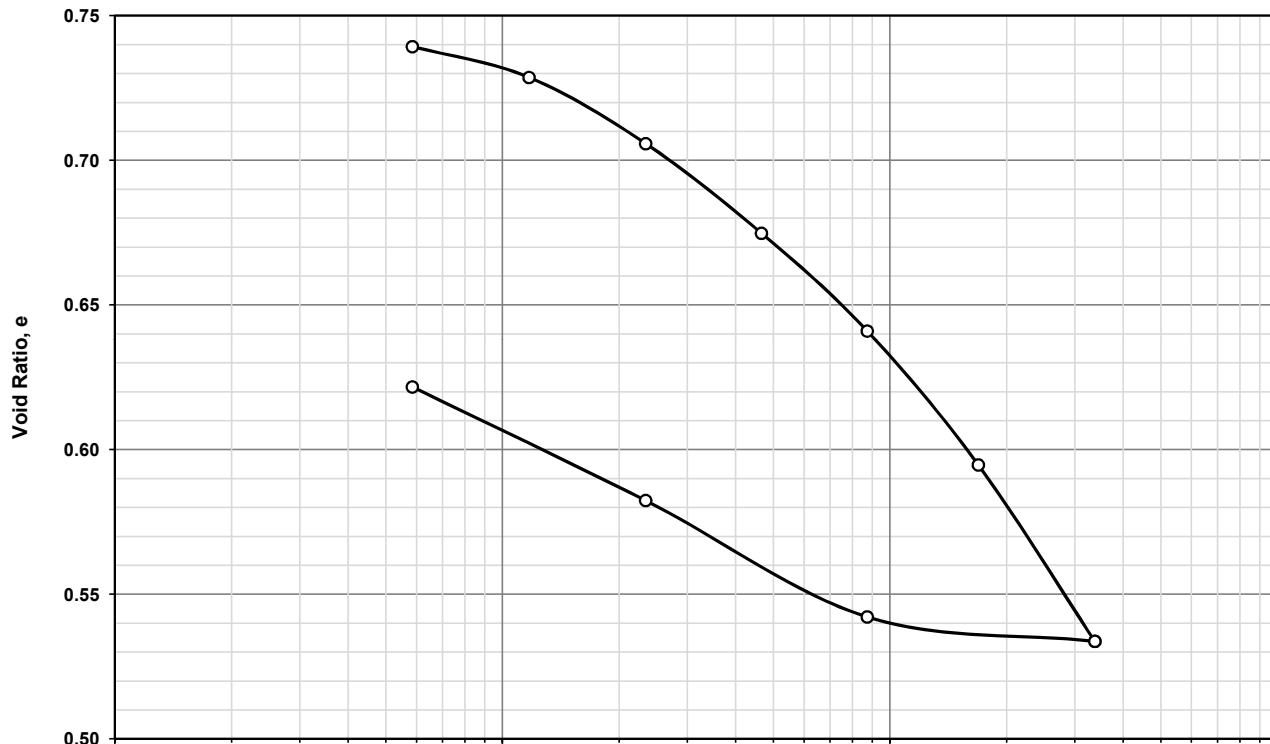
Soil Description: Gray CLAY, trace silt

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





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ASTM D-4767

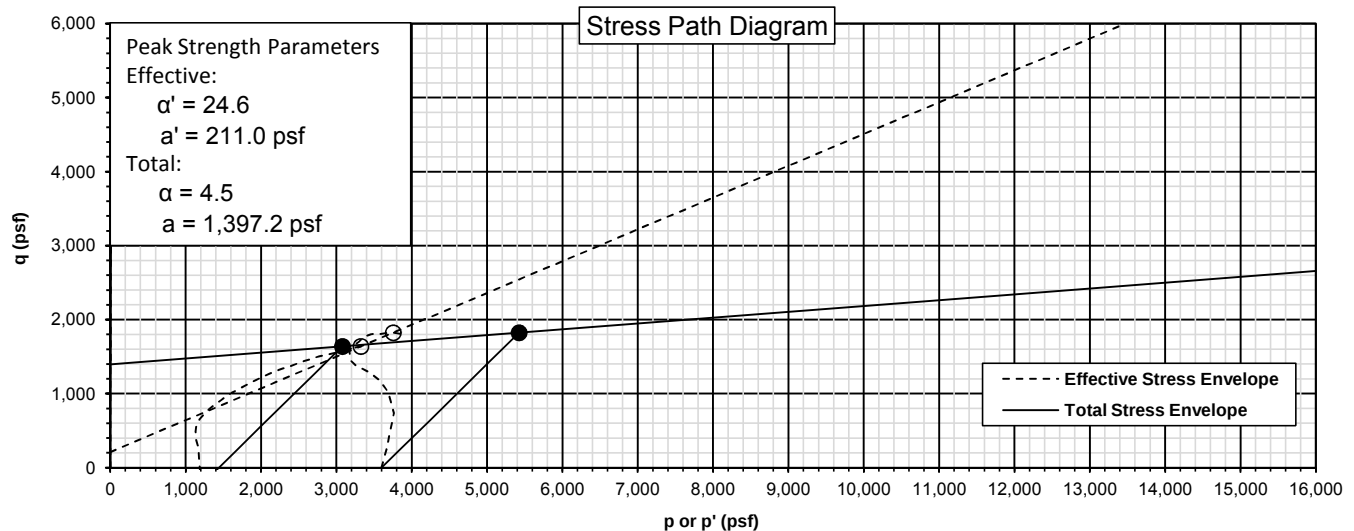
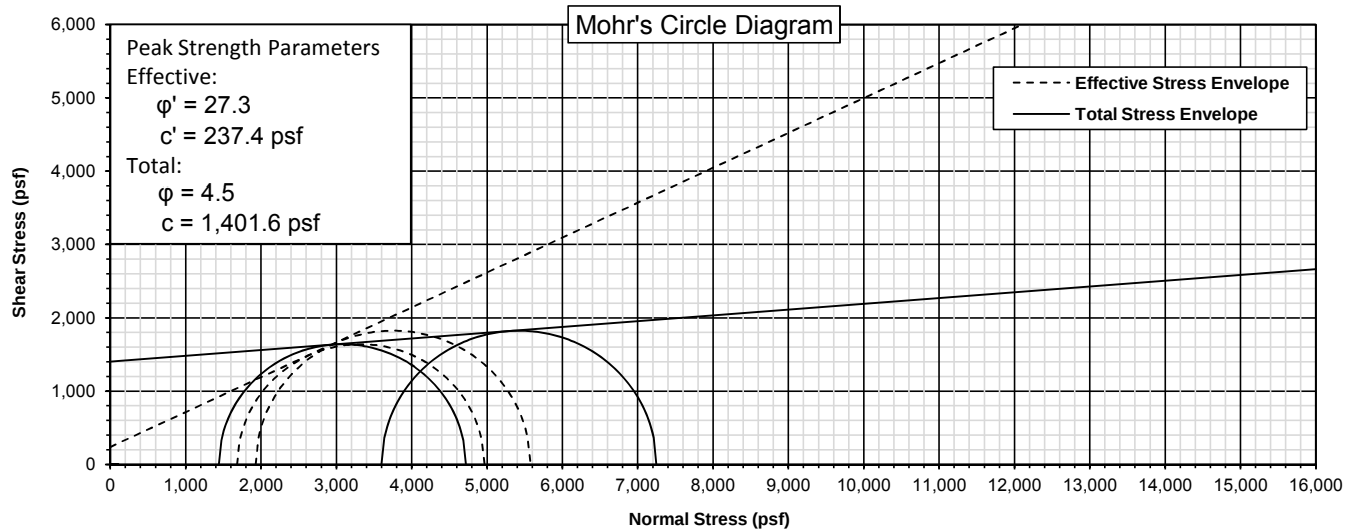
PROJECT NAME: HAM-75-7.85
JOB NUMBER: B-10-020
BORING NUMBER: B-016-0-11A
SAMPLE NUMBER: ST-3
SAMPLE DEPTH: 6.5 to 7.0 feet
DATE OF TESTING: 12/12/2011-12/28/11
TESTED BY: Hoyt

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

Physical Characteristics

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

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





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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
Area, A_0 : 6.429 in²
Height, L_0 : 5.773 in
Volume, V_0 : 37.115 in³

Volume of Solids, V_s : 25.349 in³
Initial Volume of Voids, V_v : 11.766 in³
Initial Void Ratio, e_0 : 0.464
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 %

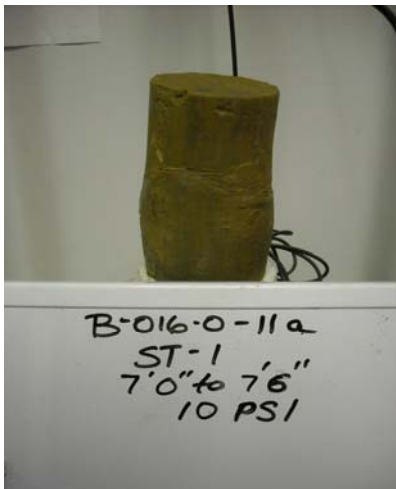
Water Content AFTER Test (Total Specimen)

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

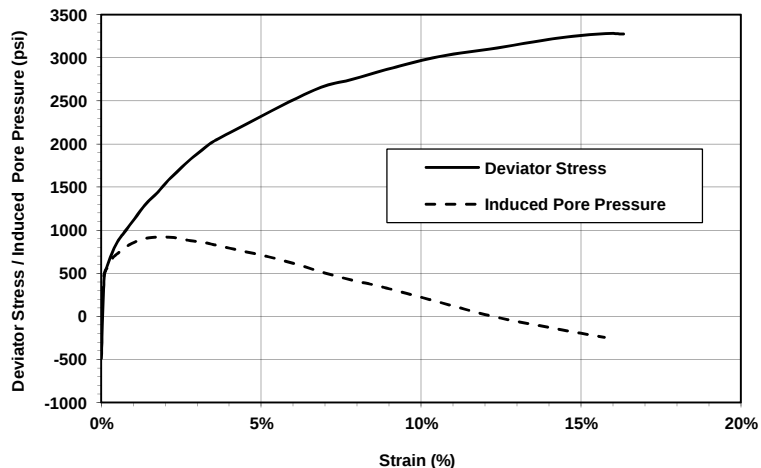
Consolidation Cell Pressure: 145.0 psi
Consolidation Back Pressure: 135.0 psi
Effective Confining Stress, σ_3 : 10.0 psi
1440.00 psf
Strain Rate: 0.0040 in/min

Deviator Stress @ Failure, D_s : 3279.09 psf
Axial Strain @ Failure: 15.74 %
Major Principal Stress @ Failure, σ_1 : 4719.09 psf
Induced Pore Pressure @ Failure: -244.80 psf
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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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
Area, A_0 : 6.350 in²
Height, L_0 : 5.990 in
Volume, V_0 : 38.032 in³

Volume of Solids, V_s : 26.099 in³
Initial Volume of Voids, V_v : 11.933 in³
Initial Void Ratio, e_0 : 0.457
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

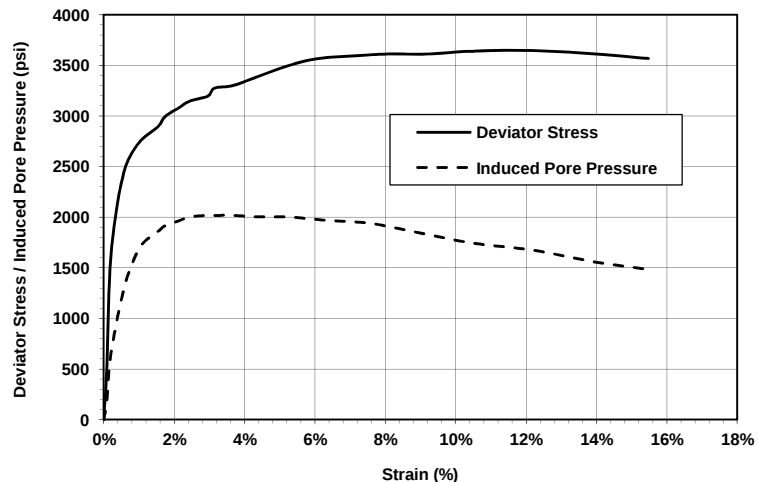
Consolidation Cell Pressure: 118.0 psi
Consolidation Back Pressure: 93.0 psi
Effective Confining Stress, σ_3 : 25.0 psi
3600.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 3648.02 psf
Axial Strain @ Failure: 12.24 %
Major Principal Stress @ Failure, σ_1 : 7248.02 psf
Induced Pore Pressure @ Failure: 1670.40 psf
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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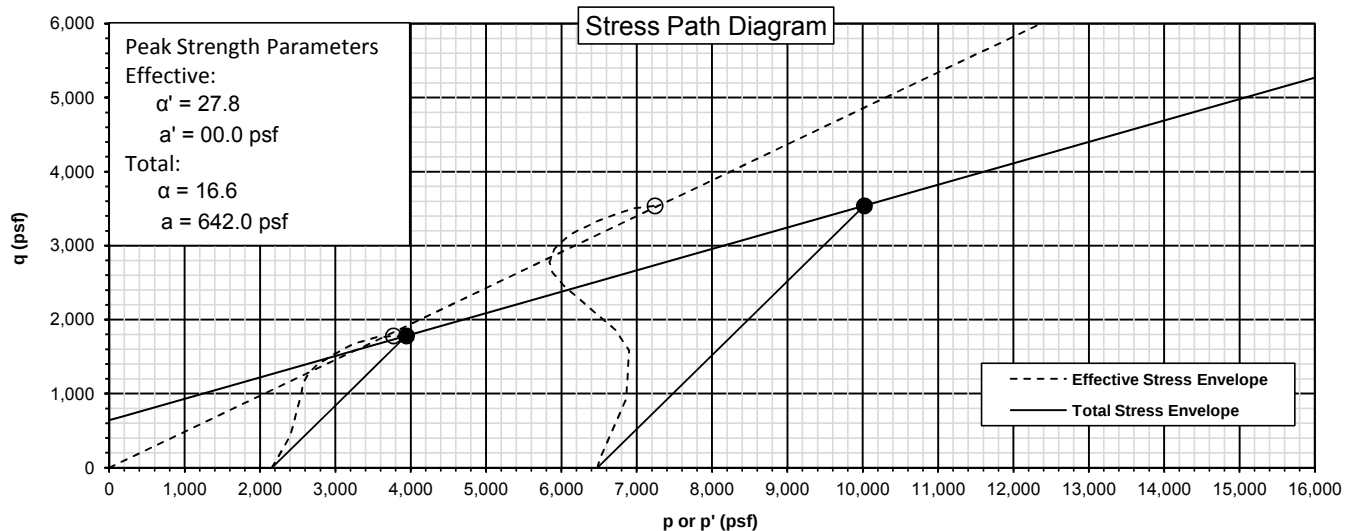
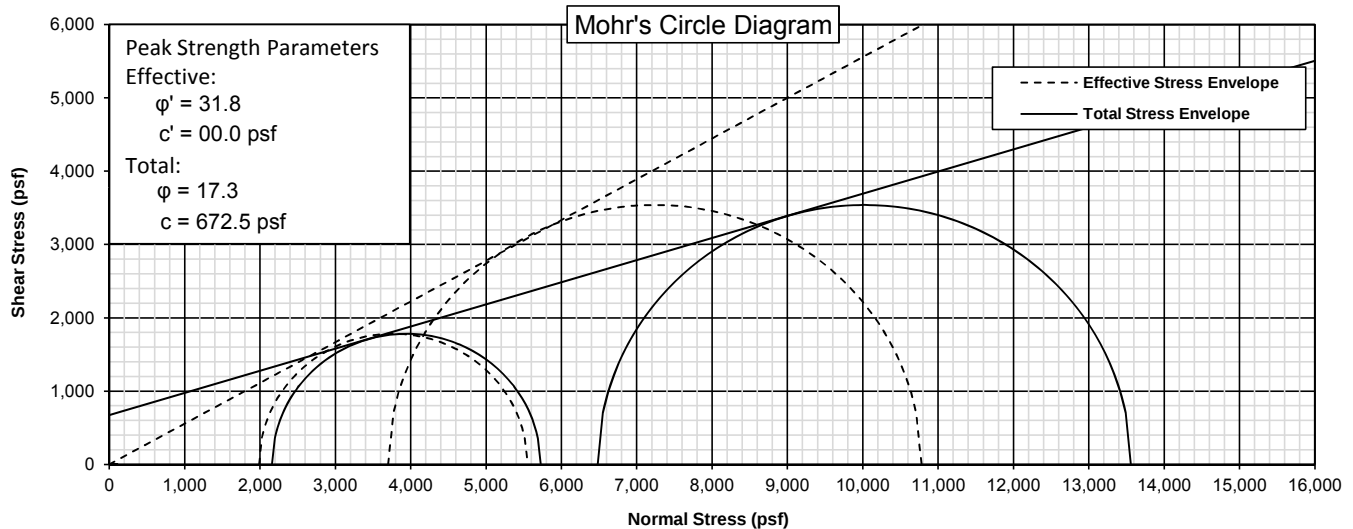
PROJECT NAME: HAM-75-7.85
JOB NUMBER: B-10-020
BORING NUMBER: B-018-0-11
SAMPLE NUMBER: ST-14
SAMPLE DEPTH: 36.8 to 38.0 ft
DATE OF TESTING: 11/24/2011 to 11/30/2011
TESTED BY: Hoyt

Soil Description: Mottled orangish brown and reddish brown SILTY CLAY, some 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%
31	14	17	1	3	22	39	35

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-018-0-11	ST-14	37.5	2,160.0	5,724.0	1,987.2	5,551.2	3,769.2	1,782.0
2	B-018-0-11	ST-14	36.8	6,480.0	13,559.0	3,700.8	10,779.8	7,240.3	3,539.5
3									





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PROJECT NAME: HAM-75-7.85
JOB NUMBER: B-10-020
BORING NUMBER: B-018-0-11
SAMPLE NUMBER: ST-14
SAMPLE DEPTH: 37.5
DATE OF TESTING: 11/30/2011
TESTED BY: Hoyt

Data for Specimen No. 1

Soil Description: Mottled orangish brown and reddish brown SILTY CLAY, some 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%
	31	14	17	1.0	3.0	22.0	39	35

Diameter, D_0 : 2.850 in
Area, A_0 : 6.378 in²
Height, L_0 : 5.949 in
Volume, V_0 : 37.940 in³

Volume of Solids, V_s : 26.345 in³
Initial Volume of Voids, V_v : 11.595 in³
Initial Void Ratio, e_0 : 0.440
Initial Degree of Saturation, S_0 : 100.904 %

Water Content BEFORE Test

Tin No.: WC-45 g
Wet Soil + Tin : 126.26 g
Dry Soil + Tin : 112.57 g
Tin Weight : 30.26 g
Dry Mass : 82.31 g
Weight of water : 13.69 g
Moisture : 16.63 %

Water Content AFTER Test (Total Specimen)

Tin No.: Freddy g
Wet Soil + Tin : 1431.60 g
Dry Soil + Tin : 1236.80 g
Tin Weight : 84.10 g
Dry Mass : 1152.70 g
Weight of water : 194.80 g
Moisture : 16.90 %
Wet Density : 135.30 pcf
Dry Density : 115.74 pcf

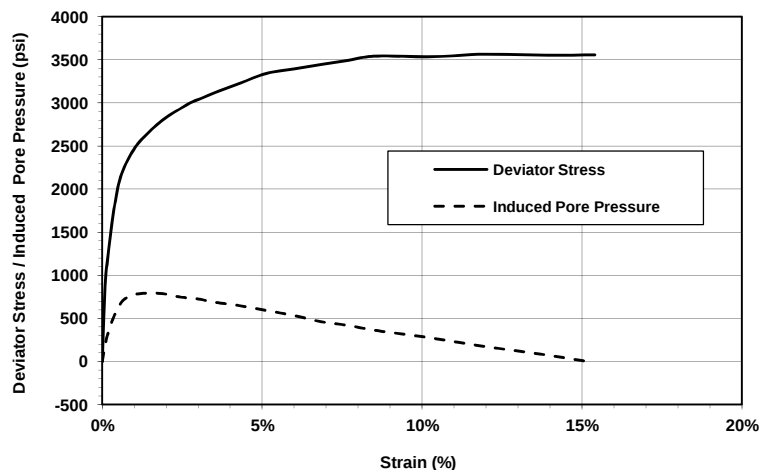
Consolidation Cell Pressure: 75.0 psi
Consolidation Back Pressure: 60.0 psi
Effective Confining Stress, σ_3 : 15.0 psi
2160.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 3563.96 psf
Axial Strain @ Failure: 11.98 %
Major Principal Stress @ Failure, σ_1 : 5723.96 psf
Induced Pore Pressure @ Failure: 172.80 psf
Effective Minor Principal Stress, σ_3' : 1987.20 psf
Effective Major Principal Stress, σ_1' : 5551.16 psf

Failure Sketch



CU Compressive Strength and Induced Pore Pressure





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CONSOLIDATED, UNDRAINED TRIAXIAL ASTM D-4767

PROJECT NAME: HAM-75-7.85
JOB NUMBER: B-10-020
BORING NUMBER: B-018-0-11
SAMPLE NUMBER: ST-14
SAMPLE DEPTH: 36.8
DATE OF TESTING: 24-Nov-11
TESTED BY: Hoyt

Data for Specimen No. 2

Soil Description: Mottled orangish brown and reddish brown SILTY CLAY, some 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%
	31	14	17	1	3	22	39	35

Diameter, D_0 : 2.852 in
Area, A_0 : 6.388 in²
Height, L_0 : 5.926 in
Volume, V_0 : 37.857 in³

Volume of Solids, V_s : 25.920 in³
Initial Volume of Voids, V_v : 11.937 in³
Initial Void Ratio, e_0 : 0.461
Initial Degree of Saturation, S_0 : 96.43 %

Water Content BEFORE Test

Tin No.: WC-45 g
Wet Soil + Tin : 126.26 g
Dry Soil + Tin : 112.57 g
Tin Weight : 30.26 g
Dry Mass : 82.31 g
Weight of water : 13.69 g
Moisture : 16.63 %

Water Content AFTER Test (Total Specimen)

Tin No.: BC g
Wet Soil + Tin : 1409.90 g
Dry Soil + Tin : 1223.60 g
Tin Weight : 89.50 g
Dry Mass : 1134.10 g
Weight of water : 186.30 g
Moisture : 16.43 %
Wet Density : 132.87 pcf
Dry Density : 114.12 pcf

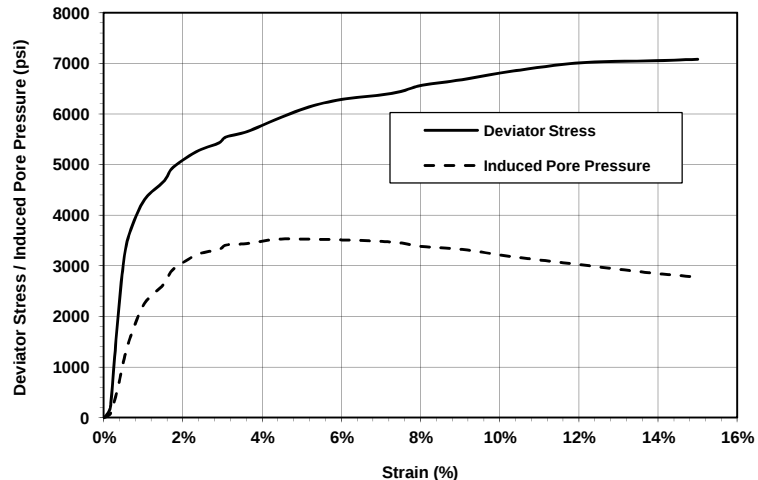
Consolidation Cell Pressure: 140.0 psi
Consolidation Back Pressure: 95.0 psi
Effective Confining Stress, σ_3 : 45.0 psi
6480.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 7078.99 psf
Axial Strain @ Failure: 15.00 %
Major Principal Stress @ Failure, σ_1 : 13558.99 psf
Induced Pore Pressure @ Failure: 2779.20 psf
Effective Minor Principal Stress, σ_3' : 3700.80 psf
Effective Major Principal Stress, σ_1' : 10779.79 psf

Failure Sketch



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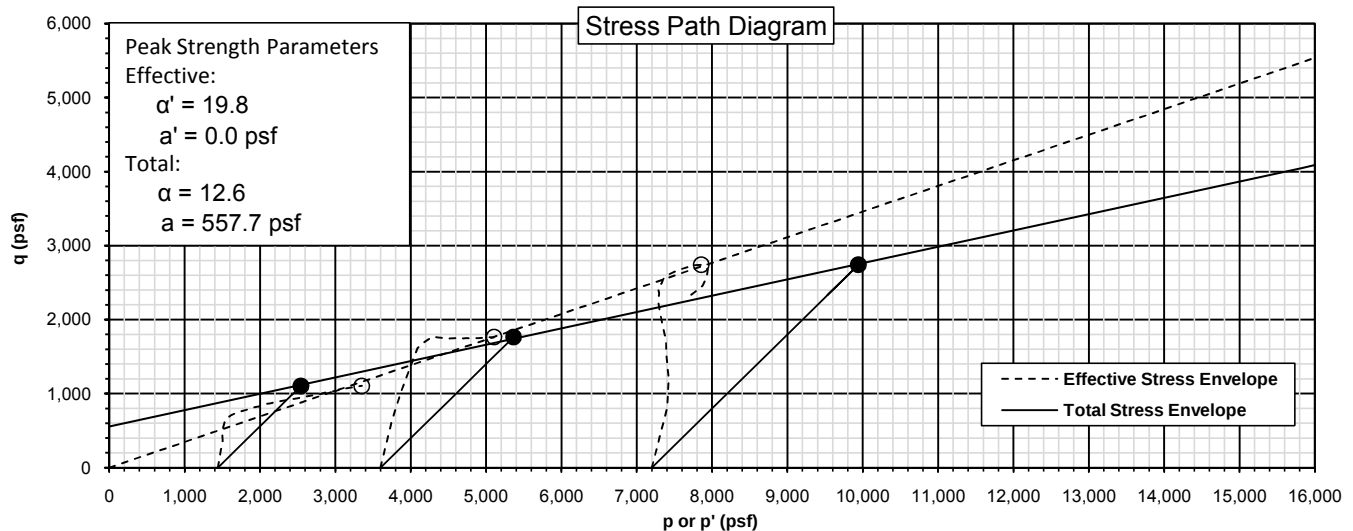
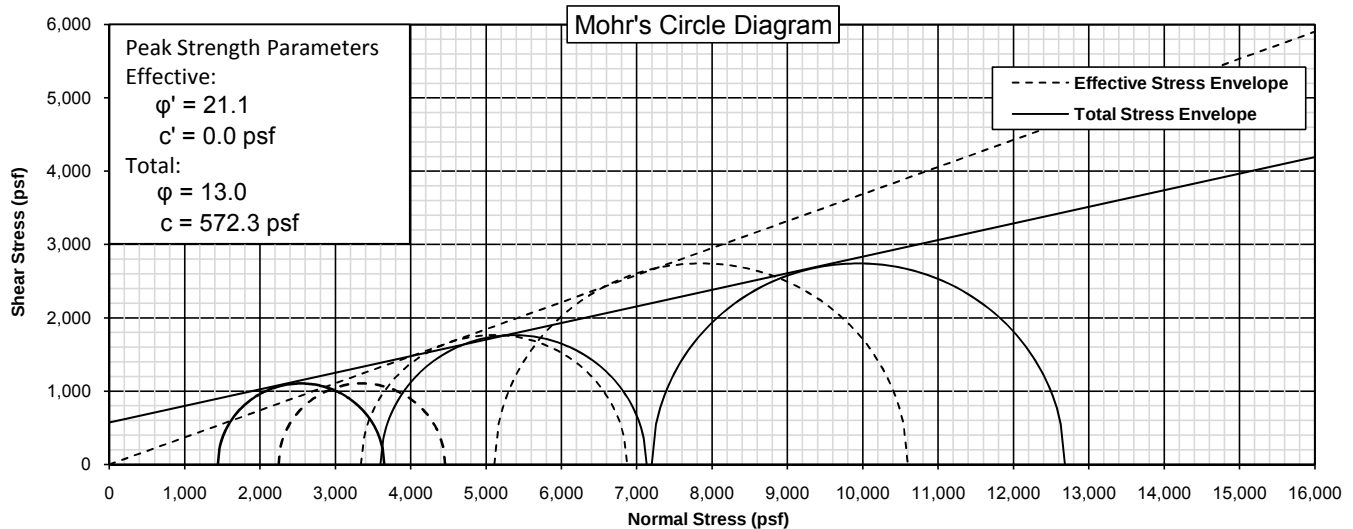
ASTM D-4767

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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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
Area, A_0 : 6.466 in²
Height, L_0 : 5.721 in
Volume, V_0 : 36.996 in³

Volume of Solids, V_s : 23.836 in³
Initial Volume of Voids, V_v : 13.160 in³
Initial Void Ratio, e_0 : 0.552
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

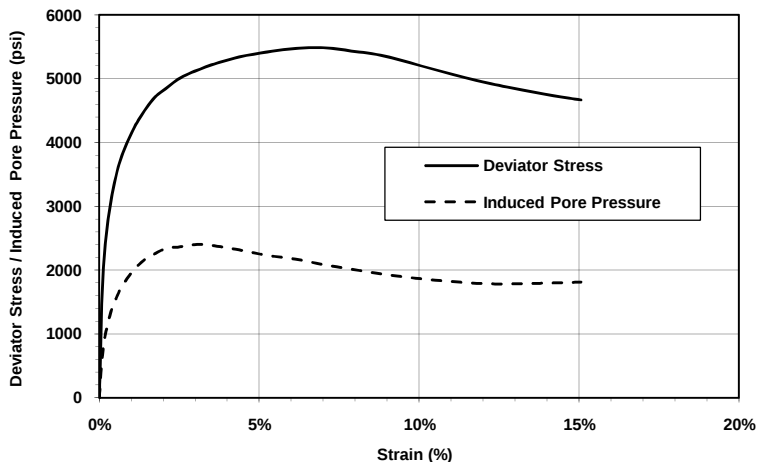
Consolidation Cell Pressure: 130.0 psi
Consolidation Back Pressure: 80.0 psi
Effective Confining Stress, σ_3 : 50.0 psi
7200.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 5484.32 psf
Axial Strain @ Failure: 7.01 %
Major Principal Stress @ Failure, σ_1 : 12684.32 psf
Induced Pore Pressure @ Failure: 2088.00 psf
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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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
Area, A_0 : 6.469 in²
Height, L_0 : 5.867 in
Volume, V_0 : 37.957 in³

Volume of Solids, V_s : 23.427 in³
Initial Volume of Voids, V_v : 14.531 in³
Initial Void Ratio, e_0 : 0.620
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

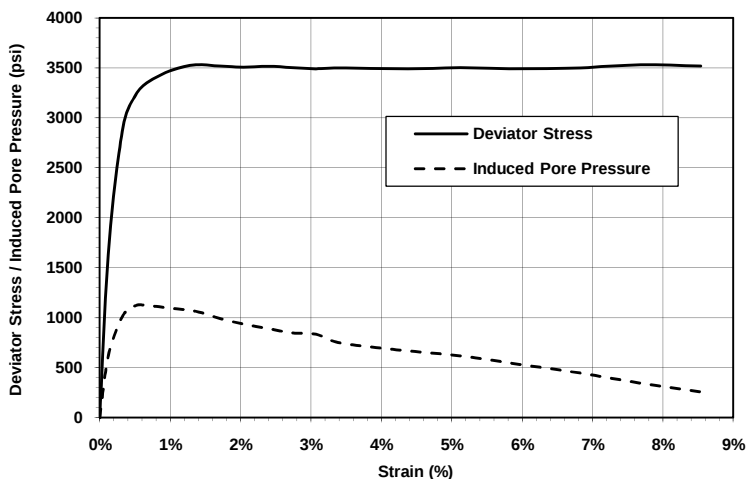
Consolidation Cell Pressure: 135.0 psi
Consolidation Back Pressure: 110.0 psi
Effective Confining Stress, σ_3 : 25.0 psi
3600.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 3530.56 psf
Axial Strain @ Failure: 8.54 %
Major Principal Stress @ Failure, σ_1 : 7130.56 psf
Induced Pore Pressure @ Failure: 259.20 psf
Effective Minor Principal Stress, σ_3' : 3340.80 psf
Effective Major Principal Stress, σ_1' : 6871.36 psf

Failure Sketch



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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
Area, A_0 : 6.466 in²
Height, L_0 : 5.908 in
Volume, V_0 : 38.203 in³

Volume of Solids, V_s : 22.291 in³
Initial Volume of Voids, V_v : 15.912 in³
Initial Void Ratio, e_0 : 0.714
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

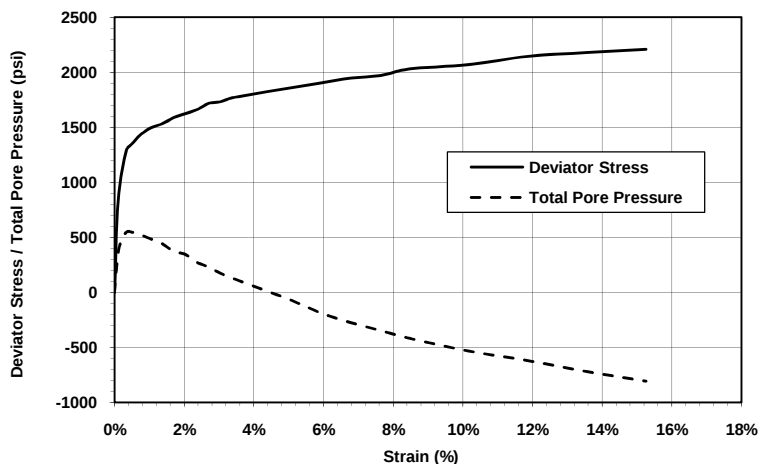
Consolidation Cell Pressure: 120.0 psi
Consolidation Back Pressure: 110.0 psi
Effective Confining Stress, σ_3 : 10.0 psi
1440.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 2208.58 psf
Axial Strain @ Failure: 15.25 %
Major Principal Stress @ Failure, σ_1 : 3648.58 psf
Induced Pore Pressure @ Failure: -806.40 psf
Effective Minor Principal Stress, σ_3' : 2246.40 psf
Effective Major Principal Stress, σ_1' : 4454.98 psf

Failure Sketch



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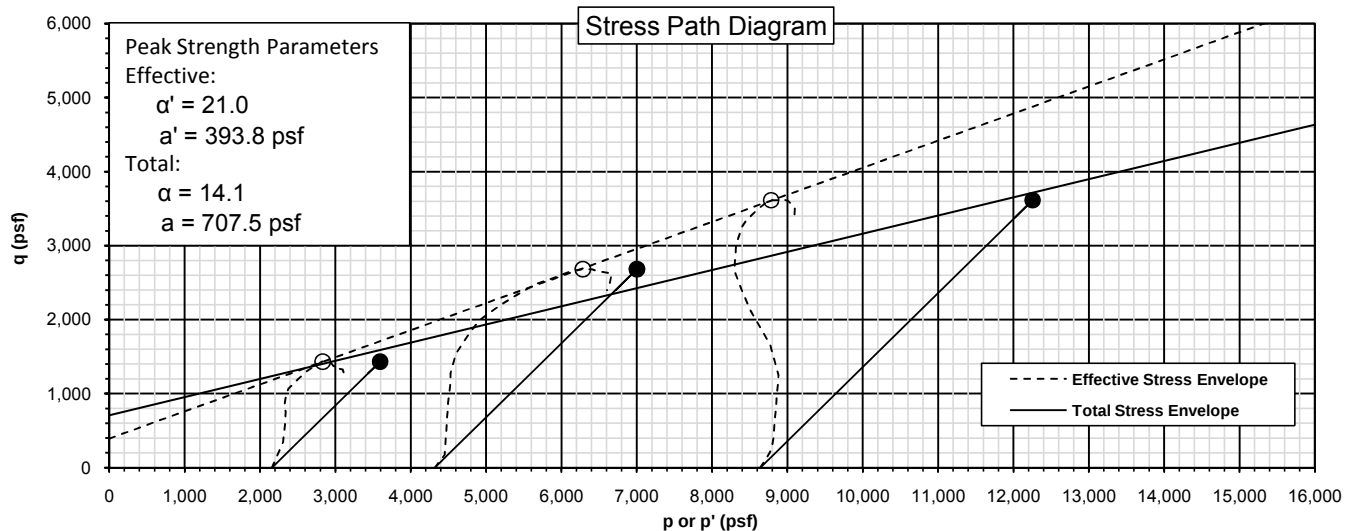
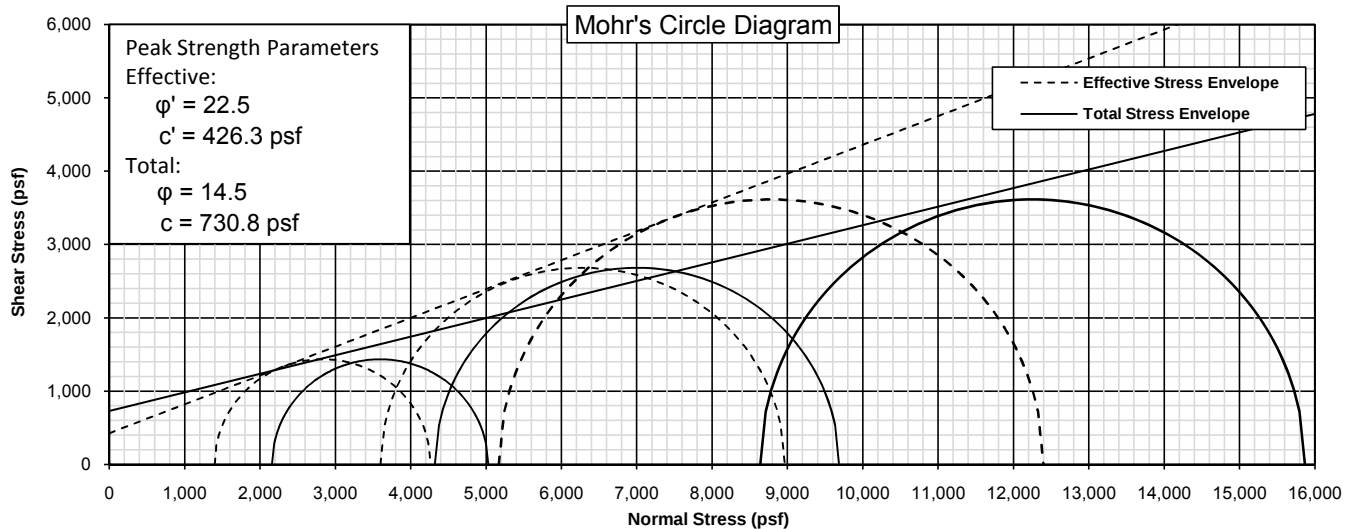
PROJECT NAME: HAM-75-12.60 Part I
JOB NUMBER: B-10-024
BORING NUMBER: B-022-0-11
SAMPLE NUMBER: ST-11
SAMPLE DEPTH: 24.3-25.9
DATE OF TESTING: 02/17/2012 through 02/23/2012
TESTED BY: J.Hoyt

Soil Description: Gray SILTY CLAY, trace 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%
40	19	21	1	1	1	33	64

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-022-0-11	ST-11	24.3	2,160.0	5,027.9	1,396.8	4,264.7	2,830.7	1,433.9
2	B-022-0-11	ST-11	24.8	4,320.0	9,685.9	3,600.0	8,965.9	6,282.9	2,682.9
3	B-022-0-11	ST-11	25.4	8,640.0	15,868.0	5,169.6	12,397.6	8,783.6	3,614.0





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PROJECT NAME: HAM-75-12.60 Part I
JOB NUMBER: B-10-024
BORING NUMBER: B-022-0-11
SAMPLE NUMBER: ST-11
SAMPLE DEPTH: 24.3
DATE OF TESTING: 2/17/2012
TESTED BY: J.Hoyt

Data for Specimen No. 1

Soil Description: Gray SILTY CLAY, trace 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%
	40	19	21	1	1	1	33	64

Diameter, D_0 : 2.902 in
Area, A_0 : 6.614 in²
Height, L_0 : 5.902 in
Volume, V_0 : 39.038 in³

Volume of Solids, V_s : 24.282 in³
Initial Volume of Voids, V_v : 14.756 in³
Initial Void Ratio, e_0 : 0.608
Initial Degree of Saturation, S_0 : 99.553 %

Water Content BEFORE Test

Tin No.: X-11 g
Wet Soil + Tin : 112.47 g
Dry Soil + Tin : 97.25 g
Tin Weight : 30.08 g
Dry Mass : 67.17 g
Weight of water : 15.22 g
Moisture : 22.66 %

Water Content AFTER Test (Total Specimen)

Tin No.: Freddy g
Wet Soil + Tin : 1,378.10 g
Dry Soil + Tin : 1,147.30 g
Tin Weight : 84.90 g
Dry Mass : 1,062.40 g
Weight of water : 230.80 g
Moisture : 21.72 %
Wet Density : 126.20 pcf
Dry Density : 103.68 pcf

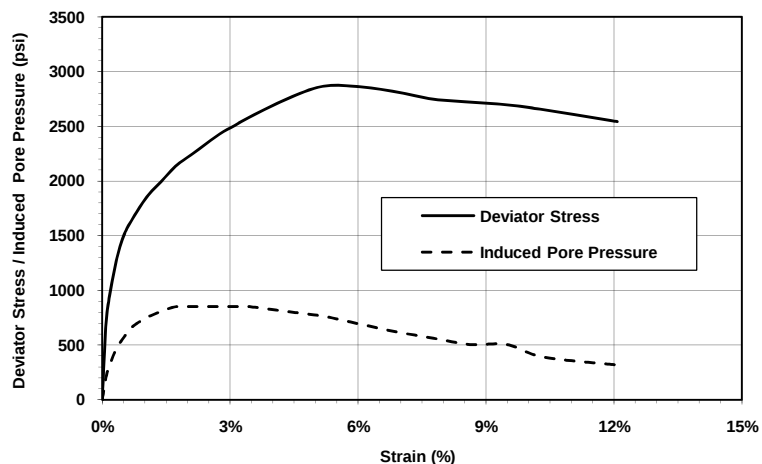
Consolidation Cell Pressure: 133.0 psi
Consolidation Back Pressure: 118.0 psi
Effective Confining Stress, σ_3 : 15.0 psi
2,160.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 2,867.87 psf
Axial Strain @ Failure: 5.18 %
Major Principal Stress @ Failure, σ_1 : 5,027.87 psf
Induced Pore Pressure @ Failure: 763.20 psf
Effective Minor Principal Stress, σ_3' : 1,396.80 psf
Effective Major Principal Stress, σ_1' : 4,264.67 psf

Failure Sketch



CU Compressive Strength and Induced Pore Pressure





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PROJECT NAME: HAM-75-12.60 Part I
JOB NUMBER: B-10-024
BORING NUMBER: B-022-0-11
SAMPLE NUMBER: ST-11
SAMPLE DEPTH: 24.8
DATE OF TESTING: 2/23/2012
TESTED BY: J.Hoyt

Data for Specimen No. 2

Soil Description: Gray SILTY CLAY, trace 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%
	40	19	21	1	1	1	33	64

Diameter, D_0 : 2.869 in
Area, A_0 : 6.465 in²
Height, L_0 : 5.936 in
Volume, V_0 : 38.375 in³

Volume of Solids, V_s : 24.421 in³
Initial Volume of Voids, V_v : 13.954 in³
Initial Void Ratio, e_0 : 0.571
Initial Degree of Saturation, S_0 : 104.13 %

Water Content BEFORE Test

Tin No.: TS-89 g
Wet Soil + Tin : 126.16 g
Dry Soil + Tin : 108.66 g
Tin Weight : 30.13 g
Dry Mass : 78.53 g
Weight of water : 17.5 g
Moisture : 22.28 %

Water Content AFTER Test (Total Specimen)

Tin No.: FUNKY g
Wet Soil + Tin : 1,353.10 g
Dry Soil + Tin : 1,124.80 g
Tin Weight : 56.30 g
Dry Mass : 1068.50 g
Weight of water : 228.30 g
Moisture : 21.37 %
Wet Density : 128.74 pcf
Dry Density : 106.07 pcf

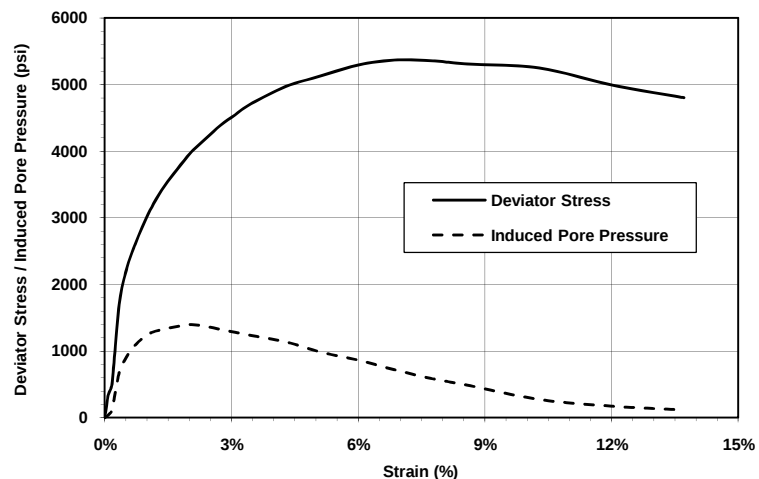
Consolidation Cell Pressure: 133.0 psi
Consolidation Back Pressure: 103.0 psi
Effective Confining Stress, σ_3 : 30.0 psi
4,320.00 psf
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 5,365.90 psf
Axial Strain @ Failure: 6.86 %
Major Principal Stress @ Failure, σ_1 : 9,685.90 psf
Induced Pore Pressure @ Failure: 720.00 psf
Effective Minor Principal Stress, σ_3' : 3,600.00 psf
Effective Major Principal Stress, σ_1' : 8,965.90 psf

Failure Sketch



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PROJECT NAME: HAM-75-12.60 Part I
JOB NUMBER: B-10-024
BORING NUMBER: B-022-0-11
SAMPLE NUMBER: ST-11
SAMPLE DEPTH: 25.4
DATE OF TESTING: 2/21/2012
TESTED BY: J.Hoyt

Data for Specimen No. 3

Soil Description: Gray SILTY CLAY, trace 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%
	40	19	21	1	1	1	33	64

Diameter, D_0 : 2.856 in
Area, A_0 : 6.405 in²
Height, L_0 : 5.914 in
Volume, V_0 : 37.878 in³

Volume of Solids, V_s : 23.838 in³
Initial Volume of Voids, V_v : 14.040 in³
Initial Void Ratio, e_0 : 0.589
Initial Degree of Saturation, S_0 : 100.434 %

Water Content BEFORE Test

Tin No.: G-25 g
Wet Soil + Tin : 142.25 g
Dry Soil + Tin : 121.93 g
Tin Weight : 30.21 g
Dry Mass : 91.72 g
Weight of water : 20.32 g
Moisture : 22.15 %

Water Content AFTER Test (Total Specimen)

Tin No.: Funky g
Wet Soil + Tin : 1,320.20 g
Dry Soil + Tin : 1,099.20 g
Tin Weight : 56.20 g
Dry Mass : 1,043.00 g
Weight of water : 221.00 g
Moisture : 21.19 %
Wet Density : 127.13 pcf
Dry Density : 104.90 pcf

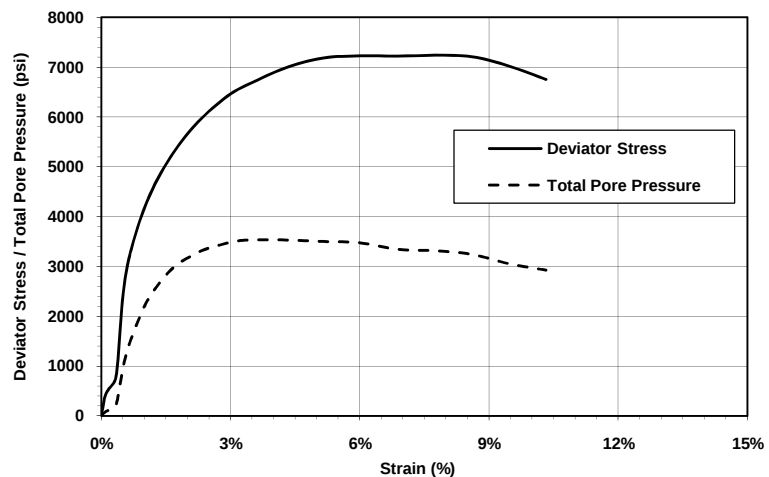
Consolidation Cell Pressure: 138.0 psi
Consolidation Back Pressure: 78.0 psi
Effective Confining Stress, σ_3 : 60.0 psi
Strain Rate: 0.0030 in/min

Deviator Stress @ Failure, D_s : 7,227.96 psf
Axial Strain @ Failure: 6.02 %
Major Principal Stress @ Failure, σ_1 : 15,867.96 psf
Induced Pore Pressure @ Failure: 3,470.40 psf
Effective Minor Principal Stress, σ_3' : 5,169.60 psf
Effective Major Principal Stress, σ_1' : 12,397.56 psf

Failure Sketch



CU Compressive Strength and Induced Pore Pressure



APPENDIX VI

SETTLEMENT CALCULATIONS

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

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

Boring B-182 - Sta. 452+15 to Sta. 453+60

26.2' MSE wall height net loading considered

H= 26.2 ft
B= 21.5 ft
 γ_{eff} = 120 pcf
 D_w = 29.4 ft depth below bottom of footing
 γ_w = 62.4 pcf
 ΔP = 3144 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_v' Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	σ_v' Midpoint	S_c (ft)	S_c (in)
1	Controlled Fill	0.0	4.0	4.0	2.0	120	N/A	0.100	0.008	0.437	N/A	480	240	240	0.09	0.976	3070.02	3310.02	0.024	0.286	0.500	1572.0	1812.0	0.018	0.220
2	Granular	4.0	100.0	96.0	52.0	125	Calculated Separately					12480	6480	5069.76	2.42	Calculated Separately			0.129	1.547	Calculated Separately			0.060	0.719

Settlement at Center of Reinforced Soil Mass: 1.833 in Settlement at Facing of Wall: 0.939 in

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

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

Borings B-017 and B-018 - Sta. 453+60 to Sta. 456+40

21.8' MSE wall height net loading considered

H= 21.8 ft
B= 20.4 ft
 γ_{soil} = 120 pcf
 D_w = 50.0 ft depth from ground surface
 γ_w = 62.4 pcf
 ΔP = 2616 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_{v1}' Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	σ_{v1}' Midpoint	S_c (ft)	S_c (in)		
1	A-3a	0.0	3.0	3.0	1.5	135	Calculated Separately					202.5	202.5	202.5	0.07	Calculated Separately				0.001	0.014	Calculated Separately				0.001	0.007
2	A-6b	3.0	5.5	2.5	4.3	115	40	0.145	0.041	0.503	2352	490	346.25	346.25	0.21	0.953	2493	2839	0.076	0.917	0.500	1308	1654	0.046	0.556		
		5.5	8.0	2.5	6.8	115	40	0.145	0.041	0.503	2640	777.5	633.75	633.75	0.33	0.924	2416	3050	0.057	0.689	0.488	1277	1910	0.033	0.392		
3	Granular	8.0	12.0	4.0	10.0	125	Calculated Separately					1277.5	1027.5	1027.5	0.49	Calculated Separately				0.009	0.113	Calculated Separately				0.004	0.053
4	A-6b	12.0	15.0	3.0	13.5	121	40	0.145	0.041	0.503	3465	1640.5	1459	1459	0.66	0.733	1918	3377	0.030	0.358	0.436	1141	2600	0.021	0.246		
		15.0	18.0	3.0	16.5	122	40	0.145	0.041	0.503	3830	2006.5	1823.5	1823.5	0.81	0.656	1715	3538	0.024	0.283	0.412	1078	2901	0.017	0.198		
		18.0	21.0	3.0	19.5	123	40	0.145	0.041	0.503	4197	2375.5	2191	2191	0.96	0.589	1541	3732	0.019	0.227	0.391	1024	3215	0.014	0.164		
		21.0	24.0	3.0	22.5	124	40	0.145	0.041	0.503	4568	2747.5	2561.5	2561.5	1.10	0.522	1366	3928	0.015	0.182	0.374	979	3541	0.012	0.138		
		24.0	27.0	3.0	25.5	125	40	0.145	0.041	0.503	4941	3122.5	2935	2935	1.25	0.471	1233	4168	0.012	0.150	0.357	934	3869	0.010	0.118		
		27.0	30.0	3.0	28.5	126	40	0.145	0.041	0.503	5318	3500.5	3311.5	3311.5	1.40	0.429	1121	4433	0.010	0.124	0.340	889	4201	0.008	0.101		

Settlement at Center of Reinforced Soil Mass: 3.057 in Settlement at Facing of Wall: 1.974 in

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

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

Borings B-019 and B-020 - Sta. 456+40 to Sta. 460+40

23.3' MSE wall height net loading considered

H= 23.3 ft
B= 22.2 ft
 γ_{ref} = 120 pcf
 D_w = 27.8 ft depth from ground surface
 γ_w = 62.4 pcf
 ΔP = 2796 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	$\Delta\sigma_v$	$\sigma_{v'}'$ Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	$\sigma_{v'}'$ Midpoint	S_c (ft)	S_c (in)
1	A-6a	0.0	2.5	2.5	1.3	120	30	0.180	0.018	0.507	2156	150	150	150	0.06	0.988	2763	2913	0.074	0.883	0.500	1398	1548	0.030	0.363
		2.5	5.0	2.5	3.8	115	30	0.180	0.018	0.507	2300	437.5	293.75	293.75	0.17	0.959	2681	2975	0.060	0.721	0.500	1398	1692	0.023	0.273
2	Granular	5.0	11.0	6.0	8.0	120	Calculated Separately					1157.5	797.5	797.5	0.36	Calculated Separately			0.030	0.355	Calculated Separately			0.014	0.170
3	A-6b	11.0	14.0	3.0	12.5	115	40	0.145	0.041	0.503	3336	1502.5	1330	1330	0.56	0.783	2190	3520	0.039	0.473	0.448	1253	2583	0.024	0.283
		14.0	17.0	3.0	15.5	115	40	0.145	0.041	0.503	3681	1847.5	1675	1675	0.70	0.700	1957	3632	0.028	0.330	0.428	1197	2872	0.019	0.230
4	A-6a	17.0	19.5	2.5	18.3	110	27	0.153	0.015	0.483	3991	2122.5	1985	1985	0.82	0.644	1802	3787	0.007	0.087	0.408	1141	3126	0.005	0.061
		19.5	22.0	2.5	20.8	110	27	0.153	0.015	0.483	4266	2397.5	2260	2260	0.93	0.600	1678	3938	0.006	0.075	0.394	1102	3362	0.004	0.053
5	Granular	22.0	30.0	8.0	26.0	120	Calculated Separately					3357.5	2877.5	2877.5	1.17	Calculated Separately			0.142	1.702	Calculated Separately			0.066	0.791

Settlement at Center of Reinforced Soil Mass: 4.626 in Settlement at Facing of Wall: 2.224 in

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

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

Borings B-021 to B-023 - Sta. 460+40 to Sta. 463+82

9.9' MSE wall height net loading considered

H= 9.9 ft
B= 12.1 ft
 γ_{eff} = 120 pcf
 D_w = 37.0 ft depth from ground surface
 γ_w = 62.4 pcf
 ΔP = 1188 psf at surface

Layer	Soil Type	Depth		Thickness	Depth to Midpoint	γ	LL	C_c	C_r	e_o	σ_p'	σ_{v0} Bottom	σ_{v0} Midpoint	σ_{v0}' Midpoint	Z_f/B	Total Settlement at Center of Reinforced Soil Mass					Total Settlement at Facing of Wall				
																I	$\Delta\sigma_v$	σ_{v0}' Midpoint	S_c (ft)	S_c (in)	I	$\Delta\sigma_v$	σ_{v0}' Midpoint	S_c (ft)	S_c (in)
1	A-6a	0.0	3.0	3.0	1.5	115	24	0.126	0.013	0.460	2179	172.5	172.5	172.5	0.12	0.971	1153	1326	0.023	0.275	0.500	594	766	0.017	0.201
		3.0	6.0	3.0	4.5	115	24	0.126	0.013	0.460	2351	517.5	345	345	0.37	0.912	1083	1428	0.016	0.192	0.480	570	915	0.011	0.132
		6.0	9.0	3.0	7.5	120	24	0.126	0.013	0.460	2704	877.5	697.5	697.5	0.62	0.750	891	1589	0.009	0.111	0.440	523	1220	0.006	0.075
2	Granular	9.0	11.0	2.0	10.0	120	Calculated Separately					1117.5	997.5	997.5	0.83	Calculated Separately			0.007	0.082	Calculated Separately			0.003	0.039
3	A-7-6	11.0	14.0	3.0	12.5	115	41	0.230	0.068	0.771	3296	1462.5	1290	1290	1.03	0.556	660	1950	0.021	0.248	0.383	455	1745	0.015	0.181
4	Granular	14.0	43.0	29.0	28.5	125	Calculated Separately					5087.5	3275	3275	2.36	Calculated Separately			0.020	0.240	Calculated Separately			0.009	0.112

Settlement at Center of Reinforced Soil Mass: 1.148 in

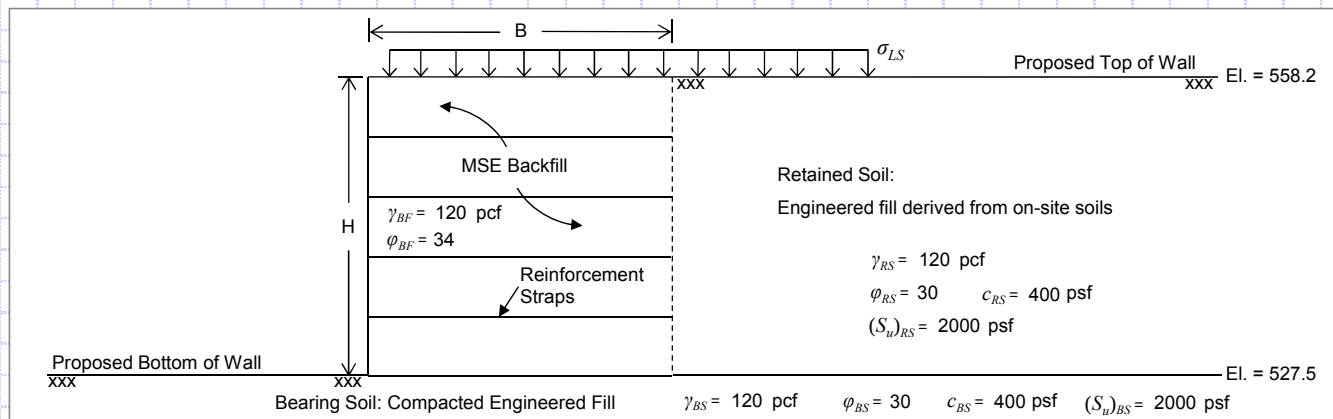
Settlement at Facing of Wall: 0.741 in

APPENDIX VII

MSE WALL CALCULATIONS



Retaining Wall I - MSE Wall - 30.7 ft. Maximum Wall Height - B-182-0-07



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, $(H) =$	30.7 ft
MSE Wall Width (Reinforcement Length), $(B) =$	21.5 ft
Live Surcharge Load, $(\sigma_{LS}) =$	240 psf
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf
Retained Soil Friction Angle, $(\phi_{RS}) =$	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, $(\gamma_{BF}) =$	120 pcf
MSE Backfill Friction Angle, $(\phi_{BF}) =$	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
Bearing Soil Friction Angle, $(\phi_{BS}) =$	30°
Bearing Soil Drained Cohesion, $(c_{BS}) =$	400 psf
Bearing Soil Undrained Shear Strength, $[(S_u)_{BS}] =$	2000 psf
Embedment Depth, $(D) =$	3.0 ft

LRFD Load Factors

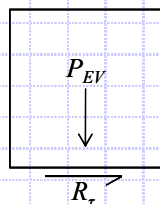
	EV	EH	LS
Strength Ia	1.00	1.50	1.75
Strength Ib	1.35	1.50	1.75
Service I	1.00	1.00	1.00

(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:

$$R_r = P_{EV} \cdot \tan \delta$$



$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(30.7 \text{ ft})(21.5 \text{ ft})(1.00) = 79.21 \text{ kip/ft}$$

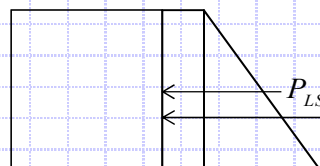
$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(30) \leq \tan(34) \rightarrow 0.58 \leq 0.67 \rightarrow \tan \delta = 0.58$$

$$R_r = (79.21 \text{ kip/ft})(0.58) = 45.94 \text{ kip/ft}$$

Sliding Force:

$$P_H = P_{EH} + P_{LS_h}$$



$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(30.7 \text{ ft})^2 (0.333)(1.5) = 28.25 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(30.7 \text{ ft})(0.333)(1.75) = 4.29 \text{ kip/ft}$$

$$P_H = 28.25 \text{ kip/ft} + 4.29 \text{ kip/ft} = 32.54 \text{ kip/ft}$$

Check Sliding Resistance

$$P_H \leq R_r \cdot \phi_r \rightarrow 32.54 \text{ kip/ft} \leq (45.94 \text{ kip/ft})(1.0) = 45.94 \text{ kip/ft} \rightarrow 32.54 \text{ kip/ft} \leq 45.94 \text{ kip/ft} \quad \text{OK}$$

Use $\phi_r = 1.0$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	30.7 ft
MSE Wall Width (Reinforcement Length), (B) =	21.5 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:

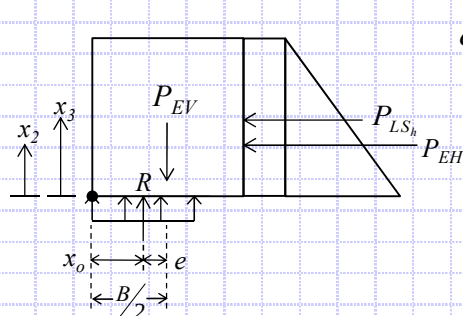
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2000 psf
Embedment Depth, (D) =	3.0 ft

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



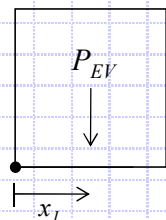
$$e = \frac{B}{2} - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = \frac{(851.51 \text{ kip-ft/ft} - 354.85 \text{ kip-ft/ft})}{(79.21 \text{ kip/ft})} = 6.27 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 851.51 \text{ kip-ft/ft} \\ M_H &= 354.85 \text{ kip-ft/ft} \\ P_{EV} &= 79.21 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (21.5 \text{ ft})/2 - 6.27 \text{ ft} = 4.48 \text{ ft}$$

Resisting Moment, M_{EV} :



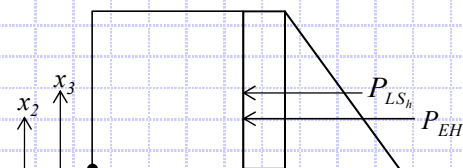
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(30.7 \text{ ft})(21.5 \text{ ft})(1.00) = 79.21 \text{ kip/ft}$$

$$x_1 = \frac{B}{2} = (21.5 \text{ ft})/2 = 10.75 \text{ ft}$$

$$M_{EV} = (79.21 \text{ kip/ft})(10.75 \text{ ft}) = 851.51 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(30.7 \text{ ft})^2(0.333)(1.5) = 28.25 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(30.7 \text{ ft})(0.333)(1.75) = 4.29 \text{ kip/ft}$$

$$x_2 = \frac{H}{3} = (30.7 \text{ ft})/3 = 10.23 \text{ ft}$$

$$x_3 = \frac{H}{2} = (30.7 \text{ ft})/2 = 15.35 \text{ ft}$$

$$M_H = (28.25 \text{ kip/ft})(10.23 \text{ ft}) + (4.29 \text{ kip/ft})(15.35 \text{ ft}) = 354.85 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = \frac{B}{4} \rightarrow e_{\max} = (21.5 \text{ ft})/4 = 5.38 \text{ ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 4.48 \text{ ft} < 5.38 \text{ ft} \quad \text{OK}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	30.7 ft
MSE Wall Width (Reinforcement Length), (B) =	21.5 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:

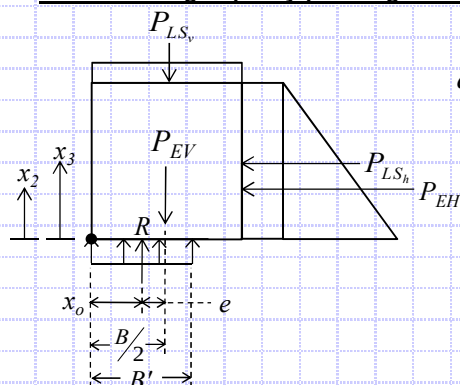
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(s_u)_{BS}$] =	2000 psf
Embedment Depth, (D) =	3.0 ft

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



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

$$B' = B - 2e = 21.5 \text{ ft} - 2(3.06 \text{ ft}) = 15.38 \text{ ft}$$

$$e = B/2 - x_o = (21.5 \text{ ft}) / 2 - 7.69 \text{ ft} = 3.06 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (1246.55 \text{ kip-ft/ft} - 354.87 \text{ kip-ft/ft}) / 115.96 \text{ kip/ft} = 7.69 \text{ ft}$$

$$q_{eq} = (115.96 \text{ kip/ft}) / (15.38 \text{ ft}) = 7.54 \text{ ksf}$$

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

$$M_V = [(120 \text{ pcf})(30.7 \text{ ft})(21.5 \text{ ft})(1.35)](10.75 \text{ ft}) + [(240 \text{ psf})(21.5 \text{ ft})(1.75)](10.75 \text{ ft}) = 1246.55 \text{ kip-ft/ft}$$

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

$$M_H = \left[\frac{1}{2} (120 \text{ pcf})(30.7 \text{ ft})^2 (0.333)(1.5) \right](10.23 \text{ ft}) + [(240 \text{ psf})(30.7 \text{ ft})(0.333)(1.75)](15.35 \text{ ft}) = 354.87 \text{ kip-ft/ft}$$

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

$$P_V = (120 \text{ pcf})(30.7 \text{ ft})(21.5 \text{ ft})(1.35) + (240 \text{ psf})(21.5 \text{ ft})(1.75) = 115.96 \text{ kip/ft}$$

Nominal Bearing Resistance:

$$q_n = cN_c + \gamma DN_q + \frac{1}{2} \gamma BN_\gamma = (2000 \text{ psf})(5.7) + (120 \text{ pcf})(3.0 \text{ ft})(1.0) + \frac{1}{2} (120 \text{ pcf})(21.5 \text{ ft})(0.0) = 11.8 \text{ ksf}$$

$$N_c = 5.7 \quad N_q = 1.0 \quad N_\gamma = 0.0$$

Check Bearing Capacity

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 7.54 \text{ ksf} \leq (11.8 \text{ ksf})(0.65) = 7.67 \text{ ksf} \rightarrow 7.54 \text{ ksf} \leq 7.67 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	30.7 ft
MSE Wall Width (Reinforcement Length), (B) =	21.5 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}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2000 psf
Embedment Depth, (D) =	3.0 ft

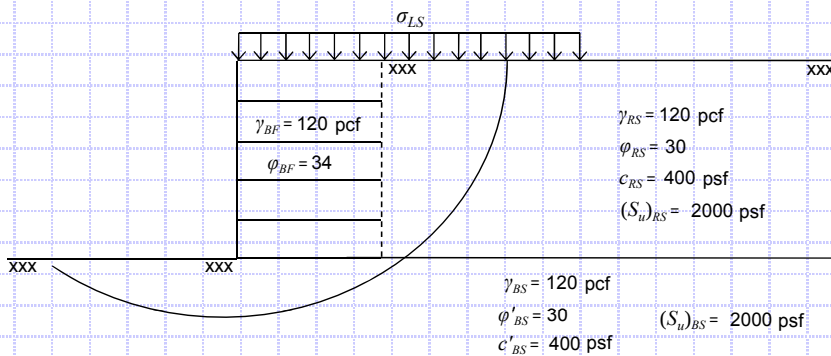
LRFD Load Factors

	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)

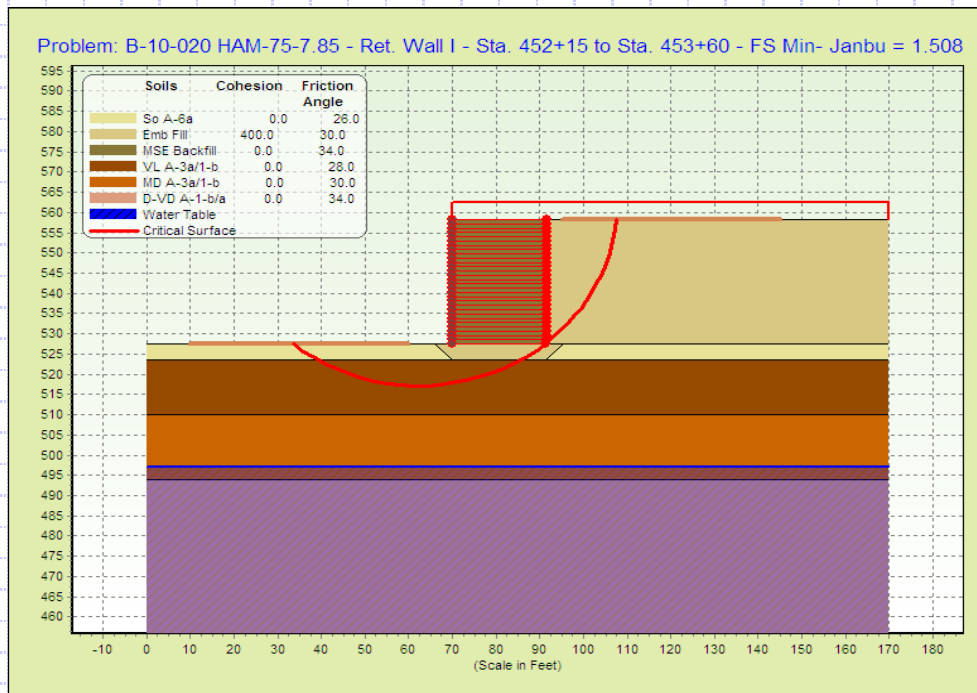
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (1.508)(0.75) = 1.13 \rightarrow 1.00 \leq 1.13 \quad \text{OK}$$

FS = 1.508 (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 I - Sta. 452+15 to Sta. 453+60

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	30.7 ft
MSE Wall Width (Reinforcement Length), (B) =	21.5 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}) =	30°
Bearing Soil Drained Cohesion, (c_{BS}) =	400 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	2000 psf
Embedment Depth, (D) =	3.0 ft

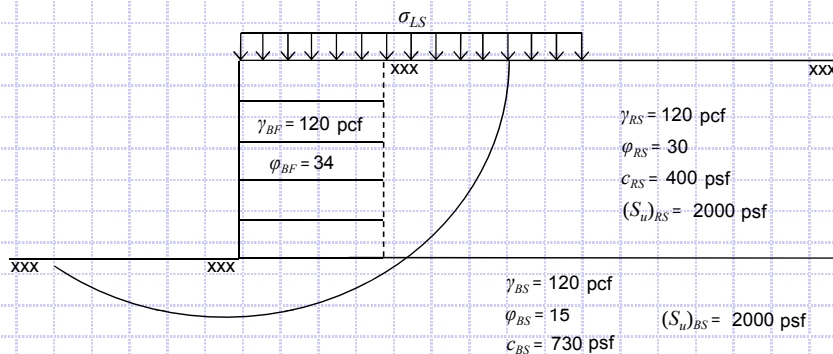
LRFD Load Factors

	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)

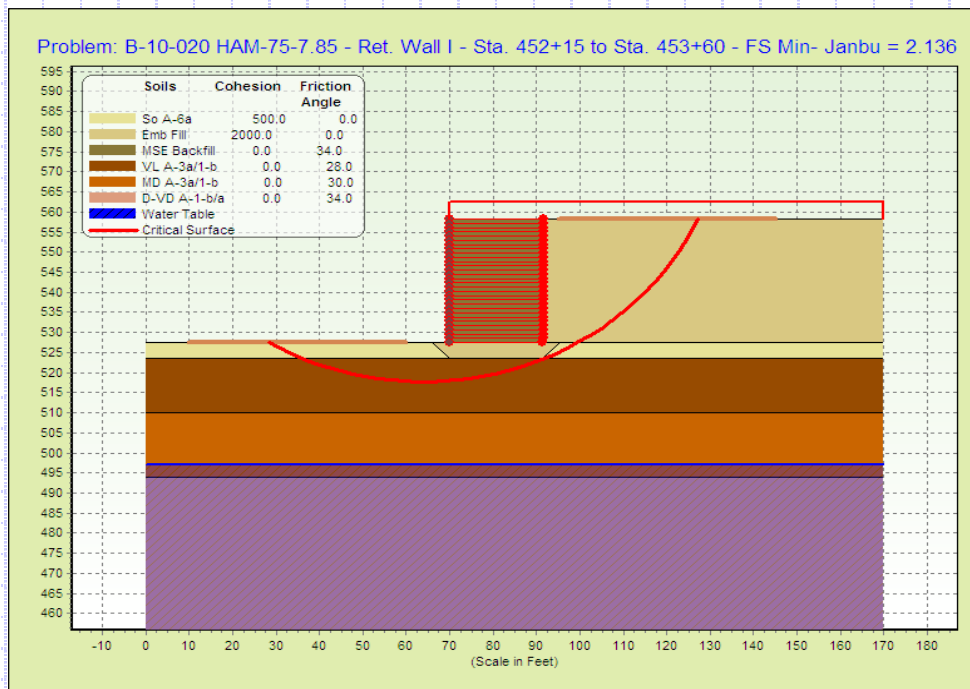
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 (Cont'd)

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (2.136)(0.75) = 1.60 \rightarrow 1.00 \leq 1.60 \quad \text{OK}$$

FS = **2.136** (From STABL Slope Stability Analysis)

Use ϕ_{GS} = **0.75** (Per AASHTO LRFD BDM Section 11.6.2.3)

result.out

** 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 I - Sta
. 452+15 to Sta. 453+60

BOUNDARY COORDINATES

5 Top Boundaries
16 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	527.50	66.00	527.50	3
2	66.00	527.50	70.00	527.50	2
3	70.00	527.50	70.10	558.20	1
4	70.10	558.20	91.60	558.20	1
5	91.60	558.20	170.00	558.20	2
6	70.00	527.50	91.50	527.50	2
7	91.50	527.50	91.60	558.20	2
8	91.50	527.50	95.50	527.50	2
9	95.50	527.50	170.00	527.50	3
10	66.00	527.50	70.00	523.50	3
11	70.00	523.50	91.50	523.50	4
12	91.50	523.50	95.50	527.50	3
13	0.00	523.50	70.00	523.50	4
14	91.50	523.50	170.00	523.50	4
15	0.00	510.00	170.00	510.00	5
16	0.00	494.00	170.00	494.00	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	110.0	120.0	0.0	26.0	0.00	0.0	1
4	120.0	125.0	0.0	28.0	0.00	0.0	1
5	125.0	130.0	0.0	30.0	0.00	0.0	1
6	130.0	135.0	0.0	34.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

result.out

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	497.00
2	170.00	497.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load NO.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	70.10	170.00	240.0	0.0

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngrou no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	3	558.2	527.5	30	21.5	1.06	1.0	7500.0

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 = 145.00 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.

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

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

Failure Surface Specified By 34 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.47	527.50
2	35.85	525.67
3	38.34	524.01
4	40.94	522.51
5	43.64	521.19
6	46.41	520.04
7	49.25	519.09
8	52.15	518.32
9	55.10	517.74
10	58.07	517.36
11	61.07	517.18
12	64.07	517.20
13	67.06	517.41
14	70.03	517.82
15	72.97	518.42
16	75.86	519.22
17	78.70	520.21
18	81.46	521.38
19	84.14	522.73
20	86.72	524.25
21	89.20	525.94
22	91.56	527.79
23	93.80	529.79
24	95.89	531.94
25	97.85	534.22
26	99.64	536.62
27	101.28	539.13
28	102.74	541.75
29	104.03	544.46
30	105.14	547.25
31	106.06	550.10
32	106.79	553.01
33	107.33	555.96
34	107.59	558.20

*** 1.508 ***

Individual data on the 41 slices

Slice No.	Width (ft)	Weight (lbs)	Water		Force Norm (lbs)	Force Tan (lbs)	Earthquake		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)			Force Hor (lbs)	Force Ver (lbs)	
1	2.4	239.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.5	729.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	0.9	363.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.7	858.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.7	1718.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	2.8	2180.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.8	2593.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.9	2945.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.9	3227.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.0	3432.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	3.0	3555.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	3.0	3592.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	1.9	2295.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	1.1	1252.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	2.9	3445.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	0.0	57.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	0.1	243.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	2.9	13805.5	0.0	0.0	0.0	0.0	0.0	0.0	689.0
19	2.9	13667.2	0.0	0.0	0.0	0.0	0.0	0.0	694.1
20	2.8	13086.2	0.0	0.0	0.0	0.0	0.0	0.0	680.0
21	2.8	12400.2	0.0	0.0	0.0	0.0	0.0	0.0	662.9
22	2.7	11621.8	0.0	0.0	0.0	0.0	0.0	0.0	643.0
23	1.3	5531.0	0.0	0.0	0.0	0.0	0.0	0.0	315.3
24	1.3	5233.9	0.0	0.0	0.0	0.0	0.0	0.0	305.0
25	2.5	9845.2	0.0	0.0	0.0	0.0	0.0	0.0	594.8
26	2.0	7521.6	0.0	0.0	0.0	0.0	0.0	0.0	477.9
27	0.3	1134.8	0.0	0.0	945.6	1206.7	0.0	0.0	74.2

result.out									
28	0.1	222.9	0.0	0.0	0.0	0.0	0.0	0.0	14.6
29	0.0	139.2	0.0	0.0	0.0	0.0	0.0	0.0	9.2
30	2.2	7745.7	0.0	0.0	0.0	0.0	0.0	0.0	527.1
31	2.1	6880.2	0.0	0.0	0.0	0.0	0.0	0.0	503.4
32	2.0	5883.5	0.0	0.0	0.0	0.0	0.0	0.0	468.4
33	1.8	4913.2	0.0	0.0	0.0	0.0	0.0	0.0	431.3
34	1.6	3987.2	0.0	0.0	0.0	0.0	0.0	0.0	392.4
35	1.5	3122.8	0.0	0.0	0.0	0.0	0.0	0.0	351.7
36	1.3	2336.1	0.0	0.0	0.0	0.0	0.0	0.0	309.5
37	1.1	1642.1	0.0	0.0	0.0	0.0	0.0	0.0	266.0
38	0.9	1054.1	0.0	0.0	0.0	0.0	0.0	0.0	221.3
39	0.7	583.6	0.0	0.0	0.0	0.0	0.0	0.0	175.7
40	0.5	240.0	0.0	0.0	0.0	0.0	0.0	0.0	129.3
41	0.3	34.6	0.0	0.0	0.0	0.0	0.0	0.0	61.8

Individual data on the 30 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	27	70.0	527.5	91.5	527.5	1533.1	21.5	7500.0	20.4
1	2	0	70.0	528.6	91.5	528.6	0.0	21.5	7500.0	0.0
1	3	0	70.0	529.6	91.5	529.6	0.0	21.5	7500.0	0.0
1	4	0	70.0	530.7	91.5	530.7	0.0	21.5	7500.0	0.0
1	5	0	70.0	531.7	91.5	531.7	0.0	21.5	7500.0	0.0
1	6	0	70.0	532.8	91.5	532.8	0.0	21.5	7500.0	0.0
1	7	0	70.0	533.9	91.5	533.9	0.0	21.5	7500.0	0.0
1	8	0	70.0	534.9	91.5	534.9	0.0	21.5	7500.0	0.0
1	9	0	70.0	536.0	91.5	536.0	0.0	21.5	7500.0	0.0
1	10	0	70.0	537.0	91.5	537.0	0.0	21.5	7500.0	0.0
1	11	0	70.0	538.1	91.5	538.1	0.0	21.5	7500.0	0.0
1	12	0	70.0	539.1	91.5	539.1	0.0	21.5	7500.0	0.0
1	13	0	70.0	540.2	91.5	540.2	0.0	21.5	7500.0	0.0
1	14	0	70.0	541.3	91.5	541.3	0.0	21.5	7500.0	0.0
1	15	0	70.0	542.3	91.5	542.3	0.0	21.5	7500.0	0.0
1	16	0	70.1	543.4	91.6	543.4	0.0	21.5	7500.0	0.0
1	17	0	70.1	544.4	91.6	544.4	0.0	21.5	7500.0	0.0
1	18	0	70.1	545.5	91.6	545.5	0.0	21.5	7500.0	0.0
1	19	0	70.1	546.6	91.6	546.6	0.0	21.5	7500.0	0.0
1	20	0	70.1	547.6	91.6	547.6	0.0	21.5	7500.0	0.0
1	21	0	70.1	548.7	91.6	548.7	0.0	21.5	7500.0	0.0
1	22	0	70.1	549.7	91.6	549.7	0.0	21.5	7500.0	0.0
1	23	0	70.1	550.8	91.6	550.8	0.0	21.5	7500.0	0.0
1	24	0	70.1	551.8	91.6	551.8	0.0	21.5	7500.0	0.0
1	25	0	70.1	552.9	91.6	552.9	0.0	21.5	7500.0	0.0
1	26	0	70.1	554.0	91.6	554.0	0.0	21.5	7500.0	0.0
1	27	0	70.1	555.0	91.6	555.0	0.0	21.5	7500.0	0.0
1	28	0	70.1	556.1	91.6	556.1	0.0	21.5	7500.0	0.0
1	29	0	70.1	557.1	91.6	557.1	0.0	21.5	7500.0	0.0
1	30	0	70.1	558.2	91.6	558.2	0.0	21.5	7500.0	0.0

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.31	527.50
2	27.71	525.71
3	30.21	524.05
4	32.80	522.54
5	35.47	521.17
6	38.22	519.96
7	41.02	518.90
8	43.89	517.99
9	46.79	517.25
10	49.74	516.68
11	52.71	516.27
12	55.70	516.02
13	58.70	515.95
14	61.70	516.04
15	64.68	516.30
16	67.65	516.72
17	70.60	517.32
18	73.50	518.07
19	76.36	518.99
20	79.16	520.06

result.out

21	81.89	521.29
22	84.56	522.67
23	87.14	524.19
24	89.63	525.86
25	92.03	527.67
26	94.32	529.61
27	96.50	531.67
28	98.56	533.85
29	100.50	536.14
30	102.30	538.54
31	103.97	541.03
32	105.49	543.61
33	106.87	546.28
34	108.10	549.01
35	109.17	551.82
36	110.09	554.67
37	110.84	557.58
38	110.97	558.20

*** 1.528 ***

1

Failure Surface Specified By 36 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	35.51	527.50
2	37.82	525.59
3	40.26	523.83
4	42.80	522.24
5	45.43	520.80
6	48.15	519.54
7	50.95	518.46
8	53.81	517.56
9	56.73	516.84
10	59.68	516.31
11	62.66	515.97
12	65.66	515.82
13	68.66	515.87
14	71.65	516.11
15	74.62	516.53
16	77.55	517.15
17	80.44	517.95
18	83.28	518.94
19	86.04	520.10
20	88.72	521.44
21	91.32	522.95
22	93.81	524.63
23	96.19	526.45
24	98.44	528.43
25	100.57	530.55
26	102.55	532.80
27	104.39	535.17
28	106.07	537.65
29	107.59	540.24
30	108.94	542.92
31	110.12	545.68
32	111.12	548.50
33	111.93	551.39
34	112.56	554.33
35	113.00	557.29
36	113.08	558.20

*** 1.535 ***

Failure Surface Specified By 37 Coordinate Points

Point	X-Surf	Y-Surf
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No.	(ft)	(ft)	result.out
1	31.43	527.50	
2	33.65	525.48	
3	35.99	523.60	
4	38.45	521.89	
5	41.01	520.33	
6	43.67	518.94	
7	46.42	517.73	
8	49.23	516.70	
9	52.11	515.85	
10	55.04	515.18	
11	58.00	514.71	
12	60.99	514.43	
13	63.98	514.35	
14	66.98	514.46	
15	69.97	514.76	
16	72.93	515.25	
17	75.85	515.93	
18	78.72	516.80	
19	81.53	517.86	
20	84.26	519.09	
21	86.91	520.50	
22	89.46	522.07	
23	91.91	523.81	
24	94.24	525.70	
25	96.44	527.74	
26	98.51	529.91	
27	100.43	532.22	
28	102.20	534.64	
29	103.81	537.17	
30	105.25	539.80	
31	106.52	542.52	
32	107.61	545.32	
33	108.52	548.17	
34	109.24	551.09	
35	109.77	554.04	
36	110.11	557.02	
37	110.17	558.20	
*** 1.536 ***			

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.57	527.50
2	40.98	525.71
3	43.49	524.07
4	46.11	522.61
5	48.82	521.31
6	51.60	520.19
7	54.45	519.25
8	57.35	518.50
9	60.30	517.94
10	63.28	517.56
11	66.27	517.38
12	69.27	517.40
13	72.26	517.60
14	75.24	518.00
15	78.18	518.59
16	81.08	519.37
17	83.92	520.33
18	86.69	521.47
19	89.38	522.80
20	91.99	524.29
21	94.49	525.94
22	96.88	527.75
23	99.15	529.72
24	101.28	531.82
25	103.28	534.06
26	105.13	536.43

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27      106.82      538.90      result.out
28      108.35      541.48
29      109.71      544.16
30      110.90      546.91
31      111.90      549.74
32      112.72      552.63
33      113.35      555.56
34      113.75      558.20

***      1.536      ***

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Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	34.49	527.50
2	36.99	525.84
3	39.58	524.32
4	42.25	522.96
5	44.99	521.75
6	47.80	520.70
7	50.67	519.82
8	53.59	519.10
9	56.54	518.56
10	59.51	518.18
11	62.50	517.98
12	65.50	517.95
13	68.50	518.09
14	71.48	518.41
15	74.44	518.90
16	77.37	519.56
17	80.26	520.38
18	83.09	521.37
19	85.86	522.53
20	88.55	523.84
21	91.17	525.30
22	93.70	526.92
23	96.13	528.67
24	98.46	530.57
25	100.67	532.59
26	102.76	534.74
27	104.73	537.01
28	106.56	539.39
29	108.25	541.87
30	109.79	544.44
31	111.18	547.10
32	112.42	549.83
33	113.50	552.63
34	114.41	555.49
35	115.11	558.20

*** 1.551 ***

1

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.37	527.50
2	30.72	525.64
3	33.18	523.92
4	35.73	522.34
5	38.37	520.91
6	41.09	519.64
7	43.87	518.53
8	46.72	517.58
9	49.62	516.80

result.out

10	52.55	516.19
11	55.52	515.76
12	58.51	515.49
13	61.51	515.40
14	64.51	515.48
15	67.50	515.74
16	70.46	516.17
17	73.40	516.77
18	76.30	517.54
19	79.15	518.48
20	81.94	519.58
21	84.66	520.85
22	87.31	522.26
23	89.86	523.83
24	92.32	525.55
25	94.68	527.40
26	96.93	529.39
27	99.05	531.51
28	101.05	533.75
29	102.92	536.10
30	104.65	538.55
31	106.23	541.10
32	107.66	543.73
33	108.93	546.45
34	110.05	549.23
35	111.00	552.08
36	111.79	554.98
37	112.40	557.91
38	112.45	558.20

*** 1.557 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	31.43	527.50
2	33.68	525.52
3	36.05	523.68
4	38.53	521.99
5	41.11	520.45
6	43.78	519.08
7	46.52	517.88
8	49.34	516.84
9	52.21	515.98
10	55.14	515.31
11	58.09	514.81
12	61.08	514.49
13	64.07	514.36
14	67.07	514.42
15	70.06	514.66
16	73.03	515.08
17	75.97	515.68
18	78.87	516.47
19	81.71	517.43
20	84.49	518.56
21	87.19	519.87
22	89.81	521.34
23	92.33	522.96
24	94.74	524.74
25	97.04	526.67
26	99.22	528.73
27	101.27	530.92
28	103.18	533.24
29	104.94	535.66
30	106.55	538.19
31	108.00	540.82
32	109.29	543.53
33	110.40	546.32
34	111.35	549.16
35	112.11	552.06
36	112.70	555.01
37	113.10	557.98

38 113.12 558.20 result.out

*** 1.558 ***

1

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	32.45	527.50
2	34.64	525.45
3	36.96	523.55
4	39.40	521.81
5	41.95	520.22
6	44.60	518.81
7	47.33	517.58
8	50.14	516.52
9	53.01	515.66
10	55.94	514.98
11	58.90	514.50
12	61.88	514.21
13	64.88	514.11
14	67.88	514.21
15	70.86	514.51
16	73.82	515.01
17	76.74	515.69
18	79.61	516.57
19	82.42	517.63
20	85.15	518.87
21	87.79	520.29
22	90.34	521.88
23	92.77	523.63
24	95.09	525.54
25	97.27	527.59
26	99.32	529.79
27	101.22	532.11
28	102.96	534.55
29	104.54	537.10
30	105.95	539.75
31	107.18	542.49
32	108.23	545.30
33	109.10	548.17
34	109.77	551.09
35	110.25	554.05
36	110.54	557.04
37	110.58	558.20

*** 1.558 ***

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	29.39	527.50
2	31.86	525.80
3	34.41	524.22
4	37.05	522.79
5	39.75	521.48
6	42.52	520.32
7	45.34	519.31
8	48.21	518.44
9	51.12	517.72
10	54.07	517.15
11	57.04	516.73
12	60.03	516.47
13	63.02	516.36
14	66.02	516.41

```

15      69.02      516.61
16      72.00      516.97
17      74.95      517.48
18      77.88      518.14
19      80.77      518.95
20      83.61      519.90
21      86.40      521.01
22      89.13      522.25
23      91.79      523.64
24      94.38      525.16
25      96.88      526.81
26      99.30      528.59
27     101.62      530.49
28     103.84      532.50
29     105.95      534.63
30     107.95      536.87
31     109.84      539.21
32     111.60      541.64
33     113.23      544.15
34     114.73      546.75
35     116.09      549.42
36     117.32      552.16
37     118.40      554.96
38     119.33      557.81
39     119.44      558.20

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result.out

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***      1.564      ***

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1

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          Y          A      X      I      S          F      T
          0.00      130.64      261.29      391.93      522.57      653.21
X      0.00 +-----+-----+-----+-----+***-----+
          |                                     .2
          |                                     41
          |                                     2G. G/1
          |                                     9g1.g
          |                                     .3111
130.64 +-----+-----+-----+-----+
          |                                     ....
          |                                     ***  '1/
          |
A      261.29 +-----+-----+-----+-----+
          |
          |
X      391.93 +-----+-----+-----+-----+
          |
          |
          |
I      522.57 +-----+-----+-----+-----+
          |
          |
          |
S      653.21 +-----+-----+-----+-----+
          |
          |
          |
          |
783.86 +-----+-----+-----+-----+
          |
          |
          |
          |

```

result.out

F	914.50	-
		+
		-
		-
		-
		-
		-
T	1045.14	+

result.out

** 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 I - Sta
. 452+15 to Sta. 453+60

BOUNDARY COORDINATES

5 Top Boundaries
16 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	527.50	66.00	527.50	3
2	66.00	527.50	70.00	527.50	2
3	70.00	527.50	70.10	558.20	1
4	70.10	558.20	91.60	558.20	1
5	91.60	558.20	170.00	558.20	2
6	70.00	527.50	91.50	527.50	2
7	91.50	527.50	91.60	558.20	2
8	91.50	527.50	95.50	527.50	2
9	95.50	527.50	170.00	527.50	3
10	66.00	527.50	70.00	523.50	3
11	70.00	523.50	91.50	523.50	4
12	91.50	523.50	95.50	527.50	3
13	0.00	523.50	70.00	523.50	4
14	91.50	523.50	170.00	523.50	4
15	0.00	510.00	170.00	510.00	5
16	0.00	494.00	170.00	494.00	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	110.0	120.0	500.0	0.0	0.00	0.0	1
4	120.0	125.0	0.0	28.0	0.00	0.0	1
5	125.0	130.0	0.0	30.0	0.00	0.0	1
6	130.0	135.0	0.0	34.0	0.00	0.0	1

1

1 PIEZOMETRIC SURFACE(S) HAVE BEEN SPECIFIED

Unit Weight of Water = 62.40

result.out

Piezometric Surface No. 1 Specified by 2 Coordinate Points

Point No.	X-Water (ft)	Y-Water (ft)
1	0.00	497.00
2	170.00	497.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load NO.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	70.10	170.00	240.0	0.0

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngrou no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	3	558.2	527.5	30	21.5	1.06	1.0	7500.0

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 = 145.00 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.

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 40 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.37	527.50
2	30.98	526.02
3	33.65	524.66
4	36.38	523.42
5	39.16	522.29
6	41.99	521.29
7	44.86	520.40
8	47.76	519.64
9	50.69	519.01
10	53.65	518.50
11	56.62	518.12
12	59.61	517.87
13	62.61	517.75
14	65.61	517.76
15	68.61	517.90
16	71.60	518.17
17	74.57	518.56
18	77.52	519.08
19	80.45	519.73
20	83.35	520.51
21	86.21	521.40
22	89.04	522.42
23	91.81	523.57
24	94.53	524.83
25	97.20	526.20
26	99.80	527.69
27	102.34	529.29
28	104.81	531.00
29	107.20	532.81
30	109.51	534.73
31	111.73	536.74
32	113.87	538.84
33	115.91	541.04
34	117.86	543.32
35	119.71	545.68
36	121.45	548.12
37	123.09	550.64
38	124.62	553.22
39	126.04	555.86
40	127.16	558.20

*** 2.136 ***

Individual data on the 48 slices

Slice No.	Width (ft)	Weight (lbs)	Water		Force Norm (lbs)	Force Tan (lbs)	Earthquake		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)			Force Hor (lbs)	Force Ver (lbs)	
1	2.6	212.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.7	634.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.5	958.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.2	80.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.8	1438.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	2.8	1824.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.9	2175.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.9	2488.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.9	2758.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.0	2984.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	3.0	3161.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	3.0	3288.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	3.0	3364.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	3.0	3387.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.4	438.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	2.6	2953.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	1.4	1583.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	0.1	297.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	1.5	7200.6	0.0	0.0	0.0	0.0	0.0	0.0	359.1
20	3.0	14217.0	0.0	0.0	0.0	0.0	0.0	0.0	713.7
21	3.0	13960.1	0.0	0.0	0.0	0.0	0.0	0.0	709.0

result.out									
22	2.9	13635.1	0.0	0.0	0.0	0.0	0.0	0.0	703.0
23	2.9	13244.9	0.0	0.0	0.0	0.0	0.0	0.0	695.6
24	2.9	12792.9	0.0	0.0	0.0	0.0	0.0	0.0	686.9
25	2.8	12283.3	0.0	0.0	0.0	0.0	0.0	0.0	677.0
26	2.5	10432.3	0.0	0.0	0.0	0.0	0.0	0.0	591.6
27	0.1	416.8	0.0	0.0	0.0	0.0	0.0	0.0	24.0
28	0.0	204.7	0.0	0.0	0.0	0.0	0.0	0.0	11.8
29	0.2	666.2	0.0	0.0	0.0	0.0	0.0	0.0	38.5
30	2.7	11083.3	0.0	0.0	0.0	0.0	0.0	0.0	653.4
31	1.0	3828.7	0.0	0.0	0.0	0.0	0.0	0.0	232.3
32	1.7	6579.6	0.0	0.0	0.0	0.0	0.0	0.0	407.5
33	2.3	8525.7	0.0	0.0	0.0	0.0	0.0	0.0	544.9
34	0.3	1226.3	0.0	0.0	0.0	0.0	0.0	0.0	80.1
35	2.5	9046.9	0.0	0.0	0.0	0.0	0.0	0.0	609.0
36	2.5	8303.3	0.0	0.0	0.0	0.0	0.0	0.0	591.9
37	2.4	7543.1	0.0	0.0	0.0	0.0	0.0	0.0	573.7
38	2.3	6773.4	0.0	0.0	0.0	0.0	0.0	0.0	554.5
39	2.2	6001.3	0.0	0.0	0.0	0.0	0.0	0.0	534.2
40	2.1	5234.3	0.0	0.0	0.0	0.0	0.0	0.0	512.9
41	2.0	4479.8	0.0	0.0	0.0	0.0	0.0	0.0	490.7
42	1.9	3745.3	0.0	0.0	0.0	0.0	0.0	0.0	467.5
43	1.8	3037.9	0.0	0.0	0.0	0.0	0.0	0.0	443.5
44	1.7	2365.0	0.0	0.0	0.0	0.0	0.0	0.0	418.7
45	1.6	1733.5	0.0	0.0	0.0	0.0	0.0	0.0	393.1
46	1.5	1150.2	0.0	0.0	0.0	0.0	0.0	0.0	366.7
47	1.4	621.6	0.0	0.0	0.0	0.0	0.0	0.0	339.7
48	1.1	157.6	0.0	0.0	0.0	0.0	0.0	0.0	269.7

Individual data on the 30 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	70.0	527.5	91.5	527.5	0.0	21.5	7500.0	0.0
1	2	0	70.0	528.6	91.5	528.6	0.0	21.5	7500.0	0.0
1	3	0	70.0	529.6	91.5	529.6	0.0	21.5	7500.0	0.0
1	4	0	70.0	530.7	91.5	530.7	0.0	21.5	7500.0	0.0
1	5	0	70.0	531.7	91.5	531.7	0.0	21.5	7500.0	0.0
1	6	0	70.0	532.8	91.5	532.8	0.0	21.5	7500.0	0.0
1	7	0	70.0	533.9	91.5	533.9	0.0	21.5	7500.0	0.0
1	8	0	70.0	534.9	91.5	534.9	0.0	21.5	7500.0	0.0
1	9	0	70.0	536.0	91.5	536.0	0.0	21.5	7500.0	0.0
1	10	0	70.0	537.0	91.5	537.0	0.0	21.5	7500.0	0.0
1	11	0	70.0	538.1	91.5	538.1	0.0	21.5	7500.0	0.0
1	12	0	70.0	539.1	91.5	539.1	0.0	21.5	7500.0	0.0
1	13	0	70.0	540.2	91.5	540.2	0.0	21.5	7500.0	0.0
1	14	0	70.0	541.3	91.5	541.3	0.0	21.5	7500.0	0.0
1	15	0	70.0	542.3	91.5	542.3	0.0	21.5	7500.0	0.0
1	16	0	70.1	543.4	91.6	543.4	0.0	21.5	7500.0	0.0
1	17	0	70.1	544.4	91.6	544.4	0.0	21.5	7500.0	0.0
1	18	0	70.1	545.5	91.6	545.5	0.0	21.5	7500.0	0.0
1	19	0	70.1	546.6	91.6	546.6	0.0	21.5	7500.0	0.0
1	20	0	70.1	547.6	91.6	547.6	0.0	21.5	7500.0	0.0
1	21	0	70.1	548.7	91.6	548.7	0.0	21.5	7500.0	0.0
1	22	0	70.1	549.7	91.6	549.7	0.0	21.5	7500.0	0.0
1	23	0	70.1	550.8	91.6	550.8	0.0	21.5	7500.0	0.0
1	24	0	70.1	551.8	91.6	551.8	0.0	21.5	7500.0	0.0
1	25	0	70.1	552.9	91.6	552.9	0.0	21.5	7500.0	0.0
1	26	0	70.1	554.0	91.6	554.0	0.0	21.5	7500.0	0.0
1	27	0	70.1	555.0	91.6	555.0	0.0	21.5	7500.0	0.0
1	28	0	70.1	556.1	91.6	556.1	0.0	21.5	7500.0	0.0
1	29	0	70.1	557.1	91.6	557.1	0.0	21.5	7500.0	0.0
1	30	0	70.1	558.2	91.6	558.2	0.0	21.5	7500.0	0.0

Failure Surface Specified By 46 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.06	527.50
2	15.63	525.95
3	18.25	524.49
4	20.93	523.13
5	23.65	521.87
6	26.42	520.71
7	29.22	519.65

result.out

8	32.07	518.70
9	34.94	517.85
10	37.85	517.11
11	40.78	516.47
12	43.74	515.95
13	46.71	515.53
14	49.69	515.22
15	52.68	515.02
16	55.68	514.93
17	58.68	514.94
18	61.68	515.07
19	64.67	515.31
20	67.65	515.66
21	70.61	516.12
22	73.56	516.69
23	76.48	517.36
24	79.38	518.14
25	82.25	519.03
26	85.08	520.02
27	87.87	521.11
28	90.62	522.31
29	93.33	523.60
30	95.99	525.00
31	98.59	526.49
32	101.14	528.07
33	103.62	529.75
34	106.05	531.52
35	108.41	533.37
36	110.69	535.31
37	112.91	537.33
38	115.05	539.44
39	117.11	541.62
40	119.09	543.87
41	120.99	546.19
42	122.80	548.59
43	124.52	551.04
44	126.15	553.56
45	127.68	556.14
46	128.81	558.20

*** 2.157 ***

1

Failure Surface Specified By 45 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.06	527.50
2	15.54	525.81
3	18.08	524.22
4	20.69	522.74
5	23.36	521.36
6	26.08	520.10
7	28.85	518.95
8	31.66	517.91
9	34.52	516.99
10	37.41	516.19
11	40.33	515.50
12	43.28	514.94
13	46.24	514.50
14	49.23	514.18
15	52.22	513.98
16	55.22	513.90
17	58.22	513.95
18	61.22	514.12
19	64.20	514.42
20	67.17	514.83
21	70.12	515.37
22	73.05	516.03
23	75.95	516.81
24	78.81	517.70
25	81.63	518.71
26	84.41	519.84

result.out

27	87.15	521.08
28	89.83	522.43
29	92.45	523.89
30	95.00	525.46
31	97.50	527.13
32	99.92	528.90
33	102.27	530.77
34	104.53	532.73
35	106.72	534.78
36	108.82	536.93
37	110.83	539.15
38	112.75	541.46
39	114.57	543.84
40	116.29	546.30
41	117.91	548.83
42	119.43	551.41
43	120.84	554.06
44	122.13	556.77
45	122.75	558.20

*** 2.161 ***

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.35	527.50
2	29.91	525.94
3	32.54	524.50
4	35.23	523.18
5	37.99	521.98
6	40.79	520.91
7	43.64	519.97
8	46.53	519.17
9	49.45	518.49
10	52.40	517.96
11	55.38	517.55
12	58.36	517.29
13	61.36	517.16
14	64.36	517.17
15	67.36	517.31
16	70.34	517.60
17	73.31	518.02
18	76.26	518.58
19	79.18	519.27
20	82.07	520.09
21	84.91	521.05
22	87.71	522.13
23	90.45	523.34
24	93.14	524.68
25	95.76	526.14
26	98.31	527.71
27	100.79	529.41
28	103.19	531.21
29	105.50	533.12
30	107.72	535.14
31	109.85	537.25
32	111.87	539.46
33	113.80	541.77
34	115.61	544.15
35	117.32	546.62
36	118.91	549.17
37	120.38	551.78
38	121.73	554.46
39	122.96	557.20
40	123.35	558.20

*** 2.162 ***

result.out

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	26.33	527.50
2	29.00	526.13
3	31.72	524.87
4	34.48	523.71
5	37.29	522.65
6	40.14	521.70
7	43.02	520.86
8	45.92	520.12
9	48.86	519.50
10	51.81	518.98
11	54.79	518.58
12	57.77	518.29
13	60.77	518.11
14	63.77	518.04
15	66.77	518.08
16	69.76	518.24
17	72.75	518.51
18	75.73	518.90
19	78.68	519.39
20	81.62	520.00
21	84.54	520.71
22	87.42	521.53
23	90.27	522.46
24	93.09	523.50
25	95.86	524.64
26	98.59	525.89
27	101.27	527.24
28	103.90	528.68
29	106.47	530.23
30	108.98	531.87
31	111.43	533.60
32	113.81	535.43
33	116.13	537.34
34	118.36	539.33
35	120.53	541.41
36	122.61	543.57
37	124.61	545.81
38	126.52	548.12
39	128.35	550.50
40	130.09	552.95
41	131.73	555.46
42	133.28	558.03
43	133.37	558.20

*** 2.162 ***

Failure Surface Specified By 42 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	24.29	527.50
2	26.80	525.86
3	29.38	524.34
4	32.03	522.93
5	34.74	521.64
6	37.51	520.47
7	40.32	519.43
8	43.17	518.52
9	46.07	517.73
10	49.00	517.07
11	51.95	516.54
12	54.92	516.14
13	57.91	515.88
14	60.91	515.75
15	63.91	515.76
16	66.91	515.89

result.out

17	69.89	516.16
18	72.87	516.57
19	75.82	517.10
20	78.74	517.77
21	81.64	518.56
22	84.49	519.49
23	87.30	520.54
24	90.06	521.71
25	92.77	523.01
26	95.41	524.42
27	97.99	525.95
28	100.50	527.60
29	102.94	529.35
30	105.29	531.21
31	107.56	533.18
32	109.73	535.24
33	111.82	537.40
34	113.80	539.64
35	115.69	541.98
36	117.47	544.40
37	119.14	546.89
38	120.69	549.45
39	122.13	552.08
40	123.45	554.78
41	124.66	557.53
42	124.91	558.20

*** 2.163 ***

1

Failure Surface Specified By 45 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	18.16	527.50
2	20.78	526.03
3	23.44	524.65
4	26.16	523.37
5	28.92	522.19
6	31.72	521.12
7	34.55	520.14
8	37.42	519.26
9	40.32	518.49
10	43.25	517.83
11	46.19	517.27
12	49.16	516.82
13	52.14	516.47
14	55.13	516.24
15	58.13	516.11
16	61.13	516.09
17	64.13	516.18
18	67.12	516.38
19	70.10	516.68
20	73.08	517.09
21	76.03	517.61
22	78.96	518.24
23	81.87	518.97
24	84.75	519.81
25	87.60	520.75
26	90.42	521.79
27	93.19	522.93
28	95.92	524.18
29	98.60	525.52
30	101.24	526.95
31	103.82	528.48
32	106.34	530.11
33	108.80	531.82
34	111.20	533.62
35	113.53	535.51
36	115.80	537.48
37	117.99	539.53
38	120.10	541.66
39	122.14	543.86

40	124.09	546.14	result.out
41	125.97	548.48	
42	127.75	550.89	
43	129.45	553.36	
44	131.06	555.90	
45	132.40	558.20	

*** 2.164 ***

Failure Surface Specified By 42 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	25.31	527.50
2	27.87	525.95
3	30.50	524.50
4	33.19	523.17
5	35.93	521.95
6	38.72	520.85
7	41.55	519.86
8	44.43	518.99
9	47.33	518.24
10	50.26	517.62
11	53.22	517.11
12	56.20	516.73
13	59.19	516.47
14	62.18	516.34
15	65.18	516.34
16	68.18	516.45
17	71.17	516.70
18	74.15	517.06
19	77.11	517.55
20	80.05	518.17
21	82.95	518.90
22	85.83	519.76
23	88.67	520.73
24	91.46	521.83
25	94.21	523.03
26	96.90	524.35
27	99.54	525.79
28	102.11	527.33
29	104.62	528.97
30	107.06	530.72
31	109.42	532.57
32	111.70	534.52
33	113.90	536.55
34	116.02	538.68
35	118.04	540.90
36	119.97	543.20
37	121.80	545.57
38	123.53	548.02
39	125.16	550.54
40	126.68	553.13
41	128.09	555.77
42	129.26	558.20

*** 2.168 ***

1

Failure Surface Specified By 39 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	31.43	527.50
2	33.98	525.93
3	36.61	524.48
4	39.31	523.16

result.out

5	42.06	521.98
6	44.87	520.92
7	47.73	520.01
8	50.63	519.23
9	53.56	518.60
10	56.52	518.10
11	59.50	517.75
12	62.49	517.55
13	65.49	517.49
14	68.49	517.57
15	71.48	517.80
16	74.46	518.17
17	77.41	518.69
18	80.34	519.35
19	83.23	520.14
20	86.08	521.08
21	88.88	522.15
22	91.63	523.36
23	94.31	524.70
24	96.93	526.17
25	99.47	527.76
26	101.94	529.47
27	104.32	531.30
28	106.60	533.24
29	108.79	535.29
30	110.88	537.44
31	112.87	539.69
32	114.74	542.04
33	116.49	544.47
34	118.13	546.98
35	119.64	549.57
36	121.03	552.23
37	122.29	554.96
38	123.41	557.74
39	123.57	558.20

*** 2.170 ***

Failure Surface Specified By 42 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.20	527.50
2	22.73	525.87
3	25.32	524.36
4	27.97	522.96
5	30.68	521.68
6	33.45	520.52
7	36.26	519.48
8	39.12	518.56
9	42.01	517.77
10	44.94	517.11
11	47.89	516.58
12	50.86	516.17
13	53.85	515.90
14	56.85	515.75
15	59.85	515.74
16	62.85	515.86
17	65.83	516.11
18	68.81	516.49
19	71.77	517.00
20	74.70	517.64
21	77.60	518.41
22	80.46	519.30
23	83.28	520.32
24	86.06	521.46
25	88.78	522.72
26	91.45	524.10
27	94.05	525.59
28	96.58	527.20
29	99.04	528.91
30	101.43	530.73
31	103.73	532.66

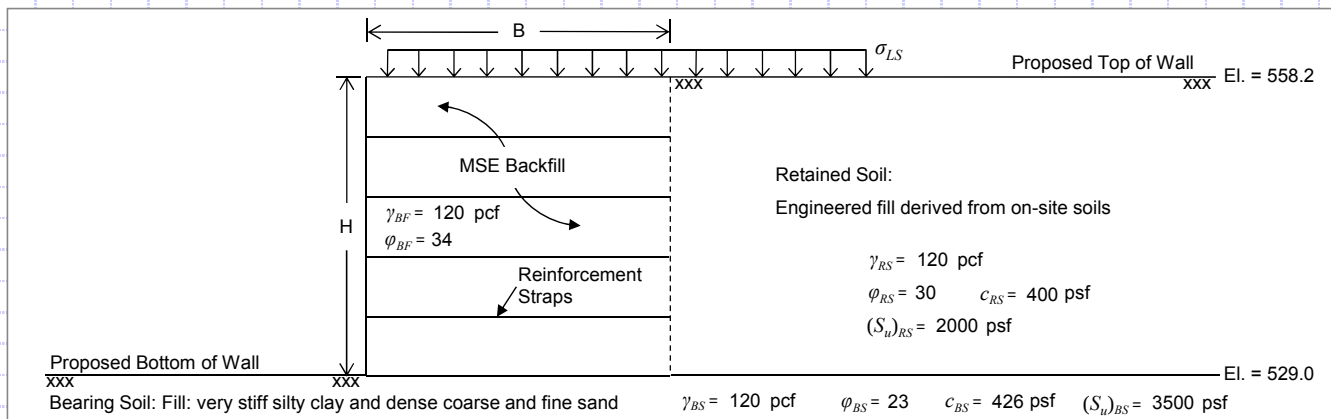
32	105.95	534.68
33	108.07	536.79
34	110.10	539.00
35	112.04	541.30
36	113.87	543.67
37	115.59	546.13
38	117.21	548.66
39	118.71	551.25
40	120.10	553.91
41	121.37	556.63
42	122.02	558.20

1

Page 11



Retaining Wall I - MSE Wall - 29.2 ft. Maximum Wall Height - B-017-0-11 to B-018-0-11



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	29.2 ft
MSE Wall Width (Reinforcement Length), (B) =	20.4 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}) =	23°
Bearing Soil Drained Cohesion, (c_{BS}) =	426 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	3500 psf
Embedment Depth, (D) =	3.0 ft

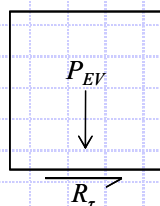
LRFD Load Factors

	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:



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

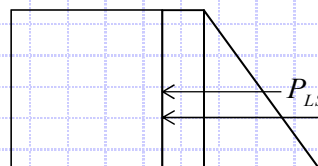
$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(29.2 \text{ ft})(20.4 \text{ ft})(1.00) = 71.48 \text{ kip/ft}$$

$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(23) \leq \tan(34) \rightarrow 0.42 \leq 0.67 \rightarrow \tan \delta = 0.42$$

$$R_{\tau} = (71.48 \text{ kip/ft})(0.42) = 30.02 \text{ kip/ft}$$

Sliding Force:



$$P_H = P_{EH} + P_{LS_h}$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(29.2 \text{ ft})^2(0.333)(1.5) = 25.55 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(29.2 \text{ ft})(0.333)(1.75) = 4.08 \text{ kip/ft}$$

$$P_H = 25.55 \text{ kip/ft} + 4.08 \text{ kip/ft} = 29.63 \text{ kip/ft}$$

Check Sliding Resistance

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 29.63 \text{ kip/ft} \leq (30.02 \text{ kip/ft})(1.0) = 30.02 \text{ kip/ft} \rightarrow 29.63 \text{ kip/ft} \leq 30.02 \text{ kip/ft} \quad \text{OK}$$

Use $\phi_{\tau} = 1.0$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	29.2 ft
MSE Wall Width (Reinforcement Length), (B) =	20.4 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:

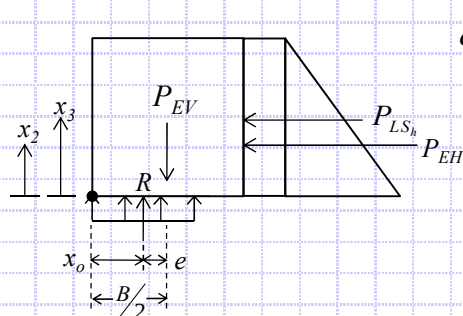
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	23°
Bearing Soil Drained Cohesion, (c_{BS}) =	426 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	3500 psf
Embedment Depth, (D) =	3.0 ft

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



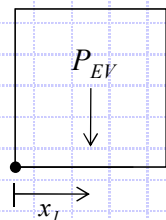
$$e = \frac{B}{2} - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (729.1 \text{ kip-ft/ft} - 308.17 \text{ kip-ft/ft}) / (71.48 \text{ kip/ft}) = 5.89 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 729.10 \text{ kip-ft/ft} \\ M_H &= 308.17 \text{ kip-ft/ft} \\ P_{EV} &= 71.48 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (20.4 \text{ ft}) / 2 - 5.89 \text{ ft} = 4.31 \text{ ft}$$

Resisting Moment, M_{EV} :



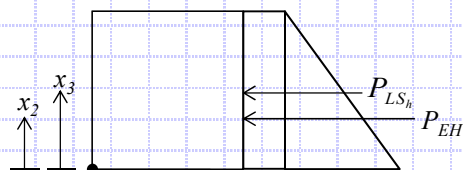
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(29.2 \text{ ft})(20.4 \text{ ft})(1.00) = 71.48 \text{ kip/ft}$$

$$x_1 = \frac{B}{2} = (20.4 \text{ ft}) / 2 = 10.20 \text{ ft}$$

$$M_{EV} = (71.48 \text{ kip/ft})(10.2 \text{ ft}) = 729.10 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(29.2 \text{ ft})^2 (0.333)(1.5) = 25.55 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(29.2 \text{ ft})(0.333)(1.75) = 4.08 \text{ kip/ft}$$

$$x_2 = \frac{H}{3} = (29.2 \text{ ft}) / 3 = 9.73 \text{ ft}$$

$$x_3 = \frac{H}{2} = (29.2 \text{ ft}) / 2 = 14.60 \text{ ft}$$

$$M_H = (25.55 \text{ kip/ft})(9.73 \text{ ft}) + (4.08 \text{ kip/ft})(14.6 \text{ ft}) = 308.17 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = \frac{B}{4} \rightarrow e_{\max} = (20.4 \text{ ft}) / 4 = 5.10 \text{ ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 4.31 \text{ ft} < 5.10 \text{ ft} \quad \text{OK}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	29.2 ft
MSE Wall Width (Reinforcement Length), (B) =	20.4 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:

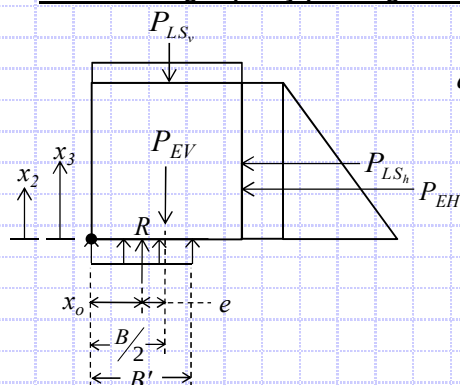
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	23°
Bearing Soil Drained Cohesion, (c_{BS}) =	426 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	3500 psf
Embedment Depth, (D) =	3.0 ft

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



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

$$B' = B - 2e = 20.4 \text{ ft} - 2(2.93 \text{ ft}) = 14.54 \text{ ft}$$

$$e = B/2 - x_o = (20.4 \text{ ft}) / 2 - 7.27 \text{ ft} = 2.93 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (1071.70 \text{ kip-ft/ft} - 308.26 \text{ kip-ft/ft}) / 105.07 \text{ kip/ft} = 7.27 \text{ ft}$$

$$q_{eq} = (105.07 \text{ kip/ft}) / (14.54 \text{ ft}) = 7.23 \text{ ksf}$$

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

$$M_V = [(120 \text{ pcf})(29.2 \text{ ft})(20.4 \text{ ft})(1.35)](10.2 \text{ ft}) + [(240 \text{ psf})(20.4 \text{ ft})(1.75)](10.2 \text{ ft}) = 1071.70 \text{ kip-ft/ft}$$

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

$$M_H = \left[\frac{1}{2}(120 \text{ pcf})(29.2 \text{ ft})^2(0.333)(1.5)\right](9.73 \text{ ft}) + [(240 \text{ psf})(29.2 \text{ ft})(0.333)(1.75)](14.6 \text{ ft}) = 308.26 \text{ kip-ft/ft}$$

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

$$P_V = (120 \text{ pcf})(29.2 \text{ ft})(20.4 \text{ ft})(1.35) + (240 \text{ psf})(20.4 \text{ ft})(1.75) = 105.07 \text{ kip/ft}$$

Nominal Bearing Resistance:

$$q_n = cN_c + \gamma DN_q + \frac{1}{2} \gamma BN_\gamma = (3500 \text{ psf})(5.7) + (120 \text{ pcf})(3.0 \text{ ft})(1.0) + \frac{1}{2}(120 \text{ pcf})(20.4 \text{ ft})(0.0) = 20.3 \text{ ksf}$$

$$N_c = 5.7 \quad N_q = 1.0 \quad N_\gamma = 0.0$$

Check Bearing Capacity

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 7.23 \text{ ksf} \leq (20.3 \text{ ksf})(0.65) = 13.20 \text{ ksf} \rightarrow 7.23 \text{ ksf} \leq 13.20 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	29.2 ft
MSE Wall Width (Reinforcement Length), (B) =	20.4 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}) =	23°
Bearing Soil Drained Cohesion, (c_{BS}) =	426 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	3500 psf
Embedment Depth, (D) =	3.0 ft

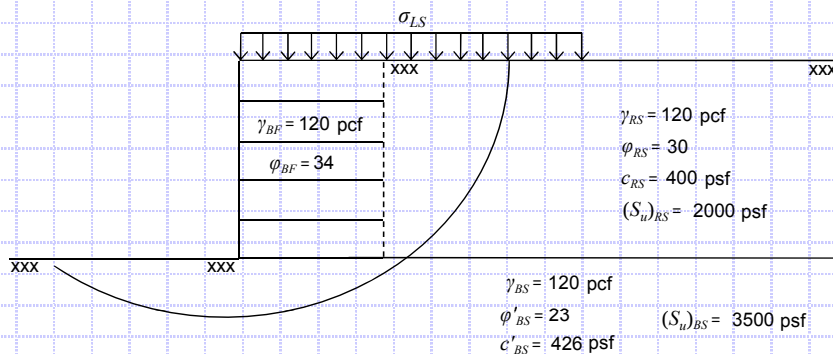
LRFD Load Factors

	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)

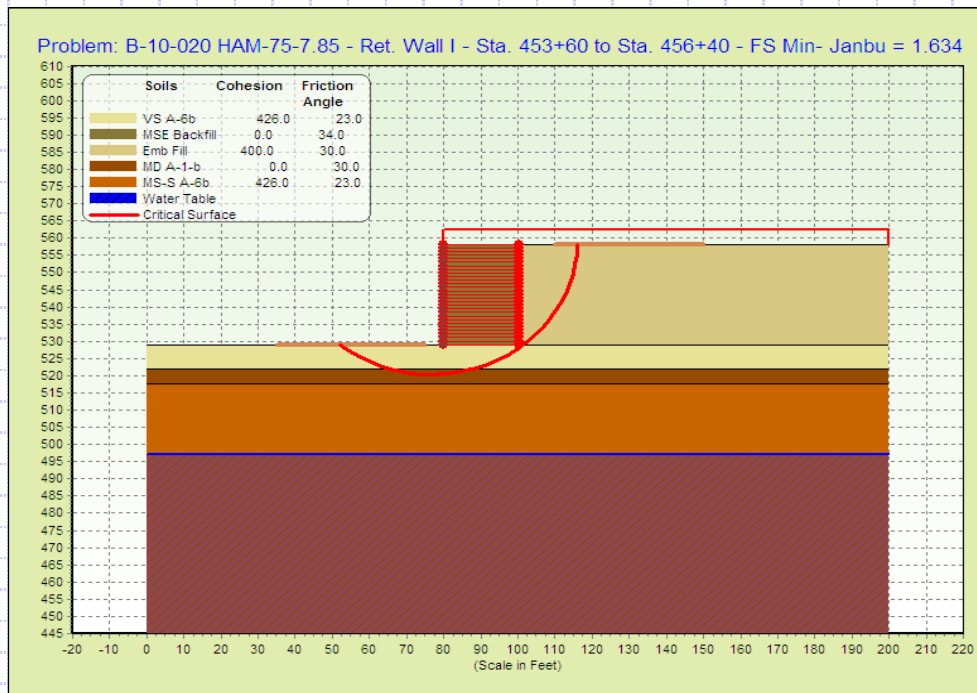
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (1.634)(0.75) = 1.23 \rightarrow 1.00 \leq 1.23 \quad \text{OK}$$

FS = 1.634 (From STABL Slope Stability Analysis)

Use ϕ_{GS} = 0.75 (Per AASHTO LRFD BDM Section 11.6.2.3)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	29.2 ft
MSE Wall Width (Reinforcement Length), (B) =	20.4 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}) =	23°
Bearing Soil Drained Cohesion, (c_{BS}) =	426 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	3500 psf
Embedment Depth, (D) =	3.0 ft

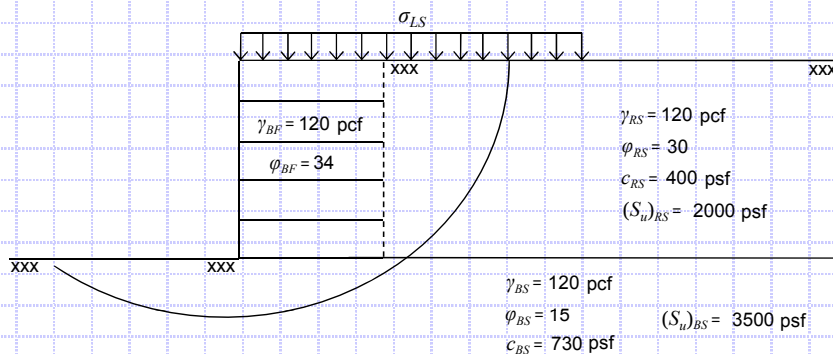
LRFD Load Factors

	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)

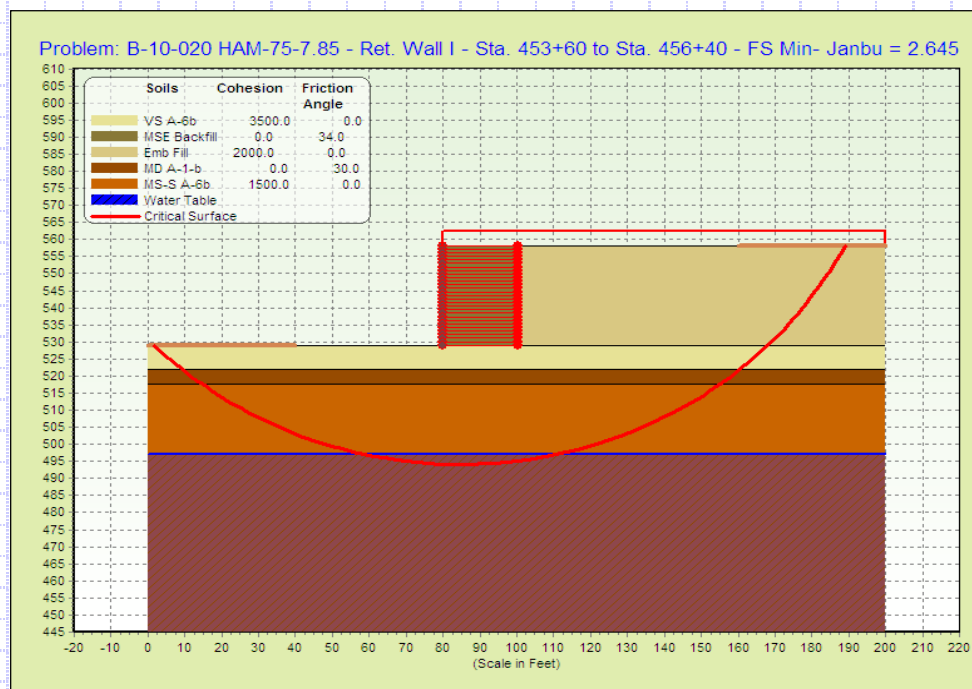
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 (Cont'd)

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (2.645)(0.75) = 1.98 \rightarrow 1.00 \leq 1.98 \quad \text{OK}$$

FS = 2.645 (From STABL Slope Stability Analysis)

Use ϕ_{GS} = 0.75 (Per AASHTO LRFD BDM Section 11.6.2.3)

result.out
 ** 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 I - Sta
 . 453+60 to Sta. 456+40

BOUNDARY COORDINATES

4 Top Boundaries
 9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	529.00	80.00	529.00	3
2	80.00	529.00	80.10	558.20	1
3	80.10	558.20	100.50	558.20	1
4	100.50	558.20	200.00	558.20	2
5	80.00	529.00	100.40	529.00	3
6	100.40	529.00	100.50	558.20	2
7	100.40	529.00	200.00	529.00	3
8	0.00	521.80	200.00	521.80	4
9	0.00	517.80	200.00	517.80	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	120.0	130.0	426.0	23.0	0.00	0.0	1
4	125.0	130.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	426.0	23.0	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)
-----------	--------------	--------------

result.out

1	0.00	497.00
2	200.00	497.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	80.10	200.00	240.0	0.0

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	558.2	529.0	29	20.4	1.04	1.0	7500.0

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 = 35.00 ft.
and X = 75.00 ft.

Each Surface Terminates Between X = 110.00 ft.
and X = 150.00 ft.

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

3.00 ft. Line Segments Define Each Trial Failure Surface.

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 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.14	529.00
2	54.56	527.22
3	57.10	525.62
4	59.75	524.22

result.out

5	62.50	523.03
6	65.34	522.05
7	68.24	521.29
8	71.19	520.76
9	74.18	520.45
10	77.18	520.36
11	80.17	520.51
12	83.15	520.88
13	86.09	521.48
14	88.98	522.30
15	91.79	523.34
16	94.52	524.59
17	97.14	526.04
18	99.65	527.69
19	102.02	529.52
20	104.25	531.53
21	106.32	533.70
22	108.22	536.03
23	109.93	538.49
24	111.46	541.07
25	112.78	543.76
26	113.89	546.55
27	114.79	549.41
28	115.47	552.34
29	115.92	555.30
30	116.14	558.20

*** 1.634 ***

Individual data on the 36 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	258.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.5	787.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.7	1299.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	2.8	1774.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.8	2197.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.0	822.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	1.9	1731.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	3.0	2835.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	3.0	3025.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.0	3114.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	2.8	2922.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	0.1	277.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	0.1	330.4	0.0	0.0	0.0	0.0	0.0	0.0	17.5
14	3.0	13413.5	0.0	0.0	0.0	0.0	0.0	0.0	714.4
15	2.9	13068.3	0.0	0.0	0.0	0.0	0.0	0.0	705.5
16	1.1	4940.4	0.0	0.0	0.0	0.0	0.0	0.0	270.2
17	1.8	7634.0	0.0	0.0	0.0	0.0	0.0	0.0	422.4
18	2.8	11951.5	0.0	0.0	0.0	0.0	0.0	0.0	675.6
19	2.7	11207.7	0.0	0.0	0.0	0.0	0.0	0.0	654.7
20	2.6	10359.6	0.0	0.0	0.0	0.0	0.0	0.0	630.0
21	2.5	9427.3	0.0	0.0	0.0	0.0	0.0	0.0	601.7
22	0.8	2720.8	0.0	0.0	0.0	0.0	0.0	0.0	180.0
23	0.1	358.7	0.0	0.0	0.0	0.0	0.0	0.0	24.0
24	0.9	3014.8	0.0	0.0	0.0	0.0	0.0	0.0	204.2
25	0.7	2338.2	0.0	0.0	0.0	0.0	0.0	0.0	161.6
26	2.2	7399.0	0.0	0.0	0.0	0.0	0.0	0.0	534.7
27	2.1	6351.0	0.0	0.0	0.0	0.0	0.0	0.0	496.5
28	1.9	5313.2	0.0	0.0	0.0	0.0	0.0	0.0	455.4
29	1.7	4310.4	0.0	0.0	0.0	0.0	0.0	0.0	411.6
30	1.5	3366.2	0.0	0.0	0.0	0.0	0.0	0.0	365.5
31	1.3	2503.3	0.0	0.0	0.0	0.0	0.0	0.0	317.2
32	1.1	1742.1	0.0	0.0	0.0	0.0	0.0	0.0	267.2
33	0.9	1101.1	0.0	0.0	0.0	0.0	0.0	0.0	215.5
34	0.7	595.7	0.0	0.0	0.0	0.0	0.0	0.0	162.6
35	0.5	238.4	0.0	0.0	0.0	0.0	0.0	0.0	108.8
36	0.2	38.2	0.0	0.0	0.0	0.0	0.0	0.0	52.7

Individual data on the 29 geosynthetics

result.out

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	80.0	529.0	100.4	529.0	0.0	20.4	7500.0	0.0
1	2	0	80.0	530.0	100.4	530.0	0.0	20.4	7500.0	0.0
1	3	0	80.0	531.1	100.4	531.1	0.0	20.4	7500.0	0.0
1	4	0	80.0	532.1	100.4	532.1	0.0	20.4	7500.0	0.0
1	5	0	80.0	533.2	100.4	533.2	0.0	20.4	7500.0	0.0
1	6	0	80.0	534.2	100.4	534.2	0.0	20.4	7500.0	0.0
1	7	0	80.0	535.3	100.4	535.3	0.0	20.4	7500.0	0.0
1	8	0	80.0	536.3	100.4	536.3	0.0	20.4	7500.0	0.0
1	9	0	80.0	537.3	100.4	537.3	0.0	20.4	7500.0	0.0
1	10	0	80.0	538.4	100.4	538.4	0.0	20.4	7500.0	0.0
1	11	0	80.0	539.4	100.4	539.4	0.0	20.4	7500.0	0.0
1	12	0	80.0	540.5	100.4	540.5	0.0	20.4	7500.0	0.0
1	13	0	80.0	541.5	100.4	541.5	0.0	20.4	7500.0	0.0
1	14	0	80.0	542.6	100.4	542.6	0.0	20.4	7500.0	0.0
1	15	0	80.0	543.6	100.4	543.6	0.0	20.4	7500.0	0.0
1	16	0	80.1	544.6	100.5	544.6	0.0	20.4	7500.0	0.0
1	17	0	80.1	545.7	100.5	545.7	0.0	20.4	7500.0	0.0
1	18	0	80.1	546.7	100.5	546.7	0.0	20.4	7500.0	0.0
1	19	0	80.1	547.8	100.5	547.8	0.0	20.4	7500.0	0.0
1	20	0	80.1	548.8	100.5	548.8	0.0	20.4	7500.0	0.0
1	21	0	80.1	549.9	100.5	549.9	0.0	20.4	7500.0	0.0
1	22	0	80.1	550.9	100.5	550.9	0.0	20.4	7500.0	0.0
1	23	0	80.1	551.9	100.5	551.9	0.0	20.4	7500.0	0.0
1	24	0	80.1	553.0	100.5	553.0	0.0	20.4	7500.0	0.0
1	25	0	80.1	554.0	100.5	554.0	0.0	20.4	7500.0	0.0
1	26	0	80.1	555.1	100.5	555.1	0.0	20.4	7500.0	0.0
1	27	0	80.1	556.1	100.5	556.1	0.0	20.4	7500.0	0.0
1	28	0	80.1	557.2	100.5	557.2	0.0	20.4	7500.0	0.0
1	29	0	80.1	558.2	100.5	558.2	0.0	20.4	7500.0	0.0

Failure Surface Specified By 30 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	52.96	529.00
2	55.49	527.40
3	58.14	525.97
4	60.87	524.74
5	63.68	523.70
6	66.56	522.86
7	69.49	522.22
8	72.46	521.79
9	75.45	521.57
10	78.45	521.56
11	81.45	521.76
12	84.42	522.16
13	87.36	522.78
14	90.24	523.60
15	93.06	524.62
16	95.81	525.83
17	98.46	527.24
18	101.00	528.82
19	103.43	530.58
20	105.73	532.51
21	107.89	534.59
22	109.90	536.82
23	111.75	539.19
24	113.42	541.68
25	114.92	544.27
26	116.23	546.97
27	117.35	549.76
28	118.28	552.61
29	119.00	555.52
30	119.46	558.20

*** 1.636 ***

result.out

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	47.25	529.00
2	49.67	527.24
3	52.21	525.64
4	54.86	524.22
5	57.59	522.98
6	60.39	521.92
7	63.26	521.05
8	66.19	520.38
9	69.15	519.90
10	72.14	519.62
11	75.14	519.54
12	78.13	519.66
13	81.12	519.98
14	84.07	520.50
15	86.98	521.21
16	89.84	522.12
17	92.64	523.22
18	95.35	524.50
19	97.97	525.95
20	100.49	527.58
21	102.89	529.38
22	105.17	531.33
23	107.32	533.43
24	109.32	535.66
25	111.16	538.03
26	112.85	540.51
27	114.36	543.10
28	115.70	545.79
29	116.85	548.56
30	117.82	551.39
31	118.60	554.29
32	119.18	557.24
33	119.30	558.20

*** 1.649 ***

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	46.43	529.00
2	48.68	527.02
3	51.08	525.22
4	53.61	523.60
5	56.25	522.18
6	59.00	520.97
7	61.82	519.97
8	64.72	519.18
9	67.67	518.62
10	70.65	518.28
11	73.64	518.18
12	76.64	518.29
13	79.62	518.64
14	82.57	519.21
15	85.46	520.01
16	88.28	521.02
17	91.02	522.24
18	93.66	523.67
19	96.18	525.30
20	98.58	527.11
21	100.82	529.10
22	102.91	531.25
23	104.83	533.55
24	106.57	536.00
25	108.12	538.57
26	109.47	541.25
27	110.61	544.02

28	111.53	546.88	result.out
29	112.24	549.79	
30	112.73	552.75	
31	112.98	555.74	
32	113.01	558.20	

*** 1.659 ***

1

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	44.80	529.00
2	47.32	527.38
3	49.94	525.92
4	52.65	524.62
5	55.42	523.49
6	58.27	522.53
7	61.16	521.75
8	64.10	521.15
9	67.07	520.73
10	70.06	520.49
11	73.06	520.44
12	76.06	520.57
13	79.04	520.89
14	82.00	521.39
15	84.93	522.07
16	87.80	522.92
17	90.62	523.96
18	93.37	525.16
19	96.03	526.53
20	98.61	528.06
21	101.10	529.75
22	103.47	531.58
23	105.72	533.56
24	107.85	535.67
25	109.85	537.91
26	111.71	540.27
27	113.41	542.74
28	114.96	545.30
29	116.36	547.96
30	117.58	550.70
31	118.64	553.51
32	119.52	556.38
33	119.96	558.20

*** 1.660 ***

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.98	529.00
2	46.59	527.52
3	49.28	526.19
4	52.03	525.00
5	54.85	523.96
6	57.71	523.08
7	60.63	522.36
8	63.57	521.79
9	66.54	521.38
10	69.53	521.14
11	72.53	521.06
12	75.53	521.14
13	78.52	521.39
14	81.49	521.80

result.out

15	84.44	522.37
16	87.35	523.09
17	90.22	523.98
18	93.03	525.01
19	95.79	526.20
20	98.47	527.54
21	101.08	529.02
22	103.60	530.64
23	106.04	532.40
24	108.37	534.28
25	110.60	536.29
26	112.72	538.42
27	114.71	540.66
28	116.59	543.00
29	118.33	545.44
30	119.94	547.98
31	121.40	550.59
32	122.73	553.28
33	123.90	556.04
34	124.69	558.20

*** 1.674 ***

1

Failure Surface Specified By 28 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	59.49	529.00
2	62.14	527.59
3	64.88	526.37
4	67.70	525.36
5	70.60	524.56
6	73.54	523.98
7	76.52	523.61
8	79.51	523.46
9	82.51	523.54
10	85.50	523.83
11	88.45	524.34
12	91.36	525.07
13	94.21	526.02
14	96.98	527.17
15	99.66	528.52
16	102.23	530.06
17	104.69	531.79
18	107.00	533.69
19	109.18	535.76
20	111.19	537.98
21	113.03	540.35
22	114.70	542.85
23	116.18	545.46
24	117.46	548.17
25	118.54	550.97
26	119.41	553.84
27	120.06	556.77
28	120.27	558.20

*** 1.676 ***

Failure Surface Specified By 32 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	49.69	529.00
2	52.21	527.37
3	54.83	525.91
4	57.54	524.61

result.out

5	60.32	523.49
6	63.17	522.55
7	66.07	521.79
8	69.02	521.22
9	71.99	520.83
10	74.99	520.64
11	77.99	520.64
12	80.98	520.82
13	83.96	521.20
14	86.90	521.76
15	89.81	522.52
16	92.66	523.45
17	95.44	524.56
18	98.15	525.85
19	100.77	527.31
20	103.30	528.93
21	105.71	530.71
22	108.01	532.64
23	110.18	534.71
24	112.22	536.92
25	114.11	539.25
26	115.84	541.69
27	117.42	544.24
28	118.84	546.89
29	120.08	549.62
30	121.15	552.42
31	122.03	555.29
32	122.73	558.20

*** 1.676 ***

1

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	54.59	529.00
2	57.14	527.41
3	59.79	526.02
4	62.54	524.82
5	65.38	523.83
6	68.27	523.06
7	71.22	522.50
8	74.20	522.16
9	77.20	522.04
10	80.20	522.15
11	83.18	522.48
12	86.13	523.03
13	89.03	523.79
14	91.87	524.77
15	94.62	525.96
16	97.28	527.34
17	99.83	528.92
18	102.26	530.69
19	104.55	532.63
20	106.69	534.73
21	108.66	536.99
22	110.47	539.39
23	112.09	541.91
24	113.52	544.55
25	114.75	547.28
26	115.77	550.10
27	116.58	552.99
28	117.18	555.93
29	117.46	558.20

*** 1.691 ***

Failure Surface Specified By 36 Coordinate Points

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result.out
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Point No.	X-Surf (ft)	Y-Surf (ft)
1	38.27	529.00
2	40.77	527.35
3	43.36	525.83
4	46.03	524.46
5	48.76	523.23
6	51.56	522.15
7	54.42	521.23
8	57.31	520.45
9	60.25	519.84
10	63.22	519.38
11	66.20	519.09
12	69.20	518.95
13	72.20	518.98
14	75.19	519.17
15	78.17	519.52
16	81.13	520.03
17	84.05	520.70
18	86.94	521.52
19	89.77	522.50
20	92.55	523.63
21	95.27	524.91
22	97.91	526.33
23	100.47	527.90
24	102.94	529.59
25	105.32	531.42
26	107.60	533.38
27	109.76	535.45
28	111.82	537.64
29	113.75	539.93
30	115.56	542.33
31	117.23	544.82
32	118.77	547.39
33	120.16	550.05
34	121.42	552.77
35	122.52	555.56
36	123.40	558.20

*** 1.692 ***

1

	Y	A	X	I	S	F	T
	0.00	130.64	261.29	391.93	522.57	653.21	
X	0.00	+	+	+	+	+	+
	-						
						1	
						.1	
						.6	G/1
						.g11g	
	130.64	+				..65	
	-					...	
						W *	*1/
	-						
A	261.29	+					
	-						
	-						
	-						
X	391.93	+					
	-						
	-						
	-						
I	522.57	+					

result.out

```
-  
-  
-  
-  
S    653.21 +  
-  
-  
-  
-  
783.86 +  
-  
-  
-  
F    914.50 +  
-  
-  
-  
-  
T   1045.14 +
```

result.out
 ** 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 I - Sta
 . 453+60 to Sta. 456+40

BOUNDARY COORDINATES

4 Top Boundaries
 9 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	529.00	80.00	529.00	3
2	80.00	529.00	80.10	558.20	1
3	80.10	558.20	100.50	558.20	1
4	100.50	558.20	200.00	558.20	2
5	80.00	529.00	100.40	529.00	3
6	100.40	529.00	100.50	558.20	2
7	100.40	529.00	200.00	529.00	3
8	0.00	521.80	200.00	521.80	4
9	0.00	517.80	200.00	517.80	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	120.0	130.0	3500.0	0.0	0.00	0.0	1
4	125.0	130.0	0.0	30.0	0.00	0.0	1
5	115.0	125.0	1500.0	0.0	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)
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result.out

1	0.00	497.00
2	200.00	497.00

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	80.10	200.00	240.0	0.0

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	558.2	529.0	29	20.4	1.04	1.0	7500.0

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 = 0.00 ft.
and X = 40.00 ft.

Each Surface Terminates Between X = 160.00 ft.
and X = 200.00 ft.

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

3.00 ft. Line Segments Define Each Trial Failure Surface.

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 75 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.63	529.00
2	3.76	526.89
3	5.95	524.83
4	8.18	522.83

result.out

5	10.47	520.89
6	12.80	519.00
7	15.19	517.18
8	17.62	515.42
9	20.09	513.72
10	22.61	512.09
11	25.16	510.52
12	27.76	509.02
13	30.40	507.59
14	33.07	506.22
15	35.77	504.93
16	38.51	503.70
17	41.28	502.54
18	44.08	501.46
19	46.90	500.45
20	49.75	499.51
21	52.62	498.64
22	55.52	497.85
23	58.43	497.13
24	61.36	496.49
25	64.31	495.93
26	67.27	495.44
27	70.24	495.02
28	73.22	494.69
29	76.21	494.43
30	79.20	494.24
31	82.20	494.14
32	85.20	494.11
33	88.20	494.16
34	91.20	494.28
35	94.19	494.48
36	97.18	494.76
37	100.15	495.12
38	103.12	495.55
39	106.08	496.06
40	109.02	496.64
41	111.95	497.30
42	114.86	498.04
43	117.75	498.85
44	120.61	499.73
45	123.46	500.69
46	126.27	501.72
47	129.06	502.82
48	131.83	503.99
49	134.56	505.24
50	137.25	506.55
51	139.91	507.94
52	142.54	509.39
53	145.13	510.90
54	147.68	512.49
55	150.18	514.14
56	152.64	515.85
57	155.06	517.63
58	157.43	519.46
59	159.76	521.36
60	162.03	523.32
61	164.25	525.33
62	166.43	527.40
63	168.54	529.53
64	170.60	531.71
65	172.61	533.94
66	174.55	536.23
67	176.44	538.56
68	178.27	540.94
69	180.03	543.36
70	181.73	545.84
71	183.37	548.35
72	184.94	550.90
73	186.45	553.50
74	187.88	556.13
75	188.95	558.20

*** 2.645 ***

result.out

Slice No.	Width (ft)	Weight (lbs)	Water	Water	Force Norm (lbs)	Force Tan (lbs)	Earthquake		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)			Force Hor (lbs)	Force Ver (lbs)	
1	2.1	270.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.2	823.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.2	1387.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.2	972.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.1	989.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	2.3	2559.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	1.6	2029.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	0.8	1131.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.4	3732.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.5	4292.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	2.5	4848.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	2.6	5398.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	2.6	5940.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	2.6	6471.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	2.7	6989.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	2.7	7493.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	2.7	7980.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	2.8	8449.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	2.8	8897.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	2.8	9323.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	2.8	9726.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	2.9	10103.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	2.9	10454.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	2.9	10776.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	0.6	2296.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	2.3	8779.3	0.0	37.6	0.0	0.0	0.0	0.0	0.0
27	2.9	11356.8	0.0	147.9	0.0	0.0	0.0	0.0	0.0
28	3.0	11604.4	0.0	246.8	0.0	0.0	0.0	0.0	0.0
29	3.0	11817.7	0.0	331.3	0.0	0.0	0.0	0.0	0.0
30	3.0	11996.0	0.0	401.6	0.0	0.0	0.0	0.0	0.0
31	3.0	12138.5	0.0	457.5	0.0	0.0	0.0	0.0	0.0
32	3.0	12244.7	0.0	499.0	0.0	0.0	0.0	0.0	0.0
33	0.8	3277.8	0.0	138.3	0.0	0.0	0.0	0.0	0.0
34	0.1	585.6	0.0	17.4	0.0	0.0	0.0	0.0	0.0
35	2.1	15981.3	0.0	370.4	0.0	0.0	0.0	0.0	503.8
36	3.0	22858.2	0.0	538.8	0.0	0.0	0.0	0.0	720.0
37	3.0	22852.7	0.0	537.0	0.0	0.0	0.0	0.0	719.9
38	3.0	22803.3	0.0	520.7	0.0	0.0	0.0	0.0	719.4
39	3.0	22710.0	0.0	490.1	0.0	0.0	0.0	0.0	718.4
40	3.0	22573.0	0.0	445.0	0.0	0.0	0.0	0.0	716.9
41	3.0	22393.0	0.0	385.6	0.0	0.0	0.0	0.0	714.9
42	0.2	1836.3	0.0	28.8	0.0	0.0	0.0	0.0	58.8
43	0.1	749.0	0.0	11.6	0.0	0.0	0.0	0.0	24.0
44	2.6	19585.3	0.0	271.4	0.0	0.0	0.0	0.0	629.7
45	3.0	21906.3	0.0	223.7	0.0	0.0	0.0	0.0	709.6
46	2.9	21601.0	0.0	121.4	0.0	0.0	0.0	0.0	706.2
47	1.6	11496.2	0.0	18.0	0.0	0.0	0.0	0.0	378.9
48	1.3	9761.6	0.0	0.0	0.0	0.0	0.0	0.0	323.5
49	2.9	20891.4	0.0	0.0	0.0	0.0	0.0	0.0	698.1
50	2.9	20492.2	0.0	0.0	0.0	0.0	0.0	0.0	693.3
51	2.9	20058.5	0.0	0.0	0.0	0.0	0.0	0.0	688.1
52	2.8	19591.9	0.0	0.0	0.0	0.0	0.0	0.0	682.4
53	2.8	19093.9	0.0	0.0	0.0	0.0	0.0	0.0	676.2
54	2.8	18566.0	0.0	0.0	0.0	0.0	0.0	0.0	669.7
55	2.8	18010.0	0.0	0.0	0.0	0.0	0.0	0.0	662.6
56	2.7	17427.6	0.0	0.0	0.0	0.0	0.0	0.0	655.2
57	2.7	16820.9	0.0	0.0	0.0	0.0	0.0	0.0	647.3
58	2.7	16191.8	0.0	0.0	0.0	0.0	0.0	0.0	639.0
59	2.6	15542.2	0.0	0.0	0.0	0.0	0.0	0.0	630.2
60	2.6	14874.4	0.0	0.0	0.0	0.0	0.0	0.0	621.0
61	2.5	14190.8	0.0	0.0	0.0	0.0	0.0	0.0	611.5
62	2.5	13493.2	0.0	0.0	0.0	0.0	0.0	0.0	601.5
63	2.5	12784.3	0.0	0.0	0.0	0.0	0.0	0.0	591.1
64	2.4	12066.4	0.0	0.0	0.0	0.0	0.0	0.0	580.3
65	0.2	1094.5	0.0	0.0	0.0	0.0	0.0	0.0	53.9
66	2.1	10229.3	0.0	0.0	0.0	0.0	0.0	0.0	515.3
67	2.3	10552.3	0.0	0.0	0.0	0.0	0.0	0.0	557.7
68	0.5	2241.9	0.0	0.0	0.0	0.0	0.0	0.0	122.4
69	1.8	7544.2	0.0	0.0	0.0	0.0	0.0	0.0	423.3
70	2.2	9036.0	0.0	0.0	0.0	0.0	0.0	0.0	533.5
71	2.2	8290.3	0.0	0.0	0.0	0.0	0.0	0.0	520.9
72	1.6	5719.5	0.0	0.0	0.0	0.0	0.0	0.0	381.3
73	0.5	1831.6	0.0	0.0	0.0	0.0	0.0	0.0	126.6

result.out									
74	2.1	6821.0	0.0	0.0	0.0	0.0	0.0	0.0	494.6
75	2.0	6102.5	0.0	0.0	0.0	0.0	0.0	0.0	481.0
76	1.9	5398.4	0.0	0.0	0.0	0.0	0.0	0.0	467.1
77	1.9	4711.2	0.0	0.0	0.0	0.0	0.0	0.0	452.8
78	1.8	4043.5	0.0	0.0	0.0	0.0	0.0	0.0	438.3
79	1.8	3397.8	0.0	0.0	0.0	0.0	0.0	0.0	423.4
80	1.7	2776.6	0.0	0.0	0.0	0.0	0.0	0.0	408.3
81	1.6	2182.3	0.0	0.0	0.0	0.0	0.0	0.0	392.9
82	1.6	1617.3	0.0	0.0	0.0	0.0	0.0	0.0	377.3
83	1.5	1083.9	0.0	0.0	0.0	0.0	0.0	0.0	361.4
84	1.4	584.3	0.0	0.0	0.0	0.0	0.0	0.0	345.2
85	1.1	131.8	0.0	0.0	0.0	0.0	0.0	0.0	254.9

Individual data on the 29 geosynthetics

Group	Level	Slice	Head Coordinates (ft)	End Coordinates (ft)	T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %		
1	1	0	80.0	529.0	100.4	529.0	0.0	20.4	7500.0	0.0
1	2	0	80.0	530.0	100.4	530.0	0.0	20.4	7500.0	0.0
1	3	0	80.0	531.1	100.4	531.1	0.0	20.4	7500.0	0.0
1	4	0	80.0	532.1	100.4	532.1	0.0	20.4	7500.0	0.0
1	5	0	80.0	533.2	100.4	533.2	0.0	20.4	7500.0	0.0
1	6	0	80.0	534.2	100.4	534.2	0.0	20.4	7500.0	0.0
1	7	0	80.0	535.3	100.4	535.3	0.0	20.4	7500.0	0.0
1	8	0	80.0	536.3	100.4	536.3	0.0	20.4	7500.0	0.0
1	9	0	80.0	537.3	100.4	537.3	0.0	20.4	7500.0	0.0
1	10	0	80.0	538.4	100.4	538.4	0.0	20.4	7500.0	0.0
1	11	0	80.0	539.4	100.4	539.4	0.0	20.4	7500.0	0.0
1	12	0	80.0	540.5	100.4	540.5	0.0	20.4	7500.0	0.0
1	13	0	80.0	541.5	100.4	541.5	0.0	20.4	7500.0	0.0
1	14	0	80.0	542.6	100.4	542.6	0.0	20.4	7500.0	0.0
1	15	0	80.0	543.6	100.4	543.6	0.0	20.4	7500.0	0.0
1	16	0	80.1	544.6	100.5	544.6	0.0	20.4	7500.0	0.0
1	17	0	80.1	545.7	100.5	545.7	0.0	20.4	7500.0	0.0
1	18	0	80.1	546.7	100.5	546.7	0.0	20.4	7500.0	0.0
1	19	0	80.1	547.8	100.5	547.8	0.0	20.4	7500.0	0.0
1	20	0	80.1	548.8	100.5	548.8	0.0	20.4	7500.0	0.0
1	21	0	80.1	549.9	100.5	549.9	0.0	20.4	7500.0	0.0
1	22	0	80.1	550.9	100.5	550.9	0.0	20.4	7500.0	0.0
1	23	0	80.1	551.9	100.5	551.9	0.0	20.4	7500.0	0.0
1	24	0	80.1	553.0	100.5	553.0	0.0	20.4	7500.0	0.0
1	25	0	80.1	554.0	100.5	554.0	0.0	20.4	7500.0	0.0
1	26	0	80.1	555.1	100.5	555.1	0.0	20.4	7500.0	0.0
1	27	0	80.1	556.1	100.5	556.1	0.0	20.4	7500.0	0.0
1	28	0	80.1	557.2	100.5	557.2	0.0	20.4	7500.0	0.0
1	29	0	80.1	558.2	100.5	558.2	0.0	20.4	7500.0	0.0

Failure Surface Specified By 75 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	3.27	529.00
2	5.39	526.88
3	7.57	524.82
4	9.79	522.81
5	12.08	520.86
6	14.40	518.97
7	16.78	517.14
8	19.21	515.37
9	21.68	513.67
10	24.19	512.03
11	26.74	510.45
12	29.33	508.95
13	31.97	507.50
14	34.63	506.13
15	37.34	504.83
16	40.07	503.60
17	42.84	502.43
18	45.63	501.34
19	48.45	500.33
20	51.30	499.38
21	54.17	498.51
22	57.06	497.71
23	59.98	496.99

result.out

24	62.90	496.34
25	65.85	495.77
26	68.81	495.28
27	71.78	494.86
28	74.76	494.52
29	77.75	494.25
30	80.74	494.07
31	83.74	493.95
32	86.74	493.92
33	89.74	493.97
34	92.74	494.09
35	95.73	494.29
36	98.72	494.56
37	101.70	494.92
38	104.67	495.35
39	107.62	495.85
40	110.57	496.44
41	113.49	497.09
42	116.40	497.83
43	119.29	498.64
44	122.16	499.52
45	125.00	500.47
46	127.82	501.50
47	130.61	502.60
48	133.37	503.78
49	136.10	505.02
50	138.80	506.33
51	141.46	507.72
52	144.09	509.17
53	146.67	510.69
54	149.22	512.27
55	151.73	513.92
56	154.19	515.63
57	156.61	517.41
58	158.98	519.25
59	161.30	521.15
60	163.57	523.11
61	165.79	525.12
62	167.96	527.20
63	170.08	529.32
64	172.14	531.51
65	174.14	533.74
66	176.08	536.02
67	177.97	538.36
68	179.79	540.74
69	181.55	543.17
70	183.25	545.64
71	184.88	548.16
72	186.45	550.72
73	187.95	553.31
74	189.39	555.95
75	190.54	558.20

*** 2.645 ***

1

Failure Surface Specified By 72 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.63	529.00
2	3.76	526.88
3	5.94	524.82
4	8.17	522.82
5	10.46	520.88
6	12.80	519.00
7	15.19	517.18
8	17.62	515.43
9	20.11	513.75
10	22.64	512.14
11	25.21	510.59
12	27.82	509.12
13	30.47	507.71

result.out

14	33.16	506.38
15	35.88	505.12
16	38.64	503.94
17	41.43	502.83
18	44.24	501.80
19	47.09	500.84
20	49.95	499.96
21	52.85	499.16
22	55.76	498.44
23	58.69	497.79
24	61.63	497.23
25	64.59	496.74
26	67.57	496.34
27	70.55	496.02
28	73.54	495.77
29	76.53	495.61
30	79.53	495.53
31	82.53	495.53
32	85.53	495.61
33	88.53	495.78
34	91.52	496.02
35	94.50	496.34
36	97.47	496.75
37	100.43	497.24
38	103.38	497.80
39	106.31	498.45
40	109.22	499.17
41	112.11	499.97
42	114.98	500.85
43	117.82	501.81
44	120.64	502.85
45	123.43	503.96
46	126.18	505.14
47	128.90	506.40
48	131.59	507.73
49	134.24	509.14
50	136.85	510.62
51	139.42	512.16
52	141.95	513.78
53	144.44	515.46
54	146.87	517.21
55	149.26	519.03
56	151.60	520.90
57	153.89	522.85
58	156.12	524.85
59	158.30	526.91
60	160.42	529.03
61	162.48	531.21
62	164.49	533.44
63	166.43	535.73
64	168.31	538.07
65	170.13	540.45
66	171.88	542.89
67	173.56	545.37
68	175.18	547.90
69	176.73	550.47
70	178.21	553.08
71	179.61	555.73
72	180.84	558.20

*** 2.649 ***

Failure Surface Specified By 72 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.00	529.00
2	2.12	526.88
3	4.30	524.82
4	6.54	522.82
5	8.83	520.88
6	11.17	519.00
7	13.56	517.19

result.out

8	16.00	515.44
9	18.48	513.76
10	21.01	512.15
11	23.58	510.61
12	26.20	509.14
13	28.85	507.74
14	31.54	506.41
15	34.27	505.16
16	37.03	503.98
17	39.82	502.87
18	42.64	501.85
19	45.48	500.90
20	48.35	500.02
21	51.25	499.23
22	54.16	498.52
23	57.09	497.88
24	60.04	497.33
25	63.00	496.85
26	65.98	496.46
27	68.96	496.15
28	71.95	495.92
29	74.95	495.77
30	77.95	495.70
31	80.95	495.71
32	83.94	495.81
33	86.94	495.98
34	89.93	496.24
35	92.91	496.58
36	95.88	497.00
37	98.84	497.50
38	101.78	498.08
39	104.71	498.74
40	107.61	499.49
41	110.50	500.31
42	113.36	501.20
43	116.20	502.18
44	119.01	503.23
45	121.79	504.36
46	124.54	505.56
47	127.25	506.84
48	129.93	508.19
49	132.57	509.62
50	135.17	511.11
51	137.73	512.68
52	140.24	514.31
53	142.72	516.01
54	145.14	517.78
55	147.51	519.62
56	149.84	521.51
57	152.11	523.47
58	154.32	525.50
59	156.48	527.58
60	158.59	529.72
61	160.63	531.91
62	162.62	534.16
63	164.54	536.47
64	166.40	538.82
65	168.19	541.23
66	169.92	543.68
67	171.58	546.18
68	173.17	548.72
69	174.69	551.31
70	176.14	553.93
71	177.52	556.60
72	178.29	558.20

*** 2.651 ***

1

Failure Surface Specified By 77 Coordinate Points

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

1	3.27	529.00
2	5.40	526.90
3	7.59	524.85
4	9.83	522.85
5	12.12	520.91
6	14.46	519.03
7	16.84	517.20
8	19.27	515.44
9	21.74	513.73
10	24.25	512.09
11	26.80	510.51
12	29.39	509.00
13	32.01	507.55
14	34.67	506.16
15	37.37	504.84
16	40.09	503.59
17	42.85	502.40
18	45.63	501.29
19	48.44	500.24
20	51.28	499.27
21	54.14	498.36
22	57.02	497.52
23	59.92	496.76
24	62.84	496.07
25	65.78	495.45
26	68.73	494.91
27	71.69	494.43
28	74.66	494.03
29	77.65	493.71
30	80.64	493.46
31	83.63	493.28
32	86.63	493.18
33	89.63	493.15
34	92.63	493.19
35	95.63	493.31
36	98.62	493.51
37	101.61	493.78
38	104.59	494.12
39	107.56	494.53
40	110.52	495.02
41	113.47	495.58
42	116.40	496.22
43	119.31	496.93
44	122.21	497.71
45	125.09	498.56
46	127.94	499.48
47	130.77	500.47
48	133.58	501.53
49	136.36	502.67
50	139.11	503.87
51	141.83	505.13
52	144.51	506.47
53	147.17	507.87
54	149.78	509.33
55	152.36	510.86
56	154.91	512.46
57	157.41	514.11
58	159.87	515.83
59	162.28	517.61
60	164.65	519.45
61	166.98	521.34
62	169.26	523.29
63	171.49	525.30
64	173.66	527.37
65	175.79	529.48
66	177.86	531.65
67	179.88	533.87
68	181.85	536.14
69	183.75	538.45
70	185.60	540.82
71	187.39	543.22
72	189.12	545.67
73	190.79	548.17
74	192.40	550.70
75	193.94	553.27
76	195.42	555.89
77	196.65	558.20

*** 2.654 ***

result.out

Failure Surface Specified By 72 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.82	529.00
2	2.95	526.89
3	5.13	524.83
4	7.37	522.84
5	9.67	520.91
6	12.01	519.04
7	14.41	517.23
8	16.85	515.49
9	19.34	513.82
10	21.88	512.21
11	24.46	510.68
12	27.07	509.21
13	29.73	507.82
14	32.43	506.50
15	35.15	505.25
16	37.92	504.08
17	40.71	502.98
18	43.53	501.96
19	46.38	501.02
20	49.25	500.15
21	52.14	499.36
22	55.06	498.65
23	57.99	498.02
24	60.94	497.47
25	63.90	497.00
26	66.88	496.61
27	69.86	496.30
28	72.85	496.07
29	75.85	495.93
30	78.85	495.86
31	81.85	495.88
32	84.85	495.97
33	87.84	496.15
34	90.83	496.41
35	93.81	496.75
36	96.78	497.17
37	99.74	497.67
38	102.68	498.26
39	105.61	498.92
40	108.51	499.66
41	111.40	500.48
42	114.26	501.37
43	117.10	502.35
44	119.91	503.40
45	122.69	504.53
46	125.44	505.73
47	128.15	507.01
48	130.83	508.35
49	133.48	509.78
50	136.08	511.27
51	138.64	512.83
52	141.16	514.46
53	143.63	516.16
54	146.05	517.93
55	148.43	519.76
56	150.76	521.65
57	153.03	523.61
58	155.25	525.63
59	157.42	527.70
60	159.52	529.84
61	161.57	532.03
62	163.56	534.28
63	165.49	536.58
64	167.35	538.93
65	169.15	541.33
66	170.88	543.78
67	172.55	546.27
68	174.15	548.81

69	175.68	551.39
70	177.13	554.01
71	178.52	556.67
72	179.27	558.20

result.out

*** 2.654 ***

1

Failure Surface Specified By 74 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	6.53	529.00
2	8.66	526.89
3	10.85	524.83
4	13.08	522.83
5	15.37	520.90
6	17.71	519.02
7	20.10	517.20
8	22.54	515.45
9	25.02	513.77
10	27.54	512.14
11	30.11	510.59
12	32.72	509.11
13	35.36	507.69
14	38.04	506.34
15	40.76	505.07
16	43.51	503.86
17	46.28	502.73
18	49.09	501.68
19	51.93	500.70
20	54.79	499.79
21	57.67	498.96
22	60.57	498.20
23	63.49	497.52
24	66.43	496.92
25	69.39	496.40
26	72.35	495.95
27	75.33	495.58
28	78.32	495.29
29	81.31	495.08
30	84.31	494.95
31	87.31	494.90
32	90.31	494.92
33	93.30	495.03
34	96.30	495.21
35	99.29	495.48
36	102.27	495.82
37	105.24	496.24
38	108.20	496.73
39	111.14	497.31
40	114.07	497.96
41	116.98	498.69
42	119.87	499.50
43	122.74	500.38
44	125.58	501.34
45	128.40	502.37
46	131.18	503.48
47	133.94	504.66
48	136.67	505.91
49	139.36	507.23
50	142.02	508.62
51	144.64	510.08
52	147.22	511.62
53	149.76	513.21
54	152.25	514.88
55	154.71	516.61
56	157.11	518.40
57	159.47	520.26
58	161.77	522.18
59	164.03	524.15
60	166.23	526.19
61	168.38	528.28

62	170.47	530.43	result.out
63	172.51	532.64	
64	174.48	534.90	
65	176.40	537.20	
66	178.26	539.56	
67	180.05	541.97	
68	181.78	544.42	
69	183.44	546.92	
70	185.04	549.46	
71	186.56	552.04	
72	188.03	554.66	
73	189.42	557.32	
74	189.85	558.20	

*** 2.660 ***

Failure Surface Specified By 71 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.00	529.00
2	2.14	526.90
3	4.34	524.86
4	6.59	522.87
5	8.90	520.96
6	11.25	519.10
7	13.66	517.31
8	16.12	515.58
9	18.62	513.93
10	21.16	512.34
11	23.75	510.82
12	26.38	509.38
13	29.05	508.00
14	31.75	506.70
15	34.49	505.48
16	37.26	504.33
17	40.06	503.25
18	42.89	502.26
19	45.75	501.34
20	48.62	500.49
21	51.53	499.73
22	54.45	499.05
23	57.39	498.45
24	60.34	497.92
25	63.31	497.48
26	66.29	497.12
27	69.27	496.84
28	72.27	496.65
29	75.26	496.53
30	78.26	496.50
31	81.26	496.55
32	84.26	496.68
33	87.25	496.89
34	90.24	497.18
35	93.22	497.56
36	96.18	498.02
37	99.13	498.56
38	102.07	499.17
39	104.98	499.87
40	107.88	500.65
41	110.76	501.51
42	113.61	502.44
43	116.43	503.45
44	119.23	504.54
45	121.99	505.71
46	124.72	506.95
47	127.42	508.26
48	130.08	509.65
49	132.70	511.11
50	135.28	512.64
51	137.82	514.24
52	140.31	515.91
53	142.76	517.65

result.out

54	145.16	519.45
55	147.50	521.32
56	149.80	523.25
57	152.04	525.24
58	154.23	527.30
59	156.36	529.41
60	158.43	531.58
61	160.44	533.80
62	162.39	536.08
63	164.28	538.42
64	166.10	540.80
65	167.85	543.23
66	169.54	545.71
67	171.16	548.24
68	172.72	550.80
69	174.20	553.41
70	175.60	556.06
71	176.67	558.20

*** 2.664 ***

1

Failure Surface Specified By 73 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	3.27	529.00
2	5.42	526.91
3	7.63	524.89
4	9.90	522.92
5	12.21	521.01
6	14.57	519.16
7	16.98	517.37
8	19.44	515.65
9	21.94	513.99
10	24.48	512.40
11	27.06	510.87
12	29.69	509.42
13	32.35	508.03
14	35.04	506.71
15	37.77	505.46
16	40.53	504.29
17	43.32	503.18
18	46.14	502.15
19	48.98	501.20
20	51.85	500.32
21	54.74	499.51
22	57.65	498.78
23	60.58	498.13
24	63.52	497.55
25	66.48	497.05
26	69.45	496.63
27	72.43	496.28
28	75.42	496.01
29	78.41	495.83
30	81.41	495.72
31	84.41	495.68
32	87.41	495.73
33	90.40	495.85
34	93.40	496.06
35	96.38	496.34
36	99.36	496.70
37	102.33	497.13
38	105.29	497.65
39	108.23	498.24
40	111.15	498.91
41	114.06	499.65
42	116.94	500.47
43	119.81	501.37
44	122.65	502.34
45	125.46	503.38
46	128.24	504.50
47	131.00	505.68

result.out

48	133.72	506.94
49	136.41	508.28
50	139.06	509.68
51	141.68	511.15
52	144.25	512.68
53	146.79	514.29
54	149.28	515.96
55	151.73	517.69
56	154.13	519.49
57	156.48	521.35
58	158.79	523.27
59	161.04	525.25
60	163.24	527.29
61	165.39	529.39
62	167.48	531.54
63	169.52	533.74
64	171.49	536.00
65	173.41	538.31
66	175.26	540.66
67	177.06	543.07
68	178.79	545.52
69	180.45	548.01
70	182.05	550.55
71	183.59	553.13
72	185.05	555.75
73	186.34	558.20

*** 2.666 ***

Failure Surface Specified By 70 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.63	529.00
2	3.77	526.89
3	5.96	524.85
4	8.21	522.86
5	10.51	520.94
6	12.87	519.08
7	15.28	517.29
8	17.74	515.57
9	20.24	513.92
10	22.79	512.34
11	25.38	510.83
12	28.01	509.39
13	30.69	508.02
14	33.39	506.74
15	36.14	505.52
16	38.92	504.39
17	41.72	503.33
18	44.56	502.35
19	47.42	501.45
20	50.31	500.63
21	53.21	499.90
22	56.14	499.24
23	59.09	498.66
24	62.05	498.17
25	65.02	497.76
26	68.00	497.44
27	70.99	497.19
28	73.99	497.03
29	76.98	496.96
30	79.98	496.97
31	82.98	497.06
32	85.98	497.23
33	88.97	497.49
34	91.95	497.83
35	94.92	498.26
36	97.87	498.77
37	100.82	499.36
38	103.74	500.03
39	106.64	500.78
40	109.52	501.62

result.out

41	112.38	502.53
42	115.21	503.52
43	118.01	504.60
44	120.79	505.75
45	123.52	506.97
46	126.23	508.28
47	128.89	509.65
48	131.52	511.10
49	134.10	512.63
50	136.64	514.22
51	139.14	515.89
52	141.58	517.62
53	143.98	519.43
54	146.33	521.30
55	148.62	523.23
56	150.86	525.23
57	153.04	527.28
58	155.17	529.40
59	157.23	531.58
60	159.23	533.81
61	161.17	536.10
62	163.05	538.44
63	164.86	540.84
64	166.60	543.28
65	168.27	545.77
66	169.87	548.31
67	171.40	550.89
68	172.86	553.51
69	174.25	556.17
70	175.23	558.20

*** 2.666 ***

1

	Y	A	X	I	S	F	T
	0.00	130.64	261.29	391.93	522.57	653.21	
X	0.00	+	+	+	+	W-*	+
	-					11	
	-					11.	
	-					1..	
	-					1.G. G/1	
	-					14g. g	
	130.64	+				11...	
	-					113..	
	-					.1113	
	-					W *51*1/	
	-						
A	261.29	+					
	-						
	-						
	-						
X	391.93	+					
	-						
	-						
	-						
I	522.57	+					
	-						
	-						
	-						
S	653.21	+					
	-						
	-						
	-						
	-						

```

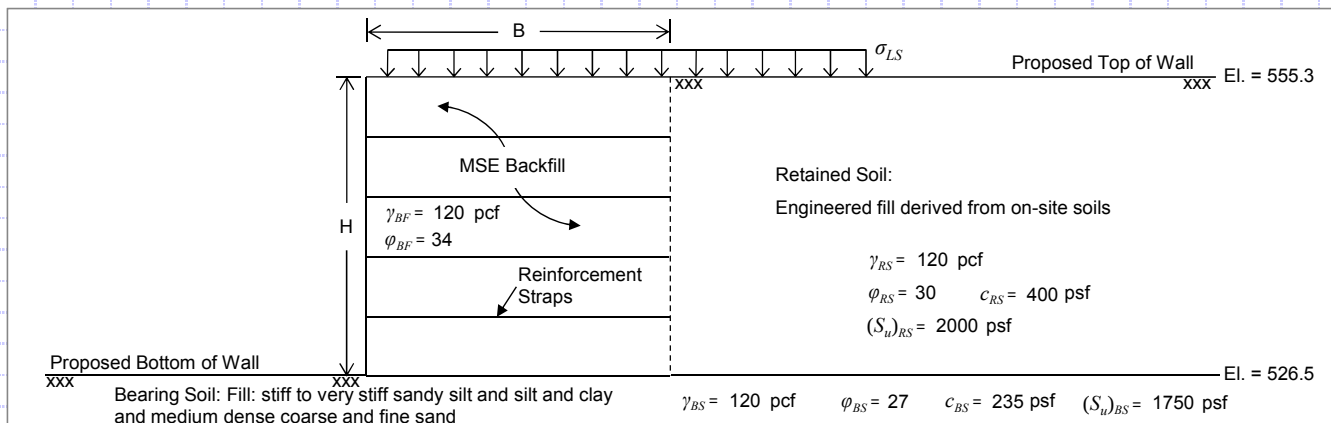
783.86 +
-
-
-
-
F  914.50 +
-
-
-
-
T  1045.14 +

```

result.out



Retaining Wall I - MSE Wall - 28.8 ft. Maximum Wall Height - B-019-0-11 and B-020-0-11



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.8 ft
MSE Wall Width (Reinforcement Length), (B) =	22.2 ft
Live Surcharge Load, (σ _{LS}) =	240 psf
Retained Soil Unit Weight, (γ _{RS}) =	120 pcf
Retained Soil Friction Angle, (φ _{RS}) =	30°
Retained Soil Drained Cohesion, (c _{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [(S _u) _{RS}] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K _a) =	0.333
MSE Backfill Unit Weight, (γ _{BF}) =	120 pcf
MSE Backfill Friction Angle, (φ _{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ _{BS}) =	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}] =	1750 psf
Embedment Depth, (D) =	3.0 ft

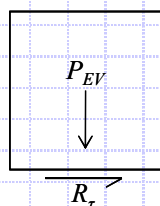
LRFD Load Factors

	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:



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

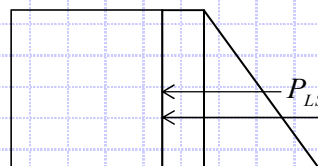
$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(28.8 \text{ ft})(22.2 \text{ ft})(1.00) = 76.72 \text{ kip/ft}$$

$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(27) \leq \tan(34) \rightarrow 0.51 \leq 0.67 \rightarrow \tan \delta = 0.51$$

$$R_{\tau} = (76.72 \text{ kip/ft})(0.51) = 39.13 \text{ kip/ft}$$

Sliding Force:



$$P_H = P_{EH} + P_{LS_h}$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(28.8 \text{ ft})^2 (0.333)(1.5) = 24.86 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(28.8 \text{ ft})(0.333)(1.75) = 4.03 \text{ kip/ft}$$

$$P_H = 24.86 \text{ kip/ft} + 4.03 \text{ kip/ft} = 28.89 \text{ kip/ft}$$

Check Sliding Resistance

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 28.89 \text{ kip/ft} \leq (39.13 \text{ kip/ft})(1.0) = 39.13 \text{ kip/ft} \rightarrow 28.89 \text{ kip/ft} \leq 39.13 \text{ kip/ft} \quad \text{OK}$$

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



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.8 ft
MSE Wall Width (Reinforcement Length), (B) =	22.2 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

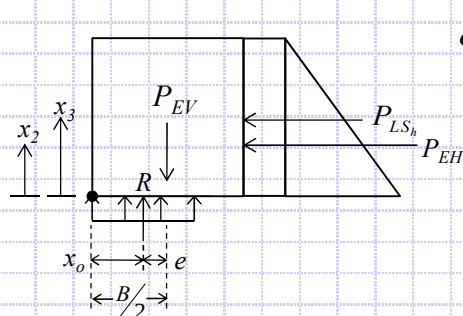
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	27°
Bearing Soil Drained Cohesion, (c_{BS}) =	235 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1750 psf
Embedment Depth, (D) =	3.0 ft

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



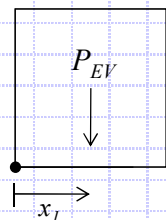
$$e = \frac{B}{2} - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (851.59 \text{ kip-ft/ft} - 296.69 \text{ kip-ft/ft}) / (76.72 \text{ kip/ft}) = 7.23 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 851.59 \text{ kip-ft/ft} \\ M_H &= 296.69 \text{ kip-ft/ft} \\ P_{EV} &= 76.72 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (22.2 \text{ ft})/2 - 7.23 \text{ ft} = 3.87 \text{ ft}$$

Resisting Moment, M_{EV} :



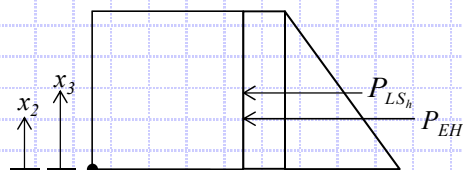
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(28.8 \text{ ft})(22.2 \text{ ft})(1.00) = 76.72 \text{ kip/ft}$$

$$x_1 = \frac{B}{2} = (22.2 \text{ ft})/2 = 11.10 \text{ ft}$$

$$M_{EV} = (76.72 \text{ kip/ft})(11.1 \text{ ft}) = 851.59 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(28.8 \text{ ft})^2(0.333)(1.5) = 24.86 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(28.8 \text{ ft})(0.333)(1.75) = 4.03 \text{ kip/ft}$$

$$x_2 = \frac{H}{3} = (28.8 \text{ ft})/3 = 9.60 \text{ ft}$$

$$x_3 = \frac{H}{2} = (28.8 \text{ ft})/2 = 14.40 \text{ ft}$$

$$M_H = (24.86 \text{ kip/ft})(9.6 \text{ ft}) + (4.03 \text{ kip/ft})(14.4 \text{ ft}) = 296.69 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = \frac{B}{4} \rightarrow e_{\max} = (22.2 \text{ ft})/4 = 5.55 \text{ ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 3.87 \text{ ft} < 5.55 \text{ ft} \quad \text{OK}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.8 ft
MSE Wall Width (Reinforcement Length), (B) =	22.2 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

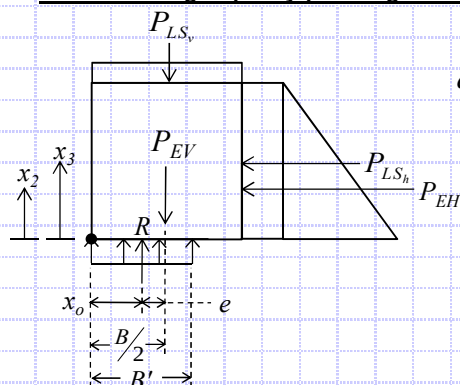
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	27°
Bearing Soil Drained Cohesion, (c_{BS}) =	235 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1750 psf
Embedment Depth, (D) =	3.0 ft

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



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

$$B' = B - 2e = 22.2 \text{ ft} - 2(2.63 \text{ ft}) = 16.94 \text{ ft}$$

$$e = B/2 - x_o = (22.2 \text{ ft}) / 2 - 8.47 \text{ ft} = 2.63 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (1253.19 \text{ kip-ft/ft} - 296.64 \text{ kip-ft/ft}) / 112.9 \text{ kip/ft} = 8.47 \text{ ft}$$

$$q_{eq} = (112.9 \text{ kip/ft}) / (16.94 \text{ ft}) = 6.66 \text{ ksf}$$

$$M_V = P_{EV}(x_1) + P_{LS}(x_2) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_2)$$

$$M_V = [(120 \text{ pcf})(28.8 \text{ ft})(22.2 \text{ ft})(1.35)](11.1 \text{ ft}) + [(240 \text{ psf})(22.2 \text{ ft})(1.75)](11.1 \text{ ft}) = 1253.19 \text{ kip-ft/ft}$$

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

$$M_H = \left[\frac{1}{2} (120 \text{ pcf})(28.8 \text{ ft})^2 (0.333)(1.5) \right](9.6 \text{ ft}) + [(240 \text{ psf})(28.8 \text{ ft})(0.333)(1.75)](14.4 \text{ ft}) = 296.64 \text{ kip-ft/ft}$$

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

$$P_V = (120 \text{ pcf})(28.8 \text{ ft})(22.2 \text{ ft})(1.35) + (240 \text{ psf})(22.2 \text{ ft})(1.75) = 112.9 \text{ kip/ft}$$

Nominal Bearing Resistance:

$$q_n = cN_c + \gamma DN_q + \frac{1}{2} \gamma BN_\gamma = (1750 \text{ psf})(5.7) + (120 \text{ pcf})(3.0 \text{ ft})(1.0) + \frac{1}{2} (120 \text{ pcf})(22.2 \text{ ft})(0.0) = 10.3 \text{ ksf}$$

$$N_c = 5.7 \quad N_q = 1.0 \quad N_\gamma = 0.0$$

Check Bearing Capacity

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 6.66 \text{ ksf} \leq (10.3 \text{ ksf})(0.65) = 6.70 \text{ ksf} \rightarrow 6.66 \text{ ksf} \leq 6.70 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.8 ft
MSE Wall Width (Reinforcement Length), (B) =	22.2 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	27°
Bearing Soil Drained Cohesion, (c_{BS}) =	235 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1750 psf
Embedment Depth, (D) =	3.0 ft

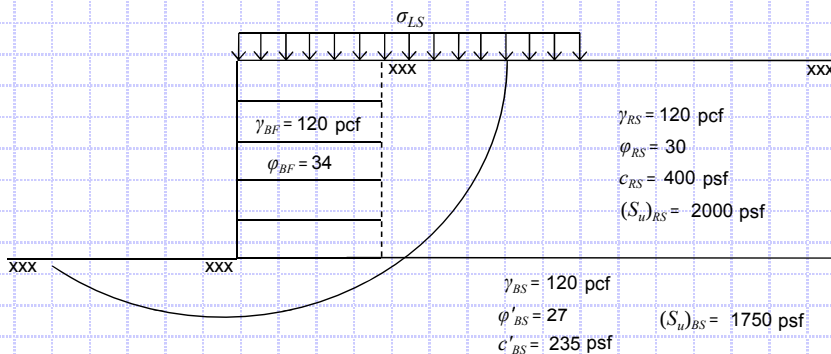
LRFD Load Factors

	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)

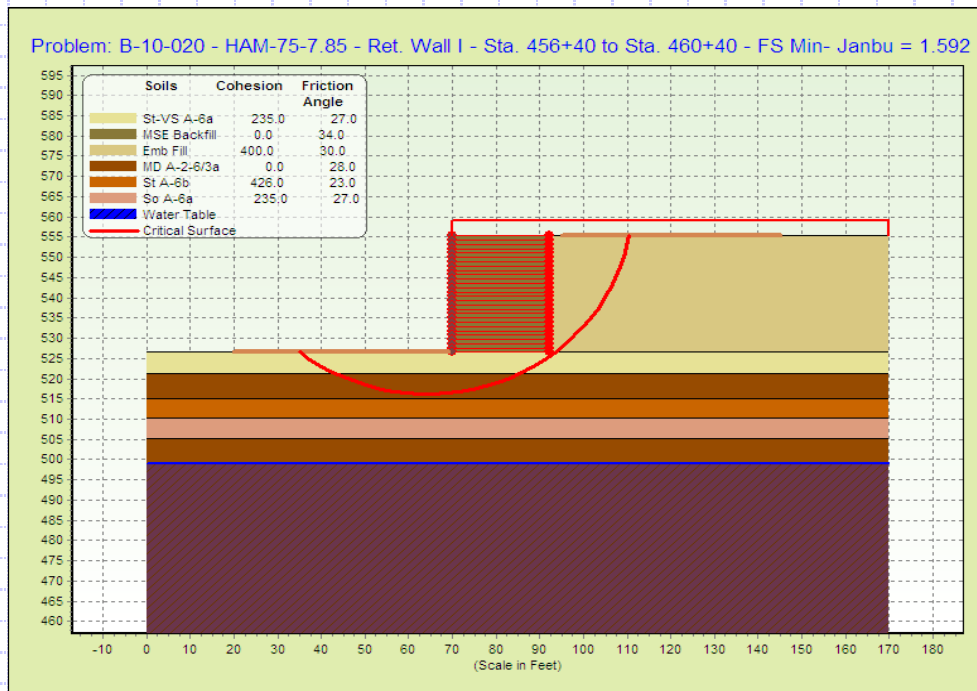
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (1.592)(0.75) = 1.19 \rightarrow 1.00 \leq 1.19 \quad \text{OK}$$

FS = **1.592** (From STABL Slope Stability Analysis)

Use ϕ_{GS} = **0.75** (Per AASHTO LRFD BDM Section 11.6.2.3)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	28.8 ft
MSE Wall Width (Reinforcement Length), (B) =	22.2 ft
Live Surcharge Load, (σ_{LS}) =	240 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf
Retained Soil Friction Angle, (ϕ_{RS}) =	30°
Retained Soil Drained Cohesion, (c_{BS}) =	400 psf
Retained Soil Undrained Shear Strength, [$(S_u)_{RS}$] =	2000 psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.333
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (ϕ_{BF}) =	34°

Bearing Soil Properties:

Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	27°
Bearing Soil Drained Cohesion, (c_{BS}) =	235 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	1750 psf
Embedment Depth, (D) =	3.0 ft

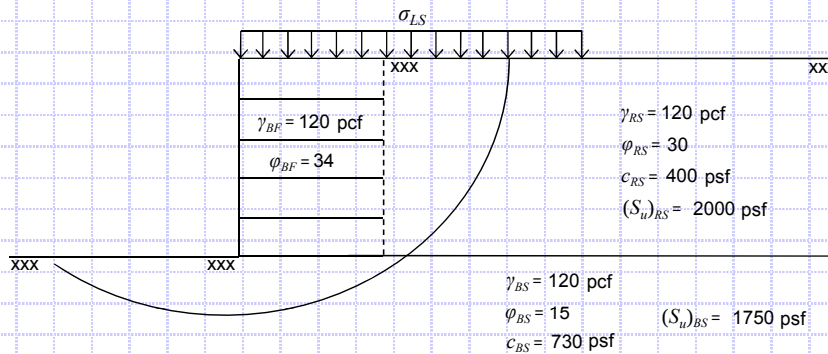
LRFD Load Factors

	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)

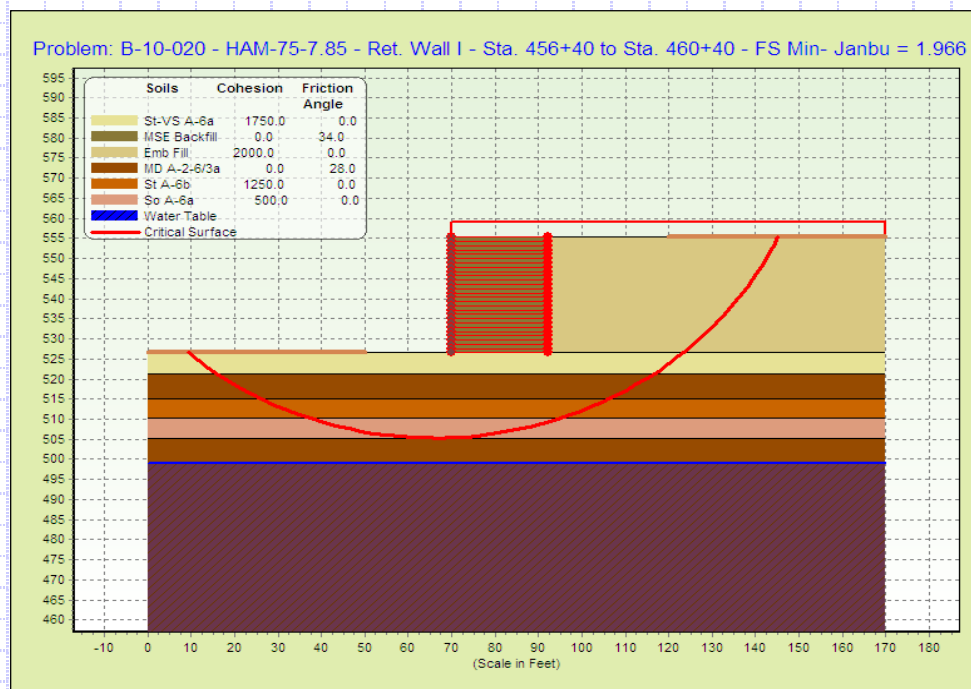
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 (Cont'd)

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (1.966)(0.75) = 1.47 \rightarrow 1.00 \leq 1.47 \quad \text{OK}$$

FS = **1.966** (From STABL Slope Stability Analysis)

Use ϕ_{GS} = **0.75** (Per AASHTO LRFD BDM Section 11.6.2.3)

result.out
 ** STABL for WINDOWS **
 by
 Geotechnical Software Solutions

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

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

PROBLEM DESCRIPTION B-10-020 - HAM-75-7.85 - Ret. Wall I - S
 ta. 456+40 to Sta. 460+40

BOUNDARY COORDINATES

4 Top Boundaries
 11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	526.50	70.00	526.50	3
2	70.00	526.50	70.10	555.30	1
3	70.10	555.30	92.30	555.30	1
4	92.30	555.30	170.00	555.30	2
5	70.00	526.50	92.20	526.50	3
6	92.20	526.50	92.30	555.30	2
7	92.20	526.50	170.00	526.50	3
8	0.00	521.20	170.00	521.20	4
9	0.00	515.20	170.00	515.20	5
10	0.00	510.20	170.00	510.20	6
11	0.00	505.20	170.00	505.20	4

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	115.0	125.0	235.0	27.0	0.00	0.0	1
4	125.0	130.0	0.0	28.0	0.00	0.0	1
5	115.0	125.0	426.0	23.0	0.00	0.0	1
6	115.0	125.0	235.0	27.0	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)	result.out
1	0.00	499.10	
2	170.00	499.10	

1

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	70.10	170.00	240.0	0.0

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	555.3	526.5	28	22.2	1.07	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 = 20.00 ft.
and X = 69.00 ft.

Each Surface Terminates Between X = 95.00 ft.
and X = 145.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 450.00 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 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	48.00	526.50
2	50.86	525.59

result.out

3	53.78	524.92
4	56.75	524.50
5	59.75	524.33
6	62.75	524.42
7	65.73	524.75
8	68.67	525.34
9	71.56	526.17
10	74.36	527.23
11	77.06	528.53
12	79.65	530.05
13	82.10	531.79
14	84.39	533.72
15	86.51	535.84
16	88.45	538.13
17	90.19	540.57
18	91.72	543.15
19	93.03	545.86
20	94.10	548.66
21	94.94	551.54
22	95.53	554.48
23	95.62	555.30

Factor Of Safety For The Preceding Specified Surface = 1.176

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

The Trial Failure Surface In Question Is Defined
By The Following 23 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	49.00	526.50
2	51.86	525.61
3	54.79	524.95
4	57.76	524.54
5	60.76	524.37
6	63.76	524.45
7	66.74	524.78
8	69.69	525.35
9	72.57	526.16
10	75.39	527.21
11	78.10	528.48
12	80.70	529.97
13	83.18	531.67
14	85.50	533.57
15	87.66	535.65
16	89.64	537.91
17	91.43	540.32
18	93.01	542.86
19	94.38	545.53
20	95.53	548.30
21	96.44	551.16
22	97.12	554.08
23	97.30	555.30

Factor Of Safety For The Preceding Specified Surface = -4.975

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 * *

result.out

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	35.00	526.50
2	37.41	524.71
3	39.92	523.07
4	42.53	521.60
5	45.24	520.30
6	48.02	519.17
7	50.87	518.23
8	53.77	517.46
9	56.71	516.89
10	59.69	516.50
11	62.68	516.31
12	65.68	516.31
13	68.67	516.50
14	71.65	516.88
15	74.60	517.45
16	77.50	518.20
17	80.35	519.14
18	83.13	520.27
19	85.83	521.56
20	88.45	523.03
21	90.97	524.66
22	93.38	526.45
23	95.67	528.39
24	97.83	530.47
25	99.85	532.69
26	101.72	535.03
27	103.45	537.48
28	105.01	540.04
29	106.41	542.70
30	107.63	545.44
31	108.67	548.25
32	109.54	551.12
33	110.22	554.05
34	110.42	555.30

*** 1.592 ***

Individual data on the 40 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force	Water Force	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force		Surcharge Load (lbs)
			Top (lbs)	Bot (lbs)			Hor (lbs)	Ver (lbs)	
1	2.4	248.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.5	755.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.6	1252.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.8	486.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	1.9	1247.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	2.8	2204.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.8	2625.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.9	2985.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	2.9	3275.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	3.0	3488.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	3.0	3618.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
12	3.0	3663.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	3.0	3620.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	1.3	1574.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	0.1	290.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	1.5	7157.3	0.0	0.0	0.0	0.0	0.0	0.0	371.9
17	2.9	13461.5	0.0	0.0	0.0	0.0	0.0	0.0	706.9
18	2.9	13026.7	0.0	0.0	0.0	0.0	0.0	0.0	696.7
19	2.8	12480.6	0.0	0.0	0.0	0.0	0.0	0.0	683.7
20	2.8	11832.7	0.0	0.0	0.0	0.0	0.0	0.0	667.8
21	2.0	8042.0	0.0	0.0	0.0	0.0	0.0	0.0	468.0
22	0.8	3054.2	0.0	0.0	0.0	0.0	0.0	0.0	181.2
23	2.6	10308.6	0.0	0.0	0.0	0.0	0.0	0.0	628.0

result.out									
24	2.5	9469.3	0.0	0.0	0.0	0.0	0.0	0.0	604.2
25	1.2	4451.1	0.0	0.0	0.0	0.0	0.0	0.0	295.5
26	0.1	355.8	0.0	0.0	0.0	0.0	0.0	0.0	24.0
27	1.1	3777.0	0.0	0.0	0.0	0.0	0.0	0.0	258.4
28	0.1	204.3	0.0	0.0	0.0	0.0	0.0	0.0	14.2
29	2.2	7453.0	0.0	0.0	0.0	0.0	0.0	0.0	535.1
30	2.2	6705.5	0.0	0.0	0.0	0.0	0.0	0.0	518.4
31	2.0	5757.0	0.0	0.0	0.0	0.0	0.0	0.0	485.4
32	1.9	4829.0	0.0	0.0	0.0	0.0	0.0	0.0	450.4
33	1.7	3938.1	0.0	0.0	0.0	0.0	0.0	0.0	413.6
34	1.6	3100.8	0.0	0.0	0.0	0.0	0.0	0.0	375.0
35	1.4	2332.7	0.0	0.0	0.0	0.0	0.0	0.0	335.0
36	1.2	1648.2	0.0	0.0	0.0	0.0	0.0	0.0	293.5
37	1.0	1060.6	0.0	0.0	0.0	0.0	0.0	0.0	250.9
38	0.9	581.5	0.0	0.0	0.0	0.0	0.0	0.0	207.2
39	0.7	220.8	0.0	0.0	0.0	0.0	0.0	0.0	162.7
40	0.2	15.6	0.0	0.0	0.0	0.0	0.0	0.0	49.8

Individual data on the 28 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	70.0	526.5	92.2	526.5	0.0	22.2	7500.0	0.0
1	2	0	70.0	527.6	92.2	527.6	0.0	22.2	7500.0	0.0
1	3	0	70.0	528.6	92.2	528.6	0.0	22.2	7500.0	0.0
1	4	0	70.0	529.7	92.2	529.7	0.0	22.2	7500.0	0.0
1	5	0	70.0	530.8	92.2	530.8	0.0	22.2	7500.0	0.0
1	6	0	70.0	531.8	92.2	531.8	0.0	22.2	7500.0	0.0
1	7	0	70.0	532.9	92.2	532.9	0.0	22.2	7500.0	0.0
1	8	0	70.0	534.0	92.2	534.0	0.0	22.2	7500.0	0.0
1	9	0	70.0	535.0	92.2	535.0	0.0	22.2	7500.0	0.0
1	10	0	70.0	536.1	92.2	536.1	0.0	22.2	7500.0	0.0
1	11	0	70.0	537.2	92.2	537.2	0.0	22.2	7500.0	0.0
1	12	0	70.0	538.2	92.2	538.2	0.0	22.2	7500.0	0.0
1	13	0	70.0	539.3	92.2	539.3	0.0	22.2	7500.0	0.0
1	14	0	70.0	540.4	92.2	540.4	0.0	22.2	7500.0	0.0
1	15	0	70.1	541.4	92.3	541.4	0.0	22.2	7500.0	0.0
1	16	0	70.1	542.5	92.3	542.5	0.0	22.2	7500.0	0.0
1	17	0	70.1	543.6	92.3	543.6	0.0	22.2	7500.0	0.0
1	18	0	70.1	544.6	92.3	544.6	0.0	22.2	7500.0	0.0
1	19	0	70.1	545.7	92.3	545.7	0.0	22.2	7500.0	0.0
1	20	0	70.1	546.8	92.3	546.8	0.0	22.2	7500.0	0.0
1	21	0	70.1	547.8	92.3	547.8	0.0	22.2	7500.0	0.0
1	22	0	70.1	548.9	92.3	548.9	0.0	22.2	7500.0	0.0
1	23	0	70.1	550.0	92.3	550.0	0.0	22.2	7500.0	0.0
1	24	0	70.1	551.0	92.3	551.0	0.0	22.2	7500.0	0.0
1	25	0	70.1	552.1	92.3	552.1	0.0	22.2	7500.0	0.0
1	26	0	70.1	553.2	92.3	553.2	0.0	22.2	7500.0	0.0
1	27	0	70.1	554.2	92.3	554.2	0.0	22.2	7500.0	0.0
1	28	0	70.1	555.3	92.3	555.3	0.0	22.2	7500.0	0.0

Failure Surface Specified By 35 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.00	526.50
2	35.37	524.67
3	37.86	522.98
4	40.44	521.46
5	43.12	520.11
6	45.88	518.92
7	48.70	517.91
8	51.58	517.08
9	54.51	516.43
10	57.48	515.97
11	60.47	515.70
12	63.46	515.61
13	66.46	515.72
14	69.45	516.01
15	72.41	516.49
16	75.33	517.15
17	78.21	518.00
18	81.03	519.03
19	83.78	520.23

result.out

20	86.45	521.60
21	89.02	523.14
22	91.50	524.84
23	93.86	526.69
24	96.10	528.68
25	98.21	530.81
26	100.19	533.07
27	102.01	535.45
28	103.69	537.94
29	105.20	540.53
30	106.55	543.21
31	107.72	545.97
32	108.73	548.80
33	109.55	551.69
34	110.18	554.62
35	110.29	555.30

*** 1.601 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.00	526.50
2	35.52	524.88
3	38.14	523.40
4	40.83	522.08
5	43.59	520.91
6	46.42	519.90
7	49.30	519.06
8	52.22	518.38
9	55.18	517.88
10	58.16	517.54
11	61.15	517.37
12	64.15	517.38
13	67.15	517.56
14	70.13	517.91
15	73.08	518.43
16	76.00	519.12
17	78.88	519.97
18	81.70	520.99
19	84.46	522.17
20	87.14	523.50
21	89.75	524.99
22	92.27	526.62
23	94.68	528.40
24	97.00	530.31
25	99.20	532.35
26	101.27	534.52
27	103.23	536.79
28	105.04	539.18
29	106.72	541.67
30	108.25	544.25
31	109.63	546.91
32	110.86	549.65
33	111.93	552.45
34	112.83	555.30

*** 1.606 ***

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.00	526.50
2	35.37	524.66

result.out

3	37.85	522.97
4	40.43	521.45
5	43.12	520.10
6	45.88	518.93
7	48.71	517.95
8	51.60	517.15
9	54.54	516.54
10	57.51	516.12
11	60.50	515.90
12	63.50	515.88
13	66.50	516.05
14	69.48	516.42
15	72.42	516.98
16	75.33	517.74
17	78.18	518.68
18	80.96	519.80
19	83.66	521.11
20	86.27	522.59
21	88.78	524.23
22	91.17	526.04
23	93.44	528.00
24	95.58	530.10
25	97.58	532.34
26	99.43	534.70
27	101.11	537.18
28	102.64	539.77
29	103.99	542.45
30	105.16	545.21
31	106.15	548.04
32	106.95	550.93
33	107.56	553.87
34	107.76	555.30

*** 1.617 ***

1

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.00	526.50
2	29.46	524.78
3	32.01	523.20
4	34.64	521.76
5	37.35	520.47
6	40.12	519.32
7	42.95	518.32
8	45.83	517.48
9	48.75	516.80
10	51.70	516.28
11	54.68	515.91
12	57.68	515.71
13	60.68	515.67
14	63.67	515.80
15	66.66	516.08
16	69.63	516.53
17	72.56	517.14
18	75.46	517.91
19	78.32	518.83
20	81.12	519.91
21	83.86	521.13
22	86.52	522.51
23	89.11	524.02
24	91.61	525.68
25	94.02	527.46
26	96.33	529.38
27	98.54	531.42
28	100.62	533.57
29	102.59	535.83
30	104.43	538.20
31	106.15	540.67
32	107.72	543.22
33	109.16	545.85

result.out

34	110.45	548.56
35	111.59	551.34
36	112.58	554.17
37	112.90	555.30

*** 1.625 ***

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	35.00	526.50
2	37.49	524.83
3	40.08	523.31
4	42.75	521.95
5	45.51	520.77
6	48.33	519.75
7	51.21	518.92
8	54.14	518.26
9	57.10	517.78
10	60.09	517.49
11	63.09	517.39
12	66.09	517.47
13	69.08	517.73
14	72.04	518.18
15	74.97	518.81
16	77.86	519.62
17	80.69	520.61
18	83.46	521.78
19	86.15	523.11
20	88.75	524.60
21	91.25	526.25
22	93.65	528.06
23	95.93	530.01
24	98.09	532.09
25	100.11	534.31
26	101.99	536.64
27	103.73	539.09
28	105.31	541.64
29	106.73	544.29
30	107.98	547.01
31	109.06	549.81
32	109.97	552.67
33	110.62	555.30

*** 1.632 ***

1

Failure Surface Specified By 34 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	39.00	526.50
2	41.56	524.93
3	44.20	523.51
4	46.92	522.24
5	49.71	521.13
6	52.55	520.18
7	55.45	519.40
8	58.38	518.78
9	61.35	518.33
10	64.33	518.05
11	67.33	517.94
12	70.33	518.00
13	73.32	518.23
14	76.30	518.63
15	79.24	519.20

result.out

16	82.15	519.94
17	85.01	520.84
18	87.81	521.91
19	90.55	523.13
20	93.22	524.51
21	95.80	526.04
22	98.29	527.71
23	100.68	529.52
24	102.97	531.47
25	105.14	533.54
26	107.18	535.73
27	109.10	538.04
28	110.89	540.45
29	112.53	542.96
30	114.03	545.56
31	115.38	548.24
32	116.57	550.99
33	117.60	553.81
34	118.05	555.30

*** 1.686 ***

Failure Surface Specified By 37 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	29.00	526.50
2	31.62	525.03
3	34.30	523.69
4	37.04	522.48
5	39.84	521.39
6	42.69	520.44
7	45.57	519.63
8	48.50	518.95
9	51.45	518.41
10	54.42	518.01
11	57.41	517.76
12	60.41	517.64
13	63.41	517.67
14	66.40	517.83
15	69.39	518.14
16	72.35	518.59
17	75.29	519.18
18	78.21	519.91
19	81.08	520.77
20	83.91	521.77
21	86.69	522.90
22	89.41	524.16
23	92.07	525.55
24	94.66	527.07
25	97.17	528.70
26	99.61	530.45
27	101.96	532.31
28	104.22	534.28
29	106.39	536.36
30	108.45	538.54
31	110.41	540.81
32	112.26	543.17
33	114.00	545.62
34	115.61	548.15
35	117.11	550.74
36	118.48	553.41
37	119.35	555.30

*** 1.693 ***

Failure Surface Specified By 33 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	43.00	526.50
2	45.41	524.71
3	47.93	523.08
4	50.56	521.63
5	53.27	520.36
6	56.07	519.28
7	58.94	518.39
8	61.85	517.70
9	64.81	517.20
10	67.80	516.91
11	70.80	516.81
12	73.80	516.93
13	76.78	517.24
14	79.73	517.76
15	82.65	518.47
16	85.51	519.38
17	88.30	520.48
18	91.01	521.77
19	93.62	523.23
20	96.14	524.88
21	98.53	526.68
22	100.80	528.65
23	102.93	530.76
24	104.91	533.01
25	106.73	535.40
26	108.39	537.90
27	109.87	540.50
28	111.18	543.20
29	112.30	545.99
30	113.23	548.84
31	113.96	551.75
32	114.50	554.70
33	114.56	555.30

*** 1.699 ***

Failure Surface Specified By 33 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	42.00	526.50
2	44.63	525.06
3	47.34	523.77
4	50.12	522.64
5	52.96	521.67
6	55.85	520.86
7	58.78	520.21
8	61.74	519.73
9	64.72	519.42
10	67.72	519.28
11	70.72	519.31
12	73.71	519.52
13	76.69	519.89
14	79.64	520.42
15	82.56	521.13
16	85.43	522.00
17	88.24	523.03
18	91.00	524.22
19	93.68	525.56
20	96.28	527.05
21	98.80	528.69
22	101.21	530.47
23	103.52	532.38
24	105.72	534.42
25	107.80	536.58
26	109.76	538.86
27	111.58	541.24
28	113.26	543.73
29	114.80	546.30

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result.out
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result.out
 ** 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 I - S
 ta. 456+40 to Sta. 460+40

BOUNDARY COORDINATES

4 Top Boundaries
 11 Total Boundaries

Boundary No.	X-Left (ft)	Y-Left (ft)	X-Right (ft)	Y-Right (ft)	Soil Type Below Bnd
1	0.00	526.50	70.00	526.50	3
2	70.00	526.50	70.10	555.30	1
3	70.10	555.30	92.30	555.30	1
4	92.30	555.30	170.00	555.30	2
5	70.00	526.50	92.20	526.50	3
6	92.20	526.50	92.30	555.30	2
7	92.20	526.50	170.00	526.50	3
8	0.00	521.20	170.00	521.20	4
9	0.00	515.20	170.00	515.20	5
10	0.00	510.20	170.00	510.20	6
11	0.00	505.20	170.00	505.20	4

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	115.0	125.0	1750.0	0.0	0.00	0.0	1
4	125.0	130.0	0.0	28.0	0.00	0.0	1
5	115.0	125.0	1250.0	0.0	0.00	0.0	1
6	115.0	125.0	500.0	0.0	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)	result.out
1	0.00	499.10	
2	170.00	499.10	

BOUNDARY LOAD(S)

1 Load(s) Specified

Load No.	X-Left (ft)	X-Right (ft)	Intensity (psf)	Deflection (deg)
1	70.10	170.00	240.0	0.0

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	555.3	526.5	28	22.2	1.07	1.0	7500.0

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 = 0.00 ft. and X = 50.00 ft.

Each Surface Terminates Between X = 120.00 ft. and X = 170.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 450.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

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 55 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	526.50

result.out

2	11.49	524.58
3	13.86	522.74
4	16.29	520.99
5	18.79	519.32
6	21.33	517.73
7	23.93	516.24
8	26.58	514.83
9	29.28	513.52
10	32.02	512.30
11	34.80	511.17
12	37.62	510.14
13	40.47	509.21
14	43.35	508.37
15	46.26	507.64
16	49.19	507.00
17	52.14	506.47
18	55.11	506.03
19	58.10	505.70
20	61.09	505.48
21	64.08	505.35
22	67.08	505.33
23	70.08	505.41
24	73.08	505.59
25	76.06	505.88
26	79.04	506.27
27	82.00	506.76
28	84.94	507.35
29	87.86	508.04
30	90.75	508.83
31	93.62	509.72
32	96.45	510.71
33	99.25	511.80
34	102.00	512.98
35	104.72	514.25
36	107.39	515.62
37	110.01	517.07
38	112.58	518.62
39	115.10	520.25
40	117.56	521.97
41	119.96	523.78
42	122.29	525.66
43	124.56	527.62
44	126.76	529.66
45	128.89	531.77
46	130.95	533.96
47	132.93	536.21
48	134.83	538.54
49	136.65	540.92
50	138.38	543.37
51	140.03	545.87
52	141.60	548.43
53	143.08	551.04
54	144.46	553.70
55	145.23	555.30

*** 1.966 ***

Individual data on the 65 slices

Slice No.	Width (ft)	Weight (lbs)	Water	Water	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force		Surcharge Load (lbs)
			Force Top (lbs)	Force Bot (lbs)			Hor (lbs)	Ver (lbs)	
1	2.3	254.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.4	773.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.1	1114.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.3	182.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	2.5	1844.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	2.5	2404.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
7	2.6	2954.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
8	2.0	2531.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
9	0.7	959.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0
10	2.7	3984.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
11	2.7	4448.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0

result.out									
12	2.8	4888.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
13	2.7	4981.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
14	0.2	321.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
15	2.9	5688.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
16	2.9	6041.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
17	2.9	6361.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
18	2.9	6643.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
19	3.0	6887.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
20	3.0	7091.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
21	3.0	7253.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
22	3.0	7372.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
23	3.0	7448.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
24	3.0	7480.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
25	2.9	7261.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0
26	0.1	324.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
27	0.0	96.7	0.0	0.0	0.0	0.0	0.0	0.0	0.0
28	3.0	17657.5	0.0	0.0	0.0	0.0	0.0	0.0	714.5
29	3.0	17630.9	0.0	0.0	0.0	0.0	0.0	0.0	716.7
30	3.0	17447.2	0.0	0.0	0.0	0.0	0.0	0.0	713.9
31	3.0	17209.3	0.0	0.0	0.0	0.0	0.0	0.0	710.3
32	2.9	16918.5	0.0	0.0	0.0	0.0	0.0	0.0	705.9
33	2.9	16576.4	0.0	0.0	0.0	0.0	0.0	0.0	700.6
34	2.9	16185.0	0.0	0.0	0.0	0.0	0.0	0.0	694.5
35	1.4	7996.0	0.0	0.0	0.0	0.0	0.0	0.0	347.5
36	0.1	549.5	0.0	0.0	0.0	0.0	0.0	0.0	24.0
37	1.3	7201.0	0.0	0.0	0.0	0.0	0.0	0.0	316.0
38	1.4	7406.7	0.0	0.0	0.0	0.0	0.0	0.0	328.1
39	1.5	7856.6	0.0	0.0	0.0	0.0	0.0	0.0	351.7
40	2.8	14738.2	0.0	0.0	0.0	0.0	0.0	0.0	671.3
41	2.8	14174.2	0.0	0.0	0.0	0.0	0.0	0.0	662.0
42	2.7	13574.6	0.0	0.0	0.0	0.0	0.0	0.0	651.8
43	1.9	9039.8	0.0	0.0	0.0	0.0	0.0	0.0	445.5
44	0.8	3901.1	0.0	0.0	0.0	0.0	0.0	0.0	195.5
45	2.6	12252.1	0.0	0.0	0.0	0.0	0.0	0.0	629.3
46	2.6	11528.7	0.0	0.0	0.0	0.0	0.0	0.0	617.0
47	2.5	10783.9	0.0	0.0	0.0	0.0	0.0	0.0	603.9
48	1.4	5580.2	0.0	0.0	0.0	0.0	0.0	0.0	324.7
49	1.1	4446.3	0.0	0.0	0.0	0.0	0.0	0.0	265.4
50	2.4	9288.2	0.0	0.0	0.0	0.0	0.0	0.0	575.6
51	2.3	8548.4	0.0	0.0	0.0	0.0	0.0	0.0	560.4
52	1.0	3407.1	0.0	0.0	0.0	0.0	0.0	0.0	233.3
53	1.3	4394.3	0.0	0.0	0.0	0.0	0.0	0.0	311.2
54	2.2	7039.0	0.0	0.0	0.0	0.0	0.0	0.0	528.1
55	2.1	6280.5	0.0	0.0	0.0	0.0	0.0	0.0	511.0
56	2.1	5532.8	0.0	0.0	0.0	0.0	0.0	0.0	493.3
57	2.0	4800.6	0.0	0.0	0.0	0.0	0.0	0.0	475.0
58	1.9	4088.3	0.0	0.0	0.0	0.0	0.0	0.0	456.2
59	1.8	3400.8	0.0	0.0	0.0	0.0	0.0	0.0	436.8
60	1.7	2742.4	0.0	0.0	0.0	0.0	0.0	0.0	416.9
61	1.7	2117.6	0.0	0.0	0.0	0.0	0.0	0.0	396.5
62	1.6	1530.8	0.0	0.0	0.0	0.0	0.0	0.0	375.7
63	1.5	985.9	0.0	0.0	0.0	0.0	0.0	0.0	354.4
64	1.4	487.1	0.0	0.0	0.0	0.0	0.0	0.0	332.6
65	0.8	73.3	0.0	0.0	0.0	0.0	0.0	0.0	183.4

Individual data on the 28 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	70.0	526.5	92.2	526.5	0.0	22.2	7500.0	0.0
1	2	0	70.0	527.6	92.2	527.6	0.0	22.2	7500.0	0.0
1	3	0	70.0	528.6	92.2	528.6	0.0	22.2	7500.0	0.0
1	4	0	70.0	529.7	92.2	529.7	0.0	22.2	7500.0	0.0
1	5	0	70.0	530.8	92.2	530.8	0.0	22.2	7500.0	0.0
1	6	0	70.0	531.8	92.2	531.8	0.0	22.2	7500.0	0.0
1	7	0	70.0	532.9	92.2	532.9	0.0	22.2	7500.0	0.0
1	8	0	70.0	534.0	92.2	534.0	0.0	22.2	7500.0	0.0
1	9	0	70.0	535.0	92.2	535.0	0.0	22.2	7500.0	0.0
1	10	0	70.0	536.1	92.2	536.1	0.0	22.2	7500.0	0.0
1	11	0	70.0	537.2	92.2	537.2	0.0	22.2	7500.0	0.0
1	12	0	70.0	538.2	92.2	538.2	0.0	22.2	7500.0	0.0
1	13	0	70.0	539.3	92.2	539.3	0.0	22.2	7500.0	0.0
1	14	0	70.0	540.4	92.2	540.4	0.0	22.2	7500.0	0.0
1	15	0	70.1	541.4	92.3	541.4	0.0	22.2	7500.0	0.0
1	16	0	70.1	542.5	92.3	542.5	0.0	22.2	7500.0	0.0
1	17	0	70.1	543.6	92.3	543.6	0.0	22.2	7500.0	0.0

								result.out	
1	18	0	70.1	544.6	92.3	544.6	0.0	22.2	7500.0
1	19	0	70.1	545.7	92.3	545.7	0.0	22.2	7500.0
1	20	0	70.1	546.8	92.3	546.8	0.0	22.2	7500.0
1	21	0	70.1	547.8	92.3	547.8	0.0	22.2	7500.0
1	22	0	70.1	548.9	92.3	548.9	0.0	22.2	7500.0
1	23	0	70.1	550.0	92.3	550.0	0.0	22.2	7500.0
1	24	0	70.1	551.0	92.3	551.0	0.0	22.2	7500.0
1	25	0	70.1	552.1	92.3	552.1	0.0	22.2	7500.0
1	26	0	70.1	553.2	92.3	553.2	0.0	22.2	7500.0
1	27	0	70.1	554.2	92.3	554.2	0.0	22.2	7500.0
1	28	0	70.1	555.3	92.3	555.3	0.0	22.2	7500.0

Failure Surface Specified By 58 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	526.50
2	11.57	524.68
3	14.00	522.93
4	16.49	521.26
5	19.03	519.66
6	21.62	518.14
7	24.26	516.71
8	26.93	515.35
9	29.65	514.08
10	32.40	512.89
11	35.19	511.79
12	38.02	510.77
13	40.87	509.84
14	43.75	509.00
15	46.65	508.24
16	49.58	507.58
17	52.52	507.01
18	55.48	506.52
19	58.46	506.13
20	61.44	505.83
21	64.43	505.62
22	67.43	505.51
23	70.43	505.48
24	73.43	505.55
25	76.43	505.71
26	79.42	505.96
27	82.40	506.30
28	85.37	506.74
29	88.32	507.27
30	91.25	507.88
31	94.17	508.59
32	97.06	509.38
33	99.93	510.27
34	102.77	511.24
35	105.58	512.30
36	108.35	513.44
37	111.09	514.67
38	113.78	515.98
39	116.44	517.38
40	119.05	518.85
41	121.62	520.41
42	124.13	522.04
43	126.60	523.75
44	129.01	525.53
45	131.37	527.39
46	133.67	529.32
47	135.90	531.32
48	138.08	533.38
49	140.19	535.51
50	142.23	537.71
51	144.21	539.97
52	146.11	542.29
53	147.95	544.66
54	149.71	547.09
55	151.39	549.57
56	153.00	552.11
57	154.53	554.69
58	154.86	555.30

*** 1.980 ***

1

Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	526.50
2	17.60	524.57
3	19.96	522.72
4	22.39	520.95
5	24.87	519.27
6	27.42	517.69
7	30.02	516.19
8	32.67	514.79
9	35.37	513.48
10	38.12	512.28
11	40.91	511.17
12	43.73	510.16
13	46.59	509.25
14	49.48	508.45
15	52.40	507.75
16	55.34	507.15
17	58.30	506.66
18	61.28	506.28
19	64.26	506.00
20	67.26	505.83
21	70.26	505.77
22	73.26	505.82
23	76.25	505.97
24	79.24	506.23
25	82.22	506.60
26	85.18	507.07
27	88.13	507.65
28	91.05	508.33
29	93.94	509.12
30	96.81	510.01
31	99.64	511.00
32	102.43	512.09
33	105.19	513.28
34	107.89	514.57
35	110.55	515.96
36	113.16	517.44
37	115.72	519.01
38	118.22	520.68
39	120.65	522.43
40	123.02	524.26
41	125.33	526.19
42	127.56	528.19
43	129.72	530.27
44	131.81	532.43
45	133.81	534.66
46	135.74	536.96
47	137.58	539.32
48	139.34	541.76
49	141.01	544.25
50	142.58	546.80
51	144.07	549.41
52	145.46	552.07
53	146.76	554.77
54	146.99	555.30

*** 1.985 ***

Failure Surface Specified By 56 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.22	526.50

result.out

2	13.59	524.65
3	16.01	522.88
4	18.48	521.19
5	21.01	519.57
6	23.59	518.04
7	26.22	516.59
8	28.89	515.23
9	31.61	513.96
10	34.36	512.77
11	37.16	511.67
12	39.98	510.66
13	42.84	509.74
14	45.72	508.92
15	48.63	508.19
16	51.56	507.55
17	54.51	507.00
18	57.48	506.55
19	60.46	506.20
20	63.45	505.94
21	66.44	505.78
22	69.44	505.71
23	72.44	505.75
24	75.44	505.87
25	78.43	506.10
26	81.41	506.42
27	84.38	506.83
28	87.34	507.34
29	90.28	507.94
30	93.20	508.64
31	96.09	509.44
32	98.96	510.32
33	101.79	511.30
34	104.60	512.36
35	107.37	513.52
36	110.10	514.76
37	112.78	516.09
38	115.43	517.51
39	118.03	519.01
40	120.57	520.60
41	123.07	522.26
42	125.51	524.00
43	127.89	525.83
44	130.22	527.72
45	132.48	529.69
46	134.68	531.74
47	136.81	533.85
48	138.87	536.03
49	140.86	538.27
50	142.78	540.58
51	144.62	542.94
52	146.39	545.37
53	148.08	547.85
54	149.68	550.38
55	151.21	552.97
56	152.48	555.30

*** 1.985 ***

1

Failure Surface Specified By 52 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	23.47	526.50
2	25.70	524.50
3	28.02	522.59
4	30.40	520.76
5	32.85	519.04
6	35.37	517.41
7	37.95	515.88
8	40.59	514.45
9	43.29	513.13
10	46.03	511.92

result.out

11	48.82	510.81
12	51.65	509.81
13	54.51	508.92
14	57.41	508.15
15	60.34	507.49
16	63.29	506.95
17	66.26	506.52
18	69.24	506.20
19	72.23	506.01
20	75.23	505.93
21	78.23	505.97
22	81.23	506.13
23	84.22	506.40
24	87.19	506.79
25	90.15	507.30
26	93.08	507.92
27	95.99	508.65
28	98.87	509.50
29	101.71	510.47
30	104.51	511.54
31	107.27	512.72
32	109.98	514.01
33	112.64	515.40
34	115.24	516.89
35	117.78	518.49
36	120.25	520.18
37	122.66	521.97
38	125.00	523.86
39	127.26	525.83
40	129.44	527.89
41	131.54	530.03
42	133.55	532.25
43	135.48	534.56
44	137.31	536.93
45	139.05	539.37
46	140.69	541.88
47	142.23	544.46
48	143.68	547.09
49	145.01	549.77
50	146.24	552.51
51	147.37	555.29
52	147.37	555.30

*** 2.020 ***

Failure Surface Specified By 50 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	19.39	526.50
2	21.53	524.40
3	23.77	522.40
4	26.08	520.49
5	28.48	518.68
6	30.95	516.98
7	33.49	515.39
8	36.09	513.90
9	38.76	512.52
10	41.48	511.26
11	44.25	510.12
12	47.07	509.10
13	49.94	508.19
14	52.83	507.41
15	55.76	506.76
16	58.71	506.23
17	61.69	505.82
18	64.67	505.55
19	67.67	505.40
20	70.67	505.37
21	73.67	505.48
22	76.66	505.71
23	79.64	506.07
24	82.60	506.56

result.out

25	85.53	507.17
26	88.44	507.91
27	91.32	508.77
28	94.15	509.75
29	96.94	510.85
30	99.68	512.07
31	102.37	513.40
32	105.00	514.85
33	107.56	516.41
34	110.05	518.08
35	112.48	519.85
36	114.82	521.72
37	117.08	523.69
38	119.26	525.75
39	121.35	527.91
40	123.34	530.15
41	125.23	532.48
42	127.03	534.88
43	128.72	537.36
44	130.30	539.91
45	131.78	542.52
46	133.14	545.19
47	134.38	547.92
48	135.51	550.70
49	136.52	553.53
50	137.07	555.30

*** 2.031 ***

1

Failure Surface Specified By 54 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	526.50
2	11.53	524.63
3	13.94	522.84
4	16.40	521.13
5	18.93	519.51
6	21.51	517.98
7	24.14	516.54
8	26.82	515.18
9	29.54	513.93
10	32.30	512.76
11	35.11	511.69
12	37.95	510.72
13	40.82	509.85
14	43.72	509.08
15	46.64	508.41
16	49.58	507.83
17	52.55	507.36
18	55.52	507.00
19	58.51	506.73
20	61.51	506.57
21	64.51	506.51
22	67.51	506.55
23	70.50	506.70
24	73.49	506.95
25	76.47	507.30
26	79.44	507.76
27	82.39	508.32
28	85.31	508.98
29	88.21	509.73
30	91.09	510.59
31	93.93	511.55
32	96.74	512.60
33	99.51	513.75
34	102.24	515.00
35	104.93	516.34
36	107.56	517.77
37	110.15	519.29
38	112.68	520.90
39	115.16	522.59

result.out

40	117.57	524.37
41	119.93	526.23
42	122.22	528.17
43	124.44	530.19
44	126.59	532.28
45	128.66	534.45
46	130.66	536.68
47	132.58	538.98
48	134.42	541.35
49	136.18	543.78
50	137.86	546.27
51	139.44	548.82
52	140.94	551.42
53	142.35	554.07
54	142.95	555.30

*** 2.032 ***

Failure Surface Specified By 53 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	13.27	526.50
2	15.58	524.59
3	17.96	522.77
4	20.41	521.03
5	22.92	519.39
6	25.49	517.84
7	28.11	516.38
8	30.78	515.01
9	33.50	513.75
10	36.26	512.58
11	39.07	511.51
12	41.91	510.55
13	44.78	509.69
14	47.69	508.93
15	50.61	508.28
16	53.56	507.74
17	56.53	507.30
18	59.51	506.98
19	62.51	506.76
20	65.50	506.64
21	68.50	506.64
22	71.50	506.75
23	74.50	506.96
24	77.48	507.28
25	80.45	507.71
26	83.40	508.25
27	86.33	508.89
28	89.23	509.64
29	92.11	510.50
30	94.95	511.46
31	97.76	512.52
32	100.52	513.68
33	103.25	514.94
34	105.92	516.30
35	108.55	517.75
36	111.12	519.30
37	113.63	520.94
38	116.08	522.67
39	118.47	524.49
40	120.78	526.39
41	123.03	528.37
42	125.21	530.44
43	127.31	532.58
44	129.33	534.80
45	131.27	537.09
46	133.12	539.45
47	134.89	541.87
48	136.57	544.36
49	138.16	546.90
50	139.65	549.51
51	141.05	552.16

52	142.35	554.86
53	142.54	555.30

result.out

*** 2.032 ***

1

Failure Surface Specified By 59 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	9.18	526.50
2	11.63	524.76
3	14.12	523.09
4	16.66	521.50
5	19.25	519.98
6	21.87	518.53
7	24.54	517.15
8	27.25	515.85
9	29.99	514.63
10	32.76	513.49
11	35.57	512.43
12	38.40	511.45
13	41.26	510.54
14	44.15	509.72
15	47.06	508.98
16	49.98	508.33
17	52.93	507.76
18	55.89	507.27
19	58.86	506.87
20	61.84	506.55
21	64.83	506.31
22	67.83	506.16
23	70.83	506.10
24	73.83	506.12
25	76.83	506.23
26	79.82	506.42
27	82.81	506.69
28	85.79	507.06
29	88.75	507.50
30	91.71	508.03
31	94.64	508.64
32	97.56	509.34
33	100.46	510.12
34	103.33	510.98
35	106.18	511.92
36	109.00	512.95
37	111.79	514.05
38	114.55	515.23
39	117.27	516.49
40	119.96	517.82
41	122.61	519.24
42	125.21	520.72
43	127.77	522.28
44	130.29	523.91
45	132.76	525.62
46	135.18	527.39
47	137.55	529.23
48	139.87	531.13
49	142.13	533.11
50	144.33	535.14
51	146.48	537.24
52	148.56	539.39
53	150.59	541.61
54	152.55	543.88
55	154.44	546.21
56	156.27	548.59
57	158.03	551.02
58	159.72	553.50
59	160.87	555.30

*** 2.037 ***

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result.out
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Failure Surface Specified By 51 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.31	526.50
2	17.48	524.43
3	19.74	522.46
4	22.07	520.57
5	24.48	518.79
6	26.96	517.10
7	29.51	515.51
8	32.12	514.03
9	34.78	512.66
10	37.50	511.39
11	40.27	510.24
12	43.09	509.20
13	45.94	508.27
14	48.83	507.46
15	51.75	506.77
16	54.69	506.20
17	57.66	505.74
18	60.64	505.41
19	63.63	505.20
20	66.63	505.11
21	69.63	505.14
22	72.63	505.30
23	75.61	505.57
24	78.59	505.97
25	81.54	506.48
26	84.48	507.12
27	87.38	507.87
28	90.25	508.75
29	93.08	509.73
30	95.87	510.83
31	98.62	512.05
32	101.31	513.37
33	103.95	514.80
34	106.52	516.34
35	109.03	517.98
36	111.48	519.72
37	113.85	521.56
38	116.14	523.49
39	118.36	525.52
40	120.48	527.63
41	122.53	529.83
42	124.48	532.11
43	126.34	534.46
44	128.10	536.89
45	129.76	539.39
46	131.32	541.95
47	132.77	544.58
48	134.11	547.26
49	135.35	549.99
50	136.47	552.78
51	137.37	555.30

*** 2.049 ***

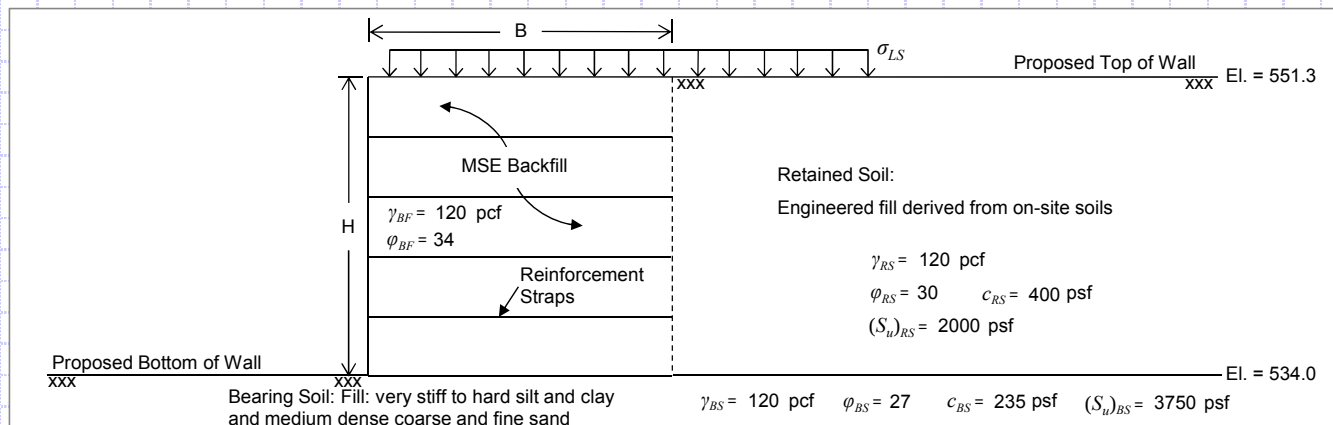
1

	Y	A	X	I	S	F	T
	0.00	129.96	259.93	389.89	519.86	649.82	
X	0.00	+	+	+	+	+	+
	-					W***	
	-					.113	
	-					.13.	
	-					.1.G G/1	
	-					.1.g g	
	-					.11...	

```
result.out
      .1116
      .211
W***. *1/
```



Retaining Wall I - MSE Wall - 14.3 ft. Maximum Wall Height - B-021-0-11 to B-023-0-11



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	17.3 ft
MSE Wall Width (Reinforcement Length), (B) =	12.1 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, [$(S_u)_{BS}$] =	3750 psf
Embedment Depth, (D) =	3.0 ft

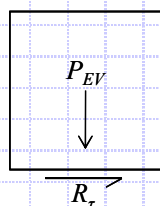
LRFD Load Factors

	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:



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

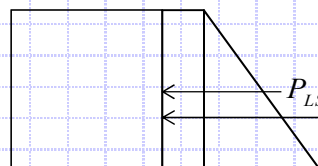
$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(17.3 \text{ ft})(12.1 \text{ ft})(1.00) = 25.12 \text{ kip/ft}$$

$$\tan \delta = (\tan \phi_{BS} \leq \tan \phi_{BF})$$

$$\tan \delta = \tan(27) \leq \tan(34) \rightarrow 0.51 \leq 0.67 \rightarrow \tan \delta = 0.51$$

$$R_{\tau} = (25.12 \text{ kip/ft})(0.51) = 12.81 \text{ kip/ft}$$

Sliding Force:



$$P_H = P_{EH} + P_{LS_h}$$

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(17.3 \text{ ft})^2 (0.333)(1.5) = 8.97 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(17.3 \text{ ft})(0.333)(1.75) = 2.42 \text{ kip/ft}$$

$$P_H = 8.97 \text{ kip/ft} + 2.42 \text{ kip/ft} = 11.39 \text{ kip/ft}$$

Check Sliding Resistance

$$P_H \leq R_{\tau} \cdot \phi_{\tau} \rightarrow 11.39 \text{ kip/ft} \leq (12.81 \text{ kip/ft})(1.0) = 12.81 \text{ kip/ft} \rightarrow 11.39 \text{ kip/ft} \leq 12.81 \text{ kip/ft} \quad \text{OK}$$

Use $\phi_{\tau} = 1.0$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	17.3 ft
MSE Wall Width (Reinforcement Length), (B) =	12.1 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:

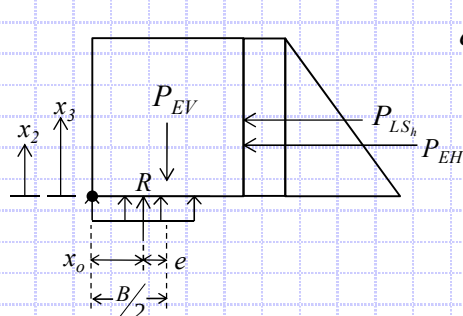
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	27°
Bearing Soil Drained Cohesion, (c_{BS}) =	235 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	3750 psf
Embedment Depth, (D) =	3.0 ft

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



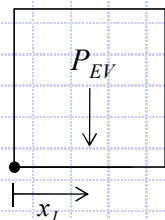
$$e = \frac{B}{2} - x_o$$

$$x_o = \frac{M_{EV} - M_H}{P_{EV}} = (151.98 \text{ kip-ft/ft} - 72.69 \text{ kip-ft/ft}) / (25.12 \text{ kip/ft}) = 3.16 \text{ ft}$$

$$\begin{aligned} M_{EV} &= 151.98 \text{ kip-ft/ft} \\ M_H &= 72.69 \text{ kip-ft/ft} \\ P_{EV} &= 25.12 \text{ kip/ft} \end{aligned} \quad \left. \begin{array}{l} \\ \\ \end{array} \right\} \text{Defined below}$$

$$e = (12.1 \text{ ft}) / 2 - 3.16 \text{ ft} = 2.89 \text{ ft}$$

Resisting Moment, M_{EV} :



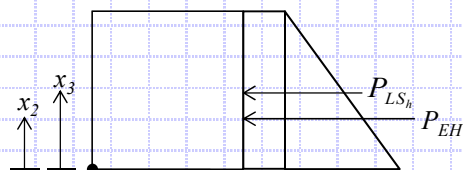
$$M_{EV} = P_{EV}(x_1)$$

$$P_{EV} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(17.3 \text{ ft})(12.1 \text{ ft})(1.00) = 25.12 \text{ kip/ft}$$

$$x_1 = \frac{B}{2} = (12.1 \text{ ft}) / 2 = 6.05 \text{ ft}$$

$$M_{EV} = (25.12 \text{ kip/ft})(6.05 \text{ ft}) = 151.98 \text{ kip-ft/ft}$$

Overturning Moment, M_H :



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

$$P_{EH} = \frac{1}{2} \gamma_{RS} H^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(17.3 \text{ ft})^2 (0.333)(1.5) = 8.97 \text{ kip/ft}$$

$$P_{LS_h} = \sigma_{LS} H K_a \gamma_{LS} = (240 \text{ psf})(17.3 \text{ ft})(0.333)(1.75) = 2.42 \text{ kip/ft}$$

$$x_2 = \frac{H}{3} = (17.3 \text{ ft}) / 3 = 5.77 \text{ ft}$$

$$x_3 = \frac{H}{2} = (17.3 \text{ ft}) / 2 = 8.65 \text{ ft}$$

$$M_H = (8.97 \text{ kip/ft})(5.77 \text{ ft}) + (2.42 \text{ kip/ft})(8.65 \text{ ft}) = 72.69 \text{ kip-ft/ft}$$

Limiting Eccentricity:

$$e_{\max} = \frac{B}{4} \rightarrow e_{\max} = (12.1 \text{ ft}) / 4 = 3.03 \text{ ft}$$

Check Eccentricity

$$e < e_{\max} \rightarrow 2.89 \text{ ft} < 3.03 \text{ ft} \quad \text{OK}$$



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	17.3 ft
MSE Wall Width (Reinforcement Length), (B) =	12.1 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:

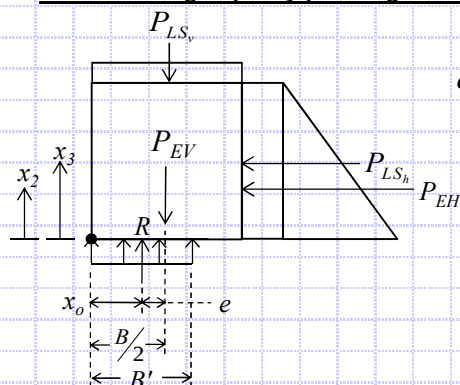
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (ϕ_{BS}) =	27°
Bearing Soil Drained Cohesion, (c_{BS}) =	235 psf
Bearing Soil Undrained Shear Strength, [$(S_u)_{BS}$] =	3750 psf
Embedment Depth, (D) =	3.0 ft

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



$$q_{eq} = \frac{P_V}{B'}$$

$$B' = B - 2e = 12.1 \text{ ft} - 2(1.86 \text{ ft}) = 8.38 \text{ ft}$$

$$e = \frac{B}{2} - x_o = (12.1 \text{ ft}) / 2 - 4.19 \text{ ft} = 1.86 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (235.91 \text{ kip-ft/ft} - 72.68 \text{ kip-ft/ft}) / 38.99 \text{ kip/ft} = 4.19 \text{ ft}$$

$$q_{eq} = (38.99 \text{ kip/ft}) / (8.38 \text{ ft}) = 4.65 \text{ ksf}$$

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

$$M_V = [(120 \text{ pcf})(17.3 \text{ ft})(12.1 \text{ ft})(1.35)](6.05 \text{ ft}) + [(240 \text{ psf})(12.1 \text{ ft})(1.75)](6.05 \text{ ft}) = 235.91 \text{ kip-ft/ft}$$

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

$$M_H = \left[\frac{1}{2}(120 \text{ pcf})(17.3 \text{ ft})^2(0.333)(1.5)\right](5.77 \text{ ft}) + [(240 \text{ psf})(17.3 \text{ ft})(0.333)(1.75)](8.65 \text{ ft}) = 72.68 \text{ kip-ft/ft}$$

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

$$P_V = (120 \text{ pcf})(17.3 \text{ ft})(12.1 \text{ ft})(1.35) + (240 \text{ psf})(12.1 \text{ ft})(1.75) = 38.99 \text{ kip/ft}$$

Nominal Bearing Resistance:

$$q_n = cN_c + \gamma DN_q + \frac{1}{2} \gamma BN_\gamma = (3750 \text{ psf})(5.7) + (120 \text{ pcf})(3.0 \text{ ft})(1.0) + \frac{1}{2}(120 \text{ pcf})(12.1 \text{ ft})(0.0) = 21.7 \text{ ksf}$$

$$N_c = 5.7 \quad N_q = 1.0 \quad N_\gamma = 0.0$$

Check Bearing Capacity

$$q_{eq} \leq q_n \cdot \phi_b \rightarrow 4.65 \text{ ksf} \leq (21.7 \text{ ksf})(0.65) = 14.11 \text{ ksf} \rightarrow 4.65 \text{ ksf} \leq 14.11 \text{ ksf} \quad \text{OK}$$

Use $\phi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.6-1)



MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	17.3 ft
MSE Wall Width (Reinforcement Length), (B) =	12.1 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, [$(S_u)_{BS}$] =	3750 psf
Embedment Depth, (D) =	3.0 ft

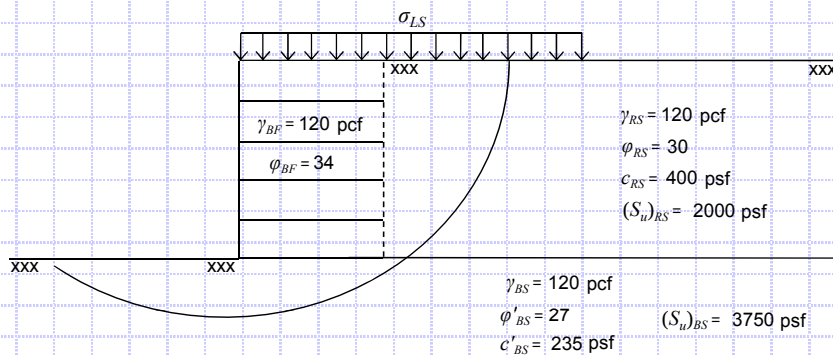
LRFD Load Factors

	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)

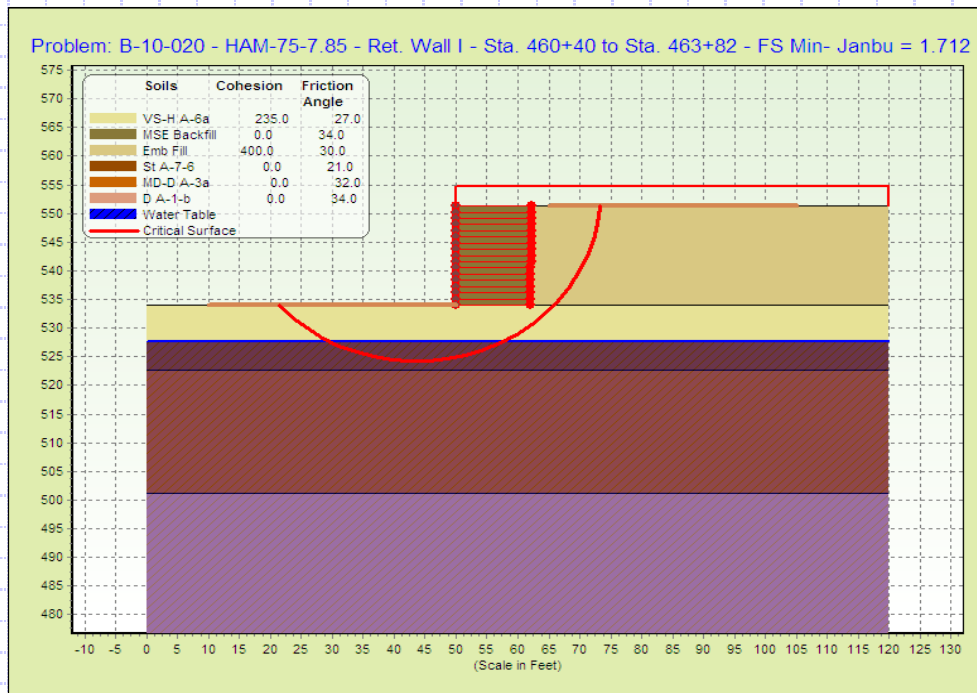
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (1.712)(0.75) = 1.28 \rightarrow 1.00 \leq 1.28 \quad \text{OK}$$

FS = 1.712 (From STABL Slope Stability Analysis)

Use $\phi_{GS} = 0.75$ (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 I - Sta. 460+40 to Sta. 463+82

MSE Wall Dimensions and Retained Soil Parameters

MSE Wall Height, (H) =	17.3 ft
MSE Wall Width (Reinforcement Length), (B) =	12.1 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, [$(S_u)_{BS}$] =	3750 psf
Embedment Depth, (D) =	3.0 ft

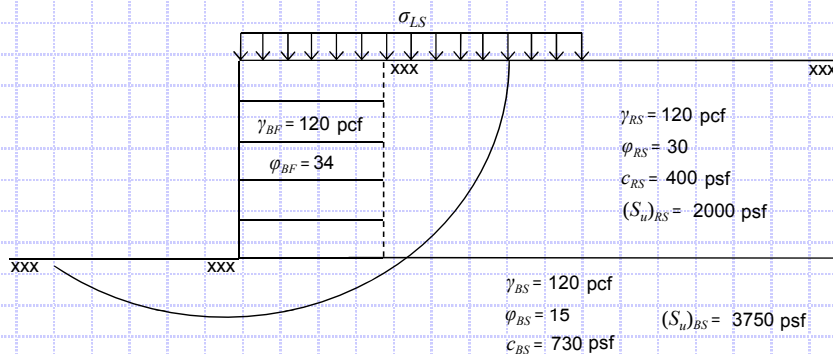
LRFD Load Factors

	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)

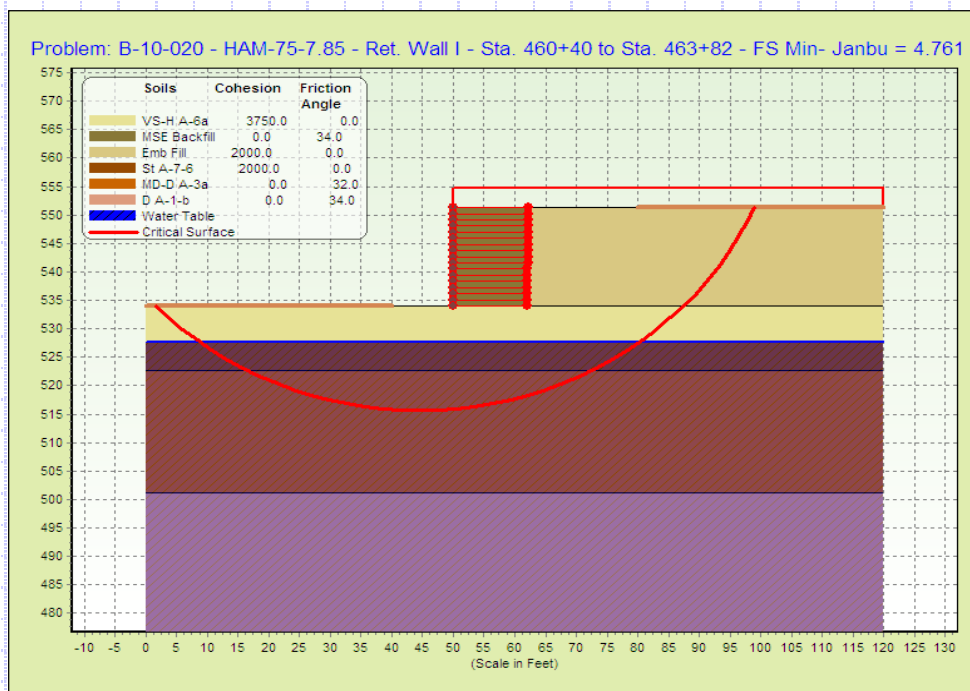
Check Overall (Global) Stability (Loading Case - Service I) - AASHTO LRFD BDM Sections 11.6.2.3 and 11.10.5.2 (Cont'd)

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

$$1.0 \leq FS \cdot \phi_{GS} \rightarrow 1.00 \leq (4.761)(0.75) = 3.57 \rightarrow 1.00 \leq 3.57 \quad \text{OK}$$

FS = **4.761** (From STABL Slope Stability Analysis)

Use ϕ_{GS} = **0.75** (Per AASHTO LRFD BDM Section 11.6.2.3)

result.out
 ** STABL for WINDOWS **
 by
 Geotechnical Software Solutions

--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 I - S
 ta. 460+40 to Sta. 463+82

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	534.00	50.00	534.00	3
2	50.00	534.00	50.10	551.30	1
3	50.10	551.30	62.20	551.30	1
4	62.20	551.30	120.00	551.30	2
5	50.00	534.00	62.10	534.00	3
6	62.10	534.00	62.20	551.30	2
7	62.10	534.00	120.00	534.00	3
8	0.00	527.70	120.00	527.70	4
9	0.00	522.70	120.00	522.70	5
10	0.00	501.20	120.00	501.20	6

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	115.0	125.0	0.0	21.0	0.00	0.0	1
5	125.0	130.0	0.0	32.0	0.00	0.0	1
6	130.0	135.0	0.0	34.0	0.00	0.0	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)	result.out
1	0.00	527.60	
2	120.00	527.60	

1

BOUNDARY LOAD(S)

1 Load(s) Specified

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

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	551.3	534.0	17	12.1	1.08	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 = 50.00 ft.

Each Surface Terminates Between X = 65.00 ft.
and X = 105.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 450.00 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 18 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	28.78	534.00
2	31.33	532.43
3	34.07	531.21

			result.out
4	36.95	530.35	
5	39.91	529.87	
6	42.91	529.78	
7	45.89	530.09	
8	48.81	530.77	
9	51.62	531.83	
10	54.26	533.25	
11	56.70	535.00	
12	58.89	537.05	
13	60.80	539.36	
14	62.39	541.91	
15	63.63	544.64	
16	64.51	547.51	
17	65.01	550.47	
18	65.04	551.30	

Factor Of Safety For The Preceding Specified Surface = -7.992

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

The Trial Failure Surface In Question Is Defined
By The Following 15 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	33.67	534.00
2	36.53	533.09
3	39.48	532.55
4	42.48	532.38
5	45.47	532.60
6	48.41	533.19
7	51.25	534.16
8	53.95	535.47
9	56.46	537.11
10	58.74	539.06
11	60.76	541.28
12	62.48	543.74
13	63.87	546.39
14	64.92	549.21
15	65.41	551.30

Factor Of Safety For The Preceding Specified Surface = -1.345

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

The Trial Failure Surface In Question Is Defined
By The Following 13 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	41.02	534.00
2	43.97	533.47
3	46.97	533.41
4	49.95	533.81
5	52.82	534.67
6	55.52	535.97
7	57.99	537.67

			result.out
8	60.17	539.74	
9	61.99	542.12	
10	63.43	544.75	
11	64.43	547.58	
12	64.99	550.53	
13	65.01	551.30	

Factor Of Safety For The Preceding Specified Surface = 5.240

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

The Trial Failure Surface In Question Is Defined
By The Following 10 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	50.00	534.08
2	52.21	536.11
3	54.40	538.16
4	56.55	540.25
5	58.68	542.37
6	60.77	544.52
7	62.83	546.70
8	64.86	548.91
9	66.86	551.15
10	66.99	551.30

Factor Of Safety For The Preceding Specified Surface = -1.516

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 25 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	21.43	534.00
2	23.55	531.88
3	25.88	529.99
4	28.38	528.34
5	31.04	526.94
6	33.82	525.82
7	36.71	524.99
8	39.66	524.45
9	42.65	524.20
10	45.65	524.26
11	48.63	524.62
12	51.55	525.27
13	54.40	526.22
14	57.14	527.44
15	59.74	528.93
16	62.18	530.68
17	64.43	532.66
18	66.48	534.86
19	68.29	537.25
20	69.85	539.81

21	71.15	542.51
22	72.17	545.33
23	72.91	548.24
24	73.35	551.21
25	73.35	551.30

result.out

*** 1.712 ***

Individual data on the 33 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.1	270.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.3	855.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.5	1454.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	1.2	871.1	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.2	145.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.3	1012.9	0.0	29.0	0.0	0.0	0.0	0.0	0.0
7	2.8	2559.4	0.0	227.7	0.0	0.0	0.0	0.0	0.0
8	2.9	3001.6	0.0	410.6	0.0	0.0	0.0	0.0	0.0
9	3.0	3327.5	0.0	539.5	0.0	0.0	0.0	0.0	0.0
10	3.0	3518.9	0.0	613.0	0.0	0.0	0.0	0.0	0.0
11	3.0	3564.9	0.0	630.5	0.0	0.0	0.0	0.0	0.0
12	3.0	3463.1	0.0	591.7	0.0	0.0	0.0	0.0	0.0
13	1.4	1541.2	0.0	248.6	0.0	0.0	0.0	0.0	0.0
14	0.1	213.8	0.0	17.0	0.0	0.0	0.0	0.0	0.0
15	1.5	4584.5	0.0	231.4	0.0	0.0	0.0	0.0	348.8
16	2.8	8758.2	0.0	347.6	0.0	0.0	0.0	0.0	683.4
17	2.7	8052.2	0.0	144.6	0.0	0.0	0.0	0.0	657.3
18	0.3	797.7	0.0	1.6	0.0	0.0	0.0	0.0	67.1
19	0.2	495.0	0.0	0.0	0.0	0.0	0.0	0.0	41.9
20	2.1	5925.3	0.0	0.0	0.0	0.0	0.0	0.0	515.6
21	2.4	6090.6	0.0	0.0	0.0	0.0	0.0	0.0	565.9
22	0.1	202.4	0.0	0.0	0.0	0.0	0.0	0.0	19.6
23	0.0	45.4	0.0	0.0	0.0	0.0	0.0	0.0	4.4
24	2.2	5261.1	0.0	0.0	0.0	0.0	0.0	0.0	536.2
25	1.2	2687.9	0.0	0.0	0.0	0.0	0.0	0.0	299.2
26	0.8	1612.2	0.0	0.0	0.0	0.0	0.0	0.0	191.1
27	1.8	3316.2	0.0	0.0	0.0	0.0	0.0	0.0	435.0
28	1.6	2396.8	0.0	0.0	0.0	0.0	0.0	0.0	375.3
29	1.3	1581.2	0.0	0.0	0.0	0.0	0.0	0.0	311.9
30	1.0	904.9	0.0	0.0	0.0	0.0	0.0	0.0	245.3
31	0.7	397.7	0.0	0.0	0.0	0.0	0.0	0.0	176.2
32	0.4	83.0	0.0	0.0	0.0	0.0	0.0	0.0	105.4
33	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0

Individual data on the 17 geosynthetics

Group	Level	Slice	Head Coordinates (ft)	End Coordinates (ft)	T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	50.0 534.0	62.1 534.0	0.0	12.1	7500.0	0.0
1	2	0	50.0 535.1	62.1 535.1	0.0	12.1	7500.0	0.0
1	3	0	50.0 536.2	62.1 536.2	0.0	12.1	7500.0	0.0
1	4	0	50.0 537.2	62.1 537.2	0.0	12.1	7500.0	0.0
1	5	0	50.0 538.3	62.1 538.3	0.0	12.1	7500.0	0.0
1	6	0	50.0 539.4	62.1 539.4	0.0	12.1	7500.0	0.0
1	7	0	50.0 540.5	62.1 540.5	0.0	12.1	7500.0	0.0
1	8	0	50.0 541.6	62.1 541.6	0.0	12.1	7500.0	0.0
1	9	0	50.0 542.7	62.2 542.7	0.0	12.1	7500.0	0.0
1	10	0	50.1 543.7	62.2 543.7	0.0	12.1	7500.0	0.0
1	11	0	50.1 544.8	62.2 544.8	0.0	12.1	7500.0	0.0
1	12	0	50.1 545.9	62.2 545.9	0.0	12.1	7500.0	0.0
1	13	0	50.1 547.0	62.2 547.0	0.0	12.1	7500.0	0.0
1	14	0	50.1 548.1	62.2 548.1	0.0	12.1	7500.0	0.0
1	15	0	50.1 549.1	62.2 549.1	0.0	12.1	7500.0	0.0
1	16	0	50.1 550.2	62.2 550.2	0.0	12.1	7500.0	0.0
1	17	0	50.1 551.3	62.2 551.3	0.0	12.1	7500.0	0.0

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	17.35	534.00
2	19.52	531.93
3	21.86	530.05
4	24.35	528.39
5	26.98	526.94
6	29.73	525.73
7	32.56	524.75
8	35.48	524.03
9	38.44	523.56
10	41.43	523.35
11	44.43	523.39
12	47.41	523.70
13	50.36	524.26
14	53.25	525.07
15	56.06	526.13
16	58.76	527.42
17	61.35	528.95
18	63.79	530.69
19	66.07	532.63
20	68.18	534.77
21	70.10	537.08
22	71.80	539.54
23	73.29	542.15
24	74.55	544.87
25	75.57	547.69
26	76.35	550.59
27	76.47	551.30

*** 1.712 ***

1

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	22.25	534.00
2	24.40	531.92
3	26.76	530.06
4	29.29	528.44
5	31.96	527.09
6	34.76	526.01
7	37.66	525.22
8	40.62	524.72
9	43.61	524.52
10	46.61	524.62
11	49.58	525.02
12	52.50	525.71
13	55.33	526.69
14	58.06	527.95
15	60.64	529.48
16	63.06	531.26
17	65.28	533.27
18	67.30	535.49
19	69.08	537.90
20	70.61	540.48
21	71.88	543.20
22	72.87	546.04
23	73.57	548.95
24	73.89	551.30

*** 1.714 ***

Failure Surface Specified By 26 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	15.71	534.00
2	17.84	531.88
3	20.15	529.96
4	22.62	528.26
5	25.23	526.79
6	27.96	525.55
7	30.80	524.57
8	33.71	523.84
9	36.67	523.38
10	39.66	523.18
11	42.66	523.26
12	45.64	523.60
13	48.58	524.21
14	51.45	525.08
15	54.23	526.21
16	56.90	527.58
17	59.44	529.18
18	61.82	531.00
19	64.03	533.04
20	66.04	535.26
21	67.85	537.65
22	69.44	540.19
23	70.79	542.87
24	71.90	545.66
25	72.75	548.54
26	73.31	551.30

*** 1.717 ***

1

Failure Surface Specified By 24 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	20.61	534.00
2	22.75	531.89
3	25.09	530.02
4	27.62	528.40
5	30.30	527.05
6	33.10	525.99
7	36.00	525.23
8	38.97	524.78
9	41.97	524.63
10	44.96	524.81
11	47.92	525.29
12	50.82	526.08
13	53.61	527.17
14	56.28	528.54
15	58.79	530.18
16	61.11	532.08
17	63.23	534.21
18	65.11	536.55
19	66.73	539.07
20	68.09	541.75
21	69.15	544.55
22	69.92	547.45
23	70.38	550.41
24	70.43	551.30

*** 1.731 ***

Failure Surface Specified By 25 Coordinate Points

Point	X-Surf	Y-Surf
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No.	(ft)	(ft)	result.out
1	16.53	534.00	
2	18.78	532.02	
3	21.21	530.25	
4	23.78	528.71	
5	26.48	527.41	
6	29.30	526.36	
7	32.19	525.57	
8	35.14	525.05	
9	38.13	524.79	
10	41.13	524.82	
11	44.12	525.11	
12	47.07	525.67	
13	49.95	526.50	
14	52.74	527.59	
15	55.43	528.93	
16	57.98	530.50	
17	60.38	532.30	
18	62.61	534.31	
19	64.64	536.52	
20	66.46	538.90	
21	68.06	541.44	
22	69.43	544.11	
23	70.54	546.90	
24	71.40	549.77	
25	71.71	551.30	

	1.747	***	

1

Failure Surface Specified By 29 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	11.63	534.00
2	13.87	532.00
3	16.25	530.18
4	18.77	528.54
5	21.40	527.10
6	24.13	525.86
7	26.95	524.83
8	29.84	524.02
9	32.78	523.44
10	35.76	523.07
11	38.75	522.94
12	41.75	523.03
13	44.73	523.35
14	47.68	523.90
15	50.58	524.66
16	53.42	525.65
17	56.17	526.85
18	58.82	528.25
19	61.36	529.85
20	63.76	531.64
21	66.03	533.61
22	68.14	535.74
23	70.08	538.03
24	71.84	540.46
25	73.41	543.02
26	74.78	545.68
27	75.95	548.45
28	76.90	551.29
29	76.91	551.30

	1.749	***

Failure Surface Specified By 23 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	27.14	534.00
2	29.36	531.98
3	31.78	530.20
4	34.37	528.69
5	37.10	527.45
6	39.95	526.51
7	42.88	525.88
8	45.86	525.55
9	48.86	525.54
10	51.85	525.84
11	54.78	526.46
12	57.64	527.38
13	60.38	528.59
14	62.98	530.09
15	65.41	531.85
16	67.64	533.85
17	69.65	536.08
18	71.42	538.51
19	72.92	541.11
20	74.14	543.85
21	75.06	546.70
22	75.68	549.64
23	75.85	551.30

*** 1.763 ***

1

Failure Surface Specified By 27 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	19.80	534.00
2	22.11	532.09
3	24.57	530.38
4	27.16	528.86
5	29.86	527.56
6	32.66	526.48
7	35.54	525.62
8	38.47	525.00
9	41.45	524.61
10	44.44	524.46
11	47.44	524.56
12	50.42	524.89
13	53.37	525.46
14	56.26	526.26
15	59.08	527.29
16	61.80	528.54
17	64.42	530.01
18	66.91	531.68
19	69.26	533.55
20	71.45	535.60
21	73.48	537.81
22	75.32	540.18
23	76.96	542.69
24	78.40	545.32
25	79.62	548.06
26	80.62	550.89
27	80.73	551.30

*** 1.764 ***

Failure Surface Specified By 29 Coordinate Points

Point	X-Surf	Y-Surf
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1

Page 10

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774.17 +
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-
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-
-
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-
-
-
-
-
T    1032.22 +

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result.out

result.out
 ** 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 I - S
 ta. 460+40 to Sta. 463+82

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	534.00	50.00	534.00	3
2	50.00	534.00	50.10	551.30	1
3	50.10	551.30	62.20	551.30	1
4	62.20	551.30	120.00	551.30	2
5	50.00	534.00	62.10	534.00	3
6	62.10	534.00	62.20	551.30	2
7	62.10	534.00	120.00	534.00	3
8	0.00	527.70	120.00	527.70	4
9	0.00	522.70	120.00	522.70	5
10	0.00	501.20	120.00	501.20	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	3750.0	0.0	0.00	0.0	1
4	115.0	125.0	2000.0	0.0	0.00	0.0	1
5	125.0	130.0	0.0	32.0	0.00	0.0	1
6	130.0	135.0	0.0	34.0	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)	result.out
1	0.00	527.60	
2	120.00	527.60	

BOUNDARY LOAD(S)

1 Load(s) Specified

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

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

GEOSYNTHETIC DATA

1 Geosynthetics(s) group(s) specified

Ngroup no	Bnr no	Y-top (ft)	Y-bot (ft)	Levels no	Length (ft)	Spacing (ft)	Efficiency	Tallow (lbs/ft)
1	2	551.3	534.0	17	12.1	1.08	1.0	7500.0

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 = 0.00 ft.
and X = 40.00 ft.

Each Surface Terminates Between X = 80.00 ft.
and X = 120.00 ft.

Unless Further Limitations Were Imposed, The Minimum Elevation At Which A Surface Extends Is Y = 450.00 ft.

3.00 ft. Line Segments Define Each Trial Failure Surface.

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 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.63	534.00
2	3.76	531.88

result.out

3	5.98	529.87
4	8.31	527.98
5	10.73	526.20
6	13.23	524.55
7	15.82	523.03
8	18.48	521.65
9	21.21	520.39
10	23.99	519.28
11	26.83	518.31
12	29.72	517.49
13	32.64	516.81
14	35.59	516.29
15	38.57	515.91
16	41.56	515.68
17	44.56	515.61
18	47.56	515.69
19	50.55	515.92
20	53.53	516.30
21	56.48	516.83
22	59.40	517.51
23	62.29	518.33
24	65.12	519.31
25	67.91	520.42
26	70.63	521.67
27	73.29	523.06
28	75.88	524.59
29	78.38	526.24
30	80.80	528.01
31	83.12	529.91
32	85.35	531.92
33	87.47	534.05
34	89.48	536.27
35	91.37	538.60
36	93.15	541.02
37	94.80	543.52
38	96.32	546.11
39	97.71	548.77
40	98.87	551.30

*** 4.761 ***

Individual data on the 50 slices

Slice No.	Width (ft)	Weight (lbs)	Water Force Top (lbs)	Water Force Bot (lbs)	Force Norm (lbs)	Force Tan (lbs)	Earthquake Force Hor (lbs)	Earthquake Force Ver (lbs)	Surcharge Load (lbs)
1	2.1	270.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2	2.2	835.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
3	2.3	1417.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0
4	0.4	278.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0
5	0.1	103.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0
6	1.9	1629.8	0.0	103.1	0.0	0.0	0.0	0.0	0.0
7	2.5	2619.6	0.0	416.1	0.0	0.0	0.0	0.0	0.0
8	2.6	3215.9	0.0	712.8	0.0	0.0	0.0	0.0	0.0
9	0.6	866.1	0.0	212.3	0.0	0.0	0.0	0.0	0.0
10	2.0	2930.1	0.0	772.6	0.0	0.0	0.0	0.0	0.0
11	2.7	4358.6	0.0	1231.8	0.0	0.0	0.0	0.0	0.0
12	2.8	4882.1	0.0	1452.9	0.0	0.0	0.0	0.0	0.0
13	2.8	5358.3	0.0	1647.6	0.0	0.0	0.0	0.0	0.0
14	2.9	5780.0	0.0	1815.4	0.0	0.0	0.0	0.0	0.0
15	2.9	6141.2	0.0	1955.8	0.0	0.0	0.0	0.0	0.0
16	3.0	6436.4	0.0	2068.5	0.0	0.0	0.0	0.0	0.0
17	3.0	6661.4	0.0	2153.2	0.0	0.0	0.0	0.0	0.0
18	3.0	6813.0	0.0	2209.7	0.0	0.0	0.0	0.0	0.0
19	3.0	6888.9	0.0	2237.8	0.0	0.0	0.0	0.0	0.0
20	3.0	6888.2	0.0	2237.5	0.0	0.0	0.0	0.0	0.0
21	2.4	5562.2	0.0	1804.9	0.0	0.0	0.0	0.0	0.0
22	0.1	330.5	0.0	73.4	0.0	0.0	0.0	0.0	0.0
23	0.5	1958.6	0.0	330.5	0.0	0.0	0.0	0.0	108.3
24	3.0	12835.1	0.0	2151.7	0.0	0.0	0.0	0.0	714.2
25	3.0	12560.6	0.0	2066.4	0.0	0.0	0.0	0.0	708.6
26	2.9	12200.3	0.0	1953.1	0.0	0.0	0.0	0.0	701.3
27	2.7	11011.3	0.0	1700.2	0.0	0.0	0.0	0.0	647.6

						result.out				
28	0.1	402.9	0.0	60.4	0.0	0.0	0.0	0.0	0.0	24.0
29	0.1	344.4	0.0	51.5	0.0	0.0	0.0	0.0	0.0	20.5
30	2.8	11241.0	0.0	1643.8	0.0	0.0	0.0	0.0	0.0	681.2
31	2.8	10654.0	0.0	1448.5	0.0	0.0	0.0	0.0	0.0	668.5
32	2.7	10005.1	0.0	1226.9	0.0	0.0	0.0	0.0	0.0	654.1
33	2.0	6918.2	0.0	748.6	0.0	0.0	0.0	0.0	0.0	471.3
34	0.7	2384.7	0.0	230.8	0.0	0.0	0.0	0.0	0.0	166.7
35	2.6	8569.1	0.0	706.7	0.0	0.0	0.0	0.0	0.0	620.3
36	2.5	7805.5	0.0	409.5	0.0	0.0	0.0	0.0	0.0	601.0
37	1.9	5425.8	0.0	97.7	0.0	0.0	0.0	0.0	0.0	444.6
38	0.1	386.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	32.7
39	0.4	1205.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	102.8
40	2.3	6229.9	0.0	0.0	0.0	0.0	0.0	0.0	0.0	557.8
41	2.2	5442.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	534.0
42	2.1	4565.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	497.9
43	0.0	95.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	11.0
44	2.0	3893.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	482.5
45	1.9	3152.6	0.0	0.0	0.0	0.0	0.0	0.0	0.0	454.8
46	1.8	2447.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	425.9
47	1.6	1787.8	0.0	0.0	0.0	0.0	0.0	0.0	0.0	396.0
48	1.5	1183.4	0.0	0.0	0.0	0.0	0.0	0.0	0.0	365.0
49	1.4	643.2	0.0	0.0	0.0	0.0	0.0	0.0	0.0	333.1
50	1.2	176.5	0.0	0.0	0.0	0.0	0.0	0.0	0.0	278.9

Individual data on the 17 geosynthetics

Group	Level	Slice	Head Coordinates (ft)		End Coordinates (ft)		T (lbs)	Length (ft)	Tallow (lbs)	T/Tall %
1	1	0	50.0	534.0	62.1	534.0	0.0	12.1	7500.0	0.0
1	2	0	50.0	535.1	62.1	535.1	0.0	12.1	7500.0	0.0
1	3	0	50.0	536.2	62.1	536.2	0.0	12.1	7500.0	0.0
1	4	0	50.0	537.2	62.1	537.2	0.0	12.1	7500.0	0.0
1	5	0	50.0	538.3	62.1	538.3	0.0	12.1	7500.0	0.0
1	6	0	50.0	539.4	62.1	539.4	0.0	12.1	7500.0	0.0
1	7	0	50.0	540.5	62.1	540.5	0.0	12.1	7500.0	0.0
1	8	0	50.0	541.6	62.1	541.6	0.0	12.1	7500.0	0.0
1	9	0	50.0	542.7	62.2	542.7	0.0	12.1	7500.0	0.0
1	10	0	50.1	543.7	62.2	543.7	0.0	12.1	7500.0	0.0
1	11	0	50.1	544.8	62.2	544.8	0.0	12.1	7500.0	0.0
1	12	0	50.1	545.9	62.2	545.9	0.0	12.1	7500.0	0.0
1	13	0	50.1	547.0	62.2	547.0	0.0	12.1	7500.0	0.0
1	14	0	50.1	548.1	62.2	548.1	0.0	12.1	7500.0	0.0
1	15	0	50.1	549.1	62.2	549.1	0.0	12.1	7500.0	0.0
1	16	0	50.1	550.2	62.2	550.2	0.0	12.1	7500.0	0.0
1	17	0	50.1	551.3	62.2	551.3	0.0	12.1	7500.0	0.0

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.00	534.00
2	2.12	531.88
3	4.35	529.87
4	6.68	527.98
5	9.10	526.21
6	11.61	524.56
7	14.20	523.05
8	16.86	521.67
9	19.59	520.43
10	22.38	519.33
11	25.23	518.37
12	28.12	517.56
13	31.04	516.90
14	34.00	516.39
15	36.98	516.03
16	39.97	515.82
17	42.97	515.77
18	45.97	515.87
19	48.96	516.12
20	51.93	516.53
21	54.88	517.08
22	57.79	517.79
23	60.67	518.65
24	63.50	519.65

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25      66.27      520.79
26      68.98      522.08
27      71.62      523.50
28      74.19      525.05
29      76.67      526.74
30      79.06      528.55
31      81.36      530.47
32      83.56      532.52
33      85.65      534.67
34      87.62      536.93
35      89.48      539.28
36      91.22      541.73
37      92.82      544.26
38      94.30      546.88
39      95.64      549.56
40      96.40      551.30

***      4.762      ***

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1

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.82	534.00
2	2.95	531.89
3	5.18	529.89
4	7.51	528.00
5	9.94	526.24
6	12.45	524.60
7	15.05	523.09
8	17.72	521.72
9	20.45	520.48
10	23.24	519.39
11	26.09	518.43
12	28.98	517.63
13	31.90	516.97
14	34.86	516.46
15	37.84	516.11
16	40.83	515.90
17	43.83	515.85
18	46.83	515.96
19	49.82	516.21
20	52.79	516.62
21	55.74	517.17
22	58.66	517.88
23	61.53	518.73
24	64.36	519.73
25	67.13	520.88
26	69.85	522.16
27	72.49	523.58
28	75.06	525.13
29	77.54	526.81
30	79.94	528.61
31	82.24	530.54
32	84.44	532.58
33	86.53	534.73
34	88.52	536.98
35	90.38	539.33
36	92.12	541.77
37	93.74	544.30
38	95.22	546.91
39	96.57	549.59
40	97.33	551.30

*** 4.765 ***

Failure Surface Specified By 39 Coordinate Points

result.out

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.00	534.00
2	2.14	531.90
3	4.39	529.91
4	6.73	528.04
5	9.17	526.30
6	11.70	524.68
7	14.31	523.20
8	16.99	521.85
9	19.74	520.64
10	22.54	519.58
11	25.40	518.67
12	28.30	517.90
13	31.24	517.28
14	34.20	516.82
15	37.18	516.51
16	40.18	516.36
17	43.18	516.36
18	46.18	516.52
19	49.16	516.83
20	52.12	517.29
21	55.06	517.91
22	57.96	518.68
23	60.81	519.60
24	63.62	520.66
25	66.37	521.87
26	69.04	523.22
27	71.65	524.71
28	74.18	526.33
29	76.61	528.08
30	78.96	529.95
31	81.20	531.94
32	83.34	534.04
33	85.37	536.25
34	87.28	538.57
35	89.07	540.98
36	90.73	543.47
37	92.26	546.06
38	93.65	548.71
39	94.84	551.30

*** 4.781 ***

1

Failure Surface Specified By 40 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.08	534.00
2	6.20	531.88
3	8.43	529.87
4	10.76	527.98
5	13.18	526.21
6	15.69	524.56
7	18.28	523.05
8	20.94	521.67
9	23.67	520.42
10	26.46	519.32
11	29.31	518.37
12	32.20	517.56
13	35.12	516.90
14	38.08	516.39
15	41.06	516.03
16	44.05	515.83
17	47.05	515.77
18	50.05	515.88
19	53.04	516.13
20	56.01	516.54
21	58.96	517.10
22	61.87	517.81

result.out

23	64.75	518.67
24	67.57	519.67
25	70.35	520.82
26	73.06	522.10
27	75.70	523.53
28	78.26	525.09
29	80.74	526.77
30	83.13	528.59
31	85.43	530.52
32	87.62	532.56
33	89.71	534.72
34	91.68	536.98
35	93.53	539.34
36	95.27	541.79
37	96.87	544.32
38	98.34	546.94
39	99.68	549.62
40	100.41	551.30

*** 4.784 ***

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	1.63	534.00
2	3.76	531.89
3	5.99	529.87
4	8.30	527.97
5	10.70	526.17
6	13.19	524.48
7	15.74	522.91
8	18.37	521.46
9	21.06	520.13
10	23.81	518.93
11	26.61	517.86
12	29.45	516.91
13	32.34	516.10
14	35.27	515.42
15	38.22	514.88
16	41.19	514.47
17	44.18	514.21
18	47.17	514.08
19	50.17	514.08
20	53.17	514.23
21	56.16	514.51
22	59.13	514.94
23	62.07	515.49
24	64.99	516.19
25	67.88	517.02
26	70.72	517.97
27	73.51	519.06
28	76.26	520.28
29	78.94	521.62
30	81.56	523.09
31	84.11	524.67
32	86.58	526.37
33	88.97	528.18
34	91.27	530.10
35	93.49	532.13
36	95.61	534.25
37	97.62	536.47
38	99.54	538.78
39	101.34	541.18
40	103.04	543.65
41	104.61	546.21
42	106.07	548.83
43	107.30	551.30

*** 4.790 ***

1

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	2.45	534.00
2	4.57	531.88
3	6.80	529.87
4	9.11	527.96
5	11.51	526.16
6	14.00	524.48
7	16.56	522.91
8	19.19	521.47
9	21.88	520.16
10	24.64	518.97
11	27.44	517.91
12	30.30	516.98
13	33.19	516.20
14	36.12	515.54
15	39.08	515.03
16	42.05	514.66
17	45.04	514.42
18	48.04	514.33
19	51.04	514.38
20	54.04	514.57
21	57.02	514.90
22	59.98	515.37
23	62.92	515.98
24	65.82	516.72
25	68.69	517.61
26	71.52	518.62
27	74.29	519.77
28	77.00	521.05
29	79.65	522.45
30	82.24	523.98
31	84.74	525.62
32	87.17	527.38
33	89.51	529.26
34	91.77	531.24
35	93.92	533.33
36	95.98	535.51
37	97.93	537.79
38	99.77	540.16
39	101.50	542.61
40	103.11	545.14
41	104.60	547.75
42	105.96	550.42
43	106.36	551.30

*** 4.794 ***

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	4.90	534.00
2	7.03	531.89
3	9.27	529.89
4	11.61	528.02
5	14.06	526.28
6	16.59	524.67
7	19.21	523.21
8	21.90	521.88
9	24.66	520.71
10	27.48	519.68
11	30.35	518.81
12	33.27	518.10
13	36.21	517.55
14	39.19	517.15

result.out

15	42.18	516.92
16	45.18	516.85
17	48.18	516.94
18	51.17	517.20
19	54.14	517.61
20	57.08	518.19
21	59.99	518.92
22	62.85	519.82
23	65.67	520.86
24	68.42	522.06
25	71.10	523.40
26	73.71	524.89
27	76.23	526.51
28	78.66	528.27
29	80.99	530.16
30	83.21	532.17
31	85.33	534.30
32	87.32	536.54
33	89.19	538.88
34	90.94	541.33
35	92.54	543.86
36	94.01	546.48
37	95.33	549.17
38	96.24	551.30

*** 4.805 ***

1

Failure Surface Specified By 43 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.82	534.00
2	3.00	531.94
3	5.28	529.99
4	7.63	528.13
5	10.07	526.39
6	12.59	524.75
7	15.18	523.23
8	17.83	521.83
9	20.54	520.55
10	23.31	519.38
11	26.12	518.35
12	28.98	517.44
13	31.88	516.66
14	34.80	516.01
15	37.76	515.49
16	40.73	515.11
17	43.72	514.85
18	46.72	514.73
19	49.72	514.75
20	52.72	514.90
21	55.70	515.18
22	58.68	515.60
23	61.62	516.15
24	64.55	516.83
25	67.43	517.64
26	70.28	518.58
27	73.09	519.65
28	75.84	520.84
29	78.54	522.15
30	81.18	523.58
31	83.75	525.13
32	86.24	526.79
33	88.67	528.56
34	91.01	530.44
35	93.26	532.42
36	95.42	534.50
37	97.49	536.67
38	99.46	538.94
39	101.32	541.29
40	103.08	543.72
41	104.73	546.23

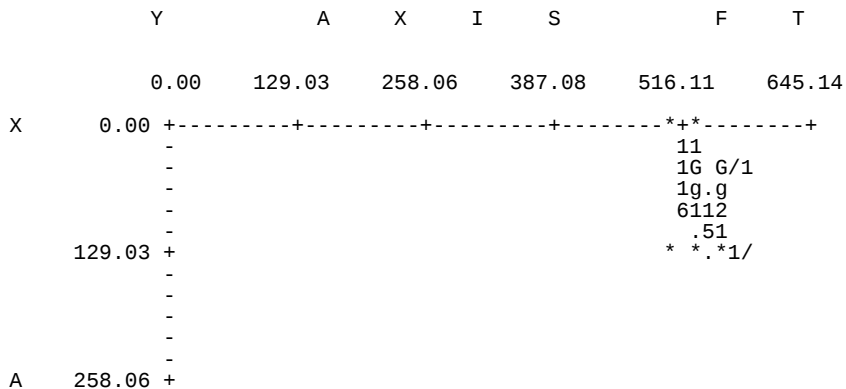
42	106.26	548.81
43	107.60	551.30

Failure Surface Specified By 38 Coordinate Points

Point No.	X-Surf (ft)	Y-Surf (ft)
1	0.00	534.00
2	2.16	531.92
3	4.43	529.96
4	6.81	528.13
5	9.27	526.42
6	11.83	524.85
7	14.46	523.41
8	17.17	522.12
9	19.95	520.98
10	22.78	519.98
11	25.66	519.14
12	28.58	518.45
13	31.53	517.92
14	34.51	517.55
15	37.50	517.34
16	40.50	517.29
17	43.50	517.39
18	46.48	517.66
19	49.45	518.09
20	52.39	518.67
21	55.30	519.42
22	58.16	520.31
23	60.98	521.36
24	63.73	522.56
25	66.41	523.90
26	69.02	525.38
27	71.54	527.00
28	73.98	528.75
29	76.32	530.63
30	78.55	532.63
31	80.68	534.75
32	82.68	536.98
33	84.57	539.31
34	86.33	541.74
35	87.95	544.27
36	89.44	546.87
37	90.79	549.55
38	91.56	551.30

*** 4.835 ***

1



result.out

```
-
-
-
-
X    387.08 +
-
-
-
-
I    516.11 +
-
-
-
-
S    645.14 +
-
-
-
-
    774.17 +
-
-
-
-
F    903.19 +
-
-
-
-
T   1032.22 +
```