

FRA-71-14.36 PHASE 6R RETAINING WALL W2 PID NO. 105588 FRANKLIN COUNTY, OHIO

STRUCTURE FOUNDATION EXPLORATION REPORT (REV. 1)

Prepared For: ms consultants, inc. 2221 Schrock Road Columbus, OH 43229-1547

Prepared By:
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Rii Project No. W-13-072

July 2019







June 18, 2015 (Revised July 19, 2019)

Mr. Gary Gardner, P.E. ms consultants, inc. 2221 Schrock Road Columbus, OH 43229-1547

Re: Structure Foundation Exploration Report (Rev. 1)

FRA-71-14.36 Phase 6R Retaining Wall W2 PID No. 105588

Rii Project No. W-13-072

Mr. Gardner:

Resource International, Inc. (Rii) is pleased to submit this revised structure foundation exploration report for the above 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 W2 as part of the FRA-71-14.36 Phase 6R project in Columbus, 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.

Director – Geotechnical Programming

Jonathan P. Sterenberg, P.E. Director – Geotechnical Planning

Enclosure: Structure Foundation Exploration Report (Rev. 1)

Planning

Engineering

Construction Management

Technology

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EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration for the design and construction of the proposed Retaining Wall W2. Based on plan information provided by the Rii design team and ms consultants, Retaining Wall W2 will be located along the west side of I-71 southbound and Ramp C3 and will provide the required grade separation to avoid right-of-way take that would be associated with graded embankments. The wall begins at Sta. 216+75, BL I-71 SB, and extends north along the west side of I-71 southbound to Sta. 228+70, BL I-71 SB, where it continues north along the west side of Ramp C3 between Sta. 3010+20 and 3017+52, BL Ramp C3. It is understood that a mechanically stabilized earth (MSE) wall type is being considered as the preferred wall type for the entire alignment of Retaining Wall W2. The wall heights along the wall alignment will range from 7.7 feet at Sta. 219+39 to 39.4 feet at Sta. 212+25 (BL Wall W2), and the total wall length is approximately 1,940 lineal feet.

Exploration and Findings

Between January 16, 2014, and March 27, 2015, fifteen (15) structural borings, designated as B-098-2-13 through B-107-4-14, were advanced to completion depths ranging from 15.0 to 54.3 feet below the existing ground surface. In addition to the borings performed by Rii as part of the current exploration, two (2) borings, designated as B-099-1-09 and B-101-0-09, were advanced to a completion depth of 12.5 and 10.0 feet below the existing ground surface, respectively, by DLZ as part of the FRA-70-8.93 preliminary exploration.

Borings B-099-2-13, B-099-3-13 and B-099-5-14 were performed in the existing MJS Carriers parking lot. Borings B-099-2-13 and B-099-3-13 encountered 2.0 inches of asphalt each at the ground surface overlying 4.0 inches of aggregate base in boring B-099-2-13, and boring B-099-5-14 encountered 8.0 inches of crushed gravel and asphalt at the ground surface. Boring B-102-2-14 was performed within the existing pavement behind the loading dock for LifeCare Alliance and encountered 4.0 inches of asphalt overlying 12.0 inches of concrete followed by 3.0 inches of aggregate base. Boring B-105-6-14 was performed within the existing parking lot of R.W. Setterlin Building Company and encountered 4.0 inches of asphalt overlying 8.0 inches of fill material. The remaining borings were performed within the grass areas adjacent to the parking lots or along the embankment supporting I-71/SR-315 southbound and encountered 1.0 to 10.0 inches of topsoil at the ground surface, as identified by the significant presence of vegetation and organic material.

Beneath the topsoil in borings B-098-2-13, B-102-4-14 and B-107-3-14, material identified as existing fill was encountered extending to a depth of 3.0 feet below the ground surface at the respective boring locations, which corresponds to elevations ranging from 701.3 to 712.0 feet msl. The fill material consisted of dark brown and brown gravel with sand, silt and clay and clay (ODOT A-2-6, A-7-6) and contained root fibers and brick fragments throughout.

Underlying the surficial materials and existing fill in borings B-098-2-13, B-102-4-14 and B-107-3-14, natural granular soils were encountered with intermittent seams of cohesive material. The granular soils were generally described as brown, gray, brownish gray and black gravel, gravel and sand, gravel with sand and silt, gravel with sand, silt and clay and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-4a). The cohesive soils were generally described as brown, dark brown, gray, brownish gray, dark gray and reddish brown sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6b, A-7-6).

Analyses and Recommendations

Design details of the proposed retaining wall were provided by the Rii design team. It is understood that a mechanically stabilized earth (MSE) wall type is being considered as the preferred wall type for the entire alignment of Retaining Wall W2. The will be located along the west side of I-71 southbound and Ramp C3 and will provide the required grade separation to avoid right-of-way take that would be associated with graded embankments. The wall heights along the wall alignment will range from 7.7 feet at Sta. 219+39 to 39.4 feet at Sta. 212+25 (BL Wall W2), and the total wall length is approximately 1,940 lineal feet.

MSE Wall Recommendations

Based on the proposed plan and profile information, wall heights along the southern portion of the proposed wall alignment, between Sta. 200+00 and 211+08 (BL Wall W2), range from 8.5 to 37.7 feet, as measured from the top of the leveling pad to the top of the coping, and will directly support the roadway on top and behind the wall. Wall heights along the northern portion of the proposed wall alignment, between Sta. 211+08 and 219+39, range from 7.7 to 38.6 feet, and will support graded embankments with 2:1 (H:V) backslopes that extend up to the proposed Ramp C3 roadway.

The anticipated bearing materials along the wall alignment consist of loose to very dense gravel, gravel and sand and gravel with sand, silt and clay (ODOT A-1-a, A-1-b, A-2-6), and stiff to very stiff silty clay and clay (ODOT A-6b, A-7-6) was encountered in several of the borings extending to depths up to 5.0 feet below the proposed bottom of wall elevation. As noted in Section 5.1 of the full report, it is recommended that the clay (ODOT A-7-6) soil, where encountered, be completely over excavated to expose the underlying competent granular soils and replaced ODOT Item 203 granular embankment. MSE wall foundations bearing on these competent natural soils or granular embankment, placed and compacted in accordance with ODOT Item 203, may be proportioned for a factored bearing resistance as indicated in the following table. A geotechnical resistance factor of ϕ_b =0.65 was considered in calculating the factored bearing resistance at the strength limit state.

Retaining Wall W2 MSE Wall Design Parameters

From Station ¹	To Station ¹	Wall Height Analyzed	Behind Required Stre		Streng	esistance at th Limit sf)	Strength Limit Equivalent Bearing
		(feet)	Analysis	Length ² (feet)	Nominal	Factored ³	Pressure ⁴ (ksf)
200+00	203+00	18.5	Level	13.0 (0.70H ≥ 8.0)	13.09	8.51	4.71
203+00	212+25	38.1	Level	26.7 (0.70H)	77.33	50.26	8.81
212+25	216+50	38.9	2:1 (Broken- back)	27.2 (0.70H)	27.50	17.88	11.64
216+50	219+39	30.2	2:1 (Infinite)	21.1 (0.70H ≥ 8.0)	41.25	26.81	9.62

- 1. Station referenced to the baseline of Retaining Wall W2.
- 2. The required foundation width is expressed as a percentage of the wall height, H.
- 3. A geotechnical resistance factor of φ_b =0.65 was considered in calculating the factored bearing resistance at the strength limit state.
- 4. The strength limit equivalent bearing pressure is the uniformly distributed pressure asserted by the wall over an effective base width based on the eccentricity of the wall system at the strength limit state.

Total settlements of up to 3.14 inches at the center of the reinforced soil mass and 2.57 inches at the facing of the wall are anticipated along the alignment of Retaining Wall W2. Based on the results of the analysis, 100 percent of the total settlement at the facing of the wall is anticipated to occur during construction of the wall or within 35 days following the completion of construction of the wall.

Based on the results of the external and global stability analysis performed for Retaining Wall W2, the recommended controlling strap length is 0.70 times the height of the MSE wall (measured from the top of the leveling pad to the proposed profile grade of the roadway or top of coping) for the entire wall alignment.

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 FRA-70/71-13.10/14.36 (Projects 6A/6R) project in Columbus, Ohio. The projects represent the central portion of FRA-70-8.93 (PID 77369) I-70/71 south innerbelt improvements project, which includes all improvements along I-70 westbound from the I-71/SR-315 interchange to Front Street and along I-71 southbound from I-70 to Greenlawn Avenue. The FRA-71-14.36 (Project 6R) phase will consist of all work associated with the reconfiguration and construction of I-71 southbound from downtown (Front Street) to Greenlawn Avenue, including Ramps C3, D6 and D7. This project includes the construction of two (2) new bridge structures, one (1) for I-71 southbound over Short Street, NS/CXS Railroad and the Scioto River (FRA-71-1503L) and one (1) for Ramp D7 over Short Street (FRA-70-1373B), as well as the construction of five (5) new retaining walls (Walls E4, E5, E7, W2 and W5) to accommodate the new configuration.

This report is a presentation of the structure foundation exploration performed for the design and construction of the proposed Retaining Wall W2, as shown on the vicinity map and boring plan presented in Appendix I. Retaining Wall W2 will be located along the west side of I-71 southbound and Ramp C3 and will provide the required grade separation to avoid right-of-way take that would be associated with graded embankments. The wall begins at Sta. 216+75, BL I-71 SB, and extends north along the west side of I-71 southbound to Sta. 228+70, BL I-71 SB, where it continues north along the west side of Ramp C3 between Sta. 3010+20 and 3017+52, BL Ramp C3. It is understood that a mechanically stabilized earth (MSE) wall type is being considered as the preferred wall type for the entire alignment of Retaining Wall W2. The wall heights along the wall alignment will range from 7.7 feet at Sta. 219+39 to 39.4 feet at Sta. 212+25 (BL Wall W2), and the total wall length is approximately 1,940 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 based on geological age, depositional process and geomorphic occurrence (physical features or landforms). The project area lies within the Columbus Lowland District of the Till Plains Section. This area is characterized by flat to gently rolling ground moraine deposits from the Late Wisconsinan age. The site topography exhibits moderate to high relief. The ground moraine deposits are composed primarily of silty loam till (Darby, Bellefontaine, Centerburg, Grand Lake, Arcanum, Knightstown Tills), with smaller alluvium and outwash deposits bordering the Scioto River, its tributaries and floodplain areas. A ground moraine is the sheet of debris left after the steady retreat of glacial ice. The debris left behind ranges in composition from clay size

particles to boulders (including silt, sand, and gravel). 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.

According to the bedrock geology and topography maps obtained from the Ohio Department of Natural Resources (ODNR), the underlying bedrock west of the Scioto River consists predominantly of the Middle to Lower Devonian-aged Columbus Limestone. This formation is further subdivided into two members in the central portion of the state, known as the Delhi and Bellepoint Members. The Delhi Member consists of light gray, finely to coarsely crystalline, irregularly bedded, fossiliferous limestone. The Bellepoint Member consists of variable brown, finely crystalline, massively bedded limey dolomite. Both of these members contain chert nodules. East of the Scioto River, the underlying bedrock consists of the Upper Devonian Ohio Shale Formation overlying the Middle Devonian-aged Delaware Limestone Formation. The Ohio Shale formation consists of brownish black to greenish gray, thinly bedded, fissile, carbonaceous shale. The Delaware Limestone consists of bluish gray, thin to medium bedded dolomitic limestone with nodules and layers of chert. Regionally, the bedrock surface forms a broad valley aligned roughly north-to-south beneath the Scioto River. According to bedrock topography mapping, the elevation of the bedrock surface ranges from approximately 600 feet mean sea level (msl) in the valley to approximately 625 feet msl near the project limits.

2.2 Existing Conditions

The proposed Retaining Wall W2 is located along the west side of the existing ramp carrying I-70 eastbound and I-71 southbound to SR-315 southbound. The existing I-70 eastbound and I-71 southbound ramps are single-lane, asphalt paved roadways with full width shoulders, and the existing SR-315 southbound roadway is a two-lane, asphalt paved roadway with full width inside and outside shoulders. The profile grade of the ramps and highway are elevated on engineered embankments approximately 35 feet above the surrounding terrain along north end of the proposed wall alignment adjacent to the I-70 eastbound ramp to approximately 5 feet above surrounding terrain along the south side of the proposed wall alignment adjacent to I-71/SR-315 southbound. The existing embankments are covered with dense vegetation and show no visible signs of instability. Commercial properties are situated along the west side of the I-70 eastbound and I-71/SR-315 roadways, and the Scioto River is situated along the west side of I-71/SR-315. The terrain along I-71/SR-315 southbound slopes down gently to the south, and the surrounding area is relatively flat-lying.

3.0 EXPLORATION

Between January 16, 2014, and March 27, 2015, fifteen (15) structural borings, designated as B-098-2-13, B-098-3-14, B-099-2-13, B-099-3-13, B-099-5-14, B-100-1-14, B-100-3-14, B-102-2-14, B-102-4-14, B-102-6-14, B-103-1-14, B-105-4-14, B-105-6-14, B-107-3-14 and B-107-4-14, were advanced to completion depths ranging from 15.0 to 54.3 feet below the existing ground surface. The borings were drilled at the toe of the existing embankment supporting I-71/SR-315 southbound and the ramp from I-70 eastbound to I-71/SR-315 southbound. In addition to the borings performed by Rii as part of the current exploration, two (2) borings, designated as B-099-1-09 and B-101-0-09, were performed DLZ in the vicinity of the bridge structure as part of the FRA-70-8.93 preliminary exploration, and their findings were published in a report dated March 18, 2010. The borings were advanced to a completion depth of 12.5 and 10.0 feet below the existing ground surface, respectively. The current project boring locations are shown on the boring plan provided in Appendix I of this report and summarized in Table 1 below.

Table 1. Test Boring Summary

Boring Number	Reference Alignment	Station	Offset	Latitude	Longitude	Ground Elevation (feet msl)	Boring Depth (feet)
B-098-2-13	BL I-71 SB	217+50.17	29.4' Lt.	39.944646825	-83.013554525	715.0	47.9
B-098-3-14	BL I-71 SB	216+00.00	23.8' Lt.	39.944287341	-83.013291632	716.3	15.0
B-099-1-09	BL I-71 SB	221+80.40	63.9' Lt.	39.945653478	-83.014366412	704.5	12.5
B-099-2-13	BL I-71 SB	219+00.12	52.5' Lt.	39.944983752	-83.013872625	705.1	25.0
B-099-3-13	BL I-71 SB	220+36.69	56.8' Lt.	39.945311743	-83.014109060	705.0	25.0
B-099-5-14	BL I-71 SB	222+00.00	69.6' Lt.	39.945694161	-83.014416489	704.2	30.0
B-100-1-14	BL I-71 SB	223+51.27	54.9' Lt.	39.946081913	-83.014616606	705.6	45.0
B-100-3-14	BL I-71 SB	225+01.50	55.6' Lt.	39.946438290	-83.014870081	706.0	30.0
B-101-0-09	BL I-71 SB	226+52.84	34.1' Lt.	39.946821934	-83.015076772	706.9	10.0
B-102-2-14	BL I-71 SB	226+56.20	52.9' Lt.	39.946802907	-83.015140045	706.1	45.0
B-102-4-14	BL I-71 SB	228+05.59	58.8' Lt.	39.947144182	-83.015436296	705.2	49.4
B-102-6-14	BL Ramp C3	3016+76.27	75.2' Rt.	39.947404459	-83.015822670	700.5	44.0
B-103-1-14	BL Ramp C3	3015+16.32	74.2' Rt.	39.947764221	-83.016136629	703.3	54.3
B-105-4-14	BL Ramp C3	3013+70.11	102.6' Rt.	39.948055710	-83.016519556	700.0	45.0
B-105-6-14	BL Ramp C3	3012+25.98	120.3' Rt.	39.948372985	-83.016857114	703.0	35.0
B-107-3-14	BL Ramp C3	3010+61.70	149.1' Rt.	39.948726068	-83.017248056	704.3	25.0
B-107-4-14	BL Ramp C3	3009+90.45	162.2' Rt.	39.948867841	-83.017410893	705.1	20.0

The locations for the current exploration borings performed by Rii were determined and located in the field by Rii representatives. Rii utilized a handheld GPS unit to obtain geographic latitude and longitude coordinates of the boring locations. Ground surface elevations at the boring locations were interpolated using topographic mapping information provided by ms consultants.

The borings performed by Rii for the current exploration were drilled using a truck or an all-terrain vehicle (ATV) mounted rotary drilling machine, utilizing either 3.25 or 4.25-inch inside diameter, hollow stem auger or a 4.5-inch outside diameter, solid flight auger to advance the holes. Standard penetration test (SPT) and split spoon sampling were performed in the borings at 2.5-foot increments of depth to 10.0 or 20.0 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 using a 140-pound hammer falling 30.0 inches to drive a 2.0-inch outside 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 6.0-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 III.

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

Where:

 N_m = measured N value

ER = drill rod energy ratio, expressed as a percent, for the system used

The hammers for the Mobile B-53, CME 750 and CME 750X drill rigs operated by Rii were calibrated on April 26, 2013, and have drill rod energy ratios of 77.7, 82.6 and 86.8 percent, respectively. The hammers for the CME 750, CME 750X and CME 55 drill rigs operated by Rii were calibrated again on October 20, 2014, and have drill rod energy ratios of 92.9, 85.7 and 92.0 percent, respectively. The updated energy ratios for the CME 750 and CME 750X drill rigs were utilized for borings performed after the recalibration date for those rigs. The hammers for the two CME 75 drill rigs operated by DLZ have drill rod energy ratios of 61.2 and 62.0 percent. No calibration date is available for the DLZ rig calibrations.

During drilling for the borings performed by Rii, field logs were prepared by Rii personnel 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	165
Plastic and Liquid Limits	AASHTO T89, T90	64
Gradation – Sieve/Hydrometer	AASHTO T88	64

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

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 (N₆₀). 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 based on the field logs, visual examination of samples and laboratory test results. Classification follows the respective version of the ODOT Specifications for Geotechnical Explorations (SGE) at the time the exploration borings were performed. The following is a summary of what was found in the test borings performed as part of the preliminary engineering phase and current exploration and what is represented on the boring logs.

4.1 Surface Materials

Borings B-099-2-13, B-099-3-13 and B-099-5-14 were performed in the existing MJS Carriers parking lot. Borings B-099-2-13 and B-099-3-13 encountered 2.0 inches of asphalt each at the ground surface overlying 4.0 inches of aggregate base in boring B-099-2-13, and boring B-099-5-14 encountered 8.0 inches of crushed gravel and asphalt at the ground surface. Boring B-102-2-14 was performed within the existing pavement behind the loading dock for LifeCare Alliance and encountered 4.0 inches of asphalt overlying 12.0 inches of concrete followed by 3.0 inches of aggregate base. Boring B-105-6-14 was performed within the existing parking lot of R.W. Setterlin Building Company and encountered 4.0 inches of asphalt overlying 8.0 inches of fill material. The remaining borings were performed within the grass areas adjacent to the

parking lots or along the embankment supporting I-71/SR-315 southbound and encountered 1.0 to 10.0 inches of topsoil at the ground surface, as identified by the significant presence of vegetation and organic material.

4.2 Subsurface Soils

Beneath the topsoil in borings B-098-2-13, B-102-4-14 and B-107-3-14, material identified as existing fill was encountered extending to a depth of 3.0 feet below the ground surface at the respective boring locations, which corresponds to elevations ranging from 701.3 to 712.0 feet msl. The fill material consisted of dark brown and brown gravel with sand, silt and clay and clay (ODOT A-2-6, A-7-6) and contained root fibers and brick fragments throughout.

Underlying the surficial materials and existing fill in borings B-098-2-13, B-102-4-14 and B-107-3-14, natural granular soils were encountered with intermittent seams of cohesive material. The granular soils were generally described as brown, gray, brownish gray and black gravel, gravel and sand, gravel with sand and silt, gravel with sand, silt and clay and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-2-6, A-4a). The cohesive soils were generally described as brown, dark brown, gray, brownish gray, dark gray and reddish brown sandy silt, silt and clay, silty clay and clay (ODOT A-4a, A-6a, A-6b, A-7-6).

The relative density of the granular soils is derived from the SPT blow counts (N_{60}). The relative density of the granular soil encountered ranged from loose ($5 \le N_{60} \le 10$ blows per foot [bpf]) to very dense ($N_{60} > 50$ bpf). Overall blow counts recorded from the SPT sampling ranged from 5 bpf to split spoon sampler refusal. Split spoon sampler refusal is defined as exceeding 50 blows from the hammer with less than 6.0 inches of penetration by the split spoon sampler. The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soil encountered ranged from stiff ($1.0 < HP \le 2.0$ tsf) to hard (HP > 4.0 tsf). The unconfined compressive strength of the cohesive soil samples tested, obtained from the hand penetrometer, ranged from 1.5 to over 4.5 tsf (limit of instrument).

Natural moisture contents of the soil samples tested ranged from 2 to 31 percent. The natural moisture content of the cohesive soil samples tested for plasticity index ranged from 7 percent below to 7 percent above the corresponding plastic limits. In general, the soil exhibited natural moisture contents considered to be significantly below to significantly above the optimum moisture levels.

4.3 Bedrock

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

4.4 Groundwater

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

Table 3. Groundwater Levels

Boring	Ground	Initial Gr	oundwater	Upon Co	mpletion ¹
Number	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-098-2-13	715.0	24.0	691.0	N/A	N/A
B-098-3-14	716.3	Dry	Dry	Dry	Dry
B-099-1-09	704.5	Dry	Dry	Dry	Dry
B-099-2-13	705.1	17.0	688.1	N/A	N/A
B-099-3-13	705.0	17.5	687.5	22.6	682.4
B-099-5-14	704.2	17.5	686.7	24.3	679.9
B-100-1-14	705.6	18.5	687.1	N/A	N/A
B-100-3-14	706.0	19.0	687.0	23.4	682.6
B-101-0-09	706.9	Dry	Dry	Dry	Dry
B-102-2-14	706.1	17.5	688.6	N/A	N/A
B-102-4-14	705.2	18.0	687.2	N/A	N/A
B-102-6-14	700.5	11.0	689.5	N/A	N/A
B-103-1-14	703.3	15.5	687.8	N/A	N/A
B-105-4-14	700.0	11.0	689.0	N/A	N/A
B-105-6-14	703.0	13.5	689.5	N/A	N/A
B-107-3-14	704.3	16.0	688.3	N/A	N/A
B-107-4-14	705.1	13.5	691.6	15.0	690.1

^{1.} N/A indicates that the groundwater level at the completion of drilling could not be obtained due to the addition of water or mud to the boreholes to counteract heaving sands.

With the exception of borings B-098-3-14, B-099-1-09 and B-101-0-09, groundwater was encountered initially during the drilling process in the remaining borings at depths ranging from 11.0 to 24.0 feet below existing grade, which corresponds to elevations ranging from 686.7 to 691.6 feet msl. At the completion of drilling and prior to removing the augers in borings B-099-3-13, B-099-5-14, B-100-3-14 and B-107-4-14, groundwater accumulated in the auger stems to depths ranging from 15.0 to 24.3 feet below existing grade, which corresponds to elevations ranging from 679.9 to 690.1 feet

msl. The groundwater level at the completion of drilling could not be obtained in several of the borings due to the addition of water or mud to the boreholes to counteract heaving sands.

Please note that short-term water level readings, especially in cohesive materials, are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels and 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 III.

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from the drilling and testing programs have been used to determine the 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 foundation systems for the subject retaining wall, 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 a mechanically stabilized earth (MSE) wall type is being considered as the preferred wall type for the entire alignment of Retaining Wall W2. The will be located along the west side of I-71 southbound and Ramp C3 and will provide the required grade separation to avoid right-of-way take that would be associated with graded embankments. The wall heights along the wall alignment will range from 7.7 feet at Sta. 219+39 to 39.4 feet at Sta. 212+25 (BL Wall W2), and the total wall length is approximately 1,940 lineal feet.

5.1 MSE Wall Recommendations

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. Per Section 204.6.2.1 of the 2019 ODOT BDM, the height of the MSE wall is defined as the elevation difference between the top of coping and the top of the leveling pad. However, it is noted that the reinforced soil mass only extends from the foundation bearing elevation (top of leveling pad) to the roadway subgrade elevation where the roadway is supported on the top of the wall, and the reinforced soil mass extends to the top of the coping where the roadway is not supported on top of the wall. The width of the MSE wall foundation (B) is defined by the length of the reinforced soil mass. Per the Section 204.6.2.1 of the 2019 ODOT BDM and Supplemental Specification (SS) 840, the minimum length of the reinforced soil mass is equal to 70 percent of the height of the MSE wall or 8.0 feet whichever is

greater. A non-structural bearing leveling pad consisting of a minimum of 6.0-inches of unreinforced concrete should be placed at the base of the wall facing for constructability purposes. Please note that the leveling pad is not a structural foundation.

Based on the proposed plan and profile information, wall heights along the southern portion of the proposed wall alignment, between Sta. 200+00 and 211+08 (BL Wall W2), range from 8.5 to 37.7 feet, as measured from the top of the leveling pad to the top of the coping, and will directly support the roadway on top and behind the wall. Wall heights along the northern portion of the proposed wall alignment, between Sta. 211+08 and 219+39, range from 7.7 to 38.6 feet, and will support graded embankments with 2:1 (H:V) backslopes that extend up to the proposed Ramp C3 roadway. For the analysis, the foundation width was set at 70 percent of the wall height and the foundation width was increased, if required, until external and global stability requirements were satisfied.

Per Section 840.06.D of ODOT SS 840, the foundation subgrade should be inspected to verify that the subsurface conditions are the same as those anticipated in this report. The anticipated soils at the proposed bearing elevation along the majority of the wall alignment consist of loose to very dense gravel, gravel with sand and gravel with sand, silt and clay (ODOT A-1-a, A-1-b, A-2-6). Cohesive soil deposits consisting of stiff to very stiff silty clay and clay (ODOT A-6b, A-7-6) were encountered at the proposed bearing elevation in borings B-098-3-14, B-099-2-13, B-099-3-13, B-099-5-14, B-100-1-14, B-103-1-14, B-105-4-14 and B-107-3-14. At borings B-098-3-14, B-099-3-13, B-099-5-14, B-100-1-14 and B-107-3-14, these deposits only extend to depths of 1.0 to 1.5 feet below the bottom of wall elevation and will likely be removed during the foundation preparation. At borings B-099-2-13, B-103-1-14 and B-105-4-14, the cohesive soils extended to a depth of 3.5, 5.0 and 2.0 feet (elevation 697.1, 692.8 and 694.5 feet msl), respectively, below the bottom of wall.

Given the high plasticity of the clay (ODOT A-7-6) soils encountered in borings B-103-1-14 and B-105-4-14, along with the reduced shear strength and increased compressibility of these soil types, it is recommended that this material, where encountered, be completely over excavated to expose the underlying competent granular soils and replaced ODOT Item 203 granular embankment. Over excavation depths on the order of 2.0 to 5.0 feet are anticipated between approximately Sta. 213+50 and 216+50 (BL Wall W2) based on the elevation of the bottom of the cohesive soil deposits encountered in borings B-103-1-14 and B-105-4-14. The actual limits and depth of over excavation will need to be determined during the construction of the wall based on observation of the subgrade condition by a qualified soil technician or geotechnical engineer.

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

5.1.1 Strength Parameters Utilized in External and Global Stability Analyses

The shear strength parameters utilized in the external and global stability analyses for the MSE wall are provided in Table 4.

Table 4. Shear Strength Parameters Utilized in MSE Wall Stability Analyses

Material Type	γ (pcf)	φ' ⁽¹⁾ (°)	c' ⁽²⁾ (psf)	S _u ⁽³⁾ (psf)
MSE Wall Backfill (Select granular backfill)	120	34	0	N/A
ltem 203 Embankment Fill (Retained soil)	120	30	0	2,000
Item 203 Granular Embankment (Over excavation backfill)	120	32	0	N/A
Loose to Very Dense Granular Soils (ODOT A-1-a, A-1-b, A-2-6, A-4a)	120 to 135	34 to 42	0	N/A
Very Stiff Silty Clay (ODOT A-6b)	120	26	0	2,500
Stiff Clay (ODOT A-7-6)	115	25	0	1,750
Hard Sandy Silt (ODOT A-4a)	130	33	100	8,000

^{1.} Per Figure 7-45, Section 7.6.9 of FHWA GEC 5 for cohesive soils and Table 10.4.6.2.4-1 of the 2018 AASHTO LRFS BDS for granular soils.

Shear strength parameters for the reinforced soil backfill and retained embankment are provided in ODOT SS 840. Per SS 840, the select granular backfill in the reinforced zone and the retained embankment must meet the shear strength requirements provided in Table 4. The shear strength parameters for the natural soils were assigned using correlations provided in FHWA Geotechnical Engineering Circular (GEC) No. 5 (FHWA-NHI-16-072) Evaluation of Soil and Rock Properties and based on past experience in the vicinity of the site with projects performed in similar subsurface profiles.

5.1.2 Bearing Stability

The anticipated bearing materials along the wall alignment consist of loose to very dense gravel, gravel and sand and gravel with sand, silt and clay (ODOT A-1-a, A-1-b, A-2-6), and stiff to very stiff silty clay and clay (ODOT A-6b, A-7-6) was encountered in several of the borings extending to depths up to 5.0 feet below the proposed bottom of wall elevation. As noted in Section 5.1, it is recommended that the clay (ODOT A-7-6) soil, where encountered, be completely over excavated to expose the underlying

^{2.} Estimated based on overconsolidated nature of soil.

^{3.} $S_u = 125(N_{60})$, Terzaghi and Peck (1967).

competent granular soils and replaced ODOT Item 203 granular embankment. MSE wall foundations bearing on these competent natural soils or granular embankment, placed and compacted in accordance with ODOT Item 203, may be proportioned for a factored bearing resistance as indicated in Table 5. A geotechnical resistance factor of ϕ_b =0.65 was considered in calculating the factored bearing resistance at the strength limit state. The reinforcement lengths presented in the following table represent the minimum foundation widths required to satisfy external and global stability requirements, expressed as a percentage of the wall height.

Table 5. Retaining Wall W2 MSE Wall Design Parameters

From Station ¹	To Station ¹	Wall Height Analyzed	Backslope Behind Wall in	Minimum Required Reinforcement	Streng	esistance at th Limit sf)	Strength Limit Equivalent Bearing
		(feet)	Analysis	Length ² (feet)	Nominal	Factored ³	Pressure ⁴ (ksf)
200+00	203+00	18.5	Level	13.0 (0.70H ≥ 8.0)	13.09	8.51	4.71
203+00	212+25	38.1	Level	26.7 (0.70H)	77.33	50.26	8.81
212+25	216+50	38.9	2:1 (Broken- back)	27.2 (0.70H)	27.50	17.88	11.64
216+50	219+39	30.2	2:1 (Infinite)	21.1 (0.70H ≥ 8.0)	41.25	26.81	9.62

^{1.} Stationing referenced to the baseline of Retaining Wall W2.

Rii performed a verification of the bearing pressure exerted on the subgrade material for the specified wall heights indicated in Table 5. Based on the minimum length of reinforced soil mass presented, the factored equivalent bearing pressure exerted below the wall **will not exceed** the factored bearing resistance at the strength limit state.

5.1.3 Settlement Evaluation

The compressibility parameters utilized in the settlement analyses of the proposed MSE wall are provided in Table 6.

^{2.} The required foundation width is expressed as a percentage of the wall height, H.

^{3.} A geotechnical resistance factor of φ_b =0.65 was considered in calculating the factored bearing resistance at the strength limit state.

^{4.} The strength limit equivalent bearing pressure is the uniformly distributed pressure asserted by the wall over an effective base width based on the eccentricity of the wall system at the strength limit state.

Table 6. Compressibility Parameters Utilized in Settlement Analysis

Material Type	γ (pcf)	<i>LL</i> (%)	C_c (1)	$C_r^{(2)}$	$e_o^{(3)}$	C_{v} ⁽⁴⁾ (ft ² /yr)	N_{60}	C' (5)
Item 203 Granular Embankment (Over excavation backfill)	120	N/A	N/A	N/A	N/A	N/A	30	149 to 207
Loose to Very Dense Granular Soils (ODOT A-1-a, A-1-b, A-2-6, A-4a)	120 to 135	N/A	N/A	N/A	N/A	N/A	8 to 120	40 to 736
Very Stiff Silty Clay (ODOT A-6b)	120	37 to 40	0.243 to 0.270	0.024 to 0.027	0.561 to 0.585	300	N/A	N/A
Hard Sandy Silt (ODOT A-4a)	130	20 to 22	0.090 to 0.108	0.009 to 0.011	0.428 to 0.444	1,000	N/A	N/A

- 1. Per Table 6-9, Section 6.14.1 of FHWA GEC 5.
- 2. Estimated at 10% of C_c per Section 8.11 of Holtz and Kovacs (1981).
- 3. Per Table 8-2 of Holtz and Kovacs (1981).
- 4. Per Figure 6-37. Section 6.14.2 of FHWA GEC 5.
- 5. Per Figure 10.6.2.4.2-1 of 2018 AASHTO LRFD BDS.

Results of the settlement analysis are tabulated in Table 7. Total settlements of up to 3.14 inches at the center of the reinforced soil mass and 2.57 inches at the facing of the wall are anticipated along the alignment of Retaining Wall W2. Based on the results of the analysis, 100 percent of the total settlement at the facing of the wall is anticipated to occur during construction of the wall or within 35 days following the completion of construction of the wall. Please note that the consolidation settlement and time rate of consolidation are based on estimates using correlated compressibility parameters provided in Table 6 for the underlying soils. Actual settlement and time rate of consolidation should be determined by monitoring the settlement of the wall using settlement platforms.

Table 7. Retaining Wall W2 MSE Wall Settlement Values

From	То	Service Limit Equivalent		ment Values hes)	Time for 100%
Station ¹	Station ¹	Bearing Pressure ² (ksf)	Center of Wall Mass	Facing of Wall	Consolidation (Days)
200+00	203+00	1.88 to 3.26	0.49 to 1.64	0.44 to 1.31	0 to 35
203+00	212+25	3.23 to 6.20	0.65 to 2.40	0.52 to 1.90	0 to 15
212+25	216+50	7.57 to 8.03	2.61 to 3.14	2.20 to 2.57	0 to 5
216+50	219+39	1.12 to 6.73	0.62 to 2.25	0.46 to 1.81	0 to 5

- 1. Stationing referenced to the baseline of Retaining Wall W2.
- 2. The service limit equivalent bearing pressure is the uniformly distributed pressure asserted by the wall over an effective base width based on the eccentricity of the wall system at the service limit state.

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 walls, maximum differential settlements in the longitudinal directions are anticipated to be less than 1/1,000, which is within the tolerable limit of 1/100. If the total or differential settlement values predicted for the proposed wall present 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 walls. If preloading the site is not a desired option, then consideration could be given to ground improvement through the use of stone columns. Settlement calculations are provided in Appendix IV.

5.1.4 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 2018 AASHTO LRFD BDS, for foundations bearing on soil, the location of the resultant of the reaction forces shall be within the middle two-thirds (2/3) of the base width. Therefore, the limiting eccentricity is one-third (1/3) of the base width of the wall. Rii performed a verification of the eccentricity of the resultant force for the specified wall heights 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.

5.1.5 Sliding Stability

The resistance of the MSE wall to sliding was evaluated per Section 11.10.5.3 of the 2018 AASHTO LRFD BDS. For drained conditions, the 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 reinforced soil backfill material, a coefficient of sliding friction of 0.49 to 0.67 was utilized for design. For the section of wall at boring B-099-2-13, sliding was also evaluated using undrained conditions. For undrained conditions, the sliding resistance is taken as the limiting value between the undrained shear strength of the bearing soil and half of the vertical stress applied by the wall multiplied by the width of the MSE wall. Based on the soil parameters listed in Section 5.1.1, the undrained shear strength of the silty clay (ODOT A-6b) encountered at the proposed bearing elevation at boring B-099-3-13 is estimated to be 2,500 psf.

A geotechnical resistance factor of ϕ_τ =1.0 was considered in calculating the factored shear resistance. 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 <u>will</u> not exceed the factored shear resistance at the strength limit state for drained or undrained conditions.

5.1.6 Overall (Global) Stability

A slope stability analysis was performed to check the global stability of the wall. As per the 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 the global stability analyses are presented in Table 4. For the global stability condition, it was considered that the failure plane will not cross through the reinforced soil mass. The computer software program Slide 2018 manufactured by Rocscience Inc. was utilized to perform the analyses.

Per Section 11.6.2.3 of the 2018 AASHTO LRFD BDS, overall (global) stability for MSE walls that are not integrated with or supporting structural foundations or elements, global stability is satisfied if the product of the factor of safety from the slope stability output multiplied by the resistance factor φ =0.75 is greater than 1.0. Therefore, global stability is satisfied when a minimum factor of safety of 1.3 is obtained. For MSE walls designed with a minimum strap length listed in Table 5, the resulting factor of safety under drained conditions (long-term stability) was greater than or equal to 1.3. Given the granular nature of the subsurface profile, an undrained analysis was not performed.

5.1.7 Final MSE Wall Considerations

Based on the results of the external and global stability analysis performed for Retaining Wall W2, the recommended controlling strap length is 0.70 times the height of the MSE wall (measured from the top of the leveling pad to the proposed profile grade of the roadway or top of coping) for the entire wall alignment.

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

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 8 and Table 9.

Table 8. Estimated Undrained (Short-term) Soil Parameters for Design

Soil Type	γ (pcf) ¹	c (psf)	φ	k_a	k_o	k_p
Soft to Stiff Cohesive Soil	115	1,500	0°	N/A	N/A	N/A
Very Stiff to Hard Cohesive Soil	125	3,000	0°	N/A	N/A	N/A
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense Granular Soil	125	0	32°	0.27	0.47	6.82
Dense to Very Dense Granular Soil	130	0	36°	0.23	0.41	9.09
Compacted Cohesive Engineered Fill	120	2,000	0°	N/A	N/A	N/A
Compacted Granular Engineered Fill	120	0	32°	0.27	0.47	6.82

^{1.} When below groundwater table, use effective unit weight, $\gamma' = \gamma$ - 62.4 pcf and add hydrostatic water pressure.

Table 9. Estimated Drained (Long-term) Soil Parameters for Design

Soil Type	γ (pcf) ¹	c (psf)	φ'	k_a	k_o	k_p
Soft to Stiff Cohesive Soil	115	0	26°	0.35	0.56	4.53
Very Stiff to Hard Cohesive Soil	125	0	28°	0.32	0.53	5.07
Loose Granular Soil	120	0	28°	0.32	0.53	5.07
Medium Dense Granular Soil	125	0	32°	0.27	0.47	6.82
Dense to Very Dense Granular Soil	130	0	36°	0.23	0.41	9.09
Compacted Cohesive Engineered Fill	120	0	30°	0.30	0.50	5.58
Compacted Granular Engineered Fill	120	0	32°	0.27	0.47	6.82

^{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 all subsurface structures and any excavation support systems. Subsurface structures (where the top of the structure is restrained from movement) should be designed based on at-rest conditions (k_o) . For proposed temporary retaining structures (where the top of the structure is allowed to move), earth pressure distributions should be based on active (k_a) and passive (k_p) conditions. The values in this table have been estimated from correlation charts based on minimum standards specified for compacted engineered fill materials. These recommendations do not take into consideration the effect of any surcharge loading or a sloped ground surface (a flat surface is considered). 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 Materials Specifications (CMS), including that all excavation and embankment preparation and construction should follow ODOT Item 200 (Earthwork) and MSE Wall Construction and foundation preparation follows Supplemental Specification 840.

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, temporary shoring may be required. The following table should be utilized as a general guide for implementing OSHA guidelines when estimating excavation back slopes at the various boring locations. Actual excavation back slopes must be field verified by qualified personnel at the time of excavation in strict accordance with OSHA guidelines.

Table 10. Excavation Back Slopes

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

5.3.2 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 36.0 inches below the deepest excavation. Any seepage or groundwater encountered at this site should be able to be controlled by pumping from temporary sumps. Additional measures may be required depending on seasonal fluctuations of the groundwater level. Note that determining and maintaining actual groundwater levels during construction is the responsibility of the contractor.

6.0 LIMITATIONS OF STUDY

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

The recommendations for this project were developed utilizing soil and bedrock information obtained from the test borings that were made at the proposed site for the 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 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

VICINITY MAP AND BORING PLAN

BORINGS B-098-2-13, B-099-2-13, B-099-3-13, B-099-5-14, B-100-1-14, B-100-3-14, B-102-2-14, B-102-4-14, B-102-6-14, B-103-1-14, B-105-4-14, B-105-6-14, B-107-3-14 AND B-107-4-14 WERE PERFORMED FOR WALL W2.

BORINGS B-099-4-14, B-100-2-14, B-100-4-14, B-102-3-14, B-102-5-14, B-105-3-14, B-105-5-13, B-107-2-14 AND B-108-7-13 WERE PERFORMED FOR WALL W5.

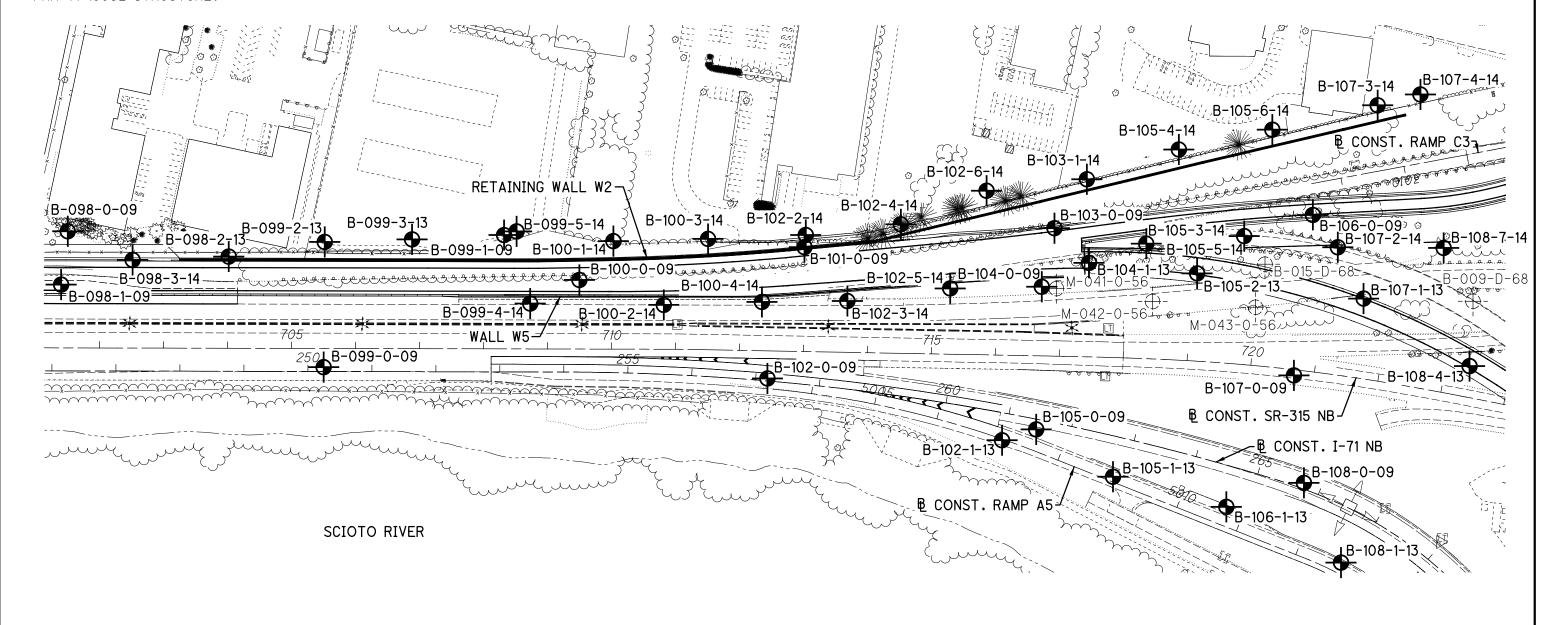
BORINGS B-104-1-13, B-105-2-13, B-107-1-13 AND B-108-4-13 WERE PERFORMED FOR THE FRA-71-1503L STRUCTURE. BORINGS B-102-1-13, B-105-1-13, B-106-1-13 AND B-108-1-13 WERE PERFORMED AS PART OF THE FRA-70-12.68 PROJECT 4A/4R.

BORINGS B-098-0-09, B-098-1-09, B-099-0-09, B-100-0-09, B-101-0-09, B-102-0-09, B-103-0-09, B-104-0-09, B-105-0-09, B-106-0-09, B-107-0-09 AND B-108-0-09 WERE DRILLED AS PART OF THE FRA-70-8.93 PRELIMINARY EXPLORATION.

LEGEND

PROJECT BORING

HISTORIC BORING



BORING PLAN
FRA-70-13.10 - RETAINING WALL W2
FRANKLIN COUNTY, OHIO

PROJECT NO. Rii W-13-072

SCALE: 1"=150' 0 75 150



DRAWN RRM REVIEWED BRT DATE 7-17-19



APPENDIX II

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>	Blows per	foot - S	SPT (N ₆₀)
Very Loose	Below		5
Loose	5	-	10
Medium Dense	11	-	30
Dense	31	-	50
Very Dense	Over		50

<u>Cohesive Soils</u> - 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

	, ,		, ,	Unconfined
<u>Description</u>	Blows per	foot - S	SPT (N ₆₀)	Compression (tsf)
Very Soft	Below		2	UCS ≤ 0.25
Soft	2	-	4	$0.25 < UCS \le 0.5$
Medium Stiff	5	-	8	0.5 < UCS ≤ 1.0
Stiff	9	-	15	1.0 < UCS ≤ 2.0
Very Stiff	16	-	30	$2.0 < UCS \le 4.0$
Hard	Over		30	UCS > 4.0

<u>Gradation</u> - The following size-related denominations are used to describe soils:

Soil Fraction	USCS Size	ODOT Size
Boulders	Larger than 12"	Larger than 12"
Cobbles	12" to 3"	12" to 3"
Gravel coarse	3" to ¾"	3" to 3/4"
fine	3/4" to 4.75 mm (3/4" to #4 Sieve)	3/4" to 2.0 mm (3/4" 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)	<u>-</u>
fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt	0.074 mm to 0.005 mm (#200 to 0.005 mm)	0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay	Smaller than 0.005 mm	Smaller than 0.005 mm

Modifiers of Components - Modifiers of components are as follows:

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

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

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

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

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

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

<u>Term</u>		Blows per	foot - S	PT (N)
Very Soft		Below		50
Soft		50/5"	_	50/6"
Medium Hard		50/3"	_	50/4"
Hard		50/1"	_	50/2"
Very Hard	50/0"			



CLASSIFICATION OF SOILS Online 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.)

C	055001071011	Classif	cation	LL _O /LL	*	×	Liquid	Plastic	Group	
SYMBOL	DESCRIPTION	AASHTO	OHIO	× 100*	Pass #40	Pass #200	Liquid Limit (LL)	Index (PI)	Index Max.	REMARKS
0000	Gravel and/or Stone Fragments	Α-	1-a		30 Max.	15 Max.	-	6 Max.	0	Min. of 50% combined grave cobble and boulder sizes
0.000	Gravel and/or Stone Fragments with Sand	Α-	1-b		50 Max.	. 25 Max.		6 Max.	0	
F.S	Fine Sand	А	-3		51 Min.	10 Max.	NON-P	LASTIC	0	
	Coarse and Fine Sand		A-3a			35 Max.		6 Max.	0	Min. of 50% combined coars and fine sand sizes
	Gravel and/or Stone Fragments with Sand and Silt		2-4			35 Max.	40 Max. 41 Min.	10 Max.	0	
	Gravel and/or Stone Fragments with Sand, Silt and Clay	-	2-6 2-7			35 Max.	40 Max. 41 Min.	11 Min.	4	
	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	Α-	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-4
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify a A-5, A-6a, A-6i A-7-5 or A-7-6

MATERIAL CLASSIFIED BY VISUAL INSPECTION

Sod and Topsoil XXXX Pavement or Base

Uncontrolled Fill (Describe)



Bouldery Zone



Peat, S-Sedimentary W-Woody F-Fibrous L-Loamy & etc

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

APPENDIX III

PROJECT BORING LOGS:

B-098-2-13 through B-107-4-14

BORING LOGS

Definitions of Abbreviations

AS	=	Auger sample
GI	=	Group index as determined from the Ohio Department of Transportation classification system
HP	=	Unconfined compressive strength as determined by a hand penetrometer (tons per square foot)
LLo	=	Oven-dried liquid limit as determined by ASTM D4318. Per ASTM D2487, if LL ₀ /LL is less than 75 percent, soil is classified as "organic".
LOI	=	Percent organic content (by weight) as determined by ASTM D2974 (loss on ignition test)
PID	=	Photo-ionization detector reading (parts per million)
QR	=	Unconfined compressive strength of intact rock core sample as determined by ASTM D2938 (pounds per square inch)
QU	=	Unconfined compressive strength of soil sample as determined by ASTM D2166 (pounds per square foot)
RC	=	Rock core sample
REC	=	Ratio of total length of recovered soil or rock to the total sample length, expressed as a percentage
RQD	=	Rock quality designation – estimate of the degree of jointing or fracture in a rock mass, expressed as a percentage:
		\sum segments equal to or longer than 4.0 inches
		core run length
S	=	Sulfate content (parts per million)
SPT	=	Standard penetration test blow counts, per ASTM D1586. Driving resistance recorded in terms of blows per 6-inch interval while letting a 140-pound hammer free fall 30 inches to drive a 2-inch outer diameter $(O.D.)$ split spoon sampler a total of 18 inches. The second and third intervals are added to obtain the number of blows per foot (N_m) .
N ₆₀	=	Measured blow counts corrected to an equivalent (60 percent) energy ratio (ER) by the following equation: $N_{60} = N_m^*(ER/60)$
SS	=	Split spoon sample
2S	=	For instances of no recovery from standard SS interval, a 2.5 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 2S sampling are not correlated with N_{60} values.
3S	=	Same as 2S, but using a 3.0 inch O.D. split spoon sampler.
		· · · · · · · · · · · · · · · · · · ·

Classification Test Data

W

Gradation (as defined on Description of Soil Terms):

Initial water level measured during drilling

Water level measured at completion of drilling

GR = % Gravel SA = % Sand SI = % Silt CL = % Clay

Atterberg Limits:

LL = Liquid limit
PL = Plastic limit
Pl = Plasticity Index

WC = Water content (%)

RESOURCE INTERNATIONAL, INC.

PROJECT: _	FRA-70-13.10 - PH		DRILLING FIRM /			/ J.B.	_			ME-750X (S						:T: _			29.4' LT	EXPLO	
Rii) TYPE: PID: 894	STRUCTURE 64 BR ID:	N/A	SAMPLING FIRM DRILLING METHO	_	4.25" HS	/ J.S. ^	_	MER:		CME AUTO	4/26/13		ALIGN			715 N		I-71 SB	D.	47.9 ft.	P
	04 BR ID 1/16/14 END:	1/16/14	SAMPLING METH		4.23 113 SPT	Α	_	CALIBRATION DATE: ENERGY RATIO (%):			86.8		LAT / LONG:			715.0 (MSL) EOB: 47 39.944647, -83.013555					1
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n	AND NOTES	TION			DEPTI	HS	SPT/ RQD	N ₆₀	(%)	ID	(tsf)		CS		_ \ _ /	_			y wc	ODOT CLASS (GI)	
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			600	1		L 23	12	29	39	SS-10	-	-	-	-	-	-	-	-	- 12	A-1-a (V)) < >

BR ID: N/A DRILLING METHOD: 4.5" CFA CALIBRATION DATE: 10/20/14 ELEVATION: 716.3 (MSL) EOB: 15.0 ft. F.	PID: 89464 BR ID: NA DRILLING METHOD: 4.5" CFA CALIBRATION DATE: 10/20/14 ELEVATION: 716.3 (MSL) EOB: 15.0 ft.	PROJECTYPE:	CT: FF	RA-70-13.10 - I STRUCTUR			FIRM / OPERATOR: FIRM / LOGGER:	RII / S.B.		LL RIG MMER:		ME 750 (SI AUTOMA		3)	STAT			SET: _			0 / 23. SB	8' LT	EXPLOR B-098
A 15 END: 2/4/15 SAMPLING METHOD: SPT ENERGY RATIO (%): 92.9 LAT / LONG: 39.944287, -83.013292 1	START: 2/4/15 END: 2/4/15 SAMPLING METHOD: SPT ENERGY RATIO (%): 92.9 LAT / LONG: 39.944287, 83.013292 1 **MARERIAL DESCRIPTION AND NOTES** **TOPSOIL (5.0") **RY STIFF, DARK BROWN SILTY CLAY, LITTLE DARKS BROWN GRAVEL, DAMP.** **TOPSOIL (5.0") **TOPSOIL (5.0") **RY STIFF, DARK BROWN SILTY CLAY, LITTLE DARK BROWN GRAVEL, DAMP.** **TOPSOIL (5.0")	-	89464											ı			_	716.3				1	5 0 ft
TERIAL DESCRIPTION AND NOTES Columbia	## AND NOTES ## - TOPSOIL (5.0°) ## - TOPSOIL (5.																	7 10.0					
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Po 0 7013							701.3	- H		45	56	SS-5	-	-	-	-	-	-	-	-	-	3	A-1-a (V
	DTES: GROUNDWATER NOT ENCOUNTERED DURING DRILLING		NATE VI	T-FN00111-																			

Client:	ms c	onsu	Itants	3			Project: FRA-70-8.93) 000-0							Job No	0.022	21-10	04.01	
LOG (9	Loc	cation: Sta. 221+80.40, 63.9' LT., BL I-71 SB			Da	te i	Drill	led:	9/2	25/2009				
Depth (ft)	Elev. (ft)	Blows per 6"	Recovery	Sam No		Hand Penetro- meter (tsf)	WATER OBSERVATIONS: Water seepage at: None Water level at completion: None FIELD NOTES: DESCRIPTION	Graphic Log	% Aggregate		M. Sand		NON sit		Naturai PL Blows pe	Mois ⊢— r foot -	ture	Conter Non-P	ON (N60) nt, % - ● H LL astic - NP
0.5	704.5	B	ц	7	ď.		Topsoil - 6"	0	9/	0/	6/	6/	% (0/	<u>10</u>	111	0 /	30	40
<u>-</u> -		12 4 5	11	1			Loose brown SANDY SILT (A-4a), little gravel; damp.		19	21		15	26	19		 			
3.5 - <u>5</u>	701.0	8 8 9	11	2			Medium dense brown GRAVEL (A-1-a), little to some fine to coarse sand, trace silt; damp.	0 0	\ \ \										
-		13 7 4	12	3				000	74	15		5	6	-		/ 			
- 1 <u>0</u>	-	8 4 6	9	4				0 (\ \ \										
- 12.5	692.0	26 13 13	16	5				00)										
- 1 <u>5</u> - - 2 <u>0</u> - - - 25							Bottom of Boring - 12.5'												

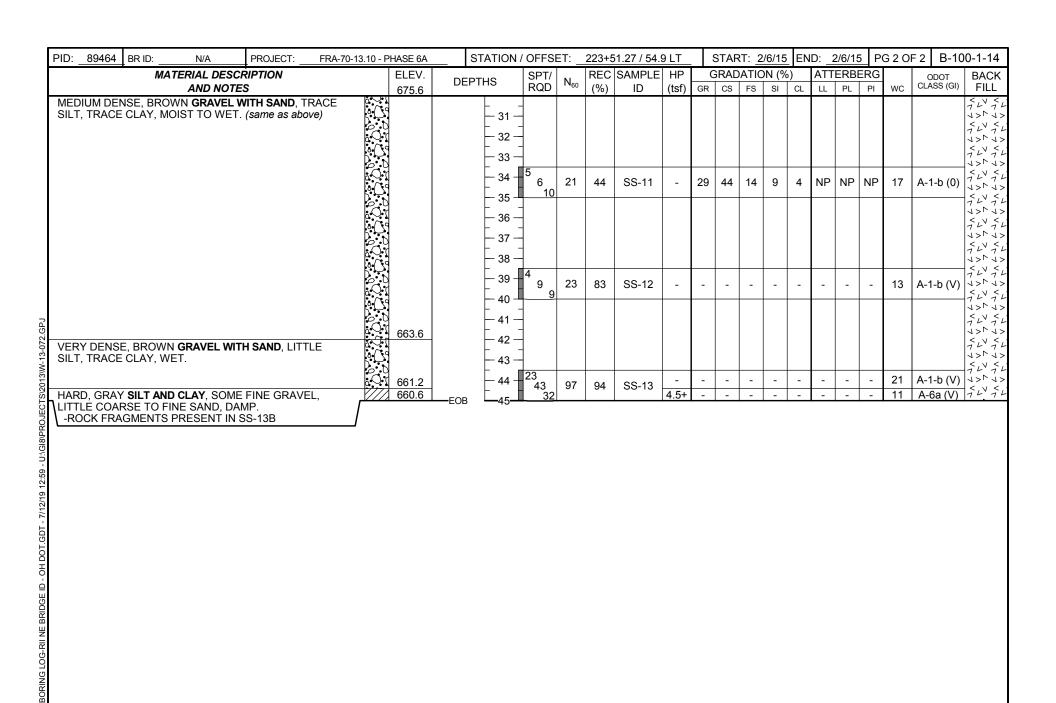
RESOURCE INTERNATIONAL, INC.

DRILLING FIRM	DRILLING FIRM / OPERATOR:			DR	DRILL RIG: MOBILE B-53 (SN 624400)				400)	STATION / OFFSET: 219					9+00.12 / 52.5' LT				EXPLORATION ID B-099-2-13	
SAMPLING FIRM / LOGGER: _		RII / C.D.		HA	HAMMER: A			JTOMATIC			NMEN	NT:		BL I-71 SB				B-09		
DRILLING METH	DRILLING METHOD:		4.5" CFA		CALIBRATION DATE:			1/26/13 ELEVAT			/ATIO	TION: 705.1 (MS			SL) EOB: 25.			25.0 ft.	PAGE	
SAMPLING MET	SAMPLING METHOD:		SPT		ENERGY RATIO (%):			77.7		LAT / LONG:				39.944984, -83.01				3	1 OF	
MATERIAL DESCRIPTION ELE		DEDTUG		SPT/	SPT/		REC SAMPLE		G	GRADATION (%)				ATTERBERG			ODOT	ODOT	BAC	
	705 1	DEPT	HS		N ₆₀	(%)	ID		GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)		
/**	704.9/							, ,											*****	
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		DRILLING F				II / J.K.				BILE B-53 (400)	STAT			ET:				8' LT		RATION II
Rii) TYPE: STRUCTURE		SAMPLING				/ C.D.		MMER:		AUTOMA			ALIG		_			_ I-71 S			- 🗀	PAGE
		DRILLING I			3.25" H			LIBRAT			4/26/13				_	705.0			EOB:		25.0 ft.	1 OF 1
		SAMPLING	METH		SPT	-	EN	ERGY F	`		77.7		LAT /							.014109	9	101
MATERIAL DESCRIPT	TION			ELEV.	DEPT	THS	SPT/			SAMPLE			RAD		N (%)	ATT	ERBI	ERG		ODOT	BACK
AND NOTES			8 / 2	705.0	<i>D</i>		RQD	160	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	FILL
0.2' - ASPHALT (2.0")		/		\704.8 <i>/</i>		-	-															
STIFF, REDDISH BROWN SILTY CLAY , "/ TO FINE SAND, LITTLE FINE GRAVEL, D		RSE				- 1 - - 2 -	4 3 3	8	39	SS-1	2.00	18	17	27	20	18	32	15	17	12	A-6b (2)	1 / 1 / 1 / 1 / 1 / 1 / 1 / 1 / 1
VERY STIFF, REDDISH BROWN CLAY , S				702.0		3 -																1> \ 1 \ 1
SOME COARSE TO FINE SAND, LITTLE I MOIST.	FINE GRVA	AEL,		699.5		- 4 - - - 5 -			46	ST-2	3.00	14	12	15	28	31	46	19	27	26	A-7-6 (12)	1 > 1 > 1 > 1 > 1 > 1 > 1 > 1 > 1 > 1 >
DENSE, GRAY GRAVEL , TRACE COARS SAND, TRACE SILT, TRACE CLAY, DAMP			000			6 7	7	34	39	SS-3	_	_	-	_	_	_	_	_	_	4	A-1-a (V)	1777
			000			- 7 - 8 -	12														,	1> \ 1 1 \ \ 1
			0000			- 9 - - 10	20 19 19	49	33	SS-4	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	1>11
DENSE, BROWN GRAVEL WITH SAND AI	יו דוופ חו	TTLE		694.5		F	-]
CLAY, MOIST. -ROCK FRAGMENTS PRESENT IN SS-5				692.0		- 11 - - - 12 -	15 12 13	32	89	SS-5	-	65	5	3	7	20	NP	NP	NP	12	A-2-4 (0)	1 × 1 × 1 × 1 × 1 × 1
MEDIUM DENSE TO DENSE, BROWN GF SAND , LITTLE SILT, TRACE CLAY, DAMF	RAVEL WITH TO WET.	Н		092.0		- 13 - - 14 -	17 14	39	56	SS-6	-	-	-	-	-	-	-	-	-	4	A-1-b (V)	7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
			60°			- 15 - - 16 -	16															1 L V 1
					W	17 -	14 15 11	34	44	SS-7	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	1 / 1 / 1 / 1 / 1
			00.0			- 18 - - 19 -	5 4	13	50	SS-8	_	60	17	6	12	5	26	20	6	21	A-1-b (0)	1 > V 1 7 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
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			0.0		▼	- 22 - - 23 -	-															1 × 1 × 1 ×
)		0.0	680.0	— ЕОВ	_ _ 24 -	11 5 6	14	89	SS-9	-	-	-	-	-	-	-	-	-	16	A-1-b (V)	1 > \ 1 \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \

MATERIAL DESCRIPTION ALL PLANT ALL P	PROJECT:	DRILLING FIRM /			_	LL RIG		BILE B-53 (400)	· ·	ΓΙΟΝ / NMEN	OFFS	SET: _		+00.0	0 / 69. SB	6' LT	EXPLO	RATIO 99-5-1
## STRETE		-			_						1		_	704.2				3	 80.0 ft.	PA
- CRAVEL AND ASPHALT (80") - CRAVEL AND ASPHALT					_						1								 S	10
- CRAVEL AND ASPHALT (80") - CRAVEL AND ASPHALT	MATERIAL DESCRIPTION	-1	ELEV.		→				HP	(RAD	ATIC	N (%	6)						BA
- GRAVEL AND ASPHALT (80°) - RY STIFE, GRAVEL, DAMP CORVER FARMENTS PRESENT IN SS-1 - TO 12 - TO 15						N ₆₀							$\overline{}$, ,	1			wc	CLASS (GI)	
RY SILF, GRAY SILT AND CLAY, LITTLE COARSE TO LESAND, THE PINE GRAVEL DAMP SOCK FRAGMENTS PRESENT IN SS-1		XX					(,,,,		(101)											***
RY STIFF DARK BROWN SILTY CLAY, SOME ARASE TO FINE SAND, SOME FINE GRAVEL, DAMP. 698.7 DIUM DENSE, BROWN GRAVEL WITH SAND AND T, LITTLE CLAY, DAMP TO MOIST. 698.7 DIUM DENSE, BROWN GRAVEL WITH MOIST. 698.7 DIUM DENSE, BROWN GRAVEL WITH SAND AND T, LITTLE CLAY, DAMP TO MOIST. 698.7 FOR THE SAND, SOME FINE GRAVEL, DAMP. 698.7 699.7 698.7 699.7 69	. ,	RSE TO			5	19	67	SS-1	3.50	-	-	-	-	-	-	-	-	15	A-6a (V)	V 7 7 V 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7 7
DIUM DENSE, BROWN GRAVEL WITH SAND AND TILLITILE CLAY, DAMP TO MOIST. 80CK FRAGMENTS PRESENT THROUGHOUT 893.7 10	(ERY STIFF, DARK BROWN SILTY CLAY , SOME COARSE TO FINE SAND, SOME FINE GRAVEL, DO -IRON STAINING PRESENT IN SS-2	AMP.		4 4	5	17	89	SS-2	3.75	24	12	12	26	26	37	19	18	16	A-6b (6)	- 1 7 V T - V
OCK FRAGMENTS PRESENT THROUGHOUT 1	EDIUM DENSE, BROWN GRAVEL WITH SAND AN ILT, LITTLE CLAY, DAMP TO MOIST.	ND STATE	698.7	6 7		25	39	SS-3	-	-	-	1	-	-	-	_	-	13	A-2-4 (V)	, , , .
DIUM DENSE TO DENSE, BROWN GRAVEL WITH ND , LITTLE SILT, TRACE CLAY, DAMP TO MOIST. ROCK FRAGMENTS PRESENT THROUGHOUT ROCK FRAGMENT THROUGHOUT ROCK FRAGM	ROCK FRAGMENTS PRESENT THROUGHOUT				9	23	50	SS-4	-	56	9	7	17	11	27	17	10	8	A-2-4 (0)	1 × 1 × 1 × 1 × 1 × 1
ROCK FRAGMENTS PRESENT THROUGHOUT 13			693.7	11 6	5 5	13	39	SS-5	-	_	_	-	-	_	_	_	_	7	A-1-b (V)	777
686.2 15				- - 13 -	0	19	39	SS-6	-	_	-	-	-	_	-	-	_	12	A-1-b (V)	7 4 7 4 7 7
DIUM DENSE TO DENSE, BROWN GRAVEL , SOME ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, DIST. 18	ROCK FRAGMENTS PRESENT THROUGHOUT			16 1	4 12	32	61	SS-7	-	58	17	9	12	4	NP	NP	NP	9	A-1-b (0)	-
ROCK FRAGMENTS PRESENT IN SS-10 -21 -22 -23 -24 4 5 17 33 SS-9 14 A-1-a (V) -25 -26 -27 -28 -29 9 14 35 44 SS-10 - 63 19 6 7 5 NP NP NP 13 A-1-a (0) 7		JIVIE F ^.	J	19 - 3	3	14	33	SS-8	-	-	-	-	-	-	-	-	-	8	A-1-a (V))
ROCK FRAGMENTS PRESENT IN SS-10 A-1-a (V) 7 7 7 7 7 7 7 7 7				- 21 - - 22 - 	,															77777777
ROCK FRAGMENTS PRESENT IN SS-10 ROCK FRAGMENT PRESENT PRESEN				24	5		33	SS-9	-	-	-	-	-	-	-	-	-	14	A-1-a (V)	17 >
ROCK FRAGMENTS PRESENT IN SS-10				- 26 - - 27 - 																V77 V77 V7
LOD	-ROCK FRAGMENTS PRESENT IN SS-10		<u> </u>	29		35	44	SS-10	-	63	19	6	7	5	NP	NP	NP	13	A-1-a (0)	
	OTES: GROUNDWATER ENCOUNTERED INITIALLY @ 1	7.5' AND AT COMP	LETION @	24.3'																

	\	ROJECT	:		x-70-13.1 STRUC		IASE 6A				OPERATOI / LOGGER:		I / J.K.		RILL RIG		BILE B-53 (400)		TION / NMEN		SET: _				.9' LT	EXPLO	
KII		/PE: D:	39464		STRUC BR ID:	TURE	N/A		RILLING I			3.25" H			ALIBRAT		AUTOMA	4/26/13	,	ELEV		_	705.6		_ I-71 :			_ 5.0 ft.	
		D TART:		□ 6/15	END	٠.	2/6/15		AMPLING			3.25 F			NERGY I			4/20/13 77.7	,	LAT /			705.0				.014617		
	3	IAKI.			_				AWFLING) IVI⊏ I I	ELEV.	35		_	_								١				.014017		Ļ
			IVIA		AL DES		TION					DEP ⁻	ΓHS	SPT/ RQD		(%)	SAMPLE	1		cs		SI (%	CL		ERBI PL			ODOT CLASS (GI)) E
0.2' - TC)DC	OII (2	0"\	A	ND NO	IIES				<u> </u>	705.6		1	NQD		(%)	ID	(tsf)	GR	US	F5	51	CL	LL	PL	PI	WC	02 100 (0.)	
VERY S				CL AV	/ COM		IE CDAY	/FI	/	`###	\705.4/		F 1 ¬																V 7 1
							E SILT, N]		- ']	3 _	16	100	SS-1	2.75	25	13	9	10	35	42	20	22	23	A 7 G (0)	$\frac{1}{2}$
-ROCK									•				<u></u>	5	7	100	33-1	2.75	25	13	9	18	აა	42	20	22	23	A-7-6 (8)	1/4
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-ROCK	(FR	AGME	NTS	PRES	SENT II	N SS	-3			10,0			- 6	6 8	22	50	SS-3										6	A-1-a (V)	17
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										10,0	<u> </u>		_ 16 _	15	70	100	SC 7		66	14	6	0	5	NP	NP	ND		A 1 a (0)	1
										β Z (<u> </u>		 17 -	33	1 10	100	SS-7	-	66	14	6	9	3	INP	INP	INP	4	A-1-a (0)) {
										PO C]		18 -																7
										100	}	W	+ ,	33	+														77
										600			_ 19 -	19	41	44	SS-8	-	-	-	-	-	-	-	-	-	7	A-1-a (V))
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VERY D)EN!	SE RD	\/\\\	I GR	VFI W	VITH 9	SAND I	ITTI F			003.0		 22	1															77
SILT, TE						•••••				$\circ \mathcal{O}$			_ 23 -	1															1
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-HEAV -INTRO						⊏∪ @	23.5			$\phi \circ \phi$]		_ 24 -		62	100	SS-9	-	55	23	6	11	5	20	16	4	9	A-1-b (0)) ~
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										0 ()	<u> </u>			L :	7									1			Ι 'Ŭ	/ · · · · (v)	' `<



AND NOTES TOPSOIL (3.0") TOPSOIL (3	24 58 21 47 15 47 15 36	100 DA RATIO (** REC (%) 67 39 100 100		4/26/13 77.7 HP (tsf) 4.5+	GR	ELEV LAT /	LONG	N:	37 - 4	(MSI 39.	9464: ERE PL 20	EOB: 6338, -8338, -8338, -8338	wc	ODOT CLASS (GI) A-7-6 (12) A-1-a (V) A-1-b (V) A-1-b (0)
## START: 2/6/15 END: 2/6/15 SAMPLING METHOD: SPT ### MATERIAL DESCRIPTION AND NOTES -TOPSOIL (3.0") RD, REDDISH BROWN CLAY, SOME SILT, LITTLE ARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. OOT FIBERS PRESENT IN SS-1 NSE TO VERY DENSE, BROWN GRAVEL, LITTLE ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MP. NSE TO VERY DENSE, BROWN GRAVEL WITH SAND, FILE SILT, TRACE CLAY, DAMP. OCK FRAGMENTS PRESENT IN SS-6 OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. DIUM DENSE, BROWN	5 16 7 1 24 58 21 15 13 36 7 29 63	RATIO (** REC (%) 67 39 100 100	%): SAMPLE ID SS-1 SS-2 SS-3 SS-4	77.7 HP (tsf) 4.5+	15 - 71	7 - 10	ATIO FS 10 - 5	31 - 10	37 - 4	39. ATT LL 43 -	9464: ERE PL 20	338, -83 BERG PI 23 23 3	16 3 5	ODOT CLASS (GI) A-7-6 (12) A-1-a (V) A-1-b (V) A-1-b (0)
MATERIAL DESCRIPTION AND NOTES -TOPSOIL (3.0") RD, REDDISH BROWN CLAY, SOME SILT, LITTLE ARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. OOT FIBERS PRESENT IN SS-1 USE TO VERY DENSE, BROWN GRAVEL, LITTLE ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MP. USE TO VERY DENSE, BROWN GRAVEL WITH SAND, FILE SILT, TRACE CLAY, DAMP. OCK FRAGMENTS PRESENT IN SS-6 OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO ESAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. OUT OF THE SILT OF THE SAND, TOP SILT OF THE SILT	5 16 7 1 24 58 21 47 15 15 36 29 63	REC (%) 67 39 100 100	SAMPLE ID SS-1 SS-2 SS-3 SS-4	HP (tsf) 4.5+	15 - 71	7 - 10	10 - 5	31 - 10	37 - 4	43 - 20	20 - 17 -	23 3	16 3 5 3	ODOT CLASS (GI) A-7-6 (12) A-1-a (V) A-1-b (V) A-1-b (0)
AND NOTES TOPSOIL (3.0") TOP	5 16 7 1 24 58 21 47 15 36 7 20 63	(%) 67 39 100 100	SS-1 SS-2 SS-3 SS-4		15 - 71	7 - 10	10 - 5	31 - 10 -	37 - 4	20	20 - 17	23	16 3 5	A-7-6 (12) A-1-a (V) A-1-b (V) A-1-b (0)
TOPSOIL (3.0") RD. REDDISH BROWN CLAY, SOME SILT, LITTLE ARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. OOT FIBERS PRESENT IN SS-1 INSE TO VERY DENSE, BROWN GRAVEL, LITTLE ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MP. INSE TO VERY DENSE, BROWN GRAVEL WITH SAND, FILE SILT, TRACE CLAY, DAMP. OOK FRAGMENTS PRESENT IN SS-6	7 1 24 21 8 21 47 15 15 13 7 20 29 63	67 39 100 100	SS-1 SS-2 SS-3 SS-4	4.5+	15 - 71 -	7 - 10	10 - 5	31 - 10 -	- 4	20	20	23	16 3 5	A-1-a (V) A-1-a (0) A-1-b (V)
RD, REDDISH BROWN CLAY, SOME SILT, LITTLE ARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. OOT FIBERS PRESENT IN SS-1 NSE TO VERY DENSE, BROWN GRAVEL, LITTLE ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MP. OO 698.0 RY DENSE, GRAY GRAVEL, TRACE COARSE TO FINE ND, TRACE SILT, DAMP. OOCK FRAGMENTS PRESENT IN SS-6 OO 684.0 OO 684.0 OO 684.0 OO 684.0 OO 684.0	7 1 24 21 8 21 47 15 15 13 7 20 29 63	39 100 100	SS-2 SS-3 SS-4	-	71	10	5	10	4	20	17	3	5 3	A-1-a (V) A-1-a (0) A-1-b (V)
ARSE TO FINE SAND, LITTLE FINE GRAVEL, DAMP. OOT FIBERS PRESENT IN SS-1 NSE TO VERY DENSE, BROWN GRAVEL, LITTLE ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MP. OOS 698.0 OO	7 1 24 21 8 21 47 15 15 13 7 20 29 63	39 100 100	SS-2 SS-3 SS-4	-	71	10	5	10	4	20	17	3	5 3	A-1-a (V) A-1-a (0) A-1-b (V)
OOT FIBERS PRESENT IN SS-1 NSE TO VERY DENSE, BROWN GRAVEL, LITTLE ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MP. NSE TO VERY DENSE, BROWN GRAVEL WITH SAND, FILE SILT, TRACE CLAY, DAMP. RY DENSE, GRAY GRAVEL, TRACE COARSE TO FINE ND, TRACE SILT, DAMP. OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. OCC 684.0 703.0 703.0 703.0 703.0 703.0 703.0 698.0 698.0 703.0 688.0 703.0 688.0 688.0 703.0 688.0 688.0 688.0 688.0 688.0 688.0 688.0 688.0 688.0	7 1 24 21 8 21 47 15 15 13 7 20 29 63	39 100 100	SS-2 SS-3 SS-4	-	71	10	5	10	4	20	17	3	5 3	A-1-a (V) A-1-a (0) A-1-b (V)
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ARSE TO FINE SAND, TRACE SILT, TRACE CLAY, MP. 4 3 5 698.0 NSE TO VERY DENSE, BROWN GRAVEL WITH SAND, TLE SILT, TRACE CLAY, DAMP. RY DENSE, GRAY GRAVEL, TRACE COARSE TO FINE ND, TRACE SILT, DAMP. OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.	24 58 21 47 15 36 13 7 20 63	100	SS-3 SS-4 SS-5	-	-	-	-	10	-	-	-	-	5	A-1-a (0) A-1-b (V) A-1-b (0)
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RY DENSE, BROWN GRAVEL, TRACE COARSE TO FINE ND, TRACE SILT, DAMP. OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.	15 36 13 7 20 63	100	SS-5	-	62	15	7	14	2	- NP	- NP	- NP		A-1-b (0)
RY DENSE, GRAY GRAVEL, TRACE COARSE TO FINE ND, TRACE SILT, DAMP. OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.	15 36 13 7 20 63	100	SS-5	-	62	15	7	14	2	- NP	- NP	- NP		A-1-b (0)
RY DENSE, GRAY GRAVEL, TRACE COARSE TO FINE ND, TRACE SILT, DAMP. OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.	7 20 29			-	62	15	7	14	2	NP	NP	NP	3	,
RY DENSE, GRAY GRAVEL, TRACE COARSE TO FINE ND, TRACE SILT, DAMP. 13	20 63 29			-	62	15	7	14	2	NP	NP	NP	3	,
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RY DENSE, GRAY GRAVEL , TRACE COARSE TO FINE ND, TRACE SILT, DAMP. OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL , SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.	29			-	62	15		14	2	NP	NP	NP	3	,
RY DENSE, GRAY GRAVEL , TRACE COARSE TO FINE ND, TRACE SILT, DAMP. - 14 - 50 - 15 - 16 - 37 - 17 - 18 - 18 - 19 - 42 - 20 - 21 - 21 - 22 - 23 - 24 - 7		50 /	SS-6											A 1 = 00
OCK FRAGMENTS PRESENT IN SS-6 DIUM DENSE, BROWN GRAVEL, SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET. 14 - 15 - 16 - 37 - 17 - 18 - 42 - 21 - 21 - 22 - 23 - 24 - 7)/2" / -	50 /	SS-6	h - 6										A 1 = AA
OCK FRAGMENTS PRESENT IN SS-6	<u> </u>	7 50 /	_ 55-6								+	+		
OCK FRAGMENTS PRESENT IN SS-6					/	\ <u>-</u>	∤	∤			<u> </u>	ᠰ-		A-1-a (V)
OCK FRAGMENTS PRESENT IN SS-6														
OCK FRAGMENTS PRESENT IN SS-6 W 19 42														
OCK FRAGMENTS PRESENT IN SS-6 W 19 42		36	SS-7			_		_			Ι.	+	3	A-1-a (V)
OCK FRAGMENTS PRESENT IN SS-6 18 - 18 - 19 - 42 - 21 - 21 - 22 - 23 - 24 - 7	50/5" -	30	33-1	-	-		-	-		-	<u> </u>	<u> </u>		A-1-a (V)
OCK FRAGMENTS PRESENT IN SS-6 19 42 20														
DIUM DENSE, BROWN GRAVEL , SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.														
DIUM DENSE, BROWN GRAVEL , SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.	50/5" -	18	SS-8	-	1	-	-	-	-	-	-	-	6	A-1-a (V)
DIUM DENSE, BROWN GRAVEL , SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.	10/3											+		, ,
DIUM DENSE, BROWN GRAVEL , SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.														
DIUM DENSE, BROWN GRAVEL , SOME COARSE TO E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.														
E SAND, LITTLE SILT, TRACE CLAY, MOIST TO WET.														
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OCK EDACMENTS DESENT IN SS 10												+-	\vdash	1
ES: GROUNDWATER ENCOUNTERED INITIALLY @ 19.0' AND AT COMPLETION @ 23.4'	8 21	100	SS-10	-	-	-	-	-	-	-	-	-	22	A-1-a (V)

Client	msc	onsu	Itants	3			Project: FRA-70-8.93	000-00						Jo	b No.	0221	1-10	04.01	
LOG (DF: Bo	ring	B-10)1-0-0	9	Loc	cation: Sta. 226+52.84, 34.1' LT., BL I-71 SB			Da	te l	Drille	ed: 8	3/21/2	2009				
Depth (ft)	Elev. (ft)	Blows per 6"	Recovery	Sam _{No}		Hand Penetro- meter (tsf)	WATER OBSERVATIONS: Water seepage at: None Water level at completion: None FIELD NOTES: DESCRIPTION	Graphic Log	Aggregate	Sand	M. Sand	% F. Sand X	% Silt NO % Clay	Na	tural I PL	Moist	ure C	ontent,	N (N60) % - ● LL stic - NP
0.3	706.6						Topsoil - 3"												
-	700.4	12 9 8	11	1		4.5+	POSSIBLE FILL: Hard brown SILT AND CLAY (A-6a), little fine to coarse sand, trace gravel; damp.		5	6		12	43 34						
3.5 - <u>5</u>	703.4	24 15 15	9	2			POSSIBLE FILL: Dense to very dense brown GRAVEL (A-1-a), little fine to coarse sand, trace to little silt; damp.	0											
- - -		5 34 35	11	3				0 6	75	9		6	10	 NIP 					
10.0 ₁₀	696.9	17 35 28	12	4				0 (
- - 1 <u>15</u> - - - 2 <u>0</u> - - -							Bottom of Boring - 10.0'												

	PROJECT: FYPE:			13.10 - I	PHASE 6	iA	_		/ OPERATOR		RII / S		_	LL RIG MMER:		ME-55 (SI		5)		TION /	OFFS	SET:				9' LT	EXPLOR B-10	
	_	0464					_				RII / N	I.A.				AUTOM						706 /		_ I-71 :			_ 	Т
	PID:8		_		N/A		_		HOD:		" HSA				ION DA		10/20/14	+			N:	706.					5.0 ft.	-
	START: _	2/26/		END: _	2/26/		SAMPL	ING MET			SPT			RGY	RATIO (92	_	LAT /				_			.015140)	4_
		MATE			RIPTION	1			ELEV.	DE	PTH	s	SPT/	N ₆₀		SAMPLE			RAD		$\overline{}$		_	ERB			ODOT	, E
			AND	NOTES	3			K 23	706.1				RQD	. 160	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	
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1.0' - CON								$- \bowtie$	704.8		F	- 1 🚽																V 7 7
0.3' - AGG	REGATE	BASE	(3.0")				_/ 🚉	704.5			- 2 🗐	5															
MEDIUM D SAND, SIL				GRAY (3RAVE	L WIT	Н		703.1		F	3	5 7	18	56	SS-1	-	-	-	-	-	-	-	-	-	10	A-2-6 (V)) 7 <
VERY DEN	NSE, BR	SINWC	SH GR								F	4	6 17	54	100	SS-2	_	53	18	15	10	4	NP	NP	NP	4	A-1-a (0)	7 7 <
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-ROOK I	IVAOIVILI	11011	\LOLI\	41 1111	.00011	001		00			E	6	14															7
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MEDIUM D							RAVEL		698.1		-	- 8 -	10															77
VITH SAN	D, LITTL	E SILT	, TRAC	CE CLA	λΥ, MO	IST.			<u>,</u>		F		10 10 7	26	100	SS-4	-	-	-	-	-	-	-	-	-	6	A-1-b (V)) <
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	\	ROJEC [*]	T: _				PHASE 6	A	_		OPERATOR		I / J.K.				BILE B-53 (400)			OFFSI	ET: _				8' LT	EXPLO	
K III	_	YPE: _				ICTURE			_		/ LOGGER:		/ C.D.		MMER:		AUTOMA				NMEN				. I-71 S				1
			8946		BR ID:		N/A	_		G METHO		3.25" H			LIBRAT			4/26/13				N:	705.2					9.4 ft.	
	S	TART:		2/4/15	_	ND:	2/4/1		SAMPLI	NG METH		SPT		$\overline{}$	IERGY I			77.7	_	LAT /							.015436		<u>.</u>
			M				IPTION				ELEV.	DEPT	HS	SPT/			SAMPLE	1				N (%)			ERBE			ODOT	(E
					ND N	IOTES	<u> </u>				705.2			RQD	. •60	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	′
0.2' - TC											\705.0/		-																7
FILL: VE				BROW	N GR	AVEL	WITH:	SAND	, SILT,	<u>•</u>			<u></u> 1 1 1	9	-	88	SS-1	-	-	-	-	-	-	-	-	-	10	A-2-6 (V)) <
AND CL				IDON	ICTA	INIINIC	DDES	ENIT I	N SS-1				_ 2 _	50/2"	+														47
-11001		DLING.	AINL	iitoit	1017	IIVIIVO	TILLO	LINI	14 00-1	A-/ V	702.2																		<
DENSE													3 -																_ ′
COARS	ET	O FINE	E SA	ND, L	ITTLE	SILT	, TRAC	E CL	AY,	60	1		⊢ 4 −	15 13	47	100	SS-2	_		_	_		_	_	_	_	6	A-1-a (V)	\ _{7}
DAMP.										60				23		100	30-2			_	_		_	_			O	Λ-1-a (V)	1/
										600																			7
										1			− 6 ¬	8															۲ٍ ⊢
										60]		F 7 -	32	74	78	SS-3	-	71	10	5	11	3	NP	NP	NP	4	A-1-a (0)) 7
										[0/	697.2		- · I	25	-								_						-_{7}
LOOSE	TO	MEDI	UM I	DENS	E. BR	OWN	GRAVI	EL WI	TH		557.2		<u></u> 8 −																1
SAND, L										$\triangleright \bigcirc$	1		F 9 F	18	26	83	SS-4			_			_ [5	A-1-b (V)	17.
													- 40 H	11		၀၁	33-4	-	-	-	-	-	-	-	-	-	Э	A-1-0 (V)	/ 3
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													12	11	26	94	SS-5	_	56	14	7	17	6	20	17	3	6	A-1-b (0)) 1
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										₀ O (]		14	6 _															77
										\bigcirc	1			7 10	22	50	SS-6	-	-	-	-	-	-	-	-	-	12	A-1-b (V)) <
										þ, t	<u> </u>		15	10	1														1
										$b \sim 1$	<u> </u>		16	4				-											17
										1°C	1			4 5	13	39	SS-7	_	64	9	6	16	5	25	19	6	12	A-1-b (0)) 1
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DOC!	<i>,</i>) V C V 1	ENIT	ם חרב	CENIT	ר ואו פי	C 7 AN	D 66	0		 	W	 18 –																\ \ 1
-ROCK	\ FF	KAGIVIE	IN I C	PKE	SEN I	IIN 23	o-i AIN	D 99-	ю		,		19	6															7
]		- 19	5	10	67	SS-8	-	-	-	-	-	-	-	-	-	23	A-1-b (V)) ~
										0 (<u> </u>		20 -	- 3	+	-							\dashv						14
										o t			_ 21 _																7
										δQ.	683.2		-																<
VERY D	FN	SF BF	ROW	N GR	AVEL	WITH	ISAND	TRA	CF	-64	000.2		<u> </u>																1
SILT, TE								,	-	\Diamond	1		_ 23 _																7
-										p, c			F =	19									-						7
										$b \stackrel{\checkmark}{\sim} $	∮		_ 24 _	28	88	100	SS-9	-	-	-	-	-	-	-	-	-	13	A-1-b (V)) < 7 7
										1°C			_ 25 _	40)														/ - 7 7
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											070.0		26 -																<
MEDILIA	\1 P	CNOC	TO !	אראים		OVA/A	CDA\"	- 1 0/			678.2		_ 27 _																1
MEDIUN COARS										10 10	1 1		_ 28 _																< 7
MOIST.		J 1 114L	_ 0/	, אט, ו	IVACL	_ OIL I	, 111/70	,_ OL	, , ,		, 1		28 -	_															1
										600	1		29 -	7 8	25	100	SS-10	_	_	_	_	_	_	_	_	_	11	A-1-a (V)) <
										10/	1			1 11		.50	55-10	1	1								l ''	a (v)	/ ²

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 200 LBS BENTONITE CHIPS AND SOIL CUTTINGS

	FRA-70-13.10 - PHASE 6A		OPERATOR:		II / S.B.				ME 750 (SI		3)				ET: _				.2' RT	EXPLOR B-10	
Rii) TYPE:	STRUCTURE	SAMPLING FIRM	_		/ N.A.		MMER:		AUTOMA			ALIG			700.5		RAMF		4	. —	P
PID: 894		DRILLING METH		4.25" H						0/20/14		LAT /		N:	700.5					1.0 ft.	1
	2/6/15 END: 2/6/15	SAMPLING METI		SPT	1	= -	RGYF	RATIO (92.9					`				.015823		<u>.</u>
N	IATERIAL DESCRIPTION		ELEV.	DEP1		SPT/ RQD	N ₆₀		SAMPLE	1		RAD		_	,			ERG	1	ODOT CLASS (GI)	B
0.0L TODOOH (0.0L	AND NOTES		700.5			KŲD		(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	OLAGO (GI)	
0.2' - TOPSOIL (2.0")	AY GRAVEL , LITTLE COAR		700.3		 																7 1
FINE SAND LITTLE	SILT, TRACE CLAY, MOIST.	SE IO					17	20	00.4		70	7	2	44	2	NP	NP	ND	_	A 1 = (O)]{
1 1142 0/1140, 211 122 1	5121, 110 (OZ OZ/(1, WO)O1.	60	d l		<u></u>	8 3	17	39	SS-1	-	76	7	3	11	3	INP	NP	INP	8	A-1-a (0)	1:
		[• ()	9		☐ 3 ☐																7
-COBBLES PRESEN	IT @ 4.0'	Po			├ . ★	10															-4;
-COBBLES FRESEI	11 @ 4.0	βŎ				5	15	33	SS-2	-	-	-	-	-	-	-	-	-	10	A-1-a (V)	17.
		60			<u></u> 5 <u> </u>	5															- 3
		0			Lad																_ 4;
		 -	ا ا		- 6 T	6	15	22	SS-3	_			_]		_				8	A-1-a (V)	17
					<u></u> 7 ┨	4	13		33-3			_	_	_		L		_	0	Λ-1-a (V)	7 <
0005 050000			692.5		F 8 -																77
LOOSE, BROWN GR DAMP.	AVEL WITH SAND, SILT, AN	D CLAY,	A		F .	2															- 3
DAIVIE.					9	3	12	33	SS-4	-	64	6	5	17	8	30	19	11	14	A-2-6 (0)	1/1
			690.0		10	5															7
OOSE TO MEDIUM	DENSE, BROWN GRAVEL,	LITTLE	-	/	11 🚽																_ <
COARSE TO FINE SA	AND, LITTLE SILT, TRACE (٩		- H	1	5	44	SS-5	_		_	_		_	_	_	_	14	A-1-a (V)	177
MOIST TO WET.					12	' 2	5	**	33-3	-	_	-	-	-	-	-	-	-	14	A-1-a (V)	1
			a		F 13 -																7
					⊢	2															7
		,0	d l		14	3	11	33	SS-6	-	-	-	-	-	-	-	-	-	19	A-1-a (V)) <
-INTRODUCED MUI	0 @ 15.0'	[• ()	685.0		15	4															77
DENSE TO VERY DE	NSE, BROWN GRAVEL , LIT	TLE PY	(16																
COARSE TO FINE SA	AND, LITTLE SILT, TRAĆE (CLAY,	٩		- H	13	48	100	SS-7	_	68	12	5	13	2	NID	NP	ND	12	A-1-a (0)	1
MOIST.	0 DDE0ENT IN 00 7				<u></u> 17 −	15 17	40	100	33-1	-	00	12	5	13	2	INF	INF	INF	13	A-1-a (0)) <
-ROCK FRAGMENT	S PRESENT IN SS-7		a		F 18 -																7<
					⊢ ⊯	13															77
		,0	d l		_ 19 _	15	57	50	SS-8	-	-	-	-	-	-	-	-	-	10	A-1-a (V)) \frac{1}{7}
		[• ()	d		20	23															1
		Po			21 —																7
		$\stackrel{\circ}{\circ}$			F 4																1 / 7
		\cdot]		_ 22 _																1
		100			_ 23 _																7
			ا			15															- 4
]		_ 24 _	17	60	56	SS-9	-	-	-	-	-	-	-	-	-	12	A-1-a (V)) < 7 / 2
		00	√		25	23															-\'\\ 1
		[0 (d		26 —																14:
		Po	673.5		⊢ ⊢																7
MEDIUM DENSE GE	AY GRAVEL WITH SAND , T	RACE	073.3		<u> </u>																1:
SILT, TRACE CLAY,		, C	d		_ 28 _																< T 7
, ,		0.1			⊢ ⊯	18) 1 ;
		In () (rı l		⊢ 29 −	10	29	50	SS-10	1		1				I	İ	1	9	A-1-b (V)	. 17

TYPE: STRUCTURE PID: 89464 BR ID: N/A START: 3/26/15 END: 3/2 MATERIAL DESCRIPTION AND NOTES 1.1' - TOPSOIL (1.0") STIFF TO VERY STIFF, DARK GRAY TO DASTROWN CLAY, LITTLE TO "AND" SILT, TRACOARSE TO FINE SAND, TRACE TO SOME DAMP TO MOIST. -ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRACOARSE TO FINE SAND, TRACE SILT, TRACOARSE TO FINE SAND, TRACE SILT, TRACOARSE TO FINE SAND, TRACE SILT, TRACOARSE TO FINE SAND, TRACE SILT, TRACOIST. -COBBLES PRESENT @ 13.0'	DRILLING SAMPLIN N RK GRAYISH CE TO SOME	S METHONG METH	HOD: ELEV. 703.3	4.25" H SP'	THS - 1 - 2 - 3 - 4 - 5 - 6 - 6 - 6	CAL ENE SPT/ RQD	MMER: LIBRATI ERGY R N ₆₀	ON DA' ATIO (9 REC (%)		0/20/14 92.9	GR	ELEV LAT /	LONG	N: 3: N (%)		(MSL	94776 ERBI	EOB: 4, -83. ERG	016137 WC	ODOT CLASS (GI) A-7-6 (V)
START: 3/26/15 END: 3/2 MATERIAL DESCRIPTION AND NOTES 1.1' - TOPSOIL (1.0") STIFF TO VERY STIFF, DARK GRAY TO DASTROWN CLAY, LITTLE TO "AND" SILT, TRACOMED AND TO MOIST. -ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRACOMED AND TRACE SILT, TRACOMED AND TRACE SILT, TRACE SILT, TRACOMED AND TRACE SILT, TRACE SILT, TRACE SILT, TRACOMED AND TRACE SILT, TRACE SIL	7/15 SAMPLIN N RK GRAYISH CE TO SOME	NG METH	HOD: ELEV. 703.3	SP [*]	THS - 1 - 2 - 3 - 4 - 5 - 6 - 6 - 6	SPT/RQD 5 4 3	N ₆₀	ATIO (SPEC) (%)	%): SAMPLE ID	92.9 HP (tsf)	GR	LAT /	LONG	G: N (%) SI)	39.9 ATT	94776 ERBI	4, -83. ERG	016137 WC	ODOT CLASS (GI)
AND NOTES 1.1' - TOPSOIL (1.0") STIFF TO VERY STIFF, DARK GRAY TO DA BROWN CLAY, LITTLE TO "AND" SILT, TRA COARSE TO FINE SAND, TRACE TO SOME OAMP TO MOIST. -ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA MOIST.	RK GRAYISH CE TO SOME		703.3 703.2	DEP'	- 1 - 2 3 4 - 5 - 6 - 6 - 6	FQD 5 4 3 1 6 7	11	33	ID	(tsf)	GR			SI	,	ATT	ERB	ERG	WC	ODOT CLASS (GI)
AND NOTES 1.1' - TOPSOIL (1.0") STIFF TO VERY STIFF, DARK GRAY TO DA BROWN CLAY, LITTLE TO "AND" SILT, TRA COARSE TO FINE SAND, TRACE TO SOME OAMP TO MOIST. -ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA MOIST.	RK GRAYISH CE TO SOME		703.3 703.2	DEP	- 1 - 2 3 4 - 5 - 6 - 6 - 6	FQD 5 4 3 1 6 7	11	33	ID	(tsf)	GR			SI	,					A-7-6 (V)
ETIFF TO VERY STIFF, DARK GRAY TO DAR GROWN CLAY, LITTLE TO "AND" SILT, TRACOARSE TO FINE SAND, TRACE TO SOME DAMP TO MOIST. -ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRACOARSE TO FINE SAND, TRACE SILT, TRACOIST.	CE TO SOME		703.2		3 - 4 - 5 - 6	1 6 7			SS-1	1.50	-	-	-	-	-	-	-	-	28	A-7-6 (V)
BROWN CLAY, LITTLE TO "AND" SILT, TRACORSE TO FINE SAND, TRACE TO SOME DAMP TO MOIST. -ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRACOARSE TO FINE SAND, TRACE SILT, TRAMOIST.	CE TO SOME				3 - 4 - 5 - 6	1 6 7			SS-1	1.50	-	-	-	-	-	-	-	-	28	A-7-6 (V)
COARSE TO FINE SAND, TRACE TO SOME DAMP TO MOIST. -ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRACOARSE TO FINE SAND, TRACE SILT, TRACOIST.					3 - 4 - 5 - 6 - 6	3 1 6 7			SS-1	1.50	-	-	-	-	-	-	-	-	28	A-7-6 (V)
-ROCK FRAGMENTS PRESENT IN SS-4 MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,				- 4 - 5 - 6 -	7	20	100												
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA					- 4 - 5 - 6 -	7	20	100												1
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA					5	7	20	400												
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA					- 6 -	7		100	SS-2	3.50	5	3	3	58	31	54	25	29	23	A-7-6 (18)
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA					- 6 - 7	_														
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA					7	2								-						
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA						- 4 6	15	100	SS-3	3.50	-	-	-	-	-	-	-	-	24	A-7-6 (V)
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA					8 -	0														
MEDIUM DENSE TO DENSE, BROWN GRA COARSE TO FINE SAND, TRACE SILT, TRA			-			1								+						
COARSE TO FINE SAND, TRACE SILT, TRA MOIST.]		9 +	4	12	78	SS-4	1.50	33	21	7	15	24	43	21	22	18	A-7-6 (4)
COARSE TO FINE SAND, TRACE SILT, TRA MOIST.			692.8		_ 10 _	- 4														
MOIST.	/EL, SOME	0,0	9		11 -	5														
-COBBLES PRESENT @ 13.0'	CE CLAT,	600			12	8 _	23	33	SS-5	-	-	-	-	-	-	-	-	-	4	A-1-a (V)
-COBBLES PRESENT @ 13.0'		60	<u> </u>		- 13 -															
		600			- I	7														
		0	1		14	14	36	0	SS-6	-	-	-	-	-	-	-	-	-	-	
		60	d	W	15	10 4	-	100	3S-6A	-	69	19	5	6	1	NP	NP	NP	14	A-1-a (0)
		00			16	7														
		600	a l		17	ً 4 ج	14	0	SS-7	-	-	-	-	-	-	-	-	-	-	
		000	685.3		- H	6	-	100	3S-7A	-	-	-	-	-	-	-	-	-	11	A-1-a (V)
ENSE TO VERY DENSE, GRAY GRAVEL V	VITH SAND,		4		<u></u> 18 - 1	8														
'RACE SILT, TRACE CLAY, MOIST. -HEAVING SANDS ENCOUNTERED @ 18.	5'		;		19	9	32	100	SS-8	-	-	-	-	-	-	-	-	-	17	A-1-b (V)
-INTRODUCED MUD @ 20.0'		$\overset{\circ}{\circ}\overset{\circ}{\circ}$	4		_ 20 _	12								+						
20.0		P. C.			_ 21 _															
					- 22 -															
		$\circ \bigcirc$	d																	
		o t			— 23 —	7														
			å		_ 24 _	10 1	30	100	SS-9	-	37	51	4	5	3	NP	NP	NP	13	A-1-b (0)
		0.0	; l		_ 25 _	10														
		۵Q.			_ 26 _															
			i		- - 27 -															
			1		F -															
		$\lozenge \bigcirc$	٩ ١		- 28 -	6														A-1-b (V)
		6.0			- 29 -	6 18	51										1			

ABANDONMENT METHODS, MATERIALS, QUANTITIES: COMPACTED WITH THE AUGER 250 LBS BENTONITE CHIPS AND SOIL CUTTINGS

Di	PROJI	ECT:	FR		13.10 - P UCTURE		6A			/ OPERATO			I / S.B. / N.A.		DRILL HAMM		CN	ME 750X (S AUTOMA		18)		TION / NMEN		SET: _		+70.1		2.6' RT	EXPLO	
KIII	PID:		464	BR ID		N/A			LING METH		` -	4.25" HS					ON DA		10/20/14	1			— N:	700.0				4	5.0 ft.	F
	STAR		2/17/15		END:	2/18			PLING MET			SPT					ATIO (85.7		LAT /							016520		1
		_	MATER							ELEV.		_		SP	Τ.			SAMPLE		(RAD			7)		ERBI			ODOT	B
					NOTES		••			700.0		DEPT	HS	RQ		1 60	(%)	ID	(tsf)		cs		SI	CL	LL	PL PL		wc	CLASS (GI)	
0.3' - TOF	PSOIL	(4.0							A	699.7	$\overline{\mathcal{A}}$						(70)		(10.)											< 7
VERY ST			<u> </u>	OWN	CLAY	′. "AN	D" SIL	Т.	─ / ⊞	H (000.17)			<u> </u>	14																7:
TRACE C													-	H ⁴ 7	, ;	20	100	SS-1	4.25	0	1	5	40	54	54	22	32	24	A-7-6 (19	1) ~
-ROOT	FIBER	S PF	RESENT	ΓINS	SS-1					Ħ			_ 2		7					Ĺ										17
													— 3	-																7
									H	Ħ			_ 4	2					Ī											7
										\blacksquare				3	3	9	33	SS-2	2.75	-	-	-	-	-	-	-	-	20	A-7-6 (V)) 4
										694.5			_ 5	1																7
LOOSE T							/EL W	/ITH	6	1			— 6	1 2		\dashv			-											\\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
SAND, SI -IRON S						151.				N			7	<u></u> 3	3	7	39	SS-3	-	-	-	-	-	-	-	-	-	9	A-2-6 (V)) 7
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									<u>• (</u>	<u> </u>	W		8	┫																1
									Ď,	Ð			— 9	² 3	, -	11	44	SS-4										12	A-2-6 (V)	7
									<u> </u>				_ 10		5	' '	44	33-4	_	_		-	-	_	•	_	_	13	A-2-0 (V)	<u>'</u>] {
VEDV DE	- 10 =					<u> </u>			99	689.5	١,,		- 10	4																7
VERY DE FINE SAI								: 10	آ ه	رم ا	W		11	19																7
I IIVL OAI	ND, II	VACL	OIL1,	IIVAC	JE OLA	ii, ivic	JIO 1 .		20	d			_ 12	20		71	100	SS-5	-	66	12	10	9	3	NP	NP	NP	14	A-1-a (0)	1 4
									6 C	1			-		30															77
				_					[oC	59			_ 13																	_ <u>`</u>
-ROCK	FRAG	MEN.	IS AND	PET	ROLE	UM O	DOR I	PRESE	NT C	g			- 14	122 23	3 6	69	100	SS-6	_	l _	_	_	_	_	_	_	_	10	A-1-a (V)	1/1
IN SS-6 -COBBL	ES FI	NCOI	JNTFRI	ED ത	14 0'				6	7			- - 15		25		.00												(v)	17
MEDIUM						ITH 6	VND i	ITTI E		684.5	-		-	4																1 1 4
SILT, TR				GRA	VEL VVI	пп Э/	, עוווט, ו	_	0 (Ş q			<u>⊢</u> 16	3 _		†														77
-HEAVII	NG SA	NDS	ENCO		ERED @	<u>@</u> 16.0	0')	Ď			- 17	 	7	17	100	SS-7	-	22	37	25	12	4	NP	NP	NP	21	A-1-b (0)) <
-INTRO	DUCE	D MU	ID @ 16	6.0'					ġ.C	1			- - 18	_					<u> </u>											1
									P. (XI .																				77
									9	.d •d			_ 19	5 6	; .	19	100	SS-8	-	-	-	-	-	-	-	-	-	25	A-1-b (V)) \
										iq			_ 20		7	_			-										. ,	74
										õ			-	\exists																7
									á C	678.0			<u> </u>	7																1
MEDIUM	DENS	SF RI	SOMN	SANI	DY SII 1	T	TIFF	INF	- Infi	q 0/0.0	-		- 22	_																77
GRAVEL	, TRA	CE C	LAY, M	OIST.	. JIL	.,	1						_ 23	4																1
-IRON S			-																											17
-IIVON 3		ING F	INLOC!	NI IIN	00-8								<u> </u>	3 7	· _ :	20	100	SS-9	-	20	11	30	33	6	NP	NP	NP	19	A-4a (1)	177
													- 25	-	7				-											-\'\{7
													_ 26																	1
										673.0			-	4																7
DENSE T	O VF	RY D	ENSF	GRA	Y GRA	VEL '	"AND"	i .	b \		1		_ 27	_																1
COARSE									60	\ ⁹			_ 28	4																V77
MOIST.			•						000	ď			- - 29	13					1											-\^<
										1.1	1		— 20		5 12	39	100	SS-10	1				1			i	1	11	A-1-a (V)) 1

Rii		ROJECT YPE:	:		70-13.10 - TRUCTUF	PHASE 6A RE			OPERATOR / LOGGER:		I / S.B. / N.A.		LL RIG		CME 750 (S		8)		TION / NMEN		ET:		2+25.98 RAMP).3' RT	EXPLO	
		D:	89464		R ID:	N/A		LING METHO		4.25" H				ION DA		10/20/14	1			N:	703.0				3	5.0 ft.	
	S	TART: _	3/25	5/15		3/25/15	SAMI	PLING METH	HOD:	SPT				RATIO (92.9		LAT /							.016857		
			MAT	ERIA	L DESCI	RIPTION			ELEV.	DEPT	.ne	SPT/	N	REC	SAMPLE	HP	(RAD	ATIC	N (%)	ATT	ERBI	ERG		ODOT	E
				AN	D NOTE	S			703.0	DEFI	по	RQD	N ₆₀	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI))
0.3' - A	SPH	ALT (4	1.0")					/ 💥	702.7		-																₩
0.7' - F								/\	702.0		├ 1 ┰	3															-XX
VERY	STIF	F, DAF	K GR	AY TO	DARK	BROWNISH	GRAY				- 2 -	5 6	17	89	SS-1	2.75	2	7	3	62	26	43	26	17	31	A-7-6 (11) 1/2
TRACE	"ANI	J" SILI F GRA	, LIIII WEI I	TE CC	JARSE I T	TO FINE SA	MD,				-	- 0															-15
TIVAOL	_ ! !!	LOIV	· · · · · · ·	WICIO]		3 -																1
									1		⊢ 4 +	3 3	14	50	SS-2	_	l _	_	_	_	_	_	_	_	24	A-7-6 (V)	17
									007.5			6			002											,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	<u>'</u>]}
MEDIL	IM D	ENICE	DDOM	V/NI GE	DA\/EI\A	VITH SAND,	QII T	و ده	697.5																		1
AND C				VIN GF	XAVEL V	VIII SAND,	SILI,]		F 6 T	1_															7
	,							أرخ			⊢ 7 ⊢	5 6	17	33	SS-3	-	-	-	-	-	-	-	-	-	15	A-2-6 (V)) 4
								à.	695.0		8 -	"															77
						TO GRAY		100	\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	W	+ ° -	2															- 5
GRAVE TRACE	EL, S	OME C	COARS	SE TO	FINE S	AND, TRAC	E SILT,	1) ^			9 +	2 6	18	39	SS-4	_	60	25	7	5	3	NP	NP	NP	12	A-1-a (0)) 4
IRACE	E CL/	AT, IVIC	JIS1.						d l		F 10 ■	6						_		_						- (-)	17
								60	۱ ا		-																1
								Po			11 1																77
								ρQ	1		- 12 -	6 8	21	44	SS-5	-	-	-	-	-	-	-	-	-	17	A-1-a (V)) <
								[° ()'	9		13 -	0															1
								6		W	<u> </u>	4															1
								60			<u> </u>	4 5	14	56	SS-6	_	_	_	_	_	_	_	_	_	12	A-1-a (V)) \frac{1}{2}
								60			_ ₁₅ _	4															77
-PETI	ROLE	EUM O	DOR F	PRESI	ENT IN S	SS-6 AND S	S-7		d l		⊢ -	-															1
								60	ا ا		- 16 - 1	6															1
								Po			17	7,	17	100	SS-7	-	-	-	-	-	-	-	-	-	11	A-1-a (V)) 7
								60	1		- 10 -	- 4															7
								[° ()°	9		<u> </u>	1															77
								00			- 19 -	11 17	47	100	SS-8	_	65	26	0	7	2	NP	NP	NP	10	A-1-a (0)) 5
								60			_ ₂₀ _	14								·							1
-HEA	VINC	SAND	S EN	COUN	ITERED	@ 20.0'		50				-															7
									d l		21																\ \ \
								[0/05	9		<u> </u>																7
								Pool																			1
								βŎ			23 -	10					<u> </u>										17
								ŀΩ,			24	10 17	47	56	SS-9	_	_	_	_	_	_	-	_	_	9	A-1-a (V)) 7
								00			25	114	.,												Ĭ	u (v)	/ 1 × 1
								$\binom{0}{2}$																			1
								P. C.			_ 26 _																1
		0= 0=	:				. = =		676.0		_ 27 _																1
				KAVE	L WITH	SAND , LITT	LE SILT				-																77
TRACE	- UL/	₹T, IVIC	JIOI.						<u>'</u>		28 –																_ <
											29	7	53	100	SS-10		38	32	7	13	10	NP	NP	ND	11	A-1-b (0)	177
								0.00	g		F 1	14 21	00	100	33-10	-	30	JZ	'	13	10	INF	INF	INF	' '	√- 1-Ω (Ω)	1 3

PID: 89464 BR ID: N/A PROJECT: FRA-70-13.10 -	PHASE 6A	STATION /	OFFSET	Γ: <u>30</u> 1	12+25.98 / 120	.3 RT	S	TART: 3	/25/15	ENI	D: <u>3</u>	/25/1	5 PC	G 2 OF	2 B-10	5-6-14
MATERIAL DESCRIPTION	ELEV.	DEPTHS	SPT/	, F	REC SAMPLE	HP	GF	RADATIO	N (%)	ATT	ERBE	ERG		ODOT	BACK
AND NOTES	673.0	JEP I I I S	RQD '	N ₆₀ ((%) ID	(tsf)	GR	CS FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	FILL
VERY DENSE, GRAY GRAVEL WITH SAND , LITTLE SILT,																1 LV 1 L
TRACE CLAY, MOIST. (same as above)	·	- 31 -													1	< \ < \ < \ < \ < \ < \ < \ < \ < \ < \
	i l	- 32 -														1>N 1>
	<u> </u>														1	1 LV 1 L
	S	- 33 -	10												1	1>1/>
-ROCK FRAGMENTS PRESENT IN SS-11	1	- 34 -	12 22	59	56 SS-11	_	_	_ _	_	_	_	_	_	11	A-1-b (V)	1 LV 1 L
-ROOKT ROMENTO TRECENT IN 00-11	668.0 E	_{ОВ}	17		30									• •	(,)	1>1.1>

	PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM /	OPERATO	R:R	II / S.B.	DF	RILL RIG	:C	ME 750 (SI	N 98048	3)	STAT	ΓΙΟΝ /	OFFS	SET:	3010	+61.70) / 149).1' RT	EXPLOR	
Ri	TYPE: STRUCTURE	SAMPLING FIRM	/ LOGGER	RII	/ N.A.	HA	MMER:		AUTOMA	TIC		ALIG	NMEN	NT:		BL	RAMP	C3		_ B-10	7-3-14
	PID: <u>89464</u> BR ID: <u>N/A</u>	DRILLING METH	OD:	4.25" H	SA		LIBRAT			0/20/14	ļ	ELE\	/ATIO	N:	704.3	(MSL	_)	EOB:	2	25.0 ft.	PAGE
	START: <u>2/4/15</u> END: <u>2/4/15</u>	SAMPLING METH	HOD:	SPT	•	EN	IERGY F	RATIO (%):	92.9		LAT	/ LON	G:		39.	94872	6, -83.	017248	3	1 OF 1
	MATERIAL DESCRIPTION		ELEV.	חבחז	-1.10	SPT/		REC	SAMPLE	HP	(GRAD	ATIC	N (%	5)	ATT	ERBI	ERG		ODOT	BACK
	AND NOTES		704.3	DEPT	пъ	RQD	N ₆₀	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	FILL
	TOPSOIL (3.0")		704.0		-																1 LV 1
COAI	HARD, BROWN CLAY , "AND" SILT, TRACE RSE TO FINE SAND, DAMP. ICK AND ROCK FRAGMENTS PRESENT IN SS	i-1	-		- 1 - - 2 -	2 2 3	8	6	SS-1	4.5+	-	-	-	-	-	-	-	-	21	A-7-6 (V)	1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 ×
	Y STIFF, BROWN CLAY, "AND" SILT, TRACE		701.3		_ 3 -	2															7277
	RSE TO FINE SAND, DAMP TO MOIST.				- 4 - - - 5 -	4 5	14	100	SS-2	3.75	0	1	3	48	48	55	24	31	27	A-7-6 (19)	12/1
-RO	OOT FIBERS PRESENT IN SS-2 AND SS-3				6 -	3															1 1 2 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1 1
			696.3		- 7 -	3 8	17	100	SS-3	4.00	-	-	-	-	-	-	-	-	21	A-7-6 (V)	1>V 1
	IUM DENSE, BROWN GRAVEL WITH SAND AN , TRACE CLAY, DAMP.	D			- 8 - - 9 -	4 5	17	44	SS-4	-	44	14	9	24	9	26	18	8	7	A-2-4 (0)	1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 ×
	SE TO VERY DENSE, BROWN GRAVEL WITH S	SAND,	693.8		- 10 - - - 11 -		2														1777
	LE SILT, TRACE CLAY, DAMP TO MOIST. OCK FRAGMENTS PRESENT THROUGHOUT				- - 12 -	14 19 23	63	67	SS-5	-	-	-	-	-	-	-	-	-	6	A-1-b (V)	1>V 1
					- 13 - - - 14 -	6 15	47	67	SS-6	_	_	_	_	_	_	_	_	_	9	A-1-b (V)	1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 ×
	BBLES PRESENT @ 15.0'		688.8		15	16		0.												7(10(1)	12/1
SANI	IUM DENSE TO DENSE, BROWN GRAVEL WIT D, TRACE SILT, TRACE CLAY, MOIST.	H	0	-W	16 - - - 17 -	4 5	18	56	SS-7	_	72	16	4	6	2	NP	NP	NP	13	A-1-a (0)	12/1
-RO	OCK FRAGMENTS PRESENT IN SS-7	.0			_ 18 _	- 7	<u>'</u>														1>V 1
-HF	AVING SANDS ENCOUNTERED @ 20.0'				- 19 - - - 20 -	14 13 16	44	100	SS-8	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 ×
	_	00	682.3		21 22																77 Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y Y
	D, GRAY SANDY SILT , LITTLE FINE GRAVEL, LE CLAY, DAMP.				_ 23 -	21															1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 × 1 ×
			679.3		_ 24 -	21 27 29	84	39	SS-9	4.5+	16	15	21	34	14	20	13	7	8	A-4a (3)	17 × 1

		1			_														1
	PROJECT: FRA-70-13.10 - PHASE 6A	DRILLING FIRM /				ILL RIG		ME 750 (SI		3)				ET: _				2.2' RT	EXPLORAT B-107-4
Ri	TYPE: STRUCTURE	SAMPLING FIRM				MMER:		AUTOMA			ALIG					RAMP			- '
	PID: <u>89464</u> BR ID: <u>N/A</u>	DRILLING METHO		4.5" CFA			ION DA		10/20/14	-			N:	705.1					.0.0 It.
	START:2/4/15 END:2/4/15	SAMPLING METH		SPT	ENI	ERGY F	PATIO (92.9		LAT /							01741	
	MATERIAL DESCRIPTION		ELEV.	DEPTHS	SPT/	N ₆₀		SAMPLE	HP	G	RAD		N (%)	ATT		∃RG		ODOT E
	AND NOTES		705.1	DEI IIIO	RQD	1 160	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)
$\overline{}$	- TOPSOIL (5.0")		704.7		-														\ \frac{<}{7}
	RY STIFF, BROWN SILT AND CLAY , LITTLE CO FINE SAND, TRACE FINE GRAVEL, DAMP.	ARSE		- 1 - - - 2 -	3 7	23	33	SS-1	_	-	_	-	-	_	-	_	_	12	A-6a (V) 7
	OOT FIBERS PRESENT IN SS-1		702.1		8														< 1
FINE	RY STIFF, DARK BROWN CLAY , "AND" SILT, TF E SAND, TRACE FINE GRAVEL, MOIST. DOT FIBERS PRESENT IN SS-2	RACE		- 4 -	5 6 7	20	100	SS-2	3.50	1	0	10	45	44	47	22	25	24	A-7-6 (15)
MED	DIUM DENSE, BROWN GRAVEL WITH SAND , LI	TTIF	699.6	5 4															7 7 7
	, TRACE CLAY, DAMP TO MOIST.			- 6 - - 7 -	2 4 5	14	67	SS-3	-	-	-	-	-	-	1	-	-	11	A-1-b (V)
				- 8 -	3														\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \
-WC	OOD FRAGMENTS PRESENT IN SS-4			- 9 - 10	6	26	100	SS-4	-	37	21	18	19	5	NP	NP	NP	6	A-1-b (0)
		6 C		- 11 -															< ₇
				- 12 - - - 13 -															< 7 7 < 7 < 7 < 7 < 7 < 7 < 7 < 7 < 7 <
-RO	OCK FRAGMENTS PRESENT IN SS-5			— 14 —	7 4 3	11	50	SS-5	-	-	-	-	-	-	-	-	-	13	A-1-b (V)
			688.1	15 - - 16 -															7 4 7 7
	Y DENSE, BROWN GRAVEL , SOME COARSE SAND, TRACE SILT, TRACE CLAY, MOIST.	16 C		- 17 - - - 18 -															< 7 7 < 7
-RO	OCK FRAGMENTS PRESENT IN SS-6		1	_ 19 _	12 21	68	100	SS-6	_	66	16	6	10	2	NP	NP	NP	10	A-1-a (0)

APPENDIX IV

MSE WALL CALCULATIONS



Use $\varphi_{\tau} = 1.0$ (Per AASHTO LRFD BDM Table 11.5.7-1)

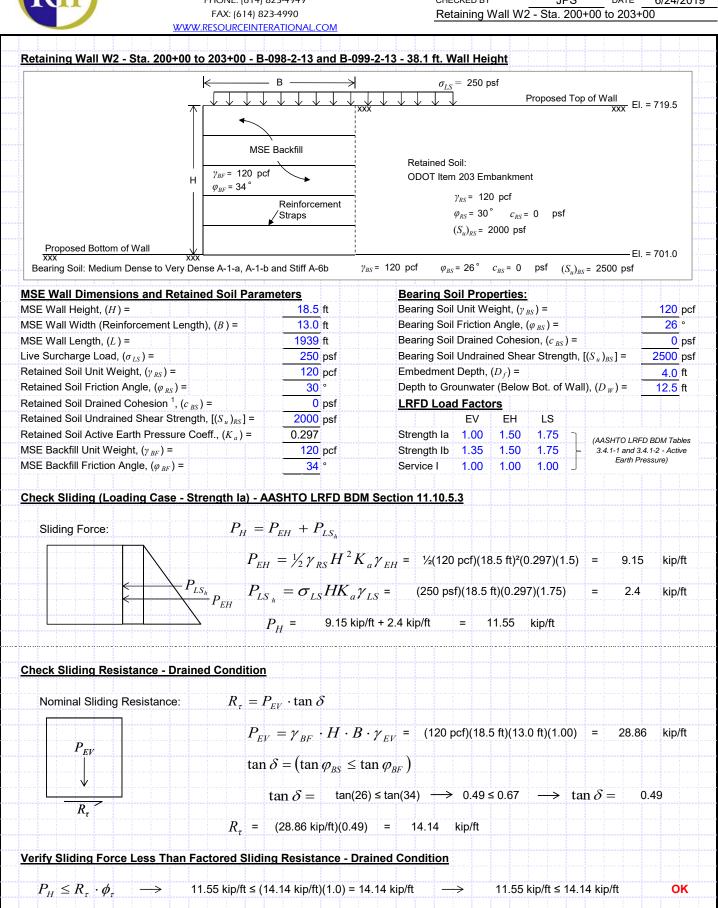
 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
 1
 OF
 6

 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

 Retaining Wall W2 - Sta. 200+00 to 203+00





 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
 2
 OF
 6

 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

Retaining Wall W2 - Sta. 200+00 to 203+00

ksf

WWW.RESOURCEINTEI	RATIONAL.COM	
MSE Wall Dimensions and Retained Soil Paran	<u>neters</u>	Bearing Soil Properties:
MSE Wall Height, (H) =	18.5 ft	Bearing Soil Unit Weight, (γ_{BS}) = 120 pcf
MSE Wall Width (Reinforcement Length), (B) =	13.0 ft	Bearing Soil Friction Angle, (φ_{BS}) = 26 °
MSE Wall Length, (L) =	1939 ft	Bearing Soil Drained Cohesion, $(c_{BS}) = 0$ psf
Live Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 2500$ psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment Depth, (D_f) = 4.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Grounwater (Below Bot. of Wall), (D_W) = 12.5 ft
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf	LRFD Load Factors
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000 psf	EV EH LS
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297	Strength Ia 1.00 1.50 1.75 \(\)
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf	Strength Ib 1.35 1.50 1.75 - 3.4.1-1 and 3.4.1-2 - Active
MSE Backfill Friction Angle, (φ_{BF}) =	34 °	Service I 1.00 1.00 1.00 Earth Pressure)

Check Sliding (Loading Case - Strength la) - AASHTO LRFD BDM Section 11.10.5.3 (Continued)

Check Sliding Resistance - Undrained Condition

Nominal Sliding Resisting: $R_{\tau} = \left(\left(S_u \right)_{BS} \leq q_s \right) \cdot B$ $\left(S_u \right)_{BS} = 2.50 \quad \text{ksf}$ $q_s = \frac{\sigma_v}{2} = (2.22 \, \text{ksf}) / 2 = 1.11 \quad \text{ksf}$ $R_{\tau} = \frac{\sigma_v}{2} = (2.886 \, \text{kip/ft}) / (13 \, \text{ft}) = \frac{\sigma_v}{2} = (28.86 \, \text{kip/ft}) / (13 \, \text{ft}) = \frac{\sigma_v}{2} = \frac{\sigma_v}{2} = (28.86 \, \text{kip/ft}) / (13 \, \text{ft}) = \frac{\sigma_v}{2} = \frac{\sigma_$

$$R_{\tau} = (2.50 \text{ ksf} \le 1.11 \text{ ksf})(13.0 \text{ ft}) = 14.43 \text{ kip/ft}$$

Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

Use $\varphi_{\tau} = 1.0$ (Per AASHTO LRFD BDM Table 11.5.7-1)

 $P_H \leq R_{\tau} \cdot \phi_{\tau} \longrightarrow 11.55 \text{ kip/ft} \leq (14.43 \text{ kip/ft})(1.0) = 14.43 \text{ kip/ft} \longrightarrow 11.55 \text{ kip/ft} \leq 14.43 \text{ kip/ft}$



JOB F	RA-70-13.10	NO.	W-13-072
SHEET NO.	3	OF	6
CALCULATED BY	BRT	DATE	6/23/2019
CHECKED BY	JPS	DATE	6/24/2019
Retaining Wall	W2 - Sta 200+00	to 203+	00

	X: (614) 823-4990 DURCEINTERATIONAL.COM	Retaining Wall W2 - Sta. 200+00 to 203-	+00
MSE Wall Dimensions and Retained S		Bearing Soil Properties:	
MSE Wall Height, (H) =	18.5 ft	Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
MSE Wall Width (Reinforcement Length), (B		Bearing Soil Friction Angle, (φ_{BS}) =	<u>26</u> °
MSE Wall Length, (L) =	1939 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Live Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	2500 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment Depth, (D_f) =	4.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Grounwater (Below Bot. of Wall), (D_W) =	12.5 ft
Retained Soil Drained Cohesion, (c_{RS}) =	0 psf	LRFD Load Factors	
Retained Soil Undrained Shear Strength, [(S	adaman da arang kanana kanana arang /del>	EV EH LS	
Retained Soil Active Earth Pressure Coeff.,	nininininininininininämmini jaan ja 	Strength Ia 1.00 1.50 1.75 7 (440)(751)	
		(AASHIU LR	RFD BDM Tables
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf	Forth F	3.4.1-2 - Active Pressure)
MSE Backfill Friction Angle, (φ_{BF}) =	34°	Service I 1.00 1.00 1.00 J	
Check Eccentricity (Loading Case - St	trength la) - AASHTO LRF e	D BDM Section 11.10.5.5	
	/2 /		
P_{EV}	$_{\scriptscriptstyle L}$ $_{\scriptscriptstyle L}$ $_{\scriptscriptstyle L}$ $_{\scriptscriptstyle L}$ $_{\scriptscriptstyle L}$ $_{\scriptscriptstyle L}$	= (187.59 kip·ft/ft - 78.66 kip·ft/ft) / (28.86 kip/ft) =	077.4
Γ	$x_o = {P_{}}$	- (101.39 KIP·IVIL - 10.00 KIP·ΤVΤΙ) / (28.80 KIP/TΙ) =	3.11 IT
	** EV		
	$M_{EV} = 187.59$	9 kip·ft/ft	
$x_o \not\models x \not\models e$	$M_H = 78.66$	kip·ft/ft Defined below	
$\downarrow \in B/2 \Rightarrow \downarrow$	$P_{EV} = 28.86$	kip/ft —	
/2 1			
	e = (13 ft)/2 - 3.7	77 ft = 2.73 ft	
Resisting Moment, M_{EV} :	$M_{\it EV} = P_{\it EV}(x_1)$		
	$P_{\scriptscriptstyle EV} \equiv \gamma_{\scriptscriptstyle BE} \cdot H \cdot B$	$v_{EV} = (120 \text{ pcf})(18.5 \text{ ft})(13.0 \text{ ft})(1.00) = 28.8$	36 kip/ft
P_{EV}	$P_{\scriptscriptstyle EV} = \gamma_{\scriptscriptstyle BF} \cdot H \cdot B$	$\gamma_{EV} = (120 \text{ pcf})(18.5 \text{ ft})(13.0 \text{ ft})(1.00) = 28.8$	36 kip/ft
P_{EV}			36 kip/ft
P_{EV}		$\gamma_{EV} = (120 \text{ pcf})(18.5 \text{ ft})(13.0 \text{ ft})(1.00) = 28.8$ 3.0 ft) / 2 = 6.50 ft	B6 kip/ft
P_{EV}	$x_1 = B_2 = (13)$	3.0 ft) / 2 = 6.50 ft	36 kip/ft
P_{EV}	$x_1 = B_2 = (13)$		86 kip/ft
P_{EV}	$x_1 = B_2 = (13)$	3.0 ft) / 2 = 6.50 ft	36 kip/ft
	$x_1 = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft	86 kip/ft
	$x_1 = B_2 = (13)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft	36 kip/ft
	$x_1 = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_H = P_{EH}(x_2) + P_{EH}(x_3)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $P_{LS_h}(x_3)$	
	$x_1 = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_H = P_{EH}(x_2) + P_{EH}(x_3)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $P_{LS_h}(x_3)$	
$\downarrow \qquad \qquad \downarrow \qquad $	$x_1 = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_H = P_{EH}(x_2) + P_{EH} = \frac{1}{2}\gamma_{RS}H^2K$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $Q_{LS_h}(x_3)$ $G_{a}\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$	
$\downarrow \qquad \qquad \downarrow \qquad $	$x_1 = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_H = P_{EH}(x_2) + P_{EH} = \frac{1}{2}\gamma_{RS}H^2K$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $Q_{LS_h}(x_3)$ $G_{a}\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$	5 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad $	$x_1 = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_H = P_{EH}(x_2) + P_{EH} = \frac{1}{2}\gamma_{RS}H^2K$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $Q_{LS_h}(x_3)$ $G_{a}\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$	
$\downarrow \qquad \qquad \downarrow \qquad $	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P$ $P_{EH} = \frac{1}{2} \gamma_{RS} H^{2} K$ $P_{LS_{h}} = \sigma_{LS} H K_{a} \gamma$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $C_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$	5 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad $	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P$ $P_{EH} = \frac{1}{2} \gamma_{RS} H^{2} K$ $P_{LS_{h}} = \sigma_{LS} H K_{a} \gamma$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $Q_{LS_h}(x_3)$ $G_{a}\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$	5 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad \qquad \qquad \qquad \downarrow \qquad \qquad $	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2}\gamma_{RS}H^{2}K$ $P_{LS_{h}} = \sigma_{LS}HK_{a}\gamma$ $x_{2} = \frac{H}{3} = (18)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $P_{LS_h}(x_3)$ $F_{a}\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $F_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$ 3.5 ft) / 3 = 6.17 ft	5 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad \qquad \qquad \qquad \downarrow \qquad \qquad $	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2}\gamma_{RS}H^{2}K$ $P_{LS_{h}} = \sigma_{LS}HK_{a}\gamma$ $x_{2} = \frac{H}{3} = (18)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $C_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$	5 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad \qquad \qquad \qquad \downarrow \qquad \qquad $	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2}\gamma_{RS}H^{2}K$ $P_{LS_{h}} = \sigma_{LS}HK_{a}\gamma$ $x_{2} = \frac{H}{3} = (18)$ $x_{3} = \frac{H}{2} = (18)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $C_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$ 3.5 ft) / 3 = 6.17 ft 3.5 ft) / 2 = 9.25 ft	5 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad \qquad \qquad \qquad \downarrow \qquad \qquad $	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2}\gamma_{RS}H^{2}K$ $P_{LS_{h}} = \sigma_{LS}HK_{a}\gamma$ $x_{2} = \frac{H}{3} = (18)$ $x_{3} = \frac{H}{2} = (18)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $P_{LS_h}(x_3)$ $F_{a}\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $F_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$ 3.5 ft) / 3 = 6.17 ft	5 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad \qquad \qquad \qquad \downarrow \qquad \qquad $	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2}\gamma_{RS}H^{2}K$ $P_{LS_{h}} = \sigma_{LS}HK_{a}\gamma$ $x_{2} = \frac{H}{3} = (18)$ $x_{3} = \frac{H}{2} = (18)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $C_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$ 3.5 ft) / 3 = 6.17 ft 3.5 ft) / 2 = 9.25 ft	5 kip/ft
Overturning Moment, M_H : P_{LS_h} P_I	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2}\gamma_{RS}H^{2}K$ $P_{LS_{h}} = \sigma_{LS}HK_{a}\gamma$ $x_{2} = \frac{H}{3} = (18)$ $x_{3} = \frac{H}{2} = (18)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $C_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$ 3.5 ft) / 3 = 6.17 ft 3.5 ft) / 2 = 9.25 ft	5 kip/ft
Overturning Moment, M_H : P_{LS_h} P_L Check Eccentricity	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2} \gamma_{RS} H^{2} K$ $P_{LS_{h}} = \sigma_{LS} H K_{a} \gamma$ $x_{2} = \frac{H}{3} = (18)$ $x_{3} = \frac{H}{2} = (18)$ $M_{H} = (9.1)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $C_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$ 3.5 ft) / 3 = 6.17 ft 3.5 ft) / 2 = 9.25 ft	5 kip/ft
Overturning Moment, M_H : P_{LS_h} P_I	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{EH}$ $P_{EH} = \frac{1}{2} \gamma_{RS} H^{2} K$ $P_{LS_{h}} = \sigma_{LS} H K_{a} \gamma$ $x_{2} = \frac{H}{3} = (18)$ $x_{3} = \frac{H}{2} = (18)$ $M_{H} = (9.1)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ $C_{LS} = (250 \text{ psf})(18.5 \text{ ft})(0.297)(1.75) = 2.4$ 3.5 ft) / 3 = 6.17 ft 3.5 ft) / 2 = 9.25 ft	5 kip/ft
Overturning Moment, M_H : P_{LS_h} P_L Check Eccentricity	$x_{1} = \frac{B}{2} = (13)$ $M_{EV} = (28.8)$ $M_{H} = P_{EH}(x_{2}) + P_{H}$ $P_{EH} = \frac{1}{2}\gamma_{RS}H^{2}K$ $P_{LS_{h}} = \sigma_{LS}HK_{a}\gamma_{EH}$ $x_{2} = \frac{H}{3} = (18)$ $x_{3} = \frac{H}{2} = (18)$ $M_{H} = (9.1)$	3.0 ft) / 2 = 6.50 ft 6 kip/ft)(6.50 ft) = 187.59 kip-ft/ft $C_{LS_h}(x_3)$ $C_a\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5) = 9.1$ LS = (250 psf)(18.5 ft)(0.297)(1.75) = 2.4 3.5 ft) / 3 = 6.17 ft 3.5 ft) / 2 = 9.25 ft 5 kip/ft)(6.17 ft) + (2.4 kip/ft)(9.25 ft) = 78.66	5 kip/ft



 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
 4
 OF
 6

 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

FAX: (614) 82 WWW.RESOURCEINTE		retaining wan w	
	<u>RATIONAL.COM</u>		V2 - Sta. 200+00 to 203+00
MSE Wall Dimensions and Retained Soil Parar		Bearing Soil Properties	ana kanana kanana Garana Samana kanana kanana kanana Garana Kanana kanana kanana
MSE Wall Height, (H) =	18.5 ft	Bearing Soil Unit Weight, (Y 55 /
MSE Wall Width (Reinforcement Length), (B) =	13.0 ft	Bearing Soil Friction Angle	
MSE Wall Length, (L) =	1939 ft	Bearing Soil Drained Cohe	aanaanaanii aanii ahaanaa Aanaani ahaanaa Aanaanii ————————————————————————————————
Live Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Undrained Sh	
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment Depth, (D_f) =	aanikaanaanikaanaanikaanaanikaanaanikaanaanikaanaani ja aasaa k aanaan
Retained Soil Friction Angle, (φ_{RS}) =	<u>30</u> °	Depth to Grounwater (Belo	ow Bot. of Wall), $(D_W) = 12.5$ ft
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf	LRFD Load Factors	
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000 psf	EV EH	
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297	Strength Ia 1.00 1.50	(AASHTO LRFD BDM Tables
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf	Strength lb 1.35 1.50	Forth Proceuro)
MSE Backfill Friction Angle, (φ_{BF}) =	34 °	Service I 1.00 1.00) 1.00 J
Check Bearing Capacity (Loading Case - Stren	nath lh) - AASHTO I	RED RDM Section 11 10 5 4	
$P_{LS_{v}}$	igili ib) - AASIII O L	KI D BDW Section 11.10.3.4	
	D /		
$q_{eq} =$	$r_{V/D'}$		
	/ D		
x_3 P_{EV} $B'=$	= B - 2e = 13.0	Oft - 2(1.76 ft) = 9.48	ft
\wedge Γ_{LS_h}			
P_{EH}	e = B/2 - x =	(13.0 ft) / 2 - 4.74 ft =	1.76 ft
	- 1 'L " 1 L L L		
	$r = \frac{M_V - M_H}{M_V}$	= (290.22 kip·ft/ft - 78.6	68 kip·ft/ft) / 44.65 kip/ft = 4.74
$x_o \leftarrow x_{-1} - e$	P_{ν}	- (230.22 Kip it/it = 70.0	70 Kip Itrity / 44.00 Kip/it = 14.74
$\stackrel{\longleftarrow}{\leftarrow} B' \stackrel{\longrightarrow}{\rightarrow} q_{eq}$	= (44 GE kin/ft)	' (9.48 ft) = 4.71 ks	
$+B' \rightarrow -$	= (44.65 kip/ft)	(9.46 ii) – 4.7 i k	sf
$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) = (\gamma_{BF} \cdot H)$	$H\cdot B\cdot \gamma_{EV})(x_1)$ \dashv	$+(\sigma_{LS}\cdot B\cdot \gamma_{LS})(x_1)$	
$M_V = [(120 \text{ pcf})(18.5 \text{ ft})(13.0 \text{ ft})(1.35)]$)](6.5 ft) + [(250 psf)(13.0 ft)(1.75)](6.5 ft) =	290.22 kip·ft/ft
$M_H = P_{EH}(x_2) + P_{LS_h}(x_3) = \left(\frac{1}{2}\gamma_{RS}\right)$	$H^2K \gamma_{FH}(x_2)$	$+(\sigma_{13}HK \nu_{13})(x_2)$	
$ LS_h (V2) - LS_h (V3) - V2/RS $	a7 EH J(**2)		
$M_H = [\frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.5)$	5)](6.17 ft) + [(250 ps	f)(18.5 ft)(0.297)(1.75)](9.25 f	ft) = 78.68 kip·ft/ft
$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$	$a + \sigma_{IS} \cdot B \cdot \gamma_{IS}$		
$P_{_{V}}=$ (120 pcf)(18.5 ft)(13.0 ft)(1.35) +	(250 psf)(13.0 ft)(1.7	75) = 44.65 kip/ft	
	_		
Check Bearing Resistance - Drained Condition	1		
Nominal Bearing Resistance: $q_{\scriptscriptstyle n} = c N_{\scriptscriptstyle cm}$ +	$+ \gamma D_f N_{qm} C_{wq} +$	$\frac{1}{2}\gamma BN_{ym}C_{w\gamma}$	
$N_{cm} = N_c s_c i_c = 22.32$	$N_{qm} = N_q s_q d_q i_q$	= 13.33 <i>N</i>	$i_{ij} = N_{\gamma} S_{\gamma} i_{\gamma} = 12.51$
- : cm - : c - c - c	$-\cdot qm - q - q - q - q$	/	· · · · · · · · · · · · · · · · · · ·
N_c = 22.25	N_q = 11.85	I	$N_{\gamma} = 12.54$
$S_{C} = 1+(9.48 \text{ ft/1939 ft})(11.85/22.25)$	$s_q = 1.002$		$S_{\gamma} = 0.998$
= 1.003			$i_{\gamma}^{'} = 1.000$ (Assumed)
i_c = 1.000 (Assumed)	1.123		$C_{yy} = 12.5 \text{ ft} < 1.5(9.48 \text{ ft}) + 4.0 \text{ ft} = 0.9$
	$i_q = 1.000$ (As		
	$C_{wq} = 12.5 \text{ft} > 4$		
$q_n = (0 \text{ psf})(22.317) + (120 \text{ pcf})(4.0 \text{ ft})$	(13.334)(1.000) + ½(120 pcf)(9.5 ft)(12.515)(0.940) = 13.09 ksf
Verify Equivalent Pressure Less Than Factore	d Bearing Resistan	ce Use $\omega_{ \scriptscriptstyle L} = 0.65$	5 (Per AASHTO LRFD BDM Table 11.5.7
		v v.o.	, 1. 3. 78 C. 11 C E.
$q_{eq} \leq q_n \cdot \phi_b \Longrightarrow 4.71 \text{ksf} \leq$	(13.09 ksf)(0.65) = 8	3.51 ksf → 4.71 l	ksf ≤ 8.51 ksf OK



FAX: (614) 823-4990 <u>WWW.RESOURCEINTERATIONAL.COM</u>

FRA-70-13.10 JOB NO. W-13-072 SHEET NO. OF 6 CALCULATED BY BRT DATE 6/23/2019 CHECKED BY JPS DATE 6/24/2019 Retaining Wall W2 - Sta. 200+00 to 203+00

MSE Wall Dimensions and Retained So	oil Parameters	Bearing Soil Propert	ies:		
MSE Wall Height, (<i>H</i>) =	18.5 ft	Bearing Soil Unit Weigh	$t, (\gamma_{BS}) =$	1	20 pcf
MSE Wall Width (Reinforcement Length), (B)) = 13.0 ft	Bearing Soil Friction Ang	gle, (φ_{BS}) =		26 °
MSE Wall Length, (L) =	1939 ft	Bearing Soil Drained Co	hesion, $(c_{BS}) =$		0 psf
ive Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Undrained	Shear Strength,	$[(s_u)_{BS}] = 25$	00 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment Depth, (D_f) =	· · · · · · · · · · · · · · · · · · ·	1.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Grounwater (B		I), $(D_W) = 12$	2.5 ft
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf	LRFD Load Factors			
Retained Soil Undrained Shear Strength, $[(S_u)]$	$(u_{RS}] = 2000 \text{ psf}$	and a configuration of the con	H LS		
Retained Soil Active Earth Pressure Coeff., (iniminiminiminimianimini — Simminiminiminimini	Strength Ia 1.00 1.	50 1.75 ¬	(440,170,1050,001	
MSE Backfill Unit Weight, (γ_{RE}) =	120 pcf	Strength lb 1.35 1.	50 1.75 -	(AASHTO LRFD BDM 3.4.1-1 and 3.4.1-2 -	
MSE Backfill Friction Angle, (φ_{BF}) =	34 °		00 1.00	Earth Pressure)
Check Bearing Capacity (Loading Case Check Bearing Resistance - Undrained		_RFD BDM Section 11.10.5	.4 (Continued)		
	$cN_{cm} + \gamma D_f N_{qm} C_{wq} +$	$V_2 \gamma B N_{m} C_{wv}$			
$N_{cm} = N_c s_c i_c = 5.150$	$N_{qm} = N_q s_q d_q i_q$		$p_m = N_{\gamma} s_{\gamma} i_{\gamma}$	= 0.000	
$N_c = 5.140$	$N_q = 1.000$		$N_{\gamma} = 0.000$		
	1.001 $S_q = 1.000$		$S_{\gamma} = 1.000$		
$i_C = 1.000 \text{ (Assumed)}$		°)[1-sin(0°)]²tan ⁻¹ (4.0 ft/9.48 ft)	$i_{\gamma} = 1.000$	(Assumed)	
r _C 1.000 (Assumed)	$a_q - \frac{1+2\tan(0)}{1.000}$	η. · οπιζο η τωπ (π.ο προ.40 π)		(Assumed) : 1.5(9.48 ft) + 4.0 ft	= 00
			_ _{wy}	· 1.∪(ฮ.40 IL) ∓ 4.U IL	- 0.8
$q_n = (2500 \text{ psf})(5.150) + (120)$	$i_q = 1.000 \text{ (A}$ $C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + ½	4.0 ft = 1.000	40) = 1	13.36 ksf	
/erify Equivalent Pressure Less Than	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + $\frac{1}{2}$ Factored Bearing Resistan	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice	40) = 1 1 ksf ≤ 8.68 ksf		
'erify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
/erify Equivalent Pressure Less Than	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
'erify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Gerify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Gerify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
'erify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_{_{n}} \cdot \phi_{_{b}} \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_{_{n}} \cdot \phi_{_{b}} \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_{_{n}} \cdot \phi_{_{b}} \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			
Verify Equivalent Pressure Less Than $q_{eq} \leq q_{_{n}} \cdot \phi_{_{b}} \longrightarrow 4.$	$C_{wq} = 12.5 \text{ ft} > 4$ pcf)(4.0 ft)(1.000)(1.000) + 1/2 Factored Bearing Resistan 71 ksf \leq (13.36 ksf)(0.65) = 8	4.0 ft = 1.000 ½(120 pcf)(9.5 ft)(0.000)(0.94 lice			



 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
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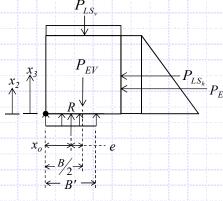
 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

 Retaining Wall W2 - Sta. 200+00 to 203+00

		F.	AX: (614)	823	-499	0		
ν	/W/W	'.RES	<u>OUR</u>	CEIN	ITER	ATIC	NAL	.CON	1
									-
Re	tain	ed	Soil	Pa	ram	etei	'S		

MSE Wall Height, (H) =	18.5 ft	Bearing Soil	Unit W	eight, (γ	_{RS}) =			120 pc
MSE Wall Width (Reinforcement Length), (B) =	13.0 ft	Bearing Soil	Friction	Angle, ($(\varphi_{BS}) =$			26 °
MSE Wall Length, (L) =	1939 ft	Bearing Soil) =		0 ps
Live Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil	Undrair	ned Shea	ar Stren	gth, [$[(s_u)_{BS}] =$	2500 ps
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment	Depth,	$(D_f) =$				4.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Gro	ounwate	r (Below	Bot. of	Wall), (D _W) =	12.5 ft
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf	LRFD Load	d Facto	ors .				
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000 psf		EV	EH	LS			
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297	Strength la	1.00	1.50	1.75	٦	(AASHTO I PI	-D BDM Tables
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf	Strength Ib	1.35	1.50	1.75	۲	3.4.1-1 and 3	3.4.1-2 - Active
MSE Backfill Friction Angle, (φ_{BF}) =	34 °	Service I	1.00	1.00	1.00	J	Earth P	ressure)



$$q_{eq} = \frac{P_{v}}{B}$$

$$P_{LS_h} P_{EH} = B - 2e = 13.0 \text{ ft} - 2(1.57 \text{ ft}) = 9.86 \text{ ft}$$

$$e = B/2 - x_o = (13.0 \text{ ft}) / 2 - 4.93 \text{ ft} = 1.57 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (208.72 \text{ kip·ft/ft} - 50.34 \text{ kip·ft/ft}) / 32.11 \text{ kip/ft} = 1.57 \text{ ft}$$

$$q_{eq} = (32.11 \, ext{kip/ft}) \, / \, (9.86 \, ext{ft}) = 3.26 \, ext{ksf}$$

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

$$M_V = [(120 \text{ pcf})(18.5 \text{ ft})(13.0 \text{ ft})(1.00)](6.5 \text{ ft}) + [(250 \text{ psf})(13.0 \text{ ft})(1.00)](6.5 \text{ ft}) = 208.72 \text{ kip-ft/ft}$$

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

$$M_H = [\frac{1}{2}(120 \text{ pcf})(18.5 \text{ ft})^2(0.297)(1.00)](6.17 \text{ ft}) + [(250 \text{ psf})(18.5 \text{ ft})(0.297)(1.00)](9.25 \text{ ft})$$
 = 50.34 kip-ft/ft

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

$$P_{V} = (120 \, {\rm pcf})(18.5 \, {\rm ft})(13.0 \, {\rm ft})(1.00) + (250 \, {\rm psf})(13.0 \, {\rm ft})(1.00) = 32.11 \, {\rm kip/ft}$$

Settlement, Time Rate of Consolidation and Differential Settlement:

	Boring	Total Settlement at Center of Reinforced Soil Mass	Total Settlement at Wall Facing	Time for 100% Consolidation	Distance Between Borings Along Wall Facing	Differential Settlement Along Wall Facing
	B-098-2-13	0.492 in	0.437 in	0 days		
	B-099-2-13	1.635 in	1.314 in	35 days	165 ft	1/2260
L						

W-13-072 - FRA-70-13.10 - Retaining Wall W2

MSE Wall Settlement - Sta. 200+00 to 203+00

Boring B-098-2-13

10.2 ft Total wall height

6.3 ft B'= Effective footing width due to eccentricity

12.5 ft Depth below bottom of footing

1,880 Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	t Center of R	einforced So	il Mass		Total Set	tlement at Fa	acing of Wall	
Layer	Soil Class.	Soil Type		Depth	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c ⁽²⁾	C _r (3)	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' ⁽⁶⁾	Z_f /B	I (7)	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-1-b	G	0.0	2.5	2.5	1.3	135	338	169	169	4,169					58	106	517	0.20	0.978	1,838	2,007	0.005	0.062	0.498	937	1,106	0.004	0.047
'	A-1-b	G	2.5	5.0	2.5	3.8	135	675	506	506	4,506					58	85	359	0.60	0.758	1,426	1,932	0.004	0.049	0.469	882	1,388	0.003	0.037
2	A-1-a	G	5.0	7.5	2.5	6.3	135	1,013	844	844	4,844					49	63	231	0.99	0.553	1,040	1,884	0.004	0.045	0.410	772	1,615	0.003	0.037
2	A-1-a	G	7.5	10.0	2.5	8.8	135	1,350	1,181	1,181	5,181					49	58	204	1.39	0.423	795	1,976	0.003	0.033	0.350	657	1,838	0.002	0.028
	A-1-b	G	10.0	13.0	3.0	11.5	125	1,725	1,538	1,538	5,538					22	24	83	1.83	0.332	625	2,162	0.005	0.064	0.294	552	2,090	0.005	0.058
3	A-1-b	G	13.0	16.0	3.0	14.5	125	2,100	1,913	1,788	5,788					22	23	81	2.30	0.268	504	2,292	0.004	0.048	0.247	464	2,252	0.004	0.045
	A-1-b	G	16.0	19.0	3.0	17.5	125	2,475	2,288	1,976	5,976					22	22	79	2.78	0.224	422	2,397	0.003	0.038	0.211	398	2,373	0.003	0.036
4	A-1-a	G	19.0	24.0	5.0	21.5	130	3,125	2,800	2,238	6,238					30	29	96	3.41	0.184	346	2,584	0.003	0.039	0.177	332	2,570	0.003	0.038
4	A-1-a	G	24.0	29.0	5.0	26.5	130	3,775	3,450	2,576	6,576					30	28	92	4.21	0.150	282	2,858	0.002	0.029	0.146	274	2,851	0.002	0.029
_	A-1-a	G	29.0	34.0	5.0	31.5	120	4,375	4,075	2,889	6,889					9	8	54	5.00	0.126	238	3,127	0.003	0.038	0.124	233	3,123	0.003	0.038
5	A-1-a	G	34.0	39.0	5.0	36.5	120	4,975	4,675	3,177	7,177					9	8	54	5.79	0.109	206	3,383	0.003	0.031	0.108	203	3,380	0.003	0.030
6	A-1-a	G	39.0	45.0	6.0	42.0	130	5,755	5,365	3,524	7,524					38	31	101	6.67	0.095	179	3,703	0.001	0.015	0.094	177	3,701	0.001	0.015
1. σ _p ' = σ _ν	, '+σ _m . Estima	te σ _m of 4,0	00 psf (mod	erately overc	consolidated)	for natural so	oil deposits;	Ref. Table 1	1.2, Coduto	2003	II.	L		L			1				Tota	l Settlement:		0.492 in		Total	Settlement:		0.437 in

Calculated By: BRT

Checked By:

Date: 6/23/2019

Date: 6/24/2019

onsolidated) for natural soil deposits; Ref. Table 11.2, Co

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} C_r = 0.10(Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

 $^{9. \ \} S_c = [C_o/(1+e_o)](H)log(\sigma_{v'}/\sigma_{v'}) \\ for \ \sigma_p' \leq \sigma_{vo'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)log(\sigma_p'/\sigma_{vo'}) \\ for \ \sigma_{vo'} < \sigma_{v'} \leq \sigma_{p'}; \ [C_r/(1+e_o)](H)log(\sigma_p'/\sigma_{vo'}) \\ for \ \sigma_{vo'} < \sigma_p' < \sigma_{v'}; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO \ LRFD \ BDS \ (Cohesive \ soil \ layers) \\ for \ \sigma_{vo'} < \sigma_{v'} < \sigma_{v$

^{10.} $S_c = H(1/C')log(\sigma_{vi}/\sigma_{vo})$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 - FRA-70-13.10 - Retaining Wall W2

MSE Wall Settlement - Sta. 200+00 to 203+00

Boring B-099-2-13

18.5 ft Total wall height H=

9.9 Effective footing width due to eccentricity

12.5 ft $D_w =$ Depth below bottom of footing

3,260 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	Center of Re	einforced So	il Mass		Total Set	ttlement at Fa	acing of Wall	
Layer	Soil Class.	Soil Type	Laye	Depth	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	Δσ _ν ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	1 (7)	Δσ _v ⁽⁸⁾ (psf)	σ _v ,' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-6b	С	0.0	3.5	3.5	1.8	120	420	210	210	4,210	40	0.270	0.027	0.585				0.18	0.984	3,207	3,417	0.072	0.867	0.499	1,626	1,836	0.056	0.674
2	A-2-6	G	3.5	6.0	2.5	4.8	130	745	583	583	4,583					32	45	150	0.48	0.831	2,710	3,292	0.013	0.150	0.482	1,570	2,153	0.009	0.113
2	A-1-b	G	6.0	8.5	2.5	7.3	130	1,070	908	908	4,908					36	46	151	0.73	0.678	2,210	3,117	0.009	0.106	0.451	1,469	2,376	0.007	0.083
3	A-1-b	G	8.5	11.0	2.5	9.8	130	1,395	1,233	1,233	5,233					36	42	137	0.98	0.556	1,813	3,045	0.007	0.086	0.412	1,342	2,574	0.006	0.070
	A-1-a	G	11.0	14.0	3.0	12.5	125	1,770	1,583	1,583	5,583					13	14	63	1.26	0.458	1,493	3,075	0.014	0.165	0.368	1,200	2,783	0.012	0.140
4	A-1-a	G	14.0	17.0	3.0	15.5	125	2,145	1,958	1,770	5,770					13	14	62	1.57	0.381	1,243	3,013	0.011	0.134	0.325	1,061	2,831	0.010	0.118
	A-1-a	G	17.0	20.5	3.5	18.8	125	2,583	2,364	1,974	5,974					13	13	61	1.89	0.321	1,048	3,022	0.011	0.127	0.286	933	2,906	0.010	0.115
1. $\sigma_{n}' = \sigma_{v}$	-'+σFstima	te σ _m of 4.0	00 psf (mod	erately over	consolidated)	for natural so	il denosits:	Ref Table 1	1.2 Coduto	2003	J							ı			Tota	Settlement:		1.635 in		Tota	Settlement:		1.314 in

Calculated By: BRT

Checked By: JPS

Date: 6/23/2019

Date: 6/24/2019

^{1.} $\sigma_p' = \sigma_{vo}' + \sigma_{m}$; Estimate σ_m of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} $C_r = 0.10(Cc)$ for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

^{9.} $S_c = [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{vo})$ for $\sigma_{p'} \leq \sigma_{vo'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{p'}/\sigma_{vo'}) + [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)

^{10.} S_c = H(1/C')log(σ_{v_i} '/ σ_{v_o} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 - FRA-70-13.10 - Retaining Wall W2 MSE Wall Settlement - Sta. 200+00 to 203+00

Calculated By: BRT Date: 06/23/2019 JPS Date: 06/24/2019 Checked By:

Boring B-099-2-13

H=	18.5	ft	Total wall height		A-6b			
B'=	9.9	ft	Effective footing width due to eccentricity	c _v =	300		ft²/yr	Coefficient of consolitation
$D_w =$	12.5	ft	Depth below bottom of footing	t =	35		days	Time following completion of construction
q _e =	3,260	psf	Equivalent bearing pressure at bottom of wall	$H_{dr} =$	3.5		ft	Length of longest drainage path considered
				$T_v =$	2.348			Time factor
				U =	100		%	Degree of consolidation
				(S _c) _t =	1.314	in	Settlement complete	at 100% of primary consolidation

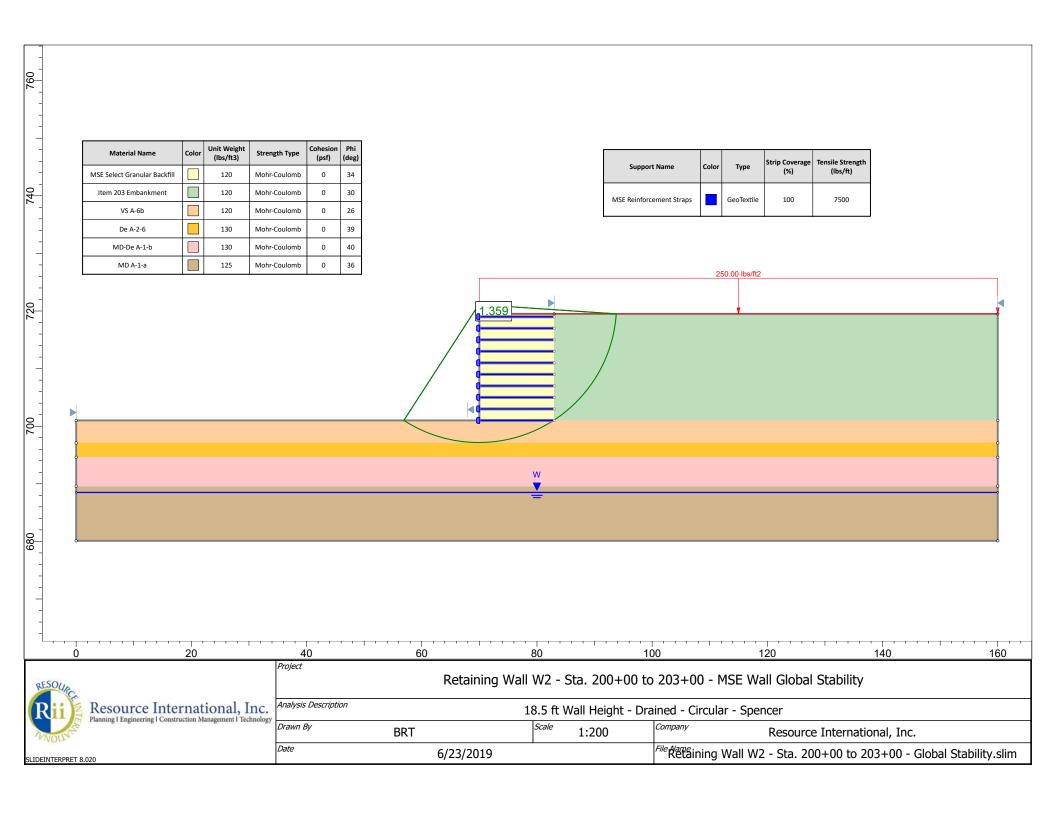
																							Total Se	ettlement at F	acing of Wall		onsolidation
Layer	Soil Type	Soil Type	Layer (1	Depth t)	Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r (3)	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' (6)	Z_f /B	I ⁽⁷⁾	$\Delta\sigma_{\rm v}^{~(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	Layer Settlement (in)	(S _c) _t ⁽¹¹⁾ (in)	Layer Settlement (in)
1	A-6b	С	0.0	3.5	3.5	1.8	120	420	210	210	4,210	40	0.270	0.027	0.585				0.18	0.499	1,626	1,836	0.056	0.674	0.674	0.674	0.674
2	A-2-6	G	3.5	6.0	2.5	4.8	130	745	583	583	4,583					32	45	150	0.48	0.482	1,570	2,153	0.009	0.113	0.113	0.113	0.113
2	A-1-b	G	6.0	8.5	2.5	7.3	130	1,070	908	908	4,908					36	46	151	0.73	0.451	1,469	2,376	0.007	0.083	0.153	0.083	0.153
3	A-1-b	G	8.5	11.0	2.5	9.8	130	1,395	1,233	1,233	5,233					36	42	137	0.98	0.412	1,342	2,574	0.006	0.070	0.155	0.070	0.155
	A-1-a	G	11.0	14.0	3.0	12.5	125	1,770	1,583	1,583	5,583					13	14	63	1.26	0.368	1,200	2,783	0.012	0.140		0.140	
4	A-1-a	G	14.0	17.0	3.0	15.5	125	2,145	1,958	1,770	5,770					13	14	62	1.57	0.325	1,061	2,831	0.010	0.118	0.374	0.118	0.374
	A-1-a	G	17.0	20.5	3.5	18.8	125	2,583	2,364	1,974	5,974					13	13	61	1.89	0.286	933	2,906	0.010	0.115		0.115	

- 1. $\sigma_p' = \sigma_{vo}' + \sigma_{m}$; Estimate σ_m of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003
- 2. C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5
- 3. $C_r = 0.10(Cc)$ for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981
- 4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
- 5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- 6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
- 7. Influence factor for strip loaded footing
- 8. $\Delta \sigma_v = q_e(I)$
- $9. \ \ S_c = [C_o/(1+e_o)](H)log(\sigma_{v_f}/\sigma_{v_o}')for \ \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_f}'; \ [C_r/(1+e_o)](H)log(\sigma_p'/\sigma_{v_o}') + [C_o/(1+e_o)](H)log(\sigma_p'/\sigma_{v_o}') + [C_o/(1+e_o)](H)log(\sigma_{v_f}/\sigma_p') \ for \ \sigma_{v_o}' < \sigma_{v_f}'; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO \ LRFD \ BDS \ (Cohesive soil \ layers)$
- 10. $S_c = H(1/C')log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
- 11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

Settlement Remaining After Hold Period: 0.000 in

Total Settlement at Facing of Wall

Settlement Complete at 100% of





 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
 1
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 6

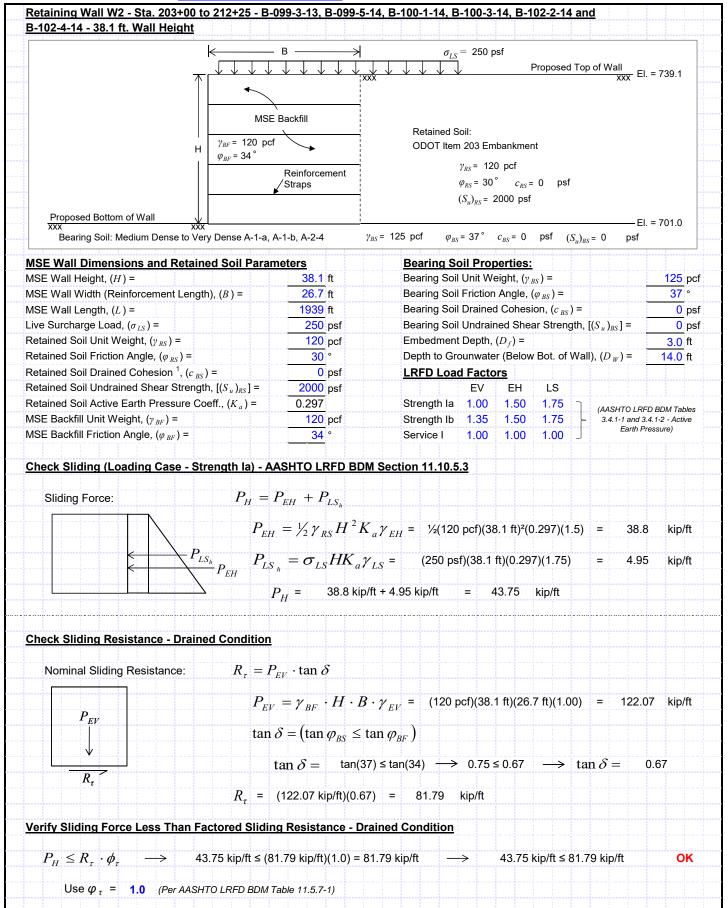
 CALCULATED BY
 BRT
 DATE
 6/22/2019

 CHECKED BY
 JPS
 DATE
 6/23/2019

Retaining Wall W2 - Sta. 203+00 to 212+25

FAX: (614) 823-4990

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 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
 2
 OF
 6

 CALCULATED BY
 BRT
 DATE
 6/22/2019

 CHECKED BY
 JPS
 DATE
 6/23/2019

Retaining Wall W2 - Sta. 203+00 to 212+25

7 ft Bearin 9 ft Bearin 0 psf Bearin 0 pcf Embed 0 ° Depth 0 psf LRFD 0 psf Streng	dment Depth, (to Grounwater Load Factor EV th la 1.00 th lb 1.35	Angle, (φ_{BS}) = 1 Cohesion, (c_{I}) ed Shear Stre (D_f) =	(BS) =	125 pc 37° 0 ps 0 ps 3.0 ft 14.0 ft
9 ft Bearin 0 psf Bearin 0 pcf Embed 0 ° Depth 0 psf LRFD 0 psf Streng 0 pcf Streng 0 pcf Service	g Soil Drained g Soil Undrain dment Depth, (to Grounwater Load Factor EV tth Ia 1.00 tth Ib 1.35	Cohesion, (c_f) ed Shear Stre (D_f) = r (Below Bot. corrections) EH LS 1.50 1.75	(BS) =	0 ps 0 ps 3.0 ft 14.0 ft
0 psf Bearin 0 pcf Embed 0 ° Depth 0 psf LRFD 0 psf Streng 0 pcf Streng 4 ° Service	g Soil Undrain dment Depth, (to Grounwater Load Factor EV th Ia 1.00 th Ib 1.35	ed Shear Stre (D_f) = r (Below Bot. or rs EH LS 1.50 1.75	ength, $[(s_u)_{BS}] =$ of Wall), $(D_W) =$ $(AASHTO LRF)$	0 ps 3.0 ft 14.0 ft
0 pcf Embed 0 ° Depth 0 psf LRFD 0 psf Streng 0 pcf Streng 4 ° Service	dment Depth, (to Grounwater Load Factor EV th la 1.00 th lb 1.35	(D_f) = r (Below Bot. c r S EH LS 1.50 1.75	of Wall), $(D_W) =$ $(AASHTO LRF)$	3.0 ft 14.0 ft
0 ° Depth 0 psf LRFD 0 psf Streng 0 pcf Streng 4 ° Service	to Grounwater Load Factor EV th la 1.00 th lb 1.35	r (Below Bot. c rs EH LS 1.50 1.75 1.50 1.75	5] (AASHTO LRF	14.0 ft
0 psf LRFD 0 psf Streng 0 pcf Streng 4 ° Service	Load Factor EV th Ia 1.00 th Ib 1.35	rs EH LS 1.50 1.75	5] (AASHTO LRF	
0 psf 7 Streng 0 pcf Streng 4 ° Service	EV th la 1.00 th lb 1.35	EH LS 1.50 1.75 1.50 1.75	5] (AASHTO LRF	-0.004-
7 Streng 0 pcf Streng 4 ° Service	th la 1.00 th lb 1.35	1.50 1.75 1.50 1.75	5] (AASHTO LRF	-0.004-
0 pcf Streng 4 ° Service	th lb 1.35	1.50 1.75	(AASHIO LRE	-D DD14 = · ·
4° Servic				- I I RI MA Tables
	el 1.00			3.4.1-2 - Active
		1.00 1.00	Earth P	ressure)
$\leq q_s \cdot B$				
$\leq q_s) \cdot B$				
= N/A ksf				
$v/_{2} = (4.57 \text{ ksf}) / 2$	= 2.29	ksf		
/ <u>/</u>				
p /				
$=\frac{r_{EV}}{R} = (122.07)$	7 kip/ft) / (26.	7 ft) =	4.57 ksf	
/ <i>D</i>				
ksf ≤ 2.29 ksf)(26.7 ft)	= N/A	kip/ft		
tance - Undrained Cor	ndition			
			/ N	
	\rightarrow	IN,	/A	
	$= \frac{P_{EV}}{B} = (122.07)$ $ksf \le 2.29 \text{ ksf}(26.7 \text{ ft})$	= N/A ksf $\frac{V}{2}$ = (4.57 ksf) / 2 = 2.29 = $\frac{P_{EV}}{B}$ = (122.07 kip/ft) / (26.	= N/A ksf $\frac{1}{2} = (4.57 \text{ ksf}) / 2 = 2.29 \text{ ksf}$ $= \frac{P_{EV}}{B} = (122.07 \text{ kip/ft}) / (26.7 \text{ ft}) = 8.6 \text{ ksf} \le 2.29 \text{ ksf}$	$= N/A ksf$ $= \frac{P_{EV}}{B} = \frac{(122.07 \text{ kip/ft})}{(26.7 \text{ ft})} = 4.57 \text{ ksf}$ $= 4.57 \text{ ksf}$ $= 4.57 \text{ ksf}$



FRA-70-13.10 JOB SHEET NO. CALCULATED BY BRT CHECKED BY JPS

W-13-072 NO. OF 6 DATE

DATE

6/22/2019 6/23/2019

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LAV. 72.171.1	823-4949	CHECKED BY JPS DATE 6/23/201
	823-4990 TERATIONAL COM	Retaining Wall W2 - Sta. 203+00 to 212+25
<u>WWW.RESOURCEIN</u>	I EIVATIONAL.COM	
MSE Wall Dimensions and Retained Soil Par	amotors	Bearing Soil Properties:
MSE Wall Height, (H) =	38.1 ft	Bearing Soil Unit Weight, (γ_{BS}) = 125 pcf
MSE Wall Width (Reinforcement Length), (<i>B</i>) =	26.7 ft	Bearing Soil Friction Angle, (φ_{BS}) = 37 °
MSE Wall Length, (L) =	1939 ft	Bearing Soil Drained Cohesion, $(c_{BS}) = 0$
Live Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Drained Corresion, $(c_{BS})^2 = 0$ ps: Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 0$ ps:
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf	Embedment Depth, (D_f) = 3.0 ft
Retained Soil Orlit Weight, $(\gamma_{RS}) =$	30 °	Depth to Grounwater (Below Bot. of Wall), $(D_W) = 14.0 \text{ ft}$
Retained Soil Drained Cohesion, (c BS) =	0 psf	LRFD Load Factors
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$	2000 psf	EV EH LS
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297	Strength la 1.00 1.50 1.75 (AASHTO LRFD BDM Tables
MSE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf	Strength Ib 1.35 1.50 1.75 - 3.4.1-1 and 3.4.1-2 - Active Earth Pressure)
MSE Backfill Friction Angle, $(\varphi_{BF}) =$	<u>34</u> °	Service I 1.00 1.00 1.00 J
Check Eccentricity (Loading Case - Strength	Ia) - AASHTO I RE	D RDM Section 11 10 5 5
e=1	$B/_2 - x_o$	
	/ _	
x_3 P_{EV}	$M_{FV} - M_H$	= (1629.63 kip·ft/ft - 587.06 kip·ft/ft) / (122.07 kip/ft) = 8.54 ft
$ \begin{array}{c c} x_3 \\ \uparrow \\ \hline \end{array} \qquad \begin{array}{c c} P_{LS_h} \\ P_{EH} \\ \end{array} \qquad x_o $	$p = \frac{P}{P} = \frac{P}{P}$	= $(1629.63 \text{ kip-ft/ft} - 587.06 \text{ kip-ft/ft}) / (122.07 \text{ kip/ft}) = 8.54 \text{ ft}$
T EH	P_{EV}	
	$M_{EV} = 1629$ $M_H = 587.4$	63 kip·ft/ft
$x_o \leftarrow \times \Rightarrow e$	$M_H = 587.$	06 kip·ft/ft ├─ Defined below
$x_o \leftarrow \Rightarrow e$	$P_{EV} = 122.$	07 kip/ft —
' / 2 '		
-	2 = (26.7 ft)/2 - 3	3.54 ft = 4.81 ft
	()	
Resisting Moment, $M_{\scriptscriptstyle EV}$: $M_{\scriptscriptstyle EV}$	$P_{EV}(x_1)$	
P_{EV}	$_{EV}=\gamma_{BF}\cdot H\cdot I$	$3 \cdot \gamma_{EV} = (120 \text{ pcf})(38.1 \text{ ft})(26.7 \text{ ft})(1.00) = 122.07 \text{ kip/ft}$
	R/	
the first of the f		20.7 (1) / 0
$ x_i $	$a_1 = \frac{D}{2} = 0$	26.7 ft) / 2 = 13.35 ft
x_1	1 1	
V	1 1	26.7 ft) / 2 = 13.35 ft 07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft
	1 1	
	$M_{EV} = (122.$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft
	1 1	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft
$\downarrow \qquad \qquad \downarrow \qquad \qquad \qquad \downarrow \qquad \qquad \qquad \downarrow \qquad \qquad \downarrow \qquad \qquad \qquad \downarrow \qquad \qquad \qquad \downarrow \qquad \qquad \qquad \downarrow \qquad \qquad \qquad \downarrow \qquad \qquad \qquad \qquad \downarrow \qquad \qquad \qquad \downarrow \qquad \qquad \qquad \qquad \qquad \downarrow \qquad	$M_{EV} = (122.$ $= P_{EH}(x_2) + 1$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft $P_{LS_h}(x_3)$
\downarrow	$M_{EV} = (122.$ $= P_{EH}(x_2) + 1$ $= \frac{1}{2} \gamma_{RS} H^2 L$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft $P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$
\downarrow	$M_{EV} = (122.$ $= P_{EH}(x_2) + 1$ $= \frac{1}{2} \gamma_{RS} H^2 L$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft $P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$
Overturning Moment, M_H : M_H P_E P_{LS_h} P_{EH}	$M_{EV} = (122.$ $= P_{EH}(x_2) + \dots$ $EH = \frac{1}{2} \gamma_{RS} H^2 + \dots$ $ES_h = \sigma_{LS} H K_a + \dots$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft $P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$
Overturning Moment, M_H : M_H P_{LS_h} P_{EH}	$M_{EV} = (122.$ $= P_{EH}(x_2) + \dots$ $EH = \frac{1}{2} \gamma_{RS} H^2 + \dots$ $ES_h = \sigma_{LS} H K_a + \dots$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft $P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$
Overturning Moment, M_H : $ \begin{array}{cccc} M_H \\ P_E \\ P_{LS_h} \\ P_{EH} \\ X \end{array} $	$M_{EV} = (122.$ $= P_{EH}(x_2) + 1$ $EH = \frac{1}{2}\gamma_{RS}H^2$ $ES_h = \sigma_{LS}HK_{ax}$ $ES_h = \frac{1}{2} = \frac{1}{4}$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft $P_{LS_n}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft}) / 3 = 12.70 \text{ ft}$
Overturning Moment, M_H : $ \begin{array}{cccc} M_H \\ P_E \\ P_{LS_h} \\ P_{EH} \\ X \end{array} $	$M_{EV} = (122.$ $= P_{EH}(x_2) + 1$ $EH = \frac{1}{2}\gamma_{RS}H^2$ $ES_h = \sigma_{LS}HK_{ax}$ $ES_h = \frac{1}{2} = \frac{1}{4}$	07 kip/ft)(13.35 ft) = 1629.63 kip-ft/ft $P_{LS_n}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft})/3 = 12.70 \text{ ft}$
Overturning Moment, M_H : $ \begin{array}{cccc} M_H \\ P_E \\ P_{LS_h} \\ P_{EH} \\ X \end{array} $	$M_{EV} = (122.00)$ $= P_{EH}(x_2) + 1.00$ $EH = \frac{1}{2} \gamma_{RS} H^2 L$ $ES_h = \sigma_{LS} H K_a L$ $ES_h = \frac{1}{3} = 0$	$P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft})/3 = 12.70 \text{ ft}$ $38.1 \text{ ft})/2 = 19.05 \text{ ft}$
Overturning Moment, M_H : M_H P_{LS_h} P_{EH} X_{J}	$M_{EV} = (122.00)$ $= P_{EH}(x_2) + 1.00$ $EH = \frac{1}{2} \gamma_{RS} H^2 L$ $ES_h = \sigma_{LS} H K_a L$ $ES_h = \frac{1}{3} = 0$	07 kip/ft)(13.35 ft) = 1629.63 kip·ft/ft $P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft})/3 = 12.70 \text{ ft}$
Overturning Moment, M_H : M_H P_{LS_h} P_{EH} X_{J}	$M_{EV} = (122.00)$ $= P_{EH}(x_2) + 1.00$ $EH = \frac{1}{2} \gamma_{RS} H^2 L$ $ES_h = \sigma_{LS} H K_a L$ $ES_h = \frac{1}{3} = 0$	$P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft})/3 = 12.70 \text{ ft}$ $38.1 \text{ ft})/2 = 19.05 \text{ ft}$
Overturning Moment, M_H : M_H P_{LS_h} P_{EH} X_{2} X_{3}	$M_{EV} = (122.00)$ $= P_{EH}(x_2) + 1.00$ $EH = \frac{1}{2} \gamma_{RS} H^2 L$ $ES_h = \sigma_{LS} H K_a L$ $ES_h = \frac{1}{3} = 0$	$P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft}) / 3 = 12.70 \text{ ft}$ $38.1 \text{ ft}) / 2 = 19.05 \text{ ft}$
Overturning Moment, M_H : $P_{LS_h} = P_{LS_h} = P_{LS_h} = P_{LS_h}$ $X_{S_h} = P_{LS_h} = P_{LS$	$M_{EV} = (122.00)$ $= P_{EH}(x_2) + 1.00$ $EH = \frac{1}{2} \gamma_{RS} H^2 L$ $ES_h = \sigma_{LS} H K_a L$ $ES_h = \frac{1}{3} = 0$	$P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft})/3 = 12.70 \text{ ft}$ $38.1 \text{ ft})/2 = 19.05 \text{ ft}$
Overturning Moment, M_H : M_H P_{LS_h} P_{EH} X_{2} X_{3} X_{4} $Check Eccentricity$	$M_{EV} = (122.00)$ $= P_{EH}(x_2) + 1.00$ $EH = \frac{1}{2} \gamma_{RS} H^2 L$ $ES_h = \sigma_{LS} H K_a L$ $ES_h = \frac{1}{3} = 0$	$P_{LS_h}(x_3)$ $K_a \gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5) = 38.80 \text{ kip/ft}$ $V_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $38.1 \text{ ft})/3 = 12.70 \text{ ft}$ $38.1 \text{ ft})/2 = 19.05 \text{ ft}$
Overturning Moment, M_H : M_H P_E P_{LS_h} P_{EH} X_s	$M_{EV} = (122.00)$ $= P_{EH}(x_2) + 1.00$	$P_{LS_h}(x_3)$ = 1629.63 kip-ft/ft $Y_{LS_h}(x_3)$ = 38.80 kip/ft $Y_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.5) = 38.80 \text{ kip/ft}$ $Y_{LS} = (250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75) = 4.95 \text{ kip/ft}$ $Y_{LS} = 12.70 \text{ ft}$ $Y_{LS} = 19.05 $

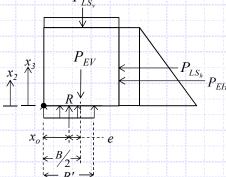


SHEET NO. CALCULATED BY CHECKED BY JPS DATE

Retaining Wall W2 - Sta. 203+00 to 212+25

WWW.RESOURCEMTER (HOTVIECOM	Rii	RESOURCE INTERNATIONAL, INC. 6350 PRESIDENTIAL GATEWAY COLUMBUS, OHIO 43231 PHONE: (614) 823-4949 FAX: (614) 823-4990 WWW.RESOURCEINTERATIONAL.COM
	MCE Wall Dimanai	and and Detained Sail Devementary

MSE Wall Dimensions and Retained Soil Param		Bearing So			činimini činimi			
MSE Wall Height, (H) =	38.1 ft	Bearing Soil	Unit We	eight, (γ	_{BS}) =			125 pc
MSE Wall Width (Reinforcement Length), (B) =	26.7 ft	Bearing Soil	Friction	Angle,	$(\varphi_{BS}) =$			37 °
MSE Wall Length, (L) =	1939 ft	Bearing Soil	Drained	Cohes	ion, ($c_{\it BS}$;)=		0 ps
Live Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil	Undrair	ned She	ar Stren	gth,	$[(s_u)_{BS}] =$	0 ps
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment	Depth,	$(D_f) =$				3.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Gro	unwate	r (Below	Bot. of	Wal	l), (D _W) =	14.0 ft
Retained Soil Drained Cohesion, (c_{BS}) =	0 psf	LRFD Load	Facto	<u>rs</u>				
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$	2000 psf		EV	EH	LS			
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297	Strength la	1.00	1.50	1.75	٦	(AASHTO LRF	D PDM Tables
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf	Strength Ib	1.35	1.50	1.75	-	3.4.1-1 and 3.	4.1-2 - Active
MSE Backfill Friction Angle, (φ_{BF}) =	34 °	Service I	1.00	1.00	1.00	J	Earth Pr	essure)
Check Bearing Capacity (Loading Case - Streng	gth lb) - AASHTO	LRFD BDM Section	on 11.1	<u>10.5.4</u>				
$P_{LS_{n}}$								



$$P_{LS_h}$$
 P_{EH} P_{EH}

$$x_o = \frac{M_V - M_H}{P_V}$$
 = (2355.99 kip·ft/ft - 587.09 kip·ft/ft) / 176.48 kip/ft = 10.02 ft

$$q_{eq} = (176.48 \, ext{kip/ft}) \, / \, (20.04 \, ext{ft}) = 8.81 \, ext{ks}$$

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

 $M_V = [(120 \text{ pcf})(38.1 \text{ ft})(26.7 \text{ ft})(1.35)](13.35 \text{ ft}) + [(250 \text{ psf})(26.7 \text{ ft})(1.75)](13.35 \text{ ft}) = 2355.99 \text{ kip-ft/ft}$

$$M_{H} = P_{EH}(x_{2}) + P_{LS_{h}}(x_{3}) = (\frac{1}{2}\gamma_{RS}H^{2}K_{a}\gamma_{EH})(x_{2}) + (\sigma_{LS}HK_{a}\gamma_{LS})(x_{3})$$

 $M_H = [\frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.5)](12.7 \text{ ft}) + [(250 \text{ psf})(38.1 \text{ ft})(0.297)(1.75)](19.05 \text{ ft})$ = 587.09 kip-ft/ft

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

 $P_V = (120 \, \mathrm{pcf})(38.1 \, \mathrm{ft})(26.7 \, \mathrm{ft})(1.35) + (250 \, \mathrm{psf})(26.7 \, \mathrm{ft})(1.75) = 176.48 \, \mathrm{kip/ft}$

Check Bearing Resistance - Drained Condition

Nominal Bearing Resistance: $q_{_n} = cN_{_{cm}} + \gamma D_f N_{_{qm}} C_{_{wq}} + \frac{1}{2} \gamma BN_{_{\gamma m}} C_{_{w\gamma}}$

$N_{cm} = N_c s_c i_c = 56.08$	$N_{qm} = N_q S_q d_q i_q = 44.82$	$N_{\gamma m} = N_{\gamma} S_{\gamma} i_{\gamma} = 65.93$
	7 7 7 7	
$N_c = 55.63$	N_q = 42.92	$N_{\gamma} = 66.19$
$S_c = 1+(20.04 \text{ ft/1939 ft})(42.92/55.63)$	$s_q = 1.008$	$s_{\gamma} = 0.996$
= 1.008	$d_q = 1+2\tan(37^\circ)[1-\sin(37^\circ)]^2\tan^{-1}(31^\circ)$	3.0 ft/20.04 ft) i_{γ} = 1.000 (Assumed)
i_c = 1.000 (Assumed)	1.036	$C_{wy} = 14.0 \text{ ft} < 1.5(20.04 \text{ ft}) + 3.0 \text{ ft} = 0.733$
	i_q = 1.000 (Assumed)	
	C_{wq} = 14.0 ft > 3.0 ft = 1.0	00

 $(0 \text{ psf})(56.075) + (125 \text{ pcf})(3.0 \text{ ft})(44.821)(1.000) + \frac{1}{2}(125 \text{ pcf})(20.0 \text{ ft})(65.925)(0.733) =$ 77.33 ksf

Verify Equivalent Pressure Less Than Factored Bearing Resistance

Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDM Table 11.5.7-1)

 $q_{eq} \leq q_n \cdot \phi_b \implies 8.81 \text{ ksf} \leq (77.33 \text{ ksf})(0.65) = 50.26 \text{ ksf}$ $8.81 \text{ ksf} \le 50.26 \text{ ksf}$ OK



RESOURCE INTERNATIONAL, INC. 6350 PRESIDENTIAL GATEWAY COLUMBUS, OHIO 43231 PHONE: (614) 823-4949 FAX: (614) 823-4990 WWW.RESOURCEINTERATIONAL.COM

FRA-70-13.10 JOB NO. W-13-072 SHEET NO. OF 6 CALCULATED BY BRT DATE 6/22/2019 CHECKED BY JPS DATE 6/23/2019 Retaining Wall W2 - Sta. 203+00 to 212+25

ISE Wall Dimensions and Retained Soil Parar	meters	Bearing Soil Pro	perties:				
ISE Wall Height, (<i>H</i>) =	38.1 ft	Bearing Soil Unit W	$'$ eight, (γ_{BS}) =			1	25 pcf
ISE Wall Width (Reinforcement Length), (<i>B</i>) =	26.7 ft	Bearing Soil Frictior	n Angle, (φ_{BS})	=			37 °
ISE Wall Length, (<i>L</i>) =	1939 ft	Bearing Soil Draine	d Cohesion, (c _{BS}) =			0 psf
ive Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Undrai	ned Shear Str	ength, [$(s_u)_{BS}$]	=	0 psf
etained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment Depth,	$(D_f) =$				3.0 ft
etained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Grounwate		of Wall), (D _W)	= 1	4.0 ft
etained Soil Drained Cohesion, (c_{RS}) =	0 psf	LRFD Load Facto			/ / / / /		
etained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$	2000 psf	EV	EH LS	3			
etained Soil Active Earth Pressure Coeff., (K_a) =	0.297	Strength la 1.00	1.50 1.7				
ISE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf	Strength lb 1.35				O LRFD BDN and 3.4.1-2	
ISE Backfill Friction Angle, (φ_{BF}) =	34 °	Service I 1.00	1.00 1.7	aanaangaana aang		arth Pressure	
heck Bearing Capacity (Loading Case - Strer		LRFD BDM Section 11.	10.5.4 (Contin	ued <u>)</u>			
	$+\gamma D_f N_{qm} C_{wq} +$	$-\frac{1}{2}\gamma BN_{m}C_{wy}$					
$N_{cm} = N_c s_c i_c = 5.150$	$N_{qm} = N_q s_q d_q i$	q = 1.000	$N_{\gamma m}=N$	$\int_{\gamma} S_{\gamma} i_{\gamma}$	= (0.000	
$N_c = 5.140$	$N_q = 1.000$		N _γ =	0.000			
$S_C = 1+(20.04 \text{ ft/}[(5)(1939 \text{ ft})]) = 1.002$			$s_{\gamma} =$				
$i_C = 1.000 \text{ (Assumed)}$		')[1-sin(0°)]²tan⁻¹(3.0 ft/20.04 ft)	$i_{\nu} =$		(Assumi	ed)	
	cr a 1. Ztanto	/[1 511(0)] tall (0.0 10 20.0 + 1t)	νγ				= 0.
			C =	110ft - 1	1 5/20 04	#\ + 2 O #	
	1.000	Assumed)	$C_{wy} =$	14.0 ft < 1	1.5(20.04	ft) + 3.0 ft	
$q_n = (0 \text{ psf})(5.150) + (125 \text{ pcf})(3.0 \text{ ft})$	$i_{q} = 1.000 \text{ (A}$ $C_{wq} = 14.0 \text{ ft} > 3$ $(1.000)(1.000) + \frac{1}{2}(1.000)$	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0			1.5(20.04 N/A	ft) + 3.0 ft ksf	
$q_n = (0 \text{ psf})(5.150) + (125 \text{ pcf})(3.0 \text{ ft})$	$i_{q} = 1.000 \text{ (A}$ $C_{wq} = 14.0 \text{ ft} > 3$ $(1.000)(1.000) + \frac{1}{2}(1.000)$	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0					
$q_n = (0 \text{ psf})(5.150) + (125 \text{ pcf})(3.0 \text{ ft})$	$i_{q} = 1.000 \text{ (A}$ $C_{wq} = 14.0 \text{ ft} > 3$ $(1.000)(1.000) + \frac{1}{2}(1.000)$ $\frac{d}{d} \text{ Bearing Resistan}$	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE					
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) erify Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow$ 8.81 ksf	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n = (0 ext{ psf})(5.150) + (125 ext{ pcf})(3.0 ext{ ft})$ erify Equivalent Pressure Less Than Factore	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Perify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Perify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Prify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Firify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) $rify$ Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Firify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Firify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Prify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Firify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Firify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Prify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Perify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) erify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) erify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) erify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) erify Equivalent Pressure Less Than Factore $q_{eq}\leq q_n\cdot\phi_b \longrightarrow 8.81 ext{ ksf}$	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Serify Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow$ 8.81 ksf	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Serify Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow$ 8.81 ksf	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Serify Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow$ 8.81 ksf	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) Serify Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow$ 8.81 ksf	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				
$q_n=$ (0 psf)(5.150) + (125 pcf)(3.0 ft) erify Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow$ 8.81 ksf	$\begin{array}{ccc} 1.000 \\ i_q &= & 1.000 \text{ (A} \\ C_{wq} &= & 14.0 \text{ ft} > 14.0 $	3.0 ft = 1.000 125 pcf)(20.0 ft)(0.000)(0 ICE	0.733)				



RESOURCE INTERNATIONAL, INC. 6350 PRESIDENTIAL GATEWAY COLUMBUS, OHIO 43231

FRA-70-13.10 SHEET NO. CALCULATED BY DATE CHECKED BY JPS

6/22/2019 DATE

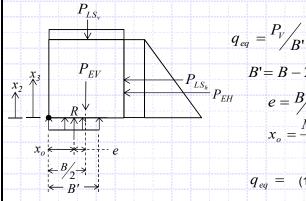
W-13-072

Retaining Wall W2 - Sta. 203+00 to 212+25

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	COLONIDOS, OT 110 13231

MSE Wall Dimensions and Retained Soil Param	<u>neters</u>		Bearing So	oil Prop	erties:				
MSE Wall Height, (H) =	38.1	ft	Bearing Soil	Unit We	eight, (γ ₁	_{3S}) =			125 pcf
MSE Wall Width (Reinforcement Length), (B) =	26.7	ft	Bearing Soil	Friction	Angle, ($(\varphi_{BS}) =$			37 °
MSE Wall Length, (<i>L</i>) =	1939	ft	Bearing Soil	Drained	d Cohesi	on, (c _{BS}) =		0 psf
Live Surcharge Load, (σ_{LS}) =	250	psf	Bearing Soil	Undrair	ned Shea	ar Stren	gth,	$[(s_u)_{BS}] =$	0 psf
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf	Embedment	Depth,	$(D_f) =$				3.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30	0	Depth to Gro	ounwate	r (Below	Bot. of	Wal	l), (D _W) =	14.0 ft
Retained Soil Drained Cohesion, (c_{BS}) =	0	psf	LRFD Load	d Facto	<u>rs</u>				
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000	psf		EV	EH	LS			
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.297	200000000000000000000000000000000000000	Strength Ia	1.00	1.50	1.75	٦	(AASHTO LRFI	D PDM Tables
MSE Backfill Unit Weight, (γ_{BF}) =	120	pcf	Strength Ib	1.35	1.50	1.75	-	3.4.1-1 and 3.4	
MSE Backfill Friction Angle, (φ_{BF}) =	34	0	Service I	1.00	1.00	1.00	J	Earth Pr	essure)

Settlement Analysis (Loading Case - Service I) - AASHTO LRFD BDM Section 11.10.4.1



$$R' - R - 2a = 26.7 \text{ ft} - 2(2.97 \text{ ft}) = 20.76 \text{ ft}$$

$$P_{LS_h} P_{EH} = B - 2e = 26.7 \text{ ft} - 2(2.97 \text{ ft}) = 20.76 \text{ ft}$$

$$e = B/2 - x_o = (26.7 \text{ ft}) / 2 - 10.38 \text{ ft} = 2.97 \text{ ft}$$

$$x_o = \frac{M_V - M_H}{P_V} = (1718.78 \text{ kip·ft/ft} - 382.41 \text{ kip·ft/ft}) / 128.75 \text{ kip/ft} = 10.38 \text{ ft}$$

$$q_{eq} = (128.75 \text{ kip/ft}) / (20.76 \text{ ft}) = 6.20 \text{ ksf}$$

$$M_{V} = P_{EV}(x_1) + P_{LS_{v}}(x_1) = (\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV})(x_1) + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$$

 $M_{\nu} = [(120 \text{ pcf})(38.1 \text{ ft})(26.7 \text{ ft})(1.00)](13.4 \text{ ft}) + [(250 \text{ psf})(26.7 \text{ ft})(1.00)](13.4 \text{ ft}) = 1718.78 \text{ kip-ft/ft}$

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

 $M_H = [\frac{1}{2}(120 \text{ pcf})(38.1 \text{ ft})^2(0.297)(1.00)](12.7 \text{ ft}) + [(250 \text{ psf})(38.1 \text{ ft})(0.297)(1.00)](19.05 \text{ ft})$ = 382.41 kip-ft/ft

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

 $P_{V} = (120 \, \mathrm{pcf})(38.1 \, \mathrm{ft})(26.7 \, \mathrm{ft})(1.00) + (250 \, \mathrm{psf})(26.7 \, \mathrm{ft})(1.00) = 128.75 \, \mathrm{kip/ft}$

Settlement, Time Rate of Consolidation and Differential Settlement:

Boring	Total Settlement at Center of Reinforced Soil Mass	Total Settlement at Wall Facing	Time for 100% Consolidation	Distance Between Borings Along Wall Facing	Differential Settlement Along Wall Facing
B-099-3-13	0.830 in	0.683 in	0 days		
B-099-5-14	1.757 in	1.437 in	15 days	150 ft	1/2390
B-100-1-14	1.189 in	0.981 in	0 days	165 ft	1/4340
B-100-3-14	0.625 in	0.515 in	0 days	150 ft	1/3860
B-102-2-14	1.353 in	1.102 in	0 days	155 ft	1/3170
B-102-4-14	2.396 in	1.904 in	6 days	155 ft	1/2320

W-13-072 - FRA-70-13.10 - Retaining Wall W2 MSE Wall Settlement - Sta. 203+00 to 212+25
 Calculated By:
 BRT
 Date:
 6/22/2019

 Checked By:
 JPS
 Date:
 6/23/2019

Boring B-099-3-13

																				Total S	Settlement a	t Center of R	einforced So	il Mass		Total Set	tlement at Fa	acing of Wall	
Layer	Soil Class.	Soil Type	Layer (Depth	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	$\Delta\sigma_{_{_{ m V}}}^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
	A-1-a	G	0.0	2.0	2.0	1.0	130	260	130	130	4,130					41	79	319	0.10	0.996	3,219	3,349	0.009	0.106	0.500	1,614	1,744	0.007	0.085
1	A-1-a	G	2.0	4.0	2.0	3.0	130	520	390	390	4,390					41	63	233	0.31	0.932	3,011	3,401	0.008	0.097	0.494	1,597	1,987	0.006	0.073
	A-1-a	G	4.0	6.0	2.0	5.0	130	780	650	650	4,650					41	56	198	0.52	0.808	2,611	3,261	0.007	0.085	0.478	1,544	2,194	0.005	0.064
2	A-2-4	G	6.0	8.5	2.5	7.3	130	1,105	943	943	4,943					32	40	131	0.75	0.670	2,163	3,105	0.010	0.119	0.448	1,448	2,391	0.008	0.093
2	A-1-b	G	8.5	11.0	2.5	9.8	130	1,430	1,268	1,268	5,268					36	42	136	1.01	0.548	1,769	3,037	0.007	0.084	0.408	1,319	2,586	0.006	0.068
3	A-1-b	G	11.0	13.5	2.5	12.3	130	1,755	1,593	1,593	5,593					36	39	126	1.26	0.458	1,479	3,071	0.006	0.068	0.368	1,189	2,781	0.005	0.057
4	A-1-b	G	13.5	16.5	3.0	15.0	125	2,130	1,943	1,818	5,818					13	13	62	1.55	0.385	1,245	3,063	0.011	0.132	0.328	1,059	2,877	0.010	0.116
4	A-1-b	G	16.5	20.5	4.0	18.5	125	2,630	2,380	2,037	6,037					13	13	61	1.91	0.319	1,032	3,068	0.012	0.140	0.285	919	2,956	0.011	0.127
1. σ _p ' = σ _v	₀'+σ _{m;} Estima	ate σ_m of 4,0	00 psf (mod	erately overc	onsolidated)	for natural s	oil deposits;	Ref. Table 1	1.2, Coduto	2003											Tota	l Settlement:		0.830 in		Total	Settlement:		0.683 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} $C_r = 0.10$ (Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

^{10.} S_c = H(1/C')log(σ_{vf} / σ_{vo} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

MSE Wall Settlement - Sta. 203+00 to 212+25

Boring B-099-5-14

H= 19.0 ft Total wall height

B'= 10.1 ft Effective footing width due to eccentricity

 D_w = 14.0 ft Depth below bottom of footing

q_e = 3,340 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	t Center of Re	einforced So	il Mass		Total Se	ttlement at Fa	icing of Wall	
Layer	Soil Class.	Soil Type	Layer ('	Depth ft)	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' (6)	Z_f /B	1 ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	1 ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-6b	С	0.0	2.0	2.0	1.0	120	240	120	120	4,120	37	0.243	0.024	0.561				0.10	0.997	3,329	3,449	0.045	0.545	0.500	1,669	1,789	0.037	0.438
,	A-2-4	G	2.0	4.5	2.5	3.3	125	553	396	396	4,396					24	37	120	0.32	0.926	3,092	3,488	0.020	0.235	0.494	1,649	2,045	0.015	0.178
2	A-2-4	G	4.5	7.0	2.5	5.8	125	865	709	709	4,709					24	32	106	0.57	0.774	2,587	3,295	0.016	0.189	0.472	1,577	2,286	0.012	0.144
	A-1-b	G	7.0	9.5	2.5	8.3	125	1,178	1,021	1,021	5,021					19	23	82	0.82	0.633	2,115	3,136	0.015	0.179	0.438	1,463	2,484	0.012	0.142
3	A-1-b	G	9.5	12.0	2.5	10.8	125	1,490	1,334	1,334	5,334					19	22	78	1.06	0.525	1,752	3,086	0.012	0.141	0.399	1,332	2,666	0.010	0.116
	A-1-b	G	12.0	14.5	2.5	13.3	125	1,803	1,646	1,646	5,646					19	20	75	1.31	0.444	1,482	3,128	0.009	0.112	0.361	1,205	2,851	0.008	0.096
	A-1-a	G	14.5	17.5	3.0	16.0	125	2,178	1,990	1,865	5,865					15	15	65	1.58	0.377	1,260	3,126	0.010	0.124	0.323	1,079	2,944	0.009	0.109
4	A-1-a	G	17.5	20.5	3.0	19.0	125	2,553	2,365	2,053	6,053					15	15	64	1.88	0.323	1,080	3,133	0.009	0.103	0.287	960	3,013	0.008	0.093
	A-1-a	G	20.5	23.5	3.0	22.0	125	2,928	2,740	2,241	6,241					15	14	64	2.18	0.282	943	3,184	0.007	0.086	0.258	861	3,101	0.007	0.080
5	A-1-a	G	23.5	26.5	3.0	25.0	130	3,318	3,123	2,436	6,436					35	33	107	2.48	0.250	836	3,273	0.004	0.043	0.233	777	3,214	0.003	0.040
1. σ _p ' = σ _v	_{/o} '+σ _{m;} Estima	ate $\sigma_{\rm m}$ of 4,0	00 psf (mode	erately over	consolidated)	for natural so	il deposits;	Ref. Table	11.2, Coduto	2003							•				Tota	l Settlement:		1.757 in		Tota	l Settlement:	1	1.437 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

 Calculated By:
 BRT
 Date:
 6/22/2019

 Checked By:
 JPS
 Date:
 6/23/2019

^{3.} $C_r = 0.10$ (Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} e_o = (C_c/1.15)+0.35; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

 $^{9. \ \} S_c = [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_{v_o}') for \ \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_i}'; \ [C_r/(1+e_o)](H) log(\sigma_p'/\sigma_{v_o}') + [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_p') \ for \ \sigma_{v_o}' < \sigma_p' < \sigma_{v_i}'; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO LRFD \ BDS \ (Cohesive soil layers)$

^{10.} S_c = H(1/C')log($\sigma_{v'}$ / σ_{vo} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

MSE Wall Settlement - Sta. 203+00 to 212+25

 Calculated By:
 BRT
 Date:
 06/22/2019

 Checked By:
 JPS
 Date:
 06/23/2019

Total Settlement at Facing of Wall

Settlement Remaining After Hold Period: 0.000 in

Settlement Complete at 100% of

Boring B-099-5-14

H=	19.0	ft	Total wall height		A-6b		
B'=	10.1	ft	Effective footing width due to eccentricity	c _v =	300	ft²/yr	Coefficient of consolitation
$D_w =$	14.0	ft	Depth below bottom of footing	t =	15	days	Time following completion of construction
q _e =	3,340	psf	Equivalent bearing pressure at bottom of wall	H _{dr} =	2	ft	Length of longest drainage path considered
				$T_v =$	3.082		Time factor
				U =	100	%	Degree of consolidation
				(S _c) _t =	1.437 in	Settlement complete a	t 100% of primary consolidation

																										Filliary Co	onsolidation
Layer	Soil Type	Soil Type	-	Depth	Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c ⁽²⁾	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' (6)	Z_f /B	1 (7)	Δσ _ν ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	Layer Settlement (in)	(S _c) _t ⁽¹¹⁾ (in)	Layer Settlement (in)
1	A-6b	С	0.0	2.0	2.0	1.0	120	240	120	120	4,120	37	0.243	0.024	0.561				0.10	0.500	1,669	1,789	0.037	0.438	0.438	0.438	0.438
2	A-2-4	G	2.0	4.5	2.5	3.3	125	553	396	396	4,396					24	37	120	0.32	0.494	1,649	2,045	0.015	0.178	0.322	0.178	0.322
	A-2-4	G	4.5	7.0	2.5	5.8	125	865	709	709	4,709					24	32	106	0.57	0.472	1,577	2,286	0.012	0.144	0.322	0.144	0.322
	A-1-b	G	7.0	9.5	2.5	8.3	125	1,178	1,021	1,021	5,021					19	23	82	0.82	0.438	1,463	2,484	0.012	0.142		0.142	
3	A-1-b	G	9.5	12.0	2.5	10.8	125	1,490	1,334	1,334	5,334					19	22	78	1.06	0.399	1,332	2,666	0.010	0.116	0.354	0.116	0.354
	A-1-b	G	12.0	14.5	2.5	13.3	125	1,803	1,646	1,646	5,646					19	20	75	1.31	0.361	1,205	2,851	0.008	0.096		0.096	
	A-1-a	G	14.5	17.5	3.0	16.0	125	2,178	1,990	1,865	5,865					15	15	65	1.58	0.323	1,079	2,944	0.009	0.109		0.109	
4	A-1-a	G	17.5	20.5	3.0	19.0	125	2,553	2,365	2,053	6,053					15	15	64	1.88	0.287	960	3,013	0.008	0.093	0.282	0.093	0.282
	A-1-a	G	20.5	23.5	3.0	22.0	125	2,928	2,740	2,241	6,241	·				15	14	64	2.18	0.258	861	3,101	0.007	0.080		0.080	
5	A-1-a	G	23.5	26.5	3.0	25.0	130	3,318	3,123	2,436	6,436	·				35	33	107	2.48	0.233	777	3,214	0.003	0.040	0.040	0.040	0.040

- 1. σ_p ' = σ_{vo} '+ σ_m ; Estimate σ_m of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003
- 2. C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5
- 3. C_r = 0.10(Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981
- 4. e_o = (C_c/1.15)+0.35; Ref. Table 8-2, Holtz and Kovacs 1981
- 5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- 6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
- 7. Influence factor for strip loaded footing
- 8. $\Delta \sigma_v = q_e(I)$
- 9. $S_c = [C_o/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{vo}')$ for $\sigma_p' \le \sigma_{vo}' < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}') + [C_o/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{v'}' \le \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{v'}' < \sigma_{v'}'$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{v'}' < \sigma_{v'}' < \sigma_{v'}' < \sigma_{v'}'$
- 10. $S_c = H(1/C')log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
- 11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

MSE Wall Settlement - Sta. 203+00 to 212+25

Boring B-100-1-14

18.6 ft Total wall height

9.8 Effective footing width due to eccentricity

16.0 ft Depth below bottom of footing

3,280 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement at	Center of R	einforced So	l Mass		Total Set	tlement at Fa	acing of Wall	
Layer	Soil Class.	Soil Type		Depth	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c ⁽²⁾	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' ⁽⁶⁾	Z_f /B	1 ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	Δσ _ν ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
	A-1-a	G	0.0	2.5	2.5	1.3	130	325	163	163	4,163					25	46	153	0.13	0.993	3,259	3,421	0.022	0.259	0.500	1,639	1,801	0.017	0.205
4	A-1-a	G	2.5	5.0	2.5	3.8	130	650	488	488	4,488					25	37	120	0.38	0.891	2,924	3,411	0.018	0.212	0.490	1,607	2,094	0.013	0.158
1	A-1-a	G	5.0	7.5	2.5	6.3	130	975	813	813	4,813					25	33	106	0.64	0.732	2,402	3,215	0.014	0.168	0.464	1,521	2,333	0.011	0.129
	A-1-a	G	7.5	10.5	3.0	9.0	130	1,365	1,170	1,170	5,170					25	30	98	0.92	0.585	1,918	3,088	0.013	0.155	0.422	1,385	2,555	0.010	0.125
	A-1-a	G	10.5	13.5	3.0	12.0	135	1,770	1,568	1,568	5,568					48	52	178	1.22	0.470	1,540	3,108	0.005	0.060	0.374	1,226	2,794	0.004	0.051
2	A-1-a	G	13.5	16.5	3.0	15.0	135	2,175	1,973	1,973	5,973					48	48	162	1.53	0.389	1,276	3,248	0.004	0.048	0.330	1,082	3,055	0.004	0.042
	A-1-a	G	16.5	19.5	3.0	18.0	135	2,580	2,378	2,253	6,253					48	46	154	1.84	0.331	1,084	3,337	0.003	0.040	0.292	959	3,212	0.003	0.036
3	A-1-b	G	19.5	24.5	5.0	22.0	135	3,255	2,918	2,543	6,543					62	57	201	2.24	0.275	901	3,444	0.003	0.039	0.252	826	3,369	0.003	0.036
	A-1-b	G	24.5	29.5	5.0	27.0	125	3,880	3,568	2,881	6,881					21	18	71	2.76	0.226	742	3,623	0.007	0.084	0.213	698	3,579	0.007	0.080
4	A-1-b	G	29.5	34.5	5.0	32.0	125	4,505	4,193	3,194	7,194					21	18	70	3.27	0.192	630	3,824	0.006	0.067	0.184	603	3,797	0.005	0.065
	A-1-b	G	34.5	39.5	5.0	37.0	125	5,130	4,818	3,507	7,507					21	17	68	3.78	0.167	547	4,054	0.005	0.055	0.161	529	4,036	0.004	0.053
1. σ _n ' = σ _v	"'+σ _m . Estima	te σ _m of 4,0	00 psf (mod	erately over	consolidated)	for natural s	oil deposits;	Ref. Table 1	1.2, Coduto 2	2003	•				•	•	•	•	•		Tota	Settlement:		1.189 in		Tota	Settlement:		0.981 in

^{1.} $\sigma_p' = \sigma_{vo}' + \sigma_{m}$; Estimate σ_m of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003

Date: 6/22/2019 Date: 6/23/2019 Checked By:

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} C_r = 0.10(Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

^{9.} $S_c = [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{vo})$ for $\sigma_{p'} \leq \sigma_{vo'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{p'}/\sigma_{vo'}) + [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v'})$ for $\sigma_{vo'} < \sigma_{v'} < \sigma_{v'}$ for $\sigma_{vo'} < \sigma_{v'}$ for $\sigma_{vo'} < \sigma_{v'} < \sigma_{v'}$ fo

^{10.} $S_c = H(1/C')log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 - FRA-70-13.10 - Retaining Wall W2 MSE Wall Settlement - Sta. 203+00 to 212+25

 Calculated By:
 BRT
 Date:
 6/22/2019

 Checked By:
 JPS
 Date:
 6/23/2019

Boring B-100-3-14

H= 22.3 ft Total wall height

B'= 11.9 ft Effective footing width due to eccentricity

13.0 ft Depth below bottom of footing

q_e = 3,840 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement at	Center of Re	einforced So	il Mass		Total Sett	tlement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type		Depth ft)	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c ⁽²⁾	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' (6)	Z_f /B	1 ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	$\Delta\sigma_{v}^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-1-a	G	0.0	2.5	2.5	1.3	135	338	169	169	4,169					52	95	431	0.11	0.996	3,826	3,994	0.008	0.096	0.500	1,919	2,088	0.006	0.076
'	A-1-a	G	2.5	5.0	2.5	3.8	135	675	506	506	4,506					52	76	303	0.32	0.929	3,568	4,074	0.007	0.090	0.494	1,897	2,403	0.006	0.067
2	A-1-b	G	5.0	7.5	2.5	6.3	135	1,013	844	844	4,844					49	63	231	0.53	0.802	3,081	3,924	0.007	0.087	0.477	1,832	2,676	0.005	0.065
2	A-1-b	G	7.5	10.0	2.5	8.8	135	1,350	1,181	1,181	5,181					49	58	204	0.74	0.676	2,597	3,778	0.006	0.074	0.450	1,728	2,910	0.005	0.058
	A-1-a	G	10.0	13.0	3.0	11.5	135	1,755	1,553	1,553	5,553					120	130	736	0.97	0.564	2,165	3,717	0.002	0.019	0.415	1,592	3,144	0.001	0.015
3	A-1-a	G	13.0	16.0	3.0	14.5	135	2,160	1,958	1,864	5,864					120	123	666	1.22	0.471	1,810	3,674	0.001	0.016	0.375	1,439	3,303	0.001	0.013
	A-1-a	G	16.0	19.0	3.0	17.5	135	2,565	2,363	2,082	6,082					120	119	625	1.47	0.403	1,546	3,628	0.001	0.014	0.338	1,298	3,380	0.001	0.012
4	A-1-a	G	19.0	23.0	4.0	21.0	125	3,065	2,815	2,316	6,316					21	20	74	1.76	0.343	1,316	3,632	0.011	0.126	0.301	1,154	3,470	0.009	0.114
4	A-1-a	G	23.0	27.0	4.0	25.0	125	3,565	3,315	2,566	6,566					21	19	73	2.10	0.292	1,122	3,688	0.009	0.104	0.265	1,017	3,584	0.008	0.096
1. σ _p ' = σ _v	_o '+σ _{m;} Estima	ate $\sigma_{\rm m}$ of 4,00	00 psf (mode	erately overc	consolidated)	for natural so	oil deposits;	Ref. Table 1	1.2, Coduto 2	2003											Total	Settlement:		0.625 in		Total	Settlement:		0.515 in

- 2. $C_c = 0.009(LL-10)$; Ref. Table 6-9, FHWA GEC 5
- 3. $C_r = 0.10$ (Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981
- 4. e_o = (C_c/1.15)+0.35; Ref. Table 8-2, Holtz and Kovacs 1981
- 5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- 6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
- 7. Influence factor for strip loaded footing
- 8. $\Delta \sigma_v = q_e$
- $9. \ \ S_c = [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_{v_o}') for \ \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_i}'; \ [C_r/(1+e_o)](H) log(\sigma_p'/\sigma_{v_o}') + [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_p') \ for \ \sigma_{v_o}' < \sigma_p' < \sigma_{v_i}'; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO \ LRFD \ BDS \ (Cohesive soil layers)$
- 10. $S_c = H(1/C')log(\sigma_{vf}/\sigma_{vo})$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

MSE Wall Settlement - Sta. 203+00 to 212+25

Boring B-102-2-14

28.5 ft Total wall height

15.4 ft Effective footing width due to eccentricity

14.5 ft Depth below bottom of footing

4,750 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	Center of Re	einforced So	il Mass		Total Set	tlement at Fa	acing of Wall	
Layer	Soil Class.	Soil Type		Depth ft)	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' ⁽⁶⁾	Z_f /B	1 ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _v ,' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-1-a	G	0.0	2.5	2.5	1.3	135	338	169	169	4,169					61	112	563	0.08	0.998	4,742	4,910	0.007	0.078	0.500	2,374	2,543	0.005	0.063
1	A-1-a	G	2.5	5.0	2.5	3.8	135	675	506	506	4,506					61	89	389	0.24	0.962	4,570	5,076	0.006	0.077	0.497	2,361	2,868	0.005	0.058
	A-1-b	G	5.0	7.5	2.5	6.3	130	1,000	838	838	4,838					26	34	110	0.41	0.877	4,168	5,005	0.018	0.213	0.488	2,319	3,156	0.013	0.158
2	A-1-b	G	7.5	10.0	2.5	8.8	130	1,325	1,163	1,163	5,163					26	31	101	0.57	0.775	3,682	4,844	0.015	0.184	0.472	2,243	3,406	0.012	0.139
	A-1-b	G	10.0	12.5	2.5	11.3	130	1,650	1,488	1,488	5,488					26	29	95	0.73	0.679	3,224	4,712	0.013	0.158	0.451	2,141	3,629	0.010	0.122
2	A-1-a	G	12.5	15.5	3.0	14.0	135	2,055	1,853	1,853	5,853					48	49	166	0.91	0.589	2,797	4,650	0.007	0.086	0.424	2,012	3,865	0.006	0.069
3	A-1-a	G	15.5	19.0	3.5	17.3	135	2,528	2,291	2,120	6,120					48	47	158	1.12	0.504	2,395	4,515	0.007	0.088	0.390	1,853	3,973	0.006	0.073
	A-1-b	G	19.0	24.0	5.0	21.5	130	3,178	2,853	2,416	6,416					29	27	91	1.40	0.421	2,000	4,416	0.014	0.172	0.349	1,656	4,071	0.012	0.149
4	A-1-b	G	24.0	29.0	5.0	26.5	130	3,828	3,503	2,754	6,754					29	26	88	1.72	0.351	1,665	4,419	0.012	0.140	0.306	1,453	4,206	0.010	0.125
_	A-1-b	G	29.0	35.5	6.5	32.3	135	4,705	4,266	3,159	7,159					51	43	143	2.09	0.293	1,392	4,550	0.007	0.087	0.266	1,262	4,420	0.007	0.080
5	A-1-b	G	35.5	42.0	6.5	38.8	135	5,583	5,144	3,631	7,631					51	41	134	2.52	0.247	1,171	4,802	0.006	0.071	0.230	1,091	4,721	0.006	0.066
1. $\sigma_{p}' = \sigma_{y}$	'+σ _m . Estima	te σ _m of 4,0	00 psf (mode	erately overc	onsolidated)	for natural so	oil deposits;	Ref. Table 1	1.2, Coduto	2003	ı		ı	ı			1		ı		Tota	Settlement:		1.353 in		Tota	l Settlement:		1.102 in

^{1.} $\sigma_p' = \sigma_{vo}' + \sigma_{m}$; Estimate σ_m of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003

Date: 6/22/2019 Checked By: JPS Date: 6/23/2019

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} C_r = 0.10(Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

^{9.} $S_c = [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{vo})$ for $\sigma_{p'} \leq \sigma_{vo'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{p'}/\sigma_{vo'}) + [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{p'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v'})$ for $\sigma_{vo'} < \sigma_{p'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v'})$ for $\sigma_{vo'} < \sigma_{v'} < \sigma_{v'}$ for $\sigma_{vo'} < \sigma_{v'}$ for $\sigma_{vo'} < \sigma_{v'} < \sigma_{v'}$ fo

^{10.} $S_c = H(1/C')log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 - FRA-70-13.10 - Retaining Wall W2 MSE Wall Settlement - Sta. 203+00 to 212+25
 Calculated By:
 BRT
 Date:
 6/22/2019

 Checked By:
 JPS
 Date:
 6/23/2019

Boring B-102-4-14

H= 38.1 ft Total wall height

B'= 20.8 ft Effective footing width due to eccentricity

D_w = 13.0 ft Depth below bottom of footing

q_e = 6,200 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement at	Center of Re	einforced So	il Mass		Total Set	tlement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type	Layer (1		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' ⁽⁶⁾	Z_f /B	1 ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	Δσ _ν ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-1-a	G	0.0	3.0	3.0	1.5	135	405	203	203	4,203					47	83	348	0.07	0.999	6,192	6,395	0.013	0.155	0.500	3,100	3,302	0.010	0.126
	A-1-b	G	3.0	5.5	2.5	4.3	125	718	561	561	4,561					25	36	116	0.20	0.976	6,051	6,612	0.023	0.277	0.498	3,089	3,651	0.018	0.210
2	A-1-b	G	5.5	8.0	2.5	6.8	125	1,030	874	874	4,874					25	32	105	0.32	0.924	5,730	6,604	0.021	0.252	0.494	3,060	3,934	0.016	0.187
	A-1-b	G	8.0	10.5	2.5	9.3	125	1,343	1,186	1,186	5,186					25	29	97	0.44	0.853	5,291	6,477	0.019	0.227	0.485	3,007	4,193	0.014	0.169
3	A-1-b	G	10.5	13.5	3.0	12.0	120	1,703	1,523	1,523	5,523					11	12	60	0.58	0.770	4,772	6,295	0.031	0.372	0.471	2,922	4,444	0.023	0.281
3	A-1-b	G	13.5	17.0	3.5	15.3	120	2,123	1,913	1,772	5,772					11	11	59	0.73	0.677	4,200	5,972	0.031	0.377	0.450	2,793	4,565	0.024	0.294
1	A-1-b	G	17.0	19.5	2.5	18.3	135	2,460	2,291	1,964	5,964					88	89	386	0.88	0.604	3,742	5,706	0.003	0.036	0.429	2,657	4,621	0.002	0.029
7	A-1-b	G	19.5	22.0	2.5	20.8	135	2,798	2,629	2,145	6,145					88	86	368	1.00	0.551	3,415	5,560	0.003	0.034	0.410	2,539	4,684	0.002	0.028
	A-1-a	G	22.0	25.0	3.0	23.5	130	3,188	2,993	2,337	6,337					28	27	90	1.13	0.501	3,105	5,443	0.012	0.147	0.389	2,409	4,747	0.010	0.123
5	A-1-a	G	25.0	28.5	3.5	26.8	130	3,643	3,415	2,557	6,557					28	26	88	1.29	0.451	2,797	5,354	0.013	0.154	0.365	2,261	4,818	0.011	0.132
	A-1-a	G	28.5	32.0	3.5	30.3	130	4,098	3,870	2,794	6,794					28	25	86	1.45	0.407	2,521	5,314	0.011	0.137	0.340	2,110	4,904	0.010	0.120
6	A-1-a	G	32.0	37.0	5.0	34.5	135	4,773	4,435	3,093	7,093					60	51	175	1.66	0.362	2,246	5,340	0.007	0.081	0.313	1,943	5,037	0.006	0.073
7	A-1-b	G	37.0	42.0	5.0	39.5	130	5,423	5,098	3,444	7,444					45	37	120	1.90	0.321	1,988	5,432	0.008	0.099	0.286	1,770	5,214	0.008	0.090
8	A-4a	С	42.0	45.0	3.0	43.5	130	5,813	5,618	3,714	7,714	22	0.108	0.011	0.444				2.09	0.293	1,819	5,533	0.004	0.047	0.266	1,648	5,363	0.004	0.043
1. σ _p ' = σ _v	₀'+σ _{m;} Estima	ate σ_m of 4,0	00 psf (mode	erately over	consolidated)	for natural so	il deposits;	Ref. Table 1	11.2, Coduto	2003											Tota	Settlement:		2.396 in		Tota	Settlement:		1.904 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} $C_r = 0.10(Cc)$ for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

 $^{9. \ \} S_c = [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{vo}) \\ \text{for } \sigma_p' \leq \sigma_{vo}' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_p' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{vo}' < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for } \sigma_{v'} < \sigma_{v'}; \ [C_r/(1+e_o)](H)\log(\sigma_{v'}/\sigma_p') \\ \text{for }$

^{10.} S_c = H(1/C')log(σ_{v_i} '/ σ_{v_o} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

MSE Wall Settlement - Sta. 203+00 to 212+25

Boring B-102-4-14

H= 38.1 ft Total wall height A-4a ft²/yr B'= 20.8 ft Effective footing width due to eccentricity 1.000 Coefficient of consolitation $c_v =$ 13.0 Depth below bottom of footing 6 days Time following completion of construction 6,200 Equivalent bearing pressure at bottom of wall $H_{dr} =$ Length of longest drainage path considered $q_e =$ psf 3 $T_v =$ 1.826 Time factor 99 Degree of consolidation U = $(S_c)_t =$ 1.904 in Settlement complete at 100% of primary consolidation

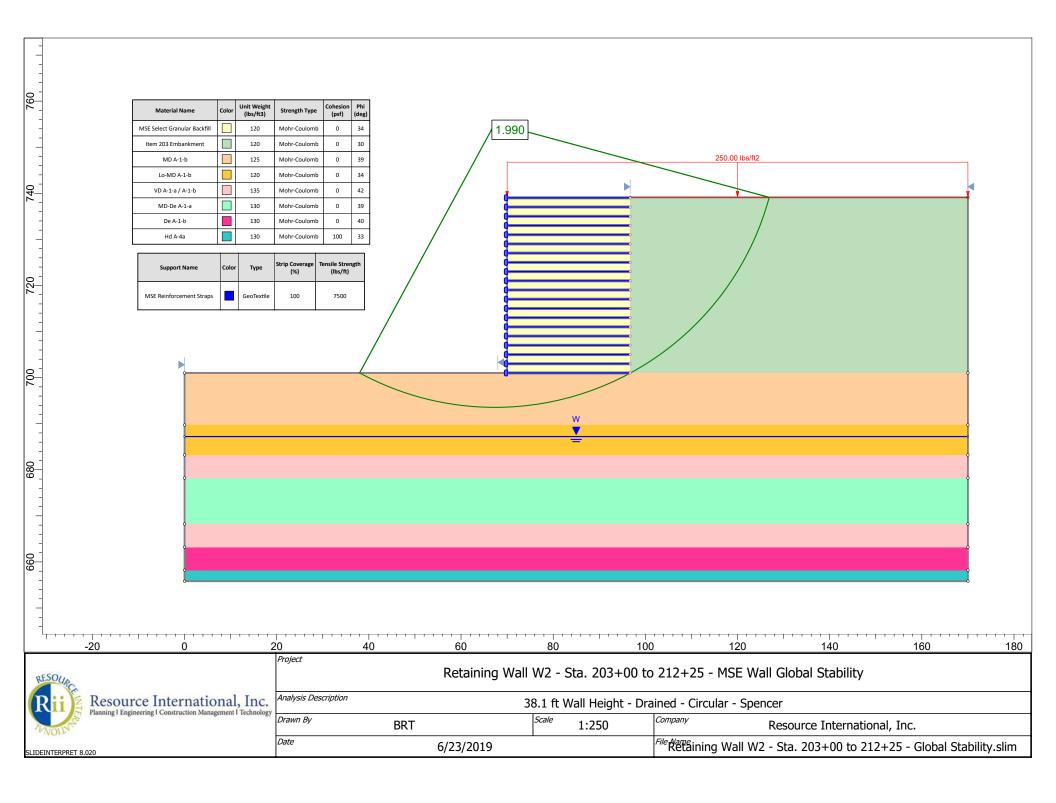
																							Total Se	ttlement at I	acing of Wall		nplete at 100% of onsolidation
Layer	Soil Type	Soil Type		Depth ft)	Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c ⁽²⁾	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' (6)	Z _f /B	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	Layer Settlement (in)	(S _c) _t ⁽¹¹⁾ (in)	Layer Settlement (in)
1	A-1-a	G	0.0	3.0	3.0	1.5	135	405	203	203	4,203					47	83	348	0.07	0.500	3,100	3,302	0.010	0.126	0.126	0.126	
	A-1-b	G	3.0	5.5	2.5	4.3	125	718	561	561	4,561					25	36	116	0.20	0.498	3,089	3,651	0.018	0.210		0.210	0.692
2	A-1-b	G	5.5	8.0	2.5	6.8	125	1,030	874	874	4,874					25	32	105	0.32	0.494	3,060	3,934	0.016	0.187	0.567	0.187	0.092
	A-1-b	G	8.0	10.5	2.5	9.3	125	1,343	1,186	1,186	5,186					25	29	97	0.44	0.485	3,007	4,193	0.014	0.169		0.169	
2	A-1-b	G	10.5	13.5	3.0	12.0	120	1,703	1,523	1,523	5,523					11	12	60	0.58	0.471	2,922	4,444	0.023	0.281	0.574	0.281	0.574
3	A-1-b	G	13.5	17.0	3.5	15.3	120	2,123	1,913	1,772	5,772					11	11	59	0.73	0.450	2,793	4,565	0.024	0.294	0.574	0.294	0.374
4	A-1-b	G	17.0	19.5	2.5	18.3	135	2,460	2,291	1,964	5,964					88	89	386	0.88	0.429	2,657	4,621	0.002	0.029	0.057	0.029	0.057
7	A-1-b	G	19.5	22.0	2.5	20.8	135	2,798	2,629	2,145	6,145					88	86	368	1.00	0.410	2,539	4,684	0.002	0.028	0.037	0.028	0.037
	A-1-a	G	22.0	25.0	3.0	23.5	130	3,188	2,993	2,337	6,337					28	27	90	1.13	0.389	2,409	4,747	0.010	0.123		0.123	
5	A-1-a	G	25.0	28.5	3.5	26.8	130	3,643	3,415	2,557	6,557					28	26	88	1.29	0.365	2,261	4,818	0.011	0.132	0.375	0.132	0.375
	A-1-a	G	28.5	32.0	3.5	30.3	130	4,098	3,870	2,794	6,794					28	25	86	1.45	0.340	2,110	4,904	0.010	0.120		0.120	
6	A-1-a	G	32.0	37.0	5.0	34.5	135	4,773	4,435	3,093	7,093					60	51	175	1.66	0.313	1,943	5,037	0.006	0.073	0.073	0.073	0.073
7	A-1-b	G	37.0	42.0	5.0	39.5	130	5,423	5,098	3,444	7,444					45	37	120	1.90	0.286	1,770	5,214	0.008	0.090	0.090	0.090	0.090
8	A-4a	С	42.0	45.0	3.0	43.5	130	5,813	5,618	3,714	7,714	22	0.108	0.011	0.444				2.09	0.266	1,648	5,363	0.004	0.043	0.043	0.043	0.043

- 1. $\sigma_p' = \sigma_{vo}' + \sigma_m$. Estimate σ_m of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003
- 2. C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5
- 3. C_r = 0.10(Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981
- 4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
- 5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- 6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
- 7. Influence factor for strip loaded footing
- 8. $\Delta \sigma_v = q_e(I)$
- 9. $S_c = [C_o/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v_o}')$ for $\sigma_p' \le \sigma_{v_o'}'$; $[C_t/(1+e_o)](H)\log(\sigma_p'/\sigma_{v_o}')$ for $\sigma_{v_o'}' \le \sigma_p'$; $[C_t/(1+e_o)](H)\log(\sigma_{v_o'}/\sigma_{v_o}')$ for $\sigma_{v_o'}' \le \sigma_{v_o'}'$; $[C_t/(1+e_o)](H)\log(\sigma_{v_o'}/\sigma_{v_o}')]$
- 10. $S_c = H(1/C')log(\sigma_{vf}'/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
- 11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

Calculated By: BRT Date: 06/22/2019 Checked By: Date: 06/23/2019

Settlement Remaining After Hold Period: 0.000 in

Settlement Complete at 100% of





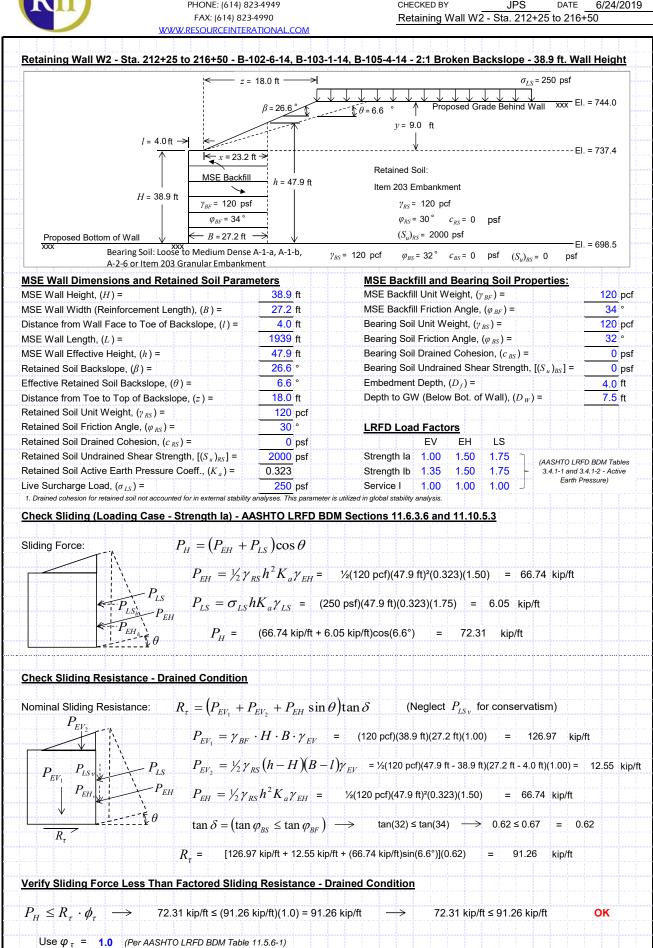
 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
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 OF
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 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

 Retaining Wall W2 - Sta. 212+25 to 216+50





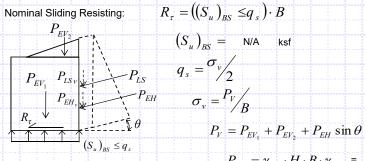
RESOURCE INTERNATIONAL, INC. 6350 PRESIDENTIAL GATEWAY COLUMBUS, OHIO 43231 PHONE: (614) 823-4949 FAX: (614) 823-4990 WWW.RESOURCEINTERATIONAL.COM

FRA-70-13.10 JOB SHEET NO. CALCULATED BY DATE CHECKED BY DATE 6/24/2019 Retaining Wall W2 - Sta. 212+25 to 216+50

MSE Wall Dimensions and Retained Soil Paran	<u>neters</u>	Bearing Soil Properties:
MSE Wall Height, (H) =	38.9 ft	MSE Backfill Unit Weight, (γ_{BF}) = 120 p
MSE Wall Width (Reinforcement Length), (B) =	27.2 ft	MSE Backfill Friction Angle, (φ_{BF}) = 34 °
Distance from Wall Face to Toe of Backslope, (l) =	4.0 ft	Bearing Soil Unit Weight, (γ_{BS}) = 120 p
MSE Wall Length, (L) =	1939 ft	Bearing Soil Friction Angle, (φ_{BS}) = 32 °
MSE Wall Effective Height, (h) =	47.9 ft	Bearing Soil Drained Cohesion, $(c_{BS}) = 0$ p
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 0$ p
Effective Retained Soil Backslope, (θ) =	6.6 °	Embedment Depth, (D_f) = 4.0 ft
Distance from Toe to Top of Backslope, (z) =	18.0 ft	Depth to GW (Below Bot. of Wall), (D_W) = 7.5 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	
Retained Soil Friction Angle, (φ_{RS}) =	30 °	LRFD Load Factors
Retained Soil Drained Cohesion, (c_{RS}) =	0 psf	EV EH LS
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000 psf	Strength la 1.00 1.50 1.75 (AASHTO LRED BDM Table
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.323	Strength lb 1.35 1.50 1.75 - 3.4.1-1 and 3.4.1-2 - Active
Live Surcharge Load, (σ_{LS}) =	250 psf	Service I 1.00 1.00 1.00 Earth Pressure)

Check Sliding (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.10.5.3 (Continued,

Check Sliding Resistance - Undrained Condition



(Neglect $P_{LS_{\nu}}$ for conservatism)

 $P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$ = (120 pcf)(38.9 ft)(27.2 ft)(1.00) = 127 kip/ft

 $P_{EV_{\star}} = \frac{1}{2} \gamma_{RS} (h-H)(B-l) \gamma_{EV}$

 $P_{EV} = \frac{1}{2}(120 \text{ pcf})(47.9 \text{ ft} - 38.9 \text{ ft})(27.2 \text{ ft} - 4.0 \text{ ft})(1.00) = 12.55 \text{ kip/ft}$

 $P_{E\!H} = \frac{1}{2} \gamma_{R\!S} h^2 K_a \gamma_{E\!H} \quad = \quad \frac{1}{2} (120 \text{ pcf}) (47.9 \text{ ft})^2 (0.323) (1.50) \quad = \quad 66.74 \text{ kip/ft}$

 $P_V = 126.97 \text{ kip/ft} + 12.55 \text{ kip/ft} + (66.74 \text{ kip/ft}) \sin(6.6^\circ) = 147.19 \text{ kip/ft}$

 $\sigma_{v} = (147.19 \text{ kip/ft}) / (27.2 \text{ ft}) =$ 5.41 ksf $q_s = (5.41 \text{ ksf})/2 = 2.71 \text{ ksf}$

 $R_{\tau} = (N/A \text{ ksf} \le 2.71 \text{ ksf})(27.2 \text{ ft}) =$

Verify Sliding Force Less Than Factored Sliding Resistance - Undrained Condition

 $P_{H} \leq R_{\tau} \cdot \phi_{\tau} \longrightarrow$

N/A

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

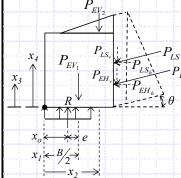


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Retaining Wall W2 - Sta. 212+25 to 216+50

MSE Wall Dimensions and Retained Soil Param		Bearing So			amana da mana da		4
MSE Wall Height, (H) =	38.9 ft	MSE Backfil	I Unit W	/eight, (₎	$(r_{BF}) =$		120 pc
MSE Wall Width (Reinforcement Length), (B) =	27.2 ft	MSE Backfil	I Frictio	n Angle,	$(\varphi_{BF}) =$		34 °
Distance from Wall Face to Toe of Backslope, (l) =	4.0 ft	Bearing Soil	Unit W	eight, (γ	_{BS}) =		120 pc
MSE Wall Length, (L) =	1939 ft	Bearing Soil	Friction	n Angle,	$(\varphi_{BS}) =$		32 °
MSE Wall Effective Height, (h) =	47.9 ft	Bearing Soil	Draine	d Cohes	ion, (c_{BS})) =	0 ps
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil	Undrai	ned She	ar Streng	$[(s_u)_{BS}] =$	0 ps
Effective Retained Soil Backslope, (θ) =	6.6 °	Embedment	Depth,	$(D_f) =$			4.0 ft
Distance from Toe to Top of Backslope, (z) =	18.0 ft	Depth to GV	۷ (Belov	w Bot. of	Wall), (<i>L</i>) _w)=	7.5 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf						
Retained Soil Friction Angle, (φ_{RS}) =	30 °	LRFD Load	d Facto	ors			
Retained Soil Drained Cohesion, (c_{RS}) =	0 psf		EV	EH	LS		
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000 psf	Strength la	1.00	1.50	1.75	(AASHTO LP	FD BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.323	Strength lb	1.35	1.50	1.75	- 3.4.1-1 and 3	3.4.1-2 - Active
Live Surcharge Load, (σ_{LS}) =	250 psf	Service I	1.00	1.00	1.00	Earth F	Pressure)
1. Drained cohesion for retained soil not accounted for in external stability	analyses. This parameter is	s utilized in global stability	analysis.				



 $x_o = \frac{M_V - M_H}{P_V} = 2179.79 \text{ kip-ft/ft} - 1219.91 \text{ kip-ft/ft}) / (147.19 \text{ kip/f} = 6.52 \text{ ft}$

 $M_V = 2179.79 \text{ kip-ft/ft}$ Defined below $M_H = 1219.91 \text{ kip-ft/ft}$ $P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta = 126.97 \text{ kip/ft} + 12.55 \text{ kip/ft} + (66.74 \text{ kip/ft}) \sin(6.6^\circ) = 147.19 \text{ kip/ft}$

$$e = (27.2 \text{ ft/ 2}) - 6.52 \text{ ft} = 7.08 \text{ ft}$$

Resisting Moment, $M_{_{\it V}}$:

 $M_V = P_{EV_1}(x_1) + P_{EV_2}(x_2) + P_{EH} \sin \theta(B)$ (Neglect P_{LS_V} for conservatism)

 $P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$ = (120 pcf)(38.9 ft)(27.2 ft)(1.00) = 126.97 kip/ft

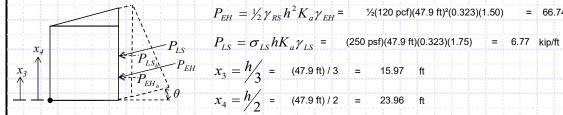
 $P_{LS} = \frac{1}{2} \gamma_{RS} (h - H) (B - l) \gamma_{EV} = \frac{1}{2} (120 \text{ pcf}) (47.9 \text{ ft} - 38.9 \text{ ft}) (27.2 \text{ ft} - 4.0 \text{ ft}) (1.00) = 12.55 \text{ kip/ft}$ $P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf}) (47.9 \text{ ft})^2 (0.323) (1.50) = 66.74 \text{ kip/ft}$ $x_1 = B/2 = (27.2 \text{ ft})/2 = 13.60 \text{ ft}$

 $x_2 = l + \frac{2}{3}(B - l) = 4.0 \text{ ft} + \frac{2}{3}(27.2 \text{ ft} - 4.0 \text{ ft}) = 19.47 \text{ ft}$

 M_V = (126.97 kip/ft)(13.60 ft) + (12.55 kip/ft)(19.47 ft) + (66.74 kip/ft)sin(6.6°)(27.2 ft) = 2179.79 kip-ft/ft

Overturning Moment, $M_{\scriptscriptstyle H}$:

$$M_H = P_{EH} \cos \theta(x_3) + P_{LS} \cos \theta(x_4)$$



 $P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(47.9 \text{ ft})^2 (0.323)(1.50) = 66.74 \text{ kip/ft}$

 $x_4 = \frac{h}{2} = (47.9 \text{ ft})/2 = 23.96 \text{ ft}$

 $M_H = (66.74 \text{ kip/ft})\cos(6.6^\circ)(15.97 \text{ ft}) + (6.77 \text{ kip/ft})\cos(6.6^\circ)(23.96 \text{ ft}) = 1219.91 \text{ kip-ft/ft}$

Limiting Eccentricity: $e_{\text{max}} = \frac{B}{3} \rightarrow e_{\text{max}} = \frac{(27.2 \text{ ft})}{3} =$ **Check Eccentricity** 9.07 $e < e_{\text{max}} \longrightarrow$ 7.08 ft < 9.07 ft OK



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 Retaining Wall W2 - Sta. 212+25 to 216+50

	(: (614) 823-4990	Retaining Wall W2 - Sta. 212+25 to 21	6+50
WWW.RESOL	<u>URCEINTERATIONAL.COM</u>		
MSE Wall Dimensions and Retained S	oil Parameters	Bearing Soil Properties:	
MSE Wall Height, (H) =	38.9 ft	MSE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B		MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Distance from Wall Face to Toe of Backslop		Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
MSE Wall Length, (L) =	1939 ft	Bearing Soil Friction Angle, (φ_{BS}) =	32 °
MSE Wall Effective Height, (h) =	47.9 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	0 psf
Effective Retained Soil Backslope, (θ) =	6.6 °	Embedment Depth, (D_f) =	4.0 ft
Distance from Toe to Top of Backslope, (z)	= 18.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	7.5 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf		
Retained Soil Friction Angle, (φ_{RS}) =	30 °	LRFD Load Factors	
Retained Soil Drained Cohesion, (c_{RS}) =	0 psf	EV EH LS	
Retained Soil Undrained Shear Strength, [(S		Strength la 1.00 1.50 1.75] (AASHTO L	.RFD BDM Tables
Retained Soil Active Earth Pressure Coeff.,	$(K_a) = 0.323$		d 3.4.1-2 - Active h Pressure)
Live Surcharge Load, (σ_{LS}) =	250 psf	Service I 1.00 1.00 1.00 J	i Fiessure)
Drained cohesion for retained soil not accounted for in ex-			
Check Bearing Capacity (Loading Cas	e - Strength lb) - AASHTO	D LRFD BDM Section 11.6.3.2	
P_{EV_2} .			
	$q_{eq} = P_{V} / R_{I}$		
innumient uniformation automation automatica automatica automatica automatica automatica automatica automatica	q_{eq} – $/B'$		
X_4 P_{EV_1} P_{LS} P_{LS}	B' = B - 2e = 27	7.0 ft 0/5 10 ft) _ 16.04 ft	
$A = P_{LS} $	B = B - 2e = 2i	7.2 ft - 2(5.18 ft) = 16.84 ft	
$\frac{1}{EH}$	a - B/ - r	= (27.2 ft / 2) - 8.42 ft = 5.18 ft	
R^{V}	/ 2		
	$_{r}$ $_{-}$ M_{V} $_{-}$ M_{H}	= (2860 65 kip;ff/ft - 1210 01 kip;ff/ft) / 106 02 kir	√f = 8.42 ft
$x_0 \leftarrow \times \rightarrow -1 - 1 - e$	P_{ν}	- = (2869.65 kip-ft/ft - 1219.91 kip-ft/ft) / 196.02 kip	/// = 0.42 it
$\leftarrow B/2 \rightarrow$	a = (196.02 kip/ft)) / (16.84 ft) = 11.64 ksf	
\overrightarrow{B}	9 eq — (100.02 kip)ii	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
X ₂ ->			
Resisting Moment, $M_{_{I\!\!\!/}}$: $M_{_{I\!\!\!/}}$	$P_{EV_1}(x_1) + P_{EV_2}(x_2)$	$+P_{\scriptscriptstyle FH}\sin\theta(B)$	
$P_{\scriptscriptstyle EV_2}$	$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EI}$	= (120 pcf)(38.9 ft)(27.2 ft)(1.35) = 171.41	kip/ft
	$P_{EV_2} = \frac{1}{2} \gamma_{RS} (h - H) (B$	$(-l)\gamma_{EV}=1/2$ (120 pcf)(47.9 ft - 38.9 ft)(27.2 ft - 4.0 ft)(1.35) =	= 16.94 kip/ft
P_{IS}			
	$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH}$		ip/ft
$P_{\it EH}$	D		
\ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \ \	$x_1 = B/2 = (27.2 \text{ ft})/2$	2 = 13.60 ft	
$\rightarrow x_I$	$x_2 = l + \frac{2}{3}(B - l) =$	$4.0 \text{ ft} + \frac{2}{3}(27.2 \text{ ft} - 4.0 \text{ ft}) = 19.47 \text{ ft}$	
	(474 4411 (5)(40 05 5)		0000 05 11 5 5
$M_{ u}$	= (1/1.41 kip/ft)(13.60 ft) +	(16.94 kip/ft)(19.5 ft) + (66.74 kip/ft)sin(6.6°)(27.2 ft) =	∠869.65 kip.ft/f
Overturning Memort M	D		
Overturning Moment, $M_{\scriptscriptstyle H}$: $M_{\scriptscriptstyle I}$	$H = P_{EH} \cos \theta(x_3) + P$	$\sum_{LS} \cos \theta(x_4)$	
	D _ 1/ 1.2 w	= 1/(120 pof)(47 0 ft)2/0 222)(4 50) = 60 74	in/ft
	$r_{EH} = \gamma_2 \gamma_{RS} n^- K_a \gamma_{EH}$	$= \frac{1}{2}(120 \text{ pcf})(47.9 \text{ ft})^2(0.323)(1.50) = 66.74 \text{ k}$	ıp/it
	D LV	(250 pef)(47 0 ft)(0 222)(4 75) = 6 77 Lii (4	
		(250 psf)(47.9 ft)(0.323)(1.75) = 6.77 kip/ft	
P_{EH}	$x_3 = h/3 = (47.9 \text{ ft})/3$	3 – 15.97 ft	
P _{EH} ,	-3 - /3 - (47.310)/3		
<u> </u>	$x_4 = h_2 = (47.9 \text{ ft})/2$	2 = 23.96 ft	
	$\frac{1}{2}$ – $\frac{1}{2}$ – $\frac{1}{2}$		
M.	$_{7} = (66.74 \text{ kip/ft})\cos(6.6^{\circ})(1.0^{\circ})$	5.97 ft) + (6.77 kip/ft)cos(6.6°)(23.96 ft) = 1219.91 ki	ip-ft/ft
1144	, (33,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	, (0, 1,500,000,000,000,000,000,000,000,000,00	·r
Vertical Forces, P_{ν} : P_{ν}	$= P_{EV_1} + P_{EV_2} + P_{EH} \operatorname{si}$	$\ln heta$	
kan da kan d	EV ₁ EV ₂ EH		
	$P_V = 171.41 \text{ kip/ft} + 16.9$	4 kip/ft + (66.74 kip/ft)sin(6.6°) = 196.02 kip/ft	



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 Retaining Wall W2 - Sta. 212+25 to 216+50

<u>ISE Wall Dimensions and Retained Soil Pa</u>	<u>rameter</u> s	Bearing Soil Properties:	
ISE Wall Height, (H) =	38.9 ft	MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
ISE Wall Width (Reinforcement Length), (<i>B</i>) =	27.2 ft	MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Pistance from Wall Face to Toe of Backslope, (l) =	= 4.0 ft	Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
1SE Wall Length, (L) =	1939 ft	Bearing Soil Friction Angle, (φ_{BS}) =	32 °
ISE Wall Effective Height, (h) =	47.9 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
letained Soil Backslope, (β) =	26.6°	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	0 psf
ffective Retained Soil Backslope, (θ) =	6.6°	Embedment Depth, (D_f) =	4.0 ft
Distance from Toe to Top of Backslope, (z) =	18.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	7.9 ft
Letained Soil Unit Weight, (γ_{RS}) =	120 pcf		
Retained Soil Friction Angle, (φ_{RS}) =	30°	LRFD Load Factors	
Retained Soil Undrained Chesion, (c _{RS}) =	0 psf	EV EH LS	
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 0$		Strength la 1.00 1.50 1.75 (AASHTO LRFD Strength lb 1.35 1.50 1.75 - 3.4.1-1 and 3.4	
Retained Soil Active Earth Pressure Coeff., (K_a) = ive Surcharge Load, (σ_{LS}) =	0.323 250 psf	Strength lb 1.35 1.50 1.75 3.4.1-1 and 3.4 Service I 1.00 1.00 1.00	
ive Surcharge Load, (σ_{LS}) – 1. Drained cohesion for retained soil not accounted for in external sta			
Check Bearing Capacity (Loading Case - Str		LRFD BDM Section 11.10.5.4 (Continued)	
Check Bearing Resistance - Drained Condit			
	$+ \gamma D_f N_{qm} C_{wq} +$		
$N_{cm} = N_c s_c i_c = 35.49$	$N_{qm} = N_q s_q d_q i_q$	$N_{pn} = N_{\gamma} S_{\gamma} i_{\gamma} = 30.2$	
N _c = 35.49	$N_q = 23.18$	$N_{\gamma} = 30.21$	
S _c = 1+(16.84 ft/1939 ft)(23.18/35.49)	$S_q = 1+(16.84 \text{ ft/}$	1939 ft)tan(32°) = 1.000 $S_{y} = 1-0.4(16.84 \text{ ft/1939 ft})$	= 1.000
= 1.000	$d_q = 1 + 2 \tan(32^\circ)$	$[1-\sin(32^\circ)]^2\tan^{-1}(4.0 \text{ ft/}16.84 \text{ ft})$ $i_\gamma = 1.000 \text{ (Assumed)}$	
i_c = 1.000 (Assumed)	= 1.100	$C_{w\gamma} = 7.9 \text{ft} < 1.5 (16.84 \text{ft}) + 4.0 \text{ft}$) ft = 0.5
	$i_q = 1.000$ (A		
	$C_{wq} = 7.9 \text{ ft} > 4.$.0 ft = 1.000	
$q_n = (0 \text{ psf})(35.49) + (120 \text{ pcf})(4.0 \text{ ft})$			
erify Equivalent Pressure Less Than Facto	red Bearing Resistar		
Verify Equivalent Pressure Less Than Facto $q_{eq} \leq q_n \cdot \phi_b \longrightarrow$ 11.64 ksf			(
$q_{\it eq} \leq q_{\it n} \cdot \phi_{\it b} \; \longrightarrow \;$ 11.64 ksf	≤ (27.50 ksf)(0.65) = 1		C
	≤ (27.50 ksf)(0.65) = 1		
$q_{\it eq} \leq q_{\it n} \cdot \phi_{\it b} \; \longrightarrow \;$ 11.64 ksf	≤ (27.50 ksf)(0.65) = 1		
$q_{\it eq} \leq q_{\it n} \cdot \phi_{\it b} \; \longrightarrow \;$ 11.64 ksf	≤ (27.50 ksf)(0.65) = 1 M Table 11.5.6-1)		
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 11.64 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BD) Check Bearing Resistance - Undrained Con	≤ (27.50 ksf)(0.65) = 1 M Table 11.5.6-1) dition	17.88 ksf → 11.64 ksf ≤ 17.88 ksf O l	
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 11.64 \mathrm{ksf}$ Use $\varphi_b = 0.65 $ (Per AASHTO LRFD BDI) Check Bearing Resistance - Undrained Confidential Bearing Resistance: $q_n = cN_{cm}$	\leq (27.50 ksf)(0.65) = 1 M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} +$	17.88 ksf \rightarrow 11.64 ksf \leq 17.88 ksf OF	
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 11.64 \mathrm{ksf}$ Use $\varphi_b = 0.65 $ (Per AASHTO LRFD BDI	≤ (27.50 ksf)(0.65) = 1 M Table 11.5.6-1) dition	17.88 ksf \rightarrow 11.64 ksf \leq 17.88 ksf OF	
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 11.64 \mathrm{ksf}$ Use $\varphi_b = 0.65 $ (Per AASHTO LRFD BDI	\leq (27.50 ksf)(0.65) = 1 M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} +$	17.88 ksf \rightarrow 11.64 ksf \leq 17.88 ksf OF	
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 11.64 \mathrm{ksf}$ Use $\varphi_b = 0.65 $ (Per AASHTO LRFD BD) Sheck Bearing Resistance - Undrained Constant Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$	$\leq (27.50 \text{ ksf})(0.65) = 3$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} + N_{qm} = N_q s_q d_q i_q$ $N_q = 1.000$ $s_q = 1.000$	17.88 ksf \longrightarrow 11.64 ksf \le 17.88 ksf OF $\frac{1}{2}\gamma B' N_{jm} C_{wy}$ $\frac{1}{2} = 1.000$ $N_{jm} = N_{\gamma} S_{\gamma} i_{\gamma} = 0.000$ $\frac{N_{\gamma}}{S_{\gamma}} = 0.000$ $\frac{N_{\gamma}}{S_{\gamma}} = 1.000$	
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 11.64 \mathrm{ksf}$ Use $\varphi_b = 0.65 $ (Per AASHTO LRFD BD) Check Bearing Resistance - Undrained Constant Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$	$\leq (27.50 \text{ ksf})(0.65) = 3$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} + N_{qm} = N_q s_q d_q i_q$ $N_q = 1.000$ $s_q = 1.000$	17.88 ksf \longrightarrow 11.64 ksf \leq 17.88 ksf Of $\frac{1}{2} \gamma B^{\dagger} N_{jm} C_{wy}$ $N_{jm} = N_{y} S_{y} i_{y} = 0.000$ $N_{y} = 0.000$ $S_{y} = 1.000$	
$q_{eq} \leq q_n \cdot \phi_b \implies$ 11.64 ksf Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Con Iominal Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(16.84 \text{ ft/(5)(1939 ft)]} = 1.000$	$\leq (27.50 \text{ ksf})(0.65) = 2$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} + N_{qm} = N_q s_q d_q i_q$ $N_q = 1.000$ $s_q = 1.000$ $d_q = 1+2\tan(0^\circ)$ $= 1.000$	17.88 ksf \longrightarrow 11.64 ksf \le 17.88 ksf OF $\frac{1}{2} \gamma B' N_{ym} C_{wy}$ $\frac{1}{2} = 1.000$ $N_{ym} = N_{y} S_{y} i_{y} = 0.000$ $N_{y} = 0.000$ $S_{y} = 1.000$	
$q_{eq} \leq q_n \cdot \phi_b \implies$ 11.64 ksf Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Con Iominal Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(16.84 \text{ ft/(5)(1939 ft)]} = 1.000$	$\leq (27.50 \text{ ksf})(0.65) = 2$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} + N_{qm} = N_q S_q d_q i_q$ $N_q = 1.000$ $S_q = 1.000$ $d_q = 1+2\tan(0^\circ)$ $= 1.000$ $i_q = 1.000$ (A	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
$q_{eq} \leq q_n \cdot \phi_b \implies$ 11.64 ksf Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Con Iominal Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(16.84 \text{ ft/(5)(1939 ft)]} = 1.000$	$\leq (27.50 \text{ ksf})(0.65) = 2$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} + N_{qm} = N_q s_q d_q i_q$ $N_q = 1.000$ $s_q = 1.000$ $d_q = 1+2\tan(0^\circ)$ $= 1.000$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
$q_{eq} \leq q_n \cdot \phi_b \implies$ 11.64 ksf Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Con Iominal Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(16.84 \text{ ft/(5)(1939 ft)]} = 1.000$	$\leq (27.50 \text{ ksf})(0.65) = 2$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} + N_{qm} = N_q s_q d_q i_q$ $N_q = 1.000$ $s_q = 1.000$ $d_q = 1+2\tan(0^\circ)$ $= 1.000$ $i_q = 1.000$ (A $C_{wq} = 7.9 \text{ ft} > 4$	17.88 ksf \longrightarrow 11.64 ksf \le 17.88 ksf OF $\frac{1}{2} \gamma B' N_{ym} C_{wy}$ $N_{m} = N_{y} s_{y} i_{y} = 0.000$ $N_{y} = 0.000$ $N_$	
$q_{eq} \leq q_n \cdot \phi_b \implies$ 11.64 ksf Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Con Hominal Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(16.84 \text{ ft/(5)(1939 ft)}] = 1.000$ $i_c = 1.000 \text{ (Assumed)}$	$\leq (27.50 \text{ ksf})(0.65) = 2$ $M \text{ Table } 11.5.6-1)$ $\frac{\text{dition}}{m} + \gamma D_f N_{qm} C_{wq} + 2 N_{qm} = N_q s_q d_q i_q i_q i_q i_q i_q i_q i_q i_q i_q i$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 11.64 \mathrm{ksf}$ Use $\varphi_b = 0.65 $ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Con Hominal Bearing Resistance: $q_n = cN_{cm}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(16.84 \mathrm{ft/(5)(1939 ft)}] = 1.000$ $i_c = 1.000 $ (Assumed)	$\leq (27.50 \text{ ksf})(0.65) = 2$ $M \text{ Table } 11.5.6-1)$ $\frac{\text{dition}}{m} + \gamma D_f N_{qm} C_{wq} + 2 N_{qm} = N_q s_q d_q i_q i_q i_q i_q i_q i_q i_q i_q i_q i$	$\begin{array}{cccccccccccccccccccccccccccccccccccc$	



RESOURCE INTERNATIONAL, INC. 6350 PRESIDENTIAL GATEWAY COLUMBUS, OHIO 43231 PHONE: (614) 823-4949 FAX: (614) 823-4990 WWW.RESOURCEINTERATIONAL.COM

FRA-70-13.10 W-13-072 JOB SHEET NO. CALCULATED BY DATE 6/23/2019 JPS CHECKED BY DATE 6/24/2019 Retaining Wall W2 - Sta. 212+25 to 216+50

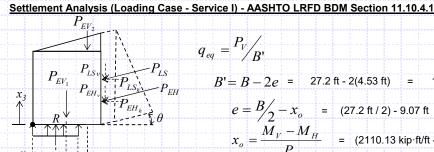
MSE Wall Dimensions and Retained Soil Param	eters	
MSE Wall Height, (H) =	38.9	ft
MSE Wall Width (Reinforcement Length), (B) =	27.2	ft
Distance from Wall Face to Toe of Backslope, (/) =	4.0	ft
MSE Wall Length, (L) =	1939	ft
MSE Wall Effective Height, (h) =	47.9	ft
Retained Soil Backslope, (β) =	26.6	0
Effective Retained Soil Backslope, (θ) =	6.6	0
Distance from Toe to Top of Backslope, (z) =	18.0	ft
Retained Soil Unit Weight, (γ_{RS}) =	120	pcf
Retained Soil Friction Angle, (φ_{RS}) =	30	0
Retained Soil Drained Cohesion, (c_{RS}) =	0	psf
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$	2000	psf
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.323	
Live Surcharge Load, (σ_{LS}) =	250	psf

Bearing Soil Properties:	
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
Bearing Soil Friction Angle, (φ_{BS}) =	32 °
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	0 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to GW (Below Bot. of Wall), (D_W) =	7.5 ft

LRFD Load Factors

	∟v	LII	LO	
Strength la	1.00	1.50	1.75	٦
Strength lb	1.35	1.50	1.75	}
Service I	1.00	1.00	1.00	ل

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



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

$$B' = B - 2e = 27.2 \text{ ft} - 2(4.53 \text{ ft}) = 18.14 \text{ ft}$$

$$e = \frac{B}{2} - x_o = (27.2 \text{ ft/2}) - 9.07 \text{ ft} = 4.53$$

$$x_o = \frac{M_V - M_H}{P_V}$$
 = (2110.13 kip·ft/ft - 797.95 kip·ft/ft) / 144.63 kip/ft = 9.07 ft

$$q_{eq} = (144.63 \, \text{kip/ft}) \, / \, (18.14 \, \text{ft}) = 7.97 \, \text{ksf}$$

$$M_{V} = P_{EV_{1}}(x_{1}) + P_{EV_{2}}(x_{2}) + P_{EH} \sin \theta(B) = (\gamma_{BF} HB\gamma_{EV})(1/2B) + (1/2\gamma_{RS}(h-H)(B-l)\gamma_{EV})(1+1/2(B-l)) + (1/2\gamma_{RS}(h-H)(B-l)\gamma_{EV})(1+1/2(B-l)\gamma_{EV})(1+1/2(B-l)\gamma_{EV})($$

 $M_V =$ [(120 pcf)(38.9 ft)(27.2 ft)(1.00)][½(27.2 ft)] + [½(120 pcf)(47.9 ft - 38.9 ft)(27.2 ft - 4.0 ft)(1.00)][4.0 ft + ¾(27.2 ft - 4.0 ft)] = 2110.13 kip·ft/ft + [1/2(120 pcf)(47.9 ft)2(0.323)(1.00)sin(6.6°)](27.2 ft)

$$M_{H} = P_{EH} \cos \theta(x_3) + P_{LS} \cos \theta(x_4) = \left(\frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} \cos \theta\right) \left(\frac{h}{3}\right) + \left(\sigma_{LS} h K_a \gamma_{LS} \cos \theta\right) \left(\frac{h}{3}\right)$$

= 797.95 kip·ft/ft ½[(120 pcf)(47.9 ft)²(0.323)(1.00)cos(6.6°)](47.9 ft /3) + [(250 psf)(47.9 ft)(0.323)(1.00)cos(6.6°)](47.9 ft /2)

$$P_{V} = P_{EV} + P_{EV} + P_{EH} \sin \theta = (\gamma_{BF} H B \gamma_{EV}) + (\frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV}) + (\frac{1}{2} \gamma_{RS} h^{2} K_{a} \gamma_{EH} \sin \theta)$$

 P_{ν} = (120 pcf)(38.9 ft)(27.2 ft)(1.00) + ½(120 pcf)(47.9 ft - 38.9 ft)(27.2 ft - 4.0 ft)(1.00) = 144.63 kip/ft + ½(120 pcf)(47.9 ft)²(0.323)(1.00)sin(6.6°)

Settlement, Time Rate of Consolidation and Differential Settlement:

	Boring	Total Settlement at Center of Reinforced Soil Mass	Total Settlement at Wall Facing	Time for 100% Consolidation	Distance Between Borings Along Wall Facing	Differential Settlement Along Wall Facing
	B-102-6-14	3.143 in	2.547 in	0 days		
	B-103-1-14	2.607 in	2.202 in	5 days	160 ft	1/5570
	B-105-4-14	3.074 in	2.569 in	0 days	145 ft	1/4740
[

MSE Wall Settlement - Sta. 212+25 to 216+50

Boring B-102-6-14

38.9 ft Total wall height

B'= 18.1 ft Effective footing width due to eccentricity

 D_w = 7.5 ft Depth below bottom of footing

q_e = 7,970 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement at	Center of Re	einforced So	il Mass		Total Sett	lement at Fa	acing of Wall	
Layer	Soil Class.	Soil Type	Layei (Depth	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	Δσ _ν ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-1-a	G	0.0	2.5	2.5	1.3	125	313	156	156	4,156					15	28	93	0.07	0.999	7,961	8,118	0.046	0.554	0.500	3,984	4,141	0.038	0.460
'	A-1-a	G	2.5	5.5	3.0	4.0	125	688	500	500	4,500					15	22	79	0.22	0.970	7,734	8,234	0.046	0.557	0.498	3,968	4,468	0.036	0.436
2	A-2-6	G	5.5	8.0	2.5	6.8	120	988	838	838	4,838					12	16	65	0.37	0.897	7,150	7,988	0.037	0.449	0.491	3,910	4,748	0.029	0.345
3	A-1-a	G	8.0	10.5	2.5	9.3	120	1,288	1,138	1,028	5,028					8	10	56	0.51	0.811	6,466	7,494	0.038	0.459	0.479	3,814	4,843	0.030	0.358
3	A-1-a	G	10.5	13.0	2.5	11.8	120	1,588	1,438	1,172	5,172					8	9	56	0.65	0.726	5,783	6,955	0.035	0.415	0.462	3,683	4,855	0.028	0.331
	A-1-a	G	13.0	16.5	3.5	14.8	135	2,060	1,824	1,371	5,371					57	64	237	0.81	0.634	5,054	6,425	0.010	0.119	0.438	3,493	4,864	0.008	0.097
4	A-1-a	G	16.5	20.5	4.0	18.5	135	2,600	2,330	1,644	5,644					57	61	219	1.02	0.541	4,311	5,955	0.010	0.122	0.406	3,233	4,877	0.009	0.103
	A-1-a	G	20.5	24.5	4.0	22.5	135	3,140	2,870	1,934	5,934					57	58	204	1.24	0.464	3,697	5,631	0.009	0.109	0.371	2,958	4,892	0.008	0.095
5	A-1-b	G	24.5	29.5	5.0	27.0	130	3,790	3,465	2,248	6,248					29	28	93	1.49	0.398	3,170	5,418	0.020	0.246	0.335	2,672	4,920	0.018	0.219
6	A-2-4	G	29.5	34.5	5.0	32.0	135	4,465	4,128	2,599	6,599					90	82	342	1.77	0.342	2,727	5,326	0.005	0.055	0.300	2,393	4,992	0.004	0.050
7	A-1-b	G	34.5	41.5	7.0	38.0	135	5,410	4,938	3,034	7,034					99	85	363	2.10	0.292	2,330	5,364	0.005	0.057	0.265	2,113	5,147	0.004	0.053
1. σ _p ' = σ	, _o '+σ _{m;} Estima	ate σ_m of 4,0	00 psf (mod	erately overc	onsolidated)	for natural so	oil deposits;	Ref. Table 1	1.2, Coduto 2	2003											Tota	Settlement:		3.143 in		Total	Settlement:	1	2.547 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

 Calculated By:
 BRT
 Date:
 6/23/2019

 Checked By:
 JPS
 Date:
 6/24/2019

^{3.} C_r = 0.10(Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

 $^{9. \ \} S_c = [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_{v_o}') for \ \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_i}'; \ [C_r/(1+e_o)](H) log(\sigma_p'/\sigma_{v_o}') + [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_p') for \ \sigma_{v_o}' < \sigma_p' < \sigma_{v_i}'; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO \ LRFD \ BDS \ (Cohesive \ soil \ layers)$

^{10.} S_c = H(1/C')log(σ_{vf} / σ_{vo} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 - FRA-70-13.10 - Retaining Wall W2 MSE Wall Settlement - Sta. 212+25 to 216+50
 Calculated By:
 BRT
 Date:
 6/23/2019

 Checked By:
 JPS
 Date:
 6/24/2019

Boring B-103-1-14

= 34.9 ft Total wall height

B'= 16.1 ft Effective footing width due to eccentricity

 D_w = 7.5 ft Depth below bottom of footing

q_e = 8,030 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement at	Center of R	einforced So	il Mass		Total Set	tlement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type	Layer (Depth ft)	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	Δσ _ν ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	$\Delta\sigma_{_{_{ m V}}}^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-1-b	G	0.0	2.5	2.5	1.3	120	300	150	150	4,150					30	56	196	0.08	0.998	8,018	8,168	0.022	0.266	0.500	4,014	4,164	0.018	0.221
(Gr. Emb.)	A-1-b	G	2.5	5.0	2.5	3.8	120	600	450	450	4,450					30	45	149	0.23	0.966	7,758	8,208	0.021	0.254	0.497	3,995	4,445	0.017	0.200
	A-1-a	G	5.0	7.5	2.5	6.3	125	913	756	756	4,756					25	33	108	0.39	0.888	7,131	7,888	0.024	0.282	0.490	3,931	4,687	0.018	0.220
2	A-1-a	G	7.5	10.0	2.5	8.8	125	1,225	1,069	991	4,991					25	31	102	0.54	0.791	6,349	7,340	0.021	0.257	0.475	3,815	4,806	0.017	0.203
	A-1-a	G	10.0	12.5	2.5	11.3	125	1,538	1,381	1,147	5,147					25	30	98	0.70	0.697	5,594	6,742	0.020	0.235	0.455	3,656	4,803	0.016	0.190
	A-1-b	G	12.5	15.5	3.0	14.0	130	1,928	1,733	1,327	5,327					31	35	115	0.87	0.607	4,877	6,204	0.017	0.210	0.430	3,451	4,778	0.015	0.174
3	A-1-b	G	15.5	18.5	3.0	17.0	130	2,318	2,123	1,530	5,530					31	34	110	1.06	0.528	4,238	5,768	0.016	0.188	0.400	3,214	4,744	0.013	0.161
	A-1-b	G	18.5	21.5	3.0	20.0	130	2,708	2,513	1,733	5,733					31	33	106	1.24	0.464	3,727	5,459	0.014	0.169	0.371	2,981	4,713	0.012	0.147
4	A-1-b	G	21.5	26.5	5.0	24.0	135	3,383	3,045	2,015	6,015					45	45	149	1.49	0.398	3,196	5,211	0.014	0.166	0.335	2,693	4,708	0.012	0.148
	A-1-b	G	26.5	31.5	5.0	29.0	130	4,033	3,708	2,366	6,366					28	26	89	1.80	0.336	2,702	5,068	0.018	0.222	0.296	2,380	4,746	0.017	0.203
Э	A-1-b	G	31.5	36.5	5.0	34.0	130	4,683	4,358	2,704	6,704					28	25	86	2.11	0.291	2,335	5,038	0.016	0.188	0.264	2,119	4,823	0.015	0.175
6	A-4a	С	36.5	41.5	5.0	39.0	130	5,333	5,008	3,042	7,042	22	0.108	0.011	0.444				2.42	0.256	2,053	5,095	0.008	0.101	0.237	1,902	4,944	0.008	0.095
7	A-1-b	G	41.5	49.0	7.5	45.3	135	6,345	5,839	3,483	7,483					78	64	234	2.81	0.222	1,782	5,265	0.006	0.069	0.209	1,681	5,164	0.005	0.066
1. σ _p ' = σ _ν	,o'+σ _{m;} Estima	ate σ _m of 4,0	00 psf (mod	erately overc	onsolidated)	for natural so	oil deposits;	Ref. Table 1	1.2, Coduto	2003					•	•	•	•	•		Total	Settlement:		2.607 in		Total	Settlement:		2.202 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} $C_r = 0.10(Cc)$ for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_o/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_c$

^{9.} $S_c = [C_c/(1+e_o)](H)[\log(\sigma_{v'}/\sigma_{v'})'$ for $\sigma_p' \leq \sigma_{v'}$; $[C_r/(1+e_o)](H)[\log(\sigma_p'/\sigma_{v'})'$ for $\sigma_{v'} < \sigma_p'$; $[C_r/(1+e_o)](H)[\log(\sigma_{v'}/\sigma_p')'$ for $\sigma_{v'} < \sigma_p' < \sigma_{v'}$; $[C_r/(1+e_o)](H)[\log(\sigma_{v'}/\sigma_p')']$ for $\sigma_{v'} < \sigma_{v'} < \sigma_{v'} < \sigma_{v'}$; $[C_r/(1+e_o)](H)[\log(\sigma_{v'}/\sigma_p')']$ for $\sigma_{v'} < \sigma_{v'} < \sigma_$

^{10.} S_c = H(1/C')log(σ_{vf} / σ_{vo} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

MSE Wall Settlement - Sta. 212+25 to 216+50

 Calculated By:
 BRT
 Date:
 06/23/2019

 Checked By:
 JPS
 Date:
 06/24/2019

Total Settlement at Facing of Wall

Settlement Remaining After Hold Period: 0.000

Settlement Complete at 100% of

Boring B-103-1-14

H=	34.9	ft	Total wall height		A-4a			
B'=	16.1	ft	Effective footing width due to eccentricity	c _v =	1,000		ft²/yr	Coefficient of consolitation
$D_w =$	7.5	ft	Depth below bottom of footing	t =	5		days	Time following completion of construction
q _e =	8,030	psf	Equivalent bearing pressure at bottom of wall	H _{dr} =	2.5		ft	Length of longest drainage path considered
				$T_v =$	2.192			Time factor
				U =	100		%	Degree of consolidation
				$(S_c)_t =$	1.368	in	Settlement complete	at 100% of primary consolidation

																										Filliary Co	onsolidation
Layer	Soil Type	Soil Type	Layer (1		Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	Layer Settlement (in)	(S _c) _t ⁽¹¹⁾ (in)	Layer Settlement (in)
1	A-1-b	G	0.0	2.5	2.5	1.3	120	300	150	150	4,150					30	56	196	0.08	0.500	4,014	4,164	0.018	0.221	0.421	0.221	0.421
ı	A-1-b	G	2.5	5.0	2.5	3.8	120	600	450	450	4,450					30	45	149	0.23	0.497	3,995	4,445	0.017	0.200	0.421	0.200	0.421
	A-1-a	G	5.0	7.5	2.5	6.3	125	913	756	756	4,756					25	33	108	0.39	0.490	3,931	4,687	0.018	0.220		0.220	
2	A-1-a	G	7.5	10.0	2.5	8.8	125	1,225	1,069	991	4,991					25	31	102	0.54	0.475	3,815	4,806	0.017	0.203	0.613	0.203	0.613
	A-1-a	G	10.0	12.5	2.5	11.3	125	1,538	1,381	1,147	5,147					25	30	98	0.70	0.455	3,656	4,803	0.016	0.190		0.190	
	A-1-b	G	12.5	15.5	3.0	14.0	130	1,928	1,733	1,327	5,327					31	35	115	0.87	0.430	3,451	4,778	0.015	0.174		0.174	
3	A-1-b	G	15.5	18.5	3.0	17.0	130	2,318	2,123	1,530	5,530					31	34	110	1.06	0.400	3,214	4,744	0.013	0.161	0.482	0.161	0.482
	A-1-b	G	18.5	21.5	3.0	20.0	130	2,708	2,513	1,733	5,733					31	33	106	1.24	0.371	2,981	4,713	0.012	0.147		0.147	
4	A-1-b	G	21.5	26.5	5.0	24.0	135	3,383	3,045	2,015	6,015					45	45	149	1.49	0.335	2,693	4,708	0.012	0.148	0.148	0.148	0.148
5	A-1-b	G	26.5	31.5	5.0	29.0	130	4,033	3,708	2,366	6,366					28	26	89	1.80	0.296	2,380	4,746	0.017	0.203	0.378	0.203	0.378
3	A-1-b	G	31.5	36.5	5.0	34.0	130	4,683	4,358	2,704	6,704					28	25	86	2.11	0.264	2,119	4,823	0.015	0.175	0.376	0.175	0.376
6	A-4a	С	36.5	41.5	5.0	39.0	130	5,333	5,008	3,042	7,042	22	0.108	0.011	0.444				2.42	0.237	1,902	4,944	0.008	0.095	0.095	0.095	0.095
7	A-1-b	G	41.5	49.0	7.5	45.3	135	6,345	5,839	3,483	7,483					78	64	234	2.81	0.209	1,681	5,164	0.005	0.066	0.066	0.066	0.066

- 1. $\sigma_p' = \sigma_{vo}' + \sigma_m$; Estimate σ_m of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003
- 2. C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5
- 3. $C_r = 0.10$ (Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981
- 4. $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
- 5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- 6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
- 7. Influence factor for strip loaded footing
- 8. $\Delta \sigma_v = q_e$
- $9. \ \ S_c = [C_o/(1+e_o)](H) log(\sigma_{v_f}/\sigma_{v_o}') for \ \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_f}'; \ [C_r/(1+e_o)](H) log(\sigma_p'/\sigma_{v_o}') for \ \sigma_{v_o}' < \sigma_{v_f}' \leq \sigma_p'; \ [C_r/(1+e_o)](H) log(\sigma_p'/\sigma_{v_o}') + [C_o/(1+e_o)](H) log(\sigma_{v_f}/\sigma_p') for \ \sigma_{v_o}' < \sigma_{v_f}' < \sigma_{v_f}'; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO \ LRFD \ BDS \ (Cohesive soil layers)$
- 10. $S_c = H(1/C')log(\sigma_{vf}/\sigma_{vo})$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
- 11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

W-13-072 - FRA-70-13.10 - Retaining Wall W2 MSE Wall Settlement - Sta. 212+25 to 216+50

 Calculated By:
 BRT
 Date:
 6/23/2019

 Checked By:
 JPS
 Date:
 6/24/2019

Boring B-102-6-14

H= 32.5 ft Total wall height

B'= 15.3 ft Effective footing width due to eccentricity

D_w = 7.5 ft Depth below bottom of footing

q_e = 7,570 psf Equivalent bearing pressure at bottom of wall

																				Total S	ettlement at	Center of Re	einforced Soi	il Mass		Total Sett	lement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type		Depth t)	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r (3)	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	$\Delta\sigma_{v}^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	$\Delta\sigma_{v}^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1 (Gr. Emb.)	A-1-b	G	0.0	2.0	2.0	1.0	120	240	120	120	4,120					30	58	207	0.07	0.999	7,563	7,683	0.017	0.210	0.500	3,785	3,905	0.015	0.176
2	A-2-6	G	2.0	4.5	2.5	3.3	120	540	390	390	4,390					9	14	63	0.21	0.973	7,368	7,758	0.052	0.621	0.498	3,770	4,160	0.041	0.492
	A-2-6	G	4.5	7.0	2.5	5.8	120	840	690	690	4,690					9	12	60	0.38	0.895	6,778	7,468	0.043	0.518	0.490	3,712	4,402	0.034	0.403
3	A-1-a	G	7.0	9.5	2.5	8.3	135	1,178	1,009	962	4,962					70	87	376	0.54	0.793	6,006	6,968	0.006	0.069	0.476	3,600	4,562	0.004	0.054
	A-1-a	G	9.5	12.0	2.5	10.8	135	1,515	1,346	1,143	5,143					70	83	348	0.70	0.694	5,257	6,401	0.005	0.064	0.455	3,443	4,586	0.004	0.052
	A-1-b	G	12.0	14.0	2.0	13.0	125	1,765	1,640	1,297	5,297					18	21	76	0.85	0.617	4,670	5,967	0.018	0.210	0.433	3,277	4,574	0.014	0.174
4	A-1-b	G	14.0	16.0	2.0	15.0	125	2,015	1,890	1,422	5,422					18	20	74	0.98	0.558	4,223	5,645	0.016	0.193	0.412	3,121	4,543	0.014	0.163
	A-1-b	G	16.0	18.5	2.5	17.3	125	2,328	2,171	1,563	5,563					18	20	73	1.13	0.502	3,798	5,360	0.018	0.219	0.389	2,945	4,507	0.016	0.188
-	A-4a	G	18.5	21.0	2.5	19.8	125	2,640	2,484	1,719	5,719					20	21	41	1.29	0.450	3,404	5,123	0.029	0.344	0.364	2,755	4,474	0.025	0.301
5	A-4a	G	21.0	23.5	2.5	22.3	125	2,953	2,796	1,876	5,876					20	20	40	1.45	0.407	3,078	4,954	0.026	0.312	0.340	2,576	4,452	0.023	0.278
6	A-1-a	G	23.5	28.5	5.0	26.0	130	3,603	3,278	2,123	6,123					39	38	125	1.70	0.355	2,684	4,807	0.014	0.171	0.308	2,335	4,458	0.013	0.155
7	A-1-a	G	28.5	33.5	5.0	31.0	135	4,278	3,940	2,474	6,474					76	71	272	2.03	0.302	2,287	4,761	0.005	0.063	0.272	2,061	4,535	0.005	0.058
'	A-1-a	G	33.5	38.5	5.0	36.0	135	4,953	4,615	2,837	6,837					76	67	253	2.35	0.263	1,989	4,826	0.005	0.055	0.243	1,836	4,672	0.004	0.051
8	A-1-b	G	38.5	41.5	3.0	40.0	135	5,358	5,155	3,127	7,127					84	72	277	2.61	0.238	1,800	4,927	0.002	0.026	0.223	1,684	4,811	0.002	0.024
1. $\sigma_p' = \sigma_v$	'+σ _{m;} Estima	te $\sigma_{\rm m}$ of 4,0	00 psf (mode	erately overc	onsolidated)	for natural so	oil deposits;	Ref. Table 1	I.2, Coduto 2	2003	•				•		•				Total	Settlement:		3.074 in		Total	Settlement:		2.569 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

^{3.} $C_r = 0.10(Cc)$ for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} e_o = (C_c/1.15)+0.35; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

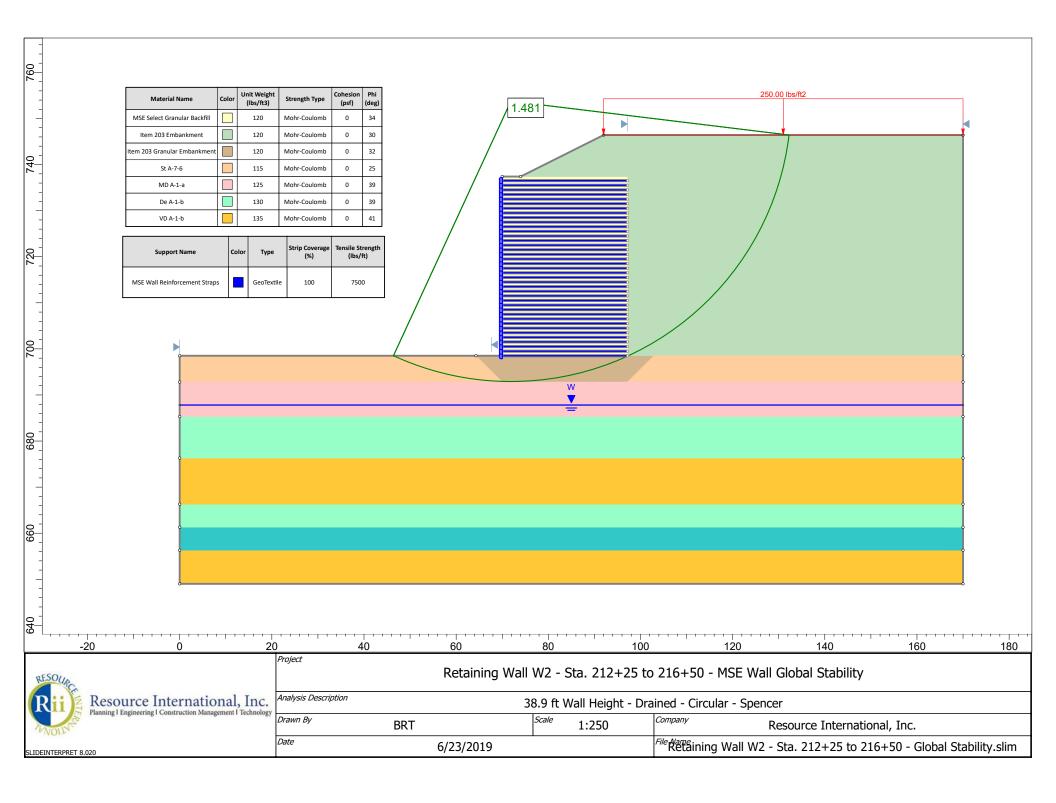
^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

 $^{9. \ \} S_c = [C_c/(1+e_o)](H)\log(\sigma_{v_i}'/\sigma_{v_o}') \\ \text{for } \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_i}'; \ [C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{v_o}') \\ \text{for } \sigma_{v_o}' < \sigma_p'; \ [C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{v_o}') \\ \text{for } \sigma_{v_o}' < \sigma_p' < \sigma_{v_i}'; \ \text{Ref. Section } 10.6.2.4.3, \ \text{AASHTO LRFD BDS (Cohesive soil layers)} \\ \text{(Cohesive soil layers)} \\ \text{(Cohes$

^{10.} S_c = H(1/C')log(σ_{vf} // σ_{vo} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)





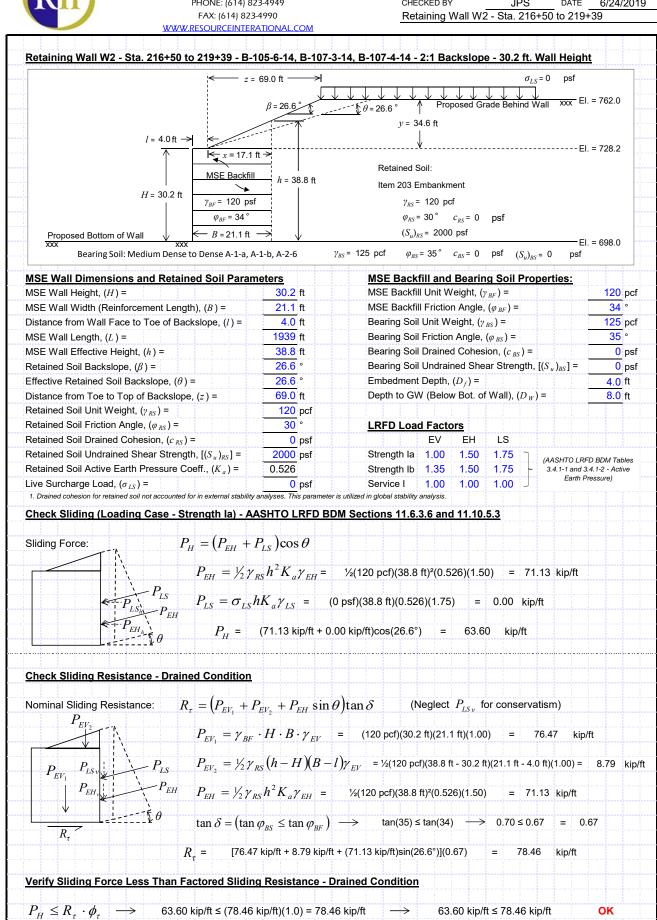
 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
 1
 OF
 6

 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

 Retaining Wall W2 - Sta. 216+50
 to 219+39



Use φ_{τ} = 1.0 (Per AASHTO LRFD BDM Table 11.5.6-1)



FRA-70-13.10 W-13-072 JOB NO. SHEET NO. OF 6 6/23/2019 6/24/2019 CALCULATED BY BRT DATE JPS CHECKED BY DATE Retaining Wall W2 - Sta. 216+50 to 219+39

MSE Wall Dimensions and Retained Soil Par	ameters	Bearing Soil Properties:	
MSE Wall Height, (H) =	30.2 ft	MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Wall Width (Reinforcement Length), (<i>B</i>) =	21.1 ft	MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Distance from Wall Face to Toe of Backslope, (l) =		Bearing Soil Unit Weight, (γ_{BS}) =	125 pcf
ASE Wall Length, (L) =	1939 ft	Bearing Soil Friction Angle, (φ_{BS}) =	35 °
#SE Wall Effective Height, (h) =	38.8 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	00 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	0 psi
Effective Retained Soil Backslope, (θ) =	26.6 °	Embedment Depth, (D_f) =	4.0 ft
Distance from Toe to Top of Backslope, $(b') = b'$	69.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	8.0 ft
anna anna anna anna anna anna anna ann		Depth to GW (Below Bot. of Wall), (D_W) -	0.0 11
Retained Soil Unit Weight, (y _{RS}) =	120 pcf 30 °	I DED I and Footon	
Retained Soil Friction Angle, $(\varphi_{RS}) = 0$	·6·······3······3·······6·····	LRFD Load Factors EV EH LS	
Retained Soil Undrained Chesion, (c _{RS}) =	0 psf		
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$	2000 psf		FD BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.526	Farth I	3.4.1-2 - Active Pressure)
ive Surcharge Load, (σ_{LS}) = 1. Drained cohesion for retained soil not accounted for in external stall	0 psf	Service I 1.00 1.00 1.00 J	
Check Sliding (Loading Case - Strength la) -	AASHTO LRFD BDN	1 Section 11.10.5.3 (Continued)	
Check Sliding Resistance - Undrained Cond	<u>ition</u>		
	<u> </u>		
Nominal Sliding Resisting: $R_{ au} = (S_{ au})^T$	$(S_u)_{BS} \leq q_s \cdot B$		
$P_{EV_{2}}$			
$(S_u)_I$	$_{ m RS}=$ N/A ksf		
	σ /		
P_{EV} P_{LS} P_{LS} $q_s =$	$\sigma_{v/2}$		
I EV ₁ LS _V			
P_{EH} , P_{EH} σ ,	$=P_{V_{R}}$		
$R \vee f \vdash f$	/ B		
	$P_{V} = P_{EV_1} + P_{EV_2} +$	$-P_{rx}\sin\theta$	
$(S) \leq a$	TEV TEV		
$\mathcal{S}_{u}/BS - 4s$	$P_{EV_1} = \gamma_{BF} \cdot H \cdot$	$B \cdot \gamma_{FV} = (120 \text{ pcf})(30.2 \text{ ft})(21.1 \text{ ft})(1.00) = 76$	6.47 kip/ft
(Neglect $P_{LS_{\mathcal{V}}}$ for conservatism)	1 EV ₁ - 1 BF 11	EV.	o Iupiii
(Neglect I _{LS_V} for conservation)	$P_{EV_2} = \frac{1}{2} \gamma_{RS} (h)$	$H \setminus D = I \setminus A$	
	$P_{EV_2} = \gamma_2 \gamma_{RS} (n$	$-\Pi \setminus D - i \int_{Y_{EV}} E_V$	
	P _ 1//1	20 pcf)/38 8 ft 30 2 ft)/21 1 ft 4 0 ft)/1 00) = 8.70	kin/ft
	$I_{EV_2} = \frac{72}{12}$	20 pcf)(38.8 ft - 30.2 ft)(21.1 ft - 4.0 ft)(1.00) = 8.79	KIP/II
	D 1/ 12	1//400 £\/20 0 £\\2/0 F0C\/4 F0\\	
	$P_{E\!H} = \frac{1}{2} \gamma_{R\!S} h^2$	$K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(38.8 \text{ ft})^2 (0.526)(1.50) = 7$	
	2112.10		1.13 kip/ft
	2112.10	$K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(38.8 \text{ ft})^2 (0.526)(1.50) = 7^{\circ}$ 8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip	1.13 kip/ft
	$P_V = 76.47 \text{ kip/ft} +$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip	1.13 kip/ft
$\sigma_{\!\scriptscriptstyle V}$	2112.10	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip	1.13 kip/ft
	$P_V = 76.47 \text{ kip/ft} +$ = (117.11 kip/ft)/(8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf	1.13 kip/ft
	$P_V = 76.47 \text{ kip/ft} +$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf	1.13 kip/ft
q_s =	$P_V = 76.47 \text{ kip/ft} +$ $= (117.11 \text{ kip/ft}) / (5.55 \text{ ksf}) / 2 =$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf	1.13 kip/ft
q_s =	$P_V = 76.47 \text{ kip/ft} +$ = (117.11 kip/ft)/(8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf	1.13 kip/ft
q_s =	$P_V = 76.47 \text{ kip/ft} +$ $= (117.11 \text{ kip/ft}) / (5.55 \text{ ksf}) / 2 =$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf	1.13 kip/ft
q_s =	$P_V = 76.47 \text{ kip/ft} +$ $= (117.11 \text{ kip/ft}) / (5.55 \text{ ksf}) / 2 =$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf	1.13 kip/ft
q_s =	$P_V = 76.47 \text{ kip/ft} +$ $= (117.11 \text{ kip/ft}) / (5.55 \text{ ksf}) / 2 =$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf	1.13 kip/ft
$q_s =$ $R_{ au} =$	$P_V = 76.47 \text{ kip/ft} +$ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 =$ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft	1.13 kip/ft
$q_s =$ $R_{ au} =$	$P_V = 76.47 \text{ kip/ft} +$ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 =$ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft	1.13 kip/ft
$q_s = R_{ au}$ = $R_{ au}$	$P_V = 76.47 \text{ kip/ft} + 100 \text{ kip/ft} = (117.11 \text{ kip/ft}) / $	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft drained Condition	1.13 kip/ft
$q_s = R_{ au}$ = $R_{ au}$ = $R_{ au}$	$P_V = 76.47 \text{ kip/ft} +$ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 =$ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft	1.13 kip/ft
$q_s =$ $R_ au$ = $R_ au$ $=$ /erify Sliding Force Less Than Factored Slice $P_H \leq R_ au \cdot \phi_ au$ \Longrightarrow	$P_{V} = 76.47 \text{ kip/ft} + $ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 = $ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$ $\frac{\text{ding Resistance - Un}}{\text{N/A}}$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft drained Condition	1.13 kip/ft
$q_s = R_{ au}$ = $R_{ au}$	$P_{V} = 76.47 \text{ kip/ft} + $ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 = $ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$ $\frac{\text{ding Resistance - Un}}{\text{N/A}}$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft drained Condition	1.13 kip/ft
$q_s =$ $R_ au =$ $R_ au$ $=$	$P_{V} = 76.47 \text{ kip/ft} + $ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 = $ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$ $\frac{\text{ding Resistance - Un}}{\text{N/A}}$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft drained Condition	1.13 kip/ft
$q_s =$ $R_ au$ = $R_ au$ $=$ Verify Sliding Force Less Than Factored Slice $P_H \leq R_ au \cdot \phi_ au$ \Longrightarrow	$P_{V} = 76.47 \text{ kip/ft} + $ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 = $ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$ $\frac{\text{ding Resistance - Un}}{\text{N/A}}$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft drained Condition	1.13 kip/ft
$q_s =$ $R_ au$ = $R_ au$ $=$ /erify Sliding Force Less Than Factored Slice $P_H \leq R_ au \cdot \phi_ au$ \Longrightarrow	$P_{V} = 76.47 \text{ kip/ft} + $ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 = $ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$ $\frac{\text{ding Resistance - Un}}{\text{N/A}}$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft drained Condition	1.13 kip/ft
$q_s =$ $R_ au =$ $R_ au$ $=$	$P_{V} = 76.47 \text{ kip/ft} + $ $= (117.11 \text{ kip/ft}) / ($ $(5.55 \text{ ksf}) / 2 = $ $(\text{N/A ksf} \le 2.78 \text{ ksf}) (21)$ $\frac{\text{ding Resistance - Un}}{\text{N/A}}$	8.79 kip/ft + (71.13 kip/ft)sin(26.6°) = 117.11 kip 21.1 ft) = 5.55 ksf 2.78 ksf .1 ft) = N/A kip/ft drained Condition	1.13 kip/ft



JOB FRA-70-13.10 SHEET NO. CALCULATED BY DATE CHECKED BY DATE

6/23/2019 6/24/2019

Retaining Wall W2 - Sta. 216+50 to 219+39

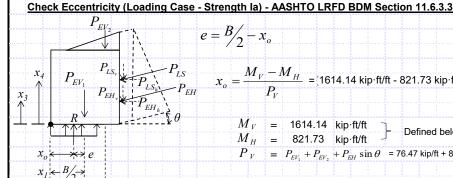
	WWW.RESOURCEINTER	ATIONAL.C	<u>.OM</u>	
MSE Wall Dimensions and	d Retained Soil Paran	<u>neters</u>		
MSE Wall Height, (H) =		30.2	ft	
MSE Wall Width (Reinforceme	ent Length), (B) =	21.1	ft	
Distance from Wall Face to To	oe of Backslope, (<i>l</i>) =	4.0	ft	
MSE Wall Length, (L) =		1939	ft	
MSE Wall Effective Height, (h) =	38.8	ft	
Retained Soil Backslope, (β)	=	26.6	0	
Effective Retained Soil Backs	lope, (θ) =	26.6	0	
Distance from Toe to Top of E	Backslope, (z) =	69.0	ft	
Retained Soil Unit Weight, (γ,	₂₅) =	120	pcf	
Retained Soil Friction Angle, (φ_{RS}) =	30	0	
Retained Soil Drained Cohesi	on, (c _{RS}) =	0	psf	
Retained Soil Undrained Shea	ar Strength, $[(S_u)_{RS}] =$	2000	psf	
Retained Soil Active Earth Pre	essure Coeff., (K_a) =	0.526		

Bearing Soil Properties:	
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Bearing Soil Unit Weight, (γ_{BS}) =	125 pcf
Bearing Soil Friction Angle, (φ_{BS}) =	35 °
Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =	0 psf
Embedment Depth, (D_f) =	4.0 ft
Depth to GW (Below Bot. of Wall), (D_W) =	8.0 ft

LRFD Load Factors

Strength la	1.00	1.50	1.75	٦
Strength lb	1.35	1.50	1.75	}
Service I	1.00	1.00	1.00	J

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

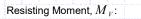


Live Surcharge Load, (σ_{LS}) =

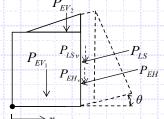
$$X_{o} = \frac{M_{V} - M_{H}}{P_{V}} = 1614.14 \text{ kip·ft/ft} - 821.73 \text{ kip·ft/ft}) / (117.11 \text{ kip/ft}) = 6.77 \text{ ft}$$

 $M_V = 1614.14 \text{ kip·ft/ft}$ Defined below $M_H = 821.73 \text{ kip·ft/ft}$ $P_V = P_{EV_i} + P_{EV_2} + P_{EH} \sin \theta = 76.47 \text{ kip/ft} + 8.79 \text{ kip/ft} + (71.13 \text{ kip/ft})\sin(26.6^\circ) = 117.11 \text{ kip/ft}$

$$e = (21.1 \text{ ft/ 2}) - 6.77 \text{ ft} = 3.78 \text{ ft}$$



$$M_V = P_{EV_1}(x_1) + P_{EV_2}(x_2) + P_{EH} \sin \theta(B)$$
 (Neglect P_{LS_V} for conservatism)



$$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(30.2 \text{ ft})(21.1 \text{ ft})(1.00) = 76.47 \text{ kip/ft}$$

 $P_{LS} = \frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV} = \frac{1}{2} (120 \text{ pcf})(38.8 \text{ ft} - 30.2 \text{ ft})(21.1 \text{ ft} - 4.0 \text{ ft})(1.00) = 8.79 \text{ kip/ft}$ $P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(38.8 \text{ ft})^2 (0.526)(1.50) = 71.13 \text{ kip/ft}$

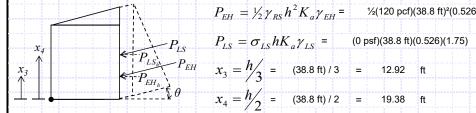
 $x_1 = B/2 = (21.1 \text{ ft})/2 = 10.55 \text{ ft}$

 $x_2 = l + \frac{2}{3}(B - l) = 4.0 \text{ ft} + \frac{2}{3}(21.1 \text{ ft} - 4.0 \text{ ft}) = 15.40 \text{ ft}$

 M_V = (76.47 kip/ft)(10.55 ft) + (8.79 kip/ft)(15.4 ft) + (71.13 kip/ft)sin(26.6°)(21.1 ft) = 1614.14 kip-ft/ft

Overturning Moment, $M_{\scriptscriptstyle H}$:

$$M_H = P_{EH} \cos \theta(x_3) + P_{LS} \cos \theta(x_4)$$



$$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(38.8 \text{ ft})^2 (0.526)(1.50) = 71.13 \text{ kip/ft}$$

$$P_{LS} = \sigma_{LS} h K_a \gamma_{LS}$$
 = (0 psf)(38.8 ft)(0.526)(1.75) = 0.00 kip/ft

$$x_3 = h/3 = (38.8 \text{ ft})/3 = 12.92 \text{ ft}$$

$$x_4 = h/2 = (38.8 \text{ ft})/2 = 19.38 \text{ ft}$$

 $M_H = (71.13 \text{ kip/ft})\cos(26.6^\circ)(12.92 \text{ ft}) + (0 \text{ kip/ft})\cos(26.6^\circ)(19.38 \text{ ft}) = 821.73 \text{ kip-ft/ft}$

Check Eccentricity

Limiting Eccentricity:
$$e_{\text{max}} = \frac{B}{3} \rightarrow e_{\text{max}} = \frac{(21.1 \text{ ft})}{3} =$$

7.03

 $e < e_{\text{max}} \longrightarrow$

3.78 ft < 7.03 ft

OK



 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
 4
 OF
 6

 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

 Retaining Wall W2 - Sta. 216+50 to 219+39

	X: (614) 823-4990 URCEINTERATIONAL.COM	Retaining Wall W2 - Sta. 216+50 t	to 219+39
MSE Wall Dimensions and Retained S	Soil Parameters	Bearing Soil Properties:	
MSE Wall Height, (H) =	30.2 ft	MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Wall Width (Reinforcement Length), (A	3) = 21.1 ft	MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Distance from Wall Face to Toe of Backslop	pe, (l) = 4.0 ft	Bearing Soil Unit Weight, (γ_{BS}) =	125 pcf
MSE Wall Length, (L) =	1939 ft	Bearing Soil Friction Angle, (φ_{BS}) =	35 °
MSE Wall Effective Height, (h) =	38.8 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_t]$	$_{BS}$] = 0 psf
Effective Retained Soil Backslope, (θ) =	26.6 °	Embedment Depth, (D_f) =	4.0 ft
Distance from Toe to Top of Backslope, (z)	= 69.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	8.0 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf		
Retained Soil Friction Angle, (φ_{RS}) =	30 °	LRFD Load Factors	
Retained Soil Drained Cohesion, (c_{RS}) =	0 psf	EV EH LS	
Retained Soil Undrained Shear Strength, [(S	$(S_u)_{RS}$] = 2000 psf	Strength la 1.00 1.50 1.75 7	HTO LRFD BDM Tables
Retained Soil Active Earth Pressure Coeff.,	$(K_a) = 0.526$		1-1 and 3.4.1-2 - Active
Live Surcharge Load, (σ_{LS}) =	0 psf	Service I 1.00 1.00 1.00	Earth Pressure)
Drained cohesion for retained soil not accounted for in ex	kternal stability analyses. This parameter is	utilized in global stability analysis.	
Check Bearing Capacity (Loading Cas	se - Strength lb) - AASHTO	LRFD BDM Section 11.6.3.2	
P_{EV_2}			
۱٬۰۲۰	P /		
	$q_{eq} = \frac{P_V}{R'}$		
D \ \ P			
	B' = B - 2e = 21.	1 ft - 2(2.91 ft) = 15.28 ft	
X_3 P_{EH_v} P_{EH_v}			
\uparrow	$e = \frac{B}{2} - x_0 =$	= (21.1 ft / 2) - 7.64 ft = 2.91 ft	
	$x_o = \frac{W_V - W_H}{V}$	= (1943.74 kip·ft/ft - 821.73 kip·ft/ft) / 146.94	4 kip/ft = 7.64 ft
$x_o \leftarrow \times -1 - 1 - e$	$P_{ u}$		
+B/2			
72	$q_{ea} = (146.94 \text{ kip/ft})$	/ (15.28 ft) = 9.62 ksf	
$\overrightarrow{B'} \rightarrow \overrightarrow{B'}$	1 eq		
λ_2			
Resisting Moment, $M_{\scriptscriptstyle V}$: M	$P_{EV_1}(x_1) + P_{EV_2}(x_2) +$	$P_{rr} \sin \theta(B)$	
	$V = EV_1 \cdot \nabla \cdot 1 \cdot J = EV_2 \cdot \nabla \cdot 2 \cdot J$	EH 3 3 CJ	
P_{EV_2}	$P_{rrr} = \gamma_{rrr} \cdot H \cdot B \cdot \gamma_{rrr}$	= (120 pcf)(30.2 ft)(21.1 ft)(1.35) = 10	3.23 kip/ft
12 X	EV_1 BF F EV		
	$P = 1/\gamma (h - H)(R -$	$I \gamma_{EV} = \frac{1}{2} (120 \text{ pcf})(38.8 \text{ ft} - 30.2 \text{ ft})(21.1 \text{ ft} - 4.0 \text{ ft})(1)$.35) = 11.86 kip/ft
_ I I V	$I_{EV_2} = /2 I_{RS} (n - II) D$	W EV	т. т.
P_{EV_1} P_{LS_V}	$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} =$	= $\frac{1}{2}(120 \text{ pcf})(38.8 \text{ ft})^2(0.526)(1.50)$ = 71.1	13 kip/ft
P_{EH}	1 EH — /2 / RS / IX a / EH		. o . n.p/n.
	r = B/= (21.1 ft)/2	= 10.55 ft	
$ar{ar{ar{b}}} heta$	$P_{EH} = \frac{1}{2} \gamma_{RS} n K_a \gamma_{EH} = \frac{1}{2} x_1 = \frac{B}{2} = \frac{(21.1 \text{ ft})}{2}$		
$\Rightarrow x_1$	x - 1 + 2/(R - 1) = 4	4.0 ft + 3/2(21.1 ft - 4.0 ft) = 15.40 ft	
$\rightarrow x_2$	$x_2 - i / 3$,	
	- (103 23 kip/ft)(10 55 ft) + (1	11.86 kip/ft)(15.4 ft) + (71.13 kip/ft)sin(26.6°)(21.1 ft)	= 1943.74 kin.ft/
	<i>y</i> = (100.20 kip/h)(10.00 k) · (1	11.00 Kipiti/(10.4 k) · (71.10 Kipit/siii/(20.0 /(21.1 k)	– 1040.74 кірчі
Overturning Moment, $M_{\scriptscriptstyle H}$: M	$H = P_{EH} \cos \theta(x_3) + P_L$	and $\theta(x)$	
Overturning Mornerit, 1974.	$_H - r_{EH} \cos \theta(x_3) + r_L$	$S \cos \theta(x_4)$	
	D 1/ 72V -	- 1//120 po5/20 9 ft/2/0 526/4 50) - 71.1	10 1.: /64
	$P_{EH} = \gamma_2 \gamma_{RS} n K_a \gamma_{EH} =$	= $\frac{1}{2}(120 \text{ pcf})(38.8 \text{ ft})^2(0.526)(1.50)$ = 71.1	із кір/п
	7.7	(0 - 1)(0 - 0)(0 - 0)(1 - 75)	
		(0 psf)(38.8 ft)(0.526)(1.75) = 0.00 kip/ft	
$A = P_{LS}$			
x_3	$x_3 = \frac{h}{3} = (38.8 \text{ ft})/3$	= 12.92 π	
	$x_4 = h_2$ = (38.8 ft) / 2		
	$x_4 = \frac{1}{2} = \frac{38.8 \text{ ft}}{2}$	= 19.38 ft	
M_I	$_{I}$ = (71.13 kip/ft)cos(26.6°)(12	2.92 ft) + $(0 \text{ kip/ft})\cos(26.6^{\circ})(19.38 \text{ ft}) = 821.73$	3 kip⋅ft/ft
Vertical Forces, $P_{_{V}}$: $P_{_{V}}$	$=P_{EV_1}+P_{EV_2}+P_{EH}\sin$	$\mathbf{H}_{oldsymbol{ heta}}$	
	$P_V = 103.23 \text{ kip/ft} + 11.86 \text{ J}$	$kip/ft + (71.13 kip/ft) sin(26.6^{\circ}) = 146.94 kip/ft$	t i i i i i i i i i i i i i i i i i i i



 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
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 JPS
 DATE
 6/24/2019

 Retaining Wall W2 - Sta. 216+50 to 219+39

<u>WWW.RESOURCEIN</u>) 823-4990 NTERATIONAL.COM					+50 to 219+	
MSE Wall Dimensions and Retained Soil Pa		Bearing Soil P		man aanaanis			
MSE Wall Height, (<i>H</i>) =	30.2 ft	MSE Backfill Un		miinomino			120 pcf
MSE Wall Width (Reinforcement Length), (B) =	21.1 ft	MSE Backfill Fri	ction Angl	e , (φ_{BF}) =		34 °
Distance from Wall Face to Toe of Backslope, (l)	= 4.0 ft	Bearing Soil Unit	t Weight,	$(\gamma_{BS}) =$			125 pcf
MSE Wall Length, (<i>L</i>) =	1939 ft	Bearing Soil Fric	tion Angle	e, (φ _{BS})	=		35 °
MSE Wall Effective Height, (h) =	38.8 ft	Bearing Soil Dra	ined Coh	esion, ($c_{BS}) =$		0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Und	drained SI	near St	ength,	$[(s_u)_{BS}] =$	0 psf
Effective Retained Soil Backslope, (θ) =	26.6 °	Embedment Dep	oth, (D_f) =	- 1			4.0 ft
Distance from Toe to Top of Backslope, (z) =	69.0 ft	Depth to GW (B	elow Bot.	of Wal), (D _w) =	7.9 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf				// \ "	<u> </u>	
Retained Soil Friction Angle, (φ_{RS}) =	30 °	LRFD Load Fa	ctors				
Retained Soil Drained Cohesion, (c_{RS}) =	0 psf	<u> </u>		LS			
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$							
		Strength la 1.0				(AASHTO LRFL	
Retained Soil Active Earth Pressure Coeff., (K_a) =		Strength lb 1.3				3.4.1-1 and 3.4 Earth Pre	
Live Surcharge Load, (σ_{LS}) = 1. Drained cohesion for retained soil not accounted for in external st	0 psf	Service I 1.0		1.0	0]		
Check Bearing Capacity (Loading Case - Si Check Bearing Resistance - Drained Condi		D LRFD BDM Section	11.10.5.	4 (Con	inued)		
Nominal Bearing Resistance: $q_{_{n}}=cN_{_{cn}}$	$_n + \gamma D_f N_{qm} C_{wq} +$	- ½ γ Β' Ν _{γm} C _{wγ}					
$N_{cm} = N_c s_c i_c = 46.12$	$N_{qm} = N_q s_q d_q$	$i_a = 36.6$	<i>N</i>	= N	"Si.	= 48.0	
CT C C	qm q q q	<i>q</i>	γm		γγγ		
N _c = 46.12	$N_q = 33.30$		1	V, =	48.03		
$S_{C} = 1+(15.28 \text{ ft/1939 ft})(33.3/46.12)$		ft/1939 ft)tan(35°) = 1.00				5.28 ft/1939 ft)	= 1,000
= 1.000	ann dan martin a far an i far an ann an i an	°)[1-sin(35°)]²tan⁻¹(4.0 ft/15.28				(Assumed)	1.000
$i_c = 1.000$ (Assumed)	$u_q = 1.100$) [1-3iii(35)] tair (4.0 it/13.20				(Assumed) 1.5(15.28 ft) + 4.	o# - o
t _c = 1.000 (Assumed)	- 1.100						
	i = 4,000 ('wy			
	$i_q = 1.000 \text{ (a}$ $C_{WQ} = 7.9 \text{ ft} > 6$			wy .			
	$C_{wq} = 7.9 \text{ft} > 6$	4.0 ft = 1.000					
$q_n = (0 ext{ psf})(46.12) + (125 ext{ pcf})(4.0 ext{ ft})$	$C_{wq} = 7.9 \text{ft} > 6$	4.0 ft = 1.000		41.25			
$q_n= ($ 0 psf)(46.12) + (125 pcf)(4.0 ft)	$C_{wq} = 7.9 \text{ft} > 0$ $(36.6)(1.0) + \frac{1}{2}(125 \text{p})$	4.0 ft = 1.000 cf)(15.3 ft)(48.0)(0.5)					
	$C_{wq} = 7.9 \text{ft} > 0$ $(36.6)(1.0) + \frac{1}{2}(125 \text{p})$ ored Bearing Resista	4.0 ft = 1.000 cf)(15.3 ft)(48.0)(0.5)			ksf		
Verify Equivalent Pressure Less Than Fact	$C_{wq} = 7.9 \text{ ft} > 6$ $(36.6)(1.0) + \frac{1}{2}(125 \text{ p})$ ored Bearing Resistation $C \le (41.25 \text{ ksf})(0.65) = 3$	4.0 ft = 1.000 cf)(15.3 ft)(48.0)(0.5)		41.25	ksf		
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 ext{ ksf}$ Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BL	$C_{wq} = 7.9 \text{ft} > 0$)(36.6)(1.0) + ½(125 p ored Bearing Resistates $0 \le (41.25 \text{ksf})(0.65) = 30$ DM Table 11.5.6-1)	4.0 ft = 1.000 cf)(15.3 ft)(48.0)(0.5)		41.25	ksf		
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BE	$C_{wq} = 7.9 \text{ft} > 0$)(36.6)(1.0) + ½(125 p ored Bearing Resistates $0 \le (41.25 \text{ksf})(0.65) = 30$ DM Table 11.5.6-1)	4.0 ft = 1.000 cf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf ->		41.25	ksf		
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BE	$C_{wq} = 7.9 \text{ft} > 0$)(36.6)(1.0) + ½(125 p ored Bearing Resistates $0 \le (41.25 \text{ksf})(0.65) = 0$ DM Table 11.5.6-1)	4.0 ft = 1.000 ocf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \longrightarrow	9.62 k	41.25	ksf 5.81 ks	f OI	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = \textbf{0.65}$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c S_c i_c = 5.140$	$C_{wq} = 7.9 \text{ft} > 2.0	4.0 ft = 1.000 ocf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \longrightarrow	9.62 k	41.25 sf ≤ 20	ksf 5.81 ks	f OI	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$	$C_{wq} = 7.9 \mathrm{ft} > 1.00 $	4.0 ft = 1.000 ocf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \longrightarrow	9.62 k	41.25 sf ≤ 20 = N V ₂ =	ksf $yS_{y}i_{y}$	f OI	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(15.28 \text{ ft/[(5)(1939 \text{ ft)}]} = 1.000$	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$	4.0 ft = 1.000 ocf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \Rightarrow $-\frac{1}{2} \gamma B' N_{ym} C_{wy}$ $i_q = 1.000$	9.62 k	41.25 $sf \le 20$ $V_{\gamma} = V$ $V_{\gamma} = V$	ksf .81 ks .81 ks .0.000 1.000	= 0.000	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{q} = 1.200$ $C_{q} = 1.200$	4.0 ft = 1.000 ocf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \longrightarrow	N _m	$= N$ $= N$ $V_{\gamma} = S_{\gamma} = I_{\gamma} = $	ksf .81 ks .81 ks 0.000 1.000 1.000	= 0.000 (Assumed)	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(15.28 \text{ ft/[(5)(1939 \text{ ft)}]} = 1.000$	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{q} = 1.000$	4.0 ft = 1.000 ocf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \Longrightarrow $-\frac{1}{2} \gamma B' N_{ym} C_{wy}$ $i_q = 1.000$	N _m	$= N$ $= N$ $V_{\gamma} = S_{\gamma} = I_{\gamma} = $	ksf .81 ks .81 ks 0.000 1.000 1.000	= 0.000	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(15.28 \text{ ft/[(5)(1939 \text{ ft)}]} = 1.000$	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{q} = 1.000$	4.0 ft = 1.000 ance 26.81 ksf \longrightarrow $i_q = 1.000$ Assumed)	N _m	$= N$ $= N$ $V_{\gamma} = S_{\gamma} = I_{\gamma} = $	ksf .81 ks .81 ks 0.000 1.000 1.000	= 0.000 (Assumed)	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(15.28 \text{ ft/[(5)(1939 \text{ ft)}]} = 1.000$	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{q} = 1.000$	4.0 ft = 1.000 ocf)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \Longrightarrow $-\frac{1}{2} \gamma B' N_{ym} C_{wy}$ $i_q = 1.000$	N _m	$= N$ $= N$ $V_{\gamma} = S_{\gamma} = I_{\gamma} = $	ksf .81 ks .81 ks 0.000 1.000 1.000	= 0.000 (Assumed)	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1+(15.28 \text{ ft/[(5)(1939 \text{ ft)}]} = 1.000$	$C_{wq} = 7.9 \text{ft} > 0$	4.0 ft = 1.000 of)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \rightarrow $i_q = 1.000$ Assumed) 4.0 ft = 1.000	N _m	$= N$ $= N$ $V_{\gamma} = S_{\gamma} = I_{\gamma} = $	ksf .81 ks .81 ks 0.000 1.000 1.000	= 0.000 (Assumed)	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1 + (15.28 \text{ ft/[(5)(1939 \text{ ft)}]} = 1.000$ $i_c = 1.000 \text{ (Assumed)}$	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 7.9 \text{ft} > 0$	4.0 ft = 1.000 of)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \rightarrow $-\frac{1}{2} \gamma B^{\dagger} N_{ym} C_{wy}$ $i_q = 1.000$ Assumed) 4.0 ft = 1.000 of)(15.3 ft)(0.0)(0.5)	9.62 k	$= N$ $= N$ $V_{\gamma} = S_{\gamma} = I_{\gamma}$	ksf 5.81 ks 5.81 ks 0.000 1.000 1.000 7.9 ft < 1	= 0.000 (Assumed)	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1 + (15.28 \text{ ft/[(5)(1939 \text{ ft)]}]} = 1.000$ $i_c = 1.000 \text{ (Assumed)}$	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 7.9 \text{ft} > 0$	4.0 ft = 1.000 of)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \rightarrow $-\frac{1}{2} \gamma B^{\dagger} N_{ym} C_{wy}$ $i_q = 1.000$ Assumed) 4.0 ft = 1.000 of)(15.3 ft)(0.0)(0.5)	9.62 k	$= N$ $= N$ $V_{\gamma} = S_{\gamma} = I_{\gamma}$	ksf 5.81 ks 5.81 ks 0.000 1.000 1.000 7.9 ft < 1	= 0.000 (Assumed)	
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \implies 9.62 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BLE) Check Bearing Resistance - Undrained Core Nominal Bearing Resistance: $q_n = cN_{cn}$ $N_{cm} = N_c s_c i_c = 5.140$ $N_c = 5.140$ $s_c = 1 + (15.28 \text{ ft/[(5)(1939 \text{ ft)]}} = 1.000$ $i_c = 1.000 \text{ (Assumed)}$ $q_n = (0 \text{ psf)(5.14)} + (125 \text{ pcf)(4.0 ft)}$ Verify Equivalent Pressure Less Than Factor	$C_{wq} = 7.9 \text{ft} > 0$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 1.000$ $C_{wq} = 7.9 \text{ft} > 0$	4.0 ft = 1.000 of)(15.3 ft)(48.0)(0.5) ance 26.81 ksf \longrightarrow $i_q = 1.000$ Assumed) 4.0 ft = 1.000 of)(15.3 ft)(0.0)(0.5)	9.62 k	$= N$ $V_{\gamma} = S_{\gamma} = i_{\gamma} = S_{\gamma} = i_{\gamma} = S_{\gamma} $	ksf 5.81 ks 5.81 ks 0.000 1.000 1.000 7.9 ft < 1	= 0.000 (Assumed)	



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 JOB
 FRA-70-13.10
 NO.
 W-13-072

 SHEET NO.
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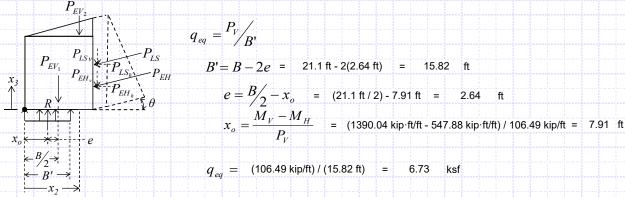
 CALCULATED BY
 BRT
 DATE
 6/23/2019

 CHECKED BY
 JPS
 DATE
 6/24/2019

 Retaining Wall W2 - Sta. 216+50 to 219+39

MSE Wall Dimensions and Retained Soil Param	<u>ieters</u>	Bearing So	oil Pro	<u>perties:</u>	<u>:</u>					
MSE Wall Height, (<i>H</i>) =	30.2 ft	MSE Backfil	II Unit W	/eight, (₁	$\gamma_{BF}) =$			120 pc		
MSE Wall Width (Reinforcement Length), (B) =	21.1 ft	MSE Backfil	II Frictio	n Angle,	$(\varphi_{BF}) =$	=		34 °		
Distance from Wall Face to Toe of Backslope, (l) =	4.0 ft	Bearing Soil	I Unit W	eight, (γ	_{BS}) =			125 pc		
MSE Wall Length, (<i>L</i>) =	1939 ft	Bearing Soil	I Friction	ո Angle,	$(\varphi_{BS}) =$			35 °		
MSE Wall Effective Height, (h) =	38.8 ft	Bearing Soil	I Draine	d Cohes	sion, (c_B	s) =		0 ps		
Retained Soil Backslope, (β) = $\frac{26.6}{3}$ ° Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ =										
Effective Retained Soil Backslope, (θ) =	26.6 °	Embedment	Embedment Depth, (D_f) =							
Distance from Toe to Top of Backslope, (z) =	69.0 ft	Depth to GV	N (Belov	w Bot. of	f Wall),	(D_W)) =	8.0 ft		
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf									
Retained Soil Friction Angle, (φ_{RS}) =	30 °	LRFD Load	d Facto	ors						
Retained Soil Drained Cohesion, (c_{RS}) =	0 psf		EV	EH	LS					
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}]$ =	2000 psf	Strength la	1.00	1.50	1.75	٦	/AASHTO I RE	D BDM Tables		
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.526	Strength lb	1.35	1.50	1.75	-	3.4.1-1 and 3.	3.4.1-2 - Active		
Live Surcharge Load, (σ_{IS}) =	0 psf	Service I	1.00	1.00	1.00		Earth Pi	Pressure)		

Settlement Analysis (Loading Case - Service I) - AASHTO LRFD BDM Section 11.10.4.1



$$M_{V} = P_{EV_{1}}(x_{1}) + P_{EV_{2}}(x_{2}) + P_{EH} \sin \theta(B) = (\gamma_{BF} H B \gamma_{EV})(1/2 B) + (1/2 \gamma_{RS} (h - H)(B - I)\gamma_{EV})(I + 1/2 (B - I)) + (1/2 \gamma_{RS} h^{2} K_{a} \gamma_{EH} \sin \theta)(B)$$

$$M_{H} = P_{EH} \cos \theta(x_{3}) + P_{LS} \cos \theta(x_{4}) = \left(\frac{1}{2} \gamma_{RS} h^{2} K_{a} \gamma_{EH} \cos \theta \right) \left(\frac{h}{3} \right) + \left(\sigma_{LS} h K_{a} \gamma_{LS} \cos \theta \right) \left(\frac{h}{2} \right)$$

 $M_H = \frac{1}{2}[(120 \text{ pcf})(38.8 \text{ ft})^2(0.526)(1.00)\cos(26.6^\circ)](38.8 \text{ ft}/3)}{+[(0 \text{ psf})(38.8 \text{ ft})(0.526)(1.00)\cos(26.6^\circ)](38.8 \text{ ft}/2)}$

$$P_{V} = P_{EV_{1}} + P_{EV_{2}} + P_{EH} \sin \theta = \left(\gamma_{BF} H B \gamma_{EV}\right) + \left(\frac{1}{2}\gamma_{RS} \left(h - H\right) \left(B - l\right)\gamma_{EV}\right) + \left(\frac{1}{2}\gamma_{RS} h^{2} K_{a} \gamma_{EH} \sin \theta\right)$$

 P_V = (120 pcf)(30.2 ft)(21.1 ft)(1.00) + ½(120 pcf)(38.8 ft - 30.2 ft)(21.1 ft - 4.0 ft)(1.00) = 106.49 kip/ft + ½(120 pcf)(38.8 ft)²(0.526)(1.00)sin(26.6°)

Settlement, Time Rate of Consolidation and Differential Settlement:

 Boring	Total Settlement at Center of Reinforced Soil Mass	Total Settlement at Wall Facing	Time for 100% Consolidation	Distance Between Borings Along Wall Facing	Differential Settlement Along Wall Facing
 B-105-6-14	2.248 in	1.812 in	0 days		
 B-107-3-14	0.642 in	0.506 in	5 days	165 ft	1/1520
 B-107-4-14	0.623 in	0.464 in	0 days	40 ft	1/11430

MSE Wall Settlement - Sta. 216+50 to 219+39

Boring B-105-6-14

H= 30.2 ft Total wall height

B'= 15.8 ft Effective footing width due to eccentricity

 D_w = 8.0 ft Depth below bottom of footing

q_e = 6,730 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	t Center of R	einforced Soi	il Mass		Total Set	tlement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type		Depth ft)	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c ⁽²⁾	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	$\Delta\sigma_{v}^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-2-6	G	0.0	2.5	2.5	1.3	125	313	156	156	4,156					17	32	103	0.08	0.998	6,719	6,875	0.040	0.477	0.500	3,364	3,521	0.033	0.393
	A-1-a	G	2.5	5.0	2.5	3.8	125	625	469	469	4,469					18	27	90	0.24	0.964	6,491	6,960	0.032	0.390	0.497	3,347	3,816	0.025	0.303
2	A-1-a	G	5.0	7.5	2.5	6.3	125	938	781	781	4,781					18	24	83	0.40	0.884	5,947	6,728	0.028	0.340	0.489	3,291	4,072	0.022	0.261
2	A-1-a	G	7.5	10.0	2.5	8.8	125	1,250	1,094	1,047	5,047					18	22	78	0.55	0.784	5,278	6,325	0.025	0.299	0.474	3,189	4,236	0.019	0.232
	A-1-a	G	10.0	12.5	2.5	11.3	125	1,563	1,406	1,203	5,203					18	21	77	0.71	0.689	4,638	5,841	0.022	0.269	0.453	3,052	4,255	0.018	0.215
	A-1-a	G	12.5	15.5	3.0	14.0	135	1,968	1,765	1,391	5,391					48	54	186	0.89	0.600	4,035	5,425	0.010	0.114	0.427	2,875	4,266	0.008	0.094
3	A-1-a	G	15.5	18.5	3.0	17.0	135	2,373	2,170	1,608	5,608					48	52	176	1.08	0.520	3,501	5,110	0.009	0.103	0.397	2,672	4,281	0.007	0.087
	A-1-a	G	18.5	21.5	3.0	20.0	135	2,778	2,575	1,826	5,826					48	50	167	1.27	0.457	3,076	4,902	0.008	0.092	0.368	2,474	4,301	0.007	0.080
1	A-1-b	G	21.5	25.5	4.0	23.5	135	3,318	3,048	2,080	6,080	·				57	56	198	1.49	0.399	2,684	4,764	0.007	0.087	0.336	2,260	4,340	0.006	0.078
4	A-1-b	G	25.5	29.5	4.0	27.5	135	3,858	3,588	2,371	6,371	·				57	54	186	1.74	0.347	2,336	4,706	0.006	0.077	0.303	2,043	4,413	0.006	0.070
1. $\sigma_p' = \sigma_p$	o'+σ _{m;} Estima	te $\sigma_{\rm m}$ of 4,0	00 psf (mode	erately over	consolidated)	for natural se	oil deposits;	Ref. Table 1	1.2, Coduto 2	2003	•					•	•				Tota	l Settlement:		2.248 in		Total	Settlement:	i .	1.812 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

 Calculated By:
 BRT
 Date:
 6/23/2019

 Checked By:
 JPS
 Date:
 6/24/2019

^{3.} $C_r = 0.10$ (Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} e_o = (C_c/1.15)+0.35; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

 $^{9. \ \} S_c = [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_{v_o}') for \ \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_i}'; \ [C_r/(1+e_o)](H) log(\sigma_p'/\sigma_{v_o}') + [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_p') \ for \ \sigma_{v_o}' < \sigma_p' < \sigma_{v_i}'; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO LRFD \ BDS \ (Cohesive soil layers)$

^{10.} S_c = H(1/C')log(σ_{vi} '/ σ_{vo} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

W-13-072 - FRA-70-13.10 - Retaining Wall W2 MSE Wall Settlement - Sta. 216+50 to 219+39

Boring B-107-3-14

H= 10.5 ft Total wall height

B'= 6.7 ft Effective footing width due to eccentricity

D_w = 8.0 ft Depth below bottom of footing

 q_e = 1,910 psf Equivalent bearing pressure at bottom of wall

																				Total S	Settlement at	Center of R	einforced So	oil Mass		Total Set	tlement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type		Depth	Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ ⁽⁵⁾	C' (6)	Z_f /B	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-2-6	G	0.0	3.5	3.5	1.8	125	438	219	219	4,219					17	30	98	0.26	0.955	1,824	2,042	0.035	0.417	0.497	948	1,167	0.026	0.312
2	A-1-b	G	3.5	6.0	2.5	4.8	135	775	606	606	4,606					56	78	318	0.71	0.691	1,320	1,926	0.004	0.047	0.454	867	1,473	0.003	0.036
2	A-1-b	G	6.0	8.5	2.5	7.3	135	1,113	944	944	4,944					56	70	269	1.08	0.518	989	1,933	0.003	0.035	0.396	757	1,700	0.002	0.029
2	A-1-a	G	8.5	11.5	3.0	10.0	130	1,503	1,308	1,183	5,183					32	38	123	1.49	0.398	759	1,942	0.005	0.063	0.335	640	1,823	0.005	0.055
3	A-1-a	G	11.5	15.0	3.5	13.3	130	1,958	1,730	1,402	5,402					32	36	117	1.98	0.309	590	1,992	0.005	0.055	0.277	529	1,932	0.004	0.050
4	A-4a	С	15.0	18.0	3.0	16.5	130	2,348	2,153	1,622	5,622	20	0.090	0.009	0.428				2.46	0.252	481	2,103	0.002	0.026	0.234	446	2,069	0.002	0.024
1. σ _p ' = σ _ν	₀'+σ _{m;} Estima	ate σ_m of 4,0	00 psf (mod	erately overc	consolidated)	for natural s	oil deposits;	Ref. Table 1	1.2, Coduto	2003											Total	Settlement:		0.642 in		Total	Settlement:		0.506 in

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

 Calculated By:
 BRT
 Date:
 6/23/2019

 Checked By:
 JPS
 Date:
 6/24/2019

^{3.} C_r = 0.10(Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_0 = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

 $^{9. \ \} S_c = [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_{v_o}') for \ \sigma_p' \leq \sigma_{v_o}' < \sigma_{v_i}'; \ [C_r/(1+e_o)](H) log(\sigma_p'/\sigma_{v_o}') + [C_c/(1+e_o)](H) log(\sigma_{v_i}'/\sigma_p') \ for \ \sigma_{v_o}' < \sigma_p' < \sigma_{v_i}'; \ Ref. \ Section \ 10.6.2.4.3, \ AASHTO LRFD \ BDS \ (Cohesive soil layers)$

^{10.} S_c = H(1/C')log(σ_{v_i} '/ σ_{v_o} '); Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

MSE Wall Settlement - Sta. 216+50 to 219+39

Boring B-107-3-14

H= 10.5 ft Total wall height A-4a ft²/yr 6.7 Effective footing width due to eccentricity Coefficient of consolitation $c_v =$ 1,000 $D_w =$ 8.0 ft Depth below bottom of footing t = 5 days Time following completion of construction 1,910 psf Equivalent bearing pressure at bottom of wall $H_{dr} =$ Length of longest drainage path considered $T_v =$ 1.522 Time factor Degree of consolidation U = 98 $(S_c)_t =$ 0.506 in Settlement complete at 100% of primary consolidation

																									1 milary C	onsolidation
Soil Type	Soil Type			Layer Thickness (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c (2)	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' (6)	Z_f /B	J ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	Layer Settlement (in)	(S _c) _t ⁽¹¹⁾ (in)	Layer Settlement (in)
A-2-6	G	0.0	3.5	3.5	1.8	125	438	219	219	4,219					17	30	98	0.26	0.497	948	1,167	0.026	0.312	0.312	0.312	0.312
A-1-b	G	3.5	6.0	2.5	4.8	135	775	606	606	4,606					56	78	318	0.71	0.454	867	1,473	0.003	0.036	0.065	0.036	0.065
A-1-b	G	6.0	8.5	2.5	7.3	135	1,113	944	944	4,944					56	70	269	1.08	0.396	757	1,700	0.002	0.029	0.003	0.029	0.003
A-1-a	G	8.5	11.5	3.0	10.0	130	1,503	1,308	1,183	5,183					32	38	123	1.49	0.335	640	1,823	0.005	0.055	0.105	0.055	0.105
A-1-a	G	11.5	15.0	3.5	13.3	130	1,958	1,730	1,402	5,402			•		32	36	117	1.98	0.277	529	1,932	0.004	0.050	0.105	0.050	0.105
A-4a	С	15.0	18.0	3.0	16.5	130	2,348	2,153	1,622	5,622	20	0.090	0.009	0.428				2.46	0.234	446	2,069	0.002	0.024	0.024	0.023	0.023
	A-2-6 A-1-b A-1-a A-1-a	Type Type A-2-6 G A-1-b G A-1-b G A-1-a G A-1-a G	Type Type (A-2-6 G 0.0 A-1-b G 3.5 A-1-b G 6.0 A-1-a G 8.5 A-1-a G 11.5	Type Type (ft) A-2-6 G 0.0 3.5 A-1-b G 3.5 6.0 A-1-b G 6.0 8.5 A-1-a G 8.5 11.5 A-1-a G 11.5 15.0	Soli Type Soli (ft) Thickness (ft) A-2-6 G 0.0 3.5 3.5 A-1-b G 3.5 6.0 2.5 A-1-b G 6.0 8.5 2.5 A-1-a G 8.5 11.5 3.0 A-1-a G 11.5 15.0 3.5	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) A-2-6 G 0.0 3.5 3.5 1.8 A-1-b G 3.5 6.0 2.5 4.8 A-1-b G 6.0 8.5 2.5 7.3 A-1-a G 8.5 11.5 3.0 10.0 A-1-a G 11.5 15.0 3.5 13.3	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) γ (pcf) A-2-6 G 0.0 3.5 3.5 1.8 125 A-1-b G 3.5 6.0 2.5 4.8 135 A-1-b G 6.0 8.5 2.5 7.3 135 A-1-a G 8.5 11.5 3.0 10.0 130 A-1-a G 11.5 15.0 3.5 13.3 130	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) A-2-6 G 0.0 3.5 3.5 1.8 125 438 A-1-b G 3.5 6.0 2.5 4.8 135 775 A-1-b G 6.0 8.5 2.5 7.3 135 1,113 A-1-a G 8.5 11.5 3.0 10.0 130 1,503 A-1-a G 11.5 15.0 3.5 13.3 130 1,958	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) Midpoint (psf) A-2-6 G 0.0 3.5 3.5 1.8 125 438 219 A-1-b G 3.5 6.0 2.5 4.8 135 775 606 A-1-b G 6.0 8.5 2.5 7.3 135 1,113 944 A-1-a G 8.5 11.5 3.0 10.0 130 1,503 1,308 A-1-a G 11.5 15.0 3.5 13.3 130 1,958 1,730	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) Midpoint (psf) Midpoint (psf) A-2-6 G 0.0 3.5 3.5 1.8 125 438 219 219 A-1-b G 3.5 6.0 2.5 4.8 135 775 606 606 A-1-b G 6.0 8.5 2.5 7.3 135 1,113 944 944 A-1-a G 8.5 11.5 3.0 10.0 130 1,503 1,308 1,183 A-1-a G 11.5 15.0 3.5 13.3 130 1,958 1,730 1,402	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) Midpoint (psf)	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (pf) γ (pcf) Bottom (psf) Midpoint (psf) Midpoint (psf) LL A-2-6 G 0.0 3.5 3.5 1.8 125 438 219 219 4,219 A-1-b G 3.5 6.0 2.5 4.8 135 775 606 606 4,606 A-1-b G 6.0 8.5 2.5 7.3 135 1,113 944 944 4,944 A-1-a G 8.5 11.5 3.0 10.0 130 1,503 1,308 1,183 5,183 A-1-a G 11.5 15.0 3.5 13.3 130 1,958 1,730 1,402 5,402	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (pcf) Post (pcf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) LL C _c (2) A-2-6 G 0.0 3.5 3.5 1.8 125 438 219 219 4,219 219 </td <td>Soli Type Soli (ft) Layer Deptit (ft) Thickness (ft) Midpoint (ft) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) LL (psf)</td> <td>Soli Type Soli (ft) Layer Deptit (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) LL /td> <td>Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (pcf) Post (pcf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) LL C_c (2) C_r (3) e_o (4) N₆₀ A-2-6 G 0.0 3.5 3.5 1.8 125 438 219 219 4,219 17 17 A-1-b G 3.5 6.0 2.5 4.8 135 775 606 606 4,606 10 56 A-1-b G 6.0 8.5 2.5 7.3 135 1,113 944 944 4,944 10 56 A-1-a G 8.5 11.5 3.0 10.0 130 1,503 1,308 1,183 5,183 10 32 A-1-a G 11.5 15.0 3.5 13.3 130 1,958 1,730 1,402 5,402 10 32</td> <td>Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) Midpoint (psf) Midpoint (psf) LL (psf)<!--</td--><td> Soli Type C C C C C C C C C </td><td> Soli Type C C C C C C C C C </td><td> Soli Type Type C C C C C C C C C </td><td> Soli Type Type C(ft) Tipe C(ft) Tipe C(ft) Thickness (ft) C(ft) C(pcf) Soli (psf) C(psf) C(</td><td> Soli Type Type C(ft) Thickness (ft) Thickness (ft) C(ft) C(ft</td><td> Soli Type Type C(ft) Thickness (ft) Midpoint (ft) C(psf) Bottom (psf) Midpoint (psf) Midpoint (psf) C(ft) C(psf) C(ft) C(</td><td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td><td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td><td></td></td>	Soli Type Soli (ft) Layer Deptit (ft) Thickness (ft) Midpoint (ft) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) LL (psf)	Soli Type Soli (ft) Layer Deptit (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) LL	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (pcf) Post (pcf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) Midpoint (psf) LL C _c (2) C _r (3) e _o (4) N ₆₀ A-2-6 G 0.0 3.5 3.5 1.8 125 438 219 219 4,219 17 17 A-1-b G 3.5 6.0 2.5 4.8 135 775 606 606 4,606 10 56 A-1-b G 6.0 8.5 2.5 7.3 135 1,113 944 944 4,944 10 56 A-1-a G 8.5 11.5 3.0 10.0 130 1,503 1,308 1,183 5,183 10 32 A-1-a G 11.5 15.0 3.5 13.3 130 1,958 1,730 1,402 5,402 10 32	Soli Type Soli (ft) Layer Depth (ft) Thickness (ft) Midpoint (ft) γ (pcf) Bottom (psf) Midpoint (psf) Midpoint (psf) LL (psf) </td <td> Soli Type C C C C C C C C C </td> <td> Soli Type C C C C C C C C C </td> <td> Soli Type Type C C C C C C C C C </td> <td> Soli Type Type C(ft) Tipe C(ft) Tipe C(ft) Thickness (ft) C(ft) C(pcf) Soli (psf) C(psf) C(</td> <td> Soli Type Type C(ft) Thickness (ft) Thickness (ft) C(ft) C(ft</td> <td> Soli Type Type C(ft) Thickness (ft) Midpoint (ft) C(psf) Bottom (psf) Midpoint (psf) Midpoint (psf) C(ft) C(psf) C(ft) C(</td> <td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td> <td>$\begin{array}{c ccccccccccccccccccccccccccccccccccc$</td> <td></td>	Soli Type C C C C C C C C C	Soli Type C C C C C C C C C	Soli Type Type C C C C C C C C C	Soli Type Type C(ft) Tipe C(ft) Tipe C(ft) Thickness (ft) C(ft) C(pcf) Soli (psf) C(psf) C(Soli Type Type C(ft) Thickness (ft) Thickness (ft) C(ft) C(ft	Soli Type Type C(ft) Thickness (ft) Midpoint (ft) C(psf) Bottom (psf) Midpoint (psf) Midpoint (psf) C(ft) C(psf) C(ft) C($ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	$ \begin{array}{c ccccccccccccccccccccccccccccccccccc$	

- 1. $\sigma_{\rm n}$ = $\sigma_{\rm vo}$ + $\sigma_{\rm m}$ Estimate $\sigma_{\rm m}$ of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003
- 2. C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5
- 3. $C_r = 0.10$ (Cc) for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981
- 4. $e_0 = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981
- 5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo})] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS
- 6. Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS
- 7. Influence factor for strip loaded footing
- 8. $\Delta \sigma_v = q_e(I)$
- 9. $S_c = [C_c/(1+e_o)](H)\log(\sigma_{v'}/\sigma_{v_o}')$ for $\sigma_p' \leq \sigma_{v_o'}' < \sigma_{v'}'$; $[C_t/(1+e_o)](H)\log(\sigma_p'/\sigma_{v_o}') + [C_c/(1+e_o)](H)\log(\sigma_p'/\sigma_{v_o}') + [C_c/(1+e_o)](H)\log(\sigma_v'/\sigma_p')$ for $\sigma_{v_o'} < \sigma_{v'}' < \sigma_{v'}'$; $[C_t/(1+e_o)](H)\log(\sigma_{v_o'}/\sigma_{v_o}') + [C_c/(1+e_o)](H)\log(\sigma_{v_o'}/\sigma_{v_o}') + [C_c/(1+e_o)](H)\log(\sigma_{v_o'}/\sigma_{v_o}')$
- 10. $S_c = H(1/C')log(\sigma_{v'}/\sigma_{vo}')$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)
- 11. $(S_c)_t = S_c(U/100)$; U = 100 for all granular soils at time t = 0

 Calculated By:
 BRT
 Date:
 06/23/2019

 Checked By:
 JPS
 Date:
 06/24/2019

Settlement Remaining After Hold Period:

Total Settlement at Facing of Wall

0.000 in

Settlement Complete at 100% of

MSE Wall Settlement - Sta. 216+50 to 219+39

Boring B-107-4-14

7.2 ft Total wall height 7.7 ft Effective footing width due to eccentricity B'= 8.0 Depth below bottom of footing

1,120 psf Equivalent bearing pressure at bottom of wall

															Total S	Settlement at	Center of R	einforced So	oil Mass	Total Settlement at Facing of Wall									
Layer	Soil Class.	Soil Type	Layer Depth (ft)		Layer Thickness H (ft)	Depth to Midpoint (ft)	γ (pcf)	σ _{vo} Bottom (psf)	σ _{vo} Midpoint (psf)	σ _{vo} ' Midpoint (psf)	σ _p ' ⁽¹⁾ (psf)	LL	C _c ⁽²⁾	C _r ⁽³⁾	e _o ⁽⁴⁾	N ₆₀	(N1) ₆₀ (5)	C' ⁽⁶⁾	Z_f /B	I ⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	I ⁽⁷⁾	$\Delta\sigma_{v}^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-1-b	G	0.0	2.0	2.0	1.0	125	250	125	125	4,125					20	39	126	0.13	0.993	1,112	1,237	0.016	0.190	0.500	559	684	0.012	0.141
	A-1-b	G	2.0	4.5	2.5	3.3	125	563	406	406	4,406					20	31	101	0.42	0.867	972	1,378	0.013	0.158	0.487	545	952	0.009	0.110
2	A-1-b	G	4.5	7.0	2.5	5.8	120	863	713	713	4,713					11	15	64	0.75	0.670	750	1,463	0.012	0.146	0.448	502	1,215	0.009	0.108
	A-1-b	G	7.0	10.0	3.0	8.5	120	1,223	1,043	1,011	5,011					11	14	62	1.10	0.510	571	1,583	0.009	0.113	0.393	440	1,451	0.008	0.091
3	A-1-a	G	10.0	13.5	3.5	11.8	135	1,695	1,459	1,225	5,225					70	82	338	1.53	0.390	437	1,661	0.001	0.016	0.331	370	1,595	0.001	0.014
1. σ _p ' = σ	$\sigma_{\rm p}' = \sigma_{\rm vo}' + \sigma_{\rm m}$: Estimate $\sigma_{\rm m}$ of 4,000 psf (moderately overconsolidated) for natural soil deposits; Ref. Table 11.2, Coduto 2003														Total Settlement:				n Total Settlemer			•	0.464 in						

^{2.} C_c = 0.009(LL-10); Ref. Table 6-9, FHWA GEC 5

Calculated By: BRT Checked By:

Date: 6/23/2019 Date: 6/24/2019

^{3.} $C_r = 0.10(Cc)$ for natural soil deposits; Ref. Section 8.11, Holtz and Kovacs 1981

^{4.} $e_o = (C_c/1.15)+0.35$; Ref. Table 8-2, Holtz and Kovacs 1981

^{5.} $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ ksf; Ref. Section 10.4.6.2.4, AASHTO LRFD BDS

^{6.} Bearing capacity index; Ref. Figure 10.6.2.4.2-1, AASHTO LRFD BDS

^{7.} Influence factor for strip loaded footing

^{8.} $\Delta \sigma_v = q_e(I)$

^{9.} $S_c = [C_c/(1+e_o)](H)\log(\sigma_{v_t}'/\sigma_{v_o}')$ for $\sigma_p' \leq \sigma_{v_o'} < \sigma_{v_t}'$; $[C_t/(1+e_o)](H)\log(\sigma_p'/\sigma_{v_o'}')$ for $\sigma_{v_o'} < \sigma_{v_t}' \leq \sigma_p'$; $[C_t/(1+e_o)](H)\log(\sigma_{v_t}'/\sigma_p')$ for $\sigma_{v_o'} < \sigma_{v_t}' < \sigma_{v_t}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesive soil layers)

^{10.} $S_c = H(1/C')log(\sigma_{vf}/\sigma_{vo})$; Ref. Section 10.6.2.4.2, AASHTO LRFD BDS (Granular soil layers)

