FRA-70-12.68 PROJECT 4R RETAINING WALL 4W12 PID NO. 105523 FRANKLIN COUNTY, OHIO

STRUCTURE FOUNDATION EXPLORATION REPORT

Prepared For: GPD GROUP 1801 Watermark Drive, Suite 210 Columbus, OH 43215

> Prepared By: Resource International, Inc. 6350 Presidential Gateway Columbus, Ohio 43231

> > Rii Project No. W-13-045

July 2018

Planning, Engineering, Construction Management, Technology 6350 Presidential Gateway, Columbus, Ohio 43231 P 614.823.4949 F 614.823.4990







May 27, 2015 (Revised July 17, 2018)

Mr. Christopher W. Luzier, P.E. Project Manager GPD GROUP 1801 Watermark Drive, Suite 210 Columbus, OH 43215

Re: Structure Foundation Exploration Report FRA-70-12.68 Project 4R Retaining Wall 4W12 PID No. 105523 Rii Project No. W-13-045

Mr. Luzier:

Resource International, Inc. (Rii) is pleased to submit this 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 foundation recommendations for the design and construction of the proposed Retaining Wall 4W12 as part of the FRA-70-12.68 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.

cian brenner

Brian R. Trenner, P.E. Director – Geotechnical Programming

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

Enclosure: Structure Foundation Exploration Report

6350 Presidential Gateway Columbus, Ohio 43231 Phone: 614.823.4949 Fax: 614.823.4990 Planning

Engineering

Construction Management

Technology

Sectio	Page
EXECU	TIVE SUMMARYI
	Exploration and Findingsi Analyses and Recommendationsii
1.0	NTRODUCTION1
2.0	GEOLOGY AND OBSERVATIONS OF THE PROJECT1
	2.1 Site Geology 1 2.2 Existing Conditions 2
3.0	EXPLORATION
4.0	FINDINGS
	I.1 Surface Materials 6 I.2 Subsurface Soils 6 I.3 Bedrock 7 I.4 Groundwater 7
5.0	ANALYSES AND RECOMMENDATIONS8
	5.1MSE Wall Recommendations95.1.1Strength Parameters Utilized in External and Global StabilityAnalyses105.1.2Bearing Stability115.1.3Eccentricity (Overturning Stability)135.1.4Sliding Stability145.1.5Overall (Global) Stability145.1.6Final MSE Wall Considerations155.2Lateral Earth Pressure155.3Construction Considerations165.3.1Excavation Considerations165.3.2Groundwater Considerations17
6.0	IMITATIONS OF STUDY

TABLE OF CONTENTS

APPENDICIES

Appendix IVicinity Map and Boring PlanAppendix IIDescription of Soil TermsAppendix IIIProject Boring Logs: B-109-0-09, B-109-1-15, B-110-0-09,
B-110-1-15 and B-111-0-09Appendix IVMSE Wall Calculations

EXECUTIVE SUMMARY

Resource International, Inc. (Rii) has completed a structure foundation exploration for the design and construction of the proposed Retaining Wall 4W12. It is understood that this wall will be connected to the forward abutment of the proposed FRA-70-1282R I-70 eastbound over Souder Avenue bridge structure at the west end of the wall alignment and will extend east. It is understood that a mechanically stabilized earth (MSE) wall is being considered as the preferred wall type for the entire alignment of Retaining Wall 4W12. Wall heights along the alignment of the proposed structure are anticipated to range from roughly 6.9 feet to a maximum height of approximately 36.9 feet at Sta. 3003+06 (BL Ramp C3), and the total wall length is anticipated to be on the order of 935 lineal feet.

Exploration and Findings

On March 21 and 22, 2015, two (2) structure borings, designated as borings B-109-1-15 and B-110-1-15, were advanced to completion depths of 85.0 and 75.0 feet, respectively, below the existing ground surface. In addition to the borings performed by Rii as part of the current exploration, three (3) borings, designated as B-109-0-09, B-110-0-09, and B-111-0-09, were advanced to depths of 50.0, 49.4 and 30.0 feet below the existing ground surface, respectively, by DLZ as part of the FRA-70-8.93 preliminary exploration.

At the existing ground surface, boring B-109-1-15 encountered 6.0 inches of asphalt overlying 12.0 inches of aggregate base, while boring B-110-1-15 encountered 8.0 inches of asphalt underlain by 14.5 inches of concrete and 5.0 inches of aggregate base. Boring B-109-0-09 was located within the grass just south of the I-70 embankment and encountered 5.0 inches of topsoil at the ground surface. Boring B-110-0-09 was performed within the existing pavement of Mound Street/Harmon Avenue, encountering 5.0 inches of asphalt overlying 7.0 inches of concrete at the ground surface. Boring B-111-0-09 was performed within the ramp pavement connecting I-70 eastbound to I-71 southbound, and encountered 6.0 inches of concrete overlying 6.0 inches of aggregate base.

Beneath the surficial pavement materials encountered in borings B-109-1-15 and B-110-1-15, existing embankment fill consisting of gray gravel with sand and silt (ODOT A-2-4) and brown to gray silt and clay, and elastic clay (ODOT A-6a and A-7-5) were encountered extending to depths of 32.0 and 27.0 feet below existing grade, respectively. Brick, clay tile, and rock fragments were noted within the fill materials in boring B-109-1-15. Beneath the surficial topsoil and pavement materials encountered in borings B-109-0-09, B-110-0-09 and B-111-0-09, material identified as existing or possible existing fill was encountered extending to depths of 6.0, 10.5, and 3.5 feet below existing grades, respectively. The fill materials consisted of brown and dark brown gravel and sand, gravel with sand, silt and clay, coarse and fine sand, sandy silt, and silt and clay (ODOT A-1-b, A-2-6, A-4a, and A-6a). The uppermost fill material



encountered at boring B-110-0-09 contained brick fragments and organic material to a depth of 8.0 feet below the ground surface; however, based on information provided by ODOT, it is anticipated that the brick fragments are likely from the demolition of an outbuilding associated with the former slaughter yards, and it is not uncommon for soils present during slaughter yard activities to be high in organic content.

Underlying the surficial materials and existing fill, the subsurface profile encountered in both the current and preliminary explorations primarily consisted of natural granular soils overlying deep, intermittent cohesive deposits. The natural granular soils were generally described as brown and gray gravel, gravel and sand, gravel with sand and silt, coarse and fine sand, and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-3a, and A-4a). The cohesive soils were generally described as brown, dark brown and gray sandy silt, silt and clay, and silty clay (ODOT A-4a, A-6a, and A-6b).

Analyses and Recommendations

Design details of the proposed retaining wall were provided by Dynotec. As stated, it is understood that a mechanically stabilized earth (MSE) wall type is currently being considered along the entire alignment of the proposed structure, which is to support the new alignment of Ramp C3. Based upon the proposed plan information, wall heights along the proposed alignment will range from a minimum height of 6.9 feet at the eastern termination point of the wall, to a maximum height of 36.9 feet at Sta. 3003+06 (BL Ramp C3), as measured from the top of the leveling pad to top of the coping.

Beginning at the forward abutment of the proposed FRA-70-1282R bridge structure, the wall will be located at the edge of the proposed Ramp C3, adjacent to Mound Street/Harmon Avenue, and will generally be aligned with the toe of the existing embankment supporting the I-70 eastbound ramp to I-71 southbound. The proposed wall will maintain this alignment as it extends eastward from approximately Sta. 5032+44 (BL Ramp C5) to Sta. 3003+06 (BL Ramp C3). At this location, the wall alignment will step up along the slope of the existing embankment and diverge from the edge of the proposed ramp alignment between approximately Sta. 3003+50 and 3007+34 (BL Ramp C3), where the wall terminates at the edge of Ramp C3. It is understood that 2:1 backslopes will be graded up to the proposed Ramp C3 roadway from the top of the wall between approximately Sta. 3003+50 and 3007+34 (BL Ramp C3), and that 4:1 slopes will be graded down from the bottom of the wall to the existing grade along Mound Street/Harmon Avenue where the wall will be aligned within the limits of the existing embankment. Additionally, it is understood that profile grade of Ramp C3 will be raised from the proposed profile grade for the current project as part of the FRA-70-13.10 Phase 6A project improvements from approximately Sta. 3005+00 to the end of the project alignment. Therefore, the geometry for both phases was considered in the analysis for the east end of the wall alignment.



The anticipated bearing materials along the proposed alignment of Retaining Wall 4W12 will likely consist of newly placed and compacted fill material, very stiff to hard cohesive soils (ODOT A-4a, A-6a or A-7-5), or loose to very dense granular soils (ODOT A-1-a, A-1-b, A-2-6, A-4a). MSE wall foundations bearing on these soils or ODOT Item 203 granular embankment, placed and compacted in accordance with ODOT Item 203, may be proportioned for a nominal bearing resistance as indicated in the following table. A geotechnical resistance factor of φ_b =0.65 was considered in calculating the factored bearing resistance at the strength limit state. Given that the existing embankment material consists primarily of cohesive soil, the bearing resistance was evaluated under both drained and undrained conditions, where applicable. Calculations were based on generalization of the conditions encountered in borings B-109-1-15, B-110-0-09, B-110-1-15, and B-111-0-15. 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.

Station Analyzed ¹	Wall Height Analyzed	Backslope Behind	Minimum Required Reinforcement	Bearing Re Strengt (k:	esistance at th Limit sf)	Strength Limit Equivalent Bearing
	(feet)	Wall	Length ² (feet)	Nominal	Factored ³	Pressure ⁴ (ksf)
3003+06	36.9	Level	25.8 (0.70H)	19.87	12.92	8.57
3004+50	25.2	2:1 (Broken-back)	19.2 (0.76H)	11.11	7.22	7.08
3005+50	18.2	2:1 (Broken-back)	16.0 (0.88H)	11.63	7.56	4.94
3006+24 (Phase 4A)	12.9	2:1 (Broken-back)	16.8 (1.30H)	13.15	8.55	3.00
3006+24 (Phase 6A)	12.9	2:1	16.8 (1.30H)	14.14	9.19	2.91

Retaining Wall 4W12 MSE Wall Design Parameters

1. Stationing is referenced to the baseline of Ramp C3.

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

3. A geotechnical resistance factor of $\varphi_b=0.65$ 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 1.17 to 2.76 inches at the center, and 0.83 to 2.01 inches at the face of the of the reinforced soil mass, respectively, are anticipated for the proposed MSE wall. Based on the total anticipated settlement at the facing of the wall, maximum differential settlement in the longitudinal direction is anticipated to be less than 1/1000, which is within the tolerable limit of 1/100. Due to the granular nature of the bearing soils, it is estimated that 90 percent of the settlement is to occur within 10 to 20 days of completion of the embankment.



Based on the results of the external and global stability analysis performed for the MSE walls, the recommended controlling strap length ranges from 0.70 to 1.30 times the height of the MSE wall (measured from the top of the leveling pad to top of the coping). Bearing resistance and global stability under drained conditions were the controlling factor in the determination of the recommended strap lengths greater than 0.70 times the height of the MSE Wall for the situations analyzed with a sloping backfill

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-70-12.68/13.11/14.05C (Project 4R/4H/4A) projects in Columbus, Ohio. The projects represent the central portion of FRA-70-8.93 (PID 77369) I-70/71 south innerbelt improvements project. The FRA-70-12.68 (Project 4R) phase will consist of all work associated with the construction of Ramp C5, starting at the bridge over Souder Avenue and extending east to Front Street. The proposed Ramp C5 will be a two-lane to four-lane ramp that will collect and direct traffic from I-71 northbound and SR-315 southbound as well as I-70 eastbound to exit in downtown at the intersection of Front Street and W. Fulton Avenue. This project includes the construction of six (6) new bridge structures for the proposed Ramp C5 alignment and replacement of three (3) bridge structures, two along I-70 and the Front Street Structure over I-70, as well as the construction of fourteen (14) new retaining walls and a culvert structure 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 4W12, as shown on the vicinity map and boring plan presented in Appendix I. It is understood that this wall will be connected to the forward abutment of the proposed FRA-70-1282R I-70 eastbound over Souder Avenue bridge structure at the west end of the wall alignment and will extend east. It is understood that a mechanically stabilized earth (MSE) wall is being considered as the preferred wall type for the entire alignment of Retaining Wall 4W12. Wall heights along the alignment of the proposed structure are anticipated to range from roughly 6.9 feet to a maximum height of approximately 36.9 feet at Sta. 3003+06 (BL Ramp C3), and the total wall length is anticipated to be on the order of 936 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 consists predominantly of the Middle to Lower Devonian-aged Columbus Limestone Formation. 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 limy dolomite. Both of these members contain chert nodules. Just east of Scioto River, the Upper Devonian Ohio Shale Formation overlies the Columbus Limestone Formation. The Ohio Shale formation consists of brownish black to greenish gray, thinly bedded, fissile, carbonaceous shale. 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

It is understood that the proposed Retaining Wall 4W12 structure will connect to the forward abutment of the proposed FRA-70-1282R structure, which carries I-70 eastbound over Souder Avenue, at the west end of the wall alignment and will extend east a distance of roughly 960 lineal feet. Currently, an existing ramp begins just east of the Souder Avenue Bridge which connects I-70 eastbound to I-71 southbound. It is understood that I-70 eastbound is to be widened towards the south at the proposed FRA-70-1282R structure to accommodate the proposed reconfiguration of the existing ramp connecting I-70 eastbound to I-71 southbound (Proposed Ramp C3), and to allow for the addition of a new ramp which will parallel I-70 eastbound into downtown Columbus (Proposed Ramp C5). Plan information indicates that the proposed retaining wall will roughly parallel Ramp C3, beginning at the forward abutment of FRA-70-1282R and extending roughly 580 lineal feet to the east, at which point the proposed wall is proposed to turn southeast, at a sharper radius than Ramp C3, for a distance of approximately 380 lineal feet prior to terminating along Ramp C3.

Located approximately 2,500 feet west of the Scioto River, the existing I-70 eastbound roadway in the vicinity of the Souder Avenue structure is a four-lane, asphalt paved roadway aligned in a primarily west-to-east orientation. At the western end of the proposed retaining wall alignment, I-70 eastbound passes over Souder Avenue, which is also a four-lane, asphalt paved roadway, however it is primarily aligned in a south-to-north orientation. The existing I-70 roadway profile grade is elevated approximately 20 feet above the surrounding terrain on engineered embankments, which are grass covered with patches of dense vegetation. The proposed retaining wall



is understood to be located within the existing embankment area, between I-70 eastbound and Mound Street/Harmon Avenue.

Within the project limits, Mound Street/Harmon Avenue roughly parallels the existing ramp connecting I-70 eastbound to I-71 southbound, along the south side of the existing embankment, intersecting with Souder Avenue just south of the FRA-70-1282R structure. A majority of Mound Street/Harmon Avenue maintains one lane of traffic in each direction, with the drive lane area widening near the intersection with Souder Avenue to accommodate both a left- and right-hand turn lane in the westbound direction. Along the eastern portion of the project limits, a concrete cast-in-place (CIP) retaining wall, Retaining Wall CB, borders the northern edge of the Mound Street/Harmon Avenue pavement, supporting the existing I-70 embankment. A chain link fence has been constructed along the top of the retaining wall, acting as the ODOT right-of-way fence along the alignment.

As stated, existing engineered embankments elevate I-70 roughly 20 feet above the surrounding terrain in this area. In general, the terrain along I-70 slopes gently downward towards the west, while the lower lying surrounding area is relatively flat. Land use along the south side of Mound Street/Harmon Avenue currently consists primarily of commercially developed properties, while the north side of I-70 is developed with primarily residential properties. It is understood that Sanborn maps of the area from 1922 and 1941 indicate that the area south of Mound Street/Harmon Avenue was once the site of slaughter yards associated with the A&E Maier Slaughter House and the David Davies Company. Furthermore, the area in the vicinity of the proposed retaining wall is understood to have been previously developed with residential properties.

3.0 EXPLORATION

On March 21 and 22, 2015, two (2) structure borings, designated as borings B-109-1-15 and B-110-1-15, were advanced to completion depths of 85.0 and 75.0 feet, respectively, below the existing ground surface. Both borings were performed within the shoulder of the existing ramp connecting I-70 eastbound to I-71 southbound to determine the subsurface conditions along the proposed alignment of Retaining Wall 4W12, and within the existing I-70 embankment fill. In addition to the borings performed by Rii as part of the current exploration, three (3) borings, designated as B-109-0-09, B-110-0-09, and B-111-0-09, were performed DLZ along the alignment of the proposed wall 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 performed on September 1 and 11, 2009, and were advanced to completion depths of 50.0, 49.4 and 30.0 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.



Boring Number	Reference Alignment	Station	Offset	Latitude	Longitude	Ground Elevation (feet msl)	Boring Depth (feet)
B-109-0-09	BL Ramp C5	5032+97.77	44.7' Rt.	39.949836696	-83.020667264	704.9	50.0
B-109-1-15	BL Ramp C3	3001+00.00	55.0' Lt.	39.950097038	-83.019715408	736.2	85.0
B-110-0-09	BL Ramp C3	3003+02.96	22.8' Rt.	39.949876643	-83.018993458	705.8	49.4
B-110-1-15	BL Ramp C3	3005+00.00	20.0' Lt.	39.949913094	-83.018276075	740.3	75.0
B-111-0-09	BL Ramp C3	3008+11.91	4.6' Rt.	39.949346358	-83.017437998	734.9	30.0

Table 1. Test Boring Summary

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 northing and easting coordinates of the boring locations. Ground surface elevations at the boring locations were interpolated using topographic mapping information provided by GPD GROUP.

The borings performed by Rii for the current exploration were drilled using truck-mounted rotary drilling machines, utilizing either a 3.25 or 4.25-inch inside diameter, hollow-stem auger to advance the holes. Standard penetration test (SPT) and split spoon sampling were performed in the borings at 5.0-foot increments to the proposed bottom of wall elevation at the respective boring location, at 2.5-foot increments to a depth of 20.0 feet below the proposed bottom of wall elevation, and at 5.0-foot increments thereafter to the boring termination depths. 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 blow 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, N₆₀, 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 hammer for the CME 55 drill rig used by Rii for boring B-109-1-15 was calibrated on October 20, 2014, and has a drill rod energy ratio of 92.0 percent. The hammer for the Mobile B-53 drill rig used by Rii for boring B-110-1-15 was calibrated on April 26, 2013, and has a drill rod energy ratio of 77.7 percent. The hammer for the CME 75 truck-mounted drill rig used by DLZ has a drill rod energy ratio of 62.0 percent.

Upon completion of drilling, the borings performed by Rii were backfilled in accordance with the ODOT policy for sealing boreholes, utilizing a cement-bentonite grout. Where borings penetrated the existing pavement, an equivalent thickness of quickset concrete was used to repair the pavement surface. Abandonment methods and quantities are not listed on the logs of the borings performed by DLZ.

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.

Laboratory Test	Test Designation	Number of Tests Performed
Natural Moisture Content	ASTM D 2216	40
Plastic and Liquid Limits	AASHTO T89, T90	14
Gradation – Sieve/Hydrometer	AASHTO T88	14

Table 2. Laboratory Test Schedule

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

As stated, borings B-109-1-15 and B-110-1-15 were performed Boring B-013-1-15 was performed within the shoulder of the existing ramp connecting I-70 eastbound to I-71 southbound. At the existing ground surface, boring B-109-1-15 encountered 6.0 inches of asphalt overlying 12.0 inches of aggregate base, while boring B-110-1-15 encountered 8.0 inches of asphalt underlain by 14.5 inches of concrete and 5.0 inches of aggregate base. Boring B-109-0-09 was located within the grass just south of the I-70 embankment and encountered 5.0 inches of topsoil at the ground surface, as identified by the significant presence of vegetation and organic material. Boring B-110-0-09 was performed within the existing pavement of Mound Street/Harmon Avenue, encountering 5.0 inches of asphalt overlying 7.0 inches of concrete at the ground surface. Boring B-111-0-09 was performed within the ramp connecting I-70 eastbound to I-71 southbound, and encountered 6.0 inches of concrete overlying 6.0 inches of aggregate base.

4.2 Subsurface Soils

Beneath the surficial pavement materials encountered in borings B-109-1-15 and B-110-1-15, existing embankment fill consisting of gray gravel with sand and silt (ODOT A-2-4) and brown to gray silt and clay, and elastic clay (ODOT A-6a and A-7-5) were encountered extending to depths of 32.0 and 27.0 feet below existing grade, respectively. Brick, clay tile, and rock fragments were noted within the fill materials in boring B-109-1-15. Beneath the surficial topsoil and pavement materials encountered in borings B-109-0-09, B-110-0-09 and B-111-0-09, material identified as existing or possible existing fill was encountered extending to depths of 6.0, 10.5, and 3.5 feet below existing grades, respectively. The fill materials consisted of brown and dark brown gravel and sand, gravel with sand, silt and clay, coarse and fine sand, sandy silt, and silt and clay (ODOT A-1-b, A-2-6, A-4a, and A-6a). The uppermost fill material encountered at boring B-110-0-09 contained brick fragments and organic material to a depth of 8.0 feet below the ground surface; however, based on information provided by ODOT, it is anticipated that the brick fragments are likely from the demolition of an outbuilding associated with the former slaughter yards, and it is not uncommon for soils present during slaughter yard activities to be high in organic content.



Underlying the surficial materials and existing fill, the subsurface profile encountered primarily consisted of natural granular soils overlying deep, intermittent cohesive deposits. The natural granular soils were generally described as brown and gray gravel, gravel and sand, gravel with sand and silt, coarse and fine sand, and sandy silt (ODOT A-1-a, A-1-b, A-2-4, A-3a, and A-4a). The cohesive soils were generally described as brown, dark brown and gray sandy silt, silt and clay, and silty clay (ODOT A-4a, A-6a, and A-6b).

The relative density of granular soils is primarily derived from SPT blow counts (N₆₀). Based on the SPT blow counts obtained, the granular soil encountered ranged from loose ($5 \le N_{60} \le 10$ blows per foot [bpf]) to very dense (N₆₀ > 50 bpf). Overall blow counts recorded from the SPT sampling ranged from 5 bpf to split spoon sampler refusal. The shear strength and consistency of the cohesive soils are primarily derived from the hand penetrometer values (HP). The cohesive soils 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 4 to 31 percent. The natural moisture content of the cohesive soil samples tested for plasticity index ranged from 14 percent below to 2 percent above their corresponding plastic limits. In general, the soils exhibited natural moisture contents considered to be significantly below to slightly above their optimum moisture levels.

4.3 Bedrock

Bedrock was not encountered in the borings analyzed as part of this exploration.

4.4 Groundwater

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



Boring	Ground	Initial Gro	oundwater	Upon Co	mpletion
Number	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)	Depth (feet)	Elevation (feet msl)
B-109-0-09	704.9	13.5	691.4	12.5 ²	692.4
B-109-1-15	736.2	Dry	Dry	N/A ¹	N/A ¹
B-110-0-09	705.8	10.5	695.3	10.6	695.2
B-110-1-15	740.3	53.5	686.8	N/A ¹	N/A ¹
B-111-0-09	734.9	Dry	Dry	Dry	Dry

Table 3. Groundwater Levels

1. The groundwater level at completion could not be obtained due to the addition of drilling fluid.

2. The groundwater level at completion includes drilling water.

Groundwater was encountered in boring B-109-0-09, B-110-0-09 and B-110-1-15 at depths ranging from 10.5 to 53.5 feet beneath the ground surface, corresponding to elevations ranging from 686.8 to 695.3 feet msl. At the completion of drilling, and prior to removing the augers, groundwater had accumulated in boring B-110-0-09 to a depth of 10.6 feet below the ground surface, corresponding to an elevation of 695.2 feet msl. Groundwater was not encountered during, or at the completion of, drilling in boring B-111-0-09. Groundwater was also not encountered in boring B-109-1-15 prior to the introduction of drilling fluid at a depth of 45.0 feet beneath the ground surface. As stated, drilling fluid was introduced to borings B-109-0-09, B-109-1-15, and B-110-1-15 to counteract the water pressure causing sands to heave into the augers. The introduction of drilling fluid to the borings prevents accurate measurements of the groundwater levels within the boreholes at the completion of drilling.

Please note that short-term water level readings, especially in cohesive soils, are not necessarily an accurate indication of the actual groundwater level. In addition, groundwater levels or the presence of groundwater are considered to be dependent on seasonal fluctuations in precipitation.

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

5.0 ANALYSES AND RECOMMENDATIONS

Data obtained from both the current and historic 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 Dynotec. As stated, it is understood that a mechanically stabilized earth (MSE) wall type is currently being considered along the entire alignment of the proposed structure, which is to support the new alignment of Ramp C3. Based on the information available at the time of this report, wall heights ranging from 4.4 to 36.9 feet are anticipated along the 936-foot long alignment, with the footings proposed to bear at a minimum depth of 3.0 feet beneath the proposed ground surface.

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 2007 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. 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 2007 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 upon the proposed plan information, wall heights along the proposed alignment will range from a minimum height of 6.9 feet at the eastern termination point of the wall, to a maximum height of 36.9 feet at Sta. 3003+06 (BL Ramp C3), as measured from the top of the leveling pad to top of the coping. Beginning at the forward abutment of the proposed FRA-70-1282R bridge structure, the wall will be located at the edge of the proposed Ramp C3, adjacent to Mound Street/Harmon Avenue, and will generally be aligned with the toe of the existing embankment supporting the I-70 eastbound ramp to I-71 southbound. The proposed wall will maintain this alignment as it extends eastward from approximately Sta. 5032+44 (BL Ramp C5) to Sta. 3003+06 (BL Ramp C3). At this location, the wall alignment will step up along the slope of the existing embankment and diverge from the edge of the proposed ramp alignment between approximately Sta. 3003+50 and 3007+34 (BL Ramp C3), where the wall terminates at the edge of Ramp C3. It is understood that 2:1 backslopes will be graded up to the proposed Ramp C3 roadway from the top of the wall between approximately Sta. 3003+50 and 3007+34 (BL Ramp C3), and that 4:1 slopes will be graded down from the bottom of the wall to the existing grade along Mound Street/Harmon Avenue where the wall will be aligned within the limits of the existing embankment.



Additionally, it is understood that profile grade of Ramp C3 will be raised from the proposed profile grade for the current project as part of the FRA-70-13.10 Phase 6A project improvements from approximately Sta. 3005+00 to the end of the project alignment. Therefore, the geometry for both phases was considered in the analysis for the east end of the wall alignment. 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.

Materials identified as either existing or possible existing fill were encountered at the proposed bearing elevation in borings B-109-0-09 and B-110-0-09, extending to depths of 4.5 and 7.5 feet below the proposed bearing elevation, respectively. The fill materials, which are not associated with the embankment fill encountered in the remaining borings, consisted of both granular and cohesive soils identified as loose to very dense gravel with sand and coarse and fine sand (ODOT A-1-b, A-3a), and very stiff to hard sandy silt and silt and clay (ODOT A-4a, A-6a). These fill materials were noted as containing brick fragments and organic material in boring B-110-0-09. Although debris was present and low blow counts were observed within these fill materials, it is anticipated that the limits of the fill will be localized and will not be present along the entirety of the proposed alignment. As previously stated, it is understood that this area was once the site of slaughter yards associated with the A&E Maier Slaughter House and the David Davies Company. The brick fragments encountered can likely be attributed to the demolition of the outbuildings associated with these operations, while soils high in organic content are not unusual in areas where such activities once occurred. Furthermore, it is anticipated that significant portions of this material would have been removed and replaced if encountered during the development and construction of the residential properties and existing Retaining Wall CB. If encountered during construction of Retaining Wall 4W12, it is recommended that any unsuitable foundation materials be remediated in accordance with ODOT SS840, Section 840.06.D.

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 bearing materials along the proposed alignment of Retaining Wall 4W12 will likely consist of newly placed and compacted fill material, very stiff to hard cohesive soils (ODOT A-4a, A-6a or A-7-5), or loose to very dense granular soils (ODOT A-1-a, A-1-b, A-2-6, A-4a).

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.



Material Type	γ (pcf)	φ' ⁽¹⁾ (°)	<i>C</i> ' ⁽²⁾ (psf)	<i>S_u</i> ⁽³⁾ (psf)
MSE Wall Backfill (Select granular fill)	120	34	0	N/A
Item 203 Embankment Fill (Retained soil)	120	30	0	2,000
Ex. Embankment Fill: Very Stiff to Hard Sandy Silt (ODOT A-4a)	120	30	0	2,000
Ex. Fill: Loose to Medium Dense Gravel and Sand and Coarse and Fine Sand (ODOT A-1-b, A-3a)	120	28	0	N/A
Loose Sandy Silt (ODOT A-4a)	115	27	0	N/A
Medium Dense to Dense Granular Soils (ODOT A-1-a, A-3a)	130	30 to 40	0	N/A
Very Dense Granular Soils (ODOT A-1-a, A-1-b, A-3a)	135	40 to 42	0	N/A
Very Stiff Silty Clay (ODOT A-6b)	120	27	0	3,125
Hard Sandy Silt (ODOT A-4a)	130	32	50	8,000

Table 4, Shear Strength Parameters	s Utilized in MSF Wall Stability	Analyses
Tuble 4. Onear Ottength Fulumeters		Analyses

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.

2. Estimated based on overconsolidated nature of soil.

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

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 proposed alignment of Retaining Wall 4W12 will likely consist of newly placed and compacted fill material, very stiff to hard cohesive soils (ODOT A-4a, A-6a or A-7-5), or loose to very dense granular soils (ODOT A-1-a, A-1-b, A-2-6, A-4a). MSE wall foundations bearing on these soils or ODOT Item 203 granular embankment, placed and compacted in accordance with ODOT Item 203, may



be proportioned for a nominal bearing resistance as indicated in Table 5. A geotechnical resistance factor of $\varphi_b=0.65$ was considered in calculating the factored bearing resistance at the strength limit state. Given that the existing embankment material consists primarily of cohesive soil, the bearing resistance was evaluated under both drained and undrained conditions, where applicable. Calculations were based on generalization of the conditions encountered in borings B-109-1-15, B-110-0-09, B-110-1-15, and B-111-0-15. 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.

		<u> </u>		<u> </u>		
Station Analyzed ¹	Wall Height Analyzed	Backslope Behind	Minimum Required Reinforcement	Bearing Re Strengt (k:	sistance at h Limit sf)	Strength Limit Equivalent Bearing
-	(feet)	waii	Length ² (feet)	Nominal	Factored ³	Pressure * (ksf)
3003+06	36.9	Level	25.8 (0.70H)	19.87	12.92	8.57
3004+50	25.2	2:1 (Broken-back)	19.2 (0.76H)	11.11	7.22	7.08
3005+50	18.2	2:1 (Broken-back)	16.0 (0.88H)	11.63	7.56	4.94
3006+24 (Phase 4A)	12.9	2:1 (Broken-back)	16.8 (1.30H)	13.15	8.55	3.00
3006+24 (Phase 6A)	12.9	2:1	16.8 (1.30H)	14.14	9.19	2.91

Table 5. Retaining Wall 4W12 MSE Wall Design Parameters

1. Stationing is referenced to the baseline of Ramp C3.

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

3. A geotechnical resistance factor of $\varphi_b=0.65$ 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.

Rii performed a verification of the bearing pressure exerted on the subgrade material for the maximum specified wall heights indicated in Table 5. Based on the minimum length of reinforced soil mass presented, and utilizing the soil parameters listed in Table 4, the equivalent bearing pressure exerted below the wall <u>will not exceed</u> the factored bearing resistance at the strength limit state.

Total settlements of 1.17 to 2.76 inches at the center, and 0.83 to 2.01 inches at the face of the of the reinforced soil mass, respectively, are anticipated for the proposed MSE wall, as noted in Table 6. Per Section 204.6.2.1 of the ODOT BDM, "the maximum allowable differential settlement in the longitudinal direction (regardless of the size of panels) is one (1) percent." Based on the total anticipated settlement at the facing of the wall, maximum differential settlement in the longitudinal direction is anticipated to be



less than 1/1000, which is within the tolerable limit of 1/100. Due to the granular nature of the bearing soils and condition of the existing embankment, it is estimated that 90 percent of the settlement is to occur within 10 to 20 days of completion of the embankment. If either the total or differential settlement predicted presents an issue with respect to the deformation tolerances that the walls can withstand, then measures should be taken to minimize the amount of settlement that will occur. Settlement calculations are provided in Appendix IV.

Station ¹	Wall Height	Backslope Behind	Service Limit Equivalent Bearing	Total An Settle (inc	ticipated ement hes)
	(feet)	Wall	Pressure (ksf)	Center of MSE	Face of MSE
3003+06	36.9	Level	6.03	2.76	2.01
3004+50	25.2	2:1 (Broken-back)	4.87	2.19	1.63
3005+50	18.2	2:1 (Broken-back)	3.43	1.40	1.04
3006+24 (Phase 4A)	12.9	2:1 (Broken-back)	2.14	1.17	0.83
3006+24 (Phase 6A)	12.9	2:1	2.11	1.19	0.83

 Table 6. Retaining Wall 4W12 MSE Wall Settlement Values

1. Stationing is referenced to the baseline of Ramp C3.

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.

5.1.3 Eccentricity (Overturning Stability)

The resistance of the MSE wall to overturning will be dependent 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 of the resultant force for the retaining wall configurations indicated in Table 5. Based on the minimum length of reinforced soil mass presented in Table 5 and utilizing the soil parameters listed in Table 4 for the retained embankment material, the calculated eccentricity of the resultant force **will not exceed** the limiting eccentricity at the strength limit state.



5.1.4 Sliding Stability

The resistance of the MSE wall to sliding was evaluated per Section 11.10.5.3 of the 2014 AASHTO LRFD BDS. Given that the existing embankment material consists primarily of cohesive soil, the sliding resistance was evaluated under both drained and undrained conditions where applicable. 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, a coefficient of sliding friction of 0.53 was utilized for design. 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 Table 4, the undrained shear strength of the existing embankment material is estimated at 2.63 ksf. A geotechnical resistance factor of φ_{τ} =1.0 was considered in calculating the factored shear resistance between the reinforced soil mass and foundation soil for sliding. Based on the minimum length of reinforced soil mass presented in Table 5 and utilizing the soil parameters listed in Table 4 for the retained embankment material, the resultant horizontal forces on the back of the MSE wall will not exceed the factored shear resistance at the strength limit state under drained or undrained conditions.

5.1.5 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 6.0 manufactured by Rocscience Inc. was utilized to perform the analyses.

Per Section 11.6.2.3 of the 2014 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 approximately equal to 1.3.

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



5.1.6 Final MSE Wall Considerations

Based on the results of the external and global stability analysis performed for the MSE walls, the recommended controlling strap length ranges from 0.70 to 1.30 times the height of the MSE wall (measured from the top of the leveling pad to top of the coping) as noted in Table 5. Bearing resistance and global stability under drained conditions were the controlling factor in the determination of the recommended strap lengths greater than 0.70 times the height of the MSE Wall for the situations analyzed with a sloping backfill.

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 7 and Table 8.

						<u> </u>
Soil Type	γ (pcf) ¹	c (psf)	φ	<i>k</i> _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	130	0	33°	0.26	0.46	7.41

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

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



Soil Type	γ (pcf) ¹	c (psf)	φ'	ka	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	130	0	33°	0.26	0.46	7.41

Table 6. Estimated Dramed (Eong-term) oon rarameters for Design

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.



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

Table 9. Excavation Back Slopes

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



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.

<u>**Granular Soils**</u> – ODOT A-1, A-2, A-3, A-4 (non-plastic) The relative compactness of granular soils is described as:

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

Cohesive Soils - ODOT A-4, A-5, A-6, A-7, A-8

The relative consistency of cohesive soils is described as:

	Unconfined			
Description	Compression (tsf)			
Very Soft	Less than		0.25	
Soft	0.25	-	0.5	
Medium Stiff	0.5	-	1.0	
Stiff	1.0	-	2.0	
Very Stiff	2.0	-	4.0	
Hard	Over		4.0	

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

Soil Frac	tion	Size
Cobbles		12" to 3"
Gravel	coarse	3" to ¾"
	fine	³ ⁄ ₄ " to 2.0 mm (³ ⁄ ₄ " to #10 Sieve)
Sand	coarse	2.0 mm to 0.42 mm (#10 to #40 Sieve)
	fine	0.42 mm to 0.074 mm (#40 to #200 Sieve)
Silt		0.074 mm to 0.005 mm (#200 to 0.005 mm)
Clay		Smaller than 0.005 mm

Modifiers of Components - The following modifiers indicate the range of percentages of the minor soil components:

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>	<u>Range - ODOT</u>
Dry	Well below Plastic Limit
Damp	Below Plastic Limit
Moist	Above PL to 3% below LL
Wet	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 the relative strength of bedrock:

<u>Description</u>	Field Parameter
Very Weak	Can be carved with knife and scratched by fingernail. Pieces 1 in. thick can be broken by finger pressure.
Weak	Can be grooved or gouged with knife readily. Small, thin pieces can be broken by finger pressure.
Slightly Strong	Can be grooved or gouged 0.05 in deep with knife. 1 in. size pieces from hard blows of geologist hammer.
Moderately Strong	Can be scratched with knife or pick. 1/4 in. size grooves or gouges from blows of geologist hammer.
Strong	Can be scratched with knife or pick with difficulty. Hard hammer blows to detach hand specimen.
Very Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to detach hand specimen.
Extremely Strong	Cannot be scratched by knife or pick. Hard repeated blows of geologist hammer to chip hand specimen.



CLASSIFICATION OF SOILS Ohio Department of Transportation

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

SYMBOL	DESCRIPTION	Classifo AASHTO	ation OHIO	LL _O /LL × 100*	% Pass #40	% Pass #200	Liquid Limit (LL)	Plastic Index (PI)	Group Index Max.	REMARKS
	Gravel and/or Stone Fragments	Α-	1-a		30 Max.	15 Max.		6 Max.	0	Min. of 50% combined gravel, cobble and boulder sizes
	Gravel and/or Stone Fragments with Sand	A - 1	1-Ь		50 Max.	25 Max.		6 Max.	0	
F S	Fine Sand	A	- 3		51 Min.	10 Max.	NON-PI	_ASTIC	0	
	Coarse and Fine Sand		A-3a			35 Max.		6 Max.	0	Min. of 50% combined coarse and fine sand sizes
0.0.0 0.0.0 0.0.0 0.0.0 0.0.0	Gravel and/or Stone Fragments with Sand and Silt	A	2-4 2-5			35 Max.	40 Max. 41 Min.	10 Max.	0	
0.0.0 0.00 0.00 0.00 0.00 0.00 0.00 0.	Gravel and/or Stone Fragments with Sand, Silt and Clay	A-:	2-6 2-7			35 Max.	40 Max. 41 Min.	11 Min.	4	
	Sandy Sil†	A-4	A-4a	76 Min.		36 Min.	40 Max.	10 Max.	8	Less †han 50% sil† 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	Α-	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-4b
	Organic Clay	A-8	A-8b	75 Max.		36 Min.				W/o organics would classify as A-5, A-6a, A-6b, A-7-5 or A-7-6
	MAT	ERIAL	CLASS	SIFIED B	Y VISUAL	INSPEC	FION			
	Sod and Topsoil $\wedge \rightarrow > V$ Pavement or Base $\sim \wedge \land \land$ $\downarrow \rightarrow \downarrow$ $\downarrow \rightarrow \downarrow$	Uncon Fill (E	trolled escribe)		Bouldery	/ Zone		PPe	o†

* 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-109-0-09, B-109-1-15, B-110-0-09, B-110-1-15 and B-111-0-09

BORING LOGS

Definitions of Abbreviations

- AS=Auger sampleGI=Group index as determined from the Ohio Department of Transportation classification systemHP=Unconfined compressive strength as determined by a hand penetrometer (tons per square foot)
- LL_o = Oven-dried liquid limit as determined by ASTM D4318. Per ASTM D2487, if LL_o/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 x 100

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 N₆₀ values.
- 3S = Same as 2S, but using a 3.0 inch O.D. split spoon sampler.
- TR = Top of rock
- W = Initial water level measured during drilling
- ▼ = Water level measured at completion of drilling

Classification Test Data

Gradation (as defined on Description of Soil Terms):

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

Atterberg Limits:

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

WC = Water content (%)

Client	Client: ms consultants Project: FRA-70-8.93										Job No. 0221-1004.01										
LOG OF: Boring B-109-0-09 Loc							cation	<i>n:</i> Sta. 5032+97.77, 44.7' RT., BL RAMP C5						d: 9	/11/2009	11/2009					
Depth (ft)	Elev. (ft)	Blows per 6"	Recovery	Sam No	Press / Core	Hand Penetro- meter (tsf)	FIELL	ER OBSERVATIONS: Water seepage at: 13.5', 42.0' Water level at completion: 12.5' (includes drilling water) D NOTES: DESCRIPTION	% Aggregate	% C. Sand	% M. Sand DA	VII. Saliu	% Clay	STANDAI Natural M PL + Blows per 1	RD PEN Noisture	IETRAT e Conte	ΊΟΝ (nt, % ⊣ Ll Plastic ₄Ω	(N60) 5 - ● L 2 - NP			
1.0	703.0						Тс	opsoil - 5"	$\langle \rangle$		-										
1.0	-	6 18 21	6	1			FI co	LL: Very dense brown SANDY SILT (A-4a), some fine to barse sand, some gravel; damp.											 		
<u>3.5</u>	701.4	10 50/1	2	2		-	P(tra	OSSIBLE FILL: Hard brown SANDY SILT (A-4a), little clay, ace to little fine to coarse gravel; damp.		_									504		
0.0		15 15 16	12	3			De fin	ense to very dense brown GRAVEL (A-1-a), little to some to coarse sand, trace silt; damp.	°0 , °	- 75	13 -	2	1	-8	NP ● 						
<u>10</u>		50/5	5	4					000												
	-	26 10 9	2	5			0	2 11.0'-12.5'; contains sandstone fragments. 2 11.0'-15.0', loose to medium dense.	0 0 0 0												
<u>15</u>	5	6 6 3	3	6			@	13.5', becomes wet.	° 0 ,							f 					
	_	8 12 18	6	7					0 C 0 C	68	18 -	6	5	-8							
<u>20</u>)	2 5 4	5	8			@	18.5'-25.0', loose to medium dense.	0000												
	-	5 8 12	2	9					000												
25	679.9	5 5 6	6	10			@	23.5'-25.0', trace fine to coarse sand.	°0,	83	6	2	2	-9	 NP 0						

DLZ Ohio, Inc.	* 6121 Huntley Road	d, Columbus, Ohio 43229	* (614) 888-0040
----------------	---------------------	-------------------------	------------------

Client: ms consultants Project: FRA-70-8.93											Job No. 0221-1004.01									
LOG	OF: Bo	ring	B-10)9-0-0)9	Lo	cation: Sta. 5032+97.77, 44.7' RT., BL RAMP C5	Da	te l	Drill	led:	9/	11/2009							
Depth (ft)	Elev. (ft)	ws per 6"	covery	Sam No	e ole ole ole ole ole ole ole ole ole ol	Hand Penetro- meter	WATER OBSERVATIONS: Water seepage at: 13.5', 42.0' Water level at completion: 12.5' (includes drilling water) FIELD NOTES:	phic Log	Agregate	GR Sand	4. Sand D	: Sand TA	ON 5	Clay	STANDA Natural PL	RD PI Moistu	ENET ire C	rRATIC Content	DN (N t, % - _LL	60) ●
	679.9	Blo	Rec	Driv	Pre	(<i>tst</i>)	DESCRIPTION	Gra	4 %	%	N %	% ⊢	% %	%	Blows per 10	foot - 20	0/1	Von-Pla 30	istic - 40	ΝP
		3 3 5	3	11			Loose to medium dense brown GRAVEL WITH SAND (A-1-b), little fine to coarse sand, trace silt; damp.	0 0 0 0												
<u>30</u>	 	5 8 9	7	12				0 2	83	9		2	6	-	I I I I I INPI I I I I I I I I I I I I I I I I I I I I I I					
3 <u>f</u>		15 14 17	1	13			@ 33.5'-35.0', dense.													
37.0	667.9						Hard gray SANDY SILT (A-4a), some fine to coarse sand, some gravel; damp.	0.0.0												
- 4 <u>0</u>)	27 36 38	18	14		4.5+			21	16		17	31 1	15						 1 76 C
42.0	662.9	0.5					Very dense gray COARSE AND FINE SAND (A-3a), little fine to coarse gravel, trace silt; wet.	· · ·	•											
4 <u>8</u>	5	25 26 23	18	15				· · ·												 51 51
47.0	657.9	04					Hard brown SANDY SILT (A-4a), trace to little gravel; moist.		• -											
50.0 50	654.9	24 36 35	12	16		4.5+	Bottom of Boring - 50.0'													

RESOURCE INTERNATIONAL, INC.

	PROJEC	T:	FRA-70-12.68	- PHASE 4A	DRILLING FIF	R:RI	DF	RILL RIG	:	CME 55 (SN	5)	STATIC	N / O	FFSET:	300)1+00.	00 / 55	.0' LT		EXPLORATION ID B-109-1-15										
(Rii)	TYPE:		STRUCTL	JRE	SAMPLING F			M.M.	HA	MMER:					ALIGNN	IENT:		BL	RAMF	P C3			BAGE							
	PID:	77372	BR ID:	N/A				4.25" HSA		CALIBRATIC		ION DATE: 10/2		ŀ		736	.2 (MS	L)	EOB:	8	5.0 ft.	1 OF 3								
	START	3/21/	15 END:	3/22/15	SAMPLING M		SPT			NERGY		(%):	92			JNG:	(0/)	39.950	.950097038, -83.019			408								
		MAI		;RIPTION ES		ELEV.	DEPT	HS	SPT/	N ₆₀	REC		(tef)				(%)		ERB		wc	ODOT CLASS (GI)	HOLE SEALED							
0 5' - AS	PHAI T	(6 0")	AND NOT			× 735.2			RQD		(70)		(131)	GI	03 1	5 0	51 02		F L	FI	wc	. ,								
1.0' - AG	GREGA	TE BASI	E (12.0")			734 7		- 1 -																						
FILL: DE	ENSE, GI CLAY, D	ray gr Amp.	AVEL WITH	SAND AND SIL	Т,			_ 2 -	10 10	34	89	SS-1	-	18	31 1	7 2	24 10	NP	NP	NP	9	A-2-4 (0)								
FILL: VE "AND" F DAMP T	RY STIF INE GRA O WET.	F TO H/	ARD, GRAY	SILT AND CLA SE TO FINE SA	Y, AND,			- 3	6 5 7 7 11	18 7 18 1 28	67 89	SS-2 SS-3	3.50	-	-	- ·		-	-	-	14 26	A-6a (V) A-6a (V)								
-ROCK FRAGMENTS PRESENT IN SS-4								- 11	18 20 18	3 58	89	SS-4	4.50	37	10 1	0 2	23 20	29	17	12	16	A-6a (2)								
															- 19 - - 20 - - 21 -	Ύ9 ε	26	89	SS-5	3.50	-	-			-	-	-	13	A-6a (V)	
							- 22 - 																							
								24	18 13 13	40	0	SS-6	-	-	-	-		-	-	-	-									
								26 26 27 28																						
-BRICK	AND CI	AY TILE	FRAGMEN	ITS PRESENT	IN SS-7			- 29 -	21 _50/3"	-	100	SS-7	4.50	-	-	-		-	-	-	16	A-6a (V)								
	PID:77372	BR ID:	N/A	PROJECT:	FRA-70-12.68 -	PHASE	4A ST/	ATION	/ OFFSI	ET: _3	3001+	00.00 / 55	.0 LT	_ ;	STAR	RT: <u>3</u> /	/21/1	5 EN	ID: <u>3</u>	8/22/1	5 P	G 2 O	F3 B-10)9-1-15						
-----------	-------------------------	-----------------------	--	-----------------------	--	--------	--------	-----------------------	----------------	--------	-------	------------	-------	-----	------	----------------	-------	------	--------------	--------	-----	-------	------------	---------						
		MA	TERIAL DESC	CRIPTION		ELEV.	DEPTH	IS	SPT/	Neo	REC	SAMPLE	HP	(GRAD	ATIC)N (%	ó)	ATT	ERB	ERG		ODOT	HOLE						
ŀ					× ////	706.2			RQD	00	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	SEALEL						
	"AND" FINE DAMP TO V	GRAVEL, VET. (same	HARD, GRAY LITTLE COAR as above)	SE TO FINE S	AND,	704.2		- 31 -	-																					
	DENSE, GR	RAY GRAVE	L AND SAND,	LITTLE SILT,				- 32 -	-																					
	CLAT, WOR	51.						- 33 - -	37															-						
								- 34 - - - 35 -	12 10	34	67	SS-8	-	-	-	-	-	-	-	-	-	7	A-1-b (V)							
-	HARD, BRC	WN SAND	Y SILT, SOME	FINE GRAVE	<u>, </u>	700.7		_ 36 _	-																					
	LITTLÉ CLA	Y, DRY.	·				-	- 37 -	7 8 9	26	89	SS-9	4.5+	27	25	12	19	17	36	29	7	15	A-4a (0)							
-	VERY DEN	SE, BROW	N GRAVEL AN	D SAND, LITTI	E	698.2		- 38 -																						
	SILT, TRAC	E CLAY, M	OIST.					- 39 - - - 40 -	8 10 28	58	89	SS-10	-	-	-	-	-	-	-	-	-	8	A-1-b (V)							
_	VERY DEN	SE, BROW	N GRAVEL, SO	OME COARSE	TO	695.7		_ 40 _ 41 -																						
40.GL	FINE SAND	, TRACE S	ILT, TRACE C	LAY, MOIST.		, ,	-	- 42 -	33 50 50	153	89	SS-11	-	60	17	9	10	4	NP	NP	NP	5	A-1-a (0)							
VV-13-U	-ROCK FR	AGMENTS	PRESENT TH	IROUGHOUT	° 0	5		- 43 -																						
15/2013/	-INTORDU	ICED WATI	ER @ 45.0'				-	- 44 - - - 45 -	18 44 22	101	67	SS-12	-	-	-	-	-	-	-	-	-	4	A-1-a (V)							
		SE, BROW	N GRAVEL AN	D SAND , LITTI	E	690.7		- 46 -	34															-						
-\GI8\F			0101.			Ś	-	47	25 25	77	67	SS-13	-	-	-	-	-	-	-	-	-	10	A-1-b (V)							
0 - 1.2.3	-COBBLES	S PRESEN	THROUGHO	UT			-	- 48 -	18																					
RI GL//						685.7		- 49 - - - 50 -	32 37	106	67	SS-14	-	-	-	-	-	-	-	-	-	8	A-1-b (V)							
- 3/2	VERY DEN	SE, GRAY		FINE SAND, LI	TTLE	000.1		- 51 -	36		05	00.45										45								
01.GL	-ROCK FR	AGMENTS	PRESENT IN	SS-16 UT	•••••• •••••• •••••• •••••• ••••••	692.2		52	50/6"	-	25	55-15	-	-	-	-	-	-	-	-	-	15	A-3a (V)	-						
HO HO	VERY DEN	SE, GRAY	GRAVEL, LITT	LE COARSE T		003.2		- 53 -	22																					
- בו	SAND, TRA	CE SILT, T	RACE CLAY, I	MOIST.		Ż		- 54 - - - 55 -	23 18	63	89	SS-16	-	70	14	5	7	4	NP	NP	NP	8	A-1-a (0)							
וב מאור					0			_ 56	-																					
2								- 57 -	_																					
NG LO	-COBBLES	5 PRESEN	THROUGHO	UT				- 58 -	18																					
BURI					°0	þ		- 59 -	19 19	58	44	SS-17	-	-	-	-	-	-	-	-	-	7	A-1-a (V)							
nnn								00 61	_																					
2014					je (S	674.2																								

ſ	PID: 77372	BR ID: N/A	PROJECT: F	RA-70-12.68 - PHA	SE 4A	STAT	ION / C	OFFSE	ET: _:	3001+(00.00 / 55	.0 LT		STAR	T: 3/2	1/15	5 EN	ID: _3	3/22/1	5 P	G 3 OI	= 3 B-10	9-1-15
		MATERIAL	DESCRIPTION	ELE	EV.	DEPTHS	. :	SPT/	Ν	REC	SAMPLE	HP	Ģ	RAD	ΑΤΙΟΙ	%) ۱	b)	ATT	ERB	ERG		ODOT	HOLE
		AND	NOTES	674	1.1		' I	RQD	N ₆₀	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	SEALED
	DENSE, GRA CLAY, DAMP	Y GRAVEL WITH : . (same as above)	Sand and Silt, Littl				63 — 64 — ¹	10 13 17	46	89	SS-18	-	30	22	13	16	19	21	14	7	10	A-2-4 (0)	
	HARD, GRAY	SILTY CLAY, LIT	TLE COARSE TO FINE		9.2	-	65 <u>-</u> 66 <u>-</u> 67 <u>-</u>																
	SAND, TRAC	E FINE GRAVEL,	MOIST.				68 — 69 — ² 70 —	23 14 18	49	89	SS-19	4.5+	-	-	-	-	-	-	-	-	20	A-6b (V)	
РJ	HARD, GRAY GRAVEL, DA	Í Sandy Silt , Lit Mp.	TLE CLAY, LITTLE FIN	E 664	1.2	-	71 — 72 — 73 —																
:\W-13-045.G						-	74 - 2 75	22 33 50/3"	-	100	SS-20	4.5+	17	22	15	27	19	22	14	8	9	A-4a (2)	
ROJECTS/2013						-	76 — 77 — 78 —																
- U:\GI8\PI						-	79 – ² 80 –	26 50/6"	-	100	SS-21	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
T - 3/27/15 18:31						-	81 — 82 — 83 —																
H DOT.GD				65	.2	ЕОВ	84 — ² 85 —	22 35 43	120	89	SS-22	4.5+	-	-	-	-	-	-	-	-	9	A-4a (V)	
2014 ODOT BORING LOG-RII NE BRIDGE ID - O																							
	NOTES: GROU	JNDWATER NOT EN	COUNTERED PRIOR TO IN	TRODUCTION OF W	ATER TO	THE BORE	HOLE																
Ē	ABANDONMEN	T METHODS, MATER	IALS, QUANTITIES: PUM	PED 376 LBS CEMEN	NT / 100	LBS BENTO	NITE CH	HIPS / 8	0 GAL	WATE	۲												

Client	: ms c	onsu	Itants	;				Project: FRA-70-8.93								Job No.	0221-	1004.	01	
LOG	DF: Bo	ring	B-11	0-0-0)9	Lo	catior	<i>h:</i> Sta. 3003+02.96, 22.8' RT., BL RAMP C3			Dat	te L	Drill	led	1:9/	11/2009				
Depth (ft)	Elev. (ft)	ws per 6"	covery	Sam No	ss / Core	Hand Penetro- meter	WAT.	ER OBSERVATIONS: Water seepage at: 10.5', 46.0' Water level at completion: 10.6' D NOTES:	phic Log	In the second se	RA Sand	A. Sand D	: Sand TA		Clay <	STANDA Natural I PL	RD PEI Aoistur	NETRA e Cont	TION tent, %	(N60) 6 - ● L
	705.8	Blo	Re	Driv	Pre	(151)		DESCRIPTION	Gra	7 %	%	۷ %	% F	%	%	Blows per 10	600t - () 20) / Non 30	-Plastic 40	C-NP
1.0	704.8	-						sphalt Concrete - 5" ortland Cement Concrete - 7"												
		9 6	6	1			FI S	ILL: Loose to medium dense dark brown GRAVEL WITH AND (A-1-b), trace clay, trace silt; damp to moist.	0											
5		2 4 4	18	2		1.5	a) 1.0'-2.5', contains trace brick fragments.) 3.5'-5.0', organic; LOI @ 440 deg. C = 11.0%	0	47	32		7	9	5		 ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ ↓ 			
6.0 	699.8	4 5 6	12	3		3.0	FI to	LL: Very stiff dark brown SILT AND CLAY (A-6a), little fine coarse sand, slightly organic; damp.												
10.5	695.3	4 3 2	12	4			FI to	LL: Loose brown COARSE AND FINE SAND (A-3a), little some gravel, little silt; moist.		20	45		18	1	7	 NP 				
	-	1 1 4	7	5			Lo fir	pose to medium dense brown SANDY SILT (A-4a), some ne to coarse sand, some gravel; wet.												
- 15	-	2 8 4	3	6																
<u>16.0</u>	689.8	8 19 18	1	7			M	edium dense to dense brown GRAVEL (A-1-a), little to ome fine to coarse sand, trace silt; wet.	°0,											
- <u>20</u>	-	1 5 6	3	8					0	80	10		2	8						
.		1 11 20	3	9					0 (0 () 0 ()											
- 25	680.8	7 22 16	8	10					0											

DLZ Ohio, Inc.	* 6121 Huntley Road	, Columbus, Ohio 43229 *	(614) 888-0040
----------------	---------------------	--------------------------	----------------

Client	: ms c	onsu	Iltants	6				Project: FRA-70-8.93							Job No.0221-1004.01
LOG	DF: Bo	oring	B-1 1	0-0-0)9	Lo	cation	n: Sta. 3003+02.96, 22.8' RT., BL RAMP C3			Da	te L	Drille	ed: 9	/11/2009
Depth (ft)	Elev. (ft)	Blows per 6"	Recovery	Sam No	Press / Core	Hand Penetro- meter (tsf)	WATE FIELD	ER OBSERVATIONS: Water seepage at: 10.5', 46.0' Water level at completion: 10.6' D NOTES: DESCRIPTION	Graphic Log	% Aggregate	R C. Sand	W. Sand A	% F. Sand NA	% Clay N	STANDARD PENETRATION (N60) Natural Moisture Content, % - • $PL \vdash LL$ Blows per foot - $\bigcirc / \text{Non-Plastic - NP}$ $20 \qquad 30 \qquad 40$
	680.8 680.8	30 30 34 30 35 41	e2 6 4 3 12	11 12 13 14	Pre	4.5+	We me Ha da	DESCRIPTION ledium dense to dense brown GRAVEL (A-1-a), little to come fine to coarse sand, trace silt; wet. a) 33.5'-34.4', very dense. ery dense gray GRAVEL WITH SAND (A-1-b), little silt; noist to wet. ard gray SANDY SILT (A-4a), little fine to coarse gravel; amp to moist.			20		4	-18	Blows per root - ○ / Non-Plastic - NP 10 20 30 40 NP 10 10 10 10 10 10 10 10 10 10 10 10 10 1
46.0 - 49.4	659.8	30 50/5	18	16			Ve	ery dense gray COARSE AND FINE SAND (A-3a), some It, some gravel; wet.							
50		1						Bottom of Boring - 49.4'							[+ + + + + + + + + + + + + + + + + + +

RESOURCE INTERNATIONAL, INC.

	PROJE	CT:	FRA-70-	12.68 - Pl	HASE 4A	DRILLING FIRM	/ OPERATO	R: RI	I / S.B.	DR	RILL RIG	: MO	BILE B-53	(SN 624	400)	STATI	ON/C	OFFSE	ET: _	3005	5+00.0	0 / 20	.0' LT	EXPLO	ATION ID
(Rii)	TYPE:		STR	RUCTURE		SAMPLING FIR	/ / LOGGER:	RII	/ N.A.	HA	MMER:		AUTOM	IATIC		ALIGN	IMENT	T:		BL F	RAMP	C3		_ В-11	U-1-15
	PID:	77372	BR ID	D:	N/A	DRILLING METI	HOD:	3.25" HS	SA	CA	LIBRAT	ION DA	TE:	4/26/13		ELEVA	ATION	l:	740.3	(MSL	<u>)</u> E	EOB:	7	5.0 ft.	PAGE
	START	3/2	1/15 E	END:	3/22/15	SAMPLING ME	HOD:	SPT		EN	IERGY F	RATIO (%):	77.7		LAT /	LONG): 	39	9.9499	913094	1, -83.	018276	6075	T UF 3
		MA	TERIAL I	DESCRI	PTION		ELEV.	DEPT	нs	SPT/	N	REC	SAMPLE	E HP	0	GRADA	ATION	N (%))	ATT	ERBE	RG		ODOT	HOLE
			AND	NOTES		N / X	740.3			RQD	• •60	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	ΡI	WC	CLASS (GI)	SEALED
0.7' - AS	PHALT	(8.0")				K	739.6																		
1.2' - CC	DNCRET	E (14.5	")			\otimes	739 4		1 -																
_ 0 4' - AG	GREGA	TE BAS	SE (5.0"))			738.0		- 2 -																
FILL: HA	ARD, BR	OWNIS	H GRAY	, TO GR	AY SILT AND	<u> </u>			- 3 -																
CLAY, S	OME CO	DARSE	TO FINE	E SAND	TRACE FIN	E				6															
GRAVEL	_, DAMF	то мс	NST.						4 -	⁹	23	100	SS-1	4.5+	-	-	-	-	-	-	-	-	13	A-6a (V)	
									- 5 -	9															
									- 6 -																
									- / -																
									- 8 -																
									_ 9 _	4	0.5		00.0	4.5.		40	~	~~	<u> </u>	~~	47	40	10	• • • •	
										9 10) 25	50	55-2	4.5+	8	12	9	36	35	30	17	13	13	A-6a (8)	
									- 10 -																
									- 11																
									- 12 -																
									- 13 -	_															
									- 14 -	2 10	35	100	<u>SS-3</u>	4 5+	_	_	_	_	-	-	_	-	22	A-6a (V)	
									L 15	17				1.0										// 64 (1)	\otimes
									- 16																\otimes
									- 17																
									- 18 -																
										4															
									- 19 -	່ 5 ຼ	21	100	SS-4	4.5+	-	-	-	-	-	-	-	-	10	A-6a (V)	
									- 20 -	11															
									21 -																
							718.3																		
FILL: HA	ARD, GR		STIC CL	AY, SO	ME COARSE	ТО																			
FINE SA	ND, SO	ME SIL	T, TRAC	E FINE	GRAVEL, M	DIST.			- 23 -																
									24	21															
						1				34 18	67	0	SS-5	-	-	-	-	-	-	-	-	-	-		\boxtimes
									25	17	-	100	2S-5A	4.5+	5	19	10	40	26	41	30	11	31	A-7-5 (7)	
						4			- 26																
							713.3		_ 27 _																
VERY D	ENSE, O	GRAY G	RAVEL,	LITTLE	COARSE TO	DFINE																			$\bigotimes \cdots$
SAND, T	RACES	SILI, IF	ACE CL	.ay, MO	151.	þ	김		28																
-ROCK	FRAG	IENTS I	PRESEN	IT IN SS	6-6	60	7		- 29 -	9 10	101	100	99 F			ΙT			Τ				4	A 1 a ()/)	
						[• (∖a		-	40	3	100	33-0	-	-	-	-	-	-	-	-	-	4	A-1-a (V)	$\bigvee / i \to i$

1	PID: 77372	BR ID:	N/A	PROJECT:	FRA-70-1	2.68 - PHASE	4A S	TATION	/ OFFSE	ET: _:	3005+0	00.00 / 20	.0 LT		STAR	:T: <u>3</u> /	21/15	5 EN	ID: <u>3</u>	8/22/1	5 P	G 2 O	F3 B-11	0-1-15
Г		МА	TERIAL DE	SCRIPTION		ELEV.	DEP	THS	SPT/	Nco	REC	SAMPLE	HP		RAD	ATIC)N (%	b)	ATT	ERB	ERG		ODOT	HOLE
_			AND NO	DTES		<u>710.3</u>			RQD	• •60	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	SEALED
	MEDIUM DEN SILT, TRACE	NSE, GRA` CLAY, MO	Y GRAVEL A DIST.	and Sand , Litt	ΊLΕ			- 31 - 32 -	7 7 12	26	100	SS-7	-	-	-	-	-	-	-	-	-	9	A-1-b (V)	
_	VERY DENS	e, gray g	RAVEL, LIT	TTLE COARSE T	O FINE	*		- 33 -	12															
	SAND, TRAC -ROCK FRA	E SILT, TF GMENTS	RACE CLAY PRESENT I	′, MOIST. IN SS-8		704.8		- 34 - - - 35 -	10 50/2"	-	75	SS-8	-	67	14	4	9	6	NP	NP	NP	5	A-1-a (0)	
	HARD, DARK CLAY, SOME GRAVEL, DA	COARSE MP TO MC	SH GRAY T TO FINE S DIST.	TO BROWN SILT AND, TRACE FI	Υ NE			- 36 -	3 6 12	23	100	SS-9	4.00	-	-	-	-	-	-	-	-	27	A-6b (V)	
								- 38	5 9 12	27	100	SS-10	4.25	4	12	18	42	24	39	23	16	18	A-6b (9)	
15.GPJ	VERY DENSI COARSE TO MOIST.	E, BROWN FINE SAN	I TO GRAY	GRAVEL , SOME SILT, TRACE CL	AY,	699.8		- 40 - 41 - 42	13 19	69	100	SS-11	-	-	-	-	-	-	-	-	-	6	A-1-a (V)	
3\W-13-04						00		43	34 0															
ECTS/201:						000		44 45	24 23	61	100	SS-12	-	56	22	7	10	5	NP	NP	NP	8	A-1-a (0)	
(GI8/PROJE								46 47 _	9 22 29	66	100	SS-13	-	-	-	-	-	-	-	-	-	8	A-1-a (V)	
5 18:31 - U.								48 49 	17 32	95	39	SS-14	-	-	-	-	-	-	-	-	-	5	A-1-a (V)	
3/27/1								50 51	- 41															
OH DOT.0						000	W	52 53																
IDGE ID -						000		54 55	15 16 24	52	100	SS-15	-	-	-	-	-	-	-	-	-	9	A-1-a (V)	
-RII NE BR									-															
DRING LOG									17 18	51	100	SS-16	-	65	21	6	5	3	NP	NP	NP	5	A-1-a (0)	
114 ODOT B(6783		60 -	21															

PID:	PHASE 4	A STATION	/ OFFS	ET: _:	3005+	00.00 / 20	0 LT	_	STAR	RT: <u>3</u> /	/21/15	5 EN	D: <u>3</u>	8/22/1	5 P	G 3 O	F 3 B-1	10-1-15
MATERIAL DESCRIPTION	ELEV.	DEPTHS	SPT/	N	REC	SAMPLE	HP	(GRAD	ATIC)N (%	b)	ATT	ERB	ERG		ODOT	HOLE
AND NOTES	678.2	DEI IIIS	RQD	1160	(%)	ID	(tsf)	GR	CS	FS	SI	CL	LL	PL	PI	WC	CLASS (GI)	SEALED
MEDIUM DENSE TO DENSE, GRAY COARSE AND FINE SAND, LITTLE SILT, TRACE FINE GRAVEL, TRACE		63 -																
CLAY, MOIST TO WET. (same as above)		- 64 -	7 8 13	27	100	SS-17	-	-	-	-	-	-	-	-	-	17	A-3a (V)	
		- 65 - - - 66 -																
		- 67 -	-															
		- 68 -	16															_
		- 69 - - - 70 -	17 17 19	47	56	SS-18	-	-	-	-	-	-	-	-	-	26	A-3a (V)	
		- 71 -	-															
		- 72 -	-															
		73 -																
	665.3	74 - 	13 17 18	45	100	SS-19	-	8	40	30	16	6	NP	NP	NP	15	A-3a (0)	

NOTES: GROUNDWATER ENCOUNTERED INITIALLY @ 53.5'

ABANDONMENT METHODS, MATERIALS, QUANTITIES: PUMPED 188 LBS CEMENT / 50 LBS BENTONITE CHIPS / 40 GAL WATER

DLZ Ohio, Inc.	* 6121 Huntle	y Road, Columbus	Ohio 43229	* (614) 888-0040
----------------	---------------	------------------	------------	------------------

Client	: ms c	onsu	Itants	6				<i>Project:</i> FRA-70-8.93							Job	No.()221-	-100	4.01		
LOG	DF: Bo	oring	B-1 1	1-0-0)9	Lo	catior	n: Sta. 3008+11.91, 4.6' RT., BL RAMP C3			Dat	e D	rille	ed: 9	/1/200)9					
Depth (ft)	Elev. (ft)	slows per 6"	Recovery	Sam No	Press / Core	Hand Penetro- meter (tsf)	WAT.	ER OBSERVATIONS: Water seepage at: None Water level at completion: None D NOTES: DESCRIPTION	Sraphic Log	% Aggregate	% C. Sand	% M. Sand DA	% F. Sand	6 Clay	STA Nati Blows	NDAF ural M PL ⊢ s per fo	ND PE	NET re Ca	RATIC ontent	DN (N t, % - LL astic -	' 60) ● NP
1.0	733.9	F	4	7			A	sphalt Concrete - 6"		0	0		3 0	\ 0 \							
3.5	731.4	9 11 12	8	1			A P S	ggregate Base - 6" OSSIBLE FILL: Medium dense brown GRAVEL WITH AND, SILT, AND CLAY (A-2-6); damp.										1 D 			
		8 11 11	12	2		4.5+	V(cc	ery stiff to hard gray SANDY SILT (A-4a), some fine to barse sand, trace to little gravel; damp.)) 			
-	-	2 7 8	18	3		1.5	a	9 6.0'-7.5', stiff.		13	10 ·	1	7 3	3 27				 + 			
- <u>10</u>)	2 5 5	18	4		3.0															
-		4 7 8	18	5		4.5+															
- <u>15</u>	5	4 14 19	18	6			a) 13.5', becomes brown.		11	13 -	1	9 4	0 17		● 					
- 16.0	718.9	4 37 50/5	9	7			V da	ery dense brown GRAVEL WITH SAND (A-1-b), little silt; amp.	0							<pre></pre>					50+
<u>18.5</u> - <u>20</u>	716.4	12 50/5	5	8			Vi da	ery dense brown SANDY SILT (A-4a), little to some gravel; amp.		Ś						9 					50+
21.0	713.9	-							Ш												
22.5	712.4	17 8 30	12	9		3.0		ery stiff brown SILTY AND CLAY (A-6a), some fine to barse sand, trace gravel; moist.		8	8	2	26 2	7 31				 			
24.0	710.9	48 50/5	10	10			V da	ery dense gray GRAVEL WITH SAND (A-1-b), little silt; amp.	0	50	22 -	1	2	-16							 50+
25	709.9	15 9		11		3.75	St	tiff to very stiff gray SANDY SILT (A-4a); damp.		26	19 ·	1	8 2	20 17		▶ ▶ +-	¦ ├┼┼┨				

DLZ Ohio, Inc.	* 6121 Huntley Re	ad, Columbus, Ohio 43	229 * (614) 888-0040
----------------	-------------------	-----------------------	----------------------

Client	: ms c	onsu	Itants	6				<i>Project:</i> FRA-70-8.93								Job	No. 02	221-1	004.	.01	
LOG	DF: Bo	ring	B-1 1	11-0-0	9	Loc	catior	n: Sta. 3008+11.91, 4.6' RT., BL RAMP C3		Date Drilled: 9/1/2009											
Depth (ft)	Elev. (ft)	Blows per 6"	Recovery	Sam _i No	Press / Core	Hand Penetro- meter (tsf)	FIEL	ER OBSERVATIONS: Water seepage at: None Water level at completion: None D NOTES: DESCRIPTION	Graphic Log	% Aggregate	GR C. Sand	W W. Sand	% F. Sand	% Sitt 0	% Clay	STAN Natu F Blows	IDARD ral Mo 'L ⊢ per foo 10	PEN isture t - ○ 20	IETRA e Con / Nor 30	ATION tent, 	I (N60) % - ● LL tic - NP
		10 10 11 10	10	12		3.75	Si	tiff to very stiff gray SANDY SILT (A-4a), some fine to barse sand, little gravel; damp.		13	8 12		17	30	28				- 		
	-	9 8 3 5	3	13 14		1.5 1.5	a	25.5'-27.0', contains rock fragments.													
	704.9 704.9	9	18					Bottom of Boring - 30.0'													

APPENDIX IV

MSE Wall Calculations



JOB	FRA-70-12.68	NO.	W-13-045				
SHEET NO.	1	OF	6				
CALCULATED BY	BRT	DATE	7/15/2018				
CHECKED BY	JPS	DATE	7/15/2018				
Retaining Wall 4W12 - Sta. 3003+06							

	←	$B \longrightarrow$	$\sigma_{\!LS}^{}=~$ 250 p	sf		
-				Proposed To	p of Wall	= 739 5
\uparrow		XXX			XXX L.	- 155.5
	MSE F	3ackfill				
			Retained Soil:	-		
Н	$\psi_{BF} = 34^{\circ}$	→	ODO'I Item 203 Em	bankment		
	1 Br	Reinforcement	$\gamma_{RS} = 120$) pcf		
	·	′Straps	$\varphi_{RS} = 30$	$c_{RS} = 0$ psf		
			$(S_u)_{RS} = 2$	2000 psf		
Proposed Bottom of Wall	<u>_</u>				El.	= 702.6
Bearing Soil: Loose to Medium Dense (A Gravel and Sand an	d Sandy Silt γ_B	φ_{BS} = 120 pcf φ_{BS} = 28°	$c_{BS} = 0$ psf $(S_u)_E$	_{BS} = 0 psf	
C Well Dimensions and Retain		-4	Pooring Soil Prot			
E Wall Diffiensions and recan	<u>Ned Soll Farann</u>	26 Q ft	Bearing Soil Unit W	<u>perties:</u>		120 p
E Wall Width (Reinforcement Leng	1th) (B) =	25.8 ft	Bearing Soil Friction	Anale. $(\sigma_{PS}) =$		<u>28</u> °
F Wall I ength. (<i>I</i> ,) =	, ש, א,	936 ft	Bearing Soil Drainer	Cohesion, $(c_{RS}) =$		 0 p
e Surcharge Load, (σ_{LS}) =		250 psf	Bearing Soil Undrair	ned Shear Strength,	$[(S_u)_{BS}] =$	 0 p
tained Soil Unit Weight, $(\gamma_{RS}) =$		120 pcf	Embedment Depth,	$(D_{f}) =$		3.0 ft
ained Soil Friction Angle, $(\varphi_{RS}) =$		<u>30</u> °	Depth to Grounwate	r (Below Bot. of Wa	all), $(D_W) =$	14.0 ft
ained Soil Drained Cohesion ¹ , (c_B	(35) =	0 psf	LRFD Load Facto	<u>vrs</u>		
ained Soil Undrained Shear Streng	th, [(<i>S _u</i>) _{RS}] =	2000 psf	EV	EH LS		
ained Soil Active Earth Pressure C	$\operatorname{coeff.}(K_a) =$	0.297	Strength la 1.00	1.50 1.75	(AASHTO LRFI	D BDM Table
E Backfill Unit Weight, $(\gamma_{BF}) =$		120 pcf	Strength Ib 1.35	1.50 1.75	- 3.4.1-1 and 3.4 Earth Pre	4.1-2 - Active
Sliding Force:	$P_{H} = r$ P_{EH}	$P_{EH} + P_{LS_h}$ $= \frac{1}{2} \gamma_{RS} H^2 K_c$	$_{a}\gamma_{EH} = \frac{1}{2}(120 \text{ pcf})(36)$	5.9 ft)²(0.297)(1.5)	= 36.4	kip/ft
	$\frac{P_{LS_h}}{P_{EH}}P_{LS_h}$	$=\sigma_{LS}HK_a\gamma_1$	$_{LS} = (250 \text{ psf})(36.9)$	ft)(0.297)(1.75)	= 4.79	kip/ft
	$\frac{\sum_{k}}{\sum} P_{EH} P_{LS_h}$	$= \sigma_{LS} H K_a \gamma_1$ _H = 36.4 kip/ft	_{LS} = (250 psf)(36.9 t + 4.79 kip/ft = 4	ft)(0.297)(1.75) I1.19 kip/ft	= 4.79	kip/ft
	$\frac{\sum_{LS_h}}{\sum} P_{EH} \xrightarrow{P_{LS_h}} P_{P_{EH}}$	$= \sigma_{LS} H K_a \gamma_1$ _H = 36.4 kip/ft	LS = (250 psf)(36.9 t + 4.79 kip/ft = 4	ft)(0.297)(1.75) I1.19 kip/ft	= 4.79	kip/ft
eck Sliding Resistance - Drain	$\frac{\sum_{LS_h}}{\sum} P_{EH} = \frac{P_{LS_h}}{P}$ $led Condition$	$= \sigma_{LS} H K_a \gamma_1$ = 36.4 kip/ft	LS = (250 psf)(36.9 t + 4.79 kip/ft = 4	ft)(0.297)(1.75) I1.19 kip/ft	= 4.79	kip/ft
eck Sliding Resistance - Drain	$\frac{\sum_{LS_h}}{\sum} P_{EH} \qquad P_{LS_h} \qquad P$ \underline{P} \underline{P}	$= \sigma_{LS} H K_a \gamma_1$ $H_H = 36.4 \text{ kip/fl}$	LS = (250 psf)(36.9 t + 4.79 kip/ft = 4	ft)(0.297)(1.75) I1.19 kip/ft	= 4.79	kip/ft
eck Sliding Resistance - Drain Nominal Sliding Resistance:	$\frac{\sum_{LS_{h}}}{\sum} P_{EH} \qquad P_{LS_{h}} \qquad P$ $\frac{1}{2} \qquad P$ $\frac{1}{2} \qquad P$ $R_{\tau} = P_{E}$	$= \sigma_{LS} H K_a \gamma_1$ = 36.4 kip/fi $V \cdot \tan \delta$	LS = (250 psf)(36.9 t + 4.79 kip/ft = 4	ft)(0.297)(1.75) I1.19 kip/ft	= 4.79	kip/ft
eck Sliding Resistance - Drain	$\frac{P_{LS_h}}{\Delta} P_{EH} \qquad P_{LS_h}$ $\frac{P_{LS_h}}{P}$ $\frac{P_{LS_h}}{P}$ $\frac{P_{LS_h}}{P}$ $\frac{P_{LS_h}}{P}$	$= \sigma_{LS} H K_a \gamma_1$ = 36.4 kip/fi $V \cdot \tan \delta$	LS = (250 psf)(36.9 t + 4.79 kip/ft = 4	ft)(0.297)(1.75) I1.19 kip/ft	= 4.79	kip/ft
eck Sliding Resistance - Drain Nominal Sliding Resistance:	$\frac{\frac{2}{LS_{h}}}{\Delta} \frac{P_{EH}}{P}$ $\frac{P_{LS_{h}}}{P}$ $\frac{P}{P}$ $\frac{P}{P}$ $\frac{P}{P}$ $\frac{P}{P}$	$= \sigma_{LS} H K_a \gamma_1$ $P_H = 36.4 \text{ kip/fi}$ $V_V \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$	$_{LS}$ = (250 psf)(36.9 t + 4.79 kip/ft = 4 γ_{EV} = (120 pcf)(36.9	ft)(0.297)(1.75) I1.19 kip/ft 9 ft)(25.8 ft)(1.00)	= 4.79 = 114.2	kip/ft kip/ft
eck Sliding Resistance - Drain Nominal Sliding Resistance: P_EV	$\frac{2}{\Delta P_{EH}} P_{EH} P_{LS_{h}}$ P <u>red Condition</u> $R_{\tau} = P_{E}$ P_{EV} to p S	$= \sigma_{LS} H K_a \gamma_A$ $= 36.4 \text{ kip/f}$ $V \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$	$L_S = (250 \text{ psf})(36.9)$ t + 4.79 kip/ft = 4 $\gamma_{EV} = (120 \text{ pcf})(36.8)$	ft)(0.297)(1.75) I1.19 kip/ft 9 ft)(25.8 ft)(1.00)	= 4.79 = 114.2	kip/ft
eck Sliding Resistance - Drain Nominal Sliding Resistance: P P P	$\frac{2}{\Delta m} \frac{P_{EH}}{P_{EH}} = \frac{P_{LS_{h}}}{P}$ $\frac{1}{2} \frac{1}{2} 1$	$= \sigma_{LS} H K_a \gamma_{I}$ $= 36.4 \text{ kip/f}$ $\gamma_{I} = 36.4 \text{ kip/f}$ $\gamma_{V} \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$ $\cdot = (\tan \varphi_{BS} \le \tan \delta)$	$_{LS}$ = (250 psf)(36.9 t + 4.79 kip/ft = 4 γ_{EV} = (120 pcf)(36.9 n φ_{BF})	ft)(0.297)(1.75) I1.19 kip/ft J ft)(25.8 ft)(1.00)	= 4.79 = 114.2	4 kip/ft
eck Sliding Resistance - Drain Nominal Sliding Resistance: P_{EV} \downarrow	$\frac{\frac{2}{LS_{h}}}{\Delta} = \frac{P_{LS_{h}}}{P}$ $\frac{1}{\Delta} = \frac{P_{ES_{h}}}{P}$ $\frac{1}{LS_{h}} = \frac{1}{LS_{h}}$	$= \sigma_{LS} H K_a \gamma_{A}$ $P_{H} = 36.4 \text{ kip/f}$ $\gamma_{V} \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$ $F = (\tan \varphi_{BS} \le \tan 2\theta)$ $= \tan 2\theta$	$L_{LS} = (250 \text{ psf})(36.9)$ $t + 4.79 \text{ kip/ft} = 4$ $\gamma_{EV} = (120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$	ft)(0.297)(1.75) 11.19 kip/ft (25.8 ft)(1.00) (25.8 ft)(1.00)	= 4.79 = 114.24 $m \delta = -0$	4 kip/ft
eck Sliding Resistance - Drain Nominal Sliding Resistance: P_{EV}	$\frac{2}{\Delta P_{EH}} P_{LS_{h}} P_{LS_{h}}$ $\frac{2}{\Delta P} P_{EH}$ $\frac{2}{\Delta P} P_{EH}$ $R_{\tau} = P_{E}$ P_{EV} $\tan \delta$ $\tan \delta$	$= \sigma_{LS} H K_a \gamma_A$ $P_H = 36.4 \text{ kip/f}$ $V_V \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$ $V = (\tan \varphi_{BS} \le \tan \theta + \delta)$ $= \tan(28)$	$L_{LS} = (250 \text{ psf})(36.9)$ $t + 4.79 \text{ kip/ft} = 4$ $\gamma_{EV} = (120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$	ft)(0.297)(1.75) 11.19 kip/ft 9 ft)(25.8 ft)(1.00) $\leq 0.67 \longrightarrow tz$	= 4.79 = 114.24 $m \delta = -0$	4 kip/ft 4 kip/ft 1.53
eck Sliding Resistance - Drain Nominal Sliding Resistance: P_{EV} \downarrow R_{τ}	$\frac{2}{\Delta R_{r}} P_{EH} P_{LS_{h}} P_{LS_{h}} P_{LS_{h}} P_{LS_{h}}$ P	$= \sigma_{LS} H K_a \gamma_{J}$ $= 36.4 \text{ kip/f}$ $\gamma_{H} = 36.4 \text{ kip/f}$ $\gamma_{V} \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$ $\dot{\gamma} = (\tan \varphi_{BS} \le \tan 28)$ $114.24 \text{ kip/ft} (0.53)$	$L_{S} = (250 \text{ psf})(36.9)$ $t + 4.79 \text{ kip/ft} = 4$ $\gamma_{EV} = (120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$	ft)(0.297)(1.75) 41.19 kip/ft 9 ft)(25.8 ft)(1.00) $\leq 0.67 \longrightarrow ta$	= 4.79 = 114.2 $m \delta = 0$	4 kip/ft
eck Sliding Resistance - Drair Nominal Sliding Resistance: P_{EV} \downarrow R_{τ}	$\frac{2}{\Delta s_{h}} P_{EH} P_{LS_{h}} P_{ES_{h}} P_{ES_{h}} P_{ES_{h}}$ $\frac{1}{2} P_{EH} P_{ES_{h}} P_{ES_{h}} P_{ES_{h}}$ $R_{\tau} = P_{E} P_{ES_{h}} P_{ES_{h}}$ $R_{\tau} = (1)$	$= \sigma_{LS} H K_a \gamma_{A}$ $= 36.4 \text{ kip/f}$ $\gamma_{H} = 36.4 \text{ kip/f}$ $\gamma_{V} \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$ $i = (\tan \varphi_{BS} \le \tan \alpha)$ $= \tan(28)$ 114.24 \text{ kip/ft}(0.53)	$L_{S} = (250 \text{ psf})(36.9)$ $t + 4.79 \text{ kip/ft} = 4$ $\gamma_{EV} = (120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$	ft)(0.297)(1.75) 11.19 kip/ft 9 ft)(25.8 ft)(1.00) $\leq 0.67 \longrightarrow ta$	= 4.79 = 114.24 $m \delta = 0$	4 kip/ft 1.53
eck Sliding Resistance - Drair Nominal Sliding Resistance: P_{EV} \downarrow R_{τ}	$\frac{\frac{2}{LS_h}}{\Delta} \frac{P_{EH}}{P_{EH}} \frac{P_{LS_h}}{P}$ $1000000000000000000000000000000000000$	$= \sigma_{LS} H K_a \gamma$ $= 36.4 \text{ kip/f}$ $\gamma_{H} = 36.4 \text{ kip/f}$ $\gamma_{V} \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$ $\gamma_{e} = (\tan \varphi_{BS} \le \tan \alpha)$ $= \tan(28)$ 114.24 \text{ kip/ft} (0.53) Resistance - Dra	$L_{S} = (250 \text{ psf})(36.9)$ $t + 4.79 \text{ kip/ft} = 4$ $\gamma_{EV} = (120 \text{ pcf})(36.9)$ $\ln \varphi_{BF}$ $h \le \tan(34) \longrightarrow 0.53 \le 10^{-5} \text{ kip/ft}$ $ined Condition$	ft)(0.297)(1.75) 11.19 kip/ft (25.8 ft)(1.00) $(50.67) \rightarrow ta$	= 4.79 = 114.2 an $\delta =$ 0	4 kip/ft 4 kip/ft).53
eck Sliding Resistance - Drair Nominal Sliding Resistance: P_{EV} R_{τ}	$\frac{2}{\Delta m} \frac{P_{EH}}{P_{EH}} \frac{P_{LS_{h}}}{P}$ $\frac{1000}{P} \frac{1000}{P} \frac{P_{EV}}{P}$ $R_{\tau} = P_{EV}$ $R_{\tau} = 0$ $R_{\tau} = 0$ $\frac{P_{EV}}{P}$ $\frac{1000}{P} \frac{1000}{P}$	$= \sigma_{LS} HK_a \gamma$ $P_H = 36.4 \text{ kip/ff}$ $V \cdot \tan \delta$ $= \gamma_{BF} \cdot H \cdot B \cdot$ $V = (\tan \varphi_{BS} \le \tan \alpha$ $A = \tan(28)$ $114.24 \text{ kip/ft} (0.53)$ $Resistance - Drain$	$L_{S} = (250 \text{ psf})(36.9)$ $t + 4.79 \text{ kip/ft} = 4$ $\gamma_{EV} = (120 \text{ pcf})(36.9)$ $(120 \text{ pcf})(36.9)$	ft)(0.297)(1.75) 11.19 kip/ft 9 ft)(25.8 ft)(1.00) $\leq 0.67 \longrightarrow tz$	= 4.79 = 114.2 $m \delta = -0$	4 kip/ft 1.53



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

JOB	FRA-7	0-12.68	NO.	W-13-045
SHEET NO.		2	OF	6
CALCULATED I	BY	BRT	DATE	7/15/2018
CHECKED BY	_	JPS	DATE	7/15/2018
Retaining W	all $4W^{7}$	12 - Sta. 3003	3+06	

ISE Wall Dimensions and Retained Soil Para	<u>imeters</u>	Bearing Soil Properties:		
ISE Wall Height, (<i>H</i>) =	36.9 ft	Bearing Soil Unit Weight, (γ_{E}	₃₅) =	<u>120 p</u>
ISE Wall Width (Reinforcement Length), (<i>B</i>) =	<u>25.8</u> ft	Bearing Soil Friction Angle, (φ_{BS}) =	<u>28</u> °
ISE Wall Length, (<i>L</i>) =	936 ft	Bearing Soil Drained Cohesi	on, $(c_{BS}) =$	<u> </u>
ive Surcharge Load, (σ_{LS}) =	<u>250</u> psf	Bearing Soil Undrained Shea	ar Strength, [(s _u	$)_{BS}] = 0$ ps
tetained Soil Unit Weight, (γ_{RS}) =	<u>120</u> pcf	Embedment Depth, (D_f) =		<u>3.0</u> ft
tetained Soil Friction Angle, (φ_{RS}) =	<u>30</u> °	Depth to Grounwater (Below	Bot. of Wall), (A	D_W) = 14.0 ft
letained Soil Drained Cohesion, $(c_{BS}) =$	<u>0</u> psf	LRFD Load Factors		
etained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$	2000 pst	EV EH	LS	
etained Soil Active Earth Pressure Coeff., $(K_a) =$	0.297	Strength la 1.00 1.50	1.75 (A	ASHTO LRFD BDM Tables
ISE Backfill Eriction Angle $(r_{BF}) =$	120 pcr 24 °	Surviço I 1 00 1 00	1.75 - 3	Earth Pressure)
$(\psi_{BF}) = \psi_{FF}$			1.00 -	
heck Sliding (Loading Case - Strength Ia) - A	AASHTO LRFD BDM	Section 11.10.5.3 (Continued)		
heck Sliding Resistance - Undrained Condit	ion			
Nominal Sliding Resisting: $R_{\tau} =$	$\left(\left(S_{u}\right)_{BS} \leq q_{s}\right) \cdot B$			
<i>P</i>	$(S_u)_{BS} = N/A$	ksf		
	$q_s = \frac{\sigma_v}{2} = 4$	1.43 ksf) / 2 = 2.22 ksf		
	ת /			
	₽~~~₽ <u>~₽</u> ~~/÷~~			
$\underbrace{\uparrow \land \uparrow \uparrow \uparrow \uparrow}_{(S_u)_{BS} \leq q_s}$	$\sigma_v = \frac{P_{EV}}{B} =$	(114.24 kip/ft) / (25.8 ft)	= 4.43	ksf
$(S_u)_{BS} \leq q_s$	$\sigma_v = \frac{P_{EV}}{B} =$	(114.24 kip/ft) / (25.8 ft) <sf)(25.8 <="" ft)="N/A" kip="" th=""><th>= 4.43 ft</th><th>ksf</th></sf)(25.8>	= 4.43 ft	ksf
$(S_u)_{BS} \le q_s$ erify Sliding Force Less Than Factored Slidi	$\sigma_v = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ ksf})$ ing Resistance - Und	(114.24 kip/ft) / (25.8 ft) ‹sf)(25.8 ft) = N/A kip/ <u>rained Condition</u>	= 4.43 fft	ksf
$\begin{array}{c} & & & & & & \\ & & & & & \\ \hline & & & & \\ \hline & & & &$	$\sigma_v = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$	(114.24 kip/ft) / (25.8 ft) <sf)(25.8 <br="" ft)="N/A" kip=""><u>rained Condition</u> →</sf)(25.8>	= 4.43 ft N/A	ksf
$(S_u)_{BS} \leq q_s$ erify Sliding Force Less Than Factored Slidi $P_H \leq R_\tau \cdot \phi_\tau \longrightarrow$ Use $\varphi_\tau = 1.0$ (Per AASHTO LRED BDM	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43 ft N/A	ksf
$ \underbrace{ \bigwedge \bigwedge (S_u)_{BS} \leq q_s}_{(S_u)_{BS} \leq q_s} $ erify Sliding Force Less Than Factored Slidi $ P_H \leq R_\tau \cdot \phi_\tau \longrightarrow $ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ $\frac{1}{B} = (N/A \text{ ksf} \le 2.22 \text{ H})$ $\frac{1}{B} = (N/A \text{ ksf} \le 2.22 \text{ H})$ $\frac{1}{B} = (N/A \text{ ksf} \le 2.22 \text{ H})$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43 ft N/A	ksf
$ \underbrace{ \uparrow \uparrow \uparrow \uparrow}_{(S_u)_{BS} \leq q_s} $ $ \underbrace{ \text{erify Sliding Force Less Than Factored Slidi}}_{P_H \leq R_\tau \cdot \phi_\tau} \longrightarrow $ $ \underbrace{ \text{Use } \varphi_\tau = 1.0 (\text{Per AASHTO LRFD BDM}) $	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ km})$ $\frac{1}{B} = (N/A \text{ ksf} \le 2.22 \text{ km})$ $\frac{1}{B} = (N/A \text{ ksf} \le 2.22 \text{ km})$ $\frac{1}{B} = (N/A \text{ ksf} \le 2.22 \text{ km})$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43 ft N/A	ksf
$ \underbrace{ \bigwedge \bigwedge \bigwedge}_{(S_u)_{BS} \leq q_s} R_t $ erify Sliding Force Less Than Factored Slidi $ P_H \leq R_\tau \cdot \phi_\tau \longrightarrow $ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_v = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ k})$ $= (N/A \text{ ksf} \le 2.22 \text{ k})$ $= (N/A \text{ ksf} \le 1.5.7 \text{ k})$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43 ft N/A	ksf
$ \underbrace{ \bigwedge \bigwedge \bigwedge}_{(S_u)_{BS} \leq q_s} R_t $ erify Sliding Force Less Than Factored Slidi $ P_H \leq R_\tau \cdot \phi_\tau \longrightarrow $ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ $= N/A$ $= 11.5.7-1$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43	ksf
$ \underbrace{ \bigwedge \bigwedge (S_u)_{BS} \leq q_s}_{(S_u)_{BS} \leq q_s} $ erify Sliding Force Less Than Factored Slidi $ P_H \leq R_\tau \cdot \phi_\tau \longrightarrow $ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_v = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ ing Resistance - Und N/A Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43 ft N/A	ksf
$(S_u)_{BS} \leq q_s$ R_t Erify Sliding Force Less Than Factored Slidi $P_H \leq R_\tau \cdot \phi_\tau \longrightarrow$ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ J})$ $\frac{1}{N/A}$ $\frac{N/A}{Table 11.5.7-1}$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	ksf
$(S_u)_{BS} \leq q_s$ R_t erify Sliding Force Less Than Factored Slidi $P_H \leq R_\tau \cdot \phi_\tau \longrightarrow$ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ km})$ $\frac{P_{EV}}{B} =$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43 ft N/A	ksf
$(S_u)_{BS} \leq q_s$ erify Sliding Force Less Than Factored Slidi $P_H \leq R_\tau \cdot \phi_\tau \longrightarrow$ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_v = \frac{P_{EV}}{B} =$ = (N/A ksf < 2.22 k ing Resistance - Und N/A 1 Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	= 4.43 ft N/A	ksf
$ (S_u)_{BS} \leq q_s $ R_t erify Sliding Force Less Than Factored Slidi $P_H \leq R_\tau \cdot \phi_\tau \longrightarrow$ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_v = \frac{P_{EV}}{B} =$ = (N/A ksf \leq 2.22 k ing Resistance - Und N/A 1 Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ \begin{array}{c} & & & & \\ & & & \\ \hline & & & \\ \hline \\ erify Sliding Force Less Than Factored Slidi} \\ P_{H} \leq R_{\tau} \cdot \phi_{\tau} \longrightarrow \\ \\ Use \phi_{\tau} = 1.0 (Per AASHTO LRFD BDM \\ \end{array} $	$\sigma_v = \frac{P_{EV}}{B} =$ = (N/A ksf \leq 2.22 H ing Resistance - Und N/A Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	ksf
$ (S_u)_{BS} \leq q_s $ R_t R_t $P_H \leq R_\tau \cdot \phi_\tau \longrightarrow$ $Use \ \varphi_\tau = 1.0 (Per \ AASHTO \ LRFD \ BDM$	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ $\frac{1}{B} = \frac{1}{B}$ $\frac{1}{B} = \frac{1}{B}$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	ksf
$ (S_u)_{BS} \leq q_s $ erify Sliding Force Less Than Factored Slidi $ P_H \leq R_\tau \cdot \phi_\tau \longrightarrow $ $ Use \ \varphi_\tau = 1.0 (Per \ AASHTO \ LRFD \ BDM$	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ J})$ $\frac{1}{N/A}$ $Table 11.5.7-1)$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ (S_u)_{BS} \leq q_s $ erify Sliding Force Less Than Factored Slidi $ P_H \leq R_\tau \cdot \phi_\tau \longrightarrow $ Use $\varphi_\tau = 1.0$ (Per AASHTO LRFD BDM	$\sigma_v = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ J})$ ing Resistance - Und N/A $(Table 11.5.7-1)$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ \begin{array}{c} & & & & \\ & & & \\ \hline & & & \\ \hline \\ erify Sliding Force Less Than Factored Slidi \\ P_{H} \leq R_{\tau} \cdot \phi_{\tau} \longrightarrow \\ \\ & \\ Use \varphi_{\tau} = 1.0 (Per AASHTO LRFD BDM \\ \hline \\ \end{array} $	$\sigma_v = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ km})$ N/A $Table 11.5.7-1)$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ \begin{array}{c} & & & & \\ & & & \\ \hline & & & \\ \hline \\ erify Sliding Force Less Than Factored Slidi\\ P_{H} \leq R_{\tau} \cdot \phi_{\tau} \longrightarrow \\ \\ Use \phi_{\tau} = 1.0 (Per AASHTO LRFD BDM \\ \hline \\ \end{array} $	$\sigma_v = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ km})$ $= N/A$ $= 11.5.7-1)$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ \underbrace{\uparrow \uparrow \uparrow \uparrow \uparrow}_{(S_u)_{BS}} \leq q_s $ $ R_t$ $ erify Sliding Force Less Than Factored Slidi P_H \leq R_\tau \cdot \phi_\tau \longrightarrow Use \ \varphi_\tau = 1.0 (Per \ AASHTO \ LRFD \ BDM$	$\sigma_v = \frac{P_{EV}}{B} =$ = (N/A ksf < 2.22 k ing Resistance - Und N/A 1 Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ \underbrace{\uparrow \uparrow \uparrow \uparrow \uparrow}_{(S_u)_{BS}} \leq q_s $ $ \underline{P_H} \leq R_\tau \cdot \phi_\tau \longrightarrow $ $ Use \ \varphi_\tau = 1.0 (Per \ AASHTO \ LRFD \ BDM \ ASHTO \ LRFD \ ASHTO \ $	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ H})$ Ing Resistance - Und N/A $Table 11.5.7-1)$	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ \uparrow \qquad \qquad$	$\sigma_v = \frac{P_{EV}}{B} =$ = (N/A ksf < 2.22) ing Resistance - Und N/A (Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ <u>rained Condition</u> →	e 4.43	
$ \underbrace{ \left(S_{u} \right)_{BS} \leq q_{s} }{R_{t}} $ $ \frac{erify Sliding Force Less Than Factored Slidit}{P_{H} \leq R_{t} \cdot \phi_{t}} \rightarrow $ $ Use \varphi_{\tau} = 1.0 (Per AASHTO LRFD BDM$	$\sigma_{v} = \frac{P_{EV}}{B} =$ $= (N/A \text{ ksf} \le 2.22 \text{ J})$ ing Resistance - Und N/A Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ rained Condition →	e 4.43	
$ \underbrace{ \left(\sum_{u} \right)_{us} \leq q_{u}}_{\left(s_{u} \right)_{us} \leq q_{u}} $ $ R_{t} $ $ \left(\frac{erify Sliding Force Less Than Factored Slidi}{P_{H} \leq R_{t} \cdot \phi_{t}} \rightarrow \right) $ $ Use \varphi_{\tau} = 1.0 (Per AASHTO LRFD BDM) $	$\sigma_v = \frac{P_{EV}}{B} =$ = (N/A ksf < 2.22 k ing Resistance - Und N/A (Table 11.5.7-1)	(114.24 kip/ft) / (25.8 ft) (sf)(25.8 ft) = N/A kip/ rained Condition →	e 4.43	



JOB	FRA-70-	12.68		NO.	W-13-045
SHEET NO.		3		OF	6
CALCULATED B	Y	BRT		DATE	7/15/2018
CHECKED BY		JPS		DATE	7/15/2018
Retaining W	all 4W12	- Sta. 30	03+	06	

MSE Wall Dimensions and Retained Soil Para	ameters	Bearing Soil Properties:	
MSE Wall Height, (<i>H</i>) =	36.9 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	25.8 ft	Bearing Soil Friction Angle, $(\varphi_{BS}) =$	<u>28</u> °
MSE Wall Length, (L) =	<u>936</u> ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 psf
Live Surcharge Load, $(\sigma_{LS}) =$	250 psf	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	0 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment Depth, (D_f) =	3.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Grounwater (Below Bot. of Wall), (D_W) =	14.0 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 I R	ED BDM Tables
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf	Strength lb 1.35 1.50 1.75 - 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	Pressure)
Check Eccentricity (Loading Case - Strength	la) - AASHTO LRF	D BDM Section 11.10.5.5	
	8/_~		
	$72^{-x_{o}}$		
	37 37		
$x_2 \uparrow^3$ \downarrow \downarrow k \downarrow P_{LS_h} r	$= \frac{M_{EV} - M_{H}}{M_{EV}}$	= (1473 7 kip·ft/ft - 536 1 kip·ft/ft) / (114 24 kip/ft) =	8.21 ft
$\bigwedge^{*} $	$P_{_{\!F\!V}}$		~ 1 IV
	Ъ'		
	$M_{TV} = 1473$	70 kip·ft/ft ¬	
	$M_{EV} = 1110$. $M_{U} = 536$	1 kin·ft/ft ≻ Defined below	
	$P_{\rm rw} = 1142$	24 kin/ft	
$\mathbf{k} = \frac{B}{2} \mathbf{z}$	I EV - 117.2		
	= (25.8 ft)/2 - 8	3.21 ft = 4.69 ft	
Resisting Moment, M_{EV} : M_{EV}	$=P_{EV}(x_1)$		
$P_{\mathcal{F}}$	$V_V = \gamma_{BF} \cdot H \cdot I$	$3 \cdot \gamma_{EV}$ = (120 pcf)(36.9 ft)(25.8 ft)(1.00) = 114.	24 kip/ft
P_{EV}	ת /		
$ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $ $	$= \frac{B}{2} = (2)$	25.8 ft) / 2 = 12.90 ft	
	<i>' '</i>		
	$M_{_{FV}} = (114.2)$	24 kip/ft)(12.90 ft) = 1473.70 kip·ft/ft	
\downarrow	2,		
	_		
Overturning Moment, M_H : M_H	$=P_{EH}\left(x_{2}\right) +I$	$P_{LS_h}(x_3)$	
$\overline{\mathbf{r}}$	1/ 172		10 <i>tⁱⁿ 1</i> 4
P_E	$_{H} = \gamma_{2} \gamma_{RS} H^{-1}$	$X_a \gamma_{EH} = \frac{\gamma_2}{(120 \text{ pcf})(36.9 \text{ ft})^2(0.297)(1.5)} = 36.4$	10 kip/ft
x_{3}	- 117		1
$\begin{array}{c c} x_2 \\ \uparrow \end{array}$	$S_h = \sigma_{LS} H K_a$	$V_{LS} = (250 \text{ psf})(36.9 \text{ ff})(0.297)(1.75) = 4.79$	kip/ft
	_H/ _ c	36 0 ft) / 3 – 12 30 ft	
	2 - /3 - (5		
X 3	$=H/_2 = (3)$	36.9 ft) / 2 = 18.45 ft	
	/ 2		
	$M_H = (36.$	4 kip/ft(12.3 ft) + (4.79 kip/ft)(18.45 ft) = 536.1	kip∙ft/ft
Check Eccentricity			
$e < e_{\rm max} \longrightarrow 4.69 {\rm ft} < 8.60 {\rm ft}$	OK		
$\mathbf{p} \cdot \mathbf{z}_{\mathrm{rest}}$			
Limiting Eccentricity: $e_{\text{max}} = \frac{B}{2}$	$\rightarrow e_{\rm max} = (2)$	25.8 ft / 3 = 8.60 ft	



JOB	FRA-70-12.68	NO.	W-13-045
SHEET NO.	4	OF	6
CALCULATED BY	BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining Wa	II 4W12 - Sta. 3003-	+06	

MSE Wall Dimensions and Retained Soil Para	<u>meters</u>	Bearing Soil Properties:	
MSE Wall Height, (<i>H</i>) =	36.9 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	25.8 ft	Bearing Soil Friction Angle, (φ_{BS}) =	<u>28</u> °
MSE Wall Length, (<i>L</i>) =	936 ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 psf
Live Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	0 psf
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf	Embedment Depth, (D_f) =	3.0 ft
Retained Soil Friction Angle, (φ_{RS}) =	30 °	Depth to Grounwater (Below Bot. of Wall), (D_W) =	14.0 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] (MSHTO LOP	D PDM Tablaa
MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf	Strength lb 1.35 1.50 1.75 – 3.4.1-1 and 3.4	4.1-2 - Active
MSE Backfill Friction Angle, (φ_{BF}) =	<u>34</u> °	Service I 1.00 1.00 1.00 Image: Constraint of the service of the	essure)
Check Bearing Capacity (Loading Case - Stree	ngth lb) - AASHTO L	RFD BDM Section 11.10.5.4	
$L_{LS_{v}}$	_		
	$P_V/$		
9 eg —	/ B'		
	$D \infty$	$9 \pm 2/2 + 10 \pm 20 \pm 10$	
$\begin{bmatrix} x_j \\ \uparrow \end{bmatrix} \xrightarrow{I EV} \models P_{IS} \xrightarrow{B'=}$	= B - 2e = 25.	$0 \Pi - 2(3.24 \Pi) = 19.32 \Pi$	
	$a-B/\sim$	(25.9 ft)/2 0.66 ft $-$ 2.24 ft	
	$c - /2^{-x_o} =$	$-\sqrt{23.0 \text{ II}/(2-9.00 \text{ II})} = 3.24 \text{ II}$	
	$M_V - M_H$	- (2125 14 kip. #/# 526 12 kin #/#) / 465 54 kin /#	- 066 4
	$x_o =P_{}$	$= (2135.14 \text{ kip} \cdot \pi/\pi - 536.13 \text{ kip} \cdot \pi/\pi) / 165.51 \text{ kip}/\pi$	= 9.00 II
$x_0 \leftarrow + 2 e$	τ γ		
$\downarrow = \bar{B}' \rightarrow \qquad $	= (165.51 kip/ft)	/ (19.32 ft) = 8.57 ksf	
$M_{V} = P_{EV}(x_{1}) + P_{LS_{V}}(x_{1}) = (\gamma_{BF} \cdot I)$	$(H \cdot B \cdot \gamma_{EV})(x_1)$	+ $(\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_1)$	
$M_V = [(120 \text{ pcf})(36.9 \text{ ft})(25.8 \text{ ft})(1.35)]$	(12.9 ft) + [(250 psf)(25.8 ft(1.75)](12.9 ft) = 2135.14 kip·ft/ft	
$M_{H} = P_{EH}(x_{2}) + P_{LS_{h}}(x_{3}) = (\frac{1}{2}\gamma_{RS})$	$H^2K_a\gamma_{EH}(x_2)$ -	+ $(\sigma_{LS}HK_a\gamma_{LS})(x_3)$	
$M_{H} = [\frac{1}{2}(120 \text{ pcf})(36.9 \text{ ft})^{2}(0.297)(1.5)]{1.5}$	5)](12.3 ft) + [(250 ps	f)(36.9 ft)(0.297)(1.75)](18.45 ft) = 536.13 kip·1	ft/ft
$P_{V} = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$	$\gamma + \sigma_{LS} \cdot B \cdot \gamma_{LS}$		
$P_V = (120 \text{ pcf})(36.9 \text{ ft})(25.8 \text{ ft})(1.35)$ +	- (250 psf)(25.8 ft)(1.	75) = 165.51 kip/ft	
Check Bearing Resistance - Drained Condition	<u>n</u>		
Nominal Bearing Resistance: $q_n = cN_{cm}$ -	$+ \gamma D_f N_{am} C_{wa} +$	$\frac{1}{2} \gamma B N_m C_{w\gamma}$	
$N_{cm} = N_c s_c i_c$ = 26.11	$N_{am} = N_a s_a d_a i_a$	$N_{\gamma m} = 15.57$ $N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} = 16.59$	
N _c = 25.8	N_q = 14.72	$N_{\gamma} = 16.72$	
S_c = 1+(19.32 ft/936 ft)(14.72/25.8)	$s_q = 1.011$	$s_{\gamma} = 0.992$	
= 1.012	$d_q = 1+2\tan(28^\circ)$	$i_{\gamma} = 1.000$ (Assumed) [1-sin(28°)] ² tan ⁻¹ (3.0 ft/19.32 ft)	
i_c = 1.000 (Assumed)	1.046	$C_{w\gamma} = 14.0 \text{ ft} < 1.5(19.32 \text{ ft}) + 3.$	0 ft = 0.742
	i_q = 1.000 (A	ssumed)	
	$C_{wq} = 14.0 \text{ ft} > 3$	0.0 ft = 1.000	
$q_n = (0 \text{ psf})(26.110) + (120 \text{ pcf})(3.0 \text{ ft})(3.0 \text{ ft}$	15.566)(1.000) + ½(120 pcf)(19.3 ft)(16.586)(0.742) = 19.87 ksf	
Verify Equivalent Pressure Less Than Factore	d Bearing Resistan	<u>ce</u> Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDM	Table 11.5.7-1)
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57 \text{ksf} \leq$	(19.87 ksf)(0.65) = 1	2.92 ksf → 8.57 ksf ≤ 12.92 ksf Ol	K



JOB	FRA-70-12.6	68	NO.	W-13-045
SHEET NO.	5		OF	6
CALCULATED B	Y B	RT	DATE	7/15/2018
CHECKED BY	JI	S	DATE	7/15/2018
Retaining Wa	all 4W12 - St	a. 3003-	+06	

ISE Wall Dimensions and Retained Soil Page 1	<u>arameters</u>	Bearing Soil Properties:	
ISE Wall Height, (<i>H</i>) =	36.9 ft	Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
ISE Wall Width (Reinforcement Length), (<i>B</i>) =	25.8 ft	Bearing Soil Friction Angle, $(\varphi_{BS}) =$	28 °
ISE Wall Length, (<i>L</i>) =	936 ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 psf
ve Surcharge Load, (σ_{LS}) =	250 psf	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	0 psf
etained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf	Embedment Depth, (D_f) =	3.0 ft
etained Soil Friction Angle, $(\varphi_{RS}) =$	<u>30</u> °	Depth to Grounwater (Below Bot. of Wall), (D_W) =	= 14.0 ft
etained Soil Drained Cohesion, (c_{RS}) =	0 psf	LRFD Load Factors	
etained Soil Undrained Shear Strength, $[(S_n)_{ps}]$	= 2000 psf	EV EH LS	
etained Soil Active Earth Pressure Coeff., (K_a) =	= 0.297	Strength la 1.00 1.50 1.75	
ISE Backfill Unit Weight, $(\gamma_{BE}) =$	120 pcf	(AASHTO) Strength lb 1.35 1.50 1.75 - 3.4.1-1 a	0 LRFD BDM Tables and 3.4.1-2 - Active
ISE Backfill Friction Angle, $(\varphi_{BF}) =$	<u>34</u> °	Service I 1.00 1.00	rth Pressure)
heck Bearing Capacity (Loading Case - S	trength Ib) - AASHTO	LRFD BDM Section 11.10.5.4 (Continued)	
ominal Bearing Resistance - Undrained Col	+ vD N C +	- ½ 1/BN C	
V = N s i = 5160	$m + \gamma D_f N_{qm} C_{wq} + N_{m} N_$	$V_2 \gamma D N_{\gamma m} C_{w\gamma}$ $V_i = 1000 \qquad N_i = N_i S_i I_i = 0$	000
	- qm - q ² q ² q ²	$q = \frac{\gamma \gamma \gamma \gamma \gamma}{\gamma}$	
N _c = 5.140	$N_q = 1.000$	$N_{\gamma} = 0.000$	
$S_c = 1+(19.32 \text{ ft/}[(5)(936 \text{ ft})]) = 1.00$	$s_q = 1.000$	$s_{\gamma} = 1.000$	
$i_c = 1.000$ (Assumed)	$d_q = 1+2\tan(0^\circ)$	°)[1-sin(0°)] ² tan ⁻¹ (3.0 ft/19.32 ft) $i_{\gamma} = 1.000$ (Assumed	d)
	1.000	$C_{wy} = 14.0 \text{ft} < 1.5(19.32 \text{ft})$	t) + 3.0 ft = 0.7
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$	$i_q = 1.000 \ (A C_{wq} = 14.0 \ ft)$ $C_{wq} = 14.0 \ ft > 14.$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A	ksf
$q_n =$ (0 psf)(5.160) + (120 pcf)(3.0 erify Equivalent Pressure Less Than Fact	$i_q = 1.000 \ (A_{wq} = 14.0 \ ft)$ $C_{wq} = 14.0 \ ft > 14.0 $	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1ce	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$	$i_q = 1.000 \ (A_{wq} = 1.000) \ (A_{wq} = 14.0 \ ft) = 14.0 \ ft > 14.0 \ ft > 14.0 \ ft > 14.0 \ ft > 12.0 \ ft) \ (1.000) \ (1.000) \ + \frac{1}{2} \ (1.000) \$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1 <u>ce</u> N/A ksf → N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ <u>erify Equivalent Pressure Less Than Fact</u> $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 \ (F_{wq} = 1.000) \ (F_{wq} = 14.0 \ ft > 1000) \ (1.000) \ (1.000) \ + \frac{1}{2} \ (1.000) \$	Assumed) 3.0 ft = 1.000 120 pcf(19.3 ft)(0.000)(0.742) = N/A <u>ICE</u> N/A ksf \longrightarrow N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 \ (A_{wq} = 1.000) \ (A_{wq} = 14.0 \ ft) \ (1.000)(1.000) + \frac{1}{2}(7) \ (20)$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A <u>nce</u> N/A ksf -> N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > C_{wq} = 14.0 \text{ ft} > 14.0 \text{ ft} > 1000 (1.000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) (1.000) + 1/2(1000) $	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A <u>nce</u> N/A ksf \longrightarrow N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2(1000) (1.000) + 1/2(10$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf \longrightarrow N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ <u>erify Equivalent Pressure Less Than Fact</u> $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 \ (A_{wq} = 1.000) \ (A_{wq} = 14.0 \ ft > 1.000) \ (1.000) \ (1.000) \ + \frac{1}{2} \ (2.0000) \ + \frac{1}{2} \ + \frac{1}{2} \ (2.0000) \ + \frac{1}{2} \ + \frac{1}{2} \ (2.0000) \ + \frac{1}{2} \ + \frac{1}{2}$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf \longrightarrow N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ <u>erify Equivalent Pressure Less Than Fact</u> $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 \ (P_{wq} = 14.0 \ ft) < C_{wq} = 14.0 \ ft > 14.0 \ ft > 12(1000)(1.000) + 1/2(1000)(1.000) + 1/2(1000)(1.000) + 1/2(1000)(1.000) + 1/2(1000)(1.000) + 1/2(1000)(1.000) + 1/2(1000)(1.000)(1.000) + 1/2(1000)(1.000)(1.000) + 1/2(1000)(1.000)(1.000) + 1/2(1000)(1.000)(1.000)(1.000) + 1/2(1000)(1.000)(1.000)(1.000)(1.000) + 1/2(1000)(1.000)$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 N/A ksf \longrightarrow N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) $	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf \longrightarrow N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1.000) (1.000) + 1/2 (1$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf \longrightarrow N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) + 1/2 $	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf → N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 \ (Prime prime}{(Prime prime}{(Prime prime}{(Pri$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf → N/A	
$q_n =$ (0 psf)(5.160) + (120 pcf)(3.0 erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b =$ 0.65 (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) + 1/2 $	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf → N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) + 1/2 $	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1CE N/A ksf → N/A N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (1000) (1.000) + 1/2 (10$	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 100 100 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 100 100 100 100 100 100 10	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ <u>erify Equivalent Pressure Less Than Fact</u> $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (4$ $C_{wq} = 14.0 \text{ ft} > 1$ 0 ft)(1.000)(1.000) + 1/2(7 cored Bearing Resistar ksf \leq (N/A ksf)(0.65) = N DM Table 11.5.7-1)	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 100 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 120 pcf)(19.3 ft)(0.000)(0.00	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (4$ $C_{wq} = 14.0 \text{ ft} > 1$ $0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(7$ cored Bearing Resistar ksf \leq (N/A ksf)(0.65) = N DM Table 11.5.7-1)	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1Ce N/A ksf → N/A N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ <u>erify Equivalent Pressure Less Than Fact</u> $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (<i>Per AASHTO LRFD B</i>	$i_q = 1.000 (A$ $C_{wq} = 14.0 \text{ ft} > 1$ $0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(7$ cored Bearing Resistar ksf \leq (N/A ksf)(0.65) = N DM Table 11.5.7-1)	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1Ce N/A ksf → N/A N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ <u>erify Equivalent Pressure Less Than Fact</u> $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A$ $C_{wq} = 14.0 \text{ ft} > 1$ $0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(7$ cored Bearing Resistar ksf \leq (N/A ksf)(0.65) = N DM Table 11.5.7-1)	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1Ce N/A ksf → N/A N/A	ksf
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ <u>erify Equivalent Pressure Less Than Fact</u> $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (4$ $C_{wq} = 14.0 \text{ ft} > 1$ $0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(7$ cored Bearing Resistar ksf \leq (N/A ksf)(0.65) = N DM Table 11.5.7-1)	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 N/A ksf → N/A N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1000) + 1/2 (1000) + 1/2 ($	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 N/A ksf → N/A N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1000) + 1/2 (1000) + 1/2 ($	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 100 N/A ksf → N/A N/A	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (A C_{wq} = 14.0 \text{ ft} > 1000) (1.000) (1.000) + 1/2 (1000) + 1/2 (1000) + 1/2 ($	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A ICE	
$q_n = (0 \text{ psf})(5.160) + (120 \text{ pcf})(3.0)$ erify Equivalent Pressure Less Than Fact $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 8.57$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD B	$i_q = 1.000 (4$ $C_{wq} = 14.0 \text{ ft} > 1$ $0 \text{ ft})(1.000)(1.000) + \frac{1}{2}(1)$ cored Bearing Resistar ksf \leq (N/A ksf)(0.65) = N DM Table 11.5.7-1)	Assumed) 3.0 ft = 1.000 120 pcf)(19.3 ft)(0.000)(0.742) = N/A 1Ce V/A ksf → N/A N/A	



јов Б	RA-70-12.68	NO.	W-13-045
SHEET NO.	6	OF	6
CALCULATED BY	BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining Wall	4W12 - Sta. 3003-	+06	

MSE Wall Dimensions and Retained Soil Param	otors	Boaring Soil Properties:	
MSE Wall Height $(H) =$	36.9.ft	Bearing Soil Unit Weight $(y_{pg}) =$	120 pcf
MSE Wall Width (Reinforcement Length) $(R) =$	25.8 ft	Bearing Soil Friction Angle $(m_{ex}) =$	28 °
MSE Wall Length $(I) =$	936 ft	Bearing Soil Drained Cohesion (c_{RS})	0_nef
Live Surcharge Load $(\sigma_{rel}) =$	250 ncf	Bearing Soil Undrained Shear Strength $[(s_{BS})]$	0 psi
Retained Soil Unit Weight (v_{LS})	120 psi	Embedment Denth $(D_{x}) =$	3 0 ff
Retained Soil Friction Angle $(a_{12}) =$	120 pci 30 °	Denth to Grounwater (Below Bot, of Wall) $(D_{-}) =$	14.0 ft
Retained Soil Prained Cohesion $(c_{RS}) =$	0 pcf	Let M be a set of the set of t	14.0 II
$\frac{1}{2}$	2000 psi		
Potained Soil Active Earth Procesure Cooff (V) =	2000 psi	EV EII E3	
MSE Backfill Unit Weight $(v_{a}) =$	0.297	Charactering (AASHTO LRF)	D BDM Tables
MSE Backfill Friction Angle $(a_{BF}) =$	120 pci	Sarvice 1 1 00 1 00 1 00 <i>Earth Pi</i>	essure)
MOL DACKIII I IICIOII AIIgie, (ψ_{BF}) –			
Sottlement Analysis (Leading Case - Service I)		D RDM Section 11 10 4 1	
	- AASITIO LKI		
$L_{S_{y}}$	n /		
a = 1	$\frac{v}{v}$		
	/ <i>B</i> '		
$P_{\rm PV}$	B 2a =	25.8 ft - 2(2.80 ft) = 20.02 ft	
$\begin{array}{c c} x_3 & -EV \\ \hline x_2 & \uparrow \end{array}$	D - 2e -	$z_{2,0}$ $(1 - z_{2,0})$ $(1 - z_{2,0})$ $(1 - z_{2,0})$	
$\tilde{\gamma}^2$	B = B / r	- (25.8 ft) / 2 10.01 ft - 2.80 ft	
	$-/2^{n_o}$	-(23.0 ft)/2 - 10.0 ft - 2.03 ft	
	$M_{V} - M$	H = (1556.02 kin ft/ft 240 kin ft/ft) (120.60 kin/ft)	- 10.01 ff
	$r_o = - P_u$	= (1550.93 kip 1/1 - 349 kip 1/11) / 120.09 kip/11	- 10.01 II
	- v		
$\leftarrow B_2 \rightarrow 0$	- (400.001.:-		
$\leftarrow B' \rightarrow$	— (120.69 kip	$V(\pi) / (20.02 \pi) = 6.03 \text{ Ksf}$	
	τ. σ		
$M_V = P_{EV}(x_1) + P_{LS_v}(x_1) = (\gamma_{BF} \cdot F)$	$I \cdot B \cdot \gamma_{EV} (x)$	$\mathcal{L}_{1} + (\sigma_{LS} \cdot B \cdot \gamma_{LS})(x_{1})$	
$M_V = [(120 \text{ pcr})(36.9 \text{ ft})(25.8 \text{ ft})(1.00)]($	12.9 π) + [(250 p	DST(25.8 ft)(1.00)](12.9 ft) = 1556.93 kip-ft/ft	
$\mathbf{M} = \mathbf{P} \left(\mathbf{r} \right) + \mathbf{P} \left(\mathbf{r} \right) \left(\frac{1}{2} \mathbf{r} \right)$	$\chi^2 \nu \dots \gamma$		
$M_{H} = P_{EH}(x_{2}) + P_{LS_{h}}(x_{3}) = (\frac{1}{2}\gamma_{RS})$	$T K_a \gamma_{EH} \lambda$	$(\sigma_{LS}HK_a\gamma_{LS})(x_3)$	
))/40 0 4) · [/05	$\Delta = -\frac{1}{2} \sqrt{2} (2 - \frac{1}{2} \sqrt{2} - \frac{1}{2} \sqrt{2} \sqrt{2} - \frac{1}{2} \sqrt{2} \sqrt{2} \sqrt{2} \sqrt{2} \sqrt{2} \sqrt{2} \sqrt{2} $	c./c.
$M_{H} = [\frac{\gamma_2}{120} \text{ pct})(36.9 \text{ m})^2(0.297)(1.00)$)](12.3 π) + [(25	(0 psf)(36.9 ft)(0.297)(1.00)](18.45 ft) = 349.00 ktp	π/π
$P_V = P_{EV} + P_{LS} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$	$+\sigma_{LS}\cdot B\cdot j$	ν_{LS}	
$P_V = (120 \text{ pct})(36.9 \text{ ft})(25.8 \text{ ft})(1.00) +$	(250 psf)(25.8 ft	:)(1.00) = 120.69 kip/ft	
Settlement (See Attached Spreadsheet Calcula	<u>tions):</u>		
	_		
Total Settlement at Center of Reinforced Soil N	/lass: S	, = 2.764 in	
Total Settlement at Wall Facing:	<i>S</i> ₁	, = 2.013 in	
Time Rate of Consolidation Settlement at Wall	Facing (See At	tached Spreadsheet Calculations):	
$(S_c)_{90}$ = in at d	ays follow	ing completion of construction	

W-13-045 - FRA-70-12.68 - Retaining Wall 4W12 MSE Wall Settlement - Sta. 3003+06

Borings B-109-1-15 and B-110-0-15

H=	36.9	ft	Total wall height
B'=	20.0	ft	Effective footing width due to eccentricity
D _w =	14.0	ft	Depth below bottom of footing
q _e =	6,030	psf	Equivalent bearing pressure at bottom of wall

																				Total S	Settlement at	t Center of Re	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	⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
	A-1-b	G	0.0	1.5	1.5	0.8	120	180	90	90	4,090					29	58	205	0.04	0.994	5,995	6,085	0.013	0.160	0.500	3,015	3,105	0.011	0.135
	A-1-b	G	1.5	3.0	1.5	1.5	120	360	270	270	4,270					29	48	163	0.08	0.988	5,959	6,229	0.013	0.151	0.500	3,015	3,285	0.010	0.120
1	A-1-b	G	3.0	4.5	1.5	2.3	120	540	450	450	4,450					29	44	143	0.11	0.976	5,888	6,338	0.012	0.144	0.500	3,015	3,465	0.009	0.111
	A-1-b	G	4.5	6.0	1.5	3.0	120	720	630	630	4,630					29	40	131	0.15	0.971	5,853	6,483	0.012	0.139	0.500	3,015	3,645	0.009	0.104
	A-1-b	G	6.0	7.3	1.3	3.7	120	876	798	798	4,798					29	38	124	0.18	0.965	5,817	6,615	0.010	0.116	0.500	3,015	3,813	0.007	0.086
2	A-4a	G	7.3	9.8	2.5	4.9	120	1,176	1,026	1,026	5,026					29	36	63	0.25	0.947	5,711	6,737	0.032	0.389	0.500	3,015	4,041	0.024	0.284
2	A-4a	G	9.8	12.8	3.0	6.4	120	1,536	1,356	1,356	5,356					29	33	59	0.32	0.929	5,604	6,960	0.036	0.434	0.488	2,943	4,299	0.026	0.306
	A-1-a	G	12.8	17.8	5.0	8.9	125	2,161	1,849	1,849	5,849					39	40	131	0.45	0.900	5,427	7,276	0.023	0.273	0.468	2,822	4,671	0.015	0.184
3	A-1-a	G	17.8	22.8	5.0	11.4	125	2,786	2,474	2,474	6,474					39	36	118	0.57	0.800	4,824	7,298	0.020	0.239	0.448	2,701	5,175	0.014	0.163
5	A-1-a	G	22.8	27.8	5.0	13.9	125	3,411	3,099	3,099	7,099					39	33	109	0.70	0.717	4,322	7,420	0.017	0.209	0.428	2,581	5,679	0.012	0.145
	A-1-a	G	27.8	33.8	6.0	16.9	125	4,161	3,786	3,605	7,605					39	31	103	0.85	0.644	3,886	7,491	0.019	0.222	0.404	2,436	6,041	0.013	0.157
4	A-1-b	G	33.8	39.8	6.0	19.9	130	4,941	4,551	4,183	8,183					64	48	162	1.00	0.578	3,484	7,667	0.010	0.117	0.386	2,326	6,509	0.007	0.085
5	A-4a	С	39.8	42.8	3.0	21.4	125	5,316	5,129	4,667	8,667	22	0.108	0.011	0.444				1.07	0.544	3,283	7,950	0.005	0.062	0.377	2,274	6,941	0.004	0.046
6	A-3a	G	42.8	52.8	10.0	26.4	130	6,616	5,966	5,192	9,192					100	68	204	1.32	0.457	2,757	7,949	0.009	0.109	0.349	2,102	7,294	0.007	0.087
1. $\sigma_{\rm p}' = \sigma_{\rm v}$,'+σ _m Estima	ate σ_m of 4,0	00 psf for mo	oderately ove	erconsolidate	ed soil deposi	it; Ref. Table	e 11.2, Codu	to 2003												Tota	Settlement:		2.764 in		Tota	I Settlement:		2.013 in

2. C_c = 0.009(LL-10); Ref. Table 26, FHWA GEC 5

3. $C_r = 0.05(C_c)$ for embankment fill and $0.10(C_c)$ for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5

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

5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ 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. $S_c = [C_o/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{p'})$ for $\sigma_{vo}' < \sigma_{p}' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv 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)

Calculated By:	BRT	Date:	7/17/2018
Checked By:	JPS	Date:	7/17/2018







JOB	FRA-7	70-12.68	NO.	W-13-045		
SHEET NO.		2	OF	6		
CALCULATE	D BY	BRT	DATE	7/15/2018		
CHECKED B	Y T	JPS	DATE	7/15/2018		
Retaining Wall 4W12 - Sta. 3004+50						

MSE Wall Height, (H) = MSE Wall Width (Reinforcement Length), (B) = Distance from Wall Face to Toe of Backslope, (l) = MSE Wall Length, (L) =		Bearing Son Properties.	
MSE Wall Width (Reinforcement Length), $(B) =$ Distance from Wall Face to Toe of Backslope, $(l) =$ MSE Wall Length, $(L) =$	25.2 ft	MSE Backfill Unit Weight, (γ_{BF}) =	120 p
Distance from Wall Face to Toe of Backslope, (<i>l</i>) = MSE Wall Length, (<i>L</i>) =	19.2 ft	MSE Backfill Friction Angle, (φ_{BF}) =	34 °
MSE Wall Length, (<i>L</i>) =	5.0 ft	Bearing Soil Unit Weight, (γ_{BS}) =	125 p
	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	27 °
/ISE Wall Effective Height, (<i>h</i>) =	31.2 ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 p:
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$] = <u>3125</u> p
ffective Retained Soil Backslope, (θ) =	<u>6.8</u> °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	12.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	16.9 ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf		
Retained Soil Friction Angle, (φ_{RS}) =	<u> </u>	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	TO LRFD BDM Table
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.324	Strength lb 1.35 1.50 1.75 - 3.4.1-	1 and 3.4.1-2 - Active
ive Surcharge Load, (σ_{LS}) =	250 psf	Service I 1.00 1.00 1.00	Earur Fressure)
. Drained cohesion for retained soil not accounted for in external stability	analyses. This parameter is	s utilized in global stability analysis.	
neck Sliding (Loading Case - Strength Ia) - A	ASHTO LRFD BDI	VI Section 11:10.5.3 (Continued)	
heck Sliding Resistance - Undrained Condition	<u>on</u>		
$\mathbf{N}_{\mathbf{r}} = \mathbf{P}_{\mathbf{r}} = \mathbf{P}_{\mathbf{r}} = \mathbf{P}_{\mathbf{r}} = \mathbf{P}_{\mathbf{r}}$) (a) D		
Nominal Sliding Resisting: $R_{\tau} = ((S_u))$	$\mathcal{J}_{BS} \geq \mathcal{Q}_{s} \mathcal{J} \cdot \mathcal{D}$		
E_{EV_2}	= 3.13 ksf		
	/		
$a = \sigma$	v		
P_{EV_1} P_{LSv} P_{LS} P_{LS}	/2		
P_{EH}	$P_V/$		
	- / <i>B</i>		
$R_{\tau} = \frac{1}{2} \theta$	מי מי		
	$Y_V = P_{EV_1} + P_{EV_2}$	$+P_{EH}\sin\theta$	
$(\mathcal{S}_u)_{BS} \leq q_s$	D 77		50.00 11 16
	$P_{EV_1} = \gamma_{BF} \cdot H$	$\cdot B \cdot \gamma_{EV} = (120 \text{ pct})(25.2 \text{ ft})(19.2 \text{ ft})(1.00) =$: 58.06 kip/ft
(Neglect P_{LS_v} for conservatism)			
	$P_{EV_2} = \frac{1}{2} \gamma_{RS} (h$	$(I + H)(B - l)\gamma_{EV}$	
	D 1//		- 10
	$P_{EV_2} = \frac{\gamma_2}{1}$	(20 pcr)(31.2 ft - 25.2 ft)(19.2 ft - 5.0 ft)(1.00) = 8	5.12 kip/π
	D 1/ 72	$T_{\rm X} = 1/(400 - 50/04.0 - 60/04.0 - 20/04$	004
	$P_{EH} = \frac{\gamma_2}{\gamma_{RS}} h^2$	$K_a \gamma_{EH} = \gamma_2 (120 \text{ pcr})(31.2 \text{ m})^2 (0.324)(1.50) =$	· 28.4 κιρ/π
α) _ 59.06 kip/fl	t + 5 + 12 kin/ft + (22 A kin/ft)nin/6 2°) = 66 5 A	kin /ft
	V = 58.06 kip/m	1 + 5.12 kip/it + (28.4 kip/it)sin(6.8) = 66.54	κιρ/π
σ_{v} =	= (66.54 kip/ft) / ((19.2 ft) = 3.47 ksf	
$q_s =$	(3.47 ksf) / 2 =	1.74 ksf	
$R_{t} = (3)$	3.13 ksf ≤ 1.74 ksf)(1	9.2 ft) = 60.00 kip/ft	



JOB	FRA-70-12.68			W-13-045		
SHEET NO.		3	OF	6		
CALCULATED E	BY	BRT	DATE	7/15/2018		
CHECKED BY	_	JPS	DATE	7/15/2018		
Retaining Wall 4W12 - Sta. 3004+50						

MSE Wall Dimensions and Retained Soil Paran	neters	Bearing Soil Properties:	
MSE Wall Height, (<i>H</i>) =	25.2 ft	MSE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	19.2 ft	MSE Backfill Friction Angle, (φ_{BF}) =	 34 °
Distance from Wall Face to Toe of Backslope, $(l) =$	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	125 pcf
MSE Wall Length, (L) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	27 °
MSE Wall Effective Height, (h) =	31.2 ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	3125 psf
Effective Retained Soil Backslope, (θ) =	6.8 °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	12.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	16.9 ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf		
Retained Soil Friction Angle, $(\varphi_{RS}) =$	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	PED BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.324	Strength lb 1.35 1.50 1.75 - 3.4.1-1 and	1 3.4.1-2 - Active
Live Surcharge Load, $(\sigma_{LS}) =$	250 psf	Service I 1.00 1.00 1.00 -	Pressure)
1. Drained cohesion for retained soil not accounted for in external stability	analyses. This parameter is	utilized in global stability analysis.	
Check Eccentricity (Loading Case - Strength la) - AASHTO LRFE	D BDM Section 11.6.3.3	
P_{rrr}			
e = B/2 -	x		
	c *		
$P_{re} \downarrow \rangle = P$	· 11		
$X_4 P_{EV_1} P_{EV_1} = P_{LS} T_{LS} X_2 = -$	$V - M_{H} = (696)$.03 kip·ft/ft - 361.75 kip·ft/ft) / (66.54 kip/ft) = 5.02	?ft
$x_3 \mid P_{EH_v} \mid P_{$	P_V		
P_{EH_h}			
\downarrow \downarrow R \downarrow $=$ $=$ $ Y^{\theta}$ M_{V}	= 696.03 k	p·ft/ft]	
	= 361.75 ki	p·ft/ft	
$x_o \not\leftarrow \not\leftarrow e$	$= P_{EV_1} + P_{EV_2} + P_{EV_2}$	$P_{EH} \sin \theta$ = 58.06 kip/ft + 5.12 kip/ft + (28.4 kip/ft)sin(6.8°)	= 66.54 kip/ft
$x \mapsto B/ \rightarrow$			
e = 1	(19.2 ft/ 2) - 5.02 ft	= 4.58 ft	
Resisting Moment, M_V : $M_V = P_{FV}$	$(x_1) + P_{FV_1}(x_2) -$	$+ P_{EH} \sin \theta(B)$ (Neglect P_{LS_v} for conserved	vatism)
P_{EV_2}	× 17 E72 × 29		
$P_{EV} = j$	$\gamma_{RF} \cdot H \cdot B \cdot \gamma_{FV}$	= (120 pcf)(25.2 ft)(19.2 ft)(1.00) $=$ 58.06	kip/ft
$P_{IS} \mid \downarrow \downarrow P_{IS} \mid P_{EV_2} = 1$	$\gamma_2 \gamma_{RS} (h-H) (B-H)$	l) γ_{EV} = ½(120 pcf)(31.2 ft - 25.2 ft)(19.2 ft - 5.0 ft)(1.00) =	= 5.12 kip/ft
P_{EV_1} L_{SV} L_{S} P_{EV_1} $P_{$			
P_{EH}	$\sqrt{2\gamma_{RS}}h^2K_a\gamma_{FH}$	= ½(120 pcf)(31.2 ft)²(0.324)(1.50) = 28.4 ki	p/ft
V 1 k 0	2, ND <i>u</i> , EN		
• • · · · · · · · · · · · · · · · · · ·	2 = (19.2 ft) / 2	= 9.60 ft	
$\mapsto x_1$	2		
	$+\frac{2}{3}(B-l) =$	5.0 ft + ⅔(19.2 ft - 5.0 ft) = 14.47 ft	
$M_V = (58.0)$	06 kip/ft)(9.60 ft) + (5	5.12 kip/ft)(14.47 ft) + (28.4 kip/ft)sin(6.8°)(19.2 ft) =	696.03 kip·ft/ft
Overturning Moment, M_H : $M_H = P_{EH}$	$\int_{U} \cos \theta(x_3) + P_U$	$s \cos \theta(x_4)$	
$P_{EH} = \frac{1}{2}$	$V_2 \gamma_{RS} h^2 K_a \gamma_{EH}$	$= \frac{1}{2}(120 \text{ pcf})(31.2 \text{ ft})^2(0.324)(1.50) = 28.40 \text{ ki}$	p/ft
$P_{IS} = c$	$\sigma_{IS}hK_a\gamma_{IS} =$	(250 psf)(31.2 ft)(0.324)(1.75) = 4.42 kip/ft	
$\uparrow P_{IS} \rightarrow P_{IS} \rightarrow$,		
x_3	3 = (31.2 ft) / 3	= 10.40 ft	
	<i>J</i>		
$- + + \bullet \qquad - + = = = = - + \delta \qquad x_4 = h/2$	2' = (31.2 ft) / 2	= 15.6 ft	
	2		
$M_{H} = (28.4)$	1 kip/ft)cos(6.8°)(10.4	40 ft) + (4.42 kip/ft)cos(6.8°)(15.60 ft) = 361.75 ki	ip∙ft/ft
	ת א		
Check Eccentricity Limiting Eccentricity	$e_{\text{max}} = \frac{B}{2}$	$\rightarrow e_{\text{max}} = (19.2 \text{ ft})/3 = 6.40 \text{ ft}$	
	/ 3		
$e < e_{\text{max}} \rightarrow 4.58 \text{ ft} < 6.40 \text{ ft}$	OK		



JOB	FRA-70-12.68			W-13-045			
SHEET NO.		4	OF	6			
CALCULATE	DBY	BRT	DATE	7/15/2018			
CHECKED B	Y	JPS	DATE	7/15/2018			
Retaining Wall 4W12 - Sta. 3004+50							

MSE wall Dimensions and Retained Soll Par	ameters	Bearing Soil Properties:	
MSE Wall Height, (<i>H</i>) =	25.2 ft	MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	19.2 ft	MSE Backfill Friction Angle, (φ_{BF}) =	<u>34</u> °
Distance from Wall Face to Toe of Backslope, $(l) =$	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	125 pcf
MSE Wall Length, (L) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	27 °
MSE Wall Effective Height. (h) =	31.2 ft	Bearing Soil Drained Cohesion, $(c_{RS}) =$	0 psf
Retained Soil Backslone (β) =	26.6 °	Bearing Soil Undrained Shear Strength [(s_)).	= 3125 nsf
Effective Detained Sail Packalone (4) -	6.8 °	Embedment Denth $(D_{i}) =$	3.0 ft
Effective Retailed Soli Backslope, (7) –	12.0 #	Depth to OW (Balaw Bat of Wall) (D) =	10 0 ft
Distance from Loe to Lop of Backslope, $(z) =$	12.0 π	Depth to GW (Below Bot. of Wall), $(D_W) =$	<u>16.9</u> π
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf		
Retained Soil Friction Angle, $(\varphi_{RS}) =$	<u>30</u> °	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 7 (AASHTO	
Retained Soil Active Earth Pressure Coeff., $(K_a) =$	0.324	Strength lb 1.35 1.50 1.75 - 3.4.1-1 a	and 3.4.1-2 - Active
Live Surcharge Load $(\sigma_{10}) =$	250 pef	Service I 1 00 1 00 1 00 Ea	rth Pressure)
1. Drained cohesion for retained soil not accounted for in external stab.	litv analyses. This parame	eter is utilized in global stability analysis.	
Check Bearing Capacity (Loading Case - Stre	ength Ib) - AASH	TO LRFD BDM Section 11.6.3.2	
P_{EV}			
	P /		
$q_{eq} =$			
מ י ן מ	/ D		
$x_4 P_{uv} P_{LSv} + P_{LS} P_{LS}$	-P 2a -	10.2 ft - 2/3.34 ft - 12.52 ft	
$P_{EH} \rightarrow P_{EH} \rightarrow P_{EH} \rightarrow P_{EH}$	= D - 2e -	19.2 II - 2(3.34 II) - 12.32 II	
\bigwedge^{λ_3}	R /		
$P \downarrow \downarrow$	$e = \frac{D}{2} - x_o$	= (19.2 ft / 2) - 6.26 ft = 3.34 ft	
	$\tilde{M} - M$	•	
	$x_o = \frac{m_V}{-}$	H = (917.00 kip·ft/ft - 361.75 kip·ft/ft) / 88.65 kip	/ft = 6.26 ft
$x_0 \leftarrow + + e$	P_{V}		
R/			
$(-\frac{1}{2})^2$	— (88.65 kin	/ft)/(12.52.ft) - 7.08 kef	
$\leftarrow B' \rightarrow P'$			
$x_2 \rightarrow x_2$			
	<u>, , , , , , , , , , , , , , , , , , , </u>		
Resisting Moment, M_V : $M_V = P_E$	$P_{V_1}(x_1) + P_{EV_2}(x_1)$	$_{2}) + P_{EH} \sin \theta(B)$	
	1 2		
$P_{FV} = P_{FV}$	$= \gamma_{PF} \cdot H \cdot B \cdot \gamma$	r_{rrv} = (120 pcf)(25.2 ft)(19.2 ft)(1.35) = 78.38	3 kip/ft
	/ BF /		
	$1/\alpha$ $(h$ $H)$	$P = I_{ac} = \frac{1}{(120 \text{ pcf})(31.2 \text{ ft} - 25.2 \text{ ft})(19.2 \text{ ft} - 5.0 \text{ ft})(1.35)}{1}$)= 6.91 kin/ft
$EV_2 =$	$\gamma_2 \gamma_{RS} (n - 11) (.$	$B = I f F_{EV} = 72(120 \text{ pol})(01.2 \text{ K} - 20.2 \text{ K})(10.2 \text{ K} - 0.0 \text{ K})(10.3 \text{ K})$	/ 0.01 Kip/it
$P_{TT} \xrightarrow{P_{LS}} P_{LS}$	1/ 12 17		
$ P_{EH} = P_{EH}$	$= \frac{V_2 \gamma_{RS} h^2 K_a \gamma_1}{\gamma_1}$	$_{EH} = \frac{1}{2}(120 \text{ pcf})(31.2 \text{ ft})^2(0.324)(1.50) = 28.4$	kip/ft
P _{EH} , ¹ EH	D /		
$ \downarrow $	$B_{2} = (19.2 \text{ ft})$	/ 2 = 9.60 ft	
• • · · · · · · · · · · · · · · · · · ·	/ 2		
$\rightarrow x_1$ $x_2 =$	$1 + \frac{2}{8}(B-1)$	$= 50 \text{ ft} + \frac{3}{2}(192 \text{ ft} - 50 \text{ ft}) = 14.47 \text{ ft}$	
$x_2 - x_2$	· · / 3 (B · /		
	2 2 kin/#)(0 60 #)	$1/(6.01 \text{ kin}/\text{ft})(11.5 \text{ ft}) + (29.4 \text{ kin}/\text{ft}) \text{sin}(6.8^{\circ})(10.2 \text{ ft}) = -$	017 00 kin #/#
$M_{V} = (n)$	ο.σο κιρ/π)(9.60 Π)	$+ (0.91 \text{ kip/ii})(14.5 \text{ ii}) + (28.4 \text{ kip/ii}) \sin(6.8^{\circ})(19.2 \text{ ft}) =$	ອ⊤7.00 KIP·π/ft
	·····		
Overturning Moment, M_H : $M_H = P$	$e_{EH}\cos\theta(x_3) +$	$P_{LS}\cos\theta(x_4)$	
$P_{rrr} =$	$\frac{1}{2}\gamma_{\rm pc}h^2 K \gamma$	$\frac{1}{2}$ = $\frac{1}{2}(120 \text{ pcf})(31.2 \text{ ft})^2(0.324)(1.50)$ = 28.40	kip/ft
	$721 \text{ KS}^{-1} = a11$	${m m}$	
P - P	$\sigma h K \chi -$	-(250 psf)(31.2 ft)(0.324)(1.75) - 4.42 kin/ft	
x_4	$O_{LS} m_a \gamma_{LS}$ -		
$P_{LS_{h}}$	h/ into in		
x_3	$\frac{1}{3} = (31.2 \text{ ft})$	/3 = 10.40 ft	
	1./		
\bot \downarrow	n/2 = (31.2 ft)	/ 2 = 15.6 ft	
	2		
$M_{II} = (2)$	8.4 kip/ft)cos(6.8°)	10.40 ft) + (4.42 kip/ft)cos(6.8°)(15.60 ft) = 361.75	kip·ft/ft
			•
Vertical Forces P_{\cdots} D_{\cdots}		cin A	
$\mathbf{r}_{V} = \mathbf{r}_{EV}$	$\tau \Gamma_{EV_2} + \Gamma_{EH}$	2111 6	
P_{V} =	78.38 kip/ft + 6	.91 kip/ft + $(28.4 \text{ kip/ft})\sin(6.8^{\circ}) = 88.65 \text{ kip/ft}$	



JOB	FRA-7	0-12.68	NO.	W-13-045		
SHEET NO.		5	OF	6		
CALCULATED) BY	BRT	DATE	7/15/2018		
CHECKED BY		JPS	DATE	7/15/2018		
Retaining Wall 4W12 - Sta. 3004+50						

MSE Wall Dimensions and Retained Soil Para	neters	Bearing Soil Pro	perties:	
MSE Wall Height, (<i>H</i>) =	25.2 ft	MSE Backfill Unit \	$Weight, (\gamma_{BF}) =$	120 pcf
MSE Wall Width (Reinforcement Length). (B) =	19.2 ft	MSE Backfill Fricti	on Angle. $(\varphi_{PE}) =$	 34 °
Distance from Wall Face to Toe of Backslope (l) =	5.0 ft	Bearing Soil Unit V	Veight. $(\gamma_{PS}) =$	125 pcf
MSF Wall Length $(L) =$	935.0 ft	Bearing Soil Frictic	on Angle. $(\rho_{BS}) =$	27 °
MSE Wall Effective Height $(h) =$	31.2 ft	Bearing Soil Drain	ed Cohesion. $(c_{PS}) =$	0 nsf
Retained Soil Backslone $(\beta) =$	26.6 °	Bearing Soil Undra	ined Shear Strength [((3125 psf)
Effective Retained Soil Backslope, $(\beta) =$	<u> </u>	Embedment Depth	$(D_{c}) =$	30 ft
Distance from Toe to Ton of Backslope, $(\sigma) =$	12 0 ft	Denth to GW (Beld	w Bot of Wall) (D) =	7 0 ft
Betained Soil Unit Weight $(y_{-x}) =$	12.0 ncf		\mathcal{W} both of \mathcal{W} and \mathcal{W} ($\mathcal{D}_{\mathcal{W}}$) =	<u> </u>
Retained Soil Friction Angle (a_{RS}) =	30 °	I RFD I oad Fact	ore	
Retained Soil Drained Cobesion (c_{RS})	0 nsf	FV	FH IS	
Retained Soil Undrained Shear Strength $[(S_{RS})]$	2000 psf	Strength la 1.00	150 175 T	
Retained Soil Active Earth Pressure Coeff (K) =	0.324	Strength lb 1 35	1.50 1.76 (AASHTO LRFD BDM Tables
Live Surcharge Load $(\sigma_{ab}) =$	250 pcf	Service I 1.00	1.00 1.00	Earth Pressure)
1. Drained cohesion for retained soil not accounted for in external stability	y analyses. This parameter is	s utilized in global stability analysis.	1.00 1.00 3	
Check Bearing Capacity (Loading Case - Strer	ngth lb) - AASHTO	LRFD BDM Section 1	1.10.5.4 (Continued)	
Check Bearing Resistance - Drained Condition	<u>1</u>			
	$\cdot D N C +$	$1/\Delta D^{1}N$		
Nominal dealing Resistance: $q_n = c_l v_{cm} + c_l v_{cm}$	$\mathcal{P}_{f} \mathcal{P}_{qm} \mathcal{C}_{wq} +$	$\gamma_2 \gamma D N_{\gamma m} C_{w\gamma}$		
$N_{cm} = N_c s_c i_c = 23.94$	$V_{am} = N_a s_a d_a u$	a = 14.5	$N_{yyy} = N_y s_y i_y =$	= 14.5
	4	4	<i>,</i> ,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,	
N _c = 23.94	N_q = 13.20		$N_{\gamma} = 14.47$	
$S_c = 1+(12.52 \text{ ft}/935 \text{ ft})(13.2/23.94)$	$S_q = 1+(12.52 \text{ f}$	t/935 ft)tan(27°) = 1.000	$S_{\gamma} = 1-0.4(12.5)$	2 ft/935 ft) = 1.000
= 1.000	$d_q = 1+2\tan(27)$	°)[1-sin(27°)]²tan⁻¹(3.0 ft/12.52 ft)	$i_{\gamma} = 1.000$ (A	ssumed)
$i_c = 1.000$ (Assumed)	= 1.100		$C_{wy} = 7.9 \text{ft} < 1.5($	12.52 ft + 3.0 ft = 0.500
	$i_q = 1.000$ (A	Assumed)		
	$C_{wq} = 7.9 \text{ ft} > 3$	3.0 ft = 1.000		
Verify Equivalent Pressure Less Than Factore $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 7.08$ ksf \leq	<u>d Bearing Resista</u> (11.11 ksf)(0.65) =	<u>nce</u> 7.22 ksf →	7.08 ksf ≤ 7.22 ksf	
Use $\omega_{h} = 0.65$ (Per AASHTO RED BDM 1	Table 11 5 6-1)			
Check Bearing Resistance - Undrained Condit	ion			
Nominal Bearing Resistance: $q_n = cN_{cm} + cN_{cm}$	$\gamma D_f N_{qm} C_{wq} +$	$\frac{1}{2} \gamma B' N_{\gamma m} C_{w\gamma}$		
$N \rightarrow N g i = 5140$	N – Nadi	- 1000	N — Ngi-	- 0.000
$\frac{1}{cm} = \frac{1}{c} c^{2} c^{2} c c = -\frac{3.140}{c}$	$\mathbf{v}_{qm} - I \mathbf{v}_q \mathbf{S}_q \mathbf{u}_q \mathbf{l}$	<i>q</i> = 1.000	$1_{\gamma m} - 1_{\gamma} S_{\gamma} \iota_{\gamma} -$	- 0.000
N _c = 5.140	$N_a = 1.000$		$N_{} = 0.000$	
$S_c = 1+(12.52 \text{ ft/l}(5)(935 \text{ ft})) = 1.000$	$s_{a} = 1.000$		$s_{n} = 1.000$	
$i_c = 1.000$ (Assumed)	$d_q = 1+2\tan(0^{\circ})$	°)[1-sin(0°)]²tan ⁻¹ (3.0 ft/12.52 ft)	$i_{v} = 1.000$ (A	(ssumed)
	= 1.000		$C_{yy} = 7.9 \text{ft} < 1.50$	(12.52 ft) + 3.0 ft = 0.500
	$i_{x} = 1.000$ (4)	Assumed)	- wy	
	$C_{wq} = 7.9 \text{ ft} > 3$, 3.0 ft = 1.000		
$q_n = (3125 \text{ psf})(5.14) + (125 \text{ pcf})(3.0 \text{ ft})$	(1.0)(1.0) + ½(125	pcf)(12.5 ft)(0.0)(0.5)	= 16.44 ksf	
Verify Equivalent Pressure Less Than Factore	d Bearing Resista	nce		
$q_{eq} \leq q_n \cdot \phi_b \longrightarrow 7.08 \text{ksf} \leq ($	16.44 ksf)(0.65) = 1	10.69 ksf \rightarrow	7.08 ksf ≤ 10.69 ksf	OK
Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDM 1	able 11.5.6-1)			



JOB	FRA-70-12.68	NO.	W-13-045					
SHEET NO.	6	OF	6					
CALCULATED B	BRT	DATE	7/15/2018					
CHECKED BY	JPS	DATE	7/15/2018					
Retaining Wall 4W12 - Sta. 3004+50								

MSE Wall Dimensions and Retained Soil Parar	<u>neters</u>	Bearing Soil Properties:	
MSE Wall Height, $(H) =$	25.2 ft	MSE Backfill Unit Weight, $(\gamma_{BF}) = \frac{12}{3}$	20 pcf
MSE Wall Width (Reinforcement Length), (B) =	19.2 ft	MSE Backfill Friction Angle, $(\varphi_{BF}) =$	34 °
Distance from Wall Face to Toe of Backslope, $(l) =$	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) = 12$	25 pct
MSE Wall Length, $(L) =$	935.0 ft	Bearing Soil Friction Angle, $(\varphi_{BS}) = 2$	<u>27</u> °
MSE Wall Effective Height, $(h) =$	31.2 ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 312$	25 pst
Effective Retained Soil Backslope, (θ) =	6.8 °	Embedment Depth, $(D_f) = 3$.0 ft
Distance from I oe to I op of Backslope, $(z) =$	12.0 ft	Depth to GW (Below Bot. of Wall), $(D_W) = 16$.9 ft
Retained Soli Unit Weight, $(\gamma_{RS}) =$	120 pcf		
Retained Soli Friction Angle, $(\varphi_{RS}) =$	<u>30</u> °	<u>LRFD Load Factors</u>	
Retained Soil Undrained Conesion, $(c_{RS}) =$		$EV E\Pi LS$	
Retained Soli Ordrained Shear Strength, $[(S_u)_{RS}] =$	2000 psr	Strength la 1.00 1.30 1.75 (AASHTO LRFD BDM	Tables
Retained Soli Active Earth Pressure Coeff., $(\Lambda_a) =$	0.324	Strength ID 1.35 1.50 1.75 - 3.4.1-1 and 3.4.1-2 - 1 Earth Pressure)	ACUVE
Live Surcharge Load, (σ_{LS}) – 1. Drained cohesion for retained soil not accounted for in external stability	230 pst analyses. This parameter is	s utilized in global stability analysis.	
Settlement Analysis (Loading Case - Service I)	- AASHTO LRFD	BDM Section 11.10.4.1	
	D /		
$q_{eq} = 1$	$V_{R'}$		
$P_{re} \vdash P_{re}$	/ D		
P_{EV_1} $P_{IS'}$ $P_{IS'}$ $B'=$	B - 2e = 19.	2 ft - 2(2.88 ft) = 13.44 ft	
$\begin{array}{c c} x_3 \end{array} & P_{EH_v} & P_{EH} \end{array}$	~ /		
$\bigwedge \qquad P_{V} \qquad \qquad P_{EH_{h}} \neq 0 \qquad \qquad e$	$e = \frac{B}{2} - x_o =$	= (19.2 ft / 2) - 6.72 ft = 2.88 ft	
	M = M		
<u>x</u>	$c_o = \frac{m_V - m_H}{D}$	= (674.50 kip·ft/ft - 234.76 kip·ft/ft) / 65.42 kip/ft =	6.72 ft
$x_o \leftarrow \leftrightarrow \rightarrow \cdots \leftarrow e$	P_{V}		
q_{eq}	= (65.42 kip/ft)	/ (13.44 ft) = 4.87 ksf	
$ \begin{array}{c} p \\ - r_{-} \end{array} $			
$M_{V} = P_{EV_{1}}(x_{1}) + P_{EV_{2}}(x_{2}) + P_{EH} \sin \theta(B) = (\gamma_{BF} H)$	$(B\gamma_{EV})(\frac{1}{2}B) + (\frac{1}{2}\gamma)$	$\gamma_{RS}(h-H)(B-l)\gamma_{EV}(l+\frac{2}{3}(B-l)) + \left(\frac{1}{2}\gamma_{RS}h^2K_a\gamma_{EH}\sin\theta\right)$	P(B)
$M_V = [(120 \text{ pcf})(25.2 \text{ ft})(19.2 \text{ ft})(1.00)][\frac{1}{2}(19.2 \text{ ft})] +$	[1/2(120 pcf)(31.2 ft - 25.2	$(2 \text{ ft})(19.2 \text{ ft} - 5.0 \text{ ft})(1.00)][5.0 \text{ ft} + \frac{2}{3}(19.2 \text{ ft} - 5.0 \text{ ft})] = 674.5 \text{ k}$.ip∙ft/ft
+ [½(120 pcf)(31.2 ft)²(0.324)(1.00)sin(6.	.8°)](19.2 ft)		
$M_{H} = P_{EH} \cos \theta(x_{3}) + P_{LS} \cos \theta(x_{4}) = (\frac{1}{2}\gamma_{RS}h^{2})$	$K_a \gamma_{EH} \cos\theta (n_3)$	$+(\sigma_{LS}hK_a\gamma_{LS}\cos\theta)n/2)$	
$M_H = \frac{1}{2} [(120 \text{ pcf})(31.2 \text{ ft})^2(0.324)(1.00)\cos(60)]$	(31.2 ft / 3) =	= 234.76 KIP·ft/ft	
+ [(250 psf)(31.2 ft)(0.324)(1.00)cos(6	5.8°)](31.2 π /2)		
$\mathbf{P} = \mathbf{P} + \mathbf{P} + \mathbf{P} = \sin \theta - (\alpha + \mathbf{H} \mathbf{P} \alpha)$	$(1/\alpha)$ $(h U)$	h = h + h + h + h + h + h + h + h + h +	
$P_V = P_{EV_1} + P_{EV_2} + P_{EH} \operatorname{Sin} \Theta = (\gamma_{BF} H B \gamma_{EV}) + P_{EV} \operatorname{Sin} \Theta$	$(\gamma_2 \gamma_{RS} (n - H))$	$(2 - l)\gamma_{EV} + (\gamma_2 \gamma_{RS} n \kappa_a \gamma_{EH} \sin \theta)$	
$P_{} = (120 \text{ pcf})(25.2 \text{ ft})(19.2 \text{ ft})(1.00) + \frac{1}{2}(120)$	pcf)(31 2 ft - 25 2 ft)((19.2 ft - 5.0 ft)(1.00) = 65.42 kip/ft	
$T_V = (120 \text{ pol})(202 \text{ ft})(1002 \text{ ft})(1000) + \frac{1}{2}(120 \text{ ft})(1000) + 1$	$sin(6.8^{\circ})$		
	,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		
Settlement (See Attached Spreadsheet Calcula	ations):		
Total Settlement at Center of Reinforced Soil I	Mass: $S_t =$	2.192 in	
Total Settlement at Wall Facing	с –	1634 in	
ime Rate of Consolidation Settlement at Wall	Facing (See Attac	ched Spreadsheet Calculations):	
$(S_c)_{100} =$ in at d	lays following	completion of construction	

W-13-045 - FRA-70-12.68 - MSE Wall 4W12 MSE Wall Settlement - Sta. 3004+50

Borings B-110-0-15 and B-110-1-15

H=	25.2	ft	Total wall height
B'=	13.4	ft	Effective footing width due to eccentricity
D _w =	19.9	ft	Depth below bottom of footing
q _e =	4,870	psf	Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	t Center of Re	einforced So	il Mass		Total Set	tlement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type	Layer (i	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	⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	(7)	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
	A-1-b	G	0.0	1.5	1.5	0.8	125	188	94	94	4,094					29	58	205	0.06	0.994	4,841	4,935	0.013	0.151	0.500	2,435	2,529	0.010	0.125
1	A-1-b	G	1.5	3.5	2.0	1.8	125	438	313	313	4,313					29	47	157	0.13	0.976	4,755	5,068	0.015	0.185	0.500	2,435	2,748	0.012	0.144
	A-1-b	G	3.5	6.5	3.0	3.3	125	813	625	625	4,625					29	40	132	0.24	0.947	4,612	5,237	0.021	0.252	0.500	2,435	3,060	0.016	0.188
	A-4a	G	6.5	9.5	3.0	4.8	120	1,173	993	993	4,993					55	68	111	0.35	0.924	4,498	5,490	0.020	0.240	0.484	2,357	3,350	0.014	0.171
	A-4a	G	9.5	12.5	3.0	6.3	120	1,533	1,353	1,353	5,353					55	62	103	0.47	0.880	4,286	5,638	0.018	0.217	0.464	2,260	3,612	0.012	0.149
2	A-4a	G	12.5	15.5	3.0	7.8	120	1,893	1,713	1,713	5,713					55	58	96	0.58	0.800	3,896	5,609	0.016	0.192	0.448	2,182	3,894	0.011	0.133
2	A-4a	G	15.5	18.5	3.0	9.3	120	2,253	2,073	2,073	6,073					55	54	91	0.69	0.717	3,490	5,563	0.014	0.169	0.428	2,084	4,157	0.010	0.119
	A-4a	G	18.5	22.5	4.0	11.3	120	2,733	2,493	2,493	6,493					55	51	86	0.84	0.644	3,138	5,631	0.016	0.197	0.404	1,967	4,460	0.012	0.141
	A-4a	G	22.5	27.5	5.0	13.8	120	3,333	3,033	3,033	7,033					55	47	81	1.03	0.567	2,760	5,792	0.017	0.209	0.383	1,865	4,897	0.013	0.155
3	A-6b	С	27.5	30.5	3.0	15.3	125	3,708	3,520	3,520	7,520	39	0.261	0.026	0.577				1.14	0.511	2,489	6,009	0.012	0.138	0.369	1,795	5,315	0.009	0.107
4	A-1-b	G	30.5	35.5	5.0	17.8	130	4,358	4,033	4,033	8,033					61	47	156	1.32	0.457	2,226	6,259	0.006	0.073	0.349	1,698	5,730	0.005	0.059
4	A-1-b	G	35.5	41.5	6.0	20.8	130	5,138	4,748	4,694	8,694					61	44	144	1.55	0.395	1,926	6,620	0.006	0.075	0.323	1,572	6,267	0.005	0.063
5	A-4a	С	41.5	43.5	2.0	21.8	125	5,388	5,263	5,147	9,147	22	0.108	0.011	0.444				1.62	0.382	1,859	7,007	0.002	0.024	0.314	1,531	6,678	0.002	0.020
6	A-3a	G	43.5	48.5	5.0	24.3	130	6,038	5,713	5,441	9,441					55	37	103	1.81	0.350	1,705	7,146	0.006	0.069	0.296	1,442	6,883	0.005	0.060
1. $\sigma_{\rm p}' = \sigma_{\rm v}$	o'+σ _m Estima	te σ_m of 4,0	00 psf for mo	oderately ove	erconsolidate	d soil deposi	t; Ref. Table	e 11.2, Codu	uto 2003											1	Tota	al Settlement:		2.192 in		Tota	Settlement:		1.634 in

2. C_c = 0.009(LL-10); Ref. Table 26, FHWA GEC 5

3. $C_r = 0.05(C_c)$ for embankment fill and $0.10(C_c)$ for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5

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

5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ 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. $S_c = [C_o/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{p'})$ for $\sigma_{vo}' < \sigma_{p}' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv 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)

Calculated By:	BRT	Date:	7/17/2018		
Checked By:	JPS	Date:	7/17/2018		







јов Б	RA-70-12.68	NO.	W-13-045					
SHEET NO.	2	OF	6					
CALCULATED BY	BRT	DATE	7/15/2018					
CHECKED BY	JPS	DATE	7/15/2018					
Retaining Wall 4W12 - Sta. 3005+50								

SE Wall Dimensions and Retain	ed Soil Param	<u>eters</u>		Bearing S	Soil Pro	perties					
SE Wall Height, (<i>H</i>) =		18.2 ft		MSE Back	fill Unit V	Veight, (γ _{BF})=				120 po
SE Wall Width (Reinforcement Length	:h), (<i>B</i>) =	16.0 ft		MSE Back	fill Frictio	on Angle	$(\varphi_{BF}) =$	=			34 °
istance from Wall Face to Toe of Bacl	kslope, (<i>l</i>) =	5.0 ft		Bearing Se	oil Unit V	/eight, (y	_{BS}) =				120 p
SE Wall Length, (<i>L</i>) =		935.0 ft		Bearing Se	oil Frictio	n Angle,	$(\varphi_{BS}) =$				28 °
SE Wall Effective Height, (<i>h</i>) =		23.7 ft		Bearing Se	oil Draine	d Cohes	sion, (c_B	_{es}) =			0 ps
etained Soil Backslope, (β) =		26.6 °		Bearing Se	oil Undra	ined She	ar Strei	ngth, [$(s_u)_{BS}$]	= 2	2625 ps
ffective Retained Soil Backslope, (θ) :	=	15.4 °		Embedme	nt Depth	$(D_{f}) =$					3.0 ft
istance from Toe to Top of Backslope	e, (z) =	20.0 ft		Depth to C	W (Belo	w Bot. o	f Wall),	(D_W)	=		19.1 ft
etained Soil Unit Weight, $(\gamma_{RS}) =$		120 pcf									
etained Soil Friction Angle, (φ_{RS}) =		30 °		LRFD Lo	ad Fact	ors					
etained Soil Drained Cohesion, (c_{RS}) =	=	0 psf			EV	EH	LS				
etained Soil Undrained Shear Strengtl	$(h, [(S_u)_{RS}] =$	2000 psf		Strength la	a 1.00	1.50	1.75	٦	(AASUT		
etained Soil Active Earth Pressure Co	$\operatorname{coeff.}(K_a) =$	0.374		Strength II	0 1.35	1.50	1.75	-	3.4.1-1	and 3.4.1-2	2 - Active
ve Surcharge Load, (σ_{LS}) =		250 psf		Service I	1.00	1.00	1.00		E	arth Pressu	ıre)
. Drained cohesion for retained soil not accounted fo	or in external stability a	nalyses. This par	rameter is utilized	in global stabil	ity analysis.						
heck Sliding (Loading Case - Str	<u>rength la) - AA</u>	SHTO LRF	D BDM Sec	tion 11.1	0.5.3 (Ca	ntinued)					
heck Sliding Resistance - Undra	ined Conditio	<u>n</u>									
	P = ((S))	<i>(a</i>)	D								
Nominal Sliding Resisting:	$K_{\tau} = ((S_u))$	$BS \geq q_s$).	D								
P_{EV_2}	(९) -	- 262	kaf								
	$(\mathcal{O}_u)_{BS}$ -	- 2.03	KST								
	$a - \sigma_v$	/									
P_{EV} P_{LSv}	$q_s - /$	[′] 2									
P_{FF}	н _	P_{v} /									
	$\sigma_v =$	'/B									
$R_{\underline{\tau}} = \frac{R_{\underline{\tau}}}{2}$	α	י מ	ת ו ת	-:- 0							
	P_V	$P = P_{EV_1} + $	$P_{EV_2} + P_{EP}$	$r \sin \theta$							
$(S_u)_{BS} \leq q_s$		~	77 D		(100		(10.0.5)				
		$P_{EV_1} = \gamma_B$	$_{H} \cdot H \cdot B \cdot \gamma$	' _{EV} =	(120 pct)(18.2 π)	(16.0 ft))(1.00)) =	34.94	kıp/ft
(Neglect P_{LSv} for conservatism)		D 1/	(1								
		$P_{EV_2} = \frac{1}{2}$	$\gamma_{RS}(h-H$	$(B-l)\gamma$	EV						
		D	1//100		10 0 4)/4	C O A F	0 4)/4 /	202	<u> </u>	C4 1.:	164
		Γ_{EV_2} =	⁷ ₂(1∠0 pc)(23.7 п -	18.2 T)(1	ο.υ π - 5	.0 π)(1.0)))	= 3	.04 кір	/π
		D 1/	$h^2 V$	_ 1	/(120 pc	f)/23 7 fi)2/0 37/	1)(1 50)) –	18 02	kin/ft
		$P_{EH} = \frac{\gamma_2}{2}$	$\gamma_{RS} n \kappa_a \gamma$	ЕН — .	/2(120 pc	1)(23.7 11) (0.374	+)(1.50	") –	10.92	кір/п
	P	- 34.04	kin/ft + 3.64	kin/ft + (1)	2 02 kin/f	t)ein(15	1°) –		3.6	kin/ft	
	1 V	- 34.34	· KIP/IL + 3.04	кір/п. т. (п.	5.52 KIP/I	t)5iii(13.4	+, –		5.0	кір/п	
	σ =	(43.6 kir	o/ft) / (16.0.ft	_	2 7 3	kef					
	ο _ν –	(+0.0 Kip	<i>s/it) /</i> (10.0 it	. –	2.13	K91					
	a - (:	2 73 ksf) / 2	- 137	kef							
	$q_s - (2$	2.75 K31)7 Z	- 1.57	K91							
	R = (2)	63 ksf < 1 37	′ ksf)(16 0 ft)		42 00	kin/ft					
	Λ_{τ} – (2.)	00 Kar = 1.07	K31)(10.0 It)		72.00	кірлі					



JOB	FRA-70-12.68			W-13-045				
SHEET NO.		3	OF	6				
CALCULATED	BY	BRT	DATE	7/15/2018				
CHECKED BY	-	JPS	DATE	7/15/2018				
Retaining Wall 4W12 - Sta. 3005+50								

MSE Wall Dimensions and Retained Soil Parar	neters	Bearing Soil Properties:	
MSE Wall Height, (H) =	18.2 ft	MSE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	16.0 ft	MSE Backfill Friction Angle, $(\varphi_{BF}) =$	34 °
Distance from Wall Face to Toe of Backslope, $(l) =$	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
MSE Wall Length, (L) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	28 °
MSE Wall Effective Height, (h) =	23.7 ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 psf
Retained Soil Backslope, (β) =	<u>26.6</u> °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	2625 psf
Effective Retained Soil Backslope, (θ) =	<u>15.4</u> °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	20.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	19.1 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf		
Retained Soil Friction Angle, $(\varphi_{RS}) =$	<u>30</u> °	LRFD Load Factors	
Retained Soil Drained Cohesion, $(c_{RS}) =$	0 psf	EV EH LS	
Retained Soil Undrained Snear Strength, $[(S_u)_{RS}] =$	2000 pst	Strength la 1.00 1.50 1.75 (AASHTO LR)	FD BDM Tables
Retained Soil Active Earth Pressure Coeff., $(K_a) =$	0.374	Strength Ib 1.35 1.50 1.75 - 3.4.1-1 and 3 Earth F	3.4.1-2 - Active Pressure)
LIVE SUICONAIGE LOAD, (σ_{LS}) = 1. Drained cobesion for retained soil not accounted for in external stability	250 pst	Service I 1.00 1.00 1.00 J	
Check Eccentricity (Loading Case - Strength la	a) - AASHTO LRF	D BDM Section 11.6.3.3	
$e = \frac{B}{2} - \frac{B}{2}$	x _o		
$P_{LS} = P_{LS} = P_{LS} = M$	и — М		
$\begin{array}{c c} X_4 \\ \uparrow \end{array} \mid P_{EV_1} \\ P_{LS_{h}} \\$	$\frac{V + H}{P} = (40)$	$4.79 \text{ kip} \cdot \text{ft/ft} - 188.43 \text{ kip} \cdot \text{ft/ft} / (43.6 \text{ kip/ft}) = 4.96$	ft
X_3 P_{EH_v} P_{eH_v} P_{eH_v}	P_V		
R			
	· = 404.79	kip ft/ft ☐ Defined below	
	r = 188.43 I		40.00 1.1 //
$x_0 \leftarrow + e$	$= P_{EV_1} + P_{EV_2} +$	$P_{EH} \sin \theta$ = 34.94 kip/ft + 3.64 kip/ft + (18.92 kip/ft)sin(15.4 ⁺) =	^{43.60} κιρ/π
$x_1 \leftarrow B_2 \rightarrow$	(16.0.ft/2) 4.06	f = 304	
e =	(10.0 10 2) - 4.90	II = 3.04 II	
Resisting Moment, M_{ν} : $M - P$	(r) + P(r)	$+ P \sin \theta(R)$ (Neglect P_{rg} for conservation	atism)
$P_{}$	$(x_1) \cap I_{EV_2}(x_2)$	<i>EH</i> SIII (IOGIOULI <u>ES</u> , IOLOGIOULI	20011)
$P_{rv} = r$	$\gamma_{nr} \cdot H \cdot B \cdot \gamma_{rr}$	f = (120 pcf)(18.2 ft)(16.0 ft)(1.00) = 34.94	kip/ft
	(BF		
$P_{EV} = \frac{1}{2}$	$\gamma_{2} \gamma_{RS} (h - H) (B - H)$	$(l)\gamma_{FV} = \frac{1}{2}(120 \text{ pcf})(23.7 \text{ ft} - 18.2 \text{ ft})(16.0 \text{ ft} - 5.0 \text{ ft})(1.00) =$	3.64 kip/ft
P_{EV_1} LS_{V} LS_{D}			
P_{EH}	$\frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{FH}$	= $\frac{1}{2}(120 \text{ pcf})(23.7 \text{ ft})^2(0.374)(1.50)$ = 18.92 kip	/ft
	16 u. En		
• $x_1 = B$	2 = (16.0 ft) / 2	2 = 8.00 ft	
$\longmapsto x_{I}$	2		
	$+\frac{2}{3}(B-l) =$	$5.0 \text{ ft} + \frac{2}{3}(16.0 \text{ ft} - 5.0 \text{ ft}) = 12.33 \text{ ft}$	
$M_{V} = (34.5)$	94 kip/ft)(8.00 ft) + ($3.64 \text{ kip/ft}(12.33 \text{ ft}) + (18.92 \text{ kip/ft})\sin(15.4^{\circ})(16 \text{ ft}) = 4$	104.79 kip·ft/ft
Overturning Moment. M_{μ} : $M - P$	$\cos\theta(r) + F$	$P \cos \theta(\mathbf{r})$	
H	$\frac{1}{1}\cos(x_3) + 1$		
$P_{EH} = 2$	$V_2 \gamma_{RS} h^2 K_a \gamma_{EH}$	= $\frac{1}{2}(120 \text{ pcf})(23.7 \text{ ft})^2(0.374)(1.50)$ = 18.92 kip	/ft
r_{r} $P_{LS} = c$	$\sigma_{LS} h K_a \gamma_{LS} =$	(250 psf)(23.7 ft)(0.374)(1.75) = 3.88 kip/ft	
$ \begin{array}{c} \begin{array}{c} & & \\ \uparrow \\ \uparrow \end{array} \end{array} = \begin{array}{c} \begin{array}{c} \\ \\ \end{array} \end{array} \begin{array}{c} \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \\ \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \\ \\ \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \\ \\ \\ \end{array} \end{array} \begin{array}{c} \\ \\ \\ \\ \\ \\ \\ \end{array} \end{array} $			
x_3	3 = (23.7 ft)/3	3 = 7.90 ft	
h			
\rightarrow \rightarrow $x_4 = t/$	2 = (23.7 ft)/2	2 = 11.85 πt	
- /18 a	2 kip/ft)cos(15 4°)/7	90 ft) + (3 88 kip/ft)cos(15 4°)(11 85 ft) - 188 43 kip	∖.ft/ft
$\mu_{H} = (10.9)$	2 KIP/11/005(10.4)(7	100 Kp^{-1} (0.00 Kp/r)(000 10.4)(11.00 II) = 100.43 Kp	ייועונ
	~ /		
Check Eccentricity Limiting Eccentricity	$e_{\text{max}} = \frac{B}{2}$	$\rightarrow e_{\text{max}} = (16.0 \text{ ft}) / 3 = 5.33 \text{ ft}$	
	/ 3		
$e < e_{\rm max} \rightarrow 3.04 {\rm ft} < 5.33 {\rm ft}$	OK		



JOB	FRA-	70-12.68	NO.	W-13-045				
SHEET NO.		4	OF	6				
CALCULATE	D BY	BRT	DATE	7/15/2018				
CHECKED B	Y	JPS	DATE	7/15/2018				
Retaining Wall 4W12 - Sta. 3005+50								

MSE Wall Dimensions and Retained Soil Para	meters	Bearing Soil Properties:	
MSE Wall Height (H) =	18.2 ft	$MSE Backfill Unit Weight (y_{pg}) =$	120 pcf
MSE Wall Width (Reinforcement Length) $(R) =$	16.0 ft	MSE Backfill Friction Angle $(a_{}) =$	34 °
Distance from Wall Ease to Tag of Paskalana (1) =	50.0 IL	Bearing Soil Unit Weight $(\gamma) =$	120 p.f
Distance from wail Face to fibe of backslope, $(l) = MCE$ Well exists $(L) =$	<u> </u>	Bearing Soil Critical Angle $(\gamma_{BS}) =$	
	935.0 II	Bearing Soil Friction Angle, $(\varphi_{BS}) =$	20
MSE Wall Effective Height, (<i>h</i>) =	23.7 ft	Bearing Soli Drained Conesion, $(c_{BS}) =$	0 pst
Retained Soil Backslope, (β) =	<u>26.6</u> °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	2625 psf
Effective Retained Soil Backslope, (θ) =	<u>15.4</u> °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, (z) =	20.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	19.1 ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	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	
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.374	(AASHTOLE) Strength lb 1.35 1.50 1.75 ⊢ 3.4.1-1 and	3.4.1-2 - Active
Live Surcharge Load $(\sigma_{12}) =$	250 pef	Service 1 1 00 1 00 1 00 Earth	Pressure)
1. Drained cohesion for retained soil not accounted for in external stabili	ty analyses. This parameter	is utilized in global stability analysis.	
Check Bearing Capacity /Leading Case Stre	nath lb) AASUT(LIPED BDM Section 11622	
Check Bearing Capacity (Loading Case - Stre	ngth ID) - AASHI (D LRFD BDM Section 11.6.3.2	
P_{EV_2}			
	P_{ν} /		
$q_{eq} =$	'/B'		
$x_i = P_{IS} + P_{IS}$			
$\bigwedge^{4} P_{EV_1} P_{IV_1} P_{IV_2} P_{IV_2} B' = B' =$	= B - 2e = 16	6.0 ft - 2(2.22 ft) = 11.56 ft	
X_3	n /		
Γ_{EH_h}	$e = \frac{B}{2} - x_o$	= (16.0 ft / 2) - 5.78 ft = 2.22 ft	
	$x_{I} = \frac{M_{V} - M_{H}}{2}$	- = (518.29 kip·ft/ft - 188.43 kip·ft/ft) / 57.10 kip/ft	= 5.78 ft
$x_{\rho} \leftarrow \Rightarrow \rightarrow -1 - 1 - \rho$	P_{V}		
B/			
$\leftarrow \frac{1}{2}$	— (57.1 kin/ft)	/(11.56 ft) - 4.94 kef	
$\leftarrow B' \rightarrow \Box$	— (37.1 Kip/it)	7 (11.30 it) - 4.84 KSI	
$x_2 \rightarrow \lambda$			
Resisting Moment, M_V : $M_V = P_{EV}$	$Y_{1}(x_{1}) + P_{EV_{2}}(x_{2})$	$+P_{EH}\sin\theta(B)$	
P_{EV_2} $P_{EV_1} =$	$\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$	$_{V}$ = (120 pcf)(18.2 ft)(16.0 ft)(1.35) = 47.17	kip/ft
$P_{EV_{2}} =$	$\frac{1}{2}\gamma_{RS}(h-H)(B)$	$(-l)\gamma_{EV} = \frac{1}{2}(120 \text{ pcf})(23.7 \text{ ft} - 18.2 \text{ ft})(16.0 \text{ ft} - 5.0 \text{ ft})(1.35) =$	· 4.91 kip/ft
P_{IS}			
P_{EV_1} P_{EV_1} P_{EV_2} P_{EV_2}	$\frac{1}{2} \gamma_{PS} h^2 K_a \gamma_{FH}$	= $\frac{1}{2}(120 \text{ pcf})(23.7 \text{ ft})^2(0.374)(1.50)$ = 18.92 ki	p/ft
P_{EH}	1 2 1 K3 U1 EH		
\downarrow \downarrow \uparrow \downarrow χ $x_{\star} = E$	$B_{2} = (16.0 \text{ ft})/3$	2 = 8.00 ft	
\bullet	⁷ 2 ` '		
$\mapsto x_1$ $\mathbf{r} = 1$	$+ \frac{2}{(R-1)} =$	$50 \text{ ft} + \frac{3}{2}(160 \text{ ft} - 50 \text{ ft}) = 12.33 \text{ ft}$	
$x_2 - t_1 \longrightarrow x_2$	1/3 (D 1)		
<u>Г</u>	17 kin/ft)/9.00 ft) 1	(4, 0.1 kin/ft)(12, 2, ft) + (12, 0.2 kin/ft) sin(12, 4%)(16, ft) =	519.20 kin #/#
$\mathcal{M}_{\mathcal{V}} = (47)$		(+.31 NIP/IL)(12.3 IL) + (10.32 KIP/IL)SIN(13.4)(10 IL) =	στο.∠σ κιρ∙π/π
Overturning Marsont M	ο <i>ι</i>		
Overturning Moment, M_H : $M_H = P_E$	$H_H \cos\theta(x_3) + P$	$L_{S} \cos \theta(x_4)$	
$\dot{P}_{EH} =$	$\frac{1}{2}\gamma_{RS}h^2K_a\gamma_{EH}$	$= \frac{1}{2}(120 \text{ pcf})(23.7 \text{ ft})^2(0.374)(1.50) = 18.92 \text{ kip}$	p/ft
$P_{LS} =$	$\sigma_{IS}hK_a\gamma_{IS} =$	(250 psf)(23.7 ft)(0.374)(1.75) = 3.88 kip/ft	
$\begin{bmatrix} x_4 \\ A \end{bmatrix}$			
x_3 $	l/2 = (23.7 ft)/3	3 = 7.90 ft	
	3		
$\perp \perp \downarrow \downarrow$	$\frac{1}{2} = (23.7 \text{ ft})/2$	2 = 11.85 ft	
	2 (
M – (10 c	02 kin/ft)coc(15 4°)/7	'90 ft) + (3.88 kin/ft)cos(15.4°)(11.85 ft) - 199.42 ki	n•ft/ft
	· · · · · · · · · · · · · · · · · · ·	100 K	
	52 KIP/IL/COS(10.4)(7		
Vartical Ecross D : D D			
Vertical Forces, P_V : $P_V = P_{EV_1}$	$+ P_{EV_2} + P_{EH} \text{ si}$	n 0	
Vertical Forces, P_{V} : $P_{V} = P_{EV_{1}}$	$+P_{EV_2}+P_{EH}$ si	nθ	
M_H (constrained on the second	$+P_{EV_2} + P_{EH}$ si 47.17 kip/ft + 4.91	n ∂ kip/ft + (18.92 kip/ft)sin(15.4°) = 57.1 kip/ft	
Vertical Forces, P_{V} : $P_{V} = P_{EV_{1}}$ $P_{V} =$	$+ P_{EV_2} + P_{EH}$ si 47.17 kip/ft + 4.91	n θ kip/ft + (18.92 kip/ft)sin(15.4°) = 57.1 kip/ft	



JOB	FRA-70-12.68			W-13-045				
SHEET NO.		5	OF	6				
CALCULATED	BY	BRT	DATE	7/15/2018				
CHECKED BY	-	JPS	DATE	7/15/2018				
Retaining Wall 4W12 - Sta. 3005+50								

MSE Wall Dimensions and Retained Soil Para	ameters	Bearing Soil Pro	verties:	
MSE Wall Height (H) =	18.2 ft	MSE Backfill Unit W	/eight (ypg) =	120 ncf
MOE Wall Height, $(H) =$	16.0 ft	MSE Backfill Frictio	n Angle $(a_{}) =$	
Distance from Wall Face to Toe of Backslone $(1) =$	<u>50</u> ft	Bearing Soil Unit W	eight $(y_{RF}) =$	120 ncf
MSE Wall Length $(I) =$	0.0 it 035.0 ft	Bearing Soil Eriction	$\Delta nale (m_{}) =$	28 °
MOE Wall Effective Height $(h) =$	23.7 ft	Bearing Soil Draine	d Cohesion $(c_{}) =$	0 nef
Batained Soil Backslone (β) =	20.7 IL 26.6 °	Bearing Soil Undrai	ned Shear Strength $[(a)$	$\frac{0}{1}$ psi
Effective Petained Soil Backslope (β) =	<u> </u>	Embedment Depth	$(D_{-}) =$	<i>u JBS</i>] – <u>2020</u> psi 3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	20.0 ft	Denth to GW (Belov	$(D_f)^{-}$	7.0 ft
Betained Soil Unit Weight $(y_{-2}) =$	120.0 it		(D, W) = (D, W)	<u> </u>
Retained Soil Friction Angle (a_{RS})	30 °	I RFD I oad Fact	re	
Retained Soil Drained Cohesion (c_{RS})	0 psf	FV	FH IS	
Retained Soil Undrained Shear Strength $[(S_{1})_{ng}] =$	2000 psf	Strength la 1.00	1.50 1.75	
Retained Soil Active Earth Pressure Coeff. $(K_{-}) =$	0.374	Strength lb 1 35	1 50 1 75 -	AASHTO LRFD BDM Tables 3.4.1-1 and 3.4.1-2 - Active
Live Surcharge Load. $(\sigma_{LS}) =$	250 psf	Service I 1.00	1.00 1.00	Earth Pressure)
1. Drained cohesion for retained soil not accounted for in external stabil	lity analyses. This parameter is	utilized in global stability analysis.	1.00 1.00 -	
Check Bearing Capacity (Loading Case - Stre	ength Ib) - AASHTO	LRFD BDM Section 11	.10.5.4 (Continued)	
Check Bearing Resistance - Drained Condition	<u>on</u>			
Nominal Bearing Resistance: $a = cN$	$+ \gamma D_c N C +$	½γB'N C		
$q_n = cr_{cm}$	$f^{1} qm \vee wq^{1}$	/ 2 / ' γm [~] wγ		
$N_{cm} = N_c s_c i_c = 25.8$	$N_{qm} = N_q s_q d_q i_q$, = 16.2	$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} =$	• 16.7
N _c = 25.80	N_q = 14.72		$N_{\gamma} = 16.72$	
$S_c = 1+(11.56 \text{ ft}/935 \text{ ft})(14.72/25.8)$	$S_a = 1+(11.56 \text{ ft})$	935 ft)tan(28°) = 1.000	$s_{\nu} = 1-0.4(11.5)$	6 ft/935 ft) = 1.000
= 1.000	d_{a}^{\prime} = 1+2tan(28°)	[1-sin(28°)]²tan⁻¹(3.0 ft/11.56 ft)	$i_{\gamma} = 1.000$ (A	ssumed)
$i_c = 1.000$ (Assumed)	= 1.100		$C_{wv} = 7.9 \text{ft} < 1.5($	11.56 ft) + 3.0 ft = 0.500
	$i_{q} = 1.000$ (As	ssumed)		
	$C_{wq} = 7.9 \text{ ft} > 3.$	0 ft = 1.000		
Verify Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 4.94$ ksf s	ed Bearing Resistar ≤ (11.63 ksf)(0.65) = 7	. <u>ce</u> ∴56 ksf —>	4.94 ksf ≤ 7.56 ksf	
Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDM	1 Table 11.5.6-1)			
Check Bearing Resistance - Undrained Cond	<u>ition</u>			
Nominal Bearing Resistance: $q_n = cN_{cm}$	+ $\gamma D_f N_{qm} C_{wq}$ +	½ γВ' N _{ут} C _{wy}		
$N_{cm} = N_c s_c i_c = 5.140$	$N_{qm} = N_q s_q d_q i_q$, = 1.000	$N_{\gamma m} = N_{\gamma} s_{\gamma} i_{\gamma} =$	• 0.000
N _c = 5.140	$N_q = 1.000$		$N_{\gamma} = 0.000$	
$S_c = 1+(11.56 \text{ ft/}[(5)(935 \text{ ft})] = 1.000$	$s_q = 1.000$		$s_{\gamma} = 1.000$	
$i_c = 1.000$ (Assumed)	$d_q = 1+2\tan(0^\circ)$	[1-sin(0°)]²tan⁻¹(3.0 ft/11.56 ft)	$i_{\gamma} = 1.000$ (A	ssumed)
	= 1.000		$C_{wy} = 7.9 \text{ft} < 1.5($	11.56 ft + 3.0 ft = 0.500
	$i_q = 1.000$ (As	ssumed)		
	$C_{wq} = 7.9 \text{ ft} > 3.$	0 ft = 1.000		
$q_n = (2625 \text{ psf})(5.14) + (120 \text{ pcf})(3.0 \text{ fr})$	t)(1.0)(1.0) + ½(120 p	cf)(11.6 ft)(0.0)(0.5)	= 13.85 ksf	
Verify Equivalent Pressure Less Than Factor	ed Bearing Resistar			
$q_{eq} \leq q_{n} \cdot \phi_{h} \longrightarrow 4.94 \text{ksf}$	≤ (13.85 ksf)(0.65) = 9	0.00 ksf —→	4.94 ksf ≤ 9.00 ksf	OK
ang maganakan kan ang manakan ang manak				
Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDM	Table 11.5.6-1)			
Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDM	1 Table 11.5.6-1)			



JOB	FRA-70-12.68	NO.	W-13-045
SHEET NO.	6	OF	6
CALCULATED E	BY BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining W	all 4W12 - Sta. 300	05+50	

MSE Wall Dimensions and Retained Soil Paran	neters	Bearing Soil Properties:	
MSE Wall Height, (H) =	18.2 ft	MSE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	16.0 ft	MSE Backfill Friction Angle, (φ_{BF}) =	1 34 °
Distance from Wall Face to Toe of Backslope, $(l) =$	5.0 ft	Bearing Soil Unit Weight, (γ_{BS}) =	120 pcf
MSE Wall Length, (L) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	28 °
MSE Wall Effective Height, (<i>h</i>) =	23.7 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, [(s	_u) _{BS}] = 2625 psf
Effective Retained Soil Backslope, (θ) =	15.4 °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	20.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	19.1 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf		
Retained Soil Friction Angle, (φ_{RS}) =	<u>30</u> °	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 (A	ASHTO LRFD BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.374	Strength lb 1.35 1.50 1.75 - 3	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 J	Editii Fiessure)
1. Drained cohesion for retained soil not accounted for in external stability	analyses. This paramete	er is utilized in global stability analysis.	
Settlement Analysis (Loading Case - Service I)	- AASHTO LRF	<u>D BDM Section 11.10.4.1</u>	
	$\frac{v}{v}$		
	/ B'		
P_{U} P_{LSv} P_{LS} P_{LS}	n 1	$ c_0 f_1^{-2}(1, 0, 0, f_1^{-1}) = -12.24$	
$P_{EH} = P_{EH} + P$	B-2e = 1	10.0 II - 2(1.08 II) = 12.24 II	
\uparrow	-B/-r	-(160f(2)) = 12f(-1)90f(-1)	
R^{\vee}	-72^{-x_o}	= (10.0 IL / 2) - 0.12 IL = 1.00 IL	
	$M_V - M_I$	4 - (377.08 kin.ft/ft 121.44 kin.ft/ft) / 41.0	03.kip/ft – 6.12.ft
Ϋ́	$o - P_{\nu}$	= (377.90 KIP 1010 - 121.44 KIP 1010) / 41.8	95 KIP/IL - 0.12 IL
$x_0 > $	V		
$+ \frac{B}{2}$	— (11.03 kin/f	t)/(12.24 ft) = 3.43 kef	
$\leftrightarrow B' \rightarrow 4$	— (41.95 KIP/I		
$x_2 \rightarrow x_2$			
$M_{V} = P_{FV}(x_{1}) + P_{FV}(x_{2}) + P_{FH} \sin \theta(B) = (\gamma_{BF} H)$	$(B\gamma_{FV})(\frac{1}{2}B) + (\frac{1}{2})$	$(2\gamma_{RS}(h-H)(B-l)\gamma_{FV})(l+2/3(B-l)) + (1/2\gamma_{RS}h)$	$(a^2 K_a \gamma_{FH} \sin \theta)(B)$
M_V = [(120 pcf)(18.2 ft)(16.0 ft)(1.00)][$\frac{1}{2}$ (16.0 ft)] +	[1/2(120 pcf)(23.7 ft - 1	8.2 ft)(16.0 ft - 5.0 ft)(1.00)][5.0 ft + ³ / ₃ (16.0 ft - 5.0 ft)] =	377.98 kip·ft/ft
+ [1/2(120 pcf)(23.7 ft)2(0.374)(1.00)sin(15	.4°)](16.0 ft)		
	. (
$M_{H} = P_{EH} \cos \theta(x_{3}) + P_{LS} \cos \theta(x_{4}) = \left(\frac{1}{2}\gamma_{RS}h^{2}\right)$	$K_a \gamma_{EH} \cos \theta h/2$	$(\sigma_{LS}hK_a\gamma_{LS}\cos\theta)(h/2)$	
	ý.		
M_H = $\frac{1}{2}[(120 \text{ pcf})(23.7 \text{ ft})^2(0.374)(1.00)\cos(15)]$	5.4°)](23.7 ft /3)	= 121.44 kip·ft/ft	
+ [(250 psf)(23.7 ft)(0.374)(1.00)cos(1	5.4°)](23.7 ft /2)		
$P_{V} = P_{EV_{1}} + P_{EV_{2}} + P_{EH} \sin \theta = (\gamma_{BF} HB\gamma_{EV}) +$	$\left(\frac{1}{2}\gamma_{RS}(h-H)\right)$	$(B-l)\gamma_{EV} + \left(\frac{1}{2}\gamma_{RS}h^2K_a\gamma_{EH}\sin\theta\right)$	
$P_V = (120 \text{ pcf})(18.2 \text{ ft})(16.0 \text{ ft})(1.00) + \frac{1}{2}(120 \text{ sc})$	pcf)(23.7 ft - 18.2	ft(16.0 ft - 5.0 ft)(1.00) = 41.93 kip/ft	
+ ½(120 pcf)(23.7 ft)²(0.374)(1.00)si	n(15.4°)		
	4		
Settlement (See Attached Spreadsheet Calcula	<u>uons):</u>		
Total Cottlement at Contar of Deirford V. C.	4000: °		
I Utal Settlement at Center of Reinforced Soll N	viass: S_t	– 1.320 N	
Total Settlement at Wall Ecology	r	= 1013 in	
	υ _t		
Time Rate of Consolidation Settlement at Wall	Facing (See Att	ached Spreadsheet Calculations):	
$(S_{n})_{in} =$ in at d	avs followi	a completion of construction	
	.,		

W-13-045 - FRA-70-12.68 - MSE Wall 4W12 MSE Wall Settlement - Sta. 3005+50

Boring B-110-1-15

H=	18.2	ft	Total wall height
B'=	12.2	ft	Effective footing width due to eccentricity
D _w =	19.1	ft	Depth below bottom of footing
q _e =	3,430	psf	Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	t Center of Re	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	⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
1	A-6a	С	0.0	2.5	2.5	1.3	120	300	150	150	4,150	29	0.171	0.009	0.499				0.10	0.982	3,369	3,519	0.020	0.235	0.500	1,715	1,865	0.016	0.187
1	A-6a	С	2.5	5.0	2.5	2.5	120	600	450	450	4,450	29	0.171	0.009	0.499				0.20	0.959	3,289	3,739	0.013	0.157	0.500	1,715	2,165	0.010	0.117
2	A-1-a	G	5.0	7.5	2.5	3.8	120	900	750	750	4,750					75	100	466	0.31	0.935	3,208	3,958	0.004	0.046	0.492	1,688	2,438	0.003	0.033
2	A-1-a	G	7.5	10.0	2.5	5.0	120	1,200	1,050	1,050	5,050					75	91	404	0.41	0.912	3,127	4,177	0.004	0.045	0.476	1,633	2,683	0.003	0.030
3	A-6b	С	10.0	12.5	2.5	6.3	125	1,513	1,356	1,356	5,356	39	0.261	0.026	0.577				0.51	0.860	2,950	4,306	0.021	0.249	0.460	1,578	2,934	0.014	0.166
5	A-6b	С	12.5	15.0	2.5	7.5	125	1,825	1,669	1,669	5,669	39	0.261	0.026	0.577				0.61	0.767	2,630	4,298	0.017	0.204	0.440	1,509	3,178	0.012	0.139
	A-1-b	G	15.0	17.0	2.0	8.5	130	2,085	1,955	1,955	5,955					65	66	244	0.70	0.717	2,458	4,413	0.003	0.035	0.428	1,468	3,423	0.002	0.024
	A-1-b	G	17.0	22.0	5.0	11.0	130	2,735	2,410	2,410	6,410					65	61	220	0.90	0.622	2,134	4,544	0.006	0.075	0.397	1,362	3,772	0.004	0.053
4	A-1-b	G	22.0	27.0	5.0	13.5	130	3,385	3,060	3,060	7,060					65	56	195	1.11	0.533	1,829	4,889	0.005	0.063	0.374	1,284	4,344	0.004	0.047
	A-1-b	G	27.0	32.0	5.0	16.0	130	4,035	3,710	3,710	7,710					65	52	177	1.31	0.464	1,593	5,303	0.004	0.053	0.351	1,205	4,915	0.003	0.042
	A-1-b	G	32.0	37.0	5.0	18.5	130	4,685	4,360	4,360	8,360					65	48	162	1.52	0.400	1,372	5,732	0.004	0.044	0.326	1,117	5,477	0.003	0.037
	A-3a	G	37.0	42.0	5.0	21.0	120	5,285	4,985	4,866	8,866					39	27	81	1.72	0.364	1,247	6,114	0.006	0.073	0.303	1,039	5,905	0.005	0.062
5	A-3a	G	42.0	47.0	5.0	23.5	120	5,885	5,585	5,310	9,310					39	26	79	1.93	0.327	1,123	6,433	0.005	0.063	0.286	981	6,291	0.005	0.056
	A-3a	G	47.0	52.0	5.0	26.0	120	6,485	6,185	5,754	9,754		1			39	25	77	2.13	0.295	1,013	6,767	0.005	0.055	0.270	926	6,681	0.004	0.051
1. $\sigma_{\rm p}' = \sigma_{\rm v}$	o'+σ _m Estima	te σ_m of 4,0	00 psf for mo	oderately ove	rconsolidate	d soil deposit	; Ref. Table	e 11.2, Codu	to 2003				•		•		•			1	Tota	Settlement:		1.396 in		Tota	Settlement:		1.043 in

2. C_c = 0.009(LL-10); Ref. Table 26, FHWA GEC 5

3. $C_r = 0.05(C_c)$ for embankment fill and $0.10(C_c)$ for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5

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

5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ 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. $S_c = [C_o/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{p'})$ for $\sigma_{vo}' < \sigma_{p}' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv 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)

Calculated By:	BRT	Date:	7/17/2018
Checked By:	JPS	Date:	7/17/2018

-													Strip Covoraça	Tancila Strongth	
-		Material Name	Color	Unit Weight	Cohesion	Phi				Support Name	Color	Туре	(%)	(lbs/ft)	
760		MSE Backfill		(IDS/π3)	(psr)	(deg)				MSE Reinforcement Straps		GeoTextile	100	7500	
-		Existing Embankment		120	0	30		1.284							
_		Vde A-1-a		135	0	41	Γ					250.00 lbs	/ft2		
-		VS A-6b		120	0	27	/								
o -		De A-3a		130	0	34						¥			
720 74															
200								₩ ▼							
680															°
660	Ĵ														
-															
	0	20		40 Proied	ct	60	80	100	120	140		160	18	0 2	200
Þ								FRA-70-2	12.68 MSE W	'all 4W12 - Sta. 300	5+50				
		-		Analy.	sis Descriptio	n		Sp	encer Method	- Drained Conditons					
	5	sien		Draw	n By		BRT	Scale	1:250	Company	Res	ource Int	ernational, I	าс.	
SLIDEI	INTERPRET 7.020			Date			07/17/2018	1		File Name St	ta 300)5+50 - (Global Stabilit	y.slim	





JOB	FRA-70-12.68	NO.	W-13-045
SHEET NO.	2	OF	6
CALCULATED	BY BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining W	/all 4W12 - Sta. 3006	5+25 - Pl	nase 4R

<u>ameters</u>	<u>Be</u>	aring So	<u>oil Pro</u>	perties				
12.9 ft	MS	E Backfil	I Unit V	Veight, ($\gamma_{BF}) =$			120 po
16.8 ft	MS	E Backfil		n Angle,	$(\varphi_{BF}) =$			34 °
<u></u>	Dea	iring Soli		eigni, (y	BS) - (a) - b = b = b = b = b = b = b = b = b = b			120 p
935.0 II 19.9 #	Bei	ring Soli		d Cohes	$(\varphi_{BS}) =$	\ -		0 ~
26.6 °	Be:	aring Soil	Undrai	ned She	ar Strei	s) – nath	[(c)]	= 2625 p
<u>20.0</u> 15.2 °	Fm	hedment	Denth	$(D_{c}) =$		igui,	L(S u JBS]	- <u>2025</u> p: 3.0 ft
14.0 ft	Dei	oth to GV	V (Belo	$(D_f) =$	f Wall)	()	. =	26.6 ft
120 ncf			V (Delo	W DOL O	r vvan),	(,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,,		20.0 1
30 °	IR	FD L oa	d Fact	ors				
00 0 psf		DLOU	FV	FH	IS			
2000 psf	Str	enath la	1.00	1.50	1.75	٦		
0.372	Str	ength Ib	1.35	1.50	1.75	-	(AASHT 3.4.1-1	O LRFD BDM Tables and 3.4.1-2 - Active
250 psf	Ser	vice I	1.00	1.00	1.00		E	arth Pressure)
ility analyses. This param	neter is utilized in glo	bal stability	analysis.					
AASHTO LRFD	BDM Section	<u>11.10.</u>	5.3 (Co	ntinued)				
<u>tion</u>								
(a) < a	}							
$u J_{BS} = \Psi_{S} J D$								
$s_{S} = 2.63$ k	sf							
σ /								
v/2								
, <u> </u>								
$= \frac{I_V}{R}$								
/ D								
$P_V = P_{EV_1} + P$	$P_{EV_{2}} + P_{EH} \sin \theta$	n $ heta$						
	2							
$P_{FV} = \gamma_{BF}$	$\cdot H \cdot B \cdot \gamma_{FV}$	= (1	20 pcf))(12.9 ft)	(16.8 ft)	(1.00	i) =	26.01 kip/ft
$P_{EV_2} = \frac{1}{2}\gamma$	$_{RS}(h-H)(E$	$(l-l)\gamma_{F}$	v					
, in the second s		<i>.</i>						
P_{EV_2} =	1/2(120 pcf)(18	3.8 ft - 12	9 ft)(10	6.8 ft - 5	.0 ft)(1.0)0)	= 4	.18 kip/ft
-								
$P_{EH} = \frac{1}{2} \gamma_1$	$_{RS}h^2K_a\gamma_{EH}$	= ½	(120 pc	f)(18.8 ft)²(0.372	2)(1.5	0) =	11.84 kip/ft
P - 26.01 k		ft _ /11 (A 4 1 1 10				3.29	
$1_V = 20.01 \text{ K}$.ip/it + 4. 18 kip	n + (11.6	34 kip/fi	t)sin(15.2	2°) =	3		kip/ft
= (22.20 kin)	.ip/it + 4.18 kip		84 KIP/TI	t)sin(15.2	2°) =	3		kip/ft
= (33.29 kip/	ip/it + 4. 18 kip ft) / (16.8 ft)	= 1	84 kip/fi 1.98	t)sin(15.2 ksf	2°) =	3		kip/ft
= (33.29 kp)	(ft) / (16.8 ft)	= 1 kef	84 кір/п 1.98	t)sin(15.2 ksf	2°) =	3		kip/ft
= (33.29 kip/ (1.98 ksf) / 2	f(t) / (16.8 ft) = 0.99	= 1 ksf	1.98	t)sin(15.2	2°) =	3		kip/ft
= (33.29 km) / 2 = (2.63 ksf) / 2 = (2.63	(ft) / (16.8 ft) (ft) / (16.8 ft) (ft) / (16.8 ft)	= 1 ksf = 4	4 KIP/TI	t)sin(15.2	2°) =	3		
$= (33.29 \text{ km}) / 2 = (2.63 \text{ ksf}) / 2 = (2.63 \text{ ksf} \le 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) / 2 = (2.63 \text{ ksf} \ge 0.99 \text{ k}) $	(16.8 ft) = 0.99 (16.8 ft)	= 1 ksf = 4	34 кір/ті 1.98 4.10	t)sin(15.2 ksf kip/ft	2°) =	3		kip/ft
$= (33.29 \text{ km}) / 2$ $(1.98 \text{ ksf}) / 2$ $(2.63 \text{ ksf} \le 0.99 \text{ k})$	(ft) / (16.8 ft) = 0.99 (sf)(16.8 ft)	= 1 ksf = 4	4.10	t)sin(15.2 ksf kip/ft	2°) =			kip/ft
$= (33.29 \text{ km})$ $= (33.29 \text{ km})$ $(1.98 \text{ ksf}) / 2$ $(2.63 \text{ ksf} \le 0.99 \text{ km})$	(ft) / (16.8 ft) = 0.99 (sf)(16.8 ft)	= /	1.98 4.10	t)sin(15.2 ksf kip/ft	2°) =			kip/ft
 I y = 20.01 kg = (33.29 kg/) (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 kg/) (2.63 ksf ≤ 0.99 kg/) (1.98 ksf) / 2 	(ft) / (16.8 ft) = 0.99 (sf)(16.8 ft) - Undrained	= ' ksf = 4 <u>Conditi</u>	84 кір/п 1.98 4.10 <u>on</u>	t)sin(15.2 ksf kip/ft	2°) =			kip/ft
 1 y = 20.01 kg = (33.29 kg/) (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 kg/) (2.63 ksf ≤ 0.99 kg/) (1.00 k	(ft) / (16.8 ft) = 0.99 (sf)(16.8 ft) <u>- Undrained</u>	= ' ksf = 4 <u>Conditi</u>	1.98 4.10 <u>on</u> 14	t)sin(15.1 ksf kip/ft	2°) = 2°) = 1000000000000000000000000000000000000	3	2/ft	kip/ft
 1 y = 20.01 kg = (33.29 kip/ (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 kg ling Resistance 10 kip/ft)(1.0) = 4. 	(ft) / (16.8 ft) = 0.99 (sf)(16.8 ft) <u>- Undrained</u> 4.10 kip/ft	= ' ksf = 4 <u>Conditi</u>	4.10 0 <u>n</u> 14	t)sin(15.2 ksf kip/ft .07 kip/	2°) = ft≤44.	3 10 ki	o/ft	kip/ft
 <i>i</i>, <i>j</i> = 20.01 kg (33.29 kip/ (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 kg (2.63 ksf ≤ 0.99 kg (1.00 kip/ft) (1.0) = 4 <i>i</i> = 11.5.6-1) 	/ft) / (16.8 ft) = 0.99 :sf)(16.8 ft) <u>- Undrained</u> 4.10 kip/ft	= ' ksf = 4 <u>Conditi</u>	4.10 <u>on</u>	t)sin(15.2 ksf kip/ft .07 kip/	2°) = ft ≤ 44.	3 10 ki	D/ft	kip/ft
 <i>i</i>, <i>j</i> = 20.01 kg (33.29 kip/ (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 kg (2.63 ksf ≤ 0.99 kg (1.00 kip/ft) (1.0) = 4 <i>i</i> = 11.5.6-1) 	fft) / (16.8 ft) = 0.99 :sf)(16.8 ft) <u>- Undrained</u> 4.10 kip/ft	= ' ksf = 4 <u>Conditi</u>	4.10 <u>on</u> 14	t)sin(15.2 ksf kip/ft .07 kip/	2°) = ft ≤ 44.	3	p/ft	
 <i>i</i>, <i>j</i> = 20.01 kg (33.29 kip/ (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 kg (2.63 ksf ≤ 0.99 kg (1.00 kip/ft) (1.0) = 4 <i>i</i> = 11.5.6-1) 	/ft) / (16.8 ft) = 0.99 :sf)(16.8 ft) <u>- Undrained</u> 4.10 kip/ft	= ' ksf = 4 <u>Conditi</u>	4.10 <u>on</u> 14	t)sin(15.2 ksf kip/ft .07 kip/	2°) = ft ≤ 44.	3	p/ft	kip/ft
 I y = 20.01 kg = (33.29 kjp/ (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 kg (2.63 ksf ≤ 0.99 kg (1.00 kg/ft) (1.0) = 4. (1.5.6-1) 	/ft) / (16.8 ft) = 0.99 :sf)(16.8 ft) <u>- Undrained</u> 4.10 kip/ft	= ' ksf = 4 <u>Conditi</u>	4.10 0n 14	t)sin(15.2 ksf kip/ft .07 kip/	2°) = ft ≤ 44.	3 10 ki	p/ft	kip/ft ok
y = 20.01 km (1.98 ksf) / 2 (2.63 ksf ≤ 0.99 km (2.63 ksf = 0.99	fft) / (16.8 ft) = 0.99 :sf)(16.8 ft) <u>- Undrained</u> 4.10 kip/ft	= ' ksf = 4 <u>Conditi</u>	4.10 0n 14	t)sin(15.2 ksf kip/ft .07 kip/	2°) = 1 − 2 − 2 − 2 − 2 − 2 − 2 − 2 − 2 − 2 −	2	p/ft	kip/ft
	fft) / (16.8 ft) = 0.99 :sf)(16.8 ft) <u>- Undrained</u> 4.10 kip/ft	= ' ksf = 4 <u>Conditi</u>	4.10 0n 14	t)sin(15.1 ksf kip/ft .07 kip/	2°) = 	2	p/ft	
	<pre>/fft) / (16.8 ft) = 0.99 (sf)(16.8 ft) - Undrained 4.10 kip/ft</pre>	= ' ksf = 4 <u>Conditi</u>	4.10 0n 14	t)sin(15.3 ksf kip/ft .07 kip/	2°) = ti ≤ 44.	3 10 ki	p/ft	
	$\begin{array}{c} \underline{ameters} \\ \hline 12.9 \text{ ft} \\ \hline 16.8 \text{ ft} \\ \hline 5.0 \text{ ft} \\ \hline 935.0 \text{ ft} \\ \hline 18.8 \text{ ft} \\ \hline 26.6 \circ \\ \hline 15.2 \circ \\ \hline 14.0 \text{ ft} \\ \hline 120 \text{ pcf} \\ \hline 30 \circ \\ \hline 0 \text{ psf} \\ \hline 2000 \text{ psf} \\ \hline \\ \hline \\ \hline \\ 2000 \text{ psf} \\ \hline \\ $	ameters Bea 12.9 ft MSI 16.8 ft MSI 5.0 ft Bea 935.0 ft Bea 935.0 ft Bea 18.8 ft Bea 15.2 ° Emil 14.0 ft Dep 120 pcf 30 ° 2000 psf Stre 0 psf Stre 2000 psf Stre 0.372 Stre 250 psf Ser 250 psf Ser 250 psf Ser 0 million AASHTO LRFD BDM Section 6 γ_2 $= P_V / B$ $P_V = P_{EV_1} + P_{EV_2} + P_{EH}$ si $\sigma_V / 2$ $= P_V / B$ $P_V = P_{EV_1} + P_{EV_2} + P_{EH}$ si $P_{EV_2} = \gamma_2 \gamma_{RS} (h - H) (B$ $P_{EV_2} = \gamma_2 \gamma_{RS} (h - H) (B$ $P_{EH} = \gamma_2 \gamma_{RS} h^2 K_a \gamma_{EH}$	ametersBearing Sci12.9 ftMSE Backfil16.8 ftMSE Backfil5.0 ftBearing Soil935.0 ftBearing Soil18.8 ftBearing Soil15.2 °Embedment14.0 ftDepth to GW120 pcf30 °30 °LRFD Load0 psfStrength la0.372Strength la250 psfService I30 service IStrength la0.372Strength la250 psfService I30 service IStrength la0.372Strength la250 psfService I110AASHTO LRFD BDM Section 11.10.110Service I110Service I111Service I112Service I113Service I114Service I115Service I116Service I117Service I118Service I119Service I110Service I110Service I110Service I111Service I112Service I113Service I114Service I115Service I115Service I116Service I117Service I118Service I119Service I120Service I131Service I140Service I141Service I141Service I <td< td=""><td>ametersBearing Soil Pro12.9 ftMSE Backfill Unit V16.8 ftMSE Backfill Unit V935.0 ftBearing Soil Unit W935.0 ftBearing Soil Draine26.6 °Bearing Soil Undrai15.2 °Embedment Depth,14.0 ftDepth to GW (Belo120 pcf30 °120 pcfEKPD Load Factur0 psfEV2000 psfStrength Ia1.000.372250 psfService I1.001.000.372Strength Ib250 psfService I1.000.372Strength Ib1.352602000 psfService I1.000.372Strength Ib1.3526020 psfService I1.001.01Service I1.02Service I1.03Go1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I<t< td=""><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, (j16.8 ftMSE Backfill Friction Angle,5.0 ftBearing Soil Unit Weight, (y935.0 ftBearing Soil Drained Cohes26.6 °Bearing Soil Undrained She15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. or120 pcf30 °30 °LRFD Load Factors0 psfEV250 psfStrength la1.001.500.372Strength la250 psfService I1.001.00illy analyses. This parameter is utilized in global stability analysis.AASHTO LRFD BDM Section 11.10.5.3 (Continued)ition$S_u$$S_g$ = 2.63 ksf$\sigma_v/2$$= P_V/B$$P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_2} = \gamma_2 \gamma_{RS} (h - H) (B - l) \gamma_{EV}$$P_{EV_2} = \gamma_2 (120 \text{ pcf})(18.8 ft - 12.9 ft)(16.8 ft - 5)$$P_{EH} = \gamma_2 \gamma_{RS} h^2 K_a \gamma_{EH} = \gamma_2 (120 \text{ pcf})(18.8 ft - 12.9 ft)(18.8 ft - 12.9 ft)(18.8 ft - 5)$</td><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$16.8 ftMSE Backfill Friction Angle, $(\varphi_{BF}) =$5.0 ftBearing Soil Unit Weight, $(\gamma_{BS}) =$935.0 ftBearing Soil Drained Cohesion, $(c_B) =$18.8 ftBearing Soil Undrained Shear Street15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. of Wall),120 pcf30 °2000 psfStrength la 1.001.50 psfEV0 psfStrength la 1.001.50 psfStrength lb 1.350.372Strength lb 1.35250 psfService l1.001.00uity analyses. This parameter is utilized in global stability analysis.AASHTO LRFD BDM Section 11.10.5.3 (continued)ition$S_u = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(12.9 \text{ ft})(16.8 ft)$$P_{EV_2} = \frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV}$$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 ft)^2(0.372 ft)$</td><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$16.8 ftMSE Backfill Friction Angle, $(\varphi_{BF}) =$5.0 ftBearing Soil Unit Weight, $(\gamma_{BS}) =$935.0 ftBearing Soil Friction Angle, $(\varphi_{BS}) =$18.8 ftBearing Soil Drained Cohesion, $(c_{BS}) =$26.6 °Bearing Soil Undrained Shear Strength,15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. of Wall), (D_W)120 pcf$0 psf$2000 psfStrength la 1.001.50 1.75$0.372$250 psfService I250 psfService I1.00 1.00$1.00$$0 psf$EVEHLS2000 psfStrength la 1.350.372Strength la 1.351.50 1.75250 psfService I1.00 1.00$1.00$1.00 1.00$f_W = nalyses$.AASHTO LRFD BDM Section 11.10.5.3 (continued)ition$S_w = 2.63$ ksf$\sigma_v / 2$$= P_V / B$$P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf)(12.9 ft)(16.8 ft)(1.00)$$P_{EV_2} = \frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV}$$P_{EV_2} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 pcf)(18.8 ft)^2 (0.372)(1.5)$</td><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$16.8 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$5.0 ftBearing Soil Drained (φ_{BF}) =935.0 ftBearing Soil Drained Cohesion, $(c_{BS}) =$18.8 ftBearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. of Wall), $(D_W) =$120 pcf30 °LRFD Load Factors0 psfEVEH2000 psfStrength la1.0372Strength la1.001.001.000 psfService I1.001.000.372Strength la250 psfService I0.372Strength la1.001.001.001.00985$(Continued)$Wilty analysis.AASHTO LRFD BDM Section 11.10.5.3 (Continued)Kition$S_u = 2.63$ ksf$\sigma_v / 2$$= P_{V/B}$$P_v = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00) =$$P_{EV_2} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft} - 5.0 \text{ ft})(1.00) = 4$$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft})^2(0.372)(1.50) =$</td></t<></td></td<>	ametersBearing Soil Pro12.9 ftMSE Backfill Unit V16.8 ftMSE Backfill Unit V935.0 ftBearing Soil Unit W935.0 ftBearing Soil Draine26.6 °Bearing Soil Undrai15.2 °Embedment Depth,14.0 ftDepth to GW (Belo120 pcf30 °120 pcfEKPD Load Factur0 psfEV2000 psfStrength Ia1.000.372250 psfService I1.001.000.372Strength Ib250 psfService I1.000.372Strength Ib1.352602000 psfService I1.000.372Strength Ib1.3526020 psfService I1.001.01Service I1.02Service I1.03Go1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I1.10Service I <t< td=""><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, (j16.8 ftMSE Backfill Friction Angle,5.0 ftBearing Soil Unit Weight, (y935.0 ftBearing Soil Drained Cohes26.6 °Bearing Soil Undrained She15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. or120 pcf30 °30 °LRFD Load Factors0 psfEV250 psfStrength la1.001.500.372Strength la250 psfService I1.001.00illy analyses. This parameter is utilized in global stability analysis.AASHTO LRFD BDM Section 11.10.5.3 (Continued)ition$S_u$$S_g$ = 2.63 ksf$\sigma_v/2$$= P_V/B$$P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_2} = \gamma_2 \gamma_{RS} (h - H) (B - l) \gamma_{EV}$$P_{EV_2} = \gamma_2 (120 \text{ pcf})(18.8 ft - 12.9 ft)(16.8 ft - 5)$$P_{EH} = \gamma_2 \gamma_{RS} h^2 K_a \gamma_{EH} = \gamma_2 (120 \text{ pcf})(18.8 ft - 12.9 ft)(18.8 ft - 12.9 ft)(18.8 ft - 5)$</td><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$16.8 ftMSE Backfill Friction Angle, $(\varphi_{BF}) =$5.0 ftBearing Soil Unit Weight, $(\gamma_{BS}) =$935.0 ftBearing Soil Drained Cohesion, $(c_B) =$18.8 ftBearing Soil Undrained Shear Street15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. of Wall),120 pcf30 °2000 psfStrength la 1.001.50 psfEV0 psfStrength la 1.001.50 psfStrength lb 1.350.372Strength lb 1.35250 psfService l1.001.00uity analyses. This parameter is utilized in global stability analysis.AASHTO LRFD BDM Section 11.10.5.3 (continued)ition$S_u = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(12.9 \text{ ft})(16.8 ft)$$P_{EV_2} = \frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV}$$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 ft)^2(0.372 ft)$</td><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$16.8 ftMSE Backfill Friction Angle, $(\varphi_{BF}) =$5.0 ftBearing Soil Unit Weight, $(\gamma_{BS}) =$935.0 ftBearing Soil Friction Angle, $(\varphi_{BS}) =$18.8 ftBearing Soil Drained Cohesion, $(c_{BS}) =$26.6 °Bearing Soil Undrained Shear Strength,15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. of Wall), (D_W)120 pcf$0 psf$2000 psfStrength la 1.001.50 1.75$0.372$250 psfService I250 psfService I1.00 1.00$1.00$$0 psf$EVEHLS2000 psfStrength la 1.350.372Strength la 1.351.50 1.75250 psfService I1.00 1.00$1.00$1.00 1.00$f_W = nalyses$.AASHTO LRFD BDM Section 11.10.5.3 (continued)ition$S_w = 2.63$ ksf$\sigma_v / 2$$= P_V / B$$P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf)(12.9 ft)(16.8 ft)(1.00)$$P_{EV_2} = \frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV}$$P_{EV_2} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 pcf)(18.8 ft)^2 (0.372)(1.5)$</td><td>ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$16.8 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$5.0 ftBearing Soil Drained (φ_{BF}) =935.0 ftBearing Soil Drained Cohesion, $(c_{BS}) =$18.8 ftBearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$15.2 °Embedment Depth, $(D_f) =$14.0 ftDepth to GW (Below Bot. of Wall), $(D_W) =$120 pcf30 °LRFD Load Factors0 psfEVEH2000 psfStrength la1.0372Strength la1.001.001.000 psfService I1.001.000.372Strength la250 psfService I0.372Strength la1.001.001.001.00985$(Continued)$Wilty analysis.AASHTO LRFD BDM Section 11.10.5.3 (Continued)Kition$S_u = 2.63$ ksf$\sigma_v / 2$$= P_{V/B}$$P_v = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00) =$$P_{EV_2} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft} - 5.0 \text{ ft})(1.00) = 4$$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft})^2(0.372)(1.50) =$</td></t<>	ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, (j16.8 ftMSE Backfill Friction Angle,5.0 ftBearing Soil Unit Weight, (y935.0 ftBearing Soil Drained Cohes26.6 °Bearing Soil Undrained She15.2 °Embedment Depth, $(D_f) =$ 14.0 ftDepth to GW (Below Bot. or120 pcf30 °30 °LRFD Load Factors0 psfEV250 psfStrength la1.001.500.372Strength la250 psfService I1.001.00illy analyses. This parameter is utilized in global stability analysis.AASHTO LRFD BDM Section 11.10.5.3 (Continued)ition S_u S_g = 2.63 ksf $\sigma_v/2$ $= P_V/B$ $P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$ $P_{EV_2} = \gamma_2 \gamma_{RS} (h - H) (B - l) \gamma_{EV}$ $P_{EV_2} = \gamma_2 (120 \text{ pcf})(18.8 ft - 12.9 ft)(16.8 ft - 5)$ $P_{EH} = \gamma_2 \gamma_{RS} h^2 K_a \gamma_{EH} = \gamma_2 (120 \text{ pcf})(18.8 ft - 12.9 ft)(18.8 ft - 12.9 ft)(18.8 ft - 5)$	ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$ 16.8 ftMSE Backfill Friction Angle, $(\varphi_{BF}) =$ 5.0 ftBearing Soil Unit Weight, $(\gamma_{BS}) =$ 935.0 ftBearing Soil Drained Cohesion, $(c_B) =$ 18.8 ftBearing Soil Undrained Shear Street15.2 °Embedment Depth, $(D_f) =$ 14.0 ftDepth to GW (Below Bot. of Wall),120 pcf30 °2000 psfStrength la 1.001.50 psfEV0 psfStrength la 1.001.50 psfStrength lb 1.350.372Strength lb 1.35250 psfService l1.001.00uity analyses. This parameter is utilized in global stability analysis.AASHTO LRFD BDM Section 11.10.5.3 (continued)ition $S_u = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$ $P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(12.9 \text{ ft})(16.8 ft)$ $P_{EV_2} = \frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV}$ $P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 ft)^2(0.372 ft)$	ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$ 16.8 ftMSE Backfill Friction Angle, $(\varphi_{BF}) =$ 5.0 ftBearing Soil Unit Weight, $(\gamma_{BS}) =$ 935.0 ftBearing Soil Friction Angle, $(\varphi_{BS}) =$ 18.8 ftBearing Soil Drained Cohesion, $(c_{BS}) =$ 26.6 °Bearing Soil Undrained Shear Strength,15.2 °Embedment Depth, $(D_f) =$ 14.0 ftDepth to GW (Below Bot. of Wall), (D_W) 120 pcf $0 psf$ 2000 psfStrength la 1.001.50 1.75 0.372 250 psfService I250 psfService I1.00 1.00 1.00 $0 psf$ EVEHLS2000 psfStrength la 1.350.372Strength la 1.351.50 1.75250 psfService I1.00 1.00 1.00 1.00 1.00 $f_W = nalyses$.AASHTO LRFD BDM Section 11.10.5.3 (continued)ition $S_w = 2.63$ ksf $\sigma_v / 2$ $= P_V / B$ $P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$ $P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf)(12.9 ft)(16.8 ft)(1.00)$ $P_{EV_2} = \frac{1}{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV}$ $P_{EV_2} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 pcf)(18.8 ft)^2 (0.372)(1.5)$	ametersBearing Soil Properties:12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$ 16.8 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$ 5.0 ftBearing Soil Drained (φ_{BF}) =935.0 ftBearing Soil Drained Cohesion, $(c_{BS}) =$ 18.8 ftBearing Soil Undrained Shear Strength, $[(s_u)_{BS}]$ 15.2 °Embedment Depth, $(D_f) =$ 14.0 ftDepth to GW (Below Bot. of Wall), $(D_W) =$ 120 pcf30 °LRFD Load Factors0 psfEVEH2000 psfStrength la1.0372Strength la1.001.001.000 psfService I1.001.000.372Strength la250 psfService I0.372Strength la1.001.001.001.00985 $(Continued)$ Wilty analysis.AASHTO LRFD BDM Section 11.10.5.3 (Continued)Kition $S_u = 2.63$ ksf $\sigma_v / 2$ $= P_{V/B}$ $P_v = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta$ $P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00) =$ $P_{EV_2} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft} - 5.0 \text{ ft})(1.00) = 4$ $P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft})^2(0.372)(1.50) =$


 $\xrightarrow{} x_1 \\ \xrightarrow{} x_2$

*x*₄

 $x_3 \uparrow$

JOB	FRA-70-12.68		W-13-045	
SHEET NO.	3	OF	6	
CALCULATED E	Y BRT	DATE	7/15/2018	
CHECKED BY	JPS	DATE	7/15/2018	
Retaining Wall 4W12 - Sta. 3006+25 - Phase 4R				

MSE Wall Dimensions and Retained Soil Paran	<u>neters</u>	Bearing Soil Properties:
MSE Wall Height, (H) =	12.9 ft	MSE Backfill Unit Weight, (γ_{BF}) = 120 pcf
MSE Wall Width (Reinforcement Length), (B) =	16.8 ft	MSE Backfill Friction Angle, $(\varphi_{BF}) = 34^{\circ}$
Distance from Wall Face to Toe of Backslope, $(l) =$	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) = 120$ pcf
MSE Wall Length, (<i>L</i>) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) = 28 °
MSE Wall Effective Height, (<i>h</i>) =	18.8 ft	Bearing Soil Drained Cohesion, $(c_{BS}) = 0$ psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 2625$ psf
Effective Retained Soil Backslope, (θ) =	15.2 °	Embedment Depth, $(D_f) = 3.0$ ft
Distance from Toe to Top of Backslope, $(z) =$	14.0 ft	Depth to GW (Below Bot. of Wall), $(D_W) = 26.6$ ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf	
Retained Soil Friction Angle, (φ_{RS}) =	<u>30</u> °	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 LRFD BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.372	Strength lb 1.35 1.50 1.75 - 3.4.1-1 and 3.4.1-2 - Active
Live Surcharge Load, $(\sigma_{LS}) =$	250 psf	Service I 1.00 1.00 1.00
$\begin{array}{c c} x_{4} & P_{EV_{1}} & P_{LS_{v}} & P_{LS} \\ & & & & \\ & & & & \\ & & & \\ & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & & & & \\ & $	$\frac{V_V - M_H}{P_V} = (32)$	4.43 kip·ft/ft - 99.4 kip·ft/ft) / (33.29 kip/ft) = 6.76 ft p·ft/ft Defined below
$x_o \leftarrow \rightarrow e$ P_v	$= P_{EV_1} + P_{EV_2} + P_{EV_2$	$\rho_{EH} \sin \theta = 26.01 \text{ kip/ft} + 4.18 \text{ kip/ft} + (11.84 \text{ kip/ft}) \sin(15.2^\circ) = 33.29 \text{ kip/ft}$
$x_1 \xleftarrow{B_2}{\longrightarrow} e =$	(16.8 ft/ 2) - 6.76 ft	= 1.64 ft
Resisting Moment, M_{V} : $M_{V} = P_{EV_{1}}$	$(x_1) + P_{EV_2}(x_2) +$	- $P_{EH} \sin \theta(B)$ (Neglect P_{LS_v} for conservatism)
$P_{EV_1} = 2$	$\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$	= (120 pcf)(12.9 ft)(16.8 ft)(1.00) = 26.01 kip/ft
$P_{EV_1} \qquad P_{LSv} \qquad P_{$	$\gamma_2 \gamma_{RS} (h-H) (B-H)$	$l)\gamma_{EV} = \frac{1}{2}(120 \text{ pcf})(18.8 \text{ ft} - 12.9 \text{ ft})(16.8 \text{ ft} - 5.0 \text{ ft})(1.00) = 4.18 \text{ kip/ft}$
$P \uparrow P_{FH} $	1/ 12 77	

	$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} =$	$\frac{120}{2}$ pcf)(18.8 ft) ² (0.372)(1.50)	
έA	~		
¥υ	$x_1 = \frac{B}{2} = (16.8 \text{ ft})/2$	= 8.40 ft	
	- 72		
	$x_2 = l + \frac{2}{3}(B-l) = 5.0$	ft + ² / ₃ (16.8 ft - 5.0 ft) = 12.87	
	2 7 3 1 7		

 M_V = (26.01 kip/ft)(8.40 ft) + (4.18 kip/ft)(12.87 ft) + (11.84 kip/ft)sin(15.2°)(16.8 ft) = 324.43 kip·ft/ft

ft

Overturning Moment, M_H :	$M_{H} = P_{FH} \cos \theta(x_{3}) + P_{LS} \cos \theta(x_{3})$	$\cos \theta(x_4)$	
	$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} =$	1/2(120 pcf)(18.8 ft)2(0.372)(1.50)	= 11.84 kip/ft

P_{rc}	$P_{IS} = \sigma_{IS} h K$	$\zeta_a \gamma_{IS} =$	(250 psf)(18.8 ft)	(0.372)(1.75)	= 3.06	kip/ft
P_{IS}						
P _{EH}	$x_3 = h/2 =$	(18.8 ft) / 3	= 6.27	ft		
T _{EH}	/ 5					
L==::¥0	$x_4 = \frac{h}{2} =$	(18.8 ft) / 2	= 9.4	ft		
	/ 2					

 M_{H} = (11.84 kip/ft)cos(15.2°)(6.27 ft) + (3.06 kip/ft)cos(15.2°)(9.40 ft) = 99.40 kip·ft/ft

		ъ /				
Check Eccentricity	Limiting Eccentricity: e_{\max}	$= \frac{B}{2}$	$\rightarrow e_{\rm max} =$	(16.8 ft) / 3	= 5.60	ft
		/ 5				
$e < e_{\max} \rightarrow$	1.64 ft < 5.60 ft OK					



JOB	FRA-70-12.68		NO.	W-13-045
SHEET NO.		4	OF	6
CALCULATE	D BY	BRT	DATE	7/15/2018
CHECKED B	Y	JPS	DATE	7/15/2018
Retaining Wall 4W12 - Sta. 3006+25 - Phase 4R				

MSE Wall Dimensions and Retained Soil Pa	arameters	Bearing Soil Properties:	
MSE Wall Height, (H) =	12.9 ft	MSE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	16.8 ft	MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Distance from Wall Face to Toe of Backslope, (l)	= 5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
MSE Wall Length, (L) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	28 °
MSE Wall Effective Height, (<i>h</i>) =	18.8 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, [($(s_u)_{BS}$] = 2625 psf
Effective Retained Soil Backslope, (θ) =	15.2 °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	14.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	= 26.6 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf		
Retained Soil Friction Angle, (φ_{RS}) =	<u>30</u> °	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 LEED BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.372	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)
1. Drained cohesion for retained soil not accounted for in external st	ability analyses. This parameter	is utilized in global stability analysis.	
Check Bearing Capacity (Loading Case - St	rength lb) - AASHTC	D LRFD BDM Section 11.6.3.2	
P_{EV_2}			
	P_{v} /		
1 geg	= '/B'		
$x_4 \mid P P_{LSv} \mid P_{LS}$			
P_{EH}	S = B - 2e = 10	$5.8 \pi - 2(1.10 \pi) = 14.60 \pi$	
\uparrow^{3}	a - B/ - r	$-(169 \pm 12) = 120 \pm 120$	
R^{\vee}	$e - \frac{1}{2} - x_o$	= (10.0 I(72) - 7.3 I(= 1.10 I(
	$r - \frac{M_V - M_H}{M_V}$	- (110 70 kip.ft/ft - 00 10 kip.ft/ft) / 13	86 kin/ft – 730 ft
$X_{\circ} \leftarrow \rightarrow $	P_{ν}		
B/			
	(43.86 kip/ft)/(14.6 ft) = 3.00 ksf	
<i>∽</i> B, →	eq		
Resisting Moment, M_{V} : $M_{V} = I$	$P_{EV_1}(x_1) + P_{EV_2}(x_2)$	$+P_{_{EH}}\sin\theta(B)$	
P_{EV_2} P_{EV_1}	$= \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$, = (120 pcf)(12.9 ft)(16.8 ft)(1.35) =	35.11 kip/ft
P_{EV_2}	$= \frac{\gamma_2}{\gamma_{RS}} (h - H) (B - H)$	$(-I)\gamma_{EV} = \frac{1}{2}(120 \text{ pcf})(18.8 \text{ ft} - 12.9 \text{ ft})(16.8 \text{ ft} - 5.0 \text{ ft})$	ft)(1.35) = 5.65 kip/ft
$P_{EV_1} = I_{SV} + I_{LS} + P_{EH}$	$= \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH}$	$= \frac{1}{2}(120 \text{ pcf})(18.8 \text{ ft})^2(0.372)(1.50) =$	11.84 kip/ft
$\downarrow \qquad \qquad \downarrow \qquad \qquad$	$\frac{B}{2} = (16.8 \text{ ft})/2$	2 = 8.40 ft	
$\mapsto x_1$ $x_2 =$	$= l + \frac{2}{3}(B-l) =$	$5.0 \text{ ft} + \frac{2}{3}(16.8 \text{ ft} - 5.0 \text{ ft}) = 12.87 \text{ ft}$	
x_2			E) 440.70 L: 5'5'
$M_{\nu} = 0$	ან.11 кip/tt)(8.40 ft) + (క	ο.οο κιρ/π)(12.9 π) + (11.84 κιρ/ft)sin(15.2°)(16.8	n) = 419.79 kip·ft/ft
Overturning Moment, M_H : $M_H = 1$	$P_{EH}\cos\theta(x_3) + P$	$P_{LS}\cos\theta(x_4)$	
	$= \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH}$	$= \frac{1}{2}(120 \text{ pcf})(18.8 \text{ ft})^2(0.372)(1.50) =$	11.84 kip/ft
x_{I} P_{IS} P_{LS}	$=\sigma_{LS}hK_a\gamma_{LS}$ =	(250 psf)(18.8 ft)(0.372)(1.75) = 3.06 k	.cip/ft
x_3	$= h/_3 = (18.8 \text{ ft})/3$	3 = 6.27 ft	
$ \begin{array}{c c} & & \\ \hline \\ \hline$	$=\frac{h}{2}$ = (18.8 ft) / 2	2 = 9.4 ft	
<u>М</u> _H = (11.84 kip/ft)cos(15.2°)(6	5.27 ft) + (3.06 kip/ft)cos(15.2°)(9.40 ft) = 99	9.40 kip·ft/ft
Vertical Forces, P_{v} : $P_{v} = P_{v}$	$_{EV_1} + P_{EV_2} + P_{EH} \operatorname{si}$	n 0	
	= 35.11 kip/ft + 5.65 l	kip/ft + (11.84 kip/ft)sin(15.2°) = 43.86 k	cip/ft



јов F	FRA-70-12.68		W-13-045	
SHEET NO.	5	OF	6	
CALCULATED BY	BRT	DATE	7/15/2018	
CHECKED BY	JPS	DATE	7/15/2018	
Retaining Wall 4W12 - Sta. 3006+25 - Phase 4R				

MSE Wall Dimonsions and Poteinod Soil Para	matara	Boaring Soil Bro	nortios:	
MSE Wall Dimensions and Retained Son Fala	12.0.#	MSE Backfill Unit V	Neight (n.) -	120 pof
MSE Wall Height, (H) -	12.9 IL 16 9 #	MSE Backfill Erictic	veight, $(\gamma_{BF}) =$	120 pci
Distance from Wall Face to Tac of Backelone (1) =	50 ft	Bearing Soil Unit M	f Angle, $(\psi_{BF}) =$	
Distance from wail Face to five of Backslope, $(l) = MSE W(all Longth (l)) =$	025.0 ft	Bearing Soil Erictio	p Angle (a) =	120 pci
MOE Wall Lengul, $(L) =$	<u>933.0 п</u> 10.0 д	Bearing Soil Proinc	In Angle, $(\varphi_{BS}) =$	0 ==6
MSE wall Effective Height, $(n) =$		Dearing Soil Uraine	$(C_{BS}) =$	
Retained Soli Backslope, (β) =	20.0	Bearing Soli Undra	(D) =	$(u_{BS}) = 2625 \text{ psr}$
Effective Retained Soil Backslope, (θ) =	15.2 °	Empedment Depth	$(D_f) =$	<u>3.0</u> ft
Distance from Toe to Top of Backslope, $(z) =$	<u>14.0</u> ft	Depth to GW (Belo	w Bot. of Wall), $(D_W) =$	<u>7.9</u> ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	<u>120</u> pcf			
Retained Soil Friction Angle, (φ_{RS}) =	<u>30</u> °	LRFD Load Fact	<u>ors</u>	
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	ך 1.50 1.75 _ע	AASHTO LRFD BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.372	Strength lb 1.35	1.50 1.75 -	3.4.1-1 and 3.4.1-2 - Active
Live Surcharge Load, $(\sigma_{LS}) =$	250 psf	Service I 1.00	1.00 1.00 🗍	Laturi ressurej
1. Drained cohesion for retained soil not accounted for in external stabilit	y analyses. This parameter is	utilized in global stability analysis.		
Check Bearing Capacity (Loading Case - Stree	<u>ngth Ib) - AASHTO</u>	LRFD BDM Section 1	1.10.5.4 (Continued)	
Check Bearing Resistance - Drained Condition	<u>n</u>			
Nominal Bearing Resistance: $a - cN \perp$	1/DNC 1	$1/ \mathcal{A} \mathcal{B}' \mathcal{N} \mathcal{C}$		
$q_n - c_1 v_{cm}$ T	$f^{IV}_{f} qm^{C}_{Wq} +$	/2 / D / m m U wy		
N = N s i = 25.8	$N_{\dots} = N_{\cdot}s_{\cdot}d_{\cdot}i$	₋ = 16.2	N = N s i =	: 16.7
<i>cmcc</i>	qm q-q-q	9	$\gamma m \gamma \gamma \gamma$	
$N_c = 25.80$	$N_a = 14.72$		$N_{,,} = 16.72$	
$S_{a} = 1+(14.6 \text{ ft/935 ft})(14.72/25.8)$	$S_{a} = 1+(14.6 \text{ ft})$	/935 ft)tan(28°) = 1.000	$s_{n} = 1-0.4(14.6)$	(ft/935 ft) = 1.000
= 1.000	$d_{\pi} = 1+2\tan(28)$	°)[1-sin(28°)]²tan ⁻¹ (3.0 ft/14.6 ft)	$i_{} = 1.000$ (A	ssumed)
$i_{\star} = 1000$ (Assumed)	= 1 100	<u>, , , , , , , , , , , , , , , , , , , </u>	C = 79 ft < 15	(14.6 ft) + 3.0 ft = 0.500
	i = 1.000 (4)	(hemuse		
	$\Gamma_q = 70 \text{ ft} > 3$	0 ff = 1000		
	C _W q 7.5 K ² C			
a = (0 psf)(25.8) + (120 pcf)(3.0 ft)(16)	$2(1.0) + \frac{1}{(120.00)}$	f)(14 6 ft)(16 7)(0 5)	– 13.15 kof	
$q_n = (0 \text{ psi})(23.0) + (120 \text{ psi})(3.0 \text{ it})(100 \text{ si})(100 \text{ si})($.2)(1.0) + /2(120 pc	1)(14.011)(10.7)(0.3)	- 13.15 KSI	
Vorify Equivalent Pressure Less Than Factore	d Boaring Poeieta	nco		
	u Dearing Resista			
$q_{aa} \leq q_{a} \cdot \phi_{b} \longrightarrow 3.00 \text{ksf} \leq$	(13.15 ksf)(0.65) =	8.55 ksf →	3.00 ksf ≤ 8.55 ksf	OK
	· · · · · · · · · · · · · · · · · · ·			
Use $\varphi_{h} = 0.65$ (Per AASHTO LRFD BDM	Table 11.5.6-1)			
Check Bearing Resistance - Undrained Condit	tion			
	<u></u>			
Nominal Bearing Resistance $a = cN + cN$	$-\gamma D N C +$	$\frac{1}{2} \nu B' N C$		
$q_n - c_1 c_m$	$f f q m wq^{-1}$	$727B_{1}m_{ym} \sim_{wy}$		
N = N s i = 5140	N = N s d i	= 1 000	N = N s i =	: 0.000
1 cm - 1 cScc c	$q_m - 1 q_q q_q q_q$	<i>q</i>	$1 \gamma_{\gamma m} 1 \gamma_{\gamma} S_{\gamma} v_{\gamma}$	0.000
N = 5140	N = 1.000		N = 0.000	
$V_c = 3.140$	$r_q = 1.000$		$IV_{\gamma} = 0.000$	
$S_c = 17(14.010[(3)(93311)]) = 1.000$	$d_{q} = 1.000$	°)[1 sin(0°)]2ton=1/2 0 ft/14 6 ft)	$s_{\gamma} = 1.000$	
$l_c - 1.000$ (Assumed)	$u_q = 1 + 2 \tan(0)$)[1-sin(0)]-tain (3.0 tt/14.0 tt)	$l_{\gamma} = 1.000$ (A	
	= 1.000		$C_{wy} = 7.9 \text{ ft} < 1.5$	(14.6 ft) + 3.0 ft = 0.500
	$l_q = 1.000$ (A	(ssumed)		
	$C_{wq} = 7.9 \text{ ft} > 3$	0.0 ft = 1.000		
			_ 40.05 1.6	
$q_n = (2625 \text{ pst})(5.14) + (120 \text{ pct})(3.0 \text{ ft})$	(1.0)(1.0) + ½(120	οτι)(14.6 π)(0.0)(0.5)	= 13.85 ksf	
Verify Equivalent Pressure Less Than Factore	d Bearing Resista	nce		
	(12.95 kaf)(0.65) -		2 00 kof < 0 00 kcf	<u>or</u>
$q_{eq} \simeq q_n \cdot \varphi_b \longrightarrow 3.00 \text{ksf} \le$	(13.00 KSI)(U.05) =	∋.∪∪ KSI →	3.00 KST ≦ 9.00 KST	UN
Use $\psi_b = 0.65$ (Per AASHTO LRFD BDM]	i able 11.5.6-1)			



JOB	FRA-70-12.68		W-13-045	
SHEET NO.	6	OF	6	
CALCULATED	BRT BRT	DATE	7/15/2018	
CHECKED BY	JPS	DATE	7/15/2018	
Retaining Wall 4W12 - Sta. 3006+25 - Phase 4R				

MSE Wall Dimensions and Retained Son Paran	12 0 ff	Bearing Soil Properties: MSE Backfill Unit Weight (vpp) =	120 pcf
MSE Wall Width (Reinforcement Length) $(B) =$	12.5 ft	MSE Backfill Friction Angle. $(\varphi_{Br}) =$	34 °
Distance from Wall Face to Toe of Backslope. $(l) =$	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
MSE Wall Length, (<i>L</i>) =	935.0 ft	Bearing Soil Friction Angle, $(\varphi_{RS}) =$	28 °
MSE Wall Effective Height, (<i>h</i>) =	18.8 ft	Bearing Soil Drained Cohesion, $(c_{BS}) =$	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	2625 psf
Effective Retained Soil Backslope, (θ) =	15.2 °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, (z) =	14.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	26.6 ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	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 LR	FD BDM Tables
Retained Soil Active Earth Pressure Coeff., (K_a) =	0.372	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	-ressure)
1. Drained cohesion for retained soil not accounted for in external stability	analyses. This parameter	er is utilized in global stability analysis.	
Settlement Analysis (Loading Case - Service I)	- AASHTO LRF	D BDM Section 11.10.4.1	
	= 1	16.8 ft - 2(0.85 ft) = 15.10 ft	
		= (16.8 ft / 2) - 7.55 ft = 0.85 ft	
		= (307.06 kip·ft/ft - 63.65 kip·ft/ft) / 32.26 kip/ft	= 7.55 ft
	(32.26 kin/	f(1) = 214 kef	
	(32.20 KIP/	I(J) / (I3. III) = 2.14 KST	
			00 I. 676
$= [(120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00)][\frac{1}{2}(16.8 \text{ ft})] + \frac{1}{2}(120 \text{ pcf})(18.8 \text{ ft})^{2}(0.372)(1.00)\text{eig}(15.8 \text{ ft}))$	[1/2(120 pcf)(18.8 ft - 1 2°)1(16.8 ft)	$2.9 \text{ ft}(16.8 \text{ ft} - 5.0 \text{ ft})(1.00) [[5.0 \text{ ft} + \frac{4}{3}(16.8 \text{ ft} - 5.0 \text{ ft})] = 307.$	υο κιρ∙π/π
	.2))(10.0 II)		
$= \frac{1}{2}[(120 \text{ pcf})(18.8 \text{ ft})^2(0.372)(1.00)\cos(150)]$	5.2°)](18.8 ft /3)	= 63.65 kip-ft/ft	
+ [(250 psf)(18.8 ft)(0.372)(1.00)cos(1	5.2°)](18.8 ft /2)		
= $(120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00) + \frac{1}{2}(120 \text{ pcf})(12.9 \text{ ft})(12.9 ft$	pcf)(18.8 ft - 12.9	ft)(16.8 ft - 5.0 ft)(1.00) = 32.26 kip/ft	
+ ½(120 pcf)(18.8 ft)²(0.372)(1.00)si	n(15.2°)		
Settlement (See Attached Spreadsheet Calcula	tions):		
Total Settlement at Center of Reinforced Soil N	Mass: S _t	= 1.168 in	
I otal Settlement at Wall Facing:	S _t	= 0.825 IN	
Time Rate of Consolidation Settlement at Wall	Facing (See Att	ached Spreadsheet Calculations):	
$(S_c)_{I00} =$ in at da	ays followir	ng completion of construction	
			A A A A A A A A A A A A A A A A A A A

W-13-045 - FRA-70-12.68 - MSE Wall 4W12 MSE Wall Settlement - Sta. 3006+24 (Phase 4A)

Borings B-110-1-15 and B-111-0-09

H=	12.9	ft	Total wall height
B'=	15.1	ft	Effective footing width due to eccentricity
D _w =	26.6	ft	Depth below bottom of footing
q _e =	2,140	psf	Equivalent bearing pressure at bottom of wall

																				Total S	Settlement a	t Center of Re	einforced So	il Mass		Total Set	tlement at Fa	cing of Wall	
Layer	Soil Class.	Soil Type	Layer (f	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	⁽⁷⁾	Δσ _v ⁽⁸⁾ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)	l ⁽⁷⁾	$\Delta \sigma_v^{(8)}$ (psf)	σ _{vf} ' Midpoint (psf)	S _c ^(9,10) (ft)	S _c (in)
	A-6a	С	0.0	2.5	2.5	1.3	120	300	150	150	4,150	29	0.171	0.009	0.499				0.08	0.988	2,115	2,265	0.017	0.202	0.500	1,070	1,220	0.013	0.156
	A-6a	С	2.5	5.0	2.5	2.5	120	600	450	450	4,450	29	0.171	0.009	0.499				0.17	0.965	2,064	2,514	0.011	0.128	0.500	1,070	1,520	0.008	0.090
1	A-6a	С	5.0	7.5	2.5	3.8	120	900	750	750	4,750	29	0.171	0.009	0.499				0.25	0.947	2,027	2,777	0.008	0.097	0.500	1,070	1,820	0.005	0.066
	A-6a	С	7.5	10.5	3.0	5.3	120	1,260	1,080	1,080	5,080	29	0.171	0.009	0.499				0.35	0.924	1,976	3,056	0.008	0.093	0.484	1,036	2,116	0.005	0.060
	A-6a	С	10.5	13.5	3.0	6.8	125	1,635	1,448	1,448	5,448	29	0.171	0.009	0.499				0.45	0.900	1,926	3,374	0.006	0.075	0.468	1,002	2,449	0.004	0.047
	A-6a	С	13.5	16.5	3.0	8.3	125	2,010	1,823	1,823	5,823	29	0.171	0.009	0.499				0.55	0.820	1,755	3,577	0.005	0.060	0.452	967	2,790	0.003	0.038
2	A-6b	С	16.5	19.0	2.5	9.5	130	2,335	2,173	2,173	6,173	39	0.261	0.026	0.577				0.63	0.767	1,641	3,813	0.010	0.121	0.440	942	3,114	0.006	0.078
2	A-6b	С	19.0	21.5	2.5	10.8	130	2,660	2,498	2,498	6,498	39	0.261	0.026	0.577				0.71	0.717	1,534	4,031	0.009	0.103	0.428	916	3,413	0.006	0.067
	A-1-b	G	21.5	27.0	5.5	13.5	130	3,375	3,018	3,018	7,018					60	52	177	0.89	0.622	1,332	4,349	0.005	0.059	0.397	850	3,867	0.003	0.040
2	A-1-b	G	27.0	32.5	5.5	16.3	130	4,090	3,733	3,733	7,733					60	48	159	1.08	0.544	1,165	4,898	0.004	0.049	0.377	807	4,540	0.003	0.035
3	A-1-b	G	32.5	38.0	5.5	19.0	130	4,805	4,448	4,448	8,448					60	44	146	1.26	0.479	1,024	5,472	0.003	0.041	0.357	764	5,212	0.003	0.031
	A-1-b	G	38.0	43.5	5.5	21.8	130	5,520	5,163	5,163	9,163					60	41	134	1.44	0.421	902	6,064	0.003	0.034	0.334	715	5,878	0.002	0.028
4	A-3a	G	43.5	50.0	6.5	25.0	120	6,300	5,910	5,910	9,910					39	25	76	1.66	0.377	807	6,717	0.005	0.057	0.311	666	6,576	0.004	0.048
4	A-3a	G	50.0	56.5	6.5	28.3	120	7,080	6,690	6,587	10,587					39	24	73	1.87	0.336	720	7,307	0.004	0.048	0.290	621	7,208	0.003	0.042
1. $\sigma_{\rm p}' = \sigma_{\rm v}$,'+σ _m Estima	te σ_m of 4,00	00 psf for mo	derately ove	erconsolidate	d soil deposi	t; Ref. Table	e 11.2, Codu	ito 2003					•			•				Tota	Settlement:		1.168 in		Tota	Settlement:		0.825 in

2. C_c = 0.009(LL-10); Ref. Table 26, FHWA GEC 5

3. $C_r = 0.05(C_c)$ for embankment fill and $0.10(C_c)$ for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5

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

5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ 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. $S_c = [C_o/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{vf}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_{vf}'/\sigma_{p'})$ for $\sigma_{vo}' < \sigma_{p}' < \sigma_{vf}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv 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)

Calculated By:	BRT	Date:	7/17/2018
Checked By:	JPS	Date:	7/17/2018





јов F	RA-70-12.68	NO.	W-13-045
SHEET NO.	2	OF	6
CALCULATED BY	BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining Wall	4W12 - Sta. 3006	+25 - Pl	nase 6A

		Bearin MCC D	ookfill Upit Waisht	<u>5.</u> (100
WSE Wall Width (Peinforcement Longth) (2)	= 169#	MGE D	ackfill Friction Angle	$(\gamma_{BF}) =$	12U pc
VISE Wall Width (Reinforcement Length), (B)	- 10.0 IL (1) $-$ 5.0 ft	Bearing	ackilli Friction Angie	$(\varphi_{BF}) =$	120 m
ASE Wall Length (I) =	, (<i>i</i>) – 5.0 ft 935.0 ft	Bearing	Soil Friction Angle	$(\alpha_{}) =$	120 pt
MSE Wall Effective Height $(h) =$	18.8 ft	Bearing	Soil Drained Cohe	$(\varphi_{BS}) =$	0 ns
Retained Soil Backslope $(\beta) =$	26.6 °	Bearing	Soil Undrained Sh	ear Strength $[(s_{BS})]$	2625 p
Effective Retained Soil Backslope (θ) =	26.0 26.6 °	Embed	ment Depth $(D_c) =$		<u> </u>
Distance from Toe to Top of Backslope, $(z) =$	<u> </u>	Depth t	o GW (Below Bot.	of Wall), $(D_w) =$	26.6 ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pc				
Retained Soil Friction Angle, $(\varphi_{RS}) =$	30 °	LRFD	Load Factors		
Retained Soil Drained Cohesion, $(c_{RS}) =$	0 pst	f	EV EH	LS	
Retained Soil Undrained Shear Strength, $[(S_u)$	$_{RS}] = 2000 \text{ ps}$	í Strengt	h la 1.00 1.50	1.75 J (AASUTO L	
Retained Soil Active Earth Pressure Coeff., (A	$(x_a) = 0.526$	Strengt	h lb 1.35 1.50	1.75 - 3.4.1-1 and	3.4.1-2 - Active
ive Surcharge Load, $(\sigma_{LS}) =$	0 pst	í Service	el 1.00 1.00	1.00 _ Earth	Pressure)
1. Drained cohesion for retained soil not accounted for in exter	rnal stability analyses. This pa	rameter is utilized in global st	tability analysis.		
heck Sliding (Loading Case - Strength	<u>ı la) - AASHTO LRF</u>	D BDM Section 11	1.10.5.3 (Continued)		
heck Sliding Resistance - Undrained (Condition				
Nominal Sliding Resisting: $R_{ au}$:	$= ((S_u)_{BS} \leq q_s).$	B			
P_{EV_2}	S) = 263	kef			
	$S_u J_{BS} = 2.00$				
	$\sigma_{v} = \frac{\sigma_{v}}{2}$				
P_{EV_1} P_{LS_V} P_{LS}	<i>is</i> /2				
P_{FH}	$\sigma = P_V /$				
	$O_{\nu} - B$				
$\mathbf{R}_{\mathbf{z}}$	P - P +	$P + P \sin \theta$)		
1 1 1 1 1 $(s) < a$	$I_V - I_{EV_1}$	I_{EV_2} + I_{EH} SIII U			
$(\mathcal{O}_u)_{BS} \rightarrow \mathcal{G}_s$	$P - \gamma$	$H \cdot R \cdot \gamma =$	(120 pcf)(12 9 f	t)(16.8 ft)(1.00) = 2	'6.01 kin/ft
(Neglect <i>P</i> for conservatism)	$I_{EV_1} - I_{I}$	$F \cdot I I \cdot D \cdot f EV$	(120 por)(12.0 f		.0.01 Kip/it
	$P - \frac{1}{2}$	$\gamma (h-H)(B-$	l)v		
	1 EV ₂ — /2	$T_{RS}(n 11)(D 1)$	° Л' ЕV		
	P_{EV_2} =	1⁄2(120 pcf)(18.8 f	t - 12.9 ft)(16.8 ft -	5.0 ft)(1.00) = 4.18	kip/ft
		*) **			0.75
	$P_{EH} = \frac{1}{2}$	$\gamma_{RS}h^2K_a\gamma_{EH} =$	¹ / ₂ (120 pcf)(18.8	(0.526)(1.50) = 1	6.75 kip/ft
	$P_{V} = 26.01$	kip/ft + 4.18 kip/ft +	(16.75 kip/ft)sin(26	.6°) = 37.69 ki	p/ft
	$\sigma_{v} = (37.69 \text{ k})$	ip/ft) / (16.8 ft) =	2.24 ksf		
	$q_s = (2.24 \text{ ksf}) / 2$	= 1.12 ksf			
R_{τ} :	= (2.63 ksf ≤ 1.12	2 kst)(16.8 ft) =	44.10 kip/ft		
erify Sliding Force Less Than Factore	d Sliding Resistand	e - Undrained Co	ndition		
$P_H \leq R_\tau \cdot \phi_\tau \longrightarrow 14.98 ext{ kip/ft} \leq R_\tau \cdot \phi_\tau$	≤ (44.10 kip/ft)(1.0) =	44.10 kip/ft —	→ 14.98 kip	/ft ≤ 44.10 kip/ft	OK
Use $\varphi_{\tau} = 1.0$ (Per AASHTO LRFD BI	DM Table 11.5.6-1)				



JOB	FRA-70-12.68	NO.	W-13-045
SHEET NO.	3	OF	6
CALCULATED B	r BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining Wa	all 4W12 - Sta. 3006	+25 - Pl	nase 6A

MSE Wall Height, $(H) =$ 12.9 ftMSE Backfill Unit Weight, $(\gamma_{BF}) =$ MSE Wall Width (Reinforcement Length), $(B) =$ 16.8 ftMSE Backfill Friction Angle, $(\varphi_{BF}) =$ Distance from Wall Face to Toe of Backslope, $(I) =$ 5.0 ftBearing Soil Unit Weight, $(\gamma_{BS}) =$ MSE Wall Length, $(L) =$ 935.0 ftBearing Soil Drained Cohesion, $(c_{BS}) =$ MSE Wall Effective Height, $(h) =$ 18.8 ftBearing Soil Drained Cohesion, $(c_{BS}) =$ Retained Soil Backslope, $(\beta) =$ 26.6 °Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$ Effective Retained Soil Backslope, $(\theta) =$ 26.6 °Embedment Depth, $(D_f) =$ Distance from Toe to Top of Backslope, $(z) =$ 30.0 ftDepth to GW (Below Bot. of Wall), $(D_W) =$ Retained Soil Unit Weight, $(\gamma_{RS}) =$ 120 pcfRetained Soil Drained Cohesion, $(c_{RS}) =$ 0 psfEVRetained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ 2000 psfStrength Ia1.001.501.75Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ 0 psfStrength Ia1.001.00Ive Surcharge Load, $(\sigma_{LS}) =$ 0 psfStrength Ia1.001.00I. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis.Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3P	120 pcf 34 ° 120 pcf 28 ° 0 psf 2625 psf 3.0 ft 26.6 ft 26.6 ft 0 BDM Tables 1.12 - Active vssure)
MSE Wall Width (Reinforcement Length), (B) = 16.8 ft MSE Backfill Friction Angle, (φ_{BF}) = Distance from Wall Face to Toe of Backslope, (I) = 5.0 ft Bearing Soil Unit Weight, (γ_{BS}) = MSE Wall Length, (L) = 935.0 ft Bearing Soil Drained Cohesion, (φ_{BS}) = MSE Wall Effective Height, (h) = 18.8 ft Bearing Soil Drained Cohesion, (e_{BS}) = Retained Soil Backslope, (β) = 26.6 ° Bearing Soil Undrained Shear Strength, [(s_u) _{BS}] = Effective Retained Soil Backslope, (β) = 26.6 ° Embedment Depth, (D_f) = Distance from Toe to Top of Backslope, (z) = 30.0 ft Depth to GW (Below Bot. of Wall), (D_W) = Retained Soil Unit Weight, (γ_{RS}) = 120 pcf Retained Soil Drained Cohesion, (e_{RS}) = 0 psf EV EH LS Retained Soil Drained Cohesion, (e_{RS}) = 0 psf Strength Ia 1.00 1.50 1.75 Retained Soil Undrained Shear Strength, [(S_u) _{RS}] = 2000 psf Strength Ia 1.00 1.50 1.75 Retained Soil Active Earth Pressure Coeff., (K_a) = 0.526 Strength Ib 1.35 1.50 1.75 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 P_{EV_2}	34 ° 120 pcf 28 ° 0 psf 2625 psf 3.0 ft 26.6 ft 26.6 ft 0 BDM Tables (.1-2 - Active vssure)
Distance from Wall Face to Toe of Backslope, $(l) = 5.0$ ft MSE Wall Length, $(L) = 935.0$ ft Bearing Soil Unit Weight, $(\gamma_{BS}) = 935.0$ ft Bearing Soil Drained Cohesion, $(\varphi_{BS}) = 120$ Retained Soil Backslope, $(\beta) = 26.6$ ° Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 26.6$ ° Effective Retained Soil Backslope, $(\beta) = 26.6$ ° Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 26.6$ ° Effective Retained Soil Backslope, $(\beta) = 26.6$ ° Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 26.6$ ° Effective Retained Soil Backslope, $(\beta) = 26.6$ ° Embedment Depth, $(D_f) = 26.6$ ° Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] = 26.6$ ° Retained Soil Unit Weight, $(\gamma_{RS}) = 120$ pcf Retained Soil Unit Weight, $(\gamma_{RS}) = 120$ pcf Retained Soil Unit Weight, $(\varphi_{RS}) = 30$ ° Retained Soil Drained Cohesion, $(c_{RS}) = 0$ psf Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 2000$ psf Strength Ia 1.00 1.50 1.75 Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 2000$ psf Strength Ib 1.35 1.50 1.75 Live Surcharge Load, $(\sigma_{LS}) = 0$ psf 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 $P_{EV_{2}} = 3$	120 pcf 28 ° 0 psf 2625 psf 3.0 ft 26.6 ft 26.6 ft 0 BDM Tables 0.1-2 - Active 1.5sure)
MSE Wall Length, $(L) =$ 933.0 ftBearing Soil Friction Angle, $(\varphi_{aS}) =$ MSE Wall Effective Height, $(h) =$ 18.8 ftBearing Soil Drained Cohesion, $(c_{aS}) =$ Retained Soil Backslope, $(\beta) =$ 26.6 °Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$ Effective Retained Soil Backslope, $(\beta) =$ 26.6 °Embedment Depth, $(D_f) =$ Distance from Toe to Top of Backslope, $(z) =$ 30.0 ftDepth to GW (Below Bot. of Wall), $(D_w) =$ Retained Soil Unit Weight, $(\gamma_{RS}) =$ 120 pcfRetained Soil Drained Cohesion, $(c_{RS}) =$ 0 psfEVRetained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ 0 psfRetained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ 0 psfEVRetained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ 0 psfStrength laRetained Soil Active Earth Pressure Coeff., $(K_a) =$ 0.526Strength lb1.351. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis.AASHTO LRFD BDM Section 11.6.3.3Perevaluation of the starting Case - Strength la) - AASHTO LRFD BDM Section 11.6.3.3	28 0 psf 2625 psf 3.0 ft 26.6 ft 26.6 ft 0 BDM Tables 0.1-2 - Active 1.1-2 - Active 1.1-2 - Market State 1.1-2 - Active 1.1-2 - Active
MSE Wall Effective Height, $(h) =$ 18.6 ft Bearing Soil Drained Consistint, $(E_{BS}) =$ Retained Soil Backslope, $(\beta) =$ 26.6 ° Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$ Effective Retained Soil Backslope, $(\theta) =$ 26.6 ° Embedment Depth, $(D_f) =$ Distance from Toe to Top of Backslope, $(z) =$ 30.0 ft Depth to GW (Below Bot. of Wall), $(D_W) =$ Retained Soil Unit Weight, $(\gamma_{RS}) =$ 120 pcf Retained Soil Drained Cohesion, $(c_{RS}) =$ 0 psf EV EH LS Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ 2000 psf Strength Ia 1.00 1.50 1.75 Retained Soil Active Earth Pressure Coeff., $(K_a) =$ 0.526 Strength Ib 1.35 1.50 1.75 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 P	0 psr 2625 psf 3.0 ft 26.6 ft 0 BDM Tables 0.1-2 - Active 1.1-2 - Active 1.1-2 - Market 0.1-2 - Active
Retained Soil Backslope, $(p) = \frac{28.6}{26.6}$ Effective Retained Soil Backslope, $(\theta) = \frac{26.6}{26.6}$ Distance from Toe to Top of Backslope, $(z) = \frac{26.6}{30.0}$ ft Distance from Toe to Top of Backslope, $(z) = \frac{30.0}{120}$ ft Retained Soil Unit Weight, $(\gamma_{RS}) = \frac{120}{30.0}$ pcf Retained Soil Drained Cohesion, $(\rho_{RS}) = \frac{30.0}{30.0}$ ft Retained Soil Drained Cohesion, $(\rho_{RS}) = \frac{0}{30.0}$ psf Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = \frac{0}{2000}$ psf Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = \frac{0}{0.526}$ Strength la 1.00 1.50 1.75 Retained Soil Active Earth Pressure Coeff., $(K_a) = \frac{0.526}{0}$ Service I 1.00 1.00 1.00 $\frac{1.00}{1.00}$ 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength la) - AASHTO LRFD BDM Section 11.6.3.3 P_{EV_2}	2625 psi 3.0 ft 26.6 ft 0 BDM Tables 1.1-2 - Active issure)
Distance from Toe to Top of Backslope, $(z) = 1000$ Retained Soil Unit Weight, $(y_{RS}) = 1000$ Retained Soil Unit Weight, $(y_{RS}) = 1000$ Retained Soil Drained Cohesion, $(c_{RS}) = 1000$ Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 10000$ Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 100000$ Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 100000000000000000000000000000000000$	26.6 ft 26.6 ft DBDM Tables 1/2 - Active issure)
Bistance from the to top of Backstope, $(2)^{-1}$ Retained Soil Unit Weight, $(\gamma_{RS}) =$ Retained Soil Friction Angle, $(\varphi_{RS}) =$ Retained Soil Drained Cohesion, $(c_{RS}) =$ Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$ Retained Soil Active Earth Pressure Coeff., $(K_a) =$ Live Surcharge Load, $(\sigma_{LS}) =$ 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 P_{EV_2}	20.0 It BDM Tables 1-12 - Active issure)
Retained Soil Friction Angle, $(\varphi_{RS}) = 120$ pcf Retained Soil Drained Cohesion, $(e_{RS}) = 0$ psf EV EH LS Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 2000$ psf Strength la 1.00 1.50 1.75 Retained Soil Active Earth Pressure Coeff., $(K_a) = 0.526$ Strength lb 1.35 1.50 1.75 Live Surcharge Load, $(\sigma_{LS}) = 0$ psf Service I 1.00 1.00 1.00 1.00 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength la) - AASHTO LRFD BDM Section 11.6.3.3 $P_{EV_2} = 0$) BDM Tables .1-2 - Active issure)
Retained Soil Undrained Cohesion, $(c_{RS}) = 0$ psf EV EH LS Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 2000$ psf Strength Ia 1.00 1.50 1.75 Retained Soil Active Earth Pressure Coeff., $(K_a) = 0.526$ Strength Ib 1.35 1.50 1.75 Live Surcharge Load, $(\sigma_{LS}) = 0$ psf Service I 1.00 1.00 1.00 1.00 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 $P_{EV_2} = 0$ $R \neq - x$) BDM Tables 1.1-2 - Active Issure)
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] = 2000 \text{ psf}$ Strength la 1.00 1.50 1.75 Retained Soil Active Earth Pressure Coeff., $(K_a) = 0.526$ Strength lb 1.35 1.50 1.75 Live Surcharge Load, $(\sigma_{LS}) = 0 \text{ psf}$ Service I 1.00 1.00 1.00 1.00 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength la) - AASHTO LRFD BDM Section 11.6.3.3 $P_{EV_{a}} = 0$) BDM Tables 1.1-2 - Active issure)
Retained Soil Active Earth Pressure Coeff., $(K_a) = 0.526$ Live Surcharge Load, $(\sigma_{LS}) = 0$ psf Service I 1.00 1.00 1.00 $H = 1.00$ 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 $P_{EV_{2}} = 1.00 + 0.00$) BDM Tables I.1-2 - Active Inssure)
Live Surcharge Load, $(\sigma_{LS}) = 0$ psf Service I 1.00 1.00 1.00 1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 $P_{EV_{2}}$	essure)
1. Drained cohesion for retained soil not accounted for in external stability analyses. This parameter is utilized in global stability analysis. Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 $P_{E_{L_{2}}^{\prime}}$	
Check Eccentricity (Loading Case - Strength Ia) - AASHTO LRFD BDM Section 11.6.3.3 $P_{EV_{a}}$	
$P_{EV_{2}} = B/-r$	
P = B / - r	
~ 1 γ ~ -10 N_0	
$\mathbf{r} = P_{is} + P_{is} + P_{is}$	
$\begin{array}{c c} x_{4} \\ \uparrow \end{array} = P_{EV_{1}} \\ P_{EV_{1$	ft
$P_{EH_v} = P_{V}$	
$P \downarrow I = P \downarrow $	
$- \frac{1}{1} \frac{\pi}{1} \frac{\pi}{1} \frac{1}{1} $	
$M_H = 93.91$ kip·ft/ft	
$x_o \leftarrow \Rightarrow e$ $P_V = P_{EV_1} + P_{EV_2} + P_{EH} \sin \theta = 26.01 \text{ kip/ft} + 4.18 \text{ kip/ft} + (16.75 \text{ kip/ft}) \sin(26.6^\circ) = 0.01 \text{ kip/ft}$	37.69 kip/ft
$x_1 \leftarrow B_2 \rightarrow$	
e = (16.8 ft/2) - 8.08 ft = 0.32 ft	
Resisting Moment, M_{ν} : $M = P(\mathbf{r}) + P(\mathbf{r}) + P \sin\theta(\mathbf{R})$ (Neglect $P_{\nu \sigma}$ for conservat	ism)
$P_{EV} = P_{EV} + P$	
$P_{EV_1} = \gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV} = (120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00) = 26.01 \text{ It}$	<ip ft<="" td=""></ip>
$P_{LS_{V_{1}V_{1}}} = \gamma_{2} \gamma_{RS} (h - H)(B - l) \gamma_{EV} = \gamma_{2} (120 \text{ pcf})(18.8 \text{ ft} - 12.9 \text{ ft})(16.8 \text{ ft} - 5.0 \text{ ft})(1.00) =$	4.18 kip/ft
P_{FU}	
$P_{EH} = \frac{1}{2} \gamma_{RS} h^2 K_a \gamma_{EH} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft})^2 (0.526)(1.50) = 16.75 \text{ kip/ft}$	<u>د</u>
• $x_1 = \frac{\nu}{2} = (16.8 \text{ ft})/2 = 8.40 \text{ ft}$	
$ \xrightarrow{1} x_1 $	
$1 x_2 x_2 = l + \frac{1}{3} (B - l) - 5.0 \text{ it} + \frac{1}{3} (10.6 \text{ it} - 5.0 \text{ it}) = 12.67 \text{ it}$	
$M = (26.01 \text{ kin/ft})(8.40 \text{ ft}) + (4.18 \text{ kin/ft})(12.87 \text{ ft}) + (16.75 \text{ kin/ft})(26.6^{\circ})(16.8 \text{ ft}) - 3000 \text{ start}^{2}$	18.28 kin.ft/
$M_{V} = (20.01 \text{ kp/l}(0.40 \text{ k}) + (4.10 \text{ kp/l}(12.01 \text{ k}) + (10.10 \text{ kp/l}(13.01 k$	0.20 Kip'il
Overturning Moment, M_{μ} : $M_{\mu} = P_{\mu} \cos \theta(\mathbf{r}_{\mu}) + P_{\mu} \cos \theta(\mathbf{r}_{\mu})$	
$H_H = I_{EH} \cos((w_3) + I_{LS} \cos((w_4)))$	
$P_{\text{ref}} = \frac{1}{2} \gamma_{\text{ref}} h^2 K \gamma_{\text{ref}} = \frac{1}{2} (120 \text{ pcf})(18.8 \text{ ft})^2 (0.526)(1.50) = 16.75 \text{ kip/ft}$	t
$EH = 727 \text{ RS}^{-1} EH = 727 \text{ RS}^{-1} EH$	
$P_{LC} = \sigma_{LC} h K \gamma_{LC} = (0 \text{ psf})(18.8 \text{ ft})(0.526)(1.75) = 0.00 \text{ kip/ft}$	
X_{4}	
$P_{EH} = \frac{1}{2} \frac{1}{3} 1$	
$- \frac{1}{2} = $	
M_H = (16.75 kip/ft)cos(26.6°)(6.27 ft) + (0 kip/ft)cos(26.6°)(9.40 ft) = 93.91 kip-ft	t/ft
$\mathbf{B} \neq \mathbf{B} \neq $	
<u>Check Eccentricity</u> Limiting Eccentricity: $e_{\text{max}} = \frac{D}{3} \rightarrow e_{\text{max}} = (16.8 \text{ ft})/3 = 5.60 \text{ ft}$	
$e < e_{max} \rightarrow 0.32 \Pi < 5.00 \Pi$ UK	



JOB	FRA-70	0-12.68	NO.	W-13-045
SHEET NO.		4	OF	6
CALCULATE	D BY	BRT	DATE	7/15/2018
CHECKED BY		JPS	DATE	7/15/2018
Retaining	Wall 4W1	2 - Sta. 300	6+25 - Ph	ase 6A

MSE Wall Dimensions and Retained Soil Para	meters	Bearing Soil Properties:	
MSE Wall Height, (H) =	12.9 ft	MSE Backfill Unit Weight, (γ_{BF}) =	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	16.8 ft	MSE Backfill Friction Angle, (φ_{BF}) =	34 °
Distance from Wall Face to Toe of Backslope, $(l) =$	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
MSE Wall Length, (L) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	28 °
MSE Wall Effective Height, (h) =	18.8 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	2625 psf
Effective Retained Soil Backslope, (θ) =	26.6 °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	30.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	26.6 ft
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf		
Retained Soil Friction Angle, $(\varphi_{RS}) =$	<u>30</u> °	LRFD Load Factors	
Retained Soil Undrained Conesion, (c_{RS}) =	0 pst	$EV E\Pi LS$	
Retained Soil Ondrained Shear Strength, $[(S_u)_{RS}] =$	2000 psr	Strength lb 1 25 1 50 1.75 (AASHTO LR	RFD BDM Tables
Live Surcharge Load $(\sigma_{a}) =$	0.520	Service 1 1 00 1 00 1 00 <i>Earth</i>	Pressure)
1. Drained cohesion for retained soil not accounted for in external stabili	ty analyses. This parameter is	s utilized in global stability analysis.	
Check Bearing Capacity (Loading Case - Stree	ngth lb) - AASHTO	LRFD BDM Section 11.6.3.2	
P_{EV_2}			
	P_V		
9 eg —	/ <i>B</i> '		
$x_4 = P_{LSv} + P_{LS}$	- P 2a - 16	$8 \text{ ft}_{-} 2(0.12 \text{ ft}) - 16.56 \text{ ft}$	
$x_2 $ P_{EH_y} P_{EH_y} P_{EH} P_{EH}	-D - 2e - 10		
\uparrow	e = B/2 - x	= (16.8 ft/2) - 8.28 ft = 0.12 ft	
	$\frac{2}{2}$		
	$x_{I} = \frac{M_{V} - M_{H}}{M_{V} - M_{H}}$	= (493.64 kip·ft/ft - 93.91 kip·ft/ft) / 48.26 kip/ft	= 8.28 ft
x _o ← → → - + e	P_{V}		
B/			
$\left[\begin{array}{c} 2 \\ p \\ \end{array}\right] \xrightarrow{2} \left[\begin{array}{c} q \\ p \\ \end{array}\right]$	= (48.26 kip/ft)	/ (16.56 ft) = 2.91 ksf	
$x_2 \rightarrow y_2 \rightarrow y_1 \rightarrow y_2 \rightarrow y_1 \rightarrow y_2 \rightarrow y_1 \rightarrow y_2 \rightarrow y_2 \rightarrow y_1 \rightarrow y_2 $			
2			
Resisting Moment, M_V : $M_V = P_{EV}$	$P_{V_1}(x_1) + P_{EV_2}(x_2)$	$+ P_{EH} \sin \theta(B)$	
σ		(120 - 5)(1
$P_{EV_1} = P_{EV_1}$	$\gamma_{BF} \cdot H \cdot B \cdot \gamma_{EV}$	= (120 pcf)(12.9 ft)(16.8 ft)(1.35) $=$ 35.11	κιρ/π
	$1/\alpha$ $(h H)/P$	I_{1}^{1} = $\frac{1}{120}$ pcf)(18.8 ft - 12.9 ft)(16.8 ft - 5.0 ft)(1.35) =	5.65 kin/ft
P $ \cdot \cdot \rangle$ D $I EV_2$	$7_2 \gamma_{RS} (n - 11) (D - 11)$		0.00 Кр/П
P_{EV_1} $P_{III} = P_{III} =$	$\frac{1}{2}\gamma_{m}h^{2}K\gamma_{m}$	$= \frac{1}{2}(120 \text{ pcf})(18.8 \text{ ft})^2(0.526)(1.50) = 16.75 \text{ kig}$	o/ft
P_{EH}	7 2 7 RS** +* a7 EH		
\downarrow	$B_{1} = (16.8 \text{ ft}) / 2$	2 = 8.40 ft	
• • • • • • • • • • • • • • • • • • •	×2		
$\mapsto x_1$ $x_2 = l$	$1 + \frac{2}{3}(B-l) =$	5.0 ft + ⅔(16.8 ft - 5.0 ft) = 12.87 ft	
\vdash			
$M_V = (35.$	11 kip/ft)(8.40 ft) + (5	$(16.5 \text{ kip/ft})(12.9 \text{ ft}) + (16.75 \text{ kip/ft})\sin(26.6^\circ)(16.8 \text{ ft}) = 4$	493.64 kip·ft/ft
Overturning Moment $M : M \rightarrow R$	$\partial \partial (\mathbf{x}) + \mathbf{p}$		
Over turning moment, M_H . $M_H = P_E$	$C_H \cos\theta(x_3) + P_I$	$L_S \cos \theta(x_4)$	
	$1/\alpha h^2 K \alpha$	$= \frac{1}{(120 \text{ pcf})(18.8 \text{ ft})^2(0.526)(1.50)} = 16.75 \text{ kin}$	√ft
	$\gamma_2 \gamma_{RS} n \kappa_a \gamma_{EH}$		<i>//</i> //
$ $ $ $ $ $ \rangle p P =	$\sigma h K \gamma =$	(0 psf)(18.8 ft)(0.526)(1.75) = 0.00 kin/ft	
X_{4}	O LSHIN at LS		
x_3	$n_{2} = (18.8 \text{ ft}) / 3$	= 6.27 ft	
	3		
$ + \bullet \qquad \qquad$	$\frac{l}{2} = (18.8 \text{ ft}) / 2$	= 9.4 ft	
	~		
$M_H = (10)$	6.75 kip/ft)cos(26.6°)((6.27 ft) + (0 kip/ft)cos(26.6°)(9.40 ft) = 93.91 kip	⊳ft/ft
Vertical Forces, P_{V} : $P_{V} = P_{EV_{1}}$	$+P_{EV_2}+P_{EH}\sin$	n <i>U</i>	
	2E 11 1:- /# · 5 05 '	in ft + (10.75 kin/ft)ain (20.0%) 10.000 11.77	
P_{r} =	ээ. i i кiр/π + 5.65 k	.ιρ/π + (10.75 kip/π)sin(26.6 ⁻) = 48.26 kip/ft	



JOB	FRA-70-12.68	NO.	W-13-045
SHEET NO.	5	OF	6
CALCULATED	BY BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining W	/all 4W12 - Sta. 3006	+25 - Pl	nase 6A

	<u>rameters</u>	Bearing So	oil Prope	rties:						
MSE Wall Height, (<i>H</i>) =	12.9 ft	MSE Backfil	l Unit Wei	ight, (γ	_{BF}) =				120 p	ocf
MSE Wall Width (Reinforcement Length), (B) =	<u>16.8</u> ft	MSE Backfil	I Friction A	Angle,	$(\varphi_{BF}) =$				34 °	•
Distance from Wall Face to Toe of Backslope, (<i>l</i>) =	5.0 ft	Bearing Soil	Unit Wei	ght, (γ_B	_{'s}) =				120 p	ocf
MSE Wall Length, (<i>L</i>) =	<u>935.0</u> ft	Bearing Soil	Friction A	Angle, ($\varphi_{BS}) =$				28 °	•
MSE Wall Effective Height, (<i>h</i>) =	<u>18.8</u> ft	Bearing Soil	Drained (Cohesio	$\operatorname{on}, (c_B)$	₅) =			0 p	osf
Retained Soil Backslope, (β) =	<u>26.6</u> °	Bearing Soil	Undraine	d Shea	r Stren	igth, [$[(s_u)_{BS}]$	=	2625 p	osf
Effective Retained Soil Backslope, (θ) =	<u>26.6</u> °	Embedment	Depth, (L	$(\mathcal{D}_f) =$					3.0 f	t
Distance from Toe to Top of Backslope, $(z) =$	<u>30.0</u> ft	Depth to GV	V (Below I	Bot. of	Wall), ((D_W)	=		7.9 f	ť
Retained Soil Unit Weight, $(\gamma_{RS}) =$	120 pcf									
Retained Soil Friction Angle, $(\varphi_{RS}) =$	<u>30</u> °	LRFD Load	d Factors	<u>5</u>						
Retained Soil Drained Cohesion, $(c_{RS}) =$	<u>0</u> psf		EV	EH	LS					
Retained Soil Undrained Shear Strength, $[(S_u)_{RS}] =$	2000 psf	Strength la	1.00	1.50	1.75	<u> </u>	(AASHT	O LRFD E	DM Table	əs
Retained Soil Active Earth Pressure Coeff., $(K_a) =$	0.526	Strength Ib	1.35	1.50	1.75		3.4.1-1 E	and 3.4.1 arth Press	-2 - Active :ure)	9
IVE Surcharge Load, $(\sigma_{LS}) =$	0 psf	Service I	1.00	1.00	1.00	_				
Check Bearing Capacity (Loading Case - Str	ength Ib) - AASHTO	LRFD BDM Sect	tion 11.1	0.5.4 (Continu	ed)				
Check Bearing Resistance - Drained Conditi	ion									
Nominal Bearing Resistance: $q_n = cN_{cm}$	$+ \gamma D_f N_{qm} C_{wq} +$	$+ \frac{1}{2} \gamma B' N_{\gamma m} C_{w \gamma}$	Y							
$N_{cm} = N_c s_c i_c = 25.8$	$N_{qm} = N_q s_q d_q$	<i>i</i> _q = 16.2	Ζ	$V_{\gamma m} =$	$N_{\gamma}s$	$i_{\gamma}i_{\gamma}$	= 1	6.7		
N _c = 25.80	$N_{a} = 14.72$			Ν.	= 16	.72				
$S_{c} = 1+(16.56 \text{ ft}/935 \text{ ft})(14.72/25.8)$	$S_{q} = 1+(16.56)$	ft/935 ft)tan(28°) =	1.000	з.,	= 1-	0.4(16	.56 ft/93	5 ft) =	1.00	00
= 1.000	$d_{q} = 1+2\tan(28)$	3°)[1-sin(28°)]²tan⁻¹(3.0 ft/	16.56 ft)	- y i	= 1.0	000	(Assum	ed)		
$i_{c} = 1.000$ (Assumed)	= 1.100			C	= 7.9	ft < 1.	、 5(16.56	, ft) + 3.0 f	i =	0.50
	$i_{a} = 1.000$ ()	Assumed)		rv y			l			
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(25.8)$	C _{wg} = 7.9π> 16.2)(1.0) + ½(120 pc	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0	.5) =	= 14	4.14	ksf				
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(100 \text{ cm})$ <i>Verify</i> Equivalent Pressure Less Than Factor $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf}$	C _{wg} = 7.9π>: 16.2)(1.0) + ½(120 pc <u>red Bearing Resista</u> ≤ (14.14 ksf)(0.65) =	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 <u>ance</u> 9.19 ksf —	.5) = ≽ 2.	= 14 .91 ksf	4.14 ≤ 9.19	ksf) ksf		OK		
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(100)$ Verify Equivalent Pressure Less Than Facto $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDI	C _{wg} = 7.9π>: 16.2)(1.0) + ½(120 pc <u>red Bearing Resista</u> ≤ (14.14 ksf)(0.65) = M Table 11.5.6-1)	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf —	.5) = > 2.	= 14 91 ksf	4.14 ≤ 9.1§	ksf) ksf				
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(100)$ Verify Equivalent Pressure Less Than Facto $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Constitution	C _{wy} = 7.9π>: 16.2)(1.0) + ½(120 pc red Bearing Resista ≤ (14.14 ksf)(0.65) = M Table 11.5.6-1) dition	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf —	5) = → 2.	= 14 91 ksf	4.14 ≤ 9.1§	ksf) ksf				
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(10)$ Verify Equivalent Pressure Less Than Facto $q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf}$ Use $\varphi_b = 0.65$ (Per AASHTO LRFD BDI Check Bearing Resistance - Undrained Contents Nominal Bearing Resistance: $q_n = cN_{cm}$	$C_{wq} = 7.9 \text{ m} + 120 \text{ pc}$ 16.2)(1.0) + 1/2(120 pc) red Bearing Resistate $\leq (14.14 \text{ ksf})(0.65) =$ W Table 11.5.6-1) diftion $+ \gamma D_f N_{qm} C_{wq} + 120 \text{ m}$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = > 2.	= 14	4.14 ≤ 9.19	ksf				
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(7)$ $Verify Equivalent Pressure Less Than Facto q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 \text{ (Per AASHTO LRFD BDI)} Check Bearing Resistance - Undrained Common Nominal Bearing Resistance: q_n = cN_{cm} N_{cm} = N_c s_c i_c = 5.140$	$C_{wq} = -7.9 \text{ m} \times 10^{-1}$ 16.2)(1.0) + ½(120 pc) red Bearing Resistance $\leq (14.14 \text{ ksf})(0.65) =$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} +$ $N_{qm} = N_q S_q d_q i$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	5) = ⇒ 2. γ	91 ksf	4.14 ≤9.15 = N _γ s	ksf		OK		
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(1)$ $Verify Equivalent Pressure Less Than Facto q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 \text{ (Per AASHTO LRFD BDI)} Check Bearing Resistance - Undrained Concentration Nominal Bearing Resistance: q_n = cN_{cm} N_{cm} = N_c s_c i_c = 5.140 N_c = 5.140$	$C_{wq} = -7.9 \text{ m} \times 10^{-1}$ 16.2)(1.0) + ½(120 pc) red Bearing Resistance $\leq (14.14 \text{ ksf})(0.65) =$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} +$ $N_{qm} = N_q s_q d_q l$ $N_q = -1.000$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	5) = ⇒ 2. × ×	= 14 91 ksf V _m = N _v	4.14 ≤ 9.15 $= N_{\gamma} S$ = 0.0	ksf } ksf				
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(1)$ $\underline{\text{/erify Equivalent Pressure Less Than Facto}}{q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf}}$ $Use \varphi_b = 0.65 (Per \text{ AASHTO LRFD BDI})$ $\text{Check Bearing Resistance - Undrained Constant of the second state of the$	$C_{wq} = -7.9 \text{ m} + 1$ 16.2)(1.0) + ½(120 pc) red Bearing Resista $\leq (14.14 \text{ ksf})(0.65) =$ M Table 11.5.6-1) dition $+ \gamma D_f N_{qm} C_{wq} +$ $N_{qm} = N_q S_q d_q i$ $N_q = -1.000$ $S_q = -1.000$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = → 2. ×	= 14 .91 ksf $N_{jm} = \frac{N_{j}}{N_{y}}$	4.14 ≤ 9.15 $= N_{\gamma}s$ = 0.0 = 1.0	ksf } ksf				
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(10)$ $Prify Equivalent Pressure Less Than Factors q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \varphi_b = 0.65 (Per AASHTO LRFD BDI Prify Equivalent Pressure - Undrained Control Prify Equivalent Pressure - Undrained Prify Equivalent Prify $	$C_{wq} = -7.9 \text{ m} + 1$ $16.2)(1.0) + \frac{1}{2}(120 \text{ pc})$ $red Bearing Resista$ $\leq (14.14 \text{ ksf})(0.65) =$ $M Table 11.5.6-1)$ $dition$ $+ \frac{1}{2}D_f N_{qm}C_{wq} +$ $N_{qm} = N_q S_q d_q d_q$ $N_q = 1.000$ $S_q = 1.000$ $d_q = 1+2 \tan(0)$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = ⇒ 2. ν κ 6.56 ft)	$V_{jm} = \frac{N_{j}}{S_{\gamma}}$	4.14 ≤ 9.19 $= N_{\gamma}s$ = 0.0 = 1.0 = 1.0	ksf ∂ksf ; _y i _y 000 000	= 1	OK		
$\begin{array}{l} q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(10) \\ \hline & \text{Verify Equivalent Pressure Less Than Factor} \\ \hline & \text{Verify Equivalent Pressure Pressure Less Than Factor} \\ \hline & \text{Verify Equivalent Pressure Pressure Less Than Factor} \\ \hline & Verify Equivalent Pressure Pressu$	$C_{wq} = 7.9 \text{ m} + 120 \text{ pc}$ $16.2)(1.0) + \frac{1}{2}(120 \text{ pc})$ $red Bearing Resista$ $\leq (14.14 \text{ ksf})(0.65) = 1000 \text{ m}$ $H Table 11.5.6-1)$ $dition$ $H \frac{1}{2}D_f N_{qm}C_{wq} + 1000 \text{ m}$ $N_{qm} = N_q S_q d_q d_q$ $N_q = 1.000 \text{ m}$ $S_q = 1.000 \text{ m}$ $d_q = 1+2 \text{ tan}(0)$ $= 1.000$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = ⇒ 2. ×	$V_{jm} = N_{y}$ N_{y} $V_{jm} = N_{y}$ N_{y}	4.14 ≤ 9.19 $= N_{y}S$ = 0.0 = 1.0 = 1.0 = 7.9	ksf 9 ksf 2 y l y 000 000 1 ft < 1.	= 1 (Assum 5(16.56	OK 0.000 ed) ft) + 3.0 f		0.50
$\begin{array}{l} q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(1) \\ \hline & \underline{\textit{Verify Equivalent Pressure Less Than Facto}} \\ q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} \\ & Use \ \phi_b = 0.65 \ (Per \ AASHTO \ LRFD \ BDI) \\ \hline & \underline{\textit{Check Bearing Resistance - Undrained Conv}} \\ \hline & \underline{\textit{Neck Bearing Resistance : } q_n = cN_{cm} \\ \hline & N_{cm} = N_c s_c i_c = 5.140 \\ & N_c = 5.140 \\ & s_c = 1+(16.56 \ \text{ft}/[(5)(935 \ \text{ft})] = 1.000 \\ & i_c = 1.000 \ (\text{Assumed}) \\ \hline \end{array}$	$C_{wq} = 7.9 \text{ m} + 120 \text{ pc}$ 16.2)(1.0) + ½(120 pc) red Bearing Resista $\leq (14.14 \text{ ksf})(0.65) = 120 \text{ m}$ $M Table 11.5.6-1)$ dition $+ \gamma D_f N_{qm} C_{wq} + 100 \text{ m}$ $M_{qm} = N_q S_q d_q d_q d_q d_q d_q d_q d_q d_q d_q d$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = ⇒ 2. ν δ.56 ft)	$V_{jm} = \frac{14}{N_{y}}$	4.14 ≤ 9.19 $= N_{\gamma}s$ = 0.0 = 1.0 = 1.0 = 7.9	ksf) ksf) ksf 000 000 (ft < 1.	= 1 (Assum 5(16.56	OK 0.000 ed) ft) + 3.0 t		0.50(
$\begin{array}{l} q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(100) \\ \hline \text{Verify Equivalent Pressure Less Than Factors} \\ q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} \\ \text{Use } \varphi_b = 0.65 (Per \text{ AASHTO LRFD BDIs}) \\ \hline \text{Check Bearing Resistance - Undrained Constrained Constrained Resistance:} q_n = cN_{cm} \\ \hline \text{Nominal Bearing Resistance:} q_n = cN_{cm} \\ \hline N_{cm} = N_c S_c i_c = 5.140 \\ \hline N_c = 5.140 \\ S_c = 1+(16.56 \text{ ft/}[(5)(935 \text{ ft})] = 1.000 \\ i_c = 1.000 (\text{Assumed}) \\ \hline \end{array}$	$C_{wq} = 7.9 \text{ m} + 120 \text{ pc}$ 16.2)(1.0) + $\frac{1}{2}(120 \text{ pc})$ red Bearing Resistation $\leq (14.14 \text{ ksf})(0.65) = 12000 \text{ m}$ M Table 11.5.6-1) $\frac{\text{dition}}{M_{qm}} = N_q S_q d_q d_q d_q d_q d_q d_q d_q d_q d_q d$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = → 2. × × 6.56 ft)	$V_{jm} = \frac{1}{s_{jm}}$	4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14 4.14	ksf → ksf → ksf 0000 000 000 (ft < 1.	= 1 (Assum: 5(16.56	ОК 0.000 ed) ft) + 3.0 1		
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(1)$ $Verify Equivalent Pressure Less Than Facto q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 (Per \text{ AASHTO LRFD BDI}) Verify Equivalent Pressure Less Than Facto Q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 (Per \text{ AASHTO LRFD BDI}) Verify Equivalent Pressure Less Than Facto Q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 (Per \text{ AASHTO LRFD BDI}) Verify Equivalent Pressure Less Than Facto Q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 (Per \text{ AASHTO LRFD BDI}) Verify Equivalent Pressure Less Than Facto Q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 (Per \text{ AASHTO LRFD BDI}) Verify Equivalent Pressure Less Than Facto Q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Q_{eq} = 0.65 \text{ ksf} Q_{eq} = 0$	$C_{wq} = 7.9 \text{ ft} > 16.2)(1.0) + \frac{1}{2}(120 \text{ pc})$ $red Bearing Resistance \leq (14.14 \text{ ksf})(0.65) = 16.2 \text{ M}$ $M Table 11.5.6-1)$ $dition = 1.000 \text{ M}_{q} = 1.000 \text{ M}_{q} = 1.000 \text{ M}_{q} = 1.000 \text{ M}_{q} = 1.2000 \text{ M}_{q} = $	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = ⇒ 2. × 6.56 ft) 1.5) =	$V_{jm} = 14$ $N_{jm} = N_{j}$ N_{j}	4.14 ≤ 9.19 $= N_{y}S$ $= 0.0$ $= 1.0$ $= 1.0$ $= 7.9$ 3.85	ksf) ksf) ksf (7, <i>i</i> , 7) 000 000 (1, ft < 1.)) (1, 1, 1) (1,	= 1 (Assum 5(16.56	OK 0.000 ft) + 3.0 1		
$q_n = (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(1)$ $Verify Equivalent Pressure Less Than Facto q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} Use \phi_b = 0.65 (Per \text{ AASHTO LRFD BDI}) Deck Bearing Resistance - Undrained Content of the second state of the second stat$	$C_{wq} = -7.9 \text{ ft} > 1$ $16.2)(1.0) + \frac{1}{2}(120 \text{ pc})$ $red Bearing Resista$ $\leq (14.14 \text{ ksf})(0.65) =$ $M Table 11.5.6-1)$ $dition$ $+ \frac{1}{2}D_f N_{qm}C_{wq} +$ $N_{qm} = N_q S_q d_{ql}$ $N_q = 1.000$ $S_q = 1.000$ $d_q = 1+2 \tan(0)$ $= 1.000$ $i_q = 1.000$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf — 9.19 ksf — $l_{2} \gamma B' N_{ym} C_{wy}$ $i_{q} = 1.000$ $l_{1}(1-\sin(0^{\circ}))^{2}\tan^{-1}(3.0 ft/1)$ Assumed) 3.0 ft = 1.000 pcf)(16.6 ft)(0.0)(0 ance	.5) = ⇒ 2. × × .56 ft) .55 ft) =	$V_{jm} = \frac{14}{N_{y}}$ $\frac{N_{y}}{i_{y}}$	4.14 ≤ 9.15 $\equiv N_{\gamma}s$ $\equiv 0.0$ $\equiv 1.0$ $\equiv 1.0$ $\equiv 7.9$ 3.85	ksf) ksf) ksf 000 000 (1ft < 1.) ksf	= 1 (Assum: 5(16.56	OK 0.000 ed) ft) + 3.01		0.550
$\begin{array}{ll} q_n = & (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(1) \\ \hline & \text{Verify Equivalent Pressure Less Than Factor} \\ \hline & q_{eq} \leq q_n \cdot \phi_b \longrightarrow 2.91 \text{ ksf} \\ & \text{Use } \varphi_b = & 0.65 (\text{Per AASHTO LRFD BDI}) \\ \hline & \text{Check Bearing Resistance - Undrained Concernation} \\ \hline & \text{Check Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & \text{Nominal Bearing Resistance - Undrained Concernation} \\ \hline & $	$C_{wq} = -7.9 \text{ m} + 3$ 16.2)(1.0) + ½(120 pc) red Bearing Resista ≤ (14.14 ksf)(0.65) = M Table 11.5.6-1) dition + $\gamma D_f N_{qm} C_{wq} +$ $N_{qm} = N_q S_q d_q i$ $N_q = 1.000$ $d_q = 1+2tan(0)$ $i_q = 1.000$ $i_q =$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = ⇒ 2. × // 6.56 ft) 1.5) = ⇒ 2.	= 14 .91 ksf $N_{ym} = N_{y}$ N_{y} i_{y} C_{wy} = 13 .91 ksf	4.14 ≤ 9.15 $\equiv N_{\gamma}S$ $\equiv 0.0$ $\equiv 1.0$ $\equiv 7.9$ 3.85 ≤ 9.00	ksf → ksf ; , i,, , , , , , , , , , , , ,	= ((Assum 5(16.56	OK		0.500
$\begin{array}{ll} q_n = & (0 \text{ psf})(25.8) + (120 \text{ pcf})(3.0 \text{ ft})(1) \\ \hline & \text{Verify Equivalent Pressure Less Than Factor} \\ \hline & q_{eq} \leq q_n \cdot \phi_b \longrightarrow & 2.91 \text{ ksf} \\ \hline & \text{Use } \varphi_b = & 0.65 (\text{Per AASHTO LRFD BDI}) \\ \hline & \text{Check Bearing Resistance - Undrained Concernance} \\ \hline & \text{Nominal Bearing Resistance:} q_n = cN_{cm} \\ \hline & N_{cm} = N_c s_c i_c = & 5.140 \\ \hline & N_c = & 5.140 \\ & s_c = & 1+(16.56 \text{ ft})((5)(935 \text{ ft})) = & 1.000 \\ & i_c = & 1.000 (\text{Assumed}) \\ \hline & q_n = & (2625 \text{ psf})(5.14) + (120 \text{ pcf})(3.0) \\ \hline & \text{Verify Equivalent Pressure Less Than Factor} \\ \hline & q_{eq} \leq q_n \cdot \phi_b \longrightarrow & 2.91 \text{ ksf} \end{array}$	$C_{wq} = -7.9 \text{ ft} > 1$ $16.2)(1.0) + \frac{1}{2}(120 \text{ pc})$ $red Bearing Resista$ $\leq (14.14 \text{ ksf})(0.65) =$ $M Table 11.5.6-1)$ $dition$ $+ \frac{1}{2}D_f N_{qm}C_{wq} +$ $N_{qm} = N_q S_q d_q d_q d_q d_q d_q d_q d_q d_q d_q d$	3.0 ft = 1.000 cf)(16.6 ft)(16.7)(0 ance 9.19 ksf	.5) = ⇒ 2. × // 6.56 ft) 1.5) = ⇒ 2.	= 14 .91 ksf $N_{ym} = N_{y}$ N_{y} i_{y} C_{wy} = 13 .91 ksf	4.14 ≤ 9.15 $\equiv N_{\gamma}S$ $\equiv 0.0$ $\equiv 1.0$ $\equiv 7.9$ 3.85 ≤ 9.00	ksf → ksf ; , i, , , , , , , , , , , , , , , , , , , ,	= ((Assum 5(16.56	OK		0.500



JOB FR.	A-70-12.68	NO.	W-13-045
SHEET NO.	6	OF	6
CALCULATED BY	BRT	DATE	7/15/2018
CHECKED BY	JPS	DATE	7/15/2018
Retaining Wall 4	W12 - Sta. 3006	+25 - Pl	nase 6A

MSE Wall Dimensions and Retained Soil Parar	neters	Bearing Soil Properties:	
MSE Wall Height, (H) =	12.9 ft	MSE Backfill Unit Weight, $(\gamma_{BF}) =$	120 pcf
MSE Wall Width (Reinforcement Length), (B) =	16.8 ft	MSE Backfill Friction Angle, (φ_{BF}) =	 34 °
Distance from Wall Face to Toe of Backslope, (<i>l</i>) =	5.0 ft	Bearing Soil Unit Weight, $(\gamma_{BS}) =$	120 pcf
MSE Wall Length, (L) =	935.0 ft	Bearing Soil Friction Angle, (φ_{BS}) =	28 °
MSE Wall Effective Height, (h) =	18.8 ft	Bearing Soil Drained Cohesion, (c_{BS}) =	0 psf
Retained Soil Backslope, (β) =	26.6 °	Bearing Soil Undrained Shear Strength, $[(s_u)_{BS}] =$	2625 psf
Effective Retained Soil Backslope, (θ) =	26.6 °	Embedment Depth, (D_f) =	3.0 ft
Distance from Toe to Top of Backslope, $(z) =$	30.0 ft	Depth to GW (Below Bot. of Wall), (D_W) =	26.6 ft
Retained Soil Unit Weight, (γ_{RS}) =	120 pcf		
Retained Soil Friction Angle, $(\varphi_{RS}) =$	<u>30</u> °	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 LI	RFD 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 Earth	3.4.1-2 - Active Pressure)
Live Surcharge Load, (σ_{LS}) =	0 psf	Service I 1.00 1.00 1.00	
Sottlomont Analysis (Loading Case - Service I)		BDM Section 11 10 4 1	
	D /		
$q_{eq} = 1$	V/R'		D
$P_{IS} = P_{IS}$	<i>, </i>		
$P_{EV_1} \xrightarrow{P} \begin{array}{c} P_{LS_k} \xrightarrow{P} \\ P_{LS_k} \xrightarrow{P} \\ P_{LS_k} \xrightarrow{P} \end{array} B' =$	B - 2e = 16	.8 ft - 2(0.05 ft) = 16.70 ft	
$\begin{array}{c c} x_3 \\ & &$	R /		
$R \downarrow = \frac{1}{2} \frac{EH_h}{2} \xi \theta$	$x = \frac{D}{2} - x_o$	= (16.8 ft / 2) - 8.35 ft = 0.05 ft	
	$M_V - M_H$		0.05 #
2	$\dot{z}_o =$	= (356.27 KIP·TI/T - 62.59 KIP·TI/T) / 35.19 KIP/T	= 8.35 π
x_0	- <i>v</i>		
$\leftarrow \frac{B_2}{2}$	— (35.10 kin/ft)	/(16.7.ft) - 2.11 kcf	
$\leftarrow B' \rightarrow P'$	_ (33.19 Kip/it)		
$x_2 \rightarrow x_2$			
$M_{V} = P_{EV_{1}}(x_{1}) + P_{EV_{2}}(x_{2}) + P_{EH} \sin \theta(B) = (\gamma_{BF} H)$	$(B\gamma_{EV})(\frac{1}{2}B) + (\frac{1}{2}\gamma_{EV})$	$\gamma_{RS}(h-H)(B-l)\gamma_{EV}(l+2\gamma_{S}(B-l)) + (1/2\gamma_{RS}h^{2}K_{a}\gamma_{EV})$	$_{_{H}}\sin\theta(B)$
$M_V = [(120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00)][\frac{1}{2}(16.8 \text{ ft})] +$	[½(120 pcf)(18.8 ft - 12.9	$\frac{1}{2} ft(16.8 ft - 5.0 ft)(1.00)][5.0 ft + \frac{2}{3}(16.8 ft - 5.0 ft)] = 356$.27 kip·ft/ft
+ [½(120 pct)(18.8 tt)*(0.526)(1.00)sin(26	5.6°)](16.8 π)		
$M = P \cos \theta(r) + P \cos \theta(r) = (1/r) h^2$	$K \sim \cos \theta (h/)$	$\pm (\sigma hK \chi \cos \theta h/)$	
$M_{H} = I_{EH} \cos(x_{3}) + I_{LS} \cos(x_{4}) - \sqrt{2} \gamma_{RS} \pi$	$(x_a)_{EH} \cos(y_3)$	$+(O_{LS}nK_a)(SOSO)(2)$	
$M_{\rm eff} = \frac{1}{120} \mathrm{pcf}(18.8 \mathrm{ft})^2 (0.526)(1.00) \mathrm{cos}(2)$	6 6°)](18 8 ft /3)	= 62.59 kip.ft/ft	
$+ [(0 \text{ psf})(18.8 \text{ ft})(0.526)(1.00)\cos(26.10)$	6°)](18.8 ft /2)		
	1		
$P_{V} = P_{FV} + P_{FV} + P_{FH} \sin \theta = (\gamma_{BF} H B \gamma_{FV}) +$	$(\frac{1}{2}\gamma_{RS}(h-H))(E$	$(l_{2}\gamma_{FV}) + (l_{2}\gamma_{RS}h^{2}K_{a}\gamma_{FH}\sin\theta)$	
$P_V = (120 \text{ pcf})(12.9 \text{ ft})(16.8 \text{ ft})(1.00) + \frac{1}{2}(120 \text{ st})(1.00)$	pcf)(18.8 ft - 12.9 ft)	(16.8 ft - 5.0 ft)(1.00) = 35.19 kip/ft	
+ ½(120 pcf)(18.8 ft)²(0.526)(1.00)s	in(26.6°)		
Sottlement (See Attached Spreadsheet Calcul	tions):		
Settlement (See Attached Spreadsheet Calcula	<u>alions).</u>		
Total Settlement at Center of Reinforced Soil	Mass: S. =	1.189 in	
	~		
Total Settlement at Wall Facing:	<i>S</i> , =	0.830 in	
	*		
Time Rate of Consolidation Settlement at Wall	Facing (See Atta	ched Spreadsheet Calculations):	
$(S_c)_{100} =$ in at d	ays following	completion of construction	

W-13-045 - FRA-70-12.68 - MSE Wall 4W12 MSE Wall Settlement - Sta. 3006+24 (Phase 6A)

Borings B-110-1-15, and B-111-0-09

H=	12.9	ft	Total wall height
B'=	16.7	ft	Effective footing width due to eccentricity
D _w =	26.6	ft	Depth below bottom of footing
q _e =	2,110	psf	Equivalent bearing pressure at bottom of wall

		Total Settlement at Center of Reinforced Soil Mass Total Settlement at Facing of Wall																											
Layer	Soil Class.	Soil Type	Layer (f	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	⁽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)
	A-6a	С	0.0	2.5	2.5	1.3	120	300	150	150	4,150	29	0.171	0.009	0.499				0.07	0.988	2,085	2,235	0.017	0.201	0.500	1,055	1,205	0.013	0.155
	A-6a	С	2.5	5.0	2.5	2.5	120	600	450	450	4,450	29	0.171	0.009	0.499				0.15	0.971	2,048	2,498	0.011	0.127	0.500	1,055	1,505	0.007	0.090
1	A-6a	С	5.0	7.5	2.5	3.8	120	900	750	750	4,750	29	0.171	0.009	0.499				0.22	0.953	2,011	2,761	0.008	0.097	0.500	1,055	1,805	0.005	0.065
	A-6a	С	7.5	10.5	3.0	5.3	120	1,260	1,080	1,080	5,080	29	0.171	0.009	0.499				0.31	0.929	1,961	3,041	0.008	0.092	0.488	1,030	2,110	0.005	0.060
	A-6a	С	10.5	13.5	3.0	6.8	125	1,635	1,448	1,448	5,448	29	0.171	0.009	0.499				0.40	0.912	1,924	3,371	0.006	0.075	0.476	1,004	2,452	0.004	0.047
	A-6a	С	13.5	16.5	3.0	8.3	125	2,010	1,823	1,823	5,823	29	0.171	0.009	0.499				0.49	0.860	1,815	3,637	0.005	0.062	0.460	971	2,793	0.003	0.038
2	A-6b	С	16.5	19.0	2.5	9.5	130	2,335	2,173	2,173	6,173	39	0.261	0.026	0.577				0.57	0.800	1,688	3,861	0.010	0.124	0.448	945	3,118	0.006	0.078
2	A-6b	С	19.0	21.5	2.5	10.8	130	2,660	2,498	2,498	6,498	39	0.261	0.026	0.577				0.64	0.750	1,583	4,080	0.009	0.106	0.436	920	3,417	0.006	0.068
	A-1-b	G	21.5	27.0	5.5	13.5	130	3,375	3,018	3,018	7,018					60	52	177	0.81	0.667	1,407	4,424	0.005	0.062	0.412	869	3,887	0.003	0.041
2	A-1-b	G	27.0	32.5	5.5	16.3	130	4,090	3,733	3,733	7,733					60	48	159	0.97	0.589	1,243	4,975	0.004	0.052	0.389	820	4,552	0.003	0.036
3	A-1-b	G	32.5	38.0	5.5	19.0	130	4,805	4,448	4,448	8,448					60	44	146	1.14	0.511	1,078	5,526	0.004	0.043	0.369	778	5,225	0.003	0.032
	A-1-b	G	38.0	43.5	5.5	21.8	130	5,520	5,163	5,163	9,163					60	41	134	1.30	0.464	980	6,142	0.003	0.037	0.351	742	5,904	0.002	0.029
4	A-3a	G	43.5	50.0	6.5	25.0	120	6,300	5,910	5,910	9,910					39	25	76	1.50	0.407	859	6,769	0.005	0.060	0.329	693	6,603	0.004	0.049
4	A-3a	G	50.0	56.5	6.5	28.3	120	7,080	6,690	6,587	10,587					39	24	73	1.69	0.368	777	7,364	0.004	0.051	0.306	645	7,232	0.004	0.043
1. $\sigma_{\rm p}' = \sigma_{\rm v}$,'+σ _m Estima	te σ_m of 4,00	00 psf for mo	derately ove	erconsolidate	d soil deposi	t; Ref. Table	e 11.2, Codu	to 2003				•			•	•				Tota	Settlement:		1.189 in		Tota	Settlement:		0.830 in

2. C_c = 0.009(LL-10); Ref. Table 26, FHWA GEC 5

3. $C_r = 0.05(C_c)$ for embankment fill and $0.10(C_c)$ for natural cohesive soils; Ref. Section 5.4.2.5 of FHWA GEC 5

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

5. $(N1)_{60} = C_n N_{60}$, where $C_N = [0.77log(40/\sigma_{vo}')] \le 2.0$ 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. $S_c = [C_o/(1+e_o)](H)\log(\sigma_{vt}'/\sigma_{vo}')$ for $\sigma_p' \leq \sigma_{vo}' < \sigma_{vf}'$; $[C_r/(1+e_o)](H)\log(\sigma_p'/\sigma_{vo}')$ for $\sigma_{vo}' < \sigma_{v}' \leq \sigma_p'$; $[Cr/(1+e_o)](H)\log(\sigma_{vt}'/\sigma_{p}')$ for $\sigma_{vo}' < \sigma_p' < \sigma_{vt}'$; Ref. Section 10.6.2.4.3, AASHTO LRFD BDS (Cohesiv 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)

Calculated By:	BRT	Date:	7/17/2018
Checked By:	JPS	Date:	7/17/2018

